TYRRHENIAN SEA CIRCULATION IN SPRING 2004: OBSERVATION AND MODEL RESULTS

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Abstract

Hydrological and current measurements collected in the Tyrrhenian Sea during May-June 2004 are analyzed with an inverse box-model (IBM) to establish the mean spring circulation patterns of the basin. These patterns are compared with those provided by a high resolution, primitive equation model (POM) implemented over the area to simulate the mean basin circulation during the survey. The good agreement between the two circulation fields represents a solid evidence for the reliability of the estimated dynamical structures. Moreover, the POM reveals the short spatial variability of the basin not always resolved by IBM because of the low spatial resolution of the in-situ measurements. The comparative study indicates the Tyrrhenian basin as a highly dynamically active region of the Mediterranean Sea, characterized by a rich mesoscale dynamics.

Keywords: Circulation, Tyrrhenian Se, Mesoscale Phenomena, Models

The Tyrrhenian Sea (TS) is a deep basin of the Mediterranean Sea characterised by a complex bottom bathymetry: A narrow continental shelf, a large shelf slope and a deep central part with a large number of isolated volcanic seamounts. Up to the 90s, TS was considered the most isolated basin of the Western Mediterranean Sea, characterized by a wind-driven circulation. Recent findings suggest that TS is a key region for the water masses exchanges between the eastern and the western Mediterranean Sea, playing an important role as a reservoir of heat and salt for the Mediterranean basin [1, 2]. A detailed description of the circulation at the level of the main water masses is still lacking.

This work is aimed at achieving a novel picture of the typical TS spring circulation patterns, based on observations collected during two recent dedicated oceanographic cruises conducted between May and June 2004 (Fig. 1). The hydrographic dataset, integrated with long-term current measurements (at the Sicily strait and the Corsica channel), has been used to estimate the absolute geostrophic flow with a linear Inverse Box Model (IBM). The IBM method [3] provides a correction to the relative geostrophic velocity field, assuming conservation of water properties inside boxes, which are closed volumes of water bounded by the geographical margins (coastline and bottom) and by the hydrographic transects. Two isopycnal surfaces (28.9 kg/m3 and 29.1 kg/m3) are chosen as boundaries between layers, corresponding to the resident water masses: Atlantic Water (AW), Levantine Intermediate Water (LIW) and Tyrrhenian Deep Water (TDW).

The IBM assessment of the circulation has been compared with the simulated circulation from a high resolution numerical model (the Princeton Ocean Model, POM), forced with ECMWF wind stress fields averaged over the cruise period. Initial and boundary conditions are obtained by interpolating on the POM grid the temperature, salinity, velocity and surface elevation fields produced by the Mediterranean Forecasting System (MFS). Both the initial and the boundary data are averaged over the cruise period. The model is forced at the open boundaries by net mean barotropic transports simulated by MFS.

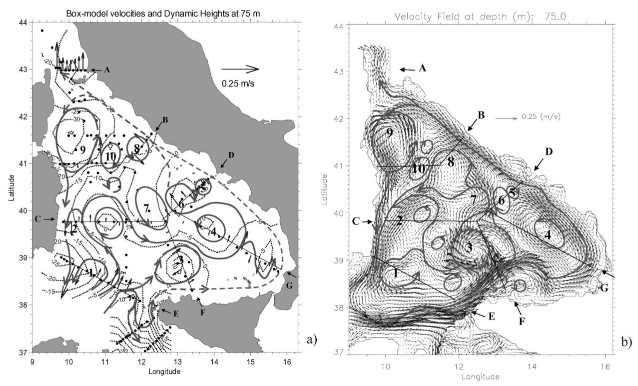

Fig. 1. Comparison between IBM (a) and POM (b) current fields at 75 m, representative for AW circulation.

Fig. 1a shows the IBM estimated geostrophic velocities (small arrows perpendicular to hydrological transects) at 75 m of depth, superimposed to the dynamic heights distribution (dotted curves) at the same depth, referenced to the surface. From both fields, a sketch of the main AW patterns (continuous curves) has been drawn and compared with a similar sketch resulting from the horizontal velocity field of the POM simulation (Fig. lb). The ten dynamical structures distributed all over the basin in both IBM and POM fields are numbered likewise, tolerating small differences in position and shape. The largest structure is the Bonifacio gyre 9, which is a permanent cyclonic circulation due to the year-round westerly jet of wind blowing through the Bonifacio strait. This gyre displays remarkably close features in the two estimates. Moving south, good agreement is found for the anticyclone 3, just above the Sicily tip, and for the cyclonic circulation 4, more to the east. The eddy 8 is well developed in POM as a wide current meander. Most of these structures are coherent with the corresponding intermediate and deep circulation patterns (not shown), indicating a strong barotropic component of the flow. For the sake of completeness, horizontal surface and intermediate mass fluxes for the main streams and gyres are shown in Fig. 2.

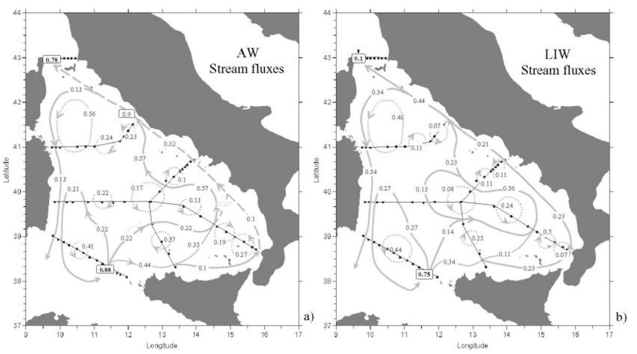

Fig. 2. IBM horizontal mass transports (Sv) through transects for AW (a) and LIW (b).

Concluding, the results indicate the presence of a rich mesoscale dynamics, until now poorly resolved, likely to be strongly influenced by the interaction of the surface forcing with the complex bathymetry of the basin. Moreover, the good agreement between the geostrophic reconstruction of the IBM and the velocity patterns of the POM indicates that the main deduced circulation patterns are representative of a typical TS spring condition.

References

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