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Biogeosciences Discussions

Interactive comment on "Annual and diurnal African biomass burning temporal dynamics" *by* G. Roberts et al.

G. Roberts et al.

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NOTE: Unfortunately the submission process for the Authors Comments prevents the inclusion of figures. As a result the figures that were included in the response have been removed and put on an ftp site. Also included on the ftp site is a document that includes the comments and figures for reviewer 1 and reviewer 2 (bgd-2008-0090_reply_reviewers_comments.doc). All documents are in Word and PDF format. The ftp sites address is :

137.73.24.199

userID : volcano

pwd: grainofsand

/array1/volcano/groberts/BIOGEOSCIENCES

If there are any problems accessing the ftp site please let me know.

(1) Although the work itself is quite well done, the objective is not explicitly stated in the introduction. For instance, just before the last paragraph that begins with This paper concentrates . . . , I would have expected to see a paragraph that clearly highlights the fact that there is need to do what has been done, perhaps in the form of a convincing argument demonstrating that what is currently available is inadequate. Fortunately, there is a subparagraph in section 2, which does not fit properly where it currently is and, with appropriate adjustment, could make a great paragraph before the last one in the Introduction. It is the second half of the last paragraph of section 2, starting with The burning fuel is _48% carbon . . . all the way to the end of that section (i.e. page 3630, lines 3 – 13).

As suggested, the final paragraph of the introduction section has been amended to :

This paper concentrates on exploiting the first full year of active fire detections, FRP and FRE data recorded by SEVIRI over the African continent, in order to investigate the seasonal and diurnal cycle of biomass burning in northern and southern hemisphere Africa (NHA and SHA), the pattern and amounts of fuel consumed, and how these vary with land cover. Over selected fires, comparisons are also made to measurements of fuel consumption derived via the alternative burned area based approach, for which data on pre-fire fuel load are estimated from net primary production datasets. Dry matter fuel is ˜48% carbon, and such data on biomass burning carbon emissions maybe of relevance to the information requested by the United Nations Framework Convention on Climate Change (UNFCCC), to which the majority of African countries are signatories (Braatz et al., 1995). Currently, African nations are unable to readily benefit, either financially or technologically, from emissions mitigation schemes implemented under the Clean Development Mechanism (CDM) of the Kyoto Protocol, which focus primarily on more easily quantified industrial emissions from fossil fuel burning (Williams et al., 2007). Improved quantification of other carbon sources (and sinks), and how these might be made to vary with altered land use practices for example, may

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offer the potential to enable African nations to derive improved benefits in future.

(2) It was not very clear how burned biomass from the FRP method compares with burned biomass from the burned-area-based method. I was expecting to see the result of this comparison in the last paragraph of section 4.2, but instead the authors seemed to give the impression that the burned-area-based method only provided the pre-burn available biomass, and the comparison allowed them to infer the combustion completeness. It made the discussion somewhat confusing, because the objective was to compare the same products from two methods rather than to combine different products from two methods to infer a third product. I think it would be better for them to apply the literature combustion completeness, which they cited as 83 – 98%, to the burned-area method and actually calculate the burned biomass, which they can then compare with the FRP-based result, so that the reader may appreciate the level of agreement between the results of the two methods. It does not matter if they do not agree, as any discrepancy can be investigated in future research.

We have altered this part of the manuscript as suggested, which improves clarity as the same quantity is now being compared on both axes of the graph in Section 4.2. This section has been revised and uses a combustion factor of 90% to convert the burned area/NPP fuel load estimates into biomass combusted. Based on the literature, a combustion completeness of 90% is reasonable value for this cover type and time of year. The error associated with the FRE-derived estimates is a constant 12.5% which is the uncertainty associated with estimating the FRP using the MIR radiance method for fires with temperatures between 650K and 1350K. Refer to Wooster et al. (2003) and Wooster et al. (2005) for further details. There is no information provided on the uncertainty of the NPP estimates. As a result the error associated with the NPP/burned area derived estimates is given by the lower (83%) and upper (98%) estimates of the combustion completeness which are taken from the literature. The relationship between the variables is similar:

1) fuel load / FRE biomass combusted ($r2 = 0.82$ and $y=0.97x$) 2) (burned area/NPP

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biomass combusted) / FRE biomass combusted ($r^2 = 0.82$ and $y=1.07x$)

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The paragraph associated with this figure has been changed (see Reviewer #1 reply #23)

(3) Although the authors converted FRE to burned biomass using the biomass combustion factor derived in Wooster et al., (2005), the value of that factor was not mentioned anywhere in the paper. I think, for the sake of completeness, it would be good to mention the value of the combustion factor (or even the conversion equation, since it is very short) in an appropriate place in the paper.

This has been added to the introduction :

At each such pixel, the rate of Fire Radiative Energy (FRE) release, also called the Fire Radiative Power (FRP), can also be retrieved from the instruments infrared radiance measures. FRP is highly correlated to the rate of fuel consumption and thus smoke emissions production (Wooster et al., 2005; Freeborn et al., 2008) and the temporal integration of FRP provides a measure of a fire’s FRE, which can be converted to an estimate of total fuel consumption using the linear relations presented in Wooster et al. (2005):

$$M = FRE * B \quad [1]$$

where M is the biomass combusted (kg), FRE is the Fire Radiative Energy (MJ), and B is the radiative fuel consumption factor, estimated as 0.368 kg/MJ by Wooster et al. (2005).

Technical Corrections: I list the corrections I consider necessary simply in the order they appear in the paper:

Page 3624, Lines 3-4: Technically, the satellite observation is made at discrete time

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intervals, while the pixels are finite areas, which represent spatial resolution. Therefore, I would change the relevant segment of the sentence to 15-min temporal interval and 3-km spatial resolution.

Changed to :

Both satellites carry the SEVIRI instrument, an imaging radiometer with a 3 km sampling distance at the sub-satellite point and a repeat cycle that provides measurements in eleven spectral channels covering the 0.6-14 μm range every 15 minutes.

Page 3624, Lines 13-14: The second part of the sentence i.e. , indicating the importance of optimizing the fire pixel detection strategy performance is not necessary because it does not convey any useful information here. I suggest that it be removed.

It has been removed.

Page 3625, Line 3: The authors name is spelt Merlet. Also, I would start the sentence after that with Depending on rather than Varying with.

Changed accordingly.

Page 3625, Line 4: Hao et al. is 1996 (not 1990) in the reference list. Verify which date is correct.

Hao, W. M., Ward, D, E., Olbu, G., and Baker, S. P. (1996) Emissions of CO2, CO and hydrocarbons from fires in diverse African savanna ecosystems. Journal of Geophysical Research. 101. D19. 23577-23584.

Page 3625, Line 6: IPCC (2001) is not listed in the reference list.

This has been added :

IPCC (Intergovernmental Panel on Climate Change) (2001) In Third Assessment Report, Climate Change 2001. The Scientific Basis, Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change

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(IPCC). Cambridge University Press. UK. pp 944.

Page 3625, Line 18: I would write, remote sensing from Earth Observation (EO) satellites, to avoid using the word observation twice so closely.

Agreed and changed.

Page 3626, Line 4-5: Right after Despite their relatively coarse spatial resolution I think it is good to actually give the resolution in parenthesis, e.g. (4 km at nadir) before continuing the sentence, so that a reader who is not familiar with GOES may not be wondering what it is exactly.

Agreed and changed.

Page 3626, Line 10: Here again, replace sampling distance with spatial resolution, because the pixels are not points located every 3 km, but contiguous areas each _3 km wide. Please try to check the rest of the paper and make the correction.

Agreed and changed.

Page 3626, Line 17: This sentence is somewhat long, and gets a little fuzzy in the middle. I would end it after the word measures, then start a new sentence by replacing a parameter that with FRP.

This sentence has been changed and is given in Reviewer 2, reply #3

Page 3627, Line 23: This is the first time you mentioned MIR. Therefore, it is necessary to write it out like mid infrared (MIR).

This has been corrected.

Page 3628, Line 5: There is only one Giglio et al 2003 (without alphabetic suffix) in the reference list.

Changed to Giglio et al., 2003

Giglio, L., Descloitres, J., Justice, C. O., and Kaufman, Y. J. (2003) An enhanced con-

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textural fire detection algorithm for MODIS. Remote Sensing of Environment. 87. 2-3. 273-282.

Page 3628, Line 8: remove by just before MODIS.

Done

Page 3628, Line 10: It is better to say fairly significant or non-negligible”rather than not insignificant.

Replaced with fairly significant

Page 3628, Line 21-26: This is a long winding sentence, and needs to be broken into two.

This sentence has been replaced with :

The FRP measures were corrected for atmospheric attenuation using the MODerate resolution atmospheric TRANsmission (MODTRAN) 4.0 radiative transfer code (Berk et al., 1999), parameterized using a tropical atmospheric profile and with water vapor concentration derived from three-hourly re-analysis data provided by the European Center for Medium Range Weather Forecasting (ECMWF) interpolated to the SEVIRI temporal frequency. Surface height estimates from the GTOPO30 digital elevation model (DEM) and a 23 km visibility were also assumed in the MODRTAN parameterization.

Page 3629, Line 10: There is no van der Werf et al 2004 in the reference list (only 2003 and 2006). Find others and correct.

The reference has been corrected to :

van der Werf et al. (2003)

Page 3629, Line 26: Delete the comma after Across.

Done

Page 3629, Line 27: The value for Chad is well below 50 Tg. Check the chart carefully.

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This has been corrected to 30Tg.

Page 3630, Line 2: I think you mean apparently largest not largest apparent.

Changed to apparently largest

Page 3630, Line 15: Insert of between amount and fuel.

Done

Page 3630, Line 21: Despite the dictionary meaning of decadal as designating tens, it has come to be regarded in common usage as representing tens of years. To avoid confusion, I think it is best to remove decadal everywhere you have used it to refer to days. It is enough to write it simply as 10-day mean.

This has been corrected in the figures and the text to 10-day mean.

Page 3631, Line 4: Yevich and Logan is 2002 (not 2003) in the reference list.

Corrected to Yevich and Logan (2003)

Page 3631, Line 13: If you look at the plot carefully, shrubland did not show a steady increase at the beginning of the season, but fluctuates.

This has been rephrased to better reflect the full detail of the plot (the figure is provided below for reference):

Conversely, from the start of the time-series (Feb 04), the mean per-pixel FRP of grassland and woodland tends to increase until the end of the dry season where the magnitudes are maximized (March – April), even though the FRE has already decreased substantially by this time. Between February and April, the mean FRP for shrubland fluctuates before gradually decreasing through the latter part of the dry season. The inference is that there is less fuel being burned at this time compared to earlier in the dry season, but where fires are occurring the combustion rates are high. One reason maybe that much of the available areas of fuel have already been burned by this stage of the season, but what is left has been drying for many months and so burns rapidly and extensively.

For figures refer to either reviewer2_technicalcorrection1.doc or bgd-2008-0090_reply_reviewers_comments.doc on the ftp site

Page 3631, Line 21: The plot shows the increase starting from April (not June).

This has been reworded to :

The situation is somewhat similar in the southern hemisphere (Figures 4b and 4d). A gradual increase in the mean FRP is observed between May and September for grassland, shrubland and to a lesser extent woodland. The increasing mean per-pixel FRP values as the dry season progresses are possibly related to decreasing fuel moisture and a resultant increasing combustion completeness. This is consistent with the findings of Hoffa et al. (1999) deduced from experimental burning, where decreasing fuel moisture and increasing fireline intensity were noted as the dry season progressed. Fires in grasslands, shrublands, and to a lesser extent woodlands, have the highest mean per-pixel FRP in August and September.

For figures refer to either reviewer2_technicalcorrection2.doc or bgd-2008-0090_reply_reviewers_comments.doc on the ftp site

Page 3632, Line 5: If you look at the chart carefully, it is actually the deciduous woodland that covers the largest area, more than twice that of the deciduous forest. Therefore, you need to interchange those two biome types in the sentence.

This sentence has been removed.

Page 3632, Line 17: Giglio et al 2006 has a or b suffix in the reference list.

Corrected to : Giglio et al. (2006b)

Page 3632, Line 19: You need to add a comment here about the montane forest type, which has the highest mean per-pixel FRP value unlike the other forest types.

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See the reply made to Reviewer #1, number 17

Page 3632, Line 27: not relate but related.

Corrected.

Page 3633, Line 10: Roberts and Wooster should be 2008 (not 2007).

Corrected to : Roberts and Wooster (2008)

Page 3633, Line 12: delete s from fires. It should be fire pixels.

Corrected

Page 3633, Line 19: Jost et al is 2003 (not 2002) in the reference list.

Corrected to Jost et al., 2003

Page 3634, Line 14: Swap et al (2003) is not in the reference list.

Swap et al. (2003) has been included in the references :

Swap, R. J., Annegarn, H. J., Suttles, T. J., King, M. D., Platnick, S., Privette, J. L. and Scholes, R. J. (2003) Africa burning: A thematic analysis of the Southern African Regional Science Initiative (SAFARI 2000). Journal of Geophysical Research. 108. 8465. doi:10.1029/2003JD003747.

Page 3635, Lines 15-16: they are believed should be replaced with a more scientific clause such as they have been shown followed by an appropriate reference. If there is no prior paper that showed that they are less perturbed by errors of commission, then you need to make a more tangible statement to justify your claim.

This has been changed to :

The baseline study region for this comparison was selected using a burned area map taken from the ESA Globcarbon project (Plummer et al., 2007). Areas of deciduous woodland, shrubland and grassland that burned during the 2003 southern African dry season (May – October) were selected as the study zones, assuming that these represent areas where fuel is likely to have been burned nearly completely in 2003 since combustion completeness is stated to vary between 83 and 98% in such regions (Scholes et al., 1996; Hoffa et al., 1999; Sa et al., 2005). Burned area products are known to miss some fire-affected areas (i.e. errors of omission) but are far less perturbed by errors of commission and so provide a suitable mask for identifying such definitively fire-affected zones (Simon et al., 2004).

Page 3636, Line 12: Veroustaete et al. (1996) is not in the reference list.

This has been added to the references :

Veroustraete, F., Patyn, J. and Myneni, R. B. (1996) Estimating net ecosystem exchange of carbon using the normalized difference vegetation index and an ecosystem model. Remote Sensing of Environment. 58. 1. 115-130.

Page 3636, Lines 25-26: g C/m2 and g/m2 are not the same. You need to check all your units carefully to make sure they are accurate and consistent.

This has been corrected to g/m2.

Page 3637, Line 19: add s to fire.

Corrected

Page 3637, Line 26: delete the after each.

Corrected

Pages 3638-3639: There was a recent attempt at roughly perceiving FRP diurnal signature from the four-times-a-day MODIS data, which may deserve to be cited somewhere in this section. It is in: Ichoku, C., L. Giglio, M. J. Wooster, and L. A. Remer, Global characterization of biomass-burning patterns using satellite measurements of Fire Radiative Energy. Remote Sens. Environ., 112, 2950-2962, 2008.

This has been included and cited in a number of places.

Page 3640, Line 7: the singular form of the word is phenomenon. See also Line 13, and check everywhere else.

Changed three occurrences

Page 3640, Lines 24-25: This last sentence tends to leave the reader wondering Why?. It would be good if, based on your experience with the data analysis, you could try to find (or even hypothesize) a reason or two why highest number of pixels translates to highest mean FRP in these biomass types.

Using the closed lowland forest land cover type as an example, the mean pixel FRP diurnal profiles (illustrated below, upper plot) are quite similar for much of the day (between 9am and 4pm) in terms of the magnitude and the shape of the profile. The main difference between the NHA and SHA mean FRP diurnal cycle is in magnitude rather than profile shape. The frequency distribution of the mean FRP from both hemispheres indicates that SHA contains a greater proportion of pixels with mean FRPs exceeding 150 MW.

A greater number of fire pixels (lower plot below) are detected in SHA than NHA for much of the diurnal cycle. Between slots 0 and 40, the difference in the number of fire pixel detections is quite small. The difference is much greater after slot 70. However, during both of these periods the difference in the mean FRP between each hemisphere is comparatively stable. This suggests that the number of pixels is not directly influencing the magnitude of the mean FRP.

For figures refer to either reviewer2_technicalcorrection3.doc or bgd-2008-0090_reply_reviewers_comments.doc on the ftp site

The image (above) is a map of the mean per-pixel FRP classed into low and high values (green\blue are high per-pixel FRP, red\orange are low per-pixel FRP) for the majority of the fire affected pixels of the closed lowland forest land cover type. Analysis of the

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MODIS Vegetation Continuous Fields dataset indicates that the closed lowland forest pixels in SHA are composed of a greater proportion of shrub/grass than are the NHA closed lowland forest (52% and 35% respectively). Nearly 34% of the SHA active fires occur in pixels containing 50% or more grass/shrub cover, whilst in NHA this figure is 19%. It is hypothesized that the reduced tree cover proportion in the SHA closed lowland forest improves the conditions for combustion (reduced relative humidity and higher temperature) that increases the period of time over the day that combustion can occur and enables greater combustion at night.

To better reflect this the following has been added to the paragraph:

Generally, results are similar for both hemispheres, although closed lowland forest and swamp/bushland/grassland are notable exceptions. In these cases, the hemisphere with the greatest number of fire pixel detections in that cover type shows the greatest mean per-pixel FRP. In the case of closed lowland forest, the diurnal profiles are similar with respect to temporal profile. However, although the mean FRP magnitudes are similar during the day, the SHA mean FRP is greater during the night. Analysis of the MODIS VCF dataset (Hansen et al., 2003) indicates that the fire pixels in SHA closed lowland forest are composed of a greater proportion of shrub/grass vegetation than are those in NHA closed lowland forest (52% and 35% respectively). It is possible that the reduced tree cover in SHA improves the conditions necessary for combustion (i.e. reduced relative humidity, higher temperatures and greater wind speeds), thus enabling more effective combustion to continue at night than in the NHA case.

Page 3641, Line 5: insert a after at.

Done

Page 3641, Line 15: After publication, this will no longer be just a manuscript. Replace it with paper or study.

Replaced with ‘study’

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Page 3641, Line 16: replace Africa with individual African countries.

Done

Page 3641, Line 17: replace African simply with the.

Done

Page 3642, Line 7: agrees quite well is not really appropriate here. It would be better to use something like falls within the range.

Replaced with falls within the range of

Page 3655, Figure 6: The vertical axes need a proper title that indicates exactly what is represented rather than just percentage.

The axis has been changed to Percentage of fire detections

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