idw - Informationsdienst Wissenschaft
Nachrichten, Termine, Experten

Press release

Max-Planck-Institut für Meteorologie
Dr. Denise Müller-Dum

06/20/2025
http://idw-online.de/en/news854115

Research results, Scientific Publications
Oceanology / climate, Physics / astronomy
transregional, national

More weather extremes in Europe during the summer under climate change

Due to global warming, the North Atlantic Oscillation, an atmospheric circulation pattern that strongly influences European weather, is becoming more extreme in the summer, according to a new study. The researchers found evidence of increasing variability in both model simulations as well as historical data, and warned of more frequent and intense weather extremes in Europe.

In recent decades, extreme events such as heatwaves and droughts have become more frequent in Europe. But sometimes a striking division within the continent occurs, as was seen in the summer of 2023: While it was quite rainy in Germany and northwestern Europe, devastating forest fires blazed in southern Europe amid exceptionally high temperatures. Such contrasting weather patterns in Europe are caused by a phenomenon known as the North Atlantic Oscillation (NAO). The NAO is characterized by fluctuations in the air pressure difference between the Azores and Iceland over the North Atlantic. These fluctuations strongly influence the weather in Europe, leading to contrasting weather conditions in different regions. In the summer of 2023, the NAO was in a strong negative phase, which is associated with a weak atmospheric pressure difference in the North Atlantic. This brought cool, moist air to northwestern Europe and warm air to the Mediterranean. During a positive phase of the summertime NAO, the opposite occurs, with heat in northwestern Europe and lower temperatures in southern Europe.

In a new study, researchers from the Max Planck Institute for Meteorology (MPI-M) and the University of Hamburg have shown that such summertime NAO extremes, and thus extreme weather conditions in Europe, are becoming more likely as a result of global warming. Previous studies had primarily examined the wintertime NAO because the fluctuations are more pronounced in winter and thus gain more attention. Meanwhile, summer NAO fluctuations directly influence agriculture and human well-being.

Amplified variability, amplified temperatures

The new study led by MPI-M scientist Quan Liu was dedicated to the changes in the occurrence of these strong positive and negative phases of the summer NAO and the associated effects on European weather extremes in the course of global warming. Since extremes occur very rarely by definition, a sufficiently large database is required to reliably determine their changes. Using several climate models and ensembles of up to one hundred simulations of the climate from 1850 to 2100, the scientists investigated NAO trends and changes in its variability in an up to four-degree warmer world.

The results were robust: They revealed a positive trend in the mean of the summertime NAO, that is, a trend towards a stronger pressure difference between the Azores and Iceland. “But what’s even more interesting is that the variability is increasing. That means that there will be more and stronger extremes of the summertime NAO – both positive and negative phases," explains Liu. The associated heatwaves would be further amplified by a stronger link between extreme states of atmospheric circulation associated with the NAO and temperatures under climate change conditions. "Increase in summertime NAO extremes can have devastating effects on the European economy and people's health," says co-author Daniela Matei.

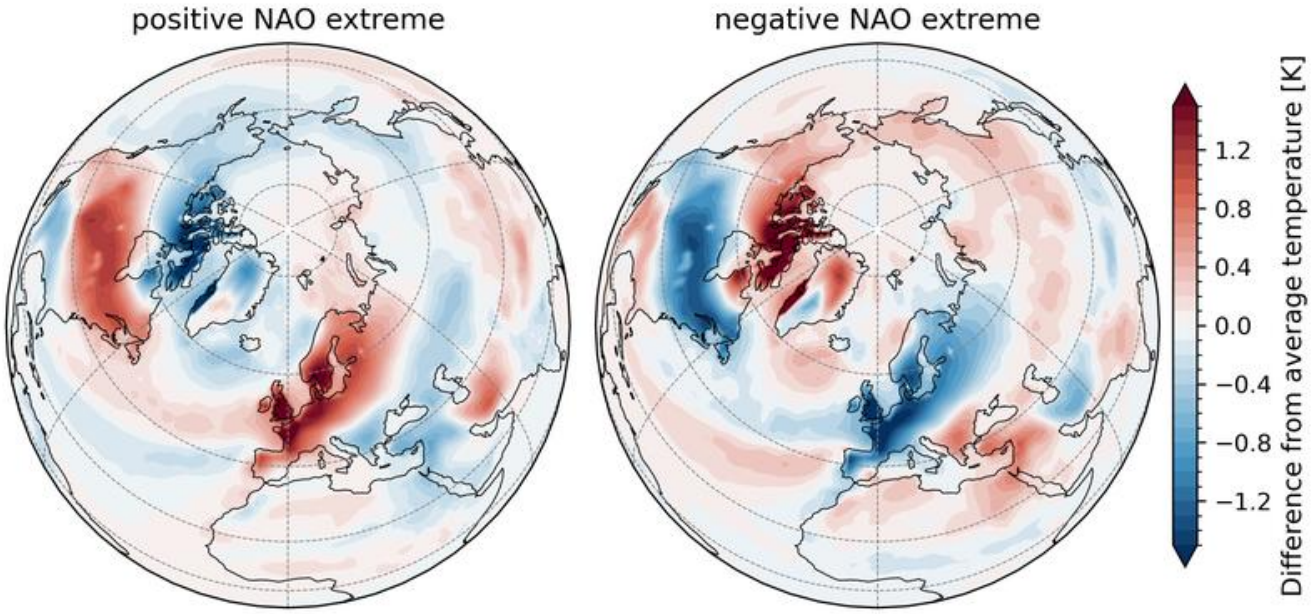
The team also looked into the past: Using observation-based so-called reanalysis data, they investigated whether extreme NAO conditions have already become more frequent since the beginning of the observational record. And indeed, there have been more NAO extremes in the most recent 40 years compared to the time period of 1850–1889. Next the researchers plan to investigate the physical mechanisms behind the increasing variability of the NAO, as well as the role of another atmospheric phenomenon—the East Atlantic Pattern—in weather extremes in Europe.

contact for scientific information:

Quan Liu, Max Planck Institute for Meteorology: quan.liu@mpimet.mpg.de
Dr. Jürgen Bader, University of Hamburg: juergen.bader@uni-hamburg.de
Dr. Johann Jungclaus, Max Planck Institute for Meteorology: johann.jungclaus@mpimet.mpg.de
Dr. Daniela Matei, Max Planck Institute for Meteorology: daniela.matei@mpimet.mpg.de

Original publication:

Liu, Q., Bader, J., Jungclaus, J., & Matei, D. More extreme summertime North Atlantic Oscillation under climate change. Communications Earth & Environment 6, 474 (2025). https://doi.org/10.1038/s43247-025-02422-x



Difference between the average temperature of summertime NAO extremes and the average summer temperature of the whole decade (2090-2099) in the climate simulation MPI-GE RCP8.5.
Quan Liu
Quan Liu, MPI-M