ETH zürich
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Comparison of airborne measurements of stable water isotopes during the HYMEX campaign and COSMOiso simulations.

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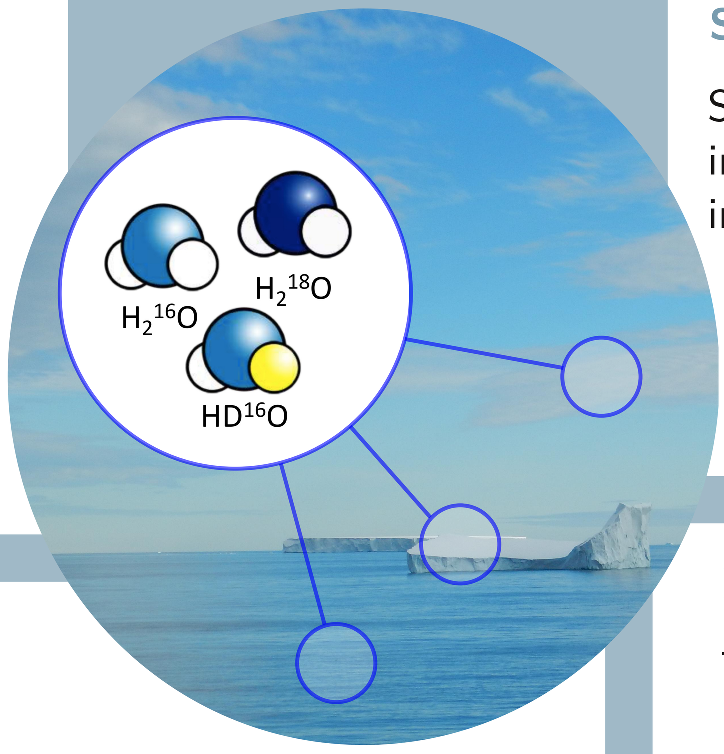
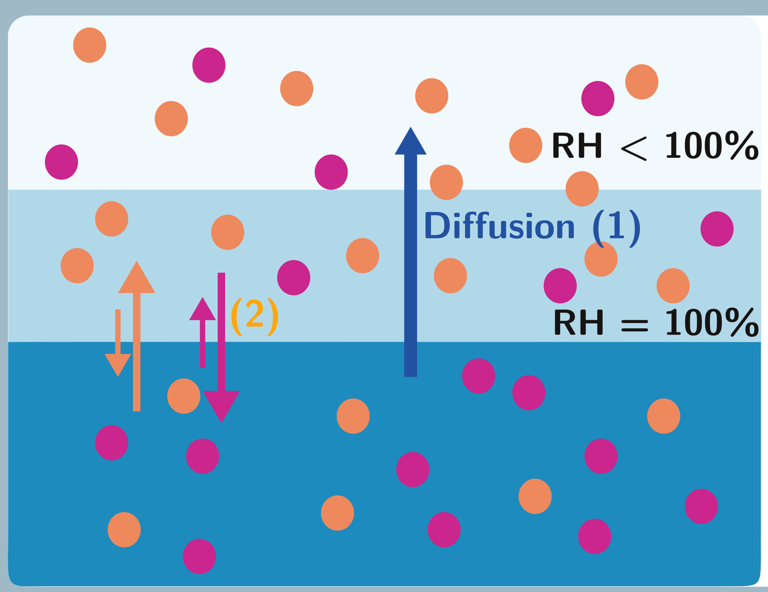
STABLE WATER ISOTOPES (SWI)

Water molecules consisting of different isotopes are natural tracers of phase-change processes in the atmospheric water cycle and provide information on:

- atmospheric conditions (RH, T) in the moisture source region
- history of atmospheric moisture





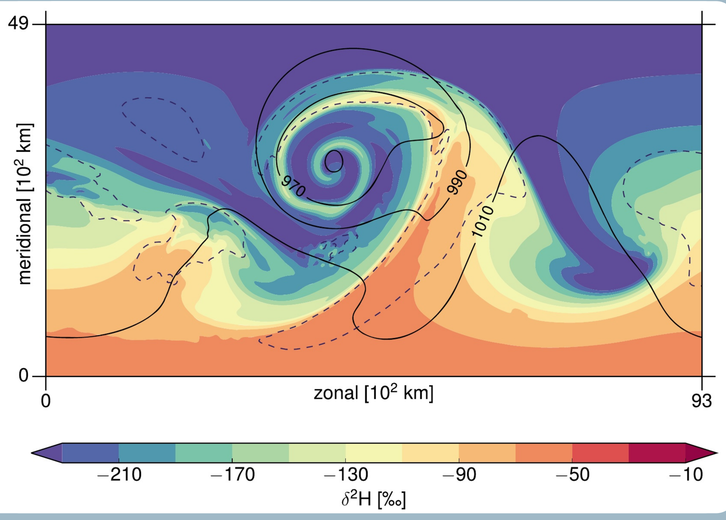
ISOTOPIC FRACTIONATION

(1) Non-equilibrium fractionation: different diffusion velocities

(2) Equilibrium fractionation: different saturation vapour pressure

SWI IN WEATHER SYSTEMS

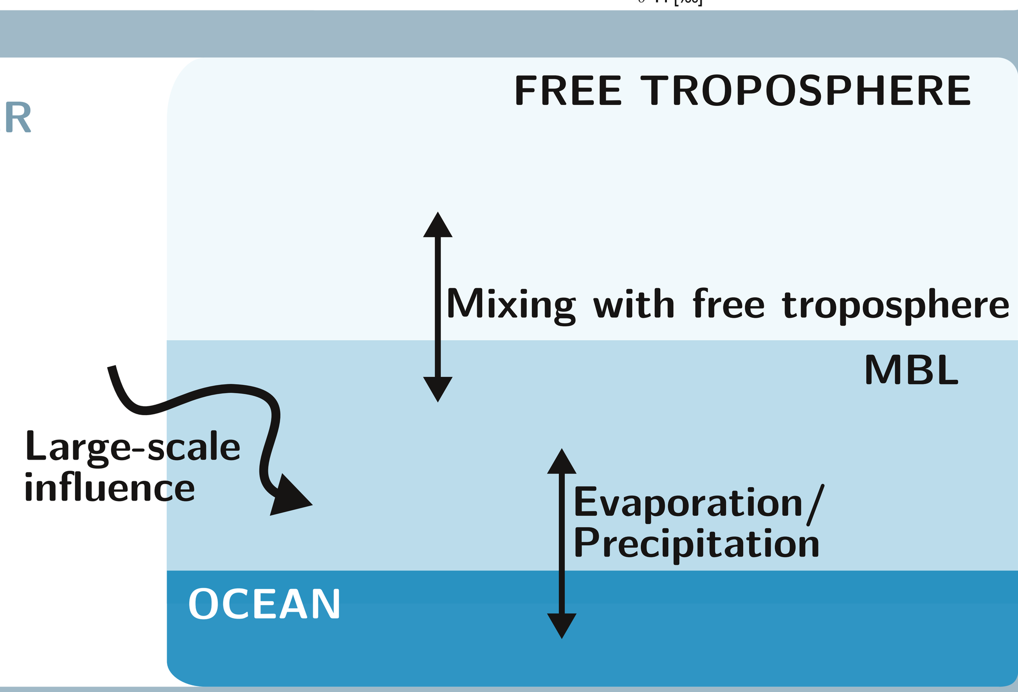
SWI are more depleted in cold air masses than in warm air. Weather systems redistribute SWI in the atmosphere.



COSMOiso simulation of an idealized extratropical cyclone (Dütsch et al. 2016)

MARINE BOUNDARY LAYER

The moisture budget of the marine boundary layer (MBL) depends on the input from and exchange with various moisture reservoirs.
SWI serve as a tool to identify different contributions to the MBL moisture budget.



COSMOiso

- isotope-enabled COSMO
- parallel water cycle for heavy isotopes
- additional humidity fields experience the same processes (e.g. transport by wind fields, cloud formation and precipitation) as the light isotopes
- Only during phase transitions different behaviour of isotopes due to isotopic fractionation.

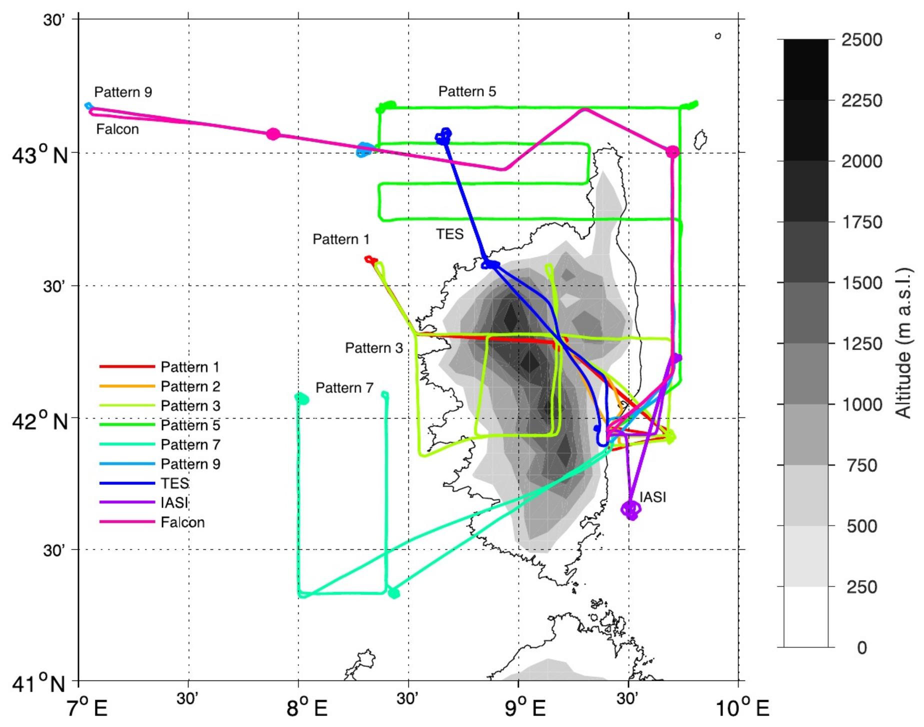
For details on COSMOiso see Pfahl at al. 2012.

HyMeX

"Hydrological Cycle in the Mediterranean Experiment"

- SWI measurements in water vapour with the laser spectrometer L2130-i from Picarro on-board a small propeller aircraft
- 11/09/2012 to 11/10/2012 over Corsica
- 21 successful flights for SWI measurements, 9 of which are analysed using COSMOiso runs

For details on this dataset see Sodemann et al. 2017.



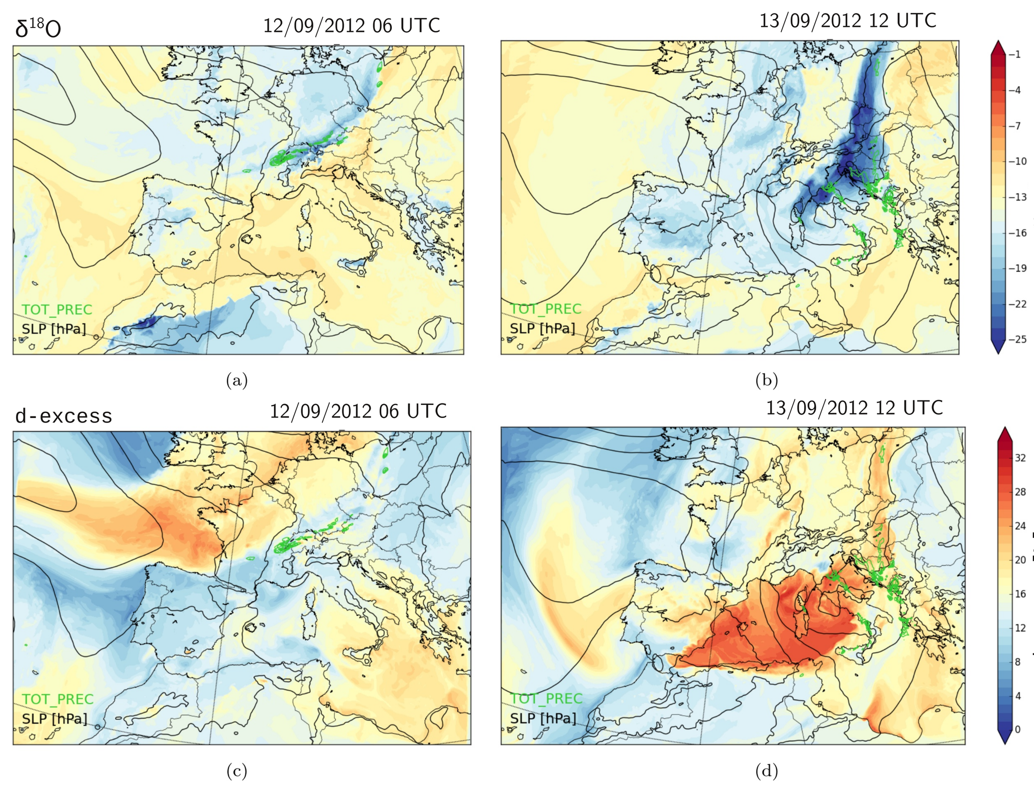
HyMeX flight patterns over Corsica. Gray contours show elevation above sea level.
(adapted from Sodemann et al. 2017)

OUTLOOK

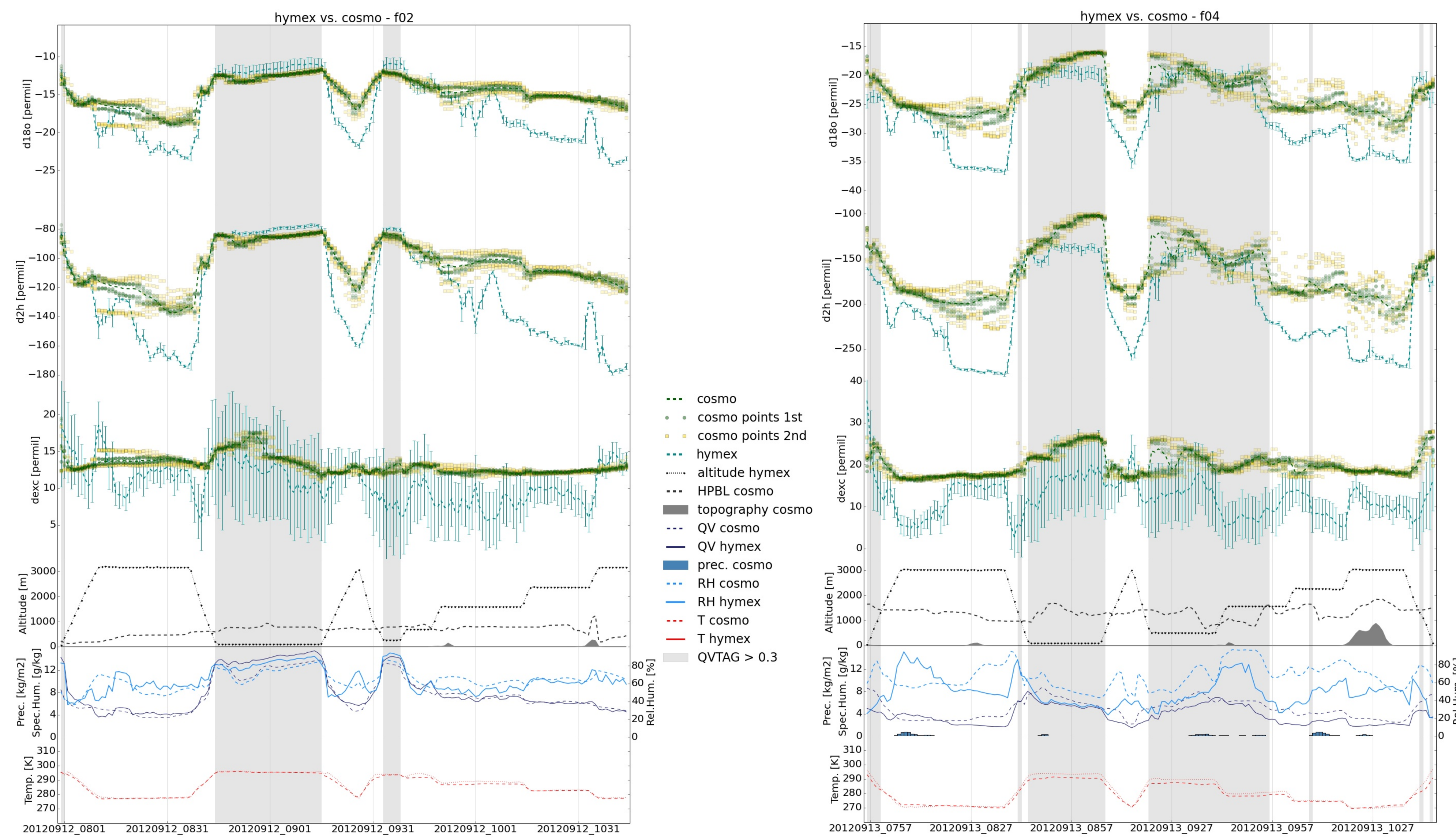
- Nudged model runs of HyMeX cases:
  - improved timing
  - higher QVtag
- model runs with different fractionation schemes
  - improved understanding of fractionation processes
- further model-measurement comparison using data from other campaigns
  - Antarctic Circumnavigation Expedition

CASESTUDY MISTRAL

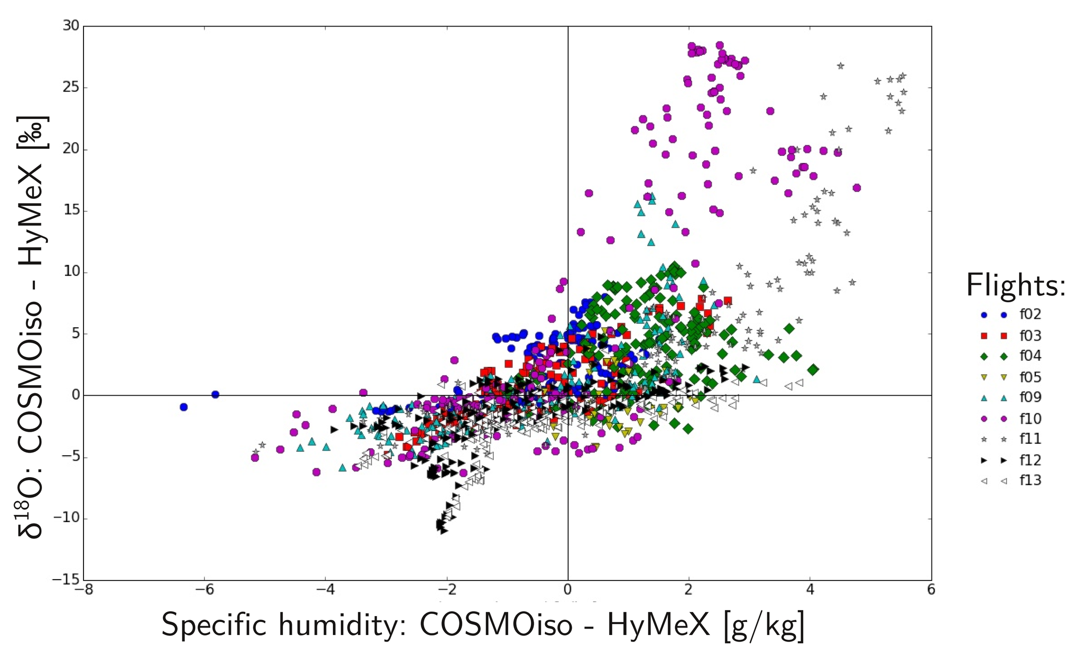
- Model setup:
  - Model domain: centered over Central Europe
  - Boundary data: ECMWF operational data and IsoGSM (Yoshimura et al. 2004)
- Genua low induces advection of terrestrial air masses over the ocean leading to strong evaporation
- Results:
  - SWI in water vapour record evaporation event
  - Comparison with COSMOiso shows good agreement within the planetary boundary layer (high QVtag)
  - better agreement before evaporation events

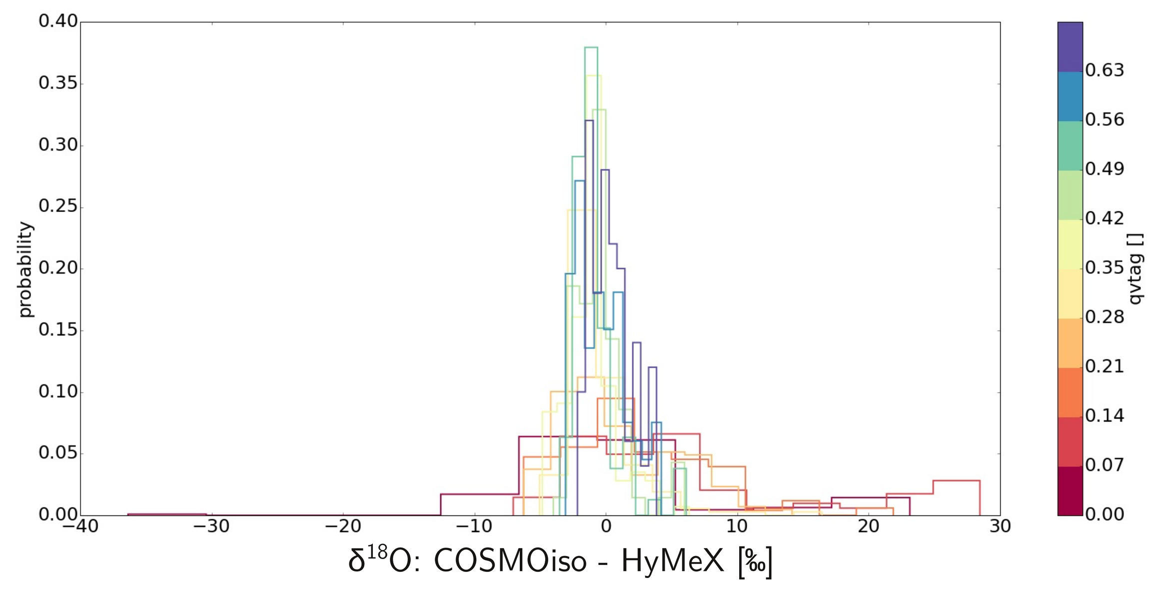


Right: COSMOiso run (lowest model level): $\delta^{18}O$ [(a),(b)] and d-excess [(c),(d)] before [12/9/12 6 UTC] and during [13/9/12 12 UTC] the evaporation event.



MODEL-MEASUREMENT COMPARISON





Left: Error in $\delta^{18}O$ versus error in specific humidity for the simulated HyMeX flights.
Top: Error in $\delta^{18}O$ binned wrt. to QVtag (i.e. the relative contribution of moisture evaporated within the model domain to the total moisture)

REFERENCES

- Dütsch, M., Pfahl, S., and Wernli, H. (2016). Drivers of δ^2H variations in an idealized extratropical cyclone. Geophys. Res. Letters, 43(10):5401–5408.
- 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., 12:1629-1648.
- Sodemann, H., Aemisegger, F., Pfahl, S., Bitter, M., Corsmeier, U., Feuerle, T., Graf, P., Hankers, R., Hsiao, G., Schulz, H., Wieser, A., and Wernli, H. (2017). The stable isotopic composition of water vapour above corsica during the HyMeX SOP1 campaign: insight into vertical mixing processes from lower-tropospheric survey flights. Atmos. Chem. Phys., 17(9):6125–6151.
- Yoshimura, K., Kanamitsu, M., Noone, D., and Oki, T. (2008). Historical isotope simulation using reanalysis atmospheric data, J. Geophys. Res., 113:D19108.

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