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Exclusion of Coarse and Giant Mineral Dust Particles Causes Significant Underestimation of Shortwave and Longwave Extinction over the Sahara

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Accurate representation of mineral dust size distributions is important yet challenging for both atmospheric circulation models as well as aerosol satellite retrieval algorithms. Recent field observations have shown that coarse (diameter (d) $>$ 2.5 μm) and giant (d $>$20 μm) dust particles are more prevalent than expected, being present up to high altitudes and undergoing long-range transport. Inaccurately representing these large dust particles in models has impacts on the radiation balance and climate processes depending on dust mass concentration.

Here the size distributions from two field campaigns are contrasted, where the coarse and giant particle size distributions were fully measured up to at least 100 μm: Fennec (over the Sahara during June 2011) and AER-D (over the Tropical Eastern Atlantic in the Saharan Air Layer (SAL) during August 2015). Vertical distributions of size distribution and mass concentration are presented. Observations show significantly more abundant coarse particles over the Sahara. Mass profiles show that in Fennec, an average of 40% of dust mass was found in the size range d $>$ 20 μm, contrasting to 2% during AER-D.

Shortwave and longwave spectral optical properties for Fennec and AER-D are presented, including the size-resolved contribution to scattering, absorption and extinction. The giant mode (d $>$ 20 μm) is found to contribute to 1% and 18% of extinction in the SAL and Sahara respectively at λ=0.55 μm. Similarly, in the longwave spectrum at λ=10.8 μm, the contribution from d$>$20 μm is 2% and 26% for SAL and Saharan dust. Excluding particles with d$>$20 μm (the typical maximum size in climate models and satellite optical models) therefore results in significant omission of both shortwave and longwave extinction over the Sahara.

Finally, Fennec and AER-D size results are combined with the latest airborne measurements of dust from the literature to suggest two regimes of dust transport. Firstly a regime where coarse and giant particles are rapidly deposited, followed by a second regime where particle size barely changes with transport, retaining the coarse mode to a much greater degree than expected from gravitational sedimentation alone.