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Full frequency dispersive numerical modelling of tsunamis. Large scale application to the South Tyrrhenian sea

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Numerical models able to reproduce transient water waves are tools of the utmost importance in all those engineering activities aimed at mitigating the effects of the tsunamis. Traditionally these models have been based on the Nonlinear Shallow Waters Equations (NSWE), in view of the fact that tsunamis were considered as extremely long, single waves able of devastating the coast. However in the recent past it has become well accepted that this kind of waves is a wave packet, that in most cases may exhibit a frequency-dispersive behaviour (Kulikov et al., 2005). The models based on the Boussinesq-type equations have therefore become the standard tool to study tsunamis.

In this paper we propose a model based on the mild-slope equation (MSE hereinafter, see Dingemans, 1997) able of reproducing the full frequency-dispersion of small amplitude tsunamis. The model uses the Fourier Transform to convert the time-dependent hyperbolic equation into a set of elliptic equations in the frequency domain. The problem therefore reduces to the solution of the traditional elliptic MSE and the time series of the surface elevation is then recovered by means of the Inverse Fourier Transform. The numerical computations are carried out using a finite element method (Bellotti et al., 2003). The results of two available experimental studies on tsunamis generated by landslides are used to validate the model. It will be shown that the effects of the frequency dispersion are carefully reproduced by the model. The experiments used have

been carried out at the Environmental and Maritime Hydraulic Laboratory (LIAM) of the University of L'Aquila (Italy), within the framework of some research projects aimed at studying landslide generated waves.

At the conference a large scale application at the South Tyrrhenian Sea (Italy) will be presented. The considered waves are generated at Stromboli, which is a volcano island in the deepwater Aeolian archipelago. The erupted lava is able to generate tsunami waves that represent a real hazard for the surrounding islands and for the Italian continental coast, as it occurred on 30^{th} of December 2002, well described by Tinti et al., 2006. With the present application we do not intend to exactly reproduce a specified event, instead we analyze the frequency-dispersive behaviour of waves generated by landslides (shorter than those induced by earthquakes) propagating in the far field.

At the conference we will describe in detail the model and its validation, and we will give many practical information about its large scale application. We will discuss points of weakness and points of strength of the model, which in our opinion appears to be suitable to be used in early warning systems for tsunami alert. One of the most important points is that the model is very robust and quick to apply at the operational stage. It can therefore work in real time also using partial input time series, i.e. it can predict the wave properties along the coast of interest while the tsunamis is being measured by sea level sensors.

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