25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

A framework for the fusion of earth observation and soil data to constrain soil organic carbon model parameters

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Abstract: It is challenging to accurately quantify changes in soil organic carbon (SOC) stocks across landscapes and over time due to the high costs associated with soil sampling to capture inherent variabilities. While process-based models can be used to quantify management-induced changes, it is increasingly important to validate and quantify uncertainties associated with model estimates. Due to monitoring, verification, and reporting requirements under carbon accounting schemes at both project and national scales, quantifying uncertainties in SOC estimates is increasingly important. Although field SOC measurements are essential for model calibration and validation, accessing large datasets with temporally repeated measurements across the landscape is limited. As a result, there is a growing interest in using earth observation (EO) datasets to integrate and constrain model inputs/outputs to reduce uncertainties. Despite the use of surrogate information, such as EO datasets, to constrain process-based models in research, there is currently no operational framework for soil carbon models.

In this study, we developed an operational framework that employs EO-derived net primary productivity and leaf area index to constrain a soil carbon model. Our case study involved using the DayCent process-based model along with field measurements from 109 sites across three catchments in New South Wales, Australia. The DayCent model is equipped with C and nitrogen cycles and biogeochemistry solutions along a 20 cm soil depth. It provides more accurate system dynamics descriptions by estimating gas exchanges of CO2, N2O, and CH4 between the soil and the atmosphere compared to RothC.

The framework incorporates a Bayesian hierarchical modelling approach to account for uncertainties associated with model inputs and parameter estimates during calibration. The resulting framework is scalable, making it applicable for soil carbon projects and national-scale GHG accounting. Implementation of this framework could enhance the credibility of the Australian National Greenhouse Inventory of the land sector.

Keywords: *DayCent, assimilation of remote sensing data, greenhouse gases, LAI, NPP*