A warming Arctic produces weather extremes in our latitudes

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Atmospheric researchers at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) have developed a climate model that can accurately depict the frequently observed winding course of the jet stream, a major air current over the Northern Hemisphere. The breakthrough came when the scientists combined their global climate model with a new machine learning algorithm on ozone chemistry. Using the combined model, they demonstrate that the jet stream's wavelike course in winter and subsequent extreme weather conditions like cold air outbreaks in Central Europe and North America are the direct result of climate change. Their findings were published in *Scientific Reports* on 28 May 2019.

For years, climate researchers around the globe have been investigating the question as to whether the jet stream's winding course over the Northern Hemisphere—observed with increasing frequency in recent years—is a product of climate change, or a random phenomenon that can be traced back to natural variations in the climate system. The term "jet stream" refers to a powerful band of westerly winds over the middle latitudes, which push major weather systems from west to east. These winds whip around the planet at an altitude of roughly 10 kilometers, are driven by temperature differences between the tropics and the Arctic, and in the past, often reached top speeds of up to 500 kilometers per hour.

But these days, as observations confirm, the winds are increasingly faltering. They blow less often along a straight course parallel to the Equator; instead, they sweep across the Northern Hemisphere in massive waves. In turn, during the winter, these waves produce unusual intrusions of cold air from the Arctic into the middle latitudes—like the extreme cold that struck the Midwest of the U.S. in late January 2019. In the summer, a weakened jet stream leads to prolonged heat waves and dry conditions, like those experienced in Europe in e.g. 2003, 2006, 2015 and 2018.

Machine learning allows climate model to grasp the role of ozone

These fundamental connections have been known for some time. Nevertheless, researchers hadn't succeeded in realistically portraying the jet stream's wavering course in climate models or demonstrating a connection between the faltering winds and global climate change. Atmospheric researchers at the AWI in Potsdam have now passed that hurdle by supplementing their global climate model with an innovative component for ozone chemistry. "We've developed a machine learning algorithm that allows us to represent the ozone layer as an interactive element in the model, and in so doing, to reflect the interactions from the stratosphere and ozone layer," says first author and AWI atmospheric researcher Erik Romanowsky. "With the new model system we can now realistically reproduce the observed changes in the jet stream."

According to the team's findings, sea-ice retreat and the accompanying increased activity of atmospheric waves are creating a significant, ozone-amplified warming of the polar stratosphere. Since the low polar temperatures form the jet stream's motor, the rising temperatures in the stratosphere are causing it to falter. In turn, this weakening of the jet stream is now spreading downward from the stratosphere, producing weather extremes.

The weakened jet stream is due to climate change

In addition, with the new model the researchers can also more closely analyze the causes of the meandering jet stream. "Our study shows that the changes in the jet stream are at least partly due to the loss of Arctic sea ice. If the ice cover continues to dwindle, we believe that both the frequency and intensity of the extreme weather events previously observed in the middle latitudes will increase," says Prof Markus Rex, Head of Atmospheric Research at the AWI. "In addition, our findings confirm that the more frequently occurring cold phases in winter in the U.S., Europe and Asia are by no means a contradiction to global warming; rather, they are a part of anthropogenic climate change."

The team's efforts also represent a significant technological advance: "After the successful use of machine learning in this study, we are now for the first time employing artificial intelligence in climate modeling, helping us arrive at more realistic climate model systems. This holds tremendous potential for future climate models, which we believe will deliver more reliable climate projections and therefore a more robust basis for political decision-making," says Markus Rex.

During the Arctic expedition MOSAiC, which will begin in September and during which the German research icebreaker Polarstern will drift through the Central Arctic along with the sea ice for an entire year, the researchers plan to gather the latest ice and atmospheric data. This will help them apply the new climate model to the future, so as to simulate the future development of the Arctic climate and sea ice. As Markus Rex explains, "Our goal is to understand in detail how the Arctic sea-ice retreat will progress—because only then will we be able to gauge how and on what scale the changes in the Arctic will lead to weather extremes in the middle latitudes."

More information: Erik Romanowsky et al, The role of stratospheric ozone for Arctic-midlatitude linkages, *Scientific Reports* (2019). DOI: 10.1038/s41598-019-43823-1

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