

Tutorial: QGIS demo part 2 and Italian NSHM demo part 1

QGIS:

- Projected coordinate systems
- Creating shapefiles

Italian National Seismic Hazard Model (NSHM):

- Adding an area source to the source model
- Introduction to simple logic trees
- Running the Italian model

A quick linguistics lesson

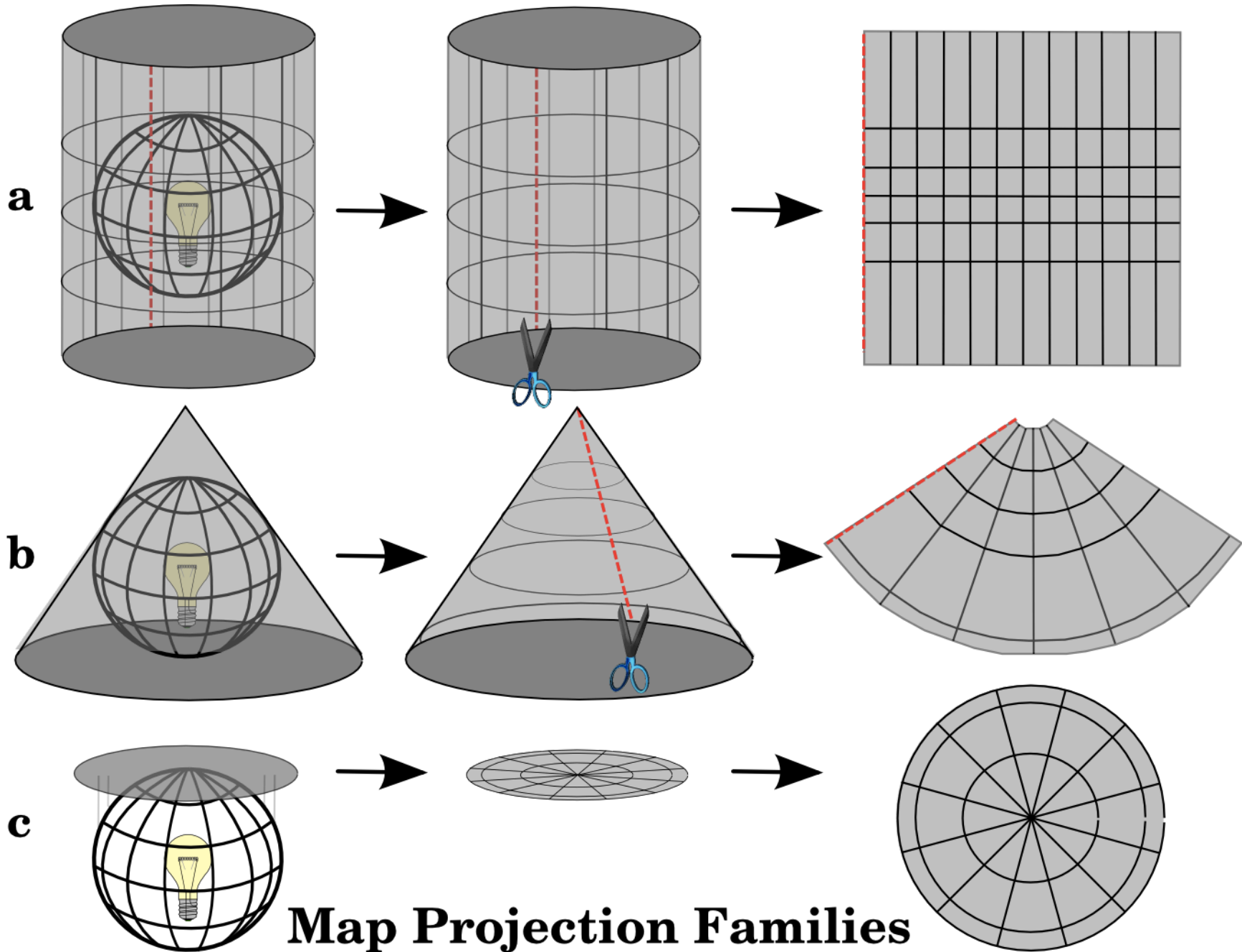
Heteronyms: words that are spelled the same, but have different meanings and pronunciations

- Examples:
 - **Lead:** “to guide” vs **Lead:** (Pb) the metal
 - **Project:** A task (in GIS: a job with all your data layers and formatting)
 - **Project:** to display in 2D (in GIS: project data with geographic coordinates)

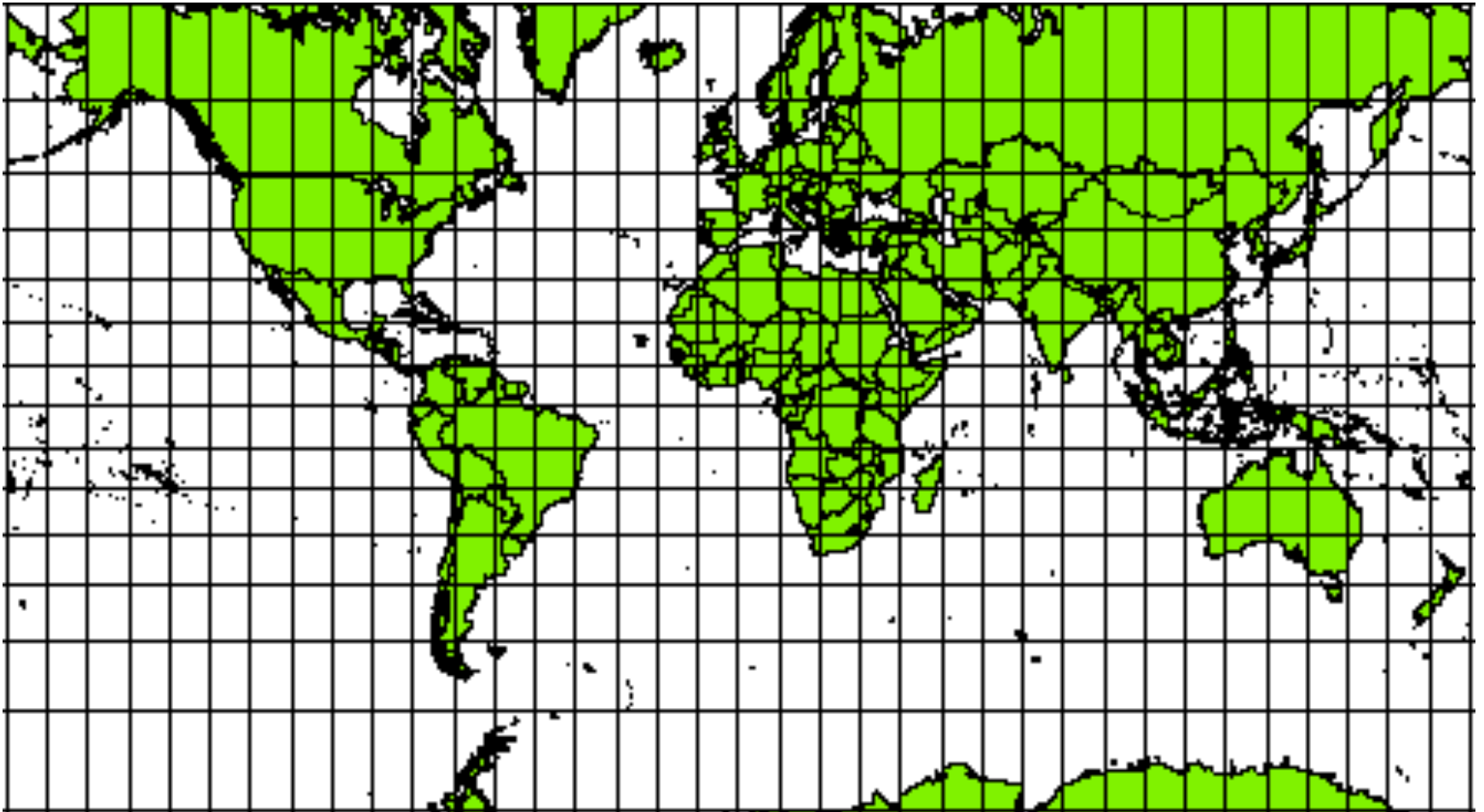
What is “projection”?

- A **geographic coordinate system** represents the earth as a spheroid, where location is given by latitude and longitude, with units of degrees
- A **projected coordinate system** represents the curved surface of the earth as something flat
- A **coordinate reference system** defines how the 2D map is related to true positions on earth

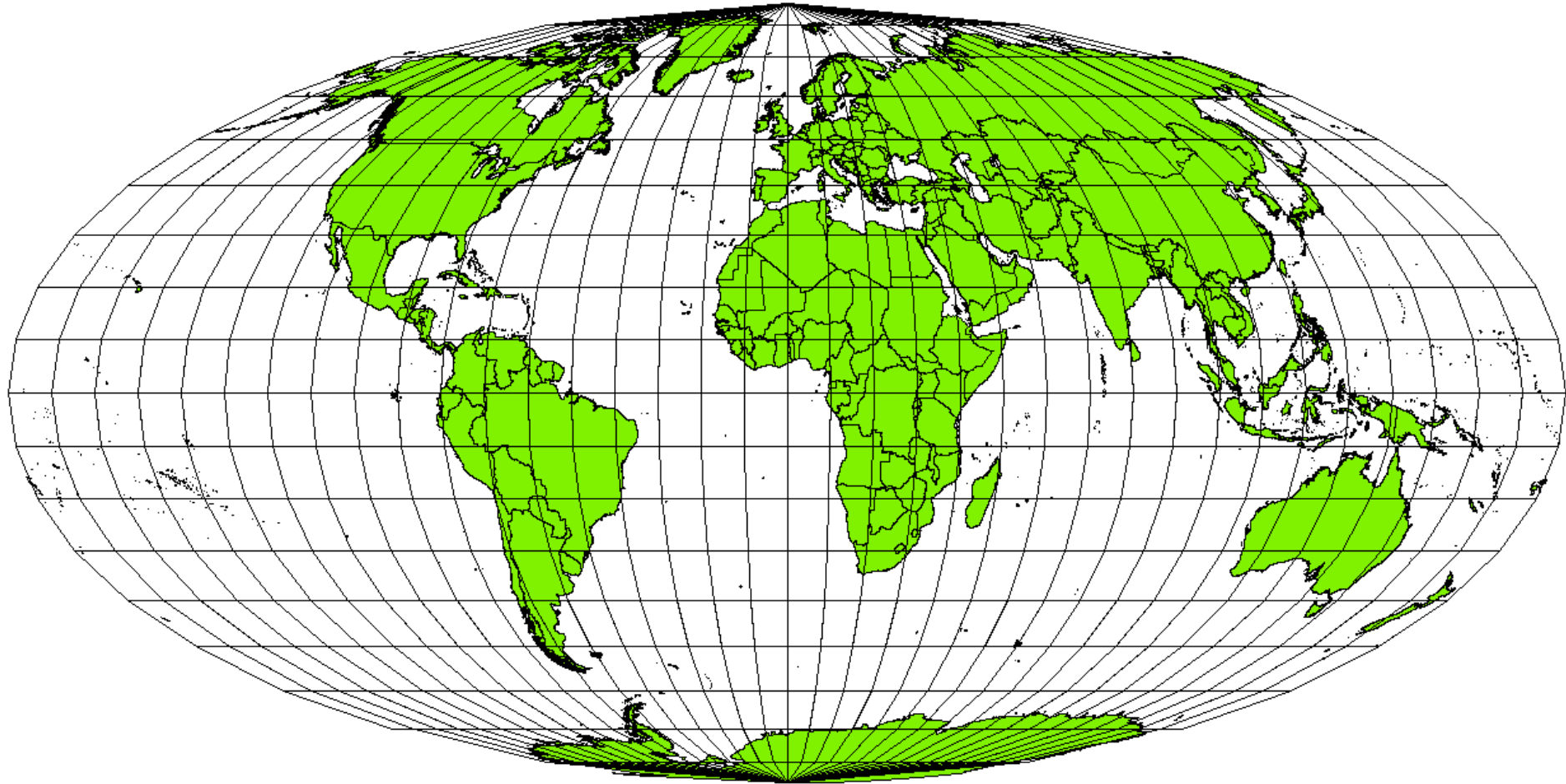
https://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/coordinate_reference_systems.html



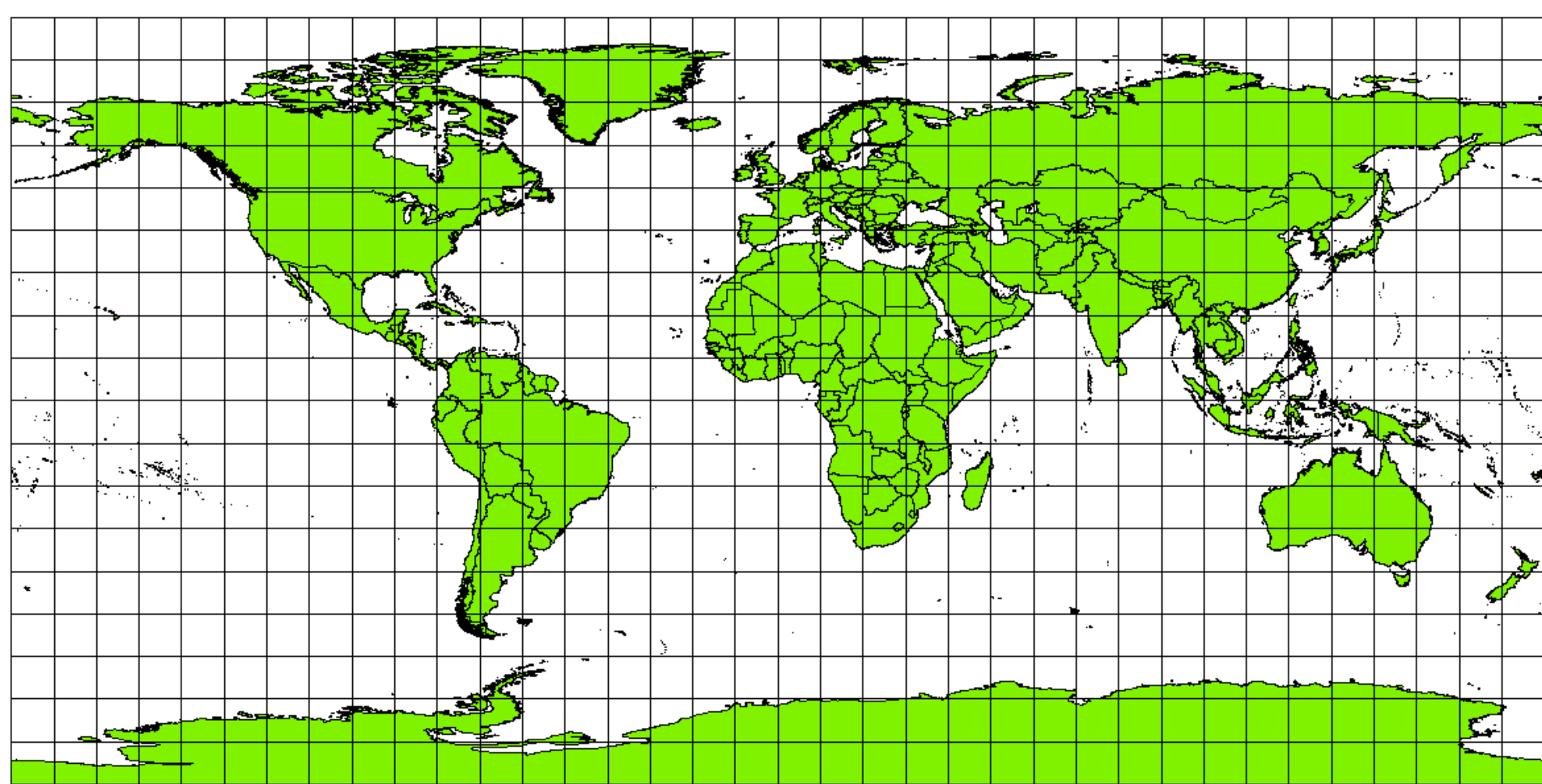
Example: Mercator



Example: Mollweide equal area

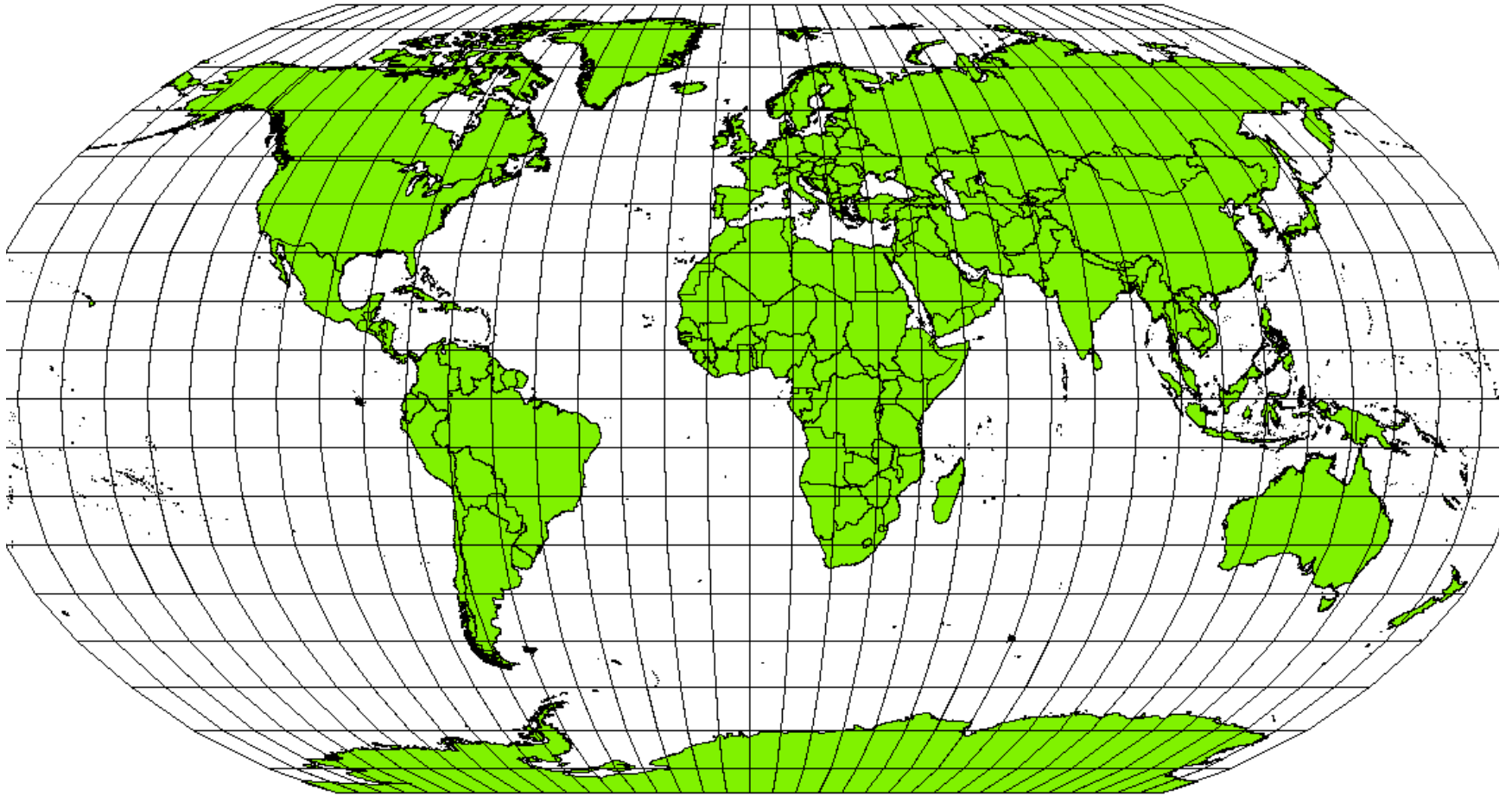


Example: Plate Carree



In QGIS, if WGS 84 is selected as the project CRS, this projection is automatically used

Example: Robinson projection



In practice...

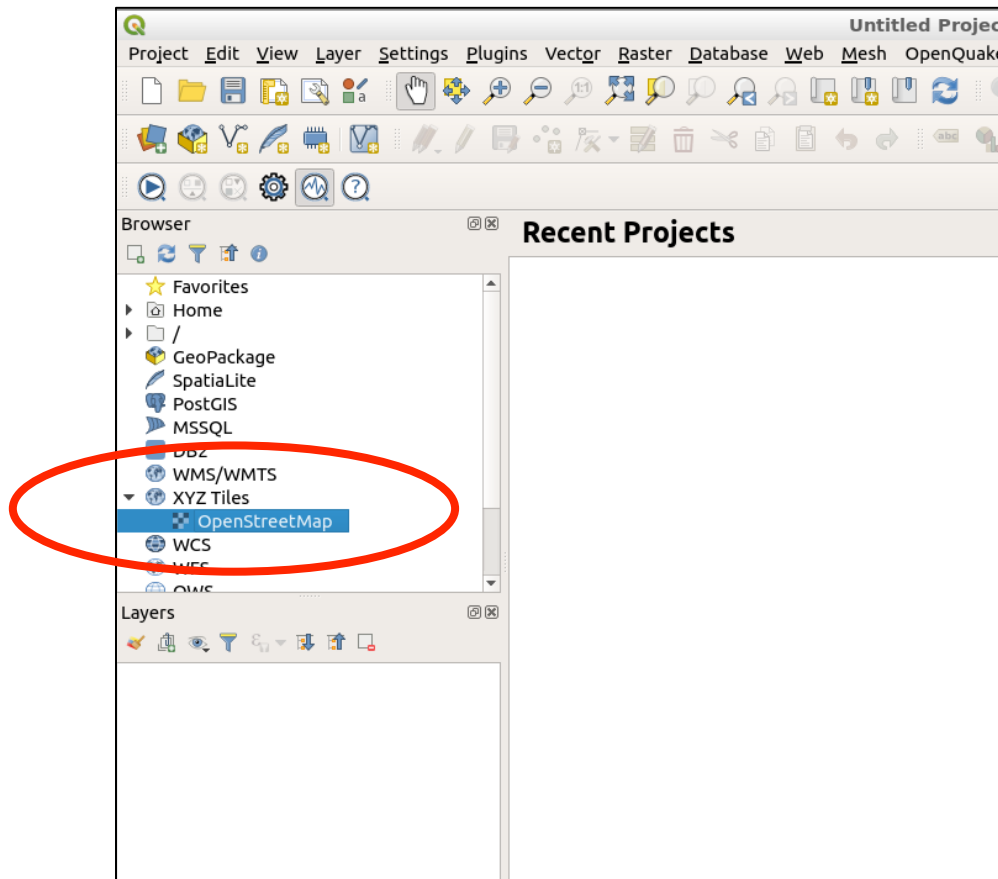
- You might want to use data or layers that use different coordinate systems
- Example: **OpenMapLayer** is defined using a **projected coordinate system** (pseudo-mercator) but the ISC-GEM catalogue uses a **geographic coordinate system**
- GIS will apply a **transformation** to the individual layers so they are all projected in the same CRS (**note**: the files themselves are not changed!)

Recall from last time

- In the VirtualBox, **open QGIS**
- Load the **OpenStreetMap** into Layers
- **Set the project CRS** to WGS 84 (EPSG:4326)

Basemap example

Let's add the default web basemap to QGIS



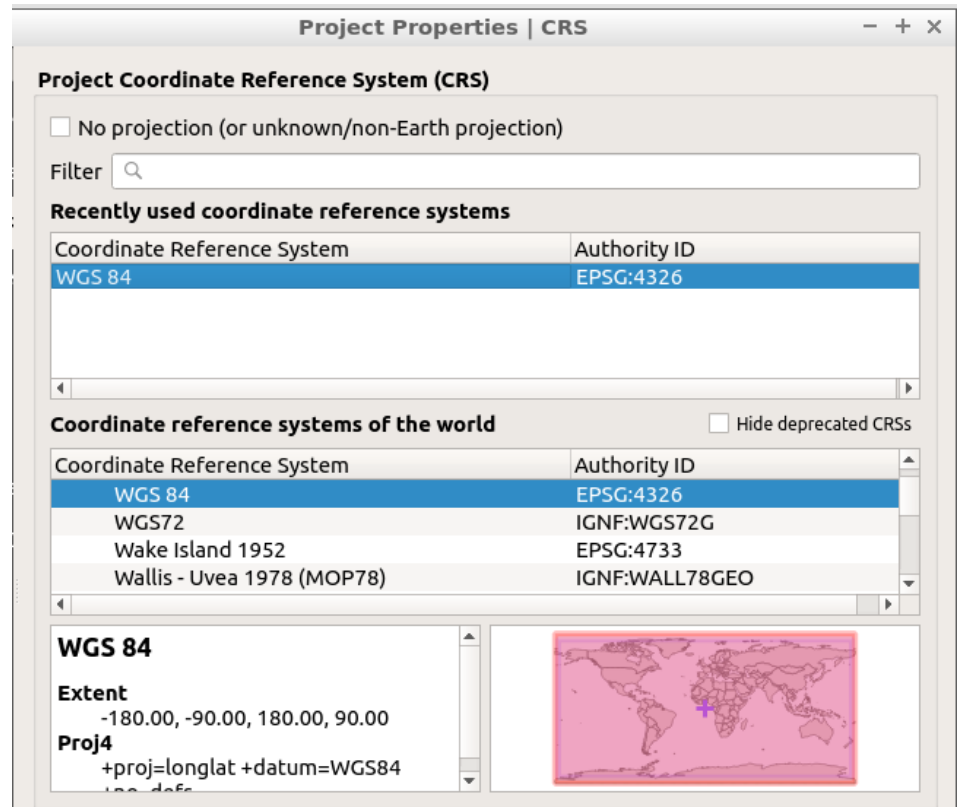
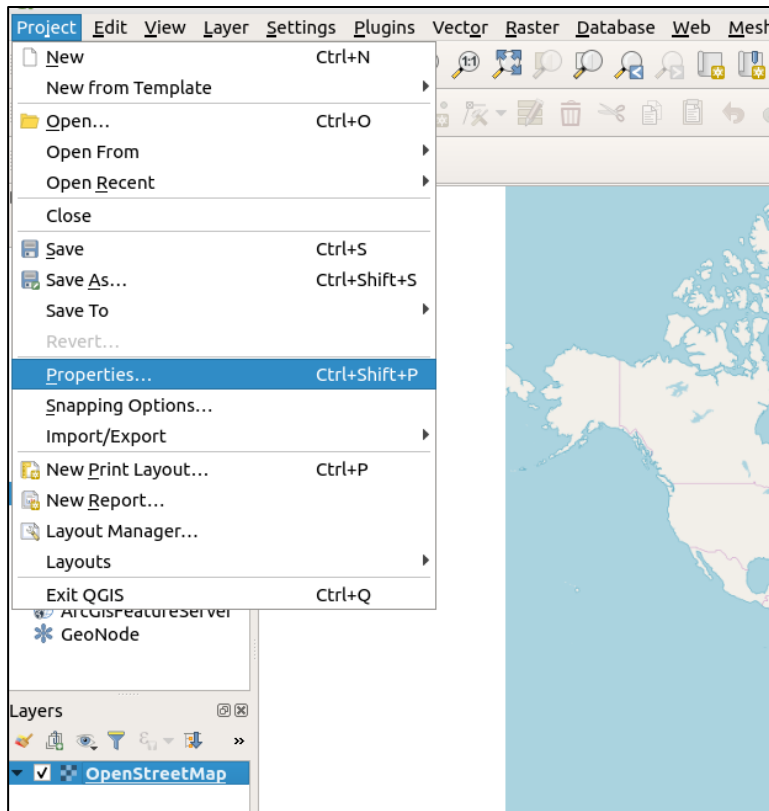
➤ Click *OpenStreetMap*

Note: web basemaps require internet during initial download, then they remain loaded in QGIS

Basemap example

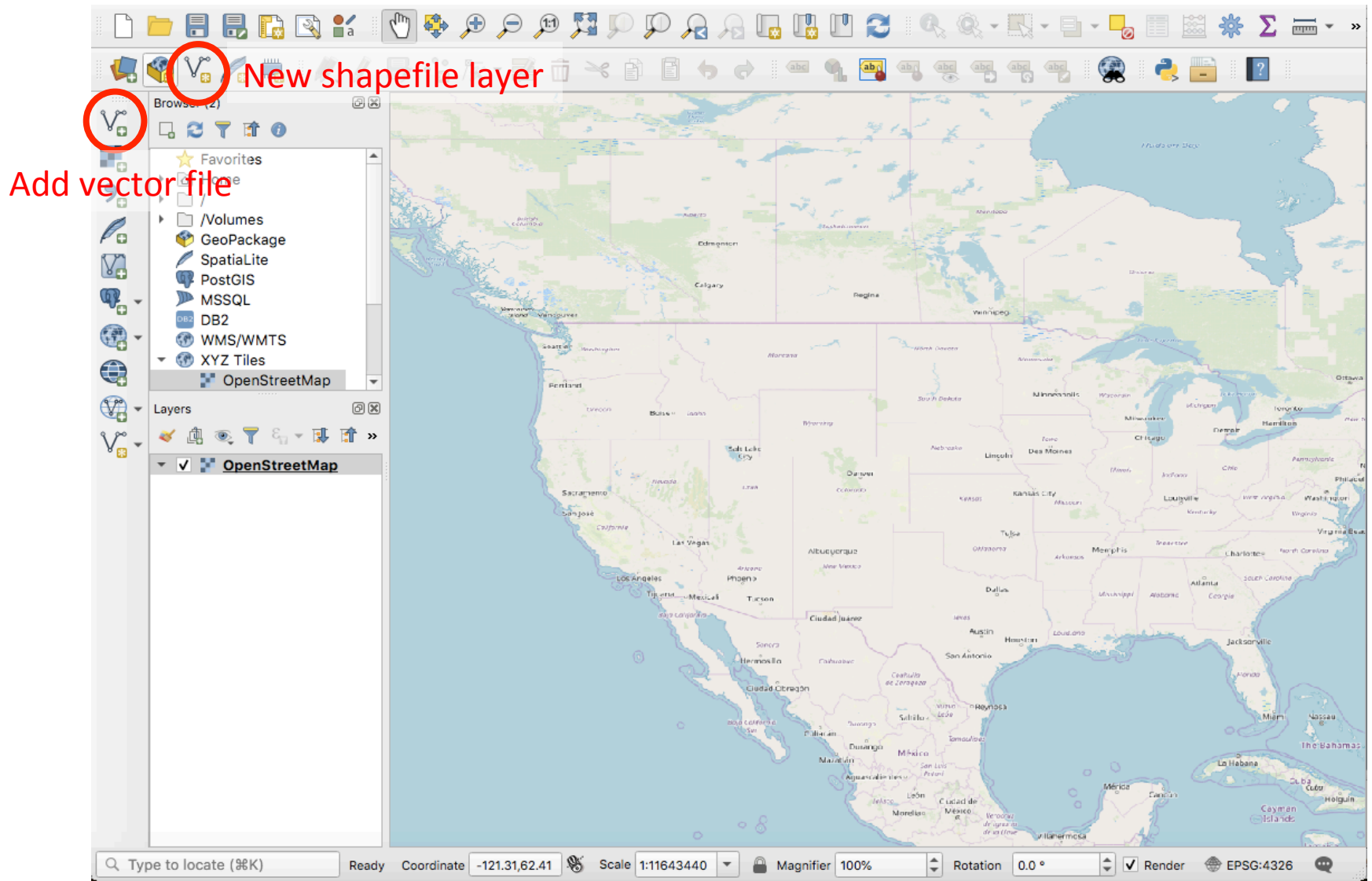
Display basemap in terms of lon, lat (to be consistent with OpenQuake) by setting the coordinate reference system (CRS) to *WGS 84*

➤ *Project > Properties > select WGS 84*

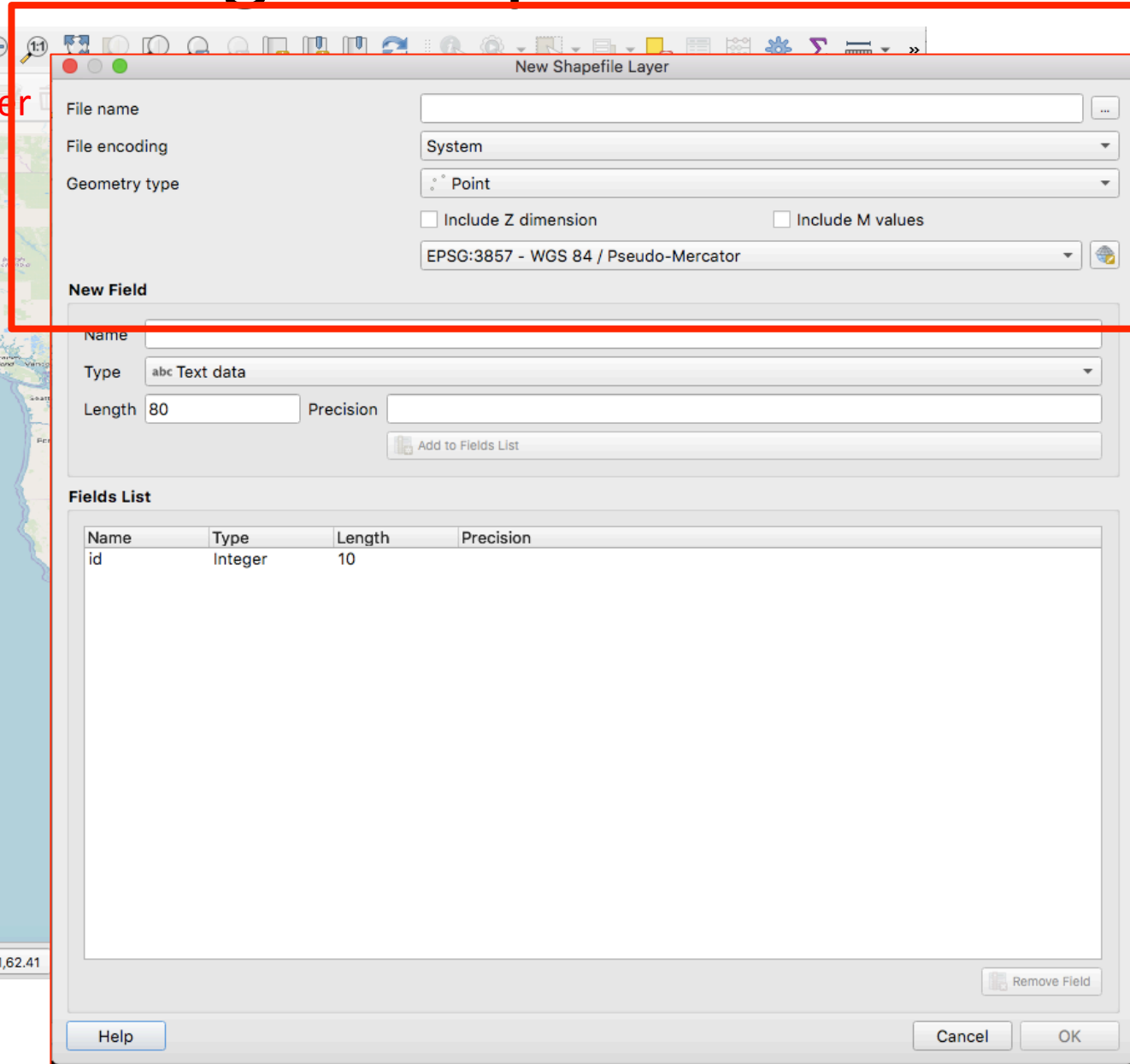
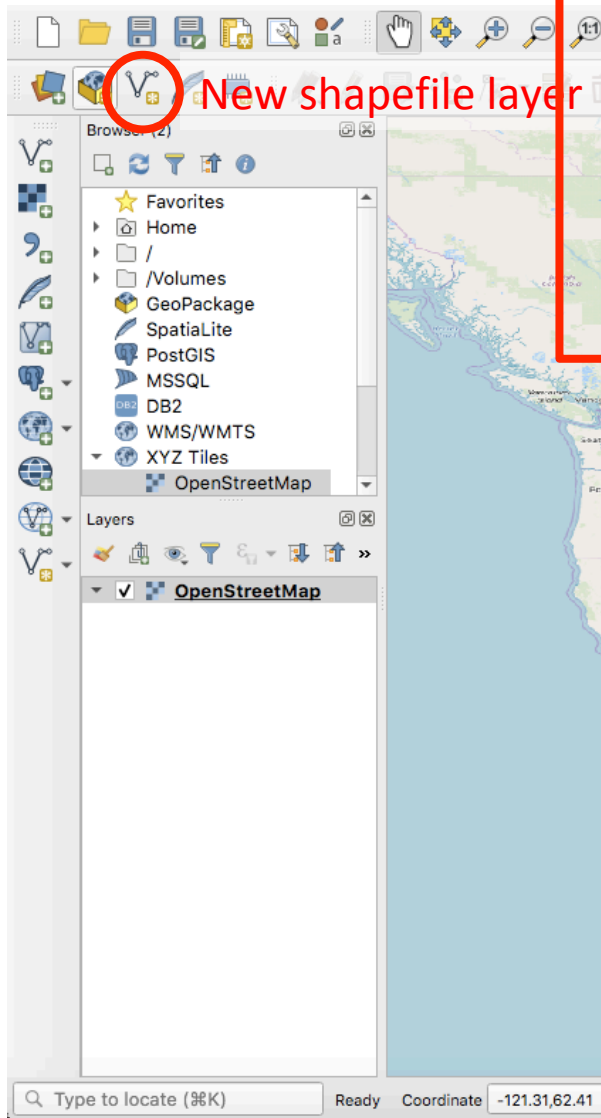


Creating shapefiles in QGIS

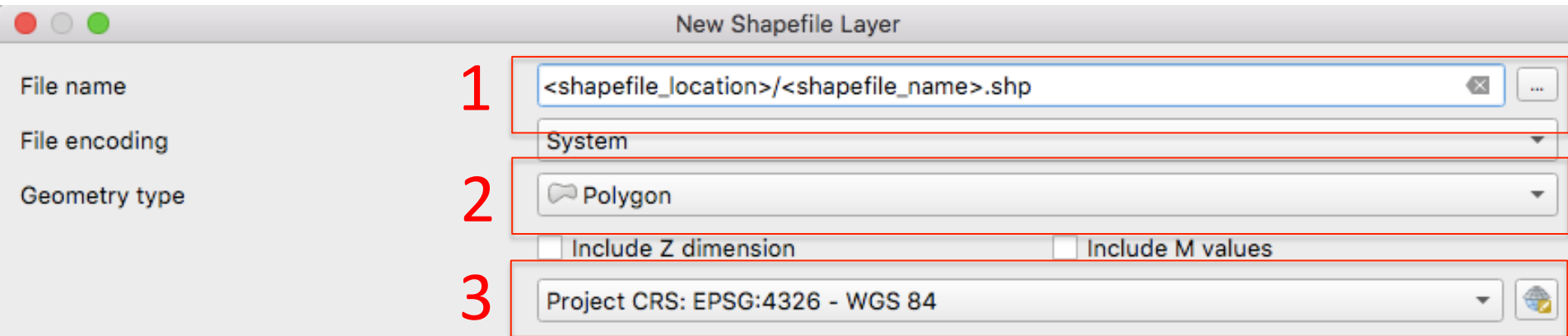
- Recall: shapefiles are **vector files**



Creating a shapefile



Creating a shapefile



- ① Choose what you want to name the shapefile, and where you want to save it (**note**: the suffix must be “.shp”)
- ② Define the geometry type. For area sources, we will use polygons
- ③ Choose the CRS. For OpenQuake, always define using latitude and longitude (WGS 84, EPSG:4326)

Creating a shapefile

The screenshot shows the QGIS interface with a map of the United States. A shapefile layer is selected in the Layers panel. The editing tool icon is circled in red. A red box highlights the 'Toggle editing' button. Another red box highlights the 'Layers' panel, and a third red box highlights the 'Colorado' layer. A red arrow points from the 'Colorado' layer to the 'Toggle editing' button.

Toggle editing

- With the shapefile selected in the Layers menu, enter editing mode

Shapefile is added to the Layers menu

Type to locate (⌘K) Ready Coordinate -81.04,33.04 Scale 1:11643440 Magnifier 100% Rotation 0.0 ° Render EPSG:4326

Creating a shapefile

The screenshot shows the QGIS desktop environment. The top toolbar has the 'Add polygon feature' tool (a green polygon with a plus sign) circled in red. A red box highlights this tool with the text 'Add polygon feature'. On the left, the 'Layers' panel shows the 'Colorado' layer selected, with a red arrow pointing to it and a text box that says 'Shapefile now shows "edit mode"'. A large red-bordered box in the center of the map contains a list of instructions.

Add polygon feature

- Choose **"Add polygon feature"**
- Click to draw the coordinates of your polygon
- Right-click to finish the polygon

Shapefile now shows "edit mode"

Ready Coordinate -133.09,50.24 Scale 1:11643440 Magnifier 100% Rotation 0.0 ° Render EPSG:4326

Creating a shapefile

Add polygon feature

- Choose “Add polygon feature”
- Click to draw the coordinates of your polygon
- Right-click to finish the polygon

Shapefile now shows “edit mode”

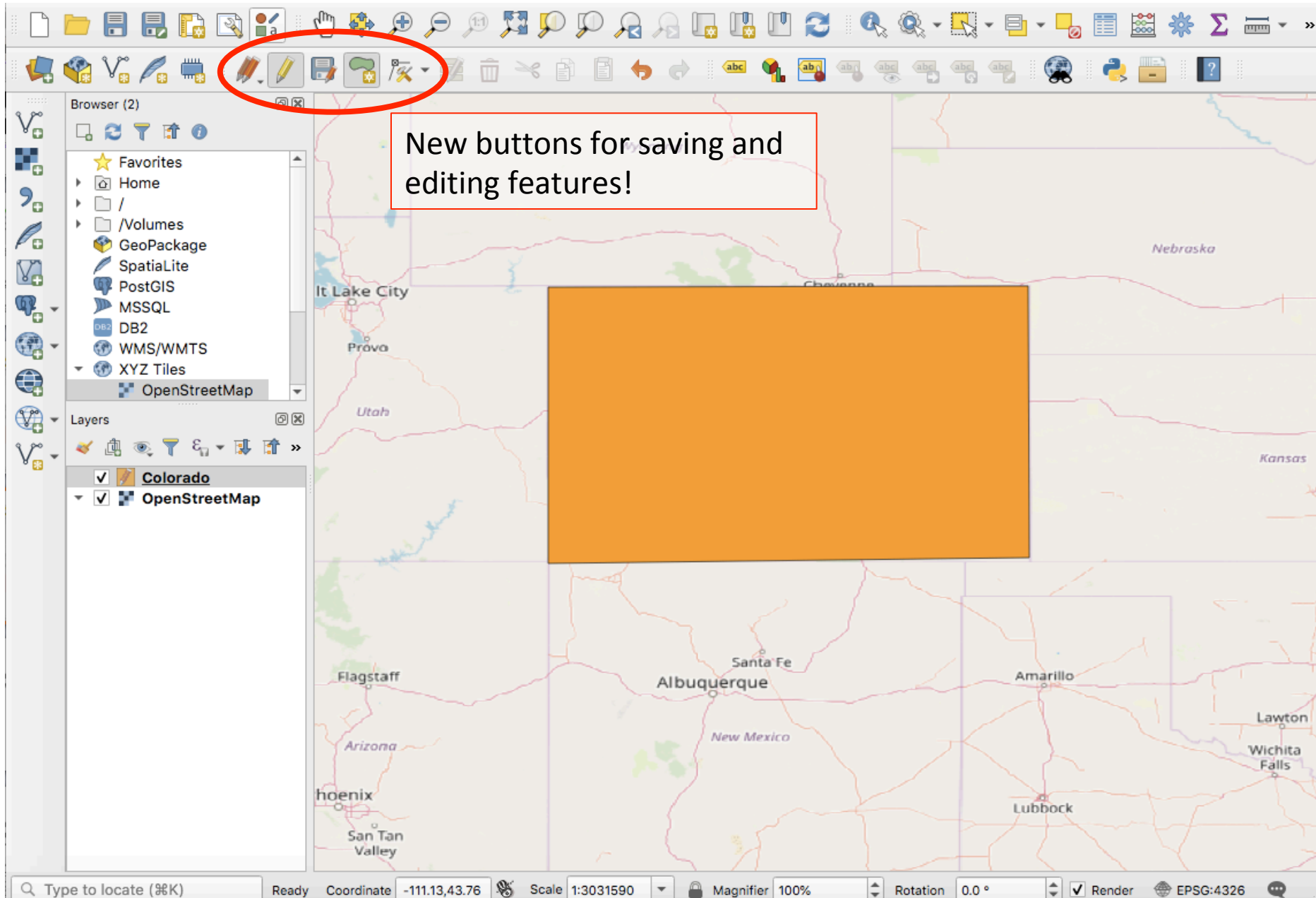
Colorado - Feature Attributes

id NULL

Cancel OK

Type to locate (⌘K) Ready Coordinate -133.09,50.24 Scale 1:11643440 Magnifier 100% Rotation 0.0 ° Render EPSG:4326

Creating a shapefile



Creating a shapefile

Vertex tool

Always save before closing the editor!

Vertex Editor

Right click on an editable feature to show its table of vertices.

When a feature is bound to this panel, dragging a rectangle to select vertices on the canvas will only select those of the bound feature.

Type to locate (%K) Validate Coordinate -108.30,40.19 Scale 1:3031590 Magnifier 100% Rotation 0.0 ° Render EPSG:4326

See the shapefile attributes

The image shows the QGIS software interface. The top toolbar contains two buttons circled in red: the Identify feature button (a magnifying glass over a cursor) and the Open attribute table button (a table icon). Below these buttons are two red-bordered text boxes: "Use the Identify feature button" and "Open attribute table". The main map area shows a map of the United States with a large orange rectangle highlighting a region in the central part of the country. On the left side, the Layers panel is open, showing a list of layers. A context menu is open over the "Colorado" layer, with the "Open Attribute Table" option highlighted in blue. The bottom status bar shows the coordinate (-120.86,38.31), scale (1:4262361), magnifier (100%), rotation (0.0°), and other settings.

Use the Identify feature button

Open attribute table

Zoom to Layer
Zoom to Selection
Show in Overview
Show Feature Count
Copy Layer
Rename Layer
Duplicate Layer
Remove Layer...
Open Attribute Table
Toggle Editing
Filter...
Set Layer Scale Visibility...
Set CRS
Export
Styles
Properties...

Type to locate (🔍K) Validation finished (0 error(s) found). Coordinate -120.86,38.31 Scale 1:4262361 Magnifier 100% Rotation 0.0° Render EPSG:4326

See the shapefile coordinates

The screenshot shows the QGIS desktop environment. The main map window displays a map of the central United States with a large yellow rectangle overlaid on a region in Colorado. The top toolbar has a red circle around the 'Select Features' icon. A red box labeled 'Select features in viewer' points to this icon. The left sidebar shows the 'Layers' panel with 'Colorado' and 'OpenStreetMap' checked. A red box labeled 'Select features from table' points to the 'Colorado' layer. A table window titled 'Colorado :: Features Total: 1, Filtered: 1, Selected: 1' is open, showing a single row with the value '1' in a highlighted cell. A red box labeled 'Invert selection' points to the 'Invert Selection' icon in the table's toolbar. A text box in the bottom right contains the following text:

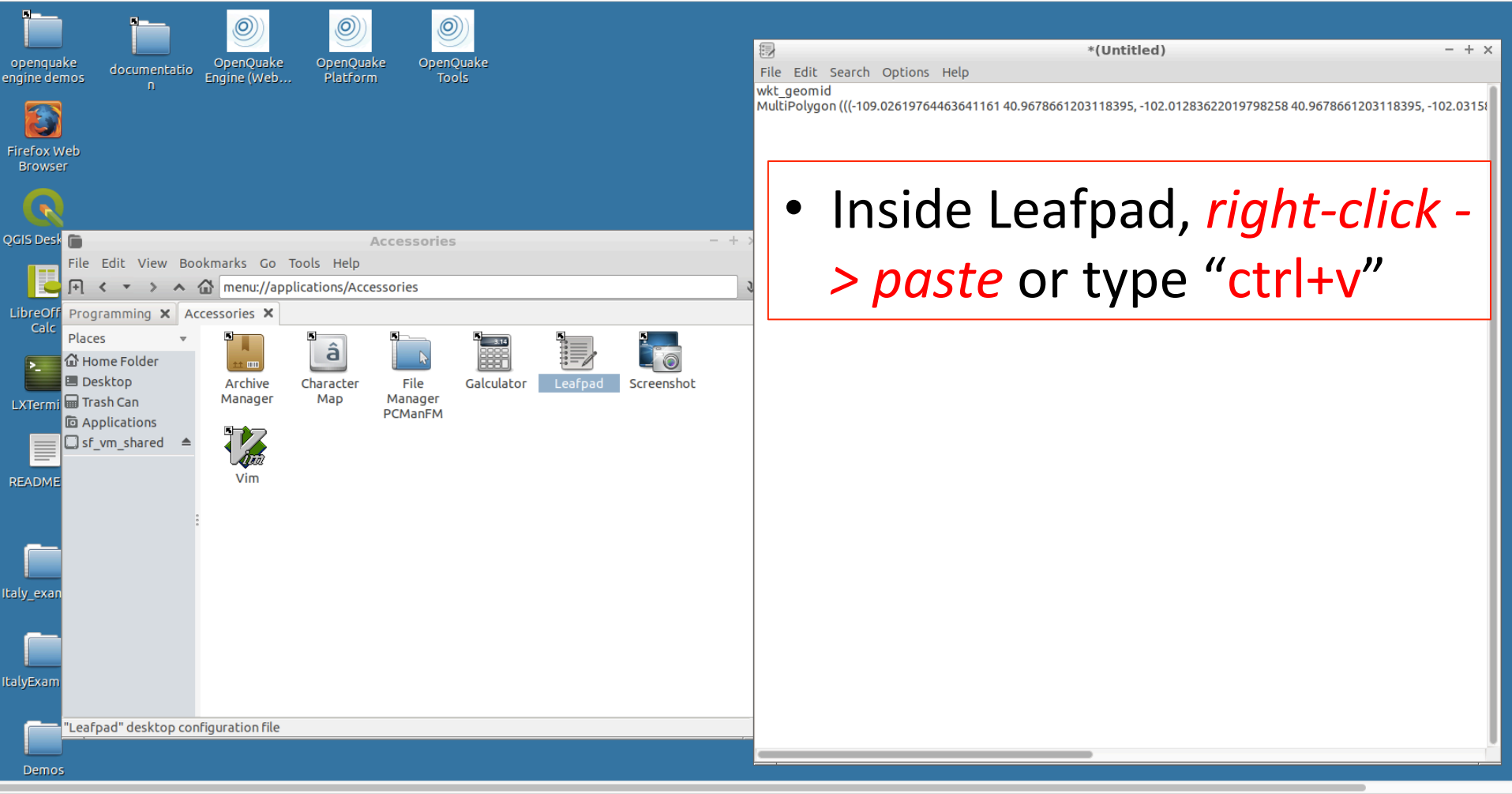
- With the feature cell highlighted, type “**ctrl+c**” to copy the cell contents

At the bottom of the QGIS window, the status bar shows the coordinate as -106.28,41.39, a scale of 1:3346028, and a magnification of 100%.

See the shapefile coordinates

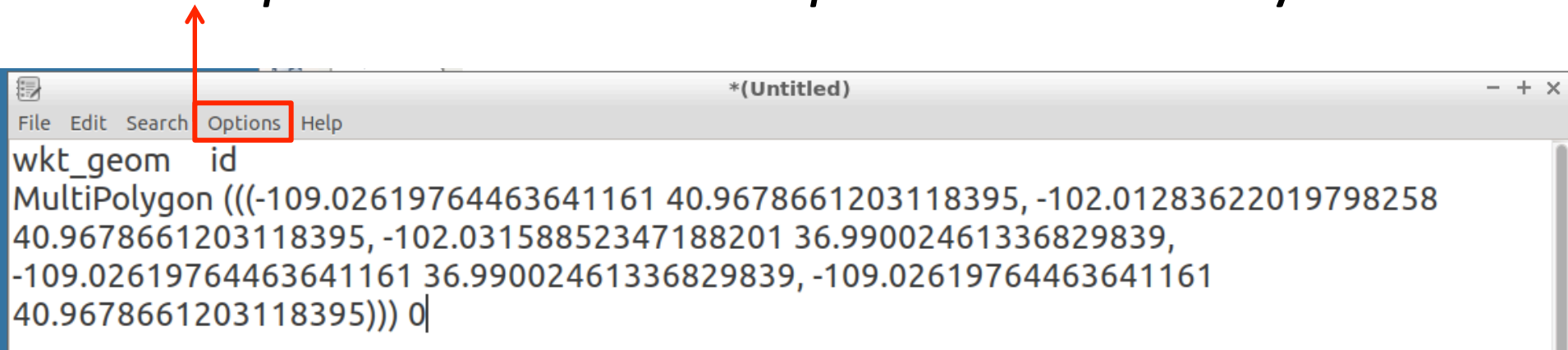
- From the File Manager, open

Applications -> Accessories -> Leafpad



See the shapefile coordinates

Use *Options* -> *Word wrap* to see on many lines

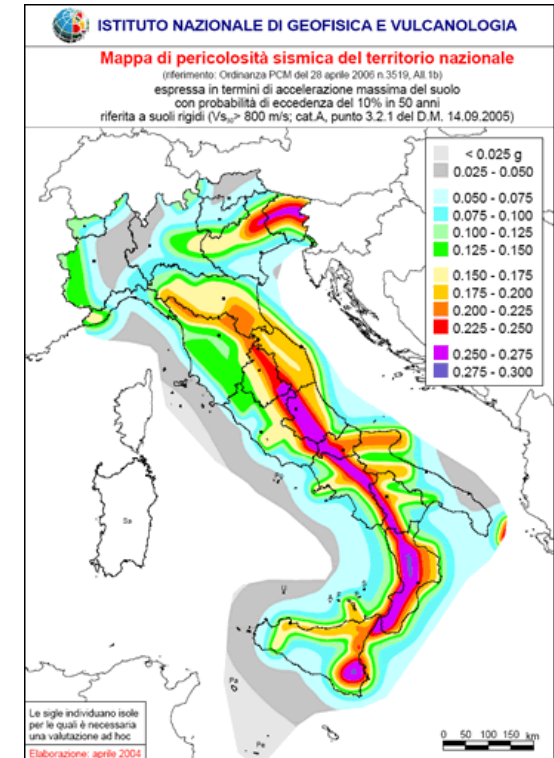
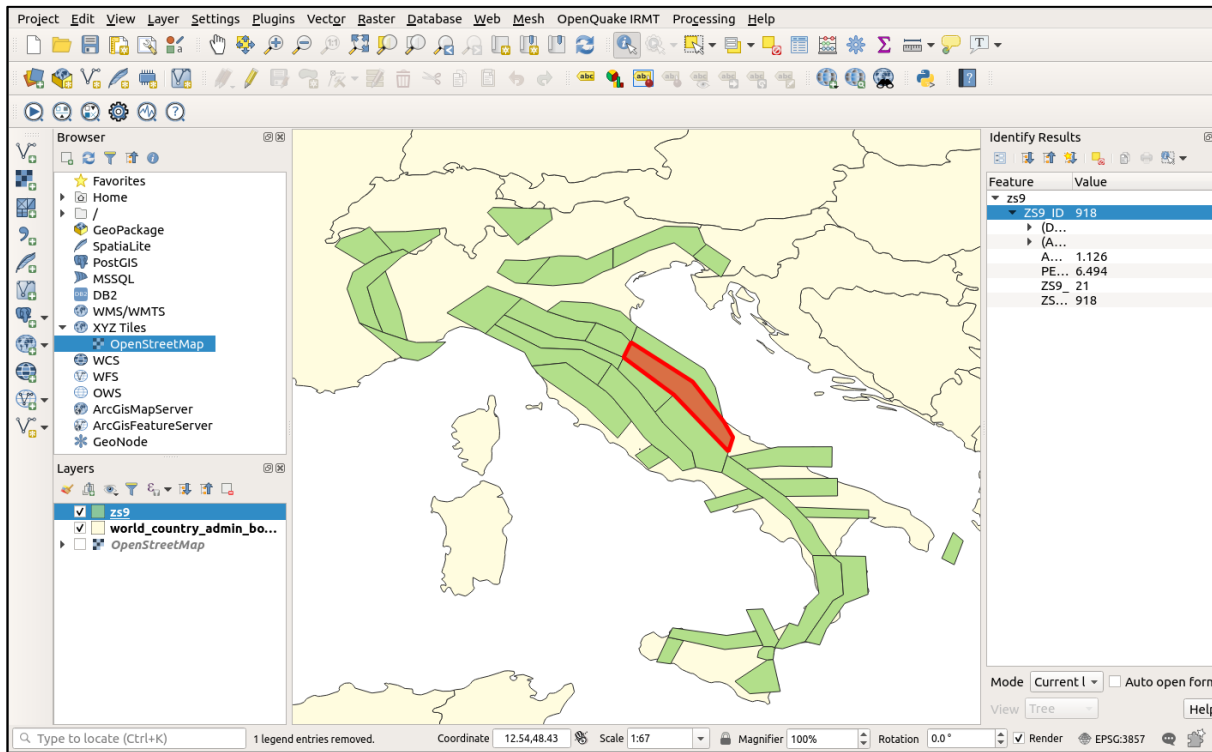
A screenshot of a text editor window titled "*(Untitled)". The menu bar includes "File", "Edit", "Search", "Options", and "Help". The "Options" menu is highlighted with a red box, and a red arrow points from the text above to it. The main text area contains a WKT geometry string:

```
wkt_geom id
MultiPolygon (((-109.02619764463641161 40.9678661203118395, -102.01283622019798258
40.9678661203118395, -102.03158852347188201 36.99002461336829839,
-109.02619764463641161 36.99002461336829839, -109.02619764463641161
40.9678661203118395)))) 0|
```

- Coordinates inside of Polygon() are comma separated and in latitude/longitude (WGS 84)
- The first and last coordinates are the same to complete the polygon

Example: Italy Model

- Together, we will implement **one source branch** of the Italian National Seismic Hazard Model (NSHM) in OpenQuake
- You will take the same steps during your project



Seismic sources (left) used in Italian National Seismic Hazard Model

Publications



Bulletin of the Seismological Society of America, Vol. 101, No. 4, pp. 1885–1911, August 2011, doi: 10.1785/0120100130

Seismic Hazard Assessment (2003–2009) for the Italian Building Code

by Massimiliano Stucchi, Carlo Meletti, Valentina Montaldo,* Helen Crowley,
Gian Michele Calvi, and Enzo Boschi



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Available online at www.sciencedirect.com



Tectonophysics 450 (2008) 85–108

TECTONOPHYSICS

www.elsevier.com/locate/tecto

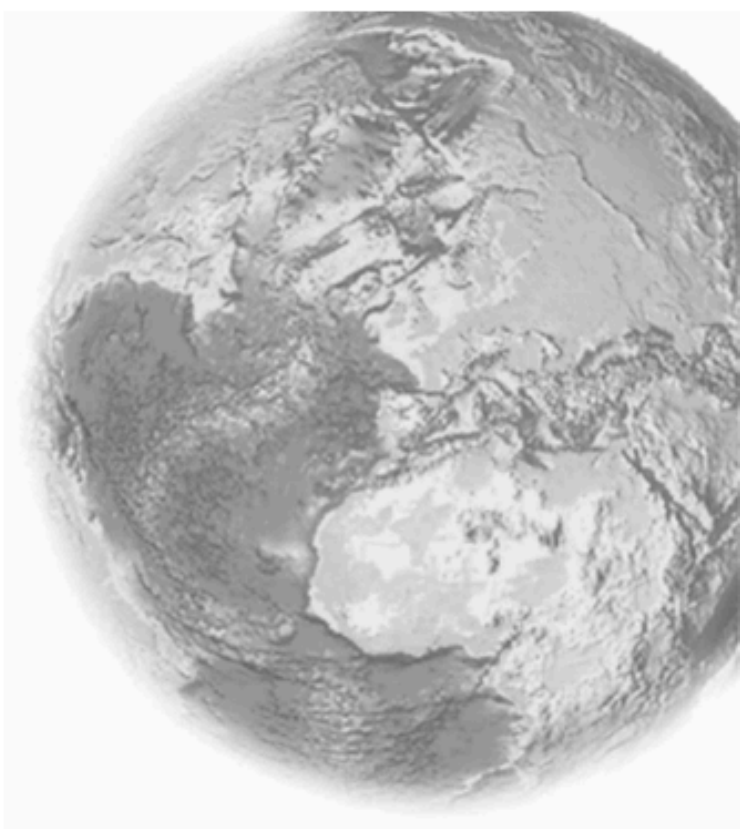
A seismic source zone model for the seismic hazard assessment of the Italian territory

Carlo Meletti *, Fabrizio Galadini, Gianluca Valensise, Massimiliano Stucchi, Roberto Basili,
Salvatore Barba, Gianfranco Vannucci, Enzo Boschi

Istituto Nazionale di Geofisica e Vulcanologia - INGV, Italy

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Available online 26 January 2008



**Redazione della
Mappa di Pericolosità Sismica**

prevista dall'Ordinanza PCM
del 20 marzo 2003, n. 3274, All.1

Rapporto Conclusivo

bozza - aprile 2004

Publications

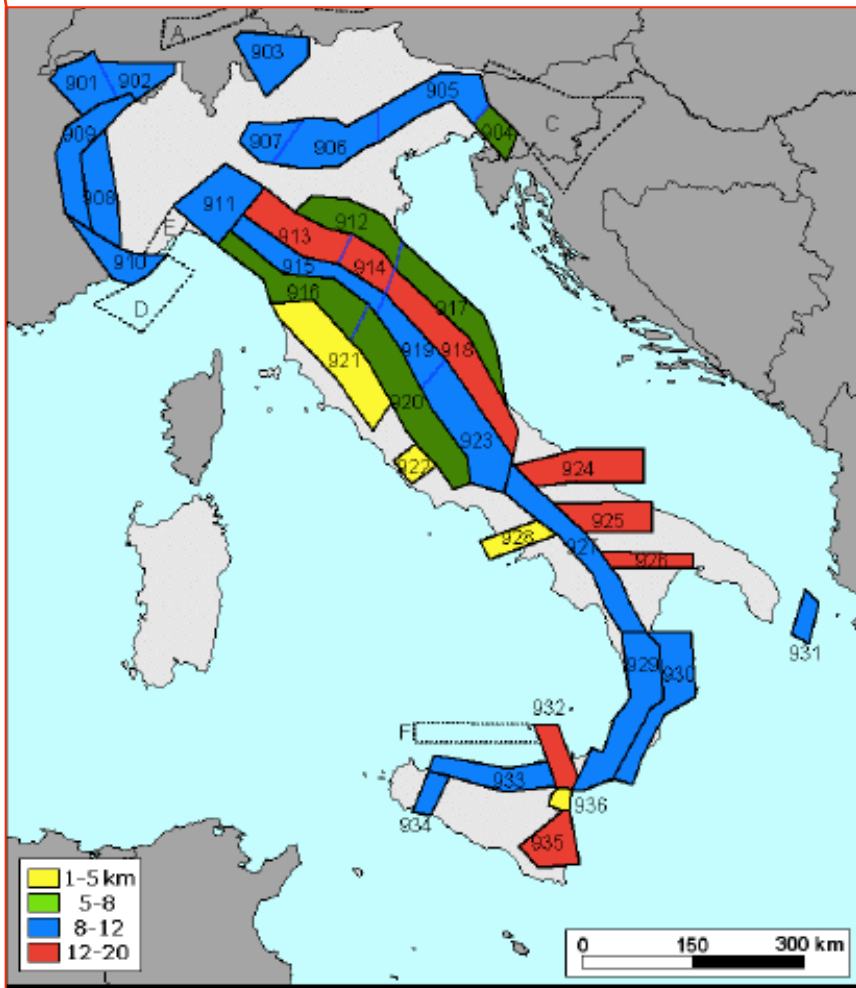
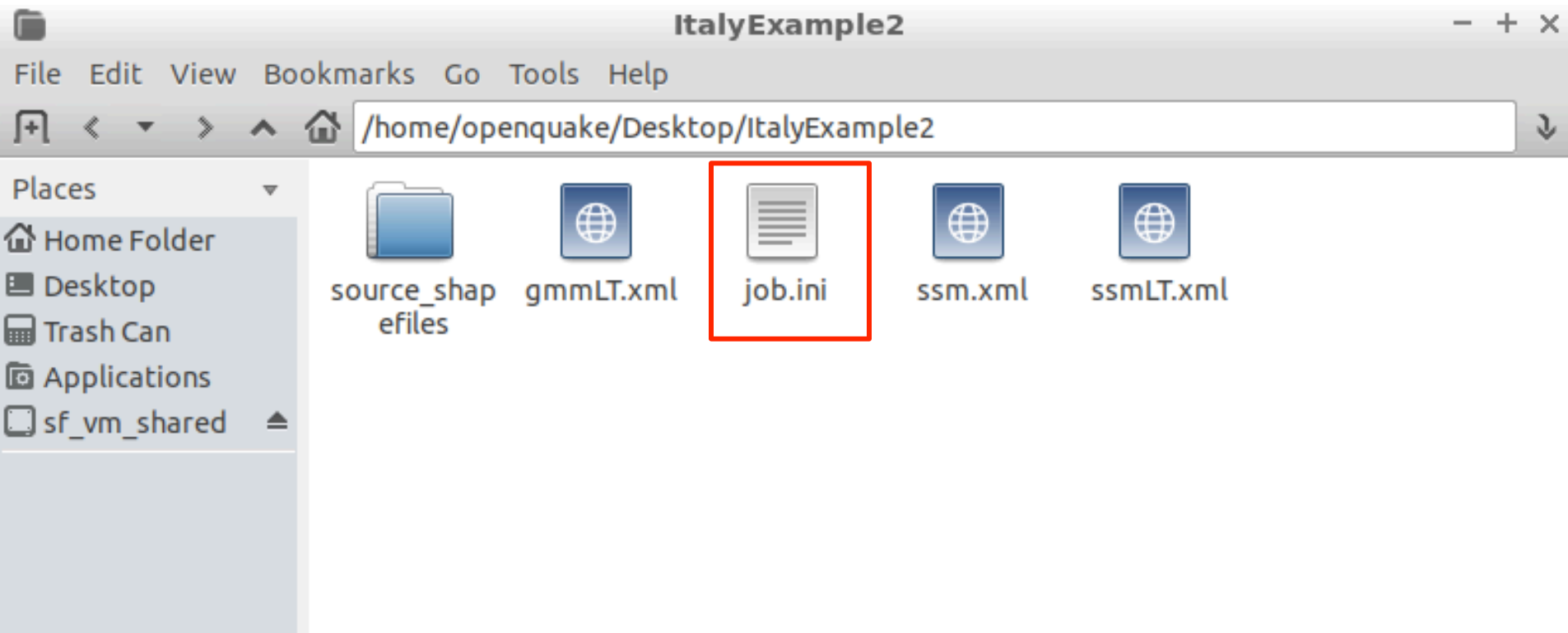


Figura 13. Attribuzione della classe di profondità alle ZS di ZS9.

Example: OpenQuake

- In the File Manager, navigate to *ItalyExample*
- Includes all the files we need to run the OQ engine, and an extra folder with shapefiles that show the sources for the demo



Example: OpenQuake



source_shapefiles



gmmLT.xml



job.ini



ssm.xml



ssmLT.xml

[general]

```
description = Seismic hazard analysis for Italy - simplified model  
calculation_mode = classical
```

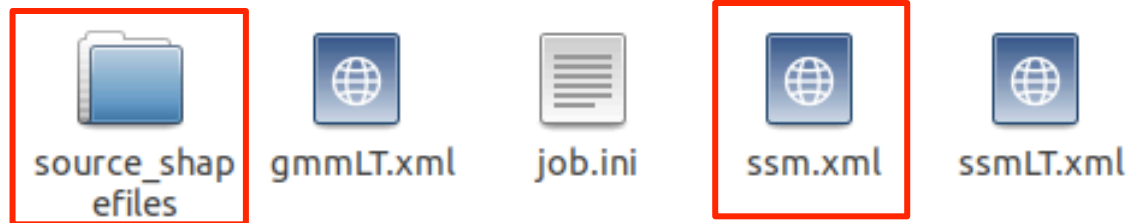
[geometry]

```
region = 5.7 47, 5.7 35, 18 35, 18 47  
region_grid_spacing = 20
```

[calculation]

```
source_model_logic_tree_file = ssmLT.xml  
gsim_logic_tree_file = gmmLT.xml
```

Example: Italian NSHMP in OpenQuake



- Here, we are implementing one branch from the Italian NSHM
- *source_shapefiles* contains the shapefile representation of *ssm.xml* (**only** *ssm.xml* is needed to run the engine)
- All of the characteristics of the sources are stored as 'attributes' in the shapefile

What are some of the 'attributes' we should expect to find?

Exercise: Implement an area source

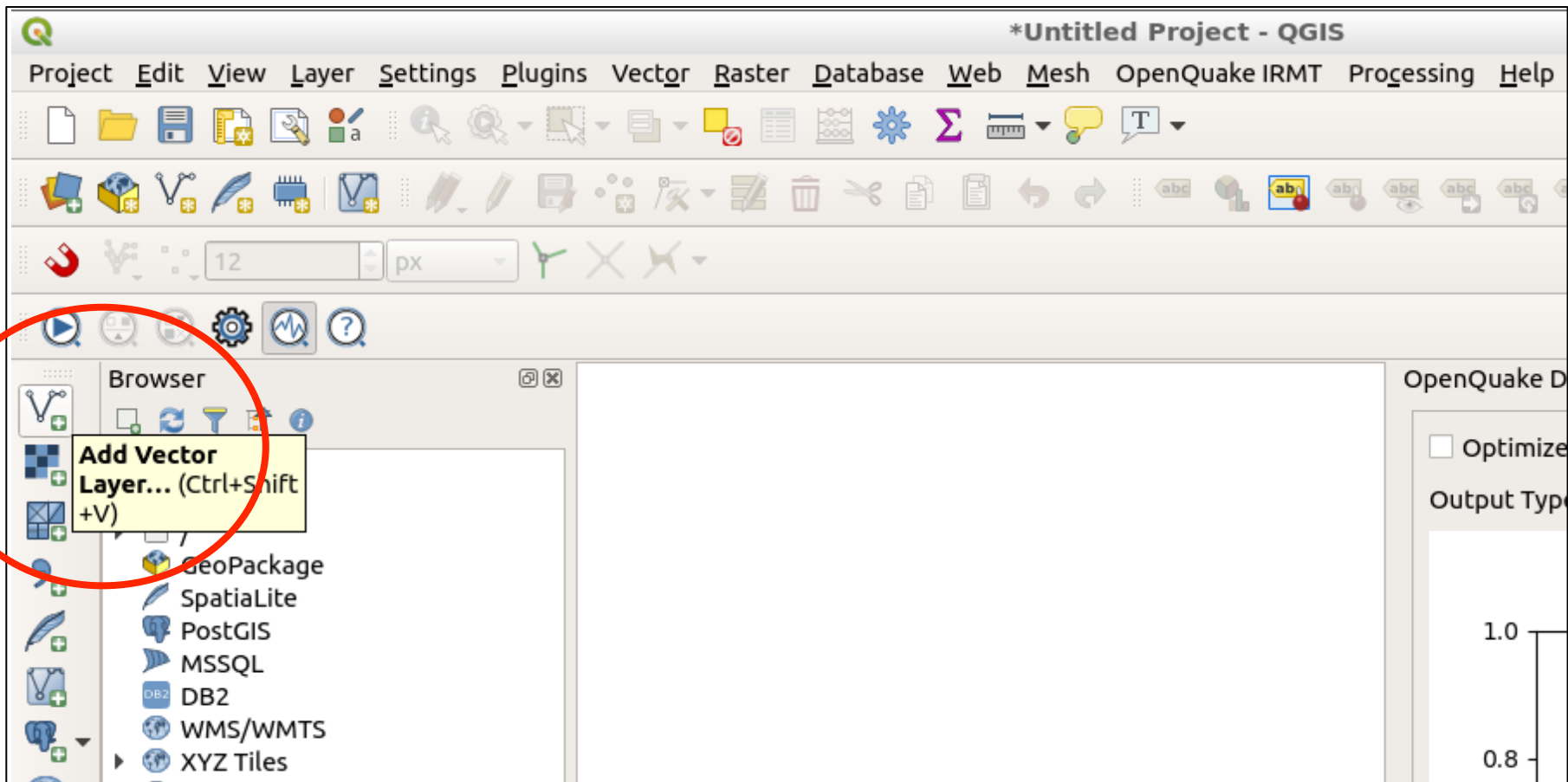
- Open the shapefiles in QGIS
- Look at the source attributes
- Compare the attribute table to the source file *ssm.xml*
- We have removed one source! Together, we will add this source to the xml
 - Define the area source perimeter in QGIS
 - Find the other attributes in the publications
 - Add everything into a new source in the xml

Exercise: Implement an area source

- **Open the shapefiles in QGIS (don't forget to specify the correct CRS!)**
- **Look at the source attributes**
- Compare the attribute table to the source file *ssm.xml*
- We have removed one source! Together, we will add this source to the xml
 - Find the other attributes in the publications
 - Define the area source perimeter in QGIS
 - Add everything into a new source in the xml

Load the shapefile into QGIS

➤ *Click Add Vector Layer*



See the shapefile attributes

The image shows a screenshot of the QGIS desktop application. The main window displays a map of the Mediterranean region with several brown polygonal features overlaid. The interface includes a toolbar at the top, a Browser panel on the left, and a Layers panel at the bottom left. Two red boxes highlight specific elements: one around the Identify feature button in the toolbar, and another around the 'Open Attribute Table' option in a context menu. The context menu is open over a selected feature, listing various actions such as 'Zoom to Layer', 'Copy Layer', and 'Open Attribute Table'. The status bar at the bottom shows the current coordinate, scale, and other application settings.

Use the Identify feature button

Open attribute table

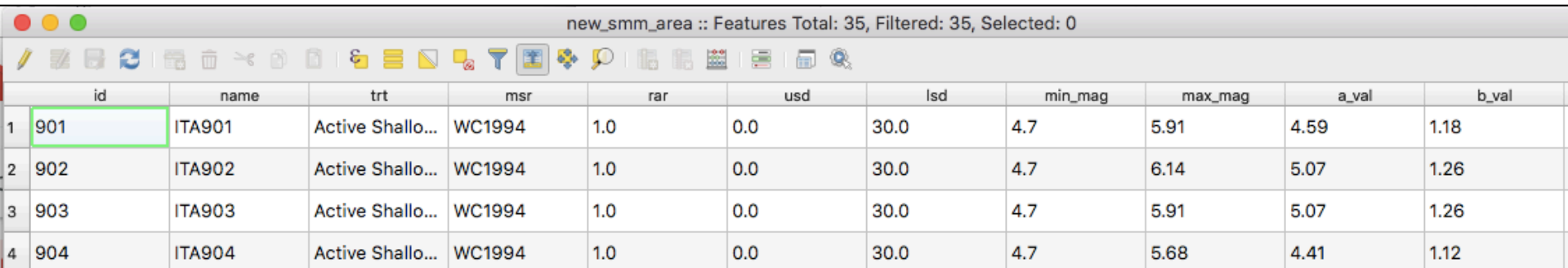
- Zoom to Layer
- Zoom to Selection
- Show in Overview
- Show Feature Count
- Copy Layer
- Rename Layer
- Duplicate Layer
- Remove Layer...
- Open Attribute Table
- Toggle Editing
- Filter...
- Set Layer Scale Visibility...
- Set CRS
- Export
- Styles
- Properties...

Type to locate (⌘K) 1 feature(s) deleted. Coordinate 9.99,38.53 Scale 1:2700687 Magnifier 100% Rotation 0.0° Render EPSG:4326

Source characteristics/attributes

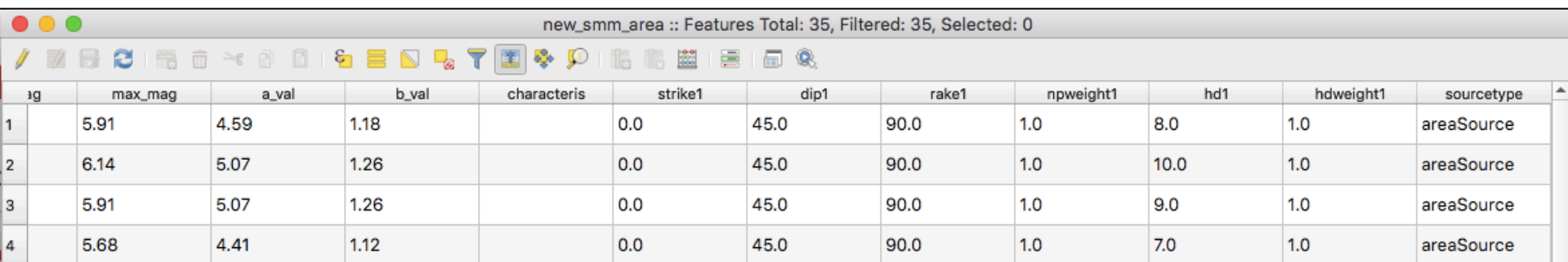
- Source ID
- name
- tectonic region type
- magnitude scaling relationship
- rupture aspect ratio
- upper/lower seismogenic depth (2 col.)
- magnitude range (2 col.)
- GR parameters (2 col.)
- Characteristic?
- [strike, dip, rake, weight]
- [hypocenter depth, weight]
- source type

Not listed: Polygon coordinates



new_smm_area :: Features Total: 35, Filtered: 35, Selected: 0

	id	name	trt	msr	rar	usd	lsd	min_mag	max_mag	a_val	b_val
1	901	ITA901	Active Shallo...	WC1994	1.0	0.0	30.0	4.7	5.91	4.59	1.18
2	902	ITA902	Active Shallo...	WC1994	1.0	0.0	30.0	4.7	6.14	5.07	1.26
3	903	ITA903	Active Shallo...	WC1994	1.0	0.0	30.0	4.7	5.91	5.07	1.26
4	904	ITA904	Active Shallo...	WC1994	1.0	0.0	30.0	4.7	5.68	4.41	1.12



new_smm_area :: Features Total: 35, Filtered: 35, Selected: 0

	ig	max_mag	a_val	b_val	characteris	strike1	dip1	rake1	npweight1	hd1	hdweight1	sourcetype
1		5.91	4.59	1.18		0.0	45.0	90.0	1.0	8.0	1.0	areaSource
2		6.14	5.07	1.26		0.0	45.0	90.0	1.0	10.0	1.0	areaSource
3		5.91	5.07	1.26		0.0	45.0	90.0	1.0	9.0	1.0	areaSource
4		5.68	4.41	1.12		0.0	45.0	90.0	1.0	7.0	1.0	areaSource

Exercise: Implement an area source

- Open the shapefiles in QGIS (don't forget to specify the correct CRS!)
- Look at the source attributes
- **Compare the attribute table to the source file *ssm.xml***
- We have removed one source! Together, we will add this source to the xml
 - Find the source attributes in the publications
 - Define the area source perimeter in QGIS
 - Add everything into a new source in the xml

Open *ssm.xml*
using *right-click* -> *Geany*

```
>
13 <areaSource
14   id="903"
15   name="ITA903"
16   tectonicRegion="Active Shallow Crust"
17 >
18   <areaGeometry>
19     <Polygon>
20       <exterior>
21         <LinearRing>
22           <posList>
23             10.1459 46.8685 10.6091 46.8561 10.6485 46.6356 9.9375 46.1137 9
24           </posList>
25         </LinearRing>
26       </exterior>
27     </Polygon>
28     <upperSeismoDepth>
29       0.0
30     </upperSeismoDepth>
31     <lowerSeismoDepth>
32       30.0
33     </lowerSeismoDepth>
34   </areaGeometry>
35   <magScaleRel>
36     WC1994
37   </magScaleRel>
38   <ruptAspectRatio>
39     1.0
40   </ruptAspectRatio>
41   <truncGutenbergRichterMFD aValue="5.07" bValue="1.26" maxMag="5.91" minMag="4.7"/>
42   <nodalPlaneDist>
43     <nodalPlane dip="45.0" probability="1.0" rake="90.0" strike="0.0"/>
44   </nodalPlaneDist>
45   <hypoDepthDist>
46     <hypoDepth
47       depth="9.0"
48       probability="1.0"
49     >
50     </hypoDepth>
51   </hypoDepthDist>
52 </areaSource>
```

The XML has the same information!

Exercise: Implement an area source

- Open the shapefiles in QGIS (don't forget to specify the correct CRS!)
- Look at the source attributes
- Compare the attribute table to the source file *ssm.xml*
- **We have removed one source! Together, we will add this source to the xml**
 - Find the source attributes in the publications
 - Define the area source perimeter in QGIS
 - Add everything into a new source in the xml

Add the missing source: 927

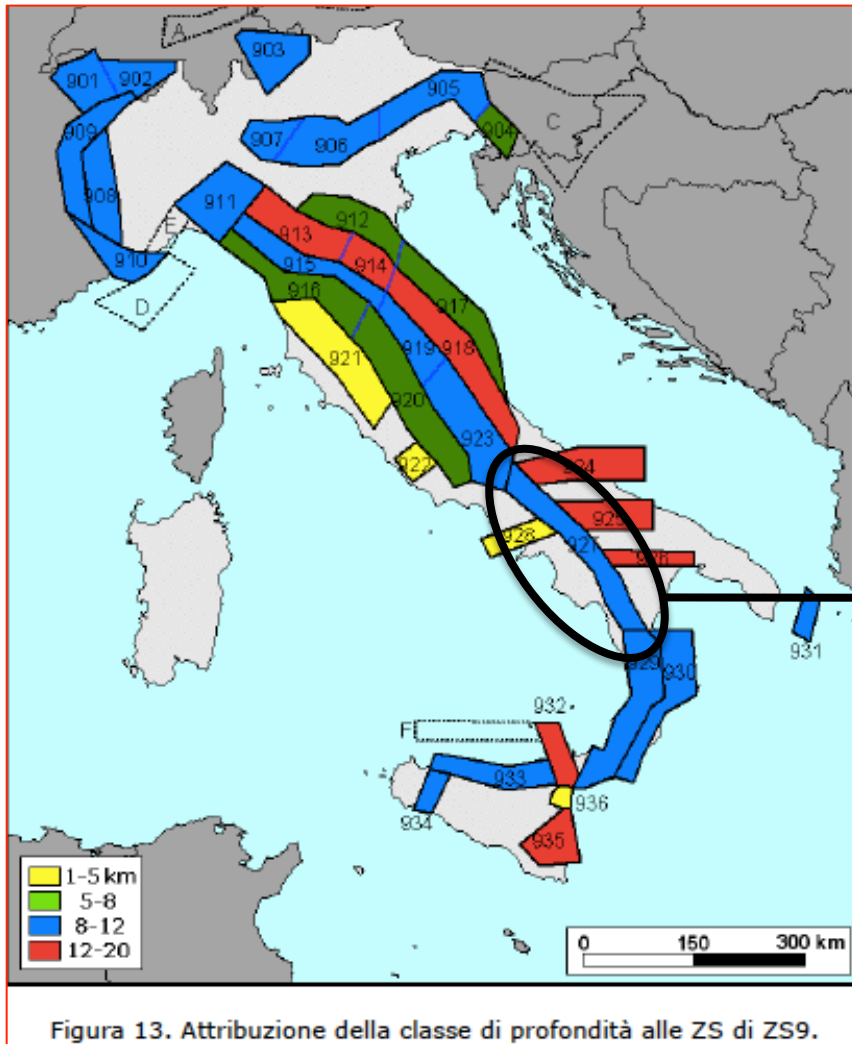


Figure 3 from Stucchi et al. (2011) or Figure 8, 13, other from the INGV report

Digitize the area source

For higher accuracy (slow):







- Georeference a map of the area sources
- Create shapefiles by tracing the area source perimeters

For “good enough” accuracy (faster):

- Use basemaps as a georeference
- Draw the approximate shape of the area source

Remember: for the project, we are not concerned with *exactly* reproducing the results!

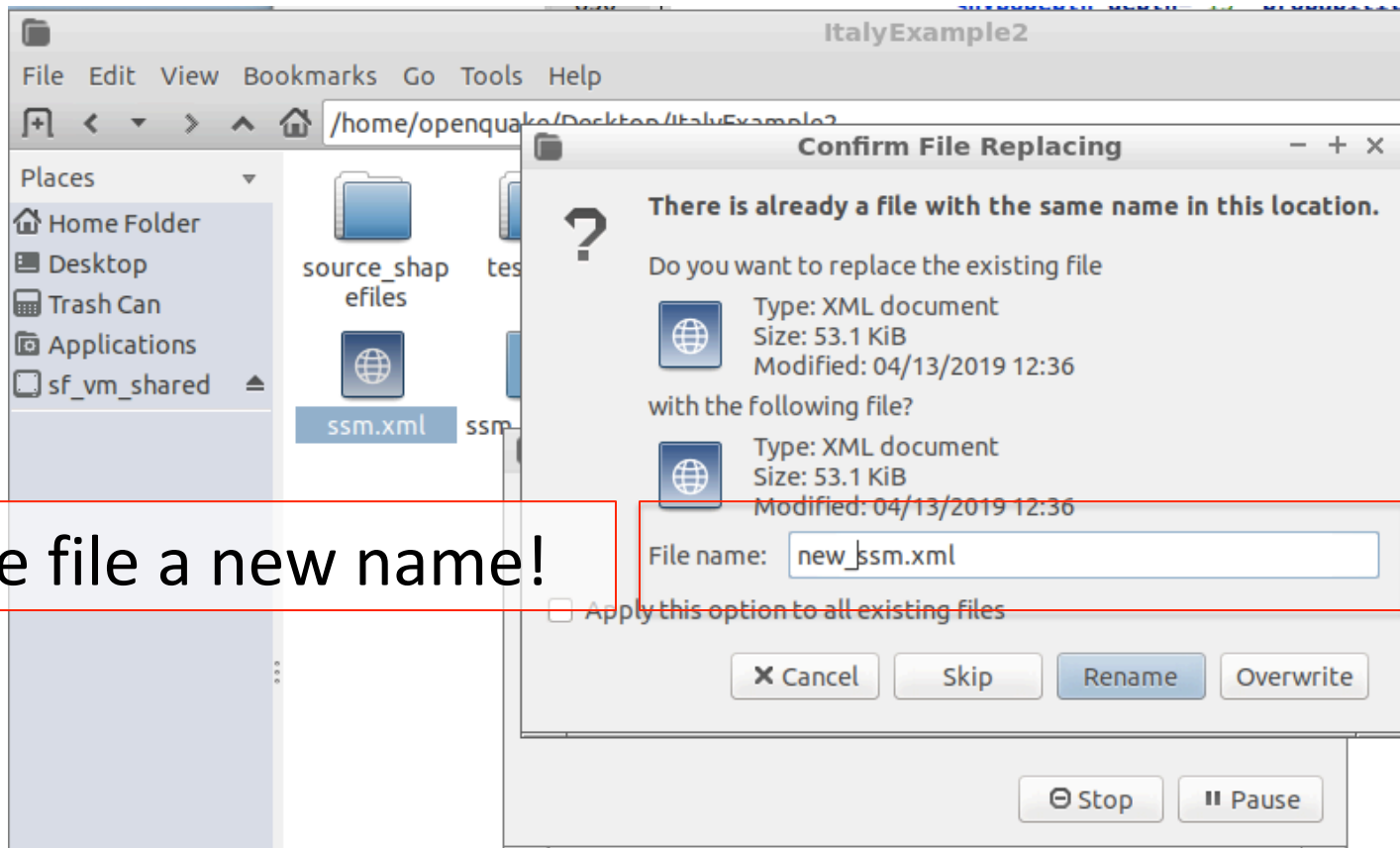
Digitize the area source

- 1) Create **a new vector layer**  with geometry type '*Polygon*' and CRS set to WGS 84
- 2) With your new shapefile highlighted in the Layers menu, click **toggle edit**  and **create a new feature** .
- 3) Draw the perimeter of area source 927. Right-click to finish drawing. Type shapefile ID 927. Edit using the **vertex tool** .
- 4) Click save  and toggle editing off .

Duplicate the source file

- Before we add the new source, we want to create a new version of *ssm.xml*

*Type **ctrl+c** and then **ctrl+v***



Give the file a new name!

Create a new source in the xml

```
<areaSource ←  
  id="903"  
  name="ITA903"  
  tectonicRegion="Active Shallow Crust"  
>  
  
  </hypoDepth>  
  </hypoDepthDist>  
</areaSource> ←
```

Opening tag for defining a single area source

Closing tag

Which fields do we need to change?

ID: `id=""`

- Assign an ID to the new area source. Here, use 927 to be consistent with the publication

Name: `name=""`

- Assign a name to the new area source. Again, use ITA927 for consistency

Which fields do we need to change?

Geometry: <posList>

- Coordinates of the area source perimeter.

MFD: <truncGutenbergRichterMFD>

aValue=" " bValue=" " maxMag=" " minMag=" "

- Magnitude-frequency distribution parameters

Nodal plane: <nodalPlaneDist>

strike=" " dip=" " rake=" " probability=" "

- Focal mechanism information and probability; can include a distribution

Depth: <hypoDepthDist>

depth=" " probability=" "

- Hypocentral depth and probability; can include a distribution

Geometry: <posList>

We will replace this field with the coordinates of area source 927 (the polygon in your newest shapefile)

Recall: How do we find the coordinates of a polygon shapefile?

See the shapefile coordinates

The image shows a screenshot of the QGIS desktop application. The main map window displays a map of the United States with a large yellow rectangle highlighting a specific area. The interface includes a top toolbar, a left sidebar with 'Browser' and 'Layers' panels, and a bottom status bar. A red circle highlights the 'Select Features' icon in the top toolbar, with a callout box containing the text 'Select features in viewer'. Another red circle highlights the 'Invert Selection' icon in the 'Colorado' layer's context menu, with a callout box containing the text 'Invert selection'. A third red circle highlights the first cell in a table window, which contains the number '1', with a callout box containing the text 'Select features from table'. A large white box with a red border in the bottom right corner contains a list item: '• With the feature cell highlighted, type "ctrl+c" to copy the cell contents'. The status bar at the bottom shows the coordinate as -106.28,41.39, scale as 1:3346028, and other settings like 'Magnifier 100%' and 'EPSG:4326'.

Select features in viewer

Invert selection

Select features from table

- With the feature cell highlighted, type "ctrl+c" to copy the cell contents

Show All Features

Type to locate (⌘K) 1: Coordinate -106.28,41.39 Scale 1:3346028 Magnifier 100% Rotation 0.0° Render EPSG:4326

See the shapefile coordinates

```
*(Untitled)
File Edit Search Options Help
wkt_geom id
MultiPolygon (((-109.02619764463641161 40.9678661203118395, -102.01283622019798258
40.9678661203118395, -102.03158852347188201 36.99002461336829839,
-109.02619764463641161 36.99002461336829839, -109.02619764463641161
40.9678661203118395))) 0
```



```
<Polygon>
  <exterior>
    <LinearRing>
      <posList>
        13.8249 46.1248 13.5463 45.8765 13.1597 46.156 12.6387 45.9916 12.2322
      </posList>
    </LinearRing>
  </exterior>
</Polygon>
```

In OQ, coordinates are listed as space-separated latitude-longitude pairs

MFD: <truncGutenbergRichterMFD>

aValue=" " bValue=" " maxMag=" " minMag=" "

Table 4

Parameters of Seismic Source Zones

Source Zone	Predominant Focal Mechanism*	CPTI04/DISS 2.0 $M_{w\max 1}^{\dagger}$	$M_{w\max 1}^{\ddagger}$	$M_{w\max 2}^{\ddagger}$	b-Value with Historical Completeness	b-Value with Statistical Completeness	Depth Hyp. A [§]	Att. REG.A [§]	Depth Hyp. B [§]	Att. REG.B [§]	
901	Savoia	Undet.	5.79	5.91	6.14	-1.18	-1.26	10	1	8	1
902	Vallese	Undet.	6.10	6.14	6.14	-1.26	-1.05	10	1	10	1
903	Grigioni-Valtellina	Undet.	5.79	5.91	6.14	-1.26	-1.05	10	1	9	1
904	Trieste-Monte Nevoso	Strike slip	5.71	5.68	6.14	-1.12	-1.32	10	2	7	2
905	Friuli-Veneto Orientale	Reverse	6.66	6.60	6.60	-1.06	-1.12	10	2	8	2
906	Garda-Veronese	Reverse	6.49	6.60	6.60	-1.14	-1.70	10	2	8	2
907	Bergamasco	Reverse	6.91	6.91	6.91	-1.71	-1.71	10	1	8	1
908	Piemonte	Strike slip	6.68	6.68	6.68	-1.91	-1.91	10	0	10	1
909	Alpi Occidentali	Normal	5.54	5.68	6.14	-1.27	-1.38	10	1	10	1
910	Nizza-Sanremo	Reverse	6.29	6.37	6.37	-1.12	-1.66	10	1	10	1
911	Tortona-Bobbio	Strike slip	5.67	5.68	6.14	-1.47	-1.33	10	1	8	1
912	Dorsale Ferrarese	Reverse	6.29	6.14	6.14	-1.35	-1.32	10	2	7	2
913	Appennino Emiliano-Romagnolo	Undet.	5.85	5.91	6.14	-1.80	-1.53	10	3	13	3
914	Forlivese	Undet.	5.97	5.91	6.14	-1.33	-1.23	10	3	13	3
915	Garfagnana-Mugello	Normal	6.49	6.60	6.60	-1.34	-1.36	10	3	8	3
916	Versilia-Chianti	Normal	5.52	5.68	6.14	-1.96	-1.58	10	3	6	3
917	Rimini-Ancona	Reverse	6.10	6.14	6.14	-1.04	-1.01	10	2	7	2
918	Medio-Marchigiana/Abruzzese	Undet.	6.23	6.37	6.37	-1.10	-1.11	10	3	13	3
919	Appennino Umbro	Normal	6.33	6.37	6.37	-1.22	-1.39	10	3	8	3
920	Val di Chiana-Ciociaria	Normal	5.57	5.68	6.14	-1.96	-1.58	10	3	6	3
921	Etruria	Normal	5.91	5.91	6.14	-2.00	-2.01	4	4	4	4
922	Colli Albani	Normal	5.53	5.45	5.45	-2.00	-2.01	4	4	4	4
923	Appennino Abruzzese	Normal	6.99	7.06	7.06	-1.05	-1.09	10	3	9	3
924	Monte Pelicciolo	Normal	6.83	6.83	6.83	-1.74	-1.74	10	2	13	2
925	Ofanto	Strike slip	6.72	6.83	6.83	-0.67	-0.75	10	2	13	2
926	Basento	Strike slip	5.84	5.91	6.14	-1.28	-1.38	10	2	13	2
927	Sannio-Irpinia-Basilicata	Normal	6.96	7.06	7.06	-0.74	-0.72	10	1	10	3
928	Ischia-Vesuvio	Normal	5.78	5.91	5.91	-1.04	-0.66	4	4	3	4
929	Calabria Tirrenica	Normal	7.24	7.29	7.29	-0.82	-0.79	10	1	10	1
930	Calabria Ionica	Undet.	6.60	6.60	6.60	-0.98	-0.89	10	1	10	1
931	Canale d'Otranto	Strike slip	6.90	6.83	6.83	-0.63	-0.63	10	2	10	3
932	Eolie-Patti	Strike slip	6.06	6.14	6.14	-1.21	-1.08	10	3	13	3
933	Sicilia Settentrionale	Reverse	5.89	6.14	6.14	-1.39	-1.24	10	3	10	3
934	Belice	Reverse	6.12	6.14	6.14	-0.96	-0.93	10	3	10	3
935	Iblei	Strike slip	7.41	7.29	7.29	-0.72	-0.69	10	2	13	2
936	Etna	Undet.	5.30	5.45	5.45	-1.63	-1.22	4	4	3	4

Stucchi et al. (2011) Table 4

Fault mechanism = normal

SZ = 927

$M_{\max} = 7.06$

$b = 0.74$

Depth = 10

MFD: <truncGutenbergRichterMFD>

aValue=" " bValue=" " maxMag=" " minMag=" "

nome ZS	N ZS	MwMax1	Tassi AR	MwMax2	b	Tassi da CO-04.2	Tassi da GR	Azione	Tassi GR adottati
Savoia	901	5.91	0.21	6.14	-1.18	0.14	0.11	A	0.11
Vallese	902	6.14	0.14	6.14	-1.26	0.14	0.19	A	0.14
Grigioni-Valtellina	903	5.91	0.21	6.14	-1.26	0.14	0.23	A	0.14
Trieste -Monte Nevoso	904	5.68	0.42	6.14	-1.12	0.14	0.14	A	0.14
Friuli - Veneto Orientale	905	6.60	0.33	6.60	-1.05	0.11	0.37	B	0.37
Garda -Veronese	906	6.60	0.11	6.60	-1.14	0.11	0.11	A	0.11
Bergamasca	907	6.14	0.14	6.14	-1.14	0.14	0.14	A	0.04
Piemonte	908	6.14	0.14	6.14	-1.14	0.14	0.14	C	0.04
Alpi Occidentali	909	6.14	0.21	6.14	-1.27	0.14	0.14	A	0.10
Nizza-Sanremo	910	6.37	0.14	6.37	-1.12	0.14	0.14	A	0.14
Tortona-Bobbio	911	5.68	0.21	6.14	-1.47	0.14	0.05	A	0.05
Dorsale Ferrarese	912	6.14	0.12	6.14	-1.35	0.12	0.13	A	0.12
Appennino Emiliano-Romagn.	913	5.91	0.14	6.14	-1.80	0.14	0.07	A	0.07
Forlivese	914	5.91	0.57	6.14	-1.33	0.14	0.26	A	0.14
Garfagnana-Mugello	915	6.60	0.14	6.60	-1.34	0.14	0.11	A	0.11
Versilia-Chianti	916	5.68	0.21	6.14	-1.96	0.14	0.02	C	0.04
Rimini-Ancona	917	6.14	0.12	6.14	-1.04	0.12	0.43	A	0.12
Medio-Marchigiana/Abruzz.	918	6.37	0.14	6.37	-1.10	0.14	0.37	A	0.14
Appennino Umbro	919	6.37	0.25	6.37	-1.22	0.12	0.26	B	0.26
Val di Chiana-Ciociaria	920	5.68	0.28	6.14	-1.96	0.14	0.06	A	0.06
Etruria	921	5.91	0.14	6.14	-2.00	0.14	0.05	A	0.05
Colli Albani	922	5.45	0.42	5.45	-2.00	0.21	0.37	B	0.37
Appennino Abruzzese	923	7.06	0.14	7.06	-1.05	0.14	0.25	A	0.14
Molise-Gargano	924	6.83	0.17	6.83	-1.04	0.17	0.13	A	0.13
Ofanto	925	6.83	0.17	6.83	-0.67	0.17	0.17	A	0.17
Basento	926	5.91	0.21	6.14	-1.28	0.21	0.10	A	0.10
Sannio-Irpinia -Basilicata	927	7.06	0.33	7.06	-0.74	0.17	0.43	B	0.43
Ischia-Vesuvio	928	5.91	0.21	5.91	-1.04	0.21	0.35	A	0.21
Calabria Tirrenica	929	7.29	0.17	7.29	-0.82	0.17	0.33	A	0.17
Calabria Ionica	930	6.60	0.17	6.60	-0.98	0.17	0.23	A	0.17

INGV Report Table 7

SZ = 927

rate = 0.43

Computing a -value from rate (λ)

From the INGV report:

- Rates (λ) are reported as number of earthquakes $M_W=4.7$ per year -> **minMag="4.7"**

$$\log_{10} \lambda(M) = a - b * M$$

- λ is a function of magnitude
- Solve for "a"

Computing a -value from rate (λ)

$$M = 4.7$$

$$\lambda(M=4.7) = 0.43$$

$$b = 0.74$$

$$\log_{10} \lambda(M) = a - b * M$$

$$a = \log_{10} \lambda(M) + b * M$$

Computing a -value from rate (λ)

$$M = 4.7$$

$$\lambda(M=4.7) = 0.43$$

$$b = 0.74$$

$$\log_{10} \lambda(M) = a - b * M$$

$$a = \log_{10} \lambda(M) + b * M$$

$$a = 3.11$$

->

$$aValue="3.11"$$

Some project groups will have to do this calculation while implementing their project!

Nodal plane: <nodalPlaneDist>
strike=" " dip=" " rake=" " probability=" "

- In PSHA, we define the *nodal plane* or *nodal plane distribution* of a area source based on what we know about faults or past earthquakes within the area source.
- From Stucchi et al. (2011), area source 927 has **normal** rupture mechanisms

Nodal plane: <nodalPlaneDist>

strike=" " dip=" " rake=" " probability=" "

- In PSHA, we define the *nodal plane* or *nodal plane distribution* of a area source based on what we know about faults or past earthquakes within the area source.
- From Table 4 in Stucchi et al. (2011), area source 927 has **normal** rupture mechanisms
e.g., strike/dip/rake = 0/45/-90

strike="0 " dip="45 " rake="-90 " probability="1.0 "

Depth: <hypoDepthDist>
depth=" " probability=" "

- From Table 4 in Stucchi et al. (2011), area source 927 has a depth (Hyp. B) of 10 km

depth="10.0" probability="1.0"

Final source added to the *ssm.xml*

```
853 <areaSource
854   id="927"
855   name="ITA927"
856   tectonicRegion="Active Shallow Crust"
857 >
858   <areaGeometry>
859     <Polygon>
860       <exterior>
861         <LinearRing>
862           <posList>
863             14.14166 41.420269 14.253578 41.775921 14.295409 41.746969 14.652621
864           </posList>
865         </LinearRing>
866       </exterior>
867     </Polygon>
868     <upperSeismoDepth>
869       0.0
870     </upperSeismoDepth>
871     <lowerSeismoDepth>
872       30.0
873     </lowerSeismoDepth>
874   </areaGeometry>
875   <magScaleRel>
876     WC1994
877   </magScaleRel>
878   <ruptAspectRatio>
879     1.0
880   </ruptAspectRatio>
881   <truncGutenbergRichterMFD minMag="4.7" maxMag="7.06" aValue="3.11" bValue="0.74"/>
882   <nodalPlaneDist>
883     <nodalPlane dip="45.0" probability="1.0" rake="-90.0" strike="0.0"/>
884   </nodalPlaneDist>
885   <hypoDepthDist>
886     <hypoDepth depth="10" probability="1.0"/>
887   </hypoDepthDist>
888 </areaSource>
```

Check: is the source syntax correct?

- We can use an OpenQuake command to convert our new source file into a shapefile
- In the terminal, navigate to the example directory

```
cd ~/Desktop/ItalyExample2
```

- Create the shapefile

```
oq to_shapefile new_ssm.xml
```

Check: is the source syntax correct?

- Check for all the shapefile components

*ls new_ssm**

- We should see:

new_ssm_area.shp

new_ssm_area.shx

new_ssm_area.dbf

~~*new_ssm.xml*~~

- Open *new_ssm_area.shp* in QGIS to check for area source 927

Update the source model logic tree

- Open the source model logic tree: *ssmLT.xml*
- Identify the link to the old source file, and replace with the name of your new source file

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <nrm1 xmlns:gml="http://www.opengis.net/gml"
3   xmlns="http://openquake.org/xmlns/nrm1/0.4">
4
5   <logicTree logicTreeID="lt1">
6     <logicTreeBranchingLevel branchingLevelID="bl1">
7       <logicTreeBranchSet uncertaintyType="sourceModel" branchSetID="bs1">
8         <logicTreeBranch branchID="b1">
9           <uncertaintyModel>ssm.xml</uncertaintyModel>
10          <uncertaintyWeight>1</uncertaintyWeight>
11        </logicTreeBranch>
12      </logicTreeBranchSet>
13    </logicTreeBranchingLevel>
14
15  </logicTree>
16 </nrm1>
```



Check the ground motion logic tree

- Open the ground motion logic tree: *gmmLT.xml*
- Look for the name of the GMPE

```
1 <?xml version="1.0" encoding="UTF-8"?>
2
3 <nrml xmlns:gml="http://www.opengis.net/gml"
4     xmlns="http://openquake.org/xmlns/nrml/0.4">
5     <logicTree logicTreeID='lt1'>
6
7         <logicTreeBranchingLevel branchingLevelID="b11">
8             <logicTreeBranchSet uncertaintyType="gmpeModel" branchSetID="bs1"
9                 applyToTectonicRegionType="Active Shallow Crust">
10
11                 <logicTreeBranch branchID="b1">
12                     <uncertaintyModel>BooreAtkinson2008</uncertaintyModel>
13                     <uncertaintyWeight>1.0</uncertaintyWeight>
14                 </logicTreeBranch>
15
16             </logicTreeBranchSet>
17         </logicTreeBranchingLevel>
18
19     </logicTree>
20 </nrml>
21
```



Find the GMPE in the OQ gsim library

- In a web browser, navigate to the OpenQuake GMPE documentation:

[http://docs.openquake.org/oq-engine/master/
openquake.hazardlib.gsim.html](http://docs.openquake.org/oq-engine/master/openquake.hazardlib.gsim.html)

- In the side menu, find and click on BooreAtkinson2008
- Use this webpage to help choose GMPEs during your project

Find the GMPE in the OQ gsim library

- In a web browser, navigate to the OpenQuake GMPE documentation:

[http://docs.openquake.org/oq-engine/master/
openquake.hazardlib.gsim.html](http://docs.openquake.org/oq-engine/master/openquake.hazardlib.gsim.html)

- In the side menu, find and click on boore_atkinson_2008

The word 'master' indicates that you are viewing the *current* documentation. Google might return another version (e.g., '2.8')

GMPE information

openquake 3.5.0 documentation » openquake.hazardlib package »

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openquake.hazardlib.gsim package

Ground-shaking intensity models

abrahamson_2014

Module exports `AbrahamsonEtAl2014`

`AbrahamsonEtAl2014RegCHN AbrahamsonEtAl2014RegJPN AbrahamsonEtAl2014RegTWN`

`class openquake.hazardlib.gsim.abrahamson_2014.AbrahamsonEtAl2014(**kwargs)` [\[source\]](#)

Bases: `openquake.hazardlib.gsim.base.GMPE`

Implements GMPE by Abrahamson, Silva and Kamai developed within the the PEER West 2 Project. This GMPE is described in a paper published in 2014 on Earthquake Spectra, Volume 30, Number 3 and titled 'Summary of the ASK14 Ground Motion Relation for Active Crustal Regions'.

COEFFS = `<openquake.hazardlib.gsim.base.CoeffsTable object>`

Coefficient tables as per annex B of Abrahamson et al. (2014)

CONSTS = `{'h1': 0.25, 'h2': 1.5, 'h3': -0.75, 'm2': 5.0, 'n': 1.5}`

equation constants (that are IMT independent)

DEFINED_FOR_INTENSITY_MEASURE_COMPONENT = `'Average Horizontal (RotD50)'`

Supported intensity measure component is orientation-independent average horizontal `RotD50`, see page 1025.

DEFINED_FOR_INTENSITY_MEASURE_TYPES = `frozenset({<class 'openquake.hazardlib.imt.PGV'>, <class 'openquake.hazardlib.imt.PGA'>, <class 'openquake.hazardlib.imt.SA'>})`

Supported intensity measure types are spectral acceleration, peak ground velocity and peak ground acceleration. see tables 4 pages 1036

GMPE information

```
class openquake.hazardlib.gsim.boore_atkinson_2008.BooreAtkinson2008(**kwargs) [source]
```

Bases: `openquake.hazardlib.gsim.base.GMPE`

Implements GMPE developed by David M. Boore and Gail M. Atkinson and published as “Ground-Motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods between 0.01 and 10.0 s” (2008, Earthquake Spectra, Volume 24, No. 1, pages 99-138).

COEFFS = `<openquake.hazardlib.gsim.base.CoeffsTable object>`

sigma, tau, std are the intra-event uncertainty, inter-event uncertainty, and total standard deviation, respectively. Note that only the inter-event and total standard deviation for ‘specified’ fault type are considered (because rake angle is always specified)

COEFFS_SOIL_RESPONSE = `<openquake.hazardlib.gsim.base.CoeffsTable object>`

Table 3, pag. 110. + coefficient values for additional frequencies extracted from Fortran code implementing soil response function developed by the original author (ab06_fmrvs_evaluate_gmpes.for available at http://www.daveboore.com/pubs_online.html - see code available for Atkinson, G. M. and D. M. Boore (2006). Earthquake ground -motion prediction equations for eastern North America)

DEFINED_FOR_INTENSITY_MEASURE_COMPONENT = `'Average Horizontal (GMRotI50)'`

Supported intensity measure component is orientation-independent measure `GMRotI50`, see paragraph ‘Response Variables’, page 100 and table 8, pag 121.

DEFINED_FOR_INTENSITY_MEASURE_TYPES = `frozenset({<class 'openquake.hazardlib.imt.PGV'>, <class 'openquake.hazardlib.imt.PGA'>, <class 'openquake.hazardlib.imt.SA'>})`

Supported intensity measure types are spectral acceleration, peak ground velocity and peak ground acceleration, see table 3 pag. 110

GMPE information

DEFINED_FOR_REFERENCE_VELOCITY = 760.0

Shear-wave velocity for reference soil conditions in [m s⁻¹]

DEFINED_FOR_STANDARD_DEVIATION_TYPES = *frozenset({'Inter event', 'Intra event', 'Total'})*

Supported standard deviation types are inter-event, intra-event and total, see equation 2, pag 106.

DEFINED_FOR_TECTONIC_REGION_TYPE = *'Active Shallow Crust'*

Supported tectonic region type is active shallow crust, see paragraph 'Introduction', page 99.

REQUIRES_DISTANCES = *frozenset({'rjb'})*

Required distance measure is Rjb. See paragraph 'Predictor Variables', pag 103

REQUIRES_RUPTURE_PARAMETERS = *frozenset({'mag', 'rake'})*

Required rupture parameters are magnitude, and rake. See paragraph 'Predictor Variables', pag 103

REQUIRES_SITES_PARAMETERS = *frozenset({'vs30'})*

Required site parameters is Vs30. See paragraph 'Predictor Variables', pag 103

get_mean_and_stddevs(*sites, rup, dists, imt, stddev_types*)

[source]

See `superclass method` for spec of input and result values.

Run the Italian NSHM in OQ: method 1

Recall: running OpenQuake from the terminal

- In the terminal, navigate to the model directory

```
cd ~/Desktop/ItalyExample2
```

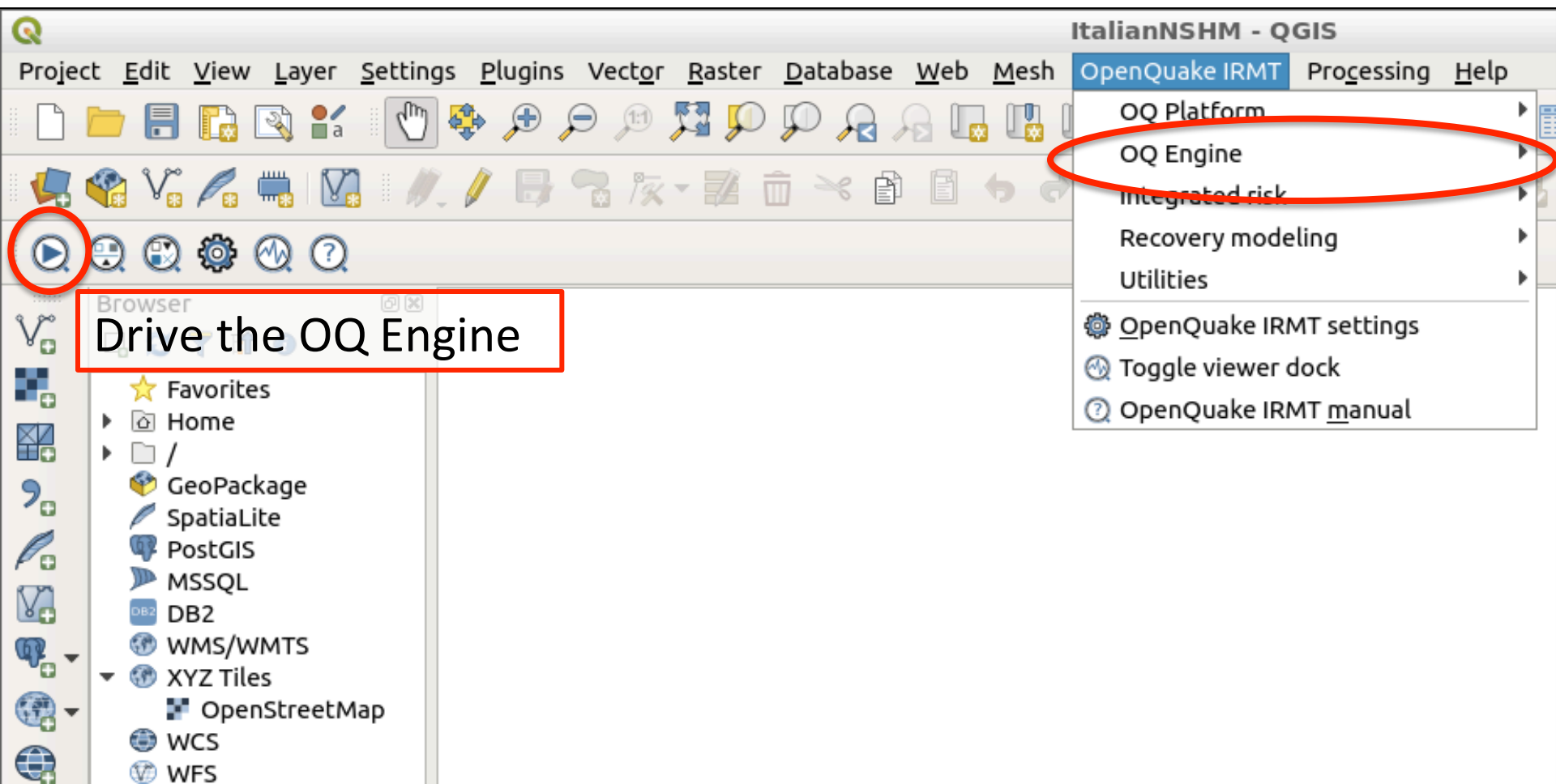
- Run the model

```
oq engine --run job.ini
```

*Note: if you already have a terminal open, you can check which directory you are in by typing **pwd***

Run the Italian NSHM in OQ: method 2

- In QGIS, click *OpenQuake IRMT -> OQ Engine*
-> *Drive the OQ Engine*



Choose the job files

Drive the OpenQuake Engine v3.4.0 (<http://localhost:8800>)

Run Calculation

List of calculations

Description	Job ID	Calculation Mode	Owner	Status					
Seismic hazard analysis for Italy - simplified model	21	classical	openq...	complete	Console	Remove	Outputs	Continue	
Seismic hazard analysis for Italy - simplified model	19	classical	openq...	complete	Console	Remove	Outputs	Continue	

Select the files needed to run the calculation, or the zip archive containing those files.

Recent
Home
Desktop
Documents
Downloads
Music
Pictures
Videos
sf_vm_shared
Other Locations

openquake Desktop ItalyExample2 job_files

Name	Size	Modified
ssmLT.xml	616 bytes	13:21
new_ssm.xml	59.4 kB	13:21
job.ini	1.0 kB	13:21
gmmLT.xml	675 bytes	13:21

Hold **ctrl+shift** while selecting the files needed to run the job (*job.ini*, *ssmLT.xml*, *new_ssm.xml*, *gmmLT.xml*)

Download HDF5 da

All Files

Cancel Open

Using the Console

The screenshot displays the OpenQuake Engine v3.4.0 interface. At the top, there is a "Run Calculation" button. Below it, a "List of calculations" table shows several entries for "Seismic hazard analysis for Italy - simplified model". The first row (Job ID 21) is highlighted, and its "Console" button is circled in red. Below the table, a "List of outputs for" section is partially visible. In the foreground, a "Console log of calculation 21" window is open, showing a detailed log of the calculation process, including progress percentages and data transfer information. The OpenQuake logo is visible at the bottom of the console window.

Drive the OpenQuake Engine v3.4.0 (http://localhost:8800)

Run Calculation

List of calculations

Description	Job ID	Calculation Mode	Owner	Status	Console	Remove	Outputs	Continue
Seismic hazard analysis for Italy - simplified model	21	classical	openq...	complete	Console	Remove	Outputs	Continue
Seismic hazard analysis for Italy - simplified model	18	classical	openq...	complete	Console	Remove	Outputs	Continue
Seismic hazard analysis for Italy - simplified model	17	classical	openq...	complete	Console	Remove	Outputs	Continue

List of outputs for

Id	Name
103	Full Report
104	Hazard Curves
105	Hazard Maps
106	Input Files
107	Seismic Scenarios
108	Uniform Hazard

Console log of calculation 21

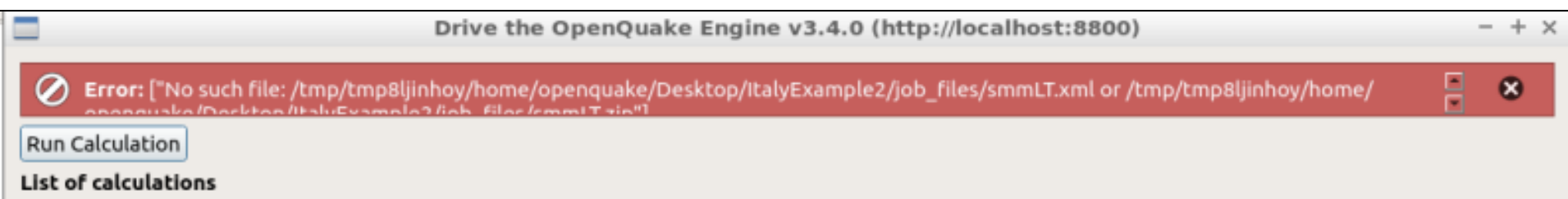
```
2019-04-13T11:23:21.91, INFO, MainProcess/2594, classical 28% [of 7]
2019-04-13T11:23:23.02, INFO, MainProcess/2594, classical 42% [of 7]
2019-04-13T11:23:31.30, INFO, MainProcess/2594, classical 57% [of 7]
2019-04-13T11:23:31.47, INFO, MainProcess/2594, classical 71% [of 7]
2019-04-13T11:23:32.34, INFO, MainProcess/2594, classical 85% [of 7]
2019-04-13T11:23:32.36, INFO, MainProcess/2594, classical 100% [of 7]
2019-04-13T11:23:32.38, INFO, MainProcess/2594, Received 883.69 KB from 7 classical outputs in 31
seconds, biggest output=187.41 KB
2019-04-13T11:23:32.39, INFO, MainProcess/2594, Received {'pmap': '880.58 KB', 'calc_times': '3.31 KB',
'eff ruptures': '538 B', 'rup_data': '133 B'}
2019-04-13T11:23:32.41, INFO, MainProcess/2594, There are 1 realization(s)
2019-04-13T11:23:32.44, INFO, MainProcess/2594, Effective sites per task: 930
2019-04-13T11:23:32.50, INFO, MainProcess/2594, Building hazard statistics
2019-04-13T11:23:33.09, INFO, MainProcess/2594, Sent 31.46 KB of data in 6 build_hazard_stats task(s)
2019-04-13T11:23:34.33, INFO, MainProcess/2594, build_hazard_stats 16% [of 6]
2019-04-13T11:23:35.84, INFO, MainProcess/2594, build_hazard_stats 33% [of 6]
2019-04-13T11:23:35.86, INFO, MainProcess/2594, build_hazard_stats 50% [of 6]
2019-04-13T11:23:35.87, INFO, MainProcess/2594, build_hazard_stats 66% [of 6]
2019-04-13T11:23:35.88, INFO, MainProcess/2594, build_hazard_stats 83% [of 6]
2019-04-13T11:23:35.90, INFO, MainProcess/2594, build_hazard_stats 100% [of 6]
```

Download HDF5 d...

OpenQuake

File errors and job failures

- Errors printed in the console can be intimidating and verbose, so it is good to know what to look for
- What if a file name is spelled wrong in the job file?
 - The Engine gives an error that there is “No such file...<filename>”



File errors and job failures

- What if the logic tree points to a file that does not exist? Job status: **failed**

Drive the OpenQuake Engine v3.4.0 (http://localhost:8800)

Run Calculation


List of calculations

Description	Job ID	Calculation Mode	Owner	Status	Console	Remove	Outputs	Continue
Seismic hazard analysis for Italy - simplified model	25	classical	openq...	failed	Console	Remove		
Seismic hazard analysis for Italy - simplified	21	classical	open...	completed	Console	Remove	Outputs	Continue

Console log of calculation 25

```
self.parse_branchinglevel(branchinglevel_node, depth, validate)
File "/home/openquake/GEM/oq-engine/openquake/commonlib/logictree.py", line 683, in
parse_branchinglevel
self.parse_branches(branchset_node, branchset, validate)
File "/home/openquake/GEM/oq-engine/openquake/commonlib/logictree.py", line 755, in parse_branches
value_node, branchnode, branchset)
File "/home/openquake/GEM/oq-engine/openquake/commonlib/logictree.py", line 946, in
validate_uncertainty_value
raise LogicTreeError(node, self.filename, str(exc)) from exc
openquake.commonlib.logictree.LogicTreeError: filename '/tmp/tmplzew_3v4/home/openquake/Desktop/
ItalyExample2/job_files/ssmLT.xml', line 9: [Errno 2] No such file or directory: '/tmp/tmplzew_3v4/
home/openquake/Desktop/ItalyExample2/job_files/new-ssm.xml'
```

Again, "No such file or directory: ..."



Next time...

- Learn ways of selecting GMPEs, and how to add more than one to a logic tree
- Learn how to choose the other configurations inside *job.ini*
- Plot the hazard outputs
- Discuss any differences from the published model

Now...

- Group work
 - TAs will go group-to-group to talk about the details of the source model for each paper