A triple-frequency radar for cloud and precipitation microphysical profiling

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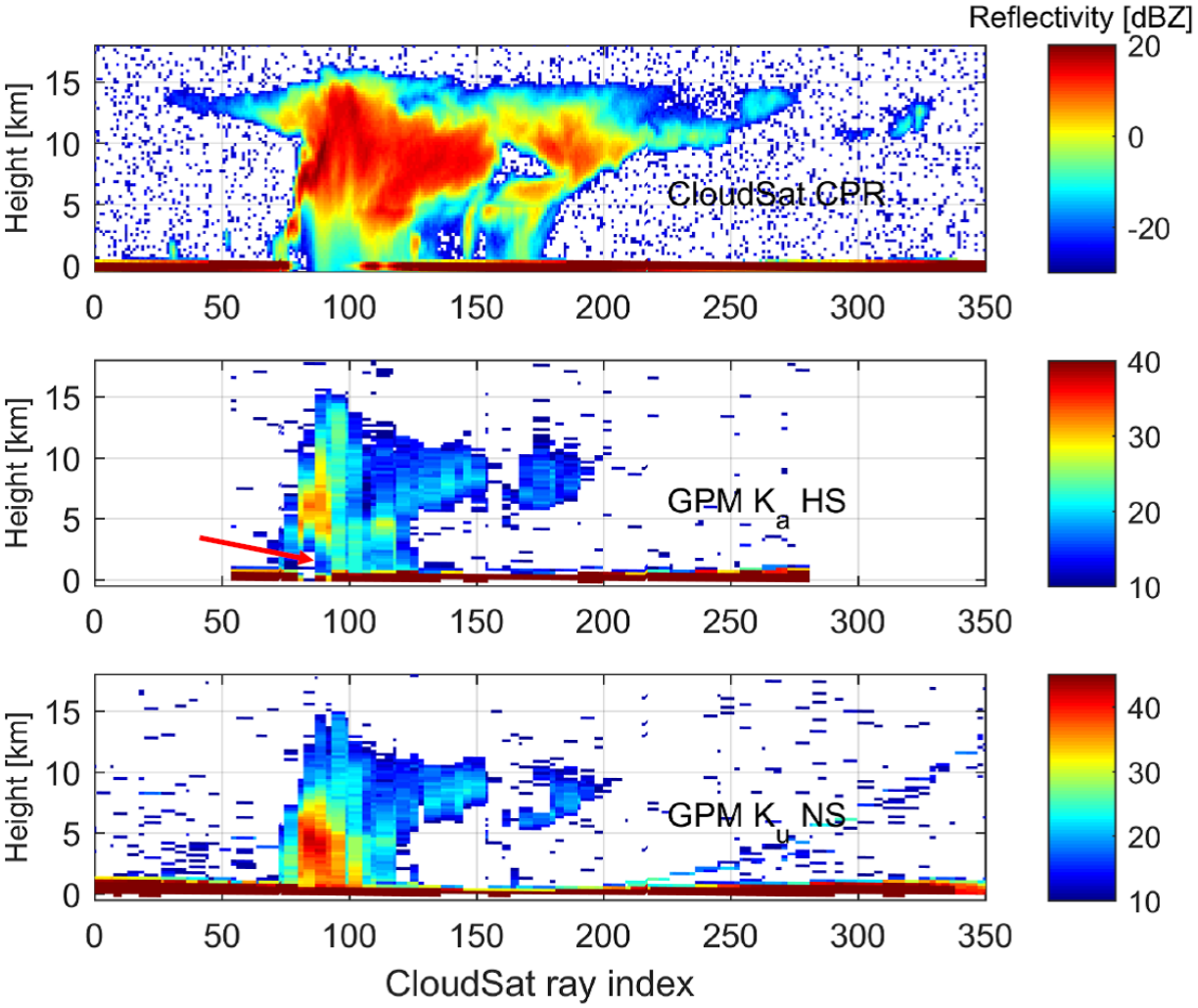
Triple frequency radar facilities have become increasingly popular over the last 5-10 years both at ground-based sites and mounted on airborne platforms. The availability of triple frequency radar observations allows seamless coverage from weak non-precipitating clouds to tropical convection and offer additional constraints in the retrieval of the hydrometeor characteristic size and water content through the application of differential scattering and absorption techniques. These advantages are expected to influence the design of the Clouds, Convection and Precipitation (CCP) future mission that was recently identify as one of the priority missions in the latest NASA’s Decadal Survey. The CCP mission is designated to study the coupled cloud-precipitation state and its dynamics. As part of early studies related to the CCP mission the potential of a multi-frequency radar-based mission for targeting cloud and precipitation microphysics will be explored. Some of the advantages in multi-frequency radar observations from space can be exploited using the coincident observations from the CloudSat Cloud Profiling Radar and the NASA-JAXA Global Precipitation Measuring Dual Precipitation Radar epitomize the potential of space-borne multi-frequency radar observations of the same precipitating system (Figure 1). Two aspects of the multi-frequency approach are paramount.1) Complementarity: cm and mm-radars are effective in mapping different parts of the precipitating system because of their different sensitivities and ranges of signal attenuation. 2) Synergy: in the regions where all radars produce detectable signals they can be used synergistically in order to better retrieve cloud microphysical properties by exploiting the complex interplay between non-Rayleigh and attenuation effects.
In this paper the benefits and potentials of a triple-frequency Ku-Ka-W band radar approach for better constraining rain and ice microphysics will be discussed on a theoretical basis and then demonstrated for a stratiform case study extracted from the OLYMPEx/RADEX (Olympic Mountain Experiment/Radar Definition Experiment 2015) field campaign with simultaneous Ku-Ka-W band radar and in-situ observations collected from two aircrafts. A variational method enables the retrieval of the full precipitation profile above and below the melting layer, by combining the observations from the three radars and from microwave radiometers. Even with three radar frequencies, the retrieval of rain properties is challenging over land, where the path integrated attenuation is not available. Otherwise, retrieved mean volume diameters and water contents of both solid and liquid precipitation are in agreement with in-situ observations and the multi-frequency approach is effective in capturing different ice microphysical processes (e.g. aggregation vs riming).

Keywords: multi-frequency radar, precipitation retrieval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Height [km]
CloudSat CPR
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GPM K_u NS
CloudSat ray index