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Effect of Mesoscale Land Use Change on Characteristics of Convective Boundary Layer: Semi-Idealized Large Eddy Simulations over Northwest China

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Although large-scale topography and land use have been properly considered in weather and climate models, the effect of mesoscale and microscale heterogeneous land use on convective boundary layer (CBL) has not been fully understood yet. In this study, the influence of semi-idealized strip-like patches of oases and deserts, which resemble irrigated land use in Northwest China, on the CBL characteristics, is investigated based on the Weather Research and Forecasting (WRF)-large eddy simulation (LES) driven by observed land surface data. The influences of soil water content in oases on aloft CBL flow structure, stability, turbulent kinetic energy (TKE), and vertical fluxes are carefully examined through a group of sensitivity experiments. The results show that secondary circulation (SC)/turbulent organized structures (TOS) is the strongest/weakest when soil water content in oases is close to saturation (e.g., when the oases are irrigated). With the decrease of soil water content in oases (i.e. after irrigation), SC (TOS) becomes weak (strong) in the lower and middle CBL, the flux induced by SC and TOS becomes small (large), which has a dramatic impact on point measurement of eddy covariance (EC) fluxes. The flux induced by SC and TOS has little influence on EC sensible heat flux, but great influence on EC latent heat flux. Under this circumstance, the area averaged heat flux cannot be represented by point measurement of flux by the EC method, especially just after irrigation in oases. Comparison of imbalance ratio (i.e. contribution of SC and TOS to the total flux) reveals that increased soil moisture in oases leads to a larger imbalance ratio as well as enhanced surface heterogeneity. Moreover, we found that the soil layer configuration at different depths has a negligible impact on the CBL flux properties.