

Geospatial analysis using GEE for Remote Sensing and Agriculture

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With the End in mind!

A close-up photograph of a person's hand, palm facing forward, holding three small, dry, brown seed pods. The seeds are irregularly shaped and textured. A few thin, dried plant stems are visible. The background is a soft-focus view of a field with similar dry vegetation.

Agriculture-Not Business as usual!

UN report: The world's farms stretched to 'a breaking point'

The world's climate-stressed and pollution-degraded farming and agricultural system must shift quickly to sustainable practices to feed an additional 2 billion mouths expected by 2050, a new United Nations report finds.



by DANA NUCCITELLI
JANUARY 19, 2022

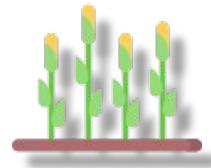


Forbes

Agriculture is not in good shape overall. The sector contributes 20% of humanity's total greenhouse gas emissions. Fertilizer [overuse triggers](#) some 405 marine dead zones in coastal waters worldwide. Massive plantings of single kinds of crops, pesticide application and agriculture-related deforestation [are major contributors](#) to the extinction of wildlife species.

Biodiversity Loss and Climate Change threatens food security

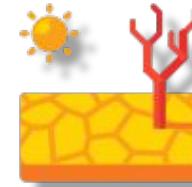
Monocultures and intensification has eroded genetic diversity, and increased vulnerability to diseases, pests, and climate shocks.



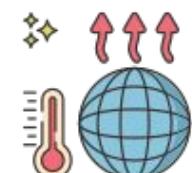
Just 12 plants provide 75% of the world's nutrition!



75% of global food crops depend on pollinators. Populations are declining due to climate, habitat loss and pesticides.

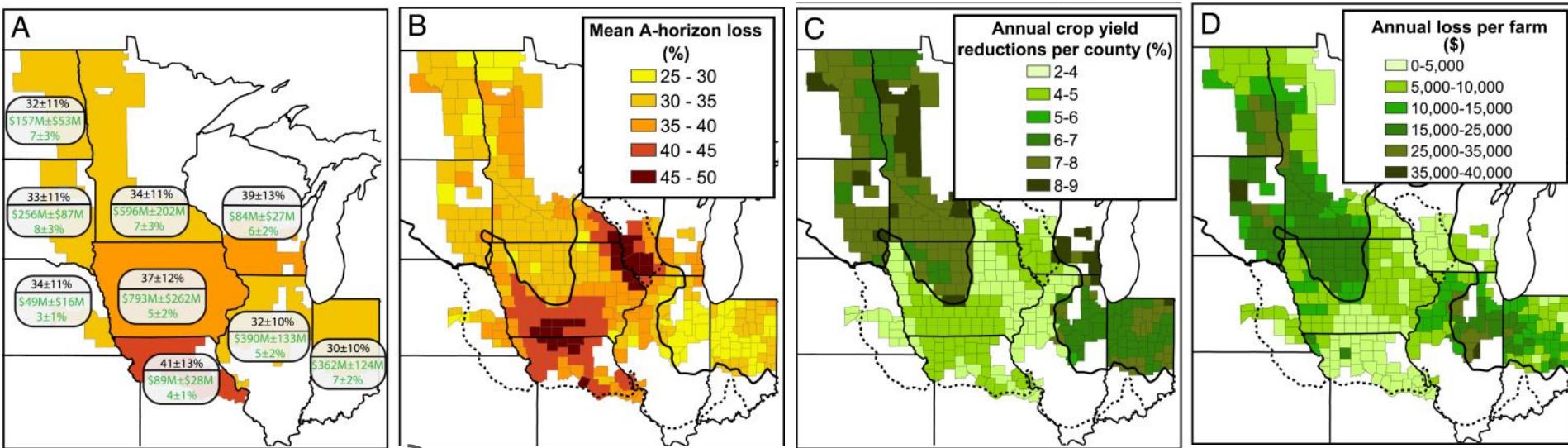


~One-third of the topsoil in the Corn Belt has been lost. Globally, ~ 33% soils are moderately to highly degraded. (Slide 5)



With climate change, many existing agriculture lands will become unsuitable to grow crops (Slide 6).

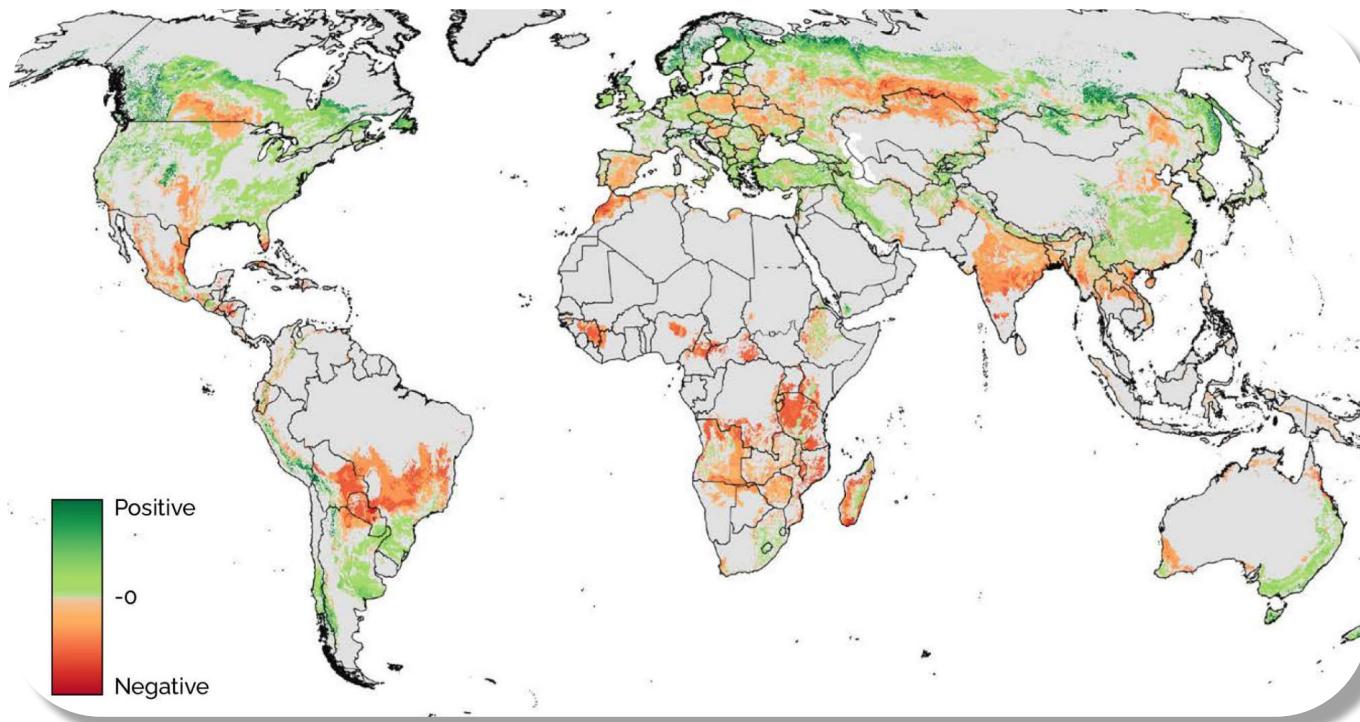
Extent of soil loss and impact across the US Corn Belt



(B) Loss of the topmost layer of soil containing the highest concentration of organic matter, nutrients, and biological activity, (C) loss in yield and (D) revenue loss per farm

(A) Aggregated percent A-horizon loss (black text) and annual economic losses expressed in millions of dollars (M) and as a percentage relative to uneroded soils (green text) for each state within the region.

Change in Crop Growing Suitability



Shifts in land areas suitable for rainfed wheat for a high-emission/high-temperature scenario to the 2080s (RCP 8.5), leading to a 4.2 °C temperature increase



We cannot change the past but we can
create a better future!



Produce from the GAIA Earth community lab

The background image is a high-resolution aerial photograph of a coastal wetland. The scene is dominated by intricate, winding patterns of water channels and mudflats, creating a complex geometric texture. Small patches of green vegetation are scattered across the landscape, particularly in the lower right quadrant. The overall color palette is a mix of earthy tones like brown, tan, and green, with some darker shadows in the upper left.

Geospatial AI

Systemic Integration Agriculture



Farm



Environment



Forestry



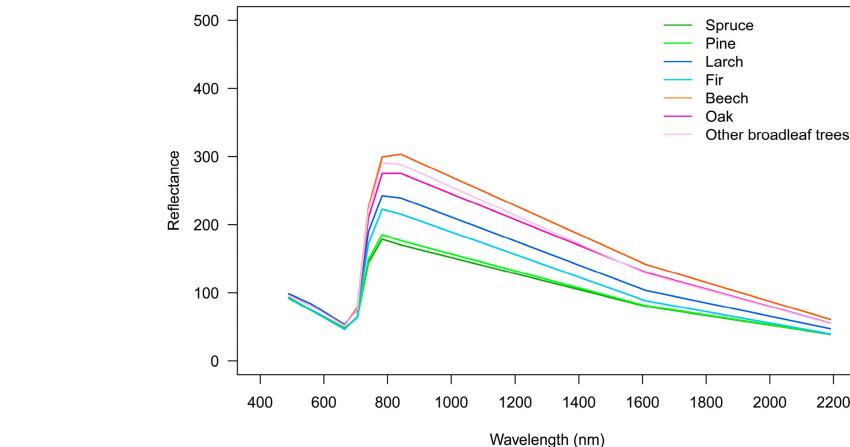
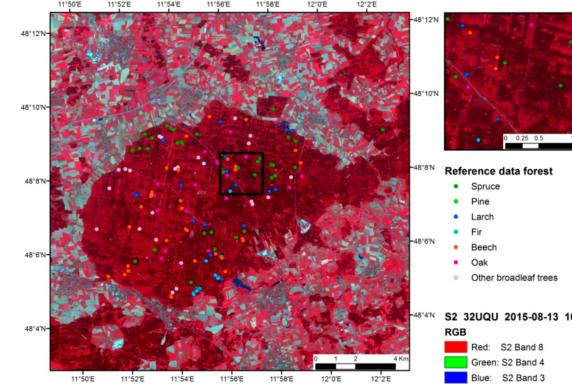
Geology

Not Obvious Applications

Biodiversity Mapping



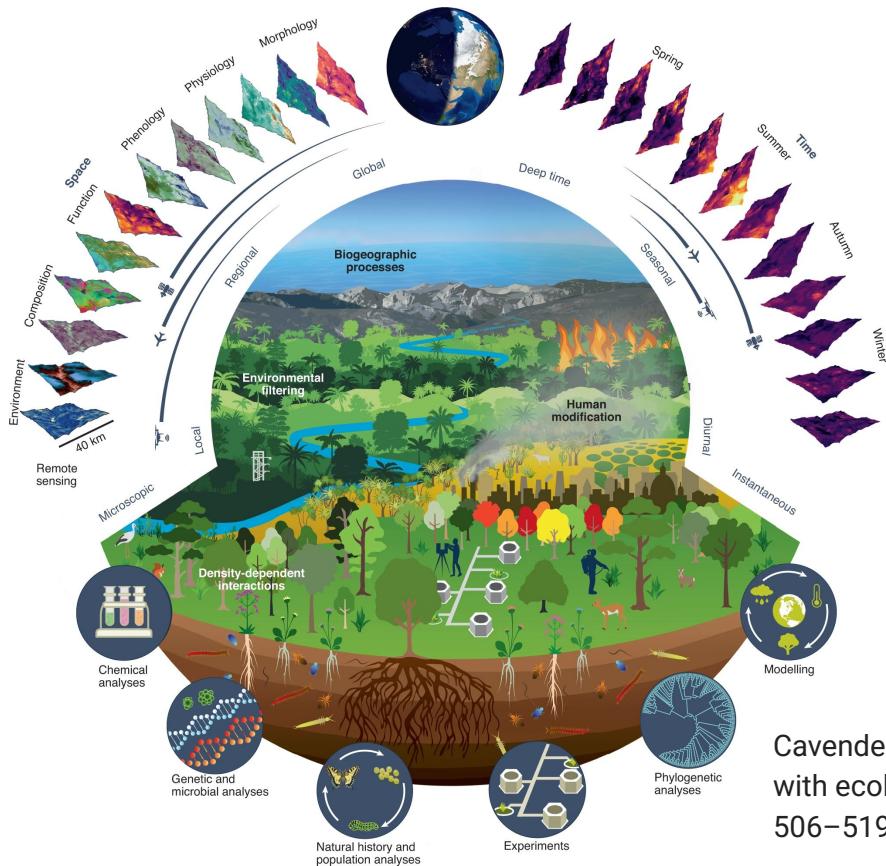
Measurable Indicators and Metrics



(above) Sentinel-2 scene of forest test site and
(below) average spectral signatures of tree species
(Spruce, Pine, Larch, Fir, Beech, Oak, broadleaf)

Immitzer, M., Vuolo, F., & Atzberger, C. (2016). First Experience with Sentinel-2 Data for Crop and Tree Species Classifications in Central Europe. *Remote Sensing*, 8(3), 166. <https://doi.org/10.3390/rs8030166>

Forestry



- Habitat Mapping and Monitoring: Mapping of landcover transformations and identifying critical habitats for protection or restoration. Tracking changes in vegetation cover, deforestation rates, and land use over time.
- Wildlife Tracking and Conflict Mitigation: Monitor animal movements and manage human-wildlife conflicts by identifying corridors that minimize habitat disruptions.
- Illegal Activity Detection: Detect activities like deforestation in protected areas, enabling timely interventions.

Cavender-Bares, J., Schneider, F.D., Santos, M.J. et al. Integrating remote sensing with ecology and evolution to advance biodiversity conservation. *Nat Ecol Evol* 6, 506–519 (2022). <https://doi.org/10.1038/s41559-022-01702-5>



Remote Sensing

Remote Sensing

“Remote sensing is the process of collecting information about the Earth’s surface without physical contact, typically using satellites, drones, or aircraft.”

Working:

- Sensors detect reflected or emitted electromagnetic radiation from objects on Earth
- Data is captured as images or spectral measurements

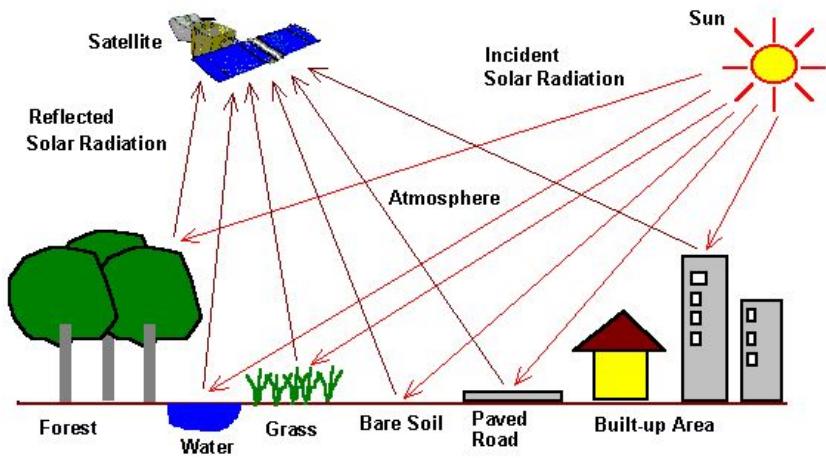
Types

- Passive → Uses natural energy (e.g., sunlight reflected from Earth)
- Active → Uses emitted energy (e.g., RADAR, LiDAR)

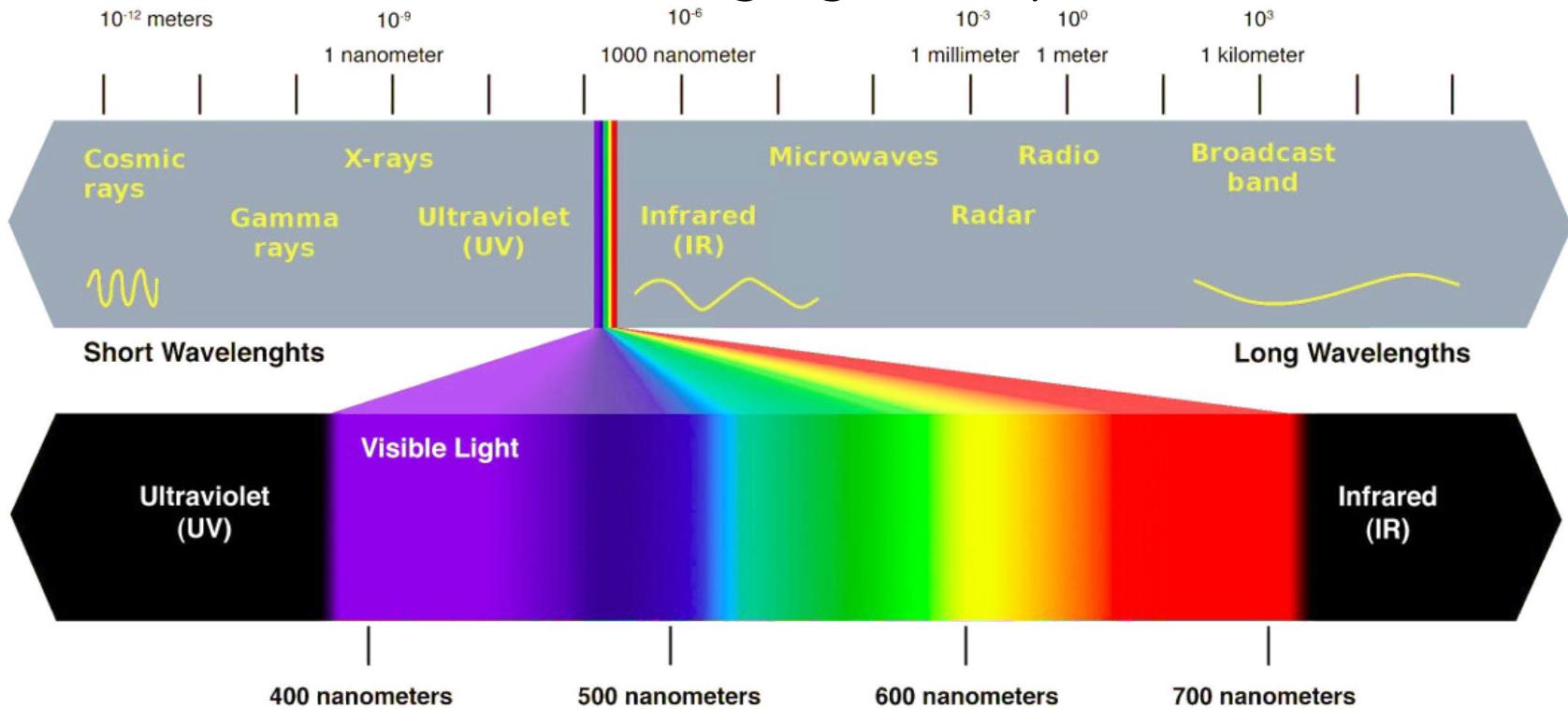
Data

Raster data → Pixel-based imagery (satellite or aerial images)

Spectral bands → Visible, infrared, thermal, microwave



Satellite Imaging and Spectra





EARTH FLEET

INVEST/CUBESATS

- CIRIS 2023
- NACHOS 2022
- CTIM 2022
- NACHOS-2 2022
- SNOOPY* 2022
- MURI-FO* 2022
- HYTI* 2023

JPSS INSTRUMENTS

- OMPS-LIMB 2022
- LIBERA 2027
- OMPS-LIMB 2027
- OMPS-LIMB 2032

ISS INSTRUMENTS

KEY

- INTERNATIONAL PARTNER
- U.S. PARTNER
- JPSS INSTRUMENT
- CUBESAT
- LAUNCH DATE TBD
- (PRE) FORMULATION
- IMPLEMENTATION
- OPERATING
- EXTENDED

08.29.22

2025

MISSIONS

Global Satellite Fleet

Optical Data

1. Sentinel -2
2. Landsat 9, 8,7
3. Planetscope
4. MODIS
5. ASTER
6. WORLDVIEW
7. SPOT
8. JAXA
9. IRS LISS IV
10. Cartosat
11. PROBA-V,
12. AVHRR,
13. GPM/TRMM

Microwave Data

1. Sentinel 1
2. ALOS PALSAR
3. ICEYE
4. RISAT
5. TerraSAR - X
6. RADARSAT
7. KOMPSAT 6
8. TanDEM-x
9. NISAR
10. JERS

Hyperspectral

1. HySIS
2. Hyperion

LiDAR

1. ICESat
2. ICESat-2

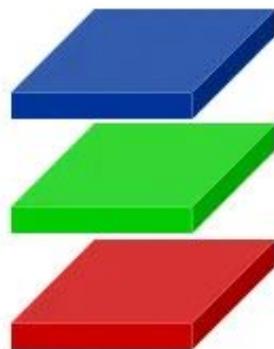
Others

1. SRTM DEM
2. ASTER DEM
3. VIIRS

Optical Imagery Types

RGB

3 separated bands



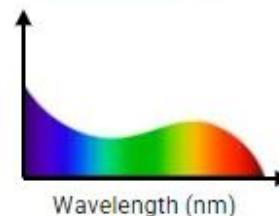
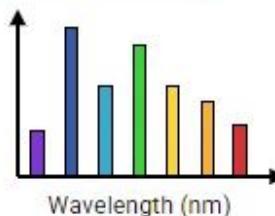
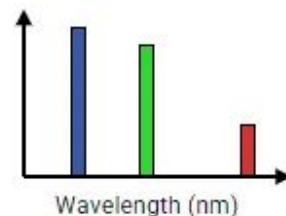
MULTISPECTRAL

N separated bands



HYPERSPECTRAL

Continuous Spectrum



Source: Nireos

Optical Imagery Types

Feature	RGB	Multispectral	Hyperspectral
Number of Bands	3	4-15	100-200 +
Spectral Range	Visible only	Medium	High
Data Volume	Small	Moderate	Very Large
Typical Applications	Photography, basic monitoring	Crop/ vegetation health, LULC	Detailed crop stress, material identification, disease detection & many more
Cost	Low	Moderate	High
Processing Complexity	Low	Moderate	High

CRS or Coordinate Reference System

1. Coordinate Reference System (CRS)

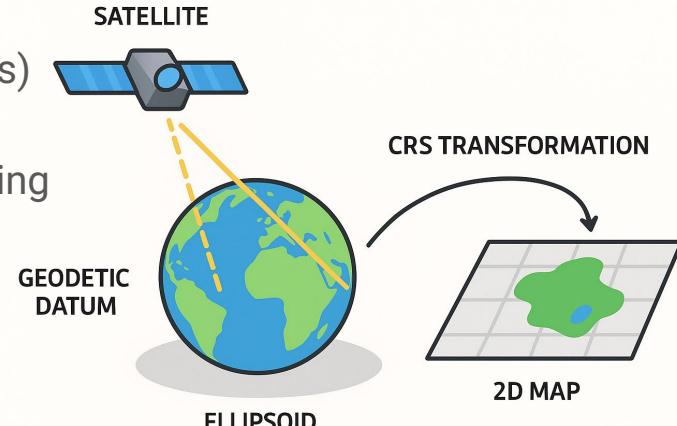
- Defines how geographic locations are represented on a flat map or globe.
- It provides a framework to map latitude, longitude, and elevation accurately.

2. Why is it important?

- Ensures accuracy in measurements (distance, area, angles)
- Allows overlaying multiple datasets correctly
- Essential for map projections, spatial analysis, and modeling

3. Types of CRS:

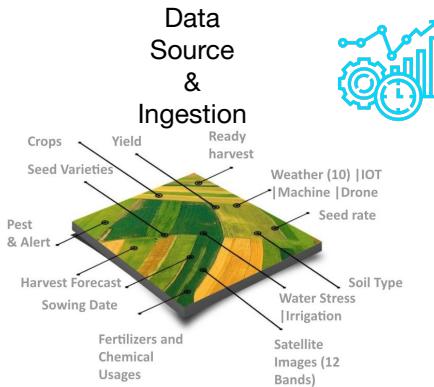
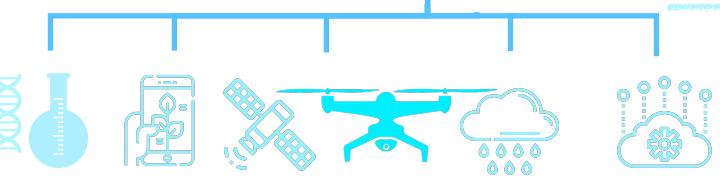
- Geographic CRS (GCS):
 - Based on latitude & longitude
 - Example: WGS84 (used in GPS and most satellites)
- Projected CRS (PCS):
 - Converts Earth's curved surface to 2D map
 - Examples: UTM (Universal Transverse Mercator), State Plane



Data, Compute and Learning!

Data

Annotations/
Ground Truth/
SME

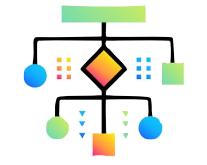


Computing

Cloud On-premise



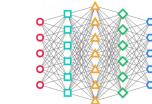
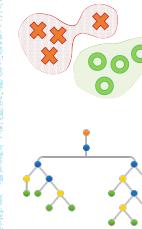
Analysis
Ready
Data
(ARD)
Or
Cloud
Optimize
d
Data



Workflow
Orchestration



Learning



$$\frac{\partial}{\partial \theta} \ln f_{\theta, \sigma}(x_i) = \frac{1}{\sigma^2} I_{\theta, \sigma}(x_i) - \frac{1}{\sigma^2}$$
$$\int T(t) \frac{\partial}{\partial \theta} f(t, \theta) dt = \left(\int T(t) \frac{\partial}{\partial \theta} f(t, \theta) dt \right) \int f(t, \theta) dt$$
$$\int T(t) \left(\sum_{i=1}^{n_{\theta}} I_{\theta, \sigma}(x_i) \right) f(t, \theta) dt = \sum_{i=1}^{n_{\theta}} \int T(t) I_{\theta, \sigma}(x_i) f(t, \theta) dt$$



Model
Life Cycle,
Tracking
&
Orchestratio
n



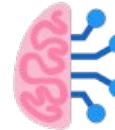
Ecosystem for Agriculture and Food Security



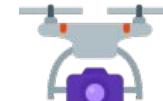
Soil, Weather, Watershed,
Irrigation, Land use
([SoilGrids](#), [AquaStat](#),
[CHIRPS](#), [ECMWF](#))



Biological, Knowledge
and Field Data (Health,
Socio-Economic)



Science Models
(DSSAT, DNDC, OpTis,
CropSuite) & AI



Geospatial Data (Raster,
Vector)

Useful Tools

- ArcGIS

- Advanced commercial GIS platform for mapping, spatial analysis, and geostatistics



- QGIS

- Free, open-source GIS tool for editing, analyzing, and visualizing spatial data
- Supports a wide range of plugins and data formats, making it flexible for research & teaching



- Google Earth Engine (GEE) (focus of today's workshop)

- Cloud-based platform with petabytes of satellite imagery & geospatial datasets
- Enables large-scale, real-time analysis of environmental, agricultural, and climate data

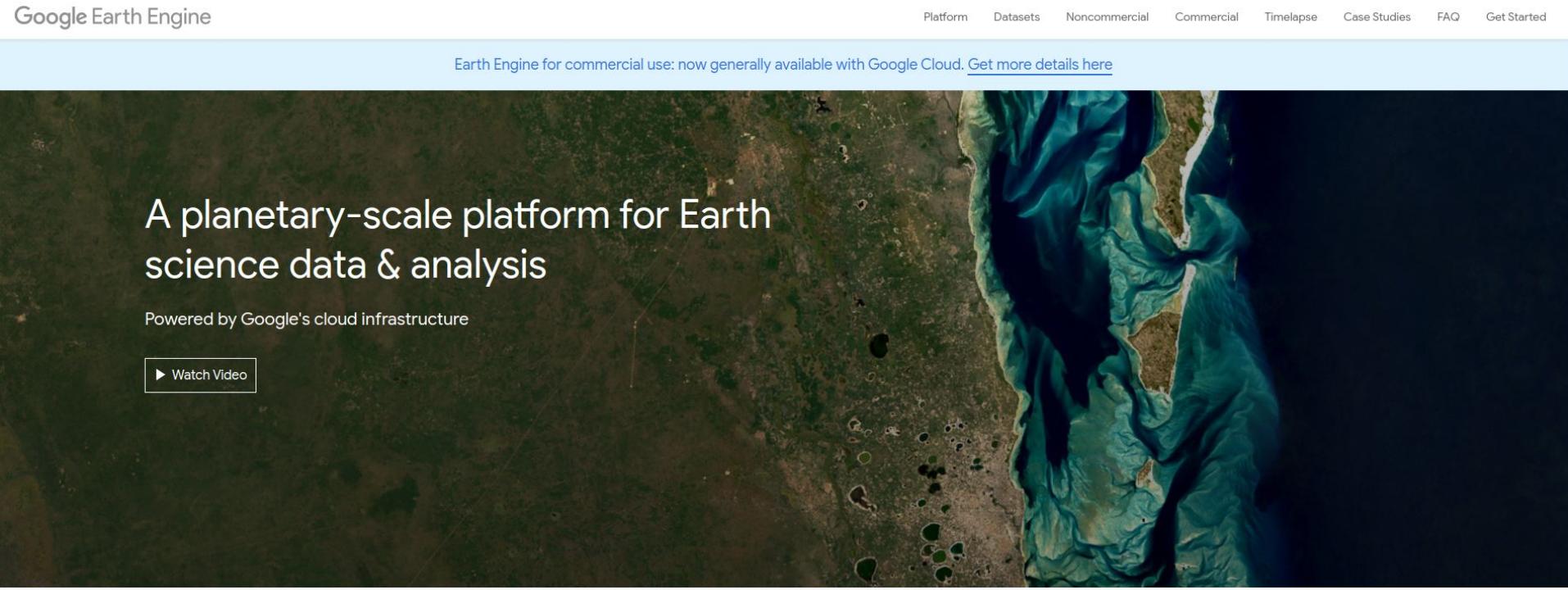
Google Earth Engine



Earth Engine

<https://earthengine.google.com/>

- A planetary-scale platform for Earth science data & analysis



The image shows the homepage of Google Earth Engine. At the top left is the "Google Earth Engine" logo. Along the top navigation bar are links for "Platform", "Datasets", "Noncommercial", "Commercial", "Timelapse", "Case Studies", "FAQ", and "Get Started". Below the navigation bar, a banner states "Earth Engine for commercial use: now generally available with Google Cloud. [Get more details here](#)". The main visual is a composite satellite image showing a mix of land and water. Overlaid on the left side is white text that reads "A planetary-scale platform for Earth science data & analysis". At the bottom left, there's a small box containing the text "Powered by Google's cloud infrastructure" and a "Watch Video" button.

Google Earth Engine

Platform Datasets Noncommercial Commercial Timelapse Case Studies FAQ Get Started

Earth Engine for commercial use: now generally available with Google Cloud. [Get more details here](#)

A planetary-scale platform for Earth science data & analysis

Powered by Google's cloud infrastructure

▶ Watch Video

GEE

Definition

- Cloud-based platform for planetary-scale geospatial analysis
- Enables users to visualize, analyze, and process vast amounts of satellite imagery and geospatial data
- Supports remote sensing research, environmental monitoring, and global decision-making

Features

- Access to massive geospatial archives → Satellites, precipitation, LULC maps, climate, and weather data
- Process large datasets → Perform complex analyses at planetary scale using cloud infrastructure
- Visualize results → Interactive maps, charts, and export options
- Develop algorithms → Web-based code editor with JavaScript & Python APIs

Applications

- Environmental Monitoring: Deforestation, water resources, vegetation health, land cover changes
- Disaster Response: Flood mapping, wildfire monitoring, earthquake damage assessment
- Resource Management: Agriculture, forestry, climate impact studies
- Climate Science: Study temperature/precipitation trends, model climate change effects
- Urban Planning: Monitor urban growth and land use changes
- Health & Business: Disease outbreak prediction, supply chain risk assessment

Geemap

- GitHub: <https://github.com/gee-community/geemap>
- Website: <https://geemap.org>

gee-community / geemap

Unwatch 116 ▾ Fork 1.1k ▾ Star 3.5k ▾

Open in Colab | launch binder | Open Studio Lab | pypi v0.35.0 | downloads 4M | recipe geemap
conda-forge v0.35.0 | downloads 303k | docs passing | YouTube Channel | License MIT | JOSS 10.21105/joss.02305
pre-commit.ci passed

A Python package for interactive geospatial analysis and visualization with Google Earth Engine

- GitHub repo: <https://github.com/gee-community/geemap>
- Documentation: <https://geemap.org>
- PyPI: <https://pypi.org/project/geemap>
- Conda-forge: <https://anaconda.org/conda-forge/geemap>
- 360+ GEE notebook examples: <https://github.com/giswqs/earthengine-py-notebooks>
- GEE Tutorials on YouTube: <https://youtube.com/@giswqs>
- Free software: [MIT license](#)



Used by 3.5k



Contributors 54



+ 40 contributors

Earth Engine Data Catalog

<https://developers.google.com/earth-engine/datasets/>



Landsat & Sentinel

10-30m, weekly



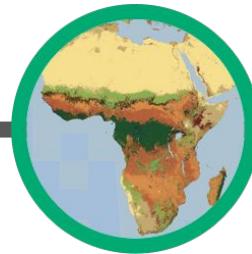
MODIS

250m daily

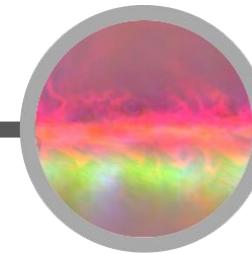


Vector Data

WDPA, TIGER, WHC



**Terrain &
Land Cover**



Weather & Climate

NOAA NCEP, OMI, ...

... and upload your own vectors and
rasters

1000+ public datasets

100+ petabytes (PB) of data = 100K+ TB

100+ datasets added yearly

1+ PB of new data every month

<https://earthengine-stac.storage.googleapis.com/catalog/catalog.json>

Earth Engine SpatioTemporal Asset Catalog (STAC)

Screenshot of a GitHub repository page for "opengeos / Earth-Engine-Catalog".

The repository has 1 star and 0 forks. The last commit was made by actions-user on 2024-10-28 UTC.

The file "gee_catalog.tsv" is displayed, showing a list of datasets:

id	title	type	snippet
AAFC/ACI	Canada AAFC Annual Crop Inventory	image_collection	ee.ImageCollection('AAFC/ACI')
ACA/reef_habitat/v1_0	Allen Coral Atlas (ACA) - Geomorphic Zonation and Benthic Habitat - v1.0 [deprecated]	image	ee.Image('ACA/reef_habitat/v1_0')
ACA/reef_habitat/v2_0	Allen Coral Atlas (ACA) - Geomorphic Zonation and Benthic Habitat - v2.0	image	ee.Image('ACA/reef_habitat/v2_0')
AHN/AHN2_05M_INT	AHN Netherlands 0.5m DEM, Interpolated	image	ee.Image('AHN/AHN2_05M_INT')
AHN/AHN2_05M_NON	AHN Netherlands 0.5m DEM, Non-Interpolated	image	ee.Image('AHN/AHN2_05M_NON')
AHN/AHN2_05M_RUW	AHN Netherlands 0.5m DEM, Raw Samples	image	ee.Image('AHN/AHN2_05M_RUW')
ASTER/AST_L1T_003	ASTER L1T Radiance	image_collection	ee.ImageCollection('ASTER/AST_L1T_003')
AU/GA/AUSTRALIA_5M_DEM	Australian 5M DEM	image_collection	ee.ImageCollection('AU/GA/AUSTRALIA_5M_DEM')
AU/GA/DEM_1SEC/v10/DEM-H	DEM-H: Australian SRTM Hydrologically Enforced Digital Elevation Model	image	ee.Image('AU/GA/DEM_1SEC/v10/DEM-H')
AU/GA/DEM_1SEC/v10/DEM-S	DEM-S: Australian Smoothed Digital Elevation Model	image	ee.Image('AU/GA/DEM_1SEC/v10/DEM-S')
BIOPAMA/GlobalOilPalm/v1	Global Map of Oil Palm Plantations	image_collection	ee.ImageCollection('BIOPAMA/GlobalOilPalm/v1')
BLM/AIM/v1/TerrADat/TerrestrialAIM	BLM AIM TerrADat TerrestrialAIM Point v1	table	ee.FeatureCollection('BLM/AIM/v1/TerrADat/TerrestrialAIM')

Catalog of Image Collections

- **Satellite Imagery** - Optical and radar imagery for land, vegetation, water, and urban monitoring. Examples: Landsat, Sentinel
- **Elevation & Topography** - Digital representations of terrain to analyze slope, aspect, and elevation. Examples: SRTM (Shuttle Radar Topography Mission), ASTER GDEM
- **Climate & Weather Data** - Observed or modeled climate and meteorological variables for environmental studies. Examples: ERA5 Reanalysis, CHIRPS
- **Land Cover & Land Use** - Classification of Earth's surface into forests, croplands, urban areas, Examples: ESA WorldCover, GlobCover
- **Hydrology & Water Resources** - Datasets capturing water bodies, rivers, lakes, wetlands, and water-related indices. Examples: JRC Global Surface Water, GRWL
- **Socioeconomic & Population Data** - Spatial datasets related to humans, settlements, and socioeconomic. Examples: VIIRS Night-Time Lights, WorldPop
- **Custom & Derived Collections** - User-generated or processed datasets for specific analyses. Examples: NDVI / EVI time-series, Cloud-free mosaics

Exploring the available Datasets

Earth Engine Data Catalog

Search / English ▾

Home Categories All datasets All tags Landsat MODIS Sentinel Publisher Community API Docs Dataset status

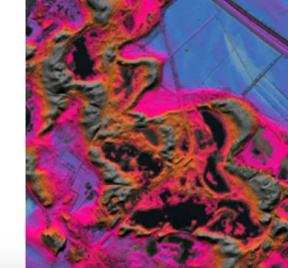
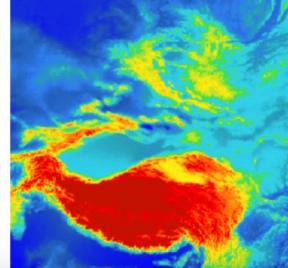
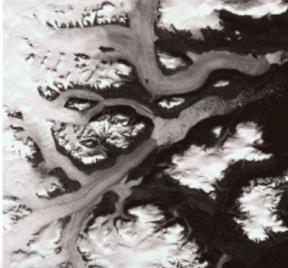
Earth Engine Data Catalog ↗

Earth Engine's public data catalog includes a variety of standard Earth science raster datasets. You can import these datasets into your script environment with a single click. You can also upload your own [raster data](#) or vector data for private use or sharing in your scripts.

Looking for another dataset not in Earth Engine yet? Let us know by [suggesting a dataset](#).

Filter list of datasets

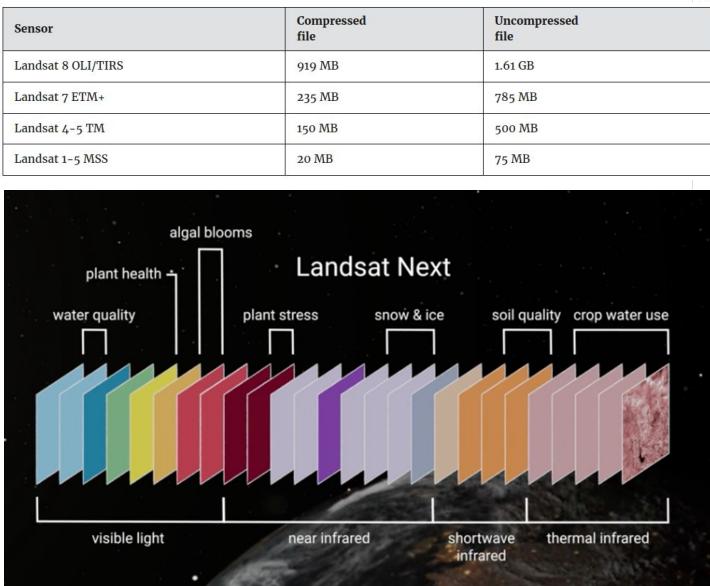
2000 Greenland Mosaic - Greenland Ice Mapping Project (GIMP)	AG100: ASTER Global Emissivity Dataset 100-meter V003	AHN Netherlands 0.5m DEM, Interpolated	AHN Netherlands 0.5m DEM, Non-Interpolated
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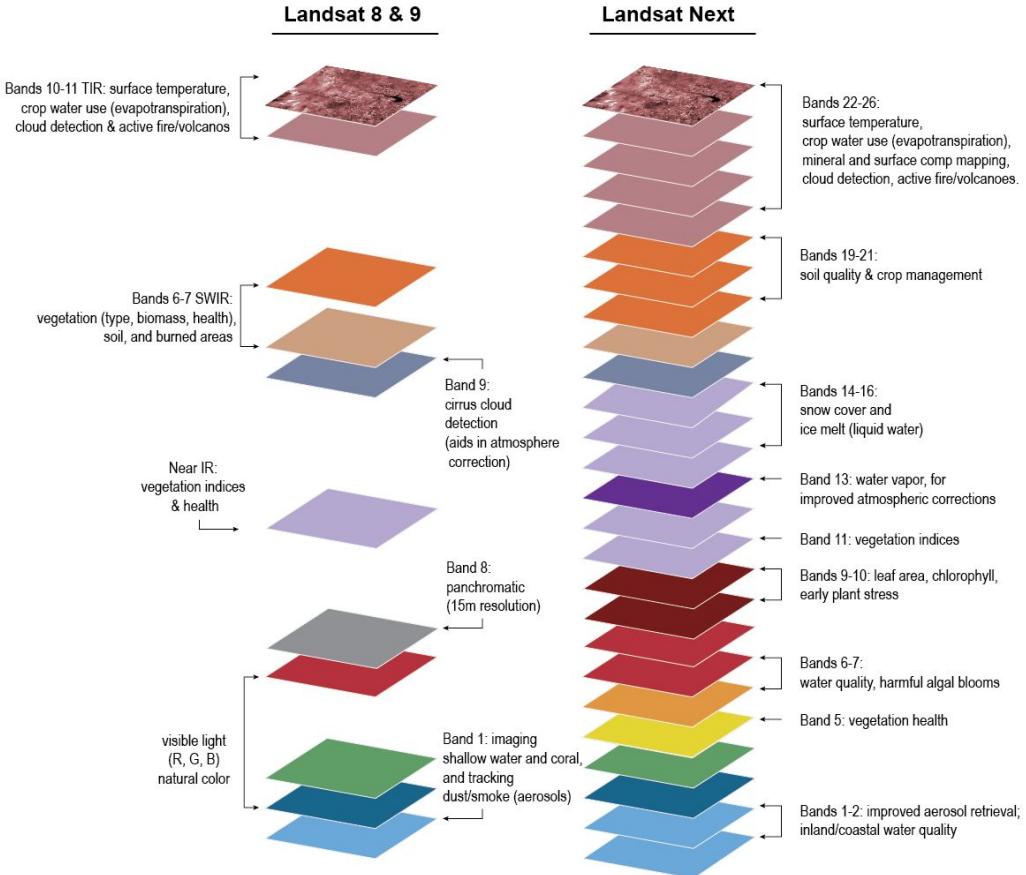
Spectral Comparison: Landsat 8/9, and Landsat Next

Increased spectral coverage with Landsat Next will enable new applications scheduled to launch in late 2030 or early 2031

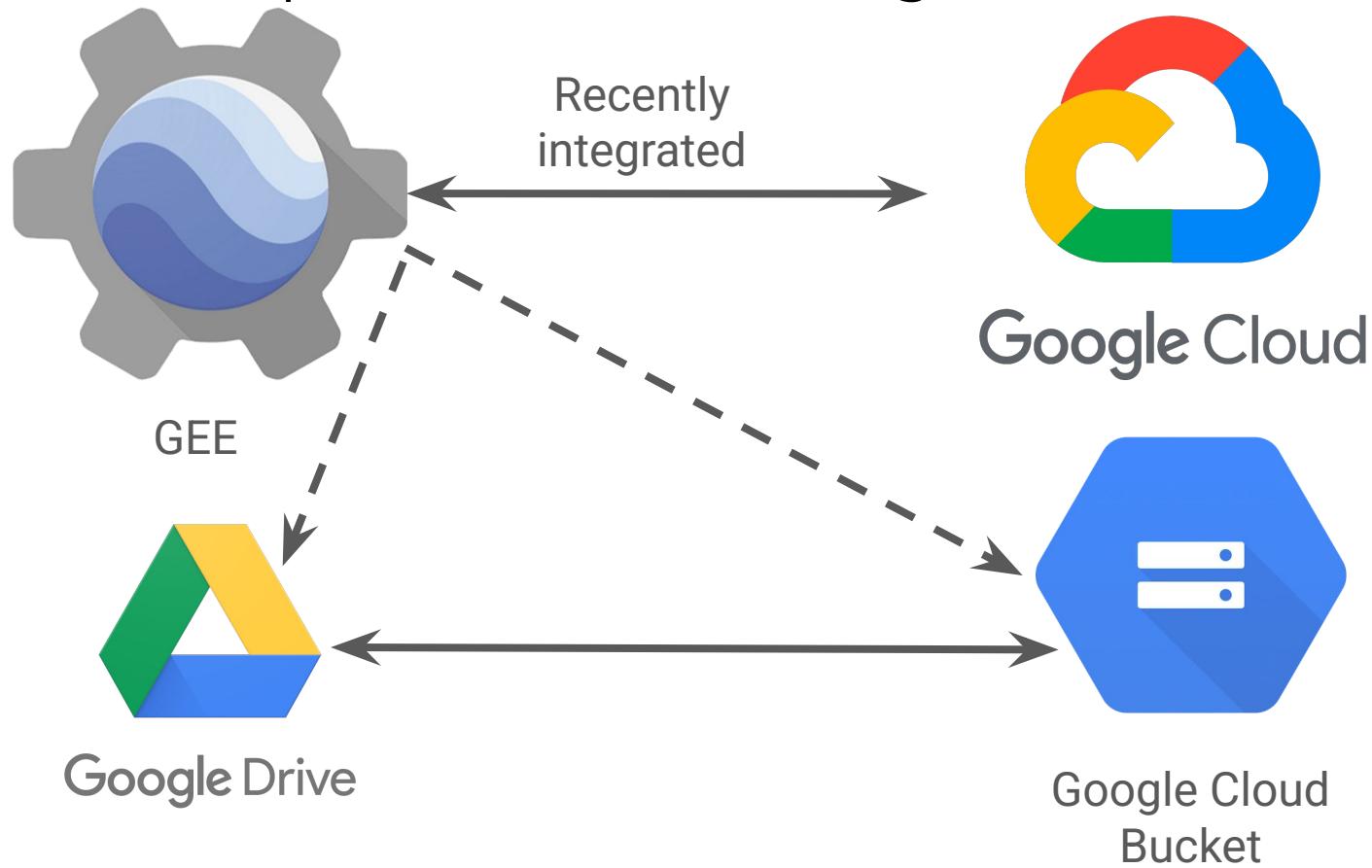
- 30 meters vs. 10 meters
- 11 bands vs. 26 bands
- 1 GB vs. 20 GB



Thermal Infrared
Shortwave Infrared
Near Infrared
Visible Light



Compute-GEE and Google Cloud



Demo and Check-in

- Google Earth Engine Account Set up
- Project Initialization
- Go to <https://code.earthengine.google.com/>
- Create and choose appropriate plan
- Open Colab: <http://colab.research.google.com/>

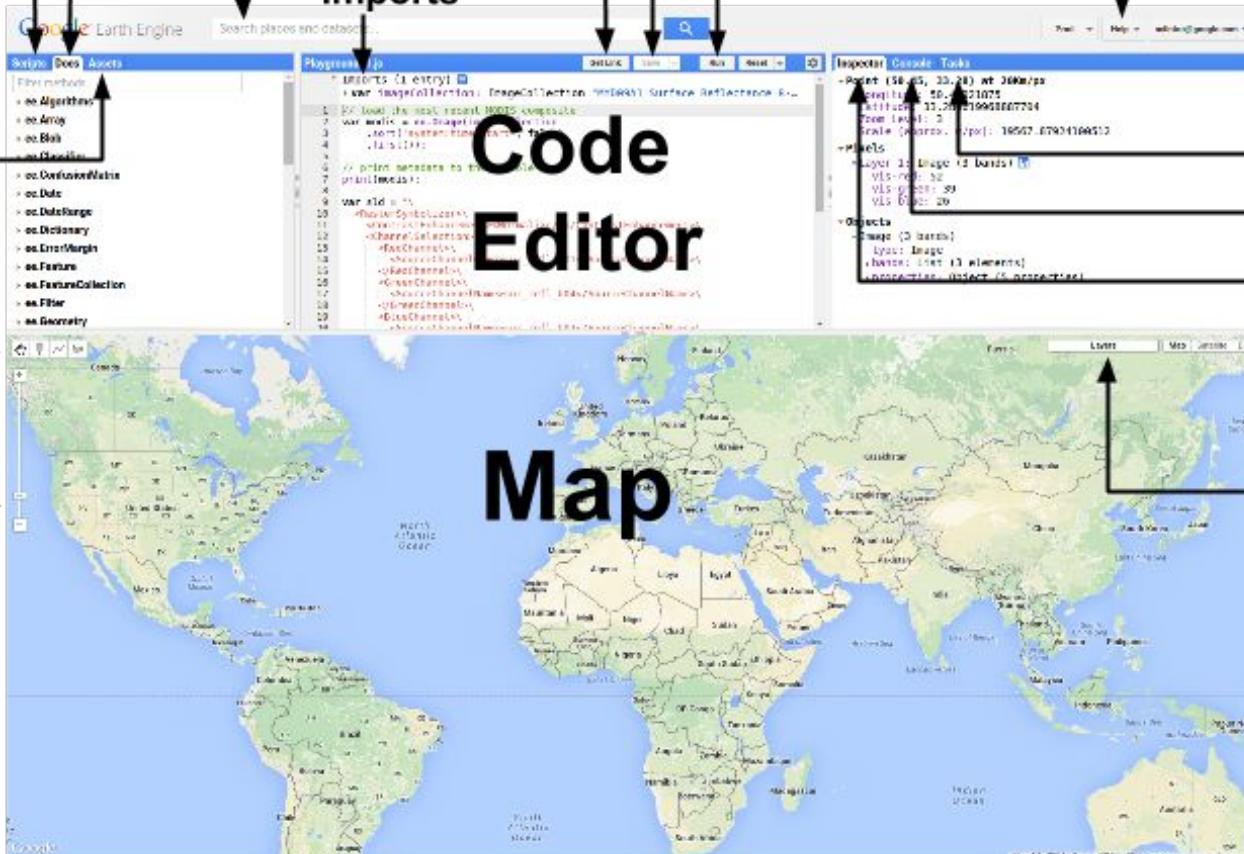


Google Earth Engine

Google colab

Code Editor

Map



Asset – Manager

Geometry → Tools

Zoom →

Script manager

API documentation

Search for data

Imports

Get a link (URL) to the script

Save the script

Run the script

Help button

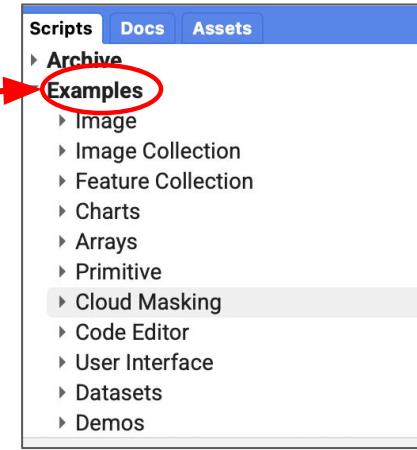
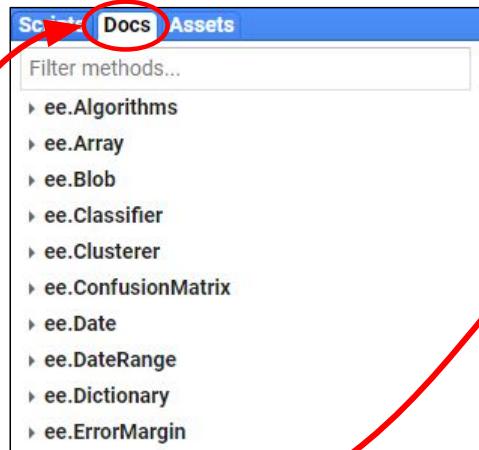
– Task manager

— Console output

- Inspect locations, pixel values, objects added to the map

— Layer manager

Resources For Help



- Docs Tab
- Example Scripts
- [Developer's Guide](#)
- [Google Earth Engine Developers Group](#)

Vector Data

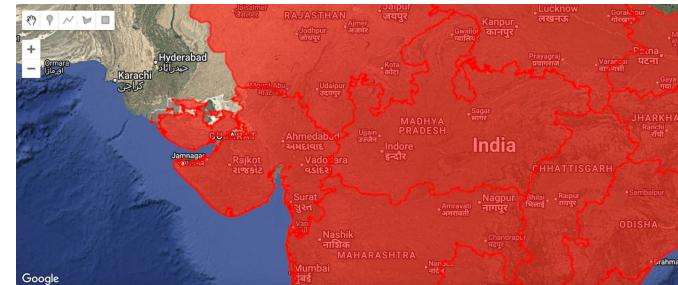
- Collection of geographic features represented as points, lines, or polygons, each with associated attributes is known as vector data.
- Describes discrete data such as countries, rivers or provinces.
- Accessible as Feature Collections in GEE
- Important Vector Data in GEE
 - GAUL (FAO Global Administrative Unit Layers) - Geographic boundaries
 - HydroSHEDS (Hydrological Data and Maps) - rivers
 - GHSL (Global Human Settlement Layer) - built-up/urban polygons and many more.

Vector data in GEE

```
var dataset = ee.FeatureCollection("DATASET_ID");
var filtered = dataset.filter(ee.Filter.eq('PROPERTY_NAME',
'VALUE'));
Map.addLayer(filtered, {color:'COLOR'}, 'Layer Name');
```

Sample:

```
var dataset = ee.FeatureCollection("FAO/GAUL/2015/level1");
var filtered = dataset.filter(ee.Filter.eq('ADM0_NAME', 'India'));
Map.setCenter(79.68, 22.88, 6)
Map.addLayer(filtered, {color:'red'}, 'India States');
```



```
var dataset = ee.FeatureCollection("FAO/GAUL/2015/level1");
var filtered = dataset.filter(ee.Filter.eq('ADM0_NAME', 'India'));
Map.setCenter(79.68, 22.88, 6)
Map.addLayer(filtered, {color:'red'}, 'India States');
```

Simple Example

Importing GEE Datasets

Google Earth Engine

Scripts Docs Assets

Archive Examples

- Image
- Image Collection
- Feature Collection
- Charts
- Arrays
- Primitive
- Cloud Masking
- Code Editor
- User Interface
- Datasets
- Demos

Search: world

PLACES

- World Golf Village, FL, USA
- World's End, Newbury, UK
- Worlds End SA, Australia
- Worlds End, Waterlooville, UK
- World's End, Aylesbury, UK

RASTERS

- Dynamic World V1
- GPWv411: Adjusted to Match 2015 Revision of UN WPP Country Totals (Gridded Population of the ...)
- GPWv411: UN-Adjusted Population Density (Gridded Population of the **World** Version 4.11)
- GPWv411: Basic Demographic Characteristics (Gridded Population of the **World** Version 4.11)
- GPWv411: Data Context (Gridded Population of the **World** Version 4.11)
- GPWv411: Land Area (Gridded Population of the **World** Version 4.11)
- GPWv411: Mean Administrative Unit Area (Gridded Population of the **World** Version 4.11)
- GPWv411: National Identifier Grid (Gridded Population of the **World** Version 4.11)
- [more »](#)

TABLES

- WDPA: **World** Database on Protected Areas (points)
- WDPA: **World** Database on Protected Areas (polygons)
- ESA **World**Cereal AEZ v100
- WDOECM: Other Effective Area-based Conservation Measures (points)
- WDOECM: Other Effective Area-based Conservation Measures (polygons)
- Global Power Plant Database
- WWF HydroSHEDS Free Flowing Rivers Network v1
- GLIMS 2023: Global Land Ice Measurements From Space
- [more »](#)

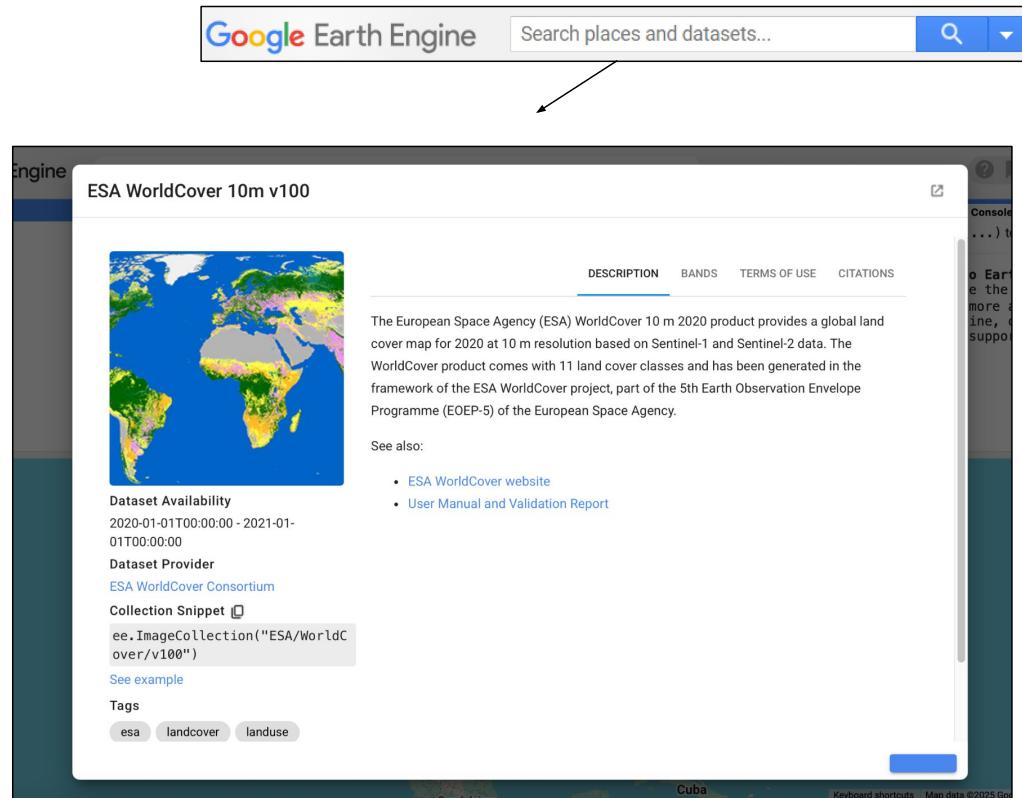
Keyboard shortcuts

Search Data

Importing GEE Datasets

1. Go to
<https://code.earthengine.google.com/>
2. At the top of the page, use the search bar to search for datasets of interest (eg. "ESA WorldCover 10m v100")
3. Select the appropriate dataset and click "Import"
4. The asset will appear as a new table under "Imports" in the central panel.
Rename the dataset.

```
var visualization = {  
  bands: ['Map'],  
};  
Map.addLayer(imageCollection, visualization,  
'ESA WorldCover 10m v100')
```



The screenshot shows the Google Earth Engine interface. At the top, there is a search bar with the placeholder "Search places and datasets..." and a magnifying glass icon. An arrow points from the text "use the search bar" in the instructions above to this search bar. Below the search bar, the title "ESA WorldCover 10m v100" is displayed, along with a thumbnail image of the world map colored by land cover. To the right of the thumbnail, there are tabs for "DESCRIPTION", "BANDS", "TERMS OF USE", and "CITATIONS". The "DESCRIPTION" tab is selected, showing a detailed description of the dataset: "The European Space Agency (ESA) WorldCover 10 m 2020 product provides a global land cover map for 2020 at 10 m resolution based on Sentinel-1 and Sentinel-2 data. The WorldCover product comes with 11 land cover classes and has been generated in the framework of the ESA WorldCover project, part of the 5th Earth Observation Envelope Programme (EOEP-5) of the European Space Agency." Below the description, there is a "See also:" section with links to the "ESA WorldCover website" and the "User Manual and Validation Report". At the bottom of the page, there are "Tags" labeled "esa", "landcover", and "landuse".

Image Collection in GEE

- A sample template for loading the collection:

```
var collection = ee.ImageCollection("DATASET_NAME")
    .filterDate(START_DATE, END_DATE) // filter by date
    .filterBounds(ROI) // filter by ROI
    .filter(ee.Filter.lt(METADATA_FIELD, THRESHOLD_VALUE));
```

- Example:

```
var roi = ee.Geometry.Point([76.4910, 9.0886]) // Example: Amritapuri
    .buffer(5000); // 5 KM buffer

var collection = ee.ImageCollection("COPERNICUS/S2_SR")
    .filterDate(startDate, endDate)
    .filterBounds(roi)
    .filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE', 20));
```

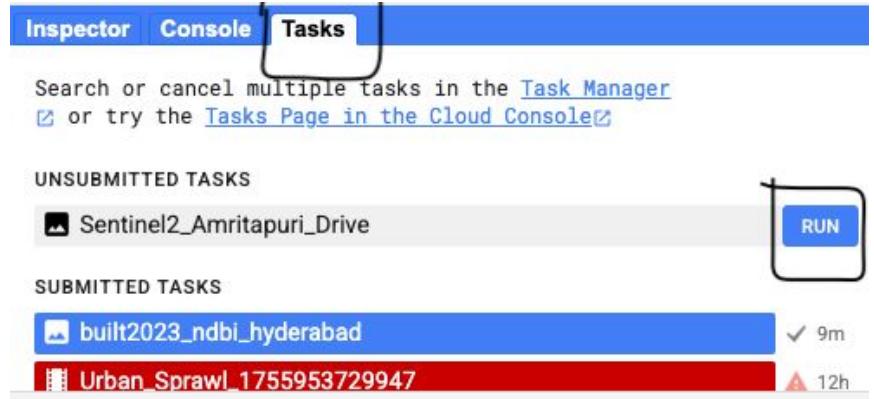
Exporting Options

Template to export an image to google drive

```
Export.image.toDrive({  
  image: IMAGE_OBJECT,          // The ee.Image you want to export  
  description: "EXPORT_NAME",   // Task name shown in Tasks tab  
  folder: "FOLDER_NAME",        // (Optional) Google Drive folder  
  fileNamePrefix: "FILE_NAME",  // (Optional) file name prefix  
  region: ROI,                 // ee.Geometry (area to export)  
  scale: SCALE_IN_METERS,      // e.g., 10 for Sentinel-2, 30 for Landsat  
  crs: "PROJECTION",          // (Optional) coordinate system, e.g. "EPSG:4326"  
  fileFormat: "FORMAT",         // Output format  
  maxPixels: 1e13              // Increase if large export  
});
```

- Example:

```
Export.image.toDrive({  
  image: composite,  
  description: "Sentinel2_Export",  
  folder: "GEE_Exports",  
  fileNamePrefix: "Amritapuri_S2",  
  region: roi,  
  scale: 10,  
  fileFormat: "GeoTIFF"  
});
```



- Supported fileFormat options for export to drive: GeoTIFF, TFRecord.
- If you're exporting tables (Export.table.toDrive()), then you can also use "CSV", "SHP", "GeoJSON", "KML".

Google Cloud Storage

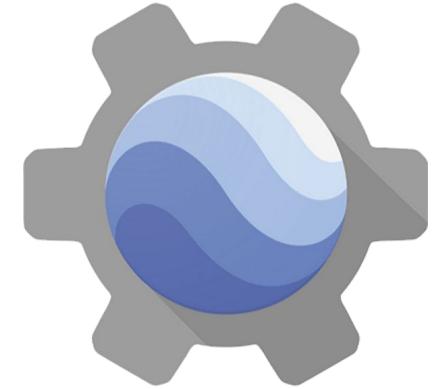
- Export to **Google Cloud Storage**

```
Export.image.toCloudStorage({  
  
  image: composite,  
  
  description: 'Sentinel2_CloudExport',  
  
  bucket: 'your-bucket-name',  
  
  scale: 10,  
  
  region: roi  
  
});
```



- Export to Earth Engine Asset

```
Export.image.toAsset({  
  image: composite,  
  description: 'Sentinel2_Asset',  
  assetId: 'users/your_username/sentinel2_amritapuri',  
  scale: 10,  
  region: roi  
});
```



Reduction on Data

Reduction in GEE means summarizing many values into fewer values using a statistical function (like mean, max, sum, etc.).

Various ways of reducing in GEE

- ImageCollection reduction → Combine multiple images over time into one
- Image reduction → Summarize pixel values in a region
- FeatureCollection reduction → Summarize attributes across features

```
var reducedImage = image.reduceRegion({  
  reducer: ee.Reducer.mean(), // can be mean, max, min, median etc.  
  geometry: roi,  
  scale: 30  
});
```

```
var reducedCollection = collection.reduce(ee.Reducer.mean());
```

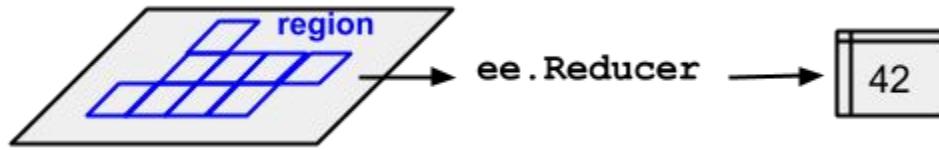
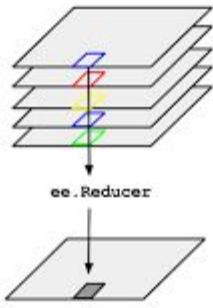


Image reduction to scalar

Image
Collection
reduction to
composite

Case Studies

<https://github.com/praveenpankaj/icsrf-geoai-tutorial/>



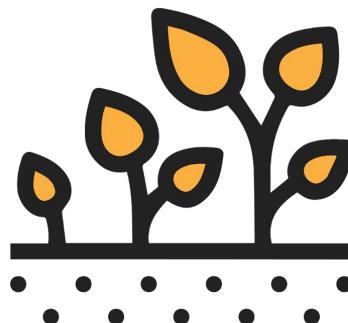
NDVI Estimation

Normalized Difference Vegetation Index

Unhealthy Vegetation

NIR
(Near Infrared) RED
(Visible Red)

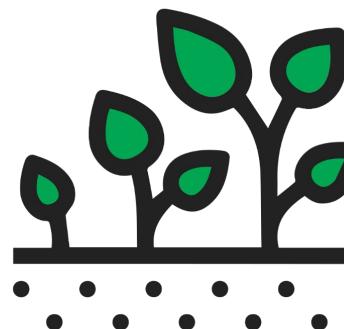
40% ↑ ↓ 30% ↑ ↓



Healthy Vegetation

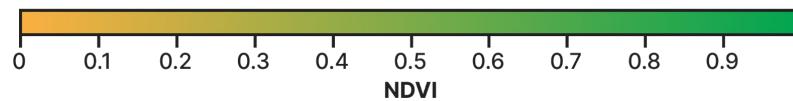
NIR
(Near Infrared) RED
(Visible Red)

50% ↑ ↓ 8% ↑ ↓

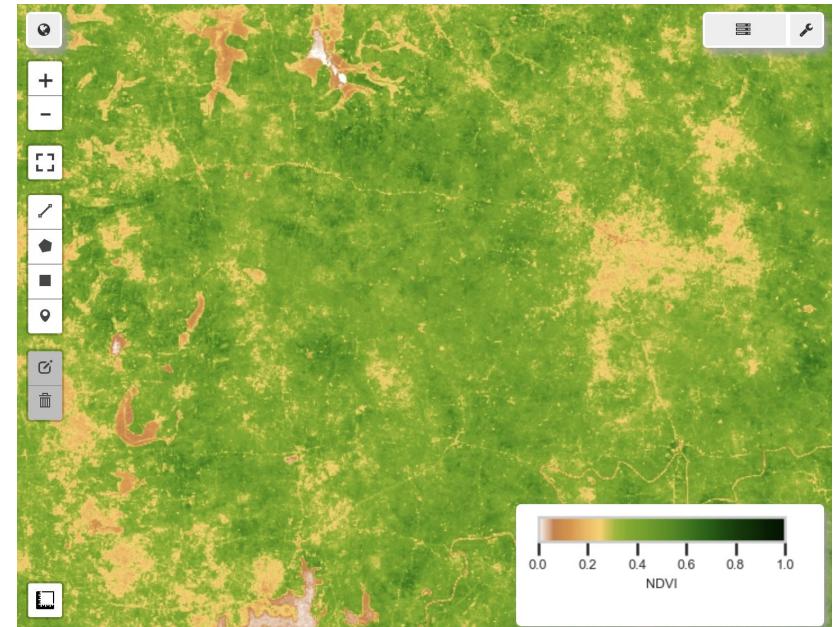
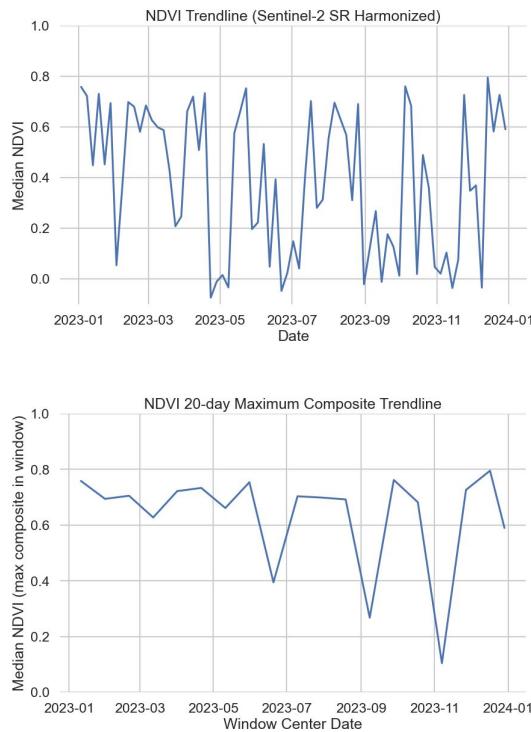


$$NDVI = \frac{0.40 - 0.30}{0.40 + 0.30} = 0.14$$

$$NDVI = \frac{0.50 - 0.08}{0.50 + 0.08} = 0.72$$



NDVI Estimation



Github Repo Code

Thanks

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