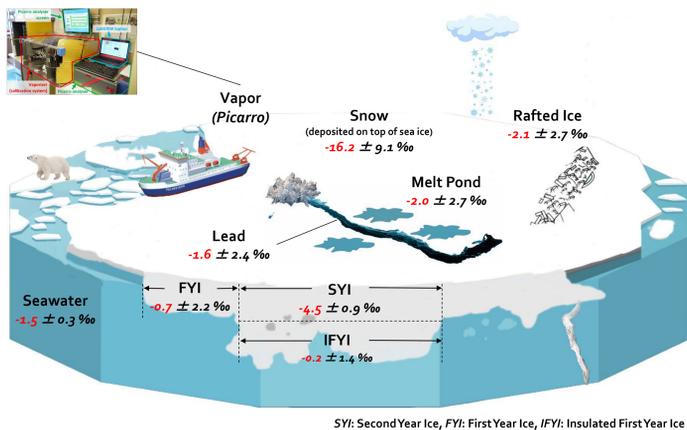


The *CiASOM* project

Changes of water isotopes in Arctic Sea ice, Ocean, and atMosphere

In our project, we employ continuous vapor and seawater isotope data, along with isotopes of discrete samples shaping the Arctic water cycle to achieve these objectives:

- A first comprehensive description of the isotopic composition of Arctic water cycle for a complete annual cycle
- Evaluation of key sea ice, ocean, and atmosphere exchange processes and their impact on Arctic water isotopes
- The imprint of sea ice conditions on the isotopic signature of Arctic water and its representation in coastal pan-Arctic stations



Water isotopes as environmental tracers

Several isotopologues of water exist in the global hydrological cycle which can be found in light to heavier water molecules. During evaporation, heavier isotopes separate from the water surface less effectively compared to lighter isotopes. This relative partitioning of heavier and lighter isotopes between liquid (or solid) phase to vapor is known as fractionation and causes enrichment of isotopes in the vapor phase.

In the atmosphere, isotopic fractionation is mostly a physical process, controlled by the mass of molecules. Meaning that the bonds between heavier molecules are stronger and their diffusion velocity is slower. These two mass-dependent effects are known as equilibrium fractionation effects and depend only on temperature. Their effect is better observed in cold temperatures and fades towards warmer conditions.

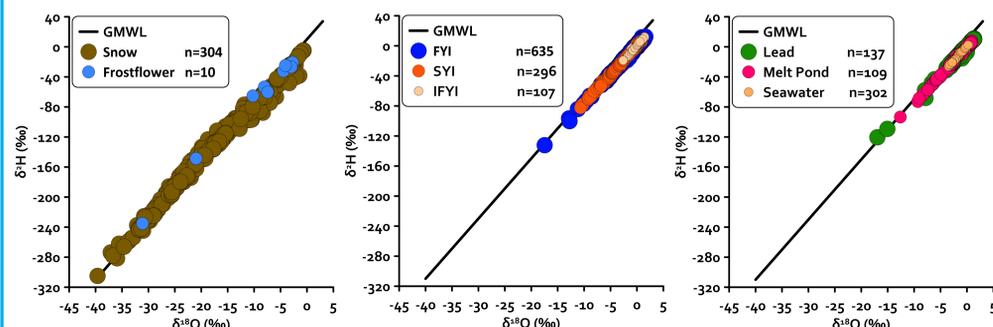
The isotopic composition of a water sample is described by δ -notation in per mille (‰): Deuterium excess or "d-excess" is a second-order isotope parameter measured in water and is affected by the conditions at the evaporation pool. When the vapor diffusion at the source happens slowly and this slow movement doesn't let the two phases reach isotopic equilibrium, non-equilibrium fractionation effects can be measured by deuterium excess (d-excess).

$$\delta^{18}O_{\text{sample}} = \left(\frac{[H_2^{18}O]}{[H_2^{16}O]}_{\text{sample}} - 1 \right) \cdot 1000$$

$$\text{deuterium excess} = \delta^2H - 8 \cdot \delta^{18}O$$

(Common standard: Vienna Mean Ocean Water, VSMOW)

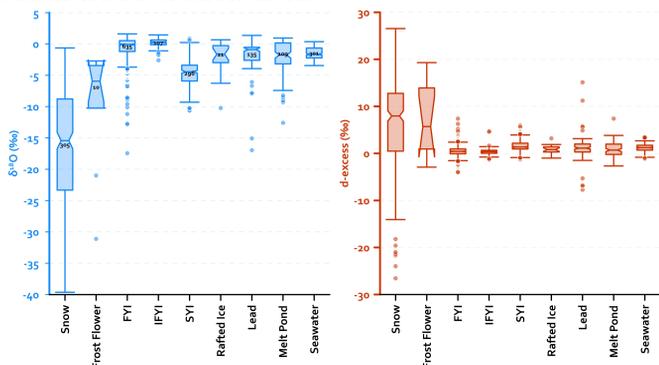
Overall statistics



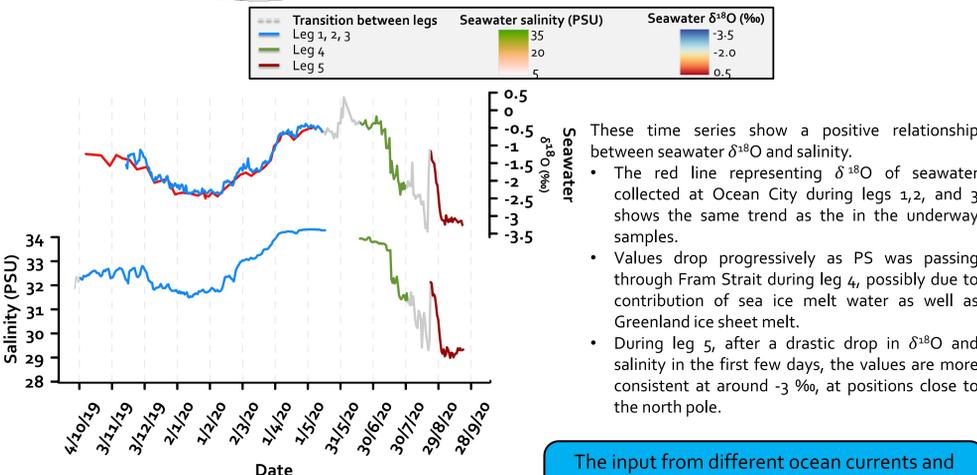
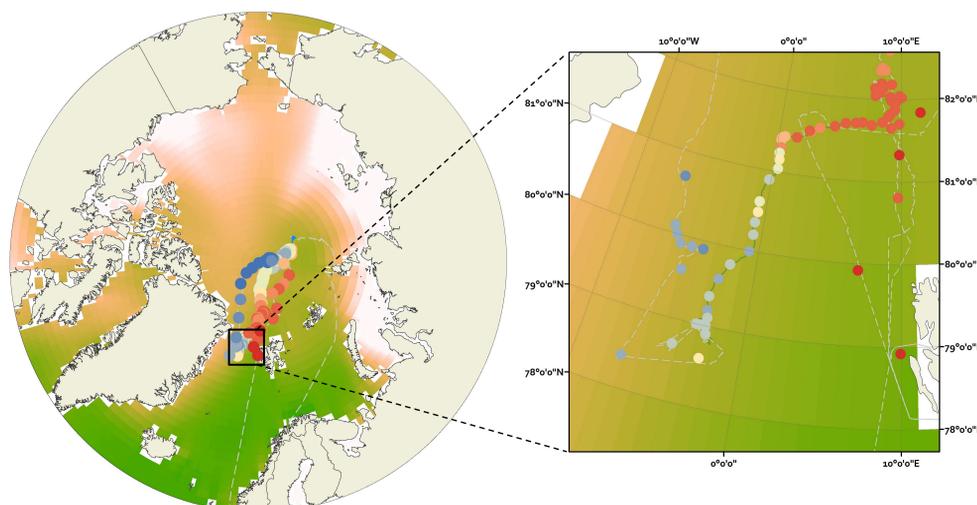
- Global Meteoric Water Line (GMWL) describes the global annual average relationship between hydrogen and oxygen isotope ratios in natural meteoric waters and is presented here as a reference for co-isotope relationships
- Snow has the most depleted & variable isotopic signature
- Seawater is the most enriched compartment in $\delta^{18}O$
- A mixture of snow and sea ice at the interface between both

is possible since many FYI and SYI samples have very light isotopic compositions

- Meltwater layers of ponds have wider range and generally more depleted values compared to seawater
- Lead plots mainly on the upper part of the line with a few samples with snow signature

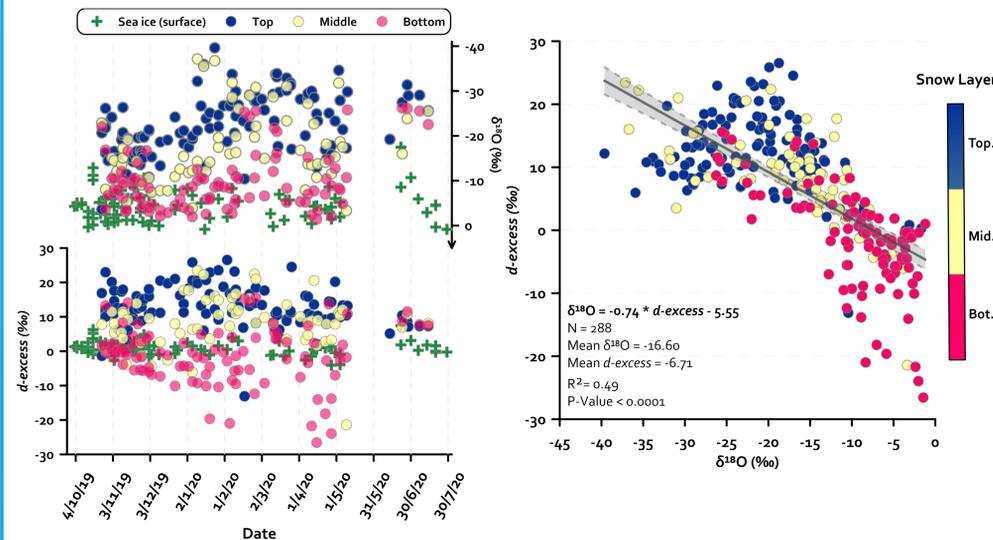


Seawater



The input from different ocean currents and freshwater sources can be traced by $\delta^{18}O$ in seawater.

Snow



Deposited snow on top of the sea ice was sampled in three layers from different locations on the MOSAIC ice floe opportunistically. Comparing the snow $\delta^{18}O$ and d-excess values at top, middle, and bottom layers with that of sea ice at surface, suggests possible mixture of snow at the bottom with sea ice surface.

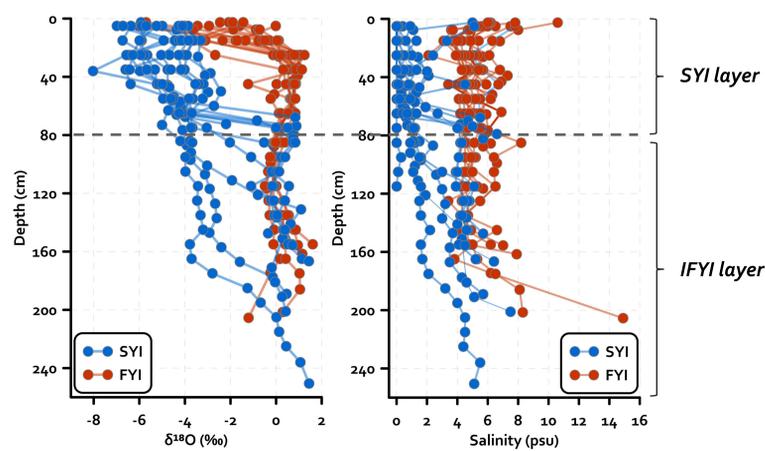
Hence, the d-excess of the bottom layer of snow shows a progressive depletion trend during the winter times. This can be interpreted as the effect of processes within the deposited snow profile.

The relationship between $\delta^{18}O$ and d-excess is variable in different layers and is a negative relationship in general.

An offset in $\delta^{18}O$ values from surface to bottom is observed. The surface snow has a lighter signature as expected from atmospheric-sourced compartments and at the bottom the more enriched values point out to sublimation and diffusion along the snow depth.

Sea Ice

Dark Sector stations (FYI & SYI)



Sea ice cores were sampled weekly at BGC stations (e.g., BGC 1, BGC2, BGC 3, DS_FYI, DS_SYI). The plots above show $\delta^{18}O$ and salinity of sea ice cores collected from dark sector FYI and SYI stations. These stations were identified as younger ice (FYI) and older ice (SYI) stations at the beginning of campaign based on

their depths. IFYI layer of the sea ice was identified as the new ice growing at the bottom of SYI during same winter. This can be also observed in isotopic signature of sea ice as $\delta^{18}O$ of older ice is more depleted than IFYI.

Sea ice growth is apparent in isotope values as the younger ice has a more enriched isotopic signature (closer to seawater signal) compared to older ice.

