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Airborne water vapor isotope measurements over the Iceland Sea in winter conditions

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Improved understanding of evaporation and condensation processes is critical to improve the representation of the water cycle in atmospheric models. Thereby, in-situ measurements along the entire moisture transport pathway, covering evaporation, mixing between different air masses in the atmospheric boundary layer and the free troposphere, and resulting precipitation are highly valuable to obtain new insight. In particular, coherent measurements of the stable isotope composition in atmospheric vapour can provide additional constraints on phase change processes of water vapour from source to sink, enabling direct comparison within isotope-enabled models.

Here we present stable isotope measurements from the Iceland Greenland Seas Project field campaign that took place in February-March 2018. This unique dataset includes simultaneous measurements from a land-station in Husavik, Iceland, a ship and an air plane in the subpolar region. Alternation between cold-air outbreaks and mid-latitude airmasses characterized the measurement period. Here we focus on the stable water isotope composition in water vapour obtained from 10 research flights, covering a large geographic range (64 °N to 72 °N). Careful data treatment was applied to ensure the quality of isotope measurements in the predominant cold, dry conditions with large gradients in isotope composition and humidity.

From an intercomparison flight over the Husavik station, we find good agreement between ground and airborne measurements. Out of 7 flights dedicated to the study of atmosphere-ocean-ice interactions, with both low-levels legs and vertical sections in predominant Cold Air Outbreak (CAO) conditions, we focus on the marginal ice zone and regions covered by shallow cumulus clouds. For open water flights, we find the horizontal and vertical distribution of $\delta^{18}O$ in the marine boundary layer to covary with cloud cover. Thereby, downdrafts bring dry and ^{18}O-depleted air from the free troposphere towards the surface, corresponding to openings in cloud cover. For flights passing over sea ice edge, both $\delta^{18}O$ and specific humidity show a clear east-west gradient, with increasing values towards the open sea reflecting ocean moisture availability. Additionally,

open leads in the sea ice also have a visible impact on isotope values. Lastly, relatively low d-excess values are observed over the sea-ice, which could either be caused by local processes or advection.