Hydrol. Earth Syst. Sci. Discuss., 11, C3894–C3901, 2014
www.hydrol-earth-syst-sci-discuss.net/11/C3894/2014/

Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Coupling a land surface model with a crop growth model to improve ET flux estimations in the Upper Ganges basin, India" *by* G. M. Tsarouchi et al.

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Received and published: 18 September 2014

Many thanks to both reviewers for their helpful comments. Please find our response following each comment.

General comments:

1. Page 6847 Lines 1–5: I agree that comparing pre-coupling and post-coupling is useful to allow understanding of the LSM sensitivity to crop dynamics. However, the results show that most ET differences are caused by LAI and I think that this finding is less novel. A more novel aspect is the application of a coupled model at large spatial

scale to an agricultural area, so this should receive greater emphasis. Spatial variation in the performance of ET estimation, through for example a comparison between rain-fed and irrigated areas (as mentioned by the author near the end), could be useful to many readers, so it should be addressed with quantitative results.

Response: The reviewer writes "the results show that most ET differences are caused by LAI and I think that this finding is less novel" – Apart from LAI, the coupled system allows for dynamic evolution of root depth and canopy height which are also important. Besides, the main objective and novelty of this paper is the quantification of the potential error of an LSM without dynamic vegetation when it estimates ET fluxes. Unfortunately, there is lack of available spatial data that separate between rain-fed and irrigated areas of different crops whilst giving timely information regarding the amount of irrigation applied throughout the year, over our study area. For instance, the Global Map of Irrigation Areas, V.5 (Siebert et. al, 2013, FAO) classifies our entire study area as a 90-100% irrigated area, but this sort of information wouldn't be useful for a comparison between irrigated and rain-fed areas. Figure 11, which separates rain-fed and irrigated zones of wheat, was obtained online through USDA but was not accompanied by any dataset.

It would be indeed very interesting to do such a comparison, but at this stage, and since the JULES model in its original setup does not account for irrigation, we believe that the main differences visible through a spatial plot would arise from the spatial variations in soil parameters, in precipitation and the other meteorological variables.

However, we added two additional plots in the manuscript (Figs. 7 & 8), which show the spatial variations in the modeled ET estimates and how they compare to MODIS ET. We agree with the reviewer that the impact of irrigation is an extremely important aspect of crop modeling. Work is currently under development, both in respect to more accurate land use classification of irrigated vs. rain-fed areas and irrigation representation in JULES.

The following lines were added to the manuscript: “Similar information arises from the spatial comparison of the modeled ET with the MODIS product, shown in Figs. 7 & 8, for wet and dry periods respectively (TRMM forcing). Within the JULES-base and JULES-Info models the spatial ET variations are attributable to differences in soil parameters, precipitation and other meteorological variables aside from the vegetation parameters, however it is evident that JULES-Info generates lower ET values which match better the MODIS values, compared to JULES-base.”

2. Page 6854 Lines 21–28: In the coupled model, ET is computed by the LSM and photosynthesis is then calculated by a crop growth model. The latter calculation (dry matter production) appeared to be based on radiation use efficiency in InfoCrop, in contrast to the biochemical model in JULES. I think that this coupling scheme is incomplete because the calculation of ET (more properly gs) in JULES is linked to photosynthesis (A) via a CO2 diffusion equation and stomatal conductance model. It is better to use the LSM photosynthesis to maintain reasonableness in a coupled model, or it is necessary to discuss and justify the use of photosynthesis from the crop growth model.

Response: The reviewer is correct. The only reason we decided to use the Radiation Use Efficiency (RUE) method of InfoCrop to calculate the dry matter production is that it is based on actually measured values of RUE during peak-vegetative growth over our study area and is also crop specific. Following your suggestion, we replace the RUE method by the JULES calculated photosynthesis; the results are indeed slightly improved. We added the following additional paragraph in Section 3.3 of the Manuscript to explain the suggested alteration:

“InfoCrop calculates dry matter production as a function of the Radiation Use Efficiency (RUE) (Aggarwal et al., 2006a). In contrast, JULES-base follows a biochemical approach which links the calculation of the leaf level stomatal conductance to the net photosynthetic uptake via a CO2 diffusion equation (Best et al., 2011). Because in the coupled scheme we maintain the ET calculation mechanism of JULES-base, it is sensible that the photosynthesis is calculated from JULES-base as well. In JULES-Info,

the dry matter production is no longer calculated as a function of RUE (according to InfoCrop) but is based on the net primary productivity (structural dry matter) as calculated by the LSM’s photosynthesis scheme.”

All Figures and results analysis have been updated accordingly.

Minor remarks:

1. Page 6851 Line 20, “there is no subsurface grid heterogeneity”: Does this mean soil moisture values are the same at all grids? Is this not a problem to calculate soil heat flux (G) or water stress impacts on ET at individual grids?

Response: No, the phrase “no subsurface grid heterogeneity” means that although the surface of each grid has 9 tiles, in the subsurface the soil moisture value is the same for all 9 tiles. Of course from one grid to the other the soil moisture values differ. We clarify this by changing the sentence as follows:

“A structural limitation of the current JULES version is that there is no subsurface heterogeneity at the sub-grid scale, in contrast to on the surface.”

2. Page 6851 Line 25, “Ground surface heat components”: Does this mean soil heat flux (G), or G plus heat flux into the plant body?

Response: It means the heat fluxes (G) that enter and exit each soil layer as well as the advective flux from the layer by flowing water (J).

3. 6852 Line 5: Why is soil evaporation restricted by stomatal resistance (though it is possible via the energy budget)? Is this soil resistance?

Response: We write: “while plant transpiration from root water uptake from all 4 soil layers (vegetated areas) and bare soil evaporation from the top soil layer are restricted by stomatal resistance and the soil moisture state, respectively”. This means that transpiration is restricted by stomatal resistance and soil evaporation is restricted by the soil moisture state (soil resistance).

4. Page 6852 Line 22, "canopy capacity Cm": Specify the subject matter for capacity. Is this "canopy capacity to hold water"? The unit of Cm is necessary.

Response: Yes, it is the canopy capacity to hold water and the unit of it is Kg/m2. Following the reviewer's suggestion, we added this information to the manuscript.

5. Page 6853 Line 7: This ET from InfoCrop seems to be unused in a coupled scheme. It is helpful for readers to distinguish the explanation for coupled and uncoupled parts throughout model description.

Response: This paragraph aims to describe the InfoCrop model as a standalone (uncoupled) system. Therefore we aim to give a full description of the model's capabilities. In the next section (3.3) where we describe how the coupled system works, it is made clear that ET is obtained from JULES and therefore ET from InfoCrop is not used.

6. Page 6855 Line 8, "JULES-Info model was parameterized for those crops": Which parameters did you use for parameterization? Describe the details of parameterization and discuss the result, such as values obtained. This information could be useful for readers.

Response: InfoCrop was already parameterized for the two crops of our study area by its developers and the set of parameters was obtained along with the model's code. For more details see the two papers describing the model by Aggrawal et al.:

i. InfoCrop: A dynamic simulation model for the assessment of crop yields, losses due to pests, and environmental impact of agro-ecosystems in tropical environments. I. Model description.

ii. InfoCrop: A dynamic simulation model for the assessment of crop yields, losses due to pests, and environmental impact of agro-ecosystems in tropical environments. II. Performance of the model.

In the manuscript, we modified the sentence as: "Therefore, the JULES-Info model was parameterized for those crops, (following the parameters suggested by the developers

of InfoCrop Aggarwal et al., 2006a, b)".

Additional References:

Siebert, S., Henrich, V., Frenken, K., and Burke, J. (2013). Global Map of Irrigation Areas version 5. Rheinische Friedrich-Wilhelms-University, Bonn, Germany / Food and Agriculture Organization of the United Nations, Rome, Italy.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 6843, 2014.

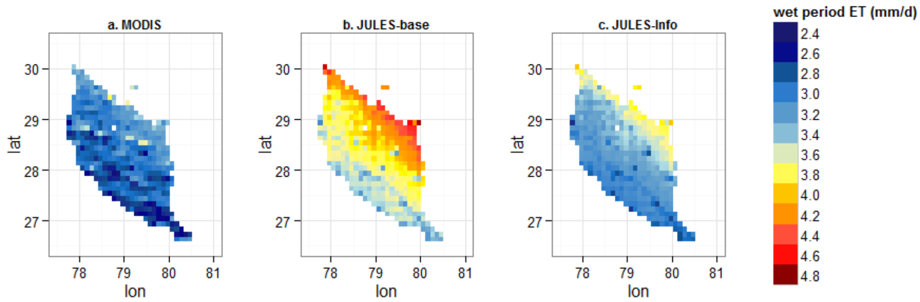

Fig. 1. Spatial comparison of the modelled ET with the MODIS product, for agricultural areas, averaged over the wet (June–September) months of years 2000-2008.

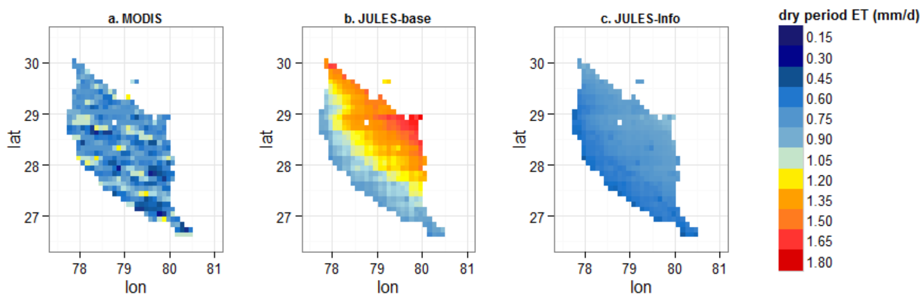

Fig. 2. Spatial comparison of the modelled ET with the MODIS product, for agricultural areas, averaged over the dry (October–May) months of years 2000-2008.