ARE SEISMOGRAMS RECORDED IN SCHOOLS EDUCATIONAL TOOLS ONLY?

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Introduction. In the frame of the NERA project and under the WP 8, an inventory of schools hosting seismic stations for educational purposes has been compiled with the aim, among others, to establish a network for data exchange. Such an inventory reveals that there are more than 600 instruments, most of which in full activity, in schools of the Mediterranean area. The number of stations is somewhat proportional to the date when educational projects began (Zollo *et al.*, in press), so countries like France, United Kingdom or Ireland, all places where a long tradition in "seismology in schools" is established, own most of the existing stations.

The make and technical characteristics of these devices widely vary: some schools have assembled their own mechanical seismometer with very simple materials while some others have designed an acquisition system and coupled it to a sensor available on the market. In some cases, stations are bought from semi-professional or professional manufacturers that have devoted a special care to the educational field. These factories have designed cheap instruments the technology of which is based on the more expensive instruments that are instead available at professional level. These recording items are often equipped with an internet connection, have a broad-band like seismometer, offer a real time view of the recording (helicorder) and provide data in SAC format. In a sentence, they are very much similar to the devices currently used in professional (national or regional) networks to monitor seismicity. Moreover, in principle stations installed in a country are very much alike or perfectly identical, representing as a matter of fact a semi-professional seismic network.

It is then straightforward to wonder what is the role of the data recorded and stored by these instruments and especially what is the potential of these information. Are these instruments providing any additional information to the professional seismic networks? Could they complement a professional database?

In this paper a rough analysis of the data collected by a school network is analysed and compared with "official" data. It is shown that in some cases seismograms recorded from stations in schools can perform very well and their data could, under certain circumstances and with some limitations, be used instead of / in addition to professional data.

Stations in schools: pro and cons. The most important bias that may affect seismic data is the time. The accuracy in the definition of time is a goal that affects even stations included in professional seismic networks and cannot be neglected. Reliable clocks are expensive, so most educational seismic digital acquisition system do not offer any gps to reduce the final cost of the instrument. Actually many schools do not care about the precision of the clock because, for example, they just aim at comparing the shape of waveforms of earthquakes occurred in different parts of the world or at the simple recognition of different wave trains. Conversely, many equipments installed in schools have their own gps to provide, with fair to good accuracy, geographical position and time. The device is often manufactured by external companies that already have sound experience in the field of gps measurements and then offer reliability.

In this study only stations that can provide an absolute timing are taken into account; this condition alone cannot be considered a proof of high quality or reliability. Investigating on this aspect is out of the aims of this paper, however the fact that all the data considered in this study are recorded by identical stations assembled and sold by the same manufacturer should ensure that if a timing problems exists it affects all stations with similar magnitude and should be considered systematic.

Another possible weak point is the signal to noise (S/N hereinafter) ratio for stations installed in schools. On the premise that instruments in schools are installed with aims that are greatly different from collecting data, it must be remarked that the choice of the site is certainly a key point. In most cases the sensor is placed in an easily reachable position within the school for guided tours by the teachers and maintenance by the students but under these conditions the site may be very noisy.

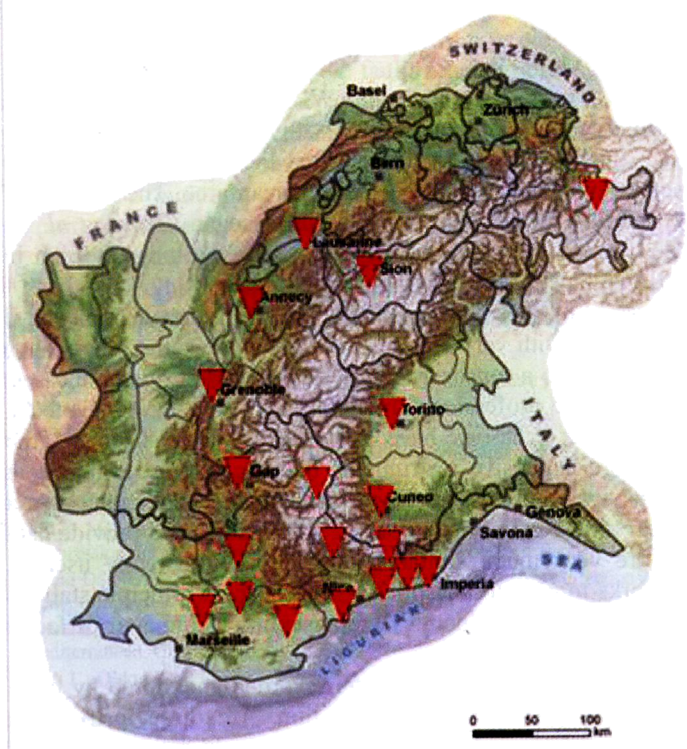

Fig. 1 - Position of the seismic stations installed in schools within the O3E project.

Moreover, schools are not "quiet" places since they are mostly close to main roads and very much disturbed during the normal daily school activity. However, having in mind that the philosophy of installation is very different from a real seismic station and especially the purposes and aim are different, it must be noted that if the station is installed under the assistance of a seismologist, the operating position will be a good compromise between data quality and easiness of access. In most cases schools have basement that are used as archives, having the double advantage of being accessible but not frequently used; sometimes gyms are located in a separate building, giving the chance to stay far from "seismic noises"; warehouses are also often present in school facilities, and sometimes they turn to be a fair site to mount seismic sensors. All these are potential fair to good places for the installation of a sensor.

Fortunately to the negative aspects of the installation in schools corresponds a series of positive elements. Schools are closed to public, and then quite, from late afternoon to early morning, during weekends and vacations. Unless they be placed in densely built-up areas, the traffic is proportional to the number of students and teachers attending the school so is in average very low during non-school hours.

Finally, most schools have their own internet connection so transmitting data through the web is not a challenge like it sometimes happens for stations that, being located in isolated places, are perfect from the point of view of noise but very much demanding from the point of view of logistic and data transmission..

Testing the quality and assessing the role of data. To answer the questions about the role of data recorded in schools, a few seismograms extracted from the database of the school network (Fig. 1) operating in northwestern Italy (https://sites.google.com/site/itaschoolseismo/; http://ftpaster2.unice.fr/o3e/index.asp) and southeastern France and established within the O3E (Observation de l'Environnement à but Éducatif pour l'École - Observation of the Environment for Education aims in schools) project are taken into account and used to locate the relative earthquake with professional softwares. The same phase picks are then merged into professional data to check their effects or bias on the location of the earthquake.

The procedure is described in the following and the obtained results are only meant to have a qualitative significance. In fact only a limited cluster of events has been used in this study due to the very low number of seismic events recorded by all schools. It must be underlined that after the end of the O3E project, that was originally designed to either help the schools to run the stations

Tab. 1 - Locations of the April 19, 2011, 20:04, M=2.8.
a) is the location obtained using data collected from regional and national networks, which is here used as a reference; b) is the location obtained with the school data only; c) to g) are for locations obtained with an increasing number of data from the school (1 to 5 stations, corresponding to 2 to 10 phases); h) shows how the "official" location would result if 5 seismograms of stations of the national network would be unavailable while i) shows the results when these seismograms are replaced by those recorded in schools. The table reports for each location the origin time, the geographical coordinates, the number of phases used for location, the gap, the errors and quality estimate as defined in Hypo. For a visual and immediate analysis, some of the results are also outlined in Fig. 2.

	ORIG TIME	LAT	LON	DEPTH	PHASES	GAP	RMS	ERH	ERZ	Q
a)	42.17	44N18.69	7E23.69	17.40	56	72	0.71	1.9	2.2	C
b)	41.32	44N19.93	7E24.68	20.07	10	111	0.44	4.4	8.2	C
c)	42.12	44N18.46	7E23.45	18.10	58	73	0.73	1.9	2.5	C
d)	42.07	44N18.38	7E23.20	18.78	60	74	0.72	1.9	2.4	C
e)	42.11	44N18.19	7E23.15	18.74	62	74	0.72	1.8	2.2	C
f)	42.06	44N18.45	7E23.14	18.72	64	74	0.73	1.8	2.2	C
g)	42.09	44N18.46	7E23.34	18.92	66	73	0.73	1.7	2.2	C
h)	42.11	44N19.15	7E23.15	18.72	46	131	0.76	2.2	4.0	D
i)	42.04	44N18.73	7E22.92	18.91	56	184	0.77	1.9	3.1	C

either assist teacher and students in their learning activities, the continuity of the data has been deeply affected by many failures. Most of the problems arose with failures in the internet connections, and were never or in very long time fixed, rendering the database incomplete. A discussion on the necessity to ensure continuation of educational projects will be presented in the last paragraph as it is a big loss to have stations the data of which are not collected or used.

The seismograms for the events with most recordings occurred inside the network have been selected and phase picked; they have then been later used for location in different ways. In a first attempt they have been used alone, after they have been added to the "official" database, that is the list of phases from the national and regional compilation of data. Finally they have been employed to substitute some of the professional picks. All three datasets have been used with a standard velocity model to get location and errors by using a standard HYPO procedure.

In order to check the improvement of a location with respect to the others, one should know the exact origin time and location of the source; these parameters are only available in case of man made triggers, like a shot or a quarry blast. Since none of these parameters were known, we used here as a reference location for each event that published in the official bulletin. Of course a level of uncertainty is introduced by acting in this way. However, since the study is aiming at a qualitative estimate, knowing how close our data can lead to the published location, which is by the way the best available because it is obtained by the most complete dataset, is enough to roughly estimate the performances of the stations.

In Tab. 1 the results for the different locations of one event (M 2.8, April 19, 2011 20:04) selected among those that have been used for this study are shown. Describing the result for one event only is of course restrictive, but the reader must take into account that the majority of events considered for this work showed similar features and that showing a comprehensive table could affect the readability of the paper.

The final locations in Tab. 1 are labelled with letters and in particular a) is the location as published, which is here used as a reference; b) is the location obtained with the school data only; c) to g) are used for locations obtained with an increasing number of data from the school (1 to 5 stations, corresponding to 2 to 10 phases); h) shows how the "official" location would result if 5 seismograms of stations of the national network would be unavailable while i) shows the results when these seismograms are replaced by those recorded in schools. The table reports for each location the origin time, the geographical coordinates, the number of phases used for location, the

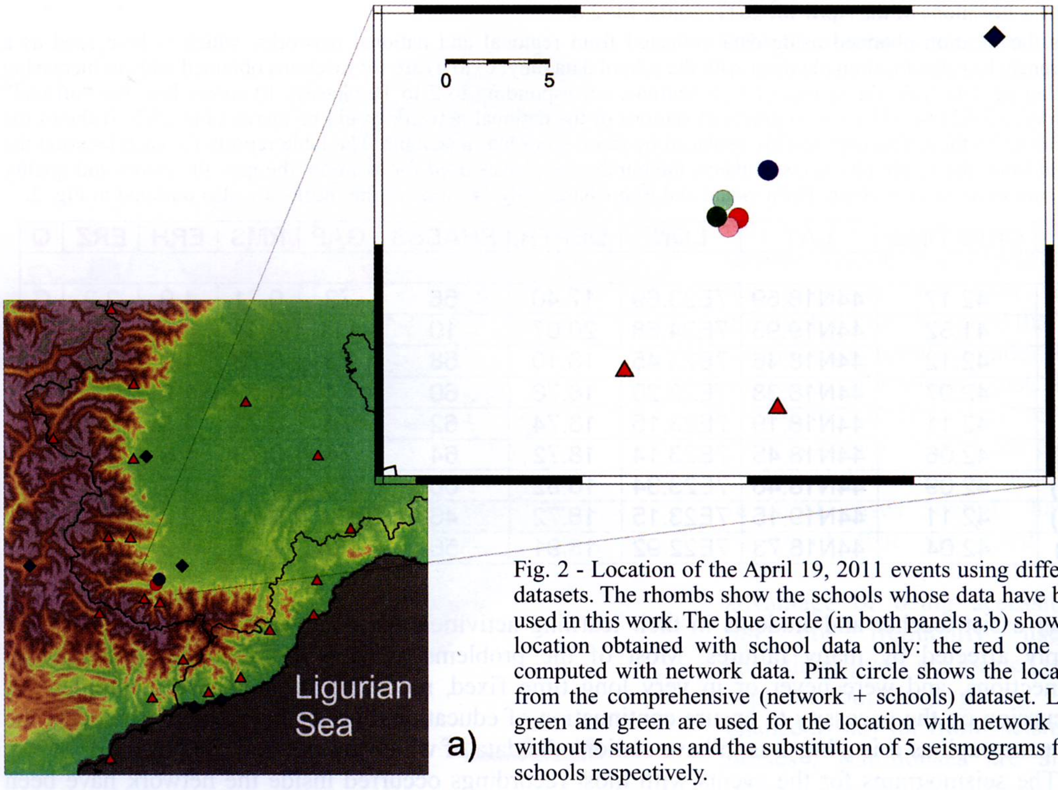

Fig. 2 - Location of the April 19, 2011 events using different datasets. The rhombs show the schools whose data have been used in this work. The blue circle (in both panels a,b) show the location obtained with school data only: the red one that computed with network data. Pink circle shows the location from the comprehensive (network + schools) dataset. Light green and green are used for the location with network data without 5 stations and the substitution of 5 seismograms from schools respectively.

gap, the errors and quality estimate as defined in Hypo. For a visual and immediate analysis, some of the results are also outlined in Fig. 2.

Both the values in Tab. 1 and the coloured symbols in Fig. 2 clearly demonstrate that the data provided by schools perform very well either as standalone or as part of a dataset. In fact the reference location (a) in Tab. 1 and ….circle in Fig. 2) and that computed with the school data only are very similar ; the differences can be easily explained by taking into consideration the very low number of data of the school data set. However the figure and Tab. also show that including data from school in a poor location (compare h) and in Tab. 1) can dramatically improve the result and mimic the official location (compare i and a lines in Tab. 1).

Conclusion. There are so many seismic stations in school spread all over Europe that a debate about the role of the data collected by these instruments is not only desirable but also necessary. In order to contribute to the discussion, in this study probably for the first time ever the performances of data collected by schools with semi-professional instruments are analysed and compared with official information. The experiment is limited to a small network located at the border between France and Italy and the data are those collected with stations available on the market and belonging to one particular brand. These two aspects greatly reduce the chance to export the results to other areas or instruments. Moreover, the restrained number of data does not permit to make a statistical analysis. However, although the results can only be treated in a qualitative way, they contribute to force the seismologists to draw more attention to the data collected in schools. In fact the present study confirms that the seismograms from schools can provide a reliable location, and then prove to be a good educational tool. On the other hand, the data show the capability to be used as a complement for existing professional databases in case of failures or lack of data. In this sense they can also be regarded as "emergency" data when the earthquake is not well recorded by the monitoring arrays or more data are needed. Apart from these particular cases, some applications of the data provided by schools can be studies of local seismicitiy in areas where the regional networks are not dense enough and/or the events occurring there are under the recording threshold or studies of local events (exlosions, quarry blasts) that may be not detected by national arrays.

Nevertheless, the aim of the present study is not to propose the prospect to regularly merge school with professional data. In fact, the establishment of a seismic network for monitoring a country or a region is often based on means adequate for the target, and does not require (nor it is recommended) an hybrid choice (semi-professional instruments in fair sites).

This study shows that under certain circumstances (failure of a station, need to fill a seismic azimuthal gap) the data provided by schools are worth more than then the educational aim only.

Unfortunately, as already discussed, the continuity of data from schools is severely affected by the absence of funding and by the fact that educational projects, except in very few cases, have a limited duration in time. These constraints do not permit a prompt intervention of seismologists and technicians in case of failure or malfunctioning after the project or activity is over; they dramatically reduce the hours devoted to learning and activities of students and teachers, with or without the assistance of a researcher; finally they render not worth the purchase of fairly expensive instruments since without continuity they are useless or under-used, and this in turn decreases the quality of data for either aspects, education and monitoring.

A good compromise could be to install more professional stations in "good" S/N schools. By doing that we would satisfy the need of schools of having available a seismometer for educational activities and the necessity of seismologists to find places in urban areas where some of the facilities required for an optimal installation (internet connection, electric power, easiness of access) are already present.

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