Isotopes in the Arctic atmospheric water cycle

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Stable isotopes in the atmosphere from vapor to precipitation

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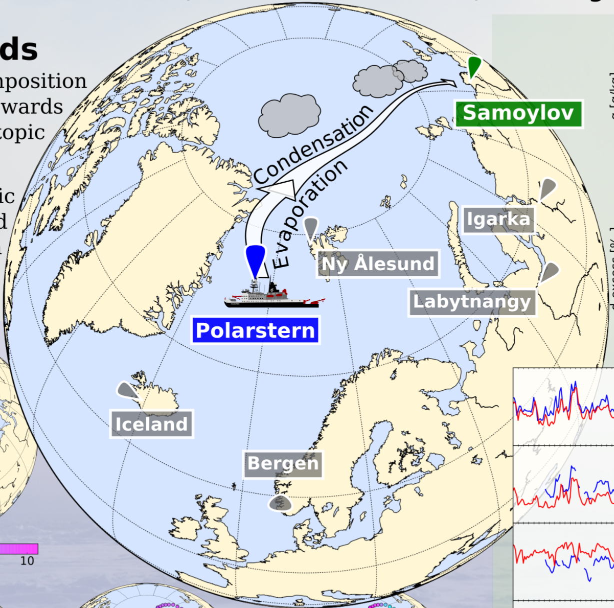
Objectives and methods

Study the water vapour isotopic composition from the sources of evaporation towards eastern Arctic and evaluate isotopic enabled General Circulation Models.

Two in situ water vapour isotopic analyzers (CRDS) installed on-board Polarstern ice-breaker and in Samoylov research station (Lena delta, Russia 72°22'N, 126°29'E).



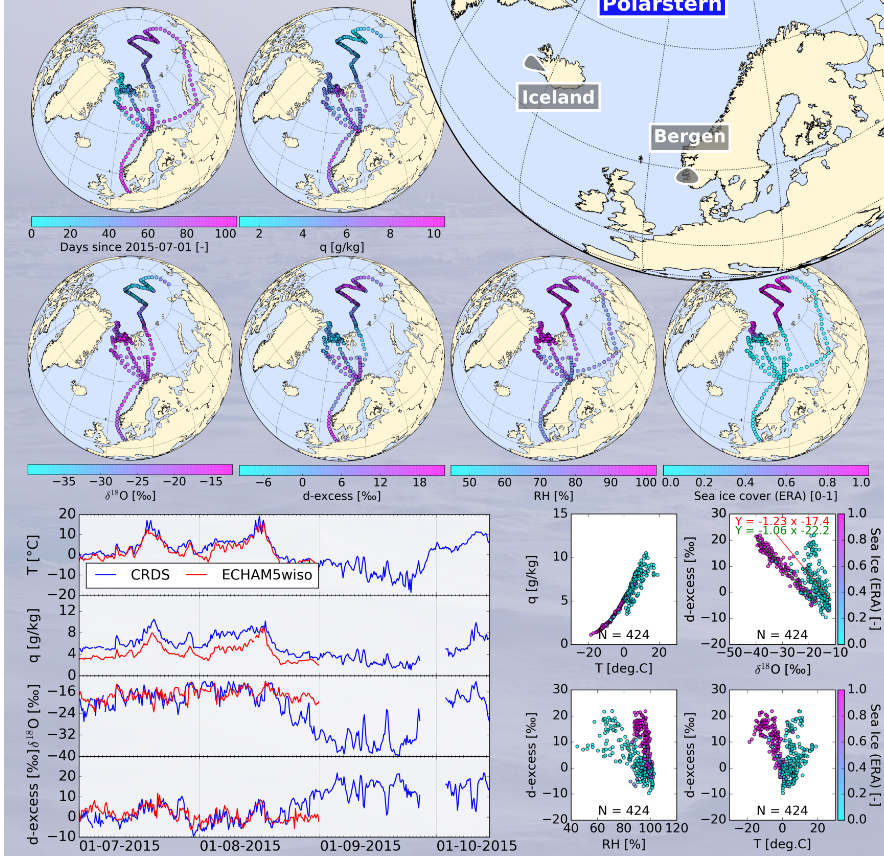


Fig.1: Polarstern data from 01-07 to 15-10-2016 at 6h resolution: along track (up); time series of observations (blue) with colocated ECHAM5-wiso model outputs (red) (down left); cross-correlations of observed data with color indicating the sea ice index around Polarstern from ERA-interim (down right).

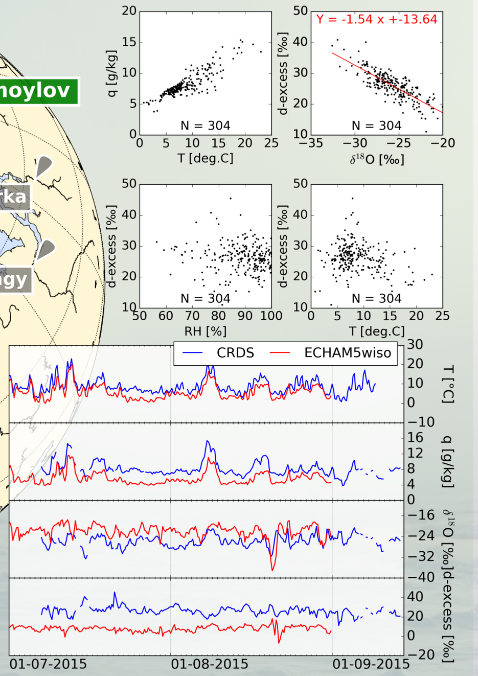


Fig.2: Samoylov data from 01-07 to 14-09-2015 at 6h resolution: observations cross-correlations (up); time series of observations (blue) & ECHAM5-wiso model outputs (red) (down).

Data analyses

We note high d-excess in north-eastern Arctic (fig.1 up & fig.2 down) and two d-excess/$\delta^{18}O$ relations depending of sea ice cover around Polastern (fig.1 down right): a low slope for sea ice areas, close to the slope in summer in NEEM (Greenland) [Steen-Larsen et. al. 2013]; an higher slope with larger dispersion in open sea, as in Iceland [Steen-Larsen et al. 2015] and in Samoylov, close to large open sea areas in summer (fig.2 up).
Despite dry biases, ECHAM5-wiso model simulates good isotopic mean levels, synoptic and spatial variabilities, but underestimated the high d-excess from Samoylov (fig.1 down left & fig.2 down).

Calibration protocols

Both instruments are automatically calibrated via vapourization of liquid standards at 170°C mixed with dry air from gas bottle for Polarstern and dry air generator for Samoylov. Very good stability of these standards measurements was obtained on Polarstern (fig.3), although higher variability was observed for Samoylov system. Humidity sensitivity tests on all standards highlighted on both instruments a strong effect at low humidity (<4000ppm) with opposite behaviour between enriched and depleted standards (fig. 4). These tests validate the systems for measurements in summer Arctic humidity conditions.

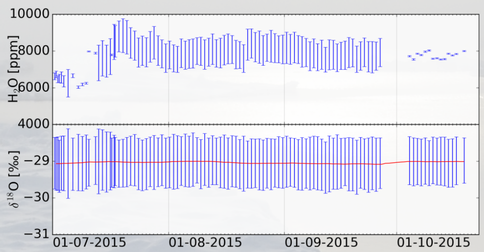


Fig.3: T27 standard ($\delta^{18}O$: -26.81‰) measurements (blue) on Polarstern instrument and 15 days running mean (red), from 01-07 to 15-10-2015.

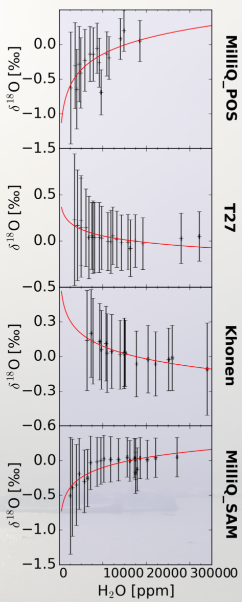


Fig.4: Samoylov humidity response test for the standards used on the vapourizer: deviations to mean above 10000 ppm (black) and applied correction curves (red).

Conclusions and perspectives

Calibrated records were obtained in summer 2015. Special care is needed for humidity correction in dry conditions.
Two distinct behaviours for d-excess exist depending on the sea ice cover around Polastern, analogous to other Arctic records.
ECHAM5-wiso simulates most isotopic variations, but underestimates Samoylov d-excess (possibly due to e.g. moisture transport toward eastern Arctic, or influence of local evaporation).

Data are to be combine with other Arctic records (see map) to track vapour along atmospheric transport [such as Bonne et al. 2015].

References

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