We thank the referees for their comments and helpful suggestions for manuscript changes. These have improved both the content and clarity of the manuscript. We are pleased that both referees see this work as a useful contribution to the field of AMOC variability and that this study has been recommended for publication. Our response to referee comments is below. A description of changes made to the manuscript as a result of these comments is included.

Referee 1

Specific Comments:

1. *There is no accounting for any ageostrophic variability in the DWBC. The vorticity balance in the DWBC is different from the basin interior, so DWBC transport is not completely represented by geostrophy. Is there any way to use direct current measurements of Rapid-WATCH in the DWBC to assess the possible additional error due to ageostrophic transport in the DWBC?*

Our opinion is that the flow, even close to the western boundary, is geostrophic, in that the zonal pressure gradient is balanced by the Coriolis force associated with the meridional flow. This has been observed for the Agulhas Current (Beal and Bryden, 1999). The alongshore pressure gradient is not (necessarily) in geostrophic balance at the western boundary but that does not matter for the ‘method’ we use at 25°N. Whilst an investigation of ageostrophic flow in the DWBC using direct current measurements from Rapid-WATCH moorings may be possible, this is not trivial and is beyond the scope of this work.

Beal, L. M. and H. L. Bryden. 1999. The velocity and vorticity structure of the Agulhas Current at 32°S, Journal of Geophysical Research, 104, 5151-5176.

2. *In the text I believe that the authors need to clearly differentiate between an error in the estimate of a mean (e.g. the +/- 2 Sv error for annual mean Ekman and Florida Straits transports) and a variability (e.g. the standard deviation of a timeseries, std(TEK) = 3.9 Sv and std(TGS) = 3.1 Sv in Kanzow et al., 2007). Using variability would increase the uncertainties in the transports significantly. Please explain why errors in the estimate of the mean are used instead of variabilities.*

We are estimating the uncertainty in treating the snapshot hydrographic transports as annual mean values. The Ekman and Florida Straits transports we use in the calculations are annual means, so their uncertainty is the uncertainty in estimating the annual mean, whereas geostrophic 'snapshots' of the mid-ocean are not annual mean values, so possess a greater uncertainty (std. dev. of Rapid-WATCH mid-ocean timeseries). The main sources of uncertainty for annual mean Ekman transport are a ≈10% error associated with wind stress estimates from the NOC climatology and the standard error of the mean. The 1957 section has a further uncertainty associated with the use of the 1980-2005 mean to represent mean transport in that year. The 2010 section calculates Ekman transport using the NCEP climatology and its main uncertainties are those associated with the standard error of the mean and the low spatial resolution of the NCEP grid. The main sources of uncertainty for annual mean Florida Straits transport is uncertainty associated with inference of transport from cable voltages, an uncertainty in the North West Providence Channel flow (for the

1957, 1981 and 1992 sections), uncertainty associated with the use of the 1980-2006 mean to represent mean transport (for the 1957 and 1981 sections) and standard error of the mean. Combining uncertainties randomly, this amounts to an order +/- 2 Sv error for combined annual mean Ekman and Florida Straits transports (reducing for later sections). As the main source of uncertainty in the snapshot hydrographic transports is that associated with the mid-ocean (see comment #4), the uncertainty in annual mean Ekman and Florida Straits transport is not discussed in great detail in the text and instead the reader is referred to Longworth (2007) where a full discussion is presented.

The uncertainties section has been changed to emphasise the distinction between annual mean and 'snapshot' mid-ocean values.

The final paragraph of the uncertainties section has been split into two separate paragraphs. The first of these addresses the type of uncertainty used in hydrographic transport estimates and now reads:

"A further source of uncertainty arises from the estimate of annual average Ekman and Florida Straits transports. This includes measurement errors and representativeness errors (e.g. the error in representing mean Florida Straits transport in 1957 using the 1982-2006 mean) and amounts to a maximum combined uncertainty of around +/- 2 Sv assuming errors are random (Longworth, 2007), reducing for more recent sections where annual averages are available. It is emphasised that the Ekman and Florida Straits transports used in the calculations are annual mean values, so the uncertainty given for these terms is the error in estimating their annual mean transports. Hydrographic 'snapshots' of mid-ocean transports are not annual mean values, so the standard deviation of Rapid-WATCH transports are used (Table 5) to estimate the uncertainty in using a 'snapshot' value to represent annual mean transport in some depth layer in the presence of a noisy baroclinic flow field. For a 1 Sv error in combined Florida Straits and Ekman transport, the associated mid-ocean transport error (in depth classes) is calculated and given in Table 2. A 1 Sv change in this transport leads to an adjustment in the reference velocity required to maintain mass balance, thus transport compensation in the mid-ocean is proportional to depth class area (and will respond linearly to changes in Florida Straits and Ekman transport error). The partitioning of Ekman and Florida Straits transport variability between mid-ocean depth levels is also a useful quantity given that Rapid-WATCH transports incorporate time variable Ekman and Florida Straits transports, but the hydrographic sections do not. This is addressed later."

3. *Table 5: Why is the Ekman flux in the Rapid data different from the Ekman flux applied to the hydrographic sections? It seems to me that they should all be the same if the goal is to filter out interannual variability in the comparison.*

In Table 5, an attempt is being made to compare mid-ocean transports from the hydrographic sections with those made by Rapid-WATCH. This comparison is not perfect because the Rapid-WATCH array and the hydrographic sections observe slightly different latitudes (the Rapid-WATCH array nominally observes 26.5°N whilst the hydrographic stations are located on average nearer 25°N). This means that slightly different Ekman transports are required for mass balance; a smaller northward Ekman transport is used for Rapid-WATCH reflecting the weaker trade winds at this latitude. Failure to account for the weaker mean northward Ekman transport at the latitude observed by Rapid-WATCH would lead to a mean southward barotropic transport adjustment being applied to the Rapid-WATCH data to maintain mass balance. This in turn would render transports in the deep ocean less comparable between the hydrographic sections and Rapid-WATCH data. It is noted that in the upper ocean (wind driven layer) the difference in latitude will affect comparisons; in the hydrographic sections a stronger southward geostrophic upper ocean transport is needed to balance stronger mean northward Ekman transport at this latitude. However, the large variability in the upper ocean renders this effect unimportant and the focus of this paper is the deep ocean. It is noted that in terms of variability (not mean transports), this study implicitly assumes that the transport variability observed by Rapid-WATCH can be used to estimate uncertainty in 'snapshot' hydrographic transports, despite the small difference in latitude.

4. *In Fig. 8, the authors show how transports in the different water mass ranges from the hydrographic sections compare to the envelope of variability in the Rapid-WATCH timeseries. The error bars for each transport must be shown since there is also uncertainty in those values.*

Figure 8 shows the mean transport from 5 years of Rapid-WATCH observations and 'snapshot' transports from six hydrographic sections in different depth layers. The standard deviation of (de-trended and de-seasonalised) Rapid-WATCH timeseries is used to estimate the uncertainty in treating each 'snapshot' of mid-ocean transport as an estimate of annual mean transport in that layer. This is the dominant source of uncertainty when comparing Rapid-WATCH transports with hydrographic transports to assess whether interannual transport variability can be detected in the hydrographic record. Other sources of uncertainty make a small contribution to these error bars and so are not shown. For example, for LNADW transports, randomly combining bottom triangle transport uncertainty (order 1 Sv) + uncertainty in mean Gulf Stream and Ekman transport (order 0.8 Sv in LNADW, see Table 2) + 'snapshot' sampling uncertainty (4.4 Sv, i.e. 2 std. dev. of Rapid-WATCH LNADW transport variability) gives a total LNADW uncertainty of 4.6 Sv. For shallower layers that have less interaction with bathymetry (e.g. UNADW), the bottom triangle effect is likely to be smaller. In general, the effect of sources of error other than 'snapshot' sampling uncertainty is of order 0.1 Sv. For visual clarity it was felt this would not benefit Figure 8 and so has not been plotted. However, this small additional uncertainty is now acknowledged in the caption for Figure 8 and is also more clearly discussed in the uncertainties section:

Extra text at end of Figure 8 caption reads:
"In addition to the +/- 2 std. dev. shown, hydrographic transport estimates will have a further uncertainty of order 0.1 Sv associated with other sources of error (Section 2.3).

The final paragraph of the uncertainties section has been split into two separate paragraphs. The second of these addresses combined uncertainty in hydrographic transport estimates and now reads:

"Additional sources of error, such as sampling resolution and choice of reference levels, increase the uncertainty of transports observed in one time hydrographic sections. All errors should combine randomly such that the main source of uncertainty for transport in a depth layer is associated with the baroclinic flow field (typically several Sverdrups, Table 5). Combining this uncertainty with other sources of errors only tends to increase overall uncertainty by order 0.1 Sv. It is therefore only this baroclinic uncertainty, as estimated from Rapid-WATCH transport variability and given as standard deviations in Table 5 (right column), which is discussed in the remainder of this study, however these further additional small sources of uncertainty should be borne in mind.

5. *Page 123, lines 7-9: What is the basis for this conclusion? In the previous paragraph, it was clearly stated that only transport in UNADW (1981 and 2010) were outside the +/- 2 standard deviation envelope, not LNADW transports. How can there be a "significant" change in LNADW?*

The original text read:
" For the above results it is the earlier 1981 and 1957 NADW transports that show the most interesting changes relative to Rapid-WATCH measurements but it is emphasised that changes in LNADW transport remain significant relative to Rapid-WATCH variability for both the 1957 and 1981 sections, whether or not a seasonal transport anomaly is removed"

The language for this sentence has now been improved. The intention of the sentence was not to comment on the statistical significance of the changes in upper and lower North Atlantic Deep Water transport, but to emphasise that the suggestive trends observed in LNADW transport are not reliant on the application of a seasonal sampling correction for them to become apparent (the use of which is itself uncertain).

The new text now reads:
"For the above results, it is the earlier 1981 and 1957 UNADW and LNADW transports that show the most interesting differences relative to Rapid-WATCH measurements. It is emphasised however that the differences in 1957 and 1981 LNADW transports relative to Rapid-WATCH are not reliant on the removal of a seasonal transport anomaly to become apparent."

6. *Pages 131-132, last paragraph of section 3.3. This whole paragraph was extremely unclear to me.*

The message of this paragraph has been somewhat confused and as such an attempt has been made to improve the clarity of the text. The final five paragraphs of Section 3.3 are now a re-write of the original paragraph and the Section heading has been slightly altered to "Water mass changes and isopycnal heave in the DWBC". The confusion seems to have partly arisen from a lack of clarity in the language of the first sentence of the original last paragraph, which described the different lines in Figure 13c-d, and which misled the reader from there onwards. This sentence is no longer present in the re-written text. Specific concerns are addressed below:

In the first sentence, how are the red lines in the bottom row of Figure 13 "deviations from density compensation"?

The red lines in the bottom row of Figure 13 represent property changes on isopycnal surfaces relative to the 2010 section. The black lines represent property changes on depth surface relative to the 2010 section. This is stated in the first of the five re-written paragraphs.

"Figure 13c-d show potential temperature and salinity changes averaged over the depth range of the DSOW (3000-4700 metres) on both depth (black lines) and potential density surfaces (red lines) for the six hydrographic sections relative to the 2010 section. A long term, decadal cooling and freshening trend is observed on depth surfaces which is outside the range of Rapid-WATCH sub-seasonal and seasonal variability (black bars, estimated for the 77°W-70°W DWBC region as described above)."

Fig. 13 shows temperature and salinity separately and we see clearly that the water freshens and cools. However, the extent to which DSOW at 25N is density compensated is not quantified. Also, where is the effect of isopycnal heave on transport quantified?

A classical way of decomposing property changes on depth surfaces is to decompose them into a component associated with water mass change, and a component associated with heave of the water column along the historical T-S gradient. In this approach, water mass changes are assumed to be density compensated (i.e. to occur on isopycnal surfaces) and the remaining change on depth surfaces is then attributed to isopycnal heave. This decomposition was done by Cunningham and Alderson (2007) for the 1957-2004 sections (referenced in the previous version of Section 3.3). However, several authors (e.g. Bindoff and McDougall, 1994) note that water mass changes are not necessarily density compensated, e.g. if a pure cooling of a water mass has occurred this will lead to an increase in its density (and the decomposition described above will not work).

The purpose of the first sentence of the paragraph in question is to qualitatively assess whether this decomposition holds for the LNADW by using Rapid-WATCH data to illustrate the changes expected on depth levels associated with sub-seasonal isopycnal heave (black bars). It is clearly seen (Figures 13c-d) that the property changes observed on depth levels (black lines) *can* be interpreted as being a combination of a long-term density compensated cooling and freshening of the LNADW water mass (red lines), plus a deviation from this long term trend associated with short term isopycnal heave (black bars). It is reasonable then to suppose that water mass changes observed in the LNADW have been density compensated and the decomposition discussed above is valid (the reader is referred to Cunningham and Alderson, 2007 for a quantitative decomposition of the changes).

This idea is now more clearly explained in the second of the five re-written paragraphs:

"A common approach used to interpret potential temperature and salinity changes observed on depth surfaces is to decompose these changes into two components. The first is a density compensated change in water mass θ-S properties (which is the property change along isopycnal surfaces) and the second is property change along the historical θ-S curve associated with isopycnal heave. Cunningham and Alderson

(2007) used this approach to decompose property changes in the 1957 to 2004 hydrographic sections (over 75°W-65°W). They showed that for DSOW, property changes from 1957 to 2004 on fixed pressure surfaces can be principally explained by property changes on isopycnal surfaces, though isopycnal heave accounts for ≈ 1/3 of the change in potential temperature. This decomposition approach assumes that water mass property changes (in this case DSOW) are density compensated (i.e. always change along isopycnal surfaces). However, some authors have suggested that water mass property changes may also be non density-compensated (Bindoff and McDougall, 1994), evidence of which has been found in LSW at 26.5°N (Vaughan and Molinari, 1997). Figure 13c-d however supports the approach of Cunningham and Alderson (2007), showing that the potential temperature and salinity changes observed on depth levels in the DSOW (black lines) can be explained as the combination of a long-term density compensated cooling and freshening of the DSOW along isopycnal surfaces (red lines) and deviations from this long term density compensated trend associated with isopycnal heave on sub-seasonal timescales (black bars). Here, the subseasonal property variability on depth surfaces observed by Rapid-WATCH (black bars) is taken to represent isopycnal heave which is dominant at these timescales."

The authors state that the changes in DSOW transport are not due to changes in water mass properties.

Yes, because density compensated water mass changes do not lead to a change in the dynamic height field (isopycnal slope), they cannot lead to changes in transport, thus a density compensated change in LNADW water mass properties cannot explain the observed reduction in LNADW transport in the 6 hydrographic sections. Instead, the change in the dynamic height field (isopycnal slope) that results in the change in LNADW transport must be due to dynamic effects that result in isopycnal heave.

The third of the five re-written paragraphs addresses this:

"The above results imply that long-term changes in DSOW properties have been (near) density compensated. Because density compensated water mass changes will not result in a change in isopycnal slope (and hence geostrophic transport) over time, this suggests that the interannual and longer term transport changes of several Sverdrups described for the DSOW in the previous Sections cannot be explained by changes in high latitude water mass properties which advect into the 25°N section along the DWBC. Instead, transport changes must be due to changes in isopycnal slope associated with some other dynamic process. This is explored below. It is emphasised that water mass changes that are not density compensated (i.e. water mass changes that have not taken place solely along isopycnal surfaces) or isopycnal heave on timescales longer than sub-seasonal cannot be ruled out in Figure 13c-d, but these cannot be distinguished from short term variability."

Is this statement the same as saying that the DSOW export has not changed because the amount of DSOW has not changed? If this is indeed what the authors are arguing here this is not surprising given the fact that most of the calculations presented here partition watermasses by depth, this resulting in (nearly) constant amounts of watermass in each section. Because the amount of (depth partitioned) DSOW is not *changing, then the only way to change the transport is with a change in velocity, which is related to the slope of the isopycnals……..*

……..Finally, in order to be consistent with the other temperature class transport calculations, one should quantify changes in the amount of DSOW when watermasses are partitioned by temperature.

As noted by the reviewer, for transport changes in depth layers, the 'amount' (cross-sectional area) of LNADW does not change much and so cannot explain the changes in LNADW transport (this is not what was meant by changes in water mass properties – it was the density compensated nature of water mass property changes that was being referred to, as above). However, as stated by the reviewer, this is not the case for transport changes in temperature classes. The interested reader is referred to Atkinson (2011) where a decomposition of transport changes in temperature classes was carried out, demonstrating that the sizeable reduction in DSOW transport in temperature classes is primarily due to changes in the velocity field and *not* changes in the amount (cross-sectional area) of the DSOW layer itself. This is also referred to in the Section 3.2.1 where it is stated:

"Most of the mid-ocean changes in potential temperature classes are broadly consistent with those seen in Table 4 over their typical depth range, which is due to the near horizontal nature of isotherms at 25°N (Figure 4) and because most transport changes in potential temperature classes occur primarily due to changes in the velocity field and not the thickness of the layers of interest (the full decomposition of transport changes in potential temperature classes into contributions from velocity changes and changes in cross-sectional area can be seen in, Atkinson, 2011).

I think it would help the reader to see a direct comparison of the density structure from each hydrographic section. This comparison would have the added benefit of helping to quantify the effect of isopycnal heave and precisely where the isopycnals are moving the most (with a focus on deep isopycnals of course).

A new figure (Figure 14) has been included showing the isopycnal depth at the western margin with the cumulative transports of Figure 9 overlaid (only the western margin is plotted as this is where most transport variability occurs – plotting the full section would make isopycnal changes in this region difficult to discern). This helps to emphasise that the final zonal transport values are set close to the western margin, consistent with the earlier discussion of Figure 9, which stated that changes in transport occur close to the western margin, rather than across the wider DWBC region. The new, second to last paragraph in Section 3.3 discusses this Figure as follows:

"Figure 14 shows that transport variability associated with property variability averaged across the DWBC does not account for long term transport changes of several Sverdrups in the DSOW (see also Atkinson, 2011). The reduced LNADW (or DSOW) transport in 1998, 2004 and 2010 relative to the earlier 1957, 1981 and 1992 hydrographic sections is achieved noisily via a reduction in southward cumulative transports approaching the western basin margin, and not through any obvious structured reduction in cumulative transports across the DWBC and its recirculation gyre (Figure 9 and Section 3.1.5). For the LNADW or UNADW the reduced or enhanced southward transport in the later hydrographic sections occurs due to a pronounced deepening or shallowing of isopycnals below or above depths of around 2500m (Figure 14). This occurs within a few degrees of longitude (a few hundred kilometers) of the western margin and is particularly pronounced for the 2010 section. Below 2500m, this isopycnal heave is associated with changes in isopycnal depth of several hundred metres."

This whole paragraph was extremely unclear to me.

As discussed above, the end of Section 3.3 has been modified and extended for clarity. The last 5 paragraphs are now a reworking of the original paragraph. In particular, the discussion of density compensated water mass changes and isopycnal heave is more thorough, which should help clarify subsequent discussion.

7. *What is the envelope of variability of the Rapid-WATCH data compared to the lines of Fig. 14? Just as it is important to assess the envelope of variability of the transports from Rapid-WATCH, to me, it seems critical to assess the envelope of variability in the DWBC shear. While the lines in Fig. 14 tell a compelling story, their spread may not be significant relative to the observed shorter term variability. Also, the authors should be explicit about the computation of dynamic height profile in order to make the comparison. What is this reference profile and are there any errors in using it?*

The envelope of Rapid-WATCH variability has now been added to the figure (now numbered Figure 15). The reference profile for the changes is the 2010 section (as stated in the original figure caption but now more clearly emphasised). The text that discusses the figure (the new, final paragraph of Section 3.3) now reads:

"Pronounced changes in the deep ocean density structure at the western margin between the later and earlier sections are seen in dynamic height anomaly profiles relative to 2010 close to the western margin for the six hydrographic sections (Figure 15). A reduced shear in the dynamic height field between UNADW and LNADW layers in the recent versus earlier sections results in a reduction in LNADW transport (deeper than 3000 metres) close to the western boundary. Isopycnal heave within a few hundred kilometres of the western margin thus appears to explain the reduction in LNADW transport in the 1998-2010 sections. This dynamic height variability at the western margin lies within the range of variability observed by Rapid-WATCH (Figure 15). It is noted that whilst the 1957 data lies at the extreme of the Rapid-WATCH envelope, this is no longer the case if a possible salinity bias in the 1957 dataset (Section 2.1) is accounted for, which brings it more in line with the 1981 data."

8. *In Section 5, conclusion #3, I disagree with the use of the word "significant". The transport values of LNADW do not lie outside the +/- 2 standard deviation envelope, especially when the errors on those transport values are taken into account (my comment #4). Conclusion #4 is correct, but it is important to point out that we don't know whether or not the changes are significant with respect to the shorter term variability. In light of my comment #6, above, I had difficulty understanding the authors reasoning resulting in conclusions #5.*

Changes as requested have been made to relevant conclusions as follows. Conclusion #5 has now been clarified (see point #6 discussion above):

"– In the deep ocean, where sub-seasonal transport variability is reduced, evidence of stronger southward transport of UNADW and weaker southward transport of LNADW of order several Sverdrups is observed in recent hydrographic sections relative to the 1957 and 1981 sections. This incorporates a seasonal correction derived from the Rapid-WATCH data, though a substantial reduction in LNADW transport in the late 1990s and 2000s is seen without this being applied. This apparent decadal variability lies within, but at the edge of, the ± 2 std. dev. range of sub-seasonal variability observed by Rapid-WATCH. "

"– In potential temperature classes, a monotonic decrease in DSOW transport is observed in the 1981 section data onwards. This is partly compensated by a monotonic increase in LSW transport over the same period. The structure of the transport changes seen in potential temperature classes suggests that changes seen in UNADW and LNADW transport in depth classes may not simply result from the aliasing of shorter term variability and could be interannual or decadal in nature. Short term transport variability in potential temperature classes cannot yet be assessed using Rapid-WATCH data."

Technical Comments:

1. In this paper, NCEP/NCAR data averaged over 2009 was used to estimate Ekman flux for 2010. It seems that 2010 data has been posted (although I have not used it yet myself). Why not use the 2010 data?

For this revision 2010 Ekman and Florida Straits data have been used. Ekman transport in 2010 was 1.6 Sv lower than 2009 due to a strong negative phase of the NAO. Florida Straits transport was 1 Sv lower, typical of its interannual variability. This combined weakening of 2.6 Sv for Ekman and Florida Straits transport leads to a weaker AMOC state in 2010 than when using 2009 values, and the addition of a northward transport anomaly to all depth levels to ensure mass balance (Table 4). Tables 1, 4 & 6 and Figures 9 & 11 have been updated (note that transports in Table 5 and Figures 5, 6 & 8 are unaffected where here the analysis holds Ekman and Florida Straits transport constant for comparison with Rapid-WATCH mid-ocean transports). The text has been edited to reflect this, notably:

Section 3.1.1 first paragraph:
"Transports calculated in depth classes for the six hydrographic sections are given in Table 4. The most striking result for the 2010 section is the partial return in strength of the total upper ocean transport (the upper limb of the AMOC) towards pre-2004 values of ≈ 17-18 Sv. This is due to a reduction in southward transport in the upper mid-ocean by 5.8 Sv relative to 2004, though a weak northward Ekman transport associated with a strong negative phase of the North Atlantic Oscillation (see Atkinson et al., 2010) means overall AMOC strength was still ≈ 1-2 Sv lower than pre-2004 levels. Even accounting for a maximum 1-2 Sv uncertainty in combined Ekman and Florida Straits northward transport used in the 2010 section (which projects on the AMOC with ≈ 0.8-1.6 Sv uncertainty, Section 2.3 and Table 2), the

total upper mid-ocean transport does not approach the high southward transport of 2004. The return in strength of the AMOC towards historic values is consistent with a mean AMOC strength of 18.6 Sv from five years of Rapid-WATCH observations (2004-2009) within the large sub-annual and seasonal variability observed by the Rapid-WATCH array over this period (de-trended std. dev. = 4.7 Sv). The return in strength of the upper mid-ocean transport to pre-1998 values is also consistent with a mean thermocline transport of -17.6 Sv and associated std. dev. of 3.3 Sv from the Rapid-WATCH observations."

Conclusion 1:
"– In the 2010 hydrographic section, the AMOC showed a return in strength towards pre-2004 values of ≈17-18 Sv (albeit reduced by 1-2 Sv due to a weak northward Ekman transport associated with a strong negative phase of the North Atlantic Oscillation). This is consistent within uncertainty with the mean AMOC strength observed by Rapid-WATCH (2004-2009) and is due to a reduction in southward upper mid-ocean gyre transport relative to the 2004 section. The absence of a trend in southward upper-mid ocean transport, and in decadal timeseries of northward Ekman and Florida Straits transports, means that no significant trend in the strength of the AMOC's upper limb has been detected in the six hydrographic sections."

2. The black line in the left column of Fig. 8 is hard to see. Please make this a contrasting colour (perhaps a light grey) so it is easier to see.

Now light green.

3. Figure 8: I think it would help to show the +/- 2 standard deviation lines (of the Rapid-WATCH time series) across the whole length of the panels on the right side of the figure.

Figure 8 has been updated.

Referee 2

General Comments:

I would be curious to know how much these adjustments (shown in Table 1) change the reference level of zero velocity, though it is not necessary for the work presented here.

Sadly, time limitations have prevented this investigation, however we acknowledge this would be worthwhile in the future, particularly given that in Table 1, a systematic reduction in reference level velocity is required in all six sections

However, I am a bit confused as to what happened to the 0.8 Sv of net transport (from Bering Strait): Tables 1 and 5 seem to indicate exact mass balance for the sections.

Table 1 does not indicate exact mass balance for the sections and does include a net southward mid-ocean transport of 0.8 Sv to account for Bering Straits inflow to the North Atlantic. For example, for the 2004 section, the combined northward transport for Florida Straits + Ekman = 31.8 + 4.5 = 36.3 Sv. Thus a southward mid-ocean transport of 36.3 + 0.8 = 37.1 Sv is required for mass balance, accounting for Bering Straits inflow. Consistent with this, Table 1 gives a mid-ocean transport of -37.1 Sv for the 2010 section. Tables 4 and 6 also account for a Bering Straits inflow of 0.8 Sv.

The transport calculations presented in Table 5 differ from those of Tables 1, 4 and 6 in that here an attempt is being made to compare mid-ocean transports from the hydrographic sections with those made by Rapid. Rapid imposes a zero net mass transport constraint during the calculation of transports at 26.5°N, thus to compare hydrographic transports with those of Rapid, a zero net mass transport is also imposed on the hydrographic sections, i.e. the 0.8 Sv Bering Strait inflow to the North Atlantic is ignored. This effectively results in a small barotropic transport adjustment to each hydrographic section, such that a small northward transport is added to each depth layer, which is similar in magnitude to the transports given in Table 2 (Table 2 gives transport changes in depth layers resulting from a 1 Sv change in the mass balance constraint - these scale linearly with changes in this constraint).

A sentence explicitly stating this has been added to the text in Section 3.1.2 (end paragraph 2):

“When comparing hydrographic transports with those from Rapid-WATCH, a zero net section-wide transport constraint is also used during the calculation of hydrographic transports (i.e. an inflow of 0.8 Sv into the North Atlantic through the Bering Strait is ignored) consistent with the mass balance approach used by Rapid-WATCH.”

I found section 3.1.5 difficult because the zonal structure being described is pretty hard to make out on the corresponding figure 9, where all the curves are quite noisy. A stronger result is that transport variability for the UNADW lies outside the seasonal signal range; and the removal of the seasonal bias does NOT change the weakening trend in the LNADW in later years (though it still lies within seasonal variability limits). The authors are careful not to overstate their case, and instead “suggest” that real change has occurred and warrants continuing investigation

Figure 9 has been updated to stretch the y-axis (as requested below). Figure 14 has also been added relating transport changes to changes in density structure at the western margin (see referee 1, point #6) however such plots (and the ocean itself) are inherently noisy.

The Conclusion section is generally strong, clearly summarising earlier detailed analysis, though I question the phrase, “as significant reduction in LNADW transport in the late 1990s and 2000s is seen without this being applied,” since earlier in the presentation it is clearly stated that the variability lies within the seasonal limits. I suspect “significant” us not being used in its technical sense, so perhaps a different word should be substituted (“substantial”?).

“Substantial” is now used. See also point #8 for referee 1.

Additionally Figures 8 and 9 could both be improved (see Technical comments for Figure 8). Figure 9 might be more persuasive if the vertical axes were elongated a bit.

Figure 8 – Line is now bolder and in light green.
Figure 9 – Has been updated.

Technical Comments:

Changes have been made where requested. Changes of particular note are:

Table 5 is mentioned before any other – this is difficult to avoid, as in the main Table 5 fits in with discussion elsewhere, but is briefly needed here to introduce the use of Rapid-WATCH observations to quantify variability.

Discrepancy between Table 3 and Figure 4, is top layer defined by 22.5 or 24.5 deg. C? – 22.5, Figure 4 has now been remade to reflect this.

Hyphenating UNADW??? – The result of the typesetting process, not by our design. The final typeset manuscript will be scanned to ensure this does not occur.

p.119, lines 1-14: very confusing discussion: seem to be switching back and forth between mid-ocean and total transports (for upper water) and also use both "high" and "record low" with "southward" to mean the same thing, I think – i.e., large in magnitude. Just needs reworking for clarification – Language now clarified as below:

"It is immediately obvious from Figures 5 and 6 that the mid-ocean hydrographic transport profile variability falls within the range of Rapid-WATCH variability in the upper 4800m of the water column, and the shape of the profiles is comparable to those observed by Rapid-WATCH. The pronounced strengthening of southward UNADW transport and weak southward LNADW transport in the 2010 section falls within the range of 's' shaped profiles observed by Rapid between 1000- 5000m, suggesting this state is not unusual. The same is true of the 1998 and 2004 sections whose weak southward LNADW transports (relative to earlier hydrographic sections) also fall in the envelope of Rapid-WATCH transport profiles. This is emphasised in Table 5 where UNADW and LNADW mid-ocean variability for all 6 hydrographic sections falls within ± 2 std. dev. of the mean Rapid-WATCH transports. In the upper mid-ocean, stronger southward transports in the 1998 and 2004 sections also fall within the envelope of Rapid-WATCH transport profiles. Interestingly, the particularly strong southward transport observed in the 2004 hydrographic section (Table 5) has a vertical transport profile that reaches the limit of the Rapid-WATCH envelope between 100-200 m (Figure 6). Whilst this state lies at the edge of this envelope, its vertical structure is not unique and appears comparable to a small number of Rapid-WATCH transport profiles that also show a similar kinked structure in the near-surface ocean. Also interesting is the return in strength of the 2010 upper mid-ocean transport to pre-1998 values, which in part appears due to a pronounced weakening of southward transport within a few hundred metres of the surface. This is typical of the mean transport profile as measured by Rapid-WATCH (Figure 5), suggesting some enhanced southward transport may persist in the main thermocline. This will be revisited in Section 3.2.”

p130, line 24: talking about Figure 13a, you say something about the 4-5 degree C class, but Figure 13a only goes up to 4.5 deg C – Scale now extended in the Figure.