



Supplement of

Quantifying land carbon cycle feedbacks under negative CO₂ emissions

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Quantifying Land Carbon Cycle Feedbacks under Negative CO₂ Emissions

A. Supplementary Material

Table S1: Comparison of carbon cycle feedback parameters from the ramp-up phase of the “CDR-reversibility” experiment to CMIP5 and CMIP6 model means and mean±1 standard deviations from Figures 5, 6 in Arora et al. (2020), calculated at the time atmospheric CO₂ concentration quadruples (4xCO₂). Model means and mean±1 standard deviations for models without a nitrogen cycle are shown in parentheses. Feedback parameters were calculated using the FULL -BGC approach (see Eq. 7), consistent with the BGC-COU (T*=0) approach used in calculating feedback parameters in CMIP5 and CMIP6.

Feedback Parameters (taken at 4xCO ₂)	“CDR-reversibility” ramp up	CMIP5	CMIP6
β_L (PgC ppm ⁻¹)	0.96	0.91 ± 0.48 (1.2 ± 0.3)	0.96 ± 0.39 (1.2 ± 0.5)
β_O (PgC ppm ⁻¹)	0.88	0.81 ± 0.07	0.78 ± 0.07
γ_L (PgC °C ⁻¹)	-121.5	-54.7 ± 36 (-75.4 ± 23.9)	-42.7 ± 47.2 (-63.8 ± 70.5)
γ_O (PgC °C ⁻¹)	-22.7	-16.3 ± 3.5	-16.4 ± 4.6

Table S2: Comparison of carbon cycle feedback parameters from the ramp-up phase of the “CDR-reversibility” experiment to CMIP5 and CMIP6 model means and mean±1 standard deviations from Table A1 in Arora et al. (2020), calculated at the time atmospheric CO₂ concentration doubles (2xCO₂). Feedback parameters were calculated using the FULL -BGC approach (see Eq. 7), consistent with the BGC-COU (T*=0) approach. Note that there is a small discrepancy with the BGC-COU approach used to calculate the values in Table A1 of Arora et al., 2020, which allows for T*≠0.

Feedback Parameters (taken at 2xCO ₂)	“CDR-reversibility” ramp up	CMIP5	CMIP6
β_L (PgC ppm ⁻¹)	1.27	1.15 ± 0.63	1.22 ± 0.40
β_O (PgC ppm ⁻¹)	0.99	0.95 ± 0.07	0.91 ± 0.09
γ_L (PgC °C ⁻¹)	-83.5	-37.01 ± 25.48	-34.1 ± 38.39
γ_O (PgC °C ⁻¹)	-3.30	-9.42 ± 2.70	-8.59 ± 2.9

Quantifying Land Carbon Cycle Feedbacks under Negative CO₂ Emissions

B. Supplementary Figures

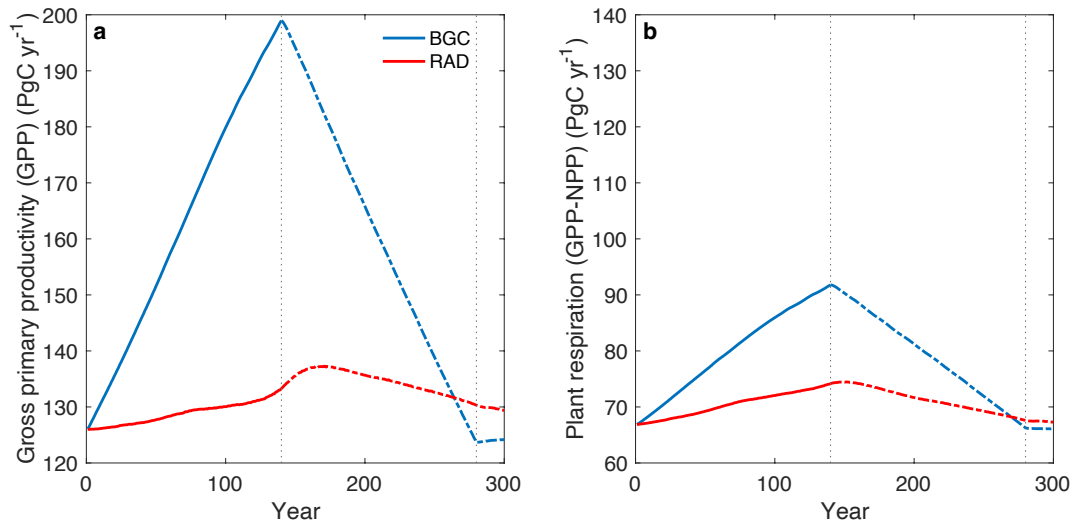


Figure S1: a. Gross primary productivity and b. plant respiration for the biogeochemically coupled (BGC) and radiatively coupled (RAD) “CDR-reversibility” simulations. (+) refers to the ramp-up phase, (-) refers to the ramp-down phase. Note the differences in scale: plant respiration rates are generally lower than gross primary productivity rates.

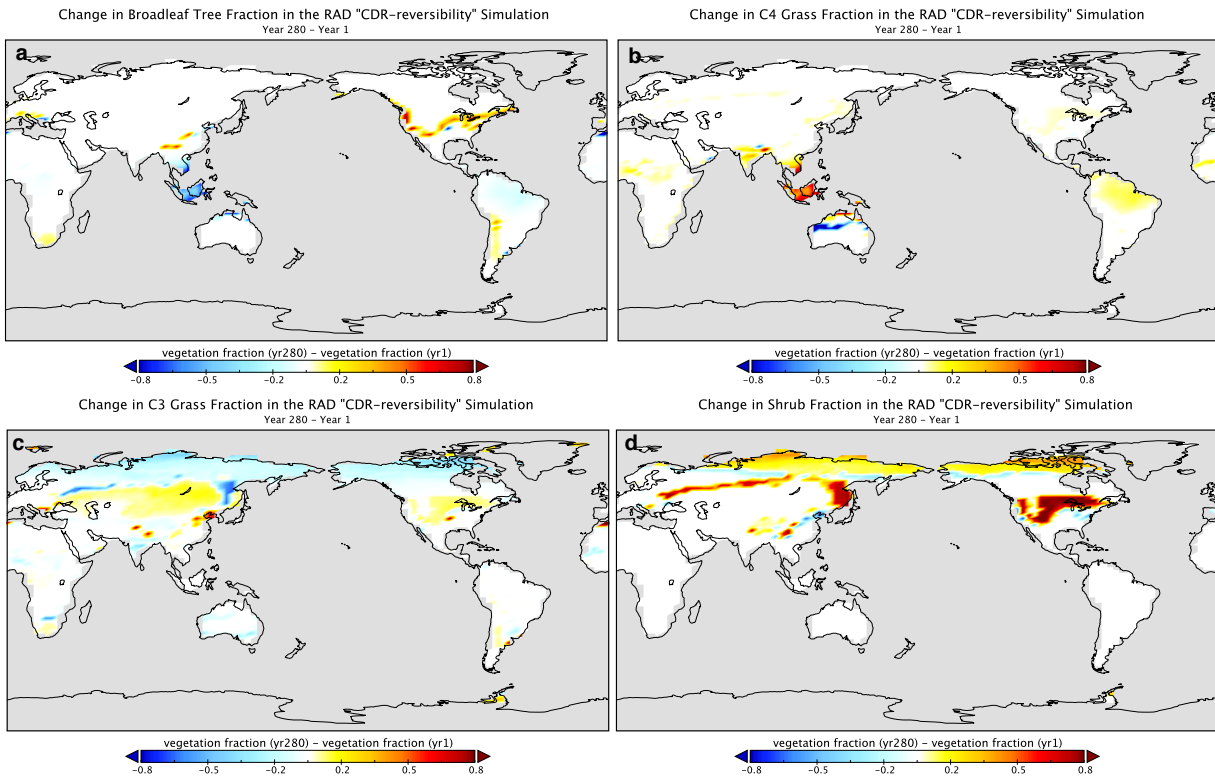


Figure S2: Vegetation fraction changes for a. broadleaf trees b. C4 grasses and c. C3 grasses and d. shrubs taken at the end of the radiatively coupled (RAD) “CDR-reversibility” simulation relative to 1850 (preindustrial).

Quantifying Land Carbon Cycle Feedbacks under Negative CO₂ Emissions

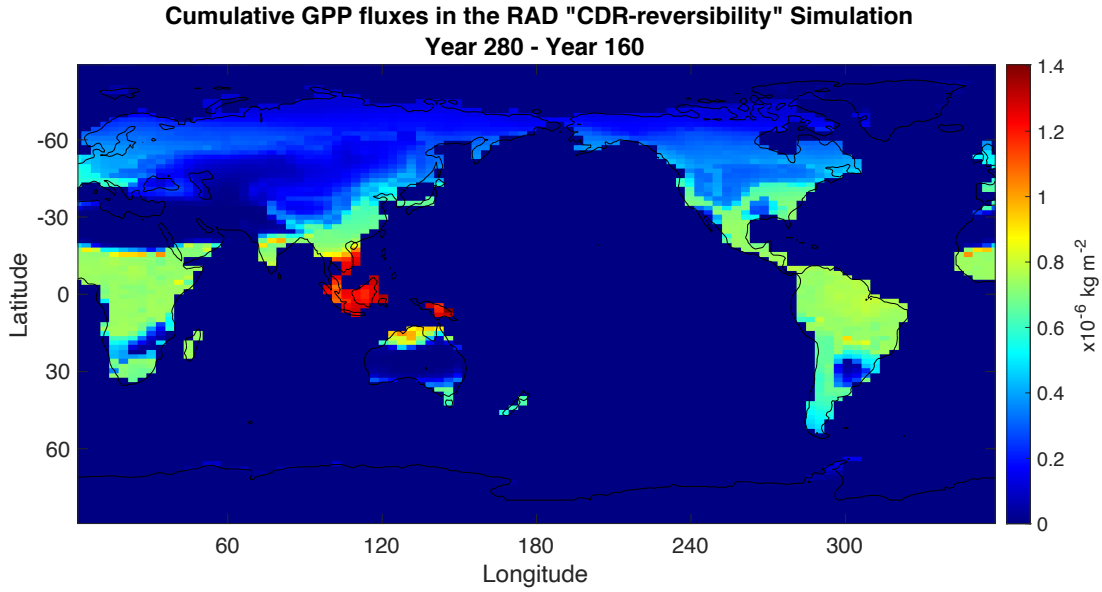


Figure S3: Cumulative gross primary productivity (GPP) fluxes for the radiatively coupled (RAD) “CDR-reversibility” simulation calculated from year 160 to year 280.

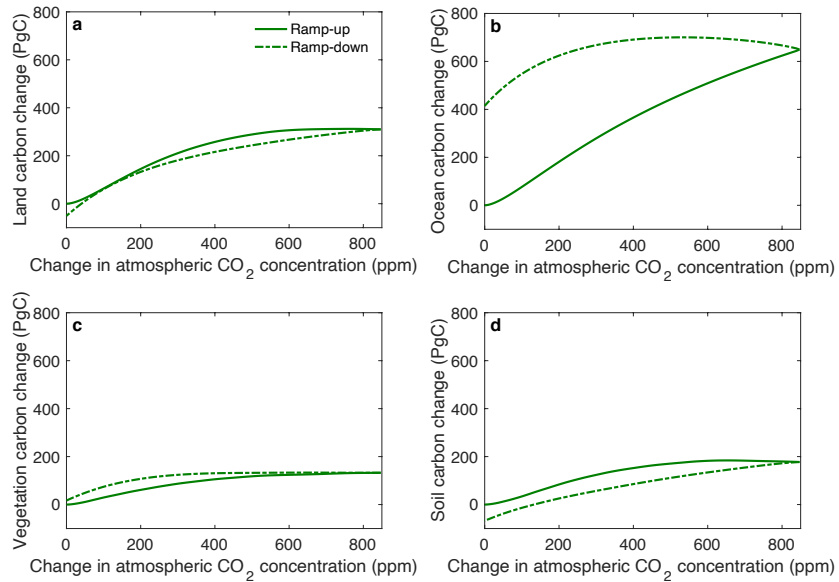


Figure S4: a. Land b. ocean c. vegetation and d. soil carbon pool changes as a function of atmospheric CO₂ concentration, taken from the fully coupled (FULL) “CDR-reversibility” simulation ramp-up and ramp-down phases. All values are calculated relative to 1850 (preindustrial).

Quantifying Land Carbon Cycle Feedbacks under Negative CO₂ Emissions

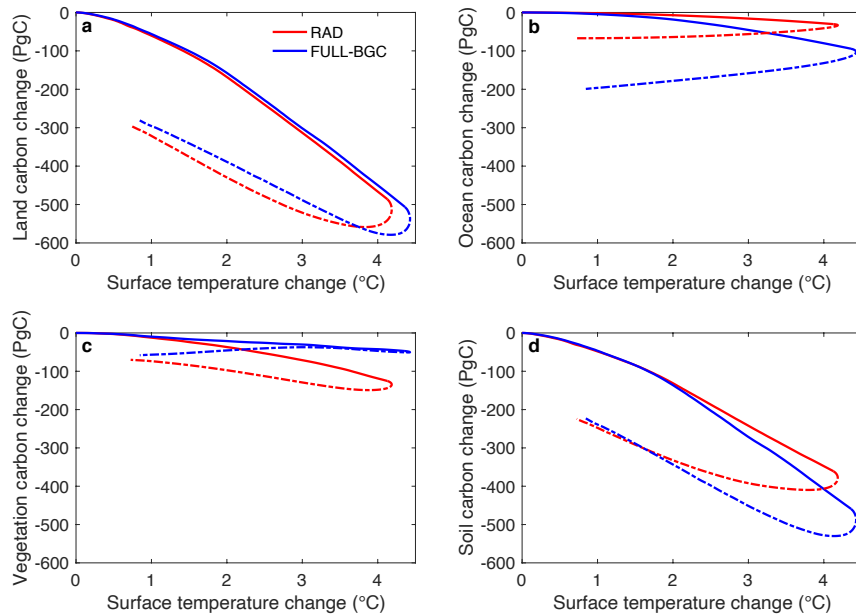


Figure S5: a. Land b. ocean c. vegetation and d. soil carbon pool changes as a function of surface air temperature change, calculated from the radiatively coupled simulation (RAD) and the difference between the fully coupled and biogeochemically coupled “CDR-reversibility” simulations (FULL-BGC). All values are calculated relative to 1850 (preindustrial). Solid lines represent the ramp-up phase; dot-dashed lines represent the ramp-down phase.

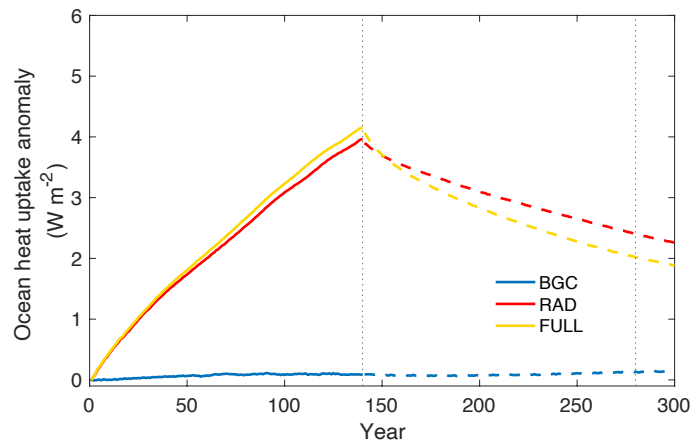


Figure S6: Ocean heat uptake anomaly in the ramp-up phase of the “CDR-reversibility” simulations (solid lines) and the zero emissions simulations (dashed lines) calculated relative to 1850 (preindustrial). BGC – biogeochemically coupled; RAD – radiatively coupled; FULL – fully coupled

References

Arora, V. K., Katavouta, A., Williams, R. G., Jones, C. D., Brovkin, V., Friedlingstein, P. ... Ziehn, T. (2020). Carbon-concentration and carbon-climate feedbacks in CMIP6 models, and their comparison to CMIP5 models. *Biogeosciences*, 17, 4173-4222. doi.org/10.5194/bg-17-4173-2020