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EDITED AND REVIEWED BY
Hayley Jane Fowler,
Newcastle University, United Kingdom

*CORRESPONDENCE
Patrick C. Taylor,
patrick.c.taylor@nasa.gov

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Editorial: Arctic amplification: Feedback process interactions and contributions

Patrick C. Taylor[1]*, Peter L. Langen[2] and Ivy Tan[3]

[1]NASA Langley Research Center, National Aeronautics and Space Administration, Hampton, VA, United States, [2]Department of Environmental Science, IClimate, Aarhus University, Roskilde, Denmark, [3]Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, QC, Canada

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Editorial on the Research Topic
Arctic amplification: Feedback process interactions and contributions

The Arctic is a system in transition. In recent decades, we have witnessed rapid and unprecedented changes within the Arctic that represent an early warning sign of global climate change. Observed rapid Arctic climate change is considered indicative of a broader phenomenon called Arctic Amplification. Arctic Amplification is most clearly described as greater surface warming in the Arctic relative to the rest of the globe (roughly 2–4 times faster) in response to increased CO_2 and is accompanied by other changes to the Arctic system, most visibly reductions in the snow and ice cover. Despite the early awareness of this fundamental feature of the Arctic for more than 100 years (e.g., Arrhenius 1896), projections of the Arctic climate system response to increased CO_2 are more uncertain than in any other region.

The evolution of the Arctic climate, and hence the uncertainty in its projected change, is of great societal relevance. The Arctic system affects the global climate through its influences on sea level, atmosphere and ocean circulation patterns, carbon storage and release, and extreme events. The societal relevance of the uncertainty in the Arctic warming rate is exemplified by considering the 2°C Paris Climate Agreement warming target. A 2°C global warming, considering present uncertainty levels, results in an Arctic warming range from + 3.5 to + 7.5°C. Substantially different degrees of land ice melt and permafrost thaw are expected for a +3.5 vs. a +7.5°C warming. Key to reducing this uncertainty in Arctic Amplification is improving our understanding of the processes driving Arctic Amplification.

The aim of this Research Topic is to focus research efforts on how local and remote atmosphere, land, ocean, sea ice, and coupled physical processes drive Arctic Amplification. By bringing together current understanding from multiple perspectives in a manner that elucidates the influence of coupled processes, this Research Topic aims to accelerate advances in our understanding of Arctic Amplification and make progress towards reducing uncertainty in climate projections. This Research Topic contains original research and review articles that expand our knowledge of Arctic Amplification.

Radiative climate feedback analysis is a key area discussed within this Research Topic as it is a critical tool for understanding Arctic Amplification. Sledd and L'Ecuyer present original research describing the interplay between the sea ice and clouds as it pertains to the ice-albedo feedback. Their findings indicate that not only do clouds influence the magnitude of the ice-albedo feedback, but they also change the ability to detect the emergence of the feedback above natural variability. Hahn et al. apply radiative feedback kernels to investigate the hemispheric asymmetry in observed and projected polar amplification in contemporary climate models. This original research reveals differences between the importance of poleward heat transport contribution to Arctic and Antarctic Amplification.

Contributions from Huang et al. and Sejas et al. discuss the shortcomings associated with current methods in quantifying radiative feedbacks. Huang et al. investigate the fidelity of linear radiative feedback methods for quantifying high-latitude feedbacks and demonstrate the need to apply non-linear methods when quantifying Arctic feedbacks. Sejas et al. tackle the inherent differences between the top-of-atmosphere and surface perspectives for quantifying climate feedbacks. This article demonstrates that the discrepancies between these perspectives are linked to the definition of the top-of-atmosphere lapse rate feedback.

Another major theme of this Research Topic is the importance of remote processes and local feedback interactions. Contributions from Finocchio and Doyle and Hendersen et al. provide perspectives on the connections between the global atmospheric circulation and high-latitude climate. Finocchio and Doyle shed light on the seasonal variations of the impacts of cyclones on sea ice loss. Their results indicate that early melt season cyclones tend to reduce sea ice melt whereas late melt season cyclones tend to enhance sea ice loss. This difference is tied to seasonal variations in cyclone properties and to differences in the surface properties. Hendersen et al. review the local and remote drivers of Arctic Amplification focusing on the role of high-latitude atmospheric blocking, poleward moisture transport, and tropical-high latitude sub-seasonal teleconnections. This review stresses the importance of capturing tropical-to-Arctic teleconnections to understanding Arctic Amplification.

Many papers within the Research Topic highlight the importance of Arctic surface characteristics to the future evolution of the Arctic. Holland and Landrum do this by analyzing the emergence of forced climate change in Arctic sea ice across seven coupled climate model large ensembles. Boisvert et al. demonstrate the importance of surface properties through their investigation of the surface turbulent fluxes across contemporary climate models finding some promising observational constraints on Arctic climate change and key biases.

Lastly, Taylor et al. contribute a comprehensive review of the processes that have been studied as contributing factors to Arctic Amplification. The review provides two key outcomes. First, Taylor et al. construct a conceptual model of Arctic Amplification containing five fundamental processes. Second, the review closes with a set of recommendations for actions needed to reduce uncertainty in future Arctic Amplification. Clear from this review is the need to account for local feedback and remote process interactions within the context of the annual cycle to constrain projected Arctic Amplification.

In the decade or so since the emergence of Arctic Amplification in observations, our understanding of Arctic Amplification has evolved considerably. Our scientific perspectives have changed from considering Arctic Amplification as the consequence of primarily a single feedback process, namely, the surface albedo feedback, to acknowledging it as the result of an interplay between the atmosphere, ocean, and sea ice at high and low latitudes. The articles within this Research Topic further demonstrate Arctic Amplification as a coupled atmosphere-ocean-sea ice process. While this Research Topic actually raises more questions than it solves, it advances our understanding of Arctic Amplification by crystalizing the notion that focusing scientific attention on measuring, modeling, and understanding cross-scale energy exchanges between the atmosphere, ocean, and sea ice is fundamental to reducing uncertainty in projections of Arctic climate change.

Author contributions

PT, PL, and IT contributed to the draft and editing of this work.

Conflict of interest

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

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Reference

Arrhenius, S. (1896). Xxxi. On the influence of carbonic acid in the air upon the temperature of the ground. *Lond. Edinb.* 41, 237–276. doi:10.1080/14786449608620846