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Cloud contribution to the degradation of radar reflectivity retrieval

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Hydrometeors backscattering is used in radar meteorology to assess, via the measured radar reflectivity factor Z_m, various physical characteristics of clouds and precipitation. However, radar retrieval of precipitating system physical properties is affected by attenuation phenomena. Several methods have been developed to estimate from radar observations attenuation fields but only attenuation by precipitation is generally taken into account. The non precipitating part of condensed atmospheric water (cloud component) can yet significantly affect electromagnetic wave propagation. In the present work, it is shown that clouds can produce a strong attenuation at operational microwave frequencies, although they present a low reflectivity preventing their radar detection. Using a simple and realistic model, simulations of radar observations through warm precipitating targets are thus presented in order to quantify cloud radar attenuation. Simulations deal with an airborne radar oriented downward and observing precipitation at four different frequencies (f = 3, 10, 35, and 94 GHz). Several situations are considered: a convective cell (vigorous cumulus congestus + rain), a stratiform one (nimbostratus + drizzle) superimposed on the previous one, and different types of cumulus (congestus, mediocris, and humilis) with various thicknesses e characterized, in a microphysical sense, by their maximum liquid water content M_c^{max}. The whole simulation confirms the low reflectivity of cumulus and nimbostratus while attenuation can be significant: the higher the frequency and/or M_c^{max} and/or e, the stronger the attenuation. All these conclusions indicate that it is necessary to be careful when some information on precipitation – as for example precipitation rate – have to be inferred from radar reflectivity measurements, particularly at high operational frequencies.