Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation

Report

Report on ERRN deployments during the project

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Summary

During the NERA project, the partners of the European Rapid Response Network (ERRN) preformed five deployments during seismic crises: (1) Pollino, Southern Italy, 2012-2014, (2) Emilia, Northern Italy, 2012, (3) Cephalonia, Greece, 2014, (4) Ubaye, France, 2014, and (5) Iquique, Chile, 2014. Two of these temporary deployments are already finished (Emilia and Ubaye missions), while the other deployments are still ongoing. Here we describe the geological background, the seismicity and the installed seismological networks during the ERRN missions and clarify how the corresponding data can be accessed. Furthermore, we describe the integration and access of the data of previous rapid response missions of the German Task Force, which we now made available within the EIDA infrastructure.

Introduction

Rapid response networks are an important element of the response to seismic crises. They temporarily improve the detection capacity of local and regional networks during periods of special interest, such as foreshock/aftershock sequences, swarms or induced seismicity. In areas where no local networks are available, temporary networks are often the only means for collecting seismic information. High quality datasets recorded by rapid response networks are important for decision makers to assess the current situation, as well as for scientific studies related to hazard, seismotectonics and earthquake physics (Parolai et al. 2004; Walter et al. 2008; Margheriti et al. 2011; Moretti et al 2012; Govoni et al. 2013; 2014).

The objective of this work package was to achieve a more efficient response to seismic crises within Europe and globally by the followings: (i) facilitate the communication and rapid information exchange between the main operators of rapid response networks in Europe; (ii) coordinate rapid deployment of seismological networks; and (iii) harmonize data collection, storage and access.

These goals have been achieved by firstly establishing a common concept of the implementation policy and rapid-response deployments (deliverable D4.1) and implementation of an ERRN communication platform (Task 4.2) with integrated tool to guide the deployment of joint rapid response networks (deliverable D4.2). For facilitation of data use and analysis, real-time data transmission in rapid deployments has been further tested in field tests and first applications in rapid response deployments in Emilia 2012 and Pollino 2012-2014 (deliverable D4.3).

In the following sections, we now describe the five rapid response deployments during the NERA-project in detail. In each case, we will discuss the geological setting, the seismicity, the deployments, and the data availability. During the project, we additionally integrated the data of previous German Task Force missions into the EIDA system, which will be briefly described in the last sections, where also precursory emergency deployments in Italy are mentioned.

Project Deployments

1. The Pollino, Italy, 2012-2014 deployment

Background and geological setting

The seismic sequence of Pollino hit an area located at the northernmost edge of the Calabrian Arc (Calabria, Southern Italy), which is one of the last oceanic subduction segment along the Africa-Eurasia plate boundary. Geodetic measurements show that the Pollino Range is subject to NE-SW anti-apenninic extension. The Pollino region is deforming and accumulating tectonic deformation, which results in a complex system of normal active faults striking sub-parallel to the Apennines.

Two principal normal faults are present in the Italian Database of the Individual Seismogenic Sources DISS version 3.1.1 (DISS Working Group, 2010) in the Pollino area: the Pollino (P) fault, the Rimendiello-Mormanno (RM) fault system. The RM fault is an active seismogenic structure having hosted in its northernmost part a M5.0 earthquake on 9th September 1998. It strikes about NNW-SSE and dips toward NE. The P fault has similar strike but dips toward SW: it shows no recent seismicity and is hence one of the most prominent seismic gaps in the Italian historical earthquake catalogue. Paleoseismic studies have shown that the P fault was active in the last 10 kyrs and is capable of producing M>6.0 events. The DISS database reports as a debated source the Piana Perretti fault (Brozzetti et al., 2009), too. A detailed structural map of the area agitated by the seismic sequence shows three fault systems (Brozzetti et al., 2013) consisting of several aligned fault segments that have been active during the Late Pleistocene and are presently reasonably active. The first fault system strikes NW-SE and dips toward SW (including the Pollino Fault and Piana Perretti fault at the NE edge of the Mercure Basin), the second one has similar strike and NE dip (including the southern portion of the RM fault) system, while the third one strikes about E-W.

Earthquakes reported in the historical catalogues for this area are not very strong. Few earthquakes with magnitude probably less than 6.0 affected the area. The Parametric Catalogue of Italian earthquakes (CPTI11, Rovida et al., 2011), shows very well the lack of strong earthquakes in the region: there is a clear evidence of large earthquakes in the Campania-Basilicata area (M~7.0) and several strong earthquakes in the Sila region and in the whole Calabrian territory. According to the seismic classification of the national territory, the area affected by the 2010-2014 seismic activity has a relatively higher probability to be shaken by a strong acceleration. Most of the seismic events occurred in areas where the peak ground acceleration has 10% chance to exceed 0.225 to 0.275 g in 50 years.

The 2010-2014 seismic activity

Between 2010 and 2014 the Italian Seismic Network (Amato and Mele, 2008) detected about 6000 earthquakes in the study area (Data source: Italian Seismological Instrumental and Parametric Data-Base, ISIDe Working Group, 2010). The seismicity shows an unusual spatio-temporal pattern (Passarelli et al., 2012): swarm like activity and mainshock-aftershock sequences coexist. In 2011 the earthquake rate has been variable, with increasing and decreasing phases and maximum magnitudes below M_L=4.0. On May 28th 2012, a shallow event with local magnitude M_L=4.3 struck about 5 km east of the previous swarm. The seismic activity remained concentrated in the M_L=4.3 source region until early August showing a mainshock-aftershock behaviour. At that time seismicity jumped back westward to the previous area, with several earthquakes of local magnitude larger than 3.0, culminating with a M_L=5.0 earthquake on October 25th 2012. The seismic rate remained high for some months, but magnitudes did not exceed 3.7. The seismic rate then suddenly decreased at the beginning of 2013 and stayed quite low for the rest of the year up to June 2014 when a magnitude 4 occurred in the eastern cluster. The fault plane solutions identified by the Time Domain Moment Tensor (TDMT; Scognamiglio et al., 2009; http://cnt.rm.ingv.it/tdmt.html) for the two major events are consistent with normal faults trending ~N20W and dipping at about 45°.

The deployment and the network configuration

During these years several temporary seismic stations were deployed in the area (Figure 1). After the increasing of seismic moment release in November 2011, the Centro Nazionale Terremoti of INGV, in collaboration with the Dipartimento di Fisica dell'Università della Calabria, improved the seismic monitoring network in the Pollino region in order to lower the detection threshold of the network and to improve the hypocentre locations of small earthquakes. One permanent station of the Italian Seismic Network was installed to the south (CET), and three real time (UMTS transmission) temporary stations were deployed along with two stand-alone stations. At the end of May 2012, after the occurrence of the M_L=4.3 event, two other temporary stations transmitting in real time to the INGV monitoring room were deployed.

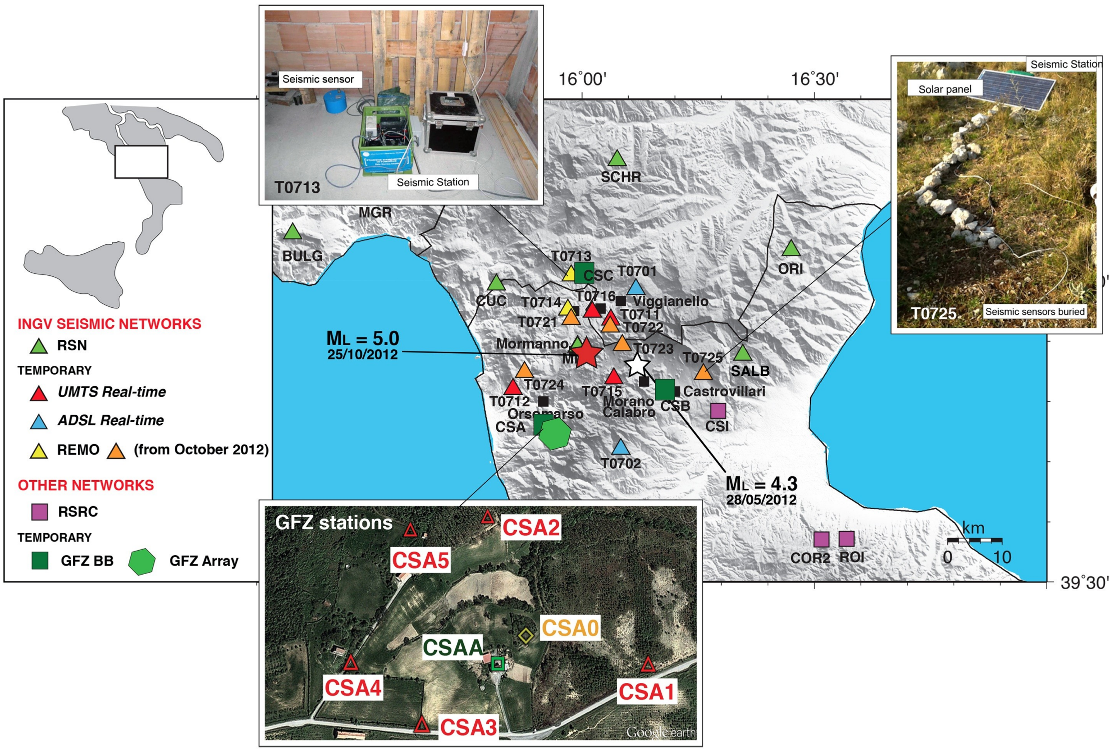

Figure 1: Seismic network present in the Pollino region. The different symbols for the different stations are explained by the legend; the stars are the epicentres of the two mainshocks. Inset show pictures of the seismic stations and the geometry of the GFZ array.

At the end of July 2012 the first temporary stations were removed leaving only the two real time stations installed at the end of May 2012 in the field (Amato et al., 2012). Between the end of October and the beginning of November 2012, after the M_L=5.0 earthquake, an international research team composed of the INGV and the German Research Centre for Geoscience (GFZ) installed 15 seismic stations and an array to improve the detection capabilities of the INGV permanent network giving us the opportunity to refine the location of the earthquake hypocentres. Six stations constitute the small aperture seismic array (Govoni et al., 2013). The array and 8 of the temporary stations are still active in the area (2 are in real time transmission).

Data

The INGV temporary network data is being stored within the EIDA waveform archive (European Integrated Data Archive, EIDA; http://eida.rm.ingv.it/; Mazza et al., 2012) to make it available to the scientific community. The data is archived in SEED format (Standard for the Exchange of Earthquake Data) and can be requested in SEED or SAC format. Data from the real time stations (8 stations named T07??, network code IV) are available on EIDA at the time of writing. All INGV station data, both real time and stand-alone, will be archived in EIDA by the end of October 2014. German data will be archived in EIDA at the GFZ node. T07?? stations are registered at the International Seismological Centre (ISC, http://www.isc.ac.uk/).

2. The Emilia, Italy, 2012 deployment

Background and geological setting

The Emilia sequence hit the central, roughly E-W trending sector of the Ferrara arc (Emilia Romagna, Italy) belonging to the external fold-and-thrust system of the Northern Apennines belt. The fold-and-thrust system is completely buried by thick Quaternary sediments of the Po Plain and, consequently, has been defined principally by hydrocarbon exploration data. In the aftershock region, the Ferrara arc is structured in two major fold-and-thrust systems: the Ferrara system in the northeast and the Mirandola system located in a more internal position in the southwest. Both systems also include distinct and minor thrust splays, back-thrusts and related folds. While the shallow architecture of fold-and-thrust structures is well imaged in seismic reflection profiles down to about 5-7 km depth, the deep geometry of the thrust planes is poorly defined because data quality and reflectivity strongly deteriorate at depth.
Even though earthquake catalogues show that seismicity (both historical and instrumental) in the Emilia sequence area is low ($M_L < 5.0$) and sparse, active shortening in the southern Po Plain is well documented by anomalies in the hydrographic pattern, folded Late Pleistocene strata in seismic profiles and GPS data. Borehole breakouts and CMT solutions indicate NE-SW regional shortening, with maximum horizontal stress (SH_{max}) directions generally perpendicular to the thrust fronts and to the axis of anticlines. It is interesting to note that the seismic sequence that struck the city of Ferrara (estimated magnitude of M_W 5.5) on November 17th, 1570 was a sequence of four very strong shocks [DBMI11]. It was a complex and long sequence, including an event, on March 17th, 1574, that produced damage in Finale Emilia (estimated magnitude of M_W 4.7).

The 2012 seismic activity

At 02:03 UTC (04:03 local time) on Sunday, May 20th 2012, an earthquake M_L=5.9 hit Northern Italy (44.89° N, 11.23° E, 6.3 km depth) causing casualties and severe damages to the historical buildings and to industrial activities of the region. In the following 72 hours (May 20th, 21st and 22nd) the National Seismic Network located about 300 events of which 68 had $M_L \geq 3.0$ (13 $M_L \geq 4.0$) (Data Source: 2005-2012 ISIDe). The mainshock was followed after few minutes by a M_L=5.1 event and after a few hours by a second M_L=5.1 earthquake (origin time 13:18 UTC). The rate of seismicity remained high with more than 60 events per day. On May 29th at 07:00 UTC a new large shock, M_L= 5.8, struck the area at the western edge of the ongoing seismic sequence (44.85° N, 11.09° E, 10.2 km depth). It was followed by several shocks including a M_L=5.2 and a M_L= 5.3 event at 10:55 UTC and at 11:00 UTC of May 29th, respectively. An event of magnitude 5.1 occurred on June 3rd at 19:20 UTC. The subsequent days of June were characterized by a progressive decrease in seismic rate and seismic moment release.

The deployment and the network configuration

After the first mainshock struck, contacts among the different INGV offices started immediately and early in the morning of May 20th the first INGV emergency rapid response group (personnel and equipment) was heading to the meizoseismal area. The first real-time station, T0822, started operating (i.e. sending real-time data to the INGV monitoring system) at about 10:30 a.m., on May 20th. The INGV groups (Ancona, Arezzo, Bologna, Milano, Irpinia, Pisa, Roma) installed 16 seismic stations within the first 48 hours from the May 20th main-shock (Figure 2). In the meanwhile INGV started the coordination with other Italian and ERRN partners.
The emergency seismic network continued to improve under the central coordination of INGV, and further stations became available following the spatial evolution of the seismic sequence as well as the second mainshock, on May 29th, a few kilometers westward of the initial seismicity. By early June, when the last M>5.0 earthquake occurred, about 70 seismic stations were deployed for the emergency (Figure 2), including stations managed by French groups.
The 10 real-time stations, together with the National Seismic Network, contributed to the INGV locations of the events for monitoring purposes. The 15 Dipartimento della Protezione Civile (DPC) stations make use of the GPRS data transmission to the DPC acquisition centre.
The about 50 other stations, recording stand-alone, from INGV and other Institutions (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS; Università di Ferrara; French IPGS-EOST stations coordinated by Institut National des Sciences de l'Univers – INSU/CNRS), provided an excellent dataset for scientific investigations and studies in various fields: seismic hazard, seismotectonics, earthquake physics, site response and wave propagation. Most of the stations were removed during summer 2012, a few recorded until the end of 2012. One new station of the Italian permanent seismic network was installed in the area (CAVE).

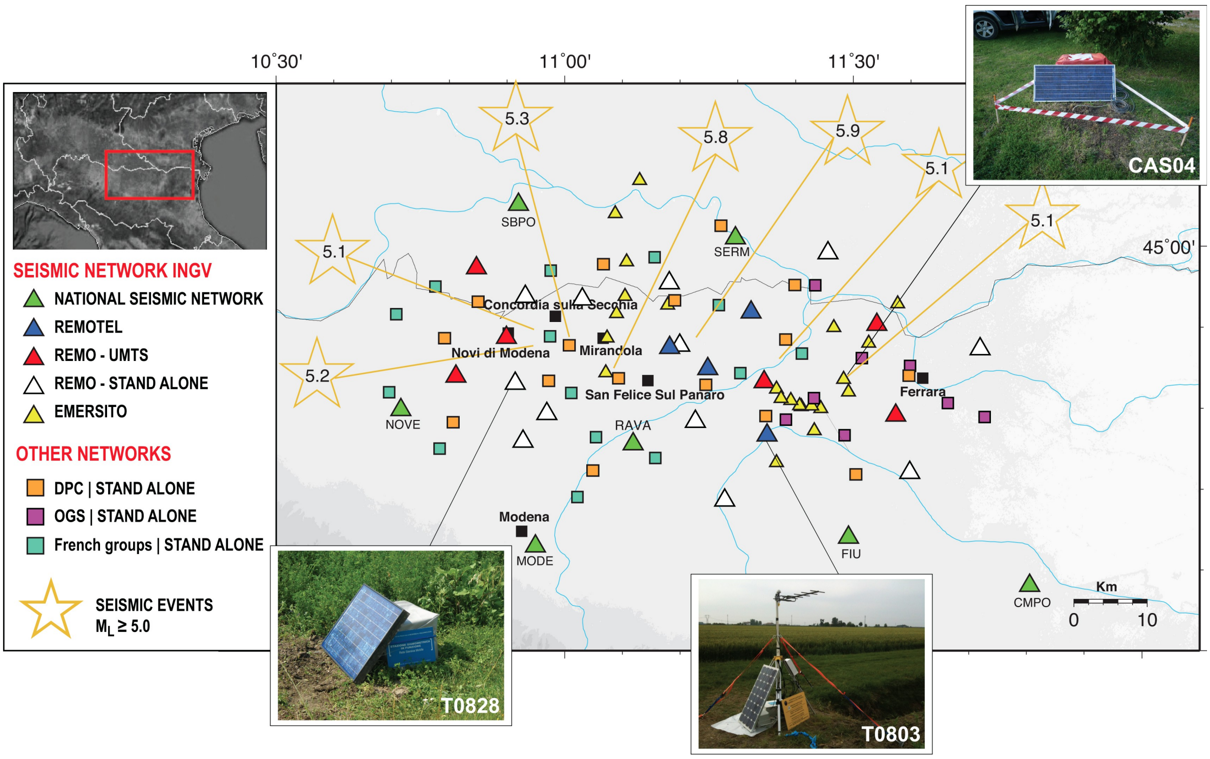

Figure 2: Seismic network deployed during Emilia 2012. The different symbols for the different stations are explained by the legend; the stars are the epicentres of the earthquakes larger than 5.0.

Data

The INGV temporary network data is being stored within the EIDA waveform archive (European Integrated Data Archive, EIDA; http://eida.rm.ingv.it/; Mazza et al., 2012) to make it available to the scientific community. The data is archived in SEED format (Standard for the Exchange of Earthquake Data) and can be requested in SEED or SAC format. Twenty-two stations named T08??, network code IV, plus 15 restricted stations, network code TV are available on EIDA at the time of writing (all INGV stations, both real time and stand-alone, are registered at the International Seismological Centre (ISC, http://www.isc.ac.uk/). French data will be possibly archived at the INGV EIDA node.
Overall the stations operation score was satisfactory: by the end of June the real-time stations contributed more than 5000 P-wave and more than 4000 S-wave picks to the locations of the National Network of about 2000 earthquakes. Consequently they increased the completeness and accuracy of the earthquake list distributed by INGV through ISIDe. Continuous data recorded by real time stations together with 12 of the stand-alone stations are available in EIDA to the scientific community.
OGS shares their continuously recorded data, without restrictions, through the OASIS portal (http://oasis.crs.inogs.it/). DPC data consists of triggered events, the two mainshocks are available on the department official web.

3. The Cephalonia, Greece, 2014 deployment

Background and geological setting

Located in the north-western boundary of the Aegean plate, Cephalonia Island is one of the seismotectonically most active region in Greece. The area is included in the highest seismic hazard class of the Greek building code. The high seismicity in the central Ionian Sea is considered to be the result of intense crustal deformation associated with right lateral strike-slip faulting along the Cephalonia Transform fault that can host earthquakes with magnitudes up to M7.4 (Louvari et al., 1999). Historical data show that the seismicity rate of the strong ($M \geq 6.5$) mainshocks in this zone remained stable during the last four centuries with an average of about one such shock per decade (Papadimitriou and Papazachos, 1985; Kokinou et al., 2006). More than 10 earthquakes with magnitudes between 6.5 and 7.5 occurred in the area between 1900 and 1998, causing major destruction.

The 2014 seismic activity

An earthquake of M_L 5.9 (M_W 6.1) occured in Western Greece, on January 26th, 2014 at 13:55 UTC, close to Cephalonia Island. This is the starting point of a long sequence of seismicity with earthquakes above magnitude 4 in the region. Damages are reported in the city of Argostoli. Eight days later, on February 3rd, 2014 at 07:00 UTC, a magnitude 6.0 occurred 20 km west from the January 26th event. Events exhibit strong ground motion (http://www.slideshare.net/itsak-eppo/20140126-kefaloniaeq-report-en) including soil liquefaction and damages.

The deployment and the network configuration

The Italian and French part of the Networking European Rapid Response Networks coordinated together with local Greek institutions a rapid deployment of seismological stations. An ITSAK team installed 3 accelerometers in the epicentral area (along the rupture zone) and two seismometers (one in the North of the island at Fiskardo and the other one at a rock site close to Argostoli). NOA operates on Cephalonia Island: 4 Seismometers: Geoinstruments Smart24 equipped with a Lennartz 3D-20sec sensor; 1 permanent seismometer: Geoinstruments Plc DR-24 connected to a Trillium 120P sensor; 3 accelerometers: 2 A-800 in triggered mode and 1 Guralp CMG-5TD in continuous mode.
The French Team installed their stations from February 10th to February 14th, 2014 and the Italian team from February 3rd to 7th. The French part provided 6 seismological stations composed of 5 three-component accelerometers (CMG5 from Guralp manufacturer) and 1 rotation sensor connected to Taurus acquisition units from the French national mobile seismological pool SISMOB (INSU/CNRS) and from CEA-LDG (Commissariat à l'Energie Atomique, Laboratoire de Détection et de Géophysique). The deployment of these stations involved participation of various French institutions (CEA Cadarache, CEA-LDG, IRSN, ISTerre) and was funded by the French ANR SINAPS@ project (2014-2017). The Italian INGV team (Grottaminarda office) installed 5 stations, equipped with both accelerometer and velocimeter (6 Quanterra: 6 Episensors + 6 Le5s), at the same locations as during the high-resolution experiment carried out in 2011-2012 within the NERA work package JRA1.
Stations were mostly deployed at sites (Figure 3) already instrumented during NERA project in 2011-2012. While Italian stations were removed by May 21st, French instrumentation is still operating in the field.

Figure 3: Seismic network deployed during the Cephalonia 2014 rapid response mission. Green symbols are the Greek stations, white and red symbols are the French and Italian stations; the red star in the inset is the January 26th mainshock.

Data

French data are available in the European Integrated Data Archive (EIDA) French website (http://portal.resif.fr/?European-Integrted-Data-Archive, network code YP). Continuous data were recorded by INGV from February 4 to May 21, 2014, and they will be shared with the others NERA partners through the INGV EIDA node with network code 4C.

4. The Ubaye, France, 2014 deployment

Background and geological setting

The Ubaye valley is one of the most active seismic areas in the French Alps (see the Sismalp network website: http://sismalp.obs.ujf-grenoble.fr/cases/stpaul/stpaul.html) that has faced several long duration seismic swarms over the last ten years (Jenatton et al., 2007), comprising a Mw 4.1 earthquake in 2012 (Courboulex et al., 2013).

The 2014 seismic activity

On April 7th, 2014, an Mw 4.9 magnitude earthquake occurred in the Ubaye valley in the French Alps. This earthquake was largely felt in an area comprised between Grenoble (France), Nice (France) and Torino (Italy).
The epicentre of the Mw 4.9 2014 earthquake (hypocentral depth of 9.9 km) is very close to the epicentre of the Mw 4.1 2012 event (hypocentral depth of 8.8 km); only located 400 m south of the 2012 epicentre. This raises interesting scientific questions concerning the underlying triggering mechanism of the new swarm, which was very intense with several thousands of recorded earthquakes (Cornou et al. 2014).

The deployment and the network configuration

Following the 2014 April 7th earthquake, the French part of the Networking European Rapid Response Networks coordinated a rapid deployment of seismological stations which lasted from April 10 to June 11, 2014. Seven seismological stations composed each of three-component short-period velocimeters and accelerometers from the French national mobile seismological pool SISMOB (INSU/CNRS) and from GEOAZUR research laboratory were deployed in the epicentral area, completing the already relatively dense Sismalp network (see Figure 4).

Data

The continuous recordings are freely available in the European Integrated Data Archive (EIDA) website (http://portal.resif.fr/?European-Integrated-Data-Archive, network code XG).

In a first analysis, Cornou et al. (2014) performed an STA/LTA based picking algorithm on vertical components to extract events. A couple of thousands of events were detected at each seismological station, except at IBVA site for which more than 32000 events were found. Then, an event was classified as a seismic one when it was detected by at least 4 stations within 5 seconds, which lead to 2926 earthquakes. For 2185 a respective location (circles in Figure 4) could be derived using HYPO71 (Lee et al., 1985).

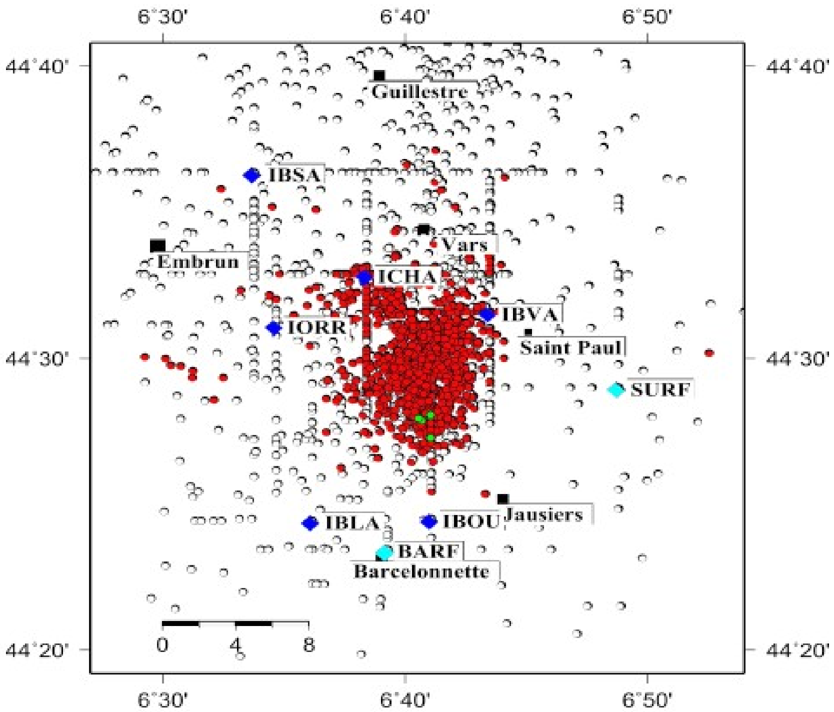

Figure 4: Ubaye, 2014, deployment: Temporary seismological stations (blue diamonds) and permanent stations (light blue diamonds; SURF, www.resif.fr; BARF, school network station, www.edusismo.org). Circles define located events which occurred between April 10 and June 11, 2014, and red filled circles indicate the best quality locations.

5. The Iquique, Chile, 2014 deployment

Background and geological setting

The plate boundary between the South American plate and the oceanic Nazca plate exhibits some of the largest earthquakes on Earth as recently manifested by the disastrous M 8.8 Maule earthquake of February 27th, 2010, in South Central Chile. Earthquakes and volcanoes are driven by the convergence between the two tectonic plates.

The northern part of the Chilean margin consists of a more than 400 km long plate boundary segment between Antofagasta and Arica, capable of producing a giant M9+ earthquake; this segment has not been broken for more than 120 years. This is the longest silent time period between large earthquakes along the Peru-Chile coastal margin, putting this segment in the terminal stage of a seismic cycle. The neighbouring segments to the south and north have been broken in 1995 and 2007 and 2001 respectively, enhancing the stress in between.

Since 2006, a European-South American network of institutions and scientists is organizing and operating a distributed system of instruments and projects dedicated to the study of earthquakes and deformation at the continental margin of Chile, the so-called IPOC (Integrated Plate boundary Observatory Chile). GFZ is a major partner of this network. The observatory is designed to monitor the plate boundary system from the

Peru-Chile state boundary to south of the city of Antofagasta, from the coast to the high Andes and capture the great earthquake to come in this seismic gap. In contrast to conventional observatories that monitor individual signals only, IPOC is designed to capture a large range of different, possibly associated deformation processes by using different geophysical and geological observation methods (seismographs, strong-motion seismographs, GPS, magnetotellurical sensors, creep-meters, accelerometers, InSAR, etc). Detailed information related to IPOC can be found at http://www.ipoc-network.org.

The 2014 seismic activity

The 2014 Iquique earthquake struck off the coast of Chile on 1 April, with a moment magnitude of 8.1, at 20:46 local time (23:46 UTC). The epicentre of the earthquake was approximately 95 kilometres northwest of Iquique. The mainshock was preceded by a number of moderate to large shocks. Starting in July 2013, three foreshock clusters with increasingly larger peak magnitudes and cumulative seismic moment occurred here. Then the mainshock rupture started at the northern end of the foreshock zone and was followed by a large number of moderate to very large aftershocks, including a M7.7 event on 3 April, 2014.
First seismological analyses of the IPOC data have shown that tension has been released by the sequence only in the central part of this segment and that there is no sign that the stresses in the Earth's crust has significantly decreased (Schurr et al. 2014). The reduction of the slip deficit by about 50% in the Iquique earthquake area decreases the probability that a future earthquake will release the whole remaining slip deficit at once. However, as the slip deficit reduction is only partial, this region will not necessarily act as a barrier: the seismic potential of this area remains high (Schurr et al. 2014).

The deployment and the network configuration

Because the IPOC seismological network has an average station spacing of about 50 km, it is too sparse to produce highly resolved aftershock locations. Therefore it was important to install additional stations to densify the permanent network in order to better detect and characterise upper plate fault activation, which is often following large subduction zone earthquakes, posing an additional seismic risk during the post-seismic period to coastal settlements due to the shallow nature of these faults. Furthermore, the intensified monitoring of the regions north and south of the mainshock rupture accounts for the increased risk of the neighbouring segments to break too. In addition to improving earthquake locations, a dense network will allow studies of crustal structure at unprecedented resolution within the rupture region of this great earthquake.

Due to its long-term interest in the region and scientific and societal importance of the earthquake sequence, the IPOC and ERRN institutions cooperated to rapidly install an additional temporary seismic network. In coordination with the Seismological Centre (CSN) and the Geophysics Department (DGF) of the University of Chile, a Chilean team led by Sergio Ruiz and Diana Comte (Departamento de Geofísica, Universidad de Chile, Santiago) were taking the lead on seismic station efforts in Chile.

Because of the intensive foreshock activity, 10 temporary broadband (BB) stations were already deployed around Pisagua-Iquique area one week before the Mw8.1 mainshock. Immediately after the occurrence of the mainshock, the Chilean team deployed 16 additional broadband stations within one week. GFZ started to deploy its stations one week after the mainshock. Then the German/Chilean team (G. Asch, P. Arias, A. Manzanares, and P. Salazar; GFZ Potsdam and U Católica del Norte) installed within two weeks 23 additional seismometers: 17 Trillium Compact broadband seismometers with cube data logger and 6 short-period Mark L4C sensors with EDL data logger with 100 Hz sampling rate. The network configuration is shown in Figure 5 and a detailed station list is provided in Table 1.

In addition to the onshore rapid-response deployment, GEOMAR (Helmholtz Centre for Ocean Research Kiel) is planning to deploy ocean bottom seismometers (OBS) in November 2014, which will be recording for one year. At least through better structural information this will hopefully allow to further improve the locations of the fore- and aftershocks.

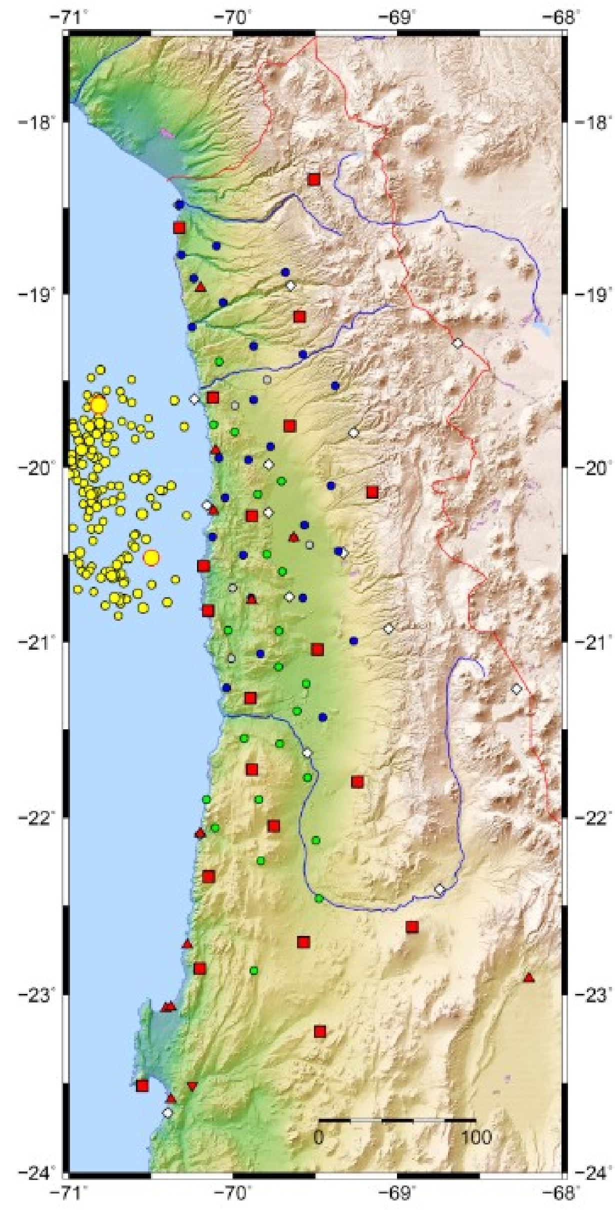

Figure 5

Station network with mainshock and first aftershock locations (yellow circles, where the two largest points refer to the main-shock and its largest aftershock).

Table 1: Installed stations during the 2014, Iquique, deployment (STA: Chilean stations; LTA: GFZ stations).

Station Name	Installation Date	Latitude (S)	Longitude (W)	Height (m)
STA-01	27.3.2014	19,18958	70,25112	58
STA-04	27.3.2014	19,87952	69,77348	1161
STA-05	27.3.2014	19,61042	69,87563	1194
STA-07	27.3.2014	20,33095	69,56593	1018
STA-09	27.3.2014	20,17337	70,04838	726
STA-10	27.3.2014	20,10387	69,40415	1713
STA-02	28.3.2014	19,34730	69,57590	2201
STA-03	28.3.2014	19,29960	69,87668	1311
STA-08	28.3.2014	20,74847	69,89025	989
STA-06	29.3-2014	19,94493	70,08660	680
STA-20	4.4.2014	20,50308	69,93968	1044
STA-21	4.4.2014	20,48042	69,35880	1278
STA-25	4.4.2014	20,99488	69,26673	1444
STA-27	4.4.2014	21,43020	69,45575	862
STA-31	4.4.2014	20,39773	70,12720	877
STA-32	4.4.2014	19,52875	69,37871	2721
STA-17	5.4.2014	19,04732	70,06175	1172
STA-23	5.4.2014	21,06753	69,83409	934
STA-33	5.4.2014	19,95617	69,90733	1125
STA-11	6.4.2014	18,87298	69,68292	2402
STA-19	6.4.2014	18,90748	70,23957	879
STA-22	6.4.2014	21,26182	70,04137	998
STA-12	7.4.2014	18,77192	70,31520	128
STA-13	7.4.2014	18,48045	70,32497	127
STA-15	7.4.2014	18,72103	70,10132	987
LTA-01	11.04.2014	21.39479	69.61015	776
LTA-02	11.04.2014	21.23878	69.55506	794
LTA-03	12.04.2014	20.40348	69.63087	990
LTA-04	12.04.2014	20.59758	69.70213	901
LTA-05	12.04.2014	20.49881	69.79481	1015
LTA-06	12.04.2014	20.07961	69.70638	1099
LTA-07	13.04.2014	19.79472	69.99116	1376
LTA-08	13.04.2014	19.75384	70.11971	1034
LTA-09	14.04.2014	19.39110	70.08536	1155
LTA-10	14.04.2014	20.15410	69.85011	1143
LTA-11	18.04.2014	20.93596	69.72207	980
LTA-12	18.04.2014	20.93262	70.03122	680
LTA-13	21.04.2014	21.14223	69.72346	858
LTA-14	22.04.2014	21.55055	69.93319	955
LTA-15	22.04.2014	21.58037	69.71726	1231
LTA-16	22.04.2014	21.77364	69.54668	1020

LTA-17	23.04.2014	21.89732	69.84379	1790
LTA-18	24.04.2014	22.05809	70.10877	1240
LTA-19	24.04.2014	21.89763	70.16108	142
LTA-20	24.04.2014	22.24585	69.83215	1600
LTA-21	25.04.2014	22.12963	69.49611	1120
LTA-22	25.04.2014	22.45850	69.47689	1295
LTA-23	25.04.2014	22.86586	69.87402	1580

Data

The waveform data of the IPOC permanent seismological network are included in EIDA. The description and list of the 20 broad-band seismometers can be found at http://www.ipoc-network.org/index.php/observatory/seismology/broadband.html. The network code is CX (Plate Boundary Project, GFZ Potsdam, Germany) and data can be freely accessed through the Geofon data centre at http://geofon.gfz-potsdam.de/waveform/archive/network.php?ncode=CX.

The data of the local permanent Iquique network are also stored in EIDA and can be found at the Geofon data centre at http://geofon.gfz-potsdam.de/waveform/archive/index.php?type=p with network code IQ (Plate boundary Project Iquique, GFZ Potsdam, Germany).

All stations installed during the rapid response deployment are off-line stations. In October 2014, first data will be recovered and integrated into the EIDA system.

Past German Task Force Deployments

Since its foundation in 1993, the German Task Force participated in 22 national and international rapid response actions after earthquakes until 2010 (see e.g. Fig. 6). Three subsections of the German Task Force were mainly active: GEO (geology, geophysics), BAU (building and underground studies) and WISO (economic and societal affairs). The Task Force GEO was the main core and was involved in all missions. It included all aspects of seismology like earthquake physics, aftershock studies, engineering seismology, macro-seismic studies or hazard assessment. Other fields were geodesy, geology including neotectonics, geohydrology and geodynamics. The aim was to cover the full spectrum of geophysical processes related to the earthquake.

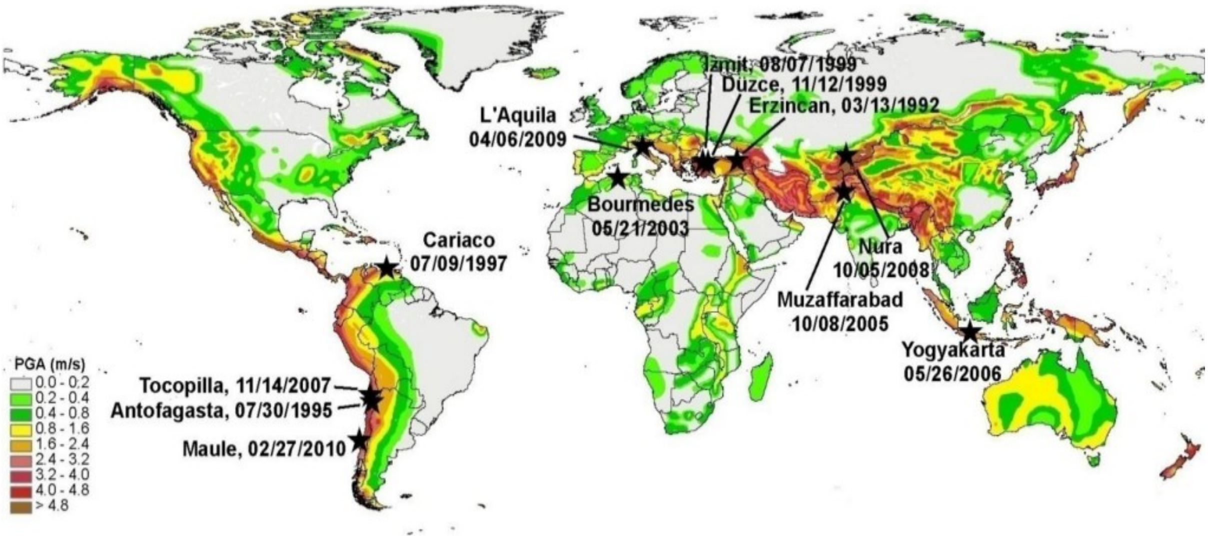

Figure 6: Map of selected German Task Force missions.

A pool of seismological instruments were fully dedicated to rapid-response missions, as e.g. 20 MARK L4-ED seismometers with Earthdata loggers for short-period recordings, 10 stations ALTUS K2 (Kinemetrics) for strong motion recordings, and a set of 20 SOSEWIN nodes, a self-organizing, wireless network of accelerometers. However, on demand, additional instruments, in particular from the Geophysical Instrument Pool Potsdam (GIPP), were used.

Within the project, we have started to integrate the data of those missions into the European Integrated Data Archive (EIDA). The data of Task Force missions which are already available are given in Table 2. Their data can be accessed from the webpage: http://geofon.gfz-potsdam.de/waveform/archive/index.php?type=t.

Year	Earthquake	Mw
1998	Adana, Turkey	6.3
2006	Yogyakarta, Indonesia	6.3
2007-2008	Tocopilla, Chile	7.7
2008-2009	Nura, Kirgizstan	6.6
2010-2011	Maule, Chile	8.8

Table 2: Past German Task Force missions with data integrated in EIDA.

Data of the remaining German Task Force missions are already converted and will be soon uploaded on EIDA.

Past and minor emergency deployments in Italy

During the 2009 seismic emergency following the April 6th earthquake (Mw6.1) near L'Aquila (Margheriti et al., 2011) the Italian, French and German Institutes coordinated the deployment of their stations in order to form a joint network; the experience gained in this mission emphasized the necessity to optimize collaboration, facilitate rapid data exchange and structure data processing procedures within the rapid response network community. Data collected by the different groups are archived in the EIDA waveform archive (European Integrated Data Archive, EIDA; http://eida.rm.ingv.it/) and is available to the scientific community. The data is archived in SEED format (Standard for the Exchange of Earthquake Data) and can be requested in SEED or SAC format. INGV stations are named RM??, network code IV, French stations are named LG??, network code XJ.

Starting from the 2009 emergency the Italian Task Force participated in 10 national and rapid response actions, following the main seismic sequences (already described in the above paragraphs) and minor ones. Most of the time real time stations were deployed and archived in EIDA (Figure 7).

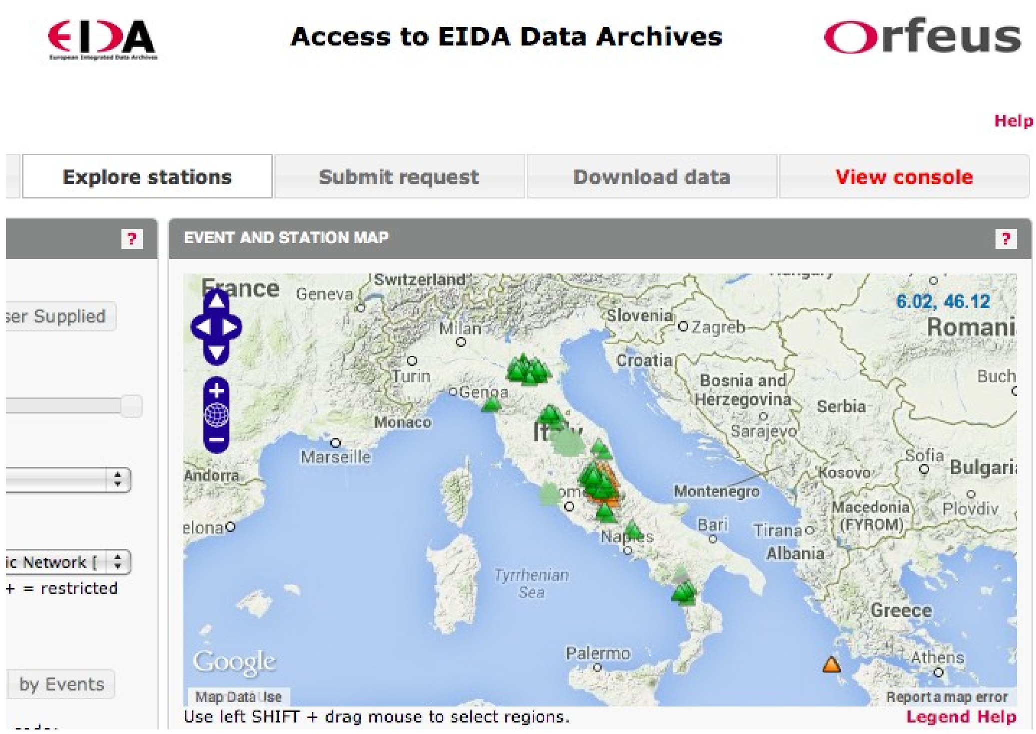

Figure 7. Stations with data available in EIDA by ERN missions and by the Italian emergency network starting from 2009 (L'Aquila earthquake where both French and German Institutions participated to the deployment).

Summary and Conclusion

The NERA-NA4 project has successfully set up the base for more efficient future rapid deployments in response to large earthquakes or earthquake swarms. The network activity of the main operators of rapid response deployments in Europe has led to the first-time establishment of a common policy for communication, deployment and data management which has been documented in deliverable D4.1. In addition, the NA4 project has resulted in the establishment of an ERRN communication platform, which helps the communication between the different partner institutes before, during and after rapid deployments.

The efficiency of the project results for real rapid response deployments have been already tested during a series of deployments described in this deliverable, consisting of the deployments in Pollino (Southern Italy), Emilia (Northern Italy), Cephalonia (Greece), Ubaye (France), and Iquique (Chile). We have found that the rapid planning and setup of the deployments was significantly improved due to the effective communication and the clarified general policy for deployments. Finally, the exchange, storage and open access of the data have been greatly simplified due to the use of the EIDA infrastructure.

In sum, the rapid response deployments performed during the NERA project have shown the value of an improved networking of the different European institutes performing rapid response deployments after seismic crises. The efficiency has been clearly improved. However, further improvements are desirable, e.g. by the use of real-time data transmission and software solutions for the control of data quality and the integration of new partner institutions. Consequently, it is very important to continue this network activity in the future.

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