Accelerating Antarctic research amid rapid changes

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Standfirst

We must prioritize diversity, scientific communication and team-based science to keep up with rapid Antarctic ice and climate change.

What got me interested in sea ice, during university about ten years ago, was the Antarctic sea ice paradox. When the world was warming, why was Antarctic sea ice expanding? This question has motivated most Antarctic sea ice research for decades. And yet, within only a few years, the trend has reversed. Antarctic sea ice area reached a satellite era record low in 2016, followed by a new record low in 2022, and then another record low in 2023. The pace of change has been dramatic, even during my short research career thus far.

Sea ice plays a crucial role in the global water cycle, acting as a reservoir for relatively fresh water. In the Southern Ocean, the amplitude of the seasonal cycle of sea ice is enormous, expanding sixfold each year, and helping transport freshwater from higher to lower latitudes. Sea ice affects the exposure of Antarctic ice shelves to ocean warming and storms, influencing mass loss from Antarctic's grounded ice, which is one of the most uncertain factors in future sea level rise and paramount for adaptation. Sea ice is essential in climate feedbacks and ecological systems in the Southern Ocean. Given its global importance, that the processes driving Antarctic sea ice expansion are not yet fully-understood, that the record-breaking sea ice lows were not anticipated, and that their drivers remain unclear, one might ask why there hasn't been more research progress.

Several connected factors complicate our understanding of Antarctic sea ice. Antarctic observations are very limited. The Southern Ocean experiences polar night, and visible satellite observations are limited to months with good light, visibility and cloud-free conditions. Being extremely cold, stormy and remote, Antarctica is a challenging destination for field campaigns. Thick sea ice in winter hinders ships and powerful storms hamper crossings. Although coverage is slowly increasing, we have very limited observations of sea ice thickness and of subsurface ocean water properties in the Southern Ocean, more so than any other ocean on Earth. State-of-the-art climate models still struggle with accurate simulation of the Southern Ocean and its sea ice. Biases in this region lead to low confidence in future projections of Antarctic sea ice. Moreover, the processes at play are complicated, and impacted by interactions between the ocean, atmosphere and cryosphere.

Naturally, we have minimal control over inherent climatic and technological limitations. And, of course, increased research funding is sorely needed (for example, glaciology research funding in the US is minuscule compared to the projected costs of sea level rise mitigation[1]). But we can determine how our polar research community conducts research. From my early-career perspective, here are three key areas where we must improve to rapidly advance understanding in polar science.

First, it is imperative that we make our scientific community more inclusive to all people, and especially newcomers. Ample evidence shows that diverse teams have better performance outcomes. The geosciences remains one of the least diverse scientific fields, with many experiencing hostile behavior[2]. In particular, harassment during remote Antarctic fieldwork is a serious and distressing issue[3]. Preventing misconduct, harassment, and discrimination is the right thing to do by any moral standard and also crucial for improving retention. We all have a duty to uphold standards of conduct every day within our research community and consider how we can make our communities more inclusive. This includes thinking about academic hierarchies and power structures. In communities that are strongly hierarchical and where publication metrics are valued above all else, it's easier for harassers to get away with bad behavior. Less reliance on reference letters and on single academic advisors would help to redistribute power in academic relationships. Besides, we must address aspects that are often exclusionary: the need to move long distances for temporary postdoc positions, the physical qualification process for Antarctic fieldwork, and overloaded work schedules that challenge work-life balance and mental wellbeing.

Second, we must improve our scientific communication across sub-discipline boundaries. I think most agree that we need to see more connections made across hydrologic, oceanic, atmosphere and cryospheric science[4], not to mention inter- and transdisciplinary connections with social sciences for adaptation and mitigation to climate change and sea level rise. There are moves towards this, evident in the new Climate Schools that are emerging in the US. However, particularly when considering sea ice—which sits at the interface of the ocean and atmosphere, and, in some locations, ice shelves—as well as the complex, coupled Antarctic ice and climate system, it is clear these connections need to be developed more quickly. How can we meet the challenge of rapidly broadening our understanding of Antarctic system components, while not sacrificing depth of knowledge in individual physical processes? To encourage more activity across disciplinary boundaries, we must develop capability to distill complex, technical concepts for a more general (but still scientific) audience through practice and education. Participating in polar fieldwork was an eye-opening experience for me, showing how scientists studying the very same phenomena could approach it from different directions and with different languages. Summer schools and other initiatives that bring together modelers and observationalists, or other groups, help researchers to speak the language of both approaches[5].

Third, as our science expands and the real-world implications of our work become ever more urgent, we must question whether our current academic system is prioritizing the most critical issues and in the most effective way. As our datasets get larger and our Earth system models more complex but our academic system continues to prioritize first-author papers, it is a struggle for early-career researchers[6] and peer reviewers to keep up. It also encourages researchers to break up large projects into small ‘publishable units and incentivizes researchers to ‘stay in their lane.’ From experience foraying from sea ice into climate and ice sheets, it’s certainly easier to keep publishing in your original field of expertise than moving to different Earth system components. Community members have suggested alternative ways to recognize scientific contributions (e.g. Github activity[7]), but this has not been widely adopted. Can we learn from fields like particle physics, where papers are written by very large teams, and how do we make sure contributions are recognized equitably?

As warming increases and sea level rises, we need to rapidly accelerate research progress in Antarctic sea ice, grounded ice and the broader Earth system. As scientists, we are privileged to enjoy a large amount of freedom and flexibility in our work. Let’s use it to build inclusive, welcoming communities that empower people to cross disciplinary boundaries and make new advances.

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Competing interests

The author declares no competing interests.