AICC Winter Meeting 2025 Underway Data Update: Water Isotopes

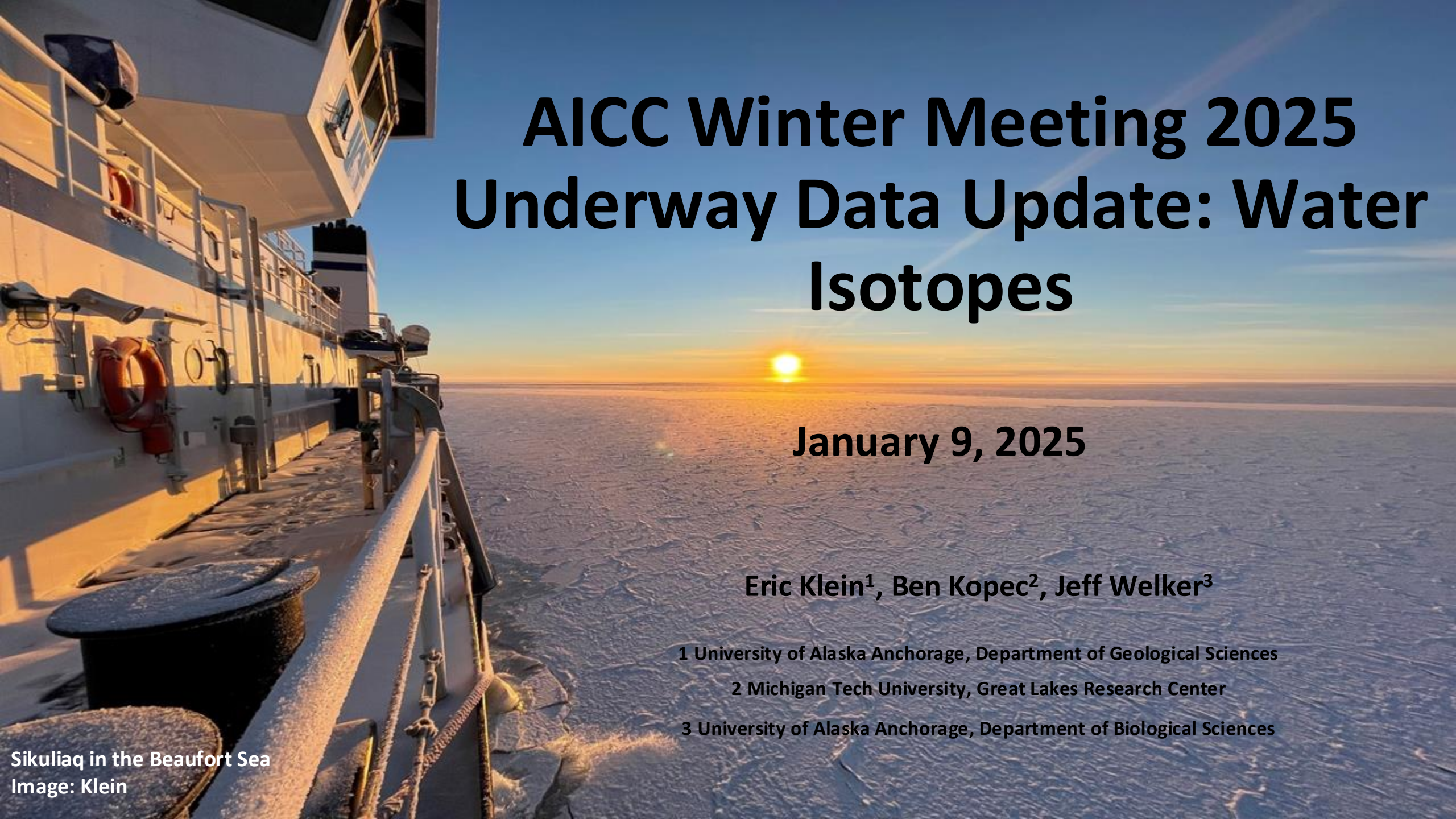
January 9, 2025

Eric Klein[1], Ben Kopec[2], Jeff Welker[3]

1 University of Alaska Anchorage, Department of Geological Sciences

2 Michigan Tech University, Great Lakes Research Center

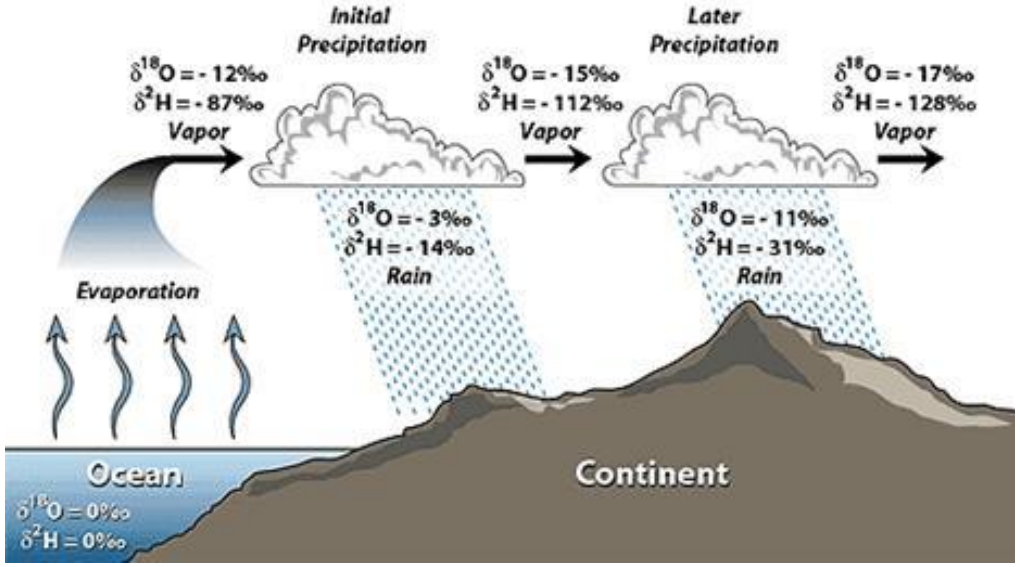
3 University of Alaska Anchorage, Department of Biological Sciences



Sikuliaq in the Beaufort Sea
Image: Klein

Overview

- Brief background info on water (vapor) isotopes in the Arctic
- Recent data, results, publications, next steps



GNS Science

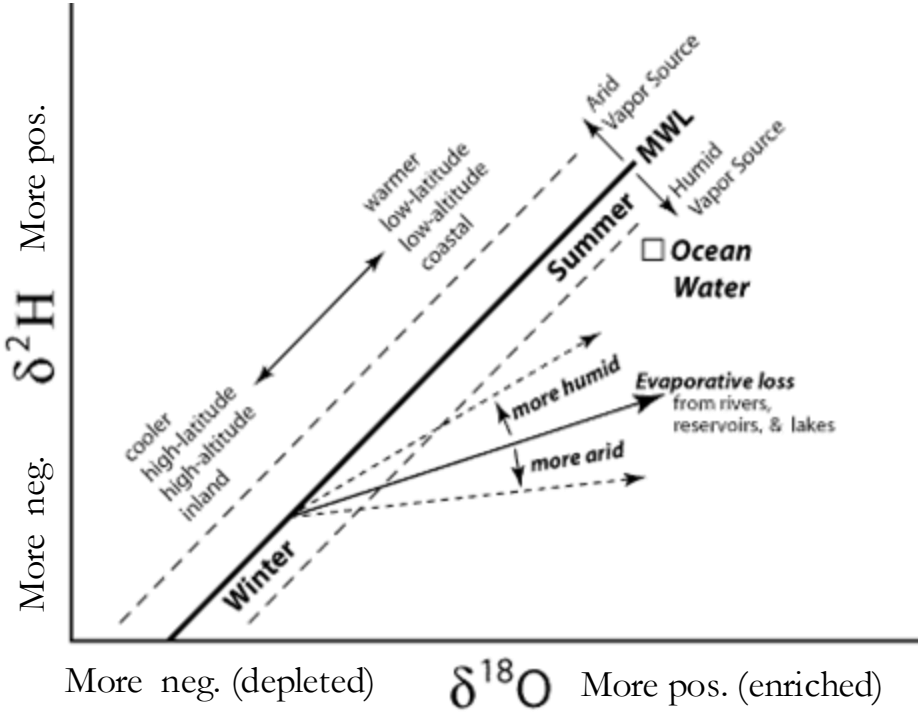
Isotopes in the water cycle

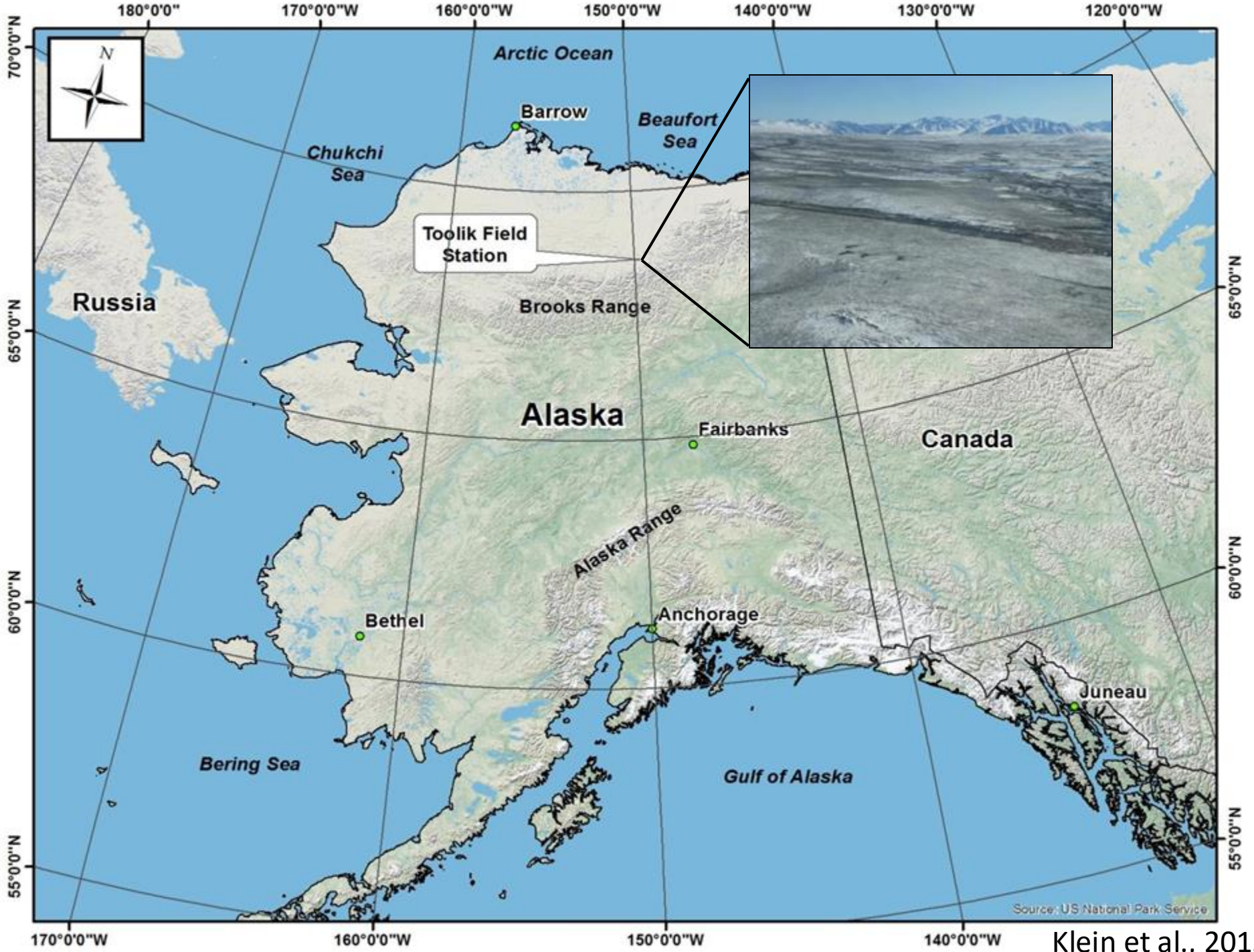
- Light and heavy isotopes of oxygen (^{16}O, ^{18}O) and hydrogen (^{1}H, ^{2}H) in water
- Preferential evaporation/precipitation

Modified from Clark and Fritz, 1997

Water lines

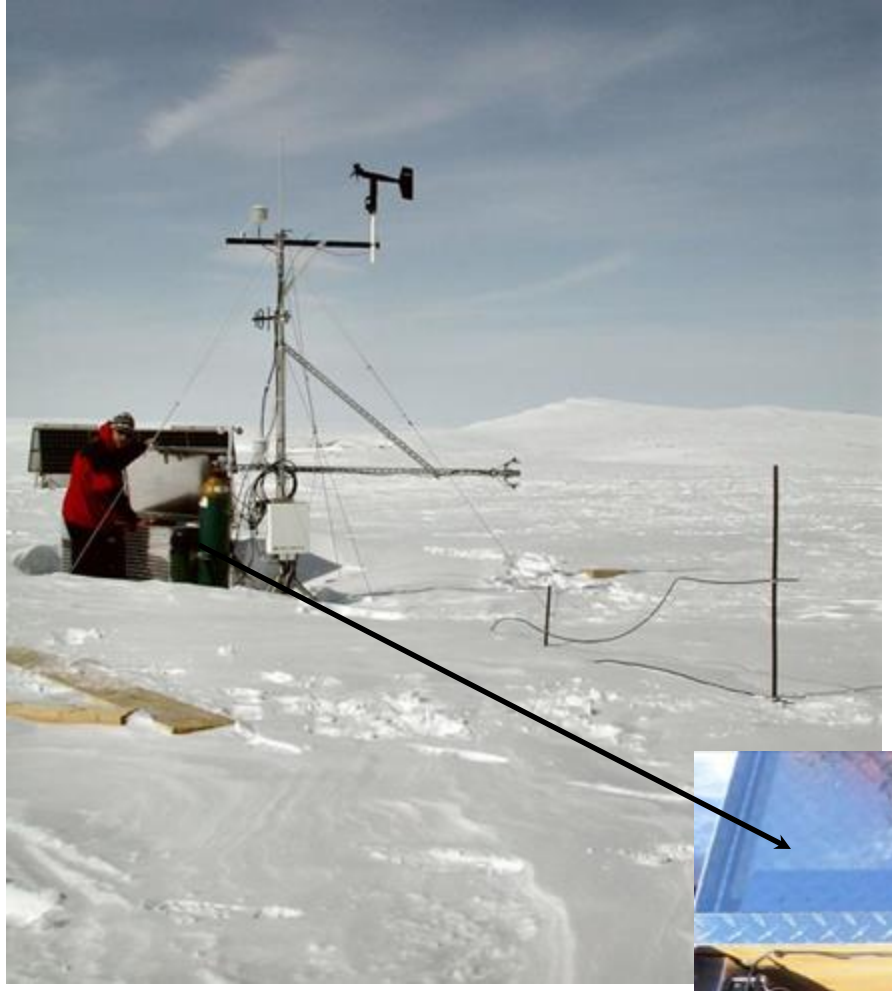
- Display relationship between isotope ratios
- Can vary across locations and climates





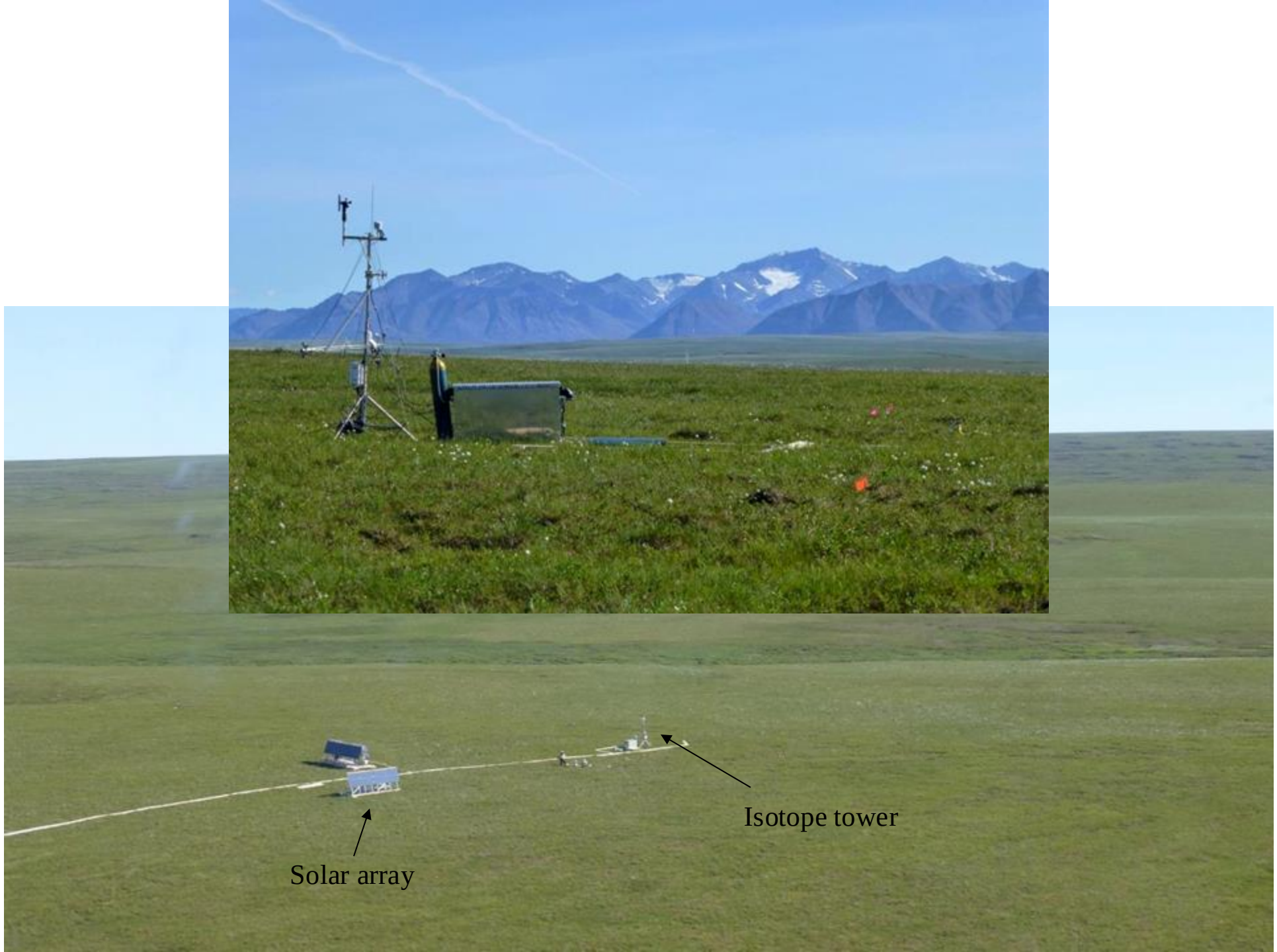
Klein et al., 2015

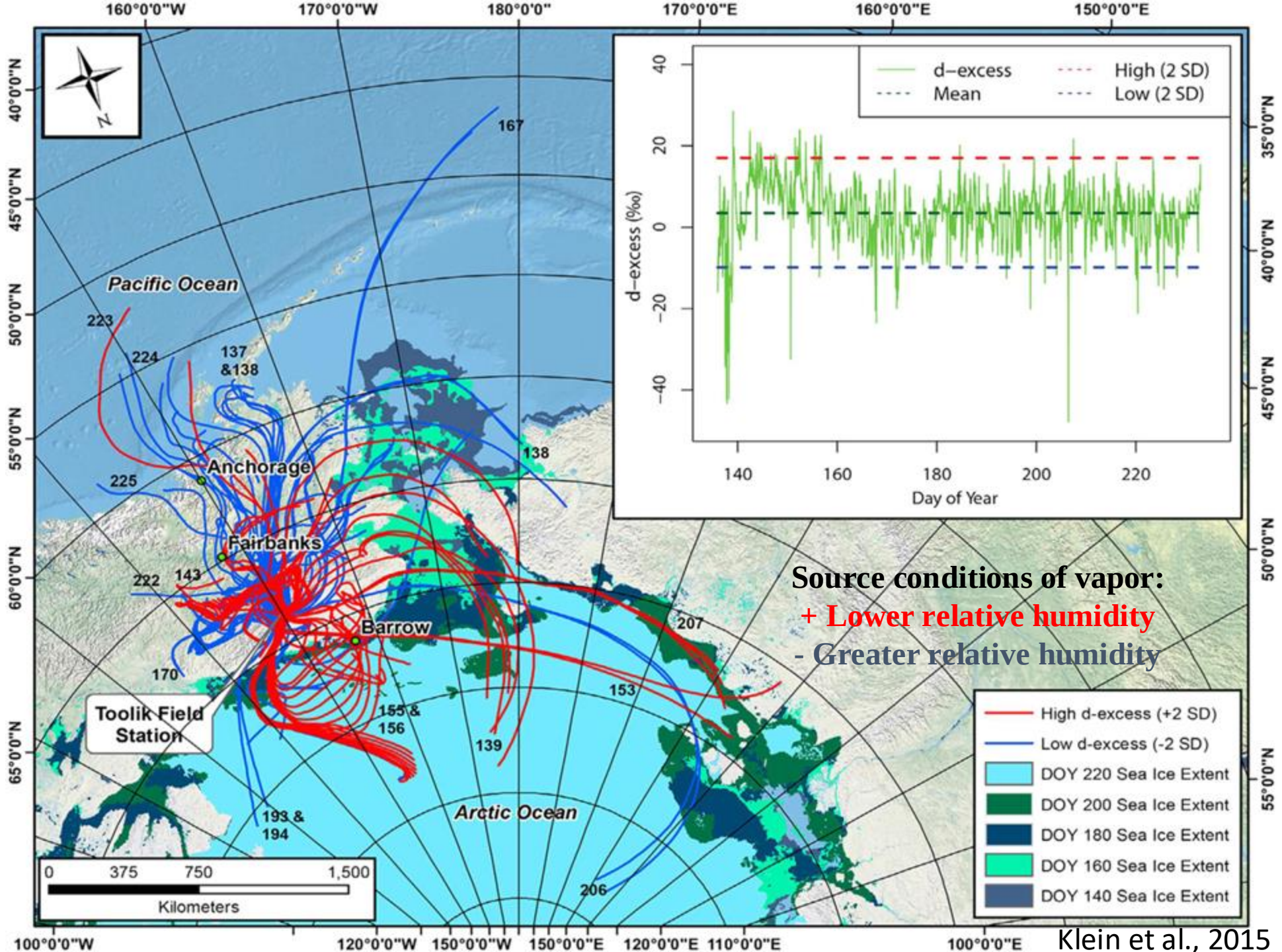

Water vapor isotopes (2013)
Isotope tower
Solar array
Toolik Lake, Arctic Alaska



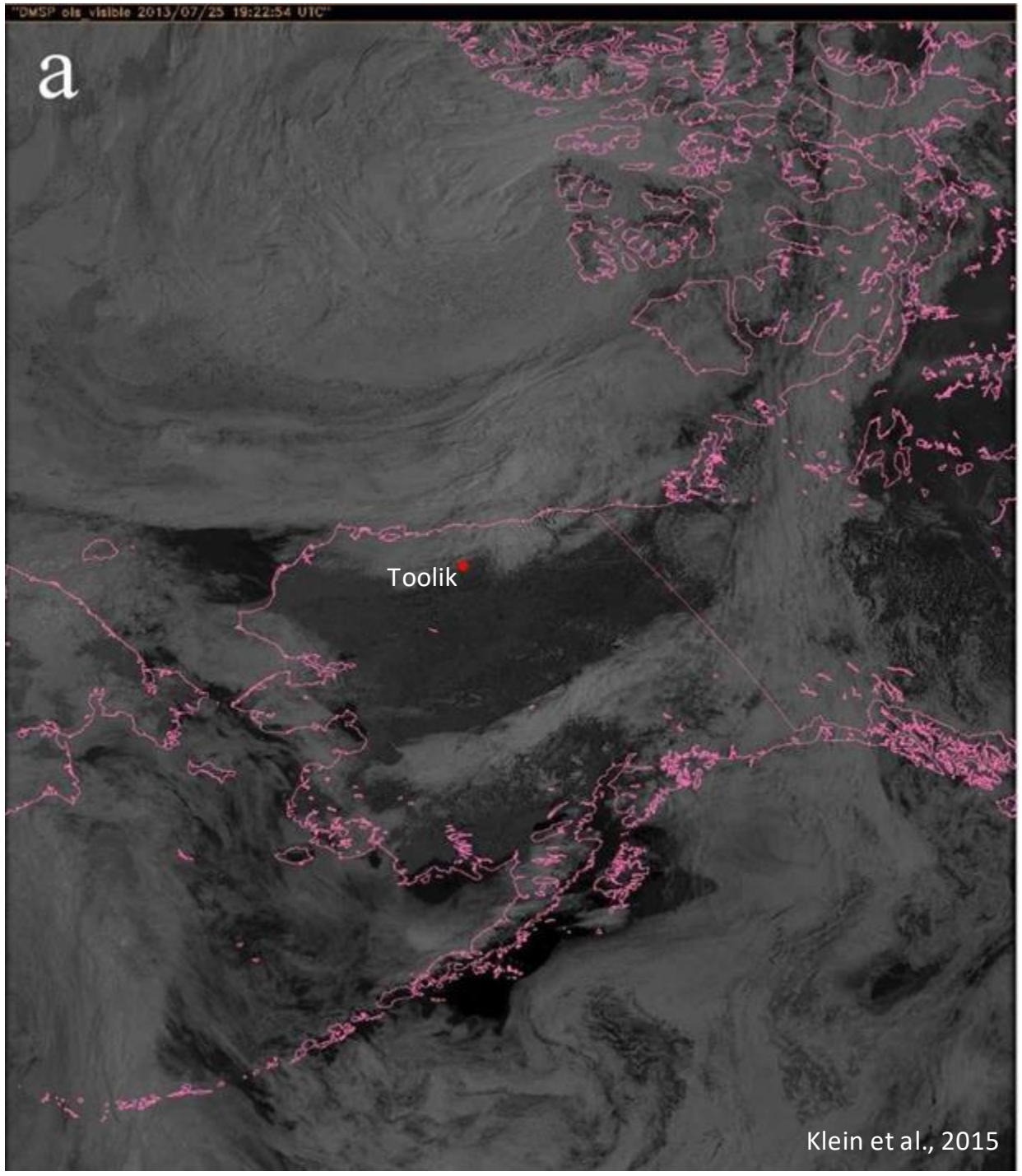
- Weather instruments on tower
- Air sample valve
- Real time measurements

- Enclosure with isotope analyzer


Isotope tower
Solar array



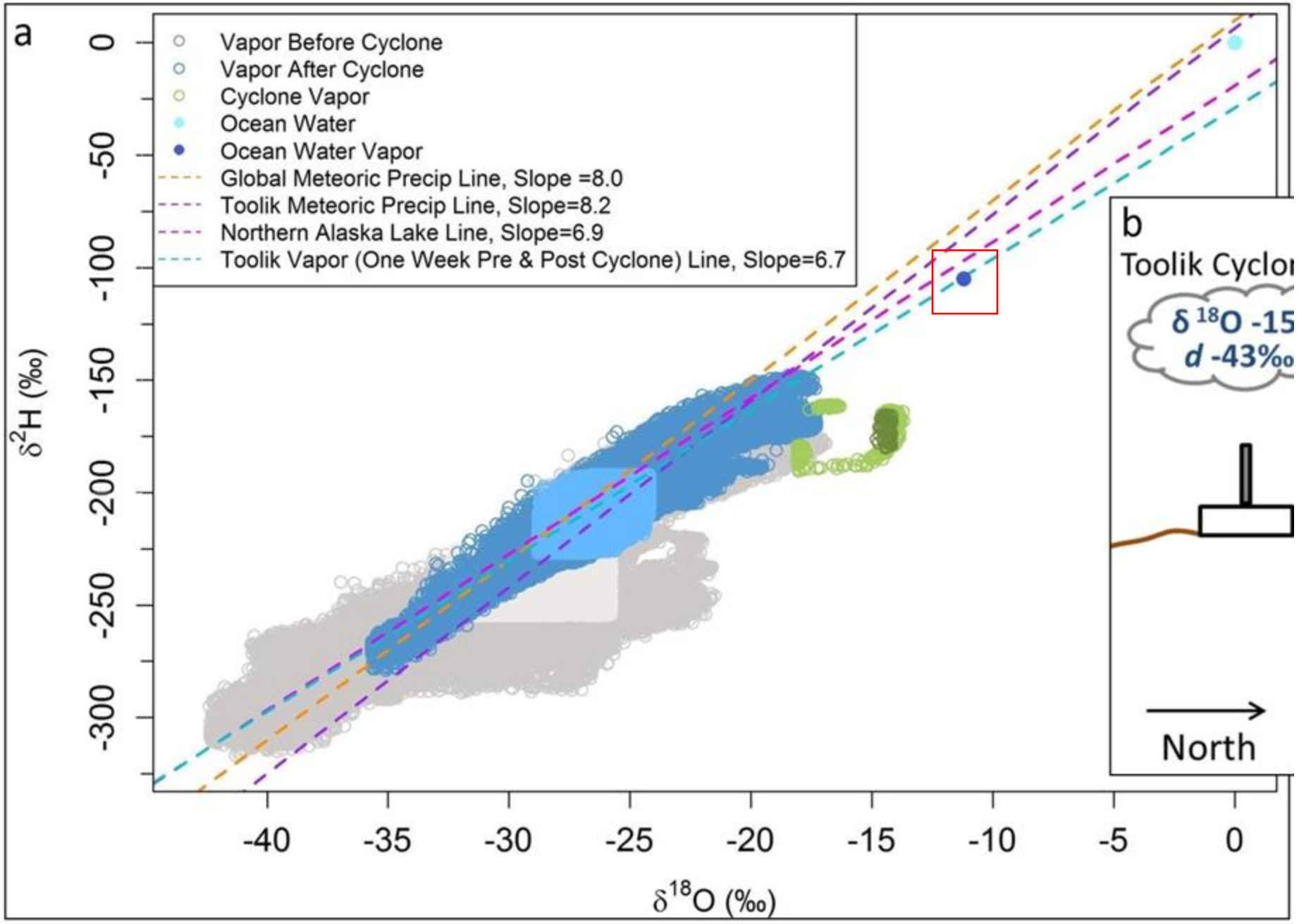
Klein et al., 2015



Arctic cyclone

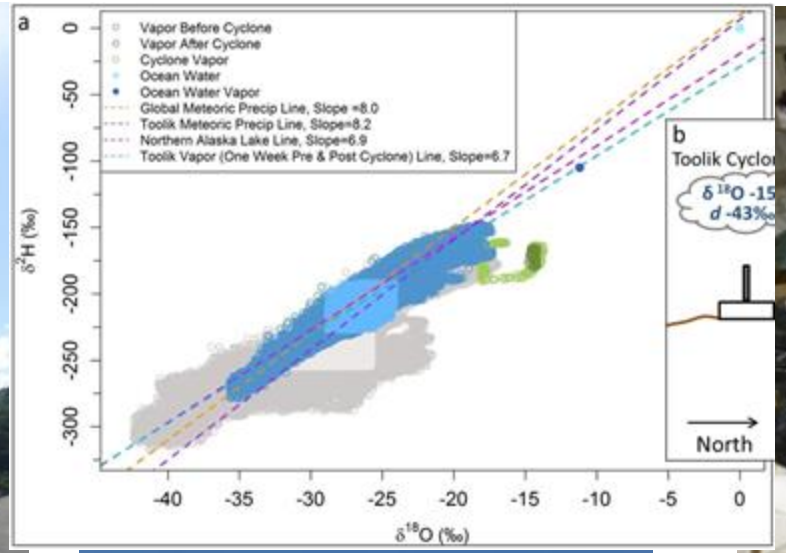
~July 24th - 26th, 2013

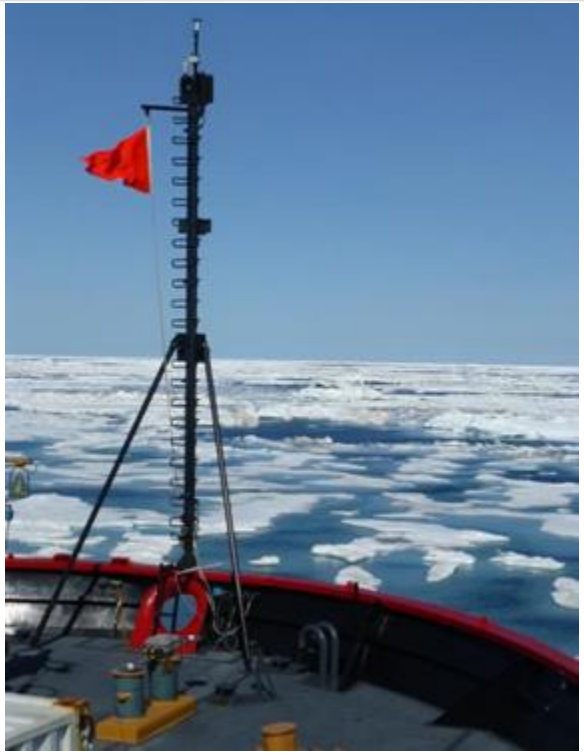
Satellite image: NOAA

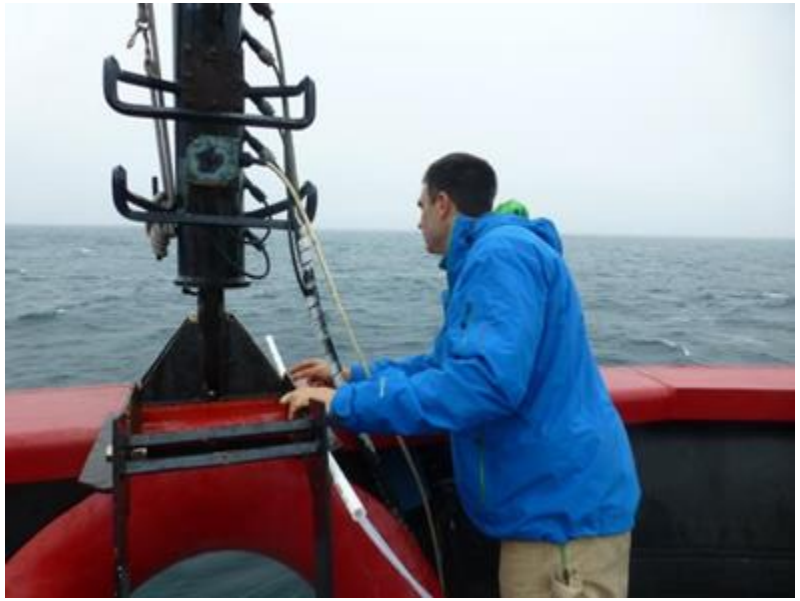


What are actual ocean water vapor isotope values? Klein et al., 2015

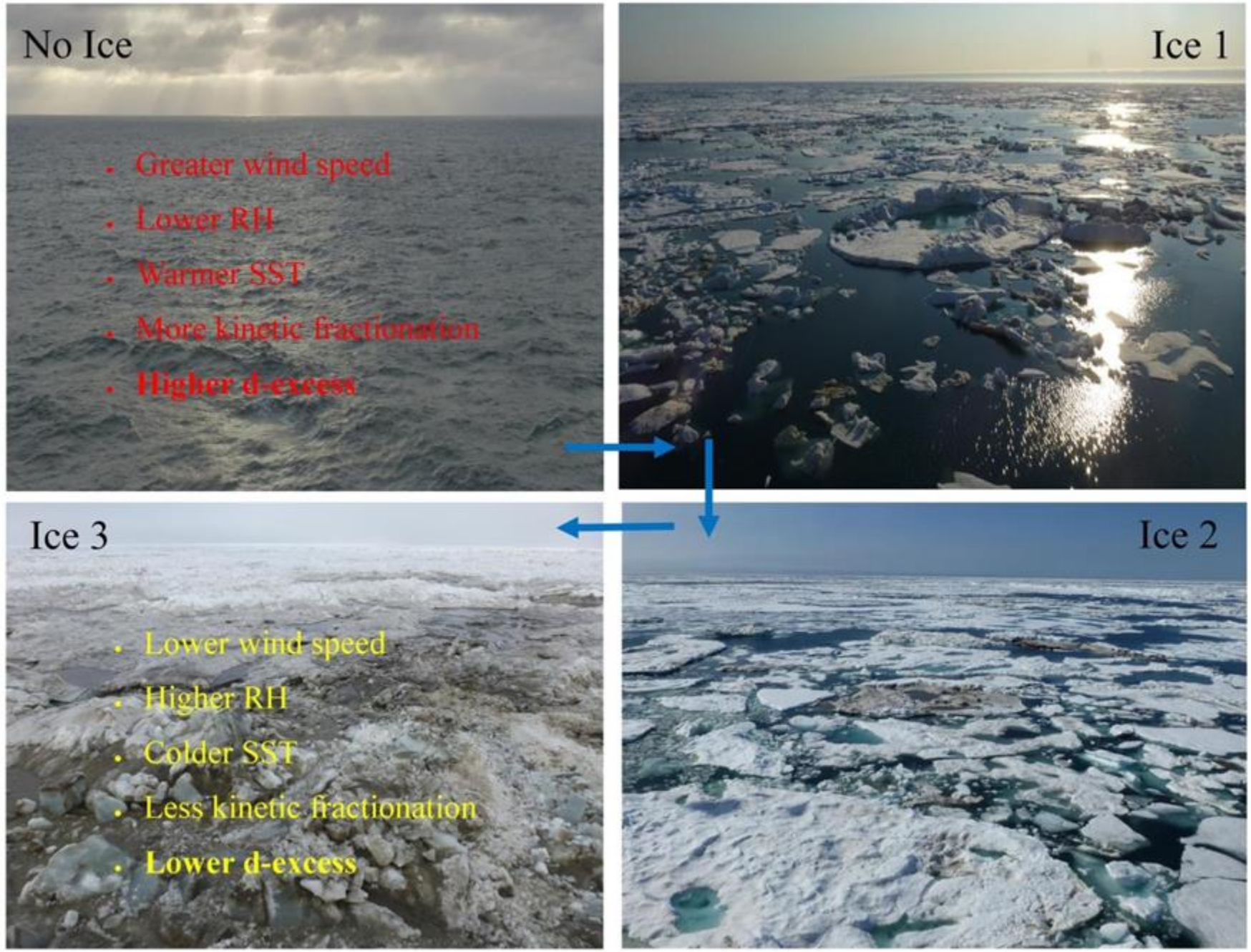
Ocean Water Isotope Sources and Sea Ice Changes

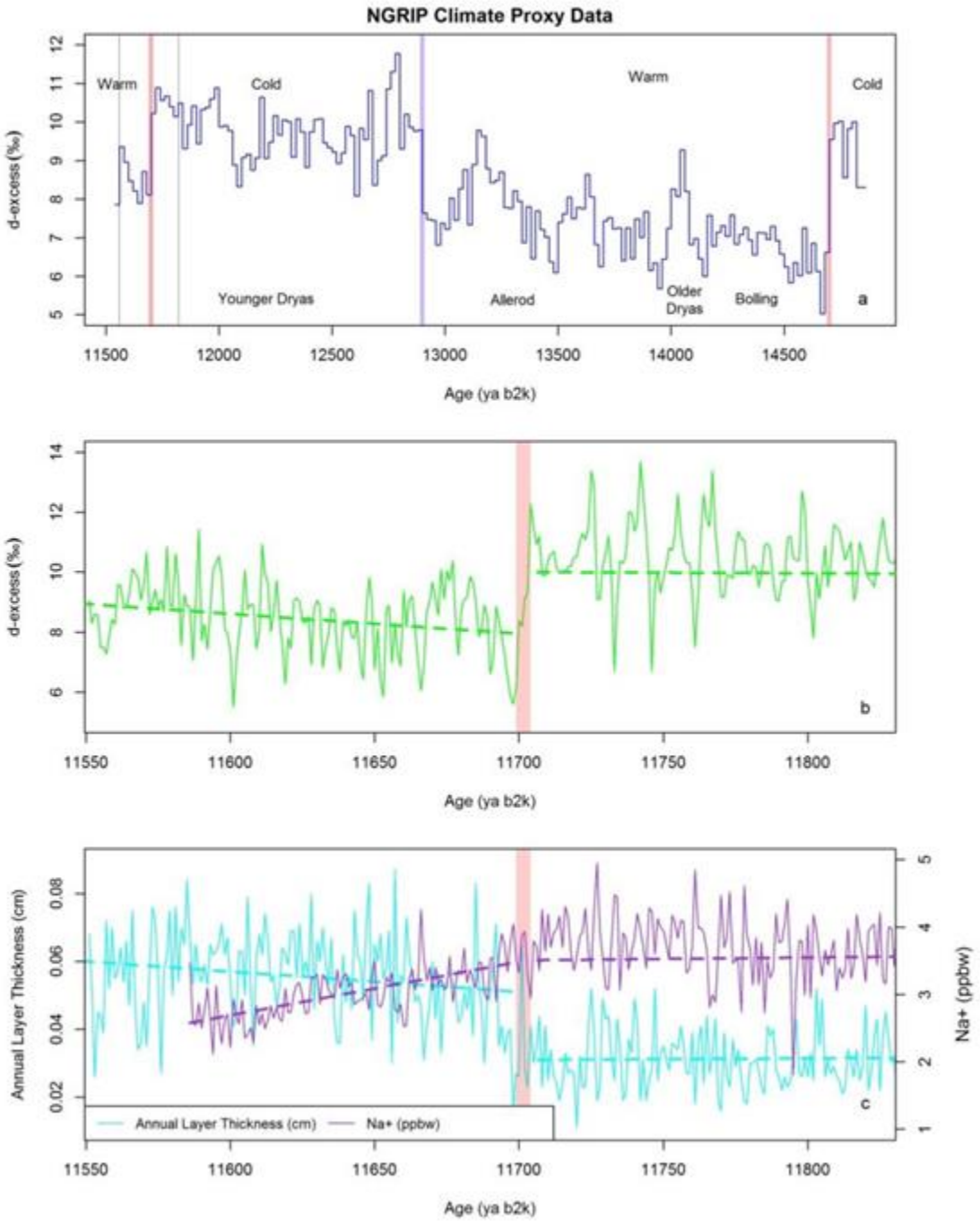




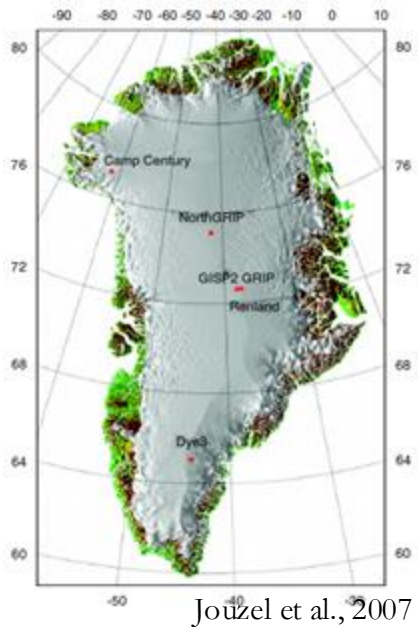


Healy in Northern Chukchi Sea

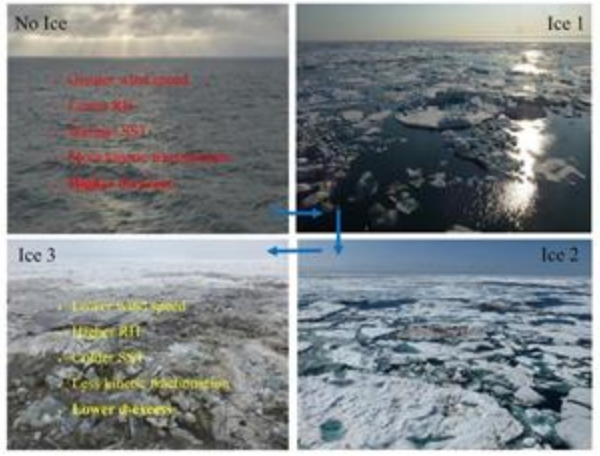

No Ice
Greater wind speed
Lower RH
Warmer SST
More kinetic fractionation
Higher d-excess
Ice 1
Ice 2
Ice 3
Lower wind speed
Higher RH
Colder SST
Less kinetic fractionation
Lower d-excess

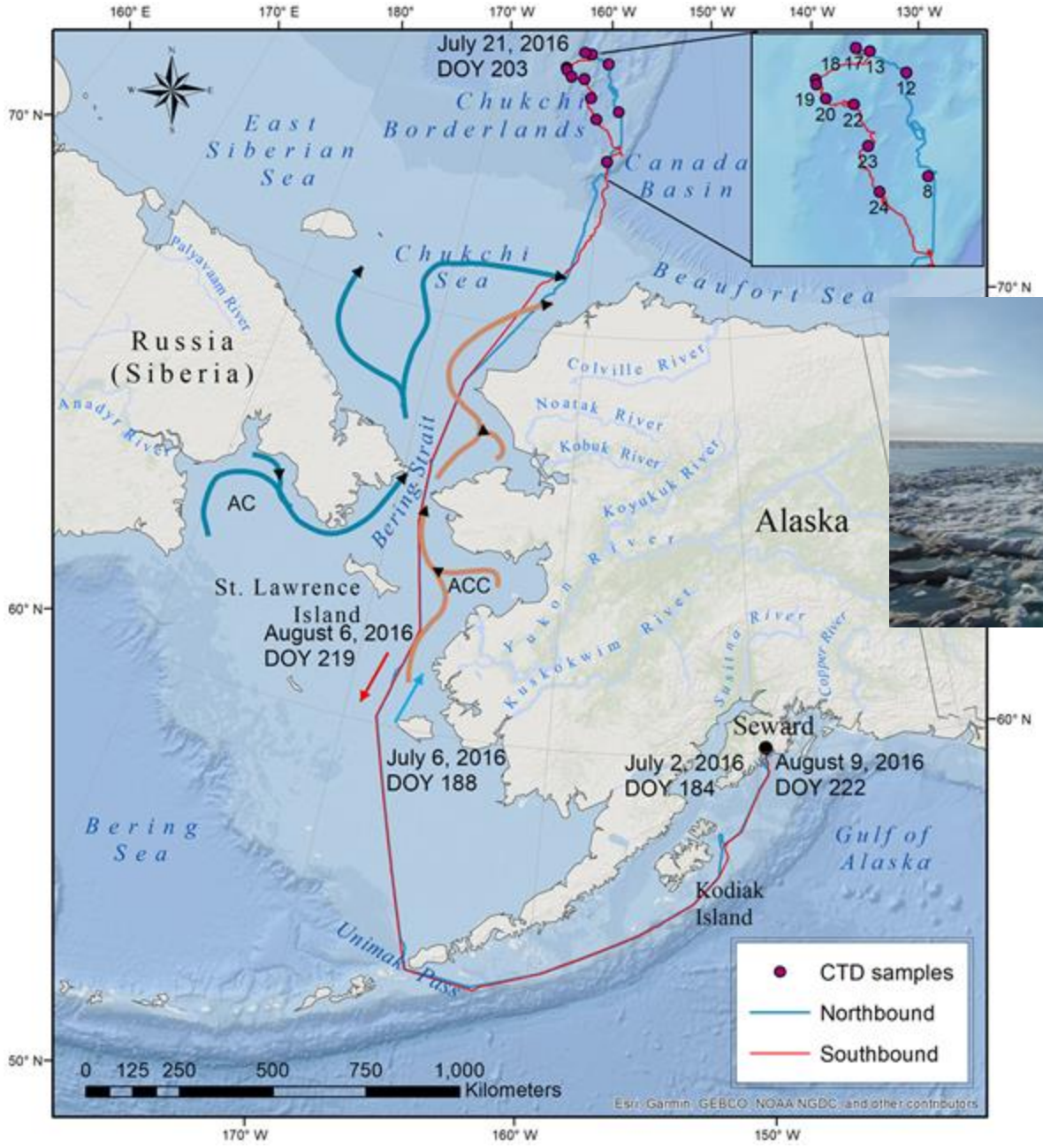


Klein and Welker, 2016 (ice core data modified from Steffensen et al., 2008)



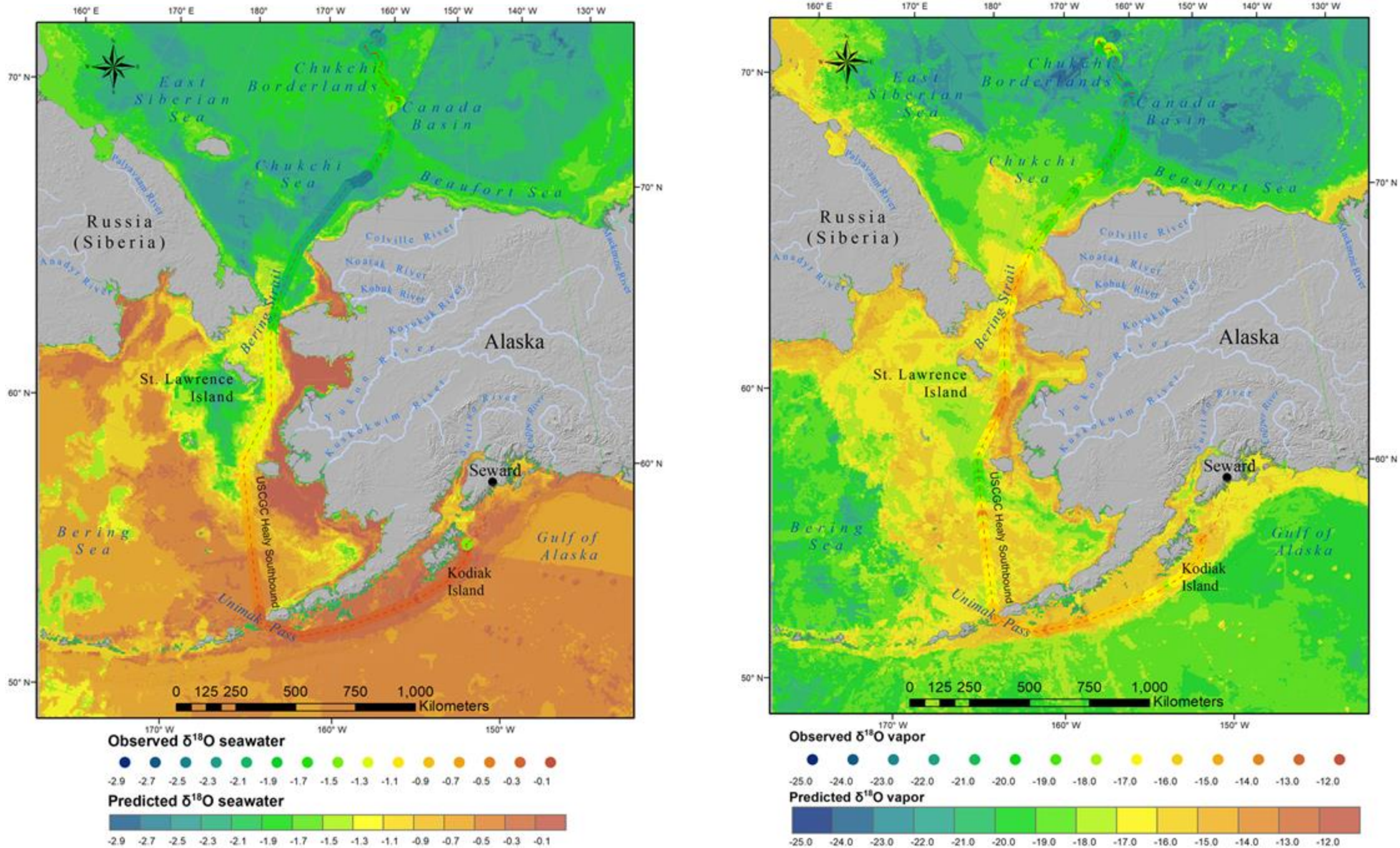
Jouzel et al., 2007



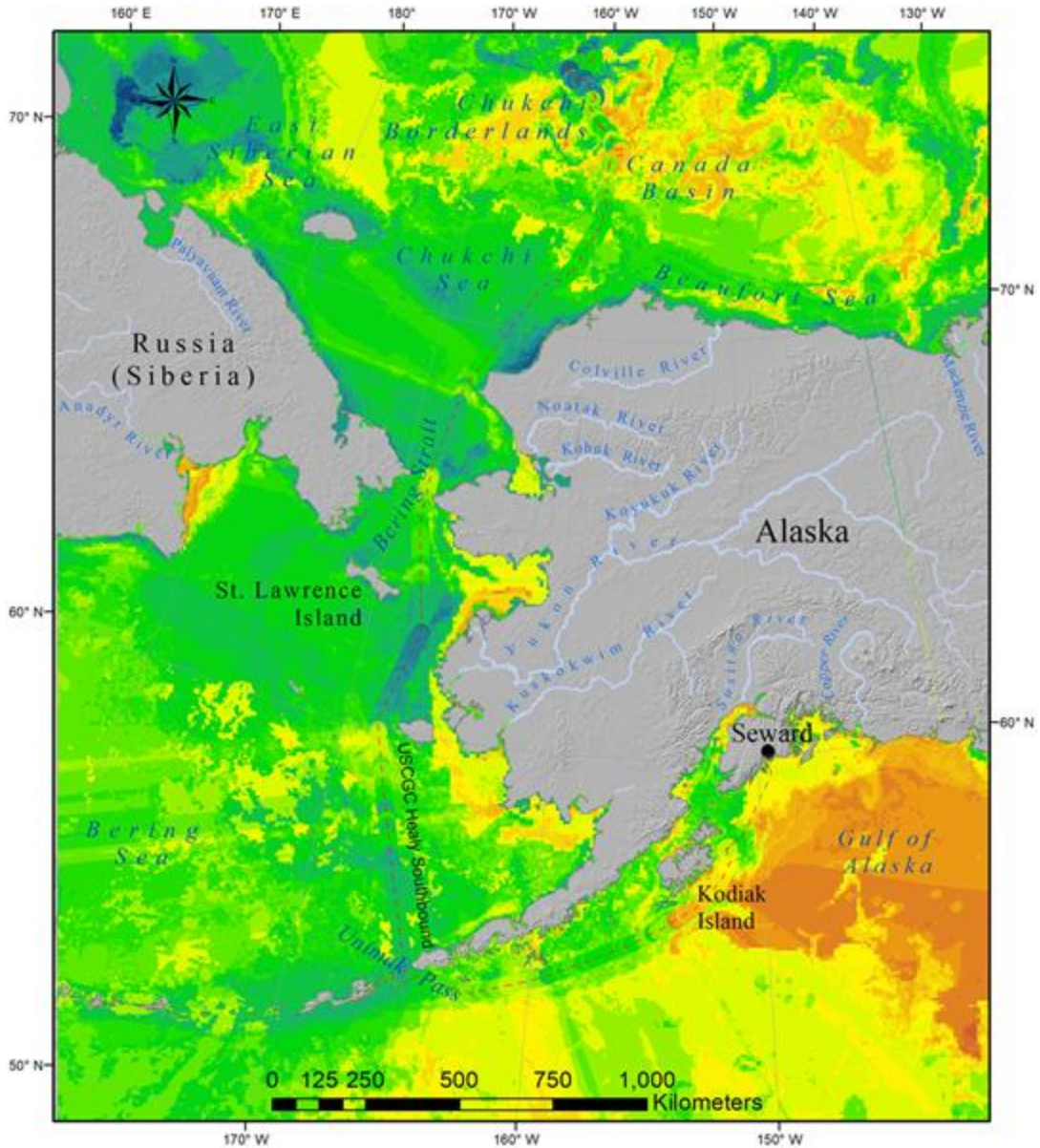


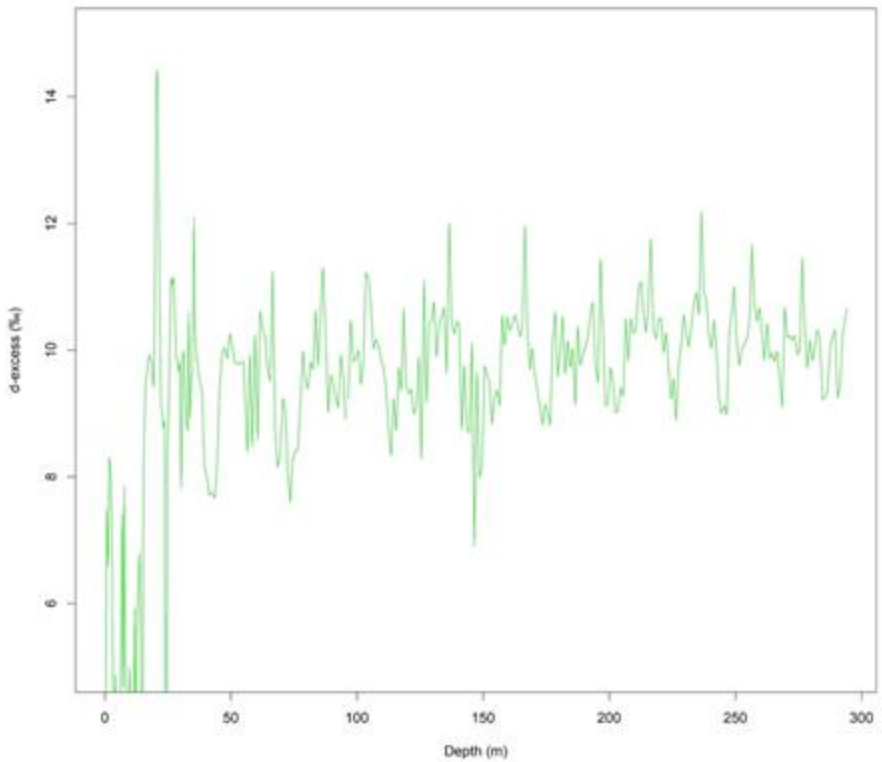
- Continuous water vapor and sea water isotopes
- First simultaneous collection: Healy 2016

Klein et al., 2024



Klein et al., 2024



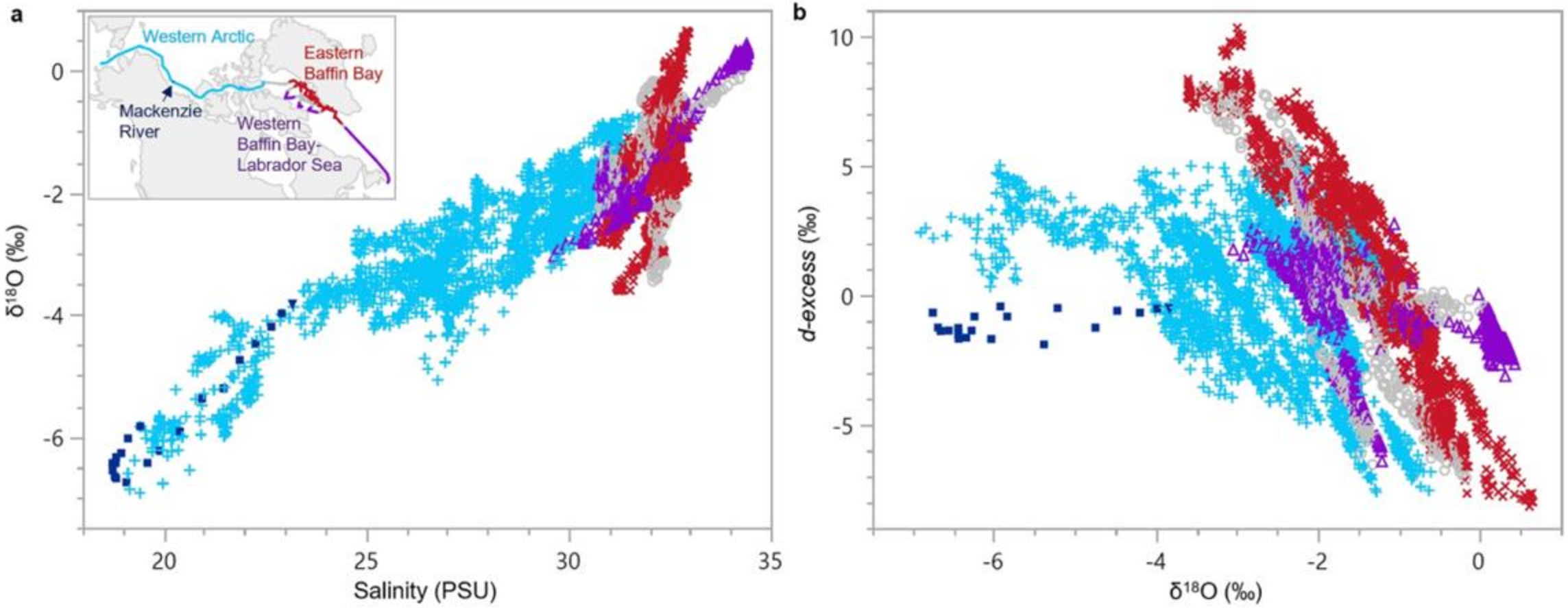


Observed d-excess vapor

-12.0 -10.0 -8.0 -6.0 -4.0 -2.0 0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0

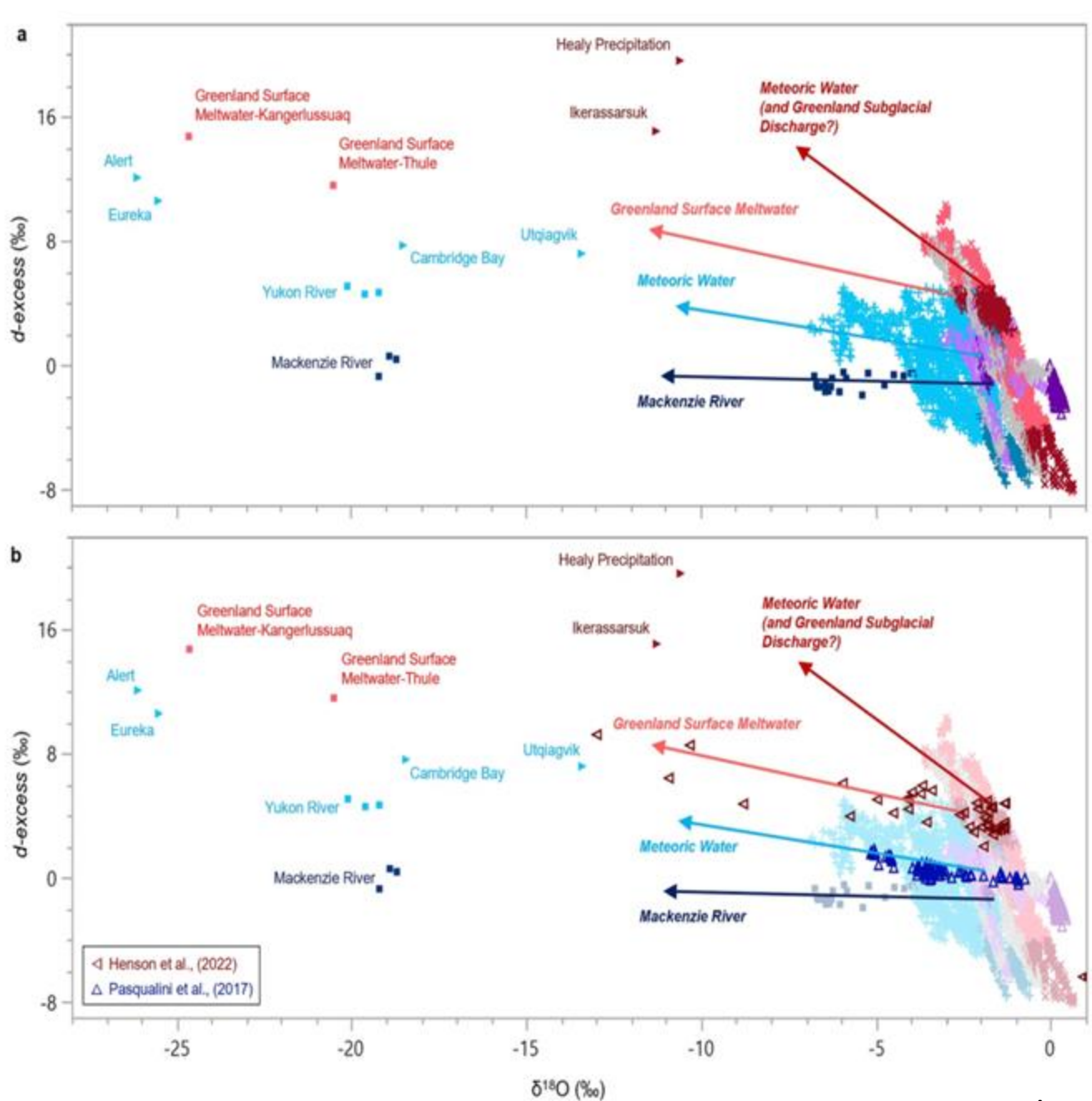
Predicted d-excess vapor

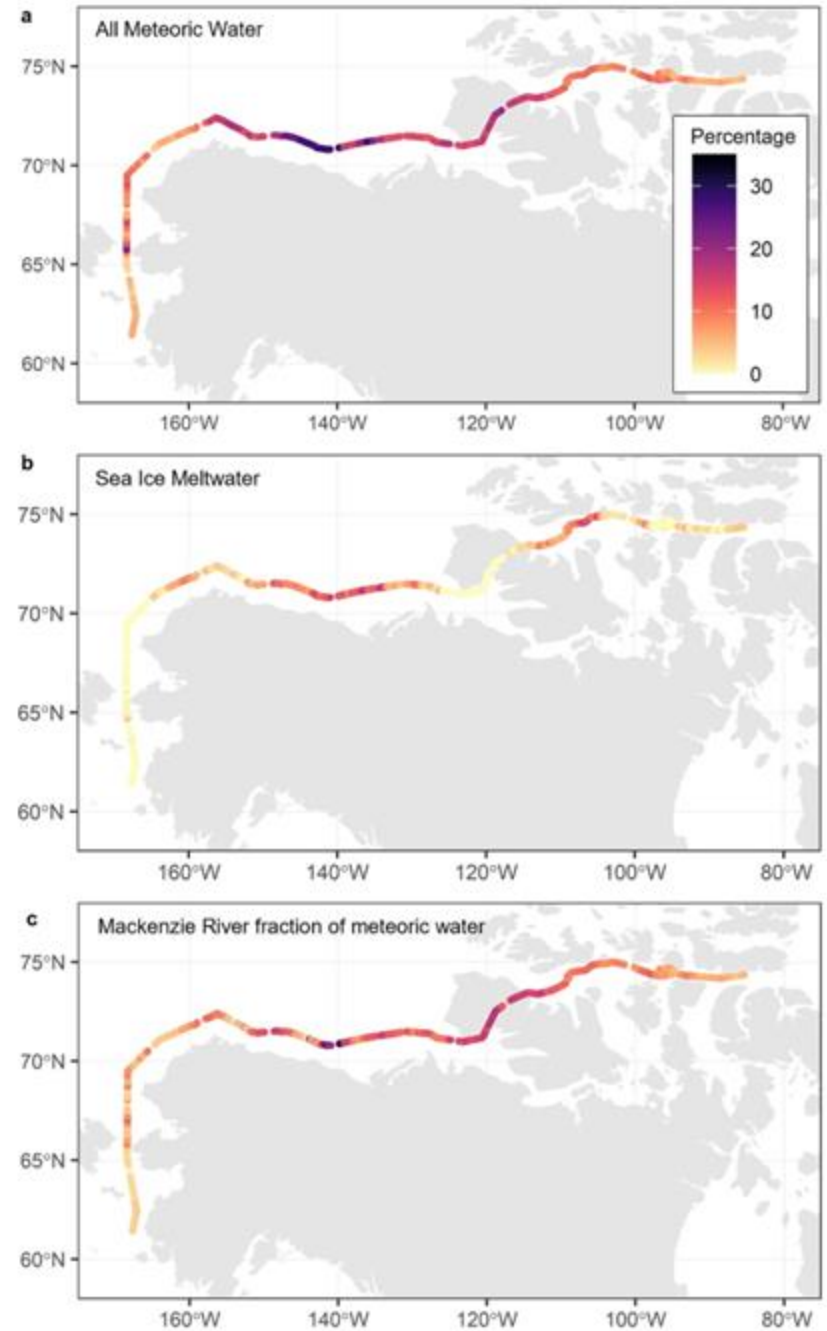
-12.0 -10.0 -8.0 -6.0 -4.0 -2.0 0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0



- d-excess sea water to separate freshwater sources: Healy 2021

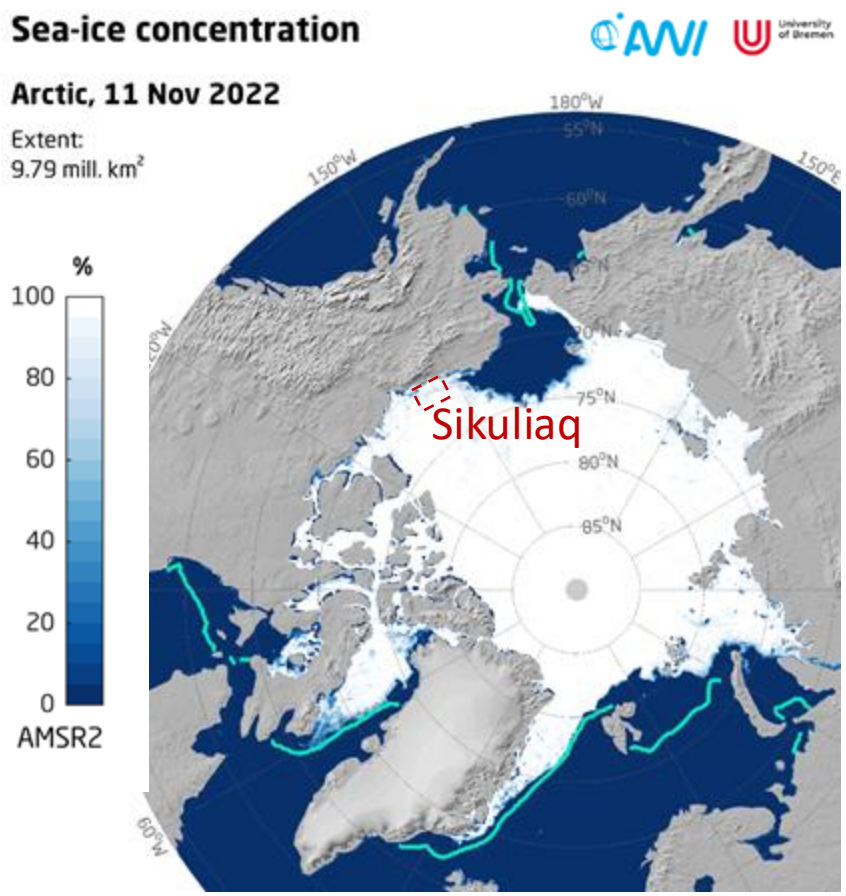
Kopec et al., 2024





Kopec et al., 2024

New Arctic moisture in response to the loss of sea ice



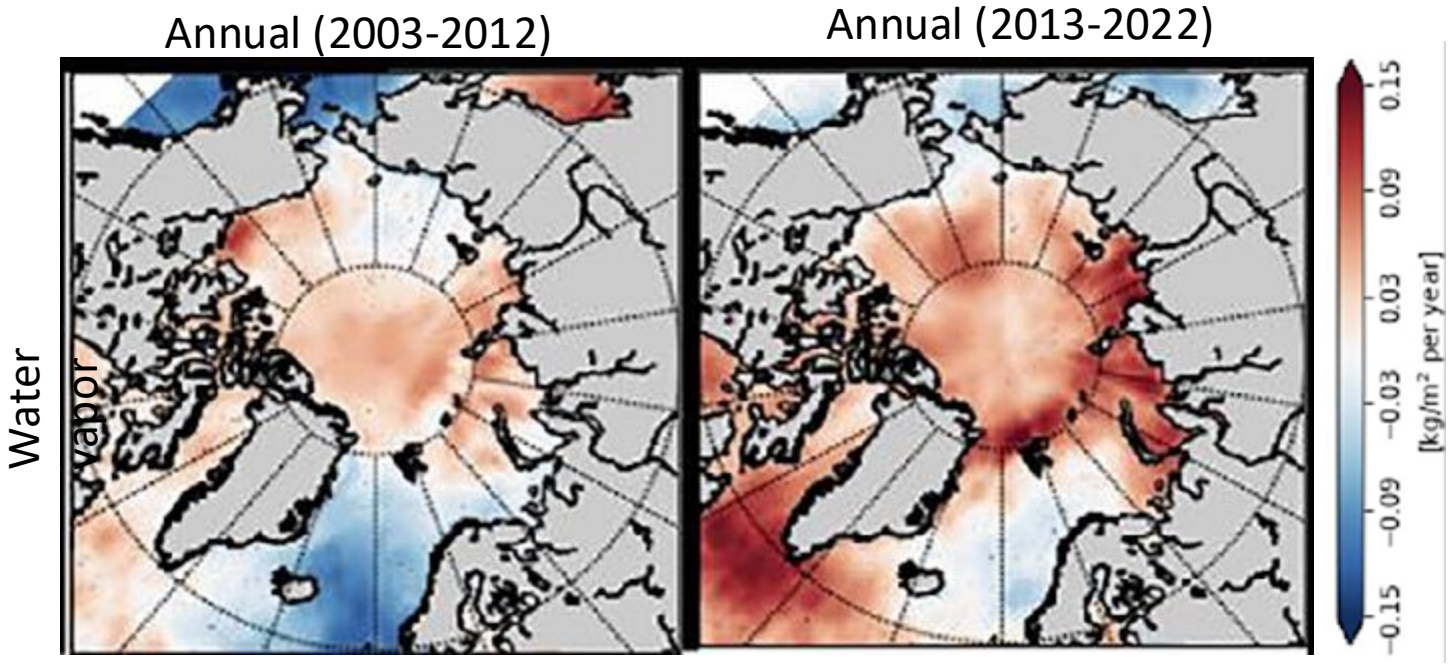
Large moisture fluxes observed on Sikuliaq despite near 100% sea ice coverage

Arctic water vapor content is increasing in association with sea ice loss, but increases occur with significant spatial and temporal variability

JGR Atmospheres

A Warmer and Wetter Arctic: Insights From a 20-Years AIRS Record

Linette Boisvert[1], Chelsea Parker[1,2], and Elina Valkonen[1,2]



Boisvert et al. (2023, *JGR-A*)

Tracing Arctic evaporation with isotopic measurements

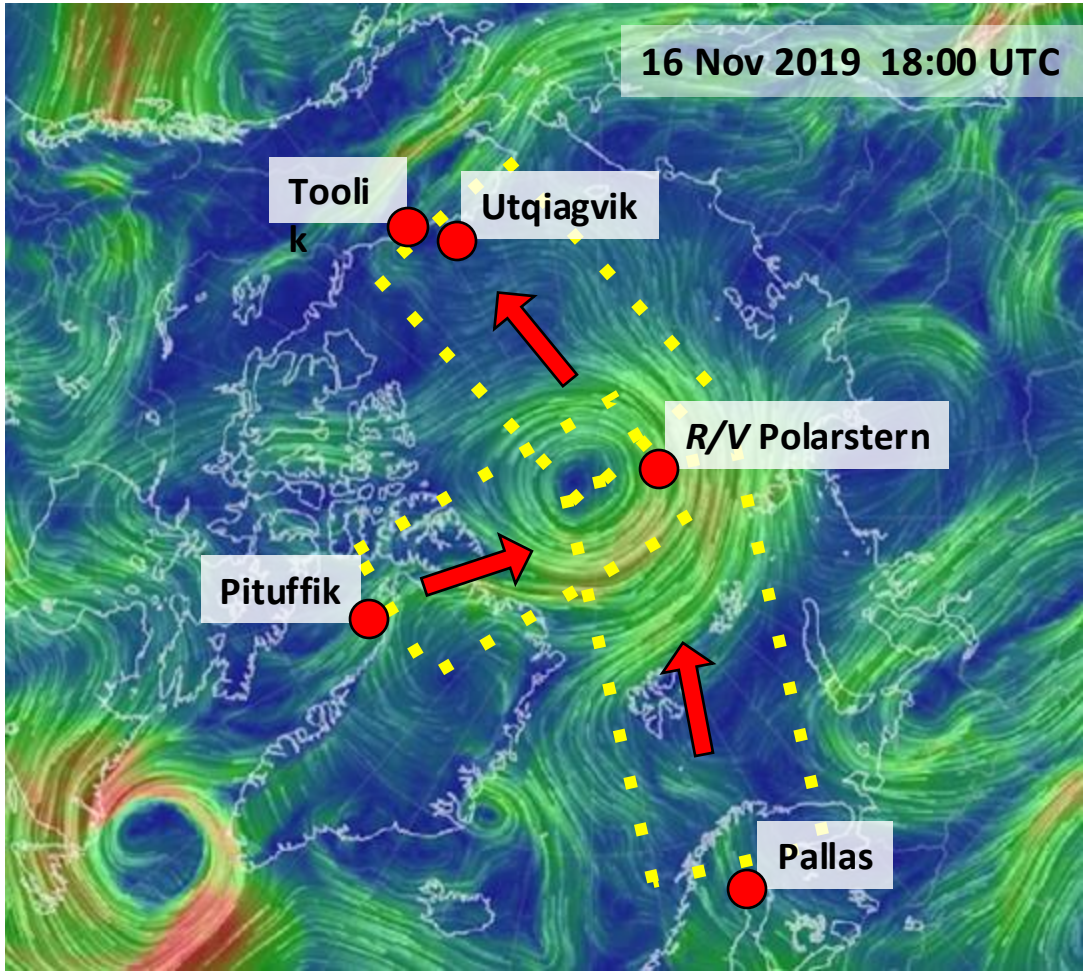
Isotopic observations allow us to identify the influence of locally-evaporated moisture:
deuterium excess (d-excess): $d = \delta D - 8 * \delta^{18}O$

Use site differences to compute the addition of local moisture between sites

$$Local\ Evaporation\ Fraction = \frac{d_{downstream} - d_{upstream}}{d_{evaporation} - d_{upstream}}$$

MOSAiC case study - November 2019 cyclone events

Consistent/repeating moisture transport into Arctic via Barents Sea and Baffin Bay where three cyclones interact directly with Polarstern within two week window - Arctic inflow past Pallas and Pituffik, Arctic outflow past Utqiagvik and Toolik



Use series of site connections throughout events to determine how much local moisture is added between sites

$$Local\ Evaporation\ Fraction = \frac{d_{downstream} - d_{upstream}}{d_{evaporation} - d_{upstream}}$$

Cruise-based isotopic observations

Four observational datasets covering a wide range of atmospheric, oceanic, and sea ice conditions

Coupled seawater and water vapor isotopic data available:

2016 Healy: 06 July – 08 August
2021 Healy: 31 August – 07 October
2022 Sikuliaq: 04 November – 02 December
2023 ARTofMELT (Oden): 05 May – 14 June

2024 Healy: July

Integrated understanding of freshwater sources and moisture transport in the Arctic Ocean

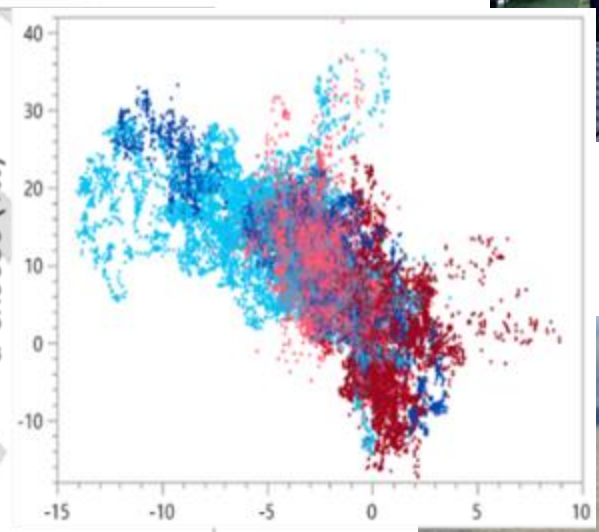


Photo: Matt Masaschi


Thank you
esklein@alaska.edu
Beaufort Sea Ice