

Part 1: Using Google Earth Engine for Land Monitoring Applications

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June 16, 2021



Course Structure and Materials

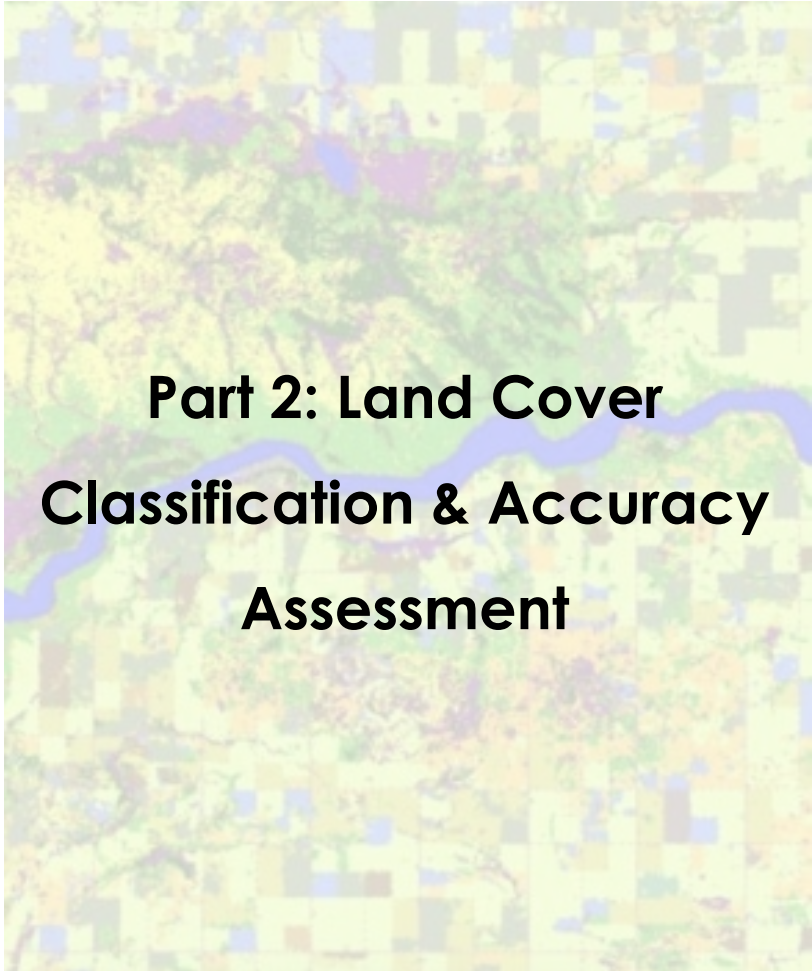
- Three 2-hour sessions on June 16, 23, & 30
- Sessions will be presented once in English 12:00-14:00 EDT
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
 - <https://appliedsciences.nasa.gov/join-mission/training/english/arset-using-google-earth-engine-land-monitoring-applications>
 - Q&A following each lecture and/or by email at:
 - bengtsson@baeri.org
 - juan.l.torresperez@nasa.gov
 - amberjean.mccullum@nasa.gov



Webinar Agenda



**Part 1: Google Earth
Engine Basics & General
Applications**



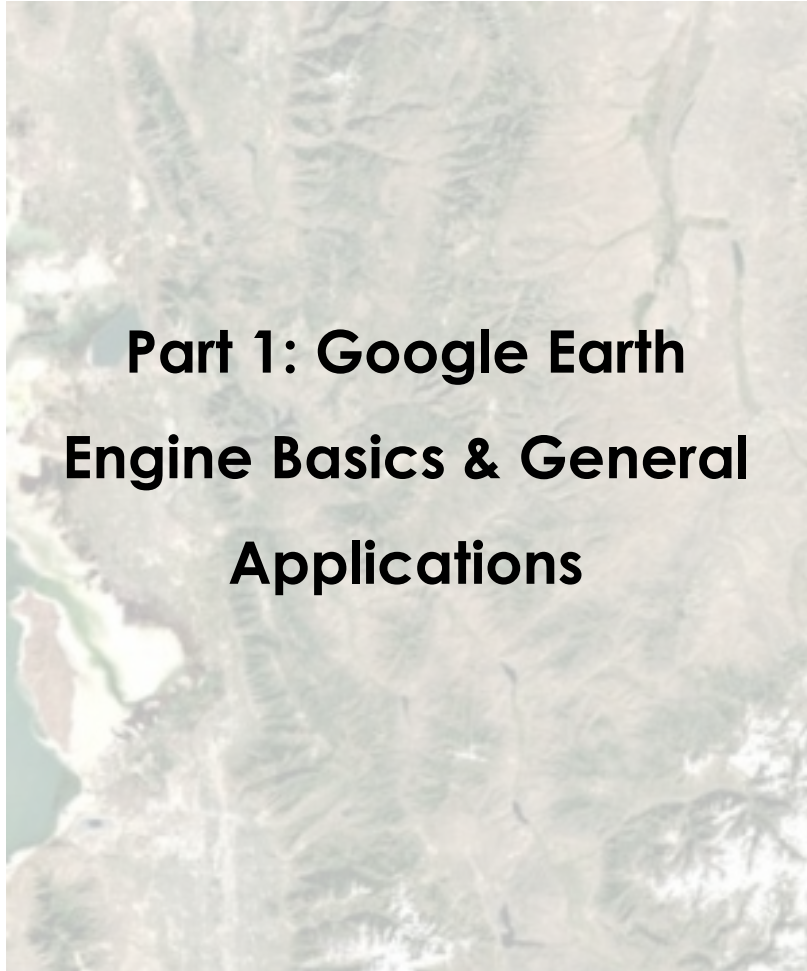
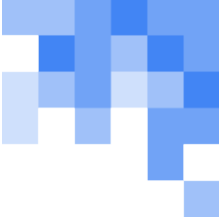
**Part 2: Land Cover
Classification & Accuracy
Assessment**



**Part 3: Time Series Analysis
& Change Detection**



Webinar Agenda



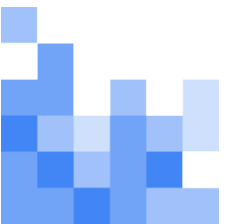
Zach Bengtsson



Juan Torres-Pérez

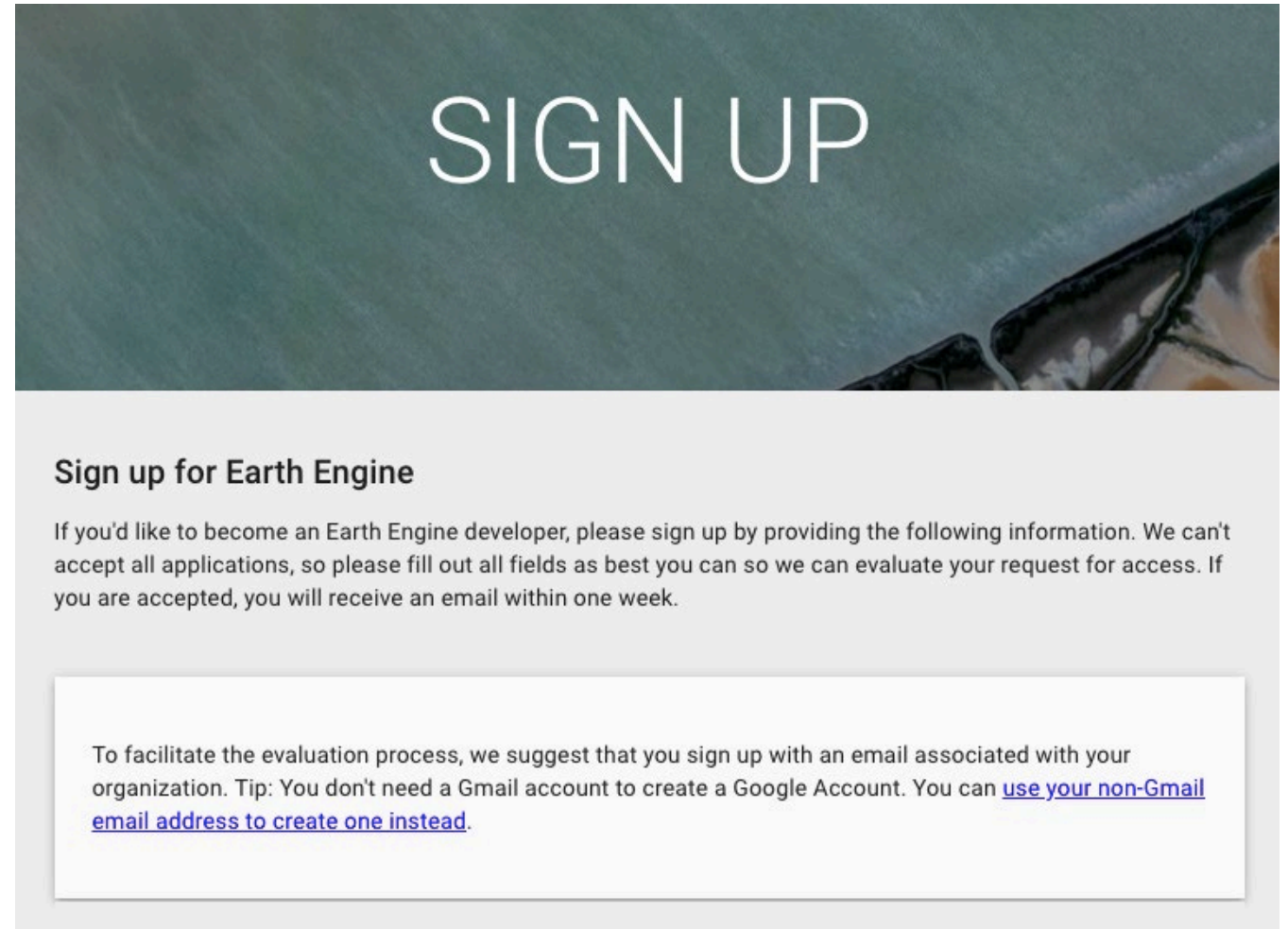


Amber McCullum



Google Earth Engine Account Reminder

- Make sure you sign up for a Google Earth Engine account as soon as possible, if you haven't already, using the link below:
 - <https://signup.earthengine.google.com/#!/>
 - A Gmail address is not required. It is recommended that you use your work/institutional email.



SIGN UP

Sign up for Earth Engine

If you'd like to become an Earth Engine developer, please sign up by providing the following information. We can't accept all applications, so please fill out all fields as best you can so we can evaluate your request for access. If you are accepted, you will receive an email within one week.

To facilitate the evaluation process, we suggest that you sign up with an email associated with your organization. Tip: You don't need a Gmail account to create a Google Account. You can [use your non-Gmail email address to create one instead.](#)



Session Outline

- **Introduction to Google Earth Engine (GEE)**
 - Advantages of cloud-based raster computing and remote sensing analysis functionalities
 - Available data from land monitoring satellite sensors
 - Applications of GEE for land management
- **GEE JavaScript API Activity**
 - API overview and data catalog search
 - Importing and filtering Landsat 8 data
 - Simple vegetation indices calculation
- **Python API Demonstration**
 - Brief review of Python API available for GEE

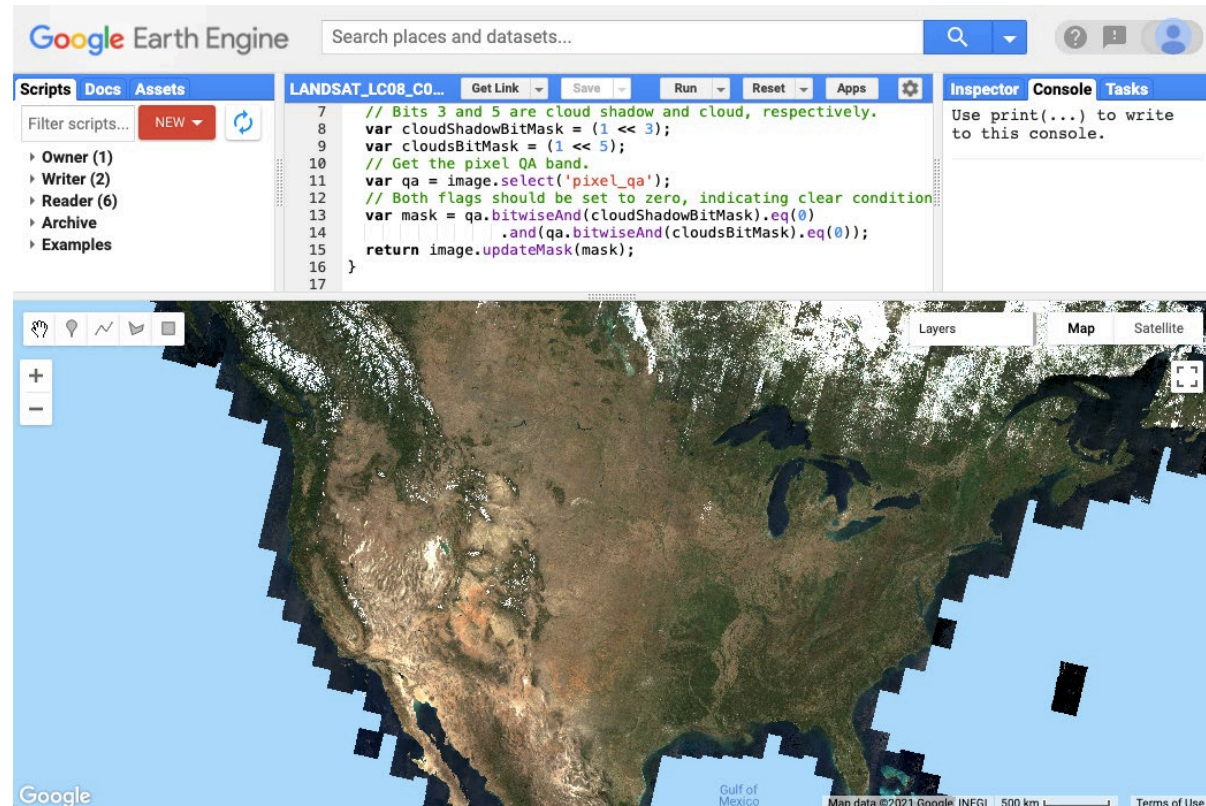




Introduction to Google Earth Engine Functionalities and Available Data Types

Cloud-Based Raster Computing for Remote Sensing Analysis

- Cloud-based raster computing removes barriers and limitations related to...
 - Data hosting and storage
 - Imagery access and availability
 - Personal computing capabilities
- GEE is also free for scientists, researchers, and developers.

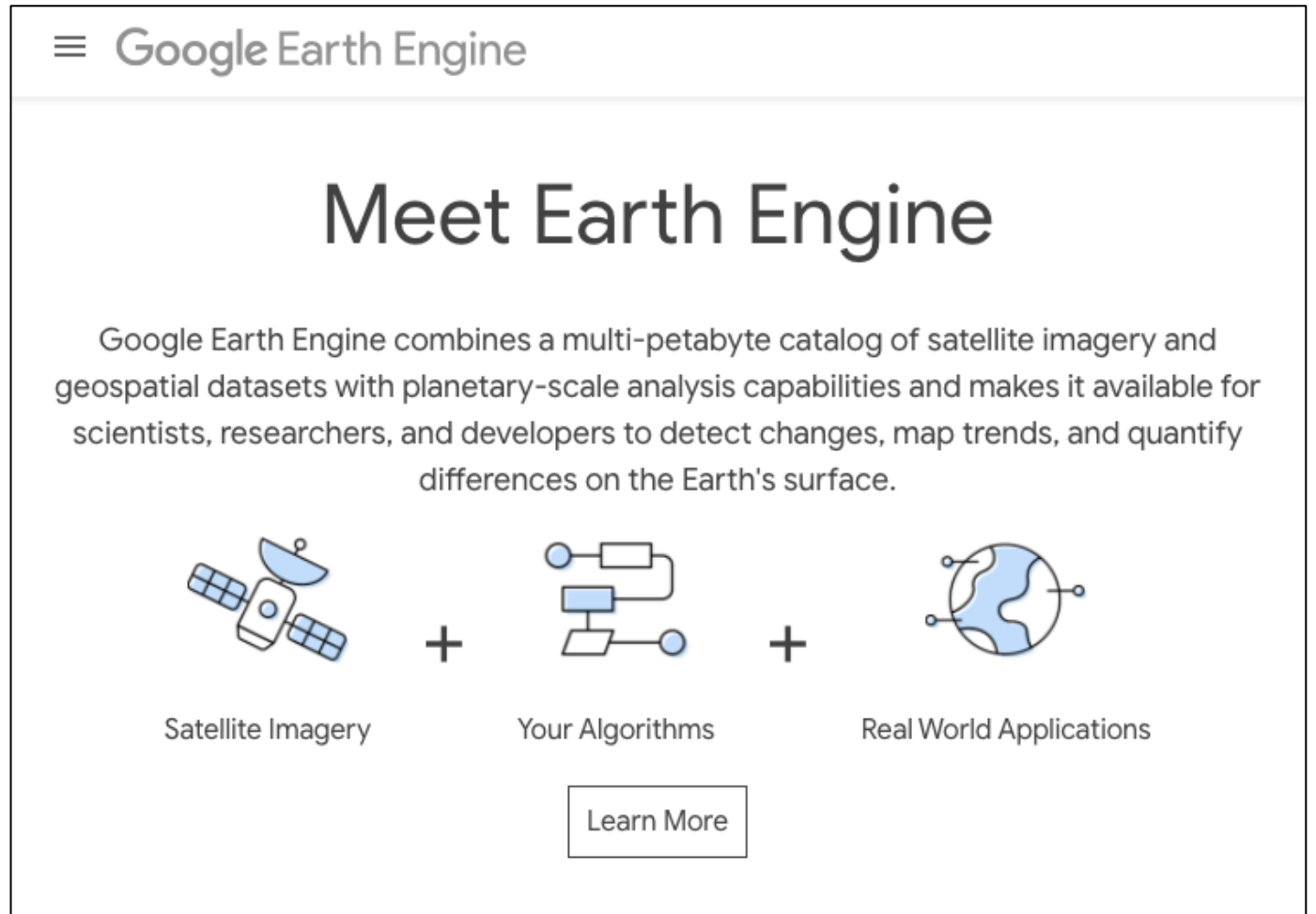


Google Earth Engine code editor interface using the JavaScript API, displaying Landsat 8 surface reflectance true color imagery for the U.S. Credit: [Google Earth Engine Developers](#)



The Google Earth Engine Platform

- Google Earth Engine (GEE) takes advantage of cloud computing capabilities to provide users with a single place for **accessing satellite data, applying remote sensing methodologies, and displaying analysis results.**
- GEE's application programming interface (API) allows users to easily apply land cover monitoring algorithms and classifications with coded commands.



The screenshot shows the Google Earth Engine website. At the top left is a hamburger menu icon followed by the text "Google Earth Engine". The main heading is "Meet Earth Engine". Below this is a paragraph: "Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and makes it available for scientists, researchers, and developers to detect changes, map trends, and quantify differences on the Earth's surface." Below the text is a diagram consisting of three icons: a satellite, a flowchart representing algorithms, and a globe with data points. These are separated by plus signs. Below the icons are the labels "Satellite Imagery", "Your Algorithms", and "Real World Applications". At the bottom center of the diagram is a "Learn More" button.

Image Credit: [Google Earth Engine](https://earthengine.google.com/)

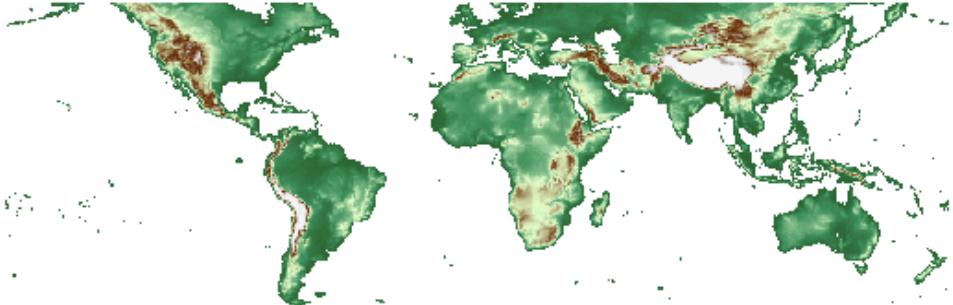


Application Programming Interface (API)

- The Earth Engine JavaScript API is currently the most widely used method of working with GEE.
- A Python API through Google Colaboratory (Colab) is also available for those interested in using Python.
 - This is a bit more complicated than working directly in the GEE code editor with JavaScript.

```
# Import the Image function from the IPython.display module.
from IPython.display import Image

# Display a thumbnail of global elevation.
Image(url = dem.updateMask(dem.gt(0))
      .getThumbURL({'min': 0, 'max': 4000, 'dimensions': 512,
                    'palette': ['006633', 'E5FFCC', '662A00', 'D8D8D8', 'F5F5F5']}))
```

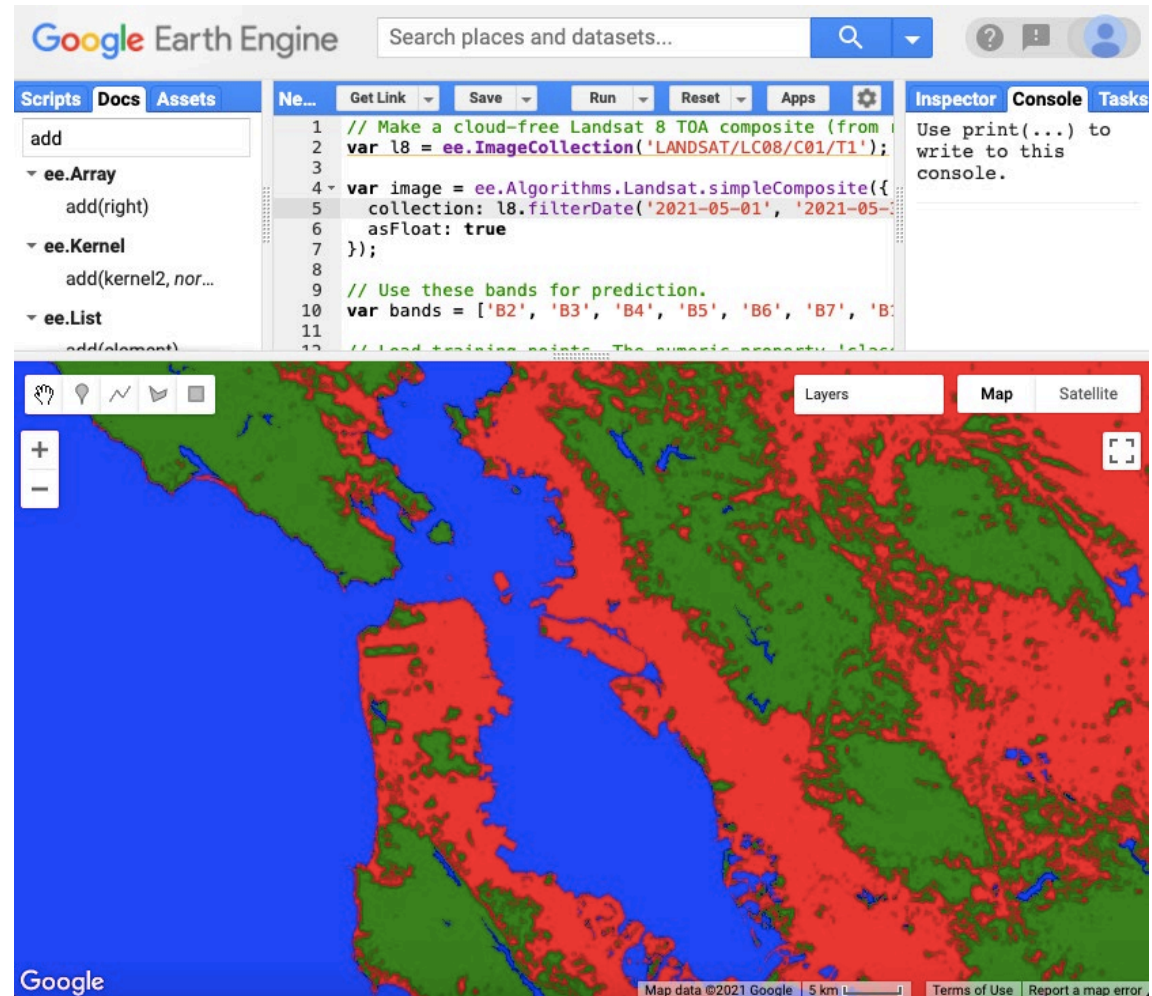


Google Colab notebook using a coded section to display elevation in an output cell. Credit: [Google Colab](#)



Google Earth Engine Functionality

- Uses of GEE for satellite imagery analysis include:
 - Automation of data processing and display
 - Near real-time monitoring (limited by the availability of data in the catalog)
 - Machine learning algorithm application
 - Graphical User Interface implementation



Simple Classification and Regression Trees (CART) classifier implemented in the GEE API to identify three classes urban, forest, and water in the San Francisco Bay Area for May 2021 using Landsat 8 imagery. Credit: [Google Earth Engine Developers](#)



GEE Land Applications

- Long-term monitoring of landscape change and land cover type
- Computation of indices relevant to land management such as normalized difference indices for vegetation, water, snow, soil, and urban areas
- Landscape time series analysis and change detection
- Summary statistics
- Validation and accuracy assessment methods
- Visualization and presentation of results

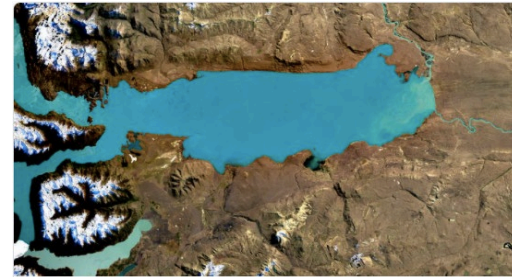


Time series of MODIS NDVI displayed using Google Earth Engine. Image Credit: [Google Earth Engine Developers](#)



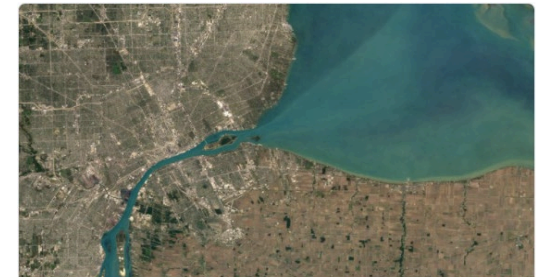
Available Satellite Sensor Data in GEE: Landsat Series

- Data from the entire Landsat series is available for use in GEE, including:
 - **Landsat 1-5**
 - Multispectral Sensor Radiance
 - **Landsat 4-8**
 - Raw Images
 - Top of Atmosphere
 - Surface Reflectance
- The full archive includes data from 1972 to present day, with data from 1982 onward at 30m resolution (Landsat 4-8).
- GEE Data Catalog Link:
 - <https://developers.google.com/earth-engine/datasets/catalog/landsat>



Landsat 8

2013 - Present



Landsat 7

1999 - Present



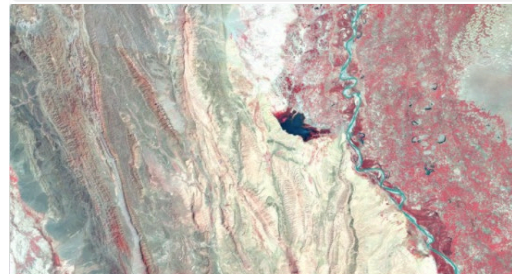
Landsat 5

1984 - 2012



Landsat 4

1982 - 1993



Landsat 1-5 MSS

1972 - 1999

Available Landsat series collections in the GEE data catalog. Image Credit: [Earth Engine Data Catalog](#)



Available Satellite Sensor Data in GEE: Sentinel-2

- Available Sentinel-2 data includes:
 - Top of Atmosphere
 - Surface Reflectance
- Sentinel-2 land applications are very similar to those of Landsat, but differences include:
 - 10-20m spatial resolution
 - 5-day revisit
 - Less temporal coverage
- GEE Data Catalog Link:
 - <https://developers.google.com/earth-engine/datasets/catalog/sentinel-2>



Surface Reflectance

Level-2A orthorectified atmospherically corrected surface reflectance.

Dataset availability: 2017-03-28 – Present



Top-of-Atmosphere Reflectance

Level-1C orthorectified top-of-atmosphere reflectance.

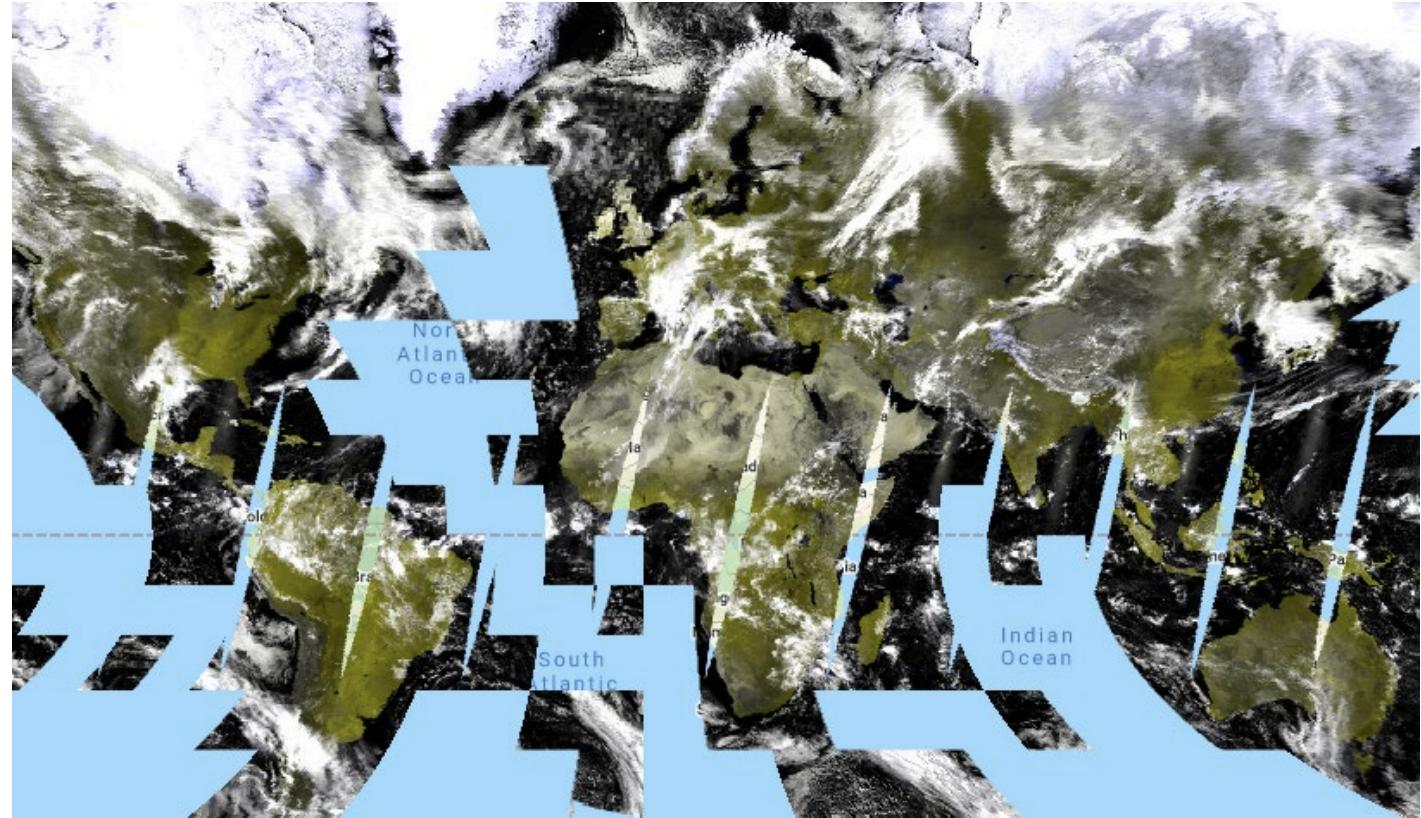
Dataset availability: 2015-06-23 – Present

Available Sentinel-2 data products in GEE. Note the temporal coverage starts in 2015 and 2017. Image Credit: [Earth Engine Data Catalog](#)



Available Satellite Sensor Data in GEE: MODIS

- MODIS reflectance data products include:
 - Daily, 500m Nadir BRDF-Adjusted Reflectance
 - Daily, Global, 250m Surface Reflectance
 - 8-Day, Global, 250m Surface Reflectance
- Pre-processed products include:
 - Daily, Global, 500m Snow Cover
 - 16-Day, Global, 250m Vegetation Indices
 - Yearly, Global, 500m Land Cover Type



False color image of the Terra Surface Reflectance Daily Global 250m projected in the GEE JavaScript API. Credit: [Google Earth Engine Developers](#)

MODIS GEE Catalog Link:

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



Available Satellite Sensor Data in GEE: Sentinel-1 SAR

- Pre-processed SAR data from Sentinel-1 is available to work with in GEE.
- Previous ARSET training:
 - [Forest Mapping and Monitoring with SAR Data](#)
- GEE Data Catalog:
 - https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S1_GRD

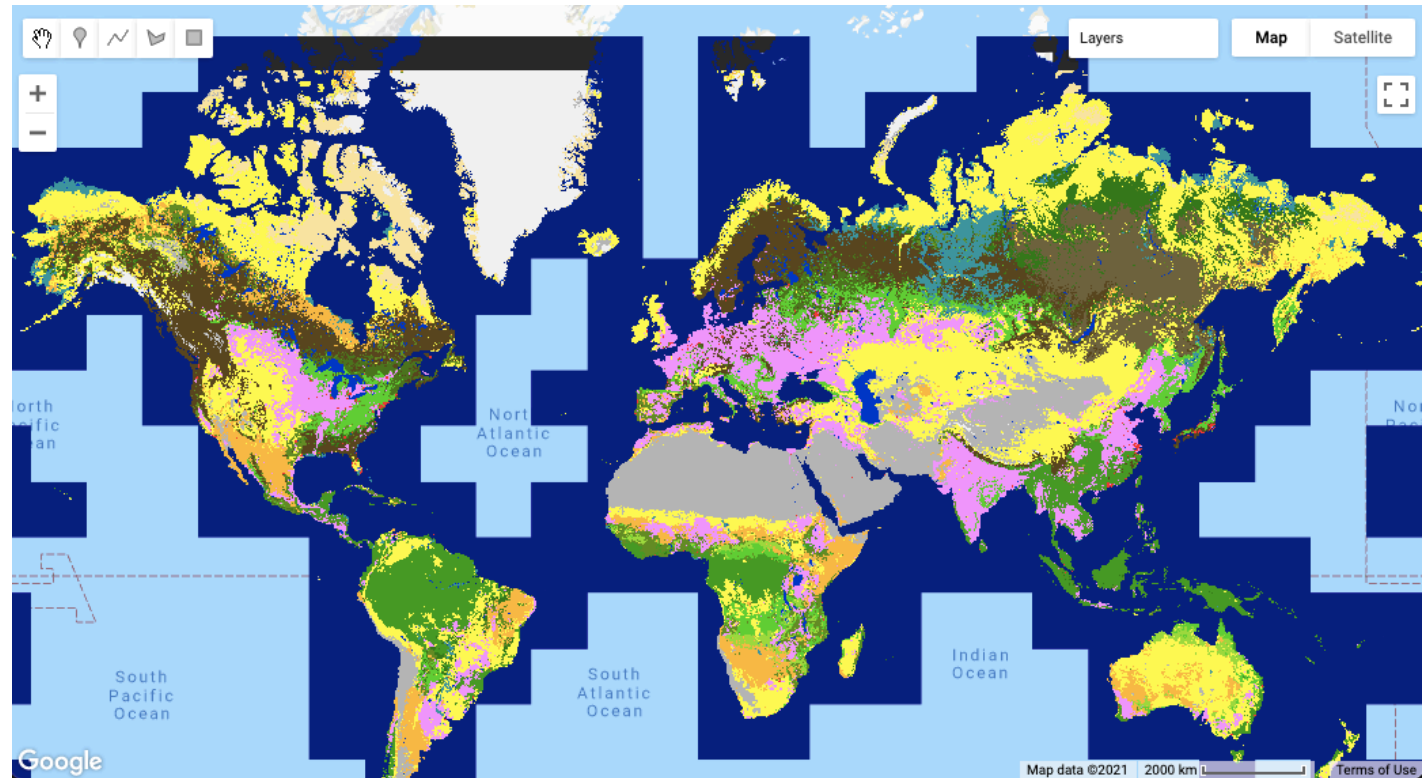


A previous ARSET training details the use of SAR data for land management, particularly in vegetated ecosystems.
Link: [ARSET](#)



Available Satellite Sensor Data in GEE: Land Cover Products

- A variety of land cover data products are available in GEE, including:
 - Copernicus Global Land Cover Layers
 - MODIS Land Cover Type Yearly Global 500m
 - Global PALSAR-2/PALSAR Forest/Non-Forest Map
 - USGS National Land Cover Database
- GEE Data Catalog:
 - <https://developers.google.com/earth-engine/datasets/tags/landcover>

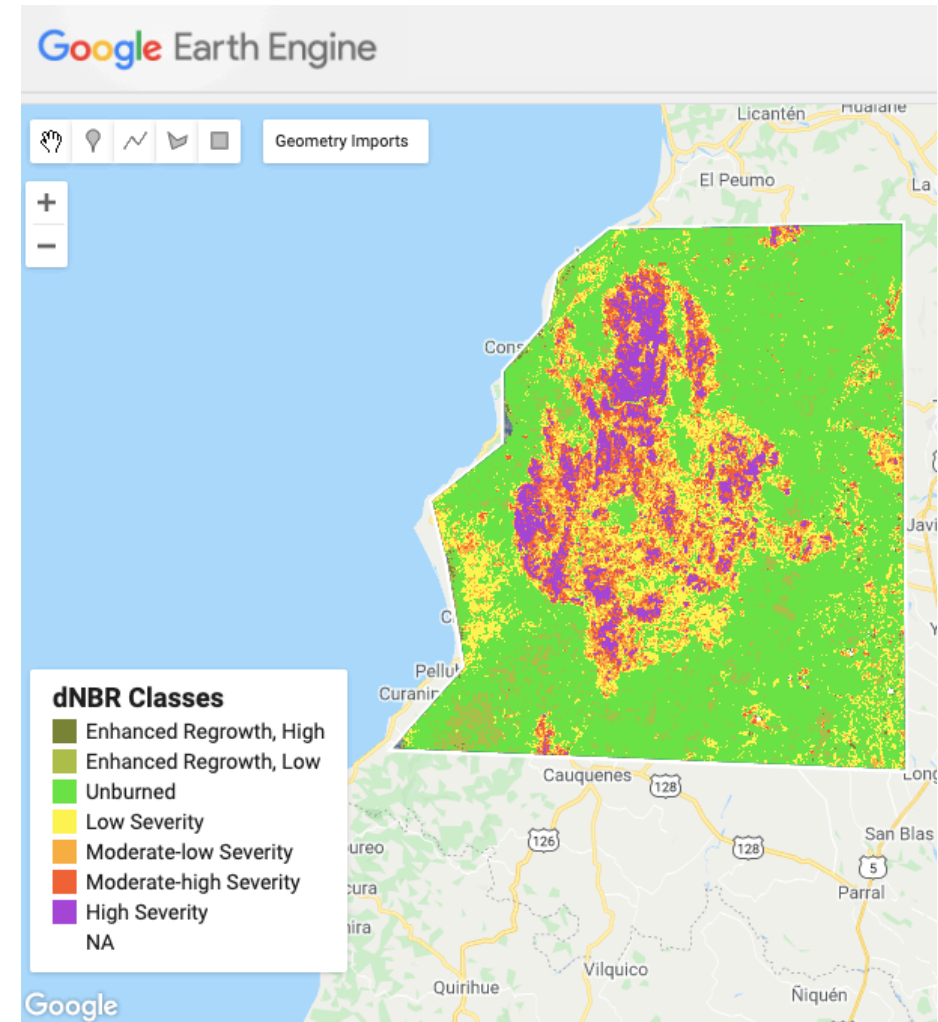


Copernicus Global Land Cover Layers: CGLS-LC100 collection 3 displayed globally in GEE. Credit: [Earth Engine Data Catalog](https://developers.google.com/earth-engine/datasets/tags/landcover)



Applications of GEE for Land Management: Burn Severity

- Burn severity mapping completed in GEE manipulates pre-loaded Sentinel-2 or Landsat 8 data and uses the GEE platform as a means to quality control and filter data.
- Normalized Burn Ratio (NBR) and differenced NBR (dNBR) are calculated.
- Thresholding rates the severity of wildfire burning to complete a full burn severity assessment.
- Refer to the step-by-step [UN-SPIDER burn severity in GEE training](#)

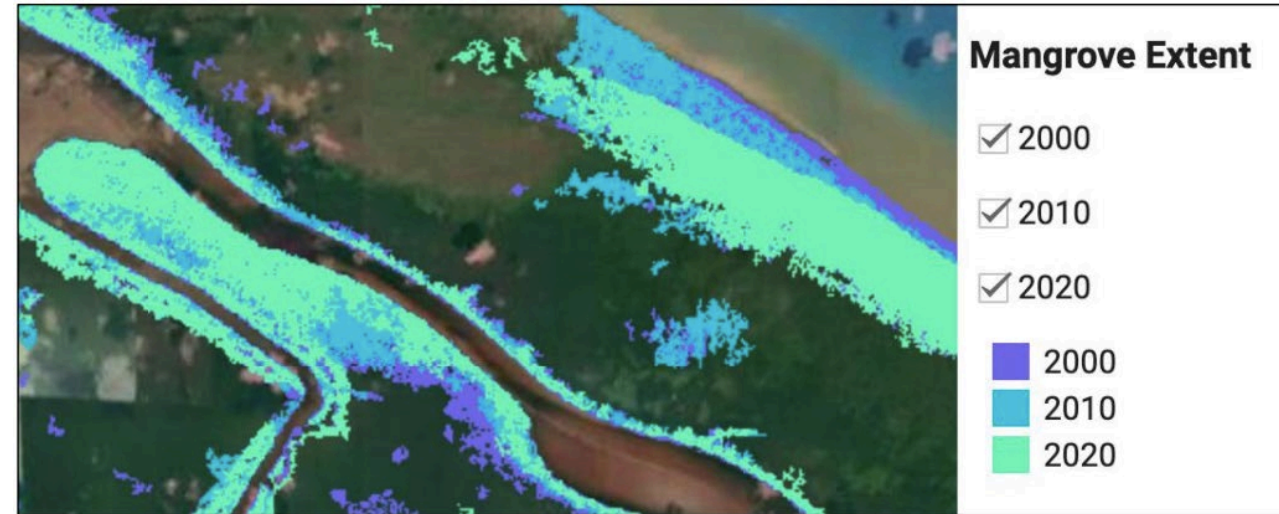


Example of burn severity mapping using Sentinel-2 data in Empedrado, Chile in February 2017. This map was produced using the UN-SPIDER Burn Severity with GEE script. Credit: [UN-SPIDER](#)



Applications of GEE for Land Management: Mangrove Mapping

- ARSET training using GEE to map mangroves:
 - [Remote Sensing for Mangroves in Support of the UN Sustainable Development Goals](#)
- Random Forest Classification to create a time series for mangrove extent change
- Creation of apps as management and communication tools
- The previously mentioned [ARSET SAR training](#) also shows methods of using SAR data in GEE to map mangroves.



Example of mangrove extent mapping over a time series to track how mangrove presence has change over a 20-year period (from the exercises completed during the ARSET Mangrove Mapping series).

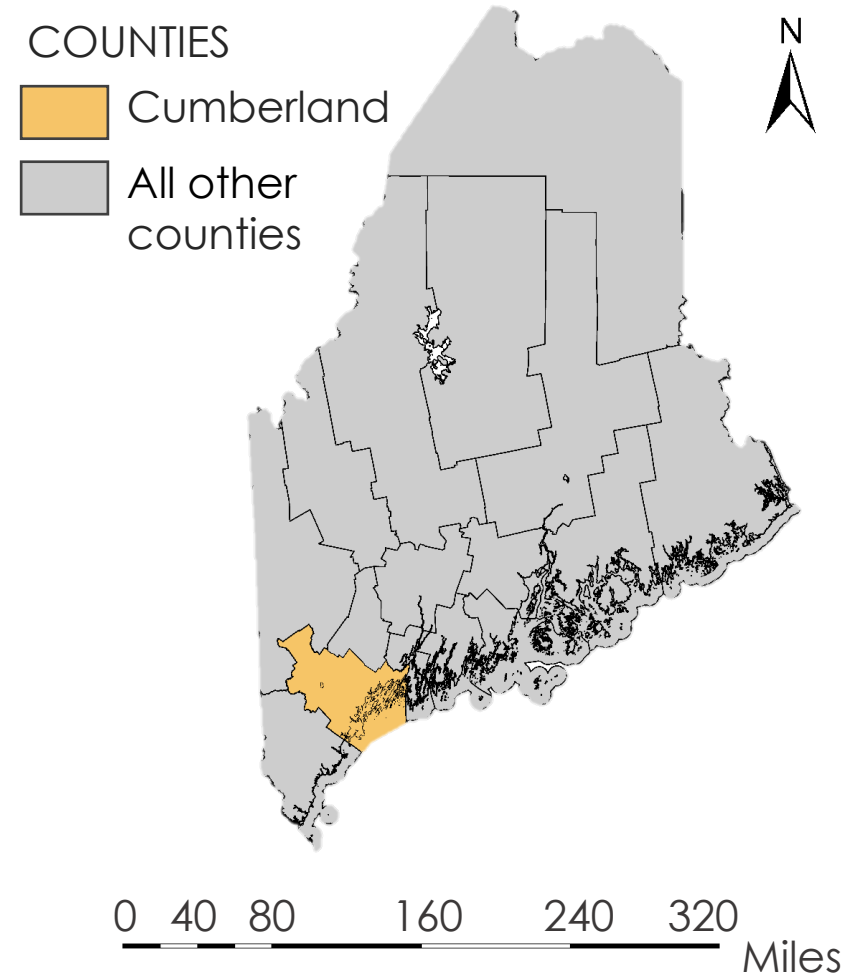
Image Credit: NASA ARSET

Visit the [Data Explorer](#) and [Comparison](#) Apps for more information on mangrove mapping and apps in GEE.



Applications of GEE for Land Management: Land Cover

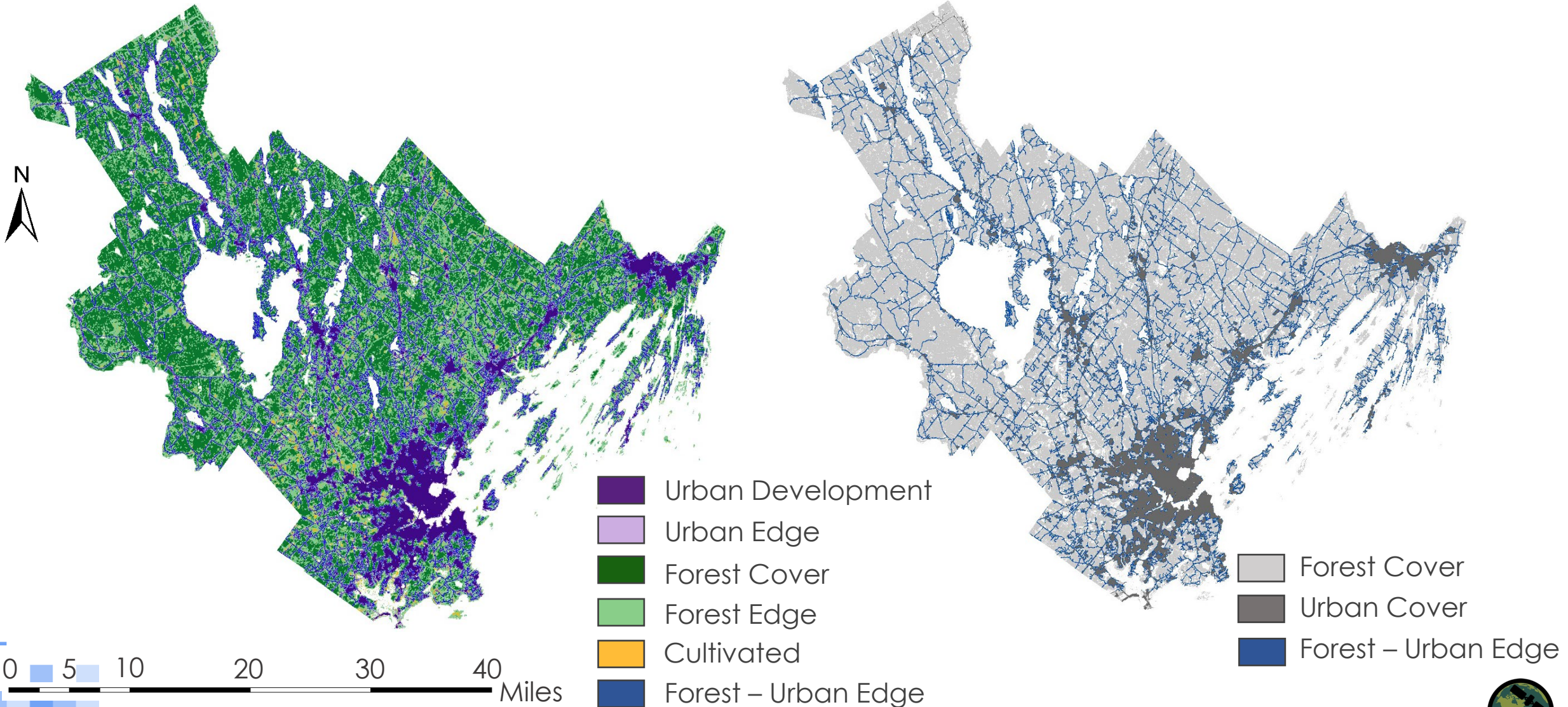
- Public health officials and vector biologists at the Maine Medical Center were interested in identifying lands within Cumberland County, Maine that represent forest edge habitat.
- These habitats are targeted for vector borne disease mitigation since they represent a higher risk of tick-human encounters and thus exposure to illnesses like Lyme Disease.
- The DEVELOP Massachusetts team completed a supervised land cover classification for the the county and then identified borders between forested and developed cover types to identify edge habitat.



Map of the State of Maine, highlighting the study area of Cumberland County.
Image Credit: NASA DEVELOP

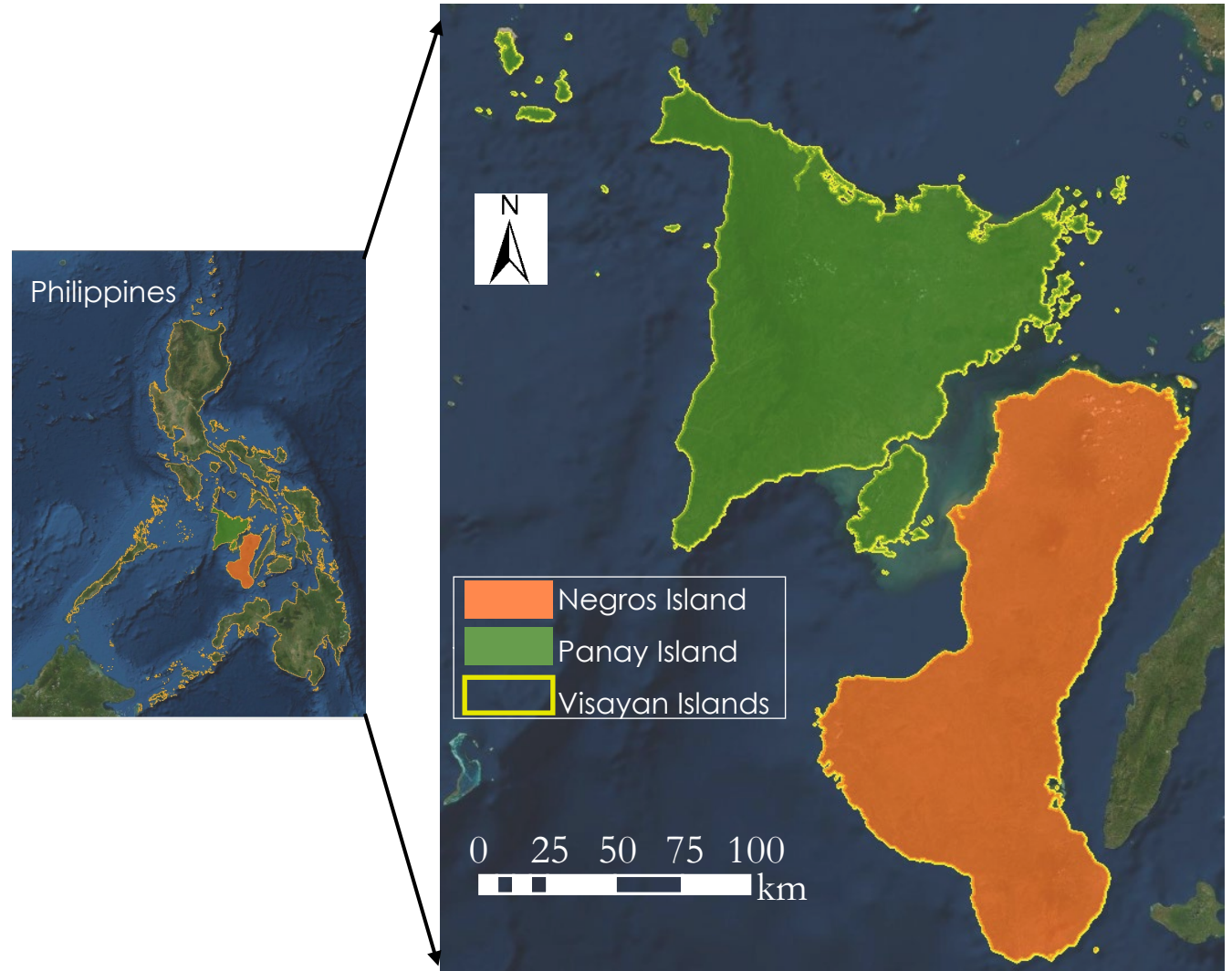


Applications of GEE for Land Management: Land Cover

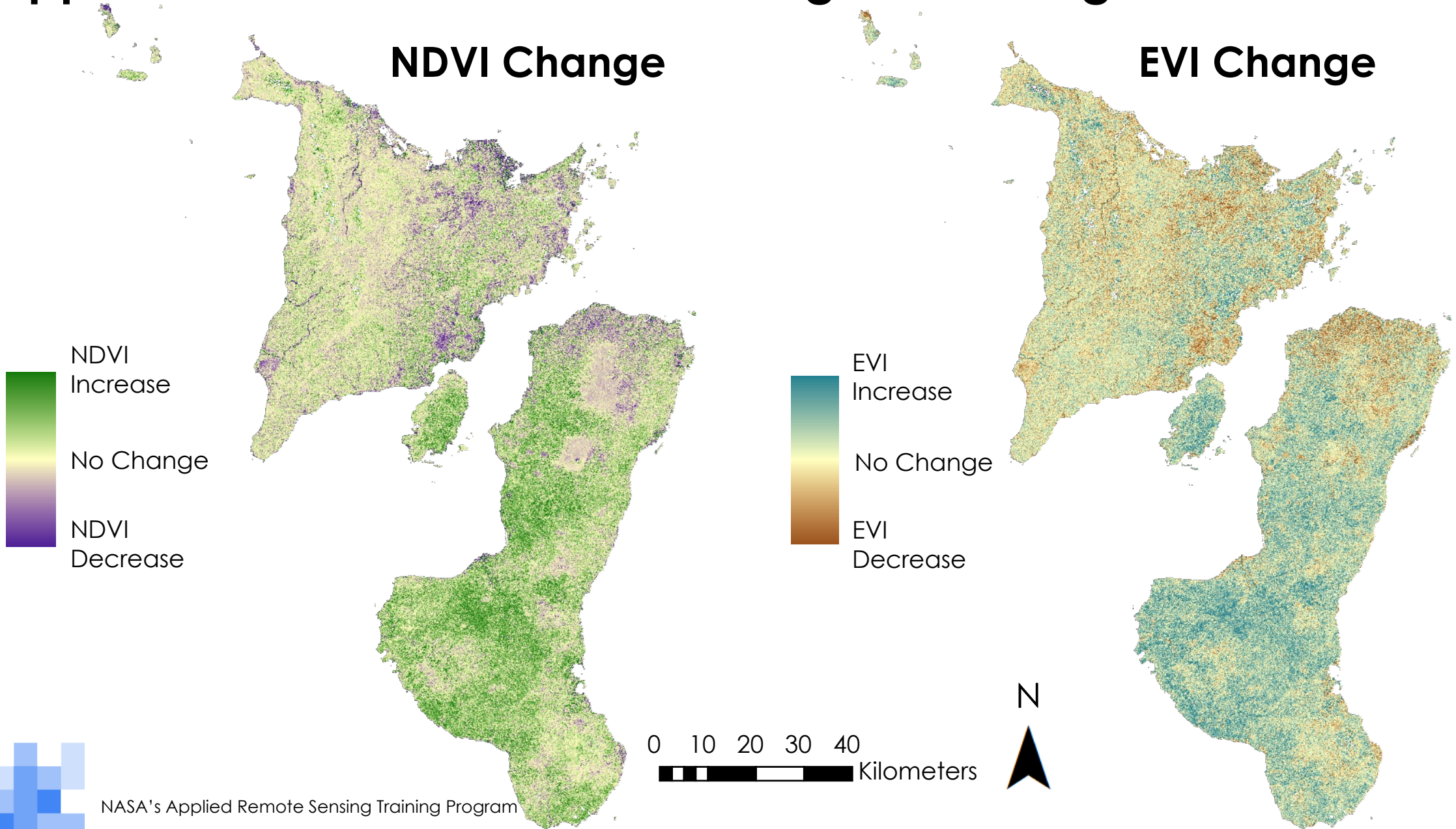


Applications of GEE for Land Management: Vegetation Indices

- Biodiversity conservation organizations working in the Visayan Islands of the Philippines are concerned about the impact of habitat degradation on endangered species.
- Vegetation decline is associated with habitat loss of two particular species: the Visayan warty pig and the Visayan spotted deer.
- The DEVELOP Georgia team used the Terra MODIS archive in GEE from 2000-2019 to map changes in vegetation and identify areas with critical vegetation loss.



Applications of GEE for Land Management: Vegetation Indices





Basics Functions in GEE JavaScript API Activity

<https://code.earthengine.google.com/00b566d9ba821f7fb3011468533bccc9>



Python API Demonstration

<https://colab.research.google.com/github/google/earthengine-api/blob/master/python/examples/ipynb/ee-api-colab-setup.ipynb>

Summary

- The GEE platform provides users with cloud-based computing resources that can decrease barriers like data storage space and personal computing power.
- The capabilities of GEE are similar to those of many GIS platforms used to manipulate satellite data for key land-related remote sensing processes, including algorithm application and land cover classification.
- GEE hosts many datasets relevant to land monitoring.
 - Landsat Series, MODIS, Sentinel-2, and Sentinel-1 SAR
- The JavaScript API enables coding and automation of basic remote sensing functions like imagery filtering, and vegetation index calculation.
- Users interested in the Python API can explore Google Colab.
- Session 2: Land Cover Classification & Accuracy Assessment



Contacts

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- Training Webpage:

- <https://appliedsciences.nasa.gov/join-mission/training/english/arset-using-google-earth-engine-land-monitoring-applications>

- ARSET Website:

- <https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset>





Thank You!

