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Hydrology and Earth System Sciences
Discussions

Interactive comment on "A general framework for understanding the response of the water cycle to global warming over land and ocean" *by* M. L. Roderick et al.

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This manuscript describes in a clear and easy to follow manner the effect of greenhouse warming on the global balance of P and E, elaborating on earlier work by Held and Soden (2006). It shows that the zonally averaged estimates of d(P-E) do not hold at the grid box level and not over land, and present an alternative Budyko-based framework for this. It also illustrates the small role of changes in surface evaporation, and the dominance of longwave cooling at the surface. It reverts the (public) rationale that elevated temperatures lead to acceleration of the hydrological cycle: had surface evaporation increased more, the surface warming would have been correspondingly

less.

The main question that then remains unanswered is the physical explanation of the current partitioning of dLin over dLout and dE: why is x in Eq 10 equal to 0.24? It probably is related to the notion that relative humidity changes relatively little, but it does not shed light on why this is the case. Do the authors have evidence for this?

The paper reads very well (very suitable for teaching at MSc/PhD level) and is certainly suitable for publication, apart from a number of minor comments:

- p 15270: the number of references to the Budyko framework (19) is a bit overdone, I would say

- Eq 1: can you give some indication of the typical value of n?

- p 15271, second para: the fact that the models obey the Budyko framework so well is not very surprising, as both are based on conservation of energy and water. A model data set can be expected to better comply with this framework than an observational data set where energy and water balance conservation are normally quite problematic

- p 15272, last sentence: add a statement that the framework is not suitable for the cryosphere since additional long-term mass balance terms (storage in snow/ice packs) violate the balance assumptions

- p 15273: the 82% explained variance shown in fig 4 is actually a bit low, since all terms in eq 3 come from the same model archive. The missing terms that explain this limited fraction of explained variance are the (ignored) changes in n and the covariance terms, is that right?

- p 15279, L15: add the word “averaged” before “model ensemble”, as the word “ensemble” often points at a large collection of model data

- Table 1: it is a coincidence that the fractional changes in dP and dE over land (5.3 and 3.7) add up to the fractional change in d(P-E) (9%). It may be helpful to make this

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10, C7231–C7233, 2014

notion

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