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An analytic representation of the total soil carbon trajectory implied by the general mathematical framework of most soil carbon models

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Most models of soil C dynamics can be expressed by the differential vector equation:

dC(t)/dt = f(t).K.C(t) + b(t)

where each element of the vector C(t) represents a carbon compartment with intrinsic decomposition rate (usually fast, slow and passive); K is the transition matrix between the compartments (decomposition rates and decomposition partitioning); the scalar function f(t) is a forcing function of the decomposition rates modifiers (e.g. soil moisture and temperature); and b(t) is the vector with rates of external C inputs for each compartment. Considering the case where only total soil carbon is measured, only the sum of C in all compartments can be used for model evaluation, calibration and data assimilation. Also, in most compartmental models there are too many parameters to be adjusted, leading to identifiability problems. Although some parameters can be constrained according to the model's assumptions, identifiability is still problematic except for the simplest compartmental models. By working on the differential equation, it is possible to deduce an explicit representation of the total carbon trajectory, in a way that the number of necessary empirical parameters is reduced, without loss of generality or need of further assumptions. In this work we propose such a representation for the total carbon trajectory whose generality embraces implicitly the mechanism of models as Century, RothC and CQESTR. The solution requires less parameters than the original models do but still allows mapping the original model parameters and decomposition modifiers functions onto the solution. Additionally, we show how the main processes of decomposition of soil organic matter can be represented by the terms of the solution found. Finally, we present the solution behavior under extreme conditions of temperature, humidity and initial stocks. We expect our general framework to help improving model's calibration and data assimilation procedures.