Quantifying the temporal variability of water vapor in Ny-Ålesund and its relation to weather systems

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The role of Water Vapor (WV) in Arctic amplification remains uncertain and is under investigation (Wendisch and coauthors, 2023). Understanding its role in the mechanisms driving Arctic amplification requires detailed information on its spatio-temporal variability. However, WV variability in the Arctic has rarely been examined. Temporally highly resolved integrated water vapor (IWV) data from ground-based MWR observations are ideally suited for the analysis of WV temporal variability. In this study, we make use of 13 years of measurements of the Humidity and Temperature PROfiler (HATPRO) at the AWIPEV atmospheric observatory (Ny-Ålesund, Svalbard). Extreme events of atmospheric moistening and drying are identified, characterized, and further related to the prevailing circulation weather systems. Since WV transport into the Arctic is episodic and primarily occurs through brief, intense events typically associated with cyclones (Henderson et al., 2021), it is essential to analyze these events in further detail. To analyze these events, we identify minima and maxima in the IWV time series. We define “extreme” using a threshold in IWV amplitudes within a respective time interval. An event can either consist of only one maximum (moistening) or minimum (drying) or of multiple maxima/minima.

When focusing on extreme atmospheric moistening and drying events, we find that absolute IWV amplitudes are highest in summer and lowest in winter. The events last between 2 and 142 hours. By contrast, winter shows a greater relative variability (with respect to the monthly mean) than summer, with IWV changes exceeding 250% within a few hours in some cases. Events with only one maximum (moistening) or one minimum (drying) are short-lived (75% last less than 24 hours), while those with multiple maxima/minima last longer, with a mean of 48 hours. We find that extreme atmospheric moistening and drying at Ny-Ålesund proceed differently: drying happens more rapidly but with smaller amplitudes than moistening. Also, the synoptic regimes favoring moistening and drying differ. For moistening the weather types AS, ASW, AS, and CSE account for half of the extreme moistening and drying events, with the anticyclonic types transporting moisture over the North Atlantic. In contrast, CSE is associated with moisture transport over Scandinavia and West Russia, spanning the Barents and Kara Seas. For drying, significantly different weather systems can be responsible. Other studies found a positive trend in cyclone activity over the Barents Sea (e.g., Wickström et al., 2019), which could favor greater moisture transport driven by CSE.

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References

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