

*Global Biogeochemical Cycles*

Supporting Information for

**Quantifying errors in observationally-based estimates of ocean carbon sink variability**

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Air-sea CO2 flux ($F\_{CO\_{2}}$) is calculated in mol C m-2 yr-1 for each month at each 1°x1° spatial location using the [(Wanninkhof, 1992)](https://www.zotero.org/google-docs/?DiEkKU) parameterization (Equation 1).

$$\bar{F\_{CO\_{2}}}=\bar{k\_{w}}\bar{S\_{CO\_{w}}}(1-\bar{f\_{ice}})(\bar{pCO\_{2,atm-moist}}-\bar{pCO\_{2,ocean}}) Equation 1\_{}$$

which parameterizes $F\_{CO\_{2}}$ as a function of the gas transfer velocity ($k\_{w}$), CO2 solubility ($S\_{CO\_{2}}$), ice fraction ($f\_{ice}$), and partial pressure of CO2 in moist air ($pCO\_{2,atm-moist}^{}$) and surface ocean ($pCO\_{2,ocean}$). Overbars denote monthly averages. We use the [(Wanninkhof, 1992)](https://www.zotero.org/google-docs/?WcNCDm) gas transfer velocity with the [(Sweeney et al., 2007)](https://www.zotero.org/google-docs/?mPlyW0) scale factor of 0.27 (Equation 2).

$$\bar{k\_{w}}=0.27(\bar{u}^{2}+\bar{u^{'2}}) (\bar{Sc}/660)^{-0.5} Equation 2$$

Because high-frequency output is not available for all large ensemble members, and to be consistent with the flux calculation used in the real-world application of the SOM-FFN flux product, we use ERA-interim 6-hourly global atmospheric reanalysis [(Dee et al., 2011)](https://www.zotero.org/google-docs/?XpoLNa) as an estimate for the wind-speed variance ($\bar{u'^{2}}$).

Solubility is calculated following [(Weiss, 1974)](https://www.zotero.org/google-docs/?Y4jFy8) with the [(Wanninkhof, 1992)](https://www.zotero.org/google-docs/?0hm7Cj) Schmidt number (Sc). Partial pressure of moist air ($pCO\_{2,atm-moist}$) is calculated following Equation 3.

$$pCO\_{2,atm-moist}=xCO\_{2}(P\_{atm }-pH\_{2}O) Equation 3$$

Where $xCO\_{2}$is the dry air mixing ratio of atmospheric CO2, $P\_{atm }$ is the total atmospheric pressure, and $pH\_{2}O$ is the saturation vapor pressure [(Dickson et al., 2007)](https://www.zotero.org/google-docs/?Ys4wQ4).

Figure S1. The average seasonal cycle (gray) and decadal component (black) is displayed across A) 35°N - 90°N and B) 35°S - 35°N. Note different y-axis scales.

[Dee, D. P., et al. (2011). The ERA-Interim reanalysis: Configuration and performance of the data assimilation system. *Quarterly Journal of the Royal Meteorological Society*, *137*(656), 553–597.](https://www.zotero.org/google-docs/?mrmQ2U) <https://doi.org/10.1002/qj.828>

[Dickson, A. G., Sabine, C. L., Christian, J. R., Bargeron, C. P., & North Pacific Marine Science Organization (Eds.). (2007). *Guide to best practices for ocean CO2 measurements*. North Pacific Marine Science Organization.](https://www.zotero.org/google-docs/?mrmQ2U)

[Sweeney, C., Gloor, E., Jacobson, A. R., Key, R. M., McKinley, G., Sarmiento, J. L., & Wanninkhof, R. (2007). Constraining global air-sea gas exchange for CO2 with recent bomb 14C measurements. *Global Biogeochemical Cycles*, *21*(2).](https://www.zotero.org/google-docs/?mrmQ2U)

[Wanninkhof, R. (1992). Relationship between wind speed and gas exchange over the ocean. *Journal of Geophysical Research: Oceans*, *97*(C5), 7373–7382.](https://www.zotero.org/google-docs/?mrmQ2U)

[Weiss, R. F. (1974). Carbon dioxide in water and seawater: The solubility of a non-ideal gas. *Marine Chemistry*, *2*(3), 203–215. https://doi.org/10.1016/0304-4203(74)90015-2](https://www.zotero.org/google-docs/?mrmQ2U)