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The impacts of thermal roughness length on land surface climate in IPSL-CM

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The aerodynamic and thermal roughness lengths (z0m and z0h) are the two crucial parameters for bulk transfer equations to calculate turbulent flux. The exchange of momentum is usually different with scalars as heat (or water vapor, carbon dioxide, traces gas). In general, the transport of scalars (by molecular diffusion) is considered less efficient than momentum (by pressure fluctuations), owing to the absence of bluff-body forces for scalar exchange. However, the z0h and z0m are equal in the current IPSL-CM model. The objective of the study is to investigate the impacts of z0h parameterizations on the land surface climate. Several sensitivity experiments that accounting for different z0h and z0m are carried out with IPSL-CM: (1) z0h = z0m/10; (2) z0h = z0m/100; (3) a more physically based z0h parameterizations. A nudging approach is used in order to avoid the time-consuming long-term simulations required to account for the natural variability of the climate.

The results show that the seasonal mean surface temperature (Ts) increases 0.5-1 K (for z0h = z0m/10) and 1-2 K (for z0h = z0m/100) over JJA due to the decrease of z0h. The most significant variation is over the Sahara. During the daytime, the increase of Ts (around 1-2 K) is higher than the air temperature (Tair, ∼0.2 K) for z0h = z0m/10. During the night time, the increase of Ts and Tair are very close (around 0.3-0.6 K) for z0h = z0m/10. The asymmetric variation of Tair during night and day causes a decrease (∼0.3 K for z0h = z0m/10; ∼0.6 K for z0h = z0m/100) of diurnal temperature range (DTR). The seasonal mean sensible heat flux decreases by ∼4-6 W/m2 (for z0h = z0m/10) with the decrease of z0h as well. The change of latent heat flux is the most significant over the tropics with the seasonal mean decrease of 4-8 W/m2 for z0h = z0m/10 over both JJA and DJF. Besides the change of mean climate, the human thermal comfort is also affected by z0h. A smaller z0h corresponds to a higher wet-bulb temperature, which implies that less net conductive and evaporative cooling of human body can occur to remove the metabolic heat.