

RESPONSES TO REVIEWERS

Responses to the reviewers are in *italics*, and new or revised text that will be included is given in *red*.

Anonymous referee #1

Response:

In order to add a perspective of the impact of changes in shortwave albedo with other radiative forcing induce by fires, we will add the following paragraph in the conclusion section as follows:

Changes in shortwave albedo are not the only source of radiative forcing when fires affect the land surface. According to the IPCC Fourth Assessment Report (REFERENCE), biomass burning accounts for the 75% of the direct radiative forcing from organic aerosols and it is estimated at $-0.5 \pm 0.5 \text{ Wm}^{-2}$ for the period of 1750-2005 (Forster et al., 2007). In the tropics, where incident solar radiation is larger than at higher latitudes, it can enhance the radiative effect from aerosols (Holben et al., 2001). Ross et al., 1998 found a radiative forcing of about $-15 \pm 5 \text{ Wm}^{-2}$ during the 1995 Amazon fire season. Total black carbon emissions from biomass burning (3.3 TgC yr^{-1}) represent 40% of the total black carbon emissions, with an additional 4.6 TgC yr^{-1} contributed by fossil fuel and biofuel combustion (Bond et al., 2004). Although the overall radiative forcing of smoke aerosol particles is negative, black carbon can produce positive radiative forcing. The global radiative forcing of total black carbon was estimated at $+0.2 \text{ Wm}^{-2}$ in the IPCC Third Assessment Report (Ramaswamy et al., 2001) and 0.55 Wm^{-2} in the IPCC Fourth Assessment Report (Forster et al., 2007).

References added:

Holben, B.N., Smirnov, A., Eck, T.F., Slutsker, I., Abuhassan, N., Newcomb, W.W., Schafer, J.S., Tanre, D., Chatenet, B., Lavenu, F.: An emerging ground-based aerosol climatology - Aerosol optical depth from AERONET. J. Geophys. Res. 106, 12067–12097, 2001.

Bond, T.C., Streets, D., Yarber, K.F., Nelson, S.M., Woo, J.-H., Klimont, Z.: A technology-based global inventory of black and organic carbon emissions from combustion. J. Geophys. Res. 109, 2004.

With regards to the evolution of burned are over some specific regions, we did not provide numbers about the evolution of burned area over time at local or regional scale. The main goal is to measure the impact of fires on the Earth system at global scale. However, we agree that some illustrative results showing the temporal evolution of burned areas over the two regions shown as examples, may be helpful. We therefore add two plots, one for Australia and another for northern hemisphere Africa, including burned area and radiative forcing over time.

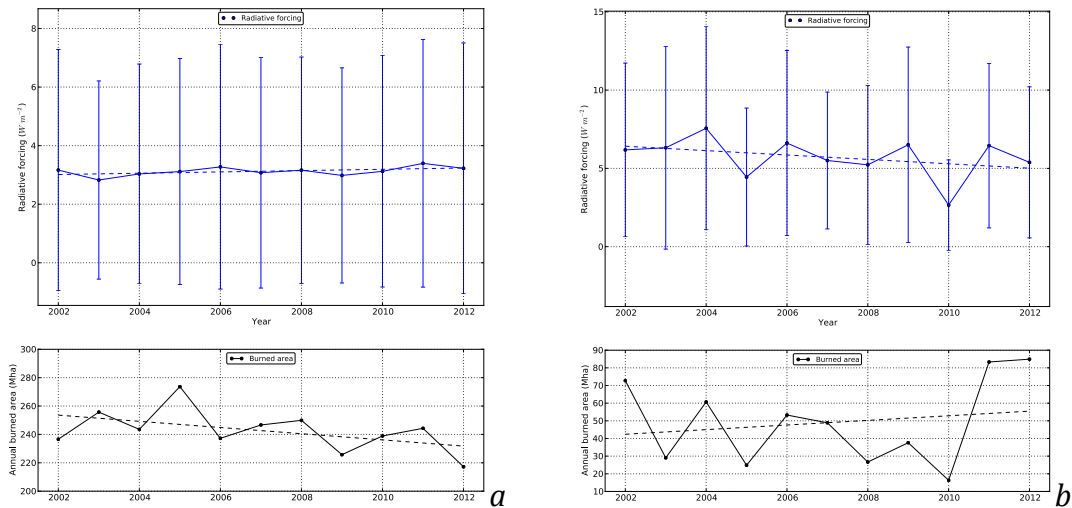


Figure 7. Temporal evolution of the radiative forcing and burned areas. Panel a) shows the profiles for Africa, panel b) for Australia.

Specific comments.

P7778-L25-26: “Using the three BRDF ...” is not clear and should be rephrased
The paragraph will be rephrased as follows:

“The Global bi-hemispherical reflectance (α_{BHR}) under isotropic illumination, also designated white-sky albedo, for every 16-day time period was computed using:

$$\alpha_{BHR}(\lambda) = f_{iso}g_{iso} + f_{vol}g_{vol} + f_{geo}g_{geo} \quad (1)$$

where f_{iso} , f_{vol} and f_{geo} are the three BRDF model parameters, isotropic, volumetric and geometric. The integrated coefficients have the following values: $g_{iso} = 1.0$, $g_{vol} = 0.189184$ and $g_{geo} = -1.377622$.

P7779-L15: “per year” → “each year” ?

The sentence will be changed to:

The areas affected by fire each year were derived using the MODIS...

P7780: What about peatlands? In which class are they included?

Response:

The MODIS land cover product we used for this study includes three different classification legends. We selected the IGBP (International Geosphere-Biosphere Programme), which is the only one that includes peatlands in class 11: Permanent wetlands. Therefore, as part of the aggregation we performed, peatlands were aggregated into the “non-forest” class.

P7781L3: identify->identified

Correction as follows:

For every pixel identified as affected by fire...

P7781L17: missing coma

Correction as follows:

However, fire affects vegetated areas, which generally are very reflective in the near-infrared and after a burning event, show a decrease in reflectance due to vegetation loss and de-position of charcoal and ash.

P7781L24: uncertainties

Correction as follows:

Second, there are uncertainties in the day of burning.

P7782L9-14: The phrase is too long and should be cut.

The phrase will be changed as follows:

Ramaswamy et al. (2001) define radiative forcing as 'the change in net (down minus up) irradiance (solar plus longwave; in $W m^{-2}$). In this study we do not consider longwave forcing. Once the change in albedo ΔA_{fire} was computed, the shortwave radiative forcing at the surface ΔF_0 exerted by changes in shortwave albedo due only to fire is estimated as: $\Delta F_0 = -dswrf_0^{\downarrow} \Delta A_{fire}$

P7782L15: DFsurface or DF0? Is it the same parameter? If so be consistent

It is the same parameter. $\Delta F_{surface}$ will be changed to ΔF_0 as in response to comment P7782L9-14.

P7782L10: It would be appreciable if the authors could justify why they neglect the longwave calculations. A quick computation could prove if a change in albedo has a significant influence or not on the amount of energy absorbed by the surface and re emitted as LW flux.

Land Surface Temperature (LST) and emissivity can indeed influence fire-induced longwave radiative forcing. However since the main goal of this study is to quantify the impact of instantaneous shortwave albedo changes in areas affected by fire and taking in to account the findings from in the scientific literature it was decided to omit the contribution of longwave fluxes. Previous studies for Africa by Govaerts et al. (2002), Northern Australia by Jin and Roy (2005), North America boreal forest by Jin et al. (2012), also ignored the role of longwave radiation.

References added:

Jin, Y., Randerson, J. T., Goetz, S. J., Beck, P. S. a., Loranty, M. M. and Goulden, M. L.: The influence of burn severity on postfire vegetation recovery and albedo change during early succession in North American boreal forests, *J. Geophys. Res.*, 117(G1), G01036, doi:10.1029/2011JG001886, 2012.

The sentence will be modify as follows:

Ramaswamy et al. (2001) define radiative forcing as 'the change in net (down minus up) irradiance (solar plus longwave; in Wm^{-2}). In this study we do not consider longwave forcing.

P7782-L22: It's very hard to see any correlated trends between BA and RF with this Y-axis scale. Maybe try to change the Y-axis for the RF?

Plot will be changed as shown below. Quantities in radiative forcing and albedo change are different due to introduction of burned area fraction requested by reviewer #2. Uncertainties are omitted, in order to show temporal variability.

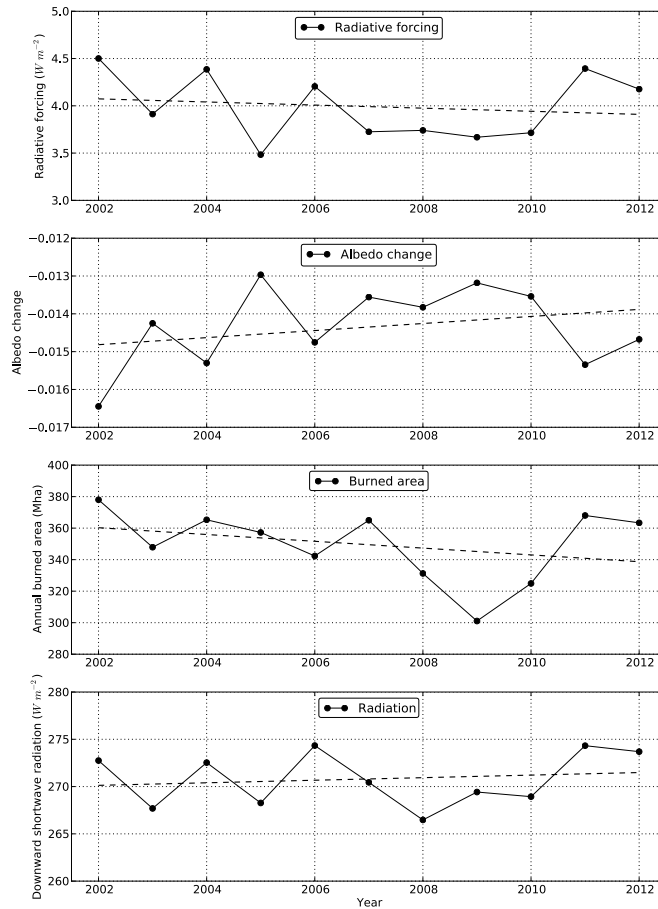


Figure 2. Temporal changes of the annual global radiative forcing induce by fires (blue line) and albedo change (in red) spanning from 2002 to 2012. Bottom plots show the total annual burned area and the downward shortwave radiation fluxes at the surface. The dashed lines depict linear trends, where changes of rate per year are, for radiative forcing: $-0.016 Wm^{-2}$, albedo change: $9.33e-05$, burned area: $-2.15 Mha$ and downward shortwave incoming radiation: $0.14 Wm^{-2}$.

P7782-L24: Figures should be introduced before referring to them. The authors should also explain the results from the figures instead of letting the reader decides what he should see in them.

The following text will be included before introducing figures 4 and 5:

Figures 5 and 6 show for the Sahel and Australia correspondingly: in panel (a), the approximate day of burn (DoB), instantaneous shortwave albedo change in panel (b), the relative albedo change in panel (c). Panel (d) depicts the associated radiative forcing. Areas in red tones indicate a large change and areas in blue tones small change in the aforementioned variables.

P7783-L10: and – and

Quantities in radiative forcing are different due to an introduction of burned area fraction requested by reviewer #2. Correction as follows:

... whereas the highest radiative forcing per unit area is located in forests of Australia in 2003 and 2006, Europe in 2010 and Asia in 2003, with mean

continental values of 15.43 Wm⁻², 15.26 Wm⁻², 13.98 Wm⁻² and 8.55 Wm⁻² respectively (Fig. 3).

P7784-L0-7: Rephrase (too long)

Quantities in radiative forcing are different due to an introduction of burned area fraction requested by reviewer #2. Paragraph will be rephrase as follows:

Since the mean radiative forcing in areas where fire occurred during 2002–2012 is 3.99Wm⁻², multiplying by the proportion of area affected by fire, the global mean radiative forcing is 0.0275Wm⁻². When performing the same calculation at regional scale, for instance, Australia, the mean radiative forcing is 5.71Wm⁻², and the mean area burned is 0.502 Mkm², representing the 6.53% of the Australian territory. Therefore, the mean radiative forcing for Australia is 0.373 Wm⁻², an order of magnitude higher than the global number.

Table 1 not useful (only 3 parameter), better to state the number in full text.
Table 1 will be omitted and values in the equation will be shown as in response to comment P7778-L25-26.

Fig.1 not usefull. It would be more interesting if we had other information than the name of continents on it (i.e. global change in SW of albedo).

Figure 1 will be omitted.

Fig.2 not easy to read:

- Thicker lines + text
- Change to a/b/c/d instead of blue red lines
- What is the linear regression of the linear fit? /year

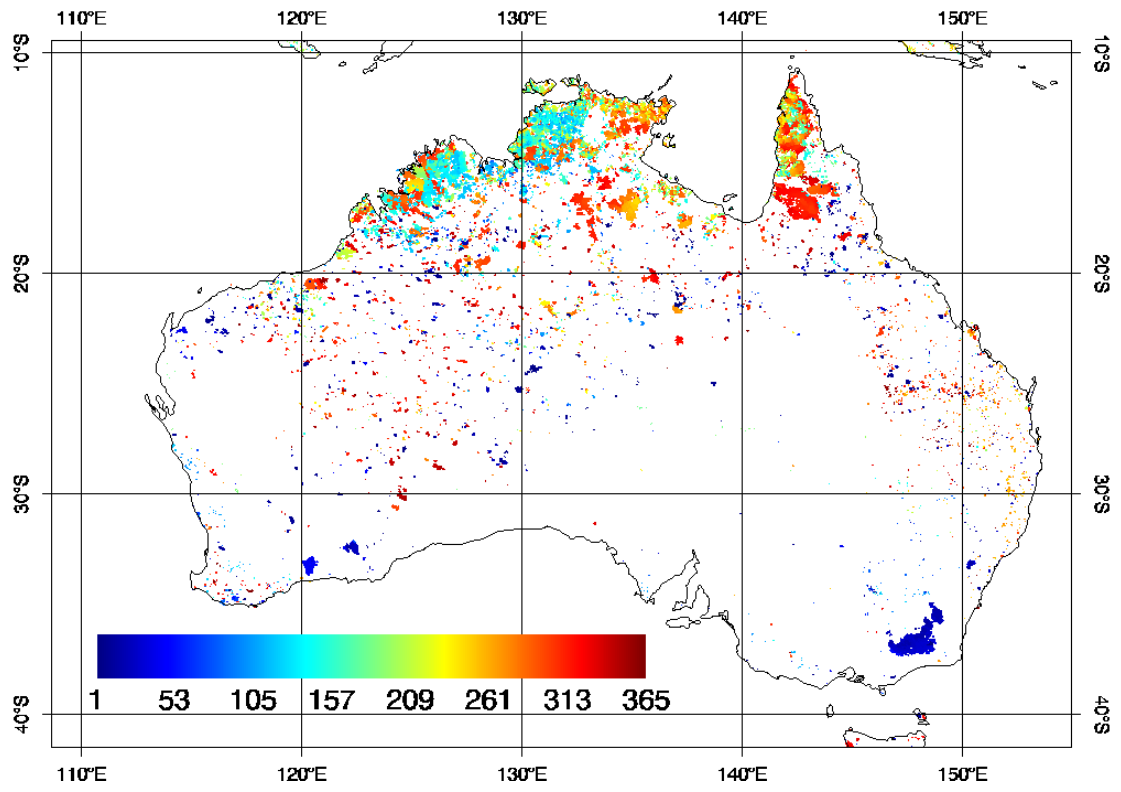
Plot will be modified as stated in comment P7782-L22. The rate of change will be part of the figure description as follows:

Figure 2. Temporal changes of the annual global radiative forcing induce by fires (blue line) and albedo change (in red) spanning from 2002 to 2012. Bottom plots show the total annual burned area and the downward shortwave radiation fluxes at the surface. The dashed lines depict linear trends, where changes of rate per year are, for radiative forcing: -0.016Wm⁻², albedo change: 9.33e-05, burned area: -2.15Mha and downward shortwave incoming radiation: 0.14 Wm⁻².

Fig 5-6: Add a-b-c-d) instead of top middle etc.

Background color white would be easier to read

Panels will have letters to be identified. Background colour will be change to white as in the following example from the approximate day of burn for Australia during 2003:



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