RESPONSE TO REVIEWER 1

The authors would like to thank Reviewer 1 for the comments and suggestions that have helped to improve the overall quality of the paper. In our answers, we have referred to the line numbers as in the revised manuscript.

General comments:

One wonders why not other products have been consulted or why no attempt has been made to explore reasons for differences.

The NEMO-based Ocean Reanalyses (ORAs) used in this work, which are quite similar products among many different existing ORAs (as pointed by the reviewer), already show large differences in the South Atlantic meridional transports. Including more and different reanalyses would only add an extra factor – different models – to be accounted for in explaining differences. We also wanted to focus on a comparison between ORAs and Free-Running Models (FRMs) and to explore differences/similarities between them, so we use FRMs and ORAs with the same basic NEMO model. We think this dataset (totalling 6 products) allows to compare the ORAs and FRMs, as well as to explore the ORA transport differences in the South Atlantic.

We agree with the reviewer that more work is needed to properly investigate the reasons for the ORA differences, but we have considerably narrowed the problem to understand how to better constrain the western boundary transports. We have shown that the current ORAs do show good agreement in currents and transports in the interior which is a big step forward. We make clear in the conclusions that future work will address specifically this western boundary problem. We intend to use one specific ORA product and run sensitivity experiments changing the data assimilation configurations near the western boundary so that we have control over the product to better address the western boundary issue. Also because we do not have a good observational truth for these western boundary flows, in our opinion this needs a different approach, rather than intercomparison of current products, to continue the investigation. These next steps to fully pin down the reasons behind the inter-product spread represent a complete study in itself.

Details:

L72: How about the contribution from the eastern boundary and the interior circulation, wouldn't these be worth to be shown or at least be mentioned?

We agree with the reviewer about mentioning the interior and eastern boundary. Both are now mentioned in the sentence starting in L70, as below:

"Their result reveals the need for further assessment of the skills and uncertainties of the ORAs in the South Atlantic, such as comparing them with Free-Running Models (FRMs) and evaluating their SAMOC contributions across the eastern, interior, and western boundary regions shown in Fig. 1."

However, for Fig.1 we still focus on the western boundary circulation to set the scene, particularly for the analyses of Fig. 9, Fig. 10 and Fig. 11 in the section 3.3 showing the western boundary role in the large-scale transports.

L163: I am not clear which studies you refer to. There were already two named, and now two different follow. Maybe this be slightly rearranged that it reads smoother.

The sentence in L161 was rearranged as below:

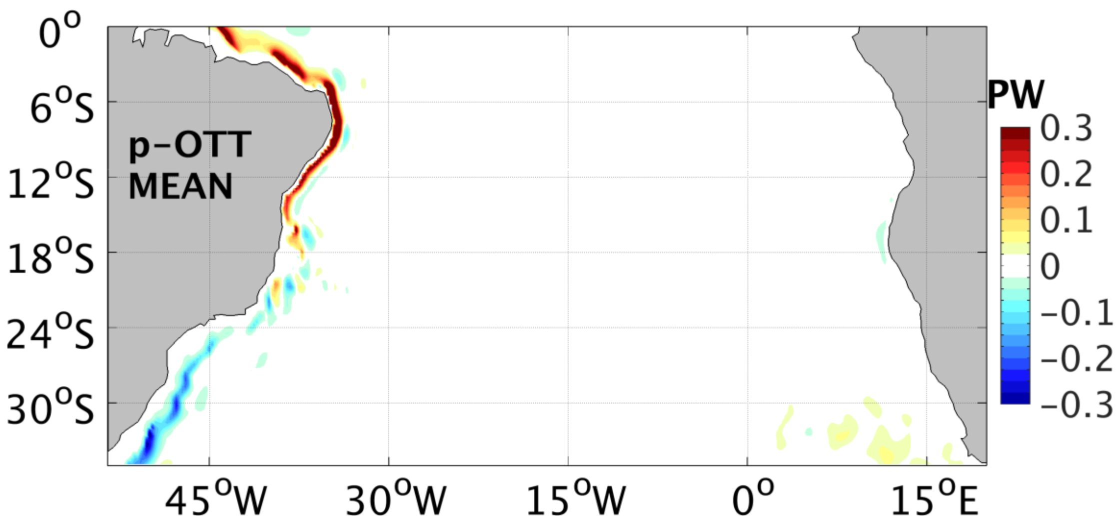
“The large-scale transports are compared to the 34 high-density XBT-based estimates (XBT-AX18) in the Southern Atlantic from 2002 to 2013, with transport estimates at 35˚S and 30˚S given by Majumder et al. (2016). Recent observational studies are also used for comparison, which employ different methodologies to calculate the SAMOC and MHT between 35˚S and 20˚S, as follows: (i) an Argo climatology (Dong et al., 2014), (ii) altimetry synthetic profiles based on the correlation of the AVISO SLA and isotherm depths (Dong et al., 2015), and (iii) dynamic height fields from Argo and AVISO SSH (Majumder et al., 2016) are used together with wind fields to estimate the total transports.”

Fig. 4g: Label g missing

Label g is now included in Fig. 4.

L258: Presumably these are the same areas that contribute most to the MHT. The trivial expectation is that the relative spread is similar, such that differences in areas that matter most for the mean MHT also matter most for their spread. Is this so? Could you check this, maybe show the ensemble mean p-OTT.

According to the plot below, areas of largest spread do correspond to areas with largest mean transports (i.e. along the western boundary).



We now note it in the text, which has been changed in L257 as below:

"The $v\bar{T}$ component captures variations from ~0.2 PW to 1 PW (Fig. 7c), explaining ~83% of the total MHT spread which is mainly concentrated in the areas with largest mean transports, i.e. the narrow western boundary region (Fig. 7d)."

L274-278: Wouldn't you expect to see an impact of the second peak of southward transports in the ORAs that the FRMs should not show? Also, since Fig.4 shows the mean, I don't see how you can infer conclusions for the time variability from this. You could investigate the contributions to the heat transport variability in more detail instead of speculating.

The ORAs southward peak between 10˚S and 5˚S in the maps of Fig. 4 does actually increase their southward flow by ~4 Sv compared with the FRMs (see Fig. 4g). However their North Brazil Current (NBC) transports can increase from ~4 up to 9 Sv compared to the FRMs (see Fig. 5). So, the ORA second southward peak is more than balanced by the increase in the western boundary transports, and this is why there are no clear sings of it in Fig. 2a or in Fig. 3c.

Answering the second part of the reviewer's question, the interior southward flow increases towards the equator for all products, reaching similar magnitudes to the overturning component, and with both having similar ΔTs. So it is natural to expect that variations in the southward flow will also contribute to the MHT variability in this region. This is all that was intended. Further investigation of this time variability would be possible but is not the main focus of this paper. The sentence is now modified in L276 as below:

"Therefore it is likely that these large upper level tropical circulations explain why ψ_{max} does not dominate the MHT variability close to the equator, as also noted by Valdivieso et al. (2014). "

L293-294: I think showing the ensemble mean p-OTT would also serve here to make this point. Fig. 1 shows the volume transport but the depth integrated heat transport could be different.

We have added this figure in answer to L258 above but we do not see how it is relevant to this point? The main point of Fig. 9 is to show the continuous band of positive MHT regression coefficients against the western boundary which means that ORAs with the largest MHTs must show less southward transport along the Brazil Current (BC) and higher northward transport along the NBC, compared to the FRMs. This pattern is further confirmed by Fig. 10 for both BC and NBC.

L299-300: It would be nice to add information on these limits to the figure caption or state them somewhere else.

We agree with the reviewer. The water masses limits are now stated in the captions of Fig. 10:

“The TW, SACW and AAIW limits are defined in kg m^{-3} with $\sigma < 25.5$, $25.5 \le \sigma < 27.1$, and $27.1 \le \sigma < 27.3$, respectively.”

L315-317: Isn’t this basically what we already know from Figure 2?

In Fig. 2 we show the AMOC strength across the basin which is a zonally integrated quantity. In the lines here we discuss the 4-box model of the transports (Fig. 11), i.e. the transports are broken down into western boundary versus interior, and into upper versus deep circulations. We agree that main difference between the products is shown in Fig. 2 but it cannot be really understood. Fig. 11 shows where the inter-product compensations occur and how the 4-box transports are balanced within products. We therefore say that GLORYS2V4 and UR025.4 are ~10 Sv and 8.5 Sv larger than ORCA025 in the upper western boundary, and these inter-product differences are mostly compensated by the deep western boundary transports. In Fig. 11, we can also see the contributions and their much better agreement from the interior boxes.

L334-335: Can this variability be considered realistic? Are the associated features similar to the high resolution model simulation? For instance, the ORAs, except ORAP5, have substantially more variability in the interior than the eddy resolving model.

Masina et al. (2015) also found that these NEMO reanalyses show an increased Eddy Kinetic Energy (EKE) and that they are in much better agreement with the OSCAR estimates when compared to no-assimilation runs. GLORYS, CGLORS and UR025-4, which have the largest transport variability here, also show the best level of agreement with OSCAR. This is an indication that the higher ORA variability caused by DA in the velocity fields is consistent with information inferred from observations. We have tried to be more specific changing the text in L334 as below:

“Figures 12a-f show that the interannual variability in p-OTTs is larger in the ORAs and in the high resolution ORCA0083 than in ORCA025. The assimilation of observations in eddy-permitting models introduces variability that would otherwise only appear with higher resolution, as in ORCA0083. According to Masina et al. (2015), this higher variability in the ORAs is in better agreement with the Eddy Kinetic Energy estimates from the ocean surface current velocities (OSCAR) product than that of the FRMs.”

L353-355: It does not become clear why these two time series are shown together. What is their relation or the intention here?

The intention is to verify how these two components of the circulation behave over time in the tropical South Atlantic. For example, how are these transports in the ORAs impacted by the introduction of Argo? From Fig. 13 the southward interior flow is better constrained by the ORAs in the later years, related with the assimilation of a larger number of (Argo) hydrographic observations (including salinity observations) across the basin. However, the overturning component is dominated by the narrow western boundary and the lack of observations in these narrow areas means the overturning is not better constrained, and so the ENS-ORA spread of the overturning component remains nearly steady over time.