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Practicing, materialising and contesting environmental data

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Abstract

While there are now an increasing number of studies that critically and rigorously engage with Big Data discourses and practices, these analyses often focus on social media and other forms of online data typically generated about users. This introduction discusses how *environmental* Big Data is emerging as a parallel area of investigation within studies of Big Data. New practices, technologies, actors and issues are concretising that are distinct and specific to the operations of environmental data. Situating these developments in relation to the seven contributions to this special collection, the introduction outlines significant characteristics of environmental data practices, data materialisations and data contestations. In these contributions, it becomes evident that processes for validating, distributing and acting on environmental data become key sites of materialisation and contestation, where new engagements with environmental politics and citizenship are worked through and realised.

Keywords

Environmental data, environmental Big Data, environmental monitoring, data practices, data materialisations, data contestations

Introduction

A range of new environmental data sources is now emerging through the proliferation of monitoring technologies and in response to increased levels of environmental change. While data has been a central concern for environmental sciences for some time, new practices and technologies are contributing to the increase of data across environmental fields and modes of engagement. For instance, environmental sensors are beginning to produce new data streams, from monitoring air pollution to tracking traffic flows, river levels, energy consumption and more. A greater distribution of sensors allows for an even greater collection of environmental data. In the logic of the Internet of Things, environmental sensor data is meant to actuate, automate and enable more efficient and effective processes, whether through responding to disaster scenarios or by regulating traffic lights. In these approaches, Big Data functionality also becomes a key emphasis, where data analytics are meant to provide new insights in relation to real-time sensor datasets. Environmental data is proliferating not just through sensors, but also through remote sensing and modelling, field observations and forecasts, cloud computing and platforms, as well as citizen-gathered data and environmental data art.

Investigating the proliferation of environmental data and data practices, this special theme critically considers the many ways in which data is increasingly seen to be essential to managing environmental systems, practices and politics. From air pollution modelling to climate change accounting, the materials and practices of environmental data collection are not only proliferating but also transforming into environmental Big Data. How do these new forms and quantities of environmental data contribute to and complicate approaches to Big Data? And how do the multiple environmental data practices that are

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emerging rework and trouble the assumed easy transfer of data to insights, engagement or action?

Reconsidering environmental data

The specificity of data as *environmental* is then a key point of focus within this collection. While many studies on Big Data attend to social media and online sources of data about users, the configurations of environmental data can raise rather different issues. Some environmental datasets have in many ways always been 'big' in the sense that they have been of considerable volume, velocity and variety (Laney, 2001). One of the first uses for mainframe computers was the analysis of weather and climate data, including modelling of climate forecasts, due to the size of datasets (Edwards, 2010). Large datasets in this sense are nothing new within some areas of environmental and biological data science (cf. NASA, n.d.; cf. Leonelli, 2014). At the same time, as problems related to environmental change increase, so too do calls for gathering more data, ostensibly to understand and manage these problems more effectively. From climate change to biodiversity surveys, there is a drive to collect more data in order to monitor and forecast environmental change (cf. Hampton et al., 2013). Whether instrumenting the planet with sensors or launching satellites dedicated to the study of environmental change, the state of the planet in crisis is often met with the response to gather more data.

Environmental data and related forms of calculation are topics that have a long and rich history of scholarship, both within science and technology studies and environmental studies broadly conceived. A number of studies have focused on the ways in which calculation and enumeration have become key ways in which to understand and address environments and environmental problems (Asdal, 2008; Verran, 2010). Numerical data often becomes the basis for generating management plans and sustainable 'solutions' to environmental problems. It is typically through numerical and data-based strategies, such as adjusting variables in the most well-known example of limiting climate change to 2°C, which environmental change is meant to be mitigated. The problem of environmental change then often becomes a problem of gathering data and acting on that data within the terms set by these modes of calculation.

Yet as many well-known analyses of environmental data also point out, data is always 'cooked' in some way (Bowker, 2000). Writing on biodiversity science, Bowker makes the claim that not only is data never raw, but also that they have to be parsed and processed in particular ways in order to circulate in scientific and policy infrastructures and discourses. These ways of cooking data are also forms of social, cultural and political work. Environmental data, monitoring practices and technologies undergo complex processes of negotiation and shaping that do not simply translate a phenomenon monitored into a data point (cf. Nafus, 2016). Processes of selecting, gathering and operationalising environmental events are also particular ways of materialising environments and ways of acting on environmental problems (see also Gabrys, 2016).

Within such a constructivist analysis, it would then go without saying that environmental data has a/effects in the world and are generative of worlds (cf. Stengers, 2008). Environmental data contributes to the remaking of objects of study. These new environmental objects include, for instance, the forming of new entities such as a 'whole ocean' along with new fields of study such as 'ocean informatics' (Baker et al., 2005; cf. Helmreich, 2009). Environmental data and data practices become tools of accountability, as well as sites of affective attachment, when taking account of environmental changes such as biodiversity loss and deforestation (Gupta et al., 2012; Lorimer, 2008). Such data practices unfold as forms of governance and assumed transparency through measurement, or 'measurementality' (cf. Lippert, 2015; Turnhout et al., 2014), including through attempts to enumerate and track organisms throughout their lifecycles (cf. Benson, 2016; Gabrys, 2016). As Fortun (2012) has elsewhere noted, this can also lead to ways of 'informating environmentalism', where information technology and environmental problems are inextricably interwoven.

Given the proliferation of data collection technologies and practices, from sensors to satellites, as well as analytic techniques for processing data, environmental data has now moved into the terrain of environmental Big Data. While studies on enumeration, calculation and accountability are well established, new sets of issues potentially arise with the data practices, data materialisations and data contestations that characterise environmental Big Data. These issues can include the need to develop new approaches to the interoperability of complex and heterogeneous environmental datasets (Borgmann, 2015; Edwards et al., 2011). They also extend to new studies on 'intensive' environmental sensor datasets that account for the emerging relations and entities that occur, rather than focus exclusively on 'extensive' characteristics of data such as volume (Mackenzie and McNally, 2015). Research on urban environmental Big Data has also called attention to the particular ways in which smart cities projects are entangled with Big Data analytics and the implications these modes of management have for digital urbanisms (cf. Batty, 2013; Kitchin, 2014). Data further has resource requirements, and the materialities of data centres, servers, innumerable devices and networks

contribute to environmental effects (Gabrys, 2014; Hogan, 2015). In this sense, Big Data is also productive of new data environments and data ecologies.

Along with these studies on environmental data and environmental Big Data, there are ever more datasets that are being generated, opened up, cross referenced and analysed in order to monitor environmental change, manage resources, attempt to achieve sustainability and even develop new forms of innovation through environmental 'Big Data Capital' (NERC; cf. Oxford e-Research Centre, 2014). Emerging environmental data initiatives range from the Digital Catapult's 'Environmental data exchange' to the London Datastore of open environmental data (Ranger, 2011), the United Nations Environment Programme Live platform for tracking sustainable development goals, as well as IBM's 'Smarter planet' initiative that has collaboratively developed sensor and Big Data environmental projects that are so heavily instrumented and analysed that researchers claim they are able to 'watch the forests breathing' in real time (Schaeffer, 2014).

In addition to these initiatives to gather more environmental data through the usual channels of expert science, there is also a proliferation of environmental data in the form of citizen science and citizen sensing, along with data from social media and data generated by creative practitioners working with alternative modes of visualisation and materialisation. As some of these early discussions of citizen sensing as well as 'volunteered' or 'participatory' geographic information have pointed out (Elwood, 2008; Goodchild, 2007; Haklay, 2013), the democratisation of technological engagement both brings new ways of addressing environmental problems as well as questions about what is meant by democratisation, especially when extended to questions of the production and circulation of data (cf. Miller, 2005). Pervasive computing, especially when extended to citizen science and citizen sensing, might then also give rise to 'pervasive analytics' (Mascolo et al., 2014), where questions emerge about what data should be collected and for whom, through what sensors or user actions, and towards which individual or collective forms of action (Mascolo et al., 2014: 18). Questions such as these that arise in relation to citizen-gathered data also point to the lived encounters with environmental data and uses to which data is put (Taylor, 2016; Taylor et al., 2014), which complicate the straightforward narratives for how data will be used. At the same time, citizen-gathered data is also operationalised to realise environmental and social justice objectives (Ottinger, 2010; Shilton, 2010).

The increasing 'bigness' of environmental data is then in part due to this diversifying range of environmental data from multiple different sites, sources and actors, as well as the problems that environmental data is meant to address. This special theme collection addresses the proliferation of these new data types and considers in what ways they are changing environmental data practices and forms of data citizenship. The proliferation of environmental data is not ultimately a matter of more content and quantity. Instead, the generation of data by alternative actors can change the criteria and values for data collection, as well as give rise to different strategies and tactics for communicating data by attempting to generate different political a/effects.

Environmental data contributions

In order to better understand these specificities of environmental data, particularly as they inform Big Data spaces and exchanges, the articles included here engage with the practices, materialisations and contestations of environmental data. Environmental data practices often engage with environmental problems to generate distinct objects and relations of concern. The materialisations of environmental data can articulate distinct connections and ways of attending to environmental problems, and the ways in which environmental data circulates and is produced can also legitimate or delegitimate actors and approaches to environments. In this way, environmental data and data practices are far from a neutral undertaking, and processes for validating, distributing and acting on environmental data can become key sites of contestation, where new engagements with environmental politics and citizenship are also worked through and realised.

Articles in this special theme then consider what the logics and commitments are that motivate environmental data collection, deployment and validation. Different engagements with environmental data emerge if collected for risk assessment, to promote behavioural change, to facilitate engagement or to inform policy. The articles included here also address the ways in which environmental data is taken up; put into action; or contested by researchers, industry and citizens. In other words, processes of forming evidence and acting on evidence inform the efficacy and circulation of data, and they also challenge the role that data plays in forming environmental collectives and matters of concern. In this respect, environmental data has particular political a/effects by informing relations and ways of life, which environmental data potentially solidify or unsettle. For instance, environmental data used for corporate carbon reporting can give rise to much different relations and attachments in comparison to environmental data gathered to measure air pollution and understand environmental health.

In exploring these areas, this special theme seeks to explore the materiality, liveliness, politics and practices of environmental data in relation to emerging (and historic) formations of environmental Big Data.

This collection of papers especially interrogates the interstices between the claims, practices, devices and agents of environmental monitoring. With case studies ranging from air pollution monitoring and modelling, remote sensing and carbon footprinting, as well as citizen sensing and locating data within arboretum archives, the papers in this special theme collection put the claims of Big Data to work by examining how specific environmental data practices give rise to more complex, entangled and even wayward engagements with data. These analyses of environmental data practices leverage perspectives from science and technology studies, creative practice, digital media theory, environmental politics, environmental health and atmospheric science. The contributions track and unpack the multiply constituted practices of environmental data, from the social and political practices they enable or foreclose, to the environmental politics that they would newly constitute or mobilise.

As these articles demonstrate, data practices materialise through air pollution instruments and models (Garnett), botanical archives (Loukissas), carbon reporting (Lippert) or environmental satellites (Nadim). The focus with these articles is not just to consider how data is sensed, felt, placed or accounted for, but also to examine how through these processes there emerge conditions of error (Garnett), spatial disjuncture (Loukissas), informational asymmetry (Lippert) and distance from environmental trouble (Nadim). These articles further demonstrate how environmental data comes into form, is constructed and also stabilised. In other words, they point to the ways in which these techniques are able to admit some perspectives through environmental data and not others – they materialise particular worlds through their modes of capture. Yet this is not merely to say that environmental data cannot account for or compute the whole of environmental processes, but rather to indicate the social, political, economic and environmental decisions and commitments that are made through materialising data in these ways.

Garnett suggests that the particular ways in which atmospheric scientists negotiate error within air pollution monitoring and modelling, particularly through sensed engagements with instruments and data, can begin to rework the linear and normative discourses of environmental Big Data to indicate how the very stabilisation of data requires affective engagements to make data settle in particular ways. Loukissas points out that place is typically left out of accounts both for understanding scientific practices and data practices. Focusing on the botanical archives at the Arnold Arboretum, he shows how place is a formative part of the datasets, which can also inform ways of engaging with other environmental data and its place attachments. While Loukissas focuses on the specificity of place and data, Lippert demonstrates how relatively universal carbon accounting mechanisms are negotiated and even break down through attempts to account for activities that increase or lessen a company's carbon footprint. Rather than promoting greater sustainability, Lippert suggests that these data-based approaches to sustainability might instead lead to forms of informational asymmetry that contradict democratic modes of governance. Also taking a critical approach to the drive to gather more environmental data, Nadim engages with satellite monitoring as a way to challenge that which can be accounted for through this particular mode of observation and data generation. Nadim proposes that we develop new 'data fictions' as a way both to critically and creatively counter the drive to render environments completely into data-based modes of management.

In complement to these articles especially focused on the materialisations of data, the remaining articles in this collection address the ways in which creative practitioners (Singer), critical data designers (Fortun et al.) and citizens (Gabrys et al.) engage with environmental data in order to contest, question, pushback or rework prevailing data practices. As the technologies of environmental data capture and analysis transform, so too have the sites of possible intervention, where new data actors and relations might converge. Singer describes how an early Preemptive Media art project adopted the use of air quality environmental sensors in order to provide alternative data that might complement and/or challenge the US Environmental Protection Agency's Air Quality Index readings. As one of the early projects undertaking a sort of citizen science meets citizen sensing, these citizen-oriented environmental data practices paved the way for a whole range of creative experiments with the 'instruments' of air quality sensing, including projects such as Beatriz da Costa's 'Pigeon Blog' (2006), which engaged with homing pigeons carrying air quality sensor 'backpacks' to collect air quality data in Southern California.

Through ethnographic research and analysis of environmental data repositories and platforms, Fortun et al. demonstrate how 'critical data designers' are important shapers and intermediaries in making sense of environmental data for wider public access and use. The decisions made about what counts in how environmental data is presented and re-presented do not end at the point of data monitoring and collection, but continue on through the further uses that are made of these data. Yet it can also be possible for

citizens to intervene at multiple points of data capture, as it were, by engaging in data collection, analysis and communication through to policy. As Gabrys et al. indicate, by engaging in these practices citizens also rework the commitments and forms of relevance that environmental data generate, so that new ways of approaching data develop. These new practices might, for instance, focus less on absolute numerical accuracy as the key criterion on which to evaluate environmental data, and instead develop 'just good enough' data practices that draw different points of connection and insights from spatially dense monitoring networks or through shared patterns within datasets. In this sense, the authors point to the ways in which data could not only be done otherwise, but also could begin to generate new practices and alignments by engaging with data in these more creative registers.

Conclusion: Engaging with the contingencies and complexities of environmental (Big) Data

Big Data are often pointed to for having distinct 'extensive' characteristics (as discussed above), and for implementing certain epistemological and ethical shifts towards new 'claims to objectivity' and away from interpretation (boyd and Crawford, 2012). Yet as many researchers have further noted, it is not typically clear what counts as Big Data in the first place (Boellstorff and Maurer, 2015), and what the politics of this designation might be. Indeed, an exclusive focus on bigness as a formal measure might obscure an emphasis on the more unique aspects of environmental. Bigness, or a certain unwieldiness of information, is also nothing particularly new if we follow Beniger's (1989) long-standing argument, since information and information technologies are regularly reaching crisis points and requiring the development of new technologies to recalibrate and 'manage' information.

This special theme draws attention to these different but parallel alignments, suggesting that the specificity of data – as environmental – is an important intervention into (and reminder of the diverse histories of) Big Data. Big Data analyses often focus on data sources culled from online activities such as social media use, yet environmental data is now being generated from a range of sources, from citizen sensing to environmental agency monitoring, and from arboretum archives to air quality modelling, as well as social media postings. This special theme collection engages with the multiple practices, materialisations and contestations that environmental data galvanises, and asks how these specific modes of environmental data challenge or rework approaches to Big Data. These practices complicate the usual designations of Big Data through the ways in which they engage with the trajectories of data to action and data engagement. These practices and trajectories also become renewed areas of focus when considering the contingencies and complexities of environmental data, and the effectiveness that this data is meant to have in relation to, and even against, the abstractions of Big Data.

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