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Interactive comment on “Improved sea level record over the satellite altimetry era (1993–2010) from the Climate Change Initiative Project” by M. Ablain et al.

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The comments provided by reviewer#1 have helped us to improve the paper. Our answers are described below. The revised version of the paper taking into account these comments are in the pdf file in attachment.

General comments

1. As discussed in Section 2, the impact of a new altimetry correction can be objectively judged based on its influences on GMSL trend or regional sea level trends, however, whether one new correction is an improvement or degradation may be determined somehow qualitatively, or even subjectively. In particular, new corrections do not always

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lead to improvement, thus the differences between SL_cci and AVISO products should not be directly labelled as “improvement” or “reduction of errors”. For example, in the end of Section 6, the authors directly use differences between SL_cci and AVISO products in Fig. 6 as an evidence of error reduction in SL_cci product.

=> Reviewer#1 suggests that new corrections do not always lead to improvements because the way to determine if a correction is an improvement or degradation may be determined qualitatively, or even subjectively. Therefore, for reviewer#1, the differences between SL_cci and AVISO products should not be directly labelled as an “improvement” or “reduction of errors”. This comment points out that this part in the paper is not explained well enough and we have to improve it. Indeed, a new altimeter correction was selected only if we were sure that it led to realistic improvements in sea level calculation on climate scales with objective criteria. This is the case for all the new corrections listed in table 1: - Most of the time, when a strong impact was detected on the sea level calculation comparing two similar altimeter standards, we were able to demonstrate whether this was a deterioration or an improvement with objective (and not subjective) validation diagnoses. These diagnoses were based on crossover analyses, long-term hemisphere or basin analyses, by comparison with other altimetry missions and in-situ measurements, etc... - In some cases, it was not possible to demonstrate whether the new corrections provide deterioration or an improvement because a) the validation diagnoses were not well adapted b) the impact of the new correction was too low to be detected by the validation diagnoses. In these rare cases, we preferred to adopt a conservative approach and keep the former altimeter standards in the SL_cci project. - All the new corrections selected in the project were approved by an independent and international group of altimeter experts during a “selection meeting” which took place in Toulouse in May 2012 (for more information, see the meeting conclusions here : http://www.esa-sealevel-cci.org/webfm_send/85) - All the tables similar to figure 1 (characterization in sea level of new SL_cci corrections in comparison to corrections defined as reference) are available for all the corrections in the project validation reports and explain the nature of these improvements. - The 2 charts in figure

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6, showing the global and regional MSL difference between SL_cci and AVISO 2010 products, illustrate the sum of the impact of all the new selected corrections separately analyzed. Therefore, they show the improvement of the SL_cci product at these scales since each new correction is better or at least has no impact on climate scales. In this part of the paper, we provide the reasons for these improvements for the global MSL as for as well as the regional MSL trends. However more details are available in the Product Validation Internal Report (PVIR) referenced at the end of the paper. Furthermore comparisons with in-situ measurements (not displayed in the paper but mentioned) also show that the differences in figure 6 are an improvement. Therefore, we think that the word “improvement” or “reduction of errors” for figure 6 is appropriate. In order to clarify this issue in the paper, we have made several evolutions in sections 2 and 3 based on the different arguments previously mentioned. In particular we have added a paragraph at the beginning of section 3 describing the role of the external and independent experts in selecting the new corrections (this comment has also been asked by reviewer #2).

2. Two ocean data assimilation (DA) products (GECCO2 and ORAS4) are used to evaluate the SL_cci product. It's concluded that SL_cci product is closer to both DA products than the AVISO product, though both of them assimilate AVISO. I think it's a not very meticulous practice and could be misleading without giving some key details about how data assimilation is done in both DA products (e.g., heavily or loosely constrained by sea level or any other observational fields), what's the sea level formula in the model (e.g., including freshwater input from land ice melting, Boussinesq vs non-Boussinesq). Ideally you want to compare both AVISO and SL_cci sea level products with a DA product which assimilates other variables excluding sea level, thus better agreement between one sea level product with above DA product can be regarded as a robust evidence for supporting better quality of this product.

=> It is correct that the GECCO2 model has assimilated the AVISO product only, and thus, as it has tried to adapt to the assimilated data from which SL_cci from AVISO is

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only one out of many variables. The synthesis result could be expected to be in closer agreement to the AVISO data set as compared to any other SL product. However, as the model is constrained by its physics itself, the synthesis result not necessarily needs to be in closest agreement to the assimilated data. Indeed, we could demonstrate that the new SL_cci product is in many places even closer to the model synthesis as compared with the assimilated AVISO product which illustrated the closer agreement of the SL_cci product with the model physics. A degradation of the SL_cci product can be seen especially in low energetic areas where the signal to noise ratio is very small and therefore a clear distinction between an improvement or a degradation is not straight forward. The GECCO2 model is a product we use in this comparison exercise and it is explained in detail in the cited paper (Köhl, 2014). With that description the product has been described and a discussion about further details of the product can easily be seen within the citation itself. However, to answer the questions: while writing: "heavily or loosely constrained", did you mean strong or week constrained? If so, the GECCO2 model is strong constrained by sea level, has no freshwater input and uses the bussinesque approximation. Further it uses the adjoint method and has virtual salt fluxes. Testing the AVISO and the SL_cci product against a model that has not assimilated any of the two data sets would indeed be of use and could illustrate a different point of view. Further, it would be useful to compare both sea level products not only to a GECCO2 synthesis that assimilated AVISO but also to a synthesis that assimilated the new SL_cci product. This more valuable evaluation is part of the current phase two of the sea level cci project and both runs have now already been performed and show even more promising results. However, for the first phase only the assimilation of the AVISO product had been planned.

Minor Comments

3. Page 2035, Lines 4, 10 & 16, Table 1 should be Fig. 1? => Anomaly not present in the files provided to the editor, but only on PDF file online.
4. P 2036, L 20 & 25, Table 2 should be Fig. 2? => Anomaly not present in the files

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provided to the editor, but only on PDF file online.

5. P 2043, L 18, Wind forcing is one important driver for regional sea level distribution, but it's not the only one. For example, buoyance forcing (heat and freshwater fluxes) may also play significant role in some regions. There are quite a few publications on this aspect. => We have changed the text for more clarity.

6. P 2043, L 25, remove "and" after "by comparing" => Has been changed

7. P 2043, L 7-12, not all processes contributing to sea level variations are included in those general circulation models, which may cause what altimeters observe and what models simulate can be different. => The reviewer is correctly pointing to the model limitation and deficiency in simulating all contributions to sea level change (such as from GIA) whereas the altimeter observes the total accumulated contribution to sea level change. The inter comparison between observations and simulations is therefore not ideally comparing apples to apples. With this in mind, the paragraph has been rewritten.

8. P 2044, L 13-14, what percent of total ocean area is in red colour (with improvement), what's the average improvement ratio? How is blue colour? It's easier to interpret with some numbers. => Values like that indeed can be useful and are added to the text.

9. P 2047 L 12-13, Similarity between sea level trend map and steric sea level trend map has been presented in many conferences & publications, and it does not critically depend on which altimeter product is used to generate the sea level trend map. So such comparison should not be counted to support the improvement of SL_cci product over previous products. => This comment is relevant. The section 5.5 has been removed.

10. P2049 L27 - P 2050 L1, "Substantial improvements" seem to be an overstatement to me. Yes, there are improvements, but some of them are not substantial or even

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marginal. Despite improvements over previous sea level products, this new sea level product still cannot address some climate study related questions raised in the Abstract, therefore we still need either longer altimeter sea level products or other in-situ fields (such as subsurface temperature and salinity) to address those questions.

=> Of course, all the improvements are not substantial but only some of them as for instance the improvement of regional sea level trends or the improvement of ERS/Envisat times series. This point has been clarified in the conclusion. In the conclusion, we have already mentioned that the user requirements have not yet been reached, and we have explained that further improvements are needed as for instance extending the sea level time series. As suggested by reviewer#1, we have improved this part explaining that the final objective is to answer to some climate study related questions raised in the abstract.

Please also note the supplement to this comment:

<http://www.ocean-sci-discuss.net/11/C1065/2014/osd-11-C1065-2014-supplement.pdf>

Interactive comment on Ocean Sci. Discuss., 11, 2029, 2014.

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