

The linkage between winter atmospheric circulation modes of variability, the Northern Hemisphere storm tracks, and Arctic sea ice cover

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Summary

We investigated the linkage between the Northern Hemisphere extratropical storm tracks, interannual atmospheric circulation patterns, and sea ice cover in winter. We employed feature tracking on 850 hPa relative vorticity and positive meridional component of wind (V) from the ERA5 data to identify storm tracks and to analyze track density and mean intensity of storms. We examined the North Atlantic Oscillation (NAO), Blocking Oscillation (BO), and Atlantic Ridge (AR) in the North Atlantic and Eurasia. Positive NAO shifts the North Atlantic storm track poleward with decreased track density upstream of the Mediterranean Sea. Positive BO disrupts the zonal propagation of cyclones and enhances the intrusion of storms into the Arctic from the east of Greenland. The BO-related warm and moist air intrusion by cyclones into the Arctic significantly increases sea ice cover in the Norwegian and Barents Seas, suggesting that BO has the strongest impact on interannual sea ice variability in these regions. In the North Pacific and North America region, we examined the Pacific North American (PNA) and West Pacific (WP) patterns. The negative PNA pattern strengthens cyclonic circulation in the eastern North Pacific, weakens the zonal propagation of cyclones, and shifts the North Pacific storm track toward the pole. Despite increased storm-induced intrusion of warm and moist air into the Arctic during negative PNA, ice cover in the Bering Sea remains largely unchanged, suggesting the contribution of other processes. The positive WP phase is associated with reduced geopotential thickness over the Bering, Chukchi, and Okhotsk Seas, but increased sea ice is limited to the Okhotsk and western Bering Seas. This pattern of anomalies of sea ice cover aligns with the increase in the mean intensity of positive V850 in these regions.

We found a poleward shift upstream of the North Atlantic storm track, along with a decrease in the intrusion of storms into the Arctic east of Greenland in recent decades. The North Pacific storm track also has shifted poleward. These changes may be linked to a strengthened cyclonic circulation over the North and Norwegian Seas, hindering the intrusion of storms from the North Atlantic into the Arctic, and strengthening the eastern Pacific anticyclonic circulation that resembles the negative PNA pattern. The decrease in the North Atlantic storms that enter the Arctic suggests that changes in atmospheric circulation and storm tracks are not the drivers of the recent decline in the Barents-Kara sea ice. The absence of the poleward shift in the downstream of the North Atlantic storm track is due to rapid Arctic warming, which is favored for an equatorward shift of storm tracks. Our findings suggest that recent climate changes may favor strengthening a positive AR-like pattern and ice-induced Ural blocking, potentially linked to the Barents-Kara sea ice loss, as well as a negative PNA-like pattern in the North Pacific.

Keywords: Arctic sea ice, atmospheric circulation, North Atlantic Oscillation (NAO), feature tracking method, North Atlantic storm track, North Pacific storm track