Review 2nd Stage

February 7, 2021

About the format

The replies of the authors to the reviewers are written as a single paragraph for all the points raised in the reviews. Also the revised manuscript has some words and a reference in red, however several changes are not documented/explained, for example, the section *2.1 Study Area* in the new document is derived from a paragraph of the introduction.

It is not required but a small summary of the changes in the document would be appreciated. Probably due to the single paragraph format, some of the replies to the questions are too synthetic and not easy to follow. To be able to visualize the improvements/answers to the first review, here it is included again my previous review, followed by grey boxes with the authors answers and my second review/comments. My main advice here is to improve the format and information of the replies/improvements for next submissions.

Abstract

- **Line 23**. First sentence needs an adjective like "current" unless the authors want to refer to a much more general assessment than the response of Northern Eurasia to current climate change.
- **Line 33**. I would not use the verb "may" in the abstract: either use "can" and develop this assessment in the paper, or skip this assessment in the abstract.

Introduction

- **Lines 46 to 56**. I think that the terminology "warming hiatus", although coming from IPCC, might be confusing for readers that are not in the topic. Several authors prefer the term slowdown: [7, 2, 3]. Unless that the authors have a given opinion on this, in line 50 they could mention as *hiatus/slowdown* and, possibly, they could include relevant references that mentioned the term slowdown. Here also is interesting for the readers to comment about hemispherical differences on this "warming hiatus/slowdown", as it seems relevant in the context of the paper. The last version of the dataset HadCrut (see figure attached) highlights these aspects and the global mean increase of temperature is tempered by the Southern Hemisphere but the Northern Hemisphere has a more clear warming signal at the period analyzed in the paper.
- **Line 53**. I would write here something "geographical components" if the authors are referring to this. Otherwise the sentence may indicate divergence of variable inputs to calculate the FWI (that might be or not also the case).
- To remark about the sensitive to current climate change of Northern Eurasia, here is a good point to mention recent references to this aspect [6], or any other that the authors consider relevant. It would support the first assessment of the abstract.
- **Line 82, 83**. This is a key fact in the context of last sentence of the abstract and could be mentioned on the discussion about modelling.

Authors' reply

Overview, Introduction Line 23, 33,46-56, 5382, 83 – Agree to change as suggested by the Reviewer 2

Second review: Here I recommend a more detailed answer. The authors did not consider the idea of comment about hemispherical differences in global mean surface temperatures, this is fine but it is better some feedback/answer to foster the discussion.

Methodology. Mapping burned areas

- **Line 88 and 89**. I would consider link better in this section this aspect with the validation done by [5]. Also note that it seems that there is an improvement in the use land cover from [5] to this manuscript. However, is the validation conditioning by the differences in land cover datasets used?

- **Lines 90 to 95**. I consider a little bit confusing these sentences. In particular if "This study used" are referring to the previous [5, 4] studies or the current manuscript under review. I recommend rewriting these sentences and being more clear "This study uses …" "That study used" or directly "[5] used…" to be sure that the reader is not lost.

- **Line 95**. This dataset no longer available is that used from previous studies [5, 4] or also for this one?

Data sources. Land Cover

- Maybe add a comment about consistency in the products of Land Cover here mentioned (MOD12) and those of section 2.1

Authors' reply

Methodology, Mapping burned areas Line 88 and 89 - (Scott, Matt) – A better description of uncertainty will be added. Line 95 – The land cover map for collection 5 were used for this study and my previous studies (4, 5) Data sources, Land Cover First bullet – A comment would be descried on the consistency of MOD12 and section 2.1.

Second review: Ok. Thank you for adding this information to your paper.

Statistical Analysis

- The M-estimation is often used to avoid that outliers condition the result. Was this a preventive decision or actually the dataset has outliers? Probably here the authors can refer already to the Figures when describing methods: annual trends Figure 2, and rank correlations Figures 5 and 6. Here also when it is indicated the validation of the estimation of burned areas, the authors may add also that it is shown in Figure 3. This helps to readers.
- **Line 159**. Any particular reason for gamma distributed response or previous studies that used this hypothesis?
- **Line 169**. Any particular reason for beta distributed or previous studies that used this hypothesis?

Authors' reply

Second bullet M-estimation – Our objective was to present consistent grid cell trends in the presence of within-cell variation. We chose to use M-estimation to mitigate the effect large within-cell variation due to a relatively small within-cell sample such that the map presents a consistent surface. If computed using ordinary least squares (OLS) estimates. Such large within-cell variation could result in some cells with inconsistent or "outlier" trends compared to their neighbors. Line 159 - We applied the correct distribution to the data instead of a normal approximation. A theoretical gamma distribution is defined as having support for y>0 and often skewed (ref. Hogg and Craig, 1974). The gamma distribution is therefore characteristic of the burned area data. Use of the data-appropriate distribution provides for more accurate estimates and confidence bounds. Mood, A.M., Graybill, F.A., Boes, D.C. (1974) Introduction to the Theory of Statistics, McGraw Hill Series in Probability and Statistics, Sec. 3.3. Line 169 Again, we applied the correct distribution to the data instead of a normal approximation. A theoretical beta distribution is defined as having support for 0 < y < 1 which is characteristic of the proportion burned area data (ref. Hogg and Craig, 1974). Use of the data-appropriate distribution provides for more accurate estimates and confidence bounds Mood, A.M., Graybill, F.A., Boes, D.C. (1974) Introduction to the Theory of Statistics, McGraw Hill Series in Probability and Statistics, Sec. 3.4.

Second review: Ok. Thank you for the answer and the references. For future publications it would be interesting to explore if there are more recent studies (than 1974) about the best statistical methods or indicate that no improvements has been done sine 70's.

Results

- For Figure S1.1 a reduced vertical range from 0 to 2 may help to visualize differences. Although I understand that the authors considered a common range for all the possible effects from figures S1.1 to S1.4
- **Lines 332 to 353**. The authors highlight the role of human-related factors and how they affect the predictability of Dynamic Global Vegetation Models. I found the figures S2 and S3 interesting for the discussion. Note, however, that Kazakhstan has been in the Russian Federation until 1991, so I understand that figures are trying to link the grazing intensity with this aspect. But without any specific reference, it may be a reasonable/possible link but anyway soft link. At this point I don't know if other factors in Kazakhstan could affect equally (or at least contribute to) the grazing intensity implied by Figures S2 and S3. For example, the human population decreased in the 90's and increased during the 2000's.

Authors' reply

Figure S1-S4 - We will change the range from 0 to 2 or another scale to improve the visualization of the differences. Lines 332-353 - We argued that the impact of grazing on fire might be a non-negligible contribution based on what was observed in Africa by Holdo et al. In turn, this study provides an additional study case in central Asia to ascertain this hypothesis so that the grazing/fire interactions might be tightly accounted for in fire DGVM interactions. The list of other possible factors associated to the change in political regime might be long but population decrease was around 10% and would technically lead to less fire settings. So we tested the two major fire related hypothesis of grazing (Holdo et al.) and land cover change (Andela et al.) based on our expert knowledge of fire driver. We'll better discuss this point in hypothesis statement and discussion.

Second review: Ok. Thank you for the answer. I would recommend here to indicate explicitly the changes in the manuscript in reply to the comments of the review.

Figures

- It is possible that the journal required an increase in resolution of several Figures to ensure good printing quality.
- In caption Figure 4, I would add write *Northern Eurasia (including Kazakhatan)* for non-linear readers of the paper.
- Also in Figure 4. Did the authors find any reason for differences between even years than in odd years? It seems to be a close to systematic pattern: burned area in even years is larger than odd years.

References

- There is a typo in the reference: [1].

References

[1] J. F. Chang, N. Viovy, N. Vuichard, P. Ciais, T. Wang, A. Cozic, R. Lardy, A.-I. Graux, K. Klumpp, R. Martin, and J.-F. Soussana. Incorporating grassland management in ORCHIDEE: model description and evaluation at 11 eddy-covariance sites in europe. *Geoscientific Model Development*, 6(6):2165–2181, December 2013.

[2] R Checa-Garcia, K P Shine, and M I Hegglin. The contribution of greenhouse gases to the recent slowdown in global-mean temperature trends. *Environmental Research Letters*, 11(9):094018, September 2016.

[3] John C. Fyfe, Gerald A. Meehl, Matthew H. England, Michael E. Mann, Benjamin D. Santer, Gregory M. Flato, Ed Hawkins, Nathan P. Gillett, Shang-Ping Xie, Yu Kosaka, and Neil C. Swart. Making sense of the early-2000s warming slowdown. *Nature Climate Change*, 6(3):224–228, February 2016.

[4] Wei Min Hao, Alexander Petkov, Bryce L. Nordgren, Rachel E. Corley, Robin P. Silverstein, and Shawn P. Urbanski. Daily black carbon emissions data from fires in northern eurasia for 2002-2015.

[5] Wei Min Hao, Alexander Petkov, Bryce L. Nordgren, Rachel E. Corley, Robin P. Silverstein, Shawn P. Urbanski, Nikolaos Evangeliou, Yves Balkanski, and Bradley L. Kinder. Daily black carbon emissions from fires in northern eurasia for 2002–2015. *Geoscientific Model Development*, 9(12):4461–4474, December 2016.

[6] Tomonori Sato and Tetsu Nakamura. Intensification of hot eurasian summers by climate change and land–atmosphere interactions. *Scientific Reports*, 9(1), July 2019.

[7] Xiao-Hai Yan, Tim Boyer, Kevin Trenberth, Thomas R. Karl, Shang-Ping Xie, Veronica Nieves, Ka-Kit Tung, and Dean Roemmich. The global warming hiatus: Slowdown or redistribution? *Earth's Future*, 4(11):472–482, 2016.