Project S6 – Data base dei dati accelerometrici italiani relativi al periodo 1972 - 2004

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Abstract

The Italian strong-motion data base includes 2182 three component waveforms relative to 1004 earthquakes with maximum magnitude 6.9 (1980-11-23 Irpinia earthquake) in the period range 1972 – 2004 and is devoted to engineering and scientific communities.

During this time span, the strong motion data have been acquired by different institutions, namely ENEL (*Ente Nazionale per l'Energia Elettrica*, Italian Electricity Company), ENEA (*Ente per le Nuove tecnologie, l'Energia e l'Ambiente*, Italian Energy and Environment Organization) and DPC (*Dipartimento della Protezione Civile*, Italian Civil Protection) with different purposes (permanent strong motion monitoring of the Italian territory and temporary monitoring during seismic sequences or before permanent installation).

In the 18 months of the S6 project the data have been collected, homogenized and processed according to the defined standards. Acceleration, velocity, displacement and acceleration response spectra have been calculated, together with the most used engineering parameters. In order to increase the data quality, the parameters relative to the seismic events have been included after a careful revision, through the use of the most updated seismic catalogues and data bases. The data relative to the recording stations have also been added, not only collecting existing data, but also promoting new field investigations of various type (borehole geophysical tests, seismic refraction, seismic reflexion, SASW, geological and geo-mechanical surveys).

The data set has been organized in a relational data base, which is made of four main "blocks", relative to waveforms, seismic events, recording stations and references. The data base is distributed in a stand-alone format, which can be downloaded on a PC and explored through the MS Access software, or it can be accessed via the web at the address: http://itaca.mi.ingv.it. The on-line data base can be interactively searched by the user according to personal needs through user friendly data queries, which allow the identification of waveforms with particular characteristics. A range of display and download options allow users to view data in multiple contexts, extract and download metadata, time series and spectra files.

The documentation relative to data collection, data format, data base structure, processing standards and waveform metadata is contained in the project web portal at http://esse6.mi.ingv.it.

1. Results of the project: general description

The project goals have been almost entirely fulfilled. The minimum expected result, represented by the mere collection of existing data has been reached. In addition, the data base has been enriched by a huge amount of metadata, some of which have been collected during the project, promoting new investigations. The data base, unlike existing ones, is characterised by the care spent in increasing the metadata quality, which cost time and financial efforts.
Another notable feature of the project is the data distribution policy. Two approaches of data distribution were adopted: a MS Access file, that can be directly downloaded on the PC, or the web portal, where the data base can be interactively searched by the user according to personal needs, through user friendly data queries. In order to help users, a wide range of display and download options were planned in order to display data in multiple contexts, extract and download metadata and time series.

Another relevant result is the interaction of the S6 project with other seismological DPC-INGV ones. In particular, there was a collaboration with project S3 for the study of the Gubbio area, where two boreholes were drilled and geophysical tests were performed to obtain the Vs and Vp profiles. A collaboration was carried on with the S1 project for the verification of the Italian hazard map (MPS04) with the peak ground acceleration values recorded in the last 30 years. Two of the research units, officially included in S4 and S3 projects, collaborated to this project receiving an integration of funds for performing field activities.
Finally there was a collaboration with the EC project NERIES at two tasks, namely NA5 *Improving accelerometric data dissemination*, for the exchange of experiences acquired in the data base structure and the strategies of data dissemination, and JRA4 *Geotechnical site characterization*, for the exchange of soil velocity profiles and the definition of the relevant soil geotechnical and geophysical parameters to be stored in the data base.

The project has a prevalent technological imprint and no research advances have been reached. The potential of the data base is the research that can be carried on with it in the immediate future. Many applications in seismology and earthquake engineering make use of strong motion data, from the evaluation of the empirical attenuation relationships, to the verification of shaking scenarios, hazard maps and real time shake-maps, among others.
These 18 months spent in collecting data, defining standards and designing data distribution facilities, represent an investment made by the scientific community. The challenge for the future is the use of the data for research advances.
As preliminary result, the data set used by Sabetta and Pugliese (1987) to derive the Italian empirical ground-motion attenuation relation has been revised and integrated with the records of the most relevant earthquakes occurred since 1984. A new set of coefficient has been obtained using the same functional form. The comparison between the new attenuation relation and the Sabetta and Pugliese (1987; 1996) shows the tendency of the latter to overestimate the PGA on rock sites (Bindi et al., 2007), as shown in Figure 1.

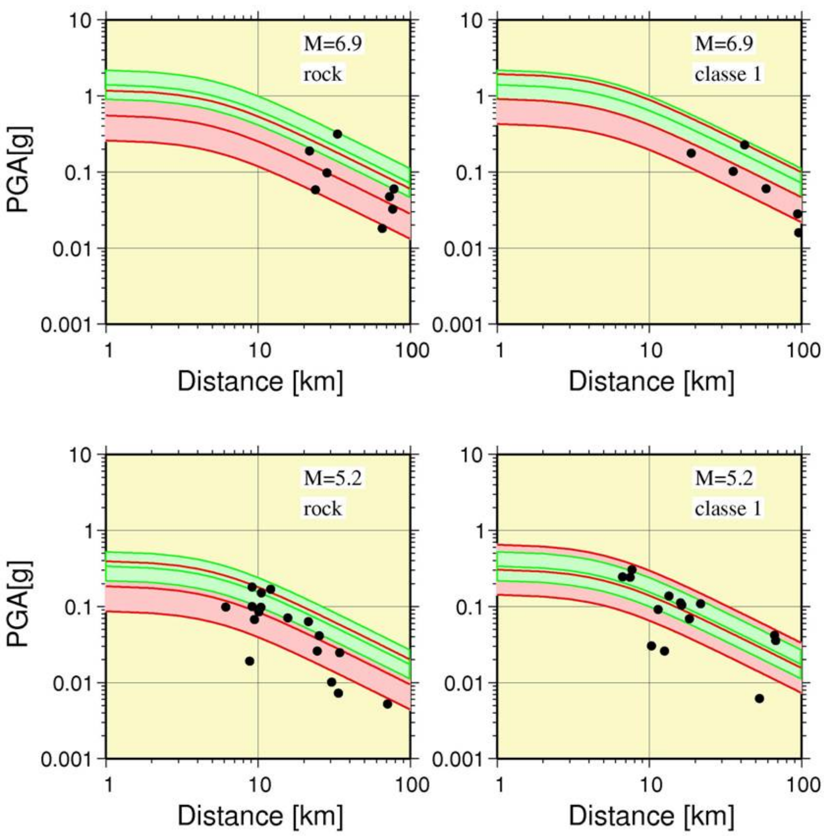

Figure 1: Comparison between the Sabetta and Pugliese (1996) attenuation relation (green) and the model obtained with the new data set (red). The areas represent the mean value ± one standard deviation. Black dots are observations for a Mw 6.9 earthquake (top) and 5.2 (bottom), respectively. On the left attenuation for rock sites, on the right attenuation for class1 sites (shallow alluvium).

However, at the conclusion of the project many issues remain opened and not solved, at least definitively. The data collection stops at 2004 and a huge amount of data has been gathered by the Department of Civil Protection in the time span 2004-2007. The quality of recording instruments increased, in accuracy and precision and the same amount of strong-motion data as in the 1972-2004 period has been collected. In addition, in the last decade new strong motion networks have been installed, managed by different institutions than DPC, whose data have not been included in the S6 data base.

The issue of the recording site characterization is still open, as only few sites were investigated during this project. But this task cannot be carried on routinely by scientific institutions, so field investigation standards should be defined in order to outsource this activity to private companies which should work under a strict scientific supervision.

2. Results of the project: detailed description by single tasks

The project was carried out in four main tasks:

Task 1 – Data base structure definition and data base control
Task 2 – Waveform collection and processing
Task 3 – Verification of seismic events, station and instrument metadata
Task 4 – Data base implementation and data dissemination

The activity 1 regarded the definition of the data base architecture and the selection of a software for the data base management.
The data base is handled through two different relational data base management system: Ms Access® 2003, of major use among research institutions and public administrations, for CD-ROM release, and MySQL for the web distribution. The selection of the former product is driven by the simplicity of the software, the worldwide diffusion and the possibility of being linked to software's for the management of spatial data, such as ESRI ArcGis® and Arcview®, and software for the scientific calculation such as Matlab®.
48 tables were created in order to store the information regarding the seismic events, the recording stations, the installed instruments and the strong-motion parameters. They are connected through a relational structure in order to avoid data redundancy.
Figure 2 exemplifies the recording station "block" of the data base.

The waveform format has been unified according to one standard. The file name is composed of 33 characters which include the event time, the recording network, the recording site, the component, the correction flag and the time series type (acceleration, velocity, displacement or acceleration spectrum). This structure was thought in order to be managed with simple OS commands. The waveform file in ASCII format contains a 43 row header of metadata which regard the event, the recording site and the instrument characteristics. The processing information are also added, for a correct data use. This structure makes each record self-consistent. The waveforms are also available in SAC format, which is mainly used by the seismological community and can be handled by many softwares. The data are distributed in processed and raw format, so that each expert user can re-process the data according to his needs.

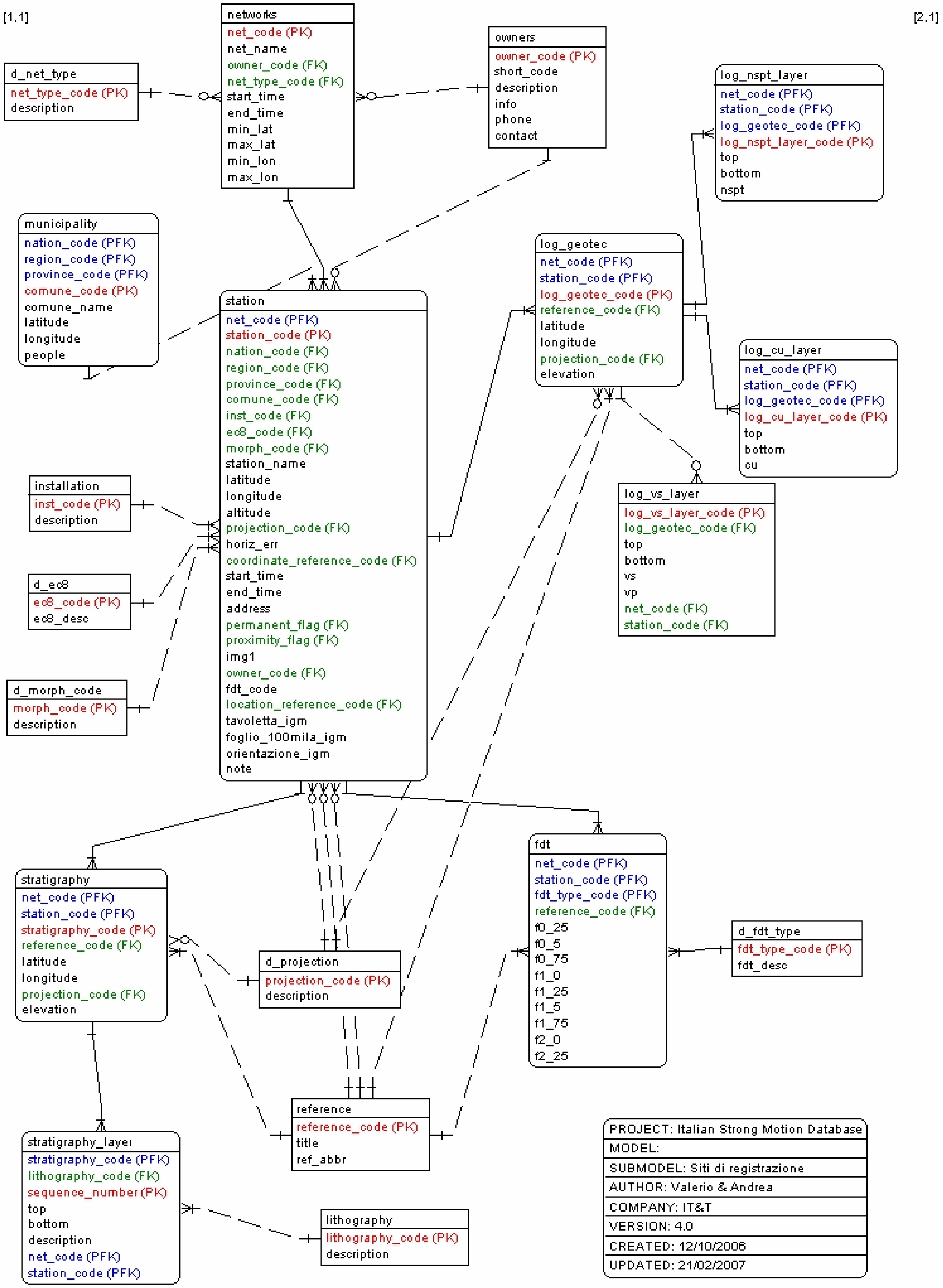

Figure 2: example of the recording site “block” of the data base

The second task mainly regarded the establishment of a standard for data processing.
It is well known that strong-motion records require processing, as they contain a variable noise level which depends on different causes. Nevertheless, there is no univocal solution for data processing, as the correction procedures not only depend on the recording instrument characteristics, but also on the user which can decide subjectively the selection of the processing parameters and options (Boore and Bommer, 2005).
In this project the correction procedures were selected in order to obtain processed data which could give reliable estimates of acceleration, velocity, displacement and acceleration response spectra, in a limited amount of time. In order to reach this goal, the fundamental choice of one-by-one waveform processing instead of automatically processing was made, although it required a big effort. To optimize the achievement of data quality in the short 18 month time period, simple, but effective processing procedures adaptable to different data type were selected.

The Italian strong-motion data base is composed by waveforms recorded by different instruments. Before 1997 the instruments were almost exclusively analog, while, after 1997 they were progressively substituted with digital ones. The two type of data have different nature and require different processing procedures.
The records obtained by analog instruments have generally the following characteristics:

- the instruments operate in stand-by and the activation depends on the exceeding of an acceleration threshold, which often causes the lack of the first arrivals in the signal (i.e. P-wave phase);
- the instrument frequency generally does not exceed 25Hz;
- the waveforms are recorded on a film and they require to be enlarged and digitized (in automatic or manual way) before being processed.

The presence of low frequency noise is particularly evident when the time series are integrated to obtain velocity and displacement, which result in unrealistic time series. This can be attributed to the data start at a trigger acceleration level, to baseline shifts, to digitizing effects, or to the lateral shift of the film during the recording.

The waveforms recorded by digital instruments, generally do not have the limitation of the analog data. They generally contain the pre-event memory, instruments have frequencies much higher than the ones of engineering interest (i.e. 50 Hz), the sampling rates are high (i.e. 200 pt/s) and the data digitizing is automatic through an internal A/D converter. Nevertheless, they are affected by "errors". The baseline effect is present and this is evident when the unprocessed time series are integrated. The pre-event memory is not enough to discriminate noise from signal at low frequency, as the noise is contained in the signal itself.

During the project several decision were taken in order to process all the data contained in the data base in a rather homogeneous way, being aware of the different origin of digital and analog data.
From the raw analog records the linear trend has been removed, the signal has been convolved for the instrument response, then the time series has been band-pass filtered, selecting the high pass frequencies by visual inspection of the Fourier spectrum, in order to detect the deviation from the omega-square shape. The low-pass frequency is generally selected close to the instrument frequency, usually centred on 20-25 Hz.

For the digital records the convolution for the instrument response has not been performed, as the instrument response is generally higher than 50 Hz. The linear trend fitting the entire record has been removed, instead of the common practice of using the pre-event trace, as very few records had a useful pre-event. A band pass filter has been applied selecting the high pass frequency similarly to the analog records, while the low-pass frequency is generally applied in the range 25-30 Hz.

The filter type was selected in order to avoid phase shifts in the signal, which can alter the calculation of velocity and displacement time-histories and the shape of the elastic response spectra at frequencies higher than the applied low-cut. A raised cosine filter was used for the analog records, which are often triggered on the S-phase, while an acausal 4th order Butterworth was used for the digital signals, after applying a cosine taper at the beginning and at the end of the signal in order to avoid the presence of filter transients. Every single processing was devoted to preserve the low frequency content. Nevertheless, the displacement time-series may be not considered enough reliable, as, in to preserve the actual displacement, it is advisable to use ad-hoc correction procedures, as it was proposed in the DPC-INGV project S5.
Figure 3 shows the uncorrected acceleration recorded by an analog instrument at Conegliano Veneto during the Friuli mainshok of 1976-05-06 20:00:12. Figure 4 show the steps adopted to process the time series, together with the obtained velocity and displacement time series.

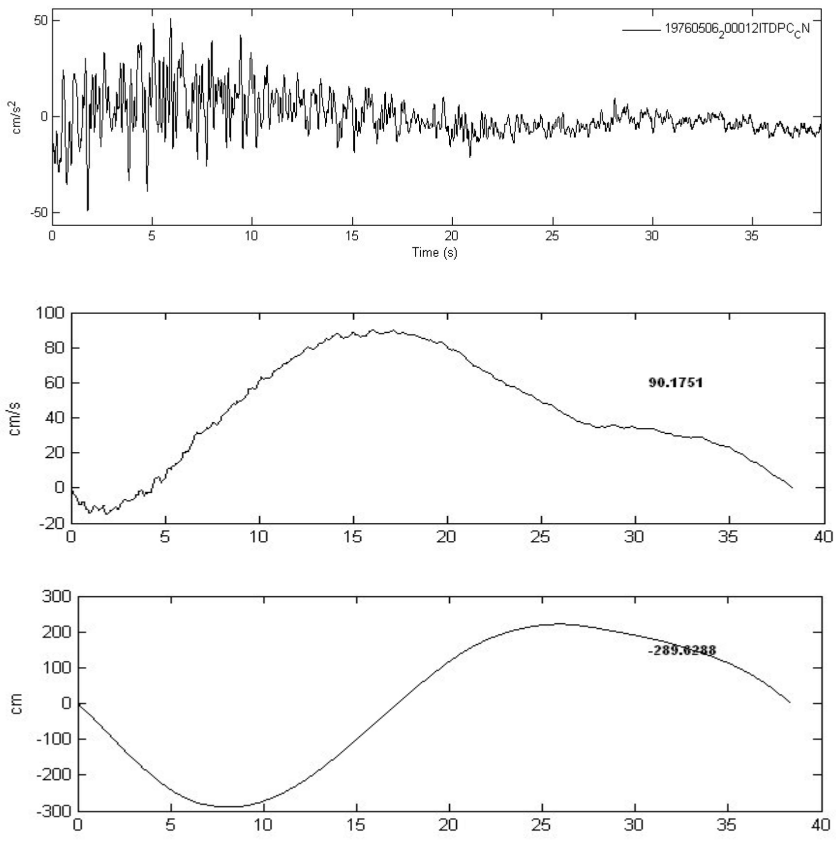

Figure 3: From top to bottom: uncorrected acceleration, velocity and displacement recorded at Conegliano Veneto, on 1976-05-06 20:00:12 (comp NS)

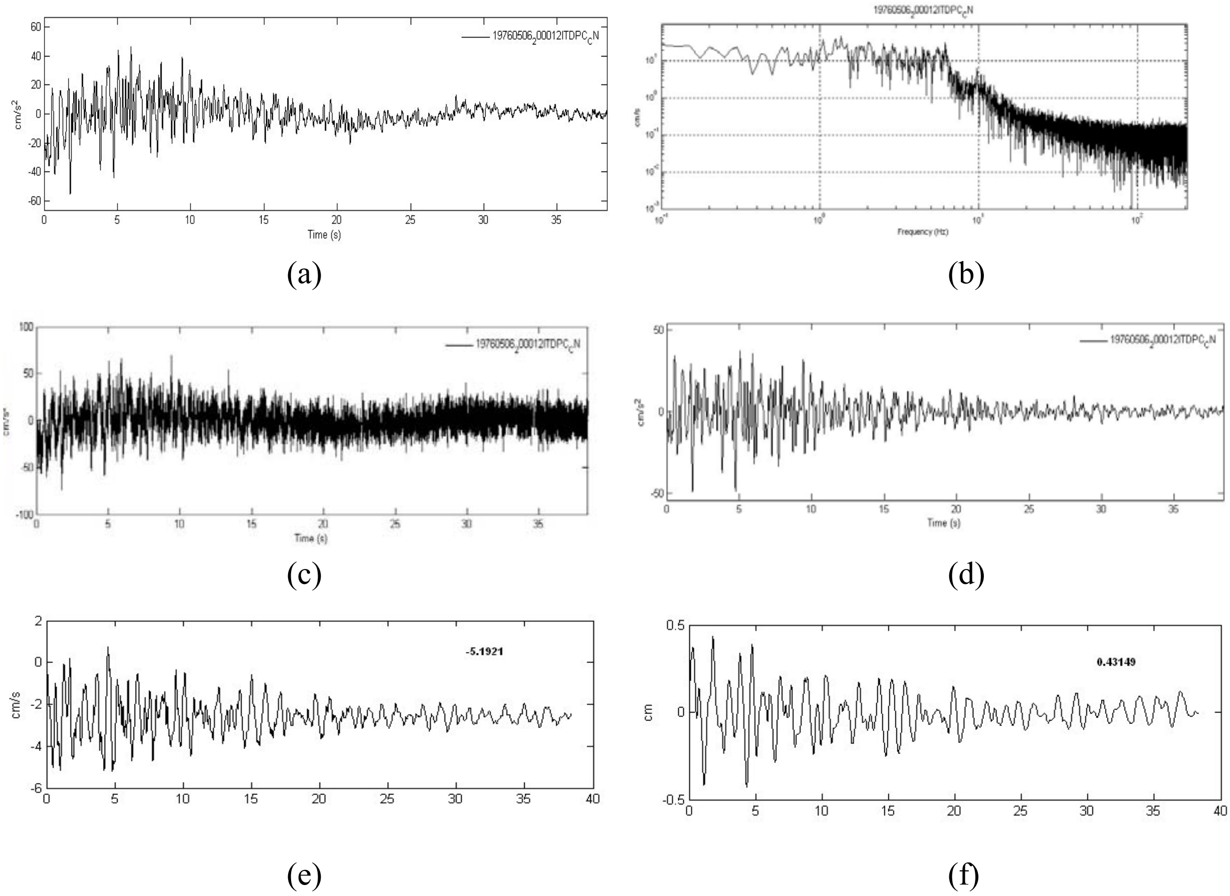

Figure 4: Data processing steps applied to the 1976-05-06 20:00:12 event recorded at Conegliano Veneto (NS component): a) linear baseline correction, b) Fourier spectrum of the uncorrected data for high pass frequency selection, c) convolution with the instrument response, d) corrected acceleration after band pass filtering, e) velocity and f) displacement.

The fulfilment of the third task required most of the efforts spent in the project. The verification of the seismic event, the recording station and the instrument metadata were time-consuming and required half of the economic budget of the project.

The Italian strong-motion data base covers a 30 year time-span, during which the Italian seismic networks have evolved rapidly. The Italian seismic network managed by INGV (ING until 1999), increased from 12 instruments in 1972 to about 180 in 2004. The Italian Seismic Bulletin of 1972 included 6 seismometers phases for the M = 5 event recorded offshore Ancona on June 14, 1972. An event with the same magnitude occurred on November 25, 2004, in the Adriatic sea, has been recorded by over 70 instruments of the National Seismic Network. Before using the data, one should bear in mind the networks and instrument evolution during the time-span covered by the strong-motion data-base, as the precision used for the event location varied enormously. Therefore the hypocentral parameters of the selected events have a precision which reflects the network evolution.

Different catalogues were used to retrieve the hypocentral parameters and magnitudes for different periods:

- ING Catalogue (internal data base of INGV) for the events in the period 1972 – 1982;
- Catalogue of Italian Seismicity, CSI, version 1.1. (Castello et al., 2006) and version 2.0 (R. Di Stefano, personal communication) for the events subsequent to 1982;

- Bollettino Sismico italiano (Istituto Nazionale di Geofisica e Vulcanologia – CNT, 2007) for the events subsequent to 1982;
- Catalogo Parametrico dei Terremoti Italiani CPTI04 (Gruppo di lavoro CPTI , 2004).

The CSI catalogues were preferred as the hypocentral parameters are instrumentally determined by integrating the Italian seismometric network with regional and non-Italian networks. Complex events, localised offshore or showing large horizontal errors in this catalogues, were relocated using the IPOP procedure, part of the *Locator* system (Mele et al. 2002).
Each event is associated with one or more magnitude estimates (local magnitude, Ml; surface wave magnitude, Ms; moment magnitude Mw; body wave magnitude, Mb).
The events with magnitude higher than 5.0 have generally the estimates of Mw, Mb and Ms. For this data base the Mw is evaluated from the solution of the parameters of the Centroid Moment Tensor, CMT, or from the Regional Centroid Moment Tensor, RCMT, (Pondrelli et al., 2006) and Earthquake Mechanisms of the Mediterranean Area (EMMA version 2, Vannucci and Gasperini, 2004), while the Mb and Ms are attributed on the base of the ISC Bulletin or from the NEIC catalogue. For earthquakes with lower magnitude values, the reference is the local magnitude, Ml, obtained from INGV instrumental catalogues. When the Ml estimate is not available from instruments, a value obtained from regression is attributed (which is usually function of duration and hypocentral distance).
For the focal mechanisms the classification of Zoback (1992) was adopted which discriminates among 5 main types, namely: normal faulting, predominately normal with strike-slip component, strike-slip faulting (with eventual minor normal or thrust component), thrust faulting and predominately thrust faulting with strike-slip component.
The fault geometry, strike, dip and rake are reported for the major events. They are obtained from the DISS catalogue, version 3.0.2 (DISS Working Group, 2006).
Figure 5 shows the spatial distribution of the seismic events included in the data base. Most of them occurred during the main Italian seismic sequences, namely Friuli 1976, Irpinia 1980, Umbria-Marche 1997-98 and Molise 2002-2003.

The recording station metadata are included in the data base after a careful collection of pre-existing data and field measurements performed during the project.
Metadata about 620 stations were collected: 270 of them are operating and are mainly located along the Apennines, the Eastern pre-Alps and Sicily (Figure 6), 330 are inoperative as they were part of temporary networks or old analogic instruments, which have been removed. The information is extremely non uniform, as few stations are characterized by detailed data, which include stratigraphy, geophysical borehole tests or laboratory tests on soil samples, while the majority of the recording sites is characterised by the location on an aerial photograph and on a small scale geologic map.
The station metadata are composed of different levels. The descriptive level includes all the synthetic information regarding the site, such as name, code, address, coordinates, name of the topographic map, geotechnical class, type of installation, etc. The map level includes the station location on a topographic map or an aerial photograph, a geological map, or others and the table level includes stratigraphy logs, NSPT logs, Vs/Vp profile, site response functions, etc.
The three different levels have been stored in the data base through the relational structure, in order to retrieve them separately according to the user needs. An alternative way to store the metadata was the creation of synthetic documents (400 have been compiled), which can be accessed through the MS Access data base, the interactive data base or through the project web portal, browsing the Italian regions.

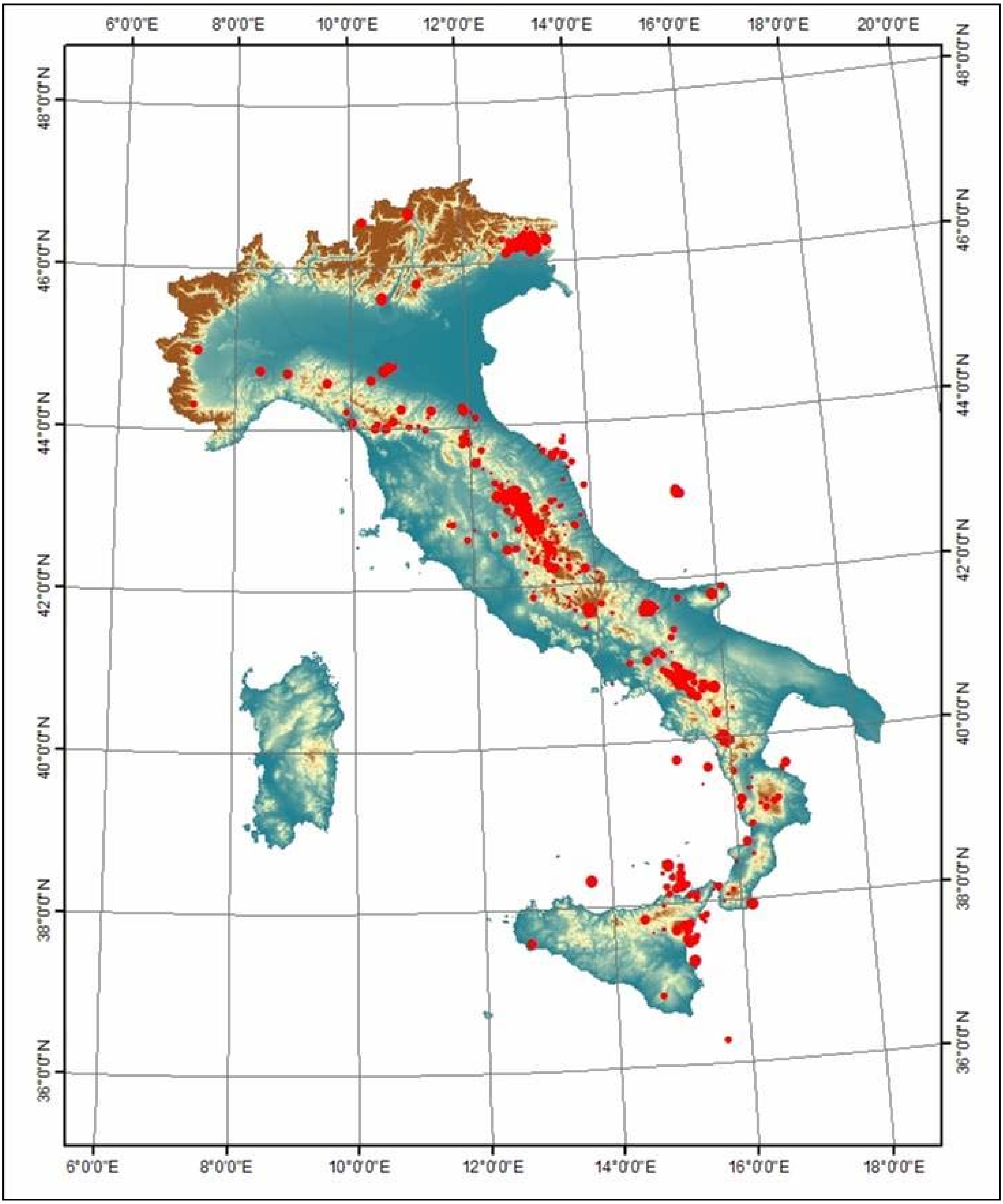

Figure 5: Spatial distribution of the seismic events included in the data base.

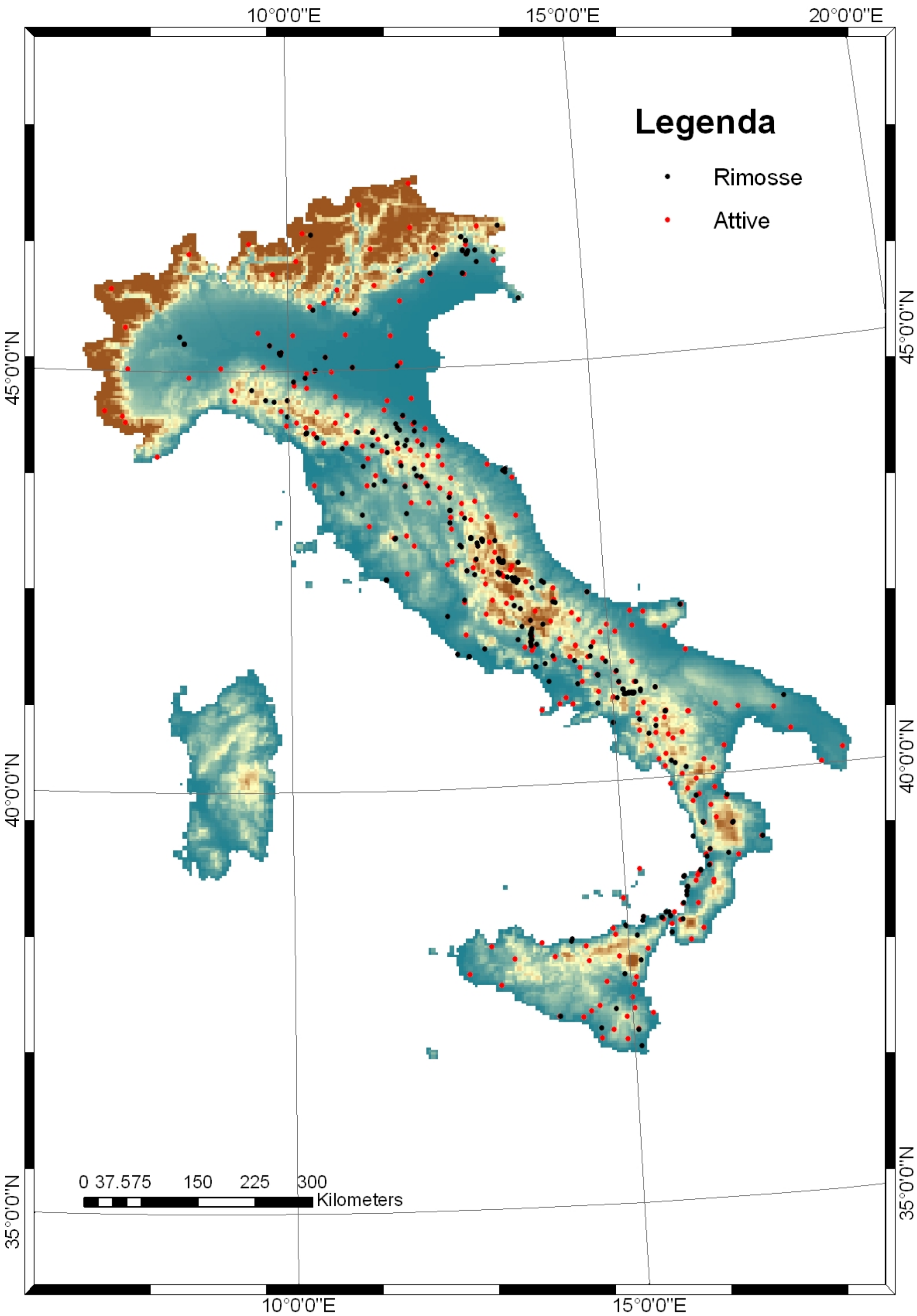

Figure 6: Location of the about 620 accelerometric stations.

Field investigations were promoted during the project in order to characterize the sites which recorded the strongest events (i. e. Irpinia, Umbria-Marche, Lazio-Abruzzo). In order to select these accelerometric stations many parameters were considered, such as the number of records available for the site (usually greater than 5), maximum recorded Pga (≥ 0.1g), type of information available on the site characterization, probable presence of site effects, state of activity of the site, geographic location and logistics.
Many different techniques were applied, depending on the nature and importance of the site: downhole measurements (Gubbio piana), cross-hole measurements (Bevagna, Valle dell'Aterno centro valle, Cesena, Sturno), seismic refraction, reflexion and SASW measurements (Ancona Palombina, Ancona Rocca, Chieti, Avezzano, Norcia, Bevagna), array measurements (Arienzo, Airola) and noise measurements (22 sites in Umbria-Marche, 2 in the Garda lake area, 5 in Abruzzo, 3 in Campania and 2 in Emilia-Romagna). Other 15 noise measurements which were previously performed by the DPC in Sicily were also collected. A detailed list of the investigations performed for each site is reported in the deliverable 6, Appendix B.
In addition, detailed geological surveys and geo-mechanical surveys were performed at Gubbio piana, Bevagna, Lauria Galdo, Airola and Villetta Barrea.
Figure 7 shows the Vs profile for the Gubbio piana site while Figure 8 is an example of the result of P-wave tomography for the Valle dell'Aterno site.

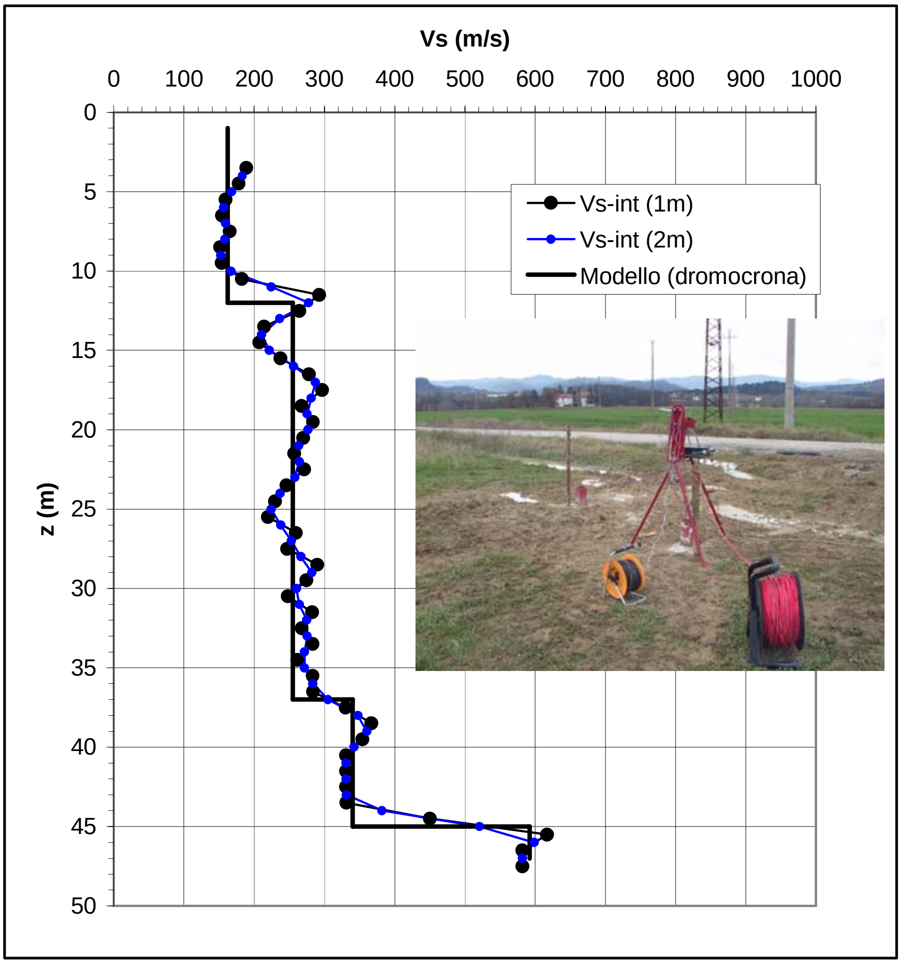

Figure 7: velocity profile for the station Gubbio piana

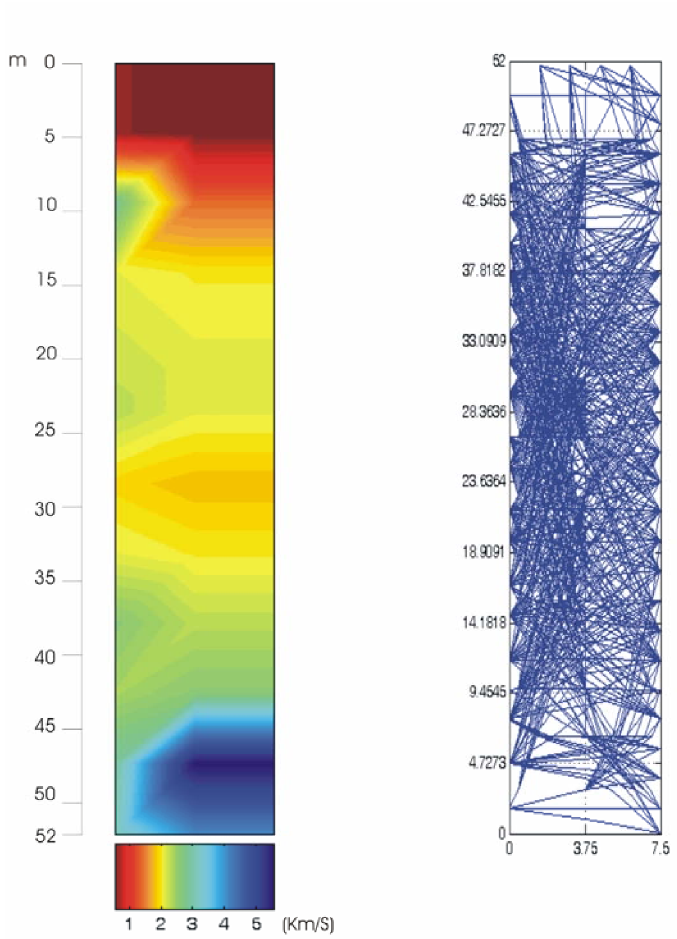

Figure 8: seismic tomography for P-waves at the station Valle dell'Aterno-centro valle

The last task of the project regards the data base implementation and data dissemination. This is achieved through the project web portal at http://esse6.mi.ingv.it (Figure 9) and the data base portal at http://itaca.mi.ingv.it (Figure 10). The first contains the documentation of the project, from the project proposal to the final results, represented by the single deliverables and the data base, reporting the step-by-step decisions and other useful documents, which can be explored and downloaded, in order to make the entire process transparent.
The data base can be downloaded in the MS Access format and locally installed on a PC and the same can be done for the entire strong-motion data set. Figure 10 shows the main mask form which the information relative to recording stations, events, waveforms and data dictionaries can be accessed.
The second web site is the interactive data base which the user can search specifying his needs. The waveforms and their metadata can be selected through step-by-step queries and the results can be visualised through a Java application, which also allows simple operation on the time series. Finally the records can be downloaded in different formats (ASCII, SAC) and in the raw or processed version.

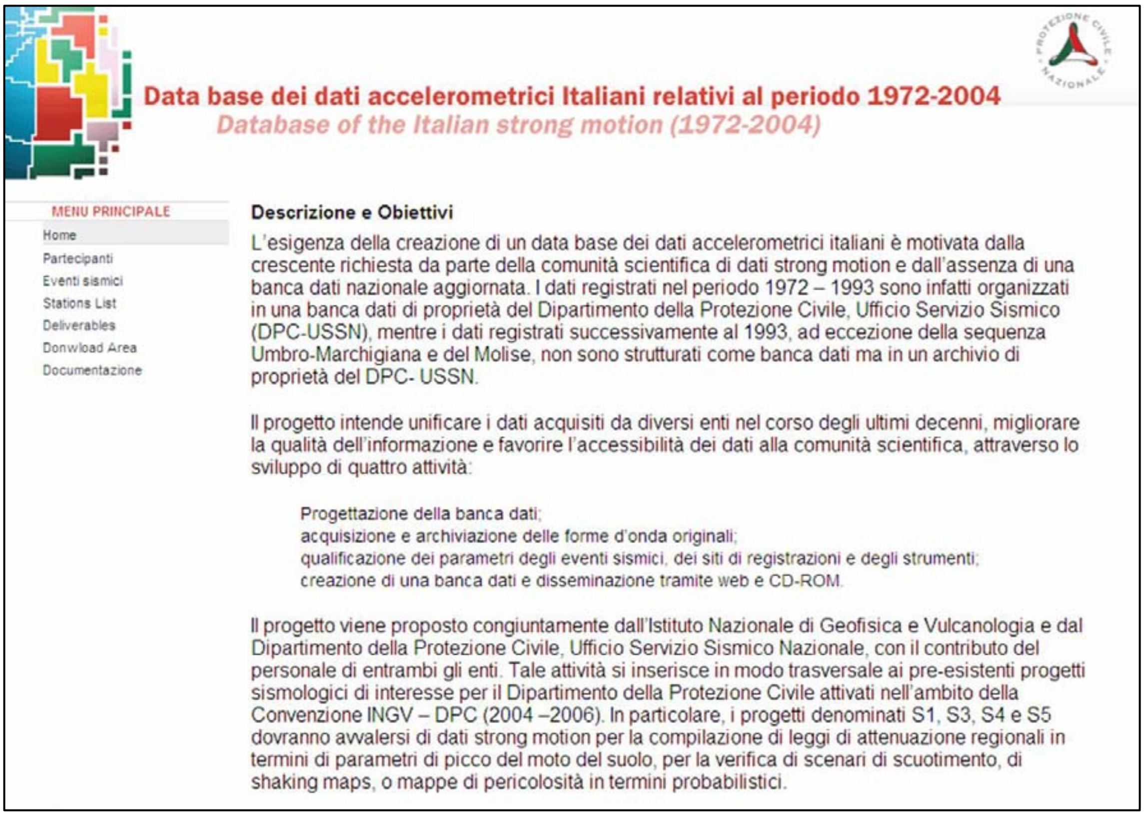

Figure 9: S6 project home page (at the moment only the Italian version is available)

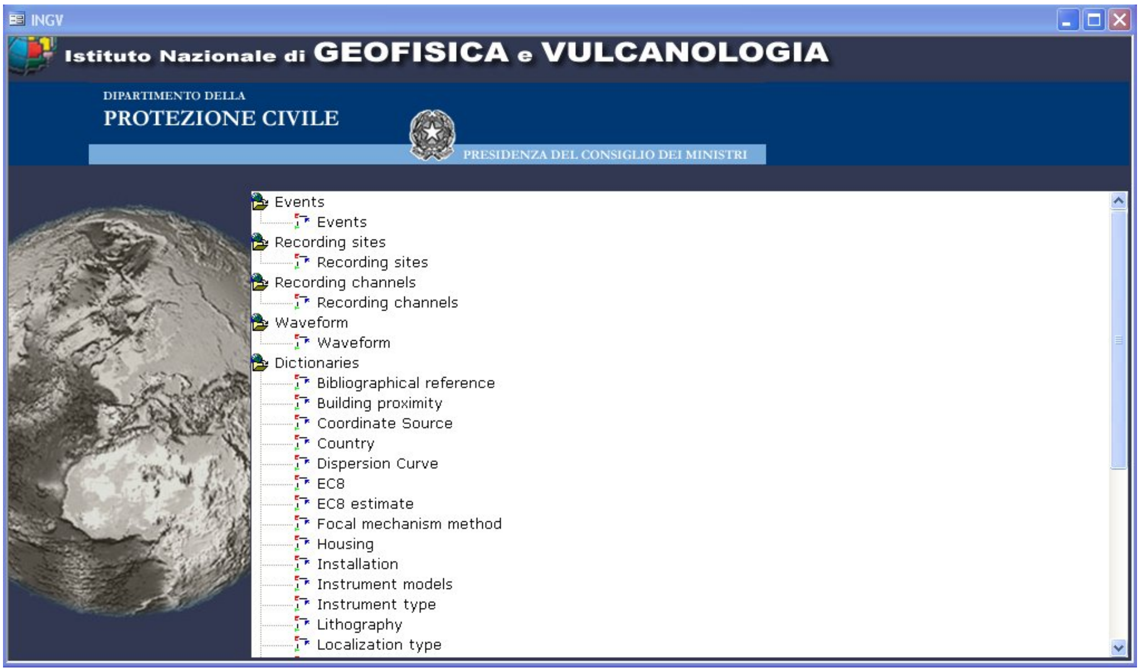

Figure 10: Main mask of the data base in the MS Access format

3. Major difficulties and modification of the initial proposal

The initial project proposal represented the description of the optimal set of procedures for the project goals fulfilment. However, during the project course, some modifications of the original plans were made, and, in particular they regarded the activities of data processing, field investigations and data base managing tools.

The first modification represented an increase of the working load in favour of data quality. The project initial plan was to process one-by-one the records with Pga greater than 0.01g and the rest in an automatic way. The final decision was to process all the waveforms one-by-one, manually selecting the parameters for the processing. This approach is certainly time-consuming, but the application of the same parameters to all the waveform could certainly lead to unrealistic velocity and displacement time-series and biased response spectra.

Many difficulties were encountered when planning the field investigations. The selection of the sites to investigate was done only after the first 6 months of the project, when a definitive list of the sites was available. This caused a shift of the field surveys to the spring-summer 2007. Many investigations could be carried out only at the end of the project.
In addition, it should be pointed out that the geotechnical and geophysical investigations have complex logistics. Some of the tests are invasive (the boreholes) and permissions should be asked to local administrators and terrain owners. The field survey times can become unpredictable, as many variable are involved in.
It is reported, as an example, the case of Arienzo, where it was planned to perform a cross-hole test. After the individuation of the most appropriate site to locate the boreholes, the municipality refused to give the permission and the investigation had to be shifted to Sturno. This caused a delay of about 2-3 weeks in the project schedule.
As a conclusion, the 18 months were a too limited amount of time for carrying out the field surveys.

The connection of the data base to a webgis, a solution for delivering GIS data via the web, to interactive explore geographic data and their attributes, planned at the beginning of the project, could not be carried on. The lack of internal experts to be dedicated to this issue, lead us to look for external consulting, that would have caused a substantial increase of the project costs. This part was substituted with the connection of the data base to the Google map tool, which enabled us to display the location of seismic events and recording stations on the background of simple topographic maps, satellite images or aerial photographs, without any extra cost.

4. Deliverable presentation, for single deliverable

In this paragraph the deliverables of the project will be described in detail.

The deliverable 1 contains the description of the data base architecture, the technical requirements for data storage and the format of the waveforms contained in the data base.
The standard for file naming is illustrated, which includes a date, the international network code, the unique code of the station, the component convention, the correction flags and the different file extension indicating the data type (acceleration, velocity, displacement or response spectra). The 43 row header for the ASCII format is designed with the purpose of record self-consistency and contains the metadata on the event, the recording station, the instrument and the correction parameters.
The 48 tables contained in the data base are listed one by one together with the description of the field content, type and format. Table 1, reported as an example, is the description of the table used to store the magnitude type descriptions.

FIELD	LENG	TYPE	N.DEC	NOTE
METHOD_CODE	16	Varchar(16)		Magnitude code
DESCRIPTION	64	Varchar(64)		Brief description
LONG_DESCRIPTION		MEMO		Detailed description of the method (if known, includes also the institution)

Table 1: Structure of the table used to store the magnitude type.

At the end of the deliverable there is a scheme of the main "blocks" of the data base (events, recording sites, waveform and references) with the relations existing among the tables.

The deliverable 2 consists in the collection of the raw and processed strong-motion data. The entire data set can be accessed via the web portal http://esse6.mi.ingv.it/ at the page *Deliverables*. Seven zip files can be downloaded which contain: i) the raw acceleration data in ASCII format (3 or 4 components, where the forth component is the fixed trace only present in case of analog data) ii) the raw acceleration data in SAC format, iii) the 3 component processed acceleration in ASCII format, iv) the 3 component processed acceleration in SAC format, v) the velocity time series, vi) the displacement time series and vii) the acceleration response spectra, calculated in the interest period range, in ASCII format.
An interactive way to access the strong-motion files is through the http://itaca.mi.ingv.it at the page *waveforms*. Here the strong-motion recordings can be selected according to the waveform characteristics, such as range of peak ground acceleration, velocity, displacement, effective duration, Arias intensity, epicentral distance or fault distance, among the others.
In alternative, a progressive search can be made starting form the event characteristics, specifying the station details and constraining the search with the waveform parameters. In this case only the selected waveforms can be downloaded in a zip file which contains the seven data types listed above.

The deliverable 3 contains the indications for data processing. After an overview of the characteristics of the strong motion data recorded by digital and analog instruments, the most common sources of "errors" contained in the raw strong-motion data are listed. Although the

strong-motion data processing is a rather subjective procedure, which depends on the parameters selected by the user, some guidelines are given in order to create a processing standard for the data base. In particular, analog and digital data are processed in different way.
Indication are given for the baseline correction, which is made fitting a linear trend to the entire record, the convolution for the instrument response, the selection of the band-pass frequencies (after the visual inspection of the Fourier spectrum) and the filter types (Butterworth or raised cosine). The selection of the optimal low-pass frequency is made after the analysis of the acceleration time series contemporary recorded by a digital and an analog instrument at Nocera Umbra.
The memory of the parameters used to process the data (i.e. filter type, pass-band frequencies) is contained in the file header, so that the acceleration response spectra is calculated only in the period range contained in the band-pass interval, in order to avoid unrealistic values, especially at very low periods.

The deliverable 4 is represented by the software for data display and processing. The software is released at its beta version. It consists in many routines written using the Matlab Macro Language and is open source.
The software can read the files in the ASCII format decided for the data base and in a SAC format. It allows basic functions, such as modify the display, process the data, according to the standards defined in the project, scroll forward and backward a list of records and display the file header. The main software window is shown in Figure 11.

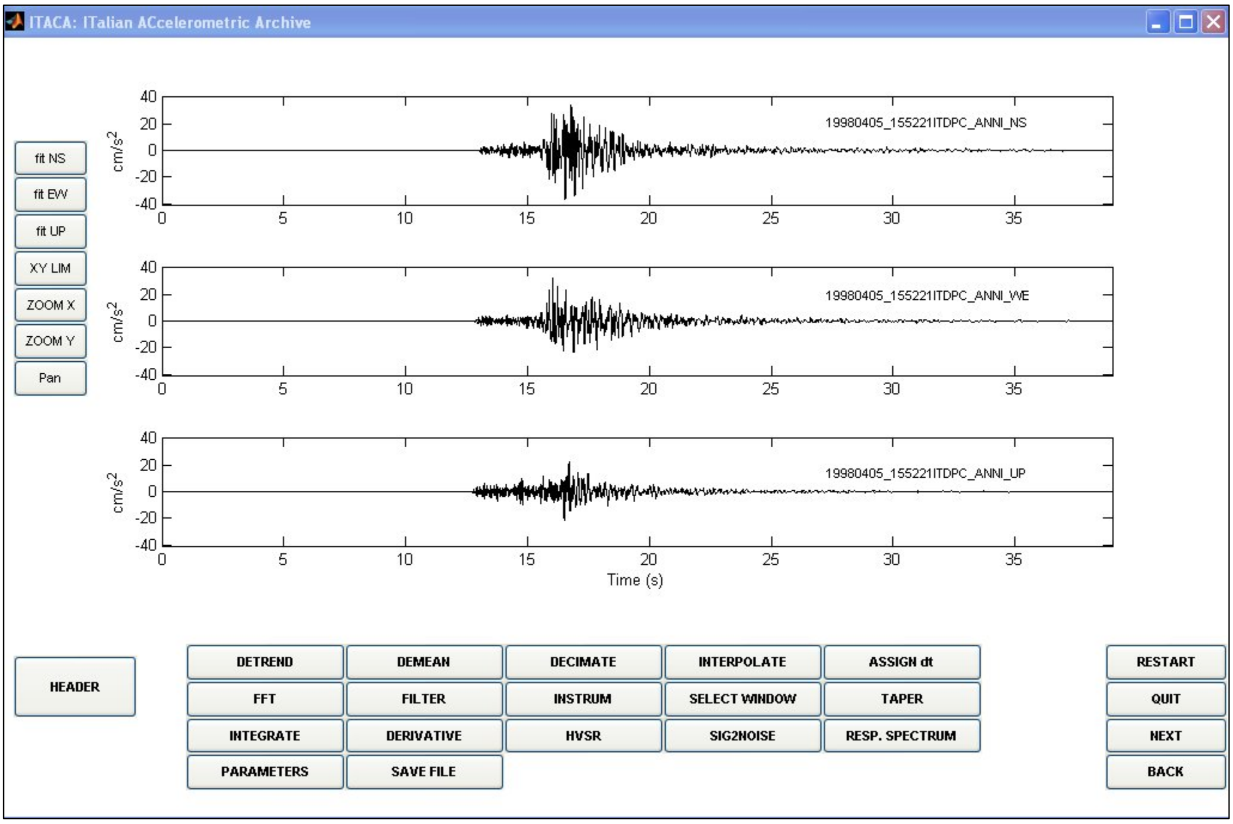

Figure 11: main window of the software for data display and processing

The basic processing functions are: data mean removal, detrending, data decimation and interpolation, Fast Fourier Transform calculation, filtering, convolution for the instrument response, signal window selection, tapering, integration and derivation in the time domain, calculation of the horizontal to vertical spectral ratio, signal to noise analysis, response spectra and engineering parameters calculation.

At the moment the software will be released at the Civil Protection Department, and, after a testing period, it will be decided whether publish it or apply it for internal use.

The deliverable 5 contains the procedures adopted for the selection of the seismic event metadata. A critical comparison of the available seismic catalogues is made, illustrating their advantages and disadvantages. Subsequently, the criteria for the hypocentral parameters attribution are explained. Only in the case when the location gave rise to doubts, the events were relocated. This happened when two hypocentres were too close in time and space or when the horizontal or the vertical error was too large to be accepted. The relocation of the event was performed with the IPOP routine, part of the system named Locator (Mele et al. 2002),

In order to attribute the most reliable magnitude value many existing catalogues were also compared, inspecting the methods used for the determination of various magnitude types. A set of criteria for reliable magnitude attribution was established.

Standards were also defined for the attribution of the focal mechanisms and the geometry of the seismogenetic faults. Finally the epicentral macroseismic intensity was attributed.

The deliverable 6a contains part of the technical reports of the field surveys. The first part regards the geophysical borehole tests description and the results for the sites of Gubbio piana and Valle dell'Aterno centro valle. Bevagna, Cesena and Sturno were surveyed at the conclusion of the project and the results will be added at the end of the data analysis.

The second part regards the geological field surveys and the geo-mechanical surveys conducted at Airola, Villetta Barrea, Gubbio piana and Bevagna together with the results on the static laboratory tests on soil samples, such as granulometric curves, Atterberg limits and determination of soil unit weight. The site of Lauria Galdo was surveyed at the conclusion of the project and the results will be included when available.

The last part of the surveys is represented by the geophysical surface tests (seismic refraction, SASW, ecc.) performed Ancona Rocca, Ancona Palombina, Chieti Avezzano, Bevagna and Norcia. This kind of surveys were also performed at the end of the project and for some sites, such as Ancona, the tests should be repeated because of the relevant presence of noise. Only the preliminary results are available at the moment (in the final report of UR5, University of Chieti).

The deliverable 6 is the collection of the synthetic documents relative to the single recording stations. Attached to the deliverable there is a MS Excel file which describes the type of investigation performed on each of the 620 stations.

About 400 forms were compiled, which are accessible through the web at the *Deliverables* page, subdivided by region. In alternative the documents can be checked interactively, through the web data base.

The deliverable 7 is the data base and represents the core-product of the project. It has two different formats thought for different uses. The first product is the MS Access data base, which can be downloaded on a PC. Data can be browsed block-by-block (events, recording sites, waveforms, references) or performing very simple queries.

The second product is the data base that can be accessed through the web at the following address http://itaca.mi.ingv.it. The software used for implement the site is Mysql. The data set can be browsed and searched starting from the recording sites, the seismic events, the waveforms or the bibliographic references.

Several parameters can be specified for each of the four information block. In particular, for the sites and the events, the search can be performed either on attribute data or on geographic location, by specifying a coordinate range. A very basic event and station mapping is obtained through a link to *Google maps* (Figure 12). The queries can also be made in a step-by-step way starting from the

event (which can be constrained selecting location, magnitude or time), going through the station information (which can also be constrained selecting location, name or type of network) and the waveforms (which can be constrained selecting the engineering parameters).
The waveforms resulting from the queries can be downloaded in the available formats and displayed together with the corresponding acceleration response spectra, with a graphic Java utility (Figure 13).

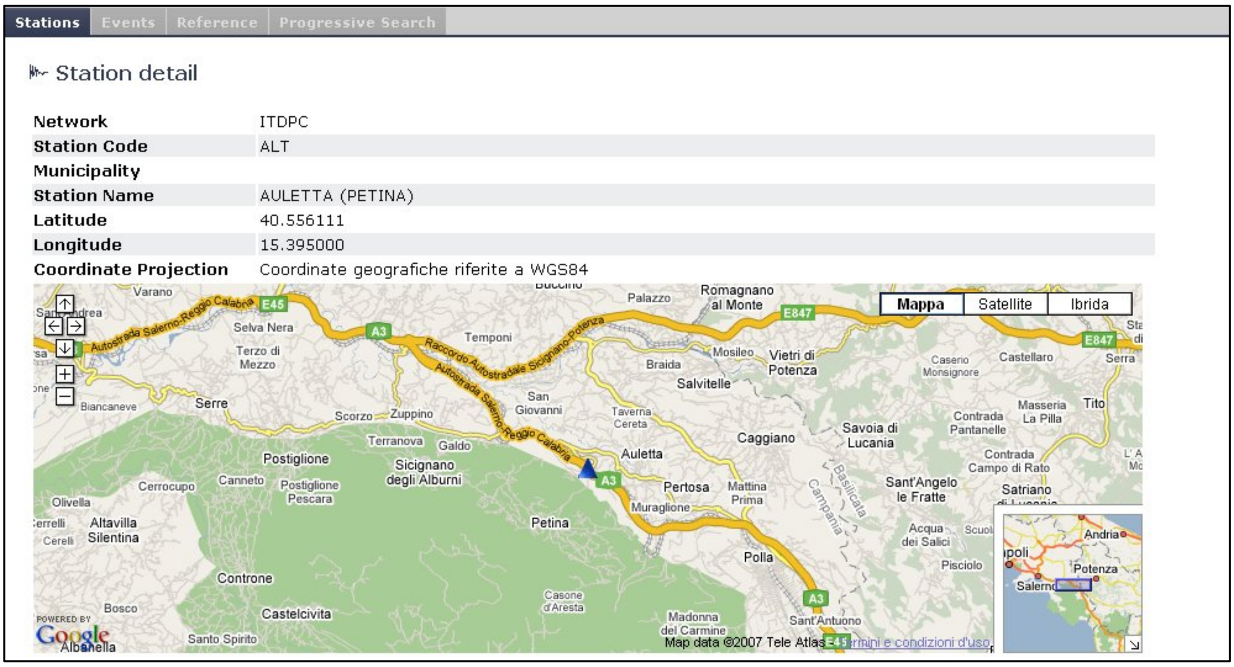

Figure 12: link to the *Google maps* tools for representing geographic information.

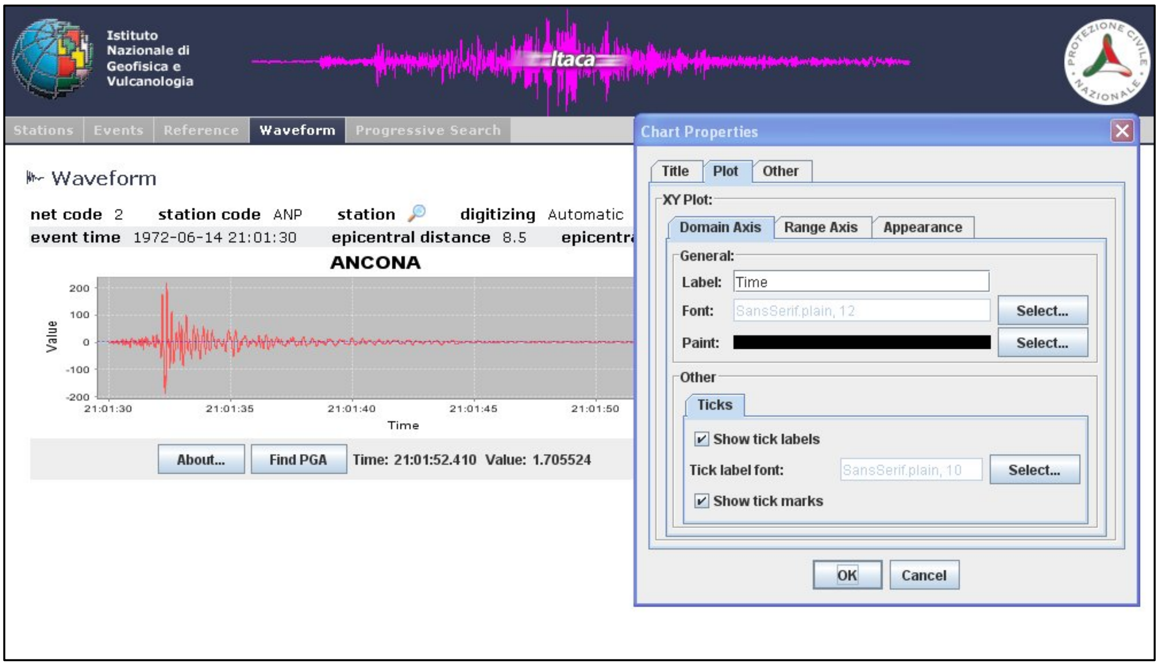

Figure 13: Java tool for the waveform display and change of display options

The utility allows to save the waveform plot which can be adapted to the user need.

The deliverable 8 consists in the web site for data dissemination. The site home page can be accessed at http://esse6.mi.ingv.it as shown in Figure 9. It contains the project history, from the early planning to the results, illustrating the decisions taken step-by-step at the collegial meetings. All the deliverables of the project can be downloaded form the site.
The site is compliant with W3C-WAI Web Content Accessibility Guidelines 1.0. The Web Accessibility Initiative (WAI) develops strategies, guidelines, and resources to help make the Web accessible to people with disabilities. The WAI resources are intended to provide basic information for people who are new to Web accessibility. More specifically, Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web.
The site runs under Apache 2.01 web server, the content of the site is managed with Mysql 5.0 database management system, while the programming language is PHP 4.5.1

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