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Interactive comment on "Integrating microbial physiology and physiochemical principles in soils with the MIcrobial-MIneral Carbon Stabilization (MIMICS) model" *by* W. R. Wieder et al.

W. R. Wieder et al.

wwieder@ucar.edu

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We appreciate the constructive suggestions made by Drs. Jones, Sierra, and Allison in response to our discussions paper. We are excited that their comments generally asked for more information, especially relating to model dynamics at larger scales and in global change scenarios. We present a revised manuscript that addresses these suggestions, but stress that our aim with this paper was to thoroughly document the theoretical underpinnings that generated the model assumptions and structure that are applied in MIMICS. Broader consideration of model dynamics, especially in non-steady state simulation and at global scales is planned for subsequent manuscripts. Specific

responses to reviewer suggestions follow.

Dr. Sierra raises a number of points in his general comments that spark an interesting discussion. We address his thoughts here and in our manuscript revisions relating to:

Equifinality. Dr. Sierra is accurate in his statement that we do not provide any evidence that MIMICS does "better" than conventional models. Instead it does just as well as some linear models at replicating site-level decomposition observations (e.g., Bonan et al. 2013). For our purposes here we feel this is adequate, because it demonstrates that microbial explicit models of moderate complexity can be parameterized to preform just as well as standard models based on first-order kinetics. As noted by reviewers Jones and Sierra the real test of these models is in their response to environmental perturbations. Datasets like the Harvard Forest soil C response to warming and N additions provide an excellent resource by which to evaluate model structures and parameterizations (Sierra et al. 2012). We look forward to evaluating MIMICS with datasets like these in the future, as our previous work (Wieder et al. 2013) demonstrates notably different responses between microbial explicit and microbial implicit model configuration. See text on lines 314-318 and the paragraph beginning on line 593 in the revised manuscript.

Validation with microbial data. We appreciate Dr. Sierra's acknowledgement that representing microbial functional types is one of MIMICS main contributions. Evaluating the patterns and processes that emerge from this structure also poses a significant challenge and opportunity for MIMICS. New techniques to quantify microbial growth rates are being developed (Aanderud & Lennon, 2011; Blazewicz & Schwartz, 2011) that may provide useful information on constraining estimates of microbial turnover in MIMICS. Co-authors Grandy and Kallenbach are currently refining these techniques in field and lab experiments. Other new approaches potentially provide insight into the relative abundances of microbial functional types, and associated physiological traits (Portillo et al. 2013; Fierer et al. 2012). Text to this effect has been modified in the paragraph beginning on line 593 of the revised manuscript.

Oscillations. Preliminary results indicate that MIMICS has a similar oscillatory behavior to the three-pool microbial model analyzed by Wang and others (2014; which W. Wieder also co-authored). Analyses and text to this effect has been added (see Figure 5, lines 293–304, 402-413, & 582-592 in the revised manuscript). The oscillations evident in Fig. 2 of this manuscript are caused by temperature variability and are not evident when forcing the model with constant soil temperature (see attached Figure). Wang et al. (2014) suggest that "a better model for capturing the soil carbon dynamics over decadal to centennial timescales would combine the sensitivity of the conventional models to carbon influx with the flexible response to warming of the nonlinear model." MIMICS begins to marry the strengths of linear and non-linear models, and investigations into the magnitude and duration of its oscillatory response deserve further investigation. Moreover, some of the language critical of non-linear model projections has been tempered in revised manuscript now available in Biogeosciences. There are aspects of the MIMICS structure and parameterization that are not realized in traditional soil C models, as they are typically parameterized- notably how changes in soil C storage are mediated by litter quality and soil texture in MIMICS (Fig. 3, and highlighted throughout the text).

Moisture control. We agree, consideration of soil moisture dynamics marks a critical development necessary for MIMICS. This is noted more explicitly in the revised text (see lines 175 and 622).

Technical comments: We agree with the statements that soil physical characteristics should determine C storage in mineral soils, and feel the confusion may have been generated by an error in Table 1 relating to how we modify rates of SOM turnover by soil texture using the "Pscalar" and "Cscalar". These formulas have been modified in the revised text.

Language about model responses was tempered (lines 470)

Symbols in fig 4b are tightly placed by design; our aim is to communicate the modeled response surface and the relative importance of parameter values in determining steady state soil C densities in these sensitivity analyses. We've modified this figure slightly to accomplish this aim.

——— References: Aanderud ZT, Lennon JT (2011) Validation of heavy-water stable isotope probing for the characterization of rapidly responding soil bacteria. Applied and Environmental Microbiology 77, 4589-4596.

Blazewicz S, Schwartz E (2011) Dynamics of 18O Incorporation from H218O into Soil Microbial DNA. Microbial Ecology, 61, 911-916.

Bonan GB, Hartman MD, Parton WJ, Wieder WR (2013) Evaluating litter decomposition in earth system models with long-term litterbag experiments: an example using the Community Land Model version 4 (CLM4). Global Change Biology, 19, 957–974.

Fierer N, Lauber CL, Ramirez KS, Zaneveld J, Bradford MA, Knight R (2012) Comparative metagenomic, phylogenetic and physiological analyses of soil microbial communities across nitrogen gradients. ISME J, 6, 1007-1017.

Portillo MC, Leff JW, Lauber CL, Fierer N (2013) Cell size distributions of soil bacterial and archaeal taxa. Applied and Environmental Microbiology, 79, 7610-7617.

Sierra CA, Trumbore SE, Davidson EA, Frey SD, Savage KE, and Hopkins FM (2012) Predicting decadal trends and transient responses of radiocarbon storage and fluxes in a temperate forest soil. Biogeosciences, 9, 3013–3028.

Wang YP, BC Chen, WR Wieder, YQ Luo, M Leite, BE Medlyn, M Rasmussen, MJ Smith, FB Agusto, and F Hoffman. (2014) Oscillatory behavior of two nonlinear microbial models of soil carbon decomposition. Biogeosciences 11, 1817–1831.

Wieder WR, Bonan GB, Allison SD (2013) Global soil carbon projections are improved by modelling microbial processes. Nature Clim. Change, 3, 909-912.

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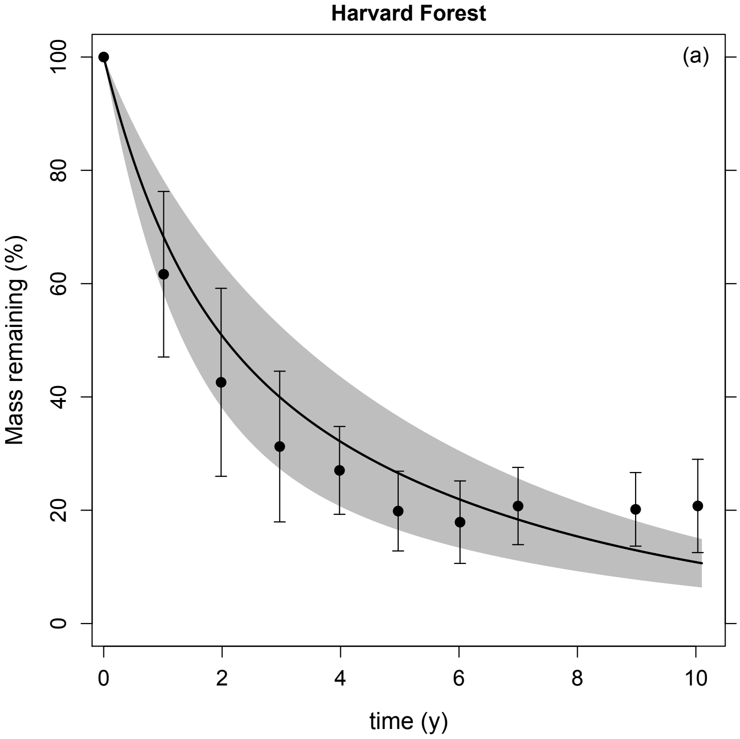

Fig. 1. Figure 2a, forced with constant soil temperature showing no oscillatory behavior

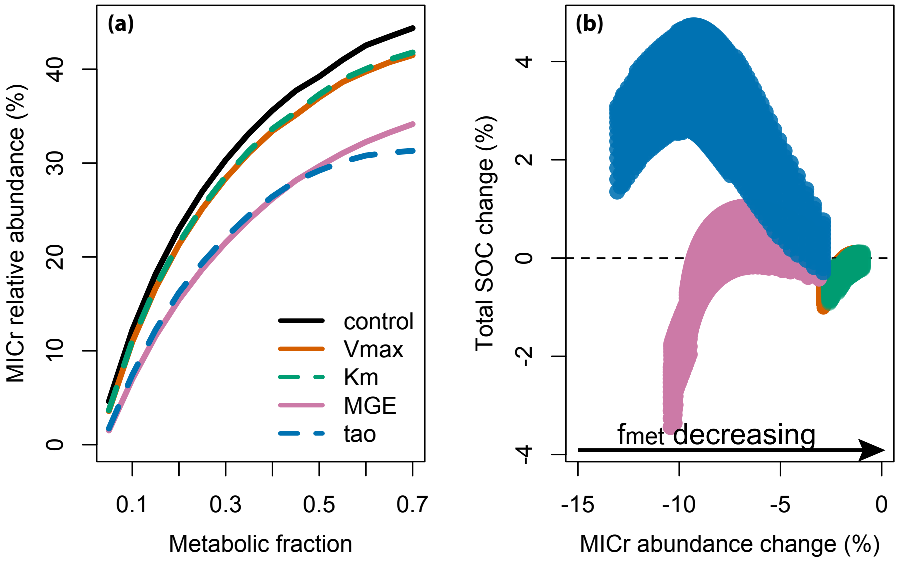

Fig. 2. Revised Figure 4, showing response surface to prameter modifications

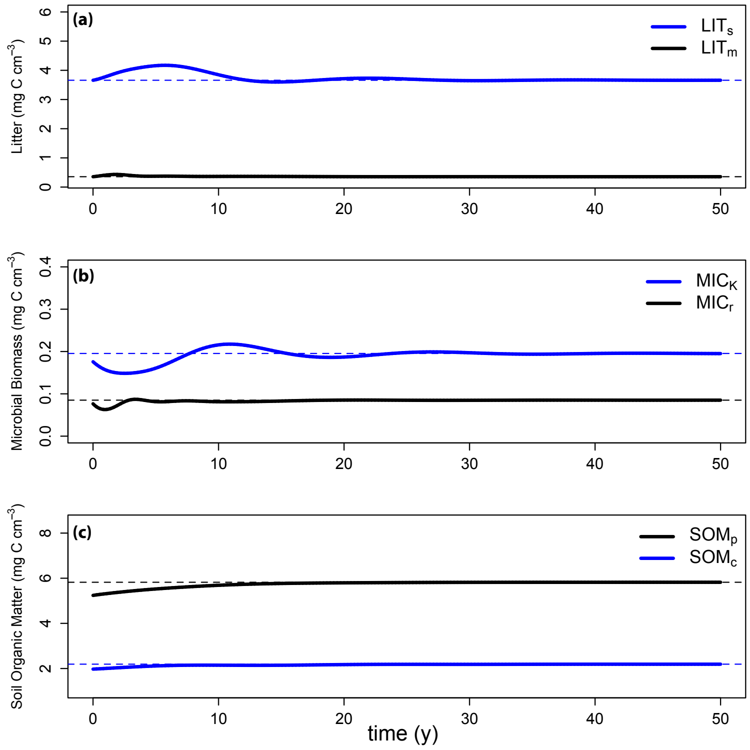

Fig. 3. Figure 5. Temporal response of (a) litter, (b) microbial biomass, and (c) soil C pools to a 10% reduction of steady state MIC and SOM pools at time zero of the experiment (solid lines).