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From fine to giant: Multi-instrument assessment of the particle size distribution of emitted dust during the J-WADI field campaign

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Mineral dust, a key component of Earth's aerosols, impacts atmospheric processes and climate. Emitted from dry soil, these particles travel long distances, influencing atmospheric radiation, cloud dynamics, and biogeochemical cycles. Dust effects are size-dependent. Larger particles, for example, tend to warm the atmosphere, whereas smaller ones (diameter d_p < 2.5 μm) typically cool it. Understanding dust transport and impacts requires detailed particle size distribution (PSD) data at emission, but measurements are sparse and larger particles (d_p > 10 μm) are understudied due to low concentrations and sampling challenges.

The Jordan Wind Erosion and Dust Investigation (J-WADI) campaign, conducted in September 2022 near Wadi Rum, Jordan, provides the platform for this study, in which we characterize the PSD at emission, focusing on super-coarse (10 < d_p ≤ 62.5 μm) and giant (d_p > 62.5 μm) particles. This study is the first to comprehensively characterize the size distribution of mineral dust directly at the emission source, covering diameters between 0.4 and 200 μm. Using a suite of aerosol spectrometers, the overlapping size ranges enabled systematic intercomparison and validation across instruments, improving PSD reliability and addressing challenges in detecting larger particles, such as inlet efficiencies or size range restrictions.

Results show significant PSD variability over the course of the campaign. During periods with friction velocities (u_*) above 0.25 ms^{-1}, super-coarse and giant particles were observed, with concentrations increasing with u_*. These large particles account for about two-thirds of the total mass during the campaign, with contributions of 90% during an active emission event, emphasizing the importance of including super-coarse and giant particles in PSD analyses. A prominent mass concentration peak was observed near 50 μm. While particle concentrations for d_p < 10 μm show strong agreement among most instruments, discrepancies appear for larger d_p due to reduced instrument sensitivity at the size range boundaries and sampling inefficiencies. Despite these challenges, physical samples collected using a flat-plate sampler largely confirm the

PSDs derived from aerosol spectrometers.

These findings advance the characterization of PSD over a large size range at emission sources and lay the foundation to further improve our understanding of the mechanisms facilitating super-coarse and giant dust particle emission and transport.

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