The role of absorption in retrievals of aerosol optical and microphysical properties from measurements of absolute and polarized phase function

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In this work, the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm is applied to airborne, in situ measurements made by a novel polar nephelometer. This instrument, the Polarized Imaging Nephelometer (PI-Neph), can make field measurements of absolute phase function and the scattering matrix element F_{12}, at three visible wavelengths, over a wide angular range of 3° to 177°. The resulting retrieved products include size distribution, complex refractive index and fraction of spherical particles. This presentation will focus primarily on GRASP's ability to retrieve absorption from PI-Neph scattering measurements alone as well as on the possibility of improving the inversion's accuracy by incorporating an independent measurement of the aerosol absorption coefficient. The retrieval technique is applied to over 2300 aerosol measurements made aboard the NASA DC-8 aircraft during the Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys ($SEAC^4RS$) and the Deep Convection Clouds and Chemistry (DC3) field experiments. The resulting samples represent desert dust, biomass burning, urban, and biogenic emissions as well as a wide array of aerosols that have been influenced by convective systems. The inversion results are compared with absorption measurements made in parallel by a Particle Soot/Absorption Photometer (PSAP). When GRASP is applied to PI-Neph light scattering measurements alone a correlation ($R^2 \approx 0.4$) is found between the measured and retrieved absorption coefficients but the retrieved values are biased high by more than a factor of two. The PSAP measurements are then used, in conjunction with the PI-Neph data, as an input to the retrieval and, as is expected, the retrieved absorption values decrease markedly. Additionally, the inclusion of an absorption measurement is found to significantly influence the retrieved fraction of spherical particles and real refractive index (RRI). The spherical fraction is decreased on average by 20% and shows a meaningfully reduction in the variability between neighboring samples. The retrieved RRI values also show a small decrease in variability and are generally found to increase by ~0.02 when absorption is included as an input to the retrieval. The interdependence among these three parameters is expected theoretically, as Mie and T-matrix computations show that, in the size and refractive index regimes spanned by these particles, changes in RRI, imaginary refractive index and spherical fraction all produce roughly similar changes in F_{11} and F_{12}.

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