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Non-additive aerosol radiative perturbations by the global microphysical aerosol system

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Aerosols are thought to play an important role in the global climate system. However, their effects on the radiation budget are not understood satisfactorily. The main reason is the requirement of the knowledge of global distribution of aerosol composition, size-distribution, and the mixing state for the calculation of their radiative effects. Due to their short lifetime, aerosol are spatio-temporal highly inhomogeneous and observations cannot retrieve these parameters globally. Only recently, global aerosol models with prognostic treatment of the aerosol size-distribution, composition, and mixing-state are becoming available.

Here, we present results from the aerosol-climate model ECHAM5-HAM with prognostic microphysical treatment of size-distribution, composition, and mixing state for the major aerosol components sulfate, black carbon, organic carbon, sea salt and mineral dust. A new measure of aerosol radiative perturbations, applicable to the application in global microphysical aerosol models is introduced. From an analysis of aerosol radiative perturbations of diverse components and source types we demonstrate that the total radiative disturbance cannot be accurately derived as the sum of the perturbations of the individual components or source types. Microphysical interactions and non-linear radiative effects are responsible for this violation of the concept of additivity underlying the radiative forcing concept applied in the third Intergovernmental Panel on Climate Change assessment report. From our analysis we suggest that only an integrated approach, including all relevant forcing agents and also radiative perturbations involving feedbacks, such as the indirect aerosol effects, might be appropriate to determine the total anthropogenic forcing with the required accuracy.