Polar change and implications for mid-latitude weather – science and policy for society in Europe

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The European Polar Board (EPB) convened a townhall session at the European Geosciences General Assembly 2017 in Vienna, titled "Polar change and implications for mid-latitude weather – science and policy for society in Europe". The session featured a range of experts who each presented on the different elements of the topic before an interactive discussion.

The panel, Chaired by meteorologist and broadcaster Peter Gibbs, consisted of Julienne Stroeve (University College London), Len Shaffrey (University of Reading/National Centre for Atmospheric Research), Hilppa Gregow (Finnish Meteorological Institute) and Tina Swierczynski (European Climate Research Alliance (ECRA)). This paper summarises the key points made by the panellists and recommendations that emerged from discussions.

Rapid transformation of the Polar regions

Perhaps the most commonly publicised and discussed physical change in the polar regions is the loss of Arctic sea ice. The loss of sea ice, particularly in summer, causes a dramatic reduction in the surface albedo of the Arctic region as well as enabling greater energy exchange between the atmosphere and ocean. September Arctic sea ice extent has declined at a rate of -87,000 km^2/year, or -13.8%/decade (1979-2016) (National Snow and Ice Data Center (NSIDC), 2017). It is important to note regionally uneven change in extent of sea ice throughout the Arctic – most of decline in sea ice has been in the Beaufort and Chukchi Seas, and the Siberian sector of the Arctic Ocean, with ice remaining largely extensive in the central Arctic Ocean, around the Canadian Archipelago and north of Greenland. Decreases to winter sea ice extent in the Arctic are smaller than summer, but also significant. Observations show Arctic sea ice has declined at a rate of -43,000 km^2/year or -2.8%/decade (1979-2017) (NSIDC, 2017). The lowest winter maximum Arctic sea ice extent on record has observed in 2017, with previous record lows in 2015 and 2016. To accurately understand how changes to Arctic sea ice impact climate and weather in the Arctic regions and elsewhere, it is essential to understand the spatial and temporal characteristics of changes.

While the observed decline in Arctic sea ice is well reported, other major changes in the polar regions cannot be ignored. Of particular note is the observed decreased in Arctic snow cover, which has declined at a rate of -13.69%/decade (1967-2016) (NSIDC, 2017b). Other significant changes include the freshening of the Arctic Ocean as river discharges increase, and greening and browning of the Arctic in response to ecological change.

Changes to the Arctic result in positive feedbacks which in turn accelerate initial change, causing an Arctic amplification of warming relative to the global average. Particularly significant positive feedbacks result from surface albedo changes resulting from sea ice and snow cover reductions, and vegetation change. With accelerated warming in the Arctic due to Arctic amplification, coupled with warm air advection into the Arctic from lower latitudes, observations suggest that the 2016-2017 winter may have been the warmest on record in the Arctic.

Polar amplification means the observed changes and rates of change in the Arctic will likely continue to increase, with growing implications for the global climate system. Model intercomparisons predict a sea ice free Arctic in summer by 2040 is likely (Stroeve & Barrett, 2015). Keeping global average temperature rise to below 1.5 °C is seen as the only way to potentially avoid more drastic change in the polar regions in the future, and potentially severe associated impacts for mid-latitudes.

Polar-mid-latitude links – a modelling perspective

In order to understand polar change and implications for mid-latitude weather, it is essential to use models. Observations are important, but alone are insufficient to for understanding changing environments and climates, and how they interact. This is particularly true for future predictions of how weather and climate will change in Europe in response to the rapid transformation of the polar regions described above.

Disagreements remain as to the linkages between polar change and mid-latitude weather, largely due to the lack of a clear signal in model outputs. This is not resolved by the observation record which, being relatively short, does not allow clear trends to be established. Trends and relationships between Arctic change and European weather are particularly difficult to identify due to the highly noisy signals, with many active weather systems and ongoing changes in the northern hemisphere mid-latitudes. Particularly noteworthy is the relationship between Arctic sea ice loss and the atmosphere – the atmospheric response to sea ice decline is highly complex and non-linear, further complicated by the spatial and temporal heterogeneity of the decline discussed above. Despite the described difficulties and complexities, there is growing confidence that the observed and ongoing changes in the Arctic are responsible for an increase in the storminess of weather in Europe. With modelling, there is the ability to more clearly identify trends and connections between polar change and mid-latitude weather.

Currently there are disparities in the outputs of different models attempting to understand the linkages between changes in the Arctic environment and mid-latitude weather in the northern hemisphere. It is suggested that a model intercomparison project or initiative, specific to the polar regions and their influence on mid-latitude weather, is needed to help resolve some of the uncertainty in model outputs.

There are several international projects and initiatives currently working to improve understanding of polar change, particularly in the Arctic, and how it may influence mid-latitude weather in the future. These include Horizon2020 projects APPLICATE, Blue-Action and INTAROS. It is hoped that the contributions of these projects, and others, will establish the strength and nature of any connections between polar change and mid-latitude weather, particularly in Europe.

Understanding climate and weather risk associated with polar change

Polar amplification means the impacts of climate change are felt most quickly in high-latitude regions (Overland *et al.*, 2015). The potential connections between the Arctic and Europe mean that implications of direct impacts may be felt beyond the polar regions. Changes to European weather, particularly in the form of extreme events, become more likely in response to ongoing changes in the Arctic (Vihma *et al.*, 2016).

Concurrent with the suggested links between Arctic change and storminess in Europe, the reanalysis data records indicate an increase in storminess in the North-Atlantic storm track region (Donat *et al.*, 2011). In the most recent research, also the nature-based observations suggest the intensity of catastrophic storms in Europe has increased. The historical records of windstorm induced tree damages indicate that intensity of catastrophic storms in Europe has increased by a factor of 3.5 since 1951. An accelerated increase in storm intensities is visible since 1990 (Gregow *et al.*, 2017). Research also indicates that the North Atlantic Oscillation (NAO) is not the driver of this increased storm intensity - Arctic amplification is a possible driver.

While Arctic change is thought to be at least partly responsible for the increased storminess in northern Europe, Arctic sea ice decline has thought to be responsible for increasing the likelihood of extreme heat and drought in southern Europe. This is due to induced changes in the positioning of atmospheric blocking zones (Coumou *et al.*, 2015; Vihma *et al.*, 2016; Screen, 2017).

It is important to note that changes in the polar regions may not only increase the likelihood of extreme weather events in Europe, but also worsen the impacts of extreme weather events. Rising sea levels, particularly resulting from ice melt in Antarctic (DeConto and Pollard, 2016), increase the risks and hazards associated with storms in coastal areas.

The state-of-the-art research thus suggests that polar change not only increases the probability and frequency of extreme weather occurrences, particularly along storm tracks and atmospheric blocking zones, but also increases risk and hazard associated with such events.

Implications for operational meteorology and public communication

Operational weather forecasters are often uncomfortable predicting extreme events, particularly those without precedent, as dramatic predictions that do not materialise reduce public confidence in weather forecasting and forecasters more broadly, regardless of how well uncertainty is communicated. Furthermore, when the whole climatic system is changing so rapidly, operational meteorologists increasingly question the how much they are able to trust the numerical weather models upon which they rely – this is particularly true of changes in the Arctic, where polar amplification means climate and environmental change is drastic.

Seasonal weather predictions are becoming increasingly important in forecasting, as they allow for effective contingency planning in both public and private sectors. Such predictions are particularly difficult in the highly variable weather regimes of the European mid-latitudes. Reduced temperature gradients as the Arctic warms leads to a weakened polar Jetstream and increased frequency of static weather patterns. These blocking events are difficult to predict, yet have major impacts on mid-latitude weather, threatening to undermine recent advances in seasonal weather prediction.

It is important to communicate the science behind weather forecasts to the public. Public communicators have a responsibility to explain the why certain weather events occur and why there is uncertainty. This is particularly true for the linkages between polar change and mid-latitude weather – the public should understand that changes in seemingly remote and distance regions have real and tangible impacts in the regions where they live.

Noting the uncertainty that remains as to the extent and nature of polar-mid-latitude weather connections, scientists are often hesitant to make predictions or definitive statements, particularly when communicating with policymakers or the public. It is suggested that the scientific community should place emphasis what is known about polar-mid-latitude weather linkages, and the global impacts of changes in the Arctic and Antarctic more generally, so to control public discourse around the issue.

Strengthening European climate research and informing policy

Scientific understanding of polar change and mid-latitude linkages must be compiled and incorporated into European policy frameworks to maximise the useful impact of knowledge. With initiatives such as ECRA and the EPB, the European climate and polar research communities can clearly and authoritatively communicate the understanding of polar changes, how they are affecting mid-latitude weather, and the associated risks for society to policymakers. To be most effective, initiatives must incorporate researchers across the physical, life and social sciences with bottom up approaches that engage stakeholders throughout.

To optimise understanding and successfully improve policymaking, science must be open and transparent, with open sharing of data and information across the research community. This is especially important in the polar regions, where the scarcity, cost and difficulty of observations means all data are highly valuable. Currently, the availability of data and information is often largely dependent on the willingness of individual researchers. It is important that the open sharing of data and information becomes standard practice.

Scientific understanding of polar-mid-latitude linkages must be more clearly, accurately and efficiently communicated to policymakers, the public and other stakeholders, as well as between scientists themselves. This will require the embrace of a variety of new methods of communication, such as social media, alongside more traditional methods such as publications, workshops and briefings.

It is important to retain accuracy in when communicating complex scientific information to different audiences. The science-policy interface organisations, such as ECRA and the EPB, thus play a useful role. Using close understanding of both the research and policymaking communities, such organisations are able to condense scientific knowledge and communicate key messages to relevant stakeholders in a clear, accurate and timely manner. Where communication is directly between researchers and non-experts, the gap in mutual understanding is often too great, information over-simplified, and accuracy lost.

A process that is focused specifically on the global implications of Arctic and Antarctic change is suggested as an ideal approach to identify trends in scientific understanding of polar-mid-latitude linkages. Such an initiative, similar to more existing processes with broader foci, would enable scientific consensuses to be formally identified and clearly communicated to policymakers.

Summary

Summarising the session, panellists identified several key gaps that need to be filled to progress understanding of polar-mid-latitude weather linkages, and effective use of knowledge to benefit European society:

- A fully coordinated effort from the entire research community, including all disciplines, and in particular integrating social sciences into research projects to formulate societal needs, is required to fully understand how changes in the polar regions influence mid-latitude weather, and the risks of associated impacts for Europe.
- A climate model intercomparison project or initiative, specific to the polar regions and linkages to mid-latitudes is necessary to help address the disparity in outputs currently produced by different models.
- A process which regularly synthesises the current state of knowledge and understanding of Arctic and Antarctic change and its global implications is needed. This will facilitate clear and authoritative communication of the state of understanding to policymakers and the public.
- Sustained observations and monitoring of changes to climate, environments and ecosystems in both polar regions is needed to better understand the physical changes ongoing in high-latitudes. Community-based monitoring and citizen science will be an important component of these efforts.
- Improved impact and risk assessments are needed to establish how changes to mid-latitude weather associated polar change will impact societies. Local communities and other stakeholders must be fully engaged throughout this process.
- Open source data and information approaches should be adopted as standard practice in all areas of research to maximise the ability of the entire scientific research community to advance understanding of polar change and implications for mid-latitude weather, and to promote a further effective uptake of knowledge in other fields (e.g. policy making, climate services).

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