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Drivers of stable water isotope variability in the cold and warm sector of extratropical cyclones from two case studies in the Southern Ocean

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Key results:

- Stable water isotope (SWI) measurements show contrasting signals during **cold** and **warm** advection
  → **See slides 2 and 3**

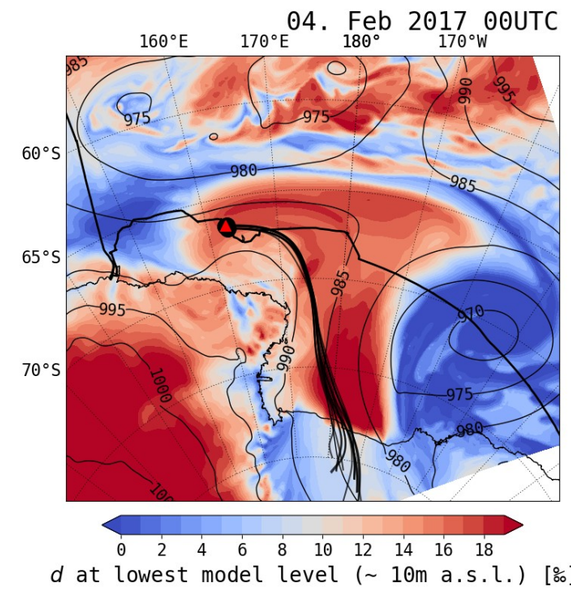
- Two case studies with COSMOiso to identify the main drivers of SWI anomalies

Please leave a comment

or contact Iris Thurnherr

if you have any questions.

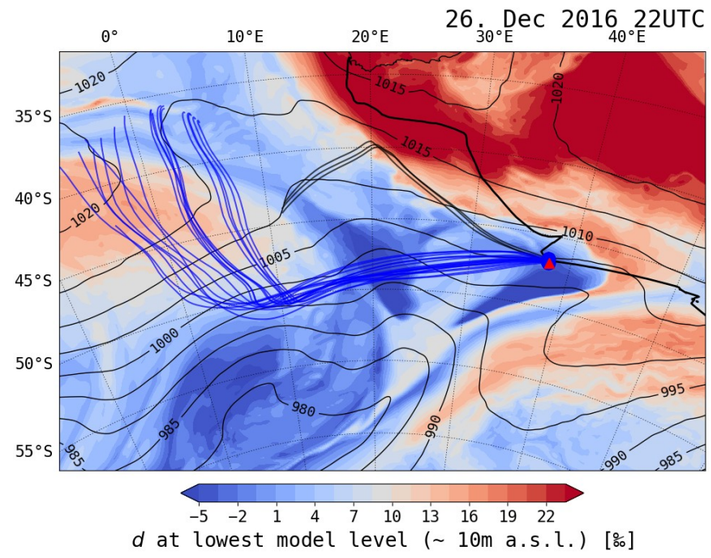
→ **See slide 4**



High *d-excess* during cold advection:

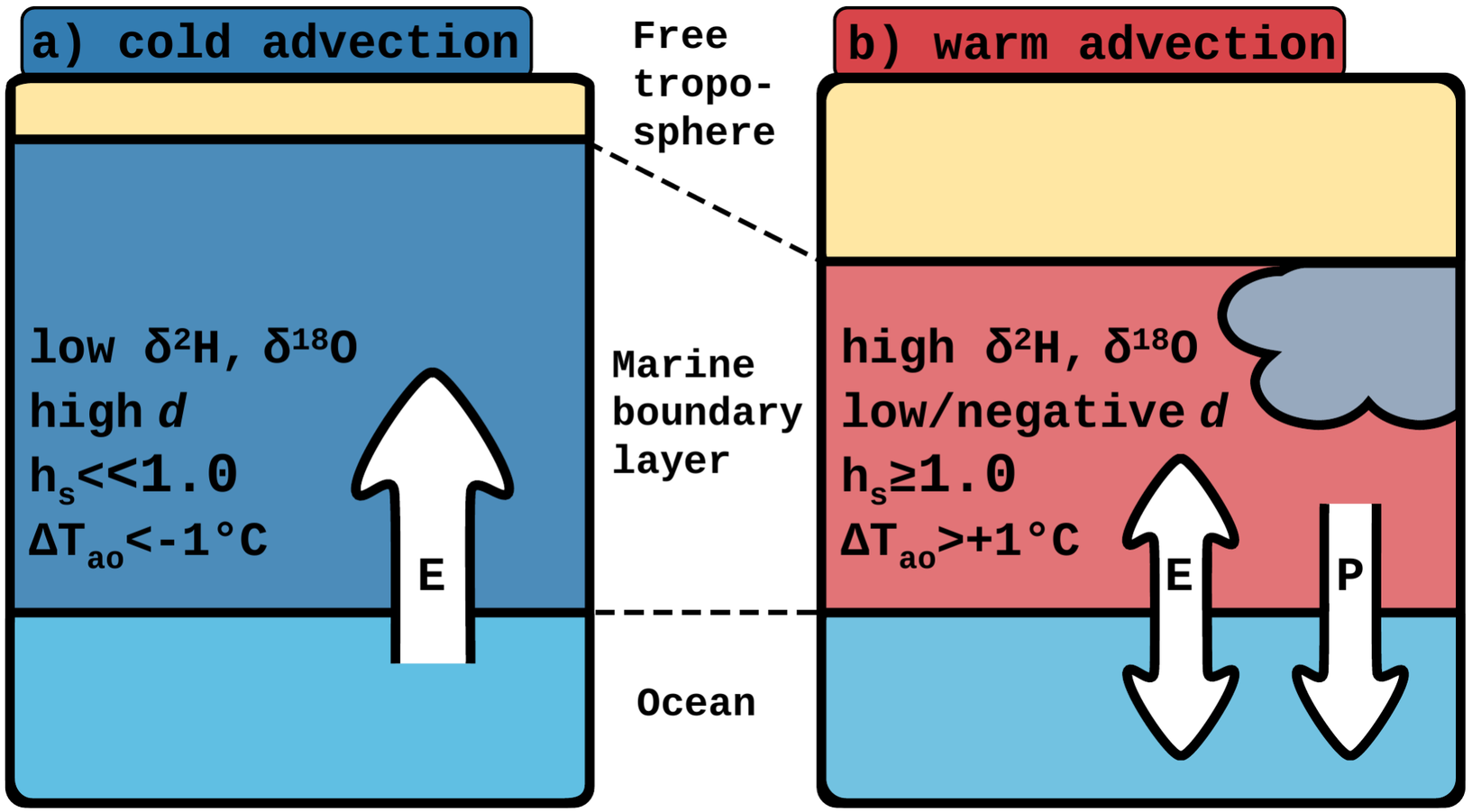
- strong ocean evaporation into dry air
- rapid moisture uptake by cold air outbreak airmasses

→ **See slide 5**



Low *d-excess* during warm advection :

- Near surface: dew deposition
- Upper part of marine boundary layer: cloud formation



Schematic of opposite moisture fluxes and isotopic composition of water vapour due to air-sea interaction during cold and warm advection.

Definitions:

Surface air colder than ocean surface (ΔT_{ao} < -1°C)

↓

cold advection

Surface air warmer than ocean surface (ΔT_{ao} >+1°C)

↓

warm advection

h_s relative humidity with respect to sea surface temperature

ΔT_{ao} temperature difference between atmosphere and ocean

E ocean evaporation (or dew deposition of opposite direction)

P precipitation

d deuterium excess $d=\delta^2H-8\cdot\delta^{18}O$ (Dansgaard 1964)

- *d* changes during moisture diffusion due to the different diffusivities of $H_2{}^{18}O$ and $HD^{16}O$
- opposite *d*-anomalies in subsatured (cold advection) and super-satured air (warm advection) due to opposite moisture fluxes

Datasets

- SWI measurements in water vapour from the Antarctic Circumnavigation Expedition (ACE) *Thurnherr et al. 2020*
- COSMOiso *Pfahl et al. 2012* simulations of cold and warm advection events during ACE
- Backward trajectories using the COSMOiso wind fields

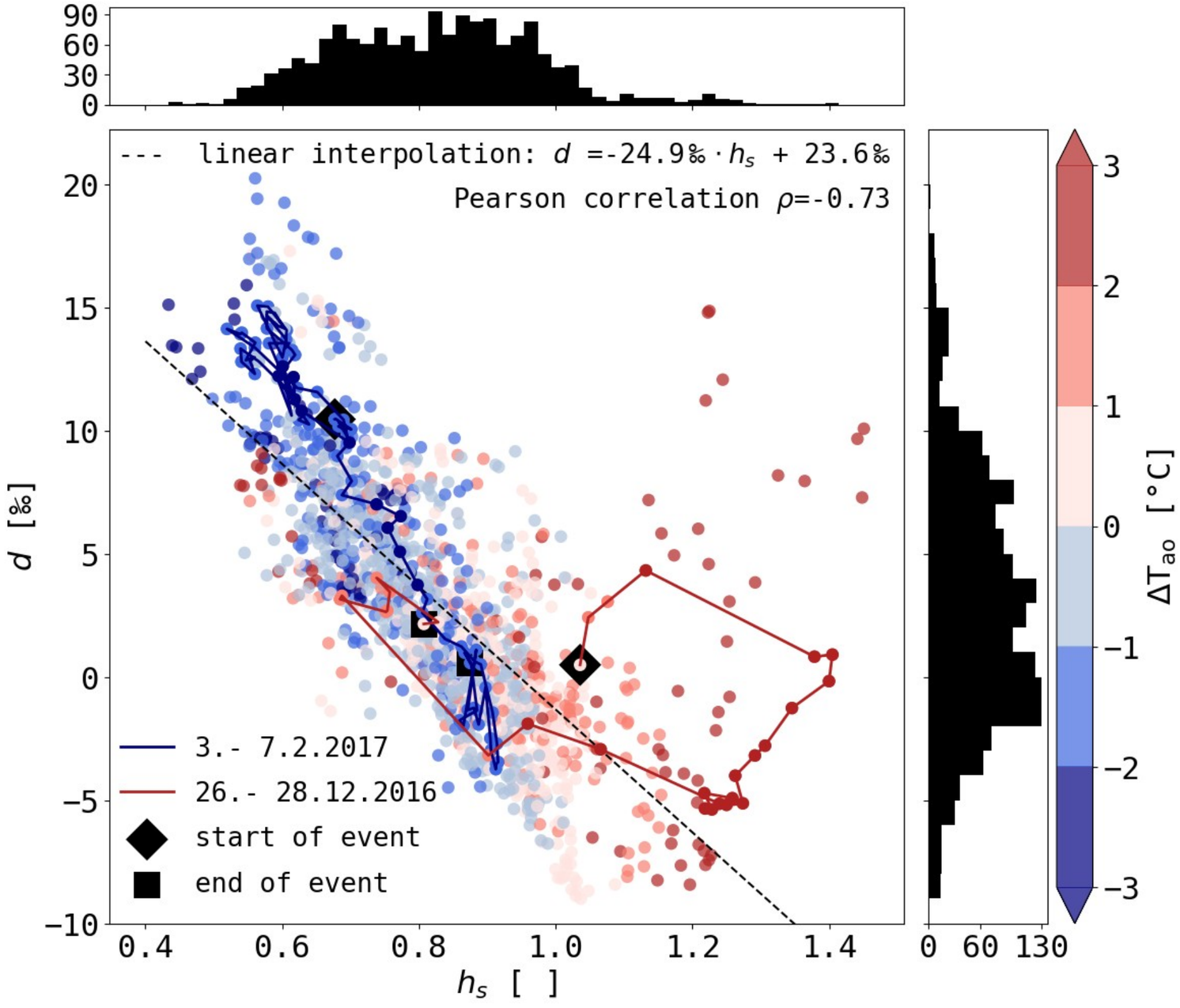
Two case studies with good agreement of ACE measurements and COSMOiso simulations
(e.g. Pearson correlation between d in measurements and COSMOiso > 0.7)

Case study 1: 3. - 7. Feb 2017

- **Cold air outbreak in Ross Sea**
- **high *d* at low h_s**

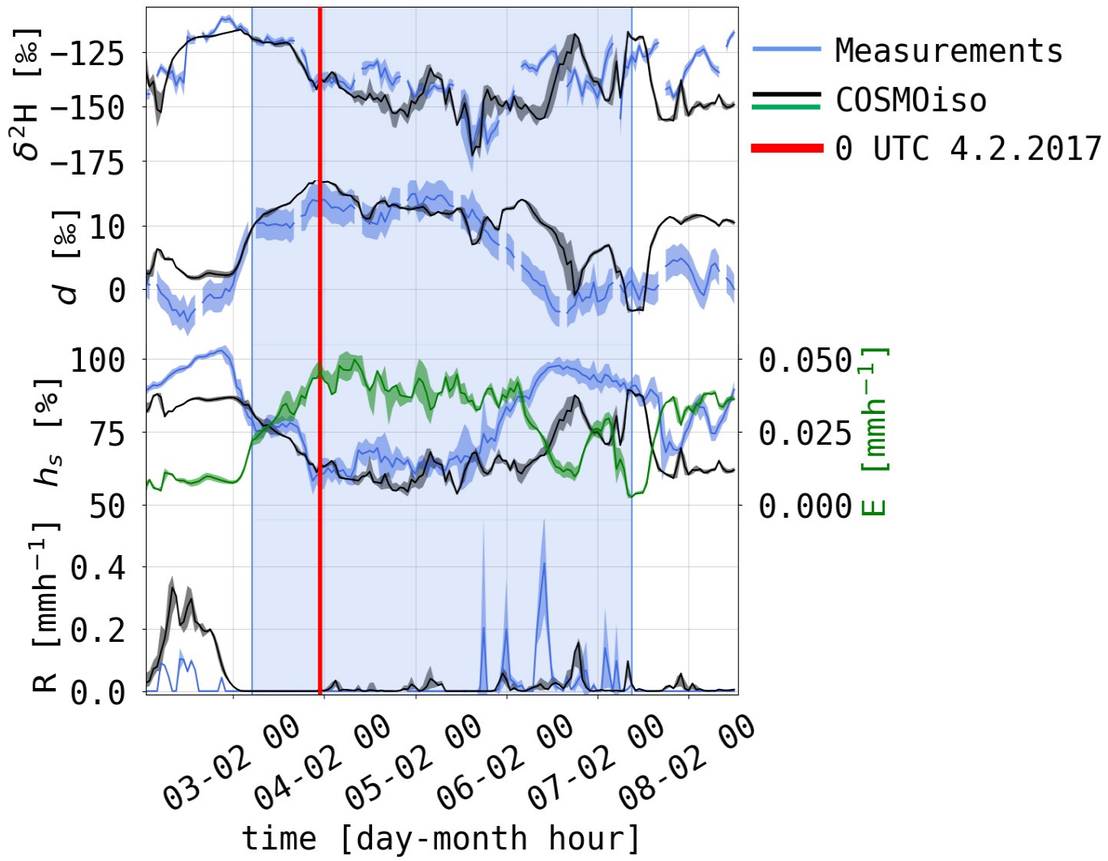
Case study 2: 26. -28. Dec 2016

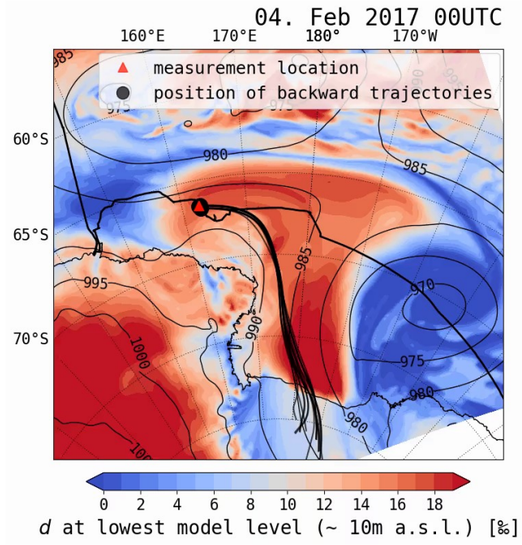
- **Passage of warm sector of extratropical cyclone in Southern Indian Ocean**
- **Low *d* at high h_s**



Histogram of h_s versus *d* coloured by the atmosphere-ocean temperature difference ΔT_{ao} using ACE measurements. The two case studies are shown with coloured lines.

Negative δ^2H- and positive *d*-anomalies in Ross Sea during cold air outbreak in the cold sector of an extratropcial cyclone





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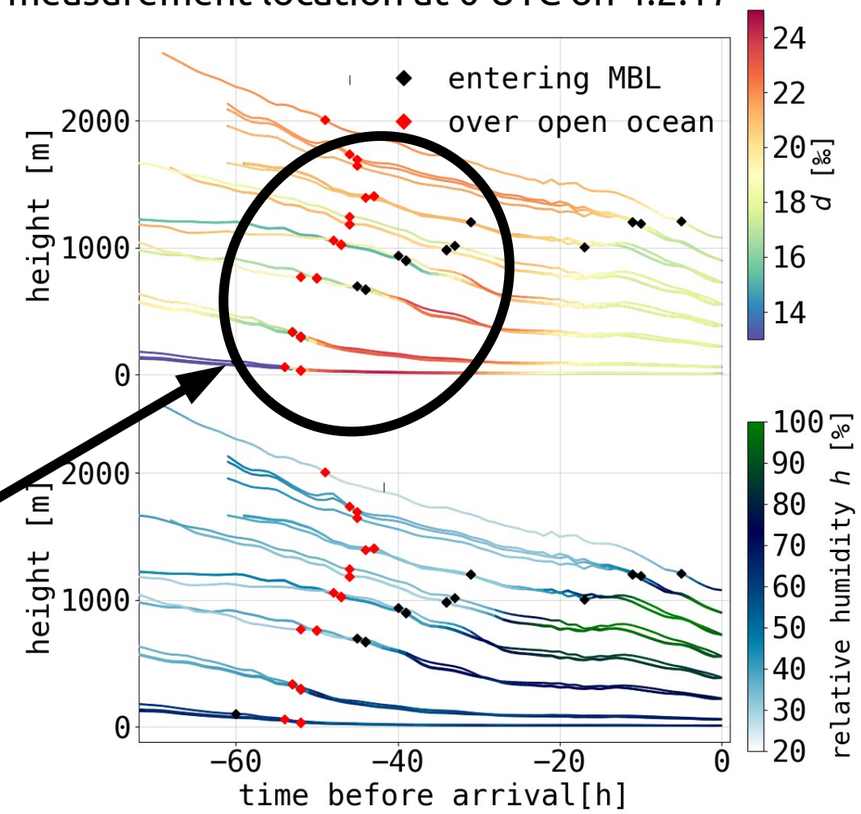
d and *h* along backward trajectories from measurement location at 0 UTC on 4.2.17

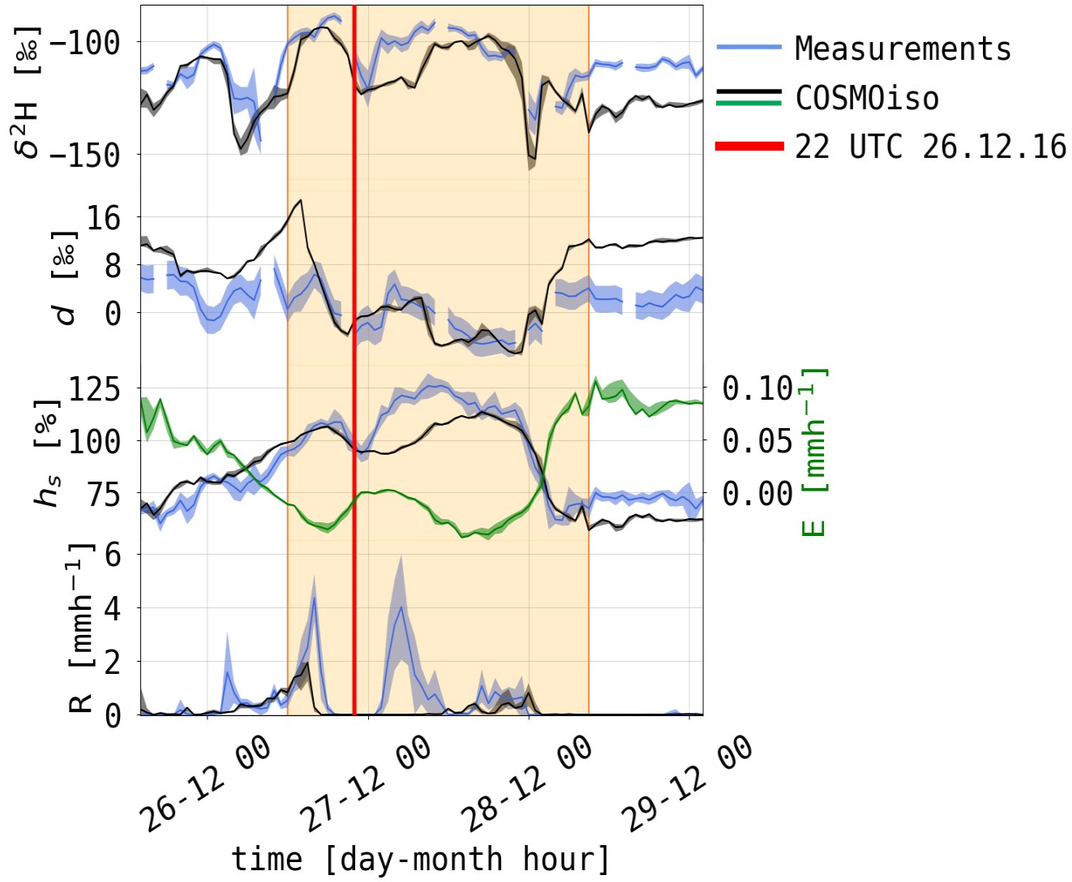


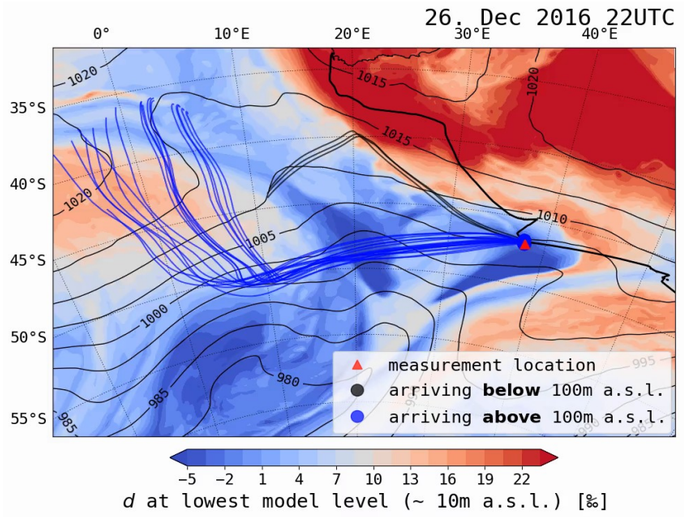
During cold advection, strong ocean evaporation into dry air is the dominant process inducing high *d*.

Aemisegger and Sjolte (2018)

Increase in *d* when the cold air outbreak trajectories are advected over the open ocean and enter the marine boundary layer (MBL).

Positive δ^2H- and negative *d*-anomalies during passage of warm sector of extratropical cyclone





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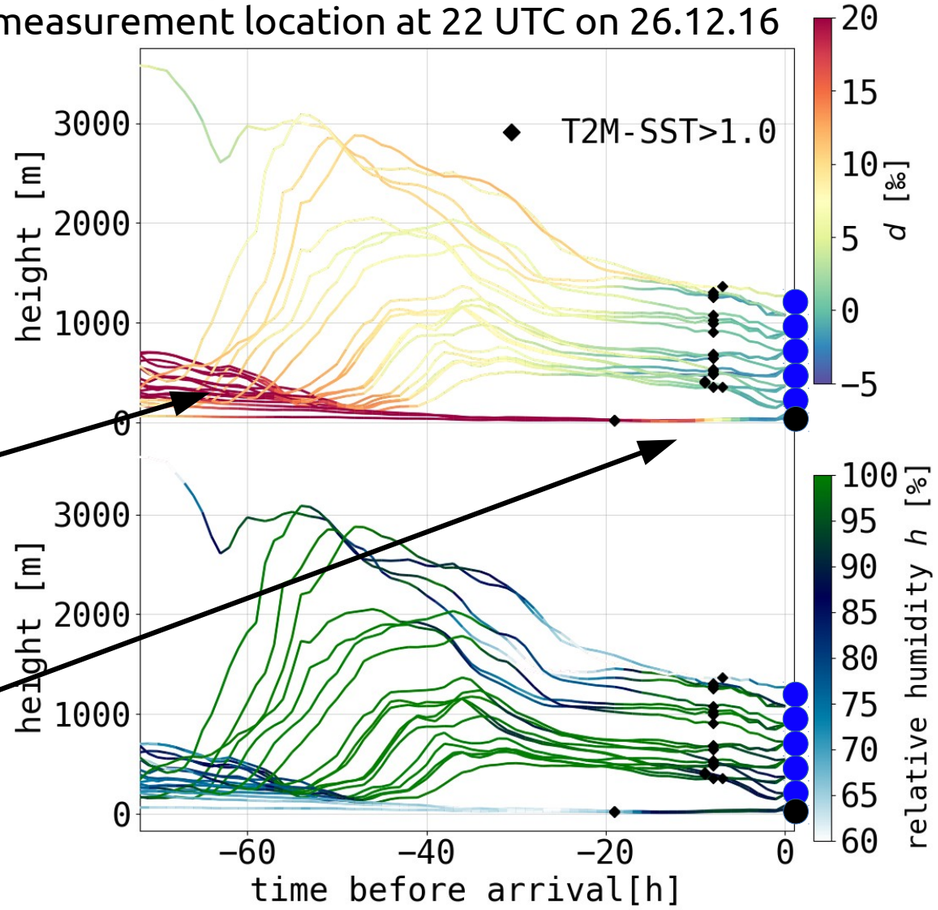
d and *h* along backward trajectories from measurement location at 22 UTC on 26.12.16



Processes inducing low *d* during warm advection:

- air masses **above** 100 m a.s.l.:
  moist adiabatic ascent and Rayleigh fractionation during **cloud formation**
- air masses **below** 100 m a.s.l.:
  dew deposition on ocean surface