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Identifying Errors in Dust Models from Data Assimilation over Northern Africa

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Airborne mineral dust is an important component of the Earth system (e.g. radiation balance, cloud microphysics). It is also relevant for many forecast applications (e.g. air quality) and is increasingly being predicted prognostically in weather and climate models. The recent development of data assimilation for remotely sensed aerosol optical depths (AODs) into models offers a new opportunity to better understand the characteristics and sources of model error. Here we examine data assimilation increments (DAI) from MODIS AODs over northern Africa in the Met Office global forecast model. Comparisons with unassimilated AERONET data from the region show that assimilation improves dust forecasts.

We find that the model underestimates dust AOD under light winds and overestimates under strong winds. This is consistent with (sub-) mesoscale processes lifting dust in reality, but being missed by the model. Dust is over-predicted in the Sahara and under-predicted in the Sahel, which is potentially linked to the model's land surface.

Using satellite observations of lighting and rainfall as a proxy for moist convection, we show that haboobs (cold pool outflows from moist convection) are an important dust source in reality, but the associated dust is missing in the model, since the parameterized convection in the model fails to represent haboobs. Results suggest that dust from haboobs may make 10-30 % of the summer time western Saharan-Sahelian dust emission. The approach shows promise to serve as a systematic framework for future model evaluation and development and highlights the importance of either parameterizing haboobs or resolving moist convection.