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Resonance interaction between Bays and Harbors forced by tsunamis

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The tsunami induced by the 21 May 2003 Boumerdès-Zemmouri (Algeria) earthquake (Mw=6.9) did not generated important inundations damages or fatalities in the western Mediterranean area. However, damages and economic losses were reported in some harbors, generated by important sea level disturbances. Noticeable impacts were noted (broken mooring lines, sunken boats, displaced moorings, etc.) in some harbours in the Balearic Islands (Palma de Majorca, Ibiza and San Antoni) and also along the French border (La Figueirette and Mouré-Rouge harbours). Various authors have attempted to simulate this event finding discrepancies between the tsunami arrival time and amplitudes of waves on the tide gauges and results with numerical models. The models underestimate the amplitude of the tsunami. In some cases the underestimations have been associated to numerical limitations due to the lack of a high-resolution bathymetry and poor harbor geometry definition. Other cases, associated to a non appropriate seismic source characterization. Finally, some authors point out the occurrence of one or several submarine landslides triggered by the earthquake simultaneously with the seafloor vertical displacement, which have not been included in the numerical simulations.

For a better knowledge of the response of a harbour interacting with a bay forced by a tsunami, a numerical study has been carried out for Palma Bay and Palma de Majorca Harbour. The transference of energy of the tsunami from the generation area to the continental shelf, the bay and the harbour has been studied for the Algerian tsunami (21 May 2003) and compared with the natural oscillation modes of the bay and the harbour water bodies. Furthermore, a sensibility analysis regarding the influence of the grid size of the harbour and bay bathymetries was also performed to understand the discrepancies between simulations and observations.

The 2003 Zemmouri tsunami measured by the tidal gauge of Palma habour showed energy concentrated mainly in periods 19 and 22 minutes. These periods are coincident with the natural modes of oscillations of the bay; no resonance appears to be associated to the harbour itself, with resonant periods smaller than 12 minutes. Thus, the wave amplification inside the harbour, principally in the Northern area, were generated by a resonance effect induced by the Palma bay. This corresponds with the reported damage zone by the Harbour Authority. Additionally, it has been shown that increasing the grid resolution in the bay and the harbour domains, and having into account the real harbour geometry and the configuration of the inside structures, the numerical simulation response in the Palma de Majorca harbour present a lightly wave high increment, but it is not enough to reproduce the observed wave height in the tidal gauge. However, the spatial and temporal behavior is very similar between simulations and observations. This leads to a revision of tsunami seismic source parameters.