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Model–data fusion across ecosystems: from multisite optimizations to global simulations

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Abstract. This study uses a variational data assimilation framework to simultaneously constrain a global ecosystem model with eddy covariance measurements of daily net ecosystem exchange (NEE) and latent heat (LE) fluxes from a large number of sites grouped in seven plant functional types (PFTs). It is an attempt to bridge the gap between the numerous site-specific parameter optimization works found in the literature and the generic parameterization used by most land surface models within each PFT. The present multisite approach allows deriving PFT-generic sets of optimized parameters enhancing the agreement between measured and simulated fluxes at most of the sites considered, with performances often comparable to those of the corresponding site-specific optimizations. Besides reducing the PFT-averaged model–data root-mean-square difference (RMSD) and the associated daily output uncertainty, the optimization improves the simulated CO_2 balance at tropical and temperate forests sites. The major site-level NEE adjustments at the seasonal scale are reduced amplitude in C3 grasslands and boreal forests, increased seasonality in temperate evergreen forests, and better model–data phasing in temperate deciduous broadleaf forests. Conversely, the poorer performances in tropical evergreen broadleaf forests points to deficiencies regarding the modelling of phenology and soil water stress for this PFT. An evaluation with data-oriented estimates of photosynthesis (GPP – gross primary productivity) and ecosystem respiration (R_{eco}) rates indicates distinctively improved simulations of both gross fluxes. The multisite parameter sets are then tested against CO_2 concentrations measured at 53 locations around the globe, showing significant adjustments of the modelled seasonality of atmospheric CO_2 concentration, whose relevance seems PFT-dependent, along with an improved interannual variability. Lastly, a global-scale evaluation with remote sensing NDVI (normalized difference vegetation index) measurements indicates an improvement of the simulated seasonal variations of the foliar cover for all considered PFTs.

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