# MOSAiC's Arctic water isotope: A basin-wide network of *in-situ* water vapor and precipitation measrurements on land and on the Polarstern

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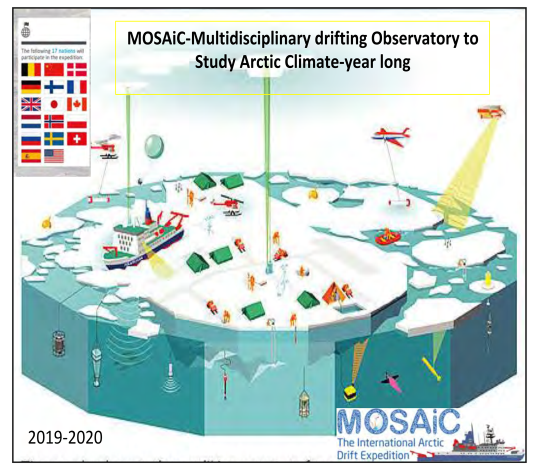
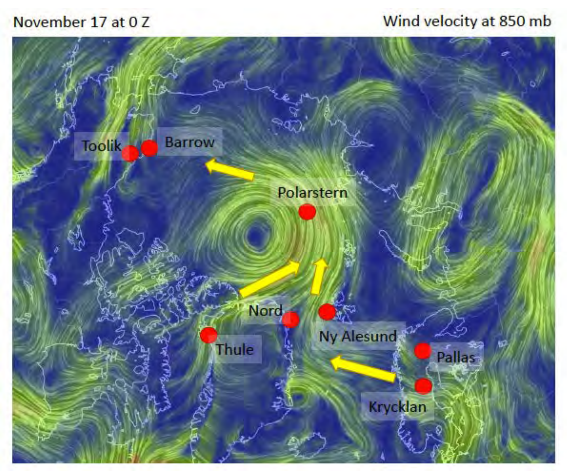
## Abstract and Context

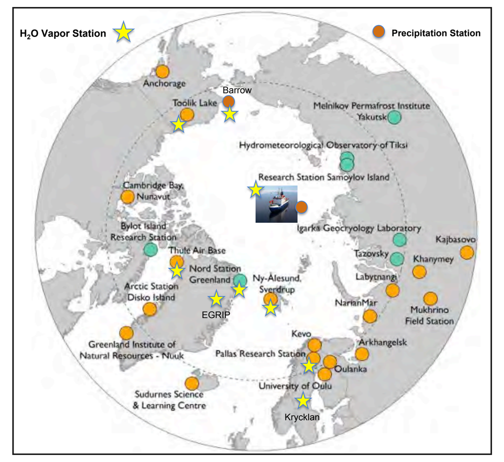
The year-long, polar night centric, interdisciplinary study of the Arctic (MOSAiC) is now underway. The Polarstern is frozen in and drifting from the eastern Arctic across the N Pole and through the Fram Statins into the Greenland Sea and the Barents region over the next 9 months. Central to MOSAiC is our study of the interactions between sea ice, atmospheric processes and synoptic climatology. We are focused on moisture source processes and isotopic ($\delta^{18}O$, $\delta^2H$ and *d-excess*) fractionation and moisture transport within, into and out of the Arctic. Our program of study uses the Arctic Water Isotope Network (AWIN) coupling land-based station measurements with those aboard the Polarstern to measure and track in near real-time Arctic water isotope processes.

## Field Measurements and the Arctic Water Isotope Network (AWIN)

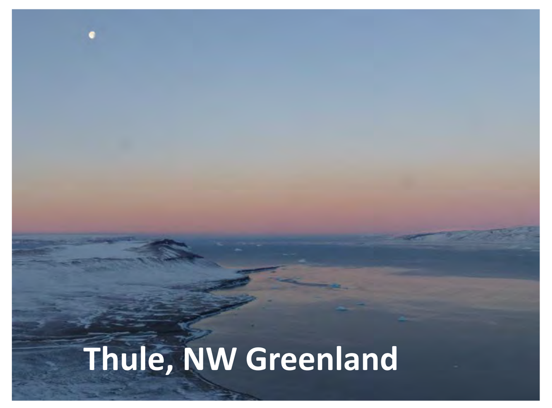
MOSAiC is now collecting atmospheric, cryosphere, and biogeochemical information and data using the Polarstern as the primary base of operations with simultaneously measurements with satellites, aircraft, on ice, under ice and with our surrounding Arctic Basin network, AWIN.



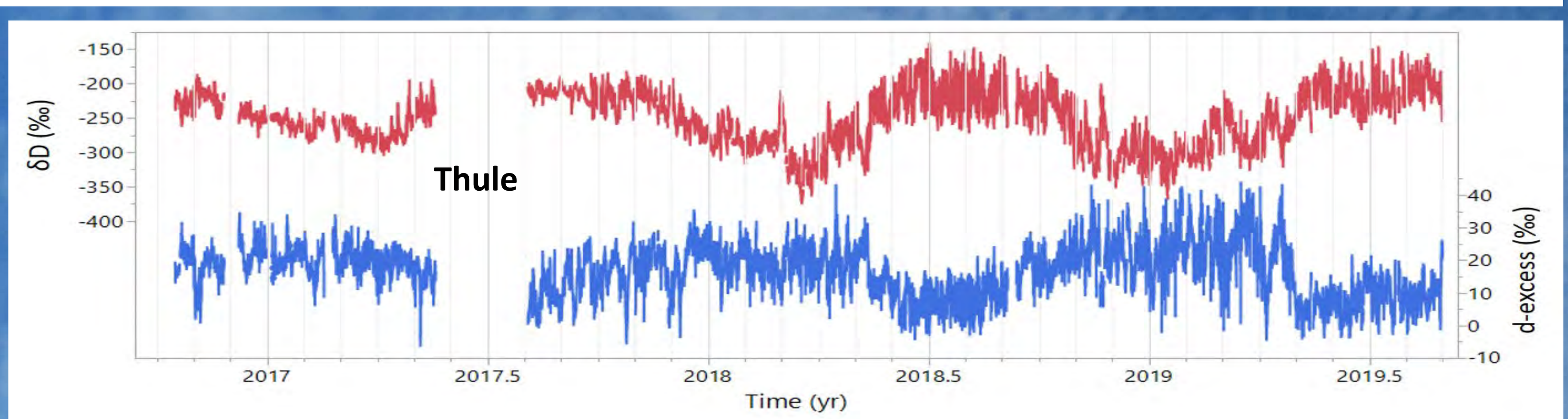



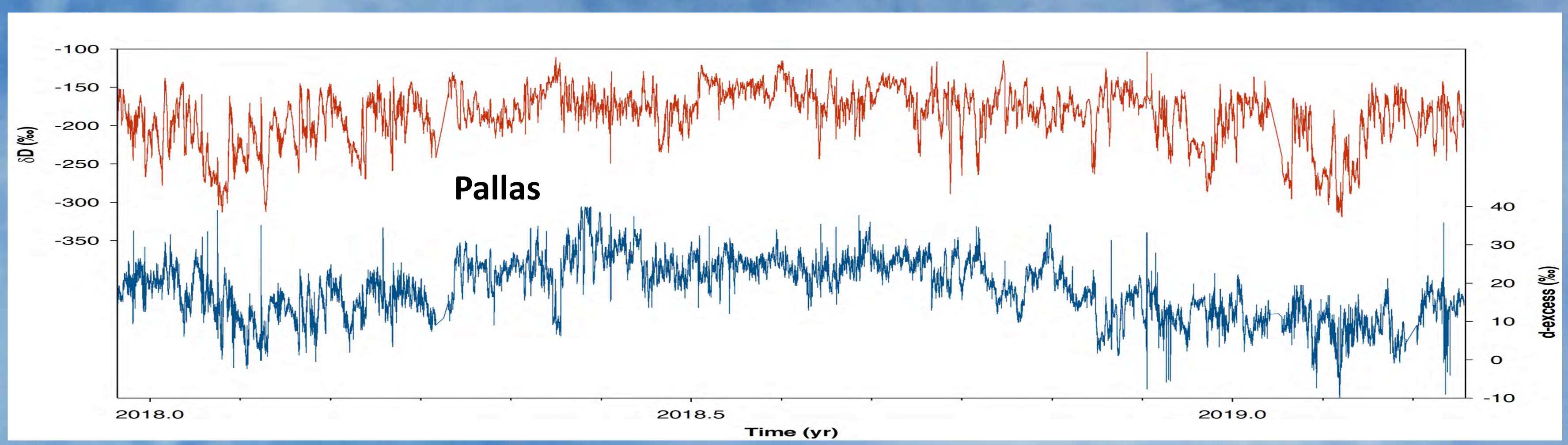







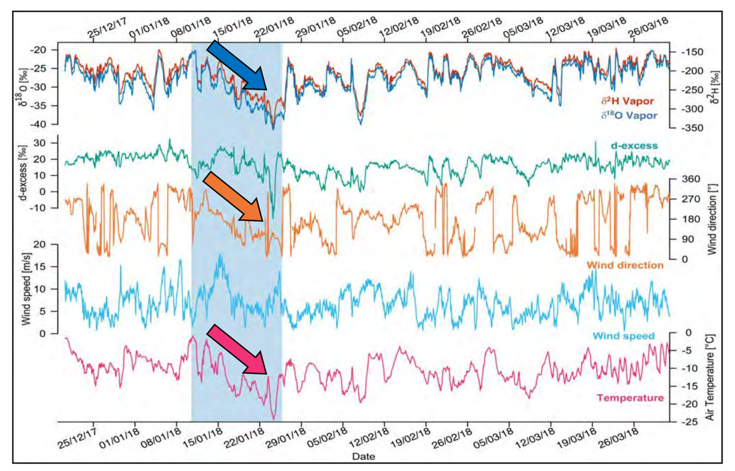

Water Vapor Isotope Time Series; Thule, NW Greenland & Pallas, Arctic Finland, (5 Min averages)




## Water Vapor $\delta^{18}O$ and $\delta^2H$ in Arctic Finland and NW Greenland

### Pallas Atmospheric Station, Finland



High frequency measurements depicting rapid shift in moisture source and water vapor isotopic values.

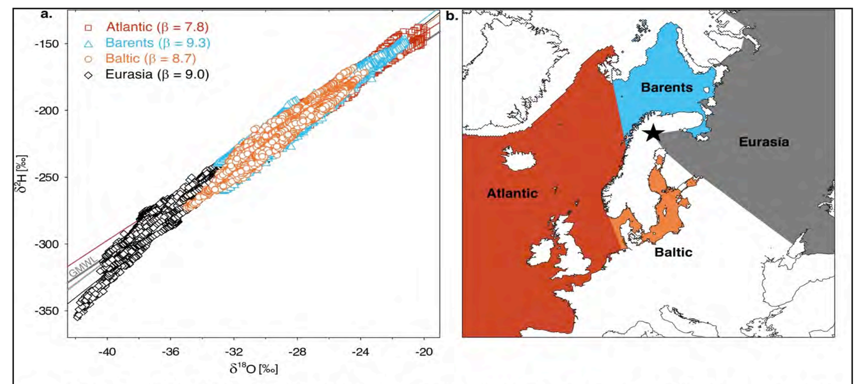



**Figure 2.** (a) Pallas winter 2017/18 water vapor isotope data (5 minute averages). Symbols and isotopic water lines are categorized into (b) vapor source regions identified by HYSPLIT back-trajectory analysis. Marine boundaries between the Barents - Atlantic - Baltic regions derive from the National Snow and Ice Data Center (NSIDC, 2019). The location of Sammaltunturi Station in Pallas-Yllästunturi National Park, Finland, is indicated (star), as well as the mean February 2018 sea ice extent (NSIDC, 2018).

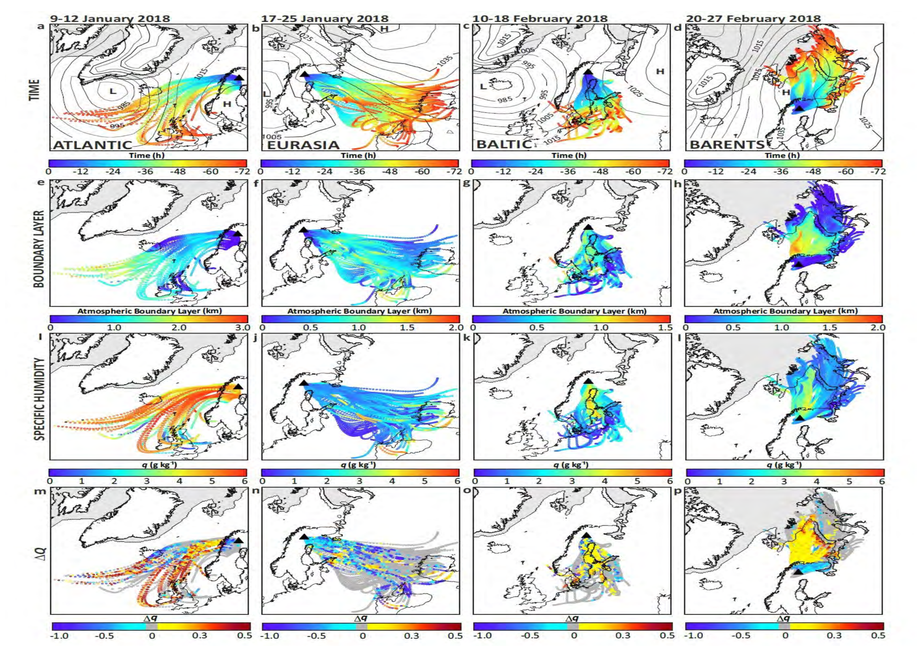
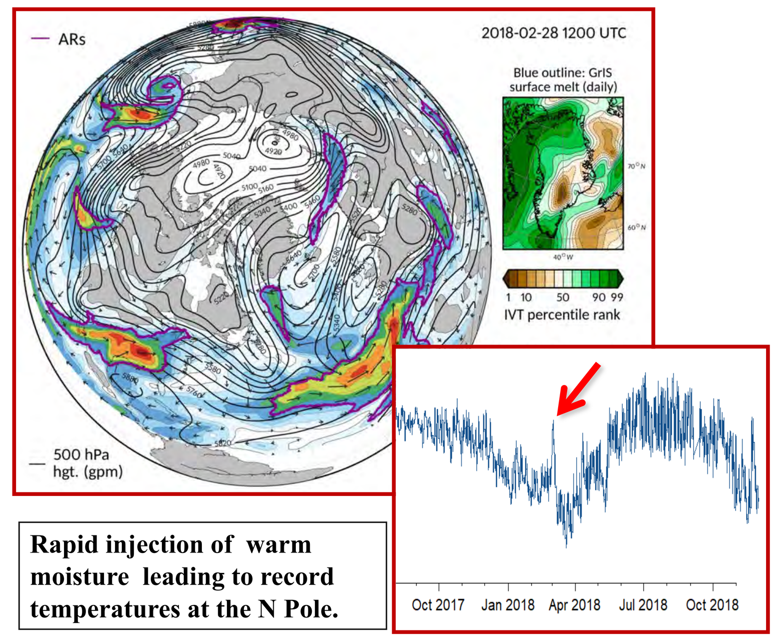



**Figure 3.** History of air parcels arriving at Pallas during four separate time periods between 9 January and 27 February 2018. Air parcel trajectories were started from Pallas at hourly intervals and modelled back in time for 72 hours. Coloured circles along the trajectories depict hourly values of (a-d) Time; (e-h) Boundary Layer Height; (i-l) Specific Humidity, $q$; and (m-p) Changes in specific humidity, $\Delta q$, of the air parcel. Positive $\Delta q$ values reflect a moisture increase associated with evaporation; negative $\Delta q$ values reflect a moisture decrease associated with precipitation. Grey circles indicate either no net moisture change, or that the change occurred *above* the atmospheric boundary layer and hence cannot be assigned to an evaporative source (e.g., Sodemann et al. 2008). Contour lines in (a-d) depict ERA-Interim daily composited sea level pressure (850 mb) over the corresponding time interval (NOAA, 2018), and the grey shaded region represents sea ice (NSIDC, 2018). Back-trajectories were computed using the GDAS (0.5 degree) dataset in HYSPLIT (Rolph et al. 2017; Stein et al. 2015) and mapped in Surfer ®.

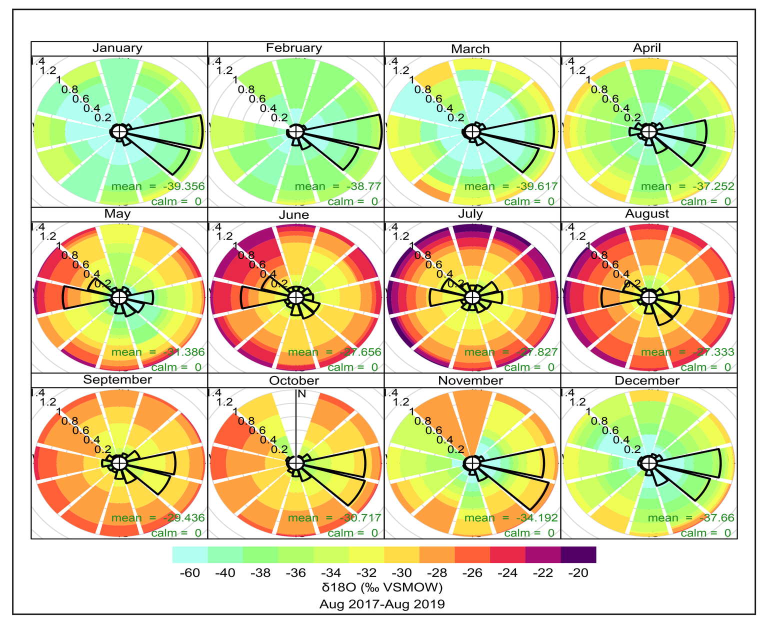
Arctic Finland Highlights

- The prevailing winter air mass is from the Barents Sea region (i.e. the north)
- The "source region" of each back-trajectory (i.e.120 hrs prior to arrival) does not clearly explain vapor isotope values
- Instead, trajectory vapor $\delta^{18}O$and $\delta^2H$ can be distinctly categorized by it's proximal sea region, prior to arrival at Pallas
- These four distinct regions are identified below – Eurasia, and the Barents, Norwegian, and Baltic Seas

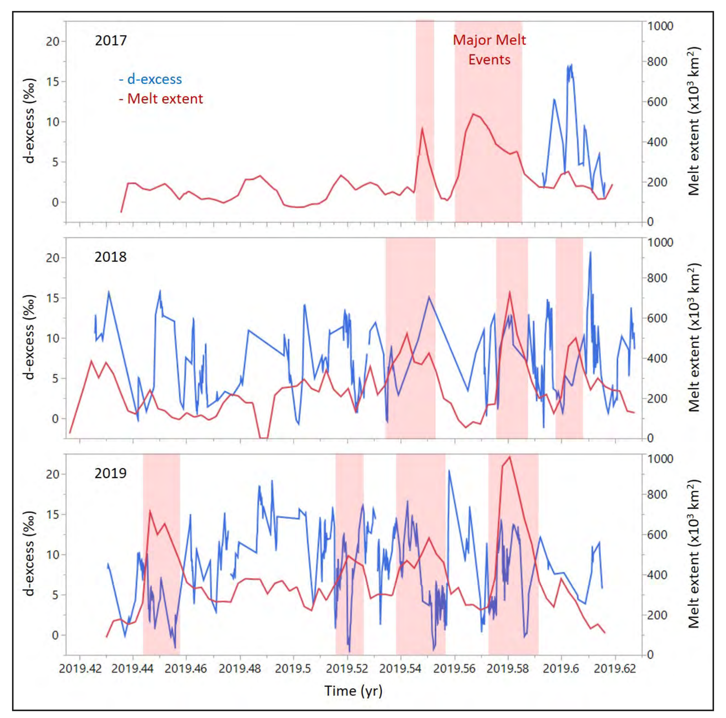
### South Mountain Station, Thule




Rapid injection of warm moisture leading to record temperatures at the N Pole.

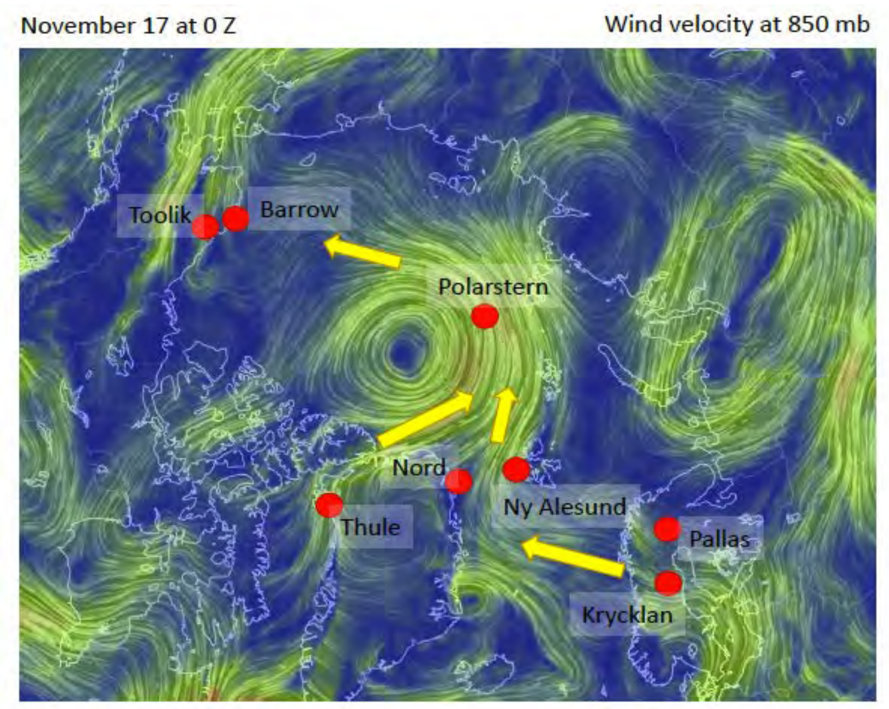


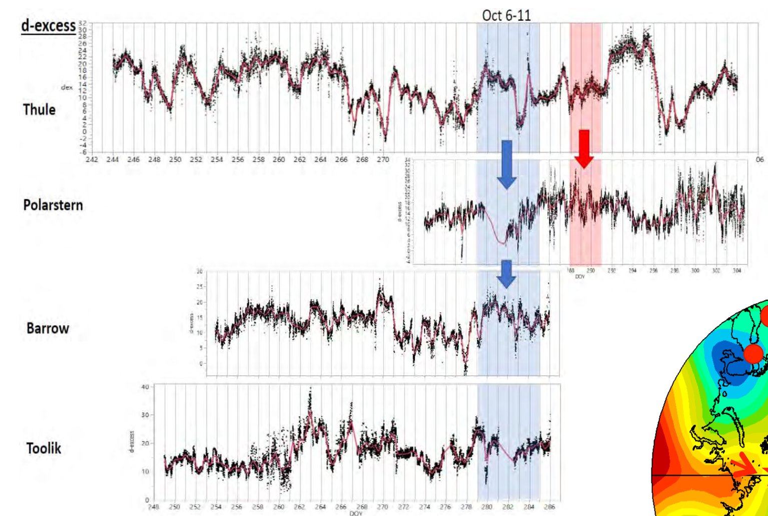

Monthly Isoroses of water vapor averaged over 2 years with the black triangles depicting the dominant wind directions.

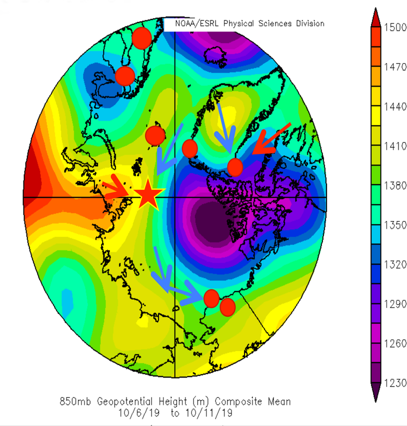



Time series of d-excess (blue) and GIS melt extent (red) over the summer melt seasons in 2017-2019. Major melt events (peak melt extent exceeds 400,000 km²) highlighted in red.

## Multi-site Water Vapor Analysis



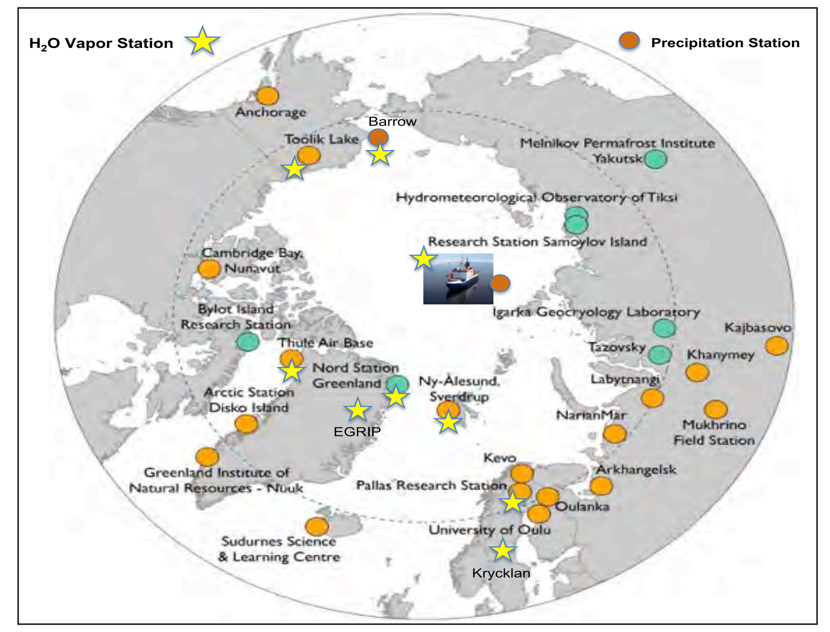
6-11 Oct 2019 daily composited Geopotential Height (850mb)

**Polarstern** Low *d-excess*/high $\delta^2H$ during the 6-11 Oct interval is mainly driven by a large region of Low pressure centered over the Arctic driving a "N Atlantic type" open water moisture signal to the Polarstern (red star). High d-excess/low $\delta^2H$ during the subsequent 15-18 Oct interval is driven by a switch in wind direct and air/moisture coming from across the Arctic sea ice to the Polarstern.

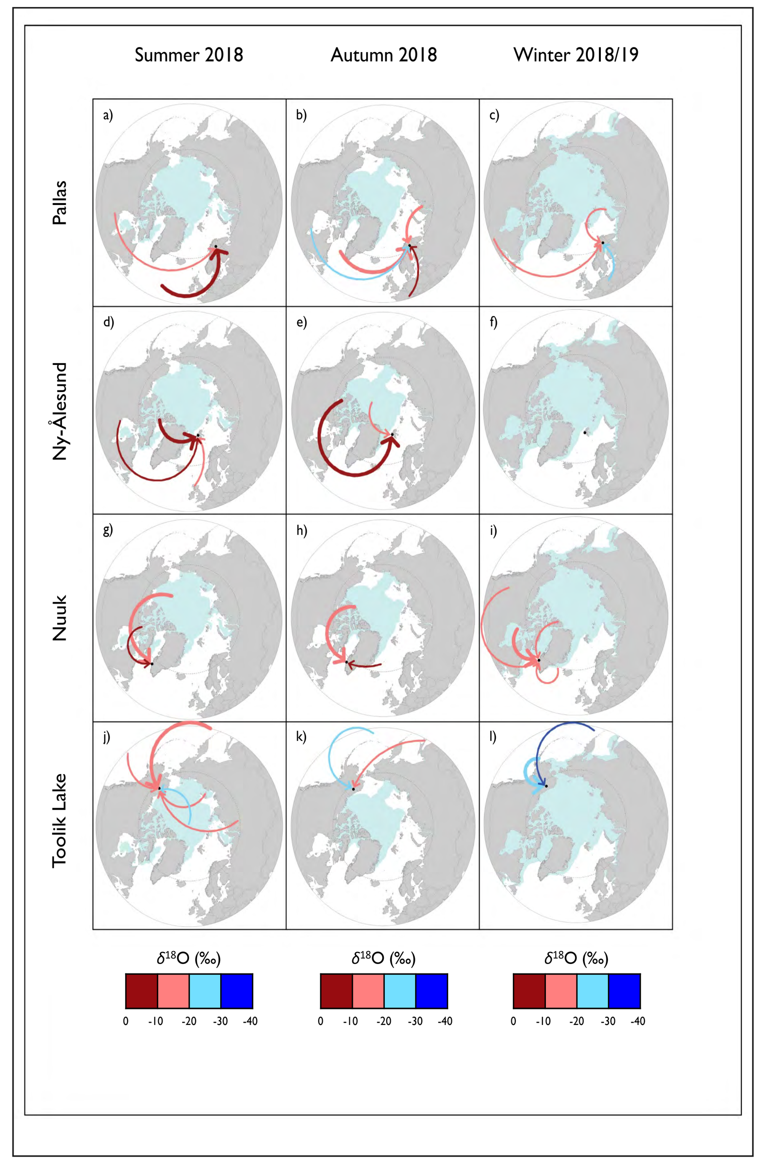
**Barrow**
Relatively low *d-excess*/high $\delta^2H$ days 271-278 seems to be driven by a Low sitting over the Chukchi Sea that's driving south-westerlies across the Bering Sea to Barrow. Then on day 279 (6 Oct) the low merges with one centered over Nunavut & we get the switch to northerlies & higher *d-excess* at Barrow. These higher Barrow *d-excess* values associated with northerlies may reflect intense evaporation as the Arctic air crosses the sea ice and into the open water of the Beaufort Sea (e.g. Kurita, 2001; Klein et al. 2015).

**Thule (21/10)**
High *d-excess*/low $\delta^2H$ event is driven by a High over Greenland that's driving wind across the ice sheet to Thule. In the subsequent days as the High moves, there is then a switch to Baffin Bay derived moisture with lower *d-excess*/higher $\delta^2H$.

## Pan Arctic Precipitation Isotope Network (PAPIN)




## Multi-site seasonality in Precipitation Sources-2018




Individual Back Trajectories and their water isotope values plotted on top of sea ice traits and synoptic weather systems.