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Discussions

Interactive comment on "NW European shelf under climate warming: implications for open ocean – shelf exchange, primary production, and carbon absorption" *by* M. Gröger et al.

Anonymous Referee #2

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In this discussion paper the authors examine the efficiency of the carbon shelf pump in the North Sea using a global ocean general circulation model coupled to a biogeochemistry model with a distorted grid providing a maximal resolution for the NW European shelf and the adjacent North Atlantic. A series of numerical experiments are conducted to examine the effects of global warming, increasing atmospheric CO2 concentration and discharge of anthropogenic nutrient loading. The model predicts that warming of about 2.0 K of the sea surface leads to a reduction of primary productivity by 30% and weakening of the shelf pump in the North Sea by 34%. Tracer experiments tracers indicate that no more than 20% of the carbon absorbed in the North Sea contributes to the long term carbon storage in the deep ocean.

Generally speaking, this is a very interesting paper with numerical experiments revealing a few important features in the function of shelf pump. The paper demonstrates the apparent importance of biological processes in contributing to the shelf pump and the significance of riverine and marine nutrient supplies. Especially important is the investigation of the fate of carbon taken up by the shelf pump. However, this is not the first attempt to attack this critical issue. An earlier study conducted by Yool and Fasham (2001) explored the same issue from a global perspective using a model with rather coarse grid resolution. Despite the rather crude results, the earlier work is worth mentioning in the new study. Compared to the old study, this paper exemplifies the unique strength of the global ocean model employed by the authors.

This paper will be more convincing, if the authors can properly clarify or address a few key points described below.

1. Model resolution: The best model resolution is 10 km in the horizontal and 16 m in the vertical. Will this resolution good enough to catch small but efficient transport modes, such as dense water cascading. Such mode of material transport has been observed in the Mediterranean Sea (Canals et al., 2006). It is capable of injecting carbon directly into the deep sea from the shelf. Please clarify.

2. Fate of organic carbon: The biogeochemistry model includes detrital and dissolved organic carbon (Lines 16-18 on p. 16629), but nothing is presented in the model output. One wonders the organic components play any role at all in the carbon shelf pump. Since the anthropogenic nutrient loads apparently stimulate primary production, it is natural that organic carbon fluxes should also increase during nutrient enhanced production. Yool and Fasham (2001) demonstrate that injection of organic carbon or inorganic carbon from the shelf edge will lead to different results in terms of penetration into the deep ocean. The authors should look into this aspect and provide some insight. If the model setup is not adequate to investigate the organic carbon fluxes (e.g., POC or DOC degradation rates are not properly modeled), the authors should also make it clear.

3. Deep water formation: According to the authors, their model predicts “too weak production of Antarctic Bottom” (Lines 14 on p. 16632). In fact, one is more concerned with the North Atlantic Deep Water Formation, which is probably more relevant to the fate of the carbon taken up by the shelf pump in the North Sea. If the NADW formation is also too weak, will it affect the assessment of efficiency for the long-term storage. Please clarify.

4. Marker experiment: The description is not very clear. How is the tracer distributed in the water column? Is the initial concentration 1 uniformly throughout the water column? If so, then this experiment is not a good analog to the reality, because the absorbed carbon is not uniformly distributed in the water column. After the model is initiated, for how many model years is it run?

There are some minor points listed below:

a. Line 20 on p. 16628: “(Sweby, 1984)” should be “Sweby (1984)”.

b. Line 6 on p. 16630: “odel” should be “model”.

c. Line 14 on p. 16640: “is rises” should be “rises”.

d. Fig. 5 caption: “along the y-achsis” should be “along the y-axis”.

e. Fig. 7 caption: “in exeriment CO2-NS” should be “in experiment CO2-NS”.

References

Canals M, Puig P, Durrieu de Madron X, Heussner S, Palanques A, Fabres J (2006) Flushing submarine canyons. Nature 444: 354–357.

Yool A, Fasham MJR (2001) An examination of the “continental shelf pump” in an open ocean general circulation model. Global Biogeochemical Cycles 15: 831–844.

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