Scenario based on numerical simulations of July 20, 2017 Bodrum-Kos tsunami

Сценарий, базиран на числените моделирования на вълните цунами от 20 юли 2017 г. в Бодрум-Кос

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Introduction
In this study we are focused in the modelling of tsunami waves in the Aegean Sea. Our scenario represents the strong earthquake-induced tsunami from July 20, 2017, near the Kos Island, a Greek Island placed only 4 km from the Turkish coastline and the city of Bodrum. The tsunami has been recorded by a closed tide gauge, located in Bodrum (Yalçiner et al., 2017).

Tectonic settings and seismicity
The region of the Aegean Sea is very complex. It includes the North Anatolian Fault (NAF), Kephalonia Fault and Hellenic Arc (West Arc and East Arc). Historical earthquake data show that the main regime of deformations for this region is normal faulting N-S direction, but also a subduction zone and its thrust faults presented by the Hellenic Arc where the African plate submerged beneath the Aegean microplate. The depth of the earthquakes varies between 0–70 km. Many historically events are documented for this area, some of them caused by underwater earthquakes, others remain with unclear origin. The volcanic activity must not be neglected, since there is a volcanic arc crossing the region, as well as the Minoan eruption of Santorini around 1600 B.C., that caused a tsunami 30 m high. We include this zone in previous study, as a tsunamigenic zone in the region of the Eastern Mediterranean (Dimova, Raykova, 2016).

Theory and methodology
The computations we performed are based on two main consideration: (a) the initial conditions are calculated via the analytical formula of Okada which helps us to obtain the displacement due to an elastic dislocation, thus we compute the coseismic deformation, as a function of the fault geometry and the ground elastic parameters, and (b) the propagation of a tsunami is presented by means of the numerical code UBO-TSUFD, developed at the University of Bologna (Tinti, Tonini, 2013), based on the non-linear shallow water theory in a Cartesian frame. The code uses a staggered grid by mean of an explicit leapfrog finite-difference method. The grid we apply has cells 500 × 500 m resolution, and a time step for every cell 1.5 s.

The event and results
This strong earthquake (Mw=6.6) occurred on 20 July, 2017 (22:31 UTC), caused severe damages in Bodrum Peninsula and Kos Island. The fault mechanism is estimated as normal faulting striking about E-W direction. Figure 1 shows the epicenter and fault mechanism solution of the earthquake.

Fig. 1. Epicenter and focal mechanism of July 20, 2017 earthquake
In our simulations the initial displacement of the ocean bottom is calculated in the range (–0.4907 m – 0.826 m). The code UBO-TSUFD allows us to compute the velocity field in the deep ocean as well as near the coastline. The results show rate of 120 ms$^{-1}$ at depth of 2000 m and decreasing of the wave velocity approaching the coast – 18 ms$^{-1}$. The estimation of minimum and maximum water elevation is in good agreement with observed and instrumentally recorded tsunami. The maximum amplitude we obtained is 2.58 m, while registered signal in Bodrum station is 1.9 m, 20 minutes after the earthquake onset. Figure 2 presents synthetic mareograms placed in three different places – two of them near the port of Kos, and one in the gulf of Bodrum. We performed two different focal mechanisms. The red continuous line shows higher values for the water elevation, while the black dashed line is in very good agreement with the time arrival of the first wave, around 13 minutes after the earthquake onset recorded on a tide gauge station Bodrum. The figure shows the first two hours of the tsunami simulation.

Conclusions

We performed scenario based on the origin of the event and the propagation of the tsunami waves. According the geological settings and the seismicity in this region it is very important and useful to perform simulations since they can be used to reconstruct recent and historical events or to create forecasts of tsunami impact and inundation in early warning systems, also to build a tsunami hazard map of the region.

References


Tinti, S., R. Tonini. 2013. The UBO-TSUFD tsunami inundation model: validation and application to a tsunami case study focused on the city of Catania, Italy. – Nat. Hazards Earth Syst. Sci., 13, 1795–1816.