Response to anonymous referee #1

Referee #1 recommends the paper be accepted for publication and suggests a few areas that she/he thinks the paper could be improved. Each of the comments arises by the reviewer are first answered.

What is the minimum expected RMS error for the reconstructed fields?
The authors evaluate their product by comparing to independent, with-held Argo profiles. This is a suitable strategy and demonstrates well the improvement from the back-ground field (climatology) to the synthetic profiles (using SLA and SST projections) and
finally the combined fields (adding Argo to the synthetic profiles). See Figure 7 as an example. The RMS (and mean) errors presented in Figures 5-8 assume that the independent profiles are error free. However, the profiles used for this evaluation contain
error associated with limitations of the instruments (this is very small – negligible for the purposes here) plus representation error (there are several different names for this component of observation error used in the literature). Representation error is the part of the true signal that cannot be represented on the chosen grid – the sub grid-scale signal. This will be large in some places (e.g., where mesoscale variability is significant) and zero in some places. I suggest that the representation error is the minimum expected RMS error. The authors have apparently generated explicit estimates of the representation error that they use for the second step of the method they describe. I suggest that they consider included these estimates, as an expected lower bound in Figure 5-8. This will help determine whether the products they produce are as good as could be expected – or could be improved if their mapping procedure or the inputs to it (e.g., the regression coefficients) were improved.
I recognize that the estimates of representation error are not well known. But the authors apparently believe them enough to use them for this gridding procedure – so they evidently have some confidence in them.
We agree that the representation error (as defined by the reviewer) is the minimum expected RMS error. The representation error is a key parameter for data assimilation and when data from different sources and having different horizontal and temporal sampling are merging together. Representation error is both function of the horizontal and temporal grid resolution of the calculated field (model resolution in the case of a data assimilation problem and grid resolution in the case of an observation-based approach).
In fact, we have not generated explicit estimates of the representation error. That is something we might considered in future studies. A measurement white noise of 10 % of the signal variance is included and it includes both instrument error (expected to be very small) and representation error. This value of 10 % has been estimated empirically (various tests have been performed with various numbers checking the shape of the resulting merged field). We think that this value of 10 % is not completely out of scale but could be improved. We have thus decided not to include it in the Figure. The text has nevertheless been changed to include the 10 % number that is missing in the present version.

If the authors were to be more precise, they should not describe the fields showed in Figures 5-8 (and elsewhere) as errors – they are really differences between the gridded products and independent observations. They might more accurately refer to them as differences.
We agree that the fields showed in Fig. 5-8 are differences between the gridded products and independent observations that include errors due to the method (vertical projection & mapping) but also representation error as mentioned above. It has been changed throughout the text to refer to them as differences.

Have the authors attempted to apply error propagation techniques to produce expected analysis errors for the synthetic profiles? Similarly, the OI mapping used in the second step of the method can presumably produce estimates of analysis errors. How do these

compare to the RMS error/difference fields they present here?

No attempt has been made to apply error propagation techniques to produce expected analysis error for the synthetic profiles. The OI mapping method provides a formal error that is hard to be compared to the RMS difference fields. The OI mapping formal error is very small where the ocean is well sampled by in situ measurements and very large away from these areas. Also it depends on the prescribed spatial and temporal correlation scales.

How many profiles are used in each 1 degree bin to compute the regression coefficients for the vertical projection? I presume the regression coefficients in the North Atlantic are better defined because of the denser Argo coverage for a longer period – compared to the Southern Ocean for example. Do you see poorer performance of this method where there was less data to "train" the regression coefficients?

A minimum number of 500 observations is used to compute the regression coefficients in each 1 degree bin (see P 1320, L16). This number increases up to 3000 profiles in the North Atlantic or North Pacific Oceans. Minimum values are obtained in the Equatorial Eastern Pacific region. Previous version of the method used regression coefficients computed from historical observations covering the 1950 to 2000 time periods. Huge improvement has been obtained including the Argo data sets: no seasonal bias, deeper estimations. We haven't seen any clear relationship between the performance of the method and the coverage of the data used to train the regression coefficients. The regression coefficients used are large scale one and we can expect improvement at finer scale (coastal areas, semi enclosed sea) with the increase of trained datasets.

Minor comments are now answered:

There are several places in the paper where the English could be improved (e.g., page 1314, line 2; "that combines efficiently the main: : :" should be "that efficiently combines the main : : :"; and many other places in the paper). The reader can easily understand what is meant, but the authors might consider addressing this.

The paper will be read again by a "professional" native English speaker.

On page 1321 the authors refer to a "tong" a few times. Do you mean "tongue"?

Yes, tongue is the correct word – sorry for that, it has been corrected.

With reference to Figure 2, showing correlation coefficients between dynamic height and temperature, etc, the authors interpret correlations that are quite small (e.g., -0.2). What is the significance of these correlations? Given the number of data used to construct these correlations, the authors should be able to estimate the level of correlation, below which, the estimate is indistinguishable from zero. If the amplitude of a correlation is smaller than this significance level, there is no point interpreting even the sign of the correlation.

Given the relatively large number of profiles used to compute the correlations, set to 500, thanks to large radius of influence used to select the profiles, the significance of these correlations is quite high. For ex., for a correlation of 0.2 and a number of profiles of 500, then, there is 95% of chance that the correlation coefficient is between 0.114 and 0.283. This is mainly true for the equatorial oceans. At mid latitude, where the number of profiles is increased, the 95 % confidence interval is even reduced. We thus think that the low correlations are significant within the 95 % confidence interval. A sentence has been added to the text.

There is a slight inconsistency in the text on page 1326 with the text on page 1324. On page 1324, the authors say that in the synthetic profiles the "mean error is almost zero" (line 8). On page 1326, they say that "the mean error that was present in the synthetic temperature fields has now disappeared" (line 7).

It is true that on page 1324 we say that in the synthetic profiles the "mean error is <u>almost</u> zero". On page 1326 we say that "the <u>very small residual</u> mean error that was present in the synthetic temperature fields has now disappeared". The words "very small residual" is associated to the word "almost", maybe it is not clear enough. The blue curve (on Fig. 7) shows very very small differences from zero and then the green curve (on Fig. 7) is equal to zero.

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This product is publicly available and can be access through the MyOcean web portal (as Global Observed Ocean Physics Temperature and Salinity Analysis – reprocessed product and real-time ones), or through request to the authors.