Variability in the Atlantic Meridional Overturning Circulation and Heat Transport Detected Remotely From Argo Floats

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Between March 04 and May 05 over 56000 float-days (cumulative) of data were collected in the North Atlantic (4°N - 65°N) mostly at three parking depths: 1000 m, 1500 m and 2000 m [http://www.argo.ucsd.edu, http://argo.jcommops.org]. Our analysis involves temperature profiles from all Argo floats and subsurface displacements of floats parked at 1000 m. Floats parked at other depths (1500, 2000 m) and shallower than 1000 m as well as those, for which there was no information on parking depth, were excluded from the analysis.

The bin method (i.e., arithmetic average of the observed temperature, salinity, and velocity over a given bin) is commonly used. For example, Fig. 1a shows the velocity vector fields computed from the Argo track data using the bin method. The weakness of this method is that the calculated temperature, salinity, and velocity fields are sparse and noisy.

To improve this, the optimal spectral decomposition (OSD) method [1] [2] is used to process the Argo track data. Two-scalar (toroidal and poloidal) spectral representation is used to reconstruct three-dimensional ocean flow from noisy data. The basis functions are the eigenfunctions of the Laplacian operator with the given boundary conditions. A cost function used for poor data statistics is introduced to determine the optimal number of basis functions. After the OSD analysis, monthly temperature, salinity, and velocity fields are established (e.g., Fig. 1b for velocity).

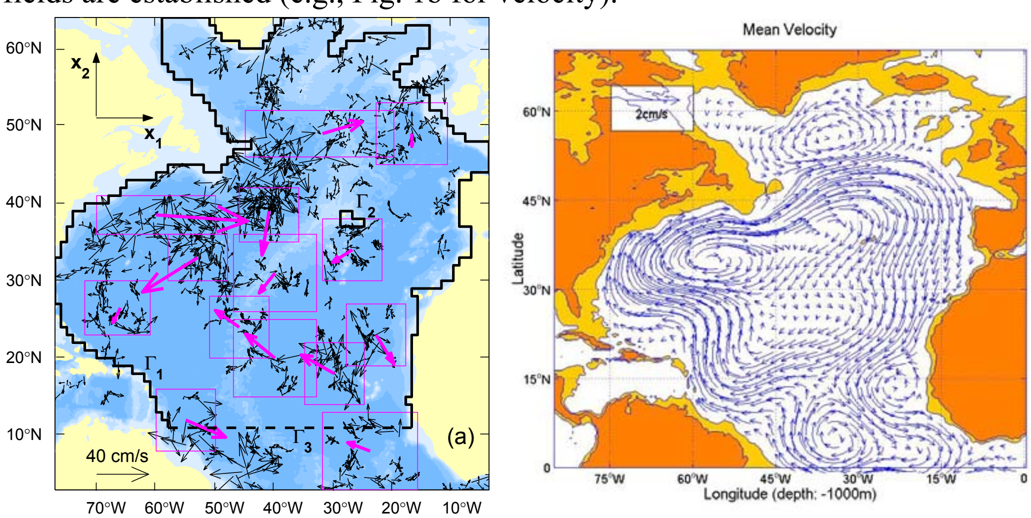

Figure 1. Circulation velocities (tiny arrows) estimated from the original ARGO float tracks at 1000 m for Dec 2003–Mar 2004 using (a) the bin method and (b) the OSD method. Red arrows are circulation velocities obtained by averaged over appropriate bins (red lines).

With the establishment of the gridded temperature, salinity, and velocity fields, we identify the variability in the Atlantic Meridional Overturning Circulation (AMOC) and heat transport, as well as the processes responsible for such variability. For example, the mid-depth (1000 m) long Rossby waves (with the characteristic scales between 1000 km and 2500 km) are important processes for the variability. They are identified in the western [west of the Mid-Atlantic Ridge (MAR)] and eastern [east of the MAR] sub-basins. Along-shore wind fluctuations and an equatorially-forced coastal Kelvin wave were found to be responsible for the excitation of annual and semi-annual propagating Rossby waves in the eastern sub-basin. These waves are transmitted along a wave-guide formed by the African shelf and the MAR. The speed of their propagation varies in magnitude and direction due to bottom topography and irregularity of the coastline. Unstable standing Rossby waves with annual and semiannual periods are shown in both the sub-basins. All unstable waves, decaying, radiate shorter free Rossby waves propagating, both westward and northwestward, with speeds up to 10 cm/s. The standing Rossby waves are probably excited by the wind-driven Ekman pumping alone or in combination with linear and nonlinear resonance mechanisms. The additional analysis of subsurface float tracks from May, 05 through May, 06 supports the obtained results.

References

[1] Chu, P.C., L.M. Ivanov, T.P. Korzhova, T.M. Margolina, and O.M. Melnichenko, 2003: Analysis of sparse and noisy ocean current data using flow decomposition. Part 1: Theory. Journal of Atmospheric and Oceanic Technology, 20 (4), 478-491.

[2] Chu, P.C., L.M. Ivanov, T.P. Korzhova, T.M. Margolina, and O.M. Melnichenko, 2003: Analysis of sparse and noisy ocean current data using flow decomposition. Part 2: Application to Eulerian and Lagrangian data. Journal of Atmospheric and Oceanic Technology, 20 (4), 492-512.