Quantification of modelling uncertainties in an ensemble of carbon simulations in grasslands and croplands

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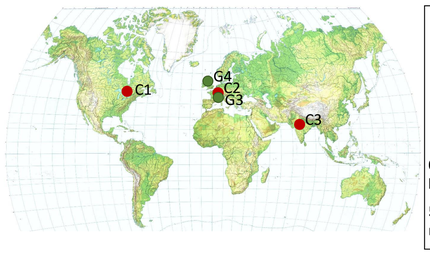
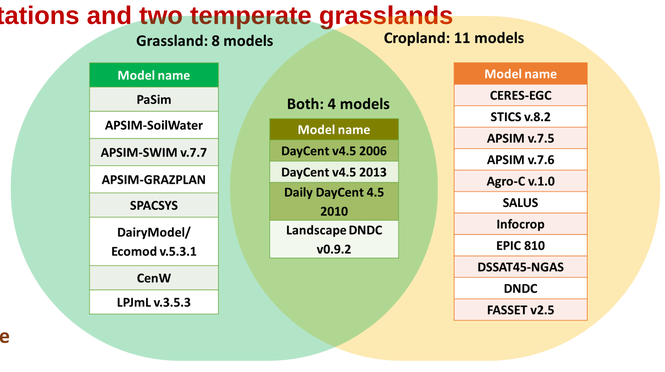
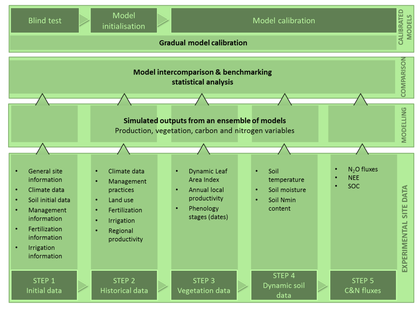
- **Biogeochemical grassland and crop models** predict carbon (C) balances in agriculture
- **Simulations of C fluxes** are inherently uncertain (complex interactions, high temporal and spatial variability of measurements
- We assessed C fluxes from 23 biogeochemical models with data from **three crop rotations and two temperate grasslands**

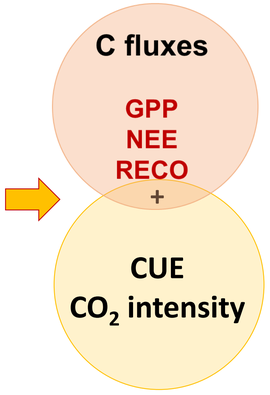


Canada Ottawa (C1)	UK Easter Bush (G4)	France Laqueuille (G3)	France Grignon (C2)	India Dehli (C3)
[SW]/[S]/[B]/[M]/[SW]/[B]			[B]/[M]/[WW]/[WW]/[P]/[M]/[WW]/[B]	[WW]/[R]/[WW]/[R]/[WW]
0-168 N kg ha^{-1} crop^{-1}	0.76 LSU ha^{-1} yr^{-1}	1.34 LSU ha^{-1} yr^{-1}	29-131 N kg ha^{-1} crop^{-1}	WW:+250mm R:+1075mm
52 P kg ha^{-1} maize^{-1}	200 kg N ha^{-1}	220 N kg ha^{-1}		120 N kg ha^{-1}

B : Canola + Mustard M: Maize P: Phacelia R: Rice S: Soybean SW: Spring wheat WW: Winter wheat + Triticale







- **Ensemble multi-model medians** (MMM) were compared to the means of observations via a multi-stage protocol (from blind simulations - S1 - to partial - S2, S3, S4 - and full calibration - S5)
- The use of **plant and soil observations for calibration** (S3 and S4) allowed achieving certain accuracy in model estimates
- Most of the models overestimated or underestimated the C fluxes observed during the growing seasons, with substantial **discrepancies across different models**
- The highest **improvements were achieved with S3 or higher calibration stages**

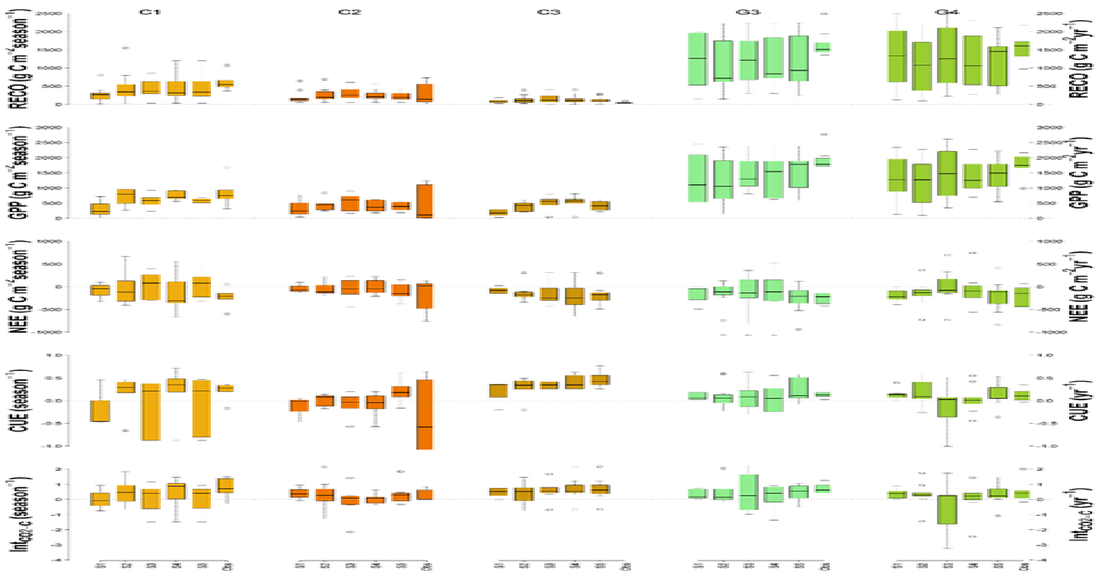


Fig 1. Seasonal changes in ecosystem respiration (RECO), gross primary production, net ecosystem exchange (NEE), carbon use efficiency (CUE) and CO_2-C intensity (Int_{CO2-C}) calculated over multiple years at C1 and C2 crop and G3 and G4 grassland sites, for five calibration stages (S1to S5) and the observation (Obs). For each calibration stage, triangles demonstrate the multi model mean, black lines show multi-model median. Boxes delimit the 25th and 75th percentiles. Whiskers are 10th and 90th percentiles. Circles indicate outliers. For Obs, diamond shows the observed mean with its standard deviation.

- Overall, the **estimation of C fluxes was more uncertain in grasslands than in crops**
- The **model ensemble proved effective in representing C sequestration** of grasslands and most of crops
- **Elimination of fallow and enhancement of cropping intensity may increase C sequestration**

Our study suggests a **cautious use of large-scale, multi-model ensembles to estimate C fluxes** in agricultural sites if some plant and soil observations are available locally for model calibration

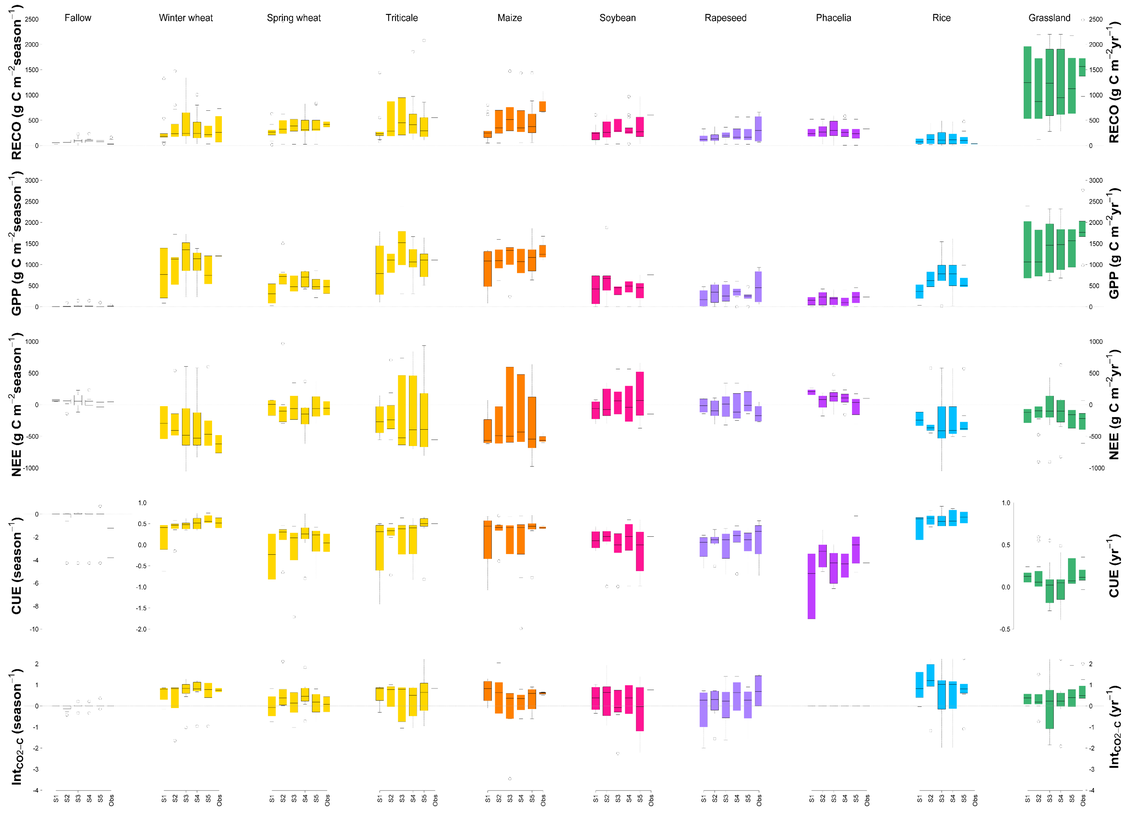


Fig 2. Seasonal variability of ecosystem respiration (RECO), gross primary production (GPP), net ecosystem exchange (NEE), carbon use efficiency (CUE) and CO_2-C intensity (Int_{CO2-C}) calculated over multiple years at C1, C2 and C3 crop and G3 and G4 grassland sites, for five calibration stages (S1-5) and the observations (Obs). Owing to largely different values of carbon use efficiency (CUE), they are presented with distinct scales for bare soil, grassland and crop systems. For each calibration stage, triangles demonstrate the multi model mean, black lines show multi-model median. Boxes delimit the 25th and 75th percentiles. Whiskers are 10th and 90th percentiles. Circles indicate outliers.

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