(Brief) Intro to (Scientific) Python!

Dr. Paige Martin

COESSING 2019

What is oceanographic data?

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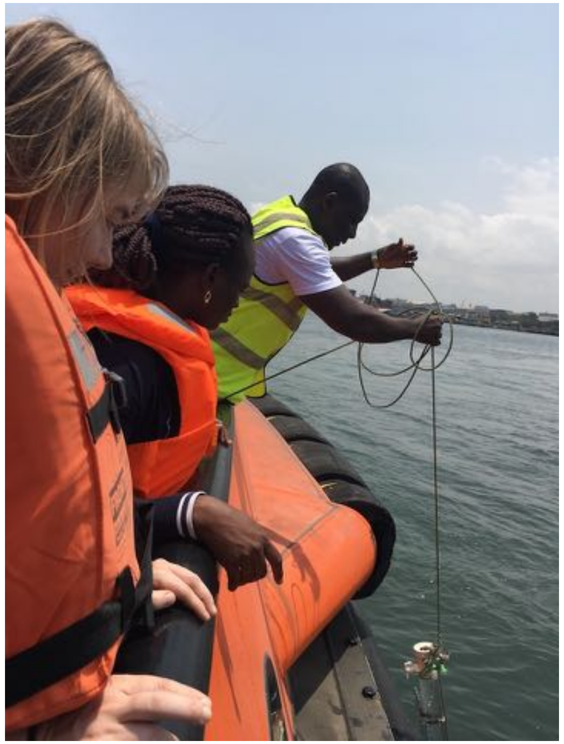
In-Situ Observations



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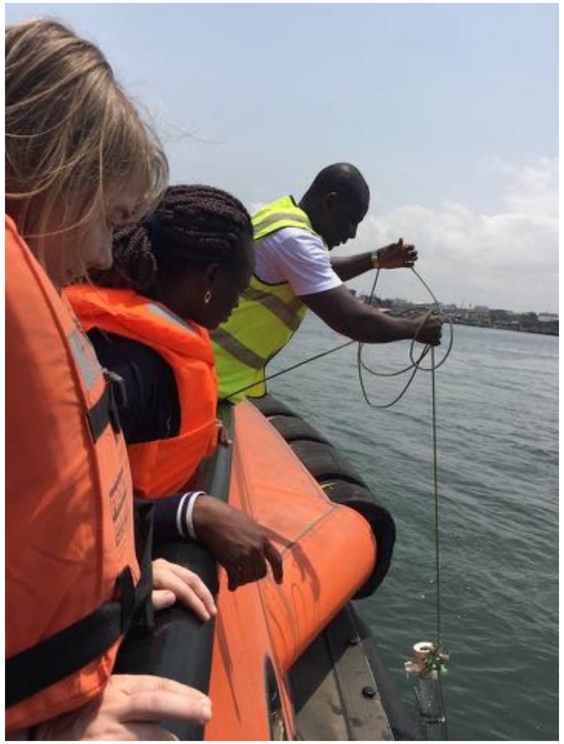
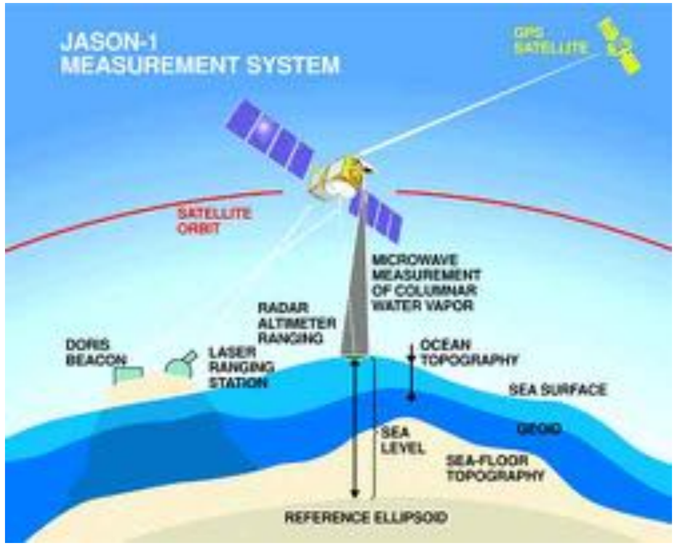
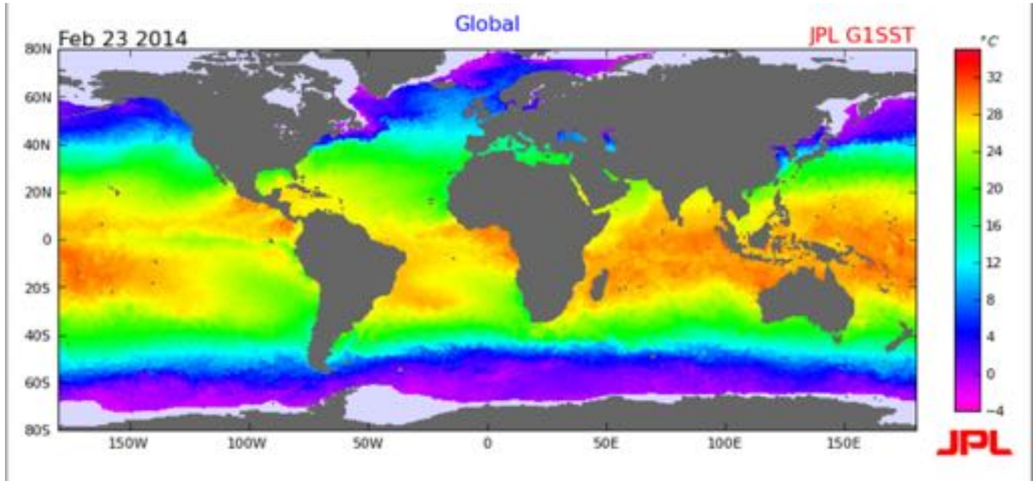


Satellite Data



What is oceanographic data?

Model output



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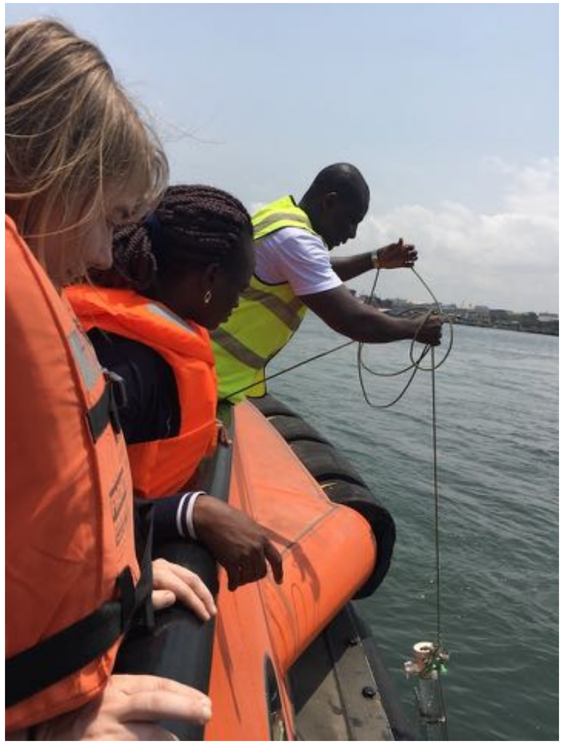

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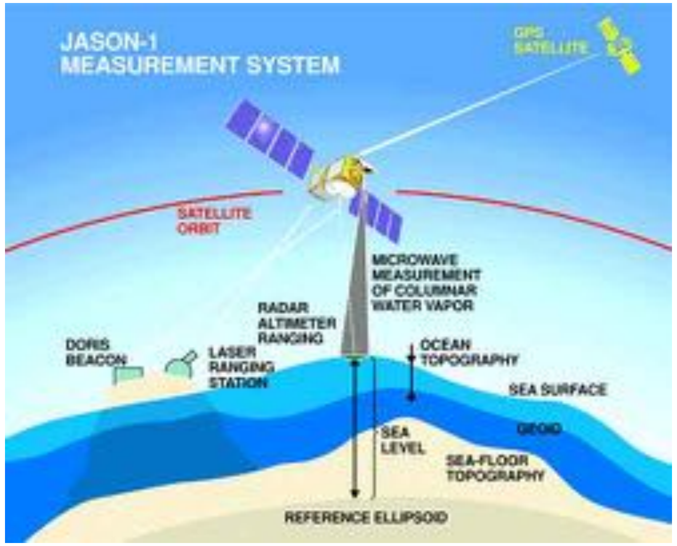

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Velocity v → Kinetic energy = $\frac{1}{2} m v^2$

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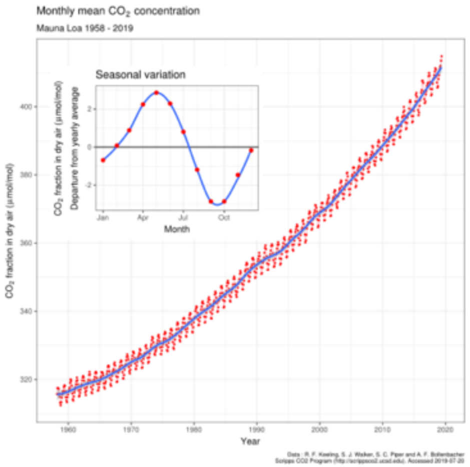
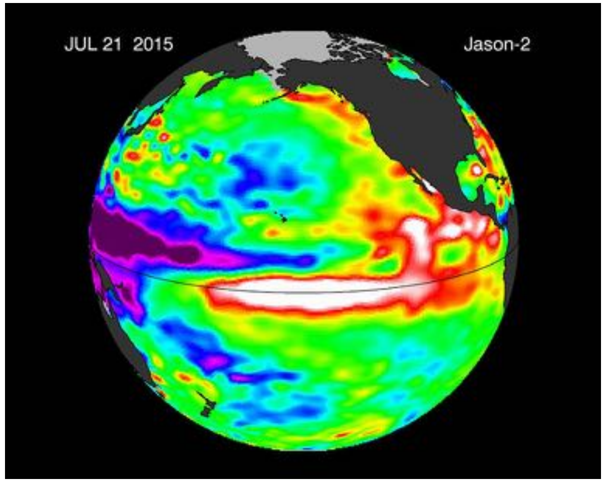
- Data analysis:
  - Manipulate data

Velocity v → Kinetic energy = ½ $m\, v^2$

  - Visualize data



Data : R. F. Keeling, S. J. Walker, S. C. Piper and A. F. Bollenbacher
Scripps CO2 Program (http://scrippsco2.ucsd.edu). Accessed 2019-07-20



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How does Python work?

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Write Python code

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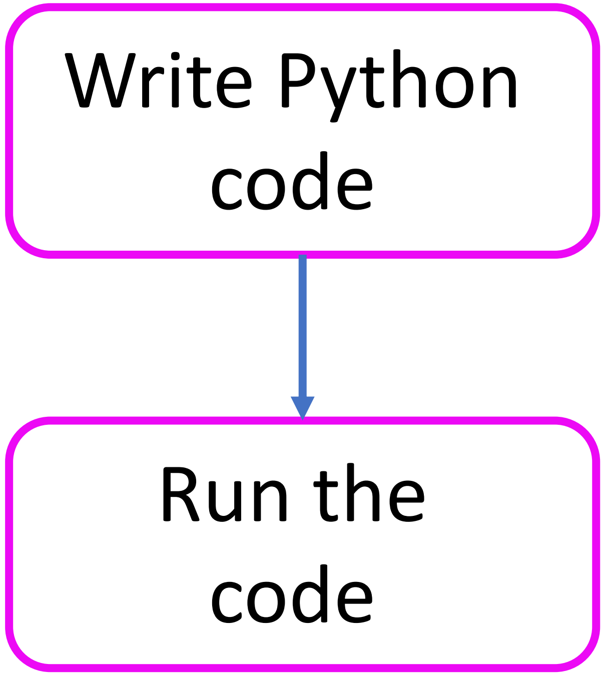

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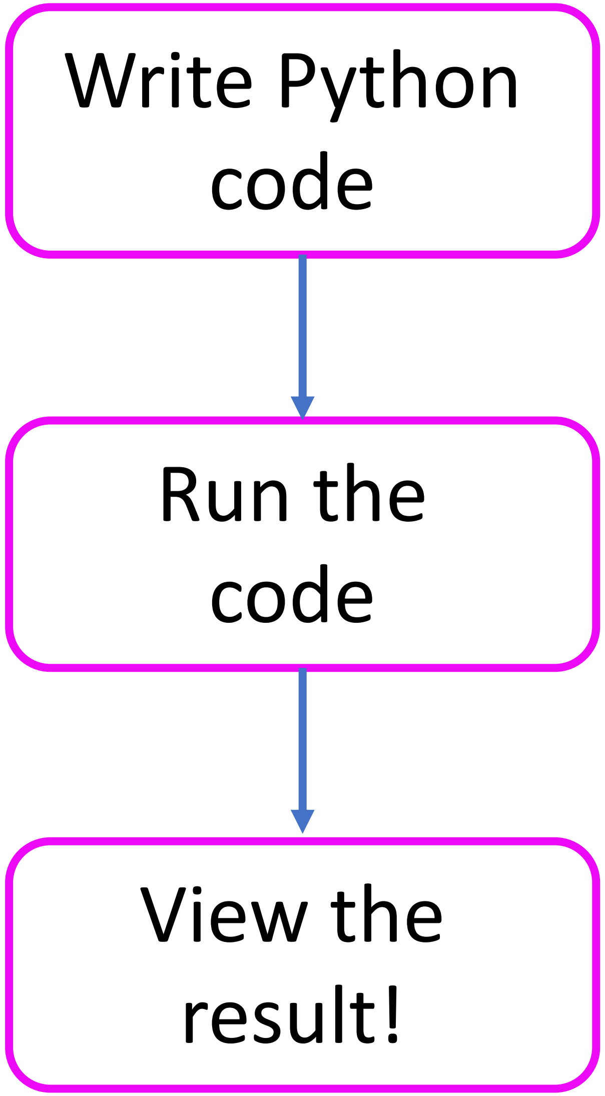

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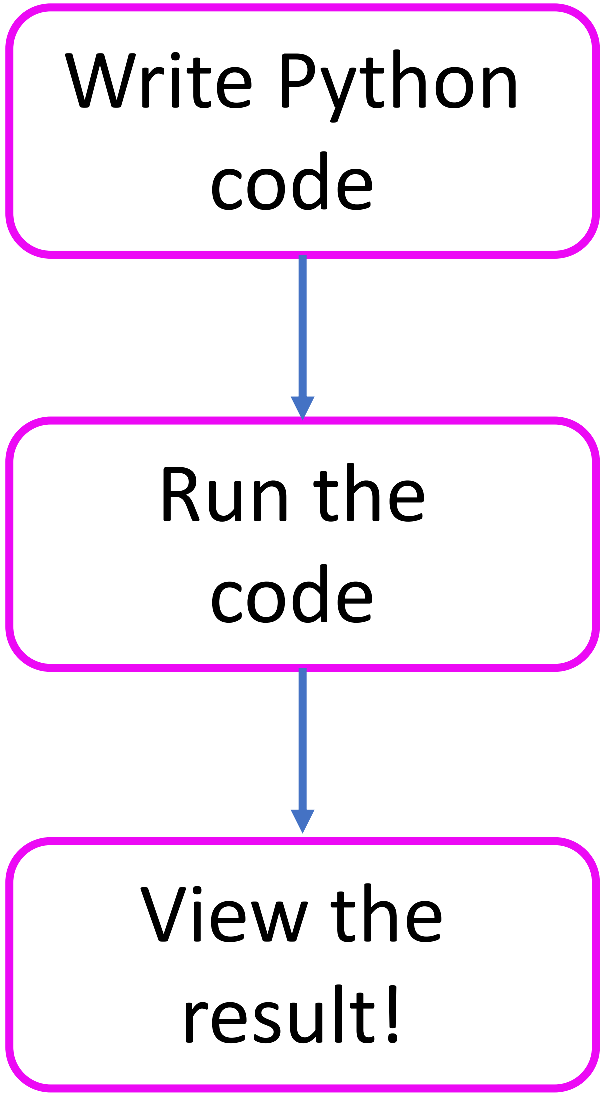

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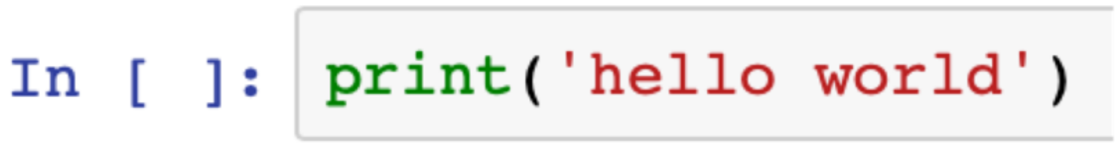

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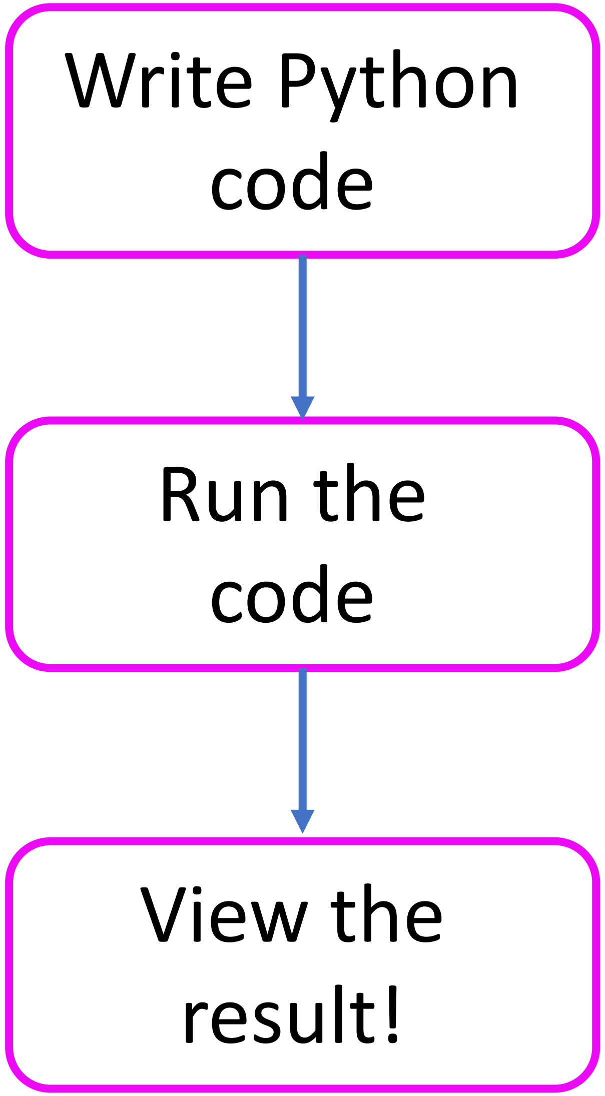

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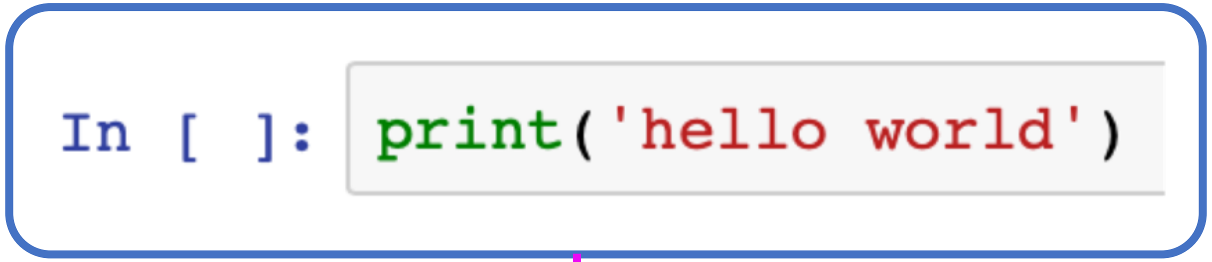

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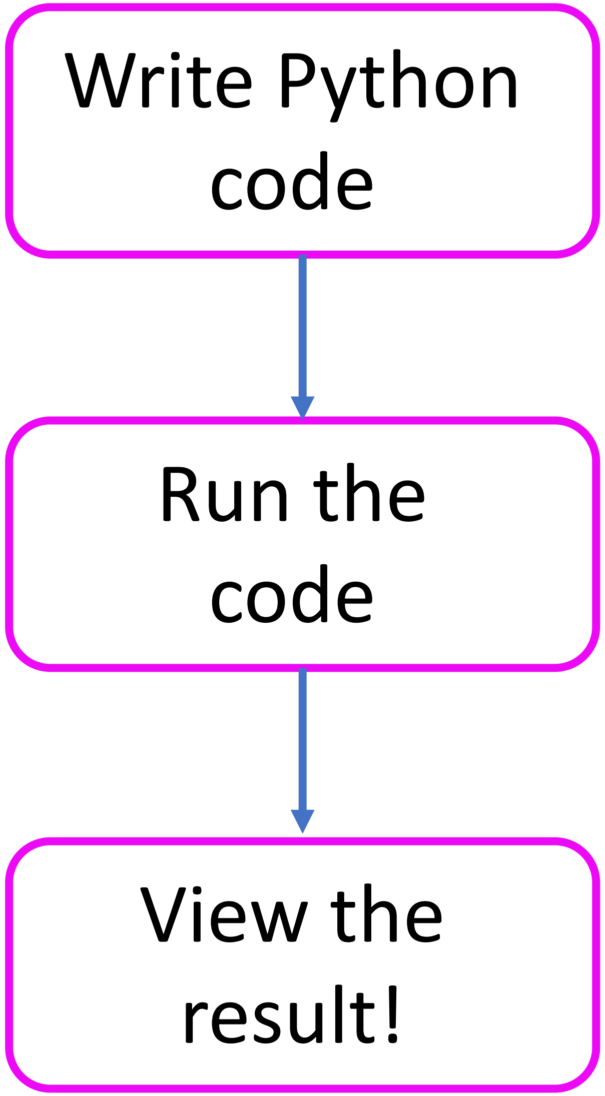

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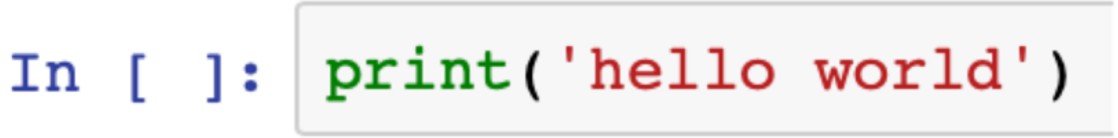

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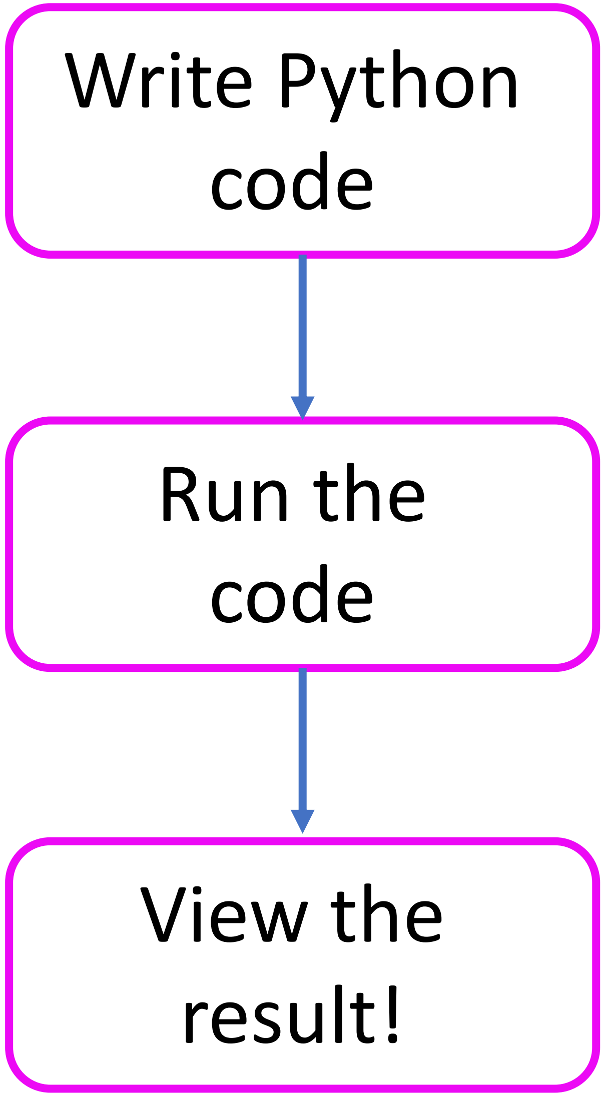

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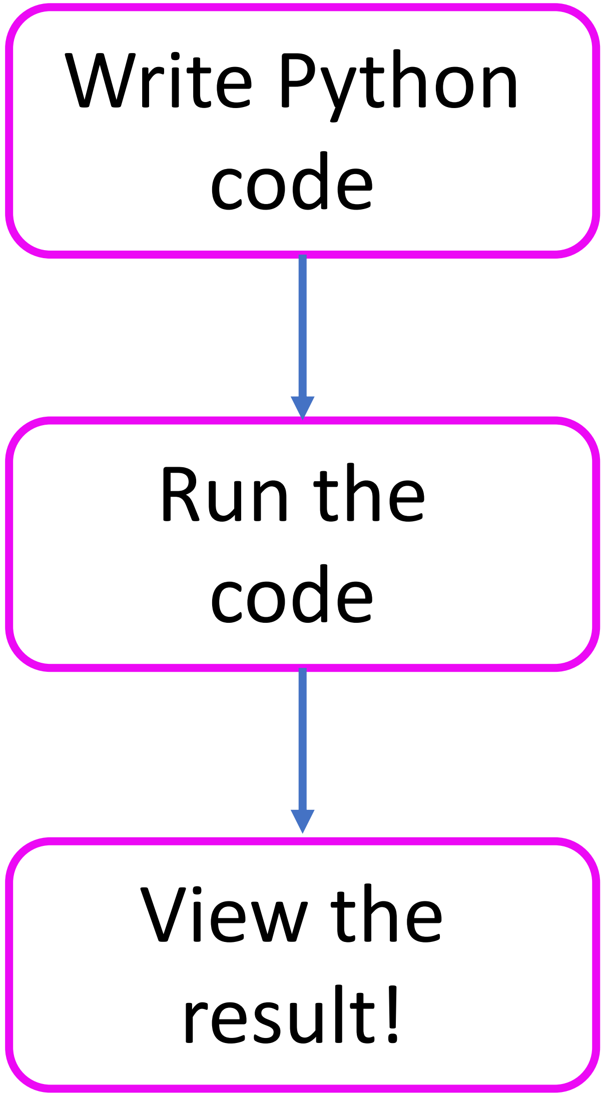

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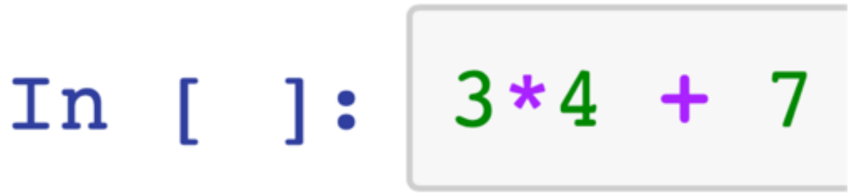

```
In [ ]: 3*4 + 7
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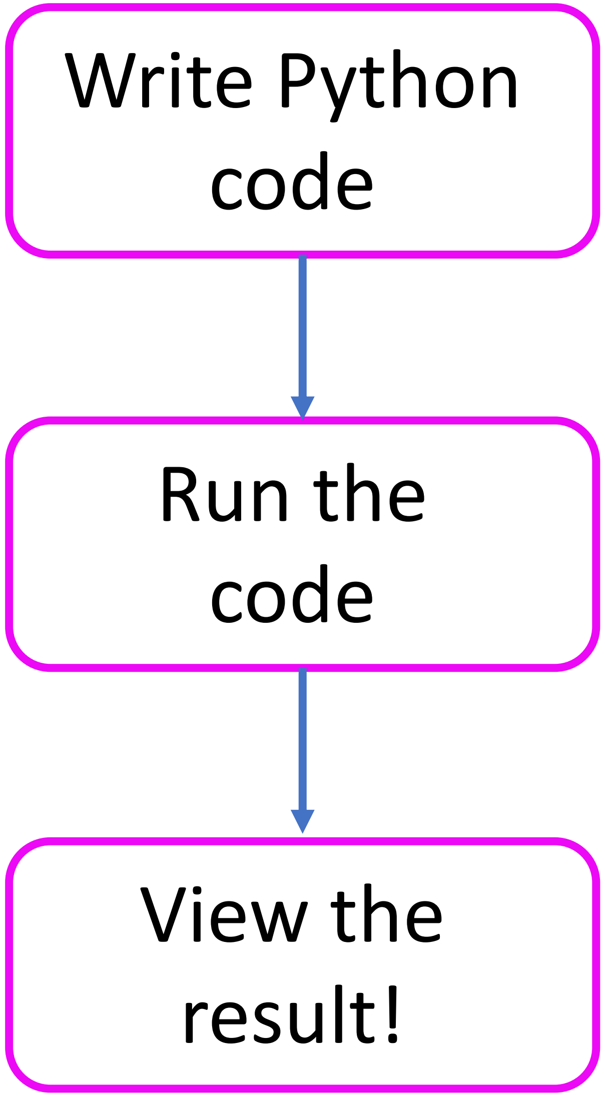

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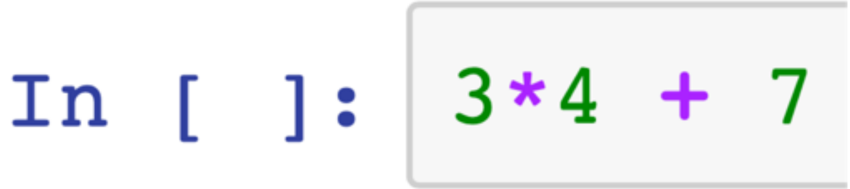

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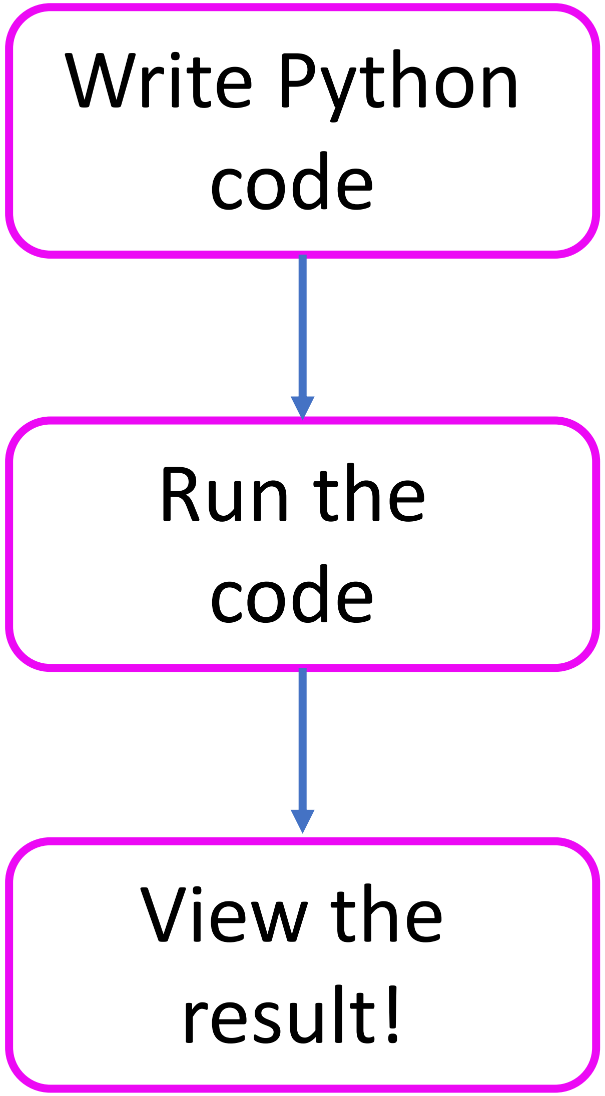

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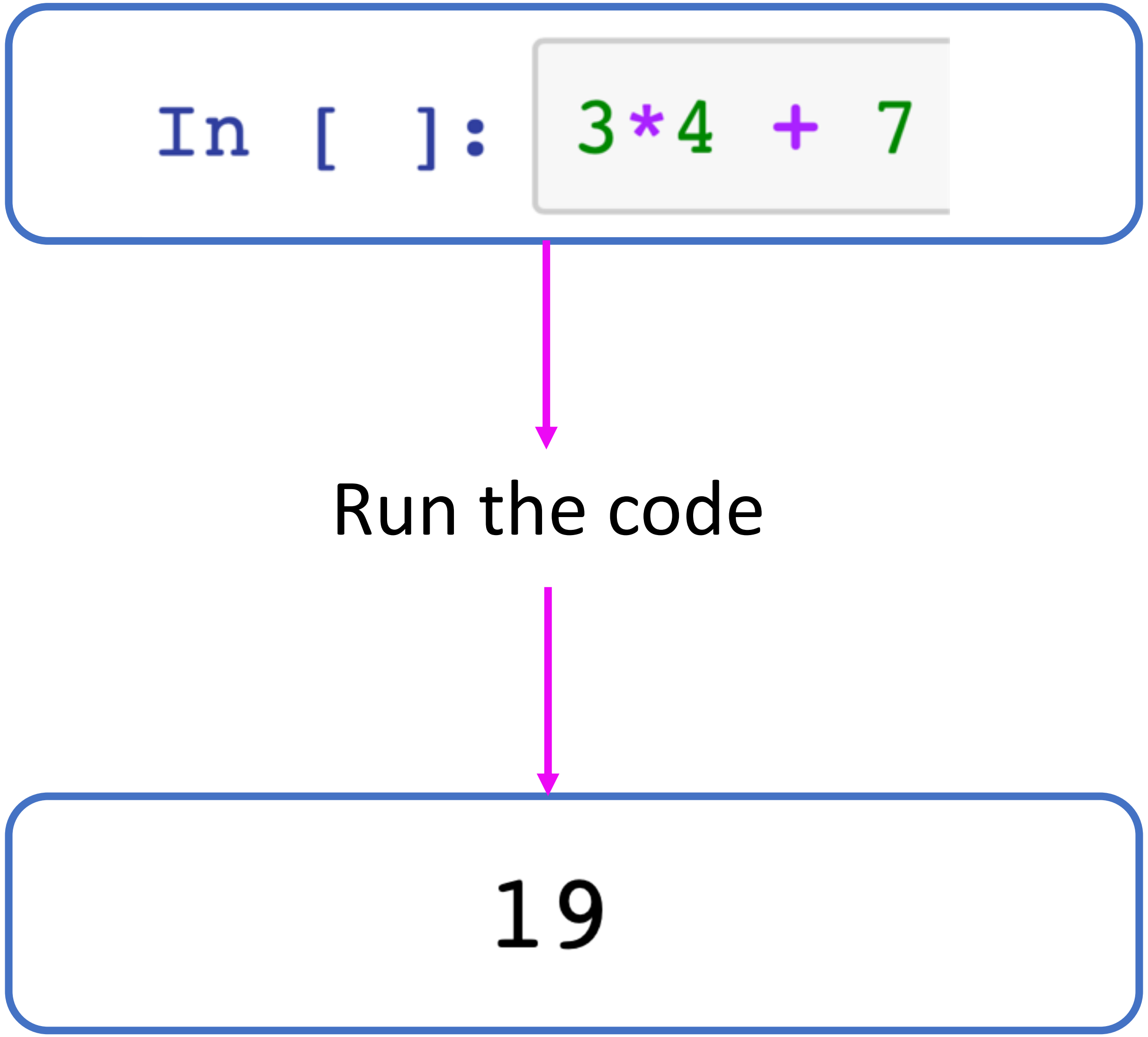

```
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```

Run the code

```
19
```

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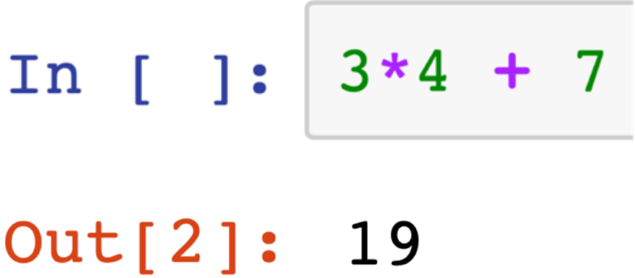
- Line-by-line:



```
In [ ]: 3*4 + 7

Out[2]: 19
```

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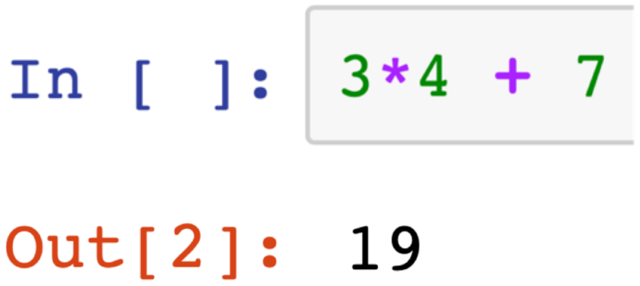

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```
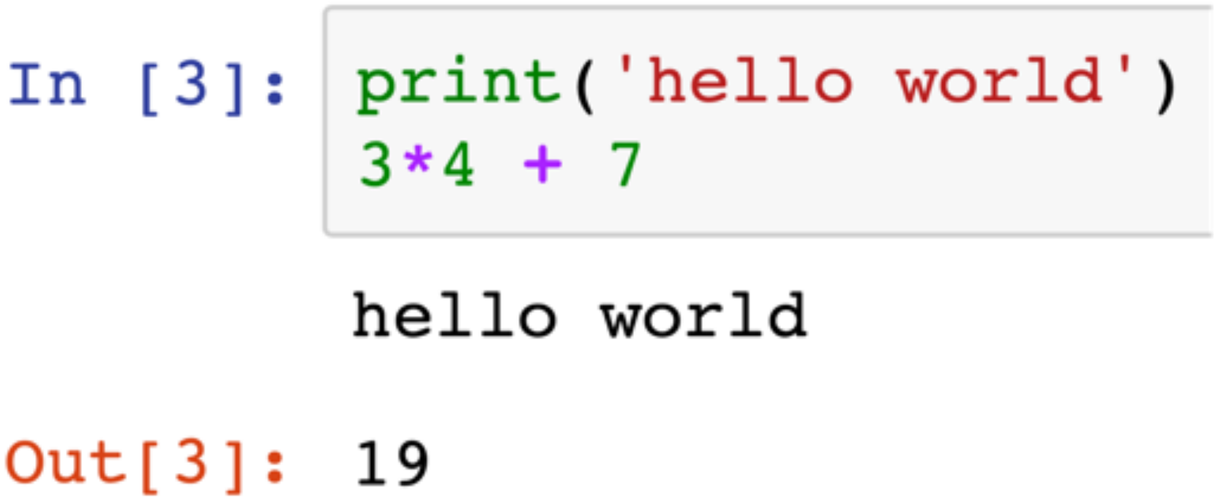

- Usually, we write scripts –
  - Many lines of code
  - Run the entire script all together



```
In [3]: print('hello world')
        3*4 + 7

        hello world

Out[3]: 19
```

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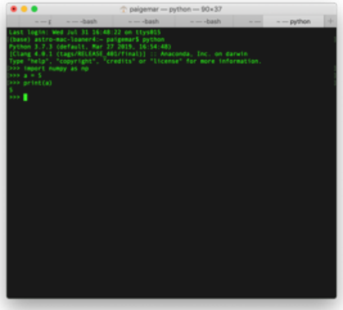

```
Last login: Wed Jul 31 16:48:22 on ttys015
(base) astro-mac-loaner4:~ paigemar$ python
Python 3.7.3 (default, Mar 27 2019, 16:54:48)
[Clang 4.0.1 (tags/RELEASE_401/final)] :: Anaconda, Inc. on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> import numpy as np
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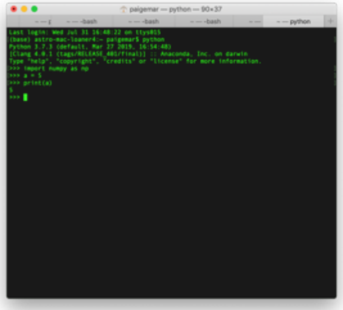

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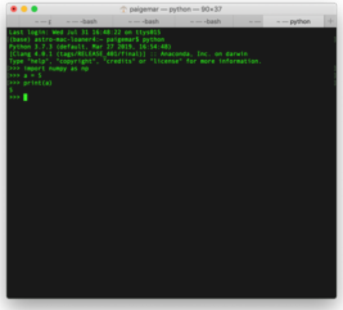

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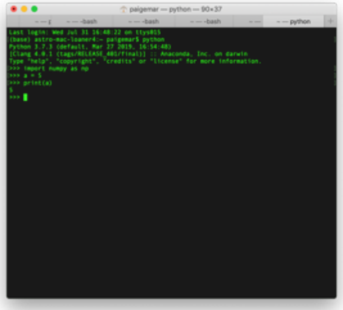

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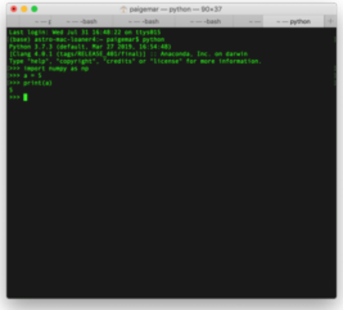

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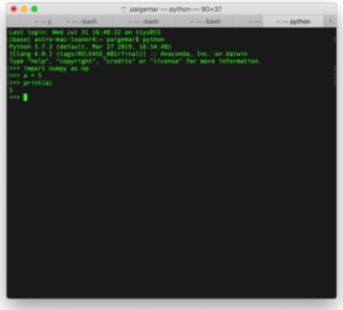

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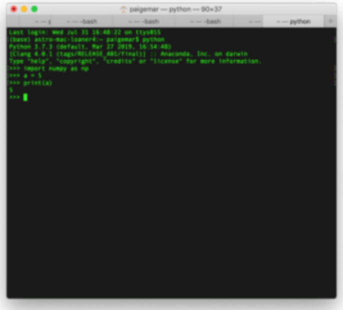

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How do I write a Python script in Jupyter notebook?

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Let’s look at a sample script!

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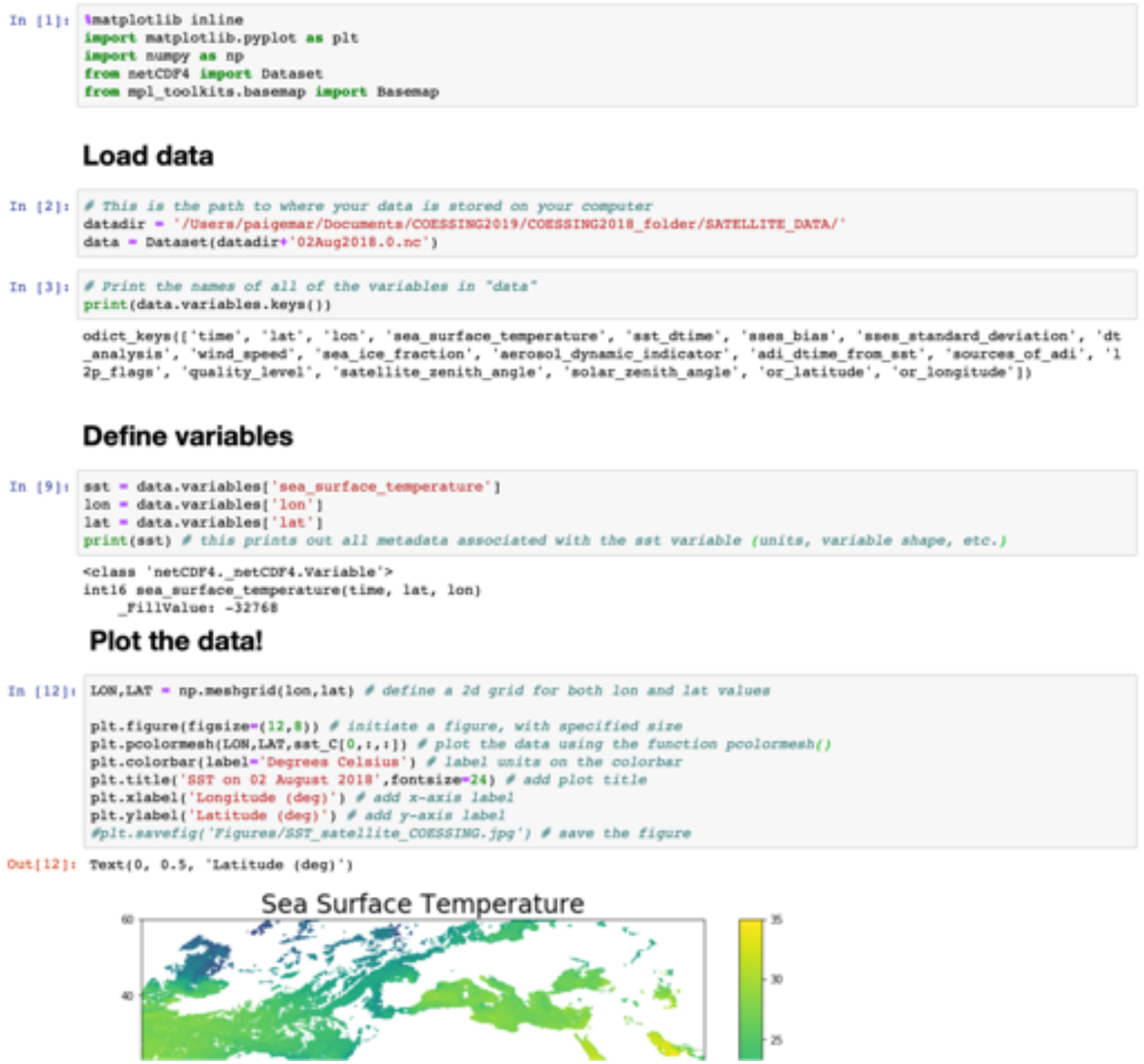

```
In [1]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from netCDF4 import Dataset
        from mpl_toolkits.basemap import Basemap
```

Load data

```
In [2]: # This is the path to where your data is stored on your computer
        datadir = '/Users/paigemar/Documents/COESSING2019/COESSING2018_folder/SATELLITE_DATA/'
        data = Dataset(datadir+'02Aug2018.0.nc')
```

```
In [3]: # Print the names of all of the variables in "data"
        print(data.variables.keys())

        odict_keys(['time', 'lat', 'lon', 'sea_surface_temperature', 'sst_dtime', 'sses_bias', 'sses_standard_deviation', 'dt
        _analysis', 'wind_speed', 'sea_ice_fraction', 'aerosol_dynamic_indicator', 'adi_dtime_from_sst', 'sources_of_adi', 'l
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Define variables

```
In [9]: sst = data.variables['sea_surface_temperature']
        lon = data.variables['lon']
        lat = data.variables['lat']
        print(sst) # this prints out all metadata associated with the sst variable (units, variable shape, etc.)

        <class 'netCDF4._netCDF4.Variable'>
        int16 sea_surface_temperature(time, lat, lon)
            _FillValue: -32768
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Plot the data!

```
In [12]: LON,LAT = np.meshgrid(lon,lat) # define a 2d grid for both lon and lat values

         plt.figure(figsize=(12,8)) # initiate a figure, with specified size
         plt.pcolormesh(LON,LAT,sst_C[0,:,:]) # plot the data using the function pcolormesh()
         plt.colorbar(label='Degrees Celsius') # label units on the colorbar
         plt.title('SST on 02 August 2018',fontsize=24) # add plot title
         plt.xlabel('Longitude (deg)') # add x-axis label
         plt.ylabel('Latitude (deg)') # add y-axis label
         #plt.savefig('Figures/SST_satellite_COESSING.jpg') # save the figure

Out[12]: Text(0, 0.5, 'Latitude (deg)')
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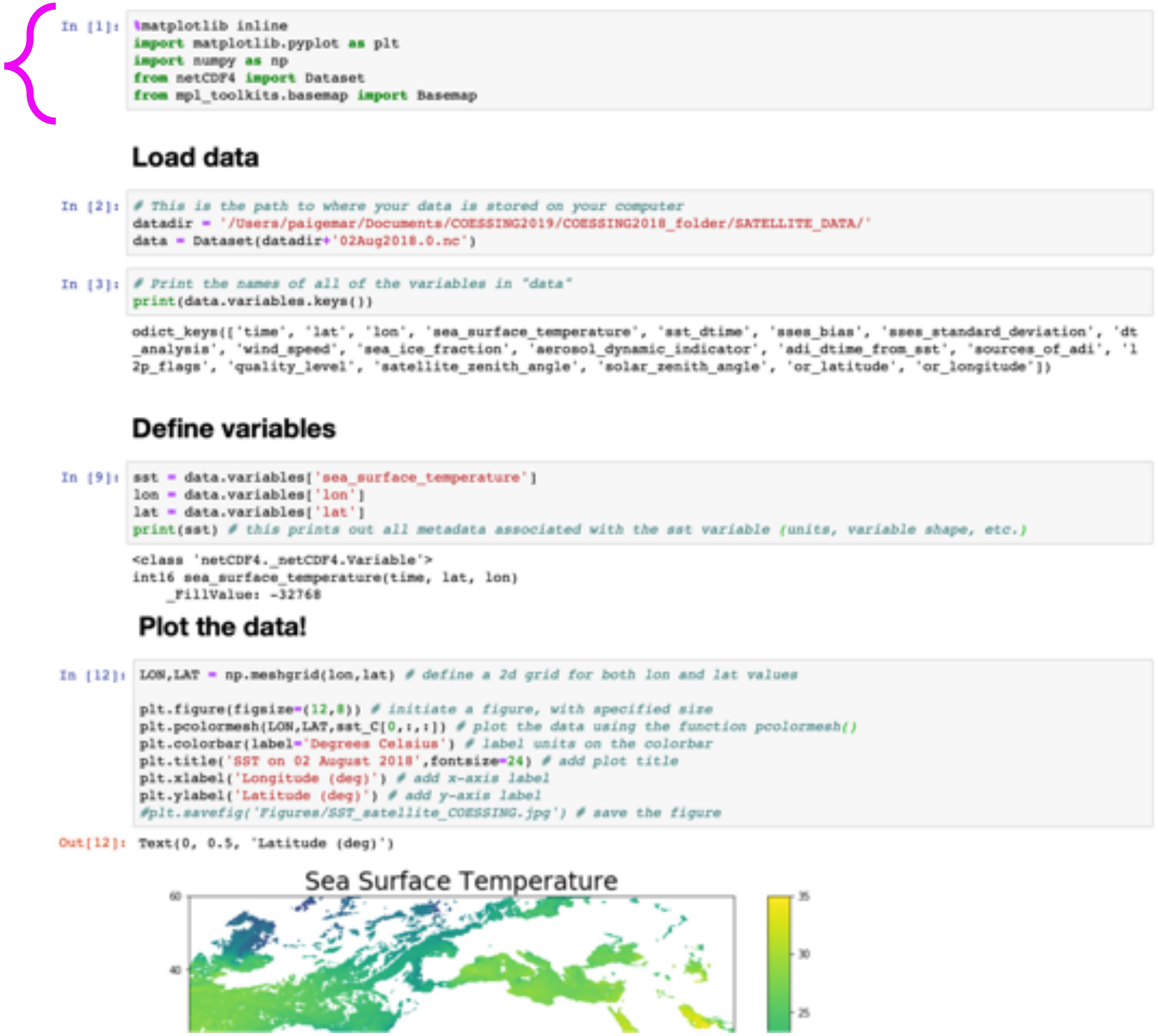
How do I write a Python script in Jupyter notebook?

Import libraries



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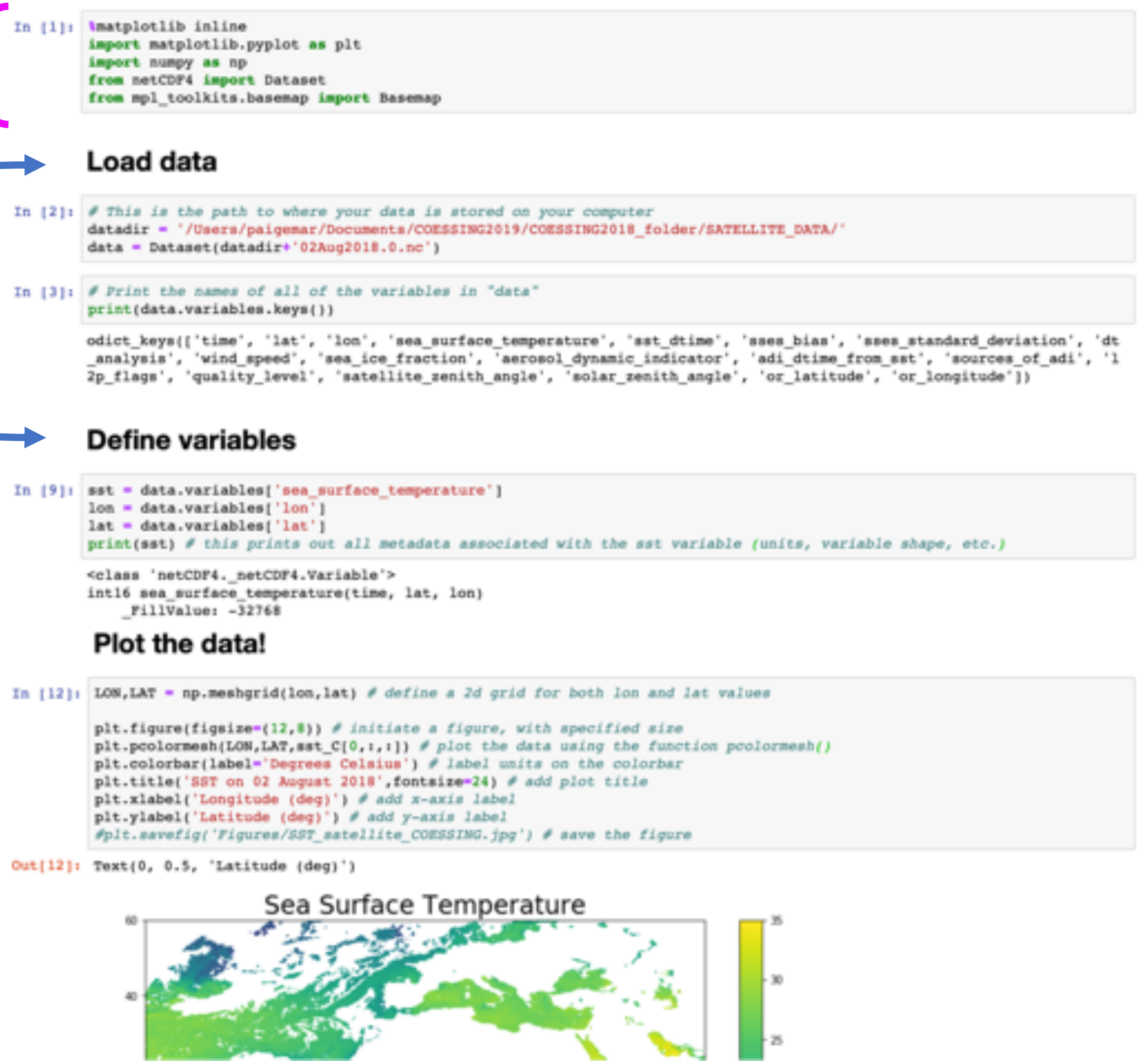

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In [9]: sst = data.variables['sea_surface_temperature']
        lon = data.variables['lon']
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        print(sst) # this prints out all metadata associated with the sst variable (units, variable shape, etc.)
```

```
<class 'netCDF4._netCDF4.Variable'>
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Plot the data!

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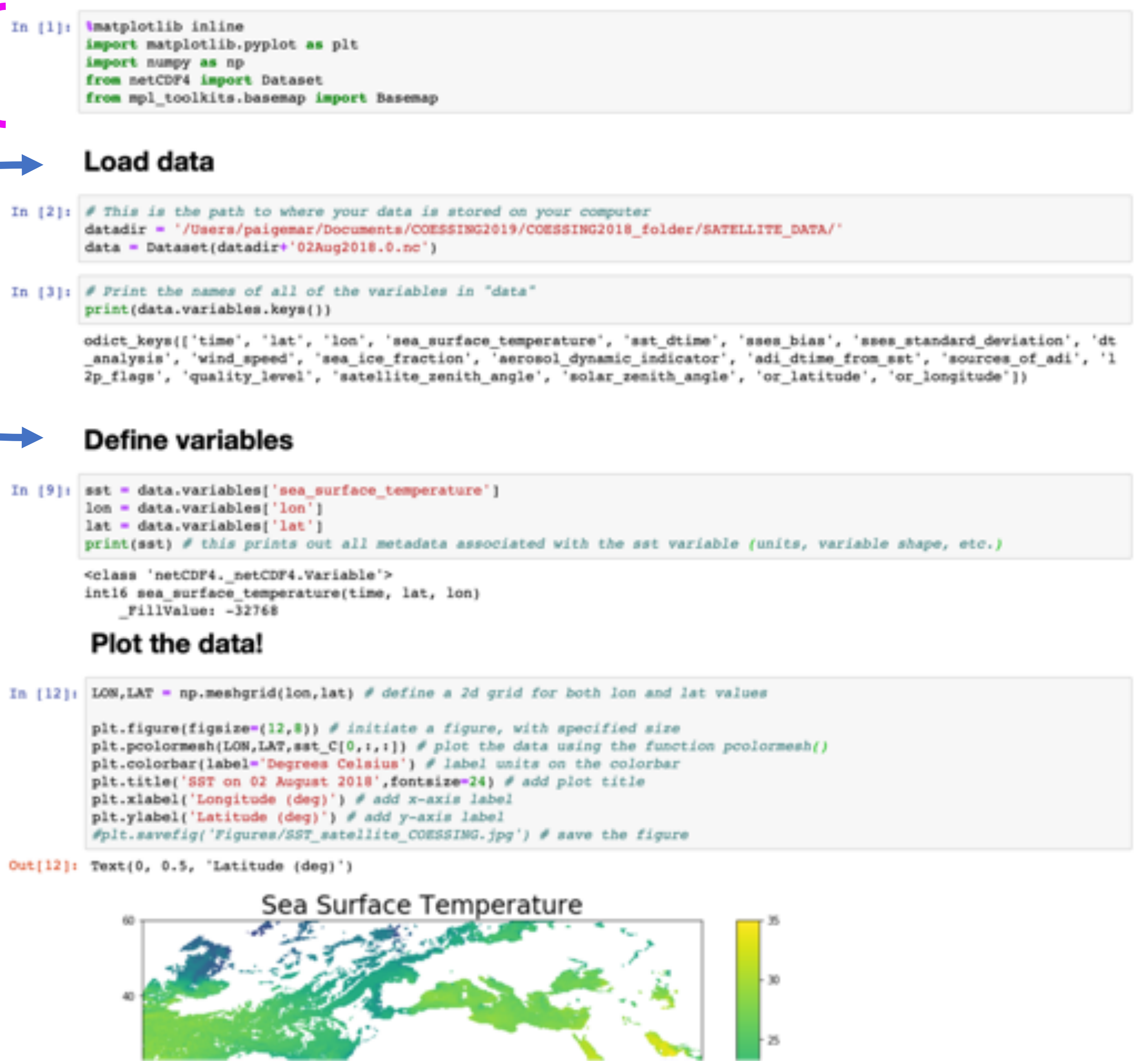
How do I write a Python script in Jupyter notebook?

Import libraries

Comments



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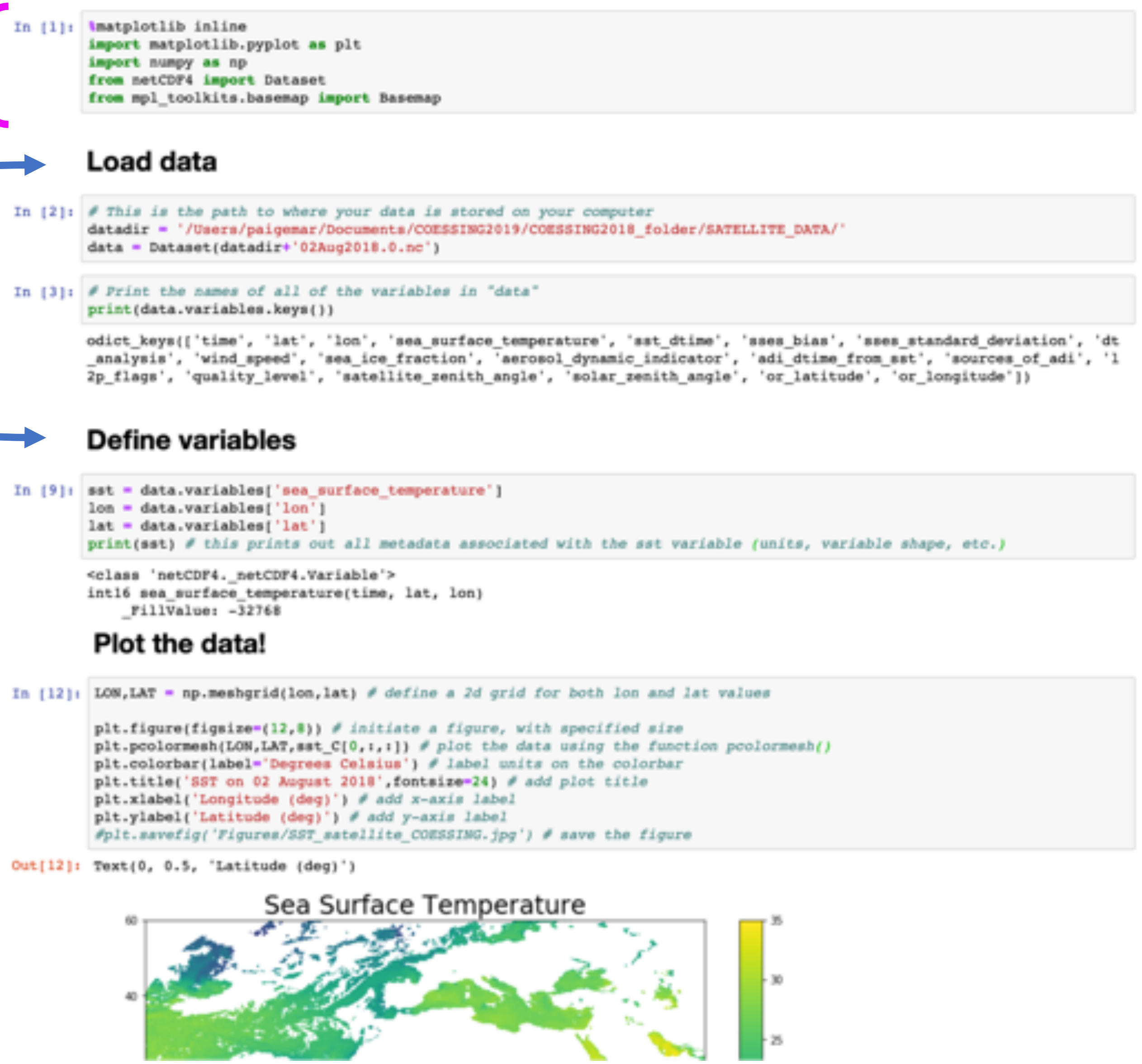

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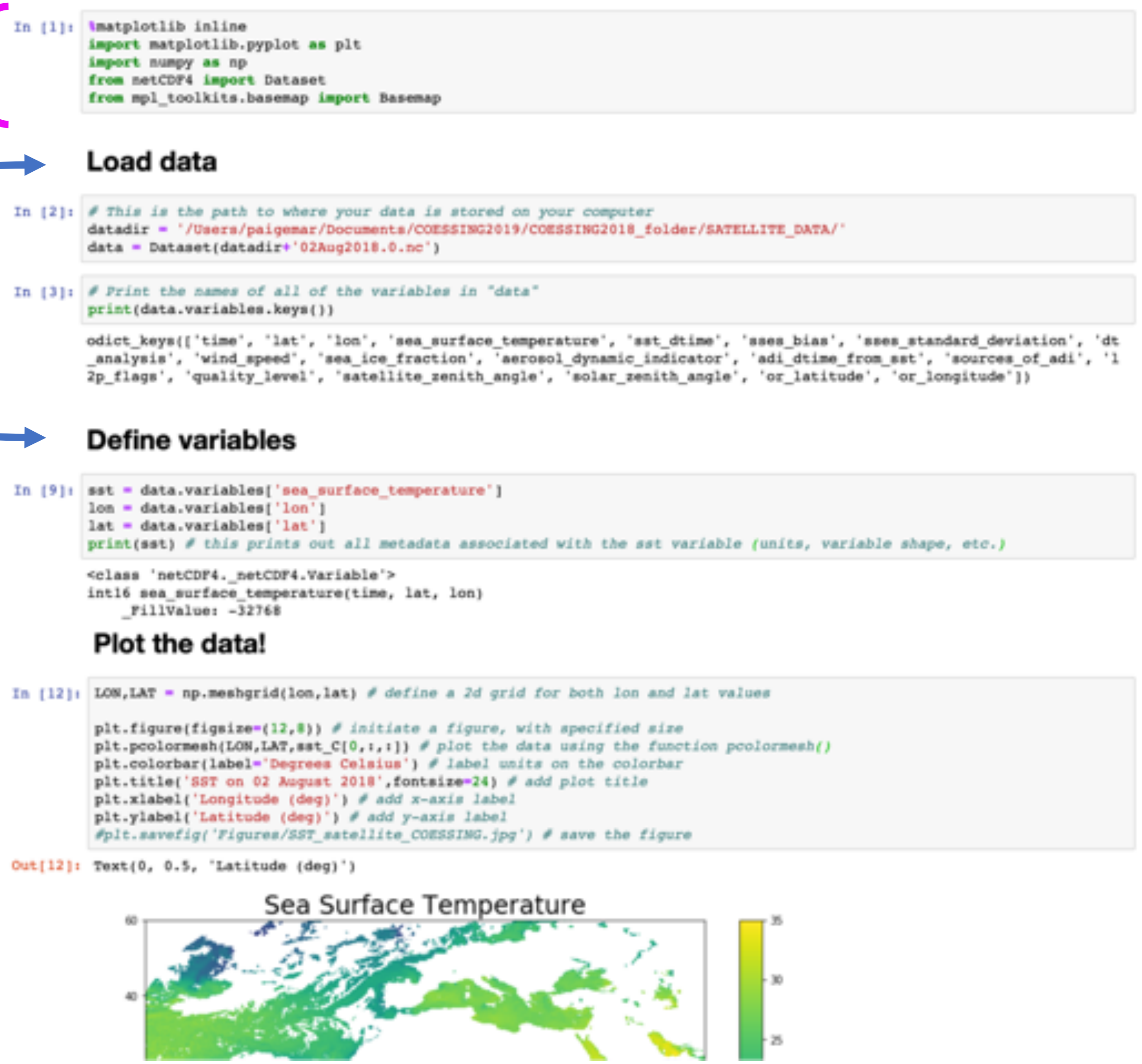

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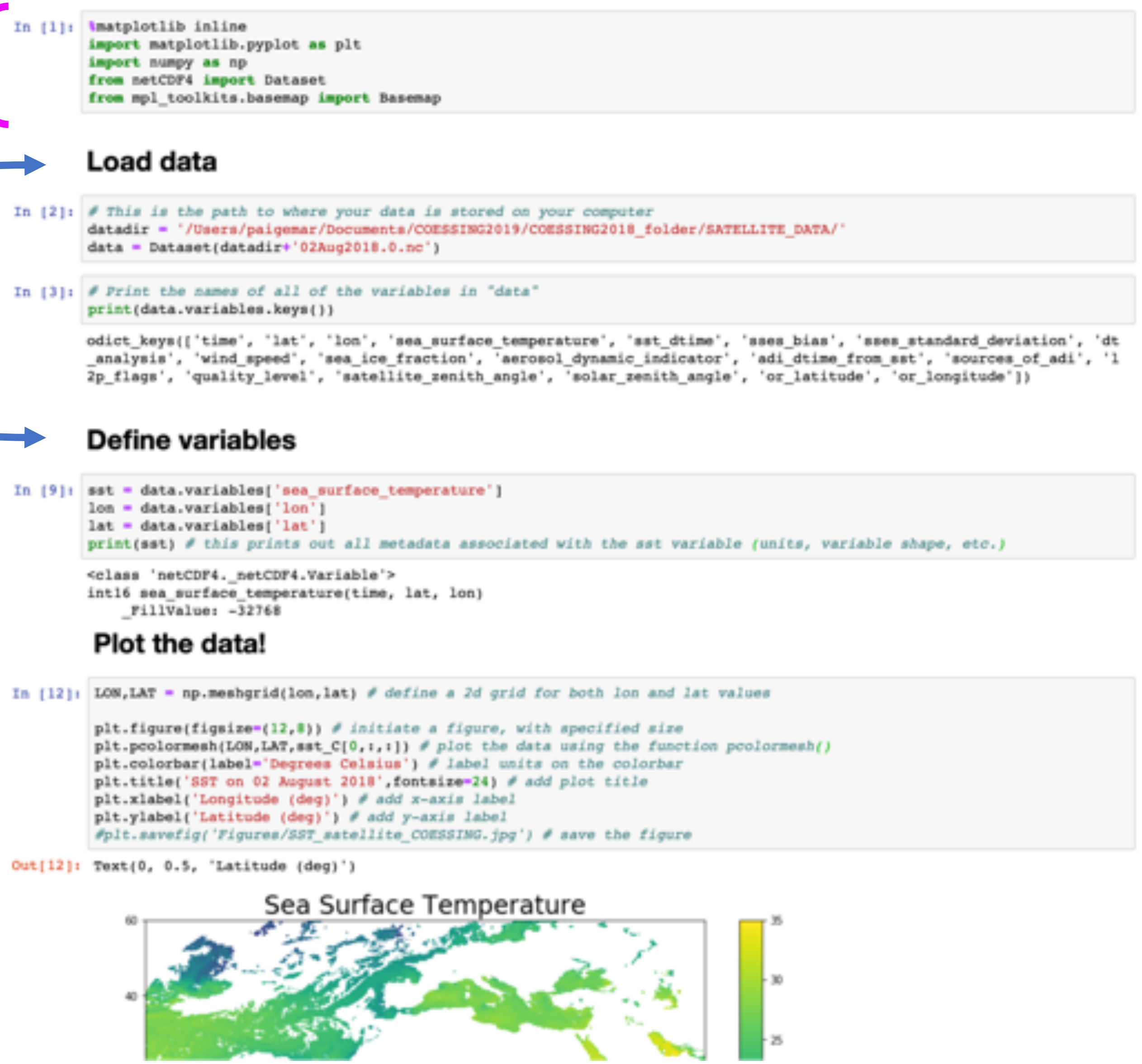

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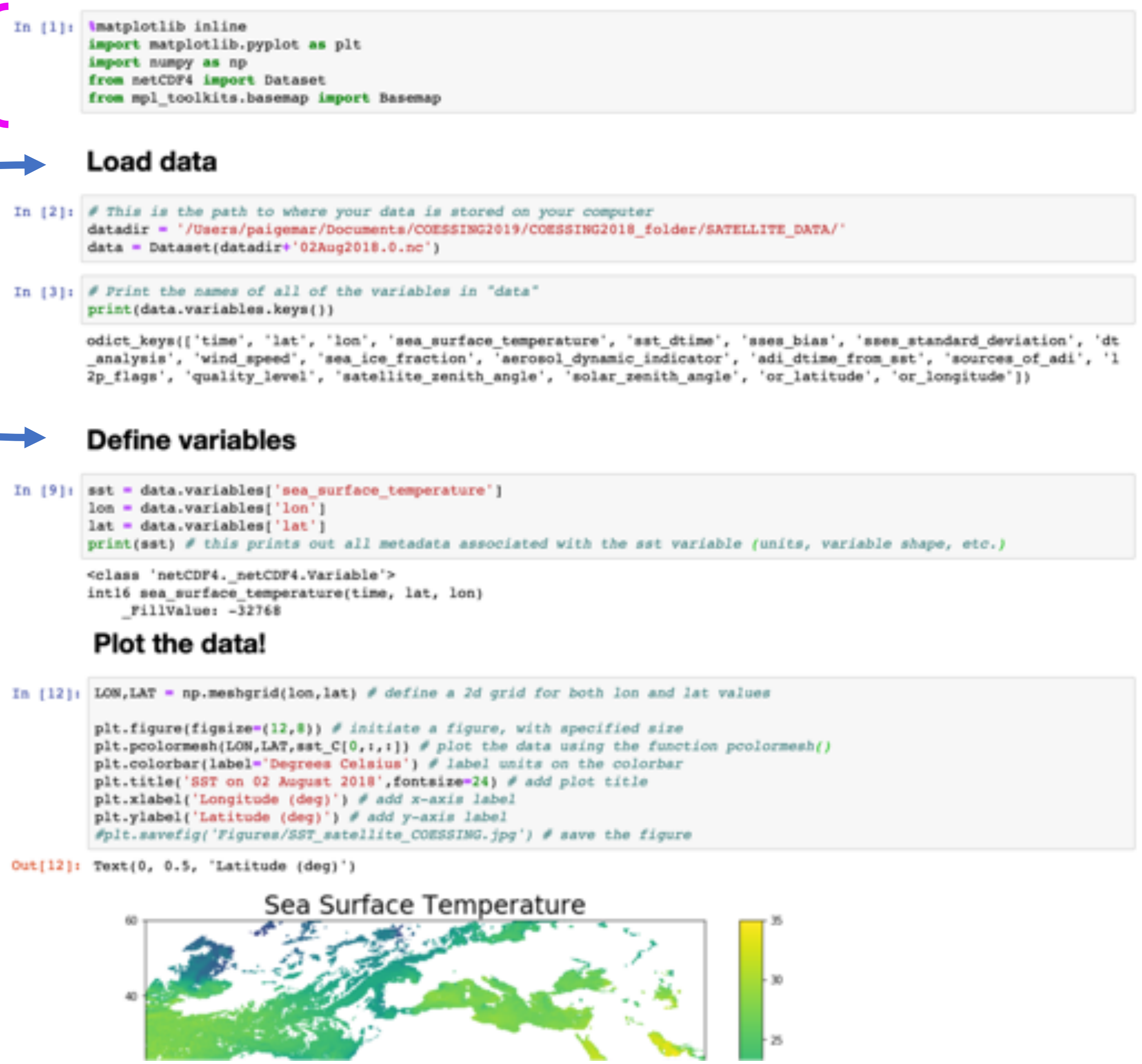

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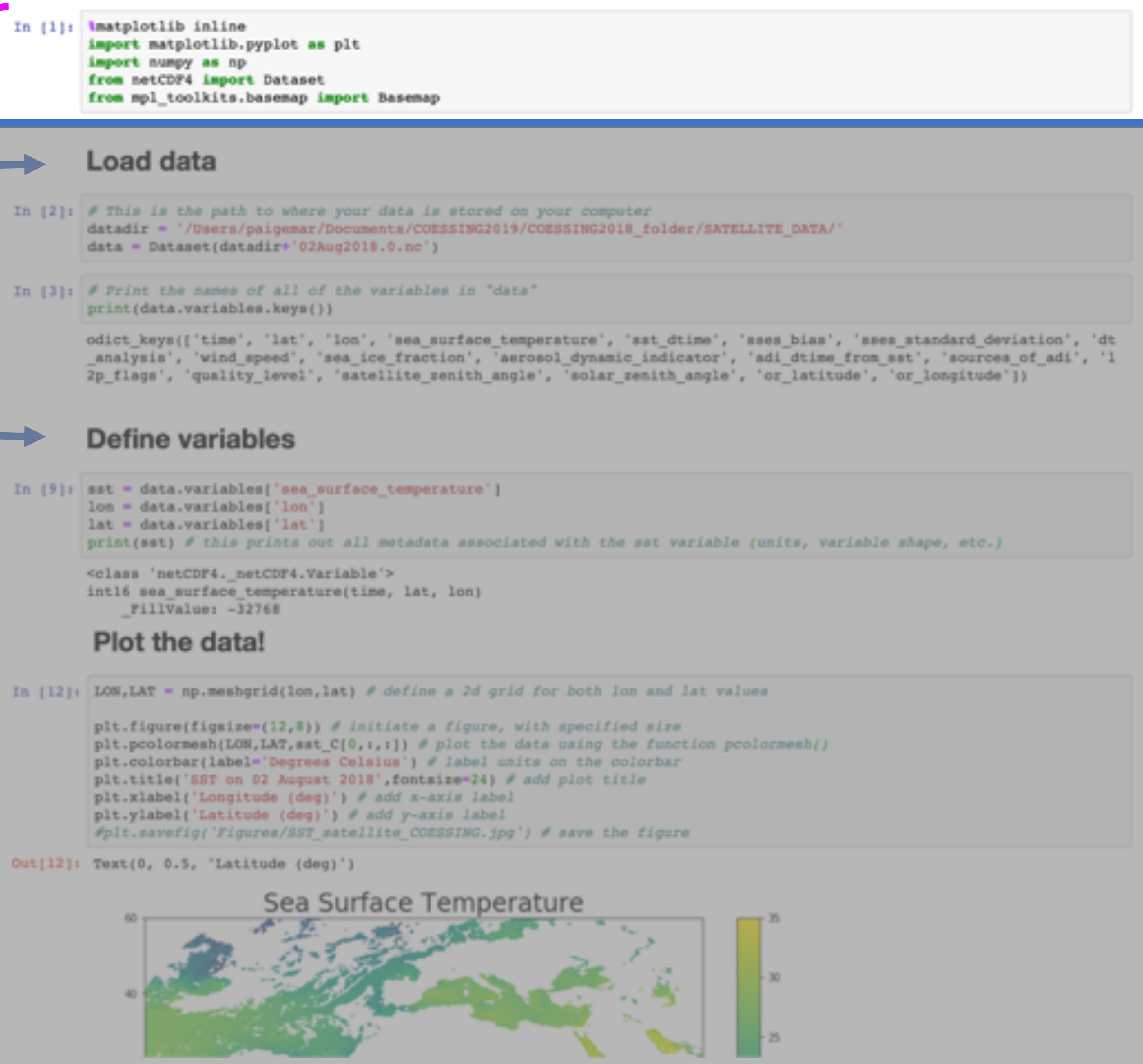

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- We need to import libraries each time we start a new script
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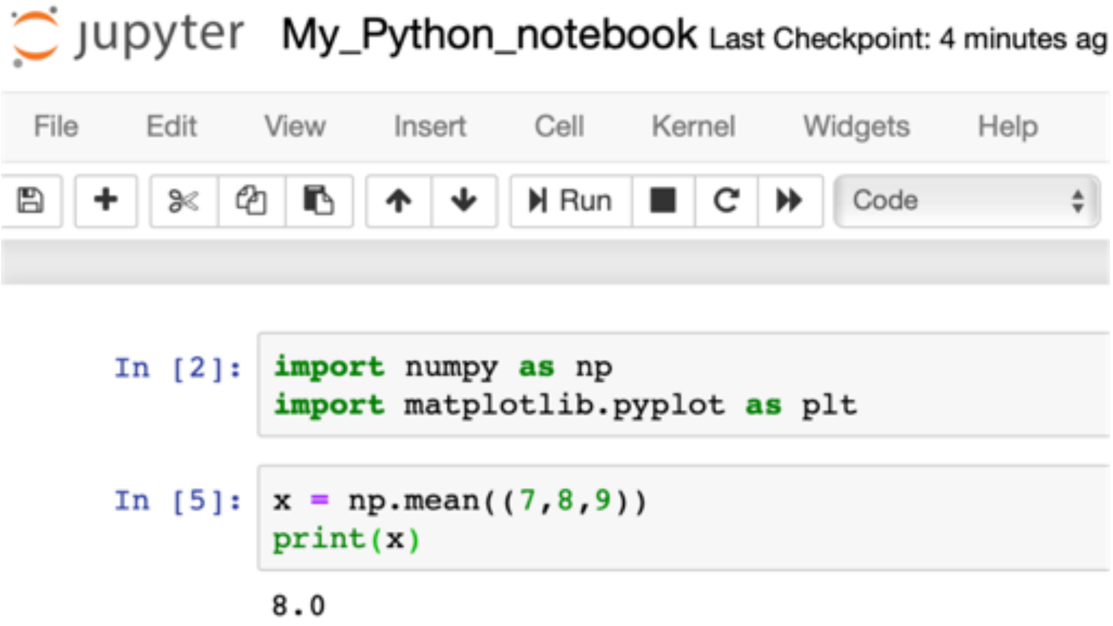

```
In [2]: import numpy as np
        import matplotlib.pyplot as plt

In [5]: x = np.mean((7,8,9))
        print(x)

        8.0
```

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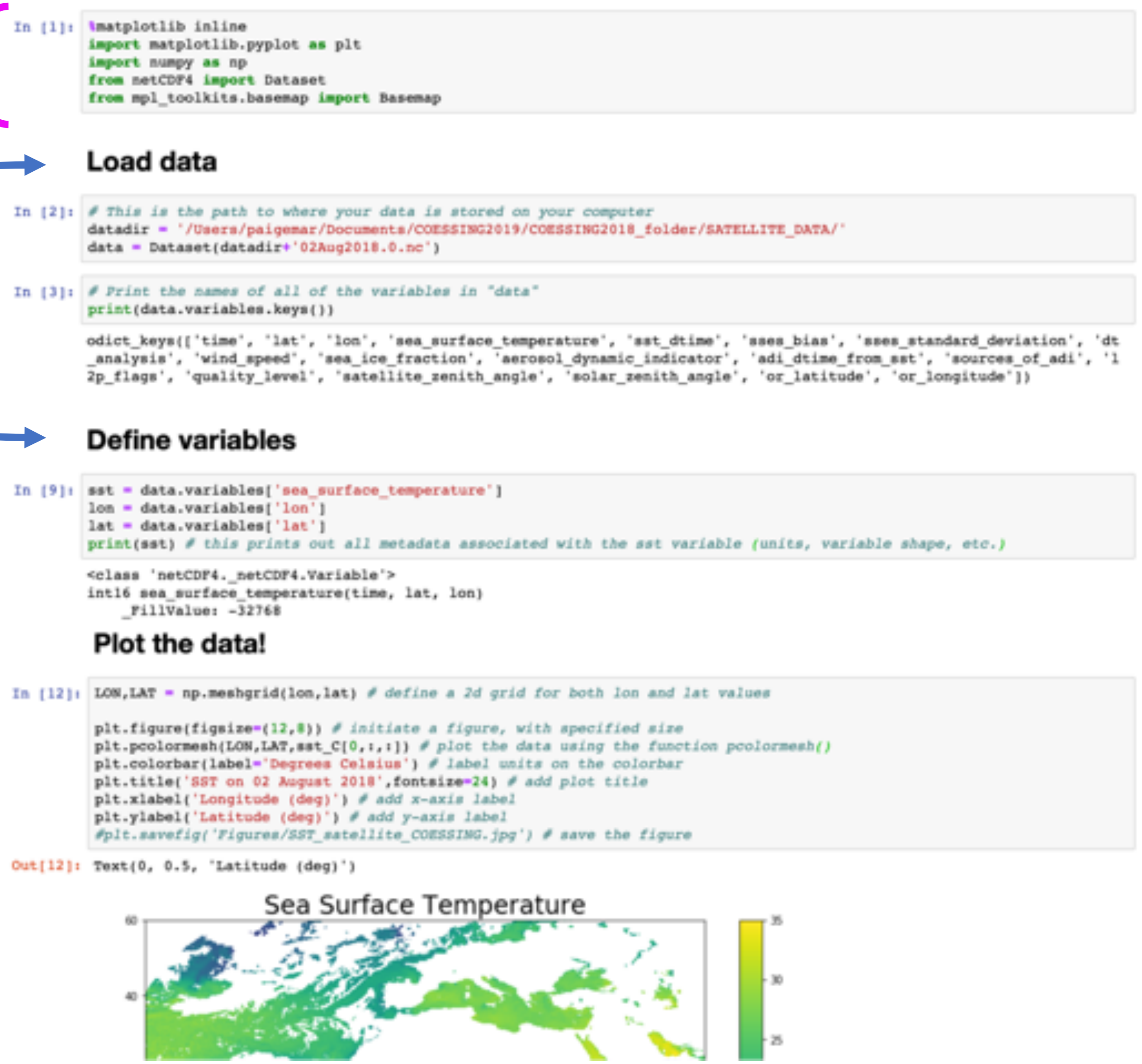

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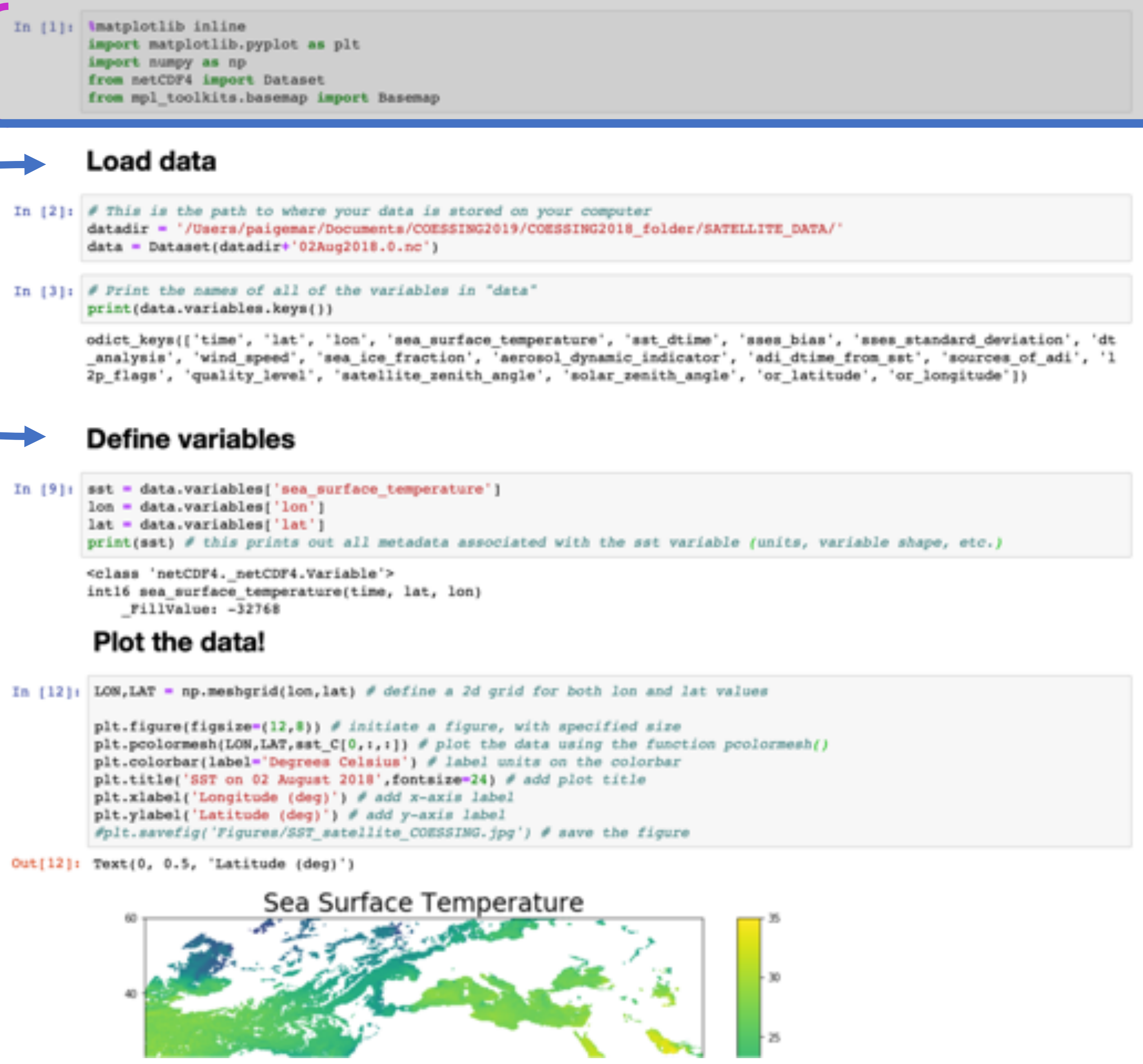

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Main code

Common actions in Python

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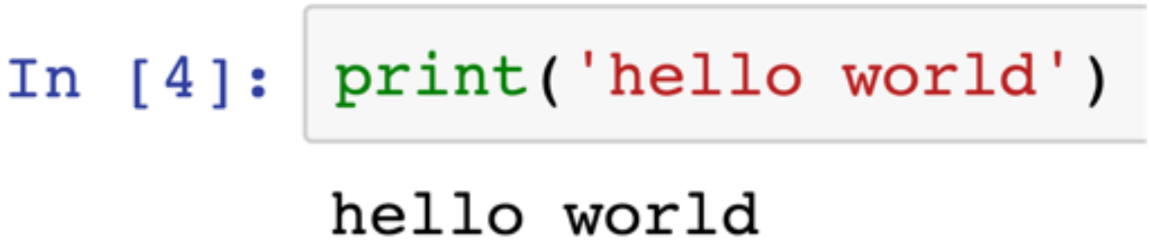
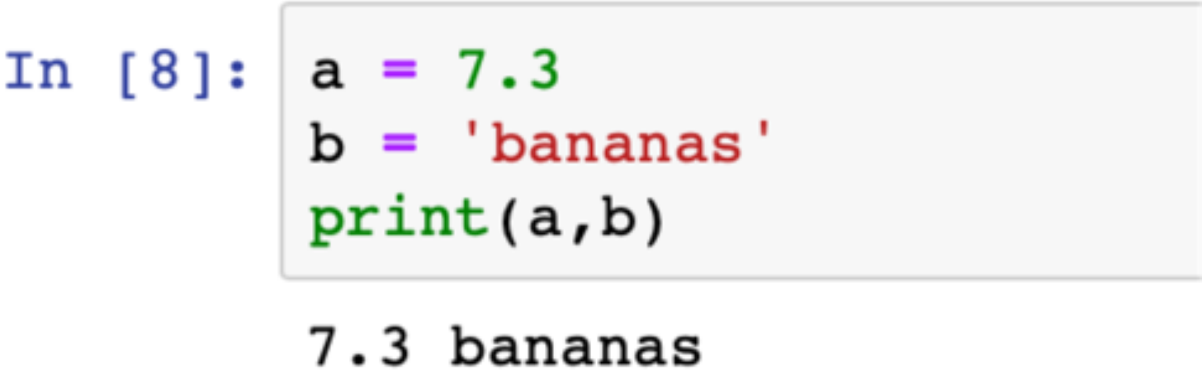


```
In [4]: print('hello world')

        hello world
```

Common actions in Python

- Print statements
- **Assign variables**

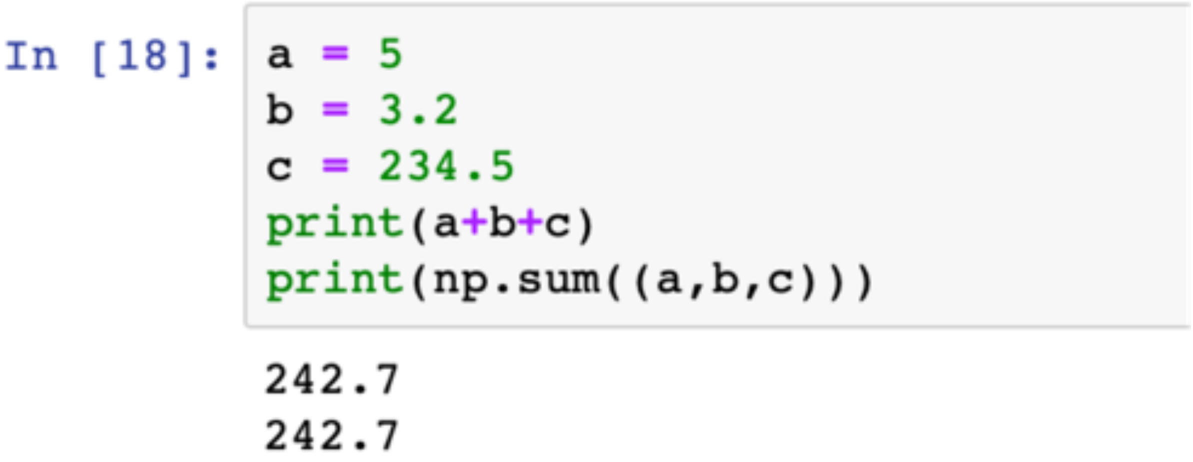


```
In [8]: a = 7.3
        b = 'bananas'
        print(a,b)
```

```
7.3 bananas
```

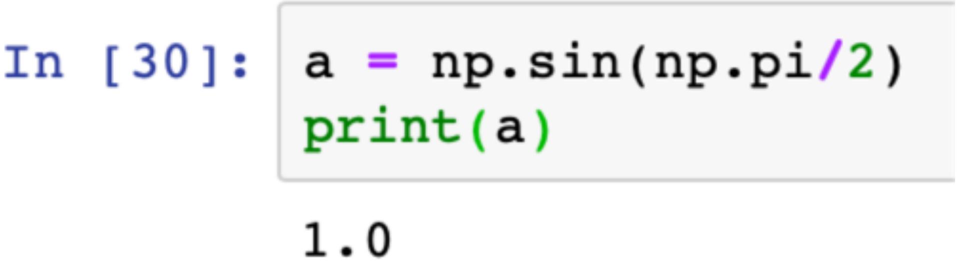
Common actions in Python

- Print statements
- Assign variables
- **Do math**



```
In [18]: a = 5
         b = 3.2
         c = 234.5
         print(a+b+c)
         print(np.sum((a,b,c)))

         242.7
         242.7
```

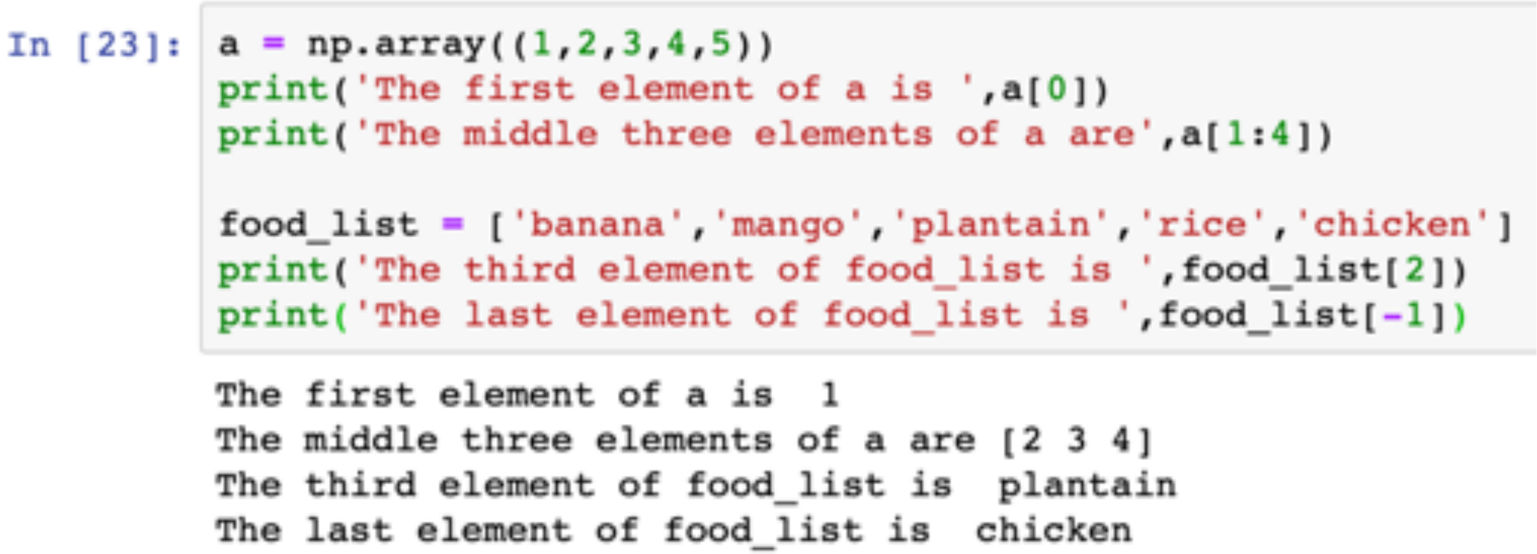


```
In [30]: a = np.sin(np.pi/2)
         print(a)

         1.0
```

Common actions in Python

- Print statements
- Assign variables
- Do math
- **Use arrays and lists**
    - **Accessing elements**



```
a = np.array((1,2,3,4,5))
print('The first element of a is ',a[0])
print('The middle three elements of a are',a[1:4])

food_list = ['banana','mango','plantain','rice','chicken']
print('The third element of food_list is ',food_list[2])
print('The last element of food_list is ',food_list[-1])
```

```
The first element of a is  1
The middle three elements of a are [2 3 4]
The third element of food_list is  plantain
The last element of food_list is  chicken
```

Common actions in Python

- Print statements
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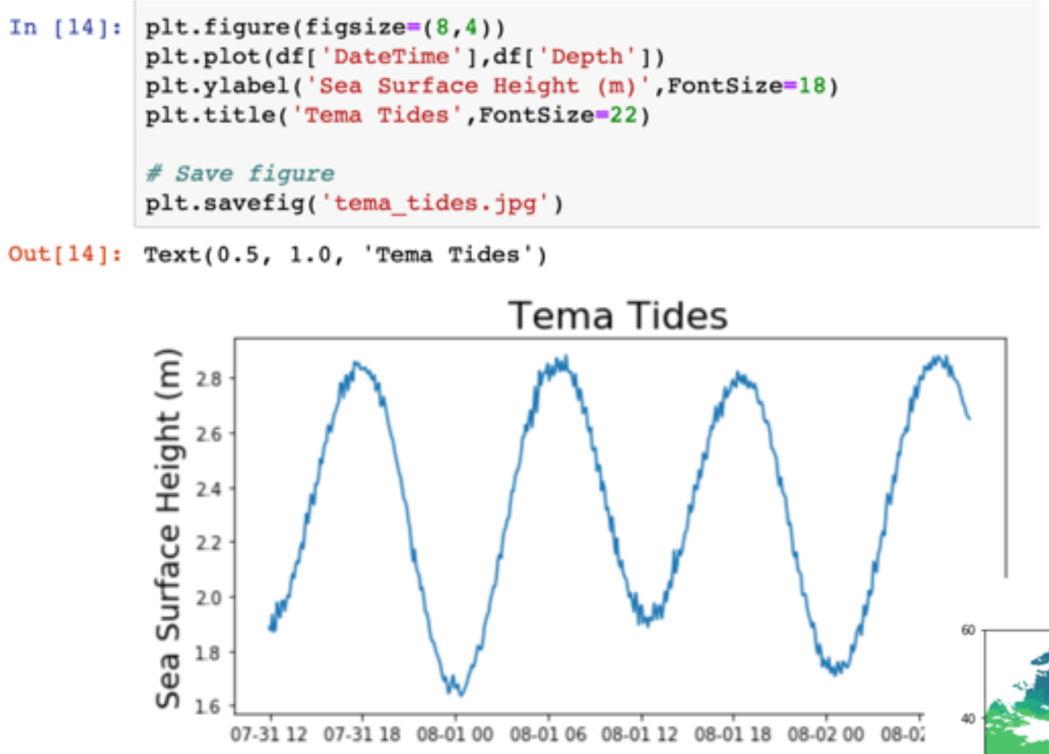
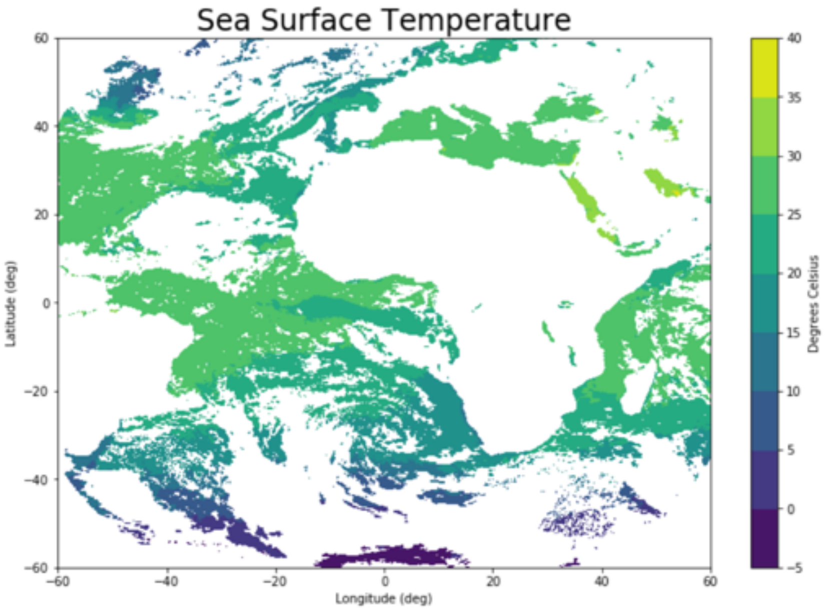
- **Plot data**



```
In [14]: plt.figure(figsize=(8,4))
         plt.plot(df['DateTime'],df['Depth'])
         plt.ylabel('Sea Surface Height (m)',FontSize=18)
         plt.title('Tema Tides',FontSize=22)

         # Save figure
         plt.savefig('tema_tides.jpg')

Out[14]: Text(0.5, 1.0, 'Tema Tides')
```



Common actions in Python

- Print statements
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- Use arrays and lists
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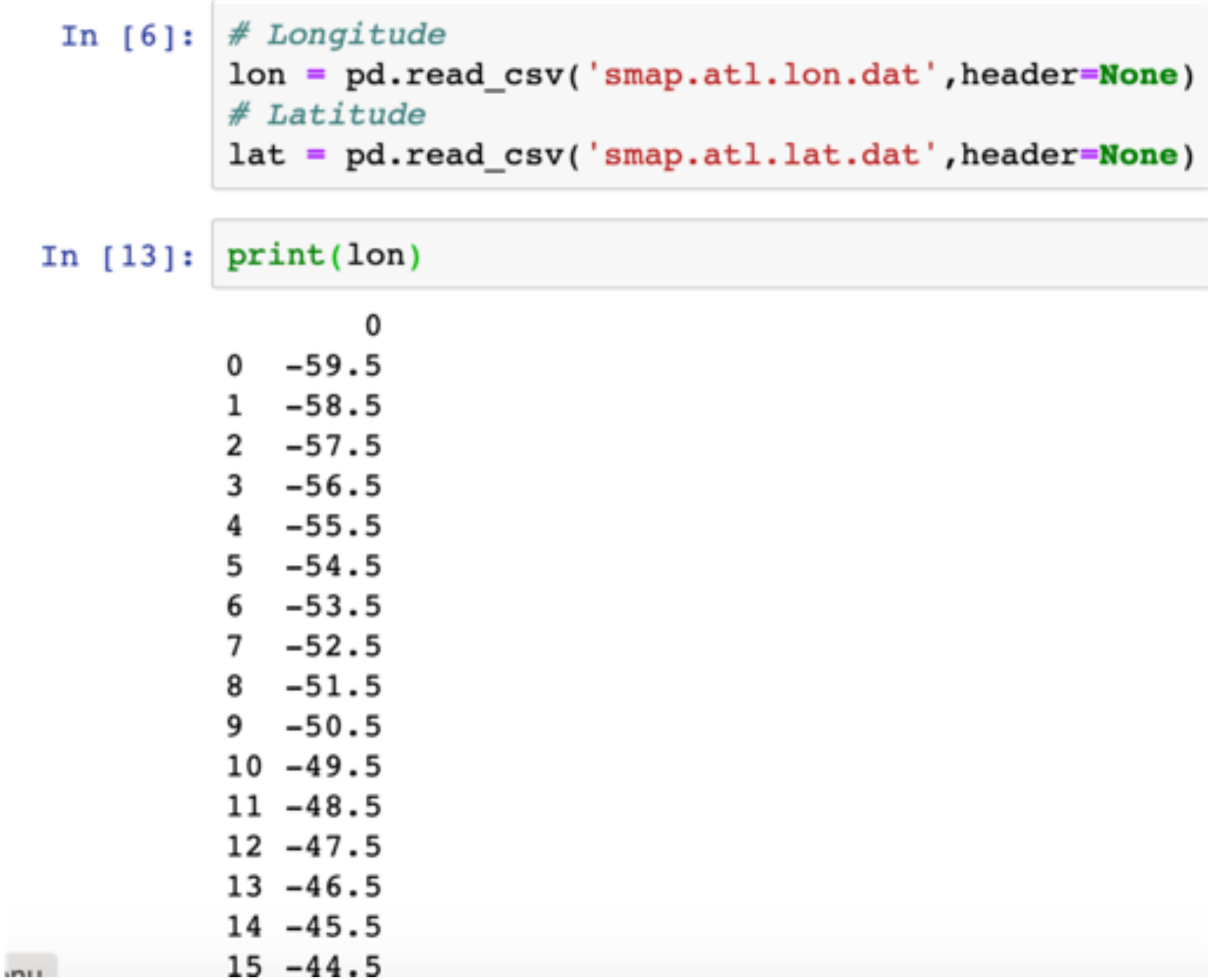
- Plot data
- **Load data – we assign a name to the dataset (e.g. ‘lon’) - same as assigning a variable!**



```
In [6]:  # Longitude
         lon = pd.read_csv('smap.atl.lon.dat',header=None)
         # Latitude
         lat = pd.read_csv('smap.atl.lat.dat',header=None)

In [13]: print(lon)

                0
         0   -59.5
         1   -58.5
         2   -57.5
         3   -56.5
         4   -55.5
         5   -54.5
         6   -53.5
         7   -52.5
         8   -51.5
         9   -50.5
         10  -49.5
         11  -48.5
         12  -47.5
         13  -46.5
         14  -45.5
         15  -44.5
```

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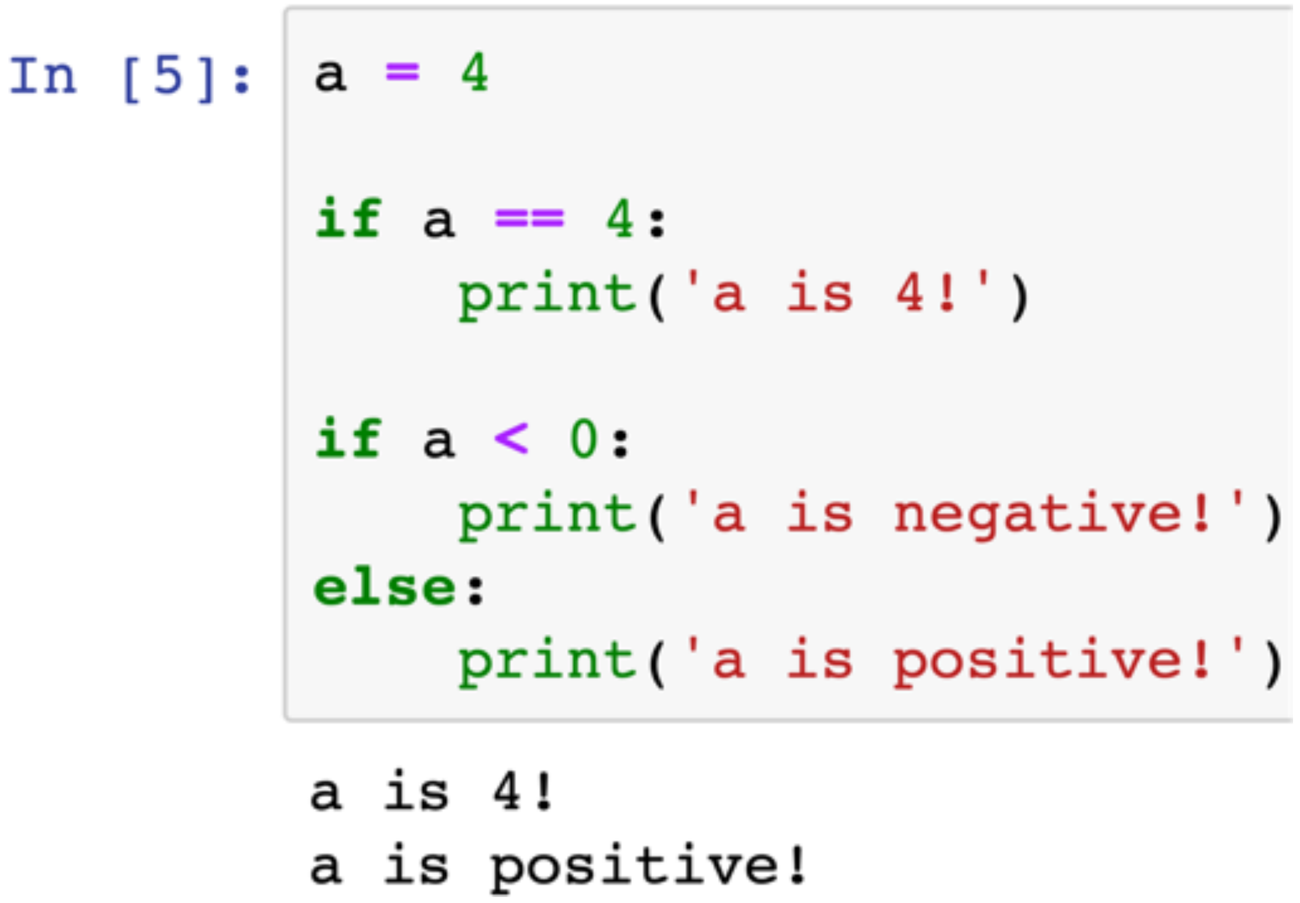
- Load data – we assign a name to the dataset (e.g. lon) - same as assigning a variable!
- **if statements** and for loops



In [5]:

```
a = 4

if a == 4:
    print('a is 4!')

if a < 0:
    print('a is negative!')
else:
    print('a is positive!')
```

```
a is 4!
a is positive!
```

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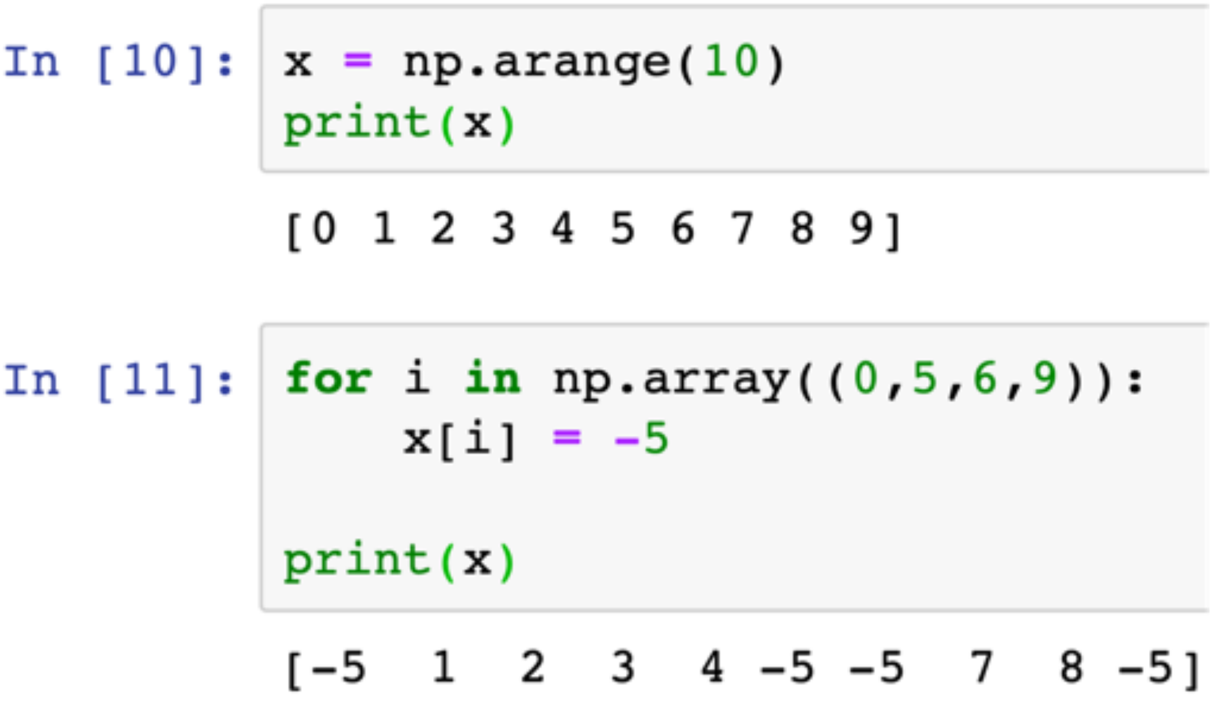

```
In [10]: x = np.arange(10)
         print(x)

[0 1 2 3 4 5 6 7 8 9]
```

```
In [11]: for i in np.array((0,5,6,9)):
             x[i] = -5

         print(x)

[-5  1  2  3  4 -5 -5  7  8 -5]
```

Common actions in Python

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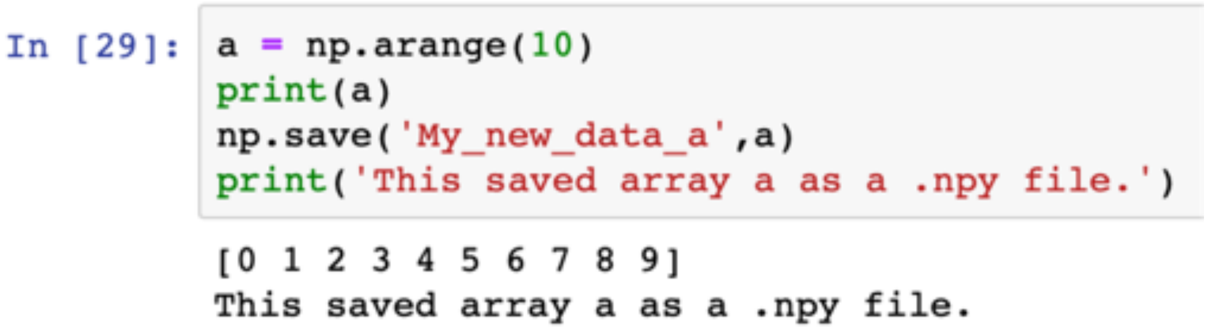
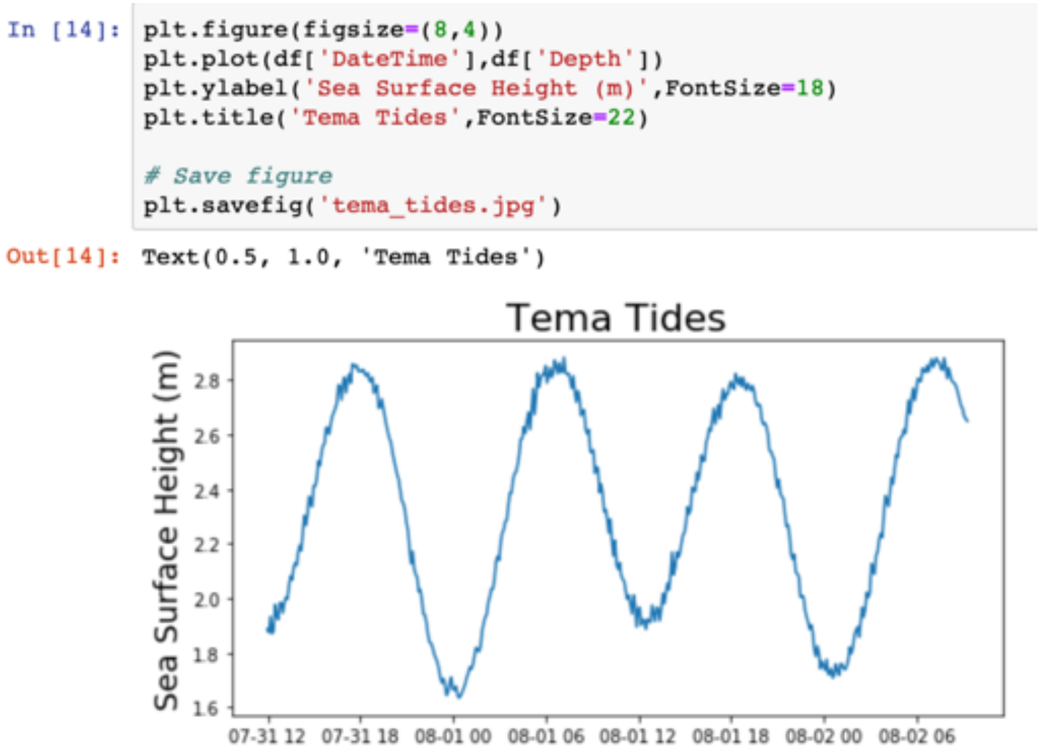
- Plot data
- Load data – we assign a name to the dataset (e.g. lon) - same as assigning a variable!
- if statements and for loops
- **Save new data or figure**



```
In [29]: a = np.arange(10)
         print(a)
         np.save('My_new_data_a',a)
         print('This saved array a as a .npy file.')

         [0 1 2 3 4 5 6 7 8 9]
         This saved array a as a .npy file.
```



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- Can be used for many different applications
- Other languages/software: Matlab, C, C++, Fortran, R, etc.

Download and install instructions

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ANACONDA

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- Introductory Python and Jupyter lessons also under the “Resources” tab
- Tomorrow afternoon, Python lab in the RMU computer lab!

Let’s open Jupyter notebook!