Responses to the Comments and Suggestions

Reviewer #1:

This paper presents an energy conservation datasets of global land surface radiation and heat fluxes from 2000 to 2020. The dataset is generated by the model of Coordinated estimates of land Surface Energy Balance components (CoSEB), with a combination of GLASS and MODIS remote sensing data, ERA5-Land reanalysis datasets, topographic data, CO2 concentration data, and observations at 258 eddy covariance sites worldwide from the AmeriFlux, FLUXNET, EuroFlux, OzFlux, ChinaFLUX and TPDC. The primary merit of this new model is energy-conservation. Although the dataset might be useful, this dataset is not the first energy conservation datasets of global land surface radiation and heat fluxes as claimed by the authors. Therefore, major revisions are required before the paper is accepted.

Ans: Thank you very much for your valuable comments and suggestions. We sincerely appreciate your recognition of the dataset and the CoSEB model's merit in ensuring energy conservation. We would like to clarify that our initial statement, which described the datasets as "the first energy-conservation datasets of global land surface radiation and heat fluxes," may not have been entirely accurate. After careful consideration, we have revised the manuscript to more precisely describe the datasets as "the first data-driven energy-conservation datasets of global land-surface radiation and heat fluxes". Besides, we have carefully considered all the comments and suggestions from you and another reviewer and made corresponding modifications and clarifications in the revised manuscript. More detailed information of our revisions can be found in the item-by-item response below.

Specific comments:

1. The authors claim that "This study presents the first energy conservation datasets of global land surface radiation and heat fluxes", but reanalysis datasets, such as ERA5 which is used as inputs of this new dataset, also provide energy conservation surface fluxes for these energy fluxes. Maybe the authors want to say that this is the first remote sensing-based dataset? But the ERA5 radiative fluxes, which are not remote sensing-based, are used to generate surface fluxes in this paper, so this dataset is neither the first remote sensing-based dataset.

Ans: We sincerely thank the reviewer for this insightful comment. We acknowledge that reanalysis datasets, such as ERA5-Land, can in principle calculate these fluxes based on surface energy conservation. However, these reanalysis datasets rarely include all eight flux components directly. For example, ERA5-Land does not explicitly provide upward shortwave radiation, upward longwave radiation, net radiation or soil heat flux. Additionally, we would also like to clarify that the CoSEB-based datasets were developed by integrating both remote sensing products (e.g., PTC from MOD44B, LAI and FVC from GLASS, DEM, slope, and aspect from GMTED2010) and meteorological reanalysis data as inputs. It should be noted that widely used surface radiation and heat flux products, commonly referred to as remote sensing-based datasets, generally require meteorological reanalysis data as

inputs, e.g., the MOD16 ET product (Mu et al., 2011), SSEBop ET product (Senay et al., 2020), and GLASS radiation products (Wang et al., 2015; Xu et al., 2022), rather than relying solely on remote sensing data. Therefore, although our CoSEB-based datasets incorporate meteorological data from ERA5-Land in addition to remote sensing data, we believe it appropriate to refer to them as remote sensing-based datasets.

After careful consideration, we have revised the manuscript to more precisely describe the datasets as "the first data-driven energy-conservation datasets of global land-surface radiation and heat fluxes". We have revised this in the new manuscript as follows:

Abstract:

"This study presents the first data-driven energy-conservation datasets of global land surface radiation and heat fluxes from 2000 to 2020 ... The developed CoSEB-based datasets are strikingly advantageous in that [1] they are the first data-driven global datasets that satisfy both surface radiation balance (SWI_N - SW_{OUT} + LW_{IN} - LW_{OUT} = Rn) and heat balance (LE + H + G = Rn) among the eight fluxes,…"

5 Discussion

"The main advantages of our CoSEB-based datasets of land surface radiation and heat fluxes lie in that [1] they are the first data-driven global datasets that satisfy both surface radiation balance (SWI_N - SW_{OUT} + LW_{IN} - LW_{OUT} = Rn) and heat balance (LE + H + G = Rn) among the eight fluxes, as demonstrated by both the RIR and EIR of 0, …"

"Despite these uncertainties, it is worth emphasizing that our work was the first attempt to innovatively develop data-driven energy-conservation datasets of global land surface radiation and heat fluxes with high accuracies."

7 Summary and Conclusion

"This study for the first time developed data-driven energy-conservation datasets of global land surface radiation and heat fluxes…"

"The CoSEB-based datasets of land surface radiation and heat fluxes are the first data-driven global datasets that satisfy both surface radiation balance (SWI_N - SW_{OUT} + LW_{IN} - LW_{OUT} = Rn) and heat balance (LE + H + G = Rn) among the eight fluxes."

2. The merit of this new dataset is still unclear to me. According to Lines 171-180, ERA5 downward solar radiation and net thermal radiation at the surface is used in this paper, but why not simply use ERA5 fluxes if someone need to surface fluxes? The new dataset might be more accurate than ERA5 in places where ground-based observations are used to generate the new dataset, but the ground sites are sparce. To solve this problem, the authors should compare in-situ measurements with both the new data and ERA5 data in independent sites (i. e., sites that are not used in the generation of the new dataset).

Ans: We sincerely appreciate the reviewer's insightful comment and suggestion. We would like to clarify that the ERA5-Land reanalysis datasets do not explicitly provide upward shortwave radiation, upward longwave radiation, net radiation, or soil heat flux, although these components can theoretically be computed using surface radiation and heat balance principles. The purpose of our work was to innovatively provide energy-conservation surface radiation and heat fluxes based on data-driven technique. This is motivated by the fact that existing data-driven products (e.g., FLUXCOM and GLASS) estimate each energy component separately, leading to obvious energy imbalance among these components (Wang et al., 2025).

To further address the reviewer's concern, we have compared estimates from CoSEB-based datasets and ERA5-Land datasets with in-situ observations from 44 sites (collected from recently published JapanFlux and updated AmeriFlux, see the sites for "test" in Table S1), which are independent from the 258 sites that are used for model construction and datasets generation. As demonstrated by the comparison results (see Figs. S6 and S7), the CoSEB-based datasets exhibit higher accuracy than the ERA5-Land datasets in estimating surface energy fluxes, especially in estimating SW_{OUT}, H and G. We have discussed this in the third paragraph of Section 5 in the revised manuscript with the following sentences:

"Furthermore, the CoSEB-based datasets outperformed the ERA5-Land reanalysis datasets in estimating surface energy fluxes (where SW_{OUT}, LW_{OUT}, Rn and G for the ERA-Land were inferred from surface radiation balance and heat balance), particularly for SW_{OUT}, H and G, with RMSE reductions of 0.13-8.15 W/m^2 when validated against in situ observations at the 44 test sites (Figs. S6 and S7 in the Supplementary Material)."

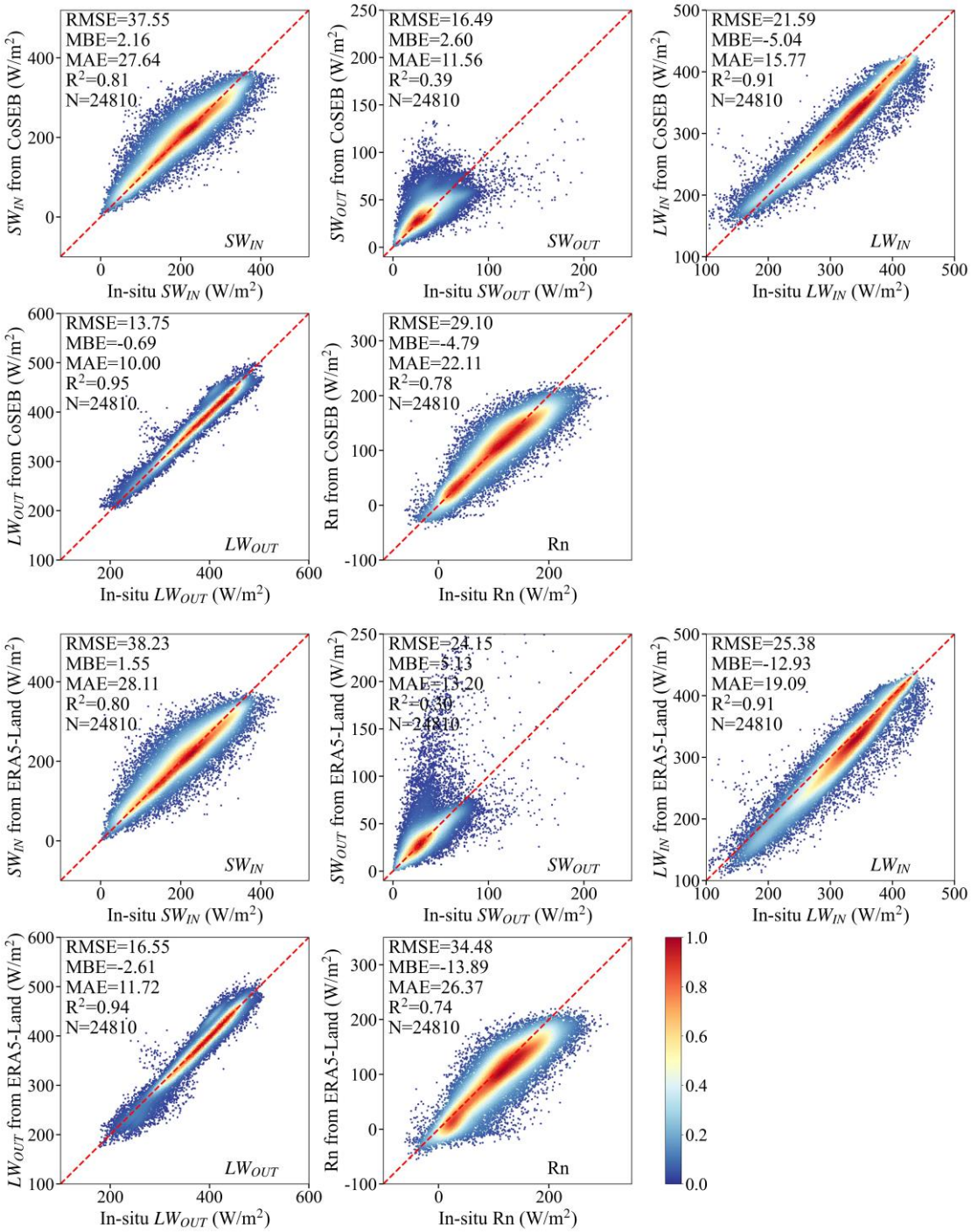

Fig. S6 Comparison of the daily downward shortwave radiation (SW_{IN}), upward shortwave radiation (SW_{OUT}), downward longwave radiation (LW_{IN}), upward longwave radiation (LW_{OUT}) and net radiation (Rn) from the CoSEB-based datasets (upper 5 panels) and ERA5-Land (lower 5 panels) with the in-situ observed SW_{IN}, SW_{OUT}, LW_{IN} and LW_{OUT} at 44 test sites. The colorbar represents the normalized density of data points.

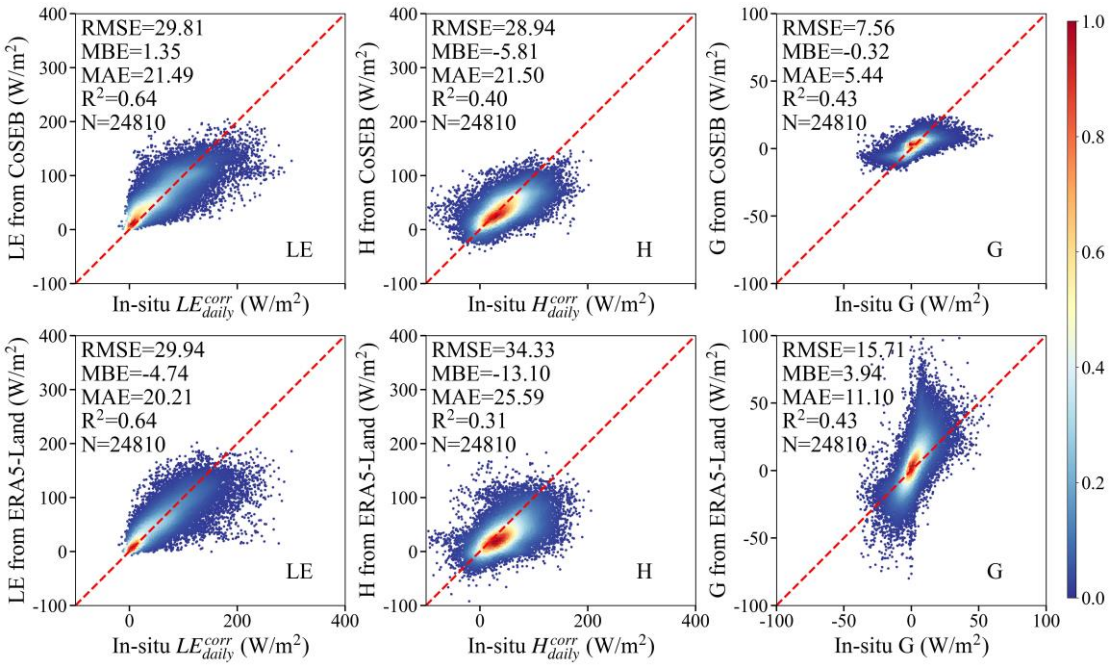

Fig. S7 Comparison of the daily latent heat flux (LE), sensible heat flux (H) and soil heat flux (G) from the CoSEB-based datasets (first row) and ERA5-Land (second row)with the in-situ energy imbalance-corrected LE (LE^{corr}_{daily}) and H (H^{corr}_{daily}), as well as observed G at 44 test sites. The colorbar represents the normalized density of data points.

3. The abstract is not well formatted. An abstract usually provides a brief and comprehensive summary, so trivial details in brackets [including downward shortwave radiation (SWIN), downward longwave radiation (LWIN), upward shortwave 15 radiation (SWOUT), upward longwave radiation (LWOUT) and net radiation (Rn)], [including latent heat flux (LE), soil heat flux (G) and sensible heat flux (H)], and (SWIN - SWOUT + LWIN - LWOUT = Rn) might be deleted. Internet links https://doi.org/10.11888/Terre.tpdc.302559 and citations (Tang et al., 2025a) should be removed from the abstract. On the other hand, the authors should briefly describe how these data sources are used to generate the new dataset.

Ans: We appreciate the reviewer's suggestion. We would like to clarify that the latter part of the Abstract describes the accuracy of each of the eight surface radiation and heat flux components, as well as the overall surface radiation balance and energy balance among them. Therefore, to ensure consistency and readability, we chose to retain the introduction of all eight fluxes and their corresponding abbreviations at the beginning of the Abstract. However, the two equations, (SW_{IN} - SW_{OUT} + LW_{IN} - LW_{OUT} = Rn) and (LE + H + G = Rn), were deleted in the Abstract, as suggested by the reviewer. Furthermore, the links and citations of the datasets are mandatorily required by the journal and editors in the Abstract, and therefore cannot be removed. Besides, following the reviewer's suggestion, we have briefly explained how multiple data sources were integrated to generate the CoSEB-based datasets in the revised manuscript as follows:

“This study presents the first data-driven energy-conservation datasets of global land surface radiation and heat fluxes from 2000 to 2020, generated by our model of Coordinated estimates of land Surface Energy Balance components (CoSEB). The model integrates GLASS and MODIS remote sensing data, ERA5-Land reanalysis datasets, topographic data, CO_2 concentration data as independent variables and in situ radiation and heat flux observations at 258 eddy covariance sites worldwide as dependent variables within a multivariate random forest technique to effectively learn the physics of energy conservation.”

Reference:

Mu, Q., Zhao, M. and Running, S. W.: Improvements to a MODIS global terrestrial evapotranspiration algorithm, Remote Sens. Environ., 115, 1781-1800. 10.1016/j.rse.2011.02.019, 2011.

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Wang, D., Liang, S., He, T. and Shi, Q.: Estimation of Daily Surface Shortwave Net Radiation From the Combined MODIS Data, IEEE Trans. Geosci. Remote Sensing, 53, 5519-5529. 10.1109/tgrs.2015.2424716, 2015.

Wang, J., Tang, R., Liu, M., Jiang, Y., Huang, L. and Li, Z.-L.: Coordinated estimates of 4-day 500 m global land surface energy balance components, Remote Sens. Environ., 326, 114795. 10.1016/j.rse.2025.114795, 2025.

Xu, J., Liang, S., Ma, H. and He, T.: Generating 5 km resolution 1981–2018 daily global land surface longwave radiation products from AVHRR shortwave and longwave observations using densely connected convolutional neural networks, Remote Sens. Environ., 280, 113223. 10.1016/j.rse.2022.113223, 2022.