Savona, 7/7/2022

MS No.: hess-2021-632
Title: High resolution satellite products improve hydrological modeling in northern Italy

Dear editor and editorial support team of HESS,
We would like to thank you and the reviewers for the positive evaluation of the article we presented. Please find below our reply to address the four comments raised by Reviewer#1. We hope that the article is now suitable for publication.

1) Thank you for proving more information on how the GLEAM data were used. Still, I think more information needs to provided. Originally, I understood that the aET was used as assimilation dataset. Now, I can read that aET can be used as dynamic input to the model. Usually, aET is simulated dynamically by a hydrological model. How does the model use aET as input? Where is the water taken from? I can also read that PET is still used to estimated aET over lakes and reservoirs. This is all very vague. Please specify... Also the baseline and the GLEAM scenario perform very similar with respect to KGE in runoff. Does that mean that the simulated aET in the baseline model is very similar to the aET from GLEAM or is aET not important for runoff predictions?

Reply:
When provided as input such as from GLEAM, AET and PET are used in the same way as in the original formulation described by Silvestro et al. (2013), depending on the water availability. See also reply to question 4). In particular, the evaporative water demand is first taken from the canopy interception and then from the soil layer.
In response to the last point of the question we have also added in Sect. 4.1 “Average evaporation in 2017-2019 computed by Continuum for the Po basin is 950 mm/year and results 21% smaller than the GLEAM average of 1200 mm/year in the same time span.”

2) I would like to add to the authors second reply that snow depth and SM data may very well be used as calibration target. Correct, they are not input variables to a hydrological model, but we can use them as calibration targets and I am still wondering why the authors did not calibrate their model against all available variables and instead used them as assimilation variables? Here an example for using snow data in calibration: https://doi.org/10.1016/j.jhydrol.2021.126020 and also one example for SM data: https://doi.org/10.1029/2019WR026085

Reply:
We fully agree with the reviewer and did not mean in our previous response that snow depth and SM data could not be used for model calibration. Both assimilation and calibration can bring benefit to improving the model output. Parameter calibration is especially beneficial in the calibration period, while data assimilation enable model updating whenever new data is available, yet usually without changing the model parameters. In the experiment design of this research, snow depth data and SM data were chosen to be used as assimilation variables rather than for parameter calibration. We are confident that such choice does not decrease the scientific significance of our research.

3) There should be a discussion that puts some of the findings in perspective. For example, changing precip to SM2RAIN leads to a deterioration of KGE. Model parameters were obtained from a calibration against the radar/gauge precip dataset. IF the authors would calibrate against SM2RAIN the KGE results would likely be improved. The parameter set obtained from a calibration has to be used with caution when transferring it to another model, with e.g. different precip or PET inputs...

Reply:
We are surprised by this comment of the reviewer. We did perform the calibration suggested by the reviewer in his comment, using SM2RAIN as forcing input. That’s actually one of the key activities and it is mentioned in various parts of the article, even in the abstract. To make this clearer, we have made some minor changes towards the end of the Introduction section, which now reads “Further, we take the first steps towards hydrological modelling fully relying on satellite data, by calibrating and subsequently running the model using SM2RAIN satellite precipitation and GLEAM evaporation as forcing, and satellite-based estimates of river discharge as benchmark data for the calibration”. Interestingly, calibration against SM2RAIN did not improve KGE of the simulation forced by SM2RAIN. This is stated and then further commented in Sect. 4.3 “Results from simulation #2 forced by the same SM2RAIN and GLEAM used in the calibration shows the lowest performance among the three (mean *KGE*=0.07 over all 27 stations). Simulation #3 (EO PE, EO Q) gives satisfactory performance (mean *KGE*=0.10), relatively close to #1 (mean *KGE*=0.13), despite relying largely on satellite data.”.

4) How is PET calculated in the baseline model. The authors mentioned the hourly weather variables which are likely used here. Please add more details.

Reply:
Upon the reviewer’s comment we have added a reference to Silvestro et al. (2013) in Sect. 3.1, which describe in details the formulation used to compute the evaporation in the Continuum model. The new sentence reads “Evaporation is estimated through a bulk formulation by solving the mass and energy balance as described in Silvestro et al. (2013) and related appendix, though it can also be provided as input variable”.