Introduction to the Strong-motion seismology session

Lucia Luzi
Summary

- ORFEUS WG5
- Session programme
- ESM and RRSM as site repositories
European coordination of acceleration and strong-motion data

ORFEUS (Observatories and Research Facilities for European Seismology), is the non-profit foundation that aims at co-ordinating and promoting digital, broadband (BB) seismology in the European-Mediterranean area.

Extension to SM seismology Proposed at the 2012 ORFEUS coordination workshop
Proposed responsibilities

• Setting rules for data dissemination
• MoU’s between data providers (extending the Consortium)
• Collaborating with EPOS for the preparation of projects
• Contacting similar establishments in the other parts of the world

• **Ensure quality of metadata and waveforms:**
  • Checking the quality of processed data of the partner institutions
  • Suggestion/development of the state-of-the-art techniques for metadata compilation and data processing

• **Ensure IT development improvements:**
  • Data transfer, optimum data dissemination techniques etc
  • Coordinate with related activities of ORFEUS/EPOS
The group

• A preliminary board has been created in June 2013 with representatives of Greece, Turkey, Italy, France, Switzerland and Iceland

• In 2014 Spain, Romania, Austria, Belgium, Portugal, Germany, Serbia, Albania joined the group and Iran asked to participate to meetings

• On October 2014 Romania (NIEP) become a new EIDA node

• Turkey (KOERI) become an EIDA node in 2015

• Greece (NOA) applied to become a new EIDA node

• The infrastructures and governance of ORFEUS will be soon included in EPOS
International workshop on strong-motion and acceleration data
(Ankara 12-13 May 2014)

Facilitating integrated data access
Establish a common data policy

From http://www.seismicportal.eu
Bucharest 2015: Site characterization

State of the art: L. Luzi (INGV - Milano)
ESM and station book as repositories for site characterization

Network operator perspective: D. Faeh (ETH - Zurich)
Station characterization: example from SED network

User perspective: K. Pitilakis (Aristotle University - Thessaloniki)
Site characterization and seismic codes
Why site characterization

• The geotechnical characteristics of the uppermost soil layers can significantly modify the amplitude and the spectral content of the recorded ground motion induced by an earthquake.

• Local site effects play a fundamental role in determining the spatial variability of the seismic hazard for a given area.

• Strong-motion waveforms cannot be properly interpreted without adequate knowledge of the main geophysical and geotechnical properties of the site where they have been recorded.
Example: Gubbio (central Italy)

Temporal domain: peak values, duration, etc

Spectral domain: Fourier spectra, response spectra, etc

3.4 56km

3.1 98km
Site characterization

Different levels of site characterization can be categorized as follows (from Michel et al. 2014):

• **simplified geological** and **geotechnical classification** (e.g., design code approach);

• **geophysical characterization** using a single parameter (e.g., $VS_{30}$, $f_0$);

• **1D profiling** of the linear elastic and eventually inelastic parameters;

• **full microzonation** using advanced 2D/3D models and nonlinear response analysis.
Site characterization studies

- **Japan**: velocity profiles from borehole logging are available for every KiK-net station (Aoi et al., 2004)
- **Taiwan**: sites of the whole network classified (Lee et al., 2001)
- **Iran**: 138 sites with site category and about 50 $Vs_{30}$ (Zaré et al., 1999)
- **Turkey**: 236 sites of AFAD were investigated with MASW, and 153 boreholes were drilled (Sandikkaya et al., 2009). Project “Compilation of National Strong-Motion Database in Accordance with International Standards”
Site characterization studies

- **United States**: geophysical site characterizations at 191 strong-motion stations USGS ARRA-funded project (Yong et al., 2013)

- **Italy**: 154 Vs /Vp profiles or site characterization of all stations based on geological surface are available in the Italian strong motion database (projects funded by DPC)

- **Switzerland**: site characterization promoted within the renewal project of the Swiss Strong Motion Network. In Michel et al (2014) example for 30 stations
Data availability

Information is accessible through the web but in different formats (Tables, papers, reports, etc.)

Kik-Net

Site AZ.PFO

Location: Cecil and Ida Green Pinion Flat Observatory, Riverside County, California

Latitude: 33.61167  Longitude: -116.45943
(Site coordinates from site GPS survey, WGS84 coordinate system)

\( V_{S0} \) (measured): 763 m/s (±10% beneath seismic line)

\( V_{S0} \) (adjusted to more accurately reflect seismic station conditions): 848 (average S-wave velocity between 1 and 31 m adjusting for assumed sensor depth).

NEHRP Site Class: B/C (significant lateral velocity variation in the immediate site vicinity will result site class ranging from C to B. Adjusting \( V_{S0} \) for seismic station conditions will result in site class ranging from C/B to B).

Geomatrix Code: IGA

Geologic Conditions/Observations: Seismic station located on Mesozoic (Cretaceous) granitic rock (quartz diorite, granodiorite).

Site Conditions: Rural site. Relatively flat terrain in site vicinity with gradual topographic decline to south.

Geophysical Methods Utilized: HVSR, Seismic Refraction (P- and S-wave), MASW (Rayleigh wave), MALW (Love wave)

Geophysical Testing Arrays:

1. Array PFO-1 (48 channel MASW array utilizing 4.5 Hz vertical geophones spaced 1.5 m apart for a length of 70.5 m, forward and reverse shot locations with multiple source offsets and source types and center shot location).
2. Array PFO-1 (48 channel MALW and S-wave seismic refraction array utilizing 4.5 Hz horizontal geophones spaced 1.5 m apart for a length of 70.5 m, forward and reverse shot locations with multiple source offsets and multiple interior shot locations). Coincident with MASW array of same name.
3. Array PFO-2 (48 channel P-wave seismic refraction array utilizing 4.5 Hz vertical geophones spaced 3 m apart for a length of 141 m, forward and reverse shot locations with multiple source offsets and multiple interior shot locations using accelerated weight drop energy source). Arrays PFO-1 and PFO-2 have a common center and orientation.
4. Three HVSR measurement locations: two distributed along array PFO-2 and the other adjacent to the seismic station.
ESM and station book as repositories for site characterization
Station metadata

Station description: net code, station code, lat, lon, elevantion, start, end, address, country, etc.

Housing / building details: housing type, type of installation, building type, no. storeys...

Images: photos, maps

Morphology: morphology class, topographic class

Instrumentation: Instrumentation history, instrumentation description
Station metadata (geotechnical/geophysical)

- **Geology**: surface geology description
- **Borehole data**: stratigraphic logs
- **Gotechnical data**: NSPT logs ....
- **Geophysical data**: Vs/Vp logs, dispersion curves...
- **Site response functions**: HVSR, SSR
- **Site classification**: $V_{s30}$, site class...
News

2015 ORFEUS Annual Observatory Coordination meeting Workshop (21 – 24 September 2015, Bucharest, Romania).

July 2015: The version 0.1 of ESM has been released.

March 2015: ESM processing web frontend has been published. Link is available in the "Tools" section below.

ESM info

- User manual
- Contributing Networks
- Contacts
- Credits
- Glossary

Links

- Strong-Motion Databases

Tools

- Processing web frontend: a web interface for waveform processing on ESM database. Registered users can select waveforms, do their own processing and save the resulting waveforms on their personal computer.
- dyna-convert.py: Python code to convert ESM files to the most popular seismic formats (MSEED, SAC, GSE, SEGY, among others). Requires ObsPy.

ESM release 0.1

The demo version of the European Strong-Motion database (ESM) has been developed in the framework of the European Project NERA (Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation), Network Activity 3: Networking acceleration networks and SM data users. The database is maintained by WGS of ORFEUS.

ESM allows users to query earthquake and station information and download earthquake waveforms and response spectra for events with magnitude ≥ 4.0 mainly recorded in the European-Mediterranean and the middle-East regions.

ESM is fully compatible with the European Integrated Data Archive (EIDA), a distributed data centre established to securely archive seismic waveform data and related metadata based on international seismological standards. ESM also includes: European Strong-Motion Database (FTS 1998-2002), the Italian ACcelerometric Archive (ITACA), the Strong Ground Motion Database of Turkey and the Hellenic Accelerogram Database (HEAD).

Read more...

Data search

- Waveforms
- Stations
- Events

Records compatible with target spectra

- NESEIS

References

The Database should be acknowledged as: "ESM working group (2015), European Strong-Motion database, version 0.1, Network Activity 3: Networking acceleration networks and SM data users. Project NERA (www.nera-eu.org)"

License

The European Strong-Motion database by ORFEUS is licensed under a Creative Commons Attribution-NoDerivatives 4.0 International License (cf. Section 4 – Sui Generis Database Rights). Based on a work at WGS-ORFEUS. Permissions beyond the scope of this license may be available at the disclaimer section hereafter.
ESM as station metadata repository

ESM European Strong Motion Database

Stations Search

Results 1 - 20 of 2079

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<th>Network</th>
<th>Code</th>
<th>Station Name</th>
<th>Notation</th>
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<th>Province</th>
<th>Municipality</th>
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<th>Longitude</th>
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<th>V_r</th>
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Aim

- **ESM** contains only stations hosting *strong-motion instruments*, therefore it is oriented to the earthquake engineering / engineering seismology applications.

- **ESM** contains *metadata* that can be related to site response.
### Station Detail

**Station Name:** L'AQUILA - V. ATERNO - CENTRO VALLE  
**Station Code:** AQV  
**Network:** IT - Italian Strong Motion Network (DPC)  
**Type:** Permanent  
**Loc.:** 42.37722, 13.34389  
**Elevation (m.a.s.l.):** 692  
**Mines, records:**  

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### Stratigraphy

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### Detail And Profiles For Stratigraphy

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<th>Sequence</th>
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<th>Top (m. from g.s.)</th>
<th>Bottom (m. from g.s.)</th>
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<td>0.0</td>
<td>0.8</td>
<td>Terreno di ripristo artificioso costituito da argilla limosa di colore marrone scuro mediamente consistente con inclusi litici calcarei eternometrici.</td>
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<tr>
<td>2</td>
<td>Inorganic clays of low to medium plasticity, gravelly-sandy silty-clayey clays. Liquid limit 50% or less.</td>
<td>0.8</td>
<td>2.0</td>
<td>Argilla e argilla limosa di colore marrone scuro mediamente consistente con scarsi inclusi litici calcarei e tracce di ossidazione.</td>
</tr>
<tr>
<td>3</td>
<td>Inorganic clays of low to medium plasticity, gravelly-sandy silty-clayey clays. Liquid limit 50% or less.</td>
<td>2.0</td>
<td>3.3</td>
<td>Argilla e argilla limosa di colore marrone scuro mediamente consistente con scarsi materie organiche e tracce di ossidazione. Presenza di inclusi litici visibili nel letto.</td>
</tr>
<tr>
<td>4</td>
<td>Gravels with fines. Silty gravels, gravel-sand-silt mixtures. 50% or more of course fraction retained on a 4 mm sieve.</td>
<td>3.3</td>
<td>4.5</td>
<td>Ghiaia calcarea eternometrica in maniera limosa di colore avera passante a matrice argillosa di colore scuro verso il letto. Ciottoli calcarei di dimensioni comprese tra 2 e 15 cm mediamente arrotondati ed appiattiti.</td>
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<td>5</td>
<td>Gravels with fines. Silty gravels, gravel-sand-silt mixtures. 50% or more of course fraction retained on a 4 mm sieve.</td>
<td>4.5</td>
<td>7.5</td>
<td>Ghiaia calcarea eternometrica in maniera limosa di colore avera passante a matrice sabbiosa di colore giallastro verso il letto. Ciottoli calcarei di dimensioni comprese tra 2 e 15 cm mediamente arrotondati ed appiattiti.</td>
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<td>6</td>
<td>Clean Gravels. Poorly graded gravels and gravel-sand mixtures, little or no fines. 50% or more of course fraction retained on a 4 mm sieve.</td>
<td>7.5</td>
<td>8.0</td>
<td>Ghiaia calcarea eternometrica scialcata. Ciottoli calcarei di dimensioni decimetiche mediamente arrotondati ed appiattiti.</td>
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<td>Ghiaia calcarea fine monometrica in abbondante matrice sabbiosa fine di colore giallastro, con presenza diffusa di ciottoli calcarei di dimensioni decimetiche. Ciottoli di dimensioni medie di circa 0.5-1 mm mediamente arrotondati ed appiattiti.</td>
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<td>11.0</td>
<td>Ghiaia calcarea eternometrica scialcata. Ciottoli calcarei di dimensioni comprese tra 2 e 10 cm mediamente arrotondati ed appiattiti.</td>
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<td>Ghiaia calcarea fine monometrica, con rari ciottoli calcarei di dimensioni decimetiche. Ciottoli di dimensioni medie di circa 0.5-1 cm mediamente arrotondati ed appiattiti.</td>
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<td>Ghiaia calcarea fine monometrica con sabbia grossolana. Ciottoli di dimensioni medie di circa 0.5-1 cm mediamente arrotondati ed appiattiti. Presenza di rari ciottoli calcarei di dimensioni decimetiche.</td>
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Station report

Annual Observatory Coordination Meeting Workshop (21-24 September 2015, Bucharest)
Station book as site repository

www.orfeus-eu.org/stationbook
Aim

• **RRSM** contains waveforms from stations instrumented with **different sensors** (short period, broad-band, accelerometric)

• Contains both **metadata on instrument response** as well as **metadata** that are **related to site response**
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Information contained in EIDA

```xml
<FDNSStationXML xmlns="http://www.fdsn.org/xml/station/1" schemaVersion="1.0">
    <Source>SeisComp3</Source>
    <Sender>ODC</Sender>
    <Created>2015-09-16T09:10:07</Created>
    <Network code="IV" startDate="1980-01-01T00:00:00" restrictedStatus="open">
        <Description>Italian Seismic Network</Description>
        <Station code="APEC" startDate="2014-02-06T12:00:00" restrictedStatus="open">
            <Latitude>43.55846</Latitude>
            <Longitude>12.41991</Longitude>
            <Elevation>488</Elevation>
        </Station>
        <Site>...</Site>
        <CreationDate>2014-02-06T12:00:00</CreationDate>
        <Channel code="HHB" startDate="2014-02-06T12:00:00" restrictedStatus="open">
            <locationCode=""></locationCode>
        </Channel>
        <Channel code="HHN" startDate="2014-02-06T12:00:00" restrictedStatus="open">
            <locationCode=""></locationCode>
        </Channel>
        <Channel code="HHZ" startDate="2014-02-06T12:00:00" restrictedStatus="open">
            <locationCode=""></locationCode>
        </Channel>
        <Channel code="HNE" startDate="2014-02-06T12:00:00" restrictedStatus="open">
            <locationCode=""></locationCode>
        </Channel>
        <Channel code="HNN" startDate="2014-02-06T12:00:00" restrictedStatus="open">
            <locationCode=""></locationCode>
        </Channel>
        <Channel code="HNZ" startDate="2014-02-06T12:00:00" restrictedStatus="open">
            <locationCode=""></locationCode>
        </Channel>
    </Network>
</FDNSStationXML>
```
FDSN StationXML

The FDSN StationXML schema and related documents are maintained by the International Federation of Digital Seismograph Networks (FDSN, http://www.fdsn.org).

StationXML is a schema definition for representing the Standard for the Exchange of Earthquake (SEED) metadata in XML.

SEED and StationXML are maintained by FDSN Working Group II (WG-II).

Approved schema are http://www.fdsn.org/xml/station/
Are we satisfied with these repositories?

No:

• Information is duplicated but can be different (EIDA stations)
• No interoperability
• No common standards
Are we satisfied with station XML?

Various repositories (files + images)

No geotechnical or geophysical info

Station xml extension
(proposal by Philip Kästlī)

SEED

FDSN StationXML

<station xmlns="http://www.fdsn.org/xml/station/1" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.fdsn.org/xml/station/1 http://www.fdsn.org/xml/station/1/schema/Station1_0.xsd">
  <meta>
    <source>http://www.geofon.de/ catalogue/model</source>
    <name>StationXML</name>
  </meta>
  <stationDescription>
    <description>Repository of StationXML records</description>
  </stationDescription>
  <network>
    <code>SEED</code>
    <locationCode>...</locationCode>
    <locationName>...</locationName>
    <site>
      <name>...</name>
      <elevation>90.0</elevation>
    </site>
    <channel>
      <code>BHZ</code>
      <eventDate>2014-02-08T12:00:00 UTC</eventDate>
      <stationCode>...</stationCode>
    </channel>
  </network>
</station>

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Conclusion

- Geotechnical characteristics of the uppermost soil layers are fundamental.
- Few stations have been characterized in the world.
- Few station metadata are standardized and available (station xml format).
- Additional metadata are required in the station xml (e.g. $V_{s30}$, 1D geophysical profiles).
Discussion

• No idea about station metadata available at single observatories
• Quantification of man-power needed to collect and uniform site metadata
• One or multiple repositories (e.g. federated approach as EIDA?)

Dedicated project?  EPOS?
Proposed actions

• Inventory of the station metadata available at each observatory
• Define all the necessary station metadata
• Extension of the station xml format

Setting a new EPOS working group on site characterization?
Thank you!
FDSN StationXML: current version

```xml
    targetNamespace="http://www.fdsn.org/xml/station/1" elementFormDefault="qualified" attributeFormDefault="unqualified" version="1.0">
  <xs:annotation/>

  <xs:element name="FXStationXML" type="fx:RootType"/>

  <xs:complexType name="RootType">
    <xs:sequence>
      <xs:element name="NetworkType"/>
      <xs:element name="StationType"/>
      <xs:element name="ChannelType"/>
      <xs:element name="CaintType"/>
      <xs:element name="FIRType"/>
      <xs:element name="CoefficientsType"/>
      <xs:element name="ResponseListElementType"/>
      <xs:element name="PolynomialType"/>
      <xs:element name="DecimationType"/>
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="FrequencyRangeGroupType">
    <xs:group name="FrequencyRangeGroup">
      <xs:sequence>
        <xs:element name="FrequencyType"/>
      </xs:sequence>
    </xs:group>
  </xs:complexType>

  <xs:complexType name="EquipmentType">
    <xs:sequence>
      <xs:element name="EquipmentName"/>
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="LocationType">
    <xs:sequence>
      <xs:element name="LocationName"/>
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CoordinateType">
    <xs:sequence>
      <xs:element name="Latitude"/>
      <xs:element name="Longitude"/>
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="AttributeGroupType">
    <xs:attributeGroup name="uncertaintyGroup">
      <xs:attributeGroup/>
    </xs:attributeGroup>
  </xs:complexType>

  <xs:complexType name="FloatNoUnitType">
    <xs:sequence/>
  </xs:complexType>

  <xs:complexType name="DerivedFromFloatType">
    <xs:sequence>
      <xs:element name="SecodnType"/>
      <xs:element name="VoltageType"/>
      <xs:element name="AngleType"/>
      <xs:element name="LatitudeBaseType"/>
      <xs:element name="LongitudeBaseType"/>
      <xs:element name="AzimuthType"/>
      <xs:element name="DistanceType"/>
      <xs:element name="FrequencyType"/>
      <xs:element name="SampleRateType"/>
      <xs:element name="CountType"/>
      <xs:element name="PersonType"/>
      <xs:element name="SiteType"/>
      <xs:element name="ExternalReferenceType"/>
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="SimpleType">
    <xs:sequence>
      <xs:element name="NominalType"/>
      <xs:element name="EmallType"/>
      <xs:element name="PhoneNumberType"/>
      <xs:element name="RestrictedStatusType"/>
      <xs:element name="UnitsType"/>
      <xs:element name="BaseFilterType"/>
      <xs:element name="ResponseType"/>
      <xs:element name="BaseNodeType"/>
    </xs:sequence>
  </xs:complexType>

</xs:schema>
```