**Response to the editor**

The authors' response to the comments of the three anonymous referees has been published on the HESSD web site.

The very in depth and interesting discussion and the many points brought forward by the referees will lead to an improvement of the manuscript. The authors would like to submit a revised version of the paper for final publication in HESS.
We have made substantial changes. In particular, the objectives of this study and the modelling approach are now better described. The Discussion Section was largely revised.
All changes relative to the published HESSD paper are detailed in the pdf of the new manuscript. They include all the response elements given by the authors in response to the reviewers' comments (yellow, blue, and gray for Reviewers 1, 2, and 3, respectively).

Figures

New Figure 3.

Tables

New Table 1.

Supplement

A supplement including a new Figure is now attached.

References

Twelve additional references were added.

Sincerely,
JC Calvet, N Canal.

# Response to Referee #1

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 $CO_2$ 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 ($g_m$) and the maximum leaf-to-air saturation deficit ($D_{max}$). 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.

REFERENCES

Jarvis, N. J.: Simple physics-based models of compensatory plant water uptake: concepts and eco-hydrological consequences, Hydrol. Earth Syst. Sci., 15, 3431–3446, 2011.

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.

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.

# Response to Referee #2

The authors thank the anonymous Referee #2 for his/her review of the manuscript and for his/her helpful comments.

2.1 [The topic of this paper is of central interest to the hydrological community, as models for predicting yield are used frequently, and how to best account for root water uptake is still unclear.]

RESPONSE 1

Thanks for this positive comment.

2.2 [GC1 - To me the motivation and the message of the paper are unclear. Why is this investigation important and which additional information does it provide beyond CA12? I understand that CA12 showed that the maximum available soil water content (max- AWC) was an important parameter in the model. Possibly, this motivated the idea that below ground processes may need to be represented in a more processes based manner? Any linking statement would be helpful.]

RESPONSE 2

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 modeled above-ground biomass 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. These motivations will be clarified in the Introduction part of the paper.

2.3 [Also, quite early in the paper in becomes clear that data on soil properties and rooting depth (defining maxAWC, eq. 4) can not be obtained at the scale at which statistical data are available. I am wondering whether this dataset was then at all suitable to address the research question? Could you comment why it is better to use this instead of other data sets? Maybe it is related to the scale, at which is model is supposed to predict?]

RESPONSE 3

So far, the French annual agricultural yield data are publicly available at the département scale, only. In order to take advantage of the existing information on soil properties, an option 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). Since these products are now available at a global scale, the methodology explored in this study over metropolitan France could be extended to other regions. 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 an 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).

REFERENCES

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-soil-database/HWSD_Documentation.pdf

2.4 [GC2 - I found it difficult to understand whether the envisaged application of the model is in (yield) prediction or in learning about soil/rooting properties? This is of importance for evaluating the suitability of the methods. The model was fit to the observation and afterwards the quality of the (same) fit was interpreted to judge whether one modeling scheme was better suited than another. If the model is intended to predict yield: I would generally assume that such a comparison can only be done on a validation period, i.e. comparing the model to data for a forward simulation, not for the period used to find the best parameter fit. If the model is intended to infer max AWC: I would have assumed that soil data are collected and presented. A discussion of the intended purpose of the model and how this paper adds to this is needed.]

RESPONSE 4

The ISBA-A-gs model is intended to bridge the gap between the terrestrial carbon cycle and the hydrological simulations (e.g. river discharge). In previous works, the ISBA-A-gs model was coupled with hydrological models able to simulate river discharge (e.g. Queguiner et al. 2011, Szczypta et al. 2012). While simulating vegetation requires a good description of the soil water stress, hydrological simulations are sensitive to changes in the representation of the surface water and energy fluxes. The latter are controlled to a large extent by vegetation. In Ca12, an effort was made to benchmark two options of the vegetation model (drought-avoiding vs. drought-tolerant). In this study, an effort was made to benchmark several options of the soil hydrology model.

ISBA-A-gs is not a crop model and does not predict yield per se. 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). Since several options could be envisaged to implement the DIF simulations, a side objective objective of this study was to benchmark these options at a regional scale and learn about the root water uptake.

2.5 [GC3 - When comparing the model to the observation, extra information is needed. Presented is only the correlation coefficient and whether it is significant. This does not inform the reader about a potential bias, which would better help to evaluate the results (see for example Gupta et al., 2007)]

RESPONSE 5

The quantitative consistency between the simulated biomass and the agricultural statistics was extensively discussed by Ca12 (Sect. 3.3 and Figs. 12 and 13 in Ca12). For cereals, they considered the ratio of crop yield to the maximum above-ground biomass, called the harvest index. The later ranged between 20% and 50% and this was consistent with typical harvest index values given by Bondeau et al. (2007) for temperate cereals. The same result is obtained in this study (not shown). For grasslands, Ca12 simulated both managed and unmanaged grasslands. For managed grasslands, DMY was explicitly simulated and ranged between 0.1 and 0.8 kg m-2. The scatter of the simulated DMY was relatively small, with a standard deviation of differences with the Agreste DMY of 0.20 kg m-2. ISBA-A-gs tended to slightly underestimate DMY values, with a mean bias of -0.08 kg m-2. For unmanaged grasslands, the simulated Bag was 0.17 kg m-2 higher than the Agreste DMY values, on average. In this study, unmanaged grasslands were considered, only, and results similar as those of Ca12 were found (not shown).

REFERENCE

Bondeau, A., Smith, P. C., Zaehle, S., Schaphoff, S., Lucht, W., Cramer, W., Gerten, D., Lotze-Campen, H., M¨uller, C., Reichstein, M., and Smith, B.: Modelling the role of agriculture for the 20th century global terrestrial carbon balance, Global Change Biol., 13(3), 679–706, 2007.

2.6 [GC4 - The discussion does not present much interpretation and implications of the results, much of it reads like the continuation of the results section (for example section 4.2). At the same time some issues are not discussed at all. For example, the representation of root water uptake in eq. 5 is known to reduce uptake too early when top soil dries out (Feddes et al. 2001), which may explain some of the results. A discussion of this would definitely improve the paper. Also, a discussion of what this paper adds to the very strongly related earlier paper CA12 is needed.]

RESPONSE 6

Yes, we agree. The Discussion section of this paper needs to be improved. The responses to the referees' comments will be incorporated into the Discussion section of the final version of the paper.
Section 4.2 was placed in the Discussion section as we considered that the impact of the representation of photosynthesis on the results was a side objective of this work.
Contrary to Feddes et al. (2001), the root water uptake in ISBA-A-gs is driven by soil moisture, not by soil water pressure head. We use a more refined representation of the soil water stress function, in relation to key photosynthesis parameters (see the response to Referee #1 comments). The impact of the shape of the root density is discussed in Sect. 4.1. It is showed that the top soil layers dry out first (through SWItop at $d_L$ = 0.46m), and the consequence is an earlier senescence than for a control simulation with a uniform root profile (DIF1-Uniform). It must be noted that Fig. 10 shows that root water uptake is reduced earlier with FR-2L than with DIF1, in relation to a faster plant growth in the FR-2L simulation. For C3 crops, a drought-avoiding response to soil water stress is simulated, triggering an increase in WUE (and in the plant growth rate) as soon as theta < theta_fc. Since the DIF1 simulations tend to accumulate water above the field capacity (i.e. theta remains longer above theta_fc than for FR-2L), the increase in WUE tends to occur later than for FR-2L.

2.7 [GC5 - Please add a table stating the abbreviation to improve navigation through the manuscript.]

RESPONSE 7

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

2.8 [DC1 - abstract: There is a discrepancy between the stated aim of the paper and the formulated take home message. The title suggests that root water uptake schemes are tested, the abstract states that both different representation of the soil (including soil hydrology) are tested together with different uptake schemes. But no conclusion is stated concerning whether or not any of those schemes was better suited than the other. It only states than within one scheme there were differences regarding the representation of additional layers below the rooting zone.]

RESPONSE 8

The following sentence could be added to the abstract:
A rather neutral impact of the most refined versions of the model with respect to the simplified soil hydrology scheme is found. This shows that efforts should be made in future studies to reduce other sources of uncertainty e.g. using a more detailed soil and root density profile description together with satellite vegetation products.

2.9 [DC2 - p5426, L15-19: I feel this explanation cannot be understood by the general audience.]

RESPONSE 9

Yes. The following sentences “For moderate soil water stress, the drought-avoiding (drought-tolerant) response results in the increase (decrease or no change) of the Water Use Efficiency (WUE). In the drought-tolerant response, WUE does not change or decreases” could be simplified and replaced by:
“For moderate soil water stress, the drought-avoiding response results in the increase of the Water Use Efficiency (WUE). In the drought-tolerant response, WUE does not change or decreases”.
Moreover, a Supplement could be added to the final version of the paper in order to better describe the photosynthesis model.

2.10 [DC3 - p5428, Eq. 2,3: I do not understand what you mean by w(dL) as opposed to wtop(dL)? Therefore, I do not understand the difference between the equations. Also, consider using "theta" for volumetric water content.]

RESPONSE 10

Yes, "theta" could be used for volumetric water content.
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.

2.11 [DC4 - p5429, L1: Do you mean “soil water content” instead of “soil water column”]

RESPONSE 11

Yes, we agree. We will replace the term “soil water column” by “soil water content”.

2.12 [DC5 - p5430, L24: an instead of a for “an hourly basis”]

RESPONSE 12

Yes, it will be done.

2.13 [DC6 - p5431, L12-14: Please state, what was done with these data points, were they removed? Do you mean “not considered [i.e. removed], in order to be consistent .. “]

RESPONSE 13

This sentence : "In the case of crops, *B*ag values after 31 July are not considered, to be consistent with the theoretical averaged harvest dates in France." could be replaced by "In the case of crops, simulated *B*ag values after 31 July are not considered, in order to be consistent with the theoretical averaged harvest dates in France."

2.14 [DC7 - p5436, section 4.1: It would be good to answer explicitly the question stated in the title. Also, this is the main question of the paper and it deserves more in depth discussion of the pros and cons of this model, making use of the available literature (good start would be looking into those citing the very relevant paper by Feddes et al 2001).]

RESPONSE 14

Yes, more elements of discussion about the question stated in the title will be added. A special attention will be made with the literature that can be found in Feddes et al. (2001). In particular, 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.

REFERENCES

Jarvis, N. J.: Simple physics-based models of compensatory plant water uptake: concepts and eco-hydrological consequences, Hydrol. Earth Syst. Sci., 15, 3431–3446, 2011.

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.

2.15 [DC7 - p5436-37, section 4.2: This section reads much like a results section. What is the interpretation of those results? Also, with “vegetation canopy” you probably mean vegetation type (crops and grassland)? It would be easier to understand, since the canopy was not much referred to in the rest of the paper.]

RESPONSE 15

For the sake of clarity, the title of Sect. 4.2 could be replaced by: "Have changes in the representation of photosynthesis an impact on the model performance ?". An introduction sentence could be added: "In this section, the impact of the revised vegetation radiative transfer scheme and refreshed gm parameter (DIF1-NRT experiment) is discussed.".
See also Response 6.

2.16 [DC8 - p5437-38, section 4.3: Title: Can you be more specific than using model “use” – do you mean model prediction? Much of this section (p5437,L17-p5437, L11) reads like results and should be moved to the results section.]

RESPONSE 16

Yes, part of Sect. 4.3 could be moved to the results section.

The title of Sect. 4.3 could be reworded as : “Can the ISBA-A-gs model predict the relative gain or loss of agricultural production during extreme years?

2.17 [DC9 - p5438-39, section 4.4: The title states an interesting question: How to better constrain MaxAWC at different scales? But I see this question only addressed in a half sentence (stating that the resolution of the database is too coarse). Other comments, such as on radiation, do not match the heading of the section. It would be good to have a more encompassing discussion of this issue here, since it is important.]

RESPONSE 17

Yes, title of Sect. 4.4 is confusing. One could remove "at various scales" from the title.

2.18 [DC10 - p5439, L1: Something went wrong with this sentence, the SAFRAN seems misplaced or needs to be explained.]

RESPONSE 18

Yes, "is SAFRAN” should read "in the SAFRAN atmospheric analysis".

# 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" 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 pedotransfer 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

Kuppel, S., Peylin, P., Chevallier, F., Bacour, C., Maignan, F., and Richardson, A. D.: Constraining a global ecosystem model with multi-site eddy-covariance data, Biogeosciences, 9, 3757–3776, 2012.

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 variables, 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.