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

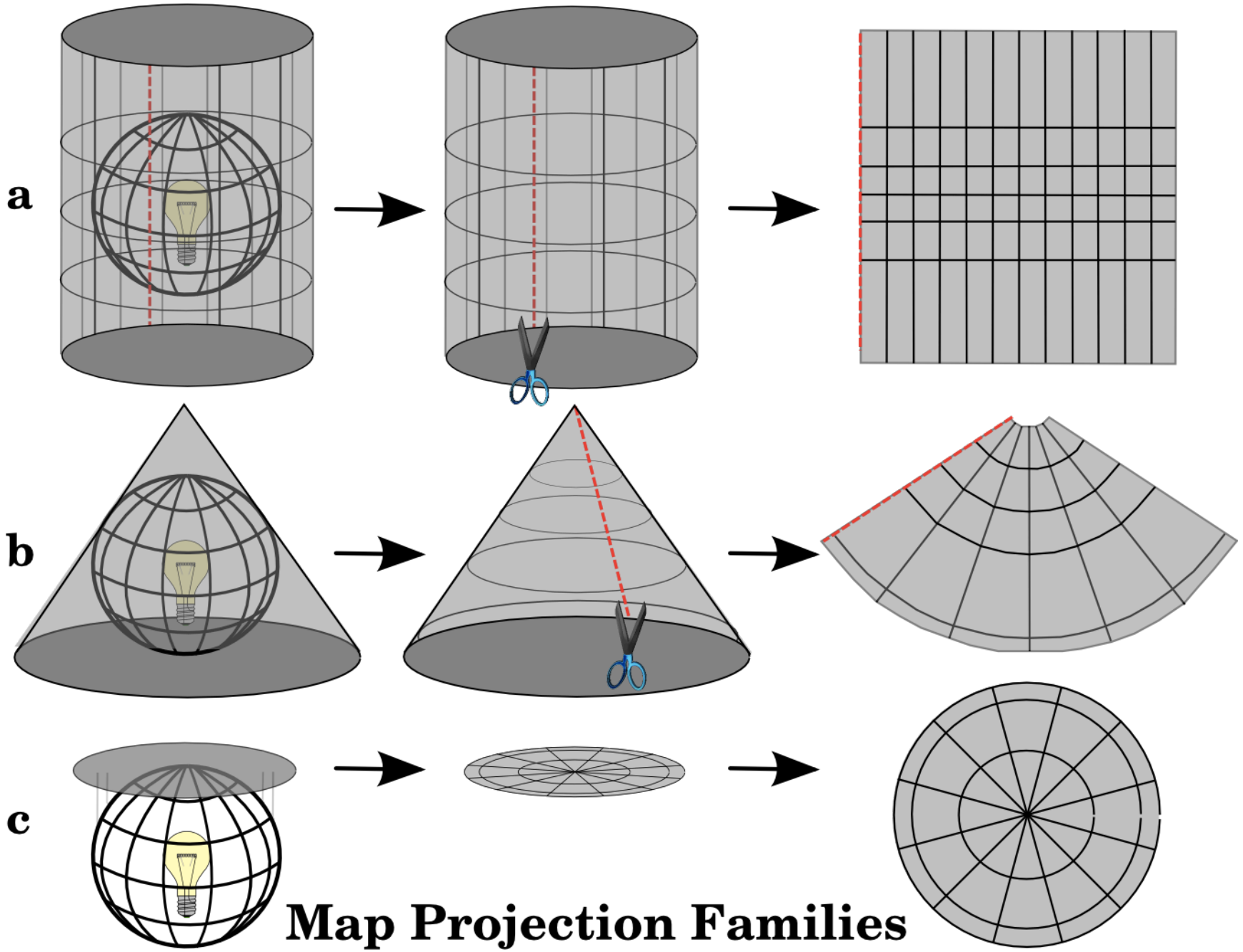
Heteronyms: words that are spelled the same, but have different meanings and pronunciations

- 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)

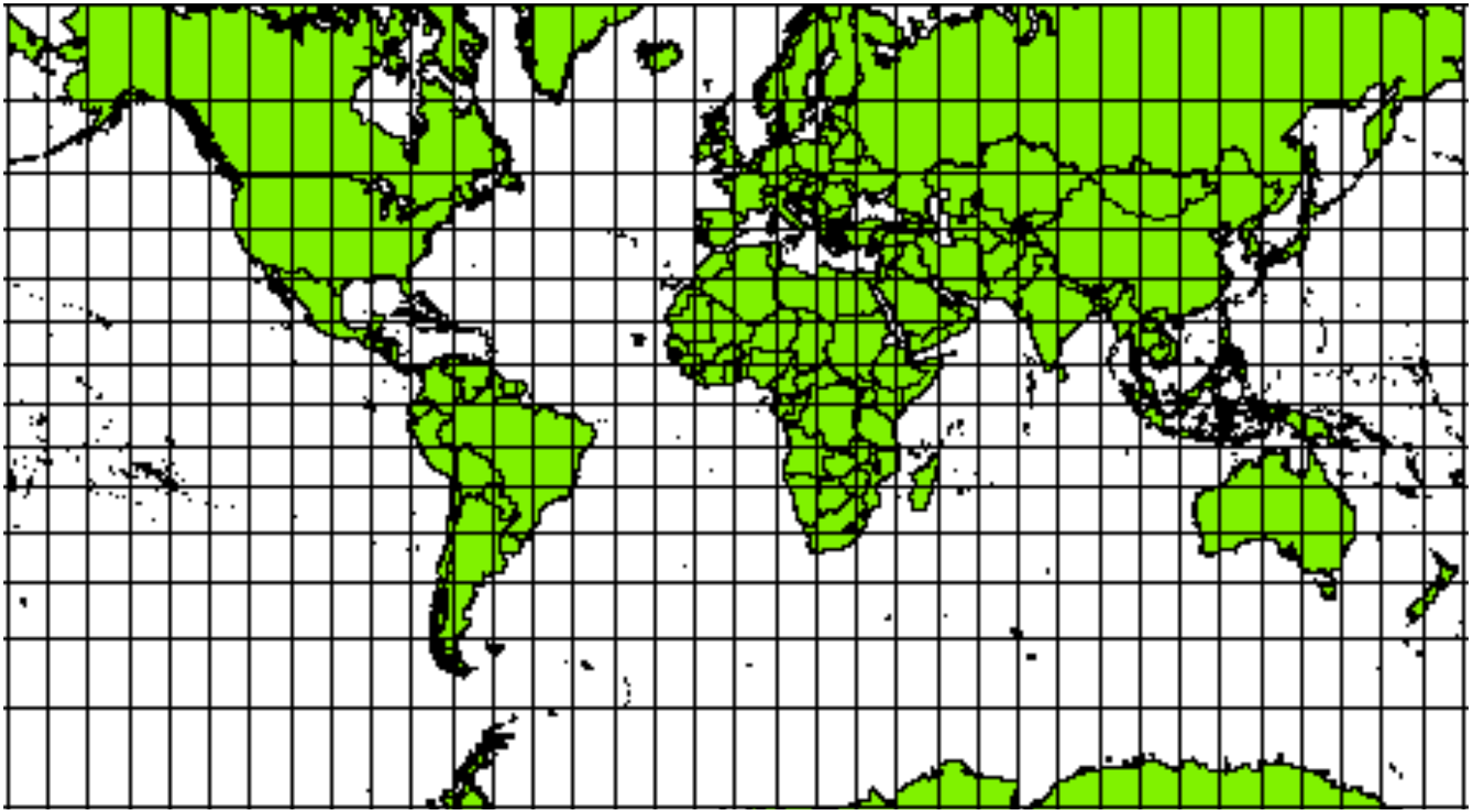
What is “projection”?

- 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

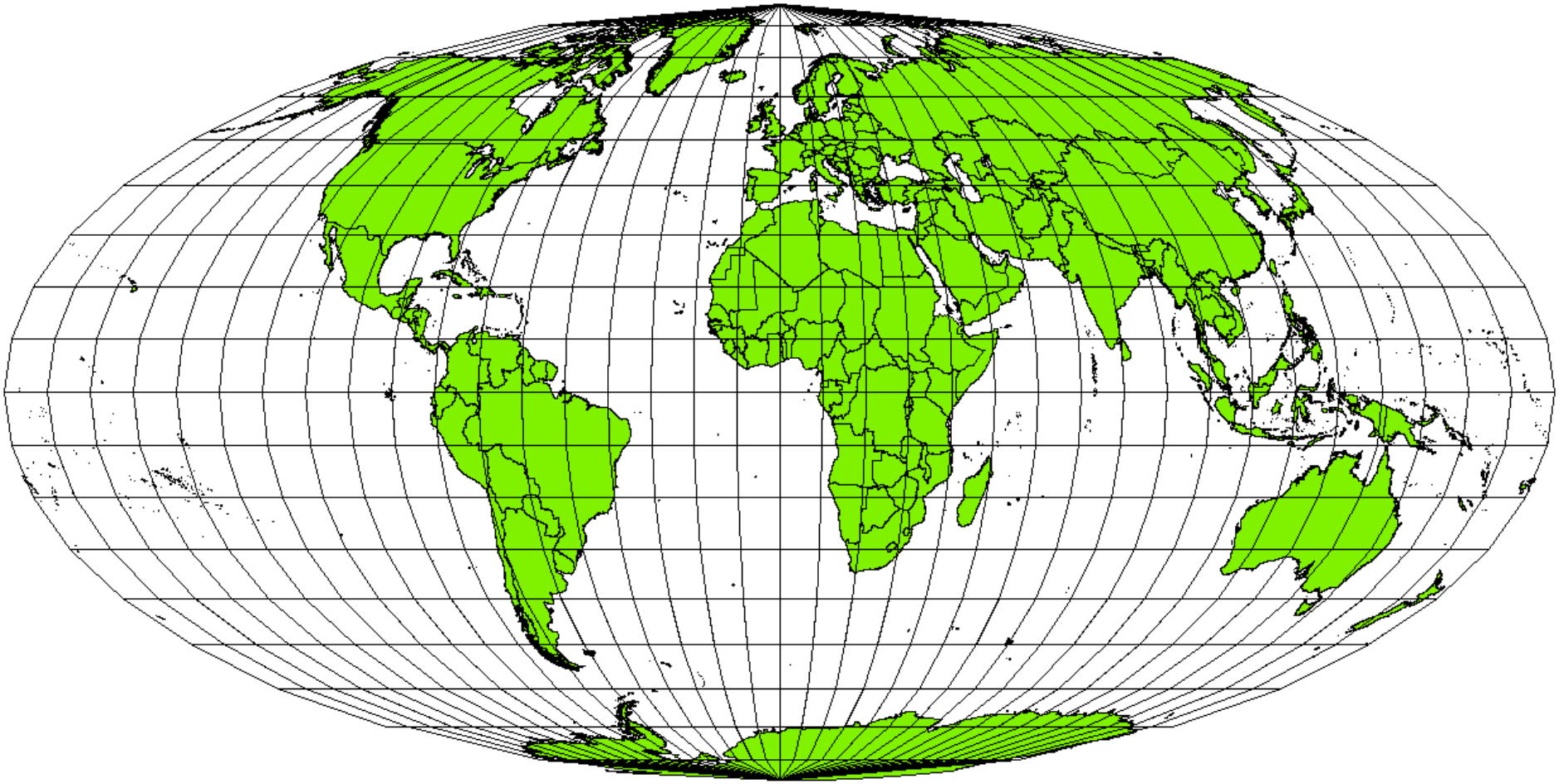
https://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/coordinate_reference_systems.html


a
b
c
Map Projection Families

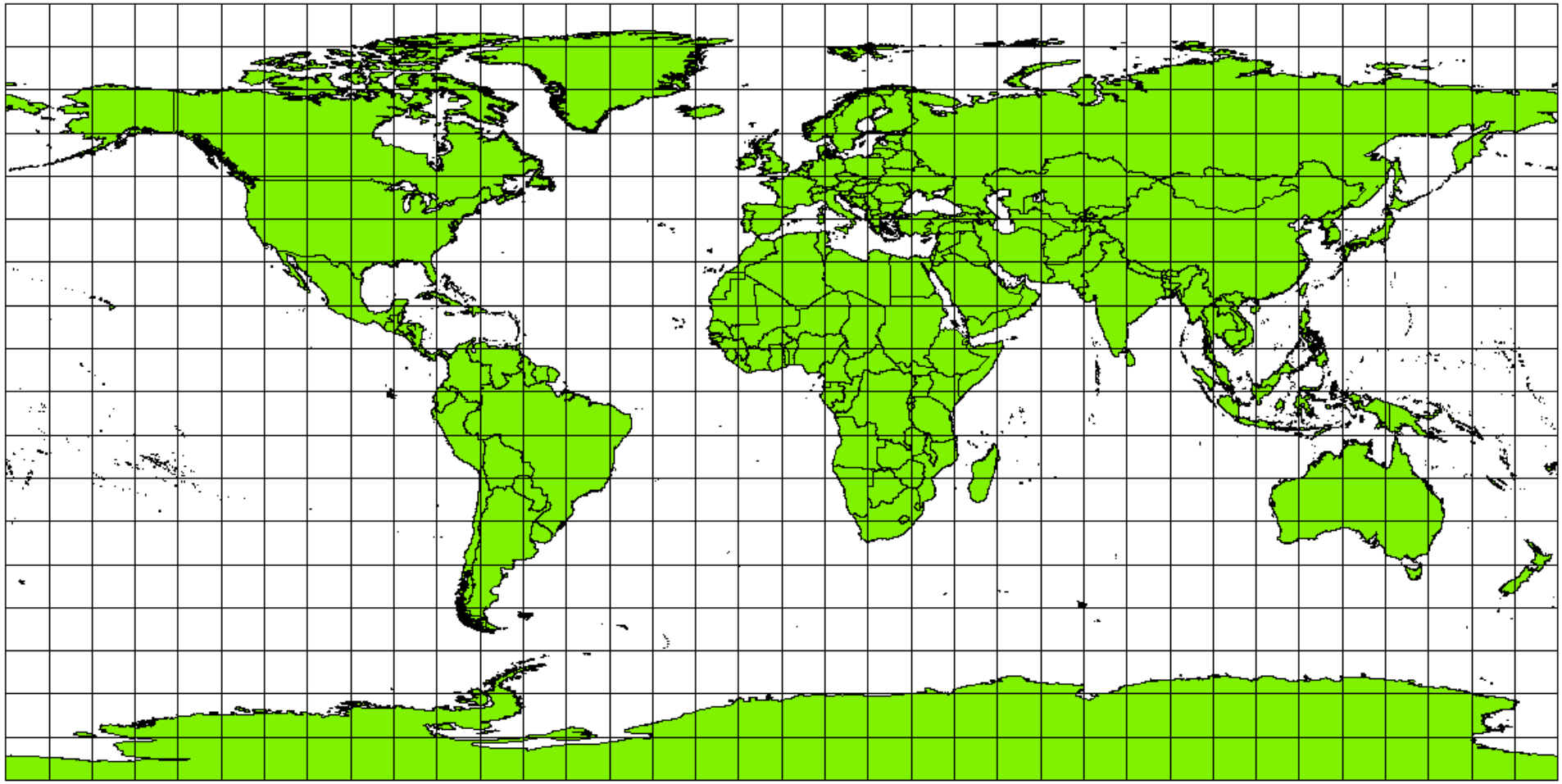
Example: Mercator



Example: Mollweide equal area

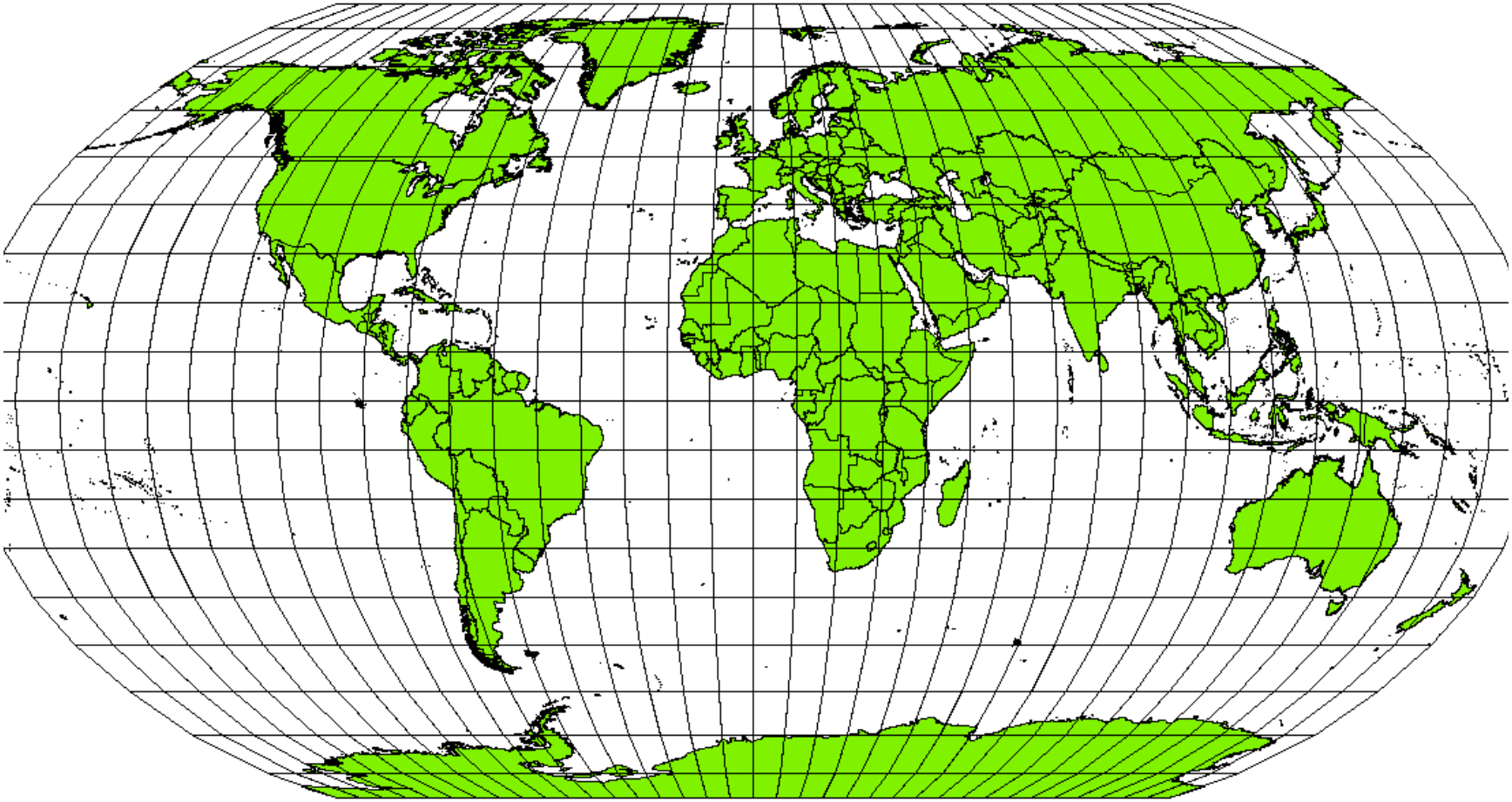


Example: Plate Carree



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

Example: Robinson projection



In practice…

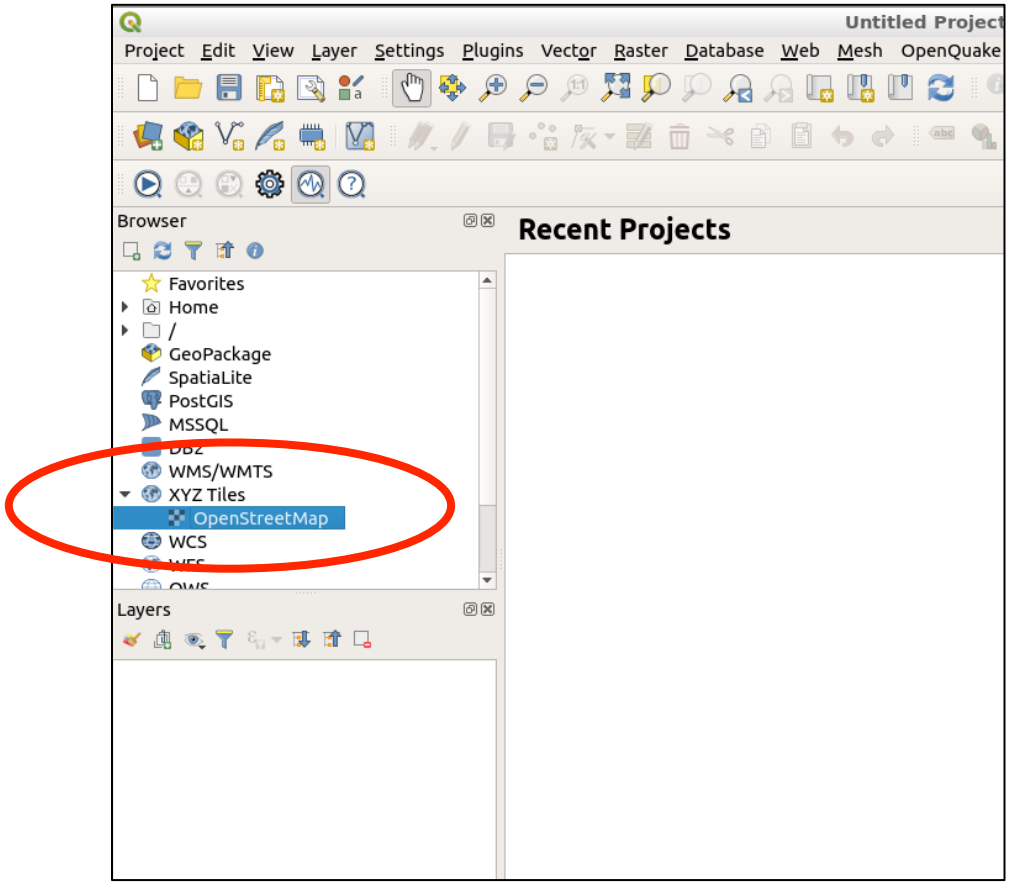
- You might want to use data or layers that use different coordinate systems
- Example: **OpenMapLayer** is defined using a **projected coordinate system** (pseudo-mercator) but the ISC-GEM catalogue uses a **geographic coordinate system**
- GIS will apply a **transformation** to the individual layers 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



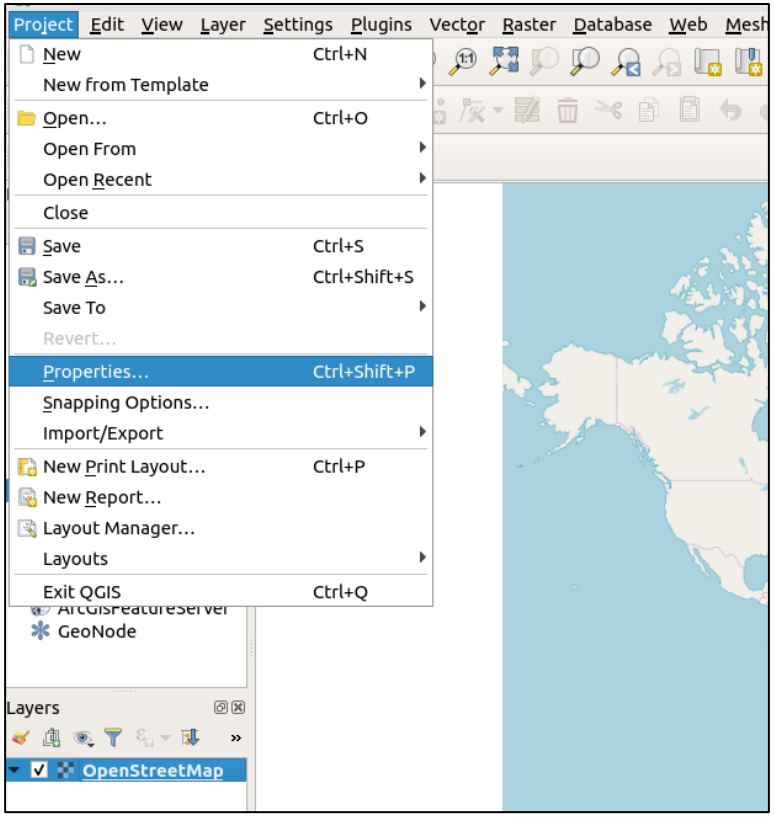
➢ Click *OpenStreetMap*

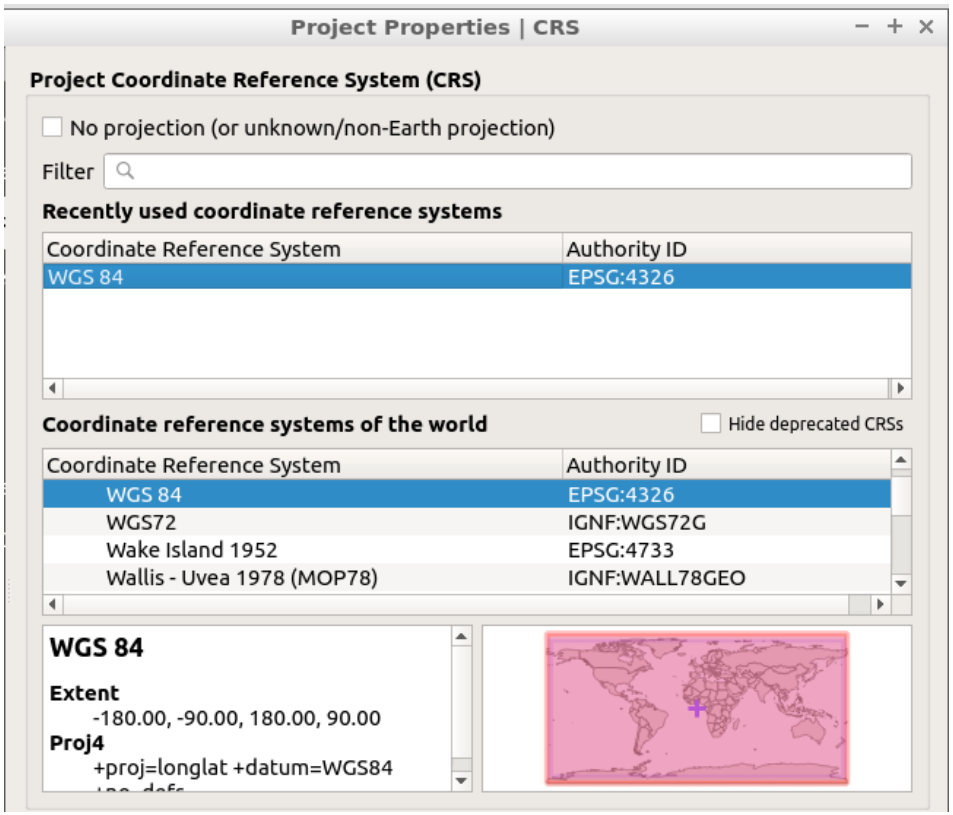
Note: web basemaps require internet during initial download, then they remain loaded in QGIS

Basemap example

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

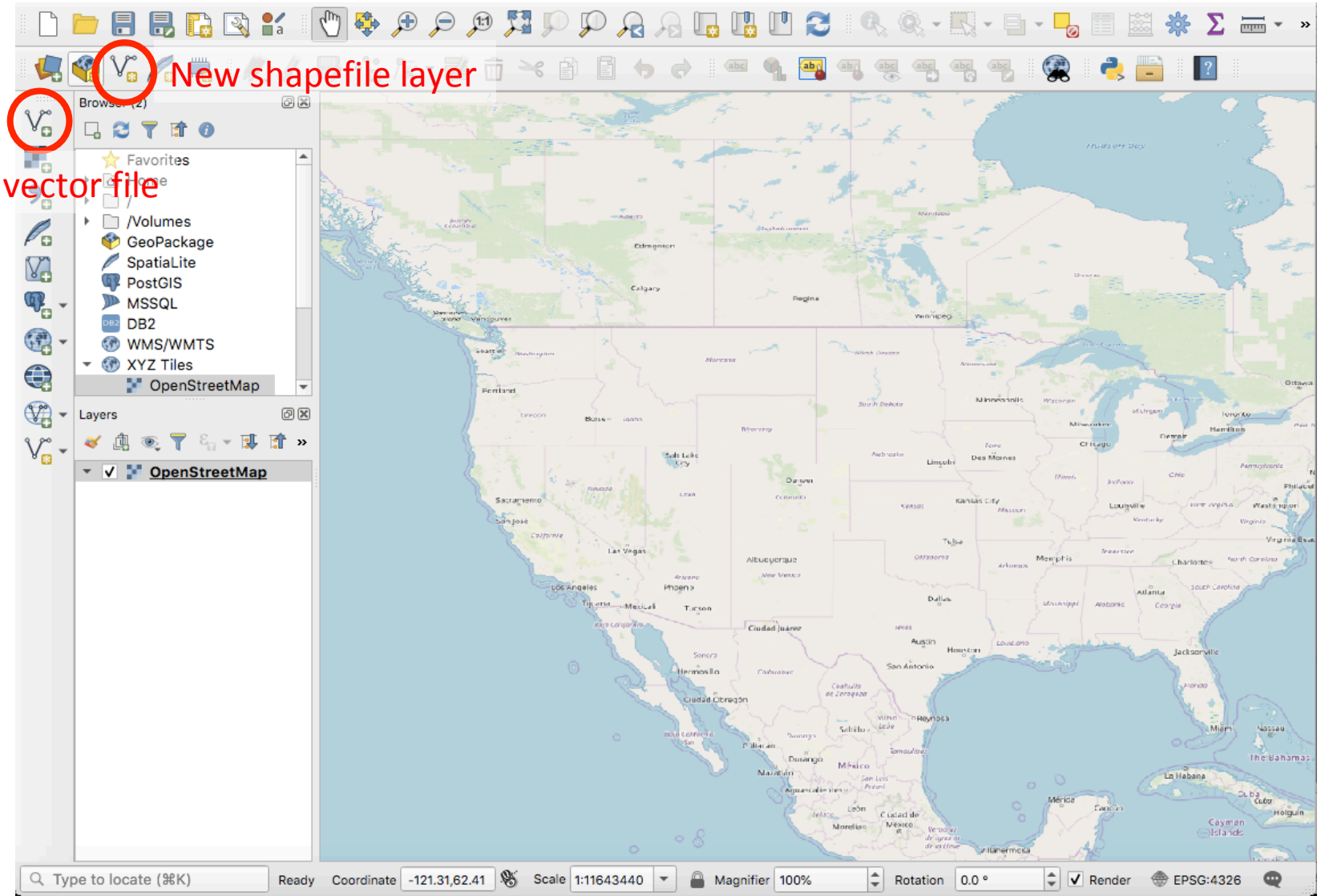
- *Project* > *Properties* > select *WGS 84*



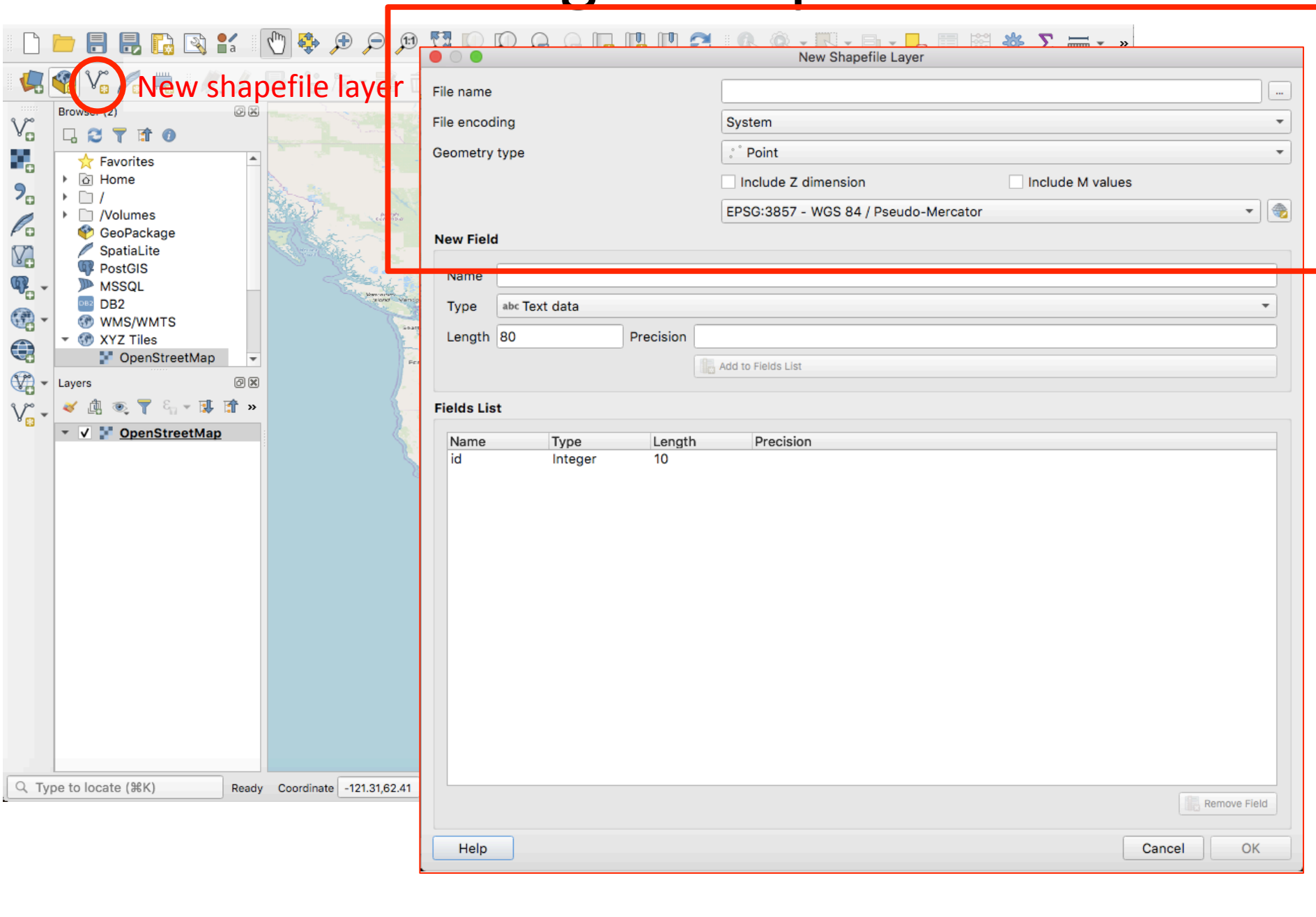


Creating shapefiles in QGIS

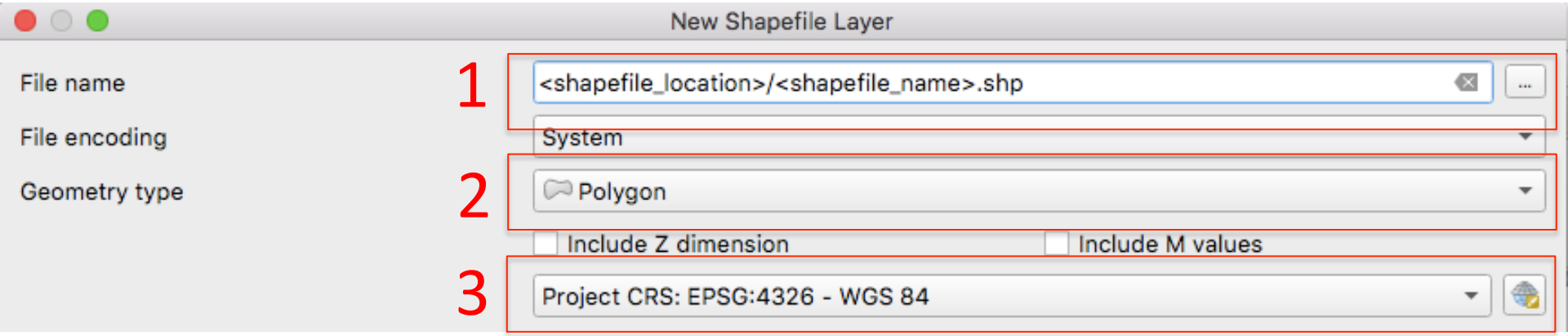
- **Recall**: shapefiles are **vector files**



Creating a shapefile



Creating a shapefile

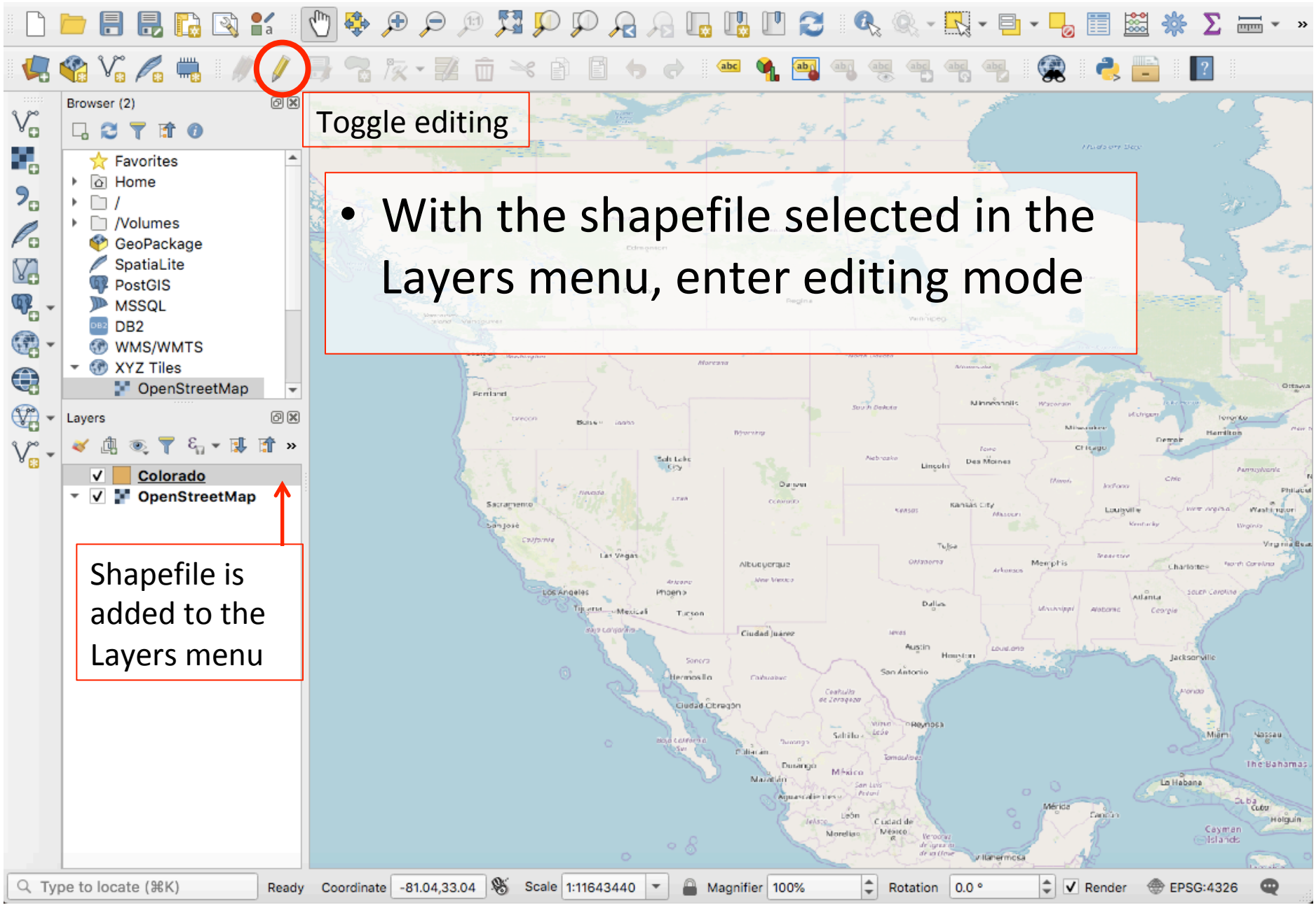


① Choose what you want to name the shapefile, and where you want to save it (**note**: the suffix must be ".shp")

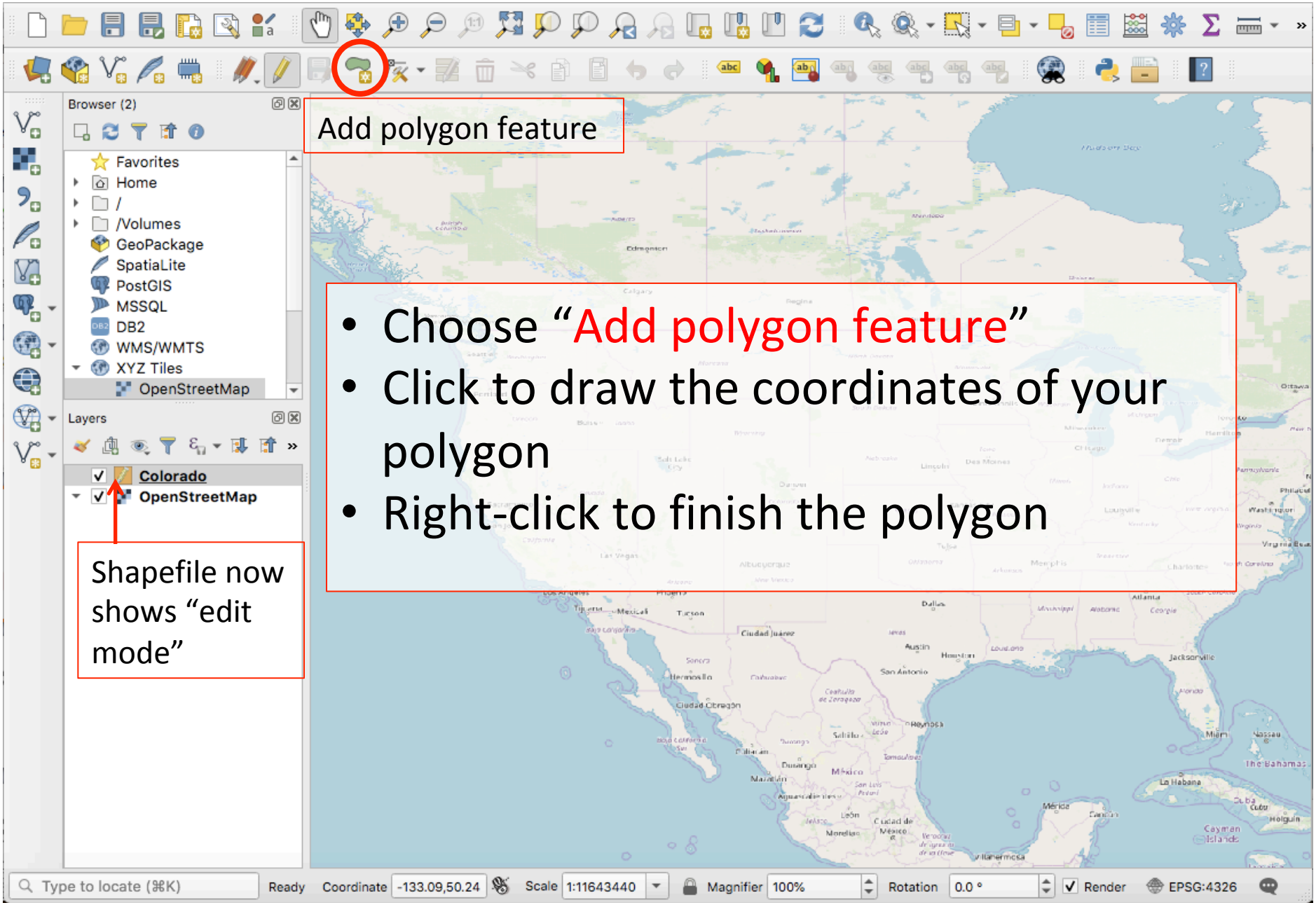
② Define the geometry type. For area sources, we will use polygons

③ Choose the CRS. For OpenQuake, always define using latitude and longitude (WGS 84, EPSG:4326)

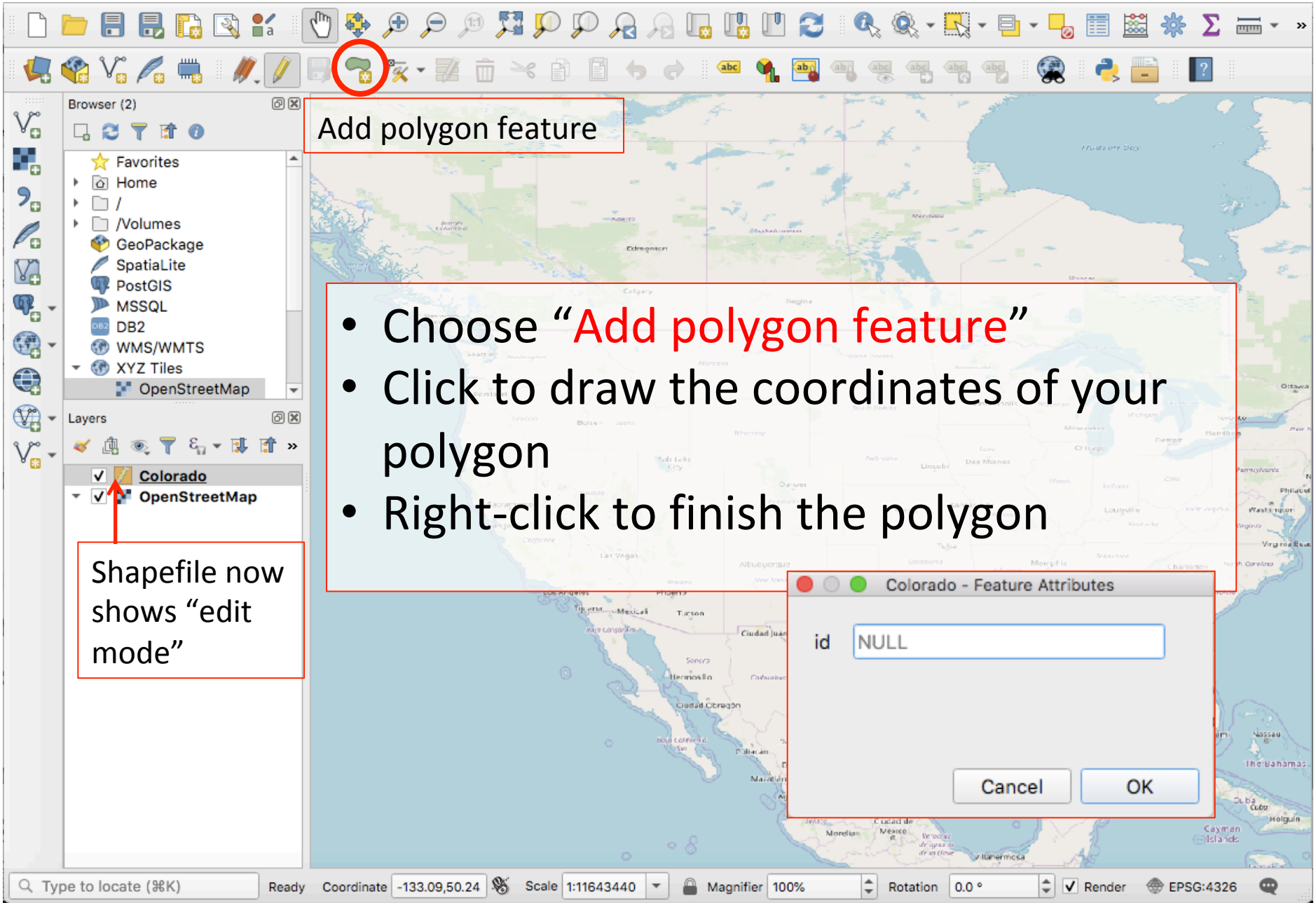
Creating a shapefile



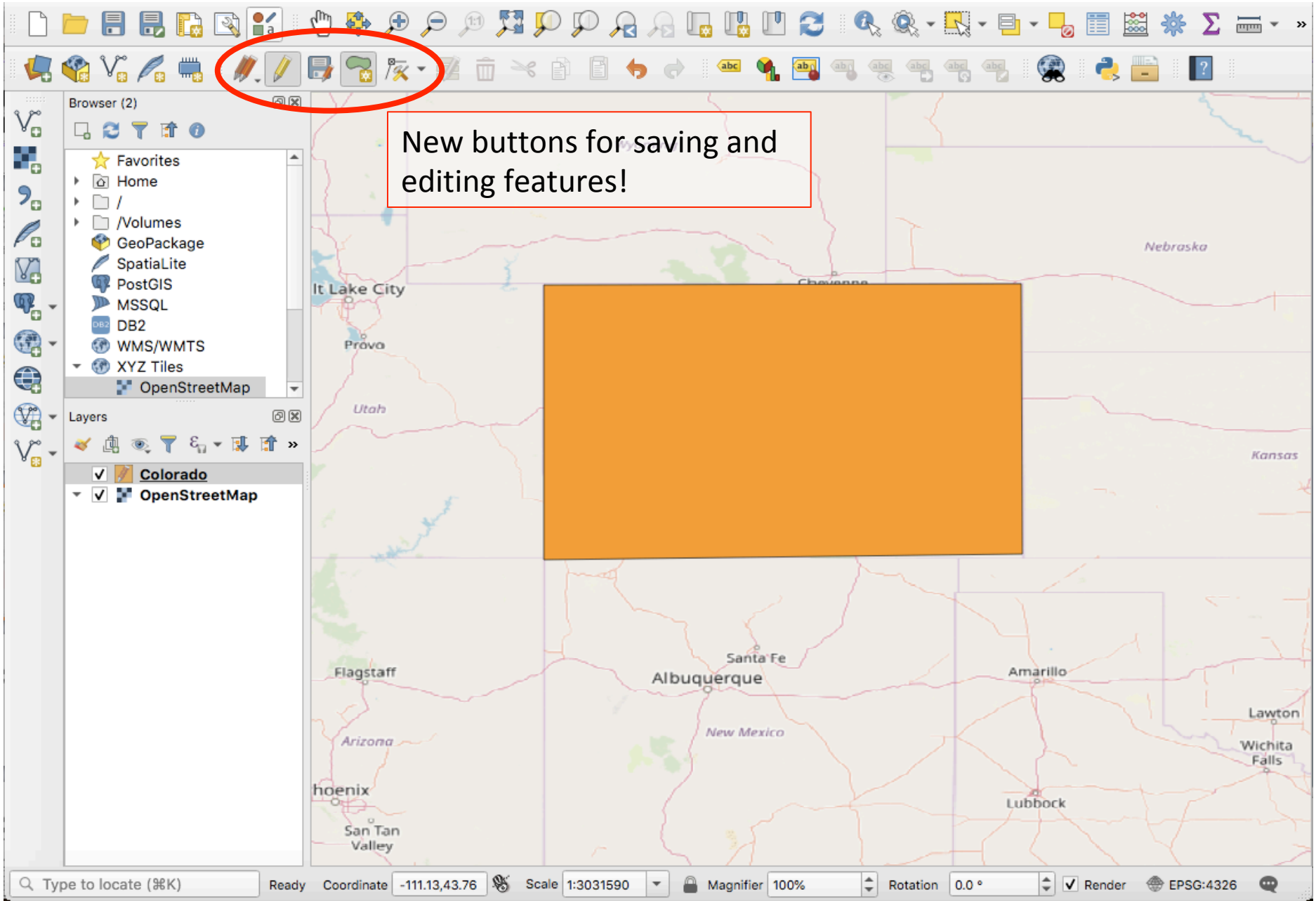
Creating a shapefile



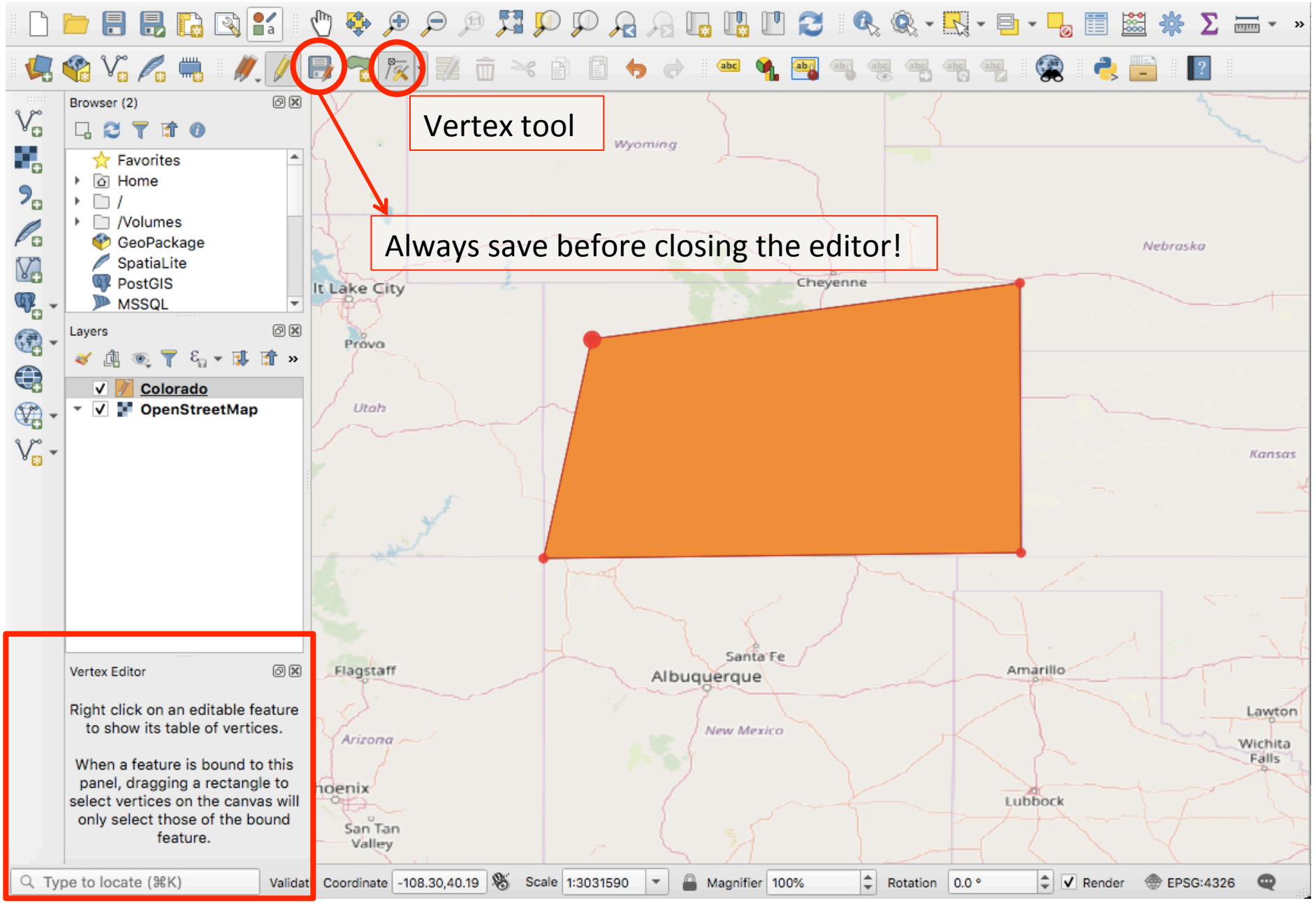
Creating a shapefile



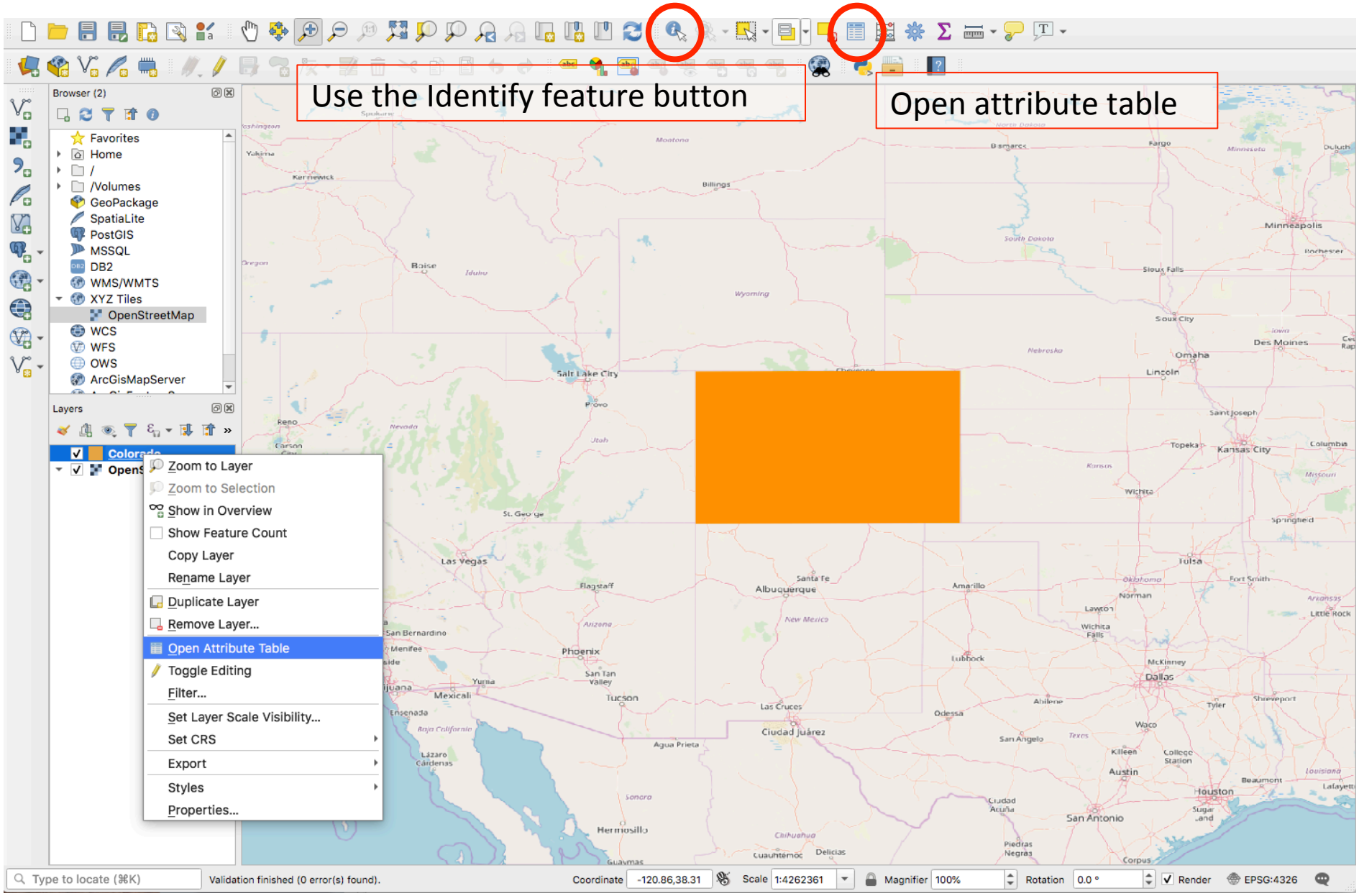
Creating a shapefile



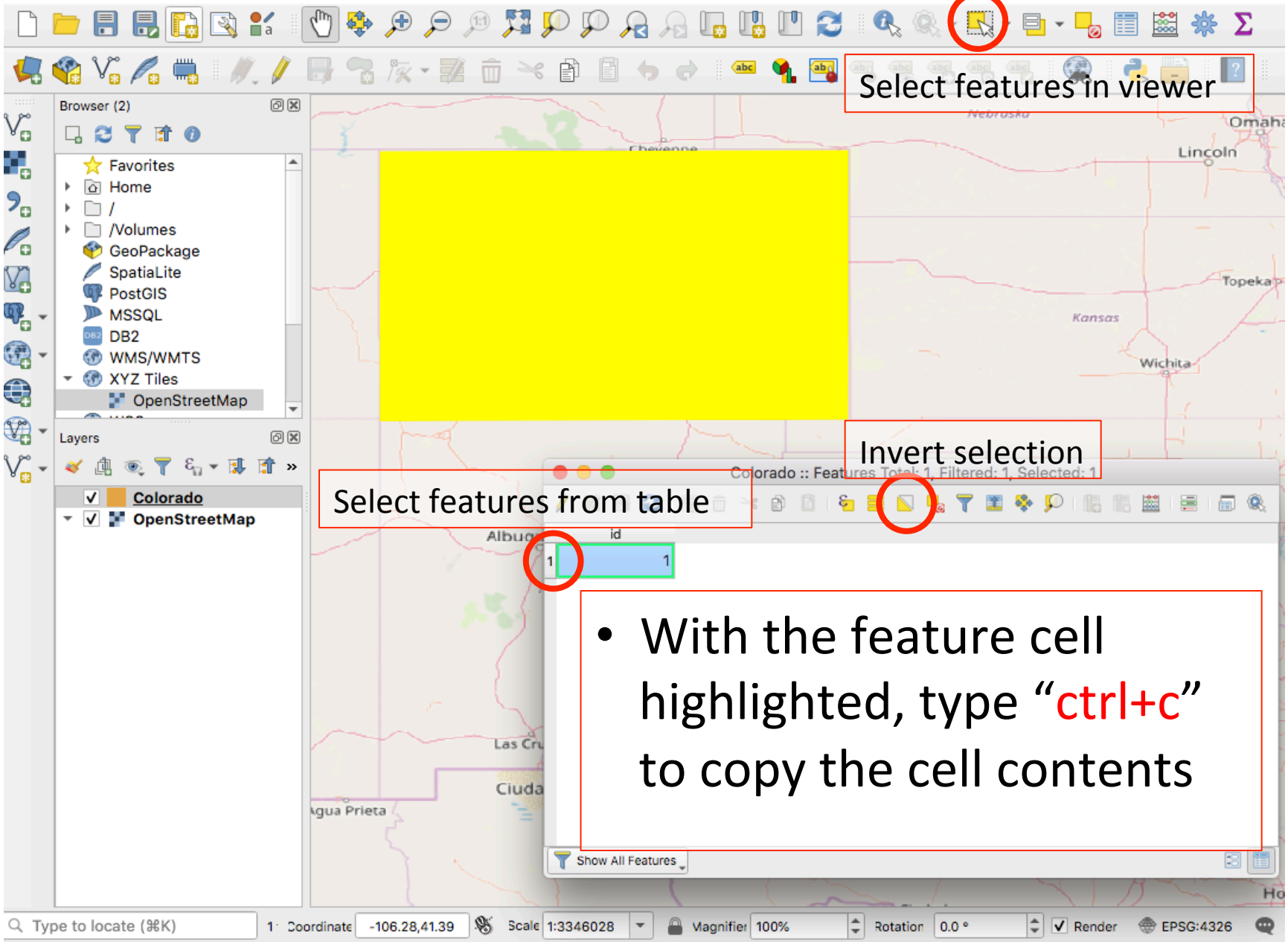
Creating a shapefile



See the shapefile attributes



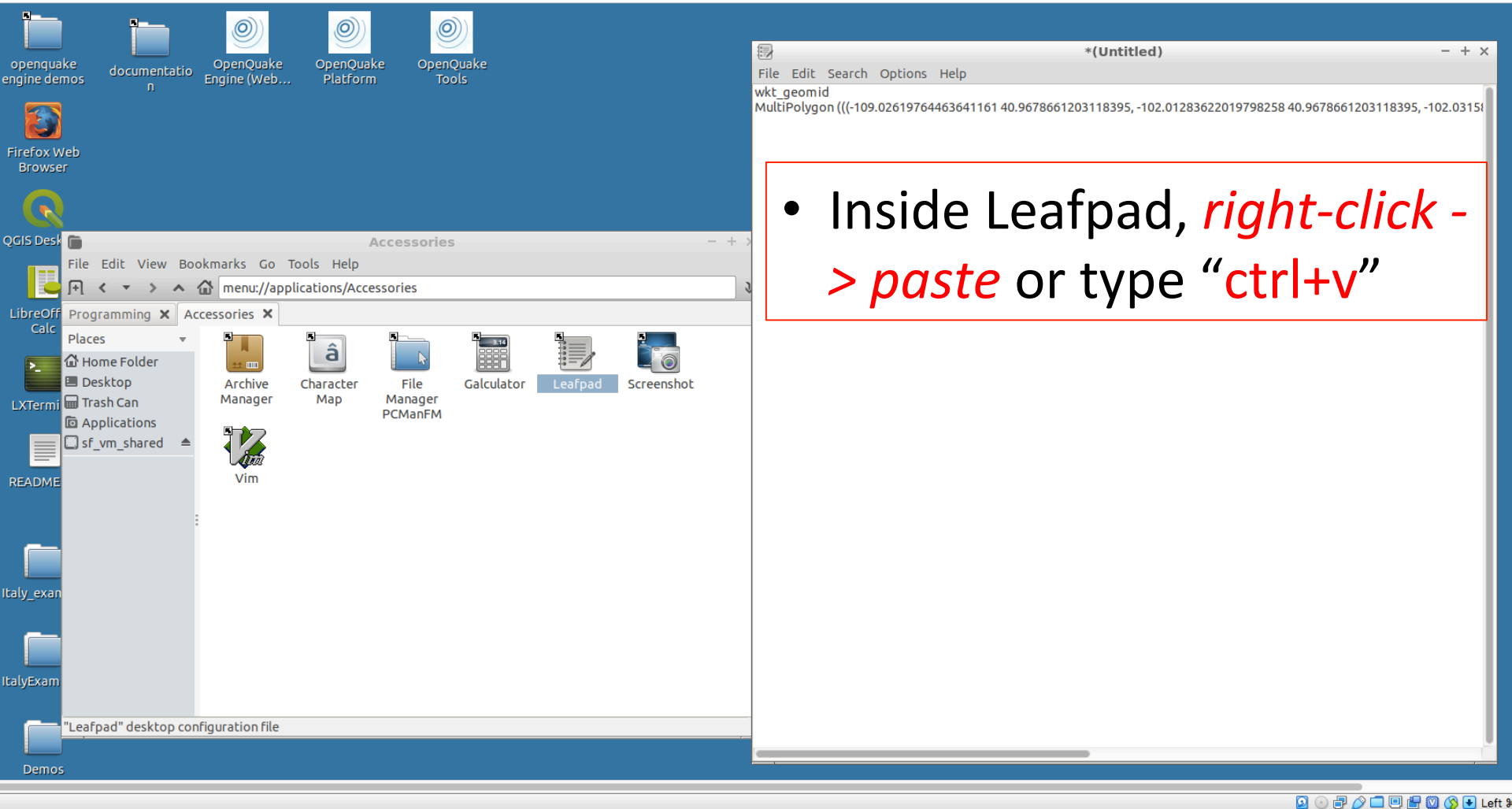
See the shapefile coordinates



See the shapefile coordinates

- From the File Manager, open

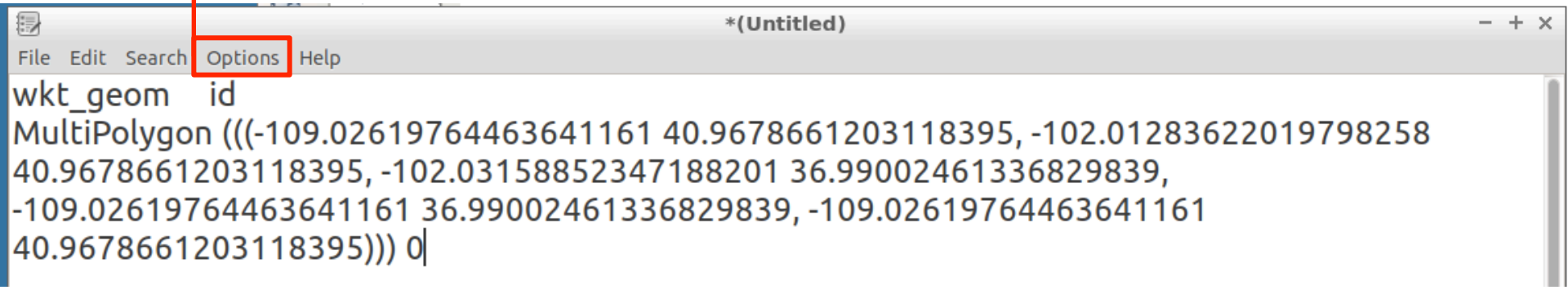
Applications -> Accessories -> Leafpad



- Inside Leafpad, *right-click -> paste* or type “ctrl+v”

See the shapefile coordinates

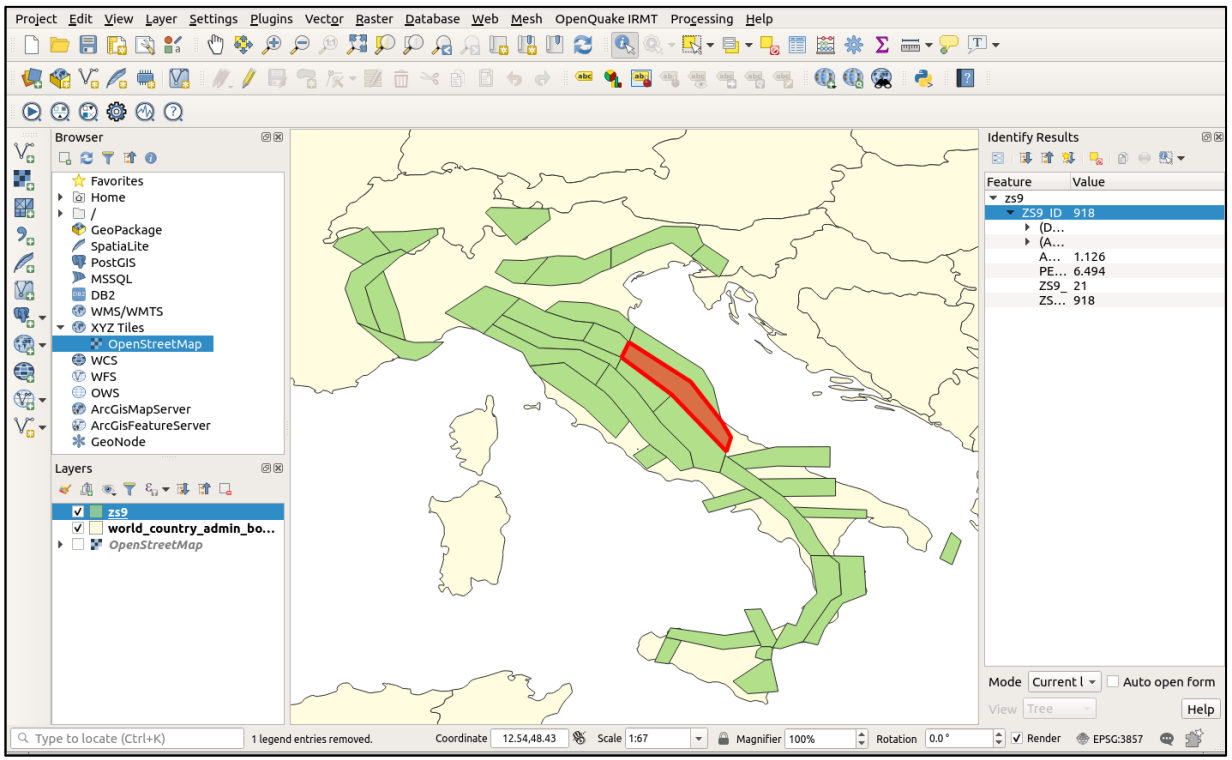
Use *Options -> Word wrap* to see on many lines

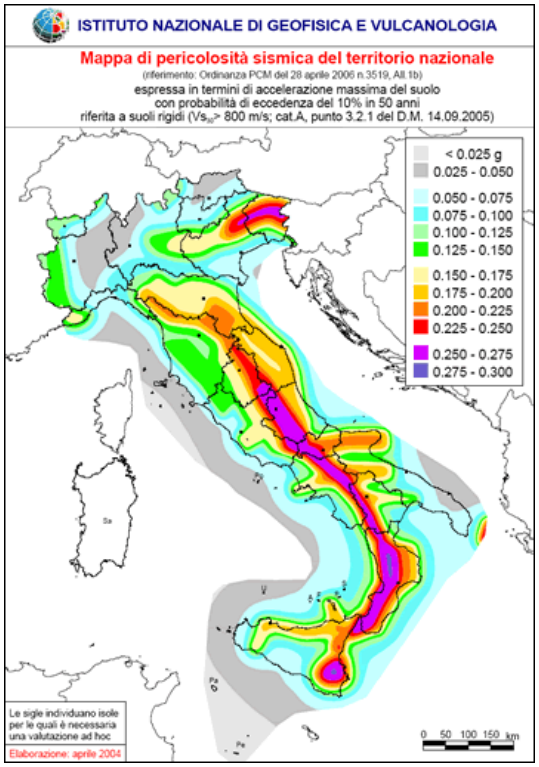


- Coordinates inside of Polygon() are comma separated and in latitude/longitude (WGS 84)
- The first and last coordinates are the same to complete the polygon

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

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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

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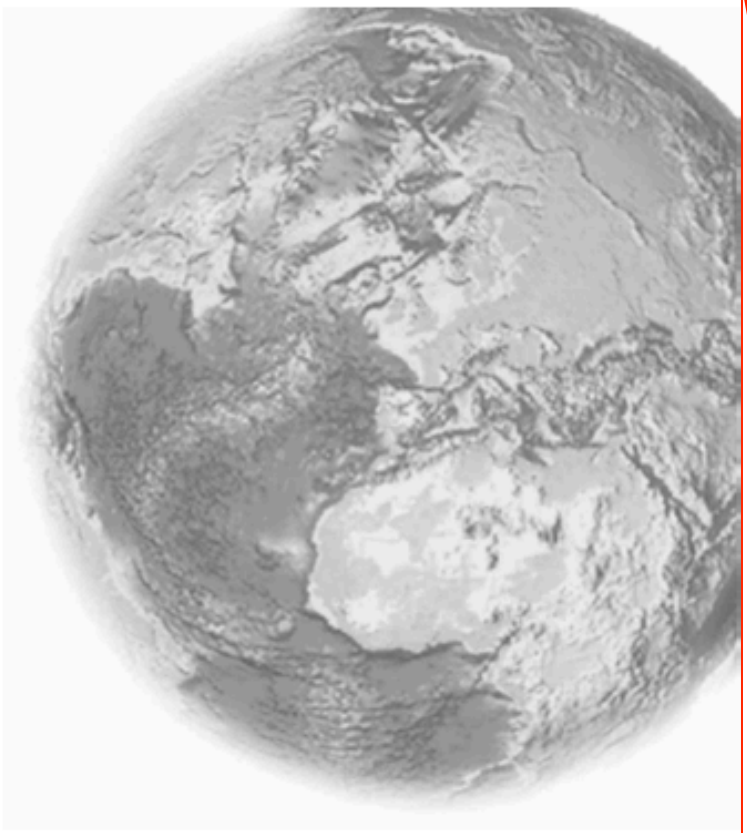
Publications



Istituto Nazionale di Geofisica e Vulcanologia

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Rapporto Conclusivo

bozza - aprile 2004

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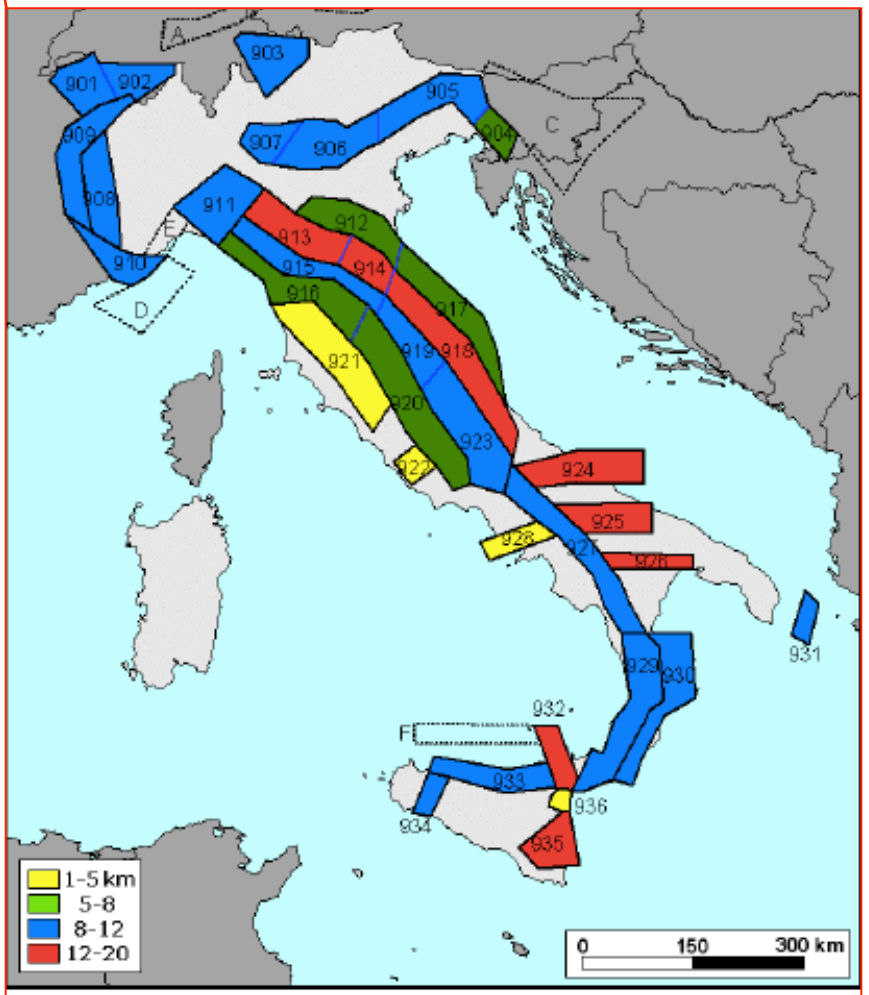
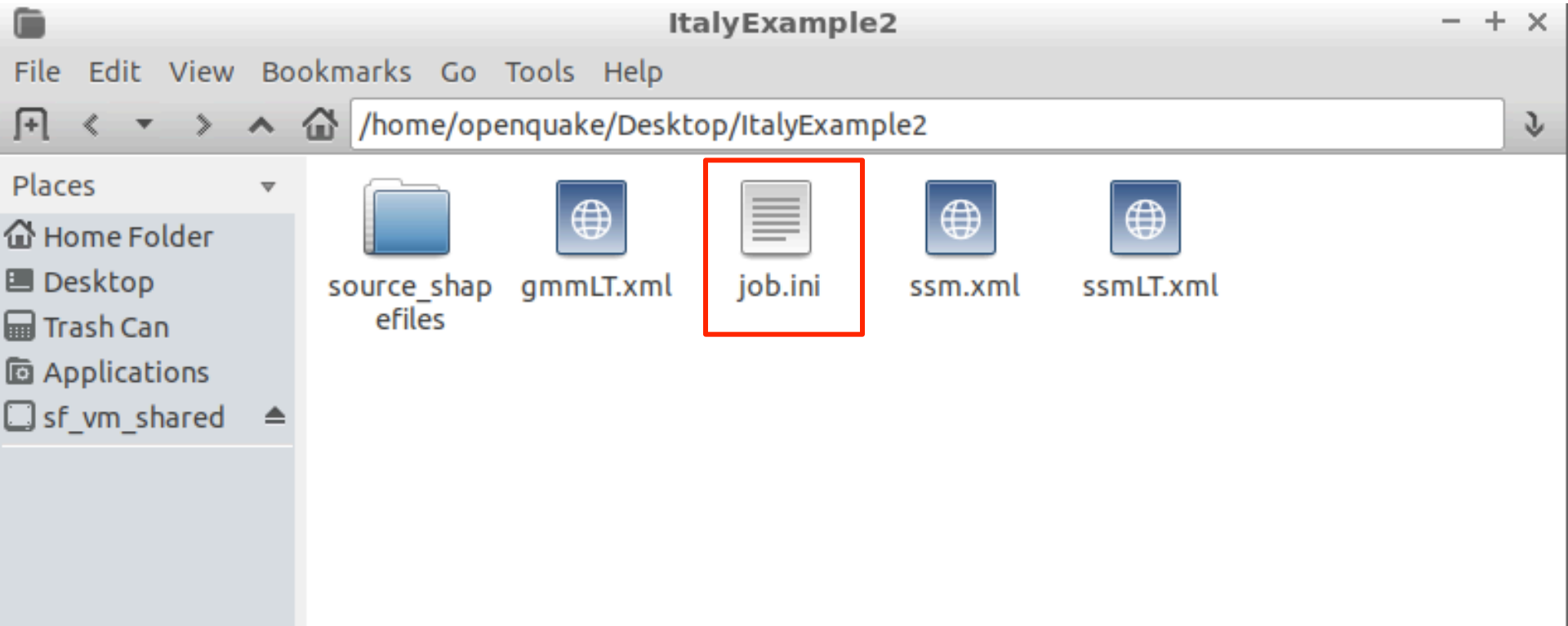


Figura 13. Attribuzione della classe di profondità alle ZS di ZS9.

Example: OpenQuake

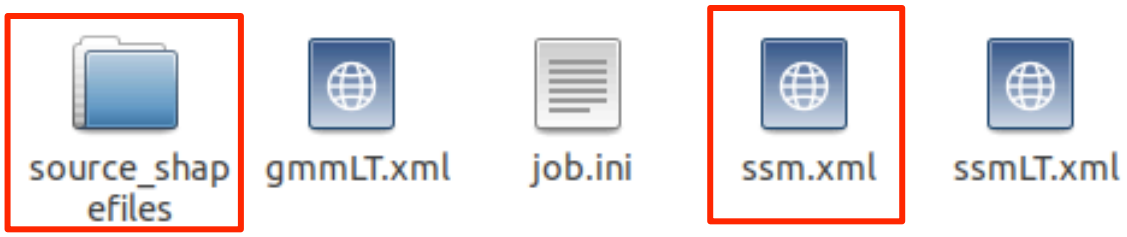
- In the File Manager, navigate to *ItalyExample*
- Includes all the files we need to run the OQ engine, and an extra folder with shapefiles that show the sources for the demo



Example: OpenQuake


```
[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

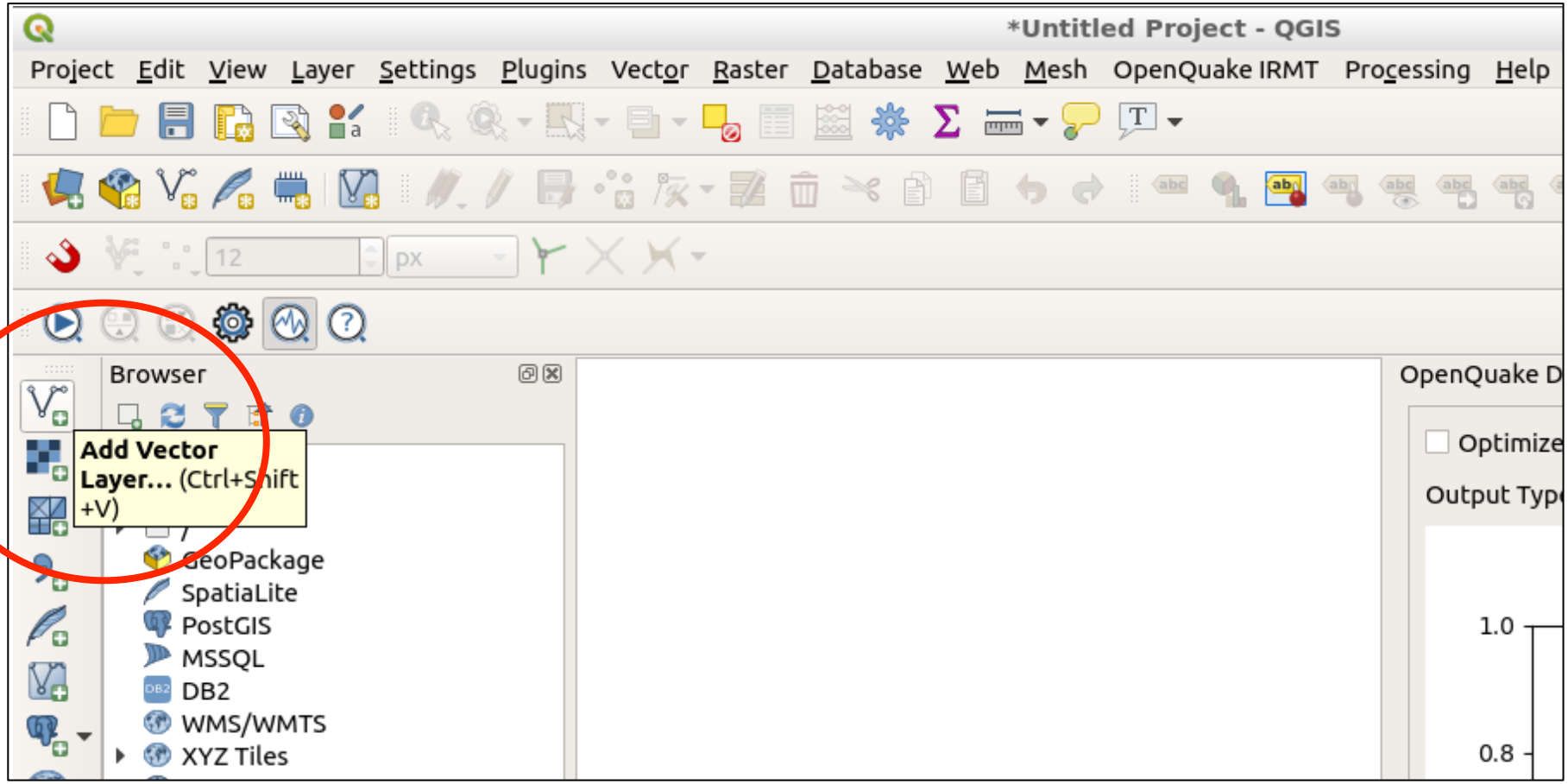
- Open the shapefiles in QGIS
- Look at the source attributes
- Compare the attribute table to the source file *ssm.xml*
- We have removed one source! Together, we will add this source to the xml
  - Define the area source perimeter in QGIS
  - Find the other attributes in the publications
  - Add everything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

Exercise: Implement an area source

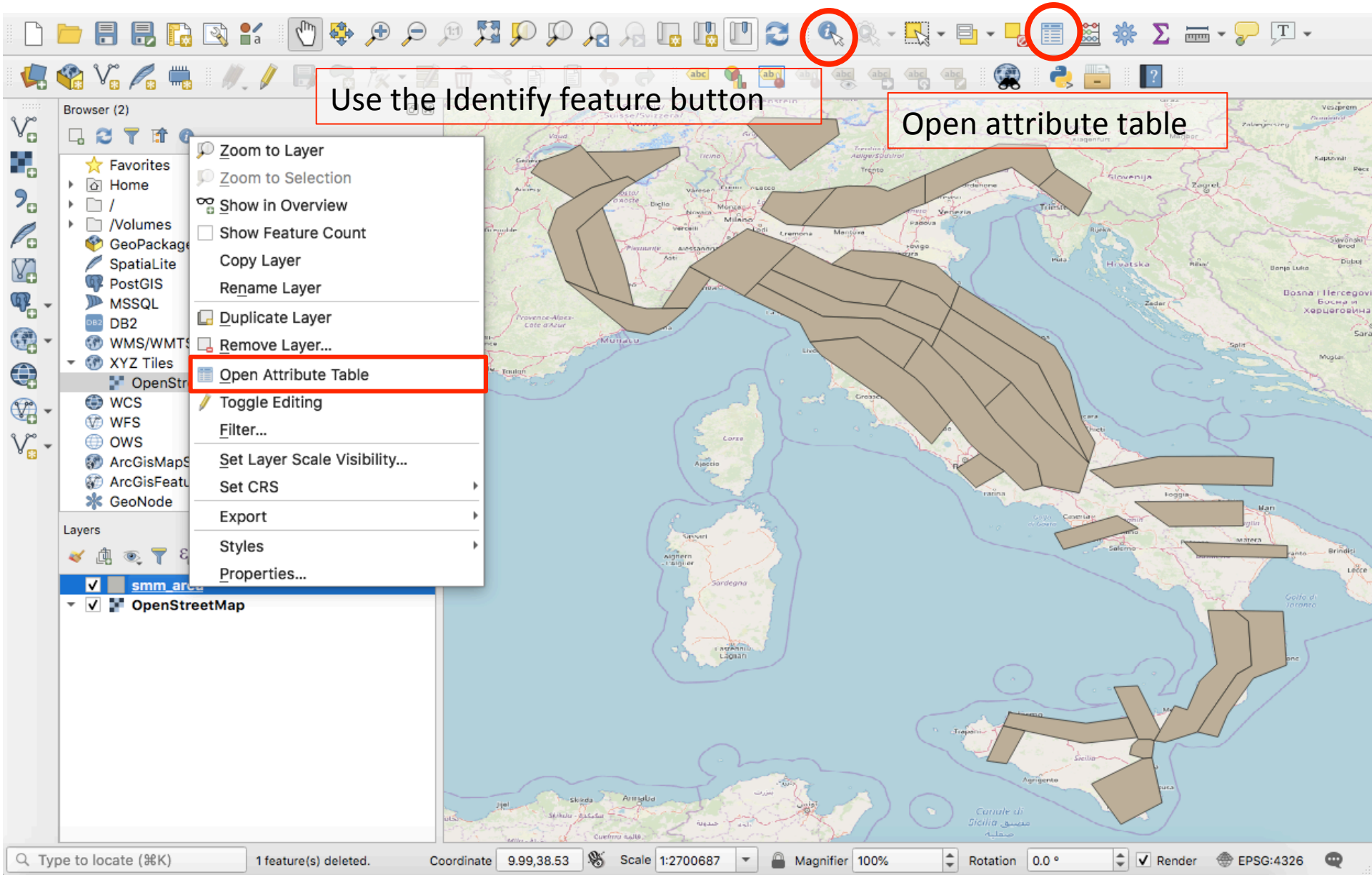
- **Open the shapefiles in QGIS (don't forget to specify the correct CRS!)**
- **Look at the source attributes**
- Compare the attribute table to the source file *ssm.xml*
- We have removed one source! Together, we will add this source to the xml
  - Find the other attributes in the publications
  -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



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

	ag	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*

```
>
    <areaSource
    id="903"
    name="ITA903"
    tectonicRegion="Active Shallow Crust"
    >
        <areaGeometry>
            <Polygon>
                <exterior>
                    <LinearRing>
                        <posList>
                            10.1459 46.8685 10.6091 46.8561 10.6485 46.6356 9.9375 46.1137 9
                        </posList>
                    </LinearRing>
                </exterior>
            </Polygon>
            <upperSeismoDepth>
                0.0
            </upperSeismoDepth>
            <lowerSeismoDepth>
                30.0
            </lowerSeismoDepth>
        </areaGeometry>
        <magScaleRel>
            WC1994
        </magScaleRel>
        <ruptAspectRatio>
            1.0
        </ruptAspectRatio>
        <truncGutenbergRichterMFD aValue="5.07" bValue="1.26" maxMag="5.91" minMag="4.7"/>
        <nodalPlaneDist>
            <nodalPlane dip="45.0" probability="1.0" rake="90.0" strike="0.0"/>
        </nodalPlaneDist>
        <hypoDepthDist>
            <hypoDepth
            depth="9.0"
            probability="1.0"
            >
            </hypoDepth>
        </hypoDepthDist>
    </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

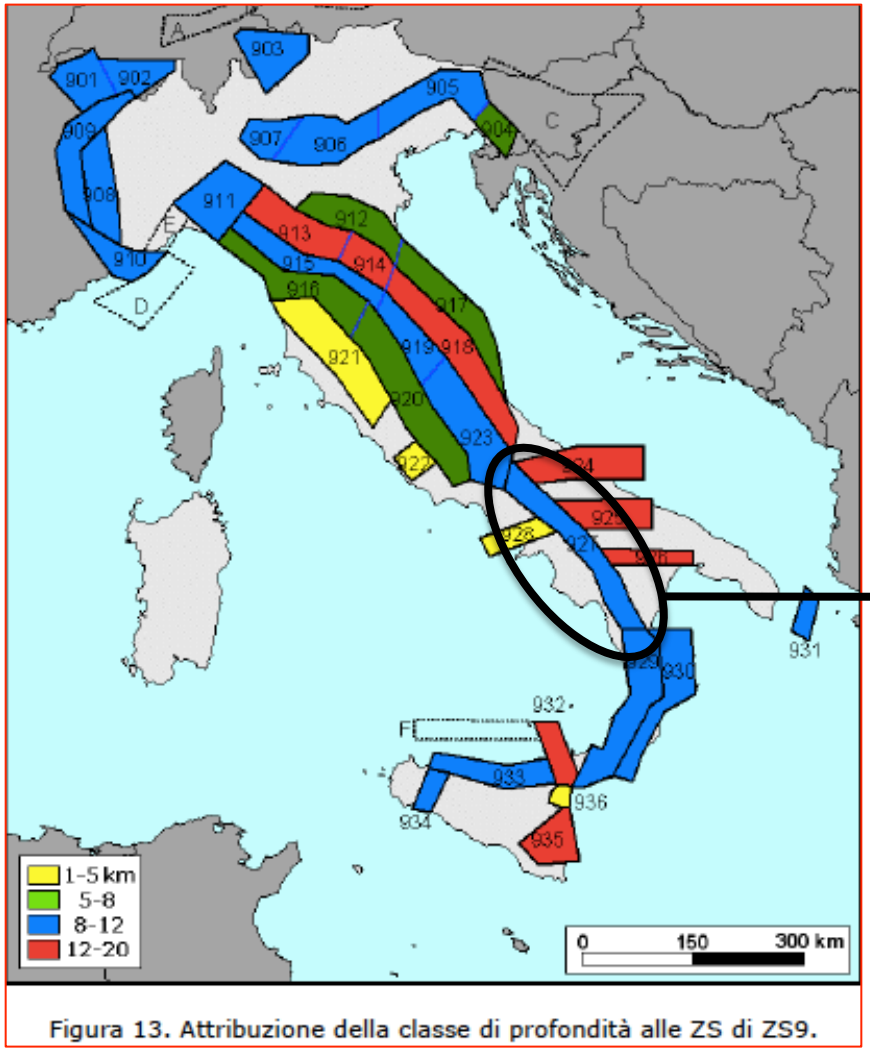


Figura 13. Attribuzione della classe di profondità alle ZS di ZS9.

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!

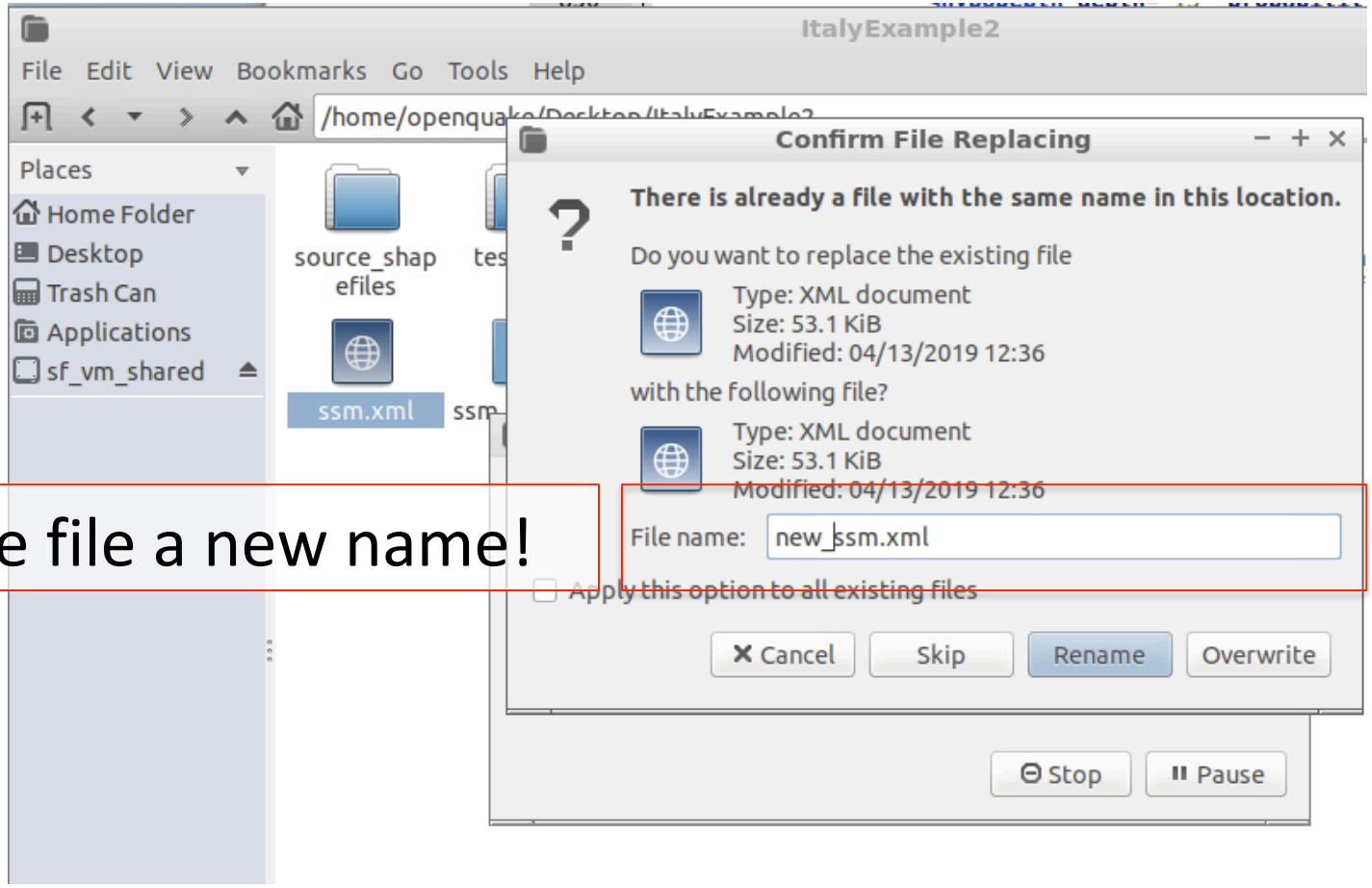
Digitize the area source

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 shapfile ID 927. Edit using the vertex tool 
4) Click save  and toggle editing off 

Duplicate the source file

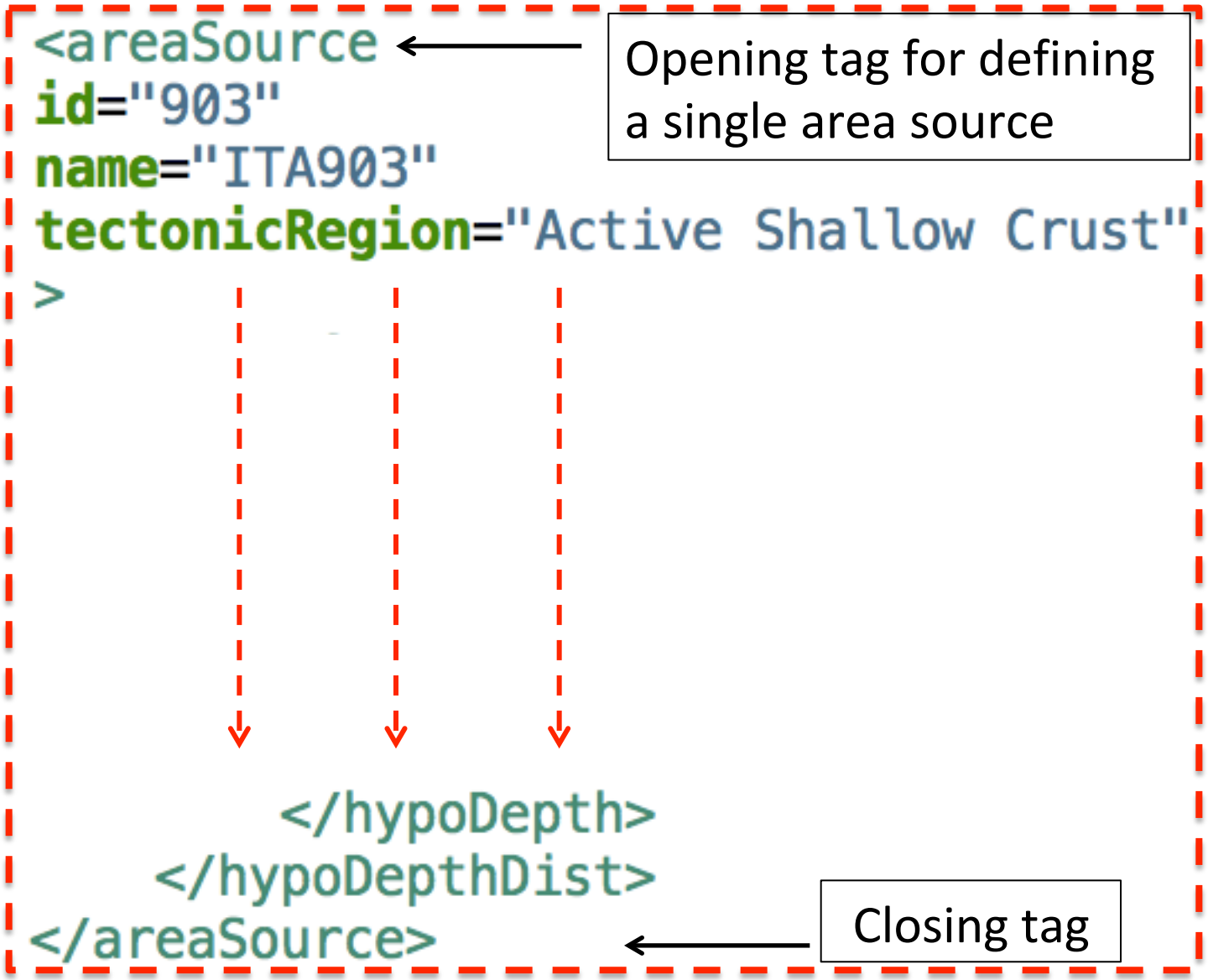
- Before we add the new source, we want to create a new version of *ssm.xml*

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



Give the file a new name!

Create a new source in the xml



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=“ ”

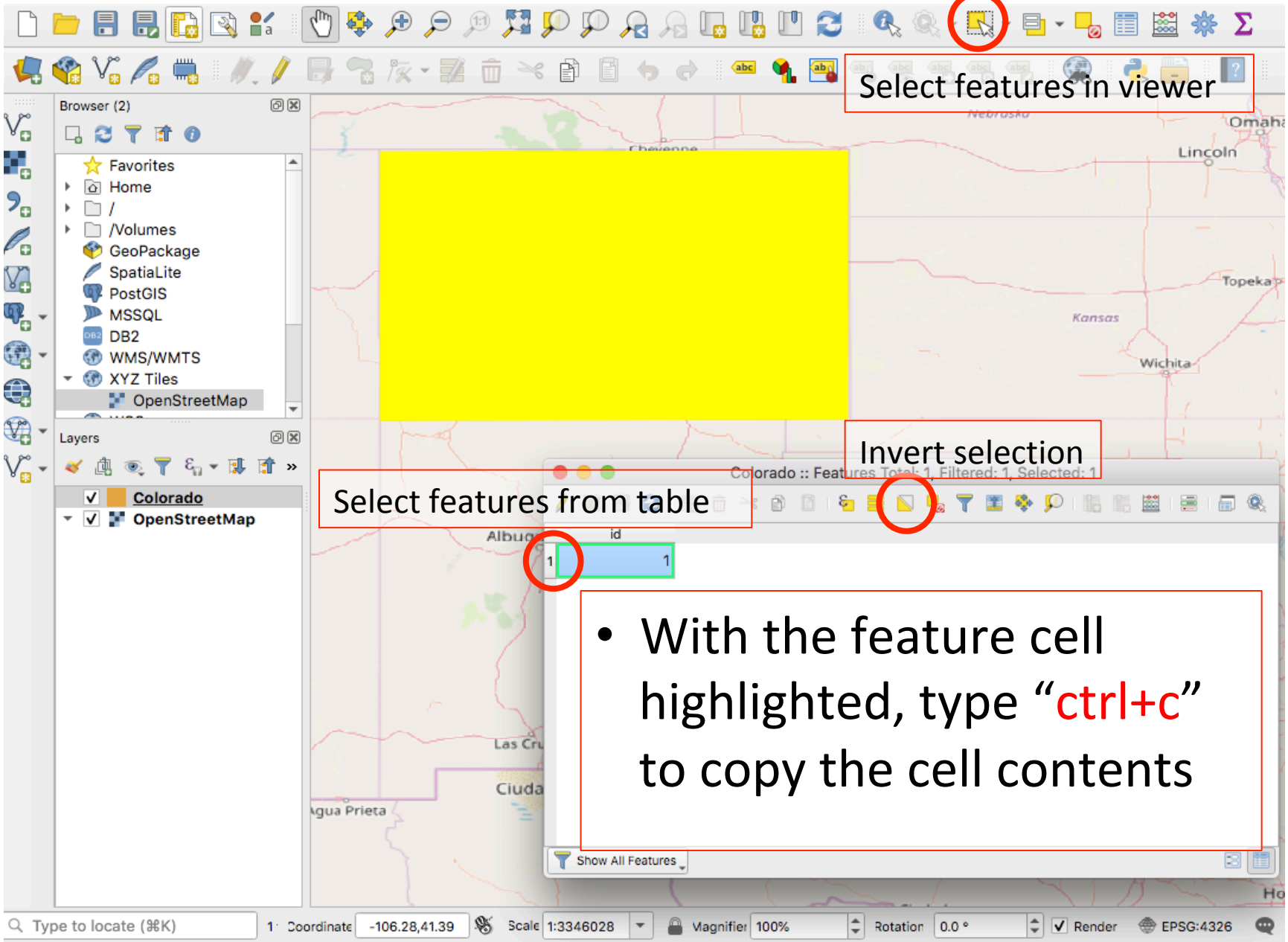
- Hypocentral depth and probability; can include a distribution

Geometry: <posList>

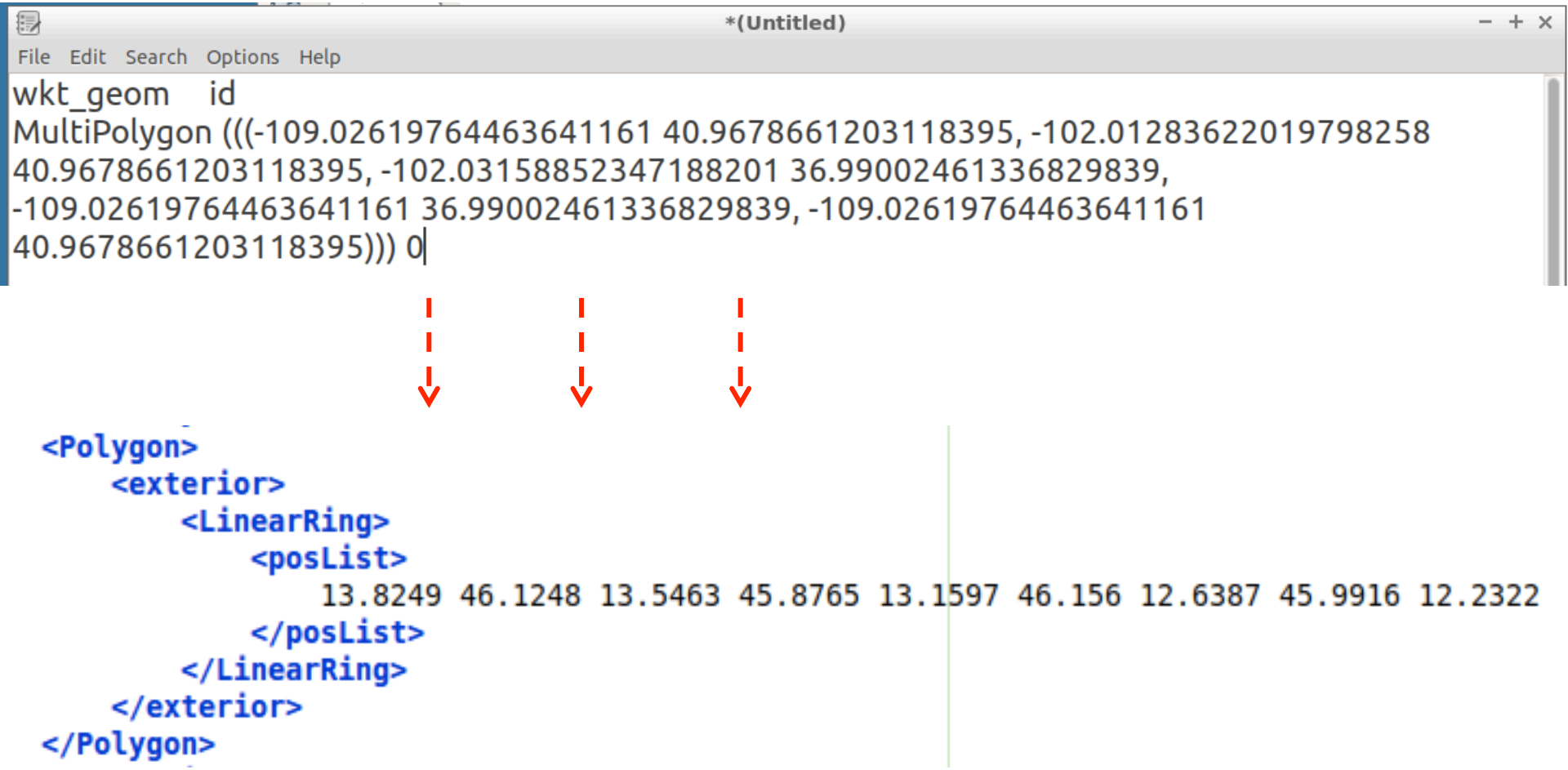
We will replace this field with the coordinates of area source 927 (the polygon in your newest shapefile)

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

See the shapefile coordinates



See the shapefile coordinates



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 $M_{w\,max}$†	$M_{w\,max\,1}$‡	$M_{w\,max\,2}$‡	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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	1
908	Piemonte	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	1
909	Alpi Occidentali	Normal	5.54	5.68	6.14	−1.27	−1.38	10	1	10	1
910	Nizza–Sanremo	Reverse	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	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	[illegible]	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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
925	Ofanto	Strike slip	6.72	6.83	6.83	−0.67	−0.75	10	2	13	3
926	Basento	Strike slip	5.84	5.91	6.14	−1.28	−1.38	10	2	13	3
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

SZ = 927

Fault mechanism = normal

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	[illegible]	6.60	0.11	6.60	-1.14	0.11	0.11	A	0.11
Bergamasco	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04
Piemonte	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	C	0.04
Alpi Occidentali	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	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  <nrml xmlns:gml="http://www.opengis.net/gml"
3        xmlns="http://openquake.org/xmlns/nrml/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 </nrml>
```

new_ssm.xml

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="bl1">
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
```

BooreAtkinson2008

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

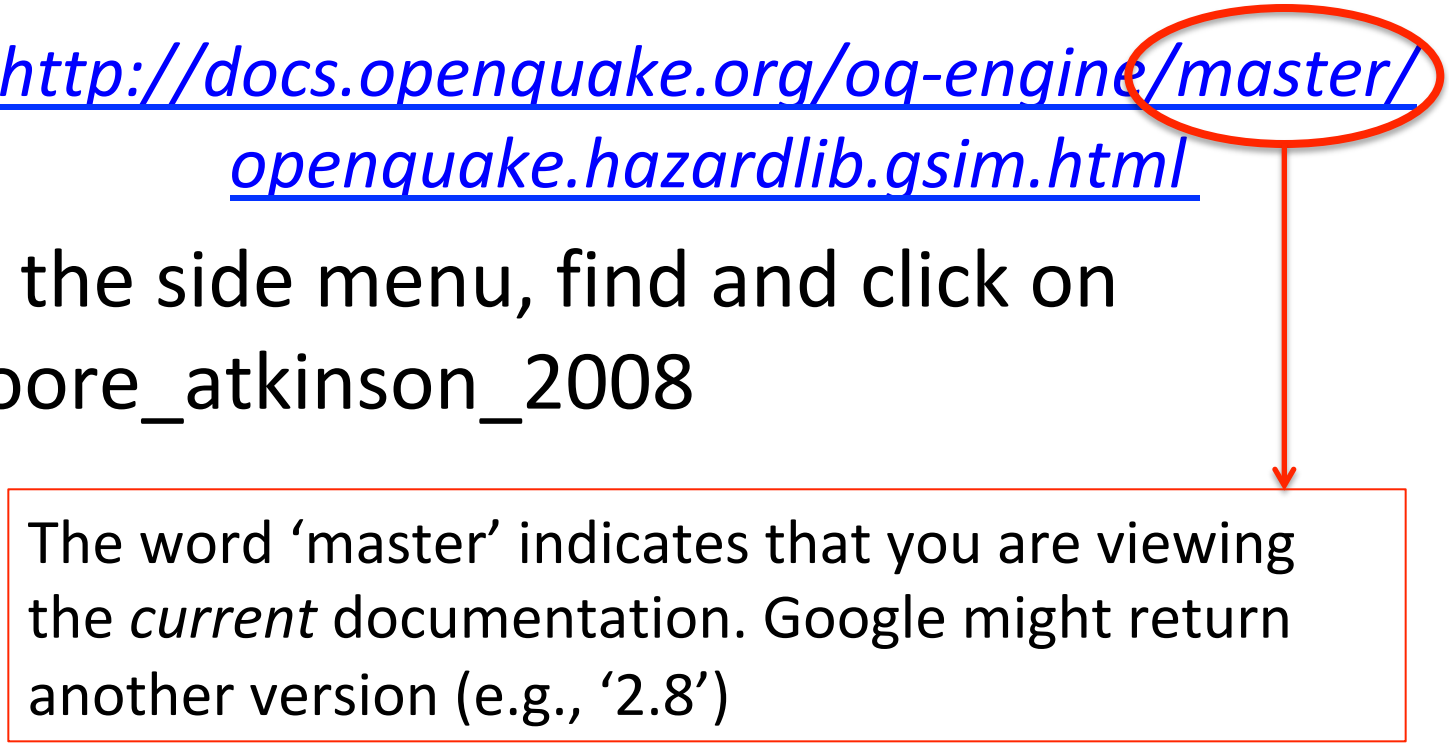
- In the side menu, find and click on BooreAtkinson2008
- Use this webpage to help choose GMPEs during your project

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

- In the side menu, find and click on boore_atkinson_2008



GMPE information

Table of Contents

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

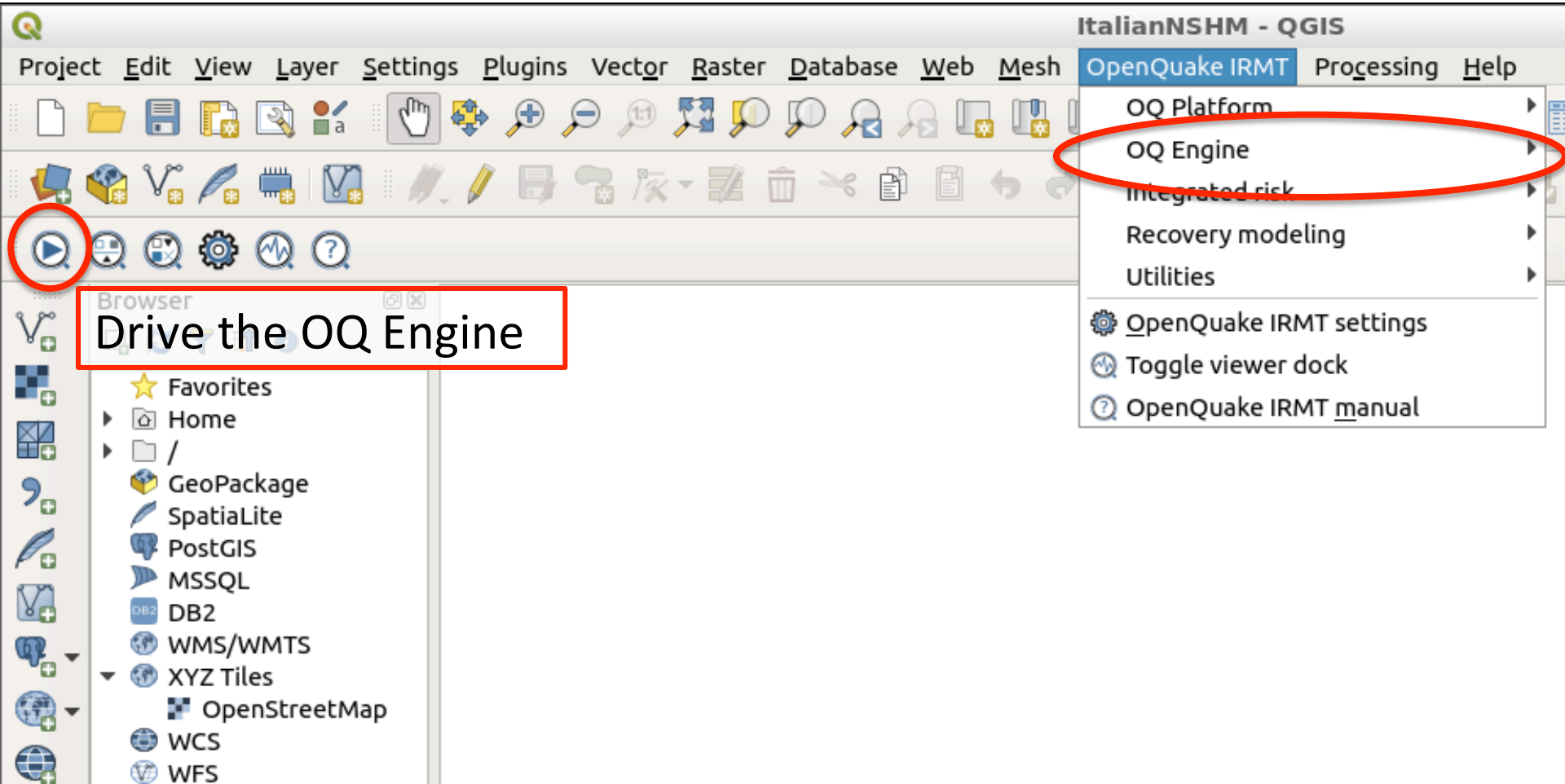
- Run the model

oq engine --run job.ini

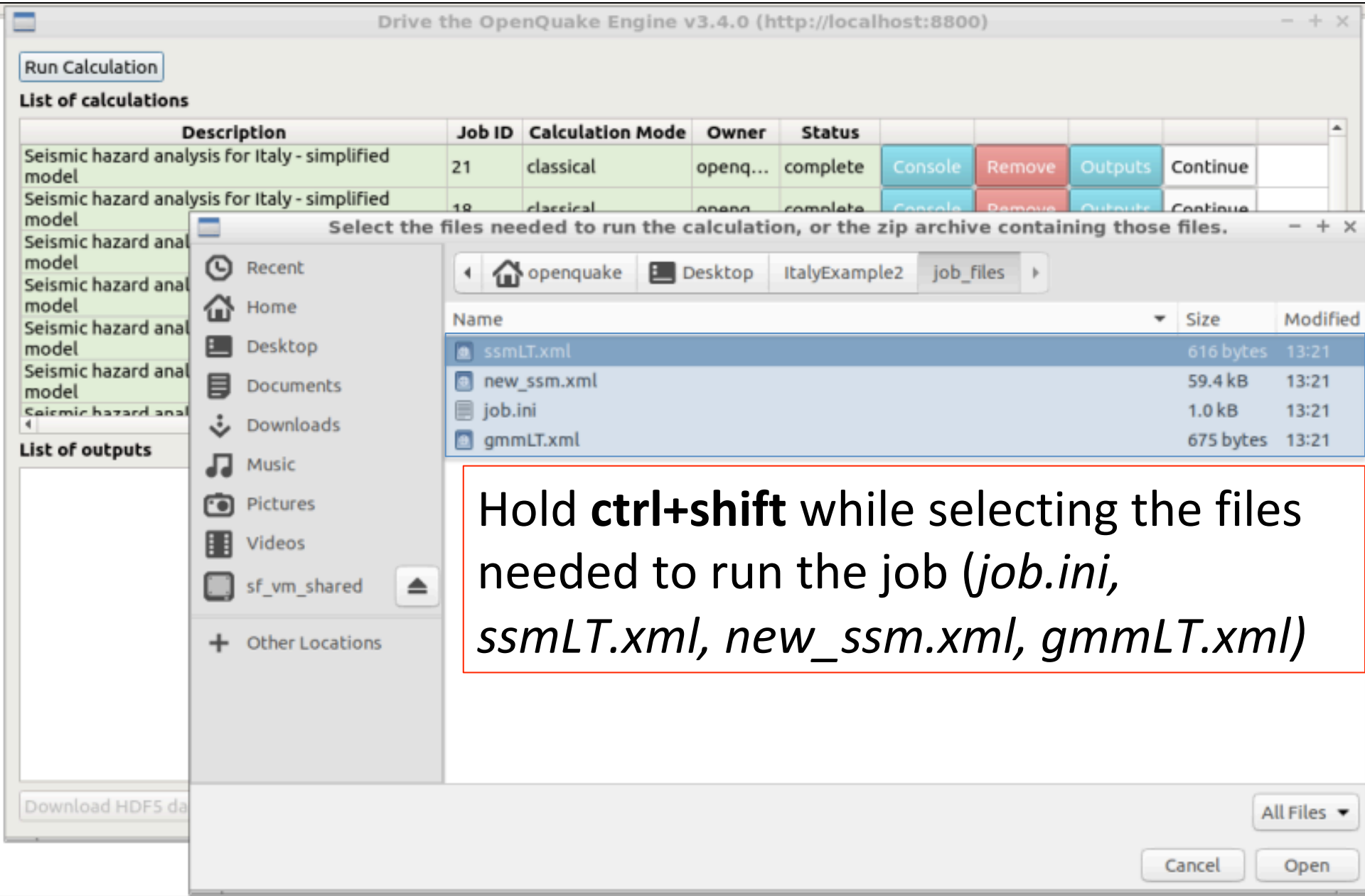
Note: if you already have a terminal open, you can check which directory you are in by typing pwd

Run the Italian NSHM in OQ: method 2

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

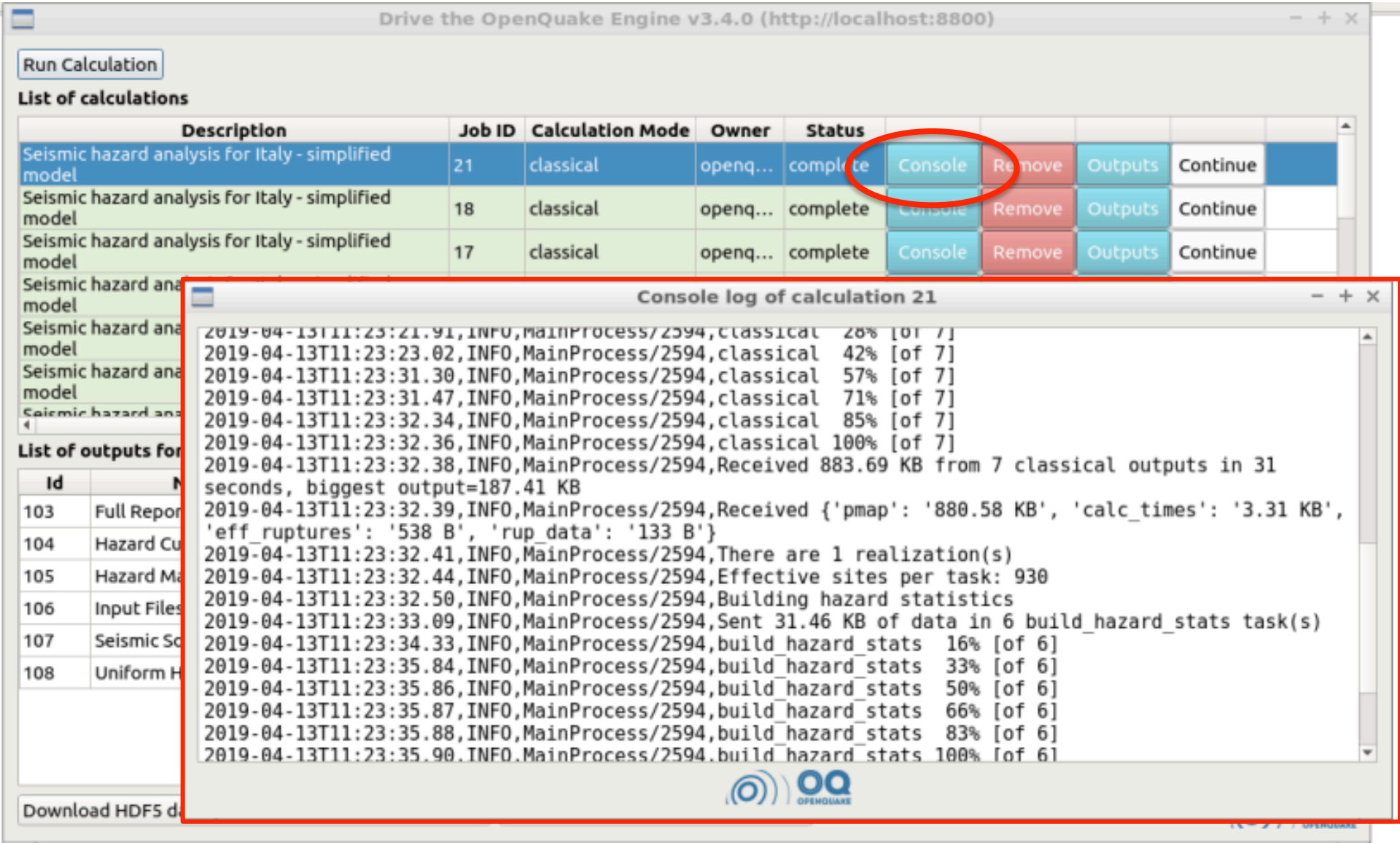


Choose the job files



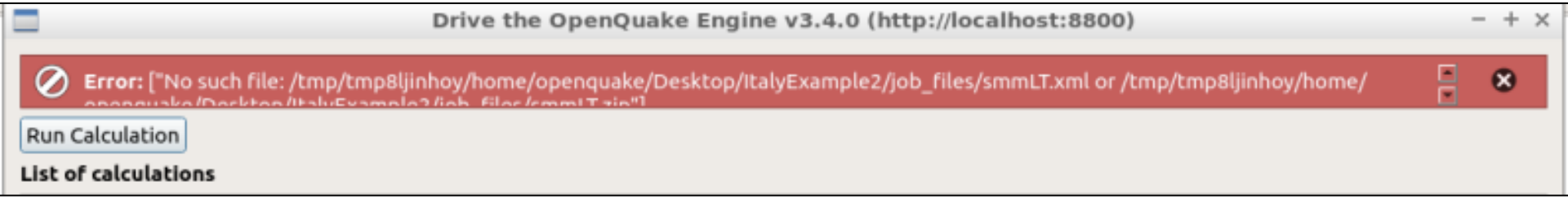
Hold **ctrl+shift** while selecting the files needed to run the job (*job.ini, ssmLT.xml, new_ssm.xml, gmmLT.xml)*

Using the Console



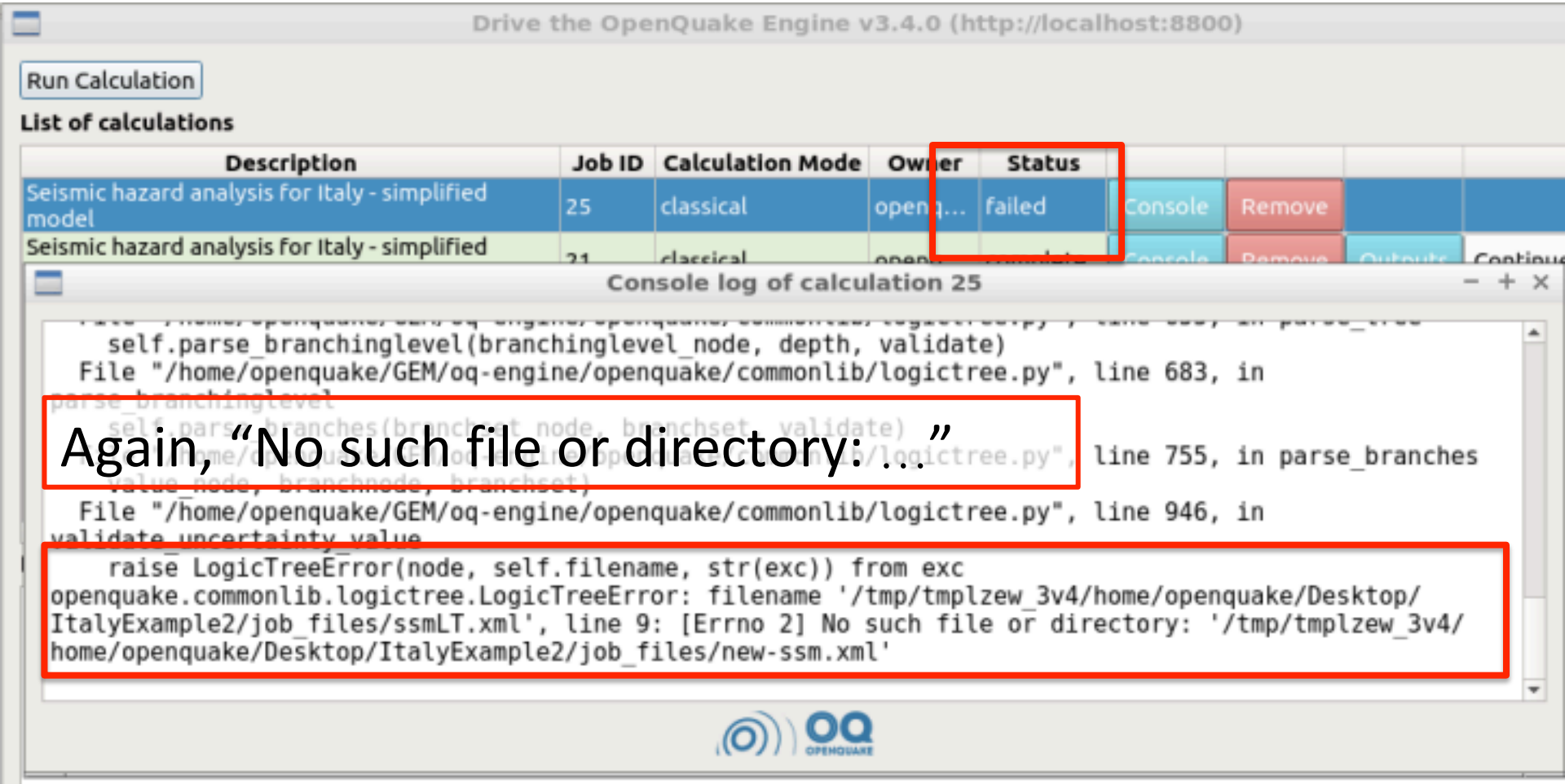
File errors and job failures

- 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**



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