NOAA-JPSS Dedicated Radiosonde Database in Support of Satellite Data Calibration/Validation

Bomin Sun[1,2], Anthony Reale[1], Lihang Zhou[1], Nick Nalli[1,2], Lori Borg[3], Michael Pettey[1,2], and Ryan Smith[1,2]

[1] NOAA/NESDIS/STAR, College Park, MD, USA; [2]I. M. Systems Group, Inc., Rockville, MD, USA; [3]University of Wisconsin-Madison, WI, USA.

Abstract

Dedicated radiosondes launched concurrent with satellite overpass constitute a valuable dataset in satellite sensor data calibration, radiative transfer model verification and satellite retrieval assessment. The NOAA Products Validation System (NPROVS, Reale et al. 2012), operated at NESDIS Office of Satellite Applications and Research (STAR), is actively involved in compiling dedicated radiosondes from various sources most notably in conjunction with the NOAA Joint Polar Satellite System (JPSS) calibration/validation program for Suomi National Polar-orbiting Partnership (S-NPP) and recently for NOAA-20. Assessments are "enterprise" assuring the integrity of perceived product difference

NOAA Sounding Products Validation System (NPROVS)

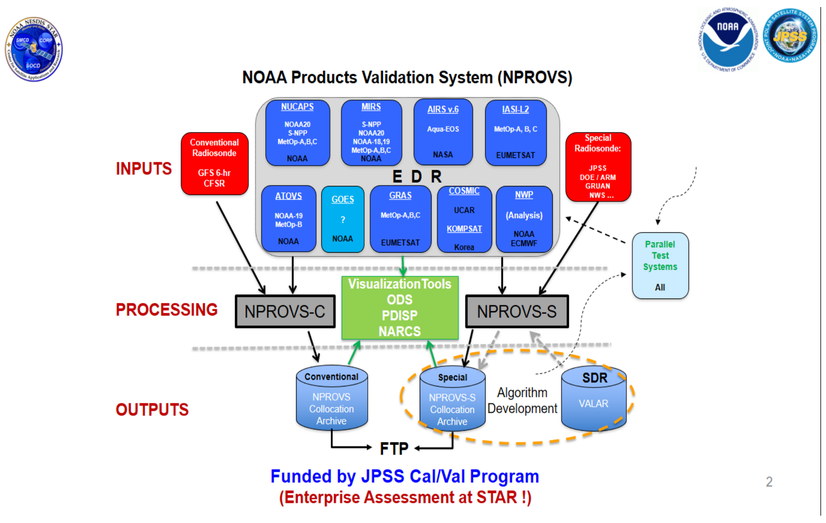

Figure 1. NPROVS provides a centralized "Enterprise (*same baseline to assess different systems*) " strategy for compiling collocations of radiosondes including dropsondes, numerical weather prediction model (NWP) outputs and satellite atmospheric temperature and water vapor sounding profiles and providing assessment. The satellite profiles are derived from different satellite platforms (i.e., NOAA, NASA, EUMETSAT, and GPSRO; 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).

Special Radiosondes

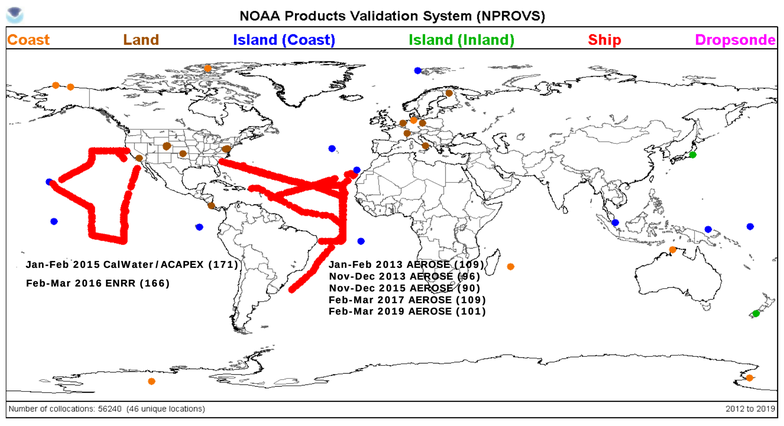

Figure 2. Spatial distribution of JPSS satellite synchronized dedicated radiosonde sites including ship campaigns and GRUAN. There are ~ 56,500 radiosondes (January 2013 through March 2019), of which, 9000 are synchronized (40000 via JPSS/ARM) with satellite overpasses. Half of the radiosondes from oceanic campaigns are synchronized with MetOp overpasses. Many of these are processed into "reference" radiosonde (STAR/GRUAN coordination)

The dedicated radiosondes, funded by the NOAA Joint Polar Satellite System (JPSS), consist of sondes launched from:

three DOE Atmospheric Radiation Measurement (ARM) sites (Tobin et al. 2006):
- Southern Great Plains at Oklahoma (SGP),
- Northern Slope of Alaska (NSA), and
- East North Atlanta (ENA)

ship campaigns:
- Multi-year NOAA Aerosols and Ocean Science Expedition (AEROSE) camaigns over Atlantic (Nalli et al. 2011),
- the 2015 CalWater ARM Cloud Aerosol Precipitation Experiment over the North Pacific Ocean.

Dedicated sondes are not assimilated in NWP, thus constituting an independent dataset for satellite data cal/val.

Additional dedicated radiosondes are also available from Beltsville GRUAN site (funded by JPSS), the Cooperative Institute for Research in the Atmosphere (CIRA), Fort Collins, CO (2016) and the National Weather Service (NWS) Sterling (Virginia) Field Support Center (SFSC). NWS radiosondes are also collocated with dedicated radiosondes from Beltsville.

In addition, routine synoptic radiosondes that happen to occur at a satellite overpass from GRUAN and ARM mobile sites in the Arctic, Antarctic and Helena Island provide a fairly robust global set of synchronized satellite and radiosonde opportunities.

Beginning February 2018, unique sets of dual radiosonde launches comprised of Vaisala RS41 and RS92 instrument types concurrent with satellite overpasses (NOAA and EUMETSAT) have been made. Referred to as **Radiosonde Intercomparison and Validation (RIVAL),** this effort is ongoing since February 2018 for two years focused at the ARM sites at SGP, NSA, and ENA.

Consistent with the routine JPSS dedicated radiosonde launch protocol, two types of **RIVAL** launch configurations are utilized. The first consists of a dual launch about 45 minutes prior to overpass followed by a single RS41 launch about 10 minutes prior to overpass. This configuration is used at SGP and at NSA. The second configuration is comprised of a single, dual launch about 15 minutes prior to overpass done at ENA due to site limitations.

Figure 3. **RIVAL** dual launch of Vaisala RS92 and RS41 synchronized with NOAA-20 at the DOE-ARM Eastern North Atlantic (ENA) Azores site. *(Courtesy Donna Holdridge)*

GRUAN

The Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) is an international observing network for monitoring climate. GRUAN strives to fill a major gaps in the current global observing system by providing fully characterized "reference" observations. GRUAN is envisaged as a network of 30-40 sites leveraging existing observational networks and capabilities (Figure 4, Bodeker et al. 2016)

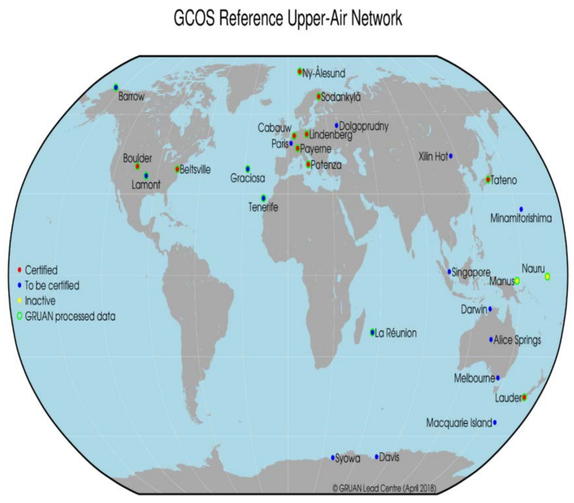

Figure 4. Current GRUAN sites and status.

The GRUAN radiosondes are currently available from about 20 sites (active) and processed by GRUAN software (www.GRUAN.org) which provides "*fully characterized*" measurements with uncertainty estimates for each individual observation. Many of the JPSS dedicated radiosonde are GRUAN processed (STAR/GRUAN coordination), effectively expanding GRUAN.

Assessing Satellite Sounding Performance (examples)

The value of dedicated and GRUAN radiosondes in assessing satellite sounding performance are demonstrated.

Figure 6 compares NOAA-Unique Combined Processing System (NUCAPS) and Microwave Integrated Retrieval System (MiRS) satellite soundings collocated to 2019 AEROSE campaign dedicated radiosonde (RS41). Satellite soundings are derived using Cross-track Infrared Sounder and/or Advanced Technology Microwave Sounding Unit (CrIS/ATMS) sounders nboard NOAA-20

Figure 6 shows "dedicated" Infrared Atmospheric Sounding Interferometer/Advanced Microwave Sounding Unit (IASI/AMSU) soundings derived by EUMETSAT from MetOp-B collocated with RIVAL launch at SGP (ARM).

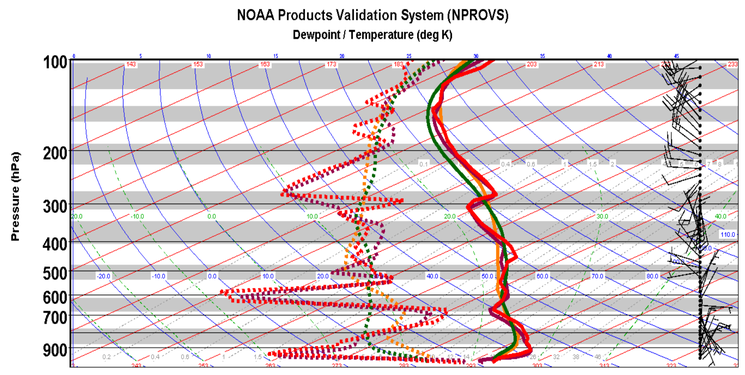

Figure 5. AEROSE 2019 radiosonde coincidence with overpass of NOAA20 NUCAPS and MiRS sounding retrievals

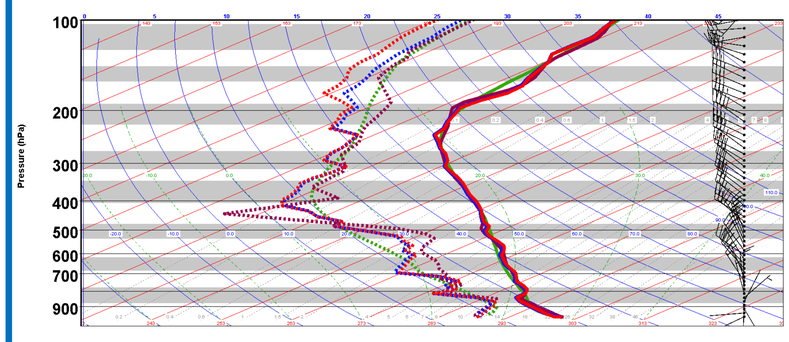

Figure 6. RIVAL RS41 and RS92 dual radiosondes launched at SGP coincidence with overpass of MetOP-B and EUMETSAT IASI sounding retrieval.

GRUAN offers a full range of high quality reference observations including fully characterized uncertainties optimal (particularly when dedicated) for assessing satellite sounding retrievals (*and respective uncertainty*).

Radiosonde Instrument Types

Figure 7. Vaisala RS41 radiosonde has been replacing the Vaisala RS92 in the past several years (since 2018), becoming the major sonde type across the GRUAN and Conventional radiosonde networks. (courtesy of https://www.vaisala.com)

Daytime upper tropospheric RS41 Humidity observations (without GRUAN processing, (not yet available) show an improvement over RS92 data (with GRUAN corrections) on the order of 1-2 % RH. The reported RS41 data is found to be consistent with IASI measurements (Sun et al. 2019).

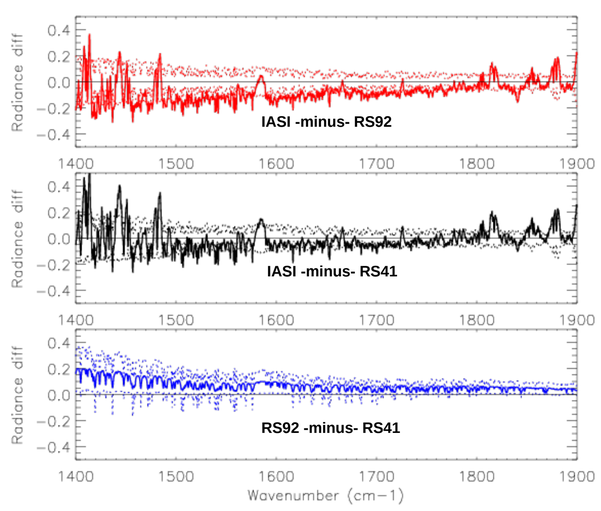

Figure 8. Mean difference (solid) curve between IASI observed and calculated (radiosonde) radiances (OBS-CAL) averaged from 16 daytime cases at Lauder, New Zealand for Vaisala RS92 (top) and for Vaisala RS41 (middle). The lower panel shows the corresponding RS92 minus RS41 differences. Dotted curves show two standard errors of the combined uncertainties.

Temperature differences in the lower stratosphere (51.5 to 26.1 hPa) appear to vary 0.1 to 0.2K based on the dual launches. For example, results from the GRUAN Lauder site shows RS41 appear to be less sensitive to changes in solar elevation angle than RS92 (Sun et al. 2019).

References

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