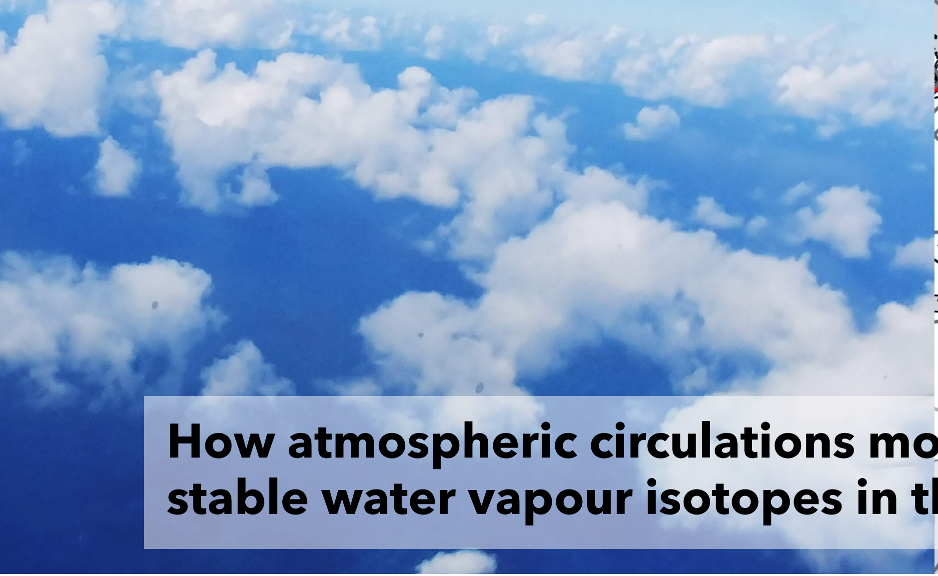
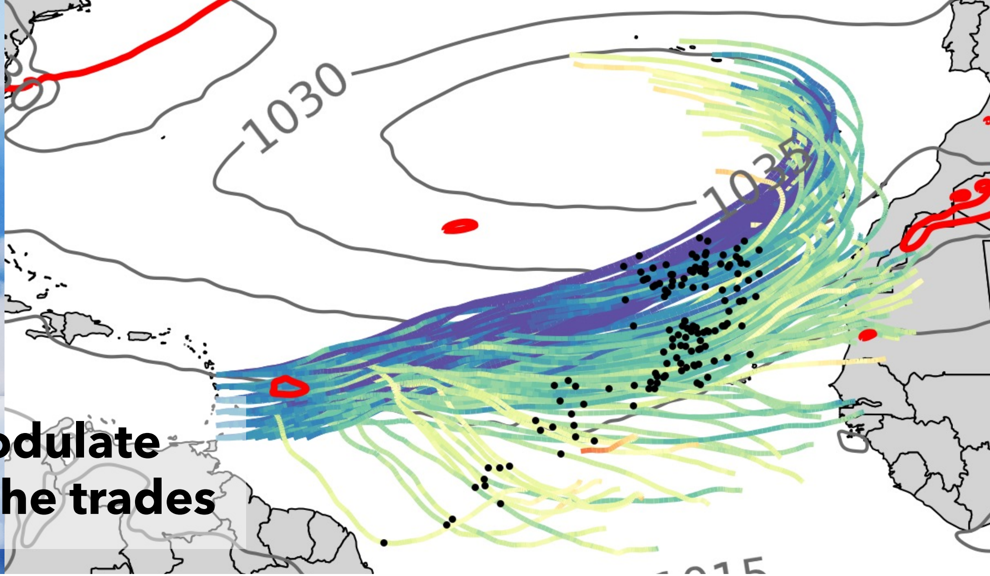


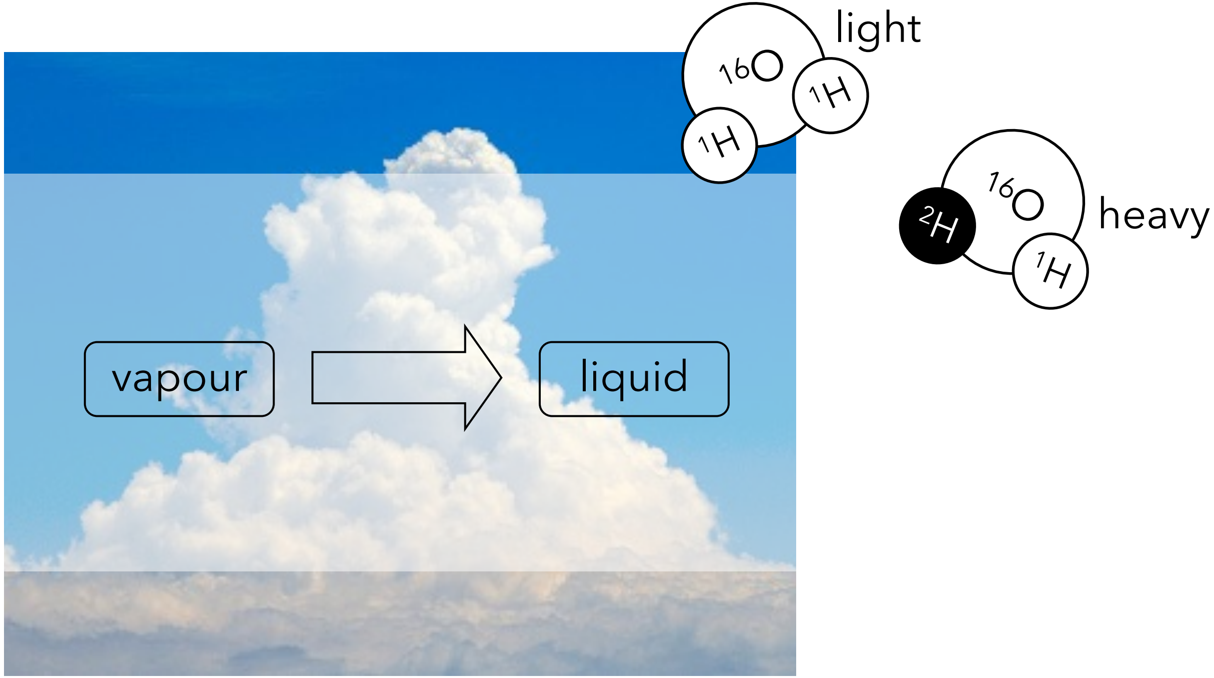


How atmospheric circulations modulate stable water vapour isotopes in the trades

Leonie Villiger, Franziska Aemisegger, Heini Wernli

MPI-LMD meeting, 17 November 2022

Isotopes



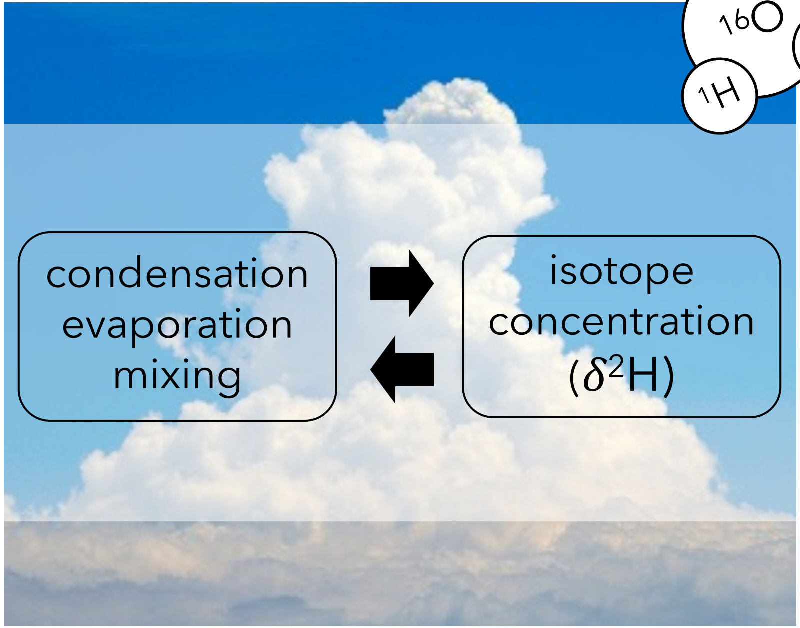
few heavy isotopes many

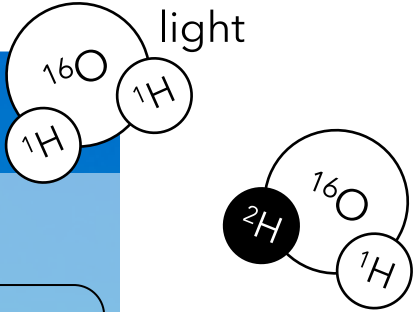
low δ^2H high

"delta deuterium"

Isotopes

O: Use isotopes as tracers to look into processes on different scales.





few — heavy isotopes — many

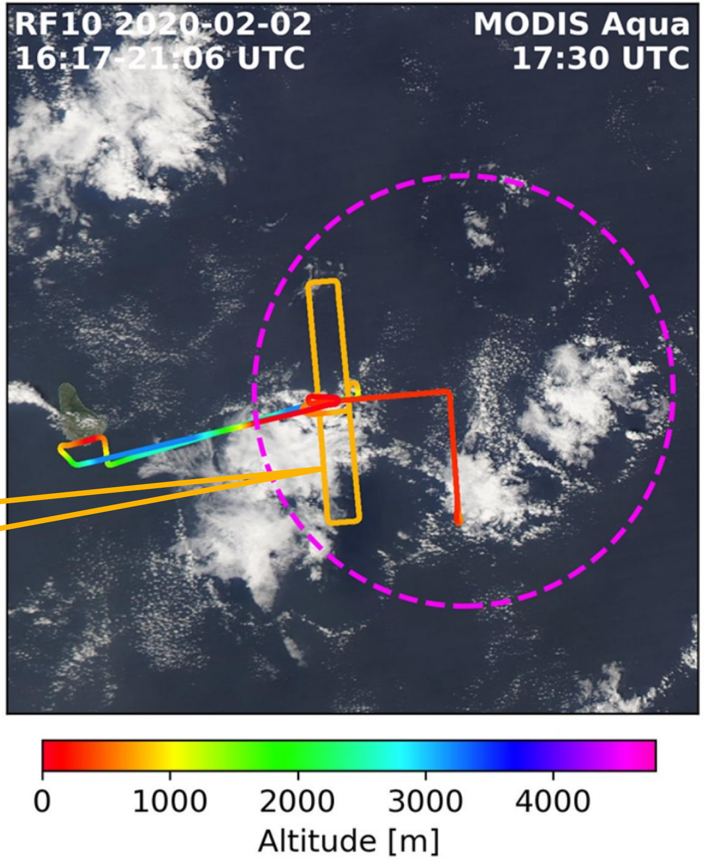
low — δ^2H — high

"delta deuterium"

Isotope observations

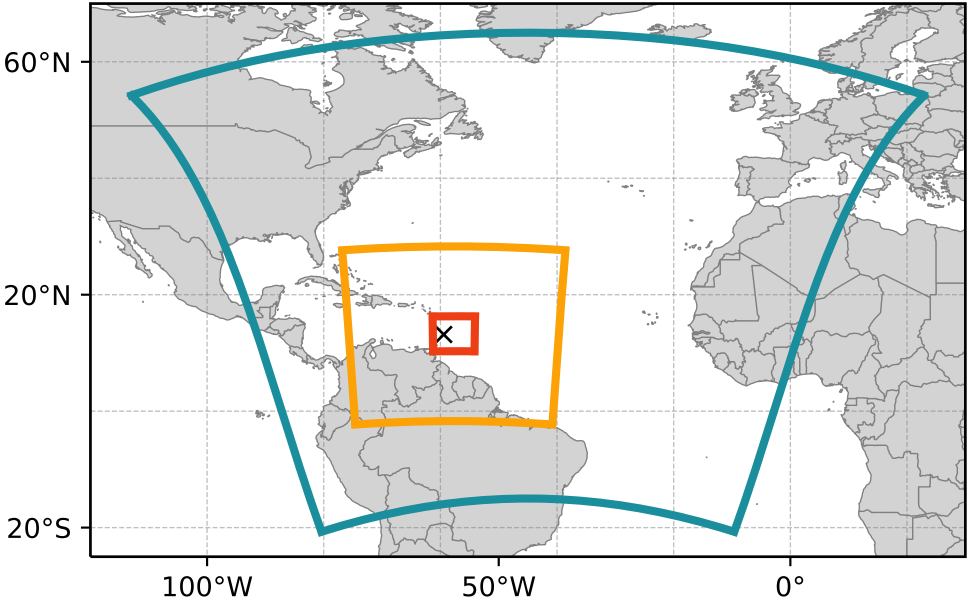
- ATR
- 19 flights (25 Jan – 13 Feb 2020)
- repetitive flight pattern

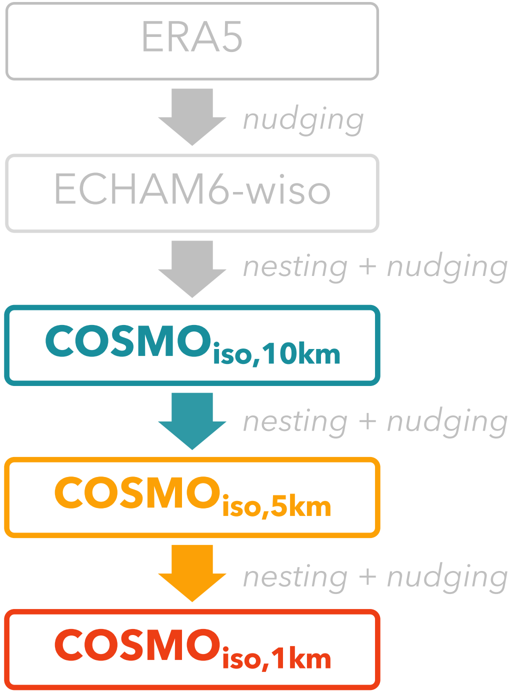
cloud base
(lowest level with
cloud liquid water)



Isotope simulations

- $COSMO_{iso}$ Pfahl et al. (2012) *ACP*
- 3 different resolutions
- hourly (20 Jan – 13 Feb 2020)



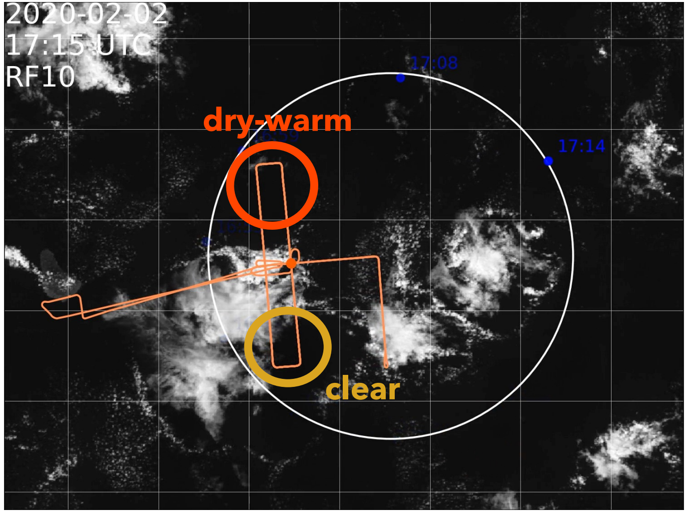


Questions

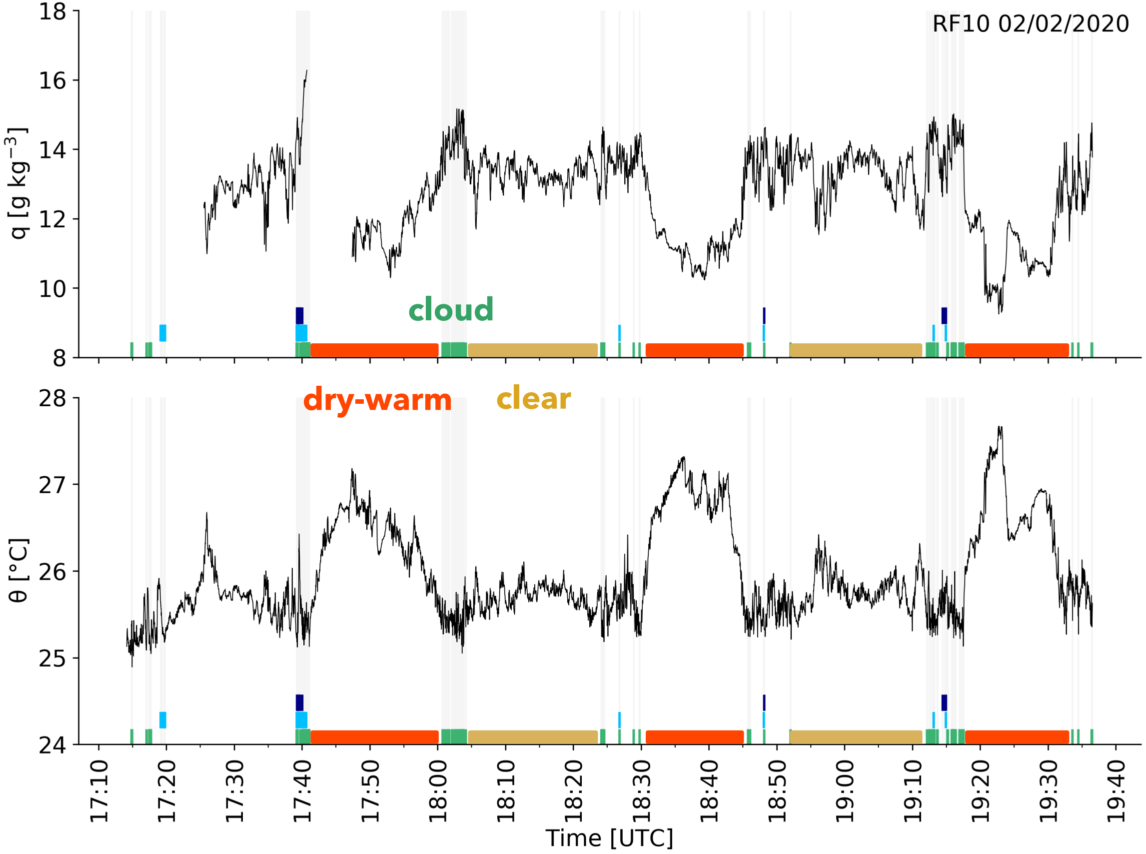
Does $COSMO_{iso}$ reproduce observed cloud base features?

ATR
+$COSMO_{iso}$

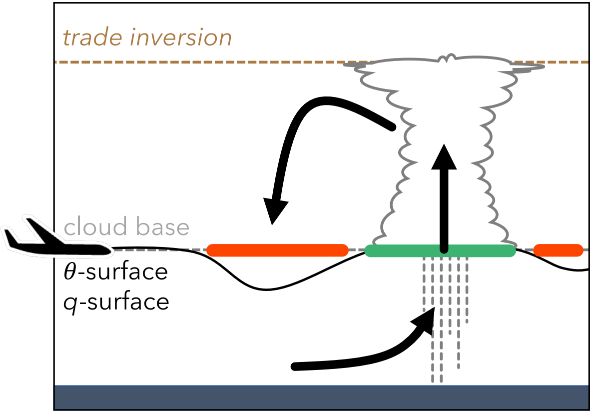
Cloud base features - ATR

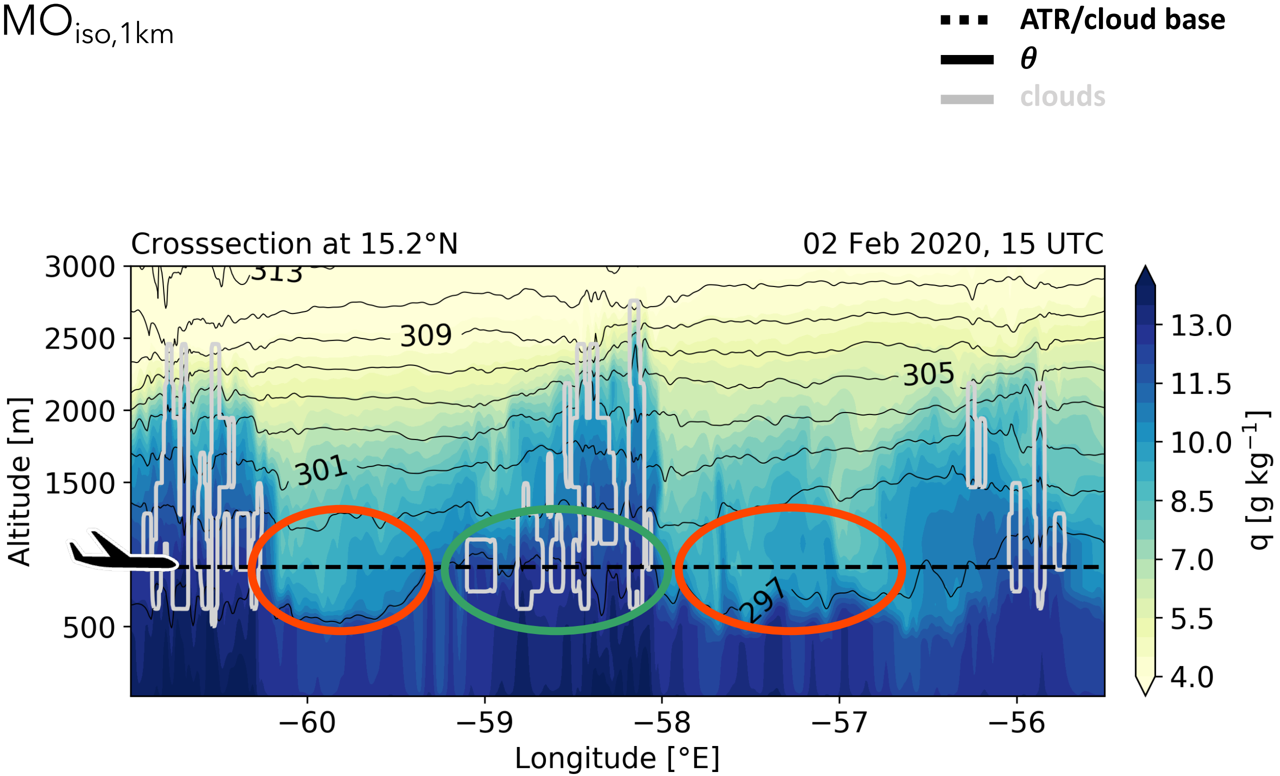


Movie by Fildier, Touzé-Peiffer, &
Schulz (2021) *AERIS*



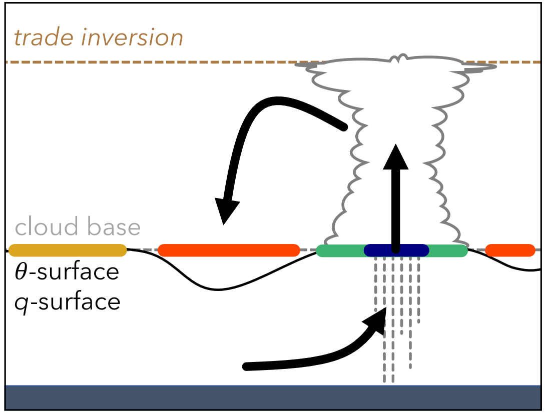
Cloud base features – COSMO$_{iso,1km}$





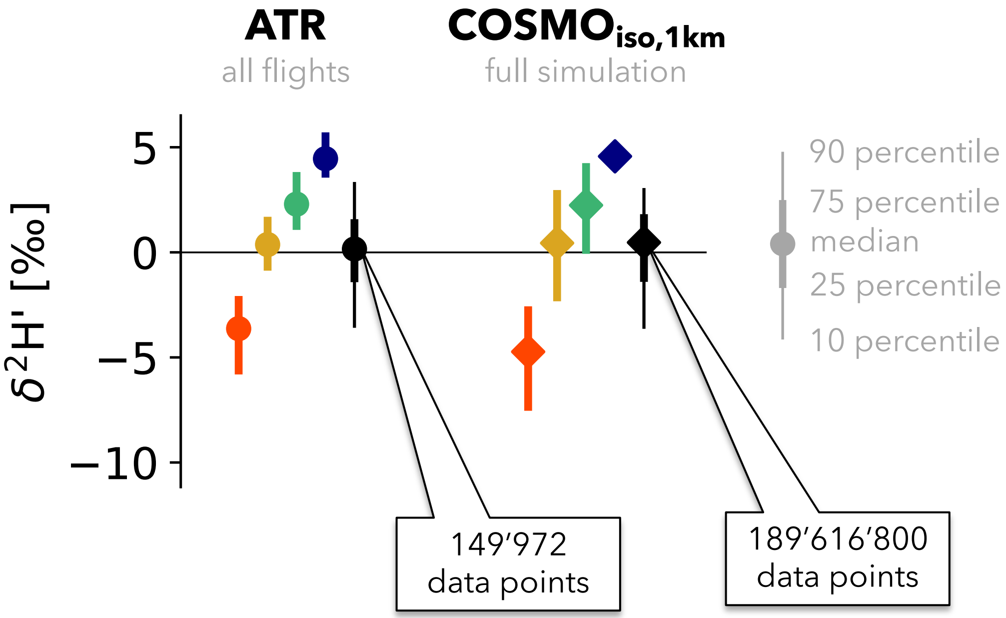
dry-warm
cloud

Cloud base features – ATR vs. COSMO$_{iso,1km}$



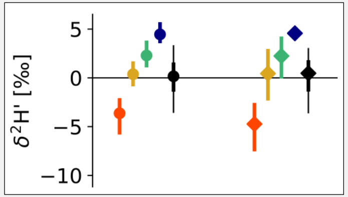
clear
dry-warm
cloud
cloud + rain
all

criteria based on liquid water, q, θ



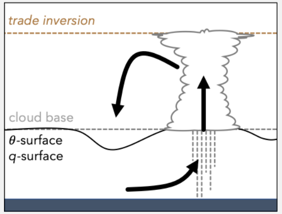
Questions

COSMO$_{iso,1km}$ reproduces cloud base features observed in ATR data



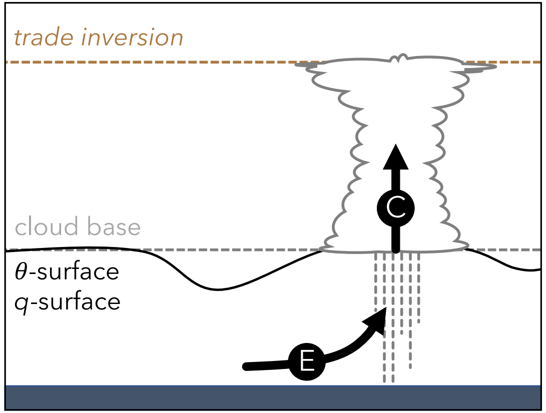
Which processes control isotopes in the cloud-circulation?

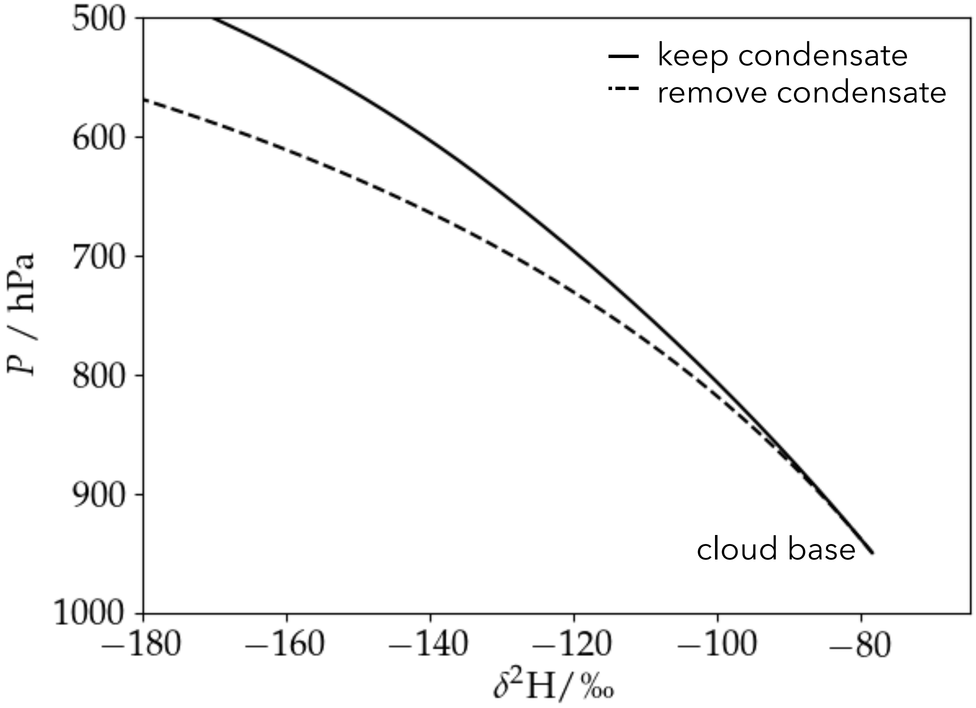
COSMO$_{iso}$



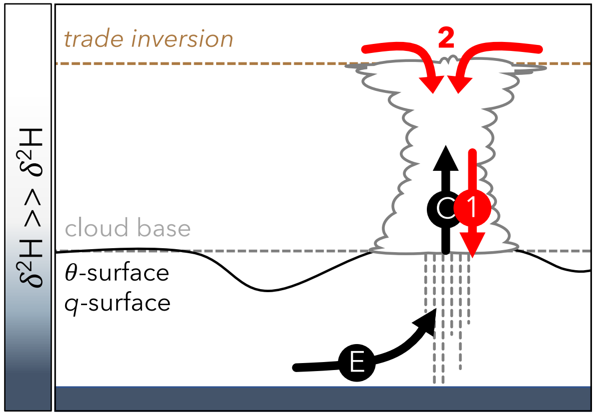
Overturning circulation - ascent

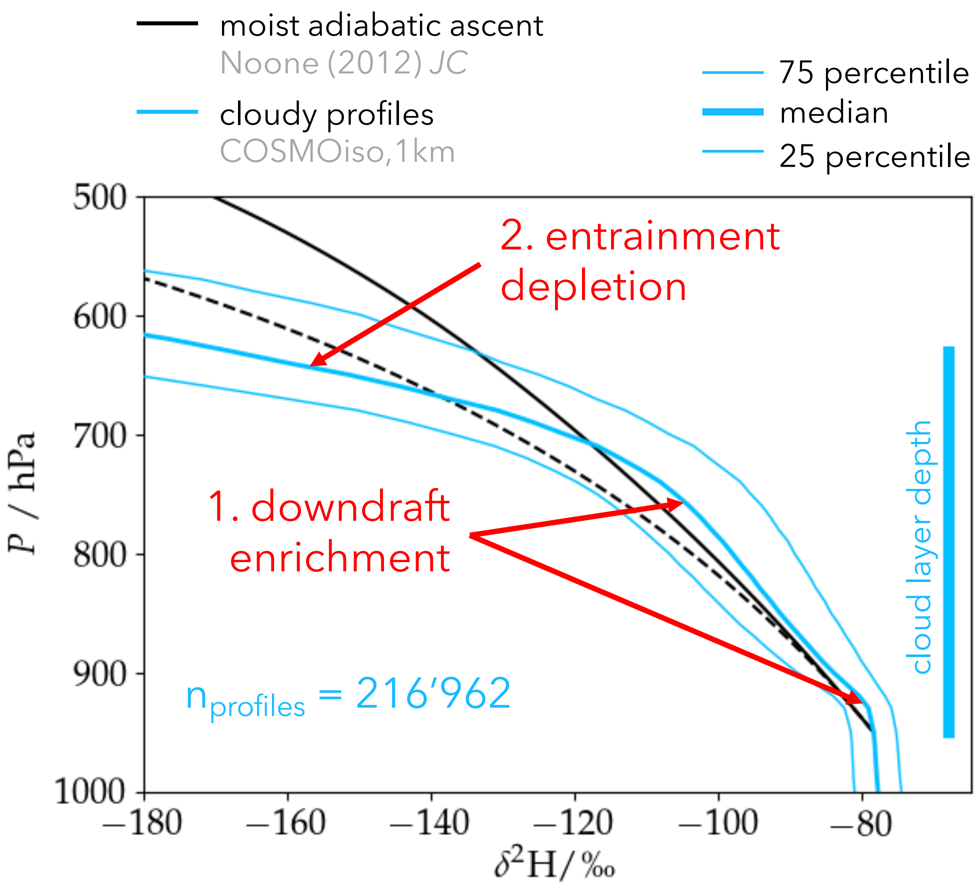
moist adiabatic ascent
Noone (2012) *JC*



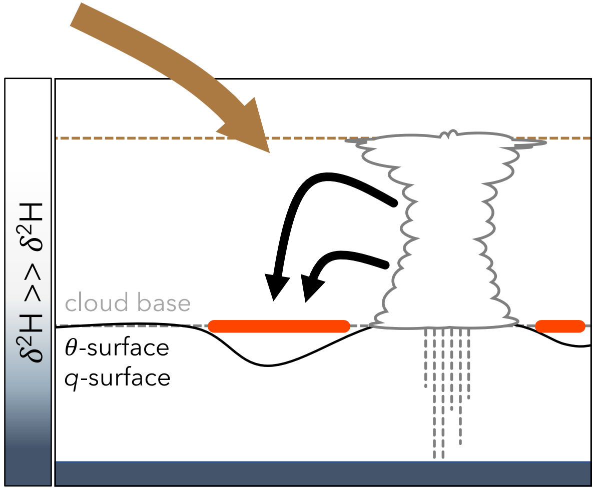


Overturning circulation - ascent





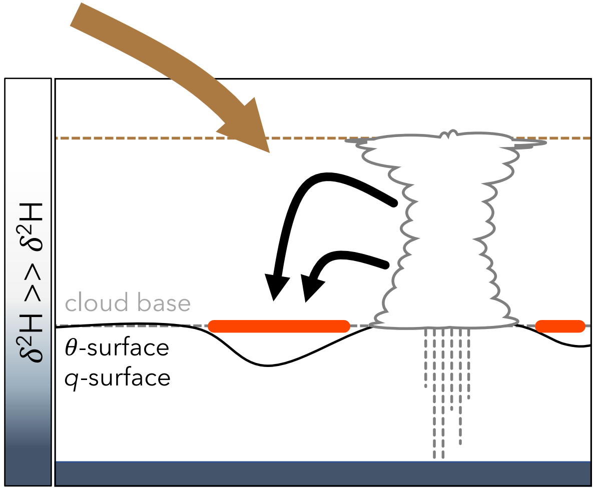
Overturning circulation - descent

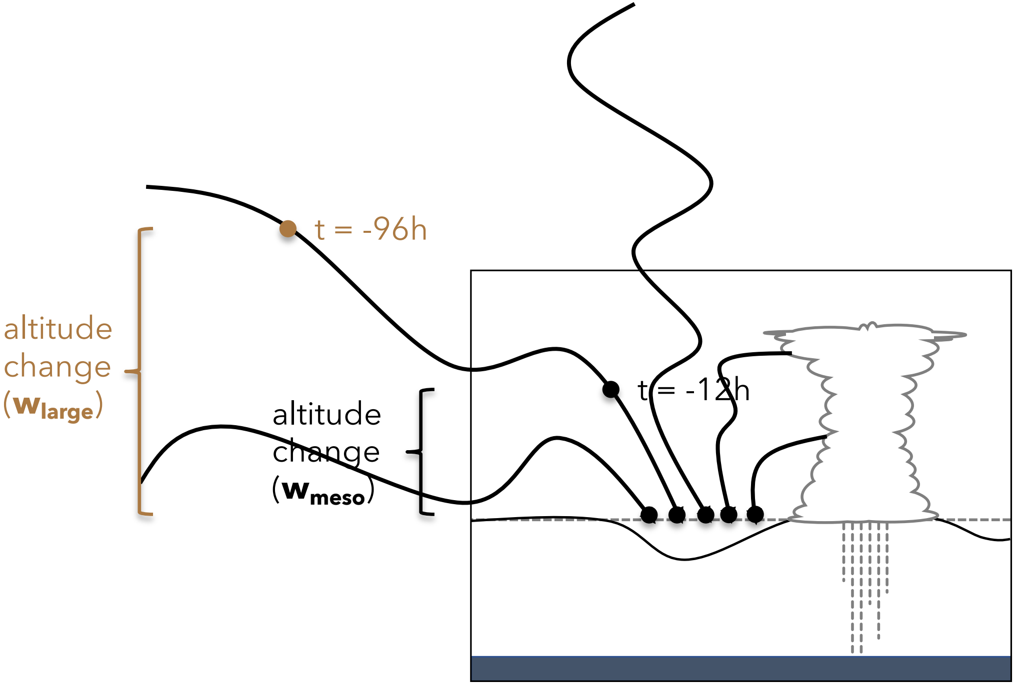


$\mathbf{w_{meso}}$
$\mathbf{w_{large}}$

H: The subsidences ($\mathbf{w_{meso}}$, $\mathbf{w_{large}}$) control δ^2H (and q) of the **dry-warm** cloud base features.

Overturning circulation - descent

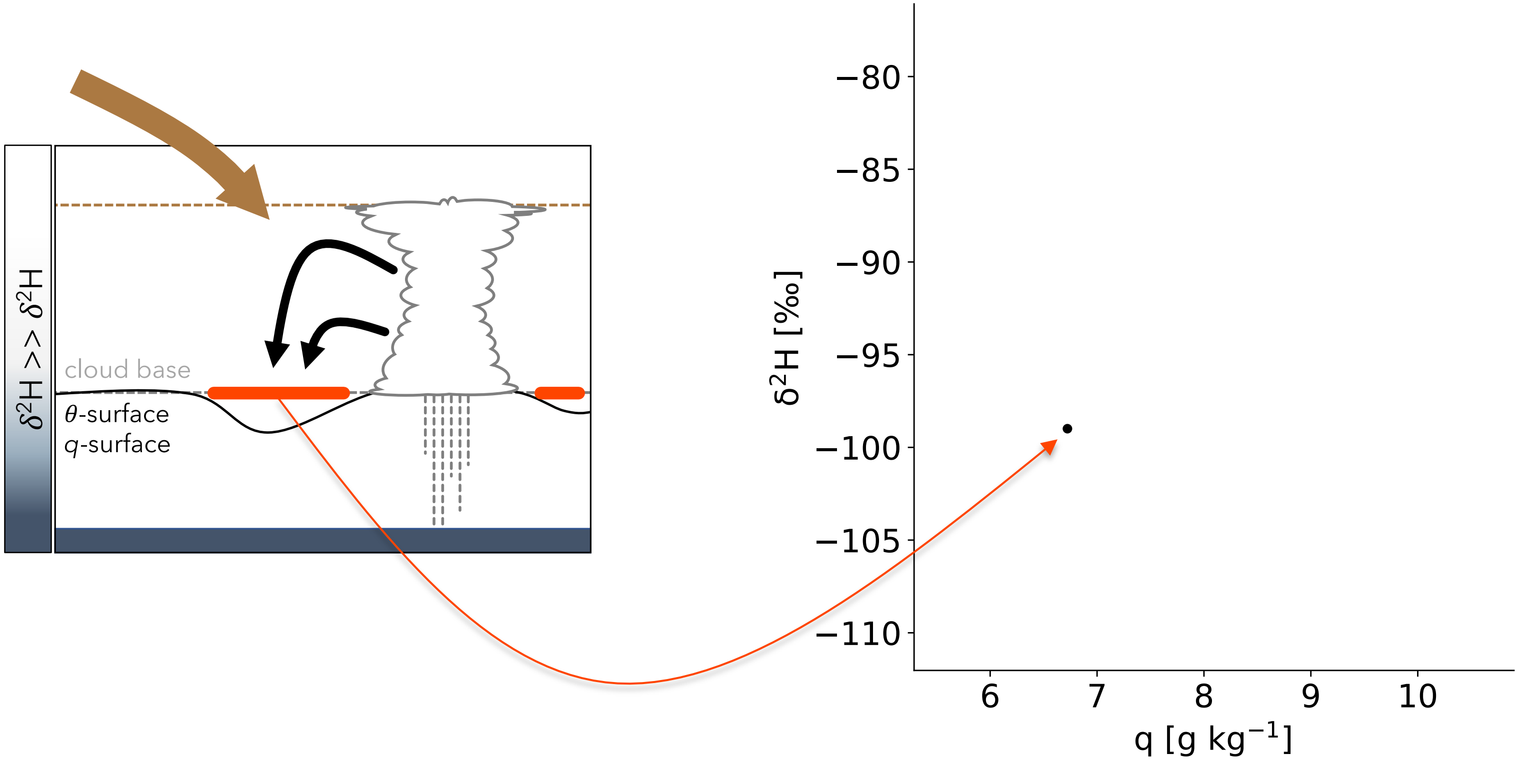




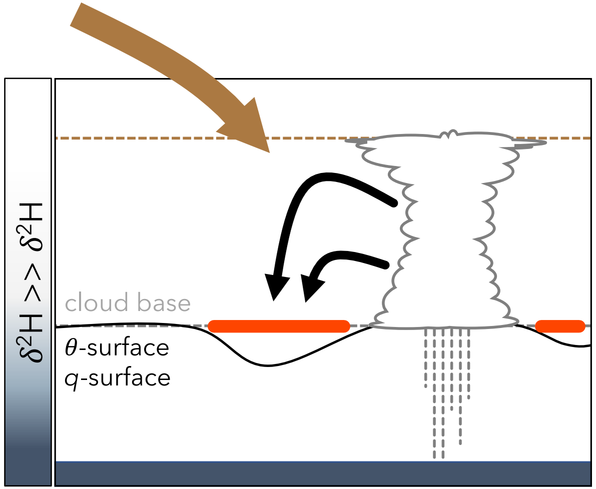
w_{meso} → COSMO$_{iso,5km}$
w_{large} → COSMO$_{iso,10km}$

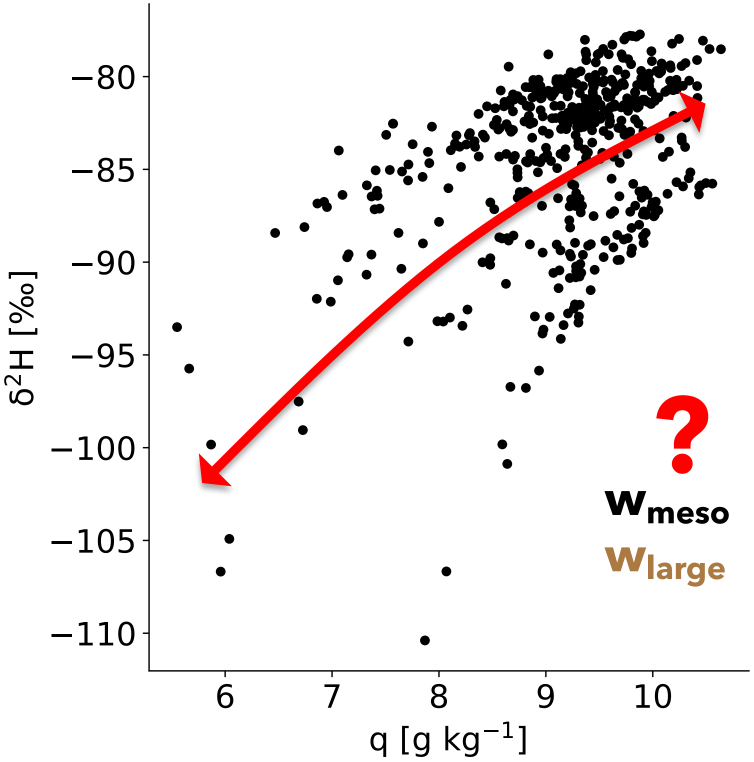
LAGRANTO trajectories after Wernli & Davies (1997) *QJRMS; Sprenger & Wernli (2015) GMD*

Overturning circulation - descent

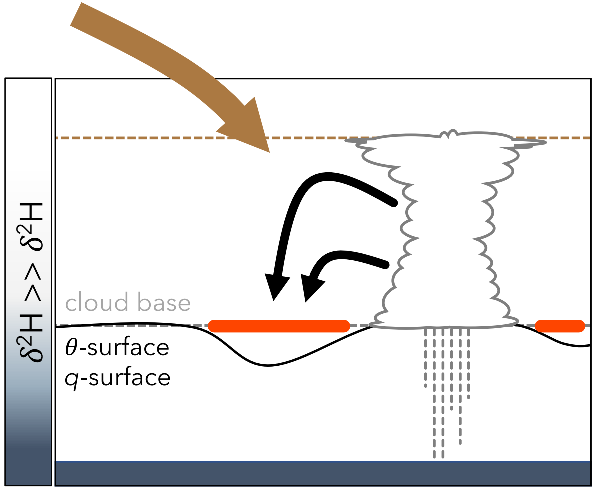


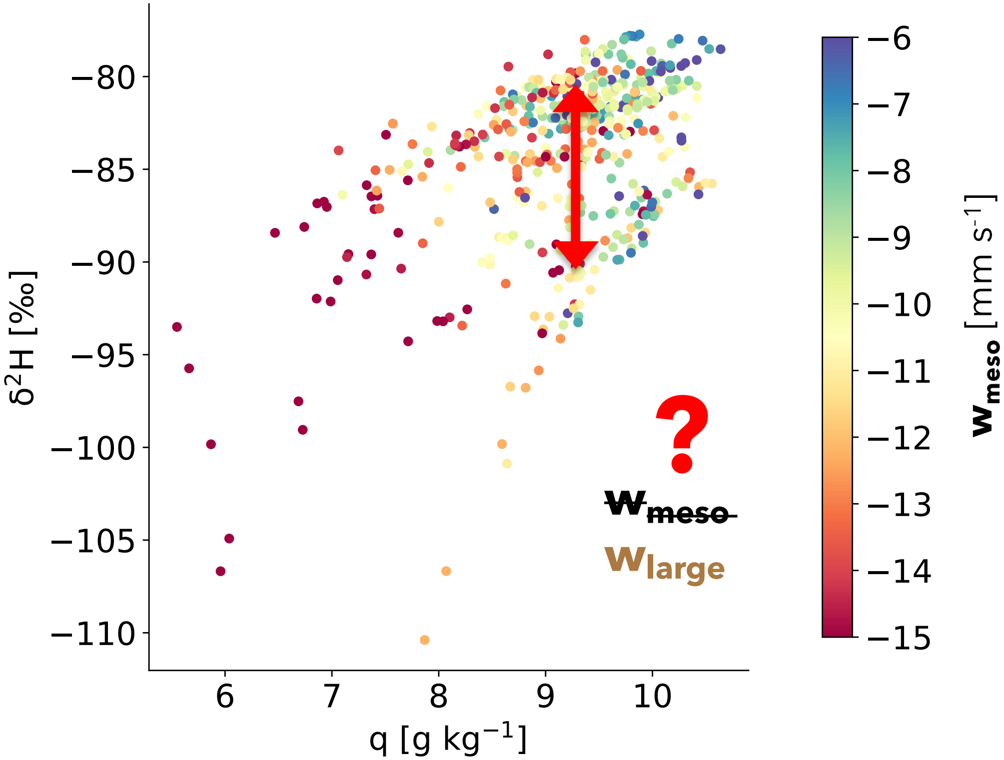
Overturning circulation - descent



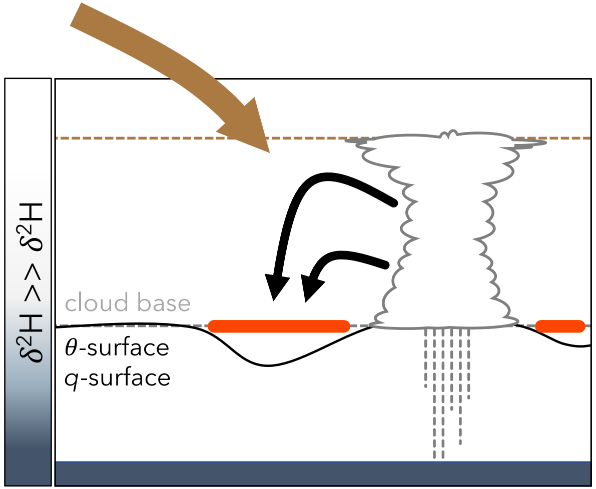


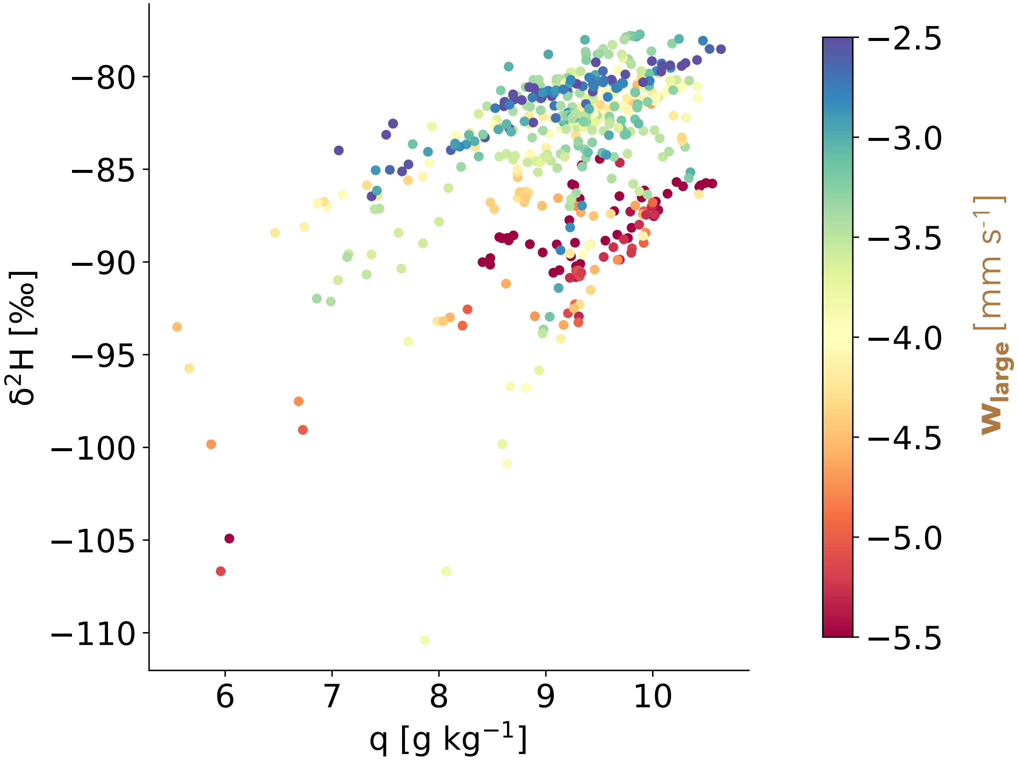
Overturning circulation - descent





Overturning circulation - descent





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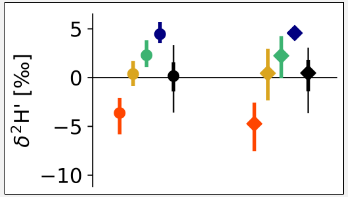
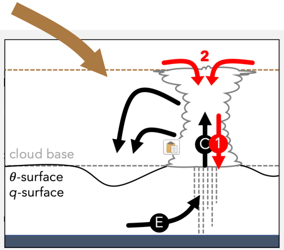
COSMO$_{iso,1km}$ reproduces cloud base features observed in ATR data



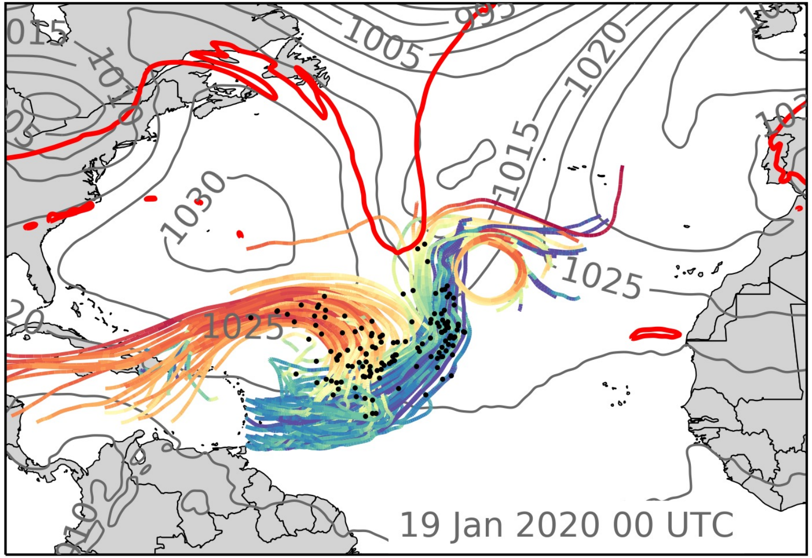


moist adiabatic ascent, rain evaporation, cloud top entrainment; subsidence strengths

What determines the strength of the large-scale subsidence?

COSMO$_{iso}$

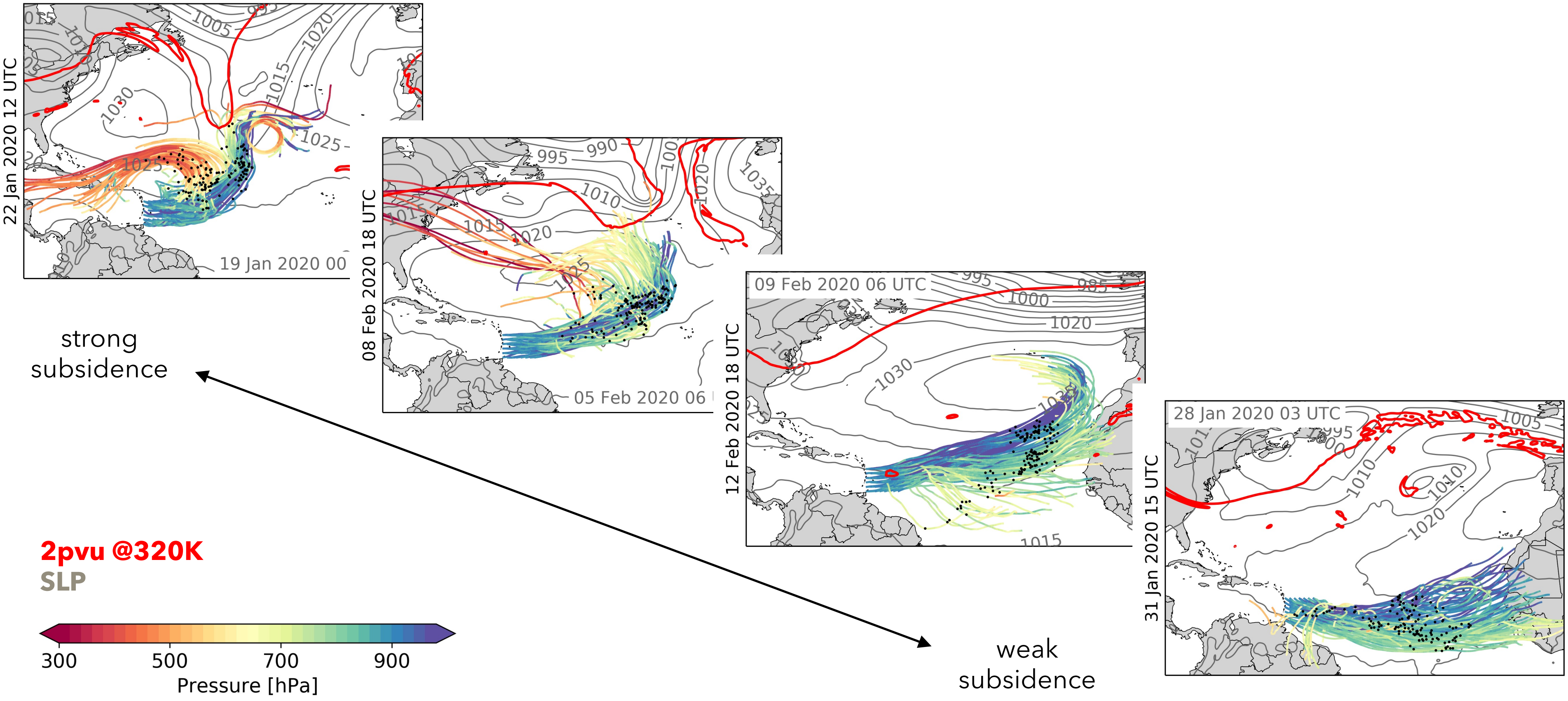
Large-scale subsidence



2pvu @320K

SLP

Large-scale subsidence



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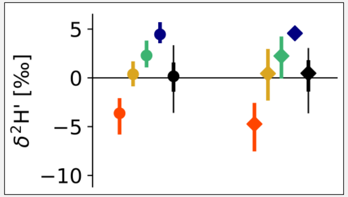

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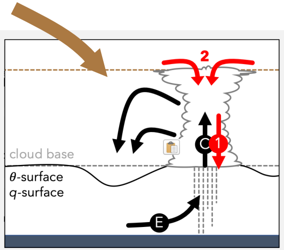
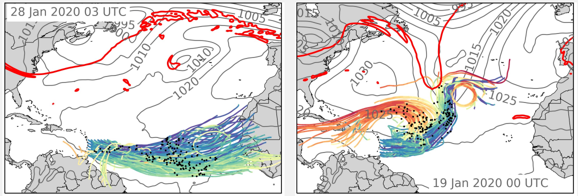


extratropical influence vs. trades



Summary

- isotopes as tracers of microphysical processes and transport on different scales
- large-scale subsidence reflects different flow patterns (trades vs. extratropical disturbance)

Outlook

- quantify amount of …
  - entrained air at cloud tops
  - evaporate in downdrafts
- publish in ACP