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```
# Install package for obtaining USGS streamflow data
!pip install -U dataretrieval
# Import the functions for downloading data from NWIS
import dataretrieval.nwis as nwis

# Specify the USGS site code
site = '04201500'  # This code refers to the Rocky River near Berea OH

# Get instantaneous values (iv)
df = nwis.get_record(sites=site, service='dv', start='2017-01-01', end='2022-
02-18')
df
```

	00010_Maximum	**00010_Maximum_cd**	**site_no**	**00010_Minimum**	**00010_Minimum_cd**	**00010_Mean**	**00010_Mean_cd**	**00060_Mean**	**00060_Mean_cd**
datetime									
2017-01-01 00:00:00+00:00	NaN	NaN	04201500	NaN	NaN	NaN	NaN	123.0	A
2017-01-02 00:00:00+00:00	NaN	NaN	04201500	NaN	NaN	NaN	NaN	107.0	A
2017-01-03 00:00:00+00:00	NaN	NaN	04201500	NaN	NaN	NaN	NaN	363.0	A
2017-01-04 00:00:00+00:00	NaN	NaN	04201500	NaN	NaN	NaN	NaN	1710.0	A
2017-01-05 00:00:00+00:00	NaN	NaN	04201500	NaN	NaN	NaN	NaN	549.0	A
...	...	...	...	...	...	...	...	...	...
2022-02-13 00:00:0	-999999.0	P, Eqp	04201500	-999999.0	P, Eqp	-999999.0	P, Eqp	728.0	P

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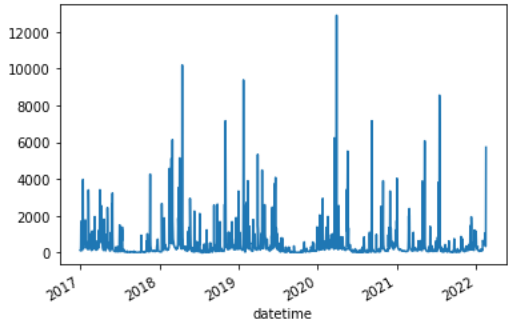
	00010_Maximum	00010_Maximum_cd	site_no	00010_Minimum	00010_Minimum_cd	00010_Mean	00010_Mean_cd	00060_Mean	00060_Mean_cd
datetime									
0+00:00									
2022-02-14 00:00:00+00:00	-999999.0	P, Eqp	04201500	-999999.0	P, Eqp	-999999.0	P, Eqp	451.0	P
2022-02-15 00:00:00+00:00	-999999.0	P, Eqp	04201500	-999999.0	P, Eqp	-999999.0	P, Eqp	343.0	P
2022-02-16 00:00:00+00:00	-999999.0	P, Eqp	04201500	-999999.0	P, Eqp	-999999.0	P, Eqp	382.0	P
2022-02-17 00:00:00+00:00	-999999.0	P, Eqp	04201500	-999999.0	P, Eqp	-999999.0	P, Eqp	5730.0	P

1867 rows × 9 columns

```
# Simple plot
df['00060_Mean'].plot()
<AxesSubplot:xlabel='datetime'>
```



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Question 1

The plot above shows the mean daily discharge (in cubic feet per second) of the Rocky River in Berea OH for the last 5 years. Here we can see an intra-annual cycle where discharge regularly increases during the melt season (February-April).

Question 2

Make an HTML table that contains the site name, site number and mean daily discharge between Oct 31, 2020 and Sep 30, 2021 (zero decimal places)** for three rivers in the US.

```
# Specify the USGS site code
willamette = '14211720'  # WILLAMETTE RIVER AT EUGENE, OR
mississippi = '07032000' # MISSISSIPPI RIVER AT MEMPHIS, TN
detroit = '04165710' # DETROIT RIVER AT FORT WAYNE AT DETROIT, MI

# Get instantaneous values (iv)
wdf = nwis.get_record(sites=willamette, service='dv', start='2020-10-31',
end='2021-09-30')
mdf = nwis.get_record(sites=mississippi, service='dv', start='2020-10-31',
end='2021-09-30')
ddf = nwis.get_record(sites=detroit, service='dv', start='2020-10-31',
end='2021-09-30')
wdf_mean_discharge = wdf['00060_Mean'].mean()
mdf_mean_discharge = mdf['00060_Mean'].mean()
ddf_mean_discharge = ddf['00060_Mean'].mean()

print("wdf = %.0f; mdf = %.0f; ddf = %.0f" %
(wdf_mean_discharge,mdf_mean_discharge,ddf_mean_discharge))
wdf = 27817; mdf = 572510; ddf = 234536
```

Site Name	Site Number	Mean Daily Discharge (between Oct 31, 2020 and Sep 30, 2021)
WILLAMETTE RIVER AT EUGENE, OR	14211720	27817
MISSISSIPPI RIVER AT MEMPHIS, TN	07032000	572510
DETROIT RIVER AT FORT WAYNE AT DETROIT, MI	04165710	234536

```
# Import packages
import numpy as np
import pandas as pd
import folium
# Read HTML table data
mountains =
pd.read_html('https://en.wikipedia.org/wiki/List_of_mountain_peaks_of_Oregon'
)
mountains
```

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```
# We would like the table that contains the highest summits of Oregon which
happens to be the second one
mountain_stats = mountains[1]
# Some wrangling
mountain_stats['Location'] =
mountain_stats['Location'].str.replace(mountain_stats['Location'].loc[0],
"45°22′25″N 121°41′45″W\ufeff / \ufeff45.3735°N 121.6959°W", regex=True)
mountain_stats
```

	Rank	Mountain peak	Mountain range	Elevation	Prominence	Isolation	Location
0	1	Mount Hood[6][7][8][9][a]	Cascade Range	3428.8 m	2349 m	92.2 km	45°22′25″N 121°41′45″W / 45.3735°N 121.6959°W
1	2	Mount Jefferson[10][11][12][13][b]	Cascade Range	3201 m	1767 m	77.5 km	44°40′27″N 121°47′59″W / 44.6743°N 121.7996°W
2	3	South Sister[14][15][16][17]	Cascade Range	3158.5 m	1705 m	63.4 km	44°06′13″N 121°46′09″W / 44.1035°N 121.7693°W
3	4	North Sister[18][19][20][21][c]	Cascade Range	3075 m	837 m	7 km	44°10′00″N 121°46′20″W / 44.1666°N 121.7723°W
4	5	Middle Sister[22][23][24][25][d]	Cascade Range	3064 m	382 m	1.8 km	44°08′54″N 121°47′02″W / 44.1483°N 121.7840°W
5	6	Sacajawea Peak[26][27][28][e][f]	Wallowa Mountains	3000 m	1949 m	202 km	45°14′42″N 117°17′34″W / 45.2450°N 117.2929°W
6	7	Steens Mountain[29][30][31][g]	Steens Mountain	2968 m	1336 m	201 km	42°38′11″N 118°34′36″W / 42.6364°N 118.5767°W
7	8	Aneroid Mountain[32][33][34][35]	Wallowa Mountains	2958.7 m	647 m	9.48 km	45°12′11″N 117°10′30″W / 45.2030°N 117.1750°W
8	9	Twin Peaks[36][37][38][h]	Wallowa Mountains	2950 m	610 m	7.79 km	45°18′17″N 117°20′43″W / 45.3046°N 117.3452°W
9	10	Red Mountain[39][40][41][42]	Wallowa	2913.8 m	610 m	11.84 km	45°03′52″N 117°14′46″W / 45.0644°N 117.2460°W

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	Rank	Mountain peak	Mountain range	Elevation	Prominence	Isolation	Location
			Mountains				
10	11	Mount McLoughlin[43][44][45][46][i][j]	Cascade Range	2895 m	1364 m	111.8 km	42°26′40″N 122°18′56″W / 42.4445°N 122.3156°W
11	12	Elkhorn Peak[47][48][49][k]	Wallowa Mountains	2816 m	567 m	5.32 km	45°13′20″N 117°23′48″W / 45.2223°N 117.3968°W
12	13	Mount Thielsen[50][51][52][53]	Cascade Range	2799.4 m	1025 m	81.1 km	43°09′10″N 122°03′59″W / 43.1528°N 122.0665°W
13	14	Broken Top[54][55][56][l]	Cascade Range	2798 m	669 m	5.52 km	44°04′59″N 121°41′58″W / 44.0830°N 121.6994°W
14	15	Rock Creek Butte[57][58][59][m]	Elkhorn Mountains	2777 m	1364 m	69.9 km	44°49′00″N 118°06′14″W / 44.8168°N 118.1039°W
15	16	Mount Bachelor[60][61][62][63]	Cascade Range	2764 m	818 m	11.02 km	43°58′46″N 121°41′19″W / 43.9794°N 121.6885°W
16	17	Strawberry Mountain[64][65][66][67][n]	Strawberry Range	2756.1 m	1253 m	74.2 km	44°18′44″N 118°43′00″W / 44.3123°N 118.7166°W
17	18	Mount Scott[68][69][70][71]	Cascade Range	2722.9 m	920 m	25.9 km	42°55′22″N 122°00′58″W / 42.9229°N 122.0162°W
18	19	Diamond Peak[72][73][74][75]	Cascade Range	2666.4 m	952 m	41.4 km	43°31′15″N 122°08′59″W / 43.5207°N 122.1496°W
19	20	Pueblo Mountain[76][77][78][79][o]	Pueblo Mountains	2633.3 m	927 m	45.5 km	42°05′58″N 118°39′02″W / 42.0995°N 118.6506°W
20	21	Crane Mountain[80][81][82][83]	Warner Mountains	2575.8 m	718 m	71.4 km	42°03′46″N 120°14′27″W / 42.0628°N 120.2408°W
21	22	Drake Peak[84][85][86][87][p]	Warner Mountains	2564 m	779 m	28.1 km	42°18′00″N 120°07′26″W / 42.3001°N 120.1238°W

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	Rank	Mountain peak	Mountain range	Elevation	Prominence	Isolation	Location
22	23	Mount Bailey[88][89][90][91][q]	Cascade Range	2553.3 m	908 m	12.49 km	43°09′18″N 122°13′12″W / 43.1551°N 122.2200°W
23	24	Gearhart Mountain[92][93][94][95]	Gearhart Mountain	2550.6 m	1049 m	65.7 km	42°29′46″N 120°52′38″W / 42.4960°N 120.8773°W
24	25	Aspen Butte[96][97][98][99]	Cascade Range	2503.83 m	947 m	23.7 km	42°18′56″N 122°05′15″W / 42.3155°N 122.0876°W
25	26	Yamsay Mountain[100][101][102][103]	Cascade Volcanic Arc	2499.3 m	970 m	53.1 km	42°55′50″N 121°21′39″W / 42.9306°N 121.3607°W
26	27	Vinegar Hill[104][105][106][107][r]	Greenhorn Mountains	2482 m	884 m	23.5 km	44°42′50″N 118°33′42″W / 44.7138°N 118.5617°W
27	28	Pelican Butte[108][109][110][111]	Cascade Range	2449.8 m	669 m	15.98 km	42°30′48″N 122°08′43″W / 42.5134°N 122.1453°W
28	29	Lookout Mountain[112][113][114][s]	Strawberry Range	2450 m	650 m	10.73 km	44°17′20″N 118°29′43″W / 44.2889°N 118.4954°W
29	30	Warner Peak[115][116][117][118][t]	Hart Mountain	2445.8 m	648 m	35.6 km	42°27′35″N 119°44′29″W / 42.4597°N 119.7414°W
30	31	Paulina Peak[119][120][121][122][u]	Paulina Mountains	2435 m	981 m	46.5 km	43°41′21″N 121°15′18″W / 43.6892°N 121.2549°W

```
# The latitude is string position 27 to 34
lat1 = mountain_stats['Location'].iloc[0][27:34]

# The longitude is string position 37 to 45
lon1 = mountain_stats['Location'].iloc[0][37:45]
# Convert to float and multiple by -1
float(mountain_stats['Location'].iloc[0][37:45]) * -1
-121.6959
# To get these data from every row, we can write a quick for loop
coords = []
for i in range(len(mountain_stats)):
    lat = float(mountain_stats['Location'].iloc[i][27:34])
    lon = float(mountain_stats['Location'].iloc[i][37:45]) * -1
    coords.append((lat, lon))
coords
```

```
[(45.3735, -121.6959),
 (44.6743, -121.7996),
 (44.1035, -121.7693),
 (44.1666, -121.7723),
 (44.1483, -121.784),
 (45.245, -117.2929),
 (42.6364, -118.5767),
 (45.203, -117.175),
 (45.3046, -117.3452),
 (45.0644, -117.246),
 (42.4445, -122.3156),
 (45.2223, -117.3968),
 (43.1528, -122.0665),
 (44.083, -121.6994),
 (44.8168, -118.1039),
 (43.9794, -121.6885),
 (44.3123, -118.7166),
 (42.9229, -122.0162),
 (43.5207, -122.1496),
 (42.0995, -118.6506),
 (42.0628, -120.2408),
 (42.3001, -120.1238),
 (43.1551, -122.22),
 (42.496, -120.8773),
 (42.3155, -122.0876),
 (42.9306, -121.3607),
 (44.7138, -118.5617),
 (42.5134, -122.1453),
 (44.2889, -118.4954),
 (42.4597, -119.7414),
 (43.6892, -121.2549)]
# Get elevation value as a float
float(mountain_stats['Elevation'].iloc[0][:-2])
3428.8
# To get these data from every row, we can write another quick for loop
elevation = []
for i in range(len(mountain_stats)):
    elev = float(mountain_stats['Elevation'].iloc[i][:-2])
    elevation.append(elev)
elevation
[3428.8,
 3201.0,
 3158.5,
 3075.0,
 3064.0,
 3000.0,
 2968.0,
 2958.7,
 2950.0,
 2913.8,
 2895.0,
 2816.0,
 2799.4,
 2798.0,
 2777.0,
 2764.0,
 2756.1,
 2722.9,
 2666.4,
 2633.3,
 2575.8,
 2564.0,
 2553.3,
 2550.6,
 2503.83,
 2499.3,
 2482.0,
 2449.8,
 2450.0,
 2445.8,
 2435.0]
map = folium.Map(location=[44, -121], zoom_start=7)
for i in range(0, len(coords)):
    folium.Marker(coords[i], popup=elevation[i]).add_to(map)
map
```

Question 3

Make a new map of the tallest mountains in Oregon but include a popup that displays the Isolation data as a float.

```
# Get isolation value as a float
float(mountain_stats['Isolation'].iloc[0][:-2])
92.2
# To get these data from every row, we can write another quick for loop
isolation = []
for r in range(len(mountain_stats)):
    iso = float(mountain_stats['Isolation'].iloc[r][:-2])
    isolation.append(iso)
isolation
[92.2,
 77.5,
 63.4,
 7.0,
 1.8,
 202.0,
 201.0,
 9.48,
 7.79,
 11.84,
 111.8,
 5.32,
 81.1,
 5.52,
 69.9,
 11.02,
 74.2,
 25.9,
 41.4,
 45.5,
 71.4,
 28.1,
 12.49,
 65.7,
 23.7,
 53.1,
 23.5,
 15.98,
 10.73,
 35.6,
 46.5]
```

```
# Create map of tallest mountains with isolation data popup
map = folium.Map(location=[44, -121], zoom_start=7)
for i in range(0, len(coords)):
    folium.Marker(coords[i], popup=isolation[i]).add_to(map)
map
```

Make this Notebook Trusted to load map: File -> Trust Notebook

Grad Student Question

Add a popup that includes the name of the mountain as a string (without any square brackets).

```
import re

# Get string data from every row and remove square brackets + contents of
square brackets
mount_name = []
for p in range(len(mountain_stats)):
    name = str(mountain_stats['Mountain peak'].iloc[p])
    name_fix = re.sub(r'\[.*?\]','',name, flags=re.DOTALL)
    mount_name.append(name_fix)
mount_name
```

```
['Mount Hood',
 'Mount Jefferson',
 'South Sister',
 'North Sister',
 'Middle Sister',
 'Sacajawea Peak',
 'Steens Mountain',
 'Aneroid Mountain',
 'Twin Peaks',
 'Red Mountain',
 'Mount McLoughlin',
 'Elkhorn Peak',
 'Mount Thielsen',
 'Broken Top',
 'Rock Creek Butte',
 'Mount Bachelor',
 'Strawberry Mountain',
 'Mount Scott',
 'Diamond Peak',
 'Pueblo Mountain',
 'Crane Mountain',
 'Drake Peak',
 'Mount Bailey',
 'Gearhart Mountain',
 'Aspen Butte',
 'Yamsay Mountain',
 'Vinegar Hill',
 'Pelican Butte',
 'Lookout Mountain',
 'Warner Peak',
 'Paulina Peak']
# Create map of tallest mountains with corrected mountain name data popup
map = folium.Map(location=[44, -121], zoom_start=7)
for i in range(0, len(coords)):
    folium.Marker(coords[i], popup=mount_name[i]).add_to(map)
map
# Install webdriver_manager:
https://github.com/SergeyPirogov/webdriver_manager
!pip3 install webdriver_manager

# Import packages
from selenium import webdriver
from selenium.webdriver.firefox.service import Service
from selenium.webdriver.common.by import By
from selenium.webdriver.support.ui import WebDriverWait
from selenium.webdriver.support import expected_conditions as EC
from webdriver_manager.firefox import GeckoDriverManager
# Install Chrome webdriver
driver = webdriver.Firefox(service=Service(GeckoDriverManager().install()))

# Open a web browser at the following page
driver.get("https://en.wikipedia.org/wiki/Category:Ski_areas_and_resorts_in_O
regon")

====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache
# Retrieve ski resort names
html_list = driver.find_element(By.ID, "mw-pages")
items = html_list.find_elements(By.TAG_NAME, "li")
ski_resort_names = []
for item in items:
    text = item.text
    print(text)
    ski_resort_names.append(text)
driver.close()
Anthony Lakes (ski area)
Mount Ashland Ski Area
Cooper Spur ski area
Ferguson Ridge Ski Area
Hoodoo (ski area)
Mount Ashland Ski Area Expansion
Mount Bachelor ski area
Mount Hood Meadows
Mount Hood Skibowl
Snow Bunny
Spout Springs Ski Area
```

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```
Summit Pass (Oregon)
Timberline Lodge ski area
Warner Canyon
Willamette Pass Resort
ski_resort_coords = []
# Loop through every ski resort to find it's coordinates
for resort in ski_resort_names:

    # Define URL to search in Google Maps and add 'Oregon' in for good
measure
    url = 'https://www.google.com/maps/place/' + resort + ' Oregon/'

    # Import web driver and search for ski resorts
    driver =
webdriver.Firefox(service=Service(GeckoDriverManager().install()))
    driver.get(url)

    # Click search
    element = WebDriverWait(driver,
20).until(EC.element_to_be_clickable((By.ID, "searchbox-searchbutton")))
    element.click()

    # Make the web driver wait until the URL updates (i.e. contains the @
sign we're looking for)
    WebDriverWait(driver, 20).until(EC.url_contains("@"))

    # Retrieve the URL
    link = driver.current_url

    # Split string
    lat, lon = link.rsplit('@', 1)[1].rsplit(',', 1)[0].rsplit(',', 1)

    # Append to list
    ski_resort_coords.append((lat, lon))

    # Close driver
    driver.close()
```

```
====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache
```

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```
====== WebDriver manager ======
Current firefox version is 97.0
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in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


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Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache
```

```
====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache
```

Question 4

Write a script to automatically derive the geographic coordinates for the following addresses and plot them on a folium map

```
address_list = ['1844 SW Morrison St, Portland, OR 97205',
                '800 Occidental Ave S, Seattle, WA 98134',
                '1001 Stadium Dr, Inglewood, CA 90301',
                '2700 Martin Luther King Jr Blvd, Eugene, OR 97401']
address_coords = []
# Loop through every ski resort to find it's coordinates
for name in address_list:

    # Define URL to search in Google Maps and add 'Oregon' in for good
measure
    url = 'https://www.google.com/maps/place/' + name

    # Import web driver and search for ski resorts
    driver =
webdriver.Firefox(service=Service(GeckoDriverManager().install()))
    driver.get(url)

    # Click search
    element = WebDriverWait(driver,
20).until(EC.element_to_be_clickable((By.ID, "searchbox-searchbutton")))
    element.click()
    # Make the web driver wait until the URL updates (i.e. contains the @
sign we're looking for)
    WebDriverWait(driver, 20).until(EC.url_contains("@"))

    # Retrieve the URL
    link = driver.current_url

    # Split string
    lat, lon = link.rsplit('@', 1)[1].rsplit(',', 1)[0].rsplit(',', 1)

    # Append to list
    address_coords.append((lat, lon))

    # Close driver
    driver.close()

====== WebDriver manager ======
Current firefox version is 97.0
Get LATEST geckodriver version for 97.0 firefox
Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache


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Driver [/Users/lily/.wdm/drivers/geckodriver/macos/v0.30.0/geckodriver] found
in cache
address_coords
[('45.5216813', '-122.693017'),
 ('47.5933137', '-122.3344609'),
 ('33.9530049', '-118.3407129'),
 ('44.0594325', '-123.0710918')]
map = folium.Map(location=[44, -121], zoom_start=7)
for i in range(0, len(address_coords)):
    folium.Marker(address_coords[i], popup=address_list[i]).add_to(map)
map
# Import package
import xarray as xr

# Define filepath
fp = '/Users/lily/Documents/GitHub/geospatial-data-science/labs/lab7/data'
```

```
# Read data
xds = xr.open_dataset(fp + '/era_monthly_snowfall_2020.nc',
decode_coords='all')
xds['time']
```

Question 5

Which ski resort received more snowfall in 2020, Mount Ashland, Willammette Pass or Hoodoo?

```
ski_resort_names
['Anthony Lakes (ski area)',
 'Mount Ashland Ski Area',
 'Cooper Spur ski area',
 'Ferguson Ridge Ski Area',
 'Hoodoo (ski area)',
 'Mount Ashland Ski Area Expansion',
 'Mount Bachelor ski area',
 'Mount Hood Meadows',
 'Mount Hood Skibowl',
 'Snow Bunny',
 'Spout Springs Ski Area',
 'Summit Pass (Oregon)',
 'Timberline Lodge ski area',
 'Warner Canyon',
 'Willamette Pass Resort']
# Get coords for the three ski resorts
ashland_coords = ski_resort_coords[1]
hoodoo_coords = ski_resort_coords[4]
willamette_coords = ski_resort_coords[14]
# Print out coordinates for reference
print(ashland_coords, hoodoo_coords,willamette_coords)
('42.081689', '-122.7069427') ('44.4086477', '-121.8736045') ('43.6000579',
'-122.0387287')
# Select location in dataset nearest to ski resort location
ashland = xds.sel(longitude=[-122.7069427], latitude=[42.081689],
method="nearest")
hoodoo = xds.sel(longitude=[-121.8736045], latitude=[44.4086477],
method="nearest")
willamette = xds.sel(longitude=[-122.0387287], latitude=[43.6000579],
method="nearest")
# Calculate sums for each nearest location
ashland_snow = ashland['sf'].sum()
hoodoo_snow = hoodoo['sf'].sum()
willamette_snow = willamette['sf'].sum()
ashland_snow.values
array(0.00922862, dtype=float32)
hoodoo_snow.values
array(0.01859693, dtype=float32)
willamette_snow.values
array(0.01963694, dtype=float32)
```

Willamette Pass Resort received the most snowfall (m of water equivalent) in 2020.

Grad Student Question 2

Rank the ski resorts by:

a) Average snowfall in November

b) Average snowfall in Spring (i.e. March, April, and May)

c)Interannual variability in snowfall

```
import datetime

# Define filepath
fp = '/Users/lily/Documents/GitHub/geospatial-data-science/labs/lab7/data'

# Read data
xds_long = xr.open_dataset(fp + '/era_monthly_snowfall_1979_2020.nc', 
decode_coords='all')
ski_resort_coords
[('44.9629273', '-118.2357129'),
 ('42.081689', '-122.7069427'),
 ('45.4188609', '-121.6064525'),
 ('45.2816889', '-117.1148305'),
 ('44.4086477', '-121.8736045'),
 ('42.081689', '-122.7069427'),
 ('44.0028975', '-121.6812601'),
 ('45.331759', '-121.6673735'),
 ('45.2943644', '-121.7896261'),
 ('45.2871456', '-121.7312302'),
 ('45.7552462', '-118.0536097'),
 ('44.0304622', '-123.4893634'),
 ('45.3311319', '-121.7131951'),
 ('42.237378', '-120.2968271'),
 ('43.6000579', '-122.0387287')]
# Create list of tuple integers of coordinates
ski_coord_ints = []
for tuple in ski_resort_coords:
    temp = []
    for x in tuple:
        if x.isalpha():
            temp.append(x)
        elif x.isdigit():
            temp.append(int(x))
        else:
            temp.append(float(x))
    ski_coord_ints.append((temp[0],temp[1]))
print(ski_coord_ints)
[(44.9629273, -118.2357129), (42.081689, -122.7069427), (45.4188609, -
121.6064525), (45.2816889, -117.1148305), (44.4086477, -121.8736045), 
(42.081689, -122.7069427), (44.0028975, -121.6812601), (45.331759, -
121.6673735), (45.2943644, -121.7896261), (45.2871456, -121.7312302),
(45.7552462, -118.0536097), (44.0304622, -123.4893634), (45.3311319, -
121.7131951), (42.237378, -120.2968271), (43.6000579, -122.0387287)]
# Create separate lists of ski resort coordinate latitudes and longitudes
ski_resort_lats, ski_resort_longs = zip(*ski_coord_ints)
resort_lats_list = list(ski_resort_lats)
resort_longs_list = list(ski_resort_longs)
# Create a new Dataset containing only November values
novembers = xds_long.isel(time=(xds_long.time.dt.month == 11))
novembers
# Calculate mean snowfall value across all novembers at the nearest location
to each coordinate pair
november_snows = []
for i in range(len(ski_resort_coords)):
    ski_resort = novembers.sel(longitude=[resort_longs_list[i]],
latitude=[resort_lats_list[i]], method="nearest")
    resort_snow_november = ski_resort['sf'].mean()
    november_snows.append(resort_snow_november.values)
# Create dictionary pairing ski resort name to average november snowfall
value
november_snow_dict = {}
# Convert to dictionary
for key in ski_resort_names:
   for value in november_snows:
      november_snow_dict[key] = value
      november_snows.remove(value)
      break
november_snow_dict
{'Anthony Lakes (ski area)': array(0.00186159, dtype=float32),
 'Mount Ashland Ski Area': array(0.0016192, dtype=float32),
 'Cooper Spur ski area': array(0.0016262, dtype=float32),
 'Ferguson Ridge Ski Area': array(0.00224436, dtype=float32),
 'Hoodoo (ski area)': array(0.00251084, dtype=float32),
 'Mount Ashland Ski Area Expansion': array(0.0016192, dtype=float32),
 'Mount Bachelor ski area': array(0.00325813, dtype=float32),
 'Mount Hood Meadows': array(0.00220338, dtype=float32),
 'Mount Hood Skibowl': array(0.00220338, dtype=float32),
 'Snow Bunny': array(0.00220338, dtype=float32),
 'Spout Springs Ski Area': array(0.00156591, dtype=float32),
 'Summit Pass (Oregon)': array(5.0190392e-05, dtype=float32),
 'Timberline Lodge ski area': array(0.00220338, dtype=float32),
 'Warner Canyon': array(0.00130316, dtype=float32),
 'Willamette Pass Resort': array(0.00286093, dtype=float32)}
```

Ski Resorts Ranked by Average snowfall (m in water equivalent) in November

1. Mount Bachelor ski area: 0.00325813
2. Willamette Pass Resort: 0.00286093
3. Hoodoo (ski area): 0.00251084
4. Ferguson Ridge Ski Area: 0.00224436
5. Mount Hood Meadows: 0.00220338
6. Mount Hood Skibowl: 0.00220338
7. Snow Bunny: 0.00220338

8. Timberline Lodge ski area: 0.00220338
9. Anthony Lakes (ski area): 0.00186159
10. Mount Ashland Ski Area: 0.0016192
11. Mount Ashland Ski Area Expansion: 0.0016192
12. Cooper Spur ski area: 0.0016262
13. Spout Springs Ski Area: 0.00156591
14. Warner Canyon: 0.00130316
15. Summit Pass (Oregon): 5.0190392e-05

b) Average snowfall in Spring (i.e. March, April, and May)

```
# Create a new Dataset containing only Spring values
springs = xds_long.isel(time=(xds_long.time.dt.season == "MAM"))
springs
# Calculate mean snowfall value across all springs at the nearest location to
each coordinate pair
spring_snows = []
for i in range(len(ski_resort_coords)):
    ski_resort = springs.sel(longitude=[resort_longs_list[i]],
latitude=[resort_lats_list[i]], method="nearest")
    resort_snow_spring = ski_resort['sf'].mean()
    spring_snows.append(resort_snow_spring.values)
# Create dictionary pairing ski resort name to average spring snowfall value
spring_snow_dict = {}
# Convert to dictionary
for key in ski_resort_names:
   for value in spring_snows:
      spring_snow_dict[key] = value
      spring_snows.remove(value)
      break
spring_snow_dict
{'Anthony Lakes (ski area)': array(0.00110986, dtype=float32),
 'Mount Ashland Ski Area': array(0.00102258, dtype=float32),
 'Cooper Spur ski area': array(0.00081359, dtype=float32),
 'Ferguson Ridge Ski Area': array(0.00153634, dtype=float32),
 'Hoodoo (ski area)': array(0.00152509, dtype=float32),
 'Mount Ashland Ski Area Expansion': array(0.00102258, dtype=float32),
 'Mount Bachelor ski area': array(0.0020058, dtype=float32),
 'Mount Hood Meadows': array(0.0014855, dtype=float32),
 'Mount Hood Skibowl': array(0.0014855, dtype=float32),
 'Snow Bunny': array(0.0014855, dtype=float32),
 'Spout Springs Ski Area': array(0.00070196, dtype=float32),
 'Summit Pass (Oregon)': array(6.345044e-05, dtype=float32),
 'Timberline Lodge ski area': array(0.0014855, dtype=float32),
 'Warner Canyon': array(0.00084139, dtype=float32),
 'Willamette Pass Resort': array(0.00175876, dtype=float32)}
```

Ski Resorts Ranked by Average snowfall (m in water equivalent) in Spring

1. Willamette Pass Resort: 0.00175876
2. Ferguson Ridge Ski Area: 0.00153634
3. Hoodoo (ski area): 0.00152509

4. Mount Hood Meadows: 0.0014855
5. Mount Hood Skibowl: 0.0014855
6. Snow Bunny: 0.0014855
7. Timberline Lodge ski area: 0.0014855
8. Anthony Lakes (ski area): 0.00110986
9. Mount Ashland Ski Area: 0.00102258
10. Mount Ashland Ski Area Expansion: 0.00102258
11. Cooper Spur ski area: 0.00081359
12. Warner Canyon: 0.00084139
13. Spout Springs Ski Area: 0.00070196
14. Mount Bachelor ski area: 0.0020058
15. Summit Pass (Oregon): 6.345044e-05

c)Interannual variability in snowfall

```
xds_long
# Group dataset by year and sum each year
annual_sums = xds_long.groupby("time.year").sum()
annual_sums
# Calculate variance across annual snowfall sums at the nearest location to
each coordinate pair
snow_variances = []
for i in range(len(ski_resort_coords)):
    ski_resort = annual_sums.sel(longitude=[resort_longs_list[i]],
latitude=[resort_lats_list[i]], method="nearest")
    resort_snow_variance = ski_resort['sf'].var()
    snow_variances.append(resort_snow_variance.values)
# Create dictionary pairing ski resort name to average spring snowfall value
snow_variance_dict = {}
# Convert to dictionary
for key in ski_resort_names:
   for value in snow_variances:
      snow_variance_dict[key] = value
      snow_variances.remove(value)
      break

snow_variance_dict
{'Anthony Lakes (ski area)': array(5.2860837e-06, dtype=float32),
 'Mount Ashland Ski Area': array(1.4122033e-05, dtype=float32),
 'Cooper Spur ski area': array(8.515051e-06, dtype=float32),
 'Ferguson Ridge Ski Area': array(9.959952e-06, dtype=float32),
 'Hoodoo (ski area)': array(1.7184255e-05, dtype=float32),
 'Mount Ashland Ski Area Expansion': array(1.4122033e-05, dtype=float32),
 'Mount Bachelor ski area': array(2.3064722e-05, dtype=float32),
 'Mount Hood Meadows': array(1.5404597e-05, dtype=float32),
 'Mount Hood Skibowl': array(1.5404597e-05, dtype=float32),
 'Snow Bunny': array(1.5404597e-05, dtype=float32),
 'Spout Springs Ski Area': array(4.885678e-06, dtype=float32),
 'Summit Pass (Oregon)': array(8.8411645e-07, dtype=float32),
 'Timberline Lodge ski area': array(1.5404597e-05, dtype=float32),
 'Warner Canyon': array(5.5629016e-06, dtype=float32),
 'Willamette Pass Resort': array(1.8924553e-05, dtype=float32)}
```

Lily Kuentz // Lab 7 submission

Ski Resorts Ranked by Interannual snowfall variability (m in water equivalent)

1. Mount Bachelor ski area: 2.3064722e-05
2. Willamette Pass Resort: 1.8924553e-05
3. Hoodoo (ski area): 1.7184255e-05
4. Mount Hood Meadows: 1.5404597e-05
5. Mount Hood Skibowl: 1.5404597e-05
6. Snow Bunny: 1.5404597e-05
7. Timberline Lodge ski area: 1.5404597e-05
8. Mount Ashland Ski Area: 1.4122033e-05
9. Mount Ashland Ski Area Expansion: 1.4122033e-05
10. Ferguson Ridge Ski Area: 9.959952e-06
11. Cooper Spur ski area: 8.515051e-06
12. Warner Canyon: 5.5629016e-06
13. Anthony Lakes (ski area): 5.2860837e-06
14. Spout Springs Ski Area: 4.885678e-06
15. Summit Pass (Oregon): 8.8411645e-07