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Recirculation of the Canary Current in fall 2014

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ABSTRACT

Hydrographic measurements together with Ship mounted Acoustic Doppler Current Profilers and Lowered Acoustic Doppler Current Profilers (LADCP) obtained in October 2014 are used to describe water masses, geostrophic circulation and mass transport of the Canary Current System, as the Eastern Boundary of the North Atlantic Subtropical Gyre. Geostrophic velocities are adjusted to velocities from LADCP data to estimate an initial velocity at the reference layer. The adjustment results in a northward circulation at the thermocline layers over the African slope from an initial convergent flow. Final reference velocities and consequently absolute circulation are estimated from an inverse box model applied to an ocean divided into 13 neutral density layers. This allows us to evaluate mass fluxes consistent with the thermal wind equation and mass conservation. Ekman transport is estimated from the wind data derived from the Weather Research and Forecasting model. Ekman transport is added to the first layer and adjusted with the inverse model. The Canary Current located west of Lanzarote Island transports to the south a mass of -1.5 ± 0.7 Sv (1 Sv $= 10^6$ m^3 s$^{-1} \approx 10^9$ kg s^{-1}) of North Atlantic Central Water at the surface and thermocline layers (~0–700 m). In fall 2014, hydrographic data shows that the Canary Current in the thermocline (below at about 80 m depth to ~700 m) recirculates to the north over the African slope and flows through the Lanzarote Passage. At intermediate layers (~700–1400 m), the Intermediate Poleward Undercurrent transports northward a relatively fresh Antarctic Intermediate Water in the range of 0.8 $\pm$ 0.4 Sv through the Lanzarote Passage and west of Lanzarote Island beneath the recirculation of the Canary Current.

1. Introduction

Subtropical gyres are comprised of intense western boundary currents flowing poleward and slower interior ocean currents flowing equatorward. The southward flowing Canary Current (CC) is the eastern boundary current of the North Atlantic Subtropical Gyre. Historical hydrographic data were used for the first studies of the CC (Stramma, 1984; Stramma and Isemer, 1988; Stramma and Müller, 1989; Stramma and Siedler, 1988). These authors estimated the seasonal variability of the geostrophic transport in the Eastern Subtropical North Atlantic, observing a change in the gyre's structure: In summer, the Canary Current approaches the African upwelling system and the Azores and North Equatorial Currents move south and north, respectively. In the second half of the 90′s under the CANIGO project (Parrilla, 2002), specific cruises were carried out in the eastern branch of the CC that flows through the Lanzarote Passage (LP) (Fig. 1). Hernández-Guerra et al. (2001, 2002) were the first to describe the northward flow at the thermocline and intermediate layers in fall in the LP. This pattern of circulation through the LP was later confirmed with current-meter data (Fraile-Nuez et al., 2010; Hernández-Guerra et al., 2003; Pérez-Hernández et al., 2015) and various hydrographic cruises (Hernández-Guerra et al., 2005; Machín et al., 2006; Pérez-Hernández et al., 2013) also extending to the west of the LP sampling the main path of the CC.

Pelegrí et al. (2005) suggested that the dynamical processes explaining the CC are different than those that explain the flow through the LP. The dynamic of the CC is presumably explained by the curl of the wind stress through the Sverdrup theory (Fraile-Nuez and Hernández-Guerra, 2006; Mason et al., 2011; Roemmich and Wunsch, 1985). On the other hand, the circulation through the LP is apparently linked to the upwelling dynamics off northwest Africa and is named the Canary Upwelling Current (CUC) following Laiz et al. (2012) and Pelegrí et al. (2006). The persistence and strength of the northwest Africa upwelling is linked to the Azores High that provides the Trade Winds flowing along the African coast (Wooster et al., 1976). The Azores High presents a seasonal variability with its northernmost position in summer. The upwelling favorable winds in the Canary Islands are

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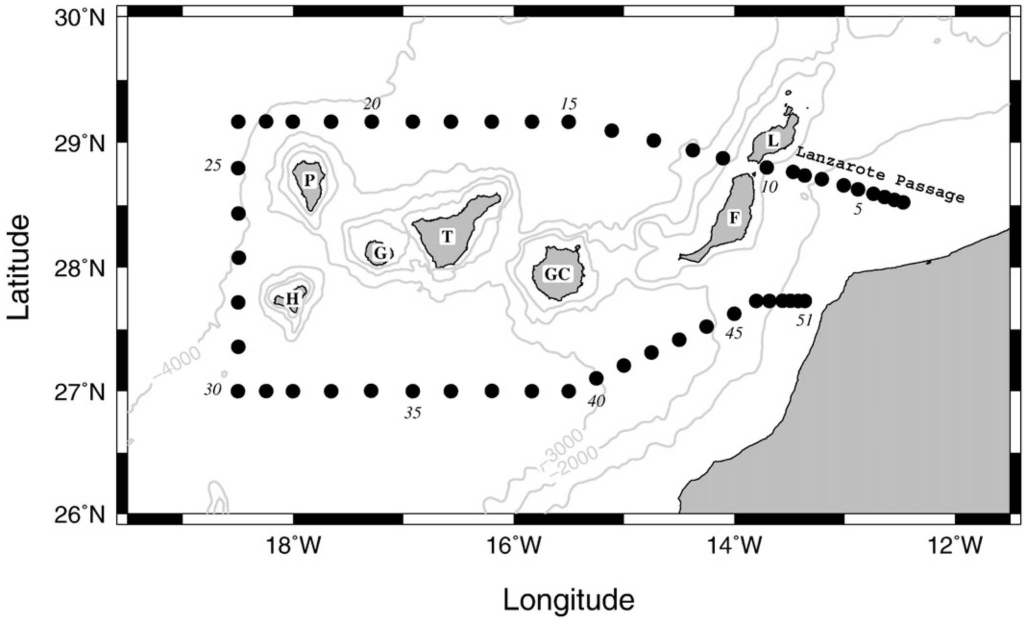

Fig. 1. Studied region. Dots correspond to the geographical location of the stations in Raprocan 1410 carried out in October 2014 (Tel et al., 2016). P stands for La Palma, H for El Hierro, G for La Gomera, T for Tenerife, GC for Gran Canaria, F for Fuerteventura and L for Lanzarote. The Lanzarote Passage between the Lanzarote Island and the African coast is shown. Bathymetry in m (Smith, 1997).

developed during the whole year but are stronger and more persistent during summer (Benazzouz et al., 2014; Hernández-Guerra and Nykjaer, 1997; Marcello et al., 2011; Nykjaer and Van Camp, 1994).

Machín et al. (2006) used four cruises carried out in 1997 and 1998 to estimate the average circulation of the CC and CUC and their seasonal behavior. The mean CC flows to the south with a transport of -2.1 ± 0.9 Sv

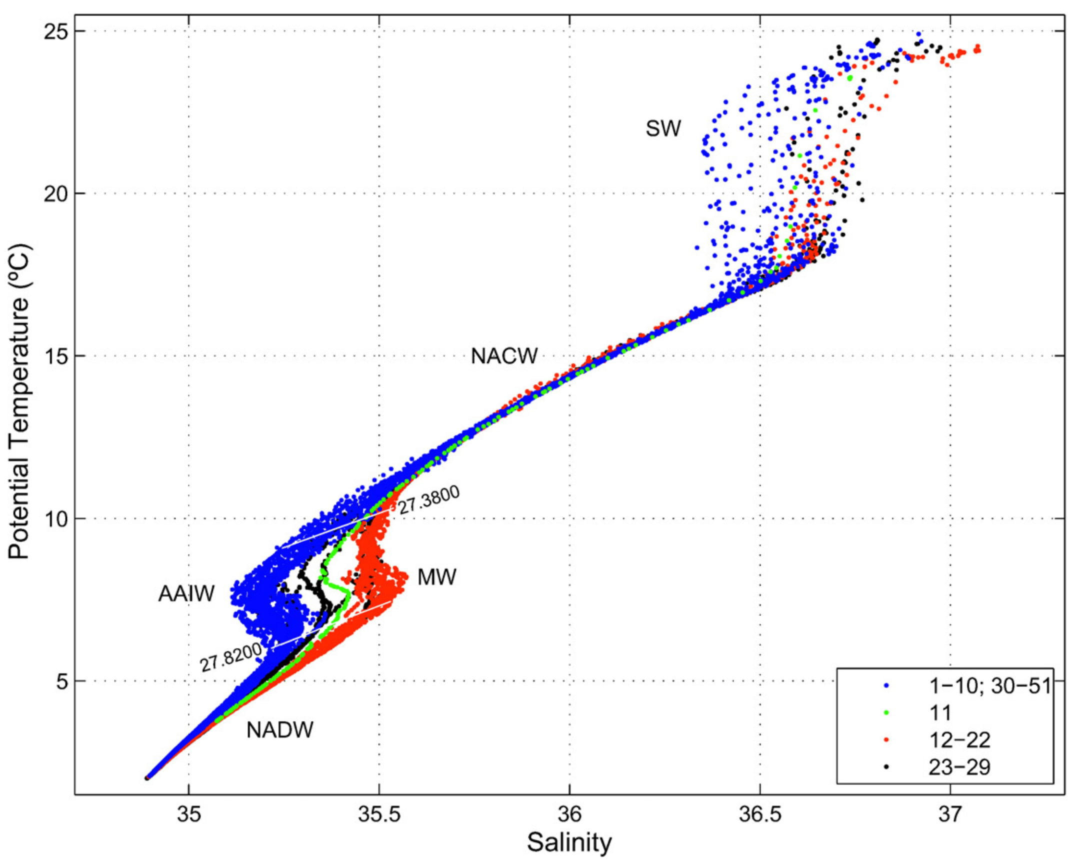

Fig. 2. Potential temperature/salinity diagram for all stations. The main water masses are shown with their corresponding acronyms. Blue dots correspond to stations 1–10 and 30–51; green dots correspond to station 11; red dots correspond to stations 12–22 and black dots correspond to stations 23–29. Plotted white lines are the isoneutrals $\gamma^n = 27.38$ and 27.82 kg/m^3 which roughly divide the water column into surface-central, intermediate and deep waters.