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Nonlinearities in vegetation functioning

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Given the current drastic changes in climate and atmospheric CO_2 concentrations, and the role of vegetation in the global carbon cycle, there is increasing attention to the carbon allocation component in biosphere terrestrial models. Improving the representation of C allocation in models could be the key to having better predictions of the fate of C once it enters the vegetation and is partitioned to C pools of different residence times. C allocation has often been modeled using systems of ordinary differential equations, and it has been hypothesized that most models can be generalized with a specific form of a linear dynamical system. However, several studies have highlighted discrepancies between empirical observations and model predictions, attributing these differences to problems with model structure. Although efforts have been made to compare different models, the outcome of these qualitative assessments has been a conceptual categorization of them. In this contribution, we introduce a new effort to identify the main properties of groups of models by studying their mathematical structure. For this purpose, we performed a literature research of the relevant models of carbon allocation in vegetation and developed a database with their representation in symbolic mathematics. We used the Python package SymPy for symbolic mathematics as a common language and manipulated the models to calculate their Jacobian matrix at fixed points and their eigenvalues, among other mathematical analyses. Our preliminary results show a tendency of inverse proportionality between model complexity and size of time/space scale; complex interactions between the variables controlling carbon allocation in vegetation tend to operate at shorter time/space scales, and vice-versa. Most importantly, we found that although the linear structure is common, other structures with non-linearities have been also proposed. We, therefore, propose a new General Model that can accommodate these nonlinearities.