Long-term observations of water vapor, clouds and precipitation in the Arctic: trends and process studies at the research station AWIPEV, Ny-Ålesund (Svalbard)

Kerstin Ebell, Christian Buhren, Sandro Dahlke, Marion Maturilli, Christoph Ritter, Melanie Lauer

Climate change is strongly pronounced in the Arctic. In particular, Arctic warming within the time period 1979 to 2001 is found to be nearly four times higher than the mean global warming (Rantanen et al., 2022). However, this temperature increase is not uniform over the Arctic: for example, the Svalbard archipelago, which is located in the warmest region of the Arctic, reveals the highest temperature increase (Dahlke and Maturilli, 2017).

The increase in near-surface temperature and resulting feedback mechanisms, e.g. surface albedo, water vapor, lapse rate, cloud and remote feedback mechanisms, have a direct impact on the hydrological cycle. Climate model studies revealed an increase of precipitation in the Arctic with a shift from solid to liquid precipitation in future (e.g. McCrystall et al., 2021, Bintanja et al., 2020; , Bintanja, 2018) and a higher interannual variability. The increase in precipitation is likely linked for example to a higher local moisture supply (Bintanja and Selten, 2014; Kopec et al., 2016) and increased poleward transport of atmospheric moisture from lower latitudes (Bengtsson et al., 2011; Bintanja et al., 2020; McCrystall et al., 2021).

Still detailed measurements of water vapor, clouds and precipitation, i.e. crucial components of the hydrological cycle, are very sparse in the Arctic: only few ground-based sites have the capability to observe these in a high temporal and vertical resolution. In this study, we thus exploit the comprehensive measurements performed at the Arctic research station AWIPEV at Ny-Ålesund, Svalbard. Some of the measurements, including radiosondes, surface meteorology, and radiation, date back to the beginning of the 1990s, while extensive cloud and precipitation observations had been added from 2016 onwards as part of the Transregional Collaborative Research Centre on Arctic Amplification TR172 (http://www.ac3-tr.de; Wendisch et al., 2023).

In this presentation, we will thus highlight the observed trends in temperature, water vapor and precipitation at Ny-Ålesund but also zoom into the period with the extended instrument setup which allows for more detailed analyses of cloud and precipitation processes at Ny-Ålesund. A focus will be the role of atmospheric rivers and related weather systems on the precipitation at Ny-Ålesund and their impact on extreme precipitation events. Atmospheric rivers are distinct bands of enhanced water vapor transport and contribute to more than 90% of the poleward moisture transport (Guan and Waliser, 2015).
For the time period 1 Aug 2017 to 31 Dec 2021, 42% of the precipitation amount at Ny-Ålesund occurred when atmospheric rivers were present, either separated or collocated with cyclones or fronts. It is thus crucial to understand how air mass transport and weather patterns over Svalbard will change in future since this will directly have an impact on the water cycle in this region.