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Discussions

Interactive comment on "Oscillatory behavior of two nonlinear microbial models of soil carbon decomposition" *by* Y. P. Wang et al.

Anonymous Referee #3

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This paper by Wang et al. provides a critical and timely analysis of the potential pitfalls associated with applying microbial physiology models at global scales. The authors use a rigorous analysis of the equations underlying non-linear microbial models to show two key model behaviors that previously have received little attention: (1) non-linear models exhibit wide oscillations in response to a 10% change in the initial microbial biomass and soil organic C pools and (2) these models have equilibrium soil and litter C pools that are insensitive to changes in the amount of new inputs derived from NPP. Given the recent push to include these non-linear models into global simulations, the results presented here provide an important moment of reflection for the soil C modeling community to consider both the upsides and downsides of explicitly representing microbes at the global scale.

In respect to the oscillations present in the microbial models, I agree with the comments by Allison that this feature is an important component of microbial models. One could even argue that the lack of oscillation in linear models is problematic given empirical evidence for seasonal fluctuation in microbial biomass pools. Logically, it makes sense that following a reduction in microbial biomass and soil C that these pools would exhibit opposite responses with declines or increases in microbial biomass leading to increased or decreased soil C until equilibrium is again reached. The troubling aspect here that the authors stress is the timescale over which this occurs. One key analysis that would strengthen this argument would be to examine the sensitivity of these oscillations to variations in the perturbation size. A 10% decline in soil C or microbial biomass is not a small perturbation when you consider that 10% of the global soil C pool is $\sim$100 Pg C. The key question here is whether the long period of oscillation is conserved at smaller perturbations.

Mechanistically, I would like to see more discussion of why these oscillations occur and how they could be addressed in the microbial models. The discussion comments here have centered on the homogeneity of the soil C pools in the microbial models. This is an important point as these non-linear models assume that microbes can access the entirety of the soil C pool. We know that this is not the case as the majority of soil C is either physically or chemically protected from microbial attack. Therefore, it is likely that unprotected C pools exhibit oscillatory behavior in the real world but we cannot detect this with our empirical measurements because the protected pools that do not oscillate dominate. Thus, a better recommendation for moving forward would be to incorporate these protection mechanisms in the models to dampen these oscillations while limiting model complexity. Simply combining the stability of the traditional linear models with the dynamics of the microbial models is unlikely to capture protection mechanisms.

Finally, the fact that the non-linear models are insensitive to changes in the inputs derived from NPP is in some aspects more troubling than the oscillatory behavior. However, there is an emerging body of evidence that suggests that NPP is not a dominant control on SOC pools. This is supported by the lack of SOC changes found in the FACE experiments (where greater NPP inputs to soils may be counterbalanced by enhanced priming of SOM to gain N by plants) cited by Allison in his comment as well as a recent paper by Averill et al. in Nature that shows that mycorrhizal association is likely more important than NPP in determining soil C storage. The authors should provide both lines of evidence in the discussion. However, highlighting the lack of sensitivity to shifts in NPP by the non-linear models remains important as these models may be getting the right answer for the wrong reason.

Interactive comment on Biogeosciences Discuss., 10, 19661, 2013.