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Impact of Barents Sea Ice Cover on Eurasian Winter Circulation in a Regional Climate Model

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Several studies in recent years have investigated how the recent Arctic sea ice decline can impact winter atmospheric circulation regimes in the northern mid and high latitudes. It has been suggested that decreased sea ice cover in the Arctic has the potential to alter the circulation over Eurasia, resulting in average cooling over the continent and increased probability of anomalously cold winters. The mechanism of the response is currently under debate. Of further interest is the question of whether such anomalous circulation regimes are primarily driven by regional scale interactions (local response), or whether shifts in hemispheric scale circulation patterns (large-scale response) are dominant. If the latter is the case, then what role do local feedback processes play in either amplifying or mitigating such anomalous circulation regimes?

To address these questions, the Weather Research and Forecasting (WRF) regional model provides a suitable platform. The model domain used in this study covers the major part of Northern Eurasia and the eastern Arctic Ocean, areas almost fully covered by sea ice in winter, except for the Barents Sea where the strongest interannual to decadal variations of sea ice cover occur. We take the anomalously cold winter of 2005/06, in which a persistent blocking pattern was present over western Russia and a strong negative sea ice cover anomaly was observed in the Barents Sea, for a case study and force the WRF model with lateral boundary conditions from that period over an ensemble of simulations. Further ensembles use the same lateral boundary forcing but are forced by enhanced sea ice cover from the winters of 1968/69 and 1990/91. Each ensemble consists of 20 members.

All ensembles on average exhibit very similar results, indicating that lateral conditions are important for forming the regional circulation pattern. However, there is a strong intra-ensemble variability in all ensembles. The circulation pattern preferentially deviates between anomalous cyclonic and anti-cyclonic regimes, with maximal anomalies centred south of the Barents Sea, suggesting the existence of a regional internal variability mode. This has knock-on effects on central and eastern European mean temperatures, with intra-ensemble differences of over 6K in places. Despite the same prescribed boundary forcing, different ensemble members result in different patterns of surface heating in the Barents Sea region, related to the anomalous cyclonic and anti-cyclonic responses. These differences are characterised in all ensembles by strong gradients in surface heat fluxes across the Barents Sea. Here, we elucidate further the modelled variability and present underlying mechanisms.