

Interactive comment on “Understanding Climate-Fire-Ecosystem Interactions Using CESM-RESFire and Implications for Decadal Climate Variability” by Yufei Zou et al.

Anonymous Referee #2

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The manuscript by Zou et al. presents an analysis of the interactions between climate, wildfires, ecosystems, and radiative balance in a recently (further) developed modelling system, CESM-RESFire. The methodology includes a suitable set of sensitivity experiments that provide substantial new insight into the role of different types of potential interactions (mainly aerosol effects and land cover changes) in driving present-day radiative effects of wildfires, and their future radiative forcing. It features some novel aspects compared to previous studies, especially when it comes to the types of feedbacks allowed and investigated, and provides a useful contribution to the improvement of our poor understanding of the role of fire in the Earth system. The manuscript is nicely written, and well within the scope of Atmospheric Chemistry and Physics. I find

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it worthy of publication, following some (mostly minor) improvements that I describe below.

GENERAL COMMENTS:

- The title, abstract and conclusions (as well as the main text) leave the reader thinking that the full climate effects of wildfires are examined in the current study. However, this is somewhat misleading, as full climate responses (i.e. temperature, precipitation, humidity etc changes) are not explored or discussed, even if they are partially included (I am saying “partially” since the oceans and sea-ice are fixed). The study goes up to radiative effect and radiative forcing quantification, and that should be reflected more accurately in the different parts of the text. In my specific comments below, there are some suggestions for amending this, but the authors should make an effort to do so further throughout the text.

- In addition, the future radiative impacts (whose study presumably is a core aim of this work) are discussed very briefly towards the end of Sect. 3.3, and in a way that does not seem accurate/consistent with what is shown on the maps (see related comment below).

- The past tense is often used in the text to refer to the work presented here, where the present tense would be more appropriate/standard. For example “We provided a brief model description and sensitivity experiment settings in Section 2...”, where “provide” would probably read better. I suggest making this amendment to wherever applicable in the text.

SPECIFIC COMMENTS:

Page 2, Lines 1-3: I suggest changing the title to “Using CESM-RESFire to Understand Climate-Fire-Ecosystem Interactions and their Implications for Radiative Forcing”. The title as it stands currently is misleading, as “implications for decadal climate variability” were not examined at all in this study. Generally speaking, it is radiative forcing/effects

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that were examined, rather than climate (temperature, humidity, precipitation etc) effects.

Page 1, Line 20: For the same reason, I suggest rephrasing to “. . .and their impacts on fire activity and radiative forcing”.

Page 2, Line 38: Please add “, respectively” at the end of the sentence.

Page 2, Lines 57-58: “are further confounded by natural processes and human interferences” – human and natural processes have been mentioned in the previous sentence. Why repeat them?

Page 2, Line 69: “used the same approach” – suggest changing to “used the same unidirectional approach”.

Page 2, Line 71: The term “fixed” may not be fully accurate here. For example, to my knowledge, Tosca et al. (2013) performed simulations with and without aerosol emissions, with no “fixing” per se involved.

Page 3, Line 79: I do not think “feedback in” is needed.

Page 3, Lines 81-84: Change past tense to present tense (just another example).

Sect. 2.1: Gas-phase chemistry (e.g. ozone and its precursors) is not mentioned at all in the model description – or anywhere really. If such a mechanism is not included, this should be mentioned (along with acknowledging the potentially sizeable effect of this missing process), and if included, the authors should describe in what fashion it is included.

Sect. 2.1: No mention at all of biogenic aerosols.

Page 3, Line 97: Probably “microphysics” and not “macrophysics”?

Page 4, Line 110: Please mention the year for the future scenario. It’s mentioned later, but worth mentioning it here too.

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Page 4, Lines 138-140: Suggested rephrasing – “. . .we allowed the semi-static historical LCC data for the year 2000 from the version 1 of the Land-Use History A product (LUHa.v1) (Hurtt et al., 2006) to be affected by post-fire vegetation changes (Zou et al., 2019)”.

Page 5, Lines 150-151: “given great uncertainties in future projections of these inputs” - Are these uncertainties larger than for the rest of the variables considered here?

Page 5, Lines 161-164: Yes, but are the timescales long enough in this case for this assumption to hold? Please discuss.

Page 5, Line 175: “the Ghan’s method” -> “the Ghan method”

Equations (1): The way these equations are written is very confusing. First of all because of the dashes (“-”) and the minuses appearing identical, and also because of the use of column (:). I suggest the following format:

“RE of interaction of radiation with fire aerosol: $RE = \Delta(F - F)$ ”

(with the appropriate subscripts in each case)

Page 6, Line 188: “nonnegligible” -> “non-negligible”

Page 6, Line 200: “budge” -> “budget”

Page 7, Lines 220-221: “However, the model well captured the high AOD regions over the Northern and Southern Hemispheres of Africa” – I am not sure I see this on Fig. 1. Therefore the statement seems too confidently positive.

Page 7, Line 228: The AERONET measurements cannot be characterised as “in situ”. They are also remotely sensed.

Fig. 3: Please specify that this is TOA radiative effect.

Page 7, Lines 243-247: There are some areas that experience pronounced positive forcing due to fire aerosol-cloud interactions. The most prominent ones are Europe

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and most of Africa. Presumably that is because of black carbon stabilisation effects? But why would these be more important in these specific regions? Any thoughts? Please comment.

Page 8, Lines 248-249: Why are there areas with both positive and negative changes? Why is Africa pretty much all negative? These are interesting features. Please elaborate.

Page 8, Lines 262-263: Please specify that the Jiang et al. (2016) study was performed with the same atmospheric model as in the current study (though older version?), as it is useful for the reader to know.

Page 9, Line 293: I am not sure where the +51% value comes from. From Table 2, the Raci is -1.31 for 2050 in this study and -1.42 in the CCSM study. Or do the authors mean something different and I am missing the point? In any case, I think it should be made clearer where the +51% value comes from.

Page 9, Lines 313-315: “Such difference is also consistent with the changes in different versions of the GFED datasets, which show a 11% increase of global fire carbon emissions in the latest GFED4s as compared with the old GFED3 for the overlapping 1997-2011 time period (van der Werf et al., 2017)” – Do the authors mean that there is an upward “trend” between older and newer GFED emissions versions, implying that eventually the GFED emissions will match the online model? That’s a rather simplistic reasoning and needs to be supported further or phrased differently.

Page 11, Lines 361-363: “Though we mainly focused on fire-climate interactions without consideration of human impacts in this study, the RESFire model is capable of reproducing the anthropogenic interference on fire activity as observed from the space (Zou et al., 2019)” – This needs some more explanation. The common understanding is that in Northern Hemisphere Africa the decline in burned area is due to agricultural conversion and resulting landscape fragmentation (e.g. Andela et al., 2017). Is this a process that is represented in this particular model? Please clarify and discuss.

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Page 11, Lines 390-394: The evidence to support this statement is somewhat weak. First of all, the precipitation changes (Fig. 9c) are not significant almost everywhere (therefore, not much difference in that respect to the wind changes). Secondly, the match between locations with decreased precipitation and increased burned area (and the other way around) is not always clear (e.g. the north of Siberia experiences increases in burned area, but simultaneous increases in precipitation; there are other examples too). It would be best to discuss this in a more quantitative fashion, e.g. report the spatial correlation coefficients between burned area and driver variables to extract more robust conclusions?

Figure 11: This figure is not really discussed in any insightful way, beyond just stating that such effects “might compensate biogeochemical warming effects of deforestation related carbon-cycle changes”. How does each individual variable shown affect warming/cooling patterns, and which of these variables seems to be more important, based on this analysis?

Page 12, Lines 427-431: This discussion is rushed and I am not sure I follow the reasoning. It is stated that the radiative forcing of aerosol-radiation interactions “show similar patterns with Fig. 3a, with generally cooling effects over the vicinities of fire areas and warming effects over the downwind regions”. Where do we see this? In Fig. 3a, this was evident e.g. in and around Africa (and possibly South America), but I cannot see this in Fig. 12c. Then for aerosol-cloud interactions, it is stated that there are “warming effects in Southeast Asia and Australia due to local cloud changes”, but how are these features consistent with Fig. 3b, in which the inclusion of fire caused negative radiative effects due to aerosol-cloud interactions over those regions (as was the case for northern high latitudes).

Page 13, Line 447: Please add “fire” between “significant” and “aerosol”.

Page 13, Lines 455-456: Please change “climate effects” to “radiative effects”, as the former implies that effects on temperature, precipitation etc due to fires were also ex-

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aminated (which is not the case).

Page 13, Line 465: Please change "their" to "its".

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