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Cloud Dynamics and Buffering of Aerosol-Cloud Interactions in Climate Models

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Studies with large-eddy simulations have suggested the possibility of strong buffering of aerosol-induced increases in liquid water path by cloud dynamics. In particular, changes in sedimentation near cloud top and increased evaporative cooling associated with entrainment can reduce water paths, opposing aerosol-related increases in water path due to changes in the precipitation process.

Understanding the implications of these buffering processes for climate forcing due to aerosol-cloud interactions has been a challenge. The scales on which these processes occur are smaller than those resolved by climate models. A goal for cloud and aerosol parameterizations in climate models is to realistically represent these small-scale interactions among aerosols, microphysics, and dynamics.

Reductions in water path as aerosols increase occur in some synoptic settings in a version of the GFDL global atmospheric model AM3 in which boundary-layer clouds are parameterized using the assumed-distribution higher-order closure CLUBB. The behavior occurs when the air overlying the clouds has low humidity, consistent with the explanation the buffering involves entrainment and associated evaporation. Although this is only one of a number of mechanisms which have been hypothesized to buffer aerosol-cloud interactions and its quantitative realism requires further assessment, the prospect that climate models can incorporate complex buffering processes is encouraging. Further progress will require close collaboration among researchers studying basic processes, field and satellite observations, and climate models.