Snow, another precipitation form besides rain, affects the Earth’s climate distinctly by modifying hydrological and radiative processes. The radiative properties of nonspherical snowflakes are much more complicated than their spherical counterparts, raindrops. Snowflakes with different structures tend to have different scattering properties. Thus, it is important for us to increase the knowledge in falling snow. However, only a few sensors have been available so far that can provide global snowfall measurements including those onboard he Global Precipitation Measurement (GPM) core observatory and the CloudSat satellites. The GPM satellite carries two important instruments for studying snow precipitations, i.e., the Dual–frequency Precipitation Radar (DPR) and the GPM Microwave Imager (GMI). By combining the GPM instruments with another active sensor onboard the CloudSat satellite, the Cloud Profiling Radar (CPR), an unprecedented opportunity arises for understanding the microphysics of snowflakes and the physical processes of snow precipitation. Seizing this opportunity, in this study, we firstly investigate the microphysical properties of snow particles by analyzing their backscattered signatures at different frequencies. Then, the accuracy of simulating passive microwave brightness temperatures at high frequencies is examined under snowfall conditions using the CPR derived snow water content profiles as radiative transfer model inputs. Lastly, a passive microwave snowfall retrieval method is developed in which the *a priori* database is optimized by tuning snow water content profiles to be consistent with the GMI observations.

To understand the microphysical properties of snow clouds, the triple-frequency radar signatures derived from the DPR and CPR collocated measurements are analyzed. It is noticed that there is a clear difference in triple-frequency radar signatures between stratiform and convective clouds. Through modeling experiments, it is found that the triple-frequency radar signatures are closely related to the size and bulk density of snow particles. The observed difference in triple-frequency radar signatures are mainly attributed to the difference in prevalent particle modes between stratiform and convective clouds, i.e., stratiform snow clouds contain abundant large unrimed particles with low density, while dense small rimed particles are prevalent in convective clouds.

To assess the accuracy of radiative transfer simulation for passive microwave high frequency channels under snowfall conditions, we evaluate the biases between observed and simulated brightness temperatures for GMI channels at 166 and 183 GHz. A radiative transfer model is used, which is capable to handle the scattering properties of nonspherical snowflakes. As inputs to the radiative transfer model, the snow water content profiles are derived from the CPR measurements. The results indicate that the overall biases of observed minus simulated brightness temperatures are generally smaller than 1 K except for the 166 GHz horizontal polarization (166H) channel. Large biases for GMI channels are found under scenes of low brightness temperatures. Further investigations indicate that the remaining biases for GMI channels are associated with either shallow or deep convective snow clouds. In shallow clouds, errors in cloud liquid water profiles are likely responsible for the large bias at the 166H channel. In deep convective clouds, strong attenuation in CPR radar reflectivities and possible sampling bias both contribute to the GMI remaining biases.

A snowfall retrieval algorithm is then developed for GMI observations. The data sources and processing methods are adopted from the above study of GMI bias characterization. First, an *a priori* database is created which contains the snow water content profiles and their corresponding brightness temperatures simulated for GMI channels. A one–dimensional variational (1D–Var) method is employed to optimize the CPR derived snow water content profiles. The so developed *a priori* database is applied in a Bayesian retrieval algorithm. The retrieval results show that the 1D–Var optimization can improve the vertical structure of retrieved snow water content. Additionally, this method can bring the global mean distribution of GMI retrieved surface snow water closer to the CPR estimates.

This research explores the application of spaceborne microwave measurements to snowfall studies by combining CloudSat and GPM instruments. It provides new knowledge on snowflake microphysics and applicable methods in retrieving three–dimensional snow water distribution from passive high frequency microwave measurements.