ON THE EXTERNAL SEA LEVEL FORCING OF METEOTSUNAMIS AT THE BALEARIC ISLANDS

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Abstract
High frequency sea level observations at four coastal sites are used to examine the external forcing causing significant seiches (meteotsunamis) in certain harbours at the Balearic Islands. Forcing characteristics estimated for different events are different, while for the same events are similar, even for sites located far away from each other. Spectacular similarities are found for two specific sites, Ciutadella (Menorca Island) and Cala Ratjada (Mallorca Island).
Keywords: Mesoscale Phenomena, Coastal Engineering

High frequency sea level oscillations in bays and harbours, known as seiches, may reach significant amplitudes depending on the external forcing in the open sea and the local topographic response. When resonance occurs, the phenomenon may pose important risks to the infrastructures as well as to the commercial or fishing activities and sometimes even threatening to human lives. When the external forcing responsible of such amplification consists of long waves generated by an atmospheric origin they are referred to as meteotsunamis. Meteotsunamis are similar to ordinary tsunami waves and can produce similar damages at the coast, although the catastrophic effects related to this type of waves are normally observed only in specific bays and inlets. One of the places where meteotsunamis with the largest sea level amplitudes are reported is Ciutadella Harbour, a natural elongated and shallow inlet located in the western coast of Menorca Island (NW Mediterranean, see Figure 1).

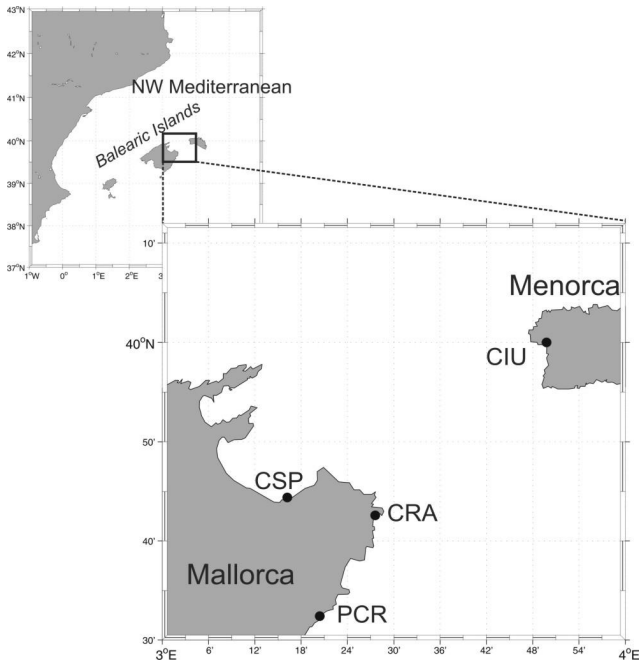

Fig. 1. Map of the area and location of the stations.

The phenomenon is locally known as "rissaga" and occurs every year mostly in late spring and summer. Ciutadella seiche has a period of approximately 10.5 minutes and typical background amplitude of few centimetres. Typical rissaga events have amplitude of around 1 m, but they may reach up to 4-5 m through to crest in an average water depth of 5 m in singular episodes. In this paper we analyze a recent set of sea level measurements recorded around de Balearic Islands (Mallorca and Menorca) to characterize large amplitude seiche oscillations at four tide gauge locations (Figure 1). The effects of the local topography and bathymetry are isolated at each site by computing the background spectral content of the sea level oscillations in absence of forcing, that is, for time periods with very small amplitudes inside the inlets. Background spectra strongly vary from one site to another but are approximately independent of time. Then, the average of several background episodes may be considered as a good proxy for the local resonant response of the given site. The frequency response of the forcing for each episode has been computed as the spectral ratio of the energy content of a seiche event and the background spectra [1]. The more constant is the background spectra for a tide gauge site, the more liable and accurate is the characterization of the external forcing. For all the episodes, the energy content for the external forcing is concentrated in periods between 5 and 50 min at the four sites. Different forcings are found among sites and events, the latter due not only to the amplitude of the incoming waves but also to the inlet orientation and other parameters. It is found that external sea level forcing at CIU and CRA are very similar, although the responses of both inlets differ significantly. The forcing is almost the same for signals with frequencies lower than 30 min^{-1}. For higher frequencies, changes in the travelling atmospheric pressure from Mallorca to Menorca seem to play a major role in the generated sea level oscillations and the obtained sea level forcing is somewhat less coherent, although the magnitude of the energy content is always comparable between the two sites.

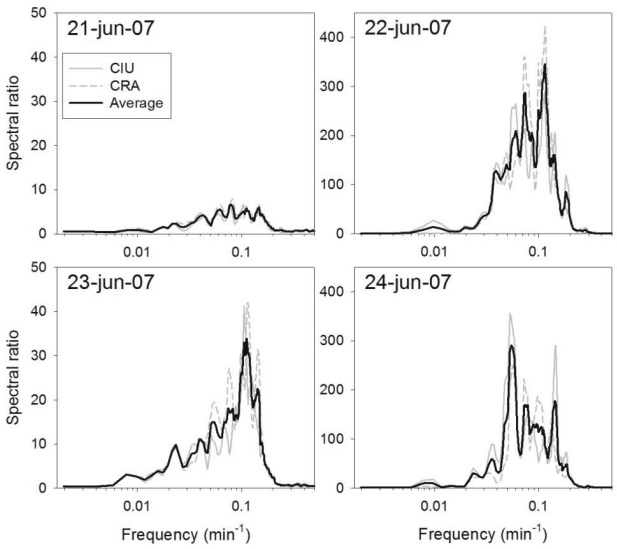

Fig. 2. One example of the spectral ratios ("source functions") of daily spectra for the rissaga event of 21-24 June 2007. Black line is the average of the spectral ratio at CIU and CRA.

Therefore, sea level oscillations in CRA could be used as an indication of an incoming rissaga event in CIU and should be used as part of an eventual rissaga warning system designed to mitigate the possible damages inside CIU harbour, maybe as part of the Mediterranean Tsunami Warning System ICG/NEAMTWS.

References
1 - Monserrat S., Rabinovich A. and Casas B., 1998. On the reconstruction of the transfer function for atmospherically-generated seiches. *Geophys. Res. Lett.*, 251 (12): 2197-2200