Response to COMMENTS

Title: The variation of numerically simulated turbulent fluxes on the Tibetan Plateau and in its surrounding areas

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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).

Anonymous Referee #3

However the analysis and writing is far below what is needed for a scientific paper. The following suggestions must be taken into account for potential acceptance of this manuscript.

Response, The American Journal Expert (AJE) edited and revised the English writing.

1) The writing is often not understandable and one must guess what the authors are trying to say. A English editing is a first requirement for the revision to be able further considered.

Response, The American Journal Expert (AJE) edited and revised the English writing.

2) The abstract does not make much sense as it is now and needs to be completely rewritten.

Response, The temporal and spatial variation characteristics of the surface roughness in the Nagqu area of the northern Tibetan Plateau were analysed in 2008, 2010 and 2012 using MODIS satellite data and station atmospheric turbulence observation data, and the Massman retrieved model and measured average wind speed and turbulent flux of a single height ultrasonic anemometer were used to determine the aerodynamic surface roughness. The results showed that the surface roughness length has obvious seasonal variation characteristics. From February to August, Z0m increased constantly with snow ablation and vegetation growth, and the maximum value reached 4-5 cm at the BJ site. From September to February, Z0m gradually decreased with the post-monsoon phase over the plateau, and the values decreased to approximately 1-2 cm. Snowfall in abnormal years was the main reason for the obviously lower Z0m compared with that in normal conditions. The underlying surface can be divided into four categories according to the different values of Z0m: snow and ice, sparse grassland, lush grassland and town. Among them, lush grassland and sparse grassland accounted for 62.49% and 33.74% respectively, and their Z0m annual changes are between 2-6 cm and 1-4 cm. The two methods were positively correlated with each other, and the retrieved data values were lower than the measured results due to non-uniformity of underlying surface. These results are substituted into Noah-MP replaces the original parameter design numerical simulation experiment. After replacing the model surface roughness, the sensible heat flux and laten heat flux has a better daily improvement effect.

3) The introduction part refers to everything that is happening on the Tibetan plateau. It must be shortened to introduce the purpose of the study and the organization of paper in L89-114.

Response, Thank reviewer for his suggestion. Introduction that is not related to this article has been deleted.

4) in eq. (5), (6), the coefficients C1, and C2 are different.

Response, yes, they are different. Eq. (5) was not used to calculate the roughness length and was deleted in this study. In eq. (6), C1 and C2 C_1=0.32, C_2=0.26, they are suitable for the canopy of the Tibetan Plateau (Chen et al., 2013).

5) L210, what is 'liquid surface drag' ? I guess they mean leaf surface drag here, could the senior authors read what they write carefully.

Response, It should be ‘drag coefficient of the foliage elements’

6) in discussing the possible reasons for the roughness due to snow coverage, in L273-284 in general, the authors need to add supporting information by adding albedo data.

Response, Table 4 shows that the winter albedo at the BJ station and Namco station is higher than that in other seasons, and the summer is the smallest. Both show that the surface albedo in November 2008 was significantly higher than that in November of the other two years.

Table 3 the observed albedo of the sites (BJ and Namco) on the northern Tibetan Plateau

site	year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
BJ	2008	0.13	0.17	0.14	0.13	0.12	0.10	0.09	0.09	0.09	0.16	**0.32**	0.16
BJ	2009	0.30	0.26	0.30	0.25	0.26	0.21	0.19	0.19	0.21	0.26	0.24	0.26
BJ	2010	0.26	0.30	0.31	0.30	0.34	0.22	0.19	0.18	0.18	0.35	0.26	0.27
NAMCO	2008	0.28	0.28	0.31	0.28	0.25	0.21	0.17	0.18	0.18	0.30	**0.89**	0.28
NAMCO	2009	0.35	0.32	0.28	0.24	0.26	0.22	0.19	0.17	0.22	0.24	0.31	0.27

NAMCO	2010	0.45	0.23	0.25	0.24	0.29	0.22	0.20	0.17	0.18	0.40	0.35	0.24

7) The authors need to add more information on shortwave and longwave radiation (the latter for deriving surface temperature), air temperature, wind speed as a minimum, and albedo to support their discussions.

Response, albedo data can be seen the answer of question 6). The model simulation discussion about replacing the surface roughness has been added to section 5. Add 'Air thermodynamics surface roughness is affected by shortwave and longwave radiation, air temperature, wind speed, precipitation or snowfall. The relationship between air thermodynamics surface roughness and them and how to parameterization them in Massman mode will be studied in the future.' In the discussion.

8) L306-308, and throughout the text, vague expression is used for potential reasons. This needs to be substantiated with data.

Response, The original intention is that the results on the representative grid point (250×250 m) calculated by the Massman model do not match the results calculated by the site data in the scale. 'which is related to the overlapping average effect of satellite data retrieved' was revised to 'which is related to non-uniformity of underlying surface in Massman mode.

9) L399-424, this reviewer is surprised by the introductory text in this last part of conclusions. This could be utilized in the introduction more properly to support the rationale for this study.

Response, thank you for your suggestion. they are removed to the introduction.

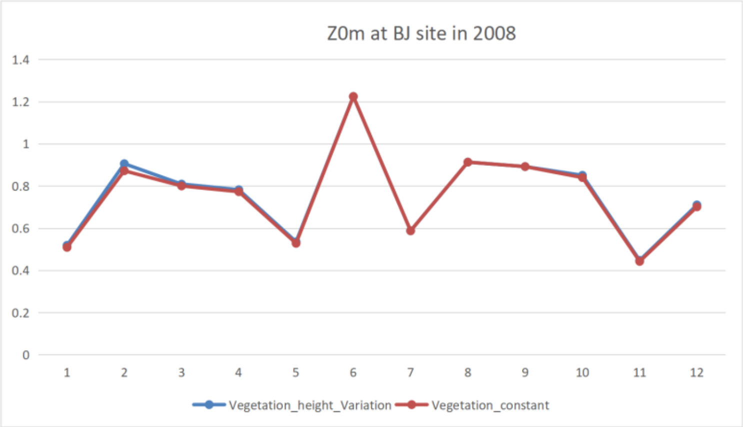
Anonymous Referee #1

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

Both zero plane displacement (D) and roughness length (z0) are dependent of surface vegetation cover. The main idea of the manuscript is to quantify spatial and temporal variation of roughness length while assuming a uniform and constant D. I don't think this is a reasonable assumption, unless the authors can demonstrate that D is much less sensitive to vegetation cover than z0.

Response, In this study, Using the measured values of the average wind speed and turbulent flux of a single height ultrasonic anemometer, the calculation scheme of surface roughness was selected.

Because this method is a single point calculation, it does not mention the relationship between vegetation cover and d0 and z0m, and it needs to be further studied in future research. In there, Stanhill's method used to calculate zero-plane displacement d. Stanhill had empirically obtained the relationship between the height of the high-stalk crop h and the height of zero-plane displacement d as: 1gd=0.979h-0.154, As a rough approximation, d can be derived from: d=0.64h (Stanhill, 1969). This study only calculates the zero plane displacement of a single point (BJ, Namco and NPAM site) using the measured values of average wind speed and turbulent flux of a single height ultrasonic anemometer. These sites are located in the seasonal frozen soil area, and the vegetation is alpine grassland. The ground of the experimental field is flat and the area is wide. The vegetation in the northern Tibet Plateau is an alpine grassland, with small changes in vegetation height, ranging from 0 cm in winter to 4.5 cm in summer. We compared the impact of vegetation height changes on d0, the difference between the two is very small (see below figure), so the previous method is feasible. Therefore, the ground is covered by a plateau meadow 4.5 cm high in summer and grass height changes little during the year. Therefore, d taken as 0.03m, calculated from the average vegetation height 0.045m.



Another major concern I have is a lack of test of the effectiveness of the complicated empirical relationship (presented in this study) in deriving the seasonal variation of z0. As I suggested earlier, the authors should compare this method with a simple empirical method (e.g., as simple function of vegetation height).

Response, The Massman retrieved model and measured average wind speed and turbulent flux of a single height ultrasonic anemometer were used to determine the aerodynamic surface roughness in this studay.

Comparison of Massman retrieved results with calculation of measured average wind speed and turbulent flux of a single height ultrasonic anemometer can be seen Sec. 3.3: The Z0m scatter plot is shown in Figure 7. A significant positive correlation is observed between the satellite retrieval and the surface roughness calculated from the site data. The correlation coefficients between the observation result and the retrieved result are large except for at the NAMCO station in 2010 in Figure 7(g). The average result of the underlying surface was consistent with the underlying surface results in different regions, further indicating that the satellite retrieved results are consistent with the site calculation results. However, the results of the NAMCO site are different from those of the 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. Because the Namco Observation Station is closer to the lake (1 km), it is more affected by local microclimates, such as lake and land winds. The results in Figure 7 all passed the F test of P=0.05, which indicates that there is no significant difference between the site data calculation results and the satellite data retrieved results.

For improve manuscript scientific value, add the part of simulation and evaluation of Noah-MP model:

5 Simulation and evaluation of Noah-MP model

5.1 Model setup

According to the surface roughness variation characteristics retrieved from satellite data, the underlying surface of Nagqu area can be divided into four types. They are urban, lush grass, sparse grass, and ice and snow. Among them, urban accounts for 0.07%, its Z0m up to 9 cm, lush grassland accounts for 62.49% of the area, its Z0m can reach up to 6cm, sparse grassland up to 33.74%, its Z0m can reach up to about 4cm, ice and snow accounts for 3.7% of the area, and Z0m does not exceed 1cm. These results are substituted into Noah- MP replaces the original parameter design numerical simulation experiment. The model after replacing the surface roughness is set as a sensitivity experiment, and the original model is set as a control experiment. The selection of other parameterization schemes suitable for numerical simulation in Nagqu area is shown in Table 3. The simulation time is from July 1 to 31, 2008, and the spin-up time is 9 days. The forcing field dataset is a Chinese meteorological forcing dataset jointly developed by the Tibetan Plateau Data Assimilation and Modelling Centre and the Institute of Tibetan Plateau Research of the Chinese

Academy of Sciences (ITPCAS).

Table 3 the selected scheme in Noah-MP

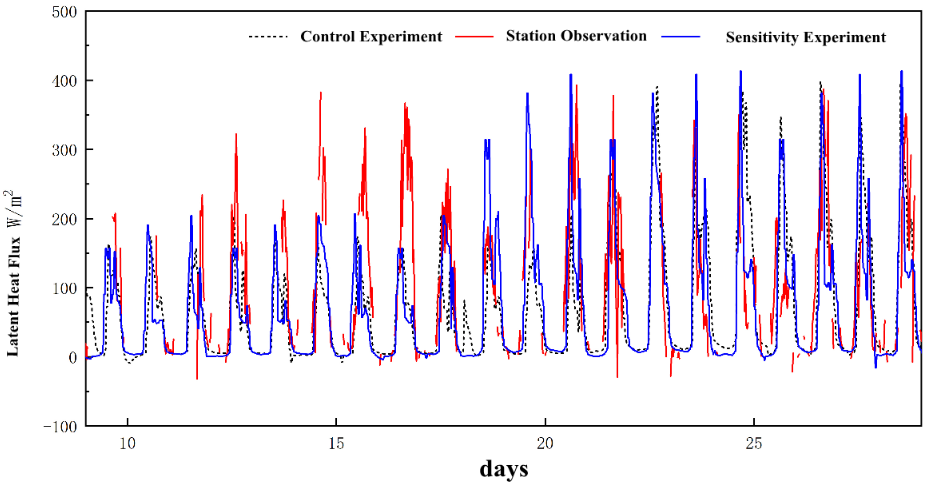
Options for different schemes	Name of the option
dynamic vegetation	Use table LAI; use FVEG=SHDFAC from input
canopy stomatal resistance	Ball-Berry's method
soil moisture factor for stomatal resistance	Noah's method
runoff and groundwater	TOPMODEL with groundwater
surface layer drag coeff	Monin-Obukhov's method
supercooled liquid water	No iteration
frozen soil permeability	Nonlinear effects, less permeable
radiation transfer	Two-stream applied to grid-cell
ground snow surface albedo	Classic method
partitioning precipitation into rainfall & snowfall	Jordan's method
lower boundary condition of soil temperature	TBOT at ZBOT (8m) read from a file
snow/soil temperature time scheme	full implicit (original Noah); temperature top boundary condition

5.2 Evaluation of the simulated single point heat flux

Figure 9(a) shows that the sensible heat flux simulated by the sensitivity experiment is closer to the measured value than the control experiment. In the daytime, the results of sensitivity experiment were smaller than those of the control experiment, and some time were larger than those of the control experiment. At night, the results of the two models were close to each other before July 21, and the sensitivity experiment results were significantly improved after July 21. Figure 9(b) shows that the sensitivity experiment results are basically consistent with the control experiment results, which are maintained at about 0W/m^2, and there is no improvement at night. Before July 19, the two experiments latent heat fluxes remained at about 200W/m^2, which was less than the observed latent heat flux, and the simulated maximum value of the sensitivity experiment was greater than that of the control experiment. After July 19, the two experiments simulation results began to increase and reached about 400 W/m^2 consistent with the observed latent heat flux, indicating that the simulation effect was improved to some extent. Similarly, it can be found from the maximum value that the sensitivity experiment results were slightly greater than the control experiment results. It also shows that improving the accuracy of surface roughness can improve the simulation effect of latent heat flux.

Figure 9 about here

(a)



(b)

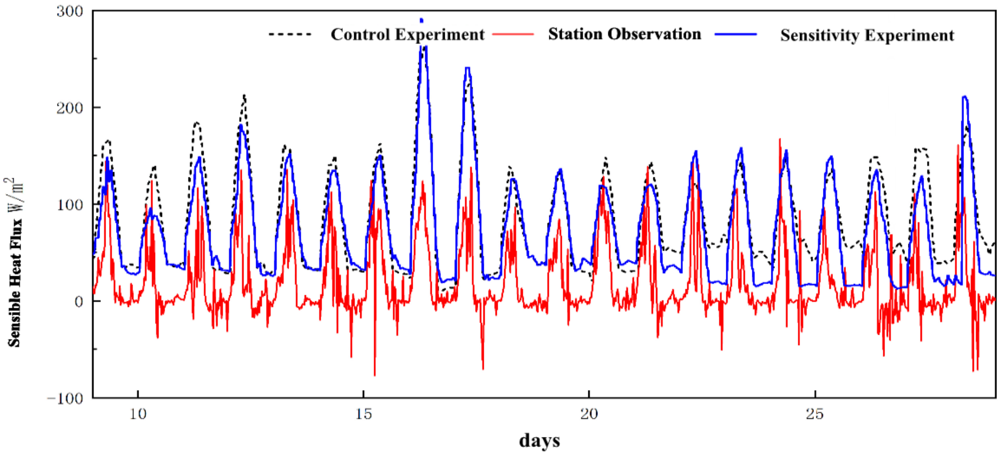


Figure 9 Comparison of simulated and observed sensible heat flux (a) and Comparison of simulated and observed latent heat flux (b)

5.3 Evaluation of regional heat flux simulation results

In order to compare the changes of sensible heat flux and latent heat flux before and after improvement, the sensitivity simulations are used to subtract the control model simulation results. By subtracting the sensible heat flux from control and sensitivity experiment, the results are shown in the figure 10. It can also be seen from the figure 10 (a) that the difference of sensible heat flux is basically negative in the daytime, indicating that the sensible heat flux after improvement is smaller than that before improvement. The above results show that the modified surface roughness can improve the simulation effect of sensible heat flux in daytime. The results in the figure 10 (c) are basically positive in the daytime, indicating that the latent heat flux after improvement is larger than that before improvement, about 15W/m^2. The above results show that the model simulation results are generally less than the actual observation results, so it can be considered that the improvement of surface roughness in the daytime can improve the simulation of the model. Figure 10 also shows that the improvement of nighttime latent heat flux is not significant, which is basically maintained at 0W/m^2.

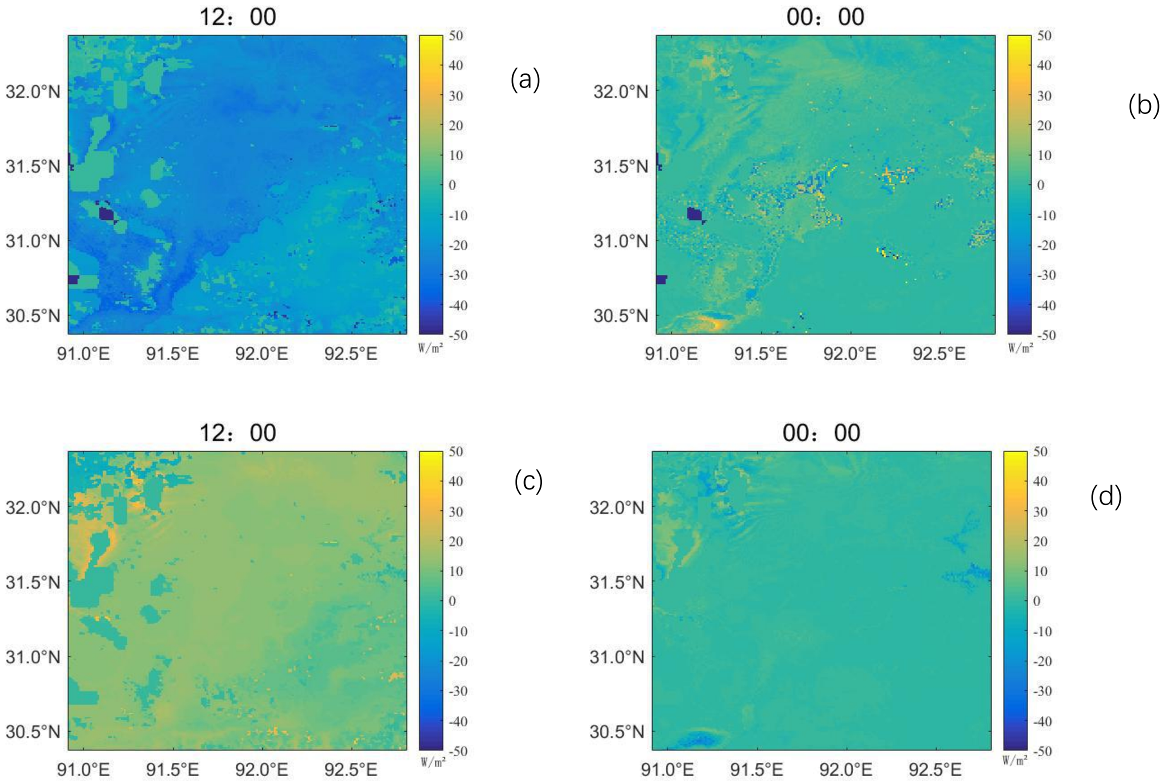


Figure 10 the difference of the control and sensitivity experiments simulated regional sensible heat flux (a) 12:00, (b) 00:00 and latent heat flux (c) 12:00, (d) 00:00

Add conclusion (4)

(4) The accuracy of ground-air flux simulation can be improved after adjusting the surface roughness in Nagqu area. After replacing the model surface roughness, the sensible heat flux has a better daily improvement effect, about 20W/m^2. The night improvement effect is poor, about 0.15W/m^2. The improvement of latent heat flux is not obvious, and there is an improvement within 15W/m^2 during the daytime.