Tracing the Fallout: An Interdisciplinary Study of Technoscientific Practices and Media Ecologies in the Radiation Monitoring of the Fukushima Nuclear Disaster

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Declaration

I declare the following thesis to be my own work. Where the works of others is used, they are cited and referenced in the bibliography. Any assistance from others is listed in the acknowledgements.

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Acknowledgement

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Abstract

This thesis examines citizen-scientific and institutional data generation and visualization of the radioactive contamination arising from the Fukushima nuclear power plant accident in 2011. Governmental and citizen science groups have used different technological methods and scientific standards to monitor and visualize the contamination in Japan. Based on the discussions of media studies, science and technology studies (STS), and philosophy of technology, an interdisciplinary analysis of the disaster is developed to question the social and technological relations, monitoring devices, and digital mapping of the disaster.

Chapter 1 develops an analysis of radiation monitoring in Japan after the disaster, drawing on theoretical frameworks such as civic epistemology and actor network theory. Subsequently, it also examines the contemporary ecological debates regarding the Anthropocene, nuclear studies, and Michel Serres's Natural Contract. Chapter 2 discusses media theories of media networks, digital archives, and interface designs to delineate the methodology of this thesis.

Thereafter, the thesis tackles questions through a series of case studies. Chapter 3 analyses the ways in which the post-2011 digital infrastructure has been related to the mobilization of social movements, the formation of monitoring projects, and the subjectivity of citizens in media ecology. Chapter 4 examines "monitoring devices" such as radiation detectors and spreadsheet software in the light of Gilbert Simondon's theory of individuation. Drawing on Simondonian relational ontology, the thesis will illustrate those monitoring devices within connected social, natural, and digital milieux. Chapter 5 investigates digital mapping initiatives of the 3.11 disaster. Relying on Deleuze and Whitehead’s discussions on time, space and extensity, this chapter will examine the way in which the radioactive contamination has been mapped on digital maps.

Through these discussions, this thesis analyses the significance of technoscientific practices in digital media in the figuration of the nuclear disaster.

Table of Contents

Table of Figure

Introduction: The Nuclear Accident Happened at the Daiichi Power Plant and Technological and Cultural Reactions

This thesis will study the ways of monitoring the ongoing radioactive disaster in Japan, which was triggered by the earthquake and tsunami in 2011. The great earthquake of magnitude 9.0 hit a wide area of the east of the Japanese peninsula, and the quake triggered a subsequent tsunami. The tsunami impacted the North-East area of Japan and inflicted catastrophic damage upon the seaside towns. According to the Japanese government's official announcement, the number of the victims exceeded 10,000 and over 15,000 people are still on the missing list.[1] Furthermore, the tsunami caused the nuclear accident at the Fukushima Daiichi Nuclear Power Plant (hereinafter referred to as the Daiichi NPP) and 164,865 residents were evacuated from residential areas at the peak period of 2011; the designated evacuation zone covered a 20 Km radius around the Daiichi NPP, where three nuclear reactors caused hydrogen explosion.[2] The Daiichi NPP is being managed by Tokyo Electric Power Company (hereinafter referred to as TEPCO), and it had been providing the capital area with electricity since 1971.[3] In the Fukushima Case, mainly eight different types of radioactive isotope have been detected, out of which caesium-137 is the most released radionuclide with the longest half-life. In total, 15 PBq of caesium-137 was released over the land of Japan and its half-life is about 30 years.[4] To make sense of the ongoing catastrophic event, not only authoritative

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[1] Kenneth Pletcher and John P. Rafferty, 'Japan earthquake and tsunami of 2011: Additional Information', *Britannica*, last updated: 13 May 2024, https://www.britannica.com/event/Japan-earthquake-and-tsunami-of-2011.

[2] Fukushima Revitalization Station, 'The Status of the Evacuation Area', accessed: 10 March 2019, http://www.pref.fukushima.lg.jp/site/portal/list271-840.html.

[3] Nippon.com, 'The History of Nuclear Power in Fukushima', 5 August 2019, https://www.nippon.com/en/japan-data/h00508/the-history-of-nuclear-power-in-fukushima.html.

[4] Ministry of the Environment, 'The comparison of the estimation of the released radionuclides from the Chernobyl nuclear power plant accident and the TEPCO Fukushima Daiichi power plant accident

science institutions but also grassroots citizens science groups have been monitoring the disaster by making use of the digital infrastructure to produce data on the contamination and visualise the empirical data into a visual form of digital mapping. As key examples introduced in the coming sections will show, significant scientific and media practices in post-Fukushima Japan can be found in the cases of citizen science involved. Additionally, it is notable that authoritative scientific institutions are producing and publicising monitoring data on the nuclear disaster, and these data have been utilised in citizens' media practices. In the media ecologies of post-Fukushima Japan, these authoritative and non-authoritative groups of scientists and citizens were independently organized, but they were also interconnected through the media network. By taking their practices as examples, this thesis will analyse how these scientific media practices of radiation monitoring emerged in reaction to the Fukushima nuclear disaster and created a novel political and scientific epistemology on the horizon of post-Fukushima Japan.

To provide the background and questions of this study, in this introduction, we will primarily consider six points. First of all, this thesis will explain how the disaster happened chronologically following the events at the Daiichi NPP. Next, it will be shown how the Japanese society has historically memorised natural disasters, and we will then look at a new practice of digital archiving that has been widely undertaken in the Fukushima case. Thirdly, by introducing a citizen science project – Safecast, this section will illustrate how questions regarding radiation monitoring have been tackled in this thesis. Fourthly, the thesis will introduce the seminal debates about Fukushima by Hiroshi Kainuma and Azuma Hiroki to situate this thesis in relation to previous debates on the political background of the nuclear disaster and on how to critically approach Fukushima after the accident. Subsequently, we will examine an art performance of *Pointing at Fukushima Live Cam* to consider some

(チェルノブイリ原子力発電所事故と東京電力福島第一原子力発電所事故の放射性核種の推定放出量の比較)', last modified: 2019, https://www.env.go.jp/chemi/rhm/h30kisoshiryo/h30kiso-02-02-05.html.

characteristics of the media in post-Fukushima Japan. Finally, based on these points, the research objectives and questions of this thesis will be shown.

How the Accident Happened at the Daiichi Nuclear Power Plant

To share the background knowledge of the nuclear disaster, this section will outline how the accident happened by following the chronological timeline. On 11 March 2011, the three nuclear reactors of Units 1, 2, and 3 were in the operation at the Daiichi Power Plant, and Units 4, 5, and 6 were out of operation for regular inspection.[5] At 2:46 PM, the Great East Japan Earthquake of magnitude 9.0 occurred at a point 130km away from the Northeast part of the Miyagi Prefecture.[6] Subsequently, because of the safety features of its design, Unit 1 of the Daiichi NPP automatically stopped operation. To reduce the nuclear fission of uranium fuel rods, control rods were inserted into them. Although the fission was reduced under the regular operation, the rods were still emanating high temperature, so the power plant needed to cool the reactor down by continuing to send cool water from the sea. Due to the damage to the external electricity supply system caused by the earthquake, the power plant lost the electricity needed to run its internal systems, causing the regular cooling system to stop as well. Therefore, the internal emergency diesel generator turned on to activate the cooling device. However, at about 3.30 PM, the 10m-high tsunami hit the Daiichi NPP, which surpassed the expected highest water level of 6.3m, and the site went underwater.[7] As a result, the diesel generator, which was located on the basement floor of the turbine building next to the unit,

[5] NHK, 'What is the TEPCO Fukushima Nuclear Daiichi Power Plant Accident? The Summery of the Accident (東電福島第一原発事故とは〈事故の概要〉) ', March 2021, https://www3.nhk.or.jp/news/special/nuclear-power-plant_fukushima/feature/article/article_08.html.

[6] World Nuclear Association, 'Fukushima Daiichi Accident', last modified: 29 April 2024, https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-daiichi-accident.aspx.

[7] World Nuclear Association, 'Fukushima Daiichi Accident'.

also sank in the tsunami. Consequently, the Daiichi NPP lost internal power, and the cooling device was also shut down. With both the external and internal power sources defunct, the shared control room of Units 1 and 2 lost all lights and the panels on the control deck went in the state of 'SBO (Station Blackout)'.[8] This was the first case of SBO at a nuclear power station in world history. Due to this circumstance, the staff could not check the water level, temperature, and air pressure in the reactor. The reactors were also equipped with an emergency condenser, which can send water for cooling down the fuel rods, but there was no way to check whether that was working properly.

Around 11:50 PM, the staff brought in a small power generator in the control room and found that the air pressure in the reactor was extremely high, so they needed to vent the containment.[9] This meant that they needed to release the inside air of the reactor, which was already filled with a high concentration of radiation. Then, Masao Yoshida, the plant manager, asked Prime Minister Naoto Kan and the chief of the Nuclear Safety Commission, Haruki Madarame for permission to vent, which would inevitably release a certain amount of radiation in the natural environment.[10] It is estimated that the water in the reactors had almost evaporated around this time and the inside rods had started melting down.

By 9 PM on 11 March, the prime minister announced a state of a nuclear emergency and the 3km around the Daiichi power plant was designated as the evacuation area. In the early morning of 12 March, Yoshida received permission for venting. Thereafter, at around 9 AM, the staff at the power plant started the operation, which was finished at 2:40 PM.[11] This venting operation was also conducted without any previous examples, so it was done by trial and error and took longer than expected. Although the venting was successful, against their estimation, the melted containment of the fuel was releasing a large amount of hydrogen, which had been

[8] NHK, 'What is the TEPCO'.

[9] NHK, 'What is the TEPCO'.

[10] NHK, 'What is the TEPCO'.

[11] NHK, 'What is the TEPCO'.

accumulated in the upper part of the reactor building. Then, at 3:36 PM, Unit 1 caused a hydrogen explosion, because of which the roof of the building was blown off leaving its framework.[12] At Units 2 and 3, the plant staff and firefighters had been conducting the cooling operation from both the inside and the outside of the reactor contaminant building since the first external power was lost. However, on 13 March, Unit 3 also lost all its power sources due to the damage to the external and internal power supply systems, causing a hydrogen explosion on the 14th. Subsequently, the hydrogen from Unit 3 reached Unit 4, which lead to another explosion on the 15th.

This is the series of events that led to the three explosions. The Daiichi NPP started its operation with Unit 1 on 26 March 1971. The reactor had been designed by the General Electric Company, which had also designed the reactor for The Three Mile Island Nuclear Power Plant.[13] In 1974, Unit 2, also based on the same design, started the operation. In 1976, so did Unit 3, which was, however, designed by Toshiba Corporation. This period overlapped with Japan's high economic growth, which also facilitated the construction of the power plant. Eventually, Unit 4 (1978), Unit 5 (1978), and Unit 6 (1979) were built in the Daiichi Power Plant. In 2011, TEPCO had been planning the construction of Units 7 and 8, which were cancelled due to the accident.[14] In the reactors of the Daiichi Power Plant, the melted fuel rods, which still remain at the bottom of the containment, are releasing a highly toxic amount of radiation of 6.4-7.6 Sv/h, which can cause a person's death within one hour of exposure.[15] To monitor

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[12] NHK, 'What is the TEPCO'.

[13] Tokyo Electric Power Company, 'TEPCO on the Numerical Chart (数表で見る東京電力) ', 2022, https://www.tepco.co.jp/corporateinfo/illustrated/nuclear-power/nuclear-plants-j.html.

[14] Nikkei, 'TEPCO cancels the construction of Uni7 and 8 at the Fukushima Daiichi Nuclear Power Plant (東電、福島第１原発の７～８号機の増設計画を中止)', 20 May 2011, https://www.nikkei.com/article/DGXNASFL200B1_Q1A520C1000000/.

[15] NHK, 'The Fukushima Daiichi Nuclear Power Plant Unit2: The Debris has an extremely high radioactivity (福島第一原発２号機デブリで極めて強い線量)', 28 February 2019, https://www.nhk.or.jp/politics/articles/lastweek/14809.html.

the inside of the reactor and to remove the radioactive debris, the government has introduced remote-controlled robots.[16]

As described above, the nuclear disaster was not only caused by the tsunami and the earthquake but is also largely due to several human errors. After the accident, there has been a strong call for revision of the managerial responsibility of the accident. For example, the design of the breakwater and the location of the emergency power generation should have been more refined to protect the containment building from the 10m-high tsunami attack. In 2008, the Headquarters for Earthquake Research Promotion had already reported to TEPCO that an earthquake of magnitude of 8.2 could potentially occur around the Japan Trench, causing a tsunami of 15.7m, which could hit the Daiichi Power Plant. However, on discussing the report, the management team of TEPCO evaluated that the estimation was only based on a virtual premise. Hence, instead of undertaking immediate reinforcement of the anti-inundation measures at the Daiichi Power plant, they asked the Japan Society of Civil Engineers to further inspect this issue. As of 2011, the inspection had not been completed.[17] Over the failure of the decision made by the management team regarding the disaster measures, 38 trials have taken place since 2017, in which over 200 people were involved as witnesses. However, at the last trial on 19 September 2019, Tokyo District Court pronounced a verdict of not guilty of criminal charges, citing the reason that it was not recognisable that the three former managers could have foreseen the occurrence of the huge tsunami.[18]

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[16] BBC, ‘Fukushima disaster: Robot finds possible melted nuclear fuel’, 23 July 2017, https://www.bbc.co.uk/news/world-asia-40696303.

[17] Junichi Taki, ‘The Fukushima Nuclear Accident, the Lesson from the Late Event: The Report from the Institution of Nuclear Power Operation in the United States (福島原発事故、遅れたベントから得た教訓: 米原子力発電運転協会が報告書)’, the *Nikkei*, 20 September 2012, https://www.nikkei.com/article/DGXNZO46247170Y2A910C1000000/.

[18] NHK, ‘TEPCO Criminal Trial: The Truth of the Nuclear Accident (東電刑事裁判「原発事故の真相は」)’, 2019, https://www3.nhk.or.jp/news/special/toudensaiban/.

In 2011, the cooling operation was still being conducted and the radiated water from the containment had been reserved at the site of the Daiichi NPP. In 2021, the Japanese government has decided to release the water into the sea by introducing a Multi-nuclide Removal Facility,[19] which reduces the amount of radioactive isotopes of tritium in the water.[20] There have been a number of criticisms against this decision, advocating that the government's explanation does not secure the safety of human health and aquatic resources. However, the government led by the Liberal Democratic Party argues that the released water will meet the global safety standard, so it would be unlikely to impact the health of residents.[21] The government and TEPCO also announced the instalment of radiation monitoring post around the releasing point to avoid and control the excessive release of the radionuclides[22] into the ocean, and that they would release the monitoring date from their eight monitoring posts at the site of the Daiichi NPP every day.[23] This is the set of events that comprise the nuclear disaster at the Daiichi NPP occurring during the decade from 2011 to 2023.

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[19] This facility is also called (this is called Advanced Liquid Processing System = ALPS).

[20] Tokyo Electric Power Company, 'Contaminated Water Treatment', On the company website, accessed: 10.05.2021, https://www.tepco.co.jp/en/decommision/planaction/alps/index-e.html.

[21] NHK, 'Why do they oppose to the release of the contaminated water?', 26 April 2021, https://www3.nhk.or.jp/news/html/20210426/k10012993691000.html.

[22] The term 'Radionuclides' pertains to substances that are radioactive and release radiation at a unique rate. In this thesis, when referring to 'radiation', it specifically denotes the radioactive rays emitted from radionuclides. The terms 'radioactive substances' and 'radionuclides' are used specifically in the study of the properties of these elements. Chapter 5 of this thesis investigates the properties of the radionuclides caesium-134 and caesium-137, with particular consideration given to their radioactive half-lives.

[23] Tokyo Electric Power Company, 'The Status of the Monitoring Post Measurement in the Site of the Fukushima Daiichi Nuclear Power Plant (福島第一原子力発電所敷地境界でのモニタリングポスト計測状況)', accessed 18 April 2021, https://www.tepco.co.jp/decommission/data/monitoring/monitoring_post/index-j.html.

The Memorisation of Disasters and Digital Archives

This section will present how the Japanese society reacted to the disaster in terms of digital archiving, which is a novel phenomenon that emerged in post-Fukushima Japan. Before introducing the Fukushima case, let us briefly take a look at the history of the memorisation of natural disasters. A society's memory locates itself both in immaterial and material forms such as legislator, culture, politics, and architecture. The way that a disastrous moment flows into these forms can be thought of as memorisation, and those who witness a disaster can be thought of as an agency of the activity. That is, memory, figured and shared, becomes a referable object dislocated from the immediacy of the event but with links to it. The memorisation of a disaster is a long-standing practice, which has existed in Japan for over a millennium. For example, *Nihonshoki* (日本書紀：720), the second oldest book of Japanese history, refers to a huge earthquake that occurred in 684 AD and how it caused massive damage. Since then, other Japanese history books, such as *Nihon Sandai Jitsuroku* (日本三代実録：901) and *Hojo-ki* (方丈記：1212), have recorded how earthquakes caused damage to the society in those days.[24] Furthermore, monuments exist that convey the memories and lessons of disasters in Japan. For example, the stone monument of Ryohei Kanokogi (鹿子木量平), a leading settlement in the Kumamoto Prefecture, where disasters such as eruption and earthquake happen frequently, teaches the lesson that was gained from the tsunami disaster in 1792.[25] The residents in the area have learned how to deal with a disaster from the descriptions on these monuments, which provide instructions on how to escape from natural

[24] *Nikkei*, 'Historical Documents Tell the History of Disasters in Japan (古文書が語る日本災害史、刻まれた「先人の教え」)', 10 March 2016, https://www.nikkei.com/article/DGXMZO98087760V00C16A3000000/.

[25] Asahi Shimbun, 'The Ancient Stele that Tells Disaster Folklore　in Kumamoto', 22 April 2017, http://www.asahi.com/articles/ASK4H7FMNK4DTLVB015.html.

disasters. Hence, the number of victims of disaster is small in the areas, where a number of monuments exist. Additionally, the development of urban areas has reflected the previous disasters. For example, in response to the great Hanshin-Awaji earthquake in 1995, the government of the Kobe Prefecture, where 6434 people died, founded the Disaster Reduction and Human Renovation Institute in 2002. The institute building is in the HAT (Happy Active Town) Kobe area, which was redeveloped as the central part of the east Kobe area after the earthquake. This institution does not only memorise the disaster through its exhibition but also provides education on the disaster.[26] As these examples show, in the past, the memorisation of such natural disasters has influenced governance and urbanisation at different scales.

The year 2011 was notable for the formation of a digital archive of the incident by researchers, news media, and governmental institutions. For example, the National Diet Library of Japan founded a digital archive called HINAGIKU in 2013.[27] From the page, users can browse the disaster-related information from distinct digital archives through its search engine, and the website can be browsed in 4 languages: Japanese, English, Korean, and Chinese. By 2018, 7 years after the disaster, 47 digital archives and database sites had joined HINAGIKU's archival network and the amount of metadata that could be accessed had increased to 376 million.[28] The provided content includes multimedia of documents, pictures, audios and videos, and the users can observe the disaster from different perspectives (Figure 1). These are all provided in the HINAGUKU database, so the users do not have to search the other digital archives. A similar approach was also adopted by the Reischauer Institute of Japan Studies at Harvard University in 2011 to establish Japan Disaster Digital Archive, which

[26] Disaster Reduction and Human Renovation Institution, 'Institution Overview', accessed: 25 March 2020, http://www.dri.ne.jp/en/centertop.

[27] National Diet Library, HINAGIKU: National Diet Library Great East Japan Earthquake Archive, accessed: 07 March 2019, https://kn.ndl.go.jp/en/#/.

[28] Atsuko Ito, 'National Diet Library Great East Japan Earthquake Archive (HINAGIKU): The Portal site for records and reports of earthquake disasters', *Journal of the Japan Society for Digital Archive* 2, no.4 (2018): 354, https://doi.org/10.24506/jsda.2.4_353.

also comprises district archives projects. However, in addition to browsing using the search engine, this project maps the related information from news articles to the social media posts on its digital map based on its location metadata (Figure2). In this way, the memorisation of a disaster through digital archives has become a common method among those institutions, and the integration of separate sources has been playing a crucial role to curate and organise a large amount of available content.

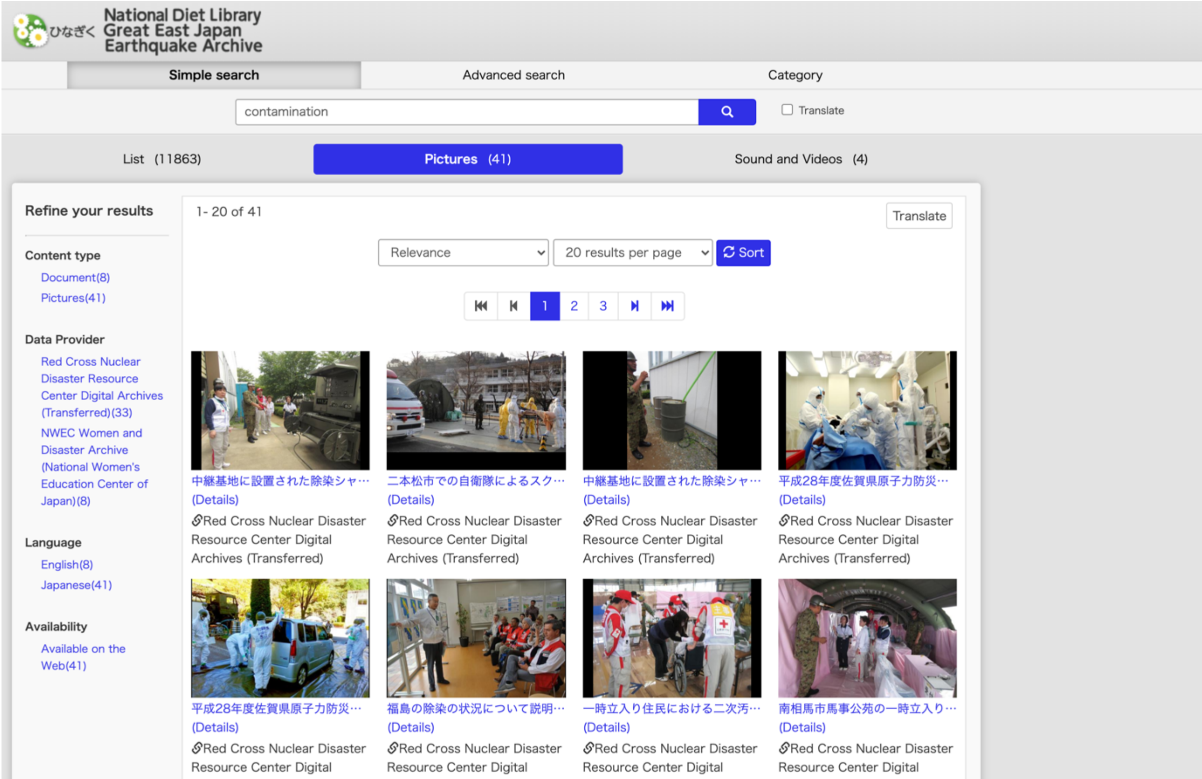

Figure 1: A screenshot from HINAGIKU.[29]

[29] The author typed 'contamination' in the search engine window, and it came up with 11863 relevant articles, 41 images, 4 audio-visual media. The left side shows the summary of the search, and the links to access other digital archives.

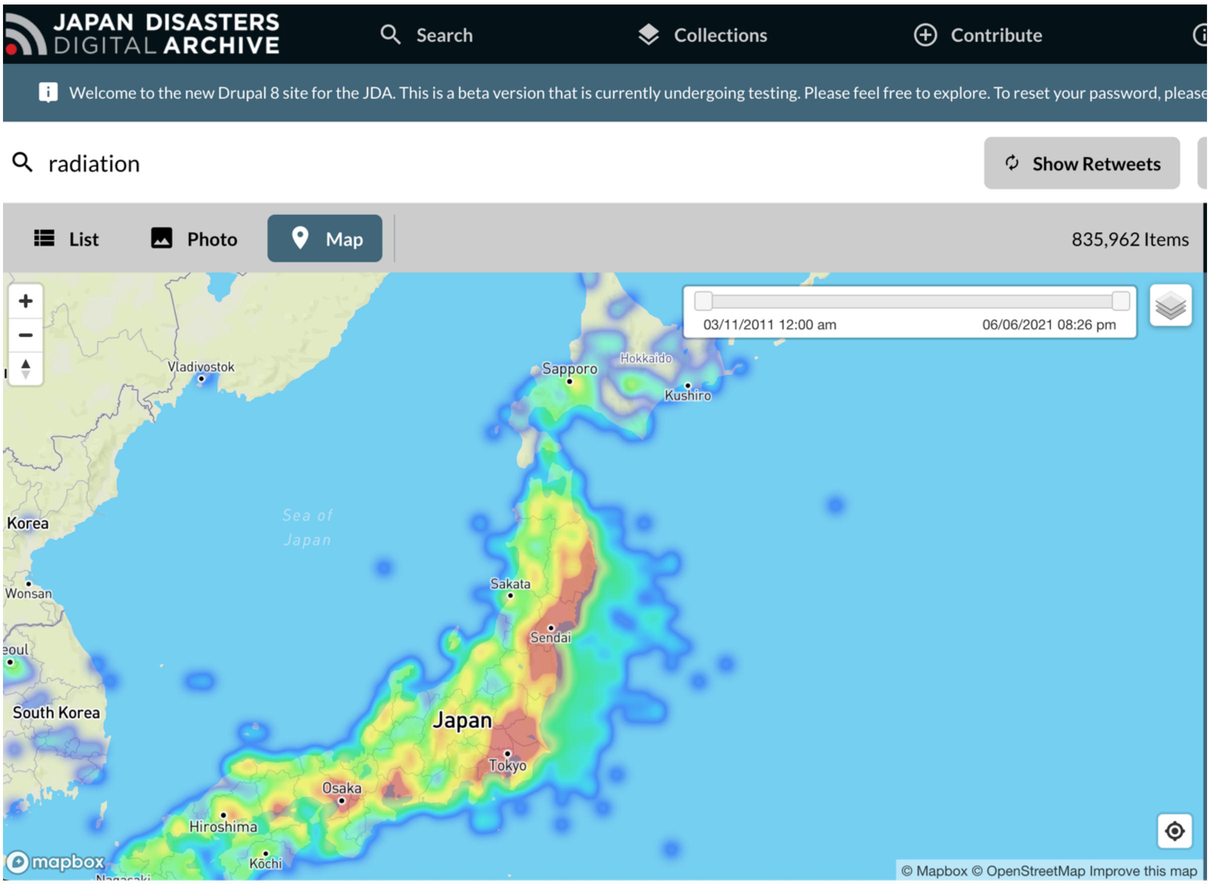

Figure 2: A screenshot from Japan Disasters Digital Archive.[30]

[30] A screenshot from Japan Disasters Digital Archive. The author typed 'radiation' in the search engine window, and it provided 835,962 results. The colour gradation on the digital map shows the concentration rate of the relevant information; the red marker means the place has the most relevant contents to the word 'radiation'. As the rate decreases, the colour transits from red to green to blue. By zooming in to the map, the users can access the content.
Reischauer Institute of Japan Studies, Japan Disasters Digital Archives, accessed: 8 May 2021, https://jdarchive.org/en/activesearch?keyword=radiation&sort=published&order=desc.

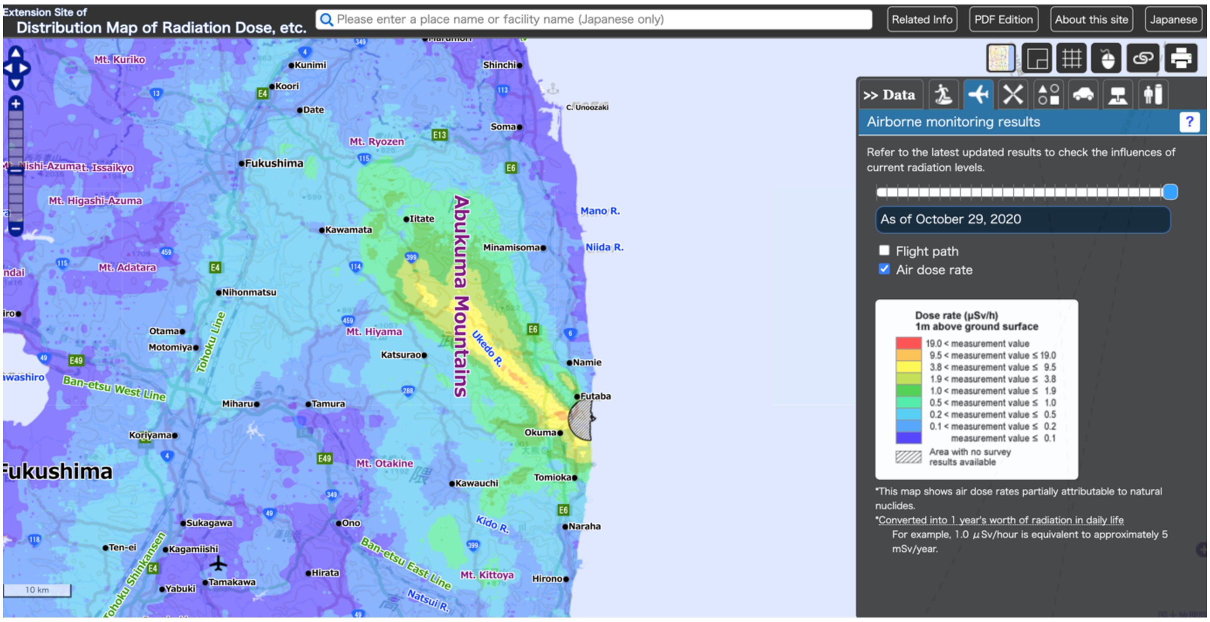

Figure 3: A screenshot from the Nuclear Regulation Authority's visualisation of the monitoring result.[31]

Additionally, radiation monitoring, followed by the publication of the data, has been common among various municipal institutions and citizen science groups. For example, the Tokyo Prefecture, which started radiation monitoring by establishing monitoring posts in seven areas, have been publishing monitoring data since 2011. Similarly, all the 47 prefectures in Japan have been conducting radiation monitoring and the corresponding data are archived at the database of the Nuclear Regulation Authority.[32] The data are available in the CSV format and can also be visualised on a digital map (See Figure 3). Even though there are differences in

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[31]The viewers can choose the date of monitoring and the method of measurements. This screenshot is around the Fukushima Prefecture and the half-circle mark under the Futaba city is where the Daiichi NPP is located. The colour gradation shows the level of radioactive contamination.
Nuclear Regulation Authority, 'Extension Site of Distribution of Radiation Dose', accessed: 29 October 2020, https://ramap.jmc.or.jp/map/eng/#lat=37.28458799999977&lon=140.5831109999977&z=9&b=std&t=air&s=0,0,0,0&c=20201029_dr.

[32] Nuclear Regulation Authority, 'Monitoring Information of Environmental Radioactivity Level', accessed: 6 February 2020, https://radioactivity.nsr.go.jp/map/ja/.

each interface design, other local municipalities are also working on the visualisation of the contamination on a digital map.

The growth of the digital infrastructure is related to the background of the emergence of digital archive projects and radiation monitoring. In 2011, the ubiquity of mobile media and the development of the internet environment reached a higher level, so this situation helped the emergence of digital archives. According to the Ministry of Internal Affairs and Communications, the diffusion rate of mobile phones was 84.5% in 2011, which greatly surpasses the 0.6% of 1990.[33] Further, 79.1% of the entire Japanese population used the internet in 2011. Additionally, the development of mapping software contributed to archiving the disaster. For example, in 2005, Google started the service of Google Maps, which made the use of a digital map common among citizens.[34] Even though these two methods adopt different mapping software, the features of mapping content, based on its location and date, are shared among them. In this sense, for both creators and viewers of content, the use of a digital map has become an established method to observe an event through the virtual spatialisation of the earth.

Safecast: Citizen Science Radiation Monitoring

As shown above, the development of the digital infrastructure is associated with the establishment of institutional digital archives and radiation monitoring. However, there has been criticism on the trustworthiness of these monitoring methods and their governance regarding the contamination. For example, the estimation of the contamination level

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[33] Ministry of Internal Affairs and Communications, 'Diffusion Rate of Mobile Phones in Japan', 2014, http://www.soumu.go.jp/soutsu/tokai/tool/tokeisiryo/idoutai_nenbetu.html.

[34] Samuel Gibbs, 'Google Maps: a decade of transforming the mapping landscape', *the Guardian*, 8 February 2015, https://www.theguardian.com/technology/2015/feb/08/google-maps-10-anniversary-iphone-android-street-view.

announced by the Japanese government has some defects such as the faults of monitoring posts and the lack of data, so they announced that the results would potentially not be precise.[35] Moreover, in the emergency period of March 2011, the government did not announce their contamination estimation quickly, which led to an increase in public distrust in the central governance.[36] With this background, 2011 saw the emergence of citizen science groups' radiation monitoring projects. For example, Safecast, a non-profit citizen science organisation, was established to monitor the contamination and make the data publicly available as open data.[37] Its participants are located worldwide, and as of 2021, over 160 million environmental measurements from 102 countries have been collected and published since 2011.[38] These data, which are also visualised on a digital map (Figure 4), can be downloaded from their website.[39]

In the few weeks after the outbreak of the disaster, even though it was clear that a large amount of the radiation was being leaked out from the Daiichi NPP to a wide part of eastern Japan, the government did not disclose the result of the measurements around north-eastern Japan. Following this uncertainty, a Portland-based technology entrepreneur, Marcellino Alvarez, set up a website, rdtn.org, to collect the contamination data in Japan and raised funds through a crowdfunding website to conduct radiation monitoring research in Japan.[40] During the development of rdtn.org, Ray Ozzie, the chief technology officer of Microsoft at the time,

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[35] Geoff Brumfiel, 'Fallout forensics hike radiation toll', *Nature* 478 (2011): 435-436, https://doi.org/10.1038/478435a.

[36] Anders Blok *et al*., 'Environmental Infrastructure of Emergency: The Formation of a Civic Radiation Monitoring Map during the Fukushima Disaster', *Nuclear Disaster at Fukushima Daiichi Social, Political and Environmental Issues*, ed. Richard Hindmarsh (Abingdon: Routledge, 2013), 91.

[37] Safecast, 'About', accessed: 10 May 2021, https://safecast.org/about/.

[38] Safecast, 'Donate', accessed: 10 May 2021, https://safecast.org/.

[39] Safecast, 'Map', accessed: 8 February 2021, https://map.safecast.org/?y=24&x=124&z=2&l=0&m=0.

[40] Akiko Hemmi and Ian Graham, 'Hacker science versus closed science: building environmental monitoring infrastructure', *Information, Communication & Society* 17, no. 7 (2014): 834, https://doi.org/10.1080/1369118X.2013.848918.

and Joi Ito, the Director of the MIT Media LAB and the Director of Creative Commons were involved in planning the surveillance methods. Through several conference meetings, the group was also joined by engineers and activists in Japan. Later in 2011, they changed their name to Safecast.[41] In this way, the formation of the group, comprising separate stakeholders – global networks, a variety of specialists, and volunteers – immediately reacted to the lack of the information, owing to the negligence of the central government. Safecast created its own survey methods and devices. In those days, following the confusion of the nuclear accident, a number of citizens were purchasing Geiger counters, so it was hard to obtain them for the survey of rdtn.org. Thus, in cooperation with the Tokyo Hackspace, they produced hardware, firmware, and cases, and assembled their own radiation detectors.[42] Since then, they have invented several types of monitoring devices. For example, their device called the bGeinie Nano is a portable dose meter (Figure 5), which can measure radiation and save the measurements to a microSD card every five seconds with the time and GPS coordinates, so it can easily monitor the contamination at various locations.[43] Moreover, they are also working on a near-real-time radiation monitoring system that can save and transmit monitoring data from the device to the database. The device is called a Pointcast sensor module, which of all the NPO-made sensors, is the only one that has been installed at the site of the Daiichi NPP.[44]

In addition to the novelty of its measurement methodology, it also designs its own social identity for the propagation of its activity. In terms of the political identity of the group, Safecast has been taking an apolitical position. On its website, to the question, ‘Is Safecast an anti-nuclear activist group?’, the answer is as follows:

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[41] Hemmi and Graham, ‘Hacker science’, 834.

[42] Hemmi and Graham, ‘Hacker science’, 834-35.

[43] Cameron Norris, ‘Safecast: DIY Radiation Mapping’, *HackSpace* 14 (January 2019): 60, https://hackspace.raspberrypi.com/issues/14#:~:text=View%20PDF%20of%20contents.

[44] Norris, ‘Safecast’, 61.

> SAFECAST is independent and has successfully remained uninfluenced by politics of any kind. Because of our jealously-guarded impartiality, SAFECAST has increasingly been viewed as an entity whose information and motivations are trusted on all sides. This has allowed us to function at times as an effective "go-between" for conflicted parties, such as environmental groups and government agencies, and to lobby effectively for increased openness in the process. SAFECAST does not accept government funding, but we welcome the input of sincere and open-minded experts wherever they are found.
>
> One caveat: SAFECAST strives to be completely transparent, and our data, device designs, and software designs are available for use by anyone, including government agencies. To the degree that this would imply that any agency doing this was becoming more like SAFECAST (as opposed to vice-versa), we'd be inclined to consider this a step in the right direction.[45]

Since the nuclear accident, the anti-nuclear movement has gained support from a wide range of citizens, and the political movement has developed on the social media platforms of Twitter and Facebook. Compared with the previous anti-nuclear movements in Japan, the participants, since 2011, tend not to belong to any political groups and most of them have never attended any political meeting. In this sense, being political, by taking an anti- or pro-nuclear position, has become common among citizens in post-Fukushima Japan. This fact implies that Safecast's apolitical stance involves taking either side regarding a nuclear policy. Therefore, by adopting an undefined position, Safecast aims to appeal to individuals across all political beliefs by providing its data to a wider range of citizens and mobilising volunteers for its projects.

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[45] Safecast, 'Frequently Asked Questions', accessed: 7 May 2021, https://safecast.org/faq/.

Additionally, it is also notable that the data collected from the Safecast monitoring project is transparent and apolitical in their argument. The transparency of its data and the device-design method derives from making these available to the public. Taking this stance into consideration, it seems that Safecast paradoxically achieves a certain form of politicality, which aims for the commonisation of things as opposed to privatisation. By focusing on the genealogy of Hackspaces, which is a foundational group of Safecast, Hemmi and Graham point out that its political stance derives from the anarchism of the 70s hacker culture, which is 'suspicious of business, government, and hierarchies, valuing practical skills over theoretical knowledge.[46] These stances, as Steven Levy outlines, follow hacker ethics such as 'Access to computers—and anything that might teach you something about the way the world works—should be unlimited and total', 'Always yield to the Hands-On Imperative!' and 'All information should be free'.[47]

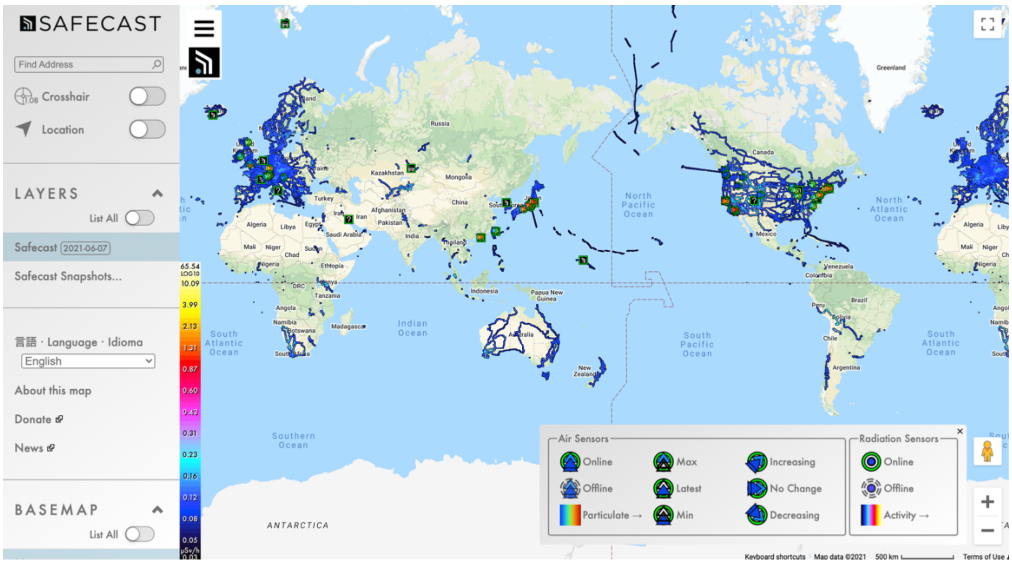

Figure 4: A screenshot from Safecast's digital map.[48]

[46] Hemmi and Graham, 'Hacker Science', 838.

[47] Steven Levy, *Hackers: Heroes of the Computer Revolution* (Sebastopol: O'Reilly, 2010), 28.

[48] It visualises the dates from their monitoring devices. It shows both near-real-time online monitoring and the saved results.

Safecast, 'Map', accessed: 5 February 2021, https://map.safecast.org/.

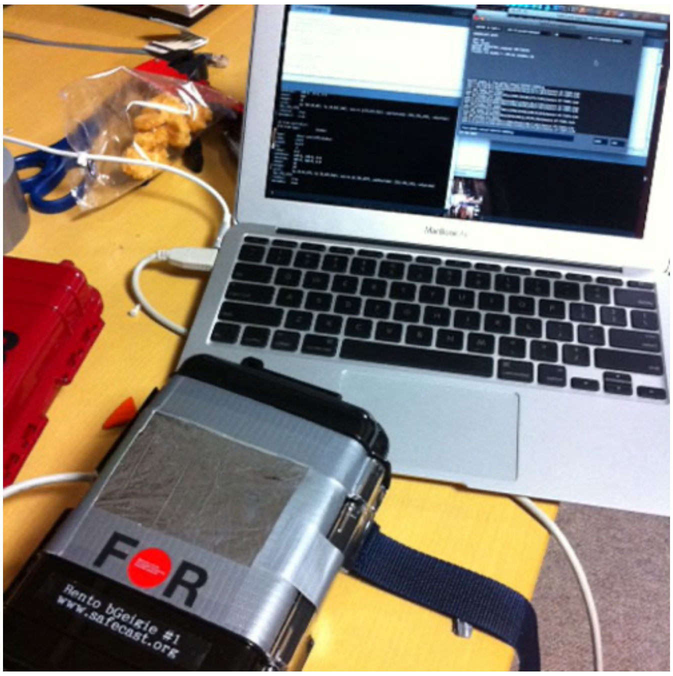

Figure 5: A picture of Safecast's radiation detector, bGeinie in operation.[49]

According to Hemmi and Graham, these hacker ethics opened the enclosed process of legitimate science, which takes a longer time from planning to operate a project. For example, they compare Safecast to KURAMA (Kyoto University Radiation Mapping System), which is a mobile monitoring project established by the nuclear research unit at Kyoto University and was developed using formal academic science with selected experts. So, access to its raw data and its closed hardware and software is restricted for third parties.[50] By comparing these two groups, Hemmi and Graham argue that KURAMA has a clear distinction between experts and non-experts; conversely, Safecast does not have such a distinction. Moreover, while KURAMA follows a traditional scientific process and produces solutions by applying scientific expertise

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[49] 'b' sands for 'bento (Japanese lunchbox)' as it looks like a bento box.
Sean Bonner, 'First Safecast Mobile recon', Safecast, 24 April 2011, https://safecast.org/2011/04/first-safecast/.

[50] Hemmi and Graham, 'Hacker Science', 834.

to a problem, the Safecast model first focuses on the problem and then develops a team to tackle it with gained knowledge.[51] These analyses provide an insight into how an non-authoritative monitoring practice can have a politicality on different scales and how legitimate and citizen science can have distinct methods of knowledge production.

In the case of Safecast, these scales are divided into, on the one hand, a political position concerning a nuclear policy and on the other hand, hacker ethics, which are reflected in its data and creative strategy. What is more, its process of knowledge production is a network between citizens with a lesser defined hierarchical structure regarding the level of scientific expertise. In an interview, an anonymous spokesperson from Safecast defines its methods as ‘guerrilla science’ rather than ‘citizen science’. This is because, just as guerrilla marketing employs unconventional methods to get results, Safecast also does not follow the traditional rules of radiation monitoring to archive a satisfactory outcome, almost the same as legitimate science.[52] In other words, the difference between the legitimate and non-authoritative sciences does not derive from whether the participants are experts or lay citizens but from the methodology employed. In this sense, the case of Safecast shows that the methodology of producing knowledge indicates its cultural and political heritage.

Cultural Reactions to the Accident: The Nuclear Village and Fukushima as a Tourist Site

So far, we have looked at how the accident occurred in Japan and examined the two different reactions to the ongoing disaster. To sum up, the nuclear disaster is an ongoing event, which was triggered by the earthquake and tsunami, and its occurrence is also related to the governance concerning the power plant management. The radioactive substances have been

[51] Hemmi and Graham, ‘Hacker Science’, 839.

[52] Hemmi and Graham, ‘Hacker Science’, 840.

spreading in the land of Japan and beyond the borders. Subsequently, to memorise the catastrophic event, several institutions have set up digital archives that organise the relevant information and data on the disaster. This emergence of digital archives overlapped the period of the development of digital infrastructure in Japanese society.

Before society reached its current level of digital ubiquity, each archive was isolated. However, as the examples of HINAGIKU and Japan Disasters Digital Archive show, one digital archive can consist in-network with other archives and their integration also can be an aim of a project. Among the digital archiving projects, the use of digital maps has become common to exhibit the content based on its location and time coordinates to display the figure of the disaster through its temporal and spatial expressions.

Additionally, another technological and digital project that has emerged in post-Fukushima Japan is radiation monitoring by citizen science groups. The previous section introduced the example of Safecast to show how it invented its monitoring methodology and planned a data strategy that has an ethical connection with the 70s hacker culture. Subsequently, the analysis of Safecast revealed that although the group shows itself as being apolitical in terms of being neither a pro- nor anti-nuclear group, its methodology of knowledge production still reflects the hacker ethics. Being less hierarchical, it has created a socially open network, which propagates knowledge to third parties. Also, its pragmatic stance has been to develop methods in accordance with the problem to be solved, rather than just apply pre-existing ones to issues. This thesis will investigate these practices with questions regarding the technical aspects of data, devices, and software.

Before proceeding to the analysis of these aspects, this section will introduce seminal debates on the Fukushima disaster to show how the disaster and the nuclear industry have been discussed. In *The 'Fukushima' Theory*, Kainuma Hiroshi, a Japanese sociologist, critically analyses the power relation between the Fukushima Prefecture and TEPCO based on postcolonial theory. He observes the relation between the central governance of Japan and the local political body in Fukushima as a form of colonial subjugation of the local to the central power.[53] According to Kainuma, the Futabamachi area where the Daiichi NPP is located developed through agriculture and fishery in the post-world war period, but its geological features were not enough to grow these industries further. Then, in 1957, Morie Kimura, a member of parliament embarked on the plan of invitation of nuclear power plants. In Japan, the introduction of nuclear power plants started in the 1950s, and in the 1960s, building power plants became one of the core businesses of power companies. Therefore, when Kimura started his invitation plan, the danger and risk of nuclear power plants were not discussed in the public.[54] Kimura's invitation plan got approved by the residents in the Futaba area in 1961, and in 1964, by inaugurating the power plant as the governor of the Fukushima Prefecture, Kimura put the construction plan into effect. Although there was an environmental movement in the 1960s Japan concerning the public hazard issues of the power plant, it did not develop into an anti-nuclear movement. The plan proceeded smoothly, as a result of which in 1971, the operation of the Daiichi NPP started. The power plant had created employment in the rural area, and it created a nuclear economy in the area, which thrived for the next 4 decades.[55] Originally, Kimura's aim was to change the governance system, whereby local Fukushima was subjugated by the central government, by introducing nuclear power plants. However, according to Kainuma, the change did not mean rejecting the subjugation, but it aimed to create a new subjugation by choosing from the side of the local rather than being passively subjugated to the central.[56] As a result, the participation in the nuclear industry consolidated the position of Fukushima as the source of electricity for the Kanto area. Hence, eventually, the relation of subjugation became more stabilised with economic interests.

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[53] Hiroshi Kainuma, *The 'Fukushima' Theory: Why Was the Nuclear Village Born?（「フクシマ」論 原子ムラはなぜ生まれたのか）* (Tokyo: Seidosha, 2011), 44-78.

[54] Kainuma, *The 'Fukushima'*, 255-257.

[55] Kainuma, *The 'Fukushima',* 270-274.

[56] Kainuma, *The 'Fukushima'*, 268.

By studying the transition of the political relation between the governors of the Fukushima Prefecture and the central governance, Kainuma reveals how such subjugation existed and how the closed community of the nuclear industry was created through the economic structure of the post-rapid economic growth period of the1970s.[57] In the course of inviting the nuclear power plant to Fukushima, the nuclear industry, the power company, and the local municipality formed a pro-nuclear group that thrived from the economic benefits of nuclear power. This pro-nuclear group is called the nuclear village. According to Kainuma, the nuclear village thrived in various ways. By providing political and academic grants to the residents and research institutions, it gained support and reduced its opposition groups. Additionally, through the mainstream media of newspaper and TV, the nuclear village propagated the safe image of nuclear power to shape public opinion.[58]

Kainuma's analysis of Fukushima suggests how to critically study the inside of the nuclear industry. The previous section introduced the fact that the management team of TEPCO did not tackle the issue of the potential earthquake and tsunami disasters, and this example also can be interpreted as an example of how the power of the nuclear village operated within the society. In post-Fukushima Japan, the term, 'the safety mythology of nuclear power plants', often appears in the analysis of the disaster at the Daiichi NPP, and this term refers to a discourse on the media that advocated the safety of nuclear power plants without showing adequate evidence.[59] This emergence of the safety mythology is also inseparable from the politics within the nuclear village, which can be interpreted to understand how the power of a pro-nuclear position influences the public through the media.

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[57] Kainuma, *The 'Fukushima'*, 304-15.

[58] Kainuma, *The 'Fukushima'*, 294-95.

[59] Kohta Juraku, 'How to Disconnect the Reproduction of the Safety Mythology of Nuclear Power Plants (原発の安全神話の再生産をどう断ち切るか)', *Ronza*, 9 March 2011, https://webronza.asahi.com/science/articles/2021030500009.html.

While Kainuma's analysis focuses on the politics of the inside of the nuclear industry, there are also cultural reactions that aim to understand the disaster from the outside of the industry. Hiroki Azuma is a Japanese philosopher and entrepreneur, who has been vigorously engaging with the accident through his publications and event organisation. One of his projects is called the Fukushima Kanko Project (Fukushima Tourism Project), which aims to utilise the site of the Daiichi NPP as a tourist attraction in 2036.[60] This time span refers to 25 years from 2011, the year of the Fukushima disaster, which, in turn, was 25 years after the Chernobyl disaster of 1986. During the period of 25 years, the site of the Chernobyl power plant has been turned into a tourist destination, which gives visitors an opportunity to learn from the history.

According to Azuma's manifesto, as the Atomic Bomb Dome became a world heritage site, the Daiichi Power Plant could also be a place where visitors can realise the importance of 'taking on the responsibility of the error that has commonly come to simply be referred to as "Fukushima"'.[61] Before the accident happened, the reputation of the Fukushima Prefecture was not known worldwide, but the accident rendered the place globally recognisable. In the Japanese language system, there are three different notation characters. 'Hiroshima (ヒロシマ)', 'Nagasaki(ナガサキ)', and 'Fukushima(フクシマ)' are often written in Katakana characters. Unlike the other two characters – Hiragana(ひらがな) and Kanji(漢字), Katakana is used for foreign words or for proper nouns, which have their origin in Japan but are known worldwide. In this way, Azuma emphasises that Fukushima has become a place where global attention was obtained through historical error; so did Hiroshima and Nagasaki.[62] Then, according to him, now the public is aware of the problem of Fukushima. Just as a tourist visits a well-known destination and is surprised by the difference between the imagination and the

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[60]Hiroki Azuma, 'About This Project', Fukushima Kanko Project, 2014, http://fukuichikankoproject.jp/project_en.html.

[61] Azuma, 'About this Project'.

[62] Azuma, 'About this Project'.

first-hand impression, Azuma argues that visiting Fukushima would be an opportunity to rethink the event without a fictitious imagination.[63]

Kainuma was also one of the supporters of the project. However, later on, he took a critical position against the project.[64] This is because, according to him, the tourist approach to the Fukushima Prefecture, through the lens of the nuclear accident, would produce a partial understanding of the historical aspects of the area. Even though the catastrophic event is still ongoing in the Fukushima Prefecture, some places have not been affected by the radiation fallout. In those areas, many people lead their lives without any relation to the nuclear disaster. Therefore, seeing Fukushima solely as a disaster site is only a partial view. Understanding it solely through the lens of the nuclear accident means violently reducing it to a single perspective, which excludes the diversity of the environment and the lives of people in Fukushima.[65]

On the one hand, Kainuma advocates the importance of the critique of Fukushima by focusing on the local politics of the nuclear industry. On the other hand, Azuma argues that it is important to think about Fukushima from a visitor's perspective because it has gained global attention that would lead to a further understanding of the disaster without a mere image. Those two different examples show how the understanding of an event can differ depending on which perspective is taken, while both sides suggest separate questions that are rooted in the historical context of the place. However, both sides seem to miss crucial points to consider. Azuma draws a distinction between people who are concerned with the Fukushima disaster and those who are bystanders like a tourist. However, this distinction can be reconsidered in light of the new possibilities brought about by radiation monitoring with which new modes of engagement in the disaster have been enabled. Also, Kainuma suggests that the nuclear disaster can shape how tourists perceive Fukushima. Nonetheless, as multiple media

[63] Hiroki Azuma, *Genron 0: The Philosophy of Tourists* (Tokyo: Genron, 2019), mobi Edition 14%.
[64] Azuma, *Genron 0,* mobi Edition 13%.
[65] Azuma, *Genron 0,* mobi Edition 13%.

approaches exist for comprehending the calamity, approaching Fukushima solely from this disaster perspective does not necessarily equate to a singular mode of understanding the region.

In this sense, the example of Safecast can be understood as the perspective towards the disaster, without a framework of studying Fukushima through the local diversity nor thinking of the disaster as a tourist visitor. To make sense of the disaster that is happening in everyday life, it invents a non-authoritative monitoring methodology to collect and share the date of the contamination on the digital infrastructure. Hence, it is crucial to understand what these knowledge production methods are and they have acquired novelty through the usage of digital media. Here, the arguments of Kainuma and Azuma are still relevant, and it is also relatable to some key questions of the thesis. As Kainuma points out, the nuclear village had created an understanding of nuclear power based on the pro-nuclear stance. Safecast aims to produce knowledge, breaking free from the ideological limitation of scientific epistemology, by rendering its method and data transparent with its 'apolitical' stance. So, how does data exist with transparency and politicality in the monitoring practice through the digital infrastructure? Moreover, a number of monitoring and archiving projects have adopted digital maps and viewers can 'visit' other contaminated sites through the spatialisation by software. Considering this, how does the aesthetical dimension of a digital map affect our understanding of the disaster? How can the radiation monitoring and mapping be strategically used, for instance, to create a new form of knowledge production that is unique in post-Fukushima Japan? Therefore, this thesis will not take the same position as either Kainuma or Azuma, but it will critique the nuclear industry and ask questions regarding how to observe the reality of the disaster.

***Pointing at Fukushima Live Cam*: Post-Fukushima Media Ecologies**

Next, in order to highlight characteristics of media in post-Fukushima Japan related to the introduced examples, we examine a case of media art performance. TEPCO has been live streaming a video of the Daiichi NPP on their website since 31st May 2011.[66] After several relocations, at present, two cameras are set up to capture footage of the units 1 to 4, which are the units that caused the series of accidents. According to TEPCO, while there is a delay of 30 seconds due to the delay of the video between multiple devices, the images of the reactor buildings and their surroundings are streamed in real-time. Prior to this live streaming, TEPCO distributed still images of the power station over a period of almost three months from 5am on 11 March 2011 to 9am on 31 May 2011. They distributed these images every hour from 5am to 7pm from a camera that was installed near unit 4; these images have been archived on their website.[67]

In front of a live camera on the power station site, an art performance was performed. On 28 August 2011, an anonymous worker at the Daiichi NPP suddenly appeared before a live camera; while checking his figure on the live stream on his smartphone, he pointed at the camera for about 20 minutes. Afterwards, he anonymously published a statement that revealed his action was a planned performance in homage to Vito Acconci's performance and video work *Centers* (1971).[68] Later, a representative of the worker, performance artist Kota

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[66] Tokyo Electric Power Company, 'Fukushima Daiichi Nuclear Power Station Live Cameras', accessed: 3 March 2023, https://www.tepco.co.jp/en/hd/decommission/progress/about/livecamera/index-e.html.
[67] Tokyo Electric Power Company, 'Fukushima Daiichi Live Camera Still Images (11st March 2011-31st May 2011)', accessed:3 March 2023, https://www.tepco.co.jp/nu/f1-np/camera/still-j.html.
[68] 'Pointing at Fukushima Live Camera', ToMuCo, accessed:3 March 2023, https://museumcollection.tokyo/en/works/6384931/.

Takeuchi, exhibited the video of this performance, which was titled *Pointing at Fukushima Live Cam* (Figure 6), at his exhibition *Open Secrets*.[69]

Figure 6: *Pointing at Fukushima Live Cam* (2011).[70]

In *Centers* (Figure 7), Acconci points at his own image on a video monitor for 20 minutes. He is pointing not only at himself but also at the viewer of the video, and his perspective as a viewer encompasses both the subject and the object, that is, the act of 'gazing' and 'being gazed upon'. Acconci maintains that 'the result (the TV image) turns the activity around: a pointing away from myself, at an outside viewer — I end up widening my focus onto passing viewers (I'm looking straight out by looking straight in)'.[71] Using the media devices of a camera

[69] Kota Takeuchi, 'Open Secret', Snow Contemporary, accessed 4 April 2023, http://snowcontemporary.com/en/exhibition/201203.html.

[70] Takeuchi, 'Open Secret'.

[71] Electronic Arts Intermix, Vito Acconci - *Centers*, accessed: 30 October 2022, https://www.eai.org/titles/centers.

and a TV screen, Acconci multiplies the relationality between viewers and himself and duplicates his action of pointing by looking out of and looking in to the screen.

Figure 7: Vito Acconci, *Centers* (1971).[72]

Similarly, *Pointing at Fukushima Live Cam* has a unique relationality between the performer, viewers, and media devices. By way of Rosalind E. Krauss and David Joselit's critique of *Centers*, Sven Lütticken observes *Pointing at Fukushima Live Cam* is a form of social act.[73] On the one hand, Krauss argues that *Centers* shows the narcissistic condition of video as a contemporary media, where the subject and the object are symmetrical; that is, they are seen

[72] 'Vito Acconci | *Centers*,' The MET, accessed: 30 April 2023, https://www.metmuseum.org/art/collection/search/292045.

[73] Sven Lütticken, 'Radio-Activity', in *Don't Follow the Wind*, ed. Nikolaus Hirsch and Jason Waite (Berlin: Sternberg Press, 2021), 92–93.

in the same way, as if one is the reflection of the other. However, on the other hand, as Joselit explains, Acconci also points at not only himself but also at the viewer of *Centers*; hence, his performance does not end in the feedback loop of pointing at the image of himself; it is 'a thoroughly social act' that involves its viewers.[74] In the same way, according to Lütticken, the worker at the power station is also pointing at himself on the live streaming monitor on his phone as well as at the viewers of the streaming and footage. Therefore, 'the aesthetics of narcissism here becomes an aesthetics of entanglement under exceptional conditions that constitute the new normal'.[75]

In this context, *Pointing at Fukushima Live Cam* can be understood as the constitution of complex relations formed through the camera, informational networks, and terminal screens. Compared with *Centers*, what is unique about the worker's performance is that the video was circulated on the Internet, and its video outputs are multiple and movable: the phone in the worker's and viewer's hands and the viewers' terminal devices. In this way, the feedback loop of 'pointing self' seamlessly extends into the different materialities and space that the media creates. The relationship between the pointing and the pointed is not confined within a fixed media relation of the TV screen and video camera, but it extends into multiple outputs of mobile terminals. In other words, the sociality exhibited by this performance illustrates that, instead of its relevance being enclosed within a fixed technosocial circuit, it extends to other media circuits via multiple outputs of distributed media.

This point is also evident in the worker's statement (Figure 8). In his illustration that describes the relation of things involved in the performance, the worker's perspective (eyes) is divided between two directions: towards the video camera and towards the mobile phone. The worker looks at himself on the phone and, at the same time, is pointing at the camera. Moreover, the illustration describes the multidirectionality of the performance. Between the camera and TEPCO's server, with the camera sending the video to the provider, TEPCO is

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[74] Lütticken, 'Radio-Activity', 92.

[75] Lütticken, 'Radio-Activity', 93.

also watching the image and the worker. Furthermore, between TEPCO's server and providers, there is not only the former sending the video image but also the latter sending an access request to the former. Finally, while the viewers are looking at the video, they are also being pointed at by the worker.

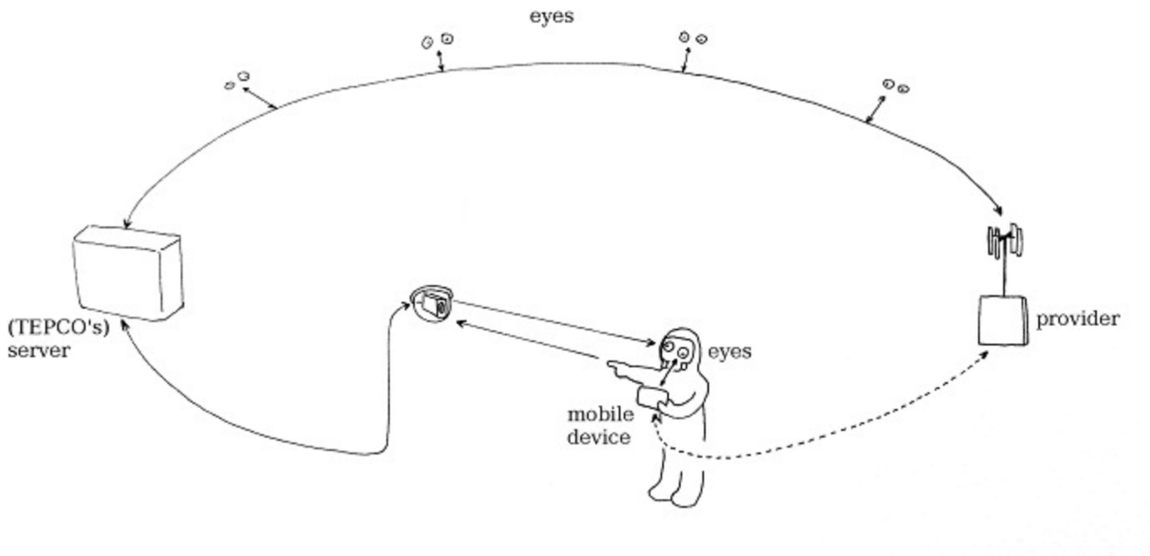

Figure 8: Illustration from The Worker's Note.[76]

Pointing at Fukushima Live Cam is not about radiation monitoring but it is highly relatable to the cases introduced so far. In terms of the debate between Azuma and Kainuma, this performance indicates a relationalities and perspectives that align with neither. By pointing at the camera, himself, and the viewers, the worker, through this performance, brings about different modes of relevance between these entities, as shown above; here, each is differently engaged in the performance on the nuclear power plant site. In this sense, while the viewers and network devices are located away from the performer, they are part of the relations, rather

[76] Worker's Note, accessed: 5 March 2023, http://pointatfuku1cam.nobody.jp/e.html. Although some articles describe Takeuchi as the worker, Takeuchi himself has said he is a representative of the worker. This note also does not indicate the identity of the author.

than a bystander like a tourist.[77] Moreover, the omnidirectional relations of pointing at the viewers from the site and gazing at the action indicate different perspectives towards Fukushima, which are multiplied through the media network.[78] In this sense, this performance demonstrates the potential of a new mode of engagement to the disaster through media devices.[79]

This example also shares a similarity with radiation monitoring. As Safecast's radiation monitoring devices have a materiality that reflects their monitoring purposes and operate in the environment, this performance also entails a certain materiality of the deployed media, such as the mobile phones and viewers' terminal interfaces. In both cases, devices are forming dynamic relations among the constituents of each project. As the performance multiplies the relationality in the media network, the monitoring system of Safecast is also in the ever-changing process of data generation and digital mapping, in which multiple constituents are constantly forming relations in the environment and the media network.

The characteristics of media devices and their relationships, as described by Matthew Fuller, can be interpreted as 'media ecologies'. This term refers to the extensive and dynamic interconnections between processes and objects, beings and things, patterns and matter in media networks.[80] As this characteristic is seen in the cases of Safecast and Ponting at *Fukushima Live Cam*, the concept of media ecologies can provide a perspective that allows us to explore media practice in post-Fukushima Japan. Throughout this thesis, we use the term to delineate relational properties regarding technoscientific and media practices. Moreover, as Lütticken maintains, *Pointing at Fukushima Live Cam* has an aesthetics of the new normal that has been brought about by the nuclear disaster, which shows characteristics of the post-Fukushima media ecologies. In observing radiation digital maps and other forms

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[77] Hiroki Azuma, *Genron 0,* mobi Edition 14%.

[78] Azuma, *Genron 0,* mobi Edition 13%.

[79] Azuma, *Genron 0,* mobi Edition 13%.

[80] Matthew Fuller, *Media Ecologies: Materialist Engines in Art and Technoculture* (Cambridge and London: The MIT Press, 2005), 2.

of interface to data and reality, this aesthetic observation is also a key critical perspective. Based on the questions and viewpoints shown in this introduction, we investigate what makes technoscientific practices of radiation monitoring possible and what they have achieved and are achieving in the post-Fukushima media ecologies.

Research Objectives and Questions

Based on this background, this thesis aims to study the ways in which environmental radioactive contamination has been monitored through different types of technoscientific practices in the media ecologies of post-Fukushima Japan. As introduced earlier, the disaster was triggered by the natural events of an earthquake and tsunami, which led to a technological accident at the power plants and subsequently to an environmental disaster. To monitor the environmental radiation level, multiple sets of monitoring technologies have been introduced by governmental and grassroots projects. In this context, the cultural phenomenon of radiation monitoring takes place transversally across different realms. Consequently, we will rely on media studies, science and technology studies, and the philosophy of science to examine radiation monitoring, which is co-constituted by these multiple registers.

The main objective is divided into four primary questions. Firstly, considering the Fukushima nuclear disaster and its aftermath as a social, technological, and environmental event, this thesis will examine how these different categories coexist and relate to each other in post-Fukushima Japan. The nuclear disaster resulted from natural, technological, and social causes. The technoscientific practices in question are deployed where these different registers interact with each other. Thus, we will explore the relationships among these realms. Particularly in Chapter 1, by reviewing a seminal study on the formation of radiation monitoring, we will investigate relational ontologies of nature, humans, and technologies and scientific epistemologies in the context of the Anthropocene and environmental concerns.

Secondly, the thesis will inquire into how knowledge and interpretations of radioactive environmental damage have been created and reconfigured through technoscientific practices.

In post-Fukushima Japan, social media and internet infrastructure have served as platforms for disseminating information on nuclear damage and social movements among citizens. We will examine the relationship between governmental nuclear policy and these practices to understand how political and scientific epistemologies were formed. Chapter 2 will demonstrate how technologies are viewed as tools to comprehend the nuclear disaster. Chapter 3 will follow the development of anti-nuclear movements and a citizen-led radiation monitoring project, examining how these social responses were enacted.

Subsequently, the third question explores how radiation monitoring devices develop and form a technological infrastructure that supports the technoscientific practices in question. As illustrated by the case of Safecast, to monitor the ongoing radioactive contamination in Japan's environment, they developed specific measurement methods and a data strategy. The development of monitoring devices and the use of informational technologies such as broadband and Bluetooth networks have become commonplace, serving as crucial technological infrastructures for technoscientific practices. Based on the relational ontological view of the thesis, we will study how monitoring devices are developed within the environment and media ecologies of post-Fukushima Japan and how they function within the scientific and social epistemologies of radiation monitoring. With the case of Safecast, we will explore how they develop their devices and produce monitoring data in light of Gilbert Simondon’s theory of individuation.

Finally, the fourth question investigates how digital maps can generate and reconfigure the interpretation of monitoring data. As mentioned in the introduction, the use of digital maps is a common method for visualising, adding to, modifying, and browsing project content. Digital maps feature unique graphic user interfaces that allow interactive access to their content. Incorporating Lütticken’s concept of the aesthetics of entanglement, this thesis will consider aesthetic practices as means to reveal specific technological and social realities. If the aesthetics of digital maps also illuminate aspects of radiation monitoring, it is crucial to examine how they visualise monitoring data in relation to scientific methods, sociopolitical epistemologies, and devices. In Chapter 3, the thesis will explore the use of digital maps in relation to the Collective Database of Citizen's Radioactivity Measuring Lab, their political agenda, and mapping practices. Focusing on the temporal and spatial manipulation of monitoring data on digital maps, Chapter 4 will examine how digital maps reconfigure the interpretation of the disaster through the cases of Safecast and the government-led radiation monitoring project.

The Structure of the Thesis

With this background, this thesis will tackle questions regarding grassroots and citizen's science radiation monitoring and data strategies in post-Fukushima Japan. The nuclear accident was triggered by a natural disaster, but it also disclosed the error of nuclear governance. In the aftermath of the nuclear accident, the government regarding the radioactive contamination caused public anxiety. This political situation in the face of the disaster led to the emergence of citizen science groups that conduct radiation monitoring. These groups collect and publish data on their website and visualise them on a digital map, which is also utilised in digital archiving projects. By examining these data and based on the discussions of media studies, science and technology studies (STS) and philosophy of technology, an interdisciplinary analysis of the disaster is developed. Particularly, this thesis will question the digital network and data production regarding radiation monitoring by focusing on the aesthetical aspect of the data visualisation on a digital map. The structure of the thesis is as follows.

Chapter 1 will introduce and review theoretical frameworks to situate this thesis among the current debates around the 3.11 disaster. Firstly, to draw key concepts for the development of this thesis, we will observe a paper written by scholars of science, technology, and society studies on the formation of citizens' radiation monitoring practice on the digital infrastructure in the emergency period of 2011. Next, we will focus on Shelia Jasanoff's notion of civic epistemology to consider the ways in which non-authoritative scientific knowledge forms among citizens in relation to the malfunction of the central governance. Then, the subsequent section will critically examine Bruno Latour's actor-network theory to draw the cooperation of agencies of humans and non-humans that creates a radiation monitoring project. Thereafter, this chapter will pay attention to the contemporary ecological debates to situate this thesis in a global context. We will begin by reviewing the concept of the Anthropocene and its relevance to this thesis to examine the role of humans in the environmental crisis of the nuclear disaster. Then, the next section will highlight Gabriel Hecht's concept of 'nuclearity' that was coined to observe the sociopolitical relations of nuclear culture. Finally, to contextualise the 3.11 disaster within current ecological debates, we will reconsider the catastrophic event through Michel Serres's *Natural Contract*.

Chapter 2 will discuss media theories to delineate the methodology of this thesis. Firstly, we will introduce a radioiodine dissipation simulation project by Hidenori Watanabe, an information architect, who has been working on archiving and monitoring the 3.11 disaster, to consider what aspects need to be addressed in this thesis. Then, relying on the discussion of Gilles Deleuze's control societies and its related arguments, the second section will examine how the notions of data and information are conceived. Then, through debates on the conceptual and technical nature of the database with reference to Foster and Azuma, we will consider how content and database form relations within themselves and with their external users. To expand the notions of the database in relation to the discussion of the concretisation of objects in relation to their external environments, this section will also introduce the concepts of technical and digital objects and milieux from the readings of Gilbert Simondon and Yuk Hui. Subsequently, through the works of Donna Haraway and Eduardo Viveiros de Castro, we will consider the ways in which technological perspectives are assembled by the interaction of humans and environments and how they create certain realities. Finally, based on this argument of perspective, this chapter will focus on how a machine can see the radiation by introducing Andersen and Pold's argument on the metainterface. Thereafter, based on these theoretical backgrounds and methods, this thesis will tackle questions through a series of case studies.

Chapter 3 will analyse the ways in which the post-2011 digital infrastructure has been related to the mobilisation of social movements, the formation of monitoring projects, and the subjectivity of citizens in media ecology. Firstly, considering the formation of the anti-nuclear movement in Japan and relying on debates on this social movement and social media, this part will observe how the use of social media enabled the mobilisation of movements in a short period. Next, taking the example of Collective Database of Citizen's Radioactivity Measuring Labs (CDCRML) and referring to Sato and Taguchi's application of Foucault's knowledge-power and Althusser's ideology in the context of the 3.11 disaster, this part will consider how citizens have been assembling to make certain political contentions regarding the government's nuclear policies and its controversial evacuation standard. Subsequently, following the same example of CDCRML and focusing on how the horizon of post-Fukushima Japan has treated radionuclides in the natural environment, this chapter will draw how the subjectivity of radiation monitoring has machinically formed with a reference to Felix Guattari's machinism. From there, following Michel Serres, we will deploy radiation as quasi-objects that change their property in relation to other entities.

Next, Chapter 4 will consider Simondon's theory of individuation to investigate the development process of radiation monitoring technologies. Specifically, Safecast's monitoring devices will be examined to study how radiation detectors as technical objects are individuated and concretized in relation to their natural, technical, digital, and social associated milieux. Based on technological and environmental relations regarding radiation monitoring, Safecast has developed their monitoring apparatuses to. The devices deployed in the environment are connected to Safecast's database, creating relations that traverse different technical objects and milieux. Simondon's concepts of transindividuality and transduction will also be discussed to illustrate how individuals are cultivated and extended through their relationships with others. Subsequently, Chapter 4 will discuss monitoring data and software as digital objects to delineate the individuation and concretization process in relation to the digital milieux of informational networks and databases. The materiality of hardware and its relation to the individuation process and the use of monitoring devices will also be considered, following Montoya and Sintonen's discussions on digital devices. Based on these discussions, the chapter will explore the ways in which technological infrastructures are involved in the process of data generation and how a sensorium that is attuned to radiation is emerging in post-Fukushima media ecologies.

Finally, Chapter 5 will build upon the preceding chapters to study digital maps used in radiation monitoring. In both citizen-led and administrative bodies' monitoring projects, digital mapping has been employed to understand radioactive contamination through temporality and spatiality unique to the functions of digital maps. The role of digital maps in reconfiguring an interpretation of contamination will be demonstrated, and DeLanda and Deleuze's concepts of intensive and extensive scales of time will be introduced to illustrate how these two temporal scales interlock with each other. Whitehead's theory of space and his concepts of prehension and extensity will also be examined to exhibit how relations stretch from the environment to digital maps through technological mediations and scientific abstractions. Case studies involving Safecast, state radiation monitoring projects, and soil and vehicle-borne surveys will be explored to observe the ways in which a particular scientific method can create an interpretation of the disaster on digital maps and how authoritative relations can be opened up to a civic data practice.

Chapter 1

Theoretically Framing Citizen-Led Monitoring and the 3.11 Disaster in Post-Fukushima Japan: Analyses of the Relevant Theoretical Framework and Debates

1.1 Introduction: On the Previous Study of Radiation Monitoring in Japan

This chapter highlights previous research on radiation monitoring and critically reviews theoretical frameworks relevant to the 3.11 disaster. In the article 'Environmental Infrastructures of Emergency: The Foundation of a Civic Radiation Monitoring Map during the Fukushima Disaster', a research group of Anders Blok, Atsuro Morita and Shuhei Kimura investigate the significance of the monitoring project that was founded by a non-governmental organisation.[81] They propose a theoretical framework by referring to science and technology theorists, such as Bruno Latour and Sheila Jasanoff, to describe the process of scientific knowledge-making and the use of technology in the emergency circumstances of the nuclear disaster. Applying those theories in the context of the 3.11 disaster, they pay attention to the sociotechnical network of monitoring instead of details of the example's technological aspects.

Blok *et al.* use the example of a radiation mapping project, which was initiated on Twitter. On 13 March 2011, a Twitter account owned by a non-specialist of nuclear science called for the voluntary posting of radiation monitoring data, both private and public. At that time, the Tokyo Electric Power Company (TEPCO) had already published their monitoring data, although it was not widely accepted. Moreover, there was a growing suspicion that the

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[81] Anders Blok *et al*., 'Environmental Infrastructures of Emergency: The Foundation of a Civic Radiation Monitoring Map during the Fukushima Disaster', in *Nuclear Disaster at Fukushima Daiichi: Social, Political and Environmental Issues*, ed. Richards Hindmarsh (New York: Routledge, 1999).

government and TEPCO might be hiding crucial data from the public. Due to these circumstances, the digital mapping was supported by a number of individuals and projects, and 3.9 million people accessed the page within one week.[82]

It is notable that, by way of Callow and Rabeharisoa, Blok *et al*. highlight the ad hoc aspect of the civic monitoring that covers up the blind spot of radioactive contamination levels around Fukushima. Scepticism towards the Japanese government was also shared among the digital mapping volunteers. According to Blok *et al*., those public concerns facilitated the fast development of the mapping project and its ad hoc networks.[83] Since the 3.11 disaster, several social movements, such as an anti-nuclear protest, were formed and facilitated using the digital information infrastructure. An ad hoc relationship is fluid and forms based on similar concerns, and this tendency was shared across different social interests in Japan. In this sense, Blok *et al*. describe well the ad hoc network of the citizens, which was subsequently observed in other social movements.

Those ad hoc relations create new associations among agencies that do not usually relate to each other. For example, it is illustrated that using a digital map visualises the network of different radiation monitoring groups and individual projects, some of which had started before the Fukushima disaster occurred. According to Blok *et al*., 'civic engagement with what was hitherto a mostly hidden environmental information system—that of networked radiation monitoring posts—turned out to be crucial, we argue, for filling one piece of the serious void of technoscientific credibility left open within Japan by the Fukushima Daiichi disaster'.[84] As they argue, the mapping project is not only the visualisation of contamination levels but also the disclosure of lesser-known radiation monitoring projects in Japan and the possibility of facing the emergent incident. The example of the digital mapping project initiated on Twitter visualises the networks among contributors in different temporal and spatial scales; the

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[82] Blok *et al*., 'Environmental Infrastructures', 87.

[83] Blok *et al*., 'Environmental Infrastructures', 79.

[84] Blok *et al*., 'Environmental Infrastructures', 78.

pre/post-3.11 disaster and the inside/outside of Fukushima. According to Blok *et al.*, those visualised entities on the digital map form sociotechnical networks of heterogeneity that are 'more than simply data expansion; it also played a crucial part in establishing the credibility of the map as such. […] as the civic map was able to juxtapose all the monitoring posts, regardless of their ownership, it was possible to compare data from government-run posts with those of individuals or universities'.[85] As this analysis describes, visualising the linkage between different datasets brings about a comparative understanding of the governmental contamination monitoring, which the civic projects complement on the digital map.

Overall, Blok *et al*. emphasise that the technoscientific infrastructure of nuclear radiation monitoring has become apparent to the public. By referring to Bruno Latour, they assert that the legitimate monitoring method had been in a 'black box', formed in the government and nuclear industry network during the pre-Fukushima period.[86] In doing so, they point out the disfunction of the Japanese government during the few months after the disaster and delineates the emergence of civic monitoring to complement the governmental function.

The research for this thesis and Blok *et al*. have some points in common. First, the thesis also focuses on how central governance of a disaster does not function properly, to investigate the emergence of new methodologies of monitoring or sensing radioactive substances. While Blok *et al*. limit its investigation to the state of emergency, the thesis takes the disaster as an ongoing event that exceeds the emergency period of 2011 through to today.

Additionally, Blok *et al*. show the use of digital mapping as a tool to show a new technoscientific reality, which consists of heterogeneous networks of a sociotechnical infrastructure. The thesis research also assumes that the figuration and objectivity of radioactive contamination are created through social and technological engagement. Blok *et al*. argue that the network complements the disfunction of the governance in a less politically biased way. Regarding the attitude towards governmental power, the thesis differs from them,

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[85] Blok *et al.*, 'Environmental Infrastructures', 87–88.

[86] Blok *et al.*, 'Environmental Infrastructures', 91.

and we argue that radiation monitoring practices can have a political meaning. To demonstrate this, Chapter 3 will argue that the measurements in those civic projects can produce a new form of knowledge-making that contests the government's nuclear policy.

Based on these points, this chapter will first critically review the concept and theoretical frameworks of civic epistemology and Latourian actor-network theory (ANT) to show how this thesis will build its argument based on such previous relevant works. The first two sections will discuss the concept of civic epistemology to focus on the making process of a scientific understanding in the relationship between a government and its public. Then, it will move to Bruno Latour's argument on the social and the natural through his ANT and critically review how his methodology is relevant to the study of the Fukushima case.

The subsequent section will consider in which context we can discuss the Fukushima disaster. The thesis will discuss the concepts of the Anthropocene and nuclearity to relate the discussion of the 3.11 disaster to the global debate on ecology and nuclear culture. Then, to further consider the 3.11 disaster, which was triggered by the natural phenomena of earthquake and tsunami, it will review the discussion of Michel Serres' *Natural Contract*.

1.2 Civic Epistemology after the Fukushima Disaster

First of all, this section focuses on Shelia Jasanoff's term 'civic epistemology', deployed to observe the scientific knowledge-making process in the relationship between the public and a group of scientists. In her book, *Designs on Nature*, Jasanoff discusses the examples of Britain, Germany, the United States, and the European Union. In this part, we will examine the concept of civic epistemology in the context of the Fukushima disaster.

According to Jasanoff, 'science and technology take hold of the public imagination in different ways across cultures – refracted by the culturally specific knowledge-ways' that are called 'civic epistemology'.[87] The public knowledge of technology and science is formed through civic epistemology, a way of knowledge-making, reflecting the diversity of society. Indeed, scientists produce scientific knowledge in cooperation with institutional or governmental support, but the public understanding of science is formed not only by these experts but also through civic engagement and technoscientific cultures. As Blok *et al*. explain, 'civic epistemologies are an important lens through which to understand public engagements with technoscience, in terms of how acceptance or rejection of particular technologies, like nuclear power, is historically and culturally shaped'.[88] Hence, a civic epistemology allows us to see the understanding of science and technology as a horizontal relationship between the public and the authority.

Jasanoff distinguishes civic epistemology from the public understanding of science (PUS) model, which has been frequently applied to 'characterise public knowledge and explain public perception of risk' by conducting a survey such as a series of true–false questions concerning a scientific fact or phenomenon.[89] The PUS model is based on the assumption that an 'understanding' is 'the phenomenon of scholarly interest and, potentially, as the source of cross-cultural variance. Science itself, by contrast, is taken as unproblematic, universal, and invariant, equally understandable in principle in all places and at all times'.[90] As this quote indicates, the PUS model sees science as an undeniable system, which applies to phenomena that occur in different cultural realms, and its scientific viewpoint presupposes a certain assumption from the public. According to Jasanoff, 'the designers of PUS surveys have tended to assume that, as long as people are properly informed about scientific facts, there should be no cross-cultural variation in their perceptions of science or their perceptivity toward

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[87] Sheila Jasanoff, *Designs on Nature: Science and Democracy in Europe and the United States* (Princeton: Princeton University Press, 2005), 255.

[88] Blok *et al.*, 'Environmental Infrastructures of Emergency', 81.

[89] Jasanoff, *Designs on Nature,* 249.

[90] Jasanoff, *Designs on Nature,* 249.

technology'.[91] In this way, the PUS model can mould social and cultural diversity into a systematic form based on the assumption that the public must have a universal standard, which produces a specific dataset from their protocol, created without a discussion between scientists and the public. Therefore, in the PUS model, a group of non-scientific citizens is subordinate to the decision-making process of an authentic group of scientists.

Furthermore, Jasanoff points out that 'if difference in social uptake do arise, as they have in relation to biotechnology, then the PUS model attributes them to public ignorance or misunderstanding; lack of understanding, in turn, becomes a deficit that states can correct through better dissemination of knowledge'.[92] The PUS model cannot accept anomalies in its protocol. Therefore, unexpected outcomes from surveys are taken as flaws. This is how the institutional power of the model corrects the public and produces an ideal outcome, not by improving its scientific formula but by changing public opinion. In this way, the PUS method underpins scientism, in which science is believed to be the universal and transcendental figure for the 'ignorant' public.

Civic epistemology takes a distance from this fixed dichotomy of science and the public. Jasanoff continues to explain its definition as follows:

> Civic epistemology refers to the institutionalised practices by which members of a given society test and deploy knowledge claims used as a basis for making collective choices. Just as any culture has established folkways that give meaning to its social interactions, so I suggest that modern technoscientific cultures have developed tacit knowledge-ways through which they assess the rationality and robustness of claims that seek to order their lives; demonstrations or arguments that fail to meet these tests may be dismissed as illegitimate or irrational.[93]

[91] Jasanoff, *Designs on Nature*, 250.
[92] Jasanoff, *Designs on Nature*, 250.
[93] Jasanoff, *Designs on Nature*, 255.

As this quote shows, civic epistemology derives from a publicly institutionalised practical knowledge of science that emerges from social interaction among people in their technoscientific culture. Therefore, in civic epistemology, the public is not seen as a group of ignorance but a subject that creates understanding by assessing the rationality of science in light of its standard. Using the term 'institutionalised', Jasanoff does not refer to a particular scientific system, which the PUS model is based on, but a civic group with its own rules formed through the practice of technoscientific cultures. Jasanoff explains that 'these collective knowledge-ways constitute a culture's civic epistemology; they are distinctive, systematic, often institutionalised, articulated through practice rather than in formal rules'.[94] In the PUS model, an undesirable outcome of a scientific survey is only an indicator of the falseness of collective public knowledge. On the other hand, civic epistemology sees such 'anomalies' to formal science as a practical and collective knowledge that complements their understanding of science.

In the light of these accounts, how does civic epistemology play its role in the Fukushima nuclear disaster? Notably, public opinion regarding the Japanese nuclear industry has been shaped by the political relationships between the government and the power industry. As Juraku explains, the nuclear industry in Japan was created with a highly systematised relationship of rights and interests, in which the government provided the residents around nuclear sites with *Ko-fu-kin* aid grants. As the concept of 'nuclear village' was defined, groups that engaged in nuclear power plant siting decisions were politically limited, and those stakeholders were leading the growth of the nuclear industry. Then, Juraku continues to maintain as follows:

[94] Jasanoff, *Designs on Nature*, 255.

> Because it was purposively assumed that the majority of these stakeholders—landowners, local politicians, residents and so forth—had a pronuclear stance, this enabled government and power utilities this somewhat 'ceremonial' or tokenistic approval process. Mutual collaboration among pronuclear interests in the public and industrial sectors, and social arrangements in local communities, were thus a key factor for concentrated siting to succeed.[95]

'Concentrated siting' means that several nuclear reactors exist on one power plant site. In the Fukushima accident, it has been estimated that this concentration led to a chain of accidents in different reactors. Several civil groups demonstrated against the concentrated plant, but as Juraku explains, those dissents were subsumed into the 'mutual collaboration' of the pronuclear groups. These highly biased political relationships shaped the public's understanding of nuclear science, so the realm of 'civic' was being invaded by institutionalised power. Therefore, before 2011, the epistemology of the nuclear industry in Japan was not 'civic' in Jasanoff's sense.

However, in post-Fukushima Japan, we can find a form of civic epistemology regarding the knowledge-making process of radioactive contamination. According to Sternsdorff-Cisterna's ethnographic work on the food safety issue after Fukushima, one of the aims of citizen-led radiation calculation groups is to create an autonomous institution and provide the citizens with an opportunity to monitor radioactive substances.[96] For example, in the Fukushima Prefecture, radiation dosemeters have already been set up in several public spaces such as schools and parks. These machines show the contamination level and the safety of the places where they are located. However, radiation contamination levels can vary depending on

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95 Kohta Juraku, 'Social Structure and Nuclear Power Siting Problems Revealed', in *Nuclear Disaster at Fukushima Daiichi: Social, Political and Environmental Issues*, ed. Richard Hindmarsh (London: Routledge, 2013), 51.

96 Nicolas Sternsdorff-Cisterna, *Food Safety After Fukushima: Scientific Citizenship and the Politics of Risk* (Honolulu: University of Hawai'i Press, 2019), 75.

weather conditions. There can be a 'hotspot' of accumulated radioactive substances, where the contamination level is higher than other parts of the monitored area. Furthermore, governmental decontamination cleans the area around the dosemeters, so monitoring posts cannot be precise about the level between these meters.

This type of civic knowledge has been widely shared among the public through the community of citizens in the area. The independent radiation monitoring groups aim to cover the gaps left by the legitimate procedures. In this way, mistrust in the government has facilitated citizens to create their own monitoring projects and set autonomous standards for their food safety. For example, the Seikatsu Club is a citizen-led independent radiation detecting and monitoring group based in Fukushima. It owns radiation detectors, available to the citizens in the local area, for checking the contamination level of food products.[97] This example indicates that civic epistemology of nuclear science has been developing since the Fukushima disaster. Collective citizens are creating their own epistemology of technoscientific culture by assessing the official knowledge and by producing their own knowledge. Hence, as Jasanoff explains, radiation monitoring can be seen as an institutionalised practice initiated and conducted by citizens who critically respond to the government's nuclear policy.[98] In this sense, civic epistemology emerged between authoritative and non-authoritative science in post-Fukushima Japan to produce and assess knowledge.

Based on this discussion, the thesis will further explore the ways in which authoritative and citizen-led radiation monitoring projects create scientific epistemology in the post-Fukushima media ecologies. The view of civic epistemology allows us to observe the relation between authoritative and non-authoritative, or civic groups. As Blok *et al.* and Sternsdorff-Cisterna's examples show, citizens collectively initiated radiation monitoring in response to the government's nuclear policy.[99] To consider this aspect further, Chapter 3 will discuss how

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[97] Sternsdorff-Cisterna, *Food Safety*, 75.

[98] Jasanoff, *Designs on Nature*, 255.

[99] Sternsdorff-Cisterna, *Food Safety*, 75.

citizens' collective actions of political activism and technoscientific practices are comprised through media networks. Also, a civic-epistemological view allows us to focus on how authoritative science is opened up to the public's practices and understanding.[100] Considering this point, in Chapter 5, we will observe how state-led radiation monitoring is interrelated to the public's technoscientific practice through the use of published data.

1.3 Bruno Latour and Actor-network Theory

Next, we will review Bruno Latour's actor-network theory (ANT), which has been applied to several previous research on the Fukushima case. According to Sismondo, ANT 'represents technoscience as the creation of larger and stronger networks'.[101] It takes humans and nonhumans as agencies of events and they exist ontologically equal without the hierarchy of things. Then, Latour uses the word 'actant' rather than 'actor' to include both humans and nonhumans as agencies of networks. These actants do not have an essence in themselves, but instead, create their own quality through the association of networks of others. In the association of networks, the quality of actants is not essential but contingent, as it can change in a different network of a different association. ANT is an approach to understand a reality, which is mediated through networks of actants. The associations among actants in ANT are also found in Latour's argument of science and technology. His book *Science in Action* analyses how scientific facts are 'fabrications' created by institutionalised groups of science, culture, and politics, and Latour calls this closed association a 'black box', which cannot be understood from outsiders of the network.[102]

The foundation of ANT was also developed through Latour's observation of the division between the natural and the social. In *We Have Never Been Modern*, he argues that in the

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[100] Blok *et al.*, 'Environmental Infrastructures', 78; Jasanoff, *Designs on Nature*, 255.

[101] Sergio Sismondo, *An Introduction to Science and Technology Studies* (New Jersey: Wiley-Blackwell, 2010), 81.

[102] Bruno Latour, *Science in Action* (Cambridge: Harvard University Press, 1999), 2–3.

history of western thought the social has always decided the quality of nature for culture through science, calling this process 'purification'.[103] The quality of nature has been purified for the sake of the social, as from a transcendental entity surpassing humans to a scientific object. Thus, nature essentially does not have its own quality, which is correlated to how the social sees it. Hence, according to Latour, the moderns have only produced the hybrids of nature and culture, and there has never been a clear distinction between them.[31] What used to be called nature can be a part of culture, so the quality of nature always has that of the social. Hence, the moderns only temporarily define the hybrid of nature and culture as either of them. As Graham Harman explains Latour's ontology, 'nature and culture are not "inextricably linked" because they are not two distinct zones at all'.[104] From this viewpoint, Latour emphasises that modern science creates a system of great division that constructs nature and conceals the hybridity of nature and culture within the black box. Additionally, in ANT, humans and non-human entities are also equally treated as actants, but this equality does not mean that the two are the same. The definition of human and non-human entity is also based on a standard created in the process of purification thus the difference and sameness are not essential. As Latour explains, his ontology of things does not mean that humans and non-humans are the same, but that those actants are neither the social nor the natural.[105] Therefore, according to Callon, the ontology of ANT can avoid falling into technological or social determinism as an actant and a network cannot be reduced to either of them.[106] This point is highly relatable to this thesis to figure out how the monitoring practices in post-Fukushima Japan have been assembled through interaction between the technological

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[103] Bruno Latour, *We Have Never Been Modern* (Cambridge: Harvard University Press, 1993), 11.
[104] Graham Harman, *Prince of Network: Bruno Latour and Metaphysics* (Victoria: re.press, 2009), 59.
[105] Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network Theory* (Oxford: Oxford University Press, 2005), 145.
[106] Michel Callon, 'Society in the Making: The Study of Technology as a Tool for Sociological Analysis', in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, eds. W. E. Bijker, T. P. Hughes and T. J. Pinch (Cambridge: MIT Press, 1987), 83–103.

and social. In particular, this will be further discussed by focusing on the development of the political manifestation of citizen-led monitoring in Chapter 3 and the development of technological and digital tools for monitoring in Chapter 4.

Next, considering this definition, it is presumable that the Latourian ANT model could be a tool to critique nuclear technology in Japan. As Blok *et al*. observe, the civic monitoring project collectively unpacked 'a technical "black box" of radiation monitoring', which was mainly used among researchers of nuclear science or workers at a nuclear power plant.[107] By making use of the digital infrastructure of social media and a digital map that visualises the contamination data collected by citizens, they produced knowledge on the radiological contamination for the public. Thus, radiation monitoring can be seen as the association of the networks that is formed and mediated by those technical and digital objects. In Chapter 3, this point will be further developed by taking the examples of the anti-nuclear movement in post-Fukushima Japan and the citizen-led monitoring project, focusing on how the digital infrastructure mobilised citizens and the political and scientific epistemology of radiation monitoring.

Additionally, the ANT model and the concept of a black box are applicable to the nuclear industry in Japan. For example, the worker's associations at a nuclear power plant do not directly concern the citizens who use the electricity made by them. The associations at the power plant are not only constituted of nuclear science but also social and political networks such as corporative investment and local governance. Such aggregates do not publicly relate to the everyday life of people who do not engage with those networks. Hence, the nuclear industry can be seen as a black box to the public. Although the black box is closed in this way, it can open suddenly to non-experts of nuclear science and 'outsiders' of the nuclear industry. Kubo explains the ANT model with the Fukushima case as an example. Even though it can be believed that 'humans made technology so they can perfectly control it', it is also merely a fabricated idea, which is stabilised on networks of artefacts and an artificial environment. Hence, when an accident or malfunction is caused by an unpredicted actor, the network

[107] Blok *et al.*, 'Environmental Infrastructures', 90.

becomes unstable. As a result, according to Kubo, the new network that forms around the event foregrounds the black box to the public, and this process was observed in the relationship between Japanese citizens and the radiation after the incident at the Fukushima Daiichi power plant.[108] In this way, the Fukushima case can be an example of the association of networks that is constituted of diverse actors and be conceived as the packing and unpacking of the black box of the nuclear industry in Japan. This thesis will investigate how the technoscientific practice of grassroots and citizen-science groups create a new perception of the disaster through media expressions after such a black box of science and industry was opened. Then, in the following chapters, we will further study how the perception of the disaster has been created in post-Fukushima Japan, where citizens participate in monitoring radiation through the digital media.

Before moving to the next section, this thesis will also point out the negative aspects of ANT to critically develop the argument of the discussion of the Fukushima case. As shown above, ANT allows us to observe the Fukushima disaster and civic monitoring by focusing on the contributors of the digital mapping as agencies and the map as the group of their networks. However, this thesis is at odds with ANT with regard to two points. First, the flatness of ANT's ontology of things does not see the constant becoming of agencies within the same relationship. As noted above, the quality of an actant is formed and mediated through its networks, and each actant itself is no more than an agency of the mediated reality. To explain the hybridity that modern science divides, Latour refers to the theory of quasi-objects coined by Michel Serres. According to Serres, quasi-objects are entities that are not objects nor subjects by themselves, but which can be both in relation to other entities. Serres delineates that the quality of things fluidly changes in relation to others. Serres explains the theory of quasi-objects through an example of a football game, in which human players control a ball,

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[108] Akinori Kubo, *A Manual of Bruno Latour: From Actor Network Theory to the Exploration of Modes of Existence (ブルーノ・ラトゥールの取説：アクターネットワーク論から存在様態探求へ)* (Tokyo: Getsuyosha, 2019), 71.

and simultaneously, the formation of players is controlled by the position of the ball. As this example shows, relations among quasi-objects can be formed between human and nonhumans. When Latour emphasises the associations of actants, including humans and nonhumans, he does not take a western traditional nature and culture distinction in which nature has been purified into objects subjugated to the side of humans and culture. Therefore, ANT's ontology of actants and Serres's quasi-objects share the character of things that cannot be taken from the binary of subjects and objects, and nature and culture.[109] However, in ANT, although an actant forms its quality in an association with other actants, its quality does not dynamically change in the same association of networks. According to Shimizu, Serres sees that quasi-objects can also change within the same relation, as the subject-object relation of the ball and players constantly changes through the association of the football match. Conversely, Latour's understanding of the quasi-object sees only a network and does not focus on an actant itself and its constant change in the same relation.[110] This thesis supposes that this point is also true of the Fukushima disaster in terms of how to detect a certain type of radiation and monitor its concentration. Instead of showing a further analysis in this chapter, this point will be discussed in relation to a technological approach to radionuclides in the next chapter. Based on the discussion of the theory of quasi-objects and Annemarie Mol's reading of Serres, this thesis will study agencies of particular associations that are in the state of consistent becoming, rather than fixed in one relation.

Secondly, ANT is capable of the stable association of agencies, but it is questionable if that theoretical framework is still valid in facing the case of an emergency such as a disaster. As Mei Ling Wong notes on the characteristic of the energies research adopting ANT, '[t]he ANT curiosity, therefore, lies in what holds these technologies together; where the weak links are that can potentially lead to failure and cascading outcomes; and how these technologies

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[109] Latour, *We Have Never*, 65.

[110] Takashi Shimizu, *Michel Serres: From Methesis Universalis to Actor-Network (ミシェル・セール：普遍学からアクター・ネットワークまで)* (Tokyo: Hakusui-Sha, 2013), 127-128.

enable other modes of exploration, action, innovation, and organisation to emerge'.[111] This quote is relatable to the argument of Morita *et al*., in which the digital mapping holds the different technological practices of separate local monitoring projects to achieve the distinct narrative of the contamination from the governmental one. However, as Wong also argues in reference to the Fukushima disaster, while this type of network analysis articulates the form of an organisation to emerge, the ANT approach deals poorly with the uncertainty of decision making in the future, especially under an emergency circumstance such as a disaster.[112] This is because political decision making has to rely on a stable knowledge system, which tends to be less effective than the uncertainty of an emergency situation.

According to Wong, ANT is cut out for studying the stable association, but in the emergency period, the association is so unstable that it is rather incapable of efficient collective decision making such as regulatory standards and technical designs.[113] Under the circumstances of a disaster, as I outlined in the example of civic epistemology, it is necessary to focus on how people can create knowledge under the condition of an emergency, in which the authoritative knowledge system itself becomes uncertain. It can thus be argued that Latour's ANT studies stable associations of agencies, whereas citizen-led monitoring projects create knowledge when faced with the uncertainty of the nuclear disaster.

Hence, in this way, while ANT provides a perspective to critically examine the Fukushima nuclear disaster, particularly its industrial and scientific backgrounds which are based on a stable association, its capacity to observe unstable circumstances still needs to be examined. However, the process where the meaning of actant changes in its associations resonates with this thesis that understand media ecologies through relations between its constituents. In

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[111]Catherine Mei Ling Wong, 'Assembling Interdisciplinary Energy Research Through an Actor Network Theory (ANT) Frame,' *Energy Research & Social Science* 12 (2016): 108. https://doi.org/10.1016/j.erss.2015.12.024.

[112] Wong, 'Assembling', 108

[113] Wong, 'Assembling', 108

Chapter 3, based on this view, we will critically examine the objectivity of radiation through a case study of a citizen-led monitoring project and its contestation against the government's nuclear policy by comparing ANT and Serres's relational ontology.

1.4 Critiques on the Concept of Humanity and the Relations of the Social and Natural

As shown in the examples of the studies on the Fukushima nuclear disaster, the unexpected disaster brought about political instability. Subsequently, it facilitated the emergence of non-governmental citizen groups whose practices rethought the scientific knowledge-making process in the post-Fukushima society. In the following chapters, the thesis will focus on local examples in Japan. However, the 3.11 disaster has also been affecting the broader environment worldwide. The contamination level of Caesium-137, one of the radioactive isotopes released from the Fukushima Daiichi power plant, has increased on a global scale. The solubility of Caesium-137 is quite high. Hence, once the radioactive fallouts were released into the air from the power plant, they fell into the oceanic environment and spread over a wide area. Even though the level of contamination has decreased, the amount of monitored Caesium-137 at a point 2000 km north of Hawaii in 2014 was six times higher than the level monitored after atmospheric nuclear testing in the 1960s. Additionally, the contamination level on the west coast of North America in 2014 was two to three times higher compared with past nuclear test measurements.[114] The amount of radioactive substances that were released from the Fukushima nuclear power plant in 2011 is estimated to be 90 quadrillion becquerels, which is equivalent to 17% of that released from the Chernobyl disaster.[115] According to the standard

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[114] Goldschmidt Conference, 'The Ocean and Fukushima Nuclear Disaster: What Have Been Found in the Last 5 Years(福島原発事故と海洋：この 5 年でわかったこと)', *EurekaAlert!,* accessed: 31 May 2019, https://www.eurekalert.org/pub_releases_ml/2016-06/gc-5_1062816.php.

[115] NHK, 'Fukushima Daiichi Power Plant Accident: 7 Years Ago and Now with Looking Back through the Data', 11 March 2018, https://www3.nhk.or.jp/news/genpatsu-fukushima/20180311/lookdata.html.

of the International Nuclear and Radiological Event Scale, the contamination is classified as a level seven major accident, which is the same as Chernobyl.[116]

Following these scientific facts, it can be supposed that the Fukushima nuclear disaster has been recognised as one of the planetary scale disasters in world history. Based on this point, in this section, the thesis focuses on how we can further discuss the relationality of the event in comparison with other modes of critique and global cases. How can we situate the 3.11 disaster in a global context? If the disaster is also thought of as a transnational event, how and what should this thesis focus on to observe the figuration of the disaster?

1.5 The Anthropocene and its Debates

The current environmental issue is often discussed in the context of the Anthropocene, and the concept is also related to a question of global scale. This term first appeared in the article 'The Anthropocene' written by Paul Crutzen and Eugene Stoermer in 2000. According to Crutzen and Stoermer, in 1833 Sir Charles Lyell first proposed the era of the Holocene, which refers to the post-glacial geological epoch of around ten thousand years ago, and it was in 1926 when V.I. Vernadsky observed humankind was gaining power on a global scale, influencing their environment.[117] Then, they explained that as the human population increased to 6,000 million over the last three centuries, the number of substances released, including CO2 and SO2, has increased due to human activities such as urbanisation, agriculture, and industrialisation, which have transformed the land surface.[118] As a result, the changes in the environment have been fed back to human life in negative ways, such as a decrease in

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[116] Ministry of the Environment of Japan, 'International Nuclear Event Scale (国際原子力事象評価尺度)', last modified: 31 March 2016, https://www.env.go.jp/chemi/rhm/h28kisoshiryo/h28kiso-02-02-01.html.

[117] Paul Crutzen and Eugene Stoermer, 'The "Anthropocene"', *The International Geosphere–Biosphere Programme Newsletter*, no. 41 (2000): 17.

[118] Crutzen and Stoermer, 'The "Anthropocene"', 17.

habitable coastal wetlands. In response to this situation, the use of the term 'Anthropocene' is maintained, which is appropriate to 'emphasise the central role of mankind in geology and ecology'.[119]

Since the term appeared, there have been discussions about the starting point of the Anthropocene, and nuclear technology is also thought of as one of the potential beginnings. According to a group of authors led by geologist Jan Zalasiewicz, the stratigraphic amount of radioactive substances has increased since 1945, when the Alamogordo nuclear weapons test was conducted, suggesting the emergence of nuclear weapons as the beginning of the Anthropocene.[120] Conversely, there is a counter opinion that the outset of nuclear testing only coincides with the period of the great acceleration, which refers to a wide range of human-driven changes that led to the drastic alteration of the earth system.[121] These discussions differ in recognition, but both sides situate the dissemination of radioactive substances on a global scale. Even though there is a difference of causality between the nuclear tests that have taken place since 1945 and nuclear disasters such as the ones in Chernobyl and Fukushima, the development and spread of nuclear technology are inextricably linked with the increase in the number of radioactive substances in the earth environment.

In contrast to the geologists who are trying to find the golden spike, in other words, starting point of the Anthropocene, there have also been counterarguments against the use of the concept. In the narrative of the Anthropocene, the entire human species has often been described as an agent of environmental change. However, this understanding of the subject of the new epoch seems to oversimplify the diversity of humankind. If only certain types of humans are the causal agencies of geological change, then other groups of humans cannot

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[119] Crutzen and Stoermer, 'The "Anthropocene"', 17.

[120] Jan Zalasiewicz *et al.*, 'When did the Anthropocene Begin? A Mid-twentieth Century Boundary Level is Stratigraphically Optimal', *Quaternary International* 383 (2015): 196–203, https://doi.org/10.1016/j.quaint.2014.11.045.

[121] Collin N. Waters *et al.*, 'Can Nuclear Weapons Fallout Mark the Beginning of the Anthropocene Epoch?', *Bulletin of the Atomic Scientists* 71, no. 3, (2015): 46–57, https://doi.org/10.1177/0096340215581357.

be treated in the same way. According to Baskin, the theory of the Anthropocene is prone to universalise and normalise 'a certain portion of humanity as the human of the Anthropocene'.[122] Indeed, in the argument from Crutzen and Stoermer, it is clear that although they emphasise humankind as the agent of environmental problems, they do not specify the figure of humankind as the agency of climate change.[123]

Can the concept of the Anthropocene contain all of humankind on a global scale? To examine this question, the argument of Dipesh Chakrabarty gives us insight. According to him, the problems of global warming or climate change cannot be mediated without global inequities that have already existed and are derived from postcolonial relationships.[124] More specifically, he argues with scientists who observe the climate change challenge as 'the analytic strategies that postcolonial and postimperial historians have deployed in the last two decades in response to the scenario of decolonisation and globalisation'.[125] Then, he explains differentiated responsibilities between developed and developing countries, which are closely tied with the history of capitalism and modernisation. For example, the western responsibility for climate change is retrospective due to their past performances such as colonialism and industrialisation. Conversely, the amount of CO2 emissions by China is greater than that of the USA. Hence, they have a prospective responsibility in the future, which is due to the current performance of development.[126] In this sense, the narrative of the Anthropocene does not reflect this historical difference among the nation states that are involved with climate change, and the Anthropocenic figure of 'man' just unifies the two types of responsibilities into the

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[122] Jeremy Baskin, 'Paradigm Dressed as Epoch: The Ideology of the Anthropocene', *Environmental Values* 24, no.1 (2019):11, https://www.jstor.org/stable/43695207.

[123] Crutzen and Stoermer, 'The "Anthropocene"', 17.

[124] Dipesh Chakrabarty, 'Postcolonial Studies and the Challenge of Climate Change', *New Literary History* 43 (2012): 1–18, https://www.jstor.org/stable/23259358.

[125] Dipesh Chakravarty, 'The Climate of History: Four Theses', *Critical Inquiry* 35, no. 2 (2009): 198, https://doi.org/10.1086/596640.

[126] Chakravarty, 'The Climate of History', 18.

prospective one. Thus, as Chakrabarty points out, it is required to think about who ‘we’ are in the Anthropocene[127] and what makes the collective ‘we’ hard to conceive.

Moreover, this problem of the Anthropocenic figure of ‘humankind’ has also been discussed in the area of contemporary visual culture. In *Against the Anthropocene*, T.J. Demos argues that the visualisation of environmental destruction on a planetary scale, which also aims to visualise the concept of the Anthropocene, tends to exclude a certain image of sociopolitical groups such as environmental activists. For example, he refers to visualisation works such as *Welcome to the Anthropocene* and *Cartography of the Anthropocene* by the research organisation Globaïa, which show the transition of the amount of carbon dioxide emissions on the virtual earth. Then, Demos contends that the images of ‘humans’ and ‘activities’ are too partial, ‘Yet the “activities” that are shown in the imagery that commonly depicts said epoch are hardly “human”, at least in that generalising, species-being sense, but are in fact mostly the “activities” of corporate industry, and area generally occluded in Anthropocene discourse’. [128] Those graphic images indeed describe merely one of the aspects of environmental destruction caused by humans, but those visualised activities are related only to an industrial perspective. Demos then refers to photos of environmental activists such as sHell No protesters and the Pacific Climate Warriors as counterpowers to the universalised Anthropocenic ‘humankind’ and ‘activities’.[129] Compared with Chakrabarty, the narrative of Demos does not distinguish between the differentiated retrospective and prospective responsibilities of climate change. However, by focusing on the ongoing environmental issues, he illustrates an exclusionist aspect of environmental representation that can omit the existence of counterforces against industrial agencies. This critique relates to this thesis’s focus on the epistemological dimension of radiation monitoring. The legitimate political-scientific epistemology in post-Fukushima can exclude civic epistemology, thus the citizen

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[127] Chakravarty, ‘Postcolonial Studies’, 10.

[128] T.J. Demos, *Against the Anthropocene: Visual Culture and Environment Today* (Berlin: Sternberg Press, 2017), 18.

[129] Demos, *Against the Anthropocene*, 37–47.

then develops their own method to create knowledge. In this sense, the argument of Demos suggests how this thesis needs to critique the kinds of sociopolitical counterforces operating in authoritative and non-authoritative monitoring.

Moreover, to point out this complexity of humankind on a certain environmental issue, several scholars are trying to articulate a new figure as the subject to substitute the Anthropocenic figure of humankind. For example, Donna Haraway argues that the universal idea of humankind in the narrative of the Anthropocene, as Chakrabarty also points out, derives from a Western-centric perspective. In addition, she is sceptical about the use of the Capitalocene, which refers to the geological period when the activity of capital, instead of humankind, damages the earth's environment on a planetary scale. According to Haraway, this is because the Capitalocene itself is unable to clarify whose ‘capital’ it is. Capital is also constituted on a massive scale and complexed assemblage.[130] As Jason Moore argues, ‘the Capitalocene does not stand for capitalism as an economic and social system’,[131] hence the problem with the term also lies in the difficulty to illustrate the figure and quality of the subject. Additionally, Haraway argues that the discussions of the Anthropocene and Capitalocene also have historical tendency, because they exclude the ongoingness and historical continuity of the planetary scale epoch in which human and nonhumans have been closely entwined for a long time. Moreover, she continues to propose the term ‘Chthulucene’ in order to not exclude beings on the earth while maintaining temporal continuity. Haraway argues that ‘ongoingness is not futurism; ongoingness is full of continuities, discontinuities, and surprises. Maybe, but only maybe, and only with intense commitment and collaborative work and play with other earthlings, flourishing for rich multispecies assemblages that include human people will be possible. I am calling all this the Chthulucene – past, present, and to come’.[132] By focusing on

[130] Donna Haraway, ‘Capitalocene and Chthulucene’, in *Posthuman Glossary*, eds. Rosi Braidotti and Maria Hlavajova (London: Bloomsbury, 2018), 80.

[131] Jason Moore, *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism* (Oakland: PM Press, 2016), 6.

[132] Haraway, ‘Capitalocene and Chthulucene’, 81.

the continuity and inclusiveness of what is going on the earth, Haraway's attempt reveals a complex assemblage, which is constituted by humans and myriads of more-than-human beings. By definition, human beings are not in the dominant position of the crisis, but Chthulucene refers to an epoch where humans and other entities are also engaged with the continuous and historical process of shared concerns. This critical analysis of the Anthropocene suggests a way in which the problematisation of environmental phenomena does not spoil historical agencies that have been excluded from Western human-centrism.

These debates on the Anthropocene show the difficulty of unifying humanity as the agency of those facing problems. In this context, the 3.11 disaster is also no exception. As mentioned in the previous part, the local politics of Fukushima regarding the huge amount of political donations suppressed the protest group against building nuclear power plants. Additionally, although the current government is still attempting to activate the nuclear reactors for power generation, the anti-nuclear movement in Japan became a social phenomenon after the accident. As humankind as a whole cannot be the agency of the Anthropocene, this local perspective in Japan shows the impossibility of unifying humankind as the agency of accidents and the driving force of the Anthropocene because the degree of the national opinion on nuclear power varies depending on political standpoints. Here, the macro perspective of the Anthropocenic figure of 'man' cannot be unified in the context of the 3.11 disaster. Hence, the critique of the Anthropocene allows us to understand differentiated engagements to nuclear power in Japan.

1.6 The 'Nuclearity' of the 3.11 Disaster

Moreover, because a global network of the nuclear industry has constituted the use of nuclear power plants in Japan, the causal agency of the accidents is more intricate in terms of macro perspective. Gabrielle Hecht coins a term, nuclearity, to grasp the materiality of radiation in light of this sociopolitical network:

> Nuclearity is a technopolitical phenomenon that emerges from political and cultural configurations of technical and scientific things, from the social relations where knowledge is produced. Nuclearity is not the same for everyone: it has different meanings for geologists and physicists, geneticists and epidemiologists, managers and workers, Nigerians, and Canadians. Nuclearity is not the same at all in time: its materialisation and distribution in the 1940s differed markedly.[133]

The understanding of a particular radiological event can vary depending on the context in which it is produced, and technical and scientific perspectives are not the only factors that contribute to its production. Therefore, nuclearity reflects the political, cultural, and social context in which knowledge of radiation and radiological events is constructed. By creating the concept of nuclearity and avoiding a single understanding on radiation, Hecht highlights how the understanding of radiation can change in relation to the political and cultural surroundings where knowledge of radiation is produced. As mentioned in the part on civic epistemology, this viewpoint is similar to my thesis in that scientific knowledge is not only produced by scientists but also non-specialists of the public. The 3.11 disaster has been releasing radioactive substances on a vast scale, but at the same time, the global nuclear industry itself has already been extended all over the world. The industrial network includes different groups of people engaged in different activities of nuclear processing such as mining uranium ore and reprocessing radioactive wastes. In this sense, Hecht's nuclearity allows us to see how the materiality of radiation in Japan has been considered in differentiated national, transnational, industrial, and public perspectives.

Although she emphasises the diversity of humans who engage in various kinds of activities related to radiation, Hecht supports the use of the Anthropocene. According to her, by

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[133] Gabriel Hecht, *Being Nuclear: Africans and the Global Uranium Trade* (Cambridge and London: The MIT Press, 2012), 15.

acknowledging the critique of the Capitalocene and Chthulucene, Hecht advocates the significance of the Anthropocene, which provides common ground with natural science disciplines and the public sphere to discuss the environmental condition of the earth.[134] Hence, instead of focusing on the entanglement in the environmental assemblage, which Haraway suggests, Hecht tries to retain the Anthropocene's 'potential to spark new narratives, methodologies, and forms of knowledge'.[135] Then, accepting the current geological age as the one when humankind is causing damage to the earth's environment, she proposes to counter the dominant narrative of the Anthropocene and focuses on how a local area or country forms a social and cultural relation of nuclearity. In her example, she focuses on how the nuclear industry in Gabon was developed in relation to French colonialism and its aftermath.[136] Hecht names this narrative as 'an African Anthropocene', instead of using 'the', because the case of Gabon is not dominant but only one of the narratives of the current geological period. In this way, she also argues that the concept of 'Anthropocene' differs in relation to the uniqueness of a local scale.

The discourse of Hecht provides us with a method to observe nuclear culture in the social and historical network, which forms a nuclearity that is entangled with local and global perspectives. Indeed, she treats knowledge of radiation as a socially constructed epistemology and emphasises the plurality of the Anthropocenic discourse, which avoids a dominant narrative. However, her method still lacks the involvement of nature and technologies in a radiological event. In the 3.11 disaster, an earthquake and tsunami became triggers of the accident, and there have emerged several critiques and artwork that cover the relations between non-human entities from inanimate objects to animals and radioactive substances. For example, Nicole Shukin analyses the 3.11 disaster as an event that allows us to rethink the centrality of humanity through a case in which the relationship between

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[134] Gabriel Hecht, 'Interscalar Vehicles for an African Anthropocene: On Waste, Temporality, and Violence', *Cultural Anthropology*, 33, no. 1 (2018): 111, https://doi.org/10.14506/ca33.1.05.

[135] Hecht, 'Interscalar Vehicles', 111.

[136] Hecht, 'Interscalar', 116–118.

farmers and their livestock in the evacuation zone in Fukushima has completely changed.[137] Additionally, *Autoradiograph*, an ongoing visualisation and archiving project of the 3.11 disaster, illustrates that the radioactive contamination level of organic and inorganic objects varies depending on the ecological life cycle and surrounding environment.[138] These examples show that the nuclearity of the 3.11 disaster consists of relations of culture, society, and nature. In this sense, my thesis attempts to extend the concept of nuclearity to the reality of the entanglement of humans and non-human entities, which Haraway reminds us to rethink. In Chapters 4 and 5, the thesis will further investigate how monitoring devices have been developed through the interaction between humans and more-than-humans that constitutes their associated milieux.

1.7 Relations and Violence from Nature

So, how can we consider relations among those entities to understand the 3.11 disaster as an event constituted by them? In *After Fukushima*, Jean-Luc Nancy argues 'there are no more natural catastrophes, there is only a civilisational catastrophe that expands every time'.[139] According to him, in the course of technological development, civilisation has transformed nature, and the distinction between civilisation and nature no longer exists as it once did. This is because the former has been intervening in the latter, and as a result, a relationship of 'this world' to any 'other world' is also no longer valid.[140] In this way, Nancy defines the 3.11 disaster as a catastrophic event, of which a causal agency is not from the outside of civilisation but the

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[137] Nicole Shukin, 'The Biocapital of Living – and the Art of Dying – After Fukushima', *Postmodern Culture* 26 (January, 2016), https://www.pomoculture.org/2020/07/09/the-biocapital-of-living-and-the-art-of-dying-after-fukushima/.

[138] Autoradiograph, (2014), https://www.autoradiograph.org/.

[139] Jean-Luc Nancy, *After Fukushima: The Equivalence of Catastrophes* (New York: Fordham University Press, 2015), 34.

[140] Nancy, *After Fukushima*.

inside. In terms of the view that a technological relation has already subsumed nature and created an amalgam of them, his argument allows us to situate the 3.11 disaster in the relation of cultural and natural elements. However, even though he points out the distinction between the civilisation and nature is no longer valid, he does not describe the involvement of nature to civilisation. As long as civilisation is unable to control the occurrence of an earthquake and tsunami, it seems to be necessary to illustrate a interrelation in which humans operate on nature and vice versa.

So, how can we consider nature that has already been within civilisation? In his book *Natural Contract*, Michel Serres discusses how violence among humans can involve one towards and from nature by taking up Goya's painting *Fighting With Cudgels*. This painting describes two fighters battling with each other and simultaneously sinking in quicksand:

> The painter, Goya, has plunged the duellists knee-deep in the mud. With every move they make, a slimy hole swallows them up, so that they are gradually burying themselves together. How quickly depends on how aggressive they are: the more heated the struggle, the more violent their movements become and the faster they sink in. The belligerents don't notice the abyss they're rushing into; from outside, however, we see it clearly.[141]

Here, Serres points out that the act of violence among humans involves another violence from a natural environment where human activities take place. While concentrating on their fight, they are unconsciously being caught by the environment and neither of them are aware of the situation. In other words, the relations among humans are always exposed to other activities of non-humans or environments. As explained in the previous section, the theory of quasi-objects illustrates a subject-object relation among humans and non-human entities is interchangeable. Here, the natural environment of mud is subsuming the relation with the

[141] Michel Serres, *Natural Contract* (Ann Arbor: The University of Michigan Press, 1995), 1.

human fight as its object. In this way, Serres's metaphysics of relationality is observable in the human-nature relation. By focusing on humans' relation within the environment, which operates on human activity without acknowledgement by them, Serres delineates the relation that forms at the overlapping point between civilisation and nature. In his view, nature is not separated from civilisation; rather, they constantly associate with each other while maintaining their singularity.

Referring to Homer's *Iliad*, Serres describes how violence among humans comes back to themselves as violence from nature 'as [Achilles] throws the innumerable corpses of adversaries vanquished and killed into the current, the level rises so that the stream bursting its banks, reaches up to his shoulders to threaten him'. Then, Serres continues, in this way violence propels 'the motor of history' and brings a victory to a winner.[142] Based on Serres's observations on violence and history, Takashi Shimizu relates Serres's argument to the 3.11 disaster. In the process of fanatical fights among humans, in which winners and losers swap their positions from time to time, their involvement with the natural is forgotten. However, as they become fanatical about their fights, including market competition, nature also inflicts fatal damage to humans.[143] This relationality can be thought of as an analogy of the 3.11 disaster, in which the Great East Japan Earthquake and tsunami caused enormous damage to the energy supply in the capital area of Tokyo. It was notable that the government and the Tokyo Electricity Company repeatedly stated that the disaster was completely unexpected, meaning that Japanese society had underestimated or forgotten the risk of the disaster. Considering Serres's explanation, this can be seen as the result of ignoring violence from nature, which is also thought of as a significant part of lawful society. Subsequently, Shimizu contends that it is required that we visualise the relation between civilisation and nature as fluid and constant.[144] To observe the visual cultures related to the 3.11 disaster, Demos shows the

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[142] Serres, *Natural Contract*, 2.
[143] Shimizu, *Michel Serres*, 100.
[144] Shimizu, *Michel Serres*, 100–01.

importance of what is excluded from the aesthetics of visualisation, and Shimizu extends the area of observation towards the realm of nature. Based on this point, this thesis will examine how the aesthetics of radiation monitoring reflect such relationality between humans and nature, and to do so, it will examine how specific uses of digital technologies are operating within those visual expressions.

1.8 Conclusion

To sum up, this section focuses on some of the current discussions on environmental issues, from which characteristics are shared with the 3.11 disaster to situate the catastrophic event within those debates. In facing climate change, the narrative of the Anthropocene emphasises the central role of humankind to solve geological and ecological issues. However, the Anthropocenic figure of 'humankind' is not based on the historical and differentiated responsibilities of environmental crisis and has to include humans as well as non-human entities so as not to simplify the complex assemblage of environment. The 3.11 disaster consists of the entangled relations of the social, technological, and natural. Hecht's concept of nuclearity allows us to understand the materiality of radiation in social, historical, and transnational correlations, but it does not include natural involvement. As Serres argues, the history of violence has been proceeding while remaining blind to violence from nature. Hence, it is required to delineate the disaster as an event in which the roles of its agencies are not fixed and changeable in relation to other entities.

At the beginning of this chapter, I introduced a previous study on radiation monitoring in Japan and its theoretical frameworks of civic epistemology and nuclearity, which understand the radioactive contamination in the relation of citizens. In addition to it, the critique on the Anthropocene delineates historical and political relationships and a figure of its subjectivity and allows us to rethink the 3.11 disaster, from which many civic groups have been questioning governmental and industrial powers since 2011. Moreover, the arguments from

Nancy and Serres provide this thesis with a way in which we can understand the disaster and the materialisation of radiation in the network of the social as well as the natural.

Chapter 2

Technical Methods and 'Eyes' Towards Radioactive Contamination: How This Thesis Tackles Questions about Technologies in Monitoring Methods

2.1 Introduction

Hidenori Watanabe is a Japanese data scientist and information architect who has vigorously engaged in several digital archiving and monitoring projects of the disaster. For example, Watanabe conducted data visualisation by mashing up data from different sources on a digital map. The term mashing up refers to a remixing art-creating method that combines parts from existing artworks to create a new piece of music, moving or still images. According to Lawrence Lessig, this mash-up method is a standard website management strategy. Different websites are assembled on one page, as Google Maps does on its interface. However, more importantly, users do not have to fully understand the mechanism of contents integration. Web services enable them to mash up other websites on their platforms by rendering the process transparent. In other words, users cannot see 'the machinery that links one service to another company'.[145]

Lessig observes a form of democratisation in this mash-up culture and open-source software that can be used and amended by anyone without copyright control. Watanabe does not analyse the mash-up method and its relation to the socio-political issue of copyrights. However, he maintains that open data and open-source software will create a new public

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[145] Lawrence Lessig, *Remix: Making Art and Commerce Thrive in the Hybrid Economy* (Bloomsbury, 2008), 138-39.

understanding of society.[146] Based on this argument, Watanabe frequently adopts open data publicised to the public and web platforms accessible to general users. For instance, one of his projects, *The East Japan Earthquake Archive*, used a digital map as its media platform.[147] His project team mapped individual testimonies of the disaster, YouTube videos, and Twitter posts based on where witnesses were, where videos were shot, and the Twitter post GPS data. In another project, based on transcripts of Japan Broadcasting Corporation news reports broadcast within 24 hours of the earthquake and tsunami hitting Japan, he visualised areas already reported from to identify where had not been covered by those reports.[148] As his work shows, Watanabe's methodology is to shed light on the disaster by giving big data a form through data visualisation on a digital map.

[146] Hidenori Watanabe, *How to Make a Digital Archive (データを繫いで社会につなぐ：デジタルアーカイブの作り方)* (Tokyo: Kodansha, 2013), electronic edition, 55.

[147] Hidenori Watanabe, The East Japan Earthquake Archive, accessed: 18 March 2021, https://e.nagasaki.mapping.jp/p/japan-earthquake.html.

[148] Hidenori Watanabe, 'Visualising Gap in Mass Media Reports with Big Data (マスメディア報道の空白域をビッグデータで可視化する)', *HuffPost Japan*, 5 July 2013, https://www.huffingtonpost.jp/hidenori-watanave/post_5121_b_3548913.html.

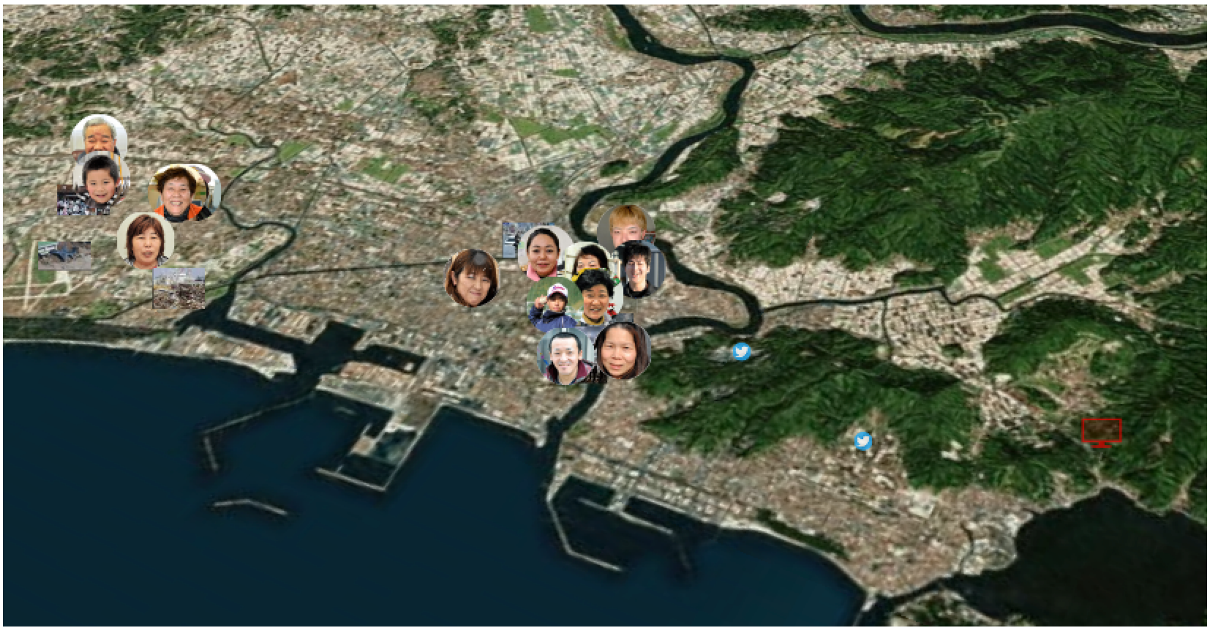

Figure 2.1: Watanabe's The East Japan Earthquake Archive.[149]

In collaboration with nuclear physicist Ryugo Hayano, Watanabe simulated and mapped the dissipation of radioiodine in Project Hayano (2013).[150] Hayano studied exotic atoms while working as an educator to propagate an understanding of the radioactive exposure and nuclear policy associated with the case of Fukushima. For example, in 2017, he organised an inspection tour of the decommissioned site of the Daiichi NPP for high school students.[151] Project Hayano used a digital map of the area around the Fukushima prefecture to visualise how the radioactive isotopes of radioiodine were disseminated and the flow of the population

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[149] Watanabe, The East Japan*.*
The pictures of citizens lead to their witness provided by Asahi Newspaper. The Twitter icons are linked to the posts posted from the location. The TV icon is linked to the video footage shot at the location.

[150] Ryugo Hayano, Project Hayano: The Mashup of the Simulation of the Dissipation of Radioiodine, accessed: 18 March 2021, https://speedi.mapping.jp/.

[151] Ryugo Hayano. 'I hope people will correctly understand radiation values in Fukushima: Part 2 (続・福島の放射線の量を正しく理解してほしい
高校生たちと一緒に、福島第一原発の廃炉作業を視察した思いとは)', 17 March 2017, *Ronza*, https://webronza.asahi.com/science/articles/2017022100003.html.

density. This was used to estimate radiological contamination and potential exposure among the public. The half-lives of radioiodine 131 and 133 are 8.06 days and 20.8 hours, respectively. The number of monitoring data on the spread of radionuclides was insufficient to understand the actual contamination condition. However, it was estimated that the amount of radioiodine released on the 15th and 16th of March was immense in the area northwest of the Daiichi NPP and Hamadori, the coastal area of the Fukushima Prefecture. Hence, Project Hayano aimed to estimate the radioactive exposure of the residents of those areas.[152]

To complement the lack of data and information, they introduced the System for Prediction of Environmental Dose Information (SPEEDI). This computer-based simulation system calculated a virtual contaminated area and estimated the radiological dosage in that area based on actual monitoring data. The National Institute for Environmental Studies and the Japan Atomic Energy Agency (JAEA) provided the simulated data of radioiodine dispersion as open data.[153] A mapping company, ZENRIN-Datacom Co. Ltd, provided the population density data. These were collected from switched-on mobile phones with users' permission; initially, the company utilised the data to predict traffic congestion.[154]

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[152] Hidenori Watanabe, 'How to Archive Fukushima (2) (福島をいかにアーカイヴするか (2))', *HuffPost Japan*, 27 June 2013, https://www.huffingtonpost.jp/hidenori-watanave/2_7_b_3507640.html.

[153] Project Hayano, Organisers' Note on Google Docs, accessed: 18 March 2021, https://docs.google.com/document/d/1VDFnB9lZM1mUZfrTcTrPzEWkX2ex4mledKpsW7wqZsk/edit?usp=sharing.

[154] Watanabe. *How to Make*, 55.

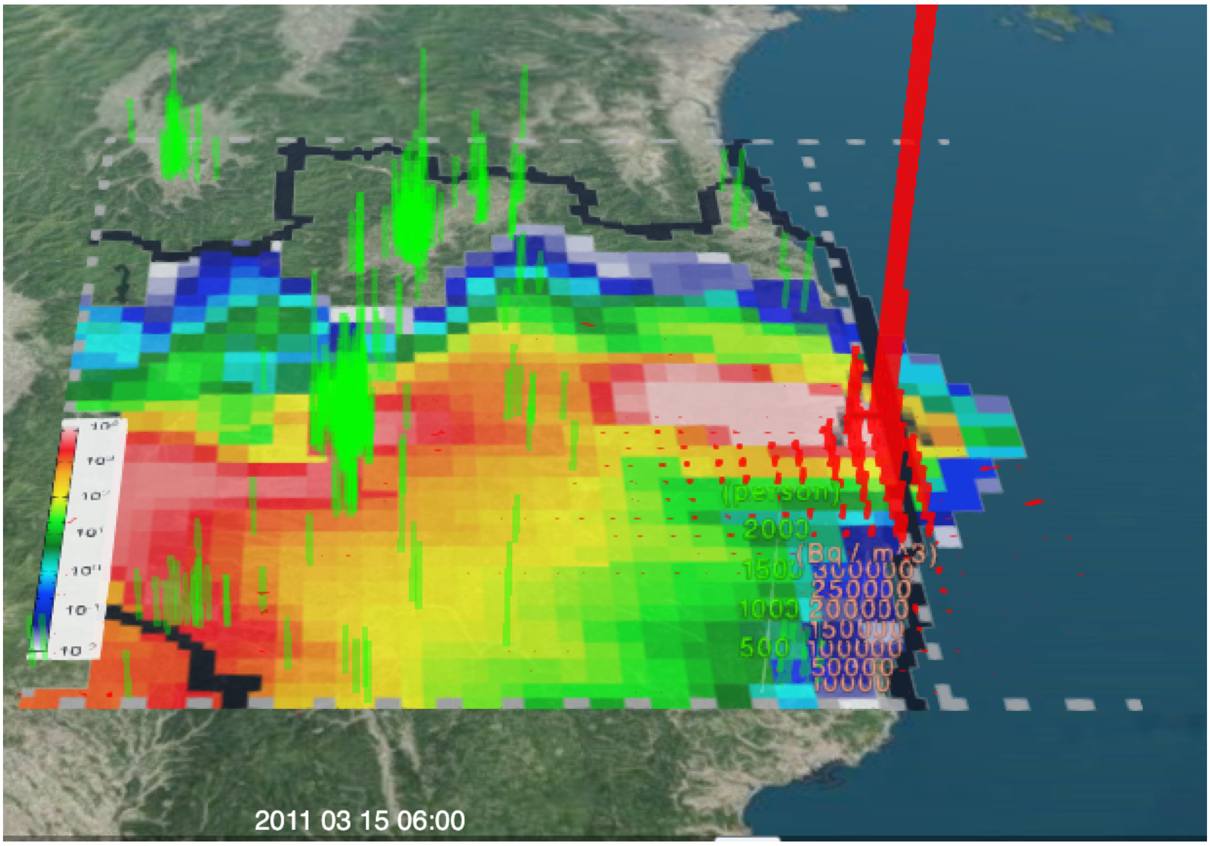

Figure 2.2: A screenshot from Project Hayano.[155]

In his book, *How to Make a Digital Archive*, Watanabe explains the methodology of his data archiving practice and the significance of using big data and open data to document the 3.11 disaster, using the examples of these projects. His main argument can be broken down into three points. First, his digital archive interface design avoids a search engine style, which requires certain background knowledge to reach what the user is looking for. Watanabe calls this style a tree structure because its user must access the database (body) from its partial entrance of a search engine window (leaf). Instead, he adopts the method of mapping contents

[155] Hayano, Project Hayano.
The red bars on the right side indicate the concentration level of simulated radioiodine in the air. The green bars on the left side are the visualised GPS data collected from turned-on mobile phones in the area. As the population density and concentration levels grow, the height of the bars grows taller. The colour gradation of the map shows the simulated transition of the radioiodine's concentration level. These figures automatically change as the timeline on the bottom shifts.

on the Google Earth digital map to enable its user to look at the whole context from a bird's-eye view for perspicuity.[156] Second, his archiving project focuses on multimedia content consisting of text, video, photography, and data visualisations. According to Watanabe, users can see connections between the contents from the bird's-eye view, leading to multiple interpretations of the event. Additionally, as his contamination visualisation project consisted of data provided by different institutions, Watanabe maintains that integrating content from different information sources on one screen can show connections between the different datasets, leading to further understanding. This is shown in Project Hayano by mashing up the data of population density and the simulation data of the radioactive contamination to show potential exposure. He also mashes up multimedia such as photos, videos, and texts to allow viewers to see one event from a different perspective.[157] Third, he emphasises the political fairness of temporal and spatialised metadata. According to Watanabe, a political debate on an event can create another interpretation, but the temporal and spatial metadata of content are not changeable. He argues that the data can stay politically neutral even if the social situation surrounding the data changes. Moreover, he also maintains that the mapping space of Google Earth does not belong to anywhere. The platform's political and social neutrality also allows users to interpret the contents at their disposal and avoid a certain stereotype derived from the belongingness of the space.[158]

In this book, Watanabe does not demonstrate theoretical evidence to support his argument. Hence, the discussion tends to lack some persuasiveness. However, there are a significant number of monitoring and archiving projects using digital mapping and the aggregation of data and multimedia. So, what is behind Watanabe's interface design and project policy directs how this thesis assembles its methodology to tackle the 3.11 disaster through the analyses of media and technologies. For example, his first argument shows the importance of the narrative

[156] Hidenori Watanabe, *How to Make*, 121–28.

[157] Hidenori Watanabe, *How to Make*, 128–31.

[158] Hidenori Watanabe, *How to Make*, 150.

of database structure, which can have a certain discourse relating to the interpretation and create an association with users. It is also notable how a certain technological perspective is related to the interpretation of database content in relation to the structure design. Next, as Watanabe focuses on the relations between different information sources and multimedia contents, it is also worth noting how we can understand the relations between archived objects, different sources, and metadata of temporal and locational data. Then, even though Watanabe observes the Google Maps perspective as an apolitical scope, the third point on the political position of data and a platform suggests an interface design itself can have a certain politicality.

Based on these points, this chapter will consider and demonstrate how this thesis methodologically understands and tackles questions concerning the strategy of using the digital infrastructure. In the first section, I will show how this thesis understands data and information. As shown in Project Hayano, in data visualisation and mapping, data are collected from radiation monitoring and the use of mobile phones, and these are then visualised to create information on contamination. Here, data are organised into a visual format to achieve a certain purpose. I will then consider how those who are monitored and produce data exist and the relation between those data and visualised information by referring to related discussions of Gilles Deleuze's societies of control. Next, the thesis will consider how contents and different sources aggregate and relate to each other while paying attention to users' interactivity and databases. This thesis will introduce Foster's and Azuma's ontological discussions on databases to focus on this point. It will then turn to technical and digital milieux and objects to elucidate the associations of different environments.

Subsequently, this chapter will consider how this thesis will understand the technological perspective of radiological contamination. First, considering the relationship between the vision of technologies and radiation, the thesis will introduce Susan Schuppli's notion of material witness. Then, to conceive a compounding perspective of humans, technology, and an environment that creates a unique reality to itself, it will consider Donna Haraway's argument of compounding eyes and Eduard Viveiros de Castro's perspectivism. Finally, based on these points, this thesis will turn to Andersen and Pold's notion of the metainterface to consider how technological and socio-political paradigms can emerge from behind an interface screen.

Based on the theoretical framework, the final section of this chapter will go on to show how this thesis selects cases for observation in the following chapters. To grapple with the questions of political and social epistemology, technical and digital objects, and the interface design and function of mapping software, this section will introduce the cases of both authoritative and citizen-led monitoring projects and technoscientific practices. It will explain how these cases are chosen and how we will observe them in the coming chapters.

2.2 From Data to Visual Information: Dividual, Variability, and the Virtual

First, this section will show how this thesis critically approaches data and information using the example of Watanabe and Hayano's project of the simulation of radioiodine contamination. This data mash-up project was facilitated by the digital infrastructure in post-Fukushima Japan. The data collection from citizens and contaminated environments consisted of databanks that provided materials for visualisation. How do we understand the process of data collection and aggregation?

To observe how data is collected, we will introduce Gilles Deleuze's discussion on societies of control. In 'Postscript on the Societies of Control', Deleuze points out that contemporary society has shifted from disciplinary societies to societies of control. In the 18th and 19th centuries, the former model was created by developing enclosed environments such as schools, factories, and prisons. In these enclosed environments, the individual is forcibly disciplined to follow their group's law, which is unique to the collective. In the latter model, the individual moves through open environments with 'different control mechanisms' that 'are inseparable variations'.[159] In this control model, what is used to disciple the individual becomes

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[159] Gilles Deleuze, 'Postscript on the Societies of Control', *October* 59 (2012): 3–4, https://www.jstor.org/stable/778828.

variable according to the individuals' variations. In the disciplinary model, an ideal figure is shaped through moulding by laws pertaining to a particular group. Contrarily, in the control model, controlling operates in relation to the variability of the controlled.[160] According to Koichiro Kokubun, the word control does not mean ‘rule’ but ‘check’, and societies of control install a checkpoint in a location where people move in and out to operate and regulate their movement.[161]

Anna Munster notes that the operation of control in the shift from digital (encoded, stored, fixed and archival management of data) to networked (distributed, connected and mobile data streaming) information is conducted by always being ‘on’.[162] In this sense, in the digital infrastructure, a mobile phone performs not only as an interpersonal communication tool but also as a checkpoint where location data is provided as long as it is turned on. This checkpoint is not limited to a particular location in the off-line real world and is also an access point to the information network that connects to several databases. As long as its owner permits it, this turned-on access/checkpoint embedded within a mobile phone is always open and can provide its location data. In this way, the variable modulation of control can be found in the use of mobile media.

Moreover, this operation of control is conducted through the digitisation of people's location and relates to how individuals are treated in control societies. ‘We no longer find ourselves dealing with the mass/individual pair’. Deleuze continues, ‘Individuals have become “dividuals” and mass samples, data, markets or “banks”’.[163] Unlike the disciplinary model that regulates and creates a mass of homogenous individuals, Deleuze sees that an individual is processed through numerical languages. They are seen as dividable or variable entities that provide

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[160] Deleuze, ‘Postscript’, 3–4.

[161] Koichiro Kokubun, *The Principles of Deleuzian Philosophy* (Edinburgh: Edinburgh University Press, 2020), 174.

[162] Anna Munster, *Materializing New Media: Embodiment in Informational Aesthetics* (New England: Dartmouth College Press, 2006), 36.

[163] Deleuze, ‘Postscript’, 5.

numerical data that aggregate in a database. This numerisation of the individual can be found in Watanabe's visualisation of radioactive contamination. In his case, the population density on the digital map is the visualisation of GPS data collected from turned-on mobile phones. Here, in the network of GIS technology and communication, part of an individual is codified into and understood as locational data. In this sense, they are dividable into a piece of parts.

This variability of entities under control is also applicable to non-human objects, such as radiation. Radioactive contamination is calculated through a particular scientific unit, and monitoring results can vary in accordance with which calculation unit is used. For example, in Fukushima, two different units are mainly used for radiation monitoring by national institutions. The becquerel (Bq) unit is used to measure the intensity of radionuclides in the soil or the air. Another frequently adopted unit, the sievert (Sv), calculates the radioactive exposure on a body to estimate potential health damage.[164] These units are convertible, and it is necessary to adopt the appropriate one for monitoring. In addition, the location and simulation data of radionuclides are important references to understand contamination status. In this way, the individuality of radiation is dividable into several forms, so radiation monitoring is also associated with the concepts of variability. As Project Hayano revealed, the different estimation of radioactive exposure and the perception of radiation are susceptible to the scientific units and methodology to access the invisible substance.

So, how can we consider this dividuality of an individual in relation to data mapping? Focusing on Deleuze's concept of dividual and modulation, Louise Amoore observes how the dividuality of a person is related to passport control at borders and governance in the identification of a person. For example, to determine the pre-subjects of several terrorist attack attempts in New York, the US attorney general revealed that the figures were assembled from passport, visa, and travel histories between certain countries within certain periods. Individuals' lives are divided into the parts of their legislative identifications, travel histories of

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[164]Ministry of the Environment, 'Becquerel and Sievert', last modified: 31 March 2019, https://www.env.go.jp/en/chemi/rhm/basic-info/1st/02-03-01.html.

destinations and periods, and dividuals are modulated into a certain figure for counterterrorism.[165] This example shows that by modulating fragmented data that do not necessarily identify a person, dividual data can assemble and prefigure a specific identity. In Project Hayano, radioiodine is measured and simulated in Bq/m^3, and the map visualises data from two different sources in two different ways. The National Institute for Environmental Studies data are simulated and put into the form of red bars. The heights of the bars indicate the concentration level in the air, and its position corresponds to the location of the radiation. The colour gradation on the map also shows a simulation of the dissipation of radioiodine based on data provided by the Japan Agency for Marine-Earth Science and Technology. Each grid shows the concentration level with colour.

In this way, by modulating the provided data with colour and shapes, the virtual figure of the contamination is assembled. The JAEA's published data on the contamination are divided into geological location data, concentration level and temporal data.[166] Radiation can be technologically perceived through these divided data, so hence, it can also be seen as dividual. Through the variability of visual expression, Project Hayano shows how technological mediation can reimagine the figure of the radiological event of the Fukushima nuclear disaster. According to Deleuze, those under the control model are 'in state of perpetual metastability'.[167] As the variable GPS data of people and the intensity level of radiation can be mashed up and rendered into diagrams, its visual forms are not unified but always potentially open to becoming so. To this extent, the control societies model can illustrate how entities are monitored and interpreted using the digital infrastructure.

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[165] Louise Amoore, *The Politics of Possibility: Risk and Security Beyond Probability*, (Durham: Duke University Press), 90–91.

[166] Japan Atomic Energy Agency, 'Results of Deposition Density Measurement of Gamma-emitting Nuclides on Soil within the 80 km Radius from Fukushima Dai-ichi NPP. (From August 2016 to October 2016)', accessed:19 March 2021, https://emdb.jaea.go.jp/emdb/assets/site_data/en/csv_utf8/1020101010/1020101010_00.csv.zip.

[167] Deleuze, 'Postscript', 4.

On the digital map, visualisation reveals the probable contamination based on these groups of data. For example, the temporal and spatial transition of the population density is visualised into blue columns, and the simulated radioiodine is visualised into the red ones. Based on these different types of data that only show the density of a monitored object in one particular space and time, the visualisation on the map shows semantic information of how many people might have been exposed to a certain density of radioiodine.

According to Alexander Galloway, data derives from the empirical proffering of measurable or observable fact and may appear without a particular visual format. On the other hand, as a specific type of visualisation shows a particular form of semantic information, information exists as things that are 'put into form'. Hence, 'Data have no necessary visual form', and 'any data visualisation will be first and foremost a theatre for the logic of necessity that has been superimposed on the vast sea of contingent relations'. Therefore, the aesthetics of a particular visual format reflect a pre-existing logic format.[168] As Galloway points out, data is inseparable from the empirical practice of data collection.

In the example of Project Hayano, the contamination data derive from dosemeters that capture the intensity of radiation. The GPS data are from mobile phones. Those data exist in digital form and are visualised through the diagrams on the digital map. This contamination simulation follows the necessity of showing the potential radioactive exposure in relation to time and space, where the social, technological, and meteorological relations are formed into a visual format. In other words, the information is susceptible to the logic of the format it follows. For example, the GPS data used for the contamination map was initially used to show traffic information, so the data collected by the same method can follow a different logic for another informational purpose. Here, a certain changeability of information is implied, which derives from a different logic of data visualisation.

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[168] Alexander Galloway, 'Are Some Things Unrepresentable?', *Theory, Culture & Society*, 28 (7–8), (2011): 87–88, https://doi.org/10.1177/0263276411423038.

Galloway points out that information is also what Deleuze calls the virtual.[169] In *Difference and Repetition*, Deleuze explains that the virtual is opposed to the actual and also has a reality. 'The possible is opposed to the real; the process undergone by the possible is, therefore, a "realisation"'. By contrast, the virtual is not opposed to the real; it possesses a full reality by itself. The process it undergoes is that of actualisation".[170] Hence, information as the virtual is the state of reality that has not actualised but exists in the process of actualisation. Taking the example of Project Hayano, what is visualised on the screen is the estimated contamination and potential radiological exposure among citizens in the areas. This is a simulation conducted through the machine learning system of SPEEDI, so this visualisation is not entirely actualised but remains in the realm of the virtual. In this sense, digital mapping shows a virtual reality based on empirical data.

According to Tiziana Terranova, information expresses the prediction of what is probable and what is improbable. An informational milieu forms around the informational couple of actual/probable that can lead to another space of 'the fluctuations that produce the unpredictable, of the inventions that break the space of possibility'. Thus, 'the cultural politics of information can be said to bypass the relationship between the real and the possible to open up the relation between the real and the virtual […]. The virtualisation of a process involves opening up a real understood as devoid of transformative potential to the action of forces that exceed it from all sides'.[171] Terranova points out that information connects the closed set of the possible to the real through virtualisation to regenerate a new reality.

In Project Hayano, what is visualised based on empirical and simulated data is potential radioactive exposure that leaves its trace on the digital map as the processual relation between the population density and the intensity of radioiodine. Those images show a reality not as the actualised but as a virtual estimation put into the form of a visualisation. This process

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169 Galloway, 'Are Some Things', 89.

170 Gilles Deleuze, *Difference and Repetition* (London: Bloomsbury, 2014), 275.

171 Tiziana Terranova, *Network Culture: Politics for the Informational Age* (London: Pluto Press, 2004), 26–27.

of data visualisation and simulation can be seen as the actualisation of data into a visual form. However, this simulated form of data still remains in the realm of the virtual because the simulated movement of radiation does not illustrate what actually happened but an estimation calculated through the prediction system. Here, the collected data are virtualised into a reality that shows a new aspect of the disaster. As Terranova explains, this feedback loop of informational culture does not merely bring negativity to the forefront against ‘a monolithic technology of power’ but is seen as ‘a positive feedback effect’ that regenerates a reality from the past.[172] With Project Hayano, the visualised movement of radiation and population density, simulated based on data obtained in the past, simulates a reality that shows potential radiation exposure among citizens. As Watanabe explains, this simulation can provide evidence to show correlations between health effects that were and would be caused to citizens and potential radiation exposure.[173] In this sense, the virtuality expressed by Project Hayano lies in the process of actualising radiation exposure and health hazards - with the actualisation occurring both in the monitored reality and in the development of data both at the level of the monitoring system and of the interface.

To sum up, as the above theoretical framework has shown, this thesis considers that the digital infrastructure of post-Fukushima Japan generates a reality through the aesthetic logic of data visualisation. Under emergency circumstances, the actual states of citizens and radiation are partially mediated through data. As the societies of control treat an individual as a dividual that provides data, the agencies are in a metastable condition. Through monitoring and visualisation, the data from these entities are organised into information by following the necessity of visualisation to regenerate a reality. From this point, it is also revealed that it is crucial to clarify how specific informational networks and visual aesthetics aggregate and organise data into a particular format.

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[172] Terranova, *Network Culture*, 27.

[173] Watanabe, *How to Make*, 191.

2.3 Critiquing Databases

Next, we will consider and demonstrate how this thesis understands databases and digital archives that aggregate data and information. In *An Archival Impulse*, Hal Foster analyses several artists such as Douglas Gordon and Liam Gallick and comments on the archival aspects of contemporary art. According to Foster, one of the archival artists' notable aims is 'to make historical information, often lost or displaced, physically present'. They collect various types of materials, from images to texts, and often take an installation format. For example, Gordon samples and combines images from the films of Alfred Hitchcock and Martin Scorsese. According to Foster, his visual narratives consisting of images from the archives of mass culture can show 'a gesture of alternative knowledge and counter memory'.[174]

Further, in referring to Pierre Huyghe and Philippe Parreno's *No Ghost Just a Shell*, which combines and edits an anime character whose copyright was bought from a Japanese company, Foster quotes Nicolas Bourriaud's analysis of postproduction. According to him, postproduction is 'the secondary manipulation' of the original and 'suggests a changed status in the work of art in an age of digital information, which is said to follow those of industrial production and mass consumption'. Developing this observation, Foster suggests that the mega archive of the Internet would be an ideal medium for archival artists and points out that words derived from the Internet culture such as 'platforms' and 'stations' have often been used in contemporary art discourse. According to his explanation, art curators such as Okwui Enwezor and Francesco Bonami emphasise the place of discussion and its discursivity, which is related to the Internet rhetoric of 'interactivity'.[175] In this sense, the materials in archival art are not merely objects, which are mechanically reprocessed, but 'they call for human interpretation'.[176]

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[174] Hal Foster, 'An Archive Impulse', *October* 110 (2004): 4, http://www.jstor.org/stable/3397555.

[175] Foster, 'An Archive', 4.

[176] Foster, 'An Archive', 5.

Foster contends that the image creation of archived materials through mash up can be seen as a form of a rhizome model because, as Deleuze and Guattari maintain, each element relates beyond a certain classification and centrality by avoiding particular start and endpoints.[177] In his design methodology, Watanabe also pays attention to a similar point to avoid a tree structure of database design. For example, institutional digital archives such as the National Diet Library of Japan and National Archives of Japan adopt a search engine browsing style. Users have to access it from the archive's top page (trunk) to the content (leaves). In this design, users cannot directly see the connection between different contents that are sorted based on categories. Watanabe's design maps multimedia contents from different sources in the same place on a digital map to avoid this content segregation.[178] As Foster highlights the rhizomatic combination of archived materials that originally belong to different sources, the works of Watanabe reflect that the connection of contents traverses predetermined categorisation.

On the other hand, Hiroki Azuma shows a postmodern database viewpoint that does not take a rhizomatic form. According to Azuma, following Lyotard, in the modern period when the grand narratives were still functioning, people's worldview consisted of small narratives manipulated by the grand narrative. In this case, the centrality of a grand narrative regulated other small parts, so he calls this modern worldview a tree model. Then, in the postmodern period, the grand narrative no longer functions, and small narratives connect with each other. However, taking the Internet as an example, Azuma argues that the small narratives are not connected on their own but are united within the perspective of who 'reads them up':

> On the Internet, rather, there is a distinct double-layer structure, wherein, on the one hand, there is an accumulation of encoded information, and, on the

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[177] Foster, 'An Archive', 6; Gilles Deleuze and Félix Guattari, *A Thousand Plateaus* (Minneapolis: University of Minnesota Press, 1987), 6–7.

[178] Watanabe, 'How to', 121–25.

> other hand, there are individual web pages made in accordance with the users "reading them up". The major difference between this double-layer structure and the modern tree model is that, with the double-layer structure, the agency that determines the appearance that emerges on the surface outer layer resides on the surface itself rather than in the deep inner layer, i.e., it belongs on the side of the user who is doing the "reading up," rather than with the hidden information itself.[179]

Compared with a rhizomatic model, in which signs or small narratives are linked with each other without centrality, Azuma emphasises the users' side that determines the appearance of the small narrative in a database model.[180] In this sense, this database model competes with the existence of its users. Unlike Foster, Azuma's database ontology does not avoid unifying the contents or small narratives through a particular centrality. Indeed, Azuma's database model allows observation of the structure of the data infrastructure and the Internet with a focus on the existence of users who combine signs and create contents at their disposal. A rhizomatic model, in which signs and parts create associations and contents, does not necessarily need the existence of users. Instead, Azuma's database model seems to consider the relationship between a human-side and a machine-side.

In terms of users as an agency unifying and connecting contents, this database model seems similar to Watanabe's archive design. However, this model ignores the bilateral interaction, or in Terranova's sense, a positive feedback loop that regenerates reality where users are also situated and susceptible to the process. As shown in the previous section, mobile phone owners can be data producers. Hence, users of the Internet or those embedded within the digital infrastructure are also part of small narratives potentially read up by others.

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[179] Hiroki Azuma, *Otaku: Japan's database Animal* (Minnesota: University of Minnesota Press, 2009), 31–32.

[180] Azuma, *Otaku*, 33.

Furthermore, in the monitoring practices that this thesis focuses on, users not only browse information but also provide information. Therefore, it is necessary to draw the interactive relation between users or people and the database.

2.4 Digital Milieux and Digital Objects

In order to delineate networks and the interactivity of things beyond the inside and outside of a database, we introduce Yuk Hui's concept of digital milieu, which was developed from Gilbert Simondon's concept of associated milieu by focusing on the existence of digital objects. For Simondon, a milieu is the activity of specific relations that pertain to an entity and its concretisation.[181] At the same time, he also emphasises the exterior of an individual entity with the term 'external milieu' to distinguish between an individual and what conditions the process of its individuation.[182] For example, based on this view, Hui argues that software applications such as Facebook and Twitter are defined as a digital milieu that constitutes a relation of multiple networks of objects and users, and has its own order.[183] Originally, an associated milieu was conceived to describe the technical concretisation of technical objects. According to Simondon, in the early part of concretisation, technical objects need an external milieu such as a laboratory or workshop to regulate themselves and the gradual concretisation processes. As a result, a technical object develops its internal coherence and a degree of self-maintenance and begins to operate on the external milieu through its functions.[184] However, he argues, 'what enables the self-maintenance of the objects conditions of functioning is its

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[181] Gilbert Simondon, *Individuation in Light of Notions of Form and Information* (Minneapolis: University of Minnesota Press, 2020), 50.
[182] Robert Mitchell, 'Simondon, Bioart and the Milieu of Biotechnology', *Inflexions* 5, 'Simondon: Milieu, Techniques, Aesthetics'(2012): 69 and 75, http://www.inflexions.org/n5_Mitchell.pdf.
[183] Yuk Hui, *On the Existence of Digital Objects* (Minnesota: University of Minnesota Press, 2016), 35.
[184] Gilbert Simondon, *On the Mode of the Existence of Technical Objects* (Minnesota: Univocal, 2017), 50.

relation to other technical and natural objects, and it is this relation that becomes regulative; this object is no longer isolated; it associates itself with other objects, or suffices unto itself, whereas at first, it was isolated and heteronomous'.[185] A technical object concretises in relation to the milieux in which it is situated. The regulation process imposed by external milieux consisting of natural and technical objects also becomes part of the association. For example, Simondon explains how the Guimbal turbine, which is used for power generation at a water dam, is designed in relation to a water stream. The turbine has its own technical order, but at the same time, to spin, it needs to intake its external and natural element of water from the river.[186] In this way, the technical object of a turbine is related to the natural milieu of the river and the technical milieu of a water dam.

According to Cabot, a technical object has a genesis. The refinement process is often defined based on external standards such as 'usefulness or profitability', but Simondon tries to grasp the concretisation process of technical objects in relation to their associated milieu that are constituted of heterogeneous objects.[187] Hence, the associated milieu can be understood as a place where organic and inorganic individuals have respectively autonomous self-maintenance systems but at the same time proliferate through interaction with each other.

Based on Simondon, Hui describes the concepts of a digital object and a digital milieu, which have developed since the 1970s until now, during which time information technologies were diffused among technologists and ordinary users.[188] He explains that 'By digital objects, I mean objects that take shape on a screen or hide in the back end of a computer program, composed of data and metadata regulated by structures or schemas'.[189] Through its external digital milieu, a digital object concretises through the combination of algorithms, protocols, machines, and computer languages. It also has a genesis in networks, which 'are created

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[185] Simondon, *On the Mode*, 50.

[186] Simondon, *On the Mode*, 59.

[187] Pascal Cabot, *The Philosophy of Simondon* (London: Bloomsbury, 2003), 12.

[188] Yuk Hui, *On the Existence of Digital Objects* (Minnesota: University of Minnesota Press, 2016), 26.

[189] Hui, *On the Existence*, 1.

among the digital objects being actualised according to certain parameters and algorithms'. Then, Hui explains that a digital milieu is constituted of 'multiple networks, which are connected together by protocols and standards'.[190] As a technical object concretises in its relations with other technical objects, a digital object concretises with the actualisation of its external networks. Moreover, users engaged in the concretisation process are part of the actualisation of the networks rather than directly creating digital objects. Drawing on Simondon's interpretation of humans and tools, Hui maintains that 'Humans created the associated milieu for the tools through their gestures and habits, stabilising and regulating the entire ensemble: tool—bearers themselves became technical individuals'.[191] This quote shows that the human users in a specific digital milieu can be understood as components that stabilise the networks of digital objects with other objects. By using Simondon's term, Hui calls this concretisation process of digital objects that become part of the networks of its associated milieu as technical *individualisation*. On the other hand, he distinguishes it from the process of *individuation*, which refers to digital objects' functions of 'maintaining emotions, atmospheres, collectivities, memories, and so on' by 're-establishing and renegotiating its relations with other objects, systems and users within their associated milieux'.[192] Digital milieux are therefore related to both individualisation, the concretisation of objects and actualisation of the network, and individuation that affects the quality of the networks and that can involve humans.

In this way, the definition of a digital milieu brings an opportunity for a more dynamic and broad discussion of humans, technical, and digital objects in certain media ecology, where they engage in different temporalities of processes. As shown in the previous section, in the rhizomatic model, stored digital content relates to each other through interaction with users. Introducing the discussion of digital milieu and objects enables an understanding of how

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[190] Hui, *On the Existence*, 26.

[191] Hui, *On the Existence*, 56.

[192] Hui, *On the Existence*, 57.

human users can be involved with content and its database in a technical and effective way. As the example of Project Hayano suggests, users of the Internet do not only browse information but also provide data for the construction of the data simulation project. Such data move from the different milieux: a social milieu of the users, a technical milieu of mobile phone, and a digital milieu of the Internet. Through this movement, data individualise into visualised data. This thesis studies this process of the individuation of an entity in relation to its situated milieux.

This view of milieu as an interrelation of entities plays an important role in this thesis to observe in what way radiation monitoring devices and data concretise and operate in the media ecologies of post-Fukushima Japan. These technical and digital objects are related to environments contaminated with radiation through the design process and monitoring activity. To describe this point, this thesis applies the concept of milieu rather than the environment. As Petit and Guillaume explain, the former means the relation between the inside and outside of an entity and its unique experience in a place. Meanwhile, the 'environment' is identical for all beings in a specific location and remains external to them.[193] As shown in this section, while technical and digital objects have their exterior, they maintain their relation to it and concretise into another individual. In this view, for example, a natural milieu does not mean 'nature' itself but relations that form between associated elements such as natural and technical in a specific place that has a certain order. Hence, the concept of milieu allows us to highlight the specificity of relations of objects while maintaining their internal and external relations. As shown in Chapter 1, this thesis understands radiation monitoring as a practice that takes place in the convergence of the social, technical and environmental without the centrality of humans. With the theory of individuation, Chapter 4 will further examine how such

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[193] Victor Petit and Bertrand Guillaume, 'We Have Never Been Wild: Towards and Ecology of the Technical Milieu', in *French Philosophy of Technology: Classical Readings and Contemporary Approaches*, ed. Sacha Loeve, Xavier Guchet, and Bernadette Bensaude Vincent (Cham: Springer, 2018), 88, https://dx.doi.org/10.1007/978-3-319-89518-5_6.

relations constitute technical and digital objects in technical and social settings in post-Fukushima Japan.

2.5 Perspectives Towards Radiation: Compounding Eyes and Perspectivism

Taking a closer look at the aesthetical dimension of the technological practice of radiation monitoring, I will consider how the radiological contamination was visualised. There are variations in monitoring the radioactive contamination depending on how to approach the invisible substances of the radionuclides. However, to observe radioactive contamination consistently means detecting and converting the intensity of radioactive substances into numerical data and putting those values into a visual form. So far, this thesis has introduced data visualisation in the digital infrastructure, but the visualisation of radiation in space has also been adapted through moving images.

For instance, Nippon Hoso Kyokai (NHK), Japan's public broadcaster, broadcast a documentary on contamination mapping in 2011. In the documentary, Masaharu Okano, a radiologist who has monitored several radioactive contamination cases such as Lucky Dragon 5 and Chernobyl, operates his handmade camera machine called the Okano machine, which is equipped with a dosemeter, a radionuclide spectrum meter and a GPS data recorder. The uniqueness of this machine is that by showing the energy spectrum of radiation, it can detect what kind of radioactive isotopes are floating in the monitored area. These data are recorded on the device every six seconds and shown in graph format on the video camera screen.[194] Thus, the machine generates a reality of the radioactive contamination on the spot by overlapping the graphic figure on the live camera. In this sense, the machine can be understood as an interface to the vision of the associated milieux where natural and machinic

[194] NHK's 'ETV Special' Team of Reporters, *Hot Spot: Making a Radioactive Contamination Map with Networks (ホットスポット：ネットワークでつくる放射能地図)*, (Tokyo: Kodansha, 2012), 117–118.

perspectives coexist. In Galloway's sense, visualisation aesthetics follow the logic of the necessity of overlapping the contamination data on the live camera.[195] This example shows how the empirical data on radioactive substances are actualised as the reality of radioactive contamination through the technological scope.

To further consider the relationship between devices that create a technological perspective, we introduce Susan Schuppli's analysis of the gamma camera. In *Material Witness: Media, Forensics, Evidence*, Schuppli coins a concept of material witness that is 'an exploration of the evidential role of matter as registering external events and exposing the practices and procedures that enable such matter to bear witness'.[196] She reconceptualises 'witness' not as limited to humans or a matter but expands the concept to non-human entities and their machinic ecologies that witness their involved event. Then, Schuppli focuses on the Fukushima case and investigates how technologies have shaped the figure of radiological contamination. For example, Schuppli pays attention to using the gamma camera, which captures and converts gamma rays from radioactive isotopes into light and then an electric signal.[197] These signals are visualised on the camera screen, indicating the concentration of radionuclides with colours. Some types of dosemeter convert the radioactive intensity into signals and then sound. The gamma camera converts gamma rays into signals without being mediated through a numerical value. This technology has been applied to a remote-control robot that shot video footage inside the Daiichi NPP, where humans cannot enter due to the high level of radioactive concentration. NHK also adopted the gamma camera for its broadcasting, and one of the video footages was broadcast on its programme, *Radioactive Forest*. Through the vision of the gamma camera, the documentary shows Iitate forest where the radioactive concentration level is higher than other areas. The Iitate area is located 30–50 km northwest of the Daiichi Power Plant. According to the Fukushima Prefecture's published

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[195] Galloway, 'Are Some Things', 87-88.

[196] Susan Schuppli, *Material Witness: Media, Forensics, Evidence* (Cambridge: The MIT Press, 2020), 3.

[197] Schuppli, *Material Witness*, 255.

data, the concentration marked 44.7 μSv/h is 700 times higher than the normal level in an unspecified location in the area.[198] Taking the example of the shot from the Iitate forest, Schuppli analyses the use of the camera as follows:

> [T]he nuclear aesthetics of the material witness are always radically indexical to themselves. In the case of the Iitate valley, this would be akin to saying that radiological contamination has rendered the forest ecosystem a living trace of the disaster. Moreover, in capturing traces of the real, the woodland also became image matter in waiting: an arboreal archive whose photogenic capacity would come to be actualised only with the invention of the portable gamma camera, which forced the ontological condition of the forest as contaminated into presence. The camera makes the forest radioactive.[199]

Schuppli advocates that the aesthetics of the vision of the gamma camera is indexical to the condition of the radiological contamination, in which the device is also part of the event as a witness. It also emphasised that the figures of contamination can be actualised through a particular type of technology. As long as the forest cannot be indexical to the contamination condition independently, the camera determines its quality as being radioactive. Indeed, the technological perspective emerging in the relation between the camera and the forest brings the contaminated figure of the natural environment into a visual format. However, the emphasis on the technological agency seems to ignore the role of the forest itself in a radiological event.

Mathew Fuller and Olga Goriunova observe how devastation as an ecological event relates to the becoming in the natural environment and its biological system. They refer to the Chernobyl nuclear accident as a case in which devastation affects the becoming of death. In

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[198] NHK's "ETV Special" Team of Reporters, *Hot Spot*, 154.
[199] Schuppli, *Material Witness*, 257.

the disaster area, radiological contamination depleted fungal and bacterial operation, and as a result, dead trees have not been decomposed by those entities and remain in the area.[200] In this way, natural environments can also be altered by the invisible radiological operation on death and life. At a visual level, forests can be indexical to the condition of the contamination. From this example, it can be argued that, instead of taking natural environments as an entity made radioactive, these can experience the radiological event in their own way. Humans interpret the event through their perspective that can be equipped with technological mediation. The high concentration level in the forest of Iitate valley is the outcome of meteorological and geographical conditions. These characteristics that human culture cannot determine are visualised through the sensorium of the gamma camera.

The gamma camera renders a perspective of the natural environment of the forest visually recognisable to humans. This also applies to the Okano machine that collects and visualises the radiodensity data and energy spectrum of radionuclides in the Fukushima area. These visions on the screens emerge through the assemblage of humans, the cameras, and the forest. The visualised radioactive concentration level comes out as the outcome of geological and meteorological interactions. In this sense, we see the radiation through a perspective of environments where those interactions occur. What is different in these visualisations is that the technology in use shows different radiation figures in different conditions. The gamma camera in the Iitate forest showed the concentration level in a particular spot in the forest that the camera is shooting with colours. On the other hand, the Okano machine collects contamination data from where the camera is situated and visualises it in graphs to show what kind of radioactive isotopes in what level of intensity in a particular area and time. Even though both capture radionuclides from the same source, the figures and the reality of the contamination differ. A figure of radioactive contamination is regenerated and multiplied through those perspectives.

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[200] Matthew Fuller and Olga Goriunova, *Bleak Joys: Aesthetics of Ecology & Impossibility*, (Minneapolis: University Minnesota Press, 2019), 5–6.

Studying the use of the Crittercam, which is attached to sea creatures to observe their ecosystem, Donna Haraway notes that the viewpoint of the device does not belong to the animal or the technological side but to the compound of those divisions. According to Haraway, the Crittercam is 'the machinic, human, and animal beings of which historically situated infoldings are the flesh of contemporary naturecultures'.[201] By introducing the concept of naturecultures, Haraway rethinks the division of nature and culture beyond human-centralism that determines the natural side. The gaze of the Crittercam is brought about not only by technological culture but also by the historical interaction of the naturecultures of machines, animals, and humans from where those are situated. Following Haraway, these compounding eyes are the embodiment of their interaction.[202] This analysis shows how to conceive technological devices deployed in a natural environment that bear a new perspective or eyes that capture a vision that humans cannot achieve by themselves. In the cases of the gamma camera and Okano machine, their eyes are technologically manipulated by humans. However, they are calibrated to an environmental condition to capture radioactive contamination susceptible to its surroundings. Hence, space itself, where these devices and their manipulators operate, can be interpreted as the compounding eyes that bear the perspectives of radiation.

So, how can we consider the reality generated from the perspectives of the compound of naturecultures? Through his ethnographic research on an Amazonian tribe, Eduardo Viveiros de Castro deploys perspectivism based on multinaturalism. In the cosmology of the Amazonian tribe, animals signify a natural environment in their own way. For example, 'Where we see a muddy saltlick on a riverbank, tapirs see their big ceremonial house'.[203] In this animist

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[201] Donna Haraway, *When Species Meet*, (Minnesota: University of Minnesota Press, 2008), 261.

[202] Haraway, *When Species Meet*, 250.

[203] Eduard Viveiros de Castro, 'Perspectival Anthropology and the Method of Controlled Equivocation', *Tipití* 2, issue1 (2004), 6, https://digitalcommons.trinity.edu/tipiti/vol2/iss1/1?utm_source=digitalcommons.trinity.edu%2Ftipiti%2Fvol2%2Fiss1%2F1&utm_medium=PDF&utm_campaign=PDFCoverPages.

cosmology, as the tapirs see the natural material of the saltlick as a house that is a cultural object, what the Amazonian tribe and animals share is the same culture. Their cosmology sees the meaning of the natural object as relativised and diversified depending on a perspective belonging to each entity regardless of humans or animals. Viveiros de Castro calls this natural and objective relativism multinaturalism in contrast to multiculturalism that imagines a universal figure of nature under the diversity of culture.[204] He continues to define the notion of perspectivism as follows:

> [P]erspectivism supposes a constant epistemology and variable ontologies, the same representations and other objects, a single meaning, and multiple referents. Therefore, the aim of perspectivist translation—translation being one of shamanism's principal tasks (…) is not that of finding a synonym in our human conceptual language for the representations that other species of subject use to speak about one and the same thing. Rather, the aim is to avoid losing sight of the difference concealed within equivocal "homonyms" between our language and that of other species, since we and they are never talking about the same things.[205]

As this quote shows, this multinaturalist perspectivism can be interpreted as a method to rethink what other species see in the natural environment based on a shared single meaning. Here, shamanism interprets the languages other species say operates as a translation media to imagine nature from their perspectives. The thesis will not investigate this animist viewpoint in the technological practices, but as methodology, it will consider that perspectives of humans and non-humans, including other species and technical objects towards the same radiological event, generate the epistemological reality of the contamination. Then, rather than assuming

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[204] Viveiros de Castro, 'Perspectival Anthropology', 6.

[205] Viveiros de Castro, 'Perspectival Anthropology', 6–7.

that human culture determines how to see the radiation, the thesis will situate the technical object as a translator that renders the visions from other perspectives intelligible. Although they are looking at different cases at different scales, Haraway and Viveiros de Castro share the point of view of how to rethink the approach to the exterior of human culture, avoiding its ontological and epistemological centrality.

2.6 The Metainterface

Next, based on these points and thinking through examples of the Fukushima case, this section shows a methodological understanding of the perspectives of technical objects from dosemeter to the interface of digital mapping. In Watanabe and Hayano's Project Hayano, data mash up of the simulation of the radioiodine dissipation by the Japan Atomic Energy Agency (JAEA), the independent administrative institution, partly provides the project with contamination data. Since 2015, the JAEA website has published their collected data with the specifications of the environmental monitoring methods adopted to collect them. The page has adopted six different types of data sampling: air, soil, atmosphere, inland water, food, and sea areas. In addition, they also publish data visualisation based on geographical information in five different environmental forms: elevation, vegetation, accumulated snow, land use, and soil.[206] In each category, they visualise collected data in digital mapping format and publicise their monitoring result data in comma-separated values (CSV) format for viewers to download. After the 3.11 disaster, data visualisation using digital mapping has been adopted by various governmental institutions, from the JAEA to local municipalities. Several municipalities also publish their collected data in CSV format.[207] What is listed in the format differs depending on

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[206] Japan Atomic emergency Agency, "Database for Radioactive Substances Monitoring Data", accessed: 20 March 2021, https://emdb.jaea.go.jp/emdb/en/.

[207] For example, the Fukushima Prefecture publish their monitoring result in CSV format on their website.
https://www.pref.fukushima.lg.jp/sec/16025d/kako-monitoring.html

each institution. However, most contain location data in longitude and latitude, the name of the monitored place and a monitoring date. The differences derive from the measurement method used. For example, JAEA's soil monitoring adopted in-situ measurements using portable germanium semiconductor detectors to detect and measure gamma rays from the soil.[208] Data was collected from the area within an 80 km radius of the Daiichi NPP and divided into 5 km x 5 km grids. The monitoring was manually conducted with each grid assigned its own code, so its CSV file lists each grid's code name. This measurement can also detect the type of radioactive isotopes, showing the Caesium-134 and 137 in each grid. Its air measurement used a monitoring post established in an area of each prefecture in Japan. Each post sent monitored data to JAEA on a daily schedule, and these were published on the Nuclear Regulatory Agency website. The air dose measurement can only measure the dose of radionuclides, so its CSV file does not carry the name of particular radioactive isotopes. Soil measurement can measure radioactive concentration more precisely but requires more time and manual labour to be conducted.

In contrast, air measurement, especially with a monitoring post, can regularly measure dosage in the air and report it to its partner institution. However, even though radionuclides can move under certain circumstances, the radioisotopes of Caesium-134 and 137 tend to accumulate in the soil. Air measurement is not as precise as soil measurement.[209] Each method has unique characteristics, so the above six sections use different environment measurements for their project purpose. In addition to the data visualisation and the row date it is based on, viewers can download their mapping tool, allowing them to express 12 different geographic keyhole markup language (KML) annotations on Google Earth using the JAEA's

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[208] Japan Atomic Energy Agency, 'In-Situ Measurement', accessed: 19 April 2021, https://emdb.jaea.go.jp/emdb/en/selects/b10201/.

[209] Citizens' Radiation Data Map of Japan, *Citizens' Radiation Data Map of Japan* (Fukushima: Minna-no Data Site Publishing, 2020), 173.

or users' own data in CSV format.[210] These 12 types of renditions are designed to visualise data collected by a particular measurement to show a different aspect of the contamination reflected from the data.

These examples of environmental monitoring show the assembling process of compounding eyes towards radiation. It starts with empirical data collection in the natural environment with technical devices converting electric signals into numerical data, listing those into CSV files and rendering them into digital mapping visualisation. This process varies depending on the adopted measurement, but the transition from natural, technical, and digital milieux is consistent among different cases. Notably, data on radiation is converted into different forms before appearing as visual information. For viewers, the contamination is shown as 3D graphics on a mapping tool. However, in the previous stage of the eventual visualisation, the monitoring devices and the database communicate through numerical data organised into CSV format.

Viveiros de Castro argues that perspectivist communication among different species is translation.[211] Here, the same object of radiation is interpreted through different languages for machines and humans. In other words, human viewers of the digital mapping interpret the nuclear disaster via a visual format. The database sees the same event in the format of CSV. The process of data mapping consists of multiple perspectives that differentiate the disaster for heterogenous intelligibility. The CSV perspective is hidden from the digital mapping view, but the latter cannot be rendered without the former operation. In this sense, the compounding eyes have their own inside ecologies that need to be unpacked to critically observe how they are internally connected.

As this relation between the interface of a mapping tool and the database, the contemporary interface culture has a hidden layer where machines communicate to stabilise a visible

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[210] Japan Atomic Energy Agency, 'Mapping Tool', accessed: 18 April 2021, https://emdb.jaea.go.jp/emdb/en/mappingtool.html.

[211] Viveiros de Castro, 'Perspective Anthropology', 6-7.

operation in everyday life. Christian Ulrik Andersen and Søren Bro Pold coin the concept of the metainterface to critically investigate the aesthetics of this hidden part of the computer's interface design. Taking an example of artworks that problematise the operation of the metainterface, they observe how certain interfaces have a critical paradigm within new technologies and the work of art that moves beyond the PC network.[212]

As one example of cloud computing and the contemporary interface, Andersen and Pold introduce YoHa and Matthew Fuller's artwork, *Endless War*. This artwork is based on a collection of information leaked from the US Military's database of tactical information from troops to WikiLeaks. The leaked group of reports is called the Afghan War Diary, composed of 91 thousand reports by the US Military on the Afghanistan war from 2004 to 2010.[213] Andersen and Pold define the database as a 'military cloud' containing reports from soldiers and intelligence officers. These contain time and geographic location data of documented events from combat to propaganda. The US Army arbitrarily chose which they thought were significant events to document. In addition, these files contain details of events, such as the number of causalities and the types: allies, enemies, and civilians.[214] YoHa and Fuller understand the Afghan War Diary as the database machine that generated military acts through the documentation in the data files and processed these datasets for machines and humans. The data files are processed by an N-gram fingerprint algorithm that sorts texts by removing predetermined categories.[215] *Endless War* takes the format of an art installation consisting of three big projectors that show live processing of the database by displaying the generated sequence of texts from the reports. They also amplify and play the sound of the computer in action with a contact microphone. This work considers the Afghan War Diary as

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[212] Christian Ulrik Andersen and Søren Bro Pold, *The Metainterface: The Art of Platforms, Cities, and Clouds* (Cambridge: The MIT Press, 2018), 5 and 11.

[213] WikiLeaks, 'Afghan War Diary, 2004–2010", 25 July 2010, https://www.wikileaks.org/wiki/Afghan_War_Diary,_2004-2010.

[214] Andersen and Pold, *The Metainterface*, 11.

[215] YoHa, '*Endless War* - YoHa with Matthew Fuller', accessed: 10 March 2021, http://yoha.co.uk/endless.

‘a sensorium, an entire sensory and intellectual apparatus of the military body readied for battle, an apparatus through which the Afghan war is both thought and fought’.[216] By recomposing the data atomised from reality into a mixture of text and sounds, the artwork shows how the war is sensed and generated through the perspective of a machine for humans. According to Andersen and Pold, this work demonstrates how the military categorises the war following the abstraction of reality through a language for the machine that regularises the expression of the event.[217]

As *Endless War* problematises the language of the machine that formulates the figure of the war in the metainterfacial paradigm, the same critique also brings the hidden technological restriction and operation to the forefront in the case of the radiation monitoring in Fukushima. Take the real-time monitoring from monitoring posts as an example; the distributed network of the devices and the database are connected through networks such as satellite and ground fixed lines that need to go through a base station.[218] In terms of technological costs to use these networks, each monitoring post minimises communication quality and frequency. As a result, current real-time monitoring can transmit numerical monitoring data at the rate of every two or ten minutes. These data are collected and published in CSV format. This file format itself unfolds the technological and cost-benefit restrictions surrounding the environmental monitoring network in post-Fukushima Japan. Therefore, it can be related to *Endless War* in terms of how the CSV format senses the nuclear disaster and how the categorisation of data reflects the particular regulation of the language of machines. Therefore, the perspective of the digital map is also not neutral, as Watanabe argues, but it cannot move beyond the speed and quantity of the machinic communication constituted under this socio-technological condition. In this way, looking through the metainterfacial paradigm, the aesthetics of

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[216] YoHa, ‘*Endless War*’.

[217] Andersen and Pold, *The Metainterface*, 142.

[218] Minoru Tanigaki, ‘Analysis for the whole area monitoring system immediately after a nuclear disaster (発災直後の面的な放射線モニタリング体制のための技術的研究)’, accessed: 5 May 2021, Nuclear Regulation Authority, https://www.nsr.go.jp/data/000330721.pdf.

contamination monitoring can show its critical viewpoint towards the inside of the technological perspective.

2.7 Methodological Design: Selecting and Analysing Cases of Radiation Monitoring

This final section of this chapter explains how cases are selected and discussed in the following chapters. As discussed in Chapter 1, radiation monitoring is regarded as a technoscientific practice occurring at the intersection of technological, social, and environmental factors. Following this argument, this chapter outlined how the thesis conceptualises media technologies and approaches technoscientific practices with a focus on these technologies. Based on the theoretical framework focusing on interface design, data, and technical objects shown in this chapter, this thesis goes on to observe and analyse cases of radiation monitoring following the Fukushima nuclear disaster.

Following the theoretical method outlined here, the chapters will analyse the use of media technologies, the development of monitoring devices, and the functions and designs of mapping software. Initially, the research plan included interviews with developers and designers of the studied institutions and fieldwork on radiation monitoring. However, due to the global COVID-19 pandemic, this plan became unfeasible. Consequently, the research method shifted to observing publicly available materials from the websites of the studied institutions and groups. As explained in the introduction, one of the thesis's aims is to analyse how radiation monitoring systems in post-Fukushima Japan created a novel political and scientific epistemology in media ecologies where both authoritative and non-authoritative groups of scientists and citizens are interconnected. Hence, the thesis observes cases of state-owned institutions and citizen-led groups alike. The case studies are divided into three chapters, with selected institutions and groups publishing their data as open data or for research purposes, thereby granting permission for data use.

Chapter 3 will examine two cases of political activism related to Japan's nuclear power policy post-Fukushima. The first case is the anti-nuclear movement in Japan in 2011, characterised by the use of social media platforms such as Twitter and Facebook to mobilise citizens.[219] This section will review previous research, news articles, and journals to profile and study the significance of social media technologies in this political activism.

The second case involves the Collective Database of Citizen’s Radioactivity Measuring Labs (CDCRML), a citizen-led radiation monitoring project initiated after the Fukushima disaster.[220] CDCRML conducts monitoring and publishes their data on a digital map. This section will study their mapping practices and their political manifesto advocating for changes in Japan's radiation exposure standards, reflecting the political epistemology and ontology of environmental radiation in relation to monitoring practices. For this observation, the thesis selects their East Japan Becquerel Measurement Map, which covers the period from 2011 to 2017, through which they contest the government’s radiation monitoring method and their low-level radiation exposure dosage standard.[221] CDCRML allows the use of their data for research purposes, making it a suitable case for this study.[222]

Chapter 4 focuses on the development of radiation monitoring devices, with a detailed study of Safecast’s radiation monitoring devices. Safecast develops, produces, and publishes contamination data as open data, thus granting permission for their data to be used for

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[219] Koichi Hasegawa. ‘The Fukushima nuclear accident and Japan’s civil society: Context, reactions, and policy impacts’, *International Sociology* 29, no. 4 (2014): 293, https://doi.org/10.1177/0268580914536413.

[220] Collective Database of Citizen’s Radioactivity Measuring Labs, accessed: 12 November 2023, https://minnanods.net/.

[221] Collective Database of Citizen’s Radioactivity Measuring Labs, East Japan Becquerel Measurement Map, accessed: 19 March 2021. https://minnanods.net/maps/?pref=prefs17&m2_kg=kg&time=2011&sum_137=sum.

[222]Collective Database of Citizen’s Radioactivity Measuring Labs, ‘About Us (私たちについて)’, accessed: 12 December 2023, https://minnanods.net/mds/notes.html.

research purposes.[223] As outlined in the introduction, compared with other monitoring projects such as the Kyoto University Radiation Mapping System (KURAMA), Safecast provides more publicly accessible content including plans and comments on device design and data strategy.[224] Considering this availability and transparency of content, this thesis focuses on Safecast as a primary case study. This chapter will utilise Safecast's published content such as their digital map and blogposts, produced between 2011 and 2023, to analyse their device design and radiation monitoring infrastructure.[225]

Chapter 5 examines the use, designs, and functions of mapping software. In addition to Safecast, this chapter studies the Nuclear Regulation Authority (NRA) and the Japan Atomic Energy Agency (JAEA). The focus will be on data generation and visualisation processes on digital maps. The NRA is an administrative body belonging to the Ministry of the Environment, formed in 2012 to ensure the safety of nuclear use in Japan.[226] The NRA conducts contamination monitoring in collaboration with local municipalities and state-led institutions, publishing data via the Radiation Monitoring Information Sharing System and their database website, Environmental Radioactivity and Radiation Japan.[227] This makes the NRA a relevant case for studying the sociopolitical conditions of data generation and monitoring locations and digital mapping. Their data is publicly available, and they permit users to use the data by

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[223] Sean Bonner, 'Open Data: Now More than Ever', Safecast, 14 January 2017, https://safecast.org/open-data-now-more-than-ever/; Safecast, 'Licenses We Use', accessed: 12 November 2023, https://safecast.org/about/licenses/.

[224] Hemmi and Graham, 'Hacker Science'; Safecast, 'Devices', accessed: 12 November 2023, https://safecast.org/devices/.

[225] Safecast, 'Safecast Map', accessed: 12 November 2023, https://map.safecast.org/.

[226] Nuclear Regulation Authority, Nuclear Regulation Authority Website, accessed: 12 November 2023, https://www.nra.go.jp/english/index.html.

[227] Nuclear Regulation Authority, 'Radiation Monitoring Information Sharing and Publication System', accessed: 23 November 2023, https://www.erms.nsr.go.jp/nra-ramis-webg/#; Environmental Radioactivity and Radiation in Japan, accessed: 23 November 2023, https://www.kankyo-hoshano.go.jp/.

providing a reference to their source.[228] In this case study, the thesis will use their monitoring map, which indicates radiation values and monitoring locations from the aforementioned radiation monitoring system. The data was collected in 2023.

The final section of Chapter 5 analyses the JAEA's radiation monitoring mapping and data. Introduced in Chapter 4, they are an independent administrative institution engaged in research and development of nuclear technologies.[229] In collaboration with KURAMA and municipalities in the Fukushima Prefecture, the JAEA conducts long-term radiation monitoring, publishing results in map and file formats such as CSV and KML, which can be read by spreadsheet and digital mapping software.[230] This section will explore the relationship between data application in mapping software and specific measurement methods, and we will use Google Earth to demonstrate how monitoring data can be visualised on a digital map. This widely-used mapping software allows users without programming backgrounds to easily map data, highlighting how Internet users in the general public can combine multiple datasets.[231] The JAEA also conducts a monitoring survey for the Fukushima Prefecture to monitor radiation levels in residential areas, and along roads and other transportation networks.[232] To consider the relation between radiation monitoring in city infrastructure, measurement methods, and mapping, this section observes the JAEA monitoring results from 2022, which were published on the Fukushima Prefecture website. The datasets from both

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[228] Environmental Radioactivity and Radiation in Japan, 'Site Policy', accessed: 23 November 2023, https://www.kankyo-hoshano.go.jp/en/sitepolicy-en/.

[229] Japan Atomic Energy Agency, accessed: 23 November 2023, https://www.jaea.go.jp/english/.

[230] Japan Atomic Energy Agency, 'Database for Radioactive Substance Monitoring Data', accessed: 20 March 2021, https://emdb.jaea.go.jp/emdb_old/en/.
This thesis uses their data in KML format that can be read by a digital mapping tool. See the footnote on the page 246 for the detail of this format.

[231] J. D. Hamerlink, 'Naive (commonsense) Geography and Geobrowser Usability after Ten Years of Google Earth', *IOP Conference Series. Earth and Environmental Science* 34, no. 1 (2016), http://dx.doi.org/10.1088/1755-1315/34/1/012013.

[232] Fukushima Prefecture, 'Radiation Monitoring Room (放射線監視室)', accessed: 11 November 2023, https://www.pref.fukushima.lg.jp/sec/16025d/.

the JAEA and the Fukushima Prefecture are permitted for use with a reference to their source.[233]

2.8 Conclusion

In conclusion, this chapter has shown how this thesis understands the digital infrastructure in terms of data, information, and the aggregation of contents in relation to users. Based on these points, this thesis also shows how the technological perspective towards the radioactive contamination is situated in post-Fukushima Japan. To repeat the main points, data are collected from metastable agencies such as humans and radiation. These data are organised through the logic of necessity, which reflects the aesthetics of data visualisation into information. This informational process is conducted through the relations at different degrees and layers. As can be seen in the example of contemporary digital archives, multimedia contents form their associations without a centrality, and those relations extend to contain human users. The interaction between the user and the contents is bidirectional and related to humans' psychological individuation and the technical individualisation of humans and technical and digital objects. This informational process of relations traverses different milieux of digital and associated milieux. Via Haraway and Viveiros de Castro, it also considered a technological perspective to monitor radiation as compounding eyes consisting of humans, natural environments, and machines that generate reality through their own perspectives. In the end, to critically observe the interface culture, the notion of the meta interface to see how the database itself can sense an external event was introduced. Based on these

[233] Japan Atomic Energy Agency, 'Terms of Use', accessed: 23 November 2023, https://emdb.jaea.go.jp/emdb_old/en/site_notes.html; Fukushima Prefecture, 'About Copyright (著作権について)', accessed: 23 November 2023, https://www.pref.fukushima.lg.jp/sec/01010d/koho-chosakuken.html.

understandings of data, information, and its aesthetical expression, this thesis will look at cases of radiation monitoring.

Chapter 3

Political, Social, and Cultural Ecologies in Post-Fukushima: The Analysis on Anti-Nuclear Movement, the Radiation Monitoring, and its Relations concerning the Subjectivity and Objectivity

3.1 Introduction

The previous chapters have shown the theoretical framework of this thesis and how it focuses on technological and epistemological aspects of contamination monitoring. In Chapter 1, we analysed the debates related to monitoring the 3.11 disasters and nuclear culture. Citizen-led monitoring exemplifies the ways in which technoscientific practices are composed of social, technological, and environmental relations. The project was triggered by the anxiety of being exposed to the radiation fallout. The participating citizens created their own network of monitoring result sharing to counteract the dysfunction of the Japanese government during the emergency period in March of 2011. Subsequently, we also looked at how the 3.11 disaster can be viewed in a global and transnational context by focusing on the debates of the Anthropocene. Then, we observed how the small and partial entities are experiencing the event and creating the epistemological system to make sense of the ongoing disaster. Rather than categorising human beings as one entity, it is required to critically examine how differentiated entities within the divisions of human activity, such as the capital, government, and residents, are operating and associating with one another in specific environmental events such as the climate crisis and the Fukushima disaster.

Then, Chapter 2 showed how this thesis focuses on the media and technologies that have been used in the monitoring practices in post-Fukushima Japan. Monitoring data, which are empirically collected from natural environments using technological devices, are organised into a visual format in which the aesthetics reflect a certain logic of a necessity. In addition, that visual information has an aspect of the virtual that can generate reality. Next, we studied a database ontology and the association of different milieux to unearth a rhizomatic network that connects content and also users that individuate through the interactions among them. Then, by introducing the concepts of the compounding eyes and perspectivism, this thesis showed how perspectives towards radionuclides are constituted of machinic, human, and environmental agencies. Here, through the notion of the metainterface, we observed the significance of critiquing the hidden layer of the interface culture that also conditions the monitoring process.

Subsequently, based on these observations, this thesis will focus on the cases of disaster monitoring. This chapter will observe how citizens utilise the internet infrastructure to mobilise the public to a project and monitor the ongoing contamination. The period around 2011 overlapped with the time when social media was widely introduced into society while the ubiquity of the internet was increasing. The individual use rate of the internet was 79.1% among the citizens of Japan in 2011, and it grew to 83.5% in 2016.[234] In 2011, social media users numbered about 42,890,000, which constituted 45% of the entire population.[235] The Internet infrastructure and its derived technologies, such as GIS technology and social media, have been widely utilised in social movements and monitoring practice in the post-Fukushima society. Hence, it is crucial to grasp what aspects of the new media and its media ecology have been shaping the perception of the disaster in relation to other social, cultural, and political transformations. To analyse the interaction between citizens and technology in post-Fukushima society, this thesis will particularly focus on how citizens were mobilised, what was

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[234] Ministry of Internal Affairs and Communication, 'Usage Situation of the Internet (インターネットの使用状況)', accessed: 26 February 2021, https://www.soumu.go.jp/johotsusintokei/whitepaper/ja/r01/html/nd232120.html.

[235] ICT Research & Consulting, 'Study on the Use of SNS and the Application of Advertisement in 2011 (２００１年度　ＳＮＳ利用動向・広告活用状況に関する調査) ', 27 November 2011, https://ictr.co.jp/report/20111127000028.html.

contested, and how those practices formed their agencies. Thus, first of all, we will turn to the example of the anti-nuclear movement that aptly reflects the media and political transitions during 2011 to grasp the sociopolitical characteristic of the assemblage of the new media and populace. Next, this chapter will turn to a citizen-led monitoring project called Collective Database of Citizen's Radioactivity Measuring Labs (CDCRML) to study how their technological practice regarding radiation monitoring has an epistemological significance in the post-Fukushima political ecology. Third, in order to describe the agency of those technologically mediated and assembled projects, we will consider how subjectivity has emerged machinically in those cases.

3.2 The Formation of Anti-Nuclear Movement: Social Media and Mobilisation

As discussed in Chapter 1, the Japanese nuclear industry has been the assemblage of technologies and political and capital interests, which were proliferating the use of nuclear power for the electric power generation and creating a political climate that stabilised pro-nuclear groups in the national and local administrations. This political climate was also propagated through the media power, which was conveying the 'mythology' of nuclear power, which advocated its safety and eco-friendly aspects via mainstream media of televisions and newspapers. However, the 3.11 disaster caused a 'turn' in the political ecologies linked with the Japanese nuclear industry and protest movements. On the 10th of April 2011, over 15,000 people gathered in the Koenji area in Tokyo for an anti-nuclear protest, which was the largest march to the date. [236] According to Mori and Inoya, before the anti-nuclear movement occurred in 2011, the scale of protests and social movements in Japan was smaller compared with the ones in the United States and European countries, and the movement agenda did not reflect

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[236] *Nikkan Berita*, 'On the 10th, Two Anti-Nuclear Demonstrations in Tokyo: 15,000 People, Mainly Young People, Participated in Koenji (10 日、都内でふたつの反原発デモ　高円寺では若者中心に 1 万 5000 人が参加)', 10 April 2011, http://www.nikkanberita.com/read.cgi?id=201104102327080.

the sociopolitical interest of the majority of the population.[237] However, after the disaster happened, the public concern with the accident and radioactive contamination increased. At the same time, the use of social media such as Twitter and Facebook was becoming common in Japanese society. As a result, these transitions in the sociopolitical condition and media environment were entangled with each other, and a majority of the public engaged with the anti-nuclear movement.[238]

The political and social conditions were also linked to social media characteristics, where the information of anti-nuclear protests was shared among protestors. For example, through its networking service, Facebook enabled interactive communication among registered users, and through the interactive communication on the news feed, certain groups could announce their activities to members and their friends.[239] After 2011, it has been reported that at several anti-nuclear protests meetings in Japan, there were participants who had never taken part in any demonstration and did not have acquaintances who took part in or were involved in the protest. Before attending their first meeting, they found a flyer on social media, which had been shared among their friends' posts on social media, leading them to participate in several protest marches.[240] In this way, viral communication driven by social media was distributed to a wide range of citizens, giving them an opportunity to take part in the protest meetings.

This user-based network establishing social media was also highly related to the effective incentive of the spontaneous mobilisation of the movement. Oguma maintains that the public's experience of the disaster and their fear of radioactive substances, which were distributed due to the nuclear disaster, drove the citizens to participate in the movement, and he continues

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[237] Yoshitaka Mori and Chika Inoya, 'Festive Anti-Nuclear Protest Becomes Ordinary and Dissipates'. *Nico Nico News*, 30 August 2012, http://news.nicovideo.jp/watch/nw355581.

[238]Mori and Inoya, 'Festive Anti-Nuclear Protest'.

[239] Dan Schultz, 'A DigiActive Introduction to Facebook Activism', *DigiActive*, accessed: 20 April 2020, http://www.viettan.org/IMG/pdf/digiactive_facebook_activism.pdf.

[240] *Labour Net*, 'Young People's Power Finally Explodes!: 15,000 People at the Anti-Nuclear Demonstration in Koenji (若者パワーがついに炸裂！～高円寺・反原発デモに 15000 人)', last modified: 12 April 2011, http://www.labornetjp.org/news/2011/0410shasin.

that these inducements were intrinsic and not related to external factors such as a certain ideology, which was a basis of the traditional protest movements.[241] Participants of these demonstrations expressed their personal feelings and a sense of their ordinary life on the street, and this fact also reveals how the inner motivations of individuals mattered in the movement.[242]

The images of the protests were then shared on digital media in various formats – pictures, videos, and audios. The images of the demonstrations on social media, which were uploaded by the protestors, were seen by other users who did not know the movement; as a result, the movement expanded explosively in a short period. As Castells explains, in the mobile media network, a comment or a video on social media can be powerful enough to evoke an emotion of certain people or societies, and even a message, which is exchanged among few people, can be broadcasted to a number of other receivers, so the wireless communication environment leads to a powerful autonomy.[243] This emotional operation through the media network is also related to the mobilisation on social media. On Facebook or Twitter, users can directly respond to content that is uploaded by other users, and this aspect can also stimulate users' feelings in various ways. Based on the media environment in post-Fukushima, Azuma points out that the features of sharing, such as Twitter's 'retweet' and Facebook's 'share', have a potential to appeal directly to users' emotions prior to their reason, and such dissemination of contents on social media via these features can traverse the boundaries between communities.[244] In the aftermath of the disaster, the anti-nuclear protests took place through

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[241] *Magazine 9*, 'Interview with Eiji Oguma: The Abandoning Nuclear Power Protest in front of the Prime Minister's Official Residence was a New Movement that Has Never Existed (小熊英二さんに聞いた:「脱原発」の首相官邸前抗議は これまでにない「新しい運動」だった)', 23 September 2015, http://www.magazine9.jp/article/konohito/22887/.

[242] Koichi Hasegawa, 'The Fukushima Nuclear Accident and Japan's Civil Society: Context, Reactions, and Policy Impacts', *International Sociology* 29, no. 4 (2014), 293.

[243] Manuel Castells, *Communication Power* (Oxford: Oxford University Press, 2009), 348.

[244] Hiroki Azuma, *General Will 2.0: Rousseau, Freud, Google* (Tokyo, Japan: Kawadeshobo Shinsha, 2015), 149.

the use of digital media, and the autonomy of the movement was formed beyond the pre-existing communities of citizens. At the beginning of the anti-nuclear protest, the Japanese mass media rarely covered the demonstrations; hence, it was also a period when the digital media formed a different degree and sense of mediation compared with the mainstream ones. [245]

Additionally, even though each country has different historical roots of nuclear policies, it is notable that the anti-nuclear movement globally expanded in the post-Fukushima political context. In contrast to the Japanese anti-nuclear movement that had been inactive until 2011, in Germany, for example, the anti-nuclear movement had already been energetic, and NGO groups with a large number of members had supported the movement since the 1970s. [246] In response to the accident in Fukushima in 2011, those groups organised a protest in which 260,000 people took part, and consequently, the German cabinet decided to stop all 17 nuclear power plants in the country by 2020.[247] Furthermore, in Taiwan, a group of scientists started the nascent anti-nuclear movement in 1985, and in response to the Chernobyl accident, it gained support. Then, in 1987, they formed the Taiwan Environmental Protection Union that had the support of the Democratic Progressive Party (DPP), the current ruling party, which had an anti-nuclear policy since it was united in 1986. Unlike Japan, the anti-nuclear policy has been discussed in mainstream politics in Taiwan. In 2011, the current opposition party, the Chinese Nationalist Party, was the ruling party, and in that political situation, the anti-nuclear movement was re-energised at the levels of the party politics and citizen activism in response to the Fukushima accident, which led to cancelling the construction of a nuclear

[245] Mori and Inoya, 'Festive Anti-Nuclear'.

[246] Mori and Inoya, 'Festive Anti-Nuclear'.

[247] Hasegawa, 'The Fukushima Nuclear Accident', 290.

power plant. Then, in 2016, DDP became the ruling party, and at the same time, Taiwan became the first country in East Asia that promised to abandon its nuclear power plants.[248]

During the citizen protests, each organiser was in touch with the others through communication on social media. Hajime Matsumoto, one of the organisers who planned the protest in Tokyo in April 2011, explains that he shared the information of the protest with some of the German protesters beforehand on social media.[249] In Japan, after the accident in Fukushima, the government stopped all the nuclear power plants in May 2012.[250] However, 9 of the 33 nuclear power plants began operating again in 2020.[251] As this comparison shows, the contexts of the anti-nuclear movements differ in Japan and Germany, and the situation around the protest has also been changing gradually. However, with the shared purpose of stopping nuclear power plants, those movements took place actively in a short time after the accident in Fukushima. According to Fenton, the expansion of the speed and space of technology has enabled greater national and international solidarity to form, and the transnational social movements are a combination of collective and individual responses.[252] As we have observed, the anti-nuclear movement has expanded in a short period through effective communication among people who had not attended any political protests before 2011. Given opportunities for a political meeting, these individuals' responses bore more

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[248] Ming-Sho Ho, 'Taiwan's Anti-Nuclear Movement: The Making of a Militant Citizen Movement', *Journal of Contemporary Asia* 48, no. 3 (2018): 445–464, https://doi.org/10.1080/00472336.2017.1421251.

[249] *Web Dice*, 'Interview with Hajime Matsumoto: The Organiser of the Anti-Nuclear Protest in Koenji (4/10 高円寺原発やめろデモ主催・素人の乱松本哉さん語る)', 10 April 2011, http://www.webdice.jp/dice/detail/3001/.

[250] Nikkei, 'All of the Nuclear Power Plants in Japan Have Stopped for the first time in the last 42 Years on the 5th. They will inspect the Kashiwa Unit 3 (国内原発 5 日に全て停止　42 年ぶり、泊 3 号機検査入り)', 4 May 2012, http://www.nikkei.com/article/DGXNASFS0400Z_U2A500C1MM8000/.

[251] Japan Atomic Industrial Forum, Inc, 'Current Status of Nuclear Power Plants in Japan', 6 October 2020, https://www.jaif.or.jp/cms_admin/wp-content/uploads/2020/10/jp-npps-operation20201006_en.pdf.

[252] Natalie Fenton, *Digital Political Radical* (Cambridge: Polity, 2016), 28.

witnesses that kept the movement growing at a greater scale. Hence, it can be estimated that the transnationality of the 2011 anti-nuclear movements is also an extension of this characteristic, which was intensified with the speed and space of social media networks.

In the debate of mobilisation, this characteristic of individual response that does not assume certain collective conditions such as a political belief and nationality has been discussed. For example, by analysing a student protest movement that transcended the university communities, Alain Touraine argues in *The Post-Industrial Society* that contemporary social movements are based not on a certain group such as class but on an individual's interest or their identity to protest against a system, which threatens their civil society. In this way, Touraine points out that a social movement becomes more ad hoc in the post-industrial society.[253] Though this argument itself is from the pre-internet period, similar points can be found in the other contemporary social mobilisation. According to Kavada, a comment on the page of Occupy Wall Street on Facebook emphasised that the system of capitalism is not working for the public and criticised the traditional social segmentation such as political party, races, gender, and religion, which disrupt the solution to the problem.[254] Additionally, taking advantage of accessibility and visibility to users on social media, the movement did not use words that imply the distinction between the inside and outside of the movement, such as 'we', and the term, 'the occupier', referring to the participants of the protest, was preferably used instead.[255] Likewise, in the Japanese anti-nuclear movement, the participants did not necessarily have a certain aim or goal but rather took part in the protest to express their feelings.[256] The organisers of the movement intended to prioritise such individuality to erase the boundary of the movement, and the flyers, which were distributed on

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[253] Alan Touraine, *The Post-Industrial Society Tomorrow's Social History: Classes Conflicts and Culture in the Programmed Society* (New York: Random House, 1971), 86–138.

[254] Anastasia Kavada, 'Creating the Collective: Social Media, the Occupy Movement and its Constitution as a Collective Actor', *Information, Communication & Society* 18, no. 8 (2015), 878, https://doi.org/10.1080/1369118X.2015.1043318.

[255] Kavada, 'Creating the Collective', 879.

[256] Hasegawa, 'The Fukushima Nuclear Accident', 293.

social media, referred not only to the anti-nuclear manifesto but also the other events in the meeting, such as music events, to maintain the diversity of the participants.[257] In this way, the protest movements reflect the features of the social movement, which was based on individuality rather than group interest.

To summarise, in the emergent and transitional period after the 3.11 disaster, the example of the anti-nuclear movement shows three characteristics of how the affordance of social media can affect the mobilisation of the populace. First, the effectiveness of the new media was combined with the ad hoc aspect of the contemporary mobilisation, and as a result, the protest grew up to a remarkable size while avoiding being centred on the traditional political ideology and maintaining the lived experience of the populace gained from their everyday life. Second, combining with similar political movements in other countries, the movement grew up on a transnational scale in a short time. Third, it shared the ad hoc aspect with contemporary socio-political movements, and this point was developed through the use of mobile media and social media platforms.

3.3 The Critiques of the Monitoring Method and the Low-Level Exposure: Ideology and Power-knowledge

The Japanese anti-nuclear movement that arose from the 3.11 disaster was developed through the digital infrastructure, in which activists and protesters shared their information on protest meetings and mobilised a large number of citizens to the movement. In parallel with this social phenomenon, different types of citizen-led radioactive contamination monitoring projects have been undertaken since 2011. In the previous section, we referred to an analysis on the formation of a civic radiation monitoring mapping project, which was initially formed on Twitter and gained a total of 5 million accesses in a short span of one week after the

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[257] *Web Dice*, ‘Interview with Hajime Matsumoto’.

accident.[258] Because of their mistrust in governmental information disclosure practices, a group of citizens shared their own contamination data that were collected independently from power companies and local governments. This project was initiated by the call for the submission of contamination data via Twitter, which was mapped on a digital map to share the results with the public. As is the case with the anti-nuclear movements, this monitoring project also had an ad hoc relationality; in other words, it mobilised citizens based on their shared issues rather than their ideology or their political belongings. Compared with the former, the uniqueness of the latter is that citizens were engaged in the process of knowledge-making regarding radioactive contamination. In this section, this thesis will critically examine how the citizen-led groups monitor the nuclear disaster. By focusing on their monitoring methodologies and their political contestations regarding the governmental monitoring policy and evacuation standards, it will be shown how groups of citizen-led monitoring projects present a technoscientific reality within the political ecology in post-Fukushima.

As the anti-nuclear movement after 2011 had the political demand of immediate decommissioning of nuclear power plants in Japan, citizen-led radiation monitoring projects involved larger epistemological dimensions than just collecting data on radioactive contamination and included action towards reviewing their understanding of the nuclear disaster based on their knowledge-making practice. The project of Collective Database of Citizen's Radioactivity Measuring Labs (CDCRML) started in 2012 through the cooperation of more than 29 citizen science groups in Japan, and Keio University's Public Technology Design Consortium also took part in the technological provision of their data curation. According to their profile, CDCRML is a 'network' of radiation monitoring laboratories, which are non-governmentally managed by citizen science groups and private enterprises in 17 prefectures in Japan. They take a form of a steering committee, and three representatives from different

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[258] Andres Blok *et al.*, 'Environmental Infrastructure of Emergency: The Formation of a Civic Radiation Monitoring Map during the Fukushima Disaster', in *Nuclear Disaster at Fukushima Daiichi Social, Political and Environmental Issues*, ed. Richard Hindmarsh (London: Routledge, 2013).

groups are on the top committee with their executive director, Kiyomi Oyama, an environmental activist.[259] Their main activity is monitoring the radioactive contamination that arose from the 3.11 disaster. The 29 groups collected data from their local area, which are curated on their website by utilising the data-visualisation on a digital map since 2012. Alongside the monitoring, in their project called the East Japan Becquerel Soil Monitoring Project, they analysed their collected data and predict the transition of the contamination in the future period from 2011 to 2111.[260]

As is the case with other citizen-led monitoring projects, one of the aims of the project is to share and visualise the radioactive contamination in Japan with precise data. CDCRML also criticises the government-led monitoring method, which adopts air measurements, as the types of dispersed radioactive particles, caesium 134 and caesium 137, tend to accumulate on the ground. Hence, although the radioactive isotopes can also move in the air under certain meteorological conditions, a soil measurement is the most effective method to precisely monitor the contamination level in an area. Hence, the participating groups in the project adopt soil measurement to show a more accurate figure of the contamination. Besides, in their project, they use the radiation unit of ‘becquerel (Bq)’ instead of ‘sievert (Sv)’, which is mainly adopted by the governmental air measurement method. ‘Sv’ is a unit indicating the amount of a person’s radiation exposure in a certain space and time. This unit is effective to immediately show one’s radioactive exposure dose amount. On the other hand, ‘Bq’ is used to calculate the intensity of radioactivity from radiated specimens such as soils and food. Compared with an air measurement, it takes a longer time to calculate the value of radioactivity, but its monitoring result is more consistent and less susceptible to meteorological conditions. Moreover, the ‘Sv’ amount from an air measurement tends to include radioactive isotopes that are from other radioactive sources, such as the Chernobyl case and nuclear weapons testing.

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[259] Collective Database of Citizen’s Radioactivity Measuring Labs, ‘About Us’.

[260]Collective Database of Citizen’s Radioactivity Measuring Labs, ‘The East Japan Becquerel Soil Monitoring Project’, accessed: 19.11.2020, https://minnanods.net/soil/.

In contrast, the 'Bq' can precisely detect the isotopes of caesium 137 from the Fukushima case.[261]

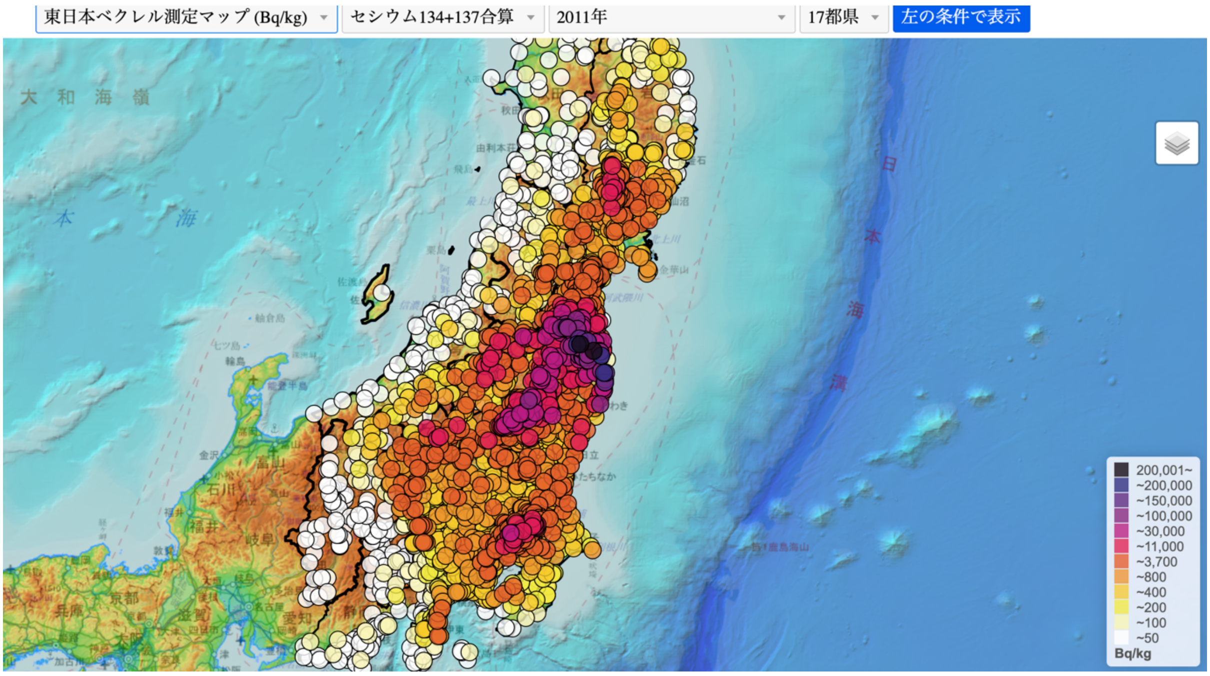

Figure 3.1: A screenshot of CDCRML.[262]

Subsequently, in addition to inventing their monitoring method, the protesting citizens also argue that the government of Japan needs to change their evacuation standard of the annual dosage of low-level radiation exposure.[263] This argument aptly reflects the political and scientific debates in post-Fukushima. According to research on the cancer risk of low-dose ionising radiation, 'the lowest dose value of ionizing radiation at which good evidence of

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[261] Collective Database of Citizen's Radioactivity Measuring Labs, *Radiation Monitoring Map and How to Read It (放射能測定マップ+読み解き集)* (Fukushima: Minna-no Data Site Publishing, 2020), 173.

[262] Collective Database of Citizen's Radioactivity Labs, 'Soil Map', accessed: 3 March 2023, https://minnanods.net/maps/?pref=prefs17&m2_kg=kg&time=2011&sum_137=sum.
In the above section, users can choose which type of radioactive isotopes, dates, and areas to visualise on the map.

[263] Collective Database of Citizen's Radioactivity Labs, *Citizens' Radiation Data Map of Japan: Digest Edition* (Fukushima: Minna-no Data Site Publishing, 2019), 1.

increased cancer risks in human exists is 10–50 mSv for an acute exposure and 50–100 mSv for prolonged exposure'. [264] Human bodies are exposed to a certain amount of radiation in everyday life. For example, the inner exposure dose from smoking is 0.01 mSv per year, and the external exposure during a flight between Tokyo and New York is 7.40 μSv per hour.[265] According to International Commission on Radiological Protection (ICRP), within the annual dosage of 1 to 20 mSv, an "individual will usually receive direct benefit from the exposure situation but not necessarily from the exposure itself". This amount is a constraint set for occupational exposure in planned situations, whereas the limit set for public exposure in planned situations is 0-1 mSv, and for evacuation in a radiological emergency is 20-100 mSv.[266] On the 21st of March, ICRP announced some advice for the government of Japan based on their protection guidelines that were published in 2007.[267] As mentioned above, this advice recommends the national authority to follow the annual dosage of 1 to 20 mSv for the public and to reduce reference levels to 1 mSv per year, and subsequently, the government followed the maximum dosage of 20mSv per year as the evacuation standard. There have been disputes regarding this decision, especially considering the exposure of children. For example, the standard for the use of schoolyards was reviewed and changed to 3.8 μSv per hour, but the public standard of 20 mSv per year is still adopted. According to CDCRML's manifesto, the governmental evacuation standard of the annual radiation dosage was 1 mSv/year before the 3.11 disaster, but this rate was raised to 20 mSv/year after the accident.

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[264] Yasser F. Ali *et al.*, 'Cancer Risk of Low Dose ionizing Radiation', *Frontiers in Physics* vol. 8 (2020), 1.

[265] Ministry of Environment, 'The amount of natural and artificial radiation exposure dosage (自然・人工放射線からの被ば゛く線量)', last modified: 31 May 2015, https://www.env.go.jp/chemi/rhm/kisoshiryo/attach/201510mat1s-01-6.pdf.

[266] International Commission on Radical Protection, 'Recommendations of the International Commission on Radiological Protection', 5 June 2006, https://www.icrp.org/docs/ICRP_Recs_02_276_06_web_cons_5_June.pdf, p.61.

[267] International Commission on Radical Protection, 'Fukushima Nuclear Power Plant Accident, 21 March 2011, https://www.icrp.org/docs/Fukushima%20Nuclear%20Power%20Plant%20Accident.pdf.

[268] Regarding this standard, the government has only explained that the dosage of 20 mSv/year does not immediately affect the health of citizens, but they have never affirmed that this annual dosage is completely safe.[269]

In the case of the Chernobyl disaster, the dissemination of caesium 137, which is also a large proportion of radioactive isotopes in the Fukushima case, has been affecting the health condition of the residents around the area. Moreover, the Chernobyl legislation guarantees relocation and recuperation rights to residents from areas where the exposure dose was estimated to be above 1 mSv/ year. By focusing on this point, CDCRML argues that the authorities should abolish the 20 mSv standard repatriation policy and return to the pre-accident public annual dosage, which is the same as the one of Chernobyl.[270] As of 2011, the evacuation area was about 1150 km^2, which covered 11 cities in the Fukushima Prefecture. Of the several types of radioactive isotopes that have exuded after the accidents, the half-life of caesium 134 is about 2 years, and that of iodine 131 is 8 days. Therefore, in the period from 2011 to 2019, the monitored amount of the radioactive isotopes reduced by 78% in the initial evacuation area, and the evacuation area has also shrunk down to 337 km^2, which extended over the towns of Konoe, Ookuma, and Futaba, where the Daiichi NPP is located.[271] In this way, the evacuation criterion of the annual dosage of 20 mSv impacts the citizens' everyday life.

Moreover, regarding the epidemiological observation of low-dosage radiation exposure in a nuclear accident, there is an ongoing debate to show scientifically how a certain amount of low-dosage of radiation exposure can affect the incidence rate of related diseases. As Hiromichi Ugaya argues, based on his fieldwork on the Three Mile Island (TMI) accident in

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[268] *Asahi Shimbun*, 'Abolishing '20 mSv' for the schoolyard standards (校庭利用の基準「２０ミリシーベルト」撤廃へ)', 25 August 2011, http://www.asahi.com/special/10005/TKY201108240683.html.

[269] Citizens' Radiation Data Map of Japan, *Citizens' Radiation Data*, 1.

[270] Citizens' Radiation Data Map of Japan, *Citizens' Radiation Data*, 1.

[271] NHK, '9 years after the nuclear power plant accident: How much has the return of the residents progressed?', 11 March 2020, https://www3.nhk.or.jp/news/html/20200311/k10012320891000.html.

1979, the number of samples that show the relationship between the dosage and the rate of related disease development is still low.[272] As 20-year-long follow-up research of the residents of TMI shows, it is impossible to deny the relation between the low-level exposure and certain illnesses such as lymphatic, hematopoietic tissue, and breast cancers. This is because the time interval between radioactive exposure and the onset of such illnesses can vary depending on an individual's characteristics, so it requires a long follow-up survey.[273] The University of Pittsburgh is one of the institutions that have been conducting a survey on the TMI accident, and in 2014, Ugaya's interviewee from the laboratory maintained that it would require ten more years to show a result on the causal relationship between low-dosage exposure and its health hazards.[274]

Based on these points, how can we define the epistemological significance of CDCRML regarding monitoring the disaster? Referring to Foucault's concept of power-knowledge and Althusser's theory of ideology, Sato and Taguchi analyse how sovereign power has operated through scientific knowledge dissemination regarding low-dose radiation exposure and the evacuation standard. To criticise the security power, which is operating on the scientific reality, Sato and Taguchi introduce Michel Foucault's concept of power-knowledge. According to Foucault, as per traditional beliefs, knowledge and power exist independently from each other, and the former can develop only where the power relations are suspended. Against this viewpoint, he argues 'power produces knowledge' and 'there is no power relation without the correlative constitution of a field of knowledge'. Then, Foucault continues as follows:

> These 'power-knowledge relations' are to be analysed, therefore, not on the basis of a subject of knowledge who is or is not free in relation to the power

[272] Hiromichi Ugaya, *Fukushima 2046* (Tokyo: Business-Sha, 2015), 83–90.

[273] Evelyn O. Talbott *et al*., 'Long-Term Follow-Up of the Residents of the Three Mile Island Accident Area: 1979- 1998', *Environmental Health Perspectives* 111, no. 3 (March 2003): 341–348, https://doi.org/10.1289/ehp.5662.

[274] Ugaya, *Fukushima 2046*, 83.

> system, but on the contrary, the subject who knows, the objects to be known and the modalities of knowledge must be regarded as so many effects of these fundamental implications of power-knowledge and their historical transformations. In short, it is not the activity of the subject of knowledge that produces a corpus of knowledge, useful or resistant to power, but power-knowledge, the processes and struggles that traverse it and of which it is made up, that determines the forms and possible domains of knowledge.[275]

Power and a knowledge system are correlative with each other, and this relationship also intervenes and forms the perception of individual subjects. Based on this point, Sato and Taguchi argue that the designation of the threshold of low-level radiation exposure affects subjects and forms the framework of their perception.[276]

For instance, they argue that the concept of 'threshold' has been applied to the standard of low-level exposure. The term 'threshold' means 'the minimum value of a parameter or variable that will produce a specified effect'.[277] In the case of the Fukushima disaster, the threshold of the annual dosage is the low-level exposure up to 20 mSv/ year, which is estimated to avoid an immediate effect on the health of the human body. However, as we observed above, this number is only an estimation, and the theoretical position of Linear Non-Threshold (LNT), which supposes the effect of low-level exposure without the concept of threshold, has also been taken up by groups of scientists who have been against the application of threshold.[278] LNT is primarily employed to assess the relationship between the

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[275] Michel Foucault, *Discipline and Punish: The Birth of the Prison* (New York: Vintage Books, 1995), 27–28.

[276] Yoshiyuki Sato and Takumi Taguchi, *Philosophy of Abandoning Nuclear Power Plant (脱原発の哲学)* (Kyoto: Jinbunshoin, 2016), 95-96.

[277] John Daintith, *A Dictionary of Science,* 5th ed. (Oxford University Press, 2005), 817.

[278] Central Research Institute of Electric Power Industry, 'About LNT Hypothesis', Central Research Institute of Electric Power Industry, accessed: 21 February 2020, http://xn--criepi-vz8im291b.denken.or.jp/jp/rsc/study/topics/lnt.html.

exposure to toxic substances and the carcinogenic effect of specific agents, and it was originally established to show that the x-rays exposure caused genetic mutations in 1927.[279] As its name shows, LNT is a scientific method to show the relationship between exposure doses and a disease rate without a threshold cut point that ignores a certain dose amount as non-significant causes. By introducing the threshold criterion into the evacuation policy, the government can reduce the number of evacuees and the cost of the evacuation support. Hence, Sato and Taguchi argue that the concept of threshold is not a scientific concept but an economic-social one.[280]

To situate this argument according to Foucault's concept in the context of the 3.11 disaster, Sato and Taguchi also refer to Althusser's theory of ideology. According to Althusser, an individual subject's way of living reflects a certain form of ideology. So, the relations of individual subjects in everyday occasions, such as the labour of production, exploitation, and scientific practice, reflect an ideology of a state and reproduce the ideological system. Thus, in this mechanism, the state and capital call on individual subjects to misrecognise and ignore a reality that reproduces their ideological relationships. Hence, Althusser defines the following: 'ideology=misrecognition/ignorance'.[281] Based on Althusser, Sato and Taguchi argue that to sustain and develop the system of the nuclear industry that was constituted for economic and military purposes, the state of Japan and the capital call on subjects to constitute their knowledge system by following the system of ideological misrecognition/ignorance, which is, in the context of the 2011 disaster, the belief that nuclear power plants are safe and they will have little effect on the health of citizens.[282] Here, the threshold of 20 mSv/year also can be thought of as the reflection of the ideology of the nuclear industry. For example, based on the

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[279] A. Alan Moghissi *et al.*, 'Linear Non-Threshold: Separating Facts from Fiction', *Dose-Response*, vol.10 (2012): 297–305, https://doi.org/10.2203/dose-response.11-019.Moghissi.

[280] Sato and Taguchi, *Philosophy of Abandoning*, 111.

[281] Louis Althusser, *On the Reproduction of Capitalism: Ideology and Ideological State Apparatus* (London: Verso, 2014), 268-270.

[282] Sato and Taguchi, *Philosophy of Abandoning,* 93–94.

research on the radiation exposure in Hiroshima and Nagasaki, John Gofman, a nuclear physicist, observes the cases of low-level exposure and cancer deaths in Hiroshima and Nagasaki by introducing an LNT model to prove that a proportional relationship may be realised in these two actors from the low exposure of 2.5 mSv. Based on this analysis, Gofman argues that the concept of 'threshold' only reflects the wish of pro-nuclear scientists who believe in the absolute safety of low-level exposure.[283] Following Isabelle Stengers, the introduction of a LNT can be seen as 'the power of fiction' that invents '"rational arguments" to bend the facts, to create illusions of necessity, and to produce an apparent submission of the world to its definitions "elaborated in the abstract"'.[284] Based on the abstraction of a threshold, the evacuation standard is rendered as a rational argument, and it creates a 'safety' that reflects a pro-nuclear stance. In this way, the mechanism of ideology=misrecognition/ignorance operates through the safety standard of 20 mSv to create an ideological recognition of the reality that ignores the relation between the lower dosage than the standard and the risk of cancer death.

Both arguments of ideology and power-knowledge are applicable to the practice of CDCRML. First, the power-knowledge regarding low-level dosage regulates not only the residential areas around the nuclear power plants but also their perception of the technoscientific reality based on the criteria of 'safety' created through the criterion of 20 mSv/year. As Foucault points out, power-knowledge historically transforms and determines the forms of knowledge and its subjects. The evacuation standard after the 3.11 disaster was determined based on the economic-social ideology of the state's pro-nuclear position, and this aspect has been historically developed around the politics of nuclear power plants since the pre-disaster period. As Hiroshi Kainuma argues, the historical establishment of the Daiichi NPP reflects the power relation among the central and local governments and the 'nuclear

[283] John W. Gofman, *Radiation and Human Health* (Sierra Club Books, 1981), 385–388.
[284] Isabelle Stengers, *The Invention of Modern Science* (Minneapolis: University of Minnesota Press, 2000), 79.

village', a term that refers to a pro-nuclear power group of the industry, government, and scientists in Japan. In the process of the construction of the power plants, the local government of the Fukushima Prefecture played its role as a mediator that had the right to adjudicate the decision-making process between the central government and the nuclear village. However, due to the Liberal Democratic Party, a ruling political party that drove the privatisation policy and energy liberalisation in the '90s, the prefectural governor of those days, who opposed the pro-nuclear policy, lost his support base. As a result, the power of the local government as a mediator declined, and they were subjugated to the nuclear village's addictive system that produced employment and revenue in the local area.[285] This subjugation of the local government to the central determination can also be found in the adoption of the evacuation standard of 20 mSv/year. In this sense, even though the case of the protection standard is not directly related to the issue of the nuclear village, it still retains the historical process of power-knowledge relation of nuclear power in Japan.

The practice of CDCRML is operating against the governmental power-knowledge system that enforces an ideological evacuation standard, and in their project, the economic-political ideology is not reflected. Against the criterion that was determined based on the economic and political ideology through the hierarchical relation between the central and local governments, the knowledge-making process of CDCRML is directly linked with and established through the life of local citizens over the land of Japan. Moreover, their practice can be seen as a separation from the historical process of the power-knowledge, which imposes a certain ideological perspective on citizens. As the anti-nuclear movement not only requires the immediate decommissions of nuclear power plants in Japan but also rejects the reproduction of ideological relationships in the nuclear industry, civic monitoring projects are inventing their own method and ask for a new safety standard.

For example, as introduced in the above section, CDCRML has adopted soil measurement to achieve more accurate and stable monitoring results. In addition to their contestation

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[285] Kainuma, *'Fukushima' Theory*, 162–172.

against the low-level standard, this practice also shows how their process of knowledge-making is different from the governmental one. As of 2019, the government had established about 3000 air measurement monitoring posts in the Fukushima Prefecture, and the live monitoring results are published and archived on the website of the Nuclear Regulation Authority.[286] However, as Sternsdorff-Cisterna describes the everyday life of citizens in the Fukushima Prefecture, non-authoritative knowledge regarding radioactive contamination has been shared among activists and citizens independently. For example, in addition to the uncertainty of air measurements, those citizens have acknowledged that the decontamination operation was conducted mainly around public monitoring posts, so the monitoring result in an area does not necessarily cover the whole of the relevant area. Therefore, those downsides of the government-led monitoring also resulted in the establishment of civic monitoring groups.[287] CDCRML consists of a network of citizen groups, most of which are based in local citizen science communities, which monitor not only land soils but also everyday products such as food and clothes. Hence, their knowledge-making process emerged from affected regions rather than from the central and hierarchical process. According to Sabu Kohso, new horizons of post-Fukushima are traversing 'inhabitant's movement defending living environments, migrant or fluid underclass workers struggle, mutual aid community building, and theoretical and cultural production tackling infrastructural power. These are interconnected either actually or virtually, and together prefigure the association and friction – the complexities – of post-Fukushima'. [288] As is the case with CDCRML, the civic radiation monitoring projects have been emerging as a struggle for living environments through the network of local citizens, who are subjugated to the central government. These entities are interconnected through the digital infrastructure and actualising into a new technoscientific reality in post-Fukushima as the data visualisation of the contamination and its sensing

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[286] Nuclear Regulation Authority, 'Monitoring information'.

[287] Sternsdorff-Cisterna, *Food Safety*, 75–97.

[288] Sabu Kohso, *Radiation and Revolution* (Durham: Duke University Press, 2020), 130.

methodology. In this way, the monitoring practice of CDCRML presents a novel way of understanding the nuclear disaster, which is critically separate from but questioning the governmental scientific and political approach towards contamination.

To sum up, in this section, through the analysis of CDCRML, we observed the epistemological significance of civic monitoring projects in the post 3.11 political ecology. As the digital infrastructure enabled activists and protesters to enlarge the anti-nuclear movement, there has been a surge in the number of civic monitoring groups since 2011. With its characteristics of ad hoc and fluid relations centred on the everyday life of citizens, CDCRML has been creating its own knowledge system that is at odds with the authoritative safety standard that reflects the ideology of the economic-political pro-nuclear position. Based on this analysis of the monitoring practice, we will focus on the relations among entities regarding the act of sensing and prefiguring the radioactive contamination.

3.4 The Subjectivity of Radiation Monitoring and the Objectivity of Radiation

In the previous sections, we have looked at how two different types of social movements have emerged. First, the anti-nuclear movement became transnationally energetic in 2011, and its formation through social media shows an ad hoc relationality that does not necessarily require a certain political collective ideology. This aspect was reflected in the participation of citizens who did not belong to a particular political group, and the mobilisation of the anti-nuclear movement was facilitated through effective communication on social media. Subsequently, through the citizen-led radiation monitoring project of CDCRML, we have observed how the historically developed power-knowledge system of nuclear governance has adopted the low-level radiation exposure standard based on a pro-nuclear cost-benefit ideology rather than prioritising the life of the residents around the nuclear power plants. Then, we turned to the ways in which CDCRML contests the governmental evacuation policy and its monitoring method. Contrary to the governmental policy in which local groups are subjugated to the central decision-making, CDCRML produces their knowledge on contamination from the lived experience of their constituent citizens who share their monitoring results and visualise it through the infrastructure of the internet. In this sense, even though both examples are operating in different political and epistemological dimensions, these technologically-mediated practices share a characteristic, which is that they are partial entities – in this sense, citizens – creating relations that lead to a movement and a knowledge system without or rejecting a certain ideology of a scientific reality regarding the governmental nuclear policy. This thesis will focus on the cases of radiation monitoring, but it is notable that these different phenomena emerged during the same post-Fukushima period when the technological infrastructure enabled the formation of the socio-political network of citizens' and non-governmental monitoring projects.

Subsequently, the final section of this chapter will look at the subjectivity and objectivity of the agencies of radiation monitoring. In the previous section, following Althusser's argument that an individual subject is constructed through a certain ideology, we confirmed how the low-level exposure reflects the pro-nuclear ideology. Moreover, through Foucault's notion of power-knowledge, we also observed the historically developed power-knowledge system of the nuclear industry and policy in Japan, and this thesis argued that the practice of CDCRML is detached from the system and presented its own knowledge system. It can thus be argued that the subject of the CDCRML rejects the power-knowledge system of the central governance and the nuclear industry or 'village' in Kainuma's sense by collecting and organising data into a visual format on the digital map that shows the figures of the contamination. This emergence of a new subject of monitoring the contamination is not separated from the digital infrastructure as the constituents of the practices are connected through the network of the Internet of Things and creating knowledge through technological devices such as a dosemeter and digital map. Hence, this section will focus on how these relations form the subjectivity of contamination monitoring.

Moreover, this section will also focus on how radiation can be ontologically rethought in relation to monitoring projects. The radionuclides released from the Fukushima Daiichi Power Plant have been widespread in the natural environment, and it has also been involved with legal issues. In the August of 2011, a golf course company in Fukushima, which is located 45 km away from the Daiichi NPP, sued Tokyo Electric Power Company (TEPCO) for its responsibility for the spread of the contaminating radiation. In those days, the contamination rate at the golf course was averagely 2-3 μSv/h, which forced the company to close its business; therefore, TEPCO was asked to conduct a decontamination operation at its own cost. However, TEPCO denied the accusation, arguing that the radionuclides unleashed from the Fukushima nuclear power plants did not belong to their power company and those were '無主物 (mushubutsu)' that means 'ownerless things'.[289] Regarding land property, Article 239 of the Civil Code of Japan defines ownerless things as property that has no owner, so, no one can claim the ownership of the property.[290] In several journalist articles, masterless things are also interpreted as 'objects' such as water, air, and resources from international waters that are not owned by a person.[291] TEPCO argued that even the highly technological objects of the distributed radionuclides that can only come into being in the process of nuclear fissions should be treated as same as water and air. Furthermore, TEPCO's trial document continues to maintain that 'even if it is able to conceive the ownership of the radioactive substances, those must have already been inseparable with the land of the golf course. In other words, it means that the debtor (TEPCO) does not own the radioactive substances. Two months later,

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[289] Asahi Simbun Special News Department, *The Trap of Prometheus (プロメテウスの罠)* (Tokyo: Gakken Publishing , 2012), 1405–1423, Kindle Edition.

[290] Ministry of Justice, Japan, 'Civil Code (Part I, Part II, and Part III)', *Japanese Law Translation Database System*, accessed: 20 March 2021, https://www.japaneselawtranslation.go.jp/en/laws/view/3494/en.

[291] The Tokyo Shimbun, '10 years of Fukushima: Drawing the Invisible Radiation (7) Black Bags Belongs to No One (＜ふくしまの１０年・見えない放射能を描く＞（７）誰の物でもない黒い袋)', 8 July 2020, https://www.tokyo-np.co.jp/article/40945; Hiroyuki Matsuda, 'Environmental Attention is the Shortcut to the Exploration of Undersea Resources: Developing Counties and Environmental Groups' Concern on the Influence on the Biodiversity (海底資源開発への近道は環境配慮: 生物多様性への影響をめぐる途上国と環境団体の思惑)', *Ronza*, 31 August 2016, https://webronza.asahi.com/science/articles/2016083000001.html?iref=pc_ss_date_article.

the court repelled the accusation from the golf course, and TEPCO did not take responsibility for the decontamination of the radionuclides unleashed from their nuclear power plant.[292]

Taking this case into consideration, Sabu Kohso translates “無主物（mushubutsu）as ‘masterless objects’ to emphasise its relation to its conceptual subject of ownership.[293] According to Kohso, the concept of masterless object ‘reveals to us the ontological horizon of the antiworld from which many worlds can be created’.[294] This is because the discourse that led to the masterless object shows the relation of responsibility and production does not get a lawful validity in post-nuclear disasters. Hence, in the ontological horizon of post-Fukushima Japan, according to Kohso, it is required to consider a new way that unleashed radiation is renowned and remastered by the power company. To do so, Kohso suggests that the struggle of living in the contaminated commons is a key factor to fight the power of the pro-nuclear governance.[295] Based on this point, the citizen-led radiation monitoring project in this thesis can be seen as a practice of how to rethink radiation separately from the discourse of governance. In the legal sense, the dissipated radionuclides as masterless objects are ontologically no less than common objects of water and soils, but on the other hand, radiation monitoring projects have been visualising how radionuclides exist within the natural environment. In the latter, rather than treating radionuclides the same as the air by focusing on their inseparability, they emphasise how those artificial substances coexist in relation to the natural environment. In this sense, the ontologies of radiation are multiple in relation to how, where, and what scale it is situated in. As we observed in the example CDCRML, the united citizens invented their soil measurement methods and contested the governmental low-level exposure standard to show their own technoscientific reality for the safety of citizens. Throughout the practice, the groups of citizens are creating their relations with disseminated

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[292] Asahi Simbun Special News Department, *The Trap*, 1405-23.

[293] Kohso, *Radiation and Revolution*, 104.

[294] Kohso, *Radiation and Revolution*, 112.

[295] Kohso, *Radiation and Revolution*, 111.

radiation in their everyday life and revealing the potential misconduct of the governance by relativising their prepared reality. In this sense, the radiation operates not only as the object of the monitoring but also as a tool or opportunity to make a critique against the pro-nuclear power. From here, the thesis does not aim to seek a specific way of remastering radiation, but it will be observed how citizen-led radiation monitoring and radionuclides form their relations in the ontological horizon of the post-Fukushima society.

This section will delineate how these subjects or the subjectivity of monitoring radiation forms to ontologically clarify how citizens, technology, and environments interact in relation to the disseminated radiation. In addition to the subject of monitoring, it is also noteworthy how radiation is the object of the monitoring practice. The radioactive isotopes were under the control of the nuclear industry, but now, they are widely distributed in natural environments and involved in social and political occasions in Japan. Citizens build their relations with radiation in personal ways, such as monitoring, living with, knowing, and decontaminating it; therefore, it is also crucial to note how the objectivity of radiation can change in relation to citizens' involvement. To observe this, first, relying on Felix Guattari's notions of machinism, we will delineate how the subjectivity of monitoring radiation emerges from the relations of citizens, technology, and environments. Next, based on the relational ontology, this thesis will focus on the relations of contamination monitoring, which forms the objectivity of radiation.

First, we will review how we can consider the subjectivity of the contamination monitoring. In post-Fukushima Japan, the objectivity of radiation transforms depending on where it is politically, geographically, and culturally situated. Then, CDCRML created their soil measurement method by focusing on the characteristic of the radioactive isotopes of caesium 137 and 134, which tends to accumulate in the soil. Then, the members of local participating groups collected data from the soil, and the aggregation of data was visualised on digital maps. In this process of monitoring, from collecting data to the mapping visualisation, the agencies of citizens are interacting with technological devices, such as dosemeters and mapping software, and natural environments in their residential area. In this sense, the agencies of radiation monitoring are not only limited to human agencies, but technological and environmental entities also form the relational subject that monitors radiation.

Here, we will consider Félix Guattari's notion of machinism to observe the process of the formation of the subjectivity that expands among humans, technology, and environments. Guattari argues that humans and nature must not be separated to transversally consider the interaction of the ecosystem, mechanosphere, and the social. The subjects that are observed in these interactions are in the process of becoming.[296] This viewpoint allows us to observe the subject of monitoring traversing different divisions of the social, technological, and environmental, and as CDCRML's practice develops from environmental monitoring to data visualisation, their subjects are becoming or changing a dimension where they operate from the environment to the cyberspace of the internet.

Moreover, according to Guattari, the subjects traversing several categories are in 'machinic ecology', and he opposes machines to mechanics. According to him, the latter is relative-enclosed and 'has perfectly coded relations with exterior flows.[297] Machines, considered in their historical evolution, constitute, on the contrary, a phylum comparable to those of living species'.[298] In other words, mechanics has its own closed system that can relate to its outside through a certain protocol, but machines are constituted of more processual relations with exterior others to form an assemblage that can be seen as an equivalent of an individual. According to Melitopoulos and Lazzarato, 'the concept of a machine (and later of assemblage) […] is not a subgroup of technique. The machine is, on the contrary, a prerequisite of technique. In Guattari's "cosmology" there are all sorts of machines: social machines, technological, aesthetics, biological, crystalline, etc'.[299] Hence, Guattari's machinism refers to a processual assemblage that forms in differential registers, and these machines are connecting with one

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[296] Félix Guattari, *The Three Ecologies* (London: Bloomsbury, 2014), 28–29.

[297] Guattari, *The Three Ecologies*, 45.

[298] Guattari *The Three Ecologies*, 289.

[299] Maurizio Lazzarato and Angela Melitopoulos, 'Machinic Animism', *Deleuze Studies* 6, no.2 (2012), 243, http://www.jstor.org/stable/45331505.

another and becoming further different machines. In the case of CDCRML, this notion of machinism also corresponds to the connection among the social machines of citizen groups and the technological machines constituted of devices. Their monitoring methodology emerged as a contestation against the governmental air measurement; their technique is invented based on their political position and actualised through the environmental and technological machines of dosemeter, GIS technology, and citizen cooperation.

Therefore, the notion of machinism enables us to understand that the subject of radiation monitoring emerges through the connection and becoming of different sorts of machines operating in different registers. In the process of assembling machines, subjectivity emerges in the relations among individual entities and the combination of machines. As the internet infrastructure mobilised a large population into the anti-nuclear movement, it is also notable to observe the connection of the social and technological machines operating affectively and politically in post-Fukushima Japan.

Next, we will consider the ontology of radiation and how the relations of radiation monitoring include it in post-Fukushima Japan. Through Guattari's notion of machinism, we confirmed that the radiation monitoring practice of CDCRML is constituted of different machines, and its subjectivity is formed in the relations among entities of an individual and a combination of machines, such as the social and the technological. Therefore, how can we grasp the objectivity of radiation in light of the relational ontology, which is underlying machinic subjectivity? To tackle this question, we will again turn to Michel Serres's theory of quasi-object. In Chapter 1, we discussed the concept in relation to Latourian Actor–Network Theory (ANT), and subsequently, we confirmed their difference in terms of how they observe the actants in a relation. Both ANT and quasi-object avoid the binary structure of nature/culture and subject/object by treating human and non-human entities equally, and they observe how relations are formed among those agencies. In ANT, actants form an association with other actants, and the quality of each actant emerges from this network of association. However, while ANT focuses on this relationality of actants and the fluidity of relation, the role of the actant does not change in relation.[300] Meanwhile, in the theory of the quasi-object, even though the same agencies are in the same relation, their role and quality can dynamically change. According to Serres, in the relation of quasi-objects, '[a] quasi-object is not an object, but it is one nevertheless, since it is not a subject, since it is in the world; it is also a quasi-subject since it marks or designates a subject who, without it, would not be a subject'.[301] By taking an example of football, Serres delineates how the subjective and objective quality of the agencies of players and a ball constantly changes. A ball is not able to move by itself, so it needs to be kicked by a player. In that sense, a ball is an object, and the player is a subject who manipulates the ball. However, the ball also controls the movement of the players, and their formation depends on the position of the ball. Then, the ball is also a subject that affects the movement of the players. The subjectivity and objectivity of the ball and players switch in relation to the match. Hence, both of them become quasi-objects or quasi-subjects.[302] In this way, the theory of the quasi-object shows a dynamic fluidity of a subject–object quality of the agencies in their relation.

The theory of the quasi-object provides us with a way of understanding the ontology of radiation, which involves society on several different occasions. Then, what is important here is that the theoretical view allows us to understand the becoming of radiation as a quasi-object in the relations formed in post-Fukushima Japan. For example, in the case of masterless objects, it is possible to think that distributed radionuclides are inseparable from natural objects, so it does not belong to any ownership. However, at the same time, as long as those were produced under the system of power generation, the relation of producer–product is also still applicable. In the same way, radiation also becomes the object of monitoring. In this sense, the quasi-quality of radiation changes in relation to its involved agencies. Thus, it can be

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[300] Takashi Shimizu, *Michel Serres: From Methesis Universalis to Actor-Network (ミシェル・セール：普遍学からアクター・ネットワークまで)* (Tokyo: Hakusui-Sha, 2013), 127-128.

[301] Michel Serres, *The Parasite* (Ann Arbor: University of Michigan Press, 2008), 225.

[302] Serres, *The Parasite*, 225–226.

thought that those different relations consist in the ongoing event of the 3.11 disaster. Hence, the distributed radiation is not only legally masterless, but those can be masterless and also by-products of nuclear fission, which was managed by TEPCO's capital power. As one football match is the aggregate of relations, the 3.11 disaster is also constituted by the relations derived from radiation, which constantly changes its quality in relation or over different relations. In light of this perspective, radiation monitoring can be thought of as an act of providing radiation with different quality in the relation between citizens and radiation. For example, as we looked in the section of CDCRML, the figure of the contamination can vary depending on which monitoring method is used. In an air measurement, the monitored radiation is shown as the amount of radiated dose per one human body, and a soil measurement shows the intensity of radioactivity per one radiated object. In this way, radiation exists as a quasi-object in the relation of citizens and radiation through the practice of monitoring. In other words, radiation monitoring can be interpreted as the act of collecting relations to radiation, which shows its multiple figures in a certain technological approach.

So, how can we situate this monitoring as the collection of relations that hold quasi-objects? According to Annemarie Mol, Serres's relational ontology rejects a deterministic holism. For instance, Mol describes that Serres takes the difference between solid boxes and flexible cloth bags as an example.[303] A solid box is either bigger or smaller than another size of a box, and only a bigger box can contain a smaller box. Here, each solid box's quality is determined by its counter, and this relationality of being bigger or smaller is not reversible. Meanwhile, flexible bags made of cloth can be folded, so the relation of the containing and the contained is flexible and reversible. In this sense, each bag's quality is not determined by the others. Mol argues that those agencies are mutually inclusive in a way that each entity does not determine the other's differentiation one-sidedly, but their character is flexibly interchangeable.[304] In the case

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[303] Annemarie Mol, *The Body Multiple: Ontology in Medical Practice* (Durham: Duke University Press, 2002), 144.

[304] Mol, *The Body Multiple,* 145–46.

of Fukushima, Mol's reading of Serres is applicable to consider how radiation's quasi-objectivity reflects observers' political position. The governmental nuclear policy takes a form of subjugation in which the local government and residents are subjugated to the central decision based on their pro-nuclear and economic ideology. As shown by the example of low-level exposure standards and the adoption of air measurements, capital and governmental powers have determined the objectivity of radiation. This corresponds to what Mol calls a transitive relation in which a larger population contains small individuals.[305] Whereas, in the case of CDCRML, local citizen groups form their association to visualise the ongoing disaster from their partial perspective without a holistic frame to centre their methodology on how they can precisely monitor the ongoing contamination through the network of local groups.

This aspect also appears in the interface design of the project. In the CDCRML, citizens as parts located in the local area adopt a soil measurement that can stably monitor the transition of the contamination in their residential area, and those collected data are visualised as dots on their digital map. Each dot shows a monitored point, and its colour shows the level of contamination. By clicking on each dot, the map also shows the specific contamination value (Figure 3.2).

[305] Mol, *The Body Multiple,* 132.

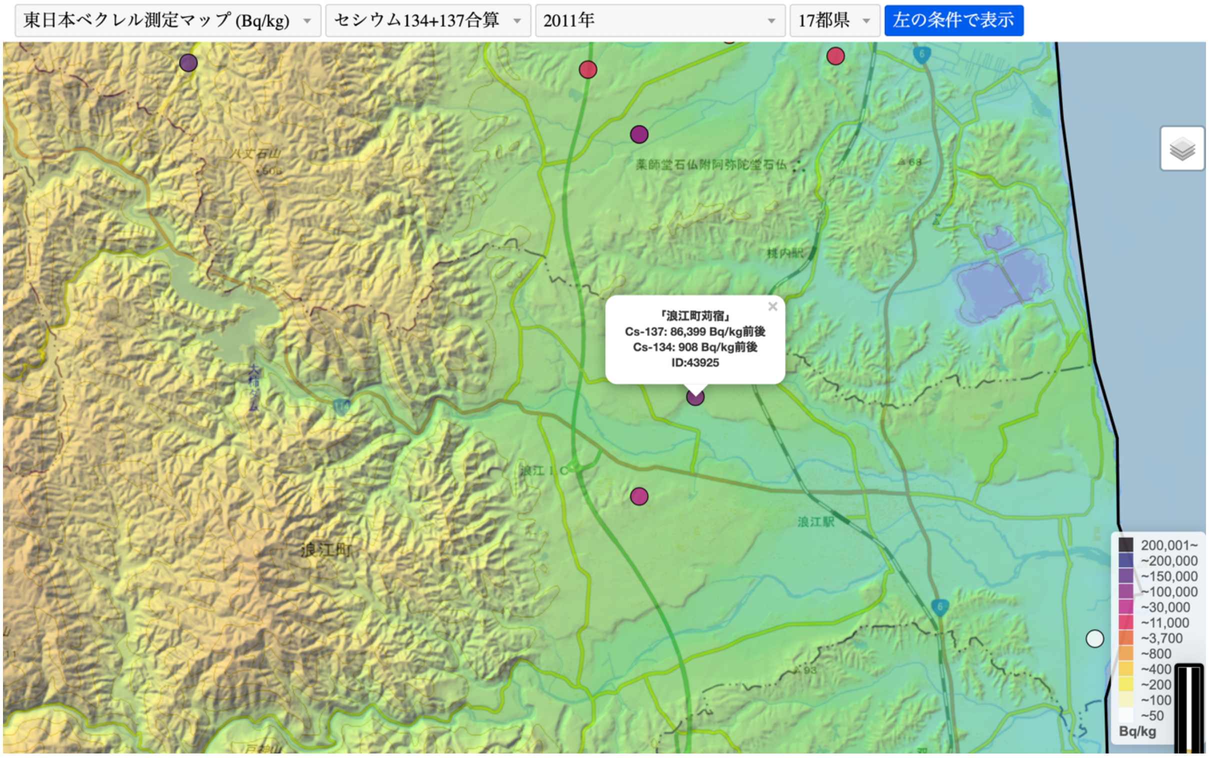

Figure 3.2: A screenshot of CDCRML's East Japan Soil Becquerel Measurement Map. [306]

In this way, the map as an aggregate of data can show its partial data from a partial perspective, and as a result, it shows a spatially wide area. Here, dots emerge as a relation between citizens and radiation, and the viewer of the map can see the contamination figure which emerges from the relations among those dots. Radionuclides exist as quasi-objects, and their figure emerges through those partial relations of monitors, which also lead to other partial relations on the map. Mol describes that individuals create the frame of an event as a whole, and in this sense, those two have each other as their own part, rather than the whole containing its individual constituents.[307] In the same way, the contamination map that shows the contamination is also formed by its partial data. To such a degree, the quasi-objectivity of

[306] Collective Database of Citizen's Radioactivity Measuring Labs, East Japan Becquerel Map.
The colour of each dot shows a contamination level corresponding to the chart on the bottom left. The window from the dot on the screen shows the name of the monitored place and the intensity of the radioactive isotopes of Caesium-137 and Caesium-134.

[307] Mol, *The Body Multiple,*132.

radiation forms in a way that individual citizens and their groups include parts of other relations, and as a result, the aggregate of those relations visualise the figure of the disaster through their practice.

To sum up this section, the radiation monitoring of CDCRML has transversally emerged as a result of the combination of different machines in Guattari's sense. The agencies of the projects are not only humans but also include the technological and environmental entities such as dosemeters and the radiated soils. These entities constitute different machines that operate in several registers, and their subjectivity emerges in relations among individuals and machinic assemblages. Subsequently, the objectivity of radiation can be thought of based on the relational ontology of Serres's quasi-object. The property of radiation can dynamically change in the relationship where it is situated in the different dimensions of the practice of CDCRML, and this project can be seen as the aggregate of those relations, including radiation as a quasi-object. Moreover, in the aggregate of parts that compose the monitoring project, an individual part and its larger population are mutually included, and it rejected a holistic viewpoint. The pro-nuclear power-knowledge system was operating in the form of subjugation of the local to the central government as a whole. Hence, it can also be argued that the partial connection of CDCRML has a different form of knowledge production compared with the pre-Fukushima nuclear society.

3.5 Conclusion

This chapter has shown how citizens are participating in technological practices in post-Fukushima Japan. In the beginning, referring to the rise of the anti-nuclear movement, we observed how the internet infrastructure and the use of social media mobilised the public in ad hoc and effective communication. Second, through the example of the radiation monitoring of CDCRML, which also shares the characteristic of the mobilisation of the anti-nuclear movement, this thesis focused on how their practice is contesting the governmental nuclear policy. Their criticism against the current evacuation standard can be understood as an extension of the anti-nuclear critique, and their adoption of the soil measurement is their own way to show a technoscientific reality, which rejects the pro-nuclear power-knowledge system. Finally, we observed the subjectivity of radiation monitoring and the objectivity of radiation. CDCRML cuts through the different registers of the social, the technological, and the environmental, and it assembles several sorts of machines. Correspondingly, the subjectivity of the practice emerges between these individuals and the collective entities. The relational ontology of radiation can be interpreted through the theory of the quasi-object, and the quality or role of radiation can change in accordance with its situated relation or even in the same relation. By way of Mol's reading of Serres, we also observed that a part aggregates its larger population, and the relation between them can be seen as mutual inclusion, in which the whole does not determine the role of its constituent part. This chapter focused on the formations of the social and technological practice, in which citizens are cooperating to contest a technoscientific reality that was driven by the pro-nuclear policy that flourished in the pre-Fukushima period. Even though the anti-nuclear movement and the radiation monitoring are operating in different dimensions, political protests and environmental monitoring developed through the technological infrastructure to contest the existing value of a technoscientific and sociopolitical reality of the nuclear industry. The interaction of the social, the technological, and the natural machinically and mutually include each other to consider disseminated radiation through the perspective of citizens. Based on these points, in the next chapter, we will observe how technological devices individuate through interaction.

Chapter 4

Monitoring Devices in Action: Technical and Digital Objects and Radiation Monitoring Infrastructures in Post-Fukushima Japan

4.1 Introduction

In Chapter 3, the political epistemologies of radiation monitoring of the nuclear disaster were investigated. During the formation of the anti-nuclear protest and citizen-led radiation monitoring, social media platforms enabled citizens to form ad hoc associations, which were used to disseminate information on the anti-nuclear plant protest marches and share data on radioactive contamination in Japan. In Mol's sense, the relationship between the organisations responsible for these events can also be viewed as mutual inclusion, in which each organisation's component creates the role of others without a holistic structure.[308] It was also discussed how these relationships traverse the boundaries of human technology and social milieux to incorporate environmental elements as part of their subjectivities. Subsequently, based on the discussion pertaining to relations and agencies, this chapter will examine the monitoring devices used in post-Fukushima Japan.

Examples of the technological tools used to detect environmental radiation were briefly introduced in the introduction and Chapter 2. The mutual inclusion and the machinic transversality that were discussed in the previous chapter are also relevant to these examples. As the case of the gamma camera demonstrates, radioactive contamination in the natural environment is highly susceptible to environmental and meteorological conditions; therefore, the gamma camera visualises the pollution status of the radioactive forest and displays the relationships observed as radionuclides accumulation. Thus, the contamination phenomenon

[308] Mol, *The Body Multiple,* 145–146.

can be conceived as the collection of associations that forms through the natural environment of the forest, and the technical milieu of monitoring devices includes gamma cameras and radiation detectors. The camera observes the environment as an object of detection and is also included in the act of 'seeing radiation'. In other words, the technical objects are immersed in the radiated environment. As a result of the interaction between the various surroundings, radioactive contamination develops and the relationships show the extent of the contamination around the scattered technical items that serve as sensors.[309]

This chapter shifts the focus of the discussion to 'objects' that are used to detect and visualise the radioactive contamination in post-Fukushima Japan based on the idea that relationships extend beyond various registers. In Chapter 2, the concept of technical and digital objects was briefly discussed with reference to Simondon and Hui. According to Simondon, the individuation of technical objects occurs when the natural and technical milieux overlap, and their metastable condition leaves room for the individuation process to continue. Using Safecast's citizen-led monitoring projects as examples, this chapter further considers the processes of the individuation and concretisation of technical objects as relations, building on Simondon's discussion of technical objects and this study's previous analysis of the relations between the technological, the social, and the natural.

It has been proposed that digital objects also go through relational processes within the digital milieu. According to Hui, the development of digital objects occurs in their external environment, which includes a relational and informational network composed of a set of

[309] It is important to note that under certain circumstances, radiation detectors can still overlook environmental radiation values. For instance, the radiation values represent the total amount of radioactivity emitted from various points in the monitored area. Radiation is also influenced by geographical and meteorological factors such as soil quality and weather conditions. Furthermore, the movement of gamma rays can be obstructed by certain materials like a thick wall of iron. As a result, the calibration of the detectors and methods to specific situations is required. See: Chauanlei Liu *et al*., 'Dose calibration of Health Canada's Fixed Point Surveillance system for environmental radiation monitoring in terms of air kerma and H*(10)', *Journal of Environmental Radioactivity* 253-254 (2022), https://doi.org/10.1016/j.jenvrad.2022.107009.

parameters and algorithms.[310] In the previous chapter, the citizen-led radiation monitoring practice with traits in common with the anti-nuclear movement and the dissemination of the radioactive contamination dataset in post-Fukushima Japan was observed. For example, when the government delayed releasing information about the fallout following the nuclear accident, citizens were mobilised through online communities and began sharing information about the contamination.

In addition, this chapter focuses on milieux that involve the process of individualising items, given the prior emphasis on the importance of the natural surroundings in radiation monitoring. It examines how technical objects, such as radiation detectors, are constructed and implemented within their associated milieux. Furthermore, it also analyses instances of radiation monitoring through the lens of Simondon's relational ontology that emphasises the connection between individuals and their milieux. At the same time, this chapter includes the external milieu of informational networks. Instances of monitoring devices in Fukushima were introduced in Chapter 2. These instances include the gamma camera and the Okano machine, which can visualise the contamination and the intensity level of radionuclides and are used to determine the different types of radionuclides in the air. Both gadgets demonstrate the relationship between technological items, such as cameras, and the environment where radioactive materials are found.

Following this, the infrastructure of radiation monitoring is discussed in more detail in this chapter's final section. The previous chapters introduced and discussed several monitoring and visualisation techniques and the internet culture wherein the monitoring processes occur. The concretisation of technologies in terms of their accompanying milieux is demonstrated in this chapter by investigating various technical and digital devices. Devices such as radiation detectors and mapping tools are developed and distributed by organisations, and it is demonstrated how these technological and social infrastructures operate as a sensorium for invisible radioactive substances in the environment.

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310 Hui, *On the Existence*, 26.

4.1.1 The Fukushima Radiation Monitoring Technical Background

The technical objects that constitute the digital monitoring of a nuclear disaster are discussed in the first section of this chapter. The Collective Database of Citizen's Radioactivity Measuring Labs case study shows that identifying radioactive contamination forms part of the political epistemologies of radiation monitoring. Chapter 3's observation of how data is manually collected using a soil measurement in light of the characteristic of radioactive caesium accumulating on the soil's surface lends support to this argument. Meanwhile, in governmental monitoring, the measurement of radionuclides in the air is widely applied. While the environmental detection results are not the same as the soil measurement results, the air measurement can reduce human involvement in the monitoring process. For example, aeroplanes and vehicles with dosimeters are often used to measure the air's contamination level and collect data from various areas.[311] During this process, the sensors of these dosimeters react to the radiation in the air surrounding them; however, for soil measurement, it is necessary to manually set a soil sample in a detector or install a survey meter in the ground.[312] As a result, in most public monitoring projects, monitoring posts are installed in public areas and government buildings. Numerous municipalities often use these posts, which are also designed to conduct air measurements automatically at different intervals. Due to its portability and ease of installation, the air measurement method is popular among public and citizen-led projects that have been constantly generating data since 2011, even if its accuracy

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[311] Ministry of the Environment, 'What does the Airplane Monitoring measure?', 16 January 2013, https://www.env.go.jp/content/900412677.pdf.

[312] Japan Atomic Energy Agency, 'Radioactivity and air dose rate', accessed: 20 April 2023, https://fukushima.jaea.go.jp/QA/en/q145.html.

Japan Atomic Energy Agency, 'The fact of the air measurement in the environment (環境中における空間線量率測定の実際)', accessed: 20 April 2023, https://fukushima.jaea.go.jp/QA/q1-4_lv3.html.

is lower than that of soil measurements.[313] Figure 4.1 displays a radiation monitoring post operating in the Fukushima Prefecture.

Figure 4.1: Field-portable real-time radiation monitoring post in the Fukushima Prefecture.[314]

[313] The radiation value in the air is susceptible to meteorological conditions. Considering this environmental factor, the Fukui Prefectural Environmental Radiation Research and Monitoring Centre installed their monitoring posts with meteorological observatory equipment.

Fukui Prefectural Environmental Radiation Research and Monitoring Centre, 'Monitoring posts (観測局（モニタリングポスト）)', accessed: 25 February 2023, http://www.houshasen.tsuruga.fukui.jp/pages/radiation/explanation/monitoringpost.html.

[314] This radiation monitoring post operates on battery and solar power, making it easier to install in the environment compared to systems that require charging via a power cable. The device panel displays the radiation value in the air, and the monitoring data is transmitted to the prefecture's database.

Fukushima Prefecture Radiation Monitoring Unit, 'Additional maintenance of monitoring posts around the nuclear power plant (原子力発電所周辺監視モニタリングポスト等の追加整備について)', 1 April 2015, https://www.pref.fukushima.lg.jp/uploaded/attachment/109878.pdf.

Noting these advantages and drawbacks, this section and the subsequent sections focus on the air measurement methods widely adopted in real-time radioactive contamination monitoring and on generalised detectors that citizens can purchase and use. The instalment and usage of air measurement monitoring devices are common in post-Fukushima Japan and are used in public areas, such as schools and parks. A further consideration is that when people browse monitoring data through a particular project's website, they do not have to know what detectors are used for data collection. These monitoring devices have become part of technological infrastructures that materialise radioactive contamination through data. Monitoring devices are now widespread and 'transparent to use', as Susan Leigh Star stated in the ethnography of Infrastructures, but they can also covertly help with information browsing.[315]

Following the Fukushima nuclear disaster, the publication of monitoring data has been common among organisations that conduct monitoring surveys. For example, the Nuclear Regulation Authority (NRA) publishes the monitoring data collected from state-owned radiation monitoring posts in all the prefectures in Japan on their website, Environmental Radioactivity and Radiation in Japan. The data can be downloaded in a comma-separated values (CSV) file,[316] which is a type of delimited text file, meaning it separates values using commas. In this file, each line represents a data record, and a comma separates each record. This format is compatible with various software applications, such as spreadsheets, and can be used for multiple purposes, such as answering queries and archiving data.[317] Figure 4.2 displays a spreadsheet screenshot of a data section published in the CSV format, as sorted

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[315] Susan Leigh Star, 'The ethnography of infrastructure', *American Behavioral Scientist* 43, no. 3 (1999): 381, https://doi.org/10.1177/00027649921955326.

[316] Environmental Radioactivity and Radiation in Japan, 'Environmental radiation database', accessed: 02.03.2023, https://www.kankyo-hoshano.go.jp/en/data-en/database-en/.

[317] Christina Christodoulakis *et al*., 'Pytheas: Pattern-based table discovery in CSV files', *PVLDB* 13, no. 11 (2020): 2075, https://doi.org/10.14778/3407790.3407810.

by columns in terms of, for example, survey name, monitoring data, and radiation values. This example shows how data publication is part of the monitoring infrastructure.

Measurement start date	Maximum measureme	Minimum measurement value	Average measurement value	
01/01/2023	125	113	116	nGy/h
02/01/2023	125	114	118	nGy/h
03/01/2023	117	113	114	nGy/h
04/01/2023	117	112	115	nGy/h
05/01/2023	117	111	114	nGy/h
06/01/2023	115	112	113	nGy/h
07/01/2023	116	113	114	nGy/h
08/01/2023	116	112	115	nGy/h
09/01/2023	132	113	117	nGy/h
10/01/2023	156	113	120	nGy/h
11/01/2023	115	111	113	nGy/h
12/01/2023	116	111	114	nGy/h
13/01/2023	116	113	114	nGy/h
14/01/2023	117	113	114	nGy/h
15/01/2023	121	112	115	nGy/h
16/01/2023	121	112	115	nGy/h
17/01/2023	115	112	114	nGy/h
18/01/2023	116	112	114	nGy/h
19/01/2023	116	113	114	nGy/h
20/01/2023	149	113	117	nGy/h
21/01/2023	141	113	116	nGy/h
22/01/2023	116	113	115	nGy/h
23/01/2023	117	113	115	nGy/h
24/01/2023	125	114	116	nGy/h
25/01/2023	120	98	112	nGy/h

Figure 4.2: Monitoring data in a CSV file opened on a spreadsheet.[318]

In addition, citizens' ownership of radiation detectors has increased, and the broadband network's digital infrastructures have made it easier to distribute monitoring data. This thesis initially introduced Safecast's example to consider the digitisation of radiation monitoring as a novel and notable phenomenon in post-Fukushima Japan. Safecast has designed portable and stationary dosimeter-types that can measure radiation dosage in the air and record GPS

[318] This file displays monitoring data from a single location in Fukushima. From left to right, the columns show the measurement data, maximum value, minimum value, and average value measured in nGy/h, which indicates the amount of radiation absorbed by 1kg of matter in 1 hour. The filtering conditions for this dataset are as follows: Survey Period: 1/2023-2/2023, Survey Region: Fukushima, Survey Sample: Monitoring Post. To enhance clarity, the author has omitted some columns in this display.
Environmental Radioactivity and Radiation in Japan, 'Environmental radiation database'.

coordinates and the date of each measurement. The data are extracted from these devices, published on their website[319] and instantly transmitted to databases. This example illustrates how radiation detectors are individuated and concretised in the media ecologies in post-Fukushima and highlights the data generation process in the devices. This section thus critically considers how Safecast's radiation detectors individuate and operate according to Simondon's theory of individuation.

4.1.2 The Mechanism of Radiation Detectors

Before discussing the case study and observations, this section illustrates how radiation detectors operate to monitor radiation in the environment. A semiconductor radiation sensor is commonly used in commercially available devices,[320] such as dosimeters and detectors.[321] Electrons are produced when radioactive rays, especially gamma rays released from radionuclides, pass through the semiconductor in the detector. The detector translates the

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[319] The entire dataset can be downloaded from the following link. Although the page describes the data as being in CSV format, it is saved in XLSX format, optimised for Microsoft's spreadsheet software, Excel. Similar to CSV, XLSX is compatible with multiple software applications. Safecast, 'Data', https://safecast.org/data/.

[320] Mihoko Nojiri, 'Basic knowledge about Geiger counters (今こそ知りたいガイガーカウンターの基礎知識) ', 11 May 2012, *imidas*, https://imidas.jp/jijikaitai/k-40-075-12-05-g435.

[321] Although dosimeters and radiation detectors are frequently used interchangeably, they are actually different types of devices used to measure radiation. The former is primarily used to measure the quantity of radiation that individuals are exposed to over a specific time period, while the latter is an apparatus that can detect and quantify the amount of radiation in a particular location. The term 'Geiger counter' sometimes refers to these devices. However, it is worth noting that a Geiger counter, formally called the Geiger–Muller counter, is a specific type of instrument that detects radiation using an inert gas that fills the device. When radiation interacts with the gas, it produces electrons, which the instrument converts into a specific measurement unit displayed on the device's meter. See: United States Nuclear Regulatory Commission, 'What is a Geiger Counter', last modified: 19 March 2020, https://www.nrc.gov/reading-rm/basic-ref/students/science-101/what-is-a-geiger-counter.html.

electrons into signals showing the radiation dosage.[322] Notably, these semiconductors do not touch radioactive substances directly; they only interact with the radioactive rays. When radioactive substances collapse, they release radioactive rays, of which there are four types: α, β, γ, and neutrons.[323] During the Fukushima nuclear disaster, the most released radioactive substances were caesium-134 and caesium-137, which release β and γ rays.[324] The β rays are weaker than γ rays and are unlikely to affect human bodies unless ingested. However, γ rays are intense and can penetrate human bodies from a 100-metre distance.[325] For this reason, semiconductor detectors are designed to detect gamma rays in the air.

Not every γ ray penetrating a detector is measured, except those that release electrons when interacting with a semiconductor. The detector then counts the strength of the translated signal multiple times, and the number counted varies depending on the detector's efficiency. The unit value is expressed in counts per minute (CPM), and more expensive detectors can calculate signals with higher CPM rates.[326] Subsequently, the counted signals are converted

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322 Britannica, 'Semiconductor detectors', accessed: 11 February 2023, https://www.britannica.com/technology/radiation-measurement/Semiconductor-detectors.

323 Ministry of the Environment, 'Penetration Power of Radiation (放射線の透過力)', last modified: 31 March 2016, https://www.env.go.jp/chemi/rhm/h30kisoshiryo/h30kiso-01-03-08.html.

324 The Ministry of the Environment, 'Radiation Exposure by Radioactive Rays (放射線による被ばく)', last modified: 31 March 2017, https://www.env.go.jp/chemi/rhm/h28kisoshiryo/h28kiso-02-02-04.html#:~:text=%E7%AC%AC%EF%BC%92%E7%AB%A0%20%E6%94%BE%E5%B0%84%E7%B7%9A%E3%81%AB%E3%82%88%E3%82%8B,2.2%20%E5%8E%9F%E5%AD%90%E5%8A%9B%E7%81%BD%E5%AE%B3&text=%E6%9D%B1%E4%BA%AC%E9%9B%BB%E5%8A%9B%E7%A6%8F%E5%B3%B6%E7%AC%AC%E4%B8%80,90%E3%81%AE%EF%BC%94%E7%A8%AE%E9%A1%9E%E3%81%A7%E3%81%99%E3%80%82.

325 Nojiri, 'Basic knowledge'.

326 In the Japanese market, comparably affordable Geiger counters that cost about £100 have 100CPM. Scintillator detectors are relatively expensive, and their prices start from £600. However, its CPM is more than 1000; Nojiri, 'Basic Knowledge'.

into the radiation value, sieverts (Sv), which indicates the radioactive energy level that can affect the human body.[327]

Detector types can vary depending on their monitoring purposes. For example, a sodium iodide (NaI) scintillator detector can measure the radiation value in the air. This detector type measures the light that a NaI crystal emits when exposed to γ rays and has a higher CPM rate than average semiconductor types. However, while scintillator types are more precise regarding the monitoring result, they are larger than semiconductor types and consume more electricity. Hence, scintillator detectors are often installed in the natural environment, and municipal monitoring projects have used them since 2011.[328]

As these examples demonstrate, radiation detectors do not directly convert the radiation energy into Sv; rather, the monitoring results are generated through different levels and types of conversion, i.e. from electron count to signal and from the chemical reaction of light to signal. Based on these conversions, the following sections demonstrate how radiation is converted into data in the individuation process.

4.1.3 Safecast

This section explores how detectors were designed during the Fukushima nuclear disaster, using Safecast as an example. In 2011, a first detector was designed and was called bGeigie,

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327 National Cancer Center Japan, 'Radiation frequent Q&A (放射線　よくあるお問い合わせ Q&A) ', accessed: 3 March 2023, https://www.ncc.go.jp/jp/other/shinsai/higashinihon/qa/index.html.

328 Fukui Prefecture Environmental Radiation Research and Monitoring Centre, 'Monitoring post'. For example, Mibu-cho in the Tochigi Prefecture, which is located 155km away from the Daiichi NPP, uses NaI Scintillator monitoring posts with a semiconductor type to cover a wide monitoring area range. They have installed 29 monitoring posts in public spaces, and the device displays monitoring results in Gy/h, which is the radiation dosage absorbed by an inanimate object; Mibu-cho, 'We are monitoring the air radiation dosage with monitoring posts (モニタリングポストによる空間放射線量率の測定をしています)', 1 December 2022, https://www.town.mibu.tochigi.jp/docs/2014112800074/.

a portable semiconductor detector operated with a computer. This portability enabled its user to carry the device in a car to areas where monitoring can be conducted.[329] Following this, Safecast designed bGeigie's successor, bGeigie Nano (Figure 4.3), which can transmit monitored data samples via a wireless network and log time and location metadata for where the monitoring is conducted.[330] This allows the user to monitor the environment without managing the device. Furthermore, this device is smaller than bGeigie, meaning its users can carry the device around when, for example, walking or cycling. Unlike scintillator-type monitoring devices that can only monitor their assigned environment, portable semiconductor detectors can monitor a wide range of areas due to their mobility.

In 2017, to constantly monitor contamination in residential areas, Safecast produced a device called Solarcast and its smaller version, Solarcast Nano (Figure 4.4).[331] In contrast to bGeigie Nano, Solarcast, designed to collect data while moving, is installed in a designated spot in the environment. As its name suggests, this device is installed with a solar battery and can automatically charge itself, while it can connect to 3G mobile networks to upload monitoring data and can be monitored on Safecast's page.[332] In addition to its connectivity and autonomy, it also contains particle sensors. As such, Solarcast can detect radioactive substances that are attached to minute particles with a size of PM10, OM2.5 and PM1.0 that drift in urban residential areas.[333]

Safecast's radiation dosimeters offer three points for consideration regarding how these technical devices are designed. First, as this chapter has already pointed out, the detectors' mobility and positional flexibility are essential to identifying radioactive contamination and

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329 Bonner, 'First Safecast'.

330 Safecast, 'bGeigie nano', accessed: 29 April 2023, https://safecast.org/devices/bgeigie-nano/.

331 Safecast, 'Introducing the Solarcast Nano', accessed 23 March 2023, https://safecast.org/2017/12/introducing-the-solarcast-nano/.

332 Safecast, 'Solarcast Nano'. On this Safecast page, each Solarcast Nano in operation is monitored in real time. Safecast, 'Sensors', accessed: 25 February 2023, https://realtime.safecast.org/.

333 Safecast, 'Introducing Solarcast', accessed: 23 March 2023, https://safecast.org/2017/04/introducing-solarcast/.

compounds accumulating on objects in the natural environment. Second, while it overlaps with mobility, the adaptability of the detectors in different milieux must also be considered for generating monitoring data in various locations, from the natural environment to residential areas. In addition, the position of the detector, how the device can take in the surrounding air and what substances they react to are also crucial for Solarcast's monitoring.

Finally, it is crucial to consider how newly designed detectors like the bGeigie Nano and Solarcast Nano have used communication tools and computer software to connect detectors via networks such as Bluetooth and 3G. Real-time monitoring across numerous sites is made possible by this feature, and in post-Fukushima Japan, it is intertwined with the digitisation of monitoring results, which have frequently been used to archive the results in a database and visualise them on a digital map. By looking at these aspects of monitoring devices, this thesis theoretically defines how these technical objects have been concretised in the environment following the Fukushima nuclear disaster.

Figure 4.3: Safecast's bGeigie Nano.[334]

[334] Safecast, 'bGeigie Nano'.

Figure 4.4: Safecast's Solarcast Nano.[335]

4.1.4 The Individuation of the Dosimeter in the Natural and Technical Milieux

According to Simondon, the technical concretisation of objects is not inseparable from their external milieu. Instead, it incorporates its external milieux within itself. Simondon describes it as follows:

> The object frees itself from the originally associated laboratory and dynamically incorporates the laboratory into itself through the play of its function; what

[335] Safecast, 'Introducing the Solarcast Nano'.

> enables the self-maintenance of the object's conditions of functioning is its relation to other technical and natural objects, and it is this relation that becomes regulative; this object is no longer isolated; it associates itself with other objects, or suffices unto itself, whereas at first it was isolated and heteronomous.[336]

As the quote indicates, Safecast's dosimeter designs incorporate the external and associated milieux. For example, a bGeigie Nano is composed of different technical objects, such as a semiconductor radiation sensor, a digital converter, a Bluetooth module, and a GPS tracker. The sensor directly interacts with air, a natural milieu where radioactive fallout can float, and passes the signal to a digital converter. The signal is then converted into digital data and accompanied by time and GPS metadata, displaying where and when the contamination was monitored. As such, these heterogeneous technical objects integrate and assemble as a self-maintained technical object, through which the radiation monitoring and metadata registration are automated. Moreover, following the developmental transition from bGeigie to bGeigie Nano, the latter can wirelessly connect to other devices via Bluetooth. Since bGeigie must be manually connected to other communication devices, these external technical interactions were incorporated and regulated within a concretised and individual dosimeter.

Notably, Simondon stated that the concretisation of objects is open to the wider world of the natural environment than its technical milieu. It is notable that Safecast's Solarcast was built with an air-absorbing structure and a solar battery that can self-charge. With its regulatory order of monitoring networks and its self-maintained function of automated monitoring, the device's design can acknowledge human–nature interactions. Furthermore, Solarcast can autonomously connect to the 3G network, meaning the device contains natural and artificial milieux.[337]

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[336] Gilbert Simondon, *Individuation in Light of Notions of Form and Information* (Minneapolis: University of Minnesota Press, 2020), 50.

[337] Following Simondon's theory, McQuire defines a digital milieu as a constantly evolving 'technology in motion' that lacks a final or stable form. This characteristic also applies to this section's natural and

As explained in the previous quote, Simondon sees an individual as composed of connections, and the form of an individual does not determine these relationships. Defining the individual in terms of relations, Simondon expresses this as follows:

> […] the individual […] is a theatre and agent of a relation; the individual can only be a term in an ancillary way because it is essentially a theater or agent of an interactive communication. To want to characterize the individual in itself or relative to other realities is to turn it into a relational term, i.e. into a relation with itself or a relation with another reality; first, one must find the point of view from which the individual can be grasped as an activity of relation, not as a term of this relation; properly speaking, the individual is in relation neither with itself nor with other realities; it is the being of relation and not a being in relation, for relation is an intense operation, an active center.[338]

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technical milieux since they are also constantly changing. For example, the ever-changing meteorological conditions demonstrate this natural milieu's feature. In the artificial milieu of the information network, technologies such as 3G and 4G are utilised for specific connection purposes. Therefore, the network does not have a pre-determined format. Thus, individuation can be seen as an adaptation to milieux in motion. This critical perspective highlights the importance of considering how certain movements within milieux may be overlooked in the design or individuation of technical objects. The East Japan earthquake in 2011 was followed by multiple earthquakes in other parts of Japan. During these events, the radiation monitoring posts in the affected areas accidentally shut down due to power cuts caused by the earthquake (Tanigaki *et al*.). This case illustrates how earthquakes and power cuts, which are movements within the associated milieu, were not considered in designing technical objects, such as radiation monitoring posts.
See: Scott McQuire, 'One map to rule them all? Google Maps as digital technical object', *Communication and the Public* 4, no. 2 (2019): 153, https://doi.org/10.1177/2057047319850192.
Minoru Tanigaki *et al*., 'Studies on network for monitoring posts based on mesh-type LPWA', *Transaction of Atomic Energy Society of Japan Journal* 22, no.1 (2013): 38, https://doi.org/10.3327/taesj.J21.025.

[338] Simondon, *Individuation*, 50.

This account of the individual and of relations is echoed in the design principle of Safecast's dosimeters. Following Simondon's theory, such dosimeters can be viewed as the activities and interactions of different relations. For example, with the high degree of self-maintenance that is displayed in the examples of automated monitoring, the solar battery and the automatic connection to the wireless network, the dosimeters are 'relations' that actively perform multiple tasks, such as sensing radioactive rays, signalising electrons and transmitting the monitoring data. From this viewpoint, rather than the components of the interactions being different individuals, the functional relations over various tasks constitute the individuality of a detector. As such, it is possible to hold that radiation detectors act as individuals in a social theatre where various technical objects carry out communications between the digital, technological and natural worlds for environmental monitoring.

If the dosimeters are the aggregation of active relations, the question remains as to how Simondon sees the environments where these relations concretise in an individual. According to Simondon, observing the state before something individuates is crucial to understanding the individual. This is due to the fact that 'the individual cannot account for itself on the basis of itself, because it is not the being's whole to the extent that it is the expression of a resolution'.[339] The individual is an outcome of the interaction with others, and the relations that express them exist before the individuation occurs. As shown previously, in the process of individuation, the individual incorporates their external relations; here, the external milieu becomes the associated milieu of the individuation. Therefore, rather than conceiving it as 'a type of being', the individual is a 'result of a certain organisational event'[340] and is still part of the location. In this sense, 'the associated milieu is the complement of the individual relative to the original whole'.[341]

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[339] Simondon, *Individuation,* 52.

[340] Simondon, *Individuation,* 51.

[341] Simondon, *Individuation*, 52.

Consequently, objects are positioned among various milieux, and their external relations influence concretisation. In the case of Safecast detectors, this individuation theory efficiently conceptualises these devices as the congruence of the relations of their external technological and natural milieux. The technological visualisation of the radiological incident of the Fukushima nuclear disaster was discussed in Chapter 2 using the example of a gamma camera that renders radiation values in the environment with colours. According to Haraway, these 'compound eyes' emerge through the interaction between technological and natural entities.[342] Gamma cameras, for example, display the degree of environmental contamination due to an interaction between the radiation sensor inside the camera and the geographical and climatic aspects of the forest's natural environment. In this sense, both technological and natural elements are present in the technological mediation of contamination. This scenario was explored to demonstrate that nature is not only an aspect to be observed but one that plays a role in the radiation visualisation process. The gamma camera operation as a component of its related milieu can be seen as the relational ontology of the individual in the discussions of individuation and milieux. Compounding eyes on the lookout for radiation make up the environment formed by the camera and the surroundings.

The individuation and concretisation of the Safecast detectors are also important for developing compounded eyes toward contamination regarding the linked technical and environmental environments. However, the difference is that when examining the individuation process, the interaction between the various milieux involves the genesis of technical objects, in this case, the natural environment that shapes the concretisation of detectors like Solarcast, which was created to sample the air around it. Then, through the detector, a new technological and natural aspect of radioactive contamination emerges in the form of monitoring data. Through environmental monitoring, a relationship is created between the technological and natural milieux. The question remains as to how the technological and natural reality that

[342] Donna Haraway, *When Species Meet*, 261.

results from monitoring can be distinguished from the natural environment that shapes the individuation of detectors.

Based on Simondon's theory of individuation, Jennifer Gabrys introduces Alfred North Whitehead's concept of concrescence to investigate the relations of environmental monitoring sensors. Concrescence refers to a process where an entity concretises through relating with other entities, and in the process, abstract entities are not separated from concrete entities.[343] According to Gabrys, environmental sensors are required not to alter the ecosystem of the natural environment but to observe it. Therefore, environmental measurement 'is not about detecting information "out there". Instead, it is an act of "tuning" relevant subjects and conditions of the experience of measuring to "new registers of becoming"';[344] in other words, a measurement results from a form of concrescence. Following this argument, the natural milieu may relate to the detectors as technical and concrete objects by adjusting their technological capacity to the environment. For example, detectors need to be adjusted to a geological condition affecting the radioactive energy level in radiation monitoring.[345] To detect radioactive rays from the soil, Safecast uses bGeigie Nano, which is tuned to detect rays at a height of 1–1.5m.[346] As a result, people and technological objects are modified to fit their surroundings, and the relationships that produce the monitoring results help to make the

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343 Alfred North Whitehead, *Process and Reality: An Essay in Cosmology* (New York: The Free Press, 1978), 20.

344 Jennifer Gabrys, *Program Earth: Environmental Sensing and the Making of a Computational Planet* (Minneapolis: University of Minnesota Press, 2016), 32.

345 Radioactive caesium accumulates in the soil rather than on paved grounds. Thus, to measure the radiation value in the air where the monitoring point is located on unpaved ground, it is necessary to conduct monitoring at a distance from the ground. During the aftermath of the 2011 nuclear disaster, it was reported that some monitoring projects did not consider this aspect. Nevertheless, some municipal guidelines have clarified that their monitoring method is based on geological conditions that can affect air measurements.
See: National Environmental Studies, Japan, 'Tsukuba City radioactive substances and radiation measurements', accessed: 23 February 2023, https://www.nies.go.jp/shinsai/1-6-1-e.html.

346 Safecast, 'Frequently Asked Questions', accessed: 7 May 2021, https://safecast.jp/faq/.

results concrete. The environment's physical components and the detectors' abstract monitoring data are connected through this dynamic process.

In Chapters 1 and 3, it was observed that the subject and object relations between humans and more-than-humans evolved in some events in post-Fukushima Japan. This chapter develops the argument to discuss how technical objects individuate and concretise through relations between concrete and abstract layers.

4.1.5 Transindividuality and Transduction

Thus far, this thesis has focused on the individuation and concretisation of technical objects in relation to their associated milieux. As previously noted, each technical object has the potential to transform into another object due to its metastability. According to Simondon, relating beyond an object's individuality might result in the transindividuation of an individual. This idea is crucial because it implies that an individual is not only a target for concretisation but also a condition for future relationships and individuation. This section investigates how this transindividuality is observed in radiation detectors.

Using a living organism as an example, Simondon argues that its psychical components connect to other beings. This connection leads to a preindividual reality that 'results in functions and structures that are not achieved within the limit of the living individuated being'.[347] According to Simondon, the psychic realities of various living organisms combine to generate preindividual reality, which can be thought of as a potential that organises the subsequent individuation. As such, an individual contains a transindividuality that is not only a component of the living person. Consequently, a person is both an individual and a collective entity.

[347] Simondon, *Individuation*, 178–179.

In Muriel Combes's interpretation of Simondon's work, the transindividuality of the psyche is subjective since it regulates the psychological aspect of an individual subject. According to Combes, an objective transindividual refers to the collective as a shared physical reality among individuals.[348] Simondon does not approach the object in this case from a formalist perspective, where the development of the object's interior is controlled by its pre-existing form. Instead, if a naturalist stance is adopted, from a Simondonian standpoint, an objective transindividual is undefined as a natural process.[349] An individual's physical reality is also related to preindividuality since it conditions further individuation. Furthermore, given that subjective transindividuality is not restricted to one individual, its *objective* transindividuality travels through the preindividual's physical reality. As such, transindividuality emerges at different levels of individuality, which regulates and conditions its next individuation phase.

To better understand the characteristics of the individuation process, Simondon introduces the concept of transduction, explaining it as follows:

> By transduction we mean a physical, biological, mental, or social operation through which an activity propagates incrementally within a domain by basing this propagation on a structuration of the domain operated from one region to another: each structural region serves as a principle and model, as an initiator for constituting the following region, such that a modification thereby extends progressively throughout this structuring operation.[350]

This quotation demonstrates Simondon's understanding of how structuring several domains allows an activity to spread throughout a territory while also affecting each area

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[348] Muriel Combes, *Gilbert Simondon and the Philosophy of the Transindividual* (Cambridge: The MIT Press, 2012), 47.

[349] Combes, *Gilbert Simondon*, 48.

[350] Simondon, *Individuation*, 13.

transindividually. Thus, the unique point of transduction is that the principle and model of each newly created region emerge as part of the structuring process. Notably, this structuring process is neither inductive nor deductive, as seen in his naturalist approach, where the pre-existing form does not determine the individuation process. Inductively, the principles and models pre-exist in the region where the process is initiated, and the operation is based on the pre-determined structure. Meanwhile, it is clear that a deductive approach assumes the existence of an order or shape outside of the region and that the structuration is dependent on them.[351]

As examples of transduction, Simondon describes the process of the individuation and concretisation of crystals, 'which, starting from a tiny germ, increases and extends following all the directions in its supersaturated mother liquor: each previously constituted molecular layer serves as the structuring basis for the layer in the process of forming; the result is an amplifying reticular structure'.[352] The interaction between a crystal and its external milieu causes it to differentiate and take on new forms; as a result, the order in which crystals develop and the subsequent crystal shape this will materialise is not pre-determined. Hence, crystallisation can be seen as a metastable and transductive process, where the principle of structuration brings about the interaction between an individual and their external milieu.

Paulo de Assis uses incandescent light bulbs as an example of the transductive operation of the individuation of technology to emphasise high energy transduction is a crucial step in the procedure.[353] According to Brian Massumi, transduction is an emission of virtuality through its actualisation: '[t]ransduction is the transmission of a force of potential that cannot but be felt, simultaneously doubling, enabling, and ultimately counteracting the limitative selections

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[351] Simondon, *Individuation*, 14–15.

[352] Simondon, *Individuation*, 13.

[353] Paulo de Assis, 'Gilbert Simondon's "Transduction" as radical immanence in performance', *Performance Philosophy* 3, no. 3 (2017): 699, https://doi.org/10.21476/pp.2017.33140.

of apparatuses of actualisation and implantation'.[354] Based on this, using a lamp as an example, de Assis maintains that the energy of electricity is transduced into visible light. This procedure converts 5% of the electricity into light, while the remaining 95% is transformed into heat. This operation is controlled in the vacuum tube to compensate for the tungsten filament's material limitations.

Furthermore, de Assis explains that the lamp as a transducer is where the transduction process occurs constantly and is simultaneously more and less than 'their past or future potentials: less, because they cannot contain all virtual possibilities; more, because they generate new, unpredictable, and unforeseeable new tensions, new potentials that require further processes of equilibrium'.[355] For example, the electrical potential is reduced but simultaneously multiplied into light and heat, which require a vacuum tube to sustain the equilibrium. As such, the light from the lamp's transduction results in a potential that actualises, or in a Simondonian sense, individuates through its transindividual subjectivity and objectivity in its technical ensemble.

Given that individuation occurs at various levels, it is important to understand it as a transindividual and transductive process to fully comprehend the individuation of radiation and radiation detectors as technical objects. First, radionuclides come in contact with a certain type of sensor at the beginning of the radiation conversion into numerical data. For example, if the detector sensor is a scintillator, the radiation is converted into light and then into an electrical signal. This signal is then measured and transformed into a digit. Similarly, semiconductor-type sensors constantly count the number of electrons that radionuclides pass through to determine the energy of the monitored radiation, and the result of this calculation is then translated into numerical data. As explained in the above example of the transduction process of electricity converting into light and heat, the energy of radiation in these sensors

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[354] Brian Massumi, *Parables for the Virtual. Movement, Affect, Sensation* (Durham/London: Duke University Press, 2022), 42–43.

[355] de Assis, 'Gilbert Simondon's "Transduction"', 700–701.

individuates into digital form. The digitisation process is determined due to the interaction between environmental radiation and the sensors that capture them. Furthermore, in terms of transindividuality, generated contamination data are conditioned by the monitored radiation, a sensor, and its associated milieu. In light of this, it is reasonable to conclude that the monitoring data have transindividuality relationships with those that determine its existence. Radiation detectors can be thought of as transducers since they are the points at which invisible radiation is converted from being indirectly perceptible to being detectable by machines.

Second, the concepts of transindividuality and transduction play an important role in observing how radiation detectors as technical objects relate to other entities. As shown in the example of Safecast, its project began with a social situation entailing a lack of information on radioactive contamination in the post-Fukushima context. The company then developed its detectors, utilising mechanical parts and information networks to make them available to citizens.[356] According to Combes's rationale, Safecast's design strategy based on the social situation might be regarded as subjective transindividuality in its detectors. The psychical regulates the psychological aspect of an individual and their individuation.

Similarly, Safecast implemented a project policy that advocates for making the contamination data accessible to citizens and the process transparent to the public. As discussed in the introduction of this thesis, the project strategy was conceived when the government delayed publicising contamination data and their monitoring methodologies, and this aspect can be seen in other citizen-led monitoring projects.[357] For example, while the government had not published their data, Safecast created the first Geiger counter to monitor and generate contamination data and distribute it via the internet.[358] In addition, considering

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[356] Safecast, 'History of Safecast', accessed: 23 February 2023, https://safecast.org/history-of-safecast/.

[357] Anders Blok *et al*., 'Environmental infrastructures of emergency: The foundation of a civic radiation monitoring map during the Fukushima disaster', in *Nuclear Disaster at Fukushima Daiichi: Social, Political and Environmental Issues*, ed. Richards Hindmarsh (New York: Routledge, 1999): 78–115.

[358] Safecast, 'History of Safecast'.

the scarcity of radiation detectors in the market, the company designed its detectors such that even non-experts could assemble them. Thus, it can be argued that the company's project policy, which concretised its detectors, was gained through these social and political conditions. As the subjective transindividuality of an individual is collective and traverses through multiple individuals, this policy was also implemented through society. Thus, it can be interpreted that the subjectivity that regulates and conditions the company's detectors is transindividual, as it was collectively or transindividually processed.

Regarding the aspect of objective transindividuality, this can be regarded as the physical circumstances that enable detectors to be developed. For example, one of Safecast's first detectors, the bGeigie Nano, was created using mechanical components that were commonplace at the time, GPS informational standards and Bluetooth networks. This allowed the company to record locational metadata to generate data for further observation and transmit it to other devices.[359] Here, multiple material conditions, such as market availability and the network infrastructure, regulate the individuation process of detectors. In this case, the objective reality of Safecast's detectors transindividually emerges under the material conditions of post-Fukushima Japan. Similarly, regarding the network infrastructure, the Solarcast device was designed to automatically monitor contamination, choose the available local communication network, and transmit the monitored data.[360] Since these detectors are seamlessly connected through the digital infrastructure, their objective reality reflects the transindividual conditions. As such, the objective transindividuality of the detectors at different levels can be defined.

The question remains as to how radiation detectors can be understood in terms of transduction. As previously demonstrated, transduction refers to the process of ordering that is not inductive or deductive. Following Simondon's example of crystals, the principle of structuration results from the interaction between the individual and the external milieu. In

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[359] Safecast, 'bGeigie Nano'.

[360] Safecast, 'Introducing the Solarcast Nano'.

addition, transduction is a process that converts an element into something different, as seen with the example of the conversion of electricity into light and heat. Based on these points, it can be presumed that Safecast's detectors are transducers and undergo transductive individuation. As noted above, radiation detectors convert the radiation intensity into numerical data using sensors, and the conversion processes differ depending on the sensor type. For example, semiconductor-type sensors count the number of radionuclides and convert the amount into numerical data. Hence, they can be regarded as transducers that turn the energy of radiation into a cognitive form for devices and users.

This section analyses how the transduction perspective applies to the concretisation of radiation detectors. The model development process of Safecast detectors can be divided into three parts. First, as seen in the shift from bGeigie to bGeigie Nano, adding a wireless connection enables more flexible and portable monitoring. Second, unlike the above two models, Solarcast, when installed in the environment, automatically monitors contamination and sends the data to the project's database. In this case, the detector functions in terms of a stand-alone configuration. Third, Solarcast is also designed to measure radiation values without being manipulated by external computers, meaning the monitoring is automated.

During the initial shift to wireless connection, the bGeigie nano gained the Bluetooth connection to allow for linkage with smartphones, with this aspect enabled by connecting the previous model of bGeigie to other mobile devices via a cable. In terms of transduction, based on the experience gained through using bGeigie, the device design structure was conditioned by the technical milieu of the wireless infrastructure and the social milieu of human behaviour. Following this, in the second and third stages of automation, these devices are more immersed within the environment than portable devices and are a direct part of the broadband network infrastructure. These points indicate that the model development of the devices is not only about the individual function of the machines but also the ability to access external networks to enable further data generation and the attendant applications, such as real-time monitoring and visualisation. Therefore, the ability to interact with other devices and use the data for various reasons apart from the device's physical attributes – such as portability and environmental stability – is what is transduced.

Massumi describes transduction as the process of creating virtuality through actualisation,[361] and the application potential as the virtuality that emerges through model development. Based on the transindividuality discussions thus far presented, this 'actualisation' can be interpreted as the development of the devices that actualise their design, which is transindividually obtained through monitoring. Therefore, in the example of the monitoring devices, alongside the physical level of the devices, it can be argued that the model development process also displays virtuality, or transindividuality, which conditions the further individuation of radiation detectors. Furthermore, considering that the device development enabled data applications such as browsing in spreadsheets and digital mapping, it can be argued that the individuation of the devices also transduces the virtuality of data usage.

As a result of these Safecast detector observations, Simondon's theories of individuation have been used to describe how the monitoring devices have evolved as technical objects within the social and technological context of post-Fukushima Japan. Subsequently, by introducing the relevant concept of transindividuality, it has been noted that the individuation of technical objects occurs while relating to other individuals through conditioning and regulating the individuation process. Regarding transduction, it has also been noted how interactions between individuals and their related milieux result in individuation. These discussions explain how the monitoring equipment was designed and modified within a social and technological context by considering the characteristics of the radiological environmental disaster. Finally, while considering the transductive aspect of the device design, it was proposed that the individuation of the detectors displays the virtuality of new devices and subsequent application and data usage. Regarding the actualisation of virtuality in data visualisation concerning questions regarding space and time, the cases of digital mapping projects enabled with the devices outlined in this section are further explored in Chapter 5. In

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[361] Massumi, *Parables*, 42–43.

the following sections, how monitoring data, which is transduced from radiation, can be reconsidered in terms of individuation discussions is analysed.

4.2 Digital Objects

In this section, digital objects for radiation monitoring are examined. As explained in Section 4.1, radioactive substances and their rays must be digitised by converting electrons to signals produced when a semiconductor comes in contact with radioactive rays and into lights when a scintillator reacts to them. The signals are evaluated and transformed into a particular unit of measurement. The monitoring results are shown if an observer uses a dosimeter with a display. Alternatively, if a dosimeter is connected to an information network, the results are sent, archived in a database, and stored in a specific file format that will be translated into different visual forms. The previous section discussed the technical objects of environmental radiation monitoring. However, this area has to be explored further to unpick the flows and the archiving of monitoring data within the context of informational and digital milieux, where technological conditions are organised differently from natural ones. Remaining grounded in Simondon's theory of individuation and the relevant arguments, this section delineates the digital objects that participated in data transaction and visualisation in the Fukushima nuclear disaster.

Before setting out the theoretical framework and cases of this section in detail, the types of digital objects being observed in this section are explained. In the previous section, examples of technical objects were selected, which included dosimeters, survey meters and monitoring posts that sense and convert the energy of radioactive substances into electric signals to gain a radiation value that is measurable and readable for humans. As noted, the design of Safecast's survey meters includes a feature that allows its devices to transmit monitoring data to the company's database via the informational network. This enables the company to conduct live monitoring and control data archiving and publication. Gabrys demonstrated how data abstraction is related to the concrete subjects of natural and technical entities. Similarly, environmental monitoring devices are connected to the digital milieux of the internet and databases. Hence, to further develop our discussion of individuation and concretisation, monitoring data as digital objects and how they individuate in the process from environmental monitoring to certain activities such as archiving and visualisation in the digital milieux are discussed.

In addition, this section focuses on the software and interfaces that render data into visually perceptible formats. As noted in the previous section, following Simondon's theory, a technical object is regarded as a group of relationships. These practices produce a specific interpretation of the contamination using data visualisation when considering the activism of the Collective Database of Citizen's Radioactivity Measuring Labs, Yoshinori Watanabe's visualisation projects, and the Japan Atomic Energy Agency's data publication, as outlined in Chapter 3. Therefore, the focus is on how the transductive and transindividual aspects of digital objects are entwined with the data combination.

Finally, before beginning the case analysis, the theory of individuation and technical objects as digital objects in a digital milieu are developed to provide a framework. Since Simondon does not discuss computation in his work, digital objects are further discussed to delineate those used in the Fukushima nuclear disaster monitoring project by following Hui's and Kitchin's theories of digital and code objects. Following this, the 'digital device' and map software that concretise data and enable an understanding of reality are discussed.

4.2.1 Digital Objects and Digital Milieux

In Chapter 1, the concept of the digital object that Yuk Hui developed was reviewed. Based on that discussion, the radiation monitoring for the Fukushima nuclear disaster is explored here. Hui defines digital objects as configured entities composed of data and metadata under specific regulations, such as protocols and algorithms, displayed on a screen and in an operating programme.[362] In this case, a digital object can be regarded as a dataset visualised on a digital map or archived data in a specific database format. Such digital objects concretise in computational networks of protocols and standards, and they co-constitute a digital milieu. Furthermore, Hui delineates the digital milieu as reciprocal networks where an ensemble of computers and integrated human participation become subsystems within different technological systems.[363] Hence, digital milieux also include technological networks and systems' economic and social aspects.

The question remains as to how these definitions can be integrated within Simondon's theory of individuation using the Fukushima nuclear disaster radiation monitoring project as an example. As shown in the previous sections, Simondon emphasises that objects are a group of relations and their associated milieu. The technical aspects of radiation detectors and monitoring posts concretise and individuate due to these relations' technological, social, and environmental interactions. According to Rob Kitchin, data is associated with 'the idea, instruments, practices, context, and knowledge used to generate, process, and analyse them',[364] and that data can be seen as 'coded machine-readable objects' that 'rely on external code to function'.[365] Following this point, it can be deduced that monitoring data, as digital objects, are conditioned through monitoring and by the digital milieux, where data exist in a readable form for machines and software.

For example, as highlighted in the example of Safecast, considering the characteristics of an environmental disaster where the damage changes over time, monitoring data are organised according to contamination level, GPS coordination, measurement date and time, and observer and detector identification. Hui observed that digital objects are 'formalised by

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362 Yuk Hui, *On the Existence of Digital Objects* (Minnesota: University of Minnesota Press, 2016), 26.
363 Hui, *On the Existence*, 26.
364 Rob Kitchin, *The Data Revolution: Big Data, Open Data, Data Infrastructures & Their Consequences* (London: SAGE Publications Ltd, 2014), 2.
365 Rob Kitchin and Martin Dodge, *Code/Space: Software and Everyday Life* (Cambridge: The MIT Press, 2011), 5

metadata and metadata schemes',[366] and the formalisation of monitoring data reflects the environmental disaster's characteristics. Therefore, the digital objects of monitoring data concretise as a result of this categorical relation that indicates the state of the radioactive contamination in a certain spatial and temporal condition. Then, based on this categorisation, the monitoring data is converted into a CSV format that is readable via software, such as spreadsheets and digital mapping tools.

It is also notable that the dataset categories vary depending on each project. According to Kitchin, data is situated in 'the constitution and operation of the assemblage surrounding them'.[367] In the previous section, it was observed that a detector's individuation is conditioned by its associated social and technological milieu. As such, data can be regarded as the digital characterisation of each project. For example, the NRA, an administrative body of the Ministry of Environment in Japan, also organises and publishes monitoring data collected from its monitoring posts installed in public areas in CSV format. These CSV files are also categorised according to place, contamination level, date, and time, but GPS coordinates and other categories, such as monitoring device identification, are not listed.[368] This is because the places and monitoring methods are listed on a separate page, and these details are not visualised on the organisation's digital map (Figures 4.5 and 4.6). As such, the monitoring data individuates with its associated milieu with different visualisation information.

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[366] Hui, *On the Existence*, 26.

[367] Kitchin, *The Data Revolution*, 23–24.

[368] Nuclear Regulation Authority, 'Radiation Dosage Measurement Map', accessed: 3 April 2023, https://www.erms.nsr.go.jp/nra-ramis-webg/general/facilityselect/initialize.

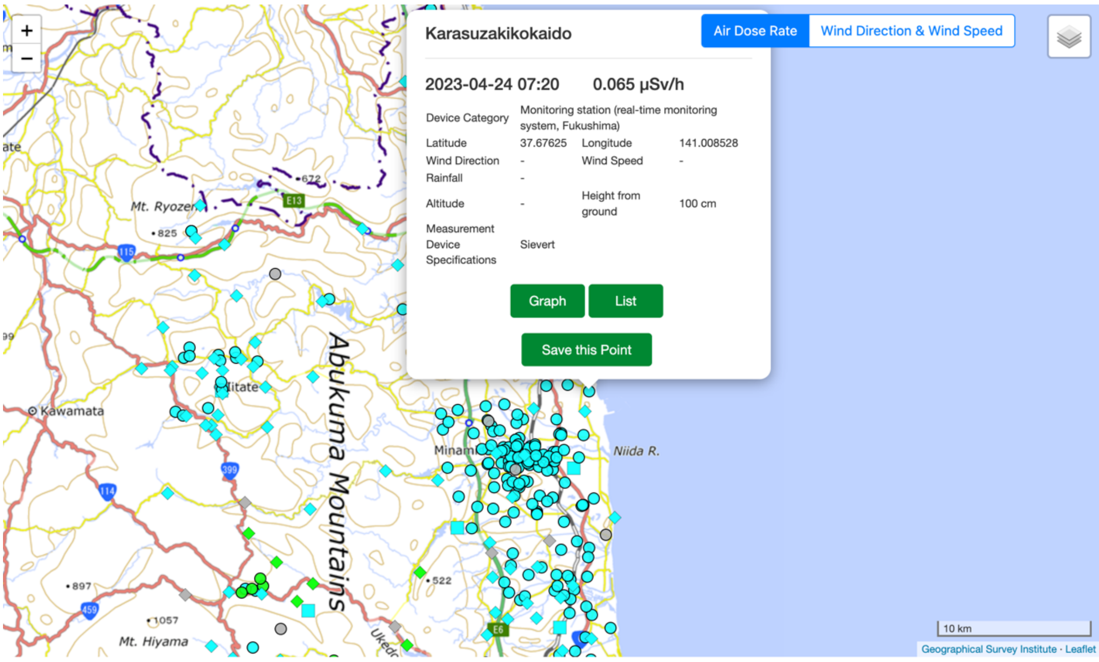

Figure 4.5: The NRA's Radiation Map.[369]

Karasuzakikokaido	0.065	µSv/h	24/04/2023 07:20
Kamikitabachikushukaijo	0.064	µSv/h	24/04/2023 07:20
Minamisomashiritsuyazawayochien	0.064	µSv/h	24/04/2023 07:20
Ouchikokaido	0.064	µSv/h	24/04/2023 07:20
Shimmachifureaihiroba	0.064	µSv/h	24/04/2023 07:20
Toshimochikushukaijo	0.064	µSv/h	24/04/2023 07:20
Fukushimakenritsusomanougyokotogakko	0.064	µSv/h	24/04/2023 07:20
Kashimahoikuen	0.063	µSv/h	24/04/2023 07:20
Sakuragaokahoikuen	0.063	µSv/h	24/04/2023 07:20
Kiyobashishukaijo	0.063	µSv/h	24/04/2023 07:20

Figure 4.6: CSV file of the monitoring data of the map displayed in Figure 4.5.[370]

[369] The map shows a radiation value that was monitored at 07:20, 24th24 April 2023, in the Soso area in the Fukushima Prefecture. The caption shows the profile of a monitoring location of Karasuzakikokaido, and. In addition, it indicates the location's GPS coordination of the location coordinates, the device category, the measurement unit for the radiation value (measurement device specification) and the device's position of the device (height from the ground).
Nuclear Regulation Authority, 'Radiation Dosage'.

[370] On the same page as the map presented in Figure 4.5, the monitoring data on which the map is visualised can be downloaded. From the left, the columns indicate the location name, radiation value, radiation unit and date. The first row shows the monitoring data from Karasuzakikokaido, corresponding to the location in Figure 4.5. As described in Section 4.2.1, the information listed on the map is omitted from the CSV file.

Much like with technical objects, it can be argued that monitoring data individuation processes have both inductive and deductive aspects, i.e. they are transductive. Specifically, monitoring data are formulated based on a specific data format, in this case, CSV files with an organisation order, such as column registry and value grids. This process is inductive, as a certain format determines the data concretisation. However, at the same time, how data should be formalised is based on the aims of the specific monitoring project, which vary from data browsing on a spreadsheet application to data visualisation. These social and technical conditions deductively structure the individuation process. Moreover, the radiation energy, the sensor quality and the monitoring methods condition the digitisation of the radiation level.

The elements constituting the relations of radiation monitoring are seen as the preindividual and metastable state of monitoring data that is also transindividually conditioned and regulated by technical aspects, such as data format, metadata categories and the software reading the data for further application. According to Massumi, the data transduction process creates a potential for data application.[371] Chapters 2 and 3 explored how the multiple orientations of the several data visualisation projects influence contamination. Following Amoore and Deleuze, and focusing on Project Hayano's data visualisation, how spatial metadata modulates contamination was observed when data from different datasets are combined.[372] Based on the discussion presented in this section, a certain perspective can be developed on data modulation with transindividuality. According to Kitchin and Dodge, software transduces space by modulating socio-spatial relations produced through codes.[373] As previously shown, this transindividuality is connected to the transductive process of data

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Nuclear Regulation Authority, 'Radiation Dosage'.

[371] Massumi, *Parables*, 124.

[372] Louise Amoore, *The Politics of Possibility: Risk and Security Beyond Probability*, (Durham: Duke University Press, 2013), 90–91; Gilles Deleuze, 'Postscript on the Societies of Control, *October*, Vol.59 (1992): 3–4, https://www.jstor.org/stable/778828.

[373] Kitchin and Dodge, *Code/Space*, 73.

generation, which is subjected to social and technical monitoring practices and actualised in the form of contamination level data and metadata on time and location. Hence, this process makes the contamination data spatially and temporally relatable with metadata and can be combined with software applications. Through the formalisation of the CSV format, monitoring data gains these relations that lead to space and time modulations.

In this section, monitoring data is defined as digital objects converted from radiation into the CSV format, and it is suggested that these digital objects have transindividuality to support data visualisation. Chapter 5 explores the modality of space and time further.

4.2.2 Monitoring Devices

Thus far, we have discussed the monitoring data as digital objects. Digital objects similarly concretise through technical and digital milieux, just as technical objects are the concretisations of interactions conditioned among various technical and natural milieu levels. In the case of radiation monitoring procedures, the signal generated when a semiconductor sensor responds to radionuclides is first digitised, and the relationship between the radiation and the technical devices is then concretised as an electric signal and then as digital monitoring data. In this digitisation process, signalised and digitised ‘radiation’ travels through natural, technical and digital milieux, as well as digital map displays. In this process of radiation becoming intelligible for machines and humans, the question remains as to how technical and digital devices function and what they conduct through their operation.

As individual devices, radiation detectors sense radiation in the natural environment and also convert the detected radiation into binary data with various metadata. Furthermore, detectors with monitor screens can display monitoring results and store and transmit the data to other databases through the informational network. Considering these characteristics, these devices mediate between data as a digital object, humans and other technologies.

Moreover, this process is performed by linking a detector and other devices. This thesis has primarily focused on monitoring data organised to be legible for personal computers through programmes such as spreadsheets and mapping software. Digital maps display the data, organised according to a specific format and displayed using various visualisation logics. In addition, certain radiation detectors with commercial availability can link to mobile terminals, such as smartphones and laptops, to display monitoring results on these devices through a software programme. For example, a non-profit organisation, Radiation-Watch Japan, develops affordable mobile radiation detectors known as the PocketGeiger (Figure 4.7). This semiconductor-type detector links with mobile devices through a headphone jack and a USB port to monitor and visualise the data on the organisation's digital mapping application.[374] This means that in addition to detectors made expressly for radiation monitoring, transmitting, receiving and browsing monitoring results, generic devices that transfer data for the radiation monitoring media ecosystem are also incorporated.

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[374] Radiation-Watch Japan, 'PoketGeiger', accessed: 23 February 2023, http://www.radiation-watch.org/p/pocketgeiger.html.
Android and Arduino users can alter and redistribute their applications using the Creative Commons licence. The electric signal from the detector is processed as an audio signal. Hence, as long as users' mobile devices have an audio jack that can take an external input signal, various devices can process these signals with different software. For example, this user creates an original software that visualises the radiation pulse compatible with PocketGeiger. It saves the data in CSV format to allow for sharing with other users. See: Supermab's blog, 'Using PocketGeiger with a Computer No.2 (ポケットガイガーを PC で使う（その２）)', 17 November 2011, http://supermab.com/wp/%E3%83%9D%E3%82%B1%E3%83%83%E3%83%88%E3%82%AC%E3%82%A4%E3%82%AC%E3%83%BC%E3%82%92pc%E3%81%A7%E4%BD%BF%E3%81%86%EF%BC%88%E3%81%9D%E3%81%AE%EF%BC%92%EF%BC%89/.

Figure 4.7: Radiation-Watch Japan's PocketGeiger.[375]

The mix of technical and digital items serving as monitoring devices that mediate data between machines and humans will be defined to consider this aspect of mediation. In Chapter 2, the concept of the meta interface was introduced to consider the aesthetic relationship between a mapping tool and a database. The organisation of monitoring data into a database in a particular format serves as an interface for both computers and people to process the data for additional data transactions. These databases are designed to be readable from the above perspectives. Users employ software applications or interfaces such as spreadsheets, graphic diagrams, web browsers and mapping tools to read the data. In the process, one interface

[375] James Holloway, 'PocketGeiger: The $46 iPhone Geiger counter', *New Atlas*, 1 March 2012, https://newatlas.com/pocket-geiger-counter/21670/.

interacts with another to produce a new understanding of the data through computational procedures that involve a particular aesthetic for data organisation. According to Andersen and Pold, this element of translating another interface is known as a 'meta interface'. The authors critically examined the hidden layers behind an interface visualisation using the concept of meta interface, as demonstrated in Chapter 2.[376]

Considering the examples presented in this chapter, the monitoring data categories in a CSV file can be viewed as a form of meta interface between the monitored contamination and the software and devices that read the data. The aesthetics of the CSV grid spreadsheet file displays certain radiation monitoring meta-relations that are hidden from the data visualisation on the digital maps since each piece of monitoring data comprises metadata, such as time, position and device identification. The transindividuality of data, which allows for observing relations spanning one monitoring dataset and being understandable by humans and machines, was highlighted in the previous section. From this perspective, it can be considered how monitoring information derived from the CSV file's sections indicates its transindividual association with its external milieu.

As previously demonstrated, data can be transmitted from a monitoring post to a database using a packet-switching technique. In this approach, data are divided into packets and transmitted through a digital network. Unlike the telephone network's circuit-switching, which charges per time, the packet-switching method only charges for transmitted packets. As a result, the latter has been applied in real-time radiation monitoring programmes in Japan to cut the communication costs between monitoring sites and databases.[377] For example, in monitoring programmes run by municipalities, data are transmitted from monitoring stations

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[376] Christian Ulrik Andersen and Søren Bro Pold, *The Metainterface: The Art of Platforms, Cities, and Clouds* (Cambridge: The MIT Press, 2018), 11.

[377] Fuyuki Maruta and Keji Kato, 'Abstract on the Environmental Radiation Surveillance Information Sharing System (環境放射線監視情報共有システムの概要について)', Niigata Prefecture radiation surveillance centre annual report 2 (2004), https://www.pref.niigata.lg.jp/uploaded/attachment/41095.pdf.

every 2–15 minutes, and the network's features cause this time lag.[378] Therefore, it is reasonable to state that the CSV files' metainterface shows the time lag created by reaching the socio-technical threshold for technological communication. Andersen and Pold state that the social aspect of a tool emerges before its mechanical aspect.[379] According to the theory of transindividuality, this sociality is the potentiality that is transductively affected by the interactions of various objects. Combining these ideas makes it possible to argue that browsing monitoring data files not only gathers relationships between data but also produces a particular perception of contamination under socio-technical contexts, such as the cost of communication. Consequently, the concerned monitoring devices may be considered both a data reader and a producer of users' perceptions influenced by technological and social transindividualities since they serve as the meta interface to monitoring data. For example, as shown in Figure 4.2, the operation spreadsheet reads the monitoring data and presents it to its viewer through the information categories organised by columns and rows.

Therefore, a particular layer of the monitoring device can be defined as a data reader tool and a perception maker. However, while Andersen and Pold describe the software application as a meta interface, they leave room for further discussion, i.e. the physical aspect of a meta interface. For example, spreadsheet software can be viewed as a metainterface for CSV files and an interface for monitoring data, as demonstrated in the examples presented in this chapter. However, at the same time, these metainterfaces are also manipulated through the physical devices that users control. As demonstrated by the PocketGeiger example, when combined with mobile devices, the detectors can be used in the environment, and its users can simultaneously monitor and browse the monitoring data. The detector becomes a monitoring device by individualising and using the mobile computer and software application. According to Lev Manovich, these generic computers serve as metamedia that manipulate

[378] The thesis referred to the NRA's CSV data publication to compare monitoring results from different prefectures. See: Nuclear Regulation Authority, 'Radiation Monitoring Information'.
[379] Andersen and Pold, *Metainterface*, 51.

many software programs of various media forms to seek data. These programmes operate interactively with their users through a graphical user interface.[380] Therefore, hardware and software can be considered inseparable, and hardware is also a component of the metainterface for monitoring data. Furthermore, generic computers can be considered monitoring devices, as they can browse the monitoring data by activating and operating certain software applications, such as browsers.

Today, radiation monitoring posts are widely distributed in post-Fukushima Japan, and the automated machines continuously generate real-time monitoring data. Screens, keyboards and touch screens are integral to the operations of the metainterface with the data, serving as a gateway to the monitoring data. However, since human reading is not an automated process, using a physical object and reading data are connected. Considering this characteristic of monitoring culture, the devices used for reading and displaying data will be the main focus. Thus far, the individuations of technical and digital devices have been discussed, while the existence of radiation monitoring agencies in the different milieux has also been described. Based on these debates, the question remains as to how monitoring devices can be understood.

Based on Simondon and Hui's research, Jorge William Montoya coined the 'digital device' concept, which is distinguishable from the digital object. According to Montoya, digital devices are entities that can read and interpret the binary code of digital objects into specific, understandable formats, such as images, applications, and sounds. However, this translation process does not interact with the external milieu.[381] Instead, Montoya continues, '[i]f the analogue object was a mediator between the world and the human being, the digital device brings with it a new schema of communication: the device's materiality allows access to a

[380] Lev Manovich, *Software Takes Command* (London: Bloomsbury, 2013), 110 and 114–115.

[381] Jorge William Montoya, 'From Analog Objects to Digital Devices: An Analysis of Technical Objects through a Simondonian Perspective', *Philosophy Today* 63, 3 (2019): 719–720, https://doi.org/10.5840/philtoday2019115291.

digital object engaging in dialogue with the world'.[382] For example, Montoya refers to the difference between a paper and a digital map. While users can directly access the information on a paper map by reading, digital maps such as Google Maps need a device to help them read the information.[383] As such, the analogue paper map mediates between the technical and informational world and the sensorial perception of humans, while the digital device translates the data for the digital map, where humans interact with the information as they browse. Hence, a digital device is an informative platform that connects humans with digital objects through reading and translating data.

Montoya also emphasises how the digital device acts between the data and the users and argues that they are closed technical objects that their users do not influence. In this case, Montoya is referring to the internal mechanism of generic computer components that do not function on a terminal that previously underwent third-party repair.[384] In addition, Montoya argues that although users control digital devices, the users are not directly exposed to the materiality of the physical aspect of these products.[385] This is because the users are not manipulating the physical part of the device but the digital objects that the device shows them. In this sense, Montoya characterises the digital device as the enclosed element that maintains its independence from its external milieux. While his theory is based on Simondon and Hui's observations, Montoya disputes the separation between digital devices and their milieu.

We can develop our perception of monitoring devices by critically analysing the concept of digital devices. The digital device is the mediator between humans and the world around them. Moreover, the monitoring devices discussed in this thesis can also serve as the bridge between the users, specifically observers and data browsers, and the contaminated environment. Furthermore, certain physical layers of these devices are shielded from the users, meaning they can retain their self-maintenance while functioning as a data reader that reflects

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382 Montoya, 'From Analog Objects', 719-720.

383 Montoya, 'From Analog Objects', 719-720.

384 Montoya, 'From Analog Objects', 723.

385 Montoya, 'From Analog Objects', 723.

certain aspects of the world. For example, while bGeigie Nano and PocketGeiger have the flexibility of network connections through cables and a Bluetooth wireless connection, their users cannot select other standard connection options for which those devices were built. Therefore, the monitoring devices maintain functional stability due to this separation from other standards.

Contrary to Montoya's claim, this thesis proposes that the materiality of physical media may impact the users of digital objects. In Montoya's analysis, how the physicality of the media can be interlinked with its user is not considered, thus, a case that bridges the gap between a user and a digital device with a physical component is introduced.

According to Sara Sintonen's auto-anthropological research on the educational use of touchscreen devices, devices' analogue and digital aspects can collectively generate sensory experiences that cannot be attributed solely to the physical or the digital.[386] In her study, Sintonen sets out a theoretical framework using Karen Barad's ideas of entanglement and intra-action as a guide. According to Barad, intra-action is a movement between the various agencies that foregrounds the entanglement, which changes the distance between a phenomenon and its observer. Entanglement is the relationship between multiple agencies in different registers that are entangled through relative actions.[387] Barad's terms 'entanglement' and 'intra-action' refer to actualised relations in operation as a result of a specific action, which is in contrast to Simondon's concept of 'transindividuality', which refers to the virtual linkages in the potential of individuation. Hence, with these concepts, we can consider how the use of devices can generate relations through actions. Sintonen elaborates on Barad's ideas by using the example of drawing to show how learners and digital learning tools develop during the intra-action of learning. This leads to a new understanding of shapes due to digital drawing

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[386] Sara Sintonen, 'From an experimental paper to a playful screen: How the essence of materiality modulates the process of creation', *British Journal of Educational Technology* 51, no. 4 (2020): 1322–1333, https://doi.org/10.1111/bjet.12906.

[387] Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham: Duke University Press, 2007), 29 and 33.

features such as layering graphics and redrawing without leaving traces. In addition, Sintonen argues that using hands on a screen causes a physiological reaction distinct from actions performed with analogue tools, such as feeling the texture of the materials. As a result, the physical aspect of digital devices can be viewed as a part of the intra-action between users and tools.

As with the usage of the monitoring device, Barad's theory of intra-action radiation monitoring, which is carried out at both the physical and the digital stages of machine usage, maintains that the physicality of machines still plays a vital role. For example, the portability of the devices is essential for simultaneous monitoring and browsing of a monitoring result within the monitored environment. Additionally, users can access monitoring data using a combination of various physical actions to access the database while browsing data with other devices, such as home computers with a screen and other physical interfaces, such as a keyboard and a touchpad. Meanwhile, when using mapping software to view data, such as when browsing digital maps with a zoom-in and zoom-out feature, the interface design can be coupled with the touchscreen of mobile devices such as tablets and smartphones.[388] The device's materiality necessitates a particular arrangement of hand and finger motions to manipulate it. As a result, intra-actions such as monitoring and data browsing can reveal a user's specific physical reactions to a device through body movement.

This viewpoint gives the earlier considerations of subjectivity a new context. In Chapter 3, the machinic subjectivity formed among observers and technologies was introduced, and through the concept of mutual inclusivity, the interactive and mutual relationship between them was defined. Similarly, the intra-action can also occur in an interactive relationality between human and more-than-human agencies. Accordingly, based on these considerations, it can be noted that through the intra-action of monitoring, the subjectivity of the action between people and technology is formed and is in metastable conditions for further individuation. Therefore, monitoring can be viewed as the process of assembling monitoring devices.

[388] Safecast, 'Safecast Map'.

Subjectivity and entanglement, in this sense, are a node where people and technology are combined using components from various milieux.

In summary, while software applications – the materiality of which can be confined to its users – can be seen as distinct from digital devices, the materiality of machines is intertwined with them through the intra-action of monitoring. For example, the interactive action of zooming through users' body movement cannot be realised without the physical device or the application since the device's mobility is crucial for monitoring the environment. Furthermore, as discussed in the previous sections, objects are a group of transindividually formed relationships. This transindividuality can be considered as the modularity or virtuality of monitoring devices. These connections serve as the monitoring tool for contamination through the interdependence of humans, actual machines, and software. Based on this, the focus will now shift to the radiation monitoring infrastructure, where the parts of the devices are assembled.

4.3 Radiation Monitoring Infrastructure in Post-Fukushima Japan

Thus far, how technical and digital objects have concretised and monitored radioactive contamination has been studied. Both technical and digital objects undergo the individuation and concretisation of multiple relations that span multiple milieux. Then, it was observed that while monitoring devices play their roles, they also form part of the monitoring system network.

This final section of this chapter explores the monitoring infrastructures of the Fukushima nuclear disaster, where digital and technical objects are operating with humans. Using Simondon's theory, objects have previously been described as relations in metastable conditions capable of further individuation. However, if the infrastructure also aggregates these relations where transductive individuation occurs while forming transindividualities, the question remains as to how its figures can be delineated.

4.3.1 The Production of Visibility and Infrastructure

To better understand the damage level of a disaster in a specific area, the technological infrastructure of that area plays a significant role in gathering knowledge. In *The Politics of Invisibility: Public Knowledge about Radiation Health Effects after Chernobyl*, Olga Kuchinskaya observes the impact of limiting public knowledge on the Chernobyl nuclear disaster. In the study, Kuchinskaya defines 'articulation' as a term used to explain the damage that the disaster caused and the necessary measures for mitigating the resulting hazards.[389] Kuchinskaya also defines 'infrastructures' as 'the information systems and equipment that support the practices of articulating Chernobyl-related effects by expert and non-expert communities. These infrastructures are embedded in existing institutional arrangements, and they invisibly support research tasks and the accumulation of data'.[390] Hence, articulating the Chernobyl nuclear disaster cannot be separated from assessing the conditions of infrastructures. Thus, enabling experts and non-experts to articulate the hazards. According to Kuchinskaya, the articulations and 'invisibility' of the radiological contamination risk are also conditioned by infrastructure:

> [a]rticulations as discursive definitions of danger are not absolute (accurate or not accurate) but relative and dialogical: they make radiation more or less visible. Infrastructural conditions define the limitations of this process, and the production of invisibility might become irreversible if the infrastructural conditions required for

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389 Olga Kuchinskaya, *The Politics of Invisibility: Public Knowledge about Radiation Health Effects after Chernobyl*, (Cambridge: The MIT Press, 2014), 9.

390 Kuchinskaya, *The Politics,* 9.

> articulating the presence of radiation and its connection to health effects are disrupted.[391]

Kuchinskaya utilises the word 'invisibility' in reference to the fact that radiation is invisible to demonstrate how impossible it is to articulate a disaster under specific infrastructure conditions. Articulations are discursive because their relative and dialogical characteristics are always local and unique to a specific context. Hence, articulation or interpretation is always embodied by the social context and infrastructures.[392]

Kuchinskaya's observation on the relationship between articulation and infrastructure is insightful for this thesis in two ways. First, during the discussion, the pre-determined radiation figure is not confirmed. The interactive articulation process among experts, non-experts, and local infrastructure produces radiation visibility. Second, the agency conditions can differ depending on the local articulation process. In this process, the technical and infrastructural conditions are crucial but are not the only factor regulating the disaster's articulation. As this thesis demonstrated in Chapter 3, the sociopolitical environment also affects the radioactive dosage threshold standard. Chapter 2 considered how a gamma camera's vision is generated through the camera's perspective, the natural environment, and the radiation. Following Kuchinskaya, the gamma camera's vision can be understood as an 'articulation' of the radiation gained through the dialogue between these entities. Additionally, the analysed radiation monitoring programmes share some elements of relative and local articulations, albeit that the forms and methods of visualisation differ.

At the same time, this thesis and Kuchinskaya's argument entail different approaches to comprehending the combinability of infrastructures. As shown in the previous sections and in Chapter 3, Safecast, a company that creates monitoring infrastructure and data publishing for public institutions, offers various monitoring instruments, including radiation detectors,

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[391] Kuchinskaya, *The Politics,* 8.

[392] Kuchinskaya, *The Politics*, 8.

software such as spreadsheets, and digital maps. These examples demonstrate how users can control monitoring equipment using communication terminals and apply their data using the provided data visualisation software. Additionally, since the monitoring data is stored in databases in publicly accessible formats, it can be stated that the data is becoming a component of the infrastructures for articulating nuclear disasters. In these instances, infrastructures are not fully integrated into pre-existing institutional systems; rather, citizens choose and reassemble them into their own digital devices that articulate the disaster. As mentioned in the introduction of this thesis, the Fukushima nuclear disaster is different from the Chernobyl incident because it is an event that occurred within the informational society.[393] Therefore, the question remains as to how the technological aspects of infrastructure can be further investigated.

4.3.2 Infrastructure as a Contingency

The infrastructures of nuclear monitoring in post-Fukushima Japan are composed of adaptive observational agencies developed and distributed through the remodelling and construction of radiation detectors and monitoring stations. Hence, these infrastructures can be observed in terms of transduction, enabling the study of their individuation without pre-determined figures. Gabrys claims that the digital infrastructures of environmental

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[393] In Susan Schuppli's art installation, *Delay Decay* (2016), she illustrated the fact that the Russian government did not publicize the Chernobyl disaster immediately after its occurrence, and with this example, the relationship between the invisibility of radiation and the media environment can be considered. The installation consists of a compilation of audio excerpts from Gorbachev's television broadcast on 14 May 1986, coupled with the front page of the Pravda newspaper, which covered the Chernobyl accident from 26 April 1986, when it occurred, until its first appearance on the newspaper's front page on 15 May 1986, which was a span of 20 days. A foreboding dark cloud looms on the screen above the vitrine. This installation illustrates how the 'delay' of the announcement can be perceived concerning the newspaper coverage that did not refer to the disaster until Gorbachev's speech.
See: Susan Schuppli, *Delay Decay*, 2016, https://susanschuppli.com/DELAY-DECAY-2.

measurements, comprised of relationships between machines, people, and environments, are in contingency, while she also compares contingent infrastructures to Norbert Wiener's automatism. As observed in the radiation monitoring posts, the infrastructure is becoming automated in the measurement systems. This is similar to Wiener's idea of cybernetics, which views humans as the sensor-actuator in the servo-mechanism system that performs automatically based on a certain trigger.[394]

According to Gabrys, automatism views the components of its system as fixed or established; however, according to Simondon, they should be viewed as open and inventive. For example, 'machines' and 'humans' transindividuate with other elements in the system, such as machines and environments. Therefore, digital infrastructures need to be depicted as open to advancing relational processes without the determined roles of its components. Subsequently, Gabrys proposes contingency as a key term to describe the concretisation of digital infrastructure. The infrastructure's components interact to produce the observer of environmental phenomena, which is then transformed into data. Hence, to bear these interactions, infrastructures constantly and contingently concretise without pre-determined forms.[395] The contingency is also situated within local relations and 'is also generating particular materialisations of sensor-spaces, transforming environments'.[396]

This account of digital infrastructures is associated with Kuchinskaya's articulation of local and dialogical processes. Radiation monitoring devices are developed through the intra-action of the observer, technical, digital objects, and natural environments. Here, the infrastructures are regenerated through the relations between multiple agencies that play different roles. For example, the monitoring observers can simultaneously be browsers of monitoring data, while computers operate as data transmitters and visualisers. Similarly, communication infrastructures for monitoring data operate as networks between detectors,

[394] Gabrys, *Program Earth*, 256.
[395] Gabrys, *Program Earth*, 256.
[396] Gabrys, *Program Earth*, 261.

humans, and databases. As a result, the infrastructure contingently changes its roles in a particular local context.

The concept of data flexibility was considered in the previous section and in Chapter 2, leading to understanding contamination through mapping and visualisation software operation. Mapping software such as Google Maps and Leaflet are incorporated into the monitoring infrastructure and have become platforms for different monitoring projects.[397] According to the study by Plantin *et al.*, this process can be viewed as 'a "platformization" of infrastructure'. In addition, since the project platforms make monitoring data available for public use, they are infrastructured for use by other platforms.[398] Therefore, infrastructures are not simply used by platforms; the former also regenerates through the latter's activities.

Based on this, as a collective entity, a platform is constantly developing and generating a new sensorium to articulate the contamination with contingent infrastructures. Each monitoring project is an entanglement of human elements, social strategy, and technological and digital objects derived from the monitoring infrastructures. Notably, entanglement formation results from the interaction between a certain group of laboratories and institutions and between them and external groups. According to Fuller and Weizman, laboratories and institutions conduct sense-making through several meetings and forums.[399]

Both Gabrys and Kitchin and Dodge argue that using sensors redefines the environment and space by creating a new perception of contamination through data collection and visualisation.[400] Furthermore, Tavmen defines data as an infrastructure where humans and

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[397] Safecast, 'Safecast Map'; The Nuclear Regulation Authority, 'Radiation Dose'.

[398] Jean-Christophe Plantin *et al*. 'Infrastructure Studies meet Platform Studies in the Age of Google and Facebook', *New Media & Society* 20, no. 1 (2018): 295, https://doi.org/10.1177/1461444816661553.

[399] Matthew Fuller and Eyal Weizman, *Investigative Aesthetics: Conflicts and Commons in the Politics of Truth* (London: Verso, 2021), 219.

[400] Gabrys, *Program Earth*, 261; Kitchin and Dodge, *Code/Space*, 73.

associations are transduced through data and software operation.[401] The infrastructure then enables the transduction of space through their actions. Similarities between this transductive process and Kuchinskaya's proposed dialogical and locational processes can be seen in the situations examined in this thesis, such as the development of Safecast through citizen collaboration, scientific workshops, and academic institutions. These organisations serve as monitoring platforms and are a component of monitoring infrastructures, supplying sensors for users to combine and utilise alongside monitoring devices.

4.3.3 The Monitoring Infrastructures and the Mesh of Monitoring

Now that the contingent character has been observed, the question remains as to how the relations in the monitoring infrastructures can be defined. Notably, networks have several connection layers, scales, and standards. In the case of Safecast's bGeigie Nano, the device is connected to mobile communication terminals via Bluetooth, after which monitoring data are uploaded to the group's database through the broadband network. This example demonstrates two different network scales: Bluetooth, which connects the device at a local scale, and the broadband network, where the local devices access the database that can be located anywhere regardless of the local terminals' position. According to Adrian Mackenzie, the multiple scales of wireless network infrastructures can be linked to framing a single space.[402] It is possible to observe that these machine networks and software frame space, which helps in understanding the contamination level. This final section considers how to frame a space in relation to monitoring strategies.

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[401] Güneş Tavmen, 'Data/infrastructure in the smart city: Understanding the infrastructural power of Citymapper app through technicity of data', *Big Data & Society* July–December, no. 3 (2020): 1–15, https://doi.org/10.1177/2053951720965618.

[402] Adrian Mackenzie, *Wireless: Radical Empiricism in Network Culture* (Cambridge: The MIT Press, 2010), 98 and 101.

The KURAMA radiation monitoring system comparisons were introduced earlier in this thesis. The scientists at the University of Kyoto developed this system, which follows a specific scientific methodology. Following this, through working with National Instruments, a US electronic company, they produced various types of mobile radiation detectors, from environmental monitoring posts to detectors designed for cars. KURAMA uses mobile networks such as 3G and LTE to transmit data between the detectors and cloud servers. The monitoring results can be browsed through an application in different forms, such as digital mapping and graphic spectral data. With these technological characteristics, KURAMA employs a 'mesh' sampling method.[403] This method divides an area to be monitored into several grids and collects and aggregates samples into a dataset. In KURAMA's monitoring strategy, an area is divided into grids of 100 m^2, which are monitored every three seconds. As such, a monitoring data mesh of grids is generated to determine the average contamination level.

This method's conceptual framework is used to describe the network type at the technological communication level rather than to describe a form of sampling. The developers also aim to materialise this concept in their distributed monitoring network. For example, KURAMA is developing an autonomous networking system among distributed radiation sensors. In this monitoring model, each sensor installed in the environment is connected through the ZETA network,[404] forming a mesh network in a particular monitoring area (Figure

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[403] In English, the term 'systemic point' is used for the same sampling method instead of 'mesh'. For example, mesh sampling is used for urban planning to grasp the rate of land use and agriculture in a certain area.
See: Toru Yoshikawa and Astuyuki Okabe, 'The Theory of the Systemic Point Sampling and its Application (メッシュポイントサンプリングの理論とその適用) ', *Journal of Geography (Chigaku Zasshi)* 99, no.6 (1990), https://doi.org/10.5026/jgeography.99.6_659.
[404] The Zeta network is an LPWA digital wireless interactive communication standard directly connecting devices without stations.
ZiFiScense, 'ZETA: Next-Gen Technology LPWAN 2.0', accessed: 25 February 2023, http://www.zifisense.co.uk/zeta/.

4.8). The company uses this autonomous mesh network, independent of the abovementioned mobile network, to conduct radiation monitoring both flexibly and constantly.[405] In so doing, a monitoring area is technologically framed by a mesh network into single spaces through a local communication network layer. Moreover, the mesh of grids and that describing the communication network differ in the sampling method. However, it is notable that this monitoring system is based on a similar geometrical concept that frames a space to generate data and envision a network system.

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[405] Institute for Integrated Radiation and Nuclear Science, Kyoto University, 'Micro KURAMA-Ⅱ（Micro KURAMA-Ⅱ（超小型 KURAMA-Ⅱ））', accessed: 5 April 2023, https://www.rri.kyoto-u.ac.jp/kurama/kurama-micro.html.
By connecting through the ZETA LPWA network, the company can reduce the cost of using the mobile packet-switching network. In the traditional monitoring network employed in municipal monitoring projects, the monitoring data is transmitted through the mobile network and due to the communication cost, the data is transmitted every 2–10 minutes.
Minoru Tanigaki *et al*. 'Studies on networks for monitoring posts based on mesh-type LPWA', Transactions of the Atomic Energy Society of Japan, Vol.22, Issue1 (2013): 38-49.

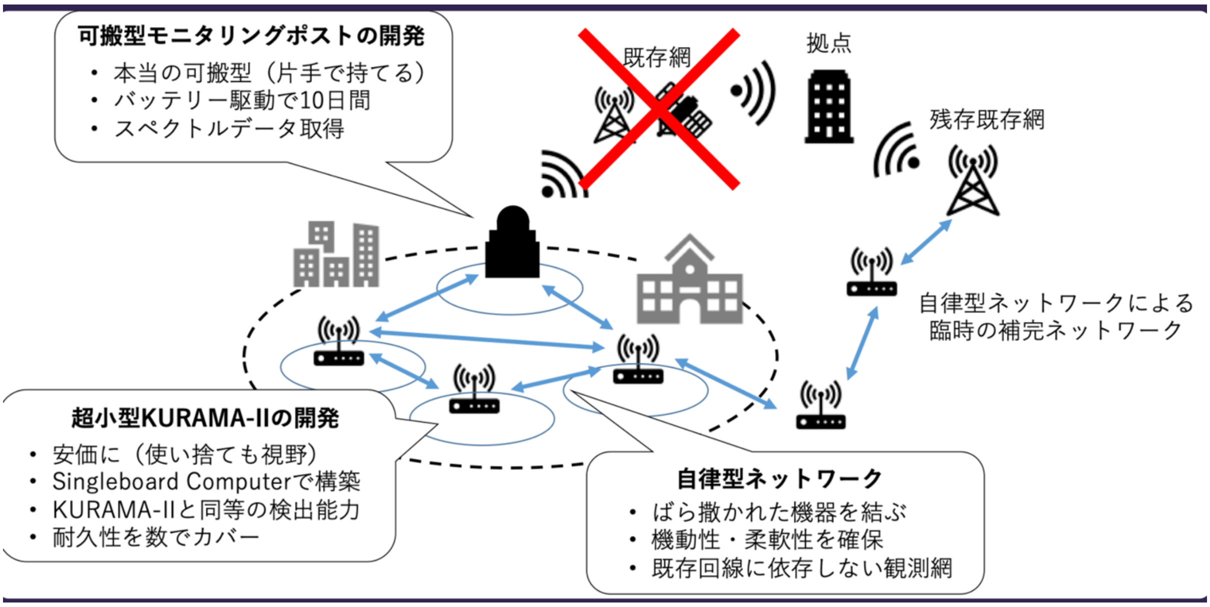

Figure 4.8: KURAMA's monitoring network.[406]

Regarding the technological communication among radiation sensors, this mesh model is not always present in other monitoring where the sensors are individually connected to the databases. For example, as Paul Baran[407] states, Safecast's monitoring network can be seen as a centralised model where each station (sensors) is linked to the centre (Safecast database).[408] Meanwhile, in the NRA's data archiving model, each municipality's monitoring datasets are collected in its database from a sensor and then archived in the NRA's information system.[409] Hence, it can be regarded as a decentralised model with multiple centres. In these initiatives, a monitored area is not framed by a grid mesh at the sensor network level. In contrast, in the KURAMA example, the monitoring devices are connected to

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406 The right bottom caption of '自律型ネットワーク' means 'Autonomous Network', and the listed bullet points explain that these monitoring devices are distributed in the monitoring area. Institute for Integrated Radiation and Nuclear Science, Kyoto University, 'Micro KURAMA-Ⅱ'.

407 Paul Baran, 'On Distributed Communications Netwroks' The Rand Corporation, 2005, https://www.rand.org/content/dam/rand/pubs/papers/2005/P2626.pdf, 3.

408 Azby Brown *et al*., 'Safecast: Successful citizen-science for radiation measurement and communication after Fukushima', *Journal of Radiation Protection* 36, S82 (2016): 88–89.

409 Nuclear Regulation Authority, 'Radiation dose measurement map'.

form a mesh network, and, according to Baran, this network corresponds to a distributed model where each station is interconnected (Figure 4.9).[410]

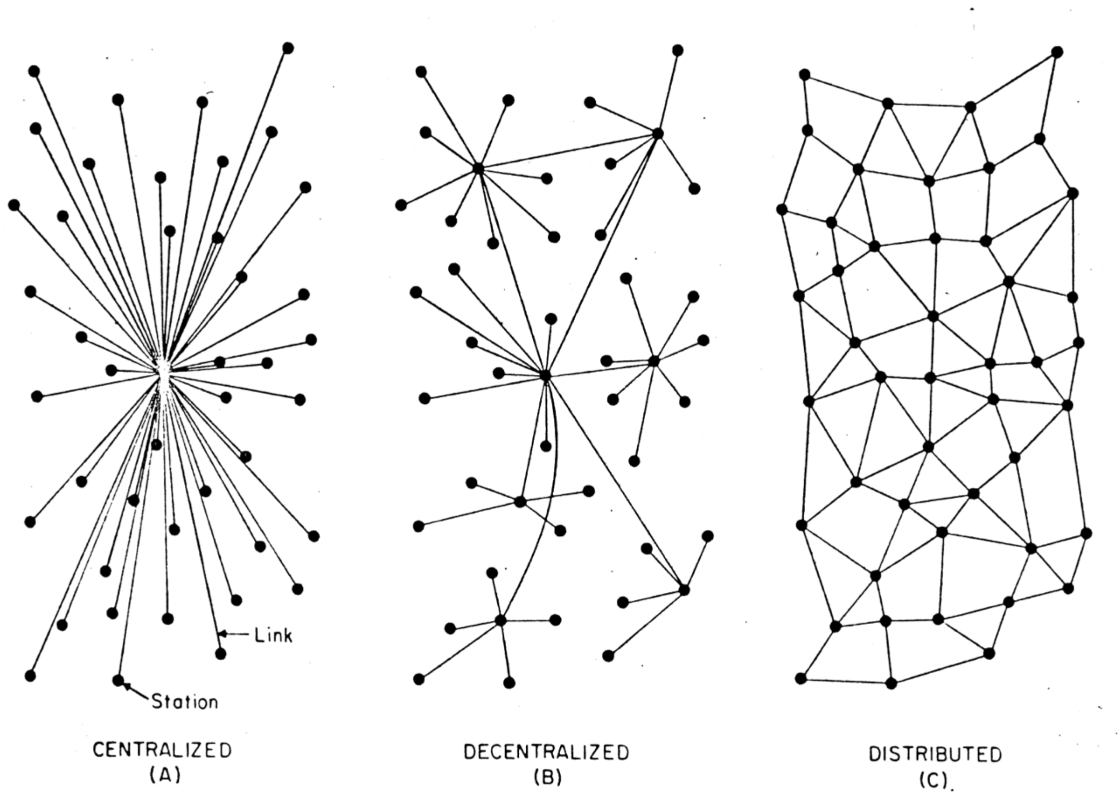

Figure 4.9: Paul Baran's image of three network models.[411]

Compared with KURAMA, the networks of Safecast and the NRA do not frame an area into single spaces in the environment at the radiation sensing layer. However, given that these platforms also make their data publicly available, it is reasonable to conclude that their databases are nodes to other layers of data applications, where users can obtain and share the publicly available data for specific reasons. On a different communication scale, a link forms between the nodes. At the data organisation scale, as shown in the previous section, formalised data in a CSV file and databases can establish connections among the data collected from topologically distributed sensors. Additionally, as observed in the Japan Atomic

[410] Baran, 'On Distributed Communications', 3.

[411] Baran, 'On Distributed Communications', 4.

Energy Agency example presented in Chapter 2, they also publicise a digital mapping tool that can visualise data submitted by users. The programme also allows users to link data that has been geographically mapped using GPS coordinates.[412]

Establishing connections between monitoring data at the software scale can also illustrate how to frame a specific area into distinct spaces. For example, another infrastructural layer of data reading and visualisation overlaps in the data application layer, and the links from sensors extend through the connection of infrastructures. The first is the environmental layer, where monitoring is conducted and data generated. The next layer is the communication and data reading layer, where users access the databases and aggregate different datasets for data visualisation. As such, the distributed sensors in the environment are not directly connected but can relate with each other through data application. Hence, each monitoring dataset is interconnected, crossing the two layers and framing space with a network of connections between the database and the digital map visualisations.

In Chapter 3, following Félix Guattari's observations, how the subjectivity of radiation monitoring forms was explored transversally across the different registers, including ecosystems, the mechanosphere, and the social.[413] Similarly, the transversality of the node connections across the different platforms and infrastructures can also be observed. An expression of these transversal relationships can be seen on data visualisation screens. From this point on, it can be considered that this relationality is flexible enough to evolve as infrastructures develop.

According to Gilles Deleuze, the moving image in a movie is made up of continuums that are constantly splitting apart at different cuts and then repeating the process to create a new continuum. Therefore, the images constantly move over the different fragment positions.[414] Deleuze also explains that those moving images are in 'the process of an always open

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[412] Japan Atomic Energy Agency, 'Mapping tool'.

[413] Felix Guattari, *The Three Ecologies* (London: Bloomsbury, 2014), 28.

[414] Gilles Deleuze, *Cinema 2: The Time-Image* (Minneapolis: University of Minnesota Press, 1989), 120.

totalisation' where different images are constantly internalised and externalised onto the screen.[415] With this viewpoint, it is possible to define the sensor node networks, generated data, database connections, and users' data reading and visualisation. The network components are fragmented but connected over the two layers of monitoring and reading. On the users' screens, monitoring data derived from topologically distributed sensors that constantly generate data are connected and form a mesh that frames an area into single spaces traversing the different layers. Then, the monitored areas are framed into single spaces through the local and dialogical or interactive action between humans and machines. Therefore, it can be inferred that the layers of the infrastructures, which are subsequently merged and updated in the radiation monitoring networks, form the topological mesh. The data visualisation images are a result of these relational processes. Furthermore, with the dynamic characteristics of infrastructures, the monitoring network develops contamination sensoriums and the understanding of the disaster is continuously updated.

4.4 Conclusion

This chapter examined the technical and digital objects of radiation detectors along with their monitoring data through individuation and concretisation. First, Simondon's rationale and the relevant discussions describe entities as relations in the ongoing transductive individuation process. Then, in focusing on the monitoring devices, it was highlighted how the users interactively engage in radiation monitoring and how monitoring influences human–machine interaction. Following this, the radiation monitoring infrastructure was described as a contingency that transduces the contamination reality and its components. The connection between sensors and detectors, databases, data reading and visualisation software, and its

[415] Deleuze, *Cinema 2*, 179.

users as a network that enables understanding radioactive contamination was then demonstrated.

This chapter has shown that nuclear disasters are continually transmitted to radiation monitoring entities such as detectors and people through the infrastructures. Based on this viewpoint, the next chapter will analyse how digital maps have been deployed to delineate disasters regarding space and time.

Chapter 5

Radiation Monitoring and Mapping in Japan: Multiple Figures of Contamination

5.1 Introduction: Digital Maps and Mapping the Fallout

Among the radiation-monitoring practices that are highlighted in this thesis, digital maps are integrated into the project to present monitoring data in relation to geographical, temporal, and meteorological information or other datasets to understand the contamination. The thesis introduction showed the use of digital maps as a significant phenomenon in post-Fukushima Japan, and we have discussed relevant cases to consider how it is related to the process of the knowledge production and the social condition in the aftermath of the disaster. In Chapter 2, we introduced information scientist Yoshinori Watanabe's mapping practice on the East Japan earthquake and the Fukushima nuclear disaster to consider the significance of data mashup in shaping an understanding of the disaster. Moreover, we also observed that, when the Japanese government did not immediately publish the data on the dissemination of the nuclear fallout, an anonymous groups of citizens started sharing their own monitoring data via Google Maps. With this example, we studied how the distrust of the government led to a citizen-centred understanding of scientific facts.[416] As shown in the thesis introduction and Chapter 2 and 3, these examples of digital mapping, the flexibility of data and multimedia mapping, the interactive functions of the digital map, such as zooming in and out, and the

[416] Anders Blok *et al.*, 'Environmental Infrastructures', 91.

accessibility to mapped contents facilitated citizens' participation in mapping the fallout and led to a formation of the knowledge in relation to geospatial information and data mashups.[417]

Regarding the data mashup and the interactivity of the digital map, mapping applications other than the above Google services are also commonly used in several mapping projects. For example, in Chapter 3, the Collective Database of Citizen's Radioactivity Labs project was explored. In this project, contamination data are mapped onto a digital map using a mapping application called Leaflet. The aim of the project is to estimate the progress of the Fukushima nuclear disaster in the future and to compare the scale of the damage to the Chernobyl nuclear disaster.[418] Then, we observed the ways in which their mapping practice contests the government's nuclear policy. These examples show that multiple understandings of the Fukushima nuclear disaster have been emerging through the common grounds of digital maps that are built upon the media and political ecologies of post-Fukushima Japan.

In Chapter 4, drawing on Simondonian relational ontologies, we explored the individuation and concretisation of the digital and technical objects that configure radiation monitoring, with focus on the relations between individuals and its associated milieux. Regarding the Simondonian analysis on digital maps and virtual spaces, the preceding research suggests some insights for this thesis. For example, observing the data collection and its application in a digital map service, Tavmen delineates this cultural and technological phenomenon as the individuation of a mapping application that transduces mapped space as the relations unique to the process.[419] Additionally, drawing on Simondon's views on the human–machine relationship, in which these are interacting and not fixed in a particular dominating relation, Woodward *et al.* illustrate the ways in which that relation can create the understanding of a

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[417] Jean-Christophe Plantin, 'The politics of mapping platforms: participatory radiation mapping after the Fukushima Daiichi disaster, Media, Culture & Society 37, no.6 (2015), https://doi.org/10.1177/0163443715584102; Hidenori Watanabe. *How to Make*.

[418] Collective Database of Citizen's Radioactivity Labs, 'What is the "East-Japan Soil Becquerel Measurement Project"?', accessed: 3 March 2023, https://en.minnanods.net/soil/.

[419] Tavmen, 'Data/infrastructure'.

natural disaster through a geographical information system and data visualisation.[420] These studies describe how individual entities, including humans, machines, data, and software, dynamically influence each other and how relations reconfigure a mapped space. Following Simondon's theory of individuation, Chapter 4 considered the order of individuation transductively; in other words, it emerges as the result of relation between an individual and its associated milieu, and these preceding studies demonstrate the relevance of the application of Simondonian ontologies in studying digital maps.

Building on the relational ontologies concerning the individuation of technical and digital objects, this chapter will consider the ways in which the data presentation through digital maps posits a particular interpretation of the contamination, focusing on functions of digital maps and data generation. There is prior research that obverses the time and space, focusing on sociopolitical relations, that constitute a digital map. For example, with the case of real-time mapping on Google Maps, which constantly synchronises its content under the condition of hyper-capitalism, where traditionally different sectors such as production and logistics are integrated, McQuire contends this real-time network further integrates and synchronises those on a global scale.[421] Additionally, observing the global political power relations behind Google Earth, Farman shows that the figure of the planet on the virtual Earth is embodied within an authorial structure, where users can also reconfigure dominant representations.[422]

Their observations well illustrate a certain figure of power and political structure that configures the global capital of Google and its services, but their arguments do not cover the technical and social relations formed through the environment, machines, software, and humans that this thesis highlights. Therefore, while this thesis resonates with those arguments

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[420] Keith Woodward *et al*., 'On Sinister Hurricane: Simondon and Collaborative Visualization', *Annals of the Association of American Geographers*,105, no. 3 (May 2015): 496–511,

[421] Scott McQuire, 'One Map to Rule Them All? Google Maps as Digital Technical Object', *Communication and the Public*, 4, no. 2 (2019): 150–165.

[422] Jason Farman, 'Mapping the Digital Empire: Google Earth and the Process of Postmodern Cartography', *New Media & Society* 12, no. 6 (2010): 869–888, https://doi.org/10.1177/1461444809350900.

in that interpretations of the contamination are formed within a particular political ideology and concerns as shown in Chapter 3, rather than mainly discussing certain political issues, this chapter will focus on the functions of digital maps and the system of data generation and presentation to envisage the process of radiation mapping in the media ecologies and epistemology of post-Fukushima Japan.

First, this chapter will consider the role of digital maps through the discussion of cyberspace. Since its first coinage in William Gibson's *Neuromancer*,[423] the concept of cyberspace is often discussed as the space configured in the internet culture. Following relevant debates, particularly drawing on Foucault and Chun,[424] we will describe the role of the digital map in reconfiguring the contamination.

Second, we will consider how time can be conceived of in digital maps. The amount of radiation in the environment is often understood through the concept of the half-life of radioactive substances, and the length of half-life is intrinsic to a type of substance. Digital maps are employed to visualise radiation values that are derived from those radiological characteristics with a particular temporal expression. Following DeLanda and Deleuze's discussion of extensive and intensive times, we will illustrate time as an interlock of those different time scales.[425]

The third section will explore the perception of space and time in digital maps while discussing Whitehead's concepts of extensive abstraction and prehension. Whitehead emphasises the function of extensive abstraction and sense of the percipient alike in perceiving space and time. Drawing on his relational metaphysics, we will delineate the digital map as an extensive continuum that will be perceived as space and time.

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[423] William Gibson, *Neuromancer* (New York: The Ace Publishing, 2000).

[424] Michel Foucault, 'Of Other Spaces', *Diacritics*, 16, no.1 (Spring, 1986): 22–27, https://doi.org/10.2307/464648; Wendy Chun, *Freedom and Control: Power and Paranoia in the Age of Fiber Optics* (Cambridge: The MIT Press, 2006).

[425] Manuel DeLanda, *Intensive Science and Virtual Philosophy* (London: Bloomsbury Academic, 2002); Gilles Deleuze, *Logic of Sense* (London: Bloomsbury Academic, 2015).

Subsequently, building upon this theoretical framework, the following section will investigate cases of radiation digital mapping. In Chapter 2, discussing data, database, and software interfaces, we observed the ways in which that computational assemblage on a screen can create a perspective to radiation that reflects the relations formed among social, technological, and natural elements.[426] Based on this point, the following sections will investigate how the screen and interface of data and digital maps draw an interpretation of the contamination.

Section 4 will investigate real-time radiation monitoring and temporal expressions of digital maps with the example of Safecast. Through this discussion, we will consider how the unique temporality of digital maps enables functions that draw novel interpretations of the contamination.

Section 5 will investigate the ways in which the monitoring locations on digital maps are determined by a particular monitoring method, considering three examples. First, by considering the Nuclear Regulation Authority's Radiation Monitoring Information Sharing Publication System, we will consider how the state radiation monitoring embeds certain social relations and how their data publication is open to a further interpretation of the contamination. Second, this section will highlight the Japan Atomic Energy Agency's soil survey to consider the ways in which scientific abstraction is prehended through its extensive capacity over different maps. Finally, building upon these discussions, we will consider the Fukushima Prefecture's vehicle-borne survey to study radiation monitoring in the transportation infrastructure.

5.2 Digital Maps as Cyberspace/Heterotopias: Exploring the Virtuality and Reality of Radiation Monitoring

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[426] Viveiros de Castro, 'Perspectival Anthropology; Andersen and Pold, *The Metainterface*; Haraway, *When Species Meet*.

So far, this thesis has considered two questions of virtuality regarding radiation monitoring. In Chapter 2, following Deleuze's distinction between the actual and the virtual, we have described data as the virtual that is not opposed to the real but a state of reality in the process of actualisation.[427] Then, we have considered the possibility of how data monitoring practices can regenerate an interpretation of the contamination.[428] Subsequently, Chapter 4, by observing the process of individuation with a Simondonian relational ontology, we argued that the process of transduction brings about the virtuality that enables a further individuation of objects. Data is gained through the network of monitoring devices that consists of relations from different layers of the monitoring infrastructures they belong to. In this process of data generation, formalisation, and presentation, monitoring data concretises into a form that is read by machines, software, and human viewers. This process is open to a further data application, and, in this sense, data have a virtuality that can actualise into a different form. Therefore, the visualised data on digital maps can also be thought of as a form of the virtuality that those data emit in the process of their concretisation. Then, in terms of the virtuality and the data, how can we describe digital maps? In the light of a virtuality, how do they function in reality?

To consider this question, the discussions on the definition of cyberspace can provide insights into the characteristics of digital maps. The term is used in describing a virtual space that is related to the internet culture where users share information and interact with each other. In the study of digital maps, the term cyberspace is often used to describe the property of digital maps as space.[429] Hence, observing the concept will provide a foundation on which to consider digital maps as a tool that operates to configure our perception of reality. The term

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[427] Gilles Deleuze, *Difference and Repetition* (London: Bloomsbury, 2014), 275.

[428] Terranova, *Network Culture,* 26–27.

[429] Eric Gordon, 'Mapping Digital Networks from Cyberspace to Google', *Information, Communication & Society*, 10, no. 6 (2007):885–901, https://doi.org/10.1080/13691180701751080; Marie-Laure Ryan, 'Cyberspace, Cybertext, Cybermaps', *Dichtung Digital. Journal für Kunst und Kultur digitaler Medien*. Nr. 31, Jg. 6, Nr. 1, S (2004): 1–34, http://dx.doi.org/10.25969/mediarep/17635.

was originally coined by novelist William Gibson in his novel, *Neuromancer*. Gibson describes cyberspace as the computational space human consciousness can access via technological mediation and where its characters act in the same way as they do in their real space. In this fiction, cyberspace is understood as a virtual space where its characters exist and interact with others while maintaining their identity that is identical to the one in their reality.[430] Since the coinage of the term cyberspace, it has been used to describe the space in the internet culture. Dodge and Kitchin define cyberspace as conceptual spaces within informational and communication technologies (ICTs), instead of technology solely, and according to them, the space is conceived from the relational network between users. Through users' interactions, such as sending emails and browsing information in other computers, the relation is conceived as a space. Then, in relation to the internet culture, the virtual reality of a visualised computer-generated environment has been developed.[431] Cyberspace in contemporary internet culture has been thought of as a place where users are relating with others through a certain computational operation, and the place is rendered with visual images, as we have seen in the case of digital maps. Also, it is important to note that those relations on the internet are partial, or from in-between elements that involve a web of communication. Discussing cyberspace and internet culture, Hiroki Azuma points out that, as the internet does not have a 'space' that holistically encompasses the informational network, cyberspace exists between multiple places, such as users' communication terminals.[432] In the sense that cyberspace does

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[430] Gibson, *Neuromancer*.

[431] Rob Kitchin and Martin Dodge, *Mapping Cyberspace* (London: Routledge, 2000),1.

[432] Hiroki Azuma, *Why Is Cyberspace Called as Such? (サイバースペースはなぜそう呼ばれるのか？)* (Tokyo: Kawadeshoboshinsha, 2006), electronic edition, 17.
Azuma criticises the view of cyberspace as a totality of the informational network and discussions that do not question why it is conceived as such space. Similar discourses can be found in the discussion of a virtual Earth that emulates the real space with maps and multiple media, such as images and videos. For example, Mark Graham defines the virtual Earth that emerges with WEB 2.0 technologies as the place that is represented in cyberspace. Contrary to this view, this thesis defines cyberspace as the group of relations, rather than a holistic integrator that contains and regulate those relations.

not holistically cover the relations in reality, this conception of space is different from the holistic vision Marshall McLuhan speaks of with the term 'global village', where space and function are instantly fused to reassemble 'all its mechanised bits into an organic whole'.[433] Hence, it is possible to say that cyberspace is a form of relations between agencies involving particular activities in the network of the internet culture.

How, then, can we consider the relation between cyberspace as a virtual space in relation to reality? To consider this question, let us consider Michael Foucault's arguments on space. Foucault coins the concept of heterotopia, which refers to a place that does not have space in a conventional sense, and he describes a heterotopia as 'counter-sites, a kind of effectively enacted utopia in which the real sites, all the other real sites that can be found within the culture, are simultaneously represented, contested, and inverted. Places of this kind are outside of all places, even though it may be possible to indicate their location in reality'.[434] Here, Foucault points out that heterotopias as a counter-site exist within reality. While heterotopias are distinguished from real sites, they simultaneously cause some effects in reality. For example, according to Foucault, a mirror itself is a utopia through which a person sees themself as they want to see; at the same time, it is a placeless place, as it has only a reflection on its surface, without depth. However, a mirror can function as a heterotopia with a person who sees their figure on the surface and reacts to the reflection. The person acts in relation to the utopic vision on the mirror, and the space where they exist is reshaped through the virtuality that mirror reflects through the action taken with the reflection.[435] Hence, heterotopia is thought of as a place where utopic visions, or the virtual, exist within reality and affect reality through the interaction between the virtual and the actual.

Mark Graham, 'Neogeography and the Palimpsests of Place: Web 2.0 and the Construction of a Virtual Earth', *Tijdschrift voor Economische en Sociale Geografie*, 101, no. 4 (2009): 422–436, https://doi.org/10.1111/j.1467-9663.2009.00563.x.

[433] Marshall McLuhan, *Understanding Media* (London: Routledge, 2001), 92–93.

[434] Foucault, 'Of Other Spaces', 24.

[435] Foucault, 'Of Other Spaces', 24.

Based on Foucault's argument, Wendy Chun describes cyberspace as a utopia 'because it enables one to see oneself—or at the very least, one's words or representations—where one is not'. According to her, cyberspace is a particular cultural form that actually exists in an interface, through which oneself is absented from one's actual physical location. For example, Chun suggests a webchat service as a form of cyberspace. In the webchat communication, a user converses by making an account that represents their self through the informational network. The user does not physically exist in the webchat, and their virtual identity interacts with others. In this case, cyberspace functions as a heterotopia that makes users unreal and connected.[436] Here, Chun defines cyberspace as 'more than a virtual location we traverse in order to reconstitute ourselves'.[437] Her argument draws an insight to delineate digital maps as cyberspace/heterotopia that affect reality with its virtuality.

With this discussion of cyberspace as heterotopia, we can portray a digital map as an interface that reconstitutes its counterpart, which, in this context, refers to a location or place in reality. As we have discussed in Chapter 3 with the example of the citizen-led radiation-monitoring project, the results of radiation monitoring can differ based on what kind of monitoring methodology is used. We observed how their mapping can show a counter figure of the contamination against the governmental policies that create safety with the pronuclear ideology.[438] As Sato and Taguchi argue, it is scientifically impossible to determine the threshold of the radiation dosage on human health, and the threshold of the dosage amount

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[436] Chun, *Freedom and Control,* 54.

[437] Chun, *Freedom and Control*, 55.

[438] In critical Geospatial Information Systems (GIS) studies, according to Peluso, this practice is defined as counter-mapping that challenge the status quo. In counter-mapping practices, what is mapped as legitimate under a certain dominant power is relativised by showing an alternative reality through mapping objects that are against the power or by mapping through an alternative mapping standard. There is also a notable critical scope to consider mapping methodologies. However, in this chapter, we will focus on how the understanding of contamination is generated through digital mapping, rather than it being viewed as a challenging figure to a certain mapping discourse. Nancy Lee Peluso, 'Whose Woods Are These? Counter-Mapping Forest Territories in Kalimantan, Indonesia', *Antipode* 27, no. 4 (1995): 383–406, https://doi.org/10.1111/j.1467-8330.1995.tb00286.x.

that is believed to be safe in the government's guideline is only a reflection of the political ideology.[439]

Also, as Chapter 2 considers the example of Project Hayano, which combines the simulation of the spread of the radioactive fallout with the dataset of the population transition, digital maps can visualise another aspect of the contamination through the virtuality of data. In these examples, the digital maps function as heterotopias in a way that they reconstitute the understanding of the contamination by virtualising the real counterparts of radiation and relevant entities, such as population and geographical characters. Digital maps combine and present data to configure space, and as Chun maintains, this is a function of an interface between the real and the virtual. In this process, these maps are formed in relation to their counterparts and what is being mapped, and they affect how reality is perceived.

Through these debates on cyberspace, we consider digital maps as a form of relation between what is being mapped and its counterparts. Here, cyberspace is defined as those relations, rather than what totalises them. The radiation digital maps discussed in this thesis operate to create a specific understanding of radioactive contamination through interactions via the functions of mapping and visualisation standards. With this view, we will further consider the process of radiation mapping with a focus on the question of time and space.

5.3 Mapping the Intrinsic and Extrinsic Time Scales of Radioactive Contamination

On the digital radiation maps, radioactive contamination is mapped based on when and where radiation values are measured. As shown in the study of the concretisation of monitoring data, the contamination is monitored and transduced into the digital objects of monitoring data in relation to its external and associated milieux. The relation from radiation is becoming and extending to the screen of the digital map where the data are presented. From here, in this

[439] Sato and Taguchi. *Philosophy of Abandoning*, 95-96.

section, we will consider how the characteristic radionuclides are related to the functions of digital maps. As shown in the introduction of this thesis, radiation value is calculated based on the unit of Sv/h to show the effect on a human body per hour. Additionally, all kinds of radionuclides have their own half-life period, and, with the example of Project Hayano in Chapter 3, we considered how the radiological characteristic needs to be considered in radiation monitoring. In these cases, radiation values are understood through a particular scientific framework of time as in Sv/h and radiological half-life. Then, to grasp the condition of the ongoing contamination, several mapping projects show the transition of the radiation values in the environment by presenting monitoring data through a particular frame of time. For example, the Fukushima Prefecture has set up its radioactivity measurement map to show the transition of the contamination in the area. Figure 5.1 shows the map of radiation values in April 2011, and the webpage automatically switches to the map that reflects radiation monitoring conducted in the following years up to 2022. Figures 5.1 and 5.2 display the maps that reflect the measurements in 2011 and 2022 to show the transition between the periods.

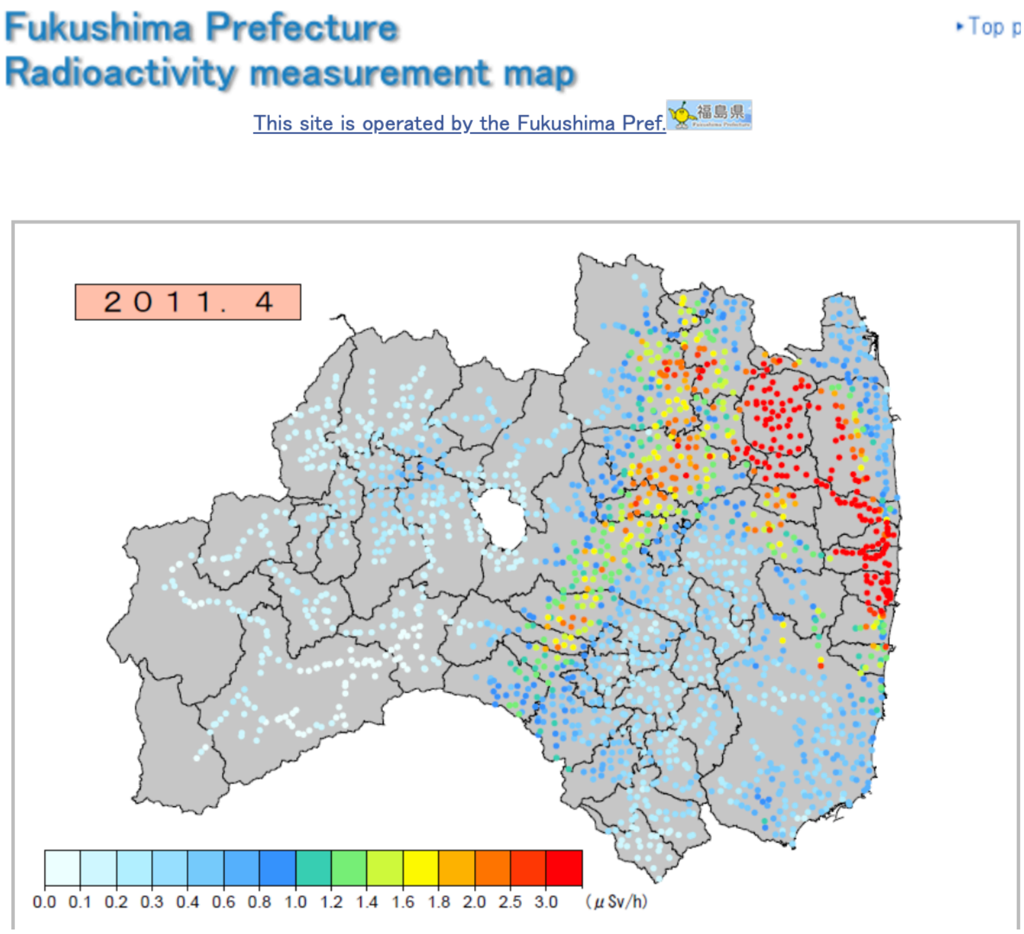

Figure 5.1: Fukushima Prefecture Radioactivity Measurement Map April 2011, one month after the nuclear accident.[440]

[440] Each dot on the map corresponds to where the values were measured. The radiation values are calculated based on μSv/h, and the degree of the values is visualised with colour gradations. The map shows that the contamination is spreading from the nuclear power plant site in the eastern part of the prefecture.
Fukushima Prefecture, 'Fukushima Prefecture Radioactivity Measurement Map', accessed: 29 April 2023, https://fukushima-radioactivity.jp/pc/?lang=en.

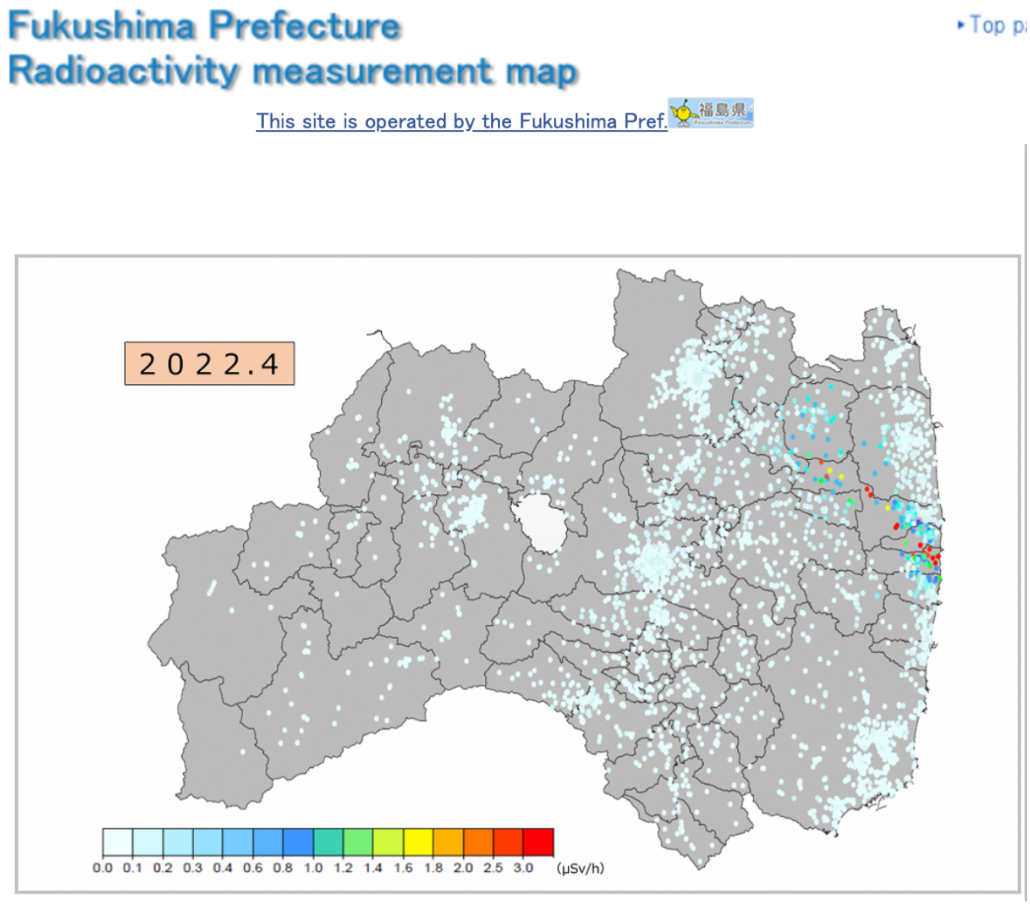

Figure 5.2: Fukushima Prefecture Radioactivity Measurement Map of April 2022.[441]

As these figures show, the transition of the contamination is grasped through the combination of two temporal frameworks: calendar date of month and year and the radiation value of Sv/h. The former is extrinsic to radioactivity, and the latter is intrinsic to it. Based on this distinction, let's consider the relation between these two frameworks of time.

First, to consider the intrinsic time of radionuclides, we will study the concept of half-life. All matter is composed of atoms and their surrounding electrons, and radionuclides have an unstable balance between their atoms and electrons, which are in the process of constant collapse that releases radiation. This process of collapse is called radioactive decay, or radioactive disintegration. In radioactive decay, the number of atoms decreases over a certain period, and accordingly, the amount of radiation also decreases. The term 'half-life' refers to

[441] Compared with Figure 5.1, the radiation values have decreased across the area.

the length of time it takes for the number of radionuclide atoms to reduce to half of the initial amount. The half-life period varies depending on the type of radionuclide. For example, among the majority of the radionuclides released in the Fukushima nuclear disaster, the half-life of iodine-131 is about eight days, that of caesium-134 is about two years, and that of caesium-137 is about 30 years.[442]

When radionuclides reach their half-life, their effects on human bodies also decrease. Therefore, it is essential for radiation monitoring to understand what kind of radionuclides are present and how long they have been in the environment. In Chapter 3, we introduced the example of Project Hayano to illustrate the relationship between half-life and a data visualisation project. In this project, radiologist Ryugo Hayano organised a collaboration with researchers, including information scientist Yoshinori Watanabe, to estimate the potential number of irradiated citizens just after the nuclear accident occurred. They focused on iodine-131 because its half-life is eight days, and they simulated how many people were potentially irradiated during this short period. In this period, radioactive substances, including iodine, were widely spread by the wind, and in a short period of eight days, it was determined a large number of the population in the East part of Japan would have been irradiated. To grasp the scale of the potential damage, they combined monitoring data from the period, meteorological data, and open data on population density changes with a digital map and SPEEDI, a computer-based radiation dosage simulation system, to visualise the potentially irradiated population around the Fukushima area.[443] This example shows the ways in which the length of the half-life that is intrinsic to a radionuclide is considered in relation the other metric time scales on the digital map.

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442 Fukushima Revitalisation Station, 'About Radiation, Radioactive Rays, and Radioactive Substances(放射能、放射線、放射性物質について)', accessed: 12 March 2023, https://www.pref.fukushima.lg.jp/site/portal/21-1.html.

443 Hidenori Watanabe, 'How to Archive Fukushima (2) (福島をいかにアーカイヴするか(2))', *HuffPost Japan*, 27 June 2013, https://www.huffingtonpost.jp/hidenori-watanave/2_7_b_3507640.html.

Then, with this view on the intrinsic and metric time systems, let's consider their relations. Following Gilles Deleuze, Manuel DeLanda explains different time scales by drawing on the concepts of intensity and extensity. According to him, extensive time refers to the metric measurement of time where time is mechanically measured by a certain exterior standard, such as seconds and minutes.[444] By discussing thermodynamics as an example of intensive time, DeLanda refers to relaxation time as a time span of an unstable system settling into a stable periodic state. This is a time scale that is intrinsic to a phenomenon and a state, such as glass and liquid; hence, it can be seen as intensive time. Relaxation time varies depending on states. For example, glass can be seen as a solid state of liquids, and compared with the transition of the liquids, the glass retains its amorphous spatial arrangement relatively longer.[445] Liquid can be thought of as a state that is vaporising, and, in this sense, it is possible to say that it also has an intrinsic characteristic time. In this way, DeLanda illustrates how each physical matter has its own intensive time. This scale of intensive time is analogous to the half-life of radionuclides in terms of intensive time that is intrinsic to an object. As shown in the above, the kinds of radionuclides are classified based on the half-life that is intrinsic to each of them. Hence, the half-life can be thought of as a time scale that shows the intensity of radionuclides.[446]

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[444] DeLanda, *Intensive Science*,100.

[445] DeLanda, *Intensive Science*,105.

[446] Deleuze pays attention to the point that 'time itself is affirmed in relation to movement' of atomic compounds. Then he maintains that the movement of atoms is smaller than the human's sensible time. This understanding of radiation from its movement is applicable to how radiation detectors operate as shown in Chapter 4 with the example count per minute (CPM). Radiation detectors count radioactive rays released from radionuclides, and they capture the movement of radiation that is not perceptible to humans' sensorium. In this sense, the role of radiation detectors can be conceived as a translation of the imperceptible and intensive time scale of radiation through the measurable time scale that is cognitive for humans. This is also an example of how the two different time scales are interlocked with each other.
Gilles Deleuze, *Logic of Sense*, 284.

DeLanda refers to Deleuze's explanation of the present time as a synthesis of extensive and intensive time scales. Deleuze's theory posits two types of time, one cyclical and one linear, which together form the present time as a synthesis of both. The former is intensive time that is unique to different forms of matter, and the latter is extensive time that is extrinsic to them.[447] DeLanda uses the concept of oscillation to explain how entities at different time scales affect one another to form a complex system. The extensive time is used to measure intensive time and constitutes an interlocking present with the intensive nonlinear time.[448]

The half-lives of radionuclides are understood as the intensive time of radioactive decay, and the time scale that is used to show the transition in Figures 5.1 and 5.2 is a linear extensive time of years. By observing the decay of radiation through the frame of extensive time, those digital maps capture the contamination within the interlocking system of time. Then, as DeLanda illustrates with the concept of oscillation, different scales of time come into relation with each other. As seen in the example of Project Hayano in Chapter 2, the movement of radionuclides are correlated with the movement of the wind, and this relation is further illustrated with the movement of the population density with the time scale of eight days. In this sense, this example shows how different time scales of radiation, a meteorological phenomenon, and the population density can interlock and oscillate with each other through the combination on the virtual map. With this discussion, we can argue that one of the functions of a digital map in radiation monitoring is to present an interpretation of the radioactive contamination within the interlock of intensive and extensive time scales, which is organised by functions of digital maps.

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[447] Deleuze, *Logic of Sense*, 65.
Here, as the example of cyclical intensive time, Deleuze refers to the movement of bodies in contrast to 'a pure straight line at the surface, incorporeal, unlimited, and an empty form of time, independent of all matter'.
[448] DeLanda, *Intensive Science*, 103.

5.4 Understanding Space and Time: Extensity, Abstraction, and the Perception of Contamination

So far, we have considered how the relation between the intensity of radiation and the digital map constitutes the interlocking of time. With this view, we will next consider how we can understand space and digital maps. As shown in the above, time in a digital map of radiation is produced in the interlocking of different time scales, such as the intensive time of radionuclides and the extensive time of the digital map. We first must consider the extensity in relation to the intensity of radioactive substances. Then, with this concept of extensity, we will consider how it works for us to perceive the space with digital maps.

As shown in Section 5.2, we considered the synthesis of the extensity and intensive times with the example of the radiation-mapping projects. In those examples, the intensity of radiation is translated via the scientific unit Sv/h, and this intensity is measured with an extensive time scale. Here, the scientific concept of the radiation unit serves as a bridge between radiation that is not perceptible to humans and the viewers of the map. In this sense, radiation becomes measurable and quantifiable through the scientific abstraction of the radiological unit, and it is also possible to maintain that this abstraction has a similarity with an extensity of time in that they both operate to measure the contamination. Moreover, in Chapter 4, considering the monitoring data as digital objects that are individuated through radiation monitoring, we have described how monitored radiation levels are assigned temporal and locational metadata and how those operate when sorted out in a CSV format. While being extrinsic to radiation, those metadata can also be thought of as something bridging and relating different data to observe radiation in a particular computational operation through which radiation becomes measurable. Hence, in this context, we can also consider another aspect of extensity that can connect different prosperities, and we will investigate how this view of extensity relates to further considerations on the function of the digital map.

To clarify this idea, we will use Alfred North Whitehead's theory of the concept of space and abstraction. In 'The Relational Theory of Space', Whitehead explains two different spaces to distinguish the one that humans sensibly experience and another that is understood through a form of abstraction such as geometry. The first one is called apparent space, where people perceive apparent objects such as colour, sounds, and odours, and each apparent space consists only of relations between things that are unique to their belonging space. Those attributes are unquantifiable and intrinsic to each apparent object. Next, Whitehead suggests another property of space that is physical space of a hypothetical world for physical science. More specifically, physical space refers to a space that is defined by a scientific abstraction, whereby people can share thoughts about the space.[449] In other words, physical space is a space where observers consider apparent space through scientific methods. In the context of this thesis, this distinction of these two different spaces is important in studying the relation between digital maps and the contamination of the environment. Radiation maps can be seen as a hypothetical world constituted by scientific abstractions to observe the apparent space of the natural environment where radioactive substances are present, which themselves are not directly perceptible to corporeal sensoriums but are measurable via technological mediation and scientific concepts. In Whitehead's sense, radiation values are mapped in physical space where the abstractions of science enable viewers to see the contamination.

Additionally, it is notable that Whitehead considers that apparent space, where concrete things exist, and physical space, the space for abstract ideas, are related because scientific concepts are derived from things in apparent space. He explains as follows:

> The fundamental order of ideas is first a world of things in relation; then the space whose fundamental entities are defined by means of these relations and whose

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[449] Patrick J. Hurley, 'Whitehead's Relational Theory of Space', *Philosophy Research Archives*, 5 (1979): 713–4.
In addition to those two spaces, Whitehead describes abstract space, which can be understood only through abstract concepts such as mathematics and geometry.

> properties are deducted from the nature of these relations. The ultimate elements of the world, thus placed in relation, do not necessarily have to occupy a position in space, or to have unique positions in space.[450]

As this quote shows, the properties of apparent and physical are constituted of things that are both tangible and intangible. Moreover, elements that consist of a space do not necessarily have to have fixed positions, as they are in changing relations that also include both the intangibles (such as what can be perceived as colours and sounds) in apparent space and abstract ideas in physical spaces. In previous chapters, we have observed the process of transduction where order is formed in relation between objects and their associated milieux. Similarly, in Whitehead's sense, ideas are derived from relations among things, and the property of the space is constituted of those relations.[451] From here, we can further consider the difference between digital maps and the contamination in the environment. So far, we have illustrated the former as a form of a virtual space, and with Whitehead, it can be seen as a form of abstraction that is relating to reality. Then, given that a digital map is an abstraction

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[450]Hurley, 'Whitehead's Relational Theory', 718.

[451] This point is further developed in *The Concept of Nature*, where Whitehead points out and criticises the bifurcation of the nature in relation to humans' perception of a reality. According to him, in modern, the reality of nature bifurcates into a scientific reality such as electrons that exist for knowledge and the other which is the byplay of the mind. Based on this discussion, Didier Debaise maintains that the bifurcation into the primary qualities of nature that expresses in the motion of itself (as in apparent space) and the secondary qualities that are explanation given of such motion is the constitutive operation of the modern experiments, in which scientists show 'a world that no one could interrogate differently than be'. In Chapter 3, with the case of CDCRML, we studied how the citizen-science groups show a counter contamination reality to relativise the concept of threshold as a sociopolitical ideology. Considering the operation of the bifurcation of the nature, we can see the practice of the digital map as a method to interrogate the contamination differently from the nuclear governance.
Alfred North Whitehead, *The Concept of Nature* (Cambridge: Cambridge University Press, 1995), 21; Didier Debaise, *Nature as Event: The Lure of the Possible* (Durham: Duke University Press, 2017), 13–14.

conceived from the relations among things and has a capacity of relation, how can we perceive the contamination with it?

In *Process and Reality*, Whitehead uses the term ‘world’ instead of ‘space’ to consider the process of how physical science constitutes its cosmological order. Then, with the example of geometry, he explains that the physical world is bound together in an extensive continuum by extensive abstractions. Here, extensity is understood as the relatedness enabled by the general properties of elements that constitute the physical world.[452] As shown in his discussions of physical space, people can share their thoughts about the space via shared scientific abstraction, and in this context, the relation of abstractions are explained as extensive properties. Whitehead also considers that this extensive continuum can also expand into actual reality. According to him, when we perceive the world with the extensiveness of space and time, and here, this world is considered as a continuum of extensive relations, we prehend the world with our intrinsic sense and extensive abstraction.[453] For Whitehead, ‘prehension’ means a way to perceive reality, including cognitive and uncognitive apprehension of the world.[454]

With this perspective of perceiving reality as prehension, digital maps can be described as a continuous network of relationships that involve elements that are not cognitively accessible to humans, such as the movement of radiation through the sensors that detect them. The question that arises, then, is how this prehensive process can be linked to the perception of space on digital maps. Drawing on Whitehead's philosophy, Luciana Parisi conceptualises information space as a set of relations of extension between events. Parisi contends that the primary characteristic of information space is the absence of a fixed spatial or temporal dimension to be experienced, as what constitutes an object or event may differ depending on the perspective of the observer. Parisi posits that this is because an object may be

[452] Alfred North Whitehead, *Process and Reality* (New York: The Free Press, 1985), 96–97.

[453] Whitehead, *Process and Reality*, 61.

[454]Alfred North Whitehead, *Science and the Modern World* (London: Free Association Books, 1985), 70.

experienced differently by individual percipients. In this context, the term ‘extension’ is used to refer to the capacity of relations to stretch or spread out.[455]

So far, we have established that extensity pertains to both metric standards and scientific concepts, and this definition can be expanded through the capacities of relating. For instance, the datafication of contamination involves the ability to relate various machines and software by means of a shared standard. Similarly, the prehension of digital maps can be conceived as a process of relating through different extensities such as GPS coordination and the temporal presentation of data. In this process, events that establish relations, such as monitoring and datafication, occur successively over time, encompassing cognitive and noncognitive events at different scales. Hence, as Parisi explains following Whitehead, those prehensive extensions form a ‘discontinuous continuity’ in which earlier events are part of wider events that are successive and divisible.[456] As discussed in the preceding chapter, the process of radiation monitoring can be reconceptualised as a discontinuous continuity, wherein numerous and successive processes occur among both machine and human percipients. Throughout this process, the technical objects involved, including radiation detectors and mobile terminals, as well as digital objects, such as contamination data and spreadsheet software, possess recombinability, and each entity is divisible, possessing an extensive capacity for relating.

By viewing reality through the concept of prehension, we can gain insight into the spatial and temporal dimensions of digital maps, as they are influenced by the prehensive processes of both abstract and concrete entities. The process of prehension, which involves the integration of events and entities into an extensive continuum, shapes our perception of space on digital maps. In this context, the spatial dimensions of digital maps are not fixed or predetermined but are instead emergent properties of the prehensive processes that bring

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[455] Luciana Parisi, ‘Symbiotic Architecture: Prehending Digitality’, *Theory, Culture & Society* 26, no. 2–3 (2017): 352, https://doi.org/10.1177/0263276409103121.
[456] Parisi, ‘Symbiotic Architecture’, 352–353.

together various elements, including machines, software, and human users. Through these processes, the abstract and concrete entities that make up digital maps are continuously reconfigured and recombined, resulting in new relations that are continually unfolding. Therefore, the process of prehension enables us to see digital maps, not as static figures of space but as dynamic and updating networks of relationships that are continuously being reconstituted and reinterpreted by the various agents involved in their creation and use. Based on this viewpoint, we will next consider specific cases to illustrate the ways in which the interpretation of radioactive contamination emerges on digital maps.

5.5 Digital Temporality on a Digital Map: Real Time and Discontinuous Time

In the context of techno-scientific practices within the media ecology of post-Fukushima Japan, real-time monitoring has emerged as a common method for publishing contamination data. In the introduction, we presented an 'art' performance by an anonymous decontamination worker who was pointing at a live-streaming camera at the Daiichi NPP site. This performance is situated within the technosocial circuit, allowing a citizen audience to observe the centre of the nuclear disaster. By pointing at the camera, the performer emphasises the inescapable realism that connects the power plant site with the audience. The performance utilises the connectedness and simultaneity of media ecologies as a tool to convey its message. As Lütticken contends, this performance shows aesthetics of entanglement in an emergency in the technosocial circuits of post-Fukushima.[457] Given that real-time streaming is one of the characteristics of the media ecology, how can we understand it within the case of radiation monitoring?

Like the live video streaming of the power plant site, radioactive contamination has been monitored through distributed sensors operating in real time, and the monitored radiation

[457] Lütticken, 'Radio-Activity', 93.

levels have been published as real-time monitoring results on several project websites. In Chapter 4, we studied the individuation of the technical and digital objects of monitoring devices using Simondonian concepts of transduction and transindividuality. Although the forms of media are different, the pointing performance can be regarded as an example of the individuating process of transduction, where time and space are translated into the form of the live-streamed moving image on the screen. In the previous section on extensive and intensive times, we considered how those different time scales are interlocked with each other. How can we, therefore, conceive of time in real-time monitoring in relation to the preceding discussions?

The term 'real-time' is often used to describe data generated by radiation sensors that are immediately published through the website of a project. For example, Japan Environmental Storage & Safety Corporation (JESCO) runs a real-time radiation- monitoring system in the interim storage of radioactive wastewater released from the Daiichi NPP (see Figure 5.3).[458] Furthermore, in Safecast's monitoring system, the term is also used to explain that their data archive is regularly and constantly updated in accordance with the data submission from their registered monitoring devices.[459]

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[458] Japan Environmental Storage & Safety Corporation, 'Radiation Monitoring Information', access:03.03.2023,
https://www1.jesconet.co.jp/interim/measurement/contents/P010110/WP0110/WP0110.html?uniquekey=187623537cb.
At the Daiichi NPP, to cool down the melted down nuclear reactor, the decommission team is continuously sending water to the part. The water used for cooling down contains toxic radionuclides and is stored in the interim storage site. The purpose of this real-time monitoring is to check if there is any leakage of water in the site.
[459] Safecast, 'Safecast Map'.

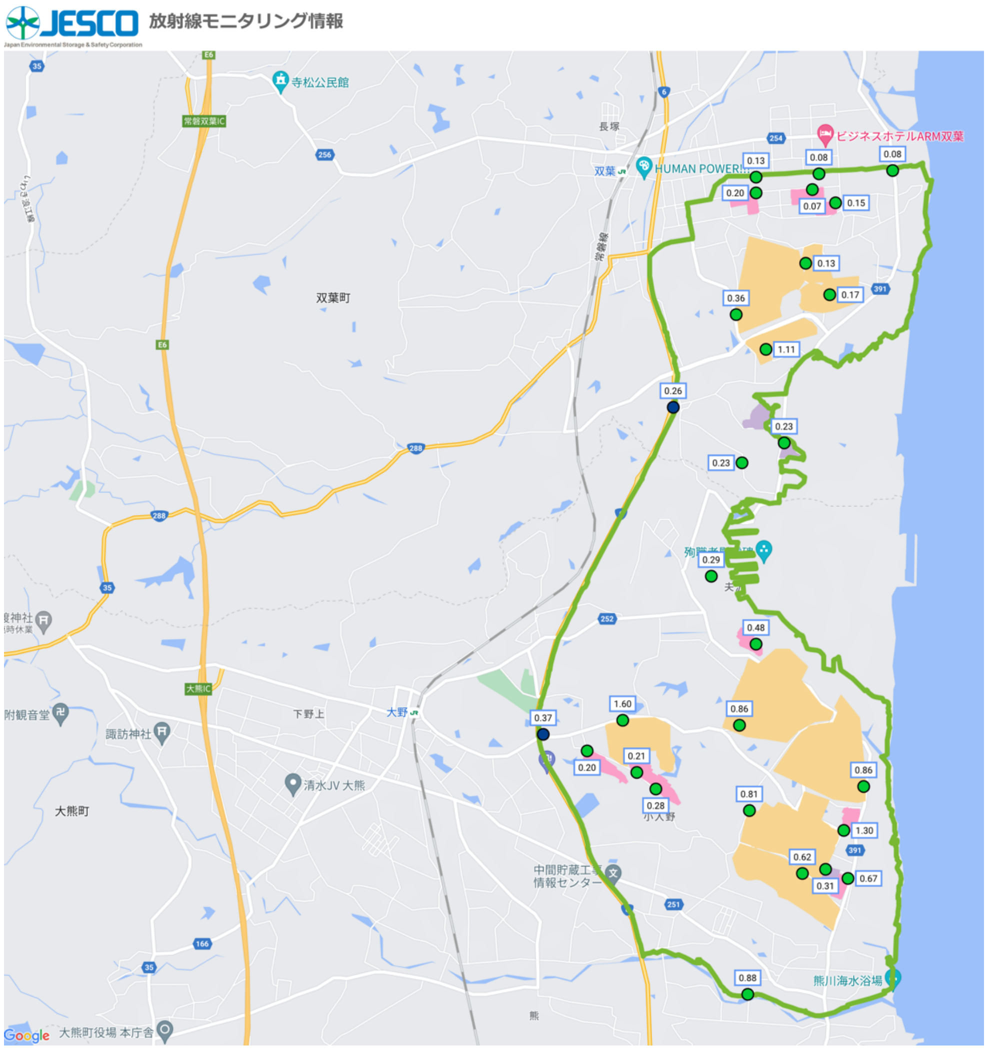

Figure 5.3: JESCO's Real-Time Monitoring Map on 3rd April 2023.[460]

According to the Cambridge English Dictionary, real-time means 'communicated, shown, presented, etc. at the same time as events actually happen', and the term is used to describe the way in which a computer system receives data and then communicates it or makes it

[460] The green line shows the boundary of the interim storage site. The green dots indicate the monitoring locations, and the boxes above them show the monitored radiation values. Japan Environmental Storage & Safety Corporation, 'Radiation Monitoring Information', accessed: 3 April 2023, https://www1.jesconet.co.jp/interim/measurement/contents/P010110/WP0110/WP0110.html?uniquekey=187623537cb.

available immediately.[461] Similarly, in the Japanese language, Kenkyusha's English-Japanese dictionary explains that 'real-time' means the simultaneity and immediacy of media-related actions, such as registration or broadcast, as well as the real-time operation of a computer.[462] Hence, in both English and Japanese definitions, the term refers to a situation in which an action, which may involve particular technological media, occurs at the same time as, or is immediately triggered by, certain events.

Although the above projects do not provide an explicit definition of 'real-time', the term denotes the process between data generation and presentation. Each project presents monitoring data on their digital maps or databases immediately after it is generated by their monitoring devices. However, as shown in the previous chapter, the immediacy of data presentation can vary depending on the type of communication network used and the frequency of data transmission regulated by communication costs. For instance, JESCO updates its radiation-monitoring data every 10 minutes. Meanwhile, Safecast updates its data repository every 5–30 minutes when each monitoring device sends its data to the Safecast database. In addition to the data mapping and a CSV format data publication introduced in the previous chapter, Safecast also publishes the data of each registered monitoring device in their Application Programming Interface (API)[463] page where its members can also upload

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[461] Cambridge English Dictionary, 'real-time', accssed: 8 April 2023, https://dictionary.cambridge.org/dictionary/english/real-time.

[462] Kosaku Takahashi, ed., *Kenkyusha English-Japanese Dictionary for the General Reader,* 3rd ed. (Tokyo: Kenkyusha, 2012), 1955.

[463] An API is an interface for programming a software application and operates as a bridge between a programme and software. Wulf and Blohm define APIs as 'machine-readable interfaces that connect multiple applications, govern application interaction, and remove the need to know the inner workings of how an API's functionality is provided'. In the Safecast database, monitoring data are submitted from users' software applications and organised for mapping. As they define it, this process between mapping and data collection is governed and automated in the APIs system.

Jochen Wulf and Ivo Blohm, 'Fostering Value Creation with Digital Platforms: A Unified Theory of the Application Programming Interface Design', *Journal of Management Information System* 37, no. 1 (2020): 251–281, https://doi.org/10.1080/07421222.2019.1705514.

their own monitoring data to the database (see Figure 5.4).[464] Then, their measurements page within the API section shows each monitor's data submission immediately after these are submitted. These entries can be sorted by the ID of monitoring data (which is assigned by the Safecast API), the values of monitored radiation, GPS coordinates, or time.[465] The page that is sorted by ID shows that Safecast's monitoring points in Tokyo conduct monitoring every one minute. The sensors page indicates how often registered sensors submit monitoring data to the API. According to Safecast, one of the real-time monitoring devices, Pointcast, submits data every five minutes.[466] As its submission time (in the section of Time of Capture) is longer than the time gap between conducted displayed in Figure 5.4, it is known that each submission has multiple data that were produced at different times (see Figure 5.5).[467] This example highlights that the submission of data does not necessarily indicate the time of monitoring and that a single submission may include multiple sets of monitoring data obtained over a certain period. According to Gerlitz *et al.*, real time in online media is not a universal temporal frame but an assemblage that emerges through the technicity of platforms.[468] In this context, the temporality of the Safecast real-time monitoring system is a constituted technological assemblage that is configured in the process of the data organisation in the API.

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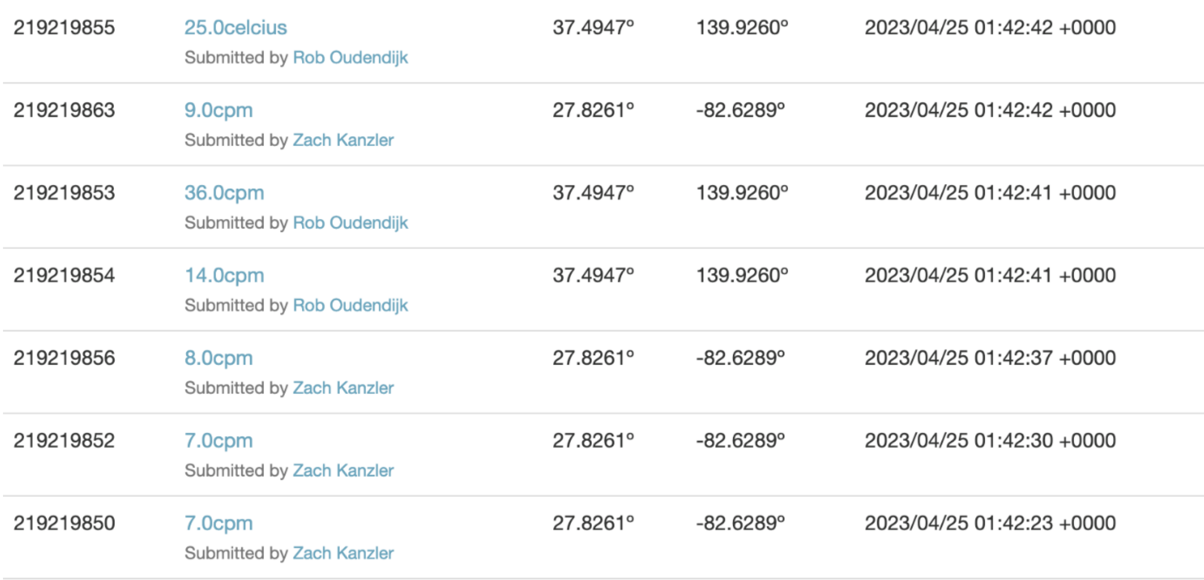
[464] Safecast, 'The Safecast API', accessed: 5 April 2023, https://api.safecast.org/en-US/home.
[465] Safecast, 'Measurements', accessed: 5 April 2023, https://api.safecast.org/en-US/measurements?order=captured_at+asc.
[466] Safecast, 'Pointcast Rollout, Part 1', accessed: 28 May 2023, https://safecast.org/2016/05/pointcast-rollout-part-1/.
[467] Safecast, 'Measurements', accessed: 5 April 2023, https://api.safecast.org/en-US/measurements?order=id+asc&page=3.
Safecast, 'Sensors', accessed: 05.04.2023, https://realtime.safecast.org/.
[468] Carolin Gerlitz *et al.*, 'The Politics of Real-time: A Device Perspective on Social Media Platforms and Search Engines', *Theory Culture & Society*, 31, no. 6 (2014): 127, https://doi.org/10.1177/0263276414537318.



219219855	25.0celcius Submitted by Rob Oudendijk	37.4947º	139.9260º	2023/04/25 01:42:42 +0000
219219863	9.0cpm Submitted by Zach Kanzler	27.8261º	-82.6289º	2023/04/25 01:42:42 +0000
219219853	36.0cpm Submitted by Rob Oudendijk	37.4947º	139.9260º	2023/04/25 01:42:41 +0000
219219854	14.0cpm Submitted by Rob Oudendijk	37.4947º	139.9260º	2023/04/25 01:42:41 +0000
219219856	8.0cpm Submitted by Zach Kanzler	27.8261º	-82.6289º	2023/04/25 01:42:37 +0000
219219852	7.0cpm Submitted by Zach Kanzler	27.8261º	-82.6289º	2023/04/25 01:42:30 +0000
219219850	7.0cpm Submitted by Zach Kanzler	27.8261º	-82.6289º	2023/04/25 01:42:23 +0000

Figure 5.4: The API Page of Safecast.[469]

[469]This is a screenshot of Safecast's API page that shows the data obtained on 24th March 2023. The left column shows the ID of each monitoring data entry. The value section shows monitored radiation values, followed by locational data of the GPS coordinates and the time when each monitoring was conducted. For the location comparison with Figure 5.5, see the data from Latitude 37.4947º Longitude 139.9260º.
Safecast, 'Measurements: captured before 26 April 2023', accessed: 26 April 2023, https://api.safecast.org/en-US/measurements?captured_after=&captured_before=2023%2F04%2F26+02%3A34%3A24&commit=Filter&distance=&latitude=&longitude=&order=captured_at+desc&since=&until=&utf8=%E2%9C%93.

Sensors

Search

Location	ID	Model	Time of Capture (GMT)	μSv/h	cpm	Latitude	Longitude	On/Offline
Japan, Fukushima, Aizuwakamatsu, Aizu Radioactivity Information Center	100361	Pointcast V1.0	11 mins ago 2023-04-25T01:22:28.000Z	0.114	38	37.494708	139.92604	Online
Japan, Fukushima, Aizu Wakamatsu, Eyes Japan	101	nGeigie 101 V2.1.5	47 mins ago 2023-04-25T00:46:34.000Z	0.132	44	37.4932	139.93305	Online
Japan, Fukushima, Aizu Wakamatsu, Aizu Wakamatsu University	300022	Solarcast	13 hours ago 2023-04-24T12:41:47.000Z	0.108	36	37.52346	139.939163	Offline long
Japan, Fukushima, Aizu Wakamatsu, Aizu Wakamatsu University	300021	Solarcast	13 hours ago 2023-04-24T12:41:47.000Z	0.126	42	37.52346	139.939163	Offline long
Japan, Fukushima, Fukushima-shi, Funabacho	100322	Pointcast V1.0	51 mins ago 2023-04-25T00:42:00.000Z	0.000	0	37.752099	140.470826	Online
Japan, Chiba, Ichikawa City, JAM	100162	Pointcast V2.0	50 mins ago 2023-04-25T00:43:07.000Z	0.091	11	35.74591	139.91815	Online
Japan, Chiba, Ichikawa City, JAM	100161	Pointcast V2.0	50 mins ago 2023-04-25T00:43:07.000Z	0.090	30	35.74591	139.91815	Online

Figure 5.5: The Sensors Page on Safecast.[470]

Based on these points, the characteristics of real-time monitoring can be broken down into two points. First, while the name implies immediacy between monitoring and data presentation, there is a certain amount of time lag between the two events. Thus, real-time monitoring data,

[470] This page shows the list of sensors that send monitoring data to Safecast's API from the same locations as Figure 5.4 as it appeared on 25 April 2023. The location in the first row (Japan, Fukushima, Aizuwakamatsu, Aizu Radioactivity Information Center) corresponds to the referred location in Figure 5.4. Since GPS coordinates are determined through a communication between a device and a satellite, there is a slight gap between the GPS coordinates between Figures 5.4 and 5.5. Although Safecast does not explain the difference, it is estimated that the sensor was registered with the initial GPS coordinates, and each monitoring data's coordinate is determined with the position of a satellite when it conducts monitoring. The left column shows the location of the registered devices, and the column next to it shows the ID of each device. The Model section shows what kind of radiation detector is used, and Time of Capture indicates the latest time when each sensor submits a set of monitoring data. The page also displays the latest monitored radiation values and their GPS coordinates. Data is accepted from both online devices and from manual submission, and the Online/Offline section shows whether each device is online or offline.
Safecast, 'Sensors', accessed: 25 April 2023, https://realtime.safecast.org/.

rather than being submitted simultaneously as it is generated, always arrives late. Second, the archived monitoring data entries are sorted with the gaps made by intermittently conducted radiation monitoring. Consequently, while real-time monitoring can continuously generate data, the generated time in that data is not seamless but an intermittent continuum of points in time. With these factors in mind, we can consider the ontology of real time in radiation monitoring.

Let us consider an example of the observation of digital time in another field of study. Discussing the digital sampling of sounds, media theorist Steve Goodman contends that digital time is not durational like analogue time. In digital sound recording and the sampling method of granular synthesis, sound is converted into binary data and stored in discrete digital particles. Hence, sound data exists discontinuously.[471] Goodman argues that the ontology of digital time is distinguished from Bergsonian duration, which is often used to describe the nature of sounds. For Bergson, time is perceived through human intuition and exists as a duration that is not divisible.[472] Goodman contrasts his view to the durational time/sound

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[471] Steve Goodman, 'Timeline (sonic)', in *Software Studies: A Lexicon*, ed. Matthew Fuller (Cambridge: The MIT Press, 2008), 258–259.

[472] Henri Bergson, *An Introduction to Metaphysics*, (New York: G.P. Putnam & Sons,1912), 1–3. Bergson distinguishes durational time from the analytical operation of extensive measurement, which divides time for scientific observations. In the previous section, we introduced Whitehead's discontinuous continuity, which is prehended with the extensive capacity of relations. Although both philosophers emphasise experience and time, Bergson's theory of time differs from Whitehead's relational ontology in this regard. According to Motonao Mori, both Whitehead and Bergson are in line with the analytical perception of space and time, whose process is impossible without abstraction. However, Bergson conceives of reality and immediate experience without scientific abstractions, unlike Whitehead.

Motonao Mori, *Philosophy of the Concrete: Whitehead's Knowledge, Life, Thought Towards Society (具体性の哲学：ホワイトヘッドの知恵・生命・社会への思考)* (Tokyo: Ibun-sha, 2015), 80.

The concept of durational time is not only discussed in sound studies, but also in relation to the consideration of time in mass media. For instance, Maurizio Lazzarato observes the time of video and television with Bergson's notion of the crystallisation of time. In Lazzarato's view, time in contemporary media society is conceived through the mediation of television broadcast. Through this process, the same video images are received by distributed television devices, and durational time crystallises in the mediation, simultaneously among those devices of mass media, in order to control time in society. Although the digital time of real time shares similarities with this form of mediation, the ontologies that argue that sound is analogue and durational when played, even if its file format is digital.[473] In contrast to this view, Goodman explains that, in some digital sound manipulation techniques, the digitality of time and sound can be expressed in between the duration of sounds. For example, in the technique called time-stretching, which is based on digital sampling, the pitch of the sound does not change even if played faster or slower. This is because digital samplings store sounds in discrete data. In contrast, in analogue playback methods, such as tapes and records, in which sounds are recorded in analogue forms of magnets and physical grooves, the pitch changes in accordance with the speed of playback.[474]

Although this is an example of sound, this argument about the digitality of time is relevant in considering how time is expressed in the database of monitoring data and on digital maps. In Section 5.3, we considered extensity and space in terms of prehension and discontinuous continuity with discussions of Whitehead. In the example of digital sound, sound and time are conceived as a form of continuity over discontinuous sampling data that has the capacity to relate to other data in sound. Hence, digital time can be argued as a form of relation that extends through a set of data that is organised separately but that can relate to other data generated at a different time. With this view, we can consider digital real time as discontinuous continuity rather than durational continuity. In the digital time of real time, as shown with the example of Safecast, particles of temporal data are continuously transmitted and archived in the database, which is addressable by the API. Figure 5.4 shows that the data sent to the database is organised based on when it was monitored, and each piece of monitoring data is assigned a unique ID. In this sense, similar to the example of sound, the radiation value is stored based on its temporal metadata. Then, when the data are presented on the map and

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transmitted data is distinct in that it has a capacity of relating but does not exist in the same form as the continuous transmission of television analogue signals. Thus, the digital time can be distinguished from analogue mediation.
Maurizio Lazzarato, *Videophilosophy: The Perception of Time in Post-Fordism*, (New York: Columbia University Press, 2019).

[474] Goodman, 'Timeline (sonic)', 258.

updated, viewers can see the relation between the presented values. Moreover, it is notable that a single data submission has multiple radiation values generated at different points in time until the submission, and a fragment of time organises and contains multiple points of time. Hence, the continuity of discrete data is also formed in this protocol of data transaction. Through this process of data organisation, it is possible to see that relations are created over those time gaps, and time is prehended by software applications and its viewers. In this way, real time is perceived as a set of continuity of discrete digital registries that have a capacity of relating.

Next, we will consider in further detail the ways in which contamination data is recombined with its temporal metadata. After being archived in the database of each project, the data of radiation levels are organised by the API to be recombined based on the metadata of time and location. First, let us highlight the case of Safecast. When opened in a web browser, Safecast's map shows the gradation of different colours centred around the Fukushima nuclear power plant. What is mapped and visualised in this default screen is all the data they have generated and collected since 2011 to the current period. This function is called 'Points'. For example, if the point of '2013-4-15' is selected on the left bar, the map shows all data that were taken since 2011 to the 15th of April 2013. By choosing different points in time, users can observe how the radiation may concentrate in a specific area, and they can also compare the transition from a chosen point of data.

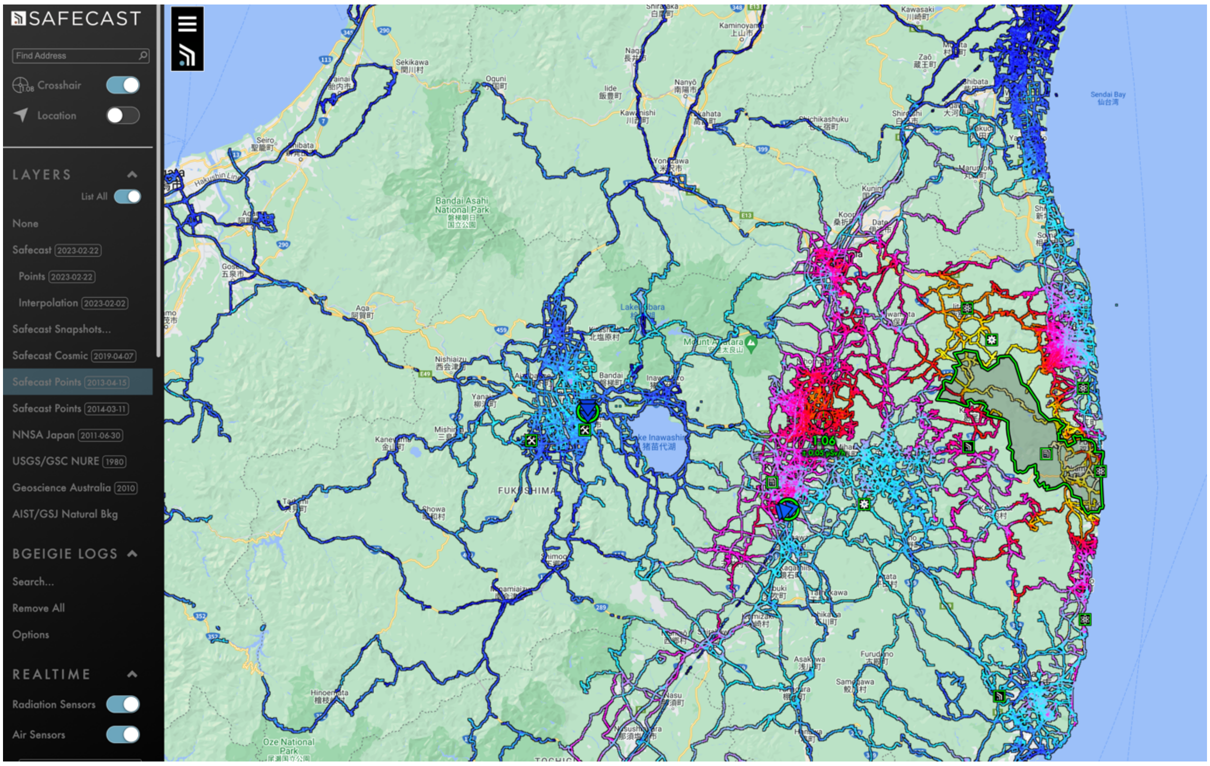

Figure 5.6: Safecast Map Sorted by the Points Function.[475]

However, in the layer of Points on the map, viewers cannot compare and observe the values of contamination for a specific period by excluding the data from 2011 to a particular date. To cover this issue, in 2016, they added the function called 'Snapshots'. With this function, the map can visualise archived data from a selected 6-month-long period on one screen by excluding the other data generated before and after the period. The monitored radiation correlates to the intensity of radionuclides, which are in a constant process of

[475] The screen shows the Fukushima Prefecture. All submitted data from March 2011 to April 2013 is mapped and visualised with colours. Vehicle-borne surveys were also conducted, and the lines on the map correspond to roads. The area coloured with red shows a high degree of contamination, but it does not necessarily mean that the area still has the same level of radioactivity. The green area on the right side of the map indicates the exclusion zone where access is restricted.
Safecast, 'Map Sorted by Points of 2013-4-15', accessed: 3 March 2023, https://map.safecast.org/?y=37.515&x=140.417&z=11&l=8&m=0.
Sean Bonner, 'Current Fukushima Exclusion Zone Map', Safecast, 5 December 2013, https://safecast.org/2013/12/current-fukushima-exclusion-zone-map/.

radioactive decay at a rate determined by their half-life. Due to the specifications of the deployed monitoring devices, they cannot identify the specific type of radionuclides. Therefore, the monitoring results potentially include multiple types of radionuclides at different stages of their half-lives. On the map of a chosen period of Snapshots, the dosage amount of radiation is visualised with multiple colours in the same way as Points. By comparing different snapshots from different chosen time periods, viewers can compare and observe the transition of the radioactive contamination. In real-time monitoring, it is required to measure radiation values constantly and regularly and to promptly update the progress of monitoring to grasp the ongoing contamination in the present. On the other hand, Snapshot focuses on the past period of the ongoing contamination to grasp how it has been changing since 2011. As Safecast explains, the viewers of Snapshot see the contamination through different time frames.[476]

[476] Sean Bonner, 'Time Snapshots now on the Safecast Map!', Safecast, 7 April 2016, https://safecast.org/2016/04/time-snapshots-now-on-the-safecast-map/.

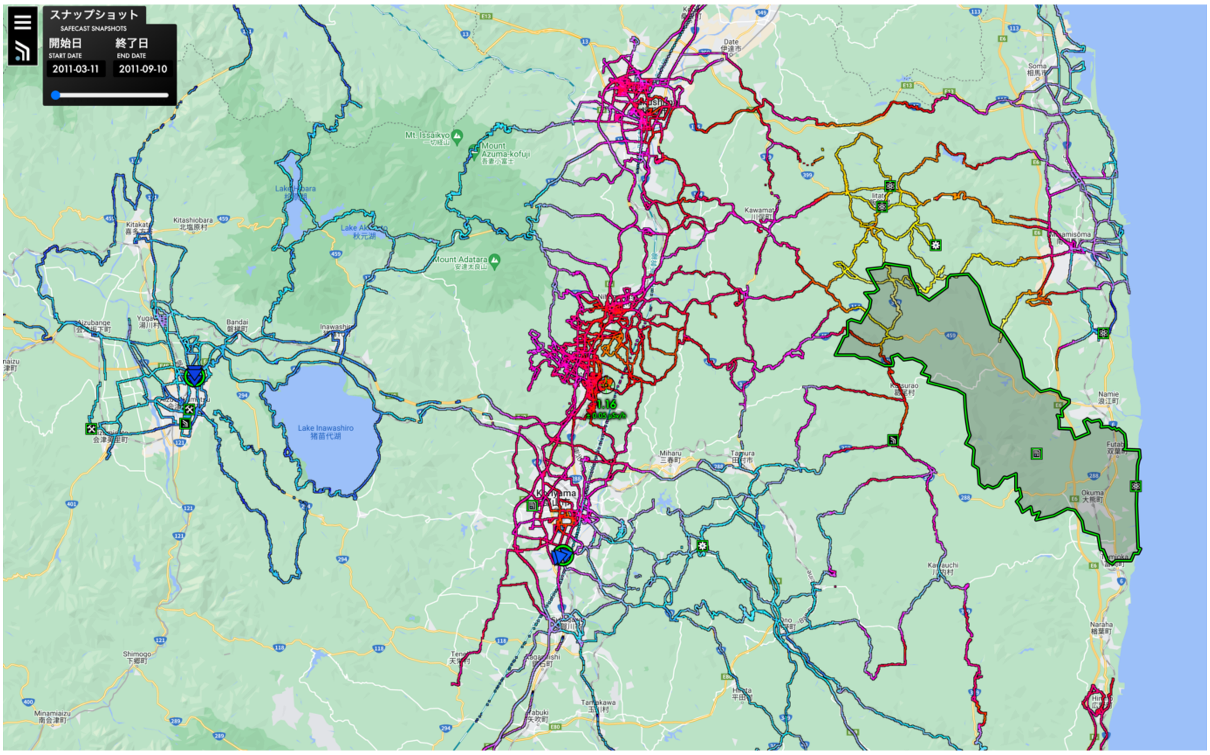

Figure 5.7: Safecast Map Sorted by Snapshots from 11 March 2011–10 September 2011.[477]

[477] This screen shows all the submitted radiation values in the six months between 11th March to 10th September 2011.
Safecast, 'Safecast map: Snapshots from 2019-03-11 to 2011-09-10', accessed: 30 April 2023, https://map.safecast.org/?y=37.303&x=141.319&z=9&l=13&m=0.

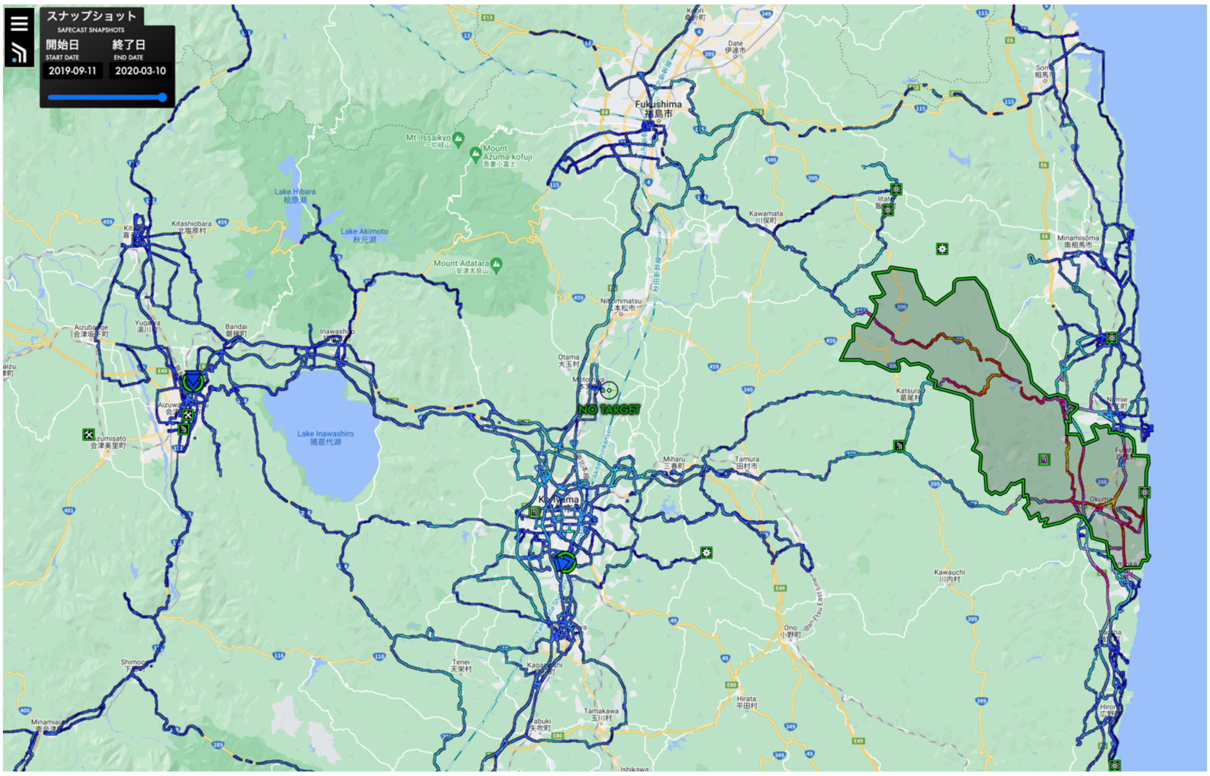

Figure 5.8: Safecast Map Sorted by Snapshots from 11 September 2019–10 March 2020.[478]

With Points and Snapshots, we can critically consider how the interlocking time of the extensive and intensive times of the radionuclides on the digital map can create an understanding of the contamination. As shown in Section 5.2, the radionuclides in the environment are decaying, and their radiation values are decreasing. The length of the half-life radionuclide is intrinsic to them and has a trajectory of decay. Hence, the half-life can be thought of as an intensive time. The time scales on the digital map, such as month and year, are extrinsic to radionuclides and are used to consider the intensity of radiation by a human equipped with the general and divisible scale of time: an extensive time. Let us consider how they are interlocked in the Points function where the archived radiation values from 2011 to a selected date are all mapped on the same screen. In Figure 5.6, the map shows all the

[478] Safecast, 'Safecast map: Snapshots from 2019-01-11to 2020-03-10', accessed: 30 April 2023, https://map.safecast.org/?y=37.303&x=141.319&z=9&l=30&m=0. This figure depicts the radiation values that were monitored between 11th September 2019 and 10th March 2020. A comparison with Figure 5.7 reveals a significant decrease in contamination levels over the 10-year period.

monitored radiation values from March 2011 to April 2013. Three years of extensive linear times of the calendar system concentrate on the screen, and the Safecast map integrates multiple points of time when radiation monitoring has been conducted. Figure 5.9 depicts a zoomed-in screen of the same map, indicating where the monitoring was conducted, with each dot corresponding to those monitoring locations.

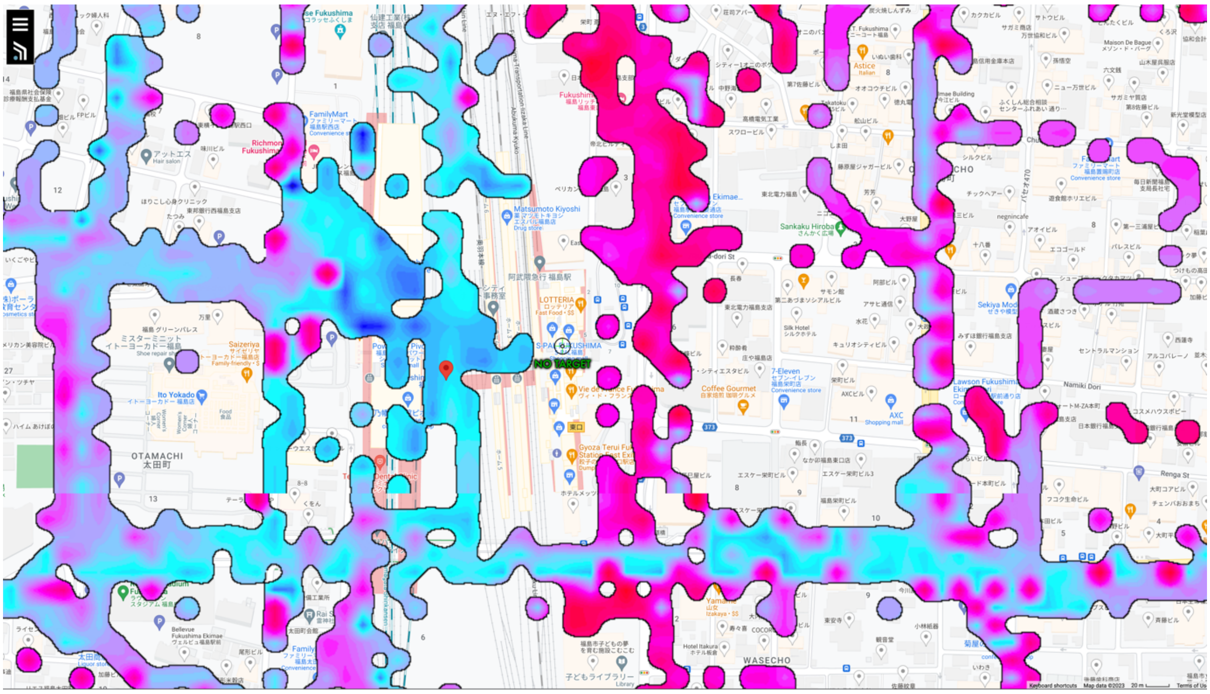

Figure 5.9: Safecast Map Sorted by the Points Function.[479]

In the chosen time frame, the map indicates the radiation values with monitoring locations, but it does not show when it was monitored. However, as shown in Figure 5.9, notably we can see the overlaps among different locational points. As highlighted in Chapter 4, Safecast developed a portable radiation detector, allowing an observer to conduct monitoring while they move. Hence, it is presumable that the overlaps of the locations emerge because of the crossing paths of observers in the different periods. As explained in Section 5.3, those data

[479] This figure displays a zoomed-in map of the Fukushima city centre with the same Points setting as Figure 5.6, indicating radiation levels and the respective monitoring locations. Notably, in this area, several monitoring points exhibit locational overlaps, which have consequently been amalgamated into a group of points for clarity and ease of interpretation.

were submitted as discrete entries, and those single data are topologically distributed on the map to display a condition of the contamination.

Each radiation value indicates the intensity of radiation that was measured at a point in the past. Then, those multiple intensities at different stages of radioactive decay are combined with the extensive, which functions as a container that makes them comparable from the viewpoint of time. Additionally, as Safecast accepts the submission from portable devices, we can consider another scale of time that is intrinsic to the observer. Their device can automatically conduct monitoring, so the observer does not necessarily go out into the area just for monitoring. Therefore, their movement can be non-linear and arbitrary, meaning it is possible to maintain that, in this kind of example, an intensive time of human/observers becomes involved. Moreover, they have also installed their monitoring devices in fixed locations, and those monitoring devices are programmed to monitor radiation automatically. Hence, these monitoring events are conducted following an extensive linear scale of time. In this way, the different time scales are interlocked with each other through the extensive capacity of relating. Through this frame of time that constitutes the interlocking of time scales, the map depicts aspects of the damage that the nuclear disaster is causing. The screen showing real-time data does not show the past figures of the contamination. Nevertheless, the Points function can display how the nuclear fallout has accumulated in the area. The overlapping of the dots on the zoomed-in screen is a result of the time integration. Those dots belong to a different temporal metadata, but they are relating on the same screen. Hence, they are bound together as a discontinuous continuum.

Similarly, the Snapshots function delineates another aspect of the contamination by applying the layer of a time frame. A chosen snapshot gathers all radiation values within the six months together on one screen to observe the transition of the contamination by focusing on the half-lives of radionuclides, which can be anywhere from several hours to decades. This period of six months includes the relative pasts and futures of the radionuclides in the different stages of the process of radioactive decay, and the map illustrates the condition of the contamination in the chosen period. Hence, a comparison between two different Snapshots screens highlights the transition of the contamination that corresponds to the intensive time of the half-life.

5.6 Mapping and Locations: Monitoring Techniques and Interpretation of Contamination

Next, we will investigate the ways in which survey methods are related to an interpretation of the contamination. As demonstrated in Chapter 4, which explored the individuation of monitoring data, the mapping of a location on a digital platform is determined by the location of the monitoring device and the method used to conduct measurements. As the radiation value in the environment is affected by specific geographical conditions, not only the characteristics of the radiation detector but also the monitoring techniques, such as air and soil measurements, have an impact on the monitoring results. In this chapter, drawing upon Whitehead's concept of prehension, we contend that the contamination depicted on digital maps is a prehension of the extensive continuum of relationships that emanate from the environment. Building upon these points, in this section, we will explore how the location of radiation detectors and monitoring methods are related to the interpretation of contamination with three examples of radiation maps. First, we will consider the sociopolitical aspect of monitoring locations. Second, this section highlights mapping radiation value under a scientific sampling method. The third study will consider a vehicle-borne survey conducted on the road transportation network.

5.6.1 State-Owned Monitoring: Nuclearity of Locations

First, let us consider the example of the Nuclear Regulation Authority (NRA), an administrative body belonging to the Ministry of the Environment that establishes and implements measures to ensure safety in the utilisation of nuclear power in Japan.[480] They run a radiation-monitoring map called Radiation Monitoring Information and Publication System. In their monitoring system, the entries of their radiation map are sorted by prefecture, allowing viewers to focus on a specific area of Japan.[481] The data on the map are collected from the radiation-monitoring posts installed in the local state-owned facilities, and the generated data is submitted to the database of their monitoring system. Then, the map shows the real-time monitoring results from those devices.

Locations of monitoring posts are assigned with state facilities, such as medical institutions, schools, and nuclear power plant sites. The number of state-owned monitoring posts varies in every prefecture, and as of 2015, the Fukushima Prefecture had installed 3,036 real-time, fixed mount type monitoring posts and deployed 578 portable monitoring posts and 12 other fixed-type posts in the area.[482] The locations of monitoring posts are mapped on each municipality's web site and the NRA's radiation monitoring information sharing and publication system. Figure 5.10 shows the Futaba area where the Fukushima nuclear power plant is located, and each map shows the area from different zoom levels. The marks assigned with each monitoring location respectively show the type of monitoring post, such as what institution owns the device and the purpose of the device. Furthermore, by clicking a figure, the detail of the selected monitoring post is shown, which reflects the current condition of the radiation levels.

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[480] Nuclear Regulation Authority, Nuclear Regulation Authority Website.

[481] Nuclear Regulation Authority Japan, 'Radiation Dose Measurement Map'.

[482] Ministry of Reconstruction Japan, 'Overview of the main initiatives and future directions based on the strengthened guidelines for addressing reputational damages (風評対策強化に基づく主な取組状況と今後の取組の方向性について)', 4 June 2015, https://www.reconstruction.go.jp/topics/main-cat1/sub-cat1-4/20150607_syoraizo_7_sanko2_fuhyo.pdf.

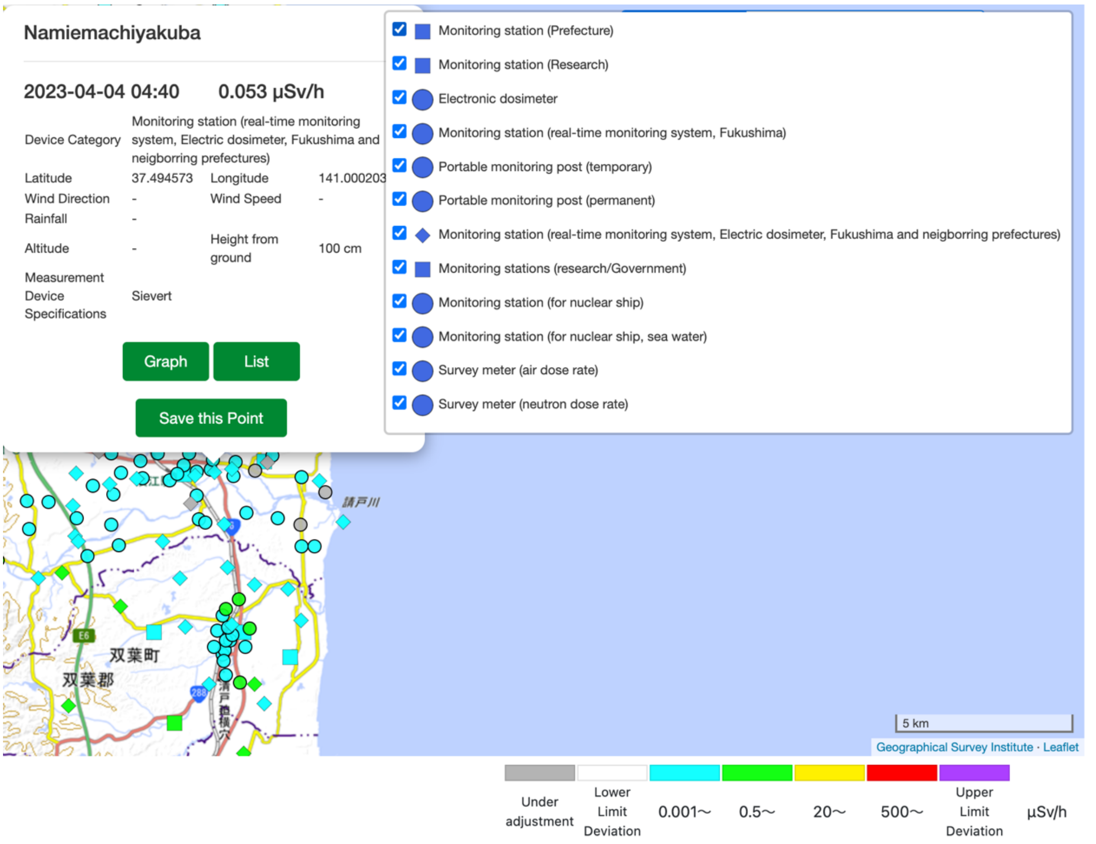

Figure 5.10: Map of Radiation Monitoring Information Sharing System.[483]

In Chapter 4, we introduced the discussion of the transduction of space through data generation. In terms of the location of the state-owned monitoring posts, the space of the monitored area is transduced under certain sociopolitical conditions of where those devices are installed. Therefore, it is evident that their fixed points are an extension of the social milieu of the state-owned monitoring infrastructure. In Chapter 1, we highlighted Hecht's concept of nuclearity, a political and cultural configuration that produces knowledge on radiation in a particular social circumstance.[484] Based on this concept, we delineated the nuclearity of the

[483] Namiemachiyakuba is a governmental office of the town of Namie, located approximately 20km away from the Fukushima nuclear power plant site. The map shows monitoring data submitted from the monitoring posts listed in the box on the right. The left box shows the real-time radiation values, and viewers also can see the transition of values from the Graph and List sections. By clicking Save, viewers can save the date to compare it with values at other points.

[484] Hecht, *Being Nuclear,* 15.

Fukushima nuclear disaster as a social, political, and natural configuration that extends on a global scale. Radiation monitoring also has a particular nuclearity in relation to the media ecology of post-Fukushima. The NRA's radiation-monitoring network is configured within the state infrastructure, and this nuclearity is reflected in the monitoring locations on the map. Chapter 2 also highlighted Jasanoff's concept of civic epistemology to illustrate the engagement of citizens in the scientific knowledge production process. At the level of the data presentation on the digital map, the contamination is depicted through the nuclearity of the local governance, and the authority deeply engages in this data generation process. This figure of relation is similar to Jasanoff's understanding of the public understanding of science (PUS) model, in which citizens are subordinated to authoritative decisions on technoscientific events.[485] However, the NRA system also publishes their data in a CSV format, and users can download them to their digital map. In this context, it is worth noting that while this map represents a fixed form of data, it is, in fact, an extensive continuum that remains open to further processes of prehension. It is, therefore, possible to integrate the nuclearity of governmental radiation monitoring into a civic epistemology of knowledge production, which is considered one of the defining features of the post-Fukushima media ecology.

5.6.2 Soil Survey: Abstraction and Digital Maps

The next example concerns soil measurement, which involves either conducting laboratory measurements or bringing monitoring devices into the environment. For the purposes of illustration, we will examine the soil survey mapping undertaken by the Japan Atomic Energy Agency (JAEA), an independent administrative institution engaged in research and development of nuclear technologies. According to the JAEA, the method of soil survey is broken down into two types. The first method involves soil sampling, where soil samples are

[485] Jasanoff, *Designs on Nature,* 249.

taken to a laboratory for measurement. The second method involves in-situ measurement, where monitoring is carried out in the environment using a portable device.[486] Soil surveys are often conducted in the designated area where radionuclides, such as caesium and radon, accumulate on the surface of the ground. For example, Chapter 4 introduced the grid monitoring method that employs a soil measurement. In the grid sampling method, a measure is taken from a designated area that is divided by a square with a certain distance. By measuring the radiation levels in each grid, this method provides an overview of the contamination levels in the area.[487] The contamination level of radiated soil is less likely to change unless the contaminated soils are removed or some form of remediation takes place. This method is commonly used to observe the long-term transition of the radiation level in the environment.

Let's consider how the soil measurement is visualised with the grid monitoring method. From 2011 to 2016, the JAEA conducted soil measurements in the Fukushima Prefecture to observe the transition of the amount of caesium-134 and caesium-137,[488] and they have published the radiation map and their collected data source in CSV, KML/KMZ, and XML for

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486 Japan Atomic Energy Agency, 'Database for Radioactive'.

487 The radiation-monitoring method described is commonly employed to monitor environmental radiation levels. For instance, in 2022, the UK Health Security Agency published a radon map illustrating the levels of radioactive radon across the United Kingdom's land. In this study, radon levels in the UK's soil were measured using a passive radon detector, and the resulting radiation measurements were reported in becquerels (Bq), which indicate the quantity of radon's radioactive substance. The estimated radon values based on the survey were presented on a map using 1 km² grids.
See: UK Health Security Agency, UK maps of radon', 1 December 2022, https://www.ukradon.org/information/ukmaps.

488 In the soil survey, observers can bring in a monitoring device that can classify the kinds of monitored radionuclides. On the other hand, monitoring posts in the environment usually are not able to discern the difference of radionuclides. Monitoring environment focusing on a specific radionuclide is also a characteristic of the soil measurement.

users' data visualisation.[489] Figures 5.11 and 5.12 visualise the soil survey on caesium-137 conducted within the 80km diameter from the Fukushima nuclear power plant in October 2016 to show the comparison between the JAEA's map image and their data mapped on Google Earth.[490] Figure 5.11 depicts the JAEA's map, which shows monitored radiation values with grids and diagrams indicating the distance from the nuclear power plant site. Figure 5.12 displays the same monitoring data which the author mapped onto Google Earth.

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[489] Japan Atomic Energy Agency, 'Deposition of Gamma-Emitting Nuclides in the Distribution Survey of Radioactive Substances', accessed: 20 April 2023, https://emdb.jaea.go.jp/emdb_old/en/portals/b1020101/.

Keyhole Markup Language (KML) is used to visualise scientific data and an assortment of technical experiments. It is an open geospatial consortium standard and is widely used in visual globes, such as Google Earth and NASA World Wind. Not only can KML files contain geospatial data of lines, diagram, and polygons but also multiple media such as web pages links and visual images. It is written in Extension Markup Language (XML), which is a World Wide Web Consortium standard and is commonly used in multiple software, such as word processors and electronic book readers, and for data transaction. For the scientific application of KML and XML, See: Gen-Tao Chian *et al.*, 'Geo-visualization Fortran library' *Computers & Geosciences*, 37 (2011): 65–74, https://doi.org/10.1016/j.cageo.2010.04.012; Lisa M. Ballagh *et al.*, 'Representing scientific data sets in KML: Methods and challenges', *Computers & Geoscience* 37 (2011): 57–64, https://doi.org/10.1016/j.cageo.2010.05.004.

[490] Japan Atomic Energy Agency, 'Deposition of Gamma-Emitting'; Japan Atomic Energy Agency, 'Results of Deposition Density Measurement of Gamma-emitting Nuclides on Soil within the 80 km Radius from the Daiichi NPP. (From August 2016 to October 2016), in KML', accessed: 20 April 2023, https://emdb.jaea.go.jp/emdb_old/assets/site_data/en/kml/1020101010/1020101010_07.kmz.

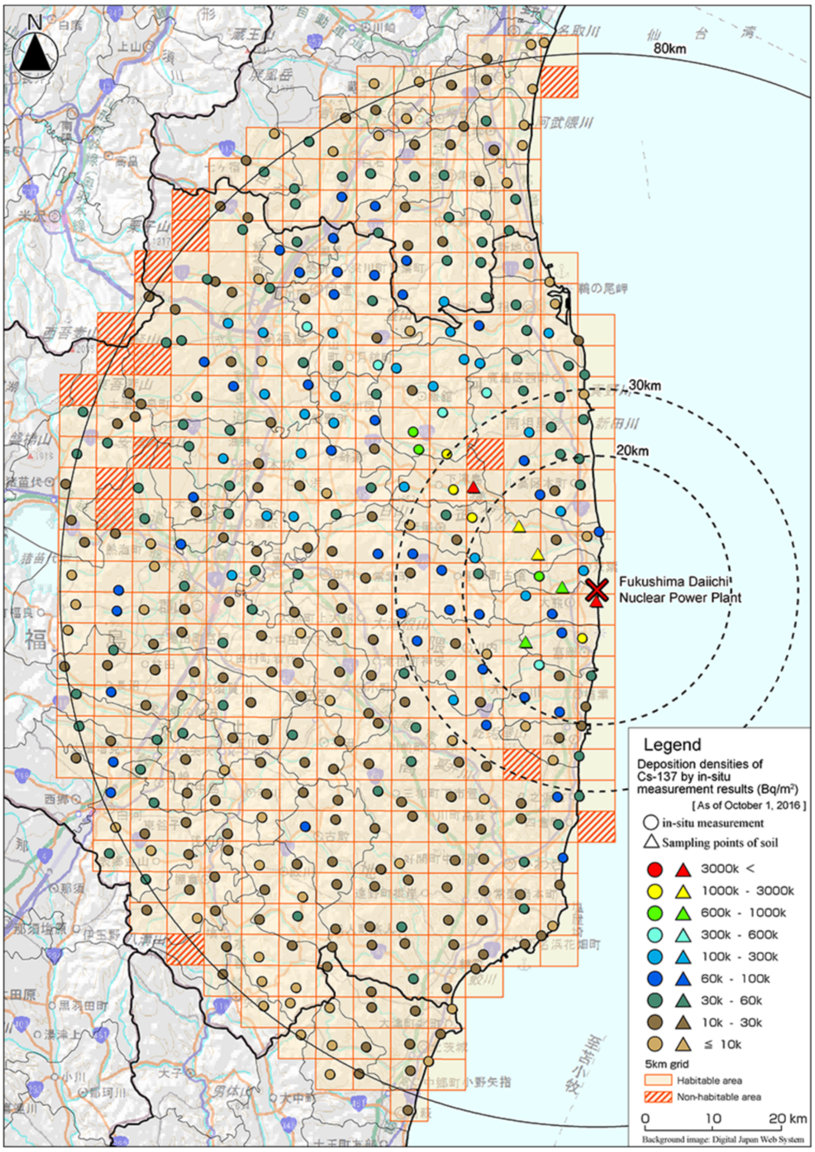

Figure 5.11: The JAEA’s Soil Survey Map.

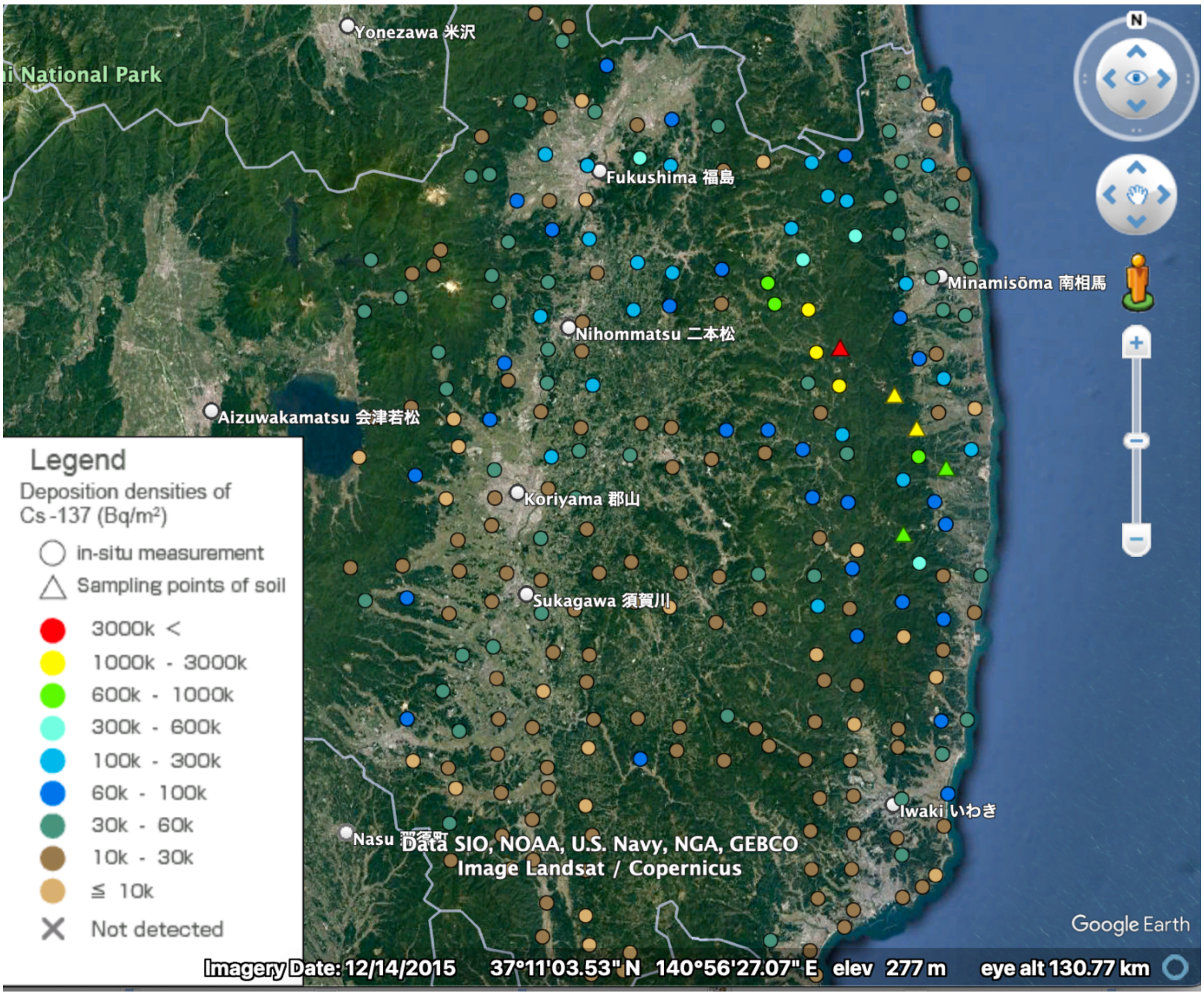

Figure 5.12: The JAEA's Soil Survey Mapped onto Google Earth.

On the map of Figure 5.11, the size of each grid is geometrically assigned based on their survey method. The samples were taken from a single location within a grid, and the measured radiation value does not mean that that area of the grid has the same value. In this sense, each grid shows the estimation, or the virtuality, of the radiation amount in the monitored area. Figure 5.12 does not include the grids shown in Figure 5.11, but the positions of each dot are still mapped based on the provided GPS coordinates of the monitoring location. Hence, the map also illustrates how mapping the fallout can reflect the scientific abstraction of a grid survey method that is part of its continuum.

In the case of the NRA's map, the monitoring points are installed in state-owned facilities. By comparison, in the JAEA survey, the points are determined based on the methodologies of the soil survey. In this sense, the monitoring locations are inductively selected based on the methodological necessity to generate data in the uniformly divided area by grids. The viewers of the map see the contamination through the abstraction of the methodology. Following Whitehead, Section 5.3 of this thesis explored how space can be perceived through extensive abstraction; this example illustrates the ways in which data are generated and presented based on the soil survey methodology's extensive character that serves as a bridge between the apparent space of the contamination and the virtual map.

Similar to the NRA's data publication system, the JAEA also publishes the soil survey data on their website, and this point can add a further perspective to the preceding discussion. In this soil survey, the monitoring locations are determined based on the scientific estimation of the dissemination of radionuclides and the size of a grid. And this process does not have the nuclearities of the NRA's state infrastructure or Safecast's citizen-led monitoring, which cover state facilities and the living area of citizens. However, through the KMZ format that can be opened with a digital map, such as Google Earth, the JAEA's data can relate to datasets that are generated in other projects that have different nuclearities. Furthermore, the soil survey can detect different types of radionuclides, while air measurements cannot distinguish between them. Therefore, by combining soil and air survey data maps, data generated by different methods can be linked with each other. In this sense, different datasets can relate with each other through the extensive capacities of scientific abstraction, data, and digital maps. For instance, Figure 5.13 displays Google Earth where the data of the JAES's soil and air surveys are mapped together. The soil survey was conducted from June to July of 2014,[491] and the air survey was conducted from April 2014 to March 2015.[492] In this way, multiple data

[491] Japan Atomic Energy Agency, 'Results of Deposition Density Measurement of Gamma-emitting Nuclides on Soil within the 80 km Radius from the Daiichi power plant. (From June 2014 to July 2014), Fukushima, KML', accessed: 20 April 2023, https://emdb.jaea.go.jp/emdb_old/assets/site_data/en/kml/1020101007/1020101007_07.kmz.

[492] Japan Atomic Energy Agency, 'Results of Air Dose Rates Measured by Route Buses in Fukushima Prefecture (4 buses, Jan. 2013-) - Weekly Average (From April 2013 to March 2014), Whole area,

that were generated based on different methods can relate with each other. In Figure 5.13, the coloured lines on the map show the air measurements that were conducted on the transportation network in the Fukushima city, and the comparison of two different datasets shows each survey covers the area comprehensively together while they are showing the contamination from different perspectives.

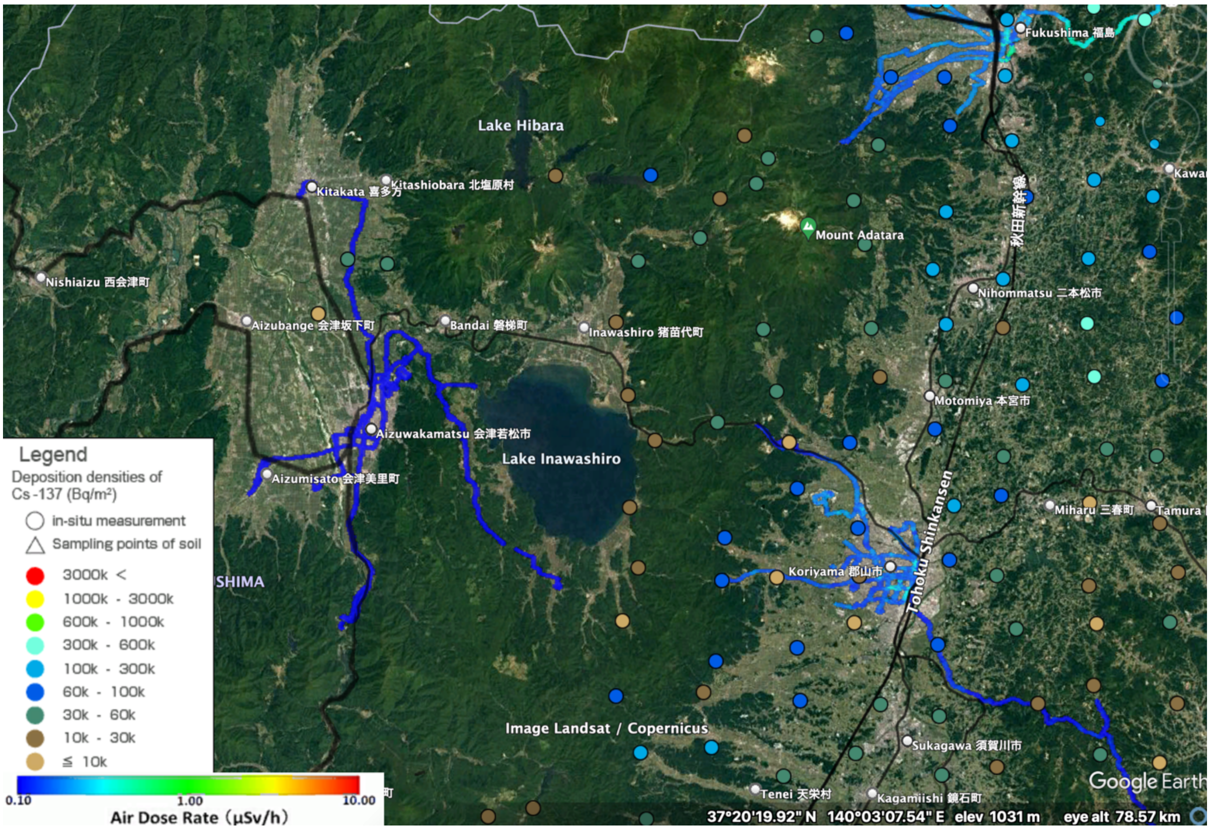

Figure 5.13: Soil and Air Measurements Data Mapped onto Google Earth.[493]

The example of the NRA data publication shows the potential of opening the nuclearity of the state monitoring system to the civic epistemology. Meanwhile, that of the JAEA suggests

KML', accessed: 18 March 2023, https://emdb.jaea.go.jp/emdb_old/assets/site_data/en/kml/1010204003/1010204003_00_kmz.zip.

[493] The author chose the period of 2014, as it was the most recent example where those two datasets overlap. The decontamination standard of the government's policy defines that the area marking 0.23 μSv/h needs to de decontaminated. In 2015, the average amount of caesium-137 in the Aizuwakamatsu area on the left side of the map is 30,000Bq/m2, which is equivalent 4,3 μSv/h. Therefore, the map shows that the area was highly contaminated during the monitored period.

how the knowledge that is produced within a scientific method can be combined with other datasets produced using a different method through the extensive capacity of scientific abstractions, data, and digital maps.

This section highlighted the ways in which the location of radiation monitoring is determined by a certain monitoring method to consider how the contamination can be constituted in terms of extensive abstractions. While the monitoring is established through the unique method of soil survey, their data has an extensive capacity that can depict the contamination by relating it through the digital map to bear an interpretation of the contamination.

5.6.3 Vehicle-Borne Survey

Finally, this thesis focuses on radiation monitoring in the transportation infrastructure. In Chapter 4, we examined how portable detectors are situated in their respective environments, using Safecast as an example. Their monitoring device, the bGeige nano, is capable of automatically measuring radiation levels and recording this data with temporal and locational metadata. The data are then mapped using the functions introduced in the preceding sections.[494] In these cases, portable devices are brought with humans or vehicles to monitor a wide range of areas from the perspective of citizens. In this method, the monitoring point is not fixed like the monitoring post, and a single device can generate radiation values in a wider

[494] In Chapter 4, we also noted that Safecast has released their data and device blueprints under a Creative Commons license. Some independent projects have utilised their technology, including the Fukushima-based entrepreneur Jun Yamadera's initiative, Fukushima Wheel. This project has developed a bike-sharing programme and accompanying software application. The application measures and archives radiation values in the air whilst cycling, utilising Safecast's portable sensor installed on the bicycles. In addition to radiation, the application monitors meteorological data, such as temperature and humidity, and air quality indicators, such as carbon monoxide and nitrogen oxygen. The data generated and archived through citizens' daily cycling activities enables users to gain insight into the environment in which they live. The data archived in their database can be visualised on a map in the application. See: Fukushima Wheel, accessed: 23 March 2023, https://fukushimawheel.org/.

area than soil measurement. In the example of Safecast's Points and Snapshots, we saw this on their radiation map. The technique of installing an air monitoring device in a vehicle is called a 'vehicle-borne survey'.[495] The JAEA has collaborated with other prominent institutions, including Tokyo Electric Power Company and the Ministry of Education, to conduct numerous surveys since 2011, and the results of their monitoring have been published on their website.[496] In one of their vehicle-borne monitoring projects, they conduct a survey using the Kyoto University RAdiation MApping (KURAMA) system, which was introduced in the thesis introduction and discussed in Chapter 4. In this project, they regularly conduct the survey in cooperation with the transportation network in the Fukushima Prefecture. Based on the preceding discussions, this section will further explore how this monitoring survey shapes a particular interpretation of the digital map.

Let us closely examine the project. Since 2013, the Fukushima Prefectural government has conducted vehicle-borne surveys to monitor the radiation levels in the atmosphere within the prefecture. Through collaboration with local bus and railway transportation networks and the Japan Post Service, portable devices have been installed on the cars and trains belonging to these institutions, which travel throughout the Fukushima Prefecture.[497] They use KURAMA to monitor radiation. As we have introduced in Chapter 4, KURAMA is a radiation-monitoring system that the nuclear research unit at the University of Kyoto has developed, and they own

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[495] This section particularly focuses on the use of KURAMA in the bus transportation network. Different methods and devices are deployed in accordance with the type of vehicles. For example, JAEA has also developed a monitoring system for an automobile. See:
Takeshi Minoru *et al.*, 'Using Two Detectors Concurrently to Monitor Ambient Dose Equivalent Rates in Vehicle Surveys of Radiocesium Contaminated Land', *Journal of Environmental Radioactivity*, 177 (2017): 1–12, https://doi.org/10.1016/j.jenvrad.2017.05.010.

[496] Japan Atomic Energy Agency, 'Vehicle-borne Survey Registered Data Catalogue', accessed: 04.02.2023, https://emdb.jaea.go.jp/emdb_old/en/selects/b10102/.

[497] Fukushima Revitalization Station, 'Vehicle-Borne Survey Monitoring in the Fukushima Prefecture (福島県における自動車走行サーベイモニタリング)', accessed: 4 April 2023, https://www.pref.fukushima.lg.jp/site/portal/ps-soukou.html.

their original portable radiation detector and data analysis software.[498] In this survey, the devices take the measurement of radiation value with GPS coordinates and send it to the database every three seconds.[499] The speed of the vehicles in the survey varies, and the spacing between each monitoring location is estimated to be between 30 and 100 metres. Based on this monitoring data, the surveyors divided the monitored area into a grid of 100m² squares and calculated the average radiation level for each square based on the monitoring points within it. Gamma rays released from caesium-134 and caesium-137 can travel between 10 and 100 metres in the environment, so the size of the grid and the frequency of monitoring for this vehicle-borne survey were chosen based on these radiological characteristics.[500] Their monitoring data are published on the website of the Fukushima Prefecture both in their map image and a KMZ format visualised on Google Earth.[501]

The calculated radiation values are mapped using diagrams on Google Earth. Viewers have the option to select a period ranging from one week to one month. The analysis presented in Figure 5.14 depicts monitoring data generated throughout the entire month of March 2021, a decade after the accident occurred. This data is mapped and visualised for analysis purposes.[502]

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[498] Institute for Integrated Radiation and Nuclear Science, Kyoto University, 'Overview of KURAMA (KURAMA の概要)', accessed: 3 March 2023, http://www.rri.kyoto-u.ac.jp/kurama/system.html.

[499] Institute for Integrated Radiation and Nuclear Science, Kyoto University, 'Bus Demonstration by KURAMA-II (KURAMA-II による路線バス実証試験について)', accessed: 4 March 2023, http://www.rri.kyoto-u.ac.jp/kurama/kouiki/explanation.html.

[500] Fukushima Revitalization Station, 'Vehicle-Borne Survey.

[501] Fukushima Prefecture, 'Result of Vehicle-Borne Survey in 2022 (令和４年度走行サーベイ結果)', accessed 4 April 2023, https://www.pref.fukushima.lg.jp/sec/16025d/r4-soukou.html.

[502] Fukushima Prefecture, 'Result of Vehicle-Borne Survey in the Fukushima Prefecture, March 2021', accessed: 4 April 2023, https://www.pref.fukushima.lg.jp/sec_file/monitoring/s-1/monthly202103_alla_r1.kmz.

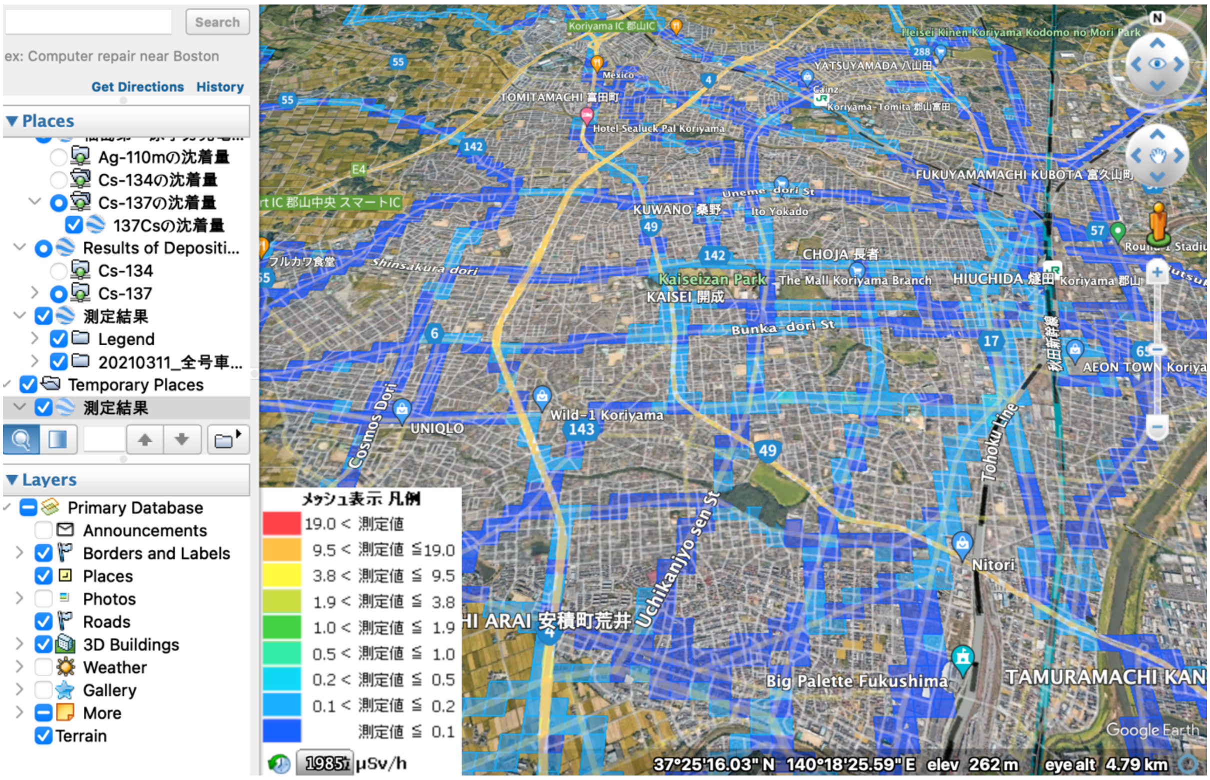

Figure 5.14: Vehicle-Borne Survey Results Mapped on Google Earth.

On Google Earth, the calculated radiation values are shown over the Fukushima area. On the bottom left of the map, the legend of values is shown with μSv/h, which indicates the radiation dosage for a human body. On the Layers section of Google Earth, users can choose what kind of information to show on the map, and on this screen, the national route roads are shown with yellow lines. Centred around the railways and roads, the sequenced grids show where monitoring has been conducted within the month.

This vehicle-borne survey provides an example of how the transportation infrastructure operates to mediate the space of a disaster. In Chapter 4, we applied Kuchinskaya's theory of infrastructures to explore how radiation-monitoring infrastructure produces a form of visibility of radiation. [503] Following Gabrys, we argued that individual radiation detectors transindividuate in relation to their associated milieux and that evidence of contamination

[503] Kuchinskaya, *The Politics*, 9.

emerges from the interaction between them. To bear witness, the sensors are tuned to the external milieux without altering them.[504] By examining infrastructure, time, and space, we can develop a deeper understanding of how contamination is perceived through technoscientific practice. In this vehicle-borne survey, radiation detectors are integrated into the local transportation network system that traverse the contaminated land near nuclear power plants. The devices are tuned to two milieux: natural and technical. These milieux refer to the environment through which the transportation networks travel. Although the word 'natural' is chosen, this milieu also includes residential areas. Moreover, gamma rays can travel up to approximately 100m, meaning a grid can contain radiation that comes from both natural objects, such as soil and woods, and technical objects, such as paved roads and houses. As shown in the last chapter, the concentration level of radiation can differ depending on those geographical characteristics.[505] Based on this point, surveyors have adjusted their monitoring methodology and adopted the average calculation of multiple monitoring results within a 100m² grid by considering the speed of cars, another technical milieu.[506]

A particularly unique aspect of this project is the presence of the transportation networks. Monitoring is conducted with the bus and train transportation networks in the area, and the monitoring devices of KURAMA are installed inside vehicles.[507] These devices are interlocked with the engine of the vehicles, and for example, in the survey with bus, the devices are

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504 Gabrys, *Program Earth*, 256.

505 All devices are installed 1m above the ground so the radiation value can reflect the geological condition well. According to the KURAMA's survey, the radiation value above paved roads is also affected by how the surrounding lands are used.

506 Institute for Integrated Radiation and Nuclear Science, Kyoto University, 'Bus Demonstration by KURAMA-II '.

507 Therefore, each radiation value is calculated higher than the values to estimate the value outside of the vehicles. The penetrating power of gamma rays is stronger than alpha and beta rays, and it can penetrate a thick iron and aluminium board. To avoid the penetration of gamma rays, a thick lead or iron sheet is used. Due to this, radiation value inside a vehicle can differ from outside. See: Ministry of the Environment Japan, 'Penetrating Power of Radiation', last modified: 31 March 2013, https://www.env.go.jp/en/chemi/rhm/basic-info/1st/01-03-08.html.

programmed to conduct in the period between when the engine of the bus starts and stops. Additionally, the position of a device in a vehicle is an important factor for the calibration within these technical milieux. According to the development team, their sensor is installed in the right back of the back seats. The reason for this location is not given, but considering that cars run on the left side of the road, it could be that they aim to collect the radiation value near the centre of the road. This can also be seen in how they calibrate the detector in the technical and social milieux of the transportation infrastructure.[508]

In this way, the monitoring methodologies of radiation sensors are calibrated to the natural, artificial, and technical milieux regarding the transportation infrastructures. In the last chapter, we studied the individuation of technical objects with the concepts of transduction and transindividuality to consider the ways in which different milieux can relate to the process. This argument is associated with the discussion of the interlocking of time. In the above section, we considered the interlocking of the intensive time of radiation and the extensive time on digital map. In the argument of Deleuze and DeLanda, it is illustrated that time is conceived of as the interlocking of different scales of time, with the interlocking being enacted through the oscillations of those multiple scales.[509]

In the example of the vehicle-borne survey, the time of the transportation infrastructure can be understood as the oscillation among the time scale of the buses that are scheduled by each bus route and that of other vehicles that move in the area, which may or may not be scheduled by a certain order of time. Then, as shown above, the frequency of monitoring is technologically interlocked with the movement of the engine. The movement of the engine is controlled by the human driver who drives the bus at a speed of up to 60km/h. On the road, the movement of the bus is regulated by traffic rules, bus schedules, and the movement of the

[508] The vehicle designs of Japanese buses can differ depending on each area, but in the Fukushima Prefecture, one floor buses with a rear entrance are commonly used. See:
Fukushima Transportation, Inc., ‘How to use bus (バスのご利用方法)’, accessed: 4 April 2023, https://www.fukushima-koutu.co.jp/bus/03_12.html.

[509] DeLanda, *Intensive Science*, 103.

citizens who commute by bus. Although bus lines repeat the same route and schedule regularly while generating data, its movements are interwoven with those other scales of time. Therefore, we can argue that, while the frequency of monitoring is programmed beforehand, it is still interlocked with the other vehicles' movements. The locations of the monitoring points on the map emerge in relation to this movement in the transportation network. As the contamination does not have a predetermined figure on digital maps, monitoring locations are always changing.

Moreover, this interlocking of the multiple time scales adds a new perspective to the preceding discussions of nuclearity and the mode of knowledge production. This vehicle-borne survey configures its nuclearity in the transportation infrastructure in the Fukushima Prefecture. While KURAMA is established in the scientific framework of nuclear physics and the technical operation of the monitoring devices installed in the chosen vehicles, this monitoring system can only function in the social relations formed in the roads that are part of citizens' everyday life. In this context, the knowledge is produced by the cooperation between the scientist, the transportation network, and the citizens of the area, and following Kuchinskaya, the contamination becomes visible through this local and dialogical process.[510] Therefore, the generated data prehends the extensive continuum that emerges on the map as the virtual space of the contamination. In this regard, the knowledge of the radiated environment is gained via the continuity cutting through the different groups that include both experts and non-experts of science.

5.7 Conclusion

In summary, this chapter began by discussing the function of the digital maps in radiation-monitoring projects through the concept of cyberspace. Cyberspace consists of relations

[510] Kuchinskaya, *The Politics,* 9.

between parts that involve a certain action on the internet, and it can be conceived as a virtual space. Then, following Foucault's and Chun's discussions of heterotopias, we argued that, through the virtual space of digital maps, the reality of the contamination is reconfigured. As shown in the example of radiation-monitoring practices, this reconfiguration of the reality is considered a process in which the understanding of the contamination is gained by combining different data and datasets through mapping them on the digital map.

Then, to further consider the operation of the functions of the digital maps deployed in radiation-monitoring practices, we introduced the discussions of time and space in the light of extensity and intensity. Reviewing Deleuze's and DeLanda's discussions on time, we considered the intensity of radionuclides as the intensive time of the half-life that is intrinsic to radioactive substances. This intensive time of radionuclides is translated into multiple scientific units that are measurable for technoscientific practices. Then, the extensity of time is understood as metric time that is used in radiology to understand the intensity of radiation, and the time system on digital maps can be thought of as a form of extensity. On digital maps, different time scales of those extensive times are interlocked with the intensive time of radionuclides, and we argued that, by switching between different scales of extensity, we can gain the understanding of the intensity of radiation – the contamination.

Next, to consider space on digital maps, we discussed Whitehead's theory of space and his concept of prehension. From Whitehead's viewpoint, space is cognised through scientific abstractions and the experience of percipients. Then, we showed those abstractions as an extensity that is a capacity of relation, and we considered the ways in which the contamination is prehending through the presentation of data on a map. In the process of prehension, divisible entities are successively continued as a discontinuous continuity where the cognitive and the uncognitive for humans and machines are prehended alike. This set of relations that extend from monitoring sites are recognised as a space by the viewer of the radiation maps.

Based on these discussions, we studied the cases of radiation mapping projects. First, we studied the formation of digital time on radiation maps and the ways in which contamination data is organised based on the metadata of time. With the example of real-time monitoring projects, we pointed out that monitoring data is generated and separated based on when the monitoring was conducted. Then, we argued that time does not exist in this context as a duration, and it can be thought as a discontinuous continuity. With the example of Safecast's API system, we showed how individual monitoring data are organised based on the metadata of time. Additionally, with the function of Points and Snapshots, we studied how those discrete data are recombined through chosen multiple time scales on the digital map.

Next, by focusing on three monitoring methods, we observed how the unique relationality of monitoring locations is related to mapping practice. As the first example, we examined the case of the NRA's state-owned monitoring projects and its data publication to consider its nuclearity in the light of the knowledge production in post-Fukushima. In this case, the monitoring locations on their map are identical to the locations of state facilities, and the nuclearity of the monitoring project has a particularly authoritative aspect that excludes the engagement of citizens in the monitoring process. However, given that this project publishes their monitoring data, we observe that their nuclearity is open to a civic epistemology that includes citizens' engagement in producing and assessing scientific knowledge.

Then, with the example of the JAEA's soil survey that is conducted using a grid sampling method, we studied the ways in which the contamination monitored is perceived within a scientific abstraction. In this case, monitoring locations are inductively determined based on the grid sampling method, and this is reflected both in their map and in published data that is readable on other mapping software. Through the extensive capacity of relation, this scientific abstraction can form another continuum through the data application on the digital map.

Subsequently, we studied the case of the vehicle-borne survey in the Fukushima Prefecture to consider the radiation monitoring that is conducted in the transportation network with monitoring devices installed in vehicles. In this case, monitoring points are interlocked with the movements of vehicles that are regulated within the interlocking of different time scales on the transportation infrastructure. In the light of the discussion of the infrastructure and different scale of extensive time, we determined the contamination is visualised through the relations between devices, the transportation networks, and the environment.

In conclusion, this chapter has explored the role of digital maps in radiation monitoring projects, highlighting how they reconfigure the reality of contamination through the combination of different data and datasets. Through an examination of time and space on digital maps, as well as various monitoring methods, we have demonstrated how data practices on digital maps can create an understanding of ongoing radioactive contamination in Japan. Ultimately, this thesis argues that digital maps are a key tool in reconfiguring the figure of contamination in post-Fukushima Japan, allowing citizens to constantly update interpretations of reality on and behind the map.

Conclusion: The Post-Fukushima Fallout

The Summary of the Thesis

This thesis began by outlining the occurrence of the Fukushima nuclear disaster and the social and cultural reaction to the catastrophic event. Throughout the history of disasters in Japan, natural disasters, such as tsunami and earthquakes, have been memorialised in various cultural forms. Historically unique reactions, such as digital archives and radiation monitoring, emerged from the 2011 disaster through the informational infrastructure of digital technologies to preserve memories and raise awareness of the environmental disaster.

Among different types of media, technological, and scientific practices, this thesis particularly focuses on radiation monitoring, in which scientists and citizens engage with the disaster in a new mode. In particular, the citizen-led monitoring project, Safecast, built a unique monitoring system that is independent from authority-based and closed scientific modes of knowledge production. As Hemmi and Graham observe, Safecast's technoscientific practices, such as the development of monitoring devices and publication of monitored open data, can be seen as a hacker approach to science that aims to share technologies with the public.[511]

In the introduction, to provide a background on how to observe the disaster and its aftermath, we highlighted the debates from Hiroki Azuma and Hiroshi Kainuma to study the disaster in a post-Fukushima context. With an emphasis on tourism, Azuma contends that visiting Fukushima as a tourist will bring a further understanding to people who are not directly related to the disaster. Since the accident, Fukushima has been recognised as a globally known place in the context of historical errors, similar to Hiroshima, Nagasaki, and Chernobyl. According to Azuma, this global and historical perspective will invite further international

[511] Hemmi and Graham, 'Hacker science'.

understanding of the location through the perspective of tourists who travel beyond the boundary of cultural borders.[512]

Hiroshi Kainuma criticises Azuma's viewpoint because the tourist approach provides only a disaster perspective of Fukushima, which has much more to offer than just a disaster site. Hence, Kainuma contends that the tourist approach is a violent act that places Fukushima under a singular vision, that of the disaster.[513] These two ideas demonstrate how the interpretation of an event can diverge based on a different approach, and both perspectives raise different inquiries that are grounded in the area's historical background. However, both arguments lack aspects that are enabled by the technoscientific practice of radiation monitoring. Azuma's view is based on a distinction between people concerned with the Fukushima disaster and tourist bystanders. However, considering the novel opportunities made available by radiation monitoring, it is possible that people who live outside of the disaster area can approach reality through technoscientific practices. In addition, although Kainuma argues that understanding Fukushima though the nuclear disaster lens can lead to a single vision, approaching Fukushima from the viewpoint of the disaster does not necessarily mean that it frames the understanding with only one perspective. As the examples of digital and technoscientific practices show, there are multiple ways to produce knowledge of the disaster and enable diverse perspectives of Fukushima as a disaster site.

To consider these points in relation to the characteristics of the media ecologies after the disaster, the thesis introduced an example of an art performance, *Pointing at Fukushima Live Cam,* which took place at the Fukushima power plant site. In this performance, an anonymous worker points at a live camera streaming the work at the nuclear power plant site. The video was streamed through Tokyo Electric Power Company's (TEPCO) website. During the performance, viewers gaze at the worker, and according to the performer, they are also

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[512] Azuma, 'About This Project'.

[513] Azuma, *Genron 0*, mobi Edition 14%.

pointed at by him on the screen.[514] This example highlights the media environment of post-Fukushima as a set of techno social circuits that connect the public to the centre of the disaster through the media. Through the technological mediation, the relationality between the performer and the viewers becomes omnidirectional, as seen in the act of gazing and being pointed at. As Lütticken argues, this particular performance possesses an aesthetic of entanglement that constitutes the new normal of post-Fukushima Japan.[515] This example shows that the media ecologies after the nuclear disaster entail a new mode of relevance, and observing its aesthetic dimension can elucidate the ways in which technologies and mediated action create relations between its constituents.

In the preceding chapters, we also considered how a radiological event accompanies socio-political relations to situate radiation monitoring in the context of its social and political backgrounds. Hecht's concept of nuclearity refers to a cultural and political configuration that is derived from a radiological event, in which knowledge of radiation is produced from the relations that constitute it as a nuclearity. [516] Following Kainuma, we gained an insight into the historical and political context of the way the political subjugation between the Fukushima Prefecture and the central government led to the dominance of pro-nuclear political groups that facilitated their nuclear power plant business.[517] This is a form of the nuclearity of the Fukushima nuclear disaster. We further considered how citizen-led radiation monitoring emerged in the socio-political relations in the aftermath of the disaster. While the government was conducting radiation monitoring in the devastated area, it did not publish the data on the contamination immediately. The lack of the information on the nuclear fallout and distrust in the central government led to the formation of radiation monitoring projects by citizens.[518]

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[514] Kadist, 'Finger Pointing Worker: Pointing at Fukushima Live Cam', 2011, https://kadist.org/work/pointing-at-fukuichi-live-cam/.

[515] Lütticken, 'Radio-Activity', 93.

[516] Hecht, *Being Nuclear,* 15.

[517] Kainuma, *'Fukushima' Theory,* 162–172.

[518] Blok *et al*., 'Environmental Infrastructures', 91.

To consider this aspect in relation to its mode of knowledge production, we paid attention to the relation between citizens and political and scientific authorities. Employing Jasanoff's concept of civic epistemology, a citizen-oriented way of understanding science, we examined the ways in which citizens' engagement in radiation monitoring can develop a particular understanding of the contamination.[519] The cases of Safecast and the Collective Database of Citizen's Radioactivity Measuring Lab exemplify how knowledge production of radiation was centred around citizens through monitoring surveys and data publication in post-Fukushima Japan. While emphasising the presence of citizens, at the same time, we also paid attention to institutional radiation monitoring projects, such as the JAEA, the NRA, and KURAMA, in which the monitoring infrastructure and survey methods follow scientific standard methods that are contrasted with citizens' projects. This thesis analysed how those institutional monitoring projects are also open to citizens' data practices and civic epistemologies via data publication. Through the extensive capacity of data formats such as CSV and KMZ, monitored radiation data can come into relation on the digital map. In this sense, standard science and citizen science can reconfigure an interpretation of radioactive contamination. In this way, we demonstrated how different modes of knowledge production coexist in the media ecology of post-Fukushima Japan.

In addition to socio-political relations, we also highlighted the environmental relations that constitute radiation monitoring projects. To consider this relationality, we reviewed the debate on the Anthropocene, the actor-network theory of Latour and others, including Michel Serres' relational ontology.[520] Discussing them, we illustrated how the post-Fukushima environment and media ecologies are co-constituted by human and non-human entities, including technologies and environments. Subsequently, with the theory of quasi-objects, we described

[519] Jasanoff, *Designs on Nature*.

[520] Crutzen and Stoermer, 'The "Anthropocene"'; Latour, *Science in Action*; Serres, *Natural Contract*.

the ways in which the property of radioactivity can change in relation to those entities that pertain to radiation monitoring.[521]

Relying on these relational modes of thought, we built our theoretical framework to explore the technological aspects of data, databases, and interfaces. Following the discussions of data as a virtual element, we argued that the characteristics of technoscientific data practices are their capacity to regenerate an interpretation of reality.[522] Then, to consider how an interpretation of data is created in relation to its formalisation, we studied the ways in which databases shape the process.[523] Following Simondon and Hui, we elucidated that data as digital objects in relation to their situated environments, such as databases, are conceived of as a digital milieu.[524] This enabled us to posit how a perspective on radiation constitutes technological and natural elements. To do so, following Viveiros de Castro, we delineated how a certain perspective can have a particular understanding of reality, and with Haraway, those perspectives can emerge from the relation between technologies and natural entities.[525] Discussing Andersen and Pold's concept of the meta interface, we contended that the aesthetics of a software interface show a relation between the interface and data and reflect a computational operation within the process of data reading and presentation.[526] Based on these viewpoints, we explored the ways in which digital mapping is deployed in radiation monitoring.

We further explored the related political, social, and cultural ecologies in relation to online media and technoscientific practices. After the disaster happened in March 2011, the anti-nuclear movement in Japan became a significant political and cultural phenomenon and drew global attention to protests demanding the abolition of nuclear power plants. The activists

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[521] Serres, *The Parasite,* 225.

[522] Galloway, 'Are Some Things Unrepresentable?', 7–8; Terranova, *Network Culture*.

[523] Azuma, *Otaku*; Foster, 'An Archive Impulse'.

[524] Hui, *On the Existence.*

[525] Viveiros de Castro, 'Perspectival Anthropology'; Donna Haraway, *When Species Meet*.

[526] Andersen and Pold, *The Metainterface*.

utilised social media to mobilise attendance on their protest marches, and the relationality of the movement has a characteristic of the ad hoc, a flexible relational form centred around the topic of the movement. This latter aspect is particularly found in the post-Fukushima anti-nuclear movement in which citizens participated in activism based on the anti-nuclear issue rather than for political ideologies that were a historical basis for activism in Japan.[527]

Next, we considered how a particular political issue can be linked with monitoring practices. In regard to the safety standard of the low-level exposure, Sato and Taguchi argue that the safety standard of the annual dosage threshold of 20mSv/year has not been scientifically proven. They contend that claiming this level of dosage as not harmful to human bodies and the related concept of the threshold of exposure reflects the political ideology of a pro-nuclear stance.[528] Subsequently, we introduced the activism of the Collective Database of Citizen's Radioactivity Labs, in which groups of citizens and citizen scientists generate and present contamination data to show defects in the government's safety standards.[529] They conducted a soil survey that shows more accurate radiation measurements in contrast to air measurements that were commonly adopted in the governmental monitoring method. Then, they mapped their data, combining it with the diagram of the Chernobyl disaster's evacuation standard on their digital map to compare the government's evacuation and safety standard, which is lower than the Chernobyl standard. Based on the concept developed by Félix Guattari, we considered how the subjectivity of this technoscientific practice forms machinic relations among groups of citizens and media technologies.[530] In addition, based on Michel Serres, we considered how the objectivity of radiation emerges in relation to the subjectivity that is constituted as an assemblage of data and software interfaces.[531]

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[527] Blok *et al*., 'Environmental Infrastructures', 78–79.

[528] Sato and Taguchi, *Philosophy of Abandoning*, 95–96.

[529] Collective Database of Citizen's Radioactivity Labs, Website, accessed: 3 April 2023, https://en.minnanods.net/.

[530] Guattari, *The Three Ecologies*, 28–29.

[531] Serres, *The Parasite*; Mol, *The Body Multiple.*

Using these relational ontologies and techno social theories to analyse radioactivity, we studied radiation monitoring technologies and digital maps in monitoring projects. To consider the process of the individuation and concretisation of radiation monitoring technologies, we rely on Simondon's theory of individuation.[532] Technical objects and digital objects, brought into the process of monitoring, are in a metastable condition that is open to further individuation in relation to its associated milieux. In this context, the concepts of transindividuality and transduction are important for the emergence of individuation.[533] Transindividuality cultivates further individuations, and the process of transductively emerges between individuals and milieux. As knowledge of radiation is produced with the particular relations that constitute a nuclearity, monitoring devices individuate and concretise in particular relations. This applies to data as digital objects, and we emphasised how the relationality of data is formed in between digital technical and natural milieux in the processes of monitoring radiation, data organisation, and presentation.[534] The technological infrastructures of society also become a part of the individuation of monitoring devices and monitoring data.[535] A sensorium sensitised to radiation emerges through this dynamic process in post-Fukushima society.

Building upon this viewpoint, we studied digital maps deployed in radiation monitoring. Following Foucault and Chun, we delineated digital maps as cyberspace/heterotopia, reconfiguring an interpretation of the radioactive contamination with its virtuality.[536] Relying on Deleuze and DeLanda, we illustrated how time in digital maps consists of the interlocking of the intensive time of radiation and extensive times, such as the calendar system and scientific measurements.[537] Subsequently, discussing Whitehead's theory of space and time with a focus on the concept of prehension, we highlighted the ways in which space and time are

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[532] Simondon, *Individuation*.

[533] Simondon, *Individuation*.

[534] Hui, *On the Existence*.

[535] Kitchin and Dodge, *Code/Space*; Gabrys, *Program Earth.*

[536] Foucault, 'Of Other Spaces'; Chun, *Freedom and Control.*

[537] DeLanda, *Intensive Science*; Deleuze, *Logic of Sense*.

perceived over a discontinuous continuum of relations formed through multiple elements.[538] As the individuation process does not have a predetermined goal, digital radiation maps constitute ever-changing dynamic processes that prevent predetermined perceptions of space and time. Based on this view, we considered how the temporality of monitoring data is expressed through the particular functions of digital maps, where time exists in discrete data while recombined with the extensive capacity of metadata.[539] We also highlighted how space is conceived in digital maps, paying attention to the nuclearity of the monitoring location and specific scientific and technical methods in surveys. The NRA's state radiation monitoring system generates data from monitoring posts in state facilities and presents this data through mapping and data publication. In this context, the authorities' nuclearity is open to civic epistemology.

With the example of the soil survey, we observed the ways in which the extensive abstraction of scientific methods relates to the perception of space in digital maps, which reconfigures an interpretation of the disaster. Institutional scientific abstraction is also shown by the nuclearity of citizens. Based on this, we examined the vehicle-borne survey, in which radiation monitoring is conducted in transportation infrastructures and the interlocking of different timescales enables the monitoring process. This process is locational and dialogical, and an understanding of the contamination emerges through a continuum of relations among citizens, scientific abstractions, data, and digital maps.

Findings, Significance, and Contribution of the Thesis

This thesis studied how radiation monitoring in the aftermath of the nuclear accident was deployed in the different registers of citizen science, activists, and administrative bodies. It

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538 Hurley, 'Whitehead's Relational'; Whitehead, *Process and Reality*; Whitehead, *Science and the Modern*.

539 Parisi, 'Symbiotic Architecture'; Goodman, 'Timeline (sonic)'.

did so through political, technological, environmental, epistemological, and ontological focuses on monitoring data generation, presentation, and sharing. Radiation monitoring is not merely a measurement of radionuclides but also a practice which creates an interpretation of these invisible and harmful substances with a temporality and spatiality that are embodied by technological mediation for inhabitants in the contaminated areas and for wider networks of citizens and society. This technoscientific practice takes place in media ecologies where authoritative and citizen-led projects are interconnected through technological infrastructures, creating a unique political epistemology of radioactive contamination. It is therefore necessary for this research to take an interdisciplinary approach to grappling with the properties of the technoscientific practices that are co-constituted by the relations formed across the different milieux of post-Fukushima Japanese society. In the introduction, this thesis proposed four questions to set-out the aim of this research. Following these questions, this section articulates the key findings and contributions of this study.

The first question asked how the nuclear disaster as a social, technological, and political event can be observed by focusing on the relation between these differing categories. In Chapter 1, we considered this question by reviewing a study on the formation of a citizen-led radiation mapping project with Jasanoff's concept of civic epistemology and Hecht's of nuclearity.[540] Subsequently, we examined relational ontologies to delineate the relation between humans, technologies, and the environment. The key finding resulting from this question is that the act of radiation monitoring in post-Fukushima Japan can be thought of as a form of civic epistemology because knowledge on radioactive contamination is created between authoritative institutions and citizens. Further, radiation manifests nuclearity in the unique relations with social groups that engage with a specific radiological event. Reviewing these debates in light of environmental studies and relational ontologies, we found that the Fukushima nuclear disaster can also be considered not only from social but also technological and environmental relations. The contribution of this analysis is that it added technological and

[540] Jasanoff, *Designs on Nature*; Hecht, *Being Nuclear*.

environmental concerns to preceding discussions of radiation culture. Additionally, the thesis showed how ontological debates on human and non-human entities can be considered in relation to a technoscientific practice.

The second question asked how knowledge and interpretations of radioactive contamination have been created and reconfigured in post-Fukushima media ecologies. In prior studies, the social aspects of technological practices of radiation monitoring and mapping are often discussed.[541] The Fukushima nuclear disaster also partially occurred in the informational networks that facilitate the communication between citizens and share information and data among them. In this context, the presence of social media is emphasised as a crucial factor that enabled citizens to form networks to react to the nuclear disaster. One of those societal reactions is the development of the anti-nuclear movement. As Hasegawa explains, the ubiquity of social media allowed for the mobilisation of such activism beyond a certain political ideology.[542] Following this, we discussed the case of CDCRML to consider in what way the governmental policy on low-level radiation exposure reflects a pro-nuclear ideology and the ways in which the citizen-led project contests government nuclear policy. Here, based on relational ontologies of machinism and quasi-object, we showed how the subject-object relation is formed, while reflecting the technological and political background of radiation monitoring.[543] The key finding of this section is that the understanding of radioactive contamination reflects social and political epistemology, and the relation between monitoring practice and radiation is conditioned scientifically and politically.

The third question aimed to explore the development and function of radiation monitoring devices and monitoring infrastructures. In Chapter 4, following Simondon, we considered how the technical and digital objects of monitoring devices and data individuate, concretise, and operate in relation to their associated milieux.[544] Here, we showed that monitoring devices,

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[541] Blok *et al.*, 'Environmental Infrastructures'; Plantin, 'Politics of mapping platforms.

[542] Hasegawa, 'The Fukushima'.

[543] Serres, *The Parasite*; Guattari, *The Three Ecologies.*

[544] Simondon, *Individuation*.

monitoring data, and users of those technical and digital objects transindividually cultivate their relations that condition the process of individuation. This view is also accompanied by a critical perspective to evaluate how radiation monitoring should be conducted. Thus, we find that radiation monitoring as a relational configuration is not only established at its genesis but also functions through its associated milieux, which are joined in a metastable condition as the monitoring devices. In this sense, the thesis also provided a discussion of technical objects with a case study of their operation in the environment. Subsequently, we also illustrated the network of radiation monitoring as the relation between technological infrastructures and users who transact monitoring data. By considering the visualisation of monitoring data as a result of these relational processes, we demonstrated how the understanding of contamination is continuously updated. The key finding of this section is that monitoring devices and monitoring data are developed in the relations of technical, digital, social, and natural milieux, and that the monitoring infrastructure is co-constituted by those elements without a pre-determined configuration.

The fourth question asked how digital mapping creates an interpretation of the nuclear disaster. To probe this matter, we examined the case of digital maps in Chapter 5. First, we defined the digital map as a form of cyberspace that reconstitutes reality, developing this argument via Chun and Foucault.[545] Subsequently, by analysing the case of Safecast, this thesis examined the aesthetics and functions of their digital map system and interface design to focus on the interpretation of monitoring data. Then, following the concept of extensity developed by Deleuze and Whitehead, we found that monitoring data are recombined with temporal and locational metadata through interface designs that create certain kinds of temporality and spatiality.[546] Subsequently, through an analysis of the cases of the state-owned radiation mapping of the NRA and the JAEA, we considered how particular political conditions and scientific survey methods can affect mapping practices in relation to the

[545] Chun, *Freedom and Control*; Foucault, 'Of Other Spaces'.

[546] Deleuze, *Logic of Sense*; Whitehead, *Process and Reality.*

applicability of monitoring data. In this relational perspective, radiation monitoring is conceived as an extensive continuum of heterogeneous entities, humans, and natural, technical, and digital objects that involve and depend upon the abstractions of science and computation. Here, we also observed how institutionally produced data can be recombined by users' mapping practices. The key finding of this observation is that although each monitoring measurement has a certain nuclearity that reflects a sociality and politicality that condition data generation, such data is still open to further use through non-authoritative technoscientific practices that are deployed through interface designs of mapping software.

Considering these findings, the key contribution of this thesis is broken down into two parts. First, the thesis contributed to preceding studies of the Fukushima nuclear disaster by adding reflection on the significance of the technoscientific practice of radiation monitoring in terms of knowledge-making. For example, in the studies on the mobilisation of the anti-nuclear movements in the post-Fukushima period, it has been discussed how social media has enabled ad hoc relations amongst citizens.[547] Also, the use of digital mapping in radiation monitoring has been considered in terms of how it facilitates public participation in measuring and sharing contamination data. Building upon these studies, as shown with the case of CDCRML, this thesis further delineated that radiation monitoring as a technoscientific practice contests the government's nuclear policy through digital mapping. Also, through closely examining data practices initiated by citizen-led and state-owned projects, the thesis shows how authoritative and non-authoritative groups are related to each other and create a civic epistemology in post-Fukushima Japan. With these arguments, the thesis showed how an observation of media technologies and knowledge making can contribute to the studies of the Fukushima nuclear disaster.

The second contribution is that, drawing on relational ontologies and an interdisciplinary approach, the thesis demonstrated the importance of considering technological and environmental elements in studies of radiation and media studies. For instance, while Hecht's

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[547] Blok *et al*., 'Environmental Infrastructures'.

concept of nuclearity pays close attention to localised social relations that constitute a radiological event, her observation has further potential in considering the technological and environmental relations that are also important factors in understanding such an event.[548] Throughout the thesis, we attempted to examine the Fukushima nuclear disaster as a social, technological, and environmental event. For example, with the discussion of the individuation of technical and digital objects, we demonstrated how they are developed in the dynamic relations of associated milieux comprising the natural, social, and technological. Then, discussing data practices on digital maps from a media studies perspective, we also emphasised how those elements are related to each other through the extensity of scientific abstractions and data. Hence, it is reasonable to state that this thesis contributes to the field of studies on radiation and media studies by showing the significance of technological and environmental aspects and how the consideration of digital media allows for a critical examination of technoscientific practices.

Fukushima and Beyond: Prospects for Future Study

Finally, we will consider the potential of this thesis to establish the grounds for future research in relation to the current situation regarding radiation monitoring. As of 2023, the government defines the evacuation standard radiation dosage as 3.8μSv/h, and the areas that supersede the standard have decreased by 97.5%. This research was collectively conducted by the Fukushima Prefectural Centre for Environmental Creation, a prefectural organisation that undertakes radiation monitoring and research, and other administrative bodies. They examined about 16 billion points of open data from radiation surveys.[549] It is estimated that

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[548] Hecht, *Being Nuclear*, 15.

[549] *Yomiuri Shimbun*, 'The radioactive contamination from the Fukushima Daiichi nuclear power plant accident has decreased by 97.5% in high-dose areas since immediately after the accident, due to decontamination efforts and natural decay (福島第一原発事故の放射能汚染、高線量地点が事故直後

the radioactive decay of the disseminated radionuclides is proceeding, and that part of the contaminated soil has been moved out into the sea.

While the radiation levels are decreasing, however, the seven areas located within a 20km radius from the Fukushima nuclear power plant within the prefecture still remain as the evacuation zone. Additionally, at the time of writing, the government is planning to release the stored contaminated water – which is used to cool the melted-down reactor – into the sea in the summer of 2023. Such cooling down has been conducted since 2011, and 1.3m tonnes of water are being stored in 1,000 tanks in the interim storage site. The wastewater will be diluted by a machine that removes radionuclides. However, although it can remove cobalt-60, strontium-90, and caesium-137, tritium will still remain in the water to be released.[550] While tritium gives off beta particles that can damage DNA, it exists in the natural environment. The World Health Organisation has defined the drinking water standard for tritium as 10,000 Becquerels per litre (Bq/l)[551] and according to TEPCO, the amount of tritium in the contaminated water will be diluted to 1,500 Bq/l before being released into the ocean from a discharge tunnel located 1km away from the nuclear power plant.[552] Although the government emphasises the safety of the water release, there are worries voiced by local inhabitants and fishers.[553]

から９７・５％減少…除染や自然減衰進む)', 6 March 2023, https://www.yomiuri.co.jp/shinsai311/news/20230306-OYT1T50133/.

[550] Jim Smith, 'Fukushima to release contaminated water – an expert explains why this could be the best option', University of Portsmouth, 23 January 2023, https://www.port.ac.uk/news-events-and-blogs/blogs/fukushima-to-release-contaminated-water-an-expert-explains-why-this-could-be-the-best-option.

[551] World Health Organization, 'Management of Radioactivity in Drinking Water' (2018): 29, https://iris.who.int/bitstream/handle/10665/272995/9789241513746-eng.pdf?sequence=1.

[552] Tokyo Electric Power Company, 'The Handling of ALPS Treated Water', Treated Water Portal Site, accessed: 20 April 2023, https://www.tepco.co.jp/en/decommission/progress/watertreatment/oceanrelease/index-e.html.

[553] Grace Tsoi, 'Fukushima nuclear disaster: Japan to release radioactive water into sea this year', BBC, 13 January 2023, https://www.bbc.co.uk/news/world-asia-64259043.

Radiation monitoring remains a global concern. In the 2022 Russian invasion of Ukraine, the Russian Army occupied the Chernobyl nuclear power plant site on 24 February. During the occupation, a sudden increase of the environmental radiation levels in the power plant site was observed. It has been estimated that radioactive substances accumulated on the ground were scattered by the movements of the army.[554] Until the incident occurred, Ukraine's administrative body, the State Agency of Ukraine on Exclusion Zone Management, was publishing their real-time monitoring results on their website.[555] Facing the invasion, due to security reasons, the Ukraine government had to shut down the monitoring network in the exclusion zone in Chernobyl.[556] Although the Russian army left Chernobyl on 31 March 2022, the Ukraine government is still unable to publish monitoring data on the website. However, Sate Specialized Enterprise Chernobyl Nuclear Power Plant (SSE), a government-owned enterprise responsible for decommissioning the exclusion zone that is under the control of the State Agency for Exclusion Zone Management, published their real-time monitoring data through SaveEcoBot, a non-profit organisation in Ukraine that publishes the real-time monitoring data provided by SSE, and those data can be accessed from their digital map.[557]

These cases show different but related insights for studies of radiation monitoring in the future. First, these cases highlight the importance of continuously generating and monitoring data for political and social reasons. In the case of the wastewater discharge, this viewpoint relates to prospective low-dosage radiation exposure and its health effects. Chapter 3 introduced the medical perspective that it takes more than 10 years to prove a causal link

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[554] BBC, 'Chernobyl: Why radiation levels spiked at nuclear plant', 25 February 2023, https://www.bbc.co.uk/news/science-environment-60528828.

[555] State Agency of Ukraine on Exclusion Zone Management, accessed: 25 April 2023, https://dazv.gov.ua/en.

[556] Reuters, 'Ukraine state nuclear company unable to monitor radiation levels around Chernobyl', 21 March 2022, https://www.reuters.com/world/europe/ukraine-state-nuclear-company-unable-monitor-radiation-levels-around-chernobyl-2022-03-21/.

[557] SaveEcoBot, 'Background Radiation Map', accessed: 25 April 2023, https://www.saveecobot.com/en/radiation-maps.

between a low dosage of radiation exposure and its resulting health effects, which is used to consider how this contingent relation can be altered through political decision making.[558] In this context, it is crucial to continuously generate data on the contamination to study the potential relation between a low dosage and its prospective hazards to health. Regarding this necessity for data generation, the case of Chernobyl adds a perspective on how radiation monitoring can continuously publish data for the public, even during an emergency. Based on the argument of this thesis, we can understand the interruption of the real-time radiation monitoring in Chernobyl as being an outcome of the dissociation of technological and political relations within the technical milieu of the monitoring network, which was dependent on a single social milieu of the administrative body. Subsequently, the dissociation was amended by the engagement of SaveEcoBot, and now, the real-time monitoring and data publication has returned. This case demonstrates the importance of understanding how radiation monitoring operates with a specific technical and political milieu. As monitoring infrastructures can contingently change, it is necessary to build networks so as not to stop publishing data. In the case of Fukushima, this point is particularly important for continuously monitoring the ongoing and foreseeable environmental contamination on the land and in the sea by creating a monitoring system based on potential risks of interruption. For example, reflecting on the invasion of Chernobyl, Safecast maintains that their monitoring system can run on multiple servers so that it can flexibly adopt to a foreseeable risk of their monitoring network being disrupted.[559] In this sense, in terms of the risk of the disruption within a technical milieu, data practices also need to consider how to sustain their technological infrastructure. Although this aspect is not examined in this thesis, there is a potential for us to further observe how a concretisation of objects and its associated milieux can reflect, and perhaps accommodate, the risk of disruption.

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[558] Ugaya, *Fukushima 2046,* 83.

[559] Azby Brown, 'War and Piecemeal Data', Safecast, 15 March 2022, https://safecast.org/2022/03/war-and-piecemeal-data/.

Another insight obtained from these cases is that a subject of radiation monitoring, or those who are conducting monitoring, can be further examined in relation to the use of technologies that are unique to each technoscientific practice. Throughout this thesis, we attended to the presence of citizens in different monitoring practices. As considered in Chapter 1, the mode of knowledge production of citizen-led radiation monitoring practices can be understood as civic epistemologies, where scientific knowledge is assessed and produced by or with non-scientific experts. The post-Fukushima media ecologies enabled citizens to conduct a survey and generate data to present on digital maps and share with the wider public. This process, however, is not limited to data generation. In Chapter 5, we noted that data produced by administrative bodies are archived and published for the public, and this led to opening up the nuclearity of those data to civic epistemologies. Thus, it is reasonable to state that citizens themselves also operate as a node where different modes of knowledge production can interact with each other. In the case of the forthcoming wastewater discharge, it will be necessary to consider how civic engagement is possible in relation to the environment of the sea that traverses different municipal bodies. In this sense, it will be a point of argument that subjectivities formed through technoscientific practices deployed in the sea environment require different approaches to monitoring on the land. The Chernobyl case shows that a subjectivity of monitoring, which implements the process collectively, is formed between the administrative body and the nonprofit organisation to publish the monitoring data for global publics on the Internet. Both cases demonstrate that the way of engagement in radiation monitoring can traverse different natural, political, and technological registers. In this sense, the thesis' account of subjects and individuals as co-constituted entities will provide a theoretical method to investigate these other cases of radiation monitoring.

Conclusion: Tracing the Fallout

In conclusion, reflecting on the thesis, we have considered what our exploration achieved and its prospects for future studies of Fukushima and beyond. The technoscientific practice of radiation monitoring became a phenomenon that brings forward new interpretations of the ongoing radioactive contamination in the post-Fukushima media ecologies. In the process, monitoring devices individuate and concretise in relation to the political and technological milieux that traverse inhabitants' living environments, administrative bodies, and technological infrastructures. These are implemented with environmental monitoring surveys to generate data on the contamination, which extends to the screens of databases and digital maps that bear multiple interpretations of the disaster.

In this exploration, this thesis particularly emphasised that this technoscientific practice's feature of local and relational interactions developed through a particular set of social, cultural, and political circumstances. The nuclear fallout from the Fukushima nuclear power plant has damaged, as Kohso argues, the commons of the inhabitants, and each of them faces challenges due to the contamination and its consequences, which occur in multiple registers.[560] From this background, radiation monitoring techniques have been developed, calibrated, and implemented while accompanying the potential to redraw our understanding of the contamination and avoid positing a single correct figure to the invisible fallout. Instead, they demand an engagement with how those figures emerge and what they mean as part of a complex of relations. This emergent continuum of relations extends from the decaying radionuclides in the environment to our computer screen through the struggles of inhabitants. In this sense, radiation monitoring is not only about measuring radiation levels. This thesis is an attempt to delineate such an ever-changing and incomplete process of tracing the fallout in the post-Fukushima media ecologies.

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[560] Kohso, *Radiation and Revolution,* 130.

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