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What drives the spreading pattern of the Mediterranean Outflow Water (MOW) in the eastern Gulf Of Cadiz, SW Iberian Peninsula?

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Summary

The inverse estuarine circulation through the strait of Gibraltar is responsible for the overflow of dense, saline MOW towards the Atlantic basin. The classical views divide MOW dynamics in an initial descent phase along the first 100 km as an entraining gravity undercurrent followed by a damped geostrophic flow phase. West of 8ºW it is seen as a multi-layered, buoyant plume parked at depths ranging 800-1300 m. Recent MB bathymetry has revealed a complex seafloor morphology that questions this classical view. Sinuous submarine channels and sharp depth falls are expected to play a relevant role in the definition of the NACW-MOW interface and the MOW spreading pattern. In this work we analyze more than 4800 CTD and 950 LADCP observations taken in the eastern Gulf of Cádiz to study the small-scale features of the MOW spreading pattern as well as the secondary circulation associated with sharp current bends. small-scale depth falls, abrupt channel turns and current-submarine mount interaction may bring the MOW to high Rossby number situations and enhance mixing past the initial plunging phase, which seems non negligible as compared with tidal stirring, shear instability and double diffusion along the MOW pathway.

Materials and Methods

CTD profiles were taken from IEO cruises series ARSA (2010-13), STOCA (2009-13), INGRES (2009-13), INDEMARES (2010) and ECOCADIZ (2013) and from individual Pis and SeaDataNet. Profiles were QC'd against WOA climatology and swath bathymetry. Nearly 950 LADCP profiles were taken from 2010-2013 IEO cruises and were processed with bottom-track and VM velocities constrains (Visbeck, 2002). To study the secondary circulation, rather than computing a zero-mean coss-stream flow rotation, each velocity profile was decomposed into the normal and tangent components to a minimum-distance across-channel section (for channeled flows) or to the maximum slope (for non-channeled flow).

Results and Discussion

According to Price et al (1993; on hereafter P93), the outflow can be divided in 3 sectors:

<u>Channel</u>: Featuring the highest salinities (~38) from the strait until a sharp right bend at 6.50ºW. Salinity lows occur at 6.00ºW and 6.36ºW, over topographic elevations (Majuán and Basement highs, Hernandez-Molina et al, 2013; on hereafter HM13). Velocities > 1m/s are also found around these highs whereas the flow decelerates in between (0.8 m/s). Ssouthern and northern channels are subjected to centrifugal accelerations of dissimilar sign with the left bend to the north (in the same sense as Coriolis acceleration) and right bend to the south that separates both MOW branches.

<u>Descent</u>: The submarine channel (Lower Terrace in HM13) forces a sharp right bend and constrain the spreading pattern. Abrupt depth fall causes intense acceleration of the flow (> 1.8 m/s) with a multi-layered flow with a northern branch oriented to the NW and a southern one to the SW. Past 6.00ºW largest salinities decrease to 37.5 and locate along the outer bend. Both are the cause of the intense centrifugal accelerations that super-elevate up the interface to the south.

Damped geostrophic: MOW current aligns with the bathymetry over a broad depth range. Max width (36.25 isohaline) extends from 20 km (250-500 m at 6.40ºW) to > 50 km (250-800 m) at 7.00ºW. Maximum salinity (37.2) and velocity (0.7 m/s) locate along the outer bend of the south channel. Past 7.00ºW the MOW pathway splits in 3 branches. The deepest component (>750 m) turns cyclonically into the deep slope, in part diverted by the marginal channels (e.g. Gil Eanes) after which it detaches from the ground. A central branch (450-750 m) with S > 36.6 and vel. ~0.6 m/s decreasing coastward exhibit topo-steered sharp turns along 37.26ºN. Past 6.75ºW it is forced to turn cyclonically by the shelf orientation. The Cadiz Diapiric Ridge (CDR) funnels the flow at 7.00ºW, leaving S < 36.13 leeward. Whereas its deepest components turn sharply forced by the CDR, the shallower part is seen to override the mounts. Outward velocities that cause super-elevation on the upper slope beyond what expected for a geostrophic current at 0.5 m/s and g'=0.01 m/s2 (65 m over 15 km). An upper branch (250-500 m) with S > 36.55 and vel ~ 0.3 m/s turns cyclonically along the upper slope. It is seen to bifurcate at 6.95ºW 36.50ºN, where interaction with the Guadalquivir DR (GDR) occurs. Rapid descent forces the flow into the sinuous, narrow Worm submarine Channel (IEO, 2012), where velocities accelerate up to 0.6 m/s to feed the intermediate branch.

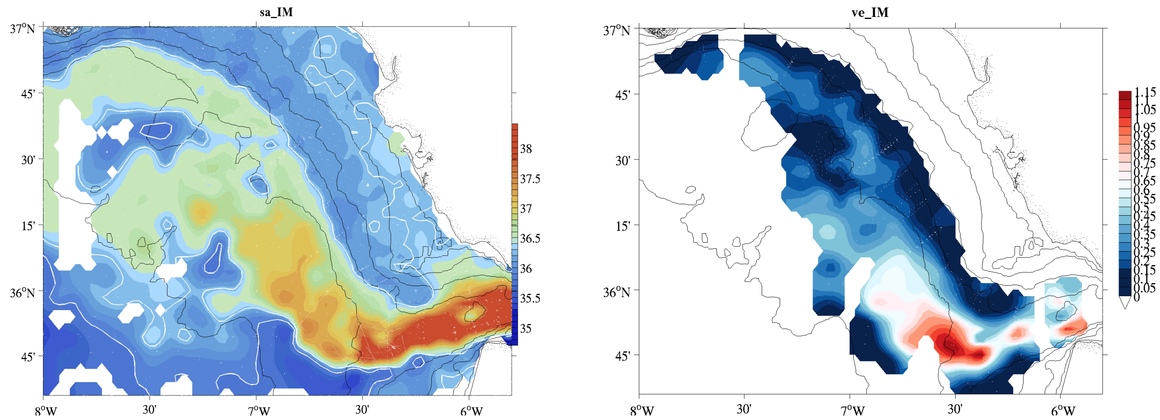

Figure 1. Left: Near-bottom salinity. Right: near-ground LADCP velocities (m/s).

Conclusions

Small-scale (submesoscale) deph falls, channel bends and current-submarine mount interactions bring the MOW outflow to high Rossby number situations. Most of these may also drive subcritical regime and mixing past the initial plunging,

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