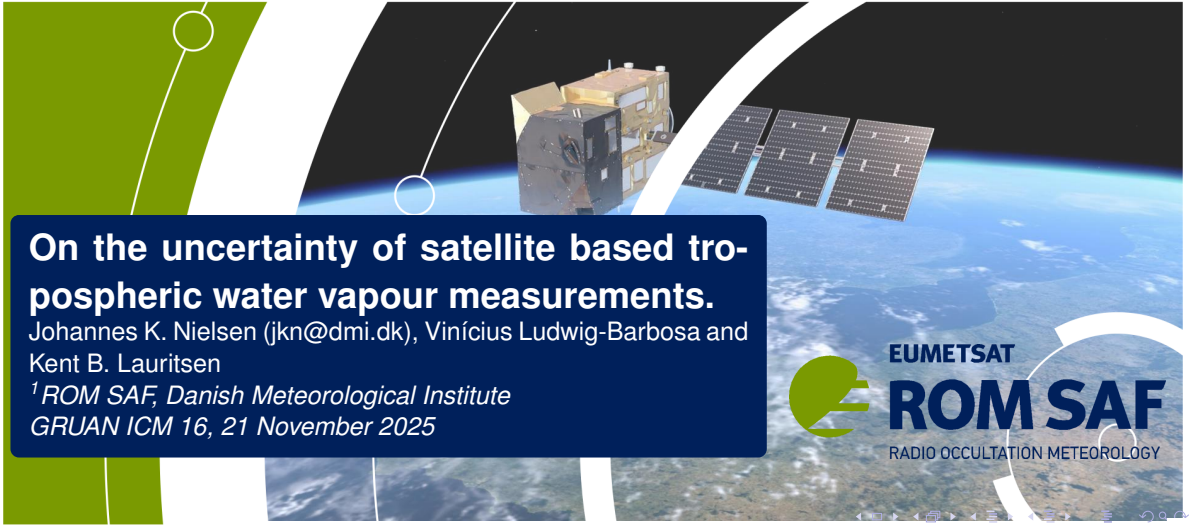
EUMETSAT

DMI



On the uncertainty of satellite based tropospheric water vapour measurements.

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GRUAN ICM 16, 21 November 2025

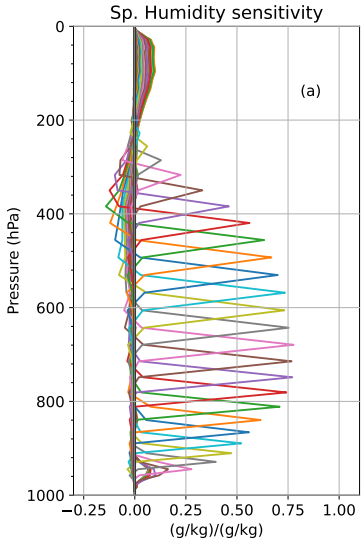
EUMETSAT ROM SAF

RADIO OCCULTATION METEOROLOGY

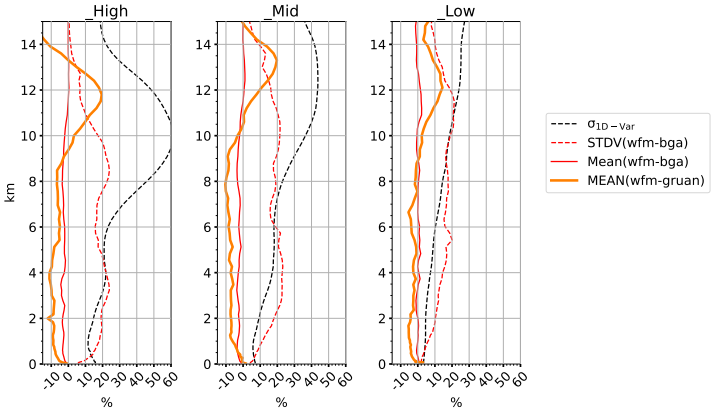
Outline

- RO specific humidity compared to GRUAN
  - ROM SAF specific humidity
  - RO specific humidity versus GRUAN
- RO and IMS humidity compared to GRUAN
  - The RAL IMS CDR
  - RO and IMS humidity compared to GRUAN RS92
- Ingestion of GRUAN RS GDPs in ROPP

- GRAS receiver on all Metop satellites
- 1D-Var
- ECMWF (reanalysis) forecast as background
- Sharp averaging kernels →
- DOFS = 7.5 to 12.5



RO specific humidity versus GRUAN



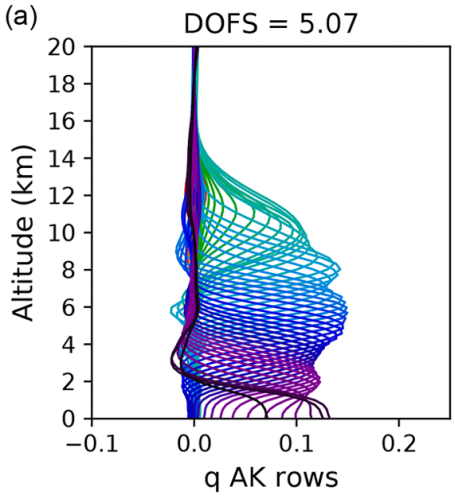
(RS92 and RS41)

RO is 0-10% dry where 1D-Var has sensitivity

The RAL IMS CDR

The Rutherford Appleton Laboratory Infrared-Microwave-Sounding, IMS, is a climate data record developed in the ESA WV cci.

The IMS scheme retrieves water vapour, temperature, ozone profiles, surface spectral emissivity, and cloud parameters, from the Metop sounding instruments IASI, MHS and AMSU.

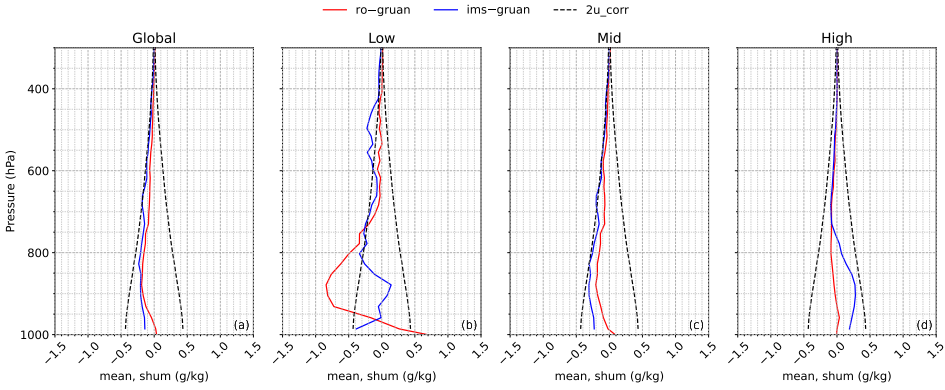


Trent et al. https://doi.org/10.5194/amt-16-1503-2023

RO and IMS humidity compared to GRUAN RS92

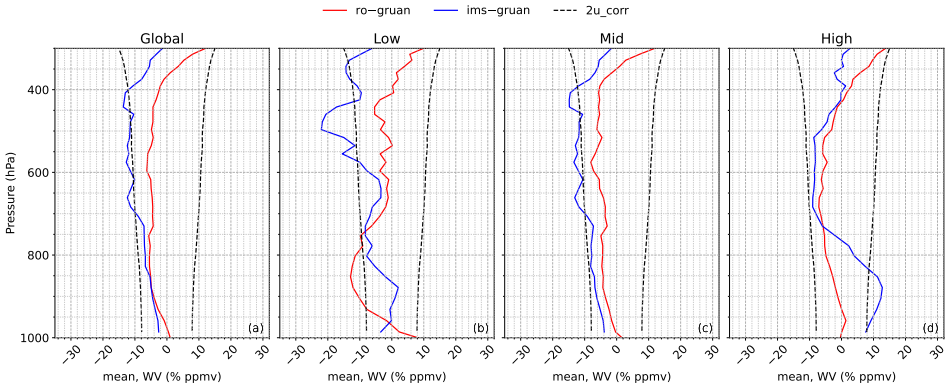
- Both ROM SAF RO specific humidity and RAL IMS mixing ratios are global Climate Data Records (CDRs)
- Collocations are within 300 km and 3 hours from GRUAN sonde for both IMS and RO
- The philosophy is to anchor the CDR comparison at GRUAN sites and then apply the conclusions globally (with caution).

Specific humidity RO and IMS versus GRUAN RS92



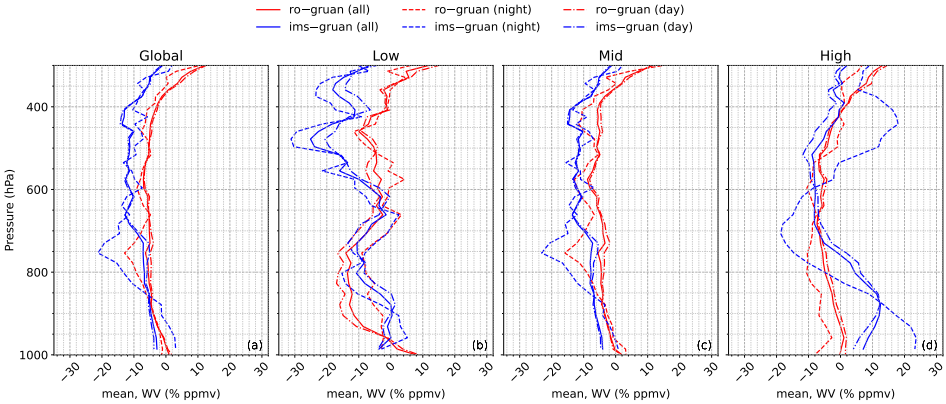
Very few tropical collocations ↑. Hence, at low latitudes there is some uncorrelated uncertainty from RO, which is not accounted for.
According to the Immler Protocol both IMS and RO are “in agreement” at mid and high latitudes — but this is maybe not so interesting.

Relative mixing ratio (RO and IMS versus GRUAN RS92)



Same data but %ppmv (not RH!). IMS is dryer than RO in the free troposphere.
IMS has a wet bias in the boundary layer at high latitudes.
Again, RO is consistently dryer than GRUAN everywhere.

Relative mixing ratio day-night (RO and IMS versus RS92)



Something is going on at 750 hPa

IMS has a night-time issue, especially at high latitudes

RO and IMS versus GRUAN RS92

Paper in review ATM: Vinicius et al. *Comparison of water vapour products retrieved from Metop-A by Radio Occultation, Infrared and Microwave systems*

Ingestion of GRUAN RS GDPs in ROPP

- ROPP is a widely a used FORTRAN package for processing of radio occultation data
- ROPP is maintained by the ROM SAF
- `gruan2ropp` converts GRUAN RS GDP to ROPP format, which implies that ROPP forward models can be applied to GRUAN data.
- `gruan2ropp` will be included in ROPP, if someone would like to test it, they are welcome (jkn@dmi.dk)

Wrap up

- GRUAN RS92-GDP2 was used to anchor a comparison between the tropospheric water vapour CDRs, IMS and ROM-SAF.
- Radio occultations are dry (0-10%), compared to RS92 GDP-2.0, at all altitudes
- IMS is even dryer than RO in the free troposphere
- IMS is positively biased in the boundary layer at high latitudes
- IMS has a pronounced bias structure at night-time at high latitudes

Thanks