



Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation

Report

Implementation

Activity:	Real-time seismic risk assessment and decision support
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Summary

In this report, we describe the products generated through the joint research activity JRA4, that is WP14 of the NERA project. These products are available via the NERA project portal or, if that should no longer exist, by contacting the authors of this report. Also ORFEUS hosts a repository with all NERA reports and products (see below).

The primary implementation products are:

- A collection of codes for users to explore their building stock data and estimate time-varying seismic risk (including forecasts of time-varying seismicity rate, seismic hazard, and losses);
- The building stock data used for the Basel case study (see D14.3);
- The simulated seismicity data used for the Basel case study (i.e., that used for the SEISMO-12 exercise, see D14.3, “Guidelines for implementing real-time risk assessment during earthquake emergencies”); and
- A WebGIS implementation of codes for users to perform and visualize damage scenarios that account for progressive damage during an earthquake sequence.

The former three products are available from the [NERA document management system](#), you can find them under Work Packages/Joint Research Activities (JRA)/WP14 – JRA4/implementation - and from the NERA repository at ORFEUS:

<http://www.orfeus-eu.org/organization/projects/NERA>

1. Data and codes used for Basel scenario

The data and codes used for our Basel case study are described in detail in D14.3, and we refer the interested reader to that document. Here we give a brief technical summary of the codes and refer the interested user to the NERA portal, where the codes and data are hosted.

Since the QLARM code, on which we base our work, was written in MATLAB, we continued to implement our ideas with this programming language. Specifically, we arranged our implementation in separate scripts, rather than making excessive use of functions.

To assess the short-term seismic risk, we have to issue two parts: (1) The loss estimation (with QLARM in its background), which is time-independent and thus only has to be run once. For a specified intensity I , it gives us the potential fatalities $F(I)$. We save the results for a 0.5 spacing of intensity, for all municipalities, and as a function of EMS vulnerability classes and casualty degree in a MAT-file for direct access. (2) For the forecast part itself, we call STEP (and the Java-based OpenSHA hazard engine where STEP is implemented), from within a MATLAB script. We may call STEP for each intensity and for a specified time. We read out the hazard forecast results and save intensity-dependent results in separate per-date-files.

Both these parts are "connected" by so called probabilistic loss curves (PLCs), which can be understood as a function of the continuous potential loss, in our case the potential fatalities $F(I)$, linked to the corresponding probabilities from the hazard forecast (for distinct intensity levels I). The PLC enables us different probabilistic expressions of the risk, e.g., the chance for an individual to die, and we can present and visualize the short-term seismic risk spatially (using maps) and temporally (as time-varying curves).

When applying the code to another study area, one requires information about the background hazard, site amplification, exposure, vulnerability classification/building typology, and district boundaries. We included additional scripts, for example to give an overview of the study region, or to show the vulnerability based on the exposure data.

Interested readers may also find the eqvis software useful: information is available at <http://www.vce.at/de/forschung/eqvis>.

2. WebGIS implementation for modelling progressive damage scenarios

We have written a standalone manual for the WebGIS implementation, and we append it here. The WebGIS implementation is open to the scientific community (upon free registration) at <http://193.206.66.17/nera/web/nera>. A link to this implementation is also available via the NERA portal.



**Network of European Research Infrastructures for
Earthquake Risk Assessment and Mitigation**

Navigation Manual of the Eucentre WebGIS



1 Introduction

The WebGIS platform was developed by Eucentre (European Centre for Training and Research in Earthquake Engineering, www.eucentre.it) within the project NERA (Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation) task JRA4 "Real-time seismic risk assessment and decision support framework".

This system allows, through interactive tabs, to make available the results of the damage scenario in real time, ie, known the magnitude, the position of the epicenter, the depth and the fault mechanism, the system evaluates the real-time damage scenario of the buildings in the municipalities around the epicenter. After the mainshock, you can simulate the earthquake evolution uploading in the WebGIS the spectra built up with calculation tools which are extern from the platform and when an aftershock occurs you can insert the input data and obtain the damage scenario. In both these cases, simulations and aftershock, the system takes into account the progressive damage.

The characteristics of the building stock, classified on the basis of structural types and number of storeys, is defined using the ISTAT building census. The building vulnerability is evaluated by a numerical method published in the technical literature by the acronym SP-BELA (Simplified Pushover-Based Earthquake Loss Assessment) (Borzi et al. 2008a, 2008b). Since SP-BELA describes the structural performance through a pushover curve, accounting for progressive damage requires to modify pushover curve parameters like initial stiffness, base shear resistance and displacement capacity. SP-BELA capacity curves are modified according to FEMA 306 (1998) coefficients. FEMA is a quantitative procedure that uses nonlinear static techniques to estimate the performance of the damaged buildings in future events. The results are expressed in terms of reaching or exceeding five damage levels from light damage to collapse. These damage levels are the same as in the EMS-98 scale (Grünthal 1998).

2 Homepage

Accessing the WebGIS platform through the dedicated link the default page shown in Figure 1 will be shown. The initial WebGIS page is subdivided in 2 sections. The section named "Processing tools and visualization" allows to input data necessary for the damage calculation and to view data. The section on the right instead prints the map and fits all results in a specific worksheet.

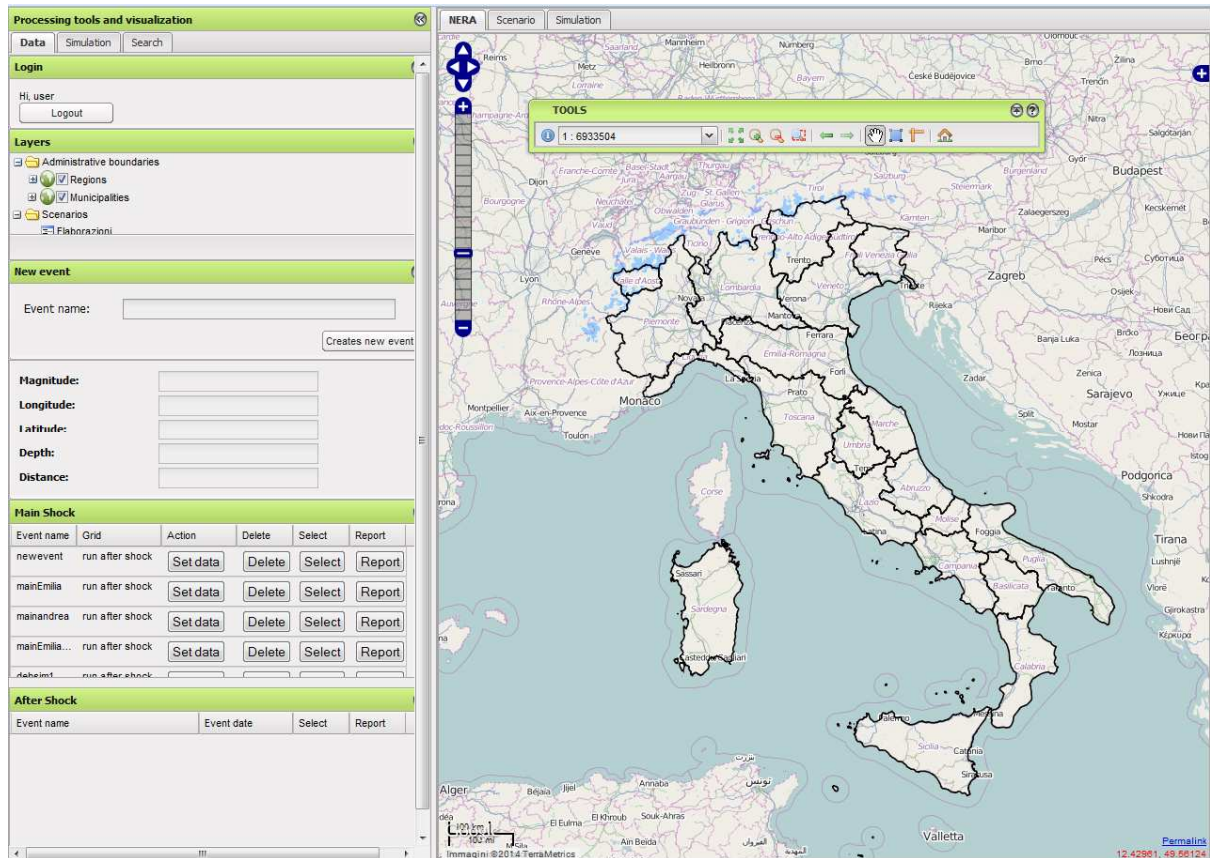


Figure 1. WebGIS Homepage.

3 Processing tools and visualization

In the left area named "Processing tools and visualization" 3 tabs are visible: "Data", "Simulation" and "Search" (Figure 1). The following paragraphs will give an overview on all potential operations feasible for each tab.

3.1 Data

Within the tab "Data" the following operations can be done (Figure 2):

- Disconnect from the page by clicking on "Logout";
- Select the layer to be visualized in the window "Layers";
- Create a new event by first naming the event in the window "Event name" to be followed by the selection "Creates new event"; a new line will hence be added to the worksheet "Main Shock";

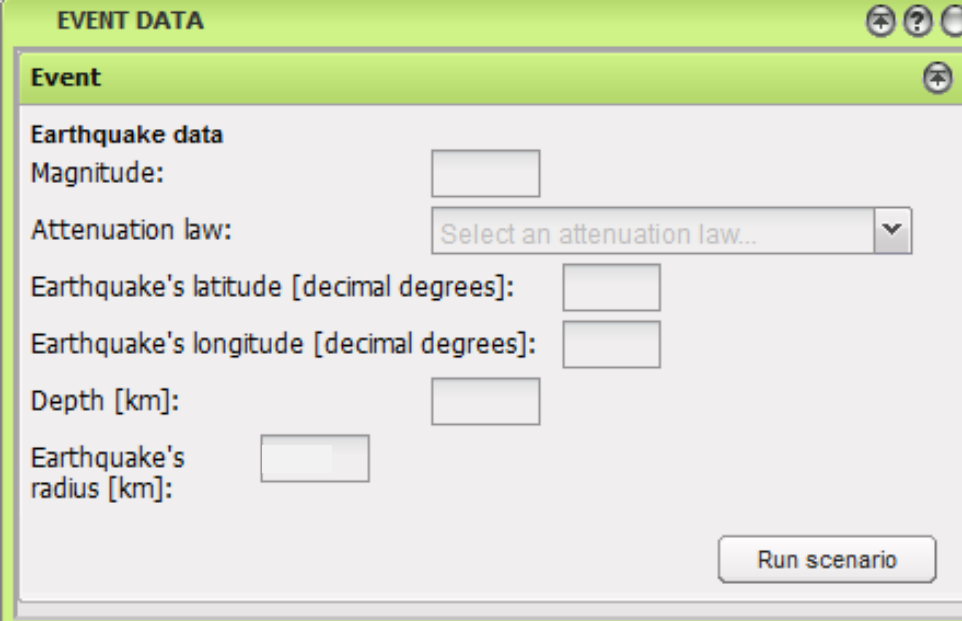
The screenshot displays a software interface titled "Processing tools and visualization" with a "Data" tab selected. The interface is divided into several sections:

- Login:** Shows "Hi, user" and a "Logout" button.
- Layers:** A tree view showing "Administrative boundaries" (expanded to "Regions" and "Municipalities"), "Scenarios", and "Elaborazioni".
- New event:** A form with an "Event name" field and a "Creates new event" button. Below are input fields for "Magnitude:", "Longitude:", "Latitude:", "Depth:", and "Distance:".
- Main Shock:** A table with columns: "Event n...", "Grid", "Action", "Delete", "Select", and "Report".

Event n...	Grid	Action	Delete	Select	Report
newevent	run after shock	Set data	Delete	Select	Report
mainE...	run after shock	Set data	Delete	Select	Report
mainan...	run after shock	Set data	Delete	Select	Report
mainE...	run after shock	Set data	Delete	Select	Report
- After Shock:** A table with columns: "Event name", "Event date", "Select", and "Report".

Figure 2. Processing and visualization tools – Data table.

- Handle the input and already present events in the worksheet "Main Shock": for each line corresponding to a single event four operations can be performed:
 - "Set data": Clicking this tag the window shown in Figure 3 pops up, in which the user has to insert the event data for the needed damage scenario visualization;



EVENT DATA

Event

Earthquake data

Magnitude:

Attenuation law:

Earthquake's latitude [decimal degrees]:

Earthquake's longitude [decimal degrees]:

Depth [km]:

Earthquake's radius [km]:

Figure 3. Event data.

- “Delete”: Clicking this tag the selected event and its corresponding line in the worksheet will be erased;
- “Select”: Clicking this tag the event data input by the user will be visualized (Figure 4) in the worksheet above and on the map on the right a little star marks the epicentre of the event. All municipalities falling into its influence perimeter are highlighted in grey (Figure 5);



Magnitude:	6.1
Longitude:	11.25
Latitude:	44.89
Depth:	10.0
Distance:	40000.0

Figure 4. Visualization of the input data.

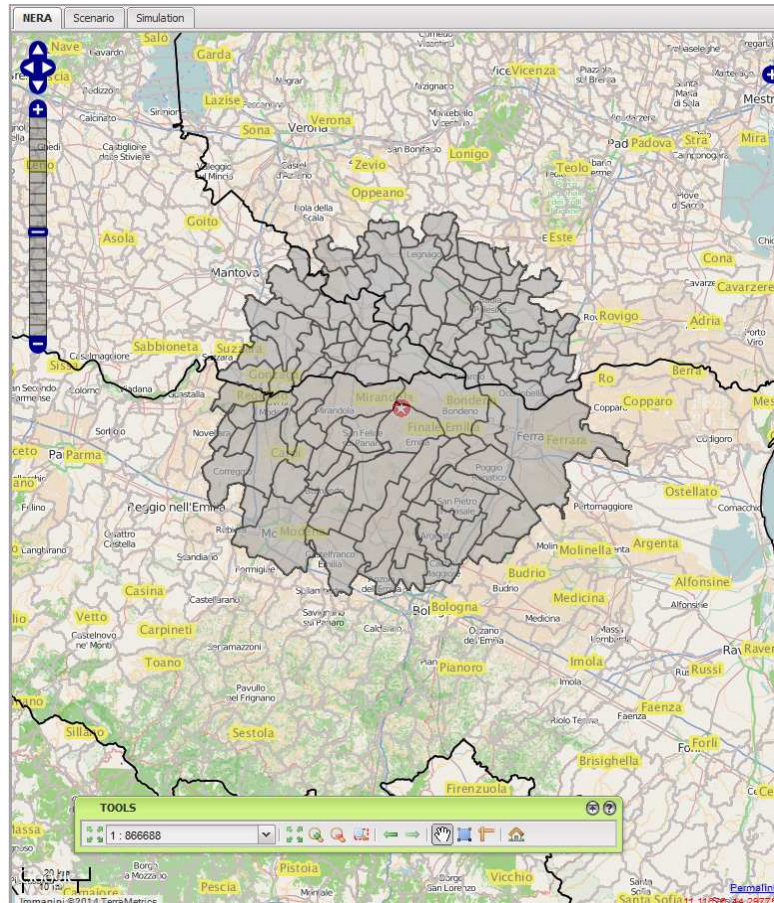


Figure 5. Visualization of an event on the map.

- “Report”: Clicking this tag the user can download an excel worksheet (Figure 6) with the results of the performed calculation in function of number of buildings, number of dwellings, population and area (m²) reaching or exceeding the five levels of damage in every involved municipality;

	A	B	C	D	E	F	G
1	Evento Main MAIN_SHOCK.xls						
2							
3	ESPOSITION	D1	D2	D3	D4	D5	ISTAT
4							
5	Number of buildings	212	35	6	2	0	18079003
6	Number of dwellings	302	50	9	3	0	18079003
7	Population	452	79	13	5	0	18079003
8	Area (m2)	28722	4860	820	313	0	18079003
9	Number of buildings	215	31	5	2	0	18079089
10	Number of dwellings	243	35	6	2	0	18079089
11	Population	327	48	8	3	0	18079089
12	Area (m2)	19360	2822	458	194	0	18079089
13	Number of buildings	143	29	5	2	0	18079142
14	Number of dwellings	225	44	8	2	0	18079142
15	Population	340	63	11	4	0	18079142
16	Area (m2)	16266	3074	560	175	0	18079142
17	Number of buildings	393	62	11	4	0	18079151
18	Number of dwellings	436	69	12	4	0	18079151
19	Population	766	122	22	8	0	18079151
20	Area (m2)	35124	5579	1001	367	0	18079151

Figure 6. Excel report.

- Aftershock: after the input of a mainshock (see “Creates new event”), it is possible to add data of an aftershock to calculate a damage scenario accounting for the additional damage. To insert data of an aftershock “Set data” needs to be selected in the worksheet “Main shock” for the specific line referring to the mainshock of the event. A window pops up like the one reported in Figure 3 in which the user will add the data of the aftershock and hit the “Run scenario” tag. Once WebGIS has done all the maths a new line will appear in the worksheet “After shock” (Figure 7) in which it is possible to select the event simply by clicking “Select”. It will be possible to view the outcomes in the worksheets available in the tab “Scenario” (described in the following) or to download an excel report with the results clicking “Report”.

After Shock			
Event name	Event date	Select	Report
after_shake_1	30-6-2014	Select	Report

Figure 7. After shock table.

3.2 Simulation

Within this tab it is possible to upload in WebGIS the offline plotted spectra representing simulations of possible events occurring after mainshocks or aftershocks. In the window “New simulation” the user needs first to select the processed event from the menu option “Events”. Afterwards the user needs to name the simulation in the tab “Simulation name”, set the start date of the simulation in the field “Start date” and finally hit “Create” (see Figure 8).

The screenshot shows the 'New simulation' interface. The 'Events' dropdown is set to 'mainEmilia'. The 'Simulation name' field is empty. The 'Start date' field is open, showing a calendar for August 2014. The 21st of August is highlighted in red. Below the calendar, there are sections for 'Simulations' and 'Days'.

Figure 8. Selection of the starting day of the simulation.

After having created the new simulation a new line will show in the worksheet "Simulations" containing the name given, the start date and the event reference (Figure 9).

The screenshot shows a web interface titled "Processing tools and visualization". It has three tabs: "Data", "Simulation" (selected), and "Search". Below the tabs is a "New simulation" section with a dropdown menu for "Events" (set to "Select event"), text input fields for "Simulation name:" and "Start date:", and a "Create" button. Below this is a "Simulations" table with columns for "Simulation name", "Start date", "Event", "Action", and "Delete". The table contains four rows of simulation data. Below the table is a "Select" button. At the bottom is a "Days" section with a table for "Simulation day", "Delete", "Select", and "Report", and a "Select" button.

Simulation name	Start date	Event	Action	Delete
sim	15_06_2014	newevent	update	delete
simtest1	22_06_2014	debsim2	update	delete
sim2	27_06_2014	provo40	update	delete
ingvsimulations	30_06_2014	calabriapaper	update	delete

Figure 9. Simulation table.

In this section it is possible to erase the simulation by clicking "delete". Selecting "update" instead it is possible to upload spectra referring to simulations. The window shown in Figure 10 opens, in which the user has to: (i) upload the spectrum representing a simulation in the field "Simulation file" (mainly text files with extension .txt or .dat in which appear, for each studied point, latitude and longitude in decimal form, spectral ordinates in cm for periods ranging from 0.1 sec to 5 sec with intervals of 0.1 sec); (ii) to input in the field "Start date" the day the uploaded file refers; (iii) to save the data by clicking on "Save". The platform will now run all damage scenarios using the file uploaded as hazard. The outcomes of these analyses will be available in the worksheets described in chapter 6.

In worksheet "Days" appears one line for each Spectrum file uploaded in the system (Figure 11). Selecting "delete" the simulation and the results of the analysis are erased. Clicking "select" a grid of points for all input simulation spectra shows on the map of Italy (Figure 12). Choosing "report" excel files with the process results in terms of number of buildings, number of dwellings, population and area (m²) that are reaching or exceeding the five levels of damage in every involved municipality can be downloaded.

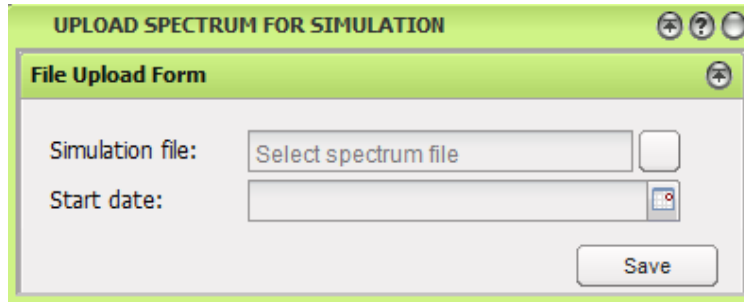


Figure 10. Uploading spectrum of the simulation.

Days			
Simulation day	Delete	Select	Report
23_6_2014	delete	select	report
24_6_2014	delete	select	report
25_6_2014	delete	select	report
			Select

Figure 11. Simulations table.

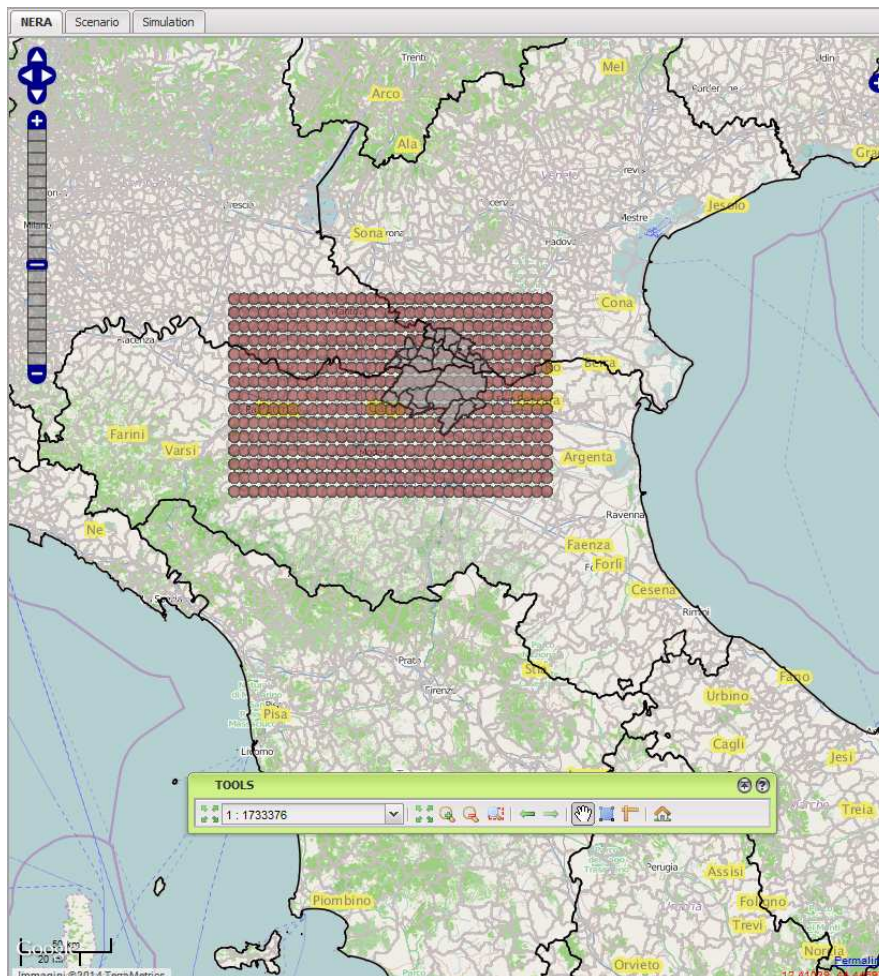


Figure 12. Grid of points for the simulation.

3.3 Search

Through the tab "Search" it is possible to select a municipality on the map. Select "Region" on the main menu for the applicable district, "Province" for the province, tick the box "Enable zoom" and click the tab "Select" (Figure 13). At this point in the worksheet "Search results" all municipalities of the province become visible. Select the desired municipality on the map, the system will automatically zoom in.

The screenshot shows a software interface with a green header bar labeled "Processing tools and visualization". Below the header are three tabs: "Data", "Simulation", and "Search". The "Search" tab is active, displaying a "Search Municipalities" section with the following controls:

- Region: A dropdown menu set to "Emilia-Romagna".
- Province: A dropdown menu set to "Ferrara".
- Enable zoom: An unchecked checkbox.
- Buttons: "Select" and "Cancel".

Below the search controls is a "Search results" section containing a table with two columns: "ID" and "Results municipalities". The table lists 18 municipalities with their corresponding IDs.

ID	Results municipalities
038001	Argenta
038002	Berra
038003	Bondeno
038004	Cento
038005	Codigoro
038006	Comacchio
038007	Copparo
038008	Ferrara
038009	Formignana
038025	Goro
038010	Jolanda di Savoia
038011	Lagosanto
038012	Masi Torello
038013	Massa Fiscaglia
038014	Mesola
038015	Migliarino
038026	Migliaro
038016	Mirabello
038017	Ostellato
038018	Poggio Renatico











Figure 13. Processing and visualization tools – Search table.

4 Map

In the right hand window with the label "NERA" it is possible to render the Italian map as shown in Figure 1. In the same window a toolbar becomes available and functional to the map in the WebGIS (see Figure 14).




Figure 14. Toolbar.

The first icon  is used to select a specific municipality and to upload its pertaining information. Immediately after we'll find a multiple selection icon  that allows to choose the map scale to be used. To return to the default map scale press . To zoom in or out or zoom in a window press the following icons ,  and/or  respectively. The history of map visualizations can be scrolled up or down by means of . Alternatively to the icons of the toolbar in Figure 14 it is possible to zoom in or out using the symbols "+" or "-" in the left vertical toolbar of the map. Sliding the whole map in different directions is made possible by the following icon . The icons  allow measurements in terms of length and area in a selected sector of the slide. To perform measurements use right mouse button clicking twice (length) or 4 times to enclose an area; clicking now left mouse button length and/or area will be available. Icon  restores everything sending back to Home Page.

5 Table "Scenario"


In the tab "Scenario" on the right hand it is possible to visualize the results of the scenario analyses (mainshock and aftershock) pertaining to a selected municipality on the map in terms of number of buildings, number of dwellings, population and area (m²) reaching or exceeding the five levels of damage.

To choose an event hit "Select" on the "Main Shock" or "After Shock" worksheet in the tab named "Data" on the left hand. At this point select with the icon  on the map one of the grey highlighted municipalities. The tab "Scenario" on the right hand will be automatically filled out showing the name of the selected municipality ("Selected municipality"), its ISTAT code ("ISTAT code") and a worksheet with all calculated scenarios ("Scenarios calculated"). Possible scenarios are always four corresponding to the four types of exposure: number of buildings, number of dwellings, population and area (m²). Clicking on a line corresponding to one of the scenarios it is possible to visualize in worksheet "Scenario values for municipalities" the five levels of damage reached in latter municipality (Figure 15) ranging from light damage (D1) to collapse (D5) according to damage levels stated in EMS-98 (Grünthal 1998).

NERA Scenario Simulation						
Selected municipality: FERRARA						
ISTAT code: 08038008						
Scenarios calculated						
ID	Esposition	Magnitude	Depth	Latitude	Longitude	Radius
9081	number of buildings	6.1	10.0	44.89	11.25	40000.0
9082	number of dwellings	6.1	10.0	44.89	11.25	40000.0
9083	population	6.1	10.0	44.89	11.25	40000.0
9084	area (m2)	6.1	10.0	44.89	11.25	40000.0
Scenario values for the municipalities						
D1	D2	D3	D4	D5		
659	192	78	5	0		

Figure 15. Table with the results of a scenario.

6 Table "Simulation"

The function of the tab "Simulation" on the right hand is identical to the one of the "Scenario" shown in chapter 5, with the exception that the event to be selected is a simulation and is located in the tab "Simulation" on the left. Here is the procedure to be followed: in the tab on the left named "Simulation" a simulation needs to be selected from the worksheet "Simulations" followed by a date in the worksheet "Days". At this point select with the mouse through the icon  one of the grey highlighted municipalities. The tab "Simulation" on the right is going to be filled out automatically as shown in Figure 16.

NERA Scenario Simulation				
Selected municipality: MIRANDOLA				
ISTAT code: 08036022				
Simulations calculated				
ID	Esposition	File Uploaded	Data	
4977	number of buildings	haz_1day_DRS_10%_2012-05-21.dat	23_6_2014	
4978	number of dwellings	haz_1day_DRS_10%_2012-05-21.dat	23_6_2014	
4979	population	haz_1day_DRS_10%_2012-05-21.dat	23_6_2014	
4980	area (m2)	haz_1day_DRS_10%_2012-05-21.dat	23_6_2014	
Simulation values for the municipalities				
D1	D2	D3	D4	D5
11202	1832	514	192	7

Figure 16. Table with the results of a simulation.

Reference List

- Borzi, B., Pinho, R., Crowley, H. 2008a. *Simplified Pushover-Based Vulnerability Analysis for Large Scale Assessment of RC Buildings*. *Engineering Structures*, 30(3): 804-820.
- Borzi, B., Crowley, H., Pinho, R. 2008b *Simplified Pushover-Based Earthquake Loss Assessment (SP-BELA) Method for Masonry Buildings*. *International Journal of Architectural Heritage*, 2(4): 353-376.
- Federal Emergency Management Agency 306 1998. *Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings*. Basic Procedures Manual. Washington DC.
- Grünthal, G. 1998. *European Macroseismic Scale 1998*. European Seismological Commission. Luxembourg.