High-Resolution Passive Millimeter-wave Measurements from Aircraft: Validation of Satellite Observations and Radiative Transfer Modeling

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The NPOESS Aircraft Sounder Testbed-Microwave (NAST-M) passive microwave spectrometer suite was used to help validate the radiometers (AMSU and MHS) on the MetOp-2/A satellite. Underflights of MetOp-2/A were made by the WB-57 high-altitude research aircraft during the Joint Airborne IASI Validation Experiment (JAIVEx – Apr. 2007). Microwave data from other satellites (Aqua, NOAA-16, and NOAA-17) will also be presented. Also, NAST-M data is used to validate the parameter tuning in a scattering Radiative Transfer Algorithm (RTA) coupled with a cloud circulation model. The NAST-M instrument suite includes a total of four spectrometers, with three operating near the oxygen lines at 50–57, 118.75, and 424.76 GHz, and a fourth spectrometer centered on the water vapor absorption line at 183.31 GHz. The NAST-M 54-GHz spectrometer has five channels corresponding to the AMSU-A instrument, and the 183-GHz spectrometer has three channels corresponding to the MHS instrument (or AMSU-B). This enables radiance-to-radiance comparisons, which can circumvent potential pitfalls and modeling errors that can be introduced when simulating spaceborne radiances. All four of NAST-M's feedhorns are co-located, and have 3-dB (full-width at half-maximum) beamwidths of 7.5°, which translates to ~2.5-km nominal pixel diameter at nadir incidence. The four feedhorns are directed at a single mirror that scans cross-track beneath the aircraft, spanning ± 65 degrees. The NAST-M sensor is mounted on an aircraft platform with a typical cruising altitude of 17-20 km, which results in a nominal swath width of 100 km. The high-altitude platform enables high spatial and temporal coincidence with satellite measurements, and NAST-M's 100-km swath width provides complete coverage of both AMSU and MHS nadir footprints. The paper will detail the essential techniques used to correct for the difference in altitude and view angle between the satellite and aircraft sensors along with procedure for co-locating NAST-M measurements with satellite measurements. The radiance-to-radiance comparisons will be evaluated against a purely simulated validation technique. The RTA parameter tuning utilizes the MM5 regional-scale circulation model to generate atmospheric thermodynamic quantities (for example, humidity and hydrometeor profiles). These data are then input into the Rosenkranz multiple-stream initial-value RTA [Rosenkranz, 2005] to simulate at-sensor millimeter-wave radiances at a variety of viewing geometries. The simulated radiances are filtered and resampled to match the sensor resolution and orientation. While the parameters chosen in the

circulation model are important, the focus of the current work is the parameter selection in the RTA, and we aim to extend the work of Surussavadee and Staelin to higher spatial resolutions (from 15 km to 2 km) and frequencies (from 183 GHz to 425 GHz). The RTA parameters are optimized by co-locating the model data with observations from the NAST-M instrument and choosing the parameters for which the RMS deviation between the simulated and actual brightness temperatures is minimized. The optimization is performed numerically with parameter sweeps using the MIT Lincoln Laboratory LLGrid High Performance Computing Facility, which consists of approximately 1000 Xeon processors. Over a dozen storms consisting of over 5,000 precipitation-impacted pixels have been studied. Comparisons of the observed versus calculated brightness temperatures will be presented. This work was sponsored by the National Oceanic and Atmospheric Administration under Air Force contract FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the authors and not necessarily endorsed by the United States Government.