Utilization Of GPSRO In NOAA Products Validation System (NPROVS)

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Abstract

The NOAA Products Validation System (NPROVS, Reale et al. 2012) was established at the NOAA Center for Satellite Applications and Research (STAR) in 2008, funded by the NOAA Joint Polar Satellite System (JPSS) calibration/validation (Cal/Val) program. Major GNSS RO products are routinely ingested in NPROVS through collocation compiling with radiosondes. In this presentation, the utilization of GNSS RO is focused as follows.

- Identification and quantification of radiosonde temperature biases,
- Trends consistency with satellite microwave and GCOS Global Reference Upper Air Network (GRUAN, Bodeker et al. 2016) data, and
- NPROVS monitoring of COSMIC-2 products.

NOAA Sounding Products Validation System (NPROVS)

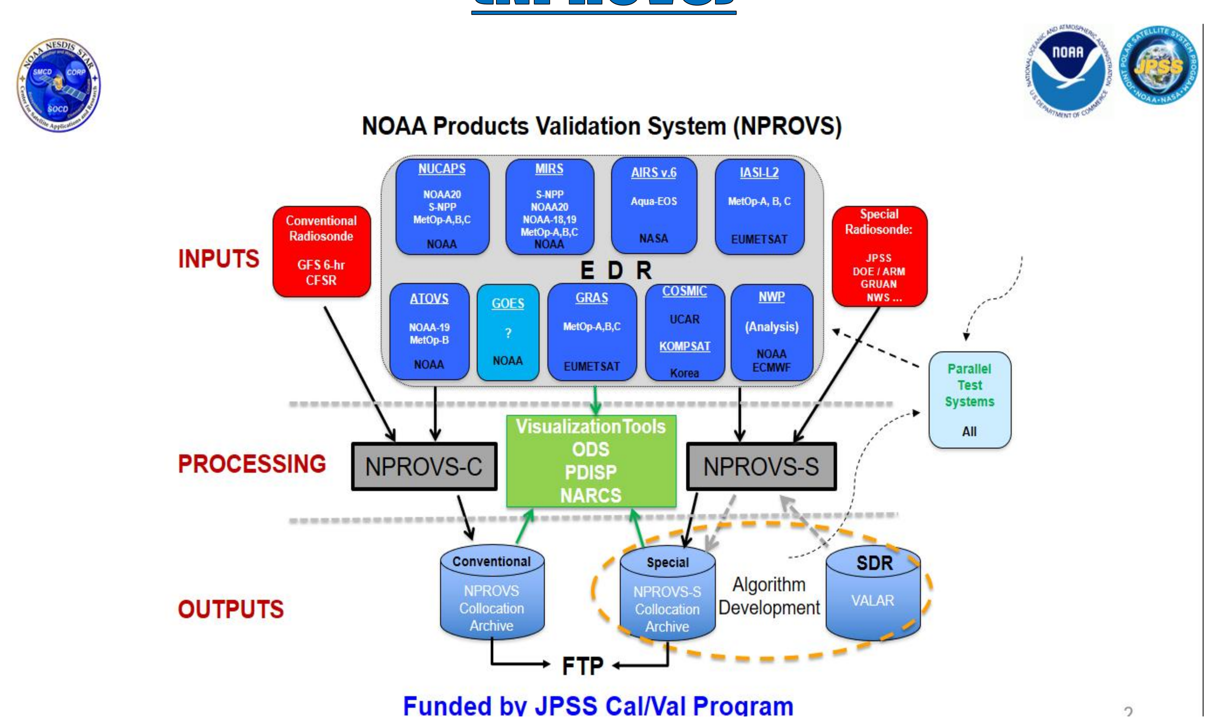

Figure 1. NPROVS provides a centralized "Enterprise (*same baseline to assess different systems*)" strategy for compiling collocations of radiosondes including dropsondes, numerical weather prediction model (NWP) outputs and satellite atmospheric temperature and water vapor sounding profiles and providing assessment. The satellite profiles are derived from different satellite platforms (*i.e*., NOAA, NASA, EUMETSAT, and GNSS RO; Infrared, Microwave and Radio Occultation) and associated retrieval algorithms. A single "closest" sounding from each platform (and NWP) is collocated to a given radiosonde that is within 6 hr and 150 km; this preserves respective product yield tracking.

Radiosonde profiles used as the collocation baseline include those from global "Conventional" network (including dropsones) and "Special" Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) and satellite synchronized "dedicated" sondes (JPSS/ARM). This enables "Enterprise Assessment, providing a common baseline for assessing satellite derived profiles from different platforms (and retrieval algorithms).

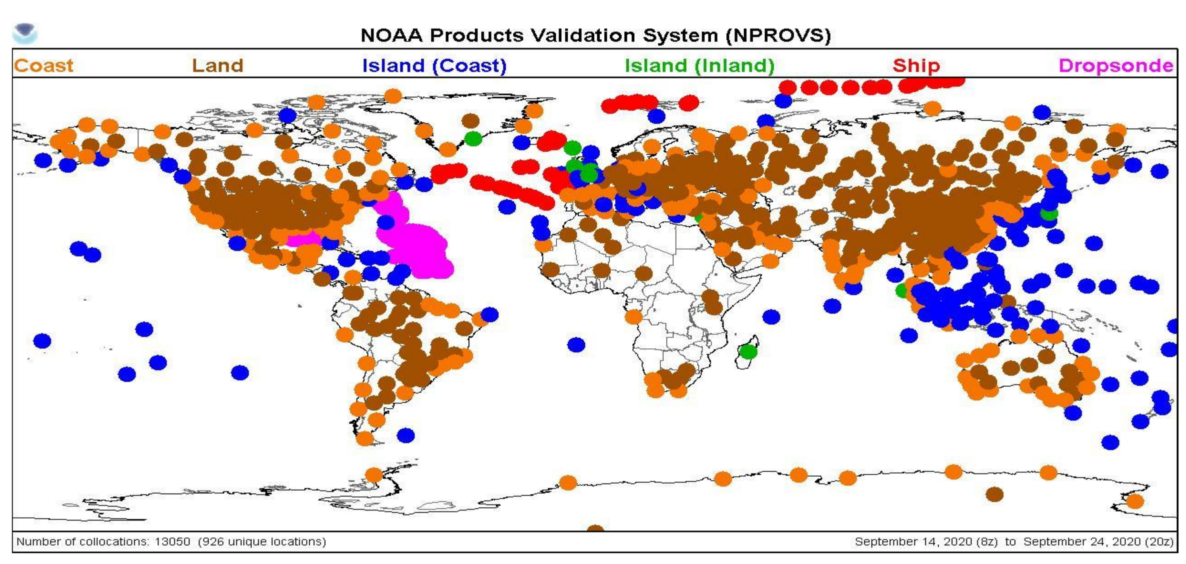

Figure 2. Example of Conventional radiosonde launches (during September 14-24 2020). Vaisala RS41 has replaced RS92, becoming the dominate sonde type in the global network.

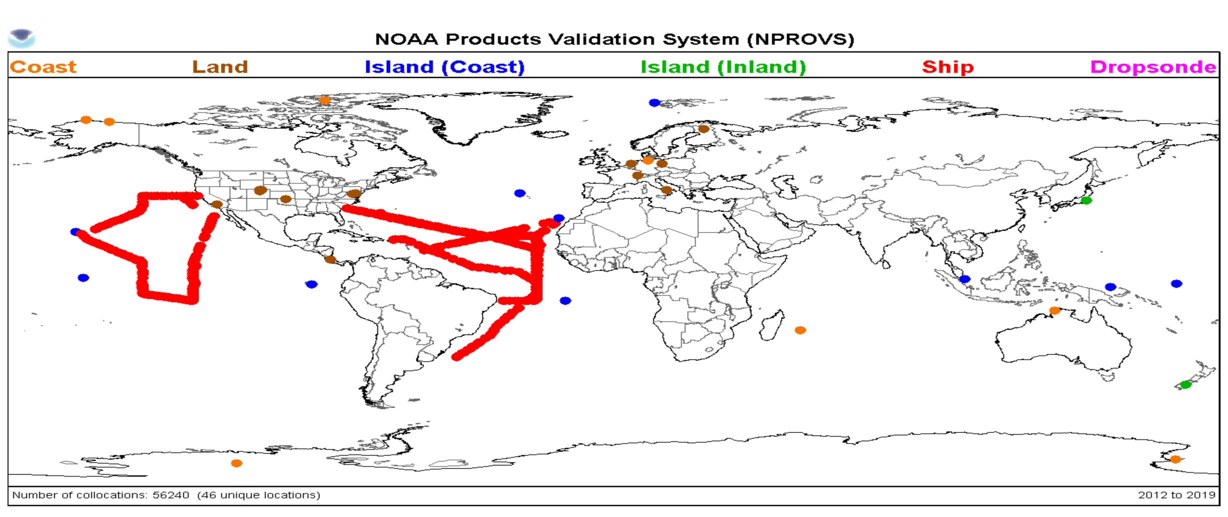

Figure 3. Spatial distribution of Special radiosondes including JPSS satellite synchronized dedicated radiosonde sites (including ship campaigns) and GRUAN. Half of the radiosondes from oceanic campaigns are synchronized with MetOp overpasses.

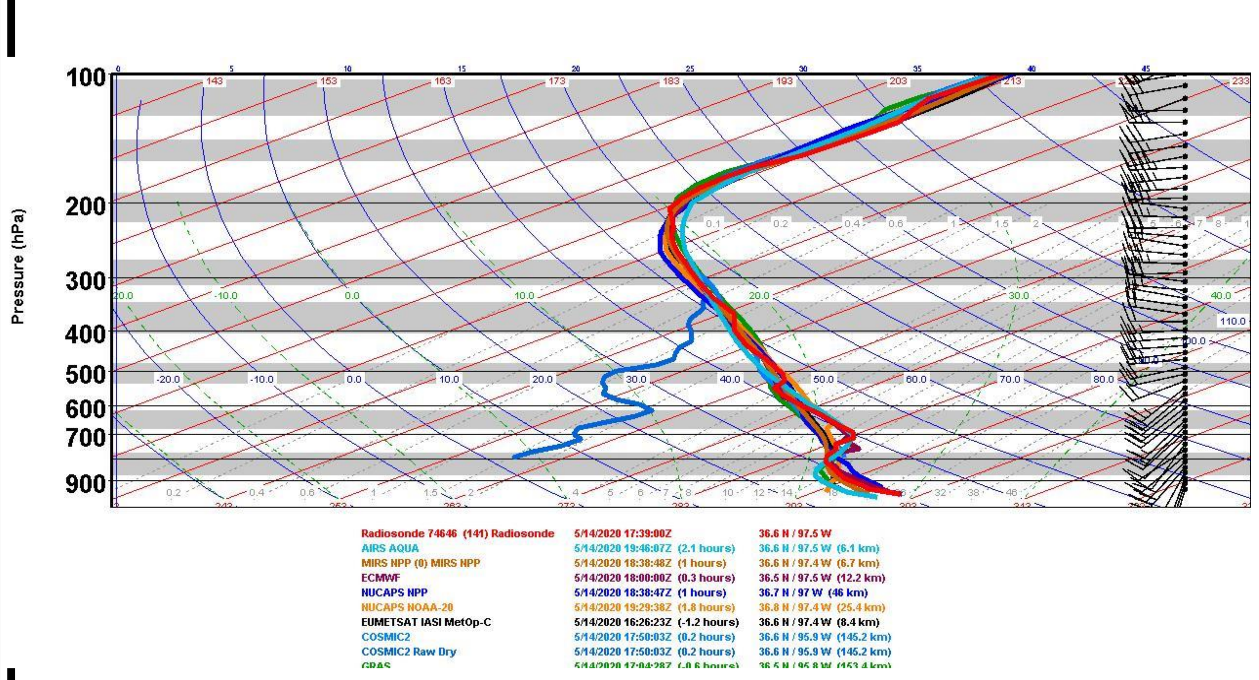

Figure 4. Example of the "enterprise" collocation: RS41 is collocated with different satellite products including COSMIC-2 and MetOp GRAS and radiance-derived products, facilitating products inter-comparison.

Radiosonde Data Assessment

Figure 5. Vaisala RS92 (left) and RS41 (right) (Courtesy of https://www.vaisala.com) . RS41 has replaced RS92 as the major sonde type in global and GCOS GRUAN network.

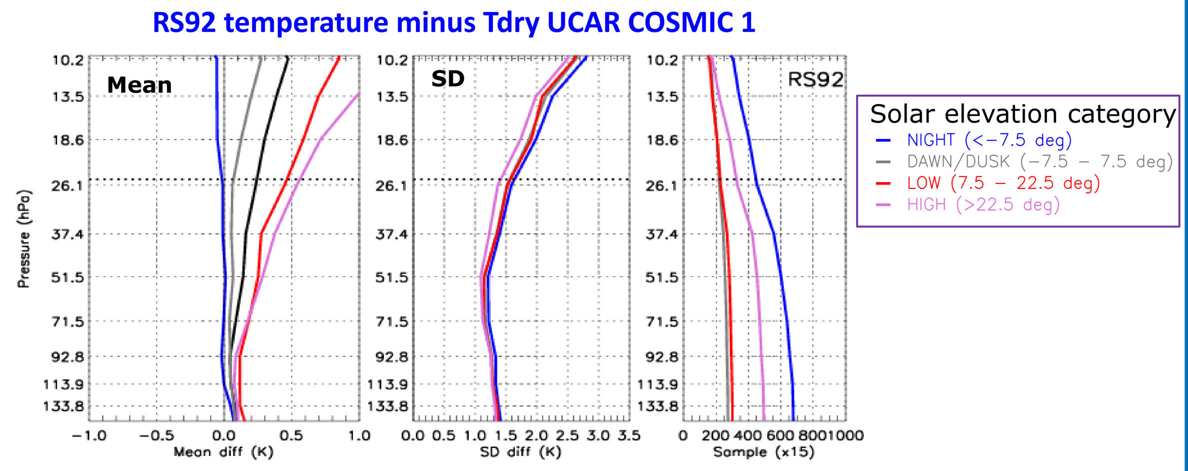

Figure 6. RS92 minus Tdry UCAR COSMIC 1 temperature. Global collocations (16126, within 3 hr/250km) for January 2015 to June 2017 are used in the assessment. The data are sorted by solar elevation categories. The horizontal dashed line at 25 hPa indicates that caution is needed to interpret the statistics above that altitude as Tdry accuracy could be degraded and also because there are fewer collocation samples (see Sun et al. 2019).

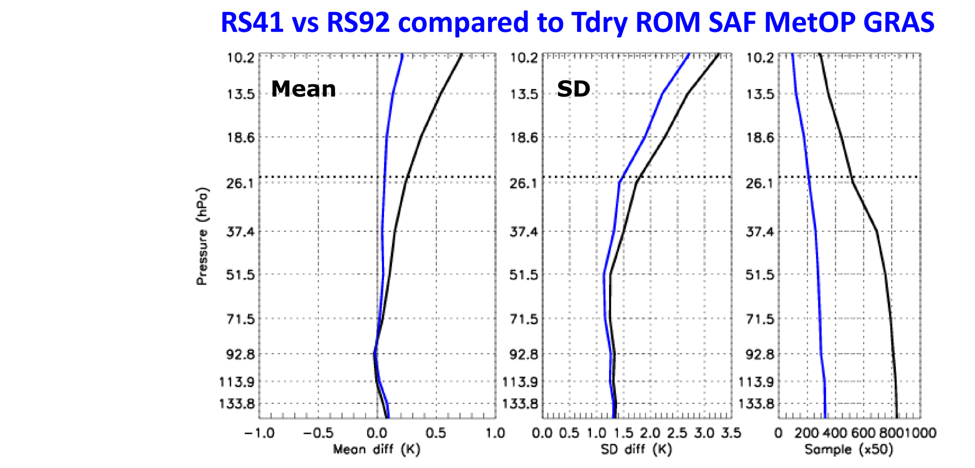

Figure 7. RS92 minus Tdry (black) and RS41 minus Tdry (blue). Tdry is from RO SAF MetOP GRAS. Data from all day for January 2015 and June 2017 (22201 collocations, within 3hr/250km) are used.

Figures 6 and 7 indicates that RS92 and RS41 agree well with global average temperature differences 0.1–0.2K in the lower stratosphere from 51.5 to 26.1 hPa based on global stations. RS41 appears to be less sensitive than RS92 to changes in solar elevation angle.

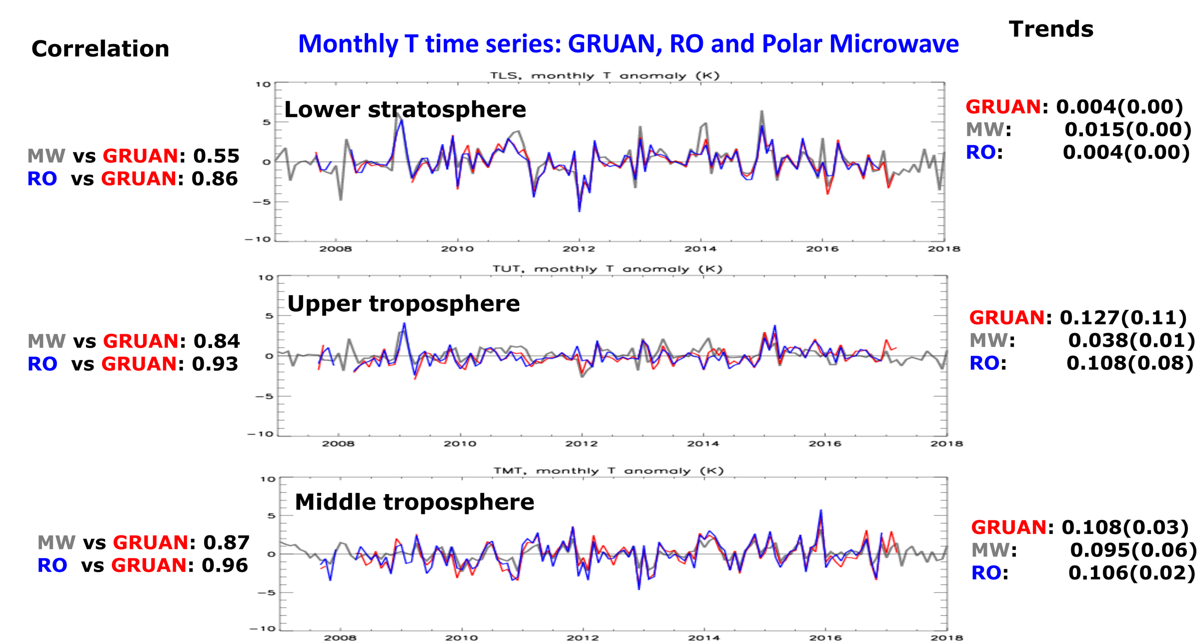

Figure 8. Monthly temperature anomaly time series (2008-2018): GRUAN, Microwave, and GNSS RO) at Lindenberg, Germany. **The "3-G" datasets are consistent with each other in terms of year to year variability and decadal trends.**

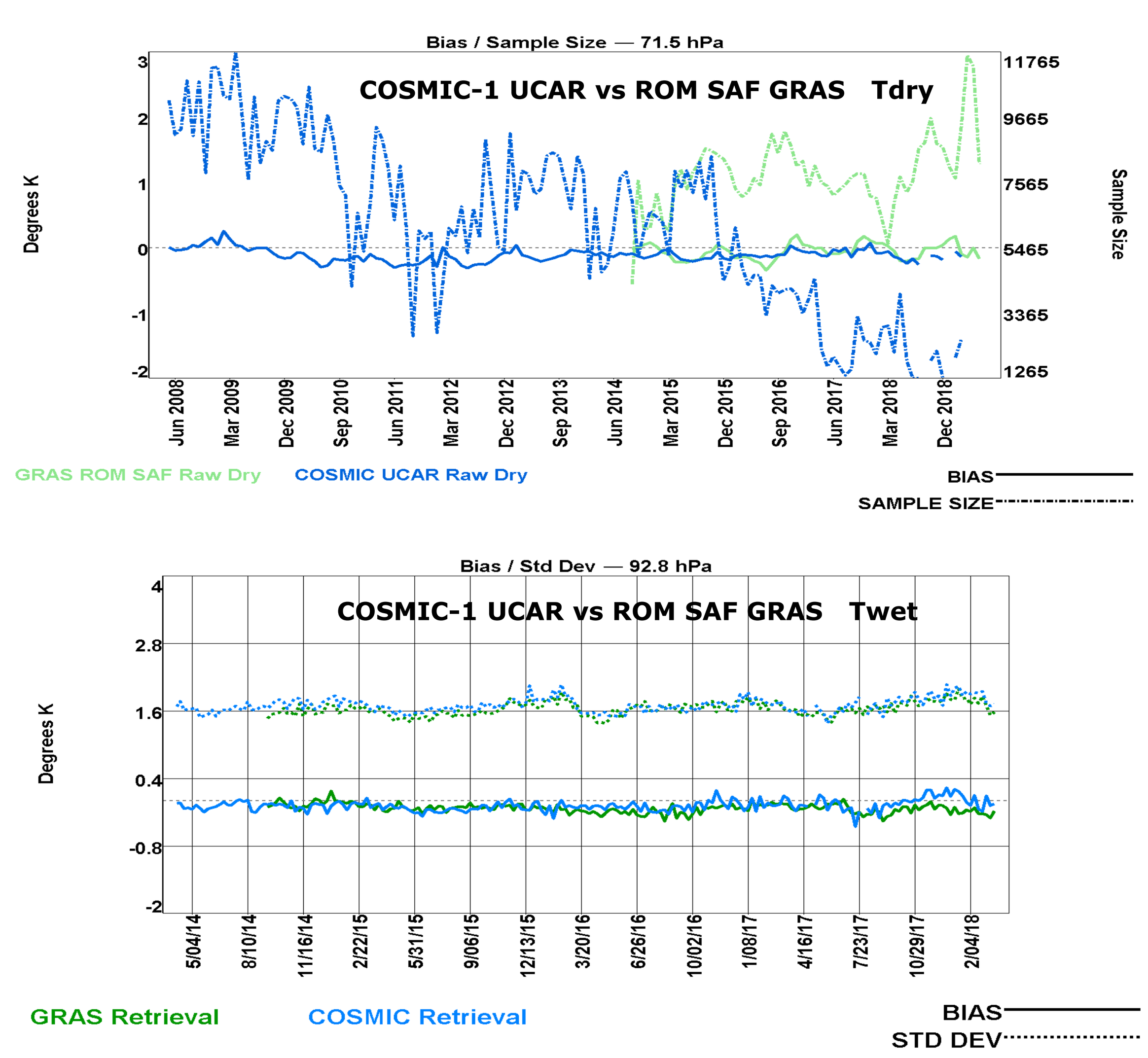

Figure 9. UCAR COSMIC-1 and ROM SAF MetOP RO samples over time (right y-axis of upper plot); differences of Tdry of those two products from global conventional radiosonde data at 71.5 hPa shown in upper plot (x-axis). Differences of "wet" T of the two RO products from conventional radiosondes at 92.8 hPa (lower plot). **Demonstrating the NPROVS monitoring capability of RO products.**

COSMIC-2 Monitoring

COSMIC-2 from UCAR has been ingested in NPROVS for routine monitoring and analysis using our visualization tools. The following Figures show the examples of NPROVS monitoring capability.

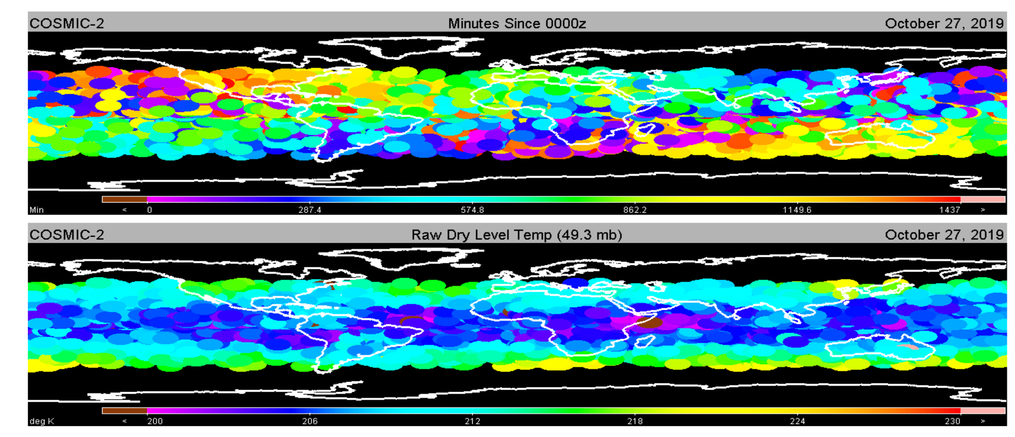

Figure 10. UCAR COSMIC-2 RO profiles for October 27 2019. Upper: times (in minutes from 0000Z), bottom: Tdry at 49.3 hPa.

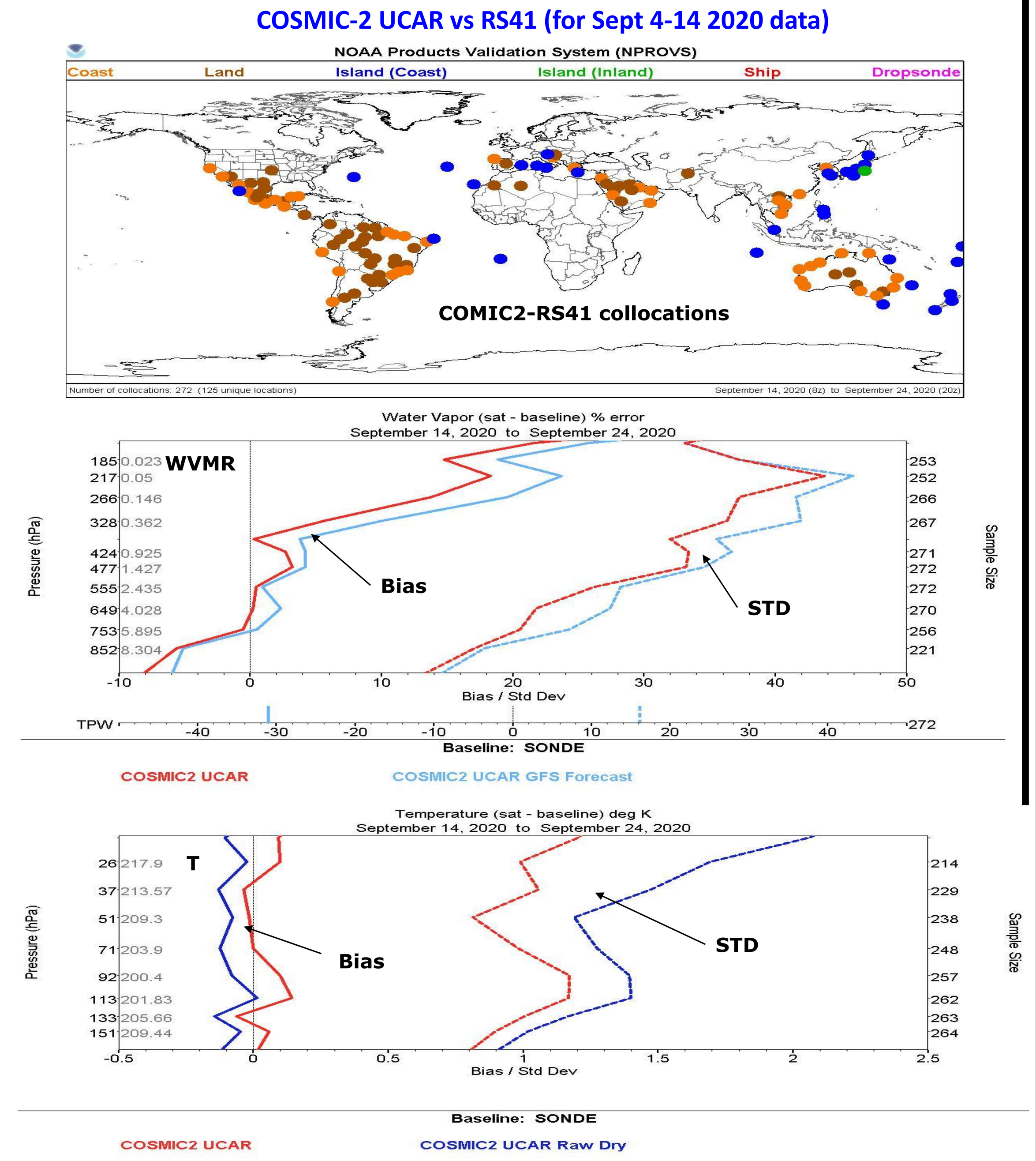

Figure 11. UCAR COSMIC-2 water vapor and temperature assessment by comparing with collocated Vaisala RS41. Ten days (September 4-14 2020) of COSMIC-RS41 collocations (2hr/150km) are used for the assessment. Upper: spatial distribution of the collocations used; middle: water vapor mixing ratio percentage difference (%), COSMIC 2 minus RS41 (red) and GFS minus RS41 (blue); bottom: temperature difference, COSMIC-2 "wet" minus RS41 (red) and COMIC-2 dry minus RS41 (blue).

It appears that UCAR COSMIC-2 1-Dvar water vapor shows improvement over its GFS background in error statistics. Note, the upper tropospheric wet bias in COSMIC-2 could partly be due to a dry tendency in RS41. Interestingly, the COSMIC-2 "wet" temperature matches well with RS41 data in t he upper tropospheric and lower stratosphere, and that could be because the "wet" T is dominated by the GFS background that assimilates the radiosonde data. A slightly warm bias (~0.1 K) is still shown in RS41 reflecting a negative difference of Tdry minus RS41. Anyway, a bigger data sample is needed to verify the results.

Summary and Path Forward

Major GNSS RO products are routinely ingested in NPROVS through collocations with radiosonde data of both conventional and GRUN networks.

- **RO Tdry plays an important role in identifying and quantifying radiosonde (including RS92 and the newly emerging RS41) temperature biases.**
- **UCAR COSMIC 2 water vapor profiles show improvement over its GFS background.**
- **The consistency of GRUAN-RO-Microwave in climate monitoring supports the Global Space-based Inter-Calibration System (GSICS) mission to monitor satellite microwave sensors by introducing ground and space reference observations.**
- **Path forward: bring NESDIS COSMIC-2 into NPROVS and update ROM SAF MetOP GRAS in NPROVS, collaborate with Rob Kursinski et al. on RO water vapour assessment.**

References

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- Sun, B., A. Reale, S. Schroeder, M. Pettey, and R. Smith, 2019: On the accuracy of Vaisala RS41 versus RS92 upper-air temperature observations. Journal of Atmospheric and Oceanic Technology. 36, 635-653, DOI:10.1175/JTECH-D-18-00181.1.

STAR Center for Satellite Applications and Research

Poster, The 8th International GPS Radio Occultation Working Group Meeting, 7-13 April 2021, Virtul Meeting (Corresponding author: Bomin.Sun@noaa.gov)