Biogeosciences Discuss., 12, C1363–C1368, 2015
www.biogeosciences-discuss.net/12/C1363/2015/

Biogeosciences
Discussions

Interactive comment on "Convergent modeling of past soil organic carbon stocks but divergent projections" *by* Z. Luo et al.

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Received and published: 17 April 2015

Göran I. Ågren Department of Ecology Swedish University of Agricultural Sciences P.o. Box 7044 ESE-750 07Uppsala Sweden goran.agren@slu.se Tel +46 18 6724449 Luo et al. present an interesting study of model projections of soil organic carbon (SOC) In spite of very good model fits to past SOC development, the projections diverge drastically. I think this illustrates what we could call "the curse of equifinality"; there are many parameter combinations, or for that matter models, that fit data equally well but it is difficult to know which do this for the right reason and which do this for wrong reasons. One way around this conundrum is to focus less on how well models fit data and find ways to constrain allowable parameter ranges and pay more attention to the internal consistency of models. I will here give an example of an analysis of the latter. I have dissected

five SOC models (CENTURY, (Parton et al., 1987; Parton et al. 1994; Paustian et al., 1992), DAISY (Hansen et al., 1990; Jensen et al,. 1997; Mueller et al., 1997),;ROTHC-16.3 (Coleman & Jenkinson, 1995; Jenkinson et al., 1992), VERBERNE Verberne et al., 1990; Whitmore et al., 1997(, and NCSOIL (Nicolardot & Molina, 1994). All five models describe SOC as consisting of between 2 and 5 pools with transfers between them and losses as CO2 (respiration).I have characterised each pool by a quality, which depends on the total rate (respiration plus transfers to other pools) at which this pool is depleted. From this I have then calculated the carbon use efficiency (CUE) as the fraction of C lost from a pool that is transferred to another pool; 1-CUE is the fraction lost as respiration. I have also calculated the dispersion D(q,q'), which describes the fraction of carbon from the pool with quality q' that is transferred to the pool with quality q. The results are presented in Figures1 &2. A more detailed description of the calculations can be bound in Nilsson (2004). CUE is in most models independent of the quality of the pool but varies considerably between models but is in the range also found by Lou et al. Model studies in general, including Lou et al., tend to point out CUE as one of the parameters to which model predictions is most sensitive (see also Hyvönen et al. 1998), However, this assumed constancy, albeit the simplest to make in view of our ignorance of its sensitivity to substrate properties, must be strongly questioned as from a theoretical perspective CUE should vary with substrate quality (Manzoni et al. 2012). If CUE is constant in the five models analyses, this is not the case for the dispersion function, where in four of the models (not ROTH-C) the function looks like an alpine landscape. This is problematic because model predictions are also very sensitive to this function (Hyvönen et al. 1998). This is also one of the properties where empirical information is really scarce because of difficulties in measuring it. However, the question is if any of the dispersion functions in Figure 2 are reasonable or if we should expect them to be much smoother and probably monotonic functions? The manuscript by Lou et al. provides no further information on this point. In conclusion, the manuscript by Lou et al. points to a problematic area for the modelling of SOC. Better control on the internal consistency of models could help constraining model prediction by preventing unrealistic parameter combinations. References Coleman, K. and Jenkinson, D.S.: RothC-26.3-A model for the turnover of carbon in soil. In: Powlson, D.S., Smith, P., and Smith, J.U. (Eds.). Evaluation of soil organic matter models using existing, long-term datasets. NATO ASI series 1, vol. 38. Springer, Berlin Heidelberg New York, pp. 237-246, 1996. Hansen, S., Jensen, H.E., Nielsen, N.E. and Svedsen, H.:. Daisy-soil plant atmosphere system model. Npo- forskning fra Miljøstyrelsen,vol A10, Miljøstyrelsen, Copenhagen, 272 pp., 1990. Hyvönen R., Ågren G.I., Bosatta E.: Predicting long-term soil carbon storage from short-term information. Soil Science Soc. Am. J., 62, 1000-1005, 1998. Jenkinson, D.S., Harkness, D.D., Vance, E.D., Adams, D.E. and Harrison, A.F.: Calculating net primary production and annual input of organic matter to soil from the amount and radiocarbon content of soil organic matter. Soil Biol. Biochem,. 24, 295-308., 1992. Jensen, L.S., Mueller, T., Nielsen, N.E., Hansen, S., Crocker, G.J., Grace, P.R., Klír, J., Körschens, M. and Poulton, P.R.: Simulating trends in soil organic carbon in long-term experiments using the soil-plant-atmosphere model DAISY. Geoderma, 81, 5-28, 1997. Manzoni S., Taylor P., Richter A., Porporato A., Ågren G.I.: Environmental and stoichiometric controls on microbial carbon-use efficiency in soils. New Phytol., 196:79-91, 2012. Mueller, T., Jensen, L.S., Magid, J. and Nielsen, N.E.: Temporal variation of C and N turnover in soil after oilseed rape straw incorporation in the field: simulations with the soil-plant-atmosphere model DAISY. Ecol. Model., 99: 247-262., 1997. Nicolardot, B. and Molina, J.A.E.: C and N fluxes between pools of soil organic matter: model calibration with long-term field experimental data. Soil Biol.Biochem., 26, 245-251., 1994. Parton, W.J., Schimel, D.S., Cole, C.V. and Ojima, D.S.: Analysis of factors controlling soil organic matter levels in great plains grasslands. Soil Sci. Soc. Am. J., 51,1173-1179., 1987. Nilsson K S.. Modelling soil organic matter turnover. Ph.D thesis. Acta Universitatis Agriculturae Sueciae 326, 2004. Parton, W.J., Ojima, D.S., Cole, C.V. and Schimel, D.S.: A general model for soil organic matter dynamics: sensitivity to litter chemistry, texture and management. Soil Sci. Soc. Am. Special publication, 39, 147-167, 1994. Paustian, K., Parton, W.J. and Persson, J.: Modelling soil organic matter in organic-amended and nitrogen- fer-

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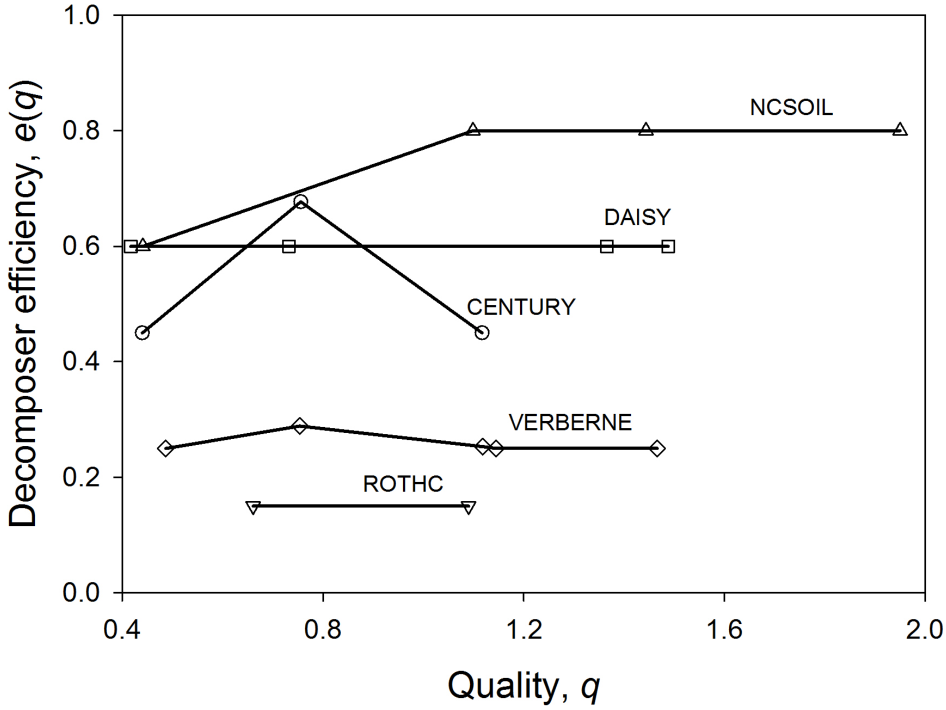
Figure 1. Calculated carbon use efficiency e(q) = CUE as a function of quality q for the five models.

Figure 2. Calculated dispersion matrix D(q,q') for the five models. q' represents the quality of origin and q the quality to which this carbon is converted. The sum of D(q,q') over q equals 1.

Interactive comment on Biogeosciences Discuss., 12, 4245, 2015.



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