Spatial representativeness of in situ δD measurements in comparison to a satellite retrieved product and model simulations

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DATASETS

L-WAIVE CAMPAIGN

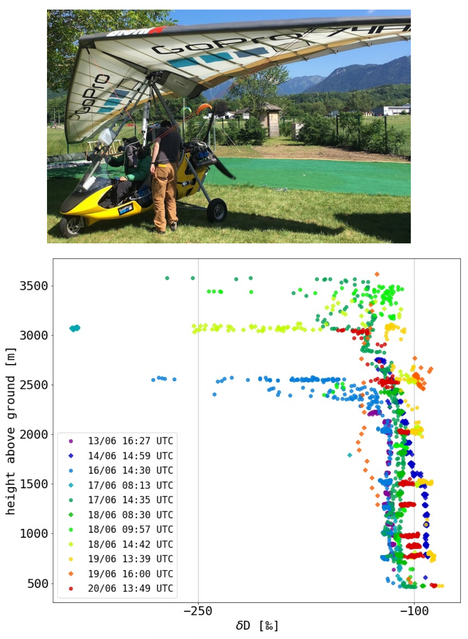


Figure 1: (top) Ultra-light aircraft during L-WAIVE campaign. (bottom) δD versus height coloured by start time of profile.

- Field campaign in June 2019 in the French Alps (Chazette et al., 2021)
- In-situ measurements using laser spectrometer on ultra-light aircraft
- 11 vertical δD profiles over 8 days up to 3500 m and 30 s resolution

S5P/TROPOMI XHDO/XH2O

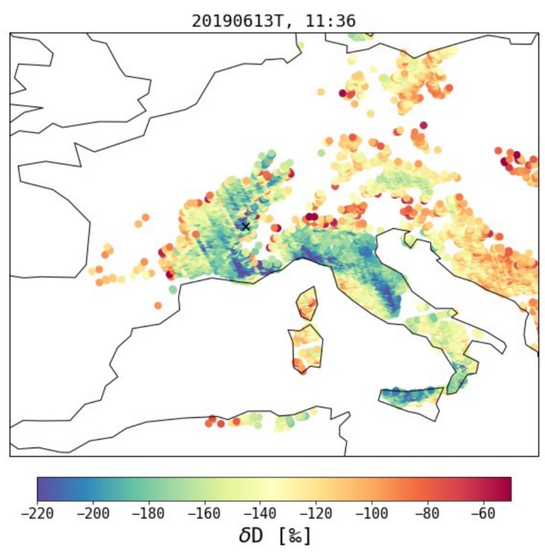


Figure 2: Total column δD retrievals (colors) at 11:36 UTC 13 June 2019

- 8 collocated overpasses during L-WAIVE campaign
- Up to 7 km spatial resolution
- Available over land under cloud-free conditions
- Total columns δD retrievals using University of Leicester algorithm (Trent et al., 2018)

$COSMO_{ISO}$ SIMULATIONS

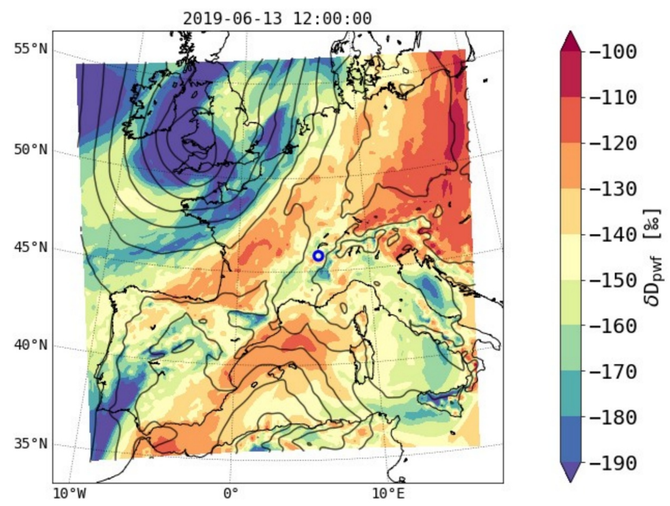


Figure 3: δD_{pwf} (colors) and sea level pressure (black contours) in $COSMO_{iso}$ at 12 UTC 13 June 2019. The blue circle denote the location of Annecy.

- Simulations with isotope-enable numerical weather prediction model $COSMO_{iso}$: 0.1° (~10 km) spatial resolution, explicit convection, 1-hourly output, ECHAM-wiso6 (Cauquoin and Werner, 2021) initial and boundary data
- 2 simulations: 12.6. - 19.6. and 15.6. - 22.6.2019
- Total column δD_{pwf} needed for comparison to S5P retrieval, which is calculated from the total column moisture content X_{Cl}: $\mathbf{X_{Cl} = h_{Cl}^T x_{Cl}}$

  where h_{Cl} is pressure weighting function and x_{Cl} the moisture profile from $COSMO_{iso}$ output. x_{Cl} is calculated for H2O and HDO from which δD is derived.

Three datasets of different temporal and spatial resolution:

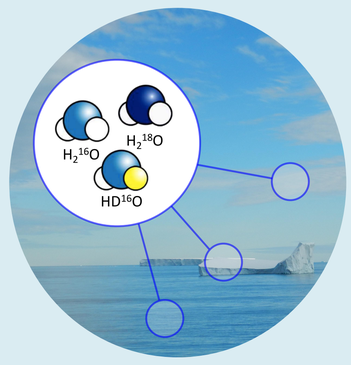
➡ **How to combine these datasets?**

➡ **How to select pixels from satellite overpasses to compare with in-situ measurements?**

WHY STABLE WATER ISOTOPES?

Water isotopologues are water molecules with different molar mass. Due to their different isotopic composition, they are used as natural tracers of phase-change processes in the atmospheric water cycle. They provide information on

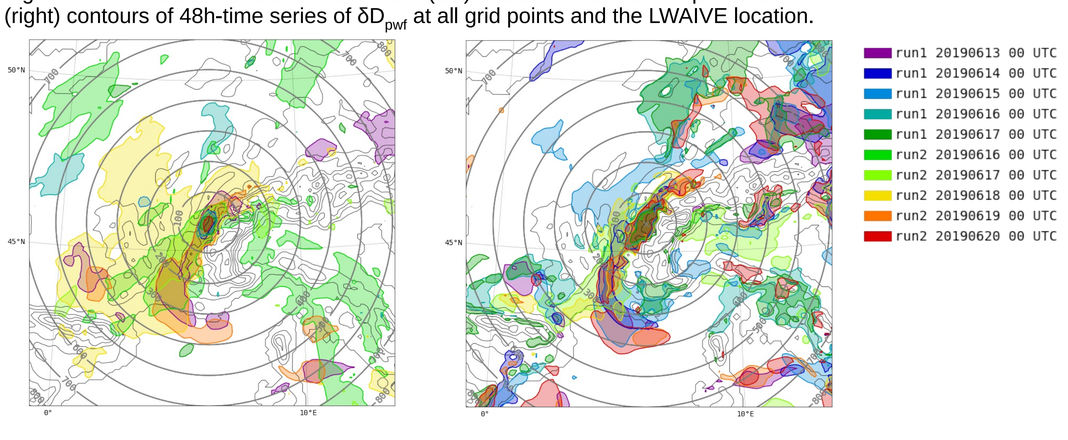
- atmospheric conditions (RH, T) in the moisture source region
- history of moisture in the air
- air-sea interactions
- phase-change processes such as rain evaporation or condensation



SCALE ANALYSIS

Investigation of temporal and spatial scales of δD variability using total colums δD in $COSMO_{iso}$ simulations and the statistical measures Pearson's correlation and root mean square deviation.

Figure 4: 0.8 Pearson correlation coefficient (left) and 10‰ root mean square deviation (right) contours of 48h-time series of δD_{pwf} at all grid points and the LWAIVE location.



0.8 contour line of different 48h time windows for δD_{pwf}.

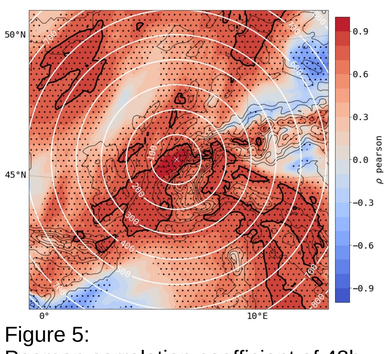


Figure 5: Pearson correlation coefficient of 48h-time series of δD_{pwf} at each grid point with the L-WAIVE location. The 0.8 contour line is highlighted in black.

Synoptic forcing:

Large-scale forcing by North Sea cyclone on 19 June

Local convection in high pressure system on 20 June

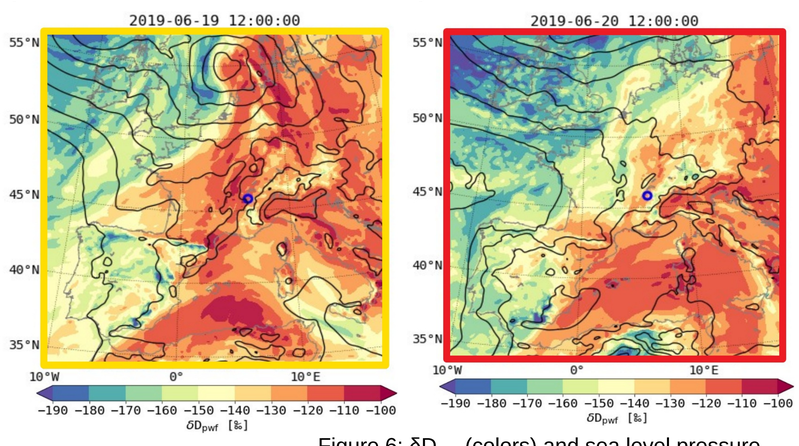


Figure 6: δD_{pwf} (colors) and sea level pressure (black contours) in $COSMO_{iso}$ at 12 UTC 19 June 2019 (left) and 12 UTC 20 June 2019 (right). The blue circles denote the location of the L-WAIVE campaign.

Spatial scales:

- Shaped by topography
- High variability due to large-scale dynamics

COMPARISON

Using the combination of ρ=0.8 and rmsd=10 ‰ for 48 h time series as a mask to improve selection of compared pixels.

S5P and $COSMO_{iso}$ total column δD

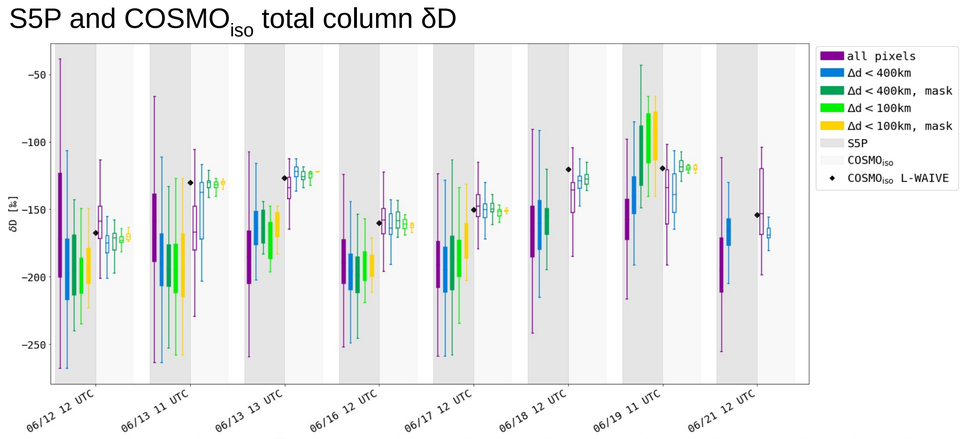


Fig. 7: Boxplots of total column δD in S5P retrievals (dark grey background) and $COSMO_{iso}$ simulations (light grey background) for collocated satellite overpasses and different pixel selection criteria (see legend). The interpolated δD in the $COSMO_{iso}$ output at the L-WAIVE location is shown as a black dot for each overpass.

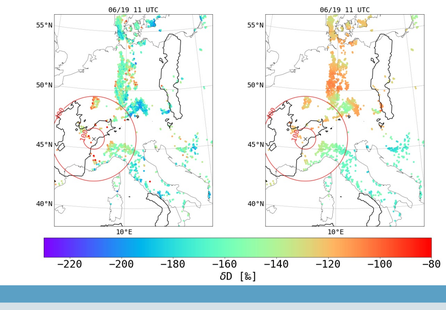


Fig. 8: Scatter plots of total column δD in S5P retrieval (left) and $COSMO_{iso}$ simulation (right) at 11 UTC 19 June 2019. The black contours shows the mask based on the scale analysis, the red circles show a distance of 100 km and 400 km from the L-WAIVE location.

OUTLOOK

- Apply scale analysis to in-situ data: subcolumn retrievals
- High-resolution $COSMO_{iso}$ simulations
- Extend time period and variables
- Comparison studies at other sites (LEMON2021 in Rhone valley, ISLAS2022 in Kiruna (SE))

REFERENCES **Chazette et al., 2021:** Experimental investigation of the stable water isotope distribution in an Alpine lake environment (L-WAIVE). Atmos. Chem. Phys.
Trent et al. 2018: Observing Water Vapour in the Planetary Boundary Layer from the Short-Wave Infrared. Remote Sens.
Cauquoin and Werner, 2021: High-Resolution Nudged Isotope Modeling With ECHAM6-Wiso: Impacts of Updated Model Physics and ERA5 Reanalysis Data. JAMES.

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