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

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Thank you to the referee's valuable comments and critical views to our manuscript. It is important to clarify some misunderstandings on the obvious discrepancies between surface water productivity derived from our model and the one cited by the referee.

Referee: "Todays primary production is described and discussed, but never critically compared with the results of the investigation.

Yes, we agree with the reviewer and have expanded this part of the discussion by incorporating the following paragraph:

"However, our modeled PP differs from ocean-ecosystem primary productivity models (Ellingsen et al., 2008; Wassmann et al., 2010). These models predict highest sea-surface PP in the southern, Atlantic Water influenced region, higher production on top of Spitsbergen Bank and overall low sea-surface PP in the northern, Arctic Water influenced region. Their modeled PP values are also higher than our reconstructed PP: > 100 gC m^{-2} yr^{-1} predicted in the south compared to < 50 gC m^{-2} yr^{-1} reconstructed; < 100 gC m^{-2} yr^{-1} predicted in the north compared to up to 90 gC m^{-2} yr^{-1} reconstructed. These differences can in part be attributed to the different modeling approaches – 3D ocean models taking currents and circulation into account compared to the sedimentary approach back-calculating from the material that was actually deposited, and averaging over different time scales (monthly/seasonal versus averaging over 100s – 1000s of years in the sedimentary model). However, more fundamental questions relating modelled PP in the euphotic zone of the surface ocean to PP reconstructed from sedimentary organic carbon remain. A central question is how the processes in the water column are translated into the sedimentary model. It is therefore very likely that the productivity estimates used in OF-Mod 3D correspond to an integrated value (over time) of the uppermost water masses and do not necessarily represent the surface water productivity trends outlined by Reigstad et al. (2011) and Ellingsen et al. (2008). This topic is under further investigation and being prepared in a follow-up manuscript".

Referee: "Fig. 8 indicates primary production as it is today and this figure is in utmost contrast to any primary production model so far published. Primary production is high in the south (150 g C m-2 y-1), inter mediate in the seasonal ice zone (100 g C?) and low in the north (50 gC?). If the model cannot provide us with figures that are approximately similar to this, what should we then think about the remaining results of the model?"

As the reviewer pointed out, the published primary production values in the Barents Sea are based on primary production models (SINMOD) executed by various authors (Slagstad, Ellingsen, Reigstad, Wassmann, see references below). These models have certainly a sound basis and we do not doubt the quality of the achieved results. Still, these are uncalibrated modeling results and always contain some uncertainties (according to the reviewer's own opinion)! The calculation method used in the present case has been tested and calibrated in many places in the world (particularly in the Arctic) and has been shown to give good results

(e.g. Knies and Mann 2002, Mann et al. 2009). The model is simple, but based on sound empirical measurements. A more complicated equation/model needs more input and calibration data, and is thus not necessarily more correct, especially if these data are not available or not used. Therefore, the statement that "compared to the present model (our study) they (SINMOD) rest upon firm(er) ground" is incorrect: both model approaches are good and both are tested, they're just different. We are confident that the results from both numerical models, (1) top-down (SINMOD)) (published by Slagstad, Ellingsen, Wassmann et al.) and (2) bottom-up (OF-Mod 3D) (the present study) are reliable and consistent for further interpretations.

This still leaves the differences between the models, and we have, of course, discussed the discrepancies for the primary production in surface waters with the principal authors of the top-down approach (Slagstad, Ellingsen) and provide here some alternative explanations. To convince the reviewer, we will show two new figures illustrating the export vertical production in 50 m water depth modeled by SINMOD (courtesy: Ingrid Ellingsen, SINTEF, Trondheim) together with the primary productivity used in OF-Mod 3D (this study). However, these figures will not be shown in the revised manuscript. Rather, these data will be discussed in a follow-up study where productivity reconstructions for the western Barents Sea are presented over the past 3000 years.

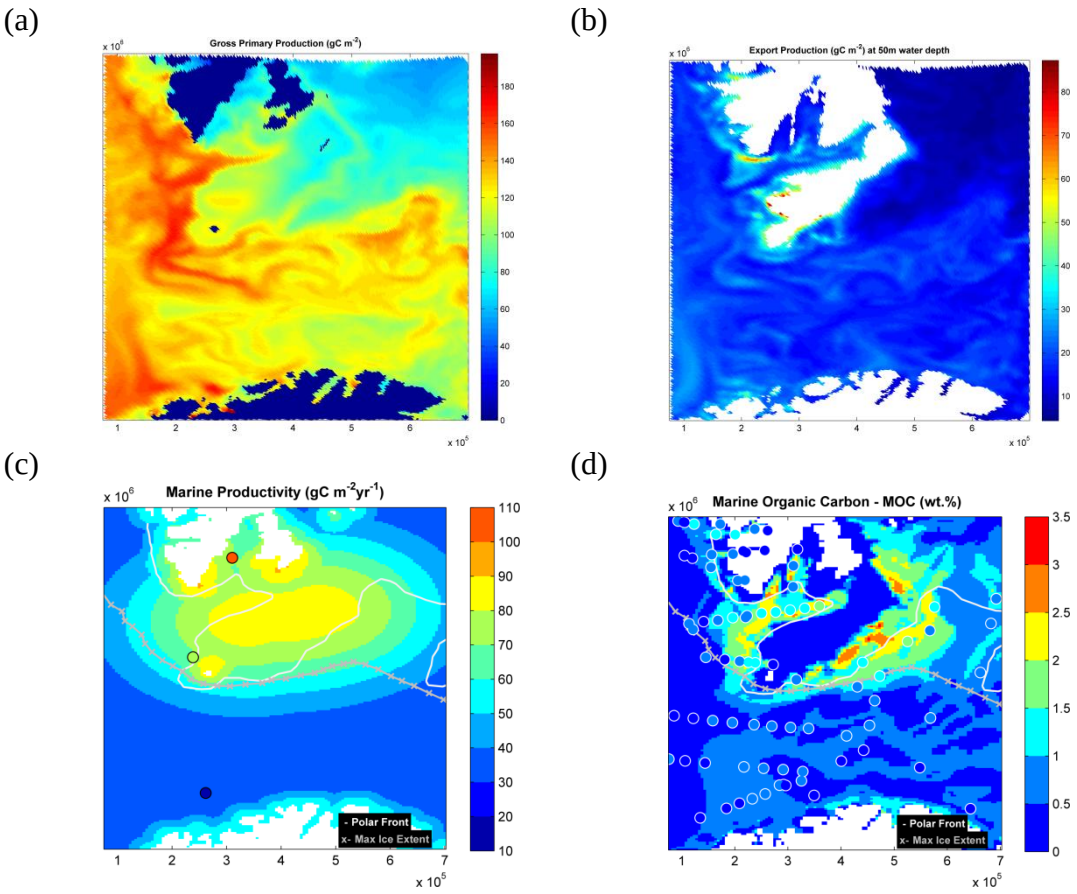

Fig. 1: (a) Gross primary production and (b) export production (in gC m^{-2} yr^{-1}) at 50 m water depth as modeled by SINMOD. (c) Marine productivity as estimated from three well-dated cores (dots) and spatial distribution used as input for OF-Mod 3D. (d) Marine organic carbon (MOC) distribution as estimated from calibration data set (dots) and modeled by OF-Mod 3D applying the data in Fig. 1c as input (spatial distribution).

The results show that vertical export production in the western Barents Sea as simulated by SINMOD deviates strongly from the surface water productivity pattern (Fig. 1a, b) published by Ellingsen et al. (2008). This is expected since a lot of the primary produced organic matter gets consumed and recycled in the upper part of the water column and only a fraction of the primary productivity leaves the photic zone (i.e. the export production). However, the vertical production pattern at 50 m water depth (i.e. export production) resembles both in magnitude (10-70 gC m^{-2} yr^{-1}) and spatial distribution (at least in areas with core control) the results of our studies (Fig. 1c, 1d). For the Spitsbergen Banken (white area in Fig. 1b), SINMOD does not produce any results because the area is shallower than 50 m. This corroborates the distribution of MOC, which is 0 wt.% on Spitsbergen Banken (Fig. 1d). The biggest discrepancy between SINMOD and OF-Mod 3D (Fig. 1b, 1c) with respect to the modeled productivity pattern is seen on the eastern flank of the Spitsbergen Banken. Here OF-Mod 3D uses productivity values as input parameter which are obviously too high to capture the MOC values in the sediments (Fig. 1d). We need to adjust this in a follow-up study. From these results, we can conclude that the productivity estimates used in OF-Mod 3D (Fig. 1c) likely correspond to an integrated value of the uppermost (50 m) water masses in the western Barents Sea. This could explain both the deviations in the modeled productivities (Fig. 1a, b) and the good correspondence between the observed and modelled MOC spatial distribution (Fig. 1d).

Referee: "Lets forget about primary production and look at Fig. 7. "Well captured" is not a term I would use when so many data are seemingly in contrast with the model. It may be that the standard are different in various fields. In my the results are not well captured.

I think, we can both agree from Fig. 7 that the modeling results for the distribution of marine organic carbon (MOC) agrees to 100 % with the observed empirical data set in the ice-free region of the western Barents Sea (in the category 0-1 wt.% MOC). We can also agree that towards the marginal ice zone (MIZ) significantly higher MOC values are both observed and modeled (in the category 1-2 wt.% MOC). We agree that maximum modeled MOC values (3 wt.%) on the eastern flank of the Spitsbergen Banken do not reproduce the measured data. However, all modeled and empirical data points are in the same order of magnitude and follow the regional trends across the MIZ. We agree further that the expression "well captured" is too exaggerated for the proxy-model comparison and will change this accordingly in the revised manuscript.

Minor comments:

(1) marginal Arctic Ocean in the title of the manuscript

Yes, we agree and will change the title accordingly

Additional References:

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