Simulation Analysis of Local Land Atmosphere Coupling in Rainy Season over a Typical Underlying Surface in the Tibetan Plateau

Genhou Sun\textsuperscript{1,2}, Zeyong Hu\textsuperscript{3,5}, Yaoming Ma\textsuperscript{5,4}, and Song Yang\textsuperscript{1,2}

\textsuperscript{1}School of Atmospheric Sciences, Sun Yat-sen University, Guangzhou, China
\textsuperscript{2}Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), Zhuhai, China,
\textsuperscript{3}Northwest Institute of Eco-Environment Resources, CAS, Lanzhou, China
\textsuperscript{4}Institute of Tibetan Plateau, Chinese Academy of Sciences, Beijing, China
\textsuperscript{5}CAS Center for Excellence in Tibetan Plateau Earth Sciences, Beijing, China

The Local land atmosphere coupling (LoCo) focuses on the interactions between soil conditions, surface fluxes, PBL growth, and the formations of convective clouds and precipitations, and a study of LoCo over the Tibetan Plateau (TP) is of great significance to understand its role of “Asian Water Tower”. This study investigates the LoCo characteristics over a typical underlying surface in central TP in the rainy season based on a series of real case simulations using Weather Research and Forecasting Model (WRF) with different combinations of land surface model (LSM) schemes and planetary boundary layer (PBL) schemes based on in-situ measurements. Then the LoCo characteristics over a typical underlying surface in central TP are analyzed using a mixing diagram. The simulations results indicates that WRF simulations using Noah with BouLac, MYNN, and YSU produce much better results in terms of curves of $C_p*\theta$ and $L_v*q$, surface fluxes ($H_{\text{sfc}}$ and $L_{\text{sfc}}$), entrainment fluxes ($H_{\text{ent}}$ and $L_{\text{ent}}$) at site BJ/Nagqu that those using CLM with BouLac, MYNN, and YSU do. The frequency distributions of $H_{\text{sfc}}$, $L_{\text{sfc}}$, $H_{\text{ent}}$, and $L_{\text{ent}}$ in the study area confirmed this result. The spatial distributions of simulated $H_{\text{sfc}}$, $L_{\text{sfc}}$, $H_{\text{ent}}$, and $L_{\text{ent}}$ using WRF with Noah and BouLac suggest that the spatial distributions of $H_{\text{sfc}}$ and $L_{\text{sfc}}$ in the study area show a good consistent with that of soil moisture, but the spatial distributions of $H_{\text{ent}}$ and $L_{\text{ent}}$ are quite different from that of soil moisture. A close examination of the relationship between entrainment fluxes and cloud water contents (QCloud) reveals that the grids with small $H_{\text{ent}}$ and large $L_{\text{ent}}$ are likely to have high QCloud and $H_{\text{sfc}}$. This means that high $H_{\text{sfc}}$ is conductive to convective cloud formations, which lead to small $H_{\text{ent}}$ and large $L_{\text{ent}}$. Sensitivity analysis of LoCo to the soil moisture at site BJ/Nagqu indicates that in a sunny day, an increase in soil moisture leads to an increase in $L_{\text{sfc}}$ but a decrease in $H_{\text{sfc}}$, $H_{\text{ent}}$, and $L_{\text{ent}}$. The sensitivity of the relationship between simulated max daytime PBLH and mean daytime EF in the study area to soil moistures indicates that the rate at which the max daytime PBLH decrease with the mean EF increases as the initial soil moisture goes up. The analysis of simulated $H_{\text{sfc}}$, $L_{\text{sfc}}$, $H_{\text{ent}}$, and $L_{\text{ent}}$ under different soil moisture conditions reveals that the frequencies of $H_{\text{ent}}$ ranging from 80 W/m$^2$ and over 240 W/m$^2$ and frequency of $L_{\text{ent}}$ ranging from -240 W/m$^2$ to -90 W/m$^2$ increase as the initial soil moisture increases. Coupled with the changes in QCloud, the changes in $H_{\text{ent}}$ and $L_{\text{ent}}$ as the initial soil moisture increases indicate that the increase in soil moisture lead to an increase in cloud amounts but a decrease in
