# The position of place in governing global problems: a mechanistic account of place-as-context, and analysis of transitions towards spatially explicit approaches to climate science and policy

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**Abstract**

Place is a central concept within the sustainability sciences, yet it remains somewhat undertheorised, and its relationship to generalisation and scale is unclear. Here, we develop a mechanistic account of place as the fundamental context in which social and environmental mechanisms operate. It is premised on the view that the social and environmental sciences are typically concerned with causal processes and their interaction with context, rather than with a search for laws. We deploy our mechanistic account to analyse the neglect of place that characterized the early stages of climate governance, ranging from the highly idealised general circulation and integrated assessment models used to characterise climate change, to the global institutions and technologies designed to manage it. We implicate this neglect of place in the limited progress in tackling climate change in both public and policy spheres, before tracing out recent shifts towards more spatially explicit approaches to climate change science and policy-making. These shifts reflect a move towards an ontology which acknowledges that even where causal drivers are in a sense global in nature (e.g. atmospheric levels of greenhouse gases), their impacts are often mediated through variables that are spatially clustered at multiple scales, moderated by contextual features of the local environment, and interact with the presence of other (localised) stressors in synergistic rather than additive ways. We conclude that a relentless focus on place, heterogeneity, and context can maximise (rather than limit) the policy relevance of climate change science and help to ensure the development of policy interventions that are robust and effective.

**Keywords**

Risk governance, science-policy, climate change, risk analysis, decision analysis

doi:10.1016/j.envsci.2015.05.015

# The position of place in governing global problems: a mechanistic account of place-as-context, and analysis of transitions towards spatially explicit approaches to climate science and policy

## 1. Introduction: place, causal mechanisms, and sustainability

Place is a central concept within many traditions of sustainability science (Kates *et al.*, 2001). The rough idea is that whilst many modern environmental and development problems are in some senses global in character, they are nevertheless the products of diverse actions that are highly contextual, exert their impacts through causal chains that are heterogeneous across space in form and effect, and require policy responses that take account of this variety and complexity (*e.g.* Lejano and Ingram, 2007; Scott, 1998). As such, many sustainability scientists restrict their methodological focus to relatively micro-level analysis (place as location), on the grounds that this is the most practical scale for uncovering the heterogeneous causal mechanisms at play (*e.g.* Wilbanks and Kates, 1999), for eliciting local knowledge, and for designing effective interventions. Yet the concept of place within sustainability science remains somewhat under-developed. In particular, its (uneasy) relationship to abstraction and generalisation remains unclear, and there are unresolved methodological problems surrounding how to address interactions across places and spatial scales (Liu *et al.*, 2013a). This slightly paradoxical situation – where place is both a central concept of sustainability science, and also a rather under-theorised and unclarified notion – is mirrored in many other academic disciplines (Casey, 2013).[1]

For example, Aristotle developed a theory of the causal agencies that places possess by virtue of their locatedness, heterogeneity, and multi-dimensionality (Morison, 2002; Casey, 2013), and more recently phenomenologists have addressed what it means to *be* in place (Heidegger, 1971). However, in the intervening millennia place rather fell out of use as a philosophical concept, being replaced by a preoccupation with absolute and unbounded space (Casey, 1996, 2013). Sociologists, meanwhile, have always been interested in *types* of places – the home, the workplace, the prison – although often without taking a spatially explicit focus. Indeed the late 20$^{th}$ Century saw many social theorists argue that revolutions in communications and transportation had transcended place (Coleman, 1993) or rendered it “phantasmagoric” (Giddens, 1990), by removing the drag imposed by location and distance on human interaction (Gieryn, 2000). However, more empirically minded sociologists have continued to focus on the highly contextual and spatially patterned nature of social processes (Gieryn, 2000), from both interpretive and mechanistic perspectives (*e.g.* Sampson, 2012). Statisticians do not speak much of place *per se*, but have always been concerned with external validity – the question of whether inferences drawn from a particular study can be generalised to contexts that differ in terms of environmental features or populations (*e.g.* Cox, 1958). On the other hand, the natural and physical sciences have historically focussed on the discovery of laws, *i.e.* fixed and invariant regularities (Cartwright, 1989, 1999). Here, context or place-effects are broadly seen as confounders or sources of variance to be screened out or adjusted for (Guala, 2003), so as to isolate the general principles or equations that govern relations between objects. However, this sits alongside an awareness that there is often a significant amount of knowledge of local conditions required to predict the implications of general laws. More controversially, scholars from “science

[1] We do not discuss the well-theorised interpretive accounts of place prominent within human geography because our account, developed later, draws on a mechanistic perspective.

studies" have problematized context-free accounts of scientific knowledge production (Collins, 1981; Ophir and Shapin, 1991), focussing on how social and cultural environments shape the production of scientific facts, and on the labour intensive activities (*e.g.* standardisation, the construction of physical and social networks, *etc.*) required to make facts travel across place and scale (Powell, 2007).

Place, in short, plays an important though contested role in how many disciplines conceive of and study the world, although the term (or cognate concepts) is defined and deployed in quite differing ways. To an extent, this is unavoidable, given the widely varying epistemological and methodological commitments held by interpretive sociologists compared to, say, statisticians, and it would be somewhat ironic if place as a concept turned out to have universal features. So on the one hand, this interpretive flexibility is quite natural and useful, but on the other it may limit theoretical development and the cross-fertilisation of ideas across disciplines. This paper seeks to address this problem, through developing a conceptualisation of place broad enough to accommodate many of these distinct epistemological and methodological commitments, and then deploying it in a case study that draws, in a targeted fashion, on the published literature on climate science and policy making. Our research aims are to:

1) Develop a mechanistic account of place that focuses on the relationship between causal processes and particular contexts;

We then deploy our mechanistic account to:

2) Trace the historical roots of spatially blind approaches to governing global problems to the logics of modernity, necessarily in a schematic fashion;
3) Highlight the neglect of place in in the early years of climate change science and policy, which we implicate in the difficulties faced in engaging publics, informing decision-making, and in reducing emissions; and
4) Account for recent transitions towards more spatially explicit approaches to climate change science and policy making.

*1.1. Conceptual framework: a mechanistic account of place-as-context*

Here we introduce our conceptualisation of *place as the fundamental context* in which social and environmental mechanisms operate, drawing on the ideas of Sampson (2012, 2013) and Cartwright (1999). Our focus is orthogonal to the humanistic accounts of place which focus on interpretative (*e.g.* sense of place) or phenomenological aspects (*e.g.* being in place) (see Casey, 1996). Our conceptualisation can best be understood by contrasting it with the Galilean ontology, which views causal mechanisms as producing universal and fixed effects independent of context (Cartwright, 1999). From the Galilean perspective, place is a mere stage in which the laws of the social and natural world play out. The place-as-fundamental-context ontology (Sampson, 2012, 2013; Cartwright and Pemberton, 2013; Cartwright, 1999), by contrast, views causal mechanisms as often being sharply bounded in scope (rather than operating universally), and sees their form, operation, and effects as variable (heterogeneous) and context-dependent. Cartwright and Pemberton (2013) class this as reflecting an Aristotelian ontology, wherein place is an active ingredient in constituting and shaping social and environmental mechanisms. These different ontological positions lead to quite different ways of learning about the world (methodology), as well as distinct approaches to intervening in the world (*e.g.* policy-making or technology design and implementation). Causal mechanisms are the chains through which causes bring about effects; they are relationships that can be exploited for the purposes of manipulation or control (Pearl, 2000). A causal mechanism might refer to something in the natural or physical world (*e.g.* the causal chains through which atmospheric CO2 levels influence local climate conditions), or to human interventions in the world (*e.g.* the process through which a mitigation policy brings about change in anthropogenic emissions). These mechanisms may not necessarily be independent of place or time, and so are distinct from the classical philosophical conception of laws (Fetzer, 2014). In broad terms, context can be understood as those spatially variable features of the world that determine whether, how, and to what extent a causal mechanism will operate and exert its effect. In our view, context cannot be defined *a priori*, as the relevant dimensions of context will depend on the particular mechanism and intervention being considered. As an example, for a government planner considering the introduction of new agricultural tools or machinery in order to improve food production, then context might refer to place-specific working practices, soil conditions, infrastructure, gender-roles, and climatic conditions. As a further clarification, a focus on place does not necessarily presuppose a localist approach, as the relevant scale(s) at which to consider context will be sensitive to the research and policy questions of interest. With this account, place-blind approaches to knowledge creation and policy making differ from those that are place-sensitive along various dimensions: universal vs. particular; law-like vs. geographically bounded; homogenous vs. heterogeneous; uniform vs. context-sensitive; and idealised vs. holistic.

The remainder of the paper is split into two main sections. The first is a stylised and relatively informal account of the origins of global risk governance (Hulme, 2010; Escobar, 1994), where we suggest that an emphasis on abstract, global, and universal principles of problem solving can be traced back to modernist ideals. We then focus on the case of climate change, beginning by using our mechanistic account of place-as-context to unpack the implications of the idealised and highly aggregated nature of early generation general circulation and integrated assessment models (*e.g.* the reduction of climate change to changes in global mean temperature; the use of a single utility function to represent global welfare, *etc.*). We next suggest that this relative neglect of place was mirrored in early global framings of the anthropogenic drivers of climate change and of the appropriate scale and nature of institutional responses (c.f. Hulme, 2010; Jasanoff, 2010; Demeritt, 2001). We then implicate this framing in the limited progress in tackling climate change in both public and policy spheres. We next turn to trace out recent shifts towards more spatially explicit approaches to climate change science. These shifts reflect a move towards an Aristotelian ontology which acknowledges that even where causal drivers are in a sense global in nature (*e.g.* atmospheric levels of greenhouse gases), their impacts are often mediated through variables that are spatially clustered at multiple scales, moderated by contextual features of the local environment, and interact with the presence of other (localised) stressors in synergistic rather than additive ways. We then reflect on the recent spatialisation of climate change mitigation, manifest in policy discourses and practices that emphasise spatial planning and local autonomy, appeal to heterogeneous worldviews and interests, and that emphasise the value of experimenting with various mitigation strategies across multiple scales and locations. We conclude that a focus on place, heterogeneity, and context can maximise (rather than limit) the policy-relevance of climate science and help to ensure the development of policy interventions that are robust and effective.

## 2. Place-neglect in historical perspective: from the mastery of nature to the global risk society

Spatially-insensitive approaches to sustainability governance can be traced back to what social theorists class as the logics of modernity, which envision a world of rational social and political organisation, where science controls nature, and technology secures abundant resources (Norgaard, 1994; Habermas and Ben-Habib, 1981; Leiss, 1974; Hedrén and Linnér, 2009). Here, humans were no longer to be at the mercy of fate, but would instead be able to navigate their way through possible futures, drawing on the relentless growth of science and technology to exploit nature in pursuit of social and economic progress (White, 1967; Leiss, 1974; Giddens, 1990). The modernist project reflected a normative vision that emphasised: the role of logic, a particular conception of scientific method, widespread technological development, and expert government (Giddens, 1990; Beck, 1992; Habermas, 1975). In other words, it was premised on an approach to reasoning about and intervening in the world that was abstract, global, and homogeneous, rather than place-sensitive, contingent, or spatially variable. For example, logic refers to the set of context-free universal rules for deriving conclusions from premises, one of the defining features of which is that the content or domain of the problem is irrelevant to what constitutes a valid argument (Skyrms, 2000). The scientific method, on the conventional Galilean account, refers to the systematic methods and principles for deriving exact and general laws relating to the natural, physical and social worlds (Cartwright, 1999; Ophir and Shapin, 1991). On this view, science's methods of inquiry (*e.g.* relating to isolation, idealisation and control) and the knowledge that it produces transcend place in a similar manner to logical truths (Ophir and Shapin, 1991). This context-independent knowledge then informs the design of globally-applicable technologies[2] that can manipulate regularities in welfare-enhancing ways, ranging from agricultural innovations that exploit relationships between input factors and yield, to an approach to social engineering that conceives of society as composed of stable and hence governable classifications of people sharing regular traits, characteristics, and values (Foucault, 1991; Scott, 1998). Here, heterogeneity in contexts – such as variations in soils, climate, work habits and institutions in the domain of agricultural development – were typically treated as irrelevances to the goal of circulating global technologies (Scott, 1998). Finally, expert government is the idea that the global truths of logic and science should provide the evidence that shapes the governance of public life, rather than (contextually-bound) practical reason, emotions, or local interests.

This system of thinking reached its peak during the later stages of the Industrial Revolution, by which time technological advances had led to dramatic economic and social changes throughout the major colonial powers. However, this sense of progress was perturbed in the mid-20$^{th}$ Century, which marked the growing recognition of the variety of ways that humans – via technology – were degrading the natural environment (Beck, 1992). These side-effects of technological progress soon entered public and political consciousness, leading to the rise of the "regulatory state" (Sunstein, 1990), namely the body of laws, regulations, and incentive structures that seek to constrain industrial activities to safeguard public and environmental health. Under this approach, scientific and technological progress was accepted as carrying with it its own set of problems, conceived of as relatively localised "externalities" (Kysar, 2010). Although these externalities were "global" problems in the sense that they were found in many nations, their manifestation was geographically bounded (*e.g.* a polluted lake), and their origins were often traced to context-specific failings (*e.g.* poor operating or maintenance practices in a nearby industrial plant). For example, they were typically

[2] Globally applicable technologies may be found in all parts of the world, although to a limited extent (*e.g.* railroads; Latour, 1987).

tackled by regulatory regimes charged with focussing on particular risk objects or technologies, following an approach that paid limited attention to interactions across domains (*e.g.* the unintended side-effects of regulatory interventions), across places (*e.g.* the shifting of harms across jurisdictional boundaries), or across scales (Wiener and Graham, 2009; Sunstein, 1990). However, the tenability of this approach was challenged by the emergence of the global-scale ecological threats such as ozone depletion, acid rain, the "population bomb," and climate change (Beck, 1992). A new category of risks had emerged: their causes and consequences were not limited to a particular location or place; they were of our own making, yet also paradoxically it was unclear whose responsibility they were; and they were deeply challenging to calculate, given their unprecedented nature and lack of time series data (Beck, 1992).

Experts and politicians began to speak in terms of "global problems," partly inspired by the 1970s Club of Rome reports, and it became fashionable to think of *Earth as a global system*, made up of interconnected parts, processes, and mechanisms (Sachs, 1988). A key idea here was that the harms associated with technology were of a grander scale than previously thought, and moreover, were tightly enmeshed with the very fabric of economic, social, and political systems. These systemic harms threatened to elide the capacities of the rather fragmented regulatory state. The discourse on the "ecological crisis" became increasingly apocalyptic, with governance now seemingly required on a planetary scale (Escobar, 1994). That the modernist project was facing difficulty did not, however, lead to the revision of its central premises. Instead, the repair program that emerged – the planetary governance that Escobar (1994) spoke of – retained those central modernist commitments in its early stages. It was modelled on purposive rationality: the idea that abstract knowledge, once passed on to expert decision makers, can resolve or control problems, this time on a global scale (Habermas, 1984; Hulme, 2012; Prins *et al.*, 2010). In the following section, we suggest that certain aspects of these modernist instincts – in particular a lack of attention to issues of place, heterogeneity, and context in both scientific and policy practices – undermined early efforts to tackle climate change, before tracing out shifts towards more spatially explicit approaches to climate science and mitigation. The transition has been gradual rather than marked by a sharp discontinuity, although we split our analysis into sections for purposes of exposition.

## 3. Case study of the history of climate change governance and its more recent evolution

### *3.1. The early years: climate change as a place-less phenomenon*

The early stages of climate change science focused on clarifying the anthropogenic signature of warming and forecasting changes in *global* mean climate under plausible emission scenarios (Spash, 2002). This involved a large element of formal modelling – both of future climate scenarios and historic trends – in particular via the construction and running of general circulation models (GCMs). It is often remarked that GCMs involve a great deal of abstraction and simplification (*e.g.* Taylor, 1997; Demeritt, 2001; Hulme, 2008). However, this is an inevitable aspect of modelling – models by their very nature cannot capture all dimensions of the systems that they seek to represent. As such, the relevant question becomes: what is being left out of these models, and with what implications? The Galilean perspective is useful in shedding light on this. GCMs are Galilean in two broad senses: they are strongly idealised models, and they draw much of their "epistemic authority" (Hulme, 2013) from being rooted in universal properties and relationships. In the first sense, early generation GCMs abstract or reduce climate change – a multi-dimensional causal capacity – to changes in (global) mean temperature (the major output variable). More on this later. In the second sense, GCMs contain entities whose properties are fixed and universal (*e.g.* the radiative properties of $CO_2$); physical laws that are similarly context-independent (*e.g.* the Navier-Stokes equations); and processes that are properly understood as operating at a global scale (*e.g.* atmospheric dispersion means that the impacts of emissions on climate are independent of their source of origin) (Hulme, 2010). To be clear, that a modelling approach draws heavily on universal, abstract knowledge does not necessarily imply that it fails to represent or encode geographic or spatial detail (*e.g.* the states of the world that serve as model inputs may be geographically patterned). However, a long standing criticism of early generation GCMs – from the impact modelling community and policy makers –has focussed on both their coarse scale and on their incomplete representation of the physical processes that will govern local and regional (rather than global) climatic change (Mearns *et al.*, 2001). In the first regard, GCMs typically resolve on grid squares spanning hundreds of kilometres, with sub-scale variability in underlying processes represented by proxy if at all (*e.g.* various methods of parameterisation). Secondly, there have been long-standing difficulties in representing certain meso and micro level processes (*e.g.* the El Niño-Southern Oscillation; local weather systems that govern heat and moisture transfer) and land surface features (*e.g.* land use, topography) that are expected to mediate global-regional climate changes (Christensen *et al.*, 2013).

This aforementioned lack of spatial detail and coarse scale of GCMs served as major constraint to impacts modelling (Cash and Moser, 2000), which typically operates at far finer resolutions given the context-sensitivity of the mechanisms through which impacts arise (*e.g.* mechanistic ecological models used to simulate climate impacts operate over scales ranging from a single plant to several hectares; Mearns *et al.*, 2001). Various regionalisation techniques which seek to bridge this scalar mismatch had been used at the pilot stage and beyond by the late 1990s, but the understanding of the geographical details of local impacts was still characterised as “patchy” by the time of AR3 (Smith *et al.*, 2001). A prominent workaround for this was to focus on aggregate impact analyses (ibid.). Informally, the idea here was to increase precision by extending the scale of analysis to that of the globe, in the hope that the model errors of local impact studies would be averaged out. In practice, this global picture relied on analyses undertaken primarily in the developed world for their inputs, with adjustments to account for differences in regional circumstances (*e.g.* geographical features, adaptive capacity, extent to which economy is climate-sensitive, etc.) undertaken to varying degrees of care (Smith *et al.*, 2001).

An example of the above approach is the first generation global Integrated Assessment Models (IAMs), which tied together economics, the carbon cycle, climate science, and impacts within highly aggregated models that allow for cost-benefit evaluations of various climate policy options (Nordhaus and Boyer, 2003; Stern, 2006). These models – which were drawn on in AR3 – typically focused on snapshot increases in global mean temperature; used a single utility function to represent global welfare; adopted a fixed equation to relate economic damages to temperature changes; and used global GDP or aggregate consumption as their primary output measure (Stern, 2006; Smith *et al.*, 2001). In other words, these IAMs were strongly reflective of an ontology that views climate change as a singular causal capacity that exerts a fixed effect that is best understood at the global scale. This ontology is problematic not solely because of the rather heroic assumptions required to make it operational (*e.g.* in the selection of the form of the damage function), but also because the reduction of climate change to a singular causal capacity (mean temperature change) that exerts a stable, context-independent effect leads to a systematic underestimate of impacts. This underestimation stems from two issues. Firstly, the impacts of climate change are sensitive not only to mean temperature changes but also to changes in precipitation, to the probability distribution of potential future climates (*e.g.* fat tails), to the rate of change, and to variance (*e.g.* extreme events) (Stern, 2013). Secondly, the effects of climate change will often interact in a synergistic rather than additive way with the presence of other (unevenly geographically distributed) stressors such as poverty (Carter *et al.*, 2007). Setting under-estimation aside, there are major questions about the precision of such context-insensitive estimates. For example, the impacts of climate change will be moderated and mediated by a range of spatially variable mechanisms and dimensions of context that simply cannot be captured within aggregated models that are calibrated with respect to a "patchy" understanding of local impacts. Finally, global-scale impact assessments have typically not taken account of the effect of future changes in socio-economic conditions in moderating the impacts of climate change (Parry, 2004; Arnell *et al.*, 2004). This matters because recent analyses suggest that these dimensions of context are often *more significant than the degree of climate change itself* in shaping the extent and distribution of impacts (ibid.). In short, climate change is a multi-dimensional causal capacity whose impacts are moderated and mediated by a range of spatially variable dimensions of context. Galilean idealisation is problematic.

We now turn away from formal modelling of climate change to focus briefly on policy discourses and practices. In the formative years of the climate debate policy-makers, academics, NGOs, and media repeatedly emphasised not only the inextricably global nature of climate change – in the sense that emissions are globally dispersed, and impacts similarly spread across the globe – but also the global and abstract nature of the underlying *causes* (Adger *et al.*, 2001). The dominant discourse portrayed climate change as stemming from an externality or "market failure," that is, the failure to include the costs of carbon emissions within the price of energy production and consumption (Adger *et al.*, 2001; Ostrom, 2009; Stern, 2006). Under this way of thinking, the natural solution was to develop technologies that place the true costs of carbon inside the market and so reduce emissions (*e.g.* cap and trade, *etc.*). Moreover, given the framing of climate change as a problem of collective action whose impacts are independent of the source of externality, the main locus of action has been the transnational level (Wiener, 2007; Stern, 2006). The aim of these governance technologies was to control the planetary climate system – with the global thermostat the key metaphor (Hulme, 2010) – with policy goals centred on keeping temperature rises within certain manageable bounds (*e.g.* 2 degrees Centigrade of pre-industrial temperatures; Hulme, 2010; Stern, 2008). Amidst growing concerns about the political realities of implementing carbon trading and related programmes, a renewed focus on geo-engineering – the technological manipulation of the planetary environment – emerged and began to lead to experimental projects (Macnaghten and Owen, 2011).

### *3.2. Implications of the place-less framing of climate change for policy and public understanding*

These efforts to characterise and tackle climate change in many ways reflected an extension of the modernist vision of mastering nature, namely a reliance on: technologies with a global reach; technocratic institutions for knowledge making and policy advice (*e.g.* the IPCC); relatively a-spatial forms of physical science; and a global calculus of costs and benefits. However, these "globalising instincts" (Hulme, 2010; Jasanoff, 2010) ran into difficulties. Political agreements so far have been partial and tentative, publics remain largely disengaged and in some cases rather polarised, and greenhouse gas emissions and atmospheric levels continue to rise (Sarewitz, 2004, 2010; Hulme, 2008). These difficulties are partly rooted in the relative neglect of place that is characteristic of modernist commitments. In relying heavily on a-spatial and idealised GCMs and IAMs – and focussing on harms that are easily expressed in economic terms (Adger *et al.*, 2011) – early climate change science was unable to represent the heterogeneity of climatic shifts and associated impacts (Liu *et al.*, 2013b); systematically underestimated the likely magnitude of economic damages; downplayed the importance of local knowledge in adaptation planning (*e.g.* indigenous knowledge; Hulme, 2011); and neglected humanistic accounts of the contextually bound consequences of changing climates (*e.g.* threats to sense of place; Adger *et al.*, 2011). These limitations have had many tangible implications, most obviously in constraining adaptation planning and providing inadequate guidance on the scale and character of the threat. Other implications are more subtle, for example critics claim that the "scientism" pervading elite discourses on climate change (Wynne, 2010; Shackley and Wynne, 1996; Hulme, 2008) has encouraged actors on both sides of the science-policy divide to overstate and oversimplify the state of knowledge on the issue (Prins *et al.,* 2010), leading in part to intense political polarisation. A further problem is that the global, abstract framing has meant that the idea of climate change lacks traction and meaning for many publics (Adger *et al.*, 2011; Hulme, 2008). It is often viewed by laypeople as a "psychologically distant" phenomenon that will affect future generations in an abstract space (Spence *et al.*, 2012), and whose underlying causes are not concrete choices or behaviours enacted in particular places, but instead systems such as technology, capitalism, and political institutions (Hinchliffe, 1996; Stoll-Kleemann *et al.*, 2001; Lorenzoni *et al.*, 2007; Wolf and Moser, 2011; McDaniels *et al.*, 1996). This may partially explain the value-action gap on climate change. In a potentially self-fulfilling feedback, much climate impact analysis treats societies as fairly passive and homogenous recipients of the impacts of climate change (mimicking the modernist view of governable populations; Foucault, 1991; Scott, 1998), rather than as composed of people who will react to both the anticipation and manifestation of climate change in complex and diverse ways (Oppenheimer, 2013).

### *3.3. Shifts towards a spatially explicit approach to climate change science*

In this section we sketch out recent shifts away from abstract, global, universal framings of climate change, towards more spatially explicit accounts of how climate change is driven and will exert its effects. One manifestation of this is the upsurge in social science and humanistic research on the causes and impacts climate change, much of which is explicitly context sensitive. For example, researchers have explored how climate-change-related risks to place attachment, cultural landscapes, and sense of identity might be valued (*e.g.* Adger *et al.*, 2011; Brace and Geoghegan, 2010), how structural features of local environments interact with norms and expectations to produce energy consumption habits (*e.g.* Shove, 2010), and how plural (rather than homogenous) worldviews, beliefs and value systems shape societal capacities to respond (Adger *et al.*, 2009). Vulnerability analysis is another area of research sensitive to the geographical dimensions of climate impacts and responses (Ford, 2012) that is gaining increased attention. The three classic dimensions of vulnerability analysis (Clark *et al.*, 2000) are place-sensitive: *exposure* (*e.g.* communities living in coastal areas are particularly exposed, given changes in storm tracks), *sensitivity* (people in areas where economies are tightly linked to the production of climate-sensitive goods are particularly sensitive), and *coping capacity* (wealth, social capital, *etc.* are spatially clustered). Vulnerability concepts have a long tradition within human geography and indeed within the climate change literature. However, the *operationalization* of these concepts is now more credible and salient owing to the increasingly spatially explicit, place-sensitive approaches to climate change science and impact modelling. For example, many of the meso-scale physical phenomena that act as bridges between global climate systems and regional climate patterns – such as the monsoon, the El Niño-Southern Oscillation, tropical cyclones – are increasingly well simulated within climate models (Christensen *et al.*, 2013). The same is also true of the representation of micro-scale processes such as soil moisture and snow albedo – now known to play important roles in modulating local and regional responses to macro scale shifts in atmospheric processes (Diffenbaugh *et al.*, 2005; Flato et al., 2013). Model performance has also been improved by enhancing the resolution of various stationary geographical features such as topography and coastlines (Flato *et al.*, 2013).

These aforementioned advances, together with developments in statistical downscaling mean that the spatial pattering of future climates is now forecast with a significantly improved level of resolution and accuracy (Flato *et al.*, 2013). As such, the long-standing scalar mismatch between climate science and the needs of the climate impact modelling community and adaptation planners is now *partially* bridged. One example of this is the Hadley Centre's PRECIS model, which has informed adaptation planning across the developing world (Mahony and Hulme, 2011). An interesting feature of PRECIS is that it was designed with a degree of "plasticity" (Mahony and Hulme, 2011), meaning that local modelling teams were able to recalibrate the model to reflect the environmental conditions of their own particular places (*e.g.* by adjusting parameterisations). Advances in impacts modelling from AR3 onwards are similarly congenial to the mechanism-context ontology, such as the growing use of mechanistic (rather than correlational) models that often have geographically explicit representations (Ahmad *et al.*, 2001). Taken together, these developments reflect the idea that a great deal of knowledge of local conditions is often required to cash out the implications of relatively general mechanisms, such as those that govern climate. For example, downscaling techniques combined with ecological models have allowed for the identification of refugia – sites where animals can survive in spite of unfavourable local or regional climates – and so correct for what may have been previously biased estimates of threats to biodiversity and also provide the level of granularity required for designing policy interventions such as the orientation of movement corridors (Ashcroft *et al.*, 2009; Ackerly *et al.*, 2010). An Aristotelian ontology is also reflected in recent efforts to explicitly model the potentially synergistic interactions between various dimensions of climate impacts (see Oppenheimer *et al.*, 2014), often with a rather localised focus. For example, in tropical regions the combined potential consequences of the loss of pollinators, increased risk of pest outbreaks, and stresses on water supply systems may lead to declines in food production that are significantly higher than the addition of their individual effects would suggest (Stern, 2006), making Galilean idealisation problematic.

The overall message of this section is that even where causal drivers are global in nature (*e.g.* atmospheric levels of greenhouse gases), their impacts are often a) mediated through variables that are spatially clustered at multiple scales, b) moderated by contextual features of the local environment, and c) interact with the presence of other (localised) stressors in synergistic rather than additive ways. In such situations, Galilean idealisation is not a reliable strategy for estimating causal effects. The methods of climate science are evolving in ways that acknowledge this perspective.

### *3.4. Shifts towards the spatialisation of climate change mitigation*

Perhaps less obviously, the climate mitigation agenda has also begun to connect with *place*, by emphasising spatial planning and local autonomy, appealing to heterogeneous worldviews and interests, and adopting policy experiments across multiple scales and locations. One manifestation of this is a partial shift away from elite discourses that focussed on global and structural drivers of climate change, towards ones that emphasise its local, contingent, and by extension more readily manipulable causes (*e.g.* Behavioural Insights Team, 2010; Seto *et al.*, 2014). This emphasis on how local norms and practices drive emissions, and how structural features of the local environment constrain or shape mitigation opportunities, is congenial to the view that human behaviour and social life is heterogeneous and context-dependent (rather than law-like). In principle, such a framing may help to redefine how local planners, policy-makers, and publics conceive of the mechanics of the climate problem in a way that enhances agency.

A case in point of the above is the behaviour change agenda, which focuses on connecting carbon emissions with actions and behaviours at relatively localised scales (Whitmarsh *et al.*, 2011; Burgess and Nye, 2008), for example through associating carbon footprint with choice-sets that crop up in everyday life (*e.g.* kg of $CO_2$ produced for alternative transport modes; Walker and King, 2008), and deploying local $CO_2$ monitoring systems integrated with feedback and incentives. However, behaviour change approaches have been critiqued for neglecting how structural features of the local environment constrain and condition human behaviour (Shove, 2010). Recent efforts to embed climate mitigation within the objective function of urban spatial planning reflect this line of thought. They take concrete form in strategies that seek to reduce sprawl and automobile dependence (*e.g.* "new urbanism"), and in efforts to protect the carbon sequestration capacities of peri-urban areas (Seto et al., 2014). Cutting across these two approaches is a proliferation of research on "co-benefits," which refers to both the side benefits of mitigation actions in other policy domains, and vice versa (see Somanathan *et al.*, 2014). Some of these co-benefits sit at the macro or meso-level (*e.g.* technology spillover and energy security), but many of them are tied to more local political or economic interests and even to the values and concerns that drive people's everyday choices and practices (*e.g.* air pollution, water quality, and energy costs; Whitmarsh, 2009; Seto et al., 2014). In theory, identifying and exploiting co-benefits should help to overcome the collective action problems (Ostrom, 2009) thought to constrain local, uncoordinated mitigation attempts. It may also ensure that potential climate mitigation practices and low emission transitions are congenial to a heterogeneous range of cultural and ideological outlooks, in contrast to the rather polarising current state of affairs (c.f. Kahan, 2010).

The above analysis is indicative of a broader post-AR4 spatialisation of climate mitigation policy. In particular, recent years have seen a substantial increase in regional, national, and sub-national policies and institutions targeted at emissions reduction, which is not well explained under the standard collective action theory (Somanathan *et al.*, 2014). This reflects a partial shift towards poly-centric approaches to climate governance (Ostrom, 2009), consisting of a series of experiments with diverse climate mitigation strategies across different scales, often integrated in formal networks, and typically tailored to the contexts of specific geographic locales (Rayner and Malone, 1997; Folke *et al.*, 2005; Lee *et al.*, 2014; Somanathan *et al.*, 2014). This variant of "muddling through" – which sits in stark contrast to the purposive rationality favoured by modernist approaches – may help to clarify which instruments and approaches to climate mitigation stake a greater claim to efficiency and effectiveness, and how these are dependent on *scale* and on *place*. Regarding scale, one idea beginning to feature in the climate mitigation literature is fiscal federalism (*e.g.* Somanathan *et al.*, 2014), which is the principle that responsibility for public policy making should be allocated to the scale best equipped to handle it (*e.g.* local authorities may have both the technical capacity and the incentives to reduce emissions from waste transport, given the relatively localised co-benefits). In relation to place, one of Ostrom's key insights was that the emergence of co-operation (on climate actions) is strongly shaped by dimensions of the social contexts within which people are rooted and where they experience environmental problems (*e.g.* norms, networks, social cohesion; Lejano and de Castro, 2014). This contrasts with the earlier focus on generic consumption practices (*e.g.* air-travel), where there was a tendency to lose sight of the fact that the possibilities and potentials for decarbonisation will vary greatly from place to place (Kates and Wilbanks, 2003), as will the transformations in broader structural and institutional mechanisms that may be needed to make them workable (Chapin *et al.*, 2010).

## Conclusions

Galilean accounts portray knowledge of the social and environmental world as fundamentally placeless; as universal, general, and transcendent, rather than parochial, contingent or particular. To show knowledge as placed – as either restricted in scope or shaped by context – has often been synonymous with critique or deconstruction (Ophir and Shapin, 1991). Here, however, we developed an account of place whose point of departure is that science is concerned with causal processes and their interaction with context, rather than with a search for laws. It draws on an ontology which views the structure, scope, and effects of causal processes as depending crucially on the settings in which they are embedded. On this account, contingency, spatial variation, and heterogeneity are central features of scientific enquiry, rather than nuisances to be adjusted for or averaged out. We used this conceptual framework to critically analyse the relative place-neglect that characterised the early stages of climate science and governance – implicating it in the failure to make meaningful progress on emissions reductions – before tracing out recent shifts towards more spatially explicit approaches that promise greater salience and credibility for publics and decision-makers at multiple scales. Our basic claim is that a fundamental focus on context, heterogeneity, and spatial variation need not diminish the policy relevance of social and environmental science, but rather may enhance it. Global sustainability problems are fundamentally placed, in the sense that they are the products of diverse actions that are highly contextual, exert impacts through causal chains that are spatially variable, interact synergistically with other localised stressors, and generate heterogeneous responses from publics and other actors. Both the methods of science and the practices of policy-making need to be sensitive to this in order to develop robust, evidence-based, and effective sustainability governance.

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