

Environmental Computability. The Politics of Knowing and Governing Climate Change

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Abstract

Digitalization increasingly shapes how environments are known and governed amid climate change. This editorial develops the notion of environmental computability to describe the socio-material conditions through which environments become measurable, comparable, and actionable through computational systems, asking what knowledge, infrastructures, and relations of authority make this possible. Rather than simply introducing the contributions to this special issue, it reads them alongside existing scholarship on digitalization and environmental governance, offering a synthesis of current insights into how computable environments become entangled with questions of expertise and extraction, maintenance and care, and inequality—sand with longer histories carried into contemporary climate futures. Drawing on feminist STS, I propose diffraction and refraction as complementary analytical perspectives: diffraction attends to how computational environments emerge through relations, while refraction traces how existing relations of power and inequality are redirected through digital infrastructures. Together, they make visible the politics of environmental computability and the dys/continuities through which digitalization and climate governance become entangled.

Keywords: Environmental computability, Climate governance, Digitalization, Feminist STS, Computational Infrastructures, Refraction

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In the Akaki catchment surrounding Addis Ababa, Ethiopia, researchers collaborated with farmers, football players, and local residents to integrate community-based flood monitoring into existing early-warning infrastructures (Nigussie et al. 2025). Situated observations of river behaviour, rainfall, and seasonal flooding were translated into computational forms of environmental knowledge and integrated into hydrological modelling (Alemu et al. 2023), becoming valuable insofar as they could be made compatible with model requirements. At the same time, these processes also depended on servers and satellite links, on cloud platforms and the data centres that run them—infrastructures operating at a material and energetic scale far removed from local monitoring practices. The example thus shows how digitalization and climate change are already entangled in the production of environmental knowledge and climate futures.

This special issue argues that digitalization cannot be framed only as a technological response to environmental change but rather as something that materializes the conditions

through which environments become knowable and governable. I use *environmental computability* to name this epistemic, material, and political condition, continuously produced through the everyday work of capture, such as sensing and classifying, modelling and standardizing, maintaining, predicting, optimizing. Environmental computability, in other words, is the labour and politics behind turning an environment into something that can be measured, compared, and anticipated. As STS scholarship has long shown, infrastructures, standards, and classifications do more than support knowledge production and enable its circulation — they actively configure the objects they organize (Bowker & Star 1999; Jackson et al. 2007; Edwards 2013; Jensen & Morita 2015). Recent discussions of computational universalism similarly remind us that these seemingly universal computational representations rest on a great deal of infrastructural work through which heterogeneous realities become scalable and comparable (Lee & Ribes 2025). Where computational universalism traces this infrastructural work across any domain computation touches, such as finance, health, logistics, environmental computability keeps the analysis tied to what is specifically at stake when the domain is an environment: land, water, energy, and species that must be extracted, monitored, or maintained for a representation to hold, and futures that must be made plausible before intervention can follow. This semblance of universality depends on a politics of scalability that privileges hyperscales, while leaving out local situatedness and alternative trajectories (Pfotenhauer et al. 2022), including forms of indigenous and local knowledge that resist standardized computational categories altogether (Roturier & Beau 2022). Environmental computability therefore shifts attention from digital technologies themselves to the socio-technical arrangements through which distinct versions of environments become computationally tangible.

Climate change forms an important horizon of these processes, but environmental computability extends across broader fields of environmental governance, including biodiversity, agriculture, and resource management. Research in anthropology, STS, sociology, and geography has demonstrated that computational infrastructures do more than represent environmental change: they increasingly help produce it as an object of knowledge and intervention (Gabrys 2020, 2024; Edwards 2013; Bruun et al. 2022).¹ Environmental STS has likewise shown that environments are enacted through practices of sensing, modelling, and management rather than existing as stable entities awaiting representation (Lippert et al. 2015; Lippert 2018; Baya-Laffite et al. 2025). At the same time, studies on slow violence, environmental justice, and feminist technoscience have drawn attention to the uneven burdens generated by technological systems, demonstrating how infrastructures redistribute environmental risks while reproducing longer histories of extraction, inequality, and environmental racism (Bullard 1993; Nixon 2013; Davies 2019; Okafor-Yarwood & Adewumi 2020; Eitel 2022; Hein & Klepp 2025; Bray 2007; Åsberg & Lykke 2010), work that runs parallel to critical data studies tracing similar asymmetries of visibility and representation within data systems more broadly (Taylor 2017; D'Ignazio & Klein 2020). In this context, computational infrastructures do not sit outside these politics, but are themselves shaped by them.

Although ethnographic research on digitalization has expanded considerably (Boellstorff 2021; Geismar & Knox 2021; Eckhardt & Klausner 2023; Richterich & Wyatt 2024),

¹ Gabrys' own notion of environmentality captures how sensing infrastructures discipline environmental subjects and shape conduct (Gabrys 2014); environmental computability asks not how subjects are governed through data, but how the environment itself becomes governable in the first place, through the comparative and infrastructural labour that lets it travel as a measurable object at all.

computational infrastructures, climate governance, and environmental knowledge have only recently begun to be brought into sustained relation. This includes work on agriculture and food systems (Atasoy 2025), energy transitions (Sareen & Müller 2023), and perspectives from the Global South (Subramanian and Hassan 2024). Meanwhile, STS studies have further demonstrated that digital infrastructures are sites where governance, openness, expertise, and political authority are continuously negotiated rather than merely implemented (Mager et al. 2026). Whatever gets digitalized still runs on resources, labour, and energy — dependencies that often become materially concentrated in data centres. Work in critical data centre studies, in particular, has shown how computation depends on water-intensive cooling (Hogan 2015), on the ongoing work of managing air and temperature (Vonderau 2019b), and on the specific rhythms of data centre operation and maintenance (Velkova & Plantin 2023). Çelik et al. (2026) push this further, tracing scientific data infrastructures through server procurement, institutional routines, energy use, and resource extraction to show how digital knowledge production is inseparable from planetary conditions.

Building on these emerging efforts, this editorial brings these debates together through the notion of *environmental computability*, asking how environments become computationally knowable and what politics follow from their computability. To examine these processes, I draw on the complementary concepts of *diffraction* and *refraction* from feminist STS. The better-known concept of diffraction, developed prominently by Karen Barad (2007) and Donna J. Haraway (1992), directs attention to the relational processes through which computational systems, environments or other entities come into being *together* as they are co-constituted. *Refraction*, instead, can be used as a complementary lens². It asks how longer trajectories of extraction, colonialism, inequality, and environmental governance are redirected rather than displaced through contemporary computational infrastructures. This also allows environmental computability to be understood as both emergent and enduring: as a process through which particular forms of environmental knowledge become visible and affective while existing relations are reworked into climate futures.

The following sections develop this argument by bringing the contributions to this special issue into conversation with existing scholarship on digitalization, environmental governance, infrastructures, and climate change. Reading them as empirical sites through which different forms and politics of environmental computability become visible, this editorial reveals how computational arrangements redistribute authority over environmental knowledge, redirect existing relations of power and inequality, and shape which environmental futures become imaginable, actionable, or foreclosed.

Following Relations: Diffraction and Refraction

Environmental phenomena do not enter computational systems as pre-given objects. They are framed as particular kinds of computational entities through heterogeneous encounters among observations, sensors, standards, software, models, institutional routines, and practices of maintenance. Building on Lee and Ribes' (2025) discussion of "computational universalism", environmental computability draws attention not only to the technical processing of environmental phenomena but also to the infrastructural labour through which

² Refraction is not introduced because diffraction cannot account for history or continuity. Rather, refraction is introduced here to foreground a particular analytical problem: how relations travel, change direction, and acquire different effects as they move across infrastructures, institutions, and temporalities.

particular representations become scalable, comparable, and seemingly universal. Environmental computability therefore names a specific epistemic and political condition in which environments become actionable insofar as they can be rendered legible to computational systems.

Diffraction offers a fruitful way of staying with these relations without reducing them to either representation or technology. Borrowing the concept from wave optics, Karen Barad argues that diffraction is not simply a metaphor but an onto-epistemological practice for attending to the relational production of difference. Building on Haraway's critique of reflection, Barad follows Haraway's observation that "a diffraction pattern does not map where differences appear, but rather maps where the effects of difference appear" (Haraway 1992, 300; see also Barad 2014: 172). Analytical attention therefore shifts from stable entities towards the relations through which they become differentiated ("inappropriate/d other" according to Haraway 1992), stabilized, and capable of acting (see also Bateson 2000 [1972]). Haraway's insistence on situated knowledges (1988) and her later observation that "things do not pre-exist their relations but are materialized through them" (1997, 95) capture this movement succinctly. Following how computational environments emerge therefore only tells one part of the story. Environmental computability also requires attention to how relations travel and what happens to them as they move through new computational arrangements.

Although both Haraway and Barad mention refraction alongside reflection and diffraction, neither develops it as an analytical figure in its own right. I therefore propose refraction as a complementary analytical figure for tracing the temporal continuity of socio-material relations as they persist, bend, and acquire new political effects across space and time. In optics, refraction describes the change in direction that occurs when waves pass through different media (Barad 2007: 51). While diffraction foregrounds the emergence of relations, refraction draws attention to *how existing trajectories of power are redirected* as they pass through computational infrastructures. It asks which forms of expertise, extraction, and environmental governance are bent into new configurations and what becomes amplified, displaced, or obscured in the process. Colonial histories, extractive economies, and regimes of expertise do not simply disappear within computational systems; they are reworked through new infrastructures, standards, and forms of governance. As Yusoff (2024) has shown for geologic and colonial orderings, systems of classification and valuation are always political as they participate in the reproduction of enduring relations of extraction and dispossession. My notion of sedimented knowledge similarly traces how knowledge accumulates along different spatial and temporal trajectories, forming the ground through which new knowledge claims and climate resilience strategies become more or less plausible (Eitel 2026).

Refraction, then, points to more than enduring continuities: it makes visible a *politics of dys/continuity*, the way computational transformations reconfigure existing arrangements even as they create new ones along historically shaped trajectories. I deliberately use the prefix dys- to move beyond a simple opposition between continuity and discontinuity, highlighting forms of continuity that persist precisely through disturbance, friction, and harm. Infrastructures that enable computational environments, in this light, do not cleanly break with longer histories of extraction and dispossession. They grow out of dys/continuities with them, which is what makes them material and epistemic in the same movement.

Becoming Relations

These dys/continuities take shape in the ordinary, often unnoticed labour through which environments are rendered computationally tangible. They emerge through alignments among observations, standards, software, classifications, maintenance practices, ecological processes, institutional routines, and situated forms of expertise. Some environments stabilize in the process; others stay uncertain, ephemeral, or out of reach of computation (Suchman 2012)—a limit this editorial returns to as itself a political question, not merely a technical one.

The flood early-warning system in the Akaki catchment, which opened this editorial, already pointed towards this process. Community observations mattered neither because they represented an authentic local reality nor because they corrected remote sensing. They became consequential once they had been calibrated against hydrological measurements, modelling practices, institutional routines, and computational infrastructures that turned rivers into forecastable entities (Nigussie et al. 2025; Alemu et al. 2023). What travelled through the system was an environmental reality stable enough to circulate between communities, government agencies, software, and predictive models. Diffraction follows these alignments. It asks how computational environments become possible before they appear as coherent objects of environmental governance.

Similarly, *Malin J. Nemeth* and *Malte B. Rödl*'s contribution "Datafied Encounters as Representational and Relational: A More-than-Human Perspective on the Biodiversity Citizen Science Project Artportalen" treats data as the outcome of what the authors call "datafied encounters" between humans, organisms, and technology, rather than as a representation of an already given reality. By investigating the Swedish digital biodiversity platform Artportalen, the authors show that these encounters draw together organisms, observers, taxonomic conventions, digital infrastructures, and environmental governance. Species observations become biodiversity data through the ongoing work of verification, negotiation, translation, and care. Computability is an effect of these socio-material relations. What eventually circulates as an observation retains its traces even as it recedes into the background of the computational infrastructure. Biodiversity becomes computable because heterogeneous ecological encounters are made comparable enough to travel across databases, institutions, and conservation practices.

Data, then, are less the starting point of computational environments than the temporary stabilization of situated practices through which heterogeneous observations come to travel across scales. Jennifer Gabrys' analyses of smart forests make a related argument: environments increasingly participate in computational infrastructures rather than being merely monitored by them (Gabrys 2020, 2022, 2024). Sensors, trees, atmospheric processes, communication networks, machine learning, and environmental management form distributed arrangements in which forests become ecosystems, environmental sensors, carbon infrastructures, and computational environments at once (Gabrys 2016). Observation, intervention, and environmental change unfold within the same assemblage, so that computational perception and ecological process shape each other's conditions.

Questions of comparability and scale return in *Mylène Tanferri*'s contribution. In "Being Granular, Becoming Sustainable: A Preliminary Inquiry into the Wor(l)ds of Smart Farming Developers", her ethnography of smart farming developers turns on what she calls granularity: the aspiration to generate increasingly fine-grained environmental knowledge through sensors, experimentation, machine learning, and continuous observation.

Granularity owes less to technological sophistication than to the patient work of interdisciplinary collaboration, software development, calibration, maintenance, agricultural expertise, and experimental practice. Plants become environmental indicators and fields become infrastructures of observation, while sustainability acquires computational resolution through countless acts of translation embedded in everyday practices of design and repair. Granularity thus names one mode in which environmental computability is assembled.

These contributions share an interest in the mundane labour that assembles environmental computability. Observations become classifications, classifications become standards, and standards become models capable of circulating across laboratories, ministries, digital platforms, and international governance arrangements. What travels across institutions and scales are relations made durable enough to survive the journey, through practices of curation, storage, maintenance, and infrastructural coordination — which is Sørensen and Kocksch's (2021) point about data durability as an ongoing socio-material accomplishment. Older STS work on the making of governable environments runs in the same direction: Laser and Sørensen (2021) show how rivers emerge through shifting configurations of ecological knowledge, valuation, temporalities, and intervention; Edwards (2013) traces how planetary climate knowledge is assembled through observations, simulations, standards, and institutions; Bowker and Star (1999) demonstrate how classifications organize the worlds they describe; and Jackson et al. (2007) and Jensen and Morita (2015) stress the ongoing work through which infrastructures acquire stability. Computability draws these lines together in a single question: how do environments acquire the stability computation requires without shedding the heterogeneity they come from?

In each case, diffraction keeps attention on the unfinished relations through which environmental realities become measurable, comparable, and actionable. But these relations never start from scratch. Every classification carries earlier classifications; every infrastructure inherits existing infrastructures; and every computational environment carries histories of expertise, extraction, labour, and environmental intervention. Following those trajectories means staying with relations as they pass through computational infrastructures and change direction along the way. I call that movement refraction.

Redirecting Relations

The trajectories of environmental computability become particularly tangible in *Eduardo Lúersen* and *Bibiana da Silva de Paula's* contribution to this issue, which follows the regional geographies of cloud infrastructure across Germany and Switzerland. In "Scenes from the Regional Geographies of Cloud Infrastructure: Hydrating, Humming, Shuttling", their analytical figures of hydrating, humming, and shuttling reveal data centres as environmental infrastructures whose relations extend far beyond the buildings in which computation appears to take place. For example, water moves through cooling systems, electricity through servers, logistics through transport corridors, sound through neighbouring communities, and landscapes through regional planning and infrastructural investment. The cloud dissolves into rivers, power grids, roads, warehouses, maintenance work, and municipal politics. In their account, computation is enacted as an environmental formation whose material requirements continually exceed the places in which digital knowledge is actually and locally produced.

Their ethnography resonates with broader analyses of infrastructural life that have followed the environmental consequences of digital systems beyond the screen. Abram et al.

(2023) show how energy infrastructures reorder the relations between environments and political economies, while Vonderau (2019a, 2019b) shows that an apparently immaterial cloud rests on constant work that redistributes resources, labour, and value. Scientific data infrastructures cannot be separated from planetary material conditions: they run on energy, on extracted metals, and on institutional routine (Çelik et al. 2026). Read through refraction, cloud infrastructures recall Starosielski's (2015) insistence that digital communication has a material geography, and Crawford's (2021) account of AI as an extractive industry. Santarius et al. (2023) and Höfner and Frick (2019) make a comparable case for digital sustainability claims, while Ortner et al. (2023) trace data centres as contested energy infrastructures. Environmental knowledge and environmental transformation are two faces of the same material arrangement.

A similar movement shapes *Steffen Dalsgaard* and *Hasib Ahsan's* contribution, "Entanglements of Sustainability in Dhaka: The Complications of Deploying Technological Solutions to Capitalist Problems". They follow computational interventions into a city where capitalist urbanization, precarious labour, and uneven infrastructures long predate digitalization. Sustainability technologies do not arrive in an empty landscape. They settle within existing political economies, redistributing responsibilities, risks, and capacities to act while leaving intact many of the asymmetries that produce environmental inequalities in the first place. The redistribution is epistemic as much as material. Paula Helm et al. (2022, 2023) show how ostensibly inclusive forms of digital knowledge production can reproduce extractive and neocolonial relations when data, expertise, and value keep circulating unevenly. Refraction therefore has a distributive quality: environmental computability appears here as an unevenly distributed capacity to anticipate and govern environmental futures. Its infrastructures redirect environmental burdens alongside information. Nixon (2013) calls this kind of harm slow violence, and Davies (2019) follows it into toxic aftermaths; Bullard (1993) had already traced the same asymmetries in his analyses of environmental racism, which reappear today in e-waste dumping in the Global South (Okafor-Yarwood & Adewumi 2020). Environmental justice scholarship has long shown that technological interventions produce differentiated vulnerabilities rather than removing them (Fortun 2012; Eitel 2022; Hein & Klepp 2025).

The same trajectories become visible at a much smaller scale in *Laura Kocksch* and *Estrid Sørensen's* account of scientists who "cuddle" servers by switching them off when they are no longer needed (Kocksch & Sørensen 2023). That is not what seamless automation is supposed to look like. Someone still has to maintain, repair, and judge, even where automation appears complete. Refraction becomes visible here because older traditions of care are folded into infrastructures of optimization and monitoring rather than displaced by them. Puig de la Bellacasa (2017) insists that care is an infrastructural relation and not an ethical add-on, and feminist technoscience has long argued that innovation tends to stabilize existing relations of power and labour instead of overcoming them (Bray 2007; Åsberg & Lykke 2010).

Environmental computability emerges, then, as a medium through which relations are refracted across spacetime. Extraction becomes data extraction, but it still depends on land, minerals, energy, and labour. Environmental management borrows the language of sensing, optimization, and prediction, yet stays tied to older distributions of expertise and authority. Care persists inside infrastructures that grow more automated by the year. Environmental inequalities resurface in new computational geographies, and infrastructures that promise dematerialization simply relocate their material dependencies elsewhere and otherwise (Eitel 2025). The promise of dematerialization (that digitalization is somehow less material and resource-intensive than its analogue counterparts) borrows the form of that possibility

without redeeming it: material dependencies do not dissolve into a more livable configuration but reappear in altered forms. Refraction follows these trajectories: it shows how computational infrastructures bend relations without breaking them, carrying histories of extraction, dispossession, and maintenance into the computational environments now organizing climate futures.

Governing Climate Futures

Environmental computability is inseparable from anticipation: computational environments bring possible environmental futures into the present as objects of knowledge and intervention. Governability here does not denote the successful control of environmental change but the socio-material conditions under which intervention becomes conceivable and institutionally actionable. Floods become forecast probabilities before rivers overflow, biodiversity becomes indicators of ecological transformation before species disappear, agricultural fields become sites of continuous optimization before harvests fail, and cloud infrastructures are planned around projected demands long before computation takes place. Futures acquire material presence through models, simulations, classifications, and infrastructures that allow environmental change to enter the present as an object of intervention (Adams et al. 2009; Appadurai 2013; Schütze 2026).

Across the contributions gathered in this special issue, computation repeatedly transforms uncertainty into forms that can be acted upon in different ways. *Malin J. Nemeth* and *Malte B. Rödl*'s contribution demonstrates how biodiversity monitoring continuously assembles environmental change before it becomes perceptible as ecological loss. *Mylène Tanferri*'s ethnography shows how smart farming developers cultivate ever finer forms of granularity in the expectation that increasingly detailed environmental knowledge will enable more sustainable futures. *Eduardo Luersen* and *Bibiana da Silva de Paula*'s analysis of cloud infrastructures likewise shows that computational environments are built around projected futures of storage, circulation, and connectivity whose material demands are anticipated long before they become visible as environmental consequences.

Prediction, however, is only one element of these computational futures. Environmental computability also redistributes authority over what becomes imaginable, actionable, and governable. Models, platforms, indicators, standards, and algorithms do not merely anticipate environmental change; they establish the conditions under which environmental futures become credible, comparable, and politically actionable. Hajer and Oomen (2025) describe such anticipatory infrastructures as central to contemporary climate governance, while Muiderman et al. (2020) show how imaginaries of future resilience increasingly become embedded in computational practices of modelling and scenario building. Environmental futures emerge not only from ecological processes but also from the infrastructures through which those processes become computationally knowable.

This movement also reshapes the meaning of sustainability itself. Rather than constituting a fixed normative horizon, sustainability increasingly emerges as an ongoing computational accomplishment, produced through optimization, granularity, resilience, prediction, and continuous monitoring. It thereby operates as a mode of governing through crisis knowledge (Eitel & Acksel 2026; Eitel & Kaur 2026), extending earlier observations that climate change is always accompanied by environmental imaginaries through which futures become collectively imaginable (Yusoff & Gabrys 2011). Across domains as diverse as energy transitions and digital agriculture, computational practices reorganize everyday environmental

decision-making while redistributing expertise across platforms, models, and infrastructures (Sareen & Müller 2023; Atasoy 2025). The promise of computational control itself becomes political, legitimizing technological innovation as an adequate response to climate crisis and thereby helping to sustain existing trajectories (Schütze 2026). It is precisely through these anticipatory capacities that the promise of the twin transition—the joint push for digital and green transformation—derives its persuasive force (Beck et al. 2021): digital infrastructures promise not simply more information about environmental change but an enhanced capacity to anticipate, optimize, and govern uncertain futures.

Yet anticipation is itself refracted through existing histories and asymmetries as computational futures are never equally available to everyone, nor do they distribute uncertainty evenly. Some futures become measurable, governable, and investable; others remain uncertain, incalculable, or politically marginal. *Steffen Dalsgaard* and *Hasib Ahsan's* contribution illustrates this particularly clearly, showing how technological sustainability initiatives in Dhaka become entangled with existing inequalities, infrastructures, and political economies that shape whose futures can be secured and whose remain exposed. Anticipation therefore does not suspend the distributive politics traced through refraction, but it extends it into the future, redistributing risks, responsibilities, and possibilities for intervention through computational infrastructures that increasingly define what counts as environmental preparedness.

Seen together, the contributions suggest that environmental computability governs futures not by predicting them accurately, but by organizing the conditions under which particular futures become thinkable, governable, and legitimate. Diffraction follows the relations through which these futures are assembled from heterogeneous encounters among environments, infrastructures, expertise, and computation. Refraction follows the historical and spatial trajectories that continue to travel through these arrangements, redirecting longer histories of extraction, inequality, and environmental governance into new computational formations. Environmental computability emerges precisely where these trajectories become sufficiently stabilized for environments to circulate as computational objects and climate futures as objects of anticipation and intervention.

The Politics of Environmental Computability

This editorial aimed to demonstrate how every alignment that makes environments measurable also carries assumptions about what counts as relevant knowledge, whose expertise matters, how change should be measured, and what kinds of intervention become thinkable. The politics of environmental computability therefore begins before a computational output ever reaches environmental governance — it is already at work in the relations through which an environment becomes computationally knowable from the outset.

Environmental phenomena become computable only through this kind of work, that is, the work of becoming relations, redirecting relations, and governing climate futures. *Becoming relations* draws attention to the heterogeneous work through which environmental phenomena acquire computational form. *Redirecting relations* shows that these arrangements never begin from scratch: classifications, infrastructures, forms of expertise, material dependencies, care, and inequalities persist as they move through new computational formations. *Governing climate futures* extends these relations into anticipation, as models, platforms, indicators, and infrastructures make particular environmental futures plausible in the present. Together, these movements show why digitalization and climate change cannot be

treated as separate domains. The infrastructures through which environmental change becomes computationally knowable are themselves material and environmental formations, while the knowledge they produce increasingly organizes how climate change is anticipated and governed.

Diffraction and refraction make it possible to follow these movements together. Diffraction attends to the relations through which computational environments emerge. Refraction follows what happens to these relations as they continue to travel across infrastructures, institutions, places, and time. This is not continuity as simple repetition; rather, relations change direction and acquire new forms and effects: environmental management becomes sensing and optimization, extraction becomes entangled with data infrastructures, expertise is redistributed through platforms and models, and care persists within systems that appear increasingly automated. Refraction therefore returns us to the politics of dys/continuity: computational arrangements can appear novel, universal, or neutral while still carrying forward older distributions of authority, responsibility, labour, and environmental burden. Not everything becomes computable, and that limit is itself political. For example, a flood that resists modelling or a species that will not be counted do not simply await better sensors or finer granularity but mark the edge of what current infrastructures can render actionable. That edge falls unevenly: some environments remain illegible because no one has yet built the capacity to compute them, others because doing so would not serve whoever funds that capacity. Asking who bears the cost of staying outside computability belongs to this politics as much as asking what gets counted, modelled, and governed.

Environmental computability is therefore a conceptual vocabulary for following these processes ethnographically. It asks how environments become computable, which relations are carried forward in doing so, and how these arrangements shape what can become visible, credible, and governable under conditions of climate change. The question is thus not only whose worlds, knowledges, and futures continue to travel through computational infrastructures, but also how these trajectories might be redirected: which relations are reproduced, which might be interrupted, and which other climate futures could become actionable. These are questions that demand responses in a world of polycrisis, grappling with anticipatory scenarios that exceed the horizon of our own experience. Yet the possibility of redirection should not itself be mistaken for political openness. The capacity to make futures actionable is unevenly distributed, materially constrained, and bound to infrastructures that privilege some trajectories while foreclosing others.

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Literatur

- Abram, Simone, Karen Waltar, Nathalie Ortar & Sarah Pink (Eds.) (2023): *Energy Futures. Anthropocene Challenges, Emerging Technologies and Everyday Life*. Berlin, Boston: De Gruyter. <https://doi.org/10.1515/9783110745641>.
- Adams, Vincanne, Michelle Murphy & Adele E. Clarke (2009): *Anticipation: Technoscience, Life, Affect, Temporality*. In: *Subjectivity* 28/1, 246–265. <https://doi.org/10.1057/sub.2009.18>.
- Alemu, Abel Negussie, Alemseged Tamiru Haile, Andrew B. Carr, Mark A. Trigg, Getahun Kebede Mengistie & Claire L. Walsh (2023): *Filling Data Gaps Using Citizen Science for Flood Modeling in Urbanized Catchment of Akaki*. In: *Natural Hazards Research* 3/3, 395–407. <https://doi.org/10.1016/j.nhres.2023.05.002>.
- Appadurai, Arjun (2013): *The Future as Cultural Fact: Essays on the Global Condition*. London: Verso.
- Åsberg, Cecilia & Nina Lykke (2010): *Feminist Technoscience Studies*. In: *European Journal of Women's Studies* 17/4, 299–305. <https://doi.org/10.1177/1350506810377692>.
- Atasoy, Yıldız (2025): *Agriculture by Algorithm: Big Data, Digitalization, and Biotechnology Under Climate Change*. In: *Science, Technology, & Human Values* 50/6, 1291–1333. <https://doi.org/10.1177/01622439251321233>.
- Barad, Karen (2007): *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham: Duke University Press.
- Barad, Karen (2014): *Diffraction: Cutting Together-Apart*. In: *Parallax* 20/3, 168–187. <https://doi.org/10.1080/13534645.2014.927623>.
- Bateson, Gregory (2000 [1972]): *Steps to an Ecology of Mind*. 5th ed. Chicago: University of Chicago Press.
- Baya-Laffite, Nicolas, Soraya Boudia & Céline Granjou (2025): *Environmental STS*. In: Soraya Boudia & Ashveen Peerbaye (Ed.), *Science and Technology in Society*. Newark: John Wiley & Sons Incorporated, 179–201.
- Beck, Silke, Sheila Jasanoff, Andy Stirling & Christine Polzin (2021): *The Governance of Sociotechnical Transformations to Sustainability*. In: *Current Opinion in Environmental Sustainability* 49, 143–152. <https://doi.org/10.1016/j.cosust.2021.04.010>.
- Boellstorff, Tom (2021): *Rethinking Digital Anthropology*. In: Haidy Geismar & Hannah Knox (Ed.), *Digital Anthropology*. London, New York: Routledge, 44–61.
- Bowker, Geoffrey C. & Susan Leigh Star (1999): *Sorting Things Out. Classification and Its Consequences*. Cambridge, London: MIT Press.
- Bray, Francesca (2007): *Gender and Technology*. In: *Annual Review of Anthropology* 36/1, 37–53. <https://doi.org/10.1146/annurev.anthro.36.081406.094328>.
- Bruun, Maja Hojer, Ayo Wahlberg, Rachel Douglas-Jones, Cathrine Hasse, Klaus Hoeyer, Dorthe Brogård Kristensen & Brit Ross Winthereik (Eds.) (2022): *The Palgrave Handbook of the Anthropology of Technology*. Singapore: Palgrave Macmillan. <https://doi.org/10.1007/978-981-16-7084-8>.
- Bullard, Robert D. (Ed.) (1993): *Confronting Environmental Racism: Voices from the Grassroots*. 1st ed. Boston: South End Press.
- Çelik, Leman, Stefan Laser, Estrid Sørensen, and Sandra Abels (2026): *Staying with the Planet: The University That Tried to Reckon with Ecological Reality, Challenged Excessive Data Infrastructures, and Nurtured a Few Alternatives Not Planned for*. Bielefeld: Transcript Verlag.

- Crawford, Kate (2021): *Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence*. New Haven: Yale University Press. <https://doi.org/10.12987/9780300252392>.
- D'Ignazio, Catherine & Lauren F. Klein (2020): *Data Feminism*. Cambridge, London: MIT Press.
- Davies, Thom (2019): Slow Violence and Toxic Geographies: 'Out of Sight' to Whom? In: *Environment and Planning C: Politics and Space* 0/0, 1–19. <https://doi.org/10.1177/2399654419841063>.
- Eckhardt, Dennis & Martina Klausner (Eds.) (2023): *Digital[ität] Ethnografieren. Forschungsmethoden für den digitalen Alltag*. Frankfurt am Main: Kulturanthropologie Notizen. <https://doi.org/10.21248/ka-notizen.85>.
- Edwards, Paul N. (2013): *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. First paperback edition. Cambridge, London: MIT Press.
- Eitel, Kathrin (2022): Reshuffling Responsibility: Waste, Environmental Justice and Urban Citizenship in Cambodia. In: *Worldwide Waste: Journal of Interdisciplinary Studies* 5/1, 1–13. <https://doi.org/10.5334/wwwj.87>.
- Eitel, Kathrin (2025): Elsewhere: Speculative Landscapes in the Climate Pluriverse. In: Martin Zähringer, Simon Probst & Matthias Grotkopp (Ed.), *Climatic Subjects: Cultural Interventions, Writing Climate, and a Burning Planet*. Bielefeld: transcript, 205–222. <https://doi.org/10.14361/9783839409503-016>.
- Eitel, Kathrin (2026): Sedimented Knowledge. Fragile Terrains of Urban Flood Governance in Ho Chi Minh City. In: *Environment & Society*.
- Eitel, Kathrin & Britta Acksel (2026): Schöne neue nachhaltige Stadt? Krisenwissen als Modus urbaner Transformation. In: *Kulturanthropologie Notizen* 87, 49–68. <https://doi.org/10.21248/ka-notizen.87.85>.
- Eitel, Kathrin & Baldeep Kaur (2026): Speculative Waste Futures. In: *Waste in Motion-Kollektiv* (Ed.), *Wie Abfall die Welt bewegt – Handbuch sozialwissenschaftliche Abfallforschung*. Bielefeld: Transcript, 463–480.
- Fortun, Kim (2012): Ethnography in Late Industrialism. In: *Cultural Anthropology* 27/3, 446–464. <https://doi.org/10.1111/j.1548-1360.2012.01153.x>.
- Gabrys, Jennifer (2014): Programming Environments: Environmentality and Citizen Sensing in the Smart City. In: *Environment and Planning D: Society and Space* 32/1, 30–48. <https://doi.org/10.1068/d16812>.
- Gabrys, Jennifer (2016): *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet*. Minneapolis: University of Minnesota Press.
- Gabrys, Jennifer (2020): Smart Forests and Data Practices: From the Internet of Trees to Planetary Governance. In: *Big Data & Society* 7/1. <https://doi.org/10.1177/2053951720904871>.
- Gabrys, Jennifer (2022): The Forest That Walks: Digital Fieldwork and Distributions of Site. In: *Qualitative Inquiry* 28/2, 228–235. <https://doi.org/10.1177/10778004211042356>.
- Gabrys, Jennifer (2024): Sensors. In: Ulrike Felt & Alan Irwin (Ed.), *Elgar Encyclopedia of Science and Technology Studies*. Cheltenham, Northampton: Edward Elgar Publishing, 587–595.
- Geismar, Haidy & Hannah Knox (Eds.) (2021): *Digital Anthropology*. London, New York: Routledge.
- Hajer, Maarten A. & Jeroen Oomen (2025): *Captured Futures: Rethinking the Drama of Environmental Politics*. Oxford, New York: Oxford University Press.

- Haraway, Donna J. (1988): Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. In: *Feminist Studies* 14/3, 575–599.
<https://doi.org/10.2307/3178066>.
- Haraway, Donna J. (1992): The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others. In: Lawrence Grossberg, Cary Nelson & Paula A. Treichler (Ed.), *Cultural Studies*. New York: Routledge, 295–337.
- Haraway, Donna J. (1997): *Modest_Witness@Second_Millennium.FemaleMan_Meets_OncoMouse: Feminism and Technoscience*. New York: Routledge.
- Hein, Jonas & Silja Klepp (2025): Umweltgerechtigkeit. In: Kathrin Eitel & Carsten Wergin (Ed.), *Handbuch Umweltethnologie*. Wiesbaden: Springer Verlag, 449–469.
- Helm, Paula, Amalia De Goetzen, Luca Cernuzzi, Shyam Diwakar, Alethia Hume, Salvador Ruiz-Correa, Niels Jørgen Gommessen & Daniel Gatica-Perez (2022): Leveraging or Exploiting? Breaking Through Data Colonialism and Ethnocentrism When Building a Diversity-Aware Social Platform. The 23rd Annual Conference of the Association of Internet Researchers.
- Helm, Paula, Amalia de Götzen, Luca Cernuzzi, Alethia Hume, Shyam Diwakar, Salvador Ruiz Correa & Daniel Gatica-Perez (2023): Diversity and Neocolonialism in Big Data Research: Avoiding Extractivism While Struggling with Paternalism. In: *Big Data & Society* 10/2.
<https://doi.org/10.1177/20539517231206802>.
- Hogan, Mél. 2015. "Data Flows and Water Woes: The Utah Data Center." *Big Data & Society* 2/2.
<https://doi.org/10.1177/2053951715592429>.
- Höfner, Anja & Vivian Frick (Eds.) (2019): *Was Bits und Bäume verbindet. Digitalisierung nachhaltig gestalten*. München: oekom.
- Jackson, Steven J., Paul N. Edwards, Geoffrey C. Bowker & Cory P. Knobel (2007): Understanding Infrastructure. History, Heuristics and Cyberinfrastructure Policy. In: *First Monday* 12/6. <https://doi.org/10.5210/fm.v12i6.1904>.
- Jensen, Casper Bruun & Atsuro Morita (2015): Infrastructures as Ontological Experiments. In: *Engaging Science, Technology, and Society* 1, 81–87. <https://doi.org/10.17351/ests2015.007>.
- Kocksch, Laura & Estrid Sørensen (2023): Investigating the Sustainability-Cybersecurity Nexus in HCI as a Practical Problem. Submission to Workshop WS27: HCI for Climate Change: Imagining Sustainable Futures. Paper presented at HCI for Climate Change, Hamburg, Germany.
- Laser, Stefan & Estrid Sørensen (2021): Re-Imagining River Restoration. Temporalities, Landscapes and Values of the Emscher Set in a Post-Mining Environment. In: Michaela Meurer & Kathrin Eitel (Eds.), *Ecological Ontologies: Approaching Human-Environmental Engagements*. Berliner Blätter, 21–34.
- Lee, Francis & David Ribes (2025): Computational Universalism, or, Attending to Relationalities at Scale. In: *Social Studies of Science*, 3063127251345089.
<https://doi.org/10.1177/03063127251345089>.
- Lippert, Ingmar, Franz Krause & Niklas Klaus Hartmann (2015): Environmental Management as Situated Practice. In: *Geoforum* 66, 107–114.
<https://doi.org/10.1016/j.geoforum.2015.09.006>.
- Lippert, Ingmar (2018): How Do Environments Come to Matter? In: *Science as Culture* 27/2, 265–275. <https://doi.org/10.1080/09505431.2017.1398225>.

- Mager, Astrid, Katja Meyer & Renée Ridgway (2026): Introduction: The Politics of Open Digital Knowledge Infrastructures. In: Katja Meyer, Astrid Mager & Renée Ridgway (Ed.), *Politics of Open Infrastructures: Power, Governance, and Justice in Digital Knowledge Practices*. Open Book Publishers, 1–18.
- Muiderman, Karlijn, Aarti Gupta, Joost Vervoort & Frank Biermann (2020): Four Approaches to Anticipatory Climate Governance: Different Conceptions of the Future and Implications for the Present. In: *Wiley Interdisciplinary Reviews: Climate Change* 11/6. <https://doi.org/10.1002/wcc.673>.
- Nigussie, Likimyelesh, Tilaye Worku Bekele, Alemseged Tamiru Haile, Anna Mdee, Alan Nicol, Joshua Cohen, Charity Osei-Amponsah, Hailay Zeray Tedla & Kirubel Demissie (2025): Does a Citizen Science Approach Enhance the Effectiveness of Flood Early Warning Systems? Evidence from the Akaki Catchment, Ethiopia. In: *Citizen Science: Theory and Practice* 10/1. <https://doi.org/10.5334/cstp.763>.
- Nixon, Rob (2013): *Slow Violence and the Environmentalism of the Poor*. Cambridge: Harvard University Press.
- Okafor-Yarwood, Ifesinachi & Ibukun Jacob Adewumi (2020): Toxic Waste Dumping in the Global South as a Form of Environmental Racism: Evidence from the Gulf of Guinea. In: *African Studies* 79/3, 285–304. <https://doi.org/10.1080/00020184.2020.1827947>.
- Ortar, Nathalie, A. R. E. Taylor, Julia Velkova, Patrick Brodie, Alix Johnson, Clément Marquet, Andrea Pollio & Liza Cirolia (2023): Powering ‘Smart’ Futures: Data Centres and the Energy Politics of Digitalisation. In: Simone Abram, Karen Waltorp, Nathalie Ortard & Sarah Pink (Ed.), *Energy Futures. Anthropocene Challenges, Emerging Technologies and Everyday Life*. Berlin, Boston: De Gruyter, 125–168. <https://doi.org/10.1515/9783110745641-005>.
- Pfotenhauer, Sebastian, Brice Laurent, Kyriaki Papageorgiou, and Jack Stilgoe (2022). The Politics of Scaling. In: *Social Studies of Science* 52/1, 3–34. <https://doi.org/10.1177/03063127211048945>.
- Puig de la Bellacasa, María (2017): *Matters of Care. Speculative Ethics in More Than Human Worlds*. Minneapolis: University of Minnesota Press.
- Richterich, Annika & Sally Wyatt (2024): Digital Transformations. In: Ulrike Felt & Alan Irwin (Ed.), *Elgar Encyclopedia of Science and Technology Studies*. Cheltenham, Northampton: Edward Elgar Publishing, 501–510.
- Roturier, Samuel & Rémi Beau (2022): Digital Technologies and ILK in the Arctic: In Search of Epistemological Pluralism. In: *Environmental Science & Policy* 133, 164–171. <https://doi.org/10.1016/j.envsci.2022.03.025>.
- Santarius, Tilman, Lina Dencik, Tomas Diez, Hugues Ferreboeuf, Patricia Jankowski, Stephanie Hankey, Angelika Hilbeck, Lorenz M. Hilty, Mattias Höjer, Dorothea Kleine, Steffen Lange, Johanna Pohl, Lucia A. Reisch, Marianne Ryghaug, Tim Schwanen & Philipp Staab (2023): Digitalization and Sustainability: A Call for a Digital Green Deal. In: *Environmental Science & Policy* 147, 11–14. <https://doi.org/10.1016/j.envsci.2023.04.020>.
- Sareen, Siddharth & Katja Müller (Eds.) (2023): *Digitisation and Low-Carbon Energy Transitions*. Cham: Palgrave Macmillan. <https://doi.org/10.1007/978-3-031-16708-9>.
- Schütze, Paul (2026): AI and the Climate Crisis: Power, Ideology, and the Politics of Collapse. In: Sahana Udupa & Peter Hervik (Eds.), *Handbook on Anthropology and Artificial Intelligence*, 430–442.

- Sørensen, Estrid & Laura Kocksch (2021): Data Durabilities: Towards Conceptualizations of Scientific Long-Term Data Storage. In: *Engaging Science, Technology, and Society* 7/1, 12–21. <https://doi.org/10.17351/ests2021.777>.
- Starosielski, Nicole (2015): *The Undersea Network*. Durham: Duke University Press. <https://doi.org/10.1215/9780822376224>.
- Subramanian, Vidya & Yousif Hassan (2024): Peripheral Visions: STS and Digitalisation in the Non-West. In: *Science, Technology and Society* 29/4, 505–516. <https://doi.org/10.1177/09717218241282531>.
- Suchman, Lucy (2012): *Human-Machine Reconfigurations*. Cambridge: Cambridge University Press.
- Taylor, Linnet (2017): What is Data Justice? The Case for Connecting Digital Rights and Freedoms Globally. In: *Big Data & Society* 4/2, 1–14. <https://doi.org/10.1177/2053951717736335>.
- Velkova, Julia & Jean-Christophe Plantin (2023): Data Centers and the Infrastructural Temporalities of Digital Media: An Introduction. In: *New Media & Society* 25/2, 273–286. <https://doi.org/10.1177/14614448221149945>.
- Vonderau, Asta (2019a): Scaling the Cloud: Making State and Infrastructure in Sweden. In: *Ethnos* 84/4, 698–718. <https://doi.org/10.1080/00141844.2018.1471513>.
- Vonderau, Asta (2019b): Storing Data, Infrastructuring the Air: Thermocultures of the Cloud. In: Mél Hogan & Asta Vonderau (Ed.), *Culture Machine 18: The Nature of Data Centers*, 1–12.
- Yusoff, Kathryn & Jennifer Gabrys (2011): Climate Change and the Imagination. In: *WIREs Climate Change* 2, 516–534.
- Yusoff, Kathryn (2024): *Geologic Life. Inhuman Intimacies and the Geophysics of Race*. Durham: Duke University Press.

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