MPO776 - Mesoscale Oceanography

Tiago Carrilho Bilo

C# 11950866

Paper Review: Sallee, J.-B., R. J. Matear, S. R. Rintoul, A. Lenton (2012), Localized subduction of anthropogenic carbon dioxide in the Southern Hemisphere oceans, Nature Geos., 5, pp. 579-584

Dear editor, bellow you will find my Salle et al. manuscript review. This document is organized in eight topics: (1) Paper's overview, (2) Importance, (3) Methodology, (4) Originality, (5) Results summary, (6) Implications, (7) Critics, and (8) My recommendation.

(1) Based on observations of anthropogenic carbon (C_{ant}) obtained during the GLobal Ocean Data Analysis Project (GLODAP), the authors computed the C_{ant} fluxes to the Southern Ocean's interior (i. e., quantity of C_{ant} that is exported from the ocean mixed layer to deeper regions) forced by physical mechanisms. They were able to quantify the relative importance of each mechanism in C_{ant} exportation. Additionally based on the observations available, the authors were able to derive the ocean's interior current C_{ant} inventory between 35°S-Antarctic marginal sea-ice zone by integrating the physical net fluxes over the last 200 years (also comparable to the carbon residence time of ~350 years) concluding that carbon sequestration largely depends physical mechanisms.

(2) Its is well established how sensible our climate system is to the CO_2 concentrations in the atmosphere. As well mentioned by the authors in their abstract and introduction paragraphs, the oceans are an important factor in climate change modulation. The Southern Ocean is estimated to sequester alone up to 40% of the C_{ant} (i. e., latitudes ≥40°S). Therefore understand and quantify the mechanisms involved in the export of C_{ant} to the ocean's interior is extremely important to better predict our climate and its dynamics.

(3) The methodology used in this work consists basically in computing the vertical fluxes of C_{ant} that cross the base of the mixed layer and its uncertainties. The fluxes are forced by Ekman dynamics (i. e., C_{ant} transport due to Ekman pumping), mean-flow (i. e., thermocline vertical motions due to the Antarctic Circumpolar Current, or ACC, geostrophic flow), and eddies (i. e., eddy-induced mixing of C_{ant}).

(4) Although the scientific community already knew about the possible pathways of the C_{ant} into the ocean's interior and its dynamics, this study is the first to quantify the importance of the primary physical mechanisms involved and how they explain the C_{ant} distributions in the Southern Ocean. Therefore this work is original.

(5) As result of their computations, the study shows spatial distribution of the C_{ant} subduction driven Ekman pumping, mean-flow and mesoscale eddies. Generally speaking, the Ekman pumping seems to be important for C_{ant} vertical transports only north of the ACC and very close to the Antarctic continent in the Indian Ocean. In contrast, the other two C_{ant} subduction terms are dominant in the ACC region and tend to have opposite effects. Integrating the three terms over the Southern Ocean, the net subduction is approximately 0.42±0.2 Pg of C_{ant} yr^{-1} towards the ocean interior.

Integrating the net flux spatial distribution over the last two centuries (1800-1995), the authors were able to estimate a C_{ant} inventory of approximately 0.23±10 Pg of C_{ant} in the Southern Ocean's interior, which is consistent with the 1995 C_{ant} inventory of 25±5 Pg of C_{ant} estimated with the GLODAP data. This result indicates that the C_{ant} subduction is mainly forced by physical processes and it behaves almost as a passive tracer.

(6) Their findings have a huge impact in how we expect the C_{ant} to behave as soon it is sequestered by the ocean and how sensible it is to our changing climate. Additionally, climate simulations can be better interpreted and calibrated in this aspect.

(7) I believe the authors successfully achieved their goals using appropriate methods, however I would be more cautious in discussing the results (see item 3). Additionally I think there are missing information in the text and in the supplementary material that must be added and clarified.

1. First of all, the dataset used in this study (i. e., GLODAP) must be better explained (at least in the supplementary material). The authors did not specified which product they used and exactly the temporal and spacial coverage and resolution of the dataset (no need for too many details). Although it is a famous project the article must be self-contained;
2. After looking for GLODAP information, its products seems to have multi-year data. So, I would like to know if the fluxes discussed in Figure 1 correspond to an annual mean from 1990-2000 or annual mean values in 1995 as pointed out in Table 1?
   Although the authors refer it to C_{ant} fluxes in the 1900's it is not clear what exactly they did, since they compare values from Figure and Table 1. Moreover if they used 1990-2000 annual mean in Figure 1, why not do the same thing for Table 1?
3. One of the most striking results is how they were able to obtain consistent estimates of the ocean's interior C_{ant} inventory by integrating the 1995 net C_{ant} subduction in the last 200 years. I agree with the authors argument that this indicates the C_{ant} behaves as a "passive tracer", i. e. physical process determine its distribution, and terms often neglected –eddy transport and lateral induction by the mean flow–make a significant contribution. However I would stress out that the 1995 net C_{ant} subduction might be close to the mean net C_{ant} subduction in the last 200 years and that important in the system was not took into account, specially in a warming climate.

(8) Finally, based on the observations above I recommend accepting this article. It fulfills the Nature's expectations and characteristics, being adequate for publication.