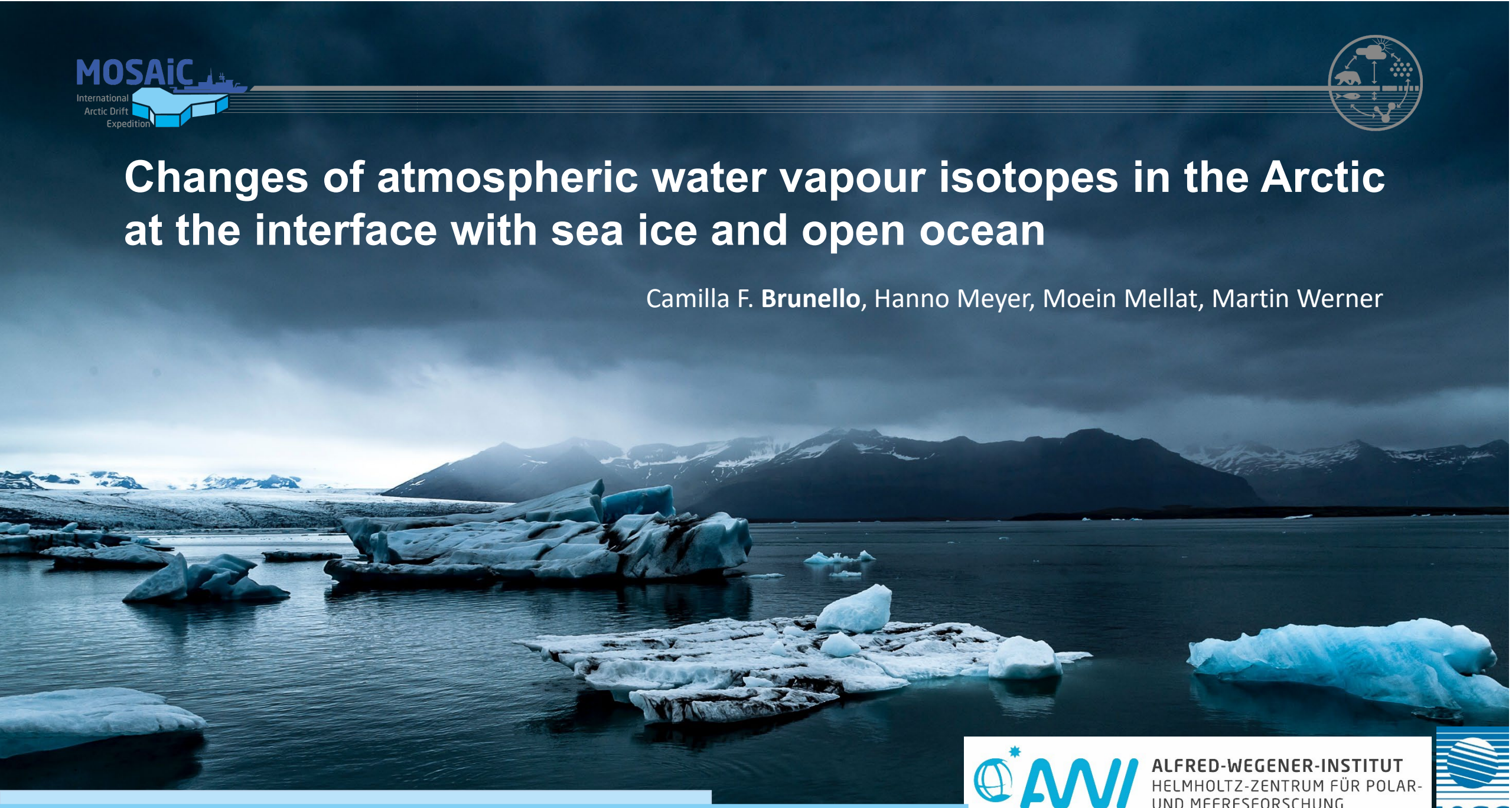
Changes of atmospheric water vapour isotopes in the Arctic at the interface with sea ice and open ocean

Camilla F. **Brunello**, Hanno Meyer, Moein Mellat, Martin Werner



ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

The Arctic water cycle is changing rapidly

1. Arctic sea ice is decreasing

Article | Open Access | Published: 01 April 2022

Unprecedented decline of Arctic sea ice outflow in 2018

Hiroshi Sumata, Laura de Steur, Sebastian Gerland, Dmitry V. Divine & Olga Pavlova

2. Arctic atmosphere is moistening

Editorial Type: Article

Trends of Vertically Integrated Water Vapor over the Arctic during 1979–2016: Consistent Moistening All Over?

A. Rinke[1], B. Segger[1], S. Crewell[2], M. Maturilli[1], ... View More +

Print Publication: 15 Sep 2019

3. Arctic moisture serves as new source of precipitation

Arctic sea-ice loss fuels extreme European snowfall

Hannah Bailey[1], Alun Hubbard[2], Eric S. Klein[3], Kaisa-Riikka Mustonen[1], Pete D. Akers[4], Hannu Marttila[5] and Jeffrey M. Welker[1,6]

4. The origin of Arctic moisture is still debated

Origin of Arctic water vapor during the ice-growth season

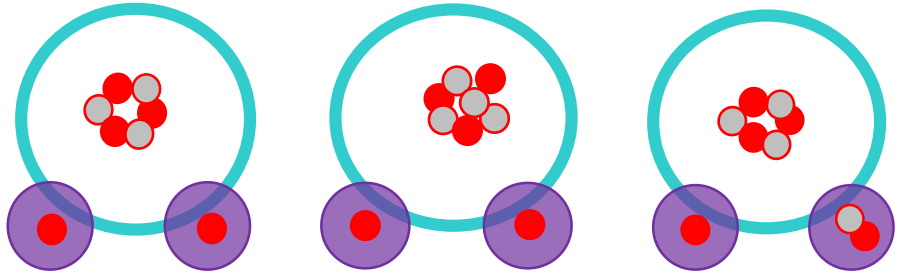
Naoyuki Kurita

First published: 29 January 2011 | https://doi.org/10.1029/2010GL046064 | Citations: 87

Objective: characterization of the new Arctic moisture

Water stable isotopes as a tracer of the water cycle

Several **isotopologues of water** exist in the Earth's water cycle



$H_2{}^{16}O$
Quantity: 99.745 %

$H_2{}^{18}O$
Quantity: 0.2 %

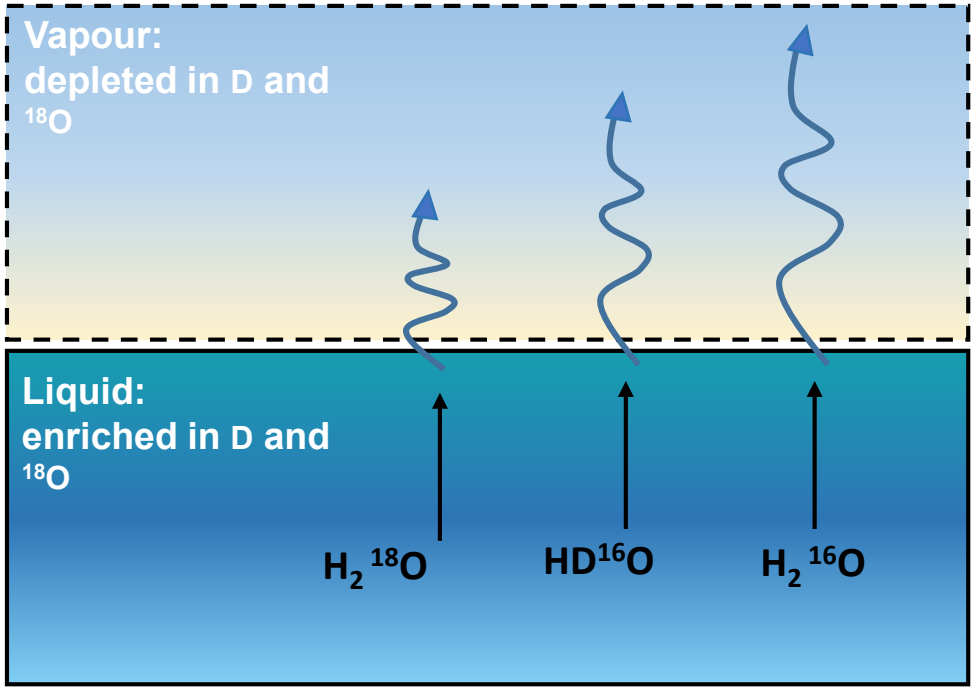
$HD\,{}^{16}O$
Quantity: 0.015 %

The isotopic composition is expressed as a ratio as a deviation from a standard:

$$\delta^{18}O = \left(\frac{\left(\frac{^{18}O}{^{16}O}\right)_{sample}}{\left(\frac{^{18}O}{^{16}O}\right)_{standard}} - 1 \right) \times 1000$$

Common standard: Vienna – Standard Mean Ocean Water (V-SMOW)

Fractionation causes an enrichment of light isotopes in the vapour phase, while heavy isotopes stay in the liquid phase



Fractionation coefficients are temperature dependent

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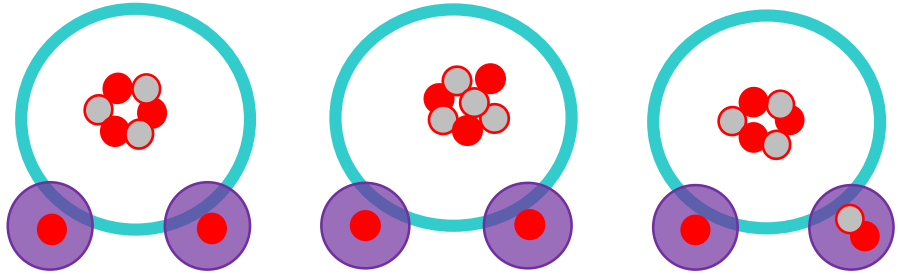

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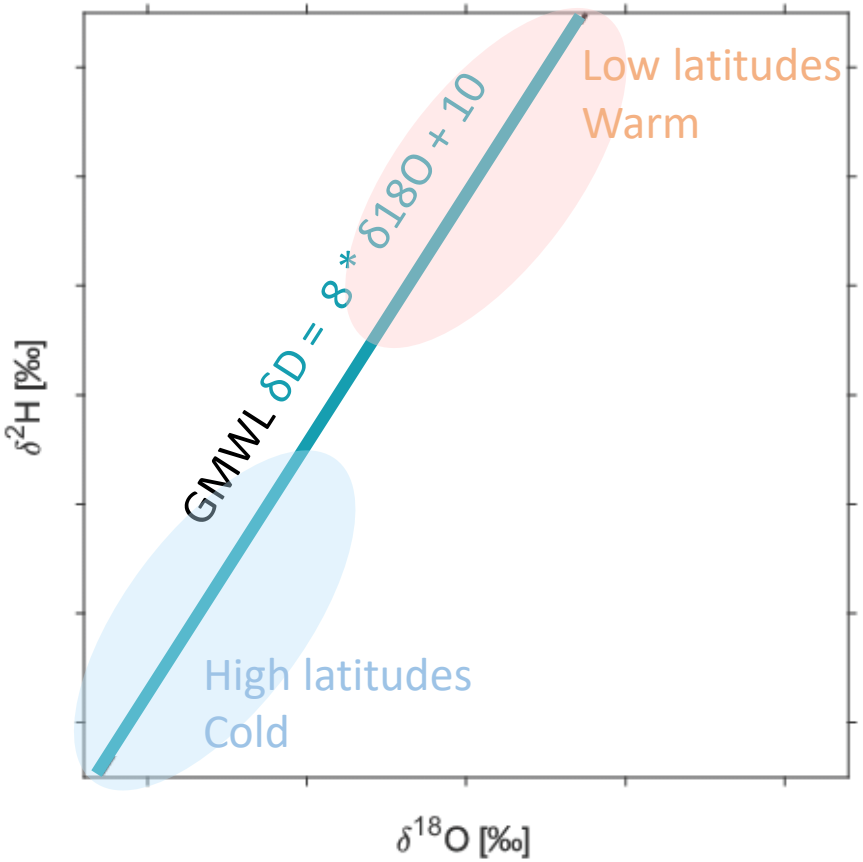

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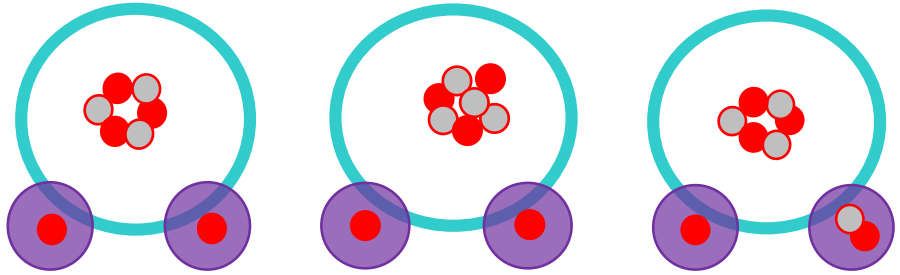

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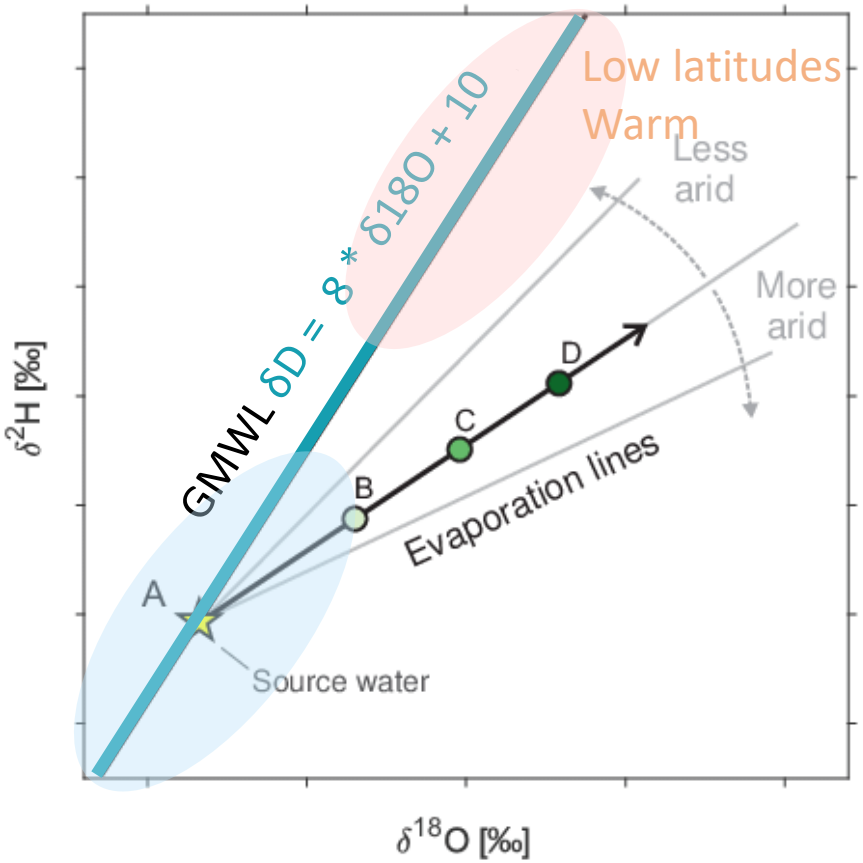
Deuterium excess = **δD – 8 * δ18O**



Deviations from the GMWL are a diagnostic for evaporative conditions

Changes of water Isotopes in the Arctic Sea ice, Ocean and Atmosphere
CiASOM

DISCRETE SAMPLING OF SEA ICE, OCEAN, SNOW, MELT PONDS

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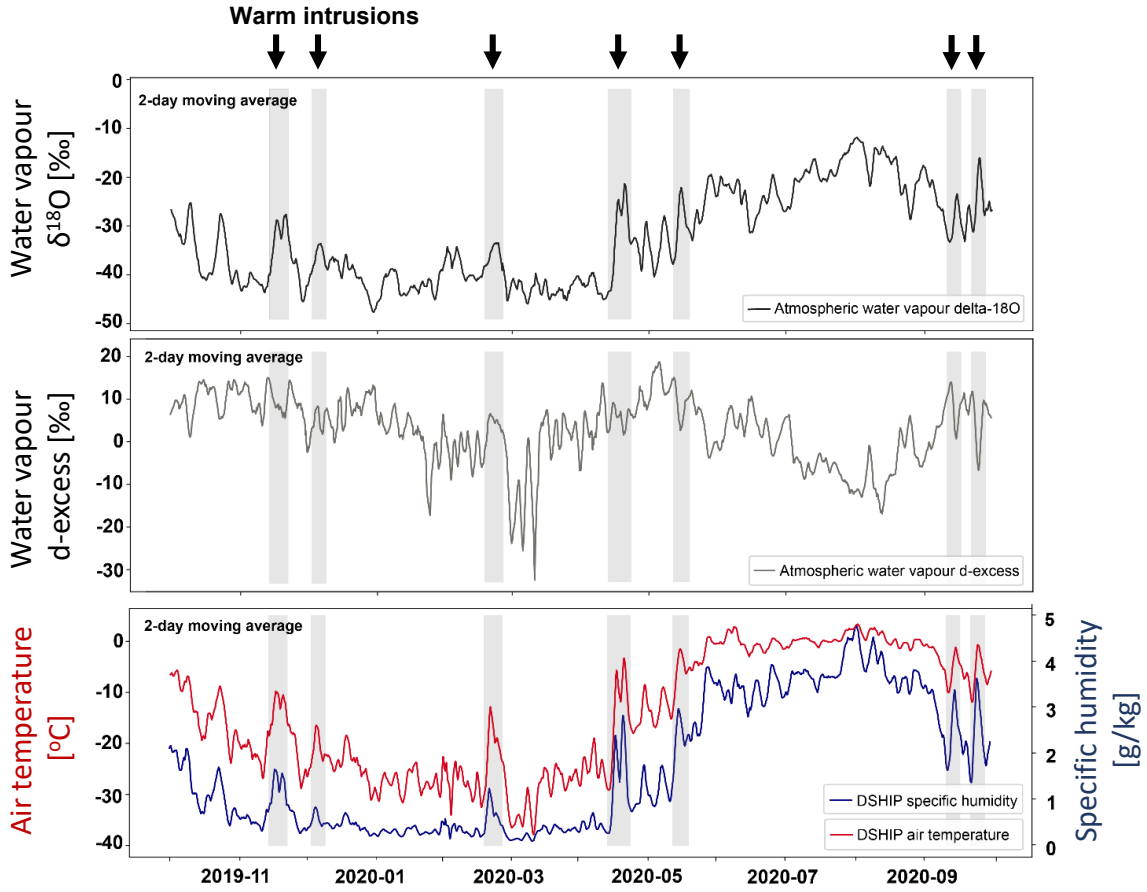
REGIONAL NETWORK OF LAND-BASED OBSERVATIONS

AWINN, Jeff Welker

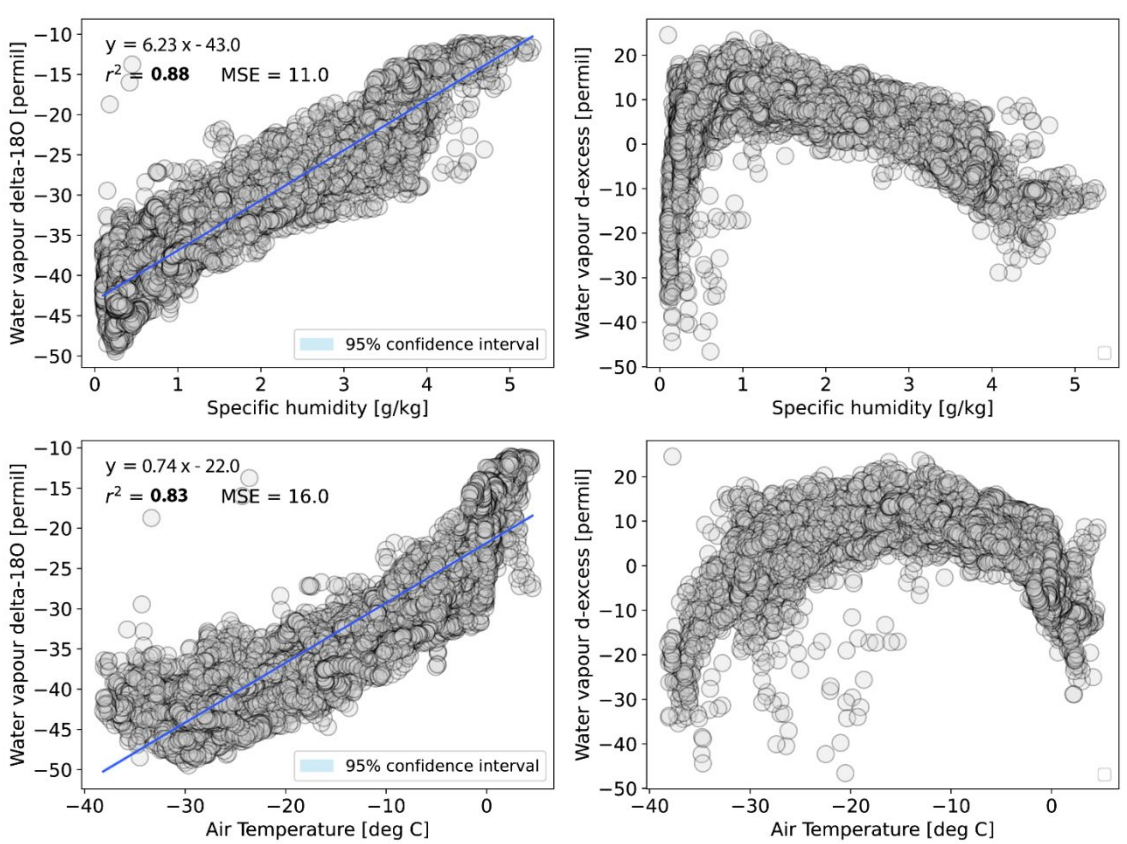
ISOTOPE ENHANCED – ATMOSPHERIC GCM

Laser spectrometer installed on deck A, in the aerology laboratory.

Seasonal correlations with local temperature and specific humidity



Annual



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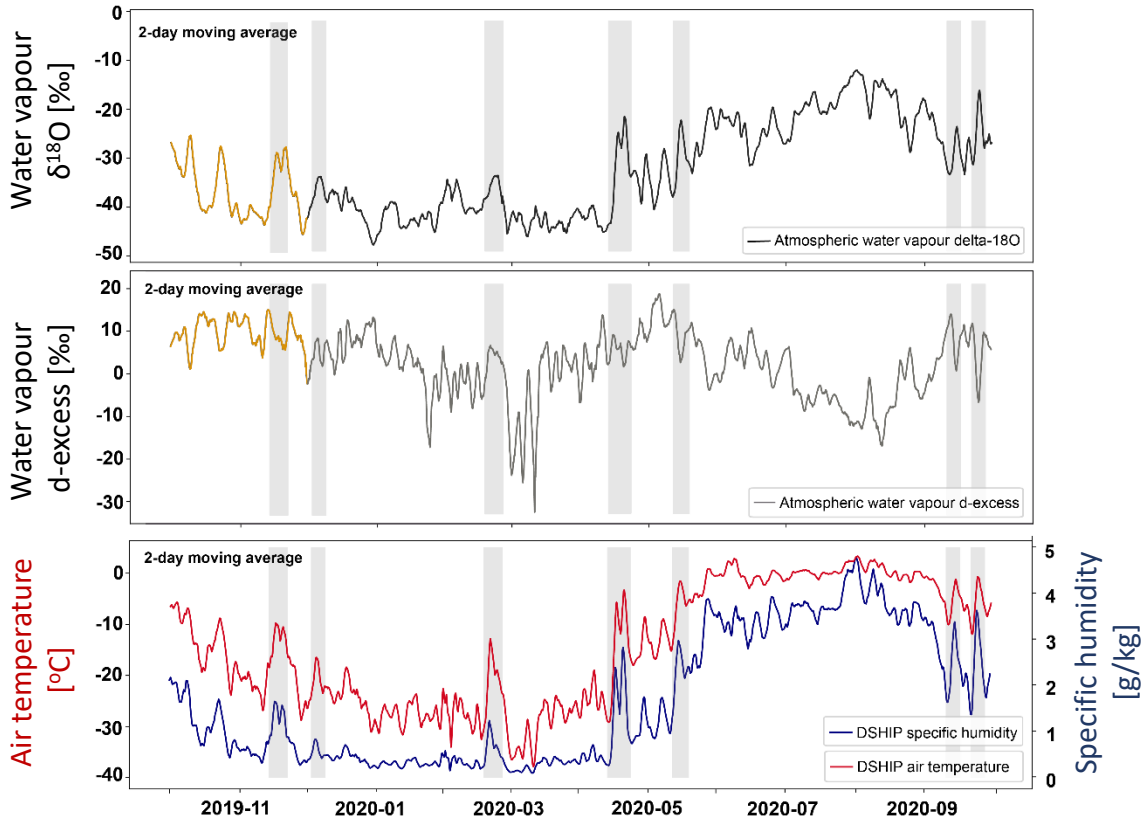
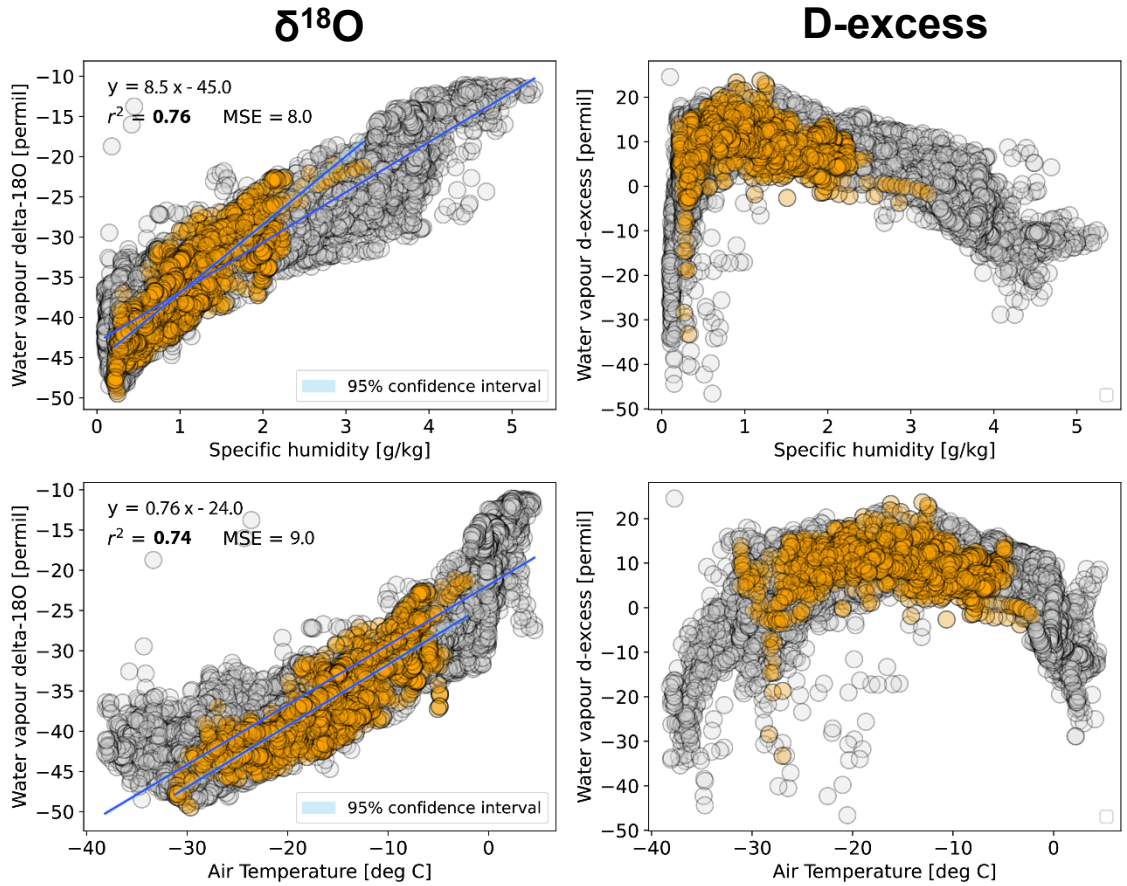
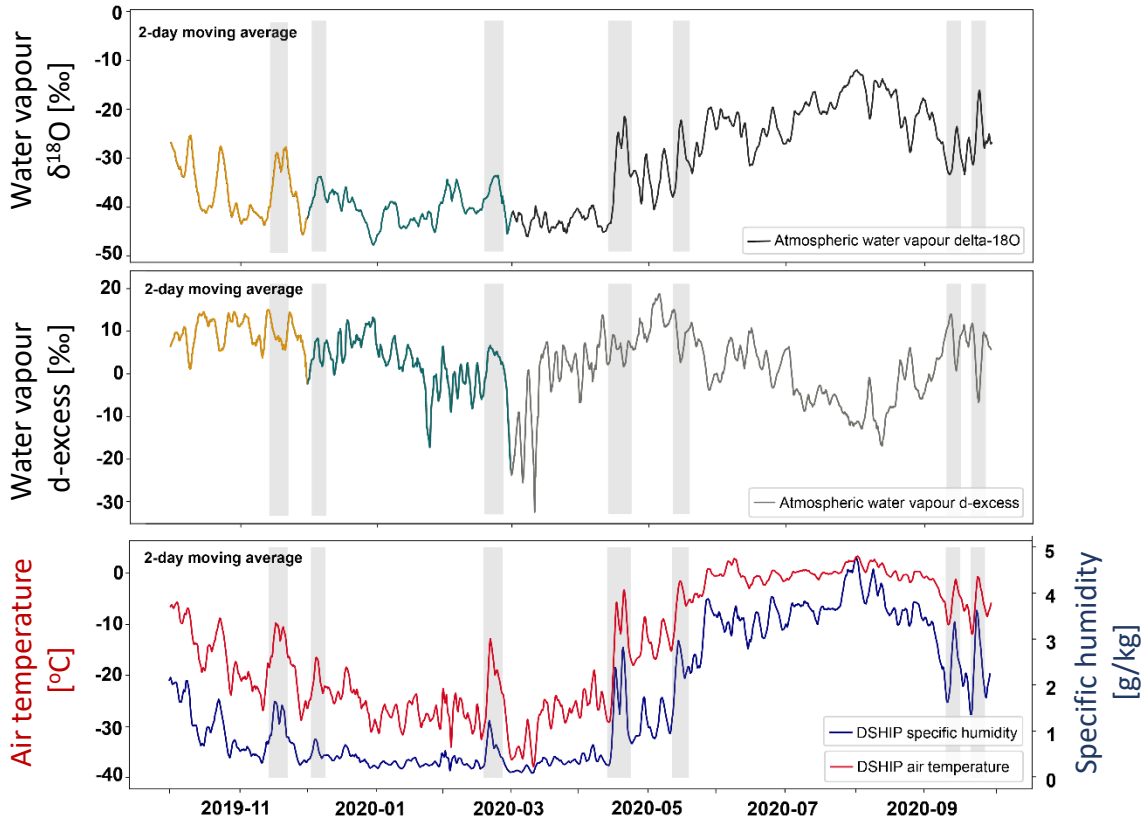


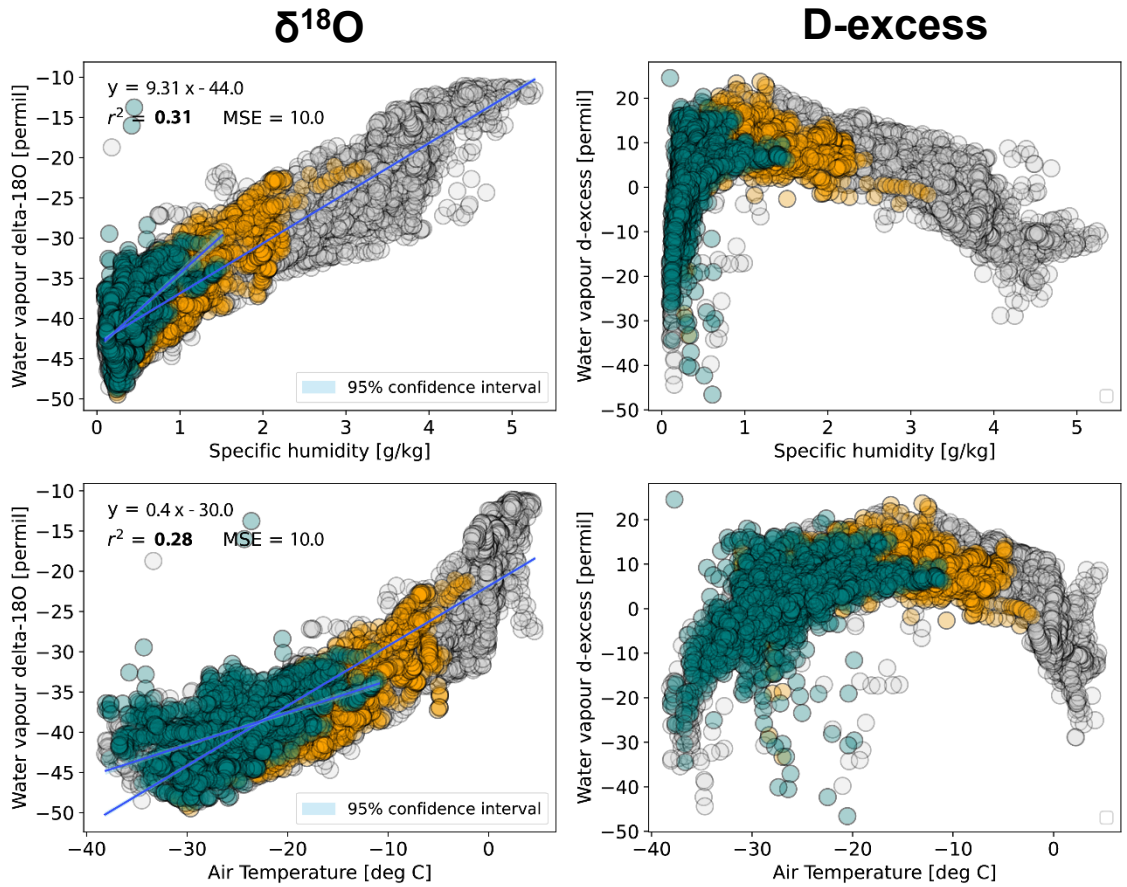
Autumn - ON



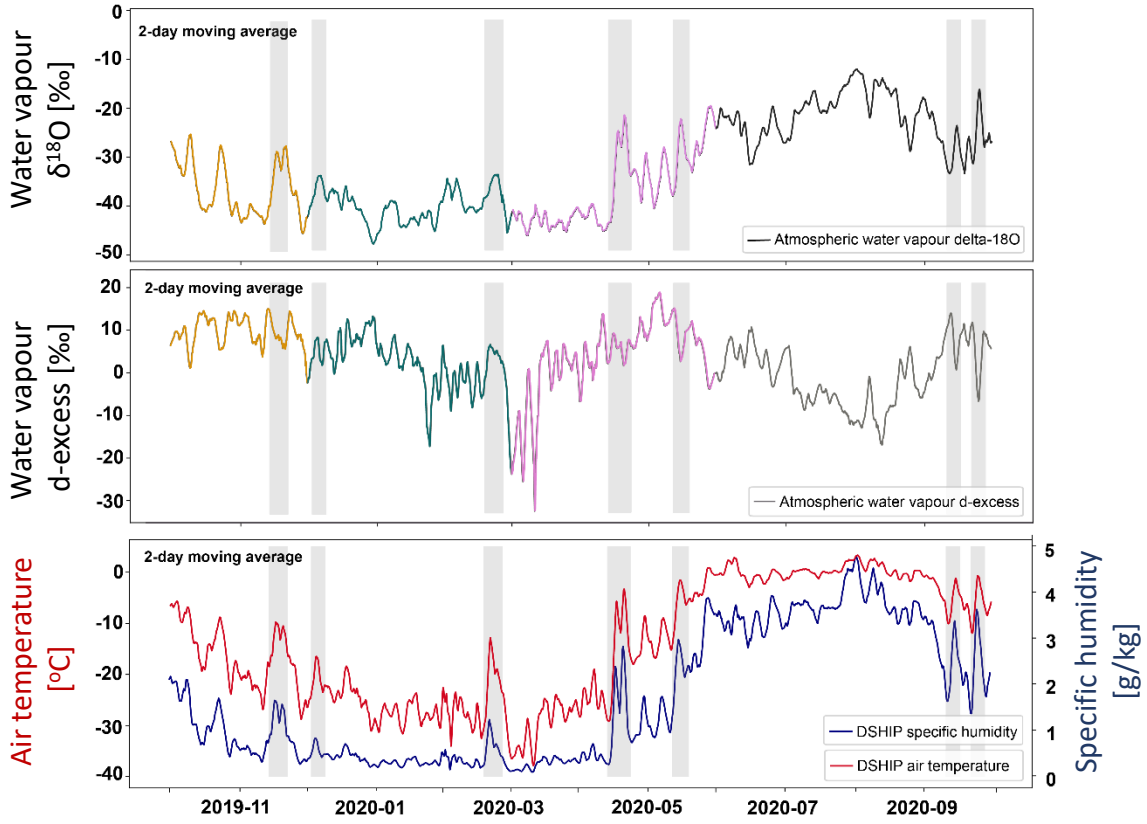
Seasonal correlations with local temperature and specific humidity



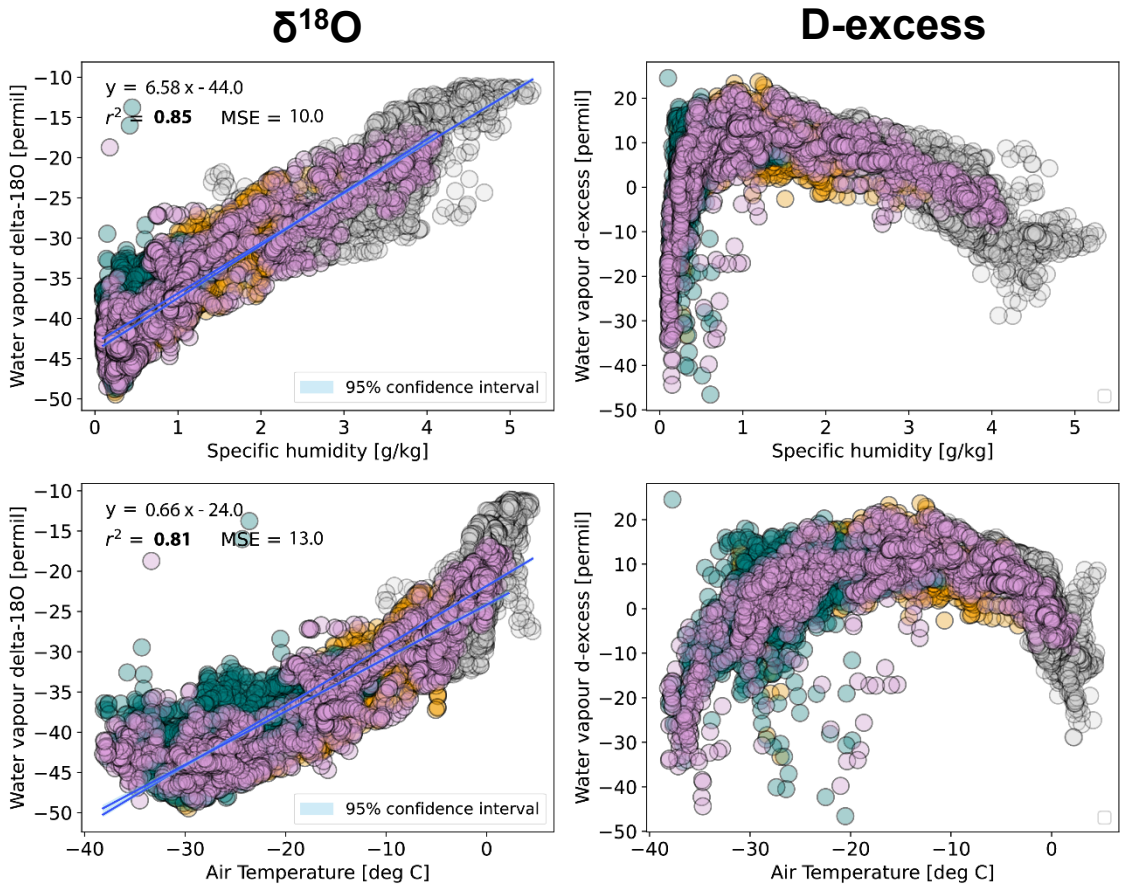
Winter - DJF



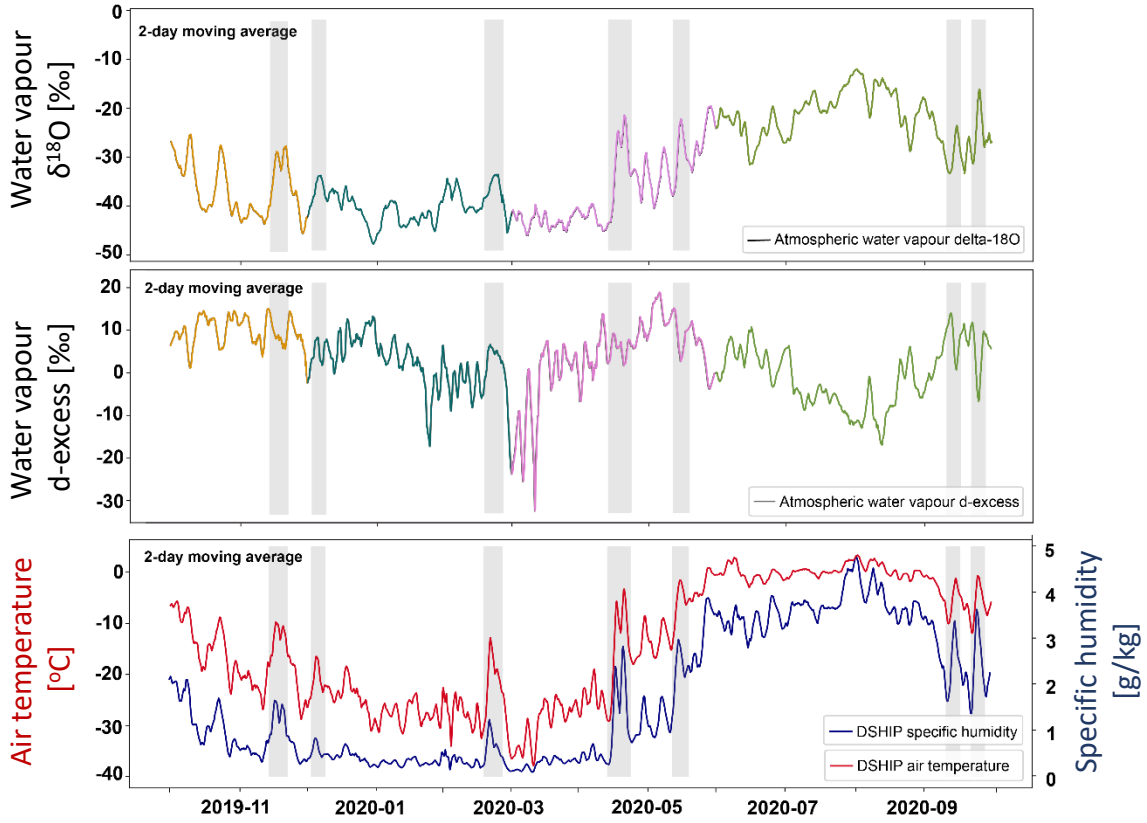
Seasonal correlations with local temperature and specific humidity



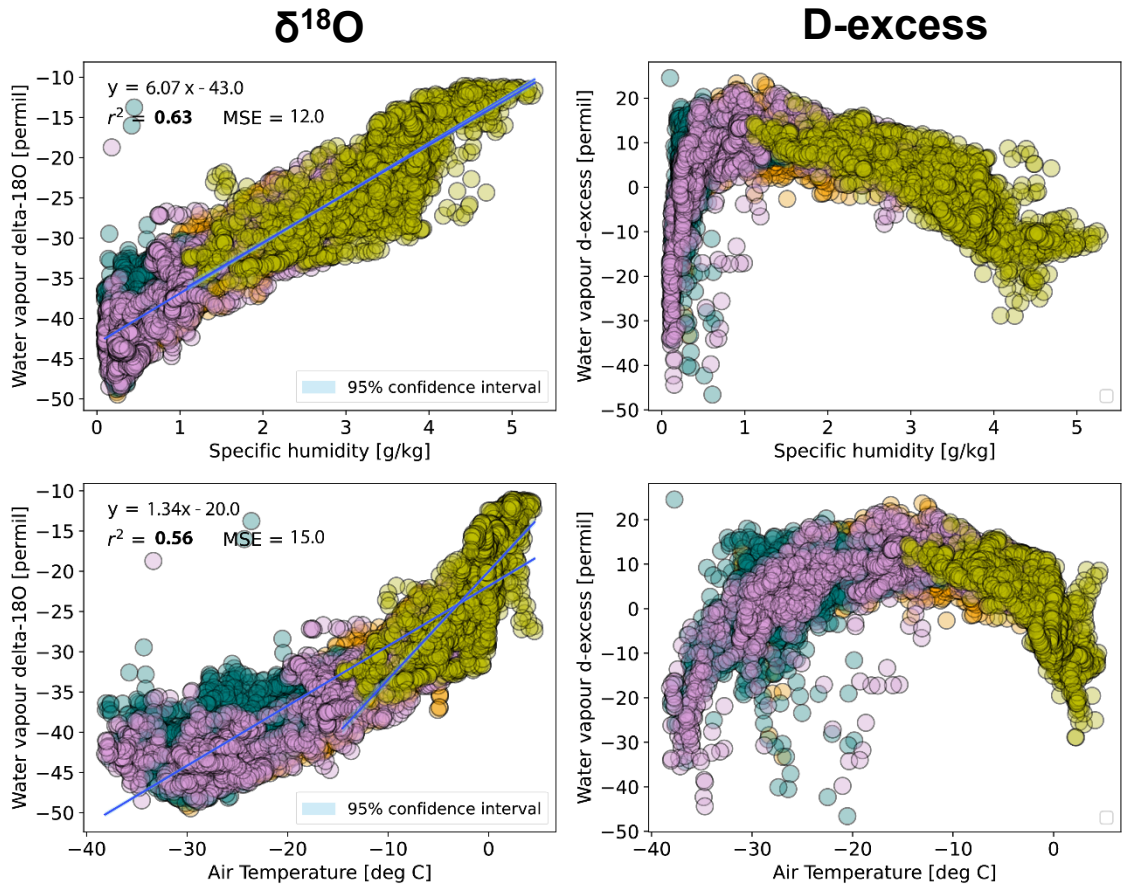
Spring - MAM



Seasonal correlations with local temperature and specific humidity

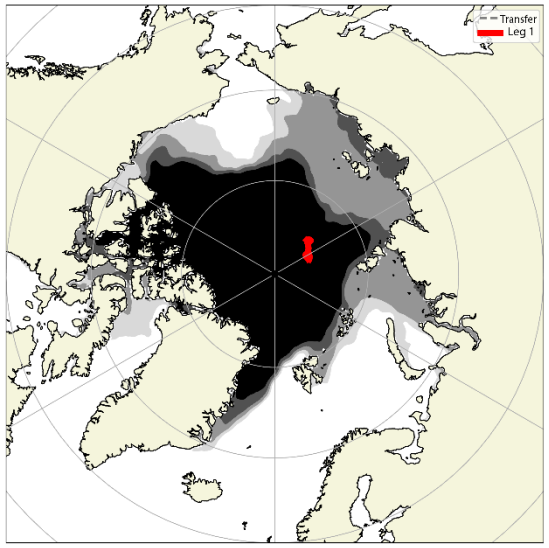


Summer - JJAS

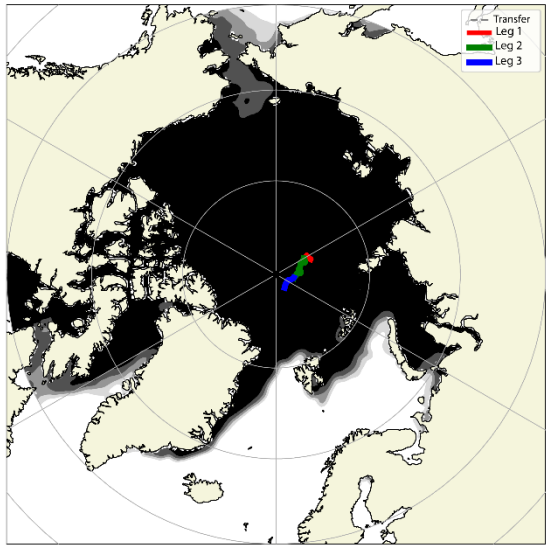


Deuterium excess as a diagnostic for the evaporative sources

Autumn - ON



Winter - DJF



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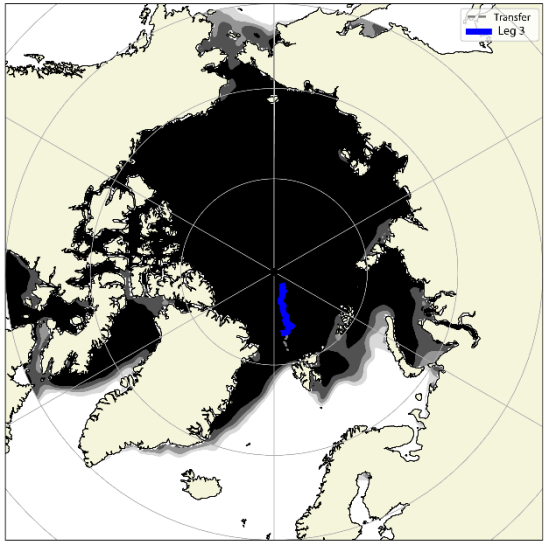
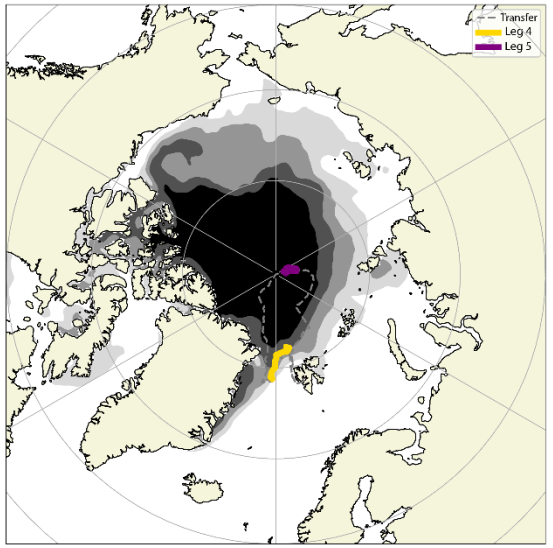
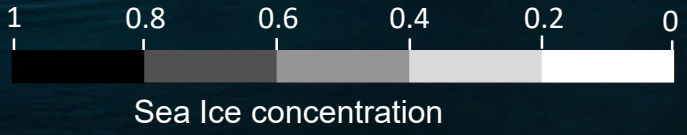


Summer - JJAS





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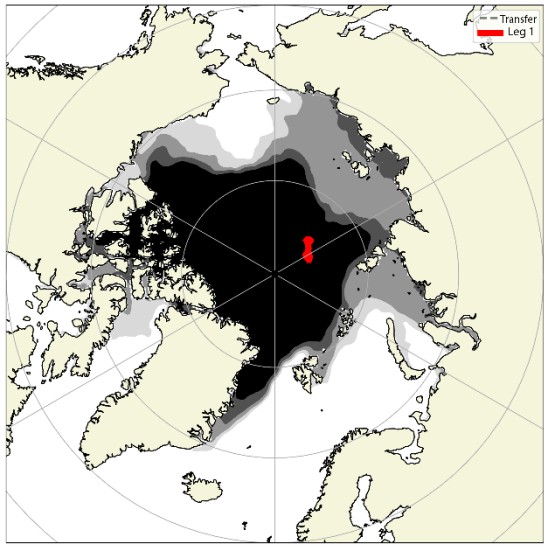
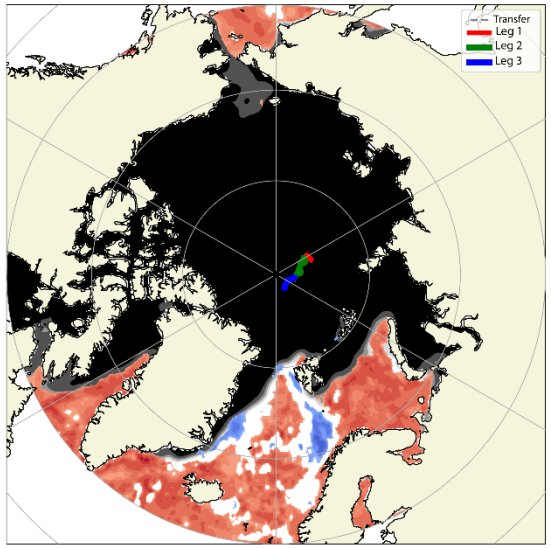


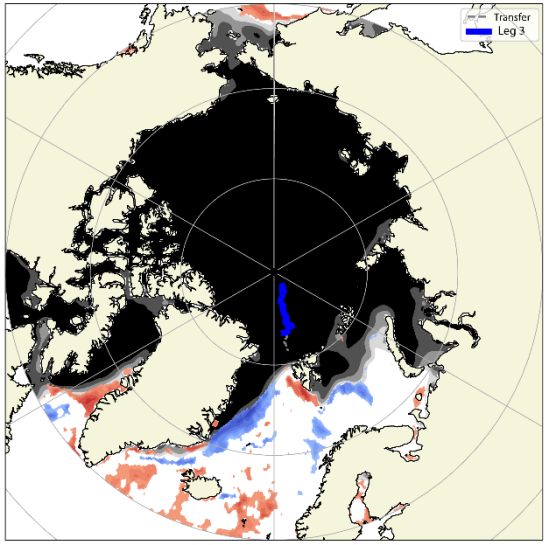
No correlation with SST.
H1: local moisture recycling.

Winter - DJF



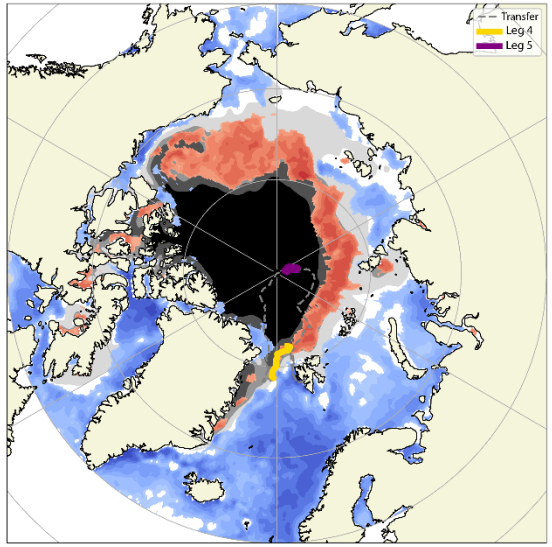
Positive correlation with large-scale SST.
H1: long distance advection.

Spring - MAM

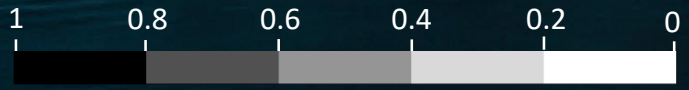


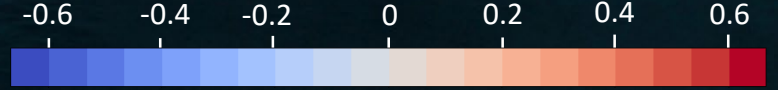
Low, sparse correlation.
H1: in-Arctic recycling and source transition.

Summer - JJAS



Positive correlation with Arctic open ocean.
H1: injection of moisture from the retreating sea ice margin.





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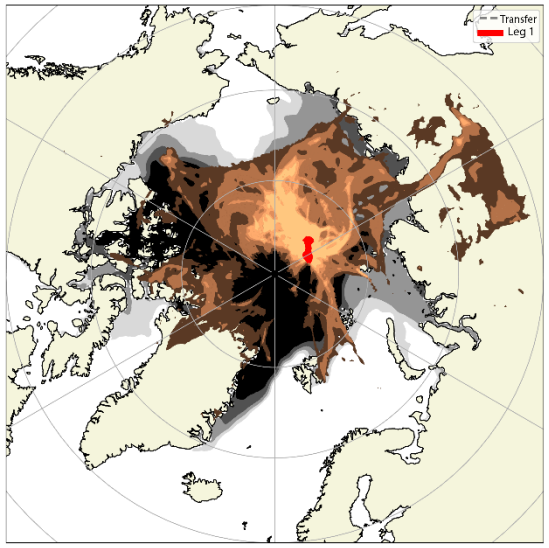
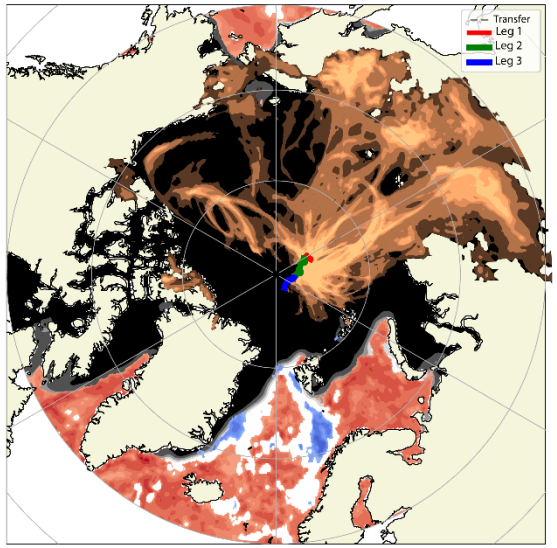


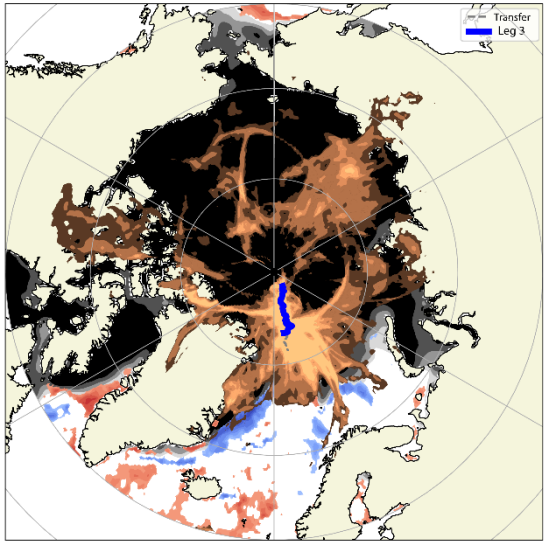
No correlation with SST.
Local moisture recycling.

Winter - DJF



Positive correlation with large-scale SST.
Long distance advection from Siberia.

Spring - MAM



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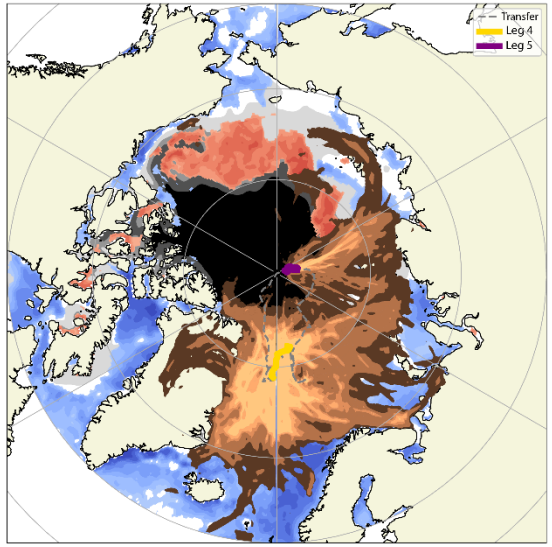
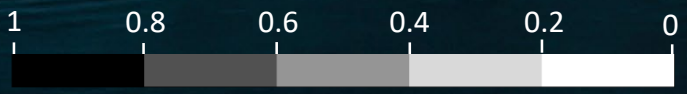
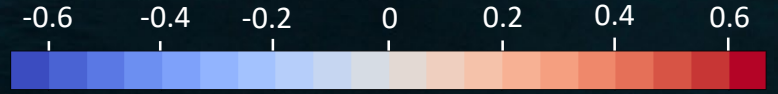
In-Arctic recycling and source transition.

Summer - JJAS



Positive correlation with Arctic open ocean.
Injection of moisture from the retreating sea ice margin.





Conclusions and outlook

DISCRETE SAMPLING OF SEA ICE, OCEAN, SNOW, MELT PONDS

CONTINUOUS MONITORING OF ATMOSPHERIC VAPOUR ISOTOPES

REGIONAL NETWORK OF LAND-BASED OBSERVATIONS

ISOTOPE ENHANCED – ATMOSPHERIC GCM

We presented one year of high resolution water vapor isotope measurements from the central Arctic

- **The $\delta^{18}O$ signal correlates with local air temperature and specific humidity**
- **The d-excess reveals seasonal changes in the moisture sources:**
  - **Autumn: local moisture**
  - **Winter: distant advection from Siberia**
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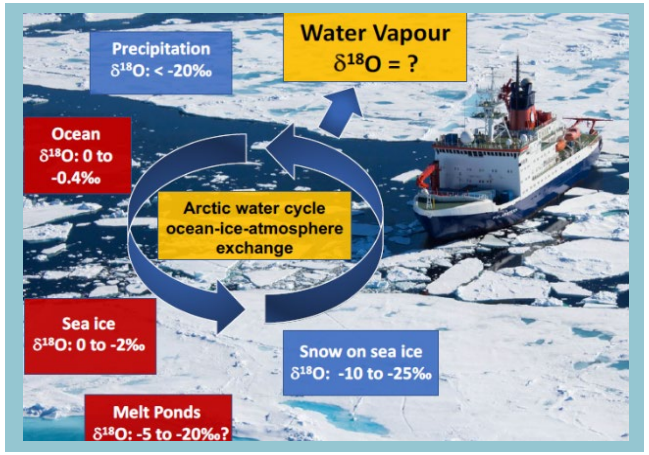
  - **Summer: evaporative injections from the margin of the retreating sea ice**

Any interest? Any advice?

camilla.brunello@awi.de

Conclusions and outlook



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Poster presentation by Moein Mellat on gather town: 'Isotopic traits of the Arctic water cycle'.

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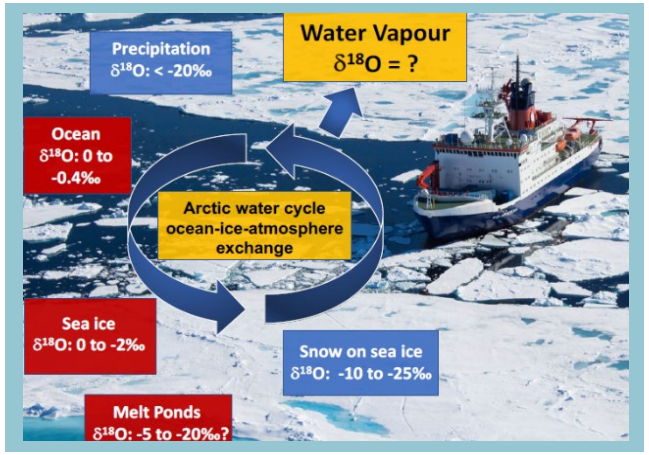
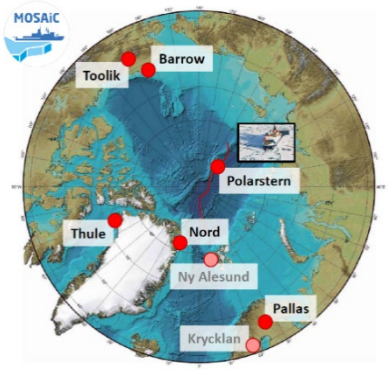
Conclusions and outlook



CONTINUOUS MONITORING OF ATMOSPHERIC VAPOUR ISOTOPES

AWIN: Isotope Network

paired observations from stations connected during synoptic events



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Kopec et al., Pan-Arctic water vapour isotope measurements reveal sea ice-ocean-atmosphere interactions during MOSAiC. *under revision for JGR Atmosphere*

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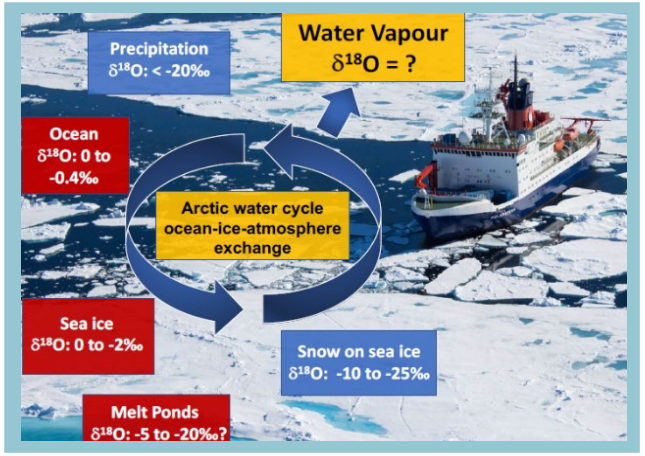
Conclusions and outlook



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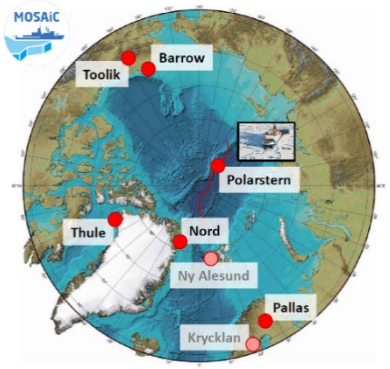

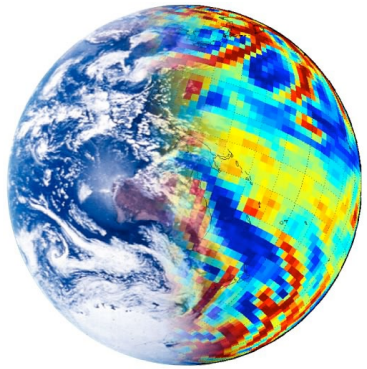

- global atmosphere model (resolution: 0.9°x0.9°, T127L95)
- simulation nudged to ERA5
- explicit simulation of isotopes in the water cycle

Poster presentation with first data-model comparison available at:
https://watercycle.w.uib.no/files/2021/11/Brunello_IsotopeWorkshop_2021_poster_final-1.pdf

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