Responses to Comments Made by Editors:

- Dear Authors, thank you for your efforts in improving the manuscript. However, one of the reviewers still has critical concerns about the revised version. For instance, since many empirical coefficients were sourced from studies conducted in different regions, it is essential to quantify, evaluate, or discuss the uncertainties associated with these coefficients. Furthermore, as suggested by the reviewer, an evaluation of ET should be included. Moreover, the data description appears to be quite limited. Please thoroughly address these concerns raised by the reviewer in your revised manuscript. Thank you!

Thank you very much for the suggestions provided by the editors and reviewers. We gladly accept them. In this paper, there are numerous empirical parameters in equations 7–17, all of which pertain to the parameterization of r_a and r_s in the MOD16-STM model. These parameters have already been assessed for their importance in ET estimation in the literature by Yuan et al. (2021). There are too many studies on investigating the empirical coefficients in equation 7–13. We will not repeat this analysis again. The uncertainty of r_s to a and b in equation 14 has been reflected by Figure 3 in the manuscript. The parameterization method of θ_{sat} in the estimation of r_s in this study is composed of various empirical parameters (ρ_p, ρ_{soc}, and $\theta_{sat,\ sc}$) for different soil types. We have conducted a uncertainty analysis of the estimated θ_{sat} and sensitivity of its uncertainty to the changes of empirical parameters. The impact of the empirical parameters on the estimation of ET is illustrated in Figure A1 (a–c). The results indicate that with a 20% uncertainty range in the estimated parameters ρ_p, ρ_{soc}, and $\theta_{sat,\ sc}$ for θ_{sat}, the loss in estimating ET is only below 3%. The uncertainty of θsat to changes in these empirical parameters (equation 15–17) is relatively low. Thus, the conclusion is drawn that the estimation of ET is not sensitive to variations in these three parameters.

We have conducted a uncertainty analysis of the estimated θ_{sat}. Figure A2 shows the accuracy of the estimated θ_{sat} by the method used in this paper. It demonstrates that the parameterized method of θ_{sat} could have a good representation of different soil types. Additionally, a sensitivity analysis is conducted on the empirical parameters a and b for calculating r_s. Keeping θ_{sat} and SM constant, r_s exhibits exponential changes with variations in a and b, leading to significant fluctuations in the estimation of ET. Within a 20% range of variation in a and b, the maximum loss in ET exceeded 50% in Figure A1 (d–e). Therefore, it is essential to perform significance tests on the fitting results of the empirical parameters a and b, as well as independent validation of the final ET estimates. The sensitivity test show that the factors that have a significant impact on r_s and ET are the topsoil moisture and soil organic matter content. The following Figure A3 present the impact of soil organic matter content on θ_{sat} and ET estimation at different soil types. We also add discussions on these sensitivity analysis in the revised manuscript. Please refer to lines 207 to 230 and lines 647 to 675 in the manuscript for more details.

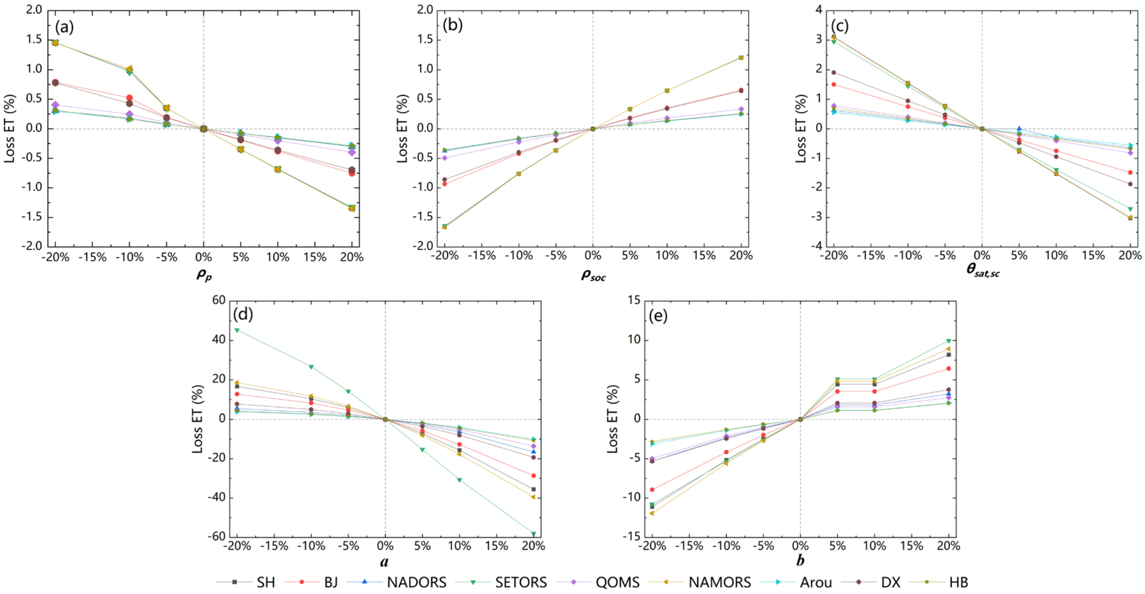

Figure A1. A sensitivity analysis on the impact of the uncertainty in the empirical parameters (ρ_p, ρ_{soc}, $\theta_{sat,\ sc}$, a and b) of the estimated θ_{sat} on the estimation of ET (test in August, 2018).

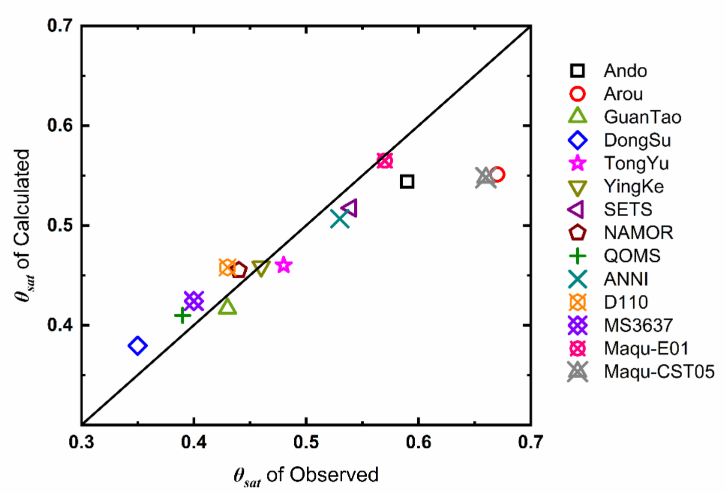

Figure A2. Validation of the consistency between the estimated values and the observed values for θ_{sat} over the TP.

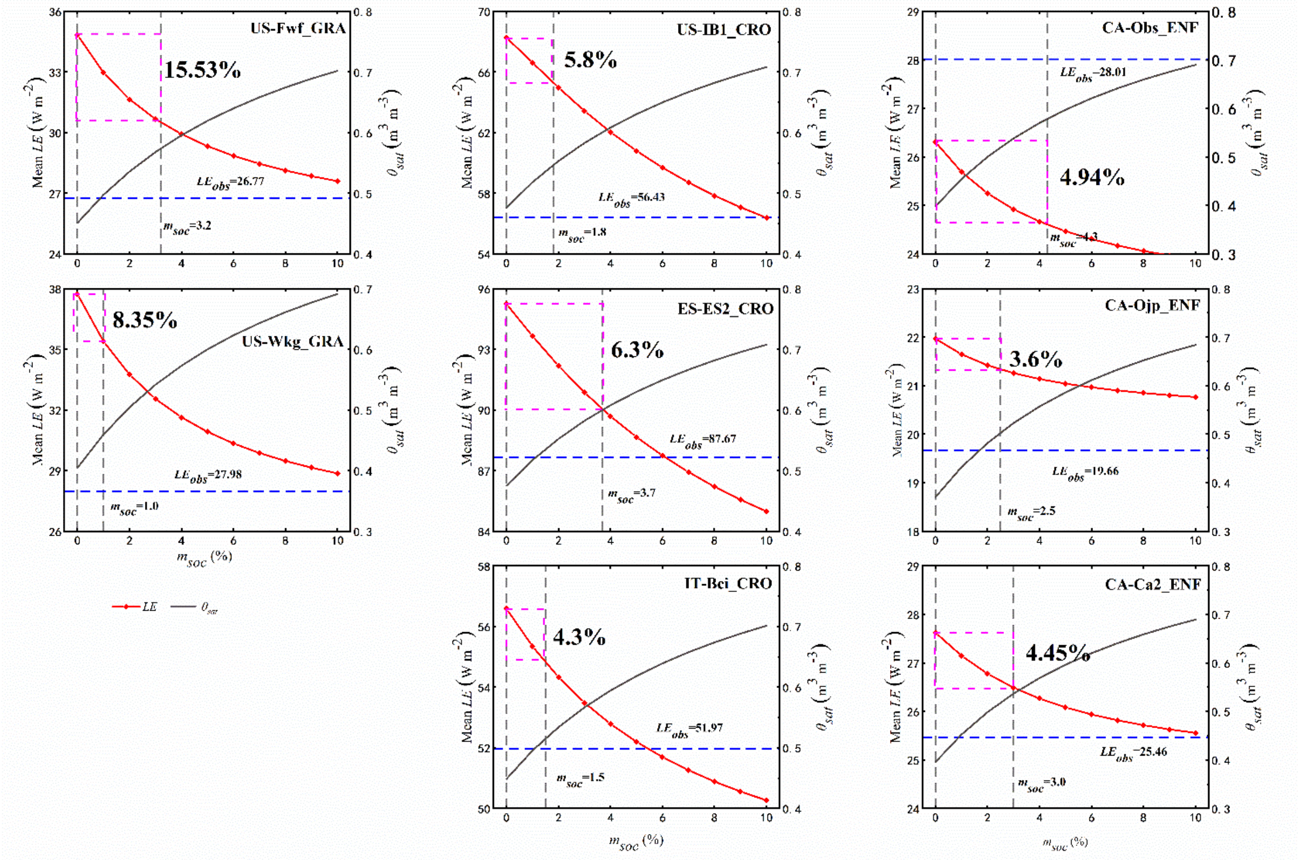

Figure A3. The sensitivity of LE and θ_{sat} to the changes of m_{soc} content at different sites.

Chen, Y., Yang, K., Tang, W., Qin, J., and Zhao, L.: Parameterizing soil organic carbon's impacts on soil porosity and thermal parameters for Eastern Tibet grasslands, Sci. China Earth Sci., 55(6), 1001–1011, https://doi.org/10.1007/s11430-012-4433-0, 2012.

Yuan, L., Ma, Y., Chen, X., Wang, Y., Li, Z.: An enhanced MOD16 evapotranspiration model for the Tibetan Plateau during the unfrozen season, J. Geophys. Res. Atmos., 126, e2020JD032787, https://doi.org/10.1029/2020JD032787, 2021.

- Dear Authors, I would like to bring to your attention that the data description provided is quite limited. Without a detailed description, including information such as the data format, it becomes challenging to thoroughly test and evaluate the data. The current description in the data repository seems more like an abstract. I kindly request that you provide a more thorough and detailed description of the data. Thank you for your attention to this matter.

Thank you very much for the suggestions provided by the editors. We gladly accept them. We have supplemented the data description as follows:

Datasets Summary:

This dataset provides gridded monthly evapotranspiration (ET) data for the Tibetan Plateau (TP) over the past 37 years (1981–2018), including soil evaporation (E_s), vegetation transpiration (E_c), and interception evaporation (E_w). The data have a horizontal resolution of 0.05° and are presented in mat format. To generate this dataset, the MOD16 evapotranspiration model (MOD16-STM) was optimized and developed using site-level flux observations and soil texture information. Combining remote sensing data and reanalysis data, the MOD16-STM model was employed to simulate monthly evapotranspiration data for the TP region over the past 37 years. The results indicate that, compared to current mainstream gridded ET products in the TP region, this dataset exhibits higher accuracy. The dataset can be utilized for climate analysis, hydrological analysis, and relevant engineering applications.

How to name and use data files:

The data files are stored in separate folders based on the year. The data files are named YYYYMM_ET.mat, YYYYMM_Es.mat, YYYYMM_Ew.mat, and YYYYMM_Ew.mat, where YYYY represents the four-digit year and MM represents the two-digit month. The dataset is in Coordinated Universal Time (UTC). The unit is mm/month, indicating the total evapotranspiration for the respective period. The data can be read using Matlab. A simple example for reading the data is provided in the readme file for this dataset.

Responses to Comments Made by Reviewer #1:

The authors did a good job in revision. In particular, the dataset at 0.05 degree has now been produced rather than that at 0.01 degree. I have no further comments and suggest accepting it.

- A technical issue that needs to be corrected: In Line 271 and Table 3, the Shuanghu station needs to cite Ma et al. (2015b), already existing in the current Reference part.

Thank you very much for the reviewer's recognition of our research findings. In response to the questions you raised, I have already made the necessary revisions in the manuscript, which are highlighted in blue font. Please refer to Table 3 on line 279 for details.

Responses to Comments Made by Reviewer #2:

Thank you very much for the reviewer's recognition of our research findings.

Responses to Comments Made by Reviewer #3:

- This is a resubmitted manuscript. The authors have addressed most of comments/suggestions and made changes to the paper, which has improved its quality considerably. Nonetheless, it seems that a few critical points were still ignored. A lot of empirical coefficients were cited from studies performed at different areas (e.g., equations 7 to 17), how large uncertainty did they cause, especially when estimating r_s using θ_{sat} (even though the validation results seem good)? Insightful discussion on such problems with sensitive analyses may be good for understanding the possible accuracy of the products, including its components.

Thank you very much for the suggestions provided by the reviewer. We gladly accept them. In this paper, there are numerous empirical parameters in equations 7–17, all of which pertain to the parameterization of r_a and r_s in the MOD16-STM model. These parameters have already been assessed for their importance in ET estimation in the literature by Yuan et al. (2021). There are too many studies on investigating the empirical coefficients in equation 7–13. We will not repeat this analysis again. The uncertainty of r_s to a and b in equation 14 has been reflected by Figure 3 in the manuscript. The parameterization method of θ_{sat} in the estimation of r_s in this study is composed of various empirical parameters (ρ_p, ρ_{soc}, and $\theta_{sat,\ sc}$) for different soil types. We have conducted a uncertainty analysis of the estimated θ_{sat} and sensitivity of its uncertainty to the changes of empirical parameters. The impact of the empirical parameters on the estimation of ET is illustrated in Figure A1 (a–c). The results indicate that with a 20% uncertainty range in the estimated parameters ρ_p, ρ_{soc}, and $\theta_{sat,\ sc}$ for θ_{sat}, the loss in estimating ET is only below 3%. The uncertainty of θ_{sat} to changes in these empirical parameters (equation 15–17) is relatively low. Thus, the conclusion is drawn that the estimation of ET is not sensitive to variations in these three parameters.

We have conducted a uncertainty analysis of the estimated θ_{sat}. Figure A2 shows the accuracy of the estimated θ_{sat} by the method used in this paper. It demonstrates that the parameterized method of θsat could have a good representation of different soil types. Additionally, a sensitivity analysis is conducted on the empirical parameters a and b for calculating r_s. Keeping θ_{sat} and SM constant, r_s exhibits exponential changes with variations in a and b, leading to significant fluctuations in the estimation of ET. Within a 20% range of variation in a and b, the maximum loss in ET exceeded 50% in Figure A1 (d–e). Therefore, it is essential to perform significance tests on the fitting results of the empirical parameters a and b, as well as independent validation of the final ET estimates. The sensitivity test show that the factors that have a significant impact on r_s and ET are the topsoil moisture and soil organic matter content. The following Figure A3 present the impact of soil organic matter content on θ_{sat} and ET estimation at different soil types. We also add discussions on these sensitivity analysis in the revised manuscript. Please refer to lines 207 to 230 and lines 647 to 675 in the manuscript for more details.

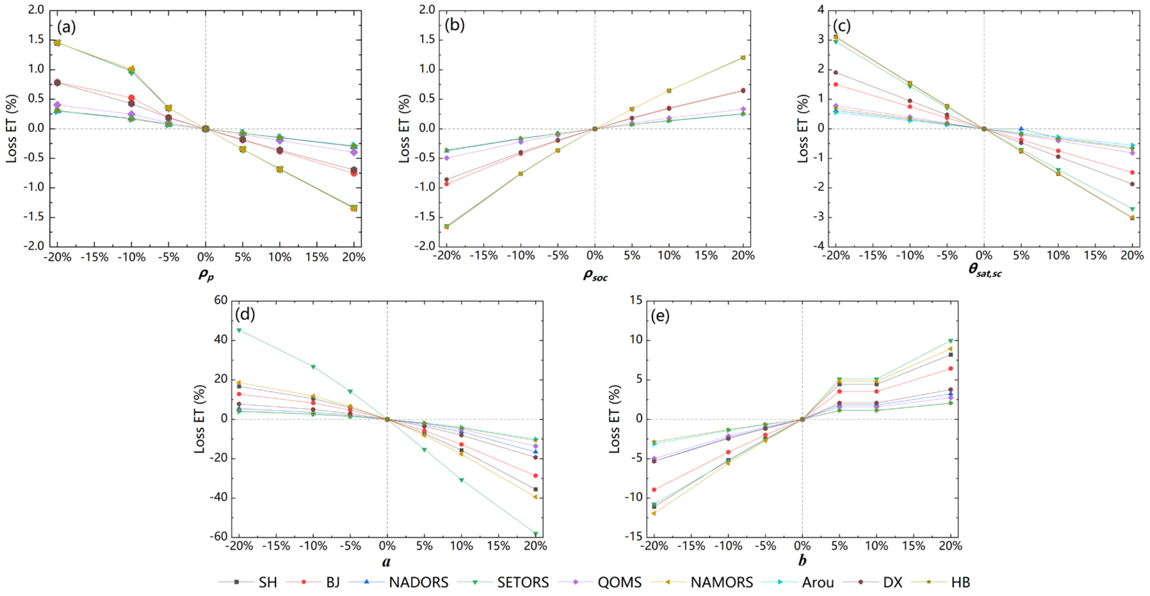

Figure A1. A sensitivity analysis on the impact of the uncertainty in the empirical parameters (ρ_p, ρ_{soc}, $\theta_{sat,\ sc}$, a and b) of the estimated θsat on the estimation of ET (test in August, 2018).

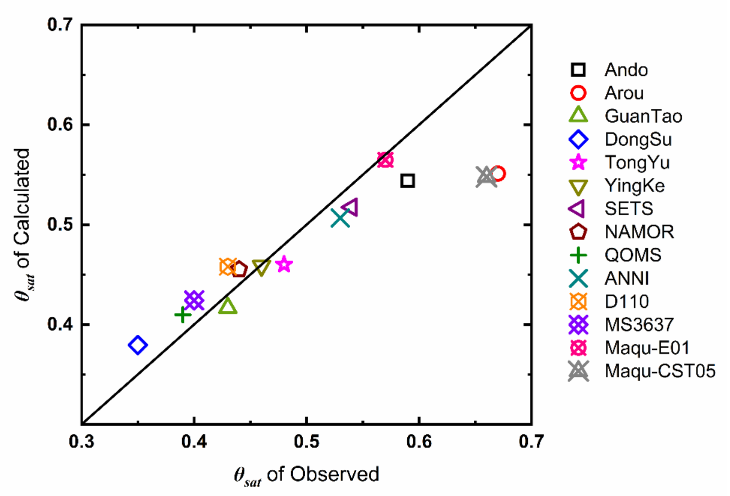

Figure A2. Validation of the consistency between the estimated values and the observed values for θ_{sat} over the TP.

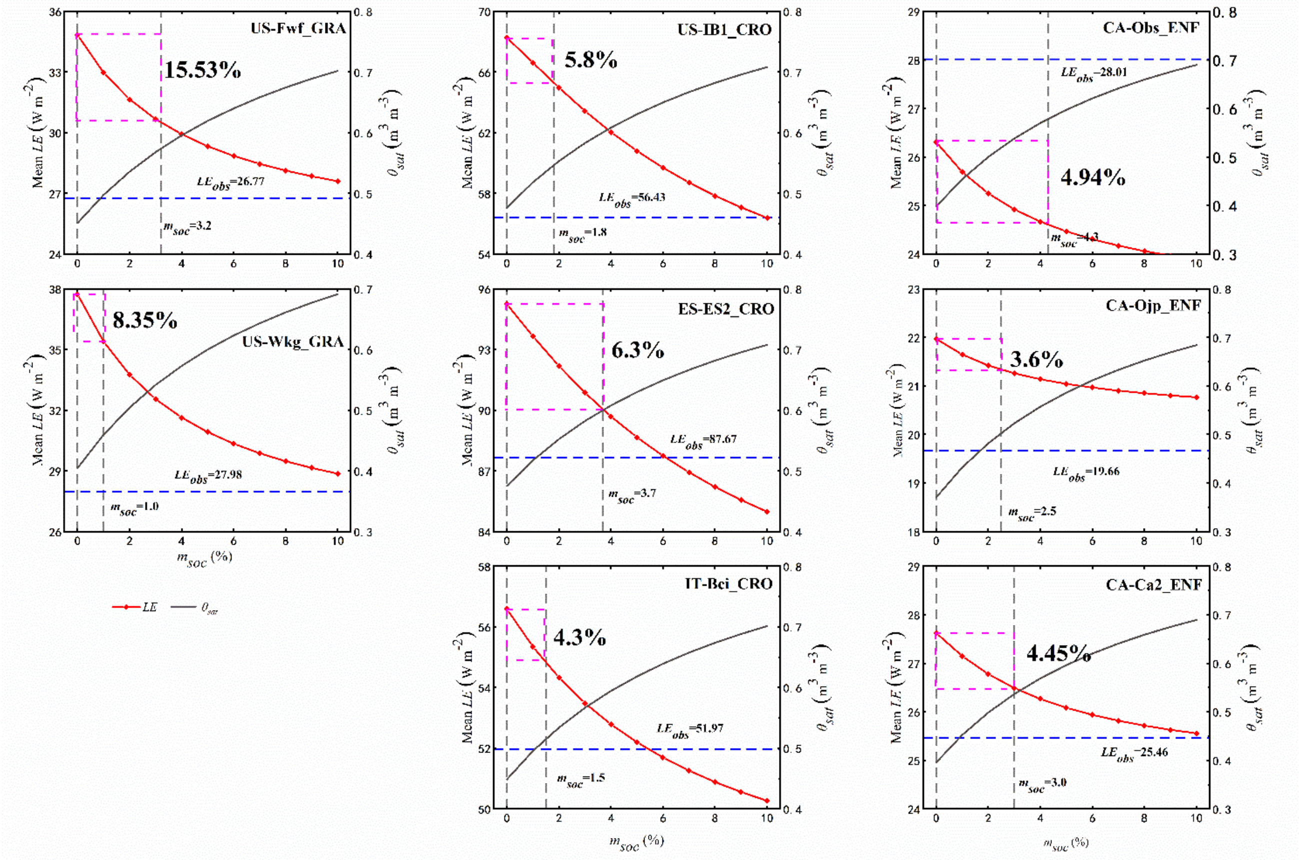

Figure A3. The sensitivity of LE and θ_{sat} to the changes of m_{soc} content at different sites.

Chen, Y., Yang, K., Tang, W., Qin, J., and Zhao, L.: Parameterizing soil organic carbon's impacts on soil porosity and thermal parameters for Eastern Tibet grasslands, Sci. China Earth Sci., 55(6), 1001–1011, https://doi.org/10.1007/s11430-012-4433-0, 2012.

Yuan, L., Ma, Y., Chen, X., Wang, Y., Li, Z.: An enhanced MOD16 evapotranspiration model for the Tibetan Plateau during the unfrozen season, J. Geophys. Res. Atmos., 126, e2020JD032787, https://doi.org/10.1029/2020JD032787, 2021.

- Moreover, I suggested that the authors compare they ET components with the other published datasets previously. Unfortunately, they said there's no publicly available data. As the author provide ET components datasets and results, I suggest the authors perform such comparison to reach the high level of the journal. Several observations (i.e., T/ET values) can be found in the following literatures (at least) (and/or using other remote sensing products such as GLEAM):

  (1) Cui, et al. (2020). Quantifying the controls on evapotranspiration partitioning in the highest alpine meadow ecosystem. Water Resources Research, 56.

  (2) Guo et al. (2017). River recharge sources and the partitioning of catchment evapotranspiration fluxes as revealed by stable isotope signals in a typical high-elevation arid catchment. Journal of Hydrology, 549, pp. 616-630.

  (3) Zheng, C., Jia, L., Hu, G. (2022). Global land surface evapotranspiration monitoring by ET-Monitor

model driven by multi-source satellite earth observations. Journal of Hydrology, 613, 128444.

Thank you very much for the suggestions provided by the reviewer. We gladly accept them. First, in Section 4, we have divided it into two part, cross-validation of ET products and cross-validation of ET components. Please refer to lines 456 to 502 in the manuscript for more details.

4.1 Cross-Comparison of the Spatial Distribution of ET on the TP

A cross-comparison of the multi-year average values of various ET products is conducted to assess the differences and consistency in their spatial patterns. From the spatial distribution of annual average ET (Figure 12), all the ET products for the TP exhibit a decreasing trend from southeast to northwest, consistent with the transition in surface types from forests to grasslands and bare soil. In the Henduan Mountains region, all products show high values (>600 mm/year) due to the dense vegetation and ample precipitation. However, significant absolute differences are observed among these 15 ET products. There are high differences among the products in the sparsely vegetated western and central TP regions. In the central TP region, where the Han-ET product exhibits the highest annual ET (>600 mm/year), while GLDAS-VIC has the lowest (approximately 35 to 50 mm/year). In the northwestern TP, EB-ET, GLDAS, MERR-2, and GLEAM-v3.5a products display low values (<50 mm/year), while others range between 100 and 300 mm/year. In the extremely arid Qiangtang Plateau, all products show low values due to limited available surface water. ERA-Interim, ERA5-Land, PML-Zhang, CR-Ma, MOD16-STM, and GLEAM-v3.5b have relatively balanced distributions in the central and western TP regions (200-350 mm/year). There are high differences in the distribution of ET among the products in the downstream area of the Yarlung Tsangpo River. The spatial resolution of our product is 0.05°. This might be the reason for MOD16-STM has low ET for this topographic complex region. It is worth noting that MOD16 ET product has many missing values in the northwestern TP region, making it inadequate for a comprehensive assessment of ET across the entire TP.

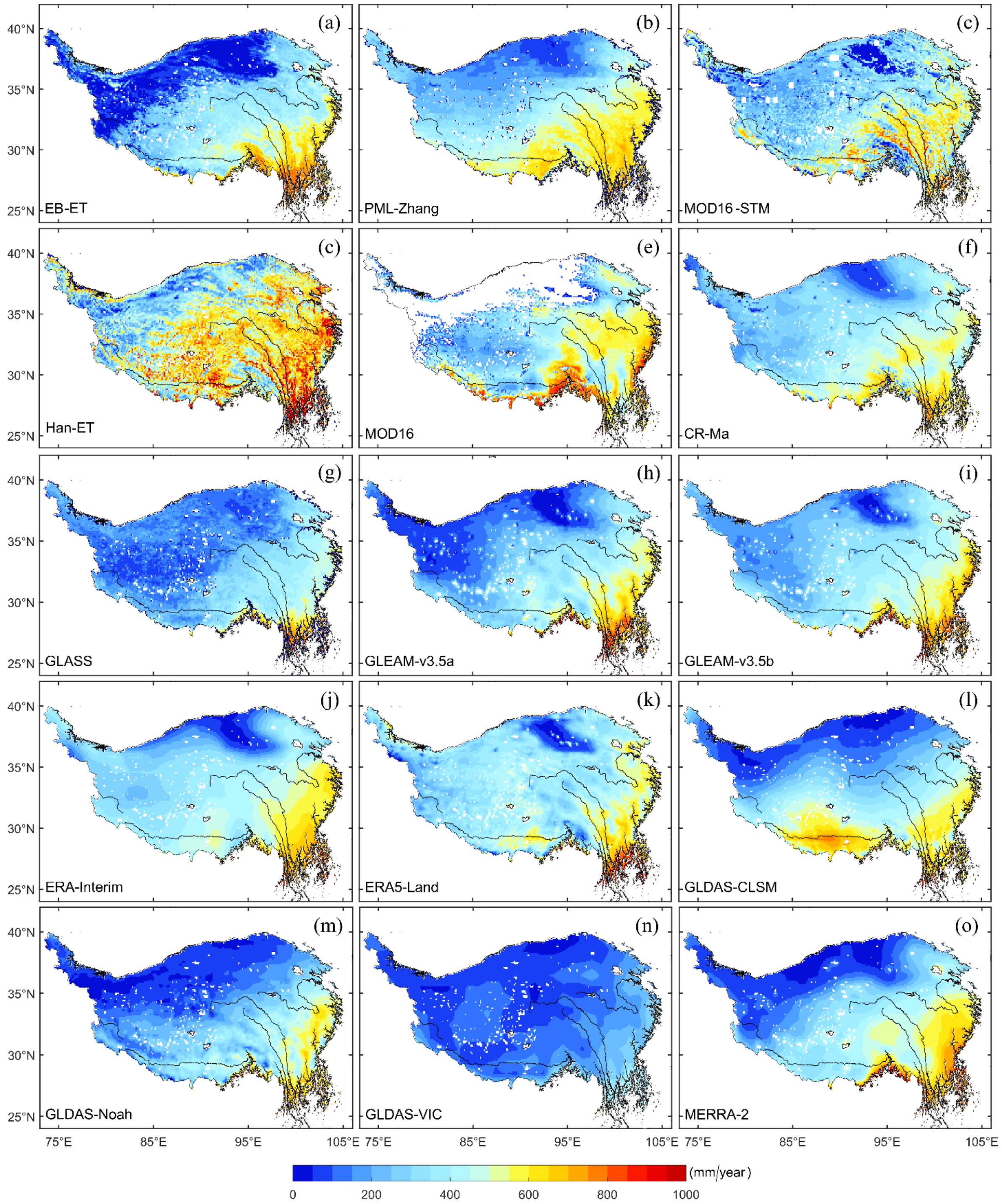

Figure 12. Spatial distribution of annual averaged ET on the TP during 2000 to 2014 derived from 15 products.

4.2 ET components partitioning

It is also necessary to have ET components comparative validation to enhance the practicality of the data generated in this study. Unfortunately, there are no measured ET component data publicly available at the moment. Comparative validation can be conducted based on existing research findings. Cui et al. (2020) estimated the E_c/ET at the Nagqu Station (31.37°N, 91.90°E; 4509 m above sea level) in the central region of the TP using laser spectroscopy and chamber methods. During the observation period, the isotopic-based E_c/ET ranged from 15% to 73%, with an average value of 43%. We calculated E_c/ET from our dataset at the same location and time period (June and July). The values of E_c/ET from MOD16-STM are in the range of 13.1% to 62.6%. The average of E_c/ET is 38.4%±4.7%, which has a difference of 4.6% relative to isotopic estimation. Our E_c/ET estimation is close to the observation at Nagqu. Guo et al. (2017) also pointed that E_c constituted less than half of total ET (41% annually, 29% during monsoon) in Magazangbu catchment over the TP.

Moreover, we assess the similarities and differences between MOD16-STM and GLEAM-v3.5a ET components on the TP. Figure 13 shows that GLEAM's E_s values are generally smaller than our estimation throughout the TP region. The most recent results from Zheng et al. (2022) also suggest that the GLEAM product underestimates global E_s outputs. Conversely, GLEAM's E_c values are overestimated in the central and eastern TP. The differences in E_w are minimal because the values in that region are inherently small. Previous research has indicated that in the central TP region, E_s/ET accounts for over 60% (Cui et al., 2020), and the average E_s/ET ratio across the entire region exceeds 65% (Wang et al., 2018). The reason for the relatively higher E_s in the central TP is that this region primarily consists of high-altitude grassland as the underlying surface. In the summer, the dominant processes are E_c and E_s, but in the winter E_s becomes the predominant process. Consequently, the proportion of E_s is higher over the entire year. GLEAM's results show that the E_c process predominates in the central TP, which differs somewhat from the findings of this study. Zheng et al. (2022) also indicate that the E_s process predominates in the central TP, exceeding 300 mm/year. Therefore, the ET components in this study, when compared with previous research, are more in line with the actual conditions in the TP.

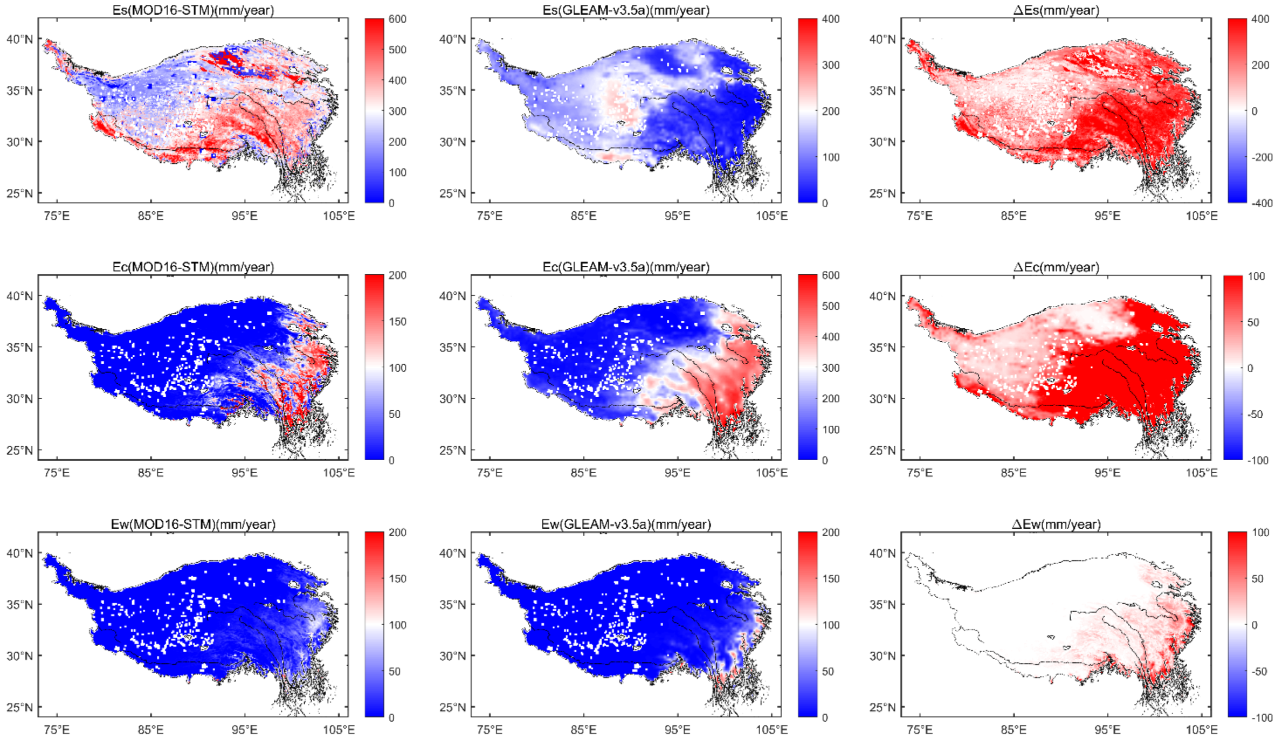
Es(MOD16-STM)(mm/year)
Es(GLEAM-v3.5a)(mm/year)
ΔEs(mm/year)
Ec(MOD16-STM)(mm/year)
Ec(GLEAM-v3.5a)(mm/year)
ΔEc(mm/year)
Ew(MOD16-STM)(mm/year)
Ew(GLEAM-v3.5a)(mm/year)
ΔEw(mm/year)

Figure 13. Spatial comparison of ET components and their differences (MOD16-STM minus GLEAM-v3.5a).

Cui, J., Tian, L., Wei, Z., Huntingford, C., Wang, P., Cai, Z., … Wang, L.: Quantifying the Controls on

Evapotranspiration Partitioning in the Highest Alpine Meadow Ecosystem. Water Resour. Res., 56(4). https://doi.org/10.1029/2019WR024815, 2020.

Guo, X., Tian, L., Wang, L., Yu, W., Qu, D.: River recharge sources and the partitioning of catchment evapotranspiration fluxes as revealed by stable isotope signals in a typical high-elevation arid catchment. J. Hydrol., 549, 616–630, https://doi.org/10.1016/j.jhydrol.2017.04.037, 2017

Zheng, C., Jia, L., Hu, G.: Global Land Surface Evapotranspiration Monitoring by ETMonitor Model Driven by Multi-source Satellite Earth Observations. J. Hydrol., 128444, https://doi.org/10.1016/j.jhydrol.2022.128444, 2022.

- Method section still contains inconsistency. First, r_s and r_c were corrected in Eq. 1. However, it seems they only use r_s in the estimation without any explanation.

Thank you very much for the suggestions provided by the reviewer. We gladly accept them. Here, r_a (s/m) is the aerodynamic resistance, r_c (s/m) is the aerodynamic resistance of water vapor of the canopy, and r_s (s/m) is the surface (or canopy) resistance. Yuan et al. (2021) optimized r_a based on the Monin-Obukhov similarity theory (MOST) and calibrated the empirical values of r_c for grassland underlying surfaces. They also pointed out that the topsoil moisture content directly affects the value of r_s, indirectly influencing the Es process. Therefore, this study extended this optimization algorithm from the site scale to the regional scale. Please refer to lines 141 to 146 in the manuscript for more details.

- Second, did the input datasets at 3h temporal scale include nighttime data (as well as the estimation)?

Thank you very much for the suggestions provided by the reviewer. The 3-hour interval data in the paper are considered as initial data, which includes nighttime data, and are subsequently averaged to daily or monthly scales.

- Thirdly, it is also unclear whether some variables are typo, such as u_* in equation 13 is different from that in line 184.

Thank you very much for the suggestions provided by the reviewer. We gladly accept them. The variable "u_*" throughout the paper represents the friction velocity. We have made modifications in the paper. Please refer to Formula 13 and lines 184 to 186 in the manuscript for details.

- Finally, it is also unclear that where a few equations were from, such as those in lines 184 to 186?

Thank you very much for the suggestions provided by the reviewer. Formulas 8-12 are derived from the references in Högström (1996) and Paulson (1970). We have added citations of these papers for equation 8–12, to show their sources. Please refer to lines 178 to 184 in the manuscript for more details.

- Grammar and typos also need to be paid attention to across the entire manuscript, such as "-3-1 mm/year" in line 43.

Thank you very much for the suggestions provided by the reviewer. We gladly accept them. We have already corrected and modified the grammar and symbols in the manuscript. The modified portions are as follows: Our findings reveal a noteworthy upward trend in ET in most central and eastern parts of the TP, with a rate of approximately 1–4 mm/year ($p<0.05$) and a significant downward trend with rates between −3 and 1 mm/year in the northwestern part of TP during the period from 1982 to 2018. Please refer to lines 41 to 44 in the manuscript for details.