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Improved velocity models for earthquake location in Sicily and surrounding region (Central Mediterranean)

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Abstract. We propose a strategy for accurate earthquakes location in Sicily and surrounding region (Central Mediterranean). We relocated the instrumental seismicity (2018-2020) falling within the central Mediterranean area dividing the study area into 47 circular sectors and assigning to each of them one of the 14 velocity models identified on the basis of a priori published data and optimized models. As results we observed an improvement in localization of about 80% of the events considered.

Keywords: Earthquake location, 1D velocity model, lithospheric model, Seismicity, Seismology, Central Mediterranean.

1 Introduction

Central Mediterranean is a very complex geodynamical area resulting from the interaction of European and African plates. Sicily is the segment of the Alpine collisional belt linking the African Maghrebides with the Southern Apennines across the Calabrian accretionary wedge, formed by the westward subduction of the Adriatic-Ionian lithosphere under the Corsica-Sardinia block. Subduction and thrusting are contemporaneous with back arc-type extensions in the Tyrrhenian Sea [1;2]. The collisional complex of Sicily is characterized by three main elements: a complex chain, a foredeep basin extending from the Gela basin to offshore Sicily in the Sicily Channel and a foreland area belonging to the African plate developed in south-eastern Sicily (Hyblean Plateau).

In recent years, some authors proposed several 1D P- and S- velocity models optimized for earthquakes location in specific sectors of this area. These studies confirm that the precision of earthquake locations is closely related to the distribution of seismic stations, seismic data quality, velocity model and the location method employed. [3] and [4] proposed that the *minimum 1D velocity model*, which represents the least square solution to the coupled hypocenter-velocity model parameter relation, help to get accurate and robust earthquake hypocenters.

2 Materials and Methods

Based on a priori available data and geological/geophysical considerations, the Central Mediterranean was divided into 47 sectors of circular areas (Fig. 1). A lithospheric velocity model was assigned to each sector of the study area: Malta escarpment [5], Calabrian Arc [6], Southern Tyrrhenian [7], Kabilian-Calabrian Units [8], Aeolian Islands [9], Central Sicily [10], Ionian Sea [11], Western Sicily [7], Marsili [7], Gela-Catania system [12], Gela basin [13], Sciacca to Termini Imerese area [12] and Etna [14]. A default model has been defined for seismic events falling outside these areas. Each of these velocity models has been optimized independently, on a different data set, and so can be considered representative only of a limited sector of our area of interest.

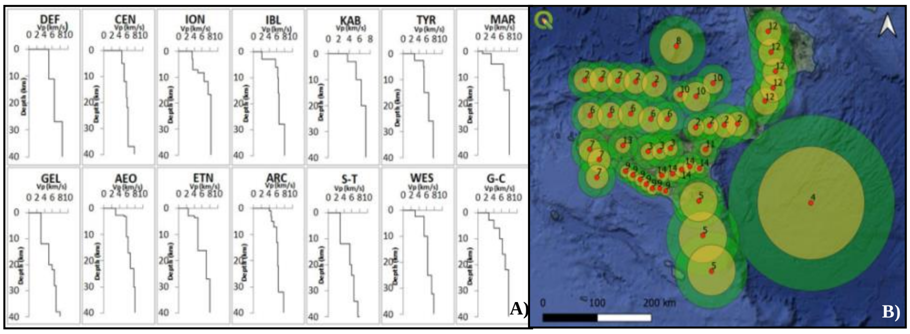

Fig. 1. A)1D velocity model. DEF: default, CEN: central Sicily, ION: Ionian Sea, IBL: Malta escarpment, KAB: Kabilian-Calabrian Units, TYR: Southern Tyrrhenian, MAR: Marsili, GEL: Gela basin, AEO: Aeolian Islands, ETN: Etna, S-T: Sciacca to Termini Imerese area WES: Western Sicily, G-C: Gela-Catania system; B)Subdivision of the study area into 47 circles, each of which is attributed a crustal model. In yellow: internal circles within which only a model is attributed; in green: external circles or transition area within which a weighted average of the models is attributed. The numbers indicate the crustal models: 2) KAB, 3) CEN, 4) ION, 5) IBL, 6) TYR, 7) WES, 8) MAR, 9) GEL, 10) AEO, 11) ETN, 12) ARC, 13) S-T-, 14) G-C.

The optimization process of velocity models and the relocalization of regional local seismicity was performed using the HYPOINVERSE 2000 code [15], which allowed to work concurrently with multiple lithospheric models to cover different regions. We considered seismic events that occurred in the last three years (2018-2020) recorded by the Italian Seismic Network managed by the Istituto Nazionale di Geofisica e Vulcanologia.

3 Results

At first, earthquake localization was carried out using the so-called default model, that is a simplified 1D velocity model generally used for the entire area of interest. Then, we re-located earthquakes using the 14 optimized 1D velocity models and velocity models obtained from seismic profile (Fig. 1). To verify the improvement in hypocentral localization as result of the use of multiple optimized models, we compare the Root Mean Squared residual. About the 80% of re-located seismic events improved with a mean reduction in RMS of approximately 10%.

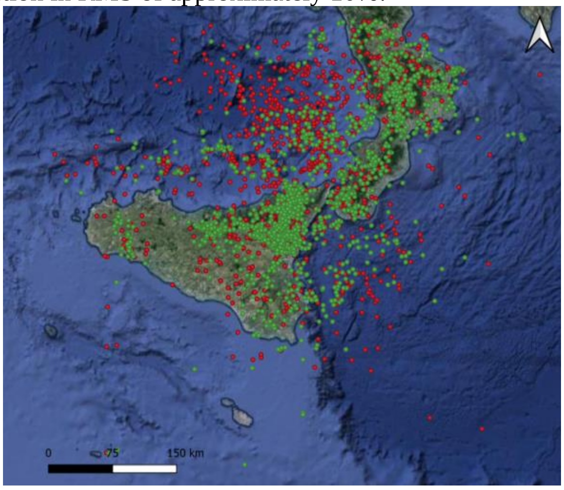

Fig. 2. Map of earthquake epicenters relocated in this study: green circles indicate events with a decrease in RMS of about 10%; red circles indicate events for which the RMS has not improved.

4 Discussion

The epicentral distribution of Fig. 2 show as the improvement in localization in terms of RMS reduction cannot be considered homogeneous. The areas where there is a significant improvement in the earthquakes location are part of western Sicily, north-eastern Sicily, Etna area and Calabrian Arc. The improvement could arise from better velocity models due to a greater seismicity in these areas than in the others and therefore a greater amount of data processed. The areas where there isn't significant improvement are Aeolian Island and Marsili. For these areas it will be necessary to improve the velocity models and optimize earthquakes location process.

5 Conclusions

In this work we have relocated the instrumental seismicity (2018-2020) falling within the central Mediterranean area dividing the study area into 45 circular sectors and assigning to each of them one of the 14 velocity models identified on the basis of a priori published data and optimized models.

As results we observed an improvement in localization of about 80% of the events considered. However, what has been obtained must be considered a preliminary result, as it still requires extensive validation on a more complete database of instrumental seismicity. Currently we are working both on the temporal extension of the instrumental seismicity catalog (up to about 30 years) and on the development of a iterative optimization strategy. When the optimization phase will be completed, this pseudo 3D velocity model could be employed also for a better definition of the earthquakes source mechanisms and as initial reference models for accurate 3D tomography.

References

1. Rehaut, J.P., Boillot G., Mauffret, A.: The Western Mediterranean Basin geological evolution. Marine Geol. 55, 447–477 (1987).
2. Malinverno, A., Ryan, W. B. F.: Extension in the Tyrrhenian sea and shortening in the Apennines as result of arc migration driven by sinking of the lithosphere. Tectonics 5(2), 227–245 (1986).
3. Eberhart-Phillips, D.: Three-dimensional P and S velocity structurein the Coalinga region, California. J. Geophys. Res. 95, 15343–15363 (1990).
4. Kissling, E., Ellsworth, W. L., Eberhart-Phillips, D., Kradolfer, U.: Initial reference models in local earthquake tomography. J. Geophys. Res. 99, 19635–19646 (1994).
5. Musumeci, C., Di Grazia, G., Gresta, S.:Minimum 1-D velocity model in Southeastern Sicily (Italy) from local earthquake data: an improvement in location accuracy. Journal of Seismology 7, 469–478 (2003).
6. Barberi, G., Cosentino, M., Gervasi, A., Guerra, I., Neri, G., Orecchio, B.: Crustal seismic tomography in the Calabrian Arc region, southItaly. Phys. Earth Planet. Inter.147, 297–314 (2004).
7. Giunta, G., Luzio, D., Tondi, E., De Luca, L., Giorgianni, A., D’Anna, G., Renda, P., Cello, G., Nigro, F., Vitale, M.: The Palermo (Sicily) seismic cluster of September 2002, in the sesismotectonic framework of the Tyrrhenian Sea-Sicily border area. Annals of Geophysics 47(6), 1175–1770 (2004).
8. Langer, H., Raffaele, R., Scaltrito, A., Scarfì, L.:Estimation of an optimum velocity model in the Calabro-Peloritan mountain. Assessment of the variance of model parameters and variability of earthquake loactions. Geophys. J. Int.(2007).
9. Gambino, S., Milluzzo, V., Scarfì, L.: Relocation and focal mechanisms of erthquakes in the south-central sector of the Aeolian Archipelago: new structural and volcanological insights. Tectonophysics 524:108-115 (2012).
10. Sgroi, T., De Nardis, R., Lavecchia, G.: Crustal structure and seismotectonics of central Sicily (southern Italy): new constraints from instrumental seismicity. Geophys. J. Int. 189, 1237–1252 (2012).
11. D’Alessandro, A., Mangano, G., D’Anna, G., Scudero, S.: Evidence for serpentinization of the Ionian upper mantle from simultaneous inversion of P- and S-wave arrival times. J. Jeodyn., vol. 102, pp. 115-120 (2016).
12. Scarfì, L., Giampiccolo, E., Musumeci, C., Patanè, D., Zhang, H.: New insights on 3D crustal structure in Southeastern Sicily (Italy) and tectonic implications from an adaptive mesh seismic tomography. Phys. Earth Planet. Inter. 161, 74–85 (2007).
13. Scarascia, S., Lozej, A., Cassinis, R.: Crustal structure of Ligurian, Thyrrenian and Ionian seas and adjacent onshore areas interpreted from wide-angle seismic profiles. Boll.Geof.Teor. Appl. 36, 141–144 (1994).
14. Cardaci, C., Coviello, M., Lombardo, G., Patané, G., Scarpa, R.: Seismic tomography of Etna volcano. J.Volcanol. Geotherm. Res. 56, 357–368 (1993).
15. Klein, F.: User's guide to HYPOINVERSE-2000, a Fortran program to solve for earthquake locations and magnitudes, version 1.40, June 2014, 9–25 (2014).