We thank referee#1 for reviewing the paper. We address point by point the concerns of the referee.

General comments:

"A major short-coming of the paper is the use of Equation 5 (Page 5) to normalize DIC. This procedure has been criticised in the past and shown to create artificial variance in DIC and TA distributions (Friis et al. 2003)."

Answer:

We agree with the referee that the traditional method of salinity normalization can create artificial variance, as argued by Friis et al. (2003), because it attributes all salinity variation to evaporation and precipitation and ignores the influences of riverine input and upwelling from below the lysocline.

However, we excluded regions subjected to significant perturbations from river inputs (the ocean areas most likely to be affected, as suggested by Kang et al. (2013) and Fry et al. (2015)) as described in section 2.1.

In addition, no major rivers flow into the Southern Ocean. Therefore this is not a concern for our study.

The influence of upwelling from below the lysocline on DIC salinity normalization is also relatively negligible in our study. We compared values normalized using the Friis et al. (2003) method (taking account of upwelling) to our original values (normalised in the traditional way) and found a maximum difference of 3.5 µmol kg^{-1}, which is of the similar magnitude to the uncertainty in DIC measurement (4 µmol kg^{-1}) and much smaller than the phenomenon of interest (>100 µmol kg^{-1}).

The calculation following Friis et al. (2003) was implemented using an empirical relationship of the form nDIC = $\frac{DIC^{meas} - DIC^{S=0}}{S^{meas}} \cdot S^{ref} + DIC^{S=0}$, where 'meas' denotes measured value and 'ref' denotes reference. This equation can then be converted into $nDIC = \frac{DIC^{meas}}{S^{meas}} \cdot S^{ref} + DIC^{S=0} \cdot (1 - \frac{S^{ref}}{S^{meas}})$, where the first term on the right side is the equation we used in the manuscript (Equation 5), and the second term on the right side indicates the difference between the traditional salinity normalization and suggested salinity normalization by Friis et al. (2003). Take the Southern Ocean for instance where the largest upwelling in the world takes place. The magnitude of the difference term (i.e., $DIC^{S=0} \cdot (1 - \frac{S^{ref}}{S^{meas}})$) depends on $DIC^{S=0}$ and S^{meas}. $DIC^{S=0}$ is the region-specific term of S=0 due to upwelling of deep water which accumulates the remineralized inorganic carbon. Based on the GLODAPv2 database, the average concentration of DIC at depth greater than 500 m (the largest mixed layer depth in winter in the Southern Ocean, Dong et al., (2008)) in the Southern Ocean (>40°S) is 2250 µmol kg^{-1}, and the average concentration of DIC at surface layer in the Southern Ocean as defined in this study is 2130 µmol kg^{-1}. As a consequence, upwelling from below the lysocline ($DIC^{S=0}$) can create the largest DIC difference of 120 µmol kg-

[1] (obviously $DIC^{S=0}$ in the modern surface ocean should be less than 120 μmol kg^{-1}, otherwise the DIC vertical distribution would be uniform). The difference term $DIC^{S=0} \cdot (1-\frac{S^{ref}}{S^{meas}})$) is always relatively small because the average measured salinity in the surface Southern Ocean is 34 and the reference salinity is 35 and so their ratio is close to 1.

Specific comments:

Page 1 L28: To avoid the wrong impression as pointed out by the referee, we removed the reference cited here since the concept of DIC has been defined very well already.

Page 1 L28: Done. Definition of $[CO_2^*]$ added.

Page 3 L5-13: Done. We added "production and export of $CaCO_3$" to be another process directly changing the surface distribution of DIC.

Page 4 L17: Corrected. Moved "the Mediterranean Sea" to the next line.

Page 7 L16: Changed.

Page 8 Equation 10: the calculation of Alk* in this manuscript followed Fry et al. (2015), which is already salinity-normalized to a constant salinity of 35. The Alk^*_{surf} in Equation 10 was calculated by Equation 11. We added a sentence for clarification.

Page 8 Equation 10: We agree with the referee that the assimilation of inorganic nutrients by primary production leads to an increase of Alk^*_{surf}. We ignored this process because the effect of primary production on TA is much smaller than that on DIC (TA:DIC = -17/106, Wolf-Gladrow et al., 2007). We now modify Equation 10 with a new term to account for the change in TA from photosynthesis or respiration. The latest calculated short-term effect of upwelling (revised Figure 8) is slightly different from the previous version.

Page 9: We thank the referee for pointing out the inconsistency in calculating NCP effect on DIC and calculating "unused DIC". We therefore decide to use phosphate as the only nutrient in Equation 12 and 16 in the next revised version.

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