Geosci. Model Dev. Discuss., 6, C1691–C1695, 2013
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Geoscientific Model Development
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Discussions

Interactive comment on "Can we model observed soil carbon changes from a dense inventory? A case study over england and wales using three version of orchidee ecosystem model (AR5, AR5-PRIM and O-CN)" *by* B. Guenet et al.

Anonymous Referee #2

Received and published: 15 October 2013

Guenet and co-authors present a thoughtful, well written analysis that examines different versions of the ORCHIDEE model to evaluate what processes may be necessary to simulate observed declines in soil C pool in England and Wales. I'd love to see more papers like this that look at different modeling approaches and evaluate their ability to simulate non-steady state soil C dynamics. After minor revisions I feel the paper will be appropriate for Geoscientific Model Development.

Overall, I would encourage the authors to: 1) Provide greater detail about model structures being evaluated; and 2) Expand discussion / evaluation of model structures nec-

essary to capture observer SOC trends from the National Soil Inventory.

Without being too familiar with ORCHIDEE (or O-CN) it's unclear what aspects of CENTURY are simulated here. It's implied throughout the text that the structure of ORCHIDEE is like CENTURY (e.g., p. 3662, l. 26). Several comments throughout the text make me think that ORCHIDEE is really CENTURYâĂŤlike, and missing some key features of CENTURY that could be included?

Finally, there seems to be some tension in the discussion and conclusion about what the authors really think needs to be done to capture soil C dynamics. The simple priming parameterization in AR5-PRIM seems promising for capturing the sign of soil C pools over the 20th century (although not over the NSI observation period). The timing of productivity changes simulated by O-CN may be more realistic- suggesting that model structures need to consider both priming and N dynamics to capture transient soil biogeochemistry dynamics. Guenet and others insinuate as much (p. 3669, l. 25-28), but conclude that such dynamics are "not straightforward". I'd agree- but there seems to be a rich experimental literature that increasingly encourages consideration of revising soil biogeochemical models in ESMs to better align with emerging theories of SOM formation and stabilization.

More specific comments follow:

Title: England, Wales, and ORCHIDEE should be capitalized.

P 3657, L 21-26. I very much like this statement about the ability of models to capture transient soil C responses, but feel like the ideas are poorly developed in the main text. Guenet and others do a good job providing a framework to test this idea, but fail to adequately explore the theory, structures, processes, or challenges that may be necessary to improve our confidence in soil C models. I realize this type of discussion is rather speculative and my not provide definitive answers, but I would encourage he authors to explore such idea.

P 3659, L 7. The phrase "Nitrogen mechanisms" is vague and awkward. Can more precise language be used? Also, see suggested references that could be included here, or elsewhere.

P 3660, L 15-19. Is there a citation available for ORCHIDEE-AR5?

P 3662, L 26-27. This would be one place to specify what CENTURY structure are used in ORCHIDEE (e.g., above and below ground pools, litter C pools, what environmental scalars modify rates of decomposition, does soil texture or pH modify decomposition rates, are effects of cultivation used?)

P 3664, L 5. N limits decomposition rates in O-CN? Could an adjustment that reduces microbial growth efficiency in nutrient limiting conditions help agreement with observations in future analyses?

P 3664, L 17. How are soil texture properties used, to calculate soil moisture?

P 3666, L 5. If N excessively limits decomposition rates (reduces k values) why would SOC stocks be too small? In OC-N either inputs are too low, or decomposition is too rapid.

P 3667, L 10-13. Modeled increases in productivity are only due to temperature and CO2 effects. My guess is that the drivers of increased agricultural yields from observations are more related to agricultural practices not simulated in ORCHIDEE. It seems somewhat misleading to compare these values without acknowledging this caveat.

P 3667, L 15. The Schmidt et al paper is an amazing resource, however, it's excessively referenced in this manuscript any time the authors want to say something about soil biogeochemistry without even glancing at that literature. Some suggested references are listed at the end of this review.

P 3668, L 20-25. Could the dynamics and timing of NPP increases from O-CN improve PRIM results?

P 3668, L 25-27. As parameterized N inputs don't show agreement with NSI results, but if these N dynamics were better represented (and included priming) could ORCHIDEE get closer to observations? Here's an opportunity to speculate on what could be / ought to be done with these models.

P 3669, L 1-7. I don't really understand how this analysis informs the questions being asked here. I gather that litter pools are explicitly simulated? But in my estimation these "trend" calculations don't answer the questions about how to simulated NSI declines in soil C pools using ORCHIDEE.

P 3670, L 14-17. I really don't understand why the authors are so hasty to throw out priming and C-N dynamics from possible drivers of observed soil C declines across England and Wales, when both seem to potentially offer partial solutions to the problem. Yes, land use practices are also likely to blame- but don't unmanaged lands also show SOC declines in the NSI observations?

P 3670, L 21-27. How do we deal with the complexity of soils in models across scales? What modifications to model structures are necessary to improve representation of soil C dynamics? This paper documents that we have a long way to go- but offers no suggestions on where we should consider heading.

I have no expectation that all of these references should appear in the revised manuscript, but some of them may help authors flush out ideas that can be developed in the discussion.

Conant, R. T. et al. 2011. Temperature and soil organic matter decomposition ratesâĂŤsynthesis of current knowledge and a way forward. Glob. Change Biol. 17, 3392–3404.

Drake et al. 2011 Increases in the Flux of Carbon Belowground Stimulate Nitrogen Uptake and Sustain the Long-Term Enhancement of Forest Productivity under Elevated CO2. Ecology Letters 14: 349-357.

Dungait, et al. 2012. Soil organic matter turnover is governed by accessibility not recalcitrance. Glob. Change Biol. 18, 1781–1796.

Hungate et al. 2013 Cumulative response of ecosystem carbon and nitrogen stocks to chronic CO2 exposure in a subtropical oak woodland New Phytologist

Manzoni, et al. 2012. Environmental and stoichiometric controls on microbial carbon-use efficiency in soils. New Phytol. 196, 79–91.

Philips et al. 2012. Roots and fungi accelerate carbon and nitrogen cycling in forests exposed to elevated CO2 Ecology letters 15 (9), 1042-1049

Todd-Brown et al. 2013. Causes of variation in soil carbon predictions from CMIP5 Earth system models and comparison with observations. Biogeosciences 10, 1717–1736.

van Groenigen et al. 2006. Element interactions limit soil carbon storage Proceedings of the National Academy of Sciences 103 (17), 6571-6574.

Wieder et al. 2013. Global soil carbon projections are improved by modelling microbial processes. Nature Climate Change 3, 909–912

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