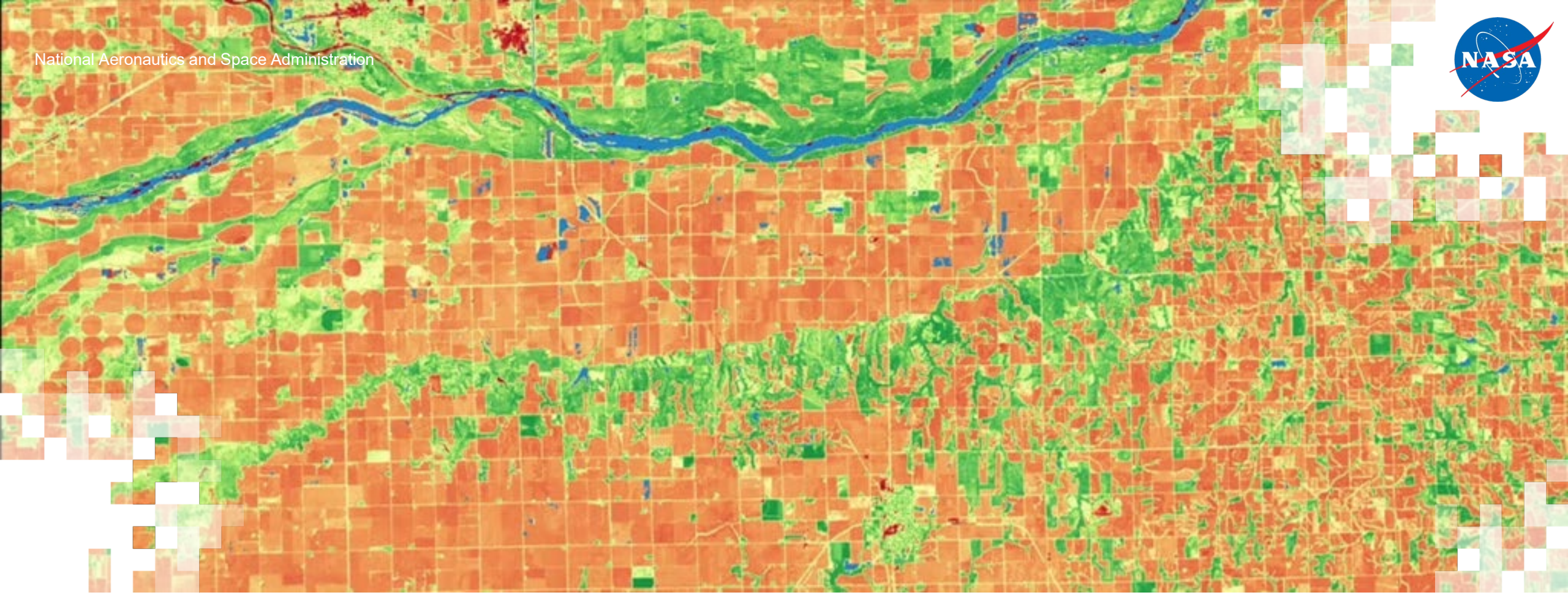
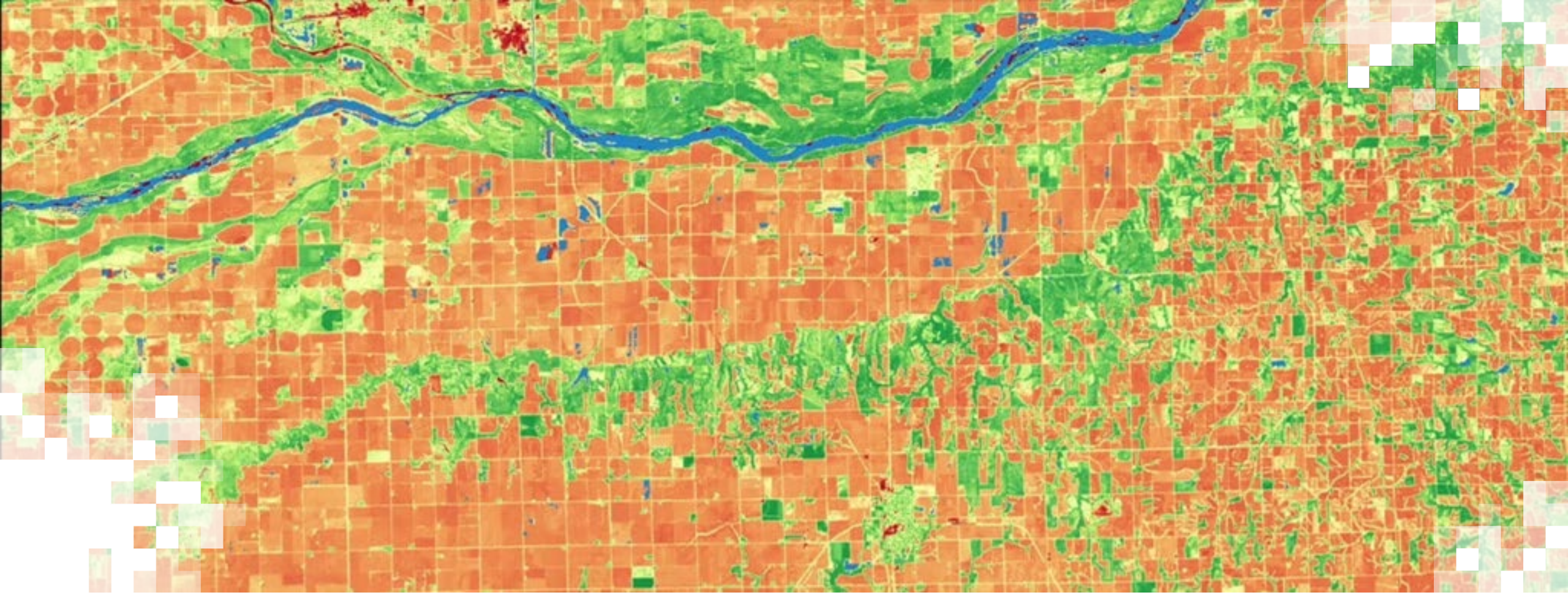


Spectral Indices for Land and Aquatic Applications

Part 3: An Overview of Common Spectral Indices Used for Land Applications

Britnay Beaudry (BAERI), Amber Jean McCullum (BAERI), Juan Torrez-Pérez (NASA ARC), & Sativa Cruz (BAERI)

November 9, 2023



Spectral Indices for Land and Aquatic Applications

Overview

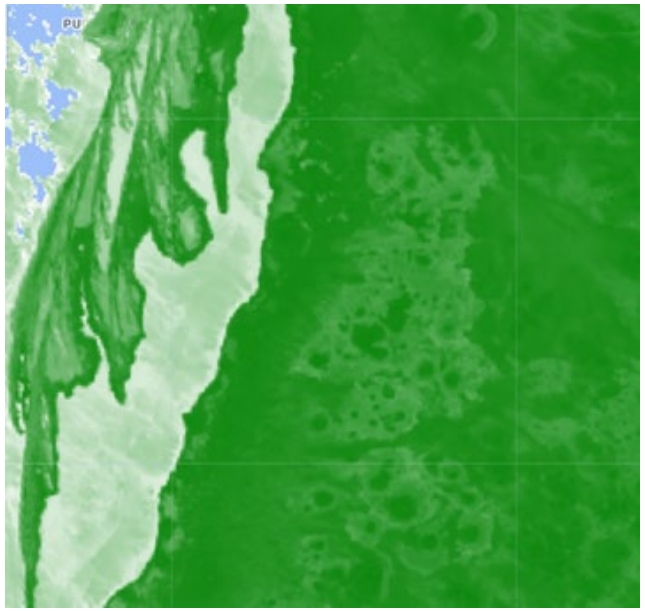
Purpose of this Training

- To provide an overview of commonly used spectral indices for aquatic and land applications.
- Learners will see examples of spectral index calculations with diverse sensors including Landsat 9 (OLI-2), Sentinel-2 MSI, and the Harmonized Landsat Sentinel-2 datasets.
- Demos using Google Earth Engine will be shown for both aquatic and land applications.

Training Learning Objectives

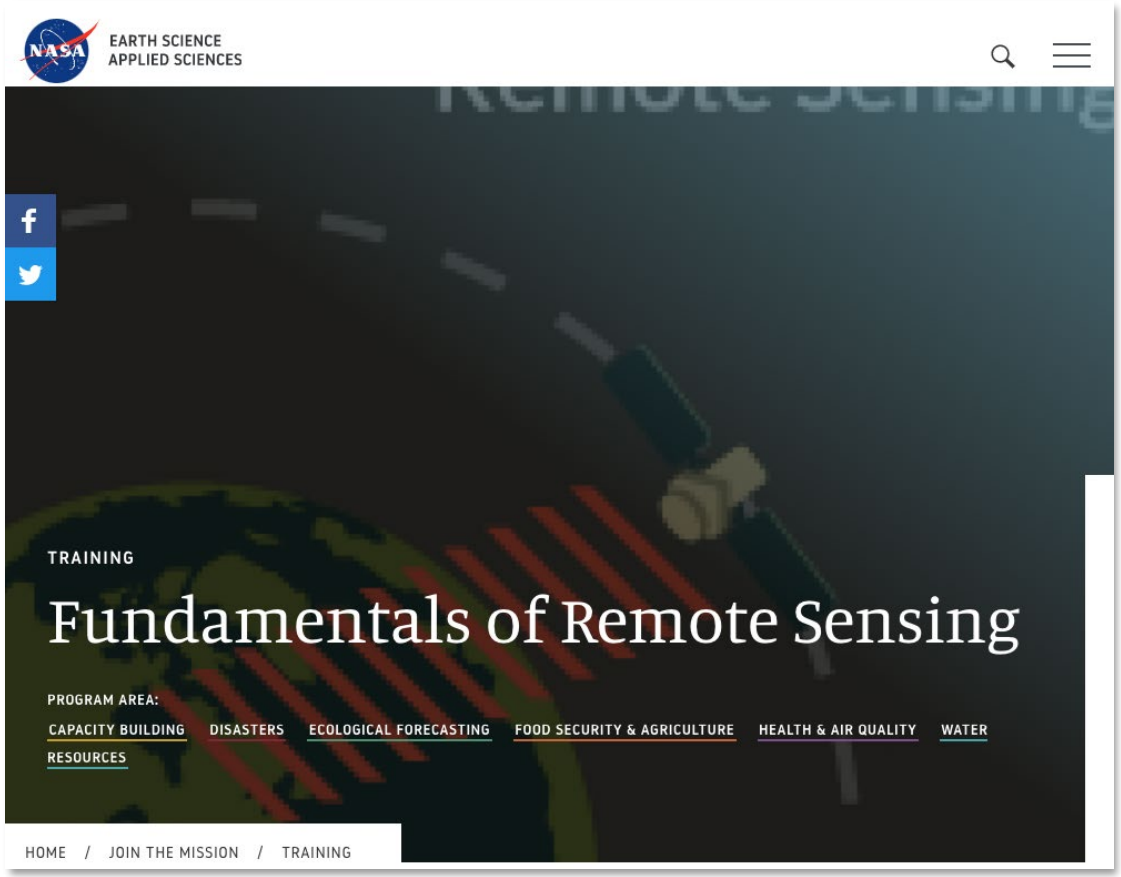
By the end of this training series, participants will be able to:

- Recognize commonly used spectral indices in land and aquatic environments
- Distinguish between spectral indices to select those best suited for a given land or aquatic system of interest
- Compute spectral index calculations over appropriate areas of interest
- Acquire spectral index products from a variety of sources



Prerequisites

- Fundamentals of Remote Sensing
  - or equivalent experience



Part 2 – Trainers

Britnay Beaudry

Instructor

Ecological Conservation

Amber Jean McCullum

Ecological Conservation Team Lead

Juan Torres-Pérez

Instructor

Ecological Conservation

Sativa Cruz

Instructor

Ecological Conservation

Training Outline

Part 1

Overview of Spectral Indices

October 26, 2023

11am-12pm OR
3pm-4pm ET

Part 2

Spectral Indices for Aquatic Applications

November 2, 2023

11am-12pm OR
3pm-4pm ET

Part 3

Spectral Indices for Land Applications

November 9, 2023

**11am-12pm OR
3pm-4pm ET**

Homework

Opens November 9 – Due November 23 – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.

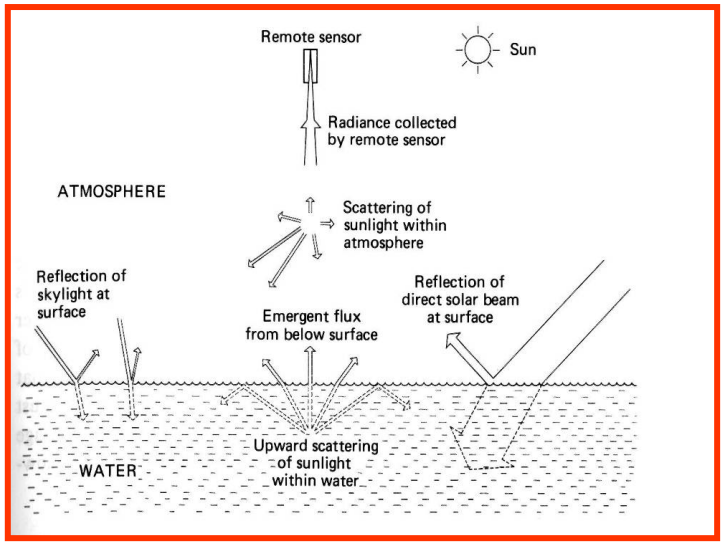
Part 3 Objectives

By the end of Part 3, participants will be able to:

- Recall main concepts and determine applications of:
  - Enhanced Vegetation Index (EVI)
  - Soil-Adjusted Vegetation Index (SAVI)
  - Normalized Burn Ratio (NBR)
- Calculate EVI, SAVI, and NBR over regions of interest in GEE
- Discuss NASA DEVELOP use cases for land indices

Review of Prior Knowledge

- Spectral indices are simple band ratios that highlight a specific process or property on the land or aquatic surface.
- The Normalized Difference Vegetation Index (NDVI) is one of the most used indices for analyzing vegetation health.
- Remote sensing reflectance is the fundamental remote sensing quantity from which most ocean color products are derived (for example chlorophyll, particulate inorganic carbon, light absorption by CDOM, suspended sediments, etc.)



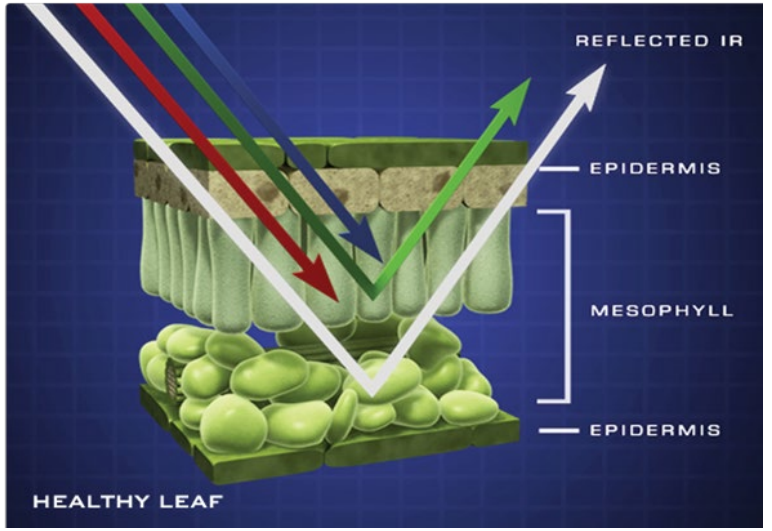
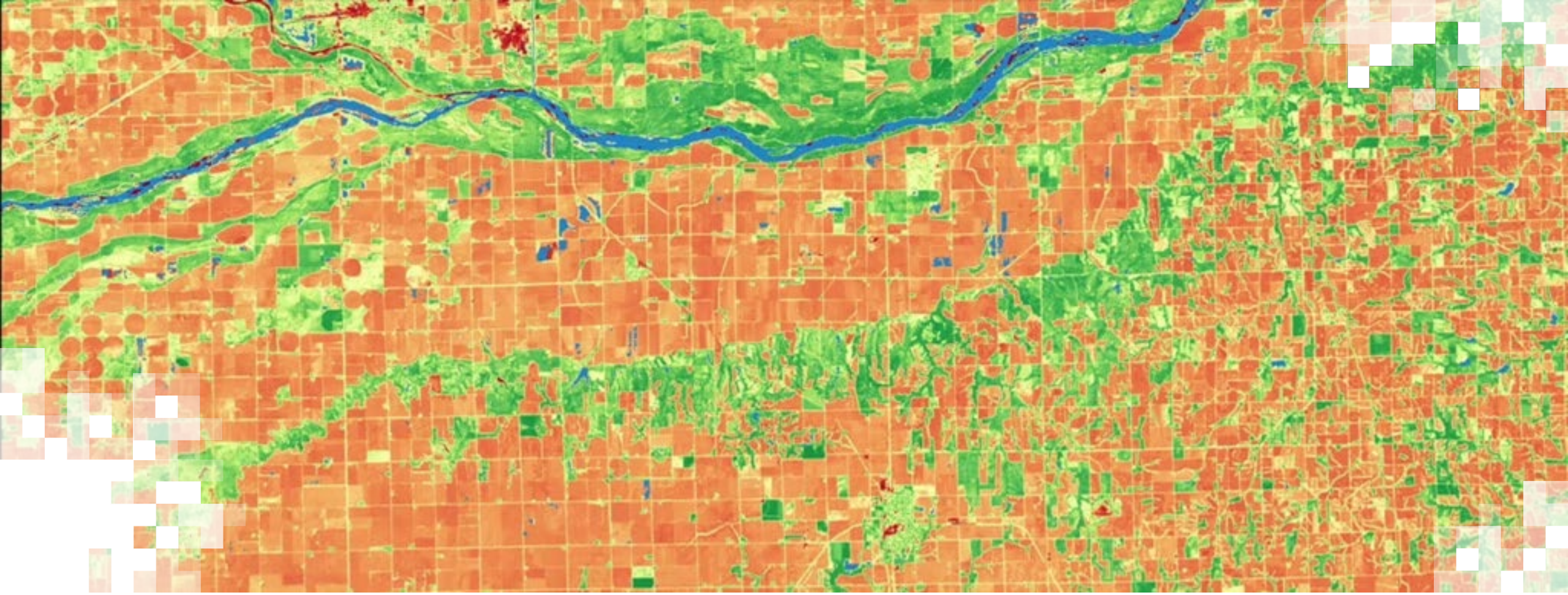


Image Credits: NASA/Jeff Carns & Ginger Butcher

How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all of the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.

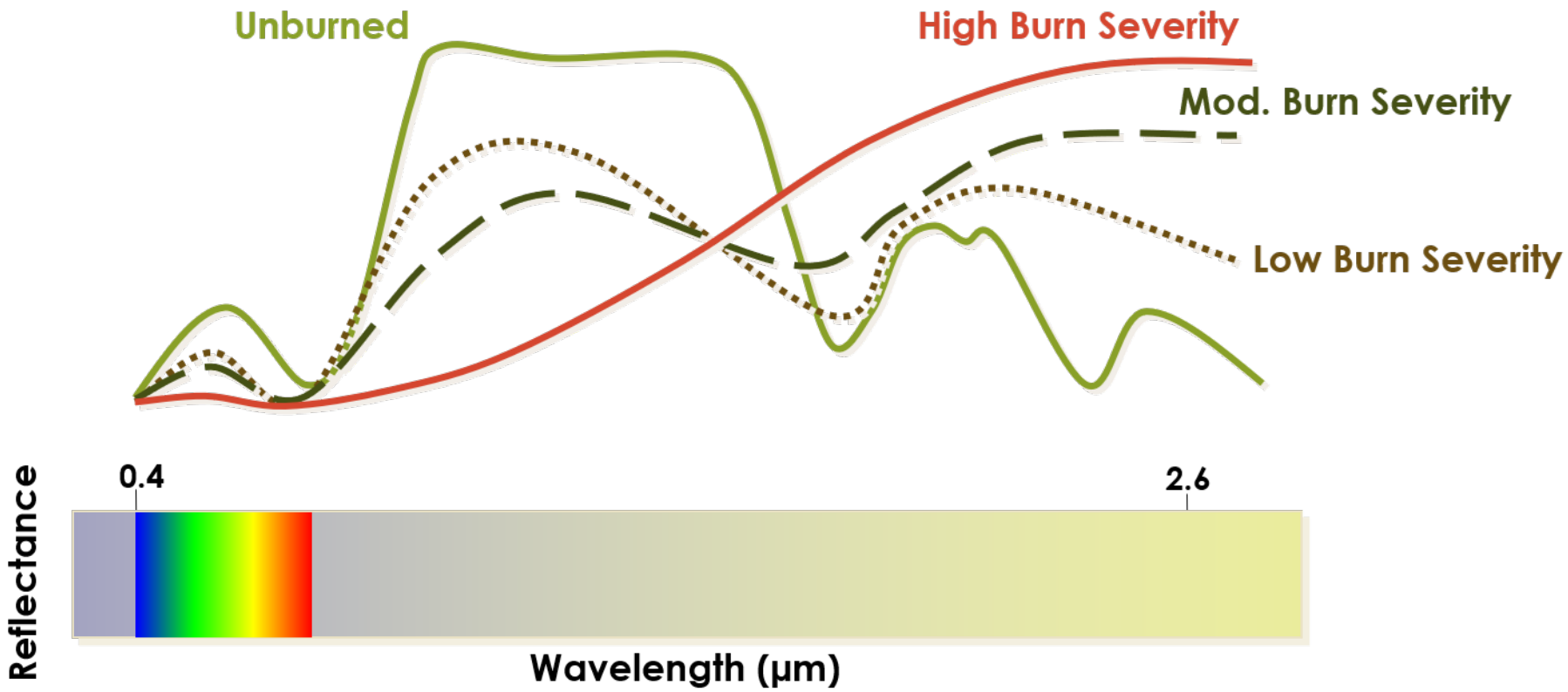


Part 1:

Normalized Burn Ratio (NBR)

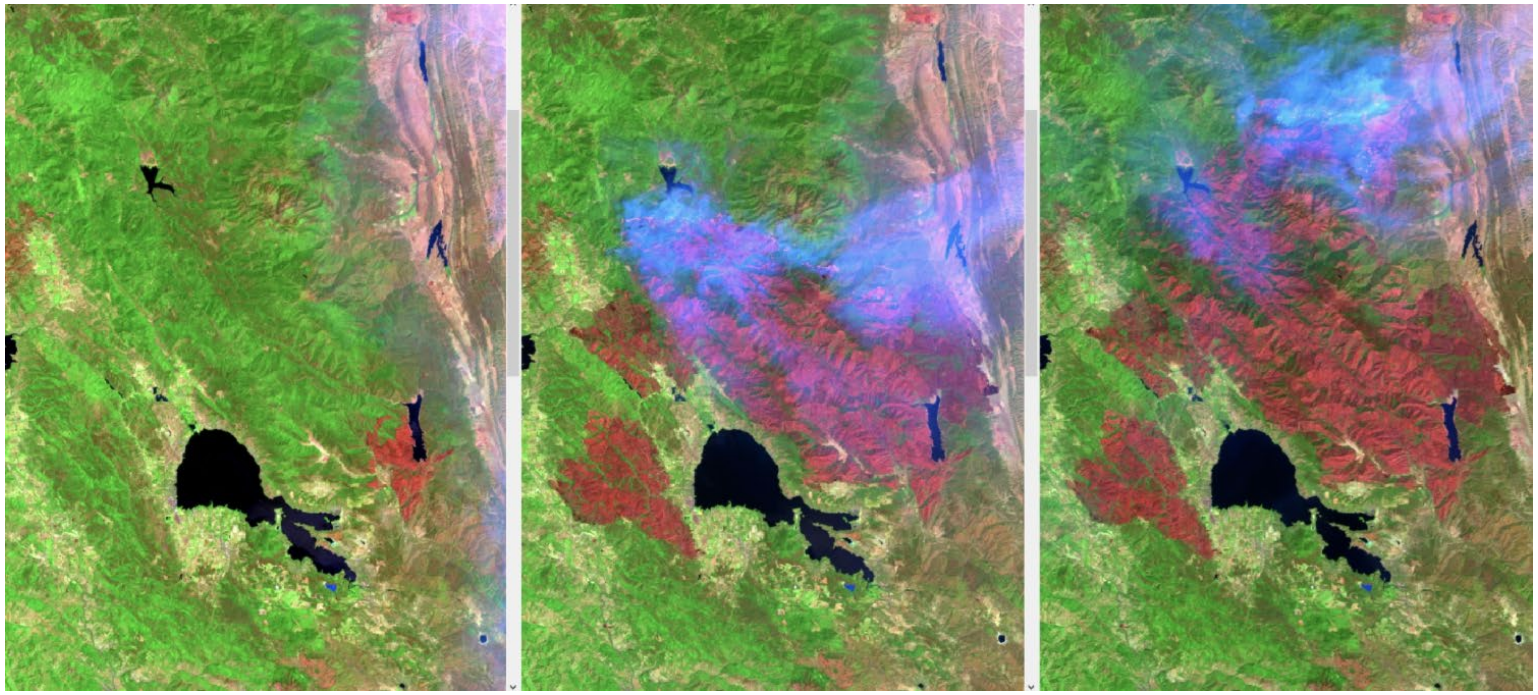
Healthy Vegetation vs. Burned Areas

Exploiting Spectral Response Curves



Burned Area: Normalized Burn Ratio (NBR)

- Used to identify burned areas
- Compare pre- and post-burn to identify burn extent and severity



July 26 Aug 11 Aug 27

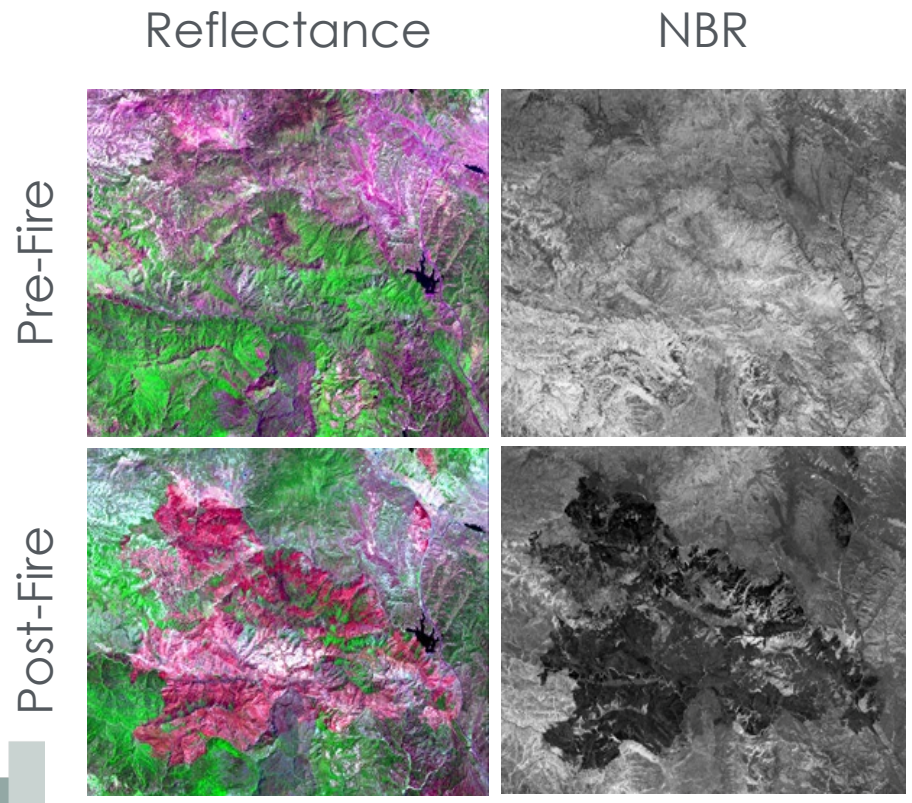
Mendocino Complex Fires, 2018

$$NBR = \frac{(NIR - SWIR)}{NIR + SWIR}$$

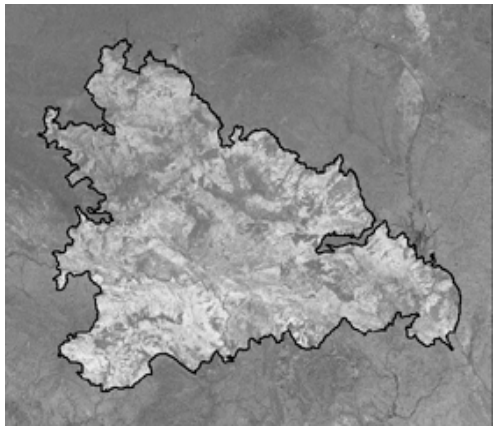
Burn Severity: Differenced Normalized Burn Ratio (dNBR)

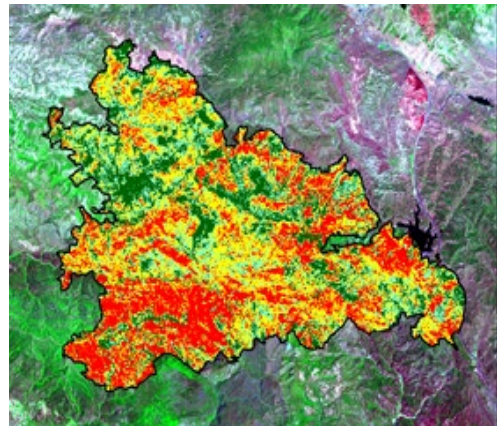
- **Normalized Burn Ratio (NBR)**
- Establishes extent of burned area before and after fire event

- **Differenced Normalized Burn Ratio (dNBR)**
- Provides a comparison of pre- and post-fire conditions to determine severity
- dNBR = Pre-Fire NBR – Post-Fire NBR



Difference



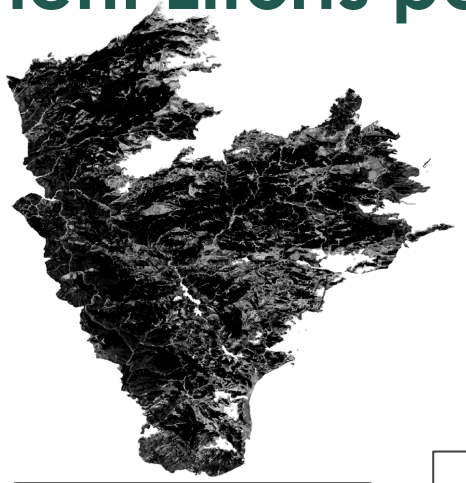


Monitoring Cheatgrass in Southern Wyoming and Northern Colorado to Inform Management Efforts post Mullen Fire

Pre-fire (2020) RGB

Normalized Burn Ratio (NBR)

$$\frac{NIR - SWIR}{NIR + SWIR}$$



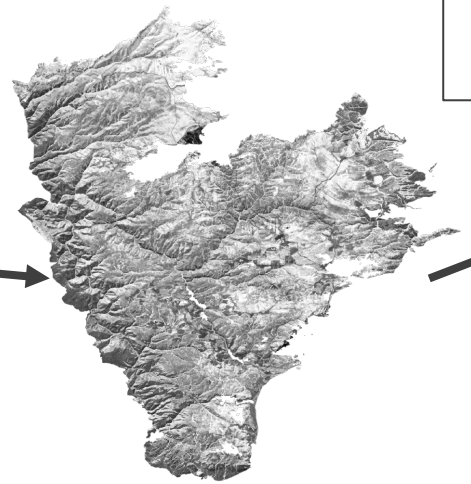
Pre-Fire NBR

Burn Severity Mapping

Difference Normalized Burn Ratio (dNBR)
Pre NBR – Post NBR

dNBR

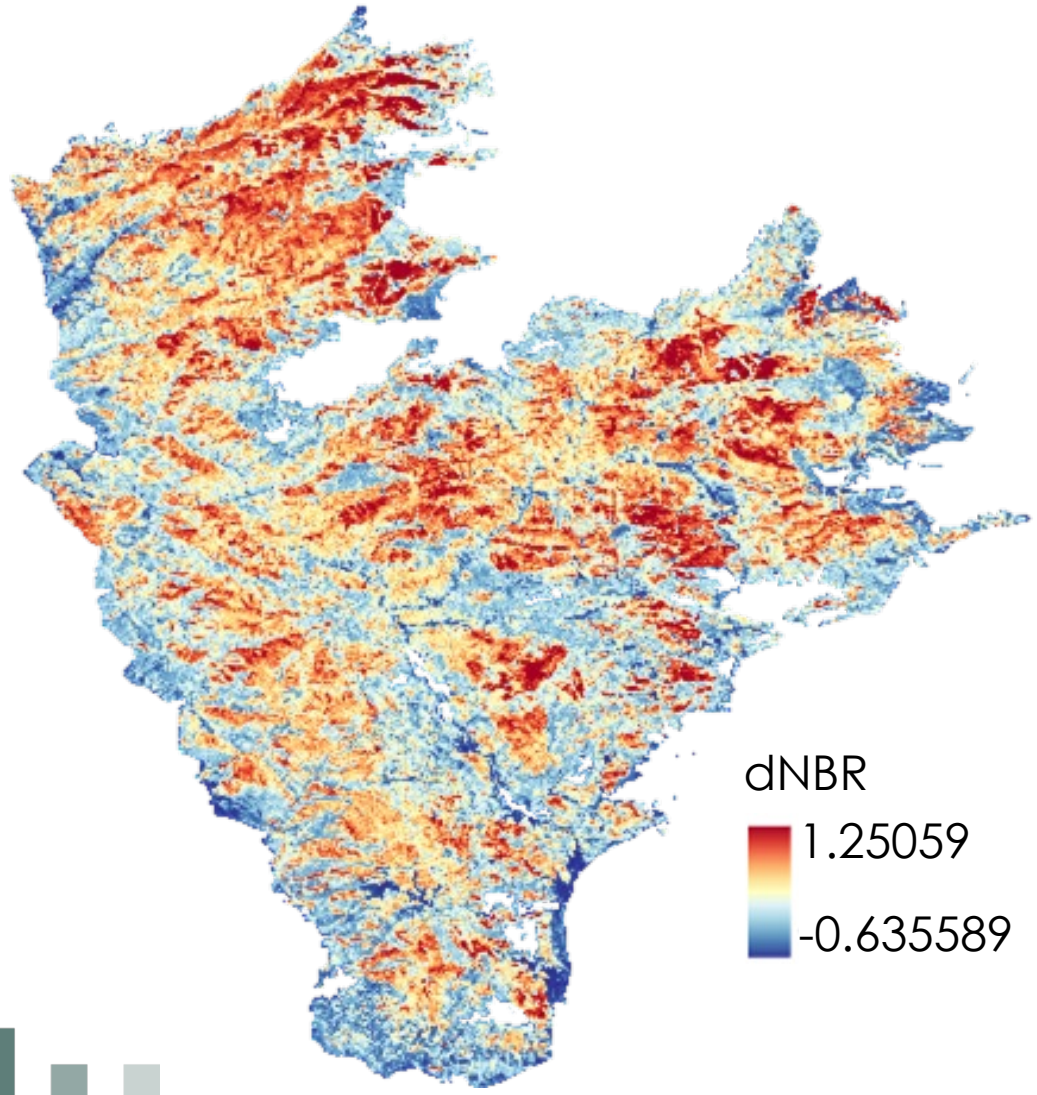
Post-fire (2021) RGB

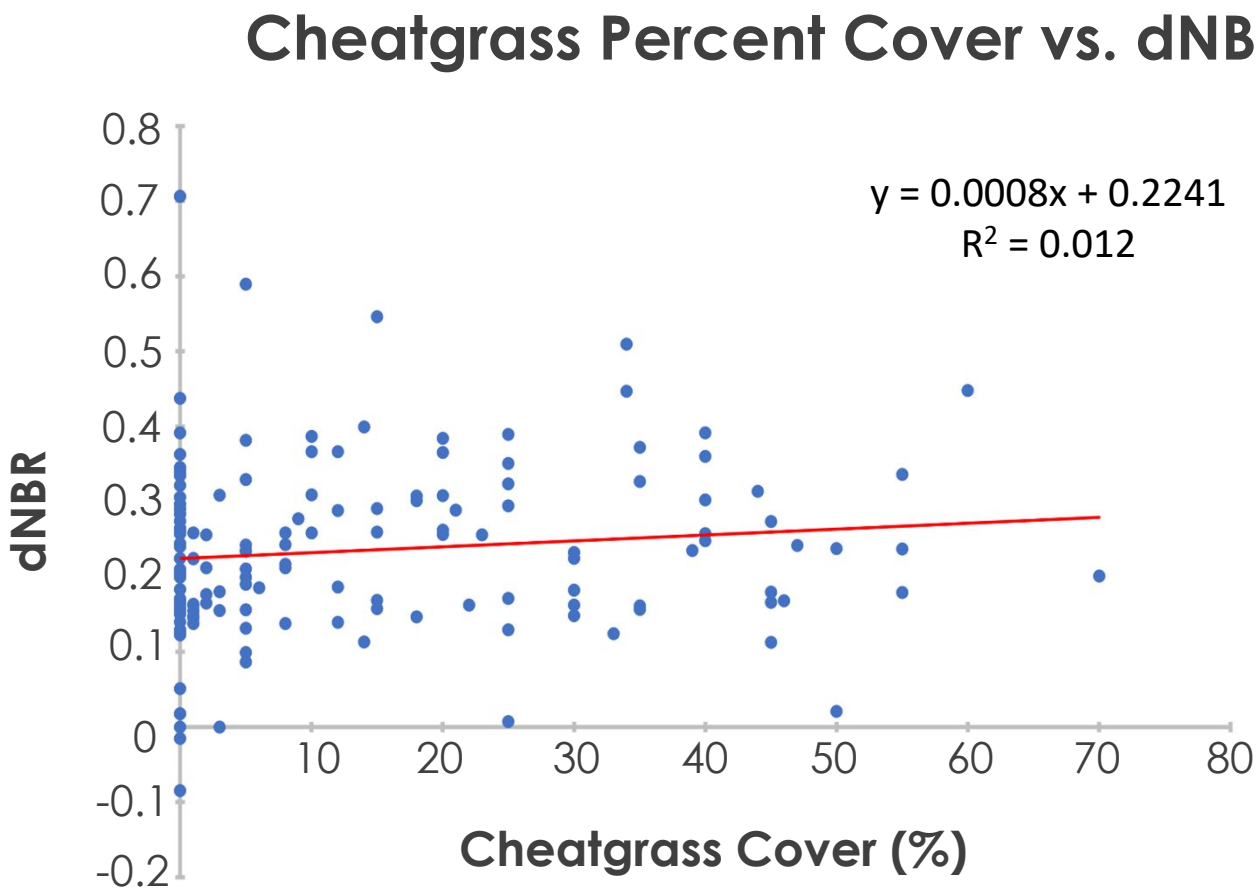


Post-Fire NBR

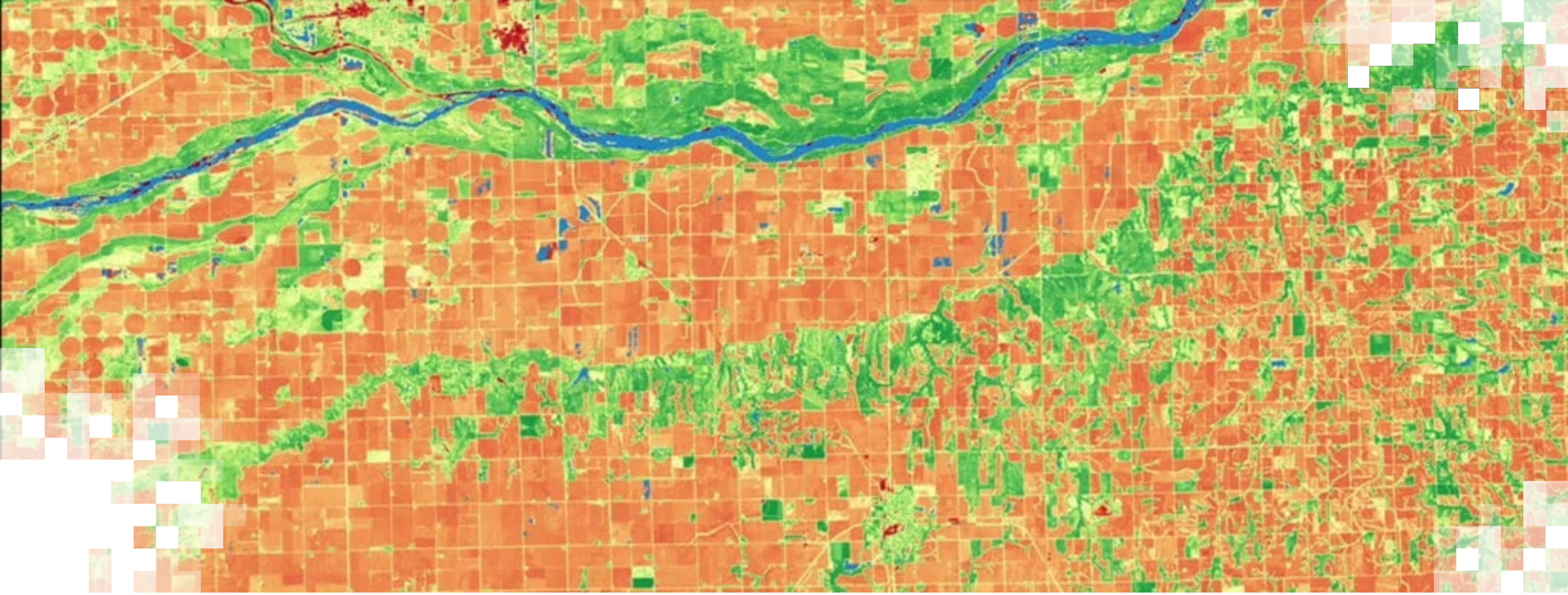
Credit: NASA DEVELOP Colorado Fall 2021
Southern Wyoming Ecological Forecasting

Monitoring Cheatgrass in Southern Wyoming and Northern Colorado to Inform Management Efforts post Mullen Fire





Credit: NASA DEVELOP Colorado Fall 2021
Southern Wyoming Ecological Forecasting



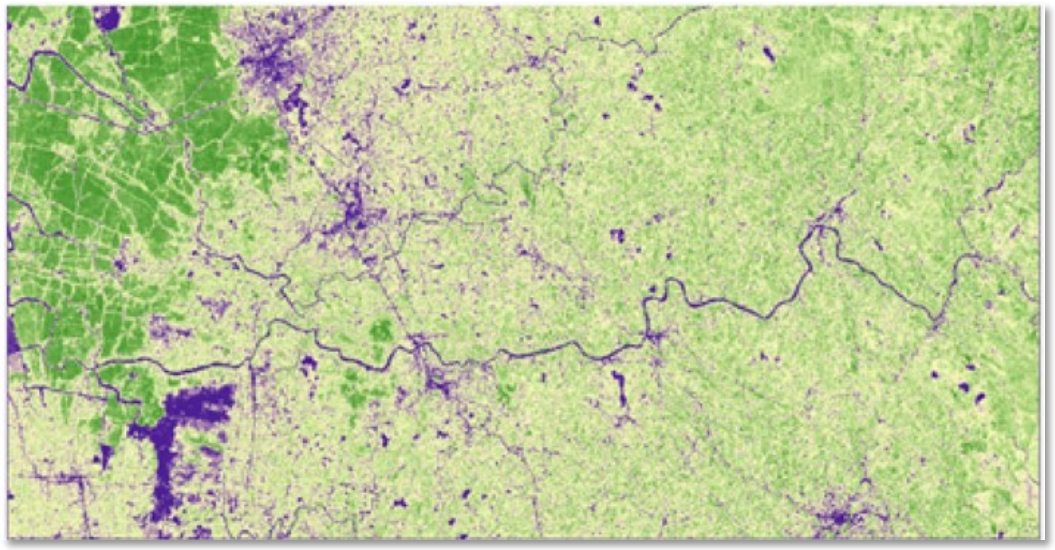
Part 2:

Soil Adjusted Vegetation Index (SAVI)

Soil Adjusted Vegetation Index (SAVI)

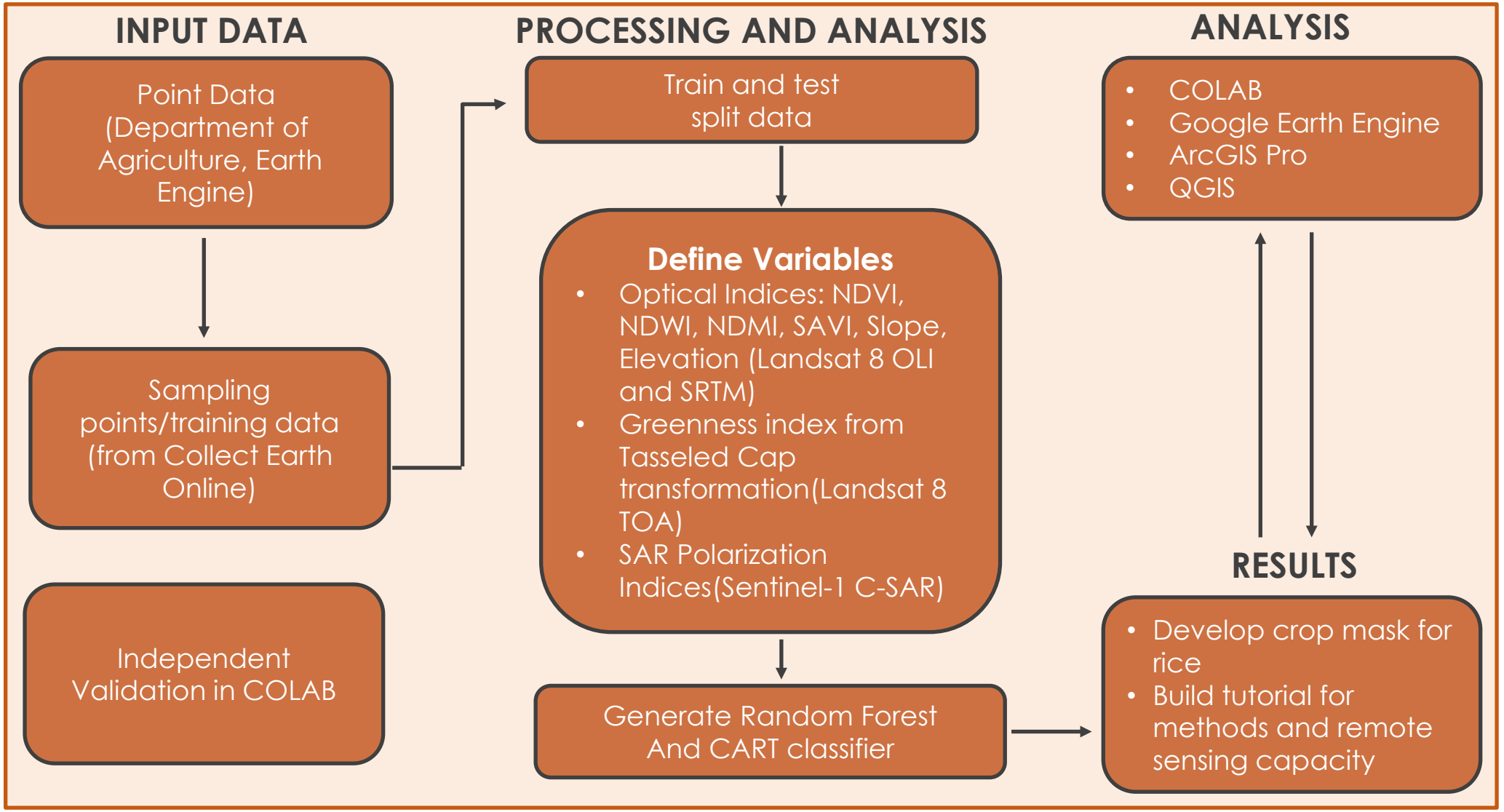
- Minimizes the influence of soil brightness
- Useful in areas with greater soil cover
  - Contains a soil brightness correction factor (L)
    - 0.5 typically used
    - Lower for areas with greater canopy cover
    - Higher for areas with less canopy cover

$$SAVI = \left(\frac{(NIR - R)}{(NIR + R + L)} \right) \times (1 + L)$$



SAVI: Image Credit: Grind GIS

Developing a Crop Mask for Rice and Creating a Data Collection Protocol Utilizing Remotely Sensed Data in Bhutan



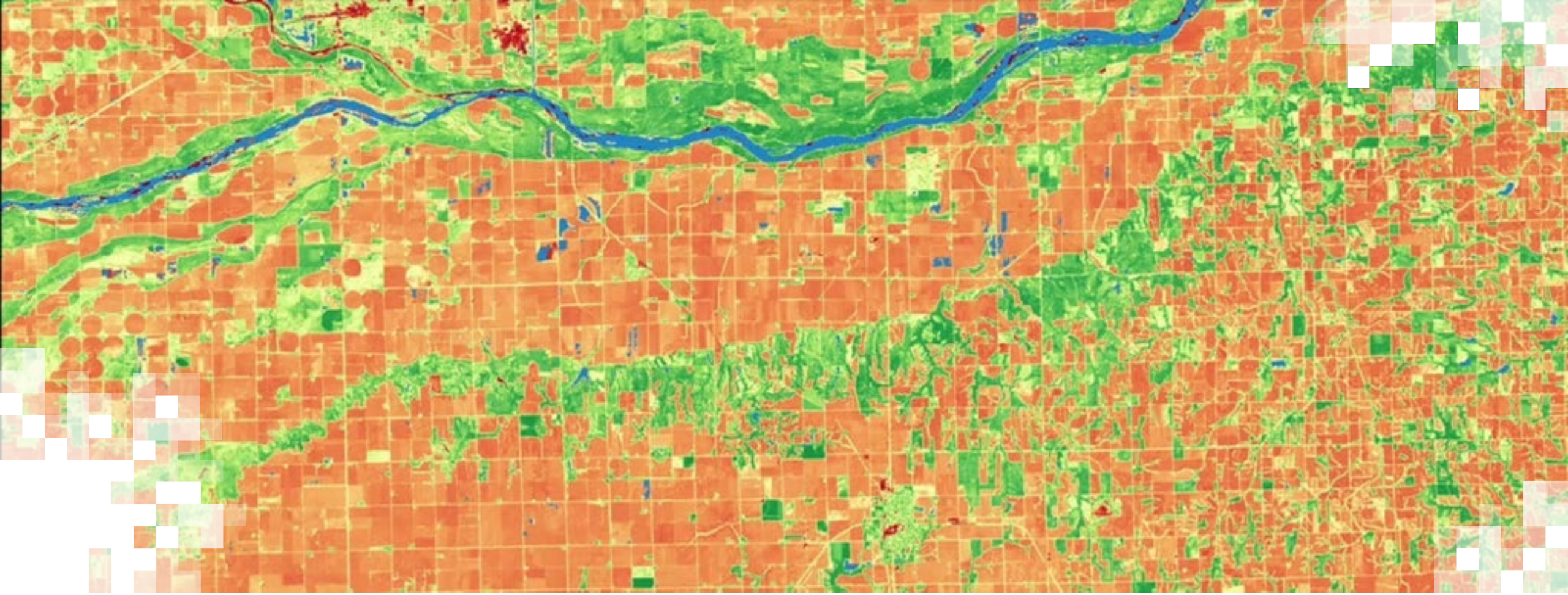
Credit: NASA DEVELOP MSFC Fall 2021 Bhutan Agriculture

Developing a Crop Mask for Rice and Creating a Data Collection Protocol Utilizing Remotely Sensed Data in Bhutan

- Developed crop mask for rice using the random forest classifier.
- As compared to the CART model, the random forest model proved to be more precise and accurate.
- Various indices were given equal importance in RF model
- The RF model was 91.8 % accurate.

Credit: NASA DEVELOP MSFC Fall 2021
Bhutan Agriculture

Credit: Nidup Dorji/DOA



Part 3:

Enhanced Vegetation Index (EVI)

Enhanced Vegetation Index (EVI)

- Can be used in place of NDVI to examine vegetation greenness
  - More sensitive in areas with dense vegetation
- Adjusts for canopy background and some atmospheric conditions

$$EVI = G * \left(\frac{(NIR - R)}{(NIR + C1 * R - C2 * B + L)} \right)$$

Constants

$G = 2.5$

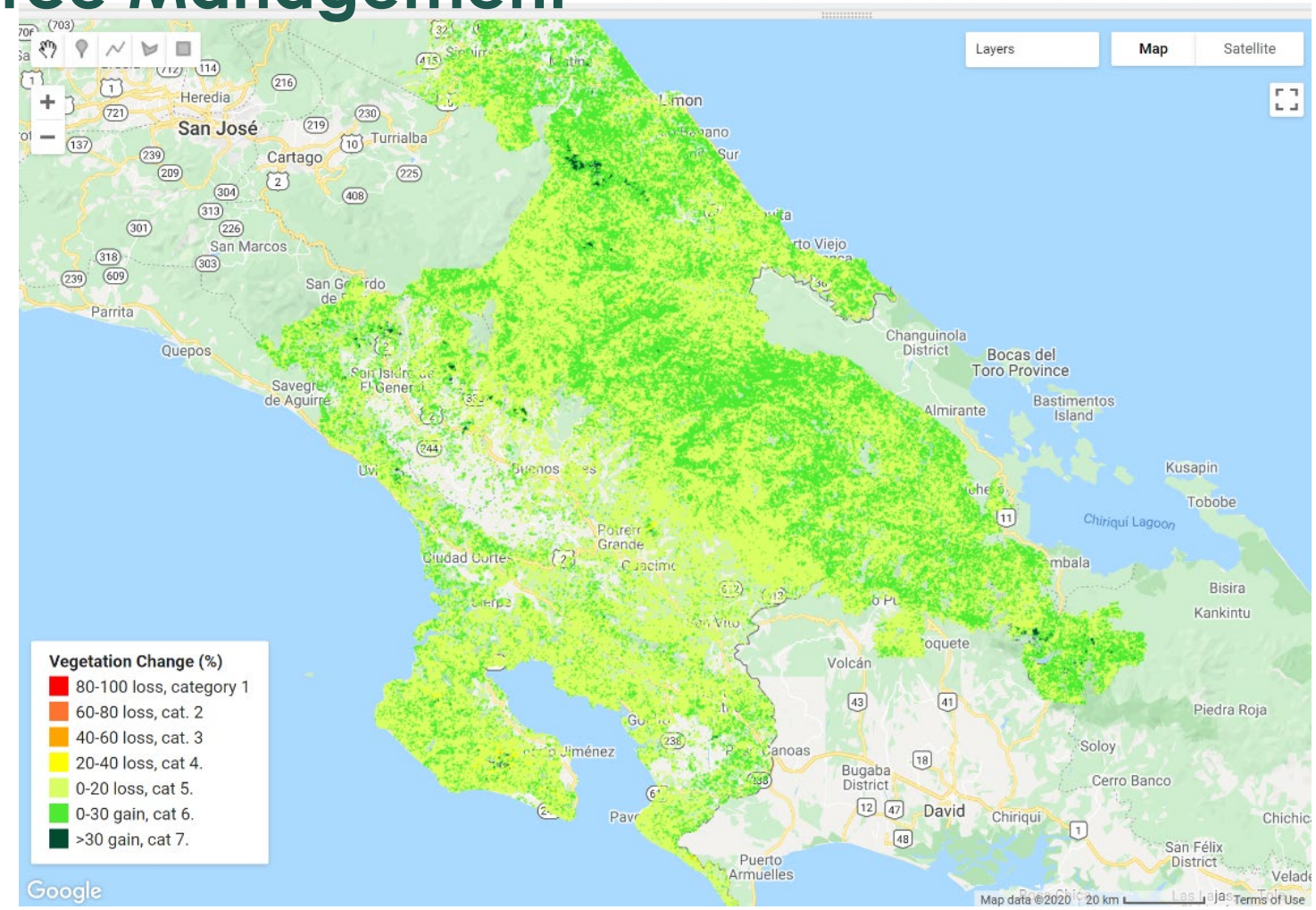
$C1 = 6$

$C2 = 7.5$

$L = 1$

- Does not saturate over high biomass regions
- L= Adjustment for canopy background
- C= Atmospheric adjustment
- Use of the blue band

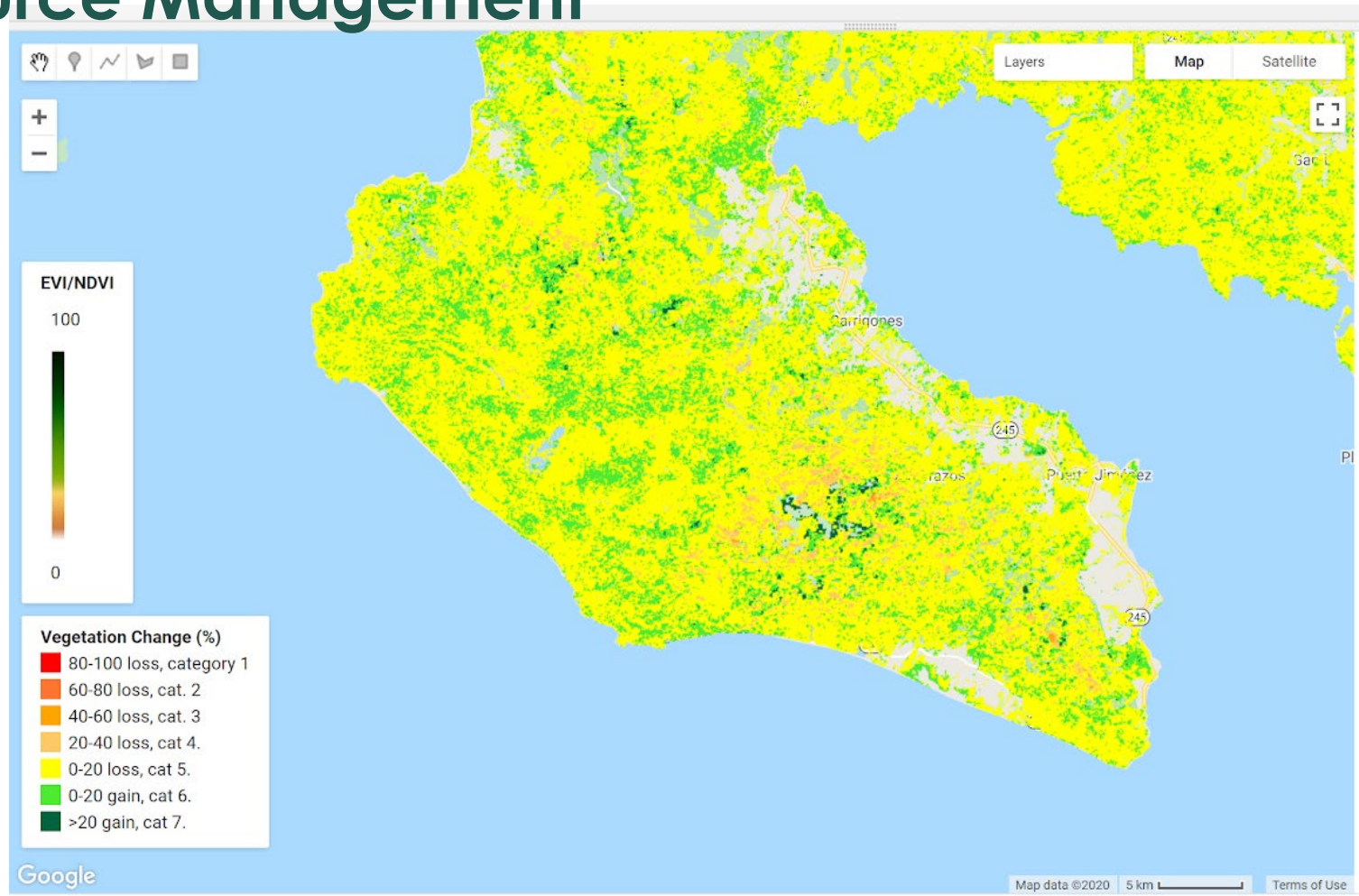
COSTA RICA & PANAMA: Identifying Current and Future Areas of Environmental Concern in La Amistad International Park to Inform Resource Management



Forest change from 01/01/2015 1 to 12/31/2018 in the study area

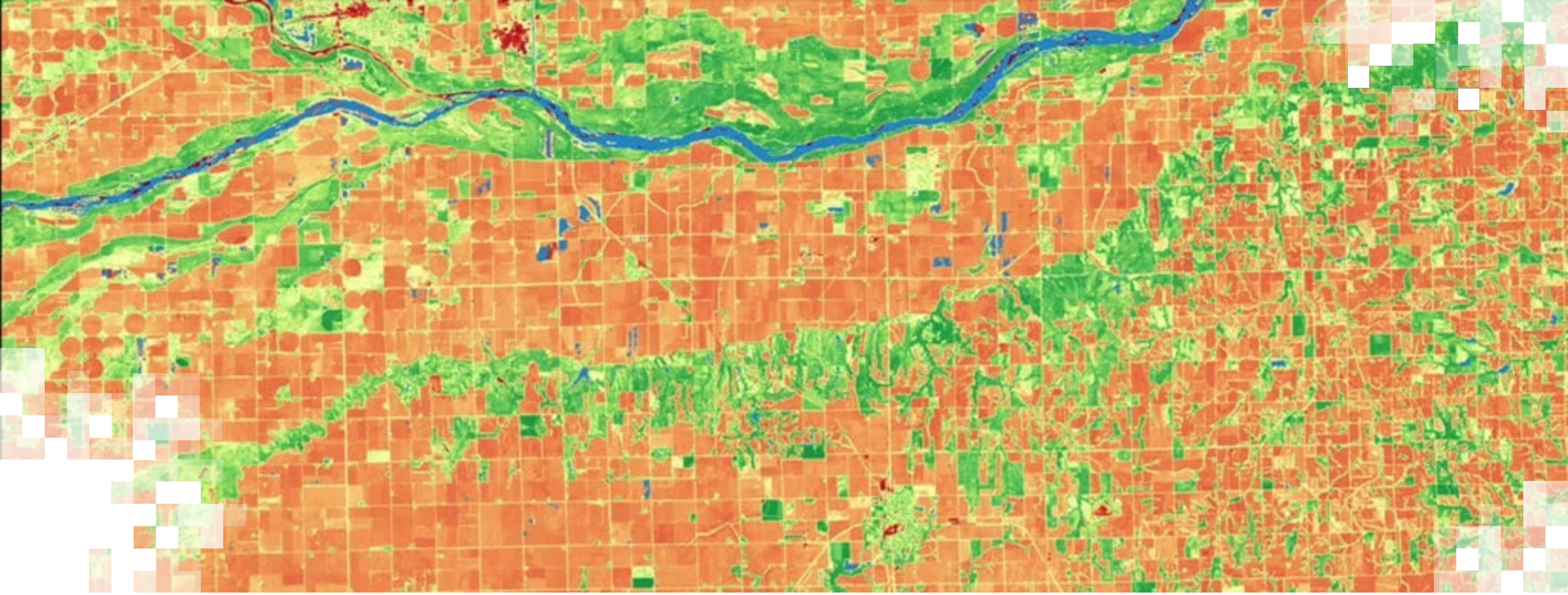
Credit: NASA DEVELOP Georgia Spring 2020
Costa Rica & Panama Ecological Forecasting II

COSTA RICA & PANAMA: Identifying Current and Future Areas of Environmental Concern in La Amistad International Park to Inform Resource Management



Forest change from 01/01/2016 to 12/31/2017 in Southern Costa Rica

Credit: NASA DEVELOP Georgia Spring 2020
Costa Rica & Panama Ecological Forecasting II



Part 4:

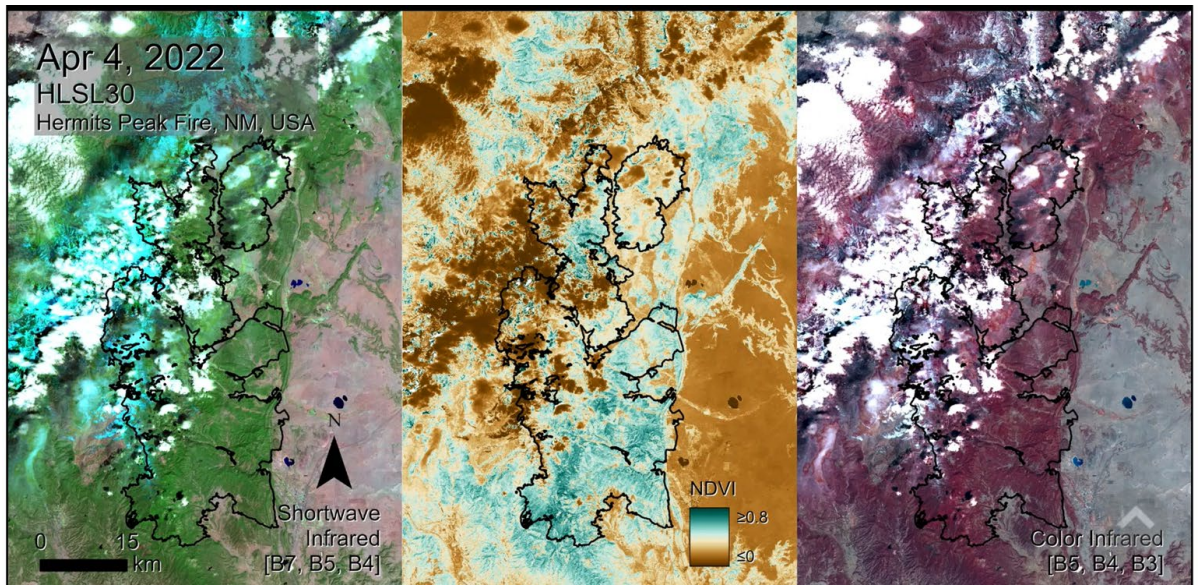
Harmonized Landsat Sentinel (HLS)

Satellite Needs Working Group (SNWG)

- Conducts biennial survey to document Earth Observing needs to NASA and other agencies
- Identified needs and new data products:
  - Harmonization of data sets from Landsat and Sentinel-2 (operational)
  - Multi-satellite products for surface water extent, surface disturbance/change detection, and surface deformation (in development)
  - ICESat-2 Quick Look products (operational)
  - Enhanced downlink bandwidth for the NISAR mission (in development)
  - Expanded access for Federal agencies to commercial data purchased and evaluated by NASA (operational)

SNWG Indices to be Produced

1. Normalized Difference Vegetation Index (NDVI)
2. Enhanced Vegetation Index (EVI)
3. Soil Adjusted Vegetation Index (SAVI)
4. Modified Soil Adjusted Vegetation Index (MSAVI)
5. Normalized Difference Moisture Index (NDMI) ← *added per stakeholder request*
6. Normalized Difference Water Index (NDWI)
7. Normalized Burn Ratio (NBR)
8. Normalized Burn Ratio 2 (NBR2)
9. Triangular Vegetation Index (TVI)



Harmonized Landsat Sentinel-2 (HLS) for the 2022 Hermits Peak Fire in U.S. Forest Service Santa Fe National Forest.

Harmonized Landsat Sentinel (HLS) Overview

What is "**harmonized**"?

- Constructing an algorithm using data from two similar sensors so products from each instrument can be used **interchangeably**.

HLS is an initiative to produce a virtual constellation of surface reflectance data from **Landsat 8/9** (L8/L9) OLI and **Sentinel-2** (S2) MSI.

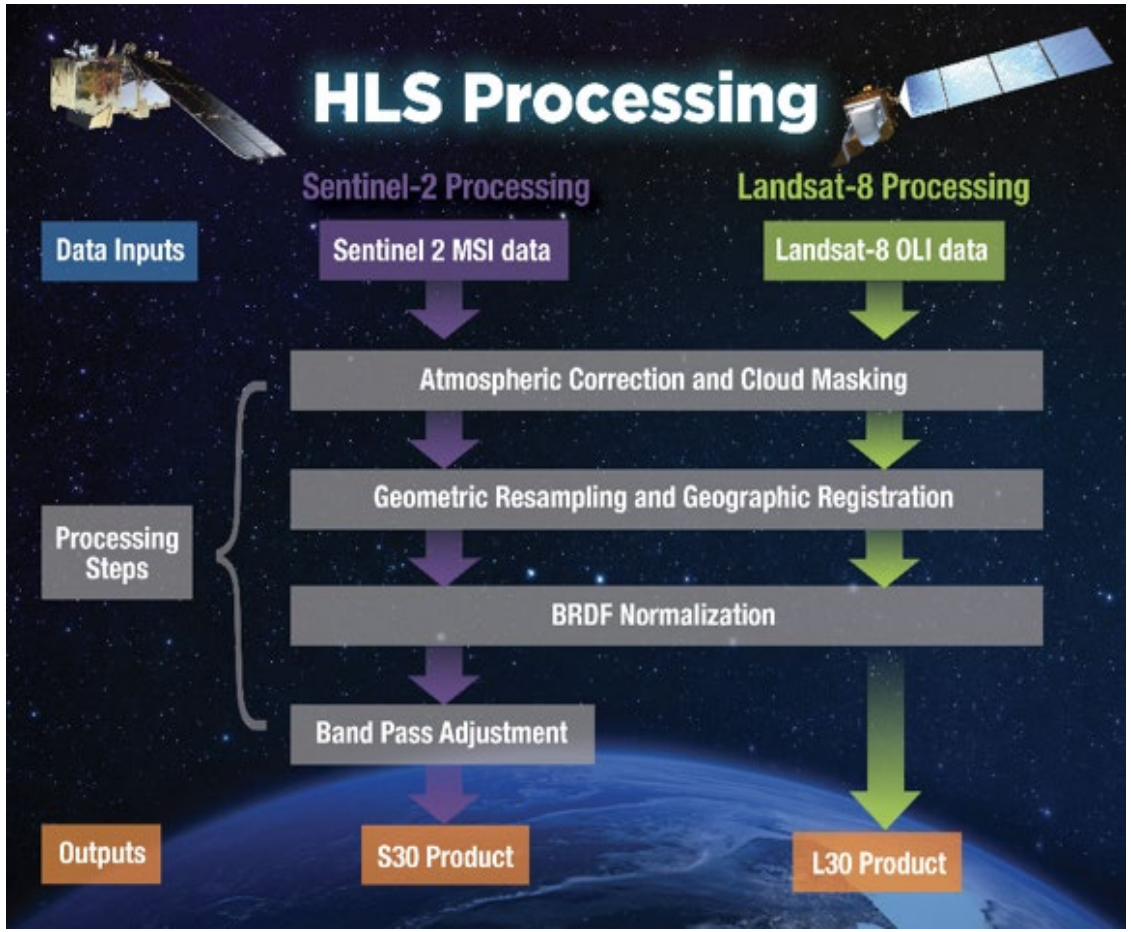
- This is possible due to spectral similarities between L8, L9 and S2.

Sentinel-2 photo credit: ESA

Landsat 8 photo credit: NASA

HLS Overview

- Merge Sentinel-2 and Landsat data streams to provide **2-4 day global coverage**.
- Goal is "seamless" near-daily **30-meter surface reflectance product** including atmospheric corrections, spectral and BRDF adjustments, regridding.
- Harmonize and process past Landsat and Sentinel-2 data. Create an archive and make it accessible to users.
- Project initiated as collaboration among NASA Goddard Space Flight Center (GSFC), University of Maryland (UMD), NASA Ames.



HLS – Who's Involved

NASA Goddard Space Flight Center

Provides overall scientific guidance and documentation for HLS algorithm, ensures data quality, and provides direction for algorithm improvements

IMPACT HLS

1. Produces full archive of S30/L30 data products.

2. Ensures products are discoverable in common metadata repository and the Earthdata Search client.

3. Stages HLS imagery for consumption into the Global Imagery Browse Service.

Land Processes Distributed Active Archive Center (LP DAAC)

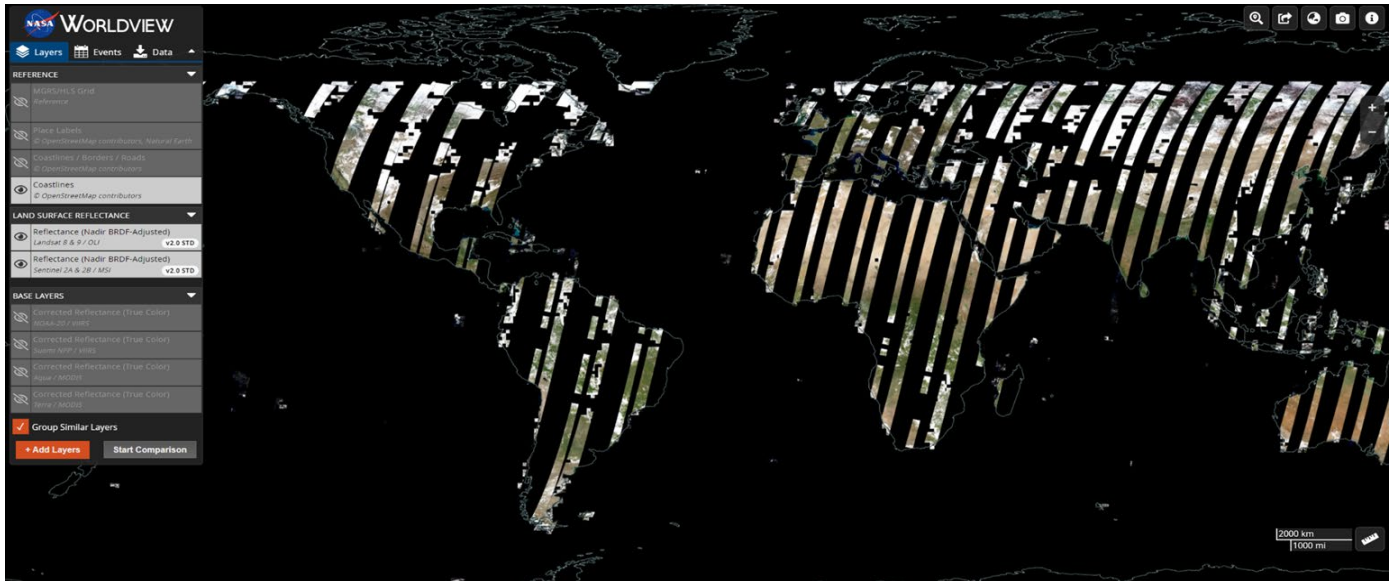
Ingests, archives, and distributes HLS data to end users, with a full archive back-up.

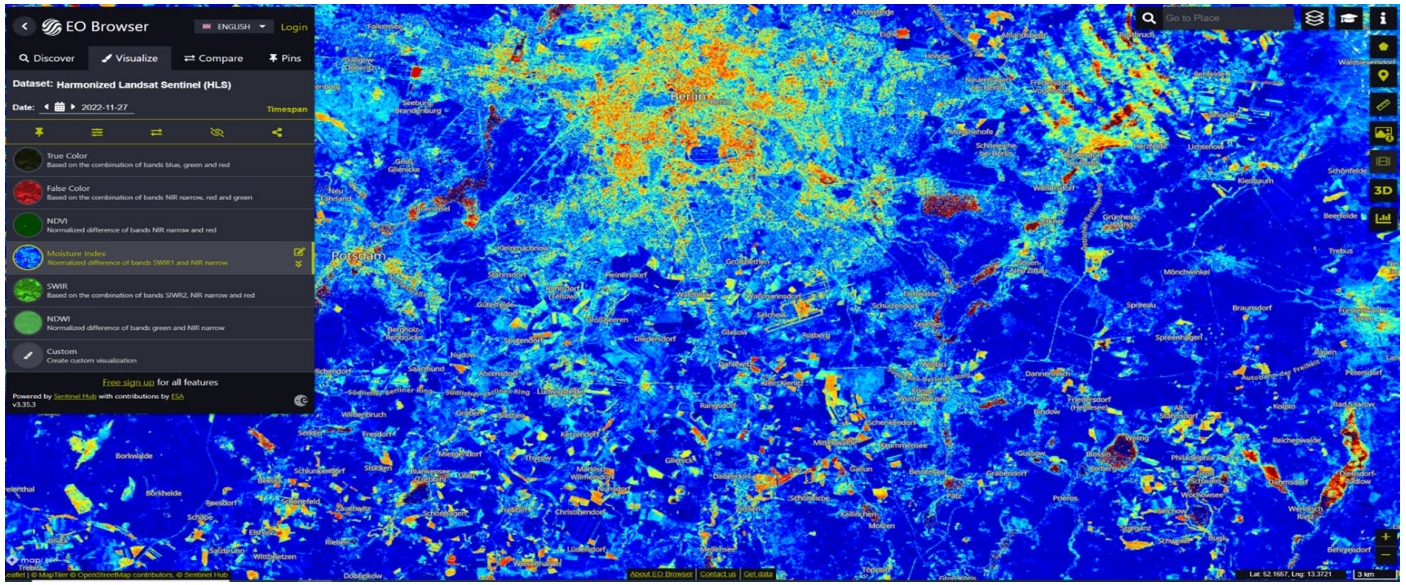
Satellite Needs Working Group Management Office (SNWG MO)

Manages stakeholder engagement, budgets, resources, and administration of HLS.

HLS Resources

[Preview HLS Data on NASA WorldView]



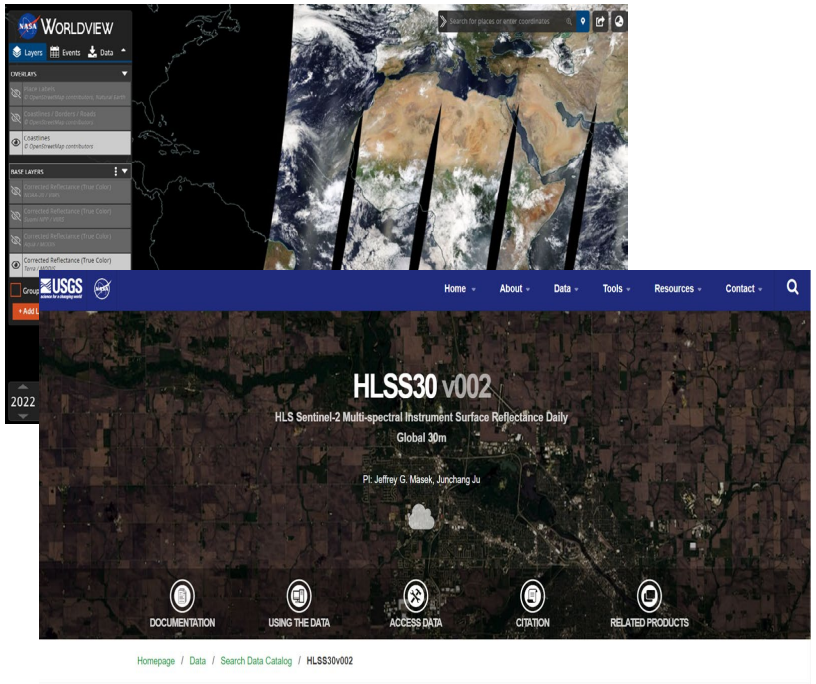


[Experiment with Different Bands in EO Browser]

HLS Resources Continued

Websites & Pages:

- HLS S30 Page
- HLS L30 Page
- NASA Worldview
- Earthdata Search
- HLS Earth Engine



Tools & Tutorials:

HLS SuPER-Script: Subset, pre-process and download HLS data directly from LP DAAC.

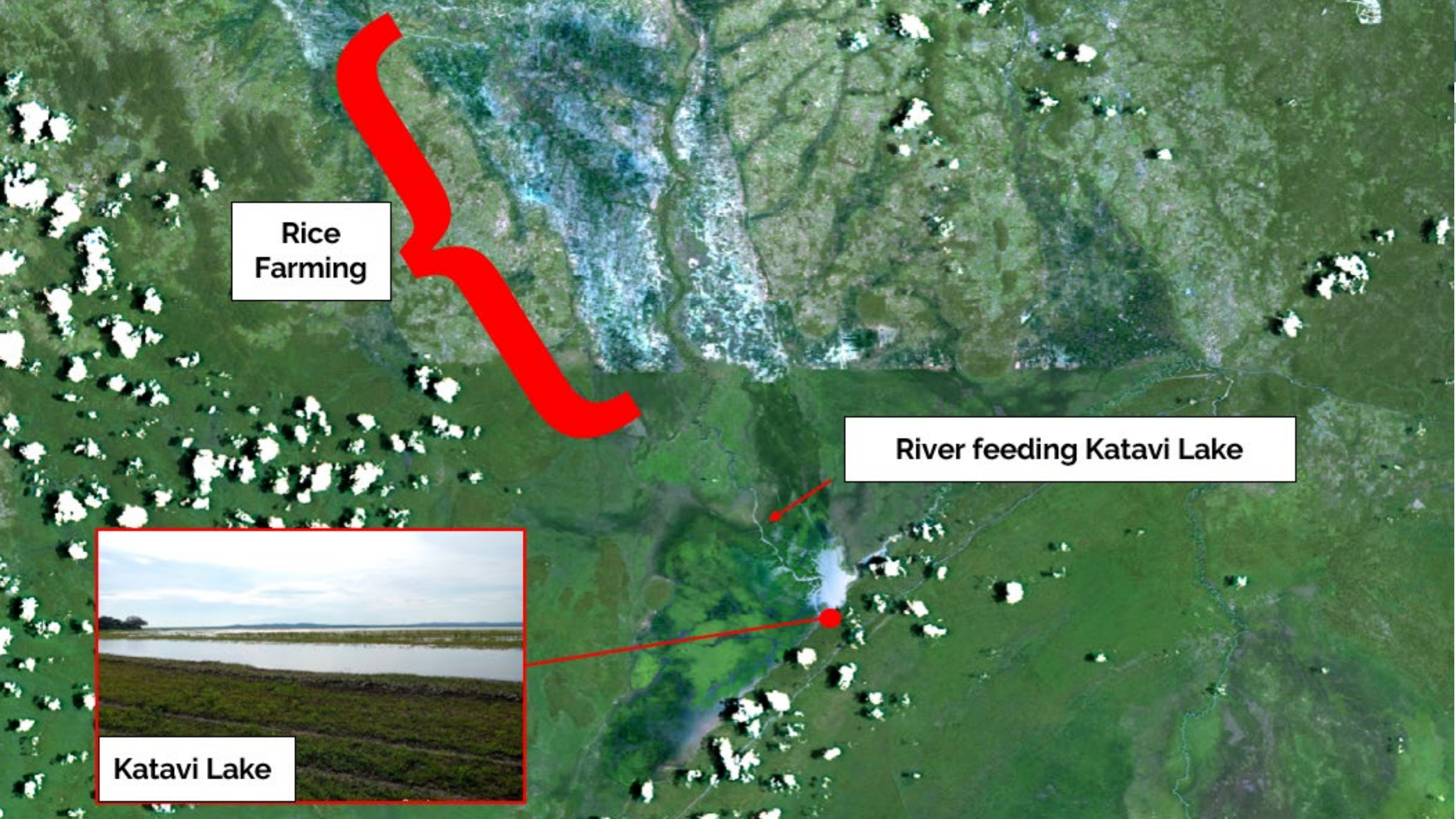
HLS Applications

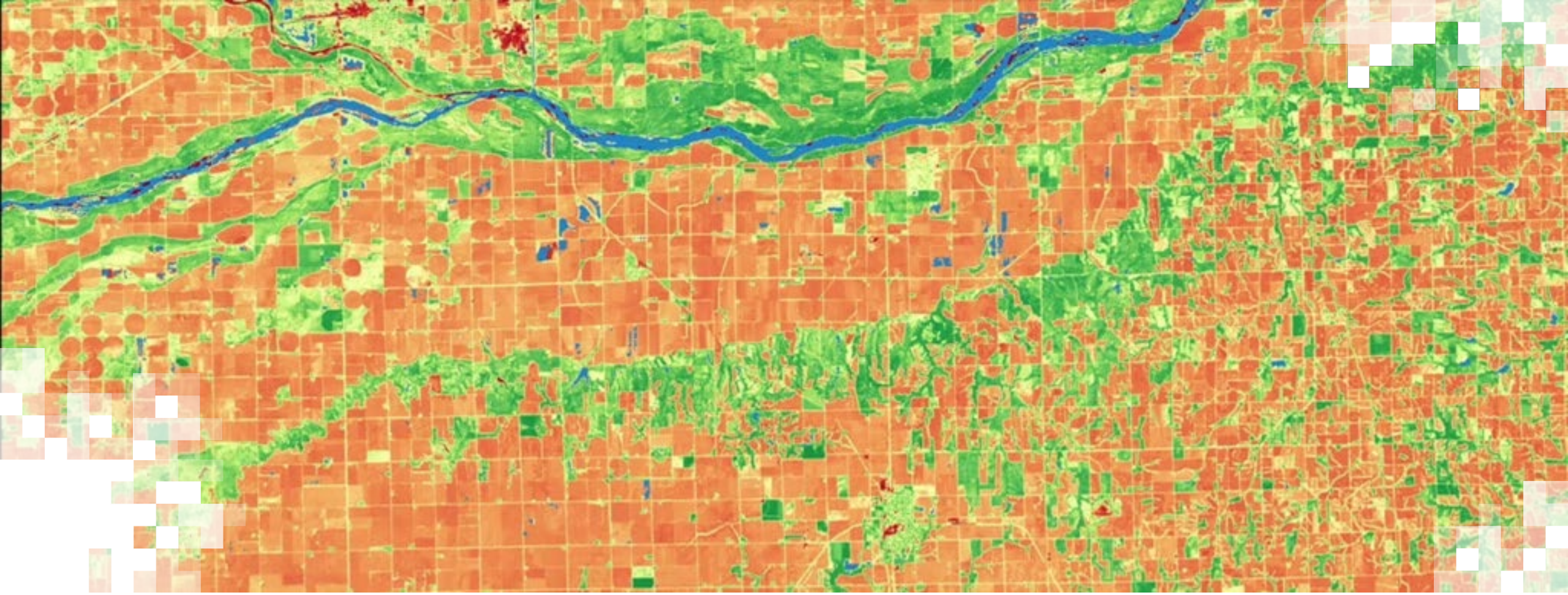
Agricultural Land-Use Change Impacting the Katavi National Park in Ikuu, Tanzania

BBC reporter Virginia (Gini) Close reached out to the HLS production team for imagery showing the impacts of rice farming on Katavi Lake, a hippo habitat in a remote region of Tanzania. This imagery will likely be used in a Planet Earth-style documentary slated for release in 2025.

Algorithmic Assessment of Cloud/Water Detection using Lake Abert Dam, Ontario

The HLS production team gets frequent questions as to the statistical accuracy of our cloud and water detection algorithm over large bodies of water. We are collaborating with the Jet Propulsion Laboratory (JPL) and the United States Geological Survey (USGS) on evaluating these tools.

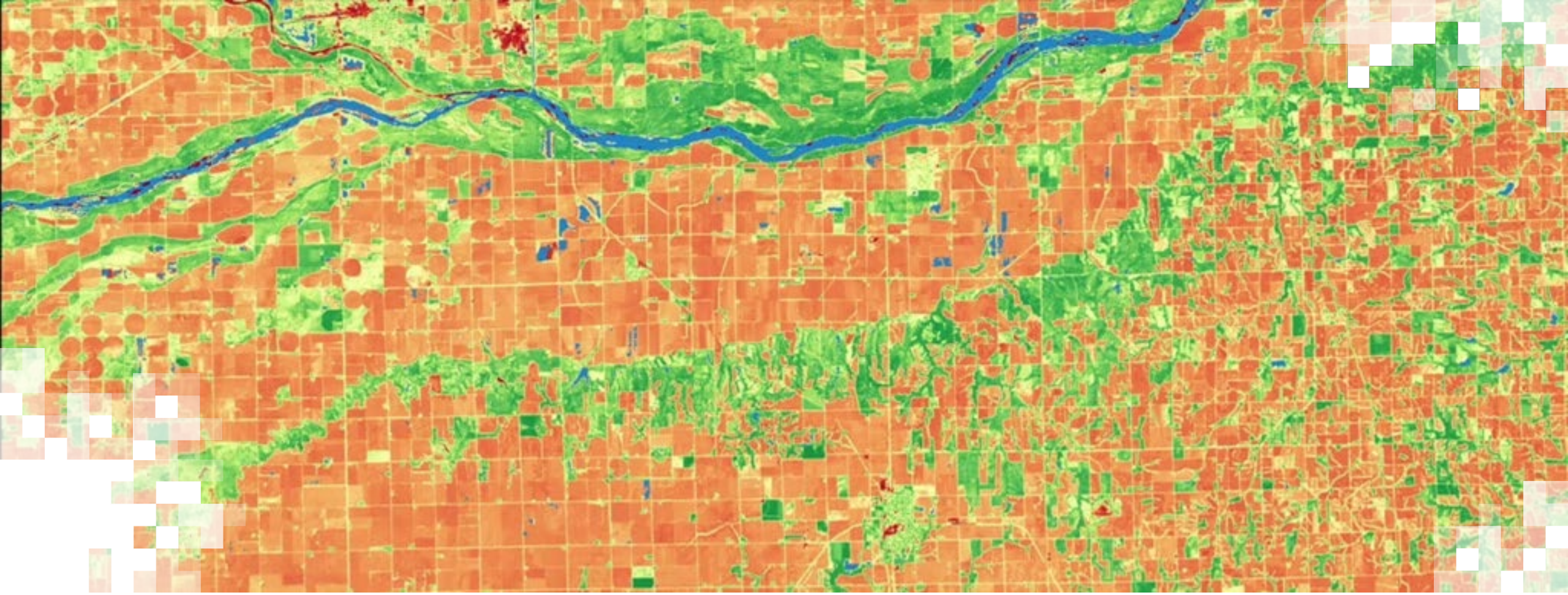

Rice Farming
River feeding Katavi Lake
Katavi Lake



Index Calculation in Google Earth Engine

CODE LINK:

https://code.earthengine.google.com/cf527405df03a3cfc4cb2e558a82bf95



Spectral Indices for Land and Aquatic Applications

Summary

Training Summary

- With multi-spectral imagery, individual bands in a band composite can be transformed to get certain features and patterns to stand out better. Simple ratios between the reflectance of the land surface can be used to highlight representations of ground objects.
- It's important to know the intended applications of a spectral index. Certain indices were created to analyze land areas (such as NDVI, EVI, SAVI, NBR, etc.) while other indices were created to analyze aquatic areas (such as NDTI, NDCI, FAI, AFAI, NDAVI, etc.)
- In addition to calculating indices by hand, there are also several indices products available from a variety of sources.

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 9/Nov/2023
  - Access from: Spectral Indices for Land and Aquatic Applications
  - Answers must be submitted via Google Forms
  - **Due by 23/Nov/2023**

- **Certificate of Completion:**
  - Attend all three live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

Acknowledgements

- **Pontus Olofsson**, Interagency Implementation and Advanced Concepts Team (IMPACT), NASA MSFC
- **Ryan Vandermeulen**, Office of Science and Technology, NOAA Fisheries
- **Lisa Tanh**, NASA DEVELOP ARC, Analytical Mechanics Associates

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- Sativa Cruz
  - sativa.cruz@nasa.gov

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Visit our Sister Programs:

- DEVELOP
- SERVIR

Resources

- NASA DEVELOP
- The Satellite Needs Working Group (SNWG)
- Harmonized Landsat and Sentinel-2 (HLS)
- Landsat Surface Reflectance-derived Spectral Indices
- The Ocean Biology Processing Group (OBPG) Algorithm Descriptions
- The Land Processes Distributed Active Archive Center (LP DAAC)


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!