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Can we reliably estimate managed forest carbon dynamics using remotely sensed data?

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Forests are an important part of the global carbon cycle, serving as both a large store of carbon and currently as a net sink of CO_2. Forest biomass varies significantly in time and space, linked to climate, soils, natural disturbance and human impacts. This variation means that the global distribution of forest biomass and their dynamics are poorly quantified.

Terrestrial ecosystem models (TEMs) are rarely evaluated for their predictions of forest carbon stocks and dynamics, due to a lack of knowledge on site specific factors such as disturbance dates and / or managed interventions. In this regard, managed forests present a valuable opportunity for model calibration and improvement. Spatially explicit datasets of planting dates, species and yield classification, in combination with remote sensing data and an appropriate data assimilation (DA) framework can reduce prediction uncertainty and error.

We use a Baysian approach to calibrate the data assimilation linked ecosystem carbon (DALEC) model using a Metropolis Hastings-Markov Chain Monte Carlo (MH-MCMC) framework. Forest management information is incorporated into the data assimilation framework as part of ecological and dynamic constraints (EDCs). The key advantage here is that DALEC simulates a full carbon balance, not just the living biomass, and that both parameter and prediction uncertainties are estimated as part of the DA analysis.

DALEC has been calibrated at two managed forests, in the USA (*Pinus taeda*; Duke Forest) and UK (*Picea sitchensis*; Griffin Forest). At each site DALEC is calibrated twice (*exp1* & *exp2*). Both calibrations (*exp1* & *exp2*) assimilated MODIS LAI and HWSD estimates of soil carbon stored in soil organic matter, in addition to common management information and prior knowledge included in parameter priors and the EDCs. Calibration *exp1* also utilises multiple site level estimates of carbon storage in multiple pools. By comparing simulations we determine the impact of site-level observations on uncertainty and error on predictions, and which observations are key to constraining ecosystem processes.

Preliminary simulations indicate that DALEC calibration *exp1* accurately simulated the assimilated observations for forest and soil carbon stock estimates including, critically for forestry, standing wood stocks (R^2 = 0.92, bias = -4.46 MgC ha^{-1}, RMSE = 5.80 MgC ha^{-1}). The results from *exp1* indicate the model is able to find parameters that are both consistent with EDC and observations. In the absence of site-level stock observations (*exp2*) DALEC accurately estimates foliage and fine root pools, while the median estimate of above ground litter and wood stocks (R^2 = 0.92, bias = -48.30 MgC ha^{-1}, RMSE = 50.30 MgC ha^{-1}) are over- and underestimated respectively, site-level observations are within model uncertainty. These results indicate that we can estimate managed forests dynamics using remotely sensed data, particularly as remotely sensed above ground biomass maps become available to provide constraint to correct biases in woody accumulation.