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Biogeosciences Discussions

Interactive comment on "The Jena Diversity-Dynamic Global Vegetation Model (JeDi-DGVM): a diverse approach to representing terrestrial biogeography and biogeochemistry based on plant functional trade-offs" *by* R. Pavlick et al.

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We thank the reviewer for their constructive review. We were glad to see that the reviewer found the JeDi-DGVM approach fascinating and that they were enthusiastic about our model.

RC: Reviewer comment, AC: Author comment

RC: This paper is a description and analysis of a new type of DGVM - one which selects its own plant growth strategies from continuous distributions in model parameter space. Vegetation parameters are carefully constructed to represent key trade-offs, allowing optimal solutions to dominate in each environment. This a fascinating approach, and has the potential to revolutionarise global vegetation modelling. Advantages are that diverse plant growth strategies are represented, making the model potentially able to respond to perturbations with much greater realism than models based on a handful of plant types, but without the perplexing difficulty of parameterisation. Because of the simulation demands of a mechanism for selecting from a vast number of potential strategies, many aspects of the model approach are rather simple, such as the calculation of GPP, and there is no treatment of competition.

AC: The aggregation scheme based on the 'biomass-ratio' hypothesis presented here is a treatment, albeit a simple one, of competition. What is not included in the presented version of JeDi-DGVM is an explicit scheme for resource competition (e.g. direct competition for light or water). We have revised and elaborated on our discussion of competition to address this point.

RC: The curious thing, then, is that the model evaluation is largely based on key structural and biogeochemical metrics, most of which have little to do with the novelty of the approach put forward. The model does relatively well on key carbon cycling metrics (although the constant referral to two other models becomes at best tedious, and at worst annoying), for example, but this is presumably much less about the innovative ecological aspects than the parameter choices made concerning the very standard GPP, NPP, litter, and SOM parameterisations.

AC: To improve the readability of a revised version of this manuscript, we have considerably reduced the number of references to the other two models.

The comparison with standard structural and biogeochemical metrics is in fact a test of how well the emergent vegetation properties in JeDi-DGVM, a novel property of the model, result in realistic structural and biogeochemical behavior.

For the revised manuscript, we are currently preparing a set of sensitivity simulations to some of the parameters choices in the GPP, NPP, litter, and SOM parameterisations of JeDi-DGVM. These sensitivity simulations, together with the set of ensemble simulations with varying allowed diversity (described below), should hopefully add support for the validity of the JeDi-DGVM approach.

RC: This is a missed opportunity, as the really interesting point would be to see how well the model does in selecting the growth strategies over environmental space, and what we learn about which are the most important and how they vary spatially.

AC: We disagree that this manuscript represents a 'missed opportunity'. Rather, we see it as a foundational study for a wide range of future applications. Reviewers of previously submitted JeDi manuscripts have mentioned the lack of a substantial biogeochemical evaluation of JeDi-DGVM as an obstacle to interpreting the significance of our results. Considering that, what we set out to do in this manuscript is to:

1. Introduce a new and more parsimonious approach to vegetation modelling based on simulating a large-number of randomly-assembled plant growth strategies that are constrained only through functional tradeoffs and environmental selection. Then, aggregating the fluxes and properties of those growth strategies using a

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simple but well-established 'biomass-ratio' hypothesis

2. Test whether the emergent vegetation properties from this new less-constrained approach are able to reproduce realistic large-scale patterns of terrestrial biogeochemistry and biogeography (e.g. richness).

We feel that achieving these two goals and presenting them constitutes a significant and novel contribution to terrestrial biogeochemical modeling. This work will act as the foundation for future work applying or expanding the JeDi approach, and we hope it will motivate other biogeochemical modeling groups to adapt some of the novel aspects of our approach. We have made small revisions throughout to emphasize specifically what we are testing here.

We fully agree that the study which the reviewer suggests would be interesting. Previously, Reu et al (2010) used an earlier non-dynamic version of the JeDi model (basically a direct reimplementation of the KM2000 model) to explore how the strength of the tradeoffs vary with climate. Reu et al (2011) also explored the implications of this for potential biome shifts under projected climate change scenarios. We currently have several new JeDi-DGVM manuscripts in various stages of preparation, including a comparison of the emergent simulated trait patterns with observed patterns reconstructed from a global trait database.

RC: This model is essentially an ecological hypothesis (or, more correctly, a set of hypotheses), including of the importance of things left out, such as competition. It is these that should be tested.

AC: All scientific models are sets of hypotheses. DGVMs are generally complex models that include many hypotheses. Here, we focused on testing the hypothesis that environmental selection of many randomly-assembled growth strategies via functional tradeoffs and aggregation based on the biomass-ratio hypothesis leads to reasonable large-scale biogeochemical patterns.

We agree that the issue of competition is interesting and requires further study. Bohn et al (2011) used the JeDi-DGVM to begin exploring the tradeoffs between seed and resource competition. We have revised the manuscript to clarify what is being tested here, what has been done before, and what needs to be done in the future.

RC: The set of metrics analysed, and the generally positive light this puts on the model, is discussed as if the reason for the model's encouraging performance is its treatment of biological diversity. However, there is nothing in this paper that substantiates this claim. A series of model simulations with, for example, varying levels of allowable diversity, would enable an idea such as this to be tested.

AC: We are currently preparing a set of ensemble simulations in which we vary the number of starting PGSs. Preliminary results show that with increasing allowed diversity, the mean ensemble values for key biogeochemical fluxes converge and the associated C-LAMP metric scores generally increase. We will include these results in a revised version of the manuscript as soon as they are ready.

These results, along with the results from the sensitivity simulations to the other key parameters in the model, should help to validate our modelling approach. However, we note that we are not seeking in this manuscript to make specific claims about diversity effects on biospheric/ecosystem functioning per se. Rather, we are solely testing whether a model approach based on i) environmental selection via functional

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tradeoffs of a large-number of randomly-assembled growth strategies, and ii) a simple 'biomass-ratio' aggregation scheme, is a valid method for simulating the large-scale patterns of terrestrial biogeochemistry. We have made some small revisions throughout the manuscript to clarify this point.

RC: p. 4652.21 2373 gC m-2? p. 4681. C2? p. 4687.3 JP. Grime? Fig 5. odd scale on (c) Fig 6. scale too wide to show differences clearly Fig 11. legend has error for (b) Fig 17. 'percent' better than 'fraction' ?

AC: Regarding these minor comments, we thank the reviewer for taking their time to read our manuscript so carefully. In each case, we have updated the revised manuscript accordingly.

Citations

B. Reu, S. Zaehle, R. Proulx, K. Bohn, A. Kleidon R. Pavlick, S. Schmidtlein (2011) The role of plant functional trade-offs for biodiversity changes and biome shifts under scenarios of global climatic change. *Biogeosciences*, 8, 1255–1266. doi:10.5194/bg-8-1255-2011

K. Bohn, J. G. Dyke, R. Pavlick, B. Reineking, B. Reu, A. Kleidon (2011) The relative importance of seed competition, resource competition and perturbations on community structure. *Biogeosciences*, 8, 1107–1120. doi:10.5194/bg-8-1107-2011

B. Reu, R. Proulx, K. Bohn, J.G. Dyke, A. Kleidon, R. Pavlick, S. Schmidtlein (2010). The role of climate and plant functional trade-offs in shaping global biome and

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biodiversity patterns. *Global Ecology and Biogeography*, 20, (4), 570–581. doi: 10.1111/j.1466-8238.2010.00621.x

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