EGU24-18308, updated on 19 Jan 2025
https://doi.org/10.5194/egusphere-egu24-18308
EGU General Assembly 2024

Dynamics of pan-Atlantic winter compound extremes in ERA5 and CMIP6 models

Richard Leeding[1], Iana Strigunova[1], and Gabriele Messori[1,2,3]
[1]Uppsala University, Department of Earth Sciences, Uppsala, Sweden (richard.leeding@geo.uu.se)
[2]Swedish Centre for Impacts of Climate Extremes (CLIMES), Uppsala University, Uppsala, Sweden
[3]Department of Meteorology, Stockholm University, Stockholm, Sweden

Recent work has provided robust evidence for the systematic co-occurrence of wintertime cold spells in North America and wet and windy extremes in Europe, which we term compound pan-Atlantic extremes. Both cold spells and wet and windy extremes are individually highly impactful, and their concurrence further amplifies their effects for actors with international exposure who are vulnerable to correlated losses. This study aims to investigate further the atmospheric processes associated with compound pan-Atlantic cold, wet and windy extremes and how these processes are represented in CMIP6 models.

On aggregate, cold spells in different parts of North America statistically co-occur with wind and precipitation extremes in specific European regions. However, North American cold spells can arise from multiple dynamical pathways, altering the location and timing of the associated European extremes for individual cold spells. Here, we use ERA5 reanalysis data (1940-2014) to identify North American wintertime cold spells in three different regions and relate the occurrence of European extremes to Pacific and Atlantic weather regimes. We further analyze the various pathways of North American cold spells by evaluating the relative contribution of planetary (k=1-3) and synoptic (k=4-8) Rossby waves to the resultant weather regimes. The evaluation is performed by partitioning the Rossby wave circulation into different zonal wavenumber ranges using the MODES software, based on the normal-mode function decomposition. This methodology has previously been employed to identify changes in the midlatitude circulation at multiple scales during Eurasian heatwaves, though it is novel in its application to cold spells. Here, we discuss how the wavenumber ranges differ across cold spells and from the climatological state before and during the cold spells. We next compare the CMIP6 historical simulation model data (1940-2014) with the ERA5 results. First, we review the ability of the models to replicate the spatial and temporal pattern of pan-Atlantic extremes for the three cold spell regions. Second, we discuss the performance of the models in capturing the weather regime frequencies and the planetary and synoptic Rossby wave contributions to the North American cold spell pathways.
The results of this study contribute to the evaluation of the model fidelity in reproducing pan-Atlantic compound extremes and the associated circulation, with direct implications for the assessment of climate projections.