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Optimal forcing perturbations for regional flow patterns conditioning polar low development

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olar lows are short lived maritime mesoscale cyclones that develop because of processes unique to the Polar Regions. In the ice-free Nordic and Barents Seas they are associated with violent weather during wintertime and form in cold air outbreaks underneath a cold through. The longer predictability of the large-scales may provide early warnings of the potential for polar lows. We investigate the rare events when the atmosphere is highly sensitive to small external forcings that excite changes in the variability of the North Atlantic Oscillation (NAO). Employing a numerical weather prediction model, the period 1957-2002 is sampled for 4-day optimal forcing sensitivity patterns (FSPs). The highly sensitive events are relatively well-defined. A flow pattern resembling the negative-phase NAO is identified as a potential precursor of the most unpredictable transitions in the NAO. The least sensitive events are dominated by a coinciding cyclonic circulation. In the former there is high polar low potential (40-45%) in the northern North Atlantic but it is low south of Iceland. The least sensitive events display high potential along the storm track reaching 80% south of Iceland.
The FSPs tend to either strengthen or hamper the transition toward the negative-phase NAO. The strengthened circulation makes the atmosphere favourable in 70% of the events for the formation of polar lows in the Nordic and Barents Seas with high potentials also in the North Sea. From the hampered transition we learn that in the Nordic Seas high- and low-pressure systems can produce similar levels of polar low potential. Temperature and momentum are equally important forcing variables and there are positive feedbacks between them. The forcing is dominantly in-situ and strongest in mid-troposphere. The variability is more localized and larger than the average. Close to the surface the FSPs appear influenced by the Norwegian current.