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Relation between weather radar equation and first-order backscattering theory

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Abstract. Aim of this work is to provide a new insight into the physical basis of the meteorological-radar theory in attenuating media. Starting form the general integral form of the weather radar equation, a modified form of the classical weather radar equation at attenuating wavelength is derived. This modified radar equation includes a new parameter, called the range-bin extinction factor, taking into account the rainfall path attenuation within each range bin. It is shown that, only in the case of low-to-moderate attenuating media, the classical radar equation at attenuating wavelength can be used. These theoretical results are corroborated by using the radiative transfer theory where multiple scattering phenomena can be quantified. From a new definition of the radar reflectivity, in terms of backscattered specific intensity, a generalised radar equation is deduced. Within the assumption of first-order backscattering, the generalised radar equation is reduced to the modified radar equation, previously obtained. This analysis supports the conclusion that the description of radar observations at attenuating wavelength should include, in principle, first-order scattering effects. Numerical simulations are performed by using statistical relationships among the radar reflectivity, rain rate and specific attenuation, derived from literature. Results confirm that the effect of the range-bin extinction factor, depending on the considered frequency and range resolution, can be significant at X band for intense rain, while at Ka band and above it can become appreciable even for moderate rain. A discussion on the impact of these theoretical and numerical results is finally included.

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