Skills Network

Hands-on Lab: Interactive Visual Analytics with Folium

Estimated time needed: **40** minutes

The launch success rate may depend on many factors such as payload mass, orbit type, and so on. It may also depend on the location and proximities of a launch site, i.e., the initial position of rocket trajectories. Finding an optimal location for building a launch site certainly involves many factors and hopefully we could discover some of the factors by analyzing the existing launch site locations.

In the previous exploratory data analysis labs, you have visualized the SpaceX launch dataset using `matplotlib` and `seaborn` and discovered some preliminary correlations between the launch site and success rates. In this lab, you will be performing more interactive visual analytics using `Folium`.

Objectives

This lab contains the following tasks:

- **TASK 1:** Mark all launch sites on a map
- **TASK 2:** Mark the success/failed launches for each site on the map
- **TASK 3:** Calculate the distances between a launch site to its proximities

After completed the above tasks, you should be able to find some geographical patterns about launch sites.

Let's first import required Python packages for this lab:

[1]:
```
import piplite
await piplite.install(['folium'])
await piplite.install(['pandas'])
```

[2]:
```
import folium
import pandas as pd
```

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Launcher | lab_jupyter_launch_site_lo

Code | Python (Pyodide)

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lab_jupyter_laun...	10s ago

[1]:
```
import piplite
await piplite.install(['folium'])
await piplite.install(['pandas'])
```

[2]:
```
import folium
import pandas as pd
```

[3]:
```
# Import folium MarkerCluster plugin
from folium.plugins import MarkerCluster
# Import folium MousePosition plugin
from folium.plugins import MousePosition
# Import folium DivIcon plugin
from folium.features import DivIcon
```

If you need to refresh your memory about folium, you may download and refer to this previous folium lab:

Generating Maps with Python

[5]:
```
## Task 1: Mark all launch sites on a map
```

First, let's try to add each site's location on a map using site's latitude and longitude coordinates

The following dataset with the name `spacex_launch_geo.csv` is an augmented dataset with latitude and longitude added for each site.

[4]:
```
# Download and read the `spacex_launch_geo.csv`
from js import fetch
import io

URL = 'https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/
resp = await fetch(URL)
spacex_csv_file = io.BytesIO((await resp.arrayBuffer()).to_py())
spacex_df=pd.read_csv(spacex_csv_file)
```

Now, you can take a look at what are the coordinates for each site.

[6]:
```
# Select relevant sub-columns: `Launch Site`, `Lat(Latitude)`, `Long(Longitude)`, `class`
spacex_df = spacex_df[['Launch Site', 'Lat', 'Long', 'class']]
launch_sites_df = spacex_df.groupby(['Launch Site'], as_index=False).first()
launch_sites_df = launch_sites_df[['Launch Site', 'Lat', 'Long']]
launch_sites_df
```

[6]:
```
# Select relevant sub-columns: `Launch Site`, `Lat(Latitude)`, `Long(Longitude)`, `class`
spacex_df = spacex_df[['Launch Site', 'Lat', 'Long', 'class']]
launch_sites_df = spacex_df.groupby(['Launch Site'], as_index=False).first()
launch_sites_df = launch_sites_df[['Launch Site', 'Lat', 'Long']]
launch_sites_df
```

[6]:

	Launch Site	Lat	Long
0	CCAFS LC-40	28.562302	-80.577356
1	CCAFS SLC-40	28.563197	-80.576820
2	KSC LC-39A	28.573255	-80.646895
3	VAFB SLC-4E	34.632834	-120.610745

Above coordinates are just plain numbers that can not give you any intuitive insights about where are those launch sites. If you are very good at geography, you can interpret those numbers directly in your mind. If not, that's fine too. Let's visualize those locations by pinning them on a map.

We first need to create a folium `Map` object, with an initial center location to be NASA Johnson Space Center at Houston, Texas.

[7]:
```
# Start location is NASA Johnson Space Center
nasa_coordinate = [29.559684888503615, -95.0830971930759]
site_map = folium.Map(location=nasa_coordinate, zoom_start=10)
```

We could use `folium.Circle` to add a highlighted circle area with a text label on a specific coordinate. For example,

[8]:
```
# Create a blue circle at NASA Johnson Space Center's coordinate with a popup label showing its name
circle = folium.Circle(nasa_coordinate, radius=1000, color='#d35400', fill=True).add_child(folium.Popup('NASA
# Create a blue circle at NASA Johnson Space Center's coordinate with a icon showing its name
marker = folium.map.Marker(
    nasa_coordinate,
    # Create an icon as a text label
    icon=DivIcon(
        icon_size=(20,20),
        icon_anchor=(0,0),
        html='<div style="font-size: 12; color:#d35400;"><b>%s</b></div>' % 'NASA JSC',
        )
    )
site_map.add_child(circle)
site_map.add_child(marker)
```

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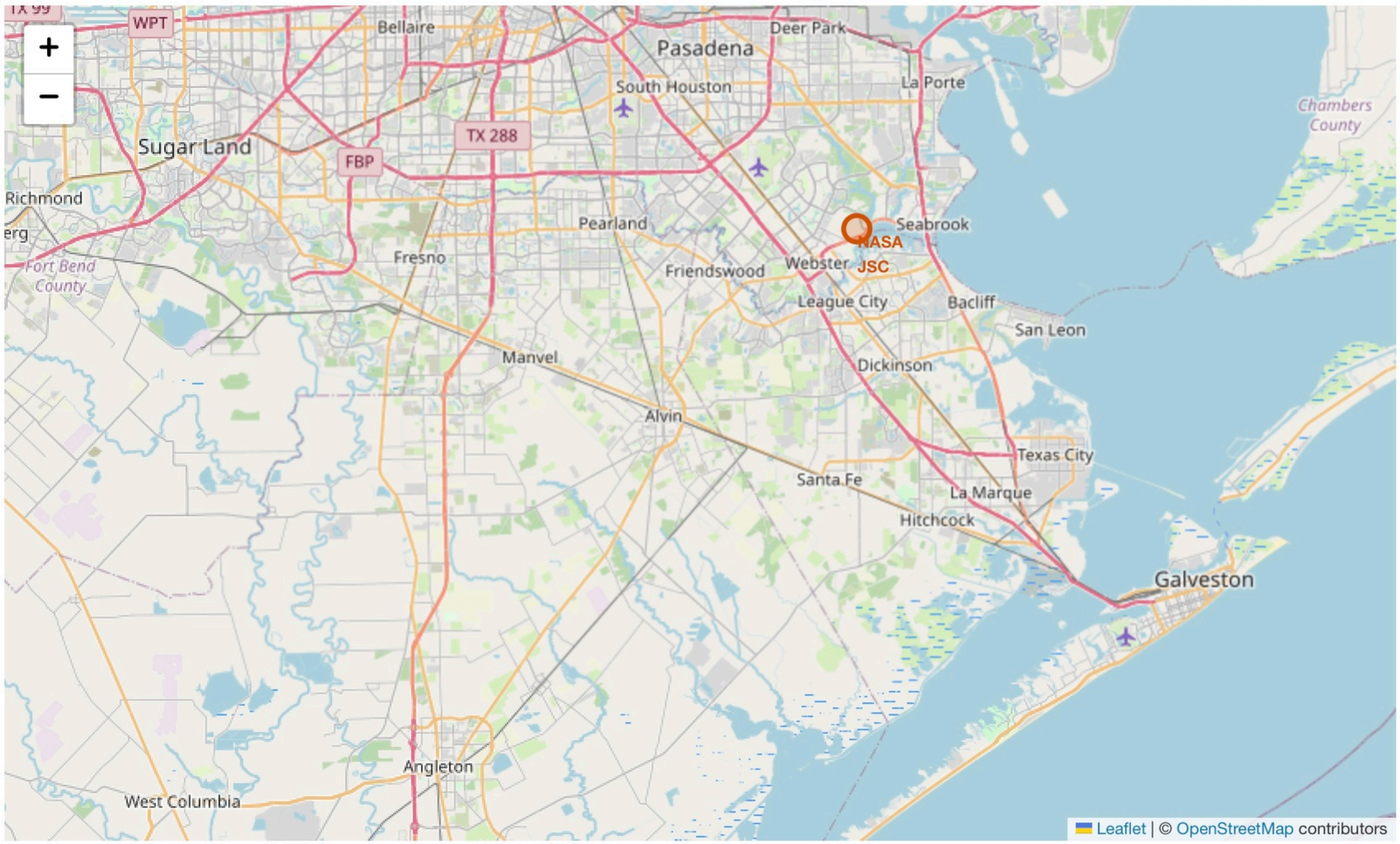
Launcher | lab_jupyter_launch_site_lo

Code | Python (Pyodide)

```
    )
site_map.add_child(circle)
site_map.add_child(marker)
```

[8]:



and you should find a small yellow circle near the city of Houston and you can zoom-in to see a larger circle.

Now, let's add a circle for each launch site in data frame `launch_sites`

TODO: Create and add `folium.Circle` and `folium.Marker` for each launch site on the site map

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Code | Python (Pyodide)

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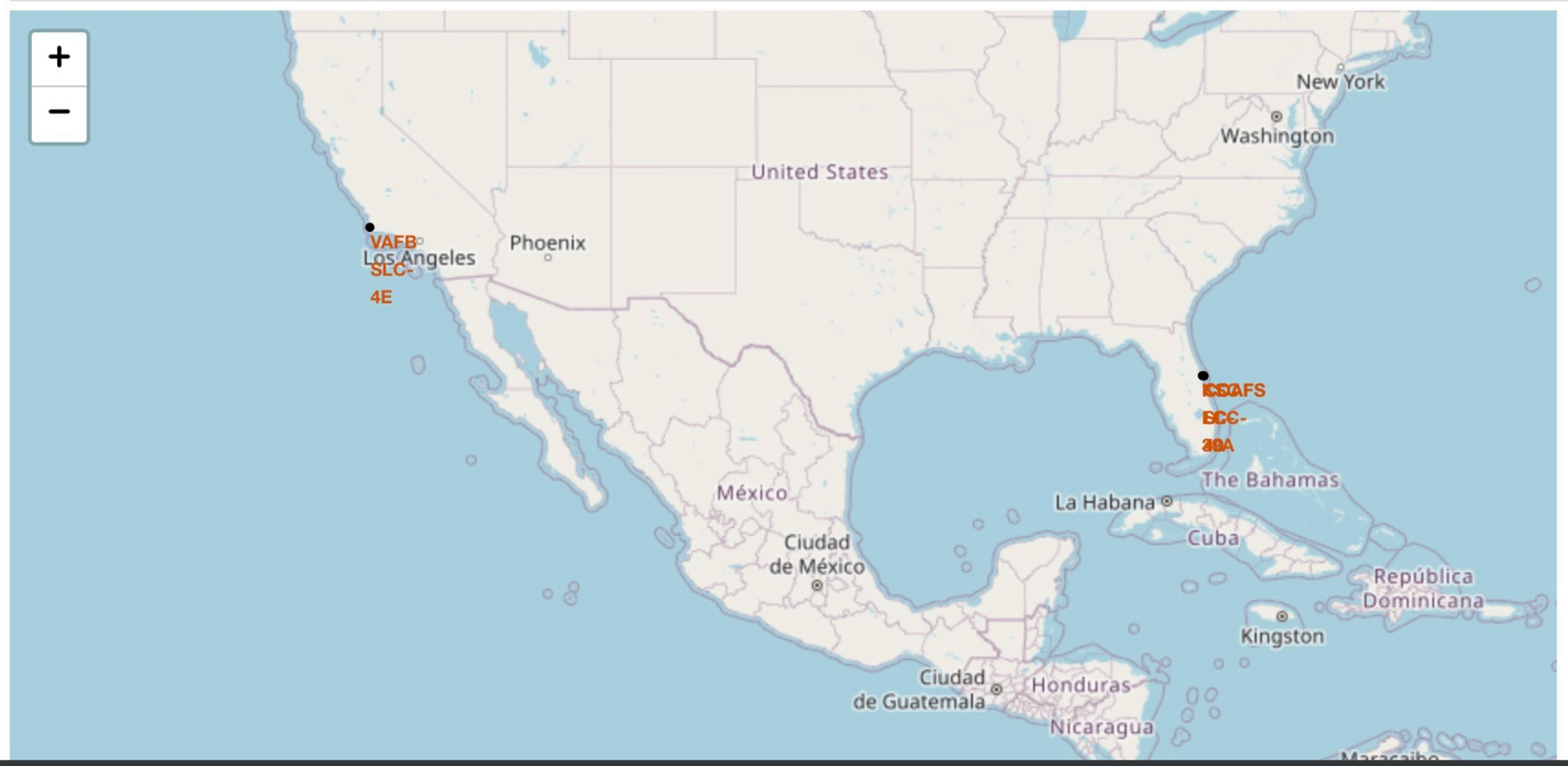
An example of folium.Marker:

```
folium.map.Marker(coordinate, icon=DivIcon(icon_size=(20,20),icon_anchor=(0,0), html='<div style="font-size: 12; color:#d35400;"><b>%s</b></div>' % 'label', ))
```

[9]:
```
# Initial the map
site_map = folium.Map(location=nasa_coordinate, zoom_start=5)
# For each launch site, add a Circle object based on its coordinate (Lat, Long) values. In addition, add Launc

for index, row in launch_sites_df.iterrows():
    coordinate = [row['Lat'], row['Long']]
    folium.Circle(coordinate, radius=1000, color='#000000', fill=True).add_child(folium.Popup(row['Launch Site
    folium.map.Marker(coordinate, icon=DivIcon(icon_size=(20,20),icon_anchor=(0,0), html='<div style="font-siz
site_map
```

[9]:



Also please try to explain your findings.

[ ]:
```
# Task 2: Mark the success/failed launches for each site on the map
```

Next, let's try to enhance the map by adding the launch outcomes for each site, and see which sites have high success rates. Recall that data frame spacex_df has detailed launch records, and the `class` column indicates if this launch was successful or not

[10]:
```
spacex_df.tail(10)
```

[10]:

	Launch Site	Lat	Long	class
46	KSC LC-39A	28.573255	-80.646895	1
47	KSC LC-39A	28.573255	-80.646895	1
48	KSC LC-39A	28.573255	-80.646895	1
49	CCAFS SLC-40	28.563197	-80.576820	1
50	CCAFS SLC-40	28.563197	-80.576820	1
51	CCAFS SLC-40	28.563197	-80.576820	0
52	CCAFS SLC-40	28.563197	-80.576820	0
53	CCAFS SLC-40	28.563197	-80.576820	0
54	CCAFS SLC-40	28.563197	-80.576820	1
55	CCAFS SLC-40	28.563197	-80.576820	0

Next, let's create markers for all launch records. If a launch was successful `(class=1)`, then we use a green marker and if a launch was failed, we use a red marker `(class=0)`

Note that a launch only happens in one of the four launch sites, which means many launch records will have the exact same coordinate. Marker clusters can be a good way to simplify a map containing many markers having the same coordinate.

[13]:
```
# Apply a function to check the value of `class` column
# If class=1, marker_color value will be green
# If class=0, marker_color value will be red

def get_marker_color(cls):
    if cls == 1:
        return 'green'
    else:
        return 'red'

spacex_df['marker_color'] = spacex_df['class'].apply(get_marker_color)
spacex_df.tail(10)
```

[13]:

	Launch Site	Lat	Long	class	marker_color
46	KSC LC-39A	28.573255	-80.646895	1	green
47	KSC LC-39A	28.573255	-80.646895	1	green
48	KSC LC-39A	28.573255	-80.646895	1	green
49	CCAFS SLC-40	28.563197	-80.576820	1	green
50	CCAFS SLC-40	28.563197	-80.576820	1	green
51	CCAFS SLC-40	28.563197	-80.576820	0	red
52	CCAFS SLC-40	28.563197	-80.576820	0	red
53	CCAFS SLC-40	28.563197	-80.576820	0	red
54	CCAFS SLC-40	28.563197	-80.576820	1	green
55	CCAFS SLC-40	28.563197	-80.576820	0	red

TODO: For each launch result in `spacex_df` data frame, add a `folium.Marker` to `marker_cluster`

[14]:
```
site_map.add_child(marker_cluster)
# for each row in spacex_df data frame
```

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Code | Python (Pyodide)

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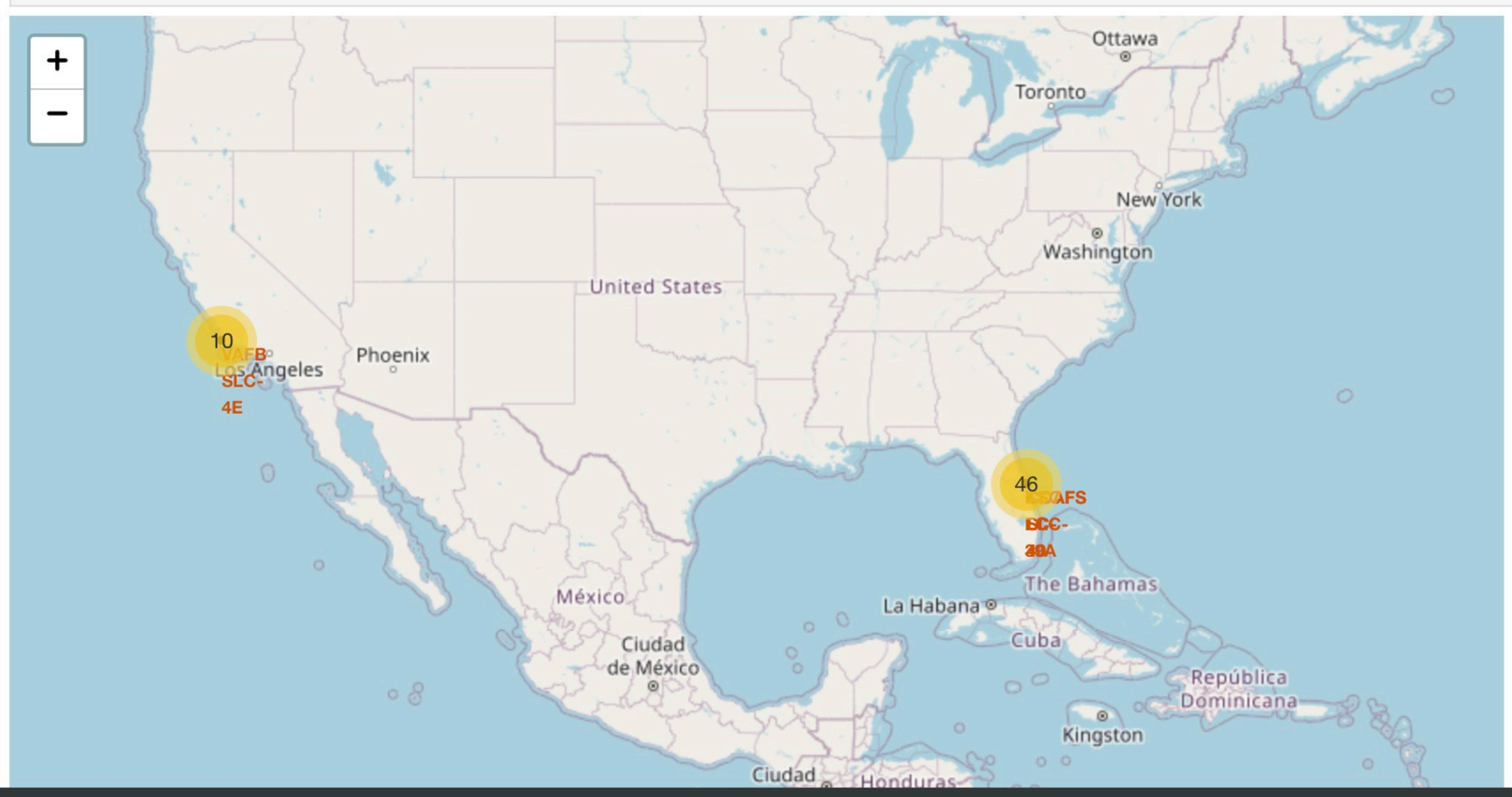
TODO: For each launch result in `spacex_df` data frame, add a `folium.Marker` to `marker_cluster`

[14]:
```
site_map.add_child(marker_cluster)
# for each row in spacex_df data frame
# create a Marker object with its coordinate
# and customize the Marker's icon property to indicate if this launch was successed or failed,
# e.g., icon=folium.Icon(color='white', icon_color=row['marker_color']
for index, row in spacex_df.iterrows():
    # TODO: Create and add a Marker cluster to the site map
    folium.map.Marker((row['Lat'], row['Long']), icon= folium.Icon(color='white', icon_color=row['marker_color
site_map.add_child(marker_cluster)

site_map
```

[14]:



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Code | Python (Pyodide)

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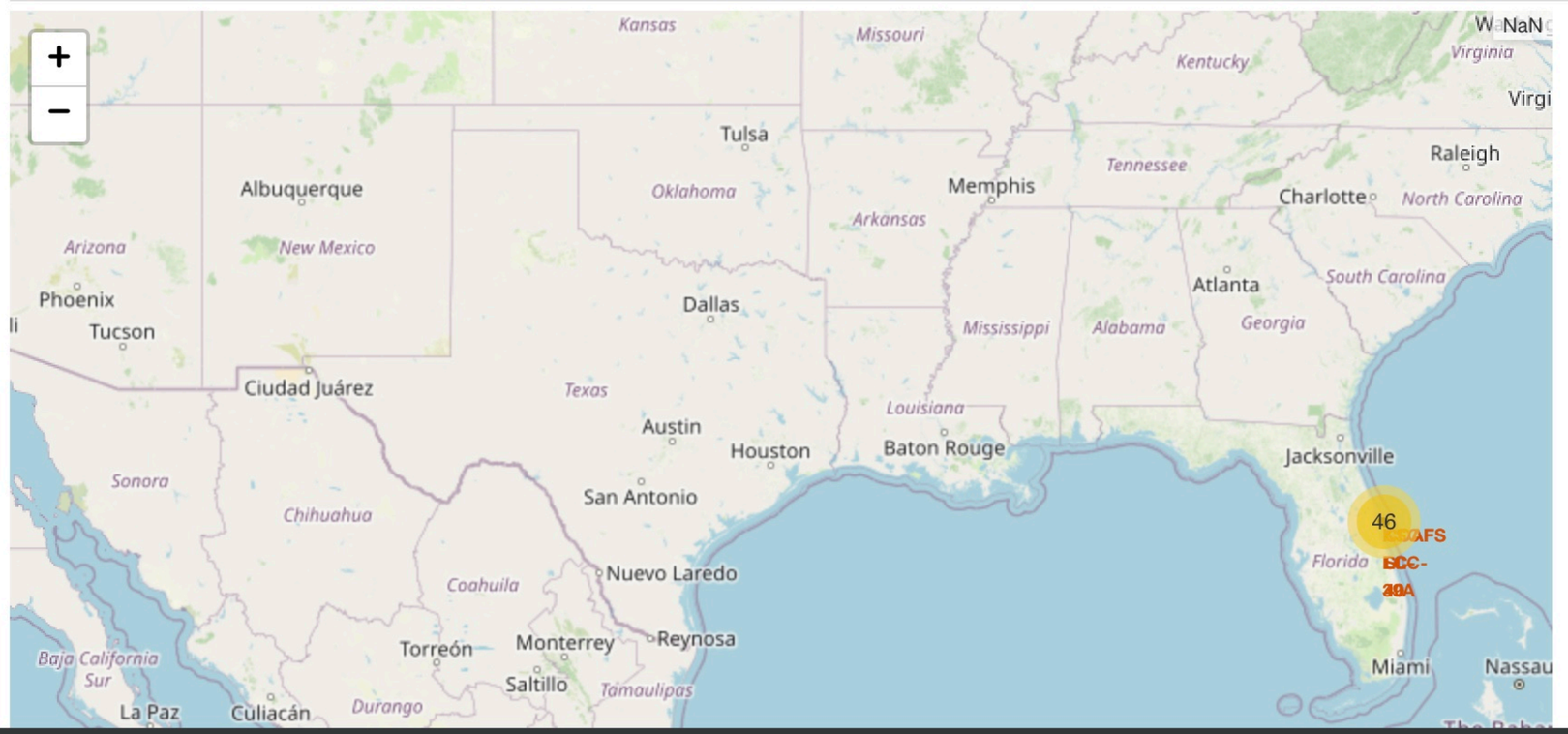
[15]:
```
# Add Mouse Position to get the coordinate (Lat, Long) for a mouse over on the map
formatter = "function(num) {return L.Util.formatNum(num, 5);};"
mouse_position = MousePosition(
    position='topright',
    separator=' Long: ',
    empty_string='NaN',
    lng_first=False,
    num_digits=20,
    prefix='Lat:',
    lat_formatter=formatter,
    lng_formatter=formatter,
)

site_map.add_child(mouse_position)
site_map
```

[15]:



[16]:
```python
from math import sin, cos, sqrt, atan2, radians

def calculate_distance(lat1, lon1, lat2, lon2):
    # approximate radius of earth in km
    R = 6373.0

    lat1 = radians(lat1)
    lon1 = radians(lon1)
    lat2 = radians(lat2)
    lon2 = radians(lon2)

    dlon = lon2 - lon1
    dlat = lat2 - lat1

    a = sin(dlat / 2)**2 + cos(lat1) * cos(lat2) * sin(dlon / 2)**2
    c = 2 * atan2(sqrt(a), sqrt(1 - a))

    distance = R * c
    return distance
```

TODO: Mark down a point on the closest coastline using MousePosition and calculate the distance between the coastline point and the launch site.

[17]:
```python
# find coordinate of the closet coastline
# e.g.,: Lat: 28.56367  Lon: -80.57163
# distance_coastline = calculate_distance(launch_site_lat, launch_site_lon, coastline_lat, coastline_lon)
coastline_lat =28.56359
coastline_lon= -80.56788
# Coordinate of launch site CCAFS SLC-40
launch_site_lat = 28.56322
launch_site_lon = -80.57632
distance_coastline = calculate_distance(launch_site_lat, launch_site_lon,coastline_lat, coastline_lon)
distance_coastline
```

[17]:
```
0.8255459982037666
```

[18]:
```python
# Create and add a folium.Marker on your selected closest coastline point on the map
```

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Launcher | lab_jupyter_launch_site_lo

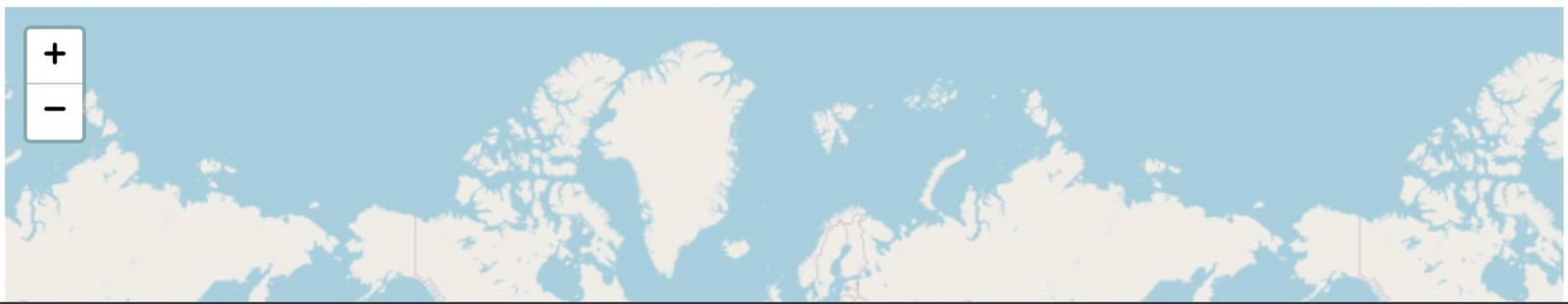
Code | Python (Pyodide)

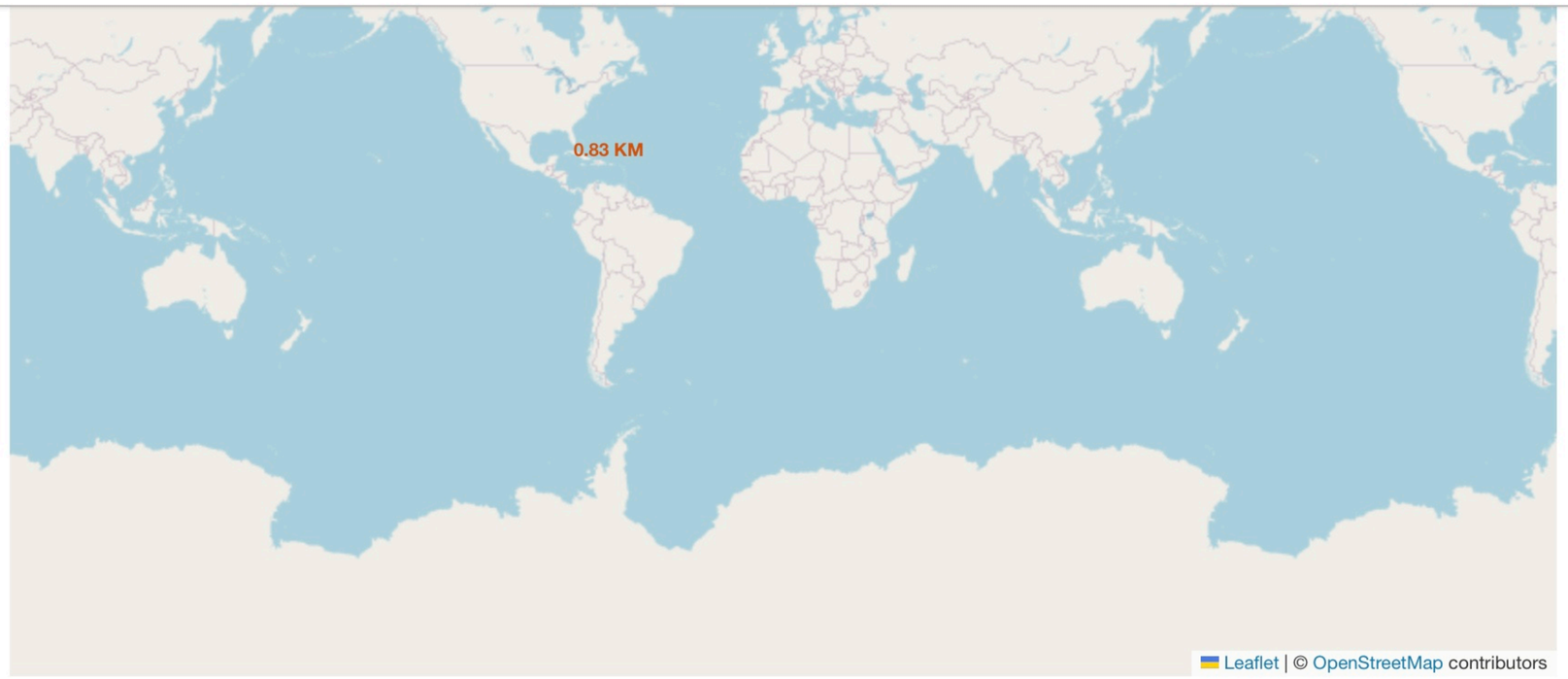
```
distance_coastline = calculate_distance(launch_site_lat, launch_site_lon,coastline_lat, coastline_lon)
distance_coastline
```

[17]: 0.8255459982037666

[18]:
```
# Create and add a folium.Marker on your selected closest coastline point on the map
# Display the distance between coastline point and launch site using the icon property
# for example
# distance_marker = folium.Marker(
#    coordinate,
#    icon=DivIcon(
#        icon_size=(20,20),
#        icon_anchor=(0,0),
#        html='<div style="font-size: 12; color:#d35400;"><b>%s</b></div>' % "{:10.2f} KM".format(distance),
#        )
#    )
site_map =folium.Map(coordinate =[launch_site_lat,launch_site_lon],zoom_start=14)
coordinate = [launch_site_lat, launch_site_lon]
#distance = distance_coastline
distance_marker = folium.Marker(
    coordinate,
    icon=DivIcon(
        icon_size=(150,36),
        icon_anchor=(0,0),
        html='<div style="font-size: 12; color:#d35400;"><b>%s</b></div>' % "{:10.2f} KM".format(distance_coas
        )
    )
# Add the marker to the map
site_map.add_child(distance_marker)
```

[18]:

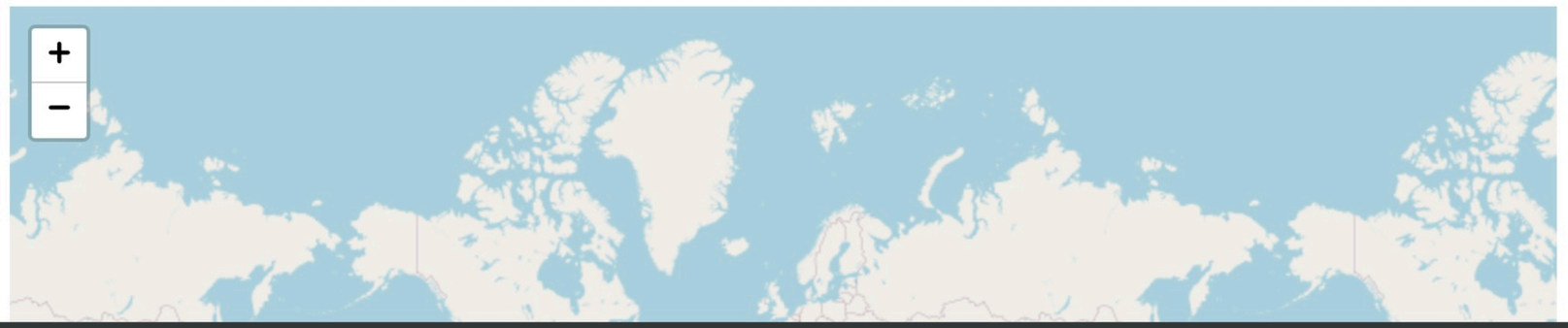




TODO: Draw a `PolyLine` between a launch site to the selected coastline point

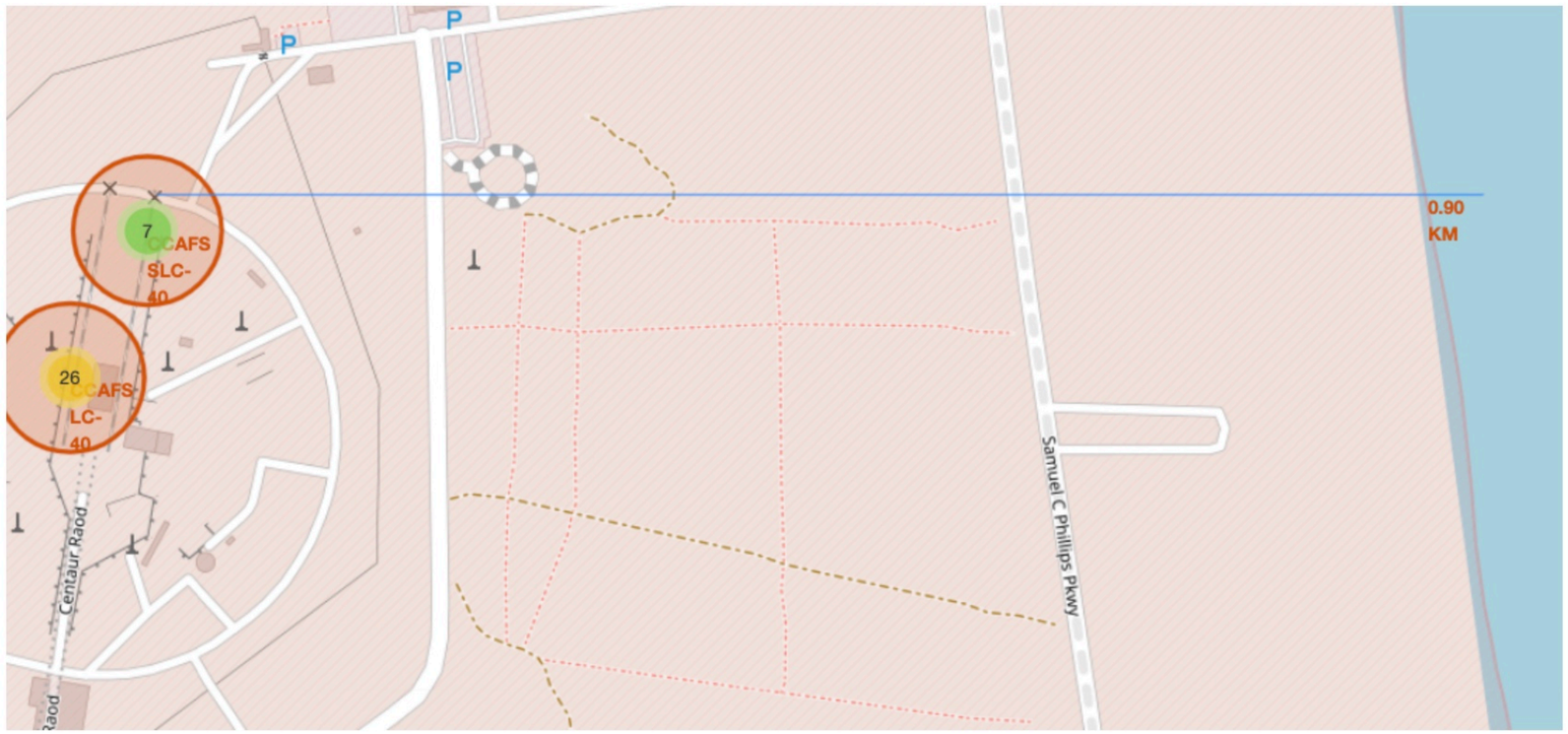
[19]:
```
# Create a `folium.PolyLine` object using the coastline coordinates and launch site coordinate
# lines=folium.PolyLine(locations=coordinates, weight=1)
coastline_coordinates = [[launch_site_lat, launch_site_lon], [coastline_lat, coastline_lon]]
lines = folium.PolyLine(locations=coastline_coordinates, weight=15)
site_map.add_child(lines)
```

[19]:



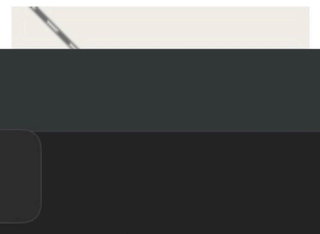
Leaflet | © OpenStreetMap contributors

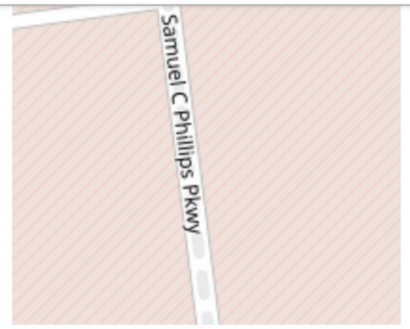
Your updated map with distance line should look like the following screenshot:



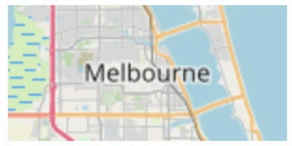
TODO: Similarly, you can draw a line betwee a launch site to its closest city, railway, highway, etc. You need to use `MousePosition` to find the their coordinates on the map first

A railway map symbol may look like this:

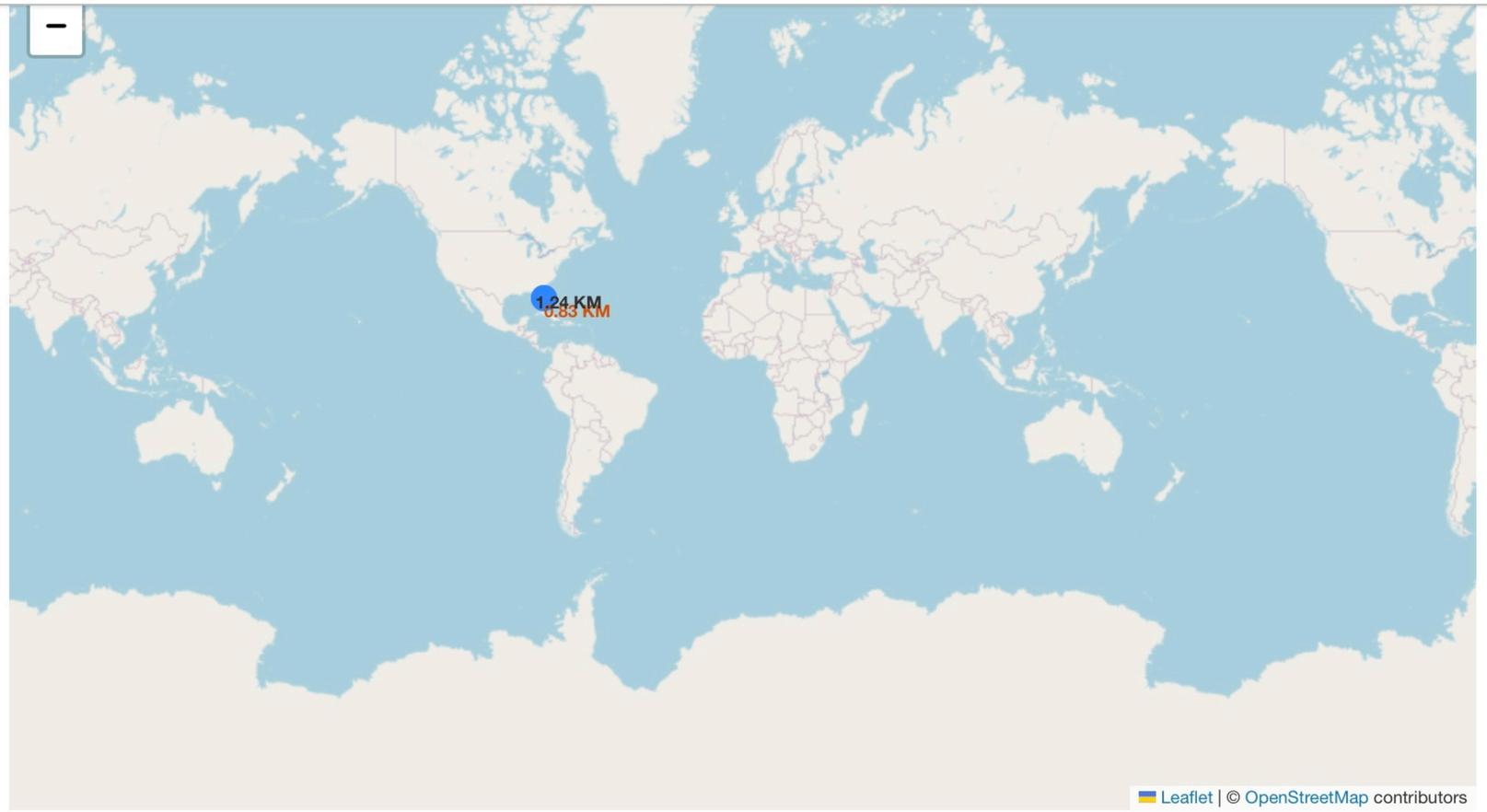




A city map symbol may look like this:



[20]:
```
railway_lat =28.57098
railway_lon= -80.58539
distance_railway = calculate_distance(launch_site_lat, launch_site_lon, railway_lat, railway_lon)
#site_map =folium.Map1(coordinate =[launch_site_lat,launch_site_lon],zoom_start=14)
#coordinate = [launch_site_lat, launch_site_lon]
#distance = distance_coastline
distance_marker1 = folium.Marker(
    coordinate,
    icon=DivIcon(
        icon_size=(150,36),
        icon_anchor=(--5,--5),
        html='<div style="font-size: 12; color:#d38d0e1;"><b>%s</b></div>' % "{:10.2f} KM".format(distance_rai
        )
    )
# Add the marker to the map
site_map.add_child(distance_marker1)
railway_coordinates = [[launch_site_lat, launch_site_lon], [railway_lat, railway_lon]]
lines1 = folium.PolyLine(locations=railway_coordinates, weight=13)
site_map.add_child(lines1)
```



[ ]:

[ ]:

After you plot distance lines to the proximities, you can answer the following questions easily:

- Are launch sites in close proximity to railways?
- Are launch sites in close proximity to highways?
- Are launch sites in close proximity to coastline?
- Do launch sites keep certain distance away from cities?