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The Dual Wavelength Ratio knee: a signature of multiple scattering in airborne Ku-Ka observations

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Deep convective systems observed by the HIWRAP radar during the 2011 MC3E field campaign in Oklahoma provide the first evidence of multiple scattering effects simultaneously at K_u and K_a band. One feature is novel and noteworthy: often, in correspondence to shafts with strong convection and when moving from the top of the cloud downward, the dual wavelength ratio (DWR) first increases as usual in K_u-/K_a-band observations, but then it reaches a maximum and after that point it steadily decreases all the way to the surface, forming what will be hereinafter referred to as a *knee*. This DWR *knee* cannot be reproduced by single-scattering theory under almost any plausible cloud microphysical profile, on the other hand it is explained straightforwardly with the help of multiple scattering theory when simulations involving hail-bearing convective cores with large horizontal extents are performed. The DWR reduction in the lower troposphere (i.e., DWR increasing with altitude) is interpreted as the result of multiple scattering pulse stretching caused by the highly-diffusive hail layer positioned high up in the atmosphere, with K_a multiple scattering typically exceeding that occurring in the K_u channel.

Since the effects of multiple scattering increase with increasing footprint size, if multiple scattering effects are present in the aircraft measurements, they are likely to be more pronounced in the space-borne dual-frequency $K_u - K_a$ radar observations, envisaged for the NASA-JAXA Global Precipitation (GPM) Measurement Mission, whose launch is expected in February 2014. Our notional study supports the idea that DWR *knees* will be observed by the GPM radar when overflying high-density ice shafts embedded in large convective systems and suggests that their explanation must not be sought in differential attenuation or differential Mie but via multiple scattering effects.