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Accuracy of Vaisala RS41 and RS92 Upper Tropospheric Humidity Compared to Satellite Hyperspectral Infrared Measurements

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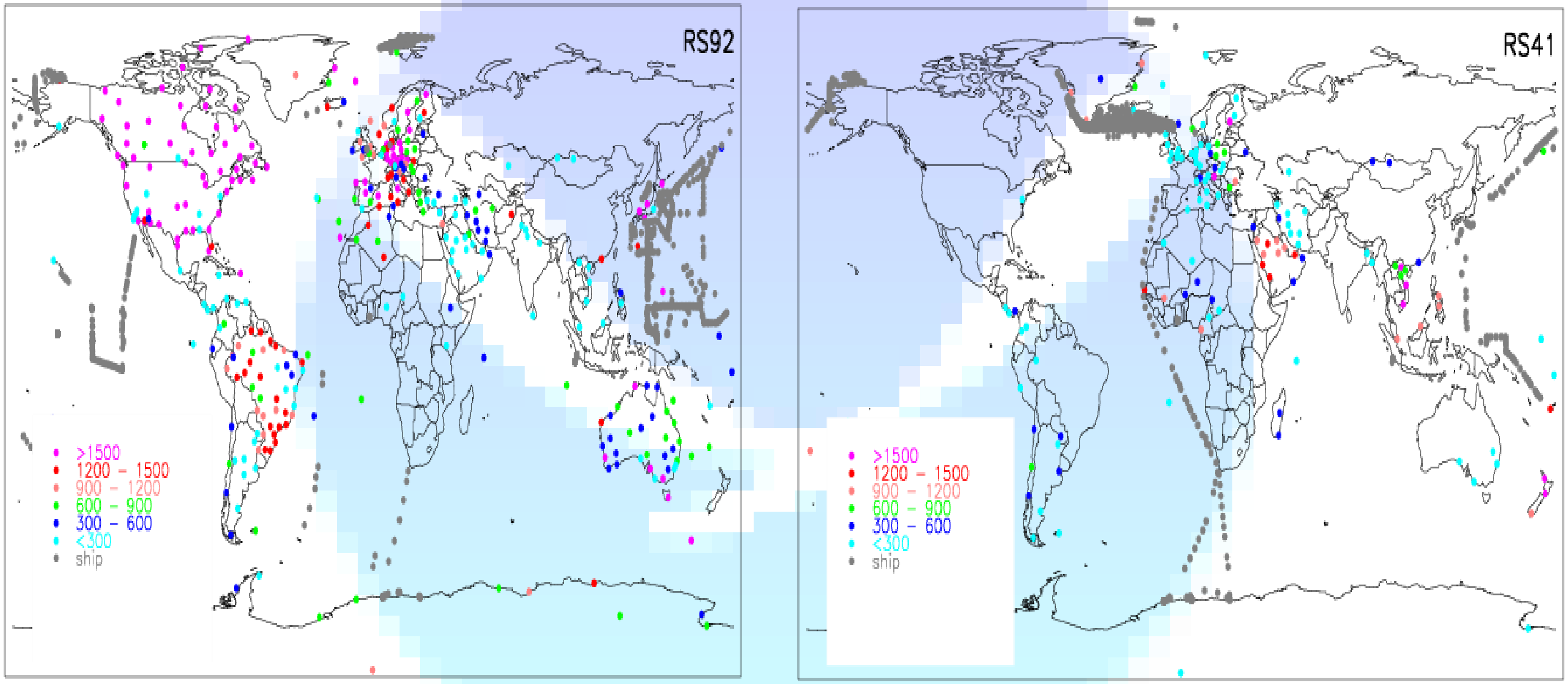
GRUAN, ARM,…

Outline

- Summarize the assessment of accuracy of RS41 and RS92 upper-air temperature observations

- Demonstrate the accuracy of RS41 and RS42 upper tropospheric humidity by comparing with satellite measurements
  – Method
  – Results

"On the accuracy of Vaisala RS41 versus RS92 upper air temperature observations" by Sun et al., (2019), J. Atmos. Ocean. Tech.



311,500 RS92 and 65,800 RS41 profiles for 2015 -2017 from global conventional network

Target Datasets for radiosonde temperature assessment

- NWP background & Analyses
  - NOAA CFSR
  - ECMWF
- GPSRO Tdry
  - UCAR COSMIC
  - EUMETSAT ROM SAF MetOp GRAS
- RS92-RS41 Dual launch data (6 sites)

Conclusions:
RS41 and RS92 agree to each other within 0.1 – 0.2 K in the lower stratosphere.
RS41 appears to be less sensitive to solar elevation change.
Both NCEP and ECMWF data are cold-biased in the lower stratosphere.

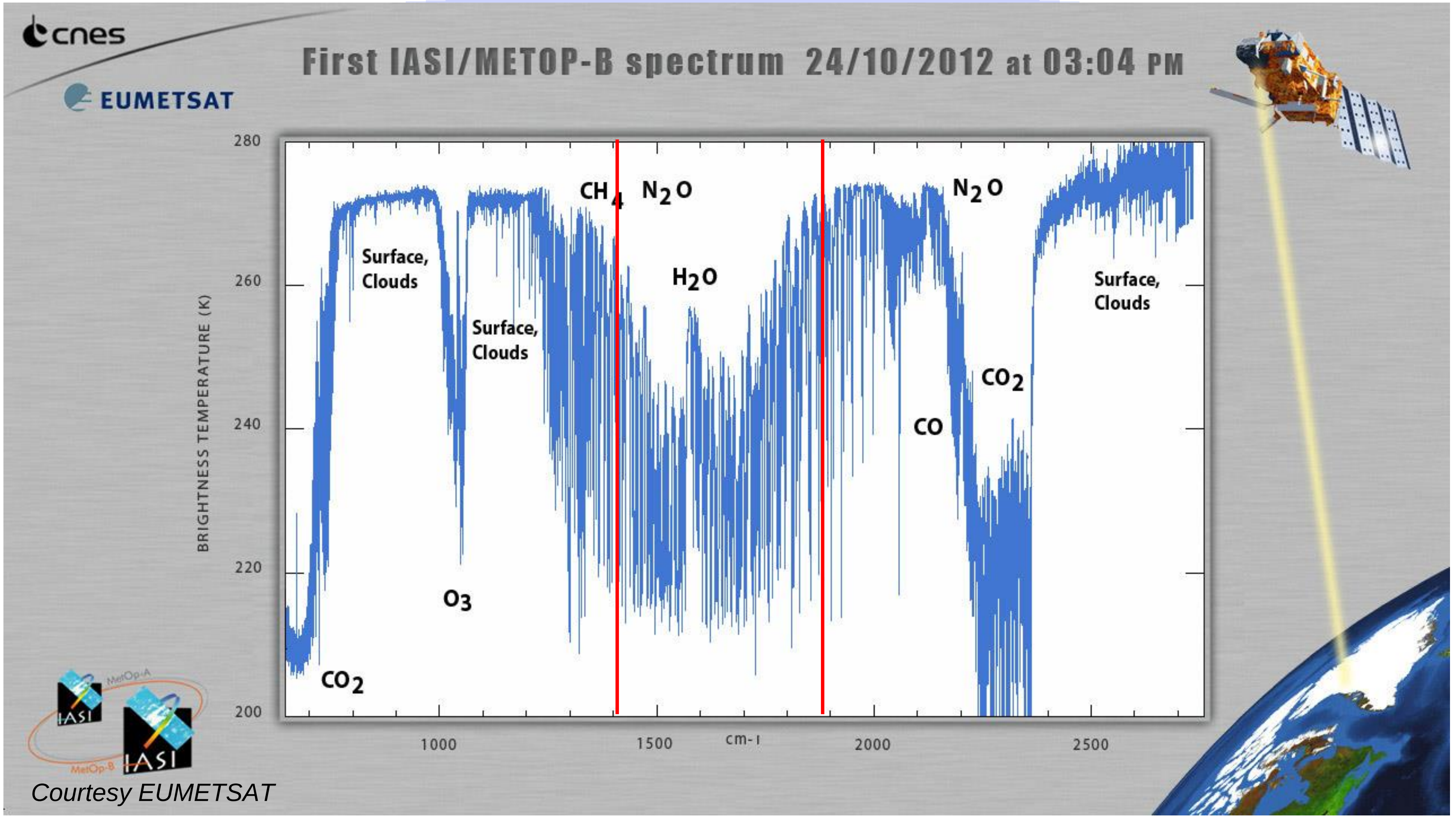
Accuracy of Vaisala RS41 and RS92 upper tropospheric humidity compared to satellite hyperspectral infared satellite measurements (Sun et al. 2020, J Remote Sensing under review)

- Infrared Atmospheric Sounding Interferometer (IASI on MetOp-B) measurements….reference in GSICS
- Assessment is conducted in radiance space
  - Find “cloud-free” IASI pixels that are closely matched with radiosondes
  - Compute radiances for the radiosonde profiles using Line-by-Line Radiative Transfer Model (LBLRTM)…. “CAL”
  - Determine the accuracy of sondes from OBS(iais)-CAL(raob) radiances
  - Assess the consistency of the radiosonde-computed radiance with IASI measurements

Radiosonde types analyzed

- Radiosondes and processing
  - RS41 STD (standard processing)
  - RS92 GDP (GRUAN data processing)
  - RS92 STD (standard processing)
  - *RS41 GDP (in plan for analysis)*
- Sites and Data
  - Lauder, New Zealand: Dual launches (daytime); <1hr before IASI overpass
  - ENA, Azores; Single launches (day & night), <30min before and <15min after IASI overpass

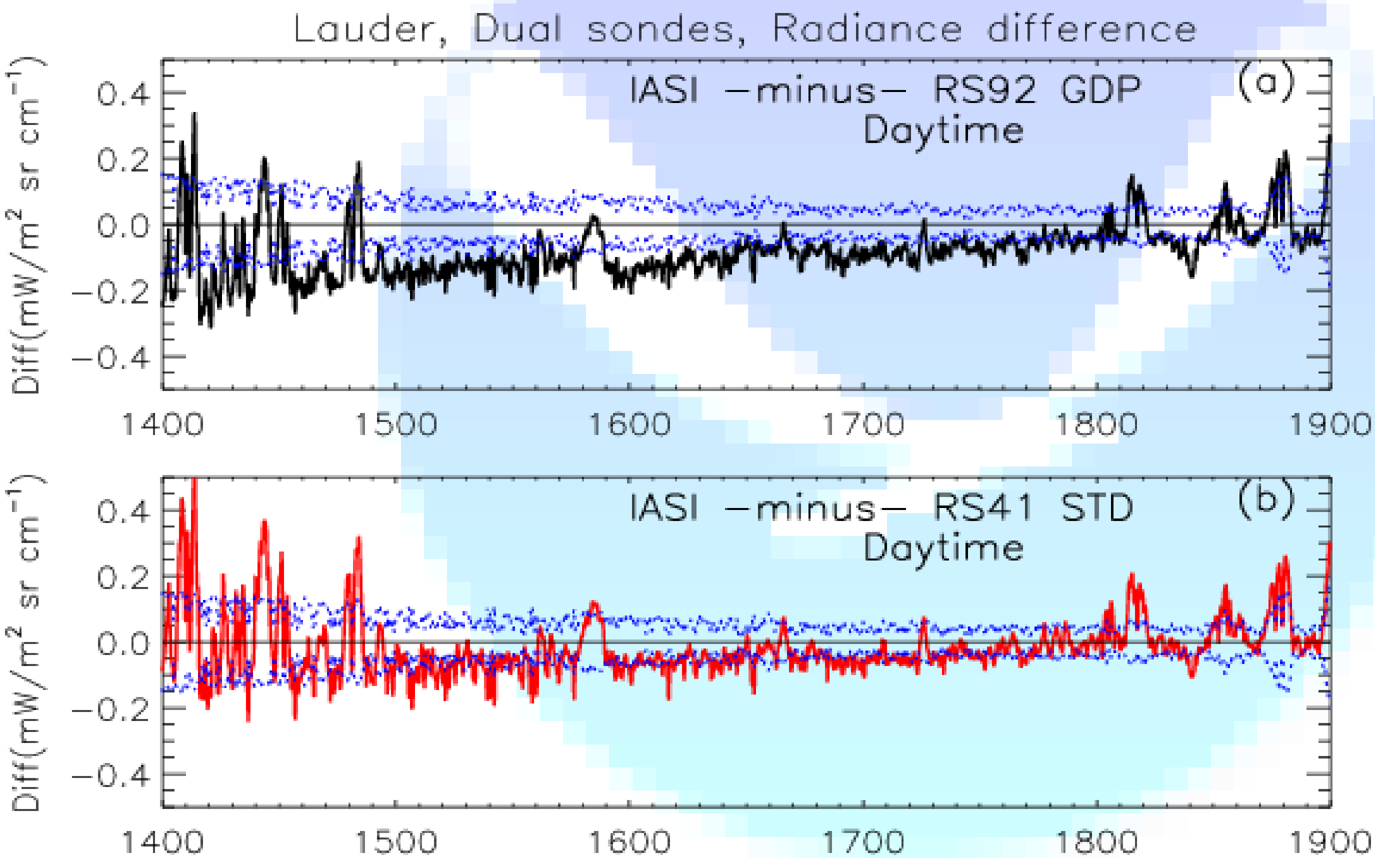
Upper tropospheric water vapor spectrum (1400-1900 cm^{-1})



Courtesy EUMETSAT

More/less water vapor in the upper air , less/more radiation arriving at satellite

Lauder, Duals (RS92 GDP & RS41 STD), 14, daytime, versus IASI “target”



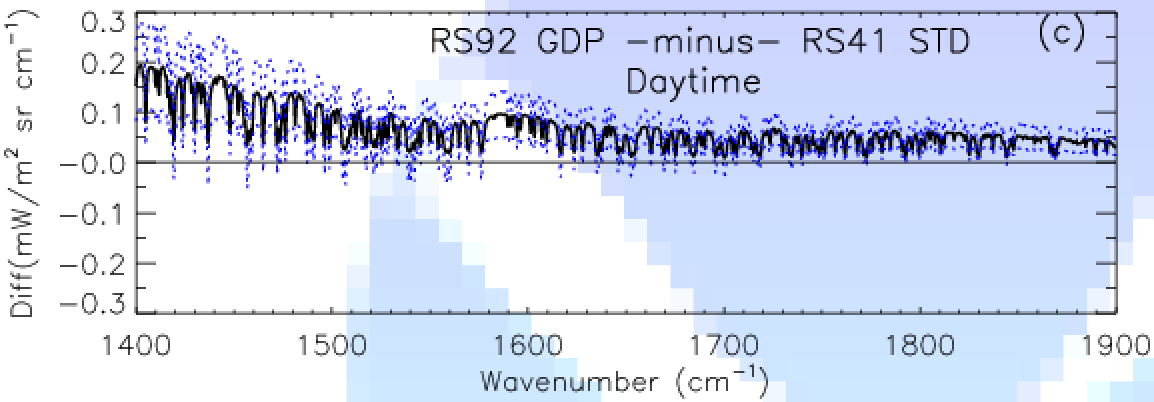
RS92 GDP: *Raob radiance bias in 1500-1570 cm-1 and (standard deviation) = -0.1291 (0.085) mW m^{-2} sr cm^{-1}*
2.8% (1.9%) dry bias in RH
(Calbet et al. 2017)

RS41 STD: *-0.0705 (0.081) mW m^{-2} sr cm^{-1}*

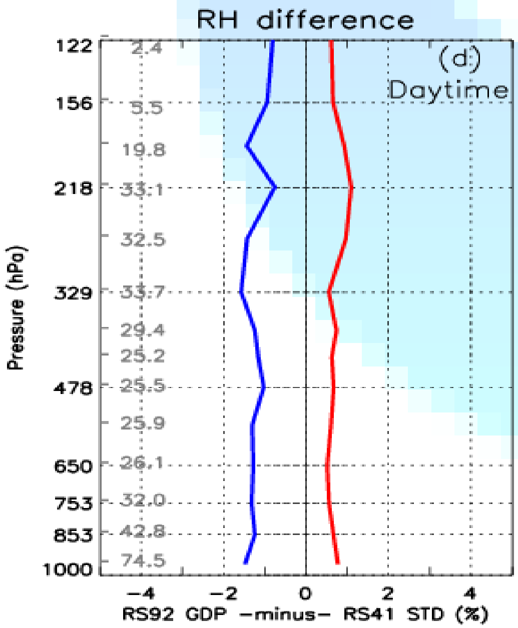
1.4% (1.9%) dry bias in RH

Blue dotted curves: 2 x sqrt (RAOB, IASI, RT, and collocation squared uncertainty)

Lauder, RS92 GDP-minus-RS41 STD



The radiance analysis indicates that RS92 GDP is drier than RS41 STD by **1.4% (0.65%)**



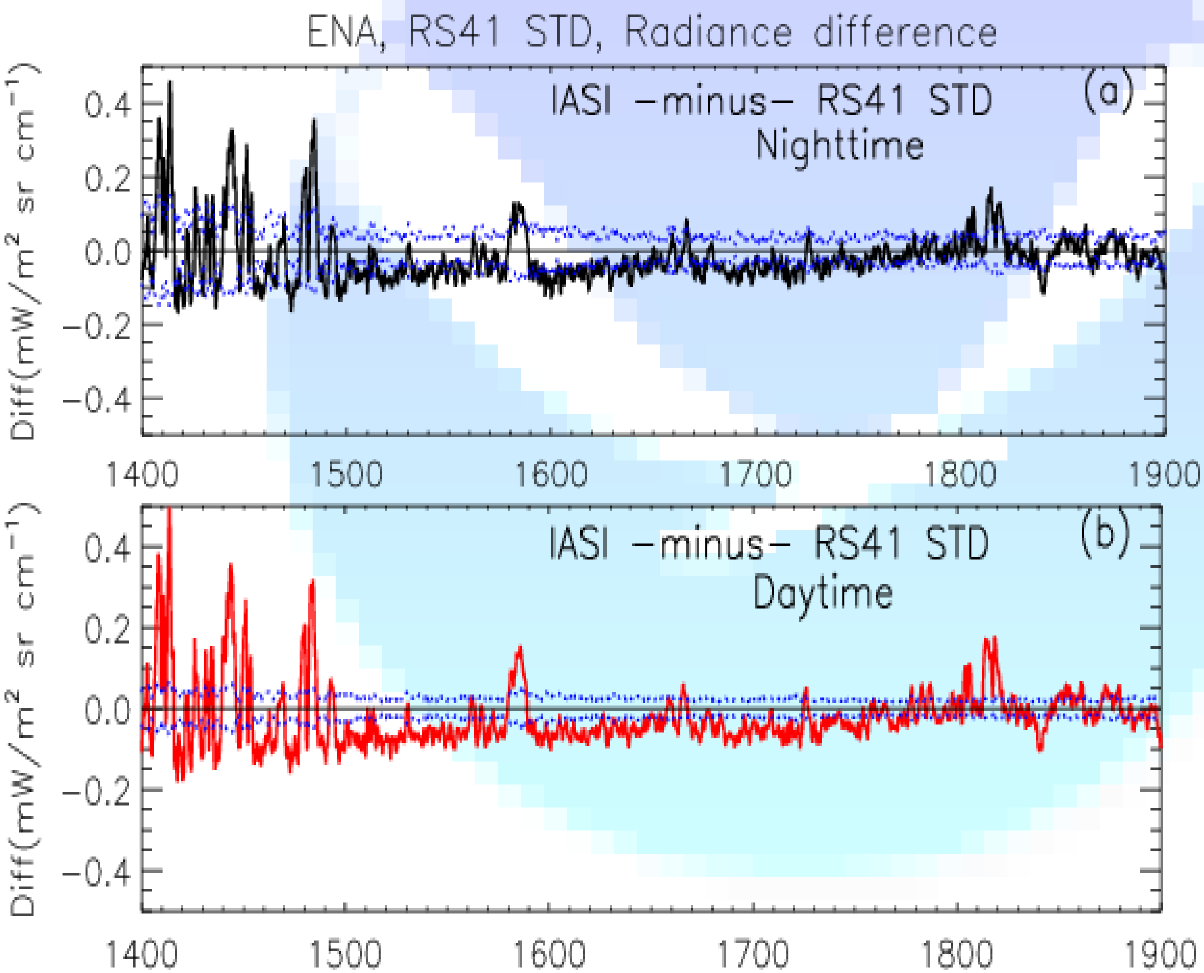
Blue line: Raob RH difference; Red Line: standard dev

The RAOB dual launch RH data indicates that RS92 GDP is drier than RS41 STD by **1.3% (0.8%)** for 201-407 hPa.

ENA, Single Launches

- RS41 STD (day & night)
- RS92 GDP (day & night)
- RS92 STD (day & night)
- ECMWF (day & night) for additional comparison with IASI

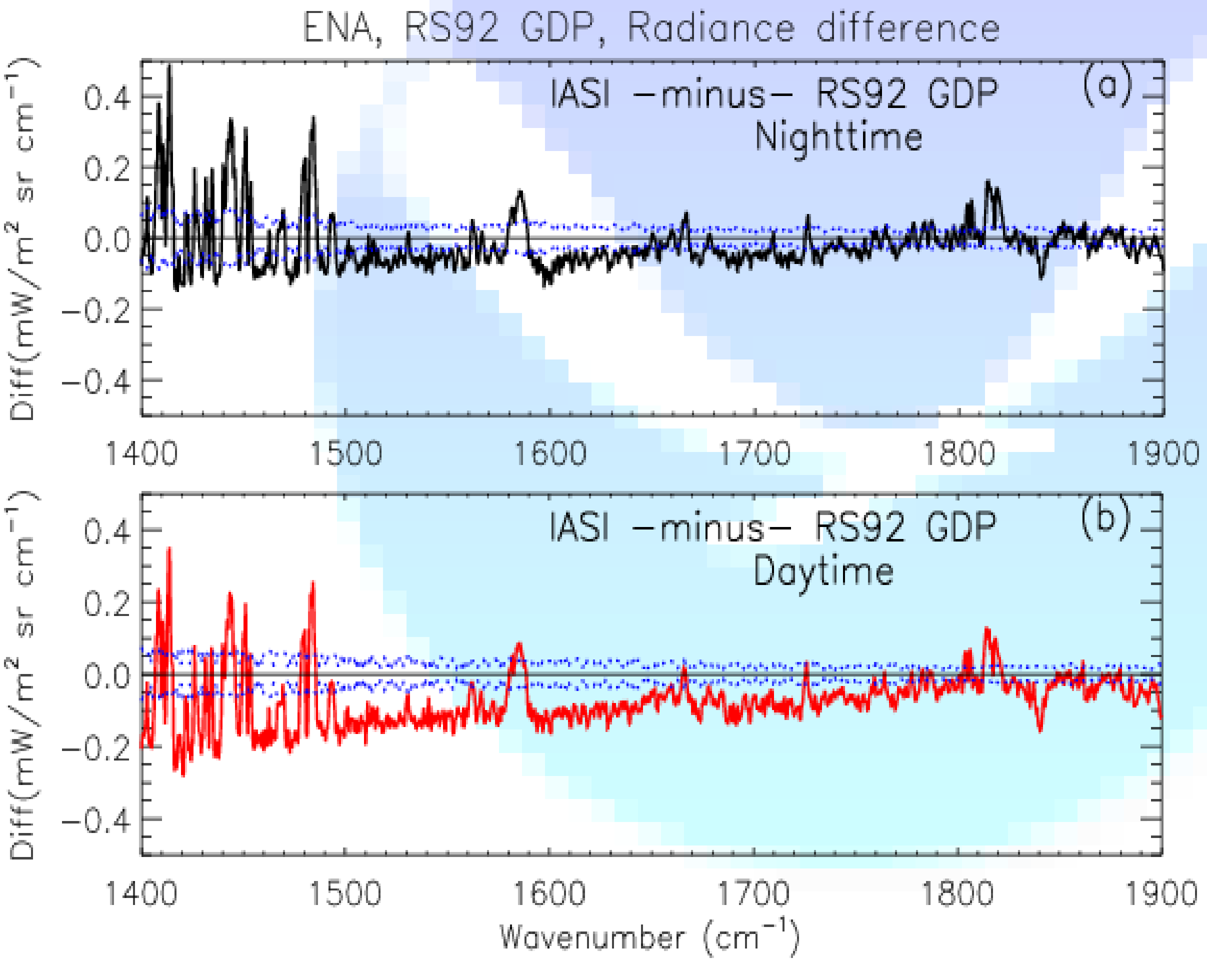
ENA, RS41 STD, single, night (12), day (27), versus IASI "target"



RS41 STD, Night (12): *-0.0528 (0.054) mW m^{-2} sr cm^{-1}*
1.2% (1.2%) dry bias in RH

RS41 STD, Day (27): *-0.0633 (0.042) mW m^{-2} sr cm^{-1}*
1.3% (1.0%) dry bias in RH

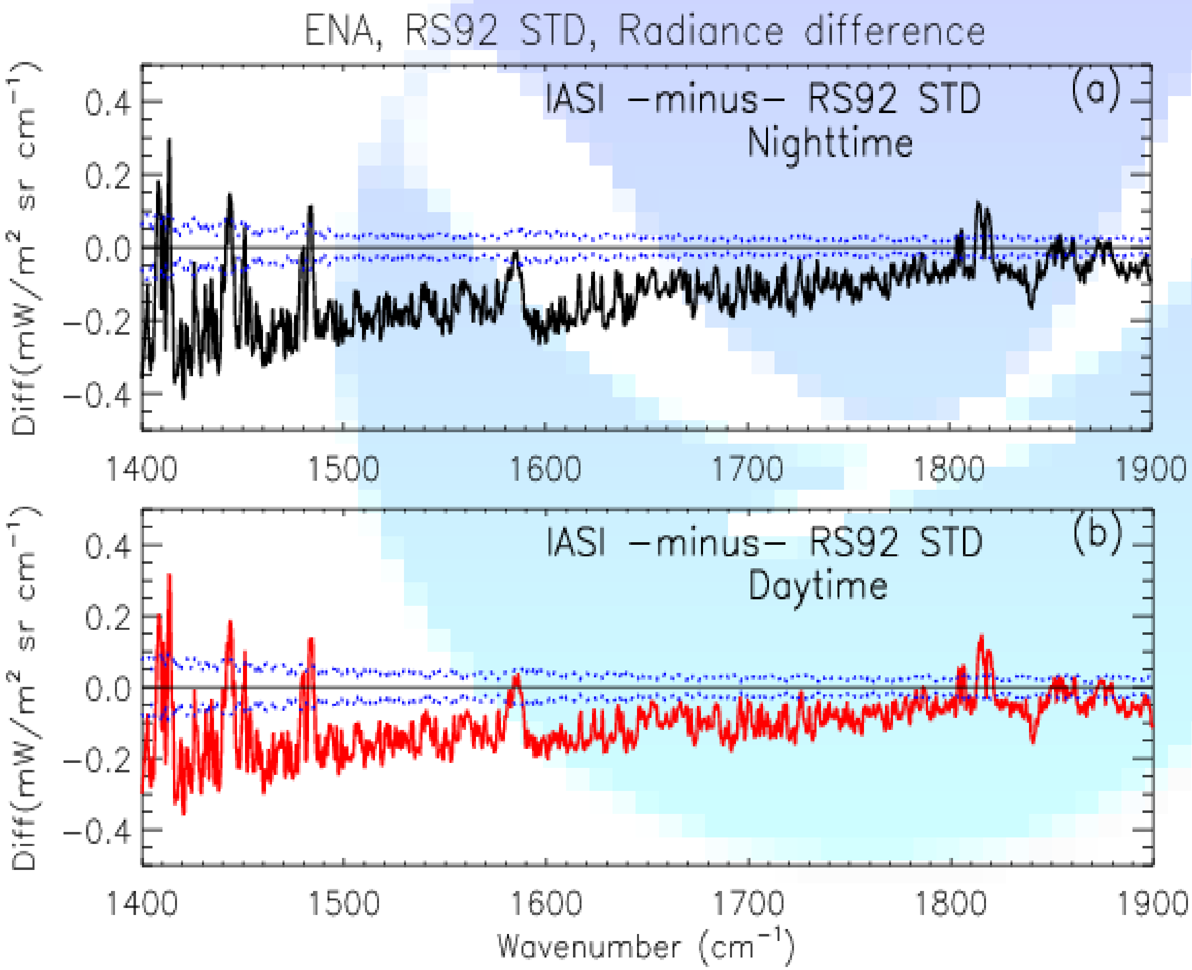
ENA, RS92 GDP, single, night(43), day(50), versu IASI “target”



RS92 GDP, Night (43):
-0.0527 (0.088) mW m^{-2} sr cm^{-1}
1.1% (1.9%) dry bias in RH

RS92 GDP, Day (50):
-0.1196 (0.090) mW m^{-2} sr cm^{-1}
2.5% (2.1%) dry bias in RH

ENA, RS92 STD, single, night(43), day(50), versus IASI "target"



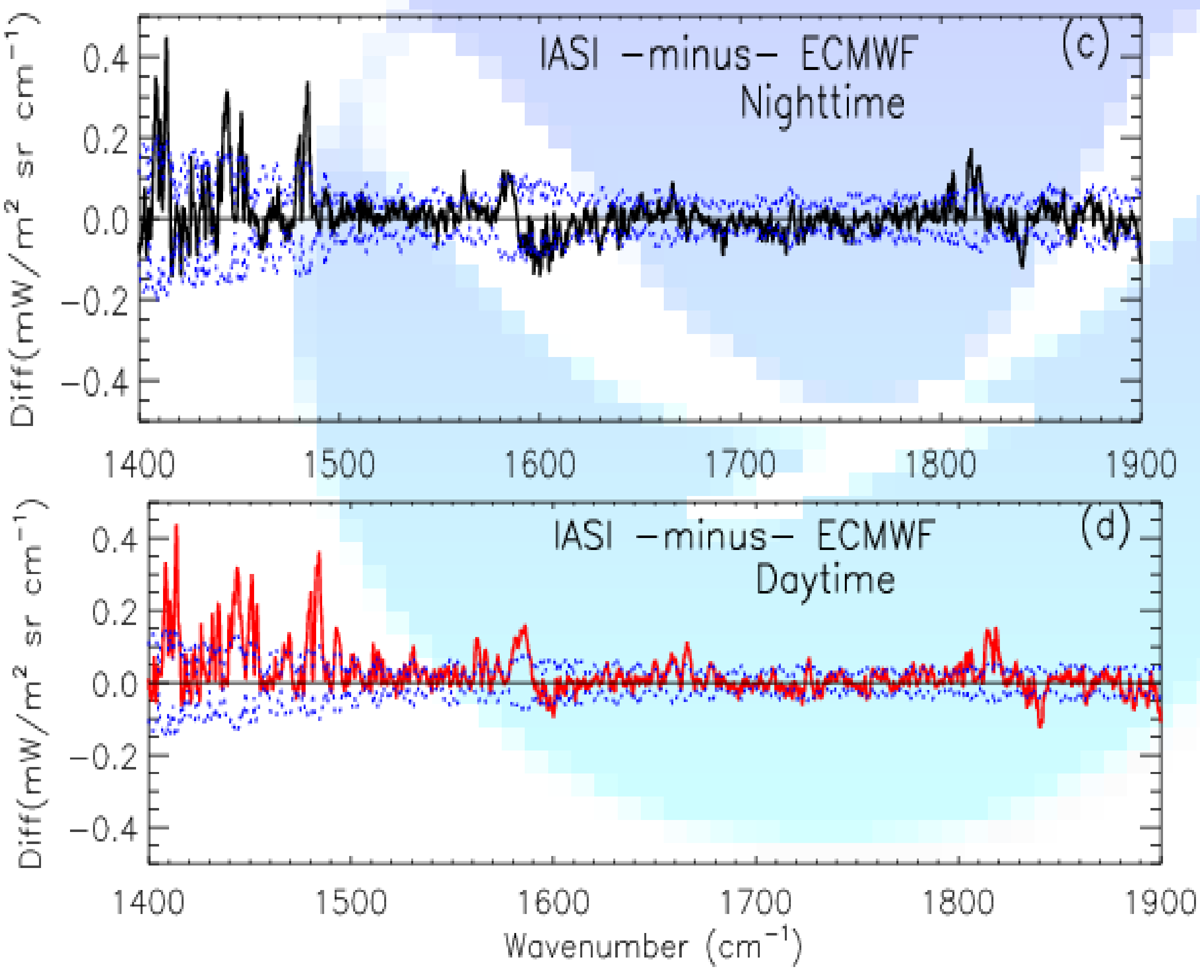
RS92 STD, Night (43):
-0.1758 (0.075) mW m^{-2} sr cm^{-1}
3.9% (1.7%) dry bias in RH

RS92 STD, Day (50):
-0.1448 (0.118) mW m^{-2} sr cm^{-1}
3.3% (2.6%) dry bias in RH

Summary

- Radiosonde upper tropospheric humidity is assessed against humidity-sensitive satellite radiance measurements via radiative transfer modeling.
- Daytime RS41 (even without GDP) has 1% plus smaller error in RH than RS92 GDP.
- RS41 may still have a dry bias of 1-1.5% for both daytime and nighttime and a similar error for nighttime RS92 GDP.
- RS41 STD (standard processing) and RS92 GDP are consistent with IASI for some cases, not for some other cases.
- RS92 STD (standard processing) may have a dry bias of 3-4% and is inconsistent with IASI.
- The sonde humidity biases are probably upper limits since “cloud-free” scenes could still be cloud contaminated

ENA, ECMWF, night(12), day(27), versus IASI "target"



ECMWF, Night (12):
0.0131 (0.057) mW m^{-2} sr cm^{-1}
0.0% (1.3%) dry bias in RH

ECMWF, Day (25):
0.0238 (0.063) mW m^{-2} sr cm^{-1}
0.3% (1.2%) dry bias in RH

Path forward

- Analyze RS41 GDP vs RS41 STD with respect to satellite measurements.
- Extend the radiosonde radiance analysis to the Cross-track Infrared Sounder (CrIS) on-board NOAA20.
- We have now strong evidence that a big source of biases comes from WV in-homogeneities within a satellite instrument Field of View → We will need "high resolution" LIDAR data to analyze this: offerings welcome!