Responses to the Editor’s Comments

Ms. Ref. No.: hess-2022-125

Title: Accuracy of five ground heat flux empirical simulation methods in the surface energy balance-based remote sensing evapotranspiration models

Author(s): *Zhaofei Liu*

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Comments to the author:

Dear author,

Thank you very much for submitting your revision and responses to reviewer's comments.

I have consulted the reviewers again and would suggest that you consider the following issues:

1) The comments raised by Reviewer #4 are important issues. Because you can not completely solve these issues, a practical solution is that you should fully discuss them in the discussion part to inform the reader about the shortcoming of your study.

The reviewer suggested that the author does not seem to have assessed and corrected the energy imbalance at the flux tower sites before using the data, which could be the reason that the author has obtained very large G based on the SEBR method at site level and thus would derive unreliable relationships between G and Rn. As such the uncertainty of G estimated by SEBR method would be very large, even larger than the magnitude of G itself.

2) With reference to Purdy et al. (2016) who evaluated six empirical methods of G simulation against G’ observations at 88 flux sites.

The reviewer suggested that the author should contact Purdy to make sure whether they have used G’ or G observations at the 88 flux sites.

I hope you can take these comments in consideration in your revision.

Best wishes

Bob Su

Editor HESS

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Dear Prof. Su,

Thanks very much for your valuable comments and suggestion. For your convenience to re-review the paper, the response corresponding to your comments are described in detail as follows:

Reply 1): Thanks very much for your valuable comments. A new section "4.1 Limitations and uncertainties" has been added to fully discuss the shortcoming of this study. It includes three points: (1), the uncertainties of the SEBR method used in this study were discussed. (2), the coarse-resolution NDVI data used in this study were discussed. (3), the limited research implications were also identified. The new section is as follows,

"4.1 Limitations and uncertainties

Theoretically, surface energy is balanced. The energy unclosure might be mainly caused by the error of the observed data. The observed G' instead of G was generally used to investigate the energy balance ratio (Wilson et al., 2002). The energy balance closure problem might be largely caused by the soil heat storage (Foken, 2008). Compared with G, other energy terms can be observed more accurately. The eddy covariance measurements of H and LE are generally considered to be the most accurate observations available, and have been widely used as a reference to evaluate other simulation methods. The **Eq. (1)** makes full use of the surface energy term that can be accurately measured at present. In other words, it assumes that the measurements of Rn, H and LE are accurate in this study. The uncertainties of measurements are not considered in this study. However, the uncertainty of G

estimated by the SEBR method could be very large at some sites, which have low magnitude of G. Although the majority of sites have G values greater than 10 W/m^2, and take up more than 15% of Rn, there are some sites (20/230) with G values lower than 5 W/m^2. There would be great uncertainties of the SEBR method in simulating G values at these sites.

The accuracies of the LC_fc_SE and LC_fc_ST methods, which embed fractional vegetation coverage in the G simulation, were satisfied for monthly simulation, but were significantly lower than those of the other three methods in simulating daily values. The weak correlation between G/Rn and NDVI might be the main reason for the poor performance of these methods. However, the coarse-resolution NDVI data used in this study are not sufficient to represent the scale of flux measurements, especially for sites with heterogeneous land surface. This might be the main reason for this weak correlation. The application of higher resolution and continuous vegetation index data series is expected to improve the simulation accuracy of these methods. A large error in the G simulation might be induced in the ET modelling process, thereby reducing the accuracy of the ET estimates. In RS ET models, Rn is generally calculated using radiation balance with RS images and meteorological inputs. However, observed Rn was used for simulating G in this study. In other words, it was assumed that Rn is accurately simulated by the RS ET models. Therefore, it should be noted that the uncertainty in Rn calculation was also a source of error in G simulations in ET models.

The evaluation results of this study are expected to provide reference for RS ET model application and developers. For example, the performance of these methods was good and poor at some sites and time periods and some land-cover types. RS ET modelers could check the advantage of the models at good performance regions, and find why the models are poor at some other areas, then revise the models to improve the accuracy at poor performance regions. However, how to improve the model to improve the accuracy needs further research. ”

Reply 2): The reference is "Purdy, A. J., Fisher, J. B., Goulden, M. L., and Famiglietti, J. S.: Ground heat flux: an analytical review of 6 models evaluated at 88 sites and globally, J. Geophys. Res. Biogeosci., 121, 3045–3059, doi:10.1002/2016JG003591, 2016." Purdy is the corresponding author of the paper. The correspondence email is ajpurdy@uci.edu.

There are 15 papers when search "Purdy AJ" for author names in the Web of Science. From these papers, the author found that Purdy transferred from University of California to the University of San Diego in 2019. However, the corresponding author for these papers is not Purdy. The author tried to contact the co-author of Purdy's latest paper (Wu, et al, 2020, Evaluating three evapotranspiration estimates from model of different complexity over China using the ILAMB benchmarking system, Journal of Hydrology.), and got another email from him (adamjpurdy@gmail.com).

In addition, the author also tried to search Purdy AJ's contact information from the Internet, but did not obtain any valid information.

The author has been contacting Purdy by emails (ajpurdy@uci.edu and adamjpurdy@gmail.com) every day since October 30. But there was no reply.

As can be seen from the reference (Purdy, et al., 2016), Purdy used the observed G' data. For example,

In the Abstract, it shows that "We provide the largest review of these methods to date (N = 6), evaluating modeled G against measured G from 88 FLUXNET sites."

In the section of Data Sets, it points that "Overall, we used measurements from 88 towers across 11 climates and 10 biomes to evaluate modeled G", and "Data are available from the FLUXNET database (http:///www.fluxdata.org). Despite being the best available collection of globally distributed observations, many locations lack a full year of observations, experience instrument quality degradation, and locate ground heat flux plates and soil thermocouples to calculate storage at different depths (2–15 cm) to measure G."

In addition, a new reference cited in the section 4.1 has been added as follows,

Foken, T.: The energy balance closure problem: An overview, Ecol. Appl., 18, 1351–1367, https://doi.org/10.1890/06-0922.1, 2008.

In the Acknowledgments, the order of grant numbers “XDA23090302; XDA2006020202” has been revised into “XDA2006020202; XDA23090302”.

Best Regards

Zhaofei Liu