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Separating dynamical and microphysical impacts of aerosols on deep convection applying piggybacking methodology

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Formation and growth of cloud and precipitation particles ("cloud microphysics") affect cloud dynamics and such macroscopic cloud field properties as the mean surface rainfall, cloud cover, and liquid/ice water paths. Traditional approaches to investigate the impacts involve parallel simulations with different microphysical schemes or with different scheme parameters (such as the assumed droplet/ice concentration for single-moment bulk schemes or the assumed CCN/IN concentration for double-moment schemes). Such methodologies are not reliable because of the natural variability of a cloud field that is affected by the feedback between cloud microphysics and cloud dynamics. In a nutshell, changing the cloud microphysics leads to a different realization of the cloud-scale flow, and separating dynamical and microphysical impacts is cumbersome. A novel modeling methodology, referred to as the microphysical piggybacking, was recently developed to separate purely microphysical effects from the impact on the dynamics. The main idea is to use two sets of thermodynamic variables driven by two microphysical schemes or by the same scheme with different scheme parameters. One set is coupled to the dynamics and drives the simulation, and the other set piggybacks the simulated flow, that is, it responds to the simulated flow but does not affect it. By switching the sets (i.e. the set driving the simulation becomes the piggybacking one, and vice versa), the impact on the cloud dynamics can be isolated from purely microphysical effects. Application of this methodology to the daytime deep convection development over land based on the observations during the Large-scale Biosphere–Atmosphere (LBA) field project in Amazonia will be discussed applying single-moment and double-moment bulk microphysics schemes. We show that the new methodology documents a small indirect aerosol impact on convective dynamics, and a strong microphysical effect. These results question the postulated strong dynamical invigoration of deep convection in polluted environments, at least for the case of scattered unorganized deep convection considered in this study.