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Simulation of soil organic carbon in different soil size fractions using 13Carbon measurement data

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We simulate the soil organic carbon (SOC) dynamics at a chronoseqeunce site in France, using the Rothamsted Carbon model. The site exhibits a transition from C3 plants, dominated by pine forest, to a conventional C4 maize rotation. The different 13C signatures of the forest plants and maize are used to distinguish between the woodland derived carbon (C) and the maize derived C. The model is evaluated against total SOC and C derived from forest and maize, respectively. The SOC dynamics of the five SOC pools of the model, decomposable plant material (DPM), resistant plant material (RPM), biomass, humus and inert C, are also compared to the SOC dynamics measured in different soil size fractions. These fractions are > 50 µm (particulate organic matter), 2-50 µm (silt associated SOC) and <2 µm (clay associated SOC). Other authors had shown that the RPM pool of the model corresponds well to SOC measured in the soil size fraction > 50 µm and the sum of the other pools corresponds well to the SOC measured in the soil size fraction < 50 µm. Default model applications show that the model underestimates the fast drop in forest C stocks in the first 20 years after land-use change and overestimates the C accumulation of maize C. Several hypotheses were tested to evaluate the simulations. Input data and internal model parameter uncertainties had minor effects on the simulations results. Accounting for erosion and implementing a simple tillage routine did not improve the simulation fit to the data. We therefore hypothesize that a generic process that is not yet explicitly accounted for in the ROTHC model could explain the loss in soil C after land use change. Such a process could be the loss of the physical protection of soil organic matter as would be observed following cultivation of a previously uncultivated soil. Under native conditions a fraction of organic matter is protected in stable soil aggregates. These aggregates are physically disrupted by continuous and repeated cultivation of the soil. The underestimation of SOC loss by the model can be mainly attributed to the slow turnover of the humus pool. This pool was shown to represent mainly the SOC associated with the silt and clay soil fraction. Here, the clay associated SOC shows as similar turnover time as the humus pool in the model. We split the humus pool into a clay and a silt associated pool. The clay pool now corresponds to the clay associated SOC with the turnover time of the humus pool. The silt pool now corresponds to the silt associated SOC. From the measurements, the latter has a turnover time similar to the turnover time of the particulate organic matter. We therefore use the turnover time of the RPM pool for the silt pool. These modifications improve the simulations of the forest derived C significantly and improve the simulations of the maize derived C. Future work will further evaluate and refine this approach to eventually capture the SOC dynamics associated with physical protection, including the effect of tillage/no-tillage, in a simple approach.