RESPONSES TO THE REFEREES

We thank the reviewers for the comments. Below are our responses (in **blue** font) to the reviewers' comments and questions (in **black** font).

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General Comments:

In this manuscript, the authors compared two different spatial aggregation approaches to retrieve and evaluate the land surface energy balance fluxes using remote sensing data from the Chinese HJ-1B. One approach (IPUS) uses information aggregated to the 300m resolution as given by the thermal channel while the second approach (TSFA) uses a thermal sharpening approach by utilizing NDVI – TS relationship and downscaling 300m Ts into the 30m. Authors showed the differences between both approaches. Validation exercise is also performed to demonstrate the advantages and improved prediction capacities of the TSFA approach. This study is very useful to the community and worth publishing. However, the authors need to address the following concerns before a possible publication.

The sentence constructions also need to be better in some part of the manuscript.

(1) A clear hypothesis and research question is missing in the manuscript.

Response: Our basic hypothesis is that the inhomogeneity of surface landscapes and variables in the mixed pixels would result in large ET estimation error. In this study, we aimed to reduce the uncertainty of ET estimations caused by landscape and surface variables. We revised the introduction to clarify our hypothesis and goals.

(2) Is it really necessary to aggregate the NDVI from 30 m to 300 m as described in the IPUS method? Why not using the 30 m NDVI with 300 m LST?

Response: Thank you for your valuable comments. Although it is important to compare the TSFA method with the IPUS method, this comparison is not sufficient. We assume that ET estimation errors mainly result from the inhomogeneity of surface landscapes and variables. We aim to reduce the uncertainties of ET estimations due to surface heterogeneities and use the TSFA method as our final method. To evaluate the ability of the TSFA method to capture surface heterogeneity and reveal the scale effect, we used the IPUS method because it does not consider the effects of mixed pixels at all. According to your comments, we added the TRFA (temperature resampling and flux aggregation) method, which uses 30 m visible/near infrared and 300 m thermal infrared band data to estimate ET and simple spatial LST resampling (300 m to 30 m) instead of spatial sharpening based on NDVI information. Comparisons of the TFSA and TRFA methods can be used to evaluate the effects of temperature sharpening on estimating ET, as well as the significance of separating inhomogeneity of landscape from that of surface variables (such as LST), and that would make our logic clearer.

(3) More emphasis is given on discussing the sensible heat flux (For example Table 11, 12, 13 and 14). A balanced discussion involving both LE and H would read better and rational.

Response: We revised the manuscript by placing more emphasis on discussing the LE with a balance analysis and discussion of H.

(4) Suggest including a table on different input data, their source and for what purpose they were used.

Response: Thank you for your suggestion. A table of abbreviations and the usage of input data were added in the appendix.

(5) The table and figure captions need to be explicit.

Response: We revised the table and figure captions.

(6) Abstract: Some statistics need to be added in the abstract. At this moment it reads too general.

Response: We revised the abstract by adding and updating statistical results as follows:

"Evapotranspiration (ET) plays an important role in surface-atmosphere interactions and can be monitored using remote sensing. However, surface heterogeneity, including the inhomogeneity of landscapes and variables, greatly affects the accuracy of ET retrieved by satellite. The objective of this study is to reduce the uncertainty that results from surface heterogeneity by using Chinese HJ-1B data. Three upscaling methods with area-weighted aggregation for different steps and variables were applied: input parameter upscaling (IPUS), which refers to parameter aggregation; temperature resampling and flux aggregation (TRFA), and temperature sharpening and flux aggregation (TSFA). Under a heterogeneous surface, the latent heat flux (LE) bias between the TSFA and IPUS methods varies statically from 35.36 to 65.66 $W \cdot m^{-2}$, and the bias between the TSFA and TRFA methods varies statically from 4.41 to 22.53 $W \cdot m^{-2}$. The footprint validation results show that the TSFA method could improve the accuracy of LE by approximately 20 $W \cdot m^{-2}$ and 10 $W \cdot m^{-2}$ relative to the IPUS and TRFA methods, respectively. Furthermore, additional analysis shows that the TSFA method can capture the sub-pixel variations of land surface temperature and integrate the effects of overlooked landscapes in mixed pixels. "

(7) Page 2, line 16: Evapotranspiration is a variable, not a 'parameter' as stated by the authors. Authors should know the difference between a parameter and a variable.

Response: We agree with your opinion that evapotranspiration is a variable rather than a 'parameter'. We have revised this phrasing throughout the manuscript.

(8) Page 2, line 16: Reference is too old. Many recent references are available.

Response: Thank you for this reminder. We agree that the presented references are old. This paragraph was mainly introduced to highlight the importance of ET. We deleted this paragraph because hydrologists should already understand the importance of ET.

(9) Page 2, line 22-22: This sentence does not carry anything meaningful. Please make your statement clear.

Response: We agree with your opinion and have deleted this meaningless sentence to introduce the models directly.

(10) Page 3, line 37: it should be 'landscapes' instead of 'landscape'.

Response: We have made this suggested correction.

(11) Page 3 (line 23 onwards to page 4): The last paragraph is quite confusing to understand.

Response: We have revised this paragraph as follows:

"However, heterogeneity is a natural attribute of the Earth's surface. Studies have shown that different landscapes (Blyth and Harding, 1995; Moran et al., 1997; Bonan et al., 2002; McCabe and Wood, 2006) and the sub-pixel variations of surface variables, such as stomatal conductance (Bin and Roni, 1994), leaf area index (Bonan et al., 1993; Maayar and Chen, 2006), and land surface temperature (Ershadi et al., 2013), can cause large errors in turbulent heat flux estimations. Surface landscape inhomogeneity can be classified using two scenarios: nonlinear vegetation density variations between sub-pixels (e.g., different types of vegetation mixed with each other or with bare soil) and coarse pixels containing different landscapes (e.g., vegetation or bare soil mixed with buildings or water). In mixed pixels, surface variables such as land surface temperature are set as singular to represent the entire pixel area in ET estimation models.

When these remotely sensed models are applied to calculate the regional ET via satellite data, large spatial scale errors occur. The non-linear operational model.is another important issue of remotely sensed spatial scale. However, it is difficult to develop linear operational models due to the complexity of mass and heat transfer processes between the atmosphere and land surface. In previous studies, researchers have coupled high- and low-resolution satellite data and statistically quantified the inhomogeneity of mixed pixels to correct the scale error in ET estimations (Zhou et al., 2016) by using temperature downscaling (Kustas et al., 2003; Norman et al., 2003; Cammalleri et al., 2013), the correction-factor method (Chen, 1999; Maayar and Chen, 2006) and the area-weighting method (Xin et al., 2012)."

References:

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Zhou, T., Peng, Z., Xin, X., and Li, F.: Remote sensing research of evapotranspiration over heterogeneous surface: A review, Journal of Remote Sensing, 20(2), 257-277, 10.11834/jrs.20155030, 2016.

(12) Page 4, L26: 'Land based parameters': : :..LAI, LST, DLR are not parameters, these are variables. This is becoming confusing now.
Response: Thank you for your suggestion. We have revised our use of 'parameters' throughout the manuscript.

(13) Page 5, L10: The resolution: : :: : :. Need to be explicit on what is intended here by 'resolution'.
Response: We revised this sentence as follows:
"The spatial resolution of TIR images is usually not as high as the spatial resolution of visible near-infrared bands (VNIR) because the energy of VNIR photons is higher than the energy of thermal photons. Thus, the inhomogeneity of TIR images would be greater than the inhomogeneity of VNIR images."

(14) Throughout the entire manuscript, the authors are confused about 'parameter'.
Response: Thank you for your suggestion. We have revised our use of 'parameter' throughout the manuscript.

(15) Section 4.3.2, paragraph 3: The authors have not mentioned anything about the LE statistics of the two methods.
Response: We revised this paragraph and emphasized the LE.

(16) Spatial comparison of surface fluxes (as mentioned in section 4.3.2) should be done at least for 2 different vegetation cover conditions.
Response: Thank you for your suggestion. We added comparisons of the turbulent heat fluxes for the two following weak heterogeneity conditions: (1) different vegetation cover conditions and (2)

vegetation mixed with bare soil.

(17) I made some edits and comments in the manuscript pdf (attached here), which the authors should consider.

Response: The provided edits and comments were addressed in the manuscript.

Specific comments in attached pdf:

How did you assign the crop height and ancillary parameter information in the stability corrections.

Response: A widely used parameterization scheme was used for stability correction. The equations used are listed below.

From the Monin-Obukhov similarity theory (MOST), the aerodynamic resistance r_a can be calculated as follows:

$$r_a = \frac{1}{ku_*}[\ln\left(\frac{z-d}{z_{om}}\right) - \psi_H\left(\frac{z-d}{L}\right)] \quad (1)$$

$$u_* = ku[\ln(\frac{z-d}{z_{om}}) - \psi_M(\frac{z-d}{L})]^{-1} \quad (2)$$

$$L = \rho c_p \frac{u_*^3 \theta_v}{kgH} \quad (3)$$

where $k = 0.4$ and is the von Karman's constant, u_* is the friction velocity, u is the wind speed at a reference height of z above the surface, d and z_{0m} are the zero plane displacement height and the roughness length for momentum transfer, respectively, L is the Monin-Obukhov length, g is the acceleration due to gravity and θ_v is the potential virtual temperature near the surface. In addition, ψ_M and ψ_H are stability functions, where $\psi_M = \psi_H = 0$ under neutral conditions and ψ_M and ψ_H can be parameterized as follows under unstable conditions (Paulson, 1970; Ambast et al., 2002):

$$\psi_M = 2\ln\left[\frac{1+x}{2}\right] + \ln\left[\frac{1+x^2}{2}\right] - 2\tan^{-1}x + \frac{\pi}{2} \quad (4)$$

$$\psi_H = 2\ln[(1+x^2)/2] \quad (5)$$

where $x = (1-16z/L)^{1/4}$. Under stable conditions, ψ_M is equal to ψ_H as follows (Webb, 1970):

$$\psi_M = \psi_H = -5 \cdot \frac{z-d}{L} \quad (6)$$

The parameterization of the zero plane displacement height d and the roughness length z_{0m} are determined as follows (Choudhury and Monteith, 1988):

$$d = 1.1h\ln(1+(c_d LAI)^{1/4}) \quad (7)$$

$$z_{0m} = \begin{cases} z_{0s} + 0.3h(c_d LAI)^{1/2} & 0 \le c_d LAI \le 0.2 \\ 0.3h\left(1-\frac{d}{h}\right) & 0.2 < c_d LAI \le 1.5 \end{cases} \quad (8)$$

where h is the canopy height and was set according to the area phenophase, classification and *a priori* knowledge. c_d is the mean drag coefficient and is assumed uniform within the canopy, LAI is the leaf area index, and z_{0s} is the substrate roughness length (for the bare soil surface, $z_{0s} = 0.01$).

References:

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Paulson, C. A.: The mathematical representation of wind speed and temperature profiles in the unstable atmospheric surface layer, Journal of Applied Meteorology, 9, 857-861, 1970.
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How can you infer "The quadrangular with a relatively large bias in Fig. 9a and b is caused by DLR, i.e. it is influenced by the MOD05 water vapor."

Response: Bad lines appeared in the images scanned by MODIS Terra due to an instrumental malfunction that occurred beginning in 2002. After preprocessing the original data by interpolation, a weak quadrangular remained in the image. In addition, the MOD05 water vapor product was used to calculate downward longwave radiation in this paper, which is an important and sensitive variable of net radiation. We compared the results with the processed MOD05 product and observed that the quadrangular overlapped well. In addition, the order of magnitude at the quadrangular was within ±5 $W{\cdot}m^{-2}$, which matches the bias caused by the downward longwave radiation between IPUS and TSFA.

We revised the expression as follows (Fig. 9 becomes Fig. 10 in the latest revised manuscript, in next page):

"The quadrangular with a relatively unstable bias shown in Fig. 10(a) is caused by the L_d that was calculated from the MOD05 water vapor product which exists quadrangular even after preprocessing the instrument malfunction gap."

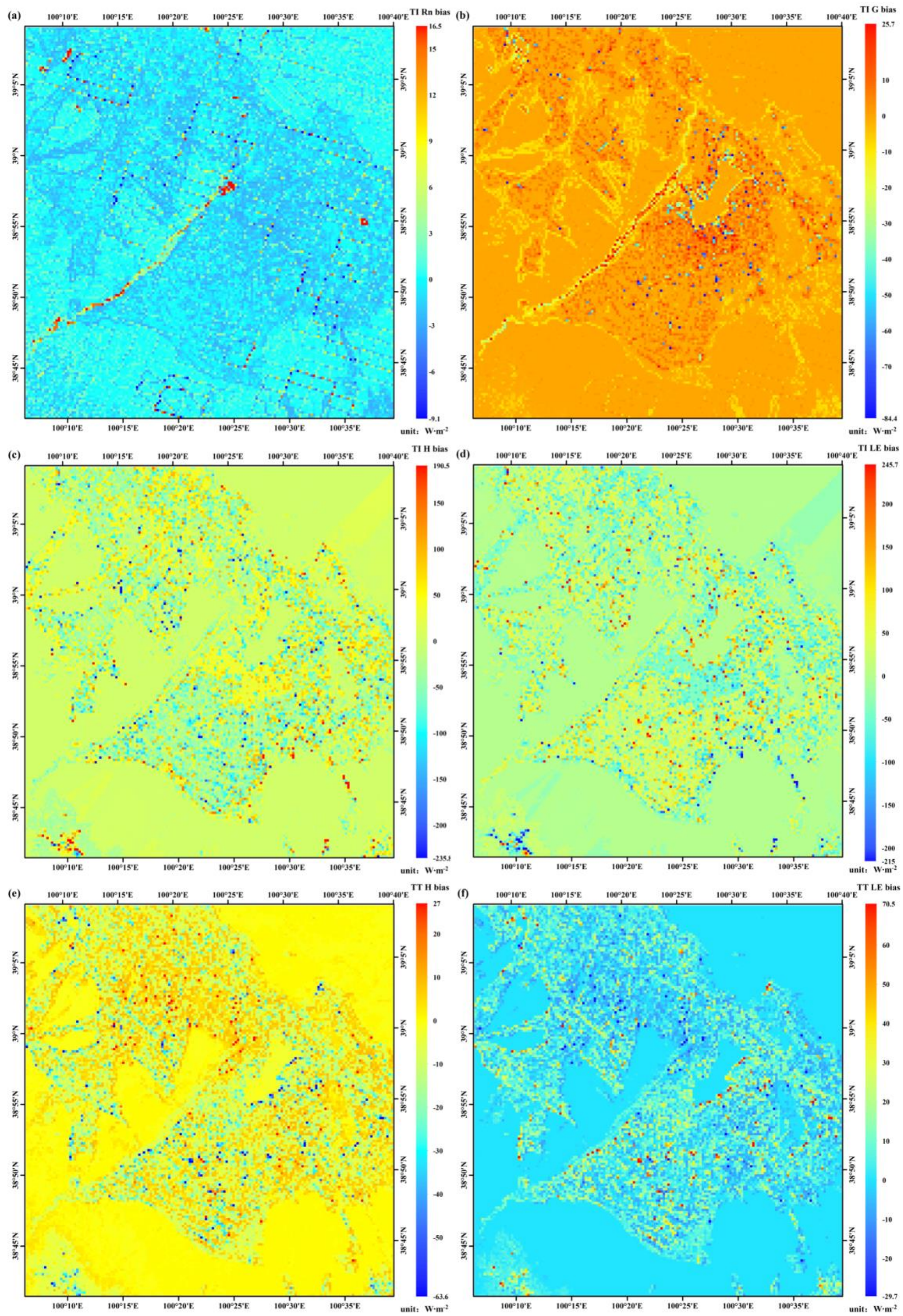

Figure 10. Maps of the bias of the energy balance components calculated using the TSFA method minus the IPUS method: (a) R_n, (b) G, (c) H, (d) LE, TSFA minus TRFA: (e) H and (f) LE.