Water vapour Isotopologues from TROPOMI (WIFT)

Andreas Schneider

SRON Netherlands Institute for Space Research, Utrecht, the Netherlands

LPF Final Review, Online, 3rd December 2020

LIVING PLANET FELLOWSHIP

ATMOSPHERE

Introduction

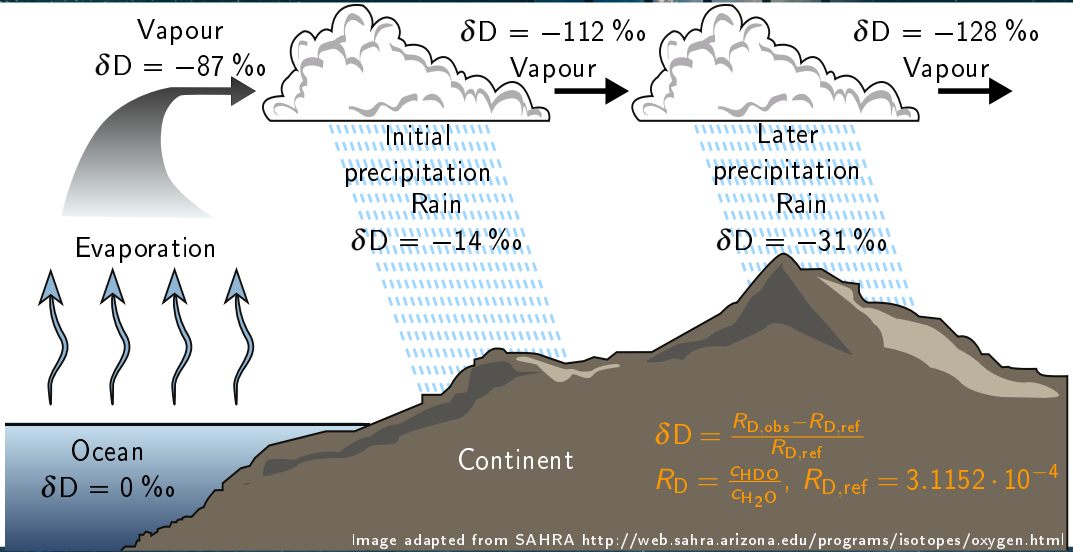


Image adapted from SAHRA http://web.sahra.arizona.edu/programs/isotopes/oxygen.html

Project objectives

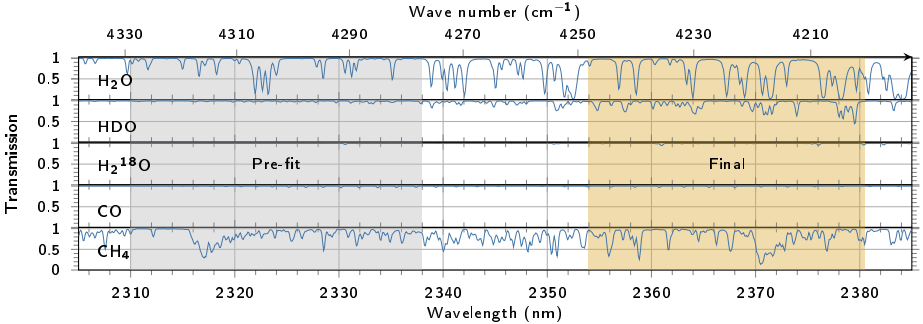
- Develop a validated water vapour isotopologue data product for TROPOMI
  - Non-scattering retrieval: clear sky scenes over land
  - Scattering retrieval: scenes with clear sky or low clouds
- Science study on hydrological cycle using the new data set

Performed work

- Bias in validation data (TCCON HDO) corrected
- Clear-sky data set
  - Produced and published
  - Small scientific case study using single overpass data
- Data set over cloudy scenes
  - Fitting effective cloud parameters concurrently to trace gases does not work
  - Different cloud models tried without success
  - Solution: fitting effective cloud parameters in other spectral range
  - Data set over low clouds or clear-sky produced
  - Large enhancement in data coverage, e. g. now data over oceans
  - Publication currently written up

Retrieval setup

- Profile-scaling approach with SICOR algorithm



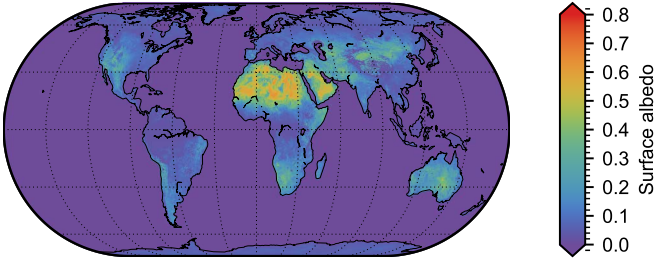
- Fit of H_2O, HDO, CH_4, CO, and Lambertian surface albedo

❶ Forward model ignoring scattering, cloud filtering with VIIRS

❷ Forward model accounting for scattering, fitting effective cloud parameters in pre-fit, regularising surface albedo

Retrieval setup: details

- Scattering cross-sections from HITRAN 2016
- A priori profiles of water vapour from ECMWF analysis, scaled according to standard abundances
- A priori profiles of CH_4 and CO from TM5 simulations
- A priori surface albedo for scattering retrieval from one year average of non-scattering retrieval (0 over oceans)



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

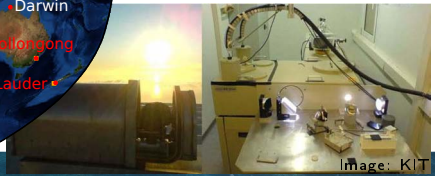


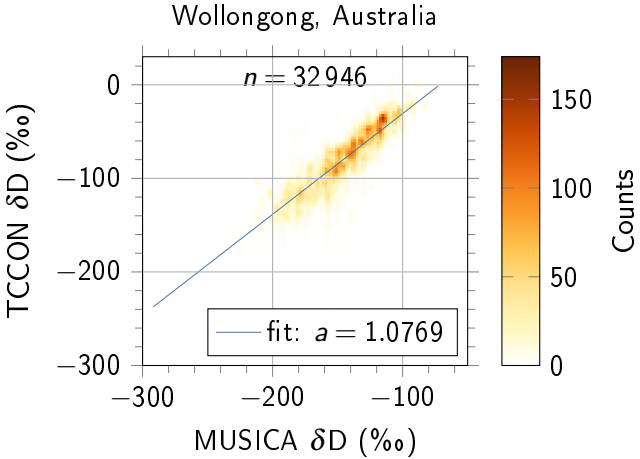
Image: KIT

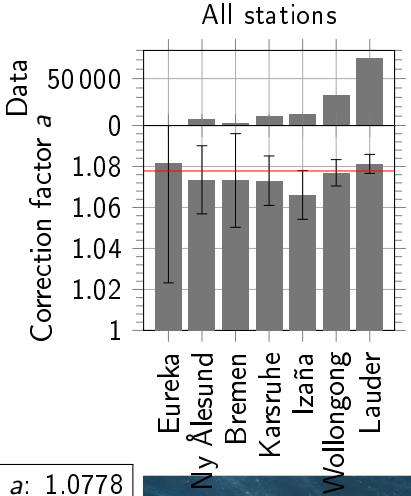
Ground based FTIR measurement data sets

- 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

Correcting inconsistency in validation data sets

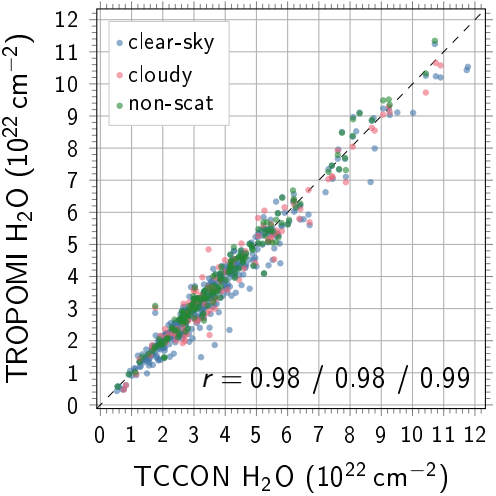
- Scaling of HDO with factor a equivalent to $\delta\mathrm{D} \mapsto a\,\delta\mathrm{D} + a - 1$

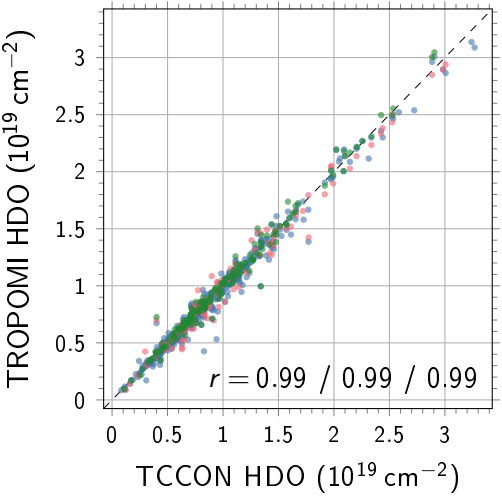




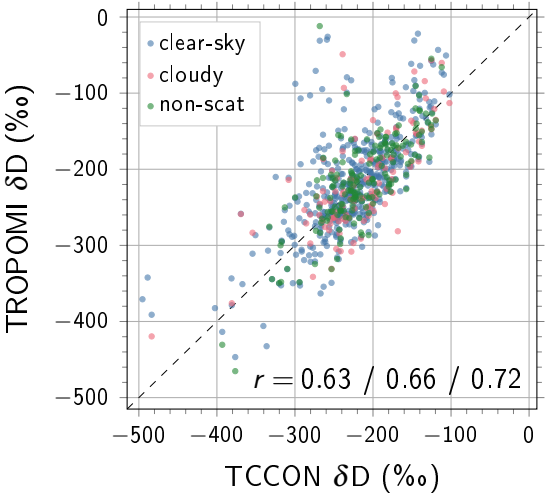
Error-weighted average a: 1.0778

Validation: Correlation H_2O/HDO at Edwards

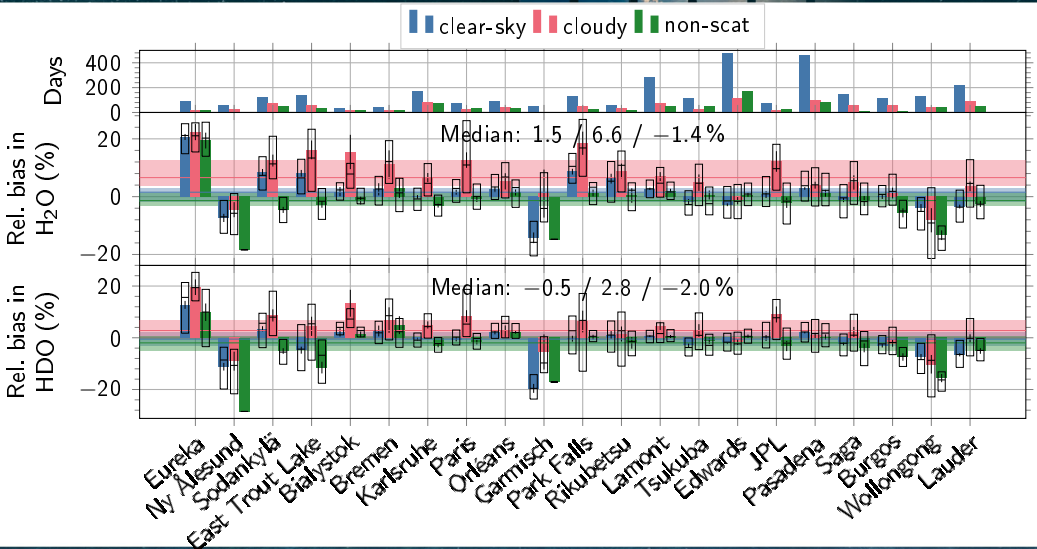




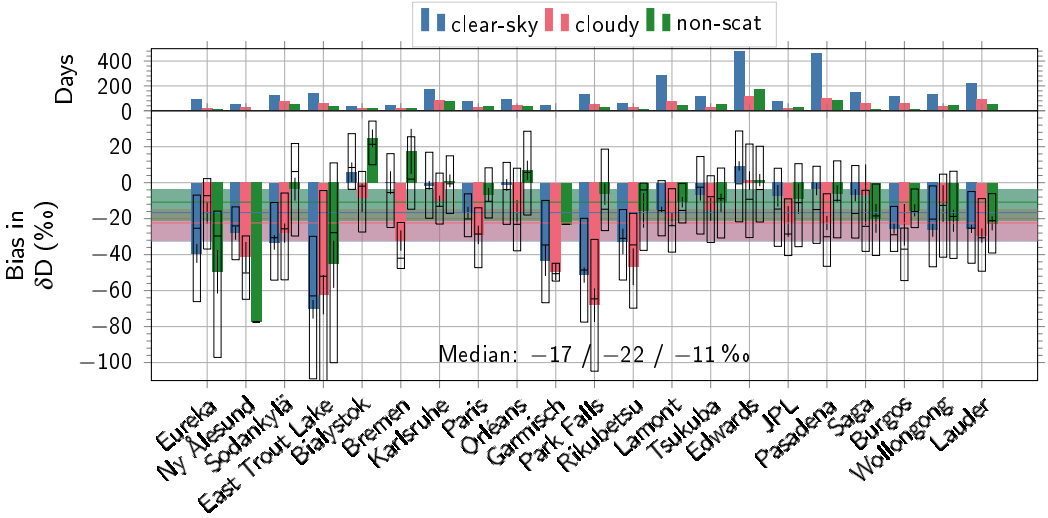
Validation: Correlation a posteriori δD at Edwards



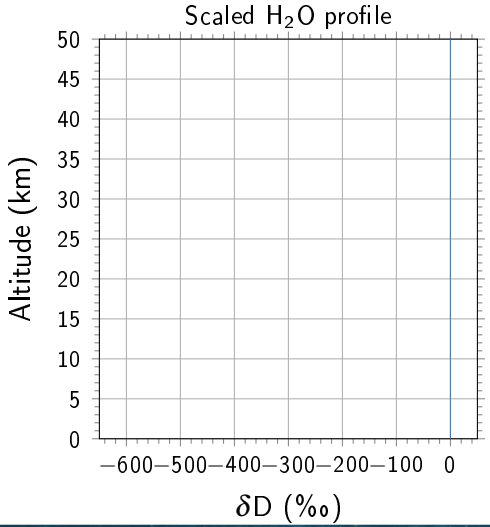
Validation at low-altitude stations: H_2O/HDO

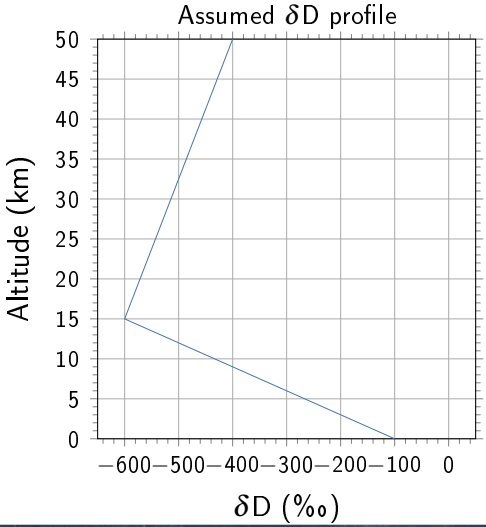


Validation at low-altitude stations: a posteriori δD

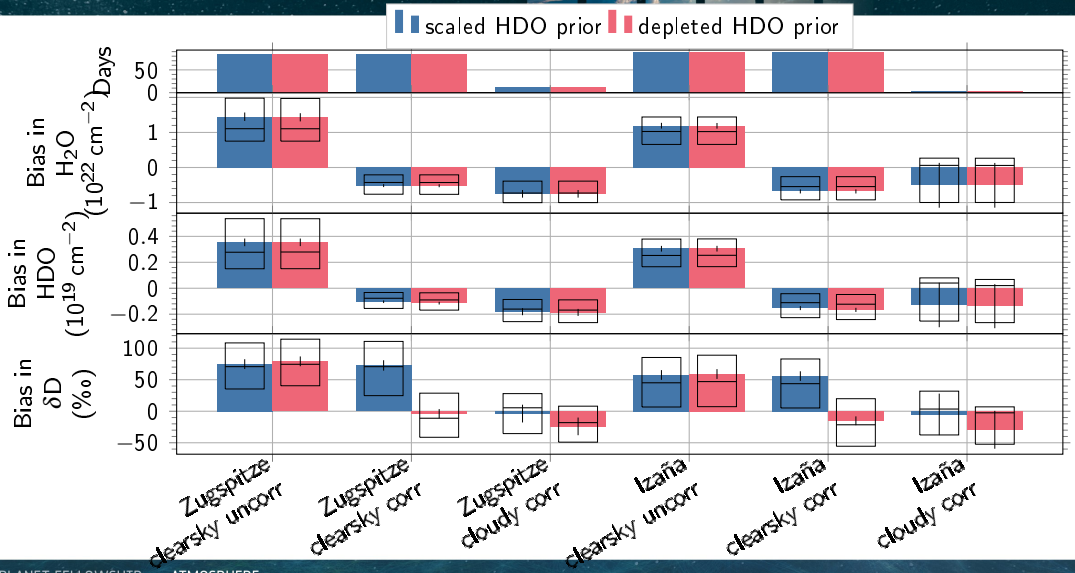


Prior profiles: Obtaining HDO profile from H_2O profile

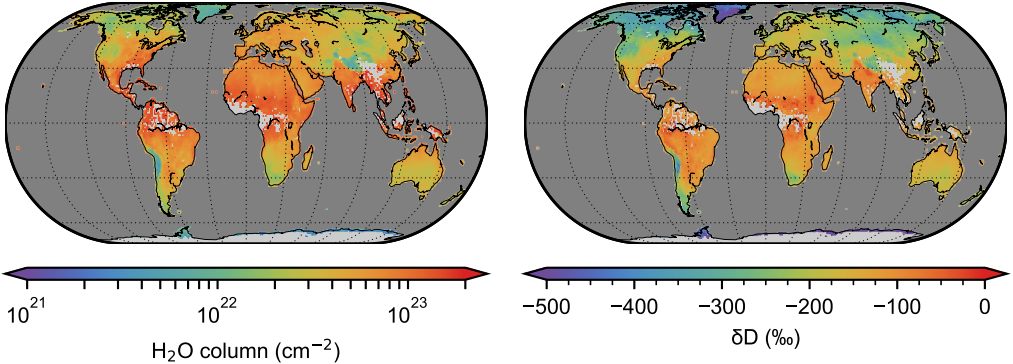




Validation at high-altitude stations

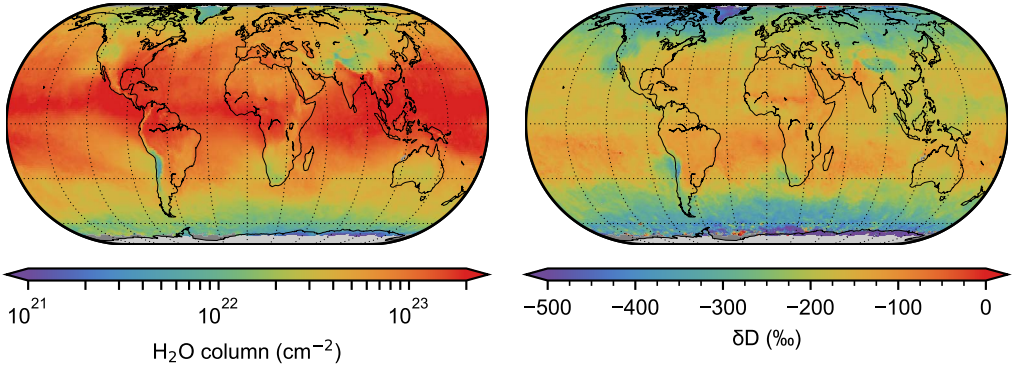


Non-scattering product September 2018



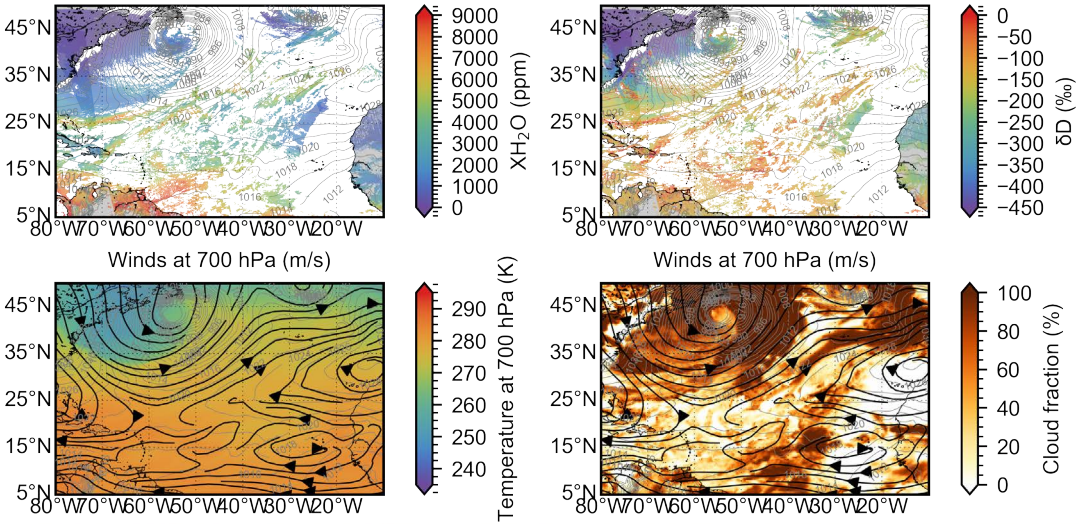
State of the art

Scattering product September 2018

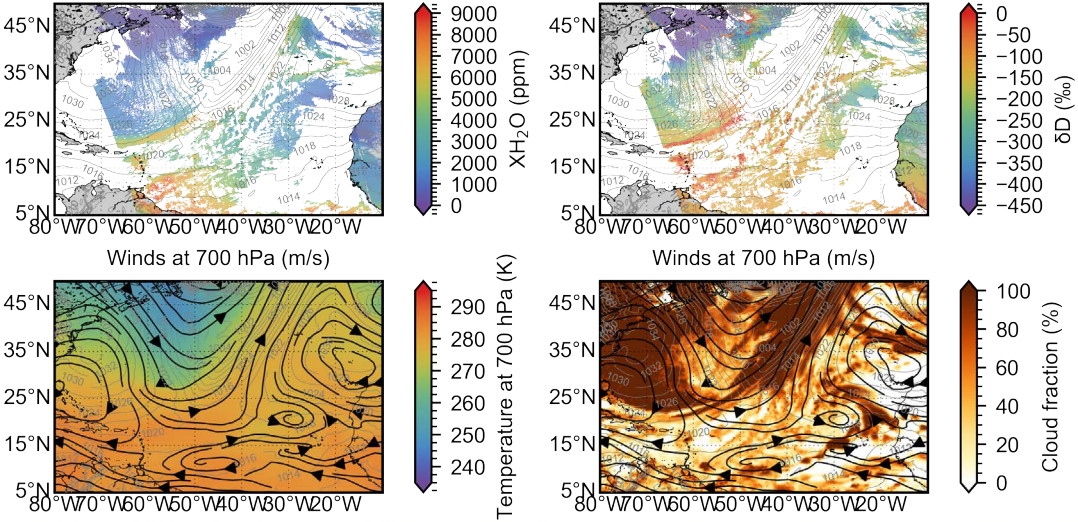


Large enhancement in data coverage: data over oceans!

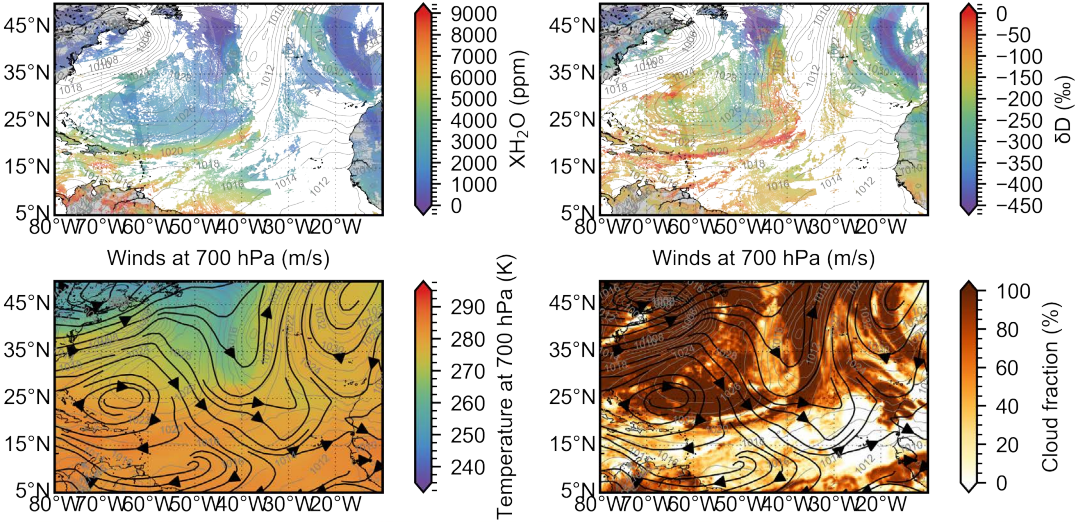
Case study: cold air outbreak: 17 Jan 2020



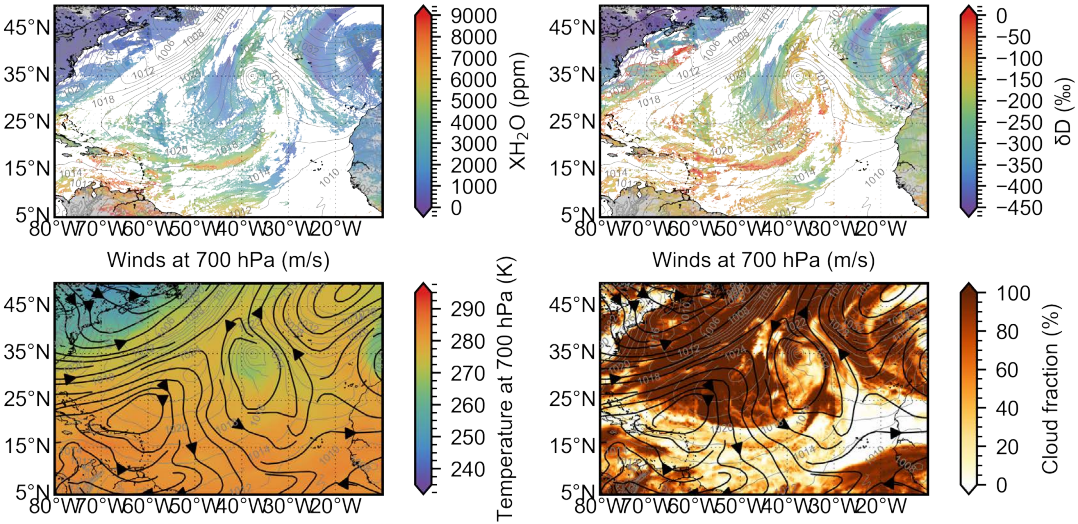
Case study: cold air outbreak: 18 Jan 2020



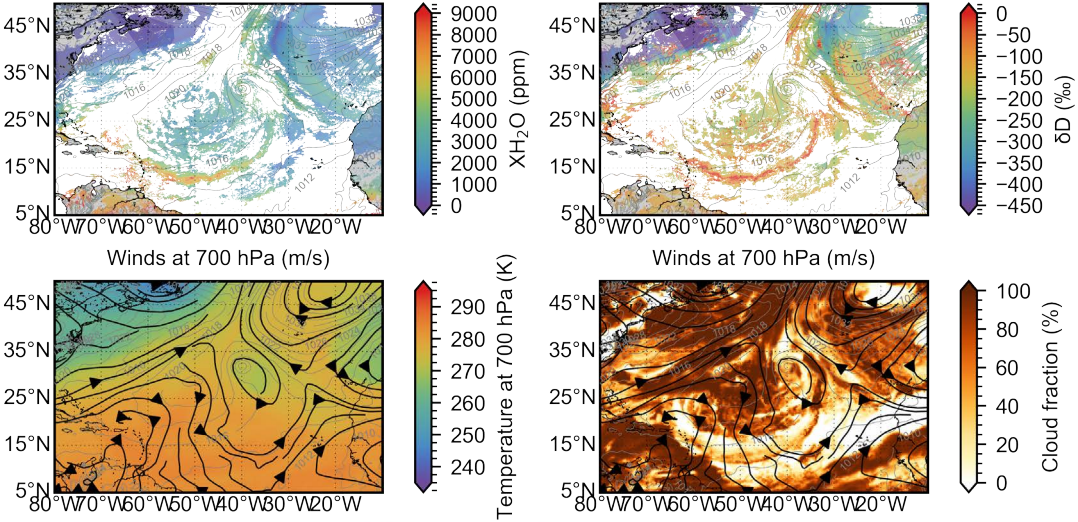
Case study: cold air outbreak: 19 Jan 2020



Case study: cold air outbreak: 20 Jan 2020



Case study: cold air outbreak: 21 Jan 2020



Summary and advancement vs. state of art, part 1

- Before beginning of fellowship: H_2O/HDO from satellite either from thermal infrared (no sensitivity in boundary layer) or with bad spatial coverage
- Achievement: first H_2O/HDO satellite data set with good data quality, daily global coverage with high spatial resolution and sensitivity in the boundary layer
- Problem with reference data sets: bias in TCCON corrected by scaling HDO to match MUSICA δD for collocated measurements
- Good agreement of TROPOMI with corrected TCCON
- Single overpass results allow new interesting case studies

Summary and advancement vs. state of art, part 2

- Current state of the art: H_2O/HDO in SWIR only for clear-sky scenes over land (e. g. S5P+I H2O-ISO)
- Achievement: first SWIR H_2O/HDO satellite data set for scenes with low clouds (also over oceans) or clear-sky
- Huge enhancement in data coverage
- Single overpass results allow new interesting case studies

Publications

- Andreas Schneider, Tobias Borsdorff, Joost aan de Brugh, Franziska Aemisegger, Dietrich G. Feist, Rigel Kivi, Frank Hase, Matthias Schneider, and Jochen Landgraf. First data set of H_2O/HDO columns from the Tropospheric Monitoring Instrument (TROPOMI). *Atmos. Meas. Tech.*, 13 (1): 85–100, 2020. doi:10.5194/amt-13-85-2020
- Andreas Schneider, Tobias Borsdorff, Joost aan de Brugh, Alba Lorente Delgado, Franziska Aemisegger, and Jochen Landgraf. Retrieving H_2O/HDO columns over cloudy and clear-sky scenes from the Tropospheric Monitoring Instrument (TROPOMI). To be submitted to *Atmos. Meas. Tech.*, 2020.