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Digital historical resources and their role in improving knowledge on 18th-century earthquakes in Carnia and the Friulian Prealps (Friuli Venezia Giulia, Italy)

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ABSTRACT The Italian Parametric Earthquake Catalogue (CPTI15 v 4.0, Catalogo Parametrico dei Terremoti Italiani) includes more than 200 earthquakes whose parameters are derived from preliminary AMGNDT95 studies, most of which are based on very few bibliographic references, or often only on a single one. The updating of AMGNDT95 studies has been underway for some years now. This paper deals with a group of $M_W \geq 5$ earthquakes that affected Carnia and the Friulian Prealps in the 18th century (1700, 1776, 1788, 1789, and 1794) and whose updating was funded by the Italian 2020 NASA4SHA PRIN project (Research Projects of National Interest). The AMGNDT95 studies, dealing with these earthquakes, were of better quality than average, having been based not only on an extensive analysis of pre-1900 earthquake compilations, but also on original historical research carried out in Carnia parish archives. However, the new study described in this paper has significantly increased knowledge on their effects (in terms of number of macroseismic observations available for all earthquakes, but most particularly for those of 1700 and 1776) thanks to the current availability of digital historical resources (Italian and European digital newspaper collections, regional heritage digital platforms) that were unimaginable in the 1990s.

Key words: historical earthquakes, Friulian Prealps, Carnia, 18th century, digital historical resources, Friuli-Venezia Giulia.

1. Introduction

Not long ago, some historical seismologists from an Italian institute were asked by an official visitor why they deemed it necessary to keep on studying past earthquakes that had already been studied before (some even more than once) and about which “all there is to know is already known”. We do not know whether their answer satisfied the inquirer or was dismissed as self-serving. However, from a historian’s viewpoint, that answer was undoubtedly the only possible one: we keep on studying earthquakes (or any other subject) because no one can really be sure that ‘the last word’ has been said on them.

The only real exception to this rule concerns the so-called fake earthquakes (Vogt, 1979;

Bellettati *et al*., 2007; Albini, 2011). When an event once believed to be an earthquake has been carefully studied and discovered to be either something else or even non-existent at all, then, and only then, it can be dismissed for good. In other cases, no matter how often and how well an earthquake is studied, there always remains at least the possibility of finding new evidence about it, somewhere. New evidence can come from the study of other subjects by researchers not at all involved in historical seismology; or from historical sources not considered by previous earthquake studies; or simply from sources that were unavailable or inaccessible for consultation at the time when those studies were made. New evidence can improve the general picture and size of a poorly-known supposedly 'minor' earthquake (e.g. Castelli, 2004; Bernardini *et al*., 2011), or cast doubts on the size of a supposedly 'major' one (e.g. Castelli and Stucchi, 2025).

This paper deals with five 18th-century earthquakes (1700, 1776, 1788, 1789, and 1794) located in Carnia and the Friulian Prealps (Table 1, bold lettering). Four of the five earthquakes considered are, together with the 27 March 1928 Tolmezzo earthquake, the most energetic ever ($M_W \geq 5$) on record in Carnia and the Friulian Prealps. The fifth one (1789), currently located elsewhere and in a lower magnitude range by Rovida *et al*. (2022), was added to the lot because reliable contemporary evidence suggests it could have been a local event of higher magnitude. For the sake of completeness of information, it should be pointed out that all the remaining records of the 18th-century earthquakes shown in

Table 1 - Earthquakes located in Carnia and its immediate surroundings in the 18th century, according to the CPTI15 v.4.0 catalogue (Rovida *et al.*, 2022). In bold: earthquakes considered in this study. Legend: ALBAL003 = Albini *et al.*, 2003; AMGNDT995 = AMGNDT, 1995; CAMAL012 = Camassi *et al.*, 2012; *MdpN* = Macroseismic data points Number; ***Io*** = epicentral intensity; *Imax* = maximum observed intensity [expressed in the Mercalli-Cancani-Sieberg (MCS) scale]; F = felt (data not sufficient for assigning an intensity degree).

Year	Month	Day	Hour	Minute	Epicentral Area	Study	*Io* (MCS)	*Mw*	*MdpN*	*Imax* (MCS)
1700	**7**	**28**	**-**	**-**	**Carnia**	**AMGNDT995**	**8-9**	**5.7**	**28**	**9**
1762	4	18	11	30	Carnia	CAMAL012	4	3.7	1	F
1767	5	10	-	-	Carnia	CAMAL012	4	3.7	1	F
1770	10	7	-	-	Carnia	CAMAL012	4	3.7	1	F
1775	8	26	-	-	Carnia	CAMAL012	4	3.7	1	F
1776	**7**	**10**			**Friulian Prealps**	**CAMAL012**	**8-9**	**5.8**	**19**	**8-9**
1778	4	21	-	-	Carnia	CAMAL012	4-5	3.9	1	4-5
1780	9	8	17	-	Carnia	CAMAL012	4	3.7	1	F
1781	12	23	17	-	Carnia	CAMAL012	4	3.7	1	F
1782	4	11	20	-	Carnia	CAMAL012	4	3.7	1	F
1782	12	10	-	-	Carnia	CAMAL012	4	3.7	1	F
1786	12	28	-	-	Carnia	CAMAL012	4	3.7	1	F
1787	4	25	-	-	Carnia	CAMAL012	4	3.7	1	F
1787	12	9	4	30	Carnia	CAMAL012	4	3.7	1	F
1788	**10**	**20**	**-**	**-**	**Carnia**	**CAMAL012**	**7-8**	**5.1**	**9**	**8-9**
1789	**8**	**4**	**-**	**-**	**Friulian Prealps**	**AMGNDT995**	**5-6**	**3.9**	**5**	**4-5**
1792	10	20	-	-	Carnia	CAMAL012	4	3.7	1	4
1794	**6**	**30**	**4**	**45**	**Friulian Prealps**	**AMGNDT995**	**7-8**	**5.4**	**8**	**7-8**
1795	1	1	2	15	Carnia	ALBAL003	5	4.1	1	5
1797	10	30	5	-	Carnia	CAMAL012	4	3.7	1	F
1799	10	26	4	-	Carnia	CAMAL012	4	3.7	1	4

Table 1, are in fact derived from single observations of low intensity macroseismic effects [$I \leq$ IV-V Mercalli, Cancani, Sieberg (MCS)] made in a single locality (Sutrio) by a contemporary witness (Tommasi, 1890). The epicentral parameters currently available for these earthquakes are extremely uncertain, and even assuming that there is some room for their improvement such an objective would not have been achievable within the scope of this study.

2. The context (geography, history, and seismicity)

The region known as Carnia (eastern Alps) lies between the Carnic and Julian Alps (*Alpi Carniche, Alpi Giulie*). Carnia encompasses the upper basin of the Tagliamento River and the valleys (locally termed *canali* or channels) of the rivers Bût (Canale di San Pietro), Chiarsò (Canale d'Incarojo), and Degano (Canale di Gorto). Most of the region is taken up by mountains, interspersed with few, widely-spaced, permanent settlements. The chief historical and administrative town is Tolmezzo; other main localities are Ampezzo (Tagliamento Valley), Comeglians and Ovaro (Gorto Valley), Paluzza (San Pietro Valley), and Paularo (Incarojo Valley). Administratively speaking, Carnia was largely autonomous in the Middle Ages, until 1420 when it was annexed to the Republic of Venice, whose destinies it followed up to the Republic's end (1797). In the first half of the 19th century, Carnia belonged to the Austrian Empire from 1814 to 1866, and afterwards to the Kingdom (now Republic) of Italy.

Historically, the main characteristic of Carnia economy was a strong seasonal mobility, both internal (related to high-altitude agriculture and forestry) and external, the latter being directed north across the Alps and south towards Venice and central-southern Italy, and mainly concerned with the trade of locally-produced textile goods.

The state of knowledge about Carnia seismicity is peculiar: the current Italian catalogue (Rovida *et al*., 2022) does not include any earthquakes located in the area prior to 1700 A.D., and the strongest local earthquakes are all concentrated in the 18th century, with the only exception of the 1928 Tolmezzo earthquake. For this reason, it is important to ensure that the level of knowledge on 18th-century Carnia earthquakes is the best possible.

3. Previous AMGNDT95 studies

The major 18th-century Carnia earthquakes were studied in the first half of the 1990s in the frame of the "Hazard Project" of the National Group for Earthquake Defense (GNDT) of the National Council of Research (CNR) (Stucchi, 1991). These studies followed the explicitly rapid methodological approach called "Analysis Through Seismological Repertories" (Stucchi, 1993), based on the retrieval/critical review of information provided by descriptive seismological compilations and their immediate sources. According to this approach, further investigation of original sources was not mandatory but left to the choice of individual researchers. The Udine Research Unit, entrusted with the study of Friuli earthquakes, carried out an in-depth investigation of several Carnia parish archives, whose results were summarised in Barbano (1993); on the contrary, the extended reports produced on the studied earthquakes were never published in their entirety, although the related intensity data were used to compile the successive versions of the Italian Parametric Earthquake Catalogue (CPTI).

4. The research

4.1. Annibale Tommasi and colleagues; the groundbreaking scholars of Friuli historical earthquakes

Dozens of historical earthquake compilations were produced in Italy in the last two decades of the 1800s, and were later used by Mario Baratta to build up his nationwide compilation (Baratta, 1901). The Friuli compilation by Tommasi (1888) is particularly outstanding for the extent of the supporting research, as evidenced by the list of historical sources cited in the chronological catalogue appended to it.

Annibale Tommasi, born in Mantua (Lombardy) in 1858, was a student of Torquato Taramelli, who introduced him to geology and palaeontology. From 1883 to 1890, while holding the chair of natural sciences in Udine, Tommasi devoted considerable time to historical research on earthquakes, benefiting from a highly productive partnership with his mentor Taramelli, and two local erudites, Vincenzo Joppi (an indefatigable collector of thousands of books and manuscripts relevant to the history of Friuli, now preserved in the Vincenzo Joppi Civic Library in Udine) and Alexander Wolf (a distinguished historian, whose extensive library was later acquired by the same Civic Library) (Lucchino, 2011; Simonetto, 2011; Tamburlini, 2011).

Tommasi also published a list of earthquakes that occurred in Sutrio, compiled by Father Francesco Del Negro (Tommasi, 1890) and co-authored a study on the earthquakes of Tolmezzo (Taramelli *et al*., 1893).

4.2 Digital resources and historical earthquake research

Annibale Tommasi, Vincenzo Joppi, and Alexander Wolf made decisive contributions to the collection and preservation of a significant portion of Friuli's bibliographic and documentary heritage. In recent years, this heritage has been largely made available in digital format thanks to European funding (POR-FESR 2014–2020 Urban Agenda). The completely open access to this vast heritage offers a truly unique opportunity for the advancement of historical earthquake studies.

All this huge amount of historical data is now freely available within Teche Udine (2025), the digital collection of the Vincenzo Joppi Civic Library in Udine, including manuscripts, rare printed materials, historical periodicals, and archival collections, from which an extremely wide range of information on historical and natural events of every kind can be derived (Fig. 1).

Among the manuscript collections of the Civic Library in Udine, two are absolutely essential: the *Fondo Principale* (the Main Collection), comprising nearly 2,000 manuscripts acquired over time by the library, and the *Fondo Joppi* (the Joppi Collection), consisting of 722 manuscripts almost entirely focused on Friuli, collected over about 60 years by brothers Vincenzo and Antonio Joppi. These, together with thousands of printed texts, constitute the core of the Civic Library's heritage.

Another great opportunity for the improvement of historical earthquake knowledge was provided, in the last few decades, by the widespread digitisation of Italian and European historical newspapers (gazettes). In the 1990s, when these earthquakes were first studied, the consultation of gazettes required lengthy and costly visits to libraries scattered about Italy and Europe, in order to browse and copy single items of relevant news. Today, a great many 18th-century gazette collections (first and foremost, those of the Austrian National Library) are freely accessible online. This greatly facilitated our investigation, allowing a much more extensive

Fig. 1 - Teche Udine: the homepage of a great Friulian heritage repository (left). An example of the multi-layered information on natural events to be found in Teche Udine: the Borta landslide of 1692 (right).

perusal of Italian and European gazettes available for the studied years than would have been possible in the 1990s (Fig. 2).

Sources of this kind are extremely important for the study of 17th/18th-century history in general and for the improvement of knowledge on natural phenomena in particular, on account

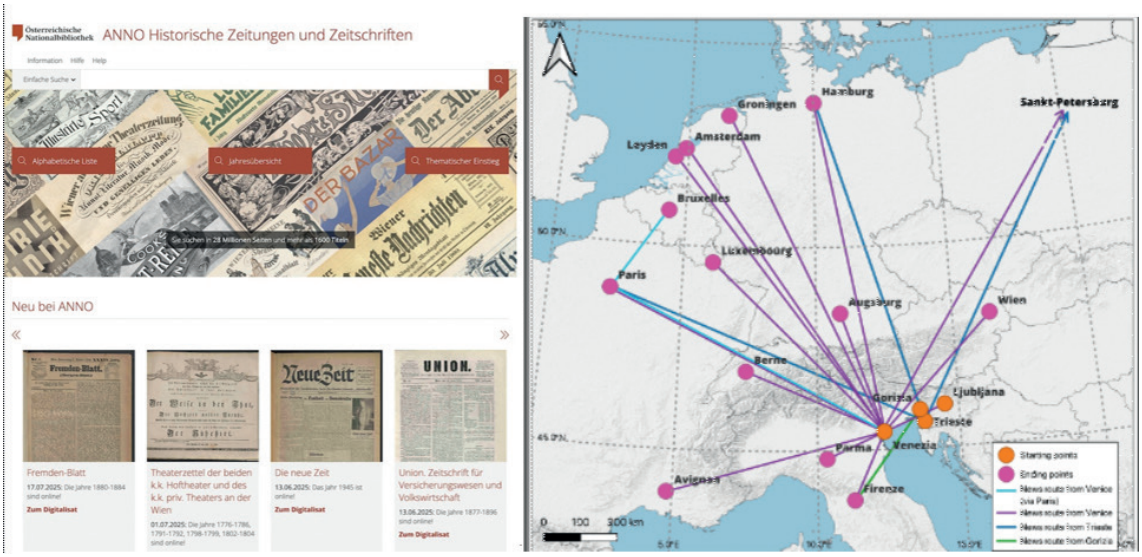

Fig. 2 - Homepage of the Austrian National Library Digital Newspaper Archive (left). Distribution of European gazettes that reported the 10 July 1776 Carnia earthquake (right).

of the mechanisms of 18th-century journalistic communication. At that time, a highly efficient European journalistic network was operating much like modern news agencies, ensuring the regular circulation of information on the most significant and relevant events (such as earthquakes, given their potential impact on trade routes). Thus, original information on Italian earthquakes can be retrieved from European gazettes, sometimes published very far from the areas directly affected by the earthquakes themselves. Fig. 2 shows, by way of illustration only, the spread of news on the 1776 earthquake throughout Europe.

The consultation of Italian and European journalistic sources was particularly rewarding for the earthquakes of 1700, 1776, and 1788, less so in the case of the latter earthquakes because of the European upheavals ensuing from the French revolution of 1789, following which the contribution from Italian gazettes completely disappeared. Table 2 lists the places of print of the gazettes that report the studied earthquakes.

Table 2 - Places of print of 18th-century gazettes reporting the studied earthquakes (names according to present usage). Links to digital versions of the above and places of preservation of original collections of the non-digitised ones are provided as Supplementary materials in Table S1.

Year	Month	Day	Places of print of 18th-century gazettes reporting the studied earthquakes
1700	7	28	Amsterdam, Ancona, Bologna, Leyden, Munich, Naples, Paris, Rotterdam, Venice.
1776	7	10	Amsterdam, Augsburg, Avignon, Berne, Brussels, Florence, Groningen, Hamburg, Leyden, Ljubljana, Luxembourg, Paris, Parma, Saint Petersburg, Venice, Vienna.
1788	10	20	Augsburg, Bologna, Bouillon, Florence, Hamburg, Karlsruhe, Leipzig, Lisbon, Liège, Luxembourg, Madrid, Mantua, Munich, Paris, Parma, Bratislava, Rome, Weimar, Vienna, Zurich.
1789	8	4	Hamburg, Munich.
1794	6	30	Parma.

5. Results

5.1. The earthquake of 28 July 1700 (Raveo)

The earliest catalogue record for this earthquake (Postpischl, 1985) cited Baratta (1901), in turn based on Tommasi (1888), who derives information on heavy damage and six victims in the Enemonzo hamlet from contemporary parish registers.

The 1990s investigation of 10 parish archives collected data on about 15 heavily affected localities in the upper Tagliamento and Degano valleys, with highest damage occurring in Raveo (Catalan, 1991). Our study found evidence of lesser damage elsewhere, in local memoirs (Ellero, 1700; Poiano, 1700), and a number of earthquake reports by contemporary gazettes. The earliest one ([Avvisi di] Venezia, 1700.07.31) describes the tremor as clearly felt in Venice, an information unknown to previous studies. Later reports ([Avvisi di] Venezia, 1700.08.07; Gazzetta Napoletana civica e commerciale, 1700.08.07) mention a death-toll of "700 people (…) in Carnia as well as in the Austrian border regions" (Gazzetta Napoletana civica e commerciale, 1700.08.14) and "in the Duchy of Carniola" (Gazette [de France], 1700.09.11). Locally given estimates of casualties were much lower: six in Raveo and 22 in Lauco (Ellero, 1700), or generically "several people" (Note su terremoti, 18th century). It is unclear whether the gazette writers gave exaggerated estimates simply to gain readers' attention, or whether their reports could be at least partly

reliable. In the latter case, this could mean that the damage area was not limited to Carnia but extended beyond the Alps. So far, however, the involvement of the Duchy of Carniola remains unverified. The authoritative Viennese newspaper *Wiener Zeitung* did not exist yet in 1700 (it was first issued in 1703) and this particular earthquake was not mentioned by seismological compilations covering Carniola (Suess, 1874; von Radics, 1901; Hoernes, 1902; Schorn, 1902; von Radics, 1908-1909). In any case, the overall picture of its impact is now significantly enhanced (Fig. 3). The macroseismic observations provided by this study, with respect to the previous studies, are 38 versus 28, and the maximum intensity is IX-X versus IX MCS (Table 3). The most heavily damaged locality was Raveo, in the Province of Udine.

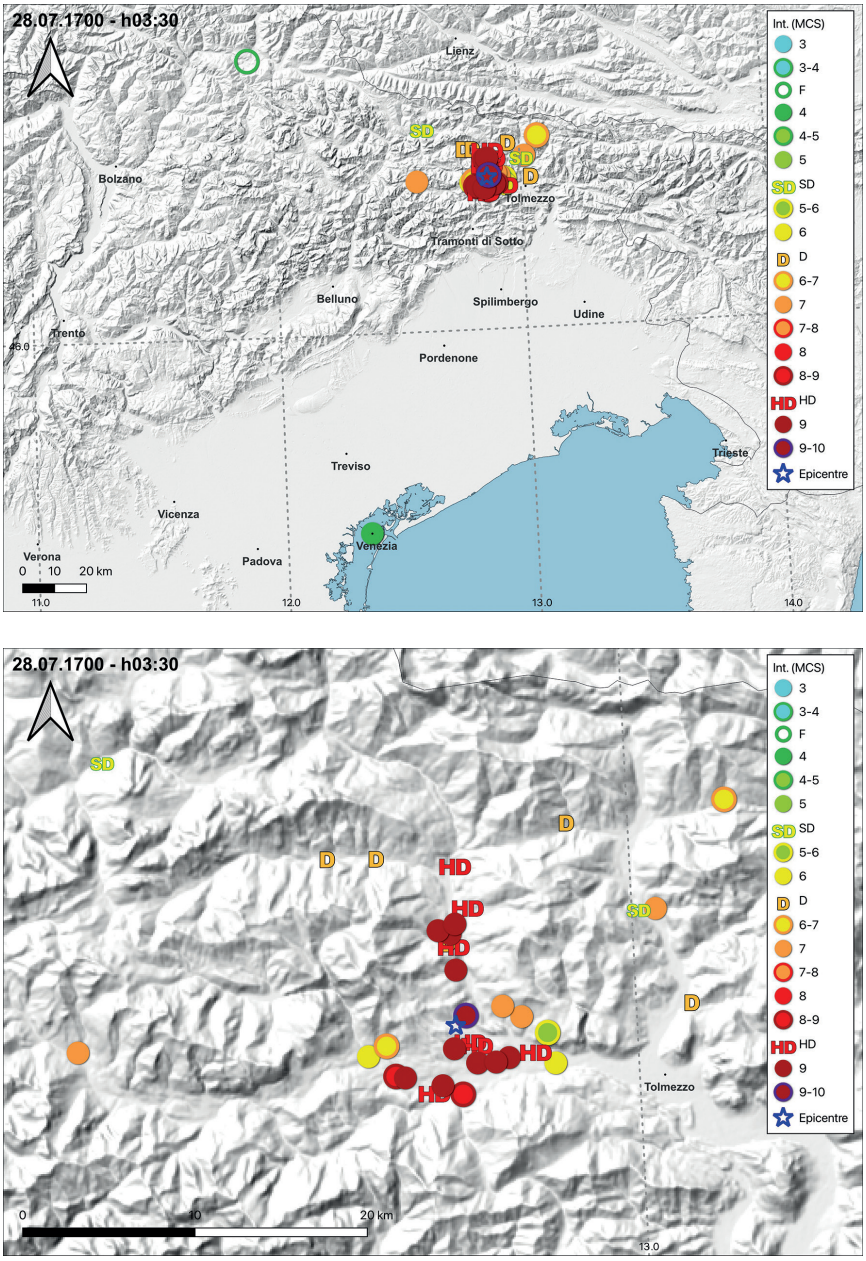

Fig. 3 - Intensity map of the 28 July 1700 Raveo earthquake according to this study: whole area (top); damage area (bottom).

5.2. The earthquake of 10 July 1776 (Carnic Prealps)

The earliest catalogue record for this earthquake (Postpischl, 1985) cited Baratta (1901). The latter provides information on about 15 localities in the damage area and in the far field, from a set of bibliographic references, chief among which are Tommasi (1888, 1890), that by themselves provide information on 11 localities. Tommasi (1888) is especially important because it is partly based on a local journalistic pamphlet, printed in Udine and Venice (Vera e distinta, 1776). We failed to find any copy of this pamphlet, despite an extensive search in the main Italian and European libraries and the manuscript collections of the Civic Library in Udine. Therefore, it is likely that the copy consulted by Tommasi was the only surviving print of a scarce print run and that it was later lost or destroyed, perhaps during World War I.

The study by Barbano and Catalan (1992) increased the available information by carefully reassessing the sources identified by previous studies and finding new data from parish archives and contemporary gazettes. A very important contribution came from a detailed eyewitness account published in the *Nuovo Giornale d'Italia*... by Count Fabio Asquino (a member of the Society of Practical Agriculture of Udine), which describes earthquake effects in about 10 localities (Asquino, 1776).

Curiously enough, the first mention of serious damage caused by this earthquake appears in a correspondence from Venice, printed in a Russian gazette (*St. Petersburgische Zeitung*, 1776.08.12). Later gazettes depict an increasingly dramatic scenario, culminating in the total destruction of a moderately-sized village: **"**The village of Ceulis, consisting of 50 houses, was so destroyed that barely a trace of it remains. Almost the same happened to Tramonti, Sequalis, Monte Reale, and other nearby towns, leaving those populations in the greatest desolation and terror**"** (*Gazzetta Universale*, 1776.08.03). This passage, concerning the most severe macroseismic effect on record, poses the crucial interpretive issue of how to identify Ceulis, a name unknown to contemporary maps and Friulan toponymic literature. According to professor Franco Finco, the foremost living expert of Friulan toponymy and editorial director of the Series QTF - *Quaderni di Toponomastica Friulana* (the Friulian Toponomy Notebooks), published by the Società Filologica Friulana, Ceulis could most plausibly correspond to Chievolis (Finco, 2004), a hamlet in the Tramonti di Sopra municipality. This identification is based on phonetic similarity and also highly compatible with the earthquake scenario.

Another important issue concerns the victims, widely reported by contemporary sources but not by seismological compilations. There is archive evidence of fatalities and Asquino (1776) gives a provisional count of 11 victims. The gazettes report gradually increasing numbers, often linked to earthquake-triggered landslides. Thus, it is at least likely that the actual death-toll was higher than 11. The overall picture of the earthquake's impact shows far more severe effects than previously believed (Fig. 4). The macroseismic observations provided by this study with respect to the previous studies are 29 versus 19, and the maximum intensity is IX-X versus VIII-IX MCS (Table 3). The most heavily damaged localities were Chievolis (IX-X MCS), Andreis, and Poffabro (IX MCS), all in the Province of Pordenone.

5.3. The earthquake of 20 October 1788 (Tolmezzo)

This earthquake was already well described by Baratta (1901), who drew not only on the compilations by Tommasi (1888, 1890), but also on the Spangaro (1788, 1789) eyewitness account and on contemporary data collected by Tellini (1895). The study by Barbano and Catalan (1993) and this one extended the range of contemporary evidence with a number of journalistic

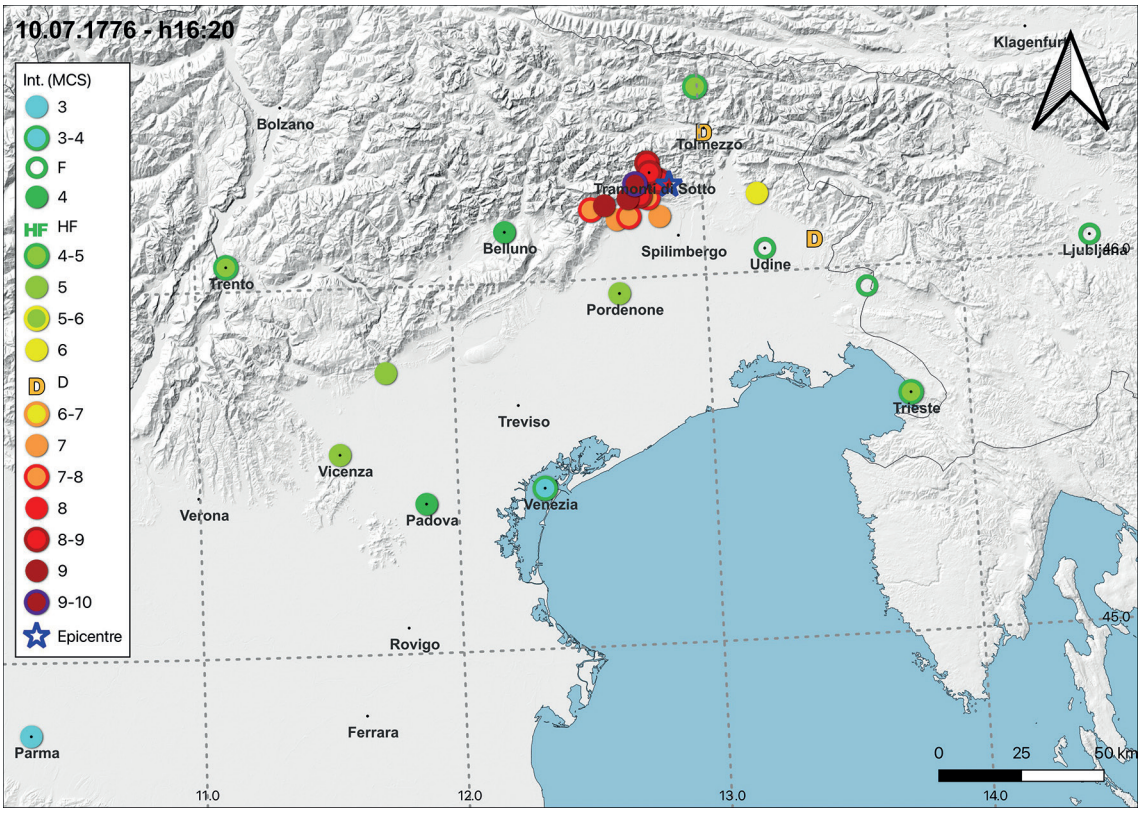

Fig. 4 - Intensity map of the 10 July 1776 Carnic Prealps earthquake according to this study.

reports (especially from German-speaking areas) and other sources published in local history journals.

The European press gave great prominence to the severe damage undergone by Tolmezzo and, particularly, by the Linussio family textile factory, an international-level business, whose fabrics were marketed throughout the continent. The Linussio family went to great lengths to reassure customers of their ability to fulfil standing orders, causing press-releases to be published in many European gazettes ([*Gazzetta di*] *Bologna*, 1788.11.04; *Gazzetta di Parma*, 1788.11.07). According to an eyewitness (Spangaro, 1788, 1789), in Tolmezzo 76 houses collapsed outright, the rest were severely damaged, and around 30 people died (other sources mention from 27 to 32 victims). After the earthquake, Tolmezzo presented a dramatic scene: Lieutenant Marco Antonio Giustinian, tasked with surveying the damage, describes "a dreadful clutter of buildings, some collapsed with the death of 27 inhabitants, and the rest about to fall down and crumbling" (ASTol, 1788).

Apart from Tolmezzo, there is no report of damage to other towns. The shaking is reported to have been strong in Paluzza, San Daniele del Friuli, and Sutrio, and slight in Padua, Udine, Vicenza, and Venice (Fig. 5). The macroseismic observations provided by this study, with respect to previous studies, are 12 versus nine, and the maximum intensity is IX vs VIII-IX MCS (Table 3).

5.4 The earthquake of 4 August 1789 (Tramonti di Sotto)

Compared to other earthquakes, this one could have attracted less attention by contemporary witnesses because of its proximity to the more well-known Tolmezzo event

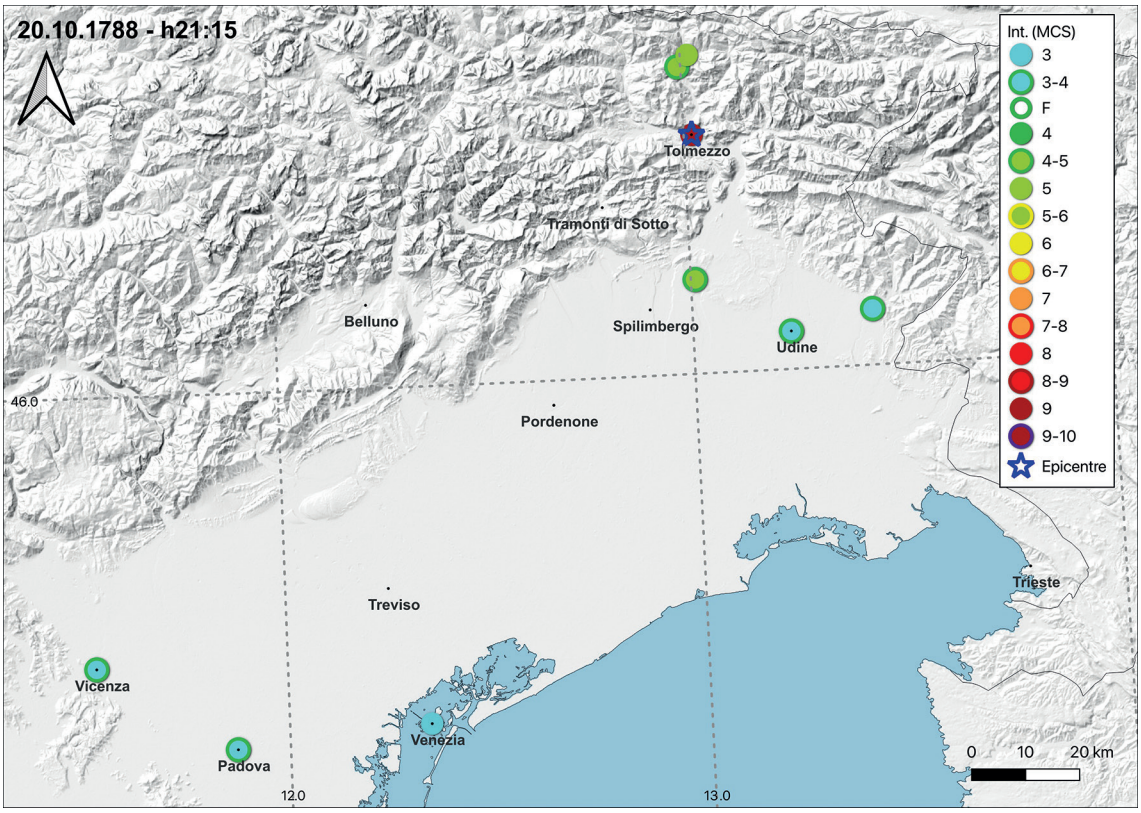

Fig. 5 - Intensity map of the 20 October 1788 (Tolmezzo) earthquake according to this study.

of 1788. Its earliest catalogue record (Postpischl, 1985) cited Baratta (1901), who once again relied on Tommasi (1888). The latter provides a dramatic enough description, based on an unidentified handwritten report kept in the Tramonti parish archive: "In August 1789, on the 3rd at 10 p.m., a violent shock was felt in Tramonti, followed on the 4th by several strong tremors that caused enormous damage. All the house roofs were destroyed, especially in Tramonti di Sotto; some dwellings collapsed; many walls fell, and many more were cracked and fissured".

The research carried out in the 1990s failed to locate the report cited by Tommasi (1888). Being, thus, unsubstantiated, the description by Tommasi (1888) was deemed doubtful and/or related to a minor, non-damaging shock, with a low intensity being assigned for Tramonti di Sotto. As a result, the earthquake's epicentre was located in the Conegliano area, about 100 km SW of Tramonti (Fig. 6) by the CPTI15 v.4.0 catalogue (Rovida *et al.*, 2022). The present study, after failing to find any mention of the 1789 earthquake in Italian gazettes, was at last able to discover explicit descriptions of collapses in the Tramonti area in German gazettes printed in Hamburg and Munich. Another general, but unmistakable, mention of high damage in Tramonti was also provided by a private diary written in Vicenza, which at the end of August notes: "It has been learned that the earthquake felt here on the 4th and 5th of the current month was devastating in the village of Tramonti in Friuli" (Tornieri, 18th–19th centuries). Thus, although the available information remains rather generic, it seems reasonable to re-evaluate the 1789 earthquake, classifying the effects in Tramonti as uncertain between degrees VII and VIII MCS (Fig. 6). The macroseismic observations provided by this study, with respect to previous studies,

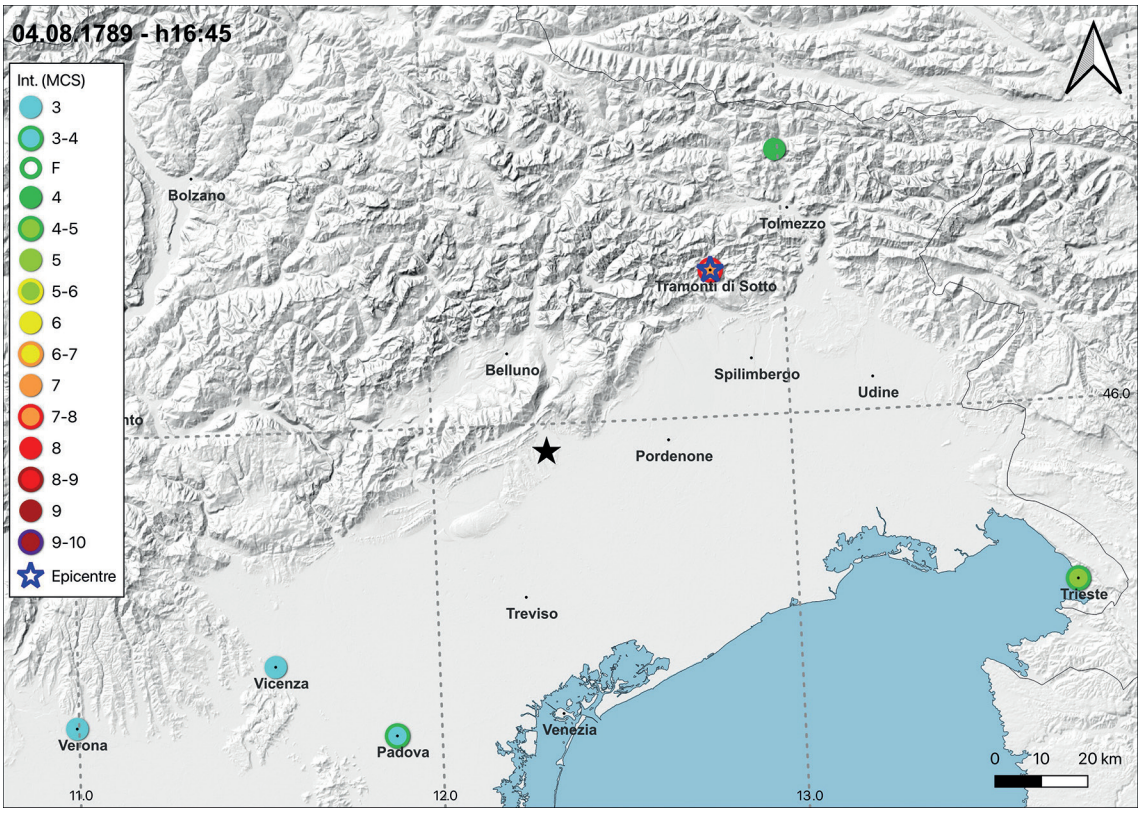

Fig. 6 - Intensity map of the 4 August 1789 (Tramonti di Sotto) earthquake according to this study. The black star represents the previous epicentral location by CPTI15 v. 4.0 (Rovida *et al*., 2022).

are six versus five and the maximum intensity is VII-VIII versus V-VI MCS in Tramonti di Sotto, in the Province of Pordenone (Table 3).

5.5. The earthquakes of June 1794, Friulian Prealps

The Baratta (1901) entry for this earthquake is based almost entirely on earlier compilations, namely Tommasi (1888), citing a report kept in the parish archives of Tramonti, and Taramelli *et al*. (1893). Tommasi (1888) affirms that the worse effects (collapse of several houses) occurred in the Canal di Cuna, identifiable with the small settlement of San Vincenzo, which counted about 15 families at the time but has now disappeared (only some ruins and a small modern church remain). In Tramonti, a settlement formed by three nuclei of buildings, half of the houses were severely damaged in the midway nucleus (Tramonti di Mezzo), while damage was less in the upper and lower nuclei (Tramonti di Sopra and Tramonti di Sotto).

This study retrieved further details from compilations that drew on contemporary local sources. The contribution of journalistic sources, in this case, is virtually nil, due to a drastic shift in the political and administrative context in which these sources were produced. Gazettes were fewer than before and mostly dedicated to political-administrative news, with little or no news from abroad. It is also worth noting that news about a major Vesuvius eruption (which started on 15 June 1794), quickly saturated the space available in the journalistic communication channels.

The scenario that emerges from the collected testimonies is of several earthquakes

occurring on the night between 6 and 7 June 1794 (Fig. 7 top). Sources disagree as to their times of occurrence and it is impossible to distinguish their effects, which are to be considered cumulative. One of them slightly damaged Trieste, confirming the high energy of the earthquake. Baratta (1901) thought this could have been an independent event, but evidence points out to its belonging to the Tramonti sequence instead. Among the aftershocks, the most significant occurred on 30 June 1794 (Fig. 7 bottom), causing further damage in the three inhabited centres of Tramonti. The compilations also mention a presumed shock on 1 September 1794 that turned out to be non-existent, having been generated by a hasty reading made by Pognici (1872) of a list of earthquakes compiled by the parish priest of Tramonti, Father G. Molinari.

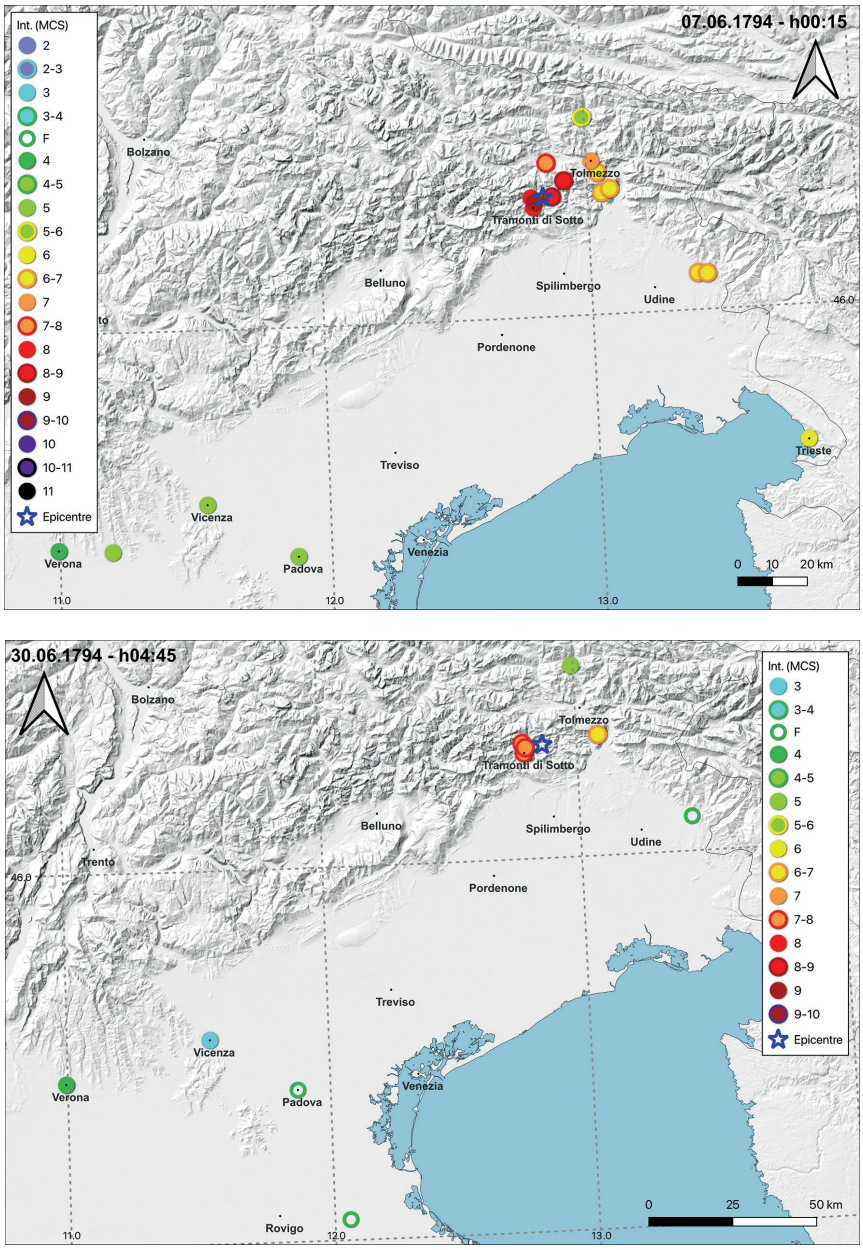

Fig. 7 - Intensity maps of the Friulian Prealps earthquakes of 7 June 1794 (top) and 30 June 1794 (bottom) according to this study.

For the 6-7 June earthquakes, the macroseismic observations provided by this study, with respect to previous studies, are 20 versus 19, with the same maximum intensity (IX MCS). For the 30 June earthquake, the macroseismic observations are 10 versus eight, with maximum intensity also remaining the same, VII-VIII MCS (Table 3). The most damaged localities are Tramonti di Mezzo (IX MCS) and San Vincenzo (VIII-IX MCS), in the Province of Pordenone, and Pozzis (VIII-IX MCS) in the Province of Udine.

Table 3 - A comparison between macroseismic observations provided by previous studies and by this study. Legend: *MdpN* = Macroseismic data points Number; *Imax* = maximum observed intensity (MCS).

Year	Month	Day	Rovida *et al.* (2022) reference studies			This study		
			Epicentral area	*Nmdp*	*Imax* (MCS)	Epicentral area	*Nmdp*	*Imax* (MCS)
1700	7	28	Carnia	28	9	Raveo	38	9-10
1776	7	10	Friulian Prealps	19	8-9	Carnic Prealps	29	9-10
1788	10	20	Carnia	9	8-9	Tolmezzo	12	9
1789	8	4	Friulian Prealps	5	5-6	Tramonti di Sotto	6	7-8
1794	6	7	Friulian Prealps	19	9	Friulian Prealps	20	9
1794	6	30	Friulian Prealps	8	7-8	Friulian Prealps	10	7-8

6. Conclusions

The revision of 18th-century earthquakes of Carnia and the Friulian Prealps led to a consistent increase of affected localities (Table 3), both in the damaged and in the felt areas, particularly for the earthquakes of 1700 and 1776. The information gathered for each locality, along with detailed descriptions of the observed effects, enabled a significant re-evaluation of the maximum intensities for the 1776 and 1789 earthquakes. For most of the studied events, we found the number of victims and, in some cases, also reports of coseismic phenomena, confirming the strong impact of these earthquakes on the environment.

The epicentral parameters are basically confirmed, with the exception of the 1789 earthquake. This event had been located by Rovida *et al*. (2022) in the Conegliano area, about 100 km SW of the area considered in this study, whereas evidence collected by this study indicates that it was instead located in the Friulian Prealps.

The results of this study confirm and detail the significance of the historical seismicity of Carnia and the Friulian Prealps, and consequently also their earthquake potential. This suggests a consideration of a general importance to be made. After the 1976 earthquakes, which caused strong damage and destruction in Friuli, building structures were upgraded, adopting earthquake-resistant criteria. This happened particularly in the easternmost part of the region (which was the one most damaged by the 1976 earthquakes), but less so in areas where the 1976 earthquakes had a more limited impact, such as the Province of Pordenone, where the 1776, 1789, and 1794 earthquakes are located. Therefore, in this area there could still be a considerable number of buildings that do not meet the earthquake-resistant technical standards adopted in other parts of the region. The results of this study suggest that in Carnia and the Friulian Prealps it would be advisable to pay particular attention to the seismic retrofitting of existing structures, in order to improve their resistance to seismic shaking.

Acknowledgments. The epicentral parameters and intensity data points provided by previous studies, for the earthquakes considered in this paper, are available at the Italian Archive of Historical Earthquake Data (ASMI) (Rovida *et al.*, 2017). The new list of intensity data points assessed for the earthquakes considered in this paper and the full list of historical sources now available (complete with their transcriptions and translations) will be made available in a dedicated issue of the *Quaderni di Geofisica* series (Baranello *et al.*, 2025, forthcoming). This study was funded by the Italian 2020 PRIN project (Reasearch Projects of National Interest "Fault segmentation and seismotectonics of active thrust systems: the Northern Apennines and Southern Alps laboratories for new Seismic Hazard Assessments in northern Italy (NASA4SHA)", directed by Riccardo Caputo (University of Ferrara), Work Package 7 coordinated by Emanuela Falcucci (INGV, Roma). A preliminary version of this paper was presented at the 43rd National Conference of the GNGTS (National Group for Solid Earth Geophysics), 11-14 February 2025, Bologna, Italy. The authors are indebted to Tullia Catalan for her groundbreaking research on the historical earthquakes of Carnia and to Franco Finco (Pedagogical University of Carinthia, Klagenfurt) for the identification of an elusive locality. Many thanks to Ina Cecić (with her aide Stanko) and to Alessandro Rebez for careful and thoughtful revisions of the first draft of this paper.

Supplementary material. Places of print of 18th-century gazettes reporting the studied earthquakes and places of preservation of original collections of the non-digitised earthquakes are provided at the BGO webpage.

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