Interactive comment on "SWAT-CUP for Calibration of Spatially Distributed Hydrological Processes and Ecosystem Services in a Vietnamese River Basin Using Remote Sensing" by Lan T. Ha et al.

Dear Anonymous Referee #1,

We thank the reviewer for these valuable comments. In the following discussion, we will provide responses to the comments point-to-point and adopt changes as suggested to the manuscript.

> *In this study, RS data and various data were used to calibrate SWAT ET and other water budget components.*
>
> *SWAT-CUP is a tool for automatic calibration of SWAT model. So the use of SWATCUP with RS data does not guarantee the publication of this manuscript. Thus authors need to modify introduction section to provide novelty of this manuscript. Lines 22-25 on Page 3 are not good enough as an objective of this study.*

[Response] We thank you for this comment. Remote Sensing (RS) estimates across a certain discrete space domain have often the same accuracy as in situ measurements. For this reason, RS could be used as a surrogate for time series of field data. The novelty of this work, is that SWAT can be calibrated with RS data instead of situ measurements, and it creates the opportunity to include actual ET data in a spatially distributed manner, hence for every HRU. The next contribution to international science is that a set of land-soil-vegetation parameters to assess different ecosystem services can be calibrated exploring the dataset of precipitation and ET. This has not done before, and creates the opportunity to calibrate eco-hydrological processes in ungauged basins, such as the Day Basin which is only a case study. As suggested by the reviewer, this section is revised to better demonstrate the objectives and novelty of the paper.

> *Lines 1-12 on Page 4, authors indicated surface runoff and baseflow were verified in this study, however, I cannot find the results/conclusion related with this. Instead of using "verified", either "calibrated" or "validated" is proper term.*

[Response] The calibration and validation was entirely based on spatially distribute ET and LAI data. This differs from the classical approach where flow is used to calibrate the hydrological system. It is as a matter of fact much richer to calibrate a spatially distribute hydrological model such as SWAT against spatially distributed data sets, rather than lumped data such as river flow. For these reasons, we believed "verification" is a suitable term since calibration/validation largely reflects the process of physically modification of model parameters, and indeed we did do this to get an appropriate ET and LAI value. The paragraph is revised to better echo the steps applied.

> *Lines 5-6 on Page 5, SWAT model has sub-daily, or hourly runoff module. Authors need a couple of sentences why 3-hourly data were integrated into daily time step data. This process will loss accuracies in SWAT estimation.*

[Response] SWAT has the ability to read rainfall in sub-daily timestep, but the objective of this application is related to the determination of eco-hydrological services. These type of services are usually evaluated on a monthly basis. Hence, there is no need for hourly data. In addition to that, the data requirements for example for air temperature, air humidity, wind speed and other input are available at daily time step only. We will included in an update version of the manuscript that the time integration is done within the water balance computations of SWAT. The model computes hydrological processes in smaller time steps then at which it is presented.

> *Lines 13 on Page 5, more detailed description of irrigation and SWAT ET optimization is needed.*

[Response] We have extended the description as suggested.

> *Line 17 on Page 5, total 7,909 HRUs were used. However, I am wondering the spatial resolution of land use and soil data are good enough to capture detailed land use boundaries and soil characteristics? In addition, land uses should not be divided by soil because rainfall falls on land flow through the land surface.*

[Response] The current hydrologic response unit (HRU) definition follows a classification of land uses, soils, and slopes within a subbasin based upon defined thresholds. This is a standard procedure being applied for more than 30 years. In this particular basin, 7909

HRUs were defined and with the total area of the basin at approximately 6300 km^2, the average HRU size is about 0.8 km^2. This standard method and our user-defined threshold for HRU discretization provides an efficient way to discretize this river basin into sufficient small units for simulation of the exuberant composition of bio-physical processes in the Day basin.

*Lines 7-20 on Page 7, the use of DEM with a spatial resolution of 30m, land use data with 300m * 300m are good enough to capture detailed land uses and topographic effects of each HRUs? Did author analyzed the effects of spatial resolution in capturing detailed topographic characteristics? If the agricultural field is less than 300m * 300m in size, we may have false LAI and thus ET estimation. I think cell size of land use is somewhat bigger to capture ET accurately.*

[Response] While the HRU approach provides a simple, computationally-efficient framework, the process of discretization of hydrological response units resulted in a lumped and disconnected HRU 'pixel'. This was mentioned in Gassman et al. (2007) and Douglas-Mankin et al. (2010) and it may create a false ET and LAI estimation in smallholder farmland. However, the Day Basin is located in the delta and has large-scale agricultural production, with rice as a monoculture crop. Hence, this impact is really minimized and the RS data used is acceptable.

Figure 5 on Page 11, authors indicated the ET, P-ET does not match during dry seasons. These mismatch water budget also, since model was not calibrated for flow since author assumed that ET estimation are good enough. In addition detailed description regarding "rating curves" is needed.

[Response] Given that actual ET (ET_{act}) estimation using satellite has progressed significantly in the past years, ET gave close-to-reality values. However, there is a need to locally assess ET_{act}. Simons et al. (2016) indicated that the performance of a certain ET_{act} algorithm is dependent on factors such as LULC type, climate and the presence of mountains, meaning that the accuracy of ET_{act} predictions will vary across the basin. An ensemble approach was taken toward generating "best-guess" maps of ET_{act} in the basin, under the assumption that spatial errors between related yet differing mapping

approaches will tend to cancel in the ensemble average. A superior performance of different ET_{act} ensemble products with respect to individual algorithms was previously observed for the Nile Basin (Hofste, 2014), where large scale water balances were available for validation.

The mismatch between ET, P-ET and discharge during dry seasons reflects the water storage mechanisms in the basin. Excessive water is stored during the high-flow season that become available for ET during the dry period.

We have revised this paragraph and provide further description in the “rating curve” part.

"Allen et al, (1998") need to be modified as "Allen et al. (1998)".

[Response] Noted and changed

Figure 6 on Page 12, The caption of Y2 axis is needed to be modified from “Total Rainfall (mm)” to “Total Precip. (mm)”. Also if authors look at the Figure 6, huge difference between blue and red lines are found.

[Response] We have corrected the language in the figure as suggested.

Figure 8 on Page 14, monthly average crop coefficient (Kc) were used in this study?

Any effects of different of water stress (or other stress) in crop growth? Various stresses are simulated in estimating crop growth in SWAT modeling.

[Response] Figure 8 is an outcome from Figure 7 where the ratio between Ensemble ET and Reference ET was displayed on monthly time steps. Other stress factors affecting vegetation growth in SWAT are not written to output files, and can therefore not be verified. By defining Kc as actual/reference ET, the stress conditions are encompassed. Within the scope of this work, we did not assess the impact of water stress in crop growth.

Line 13 on Page 15, For LAI simulation with SWAT, the monthly average data were used or monthly data were used in calibration period? No details were provided in this manuscript for this.

[Response] In our case, the monthly average was used. We have inserted further explanation into the manuscript as suggested.

Line 5 on Page 16, One single line does not explain what authors did for manuscript calibration of irrigation component.

[Response] Thank you for this comment. It was indeed incomplete and we will correct it in the manuscript.

Lines 20-23 on Page 16, various input parameters were calibrated and alpha factor was also calibrated for accurate estimation of baseflow recession.

[Response] ALPHA_BF and SCS curve number (CN2) were included in the calibration process so that the partitioning between infiltration and fast runoff can be modelled better. This was done on the basis of ET data, and more infiltration was created to meet the high ET rates on certain days. Hence ALPHA_BF and SCS do affect ET flux estimates.

So far, I was able to what authors did for this study. However, If I read through the "6. Results and discussion" section, I found additional "methodologies" were described in this section. Thus I recommend authors need to reorganize this manuscript so methodologies used in this study need to be described in "Methodology" section. Only research output need to be explained in "Results and discussion" section. For this, Flow chart will be helpful for potential readers of this manuscript to understand what author did.

[Response] We have edited the section on methodologies to be certain that all theories and approaches are mentioned in the right spot of the manuscript. We hope by improving these sections on "Methodologies" and "Results and discussion", the manuscript will be more readability and well understood.

On Page 20, it seems author computed Ensemble ET based on ET modules and assumed this is the "Observation" and calibrated the SWAT. However, computed ET, P-ET in Figure 5 during dry/wet seasons can cause mismatches in flow estimation also. Any effects of these discrepancies in ET?

[Response]. By excluding flow from the calibration, the ET simulation can be improved. This solution is better than optimizing model parameters on point-measurement from 2 discharge stations in the basin. That is in fact the clue of the paper. While Figure 5 displays a pre-analysis and instantaneous P-ET results, the major outcome as compared to the conclusions in Page 20 is the effect of more accurate local storage and plant/canopy capacities.

Line 11 on Page 21, I am wondering what author did not calibrate the flow because NSE for ET is only 0.5? There are various factors affecting flow and other hydrologic components. If one looks at Figure 13, we can see over/under estimation of discharge since not calibration was done.

[Response] Even though we did not calibrate the flow, we have included several parameters that drive the surface-subsurface flow generation process, i.e. ALPHA-BF, CN2. A calibration approach without flow measurement is actually the novelty of this work. Finally, we can now integrate the great capacity of SWAT with spatially distributed observations, albeit not from standard monitoring networks. This is a breakthrough for non-gauged and partially gauged basins.

Figure 14 on Page 25, SWAT LAI estimation ranged from 0-2 in general. However, the LAI estimation ranged from 0 to 3 using MODIS. Has crop growth module been calibrated well enough? Is the land use cell size too big to capture the crop?

[Response] The LAI simulation is SWAT is determined by several parameters, which were explained in Section 5. Among those optimized parameters, the parameter BLAI (maximum potential leaf area index) and ALAI-MIN (minimum leaf area index) determines the maximum and minimum LAI simulated. The range for LAI is between 0-2 is acceptable for paddy rice. We have tried to avoid any ambiguity by selecting the area

larger than land use pixel size (300m*300m) in the area. However, for field area smaller than the landuse pixel size, it will be difficult to simulate and distinguish LAI.

> *The manuscript contains too much information, I think it would be better for potential readers of this manuscript to understand what authors are trying to convey through this manuscript, if shortened.*

[Response] We will carefully edit the details in the revised manuscript to be as concise as possible. On the other hand, it describes advances in sciences that are relevant for (i) SWAT community and (ii) quantification of ecosystem services. Such relevant piece of work should be prepared comprehensively.

> *In conclusion section, I don't see what authors are trying to say based on "objective" of this study. The title and the contents of this manuscript does not match well.*

[Response] The updated version of the conclusions section better reflects the "objectives" of the study.

Reference:

Gassman, P.W.; Reyes, M.R.; Green, C.H.; Arnold, J.G. The soil and water assessment tool: Historical development, applications, and future research directions. Trans. ASABE 2007, 50, 1211–1250.

Douglas-Mankin, K.R.; Srinivasan, R.; Arnold, J.G. Soil and Water Assessment Tool (SWAT) model: Current developments and applications. Trans. ASABE 2010, 53, 1423–1431.

Hofste, R.W. Comparative Analysis among Near-Operational Evapotranspiration Products for the Nile Basin Based on Earth Observations; Delft University of Technology: Delft, The Netherlands, 2014.