

*Global Biogeochemical Cycles*

Supporting Information for

**The impact of changing wind speeds on gas transfer and its effect on global air-sea CO2 fluxes**

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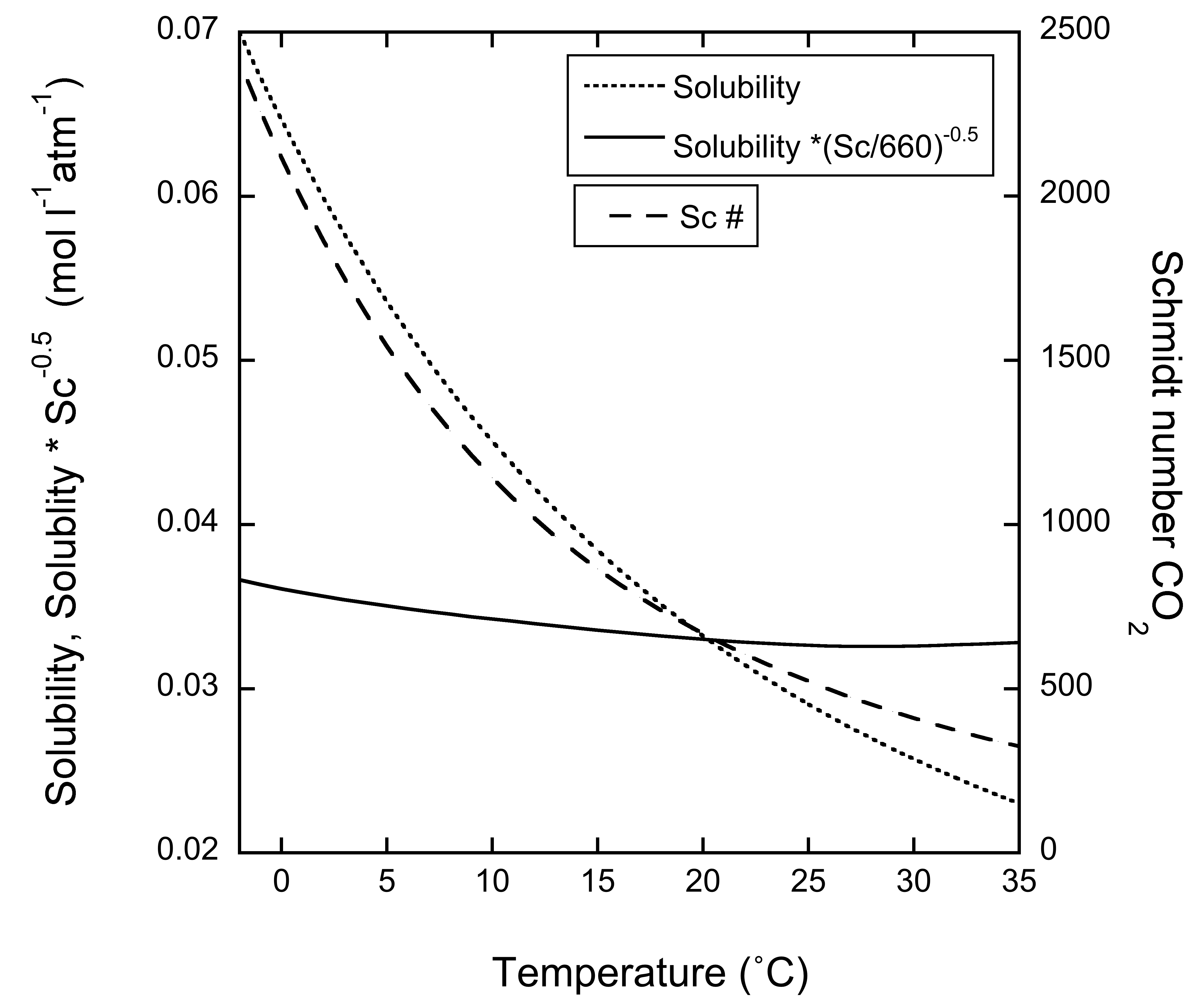
**Introduction**

Supplement 1 provides the temperature trend of solubility and Schmidt number of CO­2that are used to determine the global air-sea CO2 fluxes as described in the main text. Supplement 2 provides statistical information on the trend calculations for the global ocean and specific regions discussed in the text. Supplement 3 gives the trends in the enhancement factor of wind speed variability.

**Supplementary material**

Supplement 1

Plot of solubility, s, Schmidt number of CO2, ScCO2, and the product (ScCO2)-1/2 s. Both Sc and s of CO2 are strong decreasing functions with temperature. However, the effect of temperature on s and (ScC02)-1/2 is opposite. Therefore, the product of k and s only has a weak dependence on temperature.



**Figure S1.** Schmidt number, Sc (right axis), solubility, s (left axis), and (Sc-0.5 s) (left axis) of CO2 versus temperature.

Supplement 2

Table S1 provides a summary of the trends in wind parameters, gas exchange coefficient,  and air-sea flux of CO2 for the global ocean and select regions discussed in the text. The normal font provides the linear trend of the parameters, while the italicized text indicates the root-mean-square error (St error) of the deviation from the linear fit.

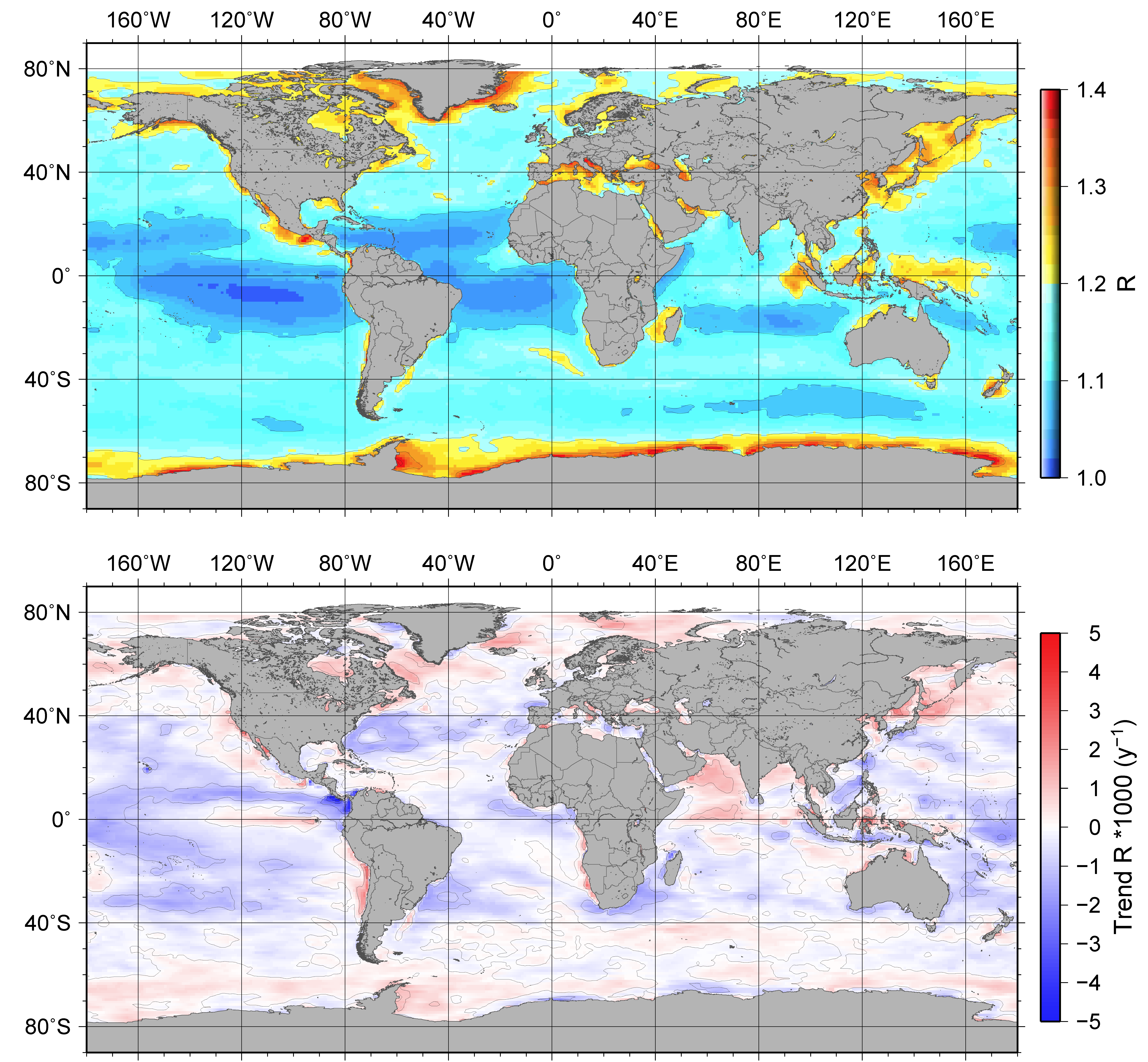
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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Table S1**. Summary of the trends in wind parameters, gas exchange coefficient, Γ, and flux for the global ocean and select regions discussed in the text. | | | | | | | |
| **Region** | **<u>**  m s-1dec-1 | **<u2>**  (m s-1)2 dec-1 | **<u3>**  (m s-1)3dec-1 | ** (quadr)**  mol m-2 µatm | ** (hybrid)**  mol m-2 µatm | **Flux (quadr)**  Pg C y-1dec-1 | **Flux (hybrid)**  Pg C y-1dec-1 |
| **Global** | 0.14 | 2.16 | 30.5 | .0015 | .0014 | 0.0155 | -0.00137 |
| *St error* | *0.018* | 0.288 | *4.2* | *2.12 10-4* | *2.05 10-4* | *0.0089* | 0*.0095* |
|  |  |  |  |  |  |  |  |
| **>62°S** | 0.053 | 1.27 | 26.1 | 5.92 *10-4* | 7.4 *10-4* | -0.0011 | -0.0011 |
| *St error* | *0.030* | 21.6 | *25.8* | *1.93 10-4* | *2.1 10-4* | *8.9 10-4* | *9.29 10-4* |
|  |  |  |  |  |  |  |  |
| **50-62°S** | 0.11 | 2.77 | 58.5 | 0.0020 | 0.0025 | -0.0036 | -0.0029 |
| *St error* | *0.05* | 1.16 | *21.3* | *8.4 10-4* | *9.4 10-4* | *0.0019* | *0.0019* |
|  |  |  |  |  |  |  |  |
| **Eq Pac** (14°S-14°N) | 0.28 | 3.49 | 35.76 | 0.0023 | 0.0018 | 0.043 | 0.033 |
| *St error* | *0.039* | *0.46* | *4.79* | *3.20 10-4* | *2.45 10-4* | *0.0055* | *0.0041* |
|  |  |  |  |  |  |  |  |
| **N Atl** (>50°N) | 0.06 | 1.47 | 32.18 | 7.29 *10-4* | 0.001 | -0.0028 | -0.0041 |
| *St error* | *0.053* | *1.20* | *24.04* | *7.49 10-4* | *9.20 10-4* | *0.0024* | *0.0028* |

Supplement 3

The effect of trends in wind speed variability

The enhancement factor, R, is the increase in k attributed to variability in the 6-hourly winds [*Wanninkhof et al.,* 2002]. It is expressed as R = <u102>/<u10>2 as an indicator of the variability of the wind. Larger enhancement factors indicate greater variability in the 6-hourly winds, which leads to higher gas transfer. The annual global pattern of R is shown in Figure S2. The trade wind regions show low R due to the prevailing steady winds. Coastal regions show larger R, particularly along the coasts of the North Pacific and polar regions, where temperature contrasts between land/ice and water can cause large changes in wind speed. Of note is the large R over the Gulf of Tehuantepec off the west coast of Mexico.

Trends in R (Figure S2b) are appreciably less than the trends observed for winds, and negative trends prevail. This indicates slightly less variability in the wind for large parts of the ocean over time. The regions with the greatest positive trend in wind speed (Figure 3b, main text) generally show a decreasing trend in R, suggesting a small offset in the increasing gas transfer associated with the decreasing magnitude of the enhancement. However, the linear trends in R over the time period do not lead to significant changes in k. The change in variability over time is implicitly accounted for by using <u10>, <u102>, and <u103> in equations (2) and (3) in the main text.



**Figure S2.** (a) Map of the annual average enhancement factor, R = <u102>/<u10>2, for 2014; (b) Linear trend in R\*1000 for 1988-2014.