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Rapid communication: Distribute paleoscience information across the next IPCC reports

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Rather than reverting to a dedicated paleoclimate chapter, knowledge about pre-industrial climate should be further integrated with other lines of evidence throughout the 7th assessment reports by the Intergovernmental Panel on Climate Change.

With the scoping phase of the next IPCC report now taking shape (IPCC, 2024), some in the paleoscience community are advocating for the inclusion of a separate chapter dedicated to this subject (PAGES, 2024). We argue here that paleoscience is made more relevant to the target audience – those interested in current and future climate change, risks and responses – and that it is afforded greater visibility when the information is distributed across the reports, as it was in the latest IPCC Assessment Report (AR6).

Rationale for the distributed approach

The outline for AR6 Working Group I report (WGI) was scoped following extensive discussions by an international group of climate scientists, with input from the broader community (IPCC, 2018a), and guided by a vision for a holistic and integrative report (IPCC, 2018b). The resulting outline focused on the state of the climate system, processes that shape global and regional climate responses, and regional information. While the previous two assessment reports (AR4 and AR5) had included a separate chapter where paleoscience experts could work as an author team to assess selected paleoscience topics in depth, this was not the case for AR6. The absence of a specific paleoscience chapter felt like a demotion for some in our scientific community who see a dedicated chapter as safeguard for relevancy and visibility.

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However, we emphasize that paleoscience information was covered more comprehensively in AR6-WGI than in previous IPCC reports (PAGES, 2021). Some of this reflects paleoscience knowledge developments, with longer time span between reports and more material to be assessed. Plus, paleoscience chapters in AR4 and AR5 had themselves stimulated new paleoscience research. Nonetheless, we find that insights from paleoscience were promoted in AR6 because, rather than consolidating the subject within a separate chapter where it might appear unconnected to actionable knowledge, the relevance of long-term climate variability was highlighted in multiple chapters of the AR6 WGI report (IPCC, 2021a) where current and projected climate changes are placed into a broader context of long-term natural variability. Empirical evidence from paleoscience studies was considered with other types of evidence when assessing the scientific understanding of a large variety of topics that range from slow-responding components of the climate system to abrupt changes. In AR6, paleoscience content was further distributed in the Working Group II report (IPCC, 2022a) as it relates to the detection and attribution of ecosystem changes, and the vulnerability and adaptation of Earth's biota, socioecosystems and societies to past climate variations. In the Working Group III report (IPCC, 2022b), centennial and longer timescales were also part of the assessment of carbon storage and removal. In this distributed approach, knowledge of pre-industrial climate was considered alongside and on par with multiple lines of evidence including observations, theory and modeling that are needed for a robust and comprehensive assessment, including to constrain future projections.

Paleoscience coverage in AR6-WGI compared with previous reports

Despite the absence of a chapter dedicated to paleoscience, or because of it, paleoscience information was featured not only more comprehensively but also more prominently in AR6 than in the previous two reports (AR5 and AR4). This assertion is based on an analysis of the contents of the WGI Summary for Policy Makers (SPM) (IPCC, 2021b), which highlights findings of greatest relevance to decision makers. Specifically, the keywords "paleo" or "millennia"(l) were mentioned more frequently, both as a total number and relative to the number of pages in AR6-WGI-SPM than in those of AR5 (IPCC, 2013) and AR4 (IPCC, 2007) (Appendix A). The frequency of key findings based on paleoscience evidence were also greater in AR6-WGI-SPM, as is the number of words that comprise these findings. Finally, unlike its AR5 predecessor, AR6-WGI-SPM notably included a figure featuring paleoclimate data.

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Paleoscience has been a part of IPCC reports since the beginning, and the SPMs of all previous WGI reports contain findings that attest to increasingly unprecedented changes in the climate system over centuries and millennia. The latest AR6-WGI-SPM expands on these findings by describing evidence from additional indicators of the state of the climate system beyond atmospheric greenhouse gas concentrations and large-scale surface temperature. Paleoscience in the AR6-WGI-SPM looks further back in time to climate states with higher global warming levels than in previous ARs. It is mentioned along with other evidence that narrows the uncertainty range of climate sensitivity, and strengthens confidence on long-term sea-level responses to different levels of sustained warming. It is also used to evaluate low-likelihood events with high-impact outcomes, including large explosive volcanic eruptions and their known climate effects.

A similar expansion of paleoscience information is also seen in the Technical Summary (TS) of the AR6-WGI report (Arias et al., 2021) compared with the previous two reports (Stocker et al., 2013; Solomon et al., 2007). All three contain a section or box dedicated to paleoscience. Outside of these more specialized sections, the keywords “paleo” or “millennia”(l) are mentioned more frequently in AR6-WGI-TS than in AR4 and AR5 relative to their number of pages (Appendix A). Furthermore, AR6-WGI-TS includes seven figures that feature paleoclimate information compared with five in AR4 and three in AR5. Among these figures is a direct comparison of atmospheric carbon dioxide levels back through the Cenozoic and forward through alternative projections to 2300, including both timeseries and maps of global temperature. This is the first time a figure with these global-scale climate indicators has appeared in an IPCC report; it is indicative of the integrative approach in AR6, with attention to placing current and projected changes into a long-term context. Finally, to reach a broader audience, paleoscience information is included in more Frequently Asked Questions of AR6 than in previous reports, and paleoclimate simulations of reference periods are incorporated into the Interactive Atlas alongside historical runs and climate projections from the same models.

Challenges of the distributed approach

While we view the integration of paleoscience topics throughout the IPCC report as an inevitable and healthy progression for an increasingly expansive and relevant subject, we are fully aware of its challenges. Its success depends on engagement and substantial input from paleoscientists during the scoping phase of the report so the full breadth of relevant paleoscience topics is explicitly identified and effectively parsed among chapters, and key expertise is ensured within the selection

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of author teams. When writing the reports, paleoscience authors need to coordinate closely to avoid redundancies, ensure important topics don't fall into cracks between chapters, and prepare dedicated cross-chapter boxes as entry points for paleoscience topics. For example, a cross-chapter box in AR6-WGI-Chapter 2 (Changing State of the Climate System; Gulev et al., 2021) describes multiple "paleoclimate reference periods," periods that have been extensively studied based on both empirical evidence and climate modeling as examples of distinct climate states, and it points to the sections across the report where further information about each period is discussed.

Like other IPCC authors, paleoscience authors primarily work within their chapter teams where space constraints challenge in-depth assessments of paleoscience methods and information. Novel and relevant paleoscience findings need to be promoted to the Executive Summary of chapters because these underpin the summary documents (TS and SPM) that are most widely read. The author team for these summary documents needs to include paleoscientists who can draw together key findings disseminated across chapters and reports and make it easier for readers specifically interested in paleoscience to find relevant information. For example, AR6-WGI-TS (Arias et al., 2021) includes a synthesis of the assessed values for global mean temperature, atmospheric carbon dioxide, and global mean sea level for multiple paleoclimate reference periods, and directly compares global mean temperatures derived from observations with those from climate models for these reference periods, with all of the data accessible and traceable.

Despite their increasing length, space available for any climate change subject is exceedingly limited in IPCC reports. There is generally no scope nor purpose for extensive analyses of datasets, textbook-style reviews of methods or lengthy discussions of knowledge gaps aimed at experts. Instead, IPCC reports rely heavily on evidence from timely published literature, including community-based assessments of relevant topics that distill policy-relevant information so that it is accessible to non-specialists.

Opportunities

Paleoscience, like all climate science communities competing for coverage in this high-level product, can work proactively and in concert with the current IPCC assessment cycle to generate or update systematic reviews of key policy-relevant topics. Now is the time to identify what appraisals of major research advances are missing from the literature and to initiate coordinated efforts to fill these gaps in support of AR7. We see potential for stronger inclusion of information

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regarding topics such as climate extremes of the past, implications of different durations of different sustained levels of warming, past abrupt events, and insights related to the vulnerability of ecosystems and biodiversity. Major efforts are needed to evaluate the state of understanding of past climate variability at global to regional levels and to distill paleoscience information regionally. Syntheses based on transparent approaches and supported by well-curated and readily traceable data are especially useful. These advances will require substantial support for community efforts. Considering the major expansion of paleoscience knowledge since AR6, such products are beyond what can be produced by a small group of IPCC authors regardless of whether those authors work within a single chapter or are distributed across reports.

Competing interests

The contact author has declared that none of the authors has any competing interests.

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Appendix A. Comparison of quantity of paleoscience information in the Working Group I contributions to last three IPCC climate assessment reports.

Working Group I	**AR4**	**AR5**	**AR6**
Publication year	2007	2014	2021
Paleoclimate chapter in report	Yes	Yes	No
FAQs with paleo content	2	2	4
Summary for Policy Makers			
Total pages of content	17	26	28
“Paleo” or “millennia” mentions*	6	8	15
Average mentions per page	0.35	0.31	0.54
Major sections with paleo content	3	2	3
Bullets/subsections with paleo content	4	6	8
Approx. words containing paleo content	390	360	460
Figures with paleo content	1	0	1
Technical Summary			
Total pages of content	71	82	107
“Paleo” or “millennia” mentions**	19	38	56
Average mentions per page	0.27	0.46	0.52
Figures with paleo content	5	3	7

* Includes “palaeo” and “millennial”

** Not counting the paleo box or paleo perspective or text within figures and their captions