BASIN-WIDE USE OF A SHIP-MOUNTED ADCP GIVES A NEW PICTURE OF THE ADRIATIC SEA CIRCULATION

Ursella L., E. Accerboni, M. Gacic* and R. Mosetti

Osservatorio Geofisico Sperimentale, Trieste, Italy

Abstract

The analysis of the data obtained from a basin-wide ship-mounted ADCP survey in the Adriatic Sea shows the existence of the M2 amphidromic point in the Middle Adriatic area. The steady current field confirm the existence of the large scale cyclonic meander with two smaller cyclonic gyres situated over the two major topographic features (South Adriatic and Middle Adriatic Pits). The stratified season is characterized by a strong vertical shear, while from summer to winter (from stratified to homogeneous water column) the horizontal circulation scales change only to a smaller extent.

Key-words: acoustics, currents, tides, vertical profile, Adriatic Sea

Introduction

Adriatic Sea general circulation is characterized by an elongated basin-wide cyclonic gyre with several sub-basin scale cyclonic structures embedded in it (1) and located above the most prominent topographic features of the basin (Jabuka Pit, South Adriatic Pit). Longitudinal fluxes play an important role in determining the horizontal distribution and exchange of properties between various Adriatic sub-basins. Italian national project PRISMA1 was aimed at determining water and mass fluxes at selected transects separating different Adriatic sub-basins. Thus, long-term Eulerian current measurements in parallel with continuous one-year long ship-borne ADCP basin-wide survey were carried out within the framework of the project. Seasonal multidisciplinary cruises were also carried out in order to determine spatial distribution of various biological and chemical parameters together with the mass field structure. In this paper we present and discuss basin-wide tidal current field structure, vertical distribution of the residual current field in various transects as well as the differences between the current field structure in the stratified and unstratified conditions.

Experiment design

The experimental activities within the PRISMA 1 project with a basin-wide coverage of Eulerian and ship-borne ADCP measurements were carried out in the period from 15 May 1995 until 28 February 1996. Current measurements were focused on four areas that delimit three Adriatic major topographic features (North Adriatic shelf area, Mid-Adriatic - Jabuka Pit and South Adriatic Pit). Eulerian current measurements were carried out to complement ADCP data but due to the intensive fishery activity in the area heavy instrument losses were encountered. The ADCP survey of the four zones was done during multiple subsequent passages of cross-isobath transects of the length of about 100 km, thus an average time needed to cover a single transect was less than 10 hours. In order to have a basin-wide coverage, but at the same time in similar stratification conditions, all the ADCP data collected during the period May-September were treated as an unique data set. Since the period in question is characterized by a vertically stratified water column, it will be called "summer". On the other hand, data collected from October 1995 through February 1996 were analyzed separately as they belong to the period when the water column in the Adriatic is vertically mixed and it will be called in the rest of the paper "winter".

Results and discussion

Tidal and other high-frequency variability that have time scales comparable to the time needed for the ship to cover a single transect, can contaminate the basin-wide residual or steady current signal. First, the importance of various tidal components was estimated carrying out spectral analysis of the available Eulerian time-series. Then, tidal oscillations were eliminated from the data set using a method developed by Candela (2). As it was mentioned earlier, summer and winter were analyzed separately and it occurred that during the stratified season tidal phase changes appreciably with depth which suggests the importance of the baroclinic tides. On the other hand, during winter the tidal phase pattern does not vary a lot in the vertical. In both cases, however, the amphidromic point of the M2 component in the current field was clearly present. As predicted by numerical and analytical models (3), its position should be 1/4 wave length (in this case about 300 km) southeast of the sea surface elevation amphidromic point. In fact data analysis shows a minimum in the M2 tidal amplitude east of Dubrovnik in the centre of the basin and a corresponding jump in the phase of about 180 degrees.

Tidal components were thus estimated at each level separately during summer and, from the vertically averaged current field, during winter. The obtained tidal parameters were then used to remove tides from each transect separately and the detided current field was divided into the steady and residual parts. Residual current field in this paper is defined as the signal remaining after the removal of the tidal and steady current components. In general the steady current component is weaker than the residual one.

The summer horizontal distributions of a steady current component show clearly a swift coastal current along the western shelf. The more we go to deeper layers, the more important becomes the influence of topography. Thus, the cyclonic curvature of streamlines above the two Adriatic pits becomes more evident. Another interesting feature is the occurrence of an important offshore current component in deeper layers near the Italian coast in the Middle Adriatic area. In intermediate layers an important longshore component is evident in that area. A possible explanation can be found in an upwelling-related transversal circulation. In fact analyzing characteristics of the climatological wind field, one notices in summer the prevalence of the northwesterly winds producing upwelling along the Croatian coast and downwelling along the Italian one. Associated to that, a closed transversal circulation cell should appear. From our ADCP data only the deeper branch of the cell was evident since the instrument is "blind" in the first ten meters. In fact, from the climatological SST data it was documented that the eastern coastal area was colder than the western shelf area only in the summer (4) providing another evidence for the possible existence of upwelling phenomena.

Differences between stratified season and a part of the year when the water column is vertically mixed, are clearly evident also in the structure of the horizontal and vertical shear of the residual current field. During the winter season analyzing cross-shore transects, one can see that the residual current field is characterized by a strong and vertically constant horizontal shear (Fig. 1). Structures are thus vertically homogeneous having scales of the order of the water depth. Their horizontal scales are of the order of ten kilometers. On the other hand, during the stratified season apart from the horizontal shear, in the residual current field strong vertical shear occurs with the appearance of countercurrents in various layers. The horizontal scale, however, remains the same. The change in the vertical current field structure is evidenced from the Eulerian current measurements where we note the current field variability at two levels being out-of-phase in the stratified season, while in homogeneous density conditions the two time-series show clear in-phase behavior. The ADCP survey enabled us also to define in more details spatial and temporal scales of the longshore coastal current at the Italian shelf. In fact it was noticed that the longshore current has at a transect south of the Po delta, a cross-shore scale of the order of ten kilometers and that it is strongly time-dependent in function of the river Po pulses. With the low discharge rates the longshore current is rather weak while within few days after the Po river discharge pulses, strong longshore current is generated (Fig. 2) as evidenced at the transect located about 50 km downstream of the Po River mouth.

References

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