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Geoscientific Model Development Discussions

Interactive comment on "Use of agricultural statistics to verify the internannual variability in land surface models: a case study over France with ISBA-A-gs" *by* J.-C. Calvet et al.

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Reviewer #2

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

2.1 [Limited Sensitivity Analysis – The authors conducted a preliminary sensitivity analysis to identify which parameters to tune in order to optimize R2 to yield data at each site. However they chose to do this only for a single region with a single crop – Rye– which yielded the best R2 using default parameter values. They do not justify why this particular crop and region were chosen and do not discuss the possibility that parameter sensitivity would vary as a function of vegetation type, crop type and/or region. Furthermore they conducted a one-at-a-time sensitivity analysis, which fails to capture interactions among model parameters. While a more sophisticated sensitivity analysis examining interactions may be beyond the scope of the study, the limitations of the approach used should be discussed more thoroughly and the specific region and crop chosen should be justified.]

RESPONSE 2.1 Yes, we agree that a more sophisticated sensitivity analysis would have been of interest. However, such a complex analysis would have been beyond the scope of this paper. The advantage of the simple sensitivity analysis performed in this study is that a rather straightforward interpretation can be made. In order to illustrate better the role of key model parameters, a parameter sensitivity study for two contrasting sites, presenting markedly different optimum MaxAWC values, will be included in the final version of the paper. Also, the impact of using sub-optimal gm or MaxAWC parameter values will be shown.

2.2 [Tuning one feature of the model at the possible expense of other features – In addition to altering the character of interannual aboveground biomass yield variability, the two parameters tuned affect the mean level of aboveground biomass as well. For instance, it can be seen from Figs 7 and 8 that the reducing MaxAWC from 200mm to 50mm leads to an overall reduction of mean aboveground biomass on the order of 35% (from 1.5 kg/m2 to 1 kg/m2). Given that the authors find variation in the optimal MaxAWC value across sites for the same vegetation and crop types, an obvious question is whether the optimized parameters improve the model's correlation to the geographic pattern of mean yield statistics. If this metric also improves, then a stronger case could be made that the model is capturing a meaningful feature of agricultural yield variability (explaining both temporal and spatial yield variability).]

RESPONSE 2.2 Yes, MaxAWC impacts the mean above-ground biomass. In the case of forage pea and grasslands, investigating the impact on the year-to-year spatial correlation of using optimized parameters instead of median values could be instructive

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and the results of such an analysis will be discussed in the final version of this paper. In the case of cereals, such an analysis would be less relevant since six cereal types are considered (i.e. winter wheat, rye, winter barley, spring barley, oat, triticale, in this study), and the highest temporal R2 at a given location is used, implying that the considered cereal type varies from one administrative unit to another.

2.3 [Use of modeled benchmarking data for grasses but not crops calls into question conclusions regarding differences in the model's ability to capture crop vs. grass interannual variability – Very different sorts of data are used to benchmark crops vs. grass yields. It is not clear to what extent the better model fit to grass data is a function of the nature of the data itself. In particular shared model biases could contribute to improved fit for grasses. A better case should be made for why comparison to ISOP data is useful and why crop and grassland R2 values are not directly comparable.]

RESPONSE 2.3 Indeed, the better model fit to grass data may be due to the fact that the crop and grassland reference data are not directly comparable, since a model (STICS) is used to produce the ISOP fodder production index (see Response 1.2 to Reviewer #1). While the Agreste crop yield data are based on harvest observations, estimating the fodder production or the productivity of pasturelands is more challenging. This is why the ISOP data are used, together with Agreste.

2.4 [Page 1479, line 15: The case is made that due to uncertainty in remotely sensed LAI data, in-situ biomass measurements are needed. However in line 6, three studies are sited that assimilate satellite LAI data. Do these studies suffer from the deficiency in LAI measurements mentioned here? In order to motivate the use of in-situ data in this study, more clarification is needed of when LAI data are useful and when they are not.]

RESPONSE 2.4 The cited LAI assimilation studies (Sabater et al., 2008; Albergel et al., 2010; Barbu et al., 2011) were performed at the local scale, for an unmanaged grassland site. All of them show that representing LAI observation errors is not easy. Barbu

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et al. (2011) conclude that for LAI values higher than 2 m2m-2, the LAI observation error is proportional to the LAI value. Therefore, at high LAI values, LAI observations are more uncertain. These uncertainties can be handled by assimilation systems able to sequentially analyse soil moisture and LAI from a daily to a 10-day basis, and LAI data are useful in all conditions. However, independent biomass estimates are needed to verify the model parameter mapping and its impact on the interannual variability of the simulated vegetation biomass.

2.5 [Page 1481, line 1: It would be useful to state more specifically how the photosynthesis parameterization differs from the standard Farquhar model?]

RESPONSE 2.5 This sentence could be rephrased as: "This parameterization is derived from the set of equations commonly used in other land surface models (Farquhar et al., 1980 for C3 plants and Collatz et al., 1992 for C4 plants), and it has the same formulation for C4 plants as for C3 plants, differing only by the input parameters. Moreover, the slope of the response curve of the light-saturated net rate of CO2 assimilation to the internal CO2 concentration is represented by the mesophyll conductance (gm). Therefore, the value of the gm parameter represents the activity of the Rubisco enzyme (Jacobs et al., 1996), while in the Farquhar model, this quantity is represented by a maximum carboxylation rate parameter (Vc,max).".

2.6 [Section 2.3.2: It is not clear from this section whether the Agreste data, the ISOP data or both will be used for benchmarking. It would be helpful to discuss the advantages or disadvantages of using one vs. the other and explain why the authors chose to use both.]

RESPONSE 2.6 Yes. It will be mentioned that both Agreste and ISOP were used to assess the ISBA-A-gs simulations. The advantage of the Agreste data is that they are produced by local experts, and Ruget et al. (2006) used this independent bottom-up information to validate the ISOP product for the 1982-1998 period (for more recent years, the two products are not independent as the local experts contributing to Agreste had

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access to ISOP). They found that the consistency between the two fodder production estimates varies a lot from one region to another (R2 varies from 0 to 0.6). The two products present shortcomings: (1) although the STICS model used to produce ISOP was calibrated and validated by Ruget et al. (2006) using five INRA grassland test sites, mapping the numerous STICS parameters is not easy, (2) the Agreste fodder production is much less accurate than the crop yield estimates. Indeed, most of the French fodder production is used on-site, and the limited commercial exchange of fodder is detrimental to the quantitative monitoring of the grassland productivity. Since the two products present advantages and disadvantages, both were used in this study.

2.7 [Page 1485, lines 6,7: Are the values chosen for MaxAWC and gm realistic? A discussion is needed of how these ranges were chosen and why.]

RESPONSE 2.7 The chosen MaxAWC and gm values explore the variability around the default values used in ISBA-A-gs for both C3 crops and C3 grasslands (129 mm and 1 mm s-1, respectively). Regarding the MaxAWC values for crops, Cabelguenne and Debaeke (1998) indicate that, at the field scale, the highest values may range between 230 mm and 350 mm. At the scale of an administrative unit, various soil types can be found and the average MaxAWC value is expected to be lower than the highest values observed a the field scale. Therefore, using 225 mm s-1 as the highest MaxAWC value, at the département level, seems reasonable. In the final version of the paper, higher MaxAWC values will be investigated in the sensitivity study. REFERENCE Cabelguenne, M., and Debaeke, P.: Experimental determination and modelling of the soil water extraction capacities of crops of maize, sunflower, soya bean, sorghum and wheat, Plant and Soil, 202, 175-192, 1998.

2.8 [Page 1485, line 8: A discussion of the method used to find the optimal parameter values at each site should be included here. It is not clear from the present description why the simulation was repeated 48 times at each site with the various parameter values described. Since the goal is to optimize R2 at each site, that goal should be stated in the methods.]

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RESPONSE 2.8 Yes. The following sentence could be added in Sect. 2.4: "Performing 48 simulations for each site permits to combine various MaxAWC and gm values. Selecting among the 48 simulations, the simulation presenting the best correlation between the annual maximum aboveground biomass and the agricultural statistics, permits to determine the optimal MaxAWC and gm values at each site".

2.9 [Page 1485, paragraph beginning at line 20: The analysis presented in this paragraph seems arbitrary and doesn't flow well with the rest of the paper, partly because results are being presented in the methods section. Figure 4 is mentioned but not discussed. Its relevance to the analysis presented elsewhere is not clear. It is not clear why the values of MaxAWC are set at their specific levels and why they differ for crops and grassland? It is also not clear why non-default values are chosen for the gm parameter for grasslands? Why does the gm parameter differ between managed and unmanaged grasslands? Why is this single province chosen? I would recommend relocating and revamping this whole paragraph so that the methodological choices are explained better and results are tied into the broader objectives of the paper or dropping it along with Figures 4 and 5.]

RESPONSE 2.9 Yes, the objective of Figs. 4 and 5 is to illustrate how the Bag variable is simulated, using the median gm and MaxAWC retrieved values of Table 2. The Puy-de-Dôme département was chosen as for this region, both crops and grasslands are present, and, also, because highly significant correlations are obtained. These Figures could be discussed in the Discussion Sect. 4.1.

2.10 [Page 1486, lines15-20: The beginning of this paragraph describes the methods for the preliminary sensitivity analysis. It would make more sense to describe these methods in the methods section before describing the method used to find the optimal values for the two parameters chosen.]

RESPONSE 2.10 Yes. A specific "sensitivity analysis" Sect. 2.5 could be added.

2.11 [Page 1487, line 27: Figures 9 and 10 add little information beyond table 2 except for showing the spatial pattern of R2 significance. However the spatial pattern is not discussed. If the spatial pattern is not important to the objectives of the paper these figures could be dropped. Otherwise the significance of the pattern should be discussed.]

RESPONSE 2.11 Yes. More discussion is needed about the (lack of obvious) spatial patterns in Figs. 9-10. More often than not, sites presenting contrasting R2 significance levels are found in the same regions. There is no specific region presenting systematically poor or high R2 values. This is a positive result as it shows that there is no regional specificity in the quality of the agricultural statistics, nor in the model simulations. However, it must be noted that for cereals, significant negative correlations are found for 6 sites mainly located in northeastern France (02-Aisne, 18-Cher, 39-Jura, 51-Marne, 55-Meuse, 60-Oise), and only 1 site (02-Aisne) for forage pea. Figure 1 will be upgraded in order to indicate the location of the administrative units which are discussed in the paper.

2.12 [Section 4.1: The change in the number of sites with significant R2 values is used as a metric to judge the sensitivity of model fit to fixing versus optimizing the two model parameters MaxAWC and gm. For croplands, a high sensitivity is found but for grasslands a large number of sites are significantly correlated to the model regardless of whether MaxAWC is held constant or set at its site-specific optimal value. The authors conclude that croplands are more sensitive than grasslands to the value of MaxAWC and go on to draw conclusions about the differences between cereal versus forage pea crops and between managed versus unmanaged grasslands. However, the metric based on the number of significantly correlated sites ignores changes to the R2 value obtained by fixing versus holding the MaxAWC value constant. As can be seen from table 2, the improvements in R2 among the significantly correlated sites going from fixed gm and fixed MAXAWC to fixed gm with optimal MaxAWC (from the 2nd last to 3rd last row of table 2) is similar for cereals and unmanaged grasslands (about 0.1 improvement in R2). Examining the change in R2 tells a different story

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than the number of significant sites. Thus, while the model describes some amount of the interannual variance in grassland yields regardless of whether MaxAWC is fixed or varied, a seemingly significant additional amount of variance is described with the optimal MaxAWC values. Through this lens, the model is just as sensitive to MaxAWC for unmanaged grasslands as cereals and the conclusions drawn from this section are incorrect.]

RESPONSE 2.12 Yes. The following could be added to Sect. 4.1: "However, using the change in the number of sites with significant R2 values as a metric to judge the sensitivity of model fit to optimizing vs. fixing the two model parameters MaxAWC and gm is not sufficient (especially for MaxAWC which has the largest impact). Table 2 presents, also, changes to the R2 value obtained by optimizing MaxAWC vs. holding its value constant. It can be seen that the improvements in R2 among the significantly correlated sites going from fixed gm and fixed MaxAWC to fixed gm with optimal MaxAWC is similar for cereals and unmanaged grasslands (about 0.1 improvement in R2). Thus, while the model describes some amount of the interannual variance in the grassland yields regardless of whether MaxAWC is fixed or varied, a seemingly significant additional amount of variance is described with the optimal MaxAWC values, at least for unmanaged grasslands". It must be noted that this remark does not question the conclusions made for the comparison of cereal versus forage pea crops and of managed vs. unmanaged grasslands.

2.13 [Section 4.2 – It is also likely that features of crop production not explicitly represented by the model are changing over time and this contributes to the poor R2 values for crop sites. Some of these limitations are listed in the intro on page 1480, line 7 and the poor fit of the model to crop sites is not surprising given these issues. The discussion in this section would benefit from mentioning these limitations. As it is currently written, this section seems to attribute the poor fit for some crop sites solely to geographic variability within departments.]

RESPONSE 2.13 Yes. The following sentence could be added to Sect. 4.2: "Apart

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from the geographic variability within départements, it is also likely that features of crop production not explicitly represented by the model (see Sect. 1), are changing over time and this contributes to the poor R2 values for crop sites.".

2.14 [Page 1490, line 6: Presumably soil type varies among grasslands as well. Do the authors mean to say that there is more variability of soil type among crops? If so, this needs to be clarified. If not, variation in soil type would not explain why crops are more heterogeneous than grasslands.]

RESPONSE 2.14 The following sentence could be added to Sect. 4.2: "It is likely that the impact of soil type variability is probably more acute for crops than for grasslands, especially managed grasslands (see Sect. 4.1)".

2.15 [Page 1492, line 10: Do the authors mean to say that the sitting of croplands on better soils explains 1) why MaxAWC is lower for grasslands within the INRA data or 2) why the optimized model estimate of MaxAWC falls at the lower end of the INRA range for grasslands. 1) makes sense but 2) does not. From the language it is unclear which is meant.]

RESPONSE 2.15 The 8km x 8km sites, although presenting a large fraction of either C3 crops or grasslands (at least 45% of the ECOCLIMAP-II grid-cells) are not homogeneous, and the three INRA MaxAWC categories may correspond to any kind of vegetation type. Table 4 shows that the optimized model estimate of MaxAWC falls at the lower end of the INRA range for grasslands. This is consistent with the lower grassland site MaxAWC within the INRA data, for the three categories.

2.16 [Fig 7 and 8: The vertical axes are not equal on all figures which masks the effect of changing MaxAWC on the mean aboveground biomass yield.]

RESPONSE 2.16 Yes, these Figures will be redrawn.

2.17 [Technical comments]

RESPONSE 2.17 These editorial issues will be addressed when preparing the final

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version of the paper.

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