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Interactive comment on "Evaluation of root water uptake in the ISBA-A-gs land surface model using agricultural yield statistics over France" *by* N. Canal et al.

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Response to Referee #3

The authors thank the anonymous Referee #3 for his/her review of the manuscript and for his/her helpful comments.

3.1 [In principal, this question of whether a new process formulation improves the performance of a land-surface model or not could be of general interest to readers of HESS, as already mentioned by the other referees.]

RESPONSE 1

Thanks for this comment. The simulation of root water uptake in land surface models is affected by large uncertainties. The difficulty in mapping soil depth and the capacity of plants to develop a rooting system is a major obstacle to the simulation of the water cycle over land and to the representation of the impacts of drought. This study shows that long time series of agricultural statistics can be used to evaluate and constrain root water uptake models.

3.2 [However, the presented method is, in my opinion, hardly suitable to rigorously test the appropriateness of the different modeling approaches. This is due to the nature of the data set used in the study and also because of the fact that the alternative model configurations are solely tested with respect to their potential to improve the simulation of the inter-annual variability of grain yields of cereals and dry matter yields of grasslands.]

RESPONSE 2

The background assumption of this work was that the regional scale above-ground biomass simulated by a generic LSM could be used as a proxy for GY or DMY in terms of interannual variability. This assumption is discussed in Sect. 4.3 (a Discussion section) (see also the response 4 to Referee #2 comments). Of course, models need to be tested at a local scale using data from instrumented sites. For example, the DIF version of ISBA was tested at a local scale by Decharme et al. (2011), over a grassland site in southwestern France. However, the soil and vegetation characteristics at a given site may differ sharply from those at neighboring sites. It is important to explore new ways of assessing and benchmarking model simulations at a regional scale. Remote sensing products can be used to monitor terrestrial variables over large areas and to benchmark land surface models (e.g. Szczypta et al. 2014). At the same time, using in situ observations as much as possible is key, as remote sensing products are affected by uncertainties. While using various sources of information can be recommended, this work focuses on the assessment of the use of GY and DMY aggregated in situ observations, relevant at a regional scale. From this point of view, the "local scale"

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term used in Sect. 4.1 is confusing. It could be replaced by "regional scale". Also, the "site" term could be replaced by "departement".

REFERENCE

Szczypta, C., J.-C. Calvet, F. Maignan, W. Dorigo, F. Baret, and P. Ciais: Suitability of modelled and remotely sensed essential climate variables for monitoring Euro-Mediterranean droughts, Geosci. Model Dev., 7, 931–946, doi:10.5194/gmd-7-931-2014, 2014.

3.3 [Others (no less important) model predictions are not considered in this study. As the ISBA-A-gs model, initially developed to simulate energy and water fluxes at the land surface, is not a crop growth or grassland model, it is not surprising that the agreement of the model with the observed data is rather low. For crops, in the best case, the model can reproduce inter-annual yield variability of yields only at 13 out of 45 sites with an $R^2 > 0.366$, even after optimization of the two most relevant parameters. In other words, R^2 is lower than 0.366 in 32 of 45 cases. A validation of the model predictions with an independent data set not used for model calibration was not performed. For grasslands the match between simulations and observations is markedly better, which is due to the fact that the model simulates biomass and does not distinguish between 'vegetative biomass' and 'generative biomass' (grains). This indicates that aggregated grain yields are not really suited for the evaluation of the performance of the model. Beside of radiation, precipitation and temperature, crop yields depend also on many local conditions such as soil properties, nutrient availability and farm management. However, all these features are not included in the model (which typically is the case in LSM designed for global and regional studies).]

RESPONSE 3

Yes. ISBA-A-gs is not a crop model and agricultural practices are not explicitly represented. On the other hand, ISBA-A-gs simulates CO2 fluxes and plant growth. Although the simulated Bag is not a direct representation of the agricultural yield, this

study shows that significant correlations (p < 0.01) can be found for grasslands (cereals) at 77 % (29 %) of the departements. Finally, we were not able to find crop model evaluation studies using the same protocol. Therefore, it is not possible to judge the added value of using a crop model vs. a LSM. Benchmarking crop models and LSMs is clearly needed, but this is out of the scope of this study. A key objective of this study was to benchmark DIF options, not to predict the agricultural yields. Therefore, using an independent dataset to assess yield prediction was not needed. These aspects will be clarified in the final version of the paper.

3.4 [Probably, other data sets such as leaf area index (LAI) or green vegetation index (GVI) from remote sensing should be better suited for the evaluation of the vegetation component of the model at regional scale. For testing the adequacy of the coupling between soil hydrology and root water uptake, field scale data including soil moisture and evapotranspiration would be a useful complementation. Moreover, given the rather low performance of the model in relation to the data from agricultural statistics, the impact of alternative root water uptake models on simulated yields has only little informative value about the performance of the model.]

RESPONSE 4

Yes, we agree. In order to assess the model at the regional scale, a future work could be to use satellite-derived LAI products at a spatial resolution of 1 km x 1 km in conjunction with soil maps at the same spatial resolution (e.g. derived from the Harmonized World Soil Database, Nachtergaele et al. 2012). As suggested by Feddes et al. (2001) and Decharme et al. (2013), the obtained "effective root distribution function" could be validated using river discharge observations by coupling the LSM with a hydrological model. We will investigate this possibility in a future work. Note however that the river discharge is often impacted by anthropogenic effects such as dams and irrigation. Such effects are not represented (or not completely represented) in large scale hydrological models (Hanasaki et al. 2006) (see also the response 3 to Referee #2 comments). Also, the soil moisture and evapotranspiration outputs of the model

have already been assessed in Decharme et al. (2011). Especially, they conclude that the ISBA model in the DIF configuration "reproduces the evolution of the soil moisture profile reasonably well, and it improves the simulation of the surface energy fluxes compared with the FR-2L configuration". Others differences are also highlighted using the DIF configuration against the FR-2L one: "The use of [DIF] leads to many differences compared with [FR-2L], in solving the diurnal cycle of the surface temperature, in partitioning latent and sensible heat fluxes at the daily to interannual timescales, and in simulating the drainage rate response after a precipitation event". These results could be mentioned into the Discussion section of the final version of this manuscript.

REFERENCES

Decharme, B., Boone, A., Delire, C. and J. Noilhan: Local evaluation of the Interaction between Soil Biosphere Atmosphere soil multilayer diffusion scheme using four pedo-transfer functions, J. Geophys. Res., 116, D20126, doi:10.1029/2011JD016002, 2011. Decharme, B., Martin, E., and Faroux, S.: Reconciling soil thermal and hydrological lower boundary conditions in land surface models, J. Geophys. Res. Atmos., 118, doi:10.1002/jgrd.50631, 2013.

Feddes, R. A., Hoff, H., Bruen, M., Dawson, T., de Rosnay, P., Dirmeyer, P., Jackson, R. B., Kabat, P., Kleidon, A., Lilly, A., and Pitman, A. J.: Modeling root water uptake in hydrological and climate models, Bull. Amer. Meteor. Soc., 82 (12), 2797-2809, 2001. Hanasaki, N., Kanae, S., and Oki, T.: A reservoir operation scheme for global river routing models, J. Hydrol., 327, 22–41, 2006.

Nachtergaele, F., van Velthuize, H., Verelst, L., Wiberg, D., Batjes, N., Dijkshoorn, K., van Engelen, V., Fischer, G., Jones, A., Montanarella, L., Petri, M., Prieler, S., Teixeira, E., and Shi, X.: Harmonized World Soil Database (version 1.2), 2012, available from: http://webarchive.iiasa.ac.at/Research/LUC/External-World-soildatabase/HWSD_Documentation.pdf.

3.5 [In my opinion it is questionable, to seek the improvement of an isolated process

in a complex LSM while ignoring the impact on others (such as soil moisture, latent heat and sensible heat). This is because it is not clear a priori whether improving (or worsening) the representation of a single process will also improve (or worsen) the overall performance of a LSM. Unforeseen interactions of parameters in a new scheme with ones in existing schemes of the LSM may occur (e.g. Rosero et al., 2010; Niu et al., 2011). Even if there is no improvement (or even worsening) in the model predictions for biomass, other state variables such as soil moisture or the fluxes of sensible and latent heat could be greatly improved. And vice versa, improvements in one process can be accompanied by decrease in the overall model performance (e.g. Gayler et al., 2014).]

RESPONSE 5

Ca12 have shown that MaxAWC is the main driver of the interannual variability of Bag in the ISBA-A-gs model. Representing the year-to-year Bag variability in a dynamic vegetation model is a prerequisite to correctly represent surface fluxes at all temporal scales (from hourly to decadal). It must be noted that using the interannual variability of plant growth to assess LSM parameters is a rather new idea. For example, Rosero et al. (2010) and Gayler et al. (2014) performed an assessment of key parameters of the Noah LSM, including a version with a dynamic vegetation module, using a set of experimental stations. However, they did not address the interannual variability of plant growth as their simulations covered one vegetation cycle, only. Such a short simulation period is not sufficient to constrain those model parameters which affect the interannual variability of plant growth (Kuppel et al. Biogeosciences, 9, 3757–3776, 2012).

REFERENCE

Rosero E, Yang Z-L, Wagener T, Gulden LE, Yatheendradas S, and Niu G-Y: Quantifying parameter sensitivity, interaction, and transferability in hydrologically enhanced versions of the Noah land surface model over transition zones during the warm season. Journal of Geophysical Research: Atmospheres 115(D3), D03106,

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Gayler, S., Wöhling, T., Grzeschik, M., Ingwersen, J., Wizemann, H.-D.,Warrach-Sagi, K., Högy, P., Attinger, S.,Streck, T., and Wulfmeyer, V.: Incorporating dynamic root growth enhances the performance of Noah-MP at two contrasting winter wheat field sites, Water Resources Research, 50, 1337-1356 10.1002/2013wr014634, 2014.

3.6 [However, this was not investigated in this work and so the question of what the most appropriate approach for root water uptake is in other applications than yield predictions remains unanswered. In its present form the paper can be more or less reduced to the question if the vegetation component of ISBA-A-gs can be used for predicting the variability of yields over a period of 17 years (partially discussed in Section 4.3.). This seems to be the case on a rather low level (at least compared to more detailed models, which are designed for this purpose) and some of the tested root water uptake schemes perform better than others.]

RESPONSE 6

We have to disagree with Reviewer 3. Table 2 shows that significant differences in the representation of the Bag interannual variability are triggered by switching from one model option to another. Also, for a given model option, the median gm and MaxAWC values obtained for cereals contrast from those obtained for grasslands. This is very valuable information for guiding the mapping the model parameters in future studies.

3.7 [However, the study does not allow conclusions about the suitability of the alternative approaches in applications of the models in hydrological simulations (e.g. regional or global scale), because the relevant observables were not considered. I therefore recommend to extend the study to further data sets which include those state vari-

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ables, such as soil moisture and evapotranspiration.]

RESPONSE 7

Yes. Next steps are to (1) improve the parameter mapping using satellite products (e.g. LAI), (2) verify that the new model parameters have a positive impact on the water and carbon fluxes derived from in situ flux-tower observations and satellite products, at a regional scale and at various timescales (hourly to decadal), (3) use an hydrology model coupled to SURFEX (Szczypta et al. 2012) to assess the impact of the new MawAWC maps on river discharge. This is ongoing work.

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