Geophysical Research Abstracts
Vol. 17, EGU2015-2287, 2015
EGU General Assembly 2015

Model structure and parameter identification in soil carbon models using incubation data

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Models of soil organic matter dynamics play an important role in integrating different sources of information and help to predict future behavior of carbon stocks and fluxes in soils. In particular, compartment-based models have proved successful at integrating data from laboratory and field experiments to estimate the range of cycling rates of organic matter found in different soils. Complex models with particular mechanisms explaining processes related to the stabilization and destabilization of organic matter usually include a large number of parameters than simpler models that omit detailed mechanisms. This poses a challenge to parameterize complex models. Depending on the type of data available, the estimation of parameters in complex models may lead to identifiability problems, i.e. obtaining different combinations of parameters that give equally good predictions in relation to the observed data. In this contribution, I explore the problem of identifiability in soil organic matter models, pointing out combinations of empirical data and model structure that can minimize identifiability issues. In particular, I will show how common datasets from incubation experiments can only help to uniquely identify small number of parameters for simple models. Isotopic data and soil fractionations can help to reduce identifiability issues, but only to a limited extend. In medium-complexity models including stabilization and destabilization mechanisms, only up to 4 to 5 parameters may be uniquely identified when a full set of respiration fluxes, stocks, fractions and isotopic data are integrated to inform parameter estimation.