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Climatic controls on water vapor deuterium excess in the marine boundary layer of the North Atlantic based on 500 days of in situ, continuous measurements

Atmospheric Chemistry and Physics

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Introduction

Å Water stable isotopes in the atmosphere are key tracers of physical processes within the hydrological cycle.

Å Use the ŭ stand for stable isotopic specific value.

ŭ $=(R_s/R_v-1)\times 1000$ă   Craig (1961a)

Where R_s and R_v respectively represent the isotopic ratio of the sample and the Vienna Standard Mean Ocean Water. SMOW $^{2}H/^{1}H$ $R_V=1.5576\times 10^{-4}$

$^{18}O/^{16}O$ $R_v=2.0052\times 10^{-3}$

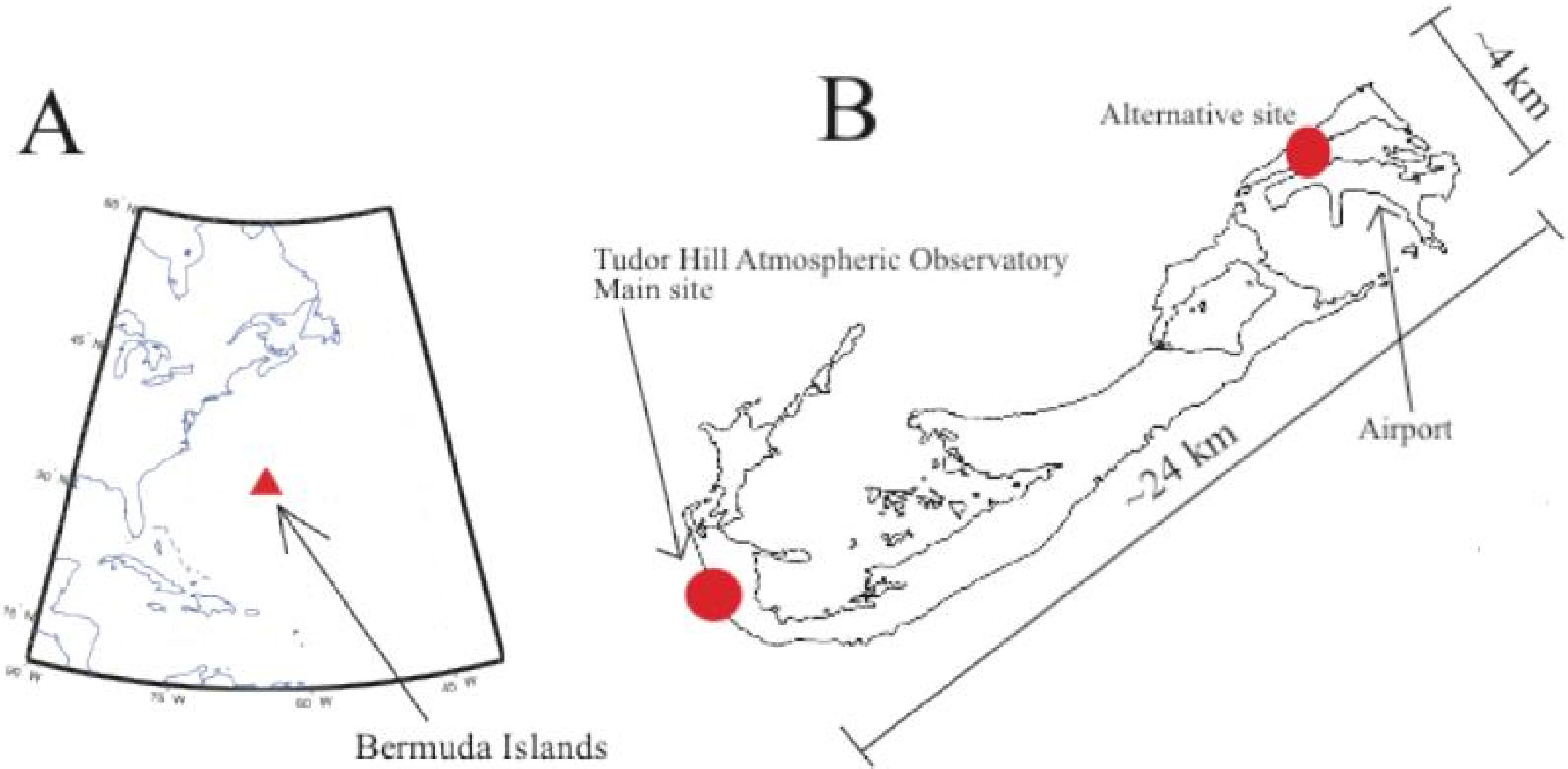
Å D-excess has been defined by Dansgaard(1964) in order to highlight the isotopic variability.

d=ŭD-8ŭ^{18}O

d-excess are dominated by kinetic fractionation.

Å Assessing the validity of MJ79 and evaporation theory of Brutsaert.

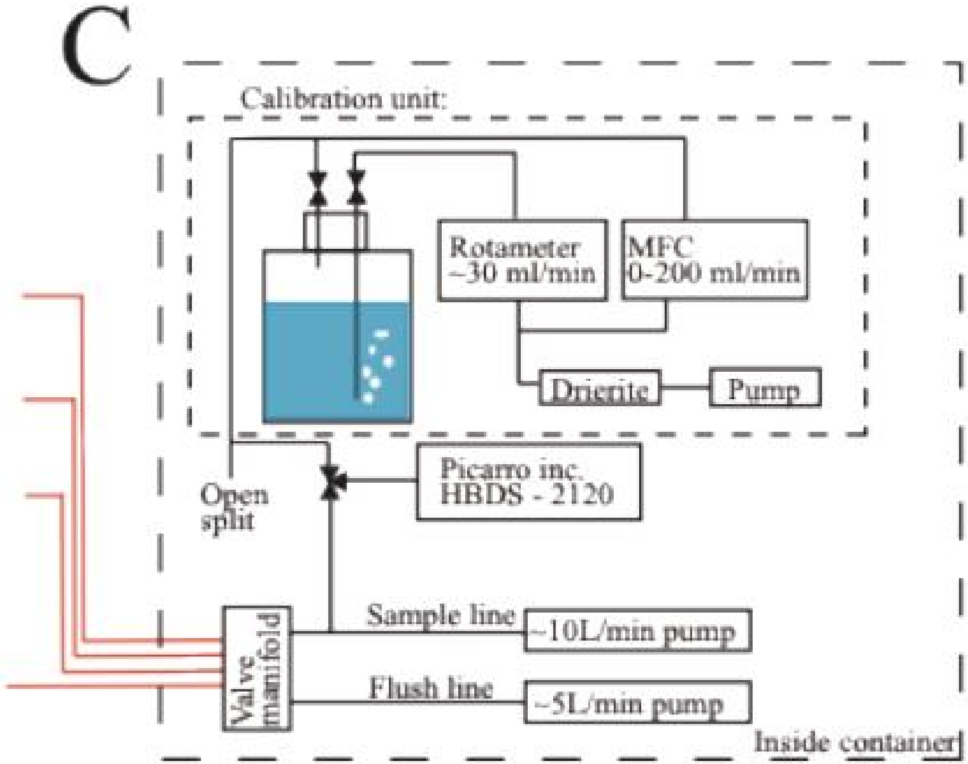
Site Description



Time: installed in November 2011.

Location: Bermuda Islands.

Fig .1



Picarro structure

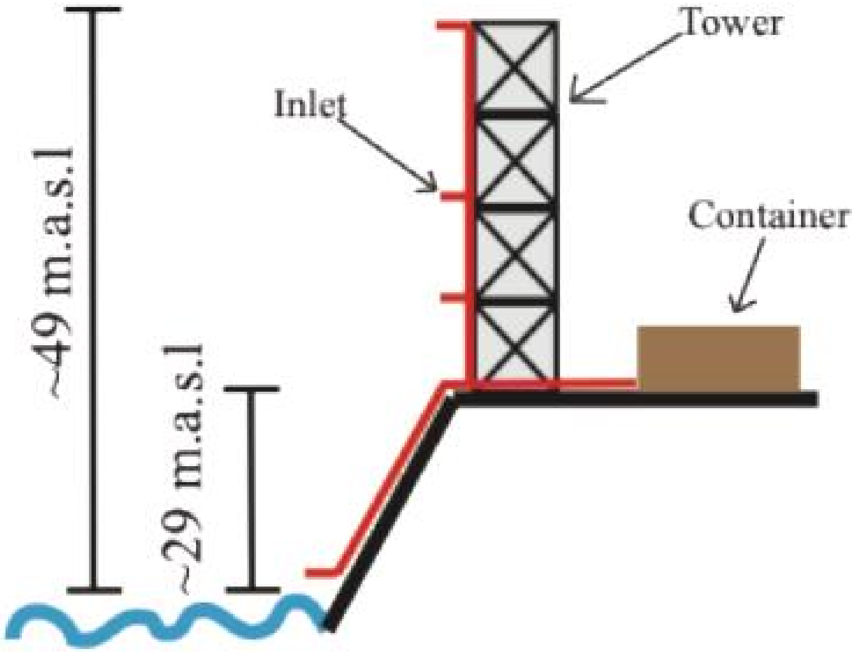
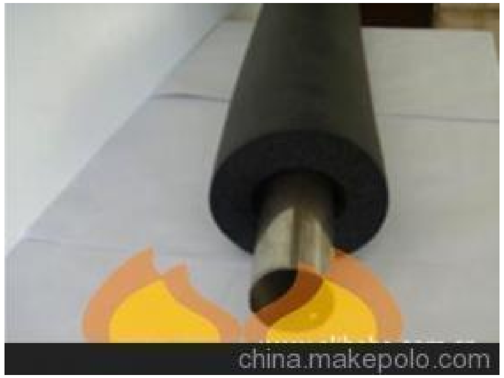


Fig. 2 Three inlets were initially installed on the tower at a height of 49ma.s.l, 42ma.s.l, 35ma.s.l(in November 2011).In June 2013 installed a separate fourth inlet about 2.5ma.s.l.

Using copper tubing to air sampling. All the tubes were placed inside Armaflex, and the entrance of the inlets was placed inside Nalgene.

Armaflex



Nalgene

Materials and method

- Meteorological observations
  - Air temperature and RH were recorded by CR1000.
  - Wind direction and speed a RM Young propeller-type vane.
  - Surface pressure data values and SST taken by the Bermuda Weather Service.
  - Lower atmosphere ozone, greenhouse gas, aerosol optical depth, and solar radiation measurements for NOAA.

Calibration

- Water vapor with a constant isotopic composition is introduced into the instrument at different humidity levels， obtained by diluting the saturated water vapor coming out of the bubbler-system.
- The humidity in steps of 10 min, but start and finish the sequence at the same humidity level in order to correct for drift of the system.

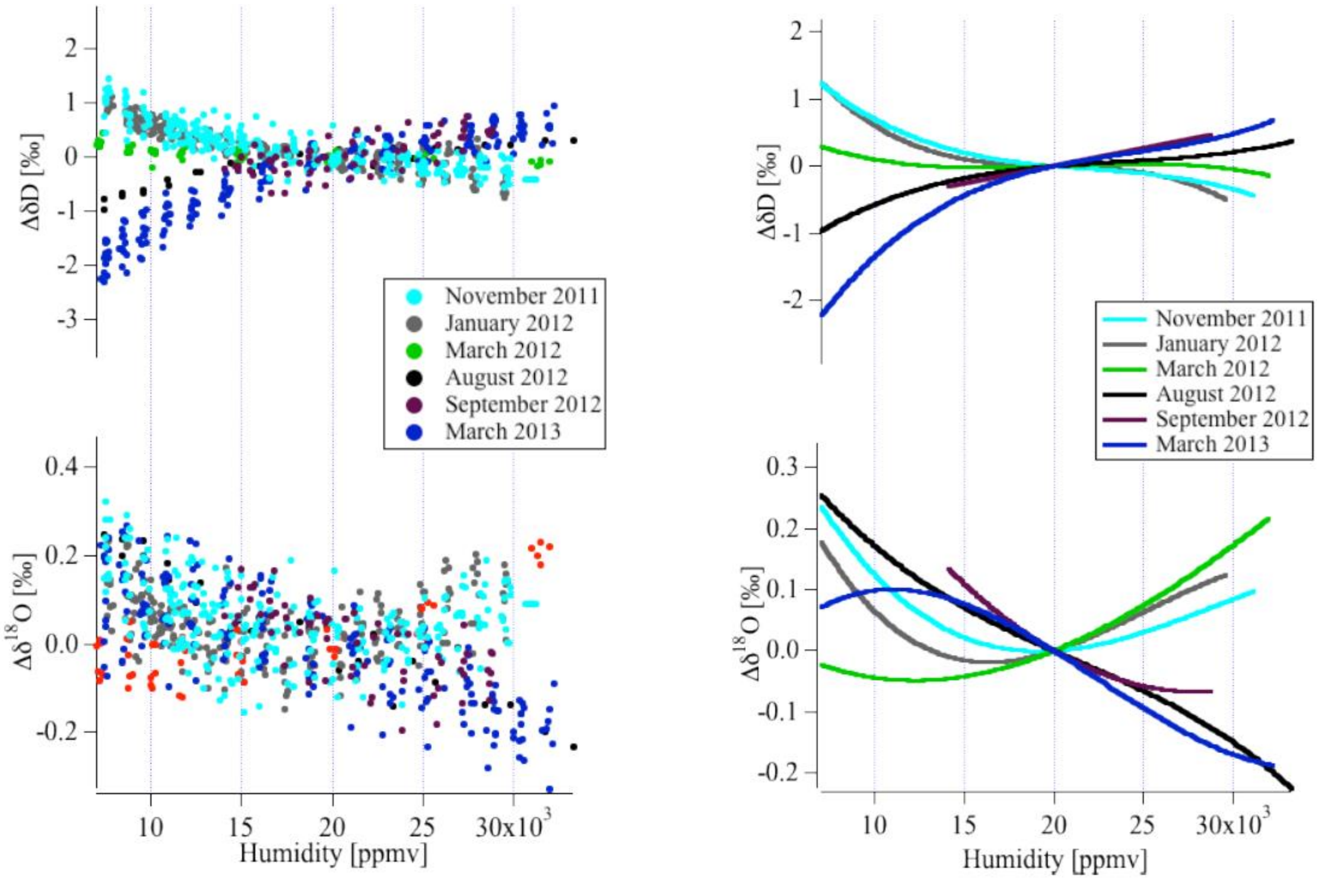


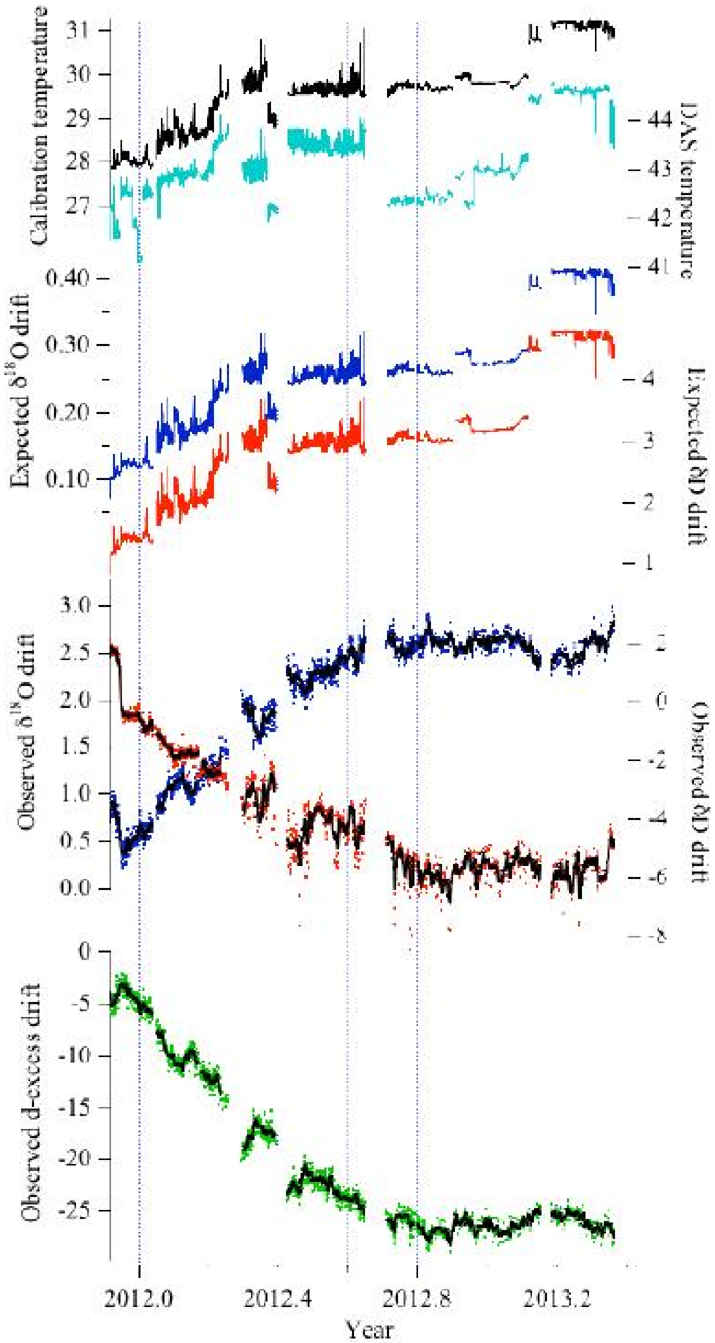
Fig.3. To assess the stability of the humidity-isotope response through time, calibrations were repeated at different dates.

Fig.4.Drift on the measures isotopic values.

Å The top panel shows the temperature of the water body in the bubbler system. Below is shown the internal temperature of the Picarro analyzer.

Å the observed drift in δ^{18}O, ŭD, and d-excess is shown for individual measurements in blue, red, and green dots.

Å The 48h running mean is shown using a black solid line to drift correct the measurements of the atmospheric water vapor isotopes.



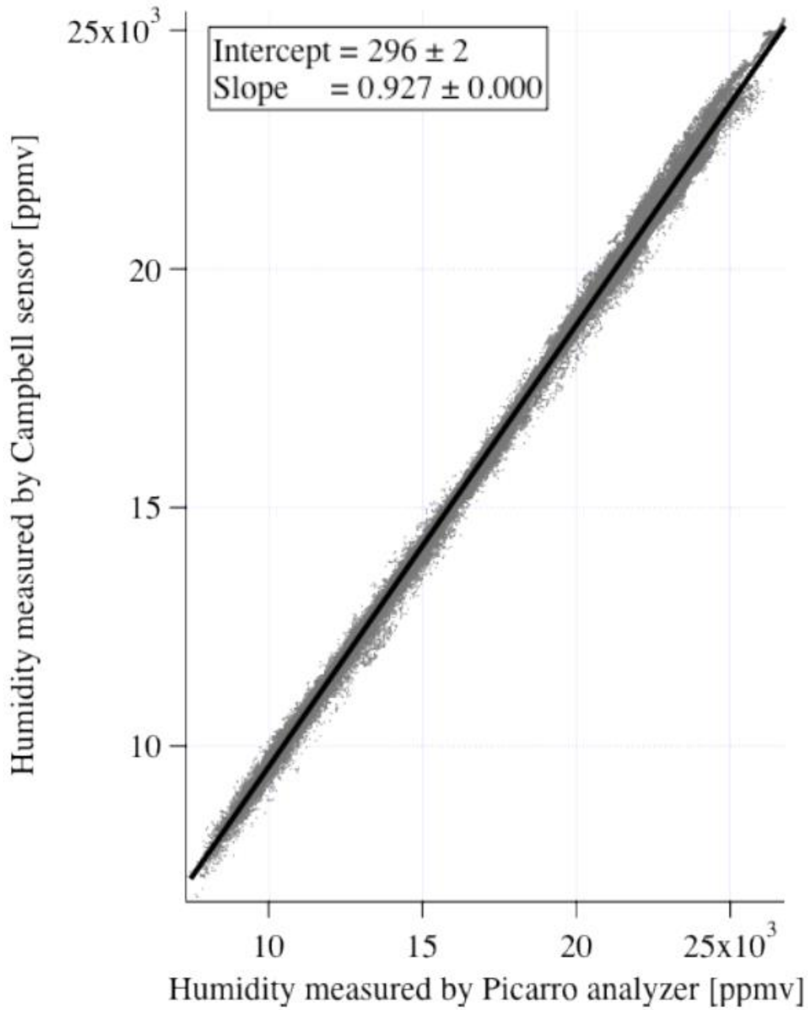


Fig.5 This relationship is used to correct the Picarro humidity measurements.

Results

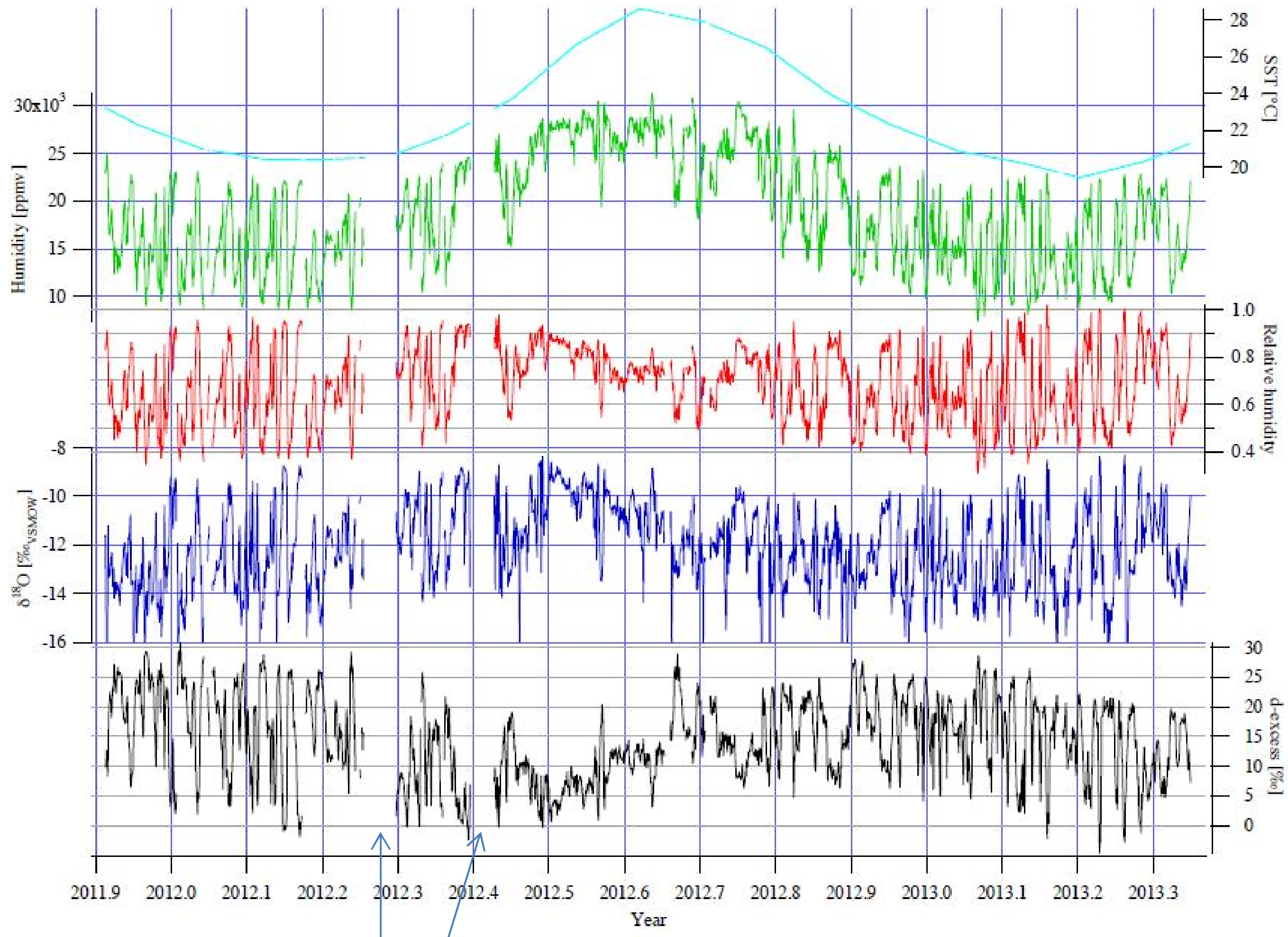
Å Seasonal d-excess vs. RH.

Å D-excess vs. RH on different time scales.

Å Influence of wind direction on d-excess.

Time: From November 2011 to June 2013(6h data).

Humidity is related to SST.



The data coverage is 95 %.
Gap the data 1. heavy rain
2. a failure of a vacuum pump

Fig. 6

Å **Table 1.** The slope and intersect of *d*-excess vs. relative humidity for the complete data set as well as seasonal, wind direction, and wind speed subsets.

		Slope [‰ [rh^{-1}]]	Intercept [‰]	R^2	N
All data		−42.6 ± 0.4	43.5 ± 0.3	0.86	1926
	High wind speed (> 7 m s^{-1})	−42.0 ± 0.5	42.9 ± 0.4	0.89	679
	Low wind speed (< 6 m s^{-1})	−43.0 ± 0.6	43.9 ± 0.4	0.82	1016
Summer data		−51.9 ± 1.5	50.8 ± 1.1	0.76	398
	Wind direction 0–180°	−45.2 ± 2.1	46.3 ± 1.5	0.69	208
	Wind direction 180–360°	−56.7 ± 2.1	54.1 ± 1.6	0.80	180
Winter data		−40.7 ± 0.5	41.4 ± 0.4	0.88	738
	Wind direction 0–200°	−41.7 ± 0.8	42.5 ± 0.6	0.88	287
	Wind direction 200–250°	−49.1 ± 1.0	48.6 ± 0.8	0.92	164
	Wind direction 250–360°	−38.7 ± 1.1	39.8 ± 0.6	0.82	275
Autumn data		−37.4 ± 1.1	41.8 ± 0.7	0.90	135
Spring data		−39.1 ± 1.8	40.0 ± 1.4	0.85	90

(A) Complete set of 6 hourly observation. Grey line is the best fit line.

(B) D-excess vs. RH Related with different wind speed.

(C) The influence of summer and winter on the d-excess and RH.

(D) The influence of spring and autumn on the d-excess and RH.

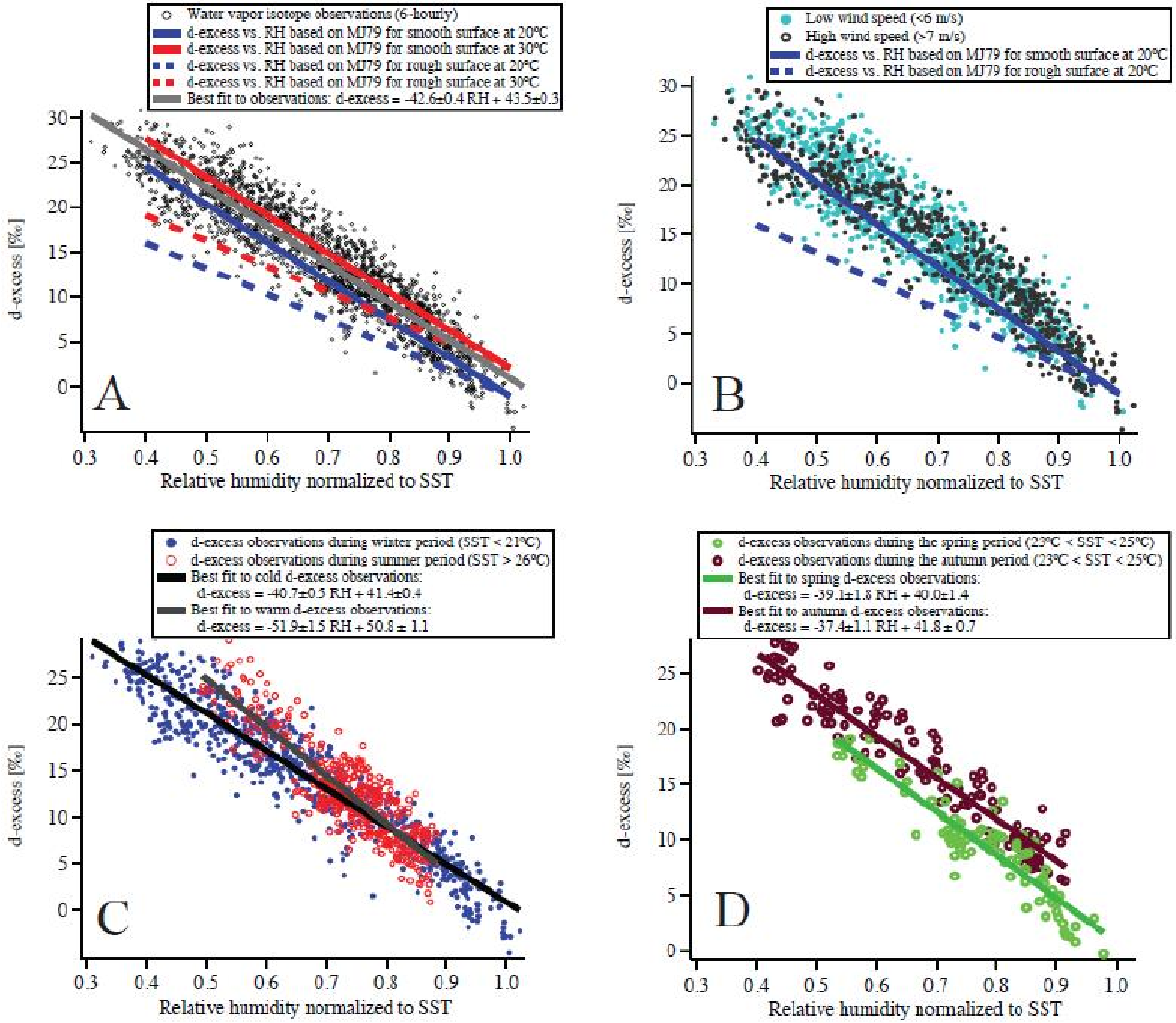


Fig .7

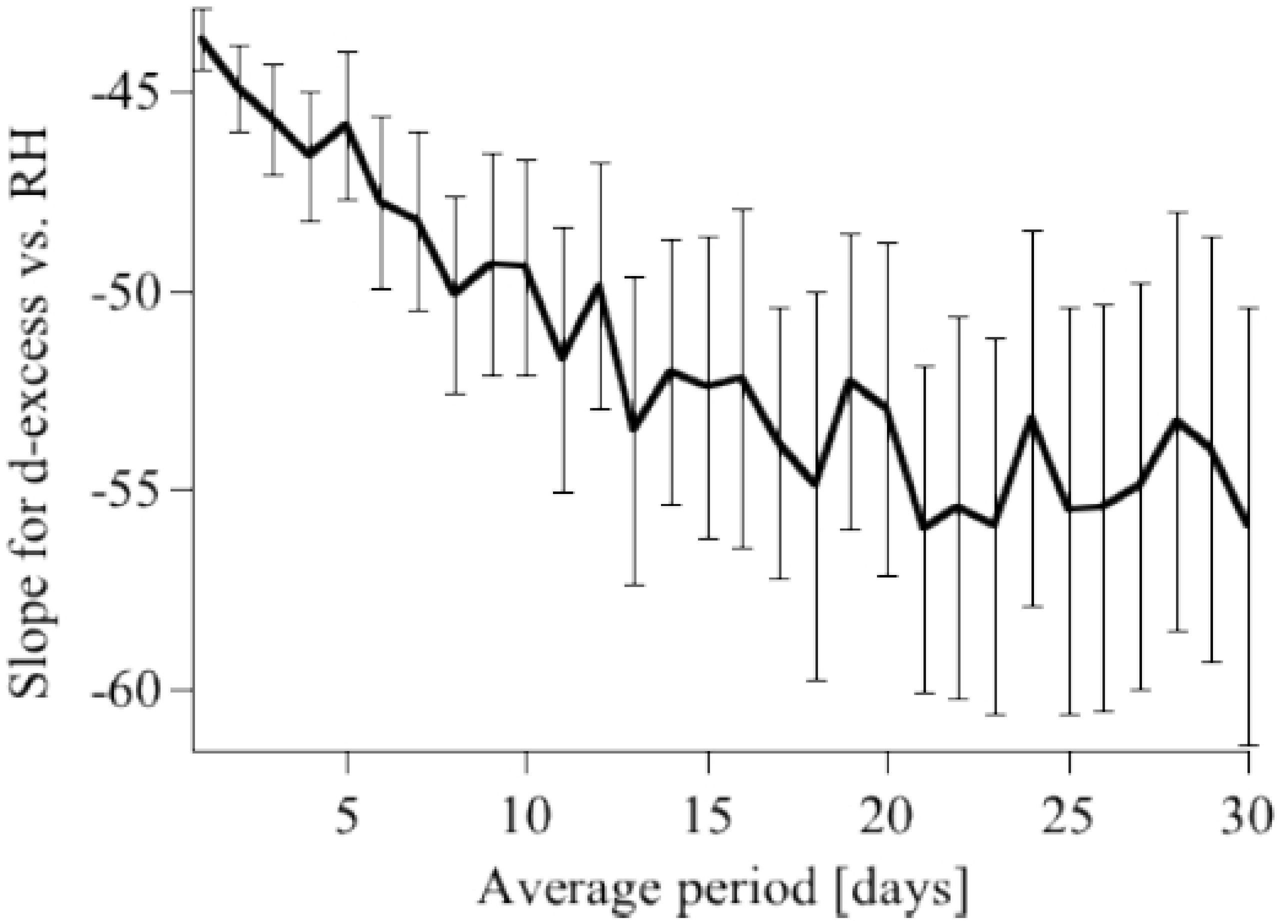
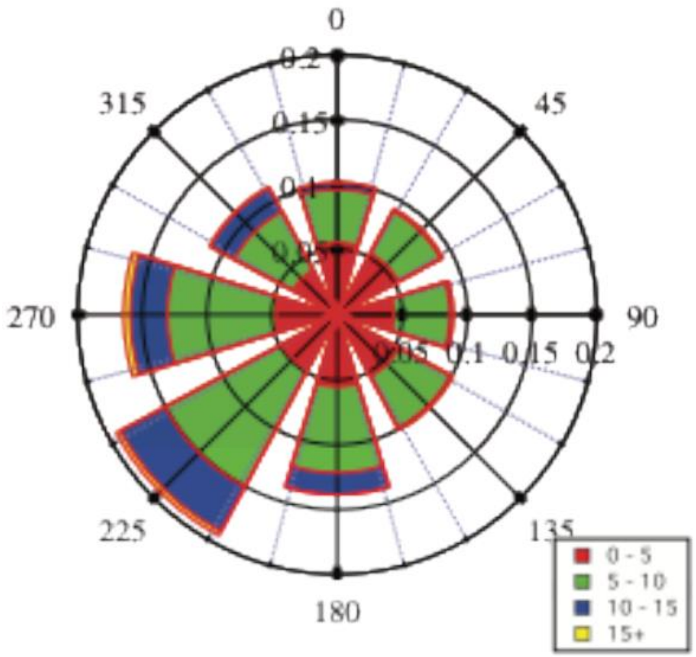


Fig. 8. Slope of d-excess vs. RH for different averaging periods varying from 1 day to 30 days.



In summer westerly winds cause high d-excess levels.

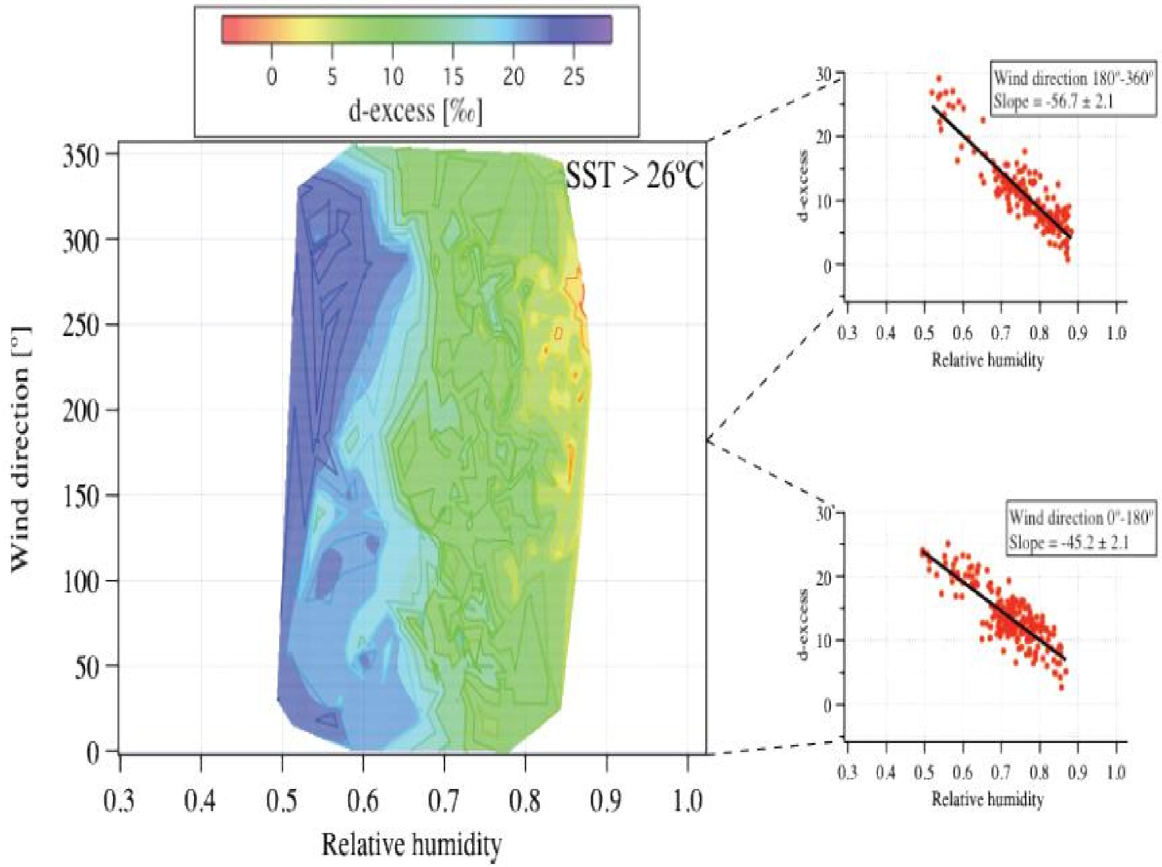


Fig .9

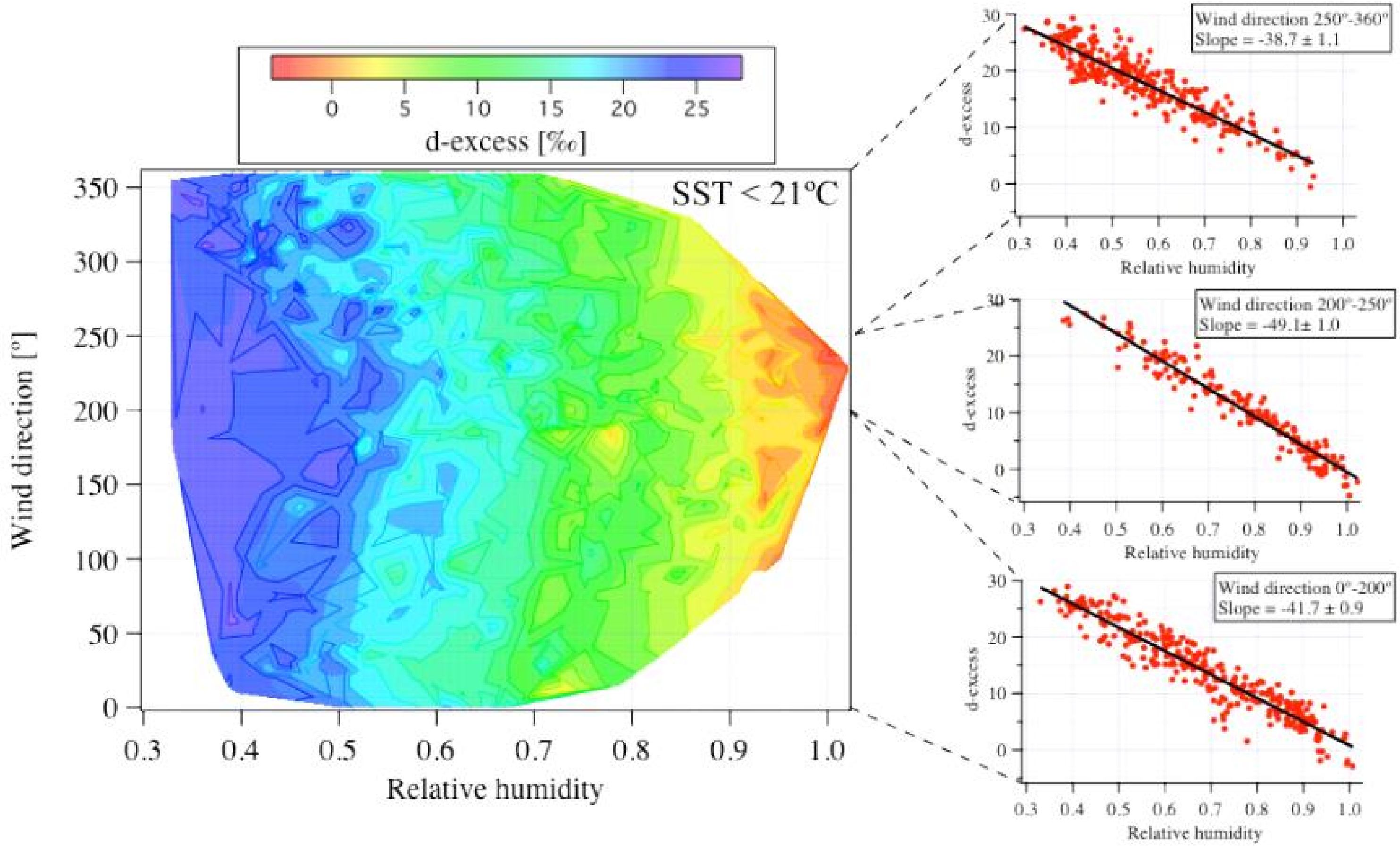


Fig .10 In winter southwestern sector leading to the most negative slop and high d-excess

Conclusions

Å Water vapor isotope signal is dominated by the marine boundary layer moisture.

Å In accordance with theory, d-excess variability is driven by the relative humidity of the air normalized to sea surface temperature. In this observed, d-excess variability maybe relationship with wind speed. Wind directions lead to unusually high d-excess values.

Å The relationship between d-excess and relative humidity depends on the season.

THANK YOU！