Advanced Engineering Science
http://publish.mersin.edu.tr/index.php/ades
e-ISSN 2791-8580

Simulation with the Mirone application for the construction of marine mechanical waves generated by possible seismic events in the territory of the Adriatic and Ionian seas

Adisa Daberdini [*1], **Fatmir Basholli** [2], **Novrus Metaj** [3]

[1]*Aleksander Xhuvani University, Informatics Department, Elbasan, Albania, adisa.daberdini@uniel.edu.al*
[2]*Albanian University, Department of Engineering, Tirana, Albania, fatmir.basholli@albanianuniversity.edu.al*
[3]*Polytechnic University of Tirana, Department of Physical Engineering, Tirana, Albania, novimetaj@gmail.com*

Cite this study: Daberdini, A., Basholli, F., & Metaj, N. (2023). Simulation with the Mirone application for the construction of marine mechanical waves generated by possible seismic events in the territory of the Adriatic and Ionian seas. Advanced Engineering Science, 3, 46-54

Keywords
Seismic Simulation
Wave
Tsunamis
Applications

Research Article
Received: 02.01.2023
Revised: 04.02.2023
Accepted: 11.02.2023
Published:13.02.2023

Abstract

In this study, we will present the practical development of some simulations that we have done with the Mirone program for the generation of tsunami waves. These simulations are taken into account for real seismic events that have occurred in the Adriatic and Ionian seas throughout history and the data that have been reported for certain areas. In practical simulations with applications, we have the opportunity to see what is actually expected to happen in such events. We have presented several scenarios and we have also analyzed all the results that we have derived from the calculations and simulations made. We have taken risk assessment scenarios in both our seas and we have also given the effects they will have on the ecology of coastal areas and underwater ecology. A scenario-based method was used to provide a tsunami hazard assessment for the first time in this region. The Ionian-Adriatic region has experienced a sudden economic and tourism boom with an increase in the coastal population and the development of large free time zones in recent years and more so in parts of coastal cities that are only a few meters above sea level. sea making them future targets of a large-scale disaster, even if the height of the tsunami wave is moderate. Various simulations and specific professional programs have been used to develop the measurements. For the calculation of the tsunami wave, the basic methods of calculating the wave have been taken into account. Some special analysis needs to be continued in further studies of the composition of the Albanian coast which may reveal some influential factors in the calculations obtained. At the end of the study are presented at the most endangered areas and a plan has been made for precautionary measures that can be taken by Civil Emergencies.

1. Introduction

Numerical modeling of the tsunami, mainly those made by Bousinesq and Green's models, are the basis for the construction and coding of the programs used for the simulations [1]. These numerical models and the algorithms built from them are integrated into the Mirone, Geowave programs that contain both numerical models. Both of these programs are matlab based. We have also presented the data we have collected through the Surfer and Wiz-map programs that serve for the visual and three-dimensional construction of the structures and for merging these data with the maps we have. As input parameters of the program, we put the data of our coast longitude and latitude and the depths [2].

Mirone is a matlab-based program that allows the display and manipulation of a large number of grid formats through its interface with the GDAL library. Its main purpose is to provide users with an easier use of graphics compared to the more frequently used programs of the GMT package [3].

In addition, it offers a large number of tools that are focused in particular on the field of geophysics and earth sciences [4]. Among them the user can find tools to do multibeam planning, elastic deformation studies, tsunami propagation modeling, IGRF calculation and Parker magnetic inversion, Euler rotations and Euler pole calculation, plate tectonic reconstructions, seismicity analysis and mechanisms of hearth, advanced image processing tools. Mirone is written using the Matlab programming language a separate version is also provided to run under the Windows operating system [5].

2. Structure of the Adriatic and the Ionian

2.1. Structure of the Adriatic Sea

In the topography of the southern Adriatic basin from the geomorphological point of view, four main forms are usually distinguished: the beach area, the continental shelf (shallow) and the plain of great depths. The South Adriatic pit is located at a depth of over 800 m. The topography of the deep plains is similar to the topography of the earth's surface. Their pages are interrupted by numerous canyons in the form of underwater streams [6]. Terrigenous deposits are observed at the bottom of these pages. Most of the materials of these plains are of marine origin. The continental slope generally has an average footing slope of the order of 1/20 where the dominant materials are silts, with rocks of discovered. On our side of the South Adriatic basin, the continental shelf extends from a depth of 200m to 800m. The term shelf or continental shelf means the relatively flat coastal part of the bottom of the sea, usually with an average slope of 1/500 and maximum 2 degrees, where the dominant material is sand, while the rocky and deltaic parts are less [6]. The upper level of the shelf is the calm sea level, while the lower level is determined for each specific case, based not only on the morphology or the shape of its relief, but also in the geomorphological features of the bottom of the sea. According to this, the shelf constitutes the last part of the sea that is located closer to the coasts and from the geomorphological and geological-structural point of view is a direct continuation of the lowlands coastal. Sedimentation processes here are important and decanted materials of terrigenous origin are under the action of waves and currents. From the above points of view, the lower level of our Adriatic shelf turns out to be at a depth of 200m [7]. On the surface of this shelf, according to the type of decanted materials, three bands can be distinguished:

1) The coastal shallow extending up to -50m, which is under the action of waves and currents, where sandy and sandy-siltstone sediments dominate.
2) Flat shelf lowland extending up to 100m, dominated by siltstone sediments.
3) The steep shelf lowland extending up to -200m, where deltinoaleurolitic and deltino sediments dominate.

Under these conditions, internal coastal waters lie in the shallow belt of our marine shelf, while the territorial waters of the Adriatic generally lie in the belt of the steep shelf lowlands. Across the maritime space there are entire areas that are exposed to the dynamic actions of the water mass. Our coast, especially the part of the Adriatic, is increasingly subjected to erosion processes [8]. There are estimates that these processes may have extended to about 60% of the total length of this coastline.

2.2. Structure of the Ionian Sea

The Ionian Sea lies in the area of the continental shelf and it is the deepest large part of our coast. In the Ionian Sea, the isobaths are smaller than 200m and cross a lot close to the coast compared to those of the Adriatic Sea.

3. Material and Method

For the study and development of the simulations, we have taken into account the bathymetry of the Adriatic and Ionian seas and also the earthquake events that have occurred in these areas. Materials for this study we used different software, while for the construction of simulations one of the software's is Mirone. Below are the bathymetry data and also the profiles that were taken into consideration for the development of the simulations. [8]. The profiles are obtained as follows: the first coordinate is taken on our coast and the second coordinate is taken on the nearest neighboring coast. We will have a very accurate presentation of the profile and the distance of each of the two points. The profiles are almost parallel to each other and have different distances starting from the geometry of the coast and the bathometric data that we had available from the institute. Also, in the construction of bathymetry we have used another program Surfer that we have built the coastal basin using the dates obtained from the depths of the profiles [9].

Each of these profiles we have obtained has a very special structure and what we expect is that an earthquake occurring in different areas of these profiles will affect in different ways [10].

3.1 Programs used for calculation of the maps

Below we have listed the programs that helped us in the simulation and construction of the tsunami wave [11]

- •Program for compiling maps Caris Base Editor 4.1 (is the program used to build the seafront) [12]
- •Surfer-Program (for creation of seas bathimetry)
- •Mirone (Program for simulation of tsunami)
- •Google tsunami mapper (Program for simulation of tsunami in different levels) [13]

Below the presented figures give us the simulations with the data used.

4. Database of Sea profiles

The following profiles are profiles obtained in three different profile areas of our coast. The areas under study were most affected by the earthquake and are the areas that could have a problem from the tsunami waves [14-15]. These three profiles are presented to give us an idea of the sea basin and an idea of how the tsunami wave can pass. Considering that tsunami waves are waves that pass at the bottom of the sea along with the last sediments of the sea and not the water wave that is on the surface of the sea [15]. The profiles obtained are from Lezha, Cape Rodoni and Durresi.

This menu has options to display data related to earthquakes and the mechanisms and elastic deformations that generate the earthquake. Below we also have the tool that allows us to simulate the spread of the tsunami [16].

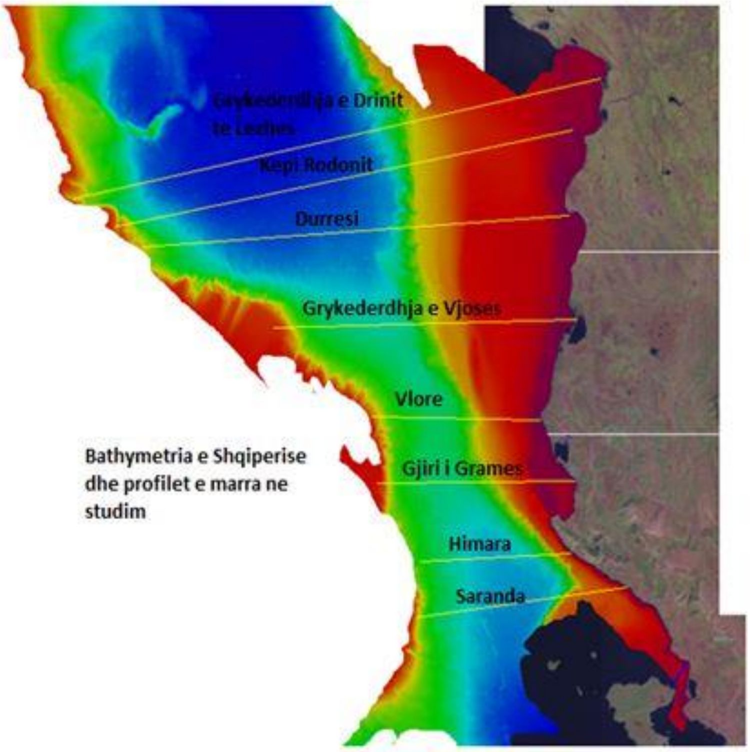

Figure 1. Bathymetry of Adriatic and Ionian Seas build with Caris Base Edition 4.1.

4.1. Profile maps of the coast of Albania and their coordinates

The maps for each of the profiles (Figures 2-9) that were considered. The profiles are taken in this way: the first coordinate is taken on our coast and the second coordinate is taken on the nearest neighboring coast [17-18]. We will have a very accurate representation of the profile and distance of each of the two points. The profiles are almost parallel to each other and have different distances based on the geometry of the coast and the bathymetric data that we had available from the institute [19].

The maximum depth of the Profile-1 is 1200m at a distance of 125km from the coast. From the Profile-2 we see that the maximum depth is 1150m taken at a distance of 125 km from the Albanian coast. From the Profile-3 we see that the maximum depth is 1100m taken at a distance of 110km from the Albanian coast. The Profile-4 was taken from divjaka and has these features, its maximum depth goes up to 900 meters and the distance from the coast for this depth is 75km. The Profile-5 was taken from the Vjosa Estuary and its maximum depth is 830m and the distance from the coast for this depth is 40km. The Profile-6 was taken from Vlora, its maximum depth goes up to 850m and the distance of this depth from the coast is 50km. The Profile-7 was taken from Grama Bay, its maximum depth reaches 970m and the distance of this depth from the coast is 25km. The Profile-8 is taken from Himara, its maximum depth goes up to 1010m and the distance of this depth from the coast is 35km [19].

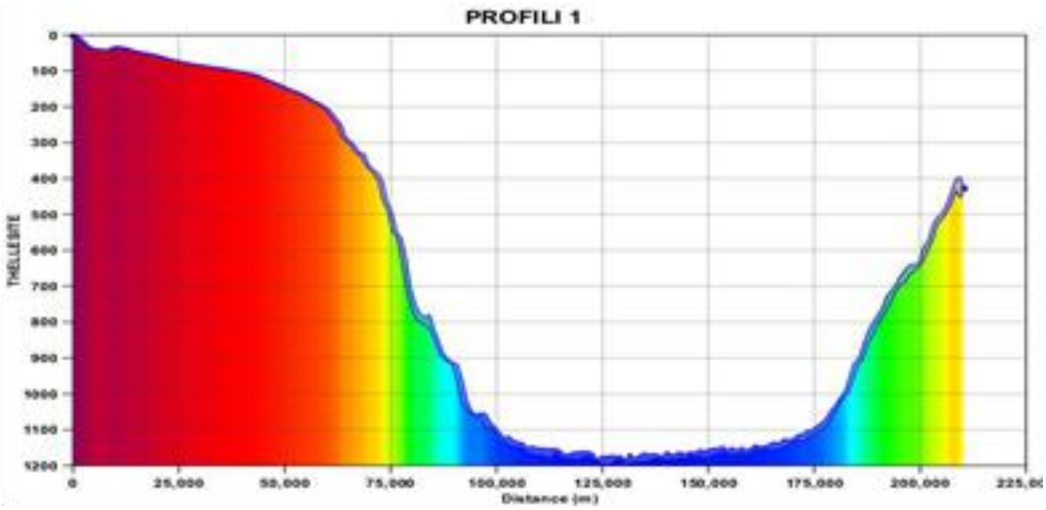

Figure 2. Profile 1 taken from Lezha

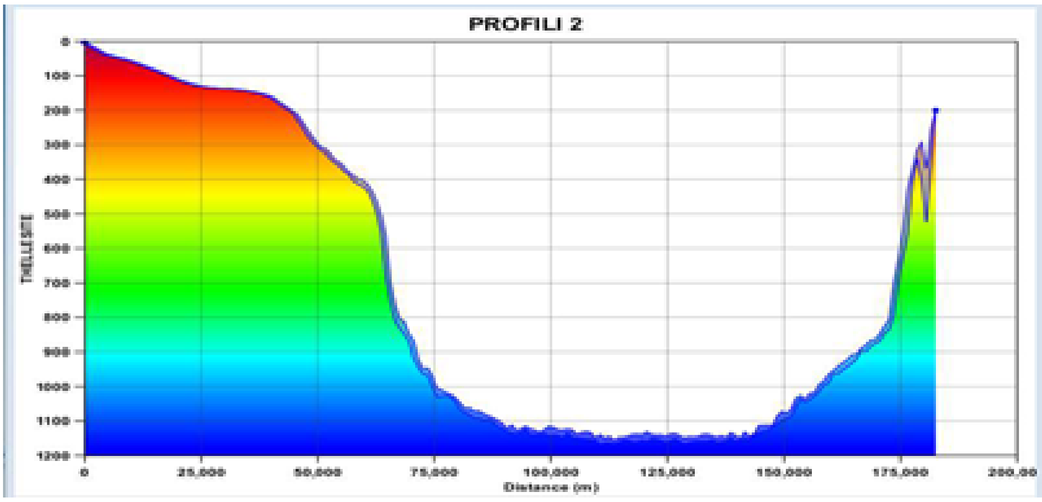

Figure 3. Profile 2 taken from “Kepi Rodonit”

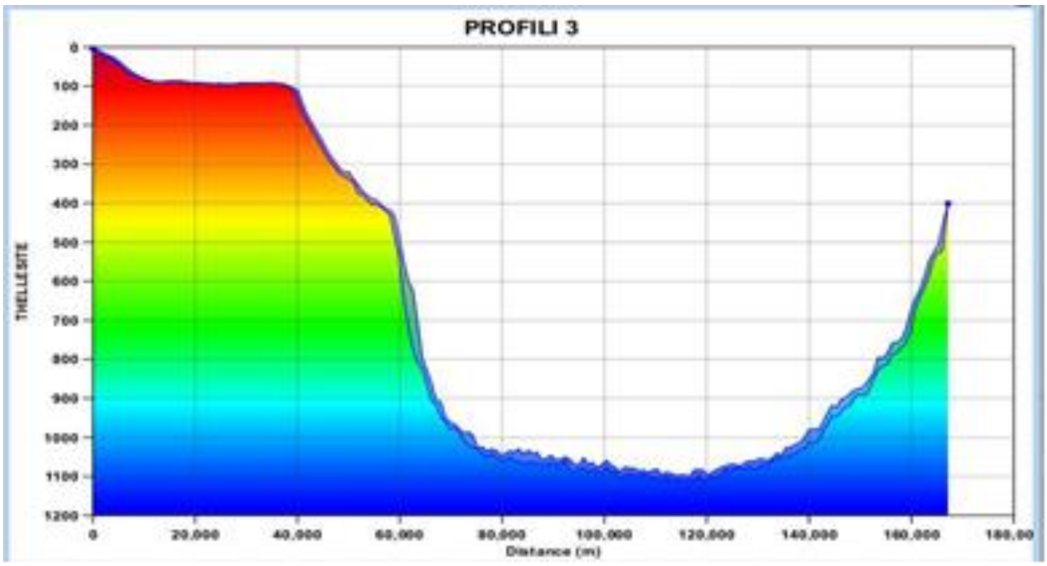

Figure 4. Profile 3 taken from Durres

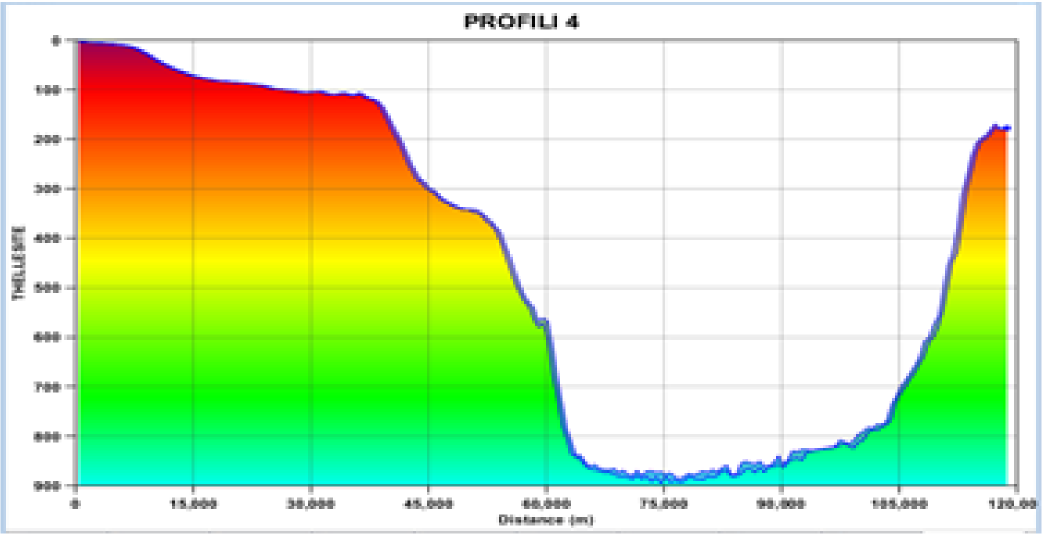

Figure 5. Profile 4 taken from Divjaka

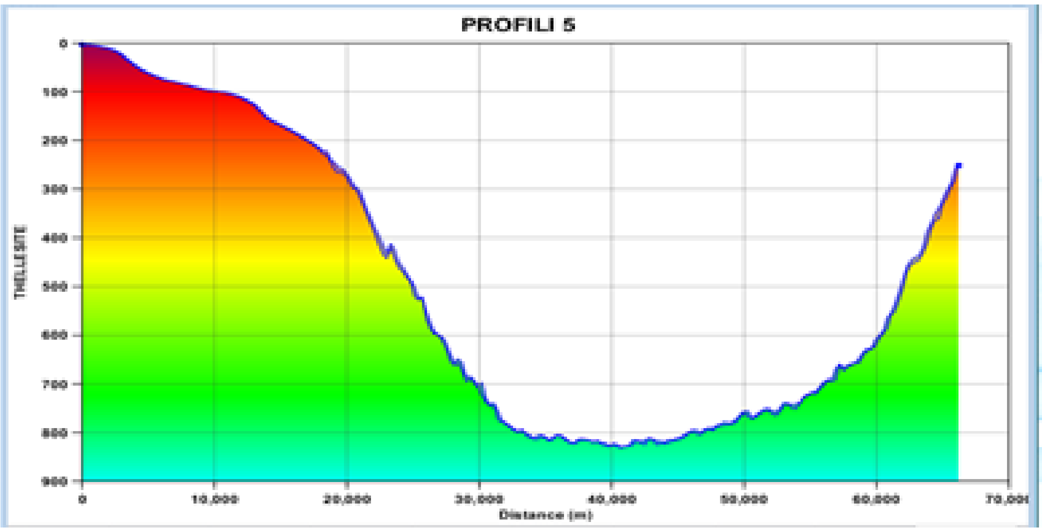

Figure 6. Profile 5 taken from the Vjosa Estuary

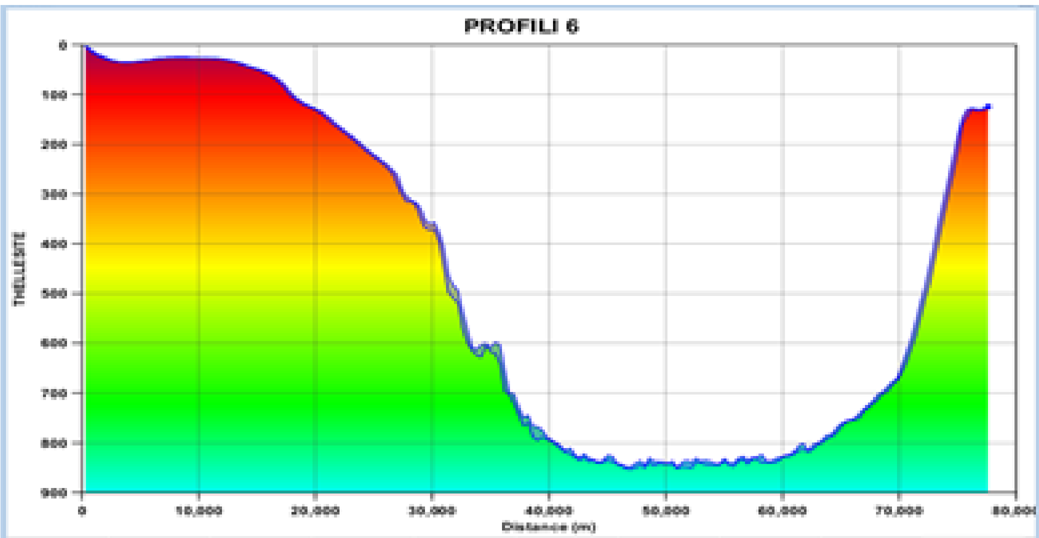

Figure 7. Profile 6 taken from Vlora

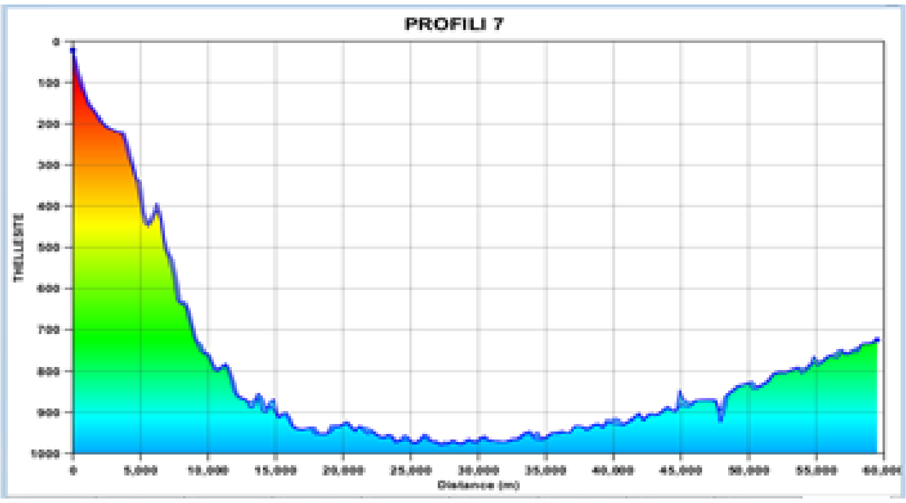

Figure 8. Profile 7 taken from Grama Bay

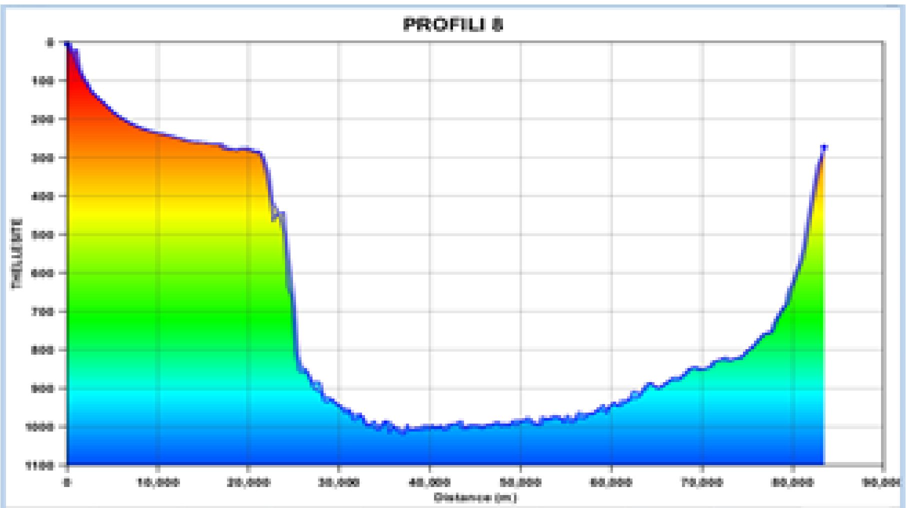

Figure 9. Profile 8 taken from Himara

5. Tsunami modeling with simulation programs in the Adriatic Sea with Mirone

The Figures 10-13 show the tsunami wave simulations for two of the main profiles we have in the study Rodon Cape and Durres and we have made other 3 profiles considered with risck for tsunami [20]. The dark blue indicates the depth zone, the yellow dot located on the first map indicates the source from which the earthquake will be taken, and then the blue areas on the side of the map show the areas that may be flooded [21-22]. The figure on the left shows the unimulated scheme and the points where the generations were taken, while on the right it shows after the simulation and the areas where the wave can propagate [23].

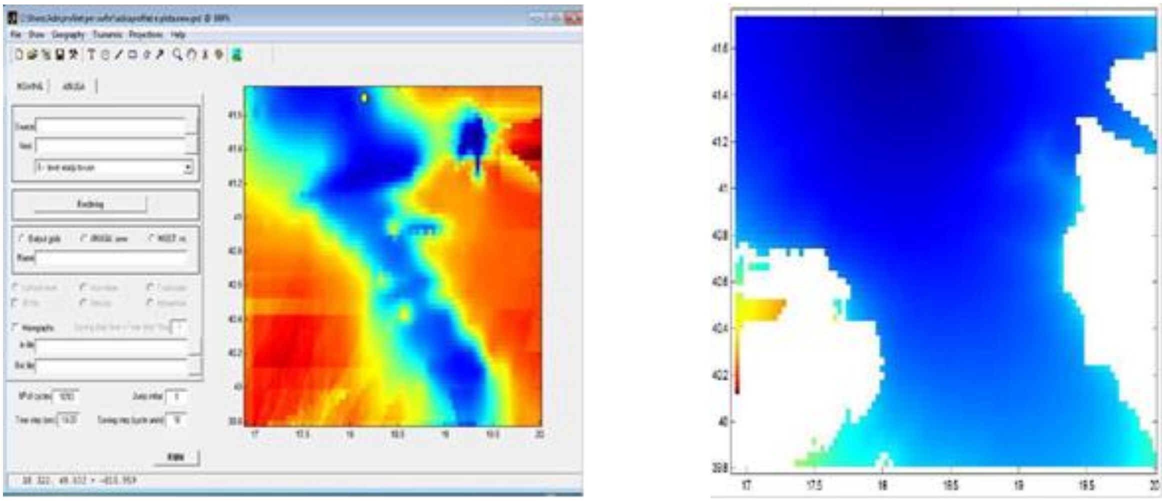

Figure 10. Profile 1 of tsunami simulation in Adriatic Sea in Lezha

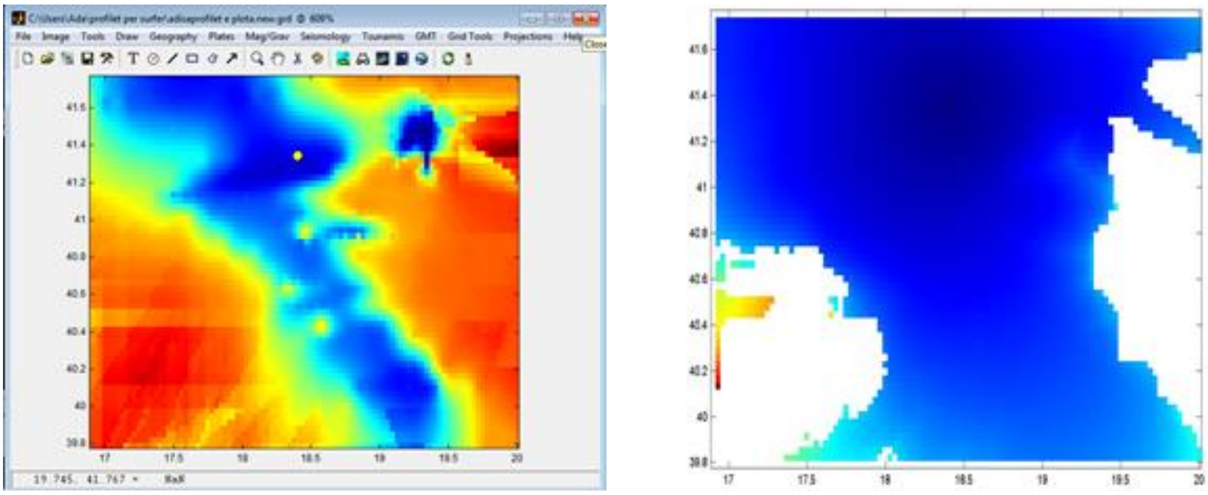

Figure 11. Profile 2 of tsunami simulation in Rodon Cape

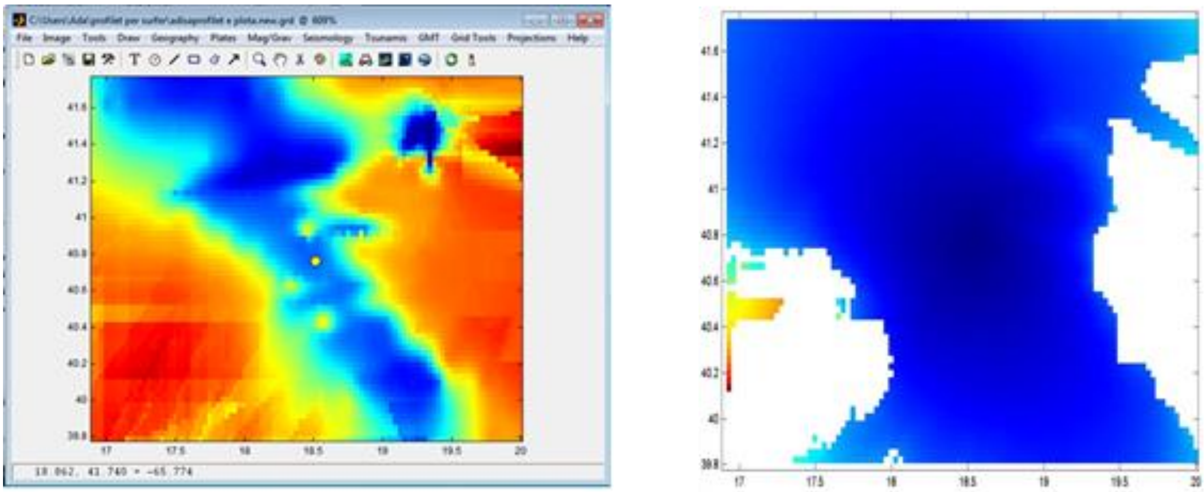

Figure 12. Profile 3 of tsunami simulation of Durres

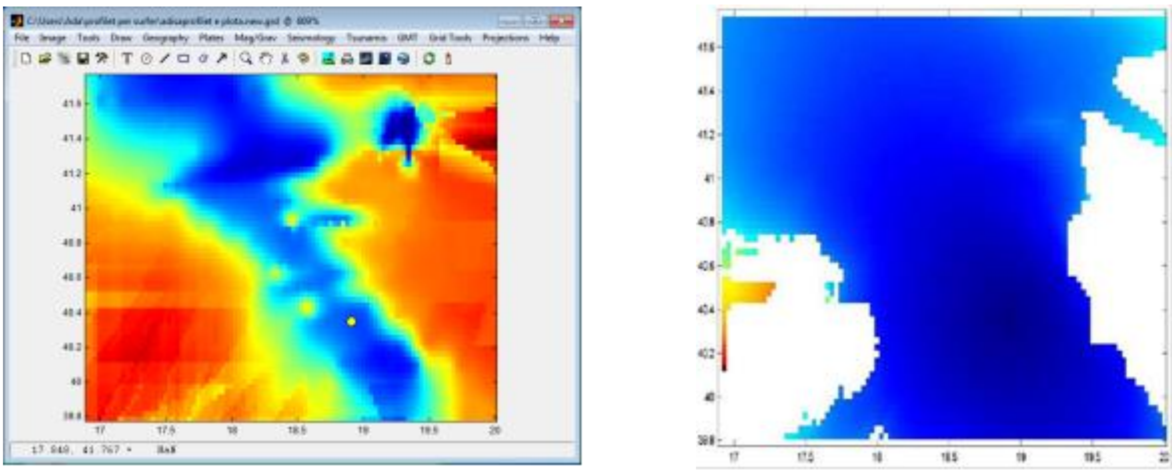

Figure 13. Profile 4 of tsunami simulation of Vlora

6. Results

First, the results of this study show how to build an approximate model for the structuring of the Adriatic and Ionian seas if the Adriatic and Ionian seas were to undergo a seismic activity and if in these cases a tsunami would develop in marine dimensions [24].

Secondly the physical structure can be damaged by the force of the wave itself, the physical removal of flora and fauna and the growth of sediments which can kill species that are sensitive to sediments and the disturbance of underwater vegetation [25].

7. Discussions

First in the north at the Drini estuary the tsunami wave has a high probability that if it occurs in a position close to the coast as a wave of a tsunami of the V degree with a height of 1 m and a tsunami of the VI degree with a tsunami wave of a height of 2 m there are many opportunities for wide spread on the coast and in the surroundings and in the villages and even on the streets. Normally, a tsunami wave with a height of 2 m will be more damaging.

Secondly, in Sarandë, the tsunami occurring near the coast will have an impact only on the parts very close to the coast due to the high profile of the coast.

Thirdly, in Vlora, Grykëderdhjen e Vjosa, Divjakë are the areas with the most risk because in these profiles due to the low height of the areas near the coast there is a risk that in the case of a tsunami the areas will be flooded and have a great impact on the beach period of holidays when these areas have a lot of population [26].

The figures below show the tsunami wave simulations for two of the main profiles we have in the study Rodon Cape and Durres. The dark blue indicates the depth zone, the yellow dot located on the first map indicates the source from which the earthquake will be taken, and then the blue areas on the side of the map show the areas that may be flooded [27]. The figure on the left shows the unimulated scheme and the points where the generations were taken, while on the right it shows after the simulation and the areas where the wave can propagate.

The simulations on the coast of Albania in the areas that have been studied have given us some results degree of tsunami risk where the most significant ones are:

- Wave V which is considered a strong tsunami (wave height reaches up to 1m)
- Grade VI which is considered a tsunami with minor damage (wave height reaches up to 2m)
- Grade VII which is considered a harmful tsunami (wave height up to 4m)

8. Conclusion

The mapping of the depths of the Adriatic Sea as well as the mapping of the depths and focal mechanisms of earthquakes of recent years has been calculated the maximum value of the wave that may have the tsunami generation in these areas.

If a thrust type earthquake with magnitude M> 6.5 Richter occurs in the area of Adriatic with with distance more than 25 km from the coast it can generate a tsunami on the coast at coordinates from Durres 41.292260, 19.503316 to Shengjin 41.809225, 19.597102 up to a height of 0.5-1m. problems can be shown even in the south of Adriatic near Divjaka with coordinates 40.832932, 19.368522.

In the recent earthquake events in addition to the damage to people and material damage we had, we can consider as something very positive the fact that the earthquakes occurred very close to the ground and there was no possibility of generating a tsunami wave.

Acknowledgement

This study was partly presented at the 5th Advanced engineering Days [10].

Funding

This research received no external funding.

Author contributions

Adisa Daberdini: Conceptualization, Methodology, Software **Fatmir Basholli:** Data curation, Writing-Original draft preparation, Software, Validation. **Novrus Metaj:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Sh, A. (2000). Active fault zones in Albania. *XVII XXVII General assembly of the European seismological commission, book of abstracts and papers*, *74*.
2. Sh, A. (2000). Neotectonics and seismicity of Albania. In book of Meço, S., Aliaj., Sh. and Turku, I:"Geology of Albania", 155-178. *Gebruder Borntraeger. Berlin. Stuttgart*.
3. Ormeni, R., Kociu, S., Fundo, A., Daja, S., & Doda, V. (2013). Moderate earthquakes in Albania during 2009 and their associated seismogenic zones. *Italian Journal of Geosciences*, *132*(2), 203-212.
4. Ormeni, R. (2015, October). Mapping b-Value in the Seismogenic Zones of Albania Region. In *8th Congress of the Balkan Geophysical Society* (Vol. 2015, No. 1, pp. 1-5). EAGE Publications BV.
5. Rrapo, O., Edmond, D., Astrit, S., Adisa, D., & Fatmir, B. (2013). Recent seismic activity of the Lezha-Ulqini seismogenic zone and its associated hazard. 2 nd International Balkans Conference on Challenges of Civil Engineering, BCCCE, 23-25 May 2013, Epoka University, Tirana, Albania
6. Daberdini, A., & Ormeni, R. (2014). Mechanical wave earthquake/generated in Adriatic Sea. Alb-Shkenca International Conference, Kosovo.
7. Daberdini, A., Rogozi, E., Ormeni, R. (2015). The effect of earthquakes on marine ecosystems in Adriatic Sea. International Conference of Echology (ICE), Tirane.
8. Ormeni, R., & Fundo, A. (2011, October). The Seismoactive Layers of the Albanian Earth's Crust Seismogenic Zones. In *6th Congress of the Balkan Geophysical Society* (pp. cp-262). EAGE Publications BV.
9. Shatro, A., & Ormeni, R. (2013). Anomalous of low-velocity zone, thermal water and seismicity in the Elbasan-Dibra fault zone.
10. Daberdini, A., Basholli, F., & Metaj, N. (2022). Simulation with the Mirone application for the construction of marine mechanical waves generated by possible seismic events in the territory of the Adriatic and Ionian seas. *Advanced Engineering Days (AED)*, *5*, 84-87.
11. Daberdini, A., & Rrapo, O. (2013). Generation of tsunami wave by earthquake in Adriatic Sea. Alb-Shkenca International Conference, Tirana.
12. Aliaj, Sh., Kociaj, S., Sulstarova, E., & Muço, B. (2010). Neotectonic Structure of Albania. AJNTS, NR.4, Tiranë 89-101.
13. Aliaj, Sh., Sulstarova, E., Muço, B., & Koçiu, S. (2000). Seismotectonic Map of Albania, scale 1:500.000. Seismological Institute Tirana.
14. Daberdini, A. (2016). Mechanical water waves generated by seismic vibrations in sea basins Adriatic and Ion. PHD thesis.
15. Ambraseys, N. N. (1962). Data for the investigation of the seismic sea-waves in the Eastern Mediterranean. *Bulletin of the seismological Society of America*, *52*(4), 895-913.
16. Ambraseys, N. N. (2002). Seismic sea-waves in the Marmara Sea region during the last 20 centuries. *Journal of Seismology*, *6*, 571-578.
17. Papazachos, B., & Papazachou, C. (1997). The Earthquakes of Greece, Ziti Publication Co., Thessaloniki, 304 pp.
18. Papazachos, B. C., & Dimitriu, P. P. (1991). Tsunamis in and near Greece and their relation to the earthquake focal mechanisms. *Tsunami Hazard: A Practical Guide for Tsunami Hazard Reduction*, 161-170.
19. Papazachos, B. C., Koutitas, C., Hatzidimitriou, P. M., Karacostas, B. G., & Papaioannou, C. A. (1986). Tsunami hazard in Greece and the surrounding area. *Ann. Geophys*, *4*(1), 79-90.
20. Papadopoulos, G. A. (2000, June). Tsunamis in the East Mediterranean: a catalogue for the area of Greece and adjacent seas. In *Proceedings of the international workshop on tsunami risk assessment beyond* (pp. 34-42).
21. Papadopoulos, G. A. (2003). Tsunami hazard in the Eastern Mediterranean: strong earthquakes and tsunamis in the Corinth Gulf, Central Greece. *Natural hazards*, *29*, 437-464.
22. Papadopoulos, G. A., & Fokaefs, A. (2005). Strong tsunamis in the Mediterranean Sea: a re-evaluation. *ISET Journal of Earthquake Technology*, *42*(4), 159-170.
23. Papadopoulos, G. A., & Plessa, A. (2001). Historical earthquakes and tsunamis of the South Ionian sea occurring from 1591 to 1837. *Bulletin of the Geological Society of Greece*, *34*(4), 1547-1554.
24. Sulstarova, E., Kociaj, S., & Aliaj, S. (1980). Seismic Regionalizition of Albania. *Shtypshkronja" Mihal Duri" Tirana (in Albanian and in English)*.
25. Taymaz, T., Jackson, J., & Westaway, R. (1990). Earthquake mechanisms in the Hellenic Trench near Crete. *Geophysical Journal International*, *102*(3), 695-731.
26. Tinti, S., & Maramai, A. (1996). Catalogue of tsunamis generated in Italy and in Côte d'Azur, France: a step towards a unified catalogue of tsunamis in Europe.
27. Tinti, S., Maramai, A., & Graziani, L. (2004). The new catalogue of Italian tsunamis. *Natural Hazards*, *33*, 439-465.