I.Colin Prentice, a prominent Earth system scientist, wrote a short comment to our manuscript with an extremely negative and (we contend) unjustified title "Limited progress in fire modelling". We feel the reviewer's comments are mostly in response / directed to the style of the written text, rather than any substantive critique of the science advances we present. We hope this negative view of our manuscript is a misunderstanding due to our writing style as we are non-native English speakers, and it was not our intention to offend any peers in the community. Nevertheless, firstly we want to thank I.Colin Prentice for his comments, which we believe will improve our manuscript, and help us avoid unnecessary and unintentional conflict among our peers.

We address individual comments below.

Introduction sentence:

"*The presentation of this model is marred by unfounded claims, inconsistencies, and unwarranted disparagement of earlier research*." No details are given later on what are these "*unfounded claims*" (except of critics of equation 9 (we will come later to it)) and/or "*inconsistences*". By "*unwarranted disparagement of earlier research*" I.Colin Prentice probably means a rather innocuous statement in our manuscript that "…(some) global fire models (including Thonicke et al., 2010) contain sets of rather complicated equations with variety of coefficients which is hard to obtain, unless satellite derived functions are used" (we will come to this point later). Otherwise, we are at a loss where our text has offended.

Main body:

"the new fire component is based on Venevsky et al.'s earlier (2002) regional fire model, RegFirm. Thus, the new model is assembled from the same components as the LPJ-SPITFIRE model published by Thonicke et al. (2010), eight years previously."

We thank the reviewer for recognizing the first author's major contribution to large-scale fire modelling, i.e. how components of LPJ-SPITFIRE actually stem from RegFIRM of 2002. We contend that RegFIRM was actually pioneering work for process-oriented DGVM fire models and major components and many ideas (using of Nesterov Index for fire danger estimate, division to lightning and human fires, estimate of number of fires, elliptic form of area burnt and using Rothermel equation with fuel bulk density) were subsequently adopted by many currently used fire models, e.g. a majority of fire models used in FIREMIP inter-comparison project (see Figures 3 and 4 in Rabin et al., 2017) have the same composition as RegFIRM. Here we present the SEVER-FIRE model that builds on and advances these earlier pioneering developments), e.g. we improve earlier algorithms and introduce new functionality with respect: 1) to estimate the numbers of lightning fires from data on convective activity in the atmosphere 2) to estimate numbers of human fires from urban against rural population (timing of their appeareance in natural landscapes and their ratio) and regional wealth index, as well 3) to estimate more realistically fire duration, which in the new model depends on human suppression and weather situation and can last for several days. All represent significant new developments.

"*The preprint does not cite more recent developments and applications based on SPITFIRE, such as Prentice et al. (2011), Pfeiffer et al.(2013), Lasslop et al. (2014), Kelley et al. (2014), Yue et al. (2014), Baudena et al.(2015) and Wu et al. (2015)*".

We agree with critics and certainly will include and cite all references suggested by the reviewer.

"*The preprint does not claim any superior ability to reproduce observed patterns. It does however claim to be based on a different, and implicitly superior, approach to modelling fire*."

This is a clear misunderstanding as we definitely do not claim that our approach to modelling of fire is implicitly superior; we simply contend that our work is a valuable contribution to the field. Our approach is arguably 1) more suitable for climate change future and past studies because, where input satellite data is unavailable, it 2) allows use of abundant historical national fire statistics not limited to the last few decades and 3) allows to validate fire model against historical regional number of lightning/number of human fires. This is described in lines 19-28 at page 3 of our preprint.

"*For example, page 3 refers to other models (including Thonicke et al., 2010) being based on "sets of rather complicated equations with variety of coefficients (despite they name themselves intermediate complexity models)...*"

We apologise for any offense caused, this was certainly not our intention. This was a poorly formulated sentence and negative message. We simply wanted to highlight a general and major challenge in large-scale modelling which is to strike a balance between mechanistic detail and availability of data, i.e. adding complexity does not necessary improve a model as it adds to the degrees of freedom, and thus with insufficient data, will not reduce uncertainty.

First author Venevsky respectfully agrees to disagree with the reviewer on the merit of some changes made going from RegFIRM to LPJ-SPITFIRE, as has been documented in the past correspondence in the year 2010 (https://www.biogeosciences-discuss.net/7/C331/2010/bgd-7-C331-2010-print.pdf). However this is a distraction in the context of our new study, where we wish to showcase our recent advances with our new SEVER-FIRE model. We therefore delete the sentence.

"*Later, the preprint states about SEVER-FIRE that "No satellite derived data are used as an input of the model. Only physically based or just 'common sense' based equations from on-ground observations allow direct implementation of SEVER-FIRE model..." and "Unlike in other global DGVM fire modules ... all equations are kept simple following ideology of Reg-FIRM."*

We agree in the second sentence that "common sense" based equations" is a bad expression. This is a terminology mistake and we meant actually "statistically-based equations from on-ground observations". As mentioned above there is a challenge in large-scale fire models, to keep equations relatively simple to avoid additional multiple unknown / uncertain parameters. We try to justify the merit of our new work in this context, and differentiate it from some earlier modelling efforts. However, the reviewer may have taken exception to this comment, therefore we remove "Unlike in other global DGVM fire modules" to keep the focus entirely on SEVER-FIRE and keeping the strategy of Reg-FIRM.

"Thus, earlier models are criticized for their use of satellite data as input (for lightning frequency in the case of SPITFIRE) although the basis for this objection is not stated"

We argue that it would be advantageous if one can produce long-term fire relationships without depending on remote-sensing, which is available for a relatively short period of time (a few decades). Fire return intervals can be of the order of hundreds of years, whereas remote sensing is available for several decades. Therefore using remote sensing to derive relationships implicitly assumes a space for time substitution, which may or may not hold. Also our approach in turn allows the remote sensing to be employed as a valuable evaluation dataset, albeit over this limited time interval.

In fact, the problems with using satellite data as input are also mentioned in one of the latest studies for Africa, a study recommended by the reviewer, namely of Baudena et al,, 2015, where frequency of fire was prescribed as an input based on MODIS data: "LPJ-GUESS-SPITFIRE simulation results do not show any low tree cover value (e.g., below 50% cover) for rainfall higher than about 900mm/yr. In other words, this model (quite surprisingly) does not predict any savanna in mesic environments….this issue is also likely to be connected to fire intensity depending on fuel moisture. In this model, fire occurrence in a patch is calculated probabilistically from the proportion of burned area as determined from the remote sensing product. This probabilistic approach is necessary because the temporal extent of the remote sensed data (now only ca. 10 years), used to generate the probability of burned area for each pixel, is much shorter than the extent of the climate data for which the model was run (ca. 100 years)." We are going to include this example of negative influence of RS based input for result of DGVM based fire model: **For example, use of remote sensing derived fire frequency for Africa as an input to SPITFIRE for Africa, resulted in absence of savanna for the area with annual rainfall larger then 900 mm/yr (Baudena et al., 2015). This shortcoming of process-oriented fire model is attributed by authors to the short temporal extent of initial remote sensed data used for preparation of input data.**

"*Appeals are made to simplicity and 'common sense' – the former being a defensible aim, the latter not a scientific concept – and, curiously, to an 'ideology'*."

As mentioned earlier we made the terminological mistake, using expression "common sense equations" and now change it "**statistically-based equations from on-ground observations**". So, false impression of "appeal to common sense" related only to this mistake. However we repeat our approach is one of simplicity, to avoid the issues of expanding the degrees of freedom and potentially adding to uncertainly, as we have aluded to above, and this is our strategy or ideology. We replace the word "ideology" with "**strategy**".

Actual justification of our approach to fire modelling (changed in accordance to the reviewer's comment) is described in lines 32 on page 3 to line 16 of page 4, (sorry for lengthy self citation): "SEVER-FIRE (Socio-Economic and natural Vegetation ExpeRimental global fire model is incorporated into the SEVER_DGVM (Venevsky and Maksyutov, 2007; Wu et al., 2017), which is a modification of LPJ-DGVM (Sitch et al., 2003) for daily time step computation. SEVER-FIRE model is a follow up of Reg-FIRM and is designed using principles of the parent model. No satellite derived data are used as an input of the model. Only physically based or just statistically based equations from on-ground observations allow direct implementation of SEVER-FIRE model in any DGVM or ESM for investigation of **future** global change impacts or **past** global fire regimes reconstruction. One of the major focuses of SEVER-FIRE model is an implementation of pyrogenic behaviour of humans (timing of their activities and their willingness/necessity to ignite or supress fire), related to socio-economic and demographic conditions in a geographical domain of the model application. Importance of description of pyrogenic behaviour of humans are confirmed by recent findings of bi-modal fire regimes, reflecting human fingerprint in global fires dynamics (Benali et al., 2017), as well as by differences in timing of ignitions determined by religious background in Sub-Sahara Africa (Pereira et al., 2015). Fire weather regimes, set by climate dynamics, and fuel state set by vegetation dynamics are other important drivers in SEVER-FIRE model. SEVER-DGVM fire module, based on climate observations, external anthropogenic parameters, and SEVER-DGVM derived vegetation, estimates fire incidence and emissions. The resulting vegetation disturbance feeds back to the DGVM, ensuring a fully coupled system"

We intent to build a process-oriented fire model which will allow simulation both in the future and in the past, which will not be limited by time span of RS input (twenty years) and which will use for validation not only limited in time RS based area burnt product but also historical statistics on number of lightning and human fires and which will describe physically reasonably socio-economic, vegetation and climate driving of fire regimes.

"*These appeals do not amount to a convincing case for a new model, especially as it includes equations – notably those determining rates of human ignition, e.g. equation (9) – presented entirely without justification*"

The only substantive technical comment, and we found it confusing …Rate of human ignitions is actually determined in equation 8, not 9. This one (eq. 8) is taken (as it explained in RegFIRM paper in 2002) directly (but with slightly modification) from calculation methods of Russian Forest Service, which are in practical use for almost 50 years. Equation 9 describes "Mathematical expectation of number of ignition produced by one person for millions of hectares *a*" Estimation of *a* for modest high income region (Spain) and low income region (Sahel) is described in RegFIRM 2002 paper. Several other values of *a* are known for other regions from methods of Russian Forest Service (for European Russia, Asian Russia, districts of Russia). These known and estimated values of *a* were logarithmically fitted to wealth index WI of UN Human Settlement Program. Justification of variation of *a* value is described in lines 23 -28 page 9 of the preprint. We are going to add details from this answer in the next version of the preprint in order to underline substantial step done in development of RegFIRM with fixed mathematical expectation of number of ignition produced by one person for millions of hectares to spatially distributed variable determined by wealth status of population.

"*Remarkably, page 5 also alludes to an explicit aim "to provide...a fully mechanistic description..." But no current fire-vegetation model, including this one, could plausibly be described as 'fully mechanistic.' The authors seem to admit this later (page 10), when they describe the treatment of human ignitions in their model as "very simplistic".*"

Very simplistic model in ecology can be also fully mechanistic, e.g. Lotka-Volterra equations for prey and predator number of individuals.

In general, this comment forwards us to some unnecessary terminological discussion. The first opened page in the Internet states that:

This is a rather minor philosophical argument. We remove the word "fully" to avoid conflict with the reviewer, and replace with "comprehensive", as we maintain that SEVER-FIRE includes key individual parts of fire phenomena, e.g. first major individual part of SEVER-FIRE is working. The second major individual part (estimate of areas burnt), based on the first part, is also working as demonstrated by comparison with RS data. The third major individual part (estimate of fire carbon emission) is also OK as seen from RS data. Thus, we think that SEVER-FIRE is **(a first) step to comprehensive mechanistic fire model**. This is how we will write in our next version of the preprint.

Conclusion

"*In principle there is always room for new models. The one presented here is new, in that it differs in several respects from earlier models, including Thonicke et al. (2010)*."

Very positive conclusion. Indeed, SPITFIRE and SEVER-FIRE differ principally in all but first component (estimate of Nesterov based fire danger Index) of the fire model.

Here is the list of significant changes which we have undertalen to move RegFIRM to SEVER-FIRE.

Number of lightning fires **simulation**: RegFIRM fixed value

SEVER-FIRE based on convective activity in the atmosphere

Number of lightning fires **validation**: RegFIRM not done

SEVER-FIRE done for limited area

Number of human fires **simulation**: RegFIRM based on equations of Russian Forest Service

SEVER-FIRE based modified equations of RegFIRM with subdivision of population to urban and rural and different timing of contact with natural vegetation for these two types and with considering wealth status of population

Number of human fires **validation:** RegFIRM done for Spain

SEVER-FIRE done for Canada and large areas in Canada, for Spain (as in RegFIRM)

Areas burnt **simulation**: RegFIRM equations based on Rothermel and eliptic up-wind form of area burnt perimeter, termination by natural reason – rain, maximum fire duration s

SEVER-FIRE initial equations of RegFIRM, termination by natural reason – rain and by human suppression, depending from geographical location of large human settlements

Areas burnt **validation:** RegFIRM Hystrorical statistics for Spain areas burnt is used

SEVER-FIRE global RS areas burnt product is used

To conclude **BOTH DERIVATION AND VALIDATION OF RegFIRM AND SEVER-FIRE ARE DIFFERENT.**

"*However, to be worth publishing, a new model should surely represent an identifiable advance, in terms of either derivation or performance, over existing models. For SEVER-FIRE, as presented, this seems not to be the case"*

Final conclusion of I.Colin Prentice contradicts the first sentence of his conclusion section where he acknowledges novelty of SEVER-FIRE.

Identifiable advance of SEVER-FIRE (Socio-Economic and natural Vegetation ExpeRimental global fire model) in terms of derivation for fire modelling is shown (as we already discussed) in lines 32 on page 3 to line 16 of page 4 of the preprint.

We cannot state performance advance of SEVER-FIRE model over other DGVM fire models unless we compare the models with the same input and comparison data base protocols. However, we hope that new approach undertaken by SEVER-FIRE for socio-economic driving of global fire regimes and for description of lightning fires can provide us with better reproduction of reality in the past, present and thus give added confidence in our future projections.

Sergey Venevsky