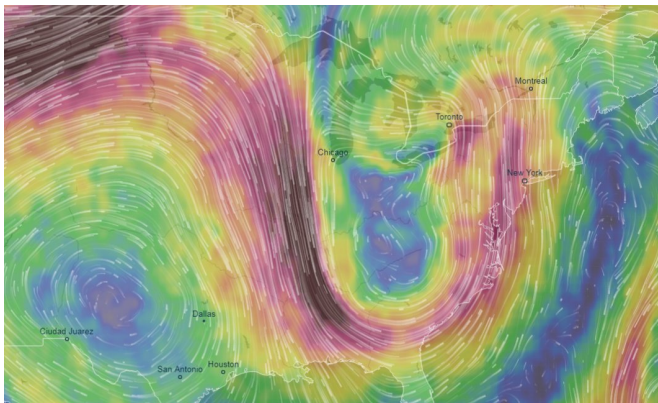


Controlling future summer weather extremes still within our grasp

31 October 2018



Jet stream on July 12, 2018, showing large undulations. Credit: Ventusky.com

Continued burning of fossil fuels is likely to fuel even more extreme summers than that of 2018 because of its impact on the jet stream. The rapid disappearance of aerosols produced by pollution may, however, mitigate the impact until mid-century if countries like China phase out these fuels, according to an international team of climate scientists using climate models to predict changes in the occurrence of so-called Quasi-Resonant Amplification (QRA) events associated with persistent weather extremes.

These extreme paths for the jet stream bring about flooding, drought and wildfires. In 2018, summer weather included flooding in Japan, record heat waves in North America, Europe and Asia, wildfires in Greece and even parts of the Arctic. Heat and drought in California led to the worst wildfire season ever recorded.

The jet stream and extreme weather events

QRA events produce extreme summer weather when the jet stream exhibits broad north-south meanders and becomes stationary with the peaks

and troughs locked in place.

"Most stationary jet stream disturbances will dissipate over time," said Michael Mann, distinguished professor of atmospheric science and director, Earth System Science Center. "However, under certain circumstances the wave disturbance is effectively constrained by an atmospheric wave guide, something similar to the way a coaxial cable guides a television signal. Disturbances then cannot easily dissipate and very large amplitude swings in the jet stream north and south can remain in place as it rounds the globe."

"If the same weather persists for weeks on end in one region, then sunny days can turn into a serious heat wave and drought, and lasting rains can lead to flooding," said Stefan Rahmstorf, Potsdam Institute for Climate Impact Research (PIK), Germany.

In summer 2018, [climate change](#) impacts on [extreme weather](#) were no longer subtle, according to Mann.

"It played out in real time on our television screens and newspaper headlines in the form of an unprecedented hemisphere-wide pattern of extreme floods, droughts, heat waves and wildfires," Mann added.

Quasi-Resonant Amplification's role

Mann notes that the phenomenon of QRA played an important role in producing that hemispheric array of unprecedented weather events.

Previous work by Mann and colleagues showed a connection between [extreme climate events](#) and climate-induced changes in the jet stream. While researchers cannot accurately identify QRA events in [climate models](#), one thing the climate models capture very well is temperature change.

"QRA events have been shown to have a well-defined signature in terms of the latitudinal variation in temperature in the lower atmosphere," explained Mann. "The change in temperature with latitude and how it responds to increasing greenhouse gas concentrations depends on physics that are well understood and well represented by the climate models."

The researchers found that the pattern of amplified Arctic warming—Arctic Amplification—that slows down the jet stream also increases the frequency of QRA episodes.

Study co-author Dim Coumou, who is both at PIK and VU Amsterdam said we do not trust climate models enough yet to predict these types of extreme weather episodes because the models are too coarse.

"However, the models do faithfully produce large scale patterns of temperature change," added co-author Kai Kornhuber of PIK.

The researchers report today (Oct. 31.) in *Science Advances* that the amplified Arctic warming, called Arctic Amplification, associated with human-caused climate change both slows down the jet stream and increases the frequency of QRA episodes.

They found that climate models, when used to project future changes in extreme weather behavior—because they are unable to capture the phenomenon of QRA—are likely underestimating how [future climate change](#) could lead to more persistent summer [weather extremes](#) like those during summer 2018. If carbon dioxide continues to be added to the atmosphere, the incidence of QRA and associated [extreme weather events](#) would continue to increase at the same rate they have over the past decades.

Aerosol's effect on regulating temperatures

However, greenhouse gases are not the only consideration when looking at the future of the Earth's climate. Although the U.S. and Europe have switched to "cleaner" coal-burning methods, which remove aerosol-generating pollutants from emissions, many other areas of the world have not.

Aerosols are particles suspended in the air.

If these countries, through midcentury, switch to cleaner coal-burning technology, then the mid-latitude areas of the world will warm and Arctic Amplification will diminish. This will occur because aerosols, especially in the mid-latitudes where there is abundant sun, cool the Earth by reflecting heat away from the planet. Without those aerosols, that area of the Earth will warm, mitigating any further increase in QRAs as the difference in warming between the Arctic and mid latitudes diminishes.

However, by mid-century, once the aerosols are no longer produced, greenhouse warming once more dominates [climate](#). Curtailing the burning of fossil fuels can prevent an increase in persistent summer weather extremes, though the current rate of occurrence of summers like 2018 will likely persist. "The future is still very much in our hands when it comes to dangerous and damaging summer [weather](#) extremes." Said Mann. "It's simply a matter of our willpower to transition quickly from [fossil fuels](#) to renewable energy."

More information: M.E. Mann et al., "Projected changes in persistent extreme summer weather events: The role of quasi-resonant amplification," *Science Advances* (2018). advances.sciencemag.org/content/4/10/eaat3272

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