Launch Sites Locations Analysis 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:

In [1]:

```
!pip3 install folium
!pip3 install wget
```

```
Collecting folium
  Downloading folium-0.12.1.post1-py2.py3-none-any.whl (95 kB)
     |████████████████████████████████| 95 kB 6.2 MB/s  eta 0:00:01
Collecting branca>=0.3.0
  Downloading branca-0.5.0-py3-none-any.whl (24 kB)
Requirement already satisfied: numpy in /opt/conda/envs/Python-3.9/lib/python
3.9/site-packages (from folium) (1.20.3)
Requirement already satisfied: requests in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from folium) (2.26.0)
Requirement already satisfied: jinja2>=2.9 in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from folium) (3.0.2)
Requirement already satisfied: MarkupSafe>=2.0 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from jinja2>=2.9->folium) (2.0.1)
Requirement already satisfied: charset-normalizer~=2.0.0 in /opt/conda/envs/P
ython-3.9/lib/python3.9/site-packages (from requests->folium) (2.0.4)
Requirement already satisfied: idna<4,>=2.5 in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from requests->folium) (3.3)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/envs/Python-3
.9/lib/python3.9/site-packages (from requests->folium) (2022.5.18.1)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/envs/Pytho
n-3.9/lib/python3.9/site-packages (from requests->folium) (1.26.7)
Installing collected packages: branca, folium
Successfully installed branca-0.5.0 folium-0.12.1.post1
Collecting wget
```

```
  Downloading wget-3.2.zip (10 kB)
Building wheels for collected packages: wget
  Building wheel for wget (setup.py) ... done
  Created wheel for wget: filename=wget-3.2-py3-none-any.whl size=9672 sha256
=4e37e94ebcc022778bafc6598e20120ce23d24f183fb10c794ff590d5ff8cc2d
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/04/5f/3e/46cc37c5d698415
694d83f607f833f83f0149e49b3af9d0f38
Successfully built wget
Installing collected packages: wget
Successfully installed wget-3.2
```

In [2]:

```
import folium
import wget
import pandas as pd
!pip install folium==0.11.0
!pip install folium==0.12.1
```

```
Collecting folium==0.11.0
  Downloading folium-0.11.0-py2.py3-none-any.whl (93 kB)
     |████████████████████████████████| 93 kB 3.4 MB/s  eta 0:00:01
Requirement already satisfied: numpy in /opt/conda/envs/Python-3.9/lib/python
3.9/site-packages (from folium==0.11.0) (1.20.3)
Requirement already satisfied: requests in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from folium==0.11.0) (2.26.0)
Requirement already satisfied: branca>=0.3.0 in /opt/conda/envs/Python-3.9/li
b/python3.9/site-packages (from folium==0.11.0) (0.5.0)
Requirement already satisfied: jinja2>=2.9 in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from folium==0.11.0) (3.0.2)
Requirement already satisfied: MarkupSafe>=2.0 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from jinja2>=2.9->folium==0.11.0) (2.0.1)
Requirement already satisfied: charset-normalizer~=2.0.0 in /opt/conda/envs/P
ython-3.9/lib/python3.9/site-packages (from requests->folium==0.11.0) (2.0.4)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/envs/Python-3
.9/lib/python3.9/site-packages (from requests->folium==0.11.0) (2022.5.18.1)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/envs/Pytho
n-3.9/lib/python3.9/site-packages (from requests->folium==0.11.0) (1.26.7)
Requirement already satisfied: idna<4,>=2.5 in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from requests->folium==0.11.0) (3.3)
Installing collected packages: folium
  Attempting uninstall: folium
    Found existing installation: folium 0.12.1.post1
    Uninstalling folium-0.12.1.post1:
      Successfully uninstalled folium-0.12.1.post1
Successfully installed folium-0.11.0
Collecting folium==0.12.1
  Downloading folium-0.12.1-py2.py3-none-any.whl (94 kB)
     |████████████████████████████████| 94 kB 6.3 MB/s  eta 0:00:01
Requirement already satisfied: numpy in /opt/conda/envs/Python-3.9/lib/python
3.9/site-packages (from folium==0.12.1) (1.20.3)
```

```
Requirement already satisfied: jinja2>=2.9 in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from folium==0.12.1) (3.0.2)
Requirement already satisfied: branca>=0.3.0 in /opt/conda/envs/Python-3.9/li
b/python3.9/site-packages (from folium==0.12.1) (0.5.0)
Requirement already satisfied: requests in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from folium==0.12.1) (2.26.0)
Requirement already satisfied: MarkupSafe>=2.0 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from jinja2>=2.9->folium==0.12.1) (2.0.1)
Requirement already satisfied: idna<4,>=2.5 in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from requests->folium==0.12.1) (3.3)
Requirement already satisfied: charset-normalizer~=2.0.0 in /opt/conda/envs/P
ython-3.9/lib/python3.9/site-packages (from requests->folium==0.12.1) (2.0.4)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/envs/Python-3
.9/lib/python3.9/site-packages (from requests->folium==0.12.1) (2022.5.18.1)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/envs/Pytho
n-3.9/lib/python3.9/site-packages (from requests->folium==0.12.1) (1.26.7)
Installing collected packages: folium
  Attempting uninstall: folium
    Found existing installation: folium 0.11.0
    Uninstalling folium-0.11.0:
      Successfully uninstalled folium-0.11.0
Successfully installed folium-0.12.1
```

In [3]:

```
!pip install geemap
import geemap
import json
import os
import requests
from geemap import geojson_to_ee, ee_to_geojson
#from iplyleaflet import GeoJson, Marker, MarkerCluster
```

```
Collecting geemap
  Downloading geemap-0.13.8-py2.py3-none-any.whl (2.0 MB)
     |████████████████████████████████| 2.0 MB 18.8 MB/s eta 0:00:01
Collecting ffmpeg-python
  Downloading ffmpeg_python-0.2.0-py3-none-any.whl (25 kB)
Collecting gdown
  Downloading gdown-4.4.0.tar.gz (14 kB)
  Installing build dependencies ... done
  Getting requirements to build wheel ... done
    Preparing wheel metadata ... done
Collecting pycrs
  Downloading PyCRS-1.0.2.tar.gz (36 kB)
Collecting ee-extra>=0.0.10
  Downloading ee_extra-0.0.13.tar.gz (187 kB)
     |████████████████████████████████| 187 kB 55.8 MB/s eta 0:00:01
Collecting ipyleaflet>=0.14.0
  Downloading ipyleaflet-0.16.0-py2.py3-none-any.whl (3.3 MB)
     |████████████████████████████████| 3.3 MB 50.8 MB/s eta 0:00:01
```

```
Collecting pyshp>=2.1.3
  Downloading pyshp-2.3.0-py2.py3-none-any.whl (46 kB)
     |████████████████████████████████| 46 kB 8.9 MB/s  eta 0:00:01
Collecting jupyterlab>=3
  Downloading jupyterlab-3.4.2-py3-none-any.whl (8.8 MB)
     |████████████████████████████████| 8.8 MB 59.1 MB/s eta 0:00:01
Requirement already satisfied: pillow in /opt/conda/envs/Python-3.9/lib/pytho
n3.9/site-packages (from geemap) (9.0.1)
Collecting ipyevents
  Downloading ipyevents-2.0.1-py2.py3-none-any.whl (130 kB)
     |████████████████████████████████| 130 kB 62.7 MB/s eta 0:00:01
Requirement already satisfied: folium>=0.11.0 in /opt/conda/envs/Python-3.9/l
ib/python3.9/site-packages (from geemap) (0.12.1)
Collecting xyzservices
  Downloading xyzservices-2022.4.0-py3-none-any.whl (36 kB)
Collecting geocoder
  Downloading geocoder-1.38.1-py2.py3-none-any.whl (98 kB)
     |████████████████████████████████| 98 kB 17.2 MB/s eta 0:00:01
Collecting colour
  Downloading colour-0.1.5-py2.py3-none-any.whl (23 kB)
Collecting ipyfilechooser>=0.6.0
  Downloading ipyfilechooser-0.6.0-py3-none-any.whl (11 kB)
Collecting earthengine-api>=0.1.304
  Downloading earthengine-api-0.1.312.tar.gz (239 kB)
     |████████████████████████████████| 239 kB 60.9 MB/s eta 0:00:01
Collecting sankee
  Downloading sankee-0.0.7.tar.gz (29 kB)
Collecting bqplot
  Downloading bqplot-0.12.33-py2.py3-none-any.whl (1.2 MB)
     |████████████████████████████████| 1.2 MB 53.9 MB/s eta 0:00:01
Collecting whiteboxgui>=0.6.0
  Downloading whiteboxgui-0.7.0-py2.py3-none-any.whl (99 kB)
     |████████████████████████████████| 99 kB 18.0 MB/s eta 0:00:01
Collecting geeadd>=0.5.1
  Downloading geeadd-0.5.5-py3-none-any.whl (30 kB)
Collecting geojson
  Downloading geojson-2.5.0-py2.py3-none-any.whl (14 kB)
Collecting mapclassify>=2.4.0
  Downloading mapclassify-2.4.3-py3-none-any.whl (38 kB)
Requirement already satisfied: matplotlib in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from geemap) (3.5.0)
Requirement already satisfied: pandas in /opt/conda/envs/Python-3.9/lib/pytho
n3.9/site-packages (from geemap) (1.3.4)
Collecting ipytree
  Downloading ipytree-0.2.1-py2.py3-none-any.whl (1.3 MB)
     |████████████████████████████████| 1.3 MB 57.9 MB/s eta 0:00:01
Requirement already satisfied: numpy in /opt/conda/envs/Python-3.9/lib/python
3.9/site-packages (from geemap) (1.20.3)
Collecting python-box
```

```
  Downloading python_box-6.0.2-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_
x86_64.whl (3.3 MB)
     |████████████████████████████████| 3.3 MB 50.1 MB/s eta 0:00:01
Requirement already satisfied: future in /opt/conda/envs/Python-3.9/lib/pytho
n3.9/site-packages (from earthengine-api>=0.1.304->geemap) (0.18.2)
Collecting google-cloud-storage
  Downloading google_cloud_storage-2.3.0-py2.py3-none-any.whl (107 kB)
     |████████████████████████████████| 107 kB 63.0 MB/s eta 0:00:01
Collecting google-api-python-client<2,>=1.12.1
  Downloading google_api_python_client-1.12.11-py2.py3-none-any.whl (62 kB)
     |████████████████████████████████| 62 kB 1.7 MB/s  eta 0:00:01
Requirement already satisfied: google-auth>=1.4.1 in /opt/conda/envs/Python-3
.9/lib/python3.9/site-packages (from earthengine-api>=0.1.304->geemap) (1.23.
0)
Collecting google-auth-httplib2>=0.0.3
  Downloading google_auth_httplib2-0.1.0-py2.py3-none-any.whl (9.3 kB)
Collecting httplib2<1dev,>=0.9.2
  Downloading httplib2-0.20.4-py3-none-any.whl (96 kB)
     |████████████████████████████████| 96 kB 11.5 MB/s eta 0:00:01
Collecting httplib2shim
  Downloading httplib2shim-0.0.3.tar.gz (17 kB)
Requirement already satisfied: six in /opt/conda/envs/Python-3.9/lib/python3.
9/site-packages (from earthengine-api>=0.1.304->geemap) (1.15.0)
Requirement already satisfied: branca>=0.3.0 in /opt/conda/envs/Python-3.9/li
b/python3.9/site-packages (from folium>=0.11.0->geemap) (0.5.0)
Requirement already satisfied: jinja2>=2.9 in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from folium>=0.11.0->geemap) (3.0.2)
Requirement already satisfied: requests in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from folium>=0.11.0->geemap) (2.26.0)
Requirement already satisfied: beautifulsoup4>=4.9.0 in /opt/conda/envs/Pytho
n-3.9/lib/python3.9/site-packages (from geeadd>=0.5.1->geemap) (4.10.0)
Collecting logzero>=1.5.0
  Downloading logzero-1.7.0-py2.py3-none-any.whl (16 kB)
Requirement already satisfied: soupsieve>1.2 in /opt/conda/envs/Python-3.9/li
b/python3.9/site-packages (from beautifulsoup4>=4.9.0->geeadd>=0.5.1->geemap)
(2.3.1)
Collecting uritemplate<4dev,>=3.0.0
  Downloading uritemplate-3.0.1-py2.py3-none-any.whl (15 kB)
Collecting google-api-core<3dev,>=1.21.0
  Downloading google_api_core-2.8.1-py3-none-any.whl (114 kB)
     |████████████████████████████████| 114 kB 57.7 MB/s eta 0:00:01
Requirement already satisfied: protobuf<4.0.0dev,>=3.15.0 in /opt/conda/envs/
Python-3.9/lib/python3.9/site-packages (from google-api-core<3dev,>=1.21.0->g
oogle-api-python-client<2,>=1.12.1->earthengine-api>=0.1.304->geemap) (3.19.1
)
Collecting google-auth>=1.4.1
  Downloading google_auth-2.6.6-py2.py3-none-any.whl (156 kB)
     |████████████████████████████████| 156 kB 59.8 MB/s eta 0:00:01
Collecting googleapis-common-protos<2.0dev,>=1.56.2
```

```
  Downloading googleapis_common_protos-1.56.2-py2.py3-none-any.whl (211 kB)
     |████████████████████████████████| 211 kB 64.2 MB/s eta 0:00:01
Requirement already satisfied: rsa<5,>=3.1.4 in /opt/conda/envs/Python-3.9/li
b/python3.9/site-packages (from google-auth>=1.4.1->earthengine-api>=0.1.304-
>geemap) (4.7.2)
Requirement already satisfied: pyasn1-modules>=0.2.1 in /opt/conda/envs/Pytho
n-3.9/lib/python3.9/site-packages (from google-auth>=1.4.1->earthengine-api>=
0.1.304->geemap) (0.2.8)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in /opt/conda/envs/Pyth
on-3.9/lib/python3.9/site-packages (from google-auth>=1.4.1->earthengine-api>
=0.1.304->geemap) (4.2.2)
Requirement already satisfied: pyparsing!=3.0.0,!=3.0.1,!=3.0.2,!=3.0.3,<4,>=
2.4.2 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from httplib
2<1dev,>=0.9.2->earthengine-api>=0.1.304->geemap) (3.0.4)
Requirement already satisfied: ipywidgets in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from ipyfilechooser>=0.6.0->geemap) (7.6.5)
Collecting traittypes<3,>=0.2.1
  Downloading traittypes-0.2.1-py2.py3-none-any.whl (8.6 kB)
Requirement already satisfied: ipython>=4.0.0 in /opt/conda/envs/Python-3.9/l
ib/python3.9/site-packages (from ipywidgets->ipyfilechooser>=0.6.0->geemap) (
7.29.0)
Requirement already satisfied: traitlets>=4.3.1 in /opt/conda/envs/Python-3.9
/lib/python3.9/site-packages (from ipywidgets->ipyfilechooser>=0.6.0->geemap)
(5.1.1)
Requirement already satisfied: jupyterlab-widgets>=1.0.0 in /opt/conda/envs/P
ython-3.9/lib/python3.9/site-packages (from ipywidgets->ipyfilechooser>=0.6.0
->geemap) (1.0.0)
Requirement already satisfied: nbformat>=4.2.0 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from ipywidgets->ipyfilechooser>=0.6.0->geemap)
(5.1.3)
Requirement already satisfied: ipykernel>=4.5.1 in /opt/conda/envs/Python-3.9
/lib/python3.9/site-packages (from ipywidgets->ipyfilechooser>=0.6.0->geemap)
(6.4.1)
Requirement already satisfied: ipython-genutils~=0.2.0 in /opt/conda/envs/Pyt
hon-3.9/lib/python3.9/site-packages (from ipywidgets->ipyfilechooser>=0.6.0->
geemap) (0.2.0)
Requirement already satisfied: widgetsnbextension~=3.5.0 in /opt/conda/envs/P
ython-3.9/lib/python3.9/site-packages (from ipywidgets->ipyfilechooser>=0.6.0
->geemap) (3.5.1)
Requirement already satisfied: tornado<7.0,>=4.2 in /opt/conda/envs/Python-3.
9/lib/python3.9/site-packages (from ipykernel>=4.5.1->ipywidgets->ipyfilechoo
ser>=0.6.0->geemap) (6.1)
Requirement already satisfied: debugpy<2.0,>=1.0.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from ipykernel>=4.5.1->ipywidgets->ipyfilech
ooser>=0.6.0->geemap) (1.5.1)
Requirement already satisfied: jupyter-client<8.0 in /opt/conda/envs/Python-3
.9/lib/python3.9/site-packages (from ipykernel>=4.5.1->ipywidgets->ipyfilecho
oser>=0.6.0->geemap) (7.0.6)
```

```
Requirement already satisfied: matplotlib-inline<0.2.0,>=0.1.0 in /opt/conda/
envs/Python-3.9/lib/python3.9/site-packages (from ipykernel>=4.5.1->ipywidget
s->ipyfilechooser>=0.6.0->geemap) (0.1.2)
Requirement already satisfied: pexpect>4.3 in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from ipython>=4.0.0->ipywidgets->ipyfilechooser>=0.6
.0->geemap) (4.8.0)
Requirement already satisfied: decorator in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from ipython>=4.0.0->ipywidgets->ipyfilechooser>=0.6.0
->geemap) (5.1.0)
Requirement already satisfied: pickleshare in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from ipython>=4.0.0->ipywidgets->ipyfilechooser>=0.6
.0->geemap) (0.7.5)
Requirement already satisfied: jedi>=0.16 in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from ipython>=4.0.0->ipywidgets->ipyfilechooser>=0.6.
0->geemap) (0.18.0)
Requirement already satisfied: setuptools>=18.5 in /opt/conda/envs/Python-3.9
/lib/python3.9/site-packages (from ipython>=4.0.0->ipywidgets->ipyfilechooser
>=0.6.0->geemap) (58.0.4)
Requirement already satisfied: prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0 i
n /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ipython>=4.0.0
->ipywidgets->ipyfilechooser>=0.6.0->geemap) (3.0.20)
Requirement already satisfied: pygments in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from ipython>=4.0.0->ipywidgets->ipyfilechooser>=0.6.0-
>geemap) (2.10.0)
Requirement already satisfied: backcall in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from ipython>=4.0.0->ipywidgets->ipyfilechooser>=0.6.0-
>geemap) (0.2.0)
Requirement already satisfied: parso<0.9.0,>=0.8.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from jedi>=0.16->ipython>=4.0.0->ipywidgets-
>ipyfilechooser>=0.6.0->geemap) (0.8.3)
Requirement already satisfied: MarkupSafe>=2.0 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from jinja2>=2.9->folium>=0.11.0->geemap) (2.0.1
)
Requirement already satisfied: entrypoints in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from jupyter-client<8.0->ipykernel>=4.5.1->ipywidget
s->ipyfilechooser>=0.6.0->geemap) (0.3)
Requirement already satisfied: pyzmq>=13 in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from jupyter-client<8.0->ipykernel>=4.5.1->ipywidgets-
>ipyfilechooser>=0.6.0->geemap) (22.3.0)
Requirement already satisfied: python-dateutil>=2.1 in /opt/conda/envs/Python
-3.9/lib/python3.9/site-packages (from jupyter-client<8.0->ipykernel>=4.5.1->
ipywidgets->ipyfilechooser>=0.6.0->geemap) (2.8.2)
Requirement already satisfied: jupyter-core>=4.6.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from jupyter-client<8.0->ipykernel>=4.5.1->i
pywidgets->ipyfilechooser>=0.6.0->geemap) (4.9.1)
Requirement already satisfied: nest-asyncio>=1.5 in /opt/conda/envs/Python-3.
9/lib/python3.9/site-packages (from jupyter-client<8.0->ipykernel>=4.5.1->ipy
widgets->ipyfilechooser>=0.6.0->geemap) (1.5.1)
Collecting jupyter-server~=1.16
```

```
  Downloading jupyter_server-1.17.0-py3-none-any.whl (342 kB)
     |████████████████████████████████| 342 kB 60.2 MB/s eta 0:00:01
Collecting jupyterlab-server~=2.10
  Downloading jupyterlab_server-2.14.0-py3-none-any.whl (54 kB)
     |████████████████████████████████| 54 kB 6.6 MB/s  eta 0:00:01
Requirement already satisfied: packaging in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from jupyterlab>=3->geemap) (21.3)
Collecting nbclassic~=0.2
  Downloading nbclassic-0.3.7-py3-none-any.whl (13 kB)
Requirement already satisfied: prometheus-client in /opt/conda/envs/Python-3.
9/lib/python3.9/site-packages (from jupyter-server~=1.16->jupyterlab>=3->geem
ap) (0.12.0)
Requirement already satisfied: Send2Trash in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from jupyter-server~=1.16->jupyterlab>=3->geemap) (1.
8.0)
Collecting anyio<4,>=3.1.0
  Downloading anyio-3.6.1-py3-none-any.whl (80 kB)
     |████████████████████████████████| 80 kB 19.6 MB/s eta 0:00:01
Requirement already satisfied: argon2-cffi in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from jupyter-server~=1.16->jupyterlab>=3->geemap) (2
0.1.0)
Collecting nbformat>=4.2.0
  Downloading nbformat-5.4.0-py3-none-any.whl (73 kB)
     |████████████████████████████████| 73 kB 4.7 MB/s  eta 0:00:01
Requirement already satisfied: terminado>=0.8.3 in /opt/conda/envs/Python-3.9
/lib/python3.9/site-packages (from jupyter-server~=1.16->jupyterlab>=3->geema
p) (0.9.4)
Collecting nbconvert>=6.4.4
  Downloading nbconvert-6.5.0-py3-none-any.whl (561 kB)
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Collecting websocket-client
  Downloading websocket_client-1.3.2-py3-none-any.whl (54 kB)
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Requirement already satisfied: idna>=2.8 in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from anyio<4,>=3.1.0->jupyter-server~=1.16->jupyterlab
>=3->geemap) (3.3)
Collecting sniffio>=1.1
  Downloading sniffio-1.2.0-py3-none-any.whl (10 kB)
Collecting json5
  Downloading json5-0.9.8.tar.gz (22 kB)
Collecting babel
  Downloading Babel-2.10.1-py3-none-any.whl (9.5 MB)
     |████████████████████████████████| 9.5 MB 46.9 MB/s eta 0:00:01 eta 0:00
:01
Requirement already satisfied: jsonschema>=3.0.1 in /opt/conda/envs/Python-3.
9/lib/python3.9/site-packages (from jupyterlab-server~=2.10->jupyterlab>=3->g
eemap) (3.2.0)
Collecting jinja2>=2.9
  Downloading Jinja2-3.1.2-py3-none-any.whl (133 kB)
```

```
     |████████████████████████████████| 133 kB 58.3 MB/s eta 0:00:01
Requirement already satisfied: importlib-metadata>=3.6 in /opt/conda/envs/Pyth
on-3.9/lib/python3.9/site-packages (from jupyterlab-server~=2.10->jupyterlab
>=3->geemap) (4.8.2)
Requirement already satisfied: zipp>=0.5 in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from importlib-metadata>=3.6->jupyterlab-server~=2.10-
>jupyterlab>=3->geemap) (3.6.0)
Requirement already satisfied: attrs>=17.4.0 in /opt/conda/envs/Python-3.9/li
b/python3.9/site-packages (from jsonschema>=3.0.1->jupyterlab-server~=2.10->j
upyterlab>=3->geemap) (21.2.0)
Requirement already satisfied: pyrsistent>=0.14.0 in /opt/conda/envs/Python-3
.9/lib/python3.9/site-packages (from jsonschema>=3.0.1->jupyterlab-server~=2.
10->jupyterlab>=3->geemap) (0.18.0)
Requirement already satisfied: networkx in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from mapclassify>=2.4.0->geemap) (2.6.3)
Requirement already satisfied: scikit-learn in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from mapclassify>=2.4.0->geemap) (1.0.2)
Requirement already satisfied: scipy>=1.0 in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from mapclassify>=2.4.0->geemap) (1.7.3)
Collecting notebook-shim>=0.1.0
  Downloading notebook_shim-0.1.0-py3-none-any.whl (13 kB)
Requirement already satisfied: notebook<7 in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from nbclassic~=0.2->jupyterlab>=3->geemap) (6.4.6)
Requirement already satisfied: pandocfilters>=1.4.1 in /opt/conda/envs/Python
-3.9/lib/python3.9/site-packages (from nbconvert>=6.4.4->jupyter-server~=1.16
->jupyterlab>=3->geemap) (1.4.3)
Requirement already satisfied: jupyterlab-pygments in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from nbconvert>=6.4.4->jupyter-server~=1.16-
>jupyterlab>=3->geemap) (0.1.2)
Requirement already satisfied: nbclient>=0.5.0 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from nbconvert>=6.4.4->jupyter-server~=1.16->jup
yterlab>=3->geemap) (0.5.3)
Collecting tinycss2
  Downloading tinycss2-1.1.1-py3-none-any.whl (21 kB)
Requirement already satisfied: defusedxml in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from nbconvert>=6.4.4->jupyter-server~=1.16->jupyterl
ab>=3->geemap) (0.7.1)
Requirement already satisfied: bleach in /opt/conda/envs/Python-3.9/lib/pytho
n3.9/site-packages (from nbconvert>=6.4.4->jupyter-server~=1.16->jupyterlab>=
3->geemap) (4.0.0)
Requirement already satisfied: mistune<2,>=0.8.1 in /opt/conda/envs/Python-3.
9/lib/python3.9/site-packages (from nbconvert>=6.4.4->jupyter-server~=1.16->j
upyterlab>=3->geemap) (0.8.4)
Requirement already satisfied: async-generator in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from nbclient>=0.5.0->nbconvert>=6.4.4->jupyter-
server~=1.16->jupyterlab>=3->geemap) (1.10)
Collecting fastjsonschema
  Downloading fastjsonschema-2.15.3-py3-none-any.whl (22 kB)
```

```
Requirement already satisfied: pytz>=2017.3 in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from pandas->geemap) (2021.3)
Requirement already satisfied: ptyprocess>=0.5 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from pexpect>4.3->ipython>=4.0.0->ipywidgets->ip
yfilechooser>=0.6.0->geemap) (0.7.0)
Requirement already satisfied: wcwidth in /opt/conda/envs/Python-3.9/lib/pyth
on3.9/site-packages (from prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0->ipyth
on>=4.0.0->ipywidgets->ipyfilechooser>=0.6.0->geemap) (0.2.5)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in /opt/conda/envs/Python
-3.9/lib/python3.9/site-packages (from pyasn1-modules>=0.2.1->google-auth>=1.
4.1->earthengine-api>=0.1.304->geemap) (0.4.8)
Requirement already satisfied: charset-normalizer~=2.0.0 in /opt/conda/envs/P
ython-3.9/lib/python3.9/site-packages (from requests->folium>=0.11.0->geemap)
(2.0.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/envs/Pytho
n-3.9/lib/python3.9/site-packages (from requests->folium>=0.11.0->geemap) (1.
26.7)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/envs/Python-3
.9/lib/python3.9/site-packages (from requests->folium>=0.11.0->geemap) (2022.
5.18.1)
Collecting whitebox
  Downloading whitebox-2.1.2-py2.py3-none-any.whl (75 kB)
     |████████████████████████████████| 75 kB 9.1 MB/s  eta 0:00:01
Requirement already satisfied: cffi>=1.0.0 in /opt/conda/envs/Python-3.9/lib/
python3.9/site-packages (from argon2-cffi->jupyter-server~=1.16->jupyterlab>=
3->geemap) (1.14.6)
Requirement already satisfied: pycparser in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from cffi>=1.0.0->argon2-cffi->jupyter-server~=1.16->j
upyterlab>=3->geemap) (2.21)
Requirement already satisfied: webencodings in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from bleach->nbconvert>=6.4.4->jupyter-server~=1.16
->jupyterlab>=3->geemap) (0.5.1)
Collecting filelock
  Downloading filelock-3.7.1-py3-none-any.whl (10 kB)
Requirement already satisfied: tqdm in /opt/conda/envs/Python-3.9/lib/python3
.9/site-packages (from gdown->geemap) (4.62.3)
Requirement already satisfied: click in /opt/conda/envs/Python-3.9/lib/python
3.9/site-packages (from geocoder->geemap) (8.0.3)
Collecting ratelim
  Downloading ratelim-0.1.6-py2.py3-none-any.whl (4.0 kB)
Collecting google-resumable-media>=2.3.2
  Downloading google_resumable_media-2.3.3-py2.py3-none-any.whl (76 kB)
     |████████████████████████████████| 76 kB 12.0 MB/s eta 0:00:01
Collecting google-cloud-core<3.0dev,>=2.3.0
  Downloading google_cloud_core-2.3.0-py2.py3-none-any.whl (29 kB)
Collecting google-crc32c<2.0dev,>=1.0
  Downloading google_crc32c-1.3.0-cp39-cp39-manylinux_2_12_x86_64.manylinux20
10_x86_64.whl (36 kB)
```

```
Requirement already satisfied: cycler>=0.10 in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from matplotlib->geemap) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in /opt/conda/envs/Python-3.
9/lib/python3.9/site-packages (from matplotlib->geemap) (4.25.0)
Requirement already satisfied: kiwisolver>=1.0.1 in /opt/conda/envs/Python-3.
9/lib/python3.9/site-packages (from matplotlib->geemap) (1.3.1)
Requirement already satisfied: PySocks!=1.5.7,>=1.5.6 in /opt/conda/envs/Pyth
on-3.9/lib/python3.9/site-packages (from requests->folium>=0.11.0->geemap) (1
.7.1)
Collecting plotly>=5.2.2
  Downloading plotly-5.8.0-py2.py3-none-any.whl (15.2 MB)
     |████████████████████████████████| 15.2 MB 51.8 MB/s eta 0:00:01
Requirement already satisfied: tenacity>=6.2.0 in /opt/conda/envs/Python-3.9/
lib/python3.9/site-packages (from plotly>=5.2.2->sankee->geemap) (8.0.1)
Requirement already satisfied: joblib>=0.11 in /opt/conda/envs/Python-3.9/lib
/python3.9/site-packages (from scikit-learn->mapclassify>=2.4.0->geemap) (0.1
7.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /opt/conda/envs/Python
-3.9/lib/python3.9/site-packages (from scikit-learn->mapclassify>=2.4.0->geem
ap) (2.2.0)
Building wheels for collected packages: earthengine-api, ee-extra, gdown, htt
plib2shim, json5, pycrs, sankee
  Building wheel for earthengine-api (setup.py) ... done
  Created wheel for earthengine-api: filename=earthengine_api-0.1.312-py3-non
e-any.whl size=268583 sha256=480747805e65effe8326093e8d1c7d08870d136ac95061ca
b3e9a4b3b72451d8
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/c9/60/69/40143710d9f5758
911f2dc532c978a540cc75b6ca3911bc3f6
  Building wheel for ee-extra (setup.py) ... done
  Created wheel for ee-extra: filename=ee_extra-0.0.13-py3-none-any.whl size=
198406 sha256=cb3037ee50add687a2dfc00328da57a1fa53daecede016e7a22754bc90433df
f
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/a7/bf/16/b672866aae85ccd
76c15853a8f3311d87eb679a0f0d38fe01d
  Building wheel for gdown (PEP 517) ... done
  Created wheel for gdown: filename=gdown-4.4.0-py3-none-any.whl size=14759 s
ha256=88ac099ab0aac9fdb1d02537678440f7d4446c7d5153584c8f1e6e161db478a6
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/7d/37/b6/b2a79c75e898c0b
8e46ff255102602d7159a10d9af0d80641a
  Building wheel for httplib2shim (setup.py) ... done
  Created wheel for httplib2shim: filename=httplib2shim-0.0.3-py2.py3-none-an
y.whl size=18058 sha256=1c416892c5d4b7e20b0f9e9a0d80c1ce2f5d602438b896e6e140a
6b6272f13e4
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/cc/e7/8f/8a433809ef32e27
c1f24d80effef7dde1212f72fec13df73aa
  Building wheel for json5 (setup.py) ... done
  Created wheel for json5: filename=json5-0.9.8-py2.py3-none-any.whl size=186
06 sha256=7ffca8db0c2d1af32e161eeb2a1213993266cd1ef436c7f529c7c8836147a00f
```

```
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/33/13/22/d6429949983cbc0
14ae883a13af8b3ce949adcc4cf9196a4b9
  Building wheel for pycrs (setup.py) ... done
  Created wheel for pycrs: filename=PyCRS-1.0.2-py3-none-any.whl size=32704 s
ha256=7f8dcb908efd6cc97bcfbe6cc1e23cb51f47348e104a644d82c9459b6fe26766
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/94/01/24/bc7bff66667ef31
7615144a15e04593a08d9bb322f2c427d6c
  Building wheel for sankee (setup.py) ... done
  Created wheel for sankee: filename=sankee-0.0.7-py3-none-any.whl size=27640
sha256=a6f094b5cf9c4ee80e36a4137443b439bb82f769d590502935073792e977f644
  Stored in directory: /tmp/wsuser/.cache/pip/wheels/8c/8b/5f/9064446073c3836
eedbf134410e8453587df0fab4833ebaba0
Successfully built earthengine-api ee-extra gdown httplib2shim json5 pycrs sa
nkee
Installing collected packages: fastjsonschema, nbformat, tinycss2, jinja2, sn
iffio, nbconvert, googleapis-common-protos, google-auth, websocket-client, ht
tplib2, google-crc32c, google-api-core, anyio, uritemplate, jupyter-server, g
oogle-resumable-media, google-cloud-core, google-auth-httplib2, notebook-shim
, json5, httplib2shim, google-cloud-storage, google-api-python-client, babel,
xyzservices, whitebox, traittypes, ratelim, plotly, nbclassic, logzero, jupyt
erlab-server, ipytree, ipyfilechooser, filelock, earthengine-api, whiteboxgui
, sankee, python-box, pyshp, pycrs, mapclassify, jupyterlab, ipyleaflet, ipye
vents, geojson, geocoder, geeadd, gdown, ffmpeg-python, ee-extra, colour, bqp
lot, geemap
  Attempting uninstall: nbformat
    Found existing installation: nbformat 5.1.3
    Uninstalling nbformat-5.1.3:
      Successfully uninstalled nbformat-5.1.3
  Attempting uninstall: jinja2
    Found existing installation: Jinja2 3.0.2
    Uninstalling Jinja2-3.0.2:
      Successfully uninstalled Jinja2-3.0.2
  Attempting uninstall: nbconvert
    Found existing installation: nbconvert 6.1.0
    Uninstalling nbconvert-6.1.0:
      Successfully uninstalled nbconvert-6.1.0
  Attempting uninstall: googleapis-common-protos
    Found existing installation: googleapis-common-protos 1.52.0
    Uninstalling googleapis-common-protos-1.52.0:
      Successfully uninstalled googleapis-common-protos-1.52.0
  Attempting uninstall: google-auth
    Found existing installation: google-auth 1.23.0
    Uninstalling google-auth-1.23.0:
      Successfully uninstalled google-auth-1.23.0
  Attempting uninstall: plotly
    Found existing installation: plotly 5.1.0
    Uninstalling plotly-5.1.0:
      Successfully uninstalled plotly-5.1.0
```

```
Successfully installed anyio-3.6.1 babel-2.10.1 bqplot-0.12.33 colour-0.1.5 e
arthengine-api-0.1.312 ee-extra-0.0.13 fastjsonschema-2.15.3 ffmpeg-python-0.
2.0 filelock-3.7.1 gdown-4.4.0 geeadd-0.5.5 geemap-0.13.8 geocoder-1.38.1 geo
json-2.5.0 google-api-core-2.8.1 google-api-python-client-1.12.11 google-auth
-2.6.6 google-auth-httplib2-0.1.0 google-cloud-core-2.3.0 google-cloud-storag
e-2.3.0 google-crc32c-1.3.0 google-resumable-media-2.3.3 googleapis-common-pr
otos-1.56.2 httplib2-0.20.4 httplib2shim-0.0.3 ipyevents-2.0.1 ipyfilechooser
-0.6.0 ipyleaflet-0.16.0 ipytree-0.2.1 jinja2-3.1.2 json5-0.9.8 jupyter-serve
r-1.17.0 jupyterlab-3.4.2 jupyterlab-server-2.14.0 logzero-1.7.0 mapclassify-
2.4.3 nbclassic-0.3.7 nbconvert-6.5.0 nbformat-5.4.0 notebook-shim-0.1.0 plot
ly-5.8.0 pycrs-1.0.2 pyshp-2.3.0 python-box-6.0.2 ratelim-0.1.6 sankee-0.0.7
sniffio-1.2.0 tinycss2-1.1.1 traittypes-0.2.1 uritemplate-3.0.1 websocket-cli
ent-1.3.2 whitebox-2.1.2 whiteboxgui-0.7.0 xyzservices-2022.4.0
```

In [4]:

```
# Import folium MarkerCluster plugin
import folium
from folium.plugins import MarkerCluster
#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

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.

In [5]:

```
# Download and read the `spacex_launch_geo.csv`
spacex_csv_file = wget.download('https://cf-courses-data.s3.us.cloud-object-s
torage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/spacex_launch_geo.
csv')
spacex_df=pd.read_csv(spacex_csv_file)
```

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

In [6]:

```
# Select relevant sub-columns: `Launch Site`, `Lat(Latitude)`, `Long(Longitud
e)`, `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
```

Out[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.

In [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,

In [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=Tr
ue).add_child(folium.Popup('NASA Johnson Space Center'))
# 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)
```

Out[8]:

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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
An example of folium.Circle:
`folium.Circle(coordinate, radius=1000, color='#000000', fill=True).add_child(folium.Popup(...))`
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', ))`

In [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 Launch site name as a popup label
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'])).add_to(site_map)
    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>' % row['Launch Site'], )).add_to(site_map)
site_map
```

Out[9]:

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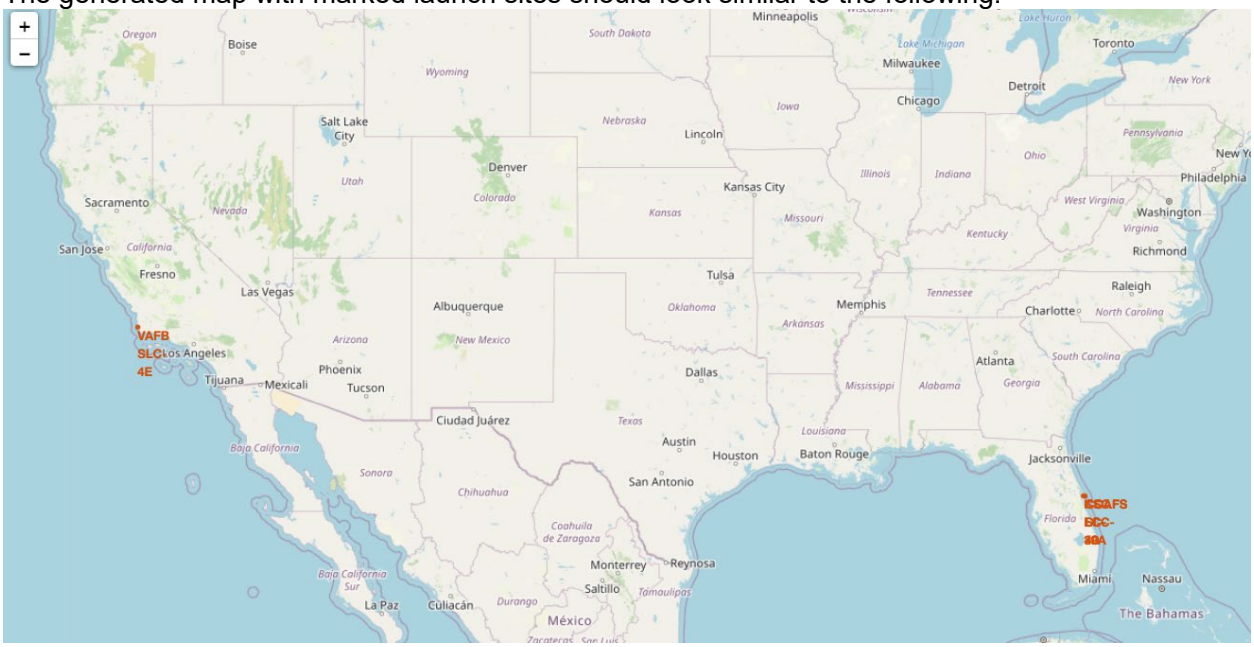
The generated map with marked launch sites should look similar to the following:



Now, you can explore the map by zoom-in/out the marked areas , and try to answer the following questions:

- Are all launch sites in proximity to the Equator line?
- Are all launch sites in very close proximity to the coast?

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

In [10]:

```
spacex_df.tail(10)
```

Out[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.
Let's first create a `MarkerCluster` object

In [11]:

```
marker_cluster = MarkerCluster()
```

TODO: Create a new column in `launch_sites` dataframe called `marker_color` to store the marker colors based on the `class` value

In [ ]:

```
# 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
```

In [12]:

```
# Function to assign color to launch outcome
def assign_marker_color(launch_outcome):
    if launch_outcome == 1:
        return 'green'
    else:
        return 'red'

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

Out[12]:

	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`

In [13]:

```
# Add marker_cluster to current site_map
```

```
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 suc
cessed or failed,
# e.g., icon=folium.Icon(color='white', icon_color=row['marker_color']

for index, row in spacex_df.iterrows():
    # create and add a Marker cluster to the site map
    coordinate = [row['Lat'], row['Long']]
    folium.map.Marker(coordinate, icon=folium.Icon(color='white',icon_color=r
ow['marker_color'])).add_to(marker_cluster)
site_map
```

Out[13]:

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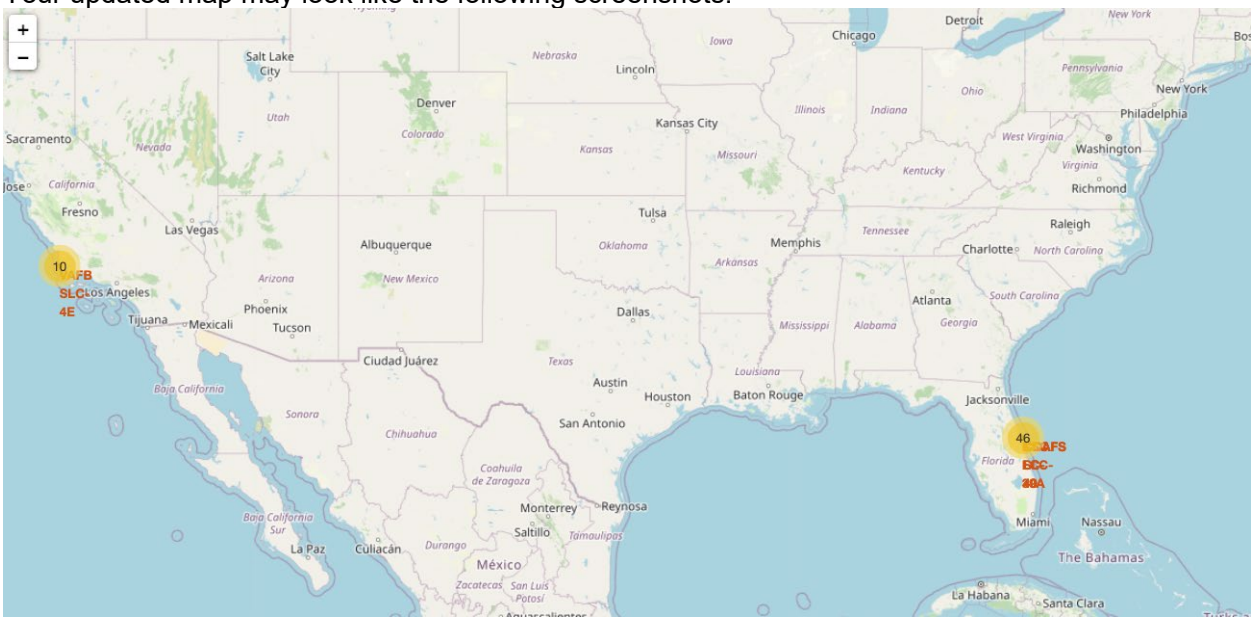
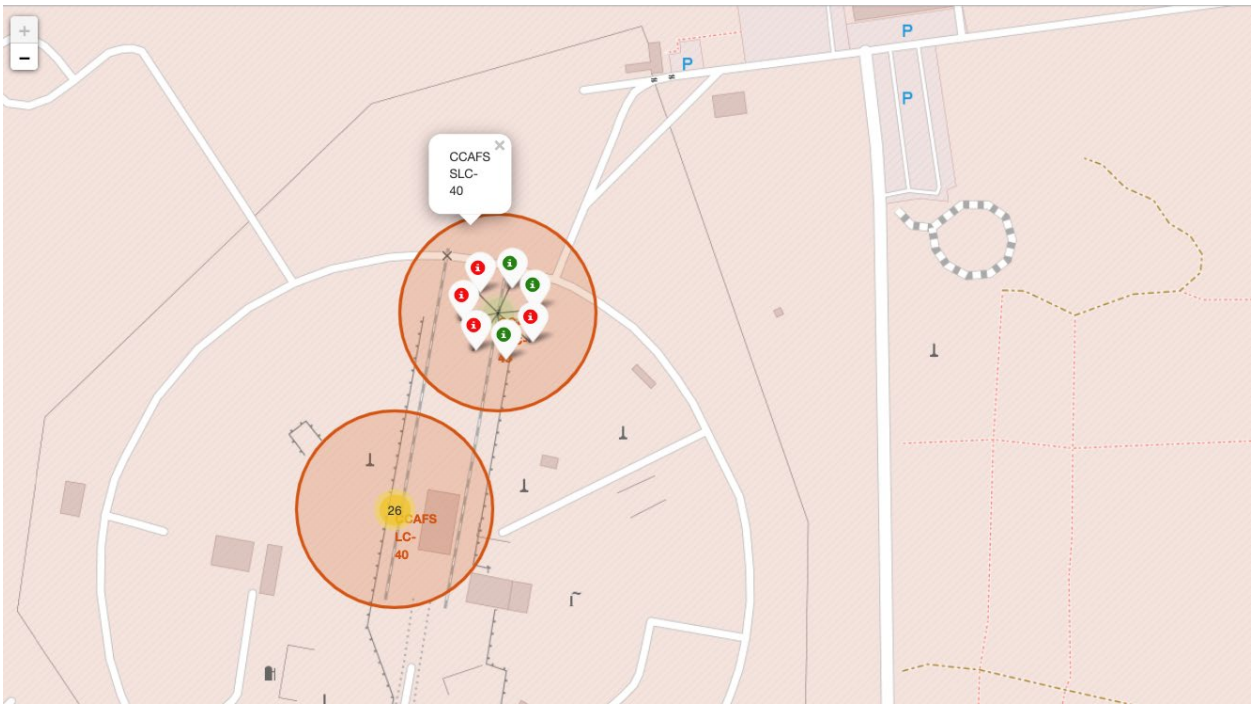
Your updated map may look like the following screenshots:





From the color-labeled markers in marker clusters, you should be able to easily identify which launch sites have relatively high success rates.

TASK 3: Calculate the distances between a launch site to its proximities

Next, we need to explore and analyze the proximities of launch sites.

Let's first add a `MousePosition` on the map to get coordinate for a mouse over a point on the map. As such, while you are exploring the map, you can easily find the coordinates of any points of interests (such as railway)

In [14]:

```
# Add Mouse Position to get the coordinate (Lat, Long) for a mouse over on th
e 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
```

Out[14]:

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Now zoom in to a launch site and explore its proximity to see if you can easily find any railway, highway, coastline, etc. Move your mouse to these points and mark down their coordinates (shown on the top-left) in order to the distance to the launch site.
You can calculate the distance between two points on the map based on their `Lat` and `Long` values using the following method:

In [15]:

```
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.

In [22]:

```
# find coordinate of the closet coastline
# e.g.,: Lat: 28.56367  Lon: -80.57163
# distance_coastline = calculate_distance(launch_site_lat, launch_site_lon, c
oastline_lat, coastline_lon)
launch_site_lat = 28.563197
launch_site_lon = -80.576820
coastline_lat = 28.56334
coastline_lon = -80.56799
distance_coastline = calculate_distance(launch_site_lat, launch_site_lon, coa
stline_lat, coastline_lon)
print(distance_coastline,' km')
```

```
0.8627671182499878  km
```

TODO: After obtained its coordinate, create a `folium.Marker` to show the distance

In [24]:

```
# 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),
#        )
#    )

distance_marker = folium.Marker(
   [coastline_lat, coastline_lon],
   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_coastline),
       )
   )
site_map.add_child(distance_marker)
```

Out[24]:

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

In [25]:

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

Out[25]:

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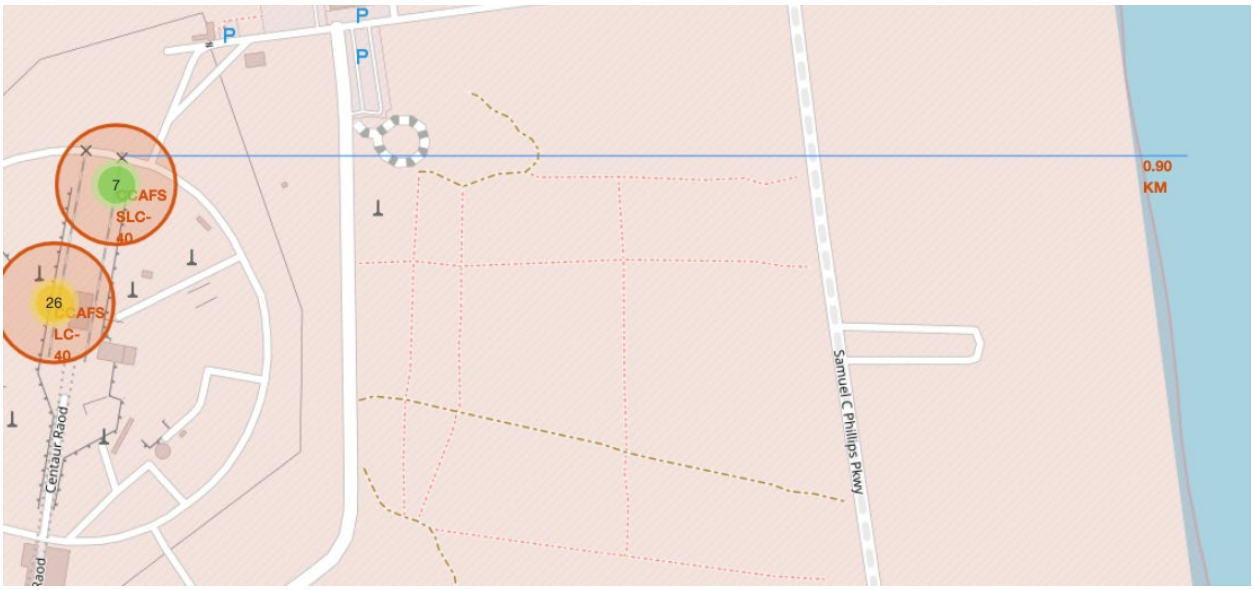
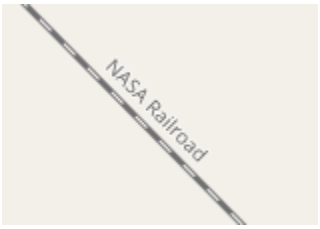
Your updated map with distance line should look like the following screenshot:

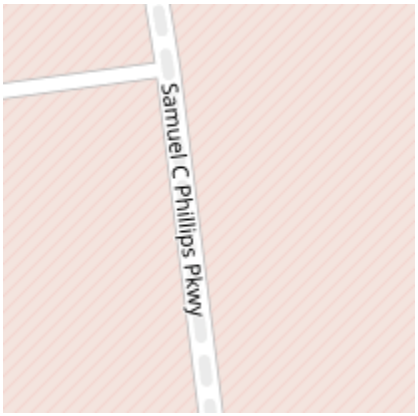


TODO: Similarly, you can draw a line betwee a launch site to its closest city, railway, highway, etc. You need to use `MousePosition` to find the their coordinates on the map first

A railway map symbol may look like this:



A highway map symbol may look like this:



A city map symbol may look like this:

In [27]:

```
# Create a marker with distance to a closest city, railway, highway, etc.
# Draw a line between the marker to the launch site
closest_highway = 28.56335, -80.57085
closest_railroad = 28.57206, -80.58525
```

```
closest_city = 28.10473, -80.64531
```

In [28]:

```
distance_highway = calculate_distance(launch_site_lat, launch_site_lon, close
st_highway[0], closest_highway[1])
print('distance_highway =',distance_highway, ' km')
distance_railroad = calculate_distance(launch_site_lat, launch_site_lon, clos
est_railroad[0], closest_railroad[1])
print('distance_railroad =',distance_railroad, ' km')
distance_city = calculate_distance(launch_site_lat, launch_site_lon, closest_
city[0], closest_city[1])
print('distance_city =',distance_city, ' km')
```

```
distance_highway = 0.5834695366934144  km
distance_railroad = 1.2845344718142522  km
distance_city = 51.43416999517233  km
```

In [29]:

```
distance_marker = folium.Marker(
   closest_highway,
   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_highway),
       )
   )
site_map.add_child(distance_marker)
# closest highway line
coordinates = [[launch_site_lat,launch_site_lon],closest_highway]
lines=folium.PolyLine(locations=coordinates, weight=1)
site_map.add_child(lines)

# closest railroad marker
distance_marker = folium.Marker(
   closest_railroad,
   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_railroad),
       )
   )
site_map.add_child(distance_marker)
# closest railroad line
coordinates = [[launch_site_lat,launch_site_lon],closest_railroad]
lines=folium.PolyLine(locations=coordinates, weight=1)
site_map.add_child(lines)

# closest city marker
distance_marker = folium.Marker(
```

```
    closest_city,
    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_city),
        )
    )
site_map.add_child(distance_marker)
# closest city line
coordinates = [[launch_site_lat,launch_site_lon],closest_city]
lines=folium.PolyLine(locations=coordinates, weight=1)
site_map.add_child(lines)
```

Out[29]:

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In [ ]:

```
After you plot distance lines to the proximities, you can answer the followin
g 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?
Also please try to explain your findings.
```

In [ ]:

```
Yes, the launch sites are in close proximity to coastline so they can fly ove
r the ocean during launch
Yes, the launch sites are in close proximity to highways making them asseable
to the workers
Yes, launch sites are in close proximity to railways making them assesable to
part that can help in assembly
Yes, launch sites are not in close proximity to cities which is good. This ke
eps people safe
```

Next Steps:

Now you have discovered many interesting insights related to the launch sites' location using folium, in a very interactive way. Next, you will need to build a dashboard using Ploty Dash on detailed launch records.

Authors

Yan Luo

Other Contributors

Joseph Santarcangelo

Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2021-05-26	1.0	Yan	Created the initial version