SIMULATION OF KU/KA BAND RADAR OBSERVATIONS OF ICE PRECIPITATION BY COMBINING C-BAND WEATHER RADAR AND CLOUDSAT CPR MEASUREMENTS

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ABSTRACT

Global Precipitation Measurement (GPM) is a NASA Earth observation satellite mission planned for launch in 2013. The goal of the mission is to characterize the role of precipitation in the Earth's water cycle. The Dual-frequency Precipitation Radar (DPR) is one of main instruments of GPM, and will be used to characterize the three dimensional structure of precipitation. This information will be used to calibrate passive microwave retrievals. DPR will operate at Ku- and Ka-bands.

A major part of the precipitation at higher latitudes falls in the form of light rain and snow [1]. Due to the lack of observations, GPM retrieval algorithms are not tested in cases of shallow light precipitation, which are common in Northern latitudes. Unfortunately, Ku/Ka-band radar observations are not readily available to study the performance of the algorithms in those cases. To augment the lack of observations, we have developed a simulation procedure that can be used to generate synthetic Ku/Ka radar observations of realistic snowfall scenarios. The simulation uses C-band weather radar observations and are constrained by coinciding CloudSat Cloud Profiling Radar (W-band) measurements.

Similar to the procedure described by Chandrasekar et al [2], the simulations are based on scattering calculations. As a starting point of the study, we generate radar reflectivity values for C/Ku/Ka/W band radar observations using a wide range of input parameters, such as particle size distributions, snow density, etc. It was observed [3] that naturally occurring ice particles can be approximated by oblate spheroids with axis ratio of 0.6. This shape model is used in our scattering calculations.

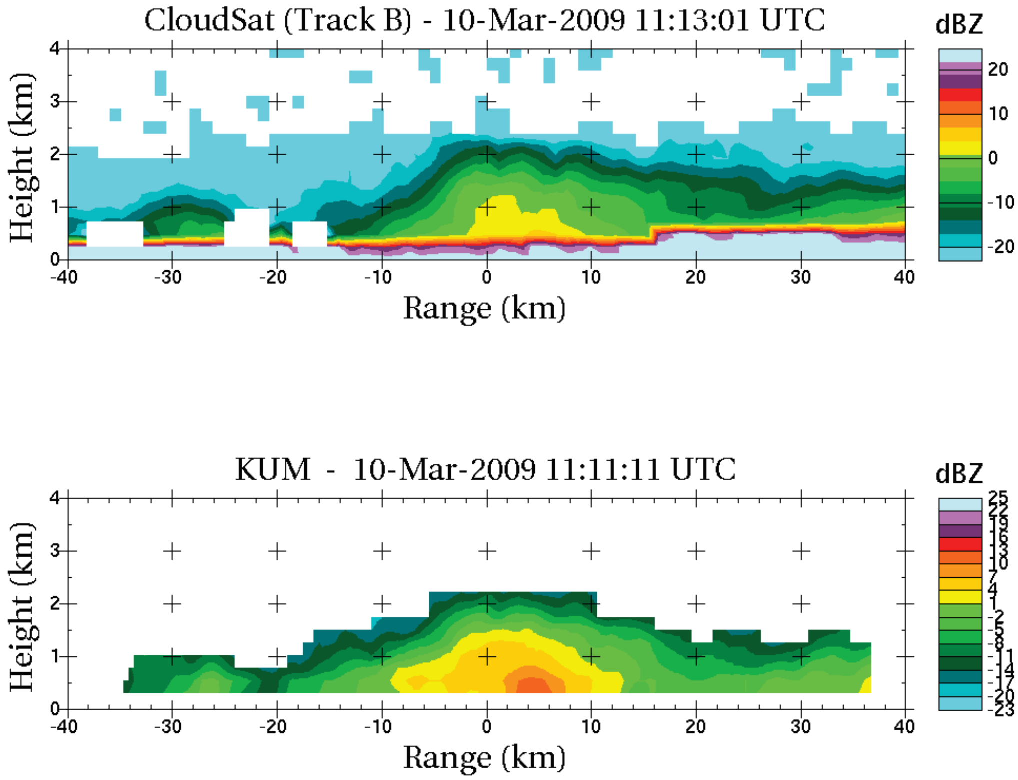

Figure 1: CloudSat CPR (top figure) and corresponding University of Helsinki Kumpula radar observations. The observations were taken during a snowfall event on March 10, 2009.

After the reflectivity values were calculated, mapping functions that relate observed reflectivities at C- and W-bands to Ku/Ka band reflectivity values are obtained. Using these calculations it was observed, that C-band radar observations can be directly mapped to Ku-band radar observations. There is very little scatter around mapping function that describes transformation of C-band reflectivity measurements to Ku-band reflectivity values. This is an expected results, since scattering at both frequencies falls mostly within Rayleigh regime. Simulation of Ka-band radar reflectivity values, however, is not as straightforward. This is due to resonance scattering at Ka-band and W-band. To mitigate this problem observations at C- and W- bands are used to simulate Ka-band reflectivity values. Based on this study, we can conclude that snowfall measurements at Ku/Ka-band can be simulated from combined data obtained from coinciding C- and W- band observations.

To augment the lack of multi-frequency radar observations of precipitation at higher latitudes, we are using a combination of C-band ground based weather radar and CloudSat Cloud Profiling Radar observations. CloudSat is operational since 2006. To collect these observations, University of Helsinki Kumpula radar, dual-polarization C-band weather radar, was carrying out dedicated sector volume scans along CloudSat track. The measurements were synchronized with CloudSat overpasses to achieve minimal spatial and temporal differences in observations. The volume scan takes around 4 minutes to complete and is initiated 2 minutes before a predicted

CloudSat overpass time. Only overpasses with a nearest ground track point within 60 km were considered. The results of simulations were applied to coinciding University of Helsinki C-band weather radar and CloudSat snowfall measurements, to generate synthetic GPM observations, as shown in Figure 2.

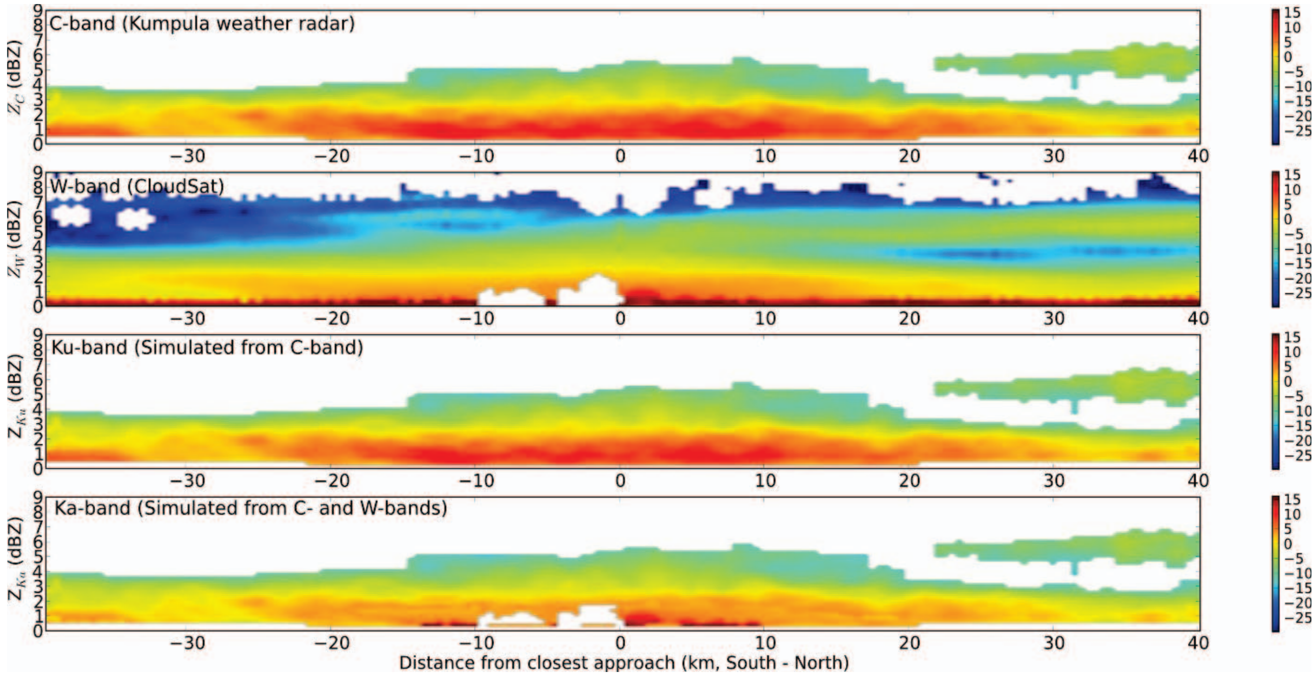

Figure 2: Simulated Ku/Ka-band data from C/W-band measurements on April 04, 2009.

We show that dual-frequency data from C- and W-bands is sufficient to construct synthetic Ku- and Ka-band measurements reliably. This approach can be used for the planning of future missions and validation of current and future radars on the Ku/Ka-bands.

REFERENCES

[1] C. Kidd, "Satellite Rainfall Climatology: A review," *Int. J. Climatol*., vol. 21, no. 9, pp. 1041-1066, 2001.

[2] V. Chandrasekar, S. Lim, and E. Gorgucci, “Simulation of X-band rainfall observations from S-band radar data,” J. Atmos. Ocean. Technol., vol. 23, no. 9, pp. 1195–1205, Sep. 2006.

[3] A. Korolev and G. Isaac, “Roundness and aspect ratio of particles in ice clouds,” J. Atmos. Sci., vol. 60, no. 15, pp. 1795–1808, Aug. 2003.

[4] G. Stephens, D. Vane, R. Boain, G. Mace, K. Sassen, Z. Wang, A. Illingworth, E. O’Connor, W. Rossow, S. Durden, S. Miller, R. Austin, A. Benedetti, C. Mitrescu, and CloudSat Sci Team, “The CloudSat mission and the A-TRAIN - A new dimension of space-based observations of clouds and precipitation,” Bull. Am. Meteorol. Soc., vol. 83, no. 12, pp. 1771–1790, Dec. 2002.