**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Global fire emissions and the contribution of deforestation, savanna, forest, agricultural, and peat fires (1997–2009)" *by* G. R. van der Werf et al.

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We greatly appreciate the thorough and constructive review and appreciate the amount of time spend on the review, please find a detailed response below.

[Reviewer] 1: The authors might want to refer in the abstract to GFED (Global fire Emission Database). The previously published GDEDv2 has been widely applied in the modeling community. To clearly distinguish between the updated and improved GFED version (GFEDv3) introduced here and previous versions, GFEDv3 should be named in the abstract and also be clearly introduced and referred to as GFEDv3 throughout

the manuscript.

[Reply] We have added "Average global fire carbon emissions according to this third revision of the Global fire Emissions Database (GFED3) were 2.0 Pg year-1" and "Total carbon emissions were on average 13% lower than in our previous work (GFED2)." in the abstract and "We publicly released the resulting fire emissions time series that was named the Global fire Emissions Database version 2 (GFED2). We refer to the improved emissions time series described here as GFED version 3 (GFED3)." in the introduction of the Methods and datasets sections. In addition, all instances where GFED was mentioned without the version number, have been changed (to GFED1, GFED2, or GFED3).

[Reviewer] 2. I do not understand how the deforestation contribution is accounted for : The authors state that they combine burned area and active fire detections as a proxy for the area cleared by fire in deforestation regions. Therefore, the burned area is separated into burned area in wooded and in herbaceous. The cleared area is the product of wooded burned area and fire persistence. How is fire persistence defined in this context?

[Reply] We have added "In addition, the number of times an active fire is observed in the same grid cell (fire persistence) yields information on the fuel load and type of burning;..." and "Specifically, the fire persistence was computed as the total number of active fire detections within the $0.5°$ grid cell each month divided by the number of 1km grid cells where active fires were observed in the month." in section 2.4.1

[Reviewer] What active fire detection product is used?

[Reply] We have used MODIS active fire products as described in section 2.3.1.

[Reviewer] How does this compare to the approach used in Giglio et al., 2006 for which a correction factor of 3.2 for burned area was defined in regions classified as deforestation areas (high fire persistence and tree cover)?; Is this correction factor not

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longer applied in Giglio et al., 2010? [Reply] The factor 3.2 in Giglio et al. (2006) was based on the geometric mean of the factor with which clearing sizes exceed the size of slash piles (between 1 and 10). The fire persistence approach has the same goal, but adds a spatial and temporal component. In general, the correction is smaller than a factor 3.2 but since the burned area estimates vary between Giglio et al. (2006) and Giglio et al. (2010), these factors are not interchangeable. Our main goal was to mimic deforestation rates based on independent data as described in 2.4.1.

[Reviewer] Does the burned area distributed with the GFEDv3 dataset include this "correction".

[Reply] No, a clarifying statement has been made in the readme file that accompanies the dataset

[Reviewer] The additional data layers used to derive the breakdown of fire emissions into different sources are certainly of interest for the users of GFEDv3 and it would be desirable to include them in the distribution of the GFEDv3 dataset.

[Reply] These are included for public use, and this is now mentioned in the conclusions section.

[Reviewer] 3. The authors state that the fraction of tree cover used to divide the burned area into wooded and herbaceous is based on the satellite observed VCf (vegetation continuous field) for the year 2004. for years other than 2004, the fraction tree cover was corrected by the cleared fraction. How is this done? The fractional tree cover is already needed to estimate the cleared fraction in the first place. - CASA also needs VCf to separate herbaceous and wooded vegetation. Is this the corrected VCf?

[Reply] We only adjusted the 0.5d VCf for use in CASA (separating herbaceous and woody vegetation). The 500m VCf was not adjusted, which might lead to errors in the deforestation rate calculation, although the fire persistence calculation is independent of VCf. We have added the following sentence in section 2.4.1 to further clarify: "This

was only done for the VCf in 0.5° grid cells to ensure proper partitioning of NPP to herbaceous and woody components; the 500 meter VCf maps used to partition burned area over different fractional tree cover bins remained unchanged due to the lack of annual maps or additional information that could be used to adjust the maps at native resolution."

Specific comments: [Reviewer] Page 16154, Line 24: Why are the woodland fires not mentioned in the title?

[Reply] Savanna fires in general include fires in a vegetation types ranging from grasslands interspersed by some trees to denser woodlands. Since the partitioning between grasslands and open savanna fires on one hand, and closed savannas (woodland) fires on the other hand was somewhat arbitrary (as acknowledged), we have chosen to lump these fire types together in most occasions, except for the detailed partitioning.

[Reviewer] Page 16162, Line 9: "2.3.1. Burned area and active fires" In this paragraph it is not clear to what extent the burned area dataset from Giglio et al. (2010), including also information on the distribution of burned area within the grid cell across different vegetation types and the distribution of burned area as function of fractional tree cover, was modified in this study, e.g. the use of a monthly climatology instead of active fire pixels for the partitioning for the pre-MODIS era.

[Reply] We have not modified the Giglio et al. (2010) burned area dataset for the MODIS era except for boosting burned area in deforestation zones as described in section 2.4.1. for the pre-MODIS era, we hope the following sentences provide additional clarity on our approach: "To partition sub grid scale burned area over the various land cover types for the pre-MODIS era and when the 500 meter burned area maps were not available, we used a monthly climatology based on burned area partitioning during the MODIS era instead of information derived from active fires in the pre-MODIS era. This was done to avoid inconsistencies among different active fire and burned area products and does not impact total burned area, only the partitioning. for example, the

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ATSR nighttime detection will give a smaller weight to those fires exhibiting a more pronounced diurnal cycle compared to MODIS.."

[Reviewer] Page 16163, Line 17: Were the MOD15 data available for the period 2000 – 2009?

[Reply] Yes, we have added "from 2000 onwards" to section 2.3.2

[Reviewer] Page 16164, Line 10: Is M(m,i) the monthly mean fAPAR value for the time period 2001-2008 ?

[Reply] That is right, as mentioned in the preceding sentence

[Reviewer] Page 16166, Line 14: fig.4 is really helpful for the reader to understand the partitioning, maybe this could be referenced earlier.

[Reply] The figure was referenced to earlier in sections 2.4.2 and 2.4.3

[Reviewer] Page 16166, Line 21: Do you mean wooded with forested?

[Reply] Yes, this has been changed

[Reviewer] Page 16169, Line 22: "fire emissions from trees that occurred in grid cells containing evergreen broadleaf forest but outside the humid tropics forest domain were here included as deforestation (or degradation) emissions to separate them from deforestation and degradation fires within the humid tropical forest biome, and to be able to assign them a different emission factor." I do not understand this sentence. from fig. 4 I conclude that there is one "deforestation and degradation" category only, or is this still separated in humid tropics and not humid tropics? The numbers given for deforestation fires throughout the manuscript do they refer to the total or humid tropics only?

[Reply] Analog to separating woodland from open savanna fires, the distinction between deforestation and degradation fires is somewhat arbitrary. In addition, degradation implies different things in different communities. We have therefore lumped

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these two classes together throughout the text and tables, and had added the following sentence in section 2.4.3: "However, this distinction is somewhat arbitrary; below we will refer to deforestation and degradation emissions to cover all non-savanna or agricultural fires occurring in the tropical forest domain irrespectively of whether they caused permanent land use changes (deforestation) or were, for example, escaped fires (degradation)."

[Reviewer] Page 16166, Line 27: "area weighted average of the previously and newly deforested fractions" Isn't this the area weighted average of the single deforested fractions occurring in one grid cell?

[Reply] Yes, but since the model does not track each event separately, information of previously deforested fractions is lost and we have to area-weight average all previous events on one hand, and the current event on the other hand.

[Reviewer] Page 16170, Line 13: "Boreal forests were unique in that emissions included burning in forest, shrubland, and wood savanna classes." This information is already stated above. Also the labeling in fig. 4 (1-fraction grassland/cropland/barren" for the forest fraction in boreal regions is not really self explaining. The authors might want to add an explanation to the figure caption.

[Reply] Indeed, the information might be interpreted as redundant. However, we included it a second time to highlight the contrast with non-boreal areas. Regarding figure 4, we have added "Since boreal fires burned in vegetation classes defined as savanna but more likely resembling forest, the approach to estimate the forest fraction is based on excluding fires in vegetation classes without woody vegetation (section 2.4.3)." to the figure caption

[Reviewer] Page 16170, Line 20: "labeled them savanna fires" . . . it is actually savanna and grassland fires. This should be consistent throughout the manuscript.

[Reply] We have changed "savanna" to "grassland and savanna" where appropriate;

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this was already done in the figures

[Reviewer] Page 16171, Line 18: Organic soil layer burning. This needs some more explanation. How is this simulated in CASA? Are the areas in which the organic soil layer burns restricted to peat regions only? How are the peat regions outside the tropics defined? Is boreal soil layer burning reported as forest fire emissions and what emission factors are applied?

[Reply] We have added "Similar to our previous work, we modified the turnover rates of the soil pools to mimic measured organic soil carbon stocks (see 2.4.6). for the boreal region, we assumed that organic soils only burn in areas with a mean annual temperature below zero, while the fraction of emissions in Indonesian peatlands was derived from the fraction of area burned observed on grid cells identified as peat (see Giglio et al., 2010). Due to the lack of spatial-explicit maps, peat or organic soil burning outside Indonesia and outside areas with below zero mean annual temperature have not been included." Regarding emission factors, we have added "We did not apply separate emission factors for above- and belowground fuel components in extratropical forest fires because available field measurements had a large range of variability that integrated across these two sources of emissions." in section 2.4.5 to avoid confusion.

[Reviewer] Page 16171, Line 21: "we set a minimum and maximum value." of burning depth?

[Reply] Yes, this has been changed

[Reviewer] Page 16173, Line 2: 2.4.5. "Trace gas emissions" - It is not clear to me what the deforestation Ef is based on. -" . . . we used a dry matter content of âĹij48% to translate calculated carbon to dr y matter conditions." Is here only a single value used, or is this done biome specific with the values given in Tab. 5?

[Reply] We have added ". . . , with tropical forest fires representing deforestation fires" to the section. We also changed the dry matter section so it reads "based on mass

balance equations of the Efs (CO_2 + CO + CH_4) we used a dry matter carbon content of ~48% for most classes except agricultural fires (44%) and peat fires (56%) to translate calculated carbon to dry matter emissions, see Table 5."

[Reviewer] Page 16180, Line 10: "This analysis was confined to the tropics". This should be rephrased. The analysis of deforestation and peat fires were restricted to the tropics but fire emissions were assessed globally (the global emissions are also the reference for the " 1 4 of all fire emissions might be net emissions" in the sentence before).

[Reply] This has been changed to "This deforestation, degradation, and peatland fire analysis was confined to the tropics (figs. 13, S8)."

[Reviewer] Page 16181, Line 11: "fire emission were doubled to account for emissions other than fires, for example from the respiration of leftover plant materials ..." Does GFED3 not track the respiration of killed but not combusted material as done in van der Werf et al., 2003?

[Reply] That is right. for deforestation total emissions, however, one not only should know the respiration from killed but not combusted materials, but also from the decomposition in soils etc. This will be part of future work.

[Reviewer] Page 16192, Line 23: "While our combustion completeness values as well as depth of burning in peatlands were scaled based on soil moisture conditions . . .." Is this scaling not applied for the depth of burning of organic soil layers?

[Reply] Yes, it is. We changed the sentence to "While our combustion completeness values as well as depth of burning in peatlands and organic soils were scaled based on soil. . ."

[Reviewer] Page 16196, Line 10: I had problems to find the biospheric ïňĆuxes (NPP and R_h) through the provided link.

[Reply] We are currently setting up a more user-friendly data portal with improved

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navigation.

[Reviewer] Table 1: "VCf (2001 onwards)" from the text I understood that VCf for the year 2004 was applied.

[Reply] That is right, it has been changed accordingly.

[Reviewer] Table4: The separation of combustion completeness into "burned" and "all" needs some further explanation.

[Reply] We have added two footnotes to explain in more detail

[Reviewer] fig. 1: It should be mentioned in the caption that this is for the Amazon basin.

[Reply] Inserted

[Reviewer] fig2/fig10/fig12: The gray scale is hard to distinguish on my print out. A colored version would be easier to read.

[Reply] We have changed the three figures to colorscale.

[Reviewer] fig 4: This figure is really helpful. However, there are a some details I do not understand: what does the 0.5d stand for? Should this 0.5 deg ?

[Reply] Yes, changed in the figure

[Reviewer] "Organic soil: f(climate, fP)" - how is the fire persistence used here?

[Reply] We have modified the text in section 2.4.4: "Organic soil burning was modeled in a similar fashion as combustion completeness; we set a minimum and maximum burning depth value (0 and 15 cm for the boreal region, 0 and 50 cm for Equatorial Asia), which was then scaled based on soil moisture conditions (from both the current and the previous month) for the boreal region, and a combination of soil moisture conditions and fire persistence for Equatorial Asia. Specifically, we used the square root of the multiplied soil moisture effect and the fire persistence to combine observed fire

activity and the climatological potential for fires to burn into the soil, something that may not be fully captured by satellite."

[Reviewer] (*) - the tropical "peat" class is not shown, but is based on the fraction of burned area detected in tropical peatlands and the tropics organic soil burning scheme" Isn't for the partitioning, explained in this figure, only the peat coverage used and not the "soil burning scheme". .

[Reply] This has been explained better in the caption: "The tropical peat class is not shown, but is based on the fraction of burned area detected in tropical peatlands and the TR scheme for estimating depth of burning into the organic soil."

[Reviewer] FTC is not introduced in the caption.

[Reply] Now added

[Reviewer] fig. S2: "linear regression between MODIS fAPAR and AVHRR NDVI" is this identical to the GIMSS NDVI as stated in the main text?

[Reply] Yes, we have changed AVHRR to GIMMS to avoid confusion

[Reviewer] fig. S2: . . . and varied between 1-60% in the tropics . . ..

[Reply] Changed

Technical corrections: [Reviewer] Page 16156, Line 20: "Schultz et al. (2002)" should be "Schultz (2002)"

[Reply] Done

[Reviewer] Page 16165, Line 7: "2.4.1 Deforestations Rates" Here and throughout the manuscript the authors should clearly state that the deforestation source is only accounted for in the tropical regions.

[Reply] We have changed the section captions 2.4.1 and 2.4.2 and modified several other occasions to highlight that our approach to capture deforestation was limited to

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the tropics.

[Reviewer] Page 16172, Line 25: "burned between less" should be "burned less"

[Reply] Changed

[Reviewer] Page 16175, Line 13: ".. best estimates" should be "... best estimates."

[Reply] Changed

[Reviewer] Page 16176, Line 19: Reference Andreae et al., 2001 should be Andreae and Merlet (2001)

[Reply] Changed

[Reviewer] Page 16178, Line 3: "Cvs" should be "CV"

[Reply] Changed

[Reviewer] Page 16178, Line 15: "One factor that had a major impact on ..." That the uncertainty is higher before 2001 is already stated two sentences before.

[Reply] That is right, however, also in the post-2001 period about 10% of the area burned was derived from fire hot spots, so these statements do not fully overlap. To clarify, we have added "This was not only the case in the pre-MODIS era, but also for about 10% of the total burned area in the MODIS era for which no burned area maps were available (Giglio et al., 2010)."

[Reviewer] Page 16179, Line 29: "BOAS" should be "Boreal Asia"

[Reply] Changed

[Reviewer] Page 16191, Line 25: "... indicate fuel loads of " should be replaced by " . . . indicate fuel consumption of "

[Reply] Changed

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 16153, 2010.

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