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A multi-model assessment of C cycling and soil C sequestration in grasslands and croplands

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Introduction

Agricultural activities can lead to either losses or gains of soil organic carbon (SOC) in croplands and grasslands. Increasing SOC stocks improves soil fertility and is seen as a short- to mid-term solution to mitigate greenhouse gas (GHG) emissions. Emerging ecological and societal challenges (climate change, food security, ecosystem sustainability) require improved knowledge of C pools and fluxes, and greater confidence in the biophysical models to assess C balances and implement effective policies in agriculture.

Objectives

An inter-comparison and benchmarking modelling exercise aimed at improving estimates of C storage and GHG fluxes in agricultural systems.

Materials & methods

Field trials from four continents, established in five temperate pastures and five crop rotations with contrasting pedo-climatic conditions, were selected to assess 24 process-based models (16 for crops, 12 for pastures) against SOC and C-N emission data. Model calibration consisted of five stages, from stage 1 (observed outputs unavailable to modellers) to stage 5 (with all observed outputs). We combined the estimates from the individual models (aggregated on annual basis) by computing median values for each output.

Results

Taking the coefficient of variation (CV) as a degree of the variability of simulations, for all the modelled C fluxes (GPP, gross primary production; RECO, ecosystem respiration; NEE, net ecosystem exchange) CV was reduced with calibration. Moving from stage 1 to 5, CV was reduced from 28.3% to 25.1% for RECO, from 45.7% to 34.6% for GPP and from 461.3% to 72.4% for NEE. The greatest decrease obtained at stage 3 responds to the need of calibrating the models against production and phenology data.

Conclusion

The uncertainty envelopes of simulated C fluxes (NEE) was reduced with more detailed calibration (improved estimates of GPP and, to a lesser extent, of RECO). We conclude that, to reduce parametric uncertainties in C estimates, production and phenology data are the minimal level requirements for model calibration.

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