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Bulk microphysics schemes suitable for assessing the indirect impact of atmospheric aerosols

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Clouds and their impact on transfer of solar and Earth's thermal radiation is the most challenging aspect of climate and climate change. This is because interactions between radiation and clouds involve microscopic properties such as phase (i.e., liquid versus solid), size, and concentration of cloud and precipitation particles. With the advent of cloud-resolving and "superparameterized" general circulation models, representation of cloud microphysics becomes the key issue. Arguably, new approaches are needed for cloud microphysics that on one hand are computationally feasible (such as bulk schemes), but on the other provide information not only on the mass of cloud condensate and precipitation (i.e., their local mixing ratios), but also on particle sizes, the latter important for the radiative transfer. This paper will first present development and validation of a two-moment bulk microphysics scheme for warm clouds, with the emphasis on droplet nucleation, drizzle/rain development, and transformations due to entrainment and mixing. The latter has recently been shown to have critical impact on mean properties of a cloud field, such as the area-averaged albedo. In the second part, a new two-moment three-variable bulk ice scheme will be discussed, with the emphasis on a novel approach to represent diffusional as well as rimig growth of the ice field. Both these schemes are being developed with the overall goal to apply them in numerical simulations aiming at quantifying indirect effects of atmospheric aerosols in "superparameterized" general circulation models.