Global sensitivity analysis of a leaf photosynthesis model composed of multiple competing hypotheses

Anthony Walker, Ming Ye, Heng Dai, Martin De Kauwe, Dan Lu, Dan Ricciuto

Accurate quantification of model sensitivities and uncertainties informs rigorous model inter-comparison, experiments targeted to improve models and maximise uncertainty reduction, and probabilistic forecasts for risk based planning in the face of future environmental change. Until now, comprehensive global methods have been available to assess model sensitivity only to variation in parameters but not to variation in the representation of processes. Systems models combine many sub-systems and processes, each of which may be conceptualised and represented mathematically in various ways. The sensitivity analysis method demonstrated here quantifies the variability in a model outcome caused by variability in process representation.

Plant photosynthetic rates increase in response to elevated atmospheric CO_2, increasing plant carbon availability. These physiological responses to CO_2 are well understood yet the response of the terrestrial carbon sink to increasing atmospheric CO_2 remains the largest uncertainty in global C cycle modelling to date. There are many sources of this uncertainty. We hypothesise that a portion of this uncertainty is related to the different assumptions that can be made while modeling photosynthesis. In this study we take an initial step towards formally assessing the sensitivity of the modelled leaf carbon assimilation response to CO_2 caused by multiple incarnations of the Farquhar model and variable parameters. Results are for demonstrative purposes only as the method is under active development for improved computational efficiency. We hope this work will provide an extremely useful and rigorous framework for the process of model development, comparison, and selection.