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Study of large eddy simulation of the effects of boundary layer convection on tracer uplift and transport

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Using large eddy model (LEM) and observed data from Dunhuang meteorological station during the intensive period of land-atmosphere interaction field experiment over arid region of North-west China, a series of sensitivity experiments have been performed to investigate the effects of the surface heat flux and wind shear on the strength and the organization of boundary layer convection as well as the growth of the convective boundary layer (CBL). The results show that surface heat flux increases with constant wind shear will give rise to a thicker and warmer CBL, stronger convections and larger thermal eddies due to intense surface turbulence transporting more energy to the upper layer. On the other hand wind shear increases with constant surface heat flux lead to a thicker and warmer CBL because of the entrainment of warm air from the inversion layer to the mixed layer, while the boundary layer convection became weaker with broken thermal eddies. To investigate the quantitative linkage of surface heat flux, wind shear with the tracer uplift rate and transport height, a passive tracer with a constant value of 100 was added at all model levels below the 100 m in all simulations. The least square analysis reveals that the tracer uplift rate increases linearly with the surface heat flux when wind shear is less than 10.5×10-3 s-1 owing to the enhancement of the downward transport of higher momentum. However, the tracer uplift rate decreases with increasing wind shear when the surface heat flux is less than 462.5 W/m2 because of the weakened convection. The passive tracer in the model is also shown to be transported to the higher altitude with increasing surface heat flux and under constant wind shear. However, under a constant surface heat flux, the tracer transport height increases with increasing wind shear only when the shear is above a certain threshold and this threshold depend on the magnitude of surface heat fluxes.