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Discussions

Interactive comment on "Simulation Analysis of Local Land Atmosphere Coupling in Rainy Season over a Typical Underlying Surface in the Tibetan Plateau" *by* Genhou Sun et al.

Genhou Sun et al.

sungh6@mail.sysu.edu.cn

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Responses to the comments of the Reviewer #1

This study investigates the local land-atmosphere coupling over a site in the Tibetan Plateau using the WRF model in a nested domain configuration. The experimental design uses several different LSM and PBL scheme combinations for a 36-hour simulation on a case study day in which many observations exist. The Tibetan Plateau is an area of great interest for water resources priorities, so this type of investigation is quite relevant to a broad community. The results show that the model coupling is sensitivity to the LSM and PBL scheme combination, as well as to the initial soil moisture. These

differences ultimately cause changes to convective cloud development. The paper is generally well-written and the scope is manageable and interesting. That being said, there are a few areas in which the manuscript should be revised before publication. In particular, the spatial soil moisture map derived from LAI seems to have unreasonably high values of volumetric soil moisture. In addition, although most of the results are discussed appropriately, there are a couple of statements in the results that are not supported by the figures or analyses as they are currently presented. These issues are discussed in more detail below in the major comments. Response: Thanks for your comments and suggestions, which are very helpful to improve our manuscript. We will do our best to answer your precious comments and suggestions and hope our responses would satisfy you.

Major comments: 1ïijĽ Lines 121-130: The spatial soil moisture map derived from LAI and shown in Figure 2b has a lot of very high values (>âĹij0.6). This is worrisome for two reasons. The first is that volumetric soil moisture is not usually that high, so I'm skeptical of how realistic this map is. What are the observed values of soil moisture at the site of interest on this date? What are the min and max soil moisture over the course of the year for this site? Although it is only for one site, this type of analysis could give insight into what is a reasonable max soil moisture for this area. The second potential issue with soil moisture values this high is that they will not even really be used in the Noah LSM. If the authors are using the standard soil texture classifications and soil parameter tables, each soil class has a maximum soil moisture. The maximum soil moisture value varies for each class but even the highest max soil moisture value is less than 0.5. Therefore, all of these high values will essentially be reset to the max SMC for the texture class anyway, making the map more dependent on the soil texture map than on the derived soil moisture from LAI. Responses: Thanks for your comments. The red area in the Fig. 2b) represents lakes in the study area, where the soil moisture is close to 1.0. The soil moisture in other parts of the study area varies from 0.2 to 0.5. This agrees with the soil parameter tables in Noah LSM. We have added this to the Fig. 2. The interactions between the lakes and land surface in the domain 3 are simulated in this study. Because this study mainly focuses on the interactions between the land surface and the atmosphere, the simulation result over lakes is not included in the study by discussing the results where the soil moisture is less than 1.0.

2ïijĽ Section 2.2: Please provide more information on the experimental design. The analysis is 8:00-17:00 local time on August 7, 2011 and the total simulation length is 36-hours, but when is the simulation initialized? Please specify the exact date and time. This is important for understanding the divergence in the starting point in the mixing diagrams between the Noah runs and the CLM runs. The Noah run is wetter and warmer than the CLM run, but they start with the same initial soil moisture and are being forced by the same atmospheric data, right? The amount of time and the time of day that has passed between the initialization and the figures shown are necessary to understand these differences. ResponseïijŽ Thanks for your comment. The simulations start in 02:00 August 7, 2011. The simulations from 02:00 to 08:00 of August 7, 2011 are the spin-up time, and the simulations from 08:00 17:00 of August 7, 2011 are used for this analysis. It is true that the initial soil moisture and forced atmospheric data are same for the Noah runs and CLM runs. The simulations of the Noah and CLM runs indicate that there are clear differences in the T2m and q2m and surface fluxes of the Noah and CLM runs, which may be caused by the physics of the Noah and CLM schemes. This has been added to the section 2.2. 3) Figure 8 does not appear to support the description given of the figure. For example, lines 248-249 say that the soil moisture pattern corresponds with the LEsfc and Hsfc. Except for a couple of spots in the higher elevations in the southwest part of the domain, I don't see how these patterns match up. Perhaps the scale on the figure is not doing the pattern justice? If so, please revise. Otherwise, perhaps the LEsfc corresponds better with the vegetation pattern? ResponseïijŽ Thanks for your comments. The spatial distribution of soil moisture in Fig. 8 shows that the soil is dry in the west and south parts of the study area and is generally wet in the middle and east parts of the study area and the areas close to lakes. The Hsfc in the west part of the study area is higher than that in

the east part of the study area except some grids of high altitudes (Fig.1b)). The LEsfc in the east part of the study area is high than that in the west part of the study area. Therefore, it is reasonable to say that the spatial distribution of surface fluxes shows a good agreement of that of soil moisture. For the spatial distribution of surface fluxes, it seems that the altitude in the study area has an influence on the surface fluxes, where the area with high altitudes show high Hsfc and low LEsfc.

Minor comments: 1) Line 35 describes the Tibetan Plateau as being the Asian Water Tower (i.e., 'also known as'). Line 41, 'TP's role in Asian Water Tower' implies that they are two different things and the TP may affect the Asian Water Tower. Please correct and clarify. Response: Thanks for your comments. Tibetan Plateau is known as the Asian Water Tower. The last sentence of paragraph has been rewritten as "Therefore, studying the LoCo over the TP is of great significance for understanding the characteristics of Asian Water Tower". 2) Line 98 refers to Fig. 1c, but there is not a Fig. 1c. Response: Thanks. It is a typo and should be Fig .1b. This typo has been corrected.

3) Lines 129-130: This statement about how the soil moisture was extended to the lower levels is unclear. Was the derived top layer soil moisture used for the entire depth down to 40 cm (so it is uniform vertically)? Please clarify. Response: Thanks for your comment. The variation of soil moisture in the ERA-Interim from 40-cm depth to the top shows very small changes and we assume that the soil moisture from top to 40 cm depth is the same. We thus modified the soil from 40-cm depth to the top by applying the relationship between soil moisture at 5 cm and LAI (Fig. 2 b)). 4) Line 142: Please specify the exact start date/time that the run was initialized. Response: All the simulations start from 02:00 August 7, 2011, Beijing Time, and run for 36 h. The first 6 h of the simulation is for the spin-up, and the simulation results from 08:00 -17:00 August 7, 2011, of the domain 3 are used for the following analysis.

5) Lines 148-149: Unless a modification was made to the Noah LSM in this study, the Noah LSM uses a static vegetation dataset. The Noah LSM is the land model

for the GFS model. The way the statement is written, it sounds like the Noah LSM is using output from GFS for vegetation, which is not correct. Please revise. Response: Thanks for your suggestion. This sentence has been rewritten "A static vegetation dataset based on the monthly Normalized Differential Vegetation Index is used for the Noah LSM." 6) Section 3.1: At 8 am, the CLM simulations are starting cooler and drier than the Noah simulations. Is this because of the initial conditions at the start of the coupled runs? Is it because of vegetation or other differences in the way CLM and Noah calculate fluxes? This is an important point and should be explored further. Response: The CLM and Noah are driven using the same surface conditions (the same initial soil moisture) and atmosphere conditions, and they all start at the same time. Therefore, the most possible reason for the differences in the simulations in the CLM and Noah runs is the differences in the physics of the models.

7) Section 3.1: In most of this section, the paper states the statistics and which runs have more or less flux, but there is little explanation of physical explanation behind the statistics. Please consider adding more physical explanation as it would be more interesting to reader if these statistics were translated into what is physically happening in the PBL to cause these differences. Response: Thanks for your comments. The simulated Hsfc by Noah-MYNN at BJ/Nagqu is larger than those by Noah-BouLac and Noah-YSU while the simulated LEsfc by Noah-MYNN is smaller. This indicates that there are more heat and less vapor into the PBL at BJ/Nagqu in the Noah-MYNN than in the Noah-BouLac and Noah-YSU. According to the Hent and LEent, there is less heat and dryer air entrained into PBL in the Noah-MYNN than that in the Noah-BouLac and Noah-YSU. The differences in Hent and LEent could be attributed to the relatively small PBLH (1418m) by Noah-MYNN than that by Noah-BouLac and Noah-YSU. The simulated Hent and LEent values using CLM with Boulac and YSU are much larger than the observed while, indicating that more heat and less dry air is entrained into PBL than the observed. The Hent using CLM-MYNN is close to the observed while the LEent is larger than the observed, indicating that similar heat and less dry air is entrained into PBL than the observation. We have added these to section 3.1. 8) Line

263: Does this approach only exclude the water points or also the grid cells nearby water? Why not dismiss the grids where the SM is 1.0 or the land cover is water instead? Response: Thanks for your comment, and we accept your suggestion We have checked the result and found that the soil moisture is much a better variable to distinguish the relationship between EF and PBLH over the lake and land. We also found that the simulated soil moisture near the lake is below 0.4, making it very easy to dismiss the lake. The relationships between EF and PBLH in different runs over land are shown as follows.

Fig. 10 Relationship between mean daytime EF and the max daytime PBLH simulated by CLM and Noah with different PBL schemes. The grid in which the mean soil moisture is 1.0 is excluded to avoid the possible influence of lakes in the study 9) Lines 266-267: The larger spread in EF seems to imply that there is more surface heterogeneity in Noah than CLM, right? What is the dominant factor causing this? The initial soil moisture is the same for both Noah and CLM, right? Does that mean that it's the treatment of vegetation and/or soil parameters? This should be explored more because it seems to be an important factor in these differences between LSMs. Response: Thanks for your comment. The larger spread in EF in the Noah run does not imply that there is more heterogeneity in Noah. The frequency distribution of the simulated 5 cm soil moisture of the study area in Fig .7 clearly shows that there is a very small difference in the soil moisture in all the runs. Therefore, the surface heterogeneity in terms of the soil moisture simulated using Noah is only a little more complicated than that simulated using CLM (Fig. 7), and this is not the main reason for the larger spread in EF simulated using Noah. The larger spread in EF simulated using Noah runs is mainly caused by larger variations in Hsfc and LEsfc (Fig. 7) by Noah than those by CLM. According to Fig. 7, the simulated LEsfc in CLM runs vary in narrower ranges than the Hsfc and LEsfc in Noah runs do, while the ranges of Hsfc in CLM runs are similar to those in the Noah runs. This is the main reason for the large spread in EF, which could be attributed to the differences in the performance of CLM and Noah in calculating surface fluxes over a typical underlying surface in Tibetan Plateau. 10)

Line 267-268: "...the simulation using BouLac produces closest result to the observation, which agrees with the results in this study." What variables/metrics are being used to determine that Noah-BouLac is the closest to observations for this study? Based on Figure 6, the Noah-BouLac is not the closest to observations. Please clarify and explain. Response: Thanks for your comment. The frequency distributions of surface fluxes in Fig.7 indicate that the Hsfc and LEsfc in the study area simulated using Noah-BouLac are more acceptable than those using Noah-MYNN. The latter produces larger Hsfc and smaller LEsfc in the study area. The accurate simulation of surface fluxes is very important for the LoCo analysis, and the calculation of entrainment fluxes relies heavily on the surface fluxes. This is why we believe the Noah-MYNN fails to produce reliable surface fluxes, despite Fig. 6 show some supports to Noah-MYNN.

11) Figures 6 and 7 show the same runs, but the color scheme is different. Please keep a consistent color scheme between these two figures so that it makes it easier on the reader to follow. Also, if possible, please consider reducing the number of colors shown here. You could do that by assigning one color to each PBL scheme (for example orange to YSU) and then using an open icon (i.e., unfilled, just the outline) for CLM and filled icon for the Noah for Figure 6. For Figure 7, you could use one color for each PBL scheme again, but dashed line for CLM and solid for Noah. Response: Thanks for your comments. Fig. 6 and 7 have been replotted.

Fig. 6 PBL energy balance at BJ/Nagqu simulated using CLM and Noah with different PBL schemes

Fig. 7 Frequency distribution of (a) mean soil moisture at 0-10 cm and (b) - (g)PBL energy budgets on August 7, 2011, simulated using different combinations of LSM and PBL schemes

Technical corrections: 1) Line 24: conductive should be conducive Response: Thanks. This has been corrected. 2) Line 64: in-sit should be in-situ Response: Thanks. This has been corrected. 3) Line 163: remove 'at the daytime' Response: Thanks. This has

been removed.

4) Line 163: 'furthered this study' -> furthered this 'method' or 'technique' might be more appropriate than study. Response: Thanks. This has been corrected.

Please also note the supplement to this comment:
https://hess.copernicus.org/preprints/hess-2020-199/hess-2020-199-AC1-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-199, 2020.

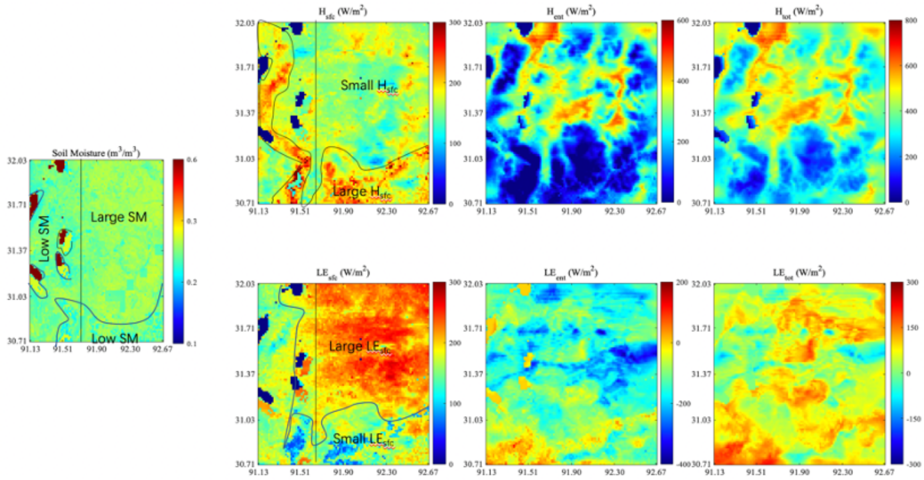

Fig. 1. Fig. 8 Spatial distributions of mean soil moisture at 0-10 cm and PBL energy budgets on August 7, 2011 simulated using WRF with Noah-BouLac. The scale of colormap for the soil moisture is 0∼0.6 m3/m3

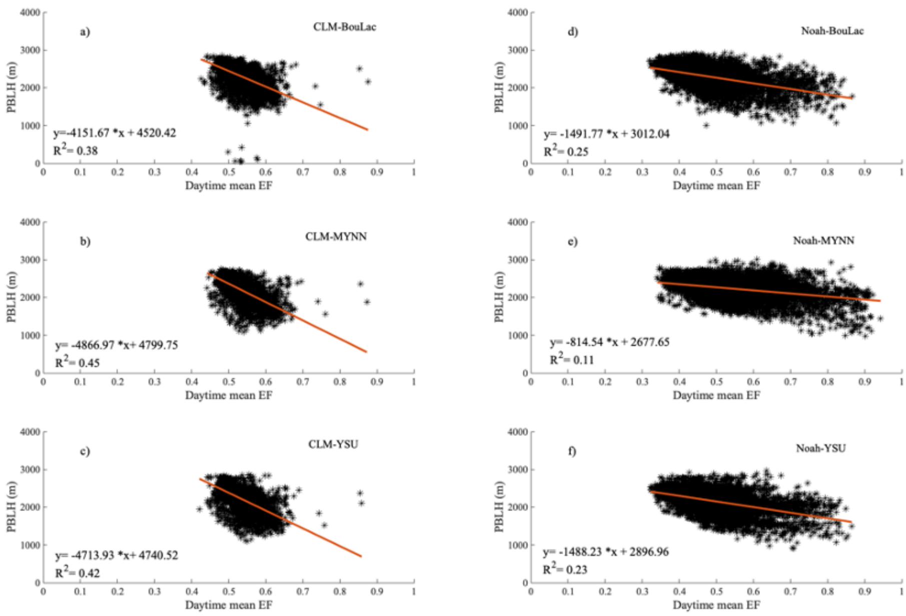

Fig. 2. Fig. 10 Relationship between mean daytime EF and the max daytime PBLH simulated by CLM and Noah with different PBL schemes. The grid in which the mean soil moisture is 0.1 is excluded to avoid the pos

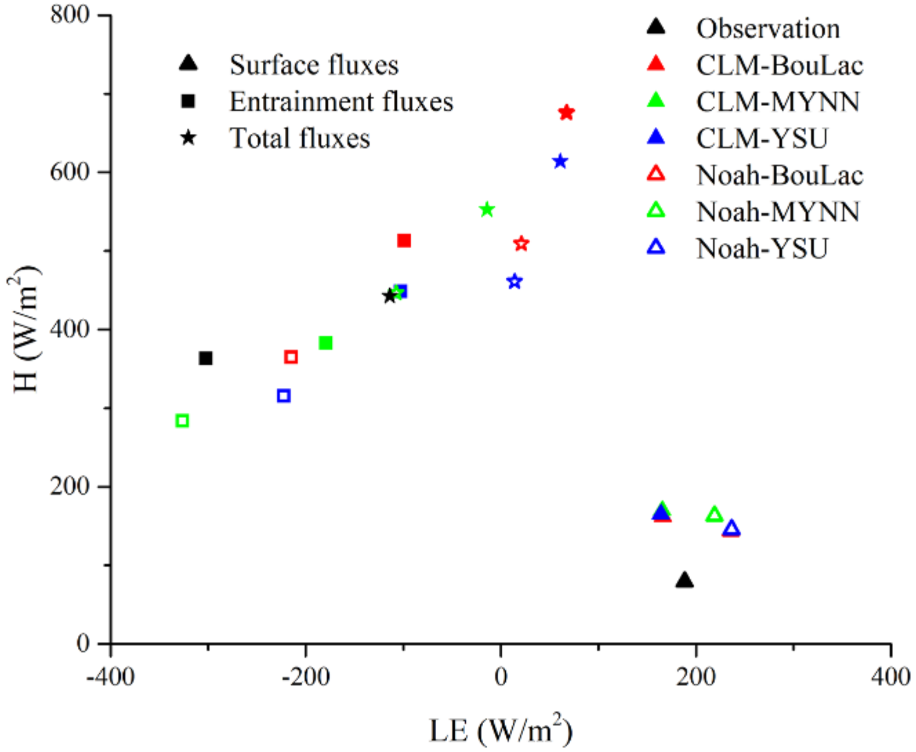

Fig. 3. Fig. 6 PBL energy balance at BJ/Nagqu simulated using CLM and Noah with different PBL schemes

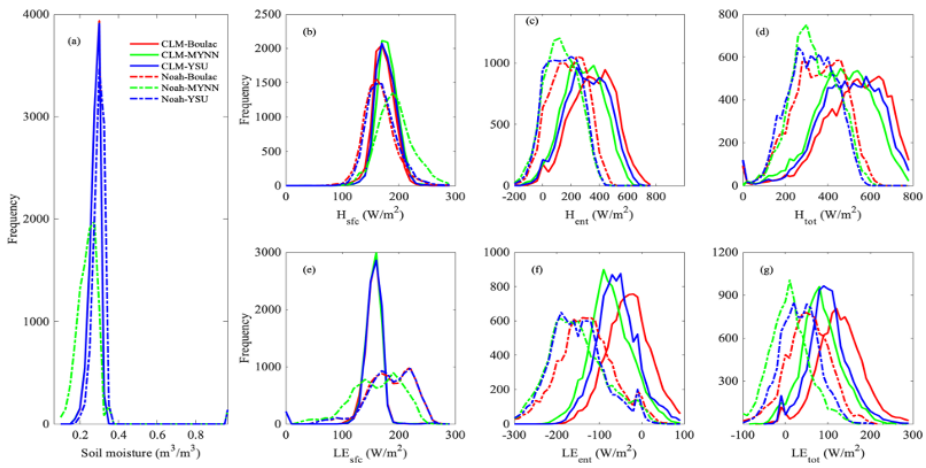

Fig. 4. Fig. 7 Frequency distribution of (a) mean soil moisture at 0-10 cm and (b) - (g)PBL energy budgets on August 7, 2011 simulated using different combinations of LSM and PBL schemes