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Relating Regional Arctic Sea Ice and climate extremes over Europe

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The potential increase of temperature extremes under climate change is a major threat to society, as temperature extremes have a deep impact on environment, hydrology, agriculture, society and economy. Hence, the analysis of the mechanisms underlying their occurrence, including their relationships with the large-scale atmospheric circulation and sea ice concentration, is of major importance. At the same time, the decline in Arctic sea ice cover during the last 30 years has been widely documented and it is clear that this change is having profound impacts at regional as well as planetary scale. As such, this study aims to investigate the relation between the autumn regional sea ice concentration variability and cold winters in Europe, as identified by the numbers of cold nights (TN10p), cold days (TX10p), ice days (ID) and consecutive frost days (CFD). We analyze the relationship between Arctic sea ice variation in autumn (September-October-November) averaged over eight different Arctic regions (Barents/Kara Seas, Beaufort Sea, Chukchi/Bering Seas, Central Arctic, Greenland Sea, Labrador Sea/Baffin Bay, Laptev/East Siberian Seas and Northern Hemisphere) and variations in atmospheric circulation and climate extreme indices in the following winter season over Europe using composite map analysis.

Based on the composite map analysis it is shown that the response of the winter extreme temperatures over Europe is highly correlated/connected to changes in Arctic sea ice variability. However, this signal is not symmetrical for the case of high and low sea ice years. Moreover, the response of temperatures extreme over Europe to sea ice variability over the different Arctic regions differs substantially. The regions which have the strongest impact on the extreme winter temperature over Europe are: Barents/Kara Seas, Beaufort Sea, Central Arctic and the Northern Hemisphere. For the years of high sea ice concentration in the Barents/Kara Seas there is a reduction in the number of cold nights, cold days, ice days and consecutive frost days over the western part of Europe. In the opposite case of low sea ice concentration over the Barents/Kara Seas an increase of up to 8 days/winter of cold nights and days is observed over the whole Europe and an increase of up to 4 days/winter in the number of ID and CFD is observed over the same regions. The cold winters over Europe (low sea ice years) are associated with anomalous anticyclone and the downstream development of a mid-latitude trough, which in turn favours the advection of cold air from the north, providing favourable conditions for severe winters over Europe.

We suggest that these results can help to improve the seasonal predictions of winter extreme events over Europe. Due to the non-linear response to high vs. low sea ice years, the skill of the predictions might depend on the sign and amplitude of the anomalies.