Progress, challenges and perspectives in modeling dust composition

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Soil dust aerosols are mixtures of different minerals, whose relative abundances, particle size distribution (PSD), shape, surface topography and mixing state influence their effect upon climate. However, Earth System Models typically assume that dust aerosols have a globally uniform composition, neglecting the known regional variations in the mineralogy of the sources. The representation of the global dust mineralogy is hindered by our limited knowledge of the global soil mineral content and our incomplete understanding of the emitted dust PSD in terms of its constituent minerals that results from the fragmentation of soil aggregates during wind erosion. The emitted PSD affects the duration of particle transport and thus each mineral's global distribution, along with its specific effect upon climate. Coincident observations of the emitted dust and soil PSD are scarce and do not characterize the mineralogy. In addition, existing theoretical paradigms disagree fundamentally on multiple aspects.

I will revise recent progress in this field, discuss remaining challenges and give a perspective on how we could tackle them.

We need a better understanding of the size-resolved mineralogy of dust at emission and its relationship with the parent soil. I will discuss how tailored measurement campaigns may allow advancing current theoretical understanding.

To improve knowledge of the global soil mineral content for dust modeling, remote spectroscopic mapping of dust source regions represents a promising (yet unexplored) path for measuring the relative abundance of the key dust source minerals. In this respect, I argue that methods to estimate the emitted PSD in terms of its constituent minerals should anticipate the coming innovation of retrieving global soil mineralogy through high quality spaceborne hyperspectral measurements.

Finally, I will focus on additional observational constraints for models. For example, the absorption of solar radiation by dust is strongly related to the presence of iron oxides. The evaluation of iron oxides with radiance measurements from multiple in-situ and spaceborne instruments should allow stronger constraints upon direct radiative forcing by dust aerosols than is currently possible from models that do not consider dust mineralogy.