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How to assess the impact of a physical parameterization in simulations of moist convection?

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A numerical model capable in simulating moist convection (e.g., cloud-resolving model or large-eddy simulation model) consists of a fluid flow solver combined with required representations (i.e. parameterizations) of physical processes. The later typically include cloud microphysics, radiative transfer, and unresolved turbulent transport. Traditional approaches to investigate impacts of such parameterizations on convective dynamics involve parallel simulations with different parameterization schemes or with different scheme parameters. Such methodologies are not reliable because of the natural variability of a cloud field that is affected by the feedback between the physics and dynamics. For instance, changing the cloud microphysics typically leads to a different realization of the cloud-scale flow, and separating dynamical and microphysical impacts is difficult. This presentation will present a novel modeling methodology, the piggybacking, that allows studying the impact of a physical parameterization on cloud dynamics with confidence. The focus will be on the impact of cloud microphysics parameterization. Specific examples of the piggybacking approach will include simulations concerning the hypothesized deep convection invigoration in polluted environments, the validity of the saturation adjustment in modeling condensation in moist convection, and separation of physical impacts from statistical uncertainty in simulations applying particle-based Lagrangian microphysics, the super-droplet method.