Replies to comment by Anonymous Referee #1, 8 September 2020:

My main critique is that it is difficult to understand the impacts of (1) and (3) in particular. I tried to look into the code, but couldn't quite locate (1) and (3). I suggest the authors to make it clear in the code where these implementations are (perhaps mark it) so that I can follow how much the codes were changed relative to the standard. To gauge theimpacts of (1), I would like to see a winter wheat simulation only at the "DE-RuS" site for with and without (1). You could show how much leaf area index, latent heat and sensible heat of winter wheat changes with this assumption. Similarly, to examine the impact of (3), you could do a simulation of sugar beet and Winter wheat at "DE-RuS" (in this case sugar beet will be rotated, which you already did) and a simulation of Winter wheat only at "DE-RuS". You could also show how much leaf area index, latent heat and sensible heat of winter wheat changes if there was no rotation. Additionally, you can check whether rotation has any impacts on the modeled nitrogen leaching and fixation rates.

Thanks for the suggestion, we will provide the source code files that were mainly modified in pdf format with the most relevant code changes marked as supplement.

In Figure 1 we show the individual effect of the winter wheat subroutines (1) and the modified parameters for winter wheat (2), as well as a combination of both. Figure 1 shows the simulation results of the LAI for one winter wheat year at the DE-RuS site, simulated with: the default CLM configuration using the default parameter set – CLM_D_d (red dashed line), the default CLM configuration using the modified parameter set CLM_D_m (orange), the modified CLM configuration using the default parameter set - CLM_WW_d (blue dahed line), and the modified CLM configuration with the modified parameter set - CLM_WW_m (lightblue).

Using only the modified parameter set with the default model configuration (CLM_D_m) resulted in slightly higher LAI values compared to the default model version (CLM_D_d) but did not reach the observed maximum LAI values and the growth cycle duration. The implementation of the winter wheat subroutines using the default parameter set CLM_WW_d led to a more realistic reproduction of the growth cycle duration compared to CLM_D_d. The combination of the modified parameter set the modified CLM configuration (CLM_WW_m) resulted in the most realistic LAI dynamics.

With the implementation of the cover cropping subroutine we present a rather technical solution to consecutively simulate crop rotations, especially those that include two plantations within one calendar year in order to realistically represent cropland sites. In this study, we did not focus on the biochemical benefits of cover crops or crop rotations but agree that this is an interesting area of application for this routine. For the revised manuscript we will add some more plots on the effects of the crop rotation with the modified CLM_WW_CC compared to what is possible with the default model configuration.

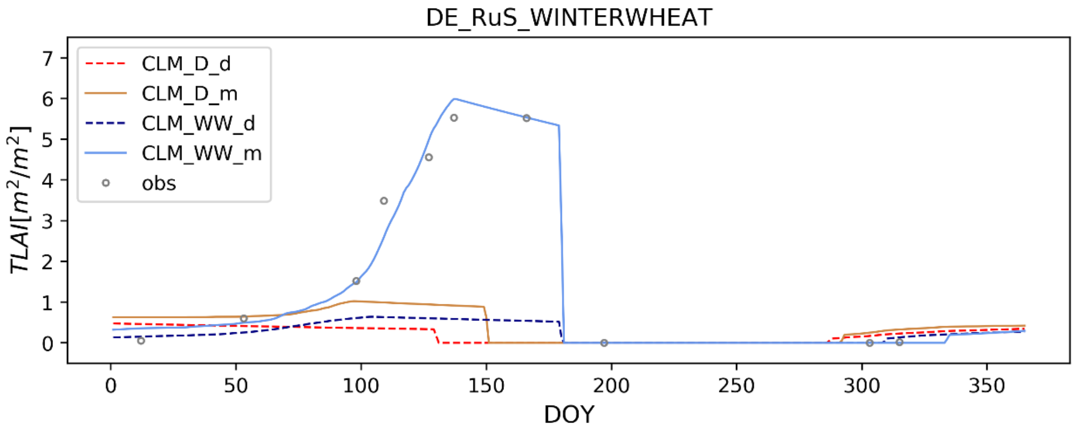

Figure R1: Simulation results of the LAI for one winter wheat year at the DE-RuS site, simulated with: (red dashed line) the default CLM configuration using the default parameter set – CLM_D_d, (orange) the default CLM configuration using the modified parameter set CLM_D_m, (blue dahed line) the modified CLM configuration using the default parameter set - CLM_WW_d, and (lightblue) the modified CLM configuration with the modified parameter set - CLM_WW_m.

Replies to the list of specific comments:

(1) While I appreciate some of the details in sections 2.1, and 2.2.1, it would be appropriate it put most of the text in the Appendix section. For example, the paragraph that starts with the description of the default crop phenology scheme (lines 139 to 152 and additional lines) is not new to this study but rather standard CLM5 documentation notes and therefore, they can be put in the Appendix. Similarly, the section about Winter cereal representation that begins with "Vernalization" is also not new to this study. The default phenology scheme of CLM5 has a Vernalization subroutine.

We agree and we will shorten and reorganize this section accordingly.

(2) The authors emphasize the importance of cash crops (e.g. sugar beets and potatoes). I would like the authors to comment on the spatial coverage of these crops in Germany and whether the famers are smallholder or largescale holder plantation owners. Along similar lines, it would be good if the authors could comment on how they plan to carry out the large scale simulations or regional simulations for these crops given that you need time series information about the rotation of these crops and also that some crops might be planted every two years or so.

We agree and will add additional statements on the local importance of the discussed cash crops in the revised manuscript.

Many thanks for the suggestion. In the revised version we will discuss how large scale simulations could be used to test 'conceptual' cover cropping schemes. For example, the effect of an overall coverage of greening mix during winter months on all crop land units where summer cash crops are planted and that would otherwise be fallow by default during winter. This could also be tested for specific cash crops only. Also it would be possible to simulate cover crop plantations based on harvest date thresholds. Here, a defined maximum harvest date for any specific cash crop could define whether a cover crop such as winter wheat would be planted or not. For example, for all sugar beet land units with harvest dates before a certain threshold (e.g. day 290 of any given year) winter wheat could be planted as a cover crop during winter. If this harvest threshold is not reached and the summer crop is harvested late in the year, no cover crop would be planted. Alternatively, these harvest thresholds could define the type of cover crop, e.g. early harvest - winter wheat, late harvest – simple greening mix, etc.

(3) A number of statements in the results section is difficult to follow. For example, in lines 407 to 412, there is no reference to any figures. What is green leaf area index in line 408? Do you mean before maturity, during maturity or after maturity?

(new line 407-412) For the BE-Lon site, CLM_WW simulated average LAI peak magnitudes, as well as seasonal LAI variations, are close to the observations. An exception is the year of 2015, where unusually high LAI values where observed in May and June, ranging from 5.40 to 6.38 m^2/m^2 (Figure 2). In general, the peak of CLM_WW simulated LAI occurred approximately one month earlier than observed in the field which in turn led to an earlier simulated harvest date of the crop compared to the observed harvest dates (Figure 2, Table 4).

(4) I think the poor seasonal dynamics and low magnitude of the leaf area index in Figures 2-5 of CLM-D could also be related to the parameter values rather than the winter wheat subroutine that was introduced in this study. There are at least 3 parameter values that are considerably different compared to the default parameters of CLM (‘gddmin’,’hybggg’ and ‘graincn’). For example, I see that the default gddmin is 50 in the default but 100 in the modified case (this study). Also hybgdd in the modified case is 30 more than the default. So couldn’t these likely explain poor seasonal dynamics and low magnitude of the leaf area index in Figures 2-5 of CLM-D?

We think this is already answered by Figure R1 where we distinguished the effects of the modified parameter set and the new winter cereal representation, as well as a combination of both.

Replies to the list of minor comments:

(1) In line 70, Bilinois et al. (2015) is cited but I think the reference is missing.

Thanks, we will correct this.

(2) Please provide fractions of sand, silt and clay in Table 2, maybe up to 5 cm or 10 cm?

We agree and will add Table R1 to the revised manuscript.

Table R1: Textural fractions (sand, silt and clay percentages) at the ICOS and TERENO cropland study sites averaged for the upper soil layers (up to 50 cm) with corresponding reference.

Site/ID	Sand [%]	Silt [%]	Clay [%]	Ref.
Selhausen/DE-RuS	16.4	63.4	14.9	Brogi et al. (2018)
Merzenhausen/DE-RuM	16.4*	63.4*	14.9*	-

Klingenberg/DE-Kli	21.5	22.8	55.7	Grünwald (personal communication, 2020)
Lonzée/BE-Lon	5-10	68-77	18-22	Moreaux et al. (2006)

*adopted from the DE-RuS site

(3) While I agree with the statement (line 289) that "CLM5 only permits land use changes at the beginning of every year", users can start a CLM5 simulation in any month the land use change actually happens in real life by performing a 'clear-cut' following spin-up, for example.

Yes, re-starting a simulation at any month is possible in order to change CFT. However, this would require a manual restart at every time the CFT/PFT changes and does not allow a consecutive simulation with flexible land use changes. While this can be done for point cases, it is not feasible for regional scale cases where CFTs might change at different times on different land units.

(4) At the "BE-Lon" site, the LAI curve of winter wheat from DOY= 0 to DOY = 100 seems to have a relatively gradual and smooth growth (Figure 2) while at sites "DERuS", "DE-RuM", "DE-Kli", the growth is relatively sudden and steep during the same period. I would like the authors to provide some explanations for this difference.

We think this is related to the temperature at the BE-Lon site. Here, recorded temperatures very higher in February and allowed for more simulated growth compared to the other sites. We will add a more detailed discussion on this to the revised version of the paper.

(5) In lines 602 to 603, the authors claim that CLM5 does not represent timing of fertilizer. Please provide a citation for this?

Unfortunately, CLM5 is not flexible enough to represent the complex management practices concerning timing and type of fertilization (Lawrence et al., 2018). Fertilization dynamics and annual fertilizer amounts depend on the crop functional types. For all cropping units, mineral fertilizer application starts during the leaf emergence phase of crop growth and continues for 20 days. We will add a short explanation in the revised version of the paper.

(6) In line 603, the authors state that CLM5 does not consider varieties of winter wheat. I agree with this statement but at the same time, many land surface models don't consider varieties or cultivars of crops. Crops can be genetically modified to boost productivity. This means there could large differences in the parameter estimates among varieties/cultivars. The authors could discuss the variation in the parameter estimates if they are measured at their sites.

Thanks for pointing this out. We will add a discussion that the structure of CLM5 allows to include easily more CFTs, e.g. from increasing availability of plant physiological trait information. There is substantial development work being done for CLM in order to include plant trait information, e.g. to allow the prediction of biome boundaries directly from plant physiological traits via their competitive interactions (Fisher et al., 2015).

(7) The authors mention in lines 626 to 629 the following: "There is a tool available for CLM5 that enables the simulation of transient land use and land cover changes (LULCC) (Lawrence et al., 2018). It was designed to simulate and study the effects of changing distributions of natural and crop vegetation, e.g. land use change from forest to agricultural fields (Lawrence et al., 2018), rather than inter-annual changes of agricultural management on crop vegetated

areas." I'm confused about the last part "rather than inter-annual changes of agricultural management on crop vegetated areas". Please explain what do you mean by this? Do you mean you cannot change the Nitrogen fertilization rate from year to year in CLM5?

With this we wanted to emphasize that although this tool allows changes in land use every year (on 1st of January), it does not account for changes happening during the year (e.g. several crop growth cycles or changes from summer to winter crop in fall) or multiple crop growth cycles within one year (e.g. multiple growth cycles of the same cash crop within one year in India due to several monsoon seasons). The annual amount of mineral nitrogen fertilization is assigned by plant/crop functional type and can be changed manually for each year. We will clarify this is the revised version of the manuscript.