MEDITERRANEAN OUTFLOW AND ITS LINK WITH UPSTREAM CONDITIONS IN ALBORAN SEA

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Abstract

The Western Alboran Gyre (WAG) can influence the Mediterranean outflow (MOW) through the Strait of Gibraltar by regulating the proportion of Levantine and Western Mediterranean (LIW and WMDW) in the MOW. Observations at Camarinal sill in the Strait and AVISO data suggest that a well-developed WAG hampers (favors) the LIW (WMDW) drainage and vice-versa.

Keywords: Water transport, Gibraltar Strait, Deep waters

The MOW through the Strait of Gibraltar is mainly formed by LIW, characterized by an absolute salinity maximum, and WMDW, the densest and usually coldest water. In the Alboran Sea these waters approach the Strait along different paths, the LIW flowing closer to the Spanish coast and the WMDW attached to the Moroccan coast. This spatial pattern is still observed in the Strait east of Camarinal ([1]), whose topography depicts two troughs (Fig. 1). Thus waters with LIW and WMDW characteristics are expected to flow across the northern and southern (CN and CS) channels, respectively. To analyze this cross-strait structure, two twin mooring lines equipped with autonomous CTs at around 10m above the seafloor and uplooking ADCPs were deployed in both channels from early June to late September of 2013.

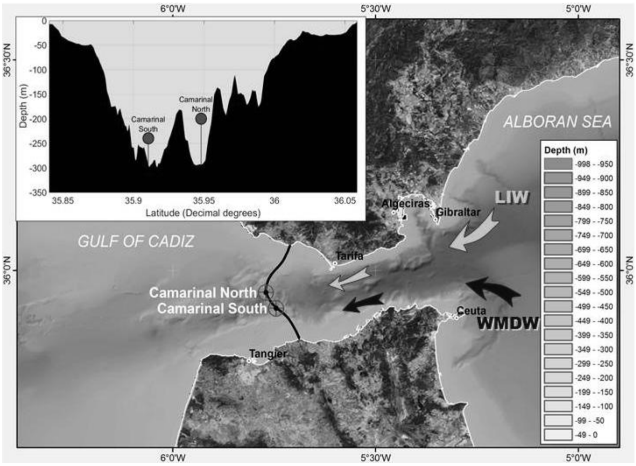

Fig. 1. Strait of Gibraltar and cross-section of Camarinal sill bathymetries. The location of the mooring lines is indicated. The arrows sketch the preferred path of the incoming LIW and WMDW in the Alboran Sea and eastern Strait.

Considering the path of each of these water masses in the Alboran Sea, the flow of WMDW would benefit from a well-developed WAG, whereas the LIW would be favored by a weak or absent WAG. While the first process has been studied by different authors ([2], [3]), the influence of the WAG on the LIW flow seems to not have been addressed yet. Should this entraining mechanism be acting, the observations collected at the Sill would show up some indication of it. We present next a first attempt to prove such a relationship using these obserations and altimetry data from AVISO. The hydrological observations confirm that, on average, saltier and warmer water flows across CN (Fig. 2c, d), although this fact only arises clearly when the tidal variability is removed by retaining the saltiest and/or coldest sample of every semidiurnal tidal cycle, as it is done in [4].

An estimate of the outflow per width unit has been obtained integrating the along-strait ADCP velocity from the deepest bin to the depth of maximum shear, which is a good indicative of the interface according to [5]. Flows are strongly dominated by tides so that the flow time series were filtered with a low-pass filter of 3-day cut-off period that removes semidiurnal and diurnal variability, but not the fortnightly cycle (Fig. 2b). It is seen that, during spring tides, both flows and salinities and potential temperatures decrease as a result of the enhanced tidal mixing during this part of the cycle. Another expected feature in Fig. 2b is the very coherent co-oscillation of the flows (r=0.95), with the flow at CS being greater than at CN by 12 m^2s^{-1} on average. The difference is not constant, however, and fluctuates between 28 m^2s^{-1} at the beginning of the series and -4 m^2s^{-1} by the end of August beginning of September. These transversal oscillations are better seen in the series of flow differences (Fig. 2d) and are just the ones of interest.

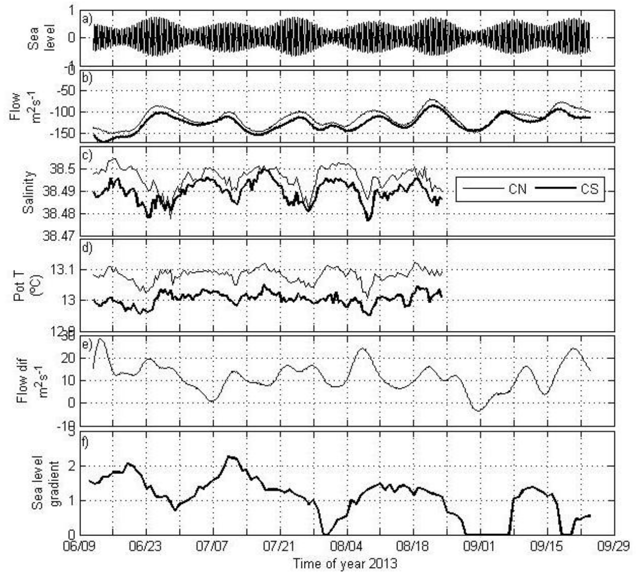

Fig. 2. (a) Sea level at Tarifa. (b) Low-passed flows per width unit at CN and CS (see legend). (c) Series of maximum salinity samples during each semidiurnal cycle at CN and CS. (d) Same as (c) for minimum potential temperature. (d) Flow difference per width unit (CN-CS; therefore positive values indicate greater absolute flow at CS). (e) Mean sea level gradient (x 10^6) across the WAG, inferred from altimetry (AVISO) data.

According to our hypothesis, a well-developed WAG would hamper (favor) the LIW (WMDW) flow and, hence, increase the difference, while a weakened WAG would produce the opposite result. In other words, negative or close-to-zero values in Fig. 2d would be associated with situations of weak or, even, non-existing WAG. Fig. 2e shows the mean surface gradient as a proxy of the strength of the WAG. Interestingly, the events of low or null (no WAG) gradient correspond with minimum differences rather satisfactorily. Of particular concern is the WAG disappearance by the end of August beginning of September coincidentally with the only period in which the difference is negative (stronger flow across CN than across CS). The coincidence is encouraging and stimulates further research on this topic.

References

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