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Uncertainty spreading and shrinking among eight land carbon cycle models in response to climate change

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Large uncertainty in model predictions of land carbon responses to climate change has been ubiquitously demonstrated in model intercomparison projects (MIPs). The large uncertainty become a major impediment in advancing climate change prediction. Thus, it is imperative to identify sources of the uncertainty before we can fully understand and address the uncertainty issue. In this presentation, I show a novel matrix approach to analytically pin down the sources of model uncertainty in predicting carbon dynamics in response to rising atmospheric CO_2 concentration and increasing temperature. We developed a matrix-based MIP by converting the carbon cycle module of eight land models (i.e., TEM, CENTURY4, DALEC2, TECO, FBDC, CASA, CLM5 and ORCHIDEE) into eight matrix models. In response to rising atmospheric CO_2 concentration and increasing temperature, predicted ecosystem net primary production (NPP), net ecosystem production (NEP), and net ecosystem carbon storage spread among the eight models as simulations go over time. We applied the traceability analysis method to decompose simulated carbon dynamics to their traceable components according to the matrix equations. Our analysis indicates that the uncertainty among the eight models was mainly due to inter-model difference in baseline carbon residence time and environmental scalar. Once the sources of model uncertainty were identified, we sequentially standardized model parameters to shrink simulated ecosystem carbon storage and NEP to almost none. Our study demonstrates that the sources of uncertainty in carbon cycle modeling can be precisely traced to model structures and parameters, regardless of their complexity, so that the uncertainty issue for MIPs can be precisely understood and well addressed.