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Estimating the contribution of carbonaceous aerosols to global cloud condensation nuclei with a global aerosol microphysics model

K. Chen (1) and **P. J. Adams** (1,2)

(1) Department of Civil and Environmental Engineering, Carnegie Mellon University, Pittsburgh, PA, USA, (2) Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA, USA (petera@andrew.cmu.edu)

A size-resolved simulation of carbonaceous aerosol microphysics has been implemented into the Goddard Institute for Space Studies general circulation model along with previously existing simulations of sulfate and sea-salt aerosols. This simulation predicts aerosol size distributions, number concentrations, and size-resolved composition such that cloud condensation nuclei (CCN) concentrations may be predicted online in the climate model. Carbonaceous tracers including elemental carbon (EC) and organic carbon (OC) are categorized into hydrophobic and hydrophilic groups. Secondary organic aerosols (SOA) form and condense directly onto the existing size-resolved aerosols based on a weighting scheme. Hydrophobic carbonaceous aerosols age to hydrophilic aerosols with a lifetime of 1.5 days. CCN concentrations are calculated using modified Kohler theory. The contribution of carbonaceous aerosols to global CCN levels is estimated by comparing model results with and without carbonaceous emissions.

The results show that EC/OC contribute between 30% and 65% to global average aerosol number concentrations and between 40% to 65% to CCN number concentrations depending on which EC/OC emissions inventories are used. Of the global CCN attributable to carbonaceous, primary particles with Dp $>$ 85 nm account for about half while growth of primary ultrafine (Dp $<$ 85 nm) EC/OC particles to CCN account for the other half. Predicted number concentrations, EC/OC mass concentrations, and size distributions are compared against observations. Modeled number concentrations agree with the measured number concentrations within a factor of 2

although predicted number concentrations in source regions are generally higher than observations. Sensitivity of predicted CCN concentrations to assumptions regarding aerosol mixing state and solubility is examined.