

*Global Biogeochemical Cycles*

Supporting Information for

**Magnitude, trends, and variability of the global ocean carbon sink from 1985-2018**

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**Introduction**

This Supplementary Information includes Supplementary Tables S1-S3, listing details of the Global Ocean Biogeochemical Models (GOBMs, Table S1) and the pCO2-observation based products (Table S2), and comparing sea-air CO2 fluxes and trends . It also includes Supplementary Figures S1-S6, cited in the main text.

**Table S1: Details of RECCAP2 model simulations. N/A indicates information is not available.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model name** | OCIM | ECCO-Darwin | CCSM | CESM-ETHZ | CNRM-ESM2-1 | EC-Earth3 | FESOM\_REcoM\_LR | MOM6-COBALT-PRINCETON | MPIOM-HAMOCC | MRI-ESM2-1 | NorESM-OC1.2 | IPSL-NEMO-PISCES | PlankTOM12 | ORCA025-  GEOMAR |
| **version** | v20210511  v2014 | v20210712 | CCSM-WHOI (CCSM 3.1) | v20211122 | v20211208 | v20220323 | v20221119 | v20210312 | v20210501 | v20220502 | v20211125 | v20211215 | v20220404 | v20210804 |
| **reference** | DeVries (2014, 2022) | Carroll et al. (2020,2022) | Doney et al. (2009) | Lindsay et al. (2014);  Yang and Gruber (2016) | Séférian et al. (2019)  Berthet et al. (2019) Séférian et al. (2020) | Doscher et al. (2021) | Hauck et al. (2020);  Sein et al. (2018) | Liao et al. (2020); Stock et al. (2020) | Ilyina et al. (2013); Mauritsen et al. (2019) | Urakawa et al. (2020); Tsujino et al. (2017) | Schwinger et al. (2016) | Aumont et al. (2015); Friedlingstein et al. (2022) | Le Quéré et al. (2016); Wright et al. (2021) | Kriest and Oschlies (2015); Chien et al., (2022) |
| **original horizontal resolution** | lon: 2°  lat: 2° | ⅓ degree at equator and ~18 km at high latitudes | lon: 3.6°  lat: 0.8° - 1.8° | lon: 1.125°  lat: 0.27° - 0.53° | eORCA1L75  lon: 1°  lat: 0.3° - 1° | ORCA1L75  lon: 1°  lat: 0.3 - 1° | 1°; refined in equatorial, coastal, and polar regions | lon: 0.5°  lat: 0.25° - 0.5° | GR15L40  bipolar grid with 1.5° resolution near equator | tripolar grid  lon: 1°  lat: 0.3° - 0.5° | tripolar grid  lon: 1°  lat: 0.17° - 0.86° | eORCA1L75  lon: 1°  lat: 0.3° - 1° | ORCA2  lon: 2°  lat: 0.3° - 2° | ORCA025  lon: 0.25°  lat: 0.25° |
| **vertical layers** | 48 (v2021)  24 (v2014) | 50 | 25 | 60 | 75 | 75 | 46 | 75 | 40 | 60 | 53 | 75 | 31 | 46 |
| **Native surface area (m2)** | 3.56x1014 | 3.59x1014 | 3.60x1014 | 3.59x1014 | 3.63x1014 | 3.65x1014 | 3.64x1014 | 3.61x1014 | 3.62x1014 | 3.61x1014 | 3.60x1014 | 3.66x1014 | 3.61x1014 | 3.61x1014 |
| **Native volume (m3)** | 1.32x1018 | 1.33x1018 | 1.32x1018 | 1.32x1018 | 1.35x1018 | 1.35x1018 | 1.31x1018 | 1.33x1018 | 1.34x1018 | 1.33x1018 | 1.33x1018 | 1.35x1018 | 1.38x1018 | 1.33x1018 |
| **spin up procedure** | spun up to a seasonally cyclostationary equilibrium using Newton’s method | Initial conditions are optimized using a suite of physical and biogeochemical observations, , model biogeochemistry was spun up from 1992-1994 | Spun-up for 751 years using repeating annual cycle forcing (CORE v1 “normal year” forcing) followed by 45 years using NCEP variable forcing | 180 years with CORE forcing and 1850 pCO2,switch to JRA forcing for 14 years  Sim A: 3x cycling through JRA with historical forcing  Sim B: 3x cycling through JRA with normal year forcing and constant CO2 | spun up to preindustrial SS from GLODAPv1 + WOA databases, cycling over 1948 for atm forcing (JRA55 v1.5). | Spin up for 1403 years forced with fixed atm CO2.  Sim A/D: 183 years with interannually variable JRA55 v1.4.  Sim B/C: 183 years with climatological forcing (JRA55 v1.4) | Spun up from 1850-1957 with JRA55-do-v1.3.1, repeating year 1961. Seperate spin-ups using increasing atm CO2 (A,C) and constant atm CO2 (B,D) | Sim A: 1959 JRA-v1.3 forcing and 1959 CO2, repeat 81 years  Sim B:  1959 JRA forcing and 1850 atm CO2 (278 ppm), repeat 81 years | Spun up to preindustrial SS using previous spin-up of HAMOCC standalone version.  Sim A: spun up wit ERA20C, 1905 + 25 years | Repeat forcing (Mar1990-Apr1991) of JRA55-do for 1464 years, followed by repeat 61-year JRA55-do forcing (1958-2018) 6 times, with CO2 increasing at 198th model year (equivalent to 1850) | Spun up for 1000 years with constant CO2 using CORE I (normal year) forcing, followed by evolving CO2 and CORE I forcing from 1762-1947. | Initialized with observations in year 1836, looping full JRA55 reanalysis for 1836-1958 | Spun up from 1750-1947 with looped 1990 NCEP forcing data | initial spin-up with ½ model (ORCA05): 3 cycles under JRA-55-do from 1958 to 2018. Second spin-up with ORCA025-GEOMAR (JRA-55-do from 1958 to 2018) |
| **intial conditions** | Preindustrial CO2 based on average ice-core CO2 concentrations from 1700-1780; constant DIC, fixed alkalinity at GLODAPv2 | -- | POP2 model using Levitus data and a state of rest, carbonate chemistry from GLODAPv1 pre-industrial | POP2 model using Levitus data and a state of rest, carbonate chemistry from GLODAPv2 pre-industrial | Initialized from a previous ocean-forced simulation of NEMO3.6-PISCESv2. (simulated for over 2000 years using 1948 for atm forcing JRA55 v1.5 and preindustrial atm CO2 level) | O2, NO3, DIP, DISi (WOA13); DIC and TA (GLODAPv2) | DIC and TA (GLODAPv2); N, Si, and O2 (WOA13); Fe (PISCES) | T, S, NO3, PO4, Si, O2 (WOA13); DIC and TA (GLODAPv2); intial DIC is corrected for accumulation of Cant to match level expected in 1959 (Sim A) and 1850 (SimB) (Khatiwala et al 2013) | initialized from previously spun-up HAMOCC standalone version (standalone spin up time of 10,0000s years) | DIC and TA (GLODAPv2); temp, sal, NO3, PO4, O2 (WOA13v2, Jan) | PO4, NO3, Si, O2 (WOA09); DIC and TA (GLODAPv1) | DIC and TA (GLODAPv2) ; N, Si, and O2 (WOA13); Fe (PISCES) | Observations for T, S, NO3, PO4, Si and O2 (WOA05), TA and DIC adjusted to pre-industrial conditions (GLODAPv1), previous model results for other fields. | Levitus (1998) for T and S,  WOAv2 for PO4, O2, and NO3, GLODAPv2.2016b for preindustrial DIC and alkalinity, pre- spin-up of sea ice from a different experiment |
| **length of spin up** | Infinite | -- | 751 years (CORE) + 45 years NCEP | 180 years (CORE) + 14 years (JRA) | several hundred years | 1403 years | 1850-1957 | 81 years | several thousand years | 1661 years | 1000 years | 1836-1957 | 1750-1947 | 1714-1957 |
| **initial xCO2 (ppm)** | 277 (v21)  280 (v14) | -- | 278 | 287 | 286 | 284.32 | 278 | 278 | 296 | 284.32 | 278 | 286 | 278 | 284 |
| **Average Fsea-air from Sim B** | -0.01 (v21)  -0.00 (v14) | -- | -0.17 | 0.01 | -0.14 | 0.20 | -0.35 | -0.22 | -0.08 | 0.18 | -0.00 | -0.25 | -0.09 | -0.36 |
| **physical forcing** | SST: ERRSTv4, COBE SST, HadSST Winds: NCEP | adjusted ERA-interim through ECCO optimization, 6 hourly | NCEP (CDC) & CORE | JRA-55 v1.3 | NCEP-2, COREII | JRA55 v1.4, 55km horizontal, 3 hourly | JRA55-do v1.3.1, 55km hortizontal, 3-hourly (repeat 1961 for B and C) | JRA55-do v1.4, 55km horizontal, 3 hourly | 1901-1947: ERA20C 6-hourly  1948-onward: NCEP 6-hourly  (repeat 1957 for Sim B) | Sim A: JRA55-do v1.5.0, 3 hourly  Sim C: repeat year forcing from May 1990 to Apr 1991 of JRA55-do v1.5.0 | NCEP1 reanalysis with CORE forcing corrections (Schwinger et al. 2016) | JRA55 v1.4 | NCEP daily reanalysis data | Sim A,D: JRA55-do v1.4, 3 hourly  Sim B,C: repeat year forcing from May 1990 to Apr 1991 of JRA55-do v1.4 |
| **atm CO2** | 1958-present: monthly  xCO2 from South Pole, American Samoa, Mauna Loa, Alaska  1780-1958: Law Dome ice core xCO2 | zonally-averaged, monthly (varying grid spacing by lat)  NOAA MBL | spatially uniform atmospheric CO2, pre-1958 Law Dome ice core; post-1958 Mauna Loa CO2 record | pre-1958: ice core xCO2 (Joos and Spahni, 2008)  1958-1979:monthly  xCO2 from Mauna Loa and South Pole 1979–:  Monthly xCO2 from multiple stations (Ballantyne et al 2012) | annual, global mean  xCO2  (Friedlingstein et al. 2022) | annual, global mean  input4MIP | monthly, global mean  xCO2 (Friedlingstein et al. 2022) | monthly, global mean  xCO2 (Friedlingstein et al. 2022) | N/A | annual, global mean  CMIP6 protocol, annual mean values linearly interpolated in time | monthly, global mean  xCO2  (Friedlingstein et al. 2022) | annual, global mean  xCO2  (Friedlingstein et al. 2022) | global monthly mean  xCO2  (Friedlingstein et al. 2022) | annual, global mean  xCO2 (Meinshausen et al., 2017). Values after 2015 are extrapolated based on the difference between 2014 and 2015. |
| **Kw parameters** | a = 0.262, 1-fice | a = 0.31 (Wanninkhof 1992), 1-fice | a = 0.31 (Wanninkhof 1992), 1-fice | a = 0.31 (Wanninkhof 1992), 1-fice | a = 0.251 (Wanninkhof 2014), 1-fice | a = 0.31 (Wanninkhof 1992), 1-fice | a = 0.251 (Wanninkhof 2014), 1-fice | a = 0.31 (Wanninkhof 2014), 1-fice | a = 0.251 (Wanninkhof 2014), 1-fice | a = 0.251 (Wanninkhof 2014), 1-fice | a = 0.337 (OCMIP2 protocol), 1-fice | a = 0.251 (Wanninkhof 2014), 1-fice | a = 0.31 (Wanninkhof 1992), 1-fice | a = 0.251 (Wanninkhof 2014), 1-fice |
| **Fland-sea (PgC yr-1)** | 0 | -1.29 | 0 | 0.08 | -0.13 | 0.14 | 0 | -0.02 | N/A | 0 | -0.54 | 0.02 | 0 | -0.34 |
| **Riverine source** | 0 | 0 | 0 | 0.33 | 0.61 | 0.61 | 0 | 0.18 | N/A | 0 | 0 | 0.61 | 0.72 | 0 |
| **Carbon burial** | 0 | 1.29 | 0 | 0.25 | 0.74 | 0.47 | 0 | 0.20 | N/A | 0 | 0.54 | 0.59 | 0.72 | 0.34 |
| **Simulations** | A, B, C (2) | A | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D | A, B | A, B(1), C(1), D(1) | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D |
| **Time period covered** | 1980-2018(2) | 1995-2018 | 1980-2017 | 1980-2018 | 1980-2018 | 1980-2018 | 1980-2018 | 1980-2018 | 1980-2019 | 1980-2018 | 1980-2018 | 1980-2018 | 1980-2018 | 1980-2018 |
| **AMOC (Sv)** | 19 | 12-14 | 22 | 3.04 | 17.03 | 15-18 | 8-12 | 17 +/- 3 | 16.75 | 13-14 | 23-24 | 16 +/- 1.3 | N/A | 13.3 |

(1)B-D have different forcing from A, so A is not combined with B-D in any analysis

(2) v2014 only goes to 2017, and simulations A and C are equivalent in this model

**Table S2: Details of pCO2 products**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Product name** | AOML\_EXTRAT | CMEMS-LSCE-FFNN | CSIR-ML6 | JenaMLS | JMAMLR | LDEO-HPD | MPI-SOMFFN | OceanSODAETHZ | UOEX\_Wat20 | Takahashi update (2010) | NIES-MLR3 |
| **version** | v20211018 | v20210709 | v2020b | v2021 | v20211208 | v20211210 | v20211121 | v20211207 | v20211204 | v2021 | v202011 |
| **references** | main paper in prep (Wanninkhof et al., 2023) | Chau et al. (2022) | Gregor et al. (2019) | Rödenbeck et al. (2013); Rödenbeck et al. (2022) | Iida et al. (2021) | Gloege et al. (2022) | Landschützer et al. (2016) | Gregor and Gruber (2021) | Watson et al. (2020) | Takahashi et al. (2009), DSRII; updated publication in prep (Fay et al., 2023) | Zeng et al. (2022) |
| **Interpolation method** | Extra Trees regressors | An ensemble of 100 feed-forward neural network models | Ensemble of clustering-regression approaches | Hybrid approach combining ocean biogeochemical mixed-layer model with linear regression and optimal interpolation | Multiple linear regression | Hybrid approach combining GOBMs and EXtreme Gradient Boosting (XGB) algorithm | Clustering-regression approach with self-organizing map (SOM) and feed-forward neural network (FFN) | Ensemble of clustering-regression approaches | SOM-FFN (Landschutzer et al., 2016) with adjustments for clustering variables and datasets | Time normalization to a reference year, spatiotemporal binning, advection-diffusion scheme to gap fill | Ensemble of Random Forest, Gradient Boost Machine, and Feedforward Neural Network |
| **sea surface pCO2 data** | SOCATv2020; monthly, 1°x1° | SOCATv2020; monthly, 1°x1° | SOCATv5; monthly, 1°x1° | SOCATv2021 | SOCATv2019 | SOCATv2019; monthly, 1°x1° | SOCATv2020 | SOCATv2019 | SOCATv2019 temperature-corrected to subskin temperature (Goddijn-Murphy et al., 2015) | SOCATv2020 | SOCATv2021 |
| **Kw formulation** | Wanninkhof (2014) with a = 0.251; scaled by 1-fice | Wanninkhof (2014); a adjusted for global mean piston velocity = 16.5 cm/h; scaled by 1-fice | Wanninkhof (1992) with a = 0.276; scaled by 1-fice | Wanninkhof (1992); a adjusted for global mean piston velocity = 16.5 cm/h; scaled by 0.9(1-fice)+0.1 | Wanninkhof (2014) with a = 0.259; global mean piston velocity = 15.8 cm/h, only in ice-free ocean | Wanninkhof (1992) with Schmidt number from Wanninkhof (2014); scaled to bomb 14C (Fay et al., 2021); scaled by 1-fice | Wanninkhof (1992); a adjusted for global mean piston velocity = 16cm/h; scaled by 1-fice | Wanninkhof (1992); scaled by 1-fice | Nightingale et al. (2000); global mean piston velocity = 14.73 cm/h; scaled by 1-fice | Wanninkhof (1992); a varies from 0.261 to 0.276 following Wanninkhof (2014) | Wanninkhof (2014) with a = 0.271 |
| **SST** | OISST | CMEMS | OISST | Hadley EN.4.2.1 (g10) | MGDSST | OISST | NOAA OISST | OSTIA | NOAA OISST v2, reduced by 0.17°C to calculate Schmidt number | NOAA OISST | COBE-SST |
| **SSS** | HYCOM | CMEMS | EN4 | WOA 2001 | MOVE/MRI.COM-G2 | EN4 | EN4 | SODA | 1992-2018: ECCO2 increased by 0.1 psu for skin effect;  1985-1991: ECCO2 monthly climatology for 1992-1995 | EN4 | WOA18 |
| **wind-speed** | ERA5 | ERA5 | ERA5 | JRA55-do v1.5.0 | JRA55 | CCMP2, ERA5, JRA55 | ERA5 | average of ERA5, JRA55, and NCEP1 | CCMP (1988-); for years 1985-1987, monthly mean wind climatology calculated for 1988-1991 was used | average of products using CCMPv2, ECMWF 5th generation, and JRA55 | ERA5 Monthly mean |
| **sea-ice fraction** | NOAA OISST | OSTIA/CMEMS product | NOAA OISST | HADISST.2.2.0.0 | -- | NOAA OISST | HadISST | OSTIA | NOAA OISST | NOAA OISST |  |
| **pCO2atm** | xCO2 from NOAA MBL; water vapor correction from Pierrot et al. (2009) | xCO2 from CAMS inversion; sea level pressure from ERA5; water vapor correction from Weiss and Price (1980) | xCO2 from NOAA MBL; sea level pressure from ERA5; water vapor correction from Dickson et al. (2007) | xCO2 from Jena CarboScope version sEXTALL\_v2021; sea level pressure from JRA55-do v1.5.0; water vapor correction from Weiss and Price (1980) | xCO2 from JMA-GSAM; sea level pressure from JRA55; assumed 100% humidity | xCO2 from NOAA MBL; sea level pressure from ERA5; water vapor correction from Dickson et al. (2007) | xCO2 from NOAA MBL; sea level pressure from NCEP; water vapor correction from Dickson et al. (2007) | xCO2 from NOAA MBL; sea level pressure from ERA5; water vapor correction from Dickson et al. (2007) | xCO2 from NOAA MBL; sea level pressure from NCEP/NCAR; water vapor correction from Cooper et al. (1998) | xCO2 from NOAA MBL; sea level pressure from ERA5; water vapor correction from Dickson et al. (2007) | xCO2 from NOAA MBL; sea level pressure from ERA5; water vapor correction from Weiss & Price (1980) |
| **Native surface area(a)** | 3.67x108 km2 | 3.48x108 km2 | 3.64x108 km2 | 3.91x108 km2 | 3.32x108 km2 | N/A | 3.48x108 km2 | N/A | 3.48x108 km2 | 3.20x108 km2 | N/A |
| **Time period** | 1997-2020 | 1985-2018 | 1985-2018 | 1985-2018 | 1985-2019 | 1985-2018 | 1982-2019 | 1985-2018 | 1985-2019 | Reference year of 2010 | 1980-2020 |

(a) Areas from Fay et al. (2021). May vary slightly from one month to another based on input data availability.

**Table S3: Comparison of global and regional fluxes from this study (“Global chapter”) and the regional RECCAP2 analyses**

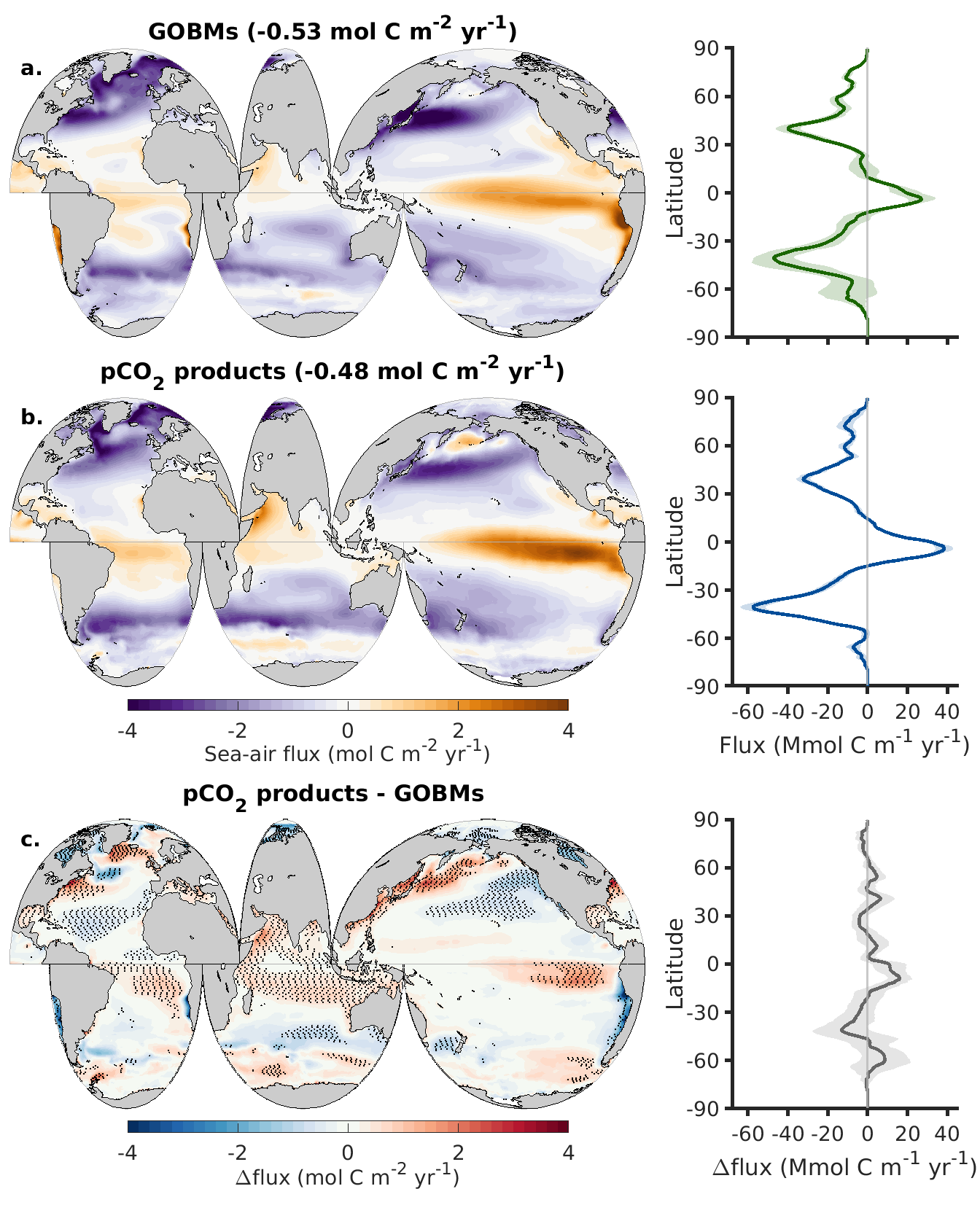
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Mean sea-to-air flux [PgC yr-1]** | | | |
|  |  | **GOBMs / ROBMs1 (Sim A - Trend Sim B)2** | | **pCO2 products** | |
| **Region3** | **Period4** | **Regional chapter estimate** | **Global chapter estimate** | **Regional chapter estimate** | **Global chapter estimate** |
| **Global Ocean (this study)** | **1985-2018** | NA | -2.11 ± 0.25 | NA | -1.64 ± 0.21 |
| **1985-2000** | NA | -1.89 ± 0.24 | NA | -1.30 ± 0.39 |
| **2001-2018** | NA | -2.31 ± 0.26 | NA | -1.88 ± 0.17 |
| **2000-2009** | NA | -2.12 ± 0.26 | NA | -1.57 ± 0.20 |
| **2010-2018** | NA | -2.47 ± 0.27 | NA | -2.14 ± 0.18 |
| **1990-2009** | NA | -2.05 ± 0.25 | NA | -1.48 ± 0.25 |
| **Atlantic Ocean** | **1985-2018** | -0.47 ± 0.15 | -0.47 ± 0.15 | -0.37 ± 0.06 | -0.36 ± 0.06 |
| **1985-2000** | -0.43 ± 0.15 | -0.44 ± 0.15 | -0.30 ± 0.09 | -0.28 ± 0.11 |
| **2001-2018** | -0.50 ± 0.15 | -0.51 ± 0.15 | -0.43 ± 0.05 | -0.42 ± 0.05 |
| **2000-2009** | -0.48 ± 0.15 | -0.48 ± 0.15 | -0.37 ± 0.05 | -0.36 ±0.05 |
| **2010-2018** | -0.53 ± 0.15 | -0.53 ± 0.15 | -0.48 ± 0.05 | -0.47 ± 0.05 |
| **1990-2009** | -0.46 ± 0.15 | -0.46 ± 0.15 | -0.33 ± 0.07 | -0.33 ± 0.07 |
| **Pacific Ocean** | **1985-2018** | -0.47 ± 0.15 | -0.50 ± 0.15 | -0.36 ± 0.12 | -0.35 ± 0.11 |
| **1985-2000** | -0.42 ± 0.15 | -0.45 ± 0.14 | -0.28 ± 0.17 | -0.26 ± 0.17 |
| **2001-2018** | -0.52 ± 0.16 | -0.54 ± 0.16 | -0.42 ± 0.10 | -0.42 ± 0.10 |
| **2000-2009** | -0.42 ± 0.15 | -0.44 ± 0.16 | -0.32 ± 0.11 | -0.33 ± 0.10 |
| **2010-2018** | -0.60 ± 0.16 | -0.63 ± 0.16 | -0.47 ± 0.10 | -0.48 ± 0.10 |
| **1990-2009** | -0.45 ± 0.15 | -0.48 ± 0.15 | -0.30 ± 0.13 | -0.32 ± 0.12 |
| **Indian Ocean (Sarma et al., 2023)** | **1985-2018** | -0.21 ± 0.102 | -0.25 ± 0.08 | -0.13 ± 0.04 | -0.10 ± 0.04 |
| **1985-2000** | -0.19 ± 0.103 | -0.23 ± 0.08 | -0.11 ± 0.05 | -0.08 ± 0.07 |
| **2001-2018** | -0.23 ± 0.102 | -0.26 ± 0.08 | -0.15 ± 0.05 | -0.12 ± 0.04 |
| **2000-2009** | -0.22 ± 0.104 | -0.26 ± 0.08 | -0.13 ± 0.04 | -0.10 ± 0.05 |
| **2010-2018** | -0.23 ± 0.102 | -0.27 ± 0.08 | -0.17 ± 0.05 | -0.14 ± 0.04 |
| **1990-2009** | -0.21 ± 0.102 | -0.24 ± 0.08 | -0.12 ± 0.04 | -0.09 ± 0.06 |
| **Southern Ocean (Hauck et al., 2023b)** | **1985-2018** | -0.75 ± 0.28 | -0.75 ± 0.31 | -0.73 ± 0.07 | -0.75 ± 0.07 |
| **1985-2000** | -0.63 ± 0.28 | -0.64 ± 0.31 | -0.62 ± 0.08 | -0.61 ± 0.09 |
| **2001-2018** | -0.85 ± 0.29 | -0.84 ± 0.31 | -0.82 ± 0.08 | -0.83 ± 0.09 |
| **2000-2009** | -0.79 ± 0.28 | -0.79 ± 0.31 | -0.71 ± 0.07 | -0.70 ± 0.08 |
| **2010-2018** | -0.90 ± 0.29 | -0.88 ± 0.31 | -0.95 ± 0.10 | -0.96 ± 0.11 |
| **1990-2009** | -0.72 ± 0.28 | -0.72 ± 0.30 | -0.68 ± 0.06 | -0.67 ± 0.06 |
| **Arctic Ocean (Yasunaka et al., 2023)** | **1985-2018** | -0.09 ± 0.03 | -0.10 ± 0.03 | -0.12 ± 0.00 | -0.11 ± 0.05 |
| **1985-2000** | -0.08 ± 0.03 | -0.09 ± 0.03 | -0.09 ± 0.02 | -0.09 ± 0.05 |
| **2001-2018** | -0.10 ± 0.03 | -0.10 ± 0.03 | -0.14 ± 0.01 | -0.12 ± 0.06 |
| **2000-2009** | -0.10 ± 0.03 | -0.10 ± 0.03 | -0.13 ± 0.01 | -0.11 ± 0.05 |
| **2010-2018** | -0.10 ± 0.03 | -0.11 ± 0.04 | -0.16 ± 0.01 | -0.13 ± 0.06 |
| **1990-2009** | -0.09 ± 0.03 | -0.10 ± 0.03 | -0.11 ± 0.01 | -0.10 ± 0.05 |

1 ROBMs = Regional Ocean Biogeochemical Models (used in some RECCAP2 regional chapters, but not this study)

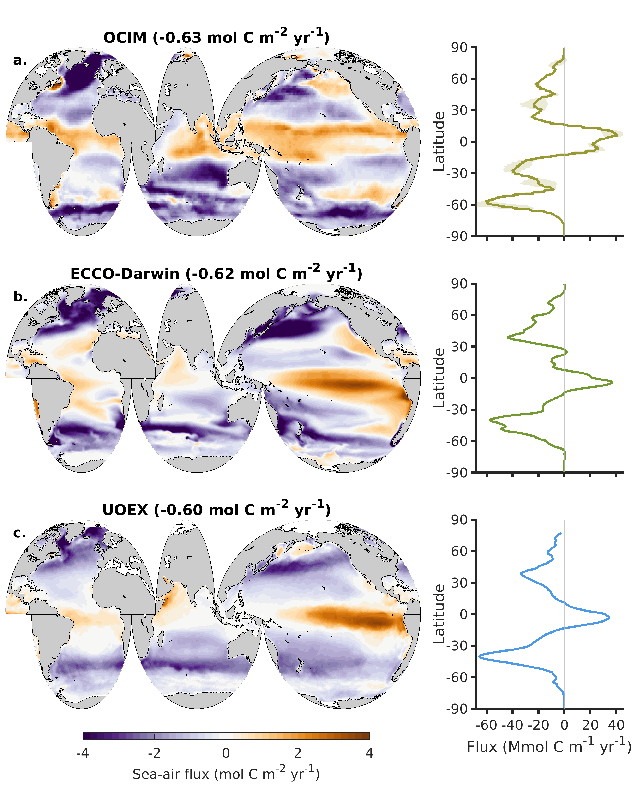
2 Only the linear trend in Sim B is subtracted, rather than the entire flux in Sim B as done throughout the rest of this study (e.g. Table 2 and 3 in main text). This is to facilitate comparison with the regional estimates, which only subtract the trend in Sim B. At the regional scale, subtracting the entire Sim B would remove the steady-state flux component (Fsea-air,ss) which is not desired. Fsea-air,ss integrates to zero at the global scale. However, the mean global flux of Sim B in the GOBMs is -0.11 PgC/yr due to model drifts.

3 The surface area of each ocean basin is defined by v20221025 of the RECCAP2-ocean basin mask: <https://reccap2-ocean.github.io/regions/>

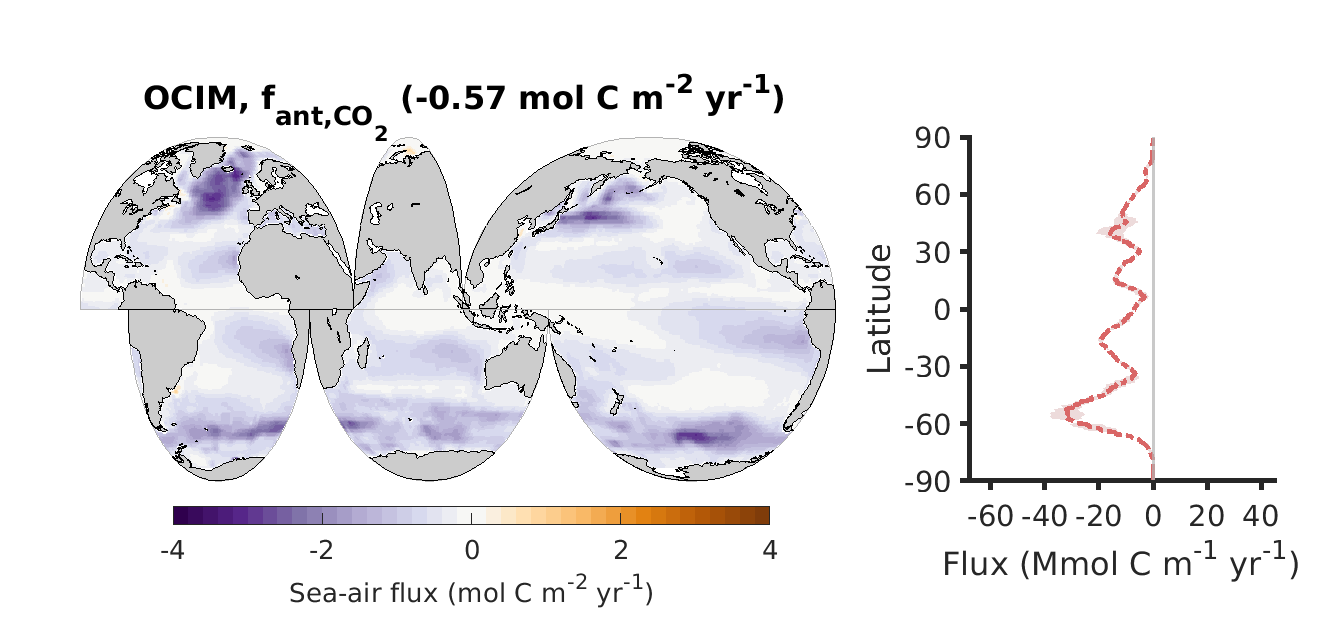
4 All time periods start in January, 1 of the first and end in December, 31 of the second year.

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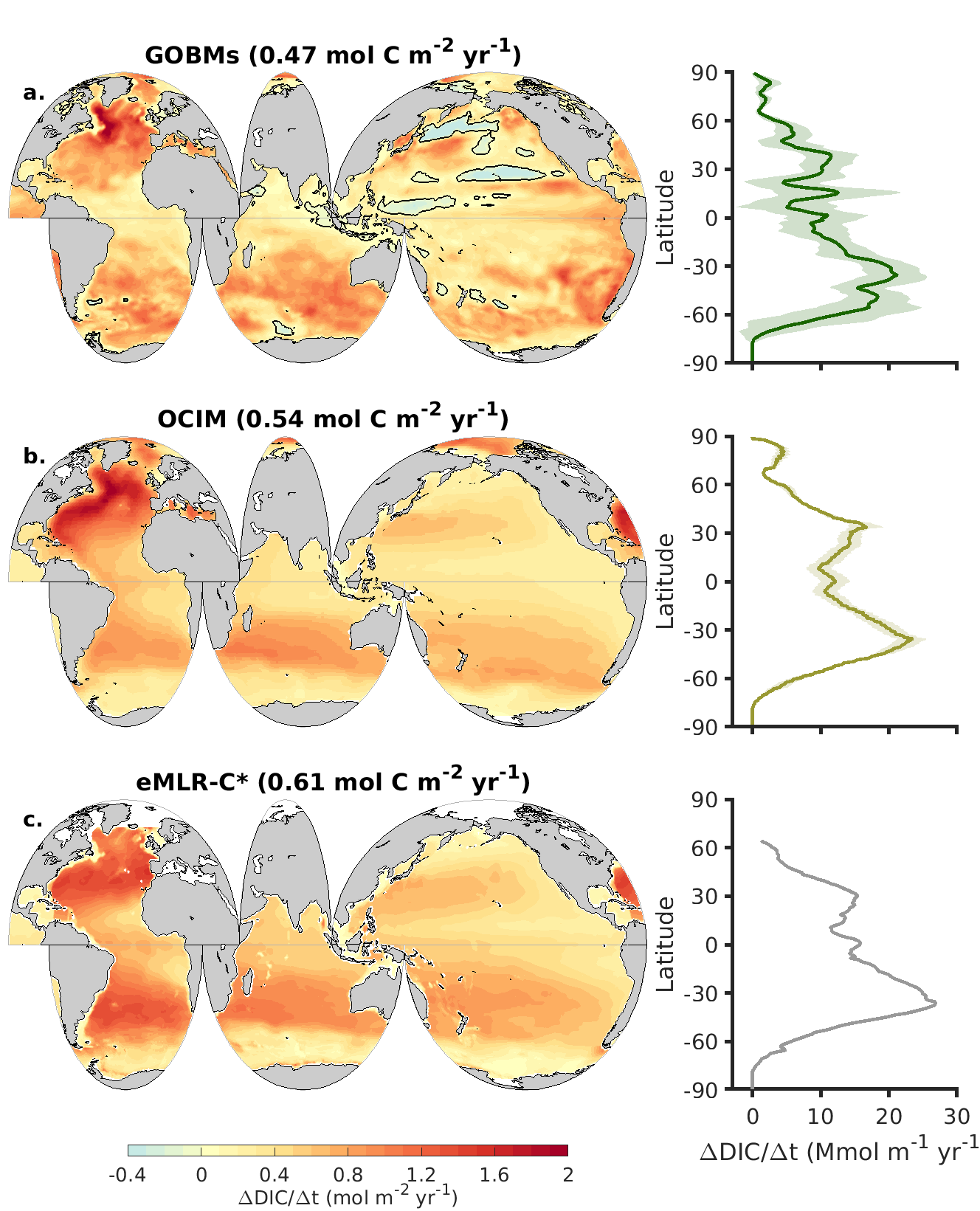
**Figure S1:** Like Figure 1 but for the period 2005-2015.



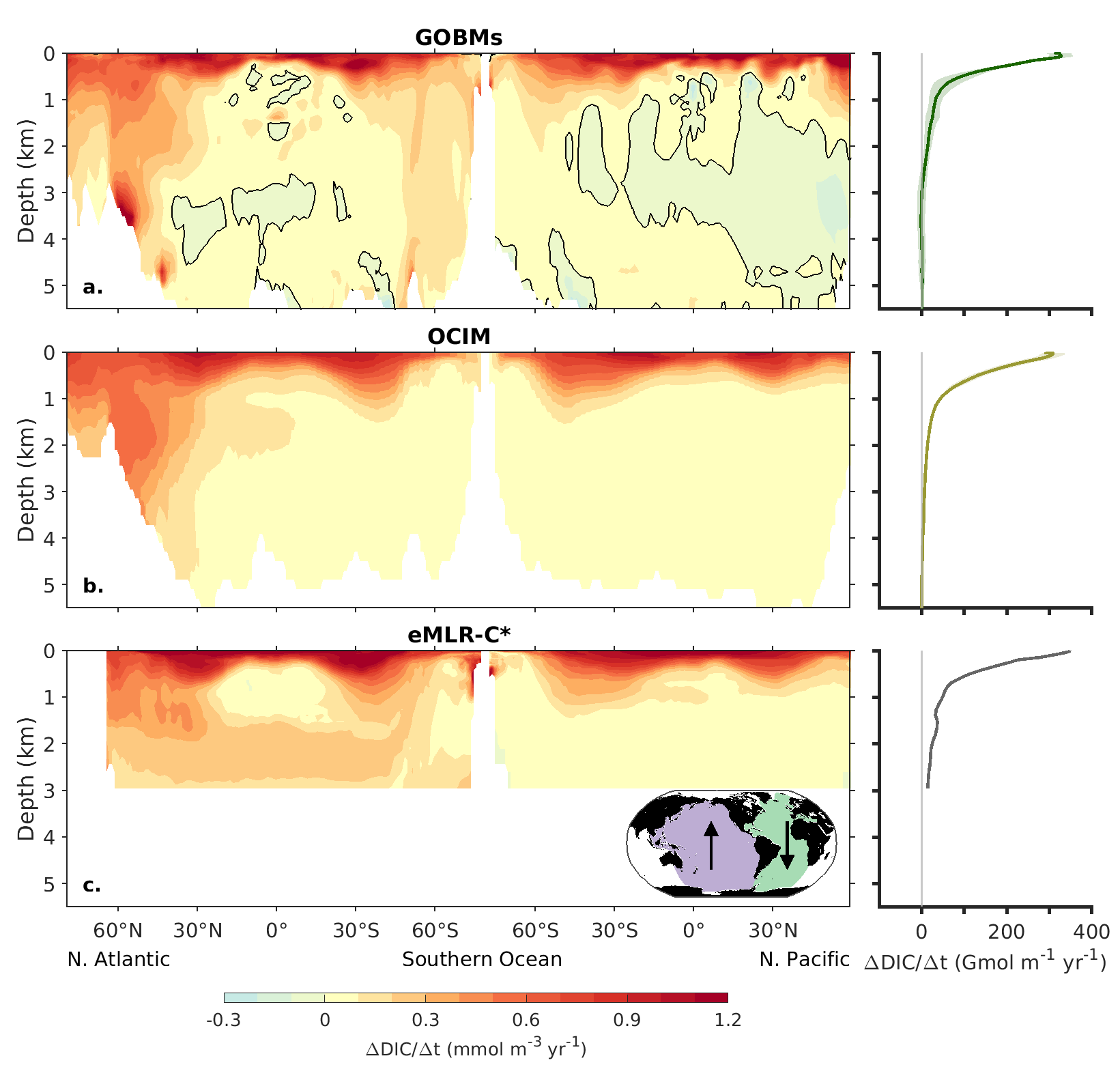
**Figure S2:** Like Figure S1a-b but for the (a) OCIM, (b) ECCO-Darwin, and (c) UOEX products sea-air CO2 flux for the 2005-2015 period.



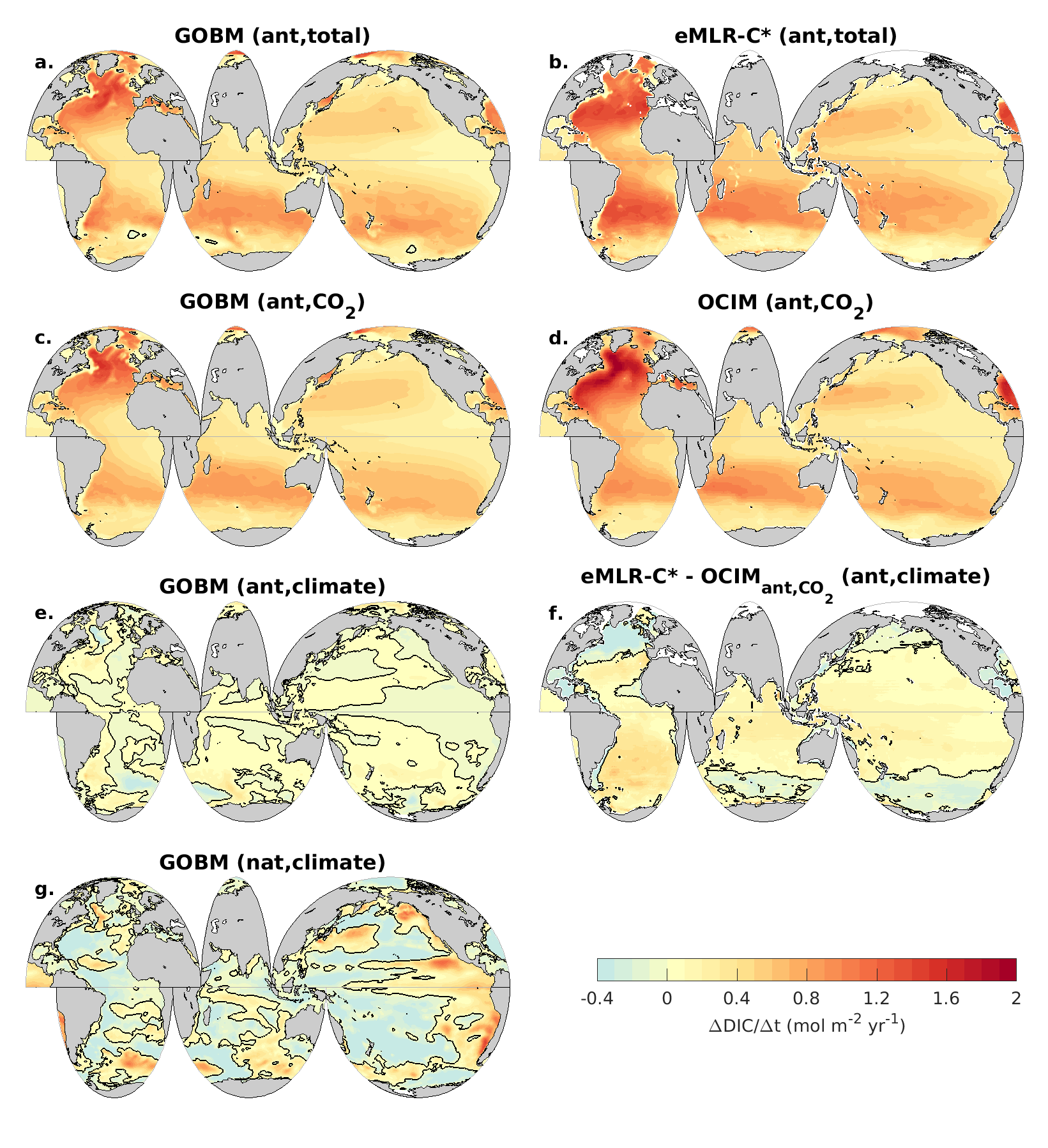
**Figure S3:** Sea-air anthropogenic CO2 fluxes from the OCIM averaged over 1985-2018. Compare with GOBMs in Figure 3b.



**Figure S4:** Like Figure 5 but for the period 1994-2007.



**Figure S5:** Like Figure 6 but for the period 1994-2007.



**Figure S6:** Like Figure 7 but for the period 1994-2007.