WHAT IS THE ROLE OF THE ROSSBY WAVES IN THE SEASONAL CYCLE OF THE ATLANTIC MERIDIONAL OVERTURNING CIRCULATION?

Pedro Vélez-Belchí(1), M. Dolores Pérez-Hernández(2), María Casanova-Masjoan(2) and Alonso Hernández-Guerra(2) pedro.velez@ieo.es

(1) Centro Oceanográfico de Canarias, Instituto Español de Oceanografía, Santa Cruz de Tenerife, Canary Islands, Spain.
(2) Instituto de Oceanografía y Cambio Global, Universidad de Las Palmas de Gran Canaria, Canary Islands, Spain.

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

Abstract

The Atlantic Meridional Overturning Circulation (AMOC) is continually monitored along 26ºN by the RAPID-MOCHA array. Measurements from this array show a +6.7 Sv seasonal cycle for the AMOC, with a +5.9 Sv contribution from the upper mid-ocean. Recent studies argue that the dynamics of the eastern Atlantic is the main driver for this seasonal cycle; specifically, Rossby waves excited south of the Canary Islands. Using inverse modeling, hydrographic, mooring, and altimetry data, we describe the seasonal cycle of the ocean mass transport around the Canary Islands and at the eastern boundary, under the influence of the African slope, where eastern component of the RAPID-MOCHA array is situated. We find a seasonal cycle of -4.1±0.5 Sv for the oceanic region of the Canary Current, and 3.7±0.4 Sv at the eastern boundary. This seasonal cycle along the eastern boundary is in agreement with the seasonal cycle of the AMOC that requires the lowest contribution to the transport in the upper mid-ocean to occur in fall.

Observations

Seven hydrographic cruises were conducted in 2013, 2014 and 2015, around the Canary Islands Archipelago. In all of them, a SeaBird 911+ CTD probe was used together with a 300/150khz LADCP. The initial geostrophic velocities were corrected using the LADCP velocities, and to reduce the mass transports imbalances an inverse model [Hernández-Guerra et al, 2005] was applied to the volume enclosed by the hydrographic stations and the African coast. A mooring in the Lanzarote Passage, with data since 2000 monitors the whole water column.

Results

The seasonal cycle, defined as $Transport_{Fall}$-$Transport_{Spring}$, for the Canary Current west of 15ºW is -4.1±0.5 Sv for the surface, central and intermediate waters. In the region east of 15ºW the seasonal cycle is +3.1±0.4 Sv, and is due to the central and intermediate waters.

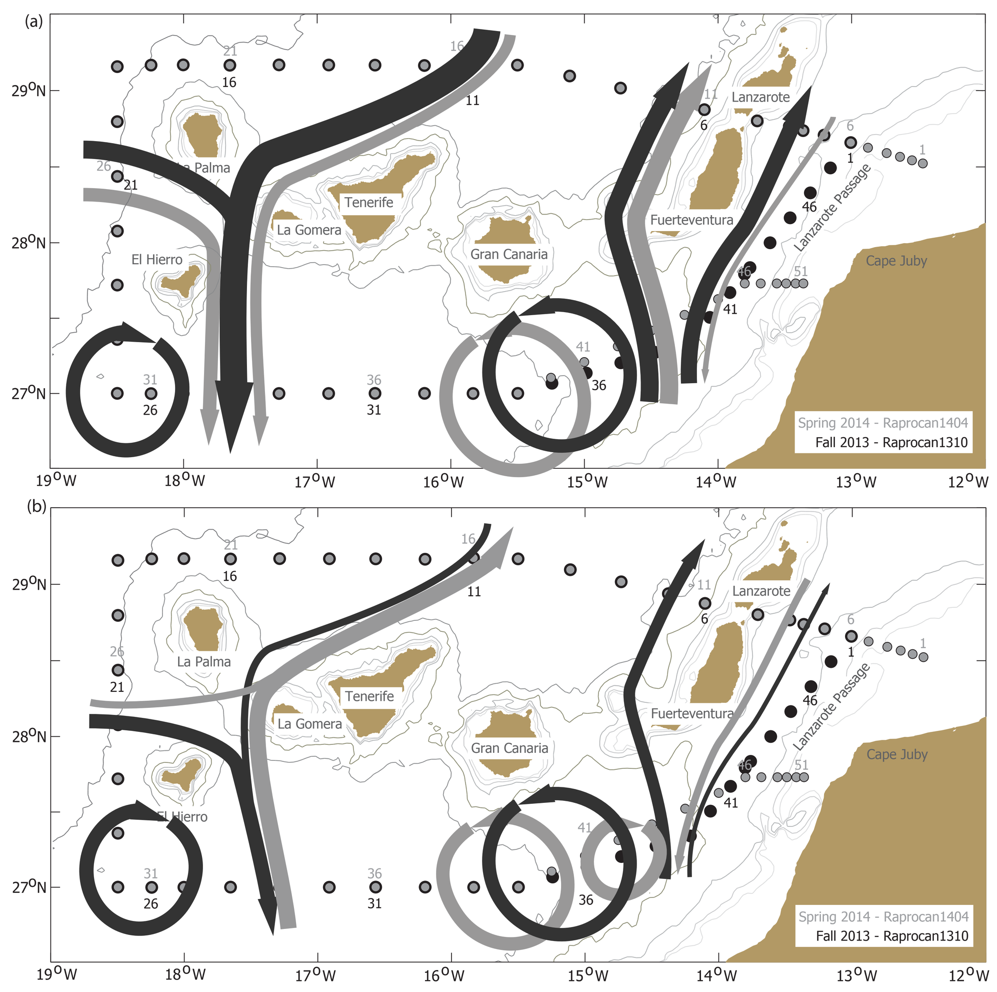

Figure 1. Schematic diagram of the mass transport for (a) the Surface and central and (b) the intermediate waters.

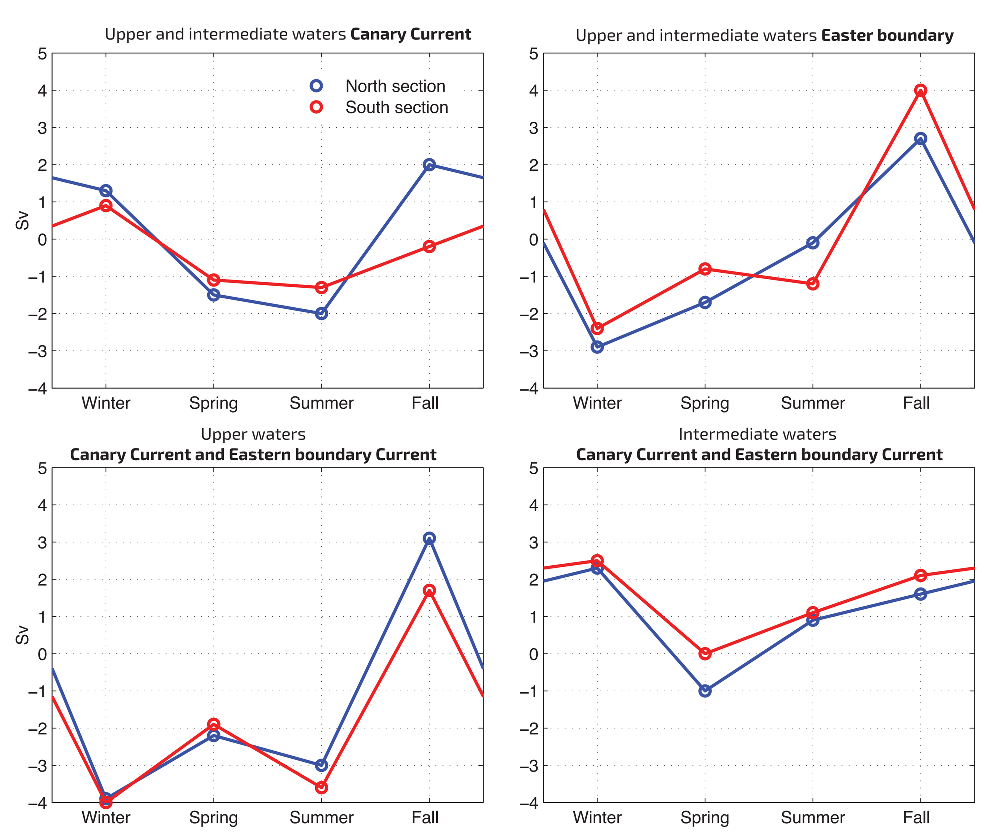

Figure 2. Seasonal cycle of the southward transport (Sv) at the north and south sides of the Canary Islands, as obtained after inverse modelling.

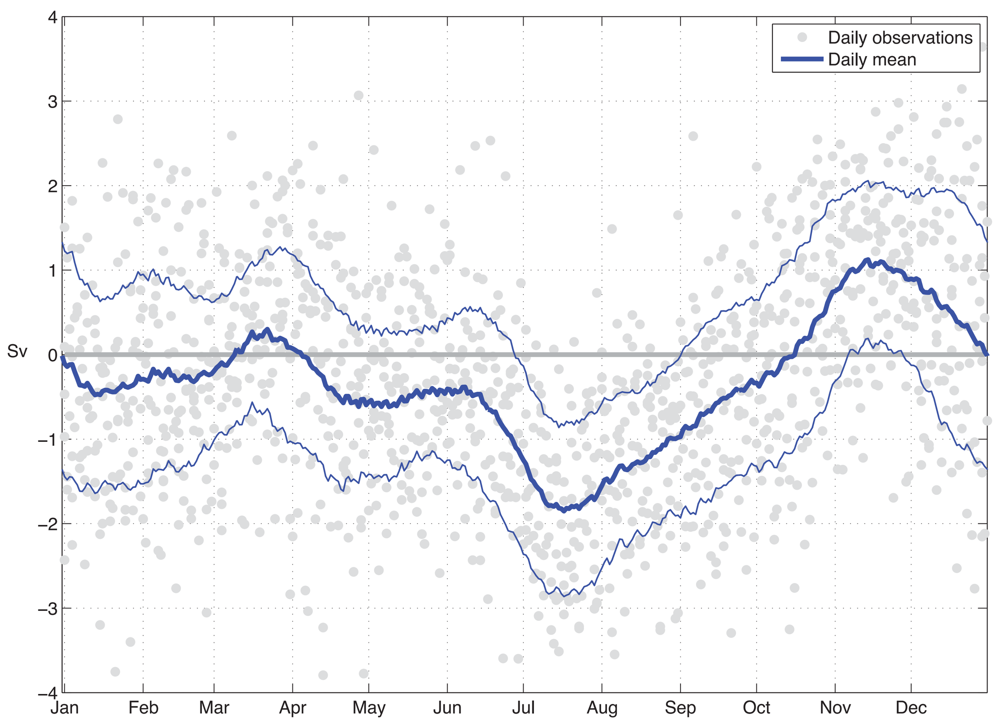

Figure 3. Mass transport estimates in the Lanzarote Passage (Sv) using geostrophic velocities from altimetric SSH, and integrated down to the depth corresponding to the SW.

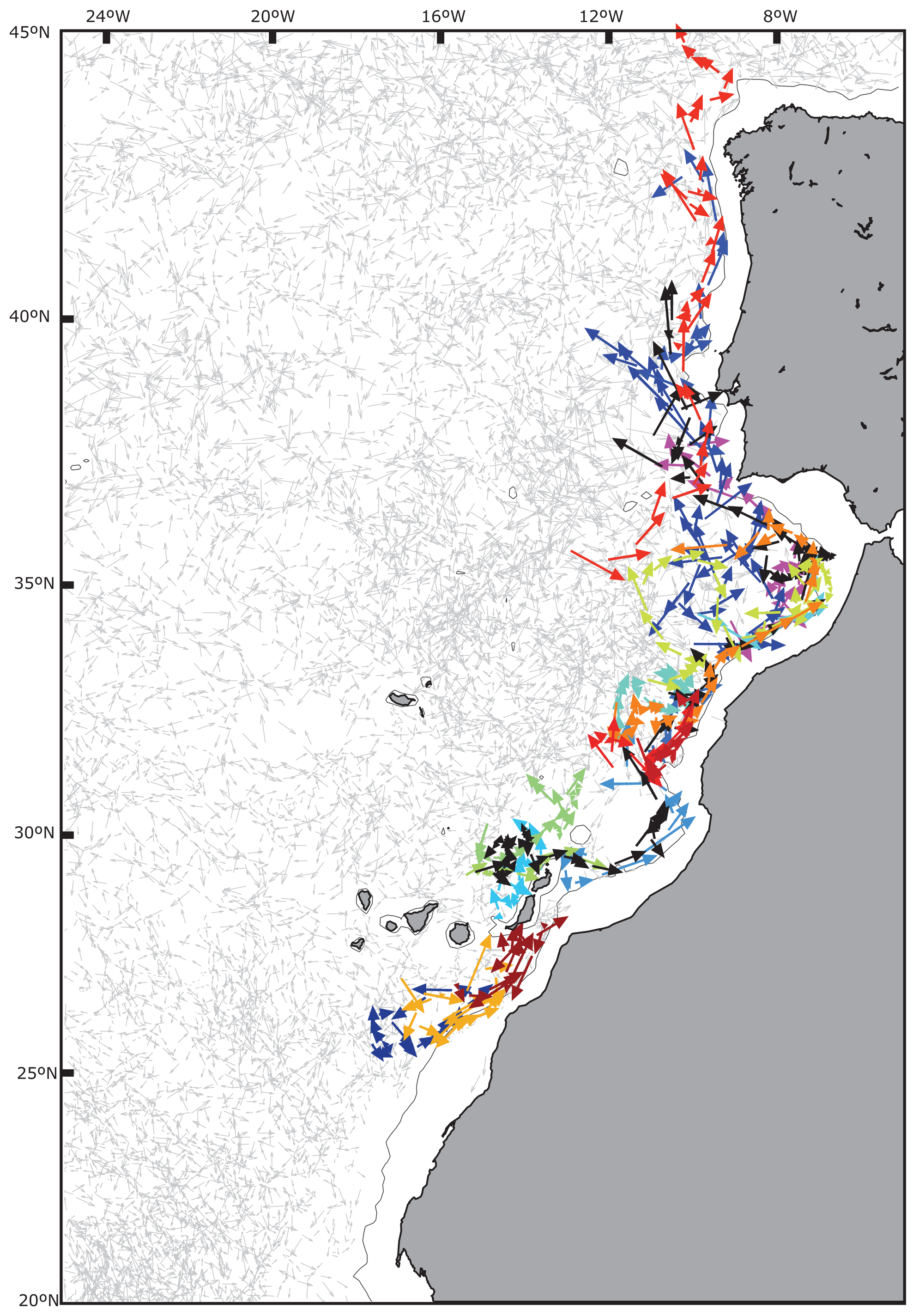

Figure 4. Trayectories at 1000 dbar from selected Argo floats, indicating the trayectory of the Canary Intermediate poleward current.

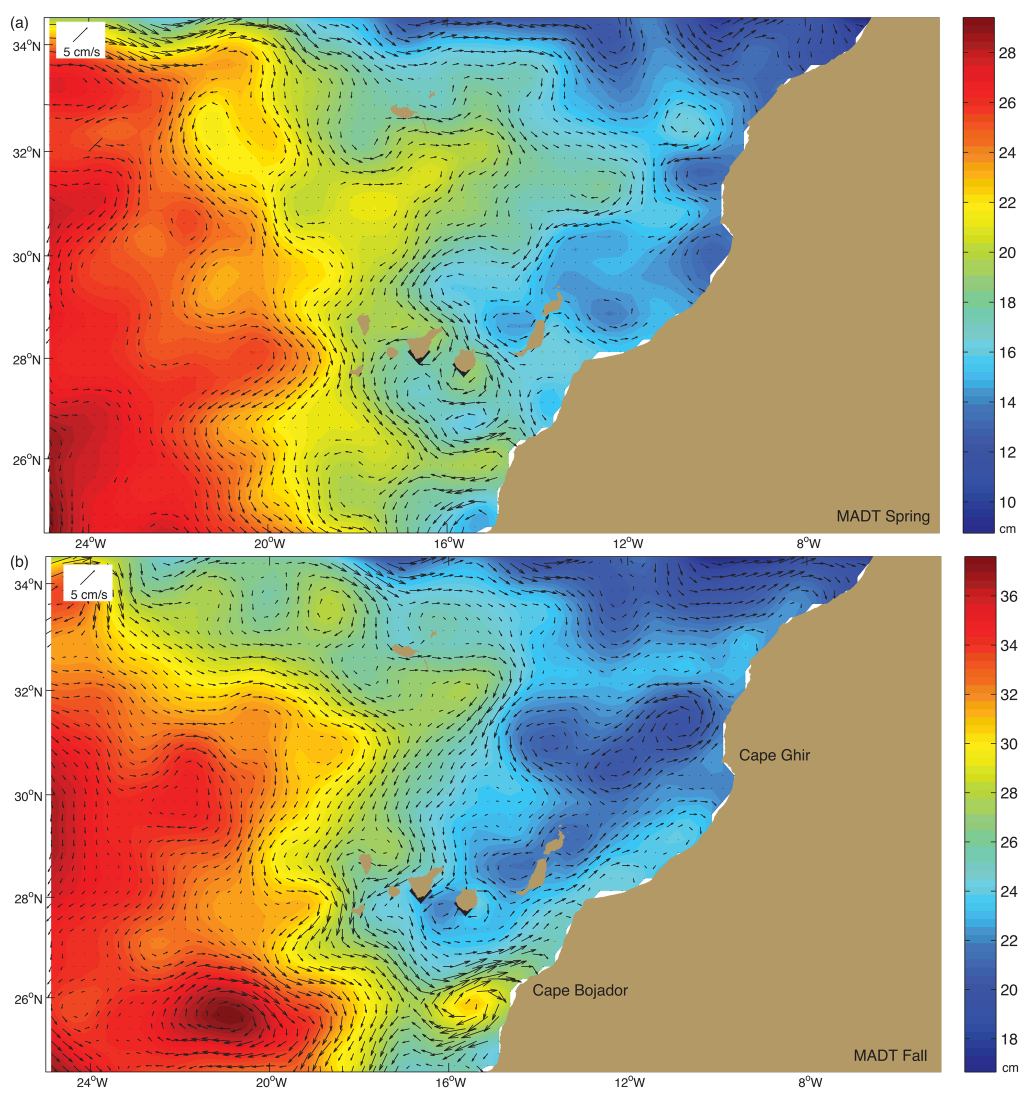

Figure 5. Composite of satellite altimetry-based absolute sea level, and geostrophic velocities obtained using the sea level data in (a) sping and (b) fall.

The seasonal cycle in the eastern boundary is consequence of both, the poleward flow (Fig. 3 and 4), characteristic of the upwelling regions, although in this region is at ~1000 m depth, and the recirculation of the thermocline and central waters (Fig. 5), consequence of the low pressure associated to the cold waters advected by the Cape Ghir filament.

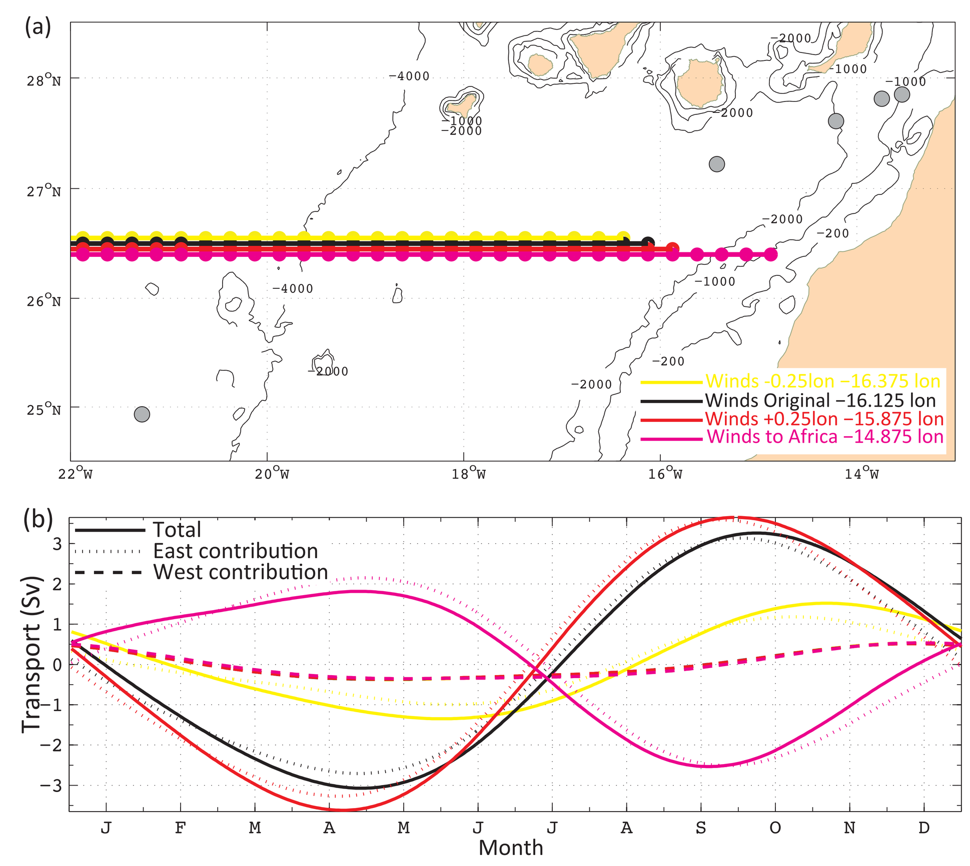

Figure 6. (a) Geographical extension of the SCOW wind stress curl anomaly. (b) Anomaly of basin-wide mid-ocean geostrophic transport for the first two baroclinic modes of a forced Rossby wave model, using the SCOW wind stress curl anomaly climatology.

The Rossby wave model configuration, the same as used by Kanzow et al. [2010], is not appropriate to simulate the seasonal cycle of the meridional overturning due to its high sensitivity to small changes in the winds that force the model (Fig. 6). Since the geostrophic approach is used to obtain the basin wide mid-ocean transport from the integrated pressure across the basin in the Rossby wave model, the wind forcing should be coherent with the geostrophic approach and its associated scales.

Conclusions

We demonstrate that the linear **Rossby wave model used previously to explain the seasonal cycle of the AMOC is not robust**, since it is extremely sensitive to the choice of the zonal range of the wind stress curl and produces the same results with a Rossby wave speed of zero. We demonstrate that **the seasonal cycle of the eastern boundary is due to the recirculation of the Canary Current and to the seasonal cycle of the poleward flow that characterizes the eastern boundaries of the oceans.**

References

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