

Interactive comment on “Seasonal trends of dry and bulk concentration of nitrogen compounds over a rain forest in Ghana” by F. Fattore et al.

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Received and published: 14 March 2014

Answer to general comments.

Authors: As the referee evidenced, there is a great scarcity of measured data for nitrogen deposition in the African continent, in particular when compared with temperate areas. Moreover, while networks like NitroEurope have introduced large scale assessment of multiple gases and aerosol using active sampling in the European continent, this is a much more difficult task in remote areas of Africa, where also the logistic problems might limit active sampling. Although we present one year of data we think, and we are glad that also the referee agrees, that our data are valuable because they are the first ones measured in the area with active sampling, which might be of significant interest for those colleague who use this technique. Moreover our data report many

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compounds including aerosol, of which not all were included in previous publications of this kind in the area. We agree with referee that only a long term dataset can give the exact magnitude of seasonal shifts. Our aim was not to define long term trends but to quantify the magnitude of N concentration over the rain forest of Ankasa, to derive later on fluxes and to relate the variation of concentration in the year of observation to the variability of potential sources, most of all fire assumed by us and previous authors to be the preferential N atmospheric source in the area, given that we could not have other direct evidence using specific markers. We think that these data can further support Chen et al. (2010) hypothesis and result, mostly based on modeling.

As suggested by the referee we will better define the international context of available measurements of N deposition and atmospheric concentrations available, in particular focusing on published data available for the tropical forests, which in the present form of the paper are only discussed in the discussion section. To make the comparison easier we will add in the revised text as required by the referee more details about the sampling technique and the analytical performance and detection limits for each gas.

As suggested by the referee, to better define the wet and dry season we will add the long term mean of the rainfall in the annual rainfall graph, centered on Ankasa, and we will better characterize and define the wet and dry period based on these data to discuss the data in the results and discussion section.

Answers to Specific comments

Authors: We agree with all the specific comment about the text and the adequate corrections will be done in the revised version.

R: P15229, L13-15: Could we assume that the rest of months represent the dry season? Please add a sentence to specify the mean dry and wet season when presenting the studied site.

Authors: As required by the referee in the site description we will define the period we

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refer to as dry and wet season on the based on climatic data (see previous comments).

R: P15230, L15-18: Please, could you indicate the reproducibility (i.e the covariance) of the two denuders for the sampling of each gas.

Authors:If the referee is referring to the two denuders which are place in series inside each Delta, there is no possibility to calculate covariance because the two systems are in series which means that almost all the compounds are trapped in the first denuder, while the second is basically almost similar to the blank. The second is placed there just to be sure of not loosing any sample in case of excess concentration. If instead the referee is referring to the reproducibility between the Delta please see the answer to the next comment.

P15230, L24: Please, would you precise the detection limits from field blanks for each trace gas?

Authors:In order to provide more analytical details as required by the referee we will add a table to the revised text which will include the reproducibility of the three delta systems and the detection limit of each gas and aerosol compound.

P1523, L1-2: Are collectors rinsed after each sampling? How filters were stored immediately after sampling and during transport?

Authors:The bulk collectors were rinsed three times with deionized water after the rain water collection, this information will be added to the text as well. The dry deposition collectors (denuder and filters) were stored in a sealed polyethylene bag and immediately shipped to Italy for analyses.

P15234, L5-6: "the amount of N present...peak". This information is not useful at all since concentrations are expressed in $\mu\text{g.m}^{-3}$ and not $\mu\text{gN.m}^{-3}$. The comparison of N quantity present in form of NO_3^- or NH_4^+ could lead to confusion since it is observed on figure 1 that NO_3^- concentrations are higher than NO_4^+ . In a case of a study of N dry deposition ($\mu\text{gN.m}^{-2}\cdot\text{s}^{-1}$), this comparison could be understandable.

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Authors:We agree that it would be better to use for the nitrogen compounds the Nitrogen amount instead of the entire compound amount. The graph units with regard the nitrogen compounds will be changed to $\mu\text{g N m}^{-3}$.

P15234, L8-10: "SO₂...exception of the period between mid-november 2011 to Mid-January." The period 11/09/12-22/10/12 must be included in the exception period since SO₂ concentration ($30 \mu\text{g.m}^{-3}$) is of the same order. "mid" and "Mid" must be written in the same way throughout the text. Sampling periods: To specify the sampling period, sometimes the authors used the whole month or "mid-month", second half of the month or first half of the month. It would be better to choose one designation.

Authors:We agree. The period 11/09/12 – 22/10/12 has to be included in the "exception period".

P5234, L15-20 It would be interesting to compare NO_3^- and NH_4^- concentrations in rainfall with those measured in a tropical forested ecosystem of Cameroon (Sigha et al., 2003, J. Atmos. Chem., 46, 173-198) in this section or discussion session.

Authors:We agree, we could compare the yearly trend of our bulk concentrations to the wet concentration measure in Cameroon and as expected our values are quite higher due to the different collection method (bulk vs wet).

P15237, L1-7: "The West...rainfalls". This paragraph is rather an introduction and it is a repetition (see P15229, L1-10).

Authors:We agree and the sentence will be removed from the manuscript.

P15238, L29-L3 (P15239): "The concentration of NO_2 ...are comparable...burning season". I disagree with this comparison. Please, I checked but I didn't find these values (0.80 and $1.3 \mu\text{g.m}^{-3}$) in Adon et al. (2010). In fact, Adon et al. (2010) reported that seasonal mean concentrations are 1.1 ppb ($2.1 \mu\text{g.m}^{-3}$) at the forested ecosystem of Cameroon (Zoetele) and 1.6 ppb ($3.0 \mu\text{g.m}^{-3}$) at the equatorial forest of Congo (Bo-massa) in the dry season, i.e the burning season. The mean monthly concentrations

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can reach a value of 2.4 ppb ($4.5 \mu\text{g}\cdot\text{m}^{-3}$) in the dry season at Bomassa. The NO₂ concentrations measured at about 3 m from soil surface in Adon et al (2010) are higher than those measured at 45 m (20 m above the canopy) in this study. A large part of NO₂ (from NO soil emissions) under the canopy could be captured by the leafy plant density (Jacob and Bakwin; 1991, *Am. Soc. Microbiol.*, Washington, DC, 237-253 ; Sparks et al., 2001, *Oecologia* 127, 214-221). There is no discussion about the values of NO₃- and NH₄⁺ (bulk concentration) in the discussion section. As already mentioned above, the authors could compare the values with other tropical forests (Sigha et al., 2003).

Authors: We indeed made a mistake in the calculation which will be corrected. However the order of magnitude of recalculated data remains comparable (taking the error into account), for the dry season, to NO₂ concentrations at Ankasa, although in the latter the concentration was always lower than in the forest site indicated by Adon et al (2010) possibly due to the different sampling height as suggested by the referee. Bulk deposition will be included in the discussion and comparison with other results from previous publication, taking however into account that different collection methods (bulk vs wet collection).

P5241 “conclusions”: The conclusion is too short. You could complete it by giving the seasonal or annual values of nitrogen compounds measured in this study. It is already known in previous studies that savannah fires represent a source of N for tropical rain forests. Limit conclusion to this statement is not useful and interesting.

Authors: We think that the conclusion should the mean annual and seasonal values of nitrogen compound concentration to the conclusion paragraph as suggested by the referee.

Authors: We agree with all the technical corrections and we will take into account these corrections in the revised manuscript.

Technical correction

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P15226, L25: ... see water” or sea water? P15227, L9-10: An Lewis et al. (2009) has... Please, change “has” by “have” P15232, L5-11 : Please, precise the units of variables. P5237, L10: “Yobouè” Please, write rather “Yoboué” or simply “Yoboue” without an acute accent. P15247: “Tabé1” Please, precise if the mean values of the period 18/07/12 to 11/09/12 represent the average concentrations of two months. P15248, fig1: It should be interesting to superimpose monthly evolution of precipitations (in histogram) on the monthly concentrations in order to distinguish the seasons. P5250: Please indicate (a) and (b) on the figure 3. Figure (a) is named “...anions” but NH₄⁺ is not an anion.

Interactive comment on Biogeosciences Discuss., 10, 15225, 2013.

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