Water vapor isotope measurements above the Greenland Ice Sheet and importance for interpretation of surface-atmosphere interactions

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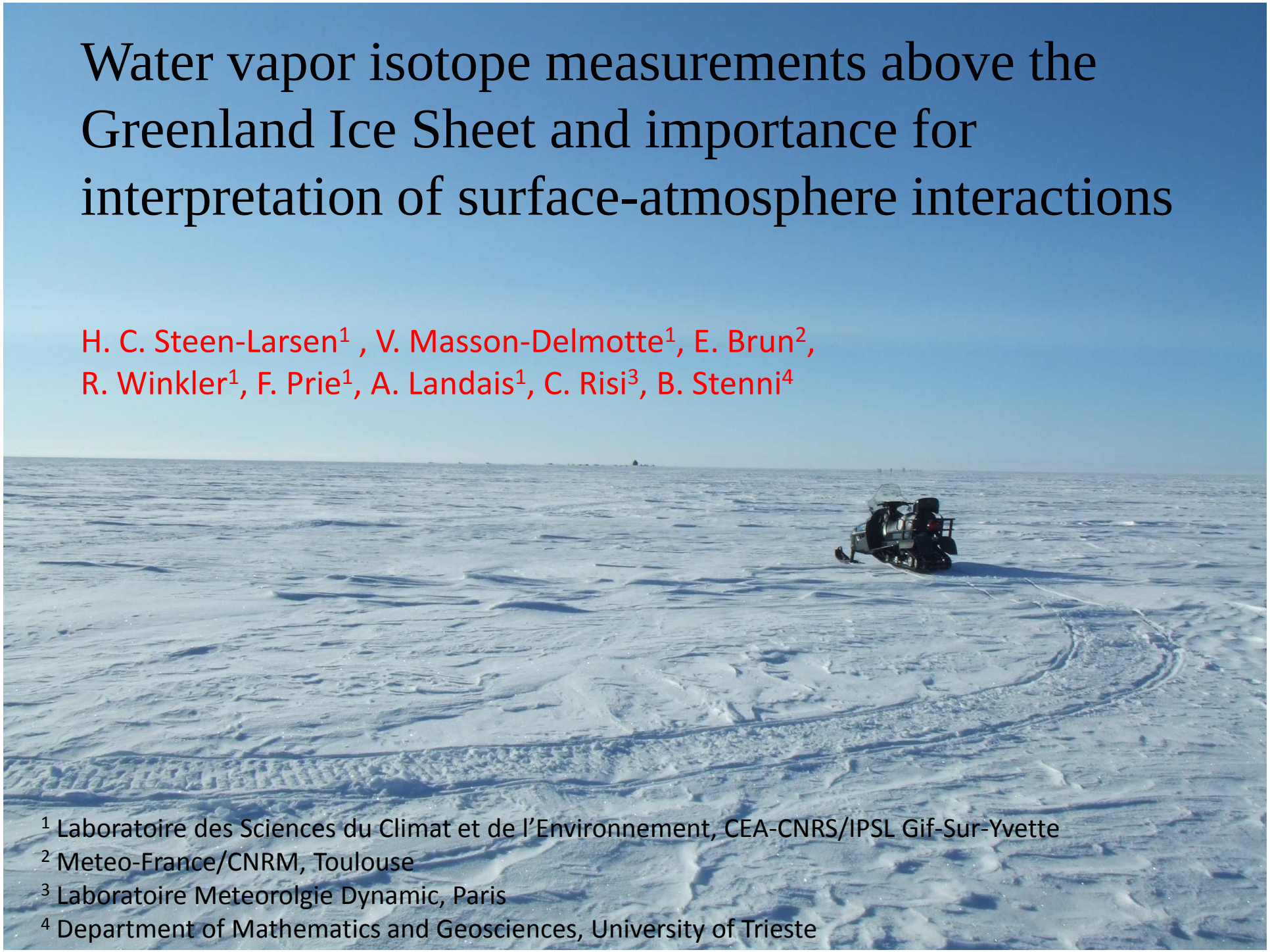

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- **Introduction to stable water isotopes**
- **The diurnal water vapor cycle above the Greenland Ice Sheet**
- **Tracing Arctic moisture using isotopes**

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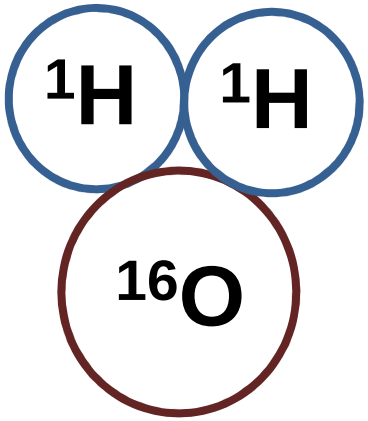
Isotope hydrology

Isotopologues are molecules with an isotope exchanged in

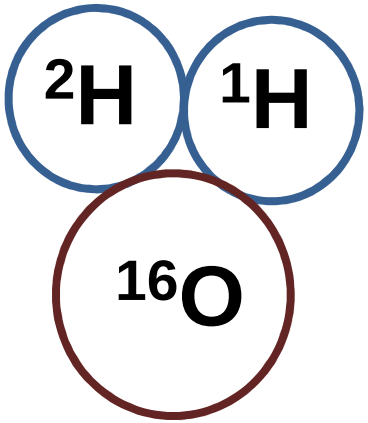
Nomenclature:

$$\delta^{18}O = \frac{(\frac{H_2^{18}O}{H_2^{16}O})_{sample}}{(\frac{H_2^{18}O}{H_2^{16}O})_{ocean}} - 1 * 1000$$

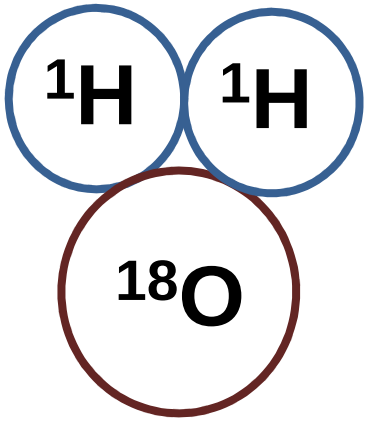
$$\delta D = \frac{(\frac{HDO}{H_2O})_{sample}}{(\frac{HDO}{H_2O})_{ocean}} - 1 * 1000$$



Regular water

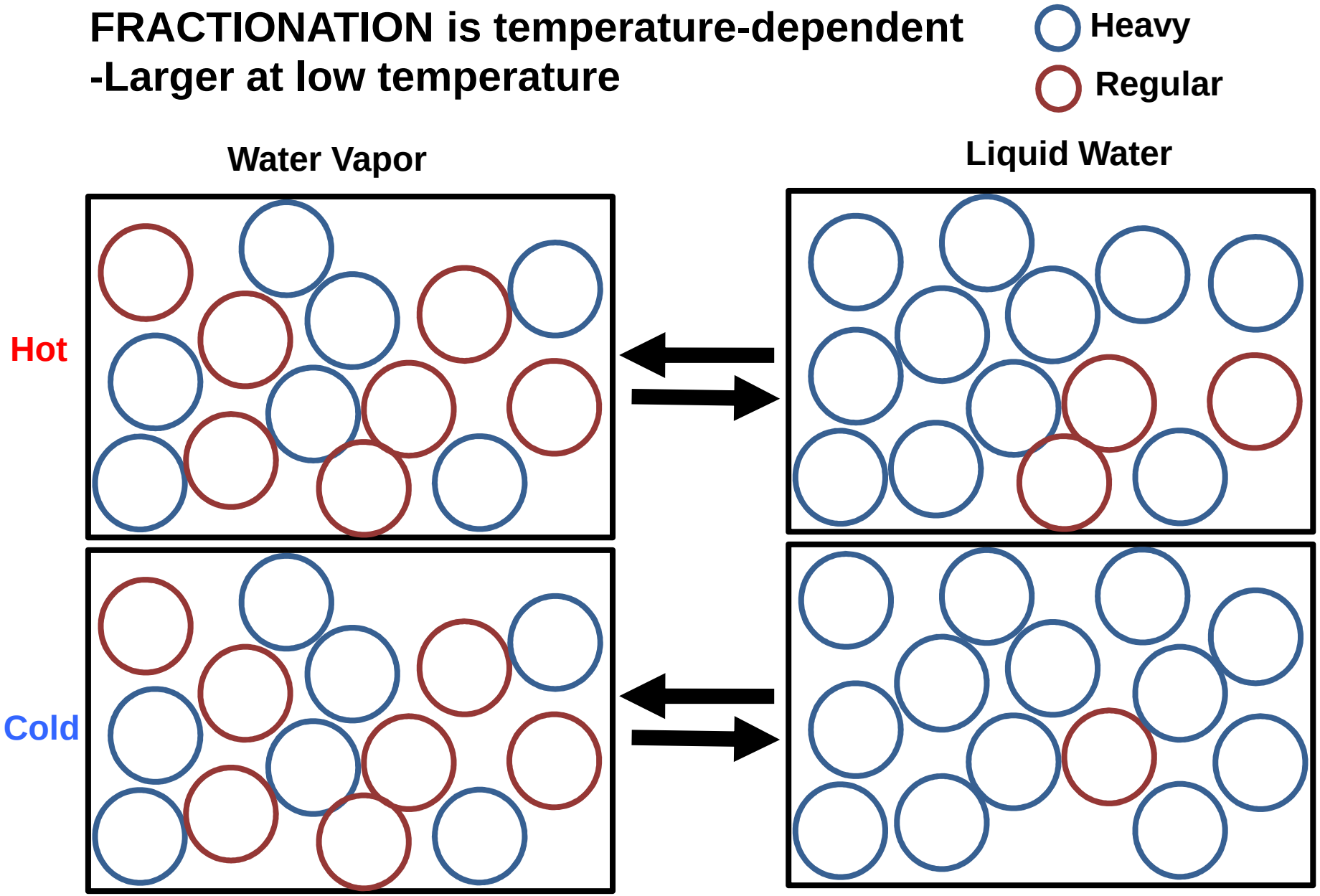


Heavy water



Even heavier water

FRACTIONATION is temperature-dependent
-Larger at low temperature



Setup of the NEEM isotopic surface campaign 2009 - 2012

Subsurface temperature
Measurements 0-150cm
With 10 mK resolution

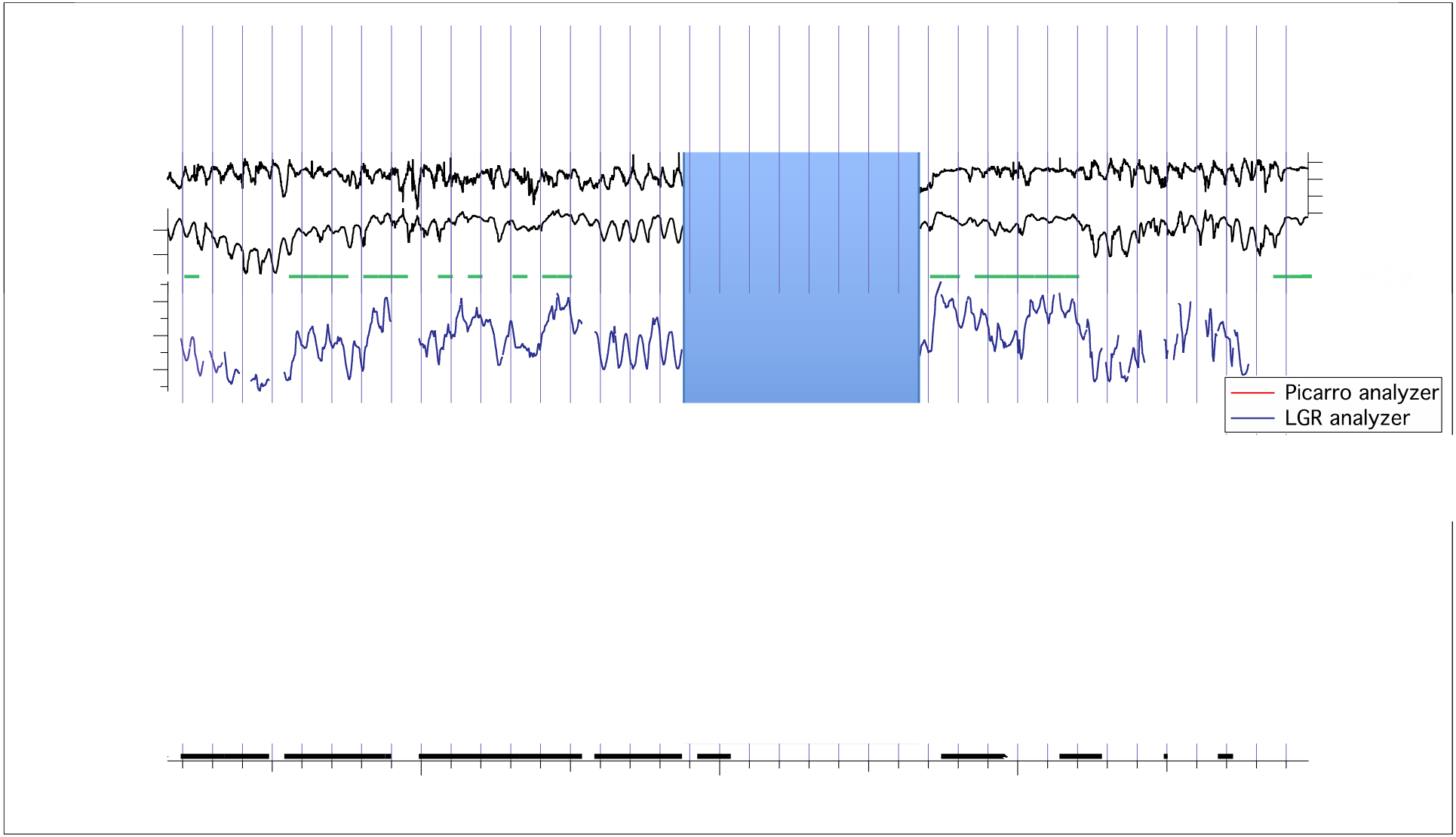
Air temperatures
1, 3, 7, 10, 13 m
above snow surface

d18O and dD of vapor
Continuously from
1, 3, 7, 10, 13 m
above snow surface

Precipitation samples
Collected as often as
possible

Surface snow
samples every
12 hours

Water vapor isotopes on top of the Greenland Ice Sheet



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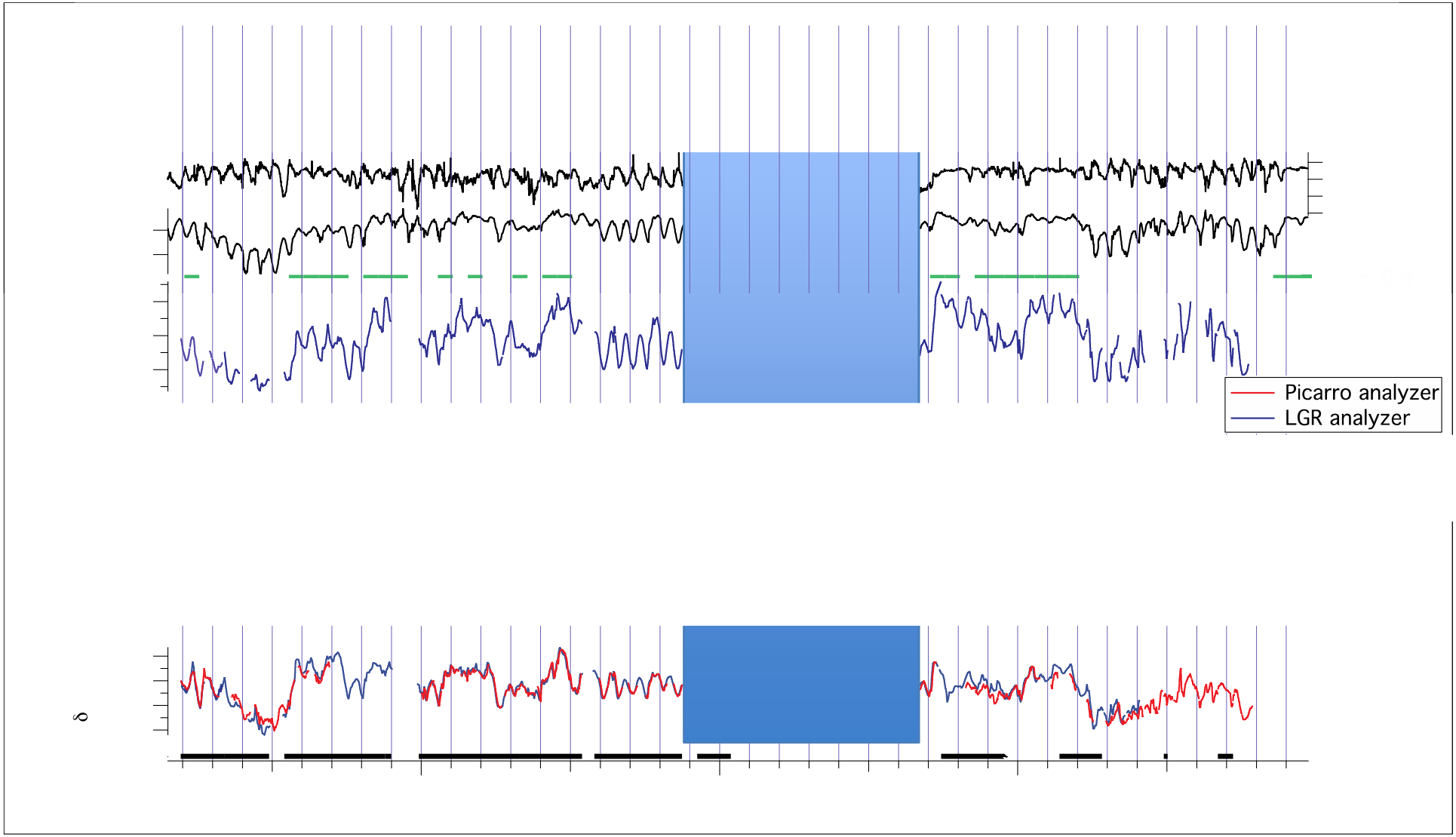
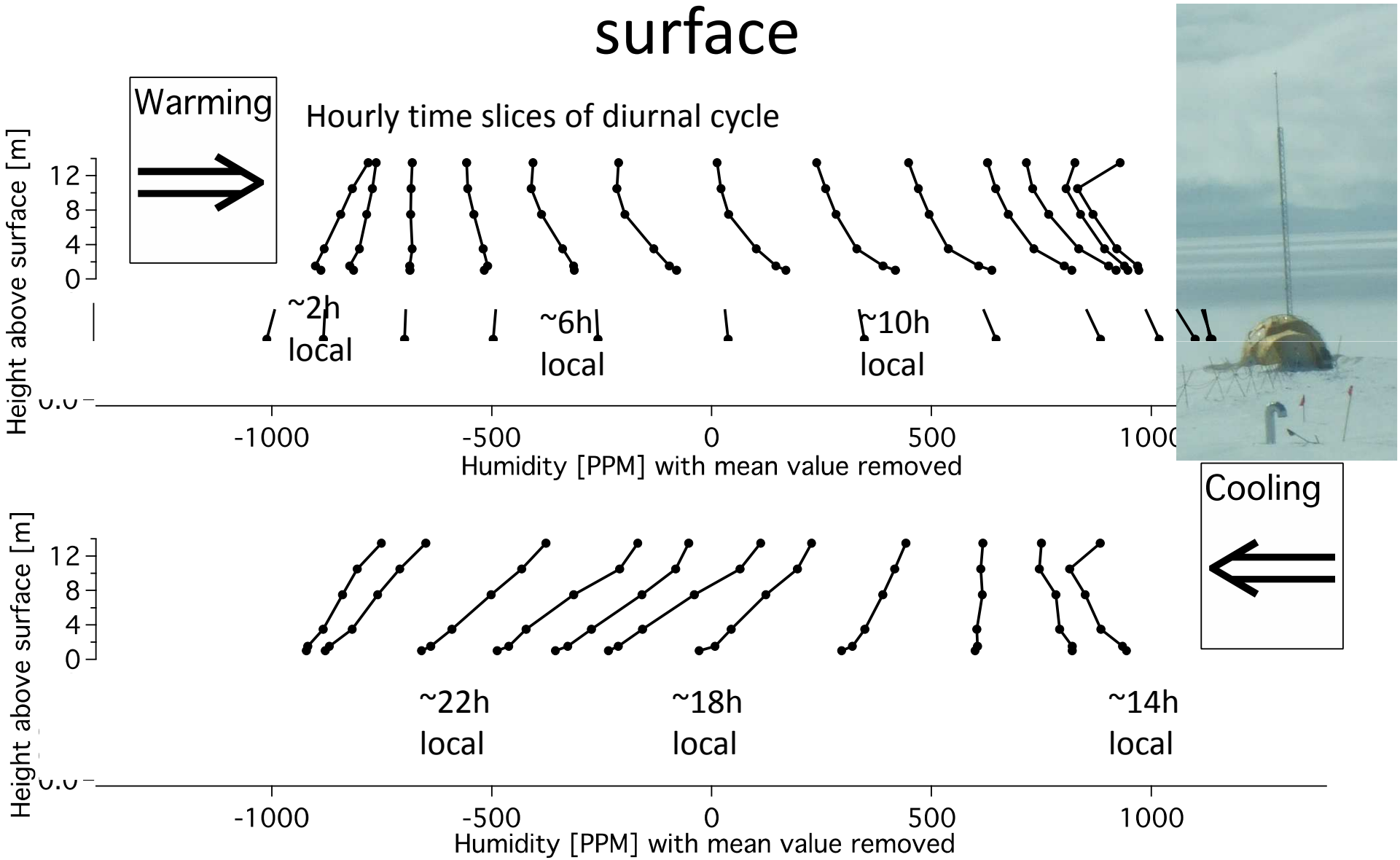
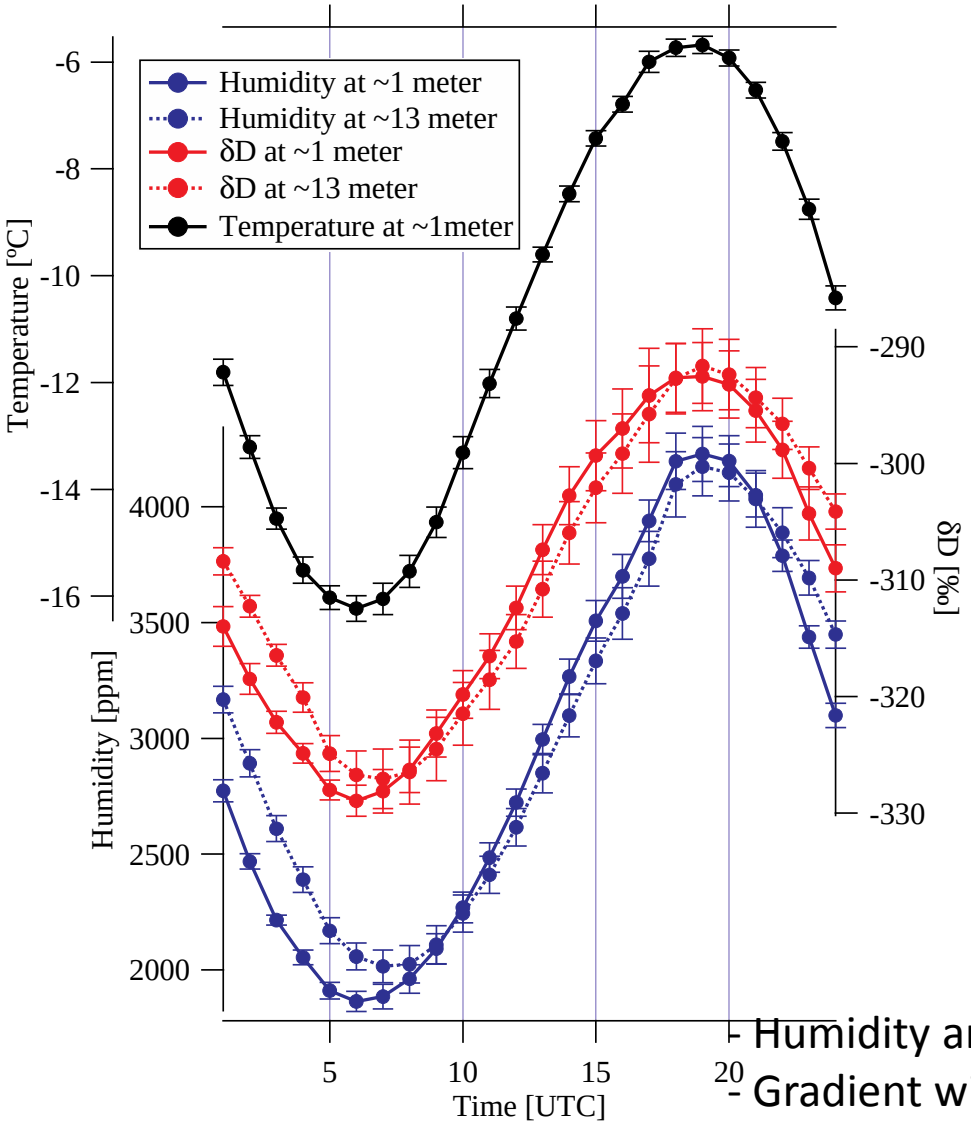
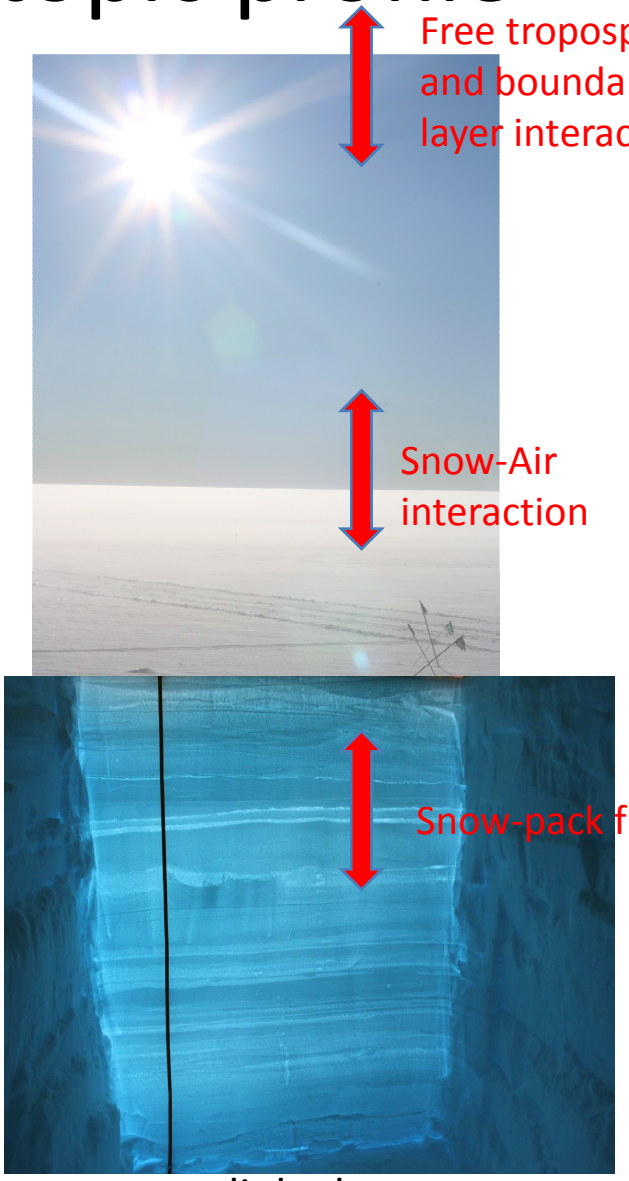


Vertical diurnal structure of the atmospheric water vapor close to the surface



The structure of the isotopic profile with height

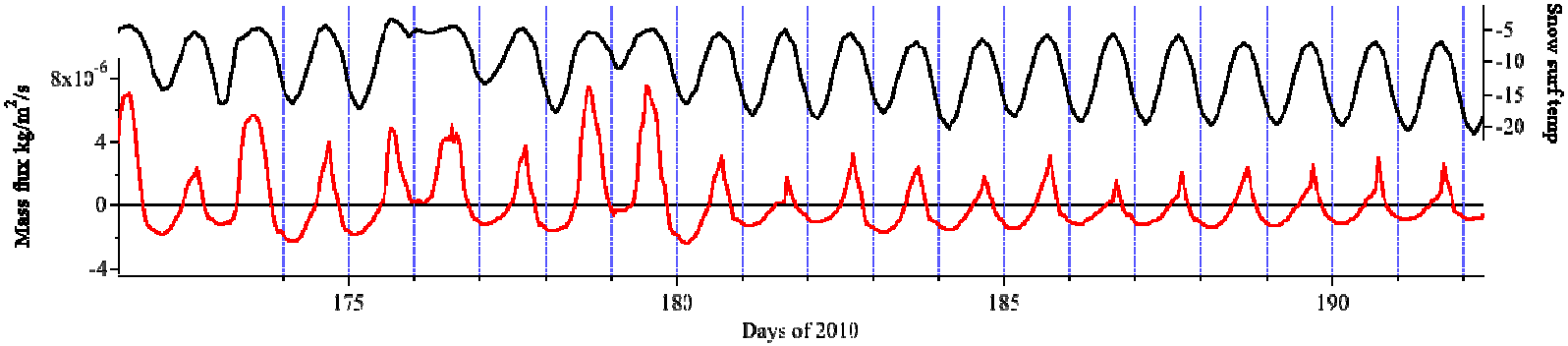




- Humidity and isotopes are linked
- Gradient with height in both humidity and isotopes

Still work in progress

Model output (Mass flux and snow surface temperature) from CROCUS

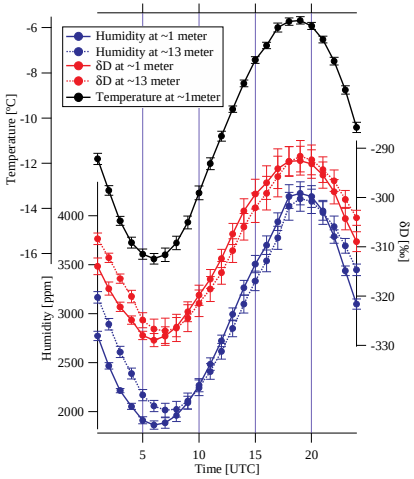


ERA-40 re-analysis → CROCUS Snow pack scheme → Validate against observation

Snow surface isotopes → Interstitial fluxes, Snow-air fluxes

Free troposphere isotopes → Boundary layer model

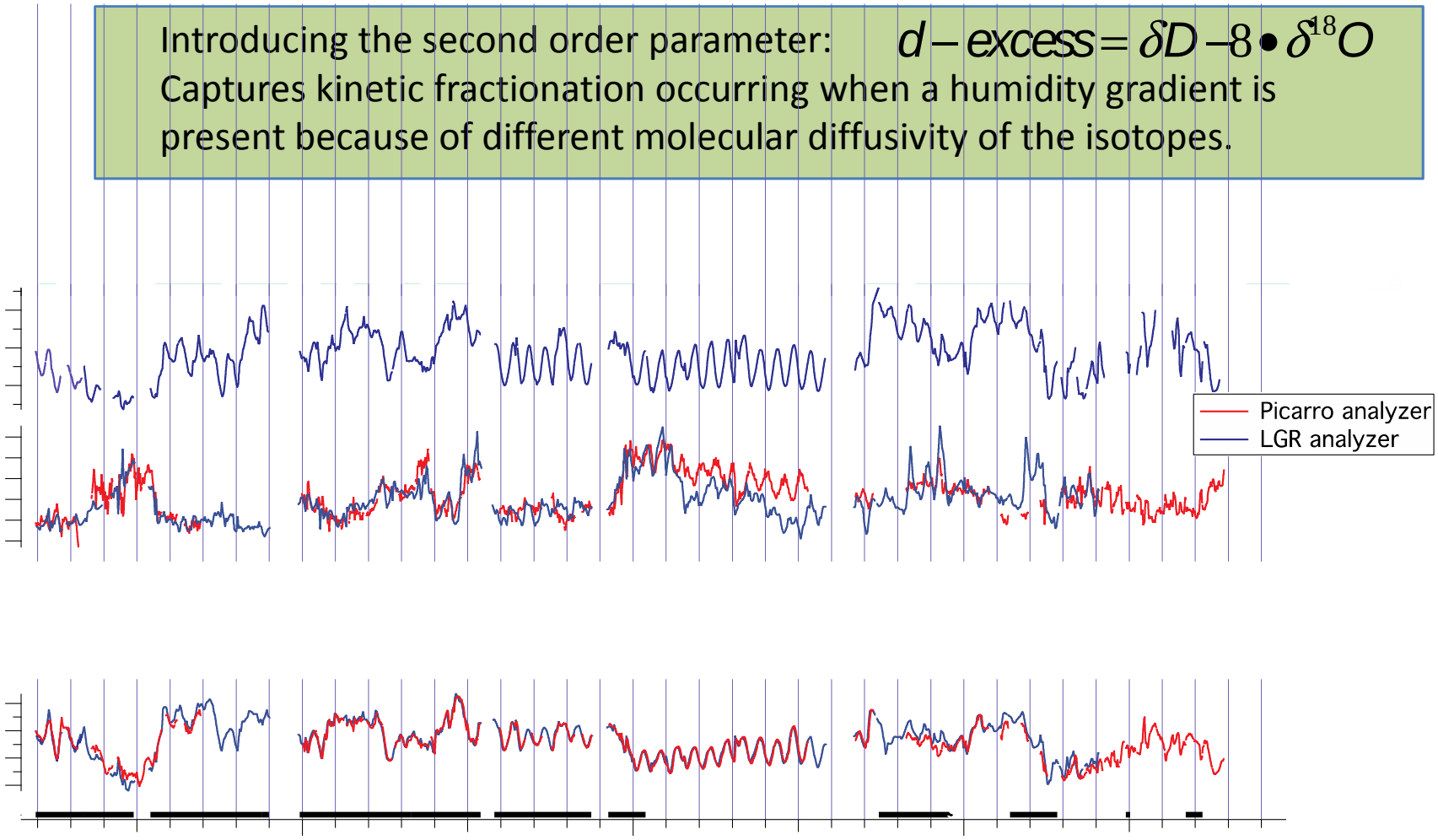
Compare with atmospheric water vapor isotopes →



Water vapor isotopes as means of tracking origin of the vapor

Introducing the second order parameter: $d-excess = \delta D - 8 \bullet \delta^{18}O$

Captures kinetic fractionation occurring when a humidity gradient is present because of different molecular diffusivity of the isotopes.



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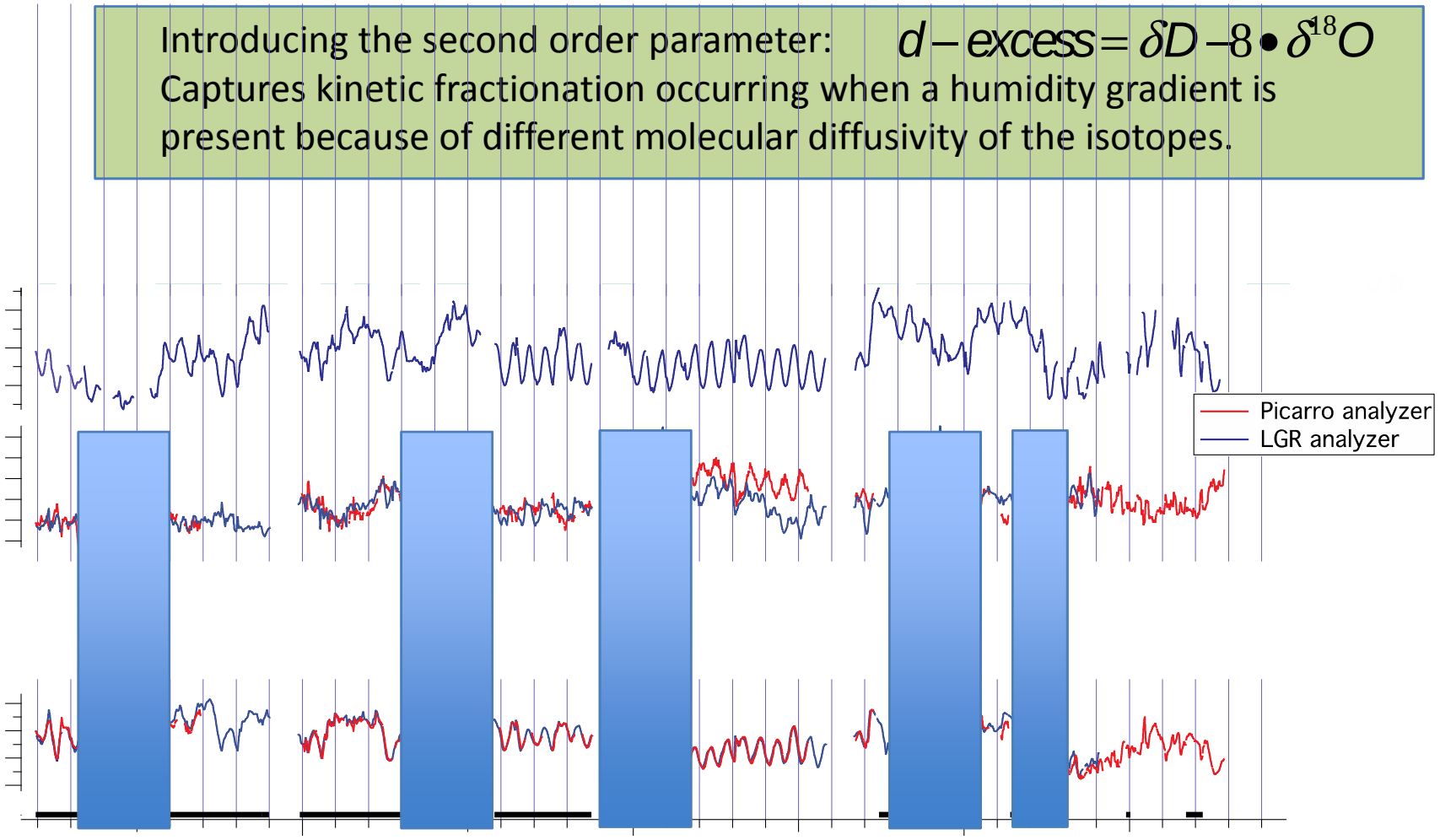
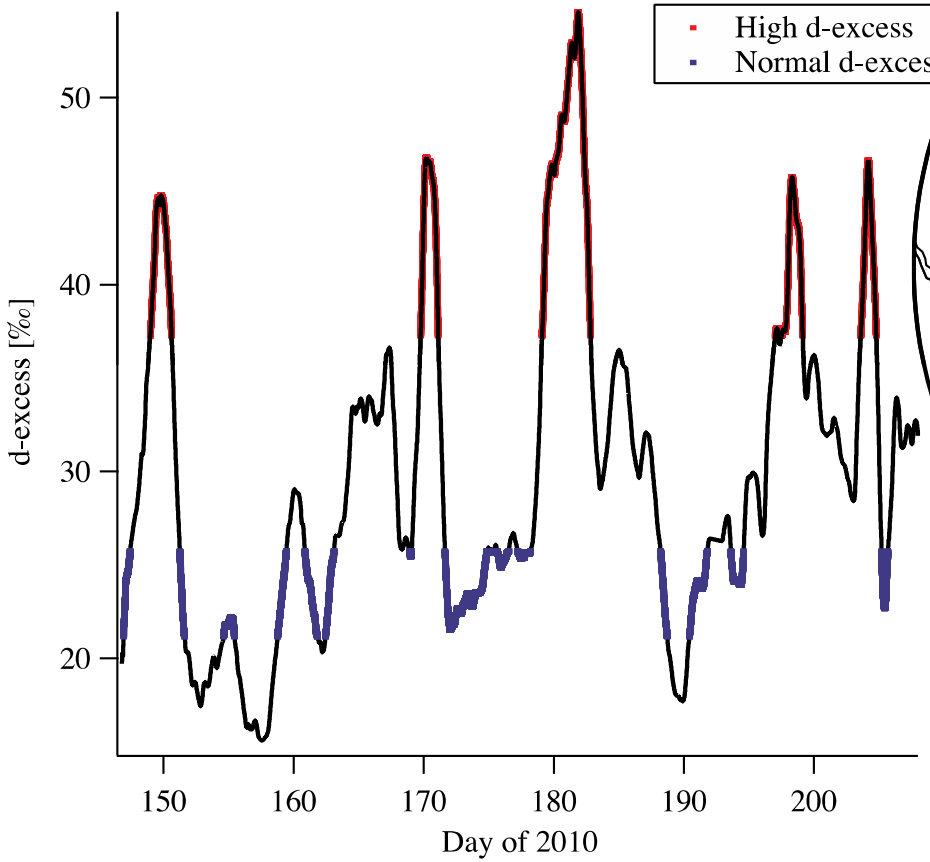
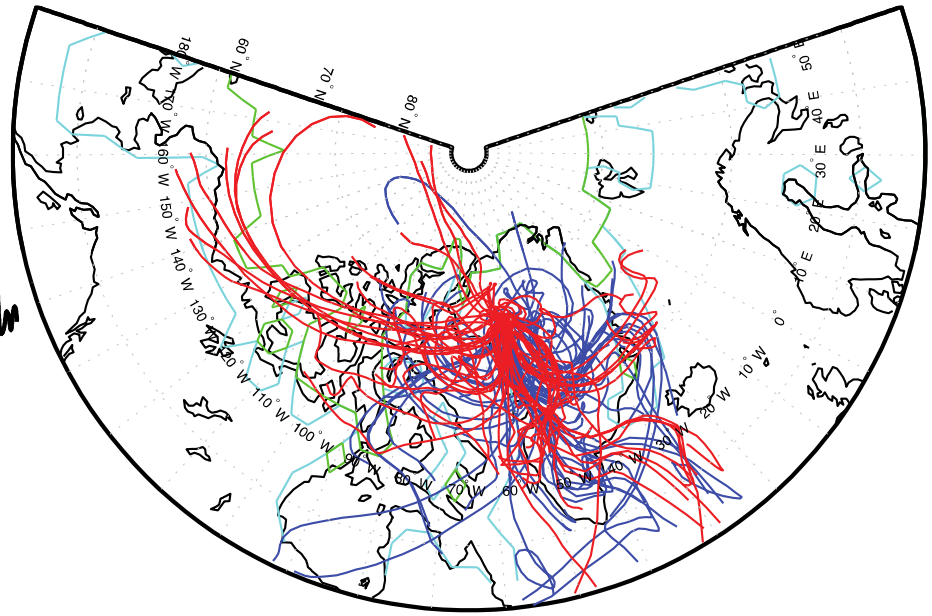


Using back trajectories to find the moisture source





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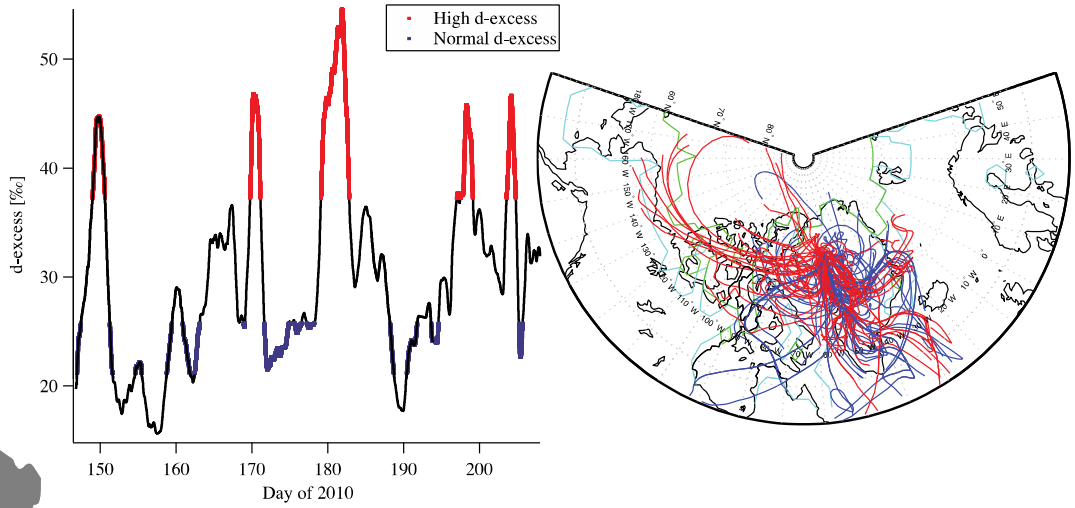
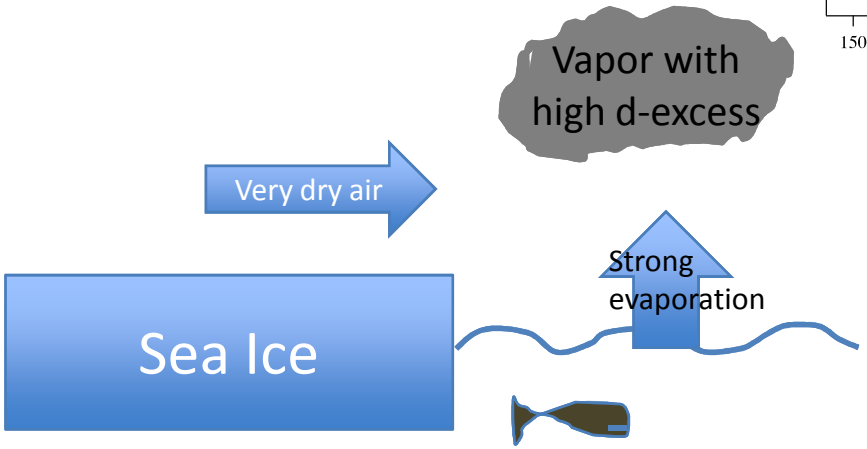
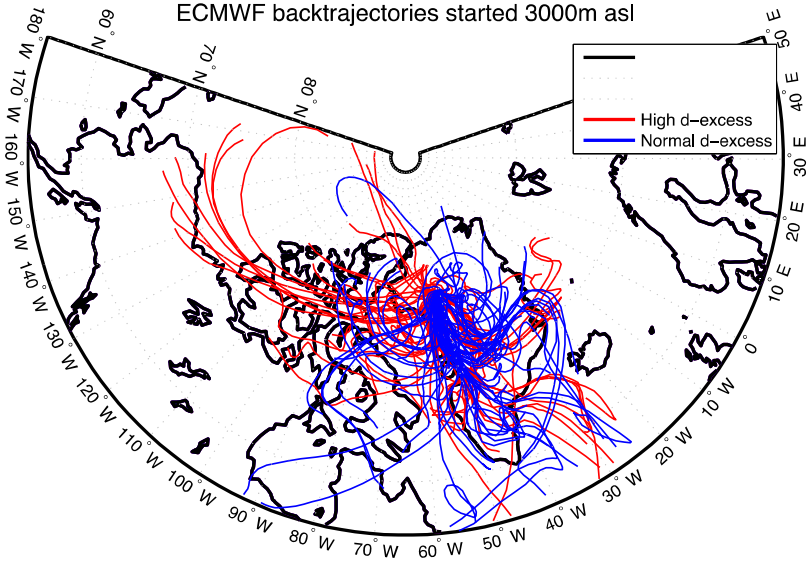




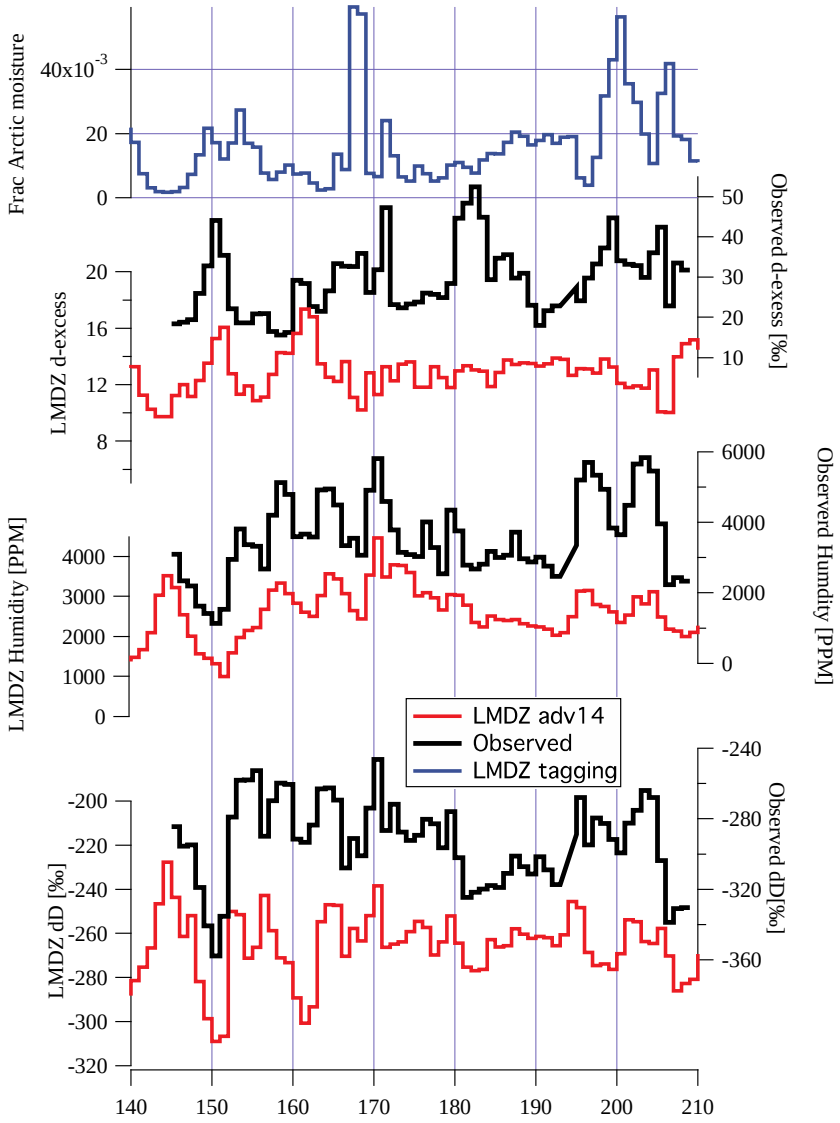


Comparing the observations with isotope enabled GCM

Bad agreement between observed and modeled d-excess

Good agreement between observed and modeled humidity.

OK agreement between observed and modeled dD isotopic composition



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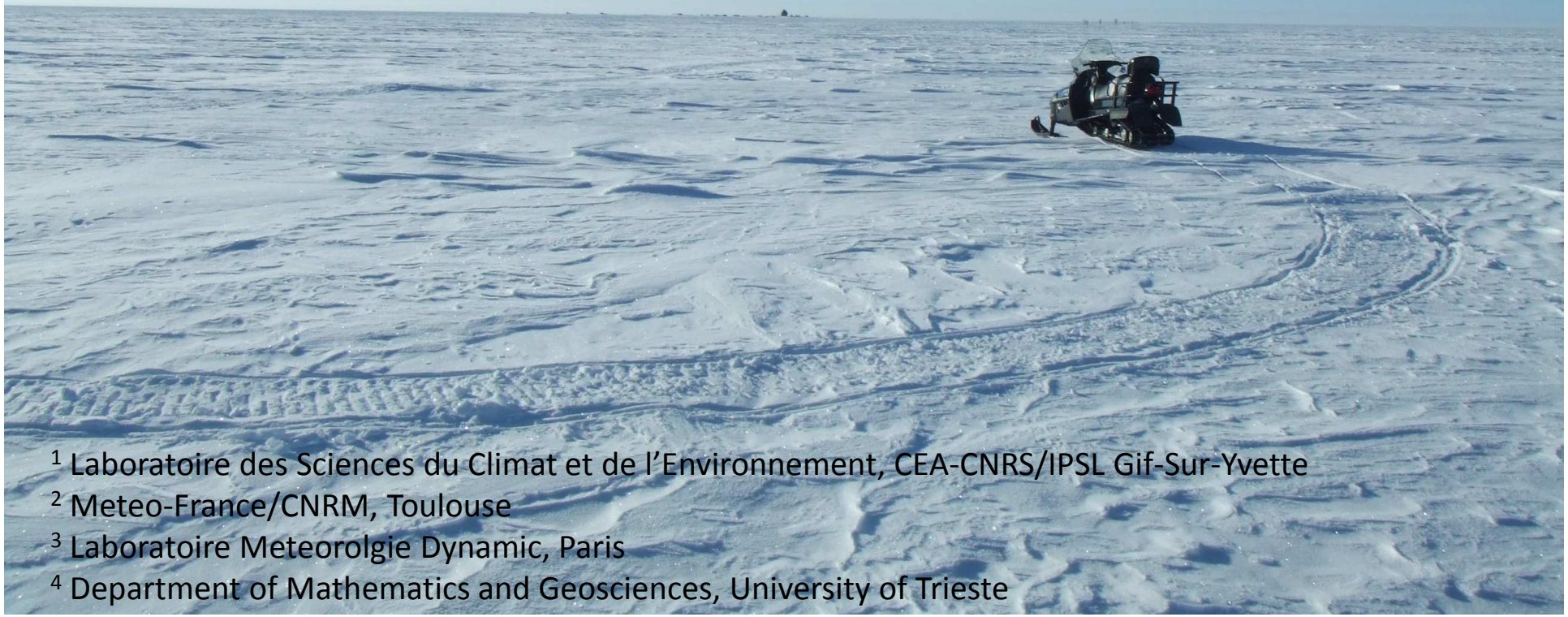

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