

Interactive comment on “The biomass burning contribution to climate-carbon cycle feedback” by Sandy P. Harrison et al.

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Response to Vivek Arora's comments.

The derivation of emissions from normalized charcoal data is based on the fact that we have first established a good relationship between the charcoal normans and the methane record (which is a more direct measure of fire emissions). It is clear from several reviewers' comments that we needed to make the logic of our approach clearer and we will therefore (a) include a paragraph at the beginning of the methods section to spell out the steps involved, (b) include a flowchart as a new figure in the methods section to illustrate the methodology for both the satellite era and the palaeo-era, (c) expand the discussion of previous studies linking changes in charcoal to changes in

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temperature while emphasizing the importance (and novelty) of establishing a qualitative relationship via the methane record.

We have used Marlon et al. (2016) because this represents the latest version of the charcoal database (version 3). Marlon et al. (2008) used version 1 of the database. The new dataset has almost double the number of sites (736 sites versus 406 sites), including sites in regions that were relatively poorly sampled before. It therefore represents a significantly better constrained picture of changes in fire over the last millennium and the extra data will naturally improve the reliability of the charcoal indices compared to version 1 of the database. It therefore doesn't really make sense to test how much of a difference this would make to the results presented here. However, we will add a sentence in the description of this data set to make it clear that the new version is an improvement, both in terms of number of sites and spatial representivity, compared to previous versions of the database.

We chose to report the feedback in ppm/degree Celsius because this facilitates the calculation of gain. The sign is opposite because gamma refers to change in land carbon and we are focusing on change in atmospheric carbon. We converted Pg/C to ppm by first dividing by 2.12 (the simple unit conversion) and multiplying by the airborne fraction. We will spell out the logic and the conversion in the results section where we make the comparison with the results of your study.

We included the analysis of the satellite-era data because so much of the analyses of fire patterns, trends, relationships with drivers focuses solely on this period. However, we were at pains to point out in the original manuscript that (a) the results are only barely significant because the records are too short, and (b) that they become insignificant if peatland and deforestation fires are not taken into account. It is worth bearing in mind that tropical peatland and deforestation fires, while anthropogenic in origin, are strongly influenced by climate variability. Although we include the satellite-era analysis for completeness, we hope that in our revised discussion we can make it clear that (a) the similarity of the gain estimated for this period and the palaeo period

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is entirely fortuitous and (b) that only the palaeodata provides a robust estimate of the fire feedback.

The derivation of $\partial C/\partial T$ is described in the text, specifically “Following the convention established by Hansen et al. (1984), gain (g) is the product of the feedback strength and the climate sensitivity (i.e. the global mean surface temperature change for a doubling of CO₂ concentration) expressed in K ppm⁻¹. However, we propose to add the equation to the flowchart that we will use to illustrate the methodology, and which will then be referred to very early in the text.

Responses to minor comments

Abstract, line 25: We gave the climate sensitivity that we actually used in calculating the gain in the abstract.

Page 3, lines 25-26: Yes, of course the emissions are derived from GFED4s. We can rephrase this to make it clear that we are describing the estimates that we used in our analysis here.

Page 4, line 6: We can clarify this as: where the c_t^* are the optimally Box-Cox transformed influx values from a particular record at time t and \bar{c}^* is the mean transformed influx for that record over the interval 1–1700 CE (the transformation and normalization base period).

Page 4, lines 12-13. All we meant here was that we used the published age models and did not attempt to construct age models ourselves. We will rewrite this as: We used the published age models for each record.

There is an offset between the values obtained for the Northern Hemisphere and the Southern Hemisphere records. In order to produce a global composite, it is necessary to deal with this and we have followed Separt et al.’s recommendation for how to do this. We will clarify this in the text.

Page 5: Pseudoreplication is the process of artificially inflating the number of samples

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or replicates, giving a false sense of sample size, which creates problems for statistical testing. Temporal pseudoreplication occurs when there is a temporal relationship between serially adjacent samples or replicates (i.e. the samples or replicates could be measured multiple times). This would arise if we sampled a continuous charcoal record at too close an interval. We added an in-line definition in the text.

Page 6, line 10: As we state in the text: Equation 4 can then be resolved into the sum of three components: a constant intercept, a component proportional to M, and a component proportional to the product δM . Perhaps what you have missed here is the intercept.

Page 6, lines 26-27: We will clarify the alternative conventions used for feedback and gain, and we will explicitly add a reference to the Appendix giving the derivation of equation 6 at the point that we introduce this equation.

Equation 6: We used increase here originally because the whole sentence was framed in terms of the impact of an increase in atmospheric CO₂ concentration, but we agree that it would be better to express this generically as change throughout.

Page 7, line 8: We will clarify that these are normalized charcoal anomalies.

Page 8, line 6. We can change “variable in sign” to “are both positive and negative”, to make this clearer.

Page 8, line 29-390. F is the significance level and df the degrees of freedom. We can clarify the conventional statistical terminology here, and these calculations are also described in full in the Supplementary Information.

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