

Final Author Comments for MS No.: os-2009-17

Journal: OS

Title: Adjustment of the Basin-Scale Circulation at 26°N to Variations in Gulf Stream, Deep Western Boundary Current and Ekman Transports as observed by the Rapid Array

Author(s): H. L. Bryden et al.

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Response To Referees' Comments on "Adjustment of the Basin-Scale Circulation at 26°N to Variations in Gulf Stream, Deep Western Boundary Current and Ekman Transports as observed by the Rapid Array" by Harry L. Bryden, Aazani Mujahid, Stuart A. Cunningham and Torsten Kanzow, August 2009

Original comments by referees are in 10-point font, our responses are in 12-point font.

## Referee 1

Resume

The paper investigates one year of data from the RAPID array. The focus is on variations in the Gulf Stream transport associated changes in the MOC. Geostrophic transports in the interior ocean are estimated from pressure differences across the basin, baroclinic transports from the T and S measurements, and barotropic components from the bottom pressure. It is found that bottom pressure changes in unison across the whole basin, suggesting a filling of the whole Atlantic north of the section. A strong compensation between different components of the transport (barotropic/-clitic, GS, Ekman) is found, yielding total MOC variations of only 3 -4 Sv.

Recommendation

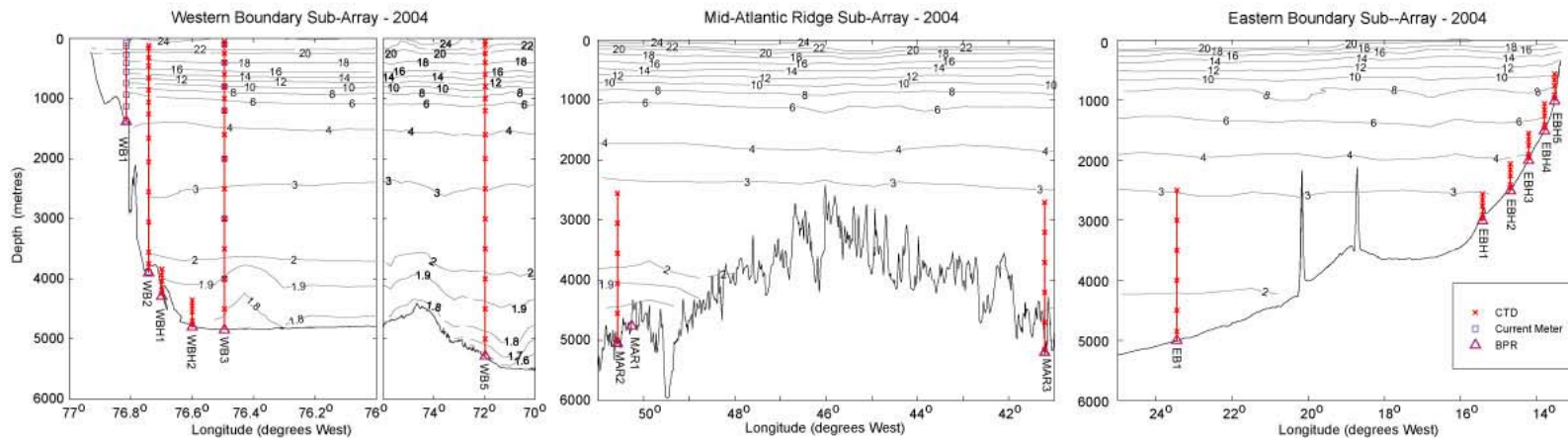
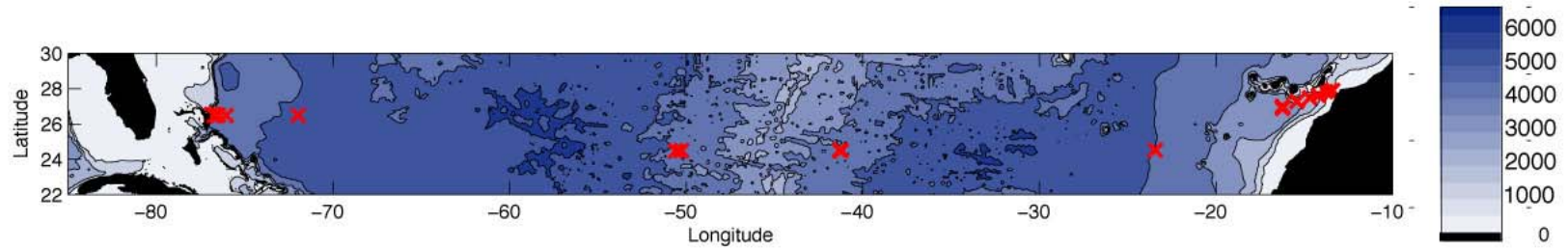
The paper describes important findings from a new dataset and should be published. Some minor comments are listed below.

Thank you for the supportive comments.

Minor remarks

Introduction, 1st para: a map would help the reader to follow the description of the array, and in particular the local details near Abaco.

We have now included a map of mooring locations in Figure 3. For the detailed Abaco topography we now refer the reader to the Johns et al. (2008) paper, their figure 2, that shows western boundary moorings with the bathymetry.



New Figure 3

p 882 l 19: figure 14 instead of 12

Fixed

p 887 l 22: compenating -> compensating

Fixed

At several places in the paper correlations are given. It would be useful to accompany them by an indication of their statistical significance.

We have now included a paragraph on the significance of the correlations at the end of the Methods section:

"To examine relations between dynamic height, bottom pressure, sea surface height, Gulf Stream and Ekman transports, we calculate correlation coefficients versus time lag. In general maximum correlation occurs with zero time lag, unless reported otherwise. Cunningham et al. (2007) have estimated the integral time scales for temporal variability in the time series used here to be 24 days. For the 366 day time series, there are then 15 independent time periods, or 13 degrees of freedom, from which we determine that correlations greater than 0.514 are significantly different from zero at a 95% confidence level. We therefore concentrate discussion in the text on correlations greater than 0.51."

Figure 3 is too small - the labels are unreadable.

We agree. Our jpg version of this figure is readable but somehow the figure lost clarity in translation to the website. We will work with the Ocean Science editorial team to make sure the final version of Figure 3 is readable.

Referee 2

The manuscript discusses results from the RAPID array, in particular the various forms of compensation that arise. A large number of correlations are given, but without much discussion (as I would have liked) of why these correlations exist. The manuscript is not particularly well written (for this lead author) and it currently falls into the dull but worthy category. The manuscript should be (and could be) made more interesting and more readable. The results from the RAPID array are of great interest to the community and so the manuscript ought to be published in some form.

Thank you for the supportive comments. We have tried to improve the writing as we re-read the manuscript and made changes to the text.

General comments

In a number of places rather tortuous grammar is used where a simple equation would be much clearer (eg p875, line 7; p876, line 9; p882, line 5; figure 14 caption)

We prefer not to use equations for these 4 cases. Our experience in other Rapid manuscripts is that many equations are needed to define words like dynamic height difference, Ekman transport, reduced pressure anomaly, western boundary transport anomaly (which are the 4 terms noted by the Referee) and that many equations interrupt the flow of the text. For example, the thesis by Longworth (2007) has many equations to define western boundary transport anomaly, which is inherently a simple concept but does requires definitions of geotrophic balance, dynamic height difference, and anomalies with various + and - signs when done with equations. We

think the terms here are well defined and are used consistently in the manuscript and we prefer to keep the text moving without too many interruptions for equations.

rms should be r.m.s.

We have used standard deviation and rms interchangeably in the text. We hope we have clarified this by stating "The standard deviation (equal to the root mean square value or rms)" on first such usage in the text. We would prefer to use rms rather than r.m.s., but the editor will have final say.

Specific comments

p876, line 10: insert "zonal" before the word "wind stress" or ideally just give an equation.

Fixed

p877, lines 11-13 (and elsewhere): Do you mean standard deviation, then rms? Be consistent in the description of the variability.

We have used standard deviation and rms interchangeably in the text. We hope we have clarified this by stating "The standard deviation (equal to the root mean square value or rms)" on first such usage in the text.

p878, lines 3 and 5: What is "they" referring to? Reword.

The text now reads: " Baroclinic transport anomalies arise due to changes in temperature and salinity. Right at the western boundary, they are perhaps due to Rossby waves or eddies propagating westward and hitting the boundary or perhaps due to Kelvin waves propagating southward along the continental slope. At the eastern boundary the anomalies may be due to changes in the upwelling regime or to Kelvin waves propagating northward along the continental slope."

p878, lines 9-15: Is there a reference or further justification that can be given here.

We have added a statement that we hope is helpful: "The resulting pressure profile (dynamic height profile relative to the bottom + predicted bottom pressure) then has zero vertical integral, and the total transport anomaly is zero." It is difficult because the resulting profile is like a baroclinic normal mode in that it has no vertical integral, but it is not necessarily like any of the baroclinic modes as one can see for example in Figure 9, green curve.

p879, lines 17-20: Reword.

These lines now read: "Whilst there is some evidence for local compensation at each site, none of the correlations for wb3, wb5 and ebh is statistically significant. Only the site wb2 right at the western boundary appears to be especially constrained for the barotropic transport variations due to bottom pressure to match (and cancel) the baroclinic transport variations due to dynamic height anomalies at the boundary.

p880: Are the higher modes degenerate or well separated? If they are degenerate they should not be displayed.

The higher modes are well separated. They are important (i.e., they have larger amplitude than the first mode) during some of the larger events like the November event.

p881, line 5 and figs 12 and 13: Be clear about which satellite product is used. Do the figures really use different products? Give due credit/references. If we want these products to continue to be available we should help the producers by acknowledging their work.

Thank you. We have now clearly labelled the satellite products as DUACS in the text, and with a website cited in the captions of Figures 12 and 13.

p882, line 19: Should this refer to figure 14, not 12.

Should be Figure 14, Fixed

p883, line 1: The compensation is not instantaneous so this is a poor choice of wording.

We have removed "(within 12 h)". The compensation is instantaneous within the temporal resolution of the time series and correlation function where maximum correlation occurs at zero time lag. The parenthetical remark was intended to convey that we cannot resolve temporal offsets of  $\pm 6$  hours. The sentence is more accurate without the parenthetical remark.

p884, line 12: This is a bit anecdotal for a scientific paper. Give a reference or cite an individual as a personal communication.

Distinguished remote sensing scientists told us that the near boundary decrease in variability was due to land effects on the altimetric measurements. We will not embarrass them by naming them.

Figure 1: The light blue 1100-3000m looks black to me.

1100-3000m is indeed black so the caption has been changed accordingly.

Figure 2: Is this really daily data - it looks like it has been smoothed. Replace "times" with "time series".

It really is daily data. Array time series were originally calculated on 12-hour time scale. Here they are subsampled daily at noontime to match the daily Gulf Stream and Ekman time series. Fixed "time series"

Figure 3: This is too small to be of any use. Even blowing it up electronically didn't really help.

We agree. Our jpg version of this figure is readable but somehow the figure lost clarity in translation to the website. We will work with the Ocean Science editorial team to make sure the final version of Figure 3 is readable. See new Figure 3 above.

Figure 5: capitalize Coriolis!

Fixed

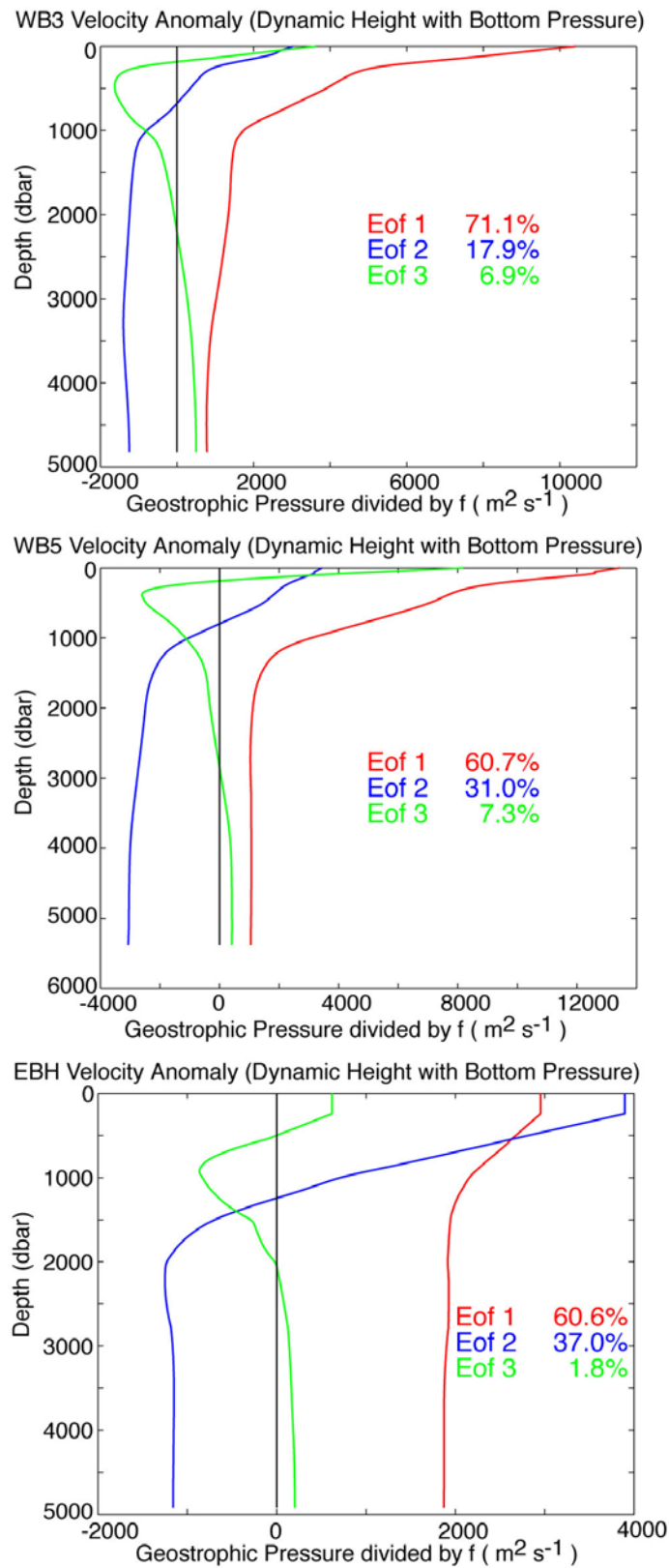
Figure 7: In the caption should the reference be to fig. 4.

The reference should be to Figure 6b, fixed now.

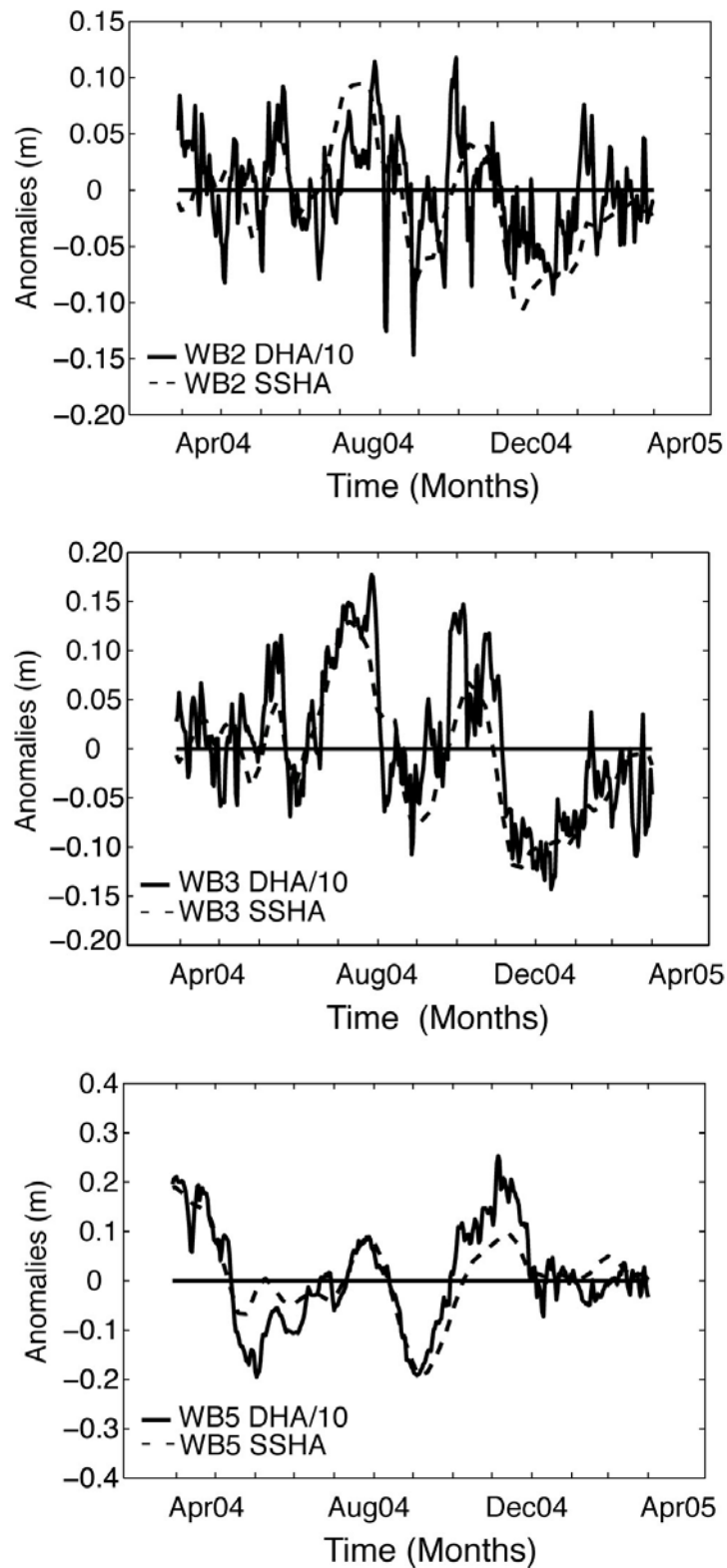
Figures 11 and 12: The text on these plots needs to be much larger.

We have made the text much larger for the final figures 11 and 12.. We originally submitted individual figures for the 3 moorings and these individual figures appeared

to have large enough text. But combining the 3 separate figures into 1 figure clearly requires larger text. For each of Figure 11 and Figure 12, we have now arranged the 3 panels vertically in portrait layout and adjusted the text size so that the labels are readable.



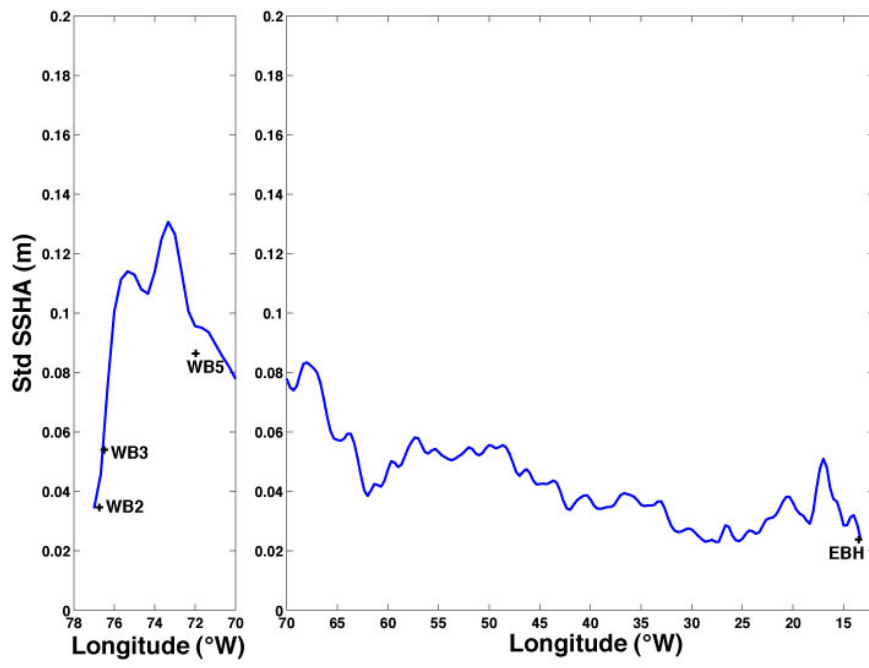
New Figure 11



New Figure 12

Figure 13: This figure should be improved by removing the vertical lines and instead plotting a cross marking the standard deviation in dynamic height for the four tall moorings.

We have re-plotted this figure and used crosses to indicate standard deviation in dynamic height for the 4 tall moorings. We have also expanded the zonal scale for the western region relative to the mid-ocean so the decrease in variability close to the western boundary can be seen more clearly. Thank you very much for the suggestion for improving the figure.



New Figure 13