IMEKO International Conference on
Metrology for The Sea
Naples, Italy, October 11-13, 2017

Predictability of sea wave anomalous (micro-tsunamis modeling) by submarine landslides applied to Cirò Marina coast along the Calabro Ionian margin

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***Abstract* – The Calabria's Ionian continental slope is deeply incised by canyons which are characterized by V-shape cross-sections in their upper parts and U-shape cross-sections in their terminal parts.**
These conditions are favorable, under seismic action, it may give rise to submarine landslides.
In this study, we propose a 3D numerical modeling of tsunami waves generated by an underwater slump with "Geowave" software. The simulated gravity instability zone is near the "Venere 1" head Canyon situated close Cirò Marina coastal area. The availability of a detailed bathymetric map both with a good knowledge of the local geology allowed us to obtain reliable simulation results.
Interesting results of tsunami simulation, in the above-mentioned shoreline areas, show that the amplitude of wave run-up ranges from 0.50 m up to 0.90 m. This difference in run-up is ascribed to the directional effects and to the different coastal morphology.

I. INTRODUCTION

The exploration of the seafloor during the last three decades by means of high-resolution swath bathymetry and sub-bottom profiling has illustrated the widespread occurrence of submarine instabilities. In consequence, and due to its multiple implications, the characterization and understanding of mass wasting phenomena on continental margins has become a priority topic [1]. Tens to hundreds of meters in thickness soft-sediment deformation generated by tectonism, rapid deposition and/or compaction and fluid flow has emerged as a highly relevant process in the evolution of sedimentary basins. Instabilities and deformation features of variable thicknesses and types, including creeping, slides, slumps and mass flows, were first recognized in the northern Gulf of Taranto and especially in the Corigliano Basin [2, 3].

The Calabria's Ionian continental margin is characterized by an extremely narrow continental shelf and by an very steep continental slope (up to 20 degrees). The continental slope is deeply incised by canyons which drain the massive continental sedimentary supply. The canyon heads are quite large and consist of numerous tributaries generally affecting the shelf break. The canyons are deep, with high slope gradient, high sinuosity indexes and their heads have a marked dendritic morphology reaching a few hundred meters from the coastline. These canyons are characterized by V-shape cross-sections in their upper parts and U-shape cross-sections in their terminal parts (fig. 1).

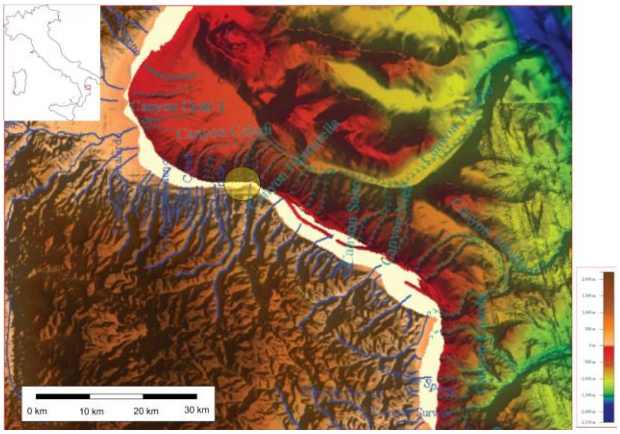

Fig. 1. Detailed bathymetric map of the canyons showing the location of modelled submarine landslide (yellow circle area).

These conditions are favorable to sediment buildup on the narrow continental shelf and therefore, under seismic action it may give rise to submarine landslides.

In this study, we propose a 3D numerical modeling of tsunami waves generated by an underwater slump with “Geowave” software. The simulated gravity instability zone is near the “Venere 1” head Canyon situated close Cirò Marina coastal area. The availability of a detailed bathymetric map (fig. 2) both with a good knowledge of the local geology allowed us to obtain reliable simulation results.

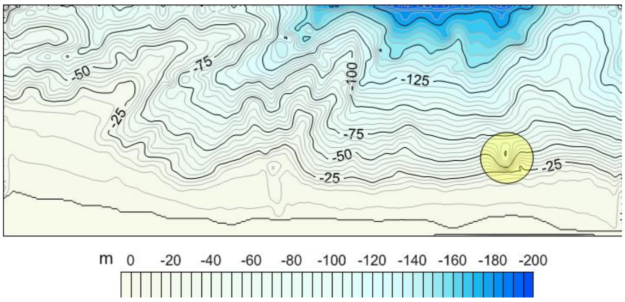

Fig. 2. Bathymetric map of the study area

II. TSUNAMI MODELLING

In the numerical simulation, the Tsunami Open and Progressive Initial Conditions System (TOPICS) is adopted to produce 3D tsunami source for tsunamis generated by submarine slides and slumps, while a 5 m uniform spacing grid is derived from the bathymetric dataset of the Cirò Marina coast.

Due to the complex nature of the generation phase of landslide tsunamis, some of the available numerical models simplify the generation phase by applying empirical equations. In fact, these models neglect the dynamic nature of the generation of waves by landslides. In this context, one set of empirical equations for modeling the generation phase of landslide tsunamis were proposed by [4]. These authors estimated the 3D distribution of the initial sea level disturbance using 2DV numerical and experimental results.

The empirical equations are based on a 2DV characteristic wave amplitude (n2d) (for detail see [4] and [5]).

In the absence of detailed information on SMF shape, an estimate of 3D characteristic tsunami amplitude in an order of magnitude sense remains possible by further simplifying the predictive tsunami amplitude equations.

For underwater slumps we use [4] to determine tsunami amplitude:

$$\eta_{3d} \cong 2.56 \cdot 10^{-3} b(sin\theta)^{0.25}\left(1 + 2.06\sqrt{\frac{d}{b}}\right)^{-1}\left(\frac{b}{d}\right)^{1.25};$$

Where θ is slope angle, d is the initial submergence at the middle of the slump and b is the total length along the down-slope axis.

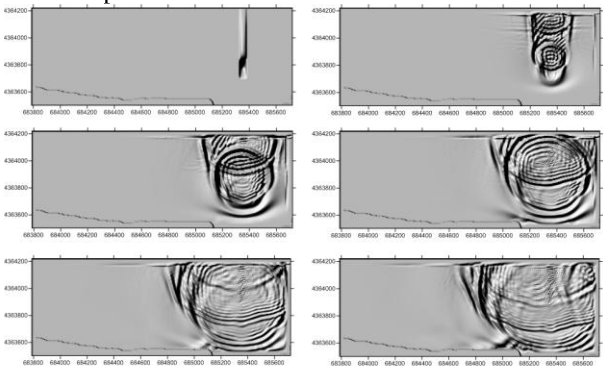
Fig. 3. Computed tsunami waves propagating at: (a) 0.0, (b) 189, (c) 205, and (d) 233 seconds

Fig. 4 reports the maxima wave height of tsunami in the area of study. It is very clear a greater effect in the proximity of the beach where a wave depth is 1 m about.

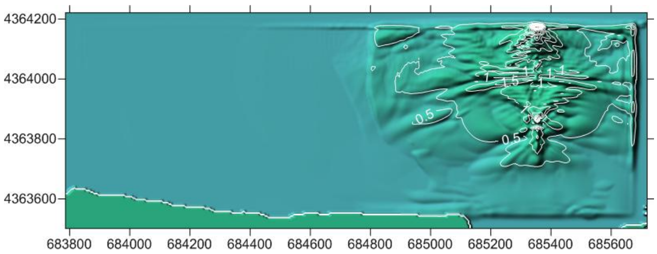

Fig. 4. Maxima wave height of the tsunami

CONCLUSION

Interesting results of tsunami simulation, in the above-mentioned shoreline areas, show that the amplitude of wave run-up ranges from 0.50 m up to 0.90 m with a wavelength variable between 35-80 m. This difference in run-up is due to the directional effects and to the different coastal morphology.

Tsunami wave effects extinguishes in about 300 seconds; considering it occurs near to the coast, it is very difficult plan an efficacy early warning system.

Although these phenomena are small, they can cause damage at the anthropic structures exposed along the coast.

It is necessary in these areas to carry out a territorial planning that takes into account this hazard.

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