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Interactive comment on "Calibration of the Crop model in the Community Land Model" *by* X. Zeng et al.

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We thank the referee for carefully reading the paper and for their suggestions. We have addressed all their comments and we hope that the referee will find satisfactory our point-by-point responses and changes discussed below. A revised manuscript will be uploaded shortly in the GMD system.

-the corresponding authors

Comment: This paper describes the use a well-established calibration method to adjust 6 parameters of the crop model recently implemented within the Community Land Model. There

is nothing innovative, but it is quite interesting to see how a method much used in the

climate community can be applied for biological processes. The methodology is well described. Nevertheless, I am asking for major revisions because I see at least two main points that are problematic enough:

1) The calibrated parameters impact the growth of soybean, but one of the variables used to tune them, the maximal NEE, is significantly impacted by the previous maize crop through the incorporated residues that lead to a high soil respiration (see e.g. Law et al. 2002 in AFM). Therefore it is not correct to calibrate a model simulating continuous soybean, as the NEE of continuous soybean should be less negative (smaller ecosystem respiration) during the growing season than the NEE of soybean following maize (larger ecosystem respiration), the one used as observation. If the model cannot simulate crop rotation, then the authors should eliminate NEE. This would result in even less observations for relatively a lot of parameters to estimate. I wonder if their number cannot be reduced, and if the authors have tested their independence. Besides, all the calibrated parameters relate to the C/N ratio, but by looking at Fig. 2, the reader might ask why other parameters related to the allocations to different plant parts are not adjusted, as leaves and grains are largely underestimated while the stem is overestimated.

Response: We are aware that NEE is impacted by rotation, which is stated in our discussion as a limitation of this model. However, since crop rotation is not simulated in the model, but widely practiced by farmers, performing calibration with data that included rotation effects on NEE allows us to indirectly include the effect of rotation without accounting for it explicitly. Crop rotation also affects GPP through nutrient availability. We are working to incorporate crop rotation into CLM and we will re-evaluate the calibrated parameters at that time. We have clarified this intent in the revised manuscript. As for looking at other parameters, as we said in our manuscript, there are over 100 parameters that are used to define crop processes in the model. Our choice to calibrate the C/N ratios was to narrow down the scope and focus on the parameters that had the largest influence on carbon and nitrogen allocation to the plant components. We note that in our study we have employed a strategy that is more robust than the ones used in Sus et al., in which case either a Gaussian posterior (Kalman filter) is assumed or only the max a posteriori estimate is computed. To that end, our approach is significantly more complex. In the future we will target other parameters for improvement by refining our statistical approach.

2) Sus et al. (Biogeosciences Discuss., 9, 11139–11176, 2012) found that: “The Bondville data also show that reported sowing of the 2002 soybean crop is clearly delayed due to abnormal precipitation in April–June, which is well reproduced by the MODIS-based model value.” This clearly indicates that the Bondville sowing dates are available, and they should be used, especially for the abnormal year 2002.

Response: We errored in our manuscript when we reported using the Sacks et al. (2010) Crop Calendar Dataset for planting date. We apologize for this mistake; in the calibration procedure, we used the actual planting date for soybean in 2004 as reported on the AmeriFlux webpage (day 127). We have corrected the source of the planting date in the revised manuscript. Since planting date is fixed in the model, this date was also used in the 2002 validation. CLM-Crop is designed as a global model, run at resolutions spanning from tens to hundreds of kilometers. To simplify the planting scheme, but maintain the spatial variability in planting date, the planting date is fixed in each grid cell for each crop type. Planting date is derived from the Crop Calendar Dataset (Sacks et al., 2010), which provides a spatially resolved average planting date for different crop types at a global scale based on statistics and reported values. We are working on a method to vary plant date with climate conditions, which will allow the model to predict planting date constrained by observations (Drewniak et al., 2013). Until this method is refined, we are focusing our attention on calibrating against the slope of the growth curve during the first half of the season and the maximum value of GPP and not the timing of the growth period.

I am asking for redoing the exercise by: 1) removing observations that reflect a situation not simulated by the model (NEE), 2) “possibly” calibrating parameters that allow the

simulation to better fit such an important variable as LAI, and if not possible, discuss this point, 3) using the reported Bondville sowing dates. Besides the point about sowing dates, the Sus et al. paper “A data assimilation framework for constraining upscaled cropland carbon flux seasonality and biometry with MODIS” is certainly worthwhile reading.

Response: (1) Since we cannot simulate crop rotation, we felt the best method to realistically represent crop rotation without explicitly doing so would be to calibrate with NEE, regardless of the influence from residue returns. We did make this point in our discussion that crop rotation would influence the soil respiration. We are actively working to incorporate crop rotation into the model, and at that time we will readdress the calibration to reflect the new management technique. (2) The LAI in the model is based on the amount of carbon in the leaves and a constant specific leaf area (SLA; the ratio of leaf area to dry leaf weight) for each crop type; however, observations show that SLA actually varies throughout the growth season (Tardieu et al., 1999) and with nitrogen fertilizer application methods (Amanullah et al., 2007), causing discrepancies between observed and model-simulated LAI. To allow varying SLA with growth period would be difficult, because this requires detailed knowledge of how SLA responds to climate for each crop during each growth phase. As we stated in the paper, there are over 100 parameters in the model that define crop processes; we could not perform a full calibration of all the parameters so we narrowed the focus to the parameters that had the most influence on crop development. (3) We did use the actual planting dates for soybean for the year 2004, we apologize for the mistake in reporting the use of the Sacks et al. (2010) Crop Calendar Dataset.

Detailed comments:

Comment: From the abstract it looks like that the calibration is done for wheat, maize, and soybean. Then the 1st section speaks about maize and soybean at two sites, then only

Bondville data are used, and only for soybean. This should be clear from the beginning.

Response: We apologize for the confusion related to the sites used for calibration. We have updated both the abstract and the introduction to include our use of Bondville data to calibrate soybean parameters. We have also updated the model description to clarify how the Mead data was used. Our intention mentioning the Mead site was to describe the source of the original parameter values used as our best guess estimate. Parameters in the first version of CLM-Crop described by Drewniak et al. (2012) were calibrated against both Bondville and Mead, however, the calibration was simplistic. The method involved varying each parameter individually until optimized values for each parameter were determined in order to match the curve of the carbon biomass for both Mead (whole plant) and Bondville (plant component) sites. The significance is these parameter values are used as our "best guess" estimate of the six parameters included in the calibration study (indicated by the solid black line in Fig. 1). This study calibrates the same model parameters, but since we had more observation data at the Bondville site, we chose that site for our calibration procedure.

Comment: p. 381: l. 3-5: soil nitrogen seems to be the only limiting resource considered. What about water? Does it mean that these crops are always irrigated? This must be clarified. In fact it is said below (p. 385 l. 20) that irrigation is uncertain, and Mead is a rain-fed site. (Only later we understand that the Mead site is not used, so what is the point to tell that?)

Response: p 381, l 3-5 does not refer to nitrogen, perhaps you are referring to p. 383? While hydrology does play a role in crop development, the parameters related to water uptake are beyond the scope of this paper and not considered in this analysis. Our focus is on the parameters that drive carbon uptake through CN ratios, since those have the largest influence on productivity. Crops are not irrigated in CLM-Crop. The Bondville site is not irrigated so our validation should not be affected by water availability. We have revised the manuscript to clarify that only Bondville was used to calibrate soybean for this study. We mention the Mead site in our description of how the param-

eters in the original version of CLM-Crop were derived.

Comment: p. 381, Equations 1 & 2: it could be useful to precise that leafcn, fleafcn, stemcn, and fstemcn are fixed parameters for each crop type, without that the reader needs to look at the Drewniak et al. paper.

Response: We have clarified these in the revised manuscript.

Comment: p.384: "Although from the literature we have minimum and maximum estimates for some variables, some parameters do not have observed ranges, as they were optimized for use in CLM based on performance.": unclear. Is the word "variables" just another word for "parameters", or do the authors mean variables like e.g. "leaf carbon mass" that can be used for parameters calibration?

Response: Parameters and variables are the same. We have clarified in the revised manuscript that crop parameters are determined from literature when available. For parameters that do not have observations, optimization techniques are used to estimate parameter values based on model performance.

Comment: Table 1: It should be specified that these parameters vary across crop types. At this time of reading, the reader still imagines that the calibration will be done for several crops.

Response: We have revised the text to clarify the parameter vary with crop and expanded the table to list the actual values for soybean, for both the initial estimated values and the calibrated values.

Comment: p.387 l. 8-17: Not all variables of the equations are explained, and not all equations do have a number.

Response: We expanded the text to clarify the meanings of all the variables and fix the equation numbers.

Comment: p. 388, l.11-12: "We generate artificial observations by using the default parameter values and then perturb the parameters". How many perturbations and which level of perturbation (20%, 50% ???)

Response: The parameters were perturbed by 30% using a normal distribution. We updated the text to reflect that.

Comment: l.20. LEAFC, TLAI, etc, should be defined at some point, even if they appear to be self-explaining. For example, what is the difference between LAI and TLAI?

Response: We have modified the text in define all parameters. TLAI is the total leaf area index output in the model, in this case TLAI is the same as LAI. We changed TLAI to LAI in the text and figures.

Comment: Figs 1-2-3: Please specify the location and the crop.

Response: We corrected the text to specify the soybean crop at the Bondville site.

Comment: Figs 2-3: The units are missing. Choose a similar scaling for GPP and NEE.

Response: We have updated the figure to have the correct units and adjusted the scale of GPP and NEE.

Comment: p.389 l. 16-17: The calibrated model outputs are indeed much better, nevertheless the TLAI remains really underestimated. Why is that not discussed?

Response: We will revise the text to reflect the dependence of LAI on SLA (discussed above). SLA is a parameter targeted for improvement in future calibration efforts, however we chose to focus on only the carbon nitrogen ratio parameters for crops in this study.

Comment: p.389 l. 28: "the yearly planting date at global scale is not available". I do not see the point of looking for yearly planting date at the global scale. I find it quite strange that, when getting flux data from the AmeriFlux data over crop sites, you cannot get such critical information like the sowing date. As we see, sowing dates drive seasonality! Indeed, after investigation, I found that such data are available and

already used (see Sus et al., 2012). Beside the sowing date problem in 2002, specific events that have affected NEE that year are described in "Dobermann et al. 2006. Comment on 'Carbon budget of mature no-till ecosystem in North Central Region of the United States'. AFM.", and in the response to the comment.

Response: Our comment related to yearly planting date at global scale refers to our inability to drive the global version of CLM-Crop with evolving planting dates due to lack of data, which relates our models use of fixed planting dates. We have rephrased the text to avoid confusion. Figure 2 clearly shows the planting date used for the calibration procedure is quite reasonable compared to observations, regardless of our reported planting date. Although we did use the actual Bondviille planting date to calibrate the model, our goal with this calibration is to simulate the slope and the peak of observations for GPP, NEE, and plant carbon, not the planting date. Crops in CLM-Crop have fixed planting date; therefore we chose to keep the same planting date to validate for 2002 to ensure our slope and peak show improvement compared to observations. As CLM-Crop is designed to run globally with spatially (not temporally) resolved planting dates, we felt this was an appropriate test of our calibration. We are aware that planting date drives seasonality and are working on developing a predictive planting date Drewniak et al (2013). The event in 2002 which affects NEE is a common occurrence in agricultural fields. Since we are not calibrating our model against this year, rather validating the results, we are not concerned about the impact on our simulation.

Comment: p. 390 l. 2-5: "The uncertainty levels represented by the size of the boxes in Fig. 1 indicate the 50 % spread of the parameter values around the median. We note that the distribution seems to be relatively symmetric, and in general, the relative uncertainty seems to be about the same." What is the point to mention that here?

Response: We agree that this is an inappropriate place for this statement and have moved it to the end of the second paragraph in section 4.2 Calibration using real data.

Comment: p. 390 l. 19-20: "Thus, the model can over- or underestimate the planting date, which, if significant, could influence the growth cycle and resulting carbon fluxes". This is misleading, as the model does not estimate the planting date, but uses a constant prescribed one. The authors use sometimes "sowing date" and sometimes "planting date", which leads to confusion.

Response: We have corrected the text to clarify that the model may plant earlier or later compared to observations. We failed to find any instance where we used the term "sowing date".

Comment: p. 390 l. 22-24: "Crop rotation can modify below-ground carbon and nitrogen cycling that would have an impact on crop productivity through nutrient availability. " This is a very important point, as discussed above. Maize-soybean rotations impact a lot on NEE: the larger biomass of maize residues entering the soil might lead to a large soil respiration next year (see discussion in Bondeau et al., 2007), which reduces the carbon sink during the soybean season.

Response: We agree that crop rotation is important. Since the model cannot simulate crop rotation at this time we tried to include the effects by calibrating against data that includes crop rotation. Allowing crop rotation in the model is an active area of model development that we are contributing. We have revised the text to clarify our intentions.

Interactive comment on Geosci. Model Dev. Discuss., 6, 379, 2013.