Accounting for land-use change and harvest substantially reduces the terrestrial carbon sink

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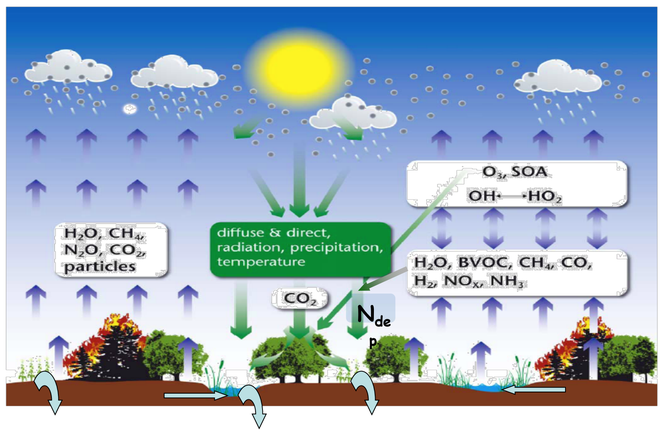
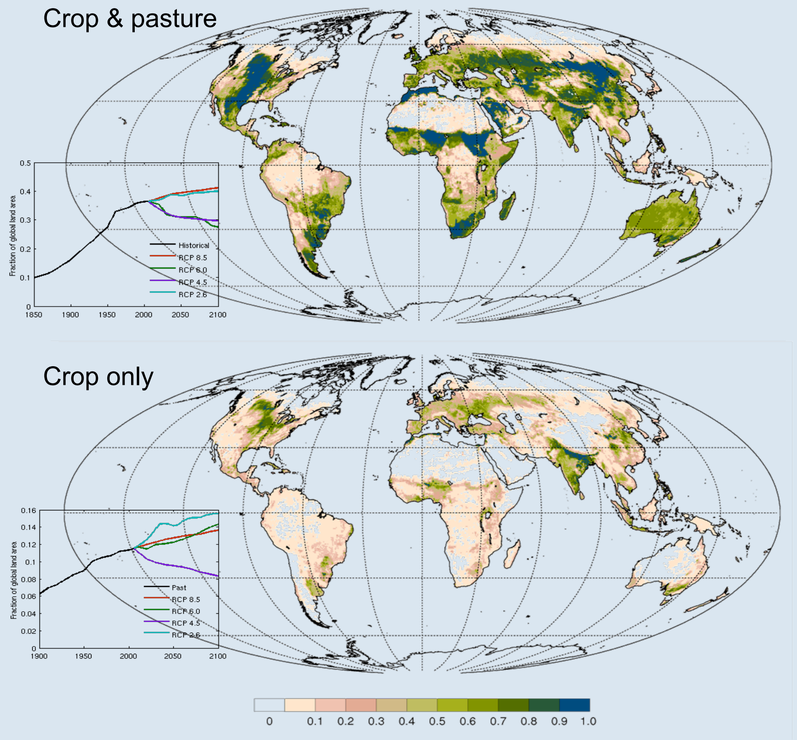


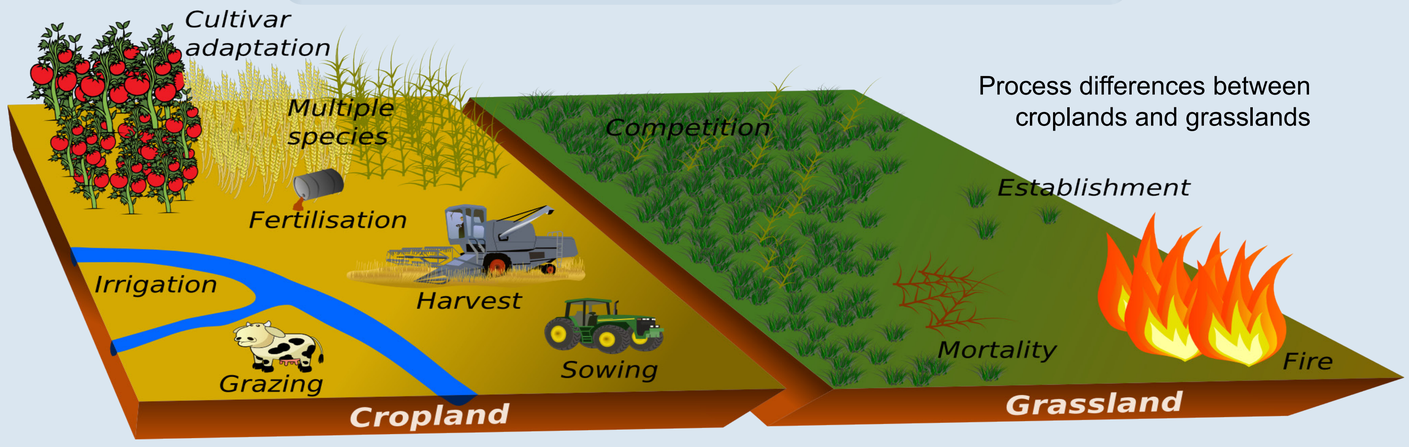
1. Motivation



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).

➢Crops and pasture cover ~1/3 global land area (2005).
➢ Many crops differ greatly from grass in their phenology, productivity, management and bioclimatic limits.
➢Response of crops to changes in climate mean and variability will also differ relative to grass.
➢CMIP5 Earth system models represent crops as simple grasses, ignoring process differences.

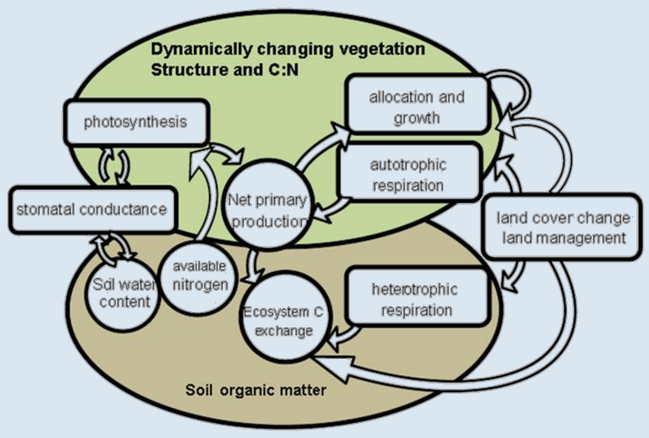
To what extent might this simplification affect projections of carbon uptake?



Process differences between croplands and grasslands

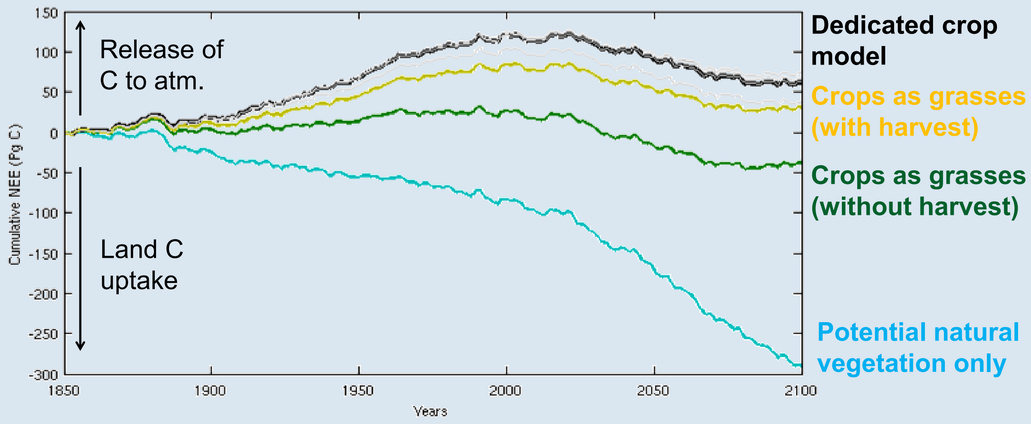
2. Methods

Global LPJ-GUESS dynamic vegetation model simulation (without interactive N) driven by forcings for the RCP 8.5 scenario from MPI-ESM-LR with Hurtt et al. (2011) land-cover data.



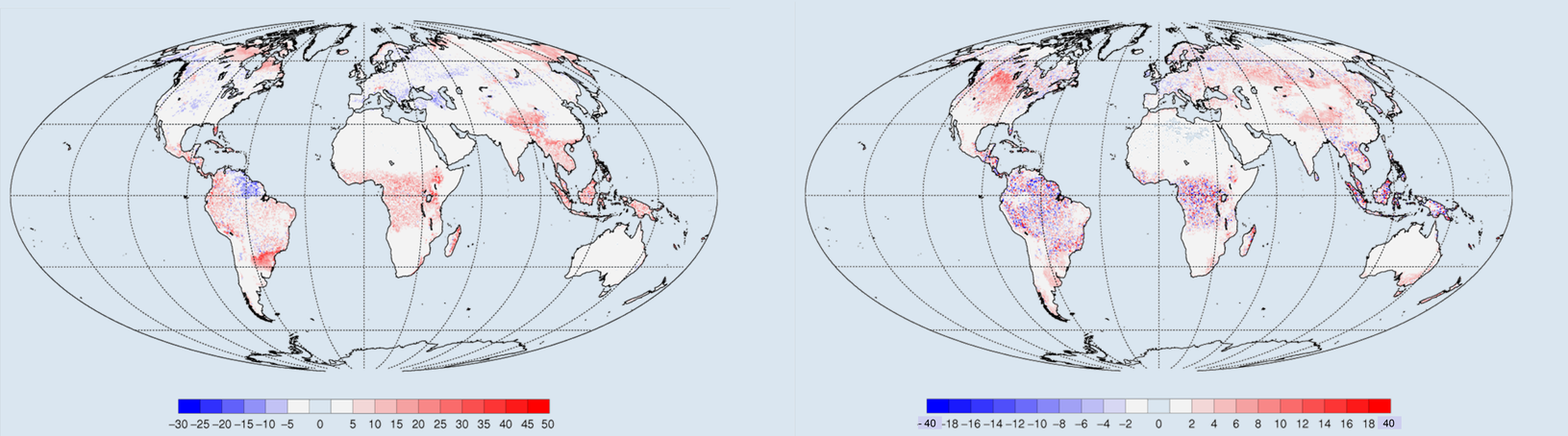
Net ecosystem exchange of carbon from different simplified crop representations is compared with those from a detailed crop model with 13 crop types and specialised processes (Lindeskog et al., 2013).

3. Results



Large disparity in C uptake of up to ~100 Pg C (~50 ppm [CO_2]) between crop representations.

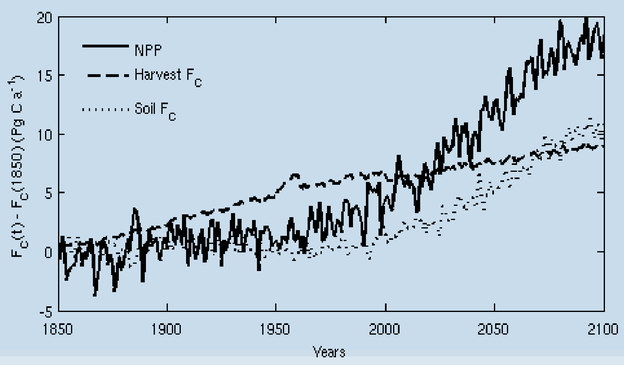
Reduction in C uptake relative to a **potential natural vegetation** simulation.



Difference in accumulated C release (Kg C m^{-2}) 1850-2100 between **dedicated crop** and **potential natural vegetation** simulations (left) and **dedicated crop** and **crops as grasses without harvest** (right). Positive values indicate a larger release for the **dedicated crop** simulation.

3. Why

① 1901-2000: Harvest dominates the change in C fluxes (F_C).



2001-2100: Increasing [CO_2] dominates the change in C fluxes.

② Intrinsic differences in productivity and respiration representations for crops, relative to grasses.

4. Conclusion

Crop representation is a key uncertainty,
➢for historical simulations,
➢in scenarios with lower [CO_2],
➢if the vegetation CO_2 fertilisation response is substantially limited, e.g. by nitrogen availability.

In these instances the current minimal crop representations in CMIP5 models may substantially overestimate the terrestrial carbon sink.

References.
Hurtt et al. (2011) *Climatic Change* **109**, 117–161.
Lindeskog et al. (2013) *Earth Syst. Dynam. Discuss.*, **4**, 235-278.

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