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Atmospheric transport of water to the European Arctic simulated with a mesoscale model with water vapour tracers: sources, structure, and energy considerations

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Coastal areas at the end of the storm track, such as the Norwegian west coast, are prone to heavy precipitation associated with moisture conveyor belts or atmospheric rivers. Previous studies have shown that both, remote and local moisture transport contribute to such heavy precipitation events. During winter 2006/2007, a series of mid-latitude cyclones brought above-average precipitation to southern Norway. We present an analysis of the transport processes for water vapour and latent heat from the evaporation sources in the North Atlantic for this period, using a mesoscale model with water vapour tracers. Water vapour tracers allow to tag water vapour by source region, and to follow its movement throughout the model's hydrological cycle, including parameterized diabatic processes. Several cases of cyclonic transport are analysed from a model simulation covering December 2006, using ECMWF's high-resolution operational data as initialisation and boundary conditions.

We use a new composite visualisation to reveal the horizontal and vertical structure of the moisture transport associated with several mid-latitude cyclones. Our results confirm that the tropospheric water transport is strongly inter-related with the upper-level circulation, in particular with respect to the formation of filaments of large values of vertically integrated water vapour. For the cases analysed here, it is shown that water vapour can be transported over longer distances within such filaments, and that different sources contribute to the total water vapour at different altitudes. It is shown that heavy precipitation events in southern Norway contain more moisture from long-range transport than average. In addition, we quantify the contribution of different areas of the North Atlantic to the meridional transport of water vapour and latent heat into the European Arctic, providing detailed insight into the mechanisms of moisture transport within and precipitation from mid-latitude cyclones. Water tracers in mesoscale model simulations offer new possibilities for the quantification of mass and energy transport, for understanding the processes leading to heavy precipitation events, and for the validation of a model's hydrological cycle with observations.