Earth Syst. Dynam. Discuss., 5, C204–C210, 2014
www.earth-syst-dynam-discuss.net/5/C204/2014/

Earth System Dynamics Discussions

ESDD

5, C204–C210, 2014

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.

L. Wang-Erlandsson et al.

l.wang-2@tudelft.nl

Received and published: 9 June 2014

We thank Anonymous Referee #3 for constructive comments. He/she raises a number of concerns, which we will address here. 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.

Unfortunately, the scientific goal of the manuscript is not clear and the reported results are not cohesive.

Referee #4 also suggested us to highlight "new aspects (phenology, irrigation, landuse change)" rather than portraying the manuscript as "a model development paper". Referee #5 suggested us to improve the scientific value of the paper by for example selecting one experiment for extensive elaboration and leave other out for a separate short paper.

In the revised manuscript, we will have a clearly formulated research goal beside model evaluation. The aim of the paper will become clearly two-fold: to present and evaluate STEAM, and to analyse the characteristics of partitioned evaporation fluxes on land. We are considering referee #5's suggestion to elaborate more on the time scales (which also referee #2 found to be most novel and interesting). The time aspect of evaporation fluxes is also useful for interpreting results of Part 2. We will use STEAM to characterise the evaporation fluxes globally by 1) providing information on the terrestrial residence time scales of evaporation fluxes, and 2) quantifying the role of precipitation for evaporation partitioning. We believe these two issues are relevant for understanding the importance of partitioning evaporation and also connect well with the subsequent analyses in Part 2. We will further condense the method descriptions (Sect 2-4), and highlight the novel aspects of the model.

Considerable amount of effort has gone into developing the STEAM model. However, I am not convinced that this model is absolutely necessary because the work could have been done using other models. For this work to be published in ESD, the authors must formulate a science question and simultaneously demonstrate that the STEAM model is necessary and it represents a significant advancement over current modeling capabilities.

We do not claim that no other models could have been used for accomplishing

ESDD
5, C204–C210, 2014

the work currently presented. However, we do believe that there is a value in developing and presenting STEAM for the scientific community. Key features of STEAM include focus on evaporation partitioning, land-use based parameters, irrigation, phenology, flexibility for land-use change, suitability for coupling with the moisture tracking scheme WAM-2layers (van der Ent et al., 2014), and model simplicity. This combination of features makes STEAM appealing for use in research with regard to the links between land-use change and moisture recycling. Please also see our recent brief reply to referee #1, in which we discuss our main reasons for developing STEAM.

Transpiration is a process that accompanies photosynthesis. Jarvis-type empirical schemes do not dynamically represent photosynthesis. Even though these schemes perform well, they do so when calibrated/tuned with good data. The problem with tuned schemes is that often their predictive capability is poor especially when the climate regime changes. The authors have invested an enormous amount of hard work in developing this model. I am surprised that they chose to use a Jarvis-type scheme instead of a mechanistic scheme like Ball-Berry-Collatz that is based on photosynthesis.

Although the Ball-Berry-Collatz is based on photosynthesis and more physically justified for transpiration simulation, we have considered the Jarvis-Stewart model to sufficiently serve our purposes given the lack of carbon representation as well as the uncertainties involved. Referee #4 also detailed several arguments for using the Jarvis model: 1) Jarvis “is pragmatic for spatially-explicit hydrological model at the global scale”, 2) “The B-B also equally suffers from uncertainties that are related to photosynthesis and soil moisture simulations under future climates” 3) “Jarvis model is pertinent here because STEAM is a global scale hydrological model that does not have a serious carbon cycle component”.

ESDD
5, C204–C210, 2014

The study ignores surface and subsurface hydrology. That is not desirable but OK because many models do not. However, I believe that all new models on ET should attempt to incorporate this feature because surface hydrology does play a role in ET by changing soil moisture availability, precipitation patterns through soil moisture feedback and by generating mesoscale circulations. At least a discussion of these issues is warranted instead of a blanket statement that these processes are not important.

We thank the referee for this suggestion and agree with the referee that such a discussion would be useful. Referee #2 was also concerned about the modelling skill when some components are neglected in "a linked and independent system". In a revised manuscript, we will expand the discussion to include the role of neglected processes based on literature review of previous research.

Many parameters used in the model such as the area reduction factor, dry out parameter, 21 day timescale to calculate leaf area, irrigation efficiency, etc. are assigned arbitrary values. They may be reasonable but these must be supported by citations or physical justifications.

We disagree as we believe our parameters are supported by references and physical justifications. Clarifications are provided below, and we will make sure to remove any ambiguities in a revised manuscript, if such is encouraged. The area reduction factor is discussed in Sect. 3.3.3 of the manuscript. In short, we used area reduction factor analogous to diagram of relationship between average and extreme precipitation obtained from catchment studies (Shuttleworth, 2012). The dry out parameter in Eq. 6 in the manuscript is based on the semi-empirical equation of (Pellarin et al., 2013). The 21-day running average window length is in agreement with the original (Jolly et al., 2005) paper that introduced Growing Season Index. It is used in order to prevent unrealistic overreaction to short term fluctuations in meteorological conditions. The irrigation efficiency, assumed as 50 %, is a simplification of the country-based efficiencies given in (Rohwer et al., 2007). Although irrigation efficiency in practice varies greatly with irrigation technique, crop type and country, we consider our assumption acceptable as our major concern is evaporation and not runoff or withdrawal. The 50 % assumption is higher than the mean national irrigation efficiencies in most Asian countries and central Africa (approx. 30-40 %), in range with those in Western Europe, North and South America, and southeast Africa (approx. 40-50 %), and lower than what is reported in Eastern Europe and Russia (approx. 70 %) (Rohwer et al., 2007).

It is not clear if the root depth parameter is relevant in STEAM.

The root depth parameter was necessary in STEAM for simulating the storage capacity of the unsaturated zone (thus, the maximum plant available water and the tendency for water stress) for different land-use types, see Eq. 24.

Is vegetation seasonality solely represented by leaf area?

We would like to clarify that the vegetation seasonality is primarily represented by leaf area through the growing season index (see Sect. 3.3.2). However, leaf area also influences aerodynamic resistance through plant height, zero-plane displacement, aerodynamic roughness length (Eq. B7-B15), stomatal resistance through effective leaf area for transpiration (Eq. B16-B17), and vegetation interception storage capacity (Eq. 21).

ESDD
5, C204–C210, 2014

The authors correctly point out the limitations of the land use change experiments due to the lack of feedback from the atmospheric component of the hydrologic cycle. In that case, how robust/realistic are the changes in flux partitioning?

The intention of the land-use change experiment was not to illustrate actual changes, but to illustrate how our model parameterisation affects the evaporation partitioning. As we wrote in the manuscript: "The aim of the experiment was to investigate the role of land-use **parametrisation** for the simulation of evaporation fluxes". We think it is beyond the scope of our study to investigate the robustness of this land-use change experiment if feedback from the atmosphere would have been considered. In the revision, we will also leave out the land-use change experiment and focus on the time scale aspect.

References

Jolly, W. M., Nemani, R. and Running, S. W.: A generalized, bioclimatic index to predict foliar phenology in response to climate, Glob. Chang. Biol., 11(4), 619–632, doi:10.1111/j.1365-2486.2005.00930.x, 2005.

Pellarin, T., Louvet, S., Gruhier, C., Quantin, G. and Legout, C.: A simple and effective method for correcting soil moisture and precipitation estimates using AMSR-E measurements, Remote Sens. Environ., 136(null), 28–36, doi:10.1016/j.rse.2013.04.011, 2013.

Rohwer, J., Gerten, D. and Lucht, W.: Development of functional irrigation types for

ESDD
5, C204–C210, 2014

improved global crop modelling, Potsdam., 2007.

Shuttleworth, W. J.: Terrestrial Hydrometeorology, 1st ed., Wiley-Blackwell, West Sussex., 2012.

Van der Ent, R. J., Wang-Erlandsson, L., Keys, P. W. and Savenije, H. H. G.: Contrasting roles of interception and transpiration in the hydrological cycle. Part II: Moisture recycling, Earth Syst. Dyn. Discuss., submitted, 2014.

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