In [ ]:
```
fig, ax = plt.subplots(1, 2, figsize=(10,5))
sns.scatterplot(x = "x", y = "y", hue = "id", data = points, palette="S
sns.scatterplot(x = "x", y = "y", hue = "id", data = points4, palette="
sns.scatterplot(x = list(zip(*cp_points["centroid"]))[0],
                y = list(zip(*cp_points["centroid"]))[1], ax=ax[0], mar
sns.scatterplot(x = list(zip(*cp_points["centroid"]))[0],
                y = list(zip(*cp_points["centroid"]))[1], ax=ax[1], mar
sns.scatterplot(x = list(zip(*cp_points4["centroid"]))[0],
                y = list(zip(*cp_points4["centroid"]))[1], ax=ax[1], ma
```

Using CT_Clusters.csv dataset

A. Some EDA and preliminary data visualization

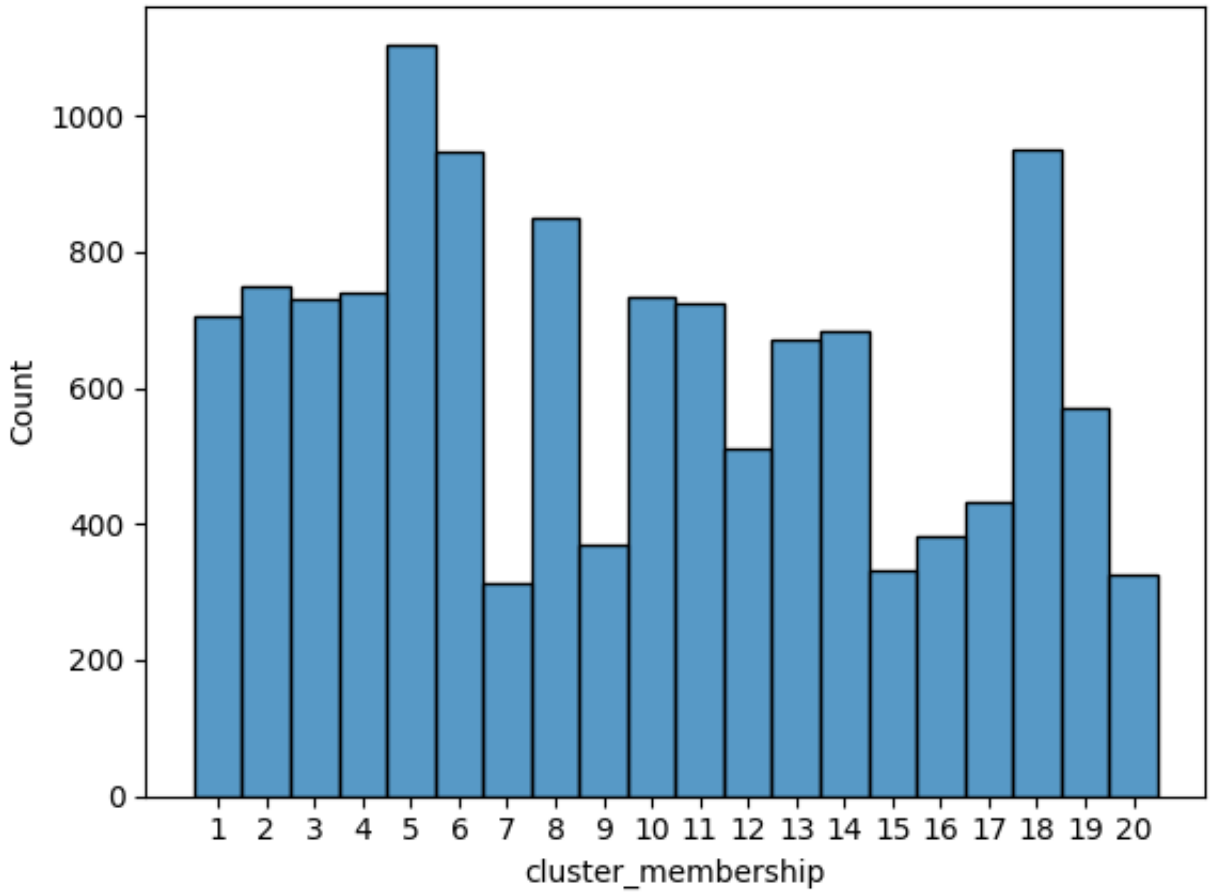
In [2]:
```
df_clusters = pd.read_csv("./CT_Clusters.csv")
print(df_clusters.info())
print(df_clusters.describe())
df_clusters.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12828 entries, 0 to 12827
Data columns (total 3 columns):
 #   Column              Non-Null Count  Dtype  
---  ------              --------------  -----  
 0   cluster_membership  12828 non-null  int64  
 1   lat_round           12828 non-null  float64
 2   lon_round           12828 non-null  float64
dtypes: float64(2), int64(1)
memory usage: 300.8 KB
None
       cluster_membership     lat_round     lon_round
count        12828.000000  12828.000000  12828.000000
mean             9.625896     41.515125    -72.870864
std              5.705690      0.257943      0.446928
min              1.000000     41.002000    -73.697000
25%              5.000000     41.310000    -73.221000
50%              9.000000     41.515000    -72.892000
75%             14.000000     41.736000    -72.601000
max             20.000000     42.042000    -71.799000
```

Out[2]:

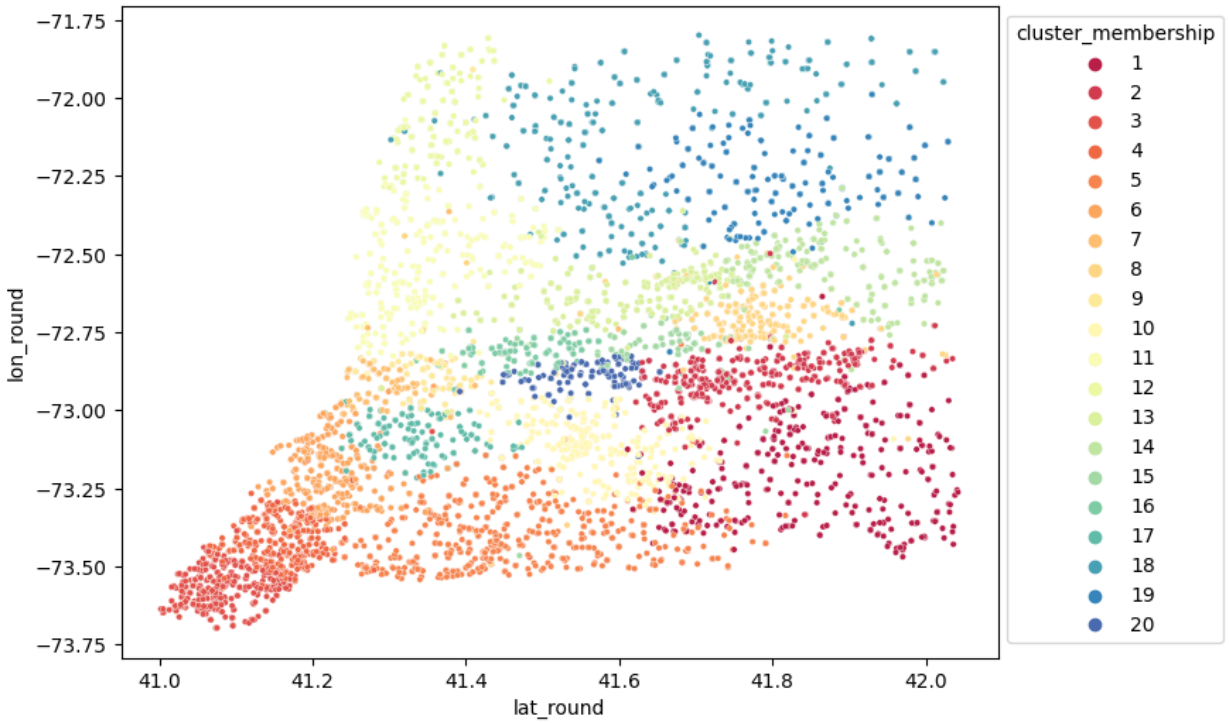
	cluster_membership	lat_round	lon_round
0	10	41.571	-73.018
1	19	41.814	-72.259
2	19	41.814	-72.259
3	19	41.814	-72.259
4	10	41.594	-73.051

In [3]:
```
sns.histplot(x = "cluster_membership", data = df_clusters, discrete =
plt.xticks(range(min(df_clusters["cluster_membership"]), max(df_cluste
plt.show()
```



In [4]:
```
'''
The max number of unique(qualitative) coloring schemes in matplotlib/s
Hence need to create our own.
'''
coloring = sns.color_palette("Spectral", n_colors=20)
# coloring = sns.color_palette("icefire", n_colors=20)
light_coloring = sns.light_palette("purple", n_colors=20)
dark_coloring = sns.dark_palette("purple", n_colors=20)
```

In [5]:
```
plt.figure(figsize=(8,6))
ax = sns.scatterplot(x = "lat_round", y = "lon_round", data = df_clust
                     palette = coloring, s=10)
sns.move_legend(ax, "upper left", bbox_to_anchor=(1, 1))
```



B. Plot the centroids.

In [6]:
```
def centroid(ls):
    arr = np.array(ls)
    length = arr.shape[0]
    sum_x = np.sum(arr[:, 0])
    sum_y = np.sum(arr[:, 1])
    return [(sum_x/length).round(2), (sum_y/length).round(2)]
```

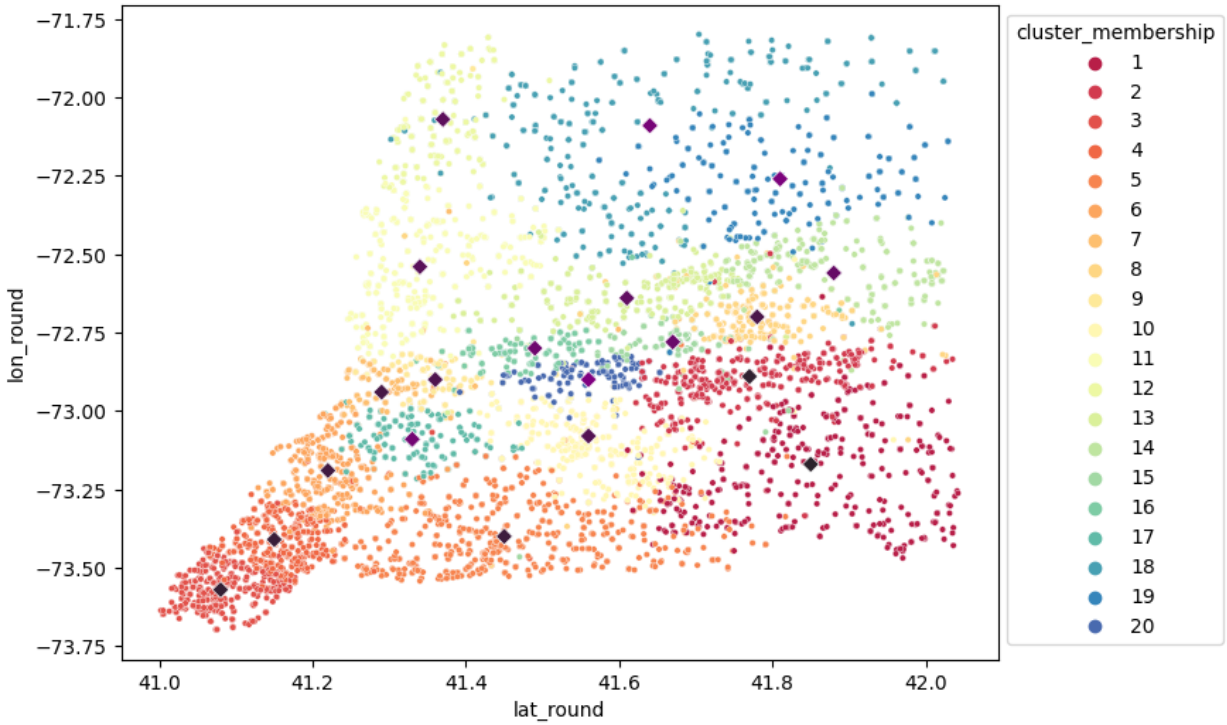
In [7]:
```
def all_coor(df):
    return list(zip(df["lat_round"], df["lon_round"]))
```

In [8]:
```
# An easier way to aggregate all points coordinates in a group, using
df_centroids = pd.DataFrame(df_clusters.groupby("cluster_membership").
df_centroids.set_index("cluster_membership", inplace = True)
df_centroids["centroid"] = df_centroids["coordinates"].apply(lambda r
df_centroids.head()
```

Out[8]:

cluster_membership	coordinates	centroid
1	[(42.009, -73.181), (42.009, -73.181), (42.009...	[41.85, -73.17]
2	[(41.893, -72.765), (41.639, -72.841), (41.855...	[41.77, -72.89]
3	[(41.02, -73.626), (41.054, -73.531), (41.054,...	[41.08, -73.57]
4	[(41.163, -73.373), (41.163, -73.373), (41.163...	[41.15, -73.41]
5	[(41.682, -73.487), (41.682, -73.487), (41.682...	[41.45, -73.4]

In [9]:
```
plt.figure(figsize=(8,6))
ax = sns.scatterplot(x = "lat_round", y = "lon_round", data = df_clust
                     palette=coloring, s=10)
sns.scatterplot(x = list(zip(*df_centroids["centroid"]))[0],
                y = list(zip(*df_centroids["centroid"]))[1],
                marker="D", legend=False, hue=df_centroids.index, pale
sns.move_legend(ax, "upper left", bbox_to_anchor=(1, 1))
```



C. Work with 15-20 membership assignments (using K-means or other ways)

1. Use jittering to change the distances so that K-means change the memberships.
2. Then calculate the centroids.
3. Use pairwise-distance to detect "same" id numbers. (check if this works)

C.1 Generate 15 k-means id's, 1 original id's, 1 minibatch-k id's

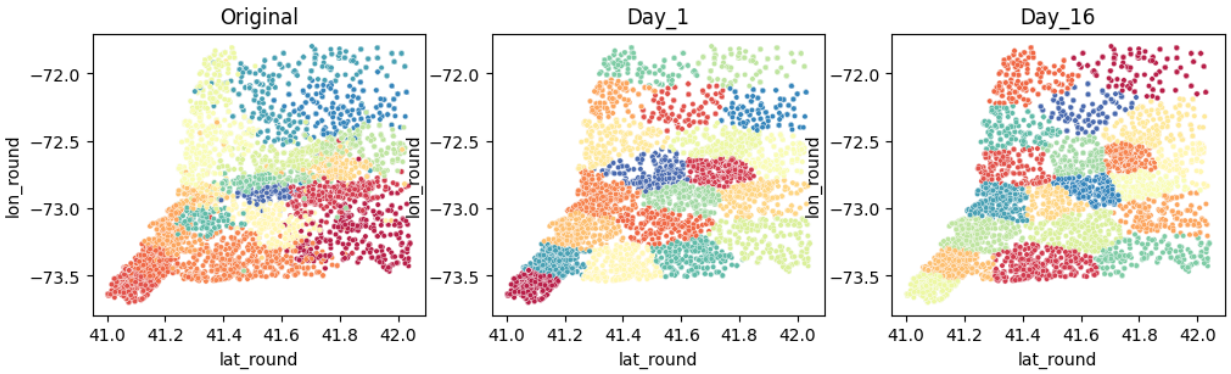
The following is used to generate `new_Clusters.csv` , hence don't run it repeatedly.

Data prep, create k-means generator.

In [10]:
```
df_new = df_clusters.copy()
coord = np.array(list(zip(df_new["lat_round"], df_new["lon_round"])))
n_clusters = df_new["cluster_membership"].nunique()

kmeans = KMeans(n_clusters=n_clusters, random_state=0)
df_new["col_1"] = kmeans.fit(coord).labels_
kmeansmb = MiniBatchKMeans(n_clusters=n_clusters, random_state=0, batc
df_new["col_16"] = kmeansmb.fit(coord).labels_
```

In [11]:
```
fig, ax = plt.subplots(1, 3, figsize=(12,3))
sns.scatterplot(x = "lat_round", y = "lon_round", data = df_new, hue =
                palette = coloring, s=10, legend=False, ax=ax[0])
sns.scatterplot(x = "lat_round", y = "lon_round", data = df_new, hue =
                palette = coloring, s=10, legend=False, ax=ax[1])
sns.scatterplot(x = "lat_round", y = "lon_round", data = df_new, hue =
                palette = coloring, s=10, legend=False, ax=ax[2])
ax[0].set_title("Original")
ax[1].set_title("Day_1")
ax[2].set_title("Day_16")
```

Out[11]:
```
Text(0.5, 1.0, 'Day_16')
```



Create jittering function. Can choose to jitter x, y, or both. Can also choose the jittering variance in a normal distribution.

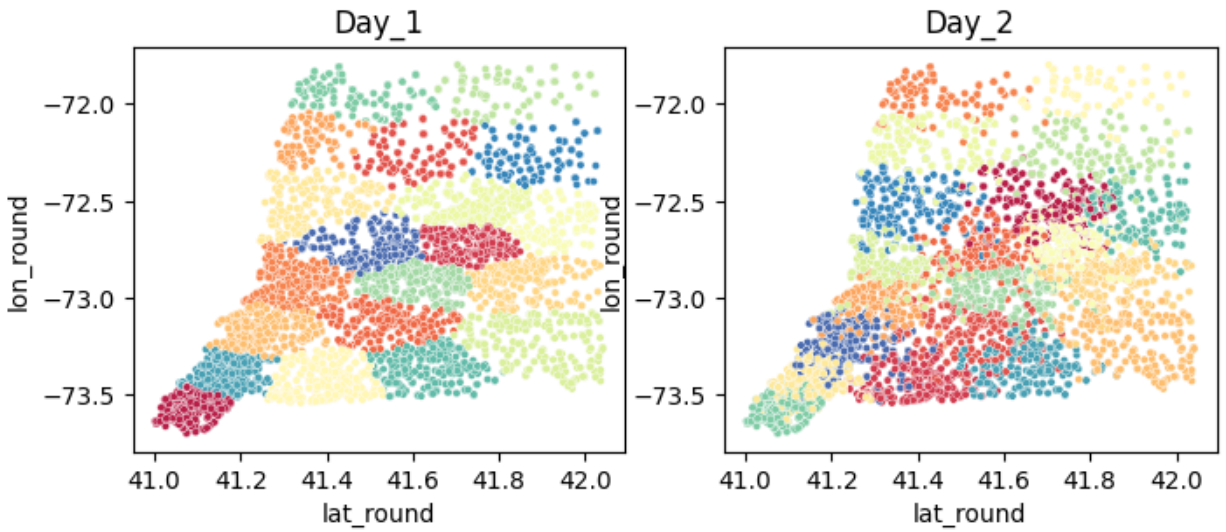
In [12]:
```
from numpy.random import RandomState

def jitter(coor, sigmax, sigmay, seed=12345):
    """
    Jitter a single point using Gaussian distribution.
    Input:
        coor - List[Float, Float]: coordinate of the point
        sigmax - Float: standard deviation for x, non-negative. If neg
        sigmay - Float: standard deviation for y, non-negative. If neg
        seed - Int: choose the seed for random generator of normal dis
    Output:
        [new_x, new_y] - List[Float, Float]: new coordinate for the in
    """
    prng = RandomState(seed)
    x, y = coor[0], coor[1]
    new_x, new_y = x, y

    if sigmax >= 0:
        new_x = prng.normal(x, scale=sigmax)
    if sigmay >= 0:
        new_y = prng.normal(y, scale=sigmay)
    return [new_x, new_y]
```

In [13]:
```
def new_membership(coord):
    """
    Input: coord - np.array[[Float, Float], ...]
    Output: new_coord - np.array[[Float, Float], ...]
    """
    new_coord = list()
    for c in coord:
        temp = jitter(c, sigmax=rd.uniform(-0.5,0.5), sigmay=rd.unifor
        new_coord.append(temp)
    return np.array(new_coord)
```

In [20]:
```
new_coord = new_membership(coord)
df_new["col_2"] = kmeans.fit(new_coord).labels_
```

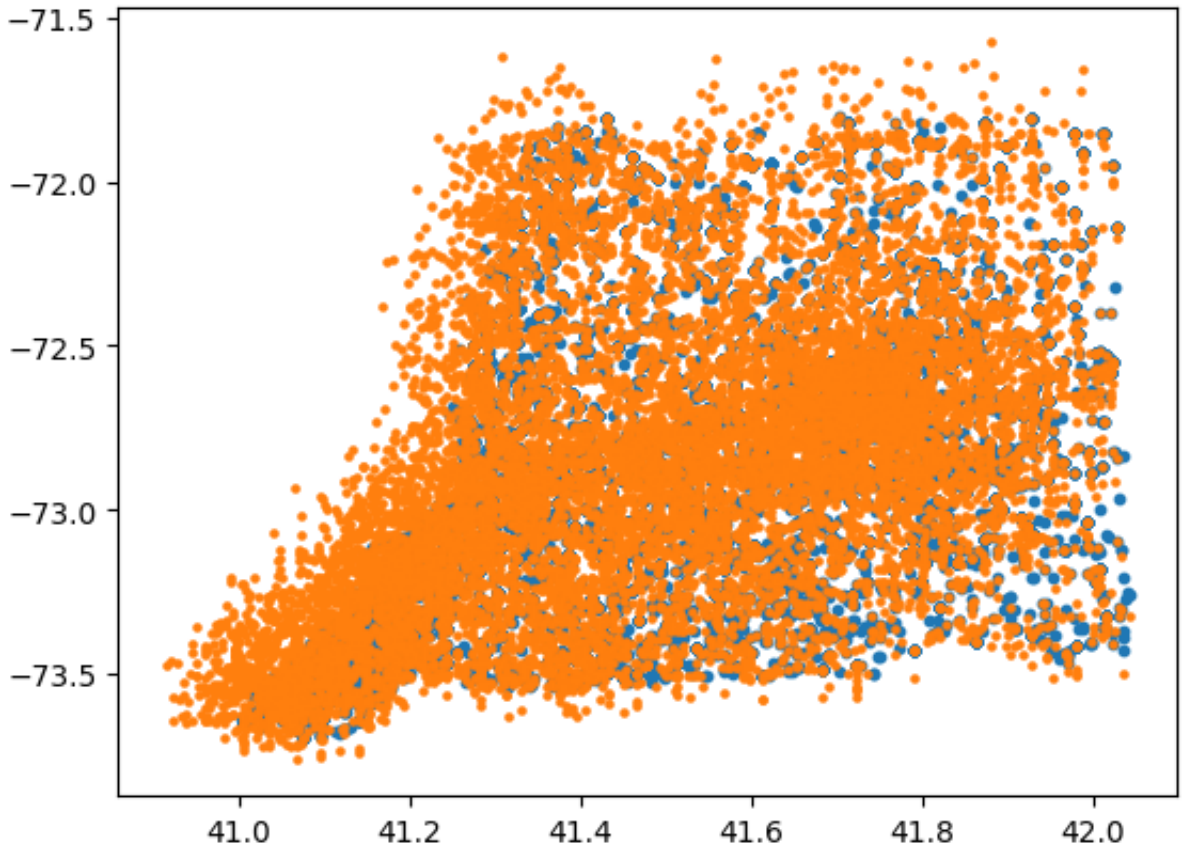
In [21]:
```
fig, ax = plt.subplots(1, 2, figsize=(8,3))
sns.scatterplot(x = "lat_round", y = "lon_round", data = df_new, hue =
                palette = coloring, s=10, legend=False, ax=ax[0])
sns.scatterplot(x = "lat_round", y = "lon_round", data = df_new, hue =
                palette = coloring, s=10, legend=False, ax=ax[1])
ax[0].set_title("Day_1")
ax[1].set_title("Day_2")
```

Out[21]: Text(0.5, 1.0, 'Day_2')



In [16]:
```
plt.scatter(coord[:,0], coord[:,1], s=10)
plt.scatter(new_coord[:,0], new_coord[:,1], s=5)
```

Out[16]:
```
<matplotlib.collections.PathCollection at 0x7ff0030dc100>
```



Apply to generate 13 more assignments.

In [22]:
```
cur_coord = new_coord
for i in range(13):
    col = "col_" + str(i+3)
    new = new_membership(cur_coord)
    df_new[col] = kmeans.fit(new).labels_
    cur_coord = new
    print(f'{col} finished generating.')
```

```
col_3 finished generating.
col_4 finished generating.
col_5 finished generating.
col_6 finished generating.
col_7 finished generating.
col_8 finished generating.
col_9 finished generating.
col_10 finished generating.
col_11 finished generating.
col_12 finished generating.
col_13 finished generating.
col_14 finished generating.
col_15 finished generating.
```

In [33]:
```
temp = df_new.pop("col_16")
df_new["col_16"] = temp
df_new.head()
```

Out[33]:

cluster_membership	lat_round	lon_round	col_1	col_2	col_3	col_4	col_5	col_6	col_7	col_8
10	41.571	-73.018	14	14	1	17	6	18	5	18
19	41.814	-72.259	18	13	17	6	7	15	13	2
19	41.814	-72.259	18	13	17	6	3	7	13	0
19	41.814	-72.259	18	13	17	6	7	15	2	8
10	41.594	-73.051	3	2	11	4	8	1	19	6

In [34]:
```
df_new.to_csv('new_Clusters.csv', index=False)
```

In [35]:
```
!cat new_Clusters.csv
```

```
cluster_membership,lat_round,lon_round,col_1,col_2,col_3,col_4,col_
5,col_6,col_7,col_8,col_9,col_10,col_11,col_12,col_13,col_14,col_15
,col_16
10,41.571,-73.018,14,14,1,17,6,18,5,18,11,4,10,2,13,1,1,7
19,41.814,-72.259,18,13,17,6,7,15,13,2,10,16,16,18,14,18,2,8
19,41.814,-72.259,18,13,17,6,3,7,13,0,0,1,6,15,11,17,17,8
19,41.814,-72.259,18,13,17,6,7,15,2,8,9,1,6,15,11,17,17,8
10,41.594,-73.051,3,2,11,4,8,1,19,6,19,4,10,2,13,1,11,12
3,41.02,-73.626,0,15,6,5,11,16,11,14,15,3,9,12,6,15,7,11
7,41.334,-72.945,4,5,13,10,6,4,0,4,18,18,8,17,15,19,18,17
7,41.334,-72.945,4,5,13,10,15,19,7,19,1,9,14,19,1,8,8,17
8,41.893,-72.765,10,7,7,12,17,9,9,3,2,19,19,13,18,13,0,10
8,41.893,-72.765,10,16,16,9,4,14,17,17,6,15,13,7,9,14,4,10
2,41.893,-72.765,10,16,16,9,4,2,10,17,6,13,7,7,14,0,14,10
14,41.788,-72.601,11,0,14,2,1,15,2,0,0,1,6,5,11,17,14,4
14,41.788,-72.601,11,16,4,16,1,2,10,17,10,13,13,18,14,18,14,4
8,41.788,-72.601,11,10,14,2,4,2,10,17,6,15,13,16,4,10,10,4
14,41.788,-72.601,11,0,17,6,7,7,13,2,10,1,6,18,11,17,17,4
14,41.788,-72.601,11,16,16,9,4,14,17,17,6,15,13,16,4,10,10,4
```

C.2 Calculate the centroids, using pairwise-min-distance to see if clusters match each other

Plot all 17 clusters, from `new_Clusters.csv` .

In [ ]:

In [ ]:

In [ ]:

In [ ]:

D. Animation for the changes

Check this: https://stackoverflow.com/questions/9401658/how-to-animate-a-scatter-plot (https://stackoverflow.com/questions/9401658/how-to-animate-a-scatter-plot)