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The contribution of aerosol hygroscopic growth to the modeled aerosol radiative effect

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The hygroscopic growth of atmospheric aerosols can have a significant effect on the direct radiative effect of atmospheric aerosol. However, there are significant uncertainties concerning how much of the radiative forcing is due to different chemical compounds, especially water. For example, modeled optical depth of water in global aerosol-climate models varies by more than a factor of two. These differences can be attributed to differences in modeled 1) hygroscopicity, 2) ambient relative humidity, and/or 3) aerosol size distribution.

In this study, we investigate which of these above-mentioned factors cause the largest variability in the modeled optical depth of water. In order to do this, we have developed a tool that calculates aerosol extinction using interchangeable global 3D data of aerosol composition, relative humidity, and aerosol size distribution fields. This data is obtained from models that have taken part in the open international initiative AeroCom (Aerosol Comparisons between Observations and Models). In addition, we use global 3D data for relative humidity from the Atmospheric Infrared Sounder (AIRS) flying on board NASA's Aqua satellite and the National Centers for Environmental Prediction (NCEP) reanalysis data. These observations are used to evaluate the modeled relative humidity fields.

In the first stage of the study, we made a detailed investigation using the aerosol-chemistry-climate model ECHAM-HAMMOZ in which most of the aerosol optical depth is caused by water. Our results show that the model significantly overestimates the relative humidity over the oceans while over land, the overestimation is lower or it is underestimated. Since this overestimation occurs over the oceans, the water optical depth is amplified as the hygroscopic growth is very sensitive to changes in high relative humidities. Over land, error in modeled relative humidity is unlikely to cause significant errors in water optical depth as relative humidities are generally much lower than over oceans and the deviation from observations is smaller.