INVERTED BAROMETER OVERSHOOT AND GREAT ADRIATIC SURGE OF 21 JUNE 1978

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Abstract

On the morning of 21 June 1978 exceptional sea-level oscillations, having a trough-to-crest height of 6 m and a period of 10-20 min, occurred in Vela Luka Bay. Slightly less pronounced variability was observed elsewhere along the east Adriatic coast and, with some delay, along the west coast. In this presentation one of the hypotheses put forward to interpret the event, the one relating it to a mesoscale air-pressure disturbance, is supported by results of the analysis of all the available data and of the runs performed with the state-of-the-art meteorological and oceanographic models.

Keywords: Adriatic Sea, Air-Sea Interactions, Coastal Models, Sea Level

On the morning of 21 June 1978 a tsunami-like event occurred in the Adriatic Sea. With the trough-to-crest height reaching 6 m in Vela Luka Bay on the Island of Korcula and exceeding 1 m in a number of places along both the east and west coasts of the Middle and South Adriatic, this was the most pronounced such event observed in the Adriatic in the 20th century. There were no casualties in Vela Luka, but the town was so heavily damaged that the state of emergency had to be proclaimed. The event was extensively commented in contemporary newspapers, along with the fact that it did not correspond with an equally dramatic process in either the atmosphere above the Adriatic or the earth below it. A dozen or so tide gauges operated in the Adriatic at the time, but although some of them did record intensified high-frequency variability, none was exposed to one of the sea-level maxima.

In the years following the event four different hypotheses on the generating mechanism have been proposed, with two of them finding the cause at the sea bottom and two in the atmosphere. The four hypotheses shared a common weakness: explanations of the relationship between the cause (earthquake-related bottom movement, landslide, cyclone, or atmospheric gravity wave) and the consequence (surge) were not supported by a proper modeling. In this presentation one of the hypotheses, the one relating it to a mesoscale air-pressure disturbance [1], is reconsidered by using all the available data as well as the state-of-the-art meteorological and oceanographic models. Careful analysis of the sea-level observations and measurements reveals that the sea-level heights at the east Adriatic coast were much larger than at the west coast and that the west coast oscillations mostly lagged behind the east coast variability [2]. A fresh look at the air-pressure data confirms the previous finding according to which a mesoscale atmospheric disturbance propagated at about 22 m/s in a northeastward direction above the area affected by surging, and also enables various timing errors in barograph records to be taken into account. Additionally, an analysis of a simultaneous wind record reveals that the disturbance lasted about 10 min.

The meteorological model employed (WRF-ARW) proves unable to reproduce the mesoscale disturbance coinciding with the surge, but shows that the background atmospheric conditions were favorable for the development of such disturbances. The oceanographic model ADCIRC-2DDI, forced by the air-pressure disturbance characterized by a 3 mbar increase, the shape of a boxcar function, and the other parameters as stated above, successfully reproduces sea-level variability in Vela Luka Bay reaching a few meters and thus surpassing the inverted barometer response by two orders of magnitude.

The enhancement appears to result from a four-phase process: (1) the air-pressure disturbance travels from the west Adriatic coast to the mouth of Vela Luka Bay and generates a pronounced wave packet in the sea due to the speed of the forcing disturbance being close to the speed of shallow-water waves, (2) leading waves in the packet enter the bay and are amplified due to the funnel-shaped form of the basin, (3) the waves are reflected at the bay head, and (4) the waves return to the bay mouth, are partially reflected there, and are constructively superimposed on the waves entering the bay from the open sea. The model also suggests that elsewhere in the Adriatic the conditions were not so close to the resonant ones as in Vela Luka Bay and that the scattering due to variable bathymetry and reflection from the east Adriatic coast resulted in waves that returned towards the west coast and generated considerable sea-level activity there. Comparison of the empirical sea levels with the modeled values carried out for the whole area strongly supports the rather weak mesoscale atmospheric disturbance as an adequate forcing agent.

The present interpretation of the Vela Luka surge of 1978 invokes only the ray theory and therefore departs somewhat from the interpretation of other similar Adriatic events, e.g. those observed in Stari Grad and Mali Ston Bays in 2003 [3] and on the Island of Ist in 2007 [4], that was based on the ray theory in the open sea combined with the mode theory in the coastal basins.

References

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