03 maps and heatmaps FVG

April 5, 2022

1 show some basic maps

[ ]:
```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from scipy.spatial import distance_matrix
np.random.seed(123)
```

2 Load Data

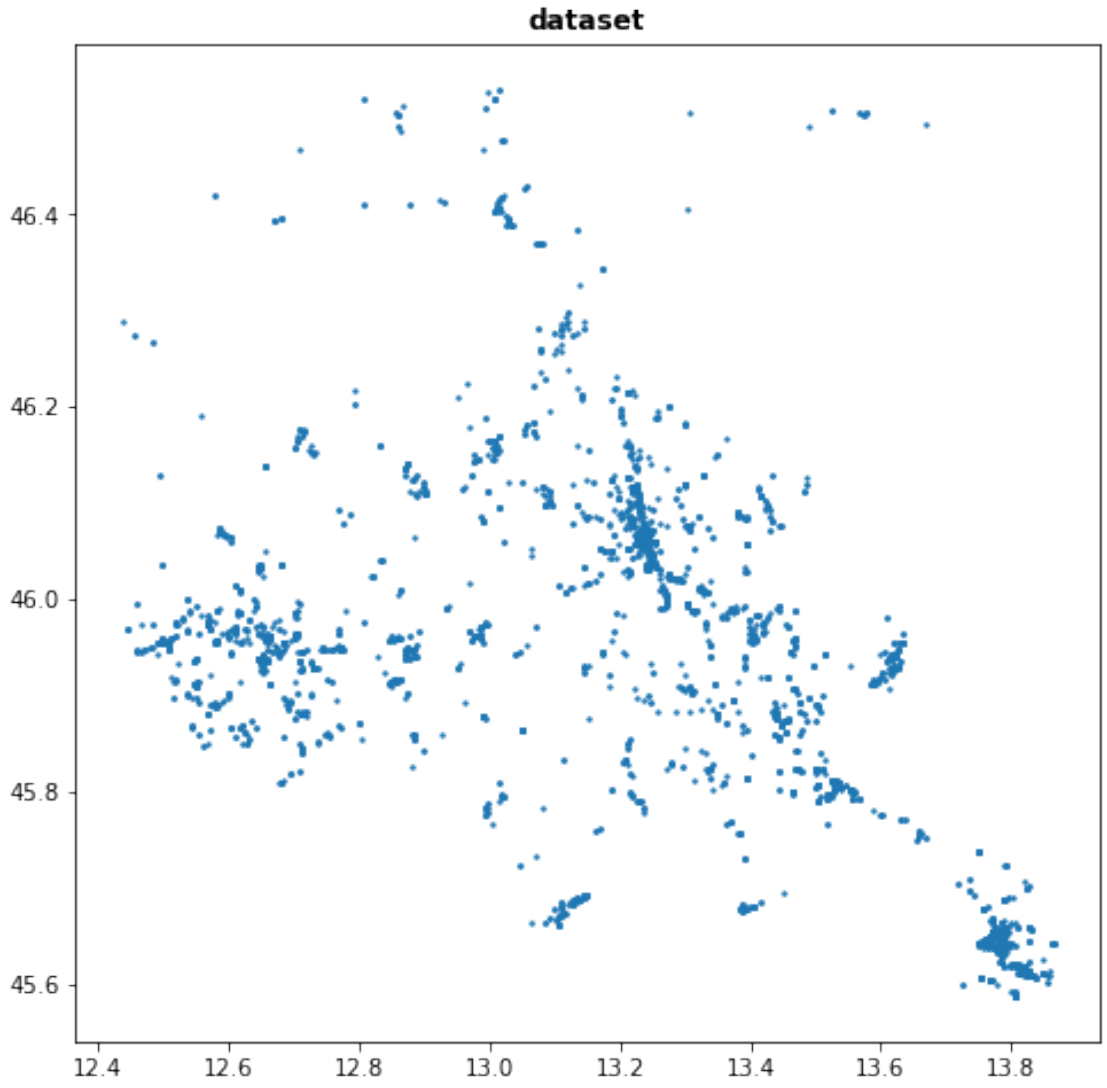
[ ]:
```
data = pd.read_csv(r'./data/data.csv')
data.columns = ['index', 'yearsInBusiness', 'rAssets', 'rIntang', 'rNOI',␣
 ↪'rating010',
       'NACE_division', 'staff_count', 'staff_turnover', 'staff_variation',
       'lat', 'lon']
# data['lat'] = data['lat'].astype(float)
# data['lon'] = data['lon'].astype(float)
data.head(3)
```

[ ]:
```
   index  yearsInBusiness   rAssets   rIntang      rNOI  rating010  \
0   1388             24.5  1.961213  1.128333  0.075187        6.0
1   1436             22.1  8.169555  0.289103  0.411161        5.0
2    550             91.8  8.822509  0.008391  0.225178        5.0

   NACE_division  staff_count  staff_turnover  staff_variation        lat  \
0             36            0              29                5  45.649961
1             69            0              35               -1  45.651428
2             28            1               9                9  46.191657

         lon
0  13.768875
1  13.780139
2  13.199971
```

3 Data Exploration

[ ]:
```
def plot_clusters(X, cluster_labels, title=""):
    for i in np.unique(cluster_labels):
        cluster_points = X[cluster_labels == i , :]
        if i == 0:
            ax.scatter(cluster_points[:,0] , cluster_points[:,1] ,␣
 ↪color="yellow", marker='.', s=2)
        else:
            ax.scatter(cluster_points[:,0] , cluster_points[:,1] , cmap = i,␣
 ↪marker='o', s=2)
    ax.set_title(title, fontweight='bold')
    return
```

[ ]:
```
X = np.array(data[ ['lon','lat'  ] ])
n, p  = X.shape
_, ax = plt.subplots(figsize=(8,8))
plot_clusters(X, np.ones(n), title = "dataset")
plt.show()
```



3.1 Scaling factor

[ ]:
```
# approximated, valid only at short distances but good enough to give a rough␣
 ↪idea of epsilon
R = 6371 #earth radius
lon1, lat1,  =  12.6, 46.0
lon2, lat2   =  13.8, 46.0
# longitude x
dx = R*(lon2-lon1)*np.cos(lat1)*np.pi/180
# latitude y
dy = R* (lat2-lat1)*np.pi/180
d =  np.sqrt(dx**2 +  dy**2)
dx, dy
```

[ ]: (-57.66719385463093, 0.0)

[ ]:
```
lon1, lat1,  =  13.2, 45.6
lon2, lat2   =  13.2, 46.6
# longitude x
dx = R*(lon2-lon1)*np.cos(lat1)*np.pi/180
# latitude y
dy = R* (lat2-lat1)*np.pi/180
d =  np.sqrt(dx**2 +  dy**2)
dx, dy
```

[ ]: (-0.0, 111.19492664455873)

[ ]:
```
# TODO add scaling factor 57,111 to have more "readable" values of epsilon in km
```

3.2 calculate density for each point

X = data points = company position G = grid points equally spaced

[ ]:
```
grid = pd.read_csv(r'./maps/FVG/FVG_grid.csv')
nbins=np.sqrt(grid.shape[0]).astype(int)
xi = np.array(grid.x).reshape(nbins,nbins)
yi = np.array(grid.y).reshape(nbins,nbins)
G =  np.array(grid)
```

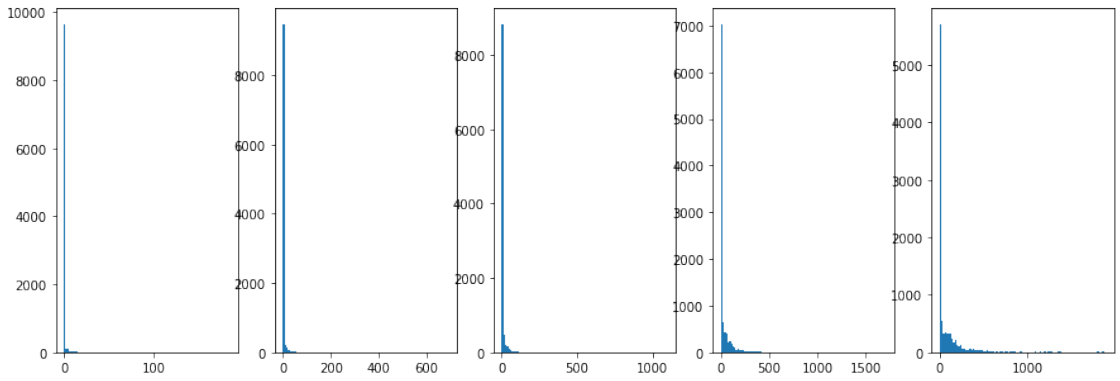
4 calculate distance matrix

[ ]:
```
dm = distance_matrix(G,X)
n_data_points= X.shape[0]
n_grid_points=G.shape[0]
n_reshape = np.sqrt(n_grid_points).astype(int)
```

[ ]:
```
def epsilon_neighborhood(dm, X, g, epsilon):
    """
    dm: distance_matrix(G,X)
    g: point of the grid G
    returns eps_neighb a list of indices of X that are within a distance␣
 ↪epsilon of point G
    """
    distances = dm[g]
    eps_neighb = np.where(X[ (distances < epsilon) ])[0]
    number_of_neighb = len(eps_neighb)

    return number_of_neighb, eps_neighb
```

[ ]:
```
minPoints = 20
fig, ax = plt.subplots(nrows = 1, ncols = 5, figsize = (15,5))
nplot=0
for epsilon in [5e-3, 1e-2, 2e-2, 5e-2, 8e-2]:
    nn_epsilon = []
    is_core = []
    for g in range(n_grid_points):
        number_of_neighb, eps_neighb = epsilon_neighborhood(dm, X, g, epsilon)
        nn_epsilon.append(number_of_neighb)
        is_core.append( number_of_neighb > minPoints  )

    ax[nplot].hist(nn_epsilon, bins = 100)
    nplot+=1
    fraction_core_points = np.array(is_core).mean()
    print(f'Given Epsilon = {epsilon} and minPoints = {minPoints}, the fraction␣
 ↪of core points is {fraction_core_points}')
```

```
Given Epsilon = 0.005 and minPoints = 20, the fraction of core points is 0.0043
Given Epsilon = 0.01 and minPoints = 20, the fraction of core points is 0.02
Given Epsilon = 0.02 and minPoints = 20, the fraction of core points is 0.0757
Given Epsilon = 0.05 and minPoints = 20, the fraction of core points is 0.2788
Given Epsilon = 0.08 and minPoints = 20, the fraction of core points is 0.4161
```



select epsilon = .05, minPoints=20

5 compute density

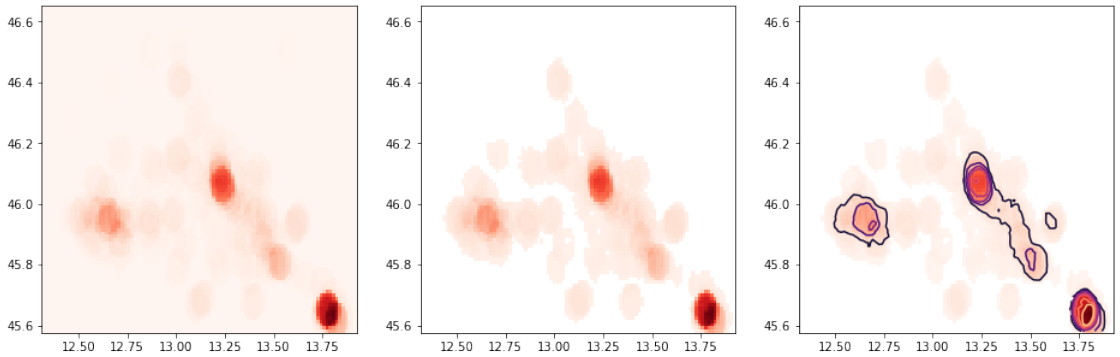
[ ]:
```
def compute_density(dm, X, G, epsilon):
    n_grid_points=  G.shape[0]
    n_data_points = X.shape[0]
    assert n_data_points > 0 , "size of X should be greater than 0"
    density = np.zeros(n_grid_points).astype(int)
    number_of_neighb = np.zeros(n_grid_points).astype(int)
```

```
    for g in range(n_grid_points):
        nnb, eps_neighb = epsilon_neighborhood(dm, X, g, epsilon)
        number_of_neighb[g] = nnb

    density = number_of_neighb/n_data_points


    return np.array(number_of_neighb), np.array(density)
```

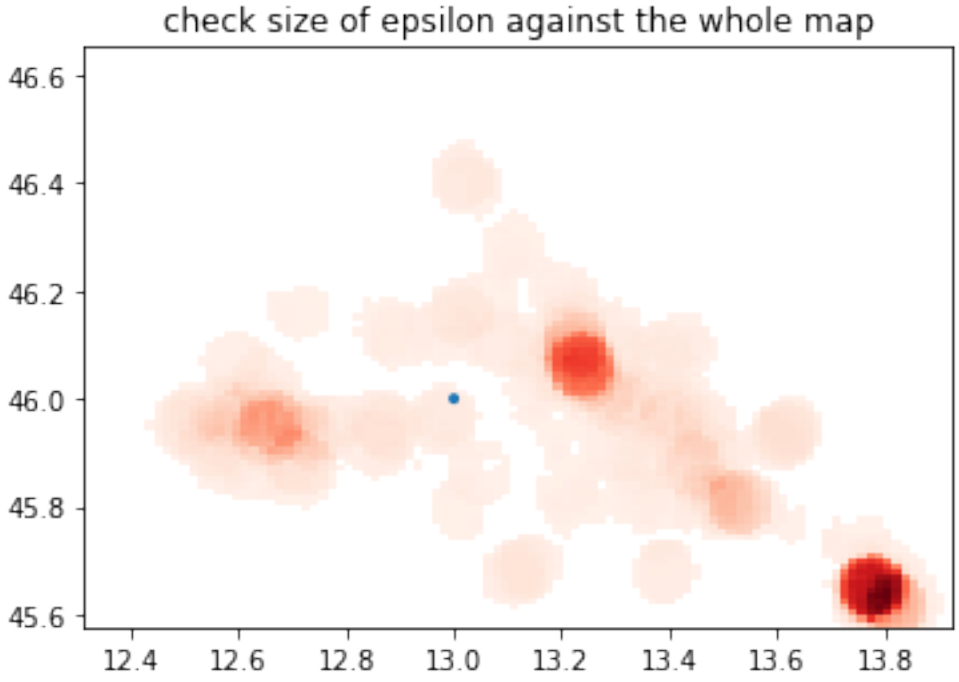
[ ]:
```
def compute_weighted_density(dm, X, G, W, epsilon):
    n_grid_points=  G.shape[0]
    n_data_points = X.shape[0]
    assert n_data_points > 0 , "size of X should be greater than 0"
    sum_of_weights = np.zeros(n_grid_points).astype(int)
    number_of_neighb = np.zeros(n_grid_points).astype(int)

    for g in range(n_grid_points):
        nnb, eps_neighb = epsilon_neighborhood(dm, X, g, epsilon)
        number_of_neighb[g] = nnb
        sum_of_weights[g] = np.sum(W[eps_neighb])

    density = sum_of_weights/n_data_points


    return np.array(number_of_neighb), np.array(density)
```

[ ]:
```
epsilon=1e-2
nn, dG1 = compute_density(dm, X, G,  epsilon=epsilon)
```

[ ]:
```
fig, (ax1,ax2, ax3) = plt.subplots(figsize=(16,5), nrows=1, ncols=3)
nn, dG1 = compute_density(dm, X, G, epsilon=0.06)

cmap="Reds"
n_reshape = 100
dG1r = dG1.reshape((n_reshape,n_reshape))

ax1.pcolormesh(xi, yi, dG1r,shading='nearest', cmap=cmap)

threshold=epsilon
dG1rM = np.ma.masked_array(dG1r, dG1r <threshold)
ax2.pcolormesh(xi, yi, dG1rM, shading='auto', cmap=cmap, vmin=0)

ax3.pcolormesh(xi, yi, dG1rM, shading='auto', cmap=cmap, alpha = 1, zorder = 1)
ax3.contour(xi, yi, dG1rM, cmap="magma", vmin=threshold, zorder = 3)

plt.show()
```



[ ]:
```
figure, axes = plt.subplots()
cc = plt.Circle( (13,46), epsilon)
plt.pcolormesh(xi, yi, dG1rM, shading='auto', cmap=cmap, vmin=0)

axes.set_aspect( 1 )
axes.add_artist( cc )
plt.title( 'check size of epsilon against the whole map' )
plt.show()
```

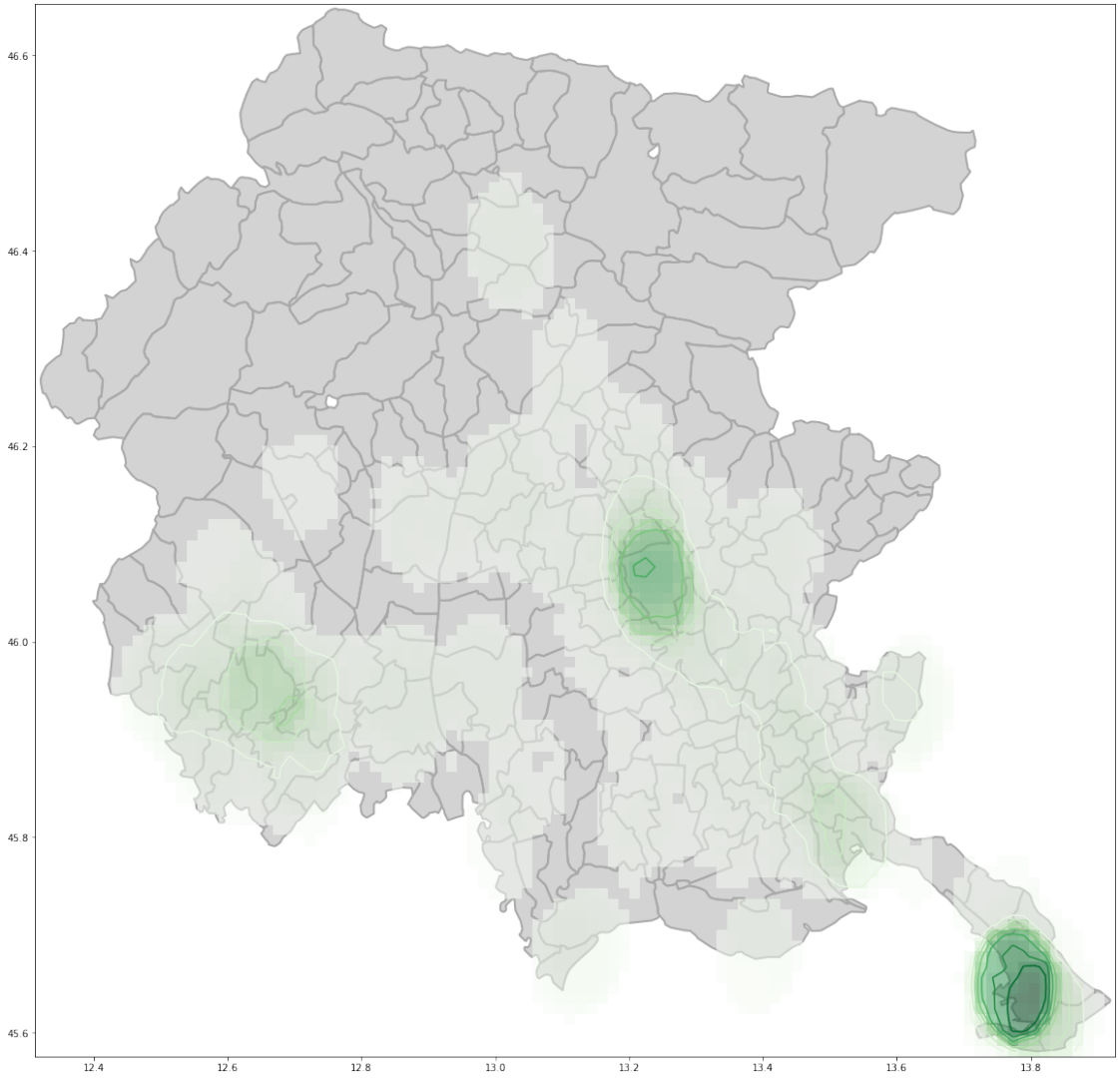


[ ]:
```
def plot_map(df, color_fill = "green", alpha = .2, color_border= "gray" ,␣
 ↪linewidth = .8):
```

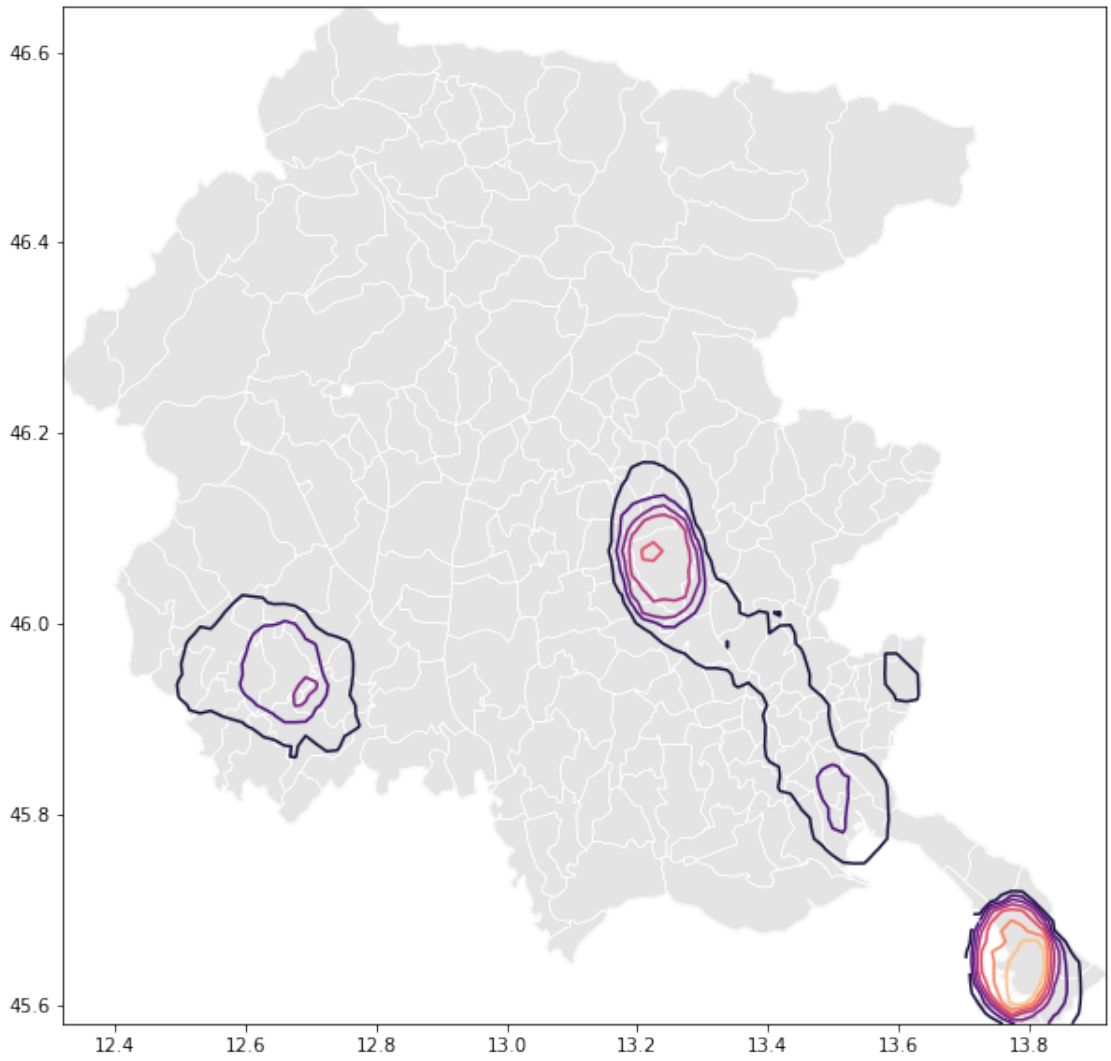
```
    for _, row in df.iterrows():
        x, y = list(zip(*row.poly))
        plt.fill(x,y, color = color_fill, alpha = alpha, zorder=1)
        plt.plot(x,y, color = color_border, linewidth=linewidth, zorder=2)
```

[ ]:
```
#load data from file
ita = pd.read_json(r'./maps/FVG/FVG_mappa.json', orient='records')
# filter a single region
fvg=ita[ ita.istat_r==6]
# plot the map
```

[ ]:
```
fig, ax = plt.subplots(figsize=(20,20))
plot_map(fvg, color_fill = "lightgray", alpha = 1, color_border= "darkgray" ,␣
 ↪linewidth = 2)
plt.pcolormesh(xi, yi, dG1rM, shading='auto', cmap="Greens",alpha = .5, zorder␣
 ↪= 3)
plt.contour(xi, yi, dG1rM, cmap="Greens", vmin=threshold, zorder = 4)
plt.show()
```



[ ]:
```
fig, ax = plt.subplots(figsize=(10,10))
plot_map(fvg, color_fill = "lightgray", alpha = .6, color_border= "white" ,␣
↪linewidth = .8)
plt.contour(xi, yi, dG1rM, cmap="magma", vmin=threshold, zorder = 4)

plt.show()
```



5.1 other data points

[ ]:
```
data.columns
```

[ ]:
```
Index(['index', 'yearsInBusiness', 'rAssets', 'rIntang', 'rNOI', 'rating010',
       'NACE_division', 'staff_count', 'staff_turnover', 'staff_variation',
       'lat', 'lon'],
      dtype='object')
```

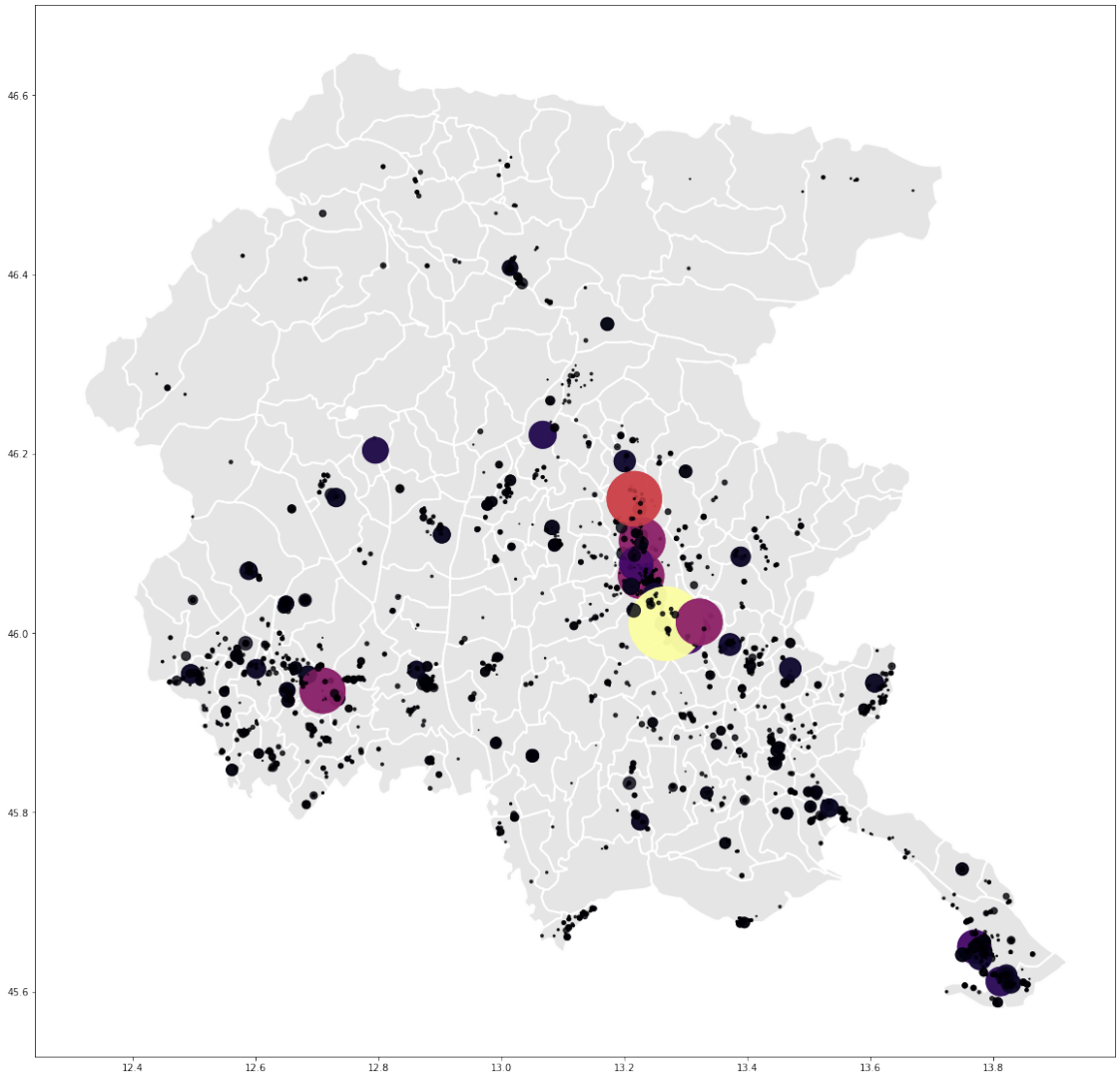
[ ]:
```
dd = data[ ['lon', 'lat', 'staff_count'] ]
dd.columns = ['x','y','z']
D = np.array(dd[ ['x','y' ] ])
D.shape
```

[ ]: (4563, 2)

5.2 a simple bubble plot

[ ]:
```
fig, ax = plt.subplots(figsize=(20,20))
plot_map(fvg, color_fill = "gray", alpha = .2, color_border= "white" ,␣
 ↪linewidth = 2)
plt.scatter(dd.x,dd.y, s=dd.z, c = dd.z, alpha = .8, cmap = "inferno", zorder =␣
 ↪5)
```

[ ]: <matplotlib.collections.PathCollection at 0x1ce12e424c0>



5.3 density

[ ]:
```
dm = distance_matrix(G,D)
n_data_points= D.shape[0]
n_grid_points= G.shape[0]
n_reshape = np.sqrt(n_grid_points).astype(int)
```

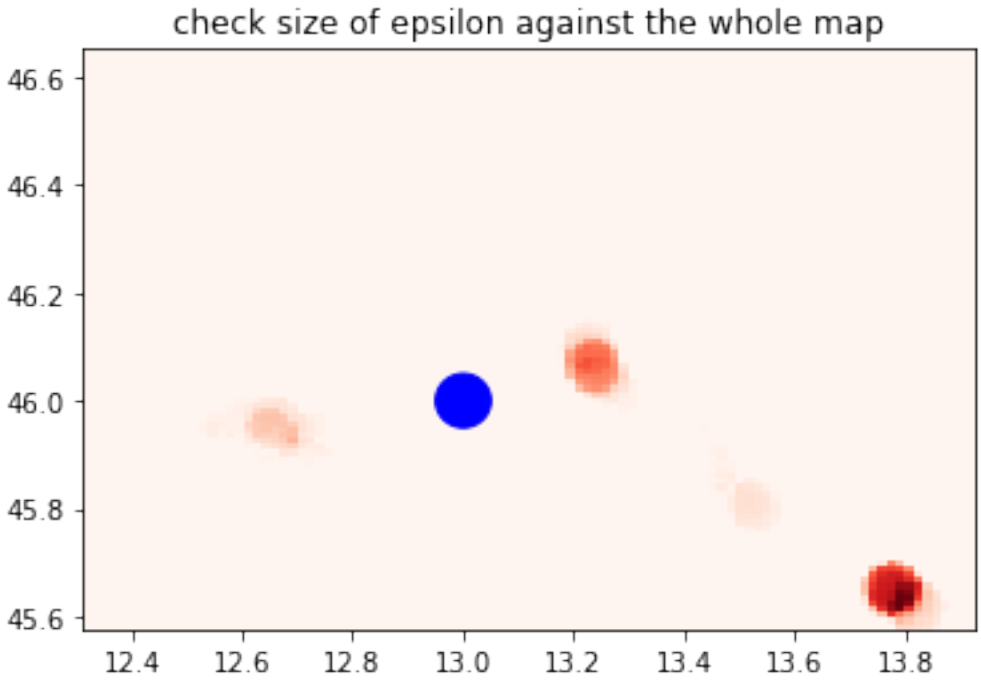
[ ]:
```
epsilon=5e-2
W = np.array(dd.z)
nn, dens = compute_weighted_density(dm, X, G, W, epsilon=epsilon)
#dens_r = dens.reshape((n_reshape,n_reshape))

dens
```

[ ]:
```
array([0., 0., 0., …, 0., 0., 0.])
```

[ ]:
```
dens.mean()
```

[ ]:
```
0.1720482577251808
```

[ ]:
```
figure, axes = plt.subplots()
plt.pcolormesh(xi, yi, dens_r, shading='auto', cmap='Reds', vmin=epsilon)
cc = plt.Circle( (13,46), epsilon,color = "blue")
axes.add_artist( cc )
plt.title( 'check size of epsilon against the whole map' )
plt.show()
```



[ ]:
```
fig, ax = plt.subplots(figsize=(20,20))
cmap = "Greens"
plot_map(fvg, color_fill = "lightgray", alpha = 1, color_border= "white" ,␣
 ↪linewidth = 2)

threshold=epsilon/2
dens_r_M = np.ma.masked_array(dens_r, dG1r <threshold)
plt.pcolormesh(xi, yi, dens_r_M, shading='auto', cmap='Reds', alpha = .8,␣
 ↪zorder = 4)


plt.contour(xi, yi, dens_r_M, cmap="autumn",  zorder = 5)


plt.show()
```