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Interactive comment on "A new terrestrial biosphere model with coupled carbon, nitrogen, and phosphorus cycles (QUINCY v1.0; revision 1772)" *by* Tea Thum et al.

Anonymous Referee #2

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Review of "A new terrestrial biosphere model with coupled carbon, nitrogen, and phosphorus cycles (QUINCY v1.0)" for GMD by Thum et al.

This manuscript describes a new model of biogeochemical and biogeophysical cycles. The motivation for the model is to build (from the bottom-up) a comprehensive model of these cycles that incorporates the latest ecophysiological understanding, rather than bolting new processes onto an old/existing TBM. This is an ambitious (and worthwhile) task, and the new model has some exciting aspects and functionality compared to the present generation of models. The authors highlight the major/novel advances in QUINCY as: source/sink dynamics enabled through fast and slow non-structural

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carbohydrate pools; including N and P limitation in initial model development; lagged responses to instantaneous variations in climate; explicitly resolved vertical soil processes affecting litter and soil organic matter; and novel diagnostics to enable model evaluation.

After reading the manuscript, I still have some questions about how the model performs, and the results section could better highlight these core processes and developments and their emergent behaviors in the model. I think the manuscript would benefit from re-organizing the results around these 5 themes. I'm sure each of these could warrant a whole study on their own, so I'm only suggesting some simple plots to exhibit the model behavior in these areas. This is already done for the nutrient limitation (although further displaying the process-level results mentioned on Page 11 Lines 13-16 would be informative) and an example using isotopes. It seems to fully document the model, the other major advances included in QUINCY should be illustrated. For example, when does down-regulation of photosynthesis due to sink-limitation occur (Also as mentioned in the SI Page 8 Line 9-12: under what conditions are severe C deficit likely to occur to down-regulate respiration?)? What is the impact of the temperature acclimation on photosynthesis and respiration (some plots of GPP and Ra vs average temperature)?

Also I can see the benefit of the uncertainty analysis but it is hard to put these results into context when most of the variables or the parameter values shown in Figure 8 are not otherwise discussed in the text.

Specific Comments Page 4, Line 26: Are the leaf chlorophyll and N concentrations updated variables in the model? Page 8, Line 24-25: It's not clear to me how the short-term uptake is not affected, if the mid-day GPP values are lower with nutrient limitation? This is also mentioned on Page 11 Lines 16-17. Page 8, Line 25-26: Which experiments do these r^2 values refer to? Page 9, Lines 19-24: It's interesting that the P cycle is not having an impact on the tropical sites, as would be expected. What is the reason for this?

Table 2: This is a lot of information which is difficult for the reader to evaluate what it means in terms of model performance. I'm not sure it's all necessary to include here. Do each of these stocks and fluxes have corresponding representation in Figure 1? It could be possible to show these results graphically, reproducing Fig. 1 for each site but having the simulated values from Table 4 in the boxes/circles. Would also be helpful to add the observed values when they are available.

SI Equation 1: Could you provide examples of where these lag effects occur later in the set of model equations?

Equation 6: What is the reason for using Tair to model leaf photosynthesis instead of leaf or canopy temperature?

Page 4 Line 8: Should this be "excessive soil moisture stress constraints"?

Equation 46: Is there an equation for S somewhere that I have missed?

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