Supplement of Solid Earth, 12, 2021–2039, 2021
https://doi.org/10.5194/se-12-2021-2021-supplement

Solid Earth
Open Access

Supplement of

A revised image of the instrumental seismicity in the Lodi area (Po Plain, Italy)

Laura Peruzza et al.

Correspondence to: Laura Peruzza (lperuzza@inogs.it)

Supplement 1

A short description of the main seismological data providers and past initiatives for updating instrumental earthquake catalogues, in Italy, is hereinafter provided.

- The National Institute of Geophysics and Volcanology - INGV: the "Centro Nazionale Terremoti" (CNT) is the authoritative centre for earthquake monitoring in Italy. Under contract with the National Civil Protection Department, it supplies the parameters of the epicentre in real-time, in order to organize emergency interventions. CNT manages the National Seismic Network (RSN – Rete Sismica Nazionale), established following the catastrophic earthquake of Irpinia in 1980. The first nucleus of the network was composed of seven stations, linked to a unique elaboration centre in Rome. Today CNT manages about 500 stations and acquires the signals of several other institutions, for a unified detection, localization and magnitude determination of seismic events, and for managing the archive of recorded events, available at the INGV website (http://terremoti.ingv.it/en/iside). The earthquake parameters are transmitted to international agencies too (see Margheriti et al., 2021 and references therein).
- The Civil Protection Department - DPC: it manages the Italian Strong Motion Network (RAN – Rete Accelerometrica Nazionale), which is the network dedicated to the measurement of the ground acceleration generated by moderate-to-high magnitude earthquakes. The network was acquired from the Italian electric company ENEL in 1997 and over the years has been improved and upgraded to digital instruments. As of today, it is composed of almost 600 seismic stations with 3-axial accelerometers, concentrated especially in high seismicity zones. These data are complementary to the seismic monitoring done by INGV, but they are usually not taken into account for the hypocentral and magnitude determination, except in the case of signal saturation of seismometers, in the near field of major earthquakes.
- The University of Genoa - UNIGE: the Regional Seismic Network of North-Western Italy (RSNI - Rete Sismica regionale dell'Italia Nord-occidentale) belongs to the Laboratory of Seismology of the University of Genoa. It started with a single instrument at the beginning of the '60 and underwent slow developments till '80, when the number of instruments, azimuthal coverage and transmission links became adequate to a regional network (Eva et al., 2010; Spallarossa et al., 2014). It is currently composed of 32 seismic stations useful both for monitoring and for scientific research purposes. It releases online bulletins of automatic and revised located earthquakes for North-Western Italy (http://www.distav.unige.it/rsni/).
- The National Institute of Oceanography and Applied Geophysics – OGS: the OGS Seismological Research Center (CRS - Centro di Ricerche Sismologiche) was established by law after the strong earthquake (M_W=6.4) occurred in 1976 in the Friuli Venezia Giulia region. It started to operate the regional seismic network of North-Eastern Italy (NEI) in 1977 with the first core of 7 stations, thus integrating the observations done since the end of the 19th century by the seismic station located in Trieste, near the Slovenian border. Currently, the network manages 43 stations, and data exchanges with national and international institutions (Bragato et al., 2021) across the eastern Italian boundaries. Bulletins of the NEI network have been released since 1978; at present, the real-time seismic monitoring releases automatic alarms and manually revised

earthquake locations for the Friuli Venezia Giulia and Veneto Regions (www.rts.crs.inogs.it). Bulletins of the Trieste station alone (that became part of the World Wide Standardized Seismic Network WWSSN in 1963; some early standardized instruments - e.g. Wood Anderson, for magnitude assessment - are still functioning, Sandron et al., 2015) were available for some decades too and were partially integrated into the data collected by the international agencies.

- The International Seismological Centre (ISC) is worth to be mentioned as well: it was set up in 1964 as a successor to the International Seismological Summary (ISS), the pioneering effort in collecting, archiving and processing seismic station and network bulletins and preparing and distributing the definitive summary of world seismicity. ISC does not have its own instrumental infrastructures, and its mission is to maintain a number of important data repositories, as the longest continuous definitive summary of world seismicity (ISC Bulletin), the International Seismographic Station Registry and the IASPEI Reference Event List. ISC, jointly with the World Data Center for Seismology (NEIC/USGS), maintains the International Seismograph Station Registry since the 1960s. At present, there are over 26,000 stations globally registered, including those already closed. The ISC Bulletin (http://www.isc.ac.uk/iscbulletin/) is a cornerstone of the Global Reference Catalogue for Global Earthquake Risk Model (GEM) too.

The RSNI and NEI regional networks are of interest for this study, as some of their stations are close to the analysed area and can thus provide additional data to the ones detected by the national network.

About the Italian national earthquake catalogues, they were the outcome of dedicated projects funded within the activities of the Gruppo Nazionale per la Difesa dai Terremoti (GNDT). In the 80s, a specific project (Progetto Finalizzato Geodinamica) released the first catalogue of Italian earthquakes from 1000 to 1980 (Postpischl, 1985), mainly based on macroseismic observations and early instrumental data. Then, the very first initiative of a quality controlled and unified earthquake catalogue for instrumental seismicity in Italy was promoted after the strong earthquakes of Colfiorito and Sellano in Central Italy, in 1997-98; a sub-project named “5.1.3 Catalogo Strumentale dei Terremoti” was approved and funded by GNDT. The objective of the project was the complete collection of phase readings from all the various networks and observatories existing in Italy at that time, and the uniform relocation of events, according to agreed procedures and standards. The compiled catalogue (Catalogo Strumentale dei Terremoti Italiani, CSTI) spans from 1981 to 1996; a CD-Rom was published in 2000 (https://emidius.mi.ingv.it/CSTI/Versione1_0/). Some years later, an updated version was released to fix some problems reckoned in the automatic location procedure (https://emidius.mi.ingv.it/CSTI/Versione1_1/). Approximately in the same years, another GNDT project led to the release of another catalogue of seismicity in Italy (CSI, https://csi.rm.ingv.it/home), covering a longer time interval. The phases previously gathered and associated by CSTI, and the new ones collected for the years 1997-2002 have been uniformly reprocessed (Chiarabba et al., 2005) and further revised in version 1.1 (Castello et al., 2006). A further initiative of expanding the time frame of the instrumental catalogue till 2009, and making uniform data to a new release of CSI 2.0 has never reached the publication stage. Today, the Italian Seismological Instrumental and Parametric Data-Base (ISIDe, 2007) collects the parameters of earthquake locations, firstly performed by the surveillance service of INGV, then reviewed by specialized analysts to produce the Italian Seismic Bulletin (BSI; http://terremoti.ingv.it/en/help#BSI), and eventually updated within ISIDe. The practices for bulletins compilation have changed over time, as well as the type of magnitudes attributed by the analysts. ISIDe is the INGV database that can be interrogated online, with customized queries on time/magnitude/location parameters, with a starting date of January 1, 1985.

Supplement 2

The comparison between the old and new locations cannot be represented in terms of graphs of statistical errors, or maps of differences in location. These limitations are due to the fact that the majority of initial earthquake locations derive from catalogues that do not list their errors in location (this is the case for example of CSI catalogue by INGV, and for the early ISC Bulletins). In addition, hypocentral solutions may adopt different standards in error definition (this is the case, for example of the datasets of UNIGE that has changed location algorithms in time), thus making the comparison of statistical errors misleading.

We graphed in this Supplement the standard errors of the relocated dataset (Fig. S1, a-c), and the distribution of distances between the initial hypocentres and the post-revision locations (Fig. S1, d). Note that some earthquakes after the revision are located outside of the area represented in Fig. 8.

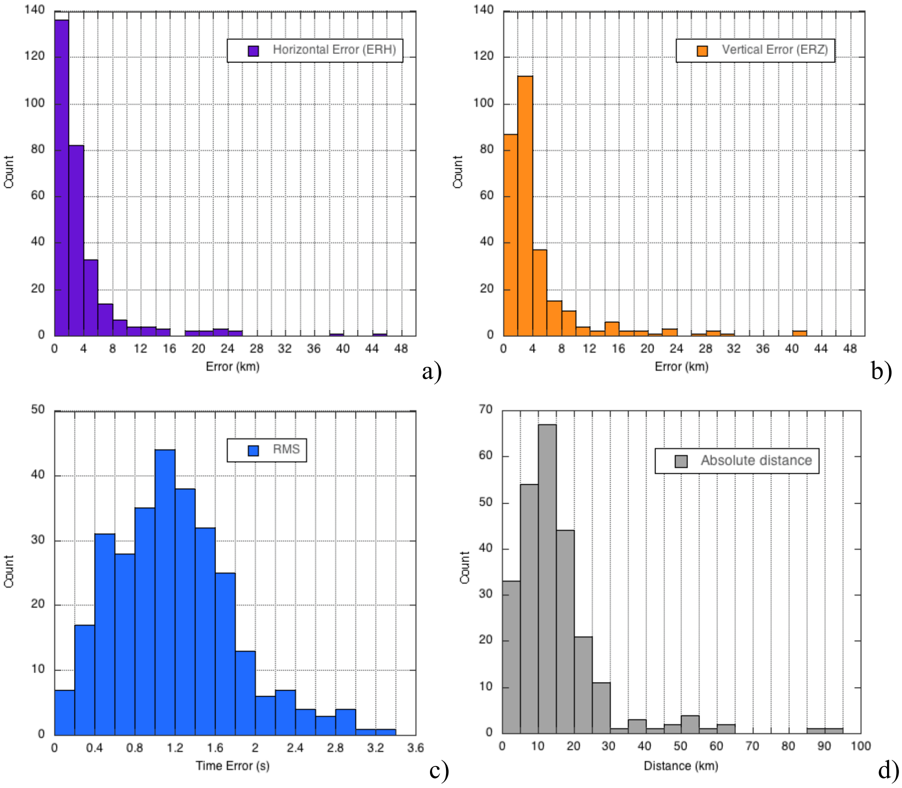

Figure S1 – Statistical errors of the relocated dataset of earthquakes, and absolute distances from the initial location; the standard errors are defined as in Hypo71 (Lee and Lahr, 1975); a) horizontal error (ERH); b) vertical error (ERZ); c) root mean squared residual in time (RMS); absolute distance of hypocentres before and after the relocation.