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Strong enhancement in light absorption by black carbon due to aerosol water uptake

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Black carbon exerts a strong, yet highly uncertain, warming effect on the climate. One source of uncertainty in predicting black carbon's radiative effects is the absorption per black carbon mass. Although models suggest that light absorption is strongly enhanced if black carbon is coated with non-absorbing aerosol material, recent ambient observations find only weak absorption enhancement from aerosol coatings.

In this study, we use a particle-resolved aerosol model to evaluate how oversimplified representations of particle composition impact modeled light absorption by black carbon. We show that oversimplifying the representation of particle composition leads to overestimation of modeled absorption enhancement. In order to improve global model representations of BC absorption, we performed a nonparametric regression on particle-reolved model data from a series of simulations. Through this nonparametric analysis we derived a relationship for absorption enhancement as a function of variables that global models already track, the population-averaged composition and the environmental relative humidity. Finally, we show how this nonparametric relationship can be exploited for use in global models to improve predictions of absorption by black carbon.

In order to quantify the global-scale impact of water uptake on light absorption by black carbon, we applied the relationship for absorption enhancement to output of the climate model GISS-MATRIX. We find weak absorption enhancement in locations with low relative humidity, but light absorption is strongly enhanced in humid regions. This enhancement in light absorption by particles taking up water strongly impacts black carbon's radiative effects at the global scale, enhancing light absorption by black carbon by 20% relative to dry conditions.