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The isotopic signature during contrasting extreme summer and winter conditions from continuous monitoring of water vapour and precipitation in Bergen, Norway

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The isotopic composition of atmospheric water vapour is influenced by evaporation at the source and cloud processes. Due to the advection of water vapour, it is immediately coupled to the atmospheric circulation, from large-scale weather systems to vertical mixing in the turbulent atmospheric boundary layer. Combined measurements of water vapour and precipitation isotopic compositions can provide valuable insight into local and remote processes affecting the hydrological cycle. Here, we present an analysis of the influence of atmospheric circulation on the isotopic composition of near surface water vapour and precipitation continuously monitored at Bergen in Southern Norway (60.38°N, 5.33°E), located downstream of the North Atlantic storm track, between December 2016 and March 2019.

The precipitation was sampled manually per precipitation event on a daily basis on the rooftop platform (54 m a.s.l, 25 m above ground) of the Geophysical Institute at Bergen and analysed for δ^{18}O, δD, and d-excess on a laser spectrometer (L2140-i, Picarro Inc.). Ambient air was continuously pumped from a heated inlet at the same location to a laser spectrometer (L2130-i, Picarro Inc.). In addition, temperature, relative humidity, wind speed and direction, and precipitation rate were measured at a nearby automatic weather station.

The two-year measurement period covered several contrasting seasons. The summer of 2017 was the wettest summer of last 50 years, in contrast to the summer of 2018 which was extremely dry and warm with long heat waves recorded. The winter of 2017/2018 was cold with unusually high snow accumulation, whereas the winter of 2018/2019 was relatively warm with mainly rain events. The strong inter-annual contrasts are associated with clear differences in seasonal circulation patterns, which are reflected by substantial differences in both surface water vapour and precipitation isotopic compositions. Furthermore, synoptic and seasonal variations in the surface water vapour and precipitation isotopic compositions coincide with the shifts in the moisture sources and transport distance, obtained from a Lagrangian moisture source diagnostic. Finally, we discuss the long-term observations at Bergen in the context of measurements from a wider network of water vapour isotopic composition monitoring in the region of the North Atlantic and the Nordic Seas.