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Key Points:

- Eddies/Rossby waves explain 42% of the upper mid-ocean transport variance
- Eddies/Rossby waves exhibit first baroclinic mode structure at 80–250 day periods
- At the boundary, higher baroclinic modes also contain substantial energy

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Vertical structure of eddies and Rossby waves, and their effect on the Atlantic meridional overturning circulation at 26.5°N

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Abstract The meridional overturning circulation (MOC) at 26.5°N in the Atlantic has a standard deviation of 4.9 Sv and contains large fluctuations at subannual periods. The geostrophic component of the MOC is believed to be influenced on subannual time scales by eddies and Rossby waves. To quantify this effect, the vertical structure and surface characteristics of westward propagating signals are studied using altimetric data and full-depth mooring measurements from the RAPID array at 26.5°N. Westward propagating features are observed in the western North Atlantic in both data sets and have periods of 80–250 days in the first baroclinic mode. These features are still observed by the RAPID moorings 20 km offshore of the western boundary. The western boundary also exhibits deep variability characterized by enhanced energy in higher baroclinic modes. The effect of eddies and Rossby waves on the geostrophic transport is quantified by representing their vertical structure with the first baroclinic mode. In total, 42% of the variance of the transbasin thermocline transport inferred from geostrophic calculations at 26.5°N can be attributed to first mode variability, which is associated with eddies and Rossby waves at periods of 80–250 days. The standard deviation of the transbasin thermocline transport due to eddies and Rossby waves is estimated to be 2.6 Sv.

1. Introduction

The Atlantic meridional overturning circulation (MOC) plays a significant role in redistributing heat from the equator to higher latitudes [*Hall and Bryden*, 1982]. An understanding of the MOC variability is essential to comprehend the fluctuations of the mild European climate [*Pohlmann et al*., 2006], to assess its link with the abrupt climate change of glacial cycles [*Broecker*, 2003], and to evaluate the effect of increased greenhouse gases [*Gregory et al*., 2005]. Despite earlier expectations of a slowly varying MOC, continuous measurements since 2004 have found significant short-term variability [*Cunningham et al*., 2007] that needs to be better understood to accurately interpret potential long-term changes.

For instance, prior to continuous measurements, transbasin hydrographic surveys occupied every 5–10 years were used to investigate large-scale and low-frequency circulation. Using five transatlantic sections at 24°N in the Atlantic, *Bryden et al*. [2005b] found a 30% decrease in the MOC from 1957 to 2004. This reduction was associated with an increased southward upper mid-ocean transport and a decreased southward lower North Atlantic deep water. The amplitude of the reduction was close to the eddy uncertainty of ± 6 Sv estimated using inverse calculations from similar hydrographic sections [*Ganachaud*, 2003]. However, a thermocline temperature anomaly extending several hundred kilometers off the western boundary and an unequal transport anomaly in the upper and lower North Atlantic deep waters led *Bryden et al*. [2005b] to discard an eddy-induced explanation. In addition, the continuous measurement of the MOC provided by the RAPID program [*Cunningham et al*., 2007] raised the question of what processes contribute to the subannual MOC variability, which is estimated to be 4.9 Sv around a mean of 18.7 Sv ($1\mathrm{Sv}=10^6\mathrm{m}^3\mathrm{s}^{-1}$) for the period 2004–2011. *Kanzow et al*. [2010] attributed most of the decline observed in *Bryden et al*. [2005b] to the seasonality of the MOC. This seasonality with an amplitude of 5.9 Sv is visible in the upper mid-ocean and mostly originates from density changes at the eastern boundary following wind-stress curl anomalies [*Chidichimo et al*., 2010]. While the transport anomaly observed by *Bryden et al*. [2005b] in 2004 is less anomalous when adjusting for the seasonality of the upper mid-ocean transport found by *Kanzow et al*. [2010], the remaining anomalous transport was localized at the western boundary which is a region of more significant eddy activity than the eastern boundary. Despite the contribution of the MOC seasonality to the MOC subannual variability, the quantification of the eddy effect on the geostrophic transport still needs to be determined.