Stable water isotopes as a tool to investigate tropospheric moisture transport pathways over the eastern subtropical North Atlantic

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Centro Svizzero di Calcolo Scientifico
Swiss National Supercomputing Centre

FNSNF
Swiss National Science Foundation

Key points

1) Comparison of **COSMOiso** and multi-platform **observations** shows that COSMOiso can be used to **study** the **isotopic composition** of water vapor above Tenerife

→ See slide 4

2) Short-term **isotopic variability** in the free troposphere **correlates** with **different transport pathways** of respective air masses

→ See slide 5

3) Three **transport pathways** can be identified, each associated with a **distinct isotope signal**: air from upper-level extratropical **North Atlantic** (NA), air from **Sahelian Africa** (AFR) and air affected by the **Saharan heat low** (SAL)

→ See slide 6

Methods

COSMOiso

- Isotope-enabled regional weather and climate prediction model [1]
- 14 km horizontal resolution
- 60 vertical levels
- Explicit convection
- ECHAM5wiso initial and lateral boundary data [2]
- Spectral nudging of horizontal wind

LAGRANTO

- Kinematic backward trajectory calculations based on COSMOiso wind fields [3]

ETHZ

process study, interpretation of stable water isotope signals

evaluation

Multi-platform observations of stable water isotopes over Tenerife

- Aircraft-based in situ isotope measurements [4]
- Ground-based remote sensing observations (Fourier transform infrared spectroscopy) [5]

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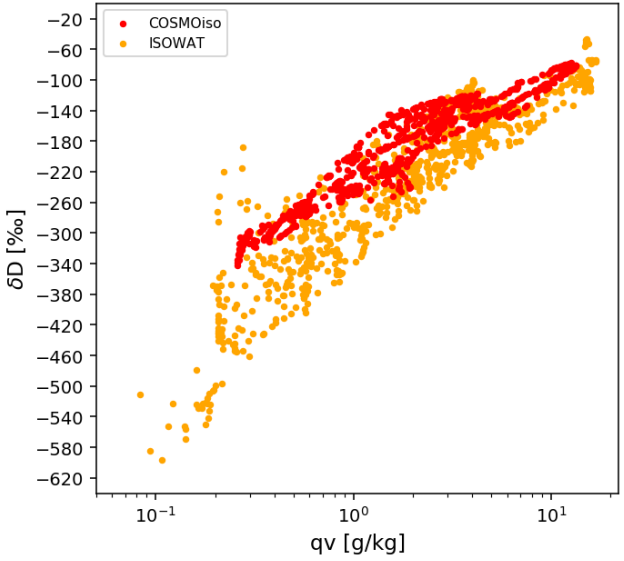
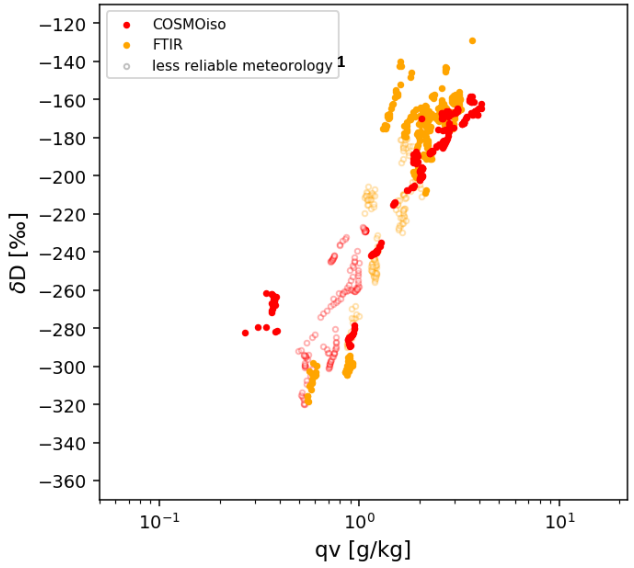
Comparison of COSMOiso δD and qv with observations

COSMOiso vs. aircraft-based in situ measurements (ISOWAT) for 0-7 km



COSMOiso vs. ground-based remote sensing (FTIR) retrievals for 4.9 km (representative of 3-7 km)



→ Comparison of COSMOiso **δD in water vapor** and **specific humidity qv** with multi-platform observations above Tenerife for July and August 2013

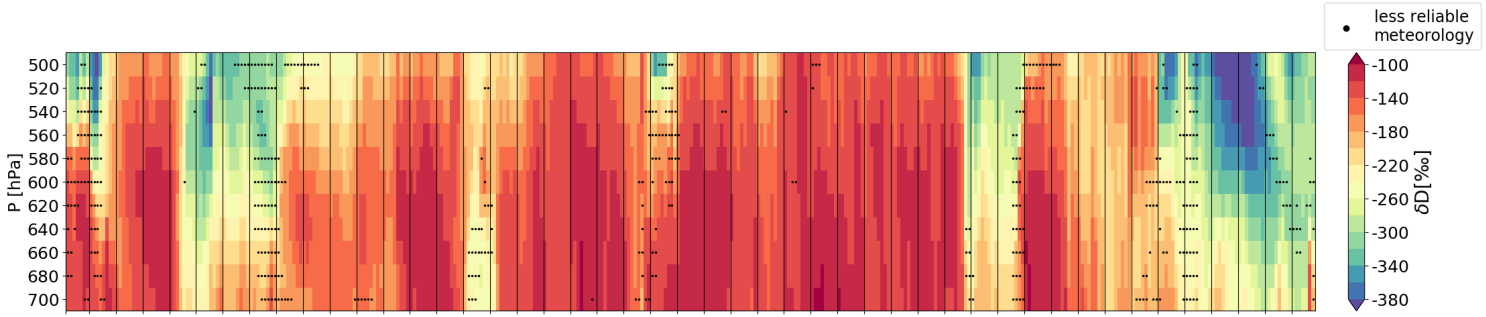
→ Overall **good agreement** between COSMOiso and observations

→ **COSMOiso** tends to be **too enriched** in middle to upper troposphere, i.e. at low qv

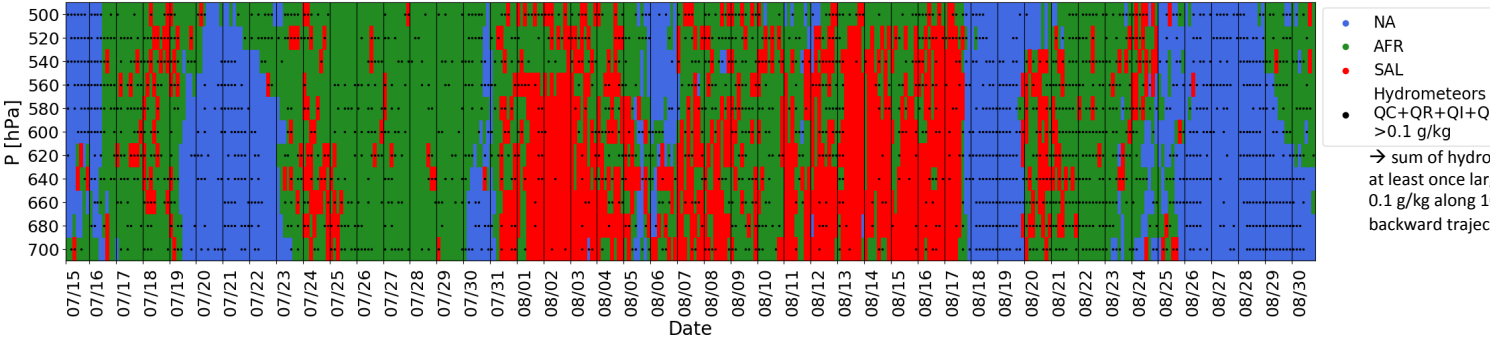
[1] less reliable meteorology: disagreement between COSMOiso and ERA-Interim air mass origin based on kinematic backward trajectories

Linking of COSMOiso δD variability and air mass origin

COSMOiso δD above Tenerife



COSMOiso air mass origin above Tenerife based on backward trajectories



→ Day-to-day **variability** in **δD** due to different **transport pathways** of respective air masses

→ **Depleted air** originates from upper-level extratropical North Atlantic (**NA**)

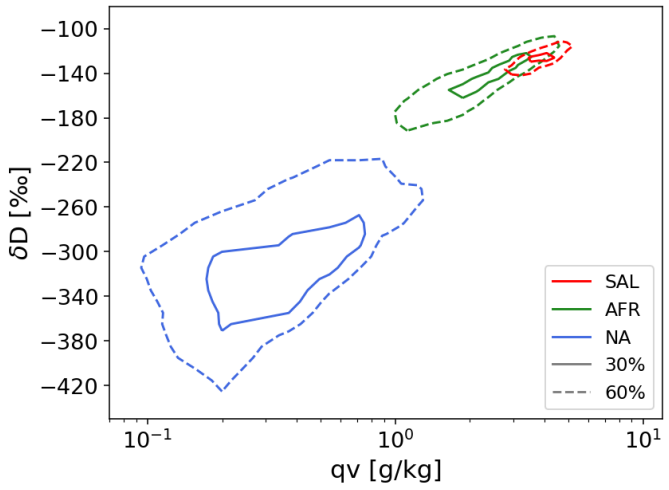
→ **Enriched air** comes from Sahelian Africa (**AFR**) or from Saharan heat low (**SAL**)

→ **SAL** air is primarily subject to **dry mixing** (almost no hydrometeors)

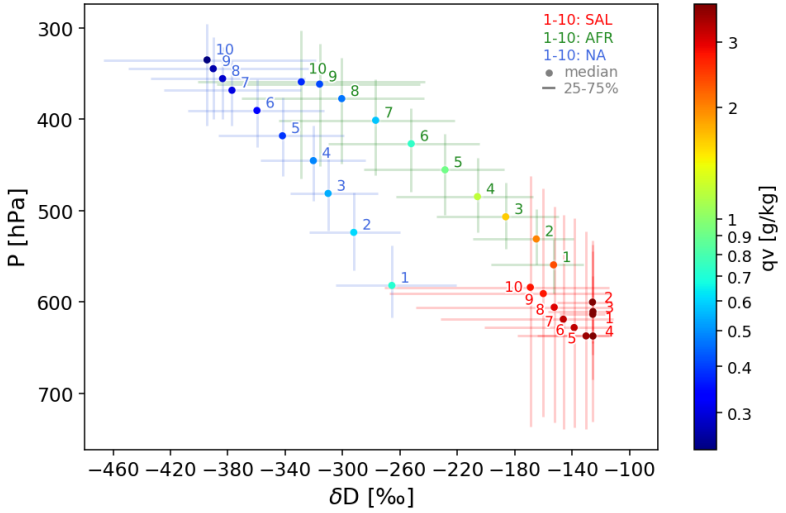
→ **AFR** air is often affected by **moist convection** or **cloud processes** (numerous hydrometeors)

Isotopic signature of different transport pathways

Isotopic signature of COSMOiso SAL, AFR and NA air masses 500-700 hPa above Tenerife



Pressure-δD plot showing history of SAL, AFR and NA air masses 500-700 hPa above Tenerife based on COSMOiso 10-day backward trajectories



→ Each **transport pathway (TP)** is associated with a **distinct isotopic signature**

→ **SAL** TP: Descending air gets enriched, then dry convectively mixed in the **Saharan heat low** and finally advected as a **well-mixed, isotopically homogeneous air layer** over the North Atlantic towards Tenerife

→ **AFR** TP: Dry, depleted air strongly descends and mixes with moist, enriched air in **convective regions** over Sahelian Africa as well as the eastern subtropical North Atlantic before arriving at Tenerife

→ **NA** TP: Subsidence of **very dry, depleted** air from the **upper-level extratropical** North Atlantic towards Tenerife

Contact

If you have questions, contact me during the

EGU2020 **Live Chat** on **Friday 8 May 8:30 – 10:15**

or via email: fabienne.dahinden@env.ethz.ch

References

[1] Pfahl, S., Wernli, H., and Yoshimura, K. (2012). *The isotopic composition of precipitation from a winter storm – a case study with the limited-area model COSMOiso.* Atmos. Chem. Phys., 12(3):1629–1648.

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[3] Sprenger, M. and Wernli, H. (2015). *The LAGRANTO Lagrangian analysis tool – version 2.0*. Geoscientific Model Development, 8(8):2569–2586.

[4] Dyroff, C. et al. (2015). *Airborne in situ vertical profiling of HDO / H216O in the subtropical troposphere during the MUSICA remote sensing validation campaign*. Atmos. Meas. Tech., 8(5):2037–2049.

[5] Barthlott, S. et al. (2017). *Tropospheric water vapour isotopologue data (H216O, H218O, and HD16O) as obtained from NDACC/ FTIR solar absorption spectra.* Earth System Science Data, 9(1):15–29.