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Aerosol indirect forcing in a global model with particle nucleation

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Abstract. The number concentration of cloud condensation nuclei (CCN) formed as a result of anthropogenic emissions is a key uncertainty in the study of aerosol indirect forcing and global climate change. Here, we use a global aerosol model that includes an empirical boundary layer nucleation mechanism, the use of primary-emitted sulfate particles to represent sub-grid scale nucleation, as well as binary homogeneous nucleation to explore how nucleation affects the CCN concentration and the first aerosol indirect effect (AIE). The inclusion of the boundary layer nucleation scheme increases the global average CCN concentrations in the boundary layer by 31.4% when no primary-emitted sulfate particles are included and by 5.3% when they are included. Particle formation with the boundary layer nucleation scheme decreases the first indirect forcing over ocean, and increases the first indirect forcing over land when primary sulfate particles are included. This suggests that whether particle formation from aerosol nucleation increases or decreases aerosol indirect effects largely depends on the relative change of primary particles and SO_2 emissions from the preindustrial to the present day atmosphere. Including primary-emitted sulfate particle significantly increases both the anthropogenic fraction of CCN concentrations and the first aerosol indirect forcing. The forcing from various treatments of aerosol nucleation ranges from −1.22 to −2.03 w/m^2. This large variation shows the importance of better quantifying aerosol nucleation mechanisms for the prediction of CCN concentrations and aerosol indirect effects.

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