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Discussions

Interactive comment on "The Budyko functions under non-steady state conditions: new approach and comparison with previous formulations" *by* Roger Moussa and Jean-Paul Lhomme

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The authors present a formulation for the use of the Budyko framework for non-steady conditions, i.e., with change in water storage within the basin. I find the manuscript an interesting approach that starts from definitions of water availability and energy demand in the "Turc space", later transposed to the "Budyko space", to end up with a formulation expressing the evaporative ratio in terms of change in storage and aridity index. Advantages: Their non-steady conditions formulation in its final way (Eq. 9) is simple, and can be obtained easily from any other steady-state formulation. It also confirms the robustness of Greve et al. (2016) and finds some important differences with those of Chen et al. (2013) and Du et al. (2013). I also appreciate the literature re-

view on the theory behind the use of the Budyko framework for non-steady conditions. Some suggestions to improve the manuscript are:

1. I find that the start from the "Turc space" and constant change to "Budyko space" gets confusing sometimes. Can't their formulation start directly from the much more commonly used "Budyko space"?

2. I find the term S* somehow difficult to grasp. First, why not just use DeltaS, for better clarity, instead of S=-delta S? Second, why not divide DeltaS (water) by P (water) instead of by EP (energy)? This would make much more sense, expressing the change in storage relative to P, something like S*=DeltaS/P. I think in this way it would be so straightforward to use by anyone...

3. The S limit definition of Line 12 page 3: 0<S<Ep, can the authors then explain in more detail this S limit definition (Line 12 page 3) for clarity? This because as it is, S is always positive, implying that delta S is always negative. So what about water storage in reservoirs (delta S >0), could the ML formulation for non-steady conditions also be used to represent this condition? Or if there is a typo there, could the ML formulation be applied conversely, deltaS<0, e.g. groundwater depletion for irrigation? See definition for both cases in "Local flow regulation and irrigation raise global human water consumption and footprint", 2015, Supplementary Information.

4. Upgrade the justification of their study (Line 20-21, page 2), something like a very-well needed validation, integration and comparison of non-steady formulations in Budyko space; that is what their work is from my point of view?

5. Why would I prefer the ML formulation, please expand? I think the fact that no-additional parameters other than PET, P and deltaS to obtain ET/P for non-steady conditions is an important advantage.

6. One of the main conclusions is 25-28 page 8: Just by reading the corresponding discussion (Line 6-14, page 8) it is somehow difficult to understand. Can the authors

use an additional figure comparing for the same storage conditions ALL the four formulations, Greve et al., ML, Chen et al. and Du et al.], either in the normal Budyko [Ep/P, E/P] or in the modified space [Ep/(P+dS), E/(P+dS)]. This synthesis would be very helpful for the reader and potential users of the ML formulation!

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