ON THE METEOROLOGICAL RADAR EQUATION IN ATTENUATING MEDIA

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The meteorological radar equation in its classical form takes into account two-way path attenuation for each range bin. Indeed, for strong attenuating media such as intense rainfall, hydrometeor extinction within each range bin can be significant. The classical radar equation (for simplicity, considered for a single-polarization or for unpolarized radiation) is here generalized to include such a range-bin extinction effect. It is shown that only in the case of low-to-moderate attenuating media, the derived range-bin extinction factor is, by definition, closed to one so that the classical radar equation can be used. These theoretical results are also obtained by using a microwave radiative transfer approach described by means of the well-known integro-differential equation taking into account multiple scattering. It is shown that, within the assumption of first-order scattering, a new definition of radar reflectivity in terms of backscattered specific intensity (normalized to the incident one) yields the same generalized radar equation previously obtained. This result supports the conclusion that radar analysis in strong attenuating media should include first-order scattering effects. Numerical simulation are performed by using a Gaussian-shaped double raincell along the path with a varying intensity at C, X, Ka, Ku and W band. Relations between reflectivity, rainrate and specific attenuation are taken from experimental results available in literature. Results confirm that the effect of the range-bin extinction factor, depending on frequency and range resolution, can be up to several decibels at C and X band for intense rain and up to tens of decibels at Ka band and above even for moderate rain. These results can also have an impact in operational procedures of reflectivity spatial averaging when significant attenuation due to rainfall is observed. Finally, the discrepancy due to this range-bin extinction factor, if not properly taken into account, can translate into relevant systematic errors of estimated rainrates.