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Variational methods to estimate terrestrial ecosystem model parameters

Sylvain Delahaies (1,2) and Ian Roulstone (1,2)
(1) Dpt of Mathematics, University of Surrey, Guildford, UK (s.b.delahaies@surrey.ac.uk), (2) NCEO, UK

Carbon is at the basis of the chemistry of life. Its ubiquity in the Earth system is the result of complex recycling processes. Present in the atmosphere in the form of carbon dioxide it is adsorbed by marine and terrestrial ecosystems and stored within living biomass and decaying organic matter. Then soil chemistry and a non negligible amount of time transform the dead matter into fossil fuels. Throughout this cycle, carbon dioxide is released in the atmosphere through respiration and combustion of fossils fuels. Model-data fusion techniques allow us to combine our understanding of these complex processes with an ever-growing amount of observational data to help improving models and predictions.
The data assimilation linked ecosystem carbon (DALEC) model is a simple box model simulating the carbon budget allocation for terrestrial ecosystems. Over the last decade several studies have demonstrated the relative merit of various inverse modelling strategies (MCMC, ENKF, 4DVAR) to estimate model parameters and initial carbon stocks for DALEC and to quantify the uncertainty in the predictions.
Despite its simplicity, DALEC represents the basic processes at the heart of more sophisticated models of the carbon cycle. Using adjoint based methods we study inverse problems for DALEC with various data streams (8 days MODIS LAI, monthly MODIS LAI, NEE). The framework of constraint optimization allows us to incorporate ecological common sense into the variational framework. We use resolution matrices to study the nature of the inverse problems and to obtain data importance and information content for the different type of data. We study how varying the time step affect the solutions, and we show how "spin up" naturally improves the conditioning of the inverse problems.