Strange Weather, Again: Climate Science as Political Art

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Abstract
For a long time before the 'climategate' emails scandal of late 2009 which cast doubt on the propriety of science underpinning the Intergovernmental Panel on Climate Change (IPCC), attention to climate change science and policy has focused solely upon the truth or falsity of the proposition that human behaviour is responsible for serious global risks from anthropogenic climate change. This article places such propositional concerns in the perspective of a different understanding of the relationships between scientific knowledge and public policy issues from the conventional 'translation' model, in which prior scientific research and understanding is communicated and translated into corresponding policies – or not, if it remains disputed and overly uncertain. Explaining some of the key contingencies and bases for uncertainty in IPCC climate projections and human influences, I show how social and technical analysis of climate science is not about denial of the scientific propositional claims at issue, but about understanding the conditional and essentially ambiguous epistemic character of any such knowledge, however *technically* sophisticated and robust it may be. Contrary to conventional wisdom, it is entirely plausible that existing scientific representations of climate change and its human causes may *understate* the risks induced by prevailing social-economic processes rather than exaggerate them. As the article shows, the public meanings given to climate science, and to 'the climate problem', and thus also the public culture which that knowledge is supposed to inform, are themselves already in key respects presumed and (attemptedly) imposed by the science and its framing. This gives rise to perverse effects on public readiness to take informed democratic responsibility for 'the global climate problem', and associated cross-cutting issues which existing scientific framings of public policy erase from view.

Key words
climate-models ■ co-production ■ imagined publics ■ long-term climate prediction ■ risk and public meaning ■ uncertainty

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Introduction

NOT COINCIDENTALLY, right on the eve of the December 2009 Copenhagen summit to negotiate a successor to the failed 1997 Kyoto Protocol to the 1992 UN Framework Convention on Climate Change, storms erupted. These assumed the political form of 'extreme weather events', as the actions of opponents of the officially-established scientific and intergovernmental policy stance on anthropogenic climate change escalated to accusations of scientific fraud and misconduct by leading researchers informing the Intergovernmental Panel on Climate Change (IPCC).[1] These markedly intensify a long history of attempts to undermine the gathering and now unambiguous global scientific consensus that human greenhouse gas (GHG) emissions increases are 'very likely' (i.e. over 90% probability, on collective expert judgement) a major causal contributor to climate change and global warming. Indeed while climate change deniers have not just turned up their volume but brought in new and nastier political weaponry, IPCC scientists were already markedly altering their own tone, away from the carefully-measured language of official documents, to an increasingly direct, urgent and radical challenge to modern society – for example from the scientific chair of IPCC, that conventional 'western lifestyles [are] unsustainable' (Pachauri, 2009) in the face of prevailing climate science.

The removal from power in January 2009 of US President George W. Bush and his militant climate change denier entourage encouraged widespread hopes that, after a long period of powerful political refusal, a new president in the world's most powerful seat of government would release a log-jam of positive collective commitment to real progress in global GHG emissions reductions. Sure enough, with a difficult domestic political context from which to achieve it, President Obama led other hesitant global greenhouse gas emitters like China and India by novel example, offering a major step forward in US commitments.[2] After the previous political impasse for a decade or more over the very acceptance of the established and increasingly urgent IPCC scientific knowledge of anthropogenic climate change (Pachauri, 2009), it has become more sharply evident that there are many other profound and ill-understood obstacles to relating scientific knowledge, and abstract belief in principle, to real grounded practice consistent with that scientific knowledge. I will suggest here that the usual understanding of this as a problem of 'translation' of that knowledge is itself a key part of the problem. This relates to the role of science in framing such public societal problems, that is, in defining their global public meaning(s).

The anthropologist Mary Douglas (1971) suggested at the very dawn of the modern environmental era that the central issue for the new scientists championing the environmental risks from business-as-usual modern development would not be the technical ones of 'getting the science right', as the eminent US physicist and science-policy guru Harvey Brooks (Brooks, 1976; Brooks and Cooper, 1987) put it, but the quintessentially unfamiliar social ones, of *credibility*. No sooner had Douglas uttered this

observation than the editor of the voice of established science, *Nature*, was condemning the new science of ecology as bare-faced 'anti-science' (Maddox, 1972a, 1972b). Almost 40 years after that fevered early-1970s period, with the *Limits to Growth* study (Meadows and Meadows, 1972), and *The Ecologist* (1972) magazine with its *Blueprint for Survival* warning of impending apocalypse, Douglas's words have proven to be prophetic for IPCC and its anthropogenic global warming scientific knowledge. Whether the critics be determined political self-interests out to destroy any attempt to regulate global emissions as 'communist' tax-justification, or sincere scientific fundamentalists insisting on further questions (Lindzen, 2006, 2007), the endemic *Achilles' heel* of IPCC has been the fundamentally social character of the aim to extract meaning from disciplined observation of nature and its human-social guests. Woven into the disciplined scientific attempt to understand what nature is saying to us about changing climate processes, and human responsibilities for them, are always ancillary but constitutive concerns and commitments. These do not automatically invalidate the painstakingly arrived at scientific reality-claims. In fact contrary to a common assumption, their recognition may lead us to conclude that IPCC's warnings, remarkably consistent since its establishment as a global scientific forum in 1988, indeed since about a decade before that (Van der Sluijs et al., 1998), may be serious *understatements* of our real predicament, and our associated responsibilities. As the evidence has accumulated across different fronts, more credible scientific voices than those of the climate deniers have been increasingly expressing this conclusion.[3]

With these factors in mind, it becomes important to ask what kind of knowledge we understand ourselves to have, about our climate and human activities and relations which may affect it. Given the vast and long-standing efforts which have been invested in this since the 19th century, particularly since the late 1970s when long-term climate modelling and prediction began to develop from (much shorter-term) numerical weather forecasting, I can only give an outline here; but the nature of predictive scientific modelling for such complex global systems and with long-term horizons is worth some examination. Whatever the positive outcomes are from the Copenhagen summit, we are nowhere remotely close to achieving the globally-diffused, diverse and distributed social capacities, commitments and aggregate political will necessary to act collectively in ways which might realistically reduce the physical-chemical pressures on the global climate system, and the global biosphere. Moreover, existing official policy mechanisms being explored, such as carbon-trading and offset schemes, are deemed woefully inadequate by many. This invites us to ask ourselves whether the intensely scientific primary framing of the issue, combined as this is with an intensely economistic imagination and framing of the appropriate responses, may engender profound alienation of ordinary human subjects around the globe from 'owning the issue' and thus from taking responsibility for it. Some authors have suggested that this leads to considerations about how, politically and ethically, as well as intellectually, we have framed 'the global

climate problem', and whether there may be more justifiable and perhaps more effective framings of the issue which are still scientifically-informed.

Climate Science as Experimental Prediction?

The scientific basis of the IPCC reports which project climate states typically to the end of this century is long-term climate change prediction using dynamic physically-representative simulation-modelling. Although its mathematical architecture is similar, this is very different from numerical weather forecasting, where it originated technically in the 1970s. When the World Climate Research Programme, WCRP, was established by the World Meteorological Organization in 1980 to try to develop long-term climate prediction, its explicit research agenda was:

> to develop the fundamental scientific understanding of the physical climate system and climate processes needed to determine *to what extent climate can be predicted*, and the extent of man's influence on climate. The two overarching objectives of the WCRP are: *to determine the predictability of climate*; and to determine the effect of human activities on climate. (WCRP, 1980: my italics)

Significantly, we can note the open-endedly experimental nature of this original commitment – (paraphrasing) 'is long-term climate prediction a scientifically do-able problem?' (Clarke and Fujimura, 1994). This is not unlike many other such large and ambitiously open-ended scientific research commitments. However, it is also notable how the original meaning of the intellectual enterprise changes in light of the large and long-term organization and the proliferating commitments involved, which were at the original moment of commitment unknown and unknowable. With the scientific modelling which became the central currency of the later IPCC and its definitive global scientific advice to policy leaders, media and civil society networks, pragmatic commitments and choices were necessarily made along the way. The original perfectly explicit founding question, 'Is long-term climate prediction scientifically do-able?', has been answered by default, and is no longer explicitly posed. Yet neither has it been deliberately and directly resolved as the attention has necessarily switched to more detailed technical questions. Strictly speaking, we still do not know the answer. In one sense the answer seems to be positive – after all, long-term climate prediction is 'being done' and, moreover, momentous, even unprecedentedly ambitious attempted political authority is being invested in a positive answer to that question. But these predictions can claim authority to predict credibly and reliably only in very complex and indirect ways – effectively only by default of evident failure. As Douglas (1971) suggested, like any other science these attempts at long-term prediction cannot *require* assent, as if a universal *intellectual necessity*. This is especially so when normative 'requirements' are woven into and confused with the propositional assertions about future climate-states and their causes.

Indeed what it would mean to demonstrate the answer – do-able or not? yes or no? – is itself negotiable. Is the key aim to show the future effect on climate (which variables and scales?) of human-emitted greenhouse gas increases? Or of the aggregate of these and natural changes? How might excluded but credible factors like abrupt discontinuous changes from known positive climate feedbacks (which are omitted from existing models) influence the perceived validity and success or failure of IPCC long-term predictions? Ultimately these scientific frames of meaning and 'demonstration' depend partly on broader human frames of meaning, such as whether we attach significance to multiple independent possible influences on observed climate changes, both slow and relatively abrupt ones, or only those for which human society is responsible. If the relative importance of the human contributions compared with the non-human ones is unknown, perhaps unknowable, do we then still assume responsibility for our part, or fatalistically declare that there can be no human responsibility if sun-spots and other factors way beyond human agency are also influencing climate?

Human questions such as these underpin the more immediate question of how we judge the significance and validity of IPCC future climate projections as scientific authority for a stuttering new global policy agenda. There is a complex of more pragmatic choices which frame the scientific enterprise, and which have not compromised the basic integrity of the science of thousands of coordinated scientists involved in reaching IPCC conclusions, because all such science requires some such commitments, in order even to begin. Their provisionality may be recognized, and this hypothetical status may be maintained or gradually dissolve as time, evidence and commitment develop. The point is that the inevitable and integral pragmatics (even if the specific choices are not integral nor inevitable in themselves) have also introduced selectivities such as whether non-linear and abrupt climate changes, such as the possible collapse of the thermohaline circulation (which brings the Gulf Stream to northwestern Europe and Scandinavia), should be noted as a scientifically-endorsed warning or set aside as 'too extreme' for the public policy world to absorb. We return to this below, but first I outline some intellectual aspects of climate prediction using the hugely complex physically representative general circulation models (GCMs) which are the central scientific currency of the field, as a prelude to explaining how, contrary to the claims that IPCC and its global scientific contributors is exaggerating or even completely making up human-induced climate change, it may well instead be seriously understating the problem. The entry point here is to outline some differences between numerical weather forecasting and long-term climate simulation and prediction.

Numerical weather forecasting, typically for a maximum time-horizon of 10 to 15 days, uses similar mathematical equations for representing relevant physical processes as the long-term general circulation models (GCMs).[4] However, unlike for GCMs, short-term weather forecasting can iterate, by waiting to see from empirical outcomes, what correspondences or differences there are with model predictions for the variables selected.

Then changes to relevant initial state input data can be made, and the predictions re-run; and so on, iteratively. With such short-term models, accurate values for detailed initial-state variables are essential. This is not true for the long-term GCMs. With long-term attempts to predict climate states, over 50 to 150 years, several important changes enter in.

Firstly, the simple validation of scientific model-simulated outcome against empirical reality which is possible for a 15-day wait is no longer available. More indirect forms of attempted validation are required, and independent testing of assumptions built into the model becomes more tenuous since the constructs required to test the model predictions may involve the same assumptions as those being 'tested'. One way round this circularity is to test the model's ability to 'retro-predict' empirically-known past climate states from present climatology, a validation on which state-of-the-art GCMs do creditably well in practice. In addition, cross-corroboration between independently generated forms of climate science, for example with palaeoclimatology which does not rely upon the general circulation models (GCMs), does provide substantial separate forms of validation of (but also some differences from) what are called the climate sensitivity GCM model-experiments.[5]

Secondly, for long-term climate futures as distinct from numerical weather forecasting, ocean dynamics become important and have to be modelled into climate dynamics. This is because most of the energy in the global biosphere is contained in the denser ocean mass, as compared with the less dense but more rapidly circulating atmosphere. Over a period of days, as for numerical weather forecasting, the oceans move so relatively slowly that they can be treated as immobile and thus ignored. However, for the GCMs and equivalent models used for simulating long-term future climate states, ocean dynamics and their interactions with the global atmosphere become crucial, so coupled ocean-atmosphere dynamic models have to be built and run, and validated. One of the key problems encountered with such coupled models was the instability or unexplained 'drift' of the unperturbed simulated coupled ocean-atmosphere system, so that obtaining a stable value for average sea-surface temperature with unperturbed existing atmospheric greenhouse gas (GHG) concentrations, to use as baseline against which the effects of perturbation through increasing atmospheric GHG concentrations can be measured, was impossible. With improved understanding, models and data, this problem has been significantly reduced since 2001.

A third fundamental difference between short-term weather forecasting and long-term climate prediction concerns the trade-offs between spatial resolution and time-horizon. Numerical weather forecasting, having remained within the same short time-horizon, has been able to drive for greater and greater resolution (smaller spatial grid-spacing) of its models and prediction outputs, as both data and computing power have improved. Given its extremely ambitious implicit starting aim of encompassing and simulating any global processes – biological, physical, chemical, human –

relevant to climate futures, over long timescales, long-term climate prediction has instead changed little in spatial resolution (for example, stable climate-simulative atmospheric grids of about 200–300km) but has (necessarily) added ocean dynamics into its complex systems. It also remains relatively empty of biological and chemical feedbacks, some of which are known to be important to climate[6] – and most of which, being positive feedbacks, would indicate that actual climate futures may be worse than those advanced by IPCC based largely (though not solely) on GCMs.

It was largely for reasons such as these, deriving from our close-quarters examination of long-term climate modelling, that Simon Shackley and I (Wynne and Shackley, 1994) suggested that this scientific knowledge should be received less as predictive truth-machine and more as reality-based social and policy heuristic. By this we meant that the prevailing scientific knowledge should be understood epistemically as an organizing basis for a broader coalition of motivations, meanings and social, ethical and political concerns than just the instrumental one of 'making the climate safe, and manageable', which is the natural scientific framing.

Climate Prediction as Socially Constructed Understatement?

While the political controversies invested in global climate science have raged back and forth, over whether human-induced climate change is real and threatening or not, a different perspective on this question of the social construction of scientific knowledge and meaning has been largely ignored. This is whether IPCC as the key scientific authority here may have understated the risks, and may also have in effect obscured the crucial commonsense question of error costs. The furore generated on the eve of the December 2009 Copenhagen climate summit by the leaked emails from the University of East Anglia (UEA) Climate Research Unit, a leading global scientific IPCC contributor, was effectively a tale of 'social construction means error and falsehood' – either incompetence or dishonesty, or both, as social explanations of that falsehood. However, a less superficial examination when science is facing such hideous natural and social system complexities indicates (a) that whatever human failings prevailed in the specific language and perhaps practice of the UEA scientists, the forms of validation of IPCC scientific conclusions and judgements are far more substantial, multi-dimensional and robust than can be seriously damaged by one such allegedly illegitimate specific instance; and (b) the dominant institutional social construction of the scientific knowledge and its meaning for policy can be seen to have been operating in the opposite sense to that of falsification and denial – in other words, to have constructed a representation of future climate change and its human causes which presents it as reassuringly gradual: in terms of rate and scale, within the bounds of policy manageability using existing cultural habits and institutional instruments; and requiring no more radical re-thinking of, for example, the powerful normatively-weighted cultural narratives of capitalist consumer modernity and its self-affirming (and other-excluding) particular and parochial

imaginaries of 'progress', rationality, policy and knowledge. Thus, for example, when Simon Shackley and I were researching climate modelling in the 1990s, we conducted ethnographic research at the UK Hadley Centre for Climate Modelling and Prediction, and in addition interviewed leading IPCC scientists, there and internationally.

One thing which became clear was that the standard climate-sensitivity range announced by IPCC as the key measure of climate change risk, namely (then) 1.5–4.5°C, and seen as a smooth and gradual change over time with accumulating GHG atmospheric concentrations, might be less stable and thus manageable than implied. A leading modeller at the Hadley Centre stated it thus (Wynne, 1996: 382):

> What they were very keen for us to do at IPCC, and modellers refused and we didn't do it, was to say we've got this range 1.5 to 4.5 degrees, what are the probability limits of that? You can't do it. It's not the same as experimental error. The range is nothing to do with probability – it is not a normal distribution or a skewed distribution [of the probabilities for each value in the range being real]. Who knows what it is?

In other words, the common idea that the range of projected average sea-surface temperature increase was under intellectual control, in the sense that at least its 'internal' probability distribution was understood, was false. It could be larger, thus possible temperature increases for rising GHG concentrations could be even higher than the top end of this range. Later experience as reflected in IPCC AR4 (2007) has indeed extended this range only upwards.

However, this dimension omits a different further 'understatement' possibility which is even more marked. This is that the GCMs and related climate-simulation models are mathematically structured so that processes are represented by continuous, smooth differences. Thus discontinuous and abrupt possible changes in the real system in all its greater complexity are not represented. Even though there have been huge and admirable developments in the sophistication, power and realism of the different models since the 1990s, this property still prevails, even with respect to known positive climate feedbacks which could amplify global warming rates over existing model-predicted IPCC values, and also introduce more fundamental instabilities in future global living conditions. Indeed recent reports, including the influential Stern (2006) report, and more recent updates[7] recognize that earlier IPCC predictions even as late as 2001 have been outstripped by recent observed acceleration of climate changes.[8] With respect to IPCC understatement of possibly greater climate change risks, including human inducement of far more radical and threatening climate instabilities, Sir John Houghton, then Director of the UK Meteorological Office as well as Chair of IPCC, stated in 1994 (Wynne, 1996: 384), that:

> there are those who home in on surprises as their main argument for action. I think that this is a weak case. No politician can be expected to take on

> board the unlikely though possible event of disintegration of the West-Antarctic ice-sheet. What the IPCC scientists have been doing is to provide a best estimate of future climate under increased greenhouse gases – rather like a weather forecast is a best estimate. Within the range of possibility no change of climate is very unlikely. Sensible planning I would argue needs to be based upon the best estimate, not the fear of global collapse or catastrophe.

This is a perfectly legitimate if disputable position. As I put it then (Wynne, 1996: 385):

> without some such delimiting social commitments at some point in the chain of interpretation, there would be no scientific knowledge of climate even roughly coherent enough to hold together the social debate [on climate and human responsibilities].

One could see Houghton's assertions as just such a commitment. However, what is interesting in this is how the formulation of the 'relevant' scientific knowledge about human-induced climate risks is then shaped in important (and indeed contested) ways by a leading scientist's own, non-scientific assumptions about 'proper' policy needs and capacities, in co-productionist fashion (Jasanoff, 2004). Even the palaeoclimatology record of abrupt climate changes, natural or not, could be excluded on this basis and, broadly speaking, only 'digestible' and (thought-to-be) 'manageable' future climate changes are recognized as scientifically accredited.

The Greenpeace climate scientist of the 1990s, Jeremy Leggett (2001), documented his experience of a similarly systematic understatement of climate risk occurring at IPCC at the time of its first Assessment Report in 1990. In May 1990 he attended an IPCC Working Group 1 meeting and asked his scientific WG1 colleagues two questions about 16 climate feedback loops which he had identified from the literature, but which were excluded for various practical reasons (e.g. lack of data, understanding, and computing power) from existing GCMs and related climate simulation models: (i) is this feedback likely? (ii) if so, will it be a positive feedback (global warming will be proportionately increased) or a negative one (global warming will be proportionately reduced)? The collective response was that 13 of the 16 feedbacks would be positive ones. In other words, IPCC projections were likely to be significantly understating climate warming and possible abrupt, unpredictable future changes. Indeed, as Leggett documents, the review copy of the IPCC Working Group 1 draft which he had received explicitly recognized the existence of such excluded feedbacks, but declined to emphasize their significance for policy-makers. The clear message was left by default, that projected human-induced climate warming would be both gradual and manageable. Again, common sense would seem to dictate that this science would be understating the climate consequences, including possible abrupt and large changes.

Indeed climate sciences other than GCM and related physical representation-based mathematical simulation modelling, which has via IPCC

shaped public policy debate and negotiation so centrally, have also centred on abrupt climate changes, including those which are plausible consequences of human activities. The US National Academies Committee on Abrupt Climate Changes report of 2002, *Abrupt Climate Changes: Inevitable Surprises* (US NRC, 2002), notes how prediction for such complex systems dynamics is particularly fallible and misleading near system tipping points which intrinsically escape the more deterministic dynamics built into such models. It also recognizes scientifically plausible abrupt human GHG-induced changes, such as the collapse or slowing of the thermohaline ocean circulation, the collapse of the west-Antarctic ice-sheet, the hydrological cycle, and the positive feedback atmospheric release of the powerful GHG methane from ground-embodied clathrates as Arctic tundra thaw.[9]

This focus on possible large and rapid disruptions to climate derives much of its knowledge and impetus from scientific disciplines with far longer intellectual-cultural horizons than 'long-term' climate prediction as this developed during the late 20th century. The factors causing many important recorded climate systems transformations over these timescales are simply not understood, and much of the highly publicized scientific scepticism over the IPCC projections and calls to action comes from such different quarters, even though IPCC has also drawn upon this independently-founded scientific work. From a focus on such large, ultra-long-term, often abrupt, and naturally-induced pre-human earth-system and climate changes, the scales and rates of change, human or non-human, which IPCC are emphasizing can look trivial, an unjustified distraction, and perhaps, also, causally unreal. An equally legitimate response is: (a) that this work shows the fragility of climate processes even before we factor in diverse human perturbations; and (b) that we cannot control natural factors, whether abrupt or continuous, and since human factors will add to or even multiply damaging natural changes, better to minimize the ones we can control. The ontological dimensions which the science selectively makes real for us are themselves influenced by these human-ontological and epistemic commitments, including our framing of their meaning and relations with other important global human issues, like our wholesale and hugely variable environmental footprint, and the unconscionable inequities and immodesties on which they are based.

Conclusions

Despite its many critics, the 1972 *Limits to Growth* study shattered the self-satisfied and self-regarding assurance of western industrialism; it can be seen to have been prophetic even though its predictions, seen as scientific claims, have been shown to be strictly false, now that we are living in the time of their early-1970s predictive shadow. Herein lies a prophetic tale in itself for contemporary climate science and policy. As the philosopher Martin Heidegger is said to have asked, 'has the Apocalypse already happened?' (Sacchi, 2002). As everyone involved knows in just a moment's reflection, the IPCC predictions will also be shown to have been strictly

false, by the time our successors come to live them out. Yet that is beside the point, since it does not necessarily invalidate the disciplined human enterprise of this global scientific knowledge-experiment. That is not the meaning of the scientific venture, and all that goes into it. They may be invalidated, however, in a much more serious sense. This relates to the question of the meanings – and thus human commitments and relations – which they bring to life; and those which they do not.

When we look at the vast range of different human activities on the planet which intersect with climate, many of which cannot be – and some of which do not need to be – represented in climate simulation models, Heidegger's question seems entirely to the point. For many people, apocalypse has indeed already arrived, and conditions which have been imposed on them by past and present – often environmentally damaging – global economic and political arrangements force them as a matter of sheer survival to do things which may well exacerbate climate and other environmental processes, some of these also global. Meanwhile the powerful rich-world policy focus, reinforced by commercial, industrial and media priorities, is restricted to greenhouse gas emissions and their control, while the cultural-economic habituated practices and global economic relations which 'enforce' those doubly destructive global conditions are backgrounded or even erased.

Passing these global issues pertaining to climate, but very far from *only* about climate and greenhouse gases, through the eye of the needle of GCMs and long-term climate simulation science has – with absolutely no deliberate intent so far as can be seen – produced its own global *policy* climate which externalizes the larger human-relational issues which contribute to the global apocalypse which is already upon us, regardless of what may happen to the climate. The moral discomforts which minority affluent world citizens feel when reminded of the grotesque poverty and desperate conditions of the majority distantly hint at this reality. Meanwhile rich-world politicians state that the only way that they can mobilize electoral support for even marginally progressive climate greenhouse gas policies is to have climate impact models which show such citizen-electors that their own self-interests are threatened, like sea-level rise inundating their local areas, or extreme weather events causing flooding to devastate their homes.[10] Of course, self-interest will always be with us, and politics will always have to recognize its various manifestations. However, to act as if politics cannot change the moral and behavioural outlook of citizens, by identifying their more generous and relational human spirit and giving collective articulation, hope and public presence – and material policy form – to these elements of human nature, is timid, wrong, and maybe even self-defeating in this domain. Elsewhere I have suggested that mainstream social science tends to reinforce an atomized and instrumental, rational choice self-interest model of the human subject, and while this is real for sure, it is not at all exhaustive (Wynne, 2007). Contrary dimensions of human subjectivity – intrinsically and ontologically as well as epistemically

relational, responsible, and other-oriented – are also real, if also contingent. It can be seen as a responsibility of social science to bring out and encourage these realities, in a manner which is anyway unavoidably interventionist.

A severe problem for this more complex and contingent, emergent-realist constructivist programme in social science is that in those many domains, such as climate, where social and human issues are interwoven with scientific-technical ones, the dominant prevailing scientific knowledge already carries tacit imaginations of human and social actors and capacities, and also (usually by default, without deliberate intent) imposes 'the' public meaning on the situation and its actors. These imaginaries are strongly normative, and they are typically instrumental, self-interest only visions, as with neo-classical economistic ideologies. Of course these cannot be blamed on climate science; but they do mutually reinforce themselves, in an implicit model of the science-policy order.

This model is reflected in the continuing official attempts which have been made since the 1990s to define a 'safe degree or rate of climate warming', suggesting that only when science achieves the impossible, of describing precisely and with universal credibility what the ultimate limits of human action (in this case greenhouse gas emissions) are for instrumental survival or 'welfare', will humans act. It is also, I suggest, reflected tacitly in the exasperated and alienated comment of a typical UK citizen during 1990s fieldwork, on what would be meaningful sustainable development indicators for citizens in Lancashire, England. This person's pregnant remark – 'They keep us in the dark – and then invent terms like that [sustainable development]' (Macnaghten et al., 1995) – deserves further interpretive effort. It was not alone in our fieldwork returns. One way of reading this attitude-statement is that esoteric terms like 'sustainable development', but here one could also add 'the climate sensitivity',[11] or in other domains 'genetic risk' (Wynne, 2005), are presented by science to policy as if they are only objects of scientific discovery rather than epistemologically and indeed ethically complex, strictly indeterminate, *heuristics*. Thus presented, as if their objective structure and limits *and human meaning* can be revealed by science, it might be considered natural that citizens would sit back, and wait to be told what they must do, rather than go out and learn as well as take their share of responsibility for what could have been presented as a more complex, multidimensional and inherently indeterminate set of human problems, which citizens and their representatives can and should help define. When science – inevitably – does not deliver what has been implicitly promised, citizens so enframed feel imprisoned in a perpetual dark, perhaps that which Swyngedouw (2007, 2010) has described, in implicit contradiction to Giddens (2009), as 'post-political'. Alienation, disempowerment and inaction are encouraged to follow even if, thank goodness, opposite commitments are also alive despite this deeply negative scientistic framing of the public and policy. Yet one can see in this alienated expression not so much an outright rejection of a false basic

idea so much as an embryonic and diffident attempt to seek a different meaning to it.

In this situation, we can see the hint of a perversely self-fulfilling political assertion that 'we cannot take the political risk of radical positive policy actions, because citizens will not accept it'. This assertion only confirms and consolidates its own premise that citizens only act in instrumentally self-interested ways. The risks involved in breaking out of this frame seem insurmountable. They require not only a radically new political will fuelled not by threat and urgent necessity but by positive commitment to building collective agency and care, and material restraint and modesty, founded on just those realities which also exist in human societies. Without this commitment, we seem left with only technical fixes and superfixes as imagined options for response to 'the climate challenge', while we continue to be encouraged as passive citizens just to consume, even if 'consuming green low-carbon', in the collective all-consuming frenzy, even climate frenzy, which is contemporary global capitalism.

An escape from this futile impasse seems to be indicated, albeit with its own unknowns and contingencies, by exit from the 'climate wars' epistemic frame of 'the' issue. Committed sceptics continue to deny the authority of IPCC science read as literalistic truth-machine, and social scientists and policy analysts who notice the over-extended thus fragile and contested character of the science may wince as they faithfully follow the credibility-wounded conventional wisdom down the corresponding technicist instrumental policy trajectory.[12] Meanwhile the other meanings to global sustainability than those to which the scientistic exclusively low-carbon climate imaginary reduces it could be empowered, and given greater priority, if we were able to step away from this literalistic polarization. Demerrit (2006) has given a lead here, building on earlier specific analysis of climate modelling (Shackley and Wynne, 1996, 1997; Jasanoff and Wynne, 1998), and also noted how the constructivist STS approach to climate scientific knowledge (as with other scientific knowledge) was never about straightforward denial of the propositional claims involved. It was about understanding their *conditional* validity, and the implicit diverse meanings and alternative potential trajectories, including potential epistemic trajectories, deeply embodied in them and their framing.

This in turn points attention to the broader and more multiple meanings, and the neglected human worlds and their needs, which the slavish one-dimensional literalism of existing science and policy cannot yet bring itself to imagine. More poetic ways of understanding this knowledge (as indeed practitioners themselves are often able to do in their own specialist and informal scientific worlds) could render its public lives, public uptakes, and public engagements more resilient, and practically rewarding.

Notes

The term 'strange weather' is borrowed from Ross (1991).

1. The UK tabloid *The Daily Express* headlined this on 2 December 2009: 'The Big Climate Change "Fraud"', referring to the talk by climate sceptic Professor Ian Plimer to a London audience, in which he called 'the [IPCC] scientific consensus that mankind has caused climate change . . . a load of hot air underpinned by scientific fraud', including alleged deliberate manipulation of data by leading UK climate scientists. A more considered but also heavily disputed critique came from Cohen (2009), freebooting on such innocent scientific statements as: 'Modellers have an inbuilt bias towards forced climate change [i.e. human-induced rather than nature-induced] because the causes and effect are clear' (Schmidt et al., 2004).

2. Thanks to an often unnoticed property of US constitutional democracy, these had to be made subject to later Congressional agreement.

3. See the blog, http://www.desmogblog.com/about-climate-cover and Hoggan and Littlemore (2009). The more recent evidence of IPCC's underestimation of rates and severity of climate change processes has even led the leading climate scientist, James Hansen, to express his wish that the Copenhagen summit fails to reach a formal international protocol, since it will, he believes, reflect an account of climate change which is far too reassuring. This mismatch has actually existed since the 1st IPCC report in 1990, which stated that GHG emissions reductions of 60% over 1990 levels would need to be achieved in order to stabilize the climate. Hansen was headlined in *The Guardian*, 3 December 2009: 'Copenhagen Must Fail – Top Scientist'.

4. The terms 'weather' and 'climate' distinguish respectively between shorter-term and usually higher-resolution aspects and more aggregated long-term factors, though ultimately both hinge on humanly relevant variables such as temperature, pressure, and precipitation. 'Climate modelling . . . and weather forecasting . . . are based on the same fundamental sets of equations, solved on similar grids using similar numerical algorithms. Those basic numerical methodologies have barely changed over subsequent decades . . .' (Slingo et al., 2009).

5. The climate sensitivity is the model-predicted average global sea-surface temperature rise which is produced by a notional doubling of atmospheric greenhouse-gas concentrations, whenever precisely in future this is assumed to occur. This is the figure – or range – which features most prominently in IPCC reports and media accounts. Until the 4th IPCC report in 2007, this was 1.5–4.5°C for a remarkably long time (Van der Sluijs et al., 1998). Reflecting new research and new model-runs, it was extended upwards by IPCC in 2007, to 1.5–5.4°C.

6. See Leggett (2001: 3–10). Also personal communications, 1997–8.

7. 'Cost of Tackling Global Climate Change Has Doubled, Warns Stern', Juliette Jowit and Patrick Wintour in *The Guardian*, 26 June 2008. This doubling of Stern's cost estimates derived from the accelerated global warming effects observed since 2002.

8. See also Hulme (2008). As the UK Newspaper *The Independent* headlined on 18 November 2009, the international Global Carbon Project had just reported that the IPCC's AR4 report worst-case scenarios of a 6°C rise of sea-surface temperature were becoming mainstream. This was in part thanks to faster human emissions of GHGs, but also due to the initiation of what were known positive climate system feedbacks which had previously been excluded.

9. There is a discursive flexibility which is itself symptomatic of the ambiguous epistemic status of the scientific outputs from models and their expert interpretation. Thus the terms forecasts, predictions, projections, scenarios, heuristics, all intermingle with little or no clarification of any possible distinct meanings.

10. UK Climate Minister Ed Milliband has been more enlightened than most politicians in encouraging civic uptake of climate-mitigating actions, but even so in his 4 December 2009 remarks preparing for the Copenhagen summit he emphasized the recent dramatic floods in Cockermouth England, as one climate consequence which such mitigating actions could avoid. See: http://www.thisislondon.co.uk/standard/article-23779546-climate-change-sceptics-are-todays-flat-earth-brigade.do (accessed 10 December 2009).

11. And in the domain of regulatory policy science, for example genomics and biotechnologies, one could say the same for the term 'risk'. See, for example, Wynne (2006).

12. For example Giddens (2009), who wholly misrepresents supporters of precautionary approaches to climate knowledge and policy, as if they advocate 'don't interfere with nature'! (p. 6), and he proposes what he calls 'The Giddens Paradox' (p. 2) as if it were a new insight – that public response to climate is undermined by the fact that we cannot see climate change processes per se. This patronizing approach to civic capacities and green alleged unrealism leaves no room for autonomous relationship to the authority of the dominant form of climate science.

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