Draft manuscript: 'Representation of disturbance in the Joint UK Land Environment Simulator Vn4.8 (JULES)" submitted to GMDD

Response to Reviewer 1

Anonymous Referee #1

Major comments:

1. The section 2 reads like a literature review on the interaction between fire and LULCC and is suggested to be included in the Introduction.

This section was intended to provide some context to the processes of fire and LULCC, so we are happy to include this section in the Introduction. We will rearrange section 1 and 2 to accommodate this change.

2. In the abstract and the context of the paper, the authors used a lot of "up to xx%". I don't think this quantification metric is sound because it stands for the maximum situation. Please use median or mean for the quantification

The comparison we use in the paper is between two different observational datasets, so we don't believe a mean is valid in this case. Instead we will amend the text so that both numbers are referred to rather than using "up to xx%", and hope this satisfies the point.

3. In the paper, the authors used the HYDE data to represent the land-use change. However, the citation of this dataset is not accurate. Please include the original publication of this dataset to appreciate the efforts by the dataset developers. Also, please add the dataset version used in this work and longer description of this dataset. http://themasites.pbl.nl/tridion/en/themasites/hyde/publications/index-2.html

Apologies that this reference was omitted in the manuscript. We will include the original Klein Goldewijk (2011) reference, and add further information on the dataset.

Klein Goldewijk, K. , A. Beusen, M. de Vos and G. van Drecht (2011). The HYDE 3.1 spatially explicit database of human induced land use change over the past 12,000 years, Global Ecology and Biogeography 20(1): 73-86.DOI: 10.1111/j.1466-8238.2010.00587.x.

4. It is not clear to me that the unit of each variables in Eqns. (1)-(8) in the paper. Could you clarify the unit of each variable in the revision and make sure the the unit is consistent between the left-hand and right-hand of equations?

We thank the reviewers for making this important point. We will include an additional table in the 'Model description and developments' section to give all the units used in the equations.

5. Page 6, lines 16-17, the authors calculated the litter due to land-use change* from *the previous time step. What is the time step of the model? Since the land-use change is yearly data, how do you incorporate the land-use change data in the model?

The agricultural land fraction is altered annually, but the dynamic vegetation updates on a 10 day-timestep. Thus the grasses within the agricultural fraction, and all vegetation outside of the agricultural fraction, update on this timestep according to competition and disturbance as described in the paper. We will include additional text in the 'Model description and developments' section explaining that the vegetation is updated on a 10-day timestep to clarify this.

6. Page 7 line 4, the authors noted the model version of JULES as Vn4.9 but the model version in the title of the paper is Vn4.8. Please correct one of them to be consistent.

Apologies for the confusion in the version numbers. The title refers to the version of code where these changes were implemented (Vn4.8), but the model set up we used for this analysis was the most up-to-date version available at the time, which was then Vn4.9. We will amend the title to Vn4.9 for consistency.

7. Page 7 Line 18, what does the TRENDY stand for?

TRENDY is not a direct acronym, but refers to a carbon cycle model intercomparison project exploring 'Trends in net land atmosphere carbon exchanges', as outlined on a number of project websites:
http://www.globalcarbonatlas.org/en/content/land-models
http://dgvm.ceh.ac.uk/

and referred to in a number of papers including:

Liu, Z., Ballantyne, A., Poulter, B., Anderegg, W., Li, W., Bastos, A., and Ciais, P. (2018) Precipitation thresholds regulate net carbon echange at the continental scale. Nature communications, 9, 3596 DOI https://doi.org/10.1038/s41467-018-05948-1

Matthew Cervarich, Shijie Shu, Atul Jain, Almut Arneth, Josep Canadell, Pierre Friedlingstein, Richard A Houghton, Etsushi Kato, Charles Koven, Prabir Patra, Ben Poulter, Stephen Sitch, Beni Stocker, Nicolas Viovy, Andy Wiltshire, Ning Zeng (2016) The terrestrial carbon budget of South and Southeast Asia. Environmental Research Letters 11, 105006, 19 October 2016. DOI:10.1088/1748-9326/11/10/105006.

We will add a short definition to the text to clarify.

8. The authors emphasized that they made an attempt to improve JULES by including EXPLICIT representation of fires and land-use change. Also they mention "Previously in JULES, fire disturbance has not been represented as a separate process, but included in a generic large-scale disturbance term as a spatially-constant turnover rate" (in Page 2, lines12-14). According to Eqns., the fire disturbance in this work is PFT dependent.
My question is: What is the difference in the impact of fire disturbances on vegetation covers between the explicit PFT-dependent treatment of fire (implemented in this work) and the previous simple treatment with constant disturbance from fires? If you run a new simulation S4, the difference between S4 and SF2 should be able to tell you if there is any improvement of this explicit treatment of fire or not compared with the previous treatment of constant disturbance. Does this explicit treatment of fire disturbance improve vegetation representations through all vegetation types or just within specific vegetation types?

The analysis throughout the paper discusses the impact of adding in explicit fire disturbance in SF2 (fire only) and SF3 (fire with land-use) compared to the standard constant disturbance rate in S2 (no fire, no land-use) and S3 (land-use only), as shown by figure 3, figure 5 (blue vs red bars for fire-only disturbance), and SF2 in Table 3 (fire-only disturbance). We acknowledge that this was not described adequately in the 'Methods' section, so we will update the description to make this clearer as follows:
"JULES was configured to the TRENDY set up (Sitch et al., 2015) using two experiments: S2 = CO_2 and climate forcing (with land-use constant at 1860, referred to as 'No LULCC, no fire'); and S3 = CO_2, climate and land-use forcing, using the standard constant disturbance rate for the purposes of comparison (referred to as 'land-use only'). These two experiment configurations were then repeated including the new explicit representation of fire for SF2 (referred to as 'fire only') and SF3 (referred to as 'land-use and fire')."

9. According to Table SI-4, the burned area and seasonal phase simulated in this work does not have so much difference between S2F and S3F. By visual comparison, I did not see much difference in burned area between S2F and that present in in Figure 2 of Mangeon et al. (2016). You may state this with respect to burned area in the context according to Table SI-4 and Figure 2.

We thank the reviewer for highlighting this important point. We will include the following text in the third paragraph in the 'Results' section to makes it clear that the coupling as described in this paper does not degrade the capability of the model to simulate burnt area as previously presented in Mangeon et al (2016): "it is clear that the integrity of the model to accurately simulate global burnt area (as presented in Mangeon et al, 2016) is preserved through the coupling of fire and vegetation, both with and without land-use". Further, this the first time INFERNO has been assessed using the same NME metrics that have been used to assess the capability of other fire models, which we believe is an important part of this analysis to show how well the model performs in the simulation of burnt area.

10. In Figure 5, what does uncertainty bar stand for? Does that relate the spatial uncertainty? Please clarify.

Yes, this relates to spatial uncertainty in the extent of the PFT cover, as described and shown in figure 4 and again in the Discussion section. We will amend the caption for figure 5 to make this clearer.

11. According to the figure given in the last column of Table 3 (i.e., improvement from control), I figured, for instance for S3, the improvement (%) = \|S3-S2\|/S3x100 (i.e., \|0.6-0.78\|/0.6=0.3). Should the percentage improvement be \|S3-S2\|/S2x100 since S2 is the control simulation? Please clarify this metric in the method section. Also, please calculate statistical significance regarding to this improvement?

We used |S3-S2|/S3x100 in the paper following the published methodology in Kelley et al (2014) as recommended by reviewers for that paper (see published reviewer comments on GMDD https://www.geosci-model-dev.net/7/2411/2014/gmd-7-2411-2014-discussion.html). However we agree that |S3-S2|/S2x100 is the more common method of calculating the percentage improvement, and so will amend the methodology for this paper. We will look into appropriate methods for testing the statistical significance.

12. The color bar of Figure 3 partially appears. Please fix it.

We will amend Figure 3 to fix the colour bar.

13. The font size of figure labels is not consistent (comparing Fig. 4 vs Fig. 5). Please fix it.

We will amend the font sizes in all the figures to be consistent.