Manuscript Review – HESSd

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Title: A simple water-energy balance framework to predict the sensitivity of streamflow to climate change

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This manuscript describes and evaluates an approach for separating the impacts of land cover change from climate change on catchment runoff. The paper is on an important topic of direct relevance to HESS.

At first reading one is led to think that this is somehow very different from previous work. For example, p. 8801 (lines 18-19) claims a better theoretical basis. However, that is not the case and the main contribution here has not actually been emphasised directly. Consider for example a comparison with the Roderick & Farquhar 2011 (hereafter RF11) scheme. RF11 separates the effect of changes in climate (dP, dEp) from changes in catchment properties (dn) to estimate changes in evapotranspiration (dE) and runoff (dQ). In contrast, the current manuscript starts with (more or less) the same estimates (P, Ep, n) but makes assumption/s about how the changes occur. These are called the CCUW and BCUW hypothesis. The way this is done, is mathematically equivalent to actually prescribing how the catchment moves through the Budyko space. This is shown very clearly in Fig. 3 where a given CE value does not perfectly follow a given value of n. Hence by keeping CE constant, then as changes occur, n must in fact also change. That is why the scheme is equivalent to prescribing the changes. In that respect the work is not an alternative to RF11, but actually builds on it by making an additional hypothesis to prescribe the changes. This paper then opens up the possibility of further investigations on the validity of the CCUW and BCUW (and any other) hypotheses. In that respect this contribution is important.

The contribution described above is diluted by adding all the different Budyko functions (Oldekop, Schreiber, Mezentsev). For example, Fig. 5 says that the calculated sensitivity varies between the different curves. That is obvious from the differences between the curves but nobody has seriously used the Oldekop and Schreiber curves for a very long time. In fact, the original Budyko curve was a geometric mean of the Oldekop and Schreiber curves. Recently, Donohue et al (2011, Assessing the differences in sensitivities of runoff to changes in climatic conditions across a large Basin, Journal of Hydrology, 406, 234-244) have noted that the original Budyko curve can be reproduced using the Mezenstev curve by setting n=1.9. Hence, why not just use the so-called Mezentsev curves and use different values of n to emphasise your main ideas.

Finally, RF11 emphasised that changes in the catchment properties term, n, are not (as yet) strictly separable between changes in climate and changes in land cover. The problem is the possibility of changes in the spatial distribution of P and Ep. They discussed this at length. Hence any mapping to the Tomer and Schilling ideas are tentative at best. Despite that, the basis idea of making assumptions (the CCUW, etc. hypotheses) and evaluating the consequences is an important contribution.

Recommend: Accept after major revision.

Comments

1. P. 8798, lines 17-18. Whether E_T can be larger than E_P depends on the way E_P is defined. Here E_P is defined as the water equivalent of net radiation. So can E_T be larger than net radiation? The answer is yes – when the net sensible heat flux is into the surface (i.e., a negative Bowen ratio). This happens all the time, especially in cold regions when the air is warmer then the surface. Please modify accordingly.

2. P. 8805, Eqn 23 & lines 10-14. Eqn 23 includes terms for changes in climate (dP, dEp) and for changes in catchment properties (dn). That needs to be stated.

3. p. 8803, Eqn 15. Mistake. The partials should be of w not u.

4. p. 8808, lines 3-5. What is the difference between predicting the climate and predicting the change? Eqn 28 is for the climatology?

5. P. 8808, line 21. I did not understand the point. i.e., "….not enough water to sustain E_T."

6. P. 8810, lines 11-16. Why compare with an Oldekop function? (See main comments).

7. P. 8810, line 1. Typo. show should be shown.

8. P. 8813, lines 20-24 & p. 8814, lines 12-15. The thrust of the argument here is a little confusing. Firstly, it is argued from the data that dn may not equal 0, and then it is argued that the climate change impact on runoff may be larger than predicted by the Budyko curve. First, Roderick & Farquhar 2011 (hereafter RF11) assumed dn = 0 but did point out that dn might in fact change. The issue here is that the Budyko prediction missed the observed change by ~ 2 mm per annum. Alternatively, RF11 also pointed out that change in storage of that magnitude could also easily account for the difference. Given the uncertainty in storage change discussed by RF11, it is perhaps premature to claim a larger impact of climate change.

9. Table 2. The units for all hydrologic fluxes should be mm/yr instead of mm.

10. P. 8820 Eqn 27. The Mezentsev Eqn is wrong. On the denominator it should be (P^n+Ep^n)^(1/n).

11. P. 8830, Fig. 8. The caption is incorrect with respect to left and right panels.

12. P. 8830, Fig. 8 and associated text. This figure summarises the main differences and shows that for the MDB, the CCUW approach predicts an overall sensitivity that far exceeds the RF11 scheme. For example, previous research, and CSIRO modelling gives a sensitivity to change in P of around 2-3 for the entire MDB (see citations in

RF11), i.e. a 10% change in P produces a 20-30% change in runoff. The RF11 (left panel) scheme is consistent with that range. Note that the RF11 scheme is a first order perturbation (and is therefore symmetrical) and limited to small changes. In contrast, the CCUW scheme suggests that a decrease in P of 10% decreases runoff by around 40% and an increase in P of 10% increases runoff by around 50%. Hence while I agree that the CCUW hypothesis lads to greater sensitivity, I think it would be useful to point out that these estimates are larger than the effects actually observed.