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Strong Near-Surface Winds over Arid West Africa and Potential Dust Uplift: Sensitivity to Convective Parametrization and Model Resolution

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West Africa is the world's largest source of airborne mineral dust, which affects weather, climate and biogeochemical processes. Understanding the physical processes in the atmosphere that create strong-enough near-surface gusts to lift fine soil material is key to a better representation of the dust cycle in Earth system models.

Here we investigate continental-scale multi-day simulations during summer 2006 using the UK Met Office Unified Model over a wide range of horizontal resolutions that include both explicit and parameterized treatment of deep moist convection. A new diagnostic parameter called Dust Uplift Potential (DUP) is introduced to represent the dependency of dust uplift on wind speed for a homogeneous idealized soil in unvegetated areas. High-resolution simulations with explicit deep convection suggest that cold pool outflows from mesoscale convective systems are potentially responsible for on the order of half the dust uplift in West Africa. Corresponding coarse-resolution simulations with parameterized convection show substantially less convection-related DUP, but a compensating increased DUP due to the morning downward mixing of momentum from nocturnal low-level jets associated with a stronger pressure gradient into the Saharan heat low (SHL). Overall this leads to comparable time- and area-averaged totals in the different simulations. The weaker SHL in the high-resolution runs could be related to a more effective ventilation by convective cold pools, but a detailed investigation of this connection is beyond the scope of this study.

The net effect of convective parameterization on DUP in terms of spatial and temporal variability is a shift towards convectively less active days, towards the morning and midday hours, as well as towards the dry Sahara and away from the Sahel. These shifts have important ramifications on the activated dust sources and on vertical transports associated with the daytime boundary layer. The common practice of tuning coarse-resolution dust models cannot resolve these problems and such models are therefore expected to misrepresent feedbacks between convection, precipitation and dust uplift. A realistic representation of the dust cycle, as well as of the SHL, requires targeted efforts to develop computationally inexpensive ways to incorporate the effects of cold-pool outflows from deep convection.