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Uncertainty analysis for estimates of the first indirect aerosol effect

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Abstract. The IPCC has stressed the importance of producing unbiased estimates of the uncertainty in indirect aerosol forcing, in order to give policy makers as well as research managers an understanding of the most important aspects of climate change that require refinement. In this study, we use 3-D meteorological fields together with a radiative transfer model to examine the spatially-resolved uncertainty in estimates of the first indirect aerosol forcing. The global mean forcing calculated in the reference case is -1.30 Wm^{-2}. Uncertainties in the indirect forcing associated with aerosol and aerosol precursor emissions, aerosol mass concentrations from different chemical transport models, aerosol size distributions, the cloud droplet parameterization, the representation of the in-cloud updraft velocity, the relationship between effective radius and volume mean radius, cloud liquid water content, cloud fraction, and the change in the cloud drop single scattering albedo due to the presence of black carbon are calculated. The aerosol burden calculated by chemical transport models and the cloud fraction are found to be the most important sources of uncertainty. Variations in these parameters cause an underestimation or overestimation of the indirect forcing compared to the base case by more than 0.6 Wm^{-2}. Uncertainties associated with aerosol and aerosol precursor emissions, uncertainties in the representation of the aerosol size distribution (including the representation of the pre-industrial size distribution), and uncertainties in the representation of cloud droplet spectral dispersion effect cause uncertainties in the global mean forcing of 0.2~0.6 Wm^{-2}. There are significant regional differences in the uncertainty associated with the first indirect forcing with the largest uncertainties in industrial regions (North America, Europe, East Asia) followed by those in the major biomass burning regions.

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