Retrieving H_2O/HDO columns over cloudy and clear-sky scenes from the Tropospheric Monitoring Instrument (TROPOMI)

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SRON Netherlands Institute for Space Research

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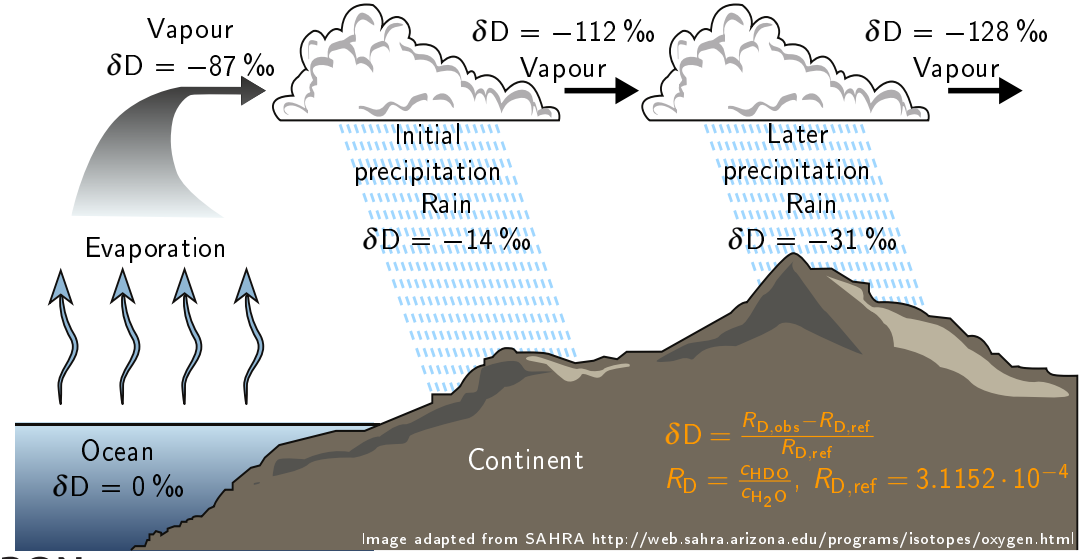
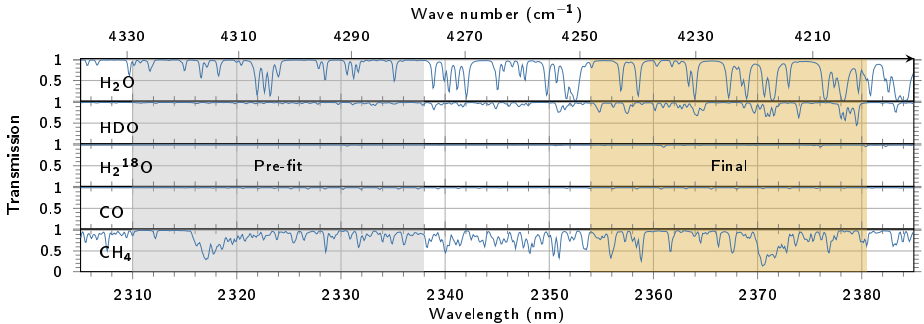
Introduction



Retrieval setup

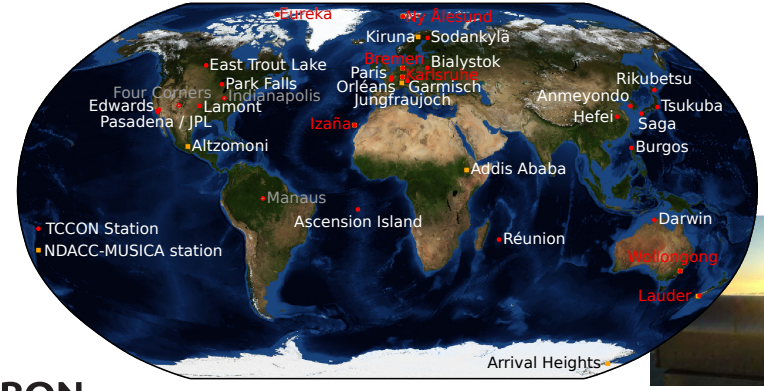
- Profile-scaling approach with SICOR algorithm
- Fit of H_2O, HDO, CH_4, CO, and Lambertian surface albedo



- Forward model accounting for scattering, effective cloud parameters from pre-fit
- Surface albedo slightly regularized

Validation data sets: ground based FTIR measurements

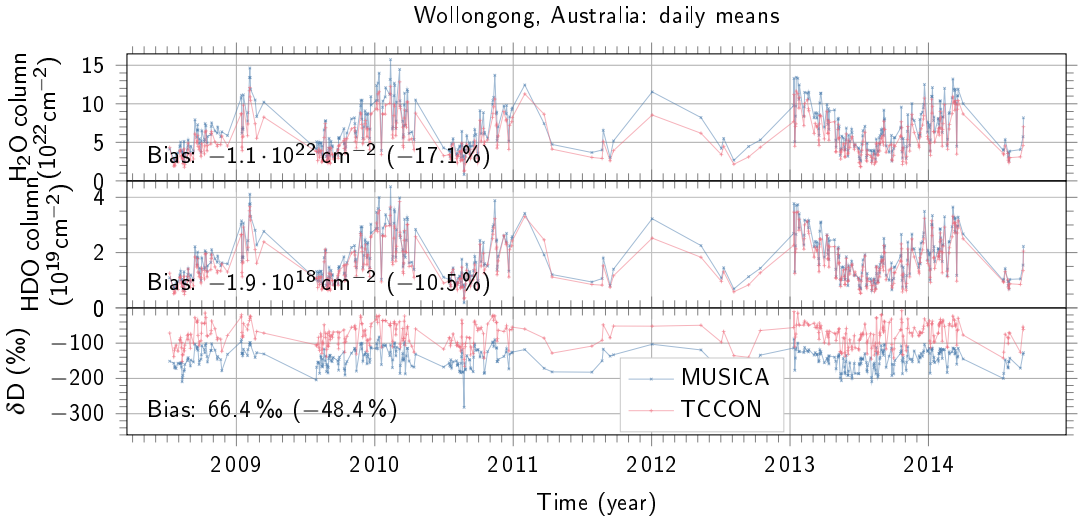
- Fourier transform infrared (FTIR) observations of direct solar beam
- Two networks of stations: Total Carbon Column Observing Network (TCCON) and Network for the Detection of Atmospheric Composition Change (NDACC)
- Seven stations in both networks



Ground based FTIR measurement data sets

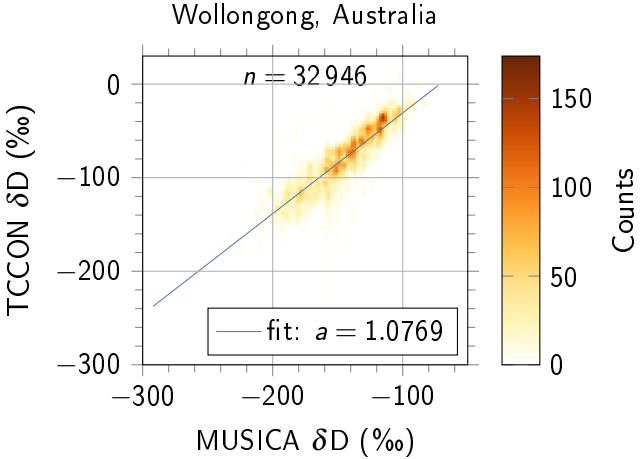
- TCCON data product 
  - H_2O and HDO included
  - H_2O column validated with and adapted to in situ measurements
  - Data available 3 months to 1 year after measurement
- MUSICA-NDACC data product 
  - Multi-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water
  - Dedicated water vapour isotopologue product from reprocessed NDACC observations
  - Includes H_2O, HDO and $H_2{}^{18}O$
  - δD validated with aircraft measurements
  - Data after 2014 available for only three stations

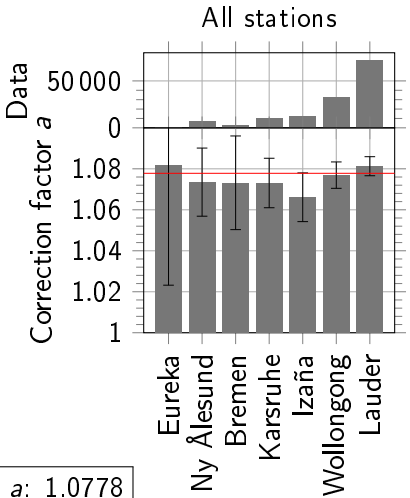
Differences between TCCON and MUSICA-NDACC



Correcting inconsistency in validation data sets

- Scaling of HDO with factor a equivalent to $\delta\mathrm{D} \mapsto a\,\delta\mathrm{D} + a - 1$

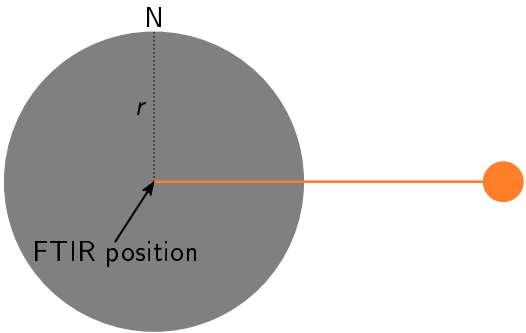




Error-weighted average a: 1.0778

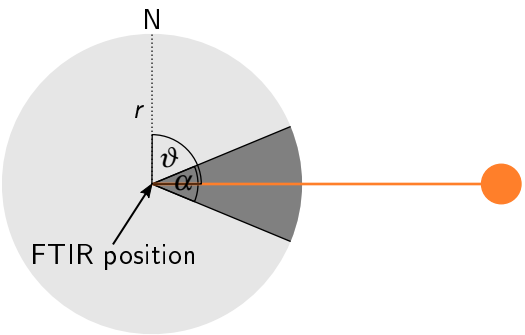
Spatial collocation

- Usual spherical collocation area with radius r around FTIR



Spatial collocation

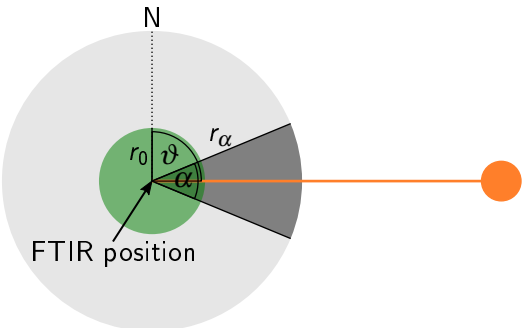
- Usual spherical collocation area with radius r around FTIR (light grey)



- Only take into account ground pixels inside cone in FTIR viewing direction ϑ with field of view α (dark grey)
- Value for α compromise between same air mass and amount of data

Spatial collocation

- Usual spherical collocation area with radius r around FTIR (light grey)

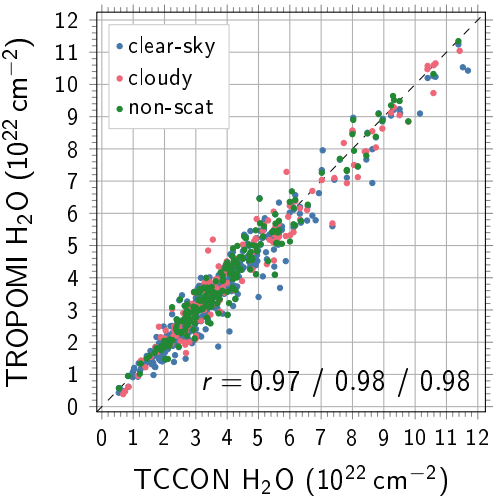


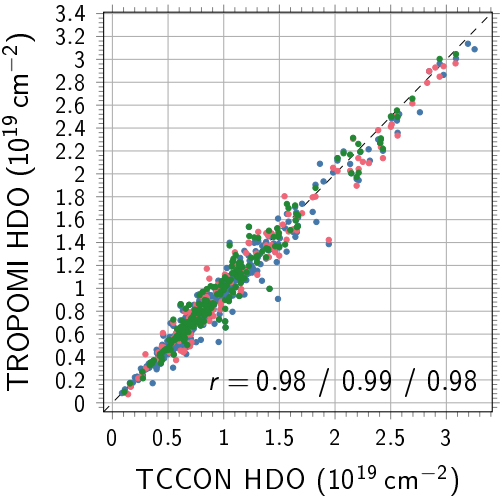
- Only take into account ground pixels inside cone in FTIR viewing direction ϑ with field of view α (dark grey)
- Value for α compromise between same air mass and amount of data
- Adapt field of view to solar zenith angle
- Condition of equal area with non-directional view at radius r_0
  $\Rightarrow r_\alpha = \sqrt{\frac{360^\circ}{\alpha}}\, r_0$
- Linear variation of field of view α with SZA φ:
  $\alpha = \alpha_0 + \frac{90^\circ - \varphi}{90^\circ}(360^\circ - \alpha_0)$

Further collocation criteria

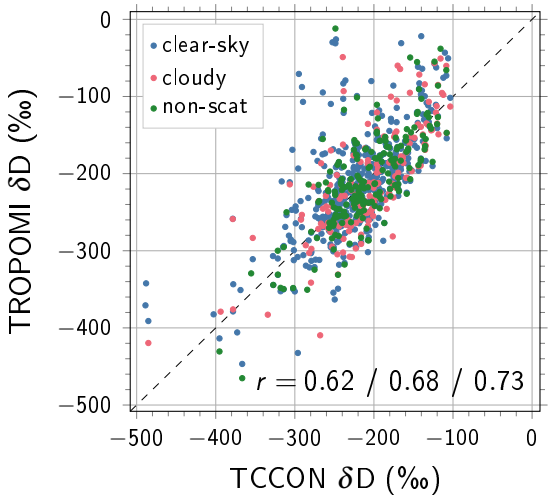
- Maximal time difference 2 h
- Maximal altitude difference 500 m
- Applying averaging kernels

Validation: Correlation H_2O/HDO at Edwards

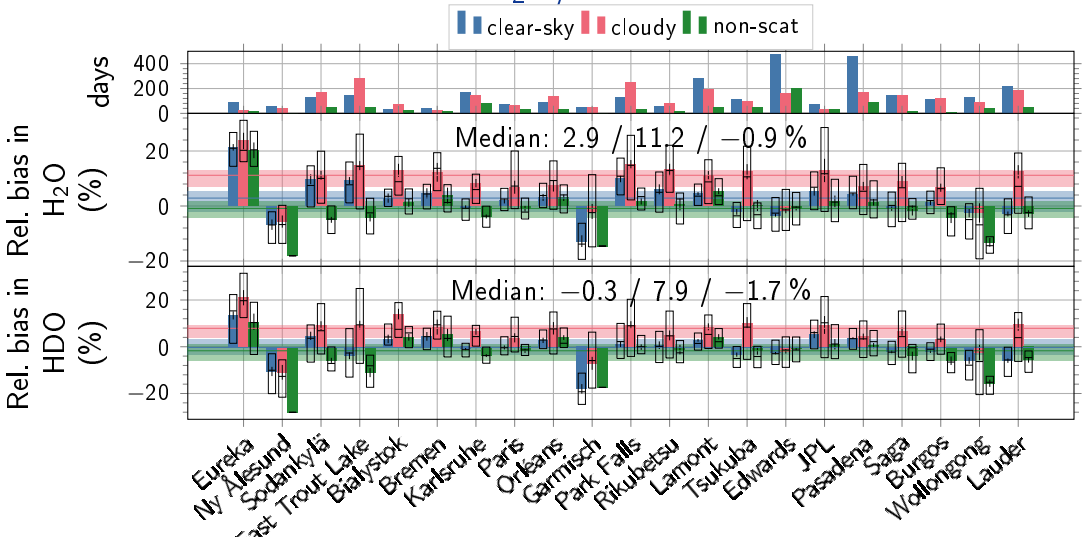




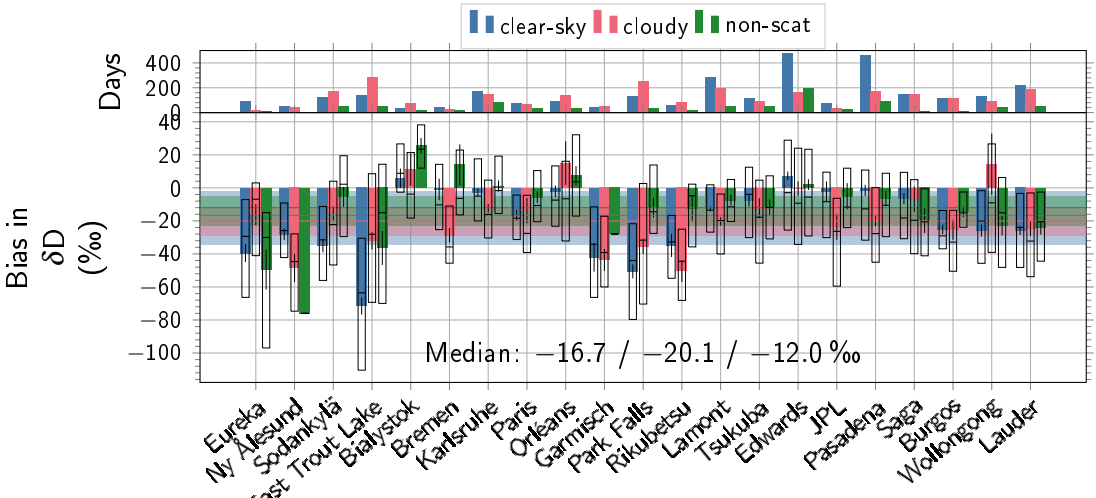
Validation: Correlation a posteriori δD at Edwards



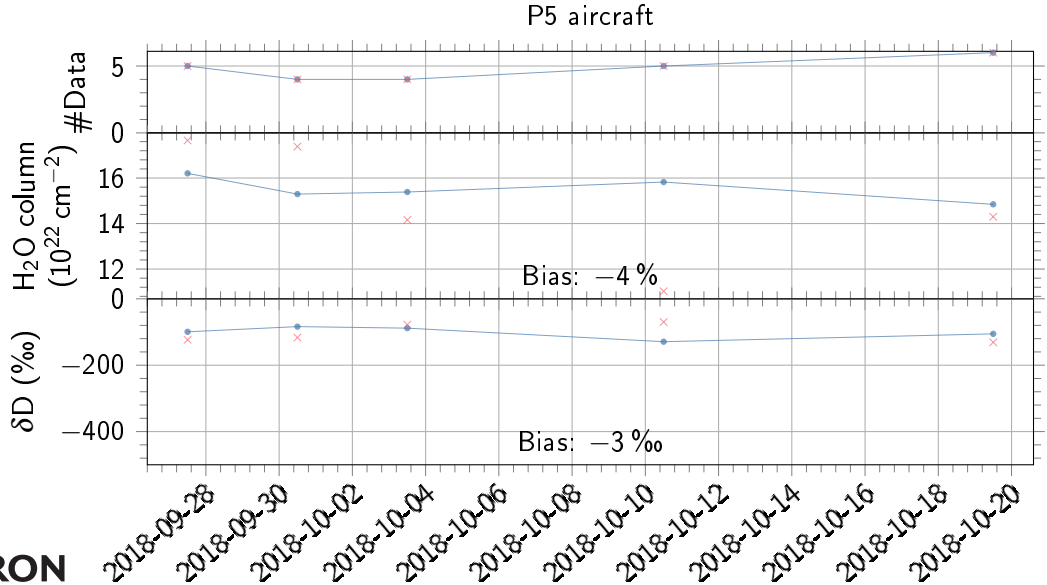
Validation at low-altitude stations: H_2O/HDO



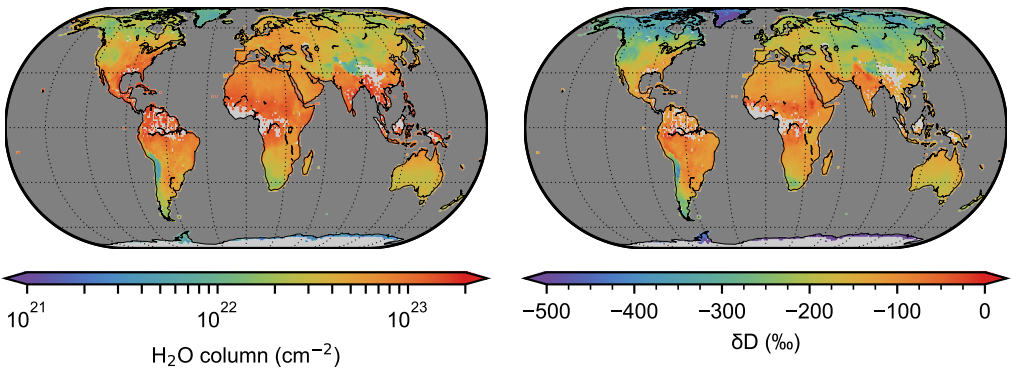
Validation at low-altitude stations: a posteriori δD



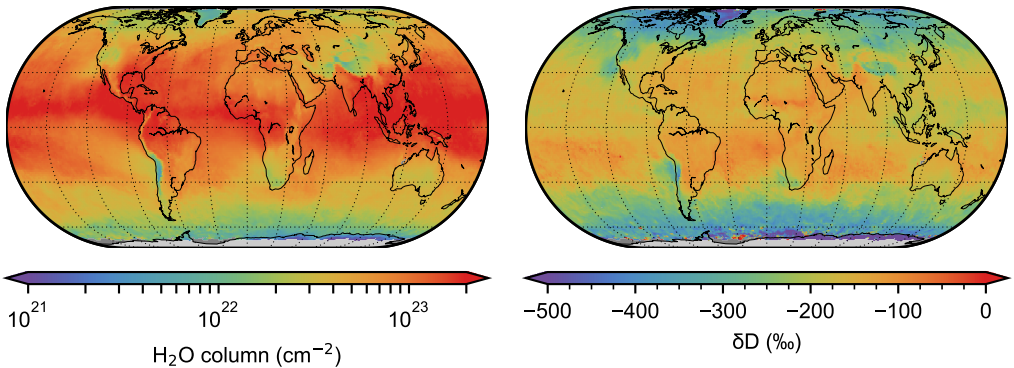
Validation over the ocean with aircraft profiles



Non-scattering product September 2018

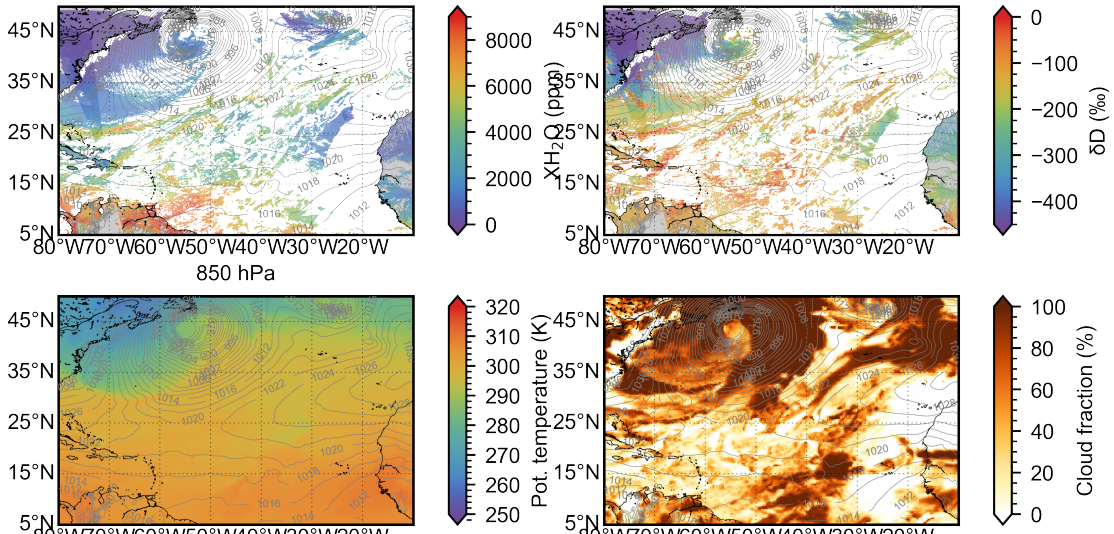


Scattering product September 2018

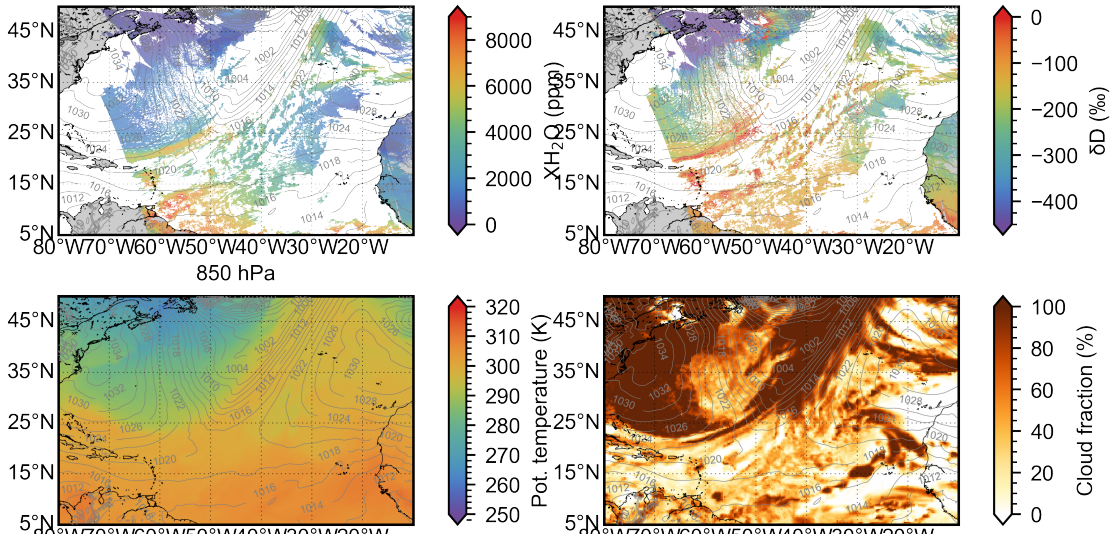


Large enhancement in data coverage!

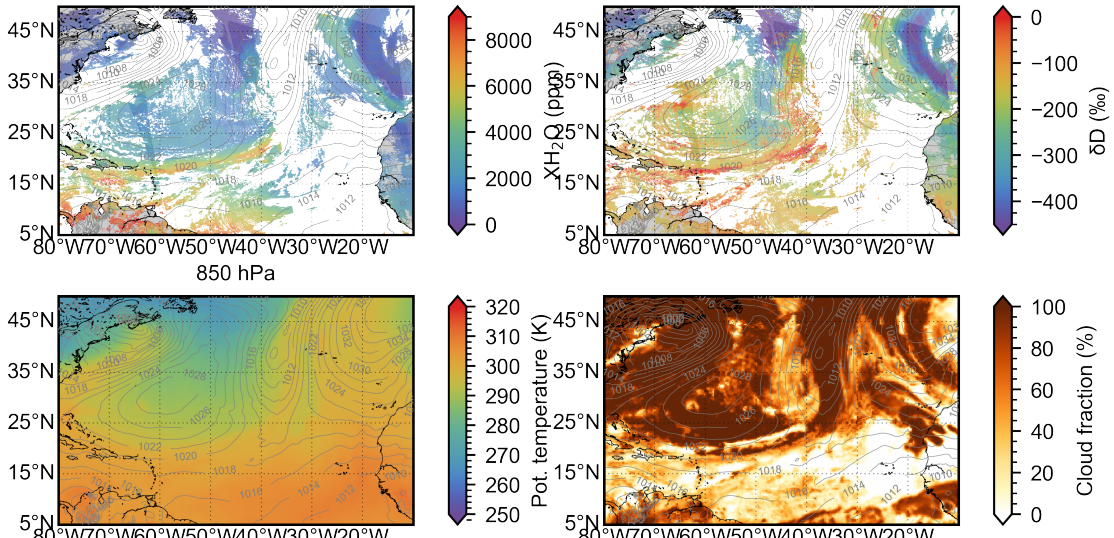
Case study: cold air outbreak: 17 Jan 2020



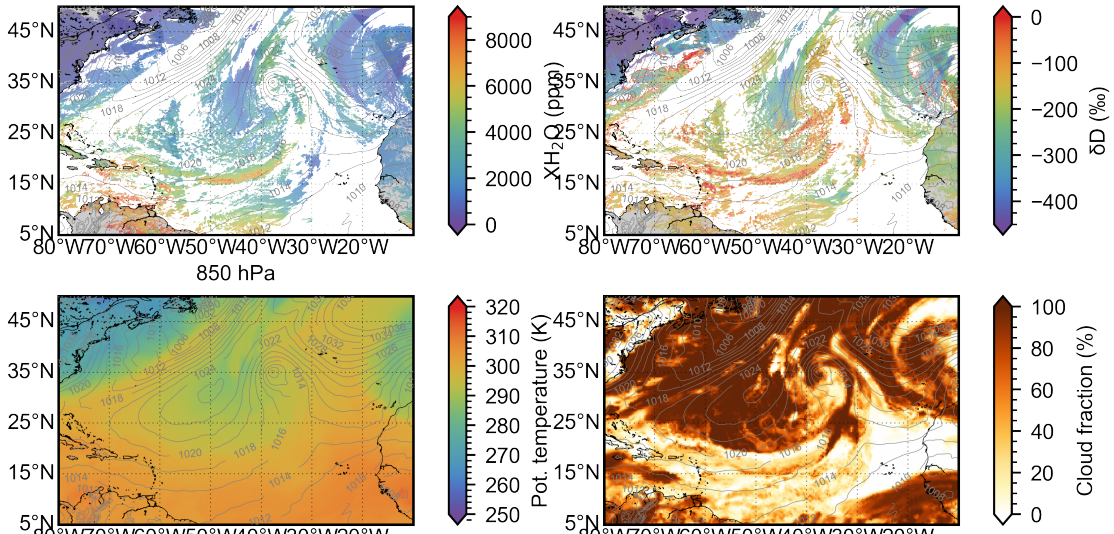
Case study: cold air outbreak: 18 Jan 2020



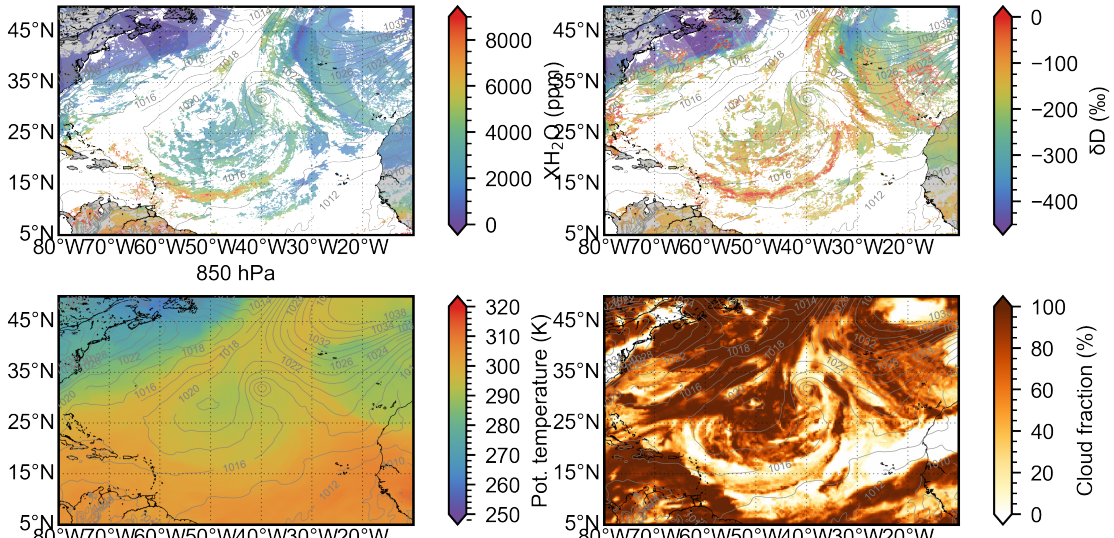
Case study: cold air outbreak: 19 Jan 2020



Case study: cold air outbreak: 20 Jan 2020



Case study: cold air outbreak: 21 Jan 2020



Summary

- First TROPOMI H_2O/HDO data set including scenes with low clouds
- Huge enhancement in data coverage
- Good data quality
- Single overpass results allow new interesting case studies
- Bias in reference data TCCON HDO corrected

- Publication: https://doi.org/10.5194/amt-2021-141 
- Dataset: https://tropomi.grid.surfsara.nl/hdo/ 

Outlook: tackling the bias in TCCON HDO

- To date: ad hoc correction to match MUSICA δD
- TCCON HDO data product should be improved and calibrated
- Profile measurements at TCCON station necessary to this end

$\Rightarrow$ project Water vapour Isotopologue Flask sampling for the Validation Of Satellite data (WIFVOS)

- Flask sampling system on a small ($<$ 20 kg payload) balloon
- Transfer existing drone sampler to balloon platform
- Field campaign at TCCON station Sodankylä in March 2022