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High-Resolution Simulations of Convective Cold Pools over the Northwestern Sahara

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Cooling by evaporation of convective precipitation in the deep and dry subcloud layer over desert regions can generate intense downdrafts and long-lived and extensive atmospheric density currents. The strong gusts at their leading edges can cause so-called haboob dust storms. Despite their importance for the dust cycle, the ability of state-of-the-art numerical weather prediction models to realistically simulate the associated convective cold pools has been investigated very little to date.

During the first field campaign of the Saharan Mineral Dust Experiment in southern Morocco in May/June 2006, several density currents were observed. They were triggered by deep moist convection over the Atlas Mountains during the afternoon and propagated into the foothills in the course of the evening. The passage of the leading edge is associated with a marked increase in dew point, wind speed and pressure, a change in wind direction, and a decrease in temperature and visibility.

Here we present numerical simulations of three of these density currents using the nonhydrostatic Consortium for Small-Scale Modelling (COSMO) model with 2.8-km horizontal grid spacing, which allows an explicit treatment of deep convection. The model is capable of simulating the timely initiation of convective cells over the Atlas Mountains and the subsequent formation of long-lived, extensive cold pools with a realistic three-dimensional structure. Deviations from available surface and satellite observations are closely related to model deficiencies in simulating precipitating convection over the Algerian Sahara. Sensitivity studies with modified microphysics reveal a large influence of raindrop size distributions on evaporation and surface rainfall but a rather moderate influence on the cold pool evolution. Decreasing the length scale for turbulent vertical mixing in the boundary layer leads to more widespread but weaker precipitation, more evaporation, and a faster and more extended cold pool.