Earth Syst. Sci. Data Discuss., community comment CC4
https://doi.org/10.5194/essd-2022-171-CC4, 2022

Reply on RC2

Yu Jiu Xiong

Community comment on "A global terrestrial evapotranspiration product based on the three-temperature model with fewer input parameters and no calibration requirement" by Leiyu Yu et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2022-171-CC4, 2022

We thank the reviewer for the positive evaluation and consideration that generating a global ET product is a much-needed idea. Although there are numerous ET products that have been rigorously evaluated, notable disagreement exists among these products, indicating that high uncertainties remain in ET estimates and products. One highlight of our study is that we retrieve a land ET product using a three-temperature model without resistance and parameter calibration, which is different from the available ET products generated by methods including Penman–Monteith equation-based and surface-energy-balance-residual-based methods. Our validation results indicated that the proposed ET product has reasonable accuracy. However, some misunderstandings occurred due to our unclear description; for example, validation of the ET product was verified at the daily scale under extreme conditions. Nonetheless, we further evaluated the ET product at 3-hour and daily scales in this revision as suggested. Please see the following point-by-point replies for details.

Responses to Comments 1:

The Köppen-Geiger climate regimes consist of 5 groups (equatorial, arid, warm temperate, snow, and polar), but they were subdivided into 31 climatic regions according to different conditions of precipitation and temperature (Kottek et al., 2006).

In fact, in our study, we further classified these 31 climatic regions of the Köppen-Geiger climate regimes into more detailed subregions via principal component analysis (PCA) and K-means clustering methods. Specifically, PCA was used to select major variables to describe regional characteristics from meteorological factors (i.e., net radiation, air temperature, humidity, wind speed, precipitation, and air pressure) and land surface conditions (i.e., albedo, land surface temperature, NDVI, soil moisture, and soil temperature). Thereafter, these variables were used to classify the 31 climate regions through the K-means clustering method. Because of meteorological and land surface variations, the subregions varied from 90 to 110 in different months. As such, each classified subregion has an area of approximately 1.35×10^6 km^2 (considering 100 subregions) and may be good enough for the reference assumption of the 3T model at the global scale.

To test the impact of region size on the 3T model-based ET estimation, we performed a comparison under two different classification methods with different subregions and sizes. In the first method, Köppen-Geiger climate regimes with 31 subregions were used, whereas detailed subregions with numbers of 90-110 were adopted as the second method. The daily ET estimates in 2011 were used as examples. In general, the two groups of daily ET estimates showed little difference, with mean values of 47 and 42 W m^{-2}, respectively, and were close to the EC observation, with RMSE values of 32 and 33 W m^{-2} (see Figures R1a and R1b in the attachment). At the yearly scale, however, the 3T model-based ET estimates from 90-110 subregions were much closer to the water balance ET than those estimates from 31 subregions (see Figures R1c and R1d in the attachment). The results indicate that the smaller the region where the reference parameters were obtained, the more accurate the 3T model, which is consistent with our previous findings (Xiong et al., 2015, 2019). The uncertainty of the 3T model at the global scale caused by region size will be incorporated into the revised manuscript.

Reference:

Kottek, M., Grieser, J., Beck, C., Rudolf, B., and Rubel, F.: World map of the Köppen-Geiger climate classification updated, Meteorol. Z., 15, 259-263, https://doi.org/10.1127/0941-2948/2006/0130, 2006.

Xiong, Y. J., Zhao, S. H., Tian, F., and Qiu, G. Y.: An evapotranspiration product for arid regions based on the three-temperature model and thermal remote sensing, J. Hydrol., 530, 392-404, https://doi.org/10.1016/j.jhydrol.2015.09.050, 2015.

Xiong, Y. J., Zhao, W. L., Wang, P., Paw U, K. T., and Qiu, G. Y.: Simple and applicable method for estimating evapotranspiration and its components in arid regions, J. Geophys. Res.: Atmos., 124, 9963-9982, https://doi.org/10.1029/2019JD030774, 2019.

Responses to Comments 2:

In fact, validation of the 3T model is performed not only at a monthly scale but also at a daily scale. In particular, the discussion that the 3T model-based ET product could accurately capture the low ET values under extreme conditions in section 4.2 used daily ET estimates. We apologize for our unclear description.

We further tested the performance of the 3T model with all daily EC observations (because the results in section 4.2 only contain extreme conditions). The results showed that the 3T model-based ET estimates agreed well with the observations (N=294058), with an RMSE of 33 W m^{-2} (or 1.1 mm day^{-1}) (see Figure R2a in the attachment), which was also comparable to other ET products, such as GLDAS (RMSE: 32 W m^{-2} or 1.1 mm day^{-1}) (this study), PML (RMSE: 0.7 mm day^{-1}) (Zhang et al., 2021), and SEBS (RMSE: 1.6 mm day^{-1}) (Chen et al., 2021).

At a 3-hour temporal scale, the data are too large to perform an entire comparison at a global scale. Moreover, as you may know, high temporal data even at the daily scale, especially remote sensing data, may encounter missing values for several reasons, such as clouds and precipitation (the MODIS land surface temperature product is a good example), which complicates the comparison and contains more uncertainty. In fact, the performance of the 3T model over a short period of time (30 minutes to 1 hour) has been tested at the point scale, and the results from both our studies (Qiu and Zhao, 2010; Tian et al., 2014; Qiu et al., 2015; Xiong et al., 2019) and others (Zhou et al., 2014; Zhang et al., 2020) show that the 3T model generally performed well. Nonetheless, we further tested the performance of the 3T model at the 3-hour scale across the world using EC observations in 2011 (6278 data points) (Figure R3a). Data were selected from the 15th day of each month in 2011. Although the RMSE (74 W m^{-2}) was slightly greater than that at the daily scale compared to the EC observations (see Figure R3a in the attachment), the 3T model-based ET estimates at the 3-hour scale agreed well with the GLDAS ET, with an r of 0.89 and RMSE of 21 W m^{-2} (see Figure R3b in the attachment).

These results indicate that the 3T model is robust at different temporal scales. These results will be incorporated into the revised manuscript.

Reference:

Chen, X., Su, Z., Ma, Y., Trigo, I., and Gentine, P.: Remote Sensing of Global Daily Evapotranspiration based on a Surface Energy Balance Method and Reanalysis Data, J. Geophys. Res.: Atmos., 126, e2020JD032873, https://doi.org/10.1029/2020JD032873, 2021.

Qiu, G. Y. and Zhao, M.: Remotely monitoring evaporation rate and soil water status using thermal imaging and "three-temperatures model (3T Model)" under field-scale conditions, J. Environ. Monit., 12, 716-723, https://doi.org/10.1039/B919887C, 2010.

Qiu, G. Y., Li, C., and Yan, C.: Characteristics of soil evaporation, plant transpiration and water budget of Nitraria dune in the arid Northwest China, Agric. For. Meteorol., 203, 107-117, https://doi.org/10.1016/j.agrformet.2015.01.006, 2015.

Tian, F., Qiu, G. Y., Lü, Y., Yang, Y., and Xiong, Y.: Use of high-resolution thermal infrared remote sensing and "three-temperature model" for transpiration monitoring in arid inland river catchment, J. Hydrol., 515, 307-315, https://doi.org/10.1016/j.jhydrol.2014.04.056, 2014.

Xiong, Y. J., Zhao, W. L., Wang, P., Paw U, K. T., and Qiu, G. Y.: Simple and applicable method for estimating evapotranspiration and its components in arid regions, J. Geophys. Res.: Atmos., 124, 9963-9982, https://doi.org/10.1029/2019JD030774, 2019.

Zhang, Y., Kong, D., Gan, R., Chiew, F. H., McVicar, T. R., Zhang, Q., and Yang, Y.: Coupled estimation of 500 m and 8-day resolution global evapotranspiration and gross primary production in 2002–2017, Remote Sens. Environ., 222, 165-182, https://doi.org/10.1016/j.rse.2018.12.031, 2019.

Zhang, Y., Qin, H., Zhang, J., and Hu, Y.: An in-situ measurement method of evapotranspiration from typical LID facilities based on the three-temperature model, J. Hydrol., 588, 125105, https://doi.org/10.1016/j.jhydrol.2020.125105, 2020.

Zhou, X., Bi, S., Yang, Y., Tian, F., and Ren, D.: Comparison of ET estimations by the three-temperature model, SEBAL model and eddy covariance observations, J. Hydrol., 519, 769-776, https://doi.org/10.1016/j.jhydrol.2014.08.004, 2014.

Responses to Comments 3:

In fact, the water balance ET was independent of the estimates from the 3T model because inputs of the 3T model only consist of net radiation (R_n), air temperature (T_a), and land surface temperature (LST) from GLDAS forcing data. Precipitation is not required in the inputs of the 3T model. Therefore, consistency between GLDAS precipitation and GPCC precipitation is unnecessary.

We agree with the comment that the performance of the 3T model should be tested at the interannual scale to enhance its robustness. We selected 10 EC sites covering different biomes across the world to test the interannual variability of the 3T model-based ET estimates at a daily scale. The variations in the 3T product generally fit the observation (see Figure R2 in the attachment). We also compared multiyear (2003–2013) mean monthly ET values between several ET products, and the results further indicate that the interannual variability of the 3T model was similar to the other ET products (see Figure R4 in the attachment). These results will be incorporated into the revised manuscript.

Please also note the supplement to this comment:
https://essd.copernicus.org/preprints/essd-2022-171/essd-2022-171-CC4-supplement.pdf