AST 426 :Satellite and Uncrewed Aircraft Systems (UAS) in Agriculture

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IKONOS

- The first high resolution satellite sensor launched into space on September 24, 1999
- **0.82-m panchromatic images** in the **450–900 nm** spectral range
- **3.28-m multispectral** imagery in the blue (450–520 nm), green (510–600 nm), red (630–700 nm) and NIR(760–850 nm) bands
- Temporal resolution: **3 days**
- Manufacturer: **Lockheed Martin Space Systems**
- Retired on 31st March 2015

- https://www.satimagingcorp.com/satellite-sensors/ikonos/
- https://devp-service.oss-cn-beijing.aliyuncs.com/8e9430f7d6f94fd5a5d3b233b0355a5f/file_1590376263540.pdf

Panchromatic v/s Multispectral Data

Feature	Panchromatic Data	Multispectral Data
Number of Bands	1 broad band (grayscale)	Multiple bands (typically 3-10) across visible and non-visible light
Spatial Resolution	Higher spatial resolution (more detailed)	Lower spatial resolution (less detailed)
Spectral Information	Captures intensity of light across a broad range of wavelengths	Captures specific wavelengths (e.g., Red, Green, Blue, NIR)
Image Type	Black-and-white (grayscale)	Color (visible and non-visible light)
Common Use	High-resolution mapping, pan-sharpening	Vegetation indices, land cover classification, environmental analysis

a. Panchromatic
b. Multispectral

Panchromatic image by IKONOS

https://www.researchgate.net/publication/351635286_Hyperspectral_and_multispectral_image_fusion_techniques_for_high_resolution_applications_a_review/figures?lo=1

- https://www.satimagingcorp.com/satellite-sensors/ikonos/
- https://devp-service.oss-cn-beijing.aliyuncs.com/8e9430f7d6f94fd5a5d3b233b0355a5f/file_1590376263540.pdf

https://www.e-education.psu.edu/natureofgeoinfo/book/export/html/1751

Panchromatic for Pansharpening of Multispectral Data

https://up42.com/blog/how-pansharpening-improves-satellite-imagery

Quickbird

- Launched by DigitalGlobe on October 18, 2001, at Vandenberg Air Force Base, California, USA
- Panchromatic and multispectral data in essentially the same spectral ranges as those of IKONOS
- Spatial resolution: **0.6 m for panchromatic** and **2.4 m for multispectral**
- Temporal resolution: **1-3.5 days**
- Retired in 2015

https://www.satimagingcorp.com/satellite-sensors/quickbird/

Satellites in Precision Agriculture

WorldView-2,3 and 4

- WorldView-2, launched into space on October 8, 2009
- Spatial resolution: 0.46 m for panchromatic and 1.85 m for multispectral
- 8 spectral bands: coastal blue(400–450 nm), blue (450–510 nm), green (510–580 nm), yellow(585–625 nm), red (630–690 nm), red edge (705–745 nm),NIR 1 (770–895 nm) and NIR 2 (860–1040 nm)
- WorldView-3, launched on August 13, 2014
- WorldView-4, previously known as GeoEye-2, was launched on November 11, 2016
- Temporal resolution:**1.1-3.7 days for WorldView-2**

WorldView 2 satellite

https://www.satimagingcorp.com/satellite-sensors/worldview-2/

Satellites in Precision Agriculture

SPOT (Satellite Pour l'Observation de la Terre i.e., Satellite for Earth Observation) -5,6 and 7

- SPOT 5 was placed into orbit on May 4, 2002
- Spatial resolution: **2.5-5 m for panchromatic** and **10 m for multispectral**
- Temporal resolution : **2-3 days for SPOT 5 and 1 day for both SPOT 6 and SPOT 7**
- SPOT 6 was launched on September 9, 2012
- SPOT 7 was launched on June 30, 2014

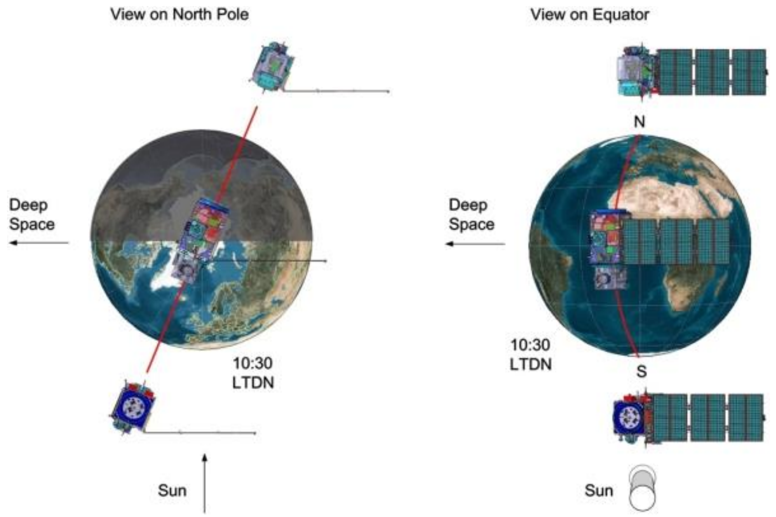
SPOT-5 satellite

https://www.satimagingcorp.com/satellite-sensors/other-satellite-sensors/spot-5/

Satellites in Precision Agriculture

Sentinel 2A and 2B

- Sentinel-2 mission comprises two polar-orbiting satellites in the same orbit, phased at 180° to each other
- The twin satellites, Sentinel-2A and -2B, were launched on June 23, 2015, and March 7, 2017, respectively
- **13 spectral bands** in the **443–2190 nm** range
- Spatial resolution: **10 m** for Red, Green, Blue and NIR bands
- Temporal resolution: **5 days at equator** and **2-3 days at mid-latitudes**



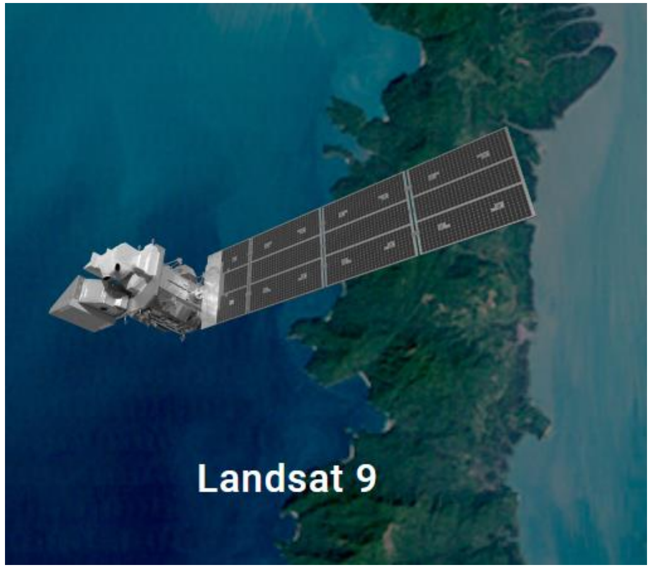
https://sentiwiki.copernicus.eu/web/s2-mission

Satellites in Precision Agriculture

Landsat

Landsat Satellite Overview

	Satellite	Launch Year	Instruments	Spatial Resolution	Temporal Resolution	Spectral Bands	Applications
1	Landsat 7	1999	ETM+ (Enhanced Thematic Mapper Plus)	30m (MS), 15m (Panchromatic)	16 days	Blue, Green, Red, NIR, SWIR1, SWIR2, Thermal, Panchromatic	Crop health monitoring, soil moisture mapping, drought detection
2	Landsat 8	2013	OLI (Operational Land Imager), TIRS (Thermal Infrared Sensor)	30m (MS), 15m (Panchromatic), 100m (Thermal)	16 days (8 days with Landsat 9)	Blue, Green, Red, NIR, SWIR1, SWIR2, Cirrus, Coastal/Aerosol, Thermal,	NDVI/EVI calculation, water stress monitoring, yield prediction
3	Landsat 9	2021	OLI-2, TIRS-2	30m (MS), 15m (Panchromatic), 100m (Thermal)	16 days (8 days with Landsat 8)	Same as Landsat 8 (OLI-2, TIRS-2)	Continuation of Landsat 8 mission with improved instruments



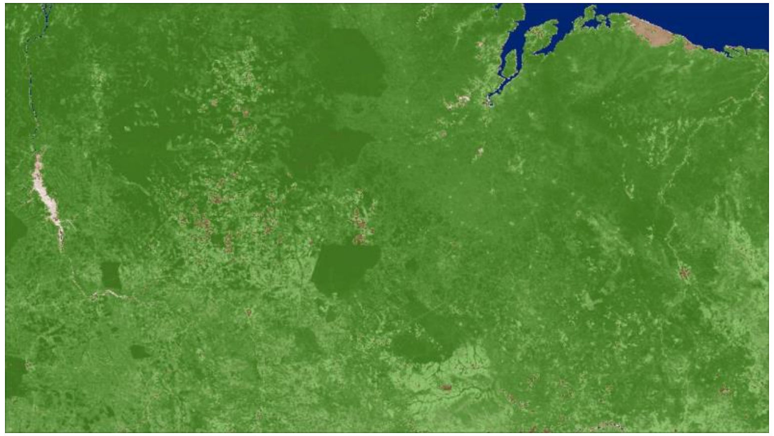
https://landsat.gsfc.nasa.gov/satellites/landsat-9/

MODIS (Moderate Resolution Imaging Spectroradiometer)

MODIS Satellite Overview

	Satellite	Launch Year	Instruments	Spatial Resolution	Temporal Resolution	Spectral Bands	Applications
1	Terra (MODIS)	1999	MODIS (Moderate Resolution Imaging Spectroradiometer)	250m (Red, NIR), 500m (Visible, NIR), 1km (Thermal)	Daily (Terra passes in the morning)	36 spectral bands (from visible to thermal infrared)	Global vegetation monitoring, land cover changes, crop yield modeling, wildfire detection
2	Aqua (MODIS)	2002	MODIS (Moderate Resolution Imaging Spectroradiometer)	250m (Red, NIR), 500m (Visible, NIR), 1km (Thermal)	Daily (Aqua passes in the afternoon)	36 spectral bands (from visible to thermal infrared)	Water vapor monitoring, crop evapotranspiration, sea surface temperature,

September 18, 2024 - First Fall Colors in the Midwestern United States



- The Terra Moderate Resolution Imaging Spectroradiometer (MODIS) Vegetation Indices Monthly (MOD13A3) Version 6.1 data are provided monthly at 1 kilometer (km) spatial resolution

https://lpdaac.usgs.gov/media/images/MOD13A3_V061_Jul2020_Brazil_HERO.original.jpg

https://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2024-09-18

Data Processing Tools for Satellite

- Google Earth Engine
- Sentinel-Hub
- SNAP (Sentinel Application Platform)
- ArcGIS
- ENVI
- QGIS

Applications in Precision Agriculture

- Detecting drought stress
- Mapping vegetation cover
- Early crop stress detection
- Crop health monitoring
- Soil moisture estimation
- Identifying water bodies and irrigation issues
- Evapotranspiration measurements, etc.

Google Earth Engine (GEE)

- **Google Earth Engine (GEE)** is a cloud-based platform designed for processing and analyzing large datasets of satellite imagery and geospatial data.
- Global-scale processing with petabytes of satellite data available
- Combines high-performance computing with geospatial analysis tools
- Free access for researchers, NGOs, and other users for scientific purposes
- Datasets from satellites like Landsat, MODIS, Sentinel, and others
- Ability to process massive datasets, from local to global scale, without requiring local storage or high computing power
- Uses **JavaScript** and **Python APIs** for flexible geospatial analysis
- Supports a wide range of image processing tasks like **filtering**, **mosaicking**, and creating **time-series analyses**
- Built-in functions for calculating **vegetation indices** (NDVI, EVI), **water indices** (NDWI), **land cover classification**, etc.

Google Earth Engine (GEE)

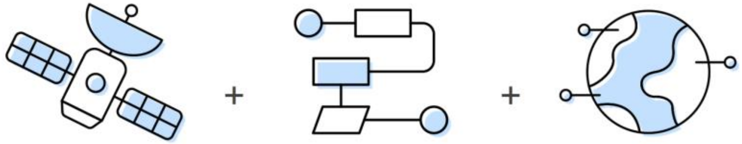
Google Earth Engine

Platform Datasets Noncommercial Commercial Timelapse Case Studies FAQ Get Started

Starting November 13, 2024, all Earth Engine access will require a Cloud project. We will be limiting quotas for accounts without Cloud projects starting September 16, 2024.

Meet Earth Engine

Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Scientists, researchers, and developers use Earth Engine to detect changes, map trends, and quantify differences on the Earth's surface. Earth Engine is now available for commercial use, and remains free for academic and research use.

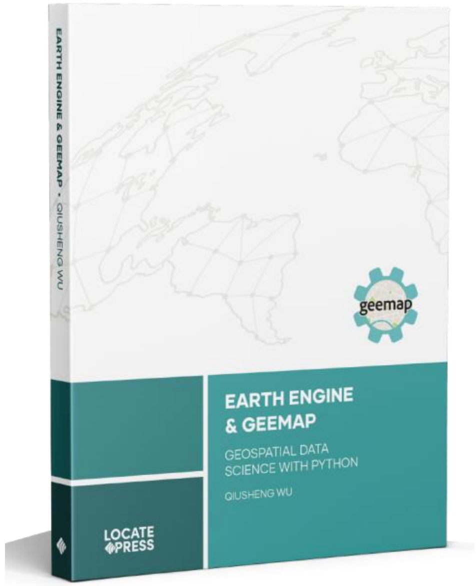


Satellite Imagery Your Algorithms Real World Applications

Google Earth Engine (GEE)

Geemap : GEE Python Package

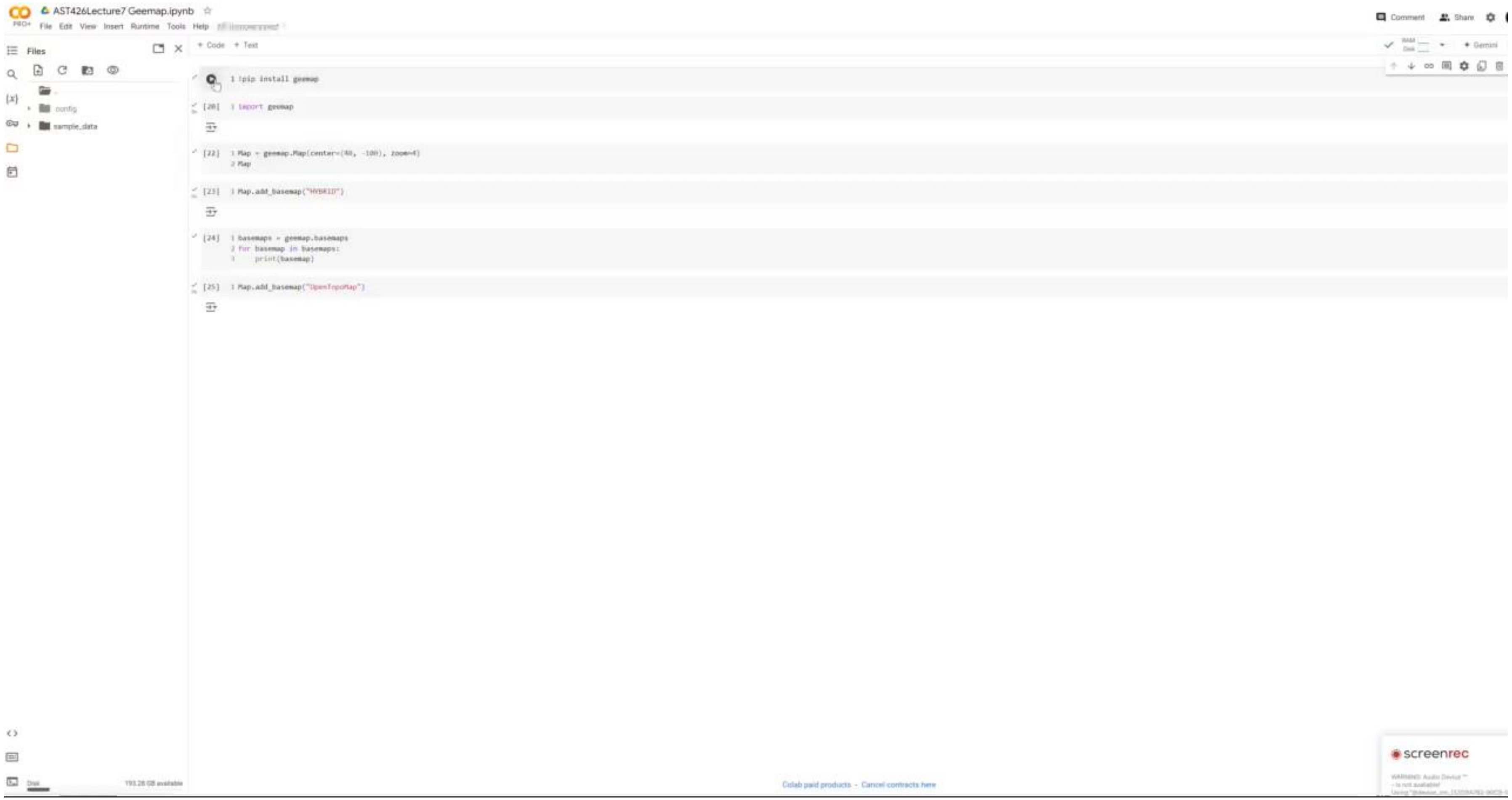
- **Geemap** is a **Python package** for interactive geospatial analysis and visualization with Google Earth Engine (GEE)
- Geemap is intended for students and researchers, who would like to utilize the Python ecosystem of diverse libraries and tools to explore Google Earth Engine
- It is also designed for existing GEE users who would like to transition from the GEE JavaScript API to Python API



https://geemap.org/#announcement

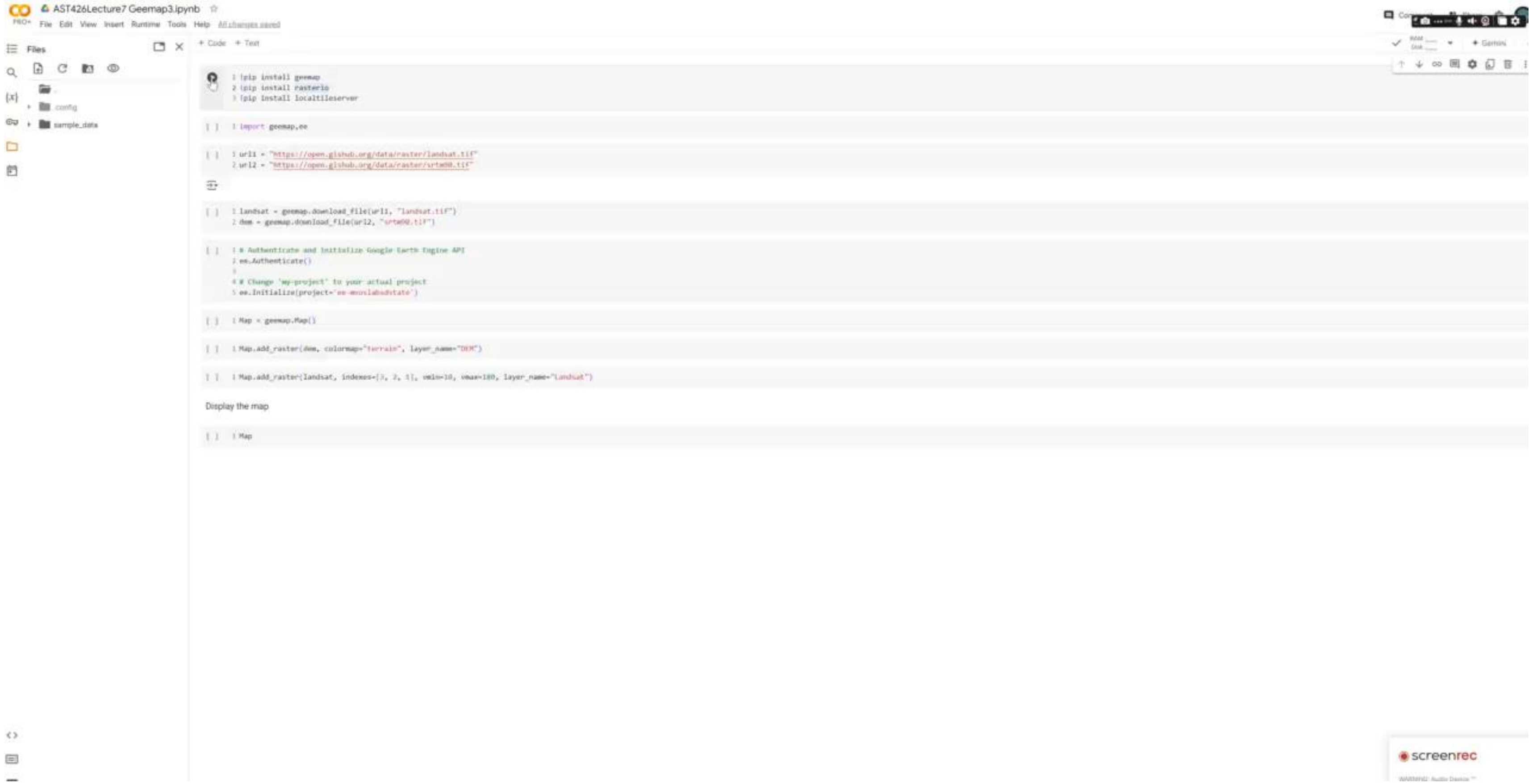
Google Earth Engine (GEE)

Geemap : GEE Python Package



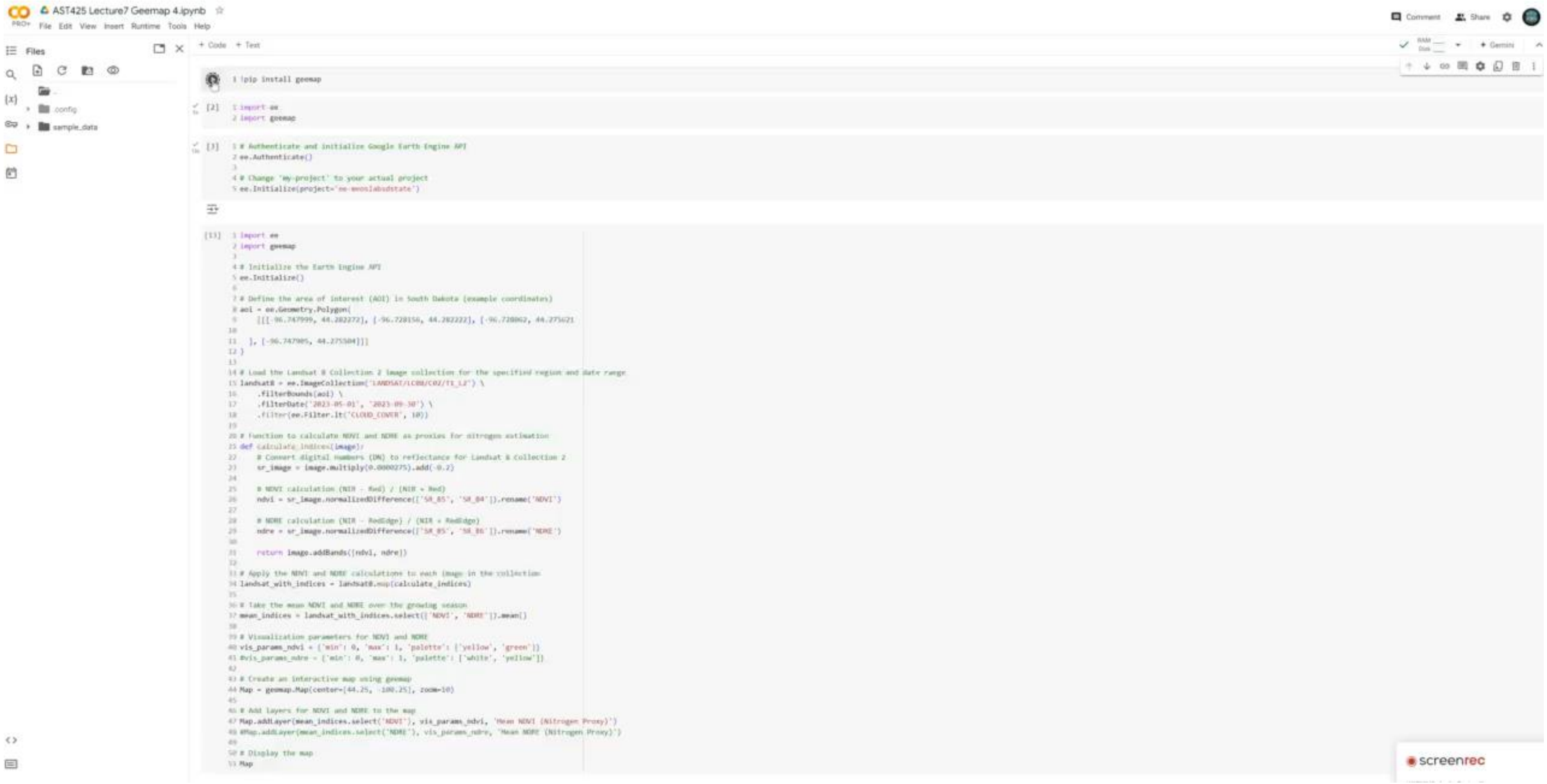
Google Earth Engine (GEE)

Geemap : GEE Python Package



Google Earth Engine (GEE)

Geemap : GEE Python Package



Key Terminologies for Satellite Data Processing

1. **Spatial Resolution**
   The size of the area on the ground that each pixel in a satellite image represents**.**
2. **Temporal Resolution**
   The frequency at which a satellite revisits and captures data for the same location on Earth.
3. **Spectral Resolution**
   The ability of a satellite sensor to capture specific wavelengths of light across the electromagnetic spectrum.
4. **Cloud Masking**
   The process of combining multiple satellite images to form a seamless larger image that covers a wide geographic area.
5. **Georeferencing**
   The process of aligning satellite images to a known coordinate system so that they match real-world locations.

Key Terminologies for Satellite Data Processing

6. **Atmospheric Correction**

   The process of removing the effects of the atmosphere (such as scattering and absorption) from satellite images to retrieve the true surface reflectance values

7. **Orthorectification**

   The process of correcting satellite images for terrain-related distortions, ensuring that the image accurately represents the Earth's surface without geometric errors.

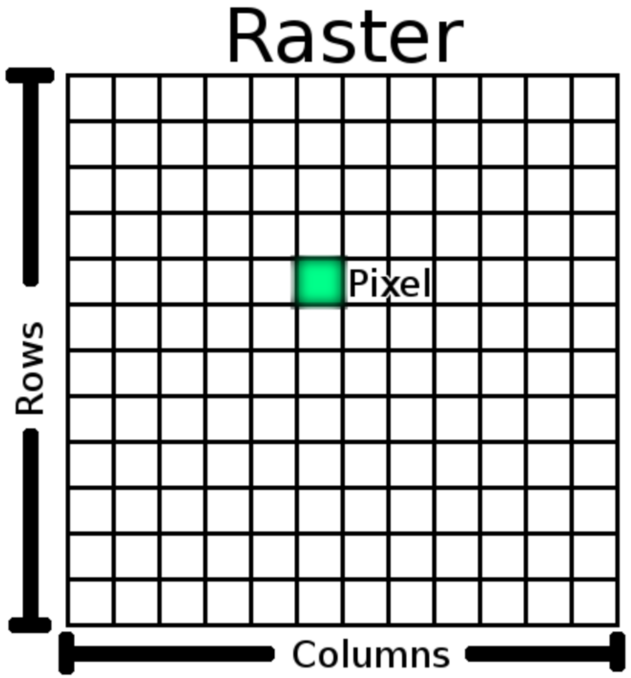
8. **Raster Data**

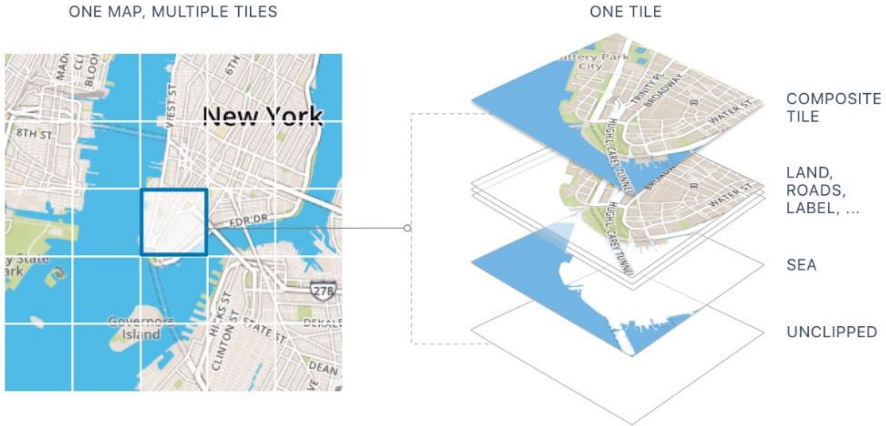
   A data format that represents geographic information as a grid of pixels, where each pixel contains a value corresponding to a specific attribute (e.g., elevation, temperature).

9. **Tiles**

In satellite data or geographic information systems (GIS), a large image or map is often broken down into **smaller, uniform rectangular sections known as tiles**. Each tile represents a portion of the larger image or dataset.

Key Terminologies for Satellite Data Processing





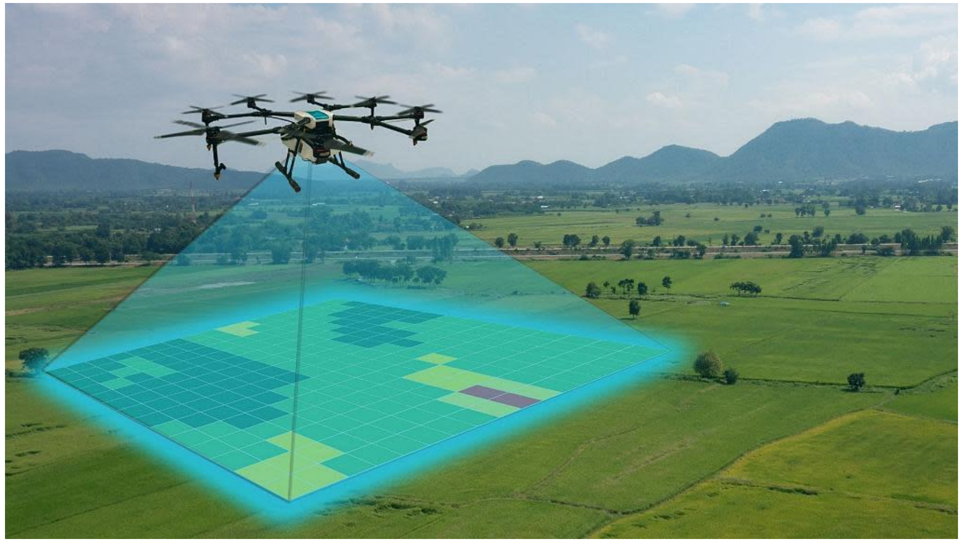
UAS in Precision Agriculture

- Unmanned Aerial Systems (UAS), commonly referred to as drones, are remote-controlled aircraft equipped with sensors and cameras used for capturing aerial imagery and data.
- Provides extremely detailed imagery at centimeter-level resolution
- UAS can be flown whenever needed, offering timely data for decision-making.
- Drones can be used on small fields and large farms alike

Applications in Precision Agriculture

- Crop health/disease monitoring
- Variable rate application
- Precision spray application
- Plant counting and crop scouting
- Irrigation management
- Nutrient management
- Weed detection and management

UAS in Precision Agriculture



Data Processing Tools for UAS

- Pix4D Mapper
- Agisoft Metashape
- DroneDeploy
- ArcGIS Drone2Map
- ArcGIS
- QGIS
- ENVI
- Google Colab
- Sentera FieldAgent
- MicaSense Atlas
- OpenDroneMap (ODM)

Next Lecture

- Guest Lecture by **Dr. Rahul Raman, Virginia Tech**