

Anonymous Referee #5

Received and published: 23 June 2015

General comments:

The manuscript deal with the important topic of assessing soil organic carbon and land cover dynamics by analyzing the C isotopic composition of soil organic matter over a vast area characterized by different climate and anthropogenic pressure. I believe it represents a substantial contribution to scientific progress, it is generally well written and its contents are within the scope of Biogeosciences. The methodology is valid and well explained. The experimental design included an important number of different ecosystems over a considerable precipitation gradient. The results are reported quite clearly and discussed taking into consideration the most relevant literature which help in considering the numerous factors that may affect a correct interpretation of C fractionation. As a general comment I suggest I) to make a deeper description of the most significant pattern occurring in the studied area in terms of climate change and human pressure and II), due to the high number of exceptions to the general pattern described throughout the results and discussion sections, to improve the conclusions recalling the three main objectives of the paper, highlighting the novel findings coming out from this study. In conclusion I welcome the publication of this article after considering the specific comments outlined in the following section.

We do thank the reviewer very much for his/her comments and provide answer to the specific comments below. Our comments are in bold font.

Specific comments:

P8088_L5 – As stated in the general comments, I think it is important to describe better what are the most important drivers promoting the progressive thickening of woody vegetation: on the climate change side, is it only a matter of increasing CO₂ concentration? Is that any historical record/evidence about changing in precipitation pattern and amount, temperature increase, frequency in the occurrence of drought or heat waves? What about the other human activities apart from changing in fire regimes like grazing or timber cutting? Were they present in the studied sites? Their intensity changed over the past years? I think both these climate and human related aspects may deeply influence land cover dynamics.

We have described the general drivers of vegetation thickening at the global scale in the introduction section. Current evidence signals increasing levels of atmospheric CO₂ as the main cause behind thickening. However, variations in precipitation and nitrogen deposition have also been suggested as other potential factors behind these vegetation dynamics. However, the effect of nitrogen deposition in these regions is likely to be of very limited significance given that the studied ecosystems are located well away from industrial centers or large population settlements. While increased rainfall would over the long term promote tree cover (provided the effect is not negated by increasing temperature) significant uncertainties exist as to the long-term precipitation trends in the region (Bernstein et al. 2007). Furthermore, rather than an increase in precipitation for West Africa, the IPCC Fourth Assessment report indicates a slight decrease in the overall amount for the period ranging from 1960-1990. Therefore, it seems highly likely that increasing levels of atmospheric CO₂ mainly drive current thickening of natural vegetation in West Africa.

- Bernstein, L., and Coauthors, 2007: Climate Change 2007: Synthesis Report. IPCC, Geneva, Switzerland, 104 pp.

We cannot totally discard the indirect effect exerted by humans as local drivers of vegetation dynamics. However, to minimise such an effect, we purposely chose legally-protected semi-natural ecosystems with little or no direct human intervention.

Fire was not suppressed from any of the studied sites as it was confirmed both by the park managers and by anecdotal evidence gathered in the field (fire scars and charred vegetation). Naturally, should there have been a suppression of fire in some of the ecosystems, it may have contributed to promote vegetation thickening. On the other hand, and as we describe in the MS, a more direct impact of human pressure on vegetation dynamics could be observed in the Sahelian ecosystems (vegetation thinning). In the MS we discuss that there may be several reasons behind this potential thinning of woody biomass at the driest sites, with a combination of overgrazing, fuel harvesting, fires, and above all the severe droughts suffered over the past few decades, as the most likely causes.

P8091_L3 - Objectives are stated clearly but it's easy to get confused by reading the result and discussion sections especially on the light of the numerous exceptions emerging from the general patterns, as confirmed by the number of times the words "however" (13), "exception" (3) and "nonetheless" (1) were used. I suggest to organize these two chapters, as well as improving the conclusions section, in a way more consistent with the three objectives.

We have modified the conclusion section following the reviewer's advice. We now recall the three main objectives of the paper, and then highlight the novel findings of this study.

P8091_L16 – It would be highly beneficial for the readers to have, besides figure 1, a table describing briefly all the sites (i.e. latitude, type of dominant land cover, precipitation amount, mean annual temperature, soil texture, principal investigations carried out, etc.). This would help the reader throughout the discussion as well as in the interpretation of several figures (i.e. Fig. 2, 6, 7 and 8).

Revised as suggested. We have now included a Table in the appendix (Table A1) which contains information on latitude, longitude, mean annual averages for precipitation and temperature, classification of the regional vegetation, soil type and soil textural classes for each site.

P8095_L10 – Why only results from the topmost soil layer are reported? I believe it would be worth to mention also the results from the 0.05-0.30 soil layer and show them in a similar way as the 0-0.05 soil layer in figure 2a.

As stated in our answer to a similar remark by Reviewer #3, we decided to include the depth that better reflects standing (current) vegetation (0-0.05 m), and not add an extra graph for the 0.30 m interval, whose $\delta^{13}\text{C}$ values are likely to be more affected by potentially contrasting SOM dynamics.

P8095_L11 – If I have understood correctly the sampling methodology, I think it is important to report the average distances at which –T and –G samples were taken in each location (this information could be added to table suggested in the third comment). I expect larger distances of –G sampling points in those sites where greater were the differences in $\delta^{13}\text{C}$ between –T and –G samples.

The reviewer is right in his/her assumption of larger distances in –G sampling points at those sites showing the largest discrepancies between –T and –G samples. However, the exact distances were not quantified to be able to calculate an average distance per site.

P8107_L16 – Conclusions were improved from the first version of the manuscript. I would still make a clearer connection with the objectives.

Please refer to our comment above (P8091_L3).

Technical comments

P8123_Figure caption – If used, the concept of fractional vegetation cover (FC) has to be introduced in the material and method section with a brief description of how and where it was calculated, in addition to indicate the previous work explaining the methodology in detail. I thus suggest removing from the figure caption the phrase starting with “Estimates of the FC. . .”

Revised as suggested. We have included a dedicated paragraph in Materials and Methods to provide an overview of the methodology. The text now reads:

Estimates of the fractional vegetation cover of woody vegetation (FC_w) were obtained as described in Veenendaal et al. (2014), while estimates of the fractional vegetation of the axylale vegetation (FC_a) are as in Torello-Raventos et al. (2013). In short, the canopy area index (C), which is defined as the sum of individual canopy projected area divided by the ground area, was estimated separately for three woody strata. These strata are distinguished on the basis of stem diameter (D) at breast height (1.3 m), and individual tree height (H). The upper (u) stratum consists of trees with $d > 0.1$ m, all of which were individually measured at each plot. The mid (m) stratum consists of woody vegetation of $0.1 > d > 0.025$ m, which was quantified through measurements made along ten 50 m-long transects. The subordinate (s) or lower stratum is made up of trees and shrubs with $d < 0.025$ m and $H > 1.5$ m, which were quantified in the same way as the mid-stratum. Subsequently, stand-level canopy projected area for each stratum (C_u , C_m , C_s) was estimated according to site-specific allometric equations presented in Torello-Raventos et al. (2013). Therefore, assuming a random distribution of trees and/or shrubs, the fraction of ground covered by crowns (including within-crown light gaps), which we refer here as the FC of woody vegetation (FC_w) can be estimated as:

$$FC_w = 1 - \exp(-C_u - C_m - C_s)$$

FC_a was visually recorded along a series of transects with a sampling intensity of 110 x1 m² quadrants per site.

P8125_Figure caption – Description of the Sahelian ecosystems (plus the three citations) have to be moved to the text. I suggest to shorten the figure caption by removing the phrase starting with “The Sahelian ecosystems. . .”

Revised as suggested. We have moved this sentence to the discussion section.