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Isotopes in the Arctic atmospheric water cycle

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The ISO-ARC project aims at documenting the Arctic atmospheric hydrological cycle, by assessing the imprint of the marine boundary conditions (e.g. temperature variations, circulation changes, or meltwater input) to the isotopic composition of the atmospheric water cycle ($H_2^{18}O$ and HDO) with a focus on North Atlantic and Arctic oceans.

For this purpose, two continuous monitoring water vapour stable isotopes cavity ring-down spectrometers have been installed in July 2015: on-board the Polarstern research vessel and in the Siberian Lena delta Samoylov research station (N 72˚22', E 126˚29'). The Polarstern measurements cover the summer 2015 Arctic campaign from July to mid-October, including six weeks in the Fram Strait region in July- August, followed by a campaign reaching the North Pole and a transect from the Norwegian Sea to the North Sea. These vapour observations are completed by water isotopic measurements in samples from the surface ocean water for Polarstern and from precipitation in Samoylov and Tiksi (120 km south-east of the station).

A custom-made designed automatic calibration system has been implemented in a comparable manner for both vapour instruments, based on the injection of different liquid water standards, which are completely vaporised in dry air at high temperature. Subsequent humidity level can be adjusted from 2000 to at least 30000 ppm. For a better resilience, an independent calibration system has been added on the Samoylov instrument, allowing measurements of one standard at humidity levels ranging from 2000 to 15000 ppm: dry air is introduced in a tank containing a large amount of liquid water standard, undergoing evaporation under a controlled environment. The measurement protocol includes an automatic calibration every 25 hours. First instrument characterisation experiments depict a significant isotope-humidity effect at low humidity, dependant on the isotopic composition of the standard.

For ambient air, our first isotope measurements highlighted significant synoptic variations in summer in both sites. In Samoylov, the premises of a seasonal cycle have been observed during the summer-fall transition, with a fast humidity level and isotopic decrease. The latitudinal gradient is also highly visible on the Polarstern record. Complementing simulations of the water vapour isotopic composition by the ECHAM5-wiso model reproduce the Polarstern synoptic variability and spatial patterns with a good accuracy.

In the near future, our records will be combined with simultaneous water isotope measurements in Iceland (by Hans Christian Steen-Larsen, CIC), Svalbard (by Valérie-Masson Delmotte, LSCE) and paired with complementing climate simulations enhanced by water isotope diagnostics. These data sets, covering an approx. 6,000 km transect of Northern Eurasia will allow for a quantitative assessment of the isotopic variations of the Arctic water cycle. The results of these analyses will also be of relevance for the interpretation of isotope signals found in ice cores and on terrestrial Arctic sites in terms of past climate change.