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EMIT Global Dust Source and Emission Mineral Abundance Maps for Dust and Climate Modeling

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Soil dust aerosols, comprised of diverse minerals with varying relative abundances, particle size distribution (PSD), shape, surface topography, and mixing state, exert a significant influence on climate. Despite this complexity, conventional Earth System Models tend to assume a globally uniform dust aerosol composition, overlooking well-documented regional variations in the mineralogy of their sources. Existing models addressing dust mineralogical variations often rely on mineral abundance maps extrapolated from an insufficient and non-uniform set of soil sample analyses, especially scarce in arid and semiarid regions.

This study introduces the first version of a series of global dust source and emission mineral abundance maps for dust and climate modelling built upon data from the Earth Surface Mineral Dust Source Investigation (EMIT) imaging spectrometer that is currently operational on the International Space Station (ISS). EMIT measures the spectral range from 0.38 to 2.50 microns through 285 contiguous spectral channels at a high spatial resolution of approximately 60 meters per pixel and ~77 km swath width. The EMIT ground system, utilizing Tetracorder, enables material identification and mapping on mineral spectra. EMIT provides quantitative maps for 10 critical minerals over dust sources pivotal for understanding interactions with the Earth System, with a specific emphasis on mapping iron oxides (hematite and goethite) to constrain the dust direct radiative effect.

Our study offers a comprehensive overview of the diverse methods explored, challenges faced, and key assumptions made to provide quantitative dust source mineralogy. Notably, addressing the absence of information on quartz and feldspar, whose absorption features extend beyond the measured spectral range, poses a significant challenge. Methodologies range from a model that linearly relates mineral abundance to absorption-feature band depth, to more advanced models solving the non-linear multiple scattering radiative transfer problem, providing abundances across a broader range of conditions.

Furthermore, the study provides insights into key assumptions guiding the derivation of mineral abundance maps for both clay and silt fractions of the soil. It also details methods rooted in brittle fragmentation theory, essential for estimating emitted size-resolved mineralogy, which is the critical input for Earth System Models.

This research contributes to advancing our understanding of soil dust aerosols, laying the foundation for improved climate models that account for nuanced regional variations in mineralogical composition.

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