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Is scientific reticence hindering climate understanding?

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Abstract

Physical climate risks are systemic, non-linear, and cascading in a manner not incorporated into climate models. Particular attention should be given to the plausible high-end possibilities, and not the mid-range probabilities, because the worst-case scenarios will result in great and potentially existential damage. The bulk of climate research has tended to underplay these risks, and exhibited a preference for conservative projections and scholarly reticence—although increasing numbers of scientists have spoken out on the dangers of such an approach. This reticence is clearly displayed in the work of the Intergovernmental Panel on Climate Change, which consistently errs on the side of "least drama," downplays the more extreme possibilities, and offers mitigation paths with unacceptable risks of failure. The drivers of this reticence are methodological, political, and social.

Keywords

Climate risk; scholarly reticence; scientific method; climate model; systemic risk; non-linearity.

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Faster than forecast, the impacts of a heating planet are wreaking havoc, with record-breaking new heat, rainfall, and ocean temperature extremes that have shocked climate scientists. The year 2023 reached 1.5 degrees Celsius of warming (about 2.7 degrees Fahrenheit) over a late-nineteenth-century baseline, which was beyond scientists' expectations, and 2024 brought a further shocker at 1.6 degrees Celsius warmer.

"This is happening at a much faster rate than ever documented in the past… we are much more likely to underestimate the impact of those changes on human society than to overestimate them," says Katharine Hayhoe, chief scientist for The Nature Conservancy (Watts 2024). Johan Rockström, director of the Potsdam Institute, agrees that "the planet is changing faster than expected… we must admit we have underestimated risks" (Rockström 2024).

That underestimation inhibits public understanding and policy making. This is a field in which knowledge is relatively new and growing quickly; the physical reality is changing rapidly; uncertainty can become an excuse for political delay; and the cost of not understanding the systemic risks may be the viability of major Earth systems and human societies.

Scientific reticence may be understood as the reluctance to spell out the full risk implications of science in the absence of perfect information. This practice has been leading to severe underestimations—and in the climate field, it has been of concern to leading researchers for more than two decades.

The issue is particularly stark in forums where politics and science intersect, such as the reports of the Intergovernmental Panel on Climate Change (IPCC). In practical terms, Earth has already reached 1.5 degrees Celsius in 2024, yet just seven years ago an IPCC special report projected that "global warming is likely to reach 1.5 degrees Celsius between 2030 and 2052," with a midpoint around 2040 (IPCC 2018). This echoes a pattern of scientific reticence and underestimation of the pace of events that has plagued IPCC reports.

A widespread affliction

In a 2007 paper titled "Scientific Reticence and Sea Level Rise," America's best-known climate scientist, James Hansen, said that scientific reticence hinders communication with the public about the dangers of potentially large sea-level rises. Provocatively, Hansen—NASA's climate chief—offered to "bet $1,000 to a donut" that his estimate of a sea-level rise "of the order of five meters this century" is a far better estimate than "a linear response for the ice sheet component of sea level rise," which was a reference to the IPCC estimate of less than a meter by 2100 (Hansen 2007). Later he added that "the [reticence] affliction is widespread and severe. Unless recognized, it may severely diminish our chances of averting dangerous climate change" (Hansen 2016).

The prevailing literature had long suggested that the polar ice sheets would be stable for a century or more in a warming climate. The IPCC's Third Assessment Report in 2001 stated that the Greenland and West Antarctic ice sheets would not lose significant mass by 2100. But in 2014, research by Eric Rignot, a glaciologist at NASA's Jet Propulsion Laboratory, showed that "the retreat of ice in the Amundsen sea sector was unstoppable [and] will likely trigger the collapse of the rest of the West Antarctic ice sheet" (Rignot 2014). In other words, a tipping point had been reached.

More recently, the stability of the Atlantic Meridional Overturning Circulation (AMOC) has become a big story. Recent research suggests it is approaching a critical tipping point for collapse around mid-century, which is only 25 years from the year of this article's publication (Ditlevsen and Ditlevsen 2023; Pontes and Menviel 2024). In contrast, an earlier IPCC report had said that the AMOC would weaken in the twenty-first century but "a collapse is very unlikely," with only a 50/50 chance of collapse by 2300 in high-emission scenarios (IPCC 2019). Climatologist Stefan Rahmstorf of Potsdam University in Germany says "the conservative IPCC estimate, based on climate models which are too stable… is in my view outdated now" (Rahmstorf 2023).

And it is not just a scatter of reticence cases. In 2011, economist Ross Garnaut reflected on his experience in presenting two climate reports to the Australian Government and questioned whether climate research had a conservative "systematic bias" due to excess "scholarly reticence" and pointed to a pattern across diverse intellectual fields of research predictions being "not too far away from the mainstream" expectations, and observed that in the climate field that this "has been associated with understatement of the risks" (Garnaut 2011).

The drivers of this reticence are methodological, political, and social.

Restraint and the scientific method

In the physical sciences, the standard research approach —the scientific method—is to construct and test a hypothesis using observations and experiments. The outcome is reviewed by peers, and the results must be reproducible.

It is an onerous burden of proof, different from expert opinion (also known as elicitation). What an experienced scientist may surmise is going on, but cannot yet provide sufficiently robust evidence for, is not part of scientific literature. This uncertainty leads to silence—which can be a serious problem when knowing what experts think may be very useful for policy makers.

One study examined a number of past climate research predictions and found the scientists to have been "conservative in their projections of the impacts of climate change" and that "at least some of the key

attributes of global warming… have been under-predicted, particularly in IPCC assessments of the physical science." There was a tendency of scientists to "err on the side of least drama," whose causes may include adherence to "the scientific norms of restraint, objectivity, skepticism, rationality, dispassion, and moderation," and this may cause scientists "to underpredict or downplay future climate changes" (Brysse et al. 2013).

Methodological conservatism may contribute more significantly to scientific reticence in a discipline such as climate change, where the physical reality is changing rapidly and delays in understanding come at a greater cost. Long lead times in getting research to publication add to the problem.

Climate models are a recent phenomenon and still do not account for all the relevant processes. A recent example is the evolving research on the relationship between Arctic warming, the destabilization of the sub-Arctic Jet Stream atmospheric circulation, and more extreme summer climate heat waves and floods. Climate scientist Michael Mann says "the models are underestimating the impact that climate change is already having on these extreme events," (Berwyn 2024)—and more broadly, when it comes to big issues such as ice sheet collapse and sea level rise, the IPCC reports "have been overly conservative, in substantial part because of processes that are imperfectly represented in the models" (Berwyn 2023).

Big-picture knowledge may also be inhibited by the complex nature of the research subject—the Earth system— which requires detailed understanding of many specific sub-systems and research specialization. Holistic relationships may not be given enough attention. Topics such as system "tipping points" and their mutually interacting cascading effects have only recently been given much scientific focus.

In the face of systemic reticence, Potsdam Institute director emeritus John Schellnhuber has emphasized thinking beyond hypothesis-driven research: "Scientific progress is often driven from the periphery, or occasionally, by eminent personalities whose seniority is beyond doubt. This does not at all imply that hypotheses need not be vindicated in due course, but out-of-the-box thinking is vital given the unprecedented climate risks which now confront human civilization" (Schellnhuber 2018).

Dealing with complexity

Climate general circulation models (GCMs), with data and relationships expressed in a complex web of equations, perform best where there are known and relatively linear relationships. A good example is the impact of rising greenhouse gas levels on atmospheric warming, which models have projected well. But some fundamental processes are still quite uncertain, such as the role of clouds and the strength of aerosol cooling.

And there are many Earth climate-system components such as major ocean and atmospheric circulation patterns, polar ice sheets, and terrestrial and ocean carbon stores which are stable within a certain temperature range, but once past a critical threshold or tipping point—and with self-reinforcing feedbacks—they move in a relatively sudden and disruptive (non-linear) manner to a very different state.

Current models are not adequately capturing such non-linear risks, and many of these systems are reaching their tipping points decades or even centuries faster than the models projected. William Ripple at Oregon State and his co-researchers have shown that many positive feedbacks are not fully accounted for in models (Ripple et al. 2023).

For example, researchers say that climate models "underestimate the abruptness of the recent changes observed in the Arctic" (Jansen et al. 2020), and Jason Box at the Geological Survey of Denmark and Greenland identifies "a more rapid response of the [Greenland] ice than is currently encoded in climate models that project sea-level rise… we cannot yet rely on ice sheets models for credible sea level projections" (Breeze 2021). Climate scientist Merritt Turetsky at the University of Colorado- Boulder says "permafrost is thawing much more quickly than models have predicted, with unknown consequences for greenhouse-gas release" (Turetsky et al. 2019), and models have not accounted well for the slowing of the AMOC (Boers 2021).

Two forms of reticence may result. One is communicating model results without explicit recognition of their limitations, endowing their outcomes with a degree of legitimacy they do not merit. The second is to look away from difficult-to-model processes, and not make them a research or communications priority. Hence the repeated shock over unexpected events and out-of-the-box projections.

The IPCC has published little on tipping-point thresholds, nor emphasized the importance of building robust risk assessment methods when faced with system complexity and deep uncertainty.

Excluding difficult-to-model processes also produces rose-tinted carbon budget mitigation paths. The IPCC's estimates of how much carbon dioxide we can still safely emit "explicitly leave out many known large-scale disruptions or tipping points because of insufficient understanding or because models cannot capture them," wrote professors Wolfgang Knoor and Will Steffen in 2020 (Knoor and Steffen 2020).

As far back as the late 1990s, scientists "questioned the policy-usefulness of GCMs because of their limitations in dealing with uncertainty" and argued that the dominance of models "leads to a technocratic policy orientation, which tends to obscure political choices that deserve wider debate" (Shackley et al. 1998).

Those words are just as pertinent for climate–energy– economy models known as Integrated Assessment Models, which feature in IPCC mitigation path reports. Integrated Assessment Models deal with risk by providing cost-benefit analysis of various emission-reduction and energy-choice scenarios, and depend on being able to quantify both the damages caused by climate disruption, and the probabilities. But this is a deeply flawed approach, because damages are essentially unquantifiable, and the likelihoods may be deeply uncertain.

While the word "model" suggests some technocratic neutrality, Integrated Assessment Models are in fact social–political constructs, and their very structure reflects the modeler's beliefs about the functioning of society (Ellenbeck and Lilliestam 2019). They may entice policy makers into believing that the forecasts of these models and the way they deal with uncertainty have a scientific legitimacy.

This is emphatically not the case. Joeri Rogelj, director of research at the Grantham Institute on Climate Change and the Environment, says that the Integrated Assessment Model scenarios in the IPCC database "opens a Pandora's box of misinterpretation and inappropriate use" because they "have no inherent predictive power—and no amount of analysis, selection or staring at spaghetti plots will change that" (Rogelj 2022).

Risky business

There is a consistent pattern in IPCC reports of giving priority to complex, quantified (numerical) modeling results. The data is often presented as a median value (middle point or most probable outcome in the data range), plus a range of uncertainty between a low and high value. Then there may be a brief note about more severe possibilities in a descriptive, non-quantified form. IPCC treatment of sea levels is a good example. This method, especially where the analysis does not account for all the risks, may be seen as a quantification fetish.

Because policy makers and the media are often drawn to headline numbers—in this case, the mid-range values —less attention is given to the most devastating, highend, non-linear, and difficult-to-quantify outcomes.

A good example is carbon budgets, an estimate of permissible emissions to keep warming below a certain threshold. Scenarios with a 50–66 percent chance of success and hence a 33–50 percent risk of failure (or overshoot) are the norm. Personally, I would not accept even a one-percent risk of failure for an airplane or a bridge. So why do scientists propose—and policy makers and advocates accept—risks of failure with Earth-system advocacy they would not accept in their own personal lives?

And why are researchers reluctant to spell out the risk of failure? In a carbon budget, a 10–percent failure risk means there is no carbon budget left for 2 degrees Celsius. And an emissions budget that has a 50–percent chance of not exceeding 2 degrees Celsius has a 10– percent chance of reaching a civilization-ending 4 degrees Celsius. But how often do we hear this being said?

The biggest risks are systemic—that is, risks inherent to a system as a whole, rather than to individual com-ponents of it. Daniel Quiggin, the lead author of the UK's Chatham House "Climate Change Risk Assessment 2021," says that systemic risks "stem from the consequence of direct impacts—materialising as a chain, or cascade, of impacts—compounding to impact a whole system, including people, infrastructure, the economy, societal systems and ecosystems. Quantifying the probability and severity of systemic risks is not possible due to their complex nature" (Quiggin et al. 2021).

Schellnhuber has made a stinging critique of the quantification fetish: "So calculating probabilities makes little sense in the most critical instances, such as the methane-release dynamics in thawing permafrost areas or the potential failure of entire states in the climate crisis. Rather, we should identify possibilities—that is, potential developments in the planetary make-up that are consistent with… the processes and the drivers we know" [italics added for emphasis] (Schellnhuber 2018).

Luke Kemp from Cambridge's Centre for the Study of Existential Risk says that prudent risk man-agement "requires consideration of the bad-to-worst- case scenarios" because low-probability, high-impact extreme outcomes have damages so large as to per-haps be unquantifiable, and that large uncertainties about dangerous surprises "are reasons to prioritize rather than neglect them" (Kemp et al. 2022). But, Kemp says, "We know least about the scenarios that matter most" (Kemp 2022), a consequence of scien-tific reticence.

When science and politics collide

While there may be a public perception that the IPCC simply reports on science research, in fact the process is one of politics and science colliding.

The IPCC is a political forum, populated by profes-sional diplomatic representatives of 195 national gov-ernments, including petrostates, and subject to the diplomatic processes of negotiation, trade-offs, and deals. They select the scientific coordinating authors, and each member nation has a veto over every para-graph of the key compilations of longer reports that receive most of the media coverage, known as the Summary for Policymakers.

The IPCC process suffers from all the dangers of consensus–building in a complex arena, leading to "least drama" and lowest-common-denominator out-comes which overlook critical issues. This is particularly the case with the high-impact but lower-probability events for which scientific knowledge is more limited, because they have never been a political or funding priority.

Environmental science professor Martin Parry was cochair of a 2007 IPCC report, and he said of it: "Governments don't like numbers, so some numbers were brushed out of it" (Adam 2007). And in 2014, the Summary for Policymakers on climate impacts and mitigation "were significantly 'diluted' under political pressure from some of the world's biggest greenhouse gas emitters, including Saudi Arabia, China, Brazil and the United States" (Ahmed 2014).

This intersection of science and politics at the IPCC may be termed "regulatory science" (as opposed to "research science") or "co-production," a term coined by Sheila Jasanoff, who studies science and technology at Harvard's Kennedy School. She describes this pro-cess as one which "straddles the dividing line between science and policy" (Jasanoff 1998) as scientists and regulators try to provide answers to policy-relevant questions. In this interplay, "science is seen neither as an objective truth, nor as only driven by social inter-ests, but as being co-produced through the interaction of natural and social orders" (Dooley, Christoff, and Nicholas 2018).

As discussed above, IPCC reports rely too much on model-based science at the expense of other forms of knowledge, including Earth's climate history (also known as paleoclimatology) and expert elicitation. This leads to reticence. A good example is sea-level rise, as James Hansen pointedly demonstrated. While IPCC reports consistently give sea-level projections of less than one meter by 2100, even a cursory look at paleoclimate data would show that "an equilibrium cli-mate under *current* temperatures would have a sea level… likely 5–10 metres higher. An equilibrium cli-mate under current CO2 concentrations would have a sea level 5–25 m. higher [emphasis added] (Pitman, Meissner, and Abram 2021)."

Broader sources of knowledge are required, including expert elicitations, that is, what leading scientific figures think is going on when there is not yet sufficient evidence to pass the peer-review process. With this in mind, Michael Oppenheimer and his colleagues urged that comparable weight should be given to evidence from paleoclimatology, and from more observationally-based, less complex semiempirical models in general, in order to overcome the reticence generated by an unhealthy reliance on climate general circulation models (Oppenheimer et al. 2007).

Group think and funding

Among a group of experts, there is always the danger of conforming to a peer-group view or to a dominant political and economic paradigm.

A 2016 report, "Thinking the unthinkable," based on interviews with global business and political leaders, identified a deep reluctance or "executive myopia" among top leaders to see and contemplate even the possibility that "unthinkable" events might happen, let alone how to handle them (Gowing and Langdon 2015). That could apply to a lot of climate research, too.

Schellnhuber describes how "experts tend to establish a peer world-view which becomes ever more rigid and focused. Yet the crucial insights regarding the issue in question may lurk at the fringes. This is particularly true when the issue is the very survival of our civilization, where *conventional means of analysis may become useless*" [emphasis added] (Schellnhuber 2018). This is a damning indictment of group-think scientific reticence in the climate field.

Climate scientist Kevin Anderson of the University of Manchester says that in areas such as emission scenarios, "the modelling community is actually self-censoring its research to conform to the dominant political and economic paradigm" (Anderson 2016), even though "it is not our job to be politically expedient with our analysis or to curry favour with our funders" (Anderson 2015). But saying unpopular things and stepping outside the peer world-view may not be a good career choice, and encourages reticence.

In 2015, Oliver Geden, head of the EU Research Division at the German Institute for International and Security Affair, described how climate researchers who advise policy makers "feel that they have two options, to be pragmatic or be ignored." He fears that many advisers are choosing pragmatism, even as "mitigation scenarios that explore policy options for transforming the global economy are more optimistic and less plausible." He urged the scientific community to "defend its independence from outside interference" (Geden 2015).

But it is a material fact of scientists' lives that research often follows the funding. Until the Paris climate policy making conference in 2015 put the 1.5 degrees Celsius goal on the political map, there had been very little work done on the subject. All the political talk and groupthink was about 2 degrees Celsius impacts and carbon budgets. But after Paris, the IPCC commissioned a 1.5 degrees Celsius report and suddenly there was funding for and an outpouring of such research. In this case, the science output flowed from a political decision.

Schellnhuber, of the Potsdam Institute for Climate Impact Research, has described this situation as the Devil's Advocate Reward: If a researcher comes up with an entirely new thought, "experts tend to reflexively dismiss it as 'speculative,' which is effectively a death warrant in the academic world. Whereas those who criticize the idea will be applauded, rewarded and promoted! This phenomenon is evident in every seminar, colloquium or learned-society assembly" (Schellnhuber 2018).

A great example is the insightful but unorthodox glaciologist, John Mercer. With great prescience, in 1978 Mercer warned that "A major disaster—a rapid deglaciation of West Antarctica—may be in progress… within about 50 years." Warming above a critical level would remove all ice shelves, and consequently all ice grounded below sea level, resulting in the deglaciation of most of West Antarctica. Such disintegration would "probably be rapid, perhaps catastrophically so, with most of the ice sheet lost in a century" (Mercer 1978).

His analysis was ignored or derided by his groupthink peers and funding became scarce. James Hansen coined the phrase "The John Mercer Effect" for scientists' response to Mercer's treatment, which led to playing down findings for fear of losing access to funding or of being considered alarmist.

What if the scientific world had instead listened to Mercer, almost 50 years ago?

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Notes on contributor

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