

Interactive comment on “Climate vs. carbon dioxide controls on biomass burning: a model analysis of the glacial-interglacial contrast” by M. Martin Calvo et al.

Anonymous Referee #2

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This is a well-written and pleasantly succinct paper that uses a sophisticated model to investigate differences in global and regional fire frequencies between the LGM and PI periods. It is concluded that the increase in fire frequency was largely driven by increases in vegetation productivity, which occurred as a result of CO₂ fertilisation of plant growth. This is interesting because previous work emphasised the role of climate, and has implications for fire frequency forecasts as atmospheric CO₂ continues to increase. The strength of the effect is remarkable.

The Abstract states that modelled global fire CO₂ flux is 70-80% lower at the LGM than during the PI period, and raising LGM CO₂ to PI levels increases fire fluxes by 4-10x! This is caused by a CO₂ change from 185 ppm to 280 ppm (i.e. a 51% increase).

C463

However, oddly, the results as reported in the paper itself do not seem to agree with these headline responses. For example, Figure 4 shows an increase in global fire fluxes of 1.8-3.8x due to PI as opposed to LGM CO₂ at the LGM. Furthermore, LGM fluxes are 33-54% lower than PI. It is very odd this does not match the text in Abstract.

However, I am most concerned about the fact that the major effect occurs only after corrections to the model biome-level outputs have been applied. Figure 3 shows that the uncorrected model output shows no reduction in the CO₂ fire flux between PI and LGM, and the effect of PI CO₂ on the LGM flux is to increase it by 19-50%. The dominant (uncorrected) flux comes from the 'Dry grass/shrub' biome, and the correction reduces this by 84%. At the same time, the correction increases the tropical forest flux by ~4x, making this biome dominate the LGM-PI difference. Tropical forest fire fluxes are negligible at the LGM with LGM CO₂, but increase to PI levels with PI CO₂. The correction then increases them to 4x these values, and so the effect of PI CO₂ at the LGM is almost entirely due to this correction. My concern is therefore that if the baseline CO₂ fire flux from tropical forests is incorrect by a factor of 4, how can we have confidence that the anomalous behaviour of this flux under changed productivity is reasonable? The authors need to very carefully explain the reasons for the incorrect baseline, and why a simple single correction factor is justified before this work can be published. Alternatively, they need to improve the model so that the correction factors are not necessary.

Some other points:

p3.2 It is stated that burnt area in the most relevant aspect of biomass burning for the carbon cycle, and Prentice et al. (2011a) is cited as evidence. I read this article, but it does not really say this. In fact, it shows that globally there is no reliable relationship.

p3.4 What about the role of wind speed? p3.7 How does weather control ignition? Presumably through lightning? If so, please state explicitly. p3.10 Independently of what?

p3.18 I am not sure this is true. The model would also have to represent the effects of CO₂ on fire, and this would not be known from patterns, and including processes

C464

mechanistically needs testing. p3.20 Well, if the model has been shown to capture the climate signal, it could be used to ascertain the CO₂ one. The argument here seems awkward in that models are claimed as useful, while the observations are described as being inadequate. p3.28 'and' > 'but' p4.8 'showed' > 'claimed'? p4.19 But, surely the spatial relationships help as CO₂ is not expected to affect these (except C3/C4 contrasts)? p4.21 'However' with respect to what? Awkward semantics. . . p6.25 Is such a coarse time resolution appropriate for fire risk? Also, what about number of wet days? I thought these were part of the fire model forcing? p7.9 I am uncomfortable with using a climate variable to classify the output of a vegetation model! p7.10 How is this justified? Why not use the average of the climate models to run the vegetation model? p7.11 Was this described earlier? Clarify exactly which simulations were performed in one place. p8.7 There is a great need to clarify exactly why these biases occur. Should we be concerned about them in the context of this study? p8.9 But, if these biases are related to productivity, then surely this compromises the ability of the model to represent effects of changes in productivity on fire emissions? p9.21 Give the absolute fractions at LGM for LGM CO₂ and PI CO₂ forcings. p10.3 Please supply more details. Also, the figures are not all clear, and switch to B&W for no obvious reason. 'CRU' is not described as such in all legends.

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