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Investigations on the slip distribution on the December 26, 2004 Sumatra-Andaman earthquake fault based on satellite-altimeter and coastal run-up tsunami data

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The tsunami generated by the December 26, 2004, M=9.3 earthquake, rupturing a very large portion of the Sumatra-Andaman arc, is one of the most devastating events in historical times. From the scientific point of view, it is probably the best documented event ever. A huge set of data of very different nature were recorded and collected. On the basis of these data, different teams of scientists working in different disciplines are trying to retrieve the detailed spatial and temporal characteristics of the earthquake rupture as well as of the ensuing tsunami. To date, there appears to be a substantial agreement on the gross features of the earthquake source, in particular regarding its magnitude, its North-South extension and its time evolution. But when it comes to the detailed slip distribution along the ruptured area, the inversion of different data does not seem to provide a unique solution.

In this contribution we infer the slip distribution on the causative fault of the December 26, 2004 earthquake by inverting separately the tsunami elevation data registered by three different satellite altimeters, and a set of tsunami run-up heights measured by different field survey teams along the coasts of the countries closest to the source region. The two datasets catch different aspects of the tsunami, and must be inverted by means of different techniques. Three satellites recorded the elevation of the tsunami along three different tracks at different times, and they describe mainly the linear propagation of the tsunami in the open ocean. On the other hand, run-up data are inherently connected to the non-linearity that arises during the impact of the tsunami waves along the coasts: local bathymetry and coastal morphology play a fundamental role in this case.

We use two different domains to study the two problems. In the case of the satellite-

altimeter data the domain embraces almost all of the Indian ocean, while a smaller domain, involving northern Sumatra, the Nicobar and Andaman islands, western Malaysia, Thailand and Myanmar, is used to study the run-up heights. In both cases, we divide the earthquake fault in a given number of sub-faults, and then compute the tsunami generated by each sub-fault by means of a finite-element code solving both the linear and non-linear Navier-Stokes equations in the shallow-water approximation. In the case of the altimeter data, the adopted inversion technique is an implementation of the classical generalized linear least-squares theory. A more sophisticated technique, allowing one to determine also different amplification factors along different coastal segments, is employed to invert run-up data. We discuss the slip distributions obtained separately in the two approaches, and compare qualitatively the results with those retrieved by modeling seismic and geodetic data.