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Comparing measured and modelled soil carbon: which site-specific variables are linked to high stability?

Andy Robertson (1), Meagan Schipanski (1), Liwang Ma (2), Lajpat Ahuja (2), Niall McNamara (3), Pete Smith (4), and Christian Davies (5)

(1) Colorado State University, Soil and Crop Sciences, Fort Collins, United States (andy.robertson@colostate.edu), (2) USDA-ARS, 2150 Centre Ave, Bldg D, Fort Collins, USA, (3) Centre for Ecology & Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK, (4) Institute of Biological and Environmental Sciences, University of Aberdeen, 23 St Machar Drive, Aberdeen AB24 3UU, Scotland, UK, (5) Shell International Exploration and Production, Shell Technology Center Houston, 3333 Highway 6 South, Houston, TX 77082-3101, USA

Changes in soil carbon (C) stocks have been studied in depth over the last two decades, as net greenhouse gas (GHG) sinks are highlighted to be a partial solution to the causes of climate change. However, the stability of this soil C is often overlooked when measuring these changes. Ultimately a net sequestration in soils is far less beneficial if labile C is replacing more stable forms. To date there is no accepted framework for measuring soil C stability, and as a result there is considerable uncertainty associated with the simulated impacts of land management and land use change when using process-based systems models. However, a recent effort to equate measurable soil C fractions to model pools has generated data that help to assess the impacts of land management, and can ultimately help to reduce the uncertainty of model predictions. Our research compiles this existing fractionation data along with site metadata to create a simplistic statistical model able to quantify the relative importance of different site-specific conditions.

Data was mined from 23 published studies and combined with original data to generate a dataset of 100+ land use change sites across Europe. For sites to be included they required soil C fractions isolated using the Zimmermann *et al*. (2007) method and specific site metadata (mean annual precipitation, MAP; mean annual temperature, MAT; soil pH; land use; altitude). Of the sites, 75% were used to develop a generalized linear mixed model (GLMM) to create coefficients where site parameters can be used to predict influence on the measured soil fraction C stocks. The remaining 25% of sites were used to evaluate uncertainty and validate this empirical model. Further, four of the aforementioned sites were used to simulate soil C dynamics using the RothC, DayCent and RZWQM2 models. A sensitivity analysis (4096 model runs for each variable applying Latin hypercube random sampling techniques) was then used to observe whether these models place as much weight on the same site parameters as the GLMM.

Sites were spread across an extensive geographic area and encompassed a wide range of conditions (2% to 44% clay content; 0.9˚C to 18˚C MAT; 300mm to 1400mm MAP). Topsoil (30 cm) C stocks also varied considerably (29.0 to 115.9 t/ha) but the proportion deemed stable (mean residence time >10 years) was relatively consistent (72 ± 2 %). The GLMM approach suggested that an interaction of soil pH and historic land use explained the largest amount of variation seen in stable fraction C stocks, closely followed by MAT and MAP interactions. For all three systems models, the stable soil C pools were most sensitive to climatic variables and land use. However, RZWQM2 did indicate that soil characteristics (texture, pH) also had an influence on stable C pool dynamics.

References

1 – Zimmermann *et al*., 2007. Measured soil organic matter fractions can be related to pools in the RothC model. European Journal of Soil Science, **58**:658–667.