Development of a regime-dependent autoconversion parameterization using satellite observations

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Aerosol-cloud interactions (ACI) are major sources of uncertainty in climate modeling due to their complex dependences on cloud regimes, which are less understood. Most of the climate models tend to overestimate the magnitude of ACI compared with satellite observations partly because of an autoconversion parameterization in which the magnitude of warm rain modulation depending on aerosol perturbations is prescribed regardless of cloud regimes. Here we develop a new autoconversion parameterization which includes the regime-dependence of ACI inferred from satellite observations. The new scheme represents the magnitude of ACI as a function of the precipitation efficiency characterized by the ratio of rainwater to total liquid water. The proposed scheme is designed to reproduce a lower cloud susceptibility to aerosols in a more efficient precipitating regime according to the satellite-derived relationship, which allows to simulate nonmonotonic cloud responses to aerosol perturbations with spatial dependence in terms of cloud regimes. This is supported by the satellite statistics that show an inverse correlation between the cloud susceptibility and precipitation efficiency, and is also in good agreement with a steady-state model in a past study. Our results that are expected to fix the magnitude of ACI and hence ignore the regime dependence are more realistic than previous autoconversion schemes. The new scheme will reconcile some of the common biases in particular the excessive ACI in current global climate models. We show an impact of the new scheme on the simulated precipitation characteristics and aerosol effective radiative forcing using a single-column model and a global aerosol-climate model.

Keywords: Aerosol-cloud interaction, autoconversion, cloud regime, precipitation efficiency, cloud susceptibility

