

The building blocks of snow

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*how can stable water isotope data
advance snow science?*

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10th national snow seminar – 2 Feb 2022



Agenda

- Introduce the basic concepts of stable water isotopes
- Raise awareness of water isotope as a potential tool for snow science
- Initiate a discussion and plant a seed for collaboration





Stable water isotopes

- Can measure the abundance of heavy isotopes in a water (or snow) sample
- Water isotope composition changed by hydrological processes
- A conservative tracer in the water cycle
- Water isotope method in snow research?

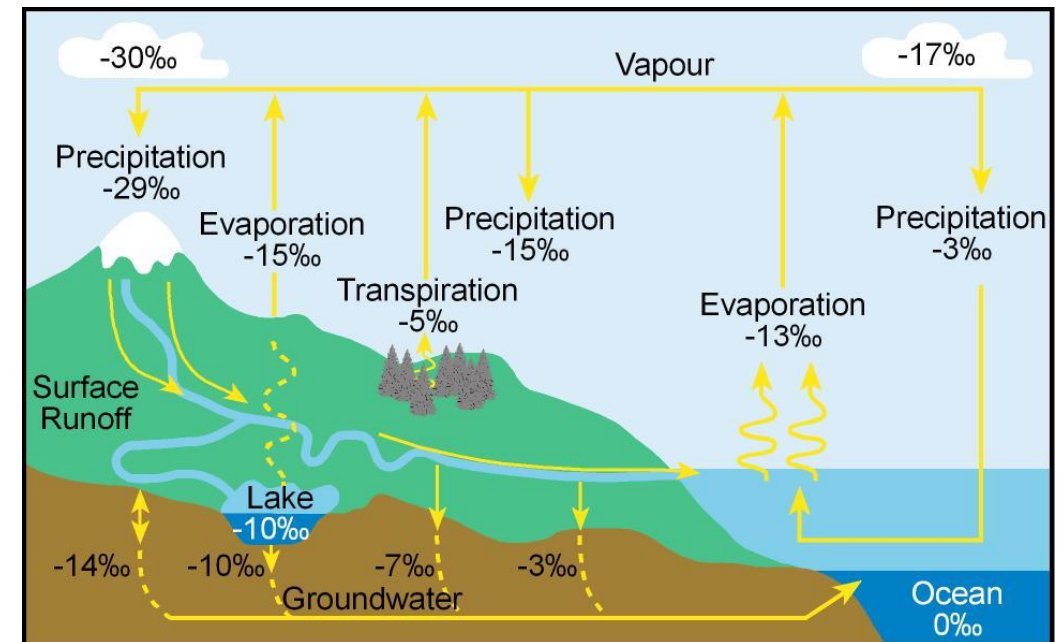
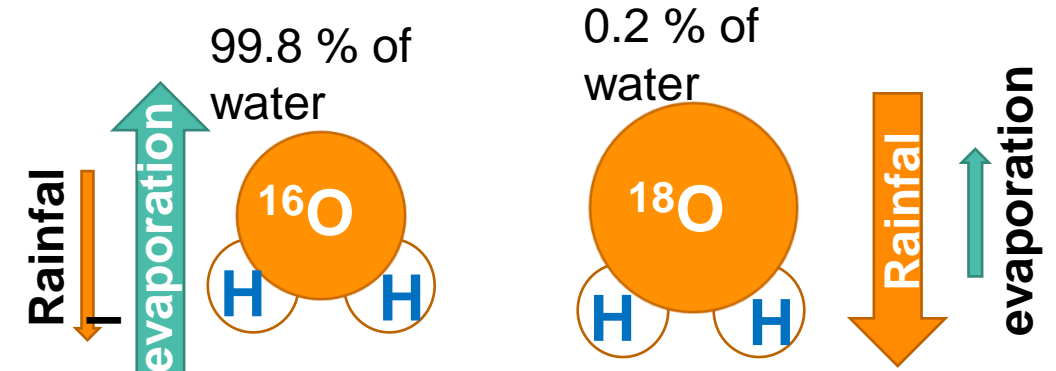
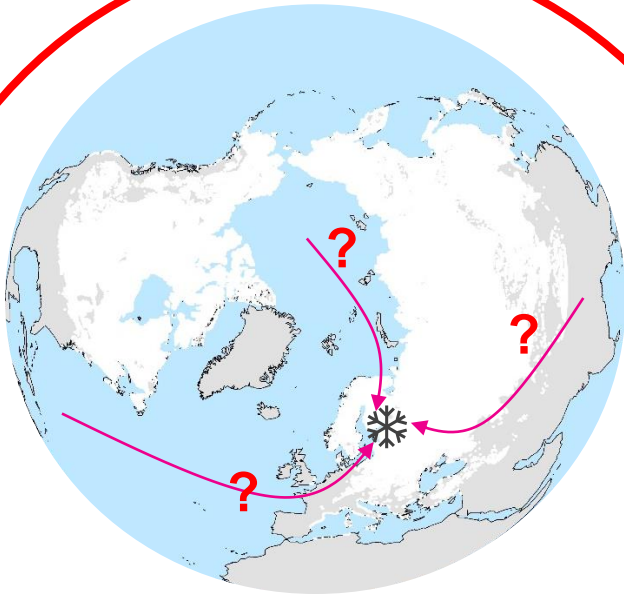


Fig: IAEA

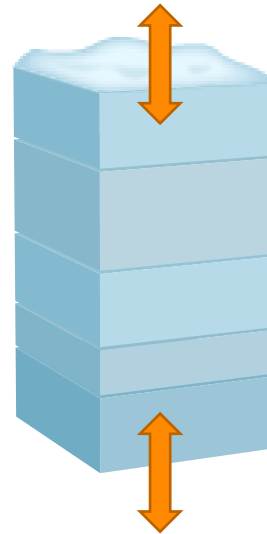


Snow water isotopes – three questions

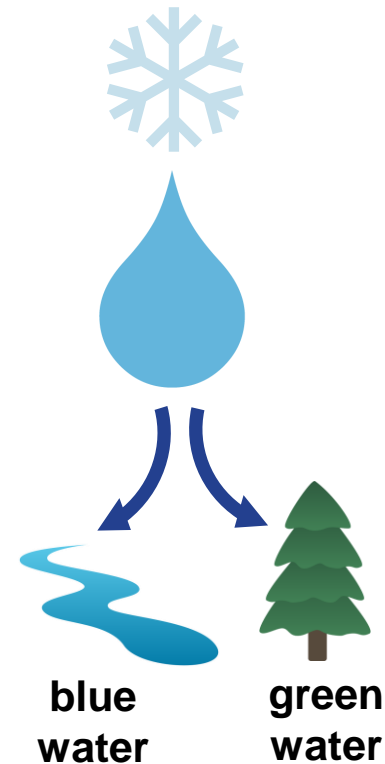


Where is snow coming from?

How snowpack and the environment interact?

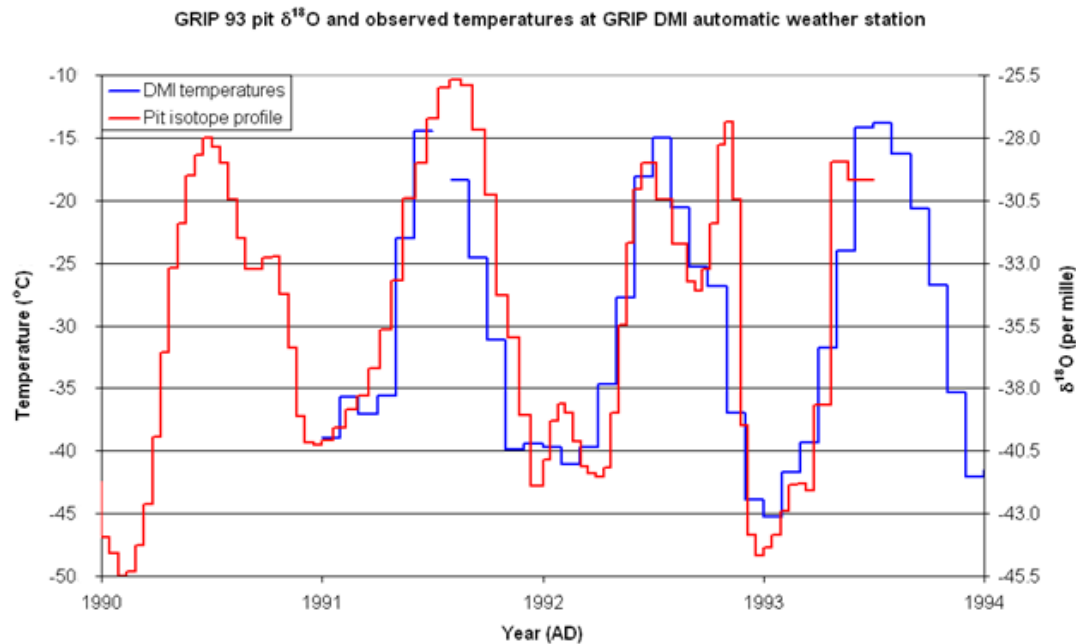


What happens to snow when it melts?





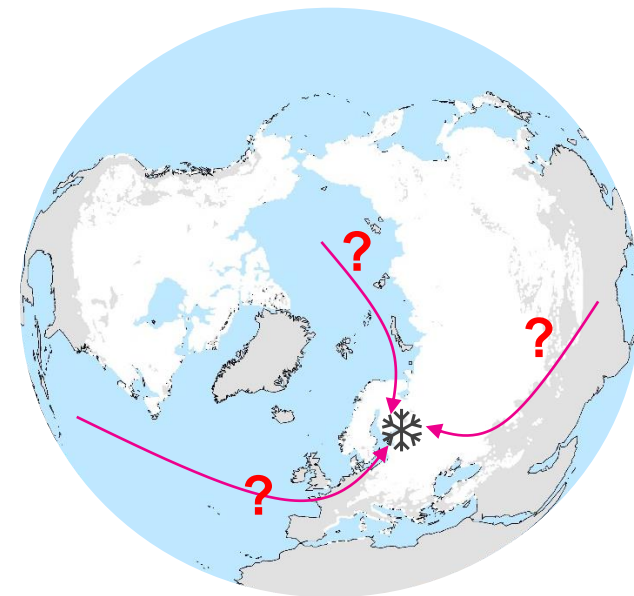
Where is snow coming from?



Figures: University of Copenhagen

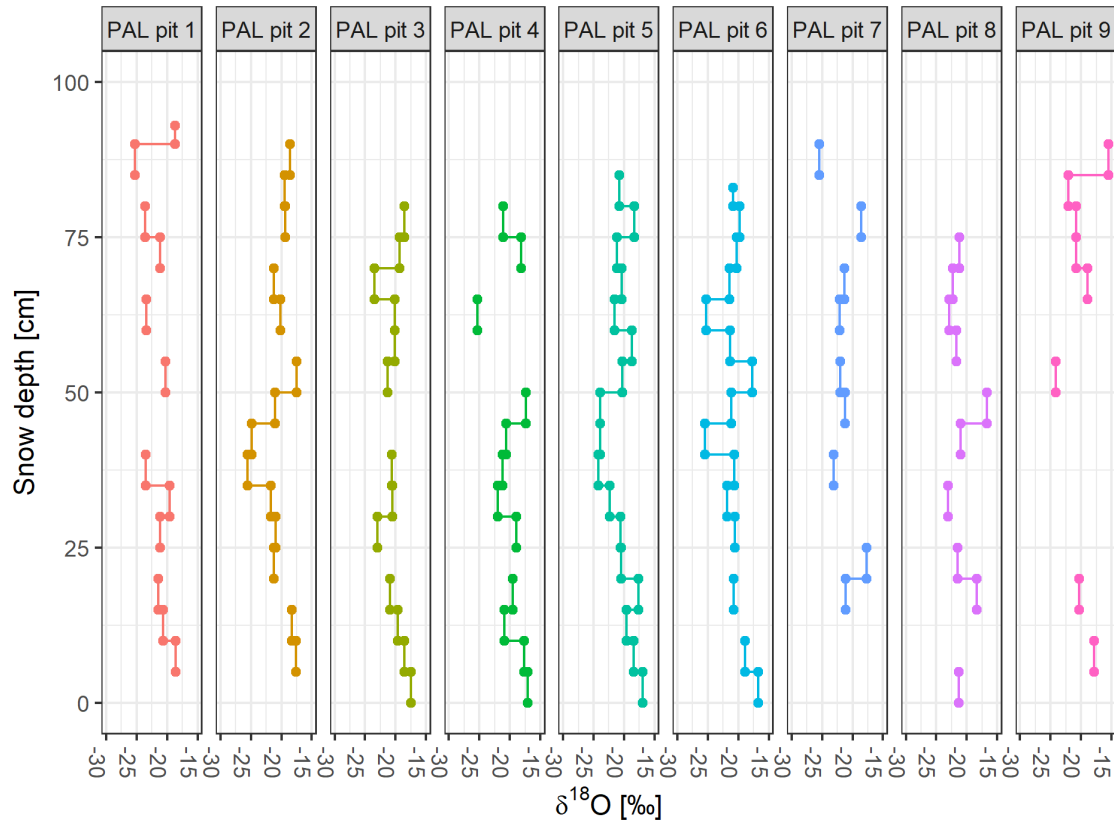
https://www.iceandclimate.nbi.ku.dk/research/strat_dating/annual_layer_count/ice_core_dating/

- Water isotope composition a proxy for ambient temperature during water evaporation
- Famously used for paleoclimate from ice cores
- Varies seasonally and
- due to origin of snow (moisture)





Where is snow coming from?



- Isotope value of each snowfall varies
- Isotope signal of each snowfall stored in the snowpack?
- Sampling isotope profiles in snow pits at Pallas study site

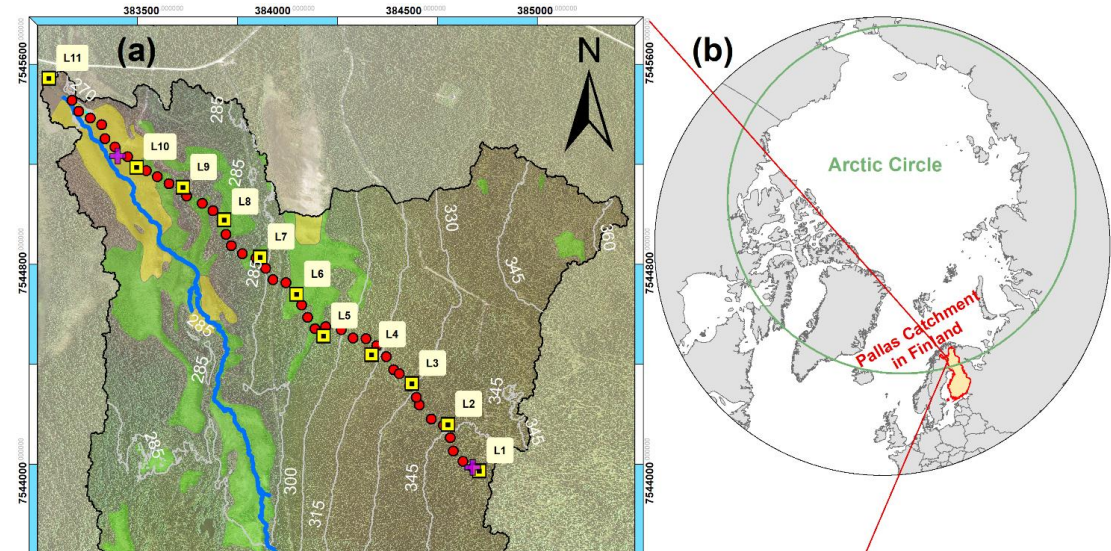
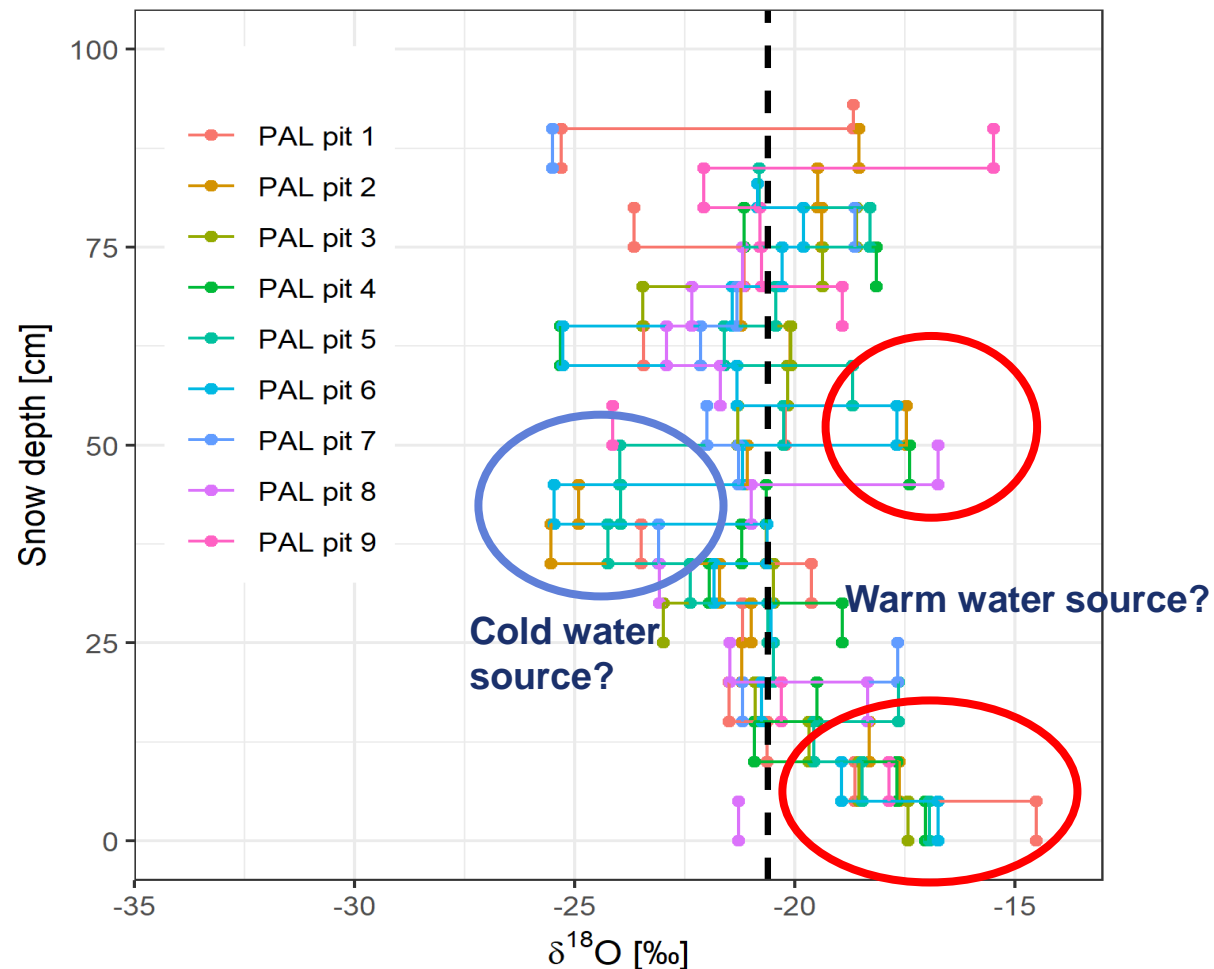


Fig: Kashif Noor



Where is snow coming from?



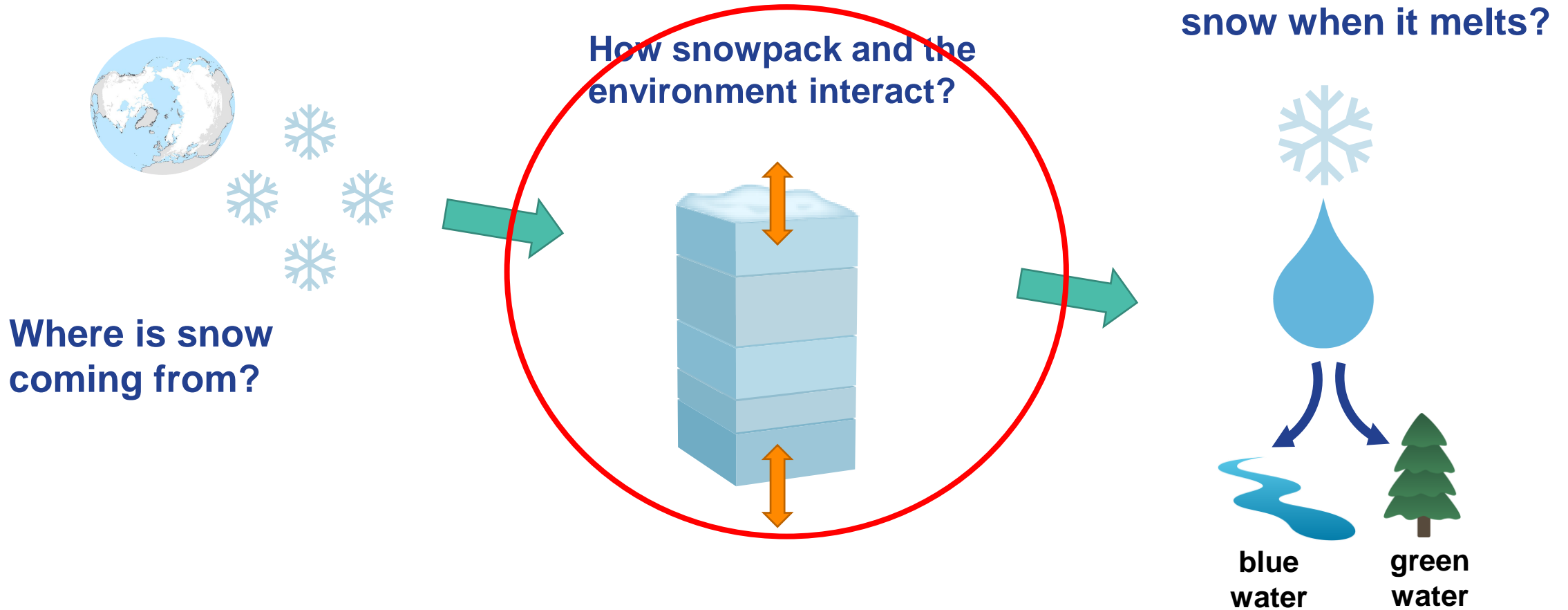
- Comparing variability between pits and snow layers
- Need to better understand
 - Spatial variability in the snowpack
 - *Post-depositional modification*

Potential for snow research:

- *Understand in Pan-Arctic water circulation during winter*
- *Isotope-aided Earth system model calibration and validation*



Snow water isotopes – three questions





Isotope fractionation

- Snowpack isotope composition changed over winter by **isotope fractionation**
- Sublimation (solid -> vapor)
- Melting (solid -> liquid)
 - **REMOVES THE LIGHT ISOTOPE FROM SNOW**
- Vapor diffusion in the snowpack
 - **ISOTOPE MIXING IN THE SNOWPACK**
- Vapor diffusion from soil water
 - **BRINGS HEAVY ISOTOPES IN THE SNOWPACK**

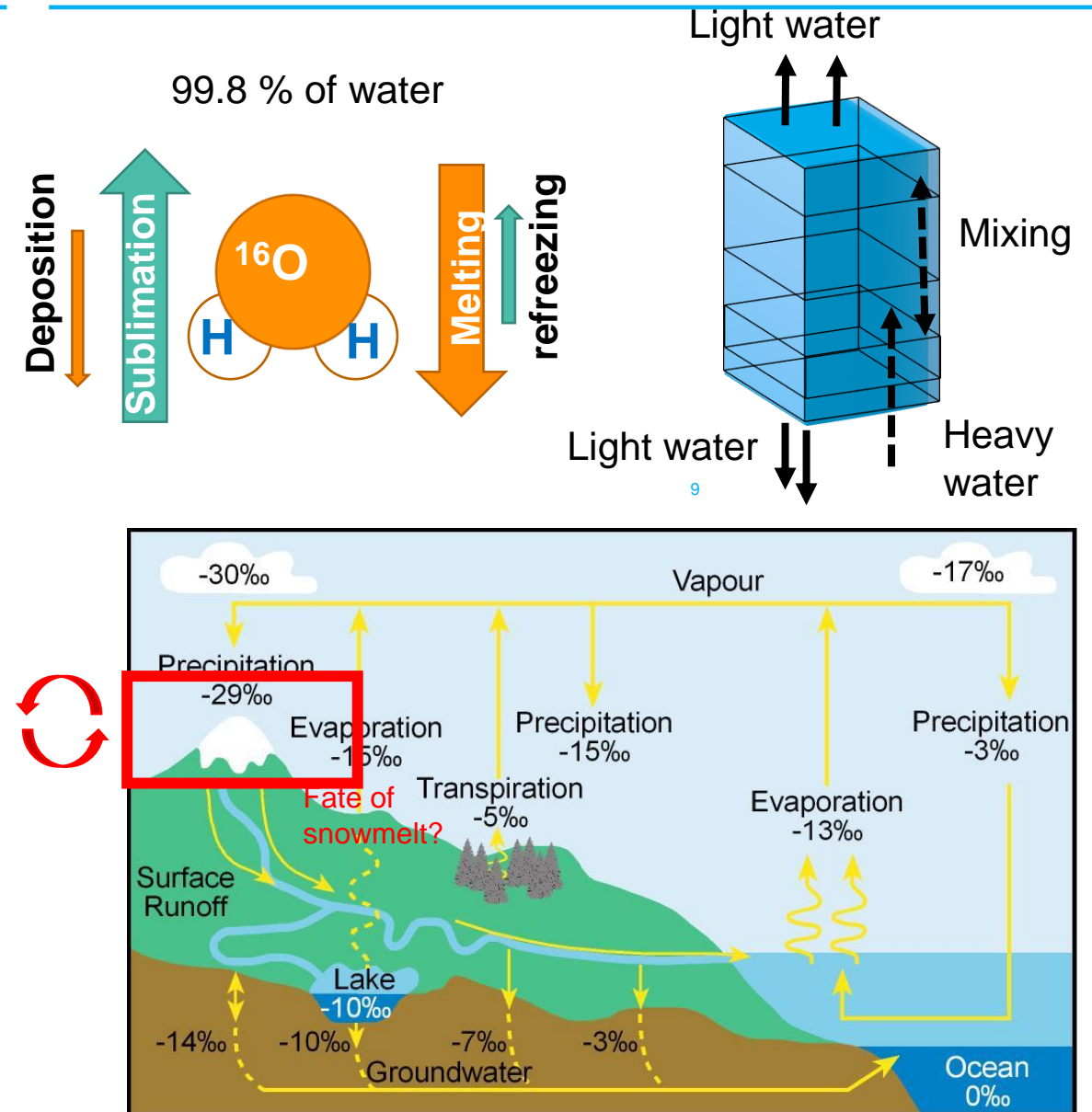
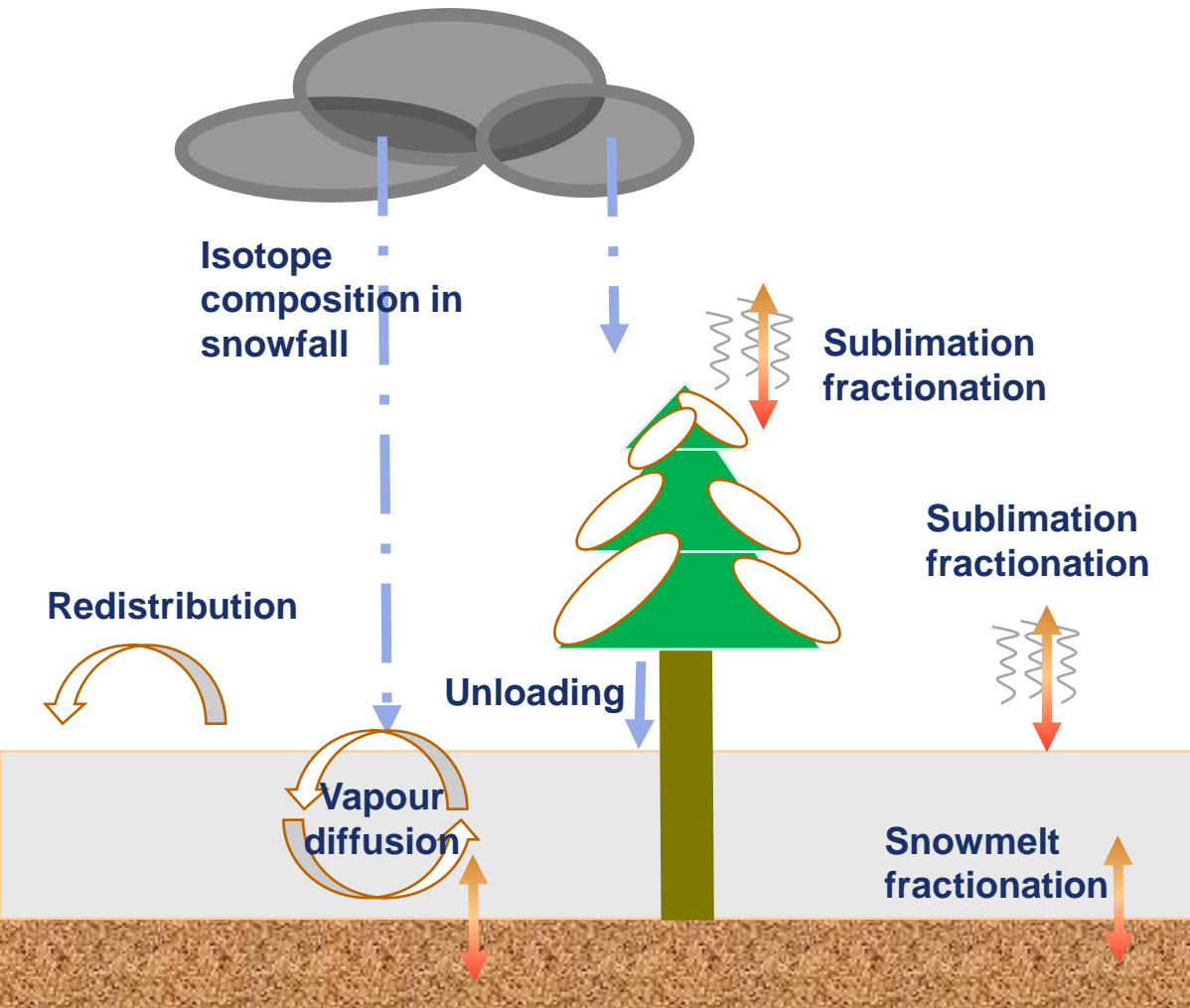


Fig: IAEA



Isotope fractionation in snowpack



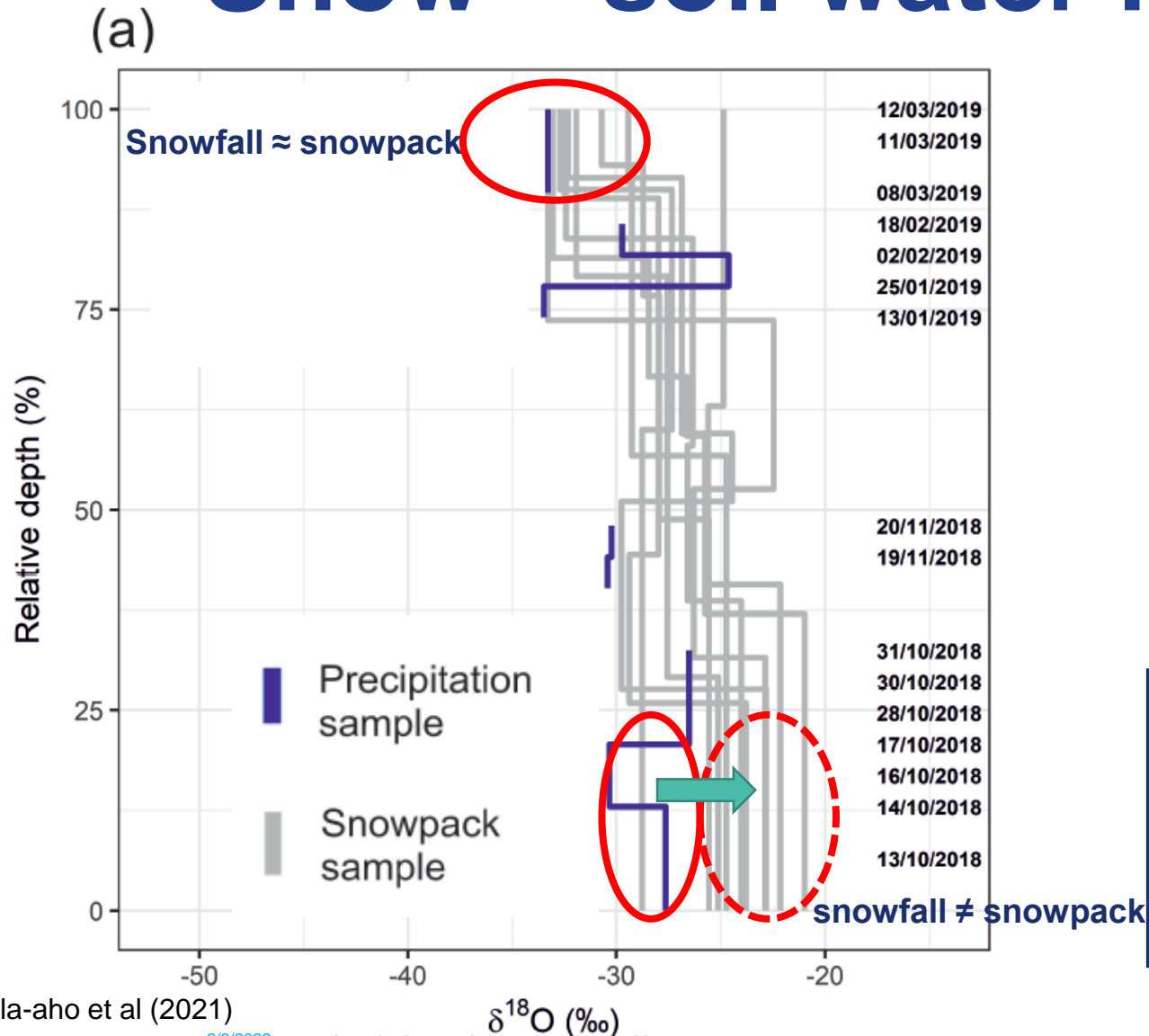
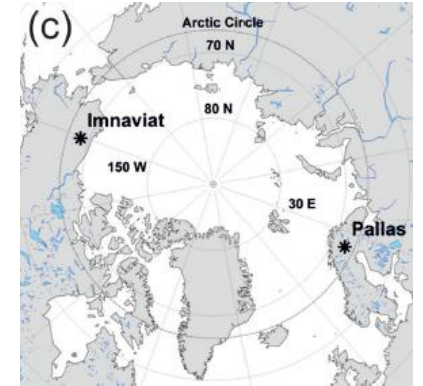
- Physical processes that move water in the snowpack

ALSO

- Modify the *isotope composition* of the snowpack



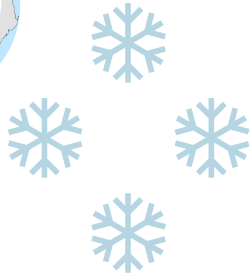
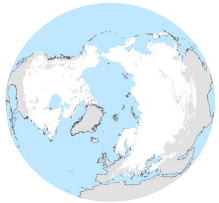
Snow – soil water interaction



- Soil water isotopically different than snowpack
 - Soil water diffusion evidenced by water isotopes in the soil profile
 - 2019 Alaska tundra snow (Imnaviat site)
- Potential for snow research: *verify and quantify the snow-environment interactions*



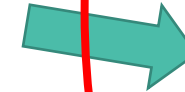
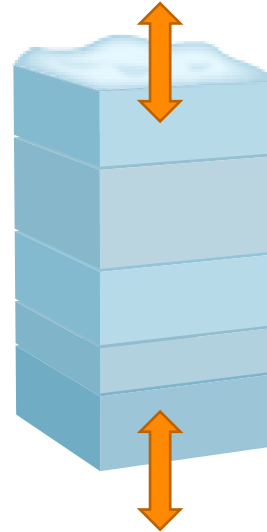
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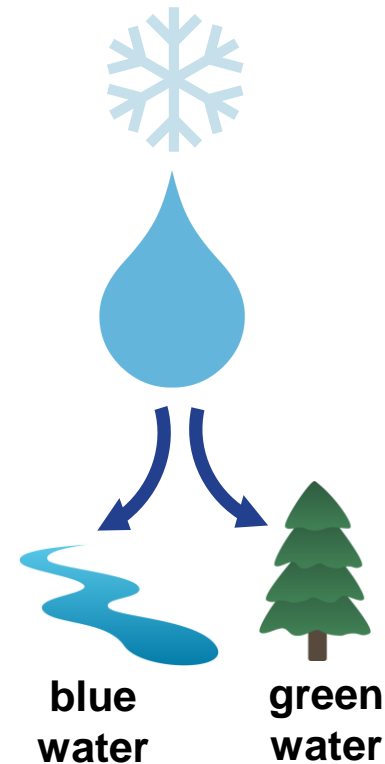
Where is snow
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How snowpack and the
environment interact?

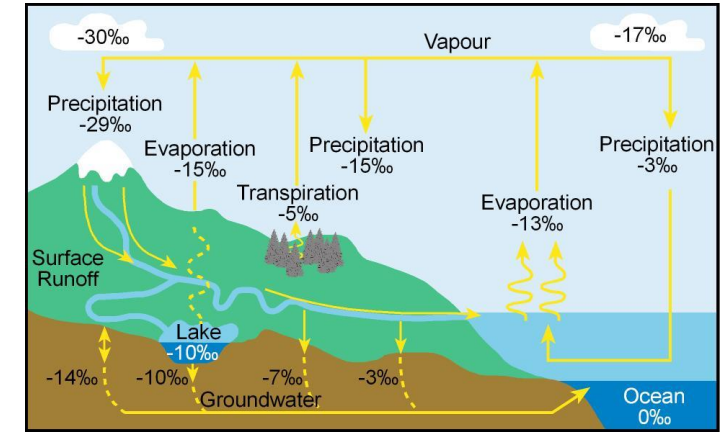
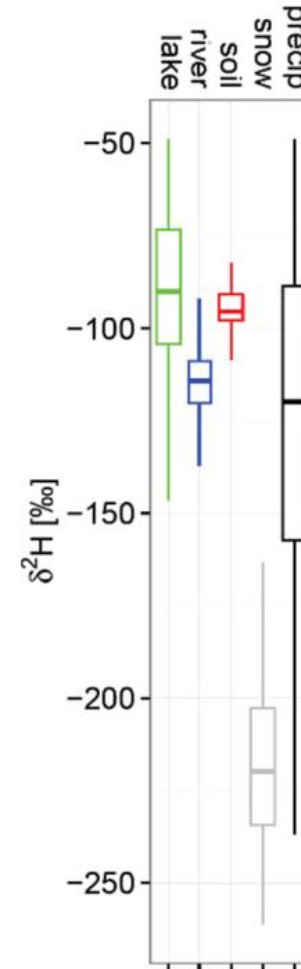
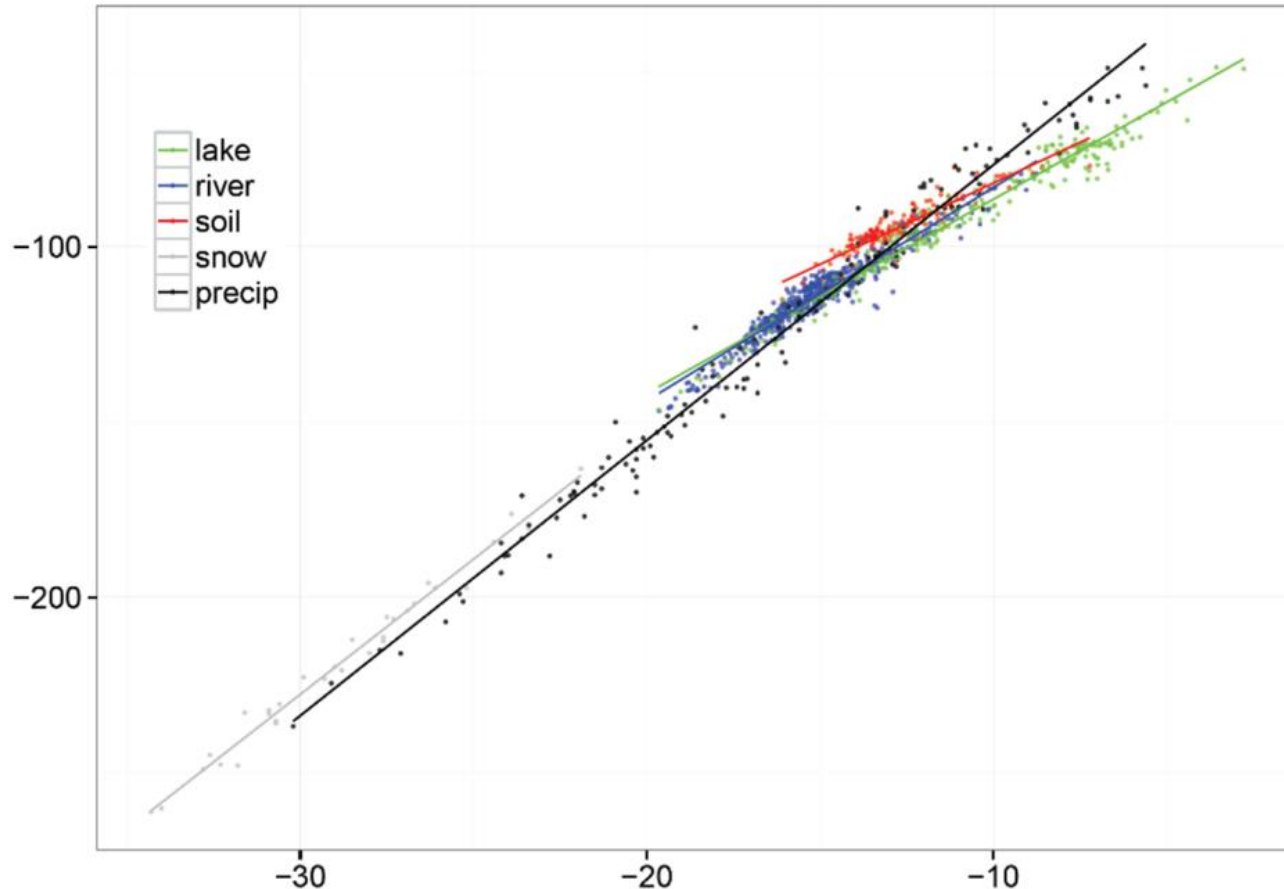
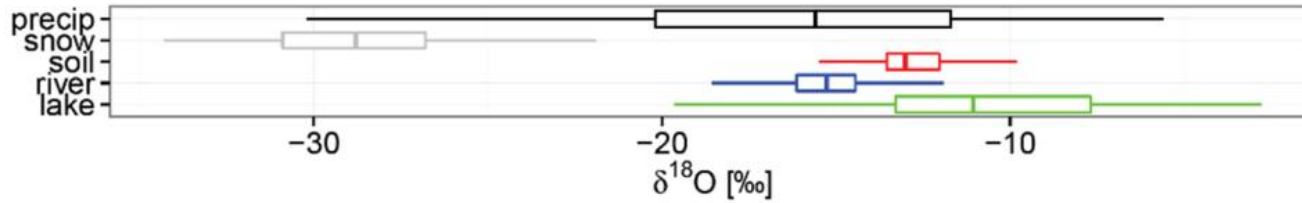


What happens to
snow when it melts?





What happens to snow when it melts?



- hydrological cycle in West Siberia, River Ob watershed
- Snow stands out in isotope values

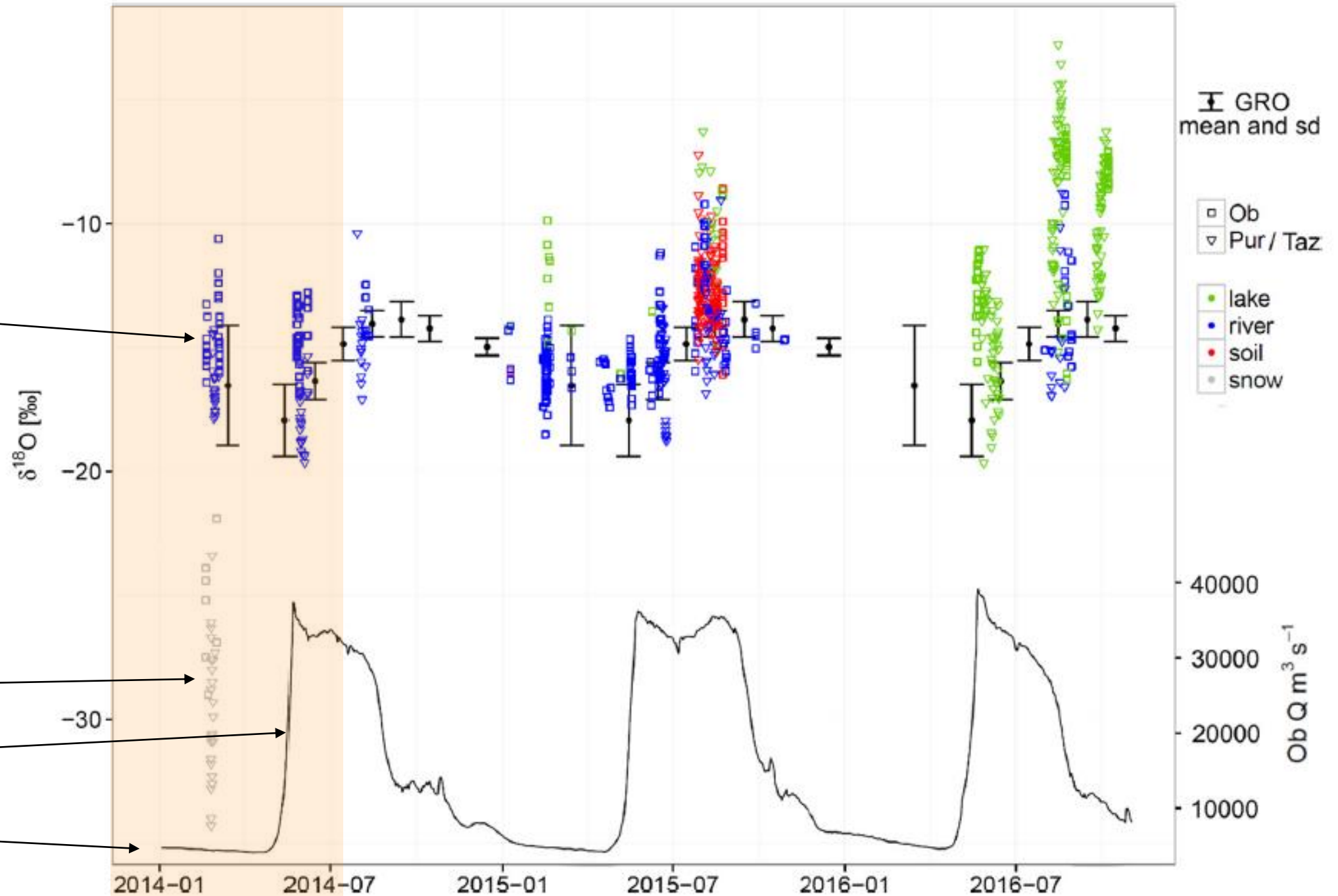


Isotopic composition of baseflow

Isotopic composition of snow

Snowmelt flood in the Ob

Winter baseflow in river Ob





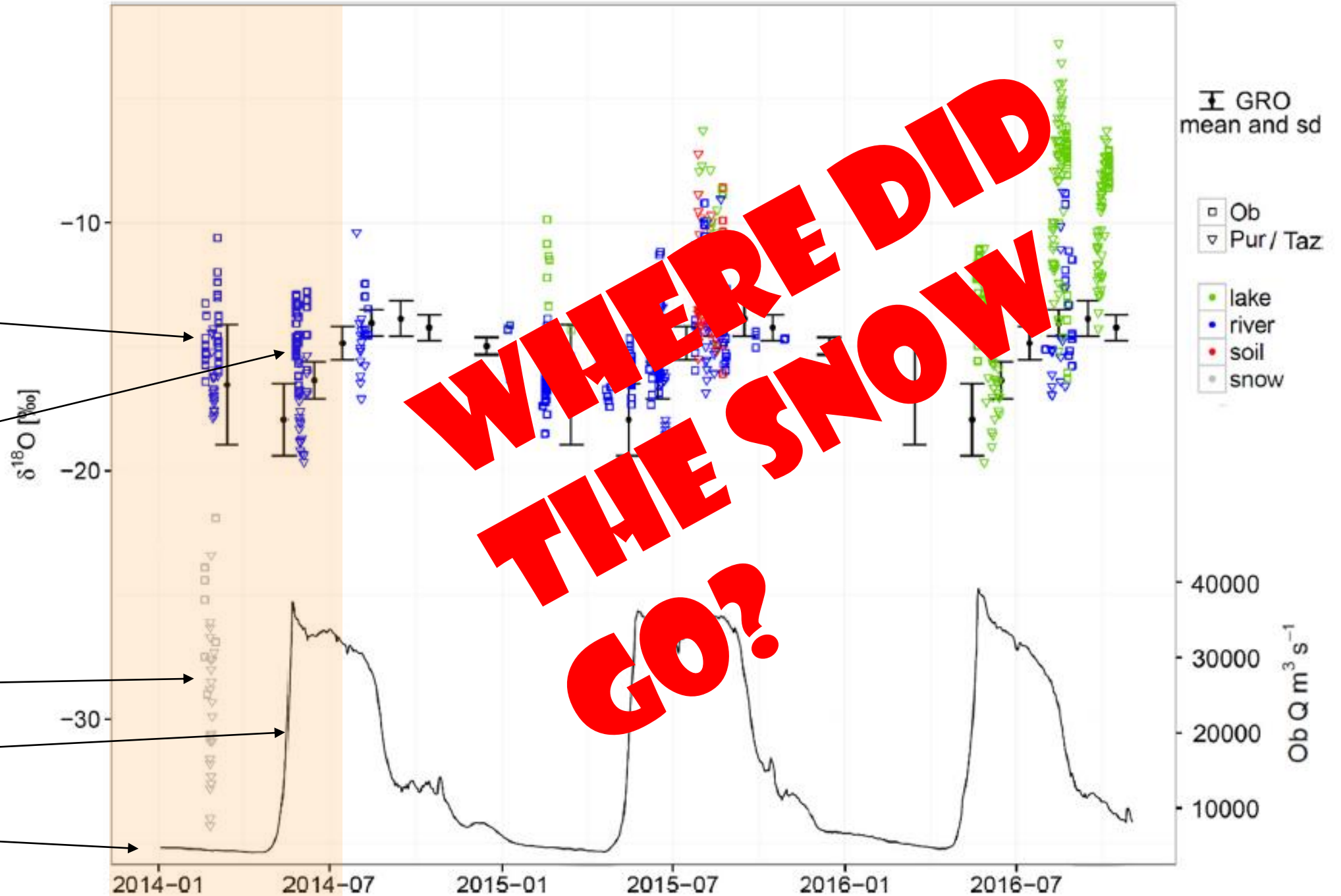
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Isotopic composition of snowmelt flood

Isotopic composition of snow

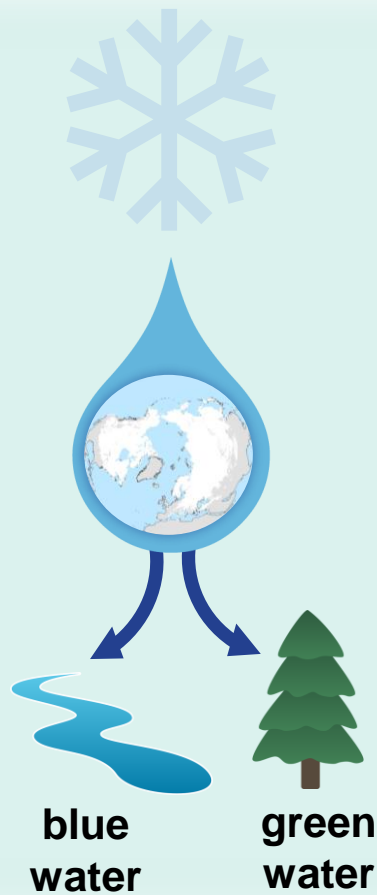
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Snow isotope hydrology



- Changes in snow huge unknown in future global water security
- **How melting snow supports BLUE AND GREEN WATER??**
 - Blue water: surface water and groundwater, available water for society
 - Green water: soil water, ecosystem water use

Potential for snow research: estimate blue and green water partitioning of SNOWMELT



Summary

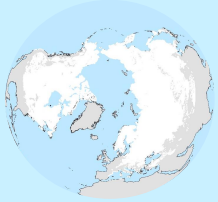


Photo: Kelly Elder

- Water isotope studies widespread hydrological and atmospheric sciences
- Water isotopes UNDER-UTILIZED in understanding snow processes
- Why?
 - Natural snowpacks are complex
 - Isotope fractionation processes are complex
 - Need a lot of samples, and the technology only "recently" available
- Our isotope work hydrological focus
 - fishing for snow experts to work with😊



How to sample

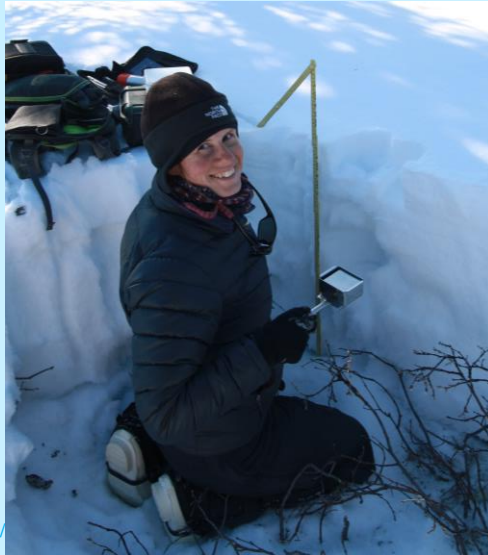


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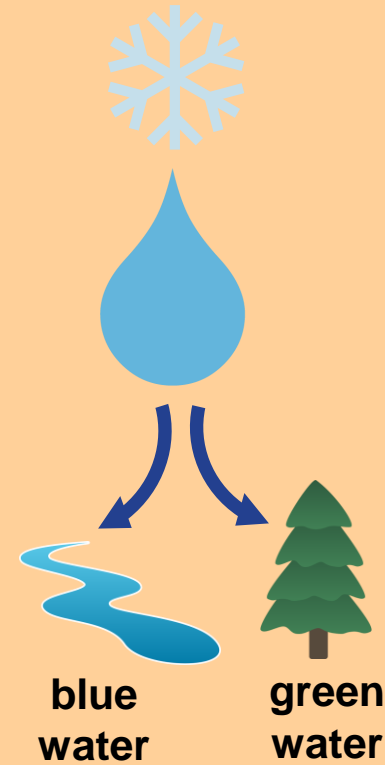
SNOW PITS



SNOW CORES



What happens to snow when it melts?



SNOWMELT LYSIMETERS

