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The isotopic composition of water vapour in the Central Arctic during the MOSAiC campaign: local versus distant-moisture sources.

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The Arctic atmosphere has undergone a process of moistening during the past decades. The loss of sea ice has led to enhanced transfer of heat and moisture from the ocean to the lower atmosphere, while strengthening of cyclonic events has enhanced the poleward transport of moisture from lower latitudes. Eventually, the increased humidity of the Arctic air masses serves today as a new, increasingly important source of moisture for the northern hemisphere. Still, to date, the relative contributions of local evaporation versus distant-moisture sources remains uncertain, as well as the processes responsible for exchanges within and between the hydrological compartments of the Arctic. Such uncertainties limit our ability to understand the importance of the Arctic water cycle to global climate change and to project its future.

In this study we use atmospheric water vapour isotopes to investigate the origin of the Arctic moisture and assess whether and which relevant changes occur within the coupled ocean-sea ice-atmosphere system (i.e., sea ice, sea water, snow, melt ponds). Stable isotopologues of water (HDO, $H_2{}^{18}O$) have different saturation vapour pressures and molecular diffusivity coefficients in air. These differences lead to isotopic fractionation during each phase change of water, making water isotopes a powerful tracer of the Arctic hydrological cycle.

Water vapour humidity, delta-18O, and delta-D have been measured continuously by a Picarro L2140i Cavity Ringdown Spectrometer installed onboard research vessel Polarstern during the MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate) expedition, which took place in the Central Arctic Ocean from October 2019 to September 2020. Our measurements depict a clear seasonal cycle and a strong and significant covariance of delta-18O and delta-D with air temperature and specific humidity. At the synoptic time scale the dataset is characterized by the occurrence of events associated with humidity peaks and abrupt isotopic excursions. We use statistical analysis and backwards trajectories to i) identify the origin of the air masses and the

relative contributions of distant vs. locally sourced moisture, and ii) illustrate the isotopic fingerprint of these two distinct moisture contributors and discuss on the source-to-sink processes leading to their differences.

Further, the MOSAiC observations are compared to an ECHAM6 simulation, nudged to ERA5 reanalysis data and enabled for water isotope diagnostics. The model-data comparison makes it possible to explore the spatial representativeness of our observations and assess whether the model can correctly simulate the observed isotopic changes. In the future, our observations may serve as a benchmark to test the parametrization of under(mis-)represented fractionation processes such as snow sublimation, evaporation from leads and melt ponds.

Our study provides the very first isotopic characterization of the Central Arctic moisture throughout an entire year and contributes to disentangling the influence of local evaporative processes versus large-scale vapour transport on the Arctic moistening.