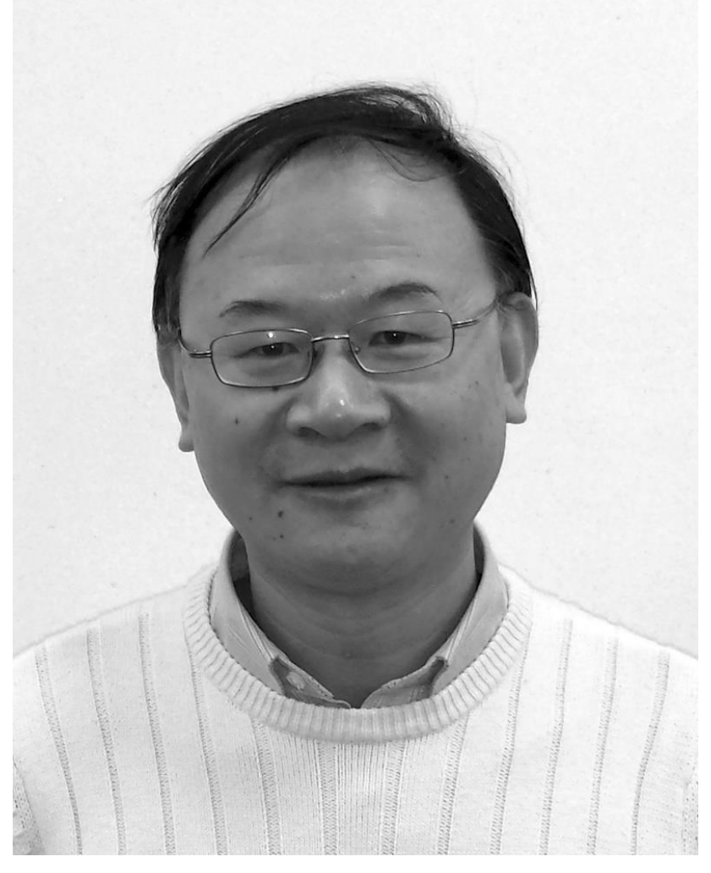

Accuracy of Newly Emerging Vaisala Radiosonde Humifity Measurements in Comparison with Satellite Hyperspectral Infrared Measurements

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Introduction

Radiosondes are important for calibrating satellite sensors and assessing sounding retrievals. Vaisala RS41 radiosondes have mostly replaced RS92 in the Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) and the conventional network. RS41 has been launched in field campaigns to synchronized with satellite overpass in satellite data calibration/validation.

This study assesses RS41 and RS92 upper tropospheric humidity (UTH) accuracy by comparing with Infrared Atmospheric Sounding Interferometer (IASI) upper tropospheric water vapor absorption spectrum measurements. Using single RS41 and RS92 soundings and RS92-RS41 dual at GRUAN and DOE Atmospheric Radiation Measurement sites, collocated with cloud-free IASI radiances (OBS), we compute Line-by-Line Radiative Transfer Model radiances for radiosonde profiles (CAL). We analyze OBS-CAL differences for daytime, nighttime, and dusk/dawn separately if data are available.

Vaisala RS41 vs. RS92

Figure 1. Vaisala RS41 radiosonde has been replacing the Vaisala RS92 in the past several years, becoming the major sonde type across the GRUAN and conventional network. (courtesy of https://www.vaisala.com).

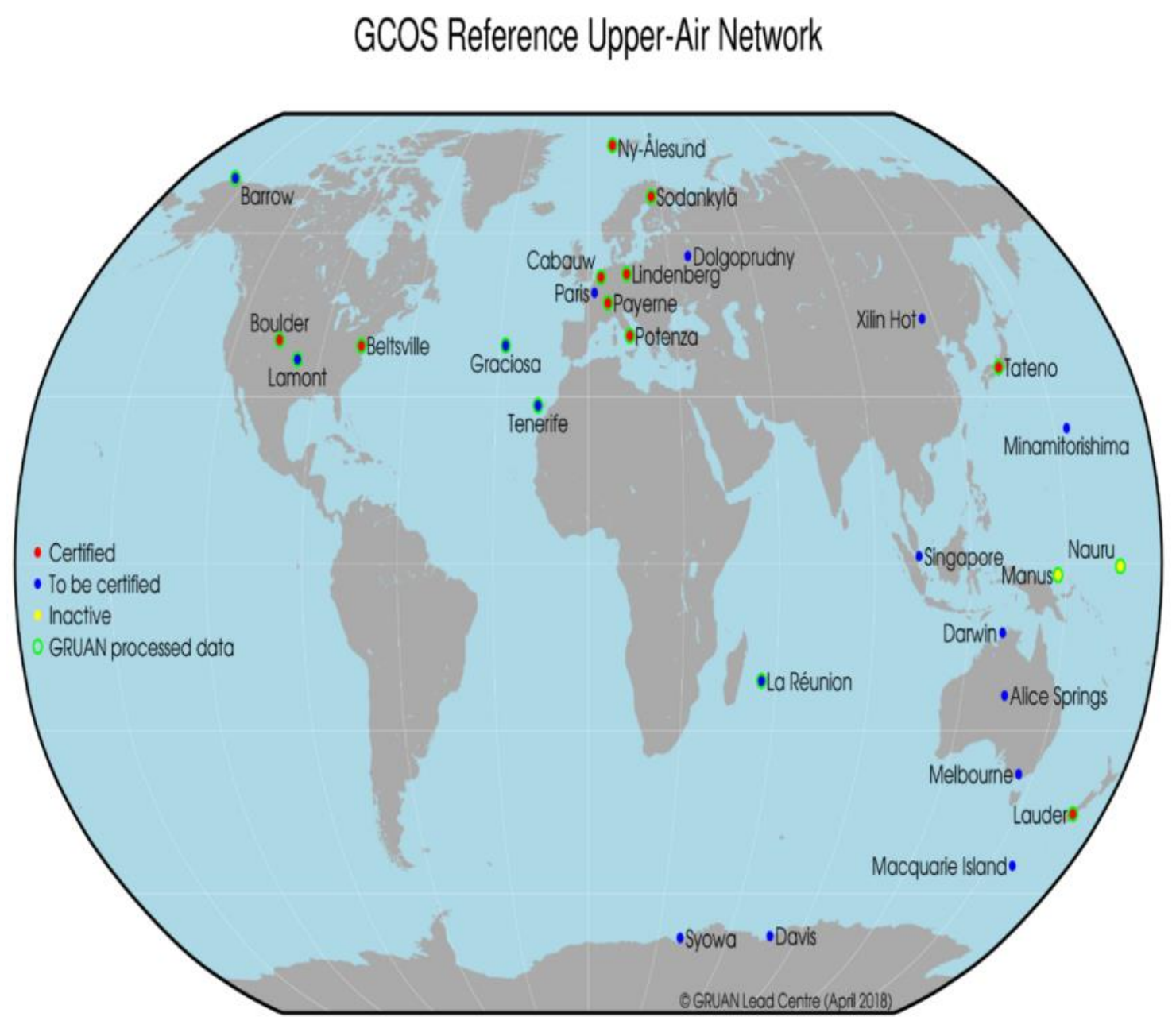

Figure 2. Current GRUAN sites. The GRUAN radiosondes, available from about 20 sites (currently active), are processed by GRUAN software (www.GRUAN.org) with the aim to provide fully characterized measurements and uncertainty estimates for each individual observation. Note, many dedicated radiosonde data have been GRUAN processed, thus expanding the GRUAN network in terms of site global distribution.

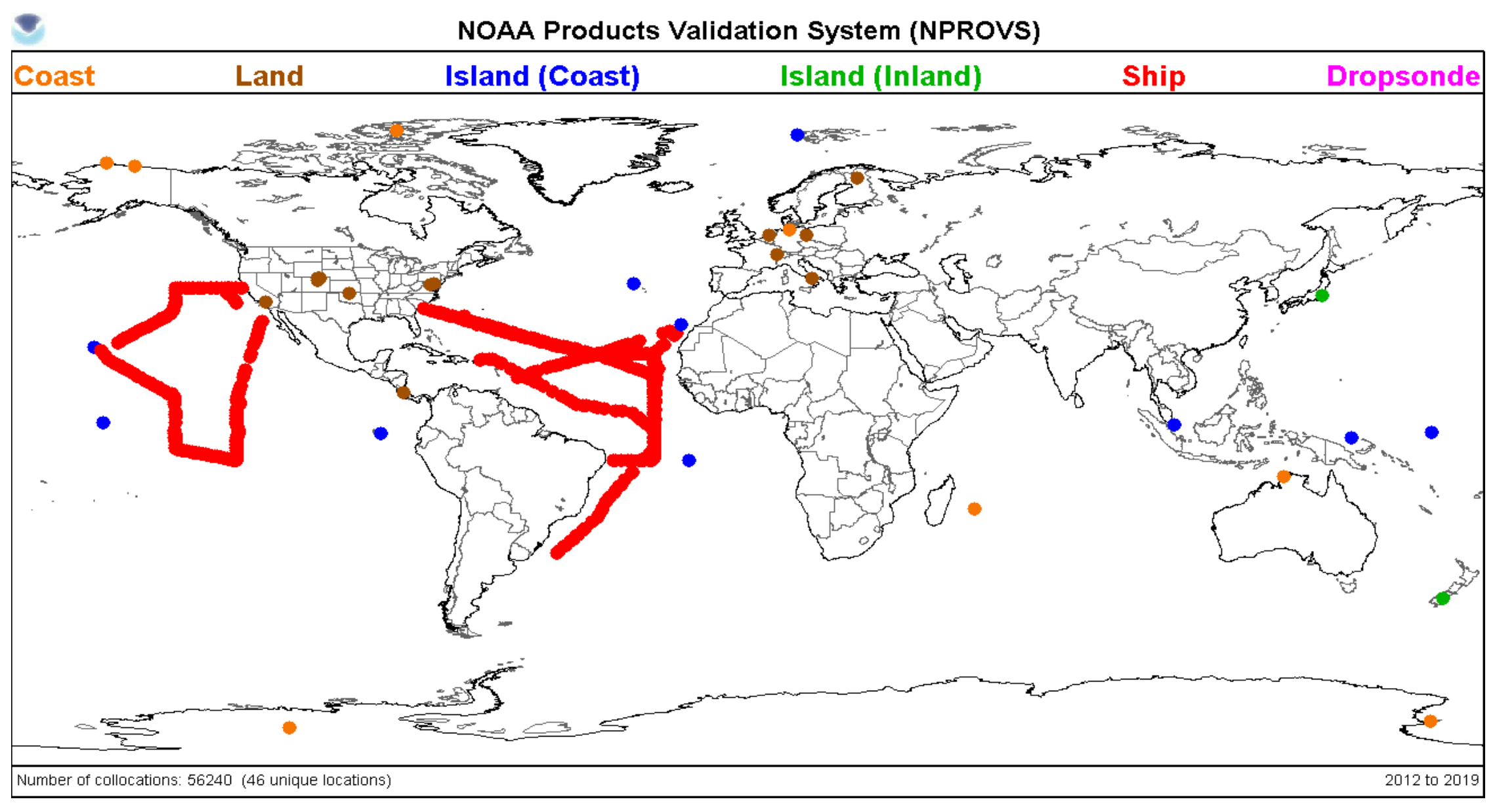

Figure 3. Spatial distribution of Special radiosondes including JPSS satellite synchronized dedicated radiosonde sites (including ship campaigns) and GRUAN. Half of the radiosondes from oceanic campaigns are synchronized with MetOp overpasses.

Data and Assessment Methodology

GRUAN and ARM sites with Vaisala RS41 and/or RS92 launches being coincident with MetOp-B IASI overpasses during 2015 and 2020 are used.

Assess methodology:

- Select radiosondes with 30 min before and 15 after IASI overpass.
- Conduct cloud screening to collocated IASI pixels to make sure the IASI scene is clear.
- Use Line-by-line RTM to compute radiances for radiosonde profiles (CAL).
- Compare the CAL with IASI radiance (OBS) for the upper tropospheric water vapor spectrums (1500-1800 cm^{-1}).
- Convert the OBS-CAL radiance difference to relative humidity difference for radiosonde bias quantification.
- Conduct the satellite and radiosonde consistency check by taking into account of collocation mismatch, and measurement errors.

Analysis of RS41-RS92 Dual Launches at Lauder, New Zealand

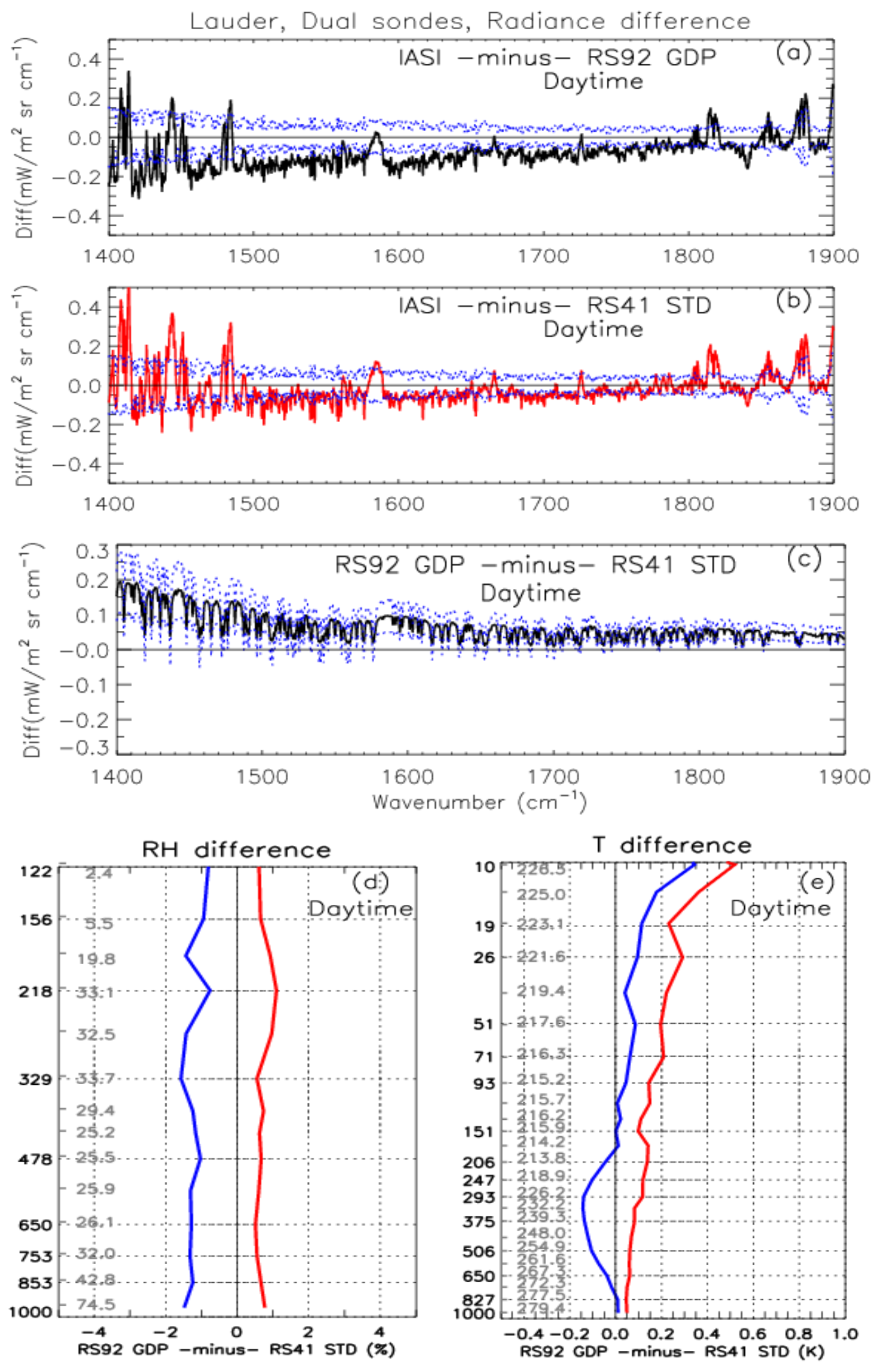

Figure 4. Lauder, New Zealand. RS92 is GRUAN Data Processing (GDP) while RS41 is vendor or standard processing (STD). (a-c) Mean radiance differences based on 14 dual launches, daytime within 1 hr of IASI overpass. (a) Solid line is mean difference between IASI observed radiances and calculated radiosonde radiances (OBS – CAL, IASI minus RS92 GDP). Dotted lines show ±2 standard errors (from zero) of the combined uncertainties (see text for more information). (b) As in (a) except for IASI minus RS41 STD based on the same dual flights. (c) Solid line is RS92 GDP minus RS41 STD. The dotted lines show ± one standard deviation of the RS92 GDP minus RS41 STD differences from the solid line. (d-e) Mean differences and standard deviations, RS92 GDP minus RS41 STD, at specified pressure levels (hPa), based on same dual launches as in (a-c). (d) Blue line is mean atmospheric relative humidity (RH) difference, averaged at specified pressure levels and red line is its standard deviation. Gray numbers toward left of plot are mean RS41 STD RH values (%) at marked pressure levels. (e) As in (d) except for mean atmospheric temperature difference, and gray numbers are RS41 STD mean temperature (K).

Analysis of Single RS41 Launches at North East Atlantic (ENA)

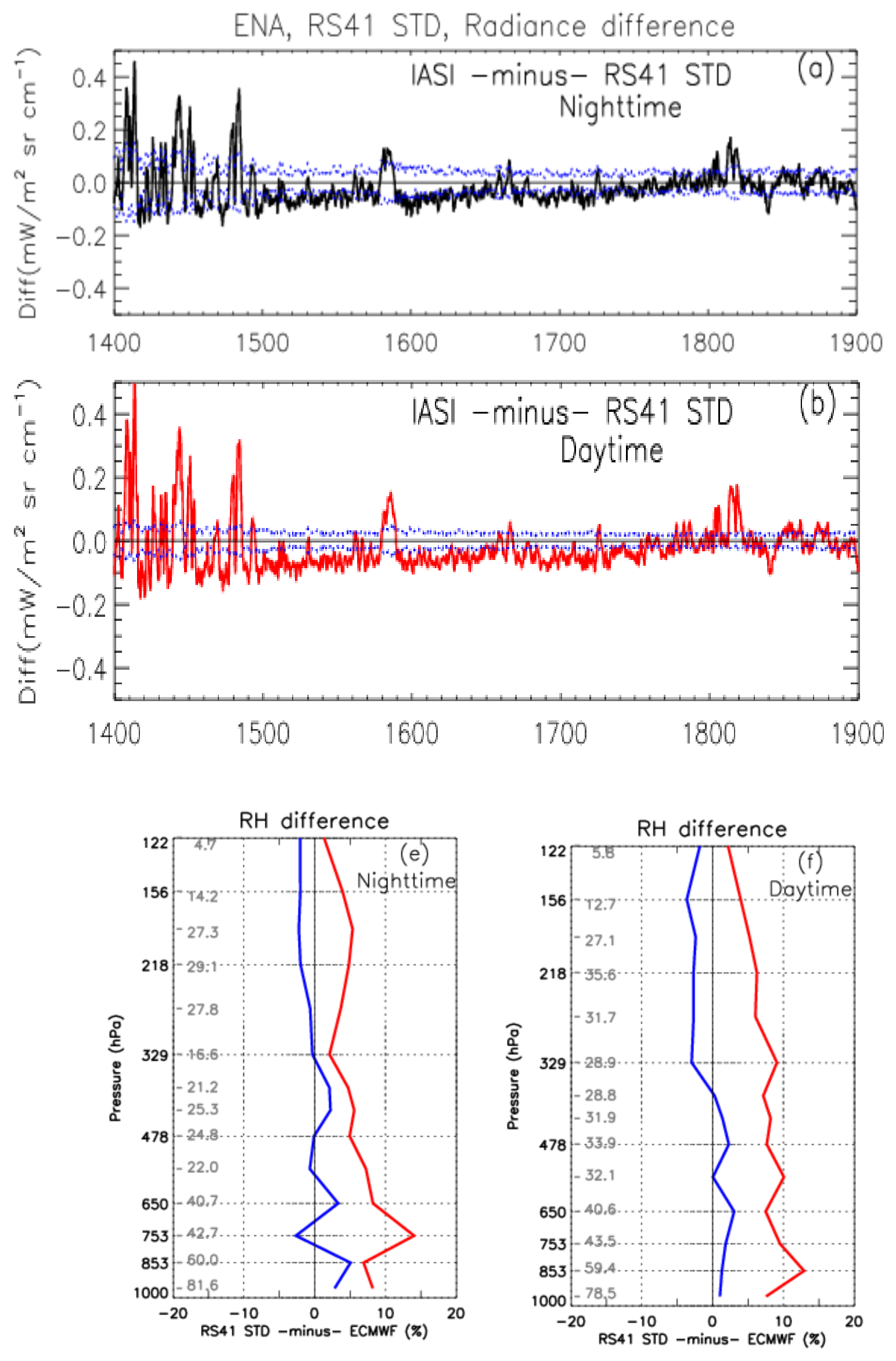

Figure 5. Eastern North Atlantic (ENA) at Graciosa, Azores, Portugal. (a-b) Mean OBS-CAL radiance differences and standard deviations as in Fig. 1a. (a) based on 12 night collocations, (b) based on 27 daytime collocations. (a,b) IASI minus RS41 STD. . (e-f) As in Fig. 3, but for RS41 STD minus ECMWF (plotted gray numbers are RS41 STD mean RH percentages), and based on (e) 12 night collocations and (f) 27 daytime collocations.

Analysis of Single RS92 Launches at North East Atlantic (ENA)

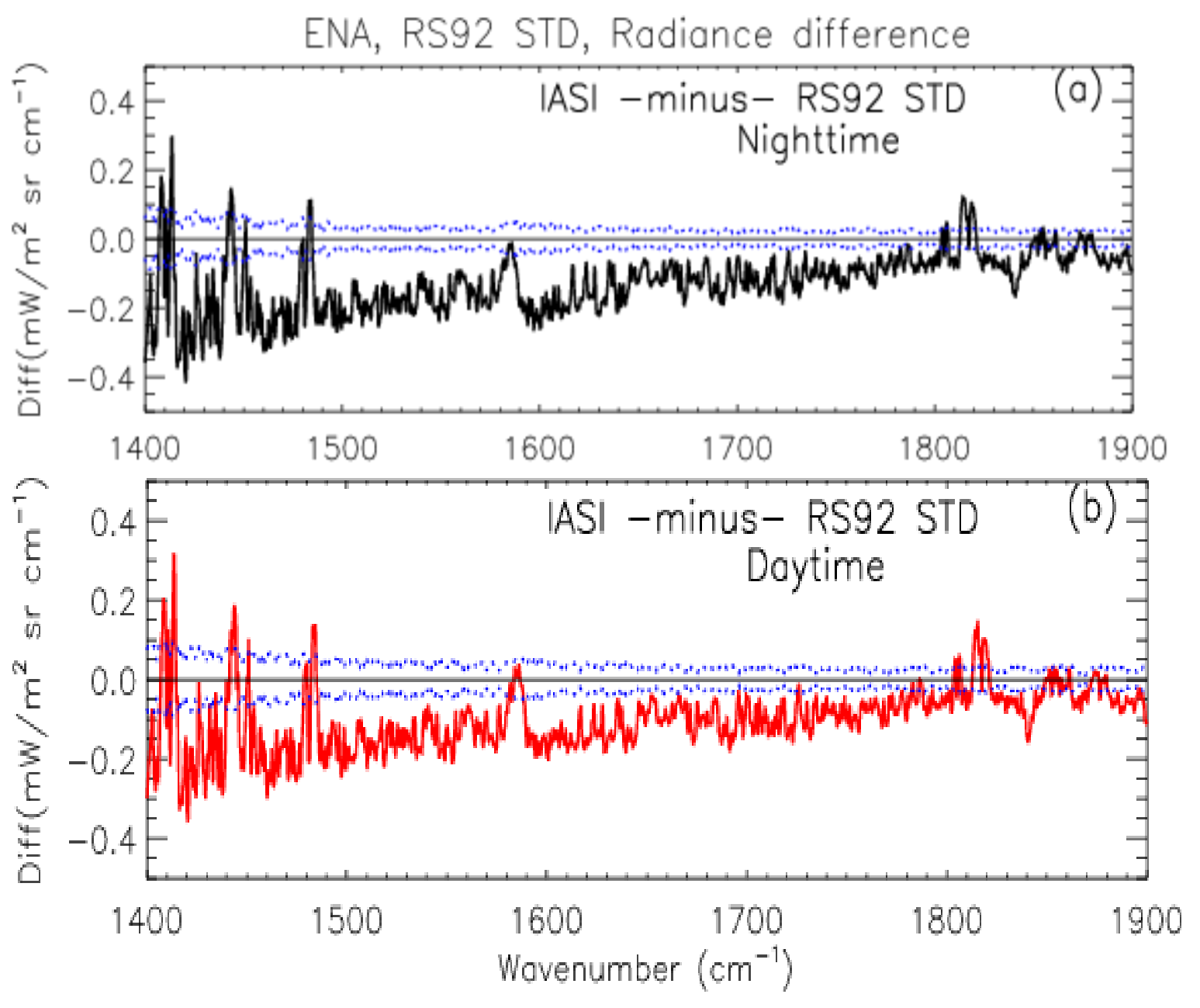

Figure 6. Eastern North Atlantic (ENA) at Graciosa, Azores. As in Figures 5a,b except for RS92 STD instead of RS41 STD, based on (a) 43 night profiles and (b) 50 daytime profiles.

Conclusion

- **Daytime RS41 (even without GDP) has ~1% smaller UTH errors than GDP RS92.**
- **RS41 may still have a dry bias of 1-1.5% for both daytime and nighttime, and a similar error for nighttime RS92 GDP.**
- **Standard RS92 may have a dry bias of 3-4%.**
- **Relative differences between RS41 STD and RS92 GDP are consistent with their differences obtained directly from the RH measurements.**

STAR Center for Satellite Applications and Research

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