AOGS 2005

Numerical simulations of the December 26, 2004 Indian Ocean tsunami: test on different possible sources and evaluation of local effects

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The tsunami that was generated by the December 26, 2004 M=9 earthquake offshore the western coasts of northern Sumatra is one of the most devastating events of this type in historical times. The greatest devastation and the highest number of victims were suffered by Indonesia, Sri Lanka, India and Thailand, but huge damages and casualties were recorded as far as the Africa coasts. The tsunami propagated even outside the Indian Ocean and its effects were recorded by instruments placed all over the world. Since the first days after the event, one of the greatest efforts of the scientific community was to constrain the position and the relevant focal and geometric parameters of the seismogenic structure. Different fault models have been proposed on the basis of different data: they all share the idea that the rupture propagated northwestward from the epicenter and that the ruptured area was at least 500 km long. Moreover, inversion of seismic data allowed for some preliminary estimations of the slip distribution on the fault plane.

In this contribution we adopt some of the proposed models for the earthquake rupture and we simulate the ensuing tsunami by means of a numerical finite-element code which implements and solves the equations of hydrodynamics in the shallow-water approximation. We perform the simulations at two different geographic scales: the first involves almost the entire Indian Ocean basin, while the second focuses especially on the source region. In the first case, our attention is devoted to the features of the tsunami propagation: in particular, we are interested in the tsunami travel times on one hand and, on the other, in the interaction of the tsunami waves with the bathymetry as well as with the numerous archipelagos scattered all over the Indian Ocean. In the second case, special attention is devoted to the impact of the tsunami on the regions placed close to the source, in particular on the northern and northwestern coasts of the island of Sumatra.