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ADVENTURES IN EO DATA

NASA INTERNATIONAL SPACE APPS CHALLENGE

HALIFAX | OCT. 06, 2023

PREPARED BY

ELLIE JONES
MACHINE LEARNING & DATA SCIENCE LEAD

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BETTER EARTH, FROM SPACE

Wyvern is the way decision makers address the world's biggest challenges. Our data reveals the hidden reality of planet Earth.

The Highest Resolution

Just High Quality Data

We Have Dragons

Deployable Optics

www.wyvern.space

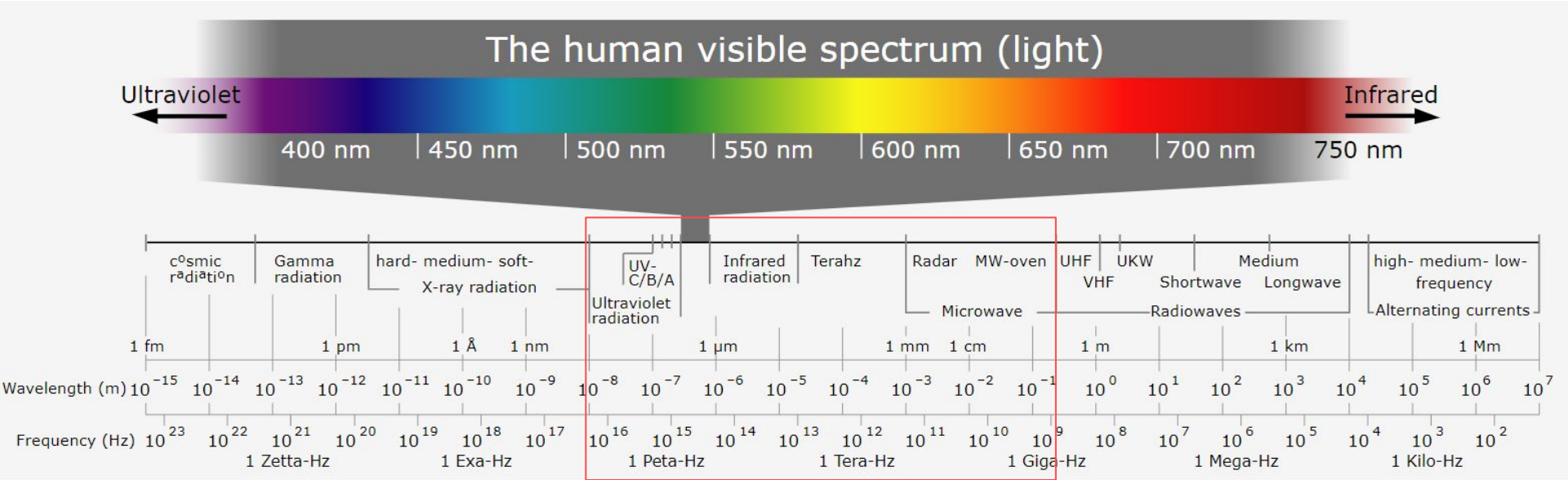
EARTH OBSERVATION

The gathering of information about the physical, chemical, and biological systems of the planet Earth

We can gather information in a variety of ways, typically by using **remote sensing**. Remote sensing can be accomplished using satellites, drones, or planes!

ELECTROMAGNETIC SPECTRUM

It’s best to start our discussion on the electromagnetic spectrum! Almost all earth observation satellites sense **some part** of this spectrum!



TYPES OF EO DATA

TYPES OF EO DATA

Active Sensors

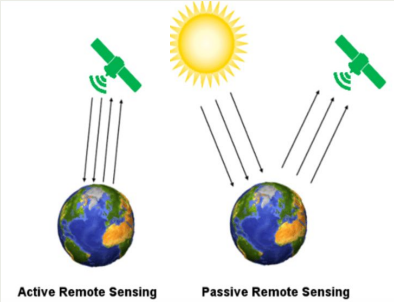
Active sensors produce their own signal that bounces off of an object, and is collected back by the sensor.

Active sensors are useful to measure features about how an object reflects back to the sensor (texture/shape/composition/distance)

Passive Sensors

Passive sensors collect information emitted by objects, and do not produce any signals that are used during measurement.

Passive sensors are useful to measure what gets reflected/emitted from an object (e.g. What wavelengths of sunlight are reflected by Earth's surface).

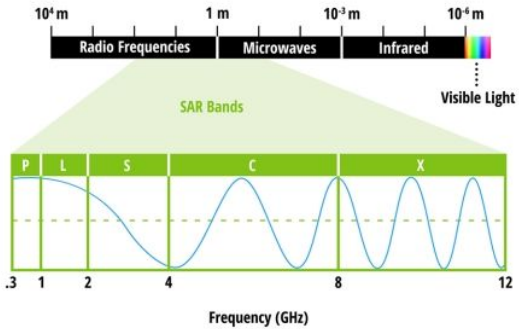


https://www.researchgate.net/figure/Differences-between-passive-and-active-sensors_fig1_339726853

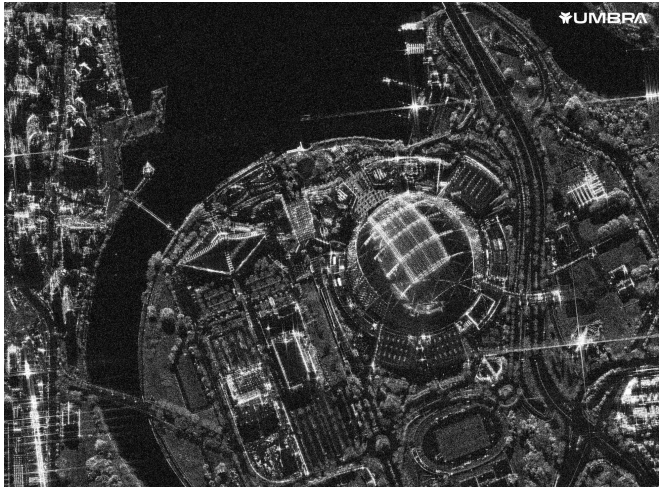
ACTIVE!

SYNTHETIC APERTURE RADAR

Synthetic Aperture Radar (SAR) satellites generate radar waves that then bounce off surfaces on earth. They have a number of special properties, including being able to image at night and through clouds!



https://www.earthdata.nasa.gov/learn/backgrounders/what-is-sar



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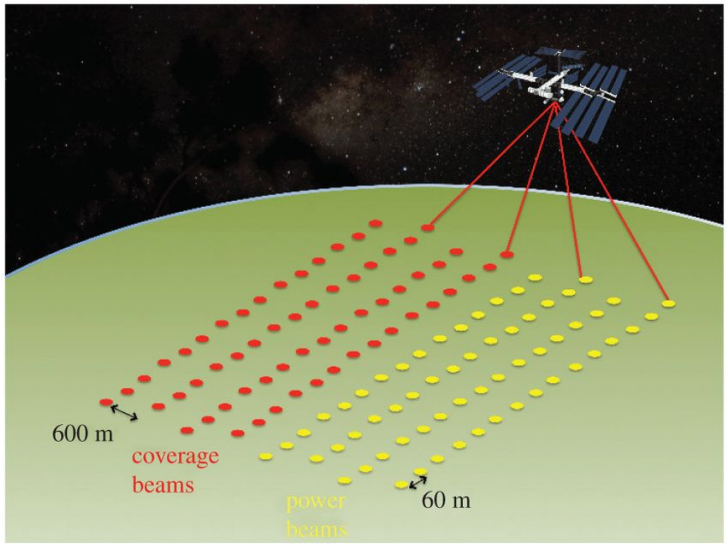
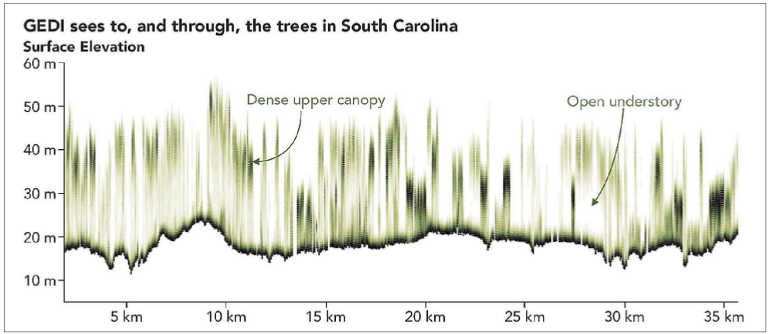
LIDAR ACTIVE!

LIDAR stands for Light Detection And Ranging, and uses pulsed laser light to calculate the distance from an object to the sensor. It is specifically designed to accurately measure surface height, however can also be used to measure other features such as forest canopies and clouds!



https://www.researchgate.net/figure/Illustration-of-GEDI-sampling_fig1_356692676



https://www.eoportal.org/satellite-missions/iss-gedi#laser-build-and-test-plan-overview

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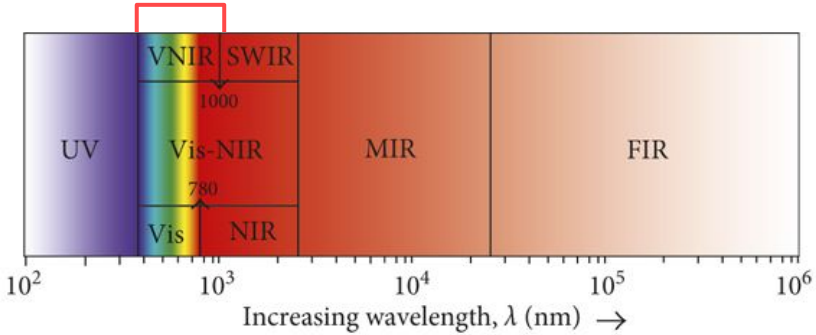
VNIR OPTICAL IMAGERY

PASSIVE!

VNIR passive sensors observe the **Visible to Near-Infrared** portion of the electromagnetic spectrum. Most of the light in this area of the spectrum is visible to us, and can be used to observe & assess vegetation, man-made objects, shallow water, and more! It is the most common type of optical imaging, with satellites of all shapes and sizes in the air right now.

False-color IR + Red & Green Wavelengths



https://www.hindawi.com/journals/jspec/2018/3168974/

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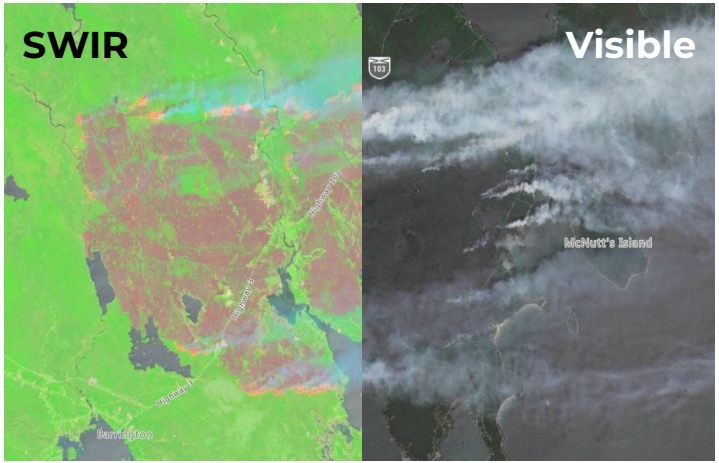
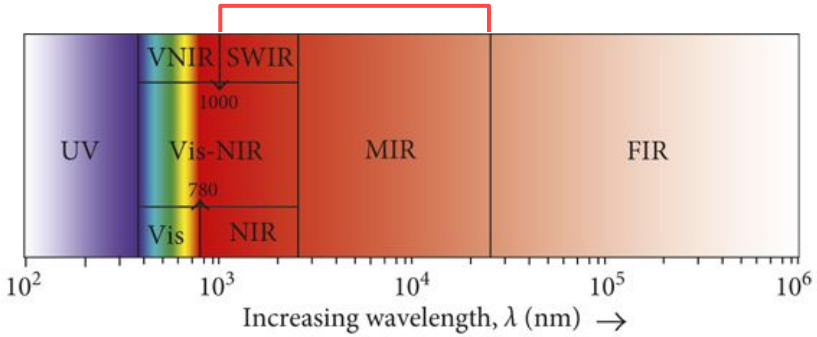
SWIR OPTICAL IMAGERY

PASSIVE!

SWIR passive sensors observe the **Short-wave infrared** portion of the electromagnetic spectrum. Objects reflect SWIR light differently than VNIR light, and can be used to discern hydrocarbons, heat, and additional detail about vegetation (moisture, cellulose, etc). Light in this spectrum also passes through clouds and smoke!





https://www.hindawi.com/journals/jspec/2018/3168974/

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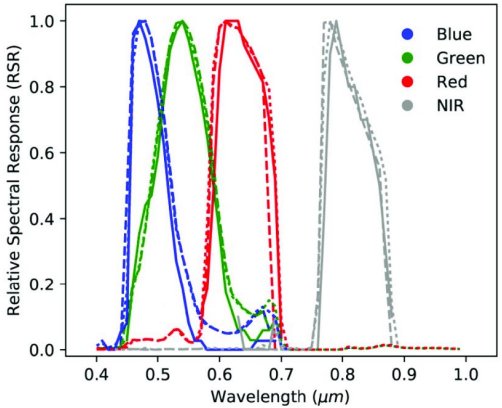
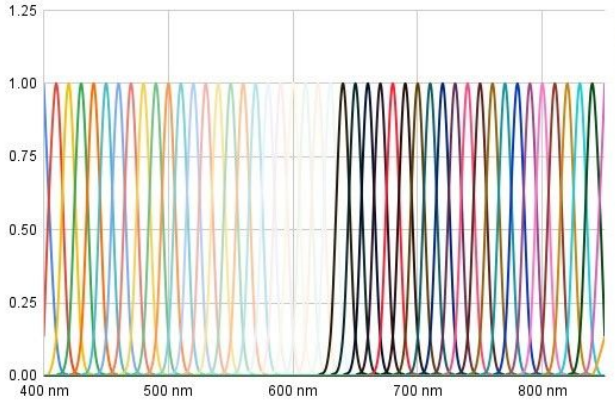
OPTICAL SATELLITE “BANDS”

Optical satellites sense different “bands” which correspond to the range of wavelengths the sensor is sensitive to. For multispectral satellites, these bands might be fairly wide (100nm). For hyperspectral satellites, these bands are fairly small (10nm)



Multispectral Bands



Hyperspectral Bands

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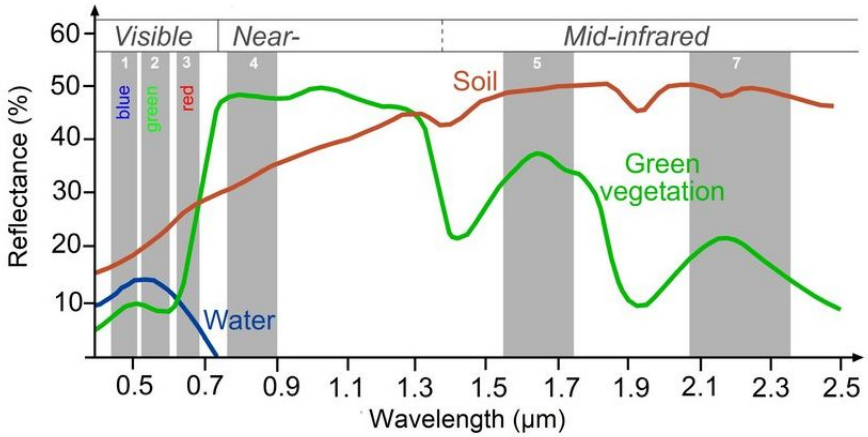
HYPERSPECTRAL IMAGERY

PASSIVE!

Hyperspectral satellites are similar to multispectral satellites, except they collect many more bands with shorter wavelength sensitivities. They produce significant amounts of data, however have many uses including chemical analysis and machine learning.



Multispectral Bandwidths over Reflectance Curves

Multispectral vs. Hyperspectral

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A NOTE ABOUT RESOLUTION...

Resolution can mean many different things (spatial resolution, bit resolution, band resolution), and we could probably have a workshop **only** on resolution.

To keep it short and simple, generally when talking about “resolution”, we’re talking about “spatial resolution”, or the size of a pixel in meters/feet/etc.

MODIS (500m)

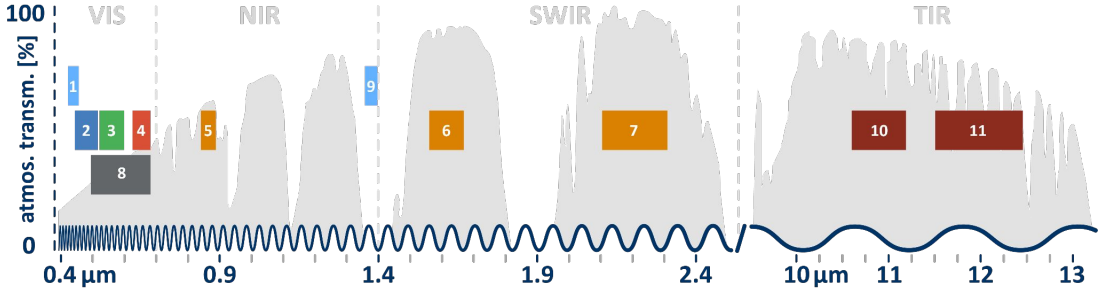
Sentinel-2 (10m)

COMMON SATELLITES

LANDSAT PROGRAM

The Landsat program is operated by NASA, and has been continually operated since 1972! Landsat 8 & 9 are currently operational and provides VNIR + SWIR + Thermal IR with a maximum resolution of **30m**.

https://earth.esa.int/eogateway/missions/landsat



https://blogs.fu-berlin.de/reseda/landsat-8/

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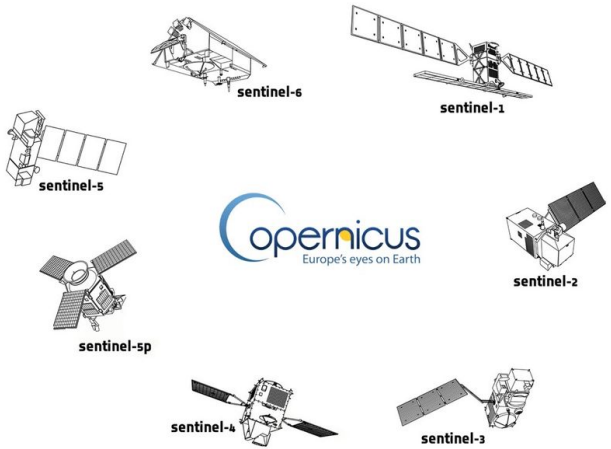
SENTINEL PROGRAM

The European Space Agency operates the Sentinel program, which is a series of satellites that collect a broad range of data:

- **Sentinel-1**: Synthetic Aperture Radar
- **Sentinel-2**: Optical VNIR+SWIR, 10m resolution (highest freely available resolution)
- **Sentinel-3**: Monitors ocean, land & surface temperature & color, plus more
- **Sentinel-4/5**: Air quality & atmospheric monitoring

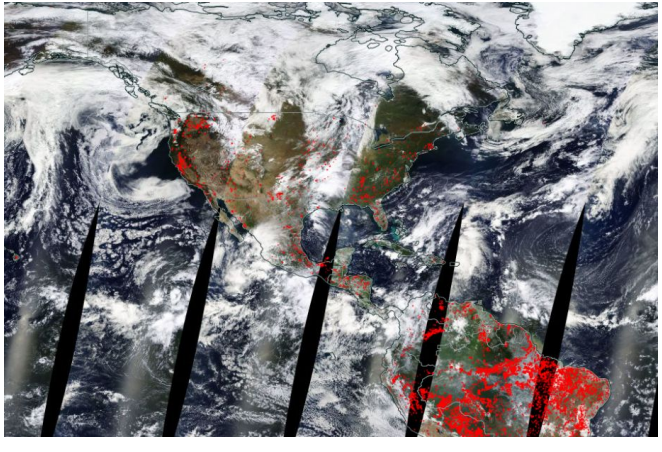
And the best part... it's all freely available!



MODIS

The Moderate Resolution Imaging Spectroradiometer is an instrument aboard NASA's Aqua and Terra satellites that provides 36 bands across the VNIR + SWIR + TIR spectrums. MODIS has a maximum spatial resolution of **250m**, which is quite coarse but suitable for large-area analysis. MODIS also has an extremely high revisit rate across the globe!

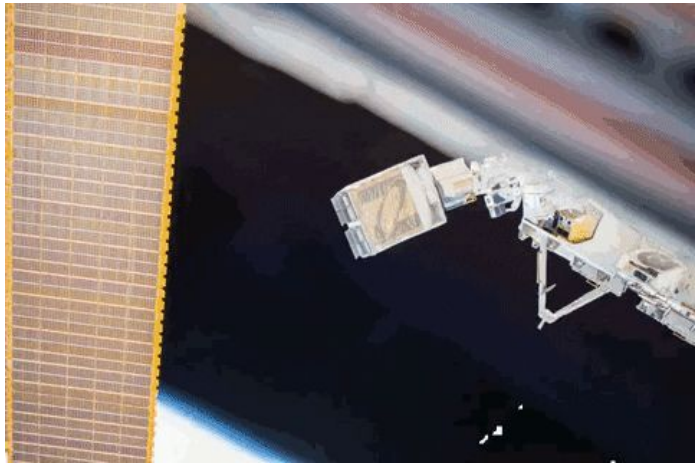
Aqua and Terra satellites also contain a number of other sensors, including ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) which is designed to measure thermal emissions at a high resolution!



AND MANY MORE...

Every day new satellites come online, many of them providing free data for everyone! If you want to measure something, chances are something is in the air right now doing it!

NASA's EarthData is a fantastic resource for searching for data: search.earthdata.nasa.gov



WORKING WITH GEOSPATIAL DATA

TYPES OF GEOSPATIAL DATA

Vectors

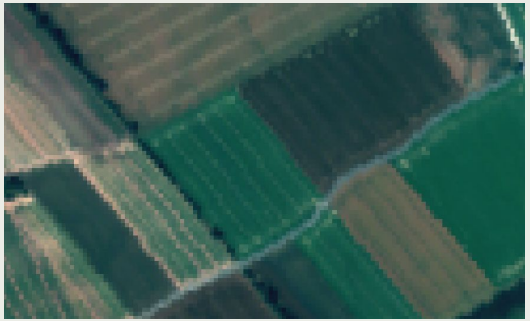
Vector data represents features as points, lines, and polygons and are stored as a series of coordinates. In other words, **it's a shape!**

It is defined by mathematical equations instead of pixels, and is easily manipulated.

Rasters

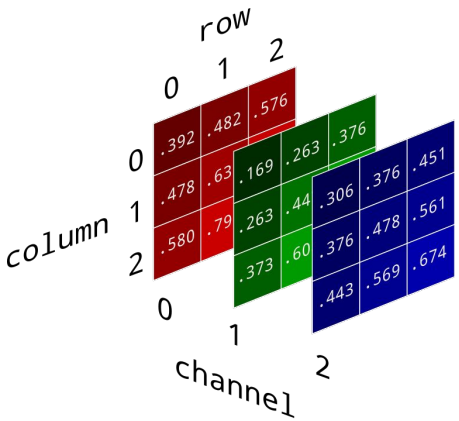
Raster data is a grid of pixels, with each pixel representing a specific location. Or in other words, **it's an image!**

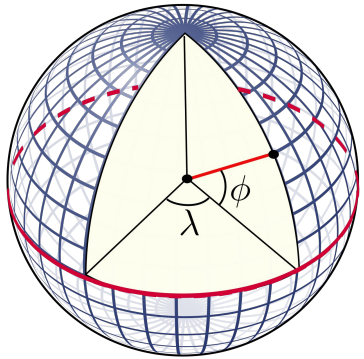
Rasters are significantly larger than vectors and are more difficult to manipulate.



RASTER IMAGERY

Raster imagery is comprised of **two** distinct parts. The image (a.k.a an array of data), and the geospatial reference (where the image is located on the earth). Without the geospatial reference, we would just have a fancy picture!





COORDINATE REFERENCE SYSTEMS

Unfortunately, the earth is not flat! We use Coordinate Reference Systems (CRS) to (as accurately as possible) locate our flat data on a spherical earth.

There are **many** different CRS', but the only one you need to worry about is WGS 84 (or EPSG:4326). It uses latitude and longitude degrees, and is the most common CRS you will come across.

Highly recommend the Map Men video on earth projections!

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WHERE TO FIND DATA

The NASA Space Apps Challenge pages provide **excellent** links to where to find data.

Additionally, here are some of my favorites:

- NASA EarthData
- AWS Open Data Registry
- Google Earth Engine STAC Catalog
- Planetary Computer STAC Catalog
- AVIRIS-NG Hyperspectral Data Portal
- STAC Datasets

STAC!

SpatioTemporal Asset Catalogs are a common way for geospatial data to be stored. It allows you to easily query a catalog for a specific time, location, or other parameter (cloud, sensor type, etc)

PyStac is commonly used when coding in Python, and QGIS has STAC plugins you can install (https://stac-utils.github.io/qgis-stac-plugin/).

STAC
SpatioTemporal
Asset Catalog

GIS SOFTWARE

Most geospatial software is expensive and closed source (ArcGIS). However, QGIS is a free alternative that is awesome! It also integrates many open source geospatial tools (Python, GDAL, etc)

If you're not comfortable with writing code, QGIS can accomplish the vast majority of GIS tasks! There's even a rich plugin community to add additional features.

www.qgis.org

GIS SOFTWARE (CONT.)

Google and Microsoft also provide products for geospatial analysis. They are both extremely powerful and provide access to the most common geospatial datasets/satellites

Both of these products may take a while to give you access! If you would like to use them, apply now!

Google Earth Engine

earthengine.google.com

Planetary Computer

planetarycomputer.microsoft.com

WRITING CODE & GIS

Python and R are the most commonly used programming languages for geospatial software development.

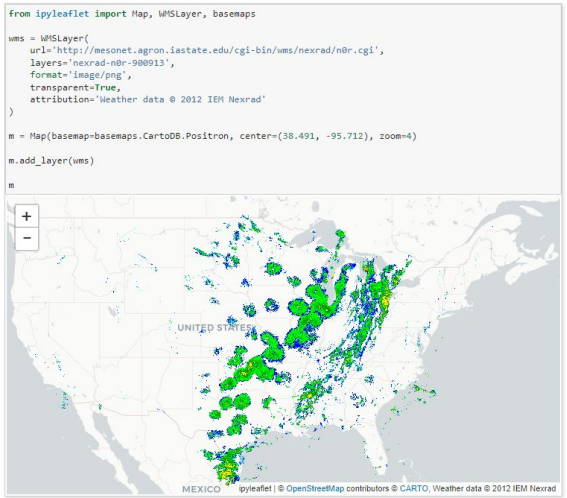
R is a programming language designed for statistical analysis. It has a number of packages available for processing geospatial data.

Python is an extremely popular programming language that is used for data science, machine learning, and more! It has a huge community, and a ton of packages for geospatial processing & analysis. Python's community and approachability makes it the **perfect** choice for beginners and experts alike.

JUPYTER NOTEBOOKS

Jupyter Notebooks allow you to **interactively** develop software, and easily visualize the output of your code. It is super commonly used in data science, and I absolutely recommend starting out with Jupyter Notebooks if you're new to software development!

You can even integrate maps and other geospatial visualizations!



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IDES

If we're going to write code, we should probably have somewhere to do it! If you're using Jupyter Notebooks, feel free to stick with that.

However, if you want to supercharge your development, I highly recommend **VS Code**. It's what my entire team uses daily, and absolutely **rocks!**

https://code.visualstudio.com/

ANACONDA & PYTHON PACKAGES

Anaconda simplifies the installation of GIS packages with Python.
I **highly** recommend using Anaconda for projects!

ANACONDA® + RASTERIO, GeoPandas, jupyter, xarray, scikit learn, NumPy, STAC SpatioTemporal Asset Catalog, GDAL =

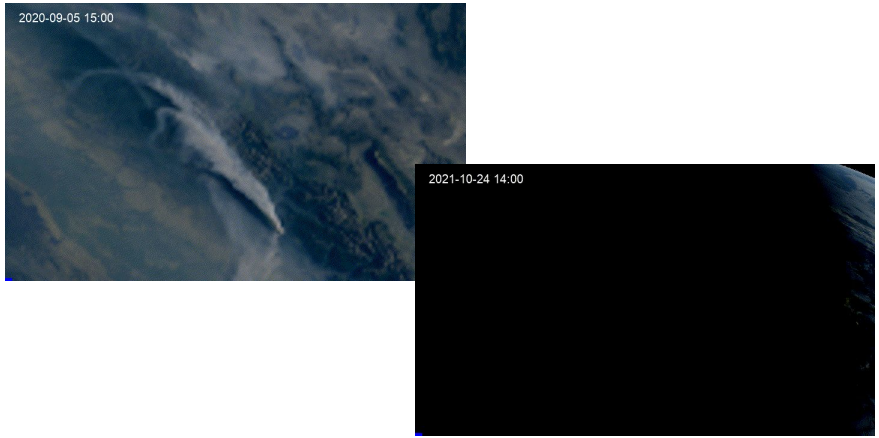
PUTTING THE “APPS” IN SPACE APPS

Many of the NASA Space Apps challenges request that you build an interactive application! There are many ways to approach challenges like this, but Python has dashboarding frameworks that you can use to easily build an actual application!

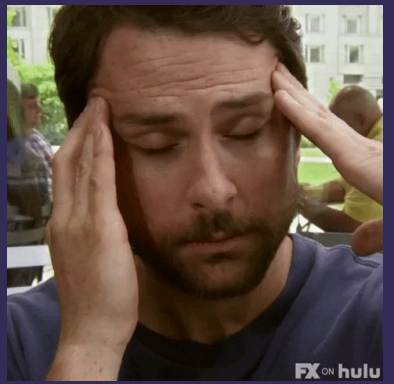
Streamlit

streamlit.io

https://giswqs-streamlit.hf.space/



QUESTIONS?



LET'S GET HANDS ON!

github.com/null-jones/hfx-nasa-2023-example

knowledge.wyvern.space