Aerosol water uptake in global aerosol models: dominant factors and their impacts on direct and indirect aerosol effect

(Oral presentation preferred)

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Abstract

Water uptake by aerosol particles plays a crucial role in determining the wet-size distribution and optical properties of aerosol particles, thus has a direct influence on the magnitude of the aerosol direct and indirect effects. The water content of aerosols depends on their composition as well as the ambient relative humidity (RH). To represent the water uptake process in global aerosol models, critical assumptions are made in the parameterizations, such as the maximum RH allowed for the water uptake calculation (RH ceiling), the sub-grid variation of RH and composition, the molality and dissociated fraction or the hygroscopic growth factor (or the κ value), and etc. The AeroCom A2 models are showing a wide spread in the simulated global aerosol water burden (60±45 Tg, range is 12-102 Tg).

We have performed various sensitivity simulations with the global aerosol-climate ECHAM-HAM (and a few with the Community Atmosphere Model CAM5) to quantify the uncertainty in the simulated aerosol water uptake. Results show that the dominant factors for global total aerosol water burden are the RH ceiling due to high non-linearity at RH>95% and the simulated sea salt loading. The use of clear-sky RH (instead of grid-box mean) reduces the global total aerosol water burden by 6%, suggesting the importance of sub-grid variability. With the κ-Koehler-theory based method, the simulated global total aerosol water burden increases rapidly and quasi-linearly with enhanced κ value of sea salt aerosols, which reflects the dominant role of sea salt aerosols in water uptake. The impact of water uptake perturbation on direct and indirect forcing estimates will also be discussed. These findings suggest that a detailed model inter-comparison of aerosol water uptake will be a useful exercise for the AeroCom community.