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Pathways leading to cold climate extremes over Eurasia in the MPI-M Grand Ensemble Simulations

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In recent decades, the Arctic region warmed at a rate that is approximately twice as large as the Northern Hemisphere average. Arctic warming manifests itself in the form of rapidly melting sea ice and plays an important role in the climate system with far-reaching impacts. The possible connection between the recent changes in the arctic cryosphere and climate extremes over the Northern Hemisphere mid-latitudes has become a topic of heated debate. Previous numerical studies have investigated the impacts of Arctic sea ice depletion on the Northern Hemispheric climate and extreme weather events, such as cold weather spells associated with record snowfalls that frequently invaded North America, Europe, and East Asia in recent winters. However, the evidence that supports such a link known as the "Warm Arctic – Cold Continents" has been disputed by other studies that did not report significant linkages.

Motivated by this controversy, we focus on the investigation of the dynamical processes that could drive climate extremes specifically over central Eurasia. The reported recent increasing trends of cold extremes in central Eurasia has been linked to the strong warming trends and sea ice depletion over the Barents-Kara regions that presents a maximum in the spatial and temporal distribution of warming across the Arctic region. To investigate this inter-linkage, we use both ERA-Interim reanalysis data and output from the Historical Grand Ensemble simulations that are available at the Max Planck Institute for Meteorology. This is a 100-member ensemble of historical simulation from 1850 to 2005 of the MPI-ESM-LR. A second 68-member ensemble is available in which the CO_2 concentration is enhanced by 1% each year. These two unique ensembles allow us to obtain rigorous and statistically robust evaluation of the linkages. We identify episodes of cold weather over central Eurasia and we investigate their dynamical precursors. Ural blocking is found to be a key dynamical harbinger leading to cold surges over central Eurasia. We present results concerning the dynamical processes that trigger the Ural blocking and cold surges by investigating both the state of the stratospheric vortex and the role of the sea ice depletion hotspots over the Barents-Kara regions through the tropospheric pathway. This study is a part of the JPI Climate project InterDec whose overarching objective is to improve the understanding of the inter-linkages among sub-seasonal to decadal climate variability in the Arctic, Mid-latitudes and Tropics, their mechanisms and potential for predictions.