Interactive comment on "Towards an improved organic carbon budget for the Barents Sea shelf, marginal Arctic Ocean.

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We would like to thank the reviewer for the thorough and constructive feedback. We will accommodate all major concerns in the revised version of the manuscript. We take the opportunity to already respond to some of the comments:

**To General Comments:**

(1) "You just talk about the model results with little description/regional context and without a "key history". The aim of the manuscript and the importance of the model results are not underlined"

Yes, we agree and will address this issue in more detail in the revised version. Particularly, the abstract and introduction chapter will be expanded to illustrate the importance of the present study. By calibrating the organic facies model on a large set of surface samples we are able to study flux, preservation and burial of organic carbon beyond sample control. This allows not only to study the variability of surface water productivity in the marginal ice zone, but particularly the refinement of the Holocene organic carbon budget for the entire western Barents Sea. The latter is particularly crucial since the Barents Sea is regarded as one of the most productive Arctic shelf regions and very susceptible to ongoing climate changes. The results show that higher organic carbon accumulation rates in the MIZ are best explained by enhanced surface water productivity compared to ice-free regions. This implies that future sea ice shrinking will have a negative effect on the organic carbon storage capacity of Arctic shelf regions.

(2) "It is written in the introduction that it will help to study modern climate changes (let's say last 50 years changes). Then in the discussion (page 4961, line 20) you admit that your model covers much longer time span – last 10,000 years. So the recent climate changes would not be visible in this model?"

We will adjust the introduction chapter towards a stronger focus on the last 10.000 years since the refinement of the organic carbon budget is valid for the Holocene.

**To Specific Comments**

(1) "Is it possible to calibrate sedimentary conditions with 6 sediment cores?"

The sedimentary conditions in the Barents Sea are complex and require a multitude of observational and modelling data to understand properly. The application of OF-Mod 3D for modelling organic matter properties in the Barents Sea requires at least two well-constrained time slices. In our case, these are the present bathymetry (cf. Jakobsson et al. 2008) regarded to present the modern sedimentary conditions, as well as the base Holocene (10.000 $^{14}$C years B.P.) (Gurevich et al. 1995). By constraining the lithological boundary conditions, and

providing the input parameter for marine (surface water productivity) and terrestrial organic carbon input (mainly coastal/river supply, sea ice melting processes), OfF-Mod 3D modelling results are able to reproduce observational data of total, marine, and terrestrial organic carbon in surface samples very well. To achieve these results, OF-Mod 3D takes into account the sedimentation rates derived from $^{14}$C-based chronostratigraphic framework provided by the given sediment cores in Table 1 and the Holocene thickness map of Gurevich et al. (1995). If using the $^{210}$Pb based sedimentation rates ranging between 0.3 to 1.9 mm yr$^{-1}$ in the uppermost (5 to 10 cm) sediments, OF-Mod 3D would produce organic carbon contents far beyond the observed values in the surface sediments. Of course, it doesn't mean that the $^{210}$Pb geochronology for the (sub-) recent sedimentation is incorrect. It only proves that modern sedimentation rates cannot be extrapolated over longer time scales, such as the last 10.000 $^{14}$C years. For the improvement of the Holocene organic carbon budget in the western Barents Sea, we have to rely on core material dated by using the AMS$^{14}$C dating technique.

(2) "There are more references on the sediment accumulation rates available in the Barents Sea"

Yes, we are aware about them and have incorporated these additional references in the revised manuscript. The mentioned Boitsov et al (2009) paper, however, does not include the datings of the 5 short cores. However, there is another paper by Boitsov et al (2009) (see reference below), which relies on the $^{210}$Pb geochronology of 5 additional sediment cores. However, these are the same cores as reported by Jensen et al. (2007), which is included in the present study. As the reviewer correctly pointed out, these additional $^{210}$Pb based results are very helpful in delineating the sedimentary conditions in the Barents Sea. Most of the cores have estimated sedimentation rates of 0.5-1.9 mm/yr, or 50-190 cm/1000 years, respectively.

(3) "Dating uncertainties between AMS$^{14}$C techniques and $^{210}$Pb geochronology"

We discuss the issue by providing an example of one sediment core (R87MC006) where we have used both techniques. We clearly show that within the upper 20 cm, the sedimentation rate differs by an order of magnitude when applying the different techniques. A general discussion on this discrepancy is given in the revised manuscript.

(4) "The largest accumulation of organic material in Storfjorden and Hopen Deep is not caused by large phytoplankton bloom and ice marginal processes"

Yes, we agree and discuss alternative explanations and refer to the proposed references. Interestingly, the high MOC accumulation rates are typically recorded in the troughs north of the MIZ while values in the Bear Island trough south of the MIZ (typically a depo-center for resuspended sediments as well) are relatively low (Fig. 11b in the revised manuscript). This likely excludes sediment resuspension as a prevailing factor for the high MOC accumulation rates in the Storfjorden and Hopen Deep.

(5) "Why the concentration of terrestrial organic carbon in sediments around mostly glaciated (whole eastern part) Edgeøya are much higher than around Sørkappland that is ice free during the summer

The reason for this possible over-estimation of the terrestrial proportions in the model results is because of the dependence of terrestrial organic matter distribution with the sand fraction. The distribution of particulate terrestrial organic matter is modelled in OF-Mod related to

distribution of the sand fraction due to hydrodynamic equivalence of the particles in near shore, shallower waters. However, this relationship is reversed at very high sand content which represents very energetic conditions in which no deposition of organic material takes place, i.e. at very high sand content no particulate terrestrial organic matter is deposited..

This relationship is incorporated into Of Mod 3D to constrain the distribution of terrestrial organic carbon input and occurs independently from glaciated or non-glaciated hinterland. This explains the high values around Edgeøya in the modelling results.

Technical Issues: correction of Table 1

We will follow the advice given by the reviewer and provide an update of Table 1 in the revised version.

References cited

Boitsov, S., Jensen, H.K.B., Klungsøyr, J., 2009. Natural background and anthropogenic inputs of polycyclic aromatic hydrocarbons (PAH) in sediments of South-Western Barents Sea. Marine Environmental Research 68, 236-245.

Gurevich, V. I.: Recent sedimentogenesis and environment on the Arctic shelf of Western Eurasia, Oslo, 1 - 92, 1995.

Jakobsson, M., Macnab, R., Mayer, L., Anderson, R., Edwards, M., Hatzky, J., Schenke, H. W., and Johnson, P.: An improved bathymetric portrayal of the Arctic Ocean: Implications for ocean modeling and geological, geophysical and oceanographic analyses, Geophysical Research Letters, 35, 10.1029/2008gl033520, 2008.

Jensen, H., Knies, J., Finne, T. E., and Thorsnes, T.: Mareano 2007 - miljøgeokjemiske resultater fra Troms II og Troms III Geological Survey of Norway, Trondheim, Norway, 253, 2008.