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*Supplement of*

# Data-based estimates of ocean carbon uptake biased high from neglect of submonthly atmospheric pressure variability

**Jeanne Dombret et al.**

*Correspondence to:* Hugo Bellenger (hugo.bellenger@lmd.ipsl.fr)

Figure S1a shows the mean annual difference $\overline{F_h} - F_{ref}$ as in Figure 1c. Figure S1b shows the difference between the bulk term in equation (6), $aA\,\overline{u^2}\,\bar{\Delta}$, and $F_{ref}$. The latter represent the error due to the assumption that $A = \bar{A}$ (see section 2.2), and it is negligible compared to the former.

Figure S2 compares the mean pattern of our reference flux $F_{ref}$ (Fig. S2a) to the mean $F_{SeaFlux}$ using 6 different ocean $fCO_2$ products and the ERA5 wind product (Fay et al., 2021, Fig. S2b). The difference is displayed on Fig. S2c. The main difference between our calculation and the ones of the GCB data-based products is that we use mocsy (Orr and Epitalon, 2015) to recompute the oceanic $CO_2$ fugacity $fCO_{2\,sea}$. In spite of this difference, our reference flux reproduces the main patterns with ingassing in the midlatitudes and outgassing in the equatorial region and in particular in the eastern Pacific Ocean. Our reference flux shows stronger outgassing in these regions and in the Austral Ocean. However, this should not impact the sensitivity to the high-frequency variations we study. Indeed, as the same wind product is used, this difference in the mean flux is due to difference in $\bar{\Delta}$ in equation (6) that do not affect the correction terms we study.

Figure S3 shows the atmospheric effect of submonthly variability of atmospheric pressure ($\overline{F_P} - F_{ref}$) and the oceanic effect of submonthly variability of temperature ($\overline{F_{P,T}} - \overline{F_P}$) on observation-based air-sea $CO_2$ fluxes. Comparing Fig. 2a and Fig. S3a, shows that the impact of atmospheric pressure variations is mainly due to the atmospheric term of the flux. Comparing Fig. 2b and Fig. S3b, shows that the impact of sea surface temperature variations is mainly due to the oceanic term of the flux.

Figure S4a shows the spatial distribution of the $u$ variance term, $aA\overline{(u')^2}\,\bar{\Delta}$, the second term in equation (6), that is already taken into account for in the GCB data-based products calculations. For comparison, figure S4b show the sum of the correction terms, the 3rd and 4th

terms in equation (6). It is maximum poleward of the maximum of the former term with some longitudinal dependency.

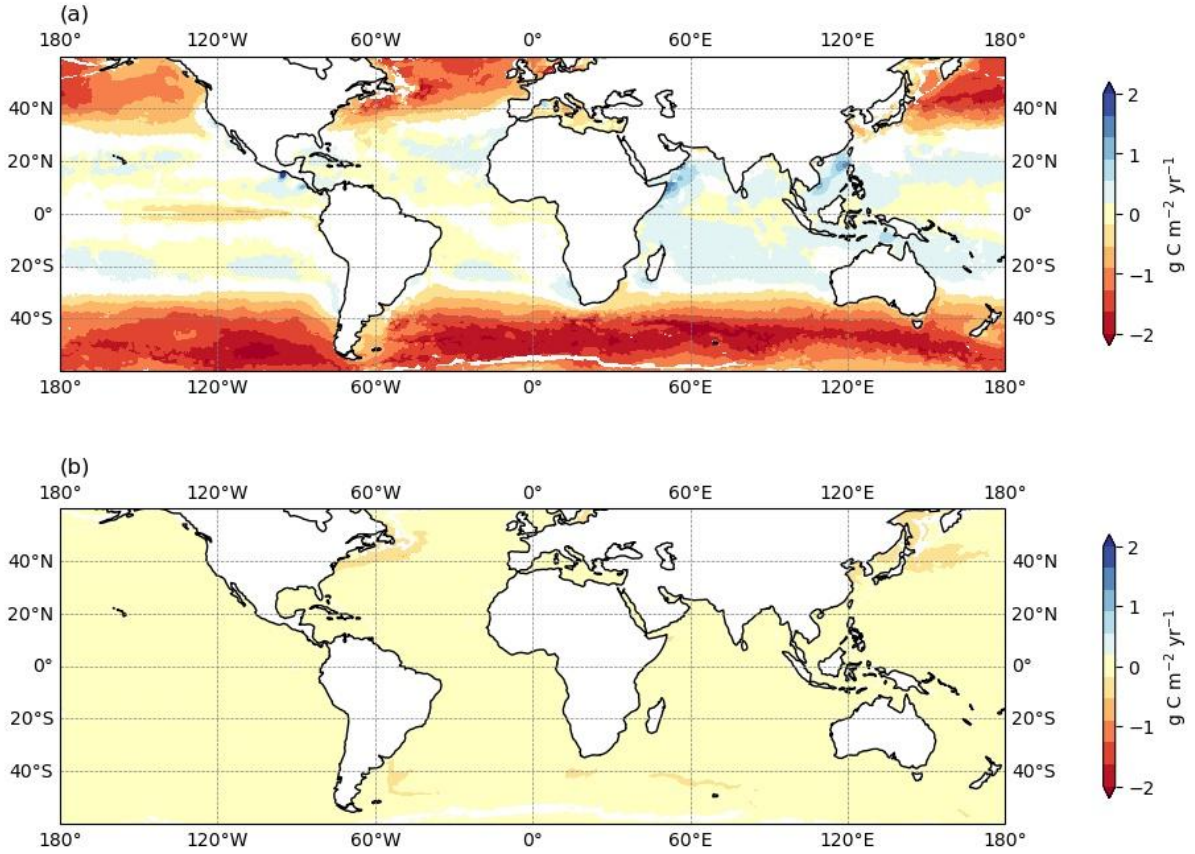


**Figure S1. Averages over 2009 to 2018 of a) the high-frequency $CO_2$ flux $\overline{F_h}$ minus the reference flux $F_{ref}$ and b) $aA\,\overline{U^2}\,\overline{\Delta}$ minus $F_{ref}$.**

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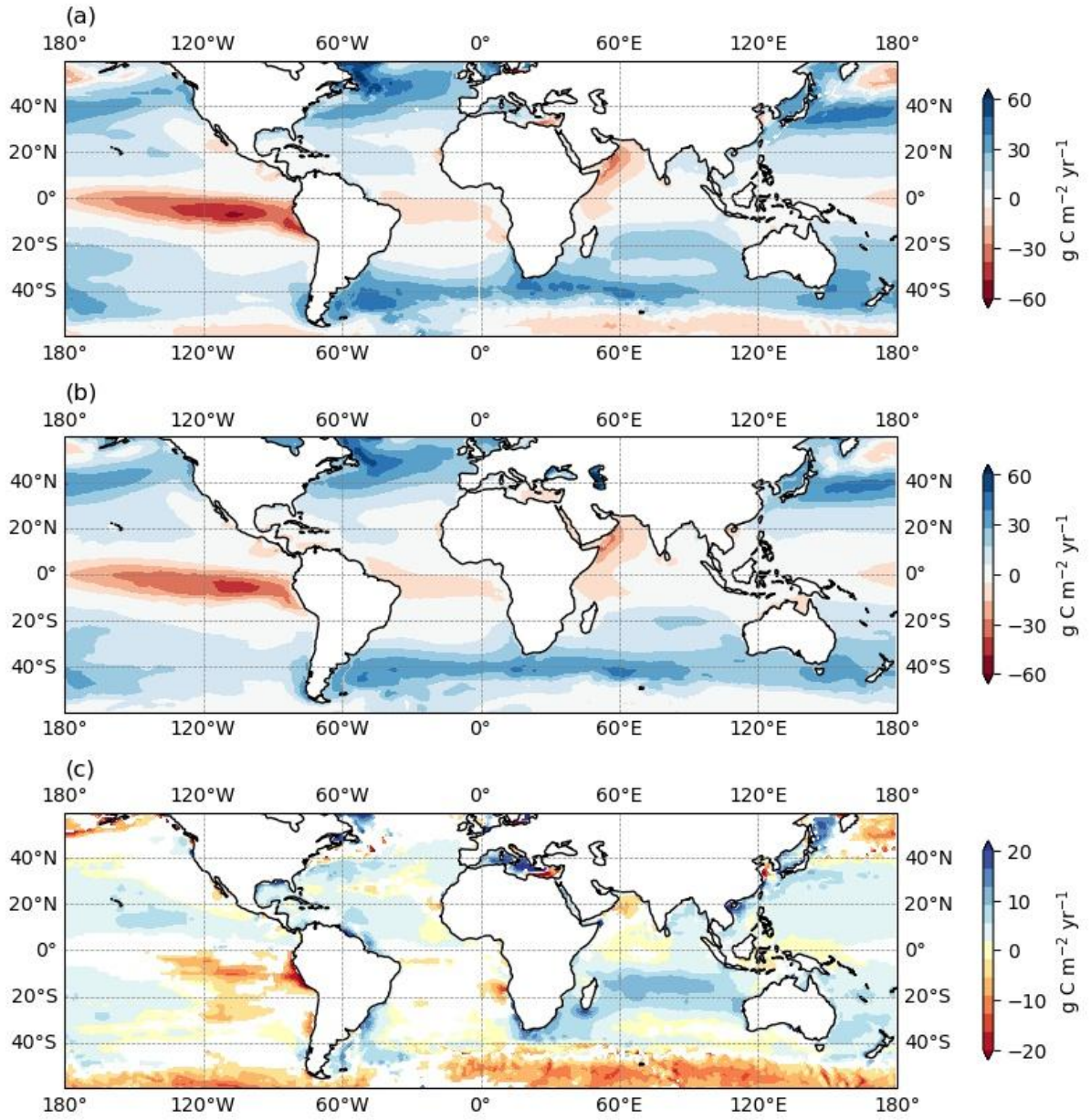


**Figure S2. Maps of a) the mean reference flux $F_{ref}$ between 2009 and 2018, b) the mean $CO_2$ flux $F_{SeaFlux}$ from the SeaFlux product (Fay et al., 2021) using 6 different ocean $fCO_2$ products and the ERA5 wind product. c) Mean 2009-2018 difference between $F_{ref}$ and $F_{SeaFlux}$ (positive if $F_{ref}$ increases uptake or decreases outgassing compared to $F_{SeaFlux}$). Only mean differences statistically significant to the 99% level, evaluated on the annual mean for each region and interannual standard deviation, are plotted.**

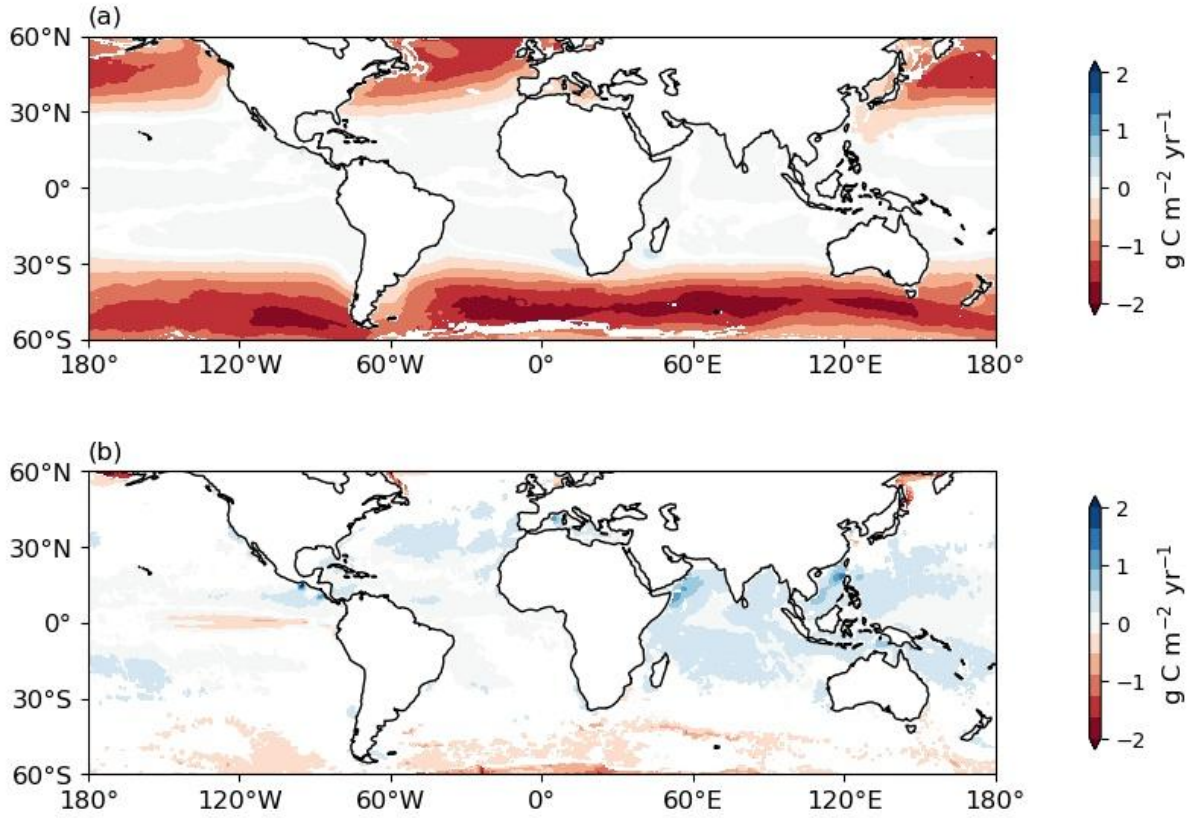


**Figure S3. Maps averaged over 2009-2018 for a) the atmospheric effect of submonthly variability of atmospheric pressure ($\overline{F_P} - F_{ref}$), and b) the oceanic effect of submonthly variability of temperature ($\overline{F_{P,T}} - \overline{F_P}$), on observation-based air-sea $CO_2$ fluxes. Positive values indicate a mean increase of $CO_2$ uptake or decrease of $CO_2$ outgassing.**

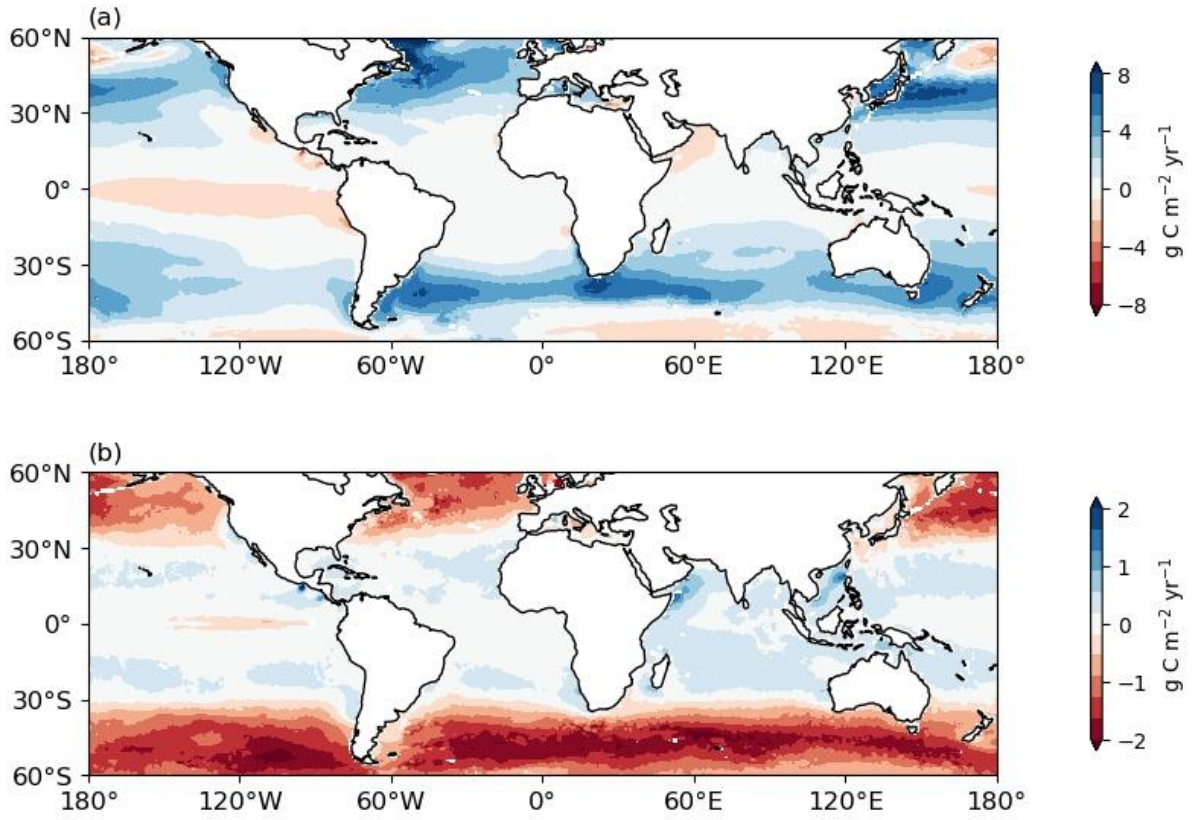


**Figure S4. Maps averaged over 2009-2018 of a) the $u$ variance term (second term in equation (6) right hand side), b) the sum of the correction terms in equation (6). Positive values indicate an increased uptake or lower outgassing.**