

BE/BAT 485/585

Remote Sensing Data and Methods Lab - 1

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**VIP lab.**

vip.arizona.edu
vegetation index & phenology Lab.
...Understanding a piece of the Earth system

 Institute of the
Environment

 USA npn
National Phenology Network

 USGS
LP DAAC
LAND PROCESS DATA DISTRIBUTED ACTIVE ARCHIVE CENTER

Scalars, Vectors, Matrices, and Tensors

Click

- Scalar

- A single quantity that has magnitude only
 - For example, $x \in \mathbb{R}$ (real numbers) or $y \in \mathbb{N}$ (Integer Numbers)
 - Example scalar quantities:
 - Length, Area, Speed, Volume, Temperature, Pressure, Energy, Work, Power, Entropy

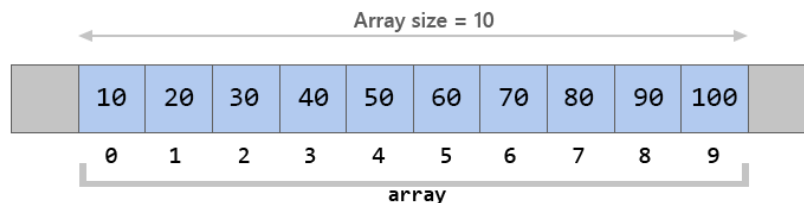
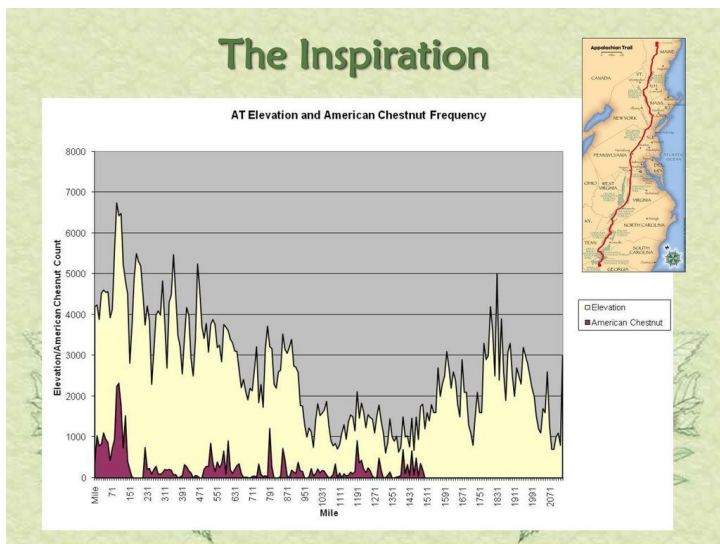


1 2 3 4 5
6 7 8 9 0

Scalars, Vectors, Matrices, and Tensors

- Vector

- A vector quantity has both magnitude and direction
 - Example: Displacement, Acceleration, Momentum, Force, Elec. Field, Magnetic field.
- Also, an ordered/indexed list of numbers/scalars
 - For example, $x \in \mathbb{R}^n$
 - Points in space where each element is a coordinate on a different axis
- Example: Height or count along a hiking trail



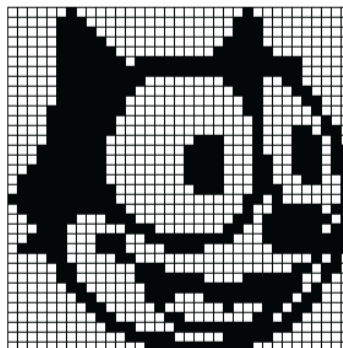
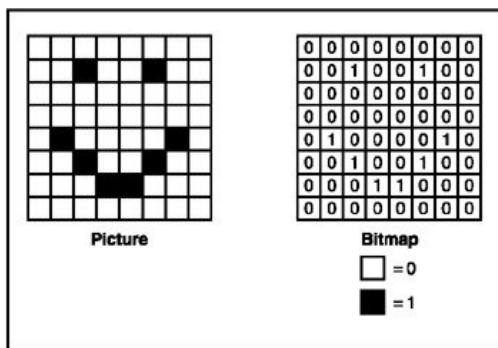
Scalars, Vectors, Matrices, and Tensors

- **Matrix**: 2D Array of numbers

- For example $X \in \mathbb{R}^{m \times n}$

| | | axis 1 | | |
|--------|---|--------|-----|-----|
| | | 0 | 1 | 2 |
| axis 0 | 0 | 0,0 | 0,1 | 0,2 |
| | 1 | 1,0 | 1,1 | 1,2 |
| | 2 | 2,0 | 2,1 | 2,2 |

- Ex: The value of a pixel in a B/W image (or color)

[illegible]

35x35

- Organized into Rows vs Columns (indices)
 - RxC, LxP, i x j, etc.
 - Helps address and navigate the content

Scalars, Vectors, Matrices, and Tensors

- Tensor: Arrays of numbers arranged on a regular grid with variables number of axes
 - Tensors are data containers and are critical and basic building blocks of modern data science & machine learning
 - A higher-order tensor can be interpreted as a multiway array, [...]
 - A tensor can be thought of as a multi-index numerical array, [...]

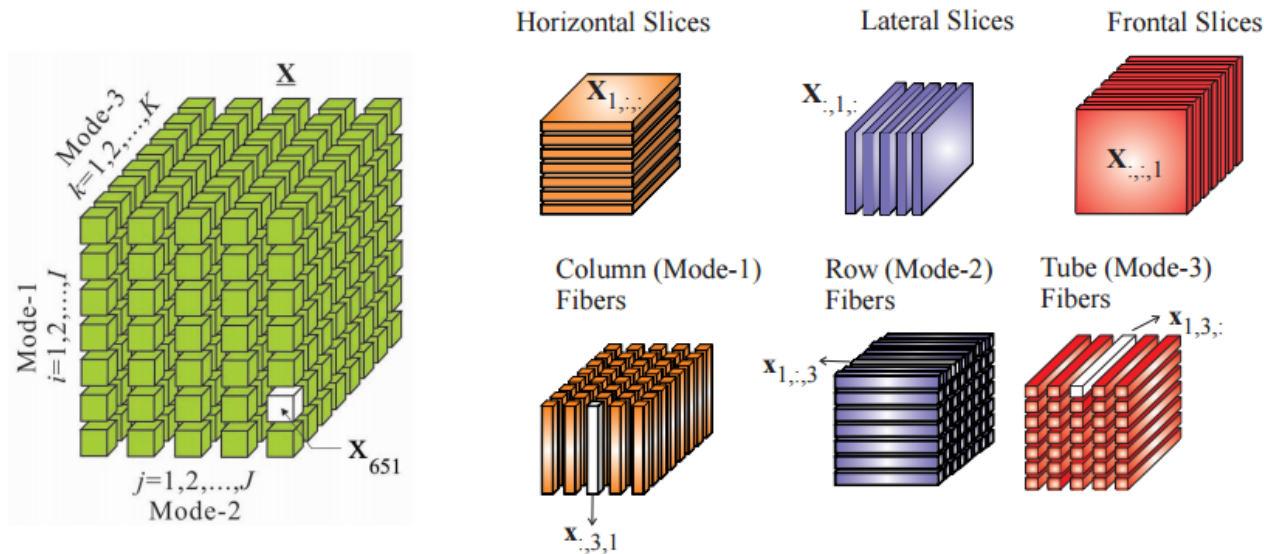
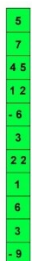


Figure 2: A 3rd-order tensor $\underline{X} \in \mathbb{R}^{I \times J \times K}$, with entries $x_{i,j,k} =$

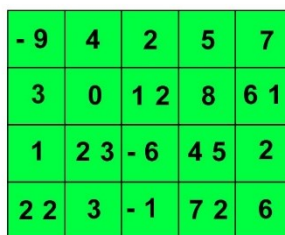
But they are all Tensors at the end

- 0D, 1D, 2D, 3D, n D
- Containing scalars (sometimes other forms of data)

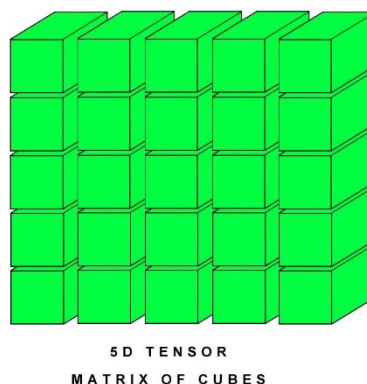
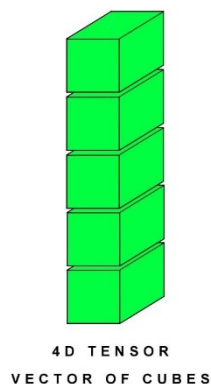
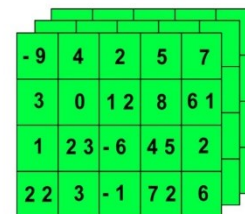
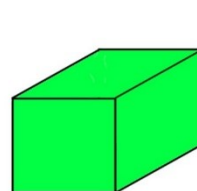
1D TENSOR /
VECTOR



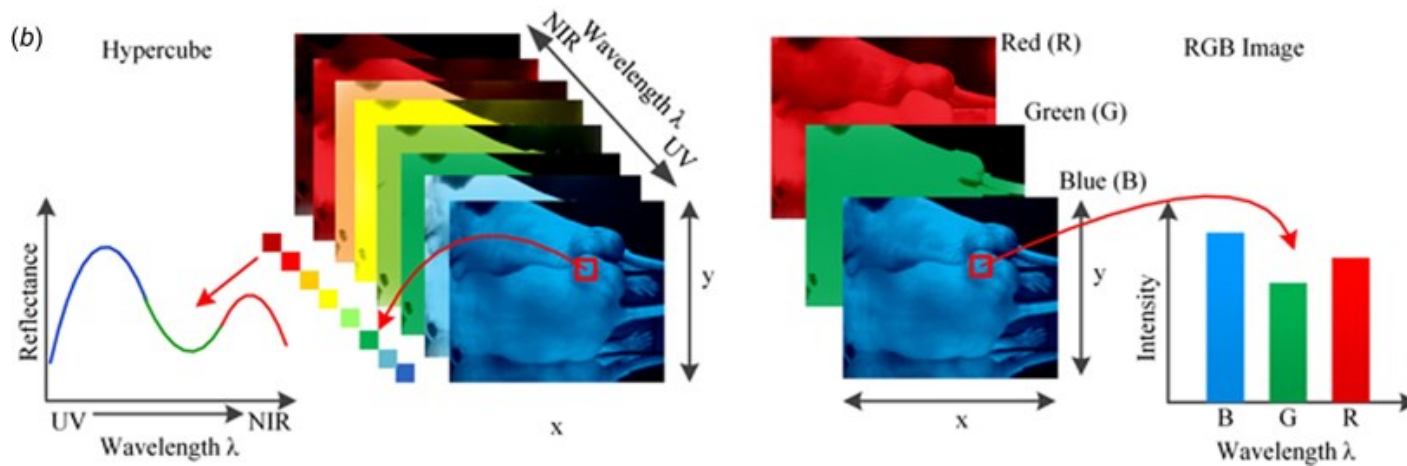
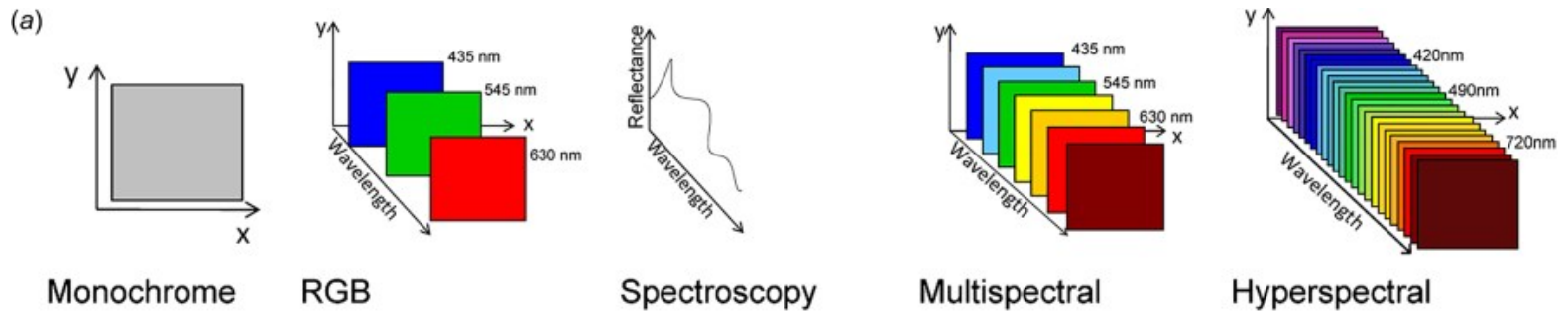
2D TENSOR /
MATRIX



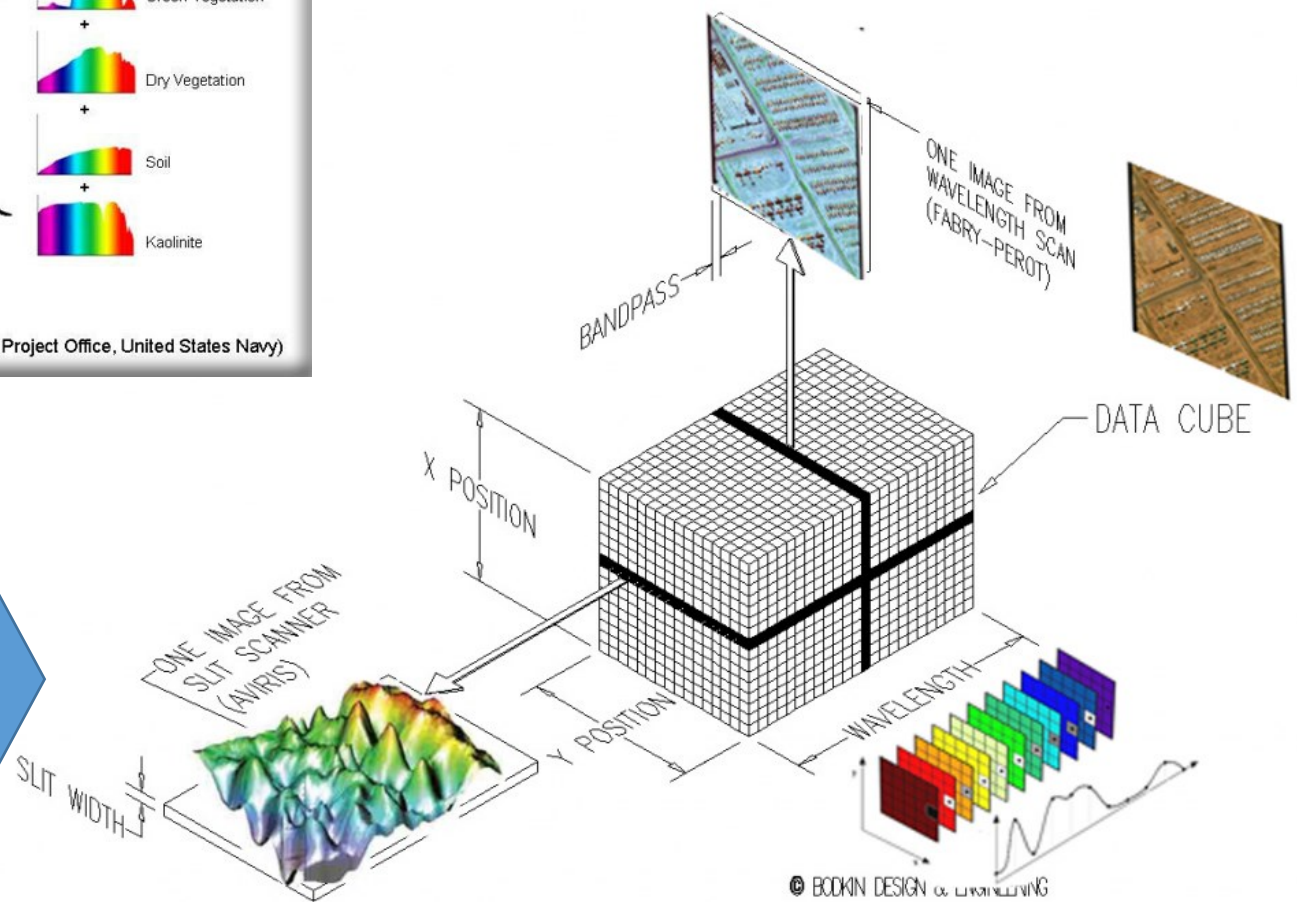
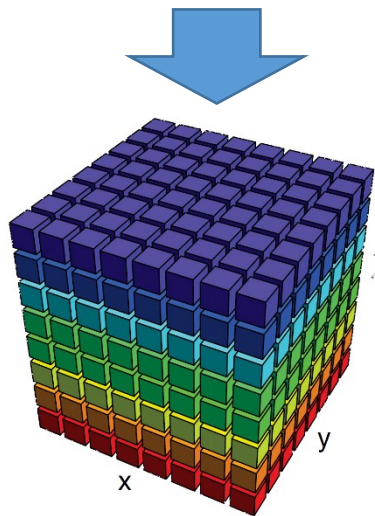
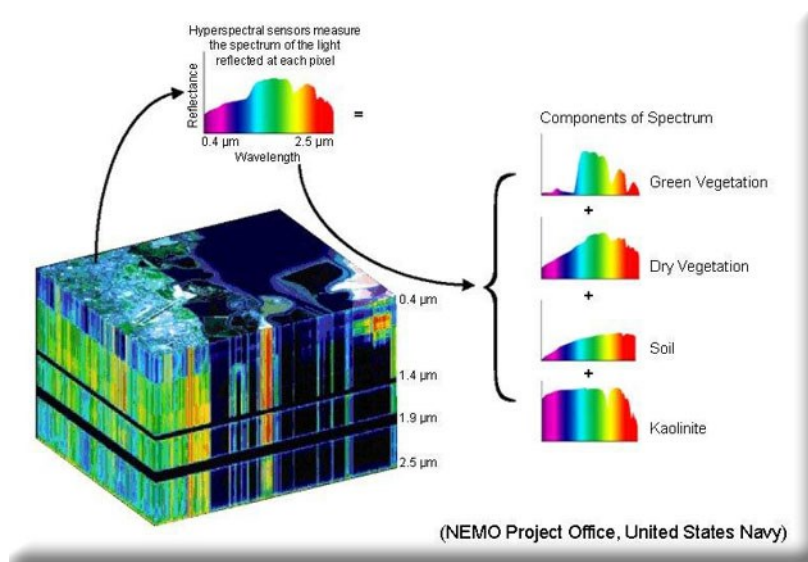
3D TENSOR /
CUBE



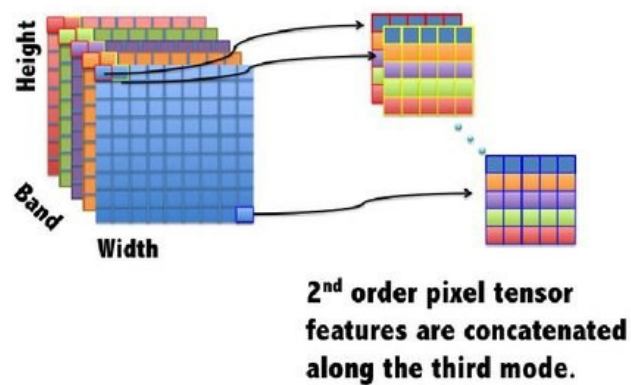
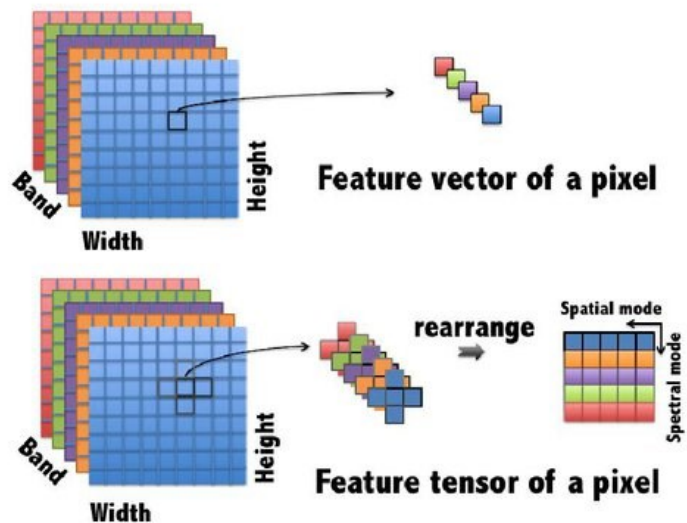
RS Data representation...become familiar with



Become familiar with



Become familiar with



Programming with Python – Quick Intro

We will use Anaconda in this Course

- Get and install the latest version of Anaconda from

- www.anaconda.com
- Follow instructions

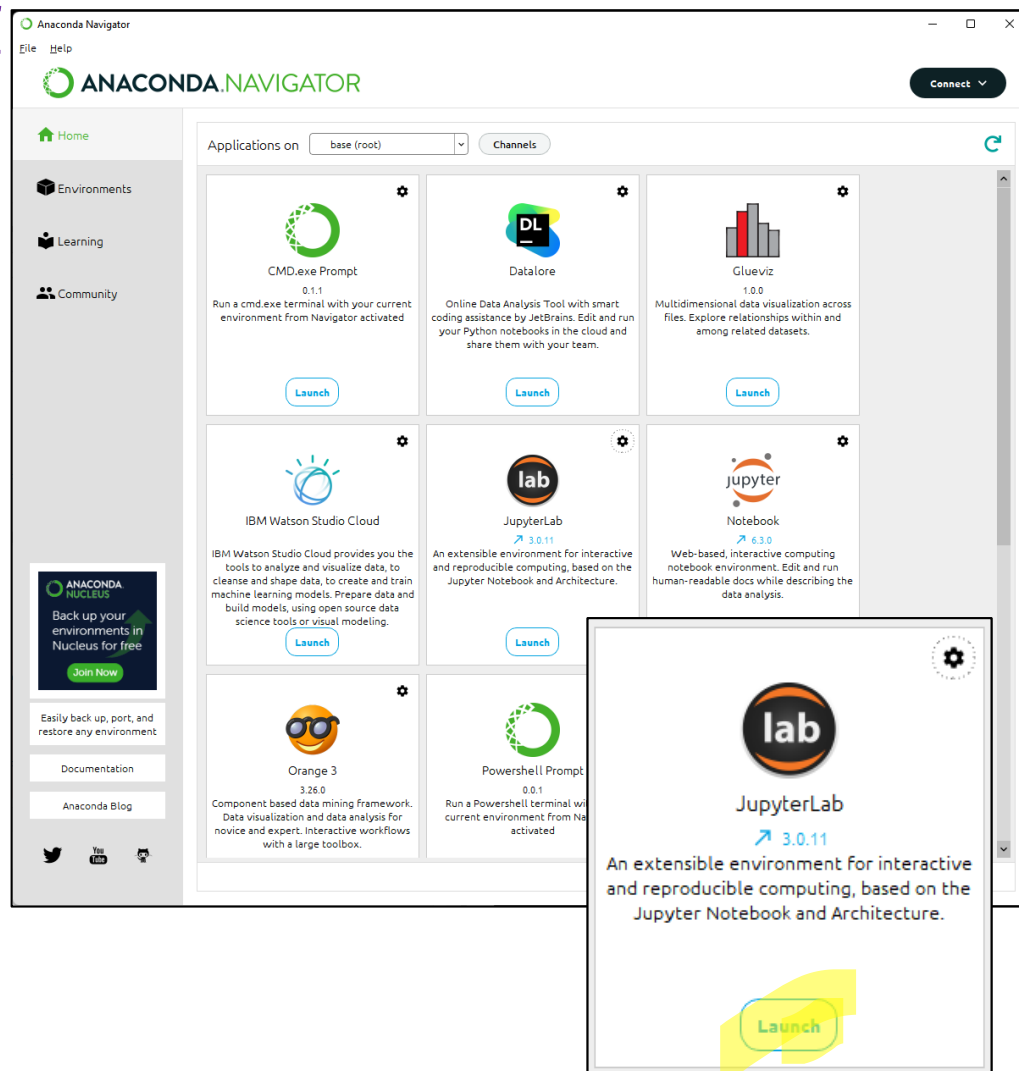


- We will add libraries as needed

- It is advisable to set it only for yourself

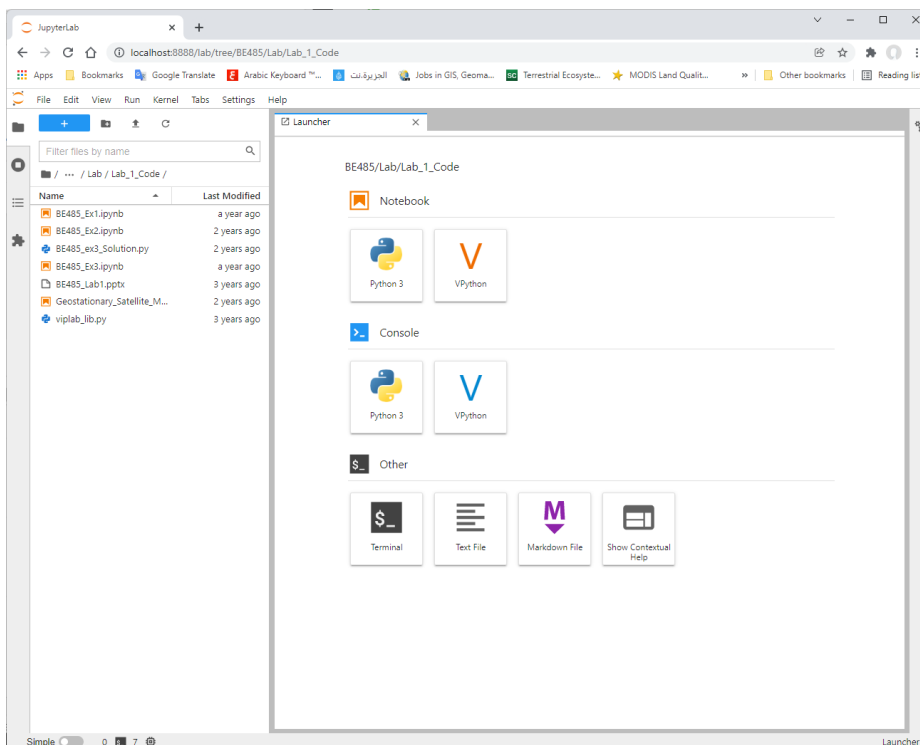
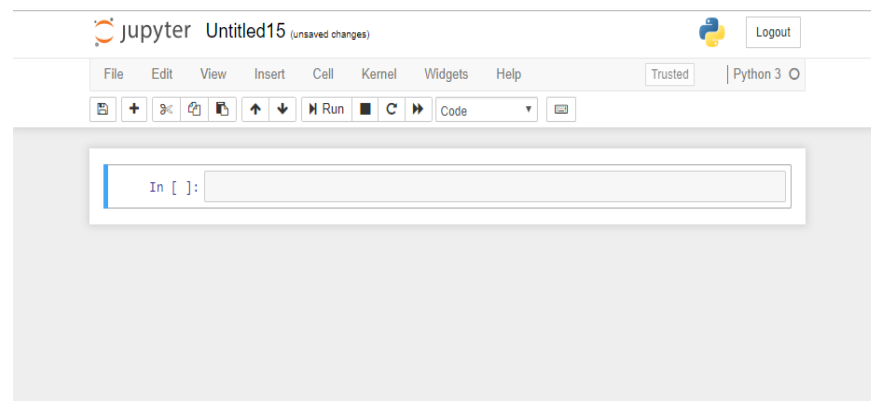
- We will also use Jupyter Lab

- Like Notebook but more integrated with the browser



Intro to Jupyter Notebook and JupyterLab

- **Jupyter Notebook** is a web application that allows you to create and share interactive documents containing live code, equations, visualizations, and narrative text, effectively creating rich and live interactive reports.
 - **Jupyter Notebook** offers several different building blocks for interactive computing: the notebook, file browser, text editor, terminal, outputs, etc.
- **JupyterLab** is an integrated rich “data science” UI (very similar to Notebook) but offers more.
 - It is a natural evolution of the classic notebook and provides a more flexible and powerful way of working with the same building blocks found in the notebook.
 - **Jupyterlab** is ‘almost’ the same as **Jupyter notebook** but more flexible, more powerful, has more tools, and more integrated with the browser



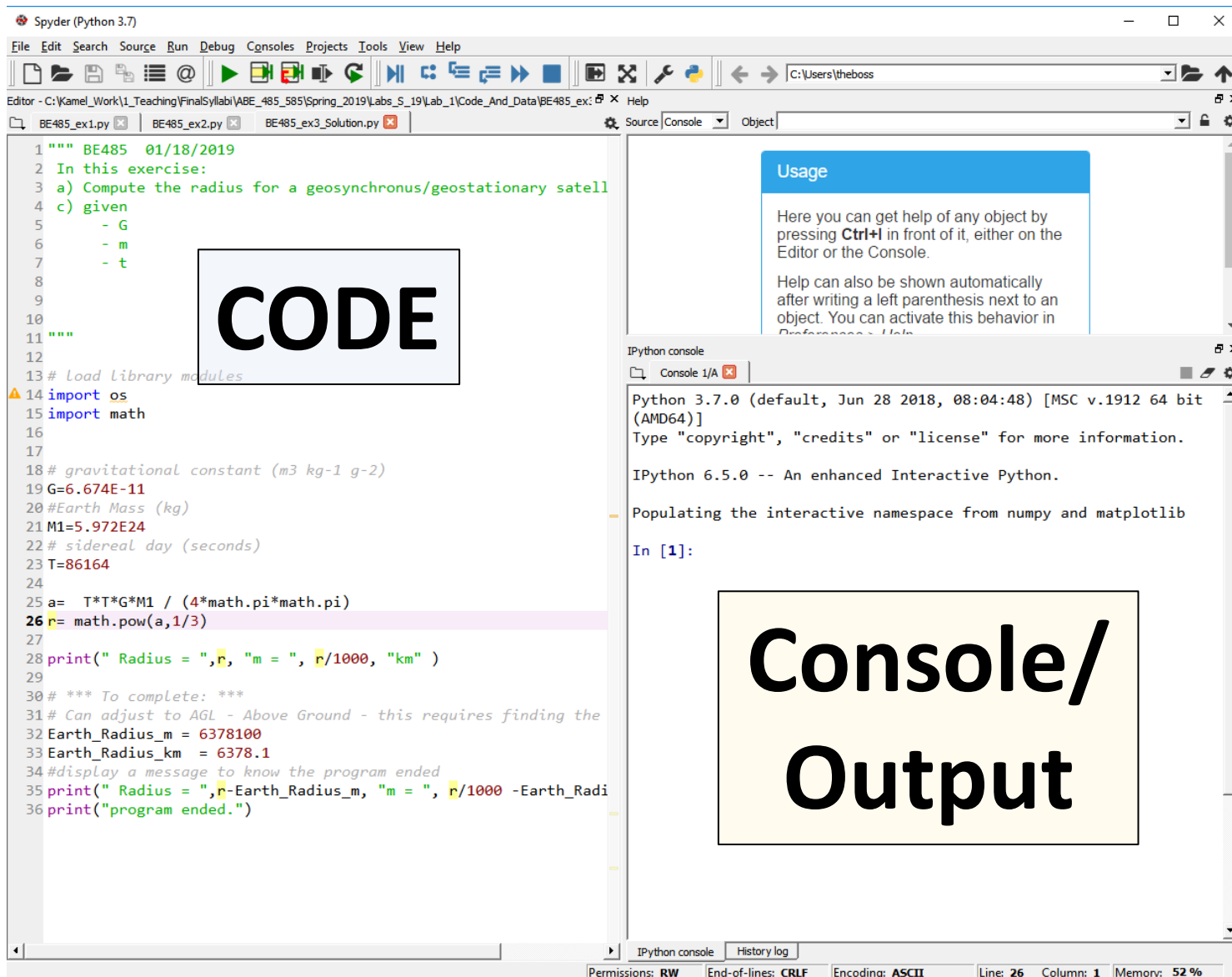
Jupyterlab - View

The image shows the Jupyterlab web interface with several yellow callout boxes and black lines pointing to specific features:

- Program name**: Points to the tab title "BE485_Ex1.ipynb".
- Kernel - Engine**: Points to the "Python 3" label in the top right corner of the editor area.
- Cell content type**: Points to the dropdown menu showing "Code", "Markdown", and "Raw".
- Run the cell content**: Points to the "Run" button (a play icon) in the top toolbar.
- Insert, cut, copy, paste, move Up/Down a new cell**: Points to the icons for inserting, deleting, copying, and pasting cells in the top toolbar.
- Stop, Restart, Rerun Kernel**: Points to the "Restart" and "Rerun" buttons in the top toolbar.
- Create a new cell**: Points to the "+" icon in the top toolbar.
- Input cell - Code or markup**: Points to a code cell containing Python code for data extraction and display.
- Output cell - Results**: Points to the output area of a code cell, showing the results of the execution.

The interface includes a top menu bar (File, Edit, View, Run, Kernel, Tabs, Settings, Help), a left sidebar with a file browser, and a main editor area with multiple cells.

Then there is Spyder and PyCharm IDEs



Which one to use

- We will use JupyterLab but feel free to use whatever suits you
 - And you may have to be on your own at times
 - You get the same functionality and more
- Standardize our Lab work/HW and makes it easier to grade, debug, and help
 - You will always turn in your notebook (*.ipynb)
 - And we will run and see the results
 - Learn to annotate and clean your work
 - Learn to create nice scientific reports

Exercise #1: Arrays and Data Access

- Arrays and datasets
 - Create a 2D array
 - Access a single pixel value
 - Retrieve a row of data
 - Retrieve a column of data

| | | | | |
|----|----|----|----|----|
| 1 | 4 | 7 | 11 | 15 |
| 2 | 5 | 8 | 12 | 19 |
| 3 | 6 | 9 | 16 | 22 |
| 10 | 13 | 14 | 17 | 24 |
| 18 | 21 | 23 | 26 | 30 |

Note: Indexes are Zero-based, so first row or column is always **zero**

- **Homework:**
 - Change the code to extract a 'subset/group' of values
 - Create a new 2D array that contains the values from row 2-4 and columns 3-6
 - Print this new array to the screen

Instructions:

- Download from D2L files:
 - BE485_UofACampus.xlsx
 - BE485_Ex1.ipynb

Exercise #2: Arrays and Data Access

- Reading data and creating Images from an Excel Table
 - Read an Excel file
 - Access the data in the Excel sheet(s)
 - Display single band/channel Images (image are 2D arrays of scalars)
 - Display an RGB Image (combine the 3 bands). That is how images are created
- Homework:
 - Using code from **Ex1**, display a window/subset that represents 'Old Main' building as an RGB image
 - You will need to define/find the extent of Old_Main
 - You can guess by estimating the corners' locations, then fine-tune it

Instructions:

- Download from D2L files:
 - BE485_UofACampus.xlsx
 - **viplab_lib.py** [Library]
 - BE485_Ex2.ipynb

RGB Images

RGB Image

Number of rows = 751

Number of columns = 1151

