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Large-eddy simulation of dust-uplift by a haboob density current

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Cold pool outflows have been shown from both observations and convection-permitting models to be a dominant source of dust emissions ("haboobs") in the summertime Sahel and Sahara, and to cause dust uplift over deserts across the world. In this paper Met Office Large Eddy Model (LEM) simulations, which resolve the turbulence within the cold-pools much better than previous studies of haboobs with convection-permitting models, are used to investigate the winds that uplift dust in cold pools, and the resultant dust transport. In order to simulate the cold pool outflow, an idealized cooling is added in the model during the first 2 h of 5.7 h run time. Given the short duration of the runs, dust is treated as a passive tracer. Dust uplift largely occurs in the "head" of the density current, consistent with the few existing observations. In the modeled density current dust is largely restricted to the lowest, coldest and well mixed layers of the cold pool outflow (below around 400 m), except above the "head" of the cold pool where some dust reaches 2.5 km. This rapid transport to above 2 km will contribute to long atmospheric lifetimes of large dust particles from haboobs. Decreasing the model horizontal grid-spacing from 1.0 km to 100 m resolves more turbulence, locally increasing winds, increasing mixing and reducing the propagation speed of the density current. Total accumulated dust uplift is approximately twice as large in 1.0 km runs compared with 100 m runs, suggesting that for studying haboobs in convection-permitting runs the representation of turbulence and mixing is significant. Simulations with surface sensible heat fluxes representative of those from a desert region during daytime show that increasing surface fluxes slows the density current due to increased mixing, but increase dust uplift rates, due to increased downward transport of mo- mentum to the surface.