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The Arctic matters: extreme weather responds to diminished Arctic Sea ice

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Abstract

Screen *et al* (2015 *Environ. Res. Lett.* **10** 084006) find that model simulations forced by past and future Arctic sea-ice conditions provide robust evidence that a variety of extreme weather events both within and beyond the Arctic will be affected by changing sea-ice conditions.

As we witness the disappearance of multi-year Arctic sea ice within the span of a human lifetime, some have hypothesized that such a profound change in a key component of the climate system will affect large-scale atmospheric patterns within and well beyond the Arctic. Screen *et al* (2015) shed new light on this highly relevant and controversial topic, and in particular, whether extreme weather events will occur more frequently in response to sea-ice loss. The short answer, they find, is yes … and no.

The recent era of rapid Arctic warming is short (since the mid-1990s), thus previous observation-based studies have struggled to identify robust signals amid the substantial noise of natural atmospheric variability. To circumvent this obstacle, Screen *et al* force two state-of-the-art atmospheric global climate models with sea-ice and ocean-temperature conditions representative of the late 20th century as well as with projections for the end of the 21st century, when sea ice will be nearly gone in summer. By comparing the atmospheric response to these contrasting conditions, they assess changes in the occurrences of a variety of standard extreme weather metrics related to temperature and precipitation. Simulations are performed for 260 years with each model and in each set of conditions, allowing the authors to detect robust signals of change in extreme events owing to Arctic sea ice loss alone. A response was considered robust only if confidence in the difference exceeded 95% and both models were in agreement.

Not surprising, the regions nearest to the Arctic exhibit the largest response to ice loss (figure 1 presents a summary of the study's results). The signs of these high-latitude changes make sense in a world with much less sea ice: reduced extreme cold as extra solar energy is gained in newly ice-free areas, increased extreme heat events as the ice-free season lengthens, and more abundant precipitation as evaporation increases.

More surprising are the robust responses detected in mid-latitudes, some of which support results from previous studies while others appear to be contradictory. For many years, climate models have projected a warmer North America, and these results support that expectation in eastern regions, along with fewer dry spells. The only robust temperature extreme in all of mid-latitude Eurasia, however, is an increase in winter cold spells in central Asia. A flurry of recent studies came to this same conclusion (e.g., Nakamura *et al* 2015, Overland *et al* 2015 and references therein), pointing to sea-ice loss in the Barents/Kara seas as a key driver. Screen *et al* also find a robust decrease in dry spells over most of Eurasia, with the notable exception of the Mediterranean, which runs counter to projections by full climate models (IPCC 2013). Severe wet extremes are projected to increase in central Asia and the Mediterranean. It should be noted, however, that the models disagreed about the signs of precipitation changes in many of the regions, highlighting the shortcomings still in modeling precipitation.

In addition to the frequency of extreme events, Screen *et al* also analyze the duration of events. They find that the length of cold spells is projected to decline in high latitudes and east of the Rockies in N. America, which contradicts a recent hypothesis and supporting analysis that weather conditions should become more persistent in response to Arctic amplification (Francis and Vavrus 2012, 2015). A nuance to this conclusion

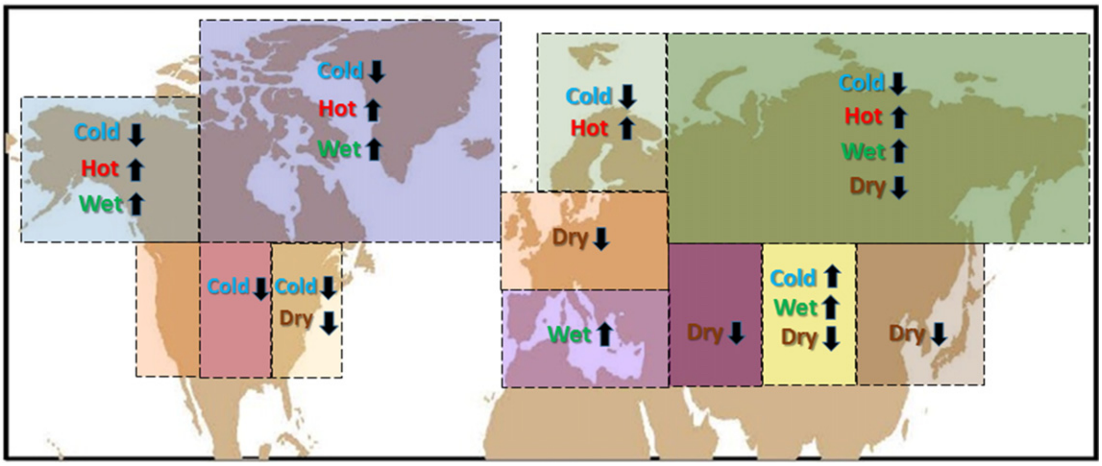

Figure 1. Summary of robust changes in simulated extreme metrics from late 20th century to the late 21st century assuming future conditions according to the RCP 8.5 scenario, as reported in Screen *et al* (2015).

involves the definition of a cold spell: at least 6 consecutive days with the minimum daily temperature below the 10th percentile of 20th century daily temperatures. As minimum daily temperatures generally rise in the future, however, people will likely become accustomed to the warmer climate, and the discomfort of a cold spell may be perceived relative to the new temperature range. This may argue for using a threshold based on the 10th percentile of the shifted range, which would likely result in longer-duration cold spells in the future than those reported here.

Another of the study's conclusions that may warrant further examination is the projected reduction in daily temperature variance in most regions. The authors interpret this decline in variance as a symptom of the weaker poleward temperature gradient and reduced temperature contrast in airmasses. This decline in variance could also be an indication of more persistent weather patterns, in which atmospheric conditions are more apt to linger. This interpretation is supported by the general increase in longest wet spells. The decline in longest dry spells may seem to contradict this response, but the overall increase in atmospheric water vapor likely favors persistent wet patterns over dry ones in high- and mid-latitudes.

While this study makes important progress toward understanding the impacts of Arctic sea-ice loss on extreme weather events, there is still much to unravel. Year-to-year variations in the location of ice loss and autumn regrowth will evoke different atmospheric responses. Combinations of ice-loss conditions with varying phases of natural teleconnection patterns will also influence extreme events differently. As the authors emphasize, they studied the atmospheric response to only sea-ice loss; recent work by Deser *et al* (2015) shows that a coupled ocean greatly amplifies the effects of ice loss. Finally, many studies have shown that sea ice is only one (albeit an important one) player in the full spectrum of Arctic amplification. Understanding the impacts of a rapidly warming Arctic—not only sea-ice loss—in different seasons and regions is still a very active research topic.

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