Geophysical Research Abstracts
Vol. 18, EGU2016-9406, 2016
EGU General Assembly 2016

Optimized sparse-particle aerosol representations for modeling cloud-aerosol interactions

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Sparse representations of atmospheric aerosols are needed for efficient regional- and global-scale chemical transport models. Here we introduce a new framework for representing aerosol distributions, based on the method of moments. Given a set of moment constraints, we show how linear programming can be used to identify collections of sparse particles that approximately maximize distributional entropy. The collections of sparse particles derived from this approach reproduce CCN activity of the exact model aerosol distributions with high accuracy. Additionally, the linear programming techniques described in this study can be used to bound key aerosol properties, such as the number concentration of CCN. Unlike the commonly used sparse representations, such as modal and sectional schemes, the maximum-entropy moment-based approach is not constrained to pre-determined size bins or assumed distribution shapes. This study is a first step toward a new aerosol simulation scheme that will track multivariate aerosol distributions with sufficient computational efficiency for large-scale simulations.