681 NOAA AEROSOLS AND OCEAN SCIENCE EXPEDITIONS (AEROSE) AND SATELLITE SOUNDER VALIDATION

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1. INTRODUCTION

The Joint Polar Satellite System (JPSS) forms the next-generation, low Earth orbit, operational environmental satellite observing system in support of the U.S. National Oceanic and Atmospheric Administration (NOAA) (Goldberg et al. 2013). The first satellite in the JPSS series, the Suomi National Polar-orbiting Partnership (S-NPP), was launched in October 2011 to serve as the risk-reduction mission between the previous NOAA-series and the future JPSS-1 and -2 satellites. Onboard the JPSS series (including S-NPP) are new sounding instruments, specifically the high spectral resolution (hyperspectral) Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS). These two instruments synergistically comprise the Cross-track Infrared Microwave Sounder Suite (CrIMSS), a sounder system designed to retrieve atmospheric vertical temperature and moisture profiles (AVTP and AVMP), with optimal vertical resolution under non-precipitating conditions (cloudy, partly cloudy and clear), much like the MetOp-A and -B Atmospheric Sounding Interferometer (IASI) (e.g., Cayla 1993) and the Aqua Atmospheric Infrared Sounder (AIRS) (Chahine et al. 2006).

Validation of CrIMSS sounder AVTP and AVMP environmental data records (EDRs) (Nalli et al. 2013b; Divakarla et al. 2014) forms an important component within the JPSS calibration/validation (Cal/Val) program (Powell and Weng 2013), which is to ensure that the EDRs and sensor data records (SDRs) copy with JPSS Level 1 accuracy requirements (Nalli et al. 2013b). Within the general sounder validation methodology, dedicated/reference radiosonde observations (RAOBs) and intensive field campaigns are considered to comprise the top of the method hierarchy due to their high quality (Nalli et al. 2013b). As part of the intensive cal/val (ICV) and long-term monitoring (LTM) phases of the cal/val program, JPSS has directly and indirectly supported a dedicated RAOB program leveraging several collaborating institutions. As part of this program, JPSS has supported dedicated RAOB launches over open-ocean during NOAA Aerosols and Ocean Science Expeditions (AEROSE) (Nalli et al. 2011). An overview of the contributions of the AEROSE campaigns within the overall validation effort is briefly given in this work.

2. AEROSE SATELLITE CAL/VAL DATASETS

The NOAA AEROSE campaigns are a series of trans-Atlantic field experiments that have thus far been conducted onboard the NOAA Ship *Ronald H. Brown*on an almost yearly basis since 2004 (see Figure 1 for cruise tracks and Atlantic basin coverage) (Morris et al. 2006; Nalli et al. 2011). One of the science objectives of AEROSE campaigns is satellite EDR, SDR and radiative transfer model (RTM) cal/val (e.g., Nalli et al. 2006, 2008, 2011, 2013a). Satellite cal/val truth datasets acquired during AEROSE include dedicated RAOBs (Vaisala radiosondes dedicated to satellite overpasses and not assimilated into numerical models), Marine Atmospheric Emitted Radi-

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ance Interferometer (M-AERI) (Minnett et al. 2001), electrochemical concentration cell (ECC) ozonesondes, and other ancillary shipboard data including Microtops sunphotometers and Vaisala ceilometers (Nalli et al. 2011, 2013b). Sounder validation performed over open-oceans has the distinct advantage of having a uniform surface that is simpler to model (Nalli et al. 2006, 2011), and oceans are also where satellite data have the greatest impact on numerical weather prediction (NWP) (Le Marshall et al. 2006). The AEROSE domain is also a region of meteorological importance germane to satellite sounder missions, including the Saharan air layer (SAL) (e.g., Dunion and Velden 2004; Nalli et al. 2005), tropical storm formation, and tropospheric ozone/carbon/aerosol chemistry and transport (Morris et al. 2006; Nalli et al. 2011).

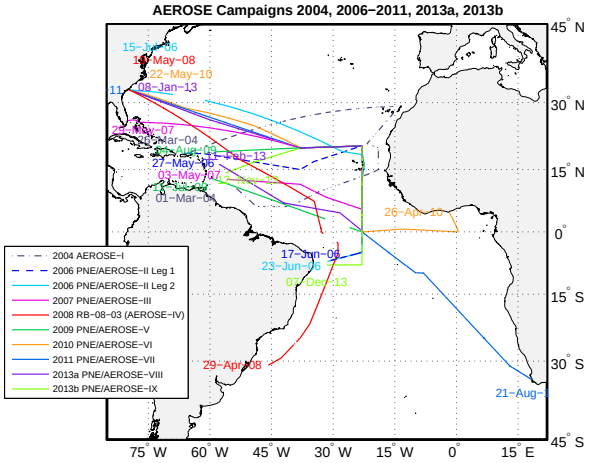

Figure 1: "Spaghetti plot" of AEROSE ship tracks and domain for ten 4–6 week cruise legs conducted in 2004, 2006–2011, and 2013).

Dedicated RAOB data acquired during AEROSE campaigns has served as truth data in the validation efforts of the Aqua AIRS (e.g., Nalli et al. 2006; Maddy et al. 2012), as well as pre-launch phase S-NPP CrIMSS (e.g., Nalli et al. 2012; Divakarla et al. 2012) and GOES-R proxy datasets (e.g., Xie et al. 2013). In the next section we present preliminary results using AEROSE data acquired during two campaigns conducted in 2013 for the MetOp-A NOAA-unique IASI and for the NOAA-Unique CrIS/ATMS Processing System (NUCAPS) (Gambacorta et al. 2014) during current ICV–LTM phase of the S-NPP satellite.

3. SATELLITE SOUNDER VALIDATION

There were two AEROSE campaigns conducted during 2013, the first during Jan–Feb (2013a), the second during Nov–Dec (2013b). Figure 2 shows the RAOB launch locations obtained during the 2013a cruise. There were a total of 11 Vaisala RS92 radiosonde launches, of which 67 and 43 were dedicated to S-NPP and MetOp-A overpasses, respectively.

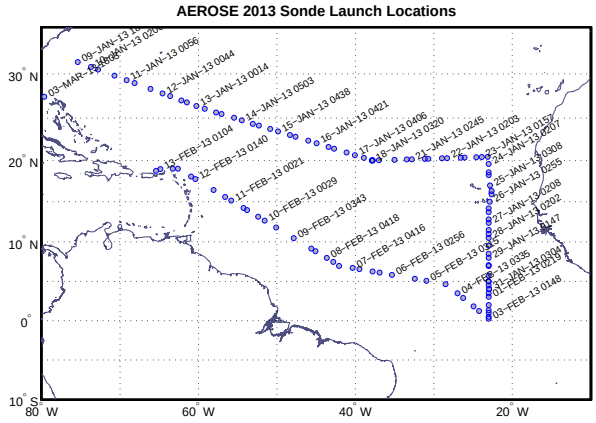

Figure 2: AEROSE 2013a dedicated Vaisala RS92 radiosonde launch locations.

The NOAA Products Validation System (NPROVS) (Reale et al. 2012), originally designed for operational RAOBs, is being extended to also acquire matchups for dedicated and reference RAOBs. Using this base RAOB matchup system, NOAA/STAR is also assembling an EDR validation archive (VALAR) whereby SDR granules in the vicinity of RAOB "anchor points" are acquired for EDR retrieval reprocessing (or "re-retrieval" for short), thus allowing validation flexibility and future algorithm development.

Figure 3 shows the CrIMSS NUCAPS field-of-regard (FOR) matchups acquired during the AEROSE 2013a campaign within 150 km radius of the RAOB launches. Figures 4 and 5 show the AVTP and AVMP EDR validation statistics for the S-NPP NUCAPS and the NOAA-unique IASI sounder products, respectively, versus AEROSE 2013a RAOB matchups; shown also in these figures are statistics versus the European Centre for Medium-Range Weather Forecasts (ECMWF). RMS, BIAS and STD (σ) statistics are calculated on coarse layers according to the methods and metrics detailed in Nalli et al. (2013b). For these tropical maritime samples ($n = 470$ and 379, respectively), the NUCAPS and NOAA-unique IASI AVTP and AVMP RMS (top left plot) are very close to meeting the specification performance requirements for the lower troposphere (cf. Nalli et al. 2013b, Tables 1 and 2). It should be borne in mind that while ocean cases may be seen as "easy," the matchup data acquired during these AEROSE campaigns include atmospheric

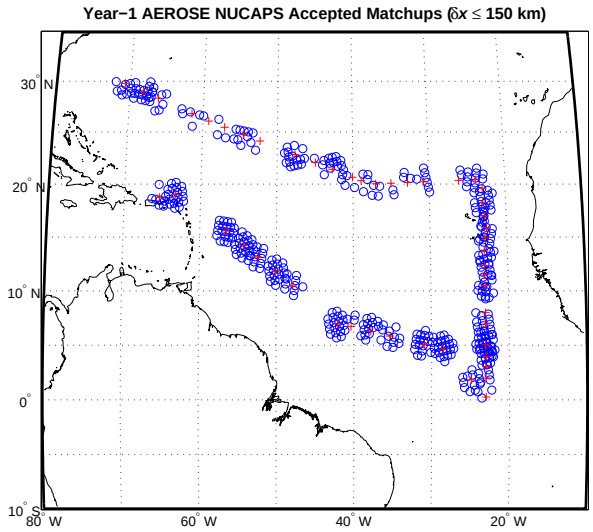

Figure 3: VALAR S-NPP CrIMSS NUCAPS matchup field-of-regard (FOR) locations within 150 km of AEROSE 2013a RAOB launches.

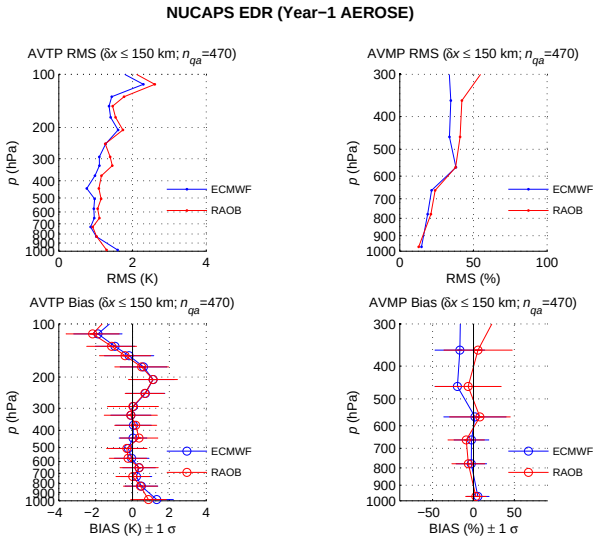

Figure 4: Preliminary assessment of NUCAPS EDRs over the tropical Atlantic Ocean versus dedicated RAOB matchups (for FOR within 150 km of RAOB launch locations) launched during the AEROSE 2013a campaign. The left and right columns are for AVTP and AVMP, respectively, with the top and bottom rows showing RMS and BIAS $\pm 1\sigma$, respectively. Red are results versus dedicated RAOBs, blue are versus ECMWF.

conditions that pose difficulties for sounder retrievals, including strong inversions associated with the SAL and subsidence, tropical convection within the intertropical convergence zone (ITCZ), and Saharan dust and smoke aerosols (Nalli et al. 2005, 2006, 2011).

4. FUTURE WORK

Within the JPSS cal/val program, the S-NPP CrIMSS NUCAPS Stages 1-3 validated maturities are upcoming milestones. Specific contributions of the AEROSE validation campaigns will include AVTP and AVMP validation over open ocean, under SAL, dust and smoke conditions; dust detection and retrieval improvement under dust conditions (e.g., Maddy et al. 2012); trace gas (e.g., O_3 and CO) profile validation and model assimilation (e.g., Smith and Nalli 2014); skin SST validation; and NUCAPS and NOAA-unique IASI EDR algorithm development. The next AEROSE is on hold until a suitable replacement is found for the *Ronald H. Brown*, which NOAA is deploying to the Pacific Ocean for the next several years.

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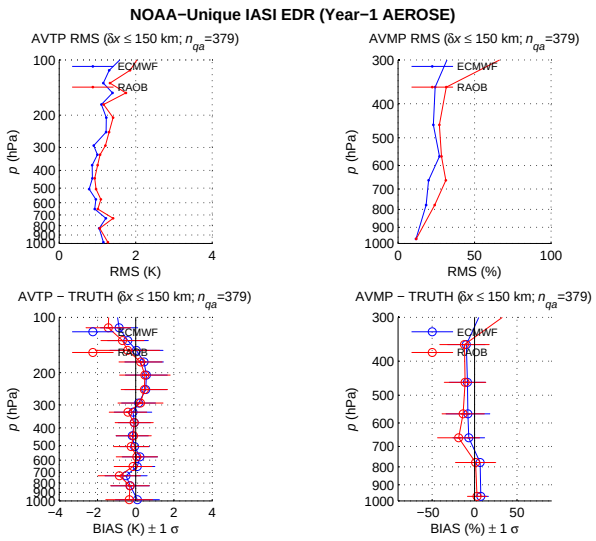

Figure 5: As Figure 4 except for NOAA-unique IASI EDR products.

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