SOLAS – June 2015

The water vapor stable isotopes over the Subtropical North Atlantic Ocean - The evaporation processes -

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« What can we learn from water vapor stable isotopes ? »

Definition

Water stable isotopes Light and heavy molecules ($H_2{}^{16}O$, $HD^{16}O$, $H_2{}^{18}O$)

Notation **$\delta^{18}O$** for Oxygen / **δD** for Hydrogen

- Integrative tracer for phase-transition and mixing processes
- Efficient tool to investigate the hydrological cycle processes

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- Estimation of the past climates from ice cores measurements
- Evaluation of atmospheric GCMs (eg. Humidity bias)
- Study of the atmospheric circulation (eg. Tracer of air masses and of the moisture source, characterisation of convective systems)

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AIM

Need to understand well how isotopic composition varies during the evaporation process at the sea surface.

« What we already know on the isotopic fractionation during evaporation ? »

≠ vapor pressure & molecular diffusivities of the water isotopes

↓

The isotopic composition of the evaporated flux is depleted compared to the surface sea water by two main mechanisms

↙ ↘

EQUILIBRIUM

$\delta D \approx 8 \times \delta^{18}O$

KINETIC

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How do local atmospheric parameters such as humidity and wind speed control the kinetic fractionation during evaporation ?

Deuterium excess

$d = \delta D - 8\delta^{18}O$

→

Strong kinetic → Strong d

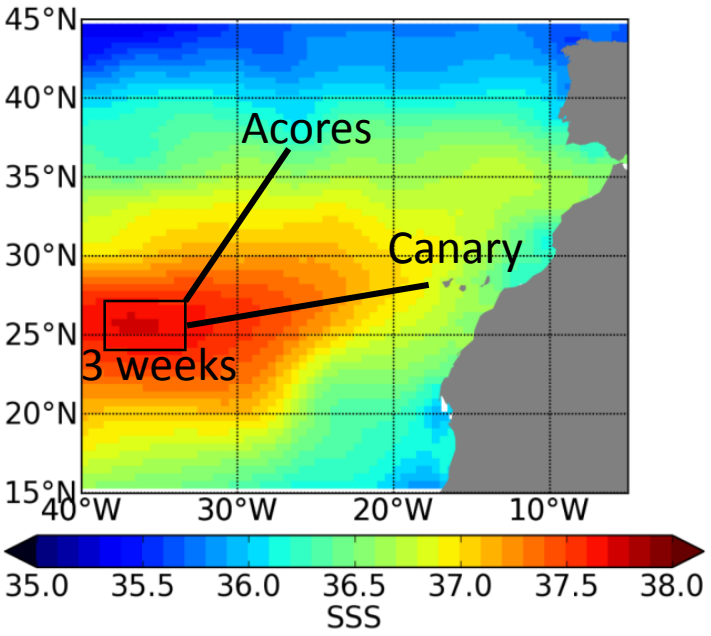
Low kinetic → Low d

Dansgaard, 1964

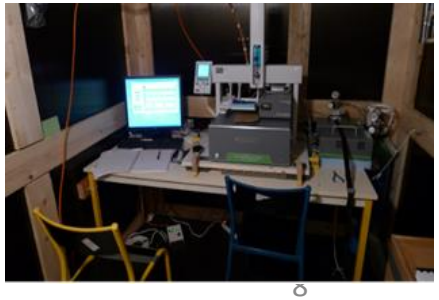
The evaporation at the North Atlantic subtropical gyre surface

How do local atmospheric parameters such as humidity and wind speed control the kinetic fractionation during evaporation ?

STRASSE
(summer 2012)



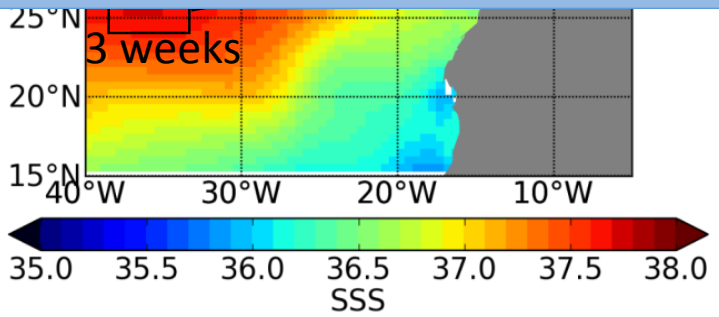
RV La Thalassa

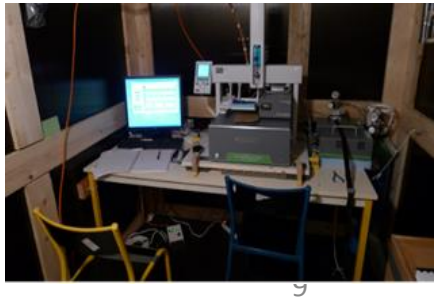


The evaporation at the North Atlantic subtropical gyre surface

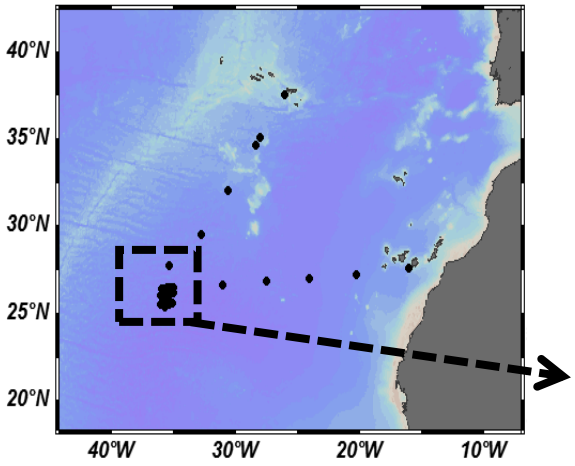
How do local atmospheric parameters such as humidity and wind speed control the kinetic fractionation during evaporation ?

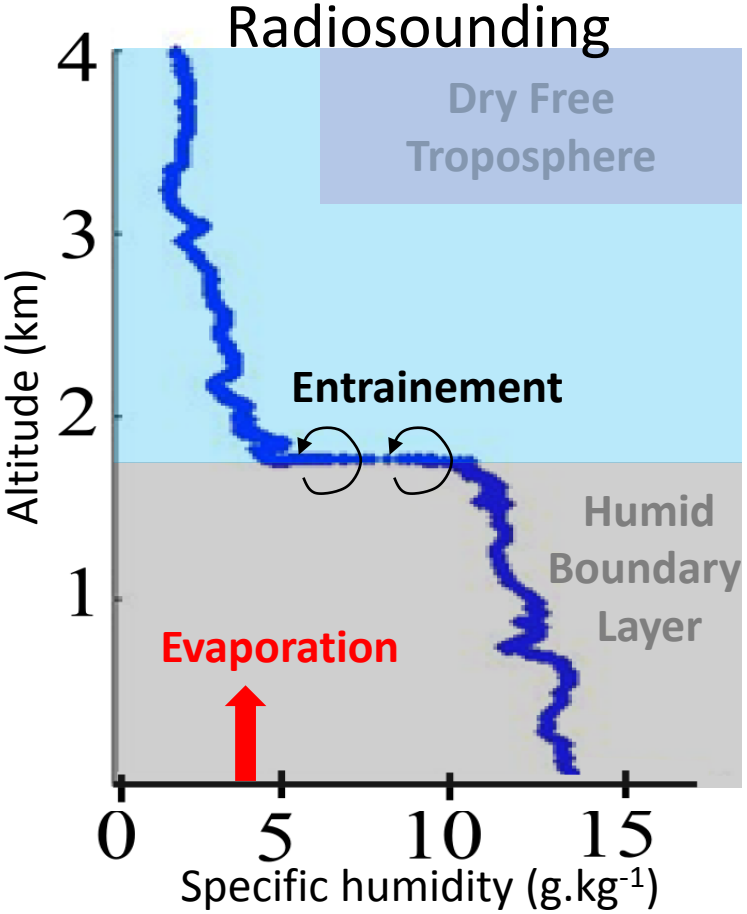
- First continuous measurements over the Atlantic Ocean
- Unique opportunity to investigate the kinetic fractionation during the evaporation processes

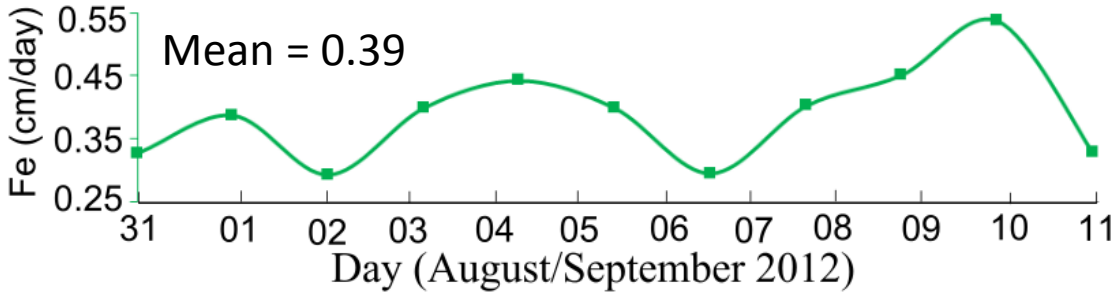




Meteorological conditions - Typical of the GST in Summer



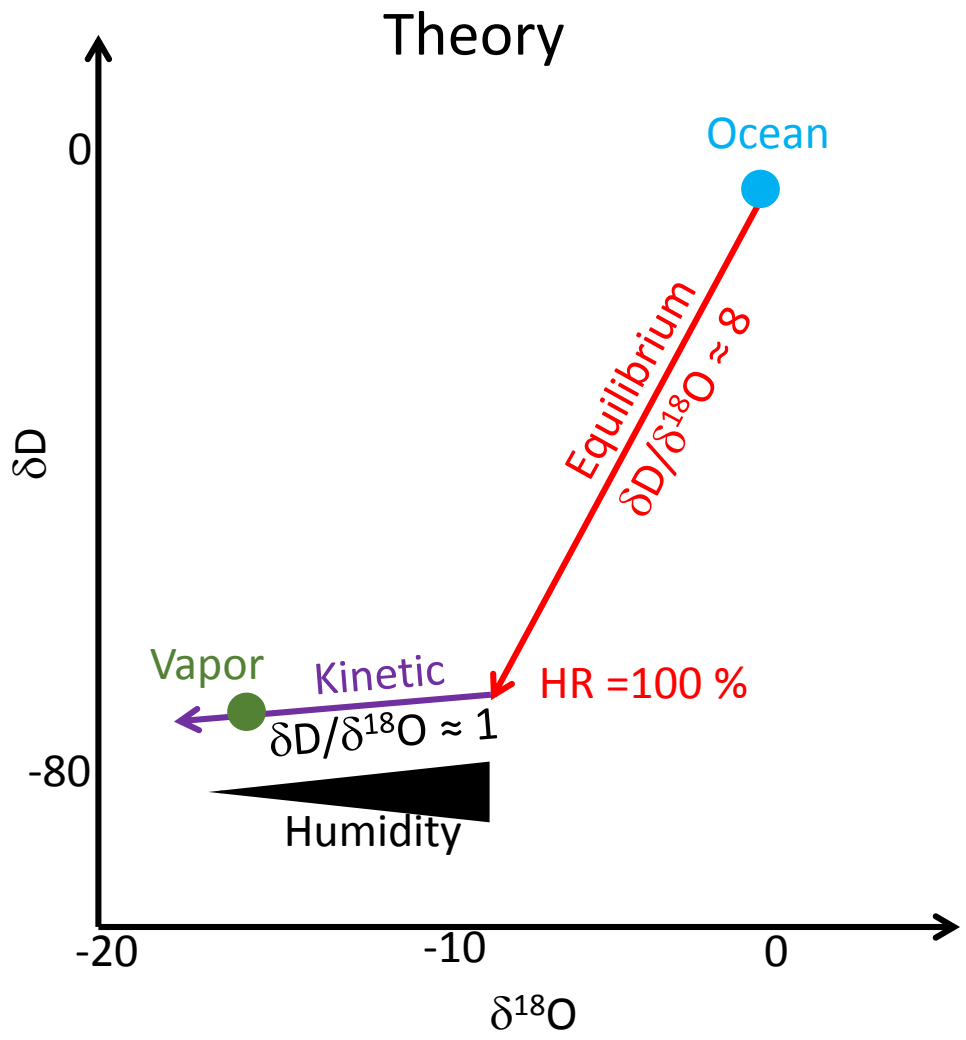




We expect a strong influence of the evaporation flux on the humidity at the sea surface.

δ variability during evaporation processes

How does evaporation affect the isotopic compositon of the water vapor at 17 m?



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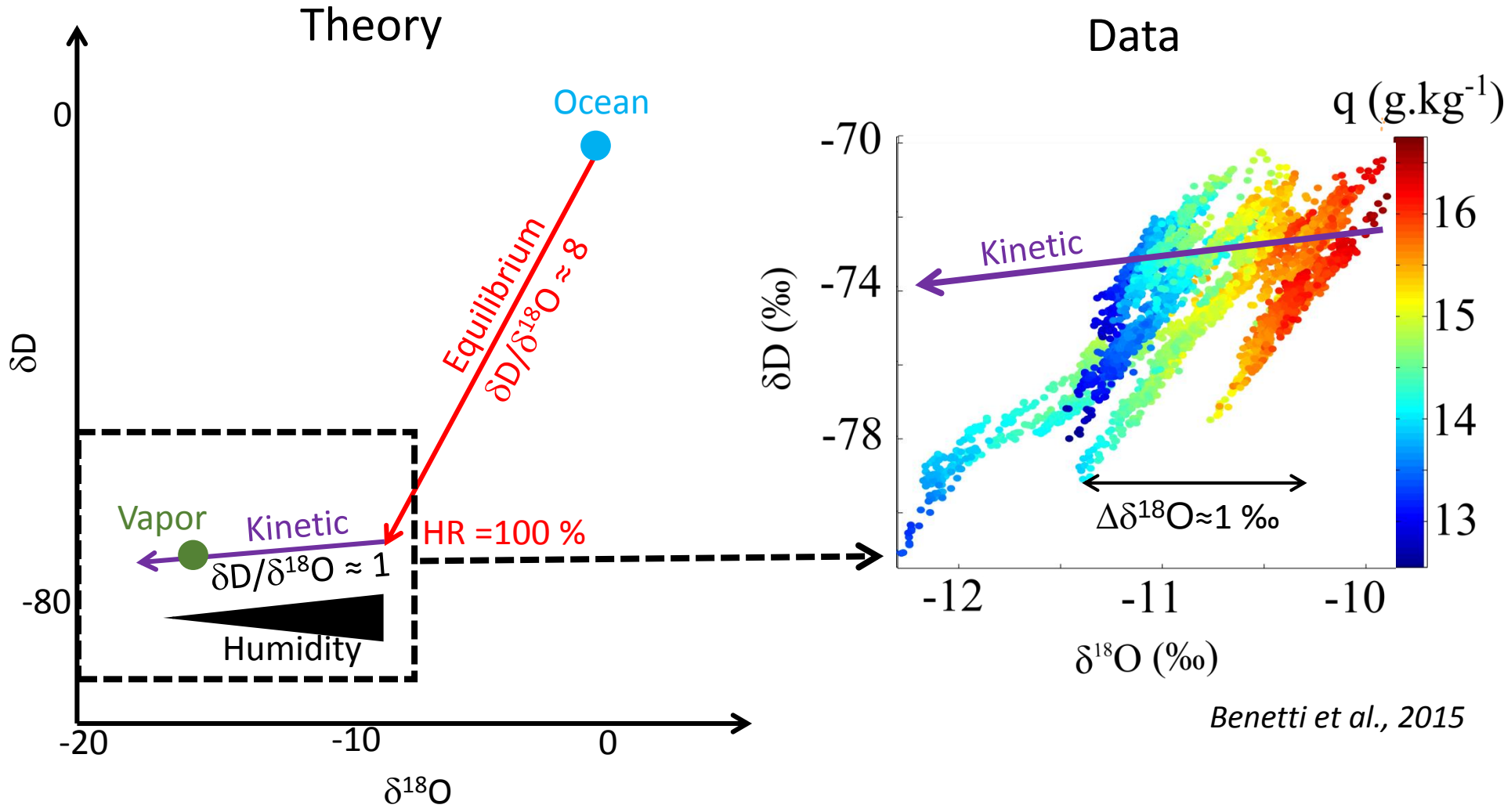

Benetti et al., 2015

Strong influence of the evaporation on the water vapor at 17 m

Results – Atmospheric surface conditions & kinetic processes

The closure assumption

(Merlivat and Jouzel, 1979)

Dependency of deuterium excess to

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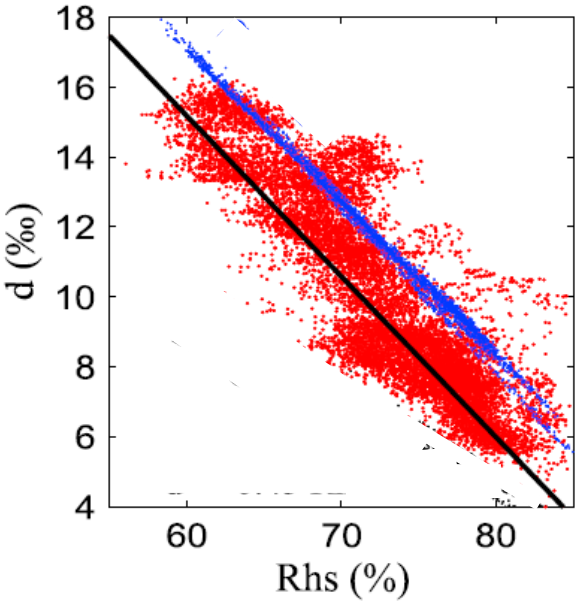
Dependency of deuterium excess to

Humidity

Wind speed



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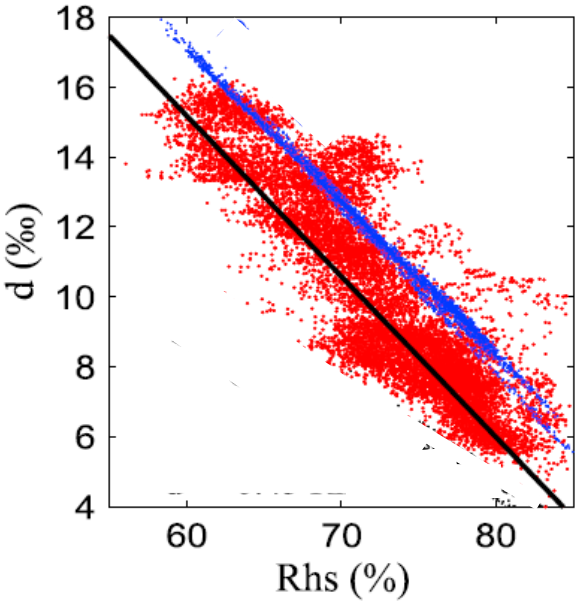
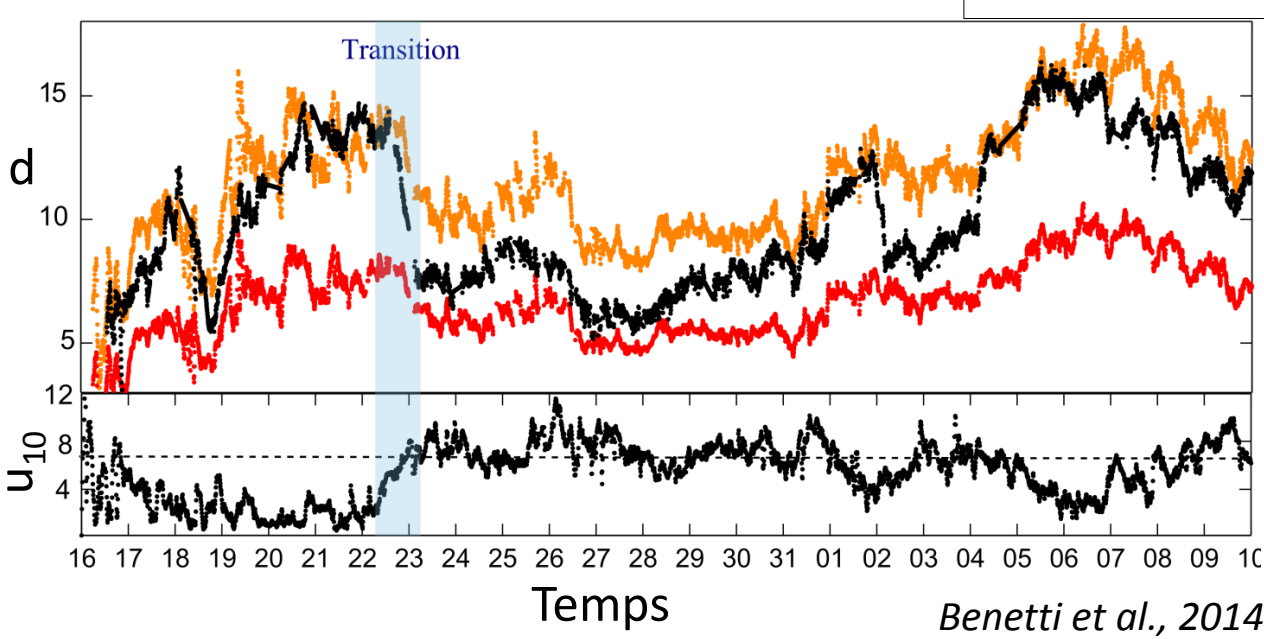




Benetti et al., 2014

Dependency of d-excess to surface conditions
Humidity / Wind speed

Conclusions

- Innovative data : Improvement of the characterisation of the isotopic fractionation during evaporation processes

- Comparison with the closure assumption : testing with observation the link between the kinetic fractionation and the atmospheric surface conditions

δD - $\delta^{18}O$ diagram

✓ Highlight the influence of the evaporation processes on the humidity at 17 m

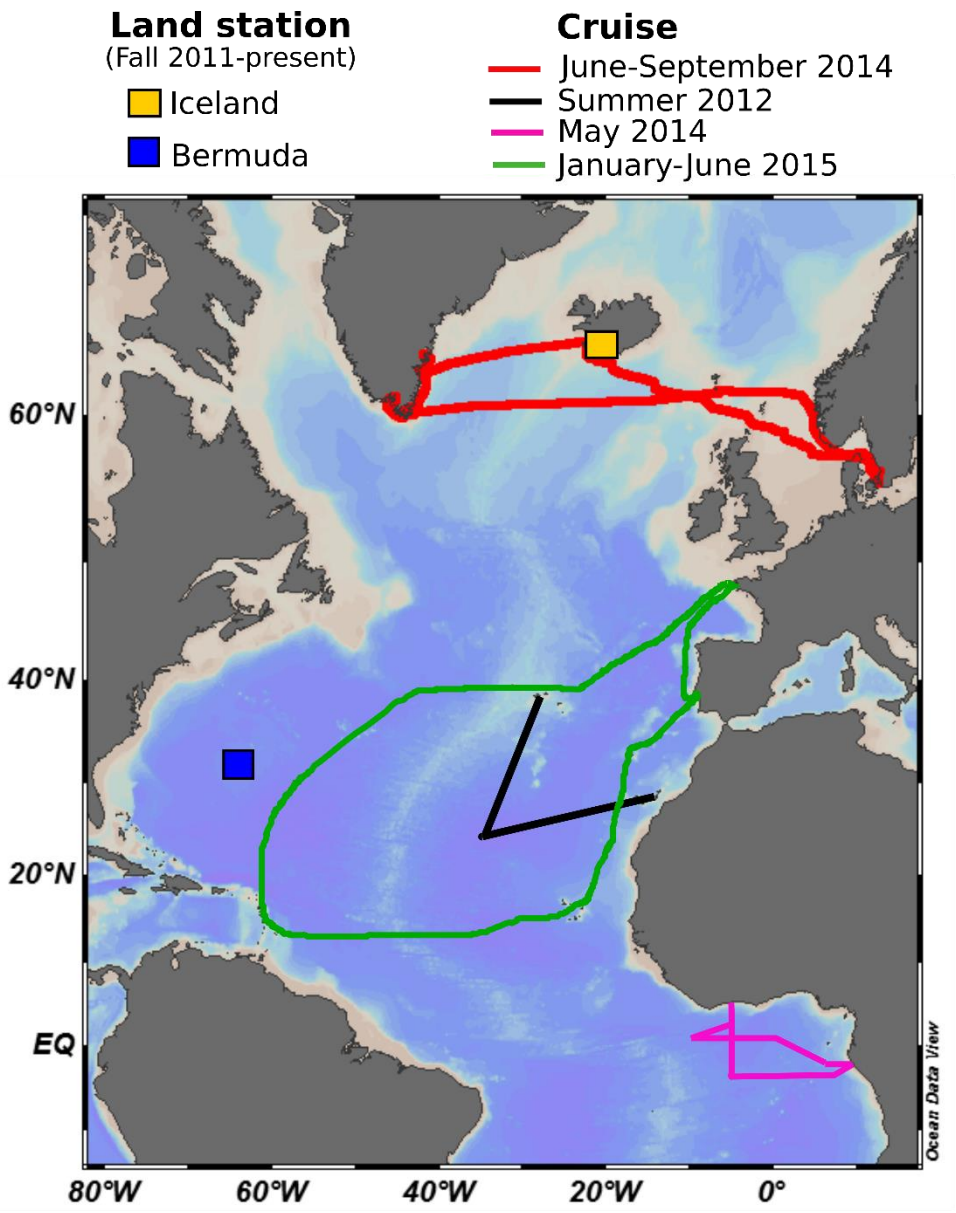
d-excess : Test of the closure assumption

✓ Robust indicator of the humidity condition

✓ Potential indicator of the wind regime

- In perspective –

Collaboration with A. Sveinbjörnsdottier and H.C. Steen Larsen



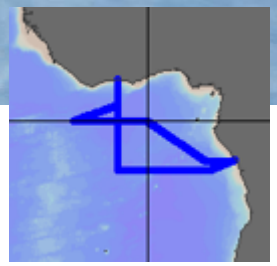
AIM

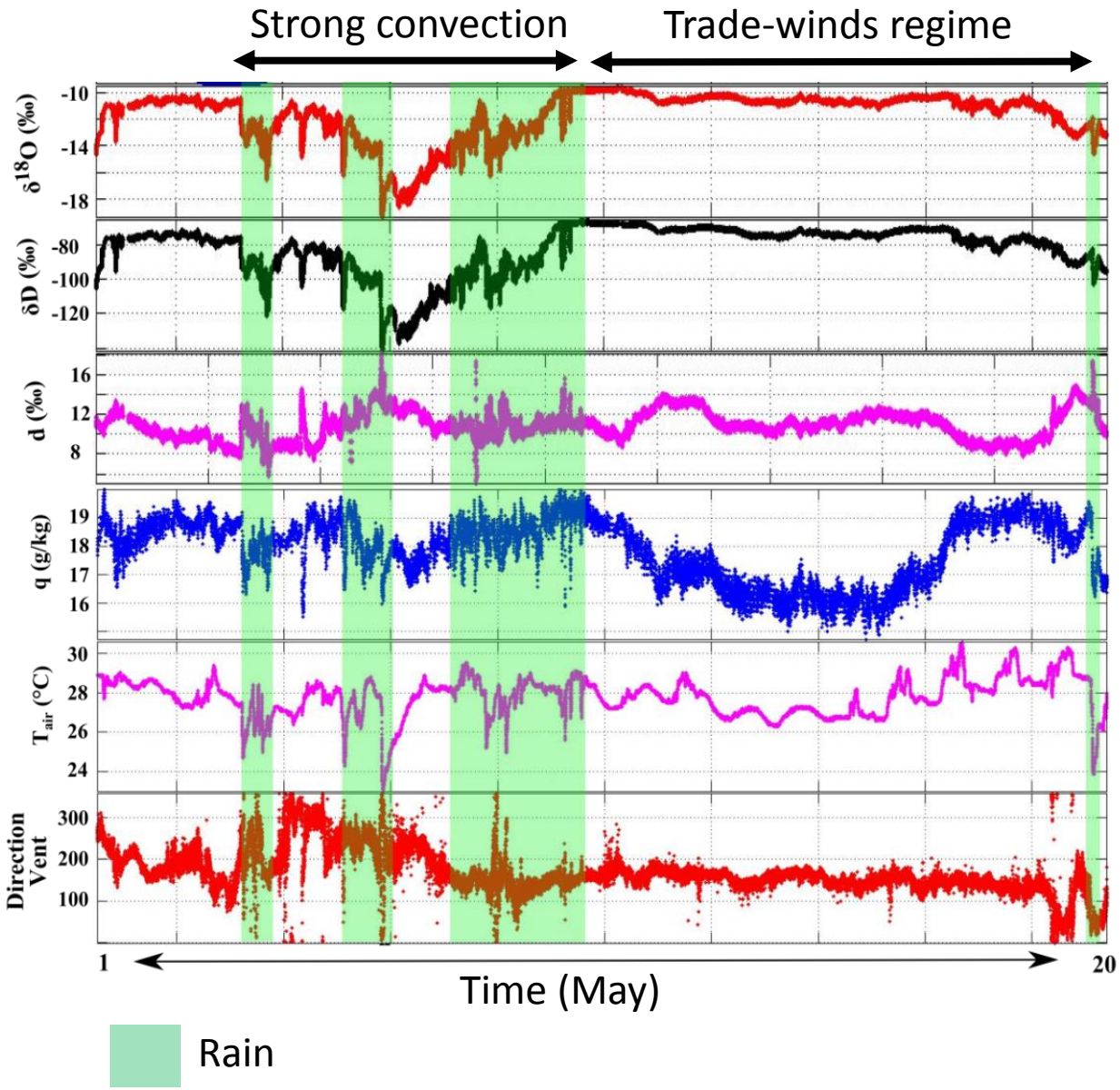
Provide a dataset with both large spatial and temporal resolution.

Investigation of the moisture budget in the NA MBL :

Contribution of the local evaporation, horizontal advection, convection processes, rain reevaporation.

PIRATA FR24 – The Guinea Gulf





Two main atmospheric regimes

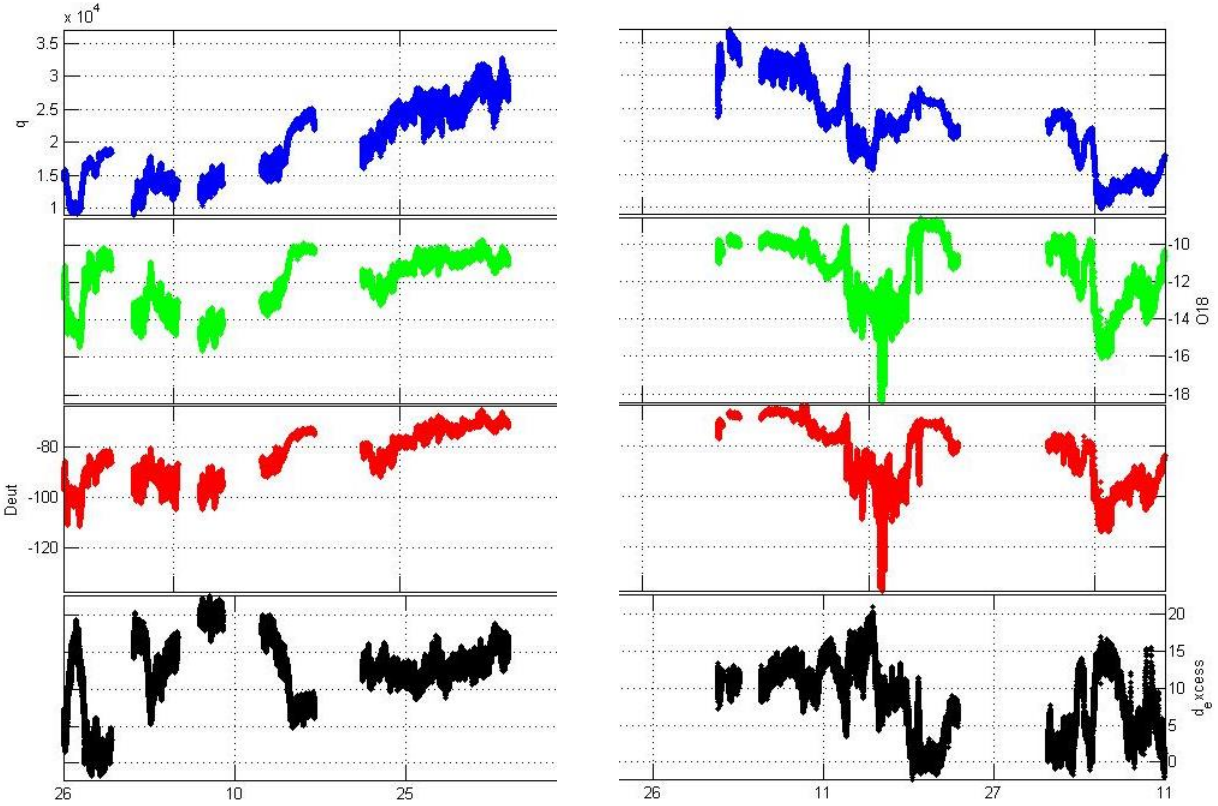
-Deep convection around the ITCZ
- A period of limited vertical mixing within the trade-winds regime

Specific question
Characterisation of the convective system
(eg. comparison with LMDZ-iso, reevaporation of the rain)

RARA AVIS 2015 – The sub/tropical North Atlantic Ocean

January – June 2015
Collaboration with AJD (French association)
35 m

Installation of the scientific material on a sailing boat (eg. limited power supply) – **Success of the protocole**



Specific questions

Seasonal variability of δ_e in the trade winds region (comparison with the summer cruise STRASSE)

Bermudes Island – Comparison with the land station measurement

Thank you for your attention