Space borne Dual Frequency Radar signatures of Hail and Graupel

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***Abstract*—This paper focuses on the study of hail and graupel signatures of GPM-DPR. Some of these signatures show multiple scattering features that cannot be explained by single scattering theory. For this study, we focus on several cases from May 2015 – July 2016. First, the DPR measurements are compared with the dual-pol ground radar measurements, to select the cases of hail and graupel. Next, the profiles that show multiple scattering features are examined for their peak values of reflectivity as well as the values in ice phase. Profiles that do not show multiple scattering features in hail and graupel are also documented.**

I. INTRODUCTION

The Global Precipitation Measurement (GPM) mission is an international satellite mission which will help in improved observations of rain and snow all over the world. As a part of this GPM mission, on February 2014, the GPM observatory satellite was launched by Japan. The GPM has onboard a Dual-Frequency Precipitation Radar (DPR). The DPR operates at two different frequency channels – 13.6 GHz (Ku-band) and 35.5 GHz (Ka-band). As a successor of the popular and effective Tropical Rainfall Measurement Mission (TRMM), the GPM offers more wider global coverage from 65^0N – 65^0S and high resolution 3D dual frequency precipitation data from space. The newly added Ka-band has a high sensitivity mode with which the DPR can sense better the winter precipitation such as the light rain and falling snow. These account for significant fractions of precipitation in the mid and high latitudes.

II. DUAL FREQUENCY RATIO

The presence of DPR on board the GPM observatory satellite, enables us to study the difference in reflectivity measurement at two frequencies. This is called as the measured Dual Frequency Ratio (DFRm). The word measured is used to indicate that the reflectivity values used for DFRm calculation, are measured values i.e., not corrected for attenuation.

$$\text{DFRm} = Z_{\text{measured}}(\text{Ku}) - Z_{\text{measured}}(\text{Ka}) \qquad (1)$$

Z(Ku) and Z(Ka) are the values of measured reflectivity at Ku and Ka bands. The shape of the DFRm profiles and their vertical features have been used in the classification module of level-2 DPR algorithm [1]. Here, we will use the DFRm profiles to study the GPM-DPR signatures of hail and graupel.

III. MULTIPLE SCATTERING FEATURES

Previous studies have shown the evidence of occurrence of multiple scattering features in certain DFRm profiles over hail and graupel regions [2]. Such features shown by the vertical profiles of reflectivity at Ka-band as well as DFRm cannot be explained by single scattering theory. Some typical features for a Multiple Scattering profile are inferred from such previous works. The anomalous small slope of reflectivity at Ka-band, which should have been otherwise in a deep-convection; masking of surface returns; presence of a knee in the DFRm with a large vertical extent, about 20 dBZ; large reflectivity in Ku-band, exceeding 40 dBZ and the Ka band showing reflectivity greater than 30 dBZ in the ice phase region are some of the features. We will study these features in the selected profiles.

IV. OVERPASS CASE STUDIES

For the current study, the DPR measurements are compared with simultaneous dual-polarized measurements from ground radars for several cases during May 2015-July 2016. The comparison is done to select the cases of graupel and hail as detected by the ground radars. The S-band dual-pol WSR-88D (NEXRAD) across various locations from the continental United States are chosen as ground radars. Simultaneous observations of precipitation between ground radar and DPR are carefully chosen such that the inner swath of the GPM-DPR, has had a good overpass within 100 km of ground radar. Also, consideration is given to the temporal closeness of the observation between the ground radar and the GPM-DPR. Hydrometeor classification is performed for the ground radars and compared with the DPR results [3]. For the DPR reflectivity profiles showing multiple scattering features, the depth of DFRm knee, the peak value of reflectivity at Ka-band in ice phase region etc. are presented. Some of the DPR profiles over hail and graupel region do not show these multiple scattering features. Such profiles are also documented as they could have the potential for furthering our understanding of observations of hail and graupel from GPM-DPR. Two sample cases are shown here - one for graupel and one for hail. Vertical profile from GPM-DPR for the case from 20160629 UTC, with graupel present about 80km and 210^0 from the KCLX radar located in Charleston, South Carolina is shown below. It is interesting to note that the Ku band reflectivity reaches well to about 45 dBZ and the Ka-band reflectivity decreases little from about 30 dBZ in ice phase to about 15 dBZ near the ground. The DFRm peak reaches close to 20 dBZ and the entire extent of the DFRm knee stretches from about 4.5 km till the ground. There is a reduction of about 10 dBZ in the DFRm below the knee region till the ground.

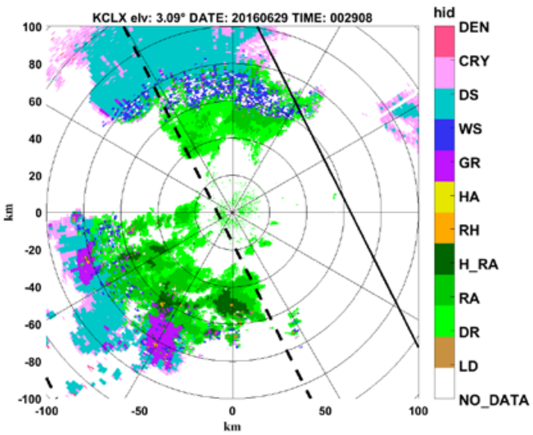

Fig.. 1. Hydrometeor Classification from KCLX (NXRAD)

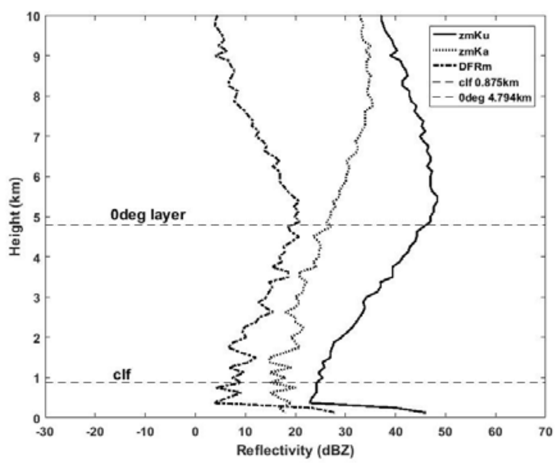

Fig. 2. Vertical Profile from GPM-DPR for Graupel region

Another vertical profile from GPM-DPR for hail region is shown next. The case is from 20160429 UTC with the hail located about 80km and 160^0 from the KICT radar in Wichita, Kansas. For this hail case we can see that the Ku band reflectivity reaches to about 52 dBZ and the Ka band is showing about 30 dBZ for most of the ice phase above the 0^0C height. Also, the DFRm has a peak value little greater than 20 dBZ.

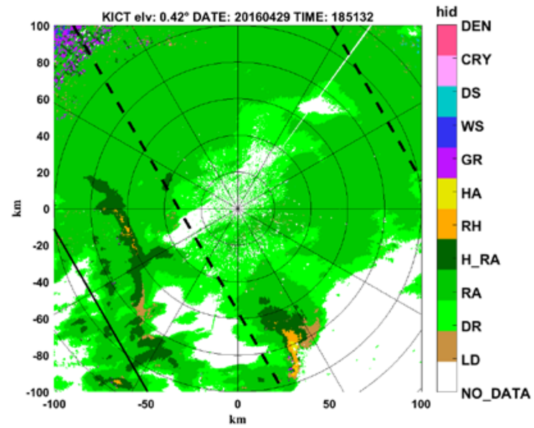

Fig.. 3. Hydrometeor Classification from KICT (NEXRAD)

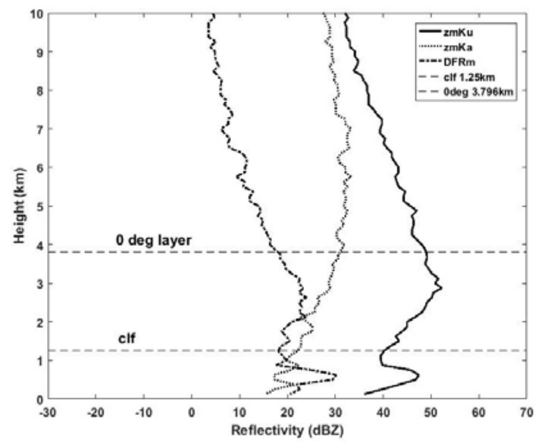

Fig.. 4. Vertical Profile from GPM-DPR for hail region

V. SUMMARY

We have studied a total of dozen cases and several profiles from GPM-DPR. Based on these studies we preset a comprehensive statistics of the key decision parameters. Thereby, we understand the DPR observations of hail and graupel much deeper.

ACKNOWLEDGEMENT

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