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Hydrology and Earth System Sciences
Discussions

Interactive comment on "The effect of water storage change in ET estimation in humid catchments based on Budyko framework and water balance models" *by* Tingting Wang et al.

Tingting Wang et al.

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Response:

The language should be largely improved. There are many typos and grammatical errors throughout the text. But even more problematically, the wording is often awkward and difficult to understand, and I actually couldn't understand the exact meaning of several sentences. Some reviewers made valuable suggestions to improve this. However, I think the authors should also consider seeking the advice of a native or fluent English speaker, or possibly using some professional language services.

We feel terribly sorry for all the inconvenience we made here. We have sought help from a native speaker, who is a postdoctor in hydrology, to revise the manuscript. Much improvement has been made in the revised version. Hoping that this version is readable and interesting to you.

General comments

This study analyzes the effect of changes in water storage at annual and multi-annual timescales for humid catchments in China. The authors perform a quantitative comparison of evapotranspiration (ET) estimates from the water balance, Budyko's framework, and two other models. They show that it is erroneous to obtain annual ET estimates from the water balance when neglecting changes in storage. I find the approach interesting, but numerous points need to be addressed. Particularly, the quality of the text needs to be greatly improved before being able to thoroughly assess the scientific merit of the study.

Thank you for your invaluable comments/suggestions sincerely! Detailed point to point response is as below. It is worth mentioning that we have added the result about the effect of ΔS on annual ET estimation based on Budyko framework in section 3.3. It shows that almost no improvement has been made in annual ET estimation based on the extended Budyko equation (Figure 6), which uses P-ΔS as 'equivalent' precipitation at monthly timescale through high R2 achieved (Figures 5 and 6), which is due to the seasonal pattern within the year. This further supports our conclusion that the common practice of ignoring annual ΔS in water balance, can lead to larger deviation in estimated ET assessment in humid catchments. Without reliable ΔS, ET estimation in humid catchments remains an important scientific challenge.

<Figure 5> <Figure 6>

Specific comments

It is not right to assume the validity of Budyko for annual timescales. The sentence:

"Subsequently analysis on annual water-energy balance have proofed that the Fu's equation can be used in both long-term and annual water-energy balances in nonhumid catchments (Yang et al., 2007) and humid catchments as well (Tekleab et al., 2011; Xu et al., 2013)", is not accurate. Both Tekleab et al. (2011) and Xu et al. (2013), together with many other studies (e.g. Gentine et al. 2012; Roderick and Farquhar 2011) indicate that the validity of Budyko's framework requires steady-state conditions, which are generally achieved by using data at time scales significantly longer than 1 year.

We agree. The Budyko hypothesis can be well applied at steady state. But the problem here is that, vast research have shown that satisfactory results have achieved in annual ET estimation in arid and semiarid region when using Budyko equation and then validating against ETwb ($\Delta S \sim 0$). So attempts have been made to improve the modelling so as to meet this ETwb in humid region as well, which is not right based on our conclusion," ignoring the variation of annual ΔS increases the variability of real ET and leads to large deviation in modelled ET assessment in humid region." As for the introduction, we have rewritten this since many sentences are very confusing.

I think it would be better if the storyline focuses from the beginning on the issue of neglecting ΔS for ETwb.

Excellent advice to the point. Thank you. We have revised the introduction and results in our manuscript as suggest. We are inspired to present the result of the effect of ΔS on annual ET estimation based on the Budyko framework in section 4.3, to further prove that ignoring the variation of annual ΔS in ETwb leads to large deviation in modelled ET assessment in humid region.

The approach for analyzing the inter-annual variability of ET needs to be clearer (equations 8 and 9). Is the effect of ΔS not accounted for? I believe it would be better to not include this section in the paper, and consequently Figure 10b. The authors already convey your point about the higher variability of ETwb compared to the other estimates

of ET in Figure 10a. They could strengthen this argument by showing the histograms or pdfs of P, PET, and ET. It may be also possible to identify years with $\Delta S>0$, for which ETwb > PET. I would also recommend plotting the time series of PET in Figure 8.

Indeed. We have removed this part from the manuscript since they are less relevant to the results. We have added the time series of PET in Figure 9a.

Large differences are among the ranges of variabilities of P, PET, ETbudyko, and ETwb, neither the plot of their pdf nor the plot of cdf looks fine, we use Figure 11 instead. The cdf of PET, ETbudyko, and ETwb is as below,

<Figure 9 here> <Figure 11 here>

Section 4.1: It seems trivial to calibrate w with observed P, PET, and Q, and then compare to ETwb = P − Q. Is w calibrated for each catchment based on long-term mean annual P, PET, and Q? Do you have any arguments for the underestimation of ET estimates from the abcd model at multi-annual timescales (ETabcd)?

Thank you for your comments. The w is calibrated using annual P, PET and Qobs for each catchment, and we have lessen the related description, lines 251-254. The underestimation of multi-annual ETabcd, we think it is mainly due to the bias in calibrated runoff. On the other hand, the Budyko equation is the major approach we used here, and multi-annual ETabcd estimation is redundant , so we remove it from section 4.1.

Section 4.3.2: As I understand it, ETwb – ΔS better represents actual ET than ETwb. Therefore, I think it would be more intuitive to compare ETwb – ΔS with ETBudyko, rather than ETwb with ETBudyko + ΔS.

We have thought about it. But we insist that using ETwb would be better than ETwb – ΔS. Because P and Qobs are observed and reliable while ΔS is the model output, using ETwb – ΔS would be less accurate. On the other hand, when comparing ETwb with ETBudyko + ΔS, the ETwb is purely observed and reliable.

The text needs to be improved overall.

We have sought help from a native speaker. If further improvement is needed, we'll go to the professional language services for help.

Define what you mean by humid and non-humid catchment at the introduction. References for studies about non-humid catchments are not really accurate; data from these studies also include humid catchments. Missing reference to Greve et al. (2016) for studies considering ΔS.

We take catchments with aridity index (PET/P) <1 as humid catchment, and we have defined it in the introduction. We use arid and semiarid in most cases instead of non-humid to avoid such confusion. Some of cited reference are indeed containing both humid and arid, semiarid catchments, and we have revised this in our manuscript, e.g., lines 81$\sim$84. And the missing reference has been added in the introduction, sorry about this.

Caption of Figure 1: The aridity index should be < 1, instead of > 1.

Done, sorry about this mistake. Thank you.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/hess-2017-151/hess-2017-151-AC3-supplement.zip

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2017-151, 2017.

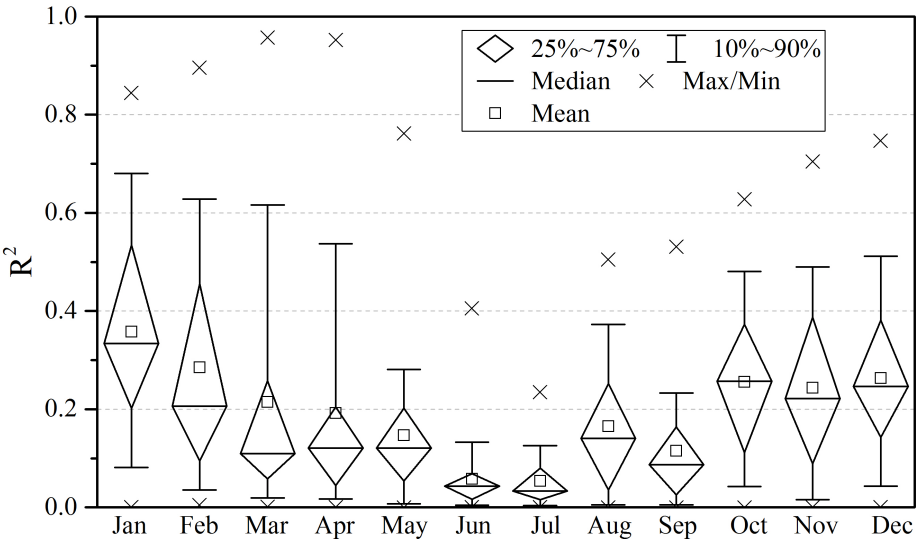

Fig. 1. Figure 5 The box plot of R2 between monthly ETwb and ETbudyko using the extended Budyko equation, i.e., P-ΔS as equivalent P, and ΔS is obtained from abcd model.

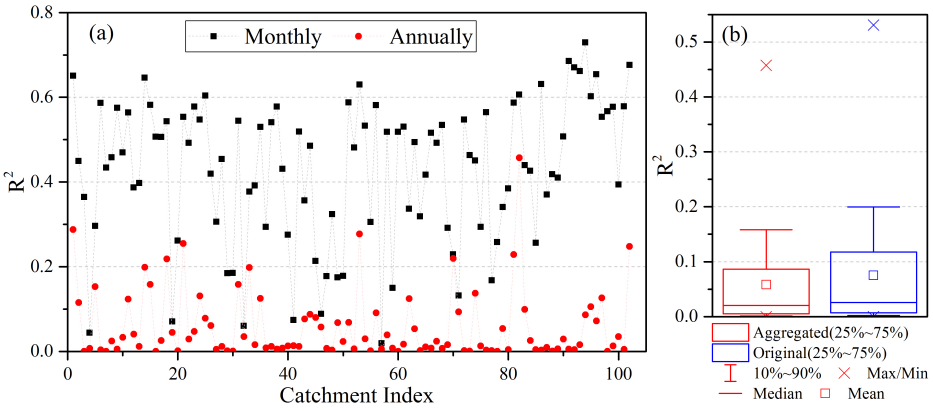

Fig. 2. Figure 6 The R2 between ETwb and ETBudyko at monthly timescale and that aggregated to annual timescale in (a), and (b) the boxplot of R2 of this aggregated annual ETbudyko and the original R2 of annua

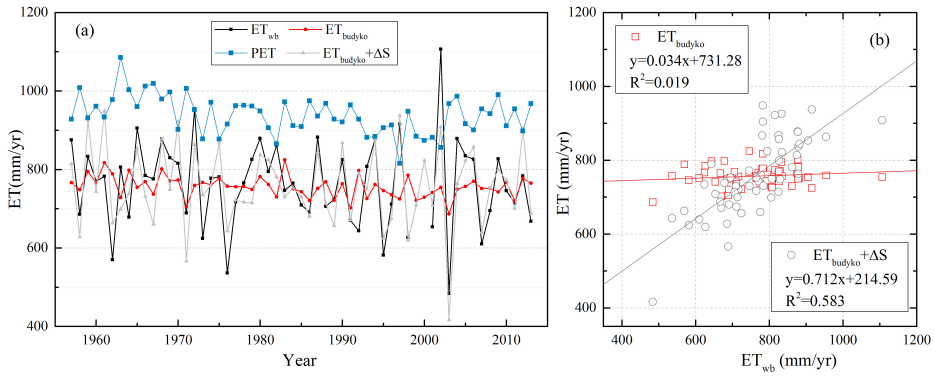

Fig. 3. Figure 9 The annual time series of PET, ETwb, ETbudyko and ETBudyko + ΔS over 1957-2013 for the selected typical catchment (a), and (b) the comparison between ETbudyko, ETBudyko + ΔS against ETwb in t

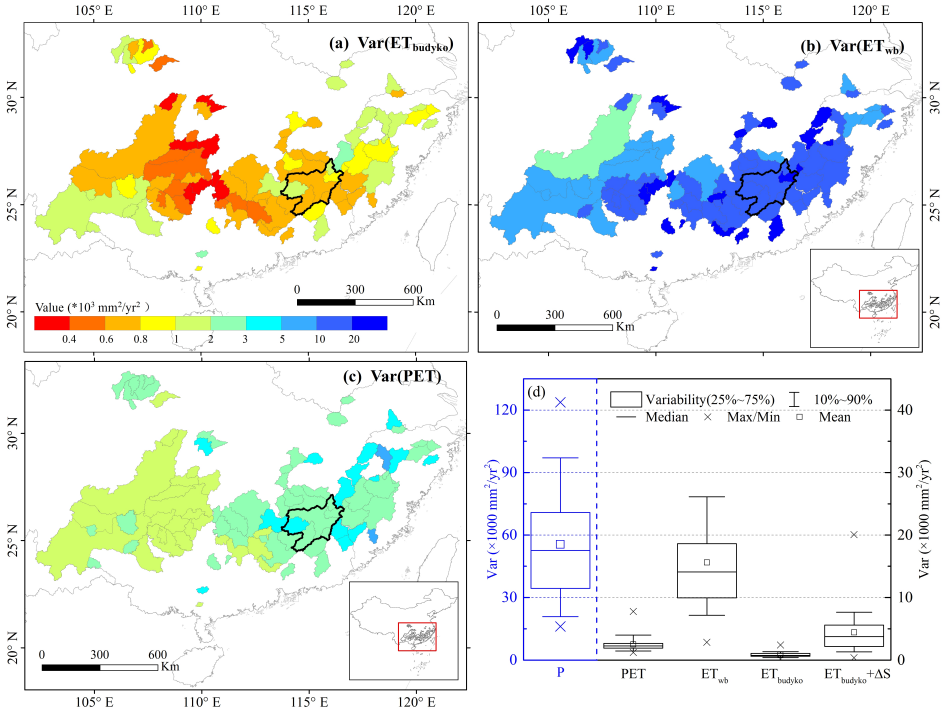

Fig. 4. Figure 11 The spatial distribution of variabilities of ETBudyko, ETwb and PET in humid catchments over China in (a), (b) and (c), respectively, and their statistics information accompanied by the vari