CLIMATE SCIENCE

Far-flung effects of Arctic warming

Arctic warming affects weather and climate thousands of miles to the south. Scientists are split on how large this effect is.

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The Arctic has changed profoundly in a short period of time. During September, when the sea ice reaches its annual minimum, ice extent has declined by 50% and ice thickness by 85% since the late 1970s. The Arctic is warming rapidly, at a pace two to three times the planet's average — a phenomenon referred to as Arctic amplification. These changes at the pole do not occur in isolation from the rest of the globe. Scientists are grappling to understand the implications of Arctic warming for places thousands of miles further south[1,2]. A three-day workshop (http://go.nature.com/2mB6w3t) in February 2017 titled 'Arctic Change and its Influence on Mid-latitude Climate and Weather' emphasized that the connection is not one-way from the Arctic to the mid-latitudes but also works in reverse, and that observations and climate models give differing estimates of the extent to which mid-latitude climate is influenced by Arctic warming.

The climate system can be split into three broad latitudinal domains: the tropics, the mid-latitudes and the polar regions. Each has its own unique characteristics and responses to climate change. However, each domain is highly interconnected to the others. If Arctic warming causes changes in weather patterns in mid-latitudes, where a vast number of people live, it would be important to know about it. However, separating out one domain's influence on another is not an easy task.

At the February workshop, it became clear that the causes of amplified warming in the Arctic are not fully understood. At present, we have a poor grasp of how much of the Arctic amplification is caused by warm and moist air transport from the mid-latitudes to the Arctic (Sukyoung Lee, Pennsylvania State Univ., USA). This knowledge gap complicates the interpretation of any subsequent connections in the other direction, from the Arctic to the mid-latitudes. Essentially, changes we are seeing now in mid-latitude weather and climate could be both a cause and an effect of Arctic change. With this in mind, it seems prudent to pursue research that investigates connections between the Arctic and mid-latitudes in both directions, rather than singling out only the Arctic-to-mid-latitude component.

A second theme at the workshop came from the contrasting conclusions drawn from observational studies compared to climate modelling studies. Observational studies tend to be more supportive of robust Arctic-to-mid-latitude connections. In contrast, analyses based climate model simulations generally suggest only weak effects of Arctic change on the mid-latitudes. A good example of this discrepancy is the so-called 'warm Arctic–cold Eurasia' trend pattern[3,4]. Since the late 1980s, average wintertime temperatures have been in decline over Eurasia (Fig. 1), a sustained cooling that bucks the global warming trend. It is statistically unlikely — though not impossible — that this counter-intuitive temperature trend has occurred by chance.

A mounting body of observational evidence has led to the suggestion that Arctic warming is a cause of Eurasian cooling: by enhancing the intensity of the Siberian high-pressure system, a specific weather pattern that brings cold air to

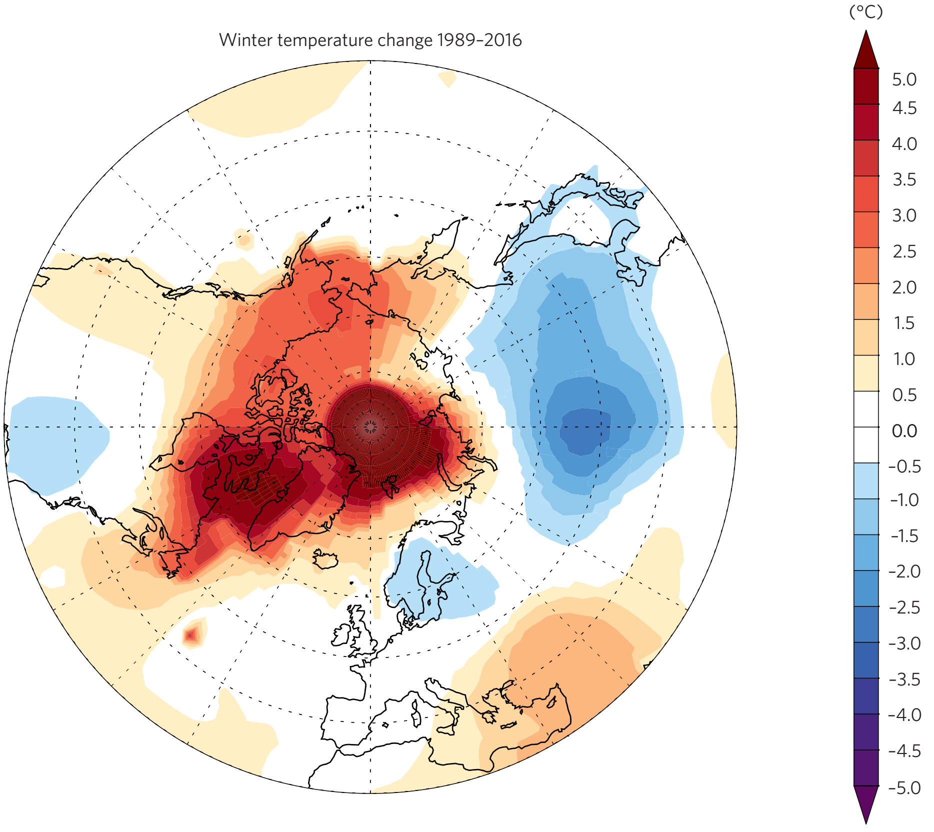

Figure 1 | Warm Arctic–cold Eurasia. Between 1989 and 2016, Arctic winter temperatures have risen substantially faster than the global mean (red shading), whereas Eurasian winters have become colder (blue shading). The global mean winter temperature rise over the same period was 0.5 °C. A workshop in February examined possible links between these contrasting trends and revealed differences between observational analyses and model studies, as well as among different climate models. Data from NASA GISTEMP (https://data.giss.nasa.gov/gistemp/).

central Eurasia (J. Cohen, Atmospheric & Environmental Research, USA). Climate modellers are more cautious, however. According to one modelling study[5], Eurasian cooling is a manifestation of unusually strong natural climate variability and is unlikely to be caused by Arctic sea-ice loss (J. Fyfe, Canadian Centre for Climate Modelling & Analysis, Canada). Other modelling groups also report a failure to find a clear connection between Arctic sea-ice decline and Eurasian cooling (F. Ogawa, Univ. Bergen, Norway; H.-J. Kim, Seoul National Univ., S. Korea).

The third emergent theme of the workshop was the wide range in modelling results more generally. The mid-latitude effects of Arctic change seem to be highly sensitive to the climate model used and to the geographic pattern of sea-ice loss (J. Screen, Univ. Exeter, UK). Understanding Arctic-to-mid-latitude linkages is additionally hampered by a low signal-to-noise ratio in models: identifying an Arctic influence on the highly variable mid-latitude weather patterns is the scientific equivalent of searching for a needle in a haystack. The Arctic influence on mid-latitudes may simply be small. However, emerging evidence that climate models may not be adequately capturing the full amplitude of this influence points the other way (D. Smith, Met Office, UK). Climate modellers first need to understand if and why their simulations underestimate this connection; then, perhaps, results from observational and modelling studies may start to converge.

So far, modelling investigations of Arctic-to-mid-latitude linkages have been conducted in a fairly ad-hoc manner by an array of different modelling groups from around the world, utilizing different models and varying experimental designs. There was a clear sense at the workshop that a coordinated model intercomparison project will be necessary to accelerate scientific progress. A subgroup of participants drew up an initial protocol for such a project. This modelling subgroup noted that differences between model predictions can be advantageous, rather than a hindrance, if this divergence can be traced to a specific parameter that varies between models. For example, the mid-latitude effects of sea-ice loss may depend on the average latitude of the polar jetstream (D. Smith, Met Office, UK). An observational estimate of that critical parameter (in the example given, the latitude of the jetstream) can inform which models best estimate the real world effects of sea-ice loss.

The diversity of perspectives that were aired at the workshop on linkages between Arctic amplification and mid-latitude weather certainly confirmed recent portrayals of this area of science as highly contested[6–8]. In a ballot of workshop attendees (D. Whittleston, Massachusetts Institute of Technology, USA), respondents were fairly equally divided on the question of whether Arctic warming has already had a noticeable effect on mid-latitude weather and climate. Intriguingly though, there was a high level of consensus that Arctic warming will significantly affect mid-latitude weather and climate in the future. So, although there is still much to be learned about how Arctic change affects the rest of our planet and how large this effect is, there does seem to be agreement amongst the experts that continued Arctic warming will have far-flung consequences. ❒

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