POLAR AMPLIFICATION DISCUSSION SESSION

The problem

Some areas of the Polar regions have warmed two or three times faster than the global average since the late 20th century, a phenomenon termed as Polar amplification (PA). Interestingly while Polar amplification has been observed in the Arctic, the Antarctic region has not experienced such phenomena. Understanding Polar amplification further is important to understand the future of the Arctic and Antarctic regions, but is also vital to predict the impacts on global climate.

Session objectives

- Synthesise the current state of scientific research around Polar amplification
- Provide a summary to assist decision-making on for Polar observations in this area.

Main messages from session speakers

Amplification in the Arctic

Polar observations were historically very sparse (e.g. Nansen expedition), and with sparse observations it is difficult to get an accurate picture of the whole environment or to reconstruct the climate. The satellite era has enabled year-round monitoring and we can now track changes in sea ice extent with high accuracy, so seasonal variability is much better understood.

Local impacts of amplification in the Arctic are also very apparent. Shrinking snow cover, reduced sea ice thickness and cover, glacier mass loss, permafrost thaw, and sea level rise have all been observed in the region. However, local changes are hard to predict or model. For example, permafrost conditions are very heterogeneous, and warming/thawing factors are very small-scale and localised.

We are recently beginning to also understand global factors and impacts. Arctic warming is connected to remote changes such as in mid-latitude weather, but our mechanistic understanding of these linkages is still under development. For example, observational studies support that Arctic amplification is contributing to winter cooling at lower latitudes but most models do not currently show this connection, leading to a divergence between model and observational studies.

Arctic amplification also adds complexity and uncertainty to predictions, but our predictions have improved greatly, thanks to observations. Even the earliest climate models predicted that there would be enhanced warming in the Arctic due to global warming. Thanks to developments in observations, by validating against the improved observations of sea ice extent and temperature, the models have been slowly improved with better physics and better observational constraints on the physics.

Amplification in the Antarctic

There is a strong warming in the Arctic, but in Antarctic warming is slow or even shows a slight cooling. Even in the RCP8.5 scenario, by the end of the century, the Arctic is still warming strongly, but in Antarctic we observe similar warming to global mean. So what is happening??

Current work is focused on understanding the many processes that can delay Polar amplification. A major reason is the role of the ocean. Heat absorbed at the Southern Ocean is transported by circulation and reaches the surface further north, thus having limited warming effect on the climate in the Antarctic region. There is also a strong uptake of heat in North Atlantic, but ocean circulation takes this heat to the Arctic, so this heat transport contributes to the warming Arctic.

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A second reason for delayed Antarctic warming is Polar lapse rate feedback, a climate feedback in which more warming occurs near the surface than at higher altitudes in the atmosphere. Antarctic elevation therefore drives hemispheric asymmetry in warming, through a stronger lapse rate feedback stronger in the Arctic than in the Antarctic. A modelled flat Antarctica (uniform elevation of 0 m) shows warming more comparable to the Arctic.

In addition, the ocean and cryosphere are strongly coupled, but the coupling is not sufficiently understood. Research is needed to better understand different processes and their interconnections. Overall, Antarctic amplification is an emergent pattern of a warming climate- it may not be observed yet, but this is likely to change and we need to understand when this might occur.

State of the art- PAMIP

Coordinated sets of experiments are being conducted to address our understanding of polar amplifications, such as PAMIP. The Polar Amplification Model Intercomparison Project (PAMIP) seeks to improve our understanding of this phenomenon through a coordinated set of numerical model experiments. For example, models investigating NAO show weaker response than observations, even when constrained, suggesting there other factors driving observed signals. These experiments are vital in improving our understanding Polar amplification, but further work is needed.

Recommendations

Polar amplification is an issue of high relevance to policy-makers:

- In understanding the global climate system, and how the global system will respond to warming over the coming decades (e.g. Antarctic warming)
- In understanding what is likely to happen to regional climate: for example a warming Arctic may lead to colder winters in Europe and North America.
- In understanding how changes in the Arctic can be used as a window into other areas that may be warming more in future.

The challenge for the future is to improve our understanding of the processes influencing Polar amplification, and the subsequent impact on global climate.

To do this, we can make better use of observations-

- To use an observations-as-reference evaluation cycle to help drive model improvement
- To correct model bias, the largest issue for improving projections / predictions
- Through data assimilation, with supermodels assimilating observations to remove bias
- To speed up model development, such as semi-automatic model tuning

Provision of observations is therefore a strong limitation. The recommendations for observational priorities for improving understanding of polar amplification moving forward are:

- Generally more polar observations – across disciplines, polar observations are sparse compared to other regions.
- Improved observations of sea ice thickness
- Improved in situ polar oceanographic observations, especially at ice-ocean interface
- Improved observations of ocean surface salinity
- Improved observa tions of ice shelf forcings of ocean
- Improved temperature inversion observations
- Mesoscale observations to better understand local/regional/rapid changes – ice, ocean, atmosphere
- Better atmospheric observations, including observations of eddies.

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