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Using in-situ observations of atmospheric water vapor isotopes to benchmark and isotope-enabled General Circulation Models and improve ice core paleo-climate reconstruction

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We have since 2010 carried out in-situ continuous water vapor isotope observations on top of the Greenland Ice Sheet (3 seasons at NEEM), in Svalbard (1 year), in Iceland (4 years), in Bermuda (4 years). The expansive dataset containing high accuracy and precision measurements of δ18O, δD, and the d-excess allow us to validate and benchmark the treatment of the atmospheric hydrological cycle's processes in General Circulation Models using simulations nudged to reanalysis products.

Recent findings from both Antarctica and Greenland have documented strong interaction between the snow surface isotopes and the near surface atmospheric water vapor isotopes on diurnal to synoptic time scales. In fact, it has been shown that the snow surface isotopes take up the synoptic driven atmospheric water vapor isotopic signal in-between precipitation events, erasing the precipitation isotope signal in the surface snow.

This highlights the importance of using General or Regional Climate Models, which accurately are able to simulate the atmospheric water vapor isotopic composition, to understand and interpret the ice core isotope signal.

With this in mind we have used three isotope-enabled General Circulation Models (isoGSM, ECHAM5-wiso, and LMDZiso) nudged to reanalysis products. We have compared the simulations of daily mean isotope values directly with our in-situ observations. This has allowed us to characterize the variability of the isotopic composition in the models and compared it to our observations. We have specifically focused on the d-excess in order to characterize why both the mean and the variability is significantly lower than our observations.

We argue that using water vapor isotopes to benchmark General Circulation Models offers an excellent tool for improving the treatment and parameterization of the atmospheric hydrological cycle. Recent studies have documented a very large inter-model dispersion in the treatment of the Arctic water cycle under a future global warming and greenhouse gas emission scenario. Our results call for action to create an international pan-Arctic monitoring water vapor isotope network in order to improve future projections of Arctic climate.