Table SI.1: Empirical approximations of dissociation constants in the default cGENIE carbonate system solver. T stands for in situ temperature, S for in situ salinity, I for in situ ionic strength after Millero [1982] and ION for in situ ionic strength after Zeebe and Wolf-Gladrow [2001].

Dissociation constant	Approximation	Reference
pK_1	-(3670.7/T - 62.008 + 9.7944·ln(T) - 0.0118·S + 0.000116·S^2)	Mehrbach [1973], Dickson & Millero [1987]
pK_2	-(1394.7/T + 4.777 - 0.0184·S + 0.000118·S^2)	Mehrbach [1973], Dickson & Millero [1987]
pK_B	148.0248 + 137.194·$S^{0.5}$ + 1.62247·S + (-8966.90 - 2890.51·$S^{0.5}$ - 77.942·S + 1.726·$S^{1.5}$ - 0.0993·S^2)/T + (-24.4344 - 25.085·$S^{0.5}$ - 0.2474·S)·ln(T) + 0.053105·$S^{0.5}$·T	Dickson [1990]
pK_W	148.9802 - 13847.26/T - 23.6521·ln(T) + (-5.977 + 118.67/T+ 1.0495·ln(T))·$S^{0.5}$ - 0.01615·S	Millero [1992]
pK_{Si}	117.40 - 8904.2/T - 19.334·ln(T) + (3.5913 - 458.79/T)·$I^{0.5}$ + (-1.5998 + 188.74/T)·I + (0.07871 - 12.1652/T)·I^2	Yao & Millero [1995]
pK_{HF}	1590.2/T - 12.641 + 1.525·$ION^{0.5}$	Dickson & Riley [1979]
pK_{HSO_4}	141.328 - 4276.1/T - 23.093·ln(T) + (324.57 - 13856.0/T - 47.986·ln(T))·$I^{0.5}$ + (-771.54 + 35474.0/T + 114.723·ln(T))·I -2698.0/T·$I^{1.5}$ + 1776.0/T·I^2	Dickson [1990]
pK_{P1}	115.54 - 4576.752/T - 18.453·ln(T) + (0.69171 - 106.736/T)·$S^{0.5}$ + (-0.01844 - 0.65643/T)·S	Yao & Millero [1995]
pK_{P2}	172.1033 - 8814.715/T - 27.927·ln(T) + (1.3566 - 160.340/T)·$S^{0.5}$ + (-0.05778 + 0.37335/T)·S	Yao & Millero [1995]
pK_{P3}	-18.126 - 3070.75/T + (2.81197 + 17.27039/T)·$S^{0.5}$ + (-0.09984 - 44.99486/T)·S	Yao & Millero [1995]
$pK_{sp,calc}$	-171.9065 - 0.077993·T + 2839.319/T + 71.595·log(T) + (-0.77712 + 0.0028426·T + 178.34/T)·$S^{0.5}$ - 0.07711·S + 0.0041249·$S^{1.5}$	Mucci [1983]
$pK_{sp,arag}$	-171.945 - 0.077993·T + 2903.293/T + 71.595·log(T) + (-0.068393 + 0.0017276·T + 88.135/T)·$S^{0.5}$ - 0.10018·S + 0.0059415·$S^{1.5}$	Mucci [1983]
pK_{HS}	225.838 - 13275.3/T - 34.6435·ln(T) + 0.3449·$S^{0.5}$ - 0.0274·S	Millero [1988]
pK_{NH_4}	-6285.33/T + 0.0001635·T - 0.25444 + (0.46532 - 123.7184/T)·$S^{0.5}$ + (-0.01992 + 3.17556/T)·S	Yao & Millero [1995]

Tab SI.2: Parameters used to calculate pressure corrections for dissociation constants in the default cGENIE carbonate system solver.

Constant	P1	P2	P3	P4	P5
K_1	-2.550E+1	+1.271E-1	+0.000E+0	-3.080E+0	+8.770E-2
K_2	-1.582E+1	-2.190E-2	+0.000E+0	+1.130E+0	-1.475E-1
K_B	-2.948E+1	+1.622E-1	+2.608E-3	-2.840E+0	+0.000E+0
K_W	-2.002E+1	+1.119E-1	-1.409E-3	-5.130E+0	+7.940E-2
K_{HSO_4}	-1.803E+1	+4.660E-2	+3.160E-4	-4.530E+0	+9.000E-2
K_{HF}	-9.780E+0	-9.000E-3	-9.420E-4	-3.910E+0	+5.400E-2
$K_{sp,cal}$	-4.876E+1	+5.304E-1	+0.000E+0	-1.176E+1	+3.692E-1
$K_{sp,arg}$	-4.596E+1	+5.304E-1	+0.000E+0	-1.176E+1	+3.692E-1
K_{P1}	-1.451E+1	+1.211E-1	-3.210E-4	-2.670E+0	+4.270E-2
K_{P2}	-2.312E+1	+1.758E-1	-2.647E-3	-5.150E+0	+9.000E-2
K_{P3}	-2.657E+1	+2.020E-1	-3.042E-3	-4.080E+0	+7.140E-2
K_{H_2S}	-1.107E+1	-9.000E-3	-9.420E-4	-2.890E+0	+5.400E-2
K_{NH_4}	-2.643E+1	+8.890E-2	-9.050E-4	-5.030E+0	+8.140E-2
K_{Si}	-2.948E+1	+1.622E-1	+2.608E-3	-2.840E+0	+0.000E+0

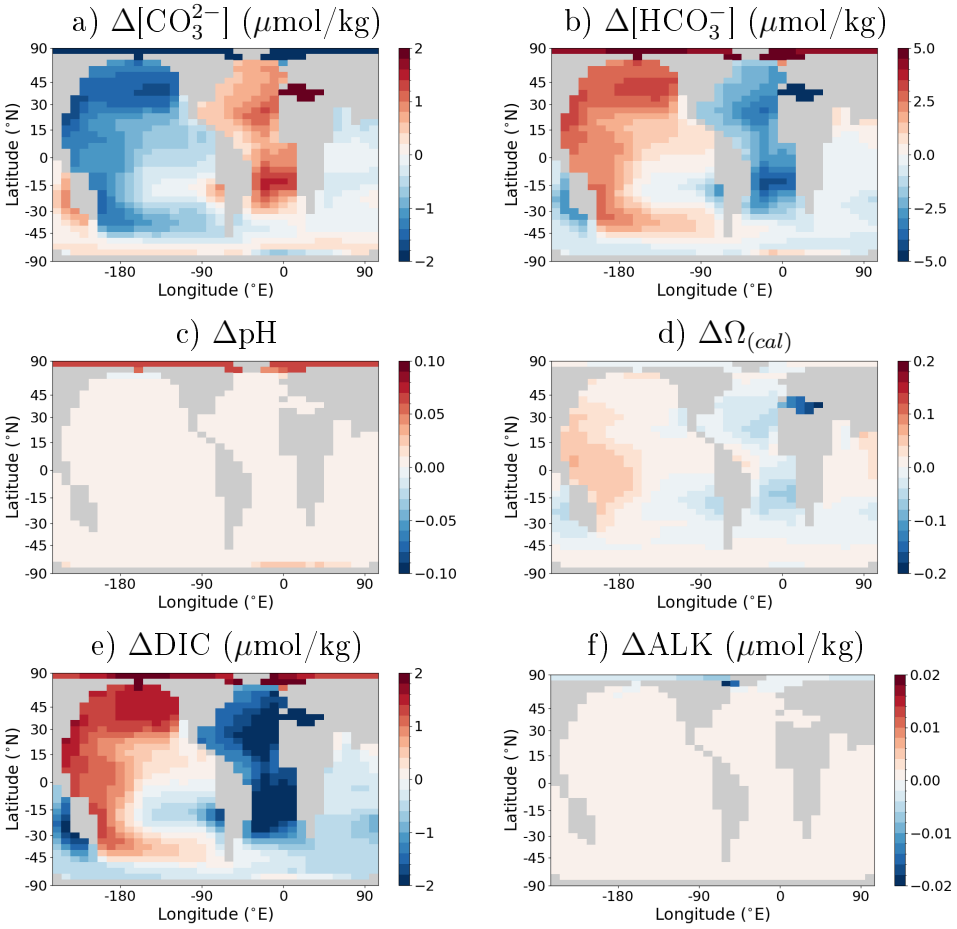

Fig. SI.1: Differences of the simulated carbonate system in the surface ocean between default cGENIE and cGENIE+MyAMI with pre-industrial Mg/Ca (simulations PI-B-ocean minus PI-A-ocean).

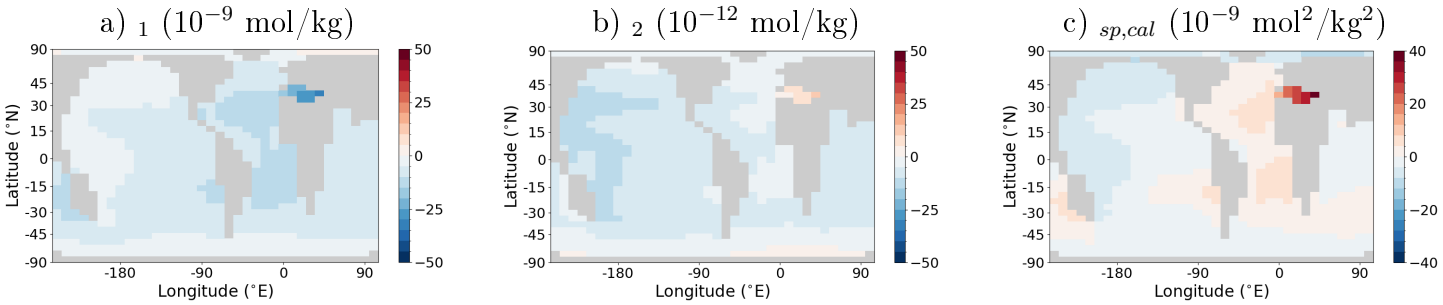

Fig. SI.2: Differences in K_1, K_2, $K_{sp,cal}$ and K_B between default cGENIE and cGENIE+MyAMI solutions for the pre-industrial carbonate system of the surface ocean with the same temperature limitations as those applied in default cGENIE (simulations PI-B2-ocean minus PI-A-ocean).

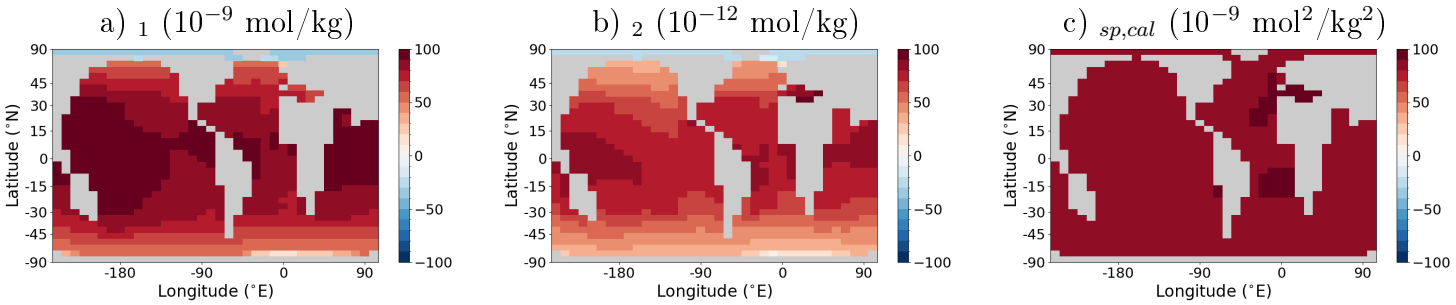

Fig. SI.3: Differences in K_1, K_2, $K_{sp,cal}$ and K_B between default cGENIE and cGENIE+MyAMI solutions for the carbonate system of the surface ocean with Eocene-like Mg/Ca (simulations EE-B-open minus EE-A-open).

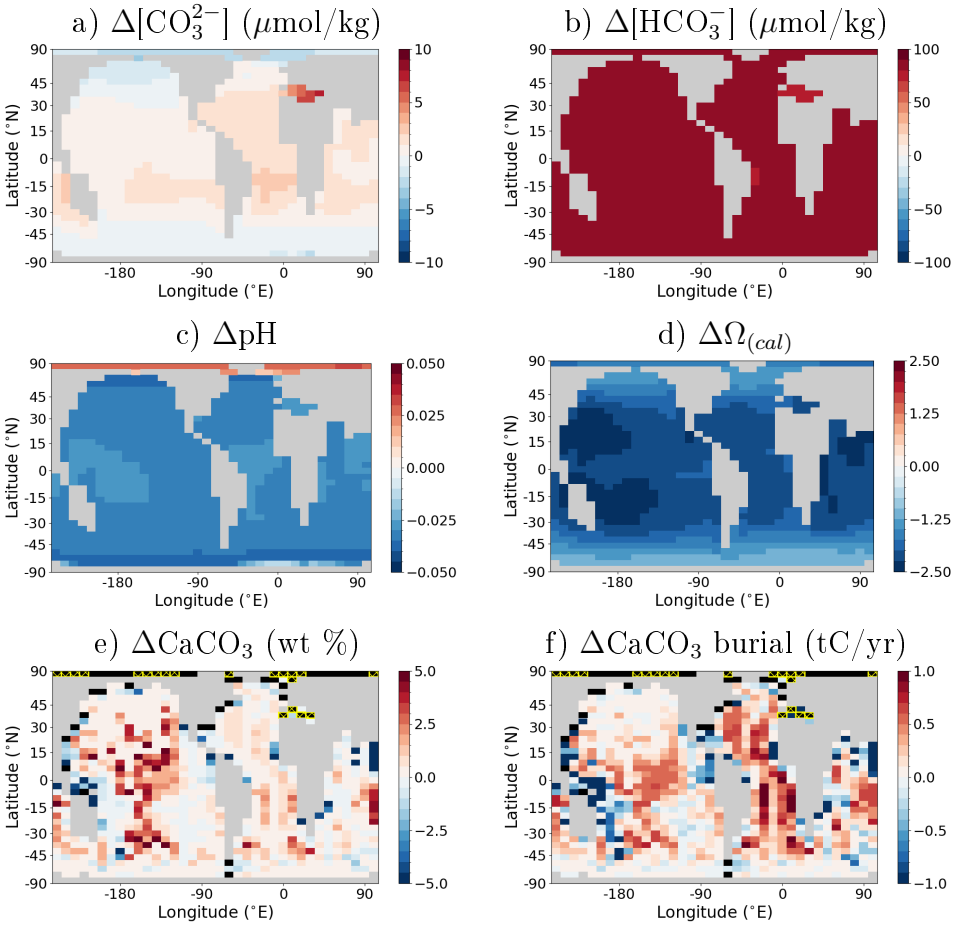

Fig. SI.4: Differences of the simulated carbonate system in the surface ocean, carbonate content in marine sediments and burial rates between cGENIE with default Mg/Ca corrections and cGENIE+MyAMI with Eocene-like Mg/Ca (simulations EE-B-open minus EE-A-open). A comparison of the respective absolute values in the two simulations is provided in Fig. SI.5 and spatial patterns of the absolute values in simulation EE-B-open are shown in Fig. SI.6. Sediments shallower than 1000 m are masked in black and locations where the sedimentary carbonate system could not be solved dynamically and was instead replaced by a lookup table value is hatched in yellow.

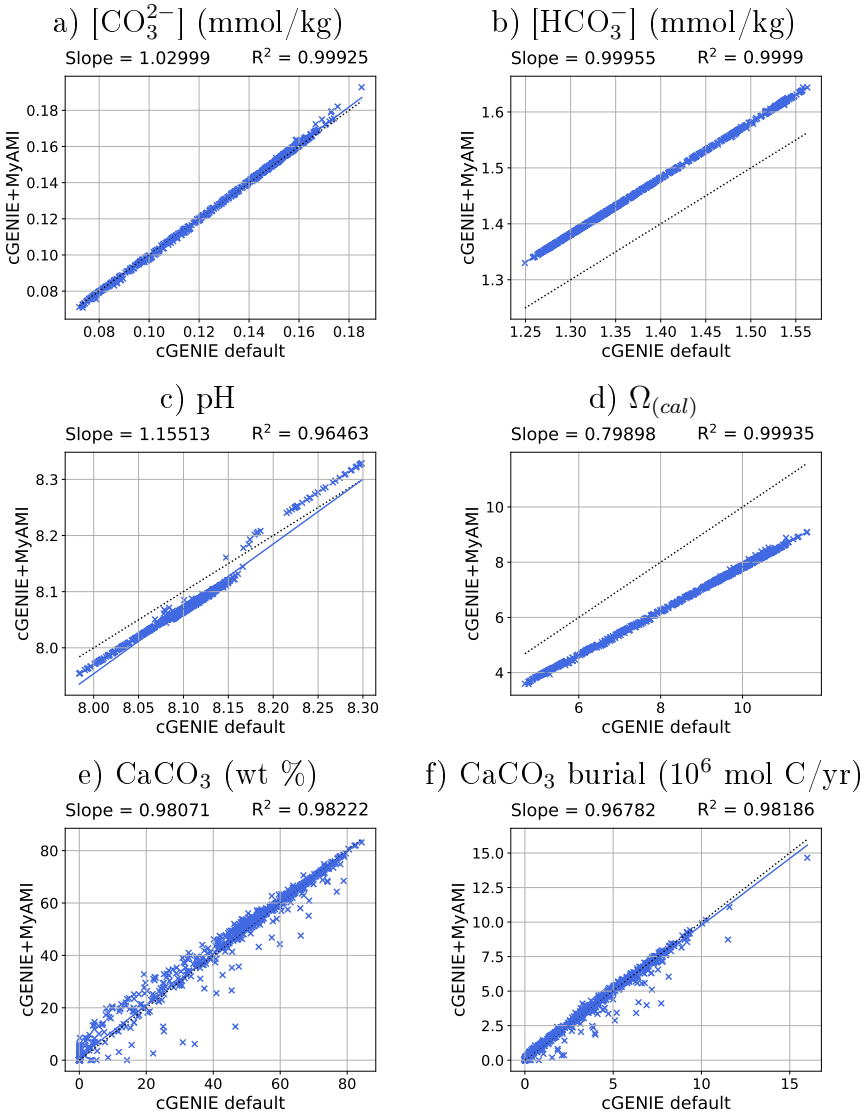

Fig. SI.5: Comparisons of absolute measures of the simulated carbonate system in the surface ocean, carbonate content in marine sediments and burial rates in simulations EE-A-open and EE-B-open.

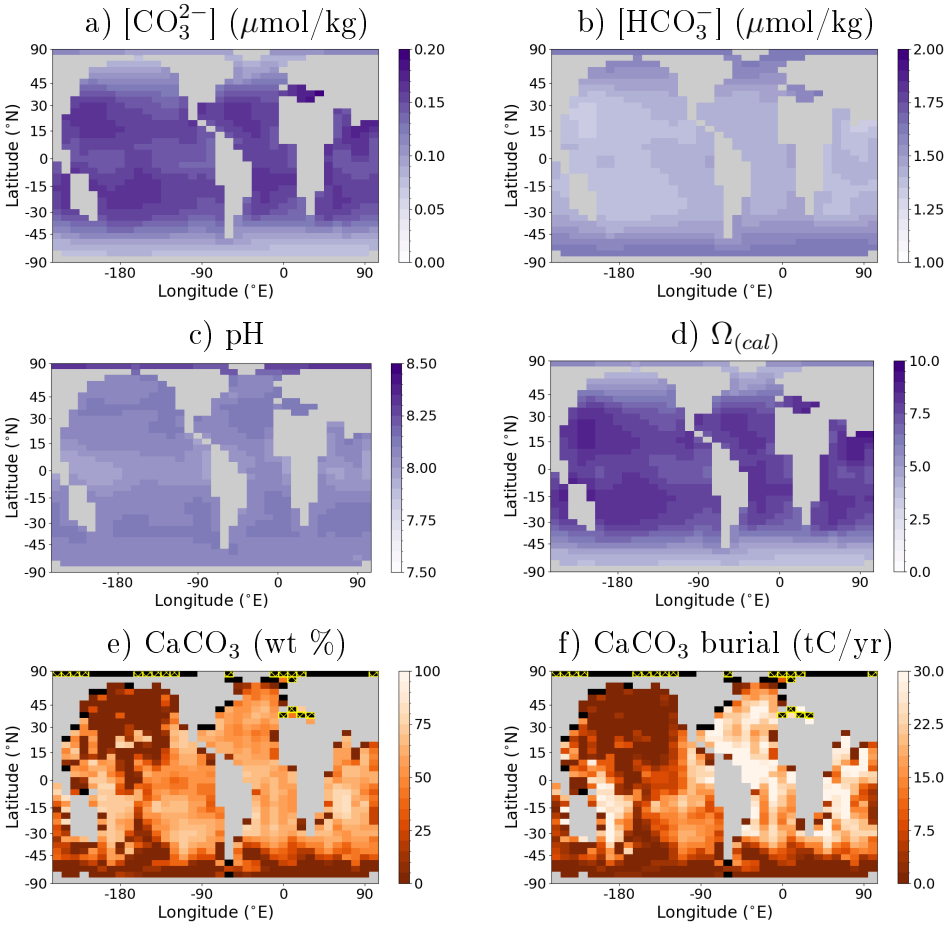

Fig. SI.6: Absolute measures of the simulated carbonate system in the surface ocean, carbonate content in marine sediments and burial rates in simulation EE-B-open. Sediments shallower than 1000 m are masked in black and locations where the sedimentary carbonate system could not be solved dynamically and was instead replaced by a lookup table value is hatched in yellow.