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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) In this contribution remote sensing data obtained from a radiometer onboard Meteosat-8 geostationary satellite have been employed to investigate biomass burning patterns in Africa. The manuscript reports interesting new data. The paper should be rejected, however. There are three reasons for this. The references section is, mildly speaking, sloppy. Several of the figures are difficult to read. The paper is written for a highly specialized community. Especially the latter suggests to consider another journal for submission

We apologize for the mistakes in the references section, which has been extensively revised. Some figures were difficult to read during the conversion of the figures to PDFs and the figure size being smaller than we anticipated. The figures have now been altered to deal with this eventuality and are now much more readable even when shrunk. In relation to the 3rd point above, the authors believe that the content of the manuscript is in fact well suited to the special issue which is entitled, Carbon Cycling in Sub-Saharan Africa. The manuscript complements a number of the publications in this special issue such as Lehsten et al. and Chevallier et al. in discussing an approach for quantifying one or more components of the African carbon cycle, and we were encouraged to submit this publication to this Special Issue for just this reason.

Lehsten, V., Tansey, K. J., Balzter, H., Thonicke, K., Spessa, A., Weber, U., Smith, B., and Arneth, A. (2008) Estimating carbon emissions from African wildfires. Biogeosciences Discuss. 5. 3091-3122.

Chevallier, F., Fortems, A., Bousquet, P., Pison, I., Szopa, S., Devaux, M., and Hauglustaine, D. A. (2008) African CO emissions between years 2000 and 2006 as estimated from MOPITT observations. Biogeosciences Discuss. 5. 3845-3868.

2) Addressing a broad audience requires understandability of highly specialized topics. Therefore referring to other journals only may not always be appropriate. SEVIRI could be explained as Spinning Enhanced Visible and Infrared Imager and FRP likewise. The

Abstract would have benefited. But several abbreviations later on in the text remain obscure, if the reader is not a member of the remote sensing community: GTOPO30, DEM, SPOT VGT, DVGM.

We agree with the reviewer and all full names have now been included together with abbreviations, in the main text and also in the abstract where necessary.

3) The references are not always well prepared, either there are misspelling (it is Merlet, not Merlot), or they are missing at the end (Giglio et al., 2003a p3628; van der Werf et al., 2004 p. 3629; Giglio et al., 2006 p. 3632; Roberts and Wooster, 2007 p. 3633; Jost et al., 2002 p.3633; Lui et al., 2005 p. 3633, Swap et al., 2003 p.3634; Veroustraete et al., 1996 p. 3636; ven der Werf et al., 2004 p. 3638. Fourteen citations are given in the references section, which do not appear in the text

This was a mistake when preparing the final version of the reference list for which we apologise. It has now been corrected.

4) Most disgusting in this manuscript are the figures, explicitly Figure 2, 4, 6, 11, 12, 14. Some colors used are hardly visible, sometimes are lines missing, high magnifications are necessary to find out what the authors want to convey. It is mainly for this reason, and the references section, why the manuscript is not acceptable.

Many of these issues relate to the way the figures were turned into PDFs and were shrunk in the process such that lines became very thin and text sometimes too small. We have now made extensive alteration to the figures to deal with this issue.

5) page 3626 What is exactly the sampling distance ? Is it the lateral length of one pixel or is it the length of an agglomerate of pixels which allow recognition of a pattern which can be attributed to a fire ? Especially in the latter case moving fires may escape detection. How large would the 3 km sampling distance be at the Cape point ?

Sampling distance is the distance on the ground between neighboring pixel centers. SEVIRI has a 3 km sampling distance at the sub-satellite point and the sampling distance increases away from this point. At the Cape Point the sampling distance is 4.1km. SEVIRI oversamples such that pixels overlap and so all the land surface contributes to the measured signal within a disk (i.e. there are no gaps that would mean moving fires could be missed due to their motion). The oversampling factor is 1.6 in both directions.

6) page 3627 Do burning mine and refuse dumps contribute to the SEVIRI signal and could they be used for internal calibration procedures.

Fires in mines and refuse dumps that were sufficiently large and intensely burning would be detected by SEVIRI. However, such fires are unlikely to be detected as they are usually not characterized by flaming activity at the surface of the Earth since much of the combustion is smoldering and is located underground. In theory, a better target for such activities might be gas flares from oil and natural gas installations. Information on the location of such (presumably quite persistent) thermal anomalies is useful for assessing the robustness of the fire detection algorithm, particularly over time. In the case of gas flares however, these are rather small in size and so most likely to be detected over the ocean or at night when the emitted thermal signal is enhanced over that of the cooler background. In terms of radiated energy, to calculate the rate of radiant energy release from gas flares it would be necessary to have information on the flame surface area and temperature, and since it is gas and not solids that are burning, the emission is preferentially occurring within the particular gas absorption and emission bands rather than extended over the entire thermal spectrum as is generally the case with vegetation fires (Wooster et al., 2005). This will then invalidate some of the assumption made within the Fire Radiative Power retrieval method. The World Bank and Government of Norway launched a Global Gas Flaring Reduction (GGFR) initiative in 2002 in which some countries in Africa participate. However, the reporting of gas flaring and venting is currently voluntary and these data are often provided as country-wide totals (Elvidge et al., 2007). SEVIRI only intermittently detects these signals, which makes using country-wide estimates unreliable for the purpose of validation.

Elvidge, C. D, Baugh, K. E., Tuttle, B. T., Howard, A. T., Pack, D. W., Milesi, C.

and Erwin, E. (2007) A Twelve Year Record of National and Global Gas Flaring Volumes Estimated Using Satellite Data. Final Report to the Wold Bank. WWW: http://www.ngdc.noaa.gov/dmsp/interest/DMSP_flares_20070530_b.pdf

7) The 40% underestimation of SEVIRI is large enough to warrant a more detailed explanation and what is meant with regional scale in the given context? (Volume 48 of IEEE Transactions on Geoscience and Remote Sensing did not appear yet

This has been expanded with the following added to the text :

Vol 46 of IEEE Transactions on Geoscience and Remote Sensing is published. However, we now have added the following text to the current paper to provide more detail:

Summing the FRP detected from all fires at the regional scale (i.e. ˜1/3 of the African continent), SEVIRI underestimates total FRP by approximately 40% compared to MODIS. Two parameters fundamental to a sensors ability to detect and characterize fires are the minimum detectable fire size and minimum measurable FRP, and the maximum fire size and FRP observable without sensor saturation. These are primarily controlled by the sensors MIR channel saturation temperature, Instantaneous Field of View (IFOV) and spectral response function. SEVIRIs MIR channel saturates at 335 K, resulting in an underestimation of FRP over the largest and/or most intense fires, but this occurs in less than 1% of the total number of fire pixels detected over Africa (Roberts and Wooster, 2008). The greatest cause of the FRP underestimation is rather the omission of low intensity/smaller fires that remain undetected by the coarser spatial resolution geostationary sensor. The degree of FRP underestimation varies spatially and temporally. Over three months of data examined, the specific levels of FRP underestimation were 39% (February), 37% (May) and 44% (August) (Roberts and Wooster, 2008).

8) page 3629 it remains rather difficult for the reader to assess the influence of clouds on the magnitude of the FRE signal. According to Figure 2 it seems that scaling factors were used. The given numbers (2 and 2.3 Tg; 263 and 290Tg) say roughly 10%. What

about the changed fire management procedures due to an overcast sky? Were the above mentioned in the 40% underestimation taken into account in the comparison to the other consumption data? Which inter-annual variability may be expected?

Quantifying the exact magnitude of the effect of cloud cover on FRP is difficult – by virtue of the fact that the clouds are obscuring the fires from view and so we cannot know how much FRP is missing. Therefore, as described in the text, we adopt the commonly used method of normalizing the observed FRP present in the (cloud-free) regions of 1 degree grid cells by the cloud-fraction of the cell. This is the approach used by, for example Giglio (2007), Giglio et al. (2006) and Streets et al. (2003). The assumption underlying this approach is that fires are equally likely to occur under clouds as clear sky conditions. This is not necessarily the case, in fact clouds are likely to suppress the number of fires if anything, so the OBSEVRED FRP acts as a minimum estimate whilst the CLOUD NORMALISED FRP acts as a maximum estimate. The approach does not consider changes in land management practices, since these cannot be known in any detail, but rather through this mechanism it provides an estimate of the minimum (Observed) and maximum (Cloud Normalised) FRP at each time-slot. It therefore gives an uncertainty measure on the FRP in that the true value is expected to lie between these Observed and Cloud Normalised measures. In truth, during the African burning season there is very low amounts of cloud cover in most fire-affected regions and so as you correctly point out the difference between the Observed and Cloud Normalised measures of FRE is around 10% (which translates into a 10% difference in fuel consumption). This difference is solely due to cloud-cover and unrelated to the previously mentioned 40% underestimation due to the non-detection of small fires that are detectably by MODIS but not by the coarser scale SEVIRI data. The inter-annual variability in this cloud cover correction will be that seen in continental-scale cloud-cover.

To further convey the impact of the cloud cover correction to the reader the following test has been added :

The mean daily combustion rate of biomass over Africa is 2 Tg (observed) and 2.3 Tg (cloud-cover weighted). The impact of the cloud cover correction actually varies significantly between seasons and hemispheres, becoming more significant on either side of the dry season (a time when absolute biomass burning activity is reduced). The minimum ($<$1%) and maximum (40%) daily correction factors occur in the dry and wet seasons respectively in both hemispheres. Schroeder et al. (2008) found that using the same cloud-cover adjustment approach assumed here for the Amazon region resulted in an overestimation of the number of fire pixels, and indeed fires are not expected to be more prevalent under clouds than under clear skies. Therefore we believe that the cloud-cover weighted data provided here represent a maximum estimate of total FRE that would have been observed in the absence of clouds (and thus a maximum fuel consumption measure), whereas the observed FRE represents a minimum estimate.

Giglio, L., Csiszar, I., and Justice, C. O. (2006b) Global distribution and seasonality of active fires as observed with Terra and Aqua Moderate Resolution Imaging Spectroradiometers (MODIS) sensors. Journal of Geophysical Research. 111. doi:10.1029/2005JG000142.

Giglio, L. (2007) Characterization of the tropical diurnal fire cycle using VIRS and MODIS observations. Remote Sensing of Environment. 108. 4. 407-421.

Streets, D. G., Yarber, K. F., Woo, J-H. and Carmichael, G. R. (2003) Biomass burning in Asia : Annual and seasonal estimates and atmospheric emissions. Global Biogeochemical Cycles. 17. 4. doi:10.1029/2003GB002040.

9) The generally greater fuel load in the southern hemisphere could be substantiated by a reference.

This is referenced as van der Werf et al. (2006) although the sentence has been revised to the following :

The marginally greater amount consumed in SHA mirrors the findings of van der Werf

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et al. (2006), who also determined that whilst a larger area is burned in NHA (129 10ˆ4 km2 as compared to 75 10ˆ4 km2 in SHA) the generally greater fuel loads in SHA result in increased overall fuel consumption.

10) Figure 3b does not show Chad to have burned 50Tg during the time of investigation. How would the graphs of Figure 3 look like, if the country area were taken into account?

This has been corrected to 30Tg and we apologise for the mistake. If the surface area (as viewed by SEVIRI and using a countries boundary mask provided by EUMETSAT) is taken into consideration Angola, CAR, Guinea-Bissau, Ghana and DRC have the greatest amount of biomass combusted per unit area. The plots below illustrate the amount of biomass combusted (kg/mˆ2) for countries in the northern (left) and southern (right) hemisphere.

For figures refer to either reviewer1_point10.doc or bgd-2008-0090_reply_reviewers_comments.doc on the ftp site

11) page 3630 Though the carbon fraction of the burning fuel is generally accepted as ˜48%, it should be kept in mind that this value refers to dry biomass mostly. In reality, the value may be lower due to fuel moister. So the fuel loading should state whether dry or moist is meant. The difference can be significant, see for instance Araujo et al., 1999.

This has been amended to the following :

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).

12) The word trajectory is somewhat irritating here, as the word points to a change pf location in space, usually not it time.

The use of the word trajectory has been replaced profile.

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13) The Fire Radiative Energy and total biomass combusted of Figure 2 are on both y-axis. So are they in a fixed linear relationship. Is that the same factor as in Figure 4a and 4b?

Based on the work described in Wooster et al. (2005) the relationship between FRE and the total biomass combusted is linear. This makes sense since the heat yield of vegetation fuels is rather consistent (Stott, 2000). The scaling factor of 0.368 kg/KJ is now included in Equation 1.

Wooster M. J., Roberts, G., Perry, G. L. W., Kaufman, Y. J. (2005) Retrieval of biomass combustion rates and totals from fire radiative power observations: FRP derivation and calibration relationships between biomass consumption and fire radiative energy release. Journal of Geophysical Research. 110. D24311. doi:10.1029/2005JD006318.

Stott, P. (2000) Combustion in tropical biomass fires : a critical review. Progress in Physical Geography. 24. 355. doi: 10.1177/030913330002400303

14) African biomass burning appears dominated by fires in woodland…. Just for interest: into which category falls savanna?

The Global Land Cover 2000 map for Africa has 27 different land cover classes.

There are a number of land cover classes within the GLC2000 that contain elements of savanna. Example land cover classes include Forest / Savanna (defined as containing forest elements and savanna elements), Deciduous open woodlands (defined as Tree canopy cover is between 15% and 40% and canopy height more than 5 meters and dominated by tree savanna and woodland savanna) and Closed grassland (defined as herbaceous cover greater than 40%, tree and shrub canopy cover less than 20%).

15) page 3631 Is there a mismatch between the sub-graphs 4b and 4c? And if so, the said correspondence between increasing mean per-pixel FRP and increasing daily FRE does not become visible. The scatter is too large. How would the variance of the ten-day means look like?

There was a mismatch between the Figure references in the text and the actual figures. The paragraph now starts with :

Figure 4c presents the time-series of 10-day mean per-pixel FRP to match the data on the 10-day mean FRE shown in Figure 4a.

The same conversion factor (0.368) is used to convert between FRE and the total amount of biomass combusted in Figure 2 and Figure 4a and 4b. For example, from Figure 4a the peak mean FRE is 11*10ˆ9 MJ which equates to 4Tg. In Figure 2, the peak biomass combusted estimate is 9Tg which equates an observed FRE of 24*10ˆ9 MJ.

The variance of the SHA mean FRP and FRE are illustrated below.

For figures refer to either reviewer1_point15.doc or bgd-2008-0090_reply_reviewers_comments.doc on the ftp site

The variance in the mean FRP is greatest outside of the dry season due to much few observations being available. The opposite is true of the variance of the mean FRE which is greatest during the dry season.

16) page 3632 The blue crosses in Figure 5c are barely visible and the horizontal axis label is another example of showing disrespect to the readers

To improve the clarity of the Figure the symbol representing the median FRP has been removed and the text and figure caption amended accordingly.

17) Forest cover types typically exhibit the lowest mean per-pixel FRPs., Montane forest obviously show a different behavior

Additional text has been included to expand on this :

An exception to this occurs in montane forest, where the mean FRP (100 MW) is higher than for the remaining forest cover types. This is due to the greater proportion of fire pixels detected with high FRP magnitudes in this class, and to a lesser extent also in

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sub-montane forest. Over 95% of the fire pixels detected in lowland forest had FRP values $<$ 60 MW, and 45% (12,000) of these detections had an FRP of 40 MW. Of the fire detections in montane forest, 75% had magnitudes $<$ 60MW whilst the remaining 25% had FRP values of between 60 and 640 MW. Analysis of the MODIS Vegetation Continuous Fields (VCF) dataset (Hansen et al., 2003) indicates that the montane forest cover type is composed of an average 48% shrub/grass cover and 52% tree cover, values similar to those for the remaining forest cover types. This similarity in fuel makeup means that the cause of higher mean FRP observations found in montane forest remains unclear.

18a) page 3633 The question of persistence of fires as derived from remote sensing data touches an interesting topic. Unfortunately, nothing has been said about the influence of how sensitive the fuel consumption data are to the 15 minutes data.

Analysis of the variation of the mean FRP with fire persistence is a good point. The plots below illustrate the monthly variation of the mean FRP with fire pixel persistence. In both hemispheres the mean FRP typically increases with increasing fire pixel persistence although the difference in magnitude of the mean FRP reduces at longer residence times. The greater mean FRP with increasing persistence is believed to result from the increased contribution of smoldering combustion to flaming combustion as the fire moves across the landscape within the sensors IFOV and thereby increasing in size.

The plot below illustrates the variation of the mean FRP with fire pixel persistence for both hemispheres. The mean FRP gradually increases with fire pixel persistence up until approximately 215 minutes. The variability of the mean FRP becomes much greater after 215 minutes due to the decreasing number of observations with increasing fire pixel persistence. The decreasing mean FRP may result from either the fire moving out of the sensors IFOV or that the proportion of less intense smoldering combustion increases over that of flaming combustion within the sensors IFOV.

For figures refer to either reviewer1_point18a.doc or bgd-2008-0090_reply_reviewers_comments.doc on the ftp site

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Interactive comment on Biogeosciences Discuss., 5, 3623, 2008.

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