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Interactive comment on "Soil phosphorus dynamics on terrestrial natural ecosystems" *by* Leonardo Deiss et al.

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We sincerely thank the editor and reviewers for evaluating our manuscript. We have responded to each comment. As requested by the editorial board, we are providing in this document responses to comments only, and not the revised manuscript, even though we already made several changes on it following the reviewers' suggestions, and specific details are presented on this document. Comments made by the reviewer are identified by "R2", and responses from authors are identified with "Response to R2".

R2 General comments.

- The writing of the paper needs to be improved. The paper is dense and hard to read

like it is.

- The main messages to take home are not clear, these must be highlighted.

- There are to many bivariate graphs that distract to understand the main messages. I would suggest to add most of them for the supplementary material and keep in the main text the ones that are significant and are used to describe main processes in the text.

- The authors present the patterns shown as global, but there is no reference on the role of different biomes and plant communities, which are in turn related to soil properties. Ecological implications for the relations seen are missing.

- Because of the distribution of the dataset, where most of the samples are from New Zealand, the authors should address the associated bias that the data could have.

- The authors consider the weathering status as a temporal proxy (as it is said in the abstract) to be crossed with soil and climate properties. However, weathering status in this paper is defined by soil type, which makes this classification at certain point redundant with soil properties and climate. The authors should clarify this decision.

- To assume organic C as total C is only acceptable in organic soils. This assumption can lead to large errors in calcareous soils.

- Why the path analysis is used to explain exclusively diester/monoester ratio and not other P-form? Is this ratio providing specific information on nutrient state of the ecosystem? Is significant for understanding P-limitation or inorganic control over the P cycle? This should be argued.

- I miss a clear explanation on the role of the basement/parent material.

Response to R2 General comments.

- The writing of the paper will be improved making it less dense and easier to read. A native language specialist will revise it.

- We believe that the main messages were responses related to the increasing complexity of phosphorus compounds as pedogenesis progress; therefore, we will emphasize those aspects across the manuscript to make more clear the take home messages.

- We agree that we have too many bivariate graphs, so we reduced one variable in Figure 3 (phosphonate, adding it as supplementary material), and added both climatic figures as supplementary material (organic and inorganic P vs. climatic drivers, Figures 4 and 5).

- Ecological implications of different biomes and plant communities over soil P composition will be added to the manuscript discussion. This will be done through determining the main biomes comprised in our data set using the annual precipitation – temperature diagram (whittaker diagram).

- The potential associated bias that the data could have because most of the samples were from New Zealand will be added to the manuscript. We will relate this discussion with the soil orders and biomes comprised.

- Regarding the redundancy between soil properties and climate with weathering , this is one reason why we used the path analysis. We can control for the redundancy using such statistical analysis. The figure of soil weathering stage relationship with soil age also showed that our classification followed the patterns that could be expected between soil weathering and soil age and between soil weathering and soil C. However, we do not have enough data to base our weathering classification only based on soil age.

-We checked all data from soils with pH higher than 7 and they have measured organic C, instead of total C. We added this description in the Material and Methods section to clarify this issue for readers.

- The diester to monoester ratio is an important soil metric that may be affected by soil and climatic factors (Nash et al. 2014). Ratio factors are important in our analyses

for several reasons (we will add this information to make it clearer to readers.): a) In general, they are more robust variable to compare P dynamics between soils as they minimize methodological between-study differences. b) Their variation is constrained compared with other continuous variables. As such, statistical assumptions are more easily considered. c) Last but not least, assumptions on their dynamics with the factor time are well-defined in literature. d) It is a key variable that give directions on how soil organic P composition is responding to environmental conditions. e) We agree that it is not explaining the inorganic P composition, but to fill this gap we have determined the complex inorganic P (pyrophosphate + polyphosphate) to orthophosphate ratio.

- We added more explanation on the role of the parent material over soil P composition and implications related to the soil weathering stages classification. The soil total P content depends on both weathering stages and parent material, but generally decreases with increasingly weathered soil orders (Yang and Post, 2011). The soil weathering stages classification also takes into account changes in soil P composition, and generally follows the Walker and Syers (1976) conceptual model: there is a gradual decrease and eventual depletion of primary mineral P (mainly apatite P), a decrease of total P, an increase and then decrease of total organic P, and a increase and eventual dominance of occluded P during soil development (Yang and Post, 2011). In highly weathered soils, occluded P increases at the expense of organic P through by encapsulation of mineralized P inside of Fe and Al minerals (Crews et al., 1995).

R2 Specific comments.

- The last sentence of the abstract is not telling anything new "organic and inorganic P pools as well as their functional groups composition are determined by distinctive drivers that regulate key ecological governing their presence. . ."

- Pag 2, line 22, which 5 factors?

- Pag 4, line 27, starts a list with "a) " but no more items are listed.

- Pag 7, line 25, the no effect of many climatic variables can be related to the geographic bias of the dataset. Should be argued.

- Pag 8, line 10. Is obvious that poorly crystalline Fe and Al, do not correspond to weathering status if we consider the classification status than the authors have used. However, the presence of these oxides can deeply influence the P pools and cycles in Oxisols and Ultisols but also Andosols.

- Pag 9, line 10. This is a too ambitious sentence. There is no information presented in this study about the variability among communities or different biomes. It is not explained neither how some edaphic variables depend on climate.

- Precipitation and moisture index give similar bivariate relations, maybe with one of both variables would be enough.

Response to R2 Specific comments.

- The last sentence of the abstract was modified to be more meaningful. It was changed to "We conclude that soil P composition is determined by edaphic and climatic drivers that regulate key ecological processes on terrestrial natural ecosystems. These processes are related to the source of P inputs, primarily determined by parent material and soil forming factors, and after altogether with plants and microbes coexistence, the bio-physico-chemical properties governing soil phosphatase activity, soil solid surface specific reactivity and P losses through leaching, and the P persistence induced by increasing complexity of P organic and inorganic compounds as pedogenesis evolve.

- Pag 2, line 22. We added the five state factors determining soil weathering.

- Pag 4, line 27. The "a)" was remaining from a previous version. It was excluded in the current version.

- Pag 7, line 25. The potential bias promoted by the geographic concentration of the studied sites was added to the manuscript.

- Pag 8, line 10. We added this explanation to the manuscript.

- Pag 9, line 10. We attenuated the sentence following the reviewer suggestion. "Unprecedented" was changed to "wide". Moreover, as described in the Response to R2 General comments we will improve discussion about what are the biomes represented in our dataset (whittaker diagram), and will add this information on that specific part of discussion. How edaphic variables depend on climate is being explored on the path analysis, but we will improve discussion on theoretical aspects of those relationships.

- Given the similarity between precipitation and the moisture index, the latter has been excluded from the manuscript.

References.

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