# Changes of water isotopes in Arctic Sea ice, Ocean and atMosphere (CiASOM)

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## Water isotopes as hydrological tracers.

Stable isotope ratios of water ($^{18}O/^{16}O$ and $^{2}H/^{1}H$), and the secondary parameter deuterium (d)-excess, are valuable hydrological tracers and can be used to constrain complex environmental processes through space and time.


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## MOSAiC and CiASOM

Over the past two decades, the Arctic has been influenced by a drastic surface air temperature (SAT) rise of 1.7°C, hence at almost twice the global rate.

As the result of this so-called "Arctic amplification", the water cycle in this region has been affected by a progressive decrease of sea ice extent which in turn contributes to the moistening of the atmosphere. This Arctic moisture is considered to be a new source of precipitation in the northern hemisphere.

Understanding these alterations in the Arctic is challenging due to the **paucity of observational data** as it is one of the most remote regions on earth.

To study this epicenter of global warming, the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) expedition took place between

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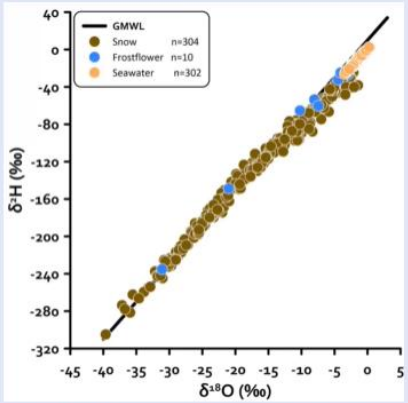
## The isotopic signature of discrete samples

The isotopic composition of discrete samples of snow, frost flowers, seawater, first-year ice(FYI), second-year ice (SYI), rafted ice, melt ponds, and lead is highly variable:

- Snow has the most depleted and most variable isotopic signature
- Seawater is the most enriched compartment in $\delta$18O
- A mixture of snow and sea ice at the interface between both is possible since many FYI and SYI samples have a very light isotopic composition
- Meltwater layers of ponds have a wider range and generally more depleted values compared to seawater




Snow and frost flowers are both atmospheric-sourced compartments compared to others and this is apparent in their positive d-excess values. Other sample types (i.e., FYI, leads) have more uniform $\delta$18O and d-excess values

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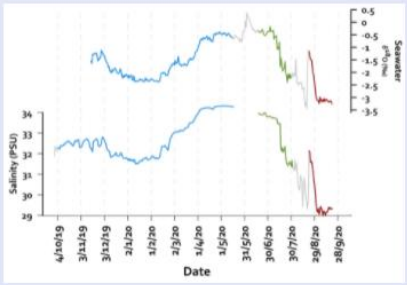
## Spatial and temporal variability of isotopes in the Arctic

**Seawater:**

Seawater samples (N=302) were collected daily from October 2019 until the end of the expedition from underneath the ship.

The isotopic signal of seawater correlates well with salinity and suggests the contribution of freshwater with more depleted values i.e. due to snow and second-year ice melt as well as Greenland Ice sheet melt release.




**Vapor:**

The calibration of the raw Picarro measurements included (i) correction for humidity-concentration dependence of the isotopic composition; (ii) correction of the instrumental drift; (iii) correction for deviations from the VSMOW-SLAP scale. The calibrated dataset, originally measured at the frequency of 1Hz, is here aggregated to daily values.

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## Outlook: investigation of the exchange processes

This unique dataset enables us to investigate the subtle exchange processes between and within different compartments of the Arctic water cycle:

- SYI $\delta^{18}O$ is more depleted at the surface and more enriched in the depth of the ice cores. Isotopes can further be used to separate the older SYI layer at the top from the insulated FYI layer at the bottom.
- Snow deposited on top of sea ice sublimates and under-goes metamorphosis during winter. This affects the snow structure and vapor flux diffusion from bottom to surface likely contributing to the progressive enrichment of snow in $\delta^{18}O$ and lower d-excess values.
- Sublimation of surface snow layering on top of the sea ice supposedly influences the vapor isotopic signature.

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## Beyond CiASOM (AWIN, PAPIN)

The isotopic observations during MOSAiC will be put in a broader regional context by comparing them to simultaneous and coordinated measurements of vapor and precipitation isotopes. The **Arctic Water Isotope Network (AWIN)** and **Pan-Arctic Precipitation Isotopes Network (PAPIN)**, both coordinated and supervised by Jeffrey Welker include sets of pan-Arctic coastal and continental stations.


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