EGU2020-5722
https://doi.org/10.5194/egusphere-egu2020-5722
EGU General Assembly 2020
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Coarse and giant particles are ubiquitous in Saharan dust export regions and are radiatively significant over the Sahara

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Mineral dust is an important component of the climate system, interacting with radiation, clouds, and biogeochemical systems and impacting atmospheric circulation, air quality, aviation, and solar energy generation. These impacts are sensitive to dust particle size distribution (PSD), yet models struggle or even fail to represent coarse (diameter (*d*) >2.5 μm) and giant (*d*>20 μm) dust particles and the evolution of the PSD with transport. Here we examine three state-of-the-art airborne observational datasets, all of which measured the full size range of dust (*d*=0.1 to >100 μm) at different stages during transport with consistent instrumentation. We quantify the presence and evolution of coarse and giant particles and their contribution to optical properties using airborne observations over the Sahara (from the Fennec field campaign) and in the Saharan Air Layer (SAL) over the tropical eastern Atlantic (from the AER-D field campaign).

Observations show significantly more abundant coarse and giant dust particles over the Sahara compared to the SAL: effective diameters of up to 20 μm were observed over the Sahara compared to 4 μm in the SAL. Excluding giant particles over the Sahara results in significant underestimation of mass concentration (40 %), as well as underestimates of both shortwave and longwave extinction (18 % and 26 %, respectively, from scattering calculations), while the effects in the SAL are smaller but non-negligible. The larger impact on longwave extinction compared to shortwave implies a bias towards a radiative cooling effect in dust models, which typically exclude giant particles and underestimate coarse-mode concentrations.

A compilation of the new and published effective diameters against dust age since uplift time suggests that two regimes of dust transport exist. During the initial 1.5 d, both coarse and giant particles are rapidly deposited. During the subsequent 1.5 to 10 d, PSD barely changes with transport, and the coarse mode is retained to a much greater degree than expected from estimates of gravitational sedimentation alone. The reasons for this are unclear and warrant further investigation in order to improve dust transport schemes and the associated radiative effects of coarse and giant particles in models.

This work has been recently published in ACP (Ryder, C. L., Highwood, E. J., Walser, A., Seibert, P.,

Philipp, A., and Weinzierl, B.: Coarse and giant particles are ubiquitous in Saharan dust export regions and are radiatively significant over the Sahara, Atmos. Chem. Phys., 19, 15353–15376, https://doi.org/10.5194/acp-19-15353-2019, 2019).