



*Geophysical Research letters*

Supporting Information for

**Observed Regional Fluxes to Constrain Modeled Estimates of the Ocean Carbon Sink**

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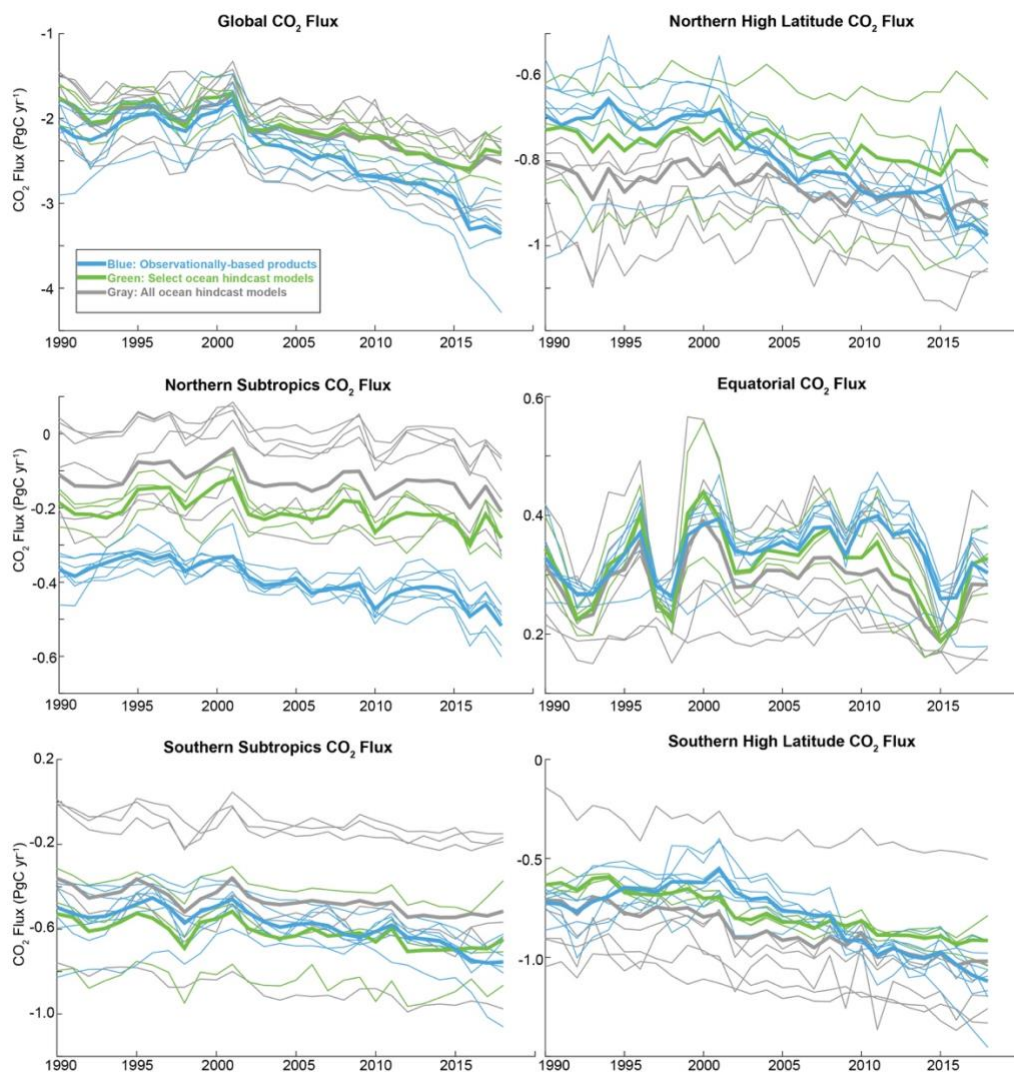
Text S1

Figures S1

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### Text S1.

Globally and in the equatorial and subtropical regions, the ensemble of the observation-based products and the ensemble of models are in good agreement with regard to the phasing of interannual variability, both prior to and after selection (Supplementary Figure 1). The high latitudes show limited agreement in either case. Selection does not significantly change interannual correlations (Supplementary Table 7).



**Figure S1.** Time series for global and regionally-integrated air-sea CO<sub>2</sub> fluxes (PgC/yr) from an ensemble of observation-based products (blue) and hindcast ocean models (gray and green), years 1990-2018. Thin lines are individual ensemble members while

bold lines show mean for the products (blue), the full ensemble of models (gray) and the selected models (green).

#### Observation-based pCO<sub>2</sub> products

Name	Reference
CMEMS-FFNN	<i>Denvil-Sommer et al. 2019 Chau et al. 2020</i>
CSIR-ML6	<i>Gregor et al. 2019</i>
Jena-MLS	<i>Rödenbeck et al. 2013</i>
JMA-MLR	<i>Iida et al. 2020</i>
LDEO-HPD	<i>Gloeger et al. 2021</i>
MPI-SOMFFN	<i>Landschützer et al. 2014 Landschützer et al. 2020a</i>
NIES-FNN	<i>Zeng et al. 2014</i>

#### Hindcast Ocean Models

Name	Reference	Selected
CESM-ETHZ	<i>Doney et al. 2009</i>	Yes
CNRM-ESM2-1	<i>Berthet et al. 2019</i>	No
CSIRO	<i>Law et al. 2017</i>	No
FESOM-1.4-REcoM2	<i>Hauck et al. 2020</i>	No
MOM6-COBALT (Princeton)	<i>Liao et al. 2020</i>	No
MPIOM-HAMOCC6	<i>Paulsen et al. 2017</i>	No
NEMO-PISCES (IPSL)	<i>Aumont et al. 2015</i>	Yes
NEMO-PlankTOM5	<i>Buitenhuis et al. 2010</i>	Yes
NorESM-OCv1.2	<i>Schwinger et al. 2016</i>	No

**Table S1.** Observation-based pCO<sub>2</sub> products and Hindcast Ocean Model names and references

Region	Percent of river efflux	River flux adjustment (% * 0.49PgC/yr)
Northern High Latitudes	10.3%	0.051 PgC yr <sup>-1</sup>
Northern Subtropics	27.2%	0.133 PgC yr <sup>-1</sup>
Equatorial	3.7%	0.018 PgC yr <sup>-1</sup>
Southern Subtropics	35%	0.172 PgC yr <sup>-1</sup>
Southern High Latitudes	6.2%	0.030 PgC yr <sup>-1</sup>

**Table S2.** River adjustment from Lacroix et al. (2020)

Region	Lacroix % of river efflux	Aumont % of river efflux
90N-20N	34%	26%
20N-20S	45%	25%
20S-90S	21%	49%

**Table S3.** River adjustment from Lacroix et al. (2020) for latitude bounds as defined by Aumont et al. (2001).

	Products	Products natural outgassing due to rivers	3 $\sigma$ Product spread	Models	Select Models
Global	-1.94 $\pm$ 0.32	-2.43 $\pm$ 0.85	-3.36; -1.50	-2.15 $\pm$ 0.64	-2.11 $\pm$ 0.42
N High Latitudes	-0.74 $\pm$ 0.13	-0.79 $\pm$ 0.17	-1.01; -0.58	-0.86 $\pm$ 0.25	-0.77 $\pm$ 0.34
N Subtropics	-0.26 $\pm$ 0.04	-0.40 $\pm$ 0.18	-0.62; -0.17	-0.13 $\pm$ 0.22	-0.77 $\pm$ 0.09
Equatorial	0.35 $\pm$ 0.08	0.33 $\pm$ 0.10	0.21; 0.46	0.29 $\pm$ 0.14	0.32 $\pm$ 0.10
S Subtropics	-0.41 $\pm$ 0.16	-0.58 $\pm$ 0.34	-0.95; -0.21	-0.47 $\pm$ 0.60	-0.62 $\pm$ 0.45
S High Latitudes	-0.77 $\pm$ 0.10	-0.80 $\pm$ 0.13	-0.95; -0.65	-0.87 $\pm$ 0.48	-0.21 $\pm$ 0.07

**Table S4** Global and regionally integrated air-sea CO<sub>2</sub> flux in PgC/yr for 7 observation-based products, products with river carbon efflux adjustment, all nine models, and select three models. Uncertainty ( $\pm$ ) represents 2 $\sigma$  spread. Middle column shows the 3 $\sigma$  bounds on the product ensemble; this is used for the model selection criteria.

	Observation-based Products	Products with natural outgassing due to rivers	Hindcast Models	Select Models
Global	7%	13%	15%	10%
NH High Latitudes	8%	9%	15%	22%
NH Subtropics	5%	19%	88%	23%
Equatorial	12%	13%	24%	15%
SH Subtropics	14%	21%	65%	36%

SH High Latitudes	6%	6%	28%	5%
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**Table S5** Coefficient of Variability (CoV) for global and regionally integrated air-sea CO<sub>2</sub> fluxes.

	Models	Select Models
Northern High Latitudes	0.47	0.37
Northern Subtropics	0.12	0.09
Equatorial	0.04	0.04
Southern Subtropics	0.29	0.22
Southern High Latitudes	0.79	0.51

**Table S6** Seasonal RMSE mean between ensemble of products and models or select models over five regions.

	Products: Models	Products: Select Models
Global	<b>0.71</b>	<b>0.64</b>
N High Latitudes	0.25	0.06
N Subtropics	<b>0.86</b>	<b>0.82</b>
Equatorial	<b>0.85</b>	<b>0.86</b>
S Subtropics	<b>0.50</b>	<b>0.53</b>
S High Latitudes	0.22	0.11

**Table S7** Correlations for detrended CO<sub>2</sub> flux time series, between the product ensemble mean and that from all models and only select models. Values in bold are significant at the 95% confidence level (student t-test with  $p < 0.05$ ).