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Interactive comment on "Stable isotope signatures of soil nitrogen on an environmental-geomorphic gradient within the Congo Basin" *by* Simon Baumgartner et al.

Anonymous Referee #2

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The manuscript quantifies the nitrogen (N) stocks and N isotopic composition of soils at three locations in the Congo Basin. The aim was to explore N availability in ecosystems across this poorly studied region, in the broader context of understanding N cycling in tropical forests. As a key macronutrient, the N cycle of these forests is a critical part of understanding how an ecosystem might respond to external drivers (changes in pCO2, climate, landuse). The study finds large contrasts in the stable N isotopic composition (d15N) between the sites, alongside changes in N stock, and seeks to link these to differences in environmental and geomorphic variables. At each site, the work explores how slope angle (and topographic position) influence d15N, building on some past work in Taiwan and Costa Rica, to explore how geomorphic processes influence

N cycling. The study was well focused, succinct, and the theme makes it worthy of attention at SOIL.

However, I found the discussion quite hard to follow, and it was hard to draw out the main findings. My main comments below reflect this, and make some suggestions for revisions:

1) Provide a clearer assessment of the potential controls on d15N in soil: This doesn't have to be more than a paragraph, as this has been done in other papers (from time to time), but the paper lacks a clear explanation of what controls the d15N values of soil N. This would be useful in the introduction, and then used to seed the structure of the discussion and help a clearer assessment of what best explains the patterns in the data. I would suggest something that talks about N inputs (and their d15N values), internal N cycling (plant to soil) and role of N losses (gaseous, dissolved, particulate) and how they may fractionate (or not) N isotopes in soil. Some of this is there in the manuscript, but its not that clear, and confused by the "open" vs "closed" discussion (see next point).

2) The "open" vs "closed" explanation for d15N values: This seems too simplified now, as we recognise that we can vary several aspects of the N cycle in an ecosystem and arrive at the same d15N values. For instance: i) the comparison between the N stock (N/km2) and input and output fluxes (N/km2/yr) can play a role, as with any isotope mass balance; ii) the N inputs (deposition, fixation) can be fractionated (or not); iii) the N outputs (gaseous, dissolved, particulate) can be fractionated (or not); iv) and pedogenesis and timescales of soil formation can vary (giving different intergration periods for different sites, and over depth). So with this explanation at hand, the simple argument of closed vs open is simplistic. In fact, the open vs closed model (I think) implicitly assumes that all N losses are fractionating, and that the ratio of N stock to N fluxes are the same at every site. Both those assumptions are flawed.

Instead, this study measures N stocks (and C/N, so relative to C). So it can say some-

thing about how this varies (and the paper doesn't use this information paired to the d15N data).

The study doesn't measure plant d15N, NO3 in porewaters or streams, or any gaseous N (that is very rare to do). This means any discussion of these important features of the N cycle and their d15N values would have to be drawn from other studies, and somewhat speculative for these sites. However, at the moment the paper doesn't discuss at all what these could be, and whether they could vary between the sites. By way of example, the lower MAP at the Miombo site could influence soil moisture – which is important for gaseous N loss (under saturated conditions) and NO3 loss (which can have a low d15N value). Thus, this could explain the shift in isotopic values: this site has less fractionating N losses. Or could it be simply a plant input (fixation) story.

Another quick example, the montane and lowland sites have similar d15N values, but the lowland site has much lower N stock (but higher relative to carbon C/N). So, to get the same d15N depletion in the soil residue, one has to invoke that the N fluxes out of the system (which fractionate) are larger in the montane system, than the lowland (because to see a d15N shift, you need the flux to be larger).

This text from me is somewhat off the top of my head. I could be completely off the mark here. But my point is that there are details to the dataset which are not discussed clearly, and the open vs closed discussion constrains this discussion in my view. A more structured discussion (see below) could also help.

3) Discussion section: I would recommend restructuring this to either take a more site by site explanation of patterns. Or a process by process explanation of patterns (e.g. starting with potential N inputs – could these explain things; then differences in N stocks; then potential N outputs). This could help draw out the key take away messages a little better.

Note – only having completed my review did I then read the comments already posted in the discussion. I found myself in agreement with queries flagged by the other re-

viewer.

Other comments (with line number):

19: maybe avoid the word "profiles" here – as the reader could infer you're talking about a soil profile, with depth.

19-20: this sentence would be better linked to the variability in d15N values measured, and how they've been interpreted.

23: this sentence on montane forest was a little confusing following the preceeding sentences, and perhaps the order of information here needs to be revised.

44: can the sentence "it is important" be rephrased to better spell out what the knowledge gaps are?

46: the "openness" section of text. I wonder if you need a couple of sentences explaining the inputs of N to ecosystems, and the losses. And then the idea that the overall size of the pool and leakiness is conceptualised as open vs closed. This might be clearer to those not familiar with the N cycle in soils.

60: I partly agree with that statement... But there is an important detail - Hilton et al., don't invoke the open vs closed concept. Instead, they argue that the nature of the N loss varies with slope, and that physical erosion and export of organic N in solid form does not fractionate the N isotope pool. In that way, the isotope mass balance is different for sites on steeper slopes (N loss dominated by non-fractionating losses), vs shallower slopes which potentially have a greater role of fractionating N losses (dissolved N forms, N gas forms).

69: please expand on the "openness of the N cycle" comment.

70: yes this is exactly what I write above! I should have been patient. Anyhow, I think perhaps that means that the order and flow of content might need some edits here.

105: experimental design seems good – and impressive range of sites across this

setting. A quick Q – do you know the bedrock geology and whether it varies (and whether it could contain N?).

Figure 1 – please add a note to the caption that the colours are elevation (I guess?) and perhaps make a note of the resolution of the DEMs shown here.

Table 1 – is there a typo here? The lowland forest has the highest mean slope (22degrees) – which doesn't seem to fit with what you have shown in the histograms of slopes in Figure 1.

135: briefly detail the external standards used to re-calibrate the d15N values and their precision etc.,

140: adapted or used?

138: a bit more context on why this model was selected would be useful.

Figure 3 B – how did you lump the sites together to get this erosion coefficient?

Section 4.1. – I found this hard to follow. There is some repetition of themes and information (especially in the final paragraph), and it was hard to take away the main discussion points the authors wanted to highlight. It might make sense to start with a discussion of the N inputs, and the top soil values (and their contrasts) and what that indicates about them. The discussion N outputs/internal cycling (and depth profiles) at each site. And try to draw together a somewhat coherent discussion. One of the striking things is how high the d15N values are in the lowland (and at depth in the montane) and I finished this section without a clear idea what that was being attributed to.

Table 2: I don't understand the "Estimate" values in this table, and struggle to follow what they refer too.

251 – "there are no steep slopes in the lowland forest" – this does suggest that Table 1 is incorrect.

255: more about the controls on the EC output would be useful – as to why Miombo is so much higher. And how you computed the EC values for the literature data. And how Figure 3B came about (and the assumptions and limitations associated with it).

301: this note on N fixation was not clearly discussed in the main text – see comment above on Section 4.1

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