4A.6 Utilizing NOAA Products Validation System (NPROVS) to Characterize Radiosonde Data

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1. INTRODUCTION

The National Weather Service's (NWS) Sterling Field Support Center (SFSC) routinely conducts evaluations on radiosondes for upper air observations as one of its primary missions. This activity is in support of the 102 operational upper air stations in the NWS network. SFSC targets specific metrics on which to test the radiosondes, either qualitatively (ex. Trending analysis) or quantitatively (ex. Point to point comparison). SFSC is the NWS's sole source for data quality metrics on radiosondes and as such must utilize all tools available for analyzing data quality and verification. The SFSC test suite is a comprehensive test cycle of all components of an upper air system including the ground station hardware, ground station software, signal processing units, radiosondes, tracking capability, and flight performance. Radiosonde specific tests include computer software repeatability flights, functional precision flights, operational-intercomparison tests, chamber reference tests, RF signal analysis, and GPS signal reference analysis.

The NOAA Center for Satellite Applications and Research (STAR) is the unit in NESDIS that connects the data from the scientific research community to the operational community. The NOAA Products and Validation System (NPROVS) is a software suite developed by NOAA STAR that has the capability for users to access on- demand calibration and validation products (NOTE: NPROVS will be used to describe both NPROVS and NPROVS+). This software includes a full graphical interface, specialized search tools, and a statistical analysis suite. The data is updated daily and published by the STAR team. For the purposes of this collaboration the software is able to optimize search results to provide the closest satellite collocation for a given radiosonde or numerical weather model. From there the user has an array of analysis tools for comparison of atmospheric profiles (Reale et al. 2012).

The NWS SFSC will be incorporating the usage of the NPROVS software developed by STAR in order to bolster the current testing, evaluation, and characterization capabilities.

2. PURPOSE

NWS and SFSC are always improving test methodology to incorporate new technology and techniques. SFSC realized the potential for utilizing the already compiled and easily accessed NPROVS comparisons as a sort of "baseline" to evaluate new, untested radiosondes against. The hypothesized impact of incorporation of this evaluation technique includes; (1) reduction in the number of live flights necessary to complete an evaluation, (2) ability to extrapolate expected test results based on current worldwide usage, and (3) ability to characterize deviations in radiosonde data quality after instrumentation change.

3. METHODOLOGY

3.1. OVERVIEW

The usage of satellite data for the NWS characterization of radiosondes will take place in three steps; (1) Retrospective analysis to obtain a baseline of current network operations, (2) analysis during multi-instrument balloon borne RAwinsonde OBservations (RAOB), and (3) post-installation analysis.

The primary statistical metrics used for this analysis are bias and standard deviation between the radiosonde and satellite/Numerical Weather Prediction (NWP) model. Meteorological variables, such as temperature and relative humidity are used to characterize a radiosondes performance. These meteorological variables and parameters were chosen due to commonality between radiosondes and satellites.

Retrospective analysis is used to determine the current bias and standard deviation between the satellite data and Current Operational Radiosondes (COR). The bias and standard deviation will be used as the reference point on which Unit Under Test Radiosondes (UUTR) vs Satellite biases will be compared. The baseline information to be gathered will consist of overall network statistics, biome-specific statistics, and site-specific statistics.

The second method for characterization will be usage of dual-bar RAOBs collocated with NPP satellite overpasses. COR will be flown with a UUTR. The COR vs Satellite biases will then be compared to the UUTR vs Satellite biases. The goal of this phase is to identify differences between these two biases, and if possible to identify specific characteristics about these biases differences (i.e. one Radiosonde warmer than the other). Ideally the results will then be extrapolated to provide pre-deployment forecasts of network wide data quality impacts.

Post-installation analysis will consist of determining the bias delta after replacement of a tracking system/radiosonde. The RAOB pre-installation biases will be compared with the RAOB post-installation biases. Biome representation sites will be chosen to examine the impacts of RAOB platform changes in different areas.

3.2. DATA COLLECTION

As previously stated NPROVS will be the primary source for data collection. SFSC will be providing the STAR team with test data, but ultimately they will retrieve the data from the NPROVS software. NPROVS identifies collocations between satellites based on user-set parameters. The collocation tolerances used in this characterization method are satellite overpasses of 6 h within 250 km of the radiosonde observation.

NPROVS provides data from the radiosondes based off of the WMO coded messages. These coded messages provide the same information regardless of radiosonde type or ground station. SFSC verifies accuracy of coded messages before utilizing the coded messages within a characterization environment.

NPROVS+ contains a specific dataset with higher temporal resolution than the coded messages. Characterizations during evaluation periods will utilize this higher resolution data as it becomes available from SFSC test campaigns.

NPROVS and NPROVS+ satellite data is gathered after the raw satellite data is processed and an atmospheric profile is produced. This is then uploaded into the NPROVS software and the data is formatted for comparisons with radiosondes.

4. PRELIMINARY RESULTS

SFSC and STAR have implemented the analysis techniques discussed in this paper on collocations of radiosondes during a test campaign at Sterling, Virginia (VA) and utilized the technique for a characterization of a radiosonde tracking system replacement in the Cooperative Hurricane Upper Air Station (CHUAS) network. These two tests represent retrospective analysis and post-installation analysis, respectively.

4.1. STERLING, VA

From winter 2015 to summer 2016, SFSC conducted a testing campaign which consisted of flying RS92s alongside LMS6s. These were not the optimal dual bar configuration, but they were flown within the same synoptic hour which is assumed to have the same atmospheric characteristics. Figure 1 displays the results of this comparison. Both radiosondes were compared against the European Centre for Medium-Range Weather Forecasts (ECMWF) model. The data shows both radiosondes trending very similar to the ECMWF up until about 100hPa. At this level the RS92 – ECMWF bias trends toward the negative indicating a warm bias in the radiosonde. This alone is not conclusive evidence of a measurement error, but it would prompt further investigation into the characteristics of the radiosonde measurements above 100hPa.

4.2. CHUAS NETWORK

In the winter of 2015-2016, NWS upgraded the upper air observing systems in the CHUAS network. This consisted of an entire overhaul of the tracking systems, computers, and radiosondes. This was a prime candidate for a characterization utilizing the NPROVS software. Before the transition the network was utilizing the Vaisala RS92-DD radiosonde tracked by the InterMet IMS-1500. After the transition the sites were flying the GRAW DFM-09 radiosonde tracked by the GRAW GS-E tracking system.

The timeframe used for the characterization was one year centered on the transition. Utilizing the NPROVs software the Global Forecast System (GFS), ECMWF Analysis, and the NOAA S-MetOP-A were selected as the transfer baseline. Biases against these baselines were then calculated. Figure 2 displays the result of the biases between the transfer baselines and the radiosondes. Initial trend analysis reveals a strong warm bias that weakens toward a neutral bias after the RS92 is replaced with the GRAW DFM-09. Obvious spikes during the transition are ignored and are likely explained by the sites acclimating to the new system.

5. FUTURE WORK

In February of 2016 SFSC will be characterizing and testing the Viasala RS41 radiosonde with the MW41 ground station. This will be the first use of the NPROVS validation method for radiosonde performance testing. The test will take place at Wallops Island, VA, a current operational NWS upper air site. The physical testing will feature a myriad of multi-radiosonde flights consisting of CORS, UUTRs, and reference radiosondes such as a Cryogenic Frostpoint Hygrometer (CFH). The retrospective analysis will be completed on the Wallops Island COR, the Lockheed Martin LMS-6. The COR bias will serve as a baseline to which SFSC and STAR will complete a comparison of the COR bias and the UUTR bias. The hypothesis remains that the analysis will show consistent Radiosonde vs. Satellite biases between the two instruments, allowing for extrapolation of the trends seen during this test.

6. REFERENCES

Reale, T., B. Sun, F. Tilley, and M. Pettey, 2012: The NOAA Products Validation System (NPROVS). *J. Atmos. Oceanic Technol.,* **29**, 629–645, doi: 10.1175/JTECH-D-11-00072.1.

7. FIGURES

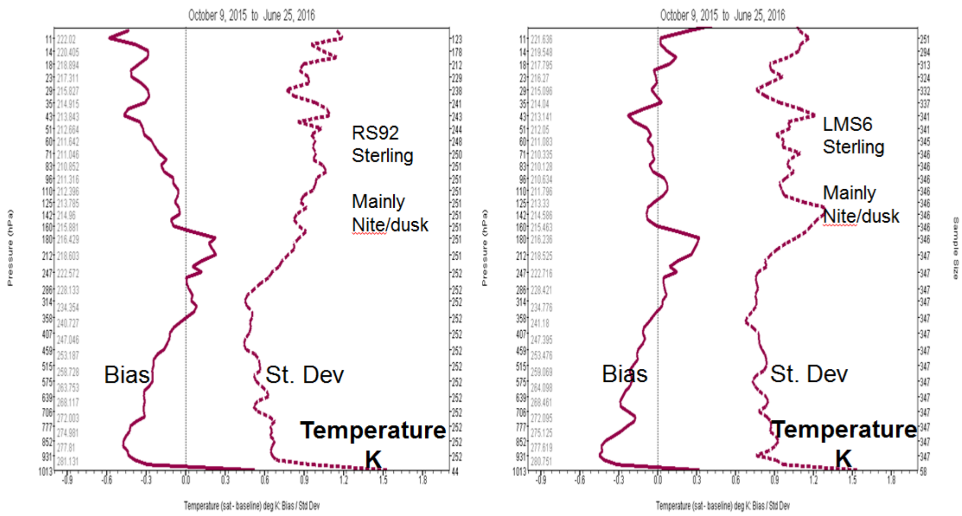

Figure 1 ECMWF – RAOB(RS92 Left/LMS6 Right) Sterling, VA

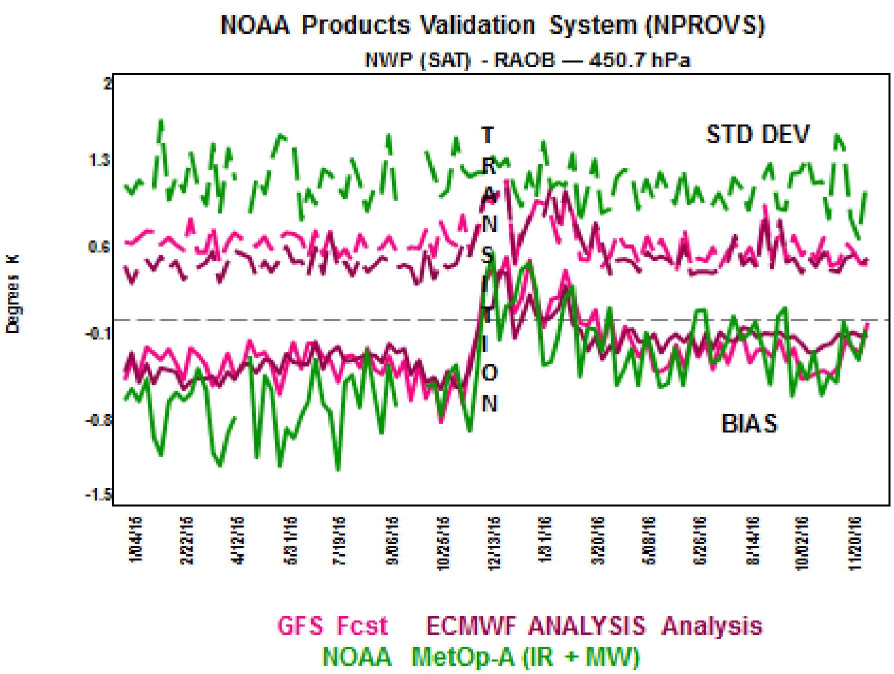

Figure 2 NWP/SAT - RAOB