

Responses to Reviewer 3 (original are in black and our responses are in blue)

The manuscript is generally well written. The authors present their ideas clearly, making the text easy to read and understand. They address an interesting question and use an appropriate tool i.e., the high-resolution regional MITgcm simulation to investigate the CO<sub>2</sub> response to the 20142015 Blob. That said, the attribution and mechanistic explanation (lines 266–287) of the main findings need to be strengthened. First, the explanation of the respective roles of horizontal and vertical transport is brief and unclear. As this is a key point of the study, it deserves a clearer discussion.

We sincerely appreciate the reviewer’s thoughtful and constructive comments, which have helped us strengthen the mechanistic interpretation of our results. In response to the request for clearer attribution of the respective roles of horizontal and vertical transport, we have performed additional analyses to clarify the respective roles of vertical and horizontal transport.

In the GOA, upwelling supplies DIC-enriched subsurface waters to the surface. DIC concentrations are also higher in the northern part of the domain than in the southern (Fig. R1a). The westerlies drive a north-to-south Ekman transport of DIC-rich waters. During winter 2013, the supply of DIC by vertical transport decreased in the central GOA. At OSP, in addition to the reduced vertical supply, a weakening of the north-to-south horizontal Ekman transport also contributed to the decrease in surface DIC.

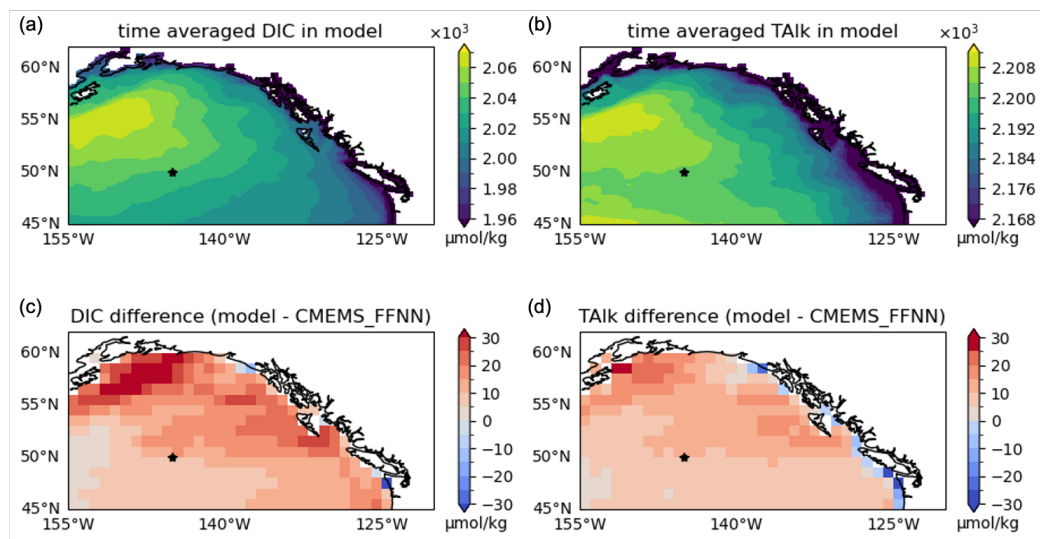


Figure R1. Comparison of the surface distributions of DIC and TAlk between the model and CMEMS\_FFNN, one of the SeaFlux datasets. The star in each panel indicates the location of OSP.

We generated new figures illustrating the potential density and wind stress curl (Figs. R2 and R4). These figures clarify the stratification changes and their impact on the vertical transport.

The influence of horizontal transport is highly local (at OSP) and does not contribute to the domain-wide DIC decrease in the same way that vertical transport does.

Second, the main finding also relies heavily on stratification changes due to warming. Although the effect of warming on stratification is somewhat obvious, it would be helpful to include an explicit analysis, perhaps in the supplementary material showing the upper-ocean density gradient or a related metric. This may not require much additional effort but would enhance the mechanistic understanding and make the manuscript more self-contained regarding attribution.

As discussed in the response to the previous comment, we generated the zonal cross sections of density (Fig. R2) to document the enhanced stratification. Comparing the winter of 2013 with the DJF climatology, the potential density in 2013 is substantially lower at the surface between 160°W and 140°W. The enhanced stratification weakened the vertical transport of DIC, thereby reducing the supply of DIC to the surface.

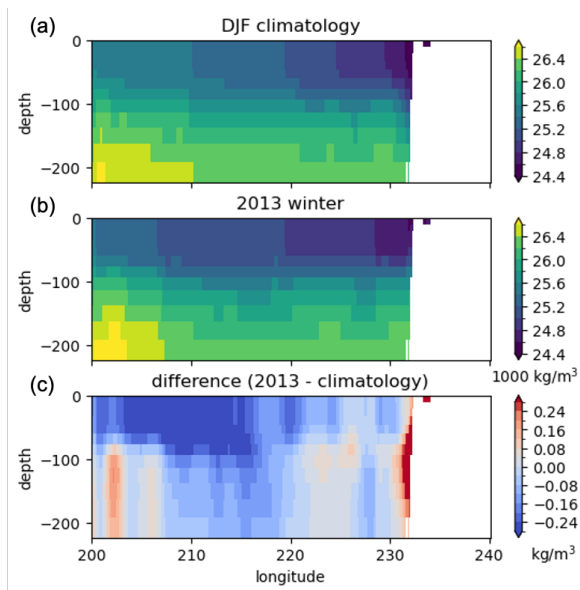


Figure R2. Vertical cross-sections of potential density along 50.5°N for (a) the DJF-mean climatology over 2010–2017, (b) 2013, and (c) their difference (2013 minus climatology).

Third, Supplementary Figure S2 appears to be central to the study, as it shows changes in surface transport. To make the analysis more complete, I suggest reducing the number of panels and moving a modified version of this figure into the main text. If there are restrictions on the number of figures, Figures 6 and 7 could be combined, this might also be visually more effective and the freed space could then be used for Figure S2. This is, of course, only a suggestion.

Regarding the maps of the horizontal advection (previous Fig. S2), we agree that these maps are informative. However, because the influence of horizontal advection is primarily localized around OSP, we believe that these results are most effectively presented in the supplementary material. We also improve the clarity of this figure (Figure R3) by focusing on the region near

the OSP. In addition, we will revise the corresponding text to better explain the localized influence of horizontal advection around OSP.

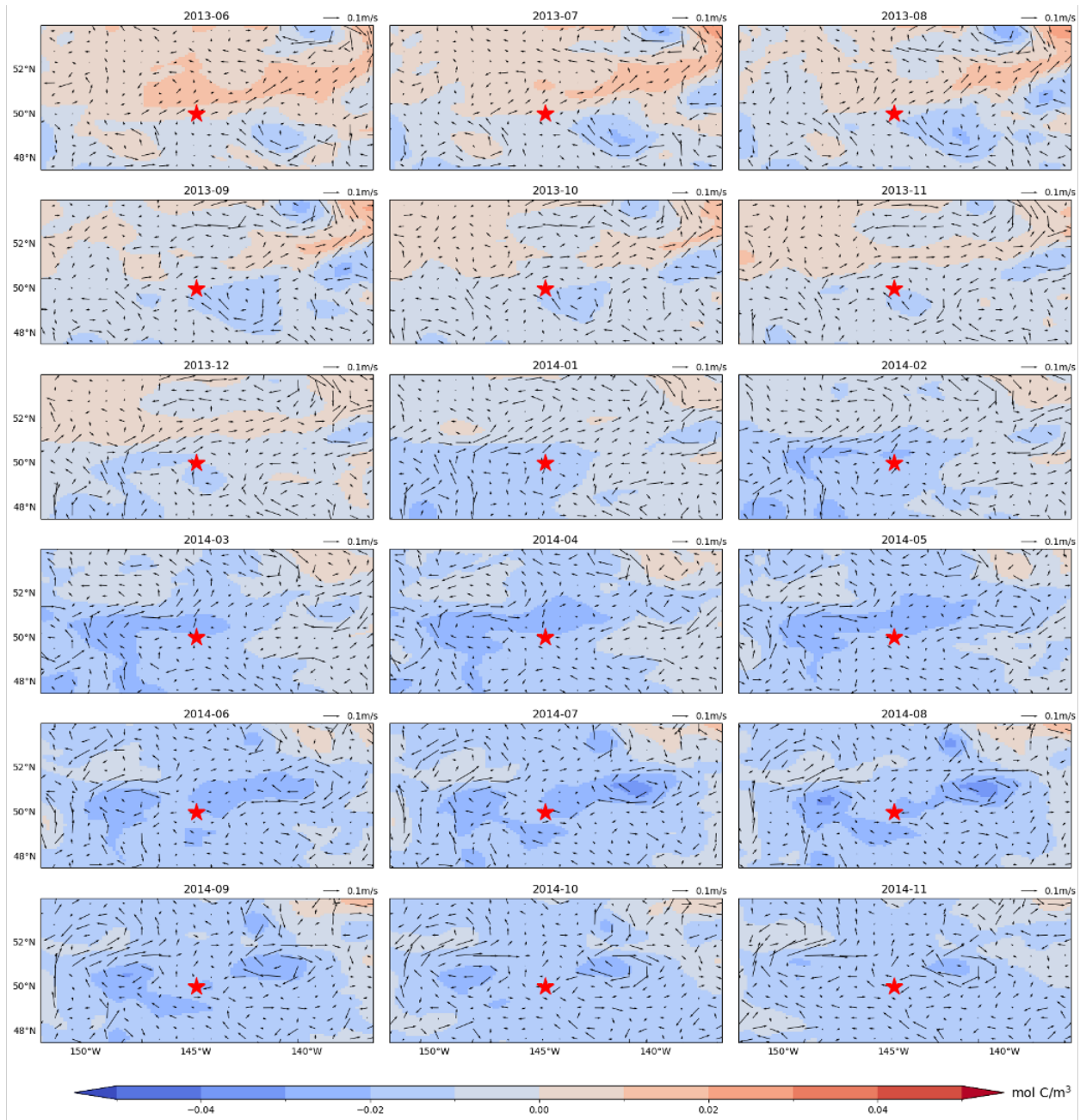


Figure R3. Surface velocity (vectors) and DIC (colored shading) anomalies relative to 2010–2017, from June 2013 to November 2014. All variables have been detrended and deseasonalized. Velocities are smoothed using a 3-month moving average. The red star indicates the location of OSP.

Finally, it would be helpful to strengthen the link to Ekman dynamics and entrainment discussed at the beginning of the Discussion section. The authors could support this point with additional literature or include a supplementary plot of wind stress curl to clarify the connection. Overall,

this is an interesting and valuable study. The authors have most of the essential analyses in place but would benefit from refining the mechanistic explanations and reinforcing the main argument.

We agree to the reviewer's suggestions. We generated a new figure of the wind stress curl ( $\text{curl}\tau$ ) (Fig. R4). The comparison between the DJF climatology of the wind stress curl and the conditions in winter 2013 shows that, although the GOA is typically an Ekman upwelling region, the period immediately preceding the onset of the Blob was characterized by Ekman downwelling. As a result, vertical supply of DIC to the surface was suppressed, leading to a reduction in surface DIC. The reduced wind stress curl prior to the Blob provides clear evidence for the physical mechanisms underlying the DIC-driven  $\text{pCO}_2$  response. We will be able to expand the corresponding discussion to clarify the link between Ekman dynamics, entrainment, and the surface DIC decrease.

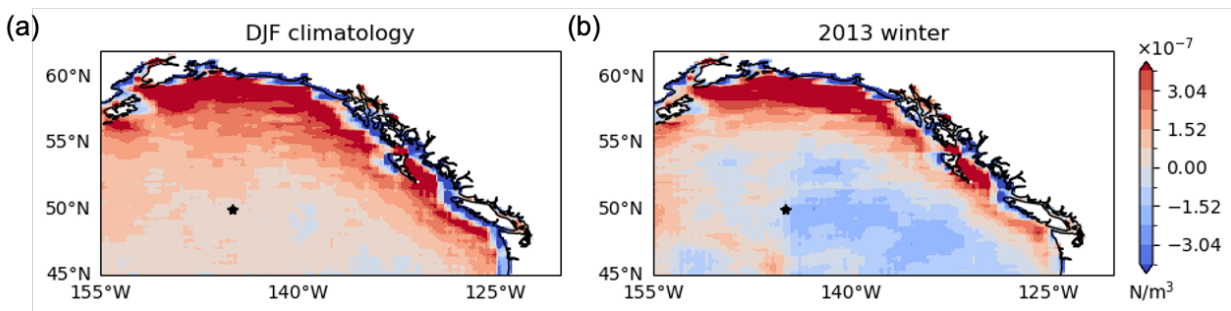


Figure R4. Spatial patterns of wind stress curl ( $\text{curl}\tau$ ) for (a) the DJF-mean climatology over 2010–2017 and (b) 2013. Positive values indicate cyclonic flow associated with Ekman upwelling. The star in each panel marks the location of OSP.