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Use of coincident radar and radiometer observations from GPM, ATMS, and CloudSat for global spaceborne snowfall observation assessment

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Snowfall is the main component of the global precipitation amount at mid and high latitudes, and improvement of global spaceborne snowfall quantitative estimation is one of the main goals of the Global Precipitation Measurement (GPM) mission. Advancements in snowfall detection and retrieval accuracy at mid-high latitudes are expected from both instruments on board the GPM Core Observatory (GPM-CO): the GMI, the most advanced conical precipitation radiometer with respect to both channel assortment and spatial resolution; and the Dual-frequency Precipitation Radar (DPR) (Ka and Ku band). Moreover, snowfall monitoring is now possible by exploiting the high frequency channels (i.e. >100 GHz) available from most of the microwave radiometers in the GPM constellation providing good temporal coverage at mid-high latitudes (hourly or less). Among these, the Advanced Technology Microwave Sounder (ATMS) onboard Suomi-NPP is the most advanced polar-orbiting cross track radiometer with 5 channels in the 183 GHz oxygen absorption band. Finally, CloudSat carries the W-band Cloud Profiling Radar (CPR) that has collected data since its launch in 2006. While CPR was primarily designed as a cloud remote sensing mission, its high-latitude coverage (up to 82° latitude) and high radar sensitivity (∼-28 dBZ) make it very suitable for snowfall-related research.

In this work a number of global datasets made of coincident observations of snowfall producing clouds from the spaceborne radars DPR and CPR and from the most advanced radiometers available (GMI and ATMS) have been created and analyzed. We will show the results of a study where CPR is used to: 1) assess snowfall detection and estimate capabilities of DPR; 2) analyze snowfall signatures in the high frequency channels of the passive microwave radiometers in relation to fundamental environmental conditions.

We have estimated that DPR misses a very large fraction of snowfall precipitation (more than 90% of the events and around 70% of the precipitating snowfall mass), mostly because of sensitivity limits of the DPR and secondly because of the effect of side lobe clutter. We will show that improved DPR detection capabilities (> 50%) of the snowfall mass can be achieved by optimally combining Ku-band and Ka-band measured reflectivity and exploiting the weak signals related to snowfall.

ATMS–CPR, GMI–CPR, and GMI-DPR coincident observations have been analyzed in order to study the multichannel brightness temperature signal related to snowfall. The main results of this study show that the high frequency channels (and the 183 GHz band channels in particular) can be successfully used to identify snowfall, but results depend strongly on proper identification of surface background and proper estimation of integrated water vapor content. In this context a new algorithm for surface classification using primarily ATMS (and GMI) low frequency channels, and identifying different snow-covered land surfaces and ice or broken-ice over ocean, is proposed and will be presented.