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Anomalous stratospheric flow as a precursor of cold air outbreaks

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Cold waves, or cold air outbreaks (CAOs) are an important phenomenon in both continental and marine regions. They are typically associated with strong southward advection of cold polar air masses. Over land, unusually low temperatures may lead to loss of life as well as damage to crops and infrastructure. Over ocean, CAOs are associated with severe weather such as polar lows, roll clouds, arctic fronts and rapid intensification of extra-tropical lows. The work presented here is a study of atmospheric precursors of CAOs over Scandinavia and the Nordic Seas. We show that the atmospheric conditions leading to CAOs may be divided into two groups. The conditions in the periods prior to CAOs in each group differ substantially. In one group, the CAOs are preceded by a low-level pressure pattern similar to the negative phase of the North Atlantic Oscillation (NAO) up to eight days before. The mid-stratospheric vortex is found to weaken around one month prior to the CAOs. This is consistent with the time-scale of downward propagating stratospheric circulation anomalies. In the other group, a tropospheric pattern similar to the positive phased NAO appears around eight days before the CAOs. The stratospheric circulation signal is characterized by a persistent negative, although weak, pressure anomaly over Northern Russia up to one month prior to the CAOs. In both groups, the synoptic conditions evolve from NAO-like signals into an east-west pressure dipole favorable for CAOs in a matter of a few days' time. Both groups show signs of wave-breaking and are distinguished by ridging over Iceland and Greenland. We conclude that both the tropospheric and stratospheric precursors are large enough to yield potential for forecasting of CAOs over Scandinavia and the Nordic Seas. Furthermore, this study shows that downward propagation of stratospheric anomalies may induce important transient regional temperature responses in addition to the canonical large-scale responses.