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Dust devil characteristics and associated dust entrainment based on large-eddy simulations

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The characteristics of dust devils, such as occurrence frequency, lifetime, size, and intensity, are usually inferred from in situ field measurements and remote sensing. Numerical models, e.g. large-eddy simulation (LES) models, have also been established as a tool to investigate dust devils and their structures. However, most LES models do not contain a dust module. Here, we present results from simulations using the WRF-LES model coupled to the convective turbulent dust emission (CTDE) scheme of Klose et al. (2014). The scheme describes the stochastic process of aerodynamic dust entrainment in the absence of saltation. It therefore allows for dust emission even below the threshold friction velocity for saltation. Numerical experiments have been conducted for different atmospheric stability and background wind conditions at 10 m horizontal resolution. A dust devil tracking algorithm is used to identify dust devils in the simulation results. The detected dust devils are statistically analyzed with regard to e.g. radius, pressure drop, lifetime, and turbulent wind speeds. An additional simulation with higher horizontal resolution (2 m) is conducted for conditions, which are especially favorable for dust devil development, i.e. unstable atmospheric stratification and weak mean winds. The higher resolution enables the identification of smaller dust devils and a more detailed structure analysis. Dust emission fluxes, dust concentrations, and dust mass budgets are calculated from the simulations. The results are compared to field observations reported in literature.