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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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jean-christophe.calvet@meteo.fr

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The authors thank the anonymous Referee #1 for his/her review of the manuscript and for his/her helpful comments.

1.1 [This study is of high interest for readers of HESS, as prediction of yield gaps caused by limited water resources is essential for safe food production.]

RESPONSE 1

Thanks for this positive comment.

1.2 [However, the presentation of the model and the results are too specific and mainly understandable only for users of the ISBA-A-gs model. This diminishes significantly the value of this modelling study and the manuscript could be rewritten and partly restructured. Here are some suggestions that may make the manuscript interesting for a broader audience].

RESPONSE 2

We agree about the fact that the presentation of the ISBA-A-gs model is particularly short in this manuscript. The objective was to be concise and to avoid repeating information that could be found in other papers cited in Section 2.2. More details will be added, following the suggestions of the Referee.

1.3 [It is not clear why the study was carried out: where the results of Ca12 not satisfying (L. 25-29 page 5423)? Please justify better this study.]

RESPONSE 3

In this study, the ISBA-A-gs model is used, as in Ca12. In ISBA-A-gs, the plant phenology is driven by photosyntesis: on a daily basis, plant growth is governed by the accumulation of the hourly net assimilation of CO2 through the photosynthesis process, and plant mortality is related to a deficit in photosynthesis. The simulated annual maximum Bag and maximum LAI may differ from one year to another in relation to the impact of the weather and climate variability on photosynthesis. In regions where a deficit of precipitation may occur, soil moisture is a key driver of photosynthesis and plant growth of rainfed crops and grasslands. Although ISBA-A-gs is not a crop model and agricultural practices are not explicitly represented, Ca12 achieved a good representation of the interannual variability of the dry matter yield (DMY) over many grasslands sites in France. On the other hand, representing the year to year variability of the grain yield (GY) of winter/spring cereals was more difficult. In particular, they showed that the model was markedly sensitive to the representation of the soil moisture stress, through the MaxAWC parameter (especially at low MaxAWC values). The study of Ca12 was carried out with a simple, single-layer representation of the root-zone soil moisture over the 1994-2008 period. The main objective of this study was to assess to what extent using more refined representations of the soil hydrology and of the root water uptake could improve the representation of the interannual variability of GY (and possibly DMY). Since several options could be envisaged to implement the DIF simulations, a side objective of this study was to benchmark these options.

1.4 [One of the difficulties is the abundant use of abbreviations that make difficult to follow the text. I recommend to add a list of symbols.]

RESPONSE 4

Yes, a lot of abbreviations have been used in this manuscript. A nomenclature Table listing the symbols and their definition will be added.

1.5 [Additionally a large part of the model is not explained and it is difficult to judge on the quality of the simulations and the differences among the tests. How is the transpiration calculated and related to the leaf area index?]

RESPONSE 5

A soil moisture stress function is applied to key parameters of the photosynthesis model. For herbaceous vegetation, two parameters are assumed to respond to soil moisture stress (Calvet, 2000): the mesophyll conductance (gm) and the maximum leaf-to-air saturation deficit (Dmax). Low (high) values of the latter correspond to high (low) sensitivity of stomatal aperture to air humidity. These photosynthesis parameters are dependent on the available soil water content, AWC. Two contrasting responses of the model parameters to soil moisture are represented: drought-avoiding and drought-tolerant. When the AWC/MaxAWC ratio is higher than the critical root-zone soil moisture content (equal to Theta_C = 0.3 in our simulations), a drop in AWC triggers an increase (decrease) in gm and a decrease (increase) in Dmax for the drought-avoiding (drought-tolerant) parameterization. The drought-avoiding parameterization is used for cereal crops and the drought-tolerant parameterization is used for grasslands. This assumption was validated by Ca12. The drought response model is illustrated by Fig. 1 in Ca12 and this Figure could be added as a Supplement to this paper. These parameters are used to calculate the hourly leaf-level net assimilation of CO2 and the stomatal conductance, in relation to sub-daily meteorological inputs such as the incoming solar radiation. A radiative transfer scheme is then used to upscale net assimilation of CO2 and transpiration at the vegetation level. The plant transpiration flux is used to calculate the soil water budget through the root water uptake. The net assimilation of CO2 serves as an input to the plant growth model, and LAI and Bag are updated on a daily basis. A new figure will be introduced in the final version of the manuscript in order to illustrate these mechanisms.

1.6 [What is the differences between eq.(2) and eq.(3)? Please explain.]

RESPONSE 6

Eq. (2) is used to assess the soil moisture stress in a single soil layer or in several soil layers forming a bulk layer from the surface to a depth dL. Eq. (3) is used to assess the soil moisture stress of an individual soil layer at depth dLi. Eq. (2) and Eq. (3) are used to calculate the stress function in FR-2L and DIF simulations, respectively.

1.7 [I was surprised to see the assumption of a stress factor for root water uptake proportional to the normalized volumetric water content (eq. 2 and 3). Transpiration is usually constant till a critical water content and then it decreases till the wilting point. A commonly reduction function is the one introduced by Feddes et al. (1978).]

RESPONSE 7

Actually, there is a typo in Eq. (6). Thanks for detecting this error. In Eq. (6), the SWI value has to be weighted by the relative root fraction at depth dLi. Moreover, a critical water content value is used when F2 is applied to the parameters of the photosynthesis scheme (see Response 5).

1.8 [It is also well known that when the upper soil layers dry out, the transpiration rate is sustained by increased water uptake in the lower layers (Jarvis 2011). Maybe it's for this reason that the simplest model (FR-2L) performs as well as DIF1 and 3, and better than DIF2 (Lines 27-28page 5433)? I suggest to critically discuss the assumption of the model.]

RESPONSE 8

The correct equation (6) is taking into account the distribution of root density. This allows the lower layers to sustain the transpiration rate to some extent when the upper soil layers dry out. However, one may emphasize that the approach used in this study to simulate the root water uptake is relatively simple and may not be relevant to represent what really happens at a local scale. Higher level models are able to simulate the root network architecture and the three dimensional soil water flow (Schneider et al. 2010, Jarvis 2011). Also, the hydraulic redistribution of water from wetter to drier soil layers by the root system (hydraulic lift) is not simulated in this study. Siquiera et al. (2008) have investigated the impact of hydraulic lift using a detailed numerical model and showed that this effect could be significant.

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Schneider, C. L., Attinger, S., Delfs, J.-O., and Hildebrandt, A.: Implementing small scale processes at the soil-plant interface – the role of root architectures for calculating root water uptake profiles, Hydrol. Earth Syst. Sci., 14, 279–289, 2010.

Siqueira, M., Katul, G., and Porporato, A.: Onset of water stress, hysteresis in plant conductance, and hydraulic lift: Scaling soil water dynamics from millimeters to meters, Water Resour. Res., 44, W01432, doi:10.1029/2007WR006094, 2008.

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1.9 [L.23 Page 5424: remove the two ",".]

RESPONSE 9

Yes. The two "," will be removed.

1.10 [L.16-18 Page 5426: remove the part in the parenthesis. As it is the sentence is confusing.]

RESPONSE 10

Yes. The part in the parenthesis will be removed.

1.11 [Additionally, are these results of the model, or are they assumptions. In the latter case, how are they implemented in the model?]

RESPONSE 11

See Response 5.

1.12 [L.9 page 5430: write "capillary" instead of "capillarity"]

RESPONSE 12

Yes. This will be done.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 5421, 2014.