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Falling snow retrievals from space

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The Global Precipitation Measurement (GPM) mission has a requirement to detect falling snow because falling snow should be captured to obtain the true global precipitation water cycle, snowfall accumulations are needed for hydrological studies, and without knowledge of the frozen particles in clouds one cannot adequately understand the Earth's energy and radiation budgets. We emphasize the use of high frequency passive microwave channels (85-200 GHz) since these are more sensitive to the ice in clouds. The challenges of estimating falling snow from space mainly include (1) weak falling snow signatures with respect to background (surface, water vapor) signatures for passive sensors over land surfaces and (2) differences in near surface snowfall versus total column snow amounts. While these challenges remain, progress is being made and knowledge of their impact on expected retrieval results is important for improving falling snow retrieval estimations.

This research is two pronged: (1) determine the percent of the brightness temperature from each component in the underlying field of view, and (2) determine the thresholds of detection for various falling snow events. The results rely on simulated Weather Research Forecasting (WRF) simulations of falling snow cases and the data from the Canadian CloudSat/CALIPSO Validation Program (C3VP) field campaign held from October 2006 through March 2007. The field campaign was heavily instrumented on the ground, with aircraft and with CloudSat and AMSU-B satellite overpasses. The simple process to detect falling snow is to compute clear air TB and compare to the precipitating cases. When the differences deviate significantly from zero (zero is expected under clear air conditions), then precipitation is considered detected. The WRF simulations are used to compute TBs for channels from 10 to 183 GHz over the great lakes and snow-covered and snow-free surfaces. These computed TB are compared to C3VP measurements and used in thresholds of detection analysis.

The percentage analysis results are presented for frequencies from 10 to 874 GHz. These results show that for snowing cases, the surface emission contributes more than 65% to the TB seen from space for channels < 89 GHz. This surface emission (if not accounted for) can contaminate the TB signal from the atmospheric falling snow and cause errors in the retrievals. The bulk structure (e.g., IWP, cloud depth) of the underlying cloud scene was also found to affect the resultant TB and percentages, producing different values for the blizzard, lake effect, and synoptic snow events. Comparing to other sensitivity techniques, Jacobians provide the magnitude and direction of change in the TB values due to a change the underlying scene, while the percentage analysis provides detailed information on how that change affected contributions to the TB from the surface, hydrometeors, and water vapor.

This work allows for an improved understanding of the relationships between radiative properties associated with radar reflectivities, brightness temperatures (TB), and the physical properties of frozen precipitation within a cloud. We will show how we validate our results using CloudSat data and other C3VP observations. This work is important for preparing for the upcoming GPM mission.