STRONG FORTNIGHTLY OSCILLATIONS OBSERVED IN THE ADRIATIC SEA

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Abstract
This paper documents the occurrence of strong fortnightly oscillations in the Adriatic Sea, frequently observed in the current measurements. For that purpose we analyzed half-decadal sea level series and long-term currents collected within different parts and layers of the Adriatic Sea. The fact that strong 10-20 day currents are occasionally in-phase with the Mf sea level tide gives a hint on a possible mechanism responsible for the generation of these oscillations. Additionally, these currents are usually strongly amplified during a weakly stratified season, indicating a baroclinic mechanism responsible for the multiplication of the fortnightly currents.
Keywords: Adriatic Sea, Tides, Currents

There are a number of studies that document the 10-20 day oscillations in current fields, which are frequently observed in the Adriatic and Mediterranean Seas [1-4]. Although the atmospheric forces have been suggested as the generator of these oscillations, such a hypothesis is still not proved and no significant interconnection with the strongest currents has been found. Therefore, we attempted to connect the observations with another force not considered in any of the documented literature, and that includes the propagation of the fortnightly wave [5, 6] coming from the Atlantic Ocean through the Strait of Gibraltar, being modulated and amplified by the topography, stratification and atmospheric processes.

We focus our study in the Adriatic Sea, as continuous multi-decadal hourly sea level series are available there, together with several long-term (about a year) current measurements. We have used the data collected at the Rovinj (RO) and Split (SP) tide gauges from 1957 to 2005, and the ADCP deployed off Dubrovnik between 27 November 2007 and 23 January 2009 at the depth of 84 m. For the assessment of the atmospheric influence we used available hourly air pressure data from Bari (BA) and Trieste (TR) meteorological stations during the same interval, analyzing their difference (gradient) that generates the winds along the Adriatic.

First we performed classical spectral analysis and found that a significant sea level energy peak between diurnal and semi-annual periods is occurring only at 13.66 days, equalling the Mf tide period. By applying harmonic analysis we estimated a Mf amplitude of 0.89±0.42 cm at Split and of 0.97±0.44 cm at Rovinj, with no changes in phase between them, indicating that the barotropic Mf tidal wave is much larger than the Adriatic. Then we extracted 10-20 day currents from the ADCP station by applying a band-pass Butterworth digital filter. It may be seen that both the barotropic Mf currents and sea levels are often in-phase (Fig. 1), indicating a progressive nature of these oscillations. The predominantly barotropic currents are changing into baroclinic ones in early April, when stratification is beginning to develop in mid latitudes. The first oscillatory event, occurring in April, is in-phase with the air pressure gradient oscillations over the Adriatic, which is following the documented speculations on atmospheric origin of the generating force of 10-20 day oscillations. However, the second and the strongest 14-day oscillatory currents event in 2008 may be observed from mid May to early July, when the atmospheric pressure gradient at these periods was quite low. The oscillatory currents with maximum velocity amplitude of 15 cm/s were in-phase with the Mf tide for more then 4 cycles. The in-phase character between the current oscillations and the force, which may be observed through the water column, also indicates that the Mf tide could be the generating force.

Two other documented studies are favouring the Mf tide to be a generator of such oscillations. Martin et al. [4] tried to reproduce the fortnightly oscillations observed at Palagruža Sill by state-of-the-art ocean numerical model, which includes all of the atmospheric forcing but not fortnightly tides at the open boundary. They did not reproduce the oscillations, yielding us to the conclusion that the force is outside of the model like fortnightly tides. Other study, given by Kovacevic et al. [3], documents the 10-20 day variability in deep Otranto Strait currents. We found both observations to be in-phase with the Mf sea level tide in the Adriatic.

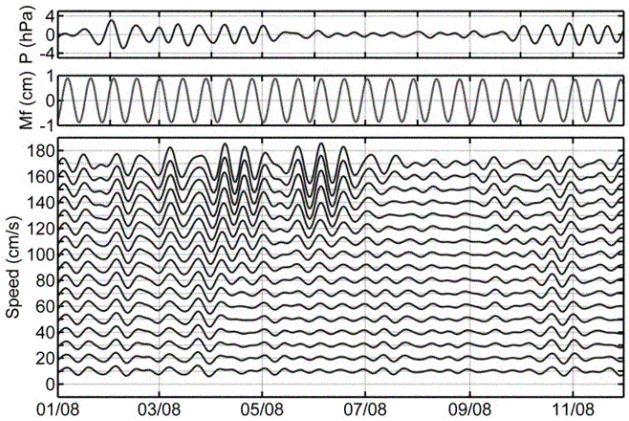

Fig. 1. The top panel shows band-pass filtered along-Adriatic air pressure differences as computed from Bari and Trieste measurements. The middle panel displays the Mf sea level tide. The bottom panel contains band-pass filtered alongshore currents measured off Dubrovnik in 2008 (the most top and most bottom current series are at 6 and 70 m, filled in by the equidistant 4-m layers).

We believe that similar fortnightly oscillations may be found in other parts of the Mediterranean Sea, still unexplained as nobody considered the Mf tidal wave as a possible generator. In addition, the significance and strength of the Mf tide over the open Mediterranean waters should be mapped through the process-oriented numerical studies, which will prove the capacity of the Atlantic Mf tide to propagate within the Mediterranean and to amplify at topographical barriers and during stratified conditions.

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