Ocean Sci., 5, 421–433, 2009
www.ocean-sci.net/5/421/2009/

Ocean Science

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

H. L. Bryden[1], A. Mujahid[1,2], S. A. Cunningham[1], and T. Kanzow[1,3]

[1]National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, UK
[2]Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia
[3]Leibniz-Institut für Meereswisschenschaften, Düsternbrooker Weg 20, 24105 Kiel, Germany

Received: 30 March 2009 – Published in Ocean Sci. Discuss.: 30 April 2009
Revised: 11 September 2009 – Accepted: 11 September 2009 – Published: 19 October 2009

Abstract. The Rapid instrument array across the Atlantic Ocean along 26° N provides unprecedented monitoring of the basin-scale circulation. A unique feature of the Rapid array is the combination of full-depth moorings with instruments measuring temperature, salinity, pressure time series at many depths with co-located bottom pressure measurements so that dynamic pressure can be measured from surface to bottom. Bottom pressure measurements show a zonally uniform rise (and fall) of bottom pressure of 0.015 dbar on a 5 to 10 day time scale, suggesting that the Atlantic basin is filling and draining on a short time scale. After removing the zonally uniform bottom pressure fluctuations, bottom pressure variations at 4000 m depth against the western boundary compensate instantaneously for baroclinic fluctuations in the strength and structure of the deep western boundary current so there is no basin-scale mass imbalance resulting from variations in the deep western boundary current. After removing the mass compensating bottom pressure, residual bottom pressure fluctuations at the western boundary just east of the Bahamas balance variations in Gulf Stream transport. Again the compensation appears to be especially confined close to the western boundary. Thus, fluctuations in either Gulf Stream or deep western boundary current transports are compensated in a depth independent (barotropic) manner very close to the continental slope off the Bahamas. In contrast, compensation for variations in wind-driven surface Ekman transport appears to involve fluctuations in both western basin and eastern basin bottom pressures, though the bottom pressure difference fluctuations appear to be a factor of 3 too large, perhaps due to an inability to resolve small bottom pressure fluctuations after removal of larger zonal average, baroclinic, and Gulf Stream pressure components. For 4 tall moorings where time series dynamic height (geostrophic pressure) profiles can be estimated from sea surface to ocean bottom and bottom pressure can be added, there is no general correlation between surface dynamic height and bottom pressure. Dynamic height on each mooring is strongly correlated with sea surface height from satellite observations and the variability in both dynamic height and satellite sea surface height decrease sharply as the western boundary is approached.

Correspondence to: H. L. Bryden
(h.bryden@noc.soton.ac.uk)

1 Introduction

The extensive Rapid instrument array deployed across the Atlantic at 26° N (Kanzow et al., 2008) provides a unique opportunity to examine the dynamics of the large-scale ocean circulation. 26° N was selected as the location for monitoring the Atlantic meridional overturning circulation for several reasons. First, at 26° N, the Gulf Stream is confined to flow through Florida Straits and its transport has been measured there by a subsea electromagnetic cable nearly continuously since 1981 (Baringer and Larsen, 2001). Secondly, the bathymetry near the western boundary of the mid-ocean section at the Bahamas is relatively simple: there is a very steep continental slope from the reef at Abaco to a depth of 4000 m at an offshore distance of only 23 km. In addition, there is a small escarpment just north of 26.5° N with a depth of about 1500 m (see detailed bathymetry near the western boundary in Fig. 2 of Johns et al., 2008) that deflects the deep western boundary current offshore so that we can deploy a tall deep water mooring at 26.5° N in its shadow, out of the strong depth-independent deep boundary current flow that would normally make the uppermost instruments dip down substantially. Thirdly, 26° N is a zone of relatively

Published by Copernicus Publications on behalf of the European Geosciences Union.