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Biogeosciences Discussions

Interactive comment on "Fire, drought and El Niño relationships on Borneo during the pre-MODIS era (1980–2000)" *by* M. J. Wooster et al.

Anonymous Referee #2

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Using so-far unexploited AVHRR GAC data, the authors establish a fire activity dataset for Borneo for the years 1982/83, 1986/87, 1991/92, 1993/94 and 1997/98. These years cover the five El Niño episodes which occurred throughout 1980 and 2000, the strongest of which are the El Niño events of 1997/98 and 1982/83. The authors analyse how rainfall and fire activity are influenced by the El Niño phenomenon during these years. The paper, which is well written and structured, presents for the first time consistent information on the spatial and temporal patterns of fire activity in Borneo for the pre-MODIS era (1980-2000). This information is of great value for improving global fire emission estimates, bearing in mind that fires in Borneo's peatlands may, in extreme fire years, significantly contribute to global emissions of carbon dioxide and of other trace species (Page et al. 2002). The analysis of the linkage between El Niño, rainfall and fire activity is of great potential interest for better understanding fire-climate interactions in this region, which finally allows an improved predictability of fire risk. However, the statistics applied to explore this linkage are not fully convincing, which I will describe in more detail below. The manuscript fits well into the scope of the journal and I recommend it for publication provided that the statistical methods/analysis and, if necessary, the conclusions will be modified. More detailed information on how fire activity was regionally distributed across Borneo (e.g. in East and Central Kalimantan) would add further value to the paper. I agree with the comments on this manuscript by A. Langner and G. van der Werf that the human factor in the fire-climate interaction needs to be stressed more in the interpretation and discussion of the findings. Suggestions for technical corrections which have already been noted by A. Langner will not be repeated here.

Abstract Thematic suggestions: As explained in the text below, please revise the abstract. Please crosscheck if the statements clearly made here are supported by the findings. E.g. "We find that the length, overall strength, and growth rate of individual El Niño episodes effects the extent and harshness of the drought, and the magnitude of fire activity." For such a statement, I would expect a quantitative analysis of the relation between a) the length (e.g. in terms of months), b) the overall strength (e.g. using the maximum positive ENSO index value) and c) the growth rate (e.g. slope of the ENSO index time series) of individual El Niño episodes and the extent (do you mean spatial extent?) and the intensity (“harshness”) of rainfall deficits and fire activity. Also the statement "We confirm significant correlations between monthly ENSO index and rainfall deficit measures, and between rainfall deficit and fire." needs to be "weakened" as you do find very small correlations between monthly ENSO indices and rainfall deficit measures in three out of five El Niño periods you studied (Table 1), and you did not test for statistical significance. I will explain this in more detail below.

1) Introduction

Thematic suggestions: * In this manuscript, the term "ENSO event" is frequently synonymously used with El Niño events, which might be misleading. (E.g.: "Fire activity

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in the SE Asian region, including Borneo, shows considerable inter-annual variability, with peaks generally coinciding with El Niño-Southern Oscillation (ENSO) events (van der Werf et al., 2006)". In climate science, the term "ENSO event" typically connotes both, El Niño (warm ENSO event) and La Niña (cold ENSO event) events. In order to avoid confusion I would recommend to exchange the term "ENSO" with "El Niño" in your manuscript if you exclusively refer to El Niño, as in the above-cited sentence.

2) Study area

Technical suggestions: * Page 980, Line 2-4: The last sentence does not fit very well into the text flow. * Page 980, Line 14: Another reference would be Schultz et al. (2008 who examined the linkage between fire activity and ENSO in Indonesia (see supplementary online material of the reference). They found the annual ATSR fire counts (years 1996 to 2003) to be highly correlated (r2=0.93, n=8 with the mean OCT-MAR multivariate ENSO index.

Thematic suggestions (section 2.2): * The current body of knowledge on the effect of ENSO, or more specifically of El Niño episodes, on precipitation in Borneo needs to be presented in more detail in this section as this is a key aspect of this paper. Which regions in Borneo experience the strongest rainfall deficits during El Niño episodes? During which months is the El Niño effect the strongest? I suggest e.g. to include the findings of Hendon (2003), Hamada et al. (2002), Aldrian (2003), Chang et al. (2004) and Heil (2007). The effect of El Niño episodes on rainfall in Borneo (in terms of negative rainfall anomalies) appears to be most pronounced south of the Equator, and here, notably during the relatively dry southwest monsoonal period (boreal summer). It is maybe noteworthy that Chang et al. (2004) found that during boreal winter, precipitation in Borneo and Nino 3 sea surface temperature are positively correlated except for South and East Kalimantan. Since you are averaging rainfall (and fire data) over entire Borneo, you cannot take into account for this spatial heterogeneity, which might, however, be important for the interpretation of the linkage between El Niño, precipitation and fire activity.

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3) Datasets

Technical suggestions: * Page 984, Line 11-12: Please add download site and date of download.

Thematic suggestions (section 3.2): * There is no real consensus about the timing of individual El Niño events because different measures are used for the definition (Trenberth 1997). However, I find it problematic to study each individual El Niño event across a two-year episode. If I take the NOAA's standard definition of El Niño and La Nina episodes as a guide (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml, which uses the running 3-month mean NINO 3.4 SST anomaly, the so-called Ocean Nino Index (ONI)), each two-year episode covers only 13 to 15 months where a so-called warm episode prevails, except for the two-year episode 1993/94, where El Niño conditions prevail in only 8 months. In 1987/88 and 1997/98, the two-year period also includes 6 to 8 months of La Niña conditions towards the end of Year 2. For 1993/94, this means that in 16 out of 24 months (67%) neutral ENSO conditions prevail. Furthermore, El Niño conditions only prevail at the end of 1994 (Year 2), while typically El Niño conditions peak between Year 1 and Year 2. This has strong implications when comparing each of the 2-year so-called El Niño episodes, and this needs to be treated with care. E.g. in 1997/98, the ENSO index - rainfall correlation is also influenced by the La Niña conditions starting by July 1998 which developed into a strong La Niña. E.g. TRMM precipitation data show that Borneo experienced a positive rainfall anomaly of around 60 mm per month from July to November 1998 (Heil 2007). For sure, this contributed to the high correlation between ENSO strength and rainfall measures in Table 1. Frankly, I would recommend reconsider the time window you have chosen for each El Niño episode.

* Are you using running mean data? In Fig. 7, it looks as if you are using monthly data. Typically, a 3-month (NOAA) or 5-month (Japan Meteorological Agency JMA) running mean filter is applied upon the raw monthly SST anomalies to smoothen out

higher-frequency oscillations (Trenberth 1997) which are not linked to ENSO. I would recommend testing if this changes your results.

4) Methodology

Technical suggestions: * Page 985, Line 25: Please introduce abbreviation AF. * Page 986, Line 2: Please consider being more precise here (..study which used approximately 1200 images...) or being more vague (..study which used a large number of images...) as this could be confusing. * Page 986, Line 16-18: Please specify which periods you selected for this analysis. * Page 987, Line 13: Please write "..during the 1997 El Niño period" as the r2 given value in Fig. 6a value refers to 1997, only. Please specify what normal and La Niña years you selected for the 19 matching LAC and GAC images for which you found the correlation of r2=0.78. * Page 989, Line 10: use "....occurred in Central and East Kalimantan", as you refer to the names of the province. * Page 989, Line 19: You are explicitly introducing here the RI, but I cannot see any quantitative result using this RI in the subsequent text. Please add cross-correlation statistics using the RI to Table 1 (or elsewhere) or please shorten this section. * Page 990, Line 10: Fuller and Murphy (2006) 'pre-whitened' their time series using a ratios-to-moving average approach (using Statsoft, 2003). I would like to see here a key word describing the mathematical principle behind the 'pre-whitening' procedure you applied (following Chatfield 2004). Did you also log10 transformed fire data as in Fuller and Murphy (2006)?

Thematic suggestions (section 4.1): * Page 986, Line 28: Did you separately normalise for El Niño and Non El Niño periods based on the actual ENSO conditions? What about La Niña conditions (e.g. end of 1998? If not, please discuss the consequences. * Page 987, Line 28: Are the selected images largely evenly spaced in time? At a given location, what is the maximum number of days between observations? How will the observational gaps influence the result? * Page 988, Line 29. It would be very helpful to see some statistics on the average cloud cover you dealt with. Are there differences in the cloud cover when you take into account the actual ENSO conditions? How does

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it affect the uncertainties of the AF counts?

5) Results Technical suggestions: * Page 991, Line 11: Please write May 1983 instead of May 2003. * Page 991, Line 14: Actually, the 1991/92 El Niño period was followed by warm ENSO conditions in 1993 and 1994, and was not immediately followed by a La Niña episode. * Page 994, Line 19: There is no Figure 8b, do you mean Figure 9b?

Thematic suggestions (section 5.1): * Fig. 8 nicely shows the clustering of fire activity in East Kalimantan. Did you try to correlate fire activity in East Kalimantan with rainfall station measurements from East Kalimantan? This could help to elaborate the critical threshold in more detail. For now, you are using all-Borneo averages; as I mentioned earlier, ENSO related rainfall anomalies are spatially incoherent across Borneo.

Thematic suggestions (section 5.2): * As mentioned before, Chang et al. (2004) found that during boreal winter, precipitation and Nino 3 sea surface temperature are positively correlated in Borneo except for South and East Kalimantan. Please enlarge here upon the regional and temporal heterogeneity of ENSO effects on precipitation in Borneo in your interpretation. Despite warm ENSO conditions (in terms of ENSO indexes) typically peaking in December (Year 1)/ January (Year 2), there might be plenty of rainfall in large parts of Borneo which reduces fire activity.

Thematic suggestions (section 5.3): * Actually, what Table 1 shows is that the ENSO indexes are correlated with rainfall in Borneo only in 2 out of 5 El Niño events. Correlation coefficients (r) below an absolute value of around 0.18 and much lower calculated for the years 1986/87, 1993/94 and 1991/92 show a very weak correlation (or better to say no correlation...) (I considered only NINO 3 and NINO 3.4 indices). This is a very critical point in this manuscript as it subverts your conclusion that e.g. you "confirm significant correlations between monthly ENSO index and rainfall deficit measures, and between rainfall deficit and fire". It also contradicts other studies which showed a link between rainfall deficits and positive SST anomalies during the relatively dry southern monsoonal period (around July to October of Year 1) (see my comments to section 2.2), please test if the correlations are statistically significant. Please discuss why the use of the various ENSO indices leads to different results. In the text, you are interpreting the difference in the correlation coefficients of the 1982/83 and 1997/98 warm ENSO events – is this difference significant? I guess you will find other results when a) you modify the time window (e.g. only consider months categorised as El Niño - although you will end up with a critically low sample size), b) you focus on rainfall station data south of the Equator, c) use running-mean ENSO indexes. From the monthly data, you found rainfall to be not correlated with ENSO (except for the two strongest events), but fire activity to be correlated with rainfall. In contrast you find a strong correlation of you take cumulative quantities of ENSO indexes and fire activity (Fig. 10). Please explain this.

* Why did you choose the cumulative ENSO NINO 3 Anomaly for the correlation in Fig. 10. From Table 1 it appears that the correlation between the NINO 3.4 index and RF deficit is higher than for the NINO 3 index.

5) Figures and Tables

Tab 1: Please specify what correlation coefficient you show (r?, linear? Pearson? Spearman?). Please label correlations which are significant. In the caption, it is possibly better to write: "Correlation between monthly ENSO indexes and rainfall and rainfall deficit during the five El Niño events." .

Fig. 1: You use the provincial subdivision of Kalimatan. Maybe better to write: "... is further subdivided into the provinces of West, Central, East and South Kalimantan". Please exchange "landcover" with "land cover". Fig. 2: Please introduce d-f. It appears to me a bit arbitrary that the boxes show different areas and different times of the year. It is not unlikely that e.g. fire activity in box d) almost looks the same on 29 July of the years 1997, 2001 or 1999. Please emphasise in the caption that the selected images show typical examples for each climatological condition.

Fig. 7: Please remove NINO1+2 and NINO4 timeseries from (c) as you do not use

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these indices in the entire paper. NINO3.4 and NINO3 SST-based indexes are the most widely used to study rainfall anomalies (or fire activity) in Indonesia (see my comments to section 2.2). Please address the differences in the NINO3 and NINO3.4 timeseries.

Fig. 9: Am I right that the labels are erroneous? The 1991/92 fires do not show up in your figure, although you categorise these fires as rank 3 (Page 992) in fire activity behind 1997/98 and 1983/83. Also fires in 1986/87 are quite prominent in Fig. 9, although very little fires show up in Fig. 8. Why did you choose NINO 3 SST Anomaly here despite the correlation between NINO 3.4 SST Anomaly and Rainfall measures being stronger (at least for 1982/83 and 1997/98 (Table 1)? Why did you choose the NINO3 SST Anomaly?

Fig. 10: I downloaded the NINO3 SST Anomaly data (http://www.cpc.ncep.noaa.gov/data/indices/sstoi.indices, downloaded March 7, 2011) and I calculated the 16 month (Jan-Apr) Cumulative NINO3 Anomaly (°C) and yield different values to those presented in this figure: JAN-APR CUMUL NINO3 Anomaly (°C) 1997/98 29.2 1993/94 3.2 1991/92 10.8 1986/87 4.4 1982/83 23.2 2002/03 6.34 Could you please recheck your numbers?

References:

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Interactive comment on Biogeosciences Discuss., 8, 975, 2011.