Additional figures and tables

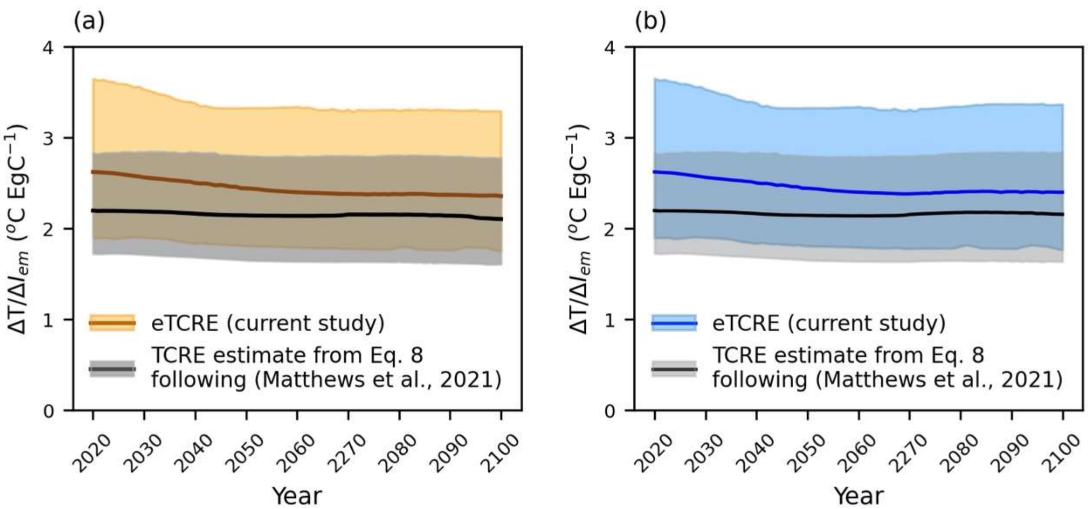

Figure S1: Effective transient climate response to the cumulative CO_2 emissions (eTCRE) (Eq. 9, current study) versus TCRE estimate from Eq. 8 following (Matthews et al., 2021) from year 2020 until 2100 for two scenarios of (a) RCP4.5 (baseline) and (b) carbon capture and storage scenarios. Solid lines show the median values, and shaded areas indicate the values between the 10^{th} and 90^{th} percentiles in baseline (orange), carbon capture and storage (blue) scenario and the results based on (Mattews et. al. 2021) (grey).

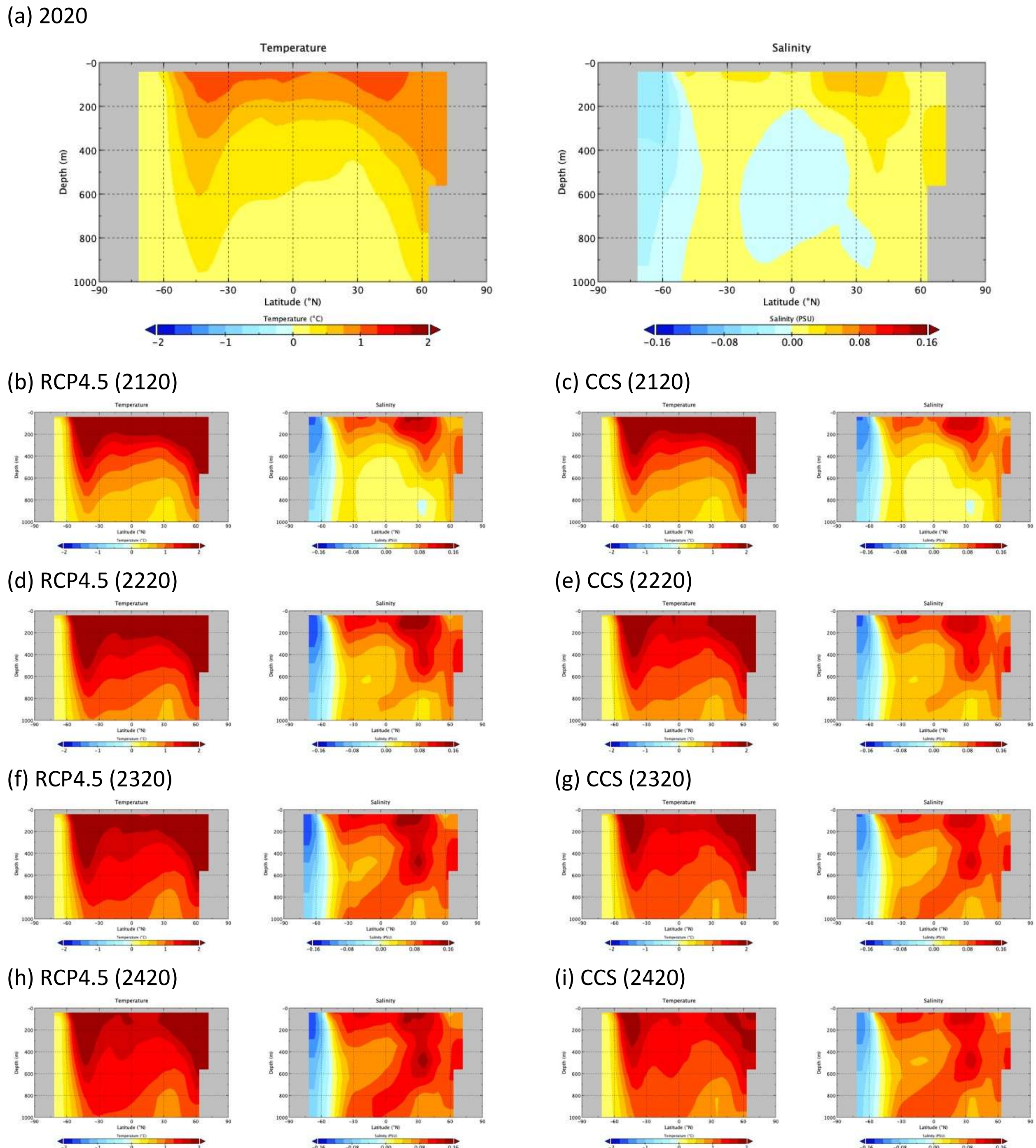

Figure S2: The change in temperature (in °C) (left plot in each panel) and salinity (in PSU) (right plot in each panel) in Atlantic cross section at (a) 2020, (b), (c) 2120, (d), (e) 2220, (f), (g) 2320 and (h), (i) 2420 relative to the year 850 CE in RCP4.5 (baseline) and carbon capture and storage scenarios.

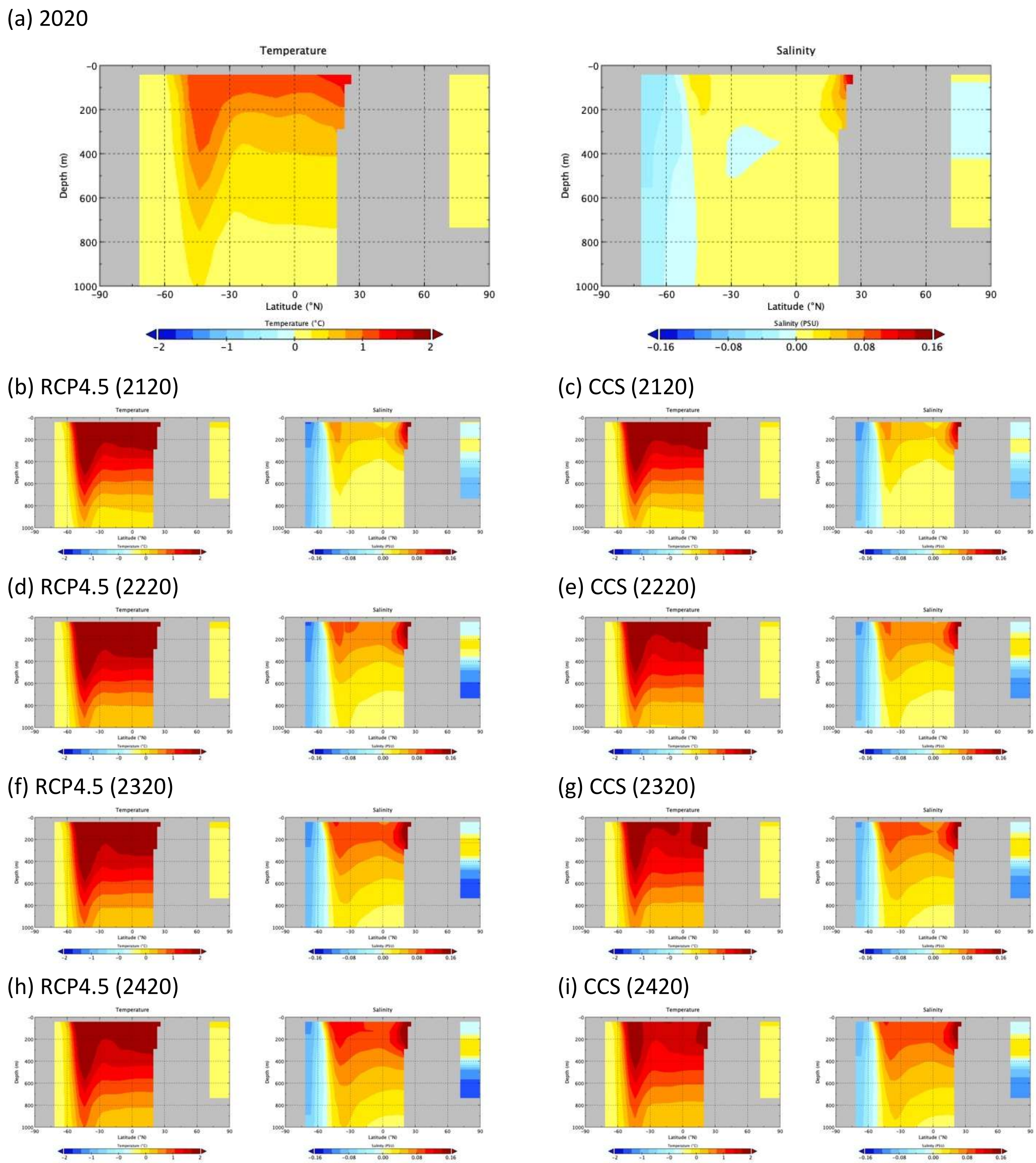

Figure S3: The change in temperature (in °C) (left plot in each panel) and salinity (in PSU) (right plot in each panel) in Indian cross section at (a) 2020, (b), (c) 2120, (d), (e) 2220, (f), (g) 2320 and (h), (i) 2420 relative to the year 850 CE in RCP4.5 (baseline) and carbon capture and storage scenarios.

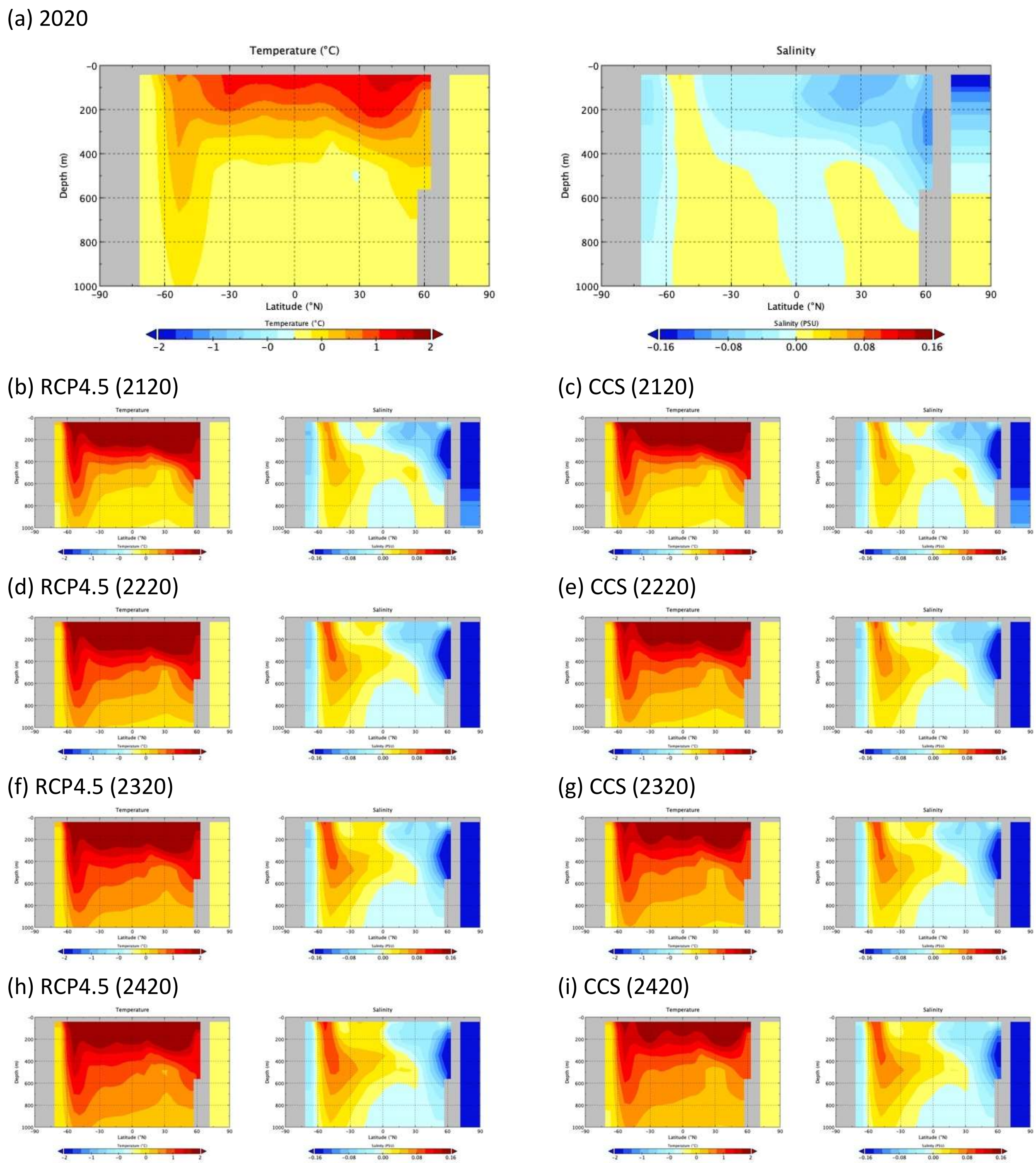

Figure S4: The change in temperature (in °C) (left plot in each panel) and salinity (in PSU) (right plot in each panel) in Pacific cross section at (a) 2020, (b), (c) 2120, (d), (e) 2220, (f), (g) 2320 and (h), (i) 2420 relative to the year 850 CE in RCP4.5 (baseline) and carbon capture and storage scenarios.

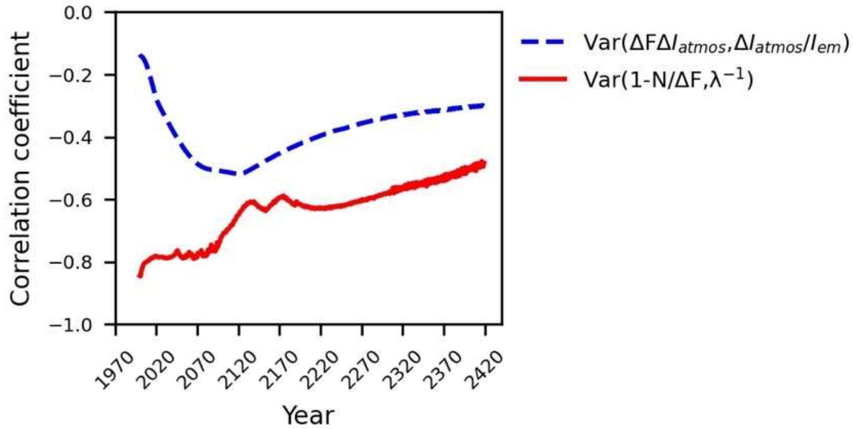

Figure S5: The correlation coefficient between the dependence of the radiative forcing on atmospheric CO_2 and airborne fraction (blue) and the fraction of the radiative forcing warming the surface and the inverse of the climate feedback (red) in RCP4.5 (baseline) scenario.

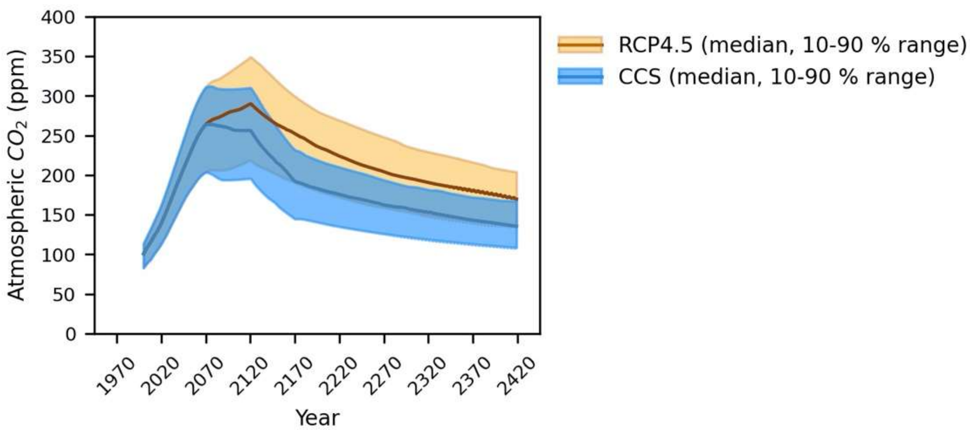

Figure S6: The evolution of the atmospheric CO_2 in RCP4.5 (baseline) and carbon capture and storage scenarios from year 2000. Solid lines show the median values, and shaded areas indicate the values between the 10th and 90th percentiles in baseline (orange) and carbon capture and storage (blue) scenarios.

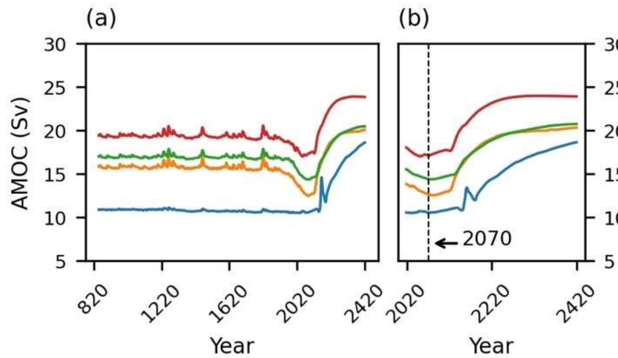

Figure S7: Abrupt re-organisation of ocean circulation during the period of negative emissions phase in four ensemble members (outliers). (a) RCP4.5 (baseline) and (b) carbon capture and storage scenarios. The dashed line shows the beginning of the carbon capture and storage application (year 2070).

Table S1- The non-CO_2 fraction of total anthropogenic radiative forcing (f_{nc} in Eq. 8) for four IPCC's representative concentration pathways (RCP2.6-8.5) at each decade between 2020 to 2100 based on the 82-member GENIE-1 ensemble simulations.

Year	RCP2.6 (%) mean (median) 25-75 % range	RCP4.5 (%) mean (median) 25-75 % range	RCP6.0 (%) mean (median) 25-75 % range	RCP8.5 (%) mean (median) 25-75 % range
2020	14 (14) 4 to 23	15 (16) 7 to 24	14 (15) 6 to 24	15 (16) 7 to 25
2030	12 (13) 4 to 21	14 (14) 7 to 22	15 (14) 12 to 17	14 (14) 7 to 22
2040	11 (12) 3 to 20	13 (13) 6 to 20	13 (13) 11 to 15	12 (13) 6 to 20
2050	11 (12) 3 to 20	12 (12) 5 to 19	12 (12) 10 to 14	11 (11) 5 to 17
2060	11 (12) 3 to 20	11 (11) 5 to 18	11 (11) 9 to 13	10 (10) 4 to 15
2070	11 (12) 3 to 20	11 (11) 5 to 17	10 (10) 9 to 12	9 (9) 4 to 14
2080	11 (12) 3 to 21	10 (10) 4 to 17	9 (9) 8 to 11	8 (8) 3 to 13
2090	11 (12) 2 to 21	10 (10) 4 to 17	9 (8) 7 to 10	7 (7) 3 to 12
2100	11 (12) 2 to 22	10 (10) 4 to16	8 (8) 7 to 10	7 (7) 2 to 11

Table S2: Effective transient climate response to the cumulative CO_2 emissions (eTCRE) and its components for the different emissions phases in the RCP4.5 (baseline) and the carbon capture and storage (CCS) scenarios. The normalised spread ($\sigma_x/\bar{x}$) is defined by the inter-model standard deviation (σ_x) divided by the inter-model mean ($\bar{x}$). The values for the CCS scenario are shown in parenthesis; where these are not provided the values are identical in both scenarios.

	Baseline (CCS)								
Variable	2020-2120			2120-2170			2170-2420		
	$\bar{x}$	σ_x	$\sigma_x/\bar{x}$	$\bar{x}$	σ_x	$\sigma_x/\bar{x}$	$\bar{x}$	σ_x	$\sigma_x/\bar{x}$
I_{em} (PgC)	1069.01 (1043.51)	73.61	0.07	1358.87 (1207.87)	73.61	0.05 (0.06)	1358.87 (1156.87)	73.61	0.05 (0.06)
ΔT (°C)	2.62 (2.59)	0.58	0.22	3.20 (2.93)	0.77 (0.73)	0.24 (0.25)	2.93 (2.56)	0.78 (0.70)	0.27
eTCRE (°C EgC^{-1})	2.48 (2.50)	0.58 (0.59)	0.23 (0.24)	2.36 (2.44)	0.59 (0.63)	0.25 (0.26)	2.16 (2.22)	0.58 (0.62)	0.27 (0.28)
$\Delta T/\Delta F$ (°C $(Wm^{-2})^{-1}$)	0.70	0.12	0.17	0.79 (0.83)	0.15 (0.16)	0.19	0.88 (0.90)	0.18 (0.19)	0.20
λ^{-1} (°C $(Wm^{-2})^{-1}$)	0.92	0.22	0.24	0.92 (0.94)	0.22 (0.23)	0.24	0.95 (0.97)	0.24 (0.26)	0.25 (0.27)
$1-N/\Delta F$	0.77	0.06	0.08	0.87	0.08	0.09	0.94	0.09	0.10
$\Delta F/I_{em}$ (Wm^{-2} EgC^{-1})	3.60	0.66	0.18	2.99 (2.97)	0.55 (0.58)	0.18 (0.20)	2.48	0.48 (0.51)	0.19 0.20
$\Delta I_{atmos}/I_{em}$	0.33 (0.48)	0.06 (0.10)	0.18 (0.21)	0.42 (0.39)	0.09	0.21	0.32 (0.29)	0.06	0.19 (0.21)
$\Delta F/\Delta F_{CO2}$	1.14	0.12	0.11	1.12 (1.14)	0.11 (0.13)	0.10 (0.11)	1.15 (1.18)	0.14 (0.16)	0.12 (0.14)
$\Delta F_{CO2}/I_{atmos}$ (Wm^{-2} EgC^{-1})	6.60	0.25	0.04	6.40 (6.72)	0.30 (0.28)	0.05 (0.04)	6.87 (7.22)	0.26 (0.22)	0.04 (0.03)

Table S3: Carbon variables for the different emissions phases in the RCP4.5 (baseline) and the carbon capture and storage (CCS) scenarios. The nomalised spread is quantified through the coefficient of variation ($\sigma_x/\bar{x}$). The values for the CCS scenario are shown in parenthesis.

	Baseline (CCS)								
Variable	2020-2120			2120-2170			2170-2420		
	$\bar{x}$	σ_x	$\sigma_x/\bar{x}$	$\bar{x}$	σ_x	$\sigma_x/\bar{x}$	$\bar{x}$	σ_x	$\sigma_x/\bar{x}$
I_{em} (PgC)	1069.01 (1043.51)	73.61	0.07	1358.87 (1207.87)	73.61	0.05 (0.06)	1358.87 (1156.87)	73.61	0.05 (0.06)
$\Delta I_{atmos}/I_{em}$	0.48	0.10	0.21	0.42 (0.39)	0.09	0.21	0.32 (0.29)	0.06	0.19 (0.21)
$\Delta I_{ocean}/I_{em}$	0.33	0.06	0.18	0.42 (0.45)	0.08	0.19	0.56 (0.58)	0.09	0.16
$\Delta I_{land}/I_{em}$	0.20	0.13	0.65	0.18 (0.19)	0.13	0.72 (0.68)	0.17	0.12	0.71 (0.65)
$\Delta I_{veg}/I_{em}$	0.08	0.02	0.25	0.07	0.02	0.29	0.06	0.02	0.33
$\Delta I_{soil}/I_{em}$	0.12	0.11	0.92	0.12	0.12	1.00	0.11	0.10	0.91
$\Delta I_{sediment}/I_{em}$	-0.02	0.01	-0.50	-0.02 (-0.03)	0.01	-0.50 (-0.33)	-0.04 (-0.05)	0.02	-0.50 (-0.40)

Table S4: Correlation between all model parameters and $\Delta T/\Delta I_{em}$ in RCP4.5 (baseline) and the carbon capture and storage (CCS) scenarios over different emissions phases based on the coefficients of determination (R^2) (%). R^2>50 % denotes strong correlation, and R^2>10 % the moderate correlation. The values less than 10 % are shown in Italic.

Parameter	Description	2020-2120		2120-2170	
		baseline	CCS	baseline	CCS
AHD	Atmospheric heat diffusivity	*2.6*	*2.6*	-	*5.9*
AMD	Atmospheric moisture diffusivity	*0.5*	*0.5*	-	*4.3*
APM	Atlantic-Pacific moisture flux scaling	*6.5*	*6.8*	-	*0.1*
OL0	Clear skies OLR reduction (OLR: outgoing long wave radiation)	*2.8*	*2.8*	-	*0.7*
OHD	Isopycnal diffusivity	*2.3*	*2.2*	-	*1.8*
OVD	Reference diapycnal diffusivity	*0.1*	*0.1*	-	*7.1*
OP1	Power law for diapycnal diffusivity depth profile	*0.9*	*1.0*	-	*3.0*
ODC	Ocean inverse drag coefficient	*1.9*	*1.8*	-	*<0.05*
WSF	Wind-scale factor	*0.1*	*0.1*	-	**16.4**
SID	Sea ice diffusivity	*0.5*	*0.5*	-	*4.0*
VFC	Fractional vegetation dependence on veg carbon density	**9.9**	**10.1**	-	*0.7*
VBP	Baseline rate of photosynthesis	*0.5*	*0.5*	-	*1.4*
VRA	Vegetation respiration activation energy	*1.0*	*1.0*	-	*7.1*
LLR	Leaf litter rate	*1.7*	*1.6*	-	*0.5*
SRT	Soil respiration temperature dependence	*0.7*	*0.7*	-	*5.8*
PMX	Maximum phosphate uptake (dummy parameter)	*0.6*	*0.6*	-	*1.4*
PHS	PO_4 half-saturation concentration	*0.0*	*0.0*	-	*0.8*
PRP	Initial proportion of POC export as recalcitrant fraction	*2.6*	*2.5*	-	*3.6*
PRD	e-folding remineralisation depth of non-recalcitrant POC	*8.3*	*8.4*	-	*0.2*
RRS	Rain ratio scalar	*0.7*	*0.8*	-	*1.8*
TCP	Thermodynamic calcification rate power	*1.4*	*1.4*	-	*2.8*
PRC	Initial proportion of $CaCO_3$ export as recalcitrant fraction	*1.1*	*1.2*	-	*6.1*
CRD	e-folding remineralisation depth of non-recalcitrant $CaCO_3$	*<0.05*	*<0.05*	-	*<0.05*
FES	Iron solubility	*0.4*	*0.4*	-	*0.8*
ASG	Air-sea gas exchange parameter	*0.2*	*0.2*	-	*1.1*
OL1	OLR feedback parameter	**63.7**	**63.0**	-	**14.6**
VPC	CO_2 fertilisation	*5.9*	*5.9*	-	**14.0**
KC	Land use change soil carbon	**12.0**	**12.3**	-	*0.5*
ALUA	Crop albedo	*1.2*	*1.3*	-	*6.1*