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Towards accounting for all known sources of uncertainty in earth system models: fully data-constraining a global terrestrial carbon model

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The absence of clear quantification of the effects of different sources of uncertainty in earth system models (ESM) makes it practically impossible to understand why different ESMs make different, and sometimes widely diverging, predictions. We tackle this directly by developing a global terrestrial carbon model within a new model engineering framework (that we also developed) to enable us to quantify parameter and structural uncertainty and to objectively assess whether alternative formulations (model components or full models) are better supported by empirical evidence. This allows us to infer probability distributions for all parameters, assess relative uncertainty in model components across the model structure, and assess the importance of such uncertainty for long term projections of the terrestrial carbon cycle; unveiling the key importance of reducing uncertainty in global environmental dependence of plant mortality rates for improving ESM predictions. This is the first step on our goal to enable objective identification of necessary and sufficient complexity for earth system model components, quantifying all known sources of uncertainty, and ultimately enabling more accurate and consistent predictions of biosphere change.