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Atmospheric and oceanic drivers of regional Arctic winter sea-ice variability in present and future climates

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The recent retreat of Arctic sea ice area is overlaid by strong internal variability on all timescales. In winter, sea ice retreat and variability are currently dominated by the Barents Sea, primarily driven by variable ocean heat transport from the Atlantic. Climate models from the latest intercomparison project CMIP6 project that the future loss of winter Arctic sea ice spreads throughout the Arctic Ocean and, hence, that other regions of the Arctic Ocean will see increased sea-ice variability. It is, however, not known how the influence of ocean heat transport will change, and to what extent and in which regions other drivers, such as atmospheric circulation or river runoff into the Arctic Ocean, will become important. Using a combination of observations and simulations from the Community Earth System Model Large Ensemble (CESM-LE), we analyze and contrast the present and future regional drivers of the variability of the winter Arctic sea ice cover. We find that for the recent past, both observations and CESM-LE show that sea ice variability in the Atlantic and Pacific sector of the Arctic Ocean is influenced by ocean heat transport through the Barents Sea and Bering Strait, respectively. The two dominant modes of large-scale atmospheric variability – the Arctic Oscillation and the Pacific North American pattern – are only weakly related to recent regional sea ice variability. However, atmospheric circulation anomalies associated with regional sea ice variability show distinct patterns for the Atlantic and Pacific sectors consistent with heat and humidity transport from lower latitudes. In the future, under a high emission scenario, CESM-LE projects a gradual expansion of the footprint of the Pacific and Atlantic inflows, covering the whole Arctic Ocean by 2050-2079. This study highlights the combined importance of future Atlantification and Pacification of the Arctic Ocean and improves our understanding of internal climate variability which essential in order to predict future sea ice changes under anthropogenic warming.