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Earth System Dynamics Discussions

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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We thank Referee #2 for the constructive comments and would like to first address the general comments. We will address the specific comments in a later response.

Referee comment: "The paper describes a new global hydrologic model (STEAM) that focuses on the representation of the partitioning of evapotranspiration into its components. To me the most novel contribution of the study is the analysis of the timescales associated with different ET components (Fig 4). This is the most interesting aspect; can this be locally validated somehow? That would be a tremendous addition to this *work."*

The purpose of analysing the evaporation time scales was to provide an understanding of the difference between the magnitude of the different evaporation fluxes and their timing. The evaporation time scales only reflect the average residence times. Thus, validation by e.g., isotope studies may be complicated by the fact that transpiration fluxes in reality can be supplied by both recent and old precipitation. Validation of the average values would require not only evaporation partitioning, but also the water storage available for each flux. Such data is to our knowledge not available to the extent needed for meaningful validation. However, we are considering providing a more detailed analysis of the contrasting time scales of the partitioned evaporation fluxes.

Referee comment: "A shortcoming is that this paper needs to reflect clearly an awareness of what has been learned about model dependencies in partitioning of the water budget between ET and runoff, components of ET, etc., as learned from the many previous inter-comparison studies, particularly PILPS. Koster and Milly (1997) is a great place to start. Furthermore, models that concentrate exclusively on one component of a linked and interdependent system, neglecting other components, will have a difficult time simulating any of the system well (cf. Koster and Mahanama 2012, and particularly Koster's recent Horton Lecture at the 2014 AMS annual meeting). The authors should defend their modelling philosophy in the context of the demonstrated pitfalls of such compartmentalization"

In order to keep the model simple, we had to make a tough prioritization on which hydrological processes to include and which to neglect. Koster and Milly (1997) and Koster and Mahanama (2012) concluded among others that compatibility between runoff and evaporation formulations can be important due to interaction through soil moisture. We do not deny that some of the neglected hydrological processes may

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have important influence on evaporation and evaporation partitioning under certain conditions, but believe that the current set-up is a reasonable simplification for the research questions we ask in Part 1 and 2. There will be seasons and regions that are more challenging to simulate than others. As we also touched upon in the manuscript (Sect. 5.3.3), dry season evaporation might for example be underestimated by the neglect of groundwater (Miguez-Macho and Fan, 2012) and hydraulic redistribution of soil water by roots (Lee et al., 2005).

In a revised manuscript, we will expand the literature review to include some of the learnings from previous model inter-comparison studies. We will also expand the Supplementary materials to show when and where STEAM estimates are similar to or differ from the WATCH evaporation datasets. Based on these, we will also expand the discussion on the limitations of STEAM.

Referee comment: "Throughout the paper the authors show a good awareness of issues and details that could affect the estimates by this model. However, in all the minutiae what becomes lost is the grand motivation for STEAM. There is one sentence (P207, L4) stating a goal and that is all. What are strengths and uniqueness of STEAM beyond what has been done before? Please describe why this is not just another tunable model that still suffers from having more parameters than data to calibrate it."

The main strength of STEAM is its ability to simulate land-use based evaporation partitioning while remaining relatively simple and transparent. First generation hydrological models do not simulate evaporation processes in such details, and today's advanced models that include these features are often complex. STEAM includes features from both groups. In short, STEAM is unique in combining

1. the simulation of floor interception, important when one wants to study the effect of land use change or land degradation,

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2. the combination of the use of a simple modelling approach but the inclusion of various factors important for evaporation processes (e.g., phenology, irrigation),
3. the land-use change flexibility, and
4. its specific suitability for coupling with the moisture tracking model WAM-2layers.

See also our first response to referee #1 on the rationale of STEAM. In a revision, we would highlight the strengths and uniqueness of STEAM in the context of what has previously been done.

Referee comment: "Along the same lines, if the model is supposed to be simpler yet better at producing 'realistic partitioning between direct and delayed evaporation', then what is the purpose of all this comparing to other global products? Is this a model to be validated for some specific application, or are the authors setting out to do something that cannot be done with other models or data? This point is not stated in the paper. If the model is to be shown to be equally or more accurate than other (more complex) models, then validation against observations at field sites should be done. If the purpose of the comparison is to 'run with the pack', to be within the range of all other models, then why do we need another model? Perhaps this becomes clear in Part 2, but all motivational aspects should be clearly stated in Part 1."

The primary need and rationale of STEAM is not to provide the best simulation fit to the truth, (see also our first response to referee #1 on the rationale of STEAM). First, most of the models and data we validate against do not provide evaporation partitioning at STEAM's spatial scale and time resolution, or have the flexibility to simulate based on land-use parameterization which we need for future research. Second, we would like to stress again that STEAM is a simple model for evaporation partitioning that needs to remain simple and transparent to facilitate experimentation and learning. While we strive for STEAM to be a well performing model, we do

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not think it is necessary for STEAM to outperform more complex models. One of STEAM's values lies in the balance between adequate evaporation simulation and model simplicity.

We compared total evaporation to assess whether STEAM is in range with current estimates. If STEAM is within the range, we consider it an indicator that STEAM performs reasonably at least with regard to the totals. Because our research is not about re-evaluating the current estimates of total evaporation, we assume that they are reasonable. In addition, we compared our evaporation estimates to the water balance of selected river basins, which is an independent check on the accuracy of our approach.

Other evaporation models we compare to may be useful for providing equally accurate estimates of evaporation by land-use, runoff, and evaporation partitioning, but cannot do this with enough flexibility and at the spatial and temporal resolution that is required for the study of moisture recycling and the impact of land use thereon.

In the revised manuscript, we will consider an expansion of the supplementary materials to show where STEAM lies in comparison with the range of total evaporation estimated by other models and data.

References

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