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Effects of Surface Heat Flux Anomalies on Stratification, Convective Growth and Vertical Transport within the Saharan Boundary Layer

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The very large surface sensible and very low latent heat fluxes in the Sahara desert lead to its unusually deep, almost dry-adiabatic boundary layer, that often reaches 6 km. This is often observed to consist of a shallow convective boundary layer (CBL) with a near neutral residual layer above (the Saharan Residual Layer, or SRL). It has been shown that the SRL can be both spatially extensive and persist throughout the day. Multiple near-neutral layers are frequently observed within the SRL, or within the SAL, each with a different water vapour and/or dust content, and each separated by a weak lid (e.g., Figure 1). A local maximum in not only relative humidity, but also water vapour mixing ratio (WVMR) is often seen at the top of the SRL or SAL. This structure suggests that in some locations, at some times, convection from the surface is mixing the full depth of the Saharan boundary layer, but in most locations and times this is not the case, and varying horizontal advection leads to the multiple layering observed.

During the GERBILS (GERB Intercomparison of Longwave and Shortwave radiation) field campaign in the Sahara, coherent couplings were observed between surface albedo, CBL air temeperatures and CBL winds. Using two cases based on observations from GERBILS, large eddy model (LEM) simulations have been used to investigate the effects of surface flux anomalies on the growth of the summertime Saharan CBL into the Saharan Residual layer (SRL) above, and transport from the CBL into the SRL. Hot surface anomalies generated updraughts and convergence in the CBL that increased transport from the CBL into the SRL. The induced subsidence in regions away from the anomalies inhibited growth of the CBL there. If the domain-averaged surface fluxes were kept constant this led to a shallower,
cooler CBL. If fluxes outside the anomalies were kept constant, so that stronger anomalies led to increased domain-averaged fluxes, this gave a warmer, shallower CBL. These effects were larger for wider, stronger anomalies, with low winds. These LEM simulations show that mesoscale variations in surface fluxes can contribute to both inhibiting the growth of the Saharan CBL into the SRL, and generating layerings within the SRL.