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European-wide simulations of present cropland phenology, productivity and carbon fluxes using an improved terrestrial biosphere model

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Aiming at producing improved estimates of carbon source/sink spatial and interannual patterns across Europe (35% croplands), this work combines the terrestrial biosphere model ORCHIDEE (for vegetation productivity, water balance, soil carbon dynamics) and the generic crop model STICS (for phenology, irrigation, nitrogen balance, harvest). The ORCHIDEE-STICS model, relying on three plant functional types for the representation of temperate agriculture, is evaluated over the last few decades at various spatial and temporal resolutions.
The simulated Leaf Area Index seasonal cycle is largely improved relative to the original ORCHIDEE simulating grasslands, and compares favourably with remote-sensing observations (the Figure of Merit in Time doubles over Europe). Crop yield is derived from annual Net Primary Productivity and compared with wheat and grain maize harvest data for five European countries. Discrepancies between 30-year mean simulated and reported yields remain large in Mediterranean countries. Interannual variability amplitude expressed relative to the mean is reduced towards the observed variability ($\sim$10%) when using ORCHIDEE-STICS.
The simulated 2003 anomalous carbon source from European ecosystems to the atmosphere due to the 2003 summer heat wave is in good agreement with atmospheric inversions ($\sim$0.2 GtC, from May to October). The anomaly is twice as large in the ORCHIDEE alone simulation, owing to the unrealistically high exposure of herbaceous plants to the extreme summer conditions.
Overall, this study highlights the importance of accounting for the specific phonologies of crops sown both in winter and in spring and for irrigation applied to summer crops in regional/global models of the terrestrial carbon cycle. Limitations suggest accounting for temporal and spatial variability in agricultural practices for further simulation improvement.