Is the DWBC on Blake Outer Ridge the Lower Limb of AMOC?

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AMOC at Blake Outer Ridge

Lagrangian floats and numerical trajectories have shown that a significant part of the lower limb of Atlantic Meridional Overturning Circulation (AMOC) transport arrives near Cape Hatteras by multiple pathways. If so, the Blake Outer Ridge (BOR), south of Cape Hatteras, is a suitable site for direct measurements of the Deep Western Boundary Current (DWBC), which may be a major component of the lower limb of the AMOC.

Experimental Setting:

1) DWBC is known to be ridge-attached from prior work.
2) Steep slope of BOR forces current into strong, narrow, bottom-intensified current.
3) Transport was previously measured with current meter mooring.

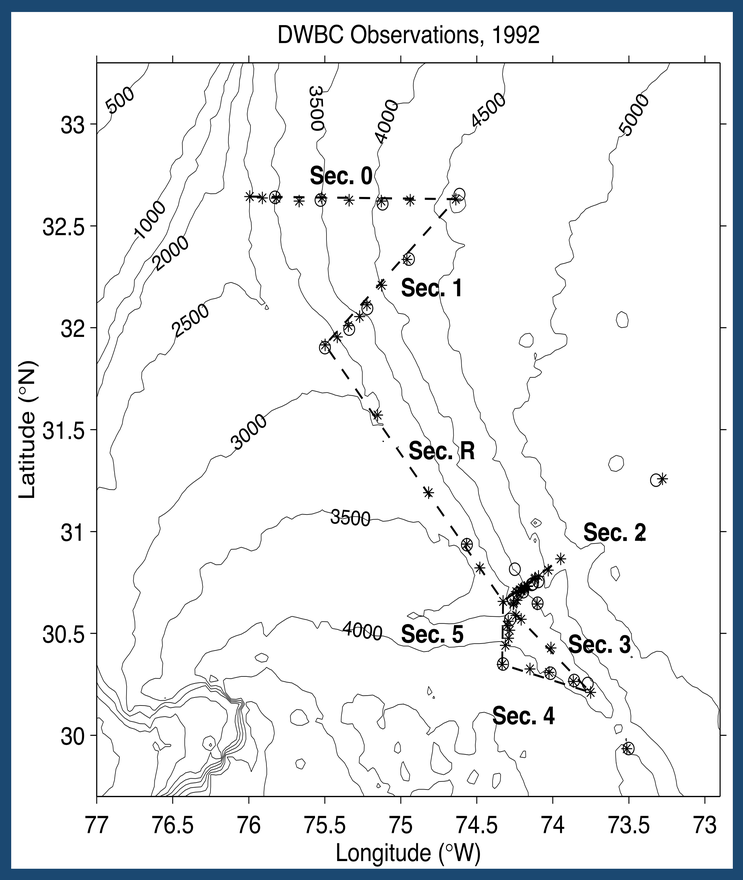

Fig. 1. Sections on Blake Outer Ridge off U.S. East Coast, Jul–Aug 1992.

Experimental Methods:

1) Density and velocity profiles with Absolute Velocity Profiler (AVP, Sanford et al, 1985).
2) Density profiles with onboard SeaBird CTD.
3) Spatial sections across and along ridge to determine current structure, water mass transport, and dynamics of large benthic boundary layer.

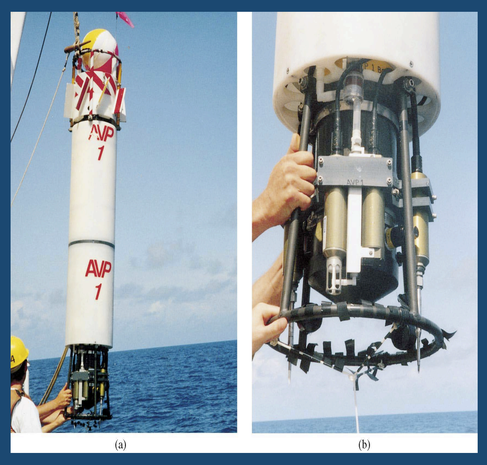

Fig. 2. (a) Absolute Velocity Profiler (AVP) — Autonomous profiler used to measure velocity and density on Blake Outer Ridge. (b) CTD and dual dissipation sensor are shown.

Observations

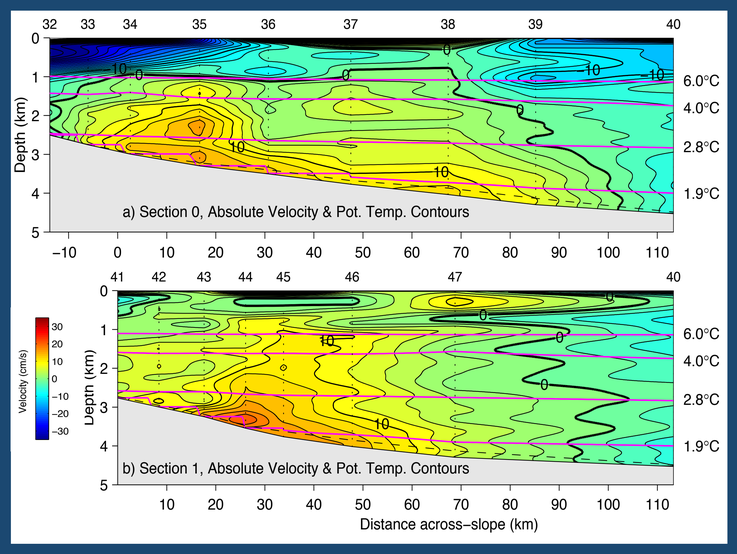

Fig. 3. Absolute velocity and potential temperature boundaries for Sections 0 and 1 on BOR. Because Sec 1 is steeper the current is narrower than Sec 0. Black line is zero along slope velocity.

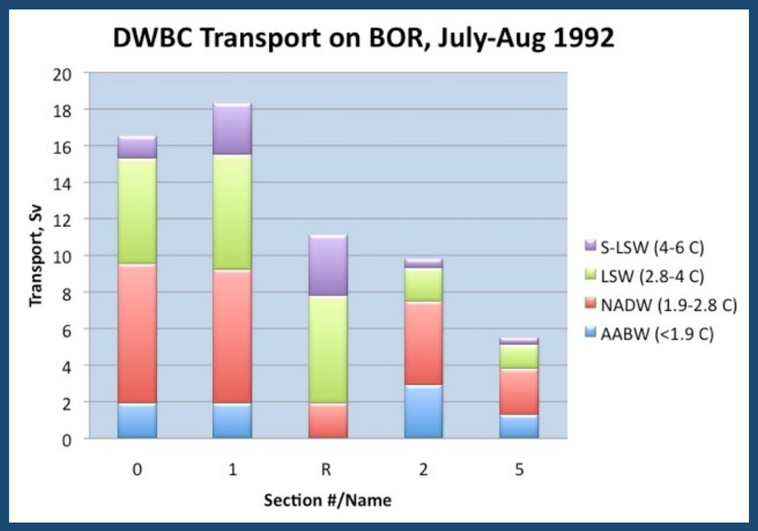

Fig. 4. Volume transport of all water classes in DWBC in sections shown in Fig. 1 on BOR. Uncertainty is ± 1.4 Sv at Sec. 0, and ± 0.7 Sv at Sec. 1. Note: Difference between Sec 2 and 5 represents water that does not go around BOR — into abyss.

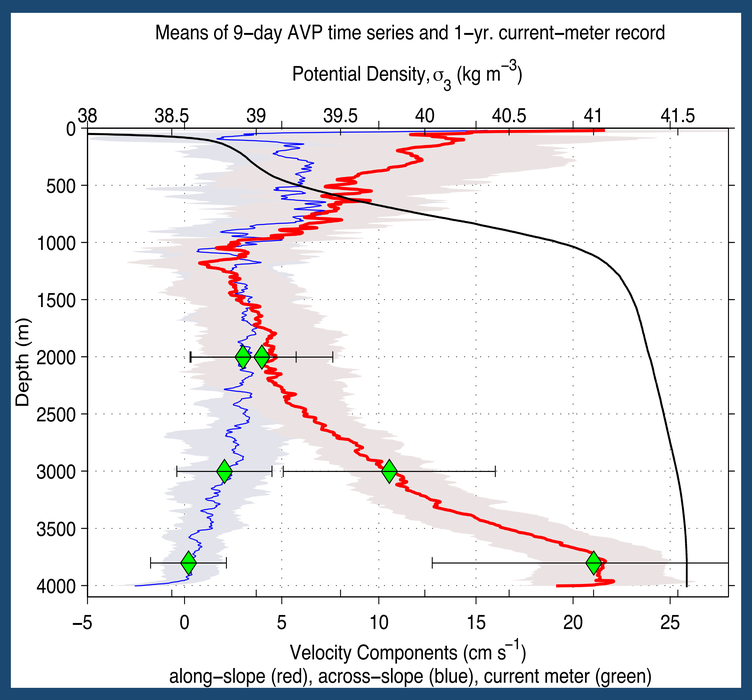

Fig. 5. Comparison of AVP profiles from 9-day time-series (red: along slope & blue: across slope) with year-long mean of current meter observations (green diamonds) from Jenkins and Rhines, 1980. Profiles are on 4000 m depth contour on Sec. 2. Shading is ± 1 standard deviation for AVP data while bars are same for mooring data.

Results and Conclusions

Results:

1) DWBC transport*s* and velocities at Sections 0 and 1 show flows concentrated on steep slope of BOR. (Fig 3)
2) Transports of 17-18 Sv below 6°C observed on both sections.
3) Comparison with current meter mooring at Site 2-5 shows consistency vs. year-long velocities. (Fig. 5)
4) Transports at Sections 2 and 5 shows loss of 5 Sv of anomalous water does not round the tip of ridge (Fig. 4) and flows into the abyssal ocean
5) Appears that multiple pathways coalesce south of Cape Hatteras and upstream of our sections (Figs. 6 and 7).

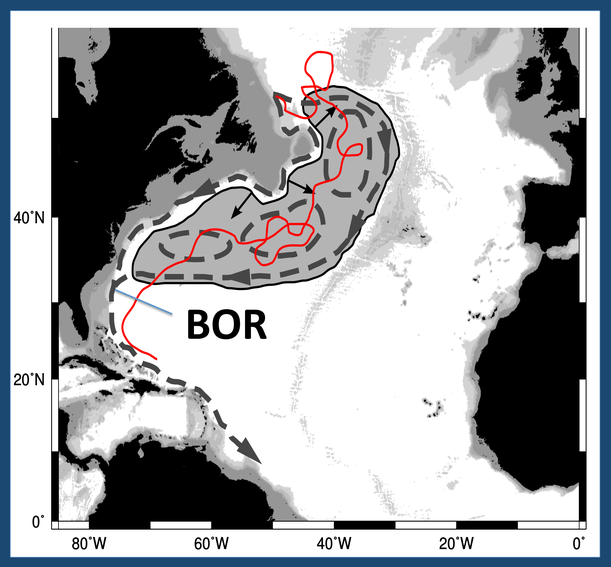

Fig. 6. Hypothesized merge of Interior and Continental pathways for the lower limb of the AMOC from Gary et al. 2011. Note the convergence near C. Hatteras.

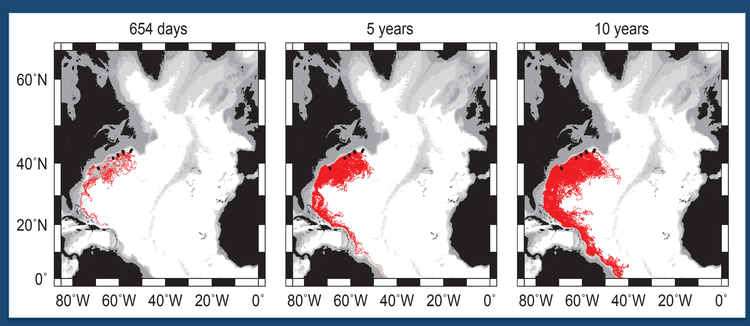

Fig. 7. Observed float and e-float tracks converge at BOR in two to five year time frame. From Lozier et al. 2013. Again, note the convergence near C. Hatteras.

Conclusions:

1) DWBC transport of 17–18 Sv is about equal to the lower limb of the AMOC
2) Synoptic velocity and property profiles across DWBC on steep BOR captured the DWBC
3) Series of AVP profiles at the site of earlier current meters at 2, 3 and 3.8 km depths agree within mm/s .
4) Synoptic and closely spaced, full water column profiles can capture an accurate estimate of DWBC at this site.
5) Meandering of DWBC core within spatially sparse array may create apparent transport variations – dense array necessary.

References:

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