DESTRUCTIVE HIGH-FREQUENCY SEA LEVEL OSCILLATIONS IN THE MEDITERRANEAN AND BLACK SEAS: PHENOMENOLOGY AND RELEVANCE

Ivica Vilibic [1]* and Jadranka Sepic [1]
[1] Institute of Oceanography and Fisheries - vilibic@izor.hr

Abstract

The paper presents recent research activities on meteotsunamis, high-frequency sea level oscillations, which are known to occur occasionally at destructive levels in the Mediterranean and Black Seas. These waves are multi-resonantly driven by intense and rapid air pressure travelling disturbances. Wide shelves and harbours with high amplification factors are found particularly vulnerable. Proper observing and reproduction of the phenomenon is particularly challenging, as non-standard meteorological and oceanographic measurements are required.

Keywords: Air-sea interactions, Sea level, Mediterranean Sea

Meteotsunamis, or meteorological tsunamis, belong to a class of a high-frequency tsunami-like sea level oscillations, triggered not by submarine earthquakes or landslides but by a small-scale atmospheric disturbances travelling over shallow regions (depths < 120 m), where their speed matches speed of long ocean waves [1]. They have been documented to appear in coastal waters of all continents and world seas [2], but with most substantial impact to coastal areas in low-tidal basins such as the Mediterranean. Intensity of meteotsunami waves is dependent on the Froude number (ratio between speeds of atmospheric disturbance and long ocean waves), bathymetry of a region and intensity/spectral content of the atmospheric disturbance.

In the Mediterranean and Black Seas, destructive meteotsunamis are documented in the Balearic Islands, eastern Spanish coast, the Adriatic Sea, western Sicily coast, the Maltese Islands, Greece, western Black Sea coast and Odessa region (Fig. 1), with several meters high waves occurring occasionally, flooding coastal areas and damaging coastal infrastructure [1]. Meteorological tsunamis normally occur during warm seasons, when inflow of warm and dry air from Africa is persistent in lower troposphere, and a strong and unstable mid-tropospheric south-westerly jet stream can become a dominant atmospheric feature serving as a reflecting layer for surface atmospheric disturbances propagating over long distances.

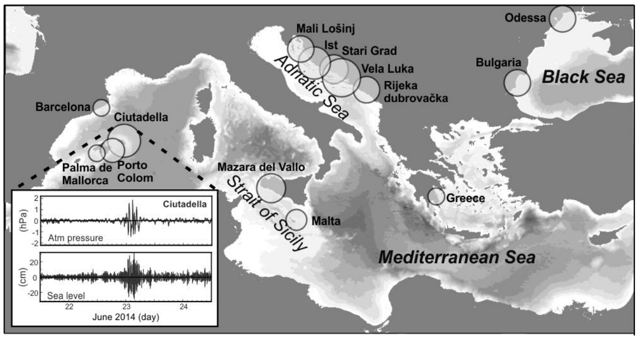

Fig. 1. Mediterranean and Black Sea locations where meteotsunamis had been documented (size of circle is proportional to intensity of the strongest events). Inset shows high-frequency (3-h cut-off period) air pressure and sea level time series recorded during a meteotsunami.

Described synoptic situation has been recognized as a necessary prerequisite for generation of a series of meteotsunami events taking place between 23 and 27 June 2014 over the Mediterranean (the Balearic Islands, the Adriatic Sea, Sicily) and the northern Black Sea shelf [3]. Strongest event occurred in Odessa, Ukraine, on 27 June when couple of beaches were hit by a sudden 2-m wave, injuring a dozen of people [4]. As similar events have been unheard of in Ukraine, a panic overtook population, with media ascribing the phenomenon to a passage of a giant submarine, underwater explosions and even to "the great cross of planets".

This event may serve as an example how a science-based education of local population, also through media, may mitigate negative impacts of such rare but vigorous ocean phenomena. Aside for affecting local population, damages to coastal infrastructure during destructive meteotsunami events have been documented to be very high, more than several millions of Euros, like during the Great Vela Luka Flood of 1978 and the 2006 Balearic meteotsunami [1, 2]. For that reason, all future coastal hazard assessment studies should include an assessment of high-frequency oscillations, which, due to recent availability of sea level data at 1-min resolutions, are finally being recognized to significantly contribute to the sea level budget in low-tidal basins, such as the Mediterranean [5].

References

1 - Monserrat S., Vilibic I. and Rabinovich A.B., 2006. Meteotsunamis: atmospherically induced destructive ocean waves in the tsunami frequency band. *Natural Hazards and Earth System Sciences*, 6: 1035-1051.
2 - Vilibic I., Monserrat S. and Rabinovich A.B., 2014. Meteorological tsunamis on the US East Coast and in other regions of the World Ocean. *Natural Hazards*, 74: 1-9.
3 - Sepic J., Vilibic I., Rabinovich A.B. and Monserrat S., 2015. Widespread tsunami-like waves of 23-27 June in the Mediterranean and Black Seas generated by high-altitude atmospheric forcing. Scientific Reports, 5: 11682, doi: 10.1038/srep11682.
4 - Rabinovich A.B. and Sepic J., 2016. Meteorological tsunami: what is it? (in Russian). Priroda, 1: 12-26.
5 - Sepic J., Vilibic I., Lafon A., Macheboeuf L. and Ivanovic Z., 2015. High-frequency sea level oscillations in the Mediterranean and their connection to synoptic patterns. *Progress in Oceanography*, 137: 284-298.