Constraining cloud lifetime effects of aerosols in global climate models using A-Train satellite and ground observations

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Abstract: Aerosol indirect effects have remained the largest uncertainty in estimates of the radiative forcing of past and future climate change. Observational constraints on cloud lifetime effects are particularly challenging since it is difficult to separate aerosol effects from meteorological influences. Here we use three global climate models, including a multi-scale aerosol-climate model PNNL-MMF, to show that the dependence of the probability of precipitation on aerosol loading, termed the precipitation frequency susceptibility (S_{pop}), is a good measure of the liquid water path response to aerosol perturbation (λ). This provides a method to use satellite observations to constrain cloud lifetime effects in global climate models. S_{pop} in marine clouds estimated from CloudSat, MODIS and AMSR-E observations is substantially lower than that from global climate models and suggests a liquid water path increase of less than 5% from doubled cloud condensation nuclei concentrations. This implies a substantially smaller impact on shortwave cloud radiative forcing (SWCF) over ocean due to aerosol indirect effects than simulated by current global climate models (a reduction by one-third for one of the conventional aerosol-climate models). Here we propose to organize a model intercomparison project on cloud lifetime effects of aerosols under the AeroCom initiative, and we plan to apply the rain frequency susceptibility derived from A-Train satellites and ground/aircraft observations to evaluate the representation of cloud lifetime effects of aerosols in global climate models.

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