Strong response in absorption by black carbon to hygroscopic growth

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Absorption by black carbon (BC) is enhanced when BC is mixed with non-absorbing aerosol components, and the degree of absorption amplification depends on particles' morphology and chemical composition. Because this particle-scale information is needed to predict BC's direct forcing at the global-scale, BC is difficult to represent in climate models. This study combines results from particle-resolved simulations with global climate model data to quantify uncertainty in BC absorption from unknown particle characteristics.

A relationship between bulk absorption amplification and relative humidity was determined using particle-resolved model simulations. Absorption was strongly sensitivity to the hygroscopicity of dry coatings, but only weakly sensitive to the coating refractive index, the distribution in coating thickness, or the assumed particle morphology.

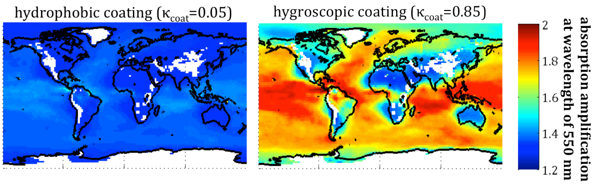

Figure 1: annual average absorption amplification at surface for dry coatings with different hygroscopic properties

Combining these findings with the spatial and temporal distribution in relative humidity from a global model, we estimated the global distribution in absorption amplification, as shown in Figure 1. The mean absorption amplification ranges between 1.35-1.7, depending on the wavelength of light and the assumed hygroscopicity of the aerosol coatings. If evaluated under dry conditions, the absorption amplification ranged from 1.25-1.35. Our findings suggest a need for more ambient measurements of BC absorption at high relative humidity and that climate models must account for hygroscopic growth to accurately represent BC's radiative effects.