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A computational framework for a database of terrestrial biosphere models

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Most terrestrial biosphere models consist of a set of coupled ordinary first order differential equations. Each equation represents a pool containing carbon with a certain turnover rate. Although such models share some basic mathematical structures, they can have very different properties such as number of pools, cycling rates, and internal fluxes. We present a computational framework that helps analyze the structure and behavior of terrestrial biosphere models using as an example the process of soil organic matter decomposition. The same framework can also be used for other sub-processes such as carbon fixation or allocation.

First, the models have to be fed into a database consisting of simple text files with a common structure. Then they are read in using Python and transformed into an internal 'Model Class' that can be used to automatically create an overview stating the model's structure, state variables, internal and external fluxes. SymPy, a Python library for symbolic mathematics, helps to also calculate the Jacobian matrix at possibly given steady states and the eigenvalues of this matrix. If complete parameter sets are available, the model can also be run using R to simulate its behavior under certain conditions and to support a deeper stability analysis. In this case, the framework is also able to provide phase-plane plots if appropriate. Furthermore, an overview of all the models in the database can be given to help identify their similarities and differences.