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Overview of the Italian strong motion database ITACA 1.0

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Abstract The Italian Strong Motion Database, ITACA, was developed within projects S6 and S4, funded in the framework of the agreements between the Italian Department of Civil Protection (Dipartimento della Protezione Civile, DPC) and the Istituto Nazionale di Geofisica e Vulcanologia (INGV), starting from 2005. The alpha version of the database was released in 2007 and subsequently upgraded to version 1.0 after: (i) including the most recent strong motion data (from 2005 to 2007) recorded in Italy, in addition to the 2008 Parma earthquake, M 5.4, and the M $\geq$ 4.0, 2009 Abruzzo seismic events; (ii) processing the raw strong motion data using an updated procedure; (iii) increasing the number of stations with a measured shear wave velocity profile; (iv) improving the utilities to retrieve time series and ground motion parameters; (v) implementing a tool for selecting time series in agreement with design-response spectra; (vi) compiling detailed station reports containing miscellaneous information such as photo, maps and site parameters; (vii) developing procedures for the automatic generation of station reports and for the updating of the header files. After such improvements, ITACA 1.0 was published at the web site http://itaca.mi.ingv.it, in 2010. It presently contains 3,955 three-component waveforms, comprising the most complete catalogue of the Italian accelerometric records in the period 1972–2007 (3,562 records) and the strongest events in the period 2008–2009. Records were mainly acquired by DPC through its Accelerometric National Network (RAN) and, in few cases, by local networks and temporary stations or networks. This paper introduces the published version of the Italian Strong Motion database (ITACA version 1.0) together with main improvements and new functionalities.

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1 Introduction

For decades, the reference ground motion for earthquake engineering was the renowned El Centro accelerogram, recorded in California in 1940, with few additions from local good quality analog records, such as, in the Italian context, the Tolmezzo record of 1976 Friuli earthquake, and the Sturno and Bagnoli records of 1980 Irpinia earthquake (see e.g., Douglas 2006). Only after the Loma Prieta (1989), Northridge (1994) and Kobe (1995) earthquakes, hundreds of strong motion records were obtained and made available worldwide through databases accessible from the web.

Among the most widespread strong motion databases, the PEER (beta-version), produced by the Pacific Earthquake Engineering Research Centre (Chiou et al. 2008) and available on the web site http://peer.berkeley.edu/peer_ground_motion_database, archives and distributes acceleration time series, response spectra, and a comprehensive set of metadata (different distance metrics, various site categorization, etc.). The PEER database presently includes more than 3,000 uncorrected and corrected records from about 170 shallow crustal earthquakes and 1,400 recording stations. Unlike other databases, records are rotated to Fault Normal (FN) and Fault Parallel (FP) directions, for providing better insight into seismic source related effects, such as rupture directivity and/or radiation pattern. Furthermore, the beta version consists of tools to select, scale, and evaluate time series for engineering applications.

The Kyoshin (K-NET) and Kiban-Kyoshin (KiK-net) networks, available, respectively, on www.k-net.bosai.go.jp and www.kik.bosai.go.jp consist of more than 1,700 digital accelerometric stations throughout Japan (1,042 from the K-NET and 691 from the KiK-net), equipped, for the Kik-net, with borehole sensors, located at depths typically ranging from 100 to 200 m. The uncorrected records are organised in a quasi-real time web-based system, and are available few days after an earthquake occurrence, accompanied by the most relevant information on the seismic event. Simple queries allow the search for seismic event, recording site and peak ground acceleration. Soil conditions of recording sites, including P and S-waves velocity profiles obtained by down-hole measurement, are provided with details.

In Europe a notable effort was made between 1998 and 2002 to produce the European Strong Motion Database (http://www.isesd.hi.is/ESD_Local/frameset.htm), containing more than 3,000, uniformly processed and formatted, strong-motion Pan-European records and associated earthquake-, station- and waveform-parameters (Ambraseys et al. 2004). The database was updated until 2005, while, more recently, only records from the Iceland M_w 6.3 earthquake on May 29th 2008 were included.

A strong motion database was recently compiled for Turkey and published in 2009. It archives more than 4,500 time series from about 3,000 events recorded by the Turkish strong-motion networks during the period 1976–2007 (Akkar et al. 2010). All data were uniformly processed and geophysical and geotechnical site features (P- and S-wave velocity profiles and soil-column stratigraphy) are available for about 240 recording stations (Sandıkkaya et al. 2010).

COSMOS (Consortium of Organizations for Strong-Motion Observation Systems) distributes different worldwide strong-motion dataset through a single web-portal (http://www.cosmos-eq.org/) with the aim to promote the advancement of strong-motion measurements in areas potentially struck by future earthquakes (Archuleta et al. 2006). This represents the

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first properly "global" strong motion archive, including records from United States and 14 other countries, made available to the engineering and scientific communities. About 9,000 strong motion data relative to 515 earthquakes with $M > 5.0$, recorded by more than 3,000 stations are present. The portal is supported by flexible search methods, including map-based, parameter-entry, and earthquake- and station-based searches. To date, most data are archived according to the formats stated by the agencies providing the waveforms, although a common standard has been proposed to store records. Processing procedures for corrected records are also dependent on the data provider.

Although Italy has one of the richest and oldest strong-motion dataset in the world, the access to the Italian strong-motion data and correlated information was not so simple in the past, since information was archived in different data-banks (Luzi et al. 2010), with different standards and formats. This is the case of the ENEA strong-motion data collection, which ended in 1993, and of the European database, where the most recent Italian data pertain to the Umbria-Marche sequence of 1997–1998 (Ambraseys et al. 2004).

Recently, a national project for archiving Italian strong-motion data within a well-framed database, integrated by the corresponding metadata and station information, was planned. The project followed the upgrade of the Italian National Accelerometric Network (RAN), designed, realized, owned and managed by the Italian Department for Civil Protection (DPC). The DPC, belonging to the Presidency of the Council of Ministers, is a state body whose mission ranges from the management of both natural and anthropic emergencies, to the prevision and prevention of the relevant risks. The RAN network consists of about 500 digital stations, 192 of which replaced the old analog stations, installed in the most active seismic regions of Italy, with an average spacing between stations of about 20–30 km (Gorini et al. 2009).The new configuration allows to densely record also moderate-seismic event. For example, the M_w 6.3 L'Aquila earthquake in Central Italy, on April 6, 2009, triggered 60 digital stations with epicentral distance from 4 up to 300 km (Ameri et al. 2009; Zambonelli et al. 2011), while the M_w 5.8 earthquake at 220 km depth along the Tyrrenian coast of Calabria, on October 26, 2006, triggered 53 stations, up to about 200 km distance.

The development of the Italian strong motion database ITACA (Italian ACcelerometric Archive) started in 2005 and continued until July 2010 in the framework of two national Projects, denoted by S6 (http://esse6.mi.ingv.it) and S4 (http://esse4.mi.ingv.it), funded by the Italian Department of Civil Protection (DPC) within the 2004–2006 and 2007–2009 agreements with Istituto Nazionale di Geofisica e Vulcanologia (INGV). Both projects involved several research groups with expertise in different fields, encompassing seismology, geology, geotechnical and earthquake engineering, as well as computer science. Such different expertise was integrated in the various stages of the database compilation, ranging from definition of the event metadata, updated procedures for record processing, seismic site characterization of stations, up to development of practical tools for engineering applications.

The alpha-version of the Italian strong motion database (Luzi et al. 2008, 2010),was implemented within Project S6 with the aim of: (i) setting up and testing the database structure; (ii) collecting strong motion data recorded up to 2004 from the National Accelerometric Network (RAN), formerly operated by the Italian Electric Company (ENEL) from 1972 to 1997 and subsequently by DPC; (iii) revising earthquakes, recording sites and instrument metadata; (iv) establishing procedures for data processing and calculation of strong motion parameters; (v) disseminate data through a web-portal.

Subsequently, Project S4 provided an upgrade and integration of the previous alpha-version, up to the currently published version ITACA 1.0 (http://itaca.mi.ingv.it), including several significant changes in the web-site frame and in the quality and quantity of data and metadata. An overview of ITACA data and metadata, as well as the search and download

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capabilities, illustrating the main improvements and updates incorporated in the database, is illustrated in this article.

The ITACA dataset consists of analog and digital strong-motion data recorded in Italy up to 2007, including the 2008 and 2009 strongest seismic events, mainly relative to the L'Aquila seismic sequence.

Station information, such as address, housing, coordinates, and instrument characteristics were updated and new information on recording sites (soil category, morphology, specific features of site response) are added in a technical report for each strong-motion station (hereinafter referred as station report) and summarized in the web-interface as well. A new header is implemented for the time-series and spectral files, containing the most relevant information about the station, event and waveform parameters. New queries and utilities for searching and downloading data optimize and enrich the web-portal structure. Additional search-fields enable users to explore the contents of the database and extra options to download and display the data increase the flexibility of ITACA. Finally, an engineering tool, named REXELite, is implemented to allow the search of strong motion records compatible with a target spectrum (Iervolino et al. 2011).

2 Itaca structure and functionality

ITACA is structured as a relational database (Luzi et al. 2008) managed by MySQL, an Oracle© open source data base management system. The parametric database contains 53 tables that store information concerning the seismic events, the recording stations, the installed instruments and the strong-motion parameters. The data-files containing the time-series and the response-spectra are archived separately from the parametric database and a web-portal

Fig. 1 Home page of ITACA v1.0 ~~the web-portal~~

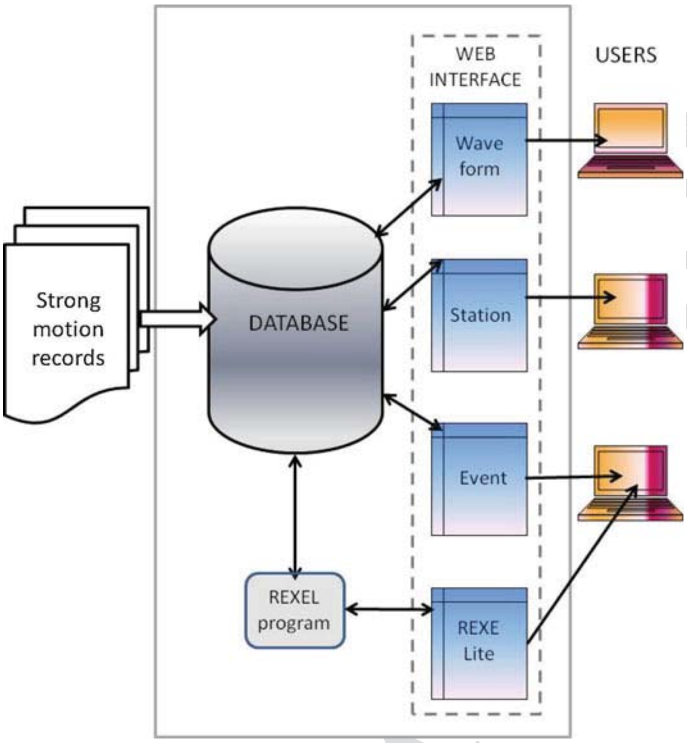

Fig. 2 Structure of the ITACA web portal

is created to explore the database, as well as to access and download the strong-motion data (Figs. 1, 2).

Since the early stages of the S6 project, the ITACA-portal was addressed to a broad variety of users, from researchers in seismology, earthquake engineering and seismic hazard up to people with less experience on strong motion data, like students or professionals.

This philosophy has driven the choice of functionality and utilities of the portal, as well as the type of data format and the display mode of the information.

The web-portal is composed by three main user-friendly interfaces, namely waveforms, station and event, supported by 53 key-fields, that allow one to explore the database: 32 are relative to waveform parameters, 12 to recording stations and 9 to seismic events. Each query returns a list of waveforms matching the request, which can be further explored. The resulting pages are supported by maps, plots and tables that can be saved and/or exported in formats compatible with the most widely used software (i.e., Ms Excel or Google map compatible).

A glossary of the most common engineering and seismological terms, together with a tool for engineering applications, REXELite (Iervolino et al. 2011), were implemented. The latter is a simplified version of the REXEL software published by Iervolino et al. (2010) which allows to search a set of strong-motion records compatible with a target spectrum chosen from the Italian Building Code (CS.LL.PP. 2008), identified as NTC08, and the Eurocode 8 (CEN 2004), identified as EC8, or a code defined by the user.

The waveforms contained in the database are available in the raw version as well as in the processed version, to be directly used for practical applications.

Journal: 10518-BEEE Article No.: 9327 MS Code: BEEE580.1 TYPESET DISK LE CP Disp.:2011/10/22 Pages: 17 Layout: Small

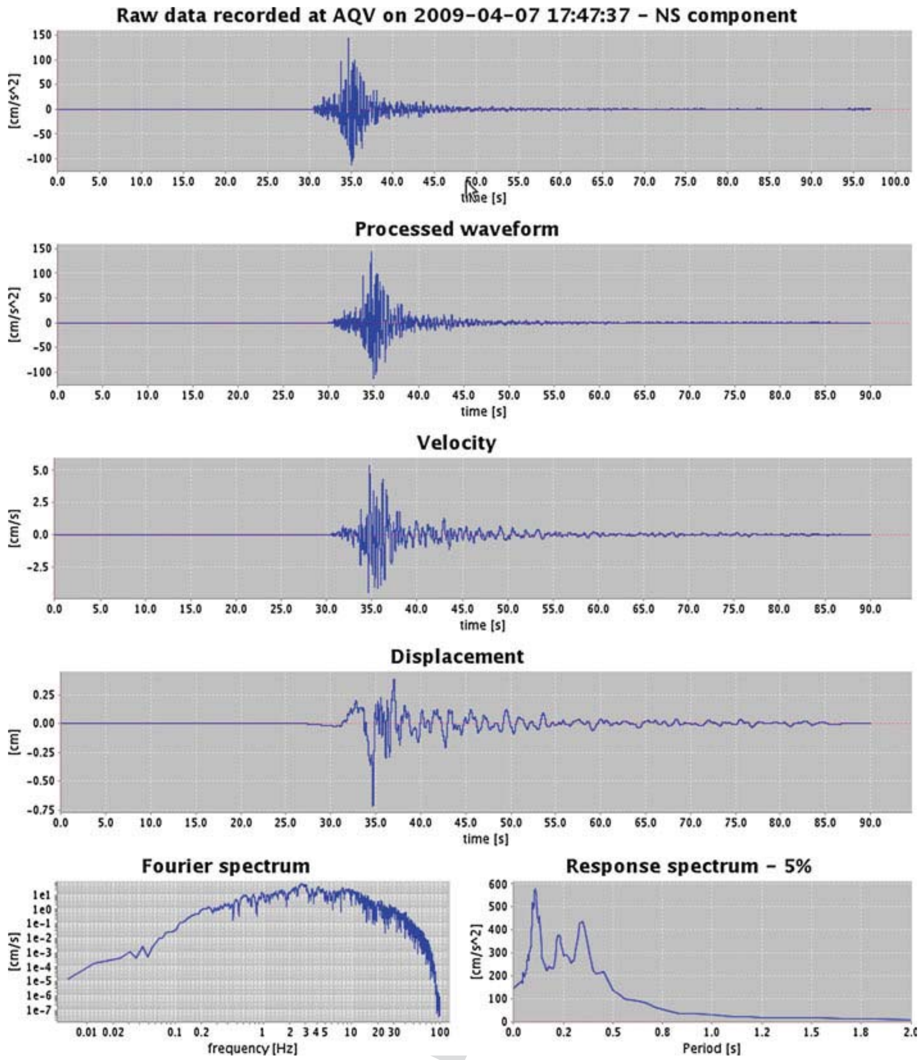

Fig. 3 ITACA waveform-plots of the NS accelerogram, M 5.6, recorded at Aquila Centro Valle (AQV, Central Italy), located at 5 km from the epicentre

The display of waveforms has also a user-friendly design, with a Java utility allowing the user to interactively display, modify and plot raw and processed waveform, together with their Fourier and acceleration response spectra (Fig. 3).

ITACA 1.0 is designed so that the information can be retrieved in multiple ways, i.e., (i) internet pages resulting from queries, (ii) table format, (iii) waveforms and response spectra, that are self-explained by means of the header information, (iv) recording station reports.

The selected records can be downloaded as compressed files and include: (i) processed accelerograms and corresponding acceleration response spectra in ASCII format; (ii) unprocessed data in ASCII and binary SAC formats (Seismic Analysis Code, Lawrence Livermore National Laboratory, a worldwide standard for seismologists); (iii) uncorrected and processed data (traces of acceleration, velocity and displacement). ASCII is the most appropriate format for wide users categories, as waveforms and spectra files can be edited with any text editor. The files of waveforms and response spectra consist of the header and the acceleration values. The header is composed of 43 commented lines (Table 1), concerning the basic information on the station, the event and waveform parameters, making each record self-consistent.

A great effort was devoted to the development of utilities to convert files into different formats and to align the information among the different parts of ITACA.

A set of data-conversion routines, written using Python programming language on top of the Obspy framework (http://www.obspy.org), are available on request at the ITACA web site, to convert the ASCII files of ITACA into standard seismological formats (such as mini-SEED and SAC). All the scripts are platform-independent and can run under GNU/Linux, FreeBSD, MacOSX and Microsoft Windows.

The different components of ITACA (tables, waveform files and station reports) are dynamically updated, so that any modification to a specific field is automatically reflected within all components, including the header of the ASCII files, the miniSEED and SAC files and the station reports. Specific routines have been written in the Perl programming language, and run on the ITACA file server either on command or scheduled for batch execution (Fig. 4).

3 Strong motion data and metadata

The alpha version of ITACA was updated, inside the S4 project, adding about 1,500 strong motion data, reaching a total of 3,955 three-component waveforms recorded, mainly, in the period 1972–2007 (3,562 records). The data set include also M_w 5.4 2008 Parma earthquake and the M_w6.3 L'Aquila earthquake and its strongest aftershocks ($M_w > 4$).

ITACA strong-motion data were mainly (about 90%) recorded by the Accelerometric National Network (RAN). The remaining come from local or temporary networks, installed either in the framework of specific projects or during the post-earthquake emergency phase. A more comprehensive overview on the strong-motion data set can be found in Pacor et al. (2011).

In Fig. 5 the dramatic increase of the available waveforms is shown, especially after 1998, when the national strong-motion network was renewed by the installation of a large number of digital instruments (Gorini et al. 2009).

The data processing strategies were deeply influenced by the evolution of the instruments (Massa et al. 2010; Pacor et al. 2011). Almost all analog and digital data recorded from 1972 to 2004 were individually processed, excluding low quality records. In order to reduce the processing and archiving efforts, a magnitude threshold of 2.5 has been established for accelerograms recorded after 2005.

The record processing procedures, adopted in the alpha version of ITACA (Massa et al. 2010), were subsequently updated (Paolucci et al. 2011), with the aim to ensure the compatibility of acceleration, velocity and displacement waveforms.

Both digital and analog data were processed by acausal Butterworth filters in the time domain after zero padding. A new feature is represented by the explicit identification and treatment of analog records triggered on the S-phase or later, denoted as late-triggered (LT) records. Some steps of the processing procedure were partially automated to treat digital records from small to moderate magnitude events, as a rational strategy to deal with the continuously increasing number of available data.

Journal: 10518-BEEE Article No.: 9327 MS Code: BEEE580.1 TYPESET DISK LE CP Disp.:2011/10/22 Pages: 17 Layout: Small

Table 1 List of the 43 fields, composing the ITACA header file

1	EVENT_NAME	APP. UMBRO-MARCHIGIANO
2	EVENT_DATE_YYYYMMDD	19971016
3	EVENT_TIME_HHMMSS	120031
4	EVENT_LATITUDE_DEGREE	43.0435
5	EVENT_LONGITUDE_DEGREE	12.8842
6	EVENT_DEPTH_KM	2.4
7	MAGNITUDE_L	4.5
8	MAGNITUDE_S	
9	MAGNITUDE_W	4.3
10	FOCAL_MECHANISM	SS
11	STATION_CODE	CLC
12	STATION_NAME	COLFIORITO CASERMETTE
13	STATION_LATITUDE_DEGREE	43.029388
14	STATION_LONGITUDE_DEGREE	12.891277
15	STATION_ELEVATION_M	
16	SITE_CLASSIFICATION_EC8	C*
17	MORPHOLOGIC_CLASSIFICATION	
18	EPICENTRAL_DISTANCE_KM	1.7
19	EARTHQUAKE_BACKAZIMUTH_DEGREE	339.8
20	TIME_FIRST_SAMPLE_S	0.000000
21	SAMPLING_INTERVAL_S	0.005000
22	NDATA	3600
23	DURATION_S	17.995000
24	COMPONENT	NS
25	UNITS	cm/s$\hat{2}$
26	INSTRUMENT	EPISENSOR A800
27	INSTRUMENTAL_FREQUENCY_HZ	52.000
28	INSTRUMENTAL_DAMPING	0.200
29	SENSITIVITY_V/G	
30	FULL_SCALE_G	1.000000
31	N_BIT_DIGITAL_CONVERTER	12
32	PGA_CM/Sˆ2	−349.849082
33	TIME_PGA_S	3.975000
34	OWNER_RECORD	DPC-USSN
35	INSTRUMENT_ANALOG/DIGITAL	D
36	BASELINE_CORRECTION	BASELINE REMOVED
37	FILTER_TYPE	BUTTERWORTH
38	FILTER_ORDER	2
39	LOW_CUT_FREQUENCY_HZ	0.300
40	HIGH_CUT_FREQUENCY_HZ	35.000
41	LATE/NORMAL_TRIGGERED	NT
42	DATA_VERSION	ITACA 1.0
43	DATA_TYPE	PROCESSED ACCELERATION

Journal: **10518-BEEE** Article No.: **9327** MS Code: **BEEE580.1** ☐ TYPESET ☑ DISK ☐ LE ☐ CP Disp.:**2011/10/22** Pages: **17** Layout: **Small**

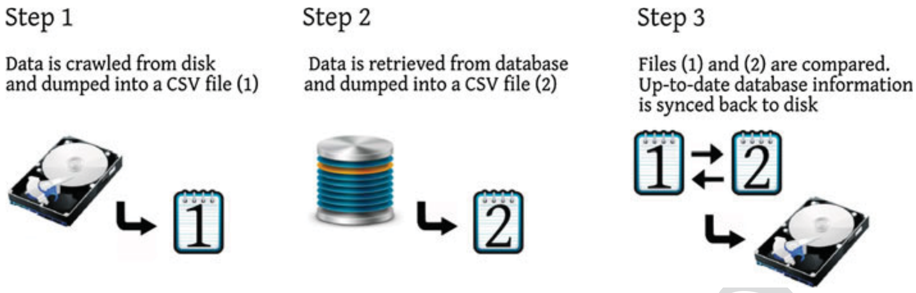

Fig. 4 Procedure to synchronize database information and header file

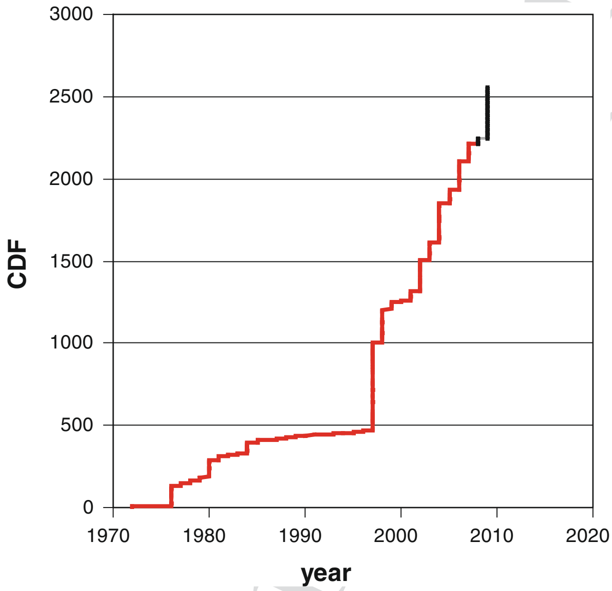

Fig. 5 Cumulative distribution of strong motion data from 1972 to 2009. The data set is non complete for the years 2008 and 2009 (*black line*). Only processed strong motion data are considered

The ASCII file header keeps track of the processing version (actually ITACA 1.0) used to correct the records, of the cut-off frequencies adopted to remove high and low frequency noise, as well as of the identification of late or normally triggered events.

For each archived waveform, several strong ground motion parameters, usable as search-keys, are computed (i.e., peak ground values, Housner and Arias intensities, significant duration) and stored in the database. The 5% damped acceleration response spectrum of each record was computed for 122 periods, ranging from 0 s to 4 s, independent of the frequency filter band. Note that use of the spectral ordinates outside the filtering band-pass should be considered with care. The basic steps of the whole ITACA processing procedure are illustrated in detail by Paolucci et al. (2011) and Pacor et al. (2011) and a summary of ITACA records and their distribution with magnitude and instrument type is listed in Table 2.

Journal: 10518-BEEE Article No.: 9327 MS Code: BEEE580.1 TYPESET DISK LE CP Disp.:2011/10/22 Pages: 17 Layout: Small

Table 2 Cumulative distribution of records as a function of earthquake magnitude

	Total	Analog	Digital
$M \geq 3$	2416 (191 with PGA >0.1 g)	648 (317 late triggered)	1768
$M \geq 4$	1487 (160 with PGA >0.1 g)	533 (252 late triggered)	954
$M \geq 5$	736 (103 with PGA >0.1 g)	264 (106 late triggered)	472
$M \geq 6$	125 (19 with PGA >0.1 g)	51 (13 late triggered)	74

3.1 Earthquake metadata

ITACA records come from about 1800 seismic events (690 with $M \geq 3$, 268 with $M \geq 4$, 74 with $M \geq 5$, and 9 with $M \geq 6$, where M is either M_L or M_W). The earthquake parameters, until 2005, were extracted from different seismic catalogues (Luzi et al. 2008, 2010), as listed in Table 3.

For the most recent earthquakes, reliable hypocentral parameters and local magnitude (M_L) are retrieved: (i) from the Italian Seismic Instrumental and parametric DatabasE (ISIDE, http://iside.rm.ingv.it/), developed by the Centro Nazionale Terremoti (INGV), and (ii) from the Italian Seismic Bulletin since April 16th 2005.

Regional and international catalogues (see Table 3) are consulted for M_w, M_b and M_s values and the DISS catalogue, version 3.0.2 (DISS Working Group 2009) for the fault geometry (strike, dip and rake) of the most relevant events.

3.2 Recording station

742 recording stations are present in ITACA 1.0, 634 of which belonging to RAN, 21 to the Basilicata region network, 12 to RAIS (Rete Accelerometrica Italia Settentrionale, operated by INGV), 56 to ENEA (now Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile), 4 to the province of Trento, and 15 to temporary networks.

A new standard version of the station reports, summarized in Table 4 and described in more detail by Di Capua et al. (2011) has been revised and enriched from the alpha-version of ITACA, with new data and re-checked information.

The station metadata are grouped into three main categories: (i) descriptive metadata of recording site, such as station name, station code, address, geographical coordinates, soil category, type of installation, etc.; (ii) geographic information, including the station location on a topographic map, an aerial view and a schematic geological map (as illustrated in Fig. 6); (iii) quantitative information for seismic site characterization, such as stratigraphic logs, Standard Penetration Test (SPT) logs, Vs/Vp profiles, dispersion curves, fundamental frequencies.

For increasing the quality and quantity of information at recording sites, several geotechnical and geophysical investigations were carried out in the framework of S6 and S4 projects.

While in the first stage of the ITACA development (project S6, ~~Lovati et al.~~ 2010) 6 sites were investigated by borehole techniques, in the following project S4 priority was given to increase the number of investigated sites by passive and/or active surface waves techniques, illustrated in this issue by Foti et al. (2011). Therefore, more than 50 additional sites were investigated and the corresponding Vs profiles included in the ITACA station report, together with an annex illustrating the measurements and results in more detail.

Journal: 10518-BEEE Article No.: 9327 MS Code: BEEE580.1 TYPESET DISK LE CP Disp.:2011/10/22 Pages: 17 Layout: Small

Table 3 List of sources, period covered, reference and code for the seismic catalogues used to compile the event parameters metadata in Itaca (after Luzi et al. 2010)

Catalogue	Agency	Time period	Reference	Code
ING Catalogue	INGV-CNT	1450b.C.–1990	Internal database	ING catalogue
Bollettino sismico Italiano	INGV-CNT	1984–up to now	http://bollettinosismico.rm.ingv.it/	INGV-CNT seismic bulletin
Catalogue of Italian seismicity, CSI, version 1.1 and 2.0	INGV-CNT	1981–2002 2003–2007	Castello et al. (2006); R. Di Stefano, p. c. http://csi.rm.ingv.it/	CSI1.1 e CSI2.0
Italian seismic instrumental and parametrica database	INGV-CNT	2005–up to now	ISIDe Working Group (~~INGV~~ 2010), http://iside.rm.ingv.it	ISIDe
Catalogo parametrico dei terremoti italiani CPTI04	INGV-MI	217 b.C.–2002	Gruppo di lavoro CPTI (2004) http://emidius.mi.ingv.it/CPTI04/	CPTI04
European Mediterranean regional centroid-moment tensors	INGV-BO	1976–up to now	Pondrelli et al. (2006)	IT-CMT-2006
Earthquake mechanisms of the Mediterranean area database (version 2)	UNI Bo-INGV BO	1905–2003	Vannucci and Gasperini (2004)	EMMA
International seismological centre bulletin	ISC	Up to now	htpp://www.isc.ac.uk	ISC
National earthquake information centre. Earthquake catalogue	NEIC	Up to now	http://earthquake.usgs.gov/regional/neic	NEIC
Global centroid-moment-tensor (CMT)	LDEO	Up to now	GöranEkström http://www.globalcmt.org/	Global-CMT
Database of individual seismogenic sources, version 3.~~0.2~~	INGV-~~RM1~~	–	DISS Working Group (20~~09~~) http://diss.rm.ingv.it/diss/	DISS 3.0.2

Journal: 10518-BEEE Article No.: 9327 MS Code: BEEE580.1 ☐ TYPESET ☑ DISK ☐ LE ☐ CP Disp.:2011/10/22 Pages: 17 Layout: Small

Table 4 Information included in the station report

General information	Name, installation data, etc
Geographical information	Location, coordinates, cartography
Geomorphology	Site morphology, landslides
Geology	Geological map and fault proximity
Geotechnical & geophysical information	Stratigraphic profile, velocity profile, in situ tests, laboratory tests,
Microtremor measurements	Horizontal-to-vertical spectral ratio
Site classification (EC8–NTC08)	Lithostratigraphic classification—estimated and based on in-situ measurements, topography classification.
Information summary	Site classification, geology, geomorphology, distinctive features of site response.
Annex	Report on seismic-wave profile measurements at the site

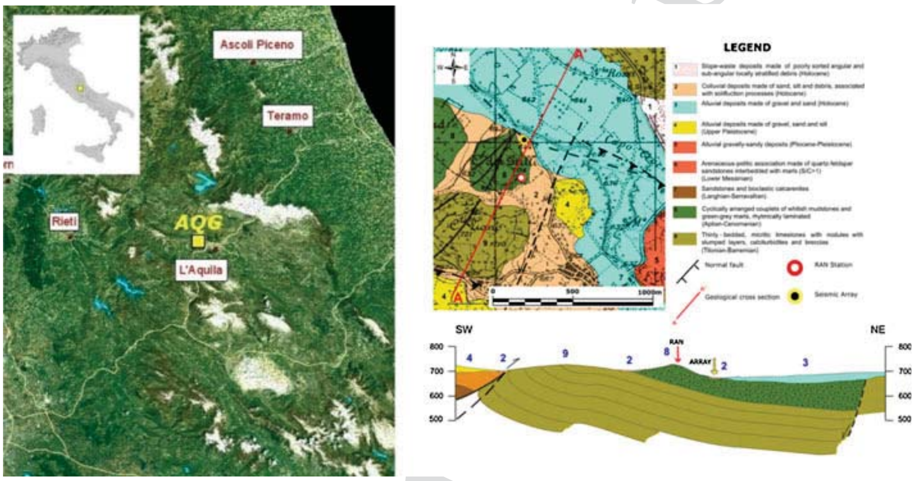

Fig. 6 ~~Aquila Colle Grilli~~ Station (AQG, Central Italy)—Example of aerial photograph and geological map

At the end of the S6 and S4 projects, with the substantial contribution from the L'Aquila post-earthquake activity, and from the previous information available especially for the sites that recorded the Friuli (1976), Irpinia (1980), Umbria–Marche (1997) earthquakes, a Vs profile is presently available for a total of 108 stations (16% of the total, see Table 4).

Besides geophysical tests, more than 200 microtremor measurements, performed mainly by the DPC team, were analyzed in order to detect the resonance frequencies of the ITACA stations by horizontal-to-vertical spectral ratios (Puglia et al. 2011).

The noise recordings were analyzed by a standard protocol, developed within S4 project (Puglia et al. 2011) with special care given to the quality of measurements. The resonance frequencies obtained by microtremors were included in the ITACA database and are available in the station reports.

ITACA sites were classified based on the Italian seismic provisions NTC08, which adopt a similar scheme as the EC8 Code. The criteria for seismic classification were chosen as follows: (1) assign the site class according to V_{S30} when available (16% of stations), or (2) infer

Journal: 10518-BEEE Article No.: 9327 MS Code: BEEE580.1 ☐ TYPESET ☑ DISK ☐ LE ☐ CP Disp.:2011/10/22 Pages: 17 Layout: Small

Table 5 Compiled Information for ITACA stations

Pages compiled in the station reports	# of stations	% of total
General information	696	100
Geographical information	696	100
Geomorphology	199	29
Geology	550	79
Geotechnical & geophysical information (Vs profile)	108	16
Microtremor H/V spectral ratios	220	32
Site classification (with Vs30)	108	16
Site classification (without Vs30)	588	84
Topography classification	688	98

the ~~remaining 84%~~ site classes, according to an expert opinion based either on (i) surface geology or (ii) information collected from nearby sites, or (iii) available geophysical information, including the horizontal-to-vertical spectral ratio. In addition, the topographic classification of the stations according to NTC08 was provided as well, based on a morphometric analysis (98% of stations).

A particular and specific feature was added into the reports for some selected ITACA stations where the observed spectral ordinates at the station lie far from the median values of the ground motion prediction equations calibrated on the ITACA records (Bindi et al. 2011a). Details for the identification of such features within the ITACA stations are illustrated by Bindi et al. (2011b).

In conclusion, in ITACA, the station information is available at different levels of detail, depending on the relevance of the site from the point of view of available strong motion records and on extent of researches performed on the site (Table 5).

4 Monitoring accesses to itaca from the web

Starting from 2008, the connections to the ITACA database were monitored, for determining the type, the affiliation and the origin of the users, and to test the correspondence between the original aims of the database with its actual use. The time-distribution of visited pages, images and data files displayed by the users is shown in Fig. 7a, while the downloaded-data bytes are illustrated in Fig. 7b. The greatest amount of accesses to the site occurred on April 2009 (Fig. 7a) and June 2009 (Fig. 7b), corresponding to the release of L'Aquila mainshock and main aftershocks strong-motion data, respectively. The number of accesses was conditioned not only by the earthquake events, but also by the presentation of ITACA at national and international conferences. Users come primarily from Italy, but after beginning of international projects on seismic hazard such as GEM (http://www.globalquakemodel.org/), SHARE (http://www.share-eu.org/) and NERIES, (http://www.neries-eu.org/, ended in 2010), users from around the world increased (Fig. 8). To keep track of the ITACA users, an *user registration* was introduced in the 1.0 release, required only for download operations. In such a way it was possible to highlight that most users come from university and research institutions, but professional consultants in earthquake engineering and seismic microzonation are also present.

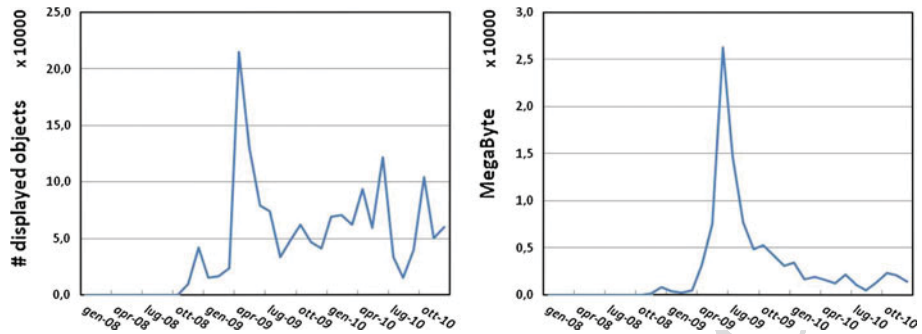

Fig. 7 Left. Numbers of pages, objects, images downloaded by the users from October 2008 to December 2010. *Right*: the same of (a) but in terms of downloaded bytes (by AWStats software)

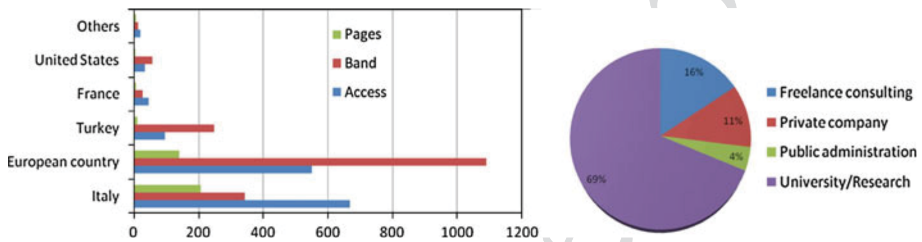

Fig. 8 Left Histograms of accesses, visited pages and used band (in Megabyte), grouped by countries (European country indicates websites ending in the .eu suffix) for the year 2010. *Right*: typology of users for the year 2010 (by AWStats software)

5 Discussion and conclusions

Italy has a long lasting history of strong ground motion observations, starting from the 1972 Ancona up to the 2009 L'Aquila earthquakes. In these about 40 years, strong motion seismology and earthquake engineering evolved very rapidly, together with the quality of instruments. In parallel, also the management of strong motion recordings in Italy changed significantly, presenting now a centralized national network (RAN) and few further local networks. Furthermore, several stations of Seismic National Networks (RSN) operated by INGV, have been recently equipped by accelerometric instruments.

In this framework, ITACA had the objective to gather a wealth of heterogeneous information from different sources and formats, often recovering some "forgotten" records or site information, and organizing such information in a homogeneous way within a single database management system. For this reason, in the development of ITACA we devoted a special care to homogenize processing techniques and to provide station reports as comprehensive as possible to summarize the amount of information and studies conducted throughout the years.

As a consequence, many of the stations that provided the most relevant strong motion records in Italy are well documented, while for many recently installed stations the available information is often inadequate.

The most distinctive features of ITACA, are: (i) its user friendly interface, (ii) the quantity and quality of information available, especially for the most important recording stations of the database, (iii) the availability of advanced record selection features such as REXELite. Such features have attracted multidisciplinary users, both from academy and profession, as well as students and teachers, as proved by monitoring accesses to ITACA.

During L'Aquila earthquake, the ITACA web site faced successfully a dramatic increase of users, especially when the processed records of the mainshock were released, a couple of weeks after its occurrence, and when the set of corrected records from the M > 4 aftershocks was released about one month later.

This was a rather satisfactory performance, if one takes into account that at that time the ITACA web site was not in its final stage yet, so that many digital stations of recent installation were not yet included in the database. Furthermore, record processing is a necessary bottleneck to provide users with reliable records, especially after strong earthquakes when a preliminary careful check of data quality and of the results of processing should be performed before release of records through the web.

However, it should be underlined that currently ITACA has no direct connection to the real time acquisition system of the Italian strong motion networks, so that data availability after an earthquake occurrence is inevitably delayed. Indeed, there is a trend in recent seismology to establish agreements among various seismic data providers, by taking advantage of new generation software for seismic data acquisition and storage of raw data, such as SeisComp3 (http://www.seiscomp3.org/). An example is the portal EIDA (http://eida.rm.ingv.it/) developed within the NERIES project (http://www.neries-eu.org/) and still in the development phase in the framework of NERA (http://www.nera-eu.org/). On the other hand, strong motion databases like ITACA find their strength by ensuring the quality of the released data and associated metadata, that require a careful revision process for waveform checking and the inclusion of correct information. This prevents truly real-time data distribution, but the revision process can be performed within a reasonably short period from the occurrence of a moderate to strong earthquake (M > 5). This is a key requirement that strengthens the role of ITACA as an important tool to support seismic research, professional activities and microzonation studies, not only in Italy but in other countries as well.

We finally note that the maintenance of a strong-motion database is a difficult task as well as its construction, especially if permanent funded structures, including technical and scientific expertise, are not planned to support it. This issue was already discussed by Ambraseys et al. (2004), referring to the European Strong Motion database, who stressed that the necessary condition for the web-portal to keep on operating is to get a permanent source of funding. This is not only to adapt the database to the most up-to-date technologies of data acquisition and storage, but also to improve the quantity and quality of information on the seismic events and recording stations.

The increasing need to keep databases alive after the end of their construction and the quasi real time release of qualified data will be the most important challenges for the future.

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