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Thresholds of Passive Microwave Snowfall Detection Determined Using CloudSat and AMSU-B

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The Global Precipitation Measurement (GPM) mission core satellite will feature a higher-inclination (65°) orbit than its predecessor, the Tropical Rainfall Measuring Mission (TRMM), with some constellation radiometers in polar orbits. At these higher latitudes, a significant fraction of precipitation falls as snow, and higher-frequency microwave channels (e.g., 183±3,5,7 GHz) will be available on the core satellite as well as many of the constellation radiometers in order to take advantage of their increased sensitivity to the scattering signature associated with ice particles.

An important consideration for GPM passive microwave precipitation retrieval algorithms is the source of a-priori information used to generate Bayesian databases. Historically, cloud resolving models have been used to generate these databases, however, these models may not adequately or fully represent the true global distribution of precipitation profiles. Hence, more modern Bayesian databases are being built with observational data. Because TRMM lacks the high frequency channels and high latitude coverage of GPM, the GPM at-launch databases for the passive microwave Bayesian retrievals must be developed from alternate combinations of passive and active sources or in-situ data. One combination of sources on existing satellite platforms is the active W-band radar on CloudSat and the Advanced Microwave Sounding Unit-B (AMSU-B), which operates at similar frequencies to the high frequencies on the GPM microwave imager (GMI).

In this study we explore a database of CloudSat+AMSU-B coincident overpasses to determine the minimum threshold of passive detection of snowfall using the combination of microwave channels available on GMI. The presence of CloudSat on the A-Train also provides the opportunity to take advantage of other A-Train sensors such as the Atmospheric Infrared Sounder (AIRS), the Moderate Resolution Imaging Spectroradiometer (MODIS), and Advanced Microwave Scanning Radiometer-EOS (AMSR-E). Using the AIRS temperature and water vapor profiles along with surface and cloud cover information from MODIS and AMSR-E, clear-sky and non-precipitating cloudy-sky radiances are simulated and compared to AMSU-B observed radiances in the presence and absence of CloudSat-detected snowfall. The reflectivity threshold (and corresponding snowfall rate) required to produce a radiance significantly different from clear-sky (or non-precipitating cloud) are reported for a variety of surface types (e.g., bare land, snow-covered land, water) and column water vapor values for each channel and combination of channels as an assessment of expected at-launch GPM passive algorithm capabilities. A parallel effort for determining thresholds of detection using cloud-resolving model simulations and theoretical computations of reflectivities and passive microwave brightness temperatures using a variety of assumptions regarding ice crystal shape and size distributions will be compared with the observational database results.