Cloud albedo increase from carbonaceous aerosol

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Airborne measurements from two consecutive days, analysed with the aid of an aerosol-adiabatic cloud parcel model, are used to study the effect of carbonaceous aerosol particles on the reflectivity of sunlight by water clouds. The measurements, including aerosol chemistry, aerosol microphysics, cloud microphysics, cloud gust velocities and cloud light extinction, were made below, in and above stratocumulus over the northwest Atlantic Ocean. On the first day, the history of the below-cloud fine particle aerosol was marine and the fine particle sulphate and organic carbon mass concentrations measured at cloud base were 2.4 μg m−3 and 0.9 μg m−3 respectively. On the second day, the below-cloud aerosol was continentally influenced and the fine particle sulphate and organic carbon mass concentrations were 2.3 μg m−3 and 2.6 μg m−3 respectively. Over the range 0.06–0.8 μm diameter, the shapes of the below-cloud size distributions were similar on both days and the number concentrations were approximately a factor of two higher on the second day. The cloud droplet number concentrations (CDNC) on the second day were approximately three times higher than the CDNC measured on the first day. Using the parcel model to separate the influence of the differences in gust velocities, we estimate from the vertically integrated cloud light scattering measurements a 6% increase in the cloud albedo principally due to the increase in the carbonaceous components on the second day. Assuming no additional absorption by this aerosol, a 6% albedo increase translates to a local daytime radiative cooling of ~12 W m−2. This result provides observational evidence that the role of anthropogenic carbonaceous components in the cloud albedo effect can be much larger than that of anthropogenic sulphate, as some global simulations have indicated.

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