Using Argo data to investigate the MOC in the North Atlantic

*Using Argo data to investigate the Meridional Overturning Circulation in the North Atlantic**

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Context

Through the poleward transport of upper ocean waters and an equatorward transport of deeper colder waters, the Meridional Overturning Circulation (MOC) is of critical importance to the global climate system. A decline of the MOC has been one of the predictions of various IPCC reports on greenhouse gas scenarios (IPCC,2001), and a particular aspect of recent findings from a single hydrographic section at 24°N in 2004 is that more equatorward flow is found in the interior of the upper 1000 meters than previously observed.

To check the robustness of this recent result, the North Atlantic MOC has been studied here (Hernandez-Guerra, 2010) through the analysis of hydrographic data along 24° and 36° N. Results confirm previous hypothesis stating no abrupt decreases in the MOC during the last decades, by comparing 1957, 1981,1992, 1998 and 2004 data. Argo float profiles and drift velocities for the period 2003-2007 in the North Atlantic are also used to estimate the total integrated mass transports in the thermocline waters at both mid-latitudes by inverse calculations. They confirm that the upper limb of the Atlantic MOC has not significantly changed since 1957.

Data and Method

All quality-controlled Argo data available for the 5-year period 2003-2007 in the North Atlantic (figure 1a) are used to quantify the MOC at mid-latitudes, representing 3349 profiles. Following a method employed previously (Fraile-Nuez and Hernandez-Guerra, 2006) based on an optimal statistical interpolation, temperature and salinity from Argo floats are objectively interpolated onto hypothetical zonal « sections » at 24°N and 36°N every degree in longitude. The WOA94 atlas (World Ocean Atlas, 1994) is used as a first guess for temperature and salinity objective interpolation.

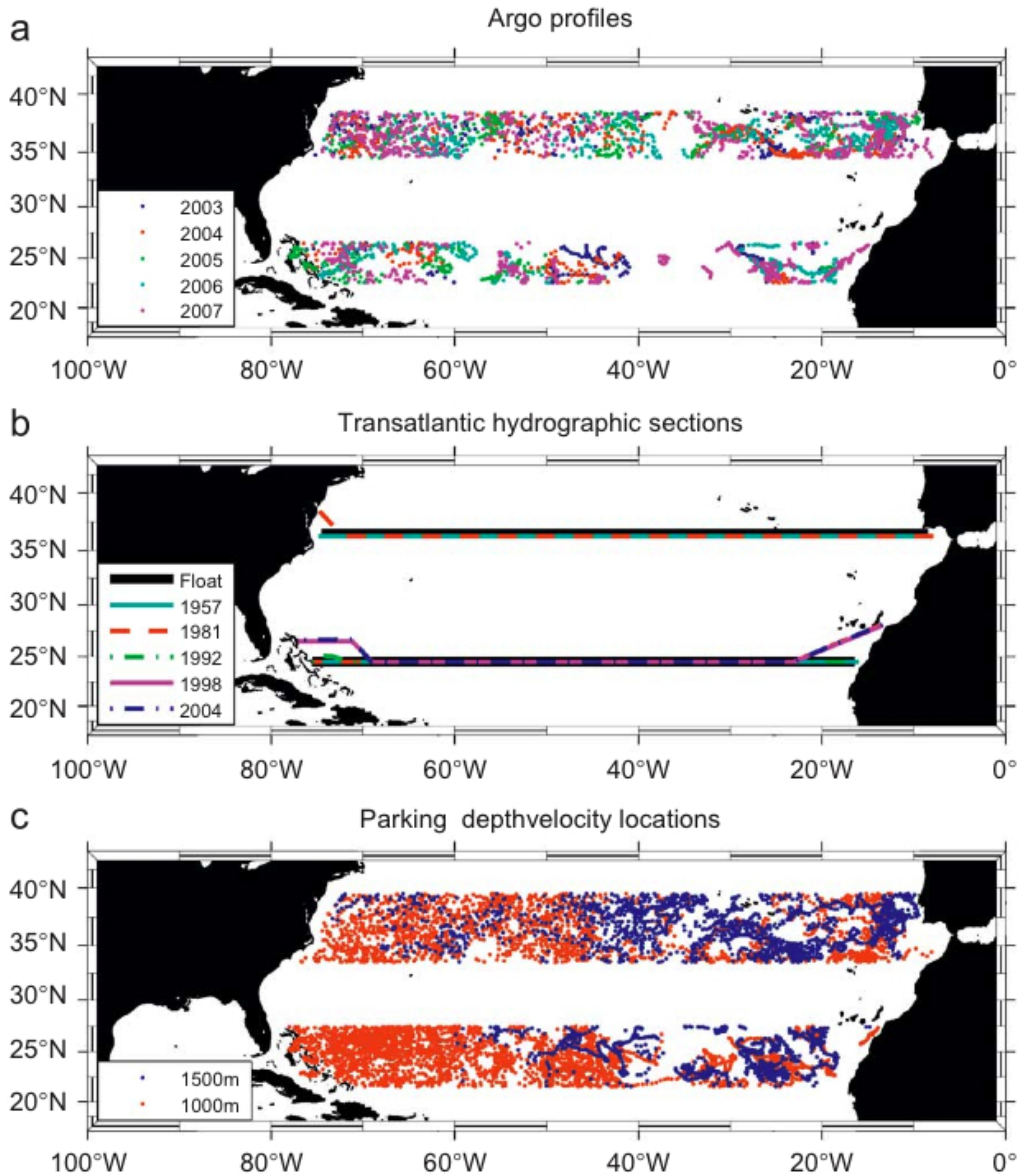


Figure 1. ***(a)*** *Locations of every temperature and salinity vertical profile in the period 2003–2007 from Argo data used to objectively interpolate the temperature and salinity every degree in longitude at 24°N and 36°N;* ***(b)*** *repeated hydrographic sections taken across 24°N and 36°N in the International Geophysical Year (IGY, 1957), 1981, the World Ocean Circulation Experiment (WOCE, 1992), 1998 and 2004. The synthetic sections used in this work are also shown;* ***(c)*** *parking depth velocity locations at 1000/ 1500 m (red/blue) from Yoshinari et al. (2006) used to objectively estimate the velocity at 1000/1500 m west/east of 45°W at the mean position used for temperature and salinity.*

A box inverse model is furthermore constructed for the MOC quantification, with a northern boundary at 36°N, a southern boundary at 24°N, including the Florida Strait. The upper ocean is divided into seven isopycnal layers, including a surface layer which carries the Ekman transport, four uppermost layers characterizing the waters of the thermocline, and three more extending down to those containing the upper portions of Labrador Sea Water. In the Ekman layer, the interior wind-driven flow is calculated from the mean wind stress in the period 2003–2007 estimated from QuikScat satellite measurements. The inverse model allows small adjustments to the Ekman transport to satisfy transport constraints. The initial geostrophic flow is estimated using a deep zero velocity surface at 27.922 γn. Estimates of float drift at 1500m in the eastern basin and 1000m in the western basin (figure 1c) provide additional constraints on the circulation. Velocity estimates, using the same procedure as for the hydrographic data, are also objectively estimated at every half degree of longitude at 24°N and 36°N. The mean velocity for each longitude interval at the parking depth is used as a first guess for the velocity fields. Mass constraints on the flow are based on the assumption that there is no net mass transport divergence for any of the seven density layers used.

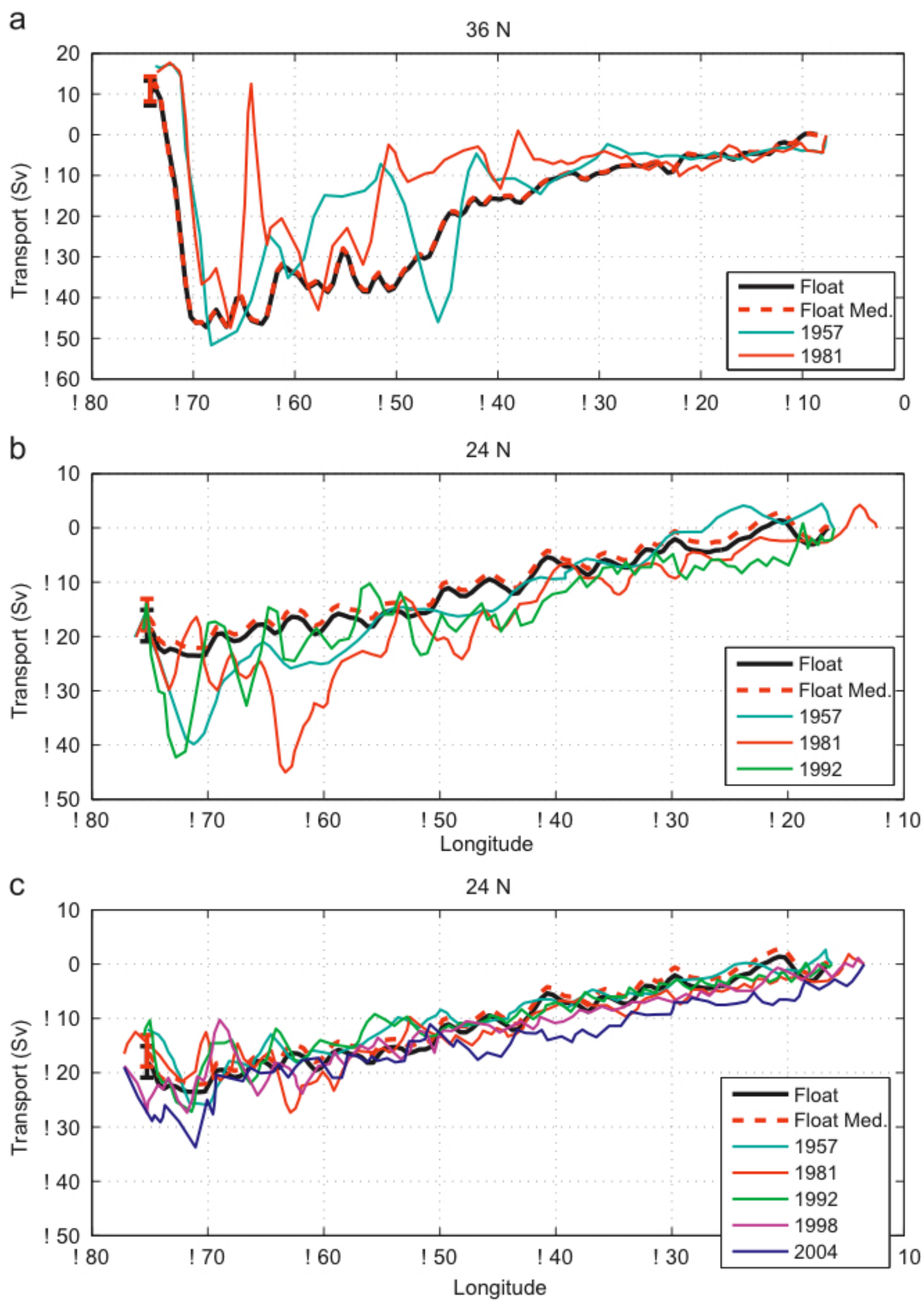
Finally, estimations obtained from Argo data inverse calculations have been compared to previous ones obtained from individual hydrographic sections at both latitudes 24°N and 36°N (figure 1b). The 24°N and 36°N transatlantic sections have been occupied twice during the same year : 1957 (Fuglister, 1960) and 1981 (Roemmich and Wunsch, 1985). The 24°N was again occupied in 1992 during the WOCE experiment (Parrilla et al., 1994), in 1998 (Baringer and Molinari, 1999) and finally in 2004 (Bryden et al, 2005b).

Results

The comparison of results for 36°N (figure 2a) shows a smaller eddy variability in accumulated mass transport than that from Roemmich and Wunsch (1985). The reduced eddy variability is most likely a result of our use of 5 years of Argo float data with similar number of profiles for each month, thereby reducing effects of individual eddies, which remain present in single hydrographic sections.

For 24°N, we show (figure 2b) a comparison of our accumulated mass transport and those as solutions of inverse models. We also include an estimate from a recent work carried out by Bryden et al. (2005b) that is closest in time to our result (Figure 2c). There is no significant change in the upper limb of the MOC in the period 2003–2007, and that changes we see are not significantly different than previous findings going back to the IGY in 1957. The recent transport from the 2004 section and sections carried out in 1981 and 1998 as computed from Bryden et al. (2005b) are within our error bars as well for the case of MW transformation.

These calculations represent a new application of Argo data to ocean circulation studies. We have found that mean hydrography and reference level flow information from Argo are valuable additions to our ocean observing system.



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