AGU PUBLICATIONS

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Supporting Information for

Global carbon cycle and climate feedbacks in the NASA GISS ModelE2.1

Gen Ito[1,2,3], Anastasia Romanou[1], Nancy Y. Kiang[1], Gregory Faluvegi[1,4], Igor Aleinov[1,4], Reto Ruedy[1,2], Gary Russell[1], Paul Lerner[1], Maxwell Kelley[1,2], and Ken Lo[1,2]

[1]NASA Goddard Institute for Space Studies, New York, NY, USA, [2]SciSpace, LLC, New York, NY, USA, [33]Centre de Recherches Pétrographiques et Géochimiques (CRPG), CNRS/Université de Lorraine, Vandoeuvre-lés-Nancy, France, [4]Center for Climate Systems Research, Earth Institute, Columbia University, New York, NY, USA

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Introduction

This supporting information provides figures of the ocean diagnostics for sections 2.3, 4.1.3, and 4.2 of the main article. For Figure S1-4, results from the concentration-driven historical experiment are averaged during the respective periods and compared against observationally based climatologies. The averaging periods are between 2000-2012 for the ocean mixed layer depth (Holte et al., 2017), between 1992-2012 for alkalinity, DIC, and temperature (Lauvset et al., 2016), between 2004-2012 for wind speed (Bosilovich et al., 2015), and between 1997-2008 for primary production (Westberry et al., 2008). The figures here and the discussion in section 4.1.3 of the main article briefly examines the biases in the ocean model in support of understanding CO_2 flux bias. More dedicated evaluations of the GISS ModelE2.1 ocean model is available in Lerner et al. (2020).

Also, included are Figures S5 and S6 which pertain to the discussion in section 4.2 of the main article about the different behavior of uptake in the fully coupled and the biogeochemically coupled experiments of the historical simulations.

In Table S1, statistical measures (r^2, bias, and standard error) of the fluxes from historical and esm-hist experiments relative to CarbonTracker CT2017 data that correspond to Figure 7 in the main article is provided. In Table S2, offline conservation diagnostics for the ocean carbon cycle is given.

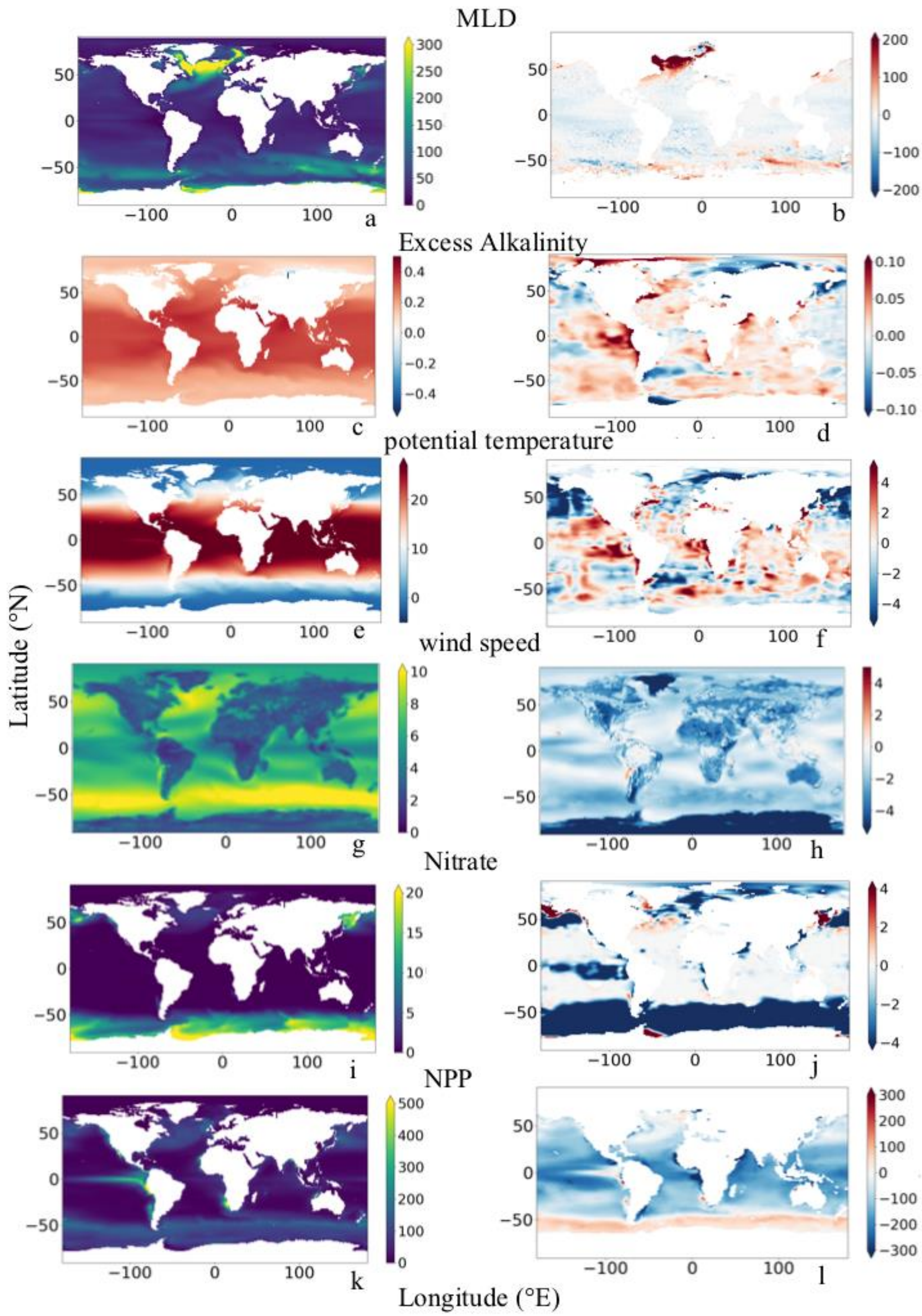

Figure S1. *Model and observed ocean surface properties, averaged over the respective period represented by the observationally-based climatologies. (a,b) mean mixed layer depth (m), (c,d)* *excess alkalinity (alkalinity - DIC; mmol/kg), (e,f) Potential Temperature (^oC), (g,h) wind speed (m/s), (i,j) nitrate (μmol/kg), and primary production (g C/m^2/yr). The left panels are from the concentration-driven historical simulation, and the right panels are the difference between this simulation and observations. Observations are from an ARGO-based climatology for MLD (Holte et al., 2017), GLODAPv2 for excess alkalinity, temperature, and nitrate (Lauvset et al., 2016), MERRA-2 for wind speed (Bosilovich et al., 2015), and the optical properties from SeaWIFS assimilated into the Carbon-based production model, version 2 for primary production (Westberry et al., 2008).*

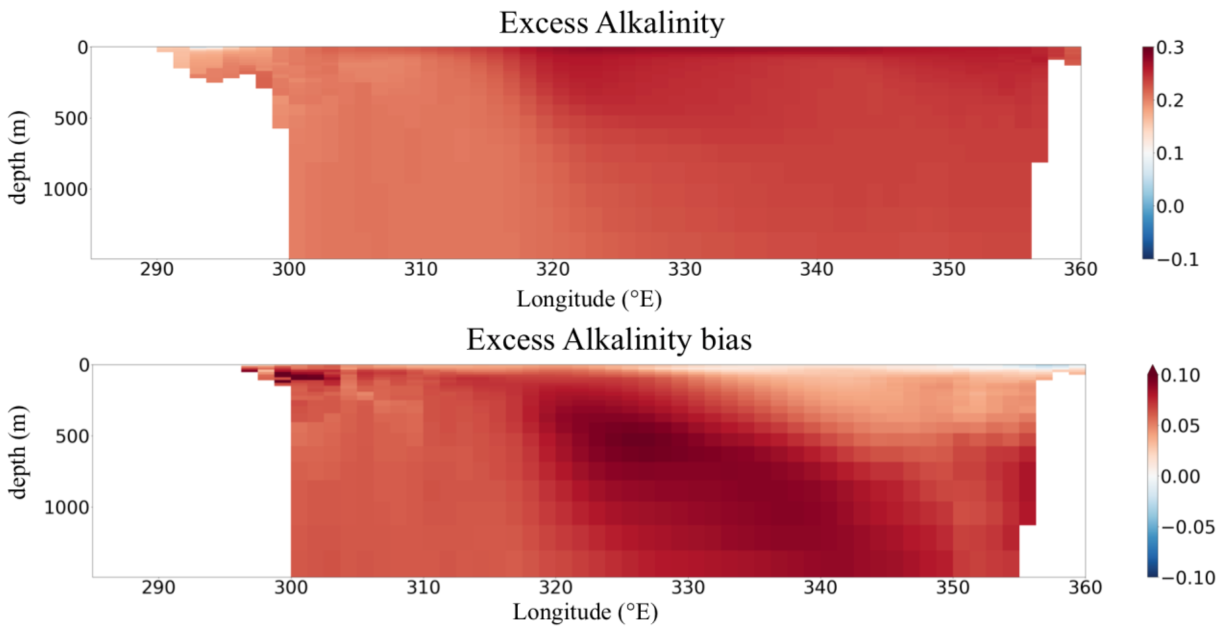

Figure S2. *Zonal section of excess alkalinity in the subpolar North Atlantic. The top panel is from the concentration-driven historical simulation, and the bottom panel is the difference between this simulation and observations. Observations are from GLODAPv2 (Lauvset et al., 2016).*

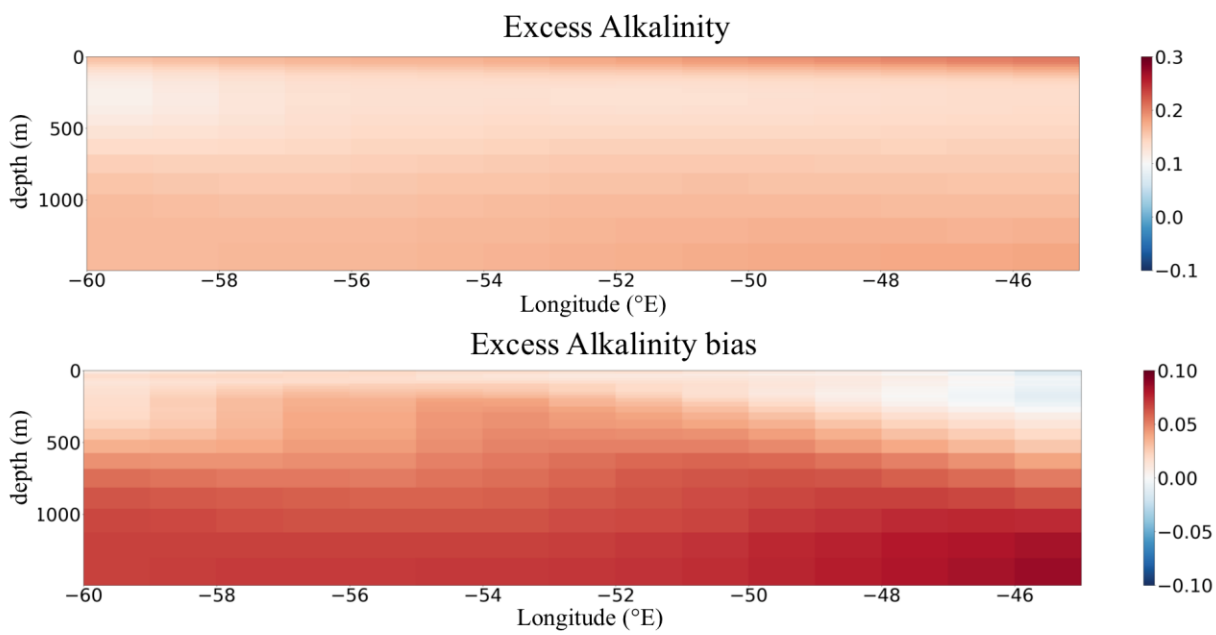

Figure S3 *Meridional section of excess alkalinity in the Atlantic sector of the Southern Ocean. The top panel is from the concentration-driven historical simulation, and the bottom panel is the* *difference between this simulation and observations. Observations are from GLODAPv2 (Lauvset et al., 2016).*

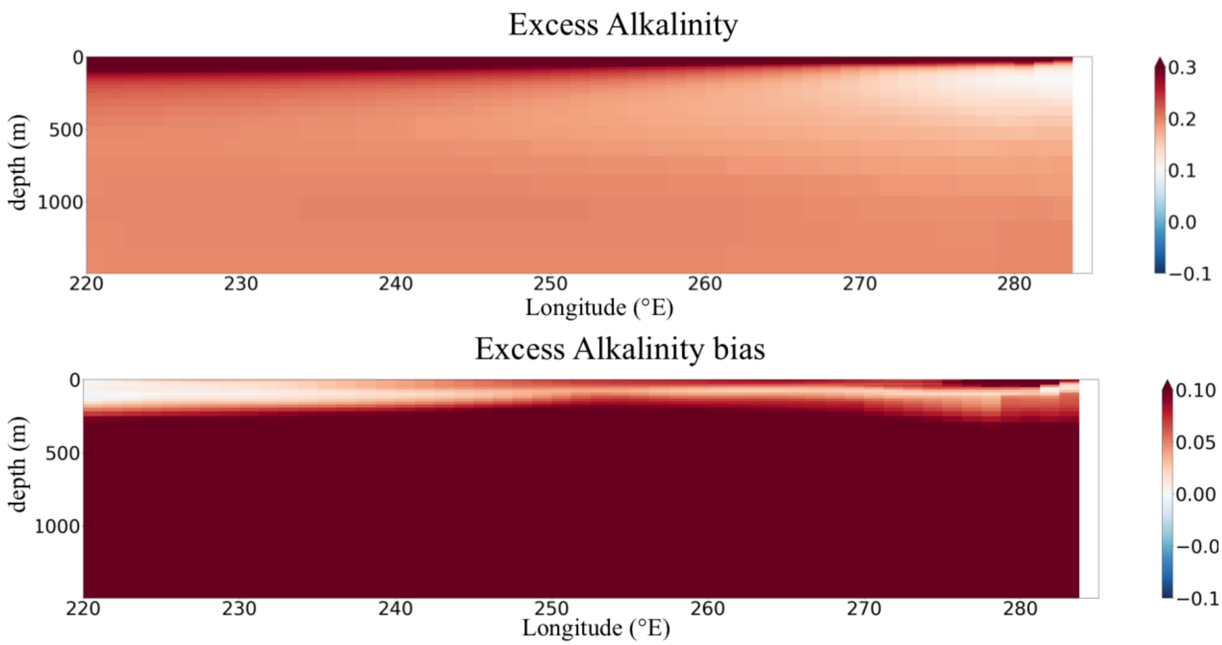

Figure S4. *Zonal section of excess alkalinity in the southern Equatorial Pacific. The top panel is from the concentration-driven historical simulation, and the bottom panel is the difference between this simulation and observations. Observations are from GLODAPv2 (Lauvset et al., 2016).*

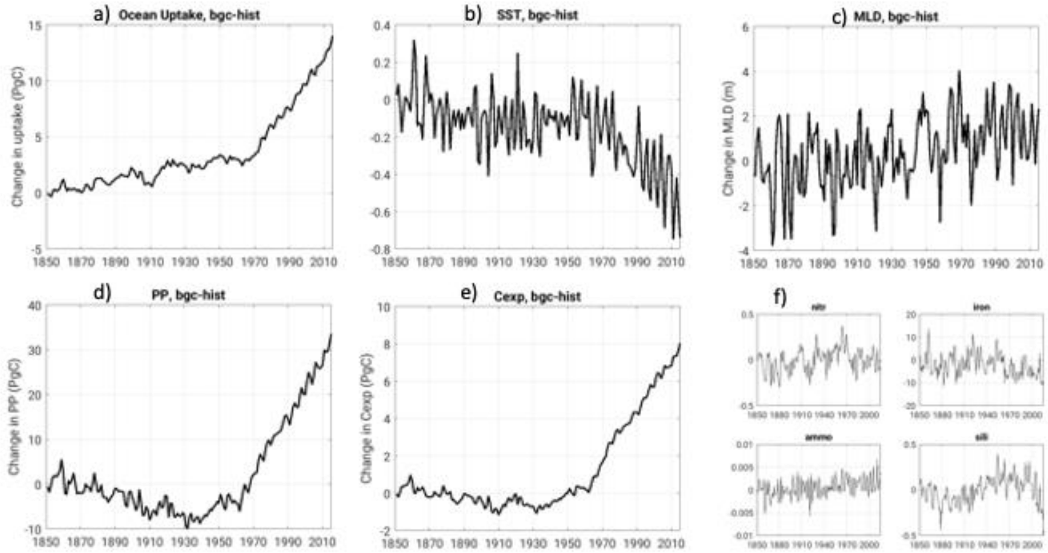

Figure S5. *Differences between the concentration-driven historical and hist-bgc experiments. (a) difference in Ocean Uptake (PgC), (b) difference in global average sea surface temperature (SST; °C), (c) difference in global average mixed layer depth (MLD, m), (d) difference in accumulated primary production (PP; PgC), (e) difference in accumulated carbon export at 75 m (PgC), (f) difference in global average surface nutrients (nitrate (µmol), iron(nmol), ammonia (µmol), silicate (µmol)).*

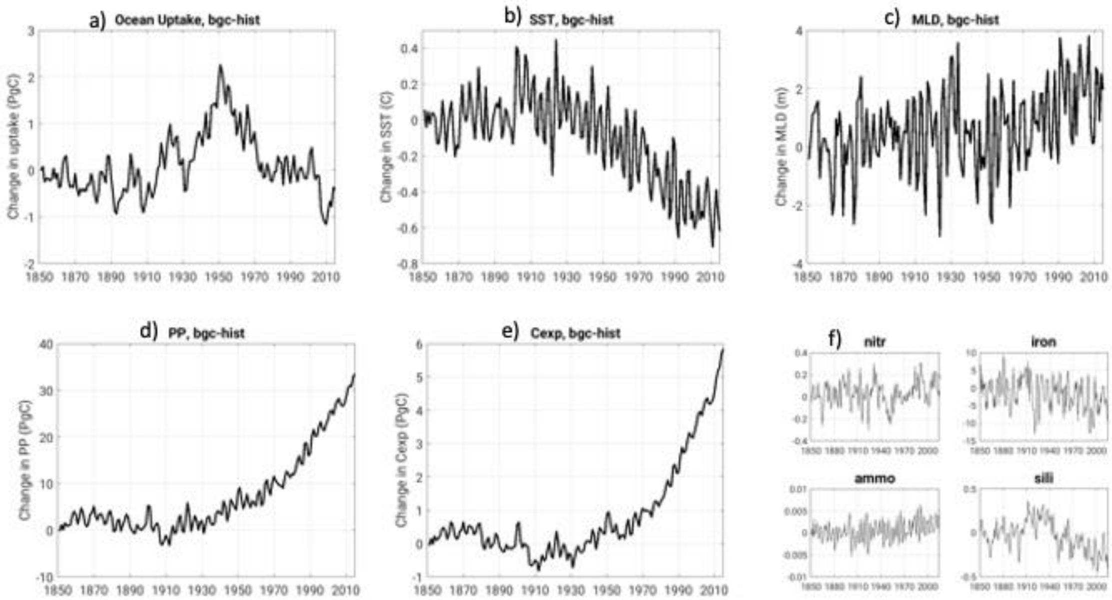

Figure S6. *Differences between the emissions-driven esm-hist and esm-hist-bgc experiments. (a) Difference in Ocean Uptake (PgC), (b) difference in global average SST (℃), (c) difference in global average mixed layer depth (MLD, m), (d) difference in accumulated PP (PgC), (e) difference in accumulated carbon export at 75 m (PgC), (f) difference in global average surface nutrients (nitrate (μmol), iron(nmol), ammonia (μmol), silicate (μmol)).*

Flux Type	r^2		Bias (gC/m^2/yr)		Standard Error (gC/m^2/yr)	
	historical	esm-hist	historical	esm-hist	historical	esm-hist
Global ANN	0.13	0.17	-4.41	-4.41	34.2	33.3
Land DJF	0.36	0.41	46.98	46.12	134.9	131.0
Land MAM	0.41	0.41	24.54	25.30	119.8	120.6
Land JJA	0.42	0.43	-181.93	-181.91	332.3	331.5

Land SON	0.58	0.59	25.74	25.65	137.0	136.0

Table S1. *Coefficient of determination (r^2), bias, and standard error of the fluxes from historical and esm-hist experiments relative to fluxes from CarbonTracker. This table corresponds to Figure 7 of the main article, and the values are computed using the 2000-2014 mean. ANN, DJF, MAM, JJA, and SON correspond to the annual, December-January-February, March-April-May, June-July-August, and September-October-November periods. Positive flux is defined as into the surface.*

ZFILE0 = /discover/nobackup/projects/giss/prod_input_files/Z1QX1N.BS1

Eargcc OCEAN CARBON MASS (Pg)

	DIAT	CHLO	CYAN	COCC	HERB	NDET	DOC	DIC	Total
	====	====	====	====	====	====	===	===	=====
OCNRSF BFR	0.07797	0.23487	0.03706	0.18877	0.16596	0.15327	50.70013	35211.55099	35263.10902
Atmos Flux								0.09233	0.09233
River Flow						0.00933	0.00874	0.01874	0.03681
Phyto Grow	0.24066	1.06028	0.10193	1.01347				-2.41634	0.00000
CyanConver			0.00996					-0.00996	0.00000
DieByZooGr	-0.16439	-0.83692	-0.04958	-0.63925	1.69015				0.00000
Die toNDET	-0.05555	-0.16323	-0.05179	-0.26902		0.53958			0.00000
DOCfromPhy	-0.01203	-0.05301	-0.00559	-0.05067			0.12131		0.00000
PhyRespira	-0.01203	-0.05301	-0.00559	-0.05067				0.12131	0.00000
HerbDeath1					-0.37182	0.37182			0.00000
HerbDeath2					-0.60678	0.60678			0.00000
DOCfromZOO					-0.08956		0.08956		0.00000
HerbGrzing					-0.42254		0.42254		0.00000
DICZooResp					-0.20866			0.20866	0.00000
Regenerate						-0.15169	0.15169		0.00000
DetriToDOC						-0.07272	0.07272		0.00000
Remineralz						-1.30892		1.30892	0.00000
BacterLoss							-0.75428	0.75428	0.00000
SinkSettle	0.00000	0.00000	0.00000	0.00000		-0.00000			0.00000
EstuarySnk						-0.02391			-0.02391
OCNRSF AFT	0.07463	0.18898	0.03639	0.19261	0.15676	0.12353	50.81242	35211.62894	35263.21425
Error	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table S2. *Offline conservation diagnostics for the ocean carbon cycle. Comparison of the change in the amount of carbon contained in each pool via each process in the model separately to the change in the total carbon pool in the before and after states (over a timestep or over any period of the simulation). The left-most column contains all the processes that change carbon in the model. All subsequent columns contain the change (in Pg) for each carbon pool. The ocean state before (OCNRSF BFR) is listed near the top and includes the initial amounts of carbon in each pool whereas the line near the bottom (OCNRSF AFT) lists the end amounts of carbon in each pool. The Error line shows if things balance across pools to real*8 accuracy.*