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Geoscientific Model Development Discussions

Interactive comment on "Interactive Impacts of Fire and Vegetation Dynamics on Global Carbon and Water Budgets using Community Land Model version 4.5" *by* Hocheol Seo and Yeonjoo Kim

Anonymous Referee #2

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General Comments

This paper is evaluating the impact of incorporating fire and dynamic vegetation in the Community Land Model (CLM). The paper presents a clear description of the impact of including each of these processes by considering the change in burned area, vegetation cover, carbon balances (net ecological production and net ecosystem exchange) and water balances (evapotranspiration, runoff and soil moisture). The structure of the paper is logical and easy to follow.

The method employed for this study is a set of four experiments with and without dynamic vegetation and with and without fire, which seems a valid way of testing the

impact of each of these processes. However, while the paper starts well and includes a good introduction, the model description and experimental design needs more detail, and the analysis is ambiguous in several places. Specific comments on this are outlined below. The experiments here are not particularly novel, with fire and dynamic vegetation having been implemented in this model for several years as cited in the paper, but it is useful to have an evaluation of the impact of both processes as they are both important in land-surface and Earth System modelling. I recommend resubmission subject to addressing the following points.

Specific Comments

1) The BGConly model can be run with and without fire, and the results show that aspects of the vegetation (GPP, NPP, NEP etc, Table 3) are impacted when fire is included. But in the model description it says that the spatial distribution of PFTs is set using satellite data from MODIS and that a whole-plant mortality rate of 2% annually is assumed, rather than being determined by heat stress and fire etc. as it is in the dynamic vegetation model. So presumably the fire effects some aspects of the carbon cycle in the BGConly model, but not vegetation cover? I think this needs some clarification in the model description section – exactly what aspects are modified by including fire in the BGConly model, and what is not. It may be that this process is described in another paper, but it is necessary to understand this for the rest of this paper so it should be outlined here.

2) Related to the previous point, the BGConly-F results (Figure 3) are at one point referred to as 'observations' (line 175). This may be the case in terms of vegetation cover if this is prescribed and not altered by fire, but in the rest of the paper this is one of the experimental runs being evaluated, so it needs to be clearly stated that this exactly the same as the satellite data, both in BGConly-F and BGConly-NF, and it is therefore valid to treat this as observations. The labelling throughout the text is also quite confusing which doesn't help. For example the label 'BGConly' on Figure 3b doesn't specify if this is the fire on or off run, and 'BGConly' is first described as the

non-dynamic vegetation option (line 99) and then later as the impact of fire 'BGConly-F minus BGConly-NF' for figure 6 onwards (line 207).

3) The method for calculating NEP should be included, probably before equation (3) for NEE

4) The GFED3 dataset is used here for evaluating the burned area, but there are more up to date datasets now including small fires such as GFED4.1s. Is there a reason why GFED4.1s was not used here?

5) It seems strange that the original fire model was designed to consider vegetation dynamics (line 69) and the fire model is always run with BGC-DV (line 144), and that it simulates agricultural fire (line 105), but the DV model doesn't include crops (line 162). Presumably the agricultural fire function is only available in BGConly mode? This also needs explaining in the model description. And related, CR (I assume this is crop) is shown in figure 3 but not mentioned at all in the text, and is only available for BGConly so cannot be compared to BGC-DV – why include this if it isn't part of the analysis?

6) ξ is the whole-plant mortality factor for each PFT (Line 120). What are the values of this factor and how is it determined?

7) Line 134 states that 'the final surface conditions should represent those of the year 2000 after running the transient simulation'. This is fine, but line 141 states 'In these simulations, the initial global land state was bare ground. . . and soil conditions. . . were adjusted to those of the year 2000'. Does this mean the initial land state was bare ground at the start of the transient simulation, not reset at 2000? I'm not sure why you would reset vegetation at 2000 after doing a transient run, so this is probably a wording issue, but then why adjust soil conditions to 2000? I would also have expected a spin-up at the beginning considering the initial state is bare soil, to equilibrate soil and vegetation carbon at 1850. What climate is used for this 200-y run, is it a climatology at 2000? I'm not sure that the 200-y simulations result in 'potential land surface conditions' (line 151-152), but rather an equilibrium state?

8) Line 273 states 'We therefore expect that the impact of fire on precipitation would be more significant in BGC-DV than in BGConly because fire directly influences land cover characteristics'; is this the case even though it states prior to this that Li and Lawrence (2017) found that the impact of fire on precipitation is limited? (line 251)? Perhaps they were not using dynamic vegetation, in which case it is worth making this point.

9) Line 214 states that carbon emissions from BGConly and BGC-DV are 'relatively high' but 'fall within the range of previous findings'. However BGConly emissions of 3.4 PgC are not within the range of 1.9-3.0 PgC given.

10) In a few places the text is vague and confusing, and could do with more explanation. E.g.:

Line 15: 'This study shows that inclusion of dynamic vegetation enhances carbon emissions from fire by reducing terrestrial carbon sinks; however, this effect is somewhat mitigated by the increase in terrestrial carbon sinks when dynamic vegetation is not used' – this seems like a circular argument, carbon emissions are either enhanced by DV compared to no DV, or they are reduced by no DV compared to DV

Line 193: 'Areas that experience a higher frequency of fire occurrence have larger vegetation distribution differences, which suggests that fire has an influence on vegetation mortality' – we know that fire influences vegetation mortality, isn't this is point of the paper?

Line 197 'However, there are no marked changes in the fractions of shrubs and deciduous trees in the middle of the ecological succession process with respect to the presence or absence of fire'- Specify that this is global totals, otherwise the following lines seem to contradict this

Line 198-200: 'When fire occurs in a region where shrubs grow, the ratio of shrubland is diminished, but fire increases the ratio of shrubland in regions where trees may evolve from shrubs. In the same way as shrubs, the deciduous trees are increased

or decreased due to fire' – I'm lost as to where and how fire increases shrubs and deciduous trees

Technical Corrections

1) Clarify labels for BGConly (see point 2 above)

2) Line 150 says CRU-NCEP data from (1991-2000) was used. Should this be 1901-2000 as stated in line 128?

3) Lines 206-208 there is a spare bracket

4) What is 'State vegetation', line 206?

5) The caption for figure 3 needs looking at. There are two references to BE, none to CR or BG, and the order should go from top to bottom. Also in the main text there is no mention of CR at all – I assume this is crop (see point 5 above)

6) Section 3.2 begins by saying this section considers figures 3 & 4 (line 197) but the rest of the section only refers to figures 4 and 5

7) Line 207 says 'BGC-CV' rather than BGC-DV

8) Line 221 'However, the overall NEP decrease is 2.5 Pg C y-1' – I think this should be increase if I've followed the paragraph correctly

9) Line 210 'average annual emissions are higher in BGConly (3.4 Pg)' – table 3 shows this should be 3.5 if rounding to 1d.p. as is done for BGC-DV

10) Vegetation types are not labelled in figure 5 caption

11) BE is labelled as bare ground in the caption for figure 7 but should be broadleaf evergreen. Also NEP, NPP, and Rh abbreviations should be defined fully in the caption as Net Ecosystem Production etc

12) State which correlation test is used for tables 4-7

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