

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 are grateful for the constructive comments, and would here like to briefly respond to Referee #1's general comments. The specific comments will be addressed in a later response.

Why a new model is needed: clarification of the rationale of STEAM

We developed STEAM as a relatively simple evaporation model for analysing land-use change effects on moisture recycling. Therefore, we prioritised realistic evaporation partitioning, land-use change flexibility and coupling with WAM-2layers, and model

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simplicity.

1. Realistic evaporation partitioning: Existing global land surface models have in general been developed for other types of use (such as to solve surface energy exchanges in climate simulations or to estimate river discharge for assessment of water availability, see e.g., Haddeland et al., 2011) than for simulating evaporation partitioning for moisture recycling analysis. While some of them offer a more complete description of a larger set of earth system dynamics, they do not necessarily simulate evaporation partitioning realistically. For example, some of the most modern and commonly used global land surface models (see Table 4 in the Part 1 manuscript and e.g., Sutanto et al., 2014) simulate relatively low transpiration ratios below 50%. The partitioning between transpiration and the other evaporative fluxes is not trivial, as was recently demonstrated in the comment-reply chain in Nature (Coenders-Gerrits et al., 2014). Features important for evaporation partitioning, such as phenology and irrigation, are included in STEAM, but not always included in other land surface models. A novel detail in STEAM is the simulation of floor interception, which other global land surface models typically neglect. This is an important addition since it is clear from field studies (e.g., Gerrits et al., 2010; De Groen and Savenije, 2006; Putuhena and Cordery, 1996; Savenije, 2004) that significant interception occurs on other surfaces than tree canopy.
2. Land-use change flexibility and coupling with WAM-2layers: STEAM simulates evaporation based on land-use wise parametrisation and land-use fraction at subgrid resolution, which provides flexibility for land-use change analyses. In recent experiments, land-use change effects on downwind precipitation were explored with promising results using two-way coupling between STEAM and WAM-2layers (Keys et al., 2014). STEAM is “tailor-made” to work together with WAM-2layers, making the model coupling seamless. In order to couple an existing model to WAM-2layers, additional adjustments (and potentially also revalidation)

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would in fact be necessary.

3. Simple specialist model approach: Complex models are necessary for holistic earth system modelling, but a simple model approach is convenient when only a few aspects of the Earth system are considered. A simple model is more transparent, contains fewer uncertain "best guess" equations and parameters, and is more flexible to change. When targeting a specific aspect, (in our case evaporation partitioning and the link to moisture recycling), a simple model may even outperform more complex models that do not take that particular aspect into account or that has to compromise it with other aspects. The simplicity of STEAM would also facilitate experiments and ideas-testing prior to coupling between more complex models and WAM-2layers (if such coupling would be necessary for the research questions asked).

Based on the combination of these features, we think that STEAM would complement existing land surface models.

Justification of conclusions

Referee #1 stated that "the conclusions are not well justified by the results and analysis". Our conclusions in the "Summary and conclusions" section were meant to be twofold: those related to model validation, and those related to the role of evaporation partitioning in linking land use and water resources. As Referee #1 acknowledges that "the paper shows that the model does an adequate job at hindcasting evaporation ratios", we assume that the criticism mainly refers to the conclusions of the second type. There, a main conclusion is that "evaporation partitioning is useful for understanding the links between land use and water resources". This is supported by analyses of the terrestrial residential time scale (Sect. 5.2, Part 1), the land-use wise evaporation partitioning (Sect. 5.3.1, Part 1) and the land-use change experiments (Sect. 5.3.3, Part 1). The results showed that different evaporation fluxes have vastly different time scales (Sect. 5.2, Part 1) and respond differently to climate based on land-use (Sect. 5.3.1,

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and 5.3.3, Part 1). Specifically, Figs. 6 and 7 (Part 1) illustrate that land-use change may affect evaporation partitioning and evaporation seasonality much more than temporally aggregated total evaporation. We think that these results support the conclusion that evaporation partitioning is an important step towards better understanding of how land use affects water resources. We thank Referee #1 for pointing out that the writing does not clearly convey our line of thought. If we are given the opportunity to submit a revised manuscript, we would improve the writing and paper organization to better clarify the links between the analysis, results and conclusions.

Why ESD

Referee #1 questions our choice to submit to ESD rather than a model journal such as Geoscientific Model Development or a hydrology-focused journal such as Hydrology and Earth System Sciences (HESS). Our intention is not only to describe STEAM, but also to present original ideas and analysis, which is the reason for not submitting our paper to a model development journal. We did indeed consider HESS based on similar arguments as Referee #1, but thought that the combination of Part 1 and 2 would fit better in ESD as it describes the dynamics of the Earth system (http://www.earth-system-dynamics.net/general_information/journal_subject_areas.html) and targets Earth System researchers.

Rationale for being part of a pair

Part 1 describes interception and transpiration in the terrestrial branch of the hydrological cycle, whereas Part 2 describes their role in the atmospheric branch. In order to interpret the results of WAM-2layers in Part 2, it is essential to have the background information of how the evaporation fluxes were created using STEAM and how the evaporation fluxes behave on land. For example, to understand why transpiration spends more time and travels further in the atmosphere compared to interception, it is useful to know that the terrestrial residence time scale of transpiration is substantially longer and that transpiration is sustained during dry spells. The global maps in Part 1 can

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with benefit be compared with maps of atmospheric moisture recycling metrics in Part 2 to aid interpretation. We agree with the referee that the rationale for two companion papers should be stated clearer already in Part 1, as this does not become obvious until Part 2.

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