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Discussions

Interactive comment on "Variations of surface roughness on inhomogeneous underlying surface at Nagqu Area over the Tibetan Plateau" *by* Maoshan Li et al.

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Title: The variation of numerically simulated turbulent fluxes on the Tibetan Plateau and in its surrounding areas ———————————————————————— We are thankful to the reviewers for their valuable comments on the paper. Below we provide the responses to the comments and questions raised. Modifications and improvements are incorporated in the revised manuscript as mentioned below for each of the comments. For easy visualization, the responses to the reviewers' comments in bold are provided below and changes in manuscript are also highlighted in RED color (Track Change). ————————————

———————————————————— The surface roughness plays an important role in understanding the land surface processes, and the land-atmosphere interactions, which will subsequently impact the land surface heat fluxes and then to the local climate. When putting this topic within the context of Tibetan Plateau (TP), the importance of surface roughness become even more prominent, due to the important role of TP in the formation, outbreak, duration and intensity of Asian monsoon, and in the global climate system. In this study, the author use MODIS satellite data and tower-based atmospheric turbulence observation data to investigate the temporal and spatial variation of the surface roughness. The results show that the satellite-derived surface roughness are consistent with the measurement data. The satellite-based surface roughness were further classified into HESSD Interactive comment Printer-friendly version Discussion paper different underlying surfaces (Urban, Lush Grassland, Sparse grassland, and ice and snow). The manuscript is well written and organized, it is suggested to clarify some minor comments before its acceptance for publication.

1. The signal of grazing activities should be captured by MODIS. Nevertheless, this is not discussed in the manuscript. Also relevant to this point, the in-situ measurements were taken within the fence, this reviewer is wondering how such differences (within fence no grazing, outside fence grazing) will impact the result and conclusion.

Response, Applying the Massman model to MODIS LAI images in northern Tibet can obtain a more reliable z0m retrieved value. However, there are still some differences between the retrieved results and the ground observation results. There are several reasons for this. First, the source area observed by EC does not necessarily overlap with the pixels of the remote sensing image. In this way, the difference in spatial representation area may cause inconsistencies between remote sensing results and ground results. Secondly, the underlying surface in the remote sensing pixel is assumed to be flat and uniform, but this does not match the actual situation. The eddy covariance observation system of BJ station is inside the fence. The height of the grass in the fence during the growing season is about 15cm, and the highest outside the fence is 5cm, but the LAS observation system reflects the difference in roughness inside and outside the fence very well. The impression of LAS can cover about 1.5km×1.4km, while the impression of EC can cover about 300m×300m. Therefore, the surface parameters obtained based on LAS data can represent a larger spatial area. EC and LAS data results represent two different spatial scales of surface parameters. The surface characteristic parameters at EC and LAS spatial scales are compared. The aerodynamic roughness lengths at EC spatial scale (EC_z0m) vary from 0.001 to 0.031 m, whereas the aerodynamic roughness lengths at LAS spatial scale (LAS _z0m) vary from 0.015 to 0.056 m. They share the same seasonal variations but LAS _z0m is larger than EC _z0m, which is attributed to the undulation of land surface. The land surface is flat in the EC footprints but undulates in the LAS footprints, and this creates the differences in the roughness elements between the two spatial scales (Sun et al., 2016). Sun G., 2016. The Upscaling Analysis of Surface Fluxes of Alpine Grassland over the in Northern Tibetan Plateau[D]. Lanzhou: Cold and Arid Regions Environmental and Engineering Research Institute Chinese Academy of Science, 1-134. (in Chinese with English abstract)

2. Figure 7, the label for x-axis are in Chinese. And it is not clear why a-d, and e-h? What are differences are not clearly explained in the main text.

Response, they have been revised as follow,

Fig. 7 Scatter plots of the retrieved and calculated surface roughness length on four sites (a-d: scatter plot of the observation results and the average result of the underlying surface; e-hïijŽscatter plot of the observation and retrieved results; a,e: BJ station in 2008; b,f: BJ station in 2012; c,g: NAMC station in 2010; d,h: NPAM station in 2012)The Z0m scatter plot is shown in Figure 7. It can be seen that there is a significant positive correlation between the satellite data and the surface roughness calculated from the site data. The correlation coefficient between the observation result and the retrieved result is different from that of the NAMCO station in 2010 in Fig. 7(g), and the others are large. It shows that the average result of the underly-

ing surface smoothed the same underlying surface results in different regions, further indicating that the satellite retrieved results are more similar to the site calculation results. However, the results of the NAMCO site are different from those of other sites. The correlation coefficient with the average results of the underlying surface is 0.83, and the correlation coefficient with the satellite retrieved results is 0.62. Or because the Namco Observation Station is closer to the lake (1km), it is more affected by local microclimate such as lake and land winds. The results in Figure 7 all passed the F test of P = 0.05. It indicates that there is no significant difference between the site data calculation results and the satellite data retrieved results.

3. This reviewer is also curious how the outcome of this research can be taken up by land surface modellers in terms of calculating land surface heat fluxes. Could the authors help detail a bit the discussion here?

Response, Research on model simulation of surface flux has achieved good results in many regions (Smirnova et al., 2016). Especially in recent years, with the continuous development and improvement of numerical models, research on the applicability of different parameterization schemes in different models to different regions has continued. Luo et al. used the land surface model CoLM to conduct a single-point numerical simulation of the BJ station and successfully simulated the energy exchange process in the Nagqu area (Luo et al., 2009). Zhang et al. Evaluated the surface physical process parameterization schemes of Noah LSM and Noah-MP in the entire East Asia region, and also evaluated the simulation of the surface heat flux of the Tibetan Plateau [Zhang et al., 2017]. Xie et al. explored the simulation effect of land surface model CLM4.5 in the alpine meadow area of the Qinghai-Tibet Plateau [Xie et al., 2017]. Xu et al. studied the applicability of different parameterization schemes in the WRF model when simulating boundary layer characteristics in the Nagqu area [Xu, et al., 2018]. Zhang, et al. Comparative analysis of the meteorological elements simulated by different land surface process schemes in the WRF model in the Yellow River source region (Zhang et al., 2019). However, the applicability of the model in the Tibetan Plateau needs further study. The terrain of the Tibetan Plateau is complex, the underlying surface is very uneven, and has high spatial heterogeneity. Because the condition of the underlying surface has a very significant impact on the surface flux, obtaining information on the surface vegetation status of a certain area is very helpful for analyzing the spatial representation of the surface flux. This study uses remote sensing images and aerodynamic roughness remote sensing retrieved model to estimate the spatial scale of aerodynamic roughness conditions in northern Tibet, which will provide parameters and parameterization scheme improvements for model simulations to study the spatial distribution of surface flux in the Tibetan Plateau.

Smirnova T., Brown J., Benjamin S., Kenyon J. (2016) Modifications to the rapid update cycle land surface model (RUC LSM) available in the weather research and forecasting (WRF) model. Mon Weather Rev 144(5):1851–1865

Luo S., Lü S., Yu Z. (2009) Development and validation of the frozen soil parameterization scheme in Common Land Model. Cold Reg Sci Technol 55:130–140

Zhang G., Zhou G., Chen F. 2017, Analysis of Parameter Sensitivity on Surface Heat Exchange in the Noah Land Surface Model at a Temperate Desert Steppe Site in China[J]. Acta Meteorologica Sinica. (6).1167-1182.doi:10.1007/s13351-017-7050-1.

Xie Z., Hu Z., Liu H., Sun G., et al., 2017 Evaluation of the Surface Energy Exchange Simulations of Land Surface Model CLM4.5 in Alpine Meadow over the Qinghai-Xizang Plateau. Plateau Meteorology, 36(1): 1-12. (in Chinese with English abstract)

Xu L., Liu H., Xu X., et al. 2018, Applicability of WRF model to the simulation of atmospheric boundary layer in Nagqu area of Tibetan Plateau[J]. Acta Meteorologica Sinica, 2018(6):955-967. (in Chinese with English abstract)

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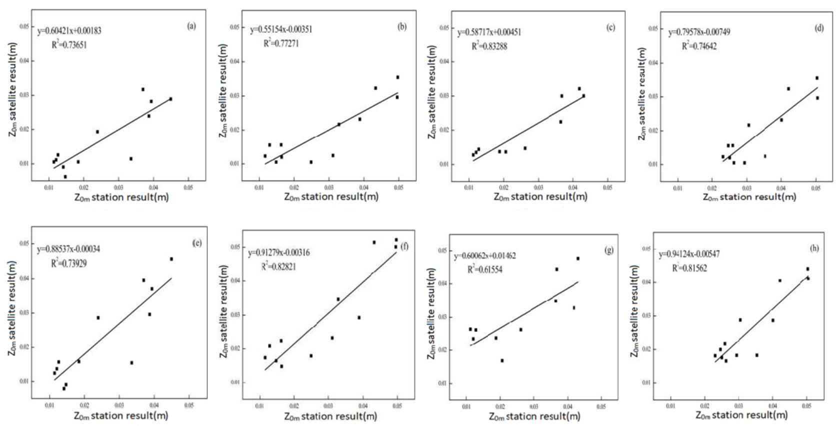

Fig. 1. Fig. 7 Scatter plots of the retrieved and calculated surface roughness length on four sites (a-d: scatter plot of the observation results and the average result of the underlying surface; e-hïijŽscatter