Create a Road Length Grid for the Modeling Domain using QGIS 3.14

September 4, 2020

1. **Merge all shapefile roads downloaded from http://download.geofabrik.de/ according to the extent of the modelling domain**
   a. Vector/Data Management Tools…/Merge Vector Layers…
      i. Save as all_roads.shp (Figure 1).
   b. Select in Layer Properties/Settings the coordinate reference as EPSG:4326 – WGS 84 (Figure 1 and rectangle in red).
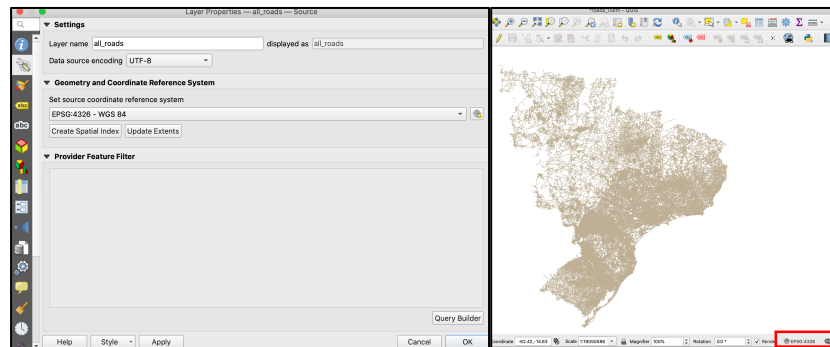

Figure 1 Layer Properties/Settings and selection of the coordinate system.

2. **Create a vector grid of 15 km and 3 km of spatial resolution:**
   a. Vector/Research Tools…/Create Grid…
   b. Grid type: Rectangle (Polygon)
   c. Grid extent for modelling domain:
      i. First modeling domain (d01): **-53.53, -39.69, -27.70, -19.30.** The first two values are coordinates in longitude; last two values are in latitude.
      ii. Second modeling domain (d02): **-49.01, -44.36, -25.05, -21.64**. The MASP is at the center of the grid.
   d. Horizontal spacing / Vertical spacing:
      i. Domain d01: 15 km ~ 0.135135 degrees.
      ii. Domain d02:   3 km ~ 0.027027 degrees.
   e. Horizontal overlay / Vertical overlay: 0
   f. Save as 1_Grid15km_d01, 1_Grid3km_d02 as shapefile, where d01 and d02 are <domain>, and 15km and 3km <res>. Take a few seconds to run this process.
3. **Extract vectors based on 1_Grid3km_<domain>**
   a. Vector/Geoprocessing Tools/Intersection…
   b. Input Layer: all_roads
   c. Overlay layer: 1_Grid<res>_<_<domain>
   d. Intersection: Saved as 2_GridDomain<res>_<domain>.shp. Take many minutes to run this process for high resolution (3 km).
4. **In 2_GridDomain<res>_<domain>:**
   a. Open Attribute Table
   b. Remove columns as "ref", "oneway", "bridge", "tunnel", "maxspeed"
   c. Open Calculator Field (Figure 2):
      i. Output field name: kmlen
      ii. Output field: Decimal number (real), length: 10, precision: 5.
      iii. Expression: $length*111. The value 111 is in km, and it is equivalent to 1 degree for São Paulo state. The result is the length of each road in km. So, it is important to consider five decimals in the values.
      iv. Save.
      v. Don't close yet the window, proceed with the next step.
5. **In 2_GridDomain<res>_<domain>, create with Calculator Field "vehroads" that represents the main roads where the vehicle flow is probably and frequently (Major**

Roads and Highway links). According to https://www.geofabrik.de/data/geofabrik-osm-gis-standard-0.7.pdf, we have roads classified as Major Roads, Minor Roads, Highway links (sliproads/ramps), Very small roads, Paths unsuitable for cars, Ferries, and Unknown. Not all of these types of ways have vehicle flows.

    a. Output field name: vehroads
    b. Output field: decimal number (real), length 10, precision 5.
    c. In "Expression" (Figure 2):

```
case
when fclass is 'motorway' then kmlen
when fclass is 'motorway_link' then kmlen
when fclass is 'trunk' then kmlen
when fclass is 'trunk_link' then kmlen
when fclass is 'primary' then kmlen
when fclass is 'primary_link' then kmlen
when fclass is 'secondary' then kmlen
when fclass is 'secondary_link' then kmlen
when fclass is 'tertiary' then kmlen
when fclass is 'tertiary_link' then kmlen
else 0
end
```
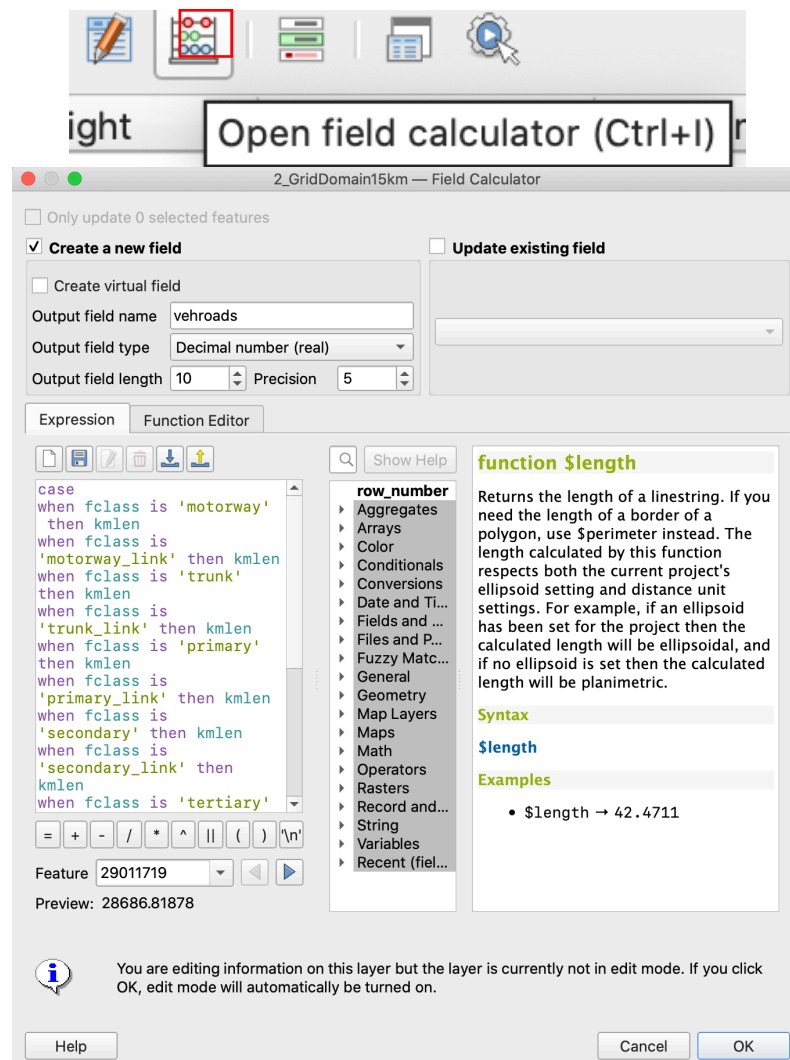
    d. Close Table Attributes and save.

Figure 2 Creation of 'vehroads' using Field Calculator.

6. In Vector General/Join Attributes by Location (summary). See Figure 3.
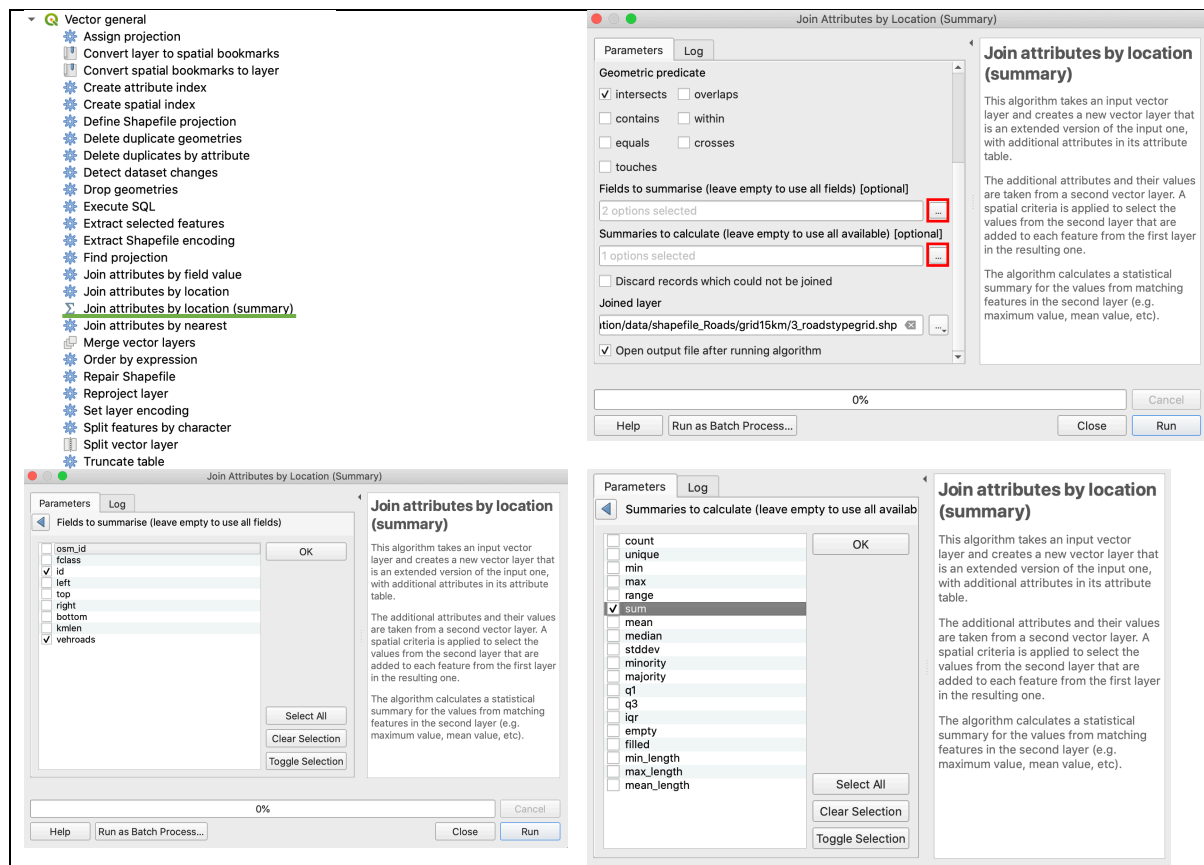

Figure 3 Join Attributes by Location (summary). In this example, a resolution of 15 km was processed; similarly, this procedure applies for 3 or 9 km grid cell of spatial resolution.

a. Input layer: 1_Grid<res>_<domain>
b. Join layer: 2_GridDomain<res>_<domain>
c. Geometric predicate: intersects
d. Summaries to calculate: sum
e. Joined layer: 3_roadstypegrid_<domain>.shp. This process could take many hours, ensure to select only the 'vehroads' and 'id' columns to join, with this we can avoid delays in the process. If you do not select only 'vehroads' and 'id', you can wait days to complete the process for the modelling domain. After you can see the results as shown in Figure 4.
f. Open Attribute Table
   i. Remove columns: ID_sum, … sum, except vehroads_s
   ii. Update vehroads_s:
```
case
when vehroads_s is NULL then 0
else vehroads_s
end
```
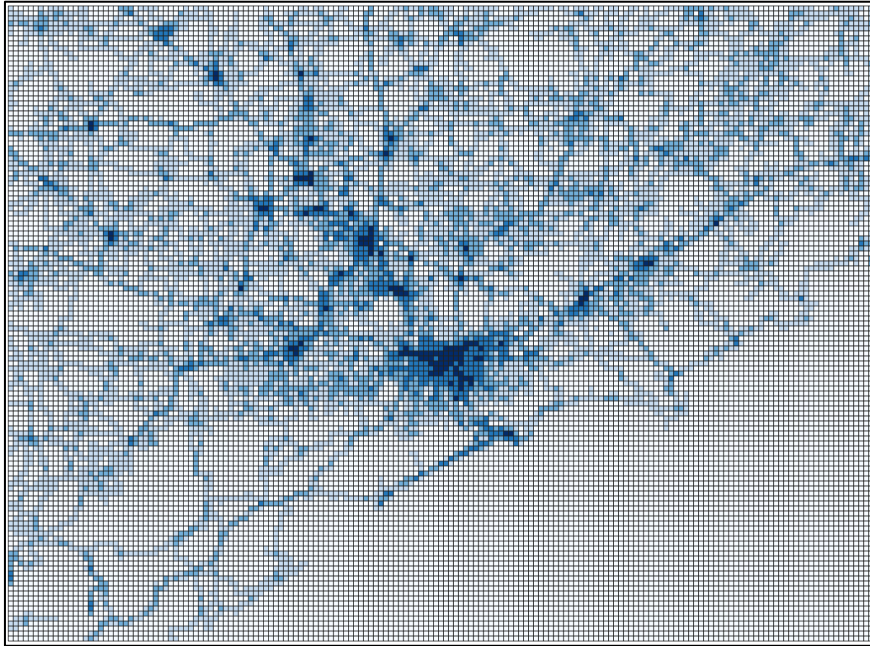   iii. Save and exit of edition mode.

Figure 4 Road length (in km) for each 3 x 3 km grid cell for 'vehroads' field. This figure was created using QGIS 3.14, selecting Properties/Graduated/Mode: Natural Breaks (Jenks) in the layer 3_roadstypegrid_d02.shp.

7. **In Vector/Geometry Tools/Centroids…**
   a. 3_roadstypegrid_<domain>
   b. Save as 4_final<res>grid_<domain>
8. **Open Attribute Table of 4_final<res>grid_<domain>:**
   a. Remove columns except for vehroads_s and id
   b. Open Field Calculator and create two fields:
      i. Ylat (decimal, length 10, and precision 2). In expression, write $y.
      ii. Xlon (decimal, length 10, and precision 2). In expression, write $x.
      iii. Save
9. **Right-click in 4_final3kmgrid_d02 and select Export, then save as csv file**
   a. Name: grid<res>_<domain>.csv
10. **Calculate nx and ny based on the number of latitude and longitude values.**
    a. In order to do this, run the Python codes in Jupyter Notebook or using the following codes as a script in Python 3:

```python
import pandas as pd
import numpy as np
path = '../2_Emissions_inventory/roads/'
df3  = pd.read_csv(path+'grid03km_d02.csv')
df15 = pd.read_csv(path+'grid15km.csv')
print("nx: ", df3.Xlon.nunique())
print("ny: ", df3.Ylat.nunique())
print("nx: ", df15.Xlon.nunique())
print("ny: ", df15.Ylat.nunique())
def order(df=df3):
    df.loc[:,'id']=range(len(df.id))
    df = df[['id','Xlon','Ylat','vehroads_s']]
    df = df.round({"id":0,"Xlon":5, "Ylat":5, "vehroads_s":3})
    df = df.sort_values(by=['Ylat','Xlon'],ascending=[False,True])
    df.loc[:,'id']=np.arange(0.0,len(df.id))
    return df
df3 = order(); df15 = order(df=df15)
def vias(fname = 'grid03km_d02.txt',file = df3):
    np.savetxt(path+fname, file, delimiter=' ',
            fmt= ['%12.0f', '%5.5f', '%14.5f','%15.2f'])
vias()
vias(fname='grid15km_final.txt', file=df15)
print("Successfully")
```