

Interactive comment on “Varying relationships between fire intensity and fire size at global scale” by Pierre Laurent et al.

Anonymous Referee #3

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Laurent et al. combine a new global dataset of fire patch sizes with observations of fire radiative power (FRP) to estimate how “fire intensity” changes as a function of fire size. The manuscript is well written. However, I do have some serious concerns about the interpretation of the data that would need to be addressed before I would recommend publication in Biogeosciences.

Major concern

The manuscript lacks a proper discussion (and references) of potential issues that may arise when estimating fuel consumption and subsequently fire intensity from FRP. FRP observations from MODIS represent infrequent snapshots of energy release across the pixel area (at best $\sim 1\text{km}^2$ at nadir). This results in a number of difficulties when linking FRP to fire temperatures or -intensity- of which several will likely be a function of envi-

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ronmental gradients. First, FRP is an estimate of energy release across an entire pixel, ~ 1 km² at nadir for MODIS. It is very uncertain what fraction of the grid cell is actually burning (and this is likely a function of fuel loads and other aspect of fire behavior). Yet, this is a requirement to estimate fire intensity because if 1% of the pixel produces 10 MW of energy, or 50% of the pixel produces the same amount makes a difference of 50 times the "intensity". Second, several studies suggest that vegetation structure (in particular tree cover) also have a significant effect on the relationship between fuel consumption and observed FRP (e.g. Roberts et al., 2018 RSE). Third, the sensitivity of the MODIS instruments to detect active fires (i.e. minimum FRP that can be observed) is a direct function of the scan angle and is up to a factor of 5 lower at large scan angles compared to nadir. This may be important when looking at distributions (e.g. median), because you are likely to strongly underestimate the occurrence of low FRP values. Fourth, the fire diurnal cycle (a function of fuel conditions, vegetation type, and climate) also produces a sampling error, since there are only few daily overpasses and in some ecosystems fire activity may peak already early in the morning while in others this maybe later in the afternoon.

It would be important to properly discuss what "MODIS FRP" actually represents. I also disagree with the statement "This is in agreement with .. , since these quantities are two proxies of the number of ignitions." (lines 120-122). I do not see how the number of active fire detections is related to ignitions? A single fire may produce up to hundreds of active fire (FRP) detections if it becomes large enough and burns for a long period of time. Several studies have linked active fire detections (with or without FRP) to total amounts of fuel consumption (or biomass burned), which would be a function of area burned, fuel loads and other conditions. Moreover, looking at the distribution of FRP detections may become problematic here. In high fuel load temperate and boreal forested systems a large share of the active fire detections may come from smouldering rather than the active fire front (and ratios may change over the fire's lifetime), while for grasslands it may be mostly actively flaming fire fronts that are observed. In this light it would be important to much better define "fire intensity" (i.e. what do the authors want

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to measure exactly?), and discuss how using FRP as a proxy for this quantity may be further influenced by the above mentioned limitations.

Minor suggestions

Line 87. That is ok, but what do you do if you have two adjacent fire patches? Are you double counting the active fire detections?

Line 95. “.., we compute for each patch the mean FRP value of all .. ”. This isn’t entirely clear to me, do you first estimate the mean of each patch and then look at the median across patches? Again, it would be important to understand what the distributions look like (e.g. across land cover types) to understand the potential implications of such decisions.

Line 155 “In each 1x1 cells”, typo.

Lines 155 – 160, please move this to the methods section, accompanied by a short explanation on how that helps to answer your research questions.

Line 170 “Following the hypothesis from Rothermel’s equation”, maybe be a bit more specific here and add references. For clarity you could also repeat your own objectives here, e.g. “We aim to investigate if fire size and intensity are driven by a same set of environmental and climate conditions..” Also, I am somewhat surprised that in addition to speed, the authors don’t mention fire duration as a potential driver of larger fire sizes.

Line 174 “Tropical areas” is not a vegetation type, delete?

Line 178 “experience limited fire energy” what does this mean? Do you mean to say something like “In equatorial areas with high annual rainfall, biomass burning is characterized by low spread rates and combustion completeness (cite), resulting in a more gradual release of energy from fires”?

Lines 198 – 214, this is an interesting discussion. However, what I miss here is a discussion on the potential influence of the spatiotemporal progression of the fire season.

For example, the authors clearly find highest median FRP in more arid environments (e.g. southern Africa or interior Australia), these regions also tend to burn later in the fire season. So in Figure 2 when focusing e.g. on Australia. The increase in “fire size : median FRP” ratio isn’t that simply because we are first looking at a dominant signal from tropical northern Australia and then the signal becomes more and more dominated by interior Australia towards the end of the fire season? In that light I like the suggestion of reviewer #1 to take an approach that has a stronger focus on vegetation types, or areas that are otherwise more similar in terms of climate and vegetation compared to the GFED regions.

Line 238 “Fire danger index has been constantly increasing during the last 50 years”, I believe conclusions of that paper were a little more nuanced.

Figure 2: why do y-axis on the right side have no caption? Also, it’s probably good to mention that “The background histograms represent the number of fire patches” in the caption. Finally, what is the size and ranges of the FRP-bins? Are you excluding bins with less than x fire patches?

Table 1: “FI at maximum size (MW)”, seems to be incorrect since you did not look at the FI for the largest fires. Something like “FI with largest associated fire patch sizes”, or similar may be more appropriate.

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