EGU24-12098, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-12098
EGU General Assembly 2024

The role of atmospheric circulation in extreme cold weather events over the Northern Hemisphere

Morteza Babaei[1], Rune Grand Graversen[1,2], and Johannes Patrick Stoll[1,2]
[1]UiT The Arctic University of Norway, Complex Systems Modelling, Department of Physics and Technology, Norway (morteza.babaei@uit.no)
[2]Norwegian Meteorological Institute, Norway

One significant and dangerous consequence of climate change is the growth in both the intensity and frequency of extreme weather events. The objective of this study is to examine the prevalent hypothesis that links Arctic amplification (AA) to the occurrence of cold weather extremes over the Northern Hemisphere (NH) in December–January–February (DJF). According to this hypothesis, AA alters the mid-latitude circulation, causing Rossby waves to become slower and wavier. More slow or wavy Rossby waves result in more persistent weather patterns in the mid-latitudes, potentially increasing the frequency and severity of extreme weather events.

We examine the link between AA and cold spells in the Northern Hemisphere by using idealized simulations with the Community Earth System Model (CESM) and the fifth-generation ECMWF reanalysis data (ERA5). We mimicked AA by adding a constant amount of downwelling longwave radiation (DLR) over the Arctic in the CESM slab-ocean model. Furthermore, we categorized ERA5 data into two separate periods: pre-Arctic amplification (1979–1999, Pre-AA) and post-Arctic amplification (2002–2022, Post-AA).

We computed the speed of planetary waves based on geopotential height using two different methodologies. In the first method, the speed of planetary wave zonal propagation was estimated through the utilization of a top-ridge and bottom-trough tracking algorithm. In the second method, we calculated the zonal propagation speed of planetary waves at each grid point following Takaya and Nakamura (2001). Both methods, although being fundamentally different, showed a significant reduction in DJF average zonal planetary wave speed over Northen-midlatitude during AA in both reanalysis data and idealized simulations.

The midlatitude extreme index (MEX) is used to identify cold weather extremes. On average, MEX showed a higher value for Pre-AA than Post-AA, consistent with a warmer climate in post-AA. However, the average wave speed during cold extremes is lower in Post-AA than Pre-AA.

As regard wave amplitude, based on the difference between the maximum peak and the minimum bottom of the waves in both the ERA5 data and the idealized simulations, we cannot confirm a change in the amplitude of planetary waves due to AA.

To summarize, Arctic amplification leads to a decrease in the speed of Rossby waves but little or no change in their amplitude. In addition, cold extremes are influenced by the deceleration of Rossby waves in response to warming conditions in the Arctic.