Interactive comment on “First evaluation of MyOcean altimetric data in the Arctic Ocean” by Y. Cheng et al.

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In response to the main points raised by reviewer 2, we generally agree with the reviewer’s statements. We were not informed about the special issue until close to the deadline. we acknowledge that the original manuscript was written in great haste to meet the submission deadline. As a consequence we acknowledge that the original paper was not mature enough (as an example we simply didn’t have time to compute and apply GIA) and consequently the paper lacked adequately quality. Taking into account the constructive comments, we are revising the results and paper and updating the scientific quality of the paper substantially and documenting the products and methods adequately over the past month. The revision will provide substantially scientific improvement and with the importance of the subject. We feel that it will be an important contribution to the MyOcean Special issue of Ocean Science.

In detail our responses to the points raised are the following.

(1) Firstly, the description of the new MyOcean product is very poor. Author should give relevant information on all the improvements performed on this new product and also give external reference (author, publication…).

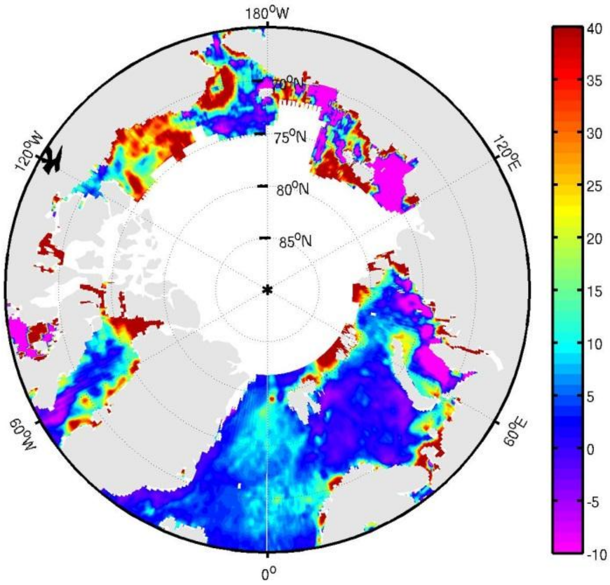
As mentioned the description of new product was very poor in the previous manuscript. More information about the new MyOcean regional Arctic sea level product and external references will be given.

The MyOcean regional Arctic Sea level product is an improvement over the DUACS Version 3 gridded global sea level product by improving the following steps:
Updated the Mean Sea Surface (MSS) with DTU10 MSS (Andersen and Knudsen, 2009).
Updated the ocean tide model with the TPXO7.2 global ocean tide model (Egbert and Erofeeva, 2002).
Increased the spatial resolution from 0.25 °×0.25 ° to 0.125 °×0.125 °.
Updated the along-track Lanczos filtering with a cut-off wavelength of 35 km. We are not aware if any update to the editing and retracking have been performed.

Currently the new MyOcean regional Arctic gridded sea level product have not been released as an official MyOcean product, but it is foreseen that this will be part of MyOcean2.

(2) My second concern deals with the poor robustness and reliability of statistics presented in this report. For instance the SLA variance indicator is not performed in similar conditions

This was the weak part of the paper and substantial effort has been devoted to update and ensure the robustness and reliability of the statistics. We have revised the entire analysis ensuring that the variance indication is only performed/computed in areas where the both altimetric data sets are available by choosing the smallest common mask of the datasets. One example of the revised work is given in the figure below.



The figure presents the distribution of sea level anomaly variance difference (cm^2) between MyOcean regional Arctic sea level product and DUACS sea level product. The reduction of sea level variance can be seen in the Barents, Kara, Laptev and East Siberian Seas. More interpretation will be given in revised manuscript.

And the error of in-situ and altimetry comparison is not discussed which lead in both cases to wrong conclusions.

Firstly we provided the standard derivations of both in-situ and altimetric data and also give the root mean square differences between in-situ and altimetric data and clearly document how this is computed.

The comparisons between weekly tide gauge and altimetric data illustrate that the new Arctic sea level data set generally presents equivalent or higher standard derivation of SLA and RMSds between tide gauge and altimetric data than DUACS data set. Lower RMSd appears at Prudhoe Bay from the new Arctic sea level product. The reasons it here interpreted to be less filtering of MyOcean regional Arctic sea level which contribute to the higher standard derivation and RMSds at tide gauges.

Secondly, as no errors were available for the altimetric products, we decided to assign error to the tide gauge observations to investigate if tide gauge and altimetry corresponds within this error estimate or to study what a realistic error level on the altimetric products should be.

Assuming a sea level error of 1 cm for monthly tide gauge observations (Proshutinsky et al., 2004; 2007; Jevrejeva et al., 2006), leads to an average amplitude error for the determined annual signal of 0.15 cm. This number is shown to be far smaller than the difference between nearly all gauges and the annual signal from satellite altimetry, even taking into account a typical interpolation error of 0.3 cm (Volkov and Pujol, 2012).

Basically the RSS (Root Sum of Squares difference taking into account amplitude and phase errors) error for all tide gauges and for the altimetric products is between 5 and 6 cm compared with averaged amplitude of 8 cm of the annual signal which calls for much more research in this region. It should be noted that the difference could have two causes. In several places the gauges are situated in rivers which mean that they are more representative of the river flow than the Arctic Sea level. Secondly the altimetric products are still suffering from a high level of noise. However, we demonstrate that in terms of annual signal the new MyOcean product corresponds closer to tide gauges than the DUACS product.

We also provide the standard deviation of inter-annual signal derived from tide gauge and altimetric data. The inter-annual signal are under estimated from altimetric data and the new Arctic sea level product fit in-situ measurements better with lower RMSd of inter-annual signal.

(3) My third point is the use of SODA model which is not justified. SODA as other models are weakly constrained on this region due the lack of data, and therefore do not provide accurate results at climate scales. The author should justify this choice and at least describe this limitation.

It is generally very hard to get models for the Arcitc Ocean that covers the entire satellite era. SODA model has been used for past sea level reconstruction (e.g., Berge-Nguyen et al., 2008; Meyssignac et al., 2012), we agreed with that the availability of the model in climate scales over the Arctic Ocean maybe constrained by the lack of the in situ measurement (e.g., Fig. 2 in Giese el. al, 2011) and we will describe this limitation.

To make statistics more robust and reliable, the MyOcean GLORYS2V1 reanalysis (1993-2009) is introduced and also used to compare with altimetry data sets. The model assimilated altimetric sea level anomaly, sea surface temperature, and salinity in situ profiles (Ferry et al., 2012).

In light of this we have removed the section of sea level trend and put more focus on the inter-annual signal which is the altimetric data were supposed to be improved and where the hydrodynamic model are thought to be reliable.

(4) Finally, the method described by the author to compare altimetry and tide gauge is not sufficient and unclear since the author mention that tide-gauge are not corrected with GIA whereas it is crucial at these latitudes (see Volkov Pujol, 2012: Quality assessment of a satellite altimetry data product in the Nordic, Barents, and Kara seas).

This was an error on our behalf not to include the GIA correction into the analysis and we have updated the results to will give more description on the method of comparing altimetric data with tide gauge data. The GIA was applied to the tide gauge records by subtracting GIA inferred from the ICE5G_VM4_L90 (Peltier, 2004; 2005).

As for the method to compare altimetry and tide gauge data, we averaged hourly tide gauge data in weekly intervals to be coherent with the altimetric sea level data set. Subsequently, the weekly averaged dynamic atmospheric corrections (Pascual et al., 2008) were applied to the weekly tide gauge data set. The overlapping data is removed if the difference between altimetry and tide gauge data larger than 12cm, which allow to get rid of strong ocean variability or potential aberrant values in altimetric data time series (Valladeau and Ablain, 2011). Unfortunately this analysis could only be performed in part of the regions as no hourly data were available for the Russian stations.

The altimteric sea level anomaly is averaged over 0.5°*0.5° bin (0.25°*0.25° for new developed Arctic sea level product due to its higher spatial resolution) around the tide gauge location. We do not perform an interpolation (e.g., Volkov and Pujol, 2012), as this we found not to improve the result.

Answers to the reviewers specific comments:

1) Chapter2.1: The description of the dataset is not complete: To be detailed and reference to be added. The naming Myocean V2p is not suitable.

Please see the comment above for the major point 1.

The description of the data set as well as related references will be added. The V2p new developed Arctic sea level product denotes the preliminary version of the product. The MyOcean V2p will be replaced by the "MyOcean regional Arctic sea level product' in the text.

2) Chapter 2.3: Altimetry standards used in RADS has to be described in this paper.

Sure and we have updated the paper to ensure this with a description of the standard range and geophysical corrections applied.

3) Chapter 2.4: The choice of SODA model is not justified. SODA as other models are weakly constrained on this region due the lack of data. The author should justify this choice and at least describe this limitation.

3. As mentioned above, we will describe the limitation. As complement to the comparison, the GLORYS2V1 reanalysis (available from http://www.myocean.eu/) will be used for the comparison to investigate the consistency between models in the region as an illustration of the limitation.

4) Chapter 2.5: The description of the method alti/tide-gauge is poor and unclear: reference has to be added. Moreover, tide-gauge has to be corrected from GIA to be compared to altilmetric-sea-level (Vokov Pujol, 2012: Quality assessment of a satellite altimetry data product in the Nordic, Barents, and Kara seas).

4. As mentioned above (response to main comment 4), more details of the method on altimetric and tide gauge data comparison will be added (averaging, methodology, corrections applied, i.e. GIA)

5) Chapter3.1: Local SLA variance computed with each dataset: Explain what do they mean, improvement, degradation, why? A variance difference map (fig3a-fig3b) would help the reader.

5. We acknowledge the suggestion and will provide the map of variance difference (see major comments above) and also add a discussion on the table of comparison. Please see the answer to the point 6 below for the discussion of the results.

6) Chapter3.1: As the new My Ocean product cover a larger area and the spatial resolution is higher, the SLA variance comparison give an statistically interesting information but not easily interpretable: the SLA variance can increase and lead to an improvement.

Similar to our answer to the main comment 2, the higher sea level variance over some coastal regions is reasonable due to higher spatial resolution of the new Arctic sea level product and the less filtering (35 km vs 60 km). The comparison with sea level RMSd at tide gauges, however, does not generally favor the new products except for the gauge at Prudhoe Bay. The comparison with tide gauges conclude that although the standard deviation of the MyOcean product is close to the standard deviation of the tide gauges, the new products are not necessarily better than the DUACS and the RMSd between the MyOcean and tide gauges are generally higher than the associated comparison for the smoother DUACS dataset.

7) Chapter3.1: Fig 4: upper legend is not consistent with the bottom legend.
The figure will be removed and the reason is given below.

8) Chapter3.1: Fig 4: The two curves do not represent the same areas, what is the contribution of the new areas available in MyOcean V2p?
8. We decided to remove the zonally averaged curve and provide the map of difference of SLA variance between them where both datasets have coverage. This consequently solves the question.

9) Chapter 3.2: A correlation difference map (fig5a-fig5b) would help the reader.
9. We will provide the map of variance difference between DUACS and the new Arctic sea level products.

10) Chapter 3.2: P298-L13: improvement probably not significant compared to the error of the method.
10. The improvement can be seen from the map of variance difference. The errors are cost of higher resolution and lower cut-off wavelength for the regional sea level products.

11) Chapter 3.2: In order to calculate the correlation and estimate the intra-annual sea-level signal, it should be interesting to know if the periodic signals have been removed or not (annual-semi-annual). The Author has to discuss of this item.

11. We updated the text and detailed how the data was processed. In order to calculate the correlation, the seasonal signal is kept and partly responsible for the high correlations between the two types of data.

To compare the intra-annual signal from the DUACS and the new Arctic sea level products, after removing the seasonal and interannual sea level variability, the sea level anomaly time series were smoothed by a 21-day running mean (Volkov et al., 2007). Furthermore we have detailed the determined coefficient (percentage of the total sea level variance) of the intra-annual signal. This is done for the various data sets. Finally comparisons with variance at several tide gauges are presented. This will be further discussed in the revised manuscript.

12) Chapter 3.3: What is the main conclusion of this part?
12. In this section, we validated the amplitude and phase of annual signal in the Arctic Ocean from independent data sets. The results from GLORYS2V1 are also involved for the comparison. More discussion on the RSS between tide gauge and altimetric data derived annual signal is given in response to main comment 2.

The main conclusions are:

(1) All data sets show similar pattern of high annual signal along the Norwegian and Russian coastline, especially in the East Siberian Sea.
(2) Compared with that derive from the DUACS product, the MyOcean regional Arctic sea level product derived amplitude of annual signal show better agreement with in-situ measurement.

13) Chapter 3.4: P300-L1: Phrasing.
13. We agree with the comments and delete the sentence ‘It agrees the results from….’.

14) Chapter 3.4: P300-L2: “Moreover” to be changed.
14. We agree with the comments and delete the word ‘Moreover’.

15) Chapter 3.4: P300-L4: reference to fig 8 not consistent.

15. We agree with the comments and revised ‘Fig.8’ as ‘Fig.8a and 8b’.

16) Chapter 3.4: P300-L9: MyOcean V2p and Duacs are not models.

16. We agree with the comments and revised ‘models’ as ‘data sets’.

17-23. The MyOcean regional Arctic sea level product is not developed for determining accurate linear sea level trend. In present work, we mainly focus on the comparison of annual, interannual and intra-annual signals derived from tide gauge (model reanalysis) with that from altimetric data. Hence we decided to delete the description on sea level trend.

Some references to the answers

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