Total column water vapor from GOME-2 UV-VIS and NIR measurements toward a climate data record

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EUMETSAT AC SAF ATMOSPHERIC COMPOSITION MONITORING

S5P PAL

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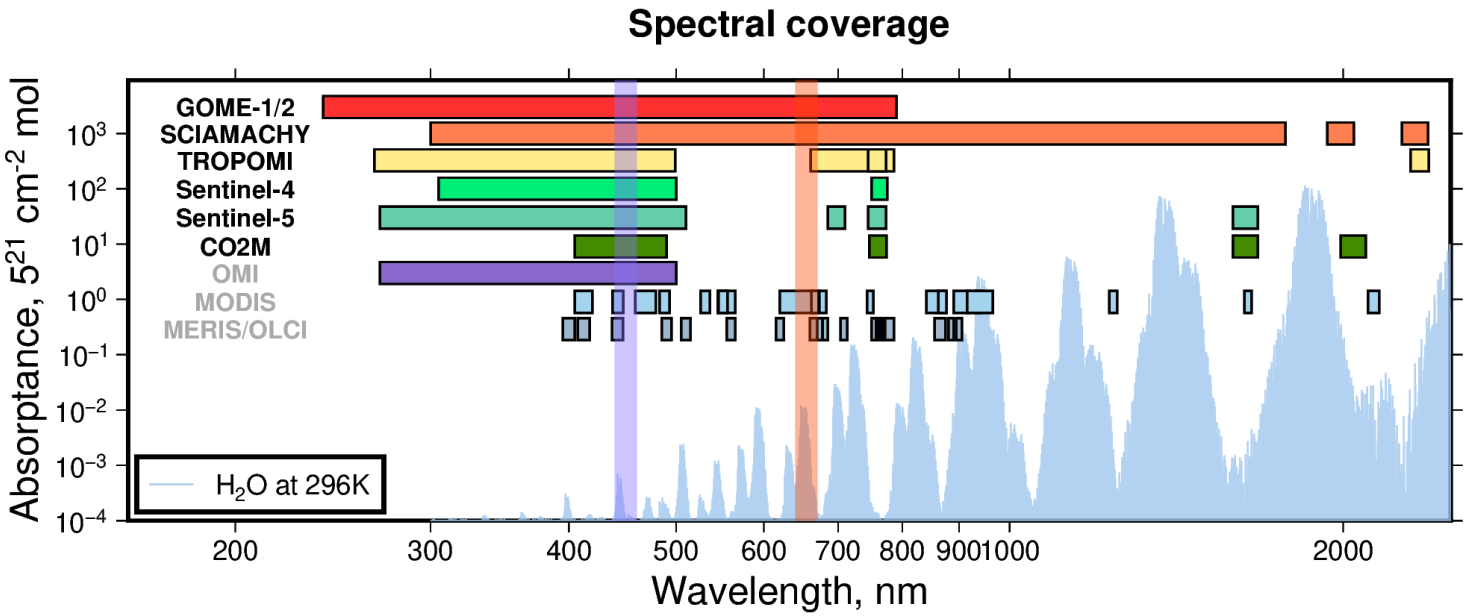
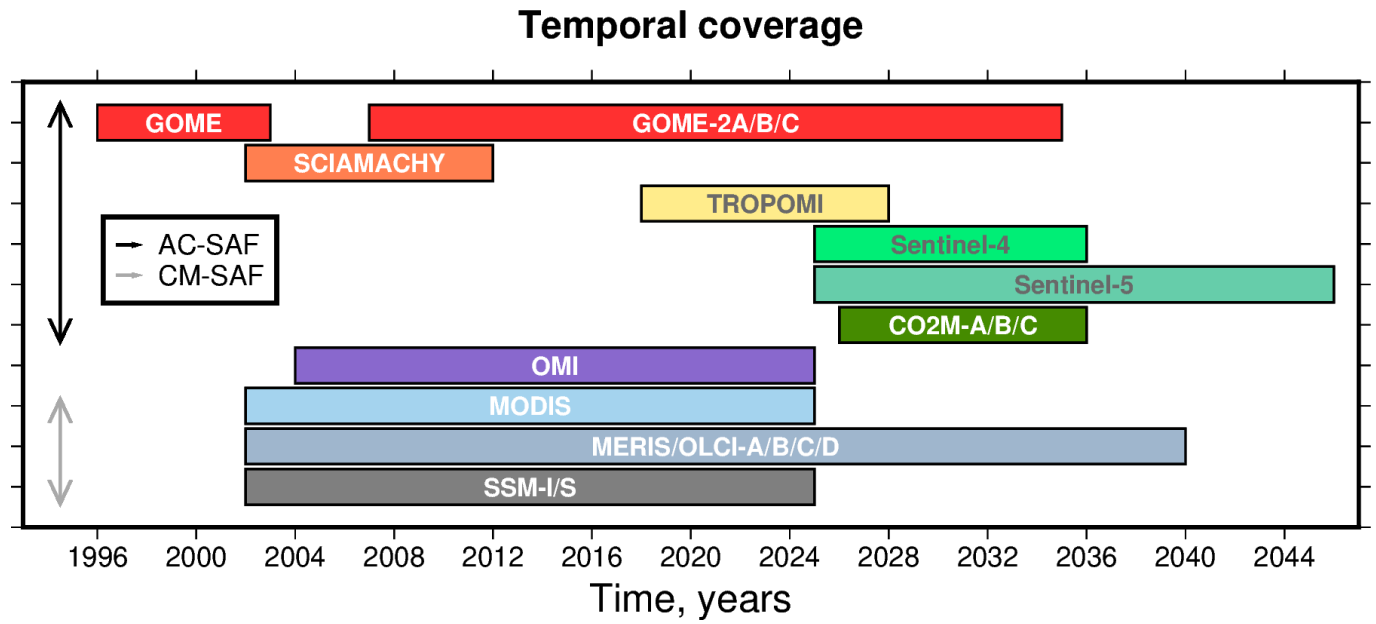
Motivation: platforms





The **blue band of water vapor** is the weakest but it is sensed by more sensors and the surface is less reflective in the UV

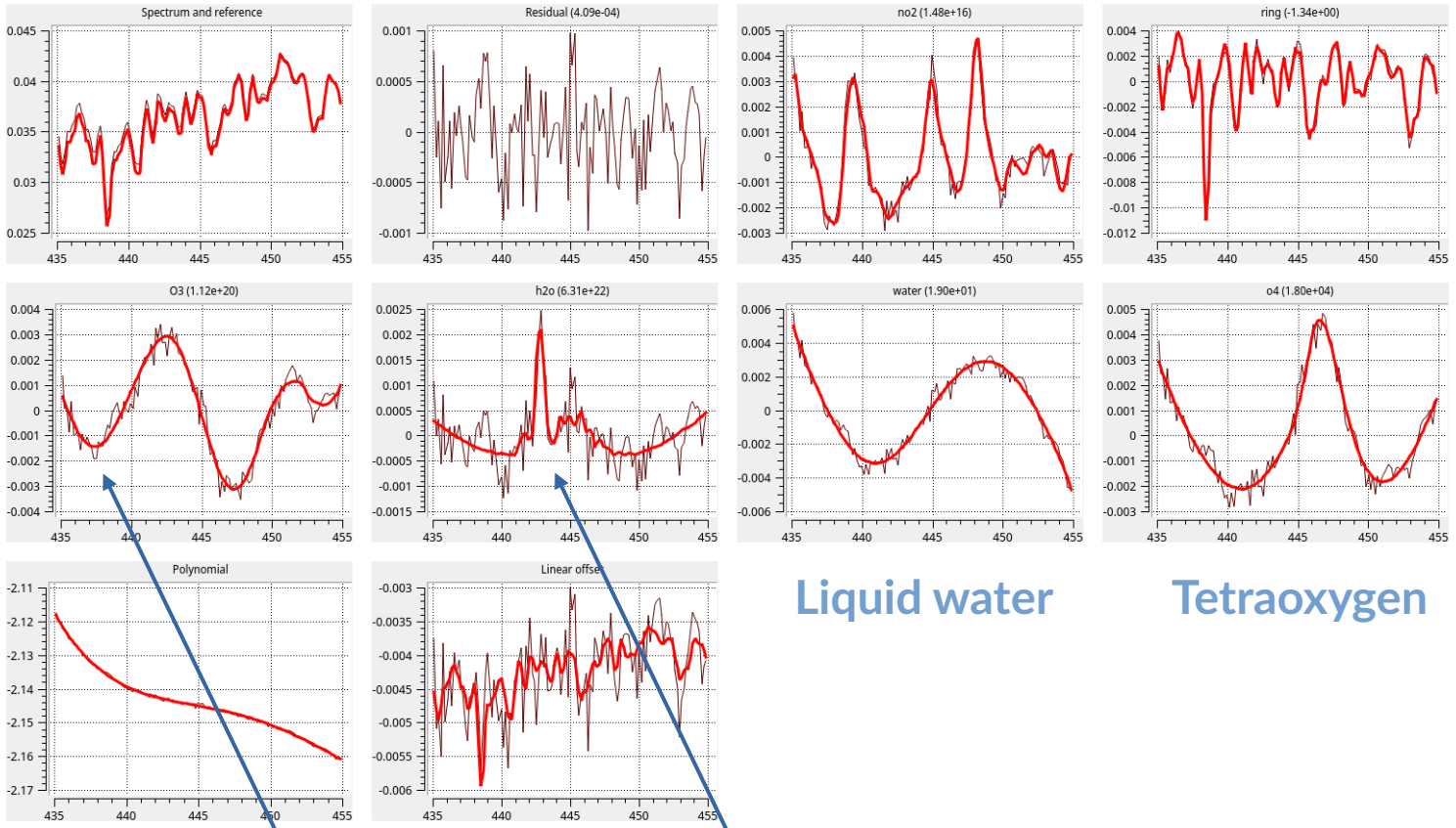
→ best trade off between sensitivity and coverage over both land and oceans

Fitting windows are different from other works

TROPOMI (S5P) 435 – 455 nm
GOME-2 (MetOp) 427.7 – 455 nm

GOME, SCIAMACHY, UVN (S4 and S5) yet to be defined

Algorithm: DOAS



Nitrogen dioxide

Raman scattering

Liquid water

Tetraoxygen

Ozone

Water vapor

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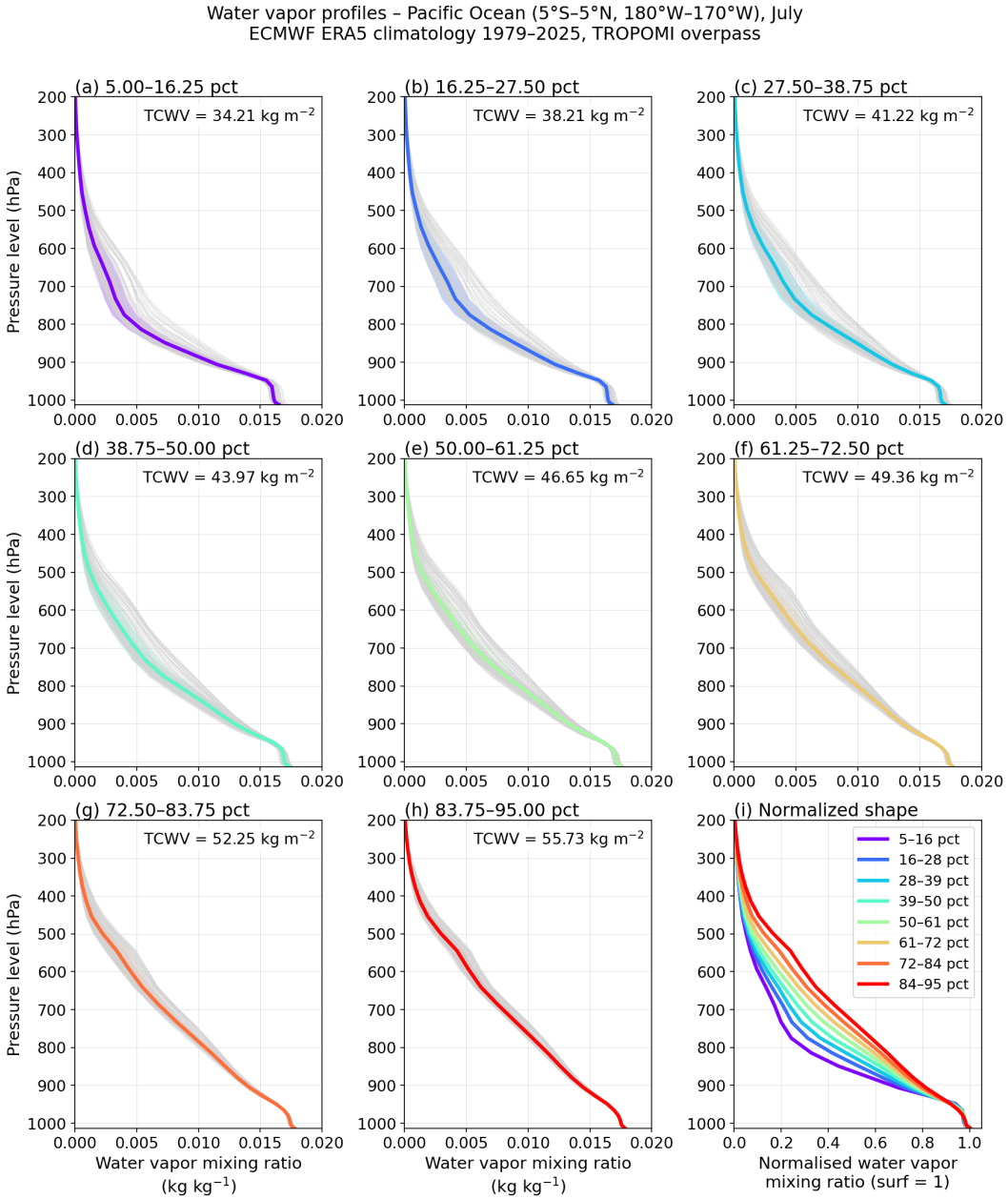
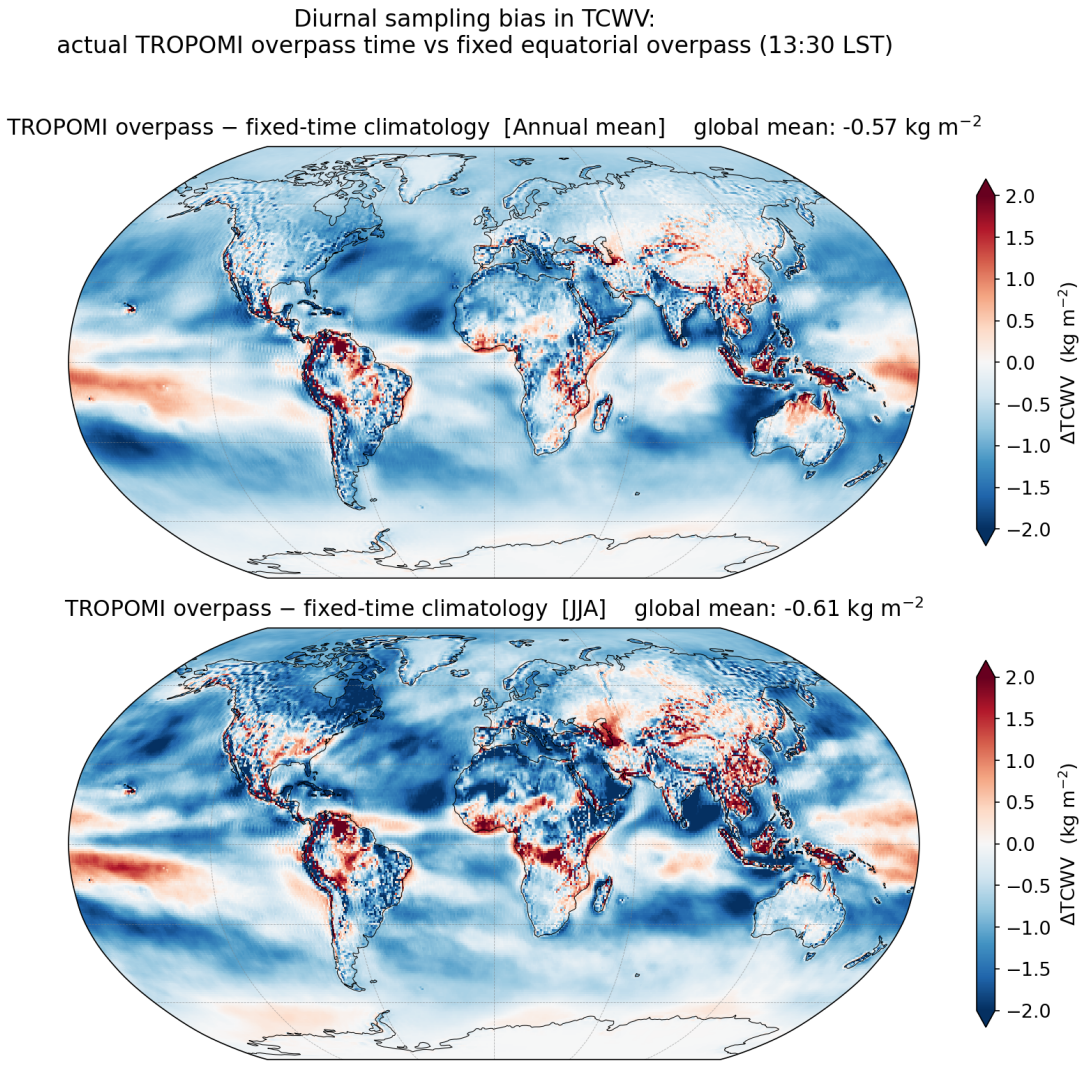
Suboptimal cross-sections account for most of the residuals

Algorithm: a-priori WV profiles

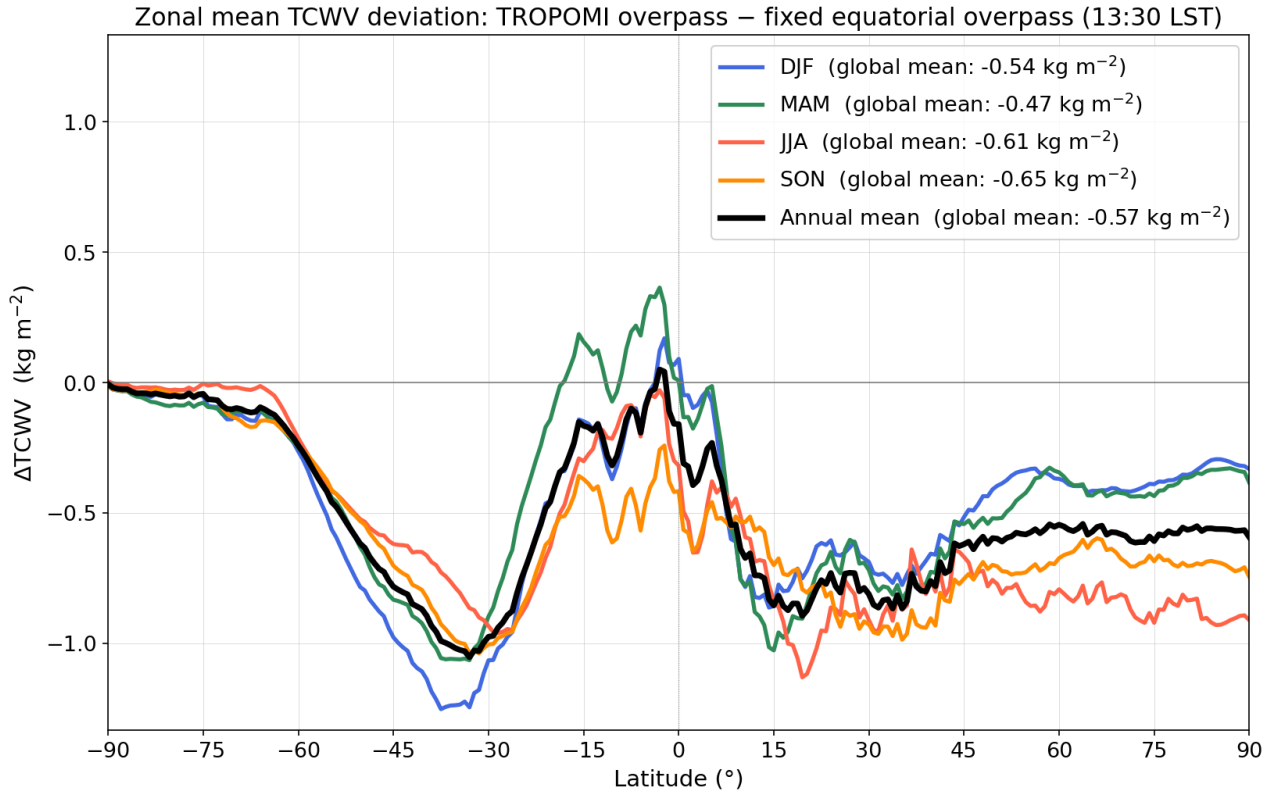


- **Prior profiles of water vapor** are from reanalysis, not models
- Distinct profiles for TCWV range classes
- ERA-5 from 1979 to 2025
- Reads 6-hourly ERA-5 files, interpolate to satellite local overpass time, downsample to 60 levels, compute TCWV distribution → Look-up table at 0.75° resolution
- Iteratively compute VCD with box air mass factors to match the proper TCWV range for a given profile

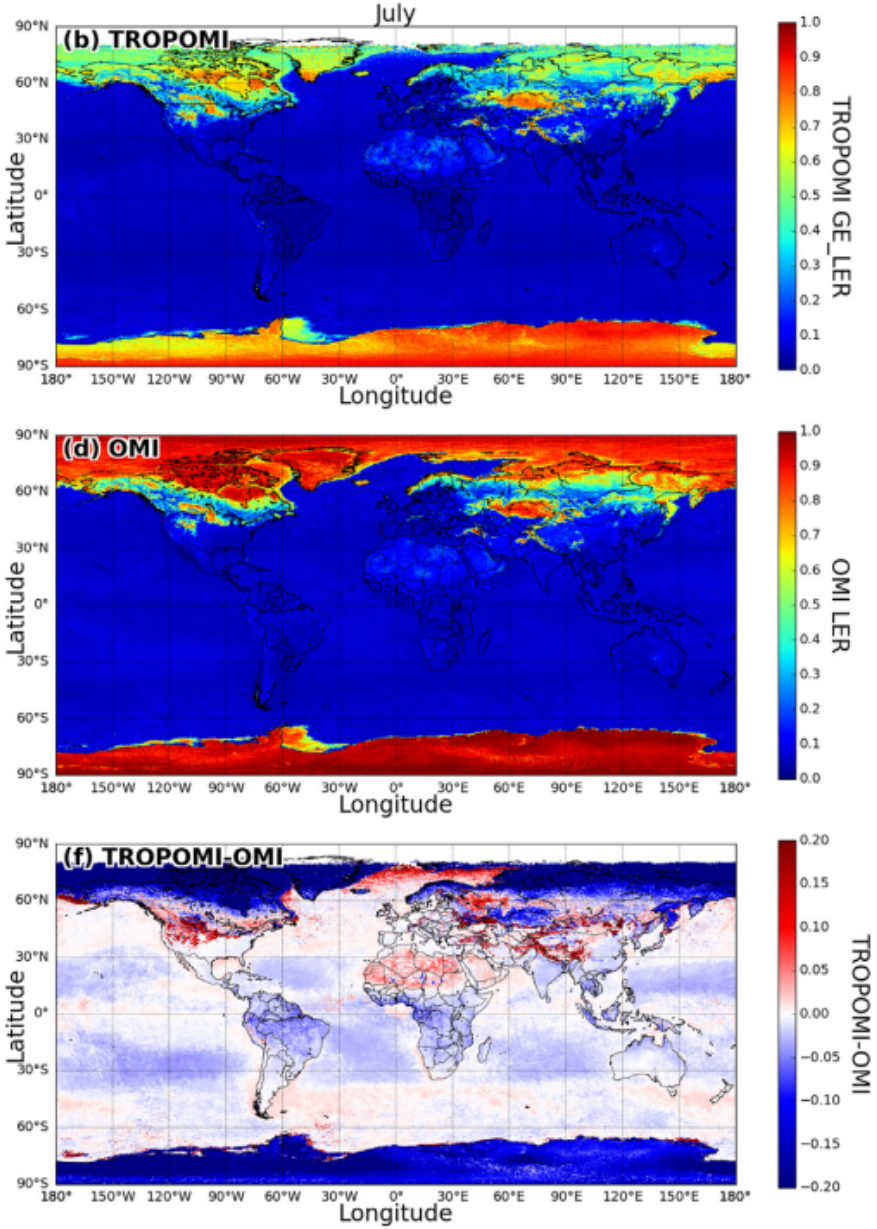
Algorithm: a-priori WV profiles



Diurnal sampling bias introduced by assuming a fixed equatorial overpass time (13:30 LST everywhere) vs. using the latitude-dependent actual TROPOMI overpass time



Surface reflectivity



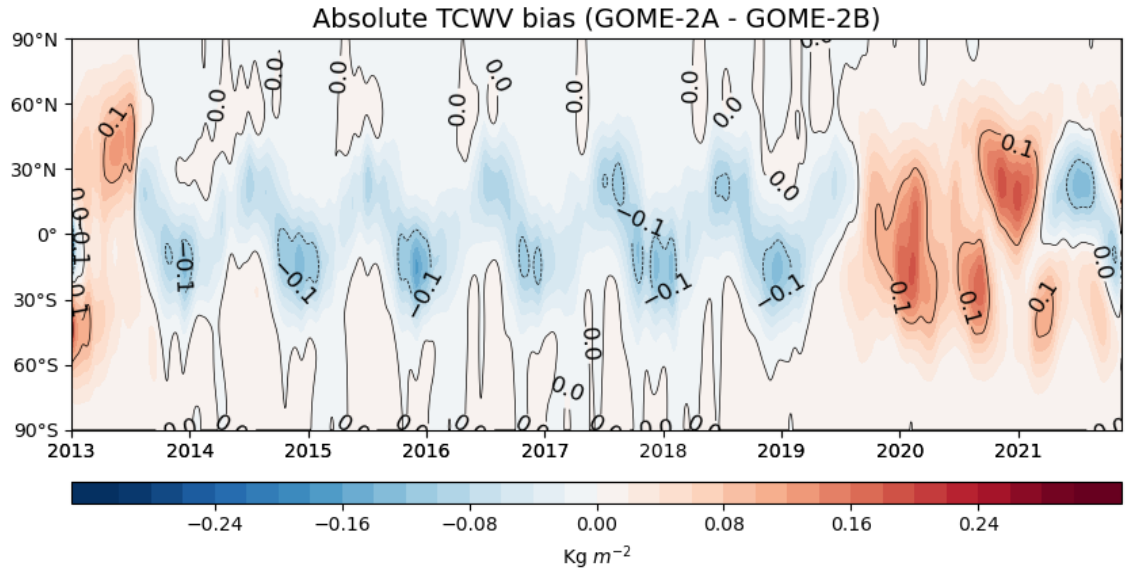
- TROPOMI surface reflectivity is

  1) Geometric Equivalent LER = directional
  2) co-fitted with the gas species
  3) spectral band 435–455 nm

- OMI surface reflectivity is

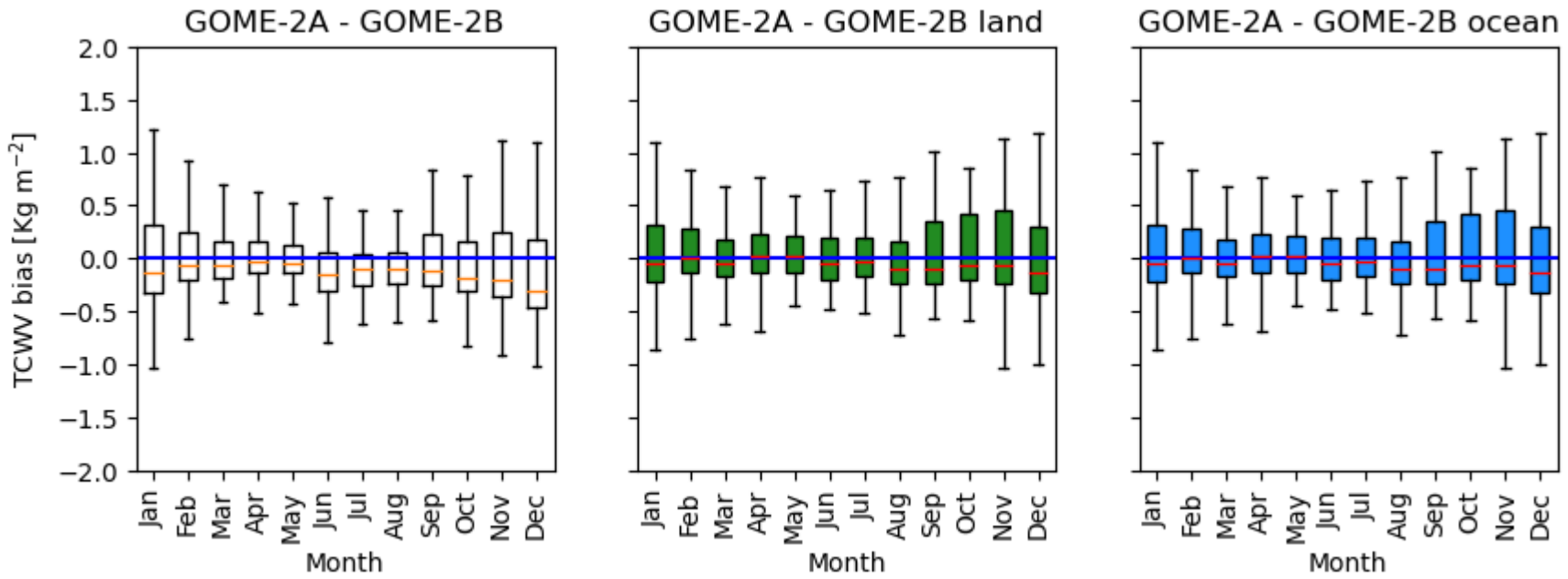
  1) Lambertian
  2) minimum dark sky
  3) wavelength 442 nm

GOME-2 A/B NIR intercomparison

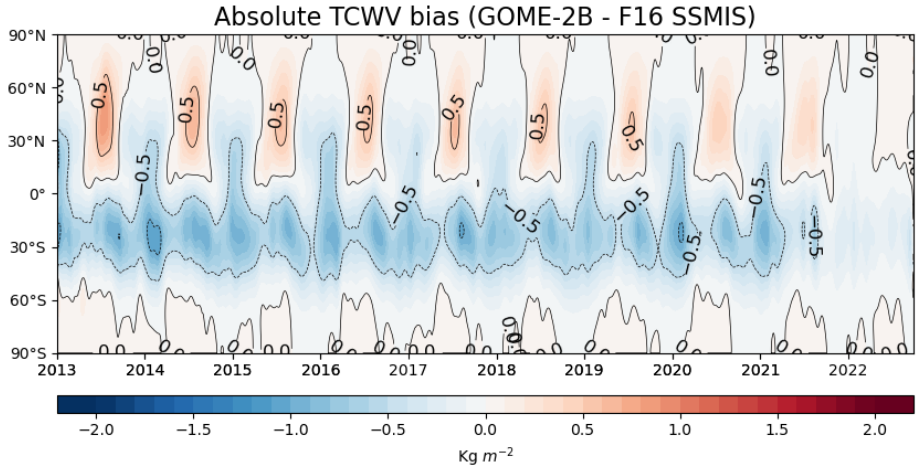


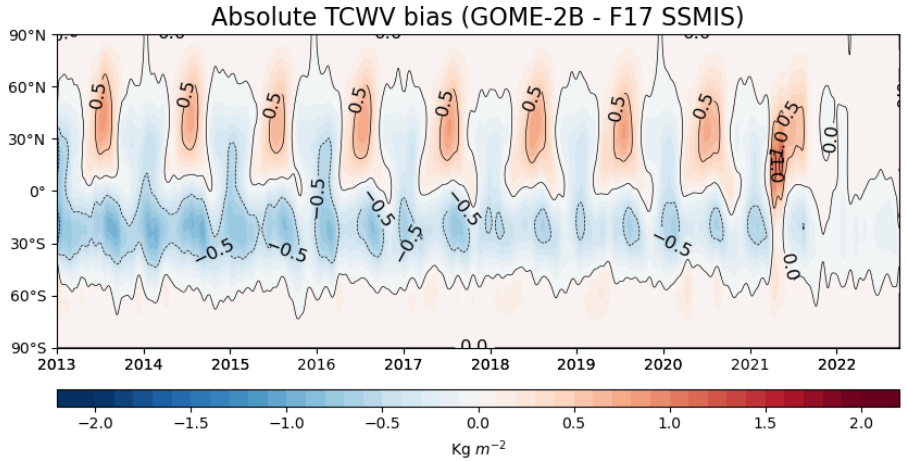
GOME-2A slightly underestimates GOME-2B (-0.035 ± 2.71 kg m $^{-2}$), largely due to difference over oceans.

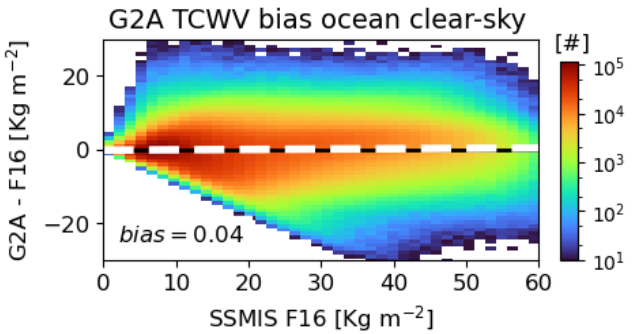
As expected, the intra-sensor differences do not show any systematic effect and are mostly of random nature

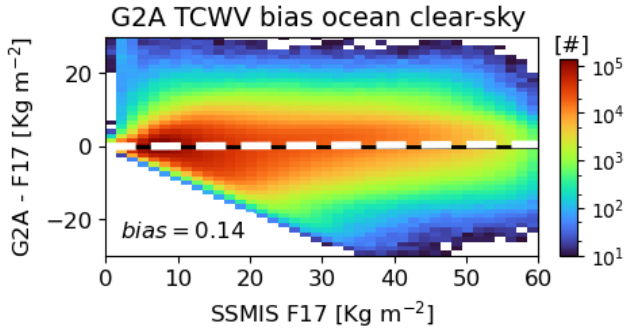


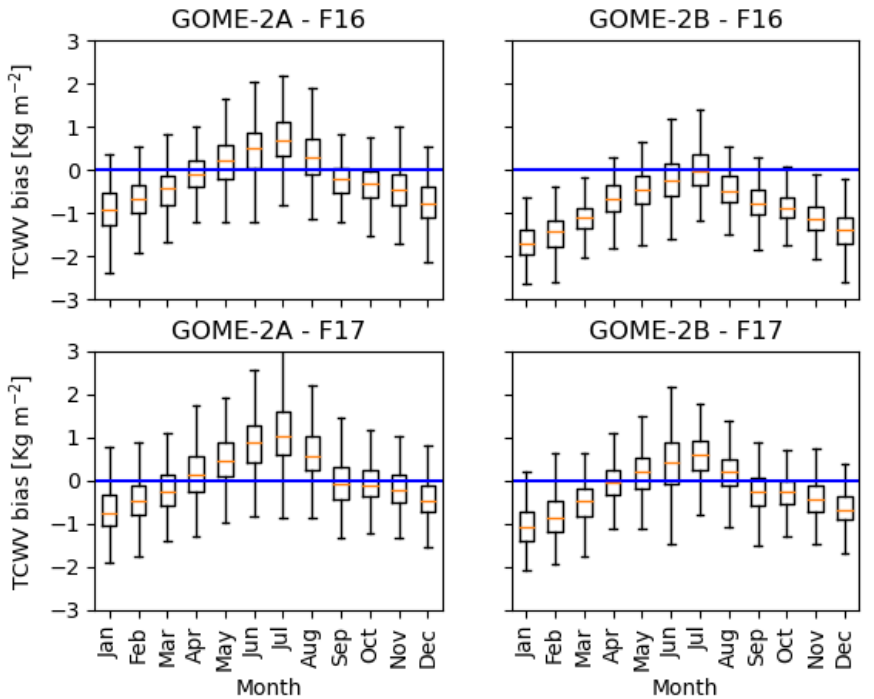
GOME-2 A/B NIR vs SSMIS F16 and F17 – ocean only





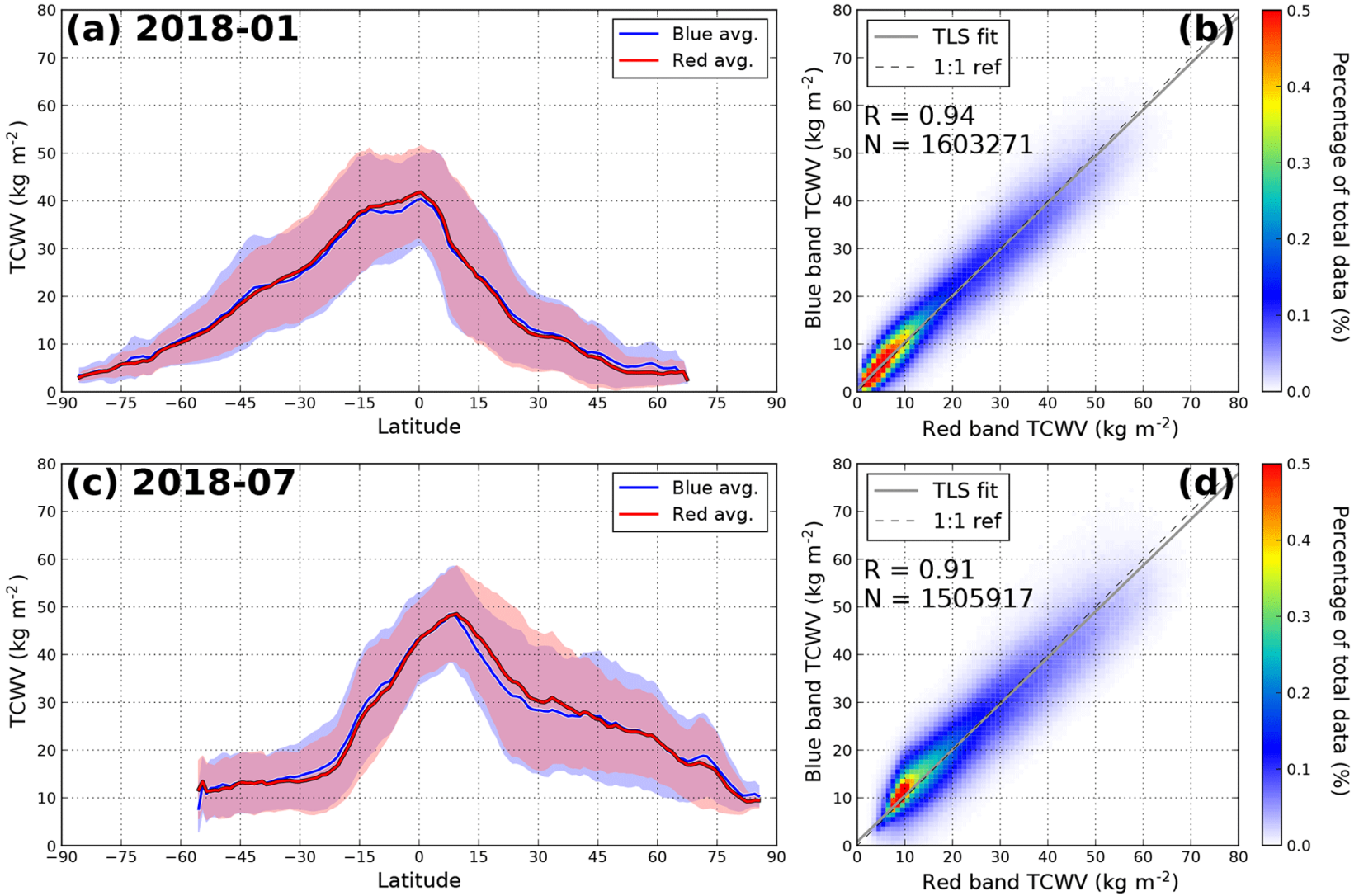






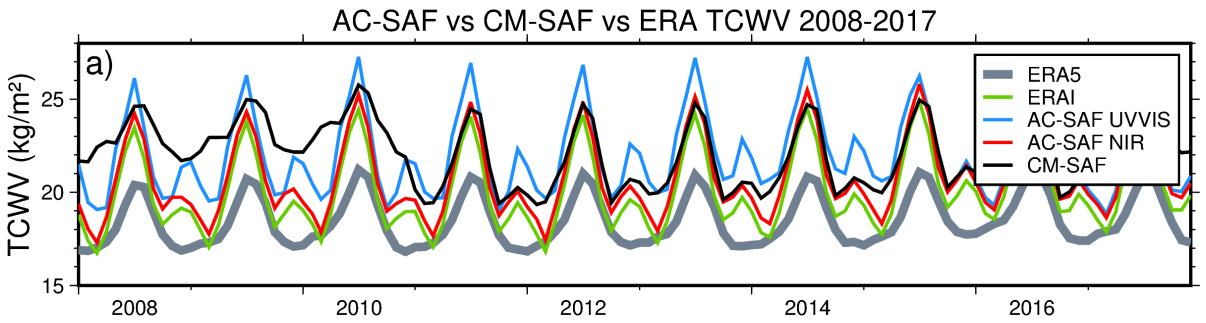
- Global long-term mean biases of less than 1 kg m $^{-2}$
- SSMIS microwave sensors are sensitive to in-cloud water vapor and fly also in the afternoon orbit (local time), thereby sampling a moister atmosphere
- A larger systematic bias between GOME-2 and SSMIS should be expected.

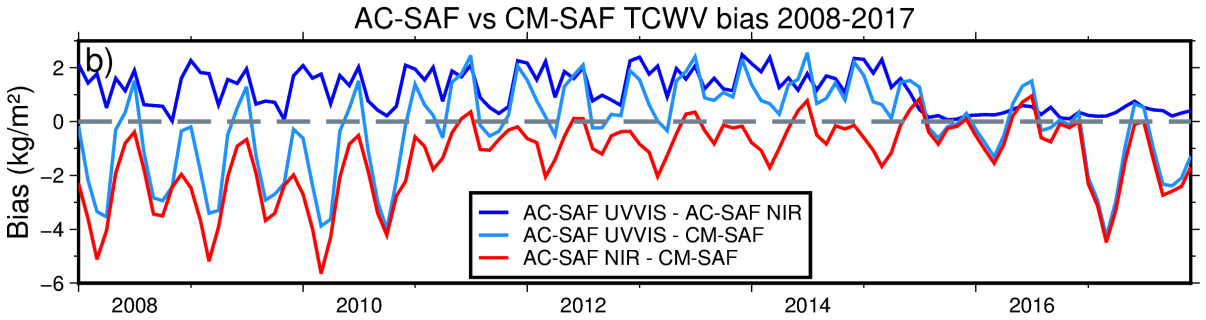
GOME-2 A/B NIR vs UV band

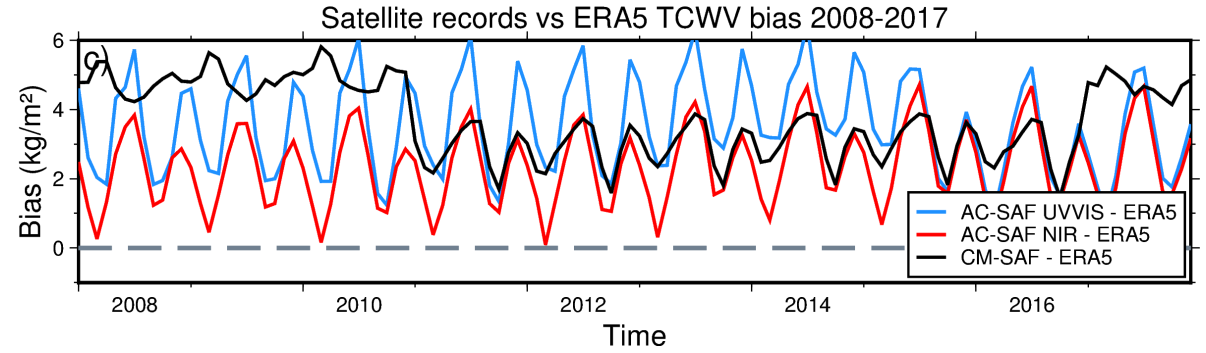


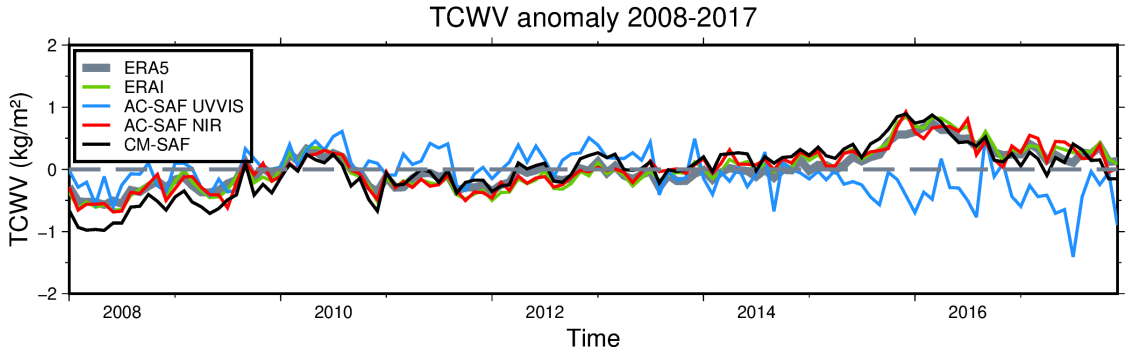
The mean bias between the blue and red band
January 0.12 kg m^{-2}
July −0.08 kg m^{-2}

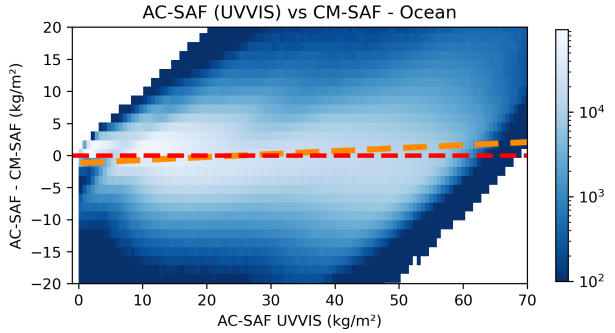
GOME-2 UV-NIR vs other datasets

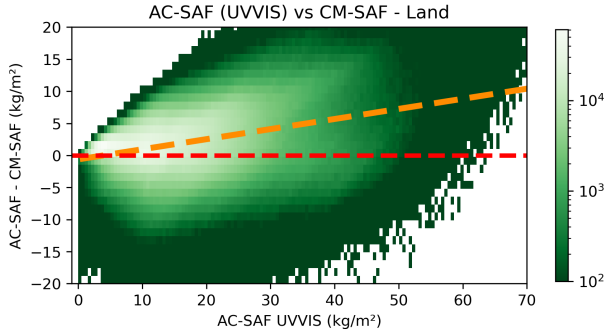


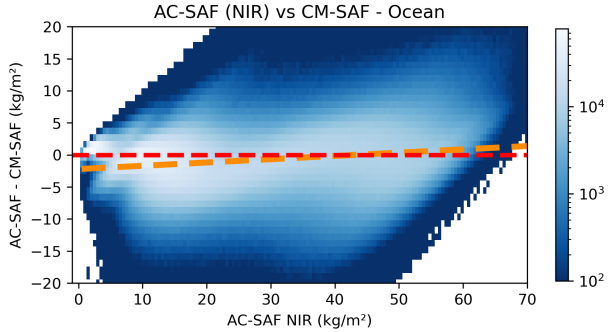


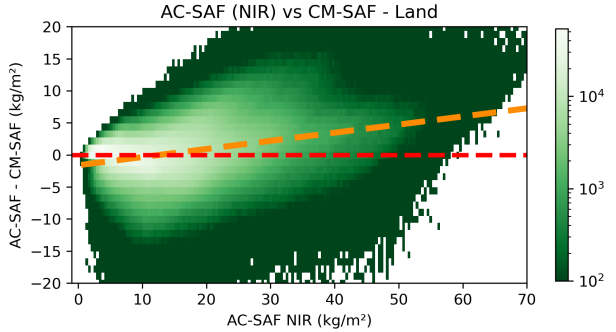




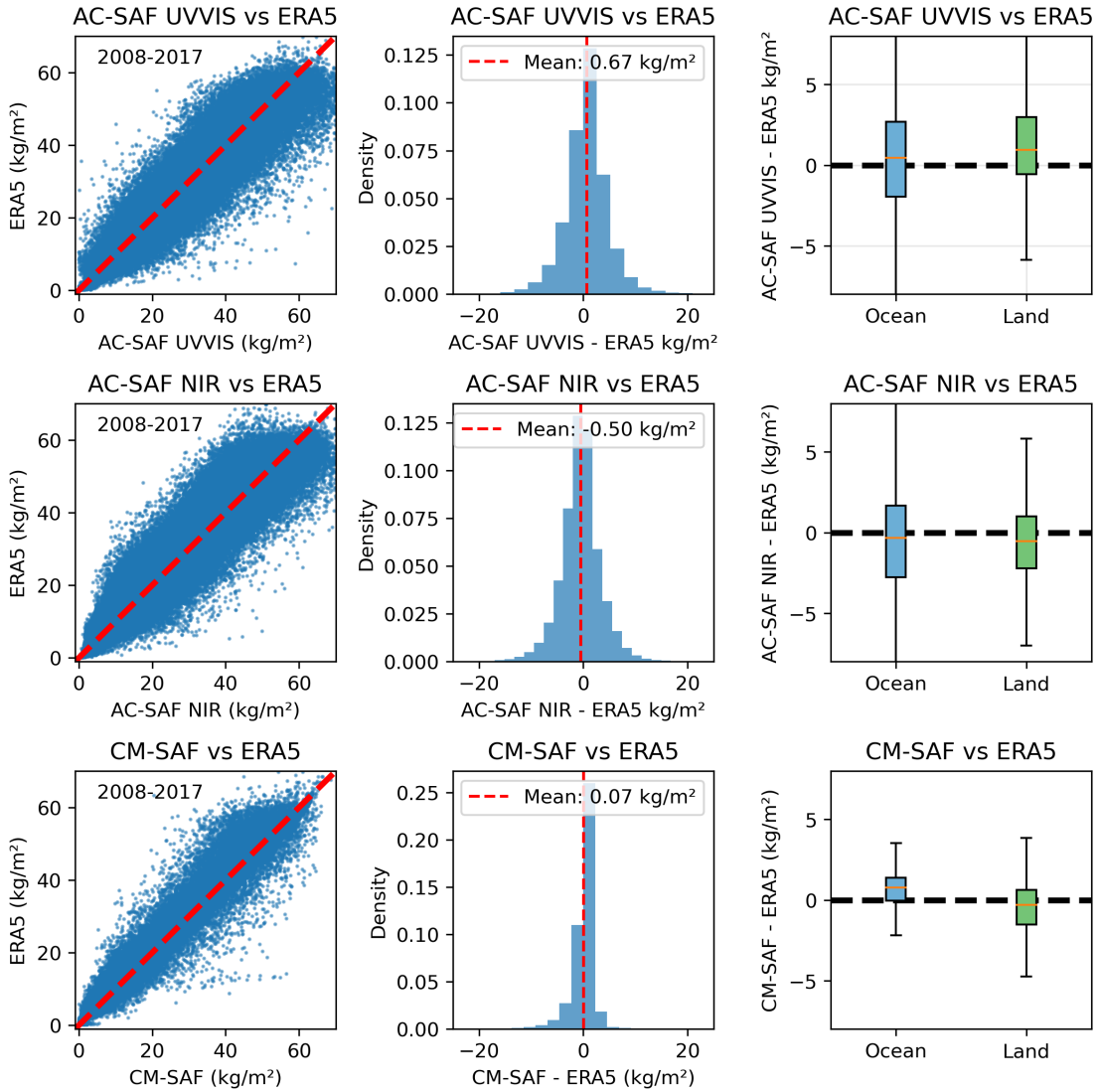


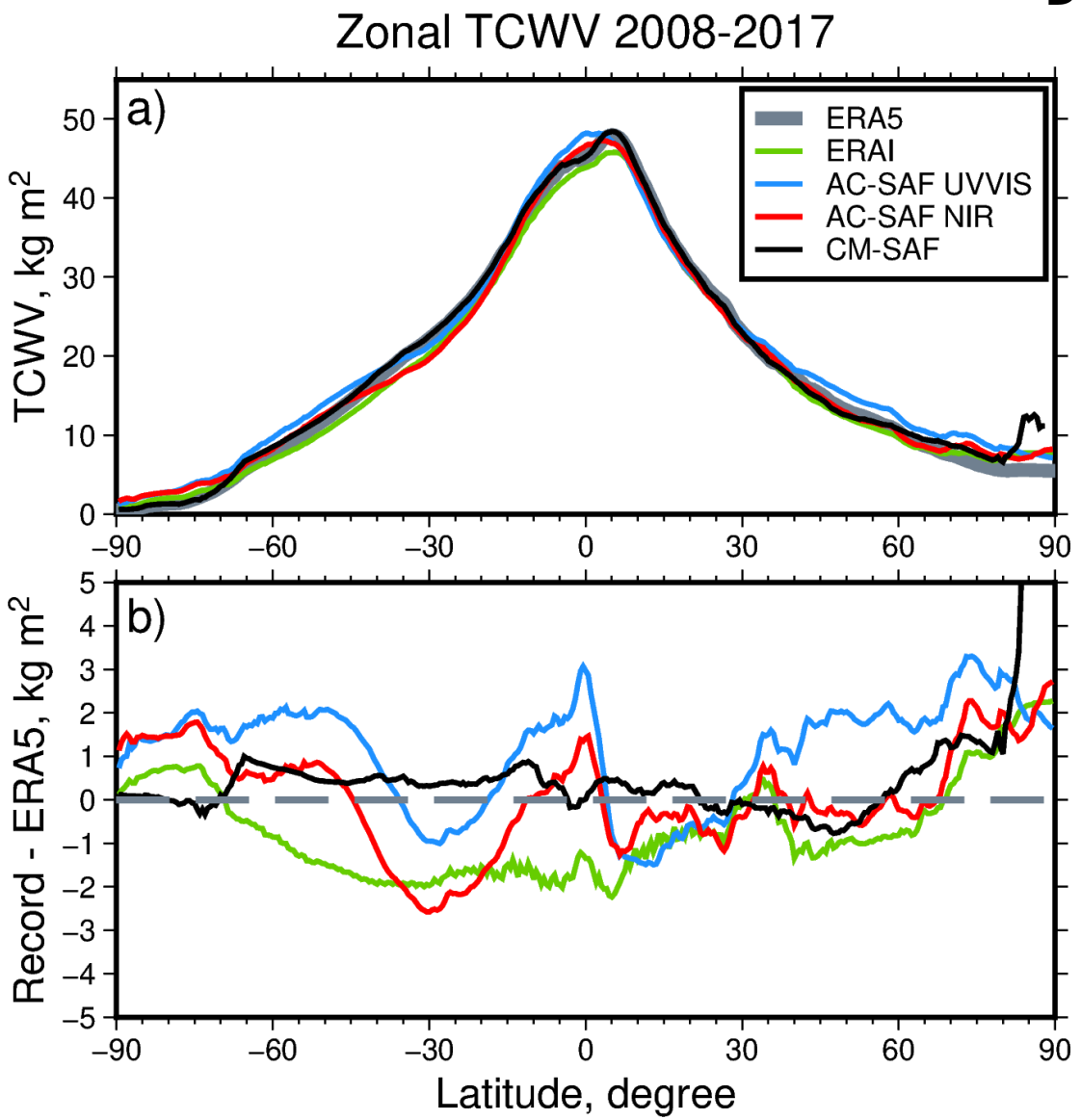






GOME-2 UV-NIR vs other datasets





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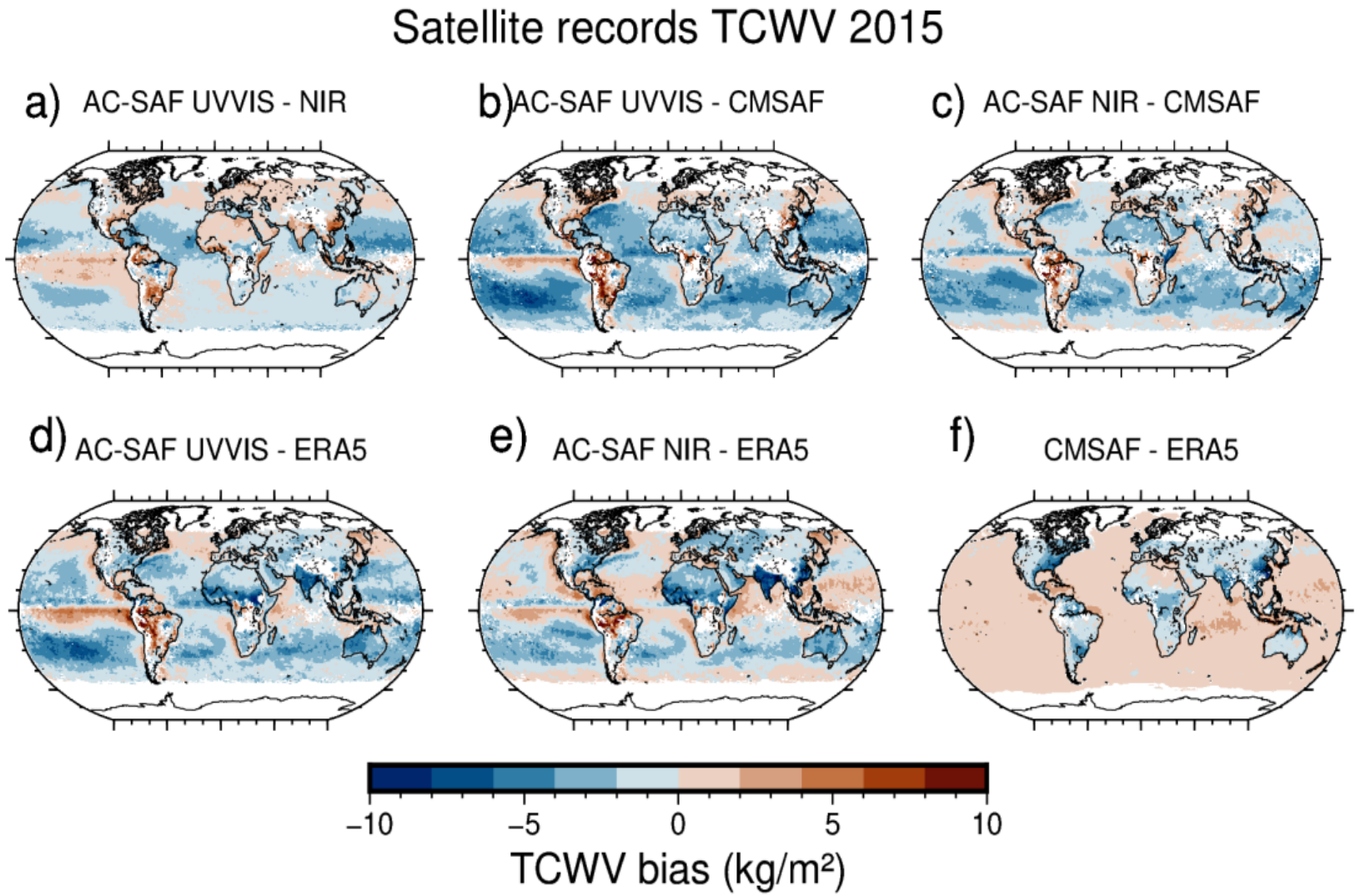
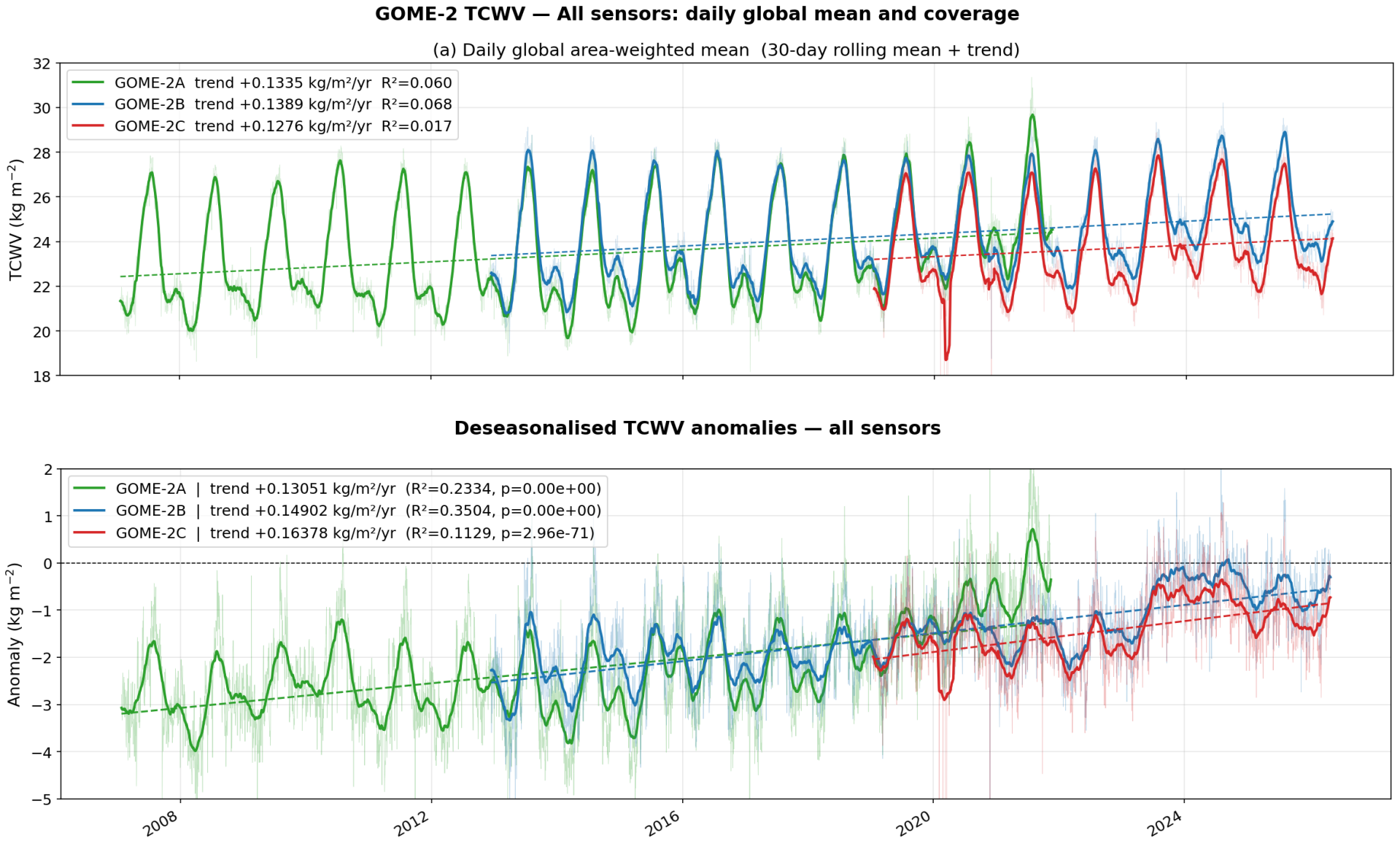
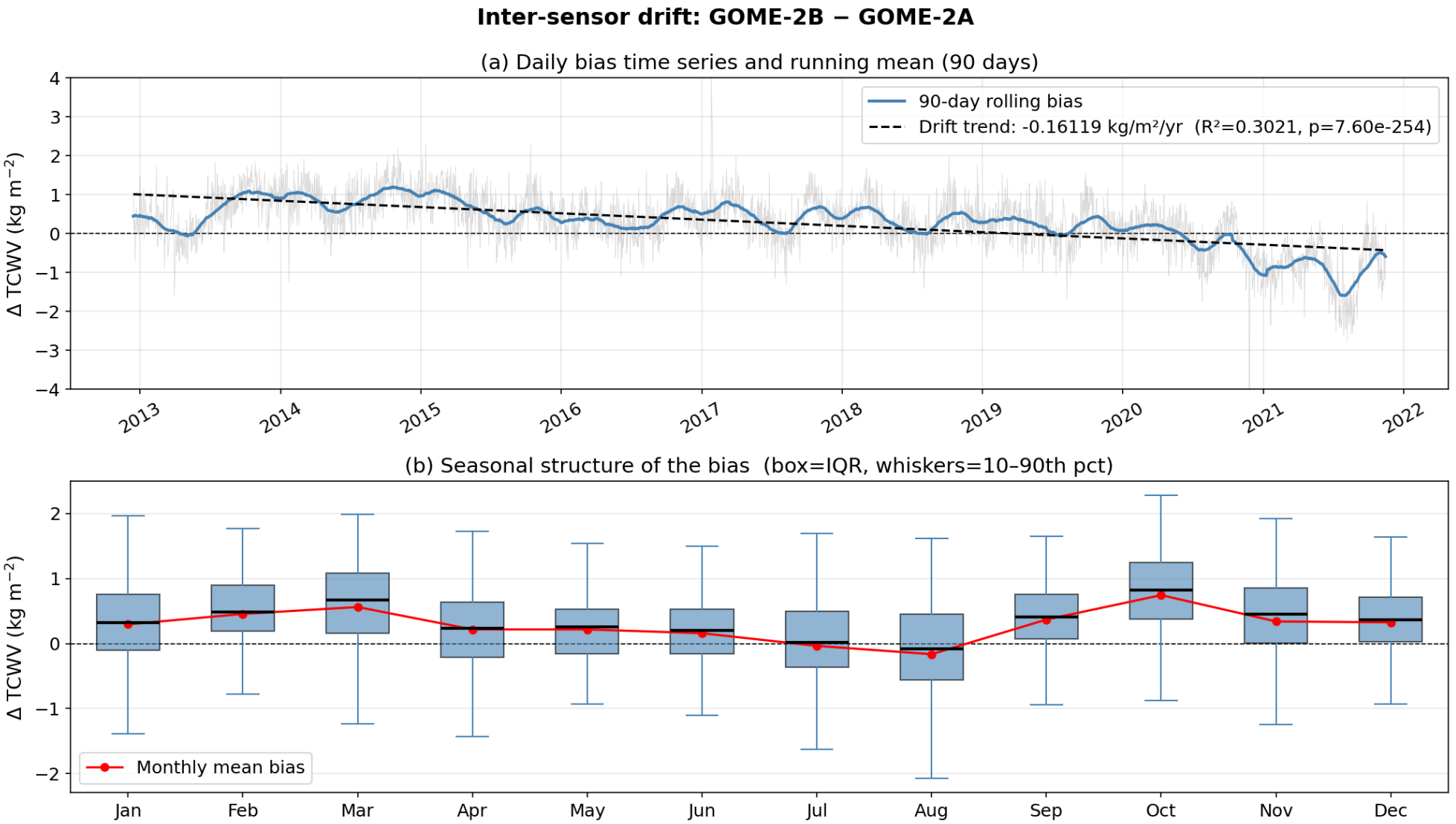


Dataset (2008-2017)	Mean±stdv	Median
AC-SAF UVVIS	19.27±12.81	16.27
AC-SAF NIR	18.02±13.11	14.39
CM-SAF	22.10±15.46	17.99
ERAI	19.97±14.74	15.73
ERA5	18.48±15.68	14.01

GOME-2 full time series (NIR)



GOME-2 full time series (drift)



Conclusions and outlook

- All satellite records show inevitable discontinuities because of differences in the design of the respective platforms and the continuous reprocessing and recalibration of measurements. To obtain CDRs, ad hoc corrections must therefore be developed and applied

- All satellite records show a general spatial, zonal, and temporal consistency in the distribution of water vapor in the atmosphere, both among themselves and with reanalysis

- Globally and long-term, the highest TCWV value is reported by CM-SAF (22.10 kg m−2), followed by ERAI (19.97), GOME-2 UVVIS (19.27), ERA5 (18.48), and GOME-2 NIR (18.02)

- Spectrally, the GOME-2 satellite record derived from the UVVIS band shows underestimation in a drier atmosphere and an overestimation in a moister atmosphere

- The GOME-2 records have the lowest variance and narrowest TCWV distribution, with this probably being the consequence of a coarser pixel size at the ground (e.g. spatial averaging)

- Spectrally and as expected, the GOME-2 NIR satellite record is more similar to CM-SAF than to UVVIS

- Reprocessing and harmonization of settings across platforms. Using L1b Fundamental Data Record (ESA-DLR project: FDR4ATMOS) → 430 – 460 nm original purpose NO_2 → no orbital drifts, radiometric-corrected, fit for climate normals → reprocessing of full record H_2O observations from 1995 (GOME) onward