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# Large-eddy-model closure and simulation of turbulent flux patterns over oasis surface

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**Supplementary material: The determination of $\alpha$**

$\alpha_j$ represents the efficiency factor of $H_{\mathrm{most}}$ for land use type *j*. For a homogeneous surface, $\alpha$ is expected to be close to one, while for other surfaces, it is expected to differ from one as the MOST assumptions are not fully met. For a domain much larger than the scale of surface heterogeneity, we expect $\alpha$ not to differ substantially from one. We will discuss the solution of $\alpha$ in several different scenarios as follows:

For any given surface, as the true flux is not known, the coefficient $\alpha$ introduced in Eq. (21) as a measure of efficiencies embedded in the various flux estimates on the macro scale (i.e., $H_{\mathrm{most}}$), either parameterized or observed, is unknown. However, a general understanding of $\alpha$ can be achieved through an inter-comparison of various estimates.

For a relatively homogeneous surface, it is plausible to assume that measurements reasonably well represent the true macroscopic fluxes. Thus, a plot of the parameterized fluxes against the observed fluxes can be interpreted as $\alpha$. For example,

$$H_{\mathrm{obs}} = \alpha H_{\mathrm{most}}, \qquad \text{(F1)}$$

where $H_{\mathrm{obs}}$ is sensible heat flux observation. Then, the macroscopic fluxes estimated using the mosaic method based on MOST (Niu et al., 2011) are compared with the observations.

For a more homogeneous surface, the idealized experiments are performed as follows to determine the $\alpha$ value. Two experiments over homogeneous surface were carried out, where two land use types, i.e., “Mixed dryland/irrigated cropland and pasture” (hereafter MDICP) and “Urban and built-up land” (hereafter UBL), are selected, respectively. The model domain is 5 km × 5 km with a depth of 2.6 km. The number of vertical layers is 100 with a resolution $\Delta z$ stretching from 10 m to 40 m. The horizontal grid spacing is $\Delta x = \Delta y = 50$ m. A Rayleigh damping layer is set at 500 m from the top to dampen the gravity waves. The initial horizontal wind speed, potential temperature, and humidity profiles are obtained from the soundings at the Zhangye Station (39.08°N, 100.27°E, 1556.06 m ASL) at 0800 local time (LT) on August 20, 2012 (Fig. 4). The model is forced by the solar shortwave radiation and upward longwave radiation flux observed at the Daman Station (38.85°N, 100.37°E, 1556.00 m ASL) from 0800 to 1800 LT. The initial soil temperature and moisture for MDICP and UBL are represented by the observations at 0800 LT on August 20, 2012, at the Daman and Village Stations, respectively. Each case runs 10 hours. For the simulation period, the weather was sunny and free from the weather system. The physics parameterization schemes are selected as follows: the 1.5-order TKE closure

(Deardorff, 1980; Zhang et al., 2018) is selected for the subgrid closure, and the revised MM5 Monin-Obukhov scheme is used for the surface layer (Jimenez, 2012). Surface heat flux observations are obtained from the eddy covariance (EC) system at the Daman and Village Stations, representing the fluxes over the MDICP and UBL surfaces, respectively. The flux measurements are quality-checked (Liu et al., 2011) and provide an additional reference for the simulations.

The scatter plots (Fig. S1a-d) show the degree of dispersion between observed fluxes and those estimated using MOST, together with the fittings of the estimated $H_{\mathrm{most}}$ to the observations. Figure S1 shows that, for sensible heat flux, the $\alpha$ values are 0.94 and 1.03 for MDICP and UBL, respectively. For latent heat flux, these values are 0.92 and 1.09 for MDICP and UBL, respectively. These comparisons show that the estimated $H_{\mathrm{most}}$ and $LE_{\mathrm{most}}$ by using MOST are generally consistent with EC measurements. This confirms our hypothesis that for a more homogeneous surface, the $\alpha$ values are found to be close to one, even though with somewhat larger scatter. It is thus justified to estimate the macroscopic constraint using MOST. The use of Eq. (21) is advantageous, because it provides a self-constraint using the data generated by LES and does not need additional independent information.

In the real experiment in Section 3.2, we set $\alpha$ values for MDICP is equal to that over CWM. Therefore, for MDICP, CWM, and UBL, $\alpha$ values of 0.94, 0.94, and 1.03 were assigned to sensible heat flux, while for latent heat flux, the values were 0.92, 0.92, and 1.09, respectively.

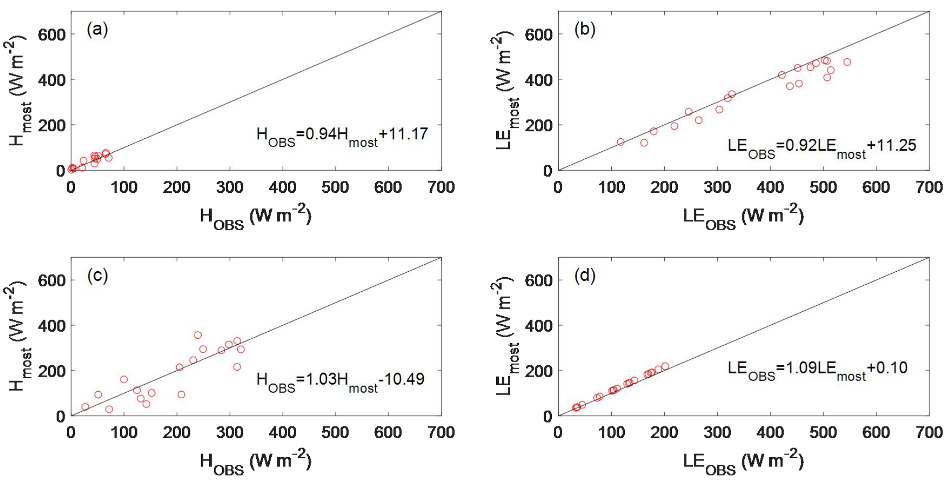


**Figure S1.** Results from simulation experiments over homogeneous surfaces. Scatter plots of (**a**) $H$ and (**b**) $LE$ estimated using MOST (Section 2.2) against the observed fluxes for MDICP. (**c**) and (**d**) as (**a**) and (**b**), respectively, but for UBL. The horizontal grid spacing is set to $\Delta x = 50$ m for the large-eddy simulations.