Joint Research Centre
European Commission

Source Localization of the Stromboli Tsunami of 3 Jul 2019

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Vers. 1.1

1 INTRODUCTION

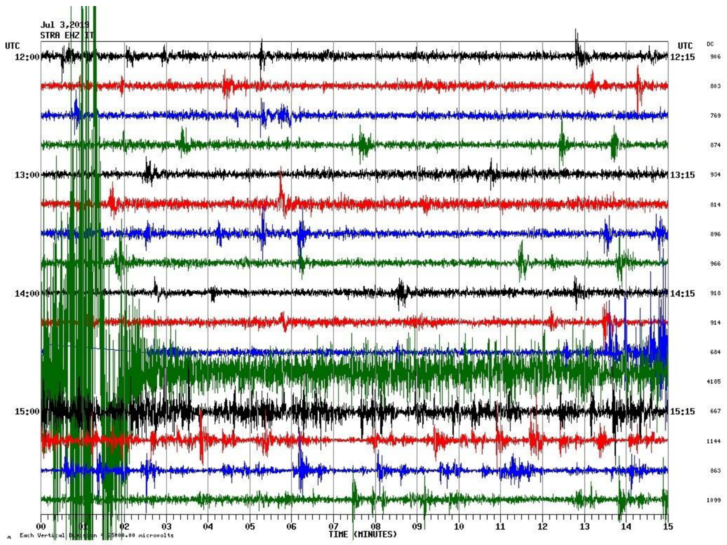
The parossism of the 3rd July 2019 triggered a Tsunami, measured in at least 4 locations around the Stromboli Volcano. The highest on-shore measured height was 40 cm in Ginostra. A floating instrument, closer to the source point, measured about 1.2 m. Probably larger values were occurring on the coasts of the Volcano but no survey has been yet performed.

As various hypotheses for the source of the Tsunami, an analysis was performed to back calculate the origin of the location of the disturb that caused the Tsunami (or at least the location of the source of the first wave). The back ray technique was adopted, propagating a small tsunami source from the location of the measurement devices. Uncertainty quantification is considered in the analysis to take into account: the unknown time of the initiating event, the data time interval, the precise identification of the arrival time in the curves, the absence of a precise bathymetry etc.

2 DATA COLLECTED AND ANALYSED

2.1 SEISMIC SIGNALS

A large explosion was measured by STRA seismic signal by INGV, starting at 14:45-14:46 and for a 1 min duration.



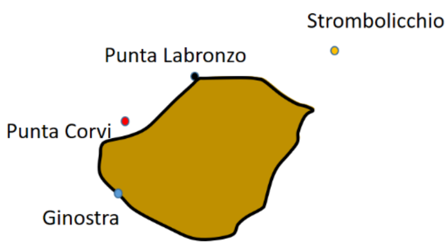
http://www.ct.ingv.it/it/segnali-sismici-in-tempo-reale.html

These signals allow to fix the initial time of the event, at least at 14:46 but there is no certainty of when the large part of the bulk of the material flowed into the water; the video sequence, obtained from the surveillance camera in the Sciara del Fuoco, courtesy of Experimental Gephysics Laboratory of Universita of Florence, seems to confirm that the initial time is 14:46 or some seconds later.

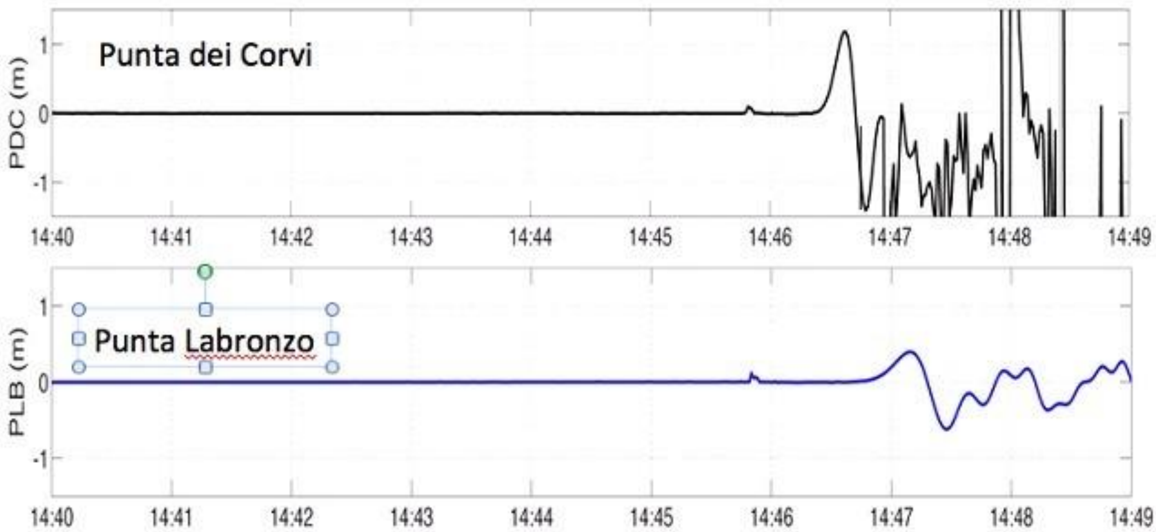
http://lgs.geo.unifi.it/index.php/blog/esplosione-parossistica-stromboli-3-luglio-2019

2.2 SEA LEVEL SIGNALS

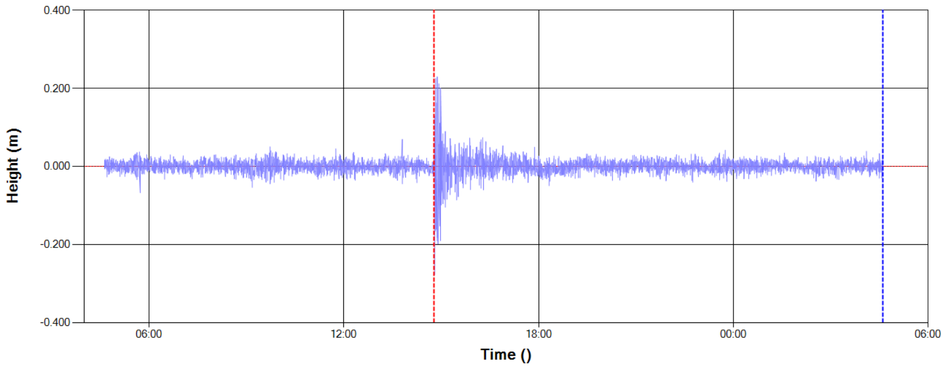
Around the Stromboli volcano 4 sea level stations are present, 2 provided from University of Florence and funded by the Italian Civil Protection , of the type elastic beacon, and 2 provided from the Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA).



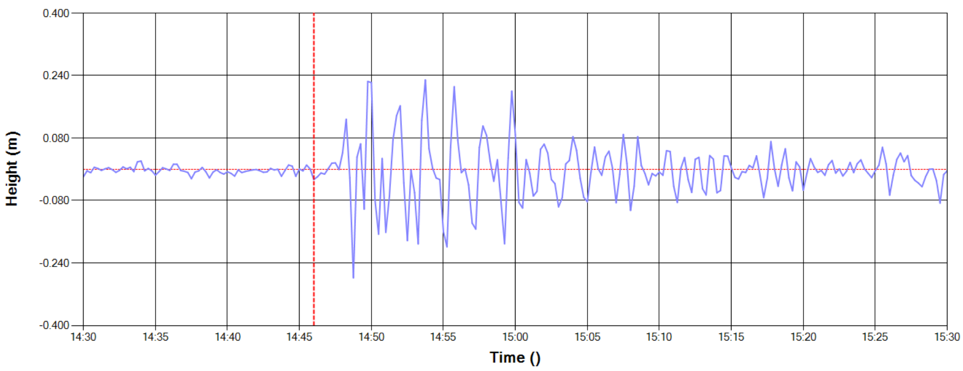
The signals are shown in the following figures



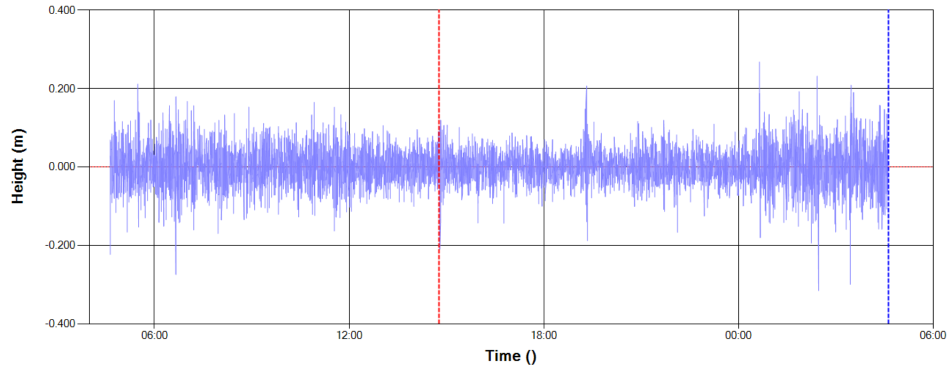
Sea level signals from the University of Florence



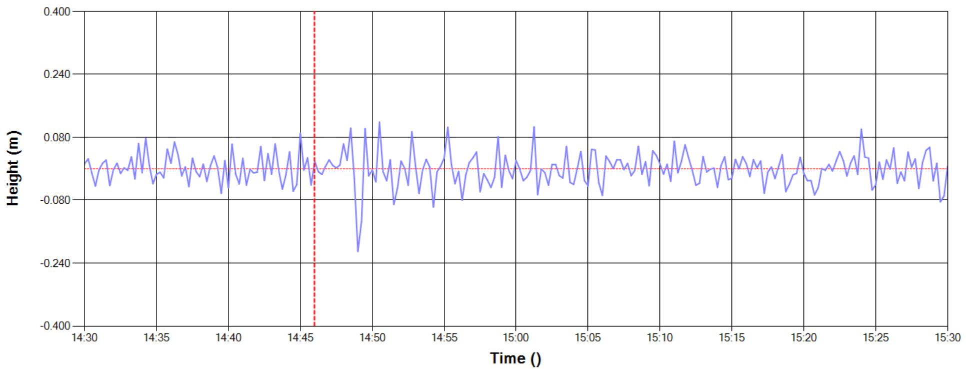
Sea level measured in Ginostra (ISPRA-02)



Sea level measured in Ginostra (ISPRA-02), detail between 14:30 and 15:30



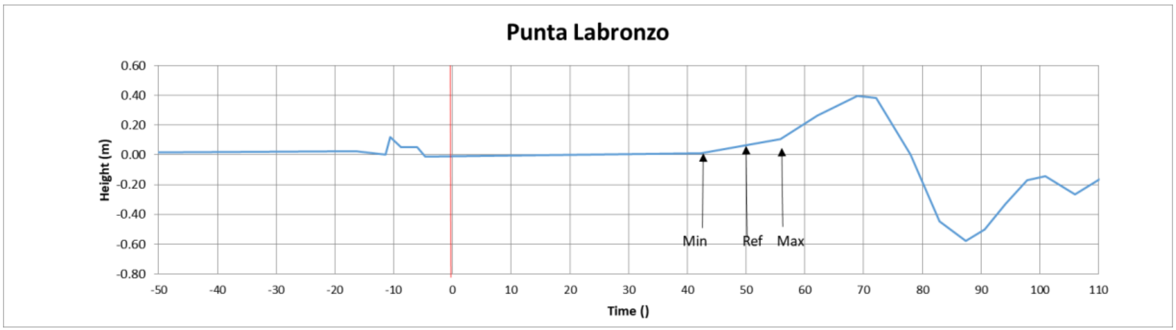
Sea level measured in Strombolicchio (ISPRA-01)

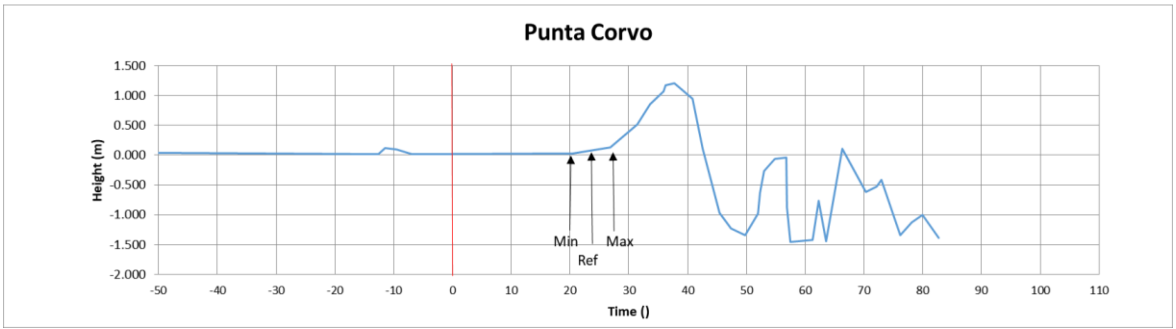


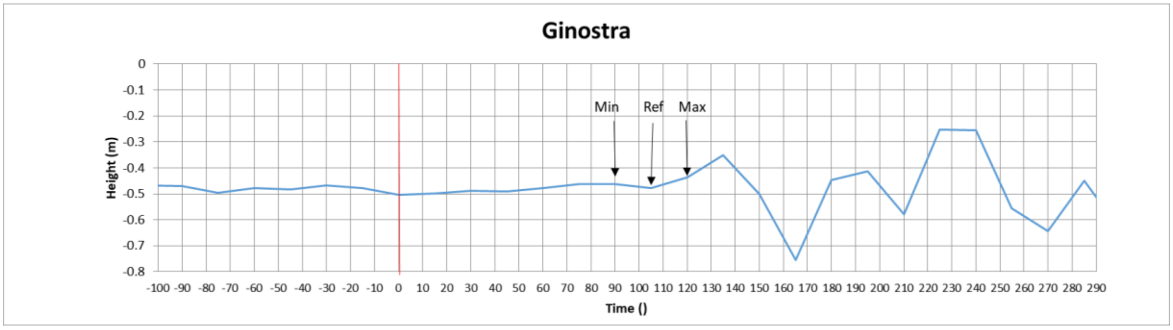
Sea level measured in Strombolicchio (ISPRA-01), detail between 14:30 and 15:30

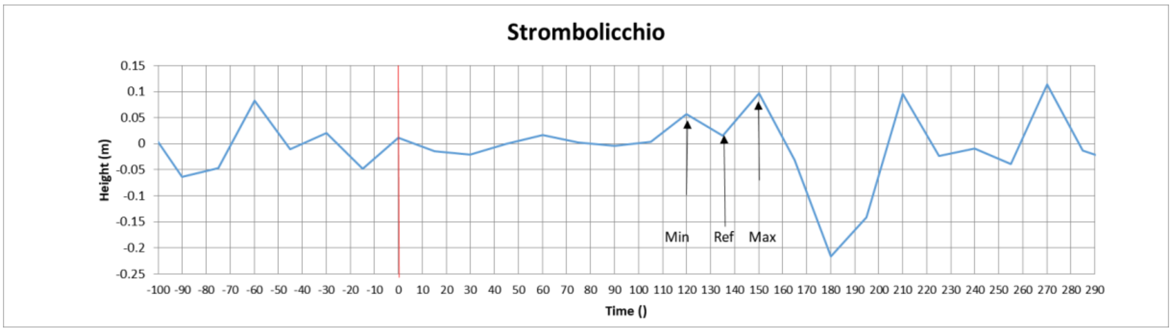
The precise identification of the arrival time at the 4 devices is not easy.

The following times are identified, once the origin of the signal has been considered 14:46:00.









The location of the devices and their arrival times ,as identified above, are considered in the following table

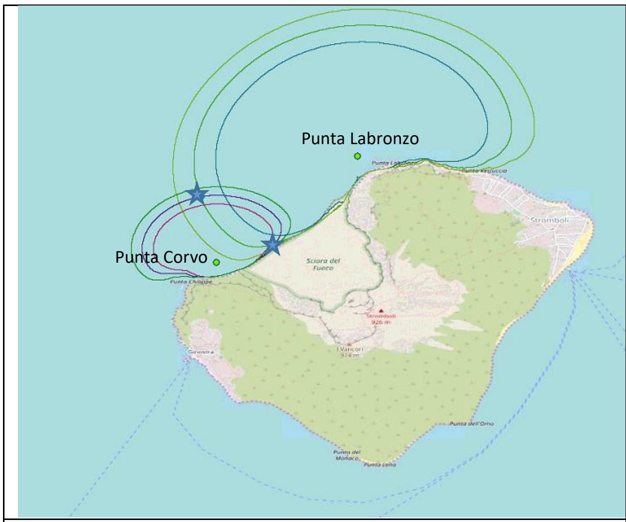
	Lon/Lat	Min (s)	Ref (s)	Max (s)	Uncert (s)
Punta Corvo	15.19310 38.7984	20.37	23.62	26.87	3.3
Punta Labronzo	15.21194 38.8125	42.29	49.07	55.84	6.8
Ginostra	15.19017 38.78403	90.00	105.00	120.00	15.0
Strombolicchio	15.25170 38.81729	120.0	135.0	150.0	15.0

3 Methodology and Results

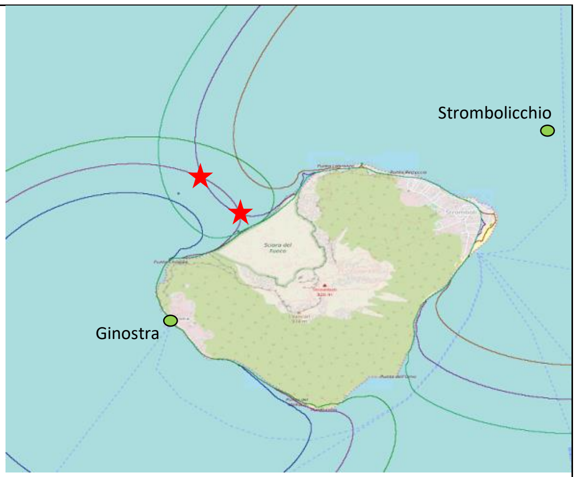
In order to identify the location of the source of the event we have performed Tsunami propagation calculations, using the NAMIDANCE computer code[1] by Middle East Technical University and imposing a small point semi-circular source at the location of the sea level gauges.

The bathymetry adopted for this calculation is obtained from the vectorial isolines from the MAGIC project[2], resampled to 4m cell size. The bathymetry is a courtesy of Italian Civil protection through the ISPRA. The characteristics of the semi-circular source is radius 100m and height 2m.

We have then analysed the position of the wave at each of the times indicated in the table above and therefore we found the minimum arrival wave line, the reference and the maximum arrival wave line.



Identification of source using UNIFI sea level data



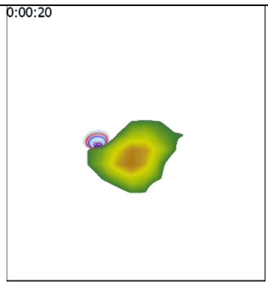
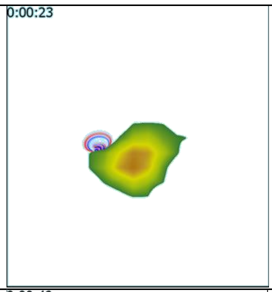
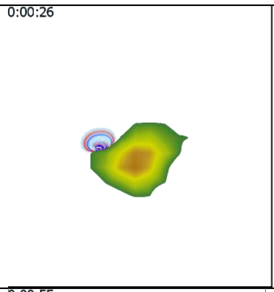
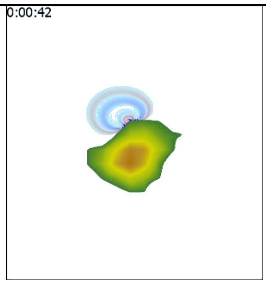
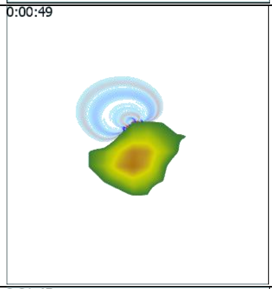
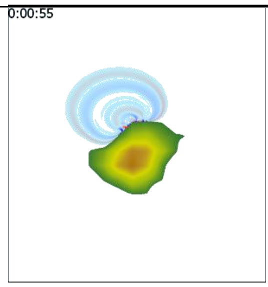
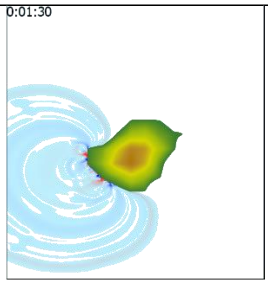
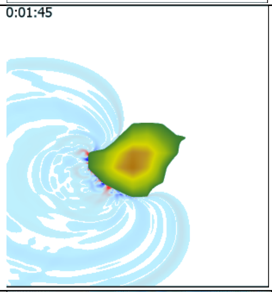
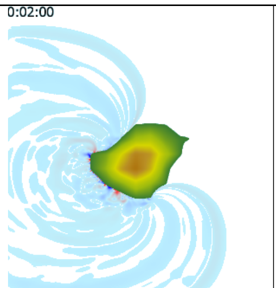
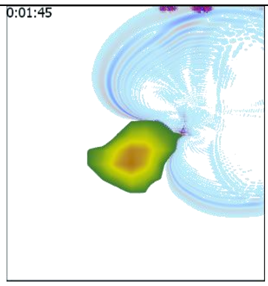
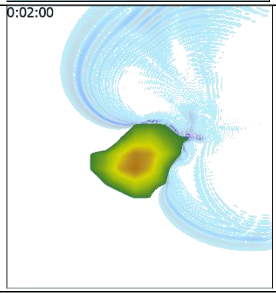
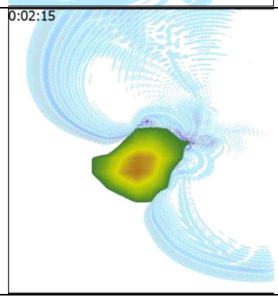
Identification of source using ISPRA sea level data

In both cases the min, ref and max front lines are identified. The intersection between the reference front lines are the points from which the arrival time respects the times found.

The BLUE star on the left results from the identification of the front line using only the University of Florence sensors; the RED star one on the right is the epicentre considering only the ISPRA sensors.

The two lower stars are relatively close (about 350m), considering the large uncertainties associated with this type of analysis. It is possible to conclude that the source of the Tsunami was very close to the Sciara del Fuoco, not far from the coast. What is identified here is the location of the first wave; further material could have been discharged but it is not easy to identify it from the sea level curves.

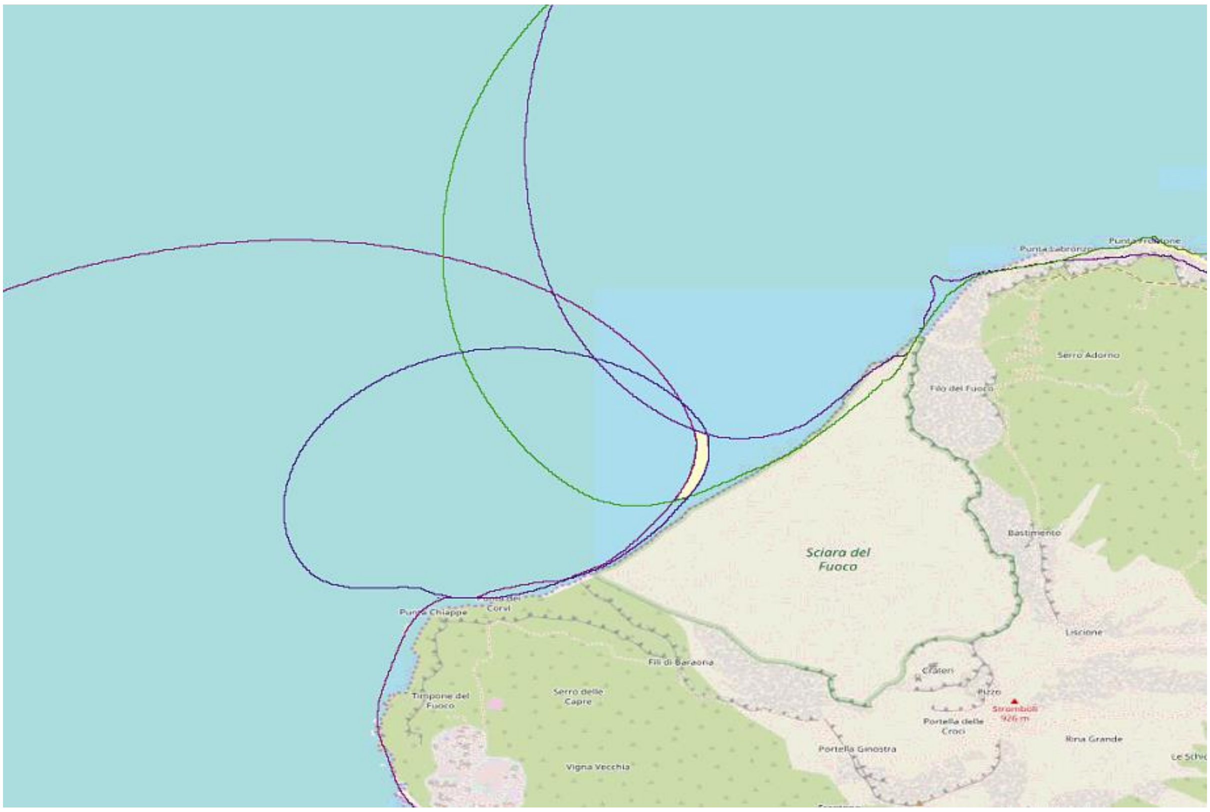
[1] http://namidance.ce.metu.edu.tr/pdf/NAMIDANCE-version-5-9-manual.pdf
[2] http://www.ismar.cnr.it/projects/national-projects/projects-in-progress/magic?set_language=en&cl=en

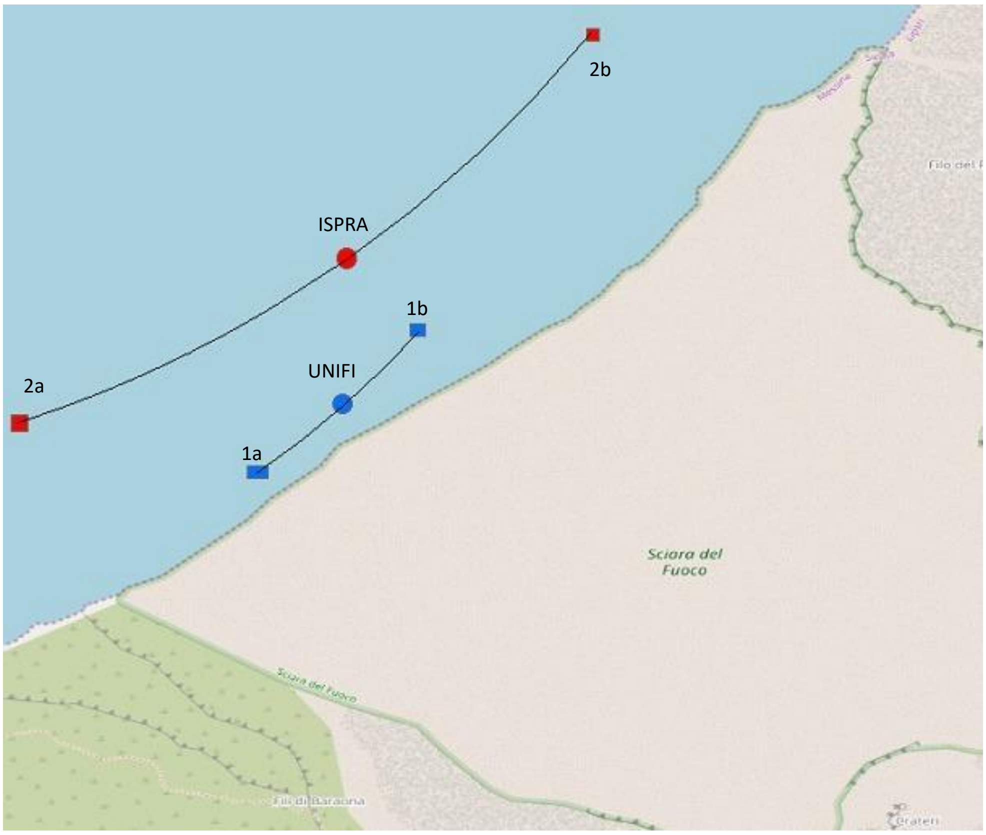
Location	Min Time	Ref Time	Max Time
Punta Corvo			
Punta Labronzo			
Ginostra			
Strombolicchio			

The figure shows the propagation obtained from the application of a semi-circular source departing from the tide gauges at the times identified as min, ref and max arrival times.

Till now, analysing independently the two UNIFI stations and the two ISPRA stations there is still an uncertainty if the real source location is the one close to the coast or the one more offshore.

However considering all the traces together, it is possible to verify that they show a rather common area close to the coast, the white area in the next figure, obtained from the intersection between all the reference curves from the 4 instruments. That is the area in which the error is the minimum among all the instruments considered. This consideration allows to exclude the most off-shore locations and concentrate on the locations close to the coast.





By considering for the 2 datasets the min/max intersections, for instance the Minimum for Punta Corvo and the Maximum for Punta Labronzo one obtains the intersection in point 1a; similarly considering the maximum for Punta Corvo and the minimum for punta Labronzo one obtains the point 1b. In principle, given the uncertainties any point along the line between 1a and 1b could satisfy the arrival time within the arrival time uncertainty. But also, if the source would be elongated from 1a to 1b it could satisfy the relations of the arrival time. Similarly for the ISPRA data for which however the size is larger due to the high interval of acquisition. However the central point fits inside the area identified by the blue point for the other sensors.

The approximate sources result of this analysis are the following

	Center	Length	Distance from shore
UNIFI Sources	15.2007/38.8008	384 m	53 m
ISPRA Sources	15.2009/38.8034	1300 m	296 m

It would be important to understand if the lava flow that was shown in Chapter 2, was approximately in this side of the Sciara del Fuoco, thus confirming this analysis or the other side. This is not yet confirmed.

4 CONCLUSIONS

The objective of the analysis performed was to identify the possible source location for the first wave of the Tsunami during the event of 3 July 2019 in the Stromboli area. The use of travel time, obtained by imposing small circular sources at the locations of the tide gauges, allowed to identify that the source is very close to the Sciara del Fuoco.

Some hypotheses for the source, like the far ejection of large masses or a landslide due to the earthquake far from the volcano are therefore ruled out.

New calculations are ongoing using a much finer bathymetry, obtained through the MAGIC project[3], funded by the Italian Civil Protection.

9 July 2019

[3] http://www.ismar.cnr.it/projects/national-projects/projects-in-progress/magic?set_language=en&cl=en