



*Supplement of*

## Quantifying land carbon cycle feedbacks under negative CO<sub>2</sub> emissions

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# Quantifying Land Carbon Cycle Feedbacks under Negative CO<sub>2</sub> 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 CO<sub>2</sub> concentration quadruples (4xCO<sub>2</sub>). 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.

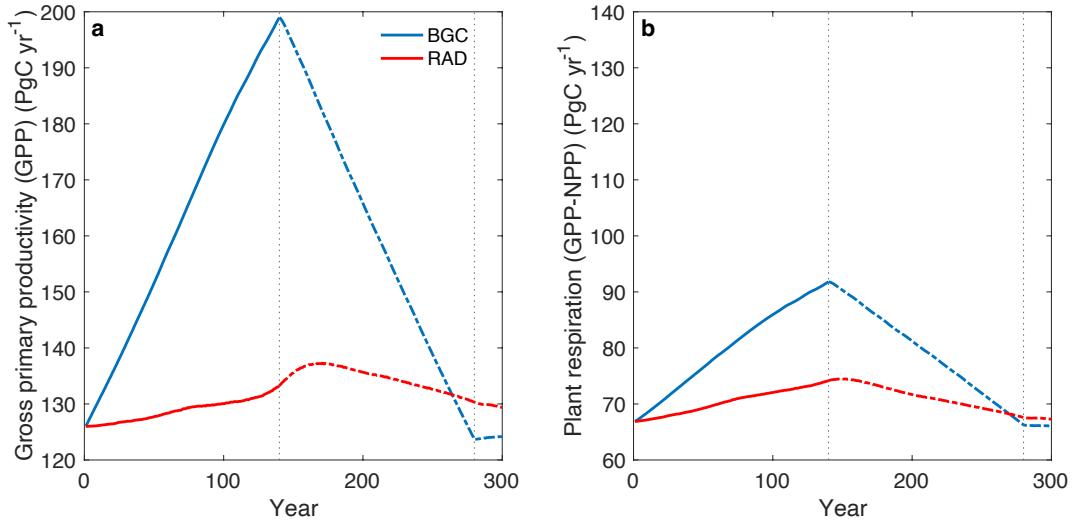
Feedback Parameters (taken at 4xCO <sub>2</sub> )	“CDR-reversibility” ramp up	CMIP5	CMIP6
$\beta_L$ (PgC ppm <sup>-1</sup> )	0.96	$0.91 \pm 0.48$ ( $1.2 \pm 0.3$ )	$0.96 \pm 0.39$ ( $1.2 \pm 0.5$ )
$\beta_o$ (PgC ppm <sup>-1</sup> )	0.88	$0.81 \pm 0.07$	$0.78 \pm 0.07$
$\gamma_L$ (PgC °C <sup>-1</sup> )	-121.5	$-54.7 \pm 36$ ( $-75.4 \pm 23.9$ )	$-42.7 \pm 47.2$ ( $-63.8 \pm 70.5$ )
$\gamma_o$ (PgC °C <sup>-1</sup> )	-22.7	$-16.3 \pm 3.5$	$-16.4 \pm 4.6$

**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 CO<sub>2</sub> concentration doubles (2xCO<sub>2</sub>). 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.

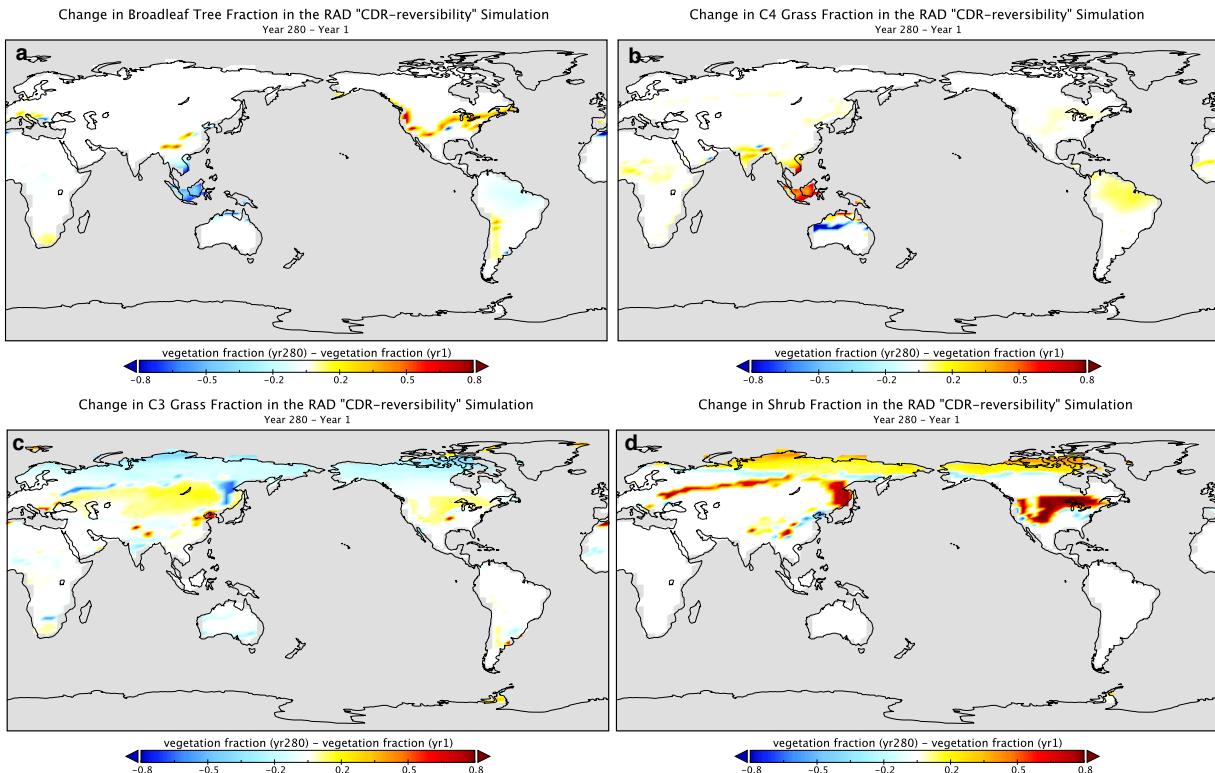
Feedback Parameters (taken at 2xCO <sub>2</sub> )	“CDR-reversibility” ramp up	CMIP5	CMIP6
$\beta_L$ (PgC ppm <sup>-1</sup> )	1.27	$1.15 \pm 0.63$	$1.22 \pm 0.40$
$\beta_o$ (PgC ppm <sup>-1</sup> )	0.99	$0.95 \pm 0.07$	$0.91 \pm 0.09$
$\gamma_L$ (PgC °C <sup>-1</sup> )	-83.5	$-37.01 \pm 25.48$	$-34.1 \pm 38.39$
$\gamma_o$ (PgC °C <sup>-1</sup> )	-3.30	$-9.42 \pm 2.70$	$-8.59 \pm 2.9$

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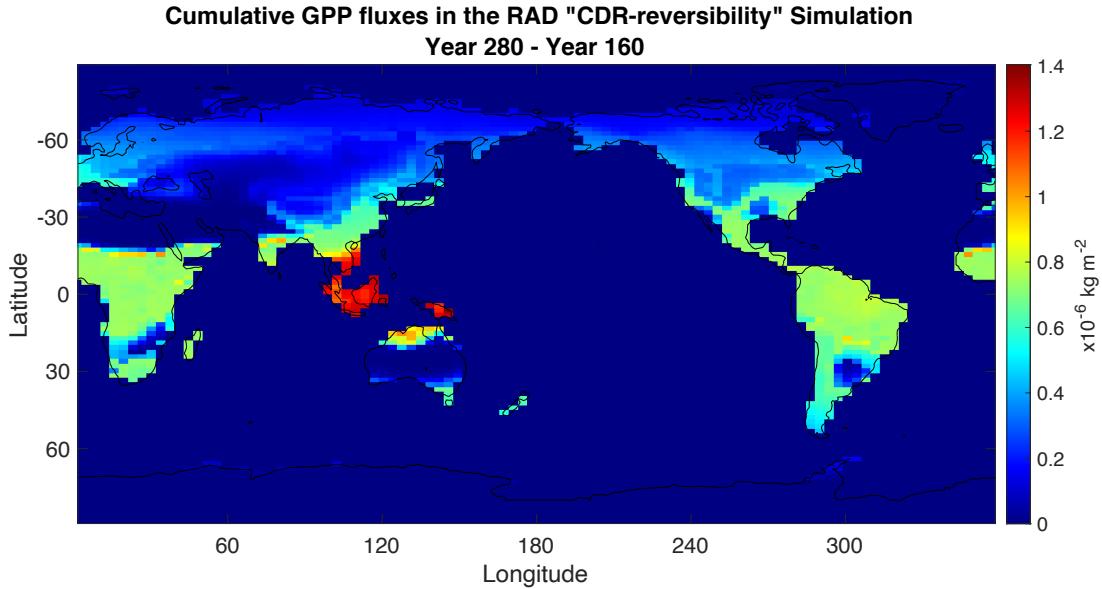
## B. Supplementary Figures



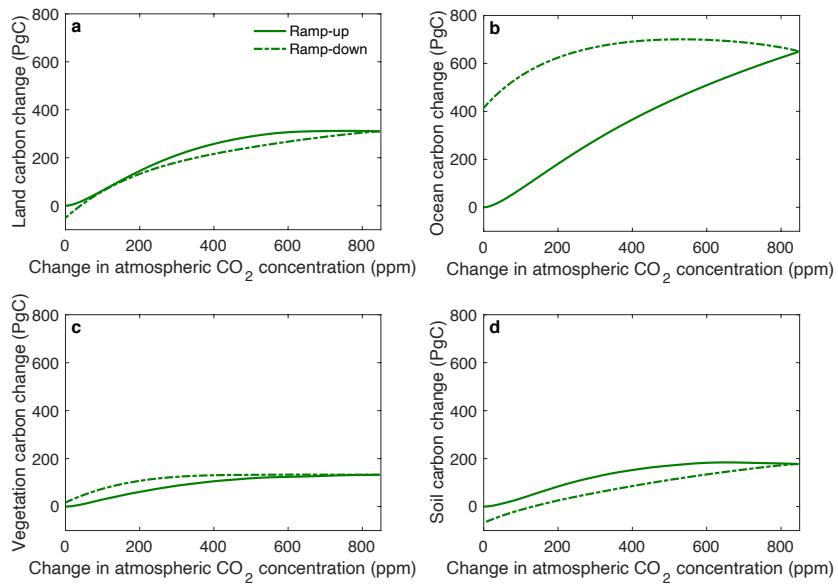
**Figure S1:** **a.** Gross primary productivity and **b.** plant respiration for the biogeochemically coupled (BGC) and radiatively coupled (RAD) “CDR-reversibility” simulations. (+) refers to the ramp-up phase, (-) refers to the ramp-down phase. Note the differences in scale: plant respiration rates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



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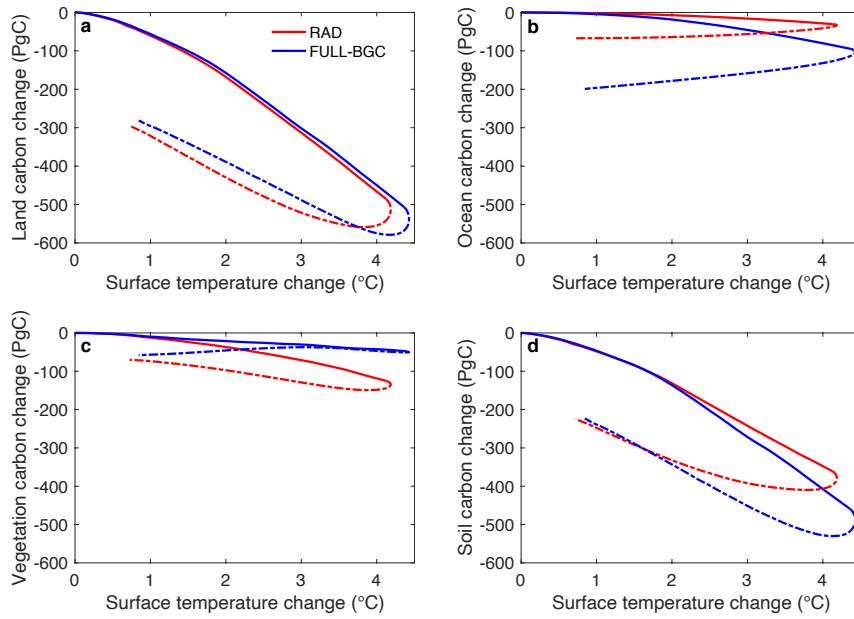


**Figure S3:** Cumulative gross primary productivity (GPP) fluxes for the radiatively coupled (RAD) “CDR-reversibility” simulation calculated from year 160 to year 280.

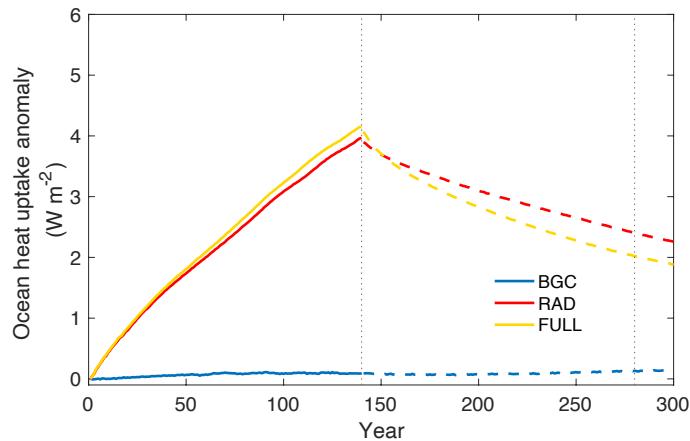


**Figure S4:** **a.** Land **b.** ocean **c.** vegetation and **d.** soil carbon pool changes as a function of atmospheric CO<sub>2</sub> concentration, taken from the fully coupled (FULL) “CDR-reversibility” simulation ramp-up and ramp-down phases. All values are calculated relative to 1850 (preindustrial).

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**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