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Discussions

Interactive comment on "Towards understanding the mean annual water-energy balance equation based on an Ohms-type approach" *by* Xu Shan et al.

Xu Shan et al.

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Response to Anonymous Referee #2

The author try to present a study on explaining the Budyko-framework based on Ohm-slaw analogy. They use an interesting moisture recycling approach, that made me really enthousiastic in the beginning of the paper. However, the paper is so oddly written that I quickly was not able to understand it anymore. I am completely lost in equations that are not properly explained and the weird structure. Nowhere in the paper I see a justification that Ohms-law can be applied on catchment evaporation. Nowhere I see any validation of the study. Figures 3-5 might be the validation, but I have no clue what

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Discussion paper

I see here. What is ’x’? Nor is clear what this paper adds: what do the authors try to solve (i.e. knowledge gap is missing)? Where are the results? Are that the graphs in Section 4?!?. This section is also totally unclear. It seems partly an introduction, partly results... at least for sure no ’discussion’. So to conclude: I am not able to grasp the paper at all. Maybe the method is OK, but based on the weird manuscript structure, it is impossible to follow and to judge it. Please improve the structure and link more to the physical processes in hydrology (HESS is a hydrological journal). Additionally, the language can also be improved.

Response:

We really appreciate the reviewer taking time to review our manuscript and giving very important comments. At the same time, I want to say sorry for our carelessness that we forgot to update the order number of sections after removing Section 3 in the initial version. In this version, the result section is Section 2, i.e. Ohms-type approach. We will carefully check and do a throughout revision in the resubmission.

Regarding to “Ohms-law approach”, it was described as Equation (11), i.e. the flux can be estimated as the function of the potential difference and the resistance of the water vapor movement or transportation process. And we will add more explanations to our manuscript.

Regarding to the structure of this paper, we will add a chart to explain the physical variables used in this manuscript. In addition, the result of this manuscript

Regarding to the validation, our logic is that our derived formulation based on totally different derivation but converge to the widely-used MCY equation, and the MCY validated in many previous studies means that our result can be validated.

Further remarks:

P1 L10: "however, few hydrological processes were involved in the derivation". Is it? And are they included in your approach?

Response: I am sorry for our vague expression. Compared with purely mathematic transformation in previous studies, our derivation tried to reason it by using an Ohm-type approach based on the water transportation between catchments.

-P1 L13-17: ?? which new constraint? What is a generalized flux?

Response: The new constraint is 1/(f(E))=1/(f(E_0))+1/(f(P)), and the general flux is explained in Section 2, i.e. “the generalized flux is defined as the potential difference divided by the resistance and is a function of flux”.

-P1 L19: What is a homogeneity constraint?

Response: This constraint is explained in previous derivation Yang et al., 2008. i.e., the generalized function has the same form for both vapor transportation and chase transition, and in other words, precipitation and potential evaporation have an equalized effect on evaporation. We will add more explanation on it in the revised version.

-P2 L10-11: The ’d’ of derivative should not be italic. it’s not a parameter -P3 L6: Be consistent in capital and non-capital parameters (phi)

Response: I am sorry for our carelessness and thank you for your specific comments. And we will revise our manuscript.

-P3 L21: "accordingly". I don’t get how your objective links to the existing work. Please describe the knowledge gap and the relevance of your work.

Response: The knowledge gap is that previous derivations lack the hydrological meaning but be full of dimensional analysis and mathematical assumptions. That’s why we want to add more physical or hydrological meaning to Budyko equation. We will revise this part to make the logic more clear.

-P4 L1: ".. phase transitionS...... namely evaporation AND condensation.."

Response: Thanks a lot for your specific comments and we will revise our manuscript.

-P4 L10: It's more that once you consider a time scale of more than 1 year, you can neglect the storage change term.

Response: Yes, we did the reasoning on the time scale of more than 1 year. And we will improve the expressions.

-P4 L13-33: This part has to be rewritten. I am completely lost here. What is the difference between i and j? Why are the assumptions valid? How do the authors justify that evaporation is driven by a 'potential' difference dU? I do see this analogy with e.g. Darcy's Law where flow is driven by a pressure difference. However, in the case of evaporation it's a trade-off between evaporative power (Epot) and water availability. This is the main idea behind Budyko. So I don't see why Ohms law analogy can be used in the Budyko framework.

Response: Thank you very much for your invaluable comment. We will rewrite this part and add more explanations. i and j have different meaning, i.e., one group of catchment is denoted as i, and different catchments within this group are denoted as different j. We agree with you that evaporation is a trade-off between evaporative power and water availability, but at the same time, water vapor above one catchment will be divided into two parts, one forming runoff (by precipitating) and the one transported outside of the catchment over a long time scale, and the Ohms analogy was used to quantify the two parts. Furthermore, we can obtain the MCY equation, which is a widely-used equation for the Budyko hypothesis.

-Figure 1-2: how are these figures linked to each other? I think they both try to explain the method, but I don't see how figure 2 follows from figure 1.

Response: Figure 1 characterizes the water transportation between different catchments while Figure 2 only denotes the water transportation from first catchment group to the second one. In addition, Figure 2 introduces resistances to quantify the fluxes, water transportation from one catchment group to another one and the net flux (P - E).

- Figure 1: So the authors use a recycling approach, where evaporation from 1 catchment can re-precipitated in the same or another downwind catchment. This is true, but what I am missing is that catchment 2 receives, beside rainfall from evaporated moisture from catchment 1, als rainfall from other catchments. How is this incorporated? Please also read and refer to: van der Ent, R. J., Savenije, H. H. G., Schaefli, B., Steele-Dunne, S. C. (2010). Origin and fate of atmospheric moisture over continents. Water Resources Research, 46(9), W09525. doi.org/10.1029/2010WR009127

Response: Thank you for your comment and suggestion. In this manuscript, we just track the precipitation in Catchment 1 using a Lagrangian approach. Regarding the precipitation on Catchment, we agree with you that some from evaporated moisture from other catchments, but we only track the part from evaporated moisture from Catchment 1. In another word, it is only the transformation and transportation of the initial evaporation from Catchment 1 that is shown in Figure 1.

- P5 L18: What is the physical meaning of U2-U1?

Response: It is the water potential difference between A and C.

-P5 L15-22: This list is not introduced -P5 L23-31: This list is not introduced.

Response: P5 L15-22 are the description on the water potential and flux in a catchment network, while P5 L23-31 are the conclusion the reasoning from P5 L15-22 based on the Ohms approach.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-283/hess-2019-283-AC2-supplement.pdf

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