TYPE Frontiers in Science Editorial
PUBLISHED 01 October 2024
DOI 10.3389/fsci.2024.1495220

Check for updates

OPEN ACCESS

EDITED BY
Frontiers in Science Editorial Office, Frontiers Media SA, Switzerland

*CORRESPONDENCE
David Frame
david.frame@canterbury.ac.nz

RECEIVED 12 September 2024
ACCEPTED 19 September 2024
PUBLISHED 01 October 2024

CITATION
Frame D. Using emerging climate signals to inform mitigation and adaptation. *Front Sci* (2024) 2:1495220. doi: 10.3389/fsci.2024.1495220

Using emerging climate signals to inform mitigation and adaptation

David Frame*

School of Physical and Chemical Sciences, University of Canterbury, Canterbury, New Zealand

KEYWORDS

climate change, greenhouse gas emissions, climate mitigation, climate adaptation, climate modeling

An Editorial on the Frontiers in Science Lead Article
Emerging signals of climate change from the equator to the poles: new insights into a warming world

Key points

- Climate modeling has improved significantly over the past decades, but these models must be developed further, particularly to understand regional extreme events and climate impacts, to inform mitigation and adaptation.
- For models to successfully aid mitigation and adaptation efforts, climate researchers must understand the diverse needs of different decision-makers and tailor models accordingly.
- Climate science producers and specialist users of this science must continue to interact to identify the most important vulnerabilities, sensitivities, and opportunities associated with climate change over the next few decades.

Introduction

As observed by Collins et al. in their lead article in *Frontiers in Science* on emerging climate science signals (1), contemporary climate and earth system modeling ranks alongside cosmology and attempts to understand the human brain as one of the "great modern scientific endeavors." While our combined understandings of the workings of physics, chemistry, and biology on a rotating sphere covered by a mix of ocean, land, and atmosphere are now mature enough to provide a reasonable picture of the way the Earth's climate works—including how it responds to a range of orbital or chemical forcings—the science of climate modeling is still developing. One aspect of this, highlighted by Collins et al. (1), is the need for further development of high-resolution models to improve regional-scale projections and thus more accurate risk assessments.

Important progress has already been achieved through inter-model comparison studies—one of the research community's main tools to contribute to institutional attempts (i.e., the Intergovernmental Panel on Climate Change) to benchmark our understanding of current and future Earth processes. Satellite platforms in particular have vastly improved our observational knowledge of the climate system over recent decades. This has resulted in larger and more comprehensive data sets, leading to improved climate models that are refining our understanding of the geographical distribution of the impact of a changing climate. In fact, within 30 years or so, we have progressed from being able to describe mostly global-scale Earth processes to zooming in on regional climate events, allowing planning agencies to respond much more accurately to localized climate hazards. Collins et al. add to this by presenting new insights into the emerging regional patterns of severe weather events and environmental changes that pose significant risks to both human and natural systems, affecting everything from infrastructure and public health to economic stability and food security (1). Their climate models indicate that monsoons are expected to grow in intensity, resulting in higher risks of flash floods, landslides, and reduced agricultural yields in affected parts of the world. Extreme storms are also more likely to impact northwestern Europe while changing precipitation patterns in the polar region will lead to increased melting, amplifying sea level rise.

Extreme weather and climate events—facing a new normal

The need for countries to mitigate and adapt to regional climate hazards is abundantly clear, especially for the severe end of climate change: extreme events. The strength of evidence for links between greenhouse gas forcing and climate events varies by the type of event and by location, but a growing body of literature shows mounting evidence for an anthropogenic role. Heat-related events in particular show strong human influence (2). One of the first event attribution studies (3) looked at the 2003 heat wave in Europe, linked to some 70,000 early deaths (4). The temperatures were unusually high by contemporary standards, and, without the effects of climate change, the event would have been exceptionally rare. We now know that those temperatures are likely to occur every second summer by the 2040s, and such summers are likely to be considered unusually cool by the standards of the late 21st century. Extreme precipitation events can in some cases be harder to attribute, but basic thermodynamic considerations imply that the warmer atmosphere has increased the amount of rain available in the warmest, most saturated conditions (5). Recent studies (1, 6) focusing on the emerging signs of climate change extend our understanding further by looking at the rate at which extreme events might be changing as well as their potential impact.

This work illustrates that much of the familiar weather around which our societies have been organized is changing rapidly: we are living through a time where events that would have been exceptional are becoming more frequent or, in some parts of the world, even routine.

Climate change mitigation and adaption requires improved dialogue between scientists and decision-makers

The magnitude, timing, location, and spatial and temporal extents of extreme events, together with the nature of the variables in question, links to other climate and environmental variables, and impacts on social and natural systems, all matter to decision-makers when assessing how best to adapt to and mitigate climate extremes and to climate change more generally.

Some choices may be economically clear. In the case of mitigation, for example, countries must be more realistic about the payoffs they face considering the often severe domestic impacts caused by more frequent extreme events. In theory, all countries, upon seeing an increase in the near-term costs associated with climate change, should, all other things being equal, support higher carbon prices/stronger mitigation efforts now since the costs of not mitigating are higher than previously estimated.

However, for adaptation efforts to be successful, we in the science community need to not only improve model performance but also tailor our analyses to the diverse needs of decision-makers. A key challenge for researchers is to better understand how their data feeds into the strategies formulated by policy stakeholders and decision-makers (7).

For instance, decisions can be made based on continuous information, or thresholds. Insurance cover for private residences, for example, is available only for low-risk scenarios. Insurance is normally unavailable for high-probability events, and it becomes more costly as the odds of damage rise until commercial insurance companies can no longer viably provide cover (8). In terms of their use of climate science information, insurers may set premiums based on risk calculations (i.e., using distributions of climate variables) and withdraw coverage if the return period of events exceeds a certain threshold (i.e., thresholds in climate variables).

The climate science community, much like the decision-makers we seek to help, also need to become more adept at understanding the nuances that model information exhibits. Collins et al. make the important point that “uncertainties in predictions and projections must be accounted for but cannot be a barrier to action” (1). As ever with social issues, it depends. There are many instances where we can act reasonably even in the face of uncertainty because we can form reasonable plans that can be adapted if needed. However, there are times when it is preferable to wait rather than take premature action. In still other instances, uncertainty can be a form of constructive ambiguity. In some cases, all three can make sense, even within the same organization, when thinking about a single dimension of climate change.

Take a local government body planning for sea-level rise as an example. I have heard engineers and planners within local councils claim that they “just need a number” for sea-level rise and that it matters less that it is accurate than that it is consistent. (This rather misunderstands the nature of science, but never mind.) I have heard others in the same organization say that it is better to wait so we do not overcommit to strategies that turn out to be excessive (in either direction). At the same time, some uncertainty can be constructive at the political level. In reality, there is considerable uncertainty about the extent of sea-level rise across different parts of the world. Peremptory attempts to draw a single line on a map, instead of displaying a more realistic spectrum of possibilities, can easily create strong incentives for people on either side of that rather arbitrary line: those below the line are incentivized to socialize the costs of adaptation and those above it to keep the costs private. Politically, drawing the line does much to create two camps. Keeping things hazier—in line with the actual scientific uncertainty around sea level rise—may help limit the formation of small but strongly motivated coalitions of voters opposed to adaptation planning. Experience shows these sorts of coalitions can have outsize influence, as "interest groups with small numbers but high per capita stakes have sizeable advantages in political action over interest groups with larger numbers and smaller per capita stakes" (9). The best and most appropriate use of climate model information might thus seem very different depending on whether one engages on the political, policy development, or implementation level of an organization.

Developing "demand-driven" from "supply-driven" science

Users of climate information often need to have expertise in both science and policy and, to justify ongoing investment, scientists will need to move from delivering predominantly "supply-driven" science focused on improvements in scientific understanding to a stronger focus on "demand-driven" science, which more directly addresses the needs of private, public, and community sectors. These are complementary activities, and smart research funding systems will recognize this and create appropriate incentives. For the latter, mission-led science, such as the United States Cancer Moonshot initiative, can play an important role in helping scientists focus on providing specific value.

Conclusion

Compared with other global catastrophic risks, such as possible future pandemics, potential regional nuclear war, bioterror, or biological warfare, climate change is both well understood and highly probable (10, 11). This creates an expanded role for climate science within the policy and decision-making arenas because we can identify more questions that can be answered in support of actionable knowledge compared with problems that are potentially of similar global significance. For many catastrophic risks, there is an awareness deficit among the public as well as among policymakers. This is no longer an issue for climate change, nor is further refinement of scientific understanding of the details of the problem sufficient to justify the comparatively large investment in climate research (compared with, say, modeling bioterror or nuclear war). The challenge is to continue to progress the fundamental scientific work associated with climate change while doing much more to demonstrate value to the communities who fund the research.

Statements

Author contributions

DF: Conceptualization, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. DF received funding from the Ministry of Business, Innovation and Employment (MBIE), New Zealand, through the Whakahura Endeavour Fund Programme.The funder was not involved in the study design, collection, analysis, interpretation of data, the writing of this article or the decision to submit it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author declared a past collaboration with the lead article authors MJ, EH, EL, DM, LW to the handling editor.

Publisher's note

References

1. Collins M, Beverley JD, Bracegirdle TJ, Catto J, McCrystall M, Dittus A, et al. Emerging signals of climate change from the equator to the poles: new insights into a warming world. *Front Sci* (2024) 2:1340323. doi: 10.3389/fsci.2024.1340323

2. Leach NJ, Roberts CD, Aengenheyster M, Heathcote D, Mitchell DM, Thompson V, et al. Heatwave attribution based on reliable operational weather forecasts. *Nat Commun* (2024) 15:4530. doi: 10.1038/s41467-024-48280-7

3. Stott P, Stone D, Allen M. Human contribution to the European heatwave of 2003. *Nature* (2004) 432:610–14. doi: 10.1038/nature03089

4. Robine J-M, Cheung SLK, Le Roy S, Van Oyen H, Griffiths C, Michel J-P, et al. Death toll exceeded 70,000 in Europe during the summer of 2003. *C R Biol* (2008) 331 (2):171–8. doi: 10.1016/j.crvi.2007.12.001

5. Seneviratne SI, Zhang X, Adnan M, Badi W, Dereczynski C, Di Luca A, et al. Weather and climate extreme events in a changing climate. In: Masson-Delmotte V, Zhai AP, Connors SL, Péan C, Berger S, Caud N, et al, editors. *Climate Change 2021: the physical science basis. Contribution of Working Group I to the sixth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press (2021). 1513–766. doi: 10.1017/9781009157896.013

6. Hawkins E, Frame D, Harrington L, Joshi M, King A, Rojas M, et al. Observed emergence of the climate change signal: from the familiar to the unknown. *Geophys Res Lett* (2020) 47(6):e2019GL086259. doi: 10.1029/2019GL086259

7. Stone DA, Rosier SM, Frame DJ. The question of life, the universe and event attribution. *Nat Clim Chang* (2021) 11:276–8. doi: 10.1038/s41558-021-01012-x

8. Storey B, Owne S, Zammit C, Noy I. Insurance retreat in residential properties from future sea level rise in Aotearoa New Zealand. *Clim Change* (2024) 177:44. doi: 10.1007/s10584-024-03699-1

9. Komesar NK. *Law's limits: the rule of law and the supply and demands of rights*. Cambridge: Cambridge University Press (2001).

10. Bostrom N, Ćirković MM, editors. *Global catastrophic risks*. Oxford: Oxford University Press (2008).

11. Barrett S. *Why cooperate? The incentive to supply global public goods. (Print edition)*. Oxford: Oxford University Press (2007).