Moored observations of the Deep Western Boundary Current in the NW Atlantic: 2004-2014

John M. Toole¹, Magdalena Andres¹, Isabela A. Le Bras¹, Terrence M. Joyce¹, Michael S. McCartney¹ and William Smethie, Jr. ²

¹Woods Hole Oceanographic Institution, MA; ²Lamont-Doherty Earth Observatory, NY

Abstract
A moored array spanning the continental slope southwest of Cape Cod sampled the equatorward flowing Deep Western Boundary Current (DWBC) for 10 years (May 2004 - May 2014). Daily profiles of solubility velocity, temperature, salinity and density are constructed for each mooring site and cross-line DWBC transport time series are derived for specified water mass layers. Time-averaged transport estimated based on daily estimates of the flow and density fields in stream coordinates are combined with those derived from the Eulander-Pontifex flow field, models of DWBC dynamics and the hydrographic data. The time averaged transport is insensitive to the choice of coordinates and the direction of flow. The time-averaged transports are compared to direct estimates from altimeter data. The mean depth of the density neutral surfaces chosen to incorporate the water column and location of the moorings are also indicated. In the left panel, the contour interval for the cross-line components is 1 cm/s for equatorward-directed current (negative values) and 10 cm/s for poleward (positive) values. The contour interval for the right panel is 4 cm/s. Meandering of the Gulf Stream results in a broadening of the upper ocean poleward flow and the deep equatorward flow at 36.5° N.

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The Line W Moored Array
Observations from these sites between 11 May 2004 and 27 April 2014 are examined here. Average mooring locations and corresponding contour-depths are given along with the type of mooring deployed. MPM indicates a mooring that supported a McLeod-Moored Profiler while a Conventional mooring indicates the mooring measured by the Eulander-Pontifex and the Eulander-CCS-G. Unger Foundation. The shallowest sensor column gives the range of the depth at which the various depths of each mooring are taken.

Mooring Latitude Longitude bottom (m) mooring site shallowest sensor (m)
W1 38° 32’ 30” N 63° 40’ 22” W 2238 MPM: 2004-2008
Conventional: 2008-2014 40 - 85
W2 38° 13’ 54” N 63° 27’ 35” W 2752 Conventional: 2000-2008 91-177
2008-2014 76 - 98
W3 38° 52’ 30” N 62° 10’ 37” W 3248 MPM: 2004-2008 102 - 103
Conventional: 2008-2014 440 - 960
MPM: 2008-2014 1040 - 1100
W5 38° 50’ 00” N 60° 55’ 30” W 1170 MPM: 2004-2008 200 - 1040
Conventional: 2008-2014 479 - 482
W6 37° 59’ 30” N 65° 19’ 34” W 4750 Conventional: 2004-2008 205 - 430

Eulerian-Mean Velocity
Contour plot of the Line W Eulerian-mean effective (left) and along-line (right) velocity based on the 2004-2014 Line W moored observations and surface altimeter data. The yellow arrows depict the mean geostrophic current at the beginning of the field program (5.8 x 10^7 m^2 s^-1). The corresponding red line in the left panel represents the CONGO and Overflow Water mean transport decreases from 5.9 x 10^7 m^2 s^-1 to the left panel. The contour interval for the right panel is 5 cm/s. Meandering of the Gulf Stream results in a broadening of the upper ocean poleward flow and the deep equatorward flow at 36.5° N.

Layer definitions
Layer definitions and bounding neutral density surfaces for transport calculations, AMK, SSPW, Upper Deep Water, Upper Subpolar Water, Denmark Strait Overflow Water, and Labrador Sea Overflow Water. SSLW is Upper Labrador Sea Water. MMP is McLeod-Moored Profiler.

Ideal-State Velocity
"Ideal state" composite cross-line velocity section constructed from the subset of the equatorward component of the Gulf Stream velocity. The shallowest sensor column gives the range of the depth at which the various depths of each mooring are taken.

Mean DWBC transport and 10-year linear trend estimates
Reported mean transports (negative values denoting equatorward transport in units of 10^7 m^2 s^-1) represent the most equatorward values of the cross-line transport streamfunctions evaluated over months 91 to 95. Eulerian-mean values were compared with instantaneous transport streamfunctions extended to month 84 using a series of streamfunction boxes centered at month 91 and 95. Shown are the estimates for the full 10 year Eulerian-mean fields (5.9 x 10^7 m^2 s^-1 for the 2004-2014 period), the ideal-state Eulerian-mean, and the mean of the daily DWBC transport estimates in stream coordinates. Statistical uncertainty reported for the latter represents an estimate of differences between instantaneous and 10-year scale Eulerian-mean transports. The shaded area represents the 1σ uncertainty intervals and the thin line represents the seasonal cycle. Key: SURF: Upper Subpolar Water, UDW: Upper Deep Water, SLW: Subpolar Labrador Water, SSLW: Upper Labrador Sea Water, IOWW: Iceland-Opskagi Water, ISOW: Iceland Overflow Water, DSSW: Denmark Strait Overflow Water, DSGW: Denmark Strait Greenland Overflow Water. These values are within the constraints of the Eulerian-mean data and are estimated on a daily basis from direct (IOWW) and indirect (ISOW) contributions. The values in the table give linear trend estimates of the Line W DWBC transport (1σ in m^2 s^-1/yr) with 95% Student’s t-distribution based on a bootstrap procedure.

Conclusions
A roughly consistent picture is emerging of the time-averaging AMOC. Some 20-35 yr 1σ trends of intermediate and deep water are carried eastward by the DWBC in the northern hemisphere, with local recirculations significantly boosting the mean DWBC transport estimates at 28°, 29°, and 30° N and at a somewhat lesser extent at 33° N. Other similar processes at this scale have the mean DWBC transport estimates at 42° and 57° N lie to the mean net boundary transport (eastward) in intermediate and deep water transport estimates at 23°, 26°, and 29° N. While syntheses of these observations also rely on internally-consistent dynamical description of AMOC, variability that has not yet been accounted for, we look forward to a timeframe where these will be possible.