A Simple Model of Global Aerosol Indirect Forcing

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Abstract

The global mean indirect effect of anthropogenic aerosol on the Earth's energy balance is expressed using analytic representations of droplet nucleation, cloud and aerosol vertical structure, and horizontal variability in cloud water and aerosol concentration. Although the simple model is able to produce estimates of aerosol indirect effects that are comparable to those from some global aerosol models using the same global mean aerosol properties, the estimates are found to be sensitive to several uncertain parameters, including primary and secondary anthropogenic emissions, the size of the primary particles, the fraction of the secondary anthropogenic emissions that accumulates on the coarse mode, the fraction of the secondary mass that forms new particles, the preindustrial cloud condensation nuclei concentration, and the sensitivity of liquid water path to droplet number concentration. This simple model provides a much stronger physical basis for representing aerosol indirect effects in integrated assessment models designed to quickly explore the parameter space of emissions-climate interactions. Although the forcing estimates cannot be made arbitrarily small without unrealistic choices for preindustrial aerosol concentrations, a variety of forcing values are possible, and parameter values can be chosen for consistency with results from detailed global aerosol-climate simulation models.