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Effects of environmental filtering and PFT-based model parameterization approaches on NBE prediction errors across the globe

Caroline A. Famiglietti[1], Matthew Worden[1], Gregory R. Quetin[2], T. Luke Smallman[3], Uma Dayal[1], A. Anthony Bloom[4], Mathew Williams[3], and Alexandra G. Konings[1]

[1]Department of Earth System Science, Stanford University, Stanford, USA
[2]Department of Geography, University of California at Santa Barbara, Santa Barbara, USA
[3]School of Geosciences, University of Edinburgh, Edinburgh, Scotland
[4]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA

Accurate forecasts of net biosphere exchange (NBE) are vital for understanding the role of terrestrial ecosystems in a changing climate. It is therefore problematic that NBE projections from most state-of-the-art terrestrial biosphere models (TBMs) diverge considerably from one another. Efforts to reduce this divergence have historically focused on improving models' structural realism, but several lines of evidence have brought the role of poorly determined and/or over-generalized parameters into sharper focus. Here we investigate how different parameterization assumptions propagate into NBE prediction errors across the globe. To do so, we simulate two methods for parameter assignment within a flexible model–data fusion framework (CARDAMOM): (a) the traditional plant functional type (PFT)-based approach, whereby parameters retrieved at a small number of select locations are applied broadly within regions sharing similar land cover characteristics; and (b) a novel top-down "environmental filtering" (EF) approach, whereby a pixel's parameters are predicted based on relationships with climate, soil, and canopy properties. In an effort to isolate the role of parametric from structural uncertainty, we benchmark the resulting PFT-based and EF-based NBE predictions with estimates from a Bayesian optimization approach (whereby "true" parameters consistent with a suite of data constraints are retrieved on a pixel-by-pixel basis). We find that the EF-based approach outperforms the PFT-based approach at twice as many pixels as the converse and across multiple performance metrics. However, NBE estimates from the EF-based approach may be more susceptible to compensation between errors in component flux predictions. This work provides insight into the relationship between TBM performance and parametric uncertainty, informing efforts to improve model parameterization via nontraditional approaches.