Dear Reviewer,

We would like to thank the reviewer for the constructive feedback. We provide our response below each comment in green font.

The article describes the procedure to develop the new ET product of the Copernicus Land Monitoring Service (CLMS), which is currently missing. The description of data inputs and the modeling chain are well described, but several points need to be addressed before the paper can be accepted.

Developing a global, operational product is constrained by certain programmatic, financial and technical limitations. The CLMS products are designed for long-term continuity and are paid for by the European Commission therefore issues like compute efficiency, data storage and dissemination costs or long-term availability of sources of core input data need to be considered. Taking those constraints into account, and in order to satisfy wide range of potential users needs and for consistency with other global CLMS products, the European Commission set the requirements for the CLMS ETa product, as well as its partitioning between soil evaporation and canopy transpiration, of a spatial resolution of 300 m and a dekadal temporal resolution and data availability in near-real-time (NRT). Other product requirements are shown in Table 1. Those requirements in turn impact the design choices presented in this study for the first version of the CLMS ETa product.

A similar clarification will be added to the Introduction (inserted around line 47) of the updated manuscript. However, despite those constraints we believe that the study adds to the scientific understanding of challenges and solutions applicable to global modelling of evapotranspiration.

We provide more details at the specific points below.

Comments

1. In the abstract the main innovation could be more explicitly included
   Thank you for the suggestion, we will modify the abstract to better highlight the main innovation which is the development of global, operational and near-real-time ET product.

2. Temporal and spatial resolution: 300 m is not the original resolution of either the vegetation and the land surface temperature products. 10 days of temporal resolution is probably not enough to capture the variations of ET, especially in agricultural areas or for water management applications, as the authors state. If daily meteorological forcings are available, with the gap filling technique described in the paper, an almost daily product cloud be produced. A detailed explanation of these aspects is needed to identify the weakness of the

product.

As described in the introduction, the 300 m spatial resolution and 10-day temporal resolution are based on cost-benefit analysis conducted by European Comission when deriving requirements of the product and they are the constraints within which we conducted this study. However, a couple of points can be highlighted:

- 300 m is indeed the spatial resolution of the Sentinel-3 OLCI sensor and therefore the vegetation products.
- 10 day temporal resolution of the FAO's WaPOR product has been successfully used in multiple studies to assess the variations of ET in agricultural areas and water management.
- The manuscript describes the design of a global product which aims to have long-term continuity. Increasing the spatial or temporal resolutions would have an impact on the data storage and distribution costs.
- Despite of the above, and in accordance with the European Commission requirements, daily heat flux dataset (instantaneous sensible and latent heat fluxes at the satellite overpass time) derived with TSEB-PT model will be distributed as part of the CLMS ET product. We will add this clarification to Section 1.

3. The choice of the two models (TSEB-PT and ETLook) should be better justified. Both models are based on the energy balance, limiting the strength of the analyses. The research community have developed and compared many models based on different approaches (energy balance, water balance, machine learning ...) agreeing that it doesn't exist a model that clearly outperforms all the others (like the OpenET approach). A clear justification from a methodological, hypotheses and inputs data analyses is missing, when the selection of only these two models has been done.

   For the justification of the selection of the two models, please see the reply to comment number 8. However, we believe that even with the selection of just the two models there is a clear scientific interest in exploring the selection and pre-processing of the various input data as the same inputs can be used in the other models. This is especially relevant since the pre-processing methods are publicly available as open-source Python packages (see Code Availability section). Similarly, looking at the individual and ensemble outputs of just those two models can lead to improved scientific understanding of the models themselves, but also to potential improvements in overall modelling of land surface water and energy fluxes.

4. It's interesting to see that the ensemble approach outperforms each of the two models. But I think the authors should justify why not more ET models based on different assumptions could not create a more accurate ensemble ET.

We agree that, as a general rule, the more models included in the ensemble the more accurate the final output will be as well as a better understanding of the model uncertainties. For the justification of the selection of the two models, please see the reply to comment number 8. Introduction of more models increases the costs of both computing and data storage and dissemination (both the individual model outputs and the ensemble will be distributed to the users). Therefore, for this first version of CLMS ET product only two models are used in the ensemble. If users and studies show clear benefit of additional models, then the European Commission might be more inclined to increase the ensemble model size in potential future evolution of this product. This is also the hope of the authors.

5. Lines52-55: actually there are many other models available in literature. A more comprehensive analysis should be done, especially many models have higher temporal resolution.
   We should have been clearer here. The short review does not focus on available ET models, of which there are many, but on ET datasets which are currently produced operationally (i.e. at regular intervals, using well established models and validated outputs, etc.) with global coverage and in near-real-time. We will update line 51-52 to the following:
   "..., global ETa datasets that are currently produced operationally and updated in NRT with closest..."

6. Line 59: ETmonitor is operational
   We agree that ETMonitor is an operational modelling approach. However, the dataset finishes in 2021 so it is not produced in near-real-time. We will modify the end of this line to read "...or are not produced in NRT (e.g. ETMonitor - Zheng et al. (2022))."

7. Line 60: who decided and why only two models should be considered?
   The decision was made by the European Commission. Please see the reply to comment number 8.

8. I suggest adding a section describing the proper selection of only two models based on the energy balance approach
   We will modify the paragraph on lines 60-65 to the following:
   Preparatory activities conducted by European Commission to develop an operational CLMS ETa product recommended that two ET modelling frameworks should be further investigated. The first one is the Sen-ET framework (Guzinski et al., 2020, 2021) developed to model ETa with Copernicus data at various spatial scales and using the Two-Source Energy Balance Priestley-Taylor (TSEB-PT) ET model (Norman et al., 1995; Kustas and Norman, 1999; Anderson et al., 2024). The second is the WaPOR framework (FRAME Consortium & FAO,

2024) developed by FAO through the WaPOR project and using the ETLook ETa model (Bastiaanssen et al., 2012). Both models, although conceptually different, estimate evaporation and transpiration and use LST as one of core input forcings. This recommendation was mainly based on the availability of mature open-source implementations of the two ET models, on previous studies demonstrating the applicability of both models with Copernicus data sources (i.e. Sentinel-3 imagery and meteorological data from European Center for Medium Range Weather Forecasts) (Guzinski et al., 2025) and on FAO's familiarity with both approaches. This does not imply that those two modelling frameworks clearly outperform all other approaches and indeed it has been shown that the performance of an individual model depends on the landcover and climatic conditions (Reitz et al, 2025). However, due to constraints on developing a publicly funded global and operational dataset (outlined previously) there was a need to limit the design of the first version of the CLMS ETa product to those two frameworks.

References

1. Guzinski, R., Nieto, H., Sandholt, I., and Karamitilios, G. (2020). Modelling High-Resolution Actual Evapotranspiration through Sentinel-2 and Sentinel-3 Data Fusion. Remote Sensing 12, 1433. https://doi.org/10.3390/rs12091433.

2. Guzinski, R., Nieto, H., Sánchez, J.M., López-Urrea, R., Boujnah, D.M., and Boulet, G. (2021). Utility of Copernicus-Based Inputs for Actual Evapotranspiration Modeling in Support of Sustainable Water Use in Agriculture. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 14, 11466–11484. https://doi.org/10.1109/JSTARS.2021.3122573.

3. Norman, J.M., Kustas, W.P., and Humes, K.S. (1995). Source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface temperature. Agricultural and Forest Meteorology *77*, 263–293. https://doi.org/10.1016/0168-1923(95)02265-Y.

4. Kustas, W.P., and Norman, J.M. (1999). Evaluation of soil and vegetation heat flux predictions using a simple two-source model with radiometric temperatures for partial canopy cover. Agricultural and Forest Meteorology 94, 13–29. https://doi.org/10.1016/S0168-1923(99)00005-2.

5. FRAME Consortium & FAO: WaPOR methodology, https://github.com/un-fao/wapor-et-look/wiki, 2024.

6. Bastiaanssen, W.G.M., Cheema, M.J.M., Immerzeel, W.W., Miltenburg, I.J., and Pelgrum, H. (2012). Surface energy balance and actual evapotranspiration of the transboundary Indus Basin estimated from satellite measurements and the ETLook model. Water Resources Research 48. https://doi.org/10.1029/2011WR010482.

7. Reitz, M., Volk, J.M., Ott, T., Anderson, M., Senay, G.B., Melton, F., Kilic, A., Allen, R., Fisher, J.B., Ruhoff, A., et al. (2025). Performance Mapping and Weighting for the Evapotranspiration Models of the OpenET Ensemble. Water Resources Research 61, e2024WR038899. https://doi.org/10.1029/2024WR038899.

9. Line 188: please explain “that Ln is usually computed internally by each ET model”. How the models compute especially the incoming longwave radiation is important due to the high uncertainty. In addition, how emissivity is computed/measured?
In the TSEB-PT model, Ln is computed according to equation 2a from Kustas & Norman (1999) using CAMS surface_thermal_radiation_downwards field together with internally computed leaf and soil temperatures, constant emissivity values for the vegetation and soil (0.98 and 0.95 respectively) and effective leaf area index. WaPOR-ETLook estimates it following the FAO-56 approach and daily values of air temperature, vapour pressure and transmissivity (FRAME Consortium & FAO, 2024).
References:
1. Kustas, W.P., and Norman, J.M. (1999). Evaluation of soil and vegetation heat flux predictions using a simple two-source model with radiometric temperatures for partial canopy cover. Agricultural and Forest Meteorology 94, 13–29. https://doi.org/10.1016/S0168-1923(99)00005-2.
2. FRAME Consortium & FAO: WaPOR methodology, https://github.com/un-fao/wapor-et-look/wiki, 2024.

10. 12 how the aerodynamic resistances are computed?
We will edit lines 361-362 to read:
“…, $r_{a,S}$ and $r_{a,C}$ are aerodynamic resistances for heat turbulent transport for soil and canopy respectively calculated following (Allen, 1998) and adjusted for buoyancy using Monin-Obukhov similarity theory in unstable conditions, and r_S and ….”
Reference
Allen, R. G., ed.: Crop evapotranspiration: guidelines for computing crop water requirements, no. 56 in FAO irrigation and drainage paper, Food and Agriculture Organization of the United Nations, Rome, repr edn., ISBN 978-92-5-104219-9, 1998.

11. Equation 13.a add the reference of the soil resistance equation. A definition of the empirical parameters a,b,c, is missing. Are they defined with soil texture? Setop is a stress factor or soil moisture?
We will clarify the mentioned points by edition lines 363-368 to:
The resistance of soil to vapour transfer is calculated as

$r_S = b(S_e^{top})^c$

where b and c are soil resistance parameters set to constant values of 800 and -2.1 respectively and S_e^{top} is relative top-soil soil moisture (Camillo & Gurney, 1996].

The resistance of canopy to vapour transfer is affected by air temperature stress (St), vapour pressure stress (Sv), radiation stress (Sr) and root-zone soil moisture stress (Sm):

$$r_C = (\frac{r_{s,min}}{LAI_{eff}})(\frac{1}{S_t S_v S_r S_m})$$

where rs,min (s m–1) is the minimum stomatal resistance, LAIeff is effective leaf area index (Jarvis, 1976; Stewart, 1988).

References:

1. Camillo, P.J., and Gurney, R.J. (1986). A RESISTANCE PARAMETER FOR BARE-SOIL EVAPORATION MODELS: Soil Science 141, 95–105. https://doi.org/10.1097/00010694-198602000-00001.

2. Jarvis, P.G. (1976). The interpretation of the variations in leaf water potential and stomatal conductance found in canopies in the field. Phil. Trans. R. Soc. Lond. B 273, 593–610. https://doi.org/10.1098/rstb.1976.0035.

3. Stewart, J.B. (1988). Modelling surface conductance of pine forest. Agricultural and Forest Meteorology 43, 19–35. https://doi.org/10.1016/0168-1923(88)90003-2.

12. From figure10 and 11, it seems that the biggest errors are present in the forest areas, especially big differences between the two models are found in transpiration during summer time. Probably the parametrization of aerodynamic resistance is not proper for high vegetation. In addition, it always seems that ET from ETLook is always higher than TSEB-PT, leading to an ensemble which is an average of the two.

    It is indeed the case that largest differences are between the models is in the transpiration, which we highlight on lines 486-490. We will add a new sub-section to the discussion in which we will look at those differences in the context of the assumptions and limitations of each of the modelling approaches. It should also be noted that in the revised manuscript we will use updated parameterization of the two models which is expected to reduce the differences between them in the forests.

13. In general there is a long description of the errors between models/climatic conditions/vegetation, but a more detailed explanation of the models hypotheses on the obtained results is needed to understand the model accuracies.

    This is a valid suggestion and we will add a section in the discussion where we put the differences between the models in the context of their different assumptions and modelling approaches.

14. Line 509: The high errors in the cities should be better discussed, as both models don't have a specific module for the urban energy balance.
    It is correct that neither of the models can deal with ET estimation in urban areas, and we highlight this point on lines 498-501. We will mention it again here.

15. Figure13: the text in the figure is not readable
    Thank you for highlighting this, it will be corrected in the updated manuscript.

16. The use of weather forcings in respect to reanalyse data should be clearly defined, and a discussion on the possible loose of accuracy in the model ET estimates discussed.
    In section 4.3.3 and in particular in Figure 22 we show that the forecast CAMS weather forcing is suitable for a global ET product to be delivered with 1-2 days timeliness. Reanalysis (ERA-5) data does not meet this timeliness requirement and therefore comparison between ERA-5 and CAMS was not conducted as part of this study.