Response to Ren Wang

essd-2023-495

Title: Satellite-based Near-Real-Time Global Daily Terrestrial Evapotranspiration Estimates

Author(s): Lei Huang et al.

MS type: Data description paper

In the reply, the reviewers' comments are in *italics*, our response is in normal text, and quotes from the manuscript are in **blue**.

Comments to Huang et al. Satellite-based Near-Real-Time Global Daily Terrestrial Evapotranspiration Estimates

This manuscript aims to present a near-real-time global terrestrial evapotranspiration (ET) estimate by utilizing their previous developed VISEA algorithm, satellite observation, and ERA5-land reanalysis data. The development of a near-real-time ET product holds great significance for drought monitoring, water resources management, and climate change study. I am pleased to witness this progress, and I think the manuscript may have potential to be published in ESSD. However, there are several major concerns that the authors should further revise or clarify.

Major comments:

1. The authors essentially use an energy balance based approach to estimate ET,but they do not discuss the limitations of this methodology. In my experience, the EF/energy balance method may not perform well in the local winter season or at high latitudes (e.g., 60-90N) due to energy Although the authors only utilize ERA5-Land downward shortwave radiation values greater than 0, they do not discuss the difficulties and limitations of the methods. However, since the focus of the study in on daily-scale ET estimation, this issue remains relevant and requires further attention. If I am right, the resulting ET estimates in this study is a near-global ET product. In the northern hemisphere (60-90 N), the ET estimates may be unavailable or miss data for nearly half of the year.

Re: We acknowledge these limitations and have discussed their potential impact on our study results, and emphasized the uncertainties in evapotranspiration estimates at latitudes between 60°N and 90°N, especially during winter when surface evaporation from frozen surfaces is not adequately represented, at lines 677-688:

“Furthermore, the VISEA model exhibits a tendency to underestimate ET in colder regions within the 60°N to 90°N latitude range, such as the western territories of Canada. This underestimation is primarily due to the model's inability to incorporate evaporation from frozen surfaces into its ET calculations. These discrepancies arise from several factors: inaccuracies in the ERA5-Land shortwave radiation data (illustrated in Figure 3), the misapplication of the VI-Ts method (explained in Figure 4), and the uncertainties in daily net radiation (depicted in Figure 5). Designed to amalgamate bare soil and full vegetation coverage as depicted in Equation 1, the VISEA model encounters difficulties in accurately estimating ET at higher latitudes, especially in conditions of reduced solar radiation. These challenges are predominantly linked to the uncertainties associated with ERA5-Land shortwave radiation data, further compounded by increased cloudiness levels in these regions, as highlighted by Babar et al. (2019). Such uncertainties have a substantial impact on the model's performance at higher latitudes, affecting its reliability in these conditions.”

Despite these challenges, our analysis confirms the VISEA model's ability to provide valuable ET estimates during the growing season, evidenced by a high Nash-Sutcliffe efficiency (NSE) of 0.4 and a correlation coefficient (R) of 0.9 when compared against local measurements. These findings support the model's applicability for ET estimation in the 60°N to 90°N latitude range, highlighting its effectiveness and relevance during the vegetative growth period.”

2. The validation of the new product appears to be insufficient. I recommend adding regional average curves to compare their changes over time. Additionally, while Figure 8 presents the spatial distribution characteristics of the multi-year average, what about the extreme values (e.g., 5th and 95th percentiles)? Considering these products are averaged over different time periods, does it affects the comparison results? Clarifying these aspects will enhance the robustness of the validation.

Re: We have added the regional average curves to compare their changes *over time* at Figure 8 (i) and added the 5th and 95th percentiles of the ET data at lines 556-558:

“It also exhibits similar distributions to other ET products, both below the 5^{th} percentile (Figure S4) and above the 95^{th} percentile (Figure S5). “

And at lines 583-590:

” Regarding the inter-annual monthly variations, panel (i) shows the fluctuations in ET across different years for the analyzed ET products and precipitation data. The graph reveals a rhythmic pattern of ET across the years, VISEA with other ET products showed distinctive peaks and troughs that correspond to seasonal changes and inter-annual climate variability. The ET products' data exhibit a close alignment with the precipitation patterns reported by GPCC, highlighting the interconnectedness between ET and precipitation as climatic variables. Notably, FLUXCOM consistently presents higher ET estimations compared to the other products, and GLEAM's ET estimations are also slightly higher during the winter, indicating a trend of systematic overestimation in these products relative to the others in the dataset.”

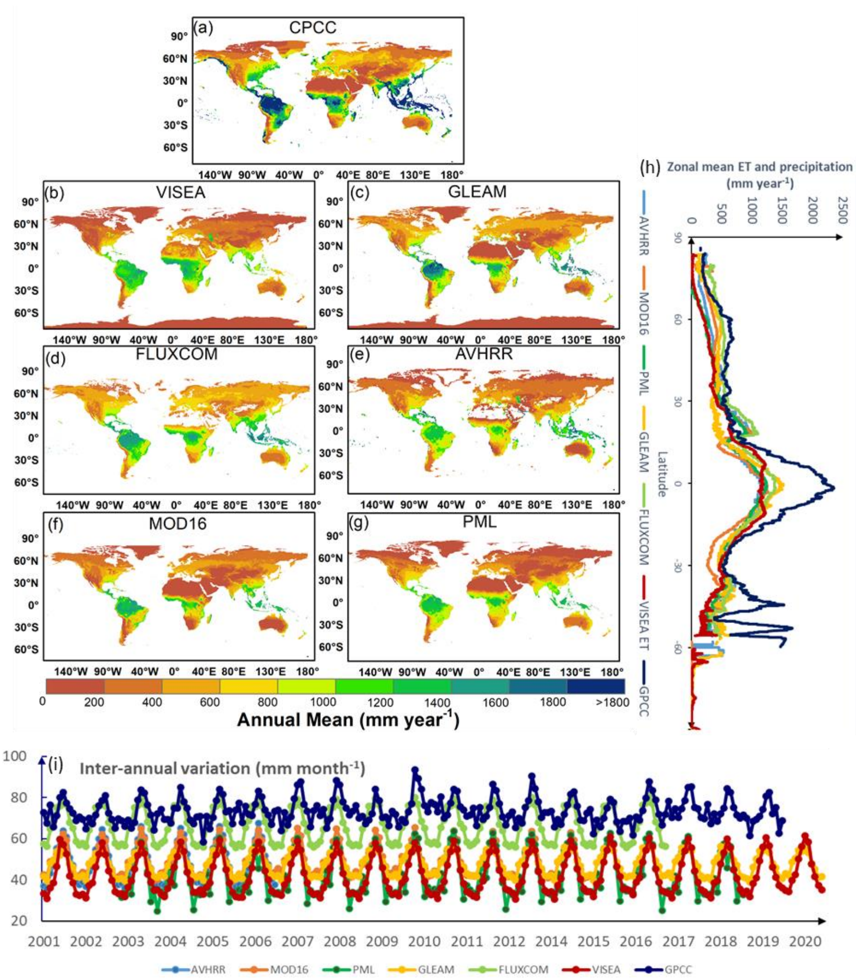

Figure 8. The spatial distribution of the multi-year average (a-g), the zonal mean (h) and inter-annual variation (i) of (a) GPCC (2001-2019), (b) VISEA (2001-2020), (c) GLEAM (2001-2020), (d) FLUXCOM (2001-2016), (e) AVHRR (2001-2006), (f) MOD16 (2001-2014) and (g) PML (2003-2018).

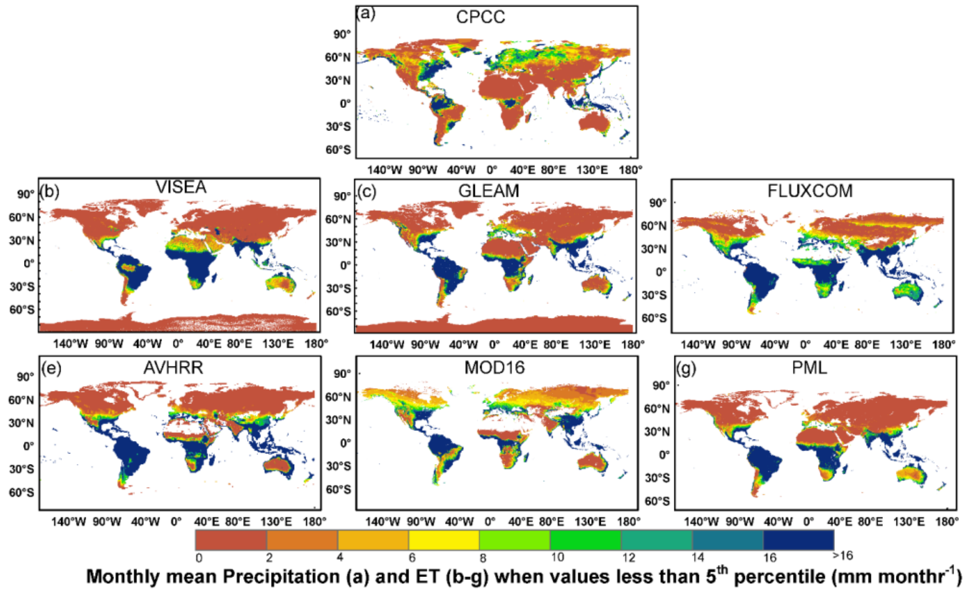

Figure S4. Monthly mean precipitation (a) and ET (b-g) when values less than 5th percentile (mm month^{-1}) (a) GPCC (2001-2019), (b) VISEA (2001-2020), (c) GLEAM (2001-2020), (d) FLUXCOM (2001-2016), (e) AVHRR (2001-2006), (f) MOD16 (2001-2014) and (g) PML (2003-2018).

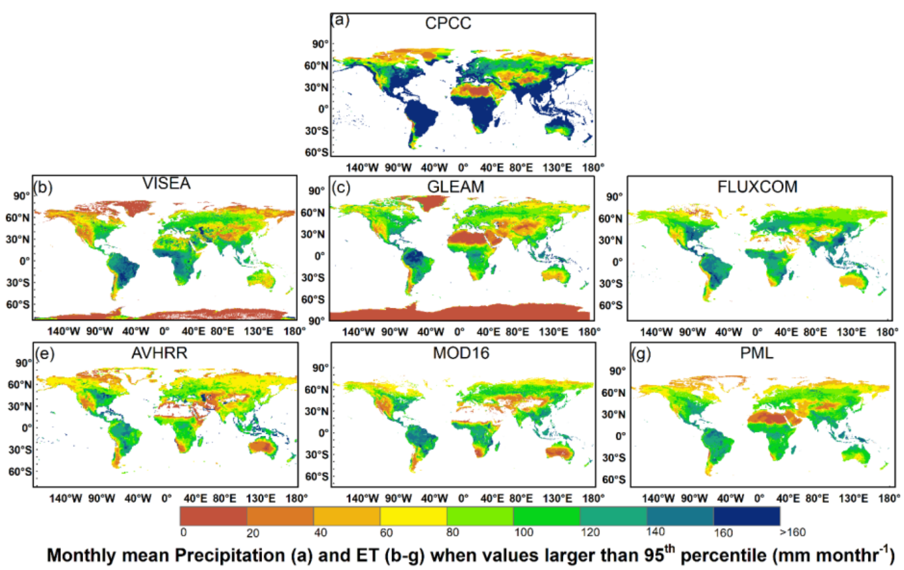

Figure S5. Monthly mean precipitation (a) and ET (b-g) when values large than 95th percentile (mm month^{-1}) (a) GPCC (2001-2019), (b) VISEA (2001-2020), (c) GLEAM (2001-2020), (d) FLUXCOM (2001-2016), (e) AVHRR (2001-2006), (f) MOD16 (2001-2014) and (g) PML (2003-2018).

3. The objective of this study is to provide a near-real-time global ET product, yet the methodology duplicates information from the authors' previously published paper (Huang et al., 2021, Earth and Space Science) (e.g., Figure1, the description of the VISEA model, and the decoupling parameter for daily EF). Therefore, it is very crucial to carefully address and further clarify the distinctions between these repeated details.

Re: we added the explanations of the differences between the algorithm from 2021 at lines 197-200:

"…different from the former study provided by Huang et al., (2023), which set we ε_s^d and ε_a^d equal, we calculated the ε_a^d by Appendix B flowing study of Brutsaert, (1975) and Wang and Dickinson(2013), ε_s^d can be retried by MOD11C1; σ is the Stefan-Boltzmann constant; T_a^d is the daily near surface air temperature (K); T_s^d is the daily surface temperature (K). We account for the influence of clouds by assuming a linear correlation between downward longwave radiation and cloud coverage in the calculation of downwards longwave radiation based on the study of Huang et al., (2021)."

Minor comments:

1. The near-real-time ET proposed in this study primarily relies on MODIS Land product at 05 degrees and ERA5 data at 0.1 degrees. Shouldn't the ET products should be limited to a relatively coarse resolution of 0.1 degree?

Re: we have included a discussion in our manuscript at Lines 401-408:

"Our local scale evaluation, as demonstrated in Figure 3, supports our stance that this resolution disparity between MODIS Land product at 05 degrees and ERA5 data at 0.1 degrees minimally impacts the final ET product's accuracy. This approach is consistent with the methodologies adopted in the studies by Huang et al. (2017, 2021, 2023), which effectively utilized MODIS land products at a 0.05-degree resolution in conjunction with downward shortwave radiation data at a 0.1-degree resolution from the China Meteorology Forcing Dataset. Such precedents underscore the feasibility of integrating these resolutions for ET estimation, bolstering our confidence in the methodological integrity of our study despite the noted resolution differences."

2. Regarding Figure 3, it would be beneficial to include the level of significance of the correlation analysis.

Re: We added the significance of the correlation in Figure 3. Specifically, we annotated the figure to indicate that all Rd values derived from ERA5 exhibit very low P-values (<0.01). At lines 387-388:
"This indicates a statistically significant correlation between the input shortwave radiation from ERA5 and the local measurements."

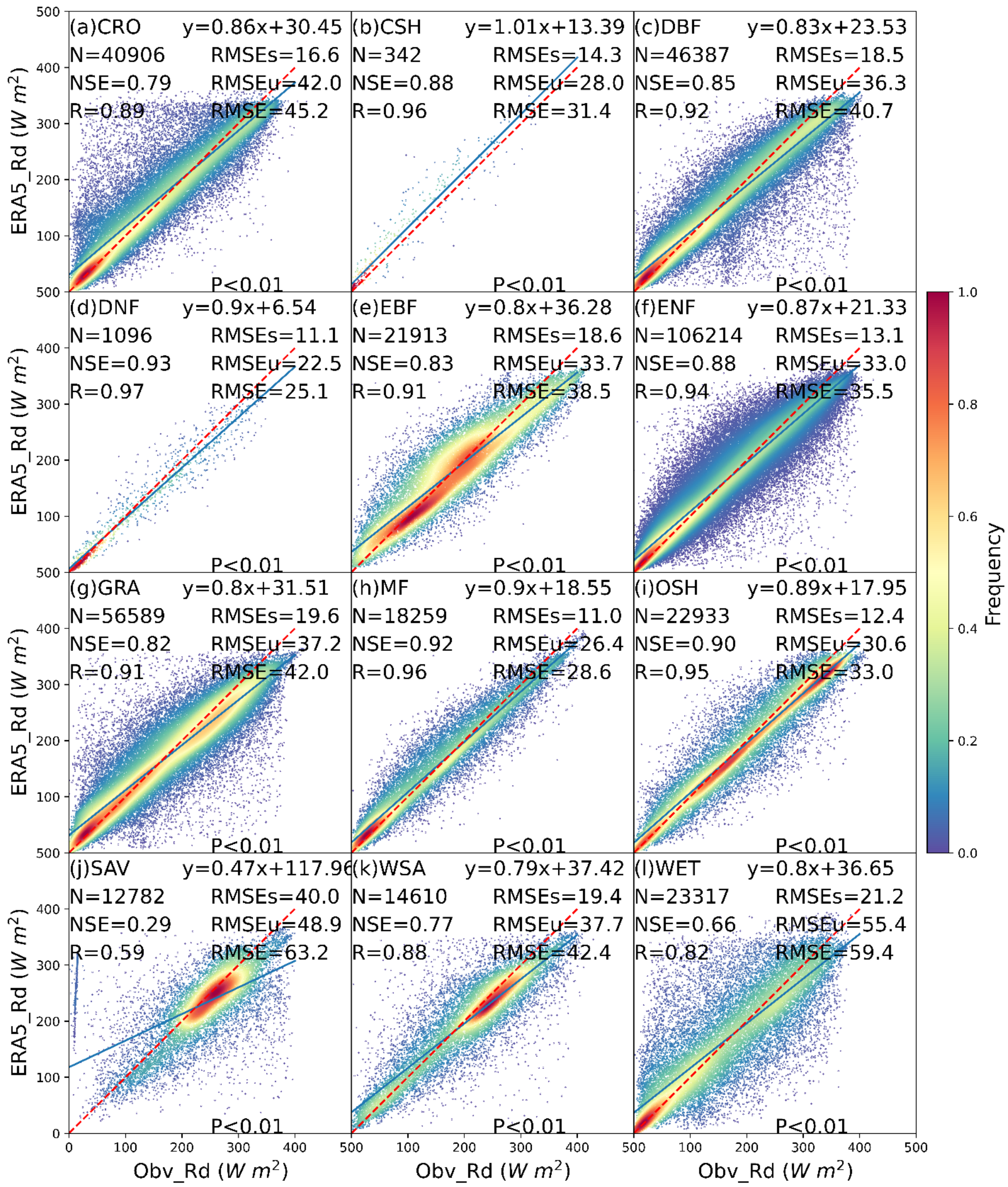

Figure 3. The scatter plot of downward solar radiation from ERA5-Land (ERA5_Rd) compared with local instruments measurements (Obv_Rd) under 12 IGBP land cover types: CRO (Croplands), CSH (Closed

shrublands), DBF (Deciduous broadleaf forests), DNF (Deciduous needle leaf forests), EBF (Evergreen broadleaf forests), ENF (Evergreen needle leaf forests), GRA (Grasslands), MF (Mixed forests), OSH (Open shrublands), SAV (Savannas), WSA (Woody savannas), WET (Permanent wetlands). The red dotted line is the 1:1 line. N is the number of data points, NSE is Nash-Sutcliffe Efficiency, R is correlation coefficients, RMSE is Root Mean Square Error, RMSEs is systematic RMSE, and RMSEu is unsystematic RMSE. The Frequency denotes the probability density estimated through the KDE method with a Gaussian kernel, and it is then scaled to ensure that the maximum value of the probability density function equals 1. P is the P-Value for the Correlation Coefficient.

3. Table 3: Why does the VISEA exhibit greater bias than other ET products in several vegetation types, such as CRO, DNF, ENF, GRA? These vegetation types are the main types on the land surface. Further clarification on the reasons for this discrepancy would enhance the interpretation of the results.

Re: We added the explanation of the greater bias in CRO, DNF, ENF, GRA at lines 636-666:

"Incoming shortwave radiation from ERA5-Land is employed to derive the available energy for vegetation coverage and bare soil (Eq. 14 and 15), which are the main parameters for calculating daily ET (Eq. 11). While ERA5-Land is widely utilized as a reanalysis dataset, offering near-real-time land variables by integrating model data with global observations based on physical laws. However, the accuracy of shortwave radiation from ERA5-Land seems compromised in savannas (Figure 3) due to the challenges associated with simulating radiation transmission under land-use changes and aerosol pollution from natural or anthropogenic sources.

Air temperature is an important parameter in determining the daily evaporation fraction of bare soil (Appendix B), canopy surface resistance, aerodynamic resistance of the bare soil (Appendix D) and atmospheric emissivity (Appendix E), available energy for vegetation coverage and bare soil (Eq. 14 and 15). Since air temperature is not measured directly by satellites, many other ET product use therefore ground observations, land model or reanalysis data. In contrast, VISEA derives the air temperature from the negative linear relationship between vegetation index (VI) and surface temperature (Ts) using the VI-Ts method (section 2.1.3). It gives very good results under grass land, open shrubland and woody savannas landcover types, as shown in Figure 4. As previously explained, the VI-Ts method relies on the negative linear correlation between the Vegetation Index (VI) and surface temperature (Ts) within a 5 × 5 grid. Therefore, both the variance of VI values across these grid cells and the negative correlation are essential for calculating the air temperature. However, in regions where the vegetation index and temperature data in adjacent grid cells show small variations, such as dense forests and bare lands and deserts. Also, in regions with freezing temperatures, the VI-T_S method does perform well, because warmer temperature is related to increased vegetation, opposite the other regions, where there is a negative.

Another bias source of the VISEA model is the uncertainties of daily net radiation, notably originating from input downward shortwave radiation from ERA5-Land (Figure 2) and VI-Ts estimated air temperature (Figure 4). The energy budget equation (Eq. 11) and these two figures indicate that net radiation shows more uncertainties than shortwave radiation and air temperature. At the same time, assuming a linear relationship between cloud coverage (Eq. 12 and 13) and the calculation of downwards longwave radiation (Eq. 14 and 15) may be an oversimplification that could introduce uncertainties. Since available energy for evapotranspiration (ET) depends on net radiation (Eq. 16 and 17), addressing these uncertainties is crucial for enhancing overall model accuracy (Brutsaert, 1975; Huang et al., 2023). Future refinements will contribute to a more precise daily net radiation estimation within the VISEA model."

4. Figure 8: Why VISEA presents an obvious higher ET values compared to other products in most tropical areas of South America and Africa?

Re: we have addressed this at lines 667-676, providing a detailed explanation for the higher ET values calculated by VISEA in tropical areas of South America and Africa.

"The VISEA model calculates ET primarily based on vegetation coverage, utilizing it as an indirect constraint to estimate evapotranspiration. However, this model does not directly incorporate variables related to water availability, which is a critical factor in ET processes. In tropical regions, where there is an abundance of solar radiation (available energy), the model tends to overestimate ET due to its emphasis on vegetation coverage without adequately accounting for the actual water available for evapotranspiration. This methodology, while effective in capturing the influence of vegetation on ET under varied conditions, can lead to overestimations in areas where energy availability significantly exceeds water availability, typical of many tropical regions. Our analysis and subsequent discussion aim to highlight this characteristic of the VISEA model, acknowledging its implications for ET estimations in such energy-rich, water-variable environments."

5. Section 2.1 should avoid repetition if the different modules and steps of these methods have been clearly described in previous published papers, ensuring that the current manuscript offers new and valuable information.

Re: We have transferred repeated equations (Eq. 2,3, 6-8 and 10-12) to the Appendix A (Eq. 2 and 3) and B (Eq. 6-8 and 10-12). However, we retained a selection of essential equations within the main text (Eq. 1, 4, 5, 9, 13-22). This approach is intended to facilitate a comprehensive understanding of the calculation process for readers who may not be familiar with our previous work, while simultaneously streamlining the manuscript to emphasize new and valuable insights.

6. Line 64: "these models often have limited spatial resolutions, making them less effective...", I do not think this is the truth. The ERA5 reanalysis, which combines climate model simulation and observational data, also produced latent heat flux (ET in energy units) with a delay of six days.

Re: we have rewritten this sentence at lines 64-70:

"While these models such as ERA5 reanalysis offer near-real-time latent heat flux (ET in energy units) with a delay of just six days, they typically feature coarser spatial resolutions, often 0.1 degrees or more. This level of resolution may limit their effectiveness for detailed assessments of drought conditions and the optimization of water resource allocation."

7. Line 65-68: It would be valuable to highlight the advantages of satellite remote sensing-based ET estimates compared to climate model simulation.

Re: we have highlighted the advantages of satellite remote sensing-based ET estimates compared to climate model simulation at lines 71-76:

"Satellite remote sensing-based ET estimates outperform climate model simulations by offering high spatial resolution for detailed water use analysis, near-real-time data for prompt environmental response, and global coverage for comprehensive water cycle studies. These estimates rely on direct observations, enhancing accuracy, especially where ground data are sparse, and allow for the dynamic monitoring of land and vegetation changes. This capability underscores their importance in water resource management and climate research, complementing the broader perspectives provided by climate models."

8. Did the authors perform energy closure correction or validation for the FLUXNET observational data?

Re: In our evaluation using FLUXNET observational data, we benefited from the extensive efforts of FLUXNET in addressing energy closure concerns. Specifically, the high-quality and gap-filling data from the 212 globally distributed flux towers. FLUXNET has implemented measures to perform energy closure corrections and validations to enhance the reliability of the observational data. For detailed information on these procedures, we refer to these publications: titled 'FLUXNET: A New Tool to Study the Temporal and Spatial Variability of Ecosystem-Scale Carbon Dioxide, Water Vapor, and Energy Flux Densities' (Baldocchi et al., 2001). And Pastorello, G., Trotta, C., Canfora, E. et al. The FLUXNET2015 dataset and the ONEFlux processing pipeline for eddy covariance data. Sci Data 7, 225 (2020). https://doi.org/10.1038/s41597-020-0534-3 and Wang, R., Li, L., Gentine, P., Zhang, Y., Chen, J., Chen, X., Chen, L., Ning, L., Yuan, L., and Lü, G.: Recent increase in the observation-derived land evapotranspiration due to global warming, Environ. Res. Lett., 17, 024020, https://doi.org/10.1088/1748-9326/ac4291, 2022.

We added the at lines 316-322

"In our evaluation using FLUXNET observational data, we leveraged FLUXNET's diligent efforts in addressing energy closure concerns. Specifically, FLUXNET has implemented rigorous measures for energy closure corrections and validations, thereby enhancing the reliability of the observational data from the 212 globally distributed flux towers (Pastorello et al., 2020; Baldocchi et al., 2001; Wang et al., 2022), We selected data spanning the period from 2001 to 2015 and excluded sites where ERA5-Land downward shortwave radiation was zero."

Here added the full reference:

Baldocchi, D., Falge, E., Gu, L., Olson, R., Hollinger, D., Running, S., Anthoni, P., Bernhofer, C., Davis, K., Evans, R., Fuentes, J., Goldstein, A., Katul, G., Law, B., Lee, X., Malhi, Y., Meyers, T., Munger, W., Oechel, W., U, K. T. P., Pilegaard, K., Schmid, H. P., Valentini, R., Verma, S., Vesala, T., Wilson, K., and Wofsy, S.: FLUXNET: A New Tool to Study the Temporal and Spatial Variability of Ecosystem-Scale Carbon Dioxide,

Water Vapor, and Energy Flux Densities, Bulletin of the American Meteorological Society, 82, 2415–2434, https://doi.org/10.1175/1520-0477(2001)082<2415:FANTTS>2.3.CO;2, 2001.

Pastorello, G., Trotta, C., Canfora, E., Chu, H., Christianson, D., Cheah, Y.-W., Poindexter, C., Chen, J., Elbashandy, A., Humphrey, M., Isaac, P., Polidori, D., Reichstein, M., Ribeca, A., van Ingen, C., Vuichard, N., Zhang, L., Amiro, B., Ammann, C., Arain, M. A., Ardö, J., Arkebauer, T., Arndt, S. K., Arriga, N., Aubinet, M., Aurela, M., Baldocchi, D., Barr, A., Beamesderfer, E., Marchesini, L. B., Bergeron, O., Beringer, J., Bernhofer, C., Berveiller, D., Billesbach, D., Black, T. A., Blanken, P. D., Bohrer, G., Boike, J., Bolstad, P. V., Bonal, D., Bonnefond, J.-M., Bowling, D. R., Bracho, R., Brodeur, J., Brümmer, C., Buchmann, N., Burban, B., Burns, S. P., Buysse, P., Cale, P., Cavagna, M., Cellier, P., Chen, S., Chini, I., Christensen, T. R., Cleverly, J., Collalti, A., Consalvo, C., Cook, B. D., Cook, D., Coursolle, C., Cremonese, E., Curtis, P. S., D'Andrea, E., da Rocha, H., Dai, X., Davis, K. J., Cinti, B. D., Grandcourt, A. de, Ligne, A. D., De Oliveira, R. C., Delpierre, N., Desai, A. R., Di Bella, C. M., Tommasi, P. di, Dolman, H., Domingo, F., Dong, G., Dore, S., Duce, P., Dufrêne, E., Dunn, A., Dušek, J., Eamus, D., Eichelmann, U., ElKhidir, H. A. M., Eugster, W., Ewenz, C. M., Ewers, B., Famulari, D., Fares, S., Feigenwinter, I., Feitz, A., Fensholt, R., Filippa, G., Fischer, M., Frank, J., Galvagno, M., et al.: The FLUXNET2015 dataset and the ONEFlux processing pipeline for eddy covariance data, Sci Data, 7, 225, https://doi.org/10.1038/s41597-020-0534-3, 2020.

Wang, L., Liu, H., Chen, D., Zhang, P., Leavitt, S., Liu, Y., Fang, C., Sun, C., Cai, Q., Gui, Z., Liang, B., Shi, L., Liu, F., Zheng, Y., and Grießinger, J.: The 1820s Marks a Shift to Hotter-Drier Summers in Western Europe Since 1360, Geophysical Research Letters, 49, e2022GL099692, https://doi.org/10.1029/2022GL099692, 2022.

9. Line 197: Is this the truth? It may be necessary to provide additional context or references to support the claim that the daily-scale G is approximately 0 and can be ignored.

Re: we have added the related references to support the claim that the daily-scale G is approximately 0 and can be ignored at lines 192-193:

"$G \approx 0$ on a daily basis (Fritschen and Gay, 1979; Nishida et al., 2003; Tang et al., 2009)"

Here added the full references:

Fritschen, L. J. and Gay, L. W.: Soil Heat Flux, in: Environmental Instrumentation, edited by: Fritschen, L. J. and Gay, L. W., Springer, New York, NY, 86–92, https://doi.org/10.1007/978-1-4612-6205-3_4, 1979.
Nishida, K., Nemani, R. R., Running, S. W., and Glassy, J. M.: An operational remote sensing algorithm of land surface evaporation, Journal of Geophysical Research: Atmospheres, 108, https://doi.org/10.1029/2002JD002062, 2003.
Tang, Q., Peterson, S., Cuenca, R. H., Hagimoto, Y., and Lettenmaier, D. P.: Satellite-based near-real-time estimation of irrigated crop water consumption, Journal of Geophysical Research: Atmospheres, 114, https://doi.org/10.1029/2008JD010854, 2009.

10. Considering the availability of more recent products, such as Jung's FLUXCOM (2019), and the potential impact of sensor developments, the choice of using older data sources, such as AVHRR (2001-2006), should be justified. Comparisons with older data may be influenced by advancements in sensor and computer technologies.

Re: we opted to use the FLUXCOM data instead of the older GBAF and the last update ET from GLEAM data (covering the period from 2001 to 2022), as depicted in Table 2. However, utilizing AVHRR data allows us to conduct meaningful comparisons between the ET calculated by MODIS and AVHRR data in a similar calculation progress. We believe this comparison will provide valuable insights into any differences influenced by sensor and technology advancements over time.

Table 2. The five global girded ET products and one precipitation product used for comparison with our near-real-time global daily terrestrial ET estimates.

Product name	Spatial/Temporal resolution	Time period	Theory
GLEAM	0.25°/Monthly	2001-2022	Priestly-Taylor Equation
FLUXCOM	0.5°/Monthly	2001-2016	Machine learning
MOD16	0.05°/Monthly	2001-2014	Penman-Monteith Equation
AVHRR	1°/Monthly	2001-2006	Improved Penman-Monteith Equation
PML	0.05°/8-day	2003-2018	Penman-Monteith Equation and a diagnostic biophysical model
GPCC	0.25°/Monthly	2001-2019	in-situ observations
GPC	0.5°/Daily	08/28/2022-09/01/2022	Global Unified Gauge-Based Analysis of Daily Precipitation

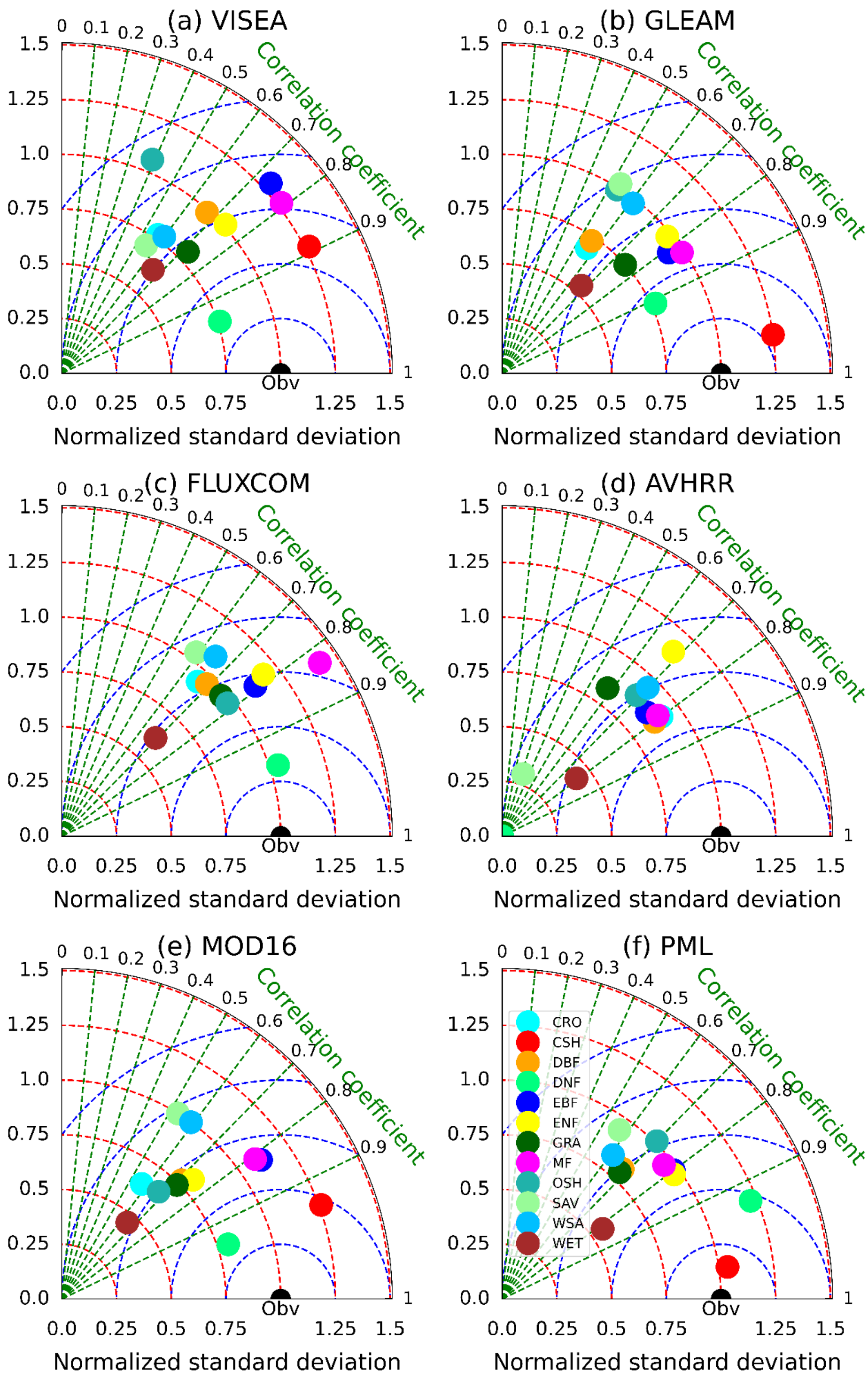

Figure 7. Taylor Diagrams comparing monthly measurements of (a) VISEA, GLEAM (b), FLUXCOM (c), AVHRR (d), MOD16 (e), and PML (f) with 150 flux towers (labeled as Obv) in different IGBP land cover types. The diagrams

display the Normalized Standard Deviation (represented by red circles), Correlation Coefficient (shown as green lines), and Centred Root-Mean-Square (depicted as blue circles).

11. Line 409: Please briefly explain the method used to estimate Rn in VISEA. I suspect it is fundamentally different from ERA5_Rd. Please clarify the purpose and significance of comparing these two variables.

Re: ERA5_Rd is the input data of VISEA which was used to calculate Rn. We have explained the method we used to calculated daily net radiation at lines 188-196:

"We used an improved daily available energy Q (W m^{-2}) method (Huang et al., 2023) for the vegetation and the bare soil surface is calculated by the energy balance equation:

$$R_n - G = Q \tag{10}$$

where R_n is the net radiation (W m^{-2}), which could be calculated by the land surface energy balance; G is the soil heat flux (W m^{-2}), G≈0 on a daily basis (Fritschen and Gay, 1979; Nishida et al., 2003; Tang et al., 2009),

$$R_n^d = \left(1 - albedo^d\right)R_d^d - \varepsilon_s^d \sigma {T_s^d}^4 + \left(1 + Cloud^d\right)\varepsilon_a^d \sigma\, {T_a^d}^4 \tag{11}$$

Where $albedo^d$ is the daily albedo of the soil surface; R_d^d is daily incoming shortwave radiation (W m^{-2}), obtained the ERA5_Land shortwave radiation (we called ERA5_Rd); ε_s^d and ε_a^d are the daily emissivity of land surface and atmosphere; different from the former study provided by Huang et al., (2021), which set we ε_s^d and ε_a^d equal, we calculated the ε_a^d by Appendix B flowing study of Brutsaert, (1975) and Wang and Dickinson(2013), ε_s^d can be retried by MOD11C1; σ is the Stefan-Boltzmann constant; T_a^d is the daily near surface air temperature (K); T_s^d is the daily surface temperature (K). "

12. Line 548: "actual ET measurement"?

Re: We have modified as "actual ET estimation" at lines 615-616

13. Line 605: Please why the VISEA approach performs better than other products at DNF? I am not sure, but the bias and RMSE values of VISEA at DNF are larger than other products (see Table 3)?

Re: we have rewritten this paragraph and explained the reason of the VISEA approach has higher bias and RMSE at DNF at lines 677-686:

“Furthermore, the VISEA model exhibits a tendency to underestimate ET in colder regions within the 60°N to 90°N latitude range, such as the western territories of Canada. This underestimation is primarily due to the model's inability to incorporate evaporation from frozen surfaces into its ET calculations. These discrepancies arise from several factors: inaccuracies in the ERA5-Land shortwave radiation data (illustrated in Figure 3), the misapplication of the VI-Ts method (explained in Figure 4), and the uncertainties in daily net radiation (depicted in Figure 5). Designed to amalgamate bare soil and full vegetation coverage as depicted in Equation 1, the VISEA model encounters difficulties in accurately estimating ET at higher latitudes, especially in conditions of reduced solar radiation. These challenges are predominantly linked to the uncertainties associated with ERA5-Land shortwave radiation data, further compounded by increased cloudiness levels in these regions, as highlighted by Babar et al. (2019). Such uncertainties have a substantial impact on the model's performance at higher latitudes, affecting its reliability in these conditions.”