Earth Syst. Dynam. Discuss., 5, C195–C203, 2014
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Interactive Comment

Interactive comment on "Contrasting roles of interception and transpiration in the hydrological cycle – Part 1: Simple Terrestrial Evaporation to Atmosphere Model" *by* L. Wang-Erlandsson et al.

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Received and published: 5 June 2014

We thank the referee for constructive and detailed comments. We addressed the general comments of referee #2 in an earlier response and would here like to respond to his/her specific comments. The referee's comments are in italics, and our responses are in upright font. Unless otherwise stated, sections and equations referred to are those of the manuscript.

1. P205 L12-14: In fact, for most locations the large difference in net radiation

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between wet and dry seasons is the main factor - wet seasons are energy limited so total ET is restricted.

The sentence referred was to explain why transpiration ratio for Mupfure catchment in the study of Savenije (2004) was relatively higher in wet years, but relatively lower in wet months. If we understand the referee correctly, we do not think his/her explanation addresses this difference.

The manuscript at p. 205 L12-14: "Using a conceptual model approach in Zimbabwe, Savenije (2004) estimated relatively high transpiration ratio in wet years, but small in wet months. This is because wet months tend to have high interception that precedes transpiration and consumes the available evaporation energy, whereas wet years tend to receive increased rainfall during the rainy season that stores and transpires into the dry season." For clarity, we intend to replace "the available evaporation energy" with "the already limited energy for evaporation".

2. P206 L18: Those results have also been challenged by Sutanto et al. (2014) in HESS [doi: 10.5194/hessd-11-2583-2014] - this should be cited.

We will cite this paper in the revised version. Please note, however, that this was not yet available when we submitted our manuscript. We will also cite Schlaepfer et al., (2014) who also just challenged the results of Jasechko et al., (2013).

3. P208 L21: Why is such a low resolution used here (1.5)? Please justify.

Our research need does not require finer resolution. Land-use is represented at sub-grid level for higher accuracy. For the moisture recycling calculations in Part 2, 1.5

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degree is adequate as is explained in (the discussion accompanying) Part 2.

4. P208 L25: Split infinitive.

We will avoid the split infinitive.

5. Sec 3: It appears there is no surface energy budget closure in STEAM. It is claimed that the diurnal ground heat flux is often near zero (P211 L18) and can be neglected, but by this argument most of the ET terms in most places could also be neglected. Without the ground heat storage / loss term, there are many locations (continental and strong thermally advective regimes, e.g. that have frequent onshore flow) and seasons (especially spring and fall in middle- and high-latitudes) where significant errors in available energy could be introduced. These may in fact average out on the annual time scale, but on monthly scales they could impact ET terms significantly, and potentially shift the simulated seasonal cycle of the long-memory terms.

We will incorporate approximation of monthly ground heat flux as a function of monthly mean air temperatures.

6. Similarly, as there is no prognostic surface temperature, ERA-I mean, max and min temperatures are used. This precludes basic feedbacks in the system (e.g., from shortwave heating or evaporative cooling) that could drastically change the vapor pressure deficit used to estimate evaporation terms. Have you looked into the sensitivity of your approach to this simplification? Could you please discuss this?

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We think it is valid to apply the ERA-I forcing to unchanged land-use, and believe it is beyond the scope of the current study to include sensitivity tests of the effect of including prognostic temperatures. In the revision, we will acknowledge the limitation of excluding prognostic temperatures.

7. Canopy interception: Driving with a low-resolution rainfall product that lacks pointscale variability in intensity can lead to over-interception (cf. Reichle et al. 2011) – great care must be taken to calibrate this properly.

The factor used to convert between the leaf area index and the capacity of canopy interception reservoir is the same as in MERRA-Land (Reichle et al., 2011). We are aware that spatial variability of rainfall is important for interception estimates. Specifically, we introduced the area reduction factor (see p 217, L12-20) to compensate for rainfall heterogeneity in space and time at the temporal resolution considered, based on catchment analyses of the relationship between average and extreme precipitation (Shuttleworth, 2012). This should vary with the area considered and the rainfall duration, but we took 0.4 as area reduction factor globally by lack of well-established functions. We do not think comprehensive calibration is the right way to go, considering the lack of sufficient interception observations globally and uncertainties in data.

8. P219 L3: What is the rationale behind directing irrigation water to the canopy interception?

Spill may occur to leaf surfaces, in particular using sprinkler techniques. Since we do not include detailed irrigation techniques, we simply assume some spill to vegetation interception.

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9. P221 L4 P229 L15: What is the point of showing 9 significant digits? Keep all quantities to 2-3 significant digits.

Although we fully agree on not suggesting more accuracy than is warranted, in this case we kept the digits for those readers who wish to convert between units and make their own comparisons to other studies. Thus, in the revision, we will keep 9 significant digits are only for conversion factors (i.e. land area), but convert results such as “73 835 km^3/year” to “74E3 km^3/year”.

10. P221 L10: LandFlux-EVAL shows a range/envelope across many models and products too. Where does STEAM fall in that range? If you are going to compare to other products, please be complete about it.

We will extend the comparison in the Supplementary materials.

11. P222 L14: Even by your own estimates, irrigation makes less than a 2% increase in total ET. Compare to other irrigation studies, e.g., Guimberteau et al. (2012), Wei et al. (2013) - again there seem to be inconsistencies in scale analysis, or at least a lack of clear justification, for what is/isn't included in this model.

Irrigation contribution to total globally average evaporation might be small, but might be important for regions and over seasons, as also the studies of e.g. Guimberteau et al., (2011) and Wei et al., (2013) show. Increase of irrigation techniques is a possible land-use change scenario that could have effect on moisture recycling (Wei et al., 2013; Tuinenburg 2013). Therefore, we think it is justified to include irrigation simulation in the model.

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12. P228 L10: The result that total ET remains constant under most land use changes just reaffirms that the model is overconstrained by fixed meteorological inputs and lack of a surface energy budget. Without a full surface energy budget including prognostic temperatures, what other result could there be?

In STEAM, land-use change leads to changed net radiation by albedo change. Also potential evaporation changes with changing surface and aerodynamic resistances. As we see in the experiment, barren land scenario produced a similar reduction in total evaporation in the Amazon as other more complex models with prognostic temperatures (see Table 7).

Excluding prognostic temperature is indeed a limitation to the model's capacity to simulate land-use change effects. In the revision, we will leave out the land-use change experiment and focus on the time scale aspect.

13. P228 L22: Regarding rooting depths, the formulation errors of land surface models was clearly exposed by Jackson et al. (1996) and Canadell et al. (1996).

We thank the referee for mentioning these two papers. Jackson et al (1996) proposed incorporation of rooting depth database in land surface modelling as a way to circumvent the difficulties of correctly formulating rooting distribution at different soil depth. Canadell et al. (1996) exposed the common model deficiency of neglecting deeper roots. We discuss this model formulation issue at p.228 L23-29, and p. 229 L1-2, and will add these two relevant papers to our discussion.

14. P230 L29: This is true regardless of climate regime; runoff errors are inversely related to precipitation gauge density (Oki et al. 1999).

At p. 230, L27-29, we noted: “This is not surprising, because runoff has been shown to be especially sensitive to precipitation uncertainties when evaporation is not limited by water availability (e.g., Fekete et al., 2004).” We meant than runoff simulations are sensitive to the precipitation forcing uncertainties in wet regions and insensitive in arid regions. In the revision, we will clearly write this out to avoid misunderstanding.

15. P231 L11: Use present tense here.

Ok.

16. Appendix D: Refer to Materia et al. (2010) for a recent relevant study of this aspect.

Ok, thanks for the suggestion.

17. Table 2: Rice is only flooded early in its life cycle, not for the whole growing season. This is probably not an accurate representation of this crop in the model.

We acknowledge that. At p. 232, L15-17, we wrote that “Crop simulations are at present simplified as their development follow meteorological forcing through the growing season index, rather than sowing and harvesting dates.”

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18. Fig 1: Label the diagram with words in addition to variables - otherwise it is cumbersome to interpret.

We are grateful for the feedback. However, we think labelling the diagram with words would make the figure clogged with text. To aid the reader in the revised manuscript, the caption will include a reference to the section in the manuscript that describes the figure.

19. Fig 5: This analysis should be done in more bands - not just the two hemispheres. At least add a separate band for the tropics. Or even better: plot as a Hovmöller diagram (zonal means - latitude vs month).

This is a very good suggestion. We will plot a Hovmöller diagram.

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Interactive comment on Earth Syst. Dynam. Discuss., 5, 203, 2014.