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Observed decline of the Atlantic meridional overturning circulation 2004–2012

D. A. Smeed[1], G. D. McCarthy[1], S. A. Cunningham[2], E. Frajka-Williams[3], D. Rayner[1], W. E. Johns[4], C. S. Meinen[5], M. O. Baringer[5], B. I. Moat[1], A. Duchez[1], and H. L. Bryden[3]

[1]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK
[2]Scottish Association for Marine Science, Scottish Marine Institute Oban, Argyll, PA37 1QA, UK
[3]National Oceanography Centre, University of Southampton, Waterfront Campus, Southampton SO14 3ZH, UK
[4]University of Miami, Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, FL, USA
[5]Atlantic Oceanographic and Meteorological Laboratory, Miami, FL, USA

Correspondence to: D. A. Smeed (das@noc.ac.uk)

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Abstract. The Atlantic meridional overturning circulation (AMOC) has been observed continuously at 26° N since April 2004. The AMOC and its component parts are monitored by combining a transatlantic array of moored instruments with submarine-cable-based measurements of the Gulf Stream and satellite derived Ekman transport. The time series has recently been extended to October 2012 and the results show a downward trend since 2004. From April 2008 to March 2012, the AMOC was an average of 2.7 Sv (1 Sv = 10^6 m^3 s^{-1}) weaker than in the first four years of observation (95 % confidence that the reduction is 0.3 Sv or more). Ekman transport reduced by about 0.2 Sv and the Gulf Stream by 0.5 Sv but most of the change (2.0 Sv) is due to the mid-ocean geostrophic flow. The change of the mid-ocean geostrophic flow represents a strengthening of the southward flow above the thermocline. The increased southward flow of warm waters is balanced by a decrease in the southward flow of lower North Atlantic deep water below 3000 m. The transport of lower North Atlantic deep water slowed by 7 % per year (95 % confidence that the rate of slowing is greater than 2.5 % per year).

1 Introduction

The poleward transport of heat in the sub-tropical North Atlantic has been shown (Johns et al., 2011) to be highly correlated with the Atlantic meridional overturning circulation (AMOC). One petawatt (PW = 10^{15} W) of heat carried by the AMOC is released to the atmosphere between 26° N and 50° N and has important impacts on the climate of the North Atlantic region (e.g. Srokoz et al., 2012). The AMOC varies on a range of timescales (e.g. Eden and Willebrand, 2001; Kanzow et al., 2010) and is thought to have played a key role in rapid climate change in the past (Ganopolski and Rahmstorf, 2001). Model simulations predict a decrease of the AMOC in the 21st century in response to increasing greenhouse gases (IPCC, 2007). Decadal-scale changes in the AMOC have been associated with the Atlantic multidecadal oscillation in climate simulations (Knight et al., 2005) and are thought to have impacts on surface temperature, precipitation and sea level in regions bordering the ocean (Delworth and Mann, 2000). The role of the AMOC in climate has motivated oceanographers to quantify its strength and variability.

The first observational estimates of the basin-wide AMOC were based on transatlantic hydrographic sections (Bryden and Hall, 1980; Roemmich and Wunsch, 1985). These observations provided important information about the structure and magnitude of the AMOC, but, with only a handful

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