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Introduction: Putting history in its place: Historicising planetary modelling

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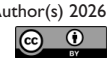
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Abstract

Earth System science (ESS) develops computer models of planetary dynamics using sets of partial differential equations. As humans have become recognised as a major determinant of Earth system change, the integration of lines of code that represent human history has become necessary. However, as yet, these representations have proven somewhat rudimentary and run into perennial concerns inherent to the human sciences. The introduction to this special issue addresses the recent history of integrating history and ESS and outlines a proposed countermove: the historicization of Earth system modelling. Outcomes of this work are presented here. Moreover, in outlining past attempts at integrating history and ESS, we note some fundamental differences between these disciplines. Rather than disavowing integration, however, we call for ongoing and mutually respectful experimentation.

Keywords

earth system modelling, history, epistemology, incommensurability

The need for integration

The articles collected in this special issue were prompted by the recognition that historians were increasingly being called upon to provide their expertise and empirical insights to another discipline, Earth system science (ESS). The papers were first presented at a series of events termed 'Historical Epistemologies of Planetary Modelling', or HEPM, held in Berlin, Stockholm, and Venice, in the years 2023, 2024, and 2025.[1] These articles were expanded, revised, and discussed, and are presented here as a critical but supportive contribution to ongoing debates about the potential integration of history and ESS.

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HEPM was convened to show how historical epistemology, the study of knowledge over time, offers tools that are suited to making Earth system models (ESMs) more socially relevant. At its most basic, historical epistemology studies knowledge as a fragile and very human achievement painstakingly cobbled together, rather than a timeless entity waiting to be revealed (Shapin, 2010). Historical epistemology does not relativise, so much as explain the contingency of knowledge. Knowledge and its objects have histories, are fashioned in particular places, in particular times, and for particular reasons. In reconstructing the contexts out of which models emerged, we want to encourage engagement with their findings in creative, humble, pluralistic, and politically progressive registers.

In the 2000s, model-making Earth system scientists came to recognise the growing importance of humanity as a driver of Earth system processes (Tapiador and Navarro, 2024). The absence of computer code representing this agentic mass of people, who were altering what was increasingly described as an 'Anthropocene' Earth, clearly undermined the representativeness of modelling (Beckage et al., 2018). Moreover, as these models were called on to produce scenarios that might inform societal interventions to stabilise this disrupted system, the need to simulate *past* human behaviour, history, became a pressing concern (Palmer and Smith, 2014).

Calls to integrate data, concepts, and dynamics from human history into ESMs have grown louder (Burke et al., 2025). Crutzen and Stoermer's famous 2000 article set out the idea that the Anthropocene epoch was coincident with Scottish engineer James Watt's invention of the steam engine in 1784 (In fact, this patent was date for a machine built by Thomas Newcomen was 72 years earlier), putting the history of technology at the centre of the debate (Crutzen and Stoermer, 2000). The Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6, 2021) affirmed that certain nations had greater 'historical responsibility' for global heating than others, leading to the suggestion that history could be used to allocate responsibility for future mitigation efforts (Lee and Romero, 2023: 42). The contested annals of industrial and colonial histories were invited into the discussion.

However, for historians, it has been difficult not to bristle at the crude conceptions of the past some early attempts at integration resulted in. There was a sense that a perceived planetary crisis was encouraging a 'mechanical' form of history shorn of its subjective, ideational, and critical facets, the attributes that had made it a long-venerated and predominantly humanistic discipline (Quenet, 2017: 172). Could these disciplines be made commensurable in a manner which does justice to both?

The general and the specific

ESS involves representations of a planet that somewhat resembles our own. They represent a sphere of rock, air, water, and ice, partly covered in plant life, which emits and stores gases, altering the energy balance. The sum of energy is governed ultimately by the Sun. Such models rest on a core set of equations that represent the conservation of linear and angular momentum and energy. Emergent properties such as atmospheric eddies or oscillations require more complex mathematics, and are parametrised by comparing simulation runs with empirically rich Earth observation (EO) data, taken from the ground, air, or most commonly satellites.

For computability, Earth's surface is generally reduced to 25 km^2 grids (Tapiador and Navarro, 2024). In each grid, clouds are crudely simulated due to their comparatively small size, a workaround that belies their influence on climate (Guo et al., 2025). While at a certain resolution, models must assume Earth and its atmosphere are flat to reduce their computational demand, a move that has consequences for their accuracy (Prather and Hsu, 2019). Animals are rarely represented, despite their considerable role in other processes (Rizzuto et al., 2024). Fundamentally, modelled

worlds are a sequence of approximations (Gramelsberger et al., 2020). So, on this fundamental level, the structure and logic of ESMs run counter to the idea that history is a science of *specific* occurrences (Gardiner, 1952).

History can only be made commensurable with ESMs in a highly generalised manner. The vast scope of human history has been reduced to an exogenous parameter that increases greenhouse gas emissions, for instance (Beckage et al., 2018). Models that attempt to represent humanity in more detail are troublesome due to their target's inherent complexity and disagreements about the determinants of human behaviour (Verburg et al., 2016). As such, integration seems to have faltered and settled on 'coupled' models that integrate historical land use data and climate models (Tan et al., 2023). However, such data and law-based models fall far from the richness of historical explanation. Historical explanation does not attempt to arrive at generalities so much as draw out a narrative by drawing associations between 'particular facts or events' (Skinner, 1966: 200). In what follows, it becomes clear that past attempts at integrating history and ESS demonstrates that integration has been possible only via acts of compromise.

A history of historical ESS

Since the early 2000s, Earth scientists connected with the International Geosphere-Biosphere Programme (IGBP) have attempted to integrate more sophisticated historical models within ESMs. Foremost among these efforts was the 'Integrated History and future of People on Earth' (IHOPE) project, launched in Dahlem, Berlin in 2005. IHOPE sought to model the relationship between human history and biophysical changes to the planet, so that the past could not only be re-envisioned in ecological terms, but also so that it could contribute to the development of model-derived forecasts of human-environmental futures. Addressing a set of histories, from the fall of the Mayan and Roman Empires to the climatic history of the Canton of Bern and the Khabur River Basin, workshop attendees sought a generalisable approach to environmental history, and a means to make it integrable as a data source for modelling the possible future of human life on Earth (Costanza et al., 2012).

Interestingly, this history-based futurology was described as constructive rather than predictive: 'IHOPE can use a deeper understanding of the past to help us create a better future, rather than to predict the future' (Costanza et al., 2007: 14). Soon, some affiliated with the project voiced concerns. They noted the risks of 'dangerous reductionism, environmental determinism, cultural imperialism, and more' that the universalist ambitions of the project posed. After just 5 years, the project backed away from its predictive ambitions. In a follow-up it was argued that 'There is no reason to argue that human or planetary existence can be subsumed in any overarching laws, nor to assume that predictions, *sensu stricto*, will be possible' (Cornell et al., 2010: 426). Rather than a general predictive method, those involved called for 'intelligent pluralism' in integrating history and ESS (Cornell et al., 2010: 427).

In part, this was because a major problem for IHOPE was how to model history itself, or 'social memory', an informational resource that informed the behaviour of human societies – both real and simulated. In fact, in ecological theories of society, memory was considered central to societal 'resilience' (IGBP, 2010: 9). History, the collective memory of past events and society's response, was something that conditioned individual and collective survival, so it had to also be integrated into the model– but how to do so? The compromise arrived at was that history would be integrated as a set of case studies which could inform a planning scheme rather than a predictive model (Uhrqvist, 2015: 287).

What has happened to IHOPE since it backed down from its predictive aims? A number of historians remain involved in the project and its successor 'Future Earth' as of 2012 (Robin, 2018;

Robin and Steffen, 2007), but the majority of those working under its banner appear to be environmental scientists and archaeologists. In their publications, such work primarily involves archaeological case studies with data-based methods that are integrable with the logics of ESS, such as radiocarbon dating or pollen counts.[2] The development of a generalisable human history module that is integrable with overarching computational logics of an ESM remains elusive.

Unpredictable humans

Human history is, as Earth system scientists are learning, a complex and slippery thing. The original 'Bretherton Diagram', the iconic founding image of ESS, was first presented by NASA's Earth System Sciences Committee in 1986, named for its chair Francis Bretherton. It was a circuit diagram representing the major components of the Earth system. Humankind was represented by a black box on the right-hand side titled 'human activities' which fed back into the wider Earth system via links representing land use, pollution, and carbon dioxide emissions (Barton, 2023: 66). Human history was reduced to a set of areal, pollutive, and gaseous processes.

This representation has proven consequential. Since Bretherton, and in ESS more generally as Eva Lövbrand and others noted, humankind has been represented 'mainly as an interconnected subsystem to the larger Earth system, and as such, a single force (of nature!), a generalized determinant of global change' (Lövbrand et al., 2015: 213). In pursuit of a workable integration of human history and ESS, the risk is that a monolithic comes to replace more nuanced forms of historical explanation that identify specific actors, events, places, and times.

By late 2000s, calls for greater sophistication in modelling the human part of the 'human-Earth' system intensified but arrived at another point of disciplinary incommensurability. Recognising the thinness of 'human dynamics' in their models, ESS practitioners tried to 'close the loop', improving their portrayal of the 'economic, social and cultural forces' that distinguish humans from other components of the Earth system. The problem, as these same scientists soon came to recognise, was that humanity, in all its diverse and agentic glory, was not only the 'most influential component of our planet' but also the 'least predictable' (Donges et al., 2017: 152).

ESS practitioners had stumbled on the central problem of the social sciences. In sociology, almost a century ago Max Weber and his school argued that humanity's individual and collective behaviour cannot be understood as that of a singular entity possessed of a shared and analysable intentionality (Weber, 1946). The very idea that humanity can be studied as a whole, made up of predictable law-like properties rather than considered a mass of conflicting subjectivities, as Weber and many subsequent sociologists have argued, puts ESS's conception of humanity in the positivist camp, a branch of the social sciences that endorses natural-science-like principles (Heymann and Dahan Dalmedico, 2019). The risk in doing so is that the unpredictable historicity of human behaviour gets lost. History is most commonly understood as a science of the specific and contingent rather than a natural science that discerns laws that govern the past and future. As such, there is no agreed-upon, law-like historical theory, that would enable integration with ESS.

Rather than accept that there is a significant degree of incommensurability between the Earth scientists' conception of the world and that of the humanities, some argue that history must change to accommodate ESS (Boldizsár Simon and Adeney Thomas, 2022). Some even argue that we 'must tilt the balance toward applying the methods of physics to social problems instead of the other way around' (Tapiador and Navarro, 2024: 4). While at the same time, Earth modellers admit that 'omitting human behaviour' from their modelling work 'is like designing a bridge without accounting for traffic' (Palmer and Smith, 2014: 365). The assumption that history should be the discipline to compromise seems to reflect an assumed hierarchy, in which the ESMs are a new

'obligatory passage point' through which other disciplines must contort if they are to seek relevance (Bowker, 1993).

Of course, social sciences have developed their own positivist theories, the most influential of which come from economics (Friedman, 1966). As such, it is no surprise that humanity is most commonly represented in ESS via Integrated Assessment Models (IAMs) which feed economic scenarios about climate change in and out of ESMs. IAMs operate on the principles of neoclassical economic theory, and in doing so assume that our plural and diverse humanity are an aggregate mass of growth-optimising and rational economic actors (Krawczyk and Braun, 2025). Currently around 50 IAMs are used in the IPCC's authoritative modelling work, and taken on average, these models assume that the economy will continue to grow at a median rate of 2.17% per annum (Cointé and Pottier, 2023). Economic growth is encoded in these models as if it were a law of nature rather than a political objective.[3]

Human hubris

Another barrier to integration is the hubris that some in ESS espouse. In the late 1990s, physicist Hans Joachim Schellnhuber described the emergence of ESS as a 'second Copernican revolution' in which Earth observation and modelling achieved 'in a way a reversal of the first' revolution, the 16th-century discovery of a heliocentric Earth. Recent work had put Earth back at the centre of the Universe, revealing a 'single, complex, dissipative, dynamic entity, far from thermodynamic equilibrium'. Perceivers of this system, Schellnhuber argued, could become powerful 'geo-cyberneticians' ably imposing control over the planet (Schellnhuber, 1999: C20).

However, around this same time, anthropologists, arguably one of the softest of the soft sciences, were having their own revolution. This was a far more humble 'neo-Copernican' discovery, which involved a number of anthropologists recognising, at that particular historical moment of geopolitical and colonial realignment, that 'other people's worlds do not revolve around ours' (Sahlins, 2013: 9). The assumed universalism of ESS has yet to accommodate this very obvious fact, even if its practitioners at times recognise their science as a cosmology indigenous to a specific culture, that of scientists from the highly-developed world (Steffen et al., 2020: 54).

Modelling an Earth system process such as atmospheric circulation no doubt invites informed criticism from other members of the atmospheric science community, but clearly attempting to model humanity's collective past and future touches on more general political questions about differences in power and reward (Lövbrand et al., 2009). A computer model of humanity attempts to represent dynamics that people disagree about in representativeness and scope but also normatively, in terms of the *political* implications that they encode. Moreover, when such models aspire to become the basis for policies that seek to reorder life on Earth, they will clearly invite contestation (Heymann and Dahan Dalmedico, 2019).

The idea of the human species as a singular modellable entity has invited scepticism from historians and political ecologists who have long sought to explain events in specific terms, via specific actors, events, and structures (Malm and Hornborg, 2014). In response, a new lexicon of geohistorical neologisms has proliferated, distinguishing culpability amid a sea of differentiated humanity: from capitalists, to plantation owners, Neolithic farmers, Manhattan Project-era physicists, corporations, men, and even British people all now have an accusative *-cene* dedicated to them (Lorimer, 2017). These competing nomenclatures indicate the many disagreements about the drivers of Earth system change that those working in the human sciences have proposed, and which would need to be represented in historical ESMs if they are to reflect the true plurality of historical interpretation.

New scientific history?

Calls for a more scientific kind of history are not new. The history of history has been full of scientific turns, from 19th-century archival positivism, to cliometrics, and recent digital methods, which some see as particularly Anthropocene-aligned (Guldi, 2022). Looking at past forms of what has been called 'scientific history' suggests that careful experiments at this intersection can yield methodological and theoretical advances, and in doing so, can advance new knowledge (Aranova, 2021).

To take an important example, France's post-war *Annales* school involved painstakingly empirical, and at times crowdsourced demographic data, records of grain and grape harvests, and quantitative records of national exchequers, large and small-scale industries, and markets. *Annales* made meaningful methodological connections between biology, epidemiology, demography, geography, meteorology, psychology, and added considerably to our historical understanding (Davis, 2018).

Annales-era datasets on past climatic conditions, drawn from harvest records, among other things, have even become important resources for climate science (Degroot et al., 2022). Moreover, it was *Annales* school historian Fernand Braudel who first suggested grounding human history in geological time (Braudel, 1949).

However, the *Annales* school historian Emmanuel Le Roy Ladurie's 1968 prediction that by the 1980s historians would have to begin to work like computer programmers or cease to exist has thankfully so far proven false (Aranova, 2021: 146). Rather than producing code, the demands of historical explanation still require historians to reimagine and narrate specific events, ideational agency, and the conflicting subjectivities that have engendered change over time, and who have described it and considered it meaningful. 'All history', as the philosopher of history R.G. Collingwood argued 'is the history of thought' (Collingwood, 1946: 117).

As the fall-out over and eventual rejection of the formal stratigraphic categorisation of the Anthropocene epoch has shown, even geological time has been altered by ideational disagreements (McCarthy, 2025). As such, we argue that history's specific, critical, and subjective mode of analysis and description remains a meaningful form of record keeping and informing society about its experiences.

Thus far, the history of attempts at modelling human history have remained underwhelming. Projects have reduced the historical record to the thinnest of descriptors, offering schematic diagrams of human agency, while our discipline's contradictions and complexities are assumed to have been addressed with requisite sophistication when abstracted into agent-based models, complex systems, World-Earth models, or social tipping points (Bentley et al., 2014; Donges et al., 2021).

Moreover, while commendable attempts have also been made to model energy infrastructure and 'sociocultural processes' such as voting, migration, or changing social norms, running simulations that include such unpredictable social variables can, modellers themselves admit, decisively alter the trajectories of forecasts (Donges et al., 2020: 403). This finding testifies to the immense challenge of attempting to model highly contingent historical events. While constrained by natural laws and enlivened by human will, imagination, and creativity, it is ultimately historical contingency that rules both planetary and human history (Wilkinson, 2006).

As it stands, history-curious Earth System scientists are acting as agents of reduction. As one methodological review puts it 'If models considered the heterogeneity of agents in all relevant aspects, they would have to be much more complex than all models that have been developed to date', so – as it stands – the only really workable alternative is to include 'formal descriptions of idealized social mechanisms' (Müller-Hansen et al., 2017: 999). As such, it is vital that historians

of science document this work. Historians should also recognise and help to improve the earnest and commendable efforts that are being made to understand sociological and historical concepts, and to engage with questions of agency, structure, institutions, and power (Otto et al., 2020). Caution and respect are needed on all sides.

At the other end of the scale, ecologist-turned-historian Peter Turchin has tried to turn history into a predictive science with 'first laws' as if it were physics or biology (Turchin, 2011). History is reduced to generalities from which abstracted lessons can supposedly be learnt (Boldizsár Simon and Adeney Thomas, 2022). This can be contrasted with two thoughtful practitioners of computational history, who conclude that the idea of carrying out their work with 'machine-like exactitude' has proved highly mistaken. Experience in fact showed that 'every step in the process drips with value-laden judgement calls' (Gibson and Ermus, 2019: 559).

Historians should affirm that modelling the future of life on Earth on the basis of a highly abstracted past risks that historical ESS becomes irredeemably reductive science or, at worst, a toolkit for those looking to 'colonialize [. . .] distant futures' (Uhrqvist, 2015: 292). In addition, basing projections about a highly uncertain and unstable Anthropocene future on patterns from more-stable Holocene history carries the risk that it forecloses the range of possible futures. To moderate the authority of planetary modelling, we argue historians should turn their descriptive and analytical methods on its work, to draw out its contingency.

We hope that in coming years the recognition of the constructivist capacities of ESMs will encourage greater reflection on the political implications of planetary modelling. Three papers presented here point in that direction (Kadiri, 2026; Pendergrass, 2026; Wickberg and Turnbull, 2026). If we accept that modelling constructs the future rather than represents the past, why not use models to try and create more inclusive, progressive futures, less tied to the levers that denuded parts of the planet in the first place? We recognise the same problem as many Earth System scientists; the need to better account for humankind as an increasingly predominant aspect of the Earth system, we simply disagree that this task should require history and other humanistic approaches to be reduced to something integrable with a quantitative model. The risk in doing so is that the contestation and political arguments that make history a human rather than a natural science become lost in the process.

As such, we are not suggesting ESS should give up its attempts at integration, but we suggest that this science should not assume authority over all other forms of knowledge. History should not be integrated in modelled worlds via its reduction. Instead, by subjecting Earth system data and models to historical scrutiny, the universalising tendencies of ESS can be shown to be contingent and idiosyncratic achievements rather than an a-historical and objective form of knowledge.

Historians can show how planetary modelling has been undertaken in specific places and specific times, for specific reasons, as any other form of knowledge. As such, we hope historicization can bring planetary modelling back down to Earth.

Historicising models in practice

If, as philosopher Thomas Hobbes was reputed to have said, 'Hell is truth seen too late', we are now in a historical moment in which myriad hellish scenarios regarding life on Earth are being modelled, but few people seem to care.[4] For instance, a 50-year update to the World-3/*Limits to Growth* study, packed with dire warnings, appeared in 2022 with little fanfare or concern outside a small coterie of non-profits and philanthropists (Dixson-Declève et al., 2022). In contrast to the furore the original *Limits to Growth* study created 50 years earlier, a lack of response to this more recent study suggests that their imagined audience has become desensitised.

The concept of crisis, as historian Reinhart Koselleck warned, has lost a sense of exceptionality, and has instead become characteristic of historical time (Koselleck and Richter, 2006). Public interest in the outputs of planetary models appears to be marginal, and little is done to address the gap between the increasingly drastic scenarios they present and the actions this might be expected to encourage (Bellamy, 2023). The modelling of relations between the evidence ESMs offer and the social and political action or inaction they provoke appears to go largely unconsidered.

This stasis has been explained as a result of ESS's current conservatism. The 'invocation of biophysical limits' that some Earth modellers make 'is seldom coupled with potent suggestions for social and political transformation' instead, responsibility for resolving crises is granted to 'the same institutions that have allowed the recent human conquest of the natural world' (Lövbrand et al., 2015: 212).

Cognisant of such conservatism, the papers in this special issue historicise both the methods and theory of planetary modelling, while also drawing out the political implications of past, current, and future simulations of human dynamics within a wider Earth system. Taken as a whole, the papers do not suggest we abandon the rationales of modelling the Human-Earth system, but do so with renewed recognition of the ideologies they enact and the audiences they attempted to move. While there are clear signs of incommensurability between these disciplines, we have argued that respectful experimentation can yield insights and advance knowledge. We hope that the papers presented here are read in that spirit.

In his contribution, Christoph Rosol traces connection between atmospheric science and electrodynamics. He revisits the work of Norwegian physicist Vilhelm Bjerknes. Rosol argues his 1904 general atmospheric circulation theorem, which is central to modern Earth system and climate models, grew not from meteorology so much as experiments that sought to prove the existence of aether. Experimental analogies between fluid and electrical phenomena were deeply embedded in physics at the time. Rosol argues this created a co-productive epistemic pathway in which knowledge about air and knowledge about electricity shaped one another. This generative co-production culminated in the 1940s, when John von Neumann merged the electronic computer with an ambitious attempt at numerical weather prediction: electron flows now simulated atmospheric flows and situated planetary modelling firmly within the history of electronic technologies (Rosol, 2026).

Melissa Charenko's paper revisits an alternative to computer models. Analogs work by accumulating date from a past state that closely resembles a potential future one, then using the better-known state to fill in details about the unknown. From the 1980s onwards, ecologists, particularly paleo-ecologists working with pollen records, promoted this technique as a complement to digital general circulation models. However, by the early 1990s, Earth scientists conceded that no satisfactory analogs for global warming existed. This created an epistemological crisis for proponents of analog modelling. Rather than abandoning their methods, they repositioned them in a supporting role. Analog data could help calibrate and verify computer models, but not come to replace them. This entrenched a planetary, model-based, physics-centred knowledge at the expense of more localised approaches (Charenko, 2026).

In her contribution, philosopher of science Julia Sánchez-Dorado engages with philosopher Wilhelm Windelband (1848–1915) who distinguished between idiographic ('the particular in the form of the historically defined structure') and nomothetic ('the general in the form of the law of nature') sciences. The models presented in her paper, Sánchez-Dorado argues, contradict this dichotomy. Models, as human artefacts, she insists, are inescapably historical. History, she further notes, 'matters for all practices of model building across the geosciences' as the data they use are fundamentally temporal. Moreover, laws are not as lawlike as in the sciences. Plate tectonics conform to the laws of physics, but they cannot be explained via a 'universally applicable causal

statement'. Hence, as Sánchez-Dorado argues 'The alleged contrast between modelling an earth system as timeless or as embedded in the specific flow of historical time can be partly contained if we acknowledge the iteration between the two approaches in practice' (Sánchez-Dorado, 2026).

In a short *Perspectives and Controversies* essay, addressed towards a model-mania in certain schools of Anthropocene research, Thomas Turnbull uses the work of philosopher Patrick Gardiner in order to defend traditional narrative history. In making the case for conventional historical explanation he argues that past realities are irreducible and require manifold means of explanation not one (Turnbull, 2026).

Environmental historian Sverker Sörlin provides an insider's history of the formulation and development of 'planetary boundaries', the idea of inviolable limits to Earth system processes which have been presented and circulated as an iconic multivariate radar chart presenting quantitative ESS data as six comparable axes since 2009, now expanded to nine. Sörlin considers the planetary boundaries as an 'environing technology' a device that reduces complex reality into a workable media technology. He emphasises that ESS has subsumed the preceding discourse of sustainability as a new managerial language, but in doing so it has 'de-territorialized the crises', eroding the impacts of breaching boundaries for specific people and places, and also dissolving specific culpability for these transgressions (Sörlin, 2026).

Drew Pendergrass, whose day job is monitoring methane and smoke at a planetary scale, envisions a more radical ESS in which the tools of Earth observation and modelling are repurposed for situated, specific, and activist work. In place of elite-centred scenarios, of the kind proffered by the IPCC, Pendergrass calls for a situated, applied science of 'planetary sensing' in which diverse political movements seize the means of Earth observation and control and reappropriate them as tools for achieving a 'view from somewhere', visceral imagery of immediate concern. In place of IAMs and ESMs, a more radical ESS would be based on 'user knowledge of specific geographies and local histories'. The creation of activist-led yet scientific views from somewhere might encourage Earth models to be taken seriously by a wider public, rather than being seen as top-down prognostications for an out-of-touch elite. As Pendergrass concludes, invoking Marx 'The planetary modelers have only interpreted the world, in various ways; the point is to change it' (Pendergrass, 2026).

Political scientist Aisha Kadiri takes the concept of the 'plantationocene' as a counter-history with which she tests the commensurability of ESS with a distinct anti-racist version of Anthropocene history. The poor fit between this violent sequence of events and of computer code, a medium which she writes, 'limits what stories about planetary change can be told in the first place', is difficult to resolve. Kadiri argues 'disengagement is not the answer'. Rather than reducing the plantationocene to something digestible in the 'court of Western science' she instead argues the concept must be 'made actionable in the political public sphere'. As she writes, if ESS is to have the legitimacy it needs, its modellers must recognise the 'need for a planetary consciousness that does not render invisible the colonial and racial subjugation which undergirds the present ecological moment' (Kadiri, 2026)

In their review essay, Wickberg and Turnbull outline what a political ecology of ESS might encompass, including an analysis of the material metabolism, state–corporate assemblages, and geographical asymmetries on which contemporary ESS depends. Working across four registers, the disciplinary memory ESS has forgotten, the geopolitics of planetary vision from Stockholm 1972 to the present, the shift from petaflop to exaflop computation exemplified by the Blue Waters (2013–2021) and Solstice (2025–2026) supercomputers, and the counter-practices through which the observational tools used in ESS are being turned to arguably more progressive ends, the essay argues that a science run on hyperscale, Big Tech–sourced and military-entangled infrastructures has inherited ethical commitments that it can no longer disavow by

appealing to the objectivity of its underlying physics. An ESS attuned to its political ecology would need to be less rather than more, as in less energy-intensive, less centralised, and less hubristic (Wickberg and Turnbull, 2026).

Taken together, the papers in this special issue make a cumulative rather than a singular argument. Across these contributions, a shared methodological disposition emerges. None of the authors argue planetary modelling should be abandoned and none argue that historical and humanistic knowledge should be reduced into integrable parameters. The argument they pursue is that historicising ESS can help moderate the universalising pretensions that have accompanied the science since its 1986 rebranding by NASA. HEPM created a space for plural, situated, and critical approaches to planetary modelling, spanning from historical epistemology to political ecology. If historical epistemology asks how planetary knowledge has been stabilised as a form of knowledge, political ecology asks at what cost? Plural perspectives are needed for complex problems. The papers that are presented here begin the work of putting planetary modelling back in its place, in space and in time.

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Notes

1. For an overview of HEPM's events see KTH Centre for Anthropocene History (n.d.) Historical Epistemologies of Planetary Modelling (HEPM). Available at: https://www.kth.se/anthropocenehistory/research/historical-epistemologies-of-planetary-modelling-hepm-1.1396729
2. Future Earth (n.d.) Selected Publications 2022–2023. Available at: https://futureearth.org/selected-publications-2022-2023/ and IHOPE (n.d.) Publications. Integrated History and Future of People on Earth Research Network. Available at: https://ihopenet.org/publications/
3. The division of labour between IAMs and ESMs is discussed in our review essay in this issue (Wickberg and Turnbull, 2026).
4. Perhaps like neoliberalism, people are sick of hearing about planetary crises, Mirowski (2019).

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