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Surface heterogeneity effects on regional-scale fluxes in stable boundary layers: an LES study

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The ability to parameterize turbulent fluxes over heterogeneous terrain is dependent upon our understanding of the complex interaction between land-surface characteristics and atmospheric boundary layer (ABL) dynamics. Under stable ABL conditions, the effect of stratification on local characteristic turbulence length scales further complicates this interaction. In this study we use large-eddy simulation (LES), with recently developed tuning-free dynamic subgrid-scale models, to study the effect of heterogeneous surface temperature on areally averaged turbulent fluxes. The simulation setup is based on the GABLS LES intercomparison case with an expanded domain. The surface heterogeneity consists of simple one-dimensional patches with different temperatures. Simulations are performed with changing patch sizes and also temperature differences between patches. Results indicate that within the surface layer both traditional and local Monin-Obukhov similarity theories fail to fully represent the average turbulent fluxes of heat and momentum. The error increases with increasing patch size and also with increasing temperature difference between patches. Above the blending height, which depends on the patch size, the turbulent fluxes follow local similarity. These results are expected to add further understanding of the limitations of current surface flux parameterizations used in large-scale weather and climate models.