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Variation in aerosol nucleation and growth in coal-fired power plant plumes due to background aerosol, meteorology and emissions: sensitivity analysis and parameterization.

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New-particle formation in the plumes of coal-fired power plants and other anthropogenic sulphur sources may be an important source of particles in the atmosphere. It remains unclear, however, how best to reproduce this formation in global and regional aerosol models with grid-box lengths that are 10s of kilometres and larger. The predictive power of these models is thus limited by the resultant uncertainties in aerosol size distributions. In this presentation, we focus on sub-grid sulphate aerosol processes within coal-fired power plant plumes: the sub-grid oxidation of SO_2 with condensation of H_2SO_4 onto newly-formed and pre-existing particles.

Based on the results of the System for Atmospheric Modelling (SAM), a Large-Eddy Simulation/Cloud-Resolving Model (LES/CRM) with online TwO Moment Aerosol Sectional (TOMAS) microphysics, we develop a computationally efficient, but physically based, parameterization that predicts the characteristics of aerosol formed within coal-fired power plant plumes based on parameters commonly available in global and regional-scale models. Given large-scale mean meteorological parameters, emissions from the power plant, mean background condensation sink, and the desired distance from the source, the parameterization will predict the fraction of the emitted SO_2 that is oxidized to H_2SO_4, the fraction of that H_2SO_4 that forms new particles instead of condensing onto preexisting particles, the median diameter of the newly-formed particles, and the number of newly-formed particles per kilogram SO_2 emitted.

We perform a sensitivity analysis of these characteristics of the aerosol size distribution to the meteorological parameters, the condensation sink, and the emissions. In general, new-particle formation and growth is greatly reduced during polluted conditions due to the large preexisting aerosol surface area for H_2SO_4 condensation and particle coagulation. The new-particle formation and growth rates are also a strong function of the amount of sunlight and NO_x since both control OH concentrations. Decreases in NO_x emissions without simultaneous decreases in SO_2 emissions increase new-particle formation and growth due to increased oxidation of SO_2.

The parameterization we describe here should allow for more accurate predictions of aerosol size distributions and a greater confidence in the effects of aerosols in climate and health studies.