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Influence of Arctic sea ice concentration on extreme Ural blocking predictability in subseasonal timescales

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Utilizing the Community Atmospheric Model version 4, the influence of Arctic sea ice concentration (SIC) on the predictability of the Ural Blocking (UB) in subseasonal timescale is investigated. Taking the zonal flows as the reference states, the optimal Arctic SIC perturbations that trigger zonal flows into UB events on subseasonal timescale are obtained with the conditional nonlinear optimal perturbation (CNOP) approach. The numerical results show that the Arctic SIC decline in the Greenland, Barents and Okhotsk Seas can trigger zonal flows into UB events on a timescale of four pentads (20 days). Further diagnosis shows that the SIC decline in these regions locally warms the low troposphere via diabatic processes in the first pentad. Then, dynamic processes, such as temperature advection, modulate the temperature in the middle troposphere and weaken the meridional temperature gradient between the Arctic and mid-latitudes upstream of the Ural sector. The weakened meridional temperature gradient further decelerates the background zonal flow near the Ural sector and triggers UB formation in four pentads. After that, the optimal Arctic SIC perturbations that have great influences on subseasonal UB predictions are also obtained with CNOP approach. It is found that SIC increase in the Greenland Sea, Barents Sea, and Okhotsk Sea would weaken the UB intensity while SIC decline in these regions would strengthen it. Further diagnoses show that the physical mechanisms are similar to those triggering UB formation. Moreover, utilizing the observing system simulation experiments, it is shown that targeted observations in the Barents Sea, Greenland Sea, and Okhotsk Sea can remarkably improve the prediction skills of UB in the fourth pentad. Numerical results show that targeted observations have a positive effect on 75% of 160 experiment members, reduce 35% forecast errors of the fourth pentad mean blocking index, and perform even better when the original forecast errors are greater. Further diagnosis shows that the improvement is related to the well-described westerly winds in the Ural region and its adjacent regions, corresponding to the more skillful predictions of blocking circulations. The above results supply a theoretical base for the design of Arctic SIC observations and more skillful subseasonal predictions for mid-latitude extreme weather.