Spectral Signature of Black Carbon Containing Aerosols Constrained by Observations of their Chemico-Physical Properties.

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Absorbing aerosols in the atmosphere represent a unique particulate constituent, as they can attenuate solar radiation through both scattering and absorption.

Absorbing aerosols are produced mainly from incomplete combustion of either fossil fuel or biofuel, resultant from various human activities from vehicle and industrial emissions to biomass burning events, such as certain organic matters/brown carbon and black carbon (BC).

Another component of absorbing aerosols is the mineral dust from deserts, rock erosion, land use, and volcanic dust. Due to their potentially large mass concentration in the atmosphere, both brown carbon and mineral dust could represent a non-negligible contribution to the total particulate absorption.

Recent field observations show tremendous variation in composition and morphology on the individual aerosol particles, such variability is also reflected in observed optical properties (i.e., Cappa et al., 2012; Nousiainen, 2009). Recent modeling studies demonstrate that individual aerosols particles, depending on their morphology and mixing state with other aerosols compounds, may have very different absorption and scattering behaviors, which cannot be parameterized by commonly used approximations based on Mie-theory (i.e. for BC containing particles Scarnato et al., 2013, 2015, China et al, 2015).

A topic that is becoming a new research focus is the coupling of aerosol chemico-physical properties, at single particle level, with atmospheric forcing.

In this paper we present sensitivity studies on climate relevant aerosols' optical properties to various approximations in aerosol shape and mixing state.

Based on aerosol samples collected in various geographical locations and in laboratory experiments, we have observationally constrained size, morphology and mixing of aerosols containing BC by processing microscope images. Further, we have accordingly simulated, using the discrete dipole approximation model (DDSCAT), optical properties of the different types of aerosols containing BC, such as dirty marine aerosol, polluted mineral dust, biomass burning, bare/fresh black carbon, and long range transported back carbon.

This paper demonstrates that observationally constrained DDSCAT simulations allow for a better understanding of the variability of the measured aerosol optical properties in ambient air, and further, to define benchmarks biases in radiative forcing estimates and aerosol remote sensing retrieval due to different approximations in aerosol parameterization.

The results discussed in this paper, are crucial for a number of disciplines involving radiative forcing analysis, global and regional aerosol modeling, aerosol-cloud interactions, visibility and precipitation forecast and, further, remote sensing of atmosphere and ocean color.

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