12.5 HOW MUCH ATTENUATION AT W AND KA BANDS IS CAUSED BY MELTING LAYER? AN ANSWER FROM MULTI-FREQUENCY RADAR DOPPLER SPECTRA

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Our knowledge of radar signal attenuation in melting layer at millimeter-wavelengths, i.e. 35 and 94 GHz, is uncertain. This uncertainty hinders retrievals of cloud properties, above the melting layer, using observations from ground-based millimeter-wave radars. Furthermore, it affects quantitative interpretation of precipitation measurements by space-borne cloud and precipitation radars. The prediction of melting layer attenuation is also demanded for Earth-space communications link which is expanding to higher frequency bands.

Model predictions of melting layer attenuation are highly uncertain. One of the main sources of uncertainty is the scattering properties of melting ice particles. In the recent studies it is shown that even for dry snowflakes the connection between scattering and physical properties is ambiguous at mm-waves. Therefore, the current melting layer models cannot be used for the prediction of the attenuation.

To quantify melting layer attenuation from ground-based observations, one can use multi-frequency radar observations, where observations at one frequency are not affected by attenuation. However, for the higher frequency observations attenuations due to radome, gaseous and rain should be taken into account. The wet radome attenuation especially at mm-waves (i.e. 35 and 94 GHz) is significant and difficult to characterize.

In this study, multi-frequency, 10, 35 and 94 GHz, Doppler spectra measurements are used to quantify melting layer attenuation for millimeter wave radar measurements. The attenuation estimation consists of two parts. Below the melting layer, the W/Ka band signal attenuation profile is derived by identifying parts of Doppler spectra that are in Rayleigh scattering regime for all the frequencies. From the spectral dual wavelength ratio measurements differential attenuations due to radome and rain are computed. Above the melting layer, the signal attenuation profile could also be calculated in the same way. In addition, pristine ice crystals at the top of the precipitating clouds are good Rayleigh scatters even at W band, and the dual wavelength reflectivity ratio is used to calculate the differential attenuation between Ka/X and W band in the melting layer. In this procedure we use X-band radar measurements as the reference and the melting layer attenuation at Ka and W bands are computed with respect to X-band observations. The melting layer attenuation at X band is relatively small. It is in the order of 0.3 to 0.8 dB.