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HDO/H_2O Retrievals from ENVISAT to Sentinel-5P

Link to this poster and references

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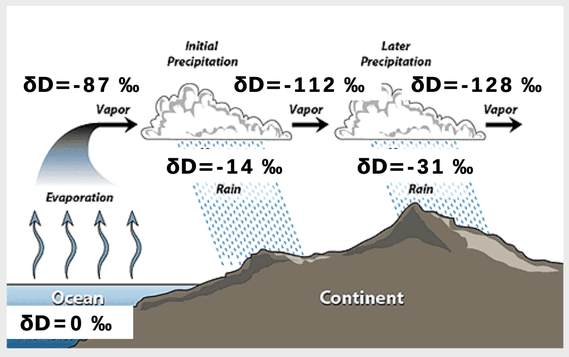
Summary:

Global measurements of water vapor isotopologues, first measured with high sensitivity in the troposphere with SCIAMACHY, are a new opportunity to better understand the hydrological cycle and thus improve climate models. We aim to complete the 10-year SCIAMACHY time series. With TROPOMI on-board ESA's Sentinel 5 Precursor mission we will greatly improve the quality, spatial, and temporal resolution of such data.

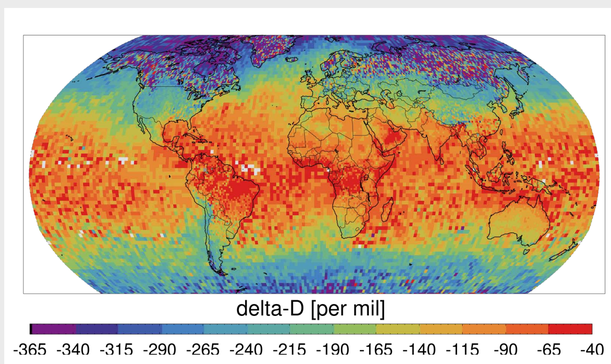
Water vapor isotopologues and the hydrological cycle

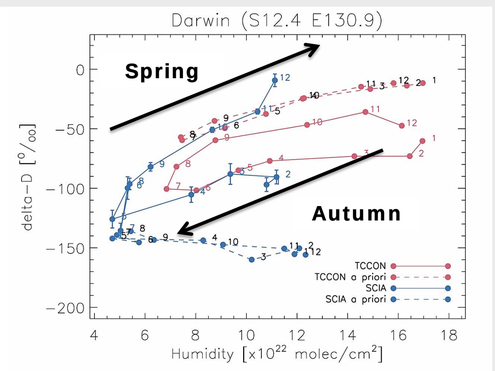


http://web.sahra.arizona.edu/programs/isotopes/oxygen.html

The ratio HDO/H_2O is expressed relative to ocean water as "δD". It's a tracer of the evaporation and condensation history of water: the lighter H_2O prefers to evaporate, while the heavier HDO prefers to condense. This leads to more HDO-depleted vapor and rain (lower δD) as the air mass travels.

HDO/H_2O from SCIAMACHY on-board ENVISAT: 2003-2007



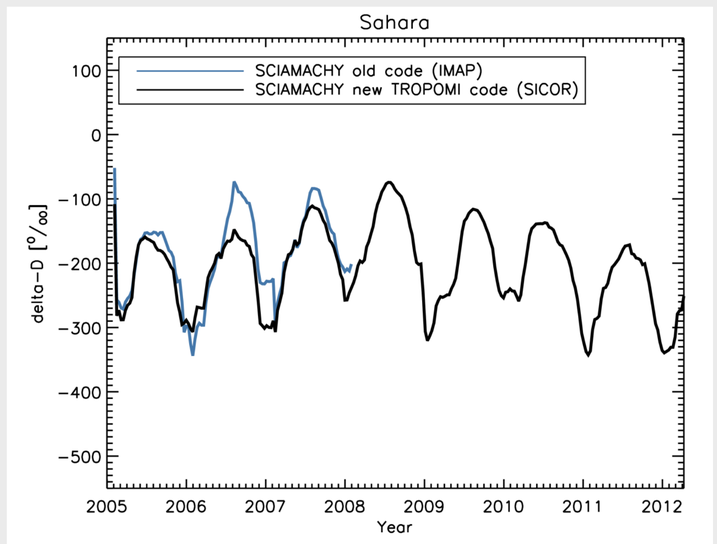


SCIAMACHY's short-wave infrared (SWIR, 2.3 μm) measurements of HDO/H_2O show the typical patterns of stronger depletion towards drier, colder or higher areas (left figure). Combined with humidity, asymmetries in the seasonal cycle of water vapor become visible above certain validation sites (right figure, numbers representing monthly averages). Differences in δD point to seasonal changes in the source of the water vapor: information that would remain hidden by humidity alone. See [1] for a complete validation study using TCCON and NDACC-MUSICA stations. These data show the potential and needed extension of global HDO/H_2O measurements from space.

New SCIAMACHY dataset using the TROPOMI code: 2003-2012

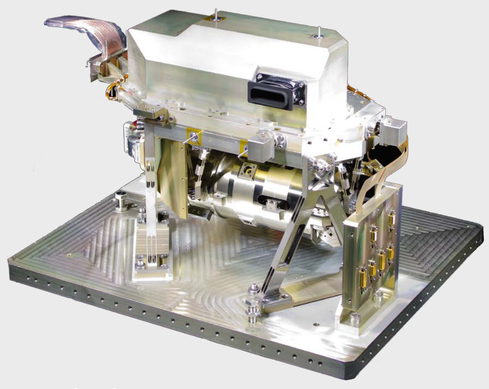
Extension of the SCIAMACHY dataset beyond 2007 is challenging due to severe degradation of the channel-8 detector. Exploiting the CO retrieval algorithm developments [2,3] for TROPOMI on-board Sentinel-5P, we developed an HDO/H_2O version of the TROPOMI algorithm and combined it with a SCIAMACHY interface. This way we can test the TROPOMI code on real data before launch, and extend the SCIAMACHY HDO/H_2O dataset with minimal coding overhead.

Preliminary results above the Sahara show that realistic SCIAMACHY time series of δD are possible till the end of the mission (April 2012).



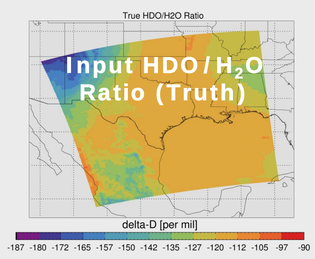
HDO/H_2O retrievals with TROPOMI on-board Sentinel-5P

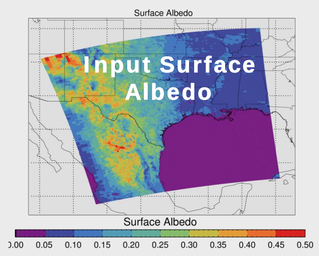
- TROPOMI is a UV-VIS-NIR-SWIR push-broom immersed grating spectrometer
- δD statistical (noise) error:
  - TROPOMI: <20 ‰
  - SCIAMACHY: <100 ‰
- Spatial resolution:
  - TROPOMI: 7x7 km
  - SCIAMACHY: 120x30 km
- More cloud-free observations
- Less spatial and temporal averaging needed
- Retrieval window: 2354–2374 nm, containing H_2O, HDO, $H_2{}^{18}O$, CH_4 and CO lines
- Retrieval algorithm: simplified non-scattering version of the operational CO algorithm, requiring land-only, cloud-free conditions
- Cloud filtering is based on a two-band (weak vs strong) methane or water absorption approach

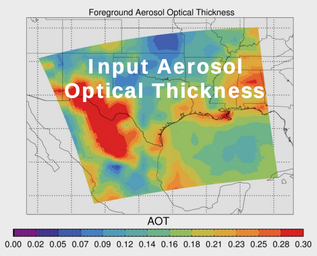


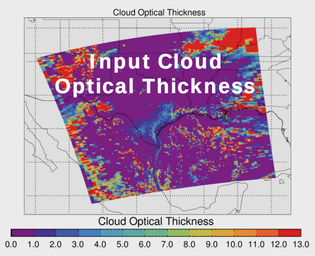
TROPOMI's SWIR module

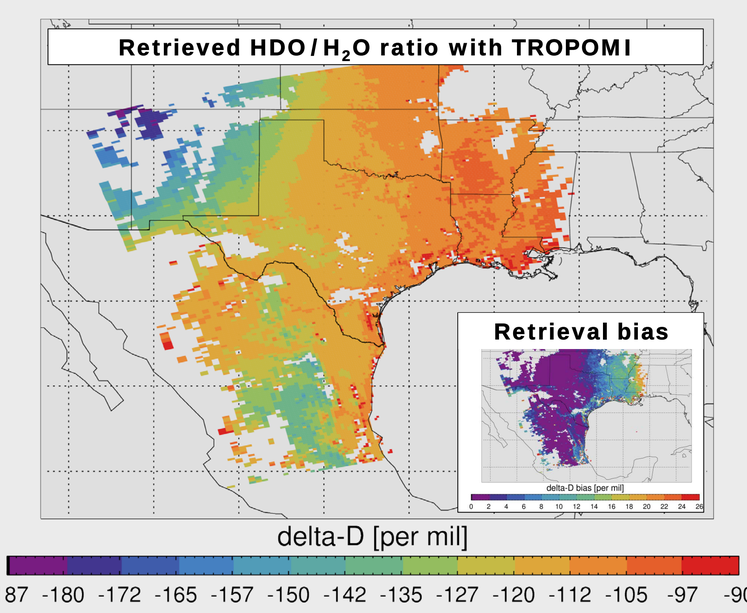
TROPOMI HDO/H_2O retrieval simulations: USA & Mexico











To test the performance of the TROPOMI HDO/H_2O retrieval, a realistic scenario was simulated. It shows that we can accurately retrieve the total column HDO/H_2O ratios. Only above low albedo regions aerosol leads to small biases. The two-band cloud filtering is very effective, leading to ~15000 usable measurements remaining in this map from a single satellite overpass.

References

1. Scheepmaker, R.A., *et al*., Atmos Meas. Tech., 8, 1799-1818, 2015
2. Vidot, J., *et al*., Remote Sensing of Environment, 120, 255-266, 2012
3. Borsdorff, T., *et al*., Atmos Meas. Tech., 2015 (in preparation)

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