Topical Editor Decision: Publish subject to technical corrections (12 Dec 2020) by Carlos Sierra
Comments to the Author:
Dear authors,
Your revised version of the manuscript addresses well most comments from the reviewers. I appreciate your effort in preparing a global sensitivity analysis, and editing your manuscript with a professional proof-reading service. This new version reads much better than the previous versions.
As pointed out by the reviewers, the model makes a number of assumptions that may need additional support from empirical studies. It is also highly parameterized, and from this version it is hard to know what would be the effect of parameter uncertainty in predictions.
I also have reservations on your use of a simple Euler scheme to solve the system of partial differential equations. It is well known that this method has serious issues with numerical stability and large approximation errors.
From my point of view, these are important issues of the current implementation of your model. However, GMD is a scientific forum for the description of models, and we are open to publish model descriptions that may be re-evaluated and improved in the future. So I will accept your current model description, but I would appreciate if you make two modifications to the current version:
- Please add a paragraph at the end of your Discussion identifying potential limitations and areas of improvement in your model. For example, the high number of parameters is one potential limitation for the use of this model in other ecosystems, and it is an issue that may translate in high uncertainties in predictions. Other implicit assumptions identified by the reviewers could also be mentioned here.
- Avoid very definite statements in the Abstract and the Conclusions about the 'need for biogeochemical models to comprehensively consider the P cycle'. Although, we all would agree that the P cycle is very important for global scale biogeochemistry, your study does not address directly this topic. You do not provide evidence that a global scale model would not be able to predict effects of global change on C sequestration globally. You have some interesting results for a gradient in Sweden, but this is far from a modeling study that compares models with and without P cycle at the global scale. So, please re-phrase or remove these definitive statements from your manuscript.

Best regards,
Carlos A. Sierra

The following revisions has been made:

**Abstract**:

Current version: “Simulations from the new Coup-CNP model provide strong evidence that P fluxes need to be further considered in ecosystem studies of how C turnover react to climate change. We conclude that biogeochemical models should include the P cycle to reliably assess how both climate change and N deposition will affect C sequestration and nutrient leaching over long time periods.”

- Revised to: “The simulations showed that Coup-CNP can describe shifting from being most N to most P limited and vice versa. The potential P-limitation of terrestrial ecosystems highlights the need for biogeochemical ecosystem models to consider the P cycle. We conclude that the inclusion of the P cycle enabled the COUP-CNP to account for various

feedback mechanisms that have a significant impact on ecosystem C sequestration and leaching under climate change and/or elevated N deposition"

**Conclusion (section 6)**

Current version: "We conclude that the potential P-limitation of terrestrial ecosystems highlights the need for biogeochemical ecosystem models to comprehensively consider the P cycle. The inclusion of the P cycle will enable a model to account for various feedback mechanisms that have a significant impact on C sequestration and N leaching under climate change and/or elevated N deposition".

- Revised to: "The simulations showed that Coup-CNP is able to reproduce shifting from being most N to most P limited and vice versa during a rotation period. We conclude that the potential P-limitation of terrestrial ecosystems highlights the need for biogeochemical ecosystem models to consider the P cycle. The inclusion of the P cycle enabled the COUP-CNP to account for various feedback mechanisms that have a significant impact on ecosystem C sequestration and N leaching under climate change and/or elevated N deposition".

Add the following model limitation and future research was added at the end of discussions:

"This paper presents the newest version of the Coup-CNP model. The evaluation data from this study offer a partial picture of the entire P cycle, and further validation should focus on the internal P fluxes and its interaction with C and N. As such, the global sensitivity analysis presented here provides an example for future use of the model. A user can choose which modules to include depending on the specific research question. The Coup-CNP was evaluated using data of Swedish forest ecosystems and model results suggest soil organic matter C/P ratio is a good indicator of plant P availability. However, in the long run, the weathering rate provides the ultimate source for P. Most of the P model concepts builds on well-established concepts. However, there are few model assumptions and parameters, which would benefit from further research and more experimental evidence to test and evaluate its more general validity. Our results show the importance of the P short-cut uptake to sustain the forest growth and thereby highlighting the role of microbes. The plant P availability is regulated by the competition between mineral P uptake, short-cut P uptake, and soil adsorption. Coup-CNP simulates such competition by different coefficients or parameters, which are largely unconstrained by observations. Similarly, while a plant-mycorrhizal symbiosis interaction scheme is suggested, it relies on several parameters or coefficients, which are largely unconstrained by independent observations. We recommend further testing of the model for agricultural, wetland and other ecosystems with a wide range of plant P availability to reduce uncertainties in the model outputs. For example, tropical ecosystems that are known to be P-limited.