DOI 10.4430/bgo00453

SHORT NOTE

The eastern Alps earthquake catalogue (1977-2022)

A. Rebez[1], G. Renner[2], D. Sandron[1] and D. Slejko[3]

[1] *National Institute of Oceanography and Applied Geophysics - OGS, Trieste, Italy*
[2] *Former seismologist of National Institute of Oceanography and Applied Geophysics - OGS, Trieste, Italy*
[3] *Affiliate of National Institute of Oceanography and Applied Geophysics - OGS, Trieste, Italy*

(Received: 28 November 2023; accepted: 12 February 2024; published online: 1 March 2024)

Key words: earthquake catalogue, eastern Alps.

1. Introduction

The National Institute of Oceanography and Applied Geophysics (OGS) manages the Monitoring System for NE Italy (SMINO), which performs the institutional tasks of monitoring and researching seismic activity in NE Italy (Bragato *et al.*, 2021), for civil protection, and includes collaboration activities concerning alert notifications, emergency plans, and voluntary work involvement (Sandron *et al.*, 2016, 2020). SMINO, an infrastructure of national importance, consists of the NE Italy Seismic Network, OX network code (OGS, 2016), a strong motion network, and a geodetic monitoring network. The first stations of the seismometric network were originally deployed in May 1977, one year after the strong earthquake, which heavily damaged central Friuli, NE Italy (Rebez *et al.*, 2018; Slejko, 2018).

Real-time data are exchanged with national and international networks in neighbouring countries, and information on seismic events is disseminated to the public through a dedicated web portal (https://terremoti.ogs.it).

Since 2010, the monitoring network managed by OGS has reached a stable configuration, in terms of the number of stations installed, the homogenisation and modernisation of the installed instruments and, ultimately, in terms of a data processing system that has reached a well-established level of robustness (Moratto and Sandron, 2015; Sandron *et al.*, 2023). Since 2015, a seismic bulletin has, also, been made available and it includes the calculation of the local magnitude on the analysis of the event waveform amplitude in addition to the historical duration magnitude, based on the readings of the earthquake duration in real-time. In a recent work of recalibration of the duration magnitude on the local magnitude, also including past reviews of more energetic earthquakes based on the estimate of the local magnitude of the Trieste station [equipped with an original Wood Anderson (WA) seismograph (Sandron *et al.*, 2015)], a new regression relation (between the duration in seconds and the local magnitude) was created and, here, used to obtain a new homogeneous catalogue from 1977 to 2022 (Sandron *et al.*, 2023).

Aim of the present work is to describe and make available a comprehensive data set of locations and magnitudes of events, which occurred in the eastern Alps in the last 45 years. The present paper can be considered an *addendum* to the paper by Sandron *et al.* (2023) and, for this reason, it is presented in the form of short note.

2. The catalogue

The Hypo71 earthquake location code (Lee and Lahr, 1975) has been used for elaborating data of regional seismicity. Tests performed on alternative earthquake location programs [Hypoellipse (Lahr, 1999), Hypoinverse (Klein, 2002), etc.] have not demonstrated evident advantages and, consequently, Hypo71 has been considered suitable for the purposes of the present work. Following is the genesis and main features of the new catalogue being proposed.

2.1. Data source and data input

The seismological bulletins and associated catalogues have been regularly published (annual files) from 1977 to 2014 and are accessible via web (http://www.crs.ogs.it/bollettino/RSFVG/). Monthly files are available for each year, and contain: 1) the input file of the readings (Readings), 2) the Bulletin, and 3) the monthly catalogue (Locations). Since 2015, only the annual catalogues, in text format, and the annual bulletins, in Quakeml format, have been published (Snidarcig *et al.*, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022).

The ALLdatain.txt initial input file, used in the present work, is a text file in Hypo71 (Lee and Lahr, 1975) format obtained by simply putting together all the individual input files (Readings) available on the above-mentioned web page (last accessed November 2023). This file was implemented with phase readings taken from the seismograms of the stations of Bad Blaiberg (BBA) and Klagenfurt (KFA) in Carinthia, deployed by the University of Vienna (Aric *et al.*, 1992) during the seismic sequence following the strong 1976 earthquake. Besides these, additional phase readings were taken from the seismograms of the private (i.e. belonging to the national company for electricity) seismometric stations controlling some facilities (e.g. dams: AMBE, LAME, PIEE, MISE, VAJ) in the piedmont belt of the eastern Alps (Renner, 1995). Further readings were collected from the bulletins of the International Seismological Centre. These data have also been used for re-computing focal mechanisms in the SE Alps (Saraò *et al.*, 2021). Preliminary earthquake locations, obtained by the Hypo71 program (Lee and Lahr, 1975), highlighted phase readings of some OX stations with large errors: a manual check on the original seismograms enabled us to adjust the data. In addition, all explosions identified by Peruzza *et al.* (2015) were excluded from further elaborations: the ALLdatain.txt final input file is included in the supplementary material. The three-letter code in the input file is explained as follows. The first letter identifies the region (F = Friuli, V = Veneto, O = Austria, C = Croatia, S = Slovenia, L = Lombardia, E = Emilia, R = Romagna, T = Trentino, A = Alto Adige). The second letter indicates the type of event [L = local earthquake, E = explosion in the narrow sense, as well as for those in quarries, various anthropogenic events, bangs, landslides, supersonic flights (not to be located), U = uncertain event]. The third letter, D, stands for “determined”, i.e. when the hypocentre is calculated.

As reported in the cited webpage, the crustal model used was calculated based on knowledge of the crust in the Friulian and Venetian plain area (Slejko *et al.*, 1989). The rete.mod file (which is included in the supplementary material) is the HYPO support file containing the test parameters, the list of stations, the magnitude formula, and the crustal model. The latter consists of a layer from the surface down to a depth of 22 km with V_P = 5.85 km/s, a layer from 22 to 39.5 km of depth with V_P = 6.8 km/s, and a half-space below 39.5 km of depth with V_P = 8.0 km/s. The P- to S-wave velocity ratio is equal to 1.78.

2.2. Magnitude

Historically, prior to the cited 1976 earthquake, only the WWSSN (World-Wide Standardized Seismograph Network) Trieste station (TRI) was active at OGS, equipped since 1972 (Parolai *et al.*, 2021) with a WA seismograph (still in operation) for the calculation of local magnitude (see Richter, 1935, 1958). For more information on the history of seismicity recording in north-eastern Italy see Sandron *et al.* (2014) and Saraò *et al.* (2023); on the TRI WA seismograph see Sandron *et al.* (2015).

After the pioneering works on TRI M_D (duration magnitude) calibration by Suhadolc (1978) and Rebez *et al.* (1984), based on WA data, Rebez and Renner (1991) performed the second M_D calibration for 21 stations of the OGS network and again considered the TRI WA M_L (local magnitude). Today, for continuity with the past, the coefficients of Rebez and Renner (1991) are still used in the normal daily routine of earthquake location and (above defined magnitude thresholds) for notification of emergency responders, authorities dealing with the emergency, and the media.

Unfortunately, the TRI M_L was calculated by combining the two horizontal components as a vector sum and, therefore, contains a recognised bias of circa +0.2 magnitude units (Gasperini, 2002). Sandron *et al.* (2015), therefore, reviewed and corrected the M_L estimates for the 1977-1988 period and, taking advantage of the renovation and new operation of the original WA implemented since 2002, produced a new catalogue of 1,522 events with magnitude $0.2 < M_L < 6.5$ for the time window 1977-2013. Consequently, a new M_D calibration was performed based on the new and updated M_L data set (Sandron *et al.*, 2018). In that work, new equations were derived for individual stations as well as an overall equation for the entire network (median). However, the conclusion of the study was that the calibration of M_D to M_L, given the data available, was limited within the range of magnitude $2.0 < M_D < 5.0$.

Taking advantage of the availability of a large new data set of M_Ls, now routinely computed in parallel with historical M_Ds, Sandron *et al.* (2023) integrated the data set of Sandron *et al.* (2018) with M_L - duration pairs in the range $0.0 < M_D < 3.5$. The new orthogonal regression takes the form:

$$M_D\ (\cong M_L) = 2.416 \log t - 2.039 \tag{1}$$

with a $0.0 \leq M_D \leq 5.0$ range of applicability. This uniform homogeneous new M_D has been applied in the elaboration of the present catalogue.

2.3. Hypo71 ouput

The standard Hypo71 ALLdata.pun output file (which is included in the supplementary material) provides, along with the origin time, location and epicentre depth, some useful parameters on the reliability of the solutions, which are: RMS (the root-mean-square travel time residual, in seconds), ERH and ERZ (the horizontal and vertical standard errors in km, respectively), GAP (the largest azimuthal gap between azimuthally adjacent stations in degrees), and No. (the number of station readings). According to some well-known rules of thumb [summarised in Husen and Hardebeck (2010) and references therein] based upon a number of these parameters, a well-constrained hypocentre location should have a GAP less than 180°, at least eight travel time arrivals (of which at least one is an S-wave arrival), and at least one of which within a focal depth distance from the epicentre. Excessively high values of ERH and ERZ (greater than 10 km) indicate epicentre solutions to be eliminated or at least to be revised.

The ALLdata.pun output file has not been modified and is as it was after the location processing. It consists of 46,213 events (lines) between 7 May 1977 and 31 December 2022 located in NE Italy (Fig. 1).

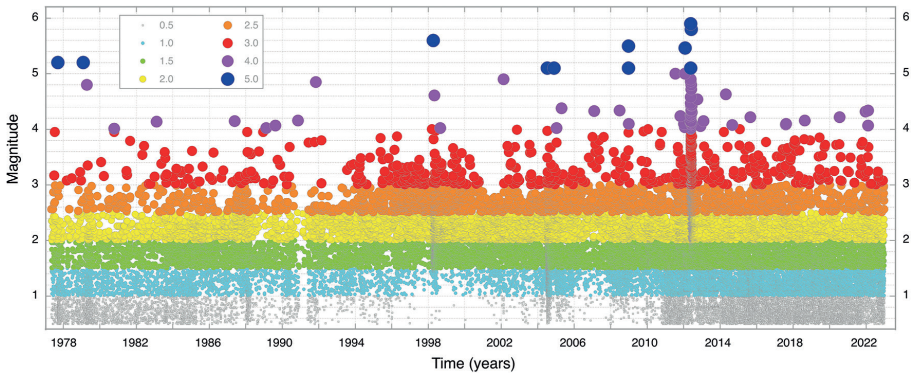

Fig. 1 - Time distribution of the located seismicity in the wide region. The interruption of the recording in 1991 was due to a fire in the building where the acquisition centre of the OX network operated.

2.4. Record selections

As far as the final catalogue is concerned, the following choices were made:

a) the magnitudes of some major events, whose value is known in the literature, were changed *a posteriori* (Table 1);

Table 1 - Earthquakes whose magnitude was taken from the literature.

Date	Time	M_L	Place
16 Sep. 1977	23:48:06.92	5.2	Tolmezzo, Friuli, NE Italy
6 Feb. 1979	09:49:46.97	5.1	Mt. Vordernberg, Austria
18 Apr. 1979	15:19:18.55	4.8	Chiusaforte, Friuli, NE Italy
12 Apr. 1998	10:55:32.88	5.6	Kobarid, Slovenia
14 Feb. 2002	03:18:02.93	4.9	Mt. Sernio, Friuli, NE Italy
12 Jul. 2004	13:04:06:36	5.1	Kobarid, Slovenia
24 Nov. 2004	22:59:39.83	5.1	Gargnano, Lombardia, N Italy
23 Dec. 2008	15:24:20.35	5.5	Neviano degli Arduini, Emilia, N Italy
23 Dec. 2008	21:58:26.32	5.1	Rossena, Emilia, N Italy
17 Jul. 2011	18:30:28.66	5.0	Sermide, Lombardia, N Italy
25 Jan. 2012	08:06:36.98	5.0	Brescello, Emilia, N Italy
20 May 2012	02:03:52.25	5.9	Camposanto, Emilia, N Italy
20 May 2012	03:02:49.31	4.9	San Felice sul Panaro, Emilia, N Italy
20 May 2012	13:18:03.01	5.1	Sant'Agostino, Romagna, N Italy
29 May 2012	07:00:02.72	5.8	San Prospero, Emilia, N Italy
29 May 2012	10:55:55.00	5.8	Carpi, Emilia, N Italy
21 Jun. 2013	10:33:56.63	5.2	Mt. Sagro, Toscana, N Italy
1 Nov. 2015	07:52:32.74	4.9	Dvor, Slovenia

b) a geographical box (Fig. 2) was introduced between the geographical coordinates 44.5° to 47.5° N and 9.5° to 15.5° E (after the selection, 45,529 events remained);
c) only events with a magnitude value were considered (39,432 events remained);
d) events with ERH and/or ERZ greater than 10 km were excluded (37,708 events remained).

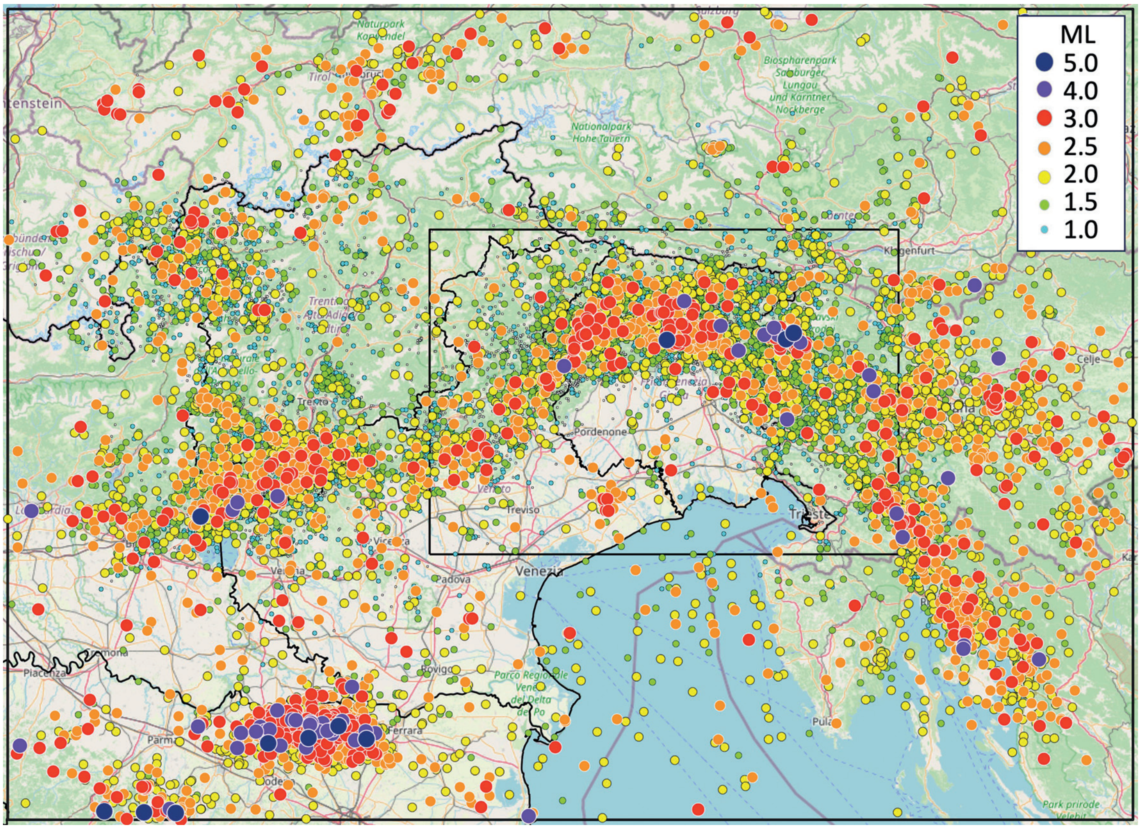

Fig. 2 - Earthquakes in the broader eastern Alps (44.5° to 47.5° N and 9.5° to 15.5° E) in the period 1977 - 2022 located in the present study. The box (45.5° to 46.7° N and 11.75° to 14.25° E) shows the area where the locations (24,980 events) are of acceptable quality. The epicentres are coloured according to the legend.

The above cited criteria should guarantee reasonably acceptable locations. At the end of the cited selection, 37,708 located events with magnitude up to 5.9 from the NE Italy earthquake catalogue: the quality of the locations obtained is quantified by the uncertainties associated with the various parameters of the location, as reported in Table 2. Very similar values have been obtained for the two areas considered.

3. Final remarks

Although a different earthquake catalogue was used by Sandron *et al.* (2023) for their study, an exhaustive description of the spatial and temporal distribution of the located seismicity can be found in that paper; in this paper only the main features are summarised.

Table 2 - Uncertainties related to the Hypo71 earthquake locations for the map and box (bold numbers) areas.

Variable	No.		GAP		DMIN		RMS		ERH		ERZ	
Mean	15.8	**15.6**	162.8	**156.9**	12.8	**9.4**	0.2	**0.2**	1.0	**0.8**	1.7	**1.6**
Median	12.0	**11.0**	151.0	**144.0**	9.9	**8.5**	0.15	**0.1**	0.8	**0.7**	1.3	**1.2**
Std Dev.	12.54	**12.23**	73.25	**72.55**	12.84	**6.18**	0.26	**0.19**	0.87	**0.66**	1.47	**1.36**
Std Error	0.064	**0.077**	0.377	**0.459**	0.066	**0.039**	0.001	**0.001**	0.005	**0.004**	0.008	**0.009**

Strong earthquakes ($M \geq 5$) are rare (Fig. 1) and are clustered during the first decade of the 21st century when the southern Apennines were involved with seismic sequences (Table 1 and Fig. 2). The main seismicity well designs the Alpine piedmont belt and continues in the External Dinarides (Carulli *et al.*, 1990).

The characteristics of the seismicity in the wide and small areas are well represented by the Gutenberg-Richter (GR) plot (Fig. 3). The *b*-value, obtained with the maximum likelihood method, is equal to 0.99 in the box area (Fig. 2) and 0.92 for the whole study region; both values are close to the *b*-value of 1.0, typical in seismically active regions. The *a*-value is 3.62 and 3.85 for the above two areas, respectively. Almost no fluctuations characterise the *b*-value of the wide region, testifying good space homogeneity. Conversely, some 'major' events ($M_L > 4.5$) move from the main distribution in the box area.

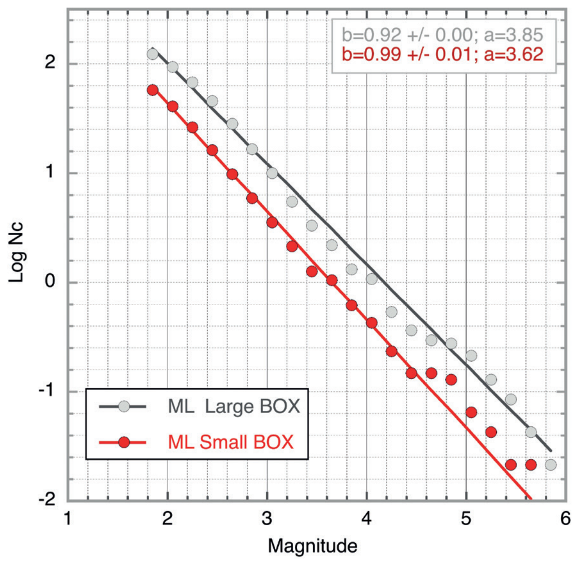

Fig. 3 - *b*-value plot for the map (grey) and box (red) areas.

Acknowledgments. The OX seismometric network is managed by OGS with the financial contribution from the Regione Autonoma Friuli Venezia Giulia. Many thanks are due to the past and current staff of the OGS Centre for Seismological Research: they deployed and maintain the OX network and manage the acquisition and elaboration of the data used in the present work. Elena Eva, INGV Genova, reviewed the manuscript suggesting interesting improvements.

Additional electronic material: phase readings, Hypo71 location parameters, Hypo71 summary output, and catalogue of selected and discarded events are available at the BGO webpage.

REFERENCES

Aric K., Freudenthaler A. and Lenhardt W.; 1992: *Seismological observations in the eastern Alps*. Phys. Earth Planet. Inter., 75, 145-152.

Bragato P.L., Comelli P., Saraò A., Zuliani D., Moratto L., Poggi V., Rossi G., Scaini C., Sugan M., Barnaba C., Bernardi P., Bertoni M., Bressan G., Compagno A., Del Negro E., Di Bartolomeo P., Fabris P., Garbin M., Grossi M., Magrin A., Magrin E., Pesaresi D., Petrovic B., Plasencia Linares M.P., Romanelli M., Snidarcig A., Tunini L., Urban S., Venturini E. and Parolai S.; 2021: *The OGS-northeastern Italy seismic and deformation network: current status and outlook*. Seismol. Res. Lett., 92, 1704-1716, doi: 10.1785/0220200372.

Carulli G.B., Nicolich R., Rebez A. and Slejko D.; 1990: *Seismotectonics of the Northwest External Dinarides*. Tectonophys., 179, 11-25.

Gasperini P.; 2002: *Local magnitude revaluation for recent Italian earthquakes (1981-1996)*. J. Seismol., 6, 503-524.

Husen S. and Hardebeck J.L.; 2010: *Earthquake location accuracy*. Community online resource for statistical seismicity analysis, 35 pp., doi: 10.5078/corssa-55815573.

Klein F.W.; 2002: *User's guide to HYPOINVERSE-2000, a Fortran program to solve for earthquake locations and magnitudes*, *4/2002 version*. U.S. Geological Survey, Menlo Park, CA, USA, Open File Report 02-171, 123 pp.

Lahr J.C.; 1999: *HYPOELLIPSE; a computer program for determining local earthquake hypocentral parameters, magnitude, and first-motion pattern*, *version 1.1*. U.S. Geological Survey, Reston, VA, USA, Open File Report 99-23, 116 pp., doi: 10.3133/ofr9923.

Lee W.H.K. and Lahr J.C.; 1975: *Hypo 71 (revised): a computer program for determining hypocenter, magnitude and first motion pattern of local earthquakes*. U.S. Geological Survey, Menlo Park, CA, USA, Open File Report 75-311, 113 pp.

Moratto L. and Sandron D.; 2015: *Optimazing the automatic location of the real-time Antelope® system in northeastern Italy.* Boll. Geof. Teor. Appl., 56, 407-424, doi: 10.4430/bgta0154.

OGS (National Institute of Oceanography and Applied Geophysics); 2016: *North-East Italy Seismic Network.* International Federation of Digital Seismograph Networks, doi: 10.7914/SN/OX.

Parolai S., Sandron D. and Rebez A.; 2021: *The 9 October 1963 Vajont catastrophe from the point of view of the WWSSN-LP recordings of the TRI-117 Station, Trieste, Italy*. Seismol. Res. Lett., 92, 3428-3436, doi: 10.1785/0220200467.

Peruzza L., Garbin M., Snidarcig A., Sugan M., Urban S., Renner G. and Romano M.A.; 2015: *Quarry blasts, underwater explosions, and other dubious seismic events in NE Italy from 1977 to 2013.* Boll. Geof. Teor. Appl., 56, 437-459, doi: 10.4430/bgta0159.

Rebez A. and Renner G.; 1991: *Duration magnitude for the northeastern Italy seismometric network.* Boll. Geof. Teor. Appl., 33, 177-186.

Rebez A., Renner G. and Slejko D.; 1984: *Calcolo della magnitudo locale da durata per la stazione sismologica di Trieste*. In: Finalità ed esperienze della Rete Sismometrica del Friuli-Venezia Giulia, Regione Autonoma Friuli-Venezia Giulia, Trieste, Italy, pp. 29-38.

Rebez A., Cecić I., Renner G., Sandron D. and Slejko D.; 2018: *Misunderstood "forecasts": two case histories from former Yugoslavia and Italy*. Boll. Geof. Teor. Appl., 59, 481-504, doi: 10.4430/bgta0244.

Renner G.; 1995: *The revision of the northeastern Italy seismometric network catalogue.* Boll. Geof. Teor. Appl., 37, 329-505.

Richter C.F.; 1935: *An instrumental earthquake magnitude scale*. Bull. Seismol. Soc. Am., 25, 1-32.

Richter C.F.; 1958: *Elementary seismology*. Freeman and Co., San Francisco, CA, USA, 768 pp.

Sandron D., Renner G., Rebez A. and Slejko D.; 2014: *Early instrumental seismicity recorded in the eastern Alps*. Boll. Geof. Teor. Appl., 55, 755-788, doi: 10.4430/bgta0118.

Sandron D., Gentile G.F., Gentili S., Saraò A., Rebez A., Santulin M. and Slejko D.; 2015: *The Wood-Anderson of Trieste (northeast Italy): one of the last operating torsion seismometers*. Seismol. Res. Lett., 86, 1645-1654, doi: 10.1785/0220150047.

Sandron D., Rebez A., Mucciarelli M., Di Bernardo F., Grimaz S. and Malisan P.; 2016: *Rapid estimation of the seismic impact through the active contribution of the Civil Protection volunteers*. Boll. Geof. Teor. Appl., 57, 183-193.

Sandron D., Rebez A. and Slejko D.; 2018: *Calibration of the duration magnitude for the North-Eastern Italy Seismic Network (OX) on the basis of the revised local magnitudes of the Trieste station*. Boll. Geof. Teor. Appl., 59, 249-266, doi: 10.4430/bgta0237.

Sandron D., Tufaro T., Scolobig A., Di Bernardo F., Parolai S. and Rebez A.; 2020: *A citizen science approach for supporting rapid earthquake impact assessments*. Int. J. Disaster Risk Reduction, 52, 101969, 10 pp., doi: 10.1016/j.ijdrr.2020.101969.

Sandron D., Rebez A., Tamaro A. and Slejko D.; 2023: *Recent earthquakes (2000-2021) in and around the Friuli Venezia Giulia region (NE Italy) and quality improvements of the OGS network monitoring capabilities*. Bull. Geoph. Ocean., 64, 237-258, doi: 10.4430/bgo00421.

Saraò A., Sugan M., Bressan G., Renner G. and Restivo A.; 2021: *A focal mechanism catalogue of earthquakes that occurred in the southeastern Alps and surrounding areas from 1928-2019.* Earth Syst. Sci. Data, 13, 2245-2258, doi: 10.5194/essd-13-2245-2021.

Saraò A., Tamaro T., Sandron D., Slejko D. and Rebez A.; 2023: *On the crowdsourcing of macroseismic data to characterize geological settings*. Int. J. Disaster Risk Reduction, 96, 103934, 14 pp., doi: 10.1016/j.ijdrr.2023.103934.

Slejko D.; 2018: *What science remains of the 1976 Friuli earthquake?* Boll. Geof. Teor. Appl., 59, 327-350, doi: 10.4430/ bgta0224.

Slejko D., Carulli G.B., Nicolich R., Rebez A., Zanferrari A., Cavallin A., Doglioni C., Carraro F., Castaldini D., Iliceto V., Semenza E. and Zanolla C.; 1989: *Seismotectonics of the eastern southern Alps: a review*. Boll. Geof. Teor. Appl., 31, 109-136.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2015: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, doi: 10.6092/58ff169a-2f02-46ae-908a-bdfcacea069c.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2016: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, doi: 10.6092/a608d853-755e-4177-aada-992857ccb44e.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2017: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, doi: 10.6092/3ff3c323-d7a4-4183-bea0-1a53814ac8b9.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2018: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, doi: 10.6092/c53f37ce-bcf3-453c-a2cf-1894d48cfbbb.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2019: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, doi: 10.6092/58ff169a-2f02-46ae-908a-bdfcacea069c.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2020: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, doi: 10.13120/108b8d94-361a-45f3-8195-fc4e8f73d264.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2021: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, doi: 10.13120/8b252b09-314f-456f-812a-b05268ecd001.

Snidarcig A., Bernardi P., Bragato P.L., Di Bartolomeo P., Garbin M. and Urban S.; 2022: *Bollettino della Rete Sismometrica dell'Italia Nord Orientale (RSINO), [Data set].* Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy, http://www.crs.ogs.it/bollettino_new/, last access 16/02/2024.

Suhadolc P.; 1978: *Total durations and local magnitudes for small shocks in Friuli*. Boll. Geof. Teor. Appl., 20, 303-312.

Corresponding author: Denis Sandron
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS
Borgo Grotta Gigante 42/c, 34010 Sgonico (TS), Italy
Phone: +39 040 2140 251; e-mail: dsandron@ogs.it