Overview

The study by Dombrey et al. investigates the role of unaccounted-for variability in the computation of monthly fluxes of fCO_2 data-products used in the GCB. The study finds that the "missing variability" contributes to the mismatch between fCO_2 data-products and GOBMs also used in the GCB. The study is thus providing an answer that partially explains a question that is puzzling the ocean CO_2 community. The manuscript is to-the-point, relatively well written with few grammatical errors. Thus, I don't have any major concerns and my review is short. However, I feel there are sections in which the authors could guide the reader a little more in terms of their methodology. In my review, I first list some overarching concerns (though not major). And then I list smaller, line-by-line comments.

Specific Comments

In the methodology section, the data sources are described late on in the section. It may be better to add these data sources as a table which is then placed earlier in the manuscript (e.g., somewhere between Eq 2 and Eq 3).

When it comes to the definition of flux (Eq 1), I recommend sticking to the notations used by Wanninkhof (2014; W14), eq. 2. This then becomes $F = k K_0 (fCO_{2\,atm} - fCO_{2\,sea})$. Then describe *k* as defined in W14, $k = a U^2 (Sc/660)^{-0.5}$. To simplify things later (eq 5), one could then use the following assignment of $A = K_0 a (Sc/660)^{-0.5}$. However, this recommendation is not a strong opinion since it is so slight, but it might just make it easier for the fCO2 data-product community, who tend to use the Wanninkhof notation.

Equation 5 seems to have two missing terms. Though, I'm not 100% certain about this, so I'd like to have the authors' input on this. The first may be implicitly incorporated into the bulk term (I think). And the other is not mentioned. I've broken down the decomposition into its basic parts first, and then shown them as shown in the paper. Note that I've factored *aA* out, and I'm showing the equation in terms of F_h and not $\overline{F_h}$ for simplification. If these terms are somehow incorporated, please make this clear in the text or supplementary and explain why the are not included.

$$\begin{aligned}\frac{F_h}{aA} &= (\overline{u}+u')^2(\overline{\Delta}+\Delta') \\ &= \overline{u}^2(\overline{\Delta}+\Delta') + (u')^2(\overline{\Delta}+\Delta') + 2\overline{u}u'(\overline{\Delta}+\Delta') \\ &= \overline{u}^2\overline{\Delta} + \overline{u}^2\Delta' + (u')^2\overline{\Delta} + (u')^2\Delta' + 2\overline{u}u'\overline{\Delta} + 2\overline{u}u'\Delta'\end{aligned}$$

$$\frac{F_h}{aA} = \underbrace{\overline{u}^2\overline{\Delta} + (u')^2\overline{\Delta}}_{\text{bulk formulation}} + \underbrace{2\overline{u}u'\Delta' + (u')^2\Delta'}_{\text{correction terms}} + \underbrace{\overbrace{\overline{u}^2\Delta'}^{\text{missing term?}} + \overbrace{2\overline{u}u'\overline{\Delta}}^{\text{in bulk formulation?}}}_{\text{terms not presented}}$$

It would also be helpful to indicate in this equation that bulk formulation is ≈ GCB flux.

There is a recent study by Ford et al. (2024) that does an excellent job of investigating uncertainties of air-sea CO_2 fluxes. This should be included in the discussion and reflected on how your study relates to theirs. See their Fig 4 specifically.

Line-based Corrections

L83: I would take this one step further and link this to wind specifically to connect the dots for the reader.

L112: Levy et al. 2012 missing a bracket at the end

L138: ~~**The**~~ K_0

L140: while -> and

L141: CO2 -> CO_2

L143: *a* is referred to as the coefficient of gas transfer in W14.

L153: New paragraph for “For simplicity…”

L15X: insert table mentioned earlier somewhere here.

L244: Indicate what you mean by synoptic scales: On synoptic scales *(< 10 days?)*

L291: See Gregor et al. (2024) Figure 15, where spatially resolved xCO2 was assessed.