Agricultural processes substantially reduce projections of the terrestrial carbon sink

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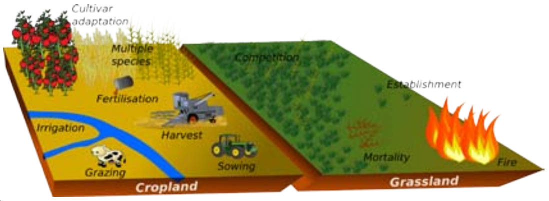
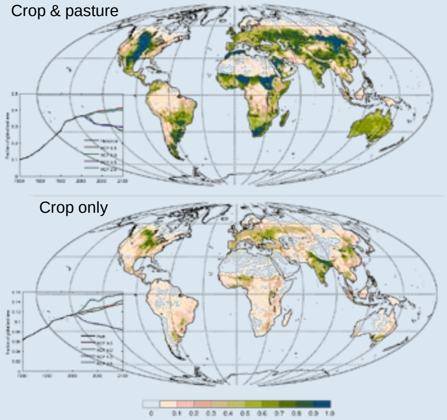


1. Motivation

- The terrestrial biosphere takes up about 1/3 of anthropogenic CO_2 emissions.
- Crops and pasture cover ~1/3 global land area (2005).
- Global climate models represent crops as simple grasses, ignoring process differences.

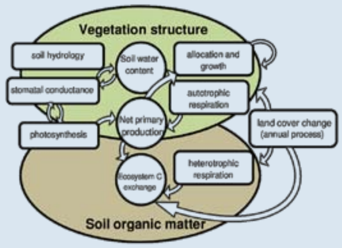
What is the effect of including a dedicated crop model in calculations of global land carbon uptake?



Fraction of global land area converted to agricultural use in 2005 (maps) and total areal change 1850-2100 (insets). Data from Hurtt et al. (2011).

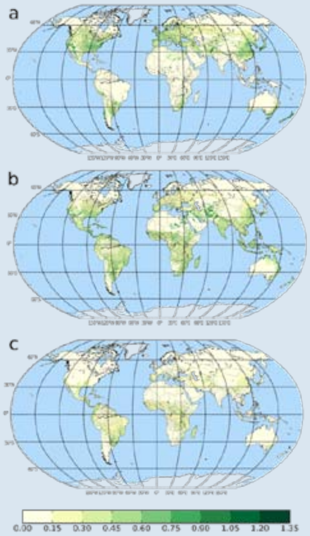
2. Methods

Global LPJ-GUESS dynamic vegetation model simulation (without interactive N) driven by forcings for the RCP 8.5 scenario from 6 different global climate models with Hurtt et al. (2011) land-cover data.



Net ecosystem exchange of carbon from different simplified crop representations is compared with those from a detailed crop model with 13 crop types and specialised processes (Lindeskog et al., 2013).

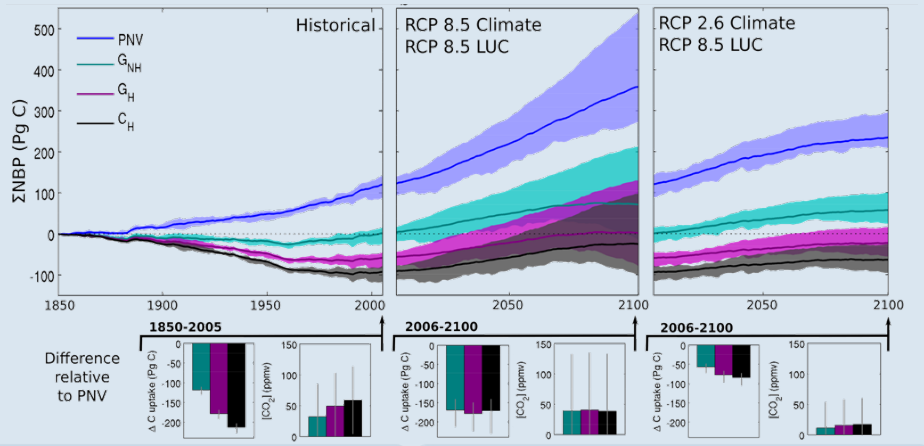
3. How good is the model?



Modelled yields for wheat (a), maize (b) and rice (c) (Kg dry weight m^{-2}). Hatching denotes model is within 1 σ of observations.

4. Results

Change in terrestrial carbon stocks since 1850 for simulations with crops-as-grasses, **crops-as-grasses with harvest/grazing**, **detailed crops**, and **potential natural vegetation only**. RCP 8.5 is a strong climate forcing scenario and RCP 2.6 a moderate one.



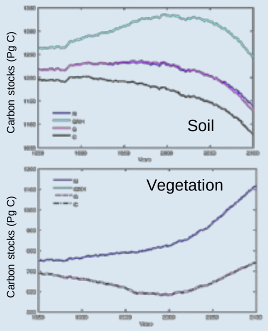
Difference in atmospheric CO_2 mixing ratio due to crop processes can be 38 ppmv in 2100

This corresponds to up to 0.5 W m^{-2} radiative forcing (*c.f.* total forcing to 2005 estimated at ~1.5 W m^{-2}; IPCC, 2007)

5. Why

Increased emissions of CO_2 are tied to re-equilibration of soil carbon stocks to changes in inputs (primarily harvest) and heterotrophic respiration rates. Most emissions (or in some cases uptake) occur in the decades immediately following a land-use change or a change in management (this timescale is extended in cold regions).

Differences in vegetation biomass are minimal.



6. Conclusion

Inclusion of key agricultural processes in global climate models greatly reduces predicted land carbon storage, and may change the biosphere from a net cooling to a net warming influence on global climate.

- Representations of harvest/grazing and soil respiration rates have the biggest potential to affect global terrestrial carbon uptake.
- Potential differential effects of CO_2 fertilisation on crop and natural vegetation have smaller but non-negligible influence on carbon uptake (despite being very important for yield)

Details of each process are still highly uncertain at the global scale.

References.

Hurtt et al. (2011) *Climatic Change* **109**, 117–161.

Lindeskog et al. (2013) *Earth Syst. Dynam. Discuss.*, **4**, 235-278.