The Observed North Atlantic Meridional Overturning Circulation: Its Meridional Coherence and Ocean Bottom Pressure

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ABSTRACT

Analyses of meridional transport time series from the Rapid Climate Change–Meridional Overturning Circulation (RAPID MOC) array at 26°N and from Argo float and altimetry data at 41°N reveal that, at semiannual and longer time scales, the contribution from the western boundary dominates the variability of the North Atlantic meridional overturning circulation (MOC), defined as the transport in the upper 1000 m of the ocean. Because the variability of the western boundary contribution is associated with a geostrophic overturning, it is reflected in independent estimates of transports from gradient of ocean bottom pressure (OBP) relative to and below 1000 m on the continental slope of the western boundary at three nominal latitudes (26°, 39°, and 42.5°N). Time series of western meridional transports relative to and below 1000 m derived from the OBP gradient, or equivalently derived from the transport shear profile, exhibit approximately the same phase relationship between 26° and 39°–42.5°N as the western contribution to the geostrophic MOC time series do: the western geostrophic MOC at 41°N precedes the MOC at 26°N by approximately a quarter of an annual cycle, resulting in a zero correlation at this time scale. This study therefore demonstrates how OBP gradients on basin boundaries can be used to monitor the MOC and its meridional coherence.

1. Introduction

At 26°N in the Atlantic Ocean, the Rapid Climate Change–Meridional Overturning Circulation and Heat-flux Array (RAPID–MOCHA, hereafter RAPID MOC array) has been in place since 2004 to monitor the variability of the meridional overturning circulation (MOC) and its heat flux with full-depth continuous measurements (Rayner et al. 2011). The array captures a circulation that consists of a relatively warm northward flow above approximately 1000 m, compensated between that depth and about 5000 m by a colder southward return flow. Because of this overturning nature, other observational arrays in the North Atlantic Ocean focus on monitoring only the deep return branch of the MOC that is expected to be concentrated on the western boundary (Stommel 1958), as a relatively strong deep western boundary current (DWBC) (e.g., Johns et al. 2008; Toole et al. 2011; Meinen et al. 2012). This is specifically the approach taken for the Meridional Overturning Experiment (MOVE) array since 2000 near 16°N in the North Atlantic (Send et al. 2011, and references therein), where only the returning southward flow in the western half of

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