



Visualizing Land Cover and Land Use Change with NASA Satellite Imagery

Part 1: Classification Methods for Land Cover

Justin Fain (NASA/BAERI)

February 24-26, 2026





About ARSET



About ARSET

- ARSET provides accessible, relevant, and cost-free training on remote sensing satellites, sensors, methods, and tools.
- Trainings include a variety of applications of satellite data and are tailored to audiences with a variety of experience levels.



AGRICULTURE



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DISASTERS



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WATER RESOURCES



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About ARSET Trainings

- Online or in-person
- Live and instructor-led or asynchronous and self-paced
- Cost-free
- Bilingual and multilingual options
- Only use open-source software and data
- Accommodate differing levels of expertise

- Visit the [ARSET website](#) to learn more



Classification Methods for Land Cover Overview



Training Learning Objectives

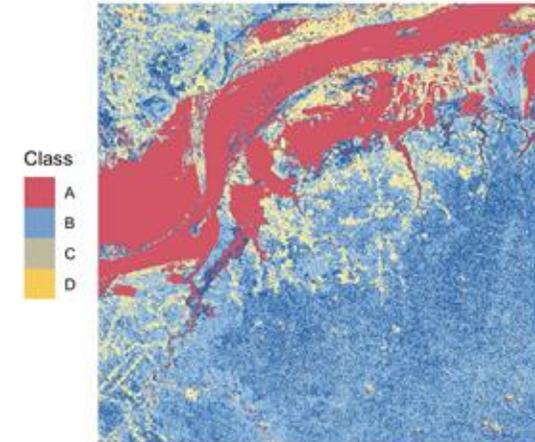
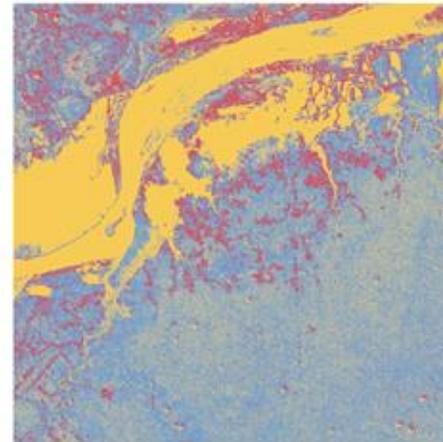
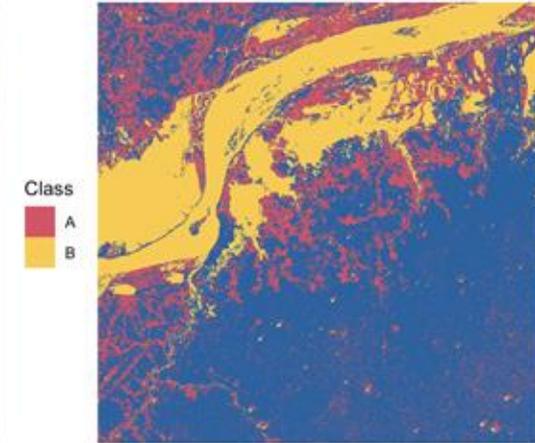
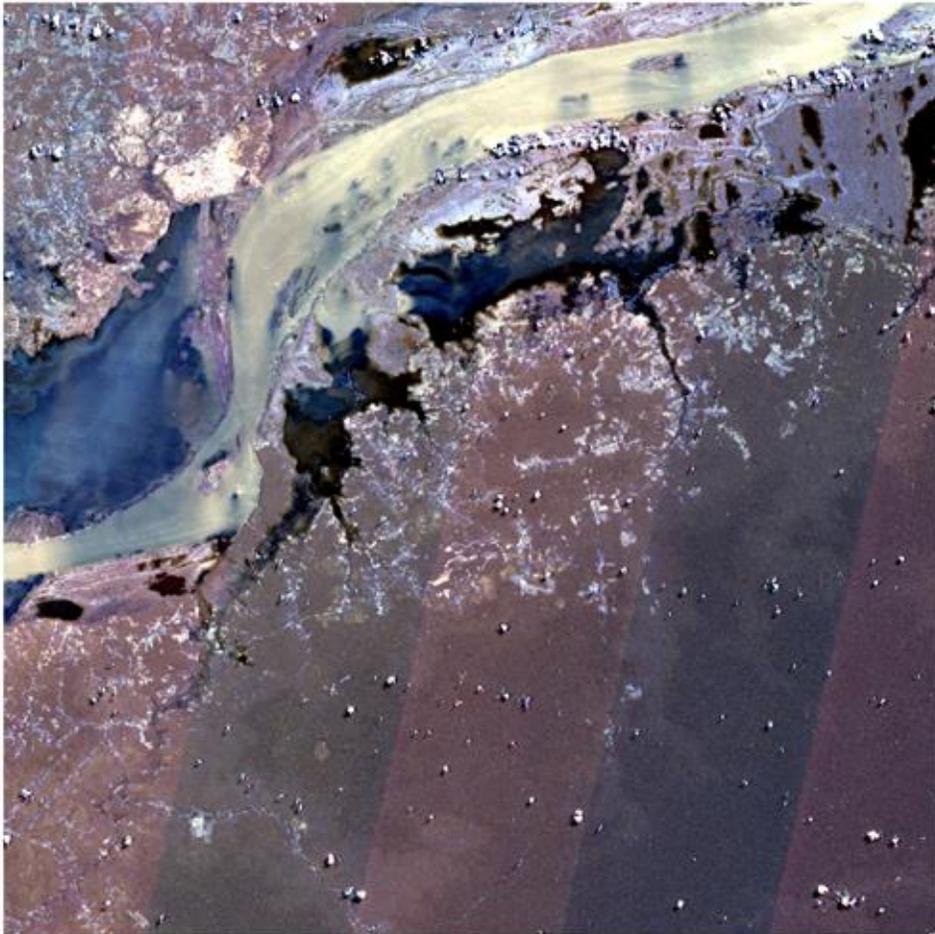
By the end of this training, participants will be able to:

- Access NASA Earth Observation Data (e.g. HLS) relevant to Land Cover and Land Use (LCLU) Change mapping
- Convert NASA Earth Observation data into distinct LCLU classes using supervised and unsupervised machine learning (ML) classification methods in the R programming language
- Recognize the role of classification methods as one part of a change monitoring strategy
- Compute a change matrix representing the change in LCLU between two dates
- Create a map in RStudio visualizing the differences in LCLU between two dates



Quick Preview

This is where we are headed today, a decent classifier that doesn't use any training data



Prerequisites

- [Fundamentals of Remote Sensing](#)
- Experience with R and RStudio



Training Outline

Part 1
**Classification
Methods for Land
Cover**

February 24, 2026
Time

Part 2
**Visualizing Land
Cover Change**

February 26, 2026
Time

Homework

Opens February 26 – Due March 12 – 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.





Visualizing Land Cover and Land Use Change with NASA Satellite Data Part 1: Classification Methods for Land Cover



Part 1 – Trainers

Justin Fain

Research Scientist

NASA Ames / BAERI



Part 1 Objectives

By the end of Part 1, participants will be able to:

- Understand the utility of LCLU classification and LCLUC mapping as part of a comprehensive change detection strategy
- Use NASA data in unsupervised models for LCLU classification



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 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: Introduction



Important Terms and Acronyms: LCLUC

- **Land cover** is the description of what is on the ground
 - Often paired with land use and written as LCLU (or sometimes LULC)
- **Land use** is how the features of land cover are utilized
- **LCLU** describes the configuration and uses of features on the ground
- We can measure LCLU changes over time
 - That gives us the acronym **LCLUC**
 - Usually pronounced “*el-see-luck*”
- The factors which influence or drive LCLUC are called the **drivers of change**



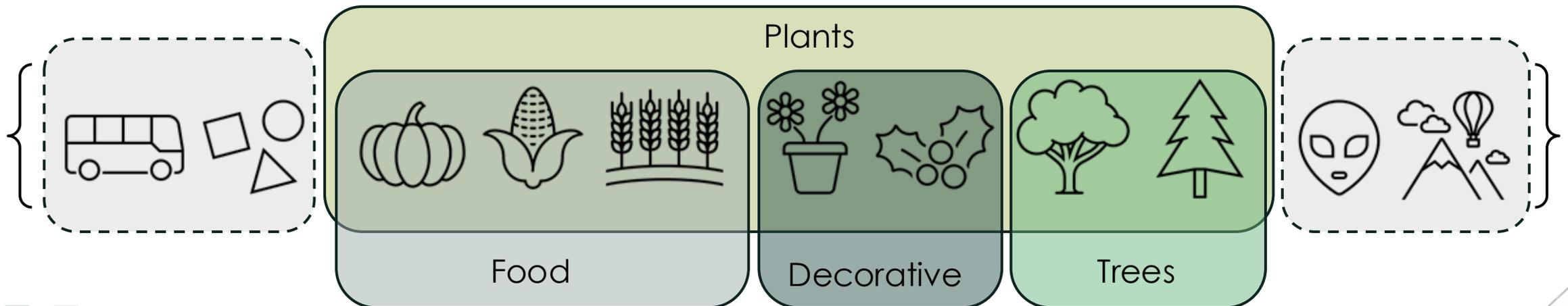
Important Terms and Acronyms: Classification

- **Classification** is the process of dividing things into categories or **classes**
- A **classifier** is the person, model, or process that assigns classes
 - You act as a classifier every day when you do simple tasks:
 - Classifying shoes as footwear rather than headwear (category of function)
 - Determining what is and is not safe to eat (category of edibility)
 - Deciding that this training is worth attending (category of value)



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Important Terms and Acronyms (Simplified)

This is the way I prefer to think of these concepts:

Glossary Term	Question / Statement
Land Cover Land Use (LCLU)	What is that? (and how is it used?)
Class	What kind of thing is that?
Classifier	I know what kind of thing that is
LCLU Change (LCLUC)	I remember what that used to be
Driver(s)	I know what caused that to change



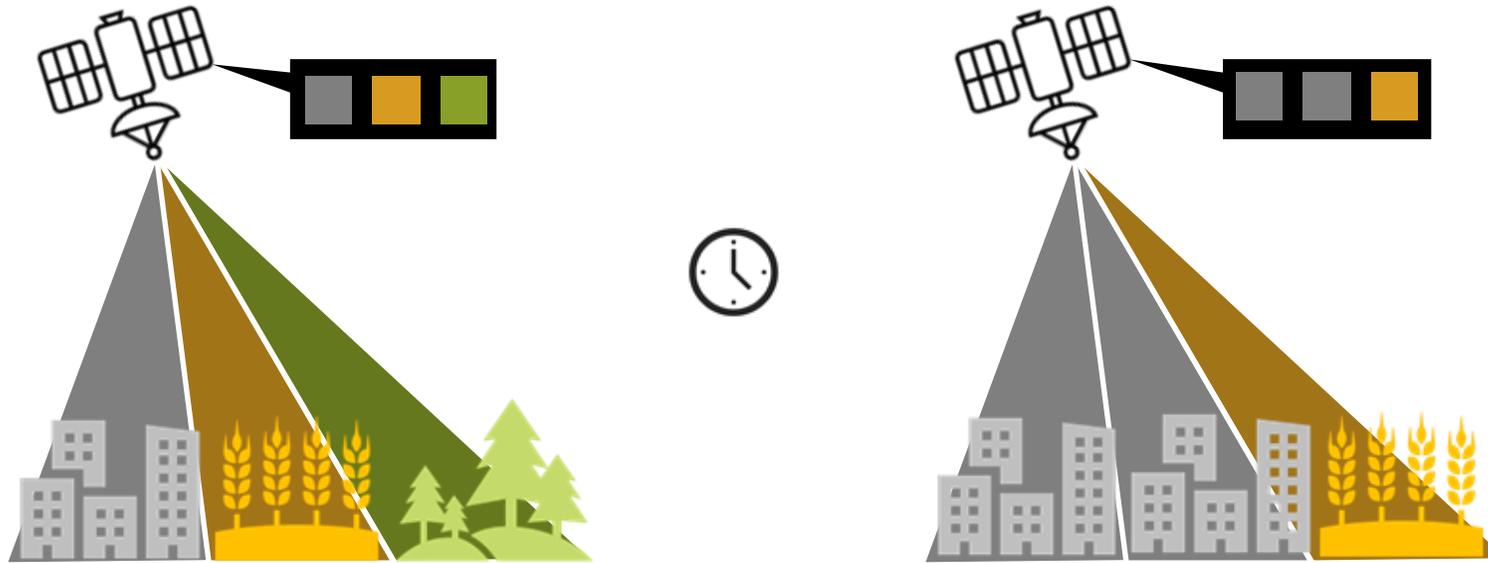


Why Land Cover Land Use Change Matters



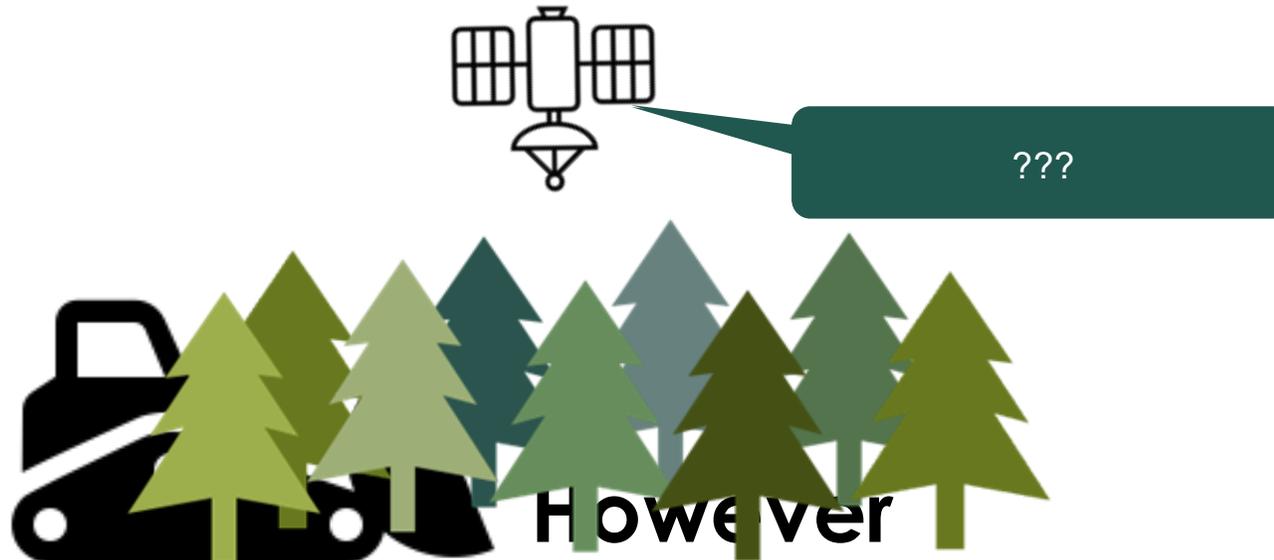
Why LCLUC Matters: Drivers

- **LCLU** describes the configuration of features on the surface of the Earth
- These features and the way that they are arranged:
 - are responsive to **drivers** which influence the rate and likelihood of change
 - potentially reveal information about the **drivers** themselves
 - are observable with remote sensing data
- Forest fires, urban growth, erosion, landslides, and cropland expansion are just some examples of things which can be observed as **LCLUC**



Why LCLUC Matters: Classes

- Classes divide LC based on shared spectral characteristics
- The similarity or dissimilarity of classes represents meaningful differences in the real world



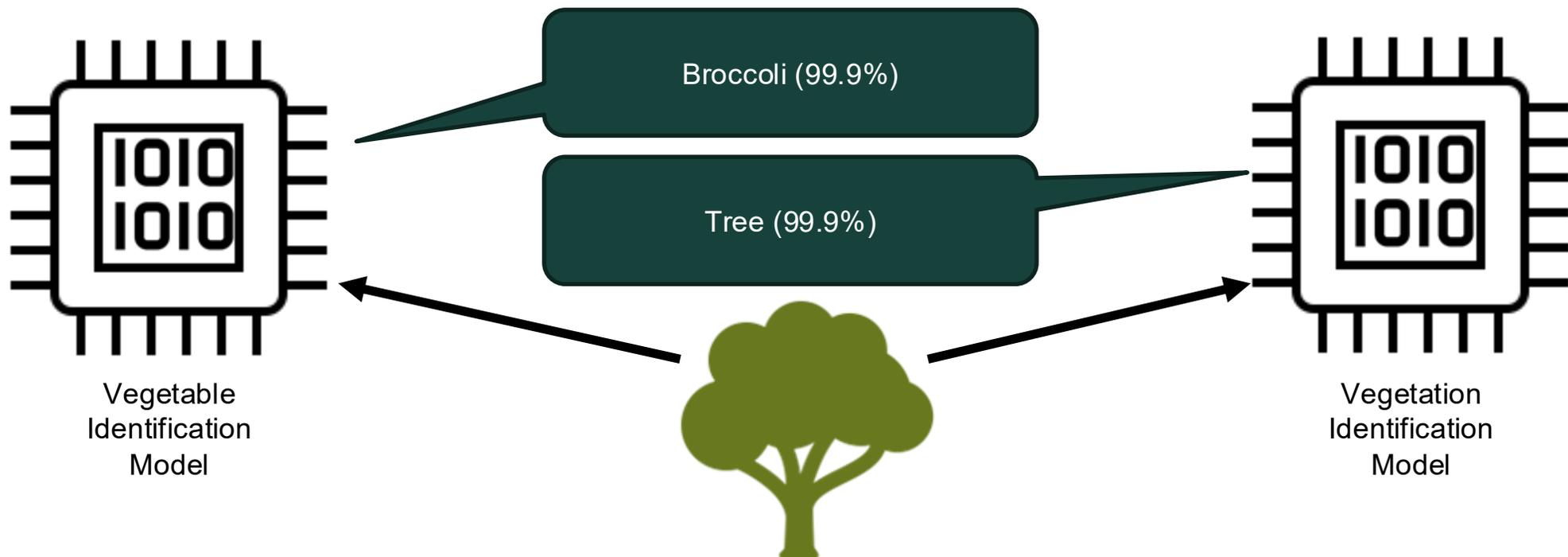


Considerations for LCLU Classification



Limitations of Classification: Knowledge Bias

- **Classification** can only divide LC classes when their spectral characteristics are sufficiently different
 - Supervised ML models only work within the classes they have been trained to expect
- This can lead to some strange and contradictory outcomes if you aren't careful with your setup
 - It is easy to accidentally make a classifier that is consistent but not correct

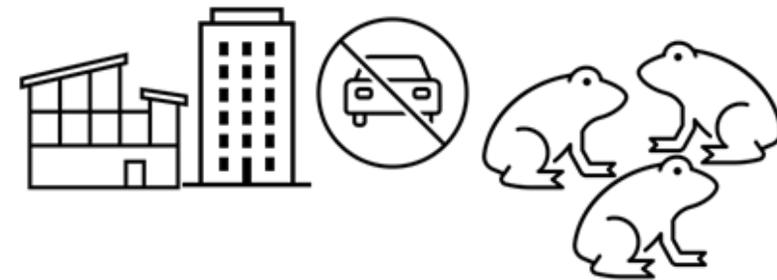
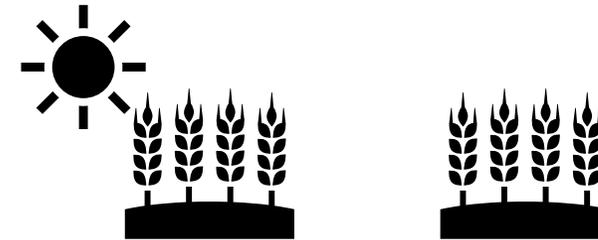




Drivers of LCLU Change

Drivers of LCLU Change: Considerations

- Considerations when examining LCLUC drivers:
 - Come from a variety of sources
 - May be indirect
 - Change(s) in one place or time drive changes in another
 - May be related
 - There may be multiple effects of a single driver



Drivers of LCLU Change: Examples

- We usually want to divide drivers into neat categories like human caused (anthropogenic) or natural
- To demonstrate why that's hard to do, here are some examples of LCLUC and their sources:

Event	Human caused?	Naturally occurring?	Change Direction	Example(s)
Mowing the lawn	YES	NO	Grass → Less Grass	Golf courses
Sheep grazing	Sometimes	Sometimes	Grass → Less Grass	Managed and unmanaged herds
Grassland fire	Sometimes	Sometimes	Grass → Barren	Any grassland fires
New parking lot	YES	NO	? → Built Environment	Urban expansion
Landslide	Sometimes	YES	? → Barren (soil)	Tracy Arm, AK (2025 CE) Zion Canyon, UT (~2800 BCE)
Flood	Maybe	Sometimes	? → Water	Rice agriculture Seasonal flooding Erosion events

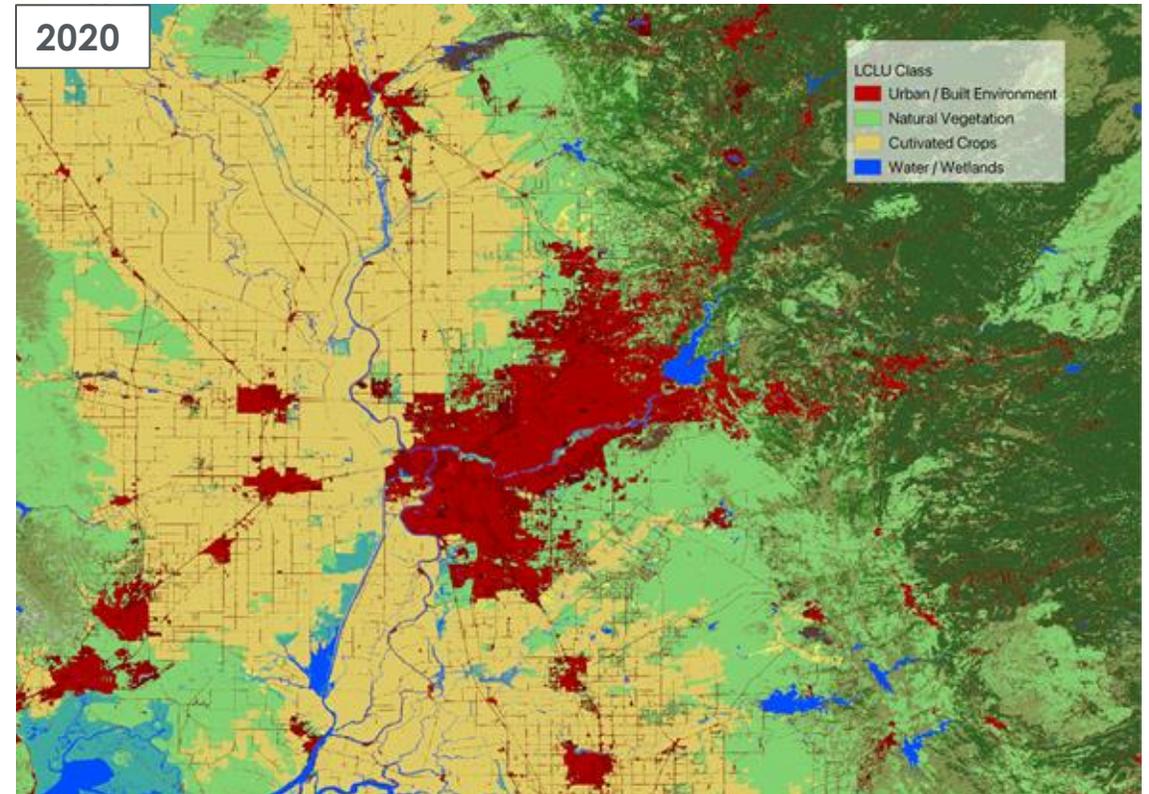
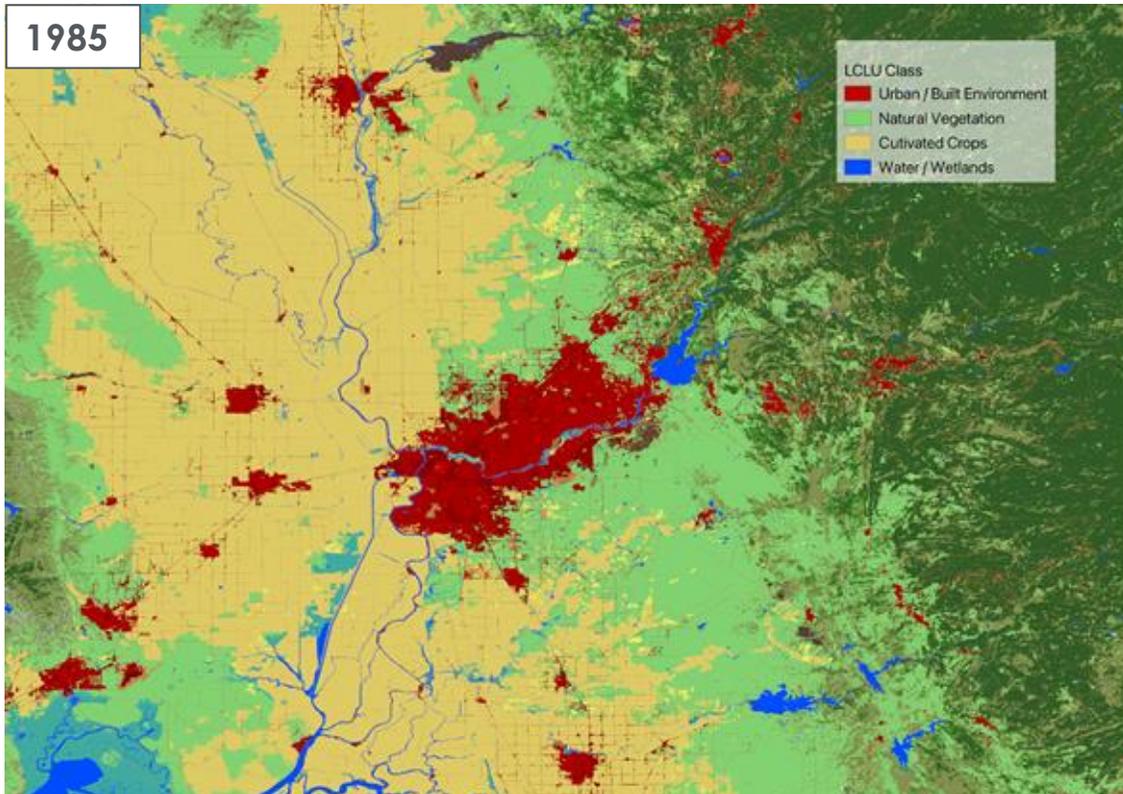




LCLUC Example

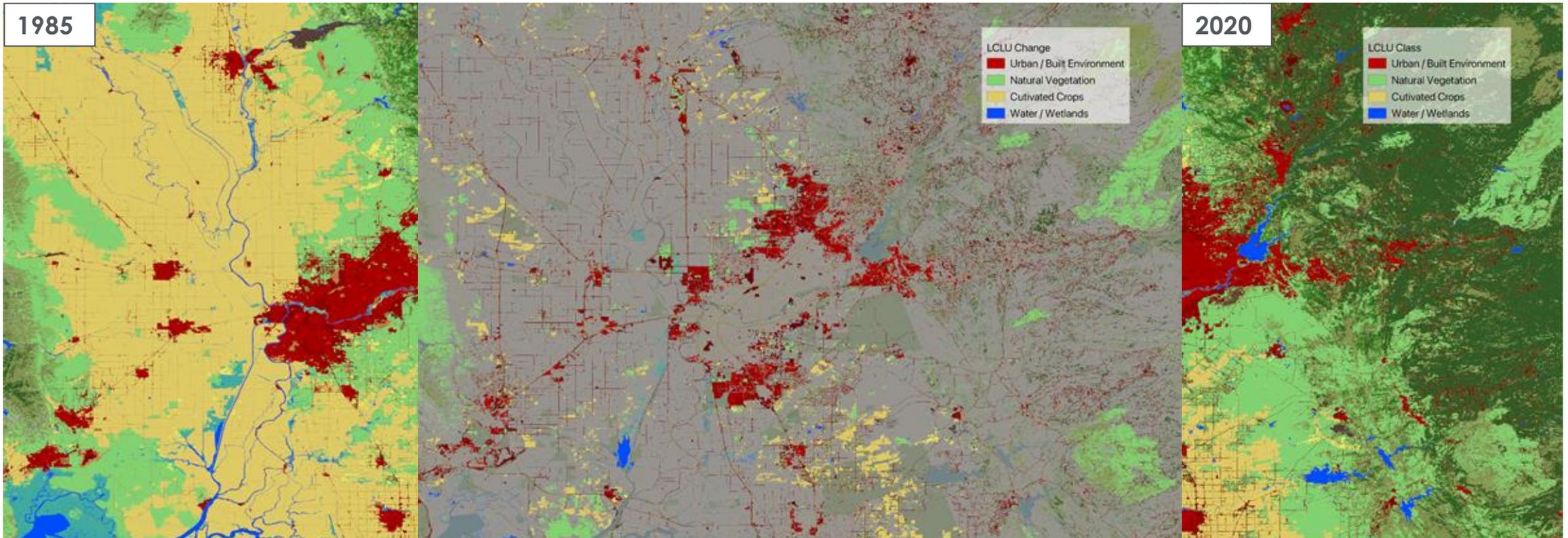
LCLU Case Study

- Here's a simplified LCLU map of the Sacramento California Metro area
 - 1985 (left) and 2020 (right)
- You can see the expansion of urban areas as well as a few other notable features



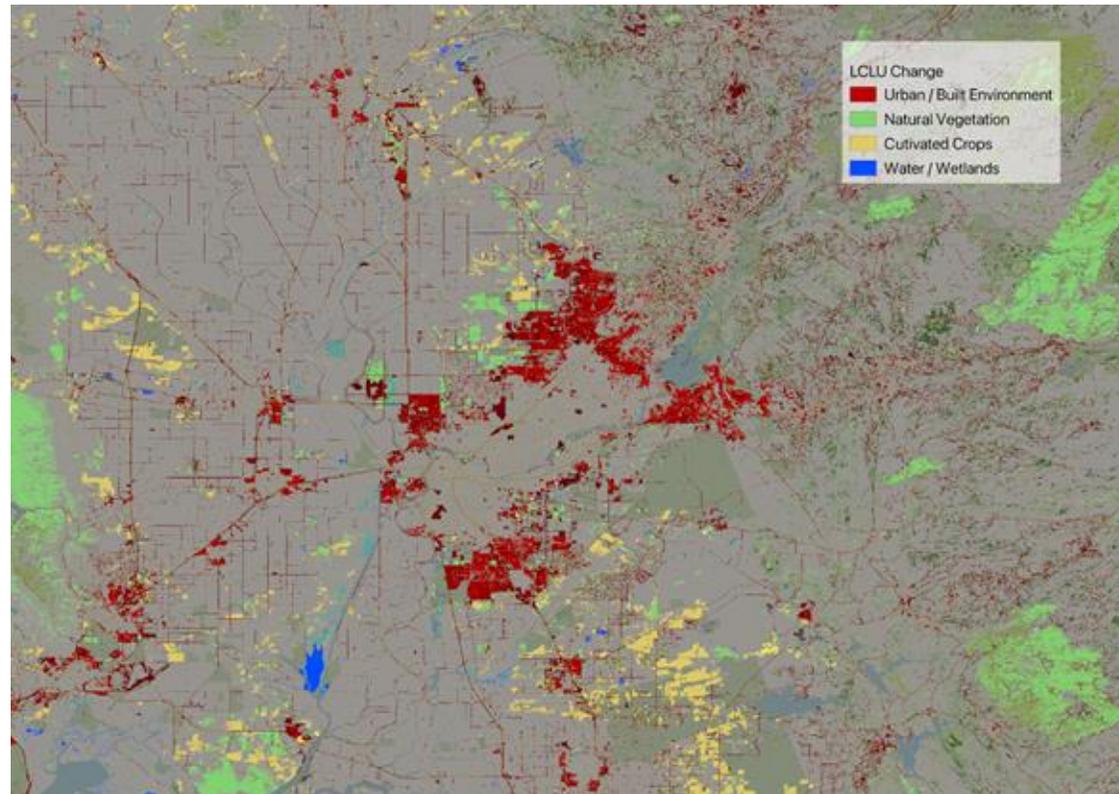
LCLUC Case Study

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LCLUC Map

- We can highlight the changes over time
- This gives us a lot of information about **where** and **how** things have changed
- We might even be able to make some guesses about the **drivers** of change





Classification Methods

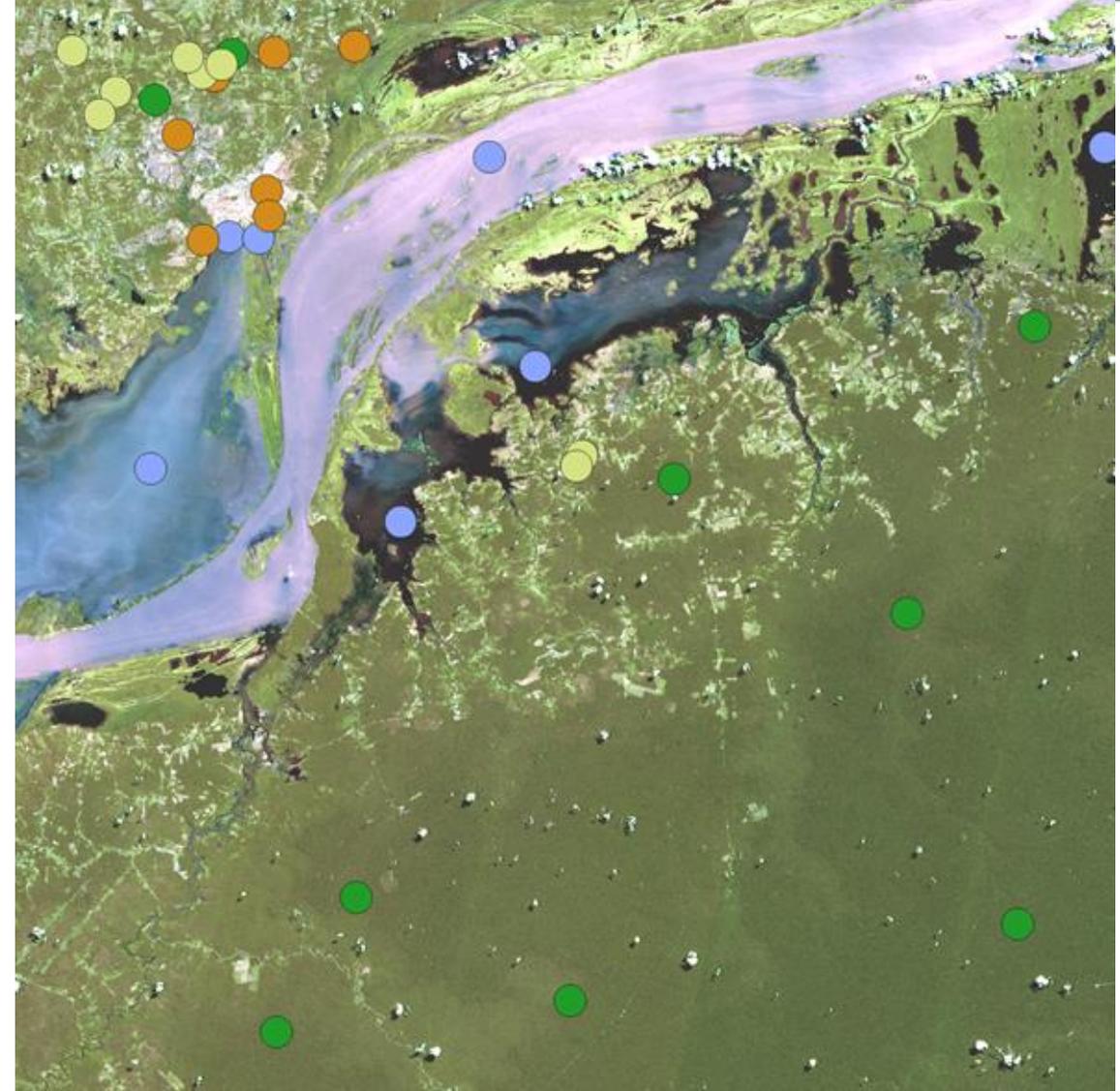
Classification: Supervised or Unsupervised

	Supervised	Unsupervised
Training Data	Yes	No
Number of Classes	Fixed	Flexible
Classes are...	Targets	Groupings
Limited by...	Training data	Spectral difference
Examples	Random Forest (RF) K-Nearest Neighbor (KNN) CART SVM	Hierarchical Clustering K-Means DBSCAN ISODATA
We will cover...	RF KNN	K-Means



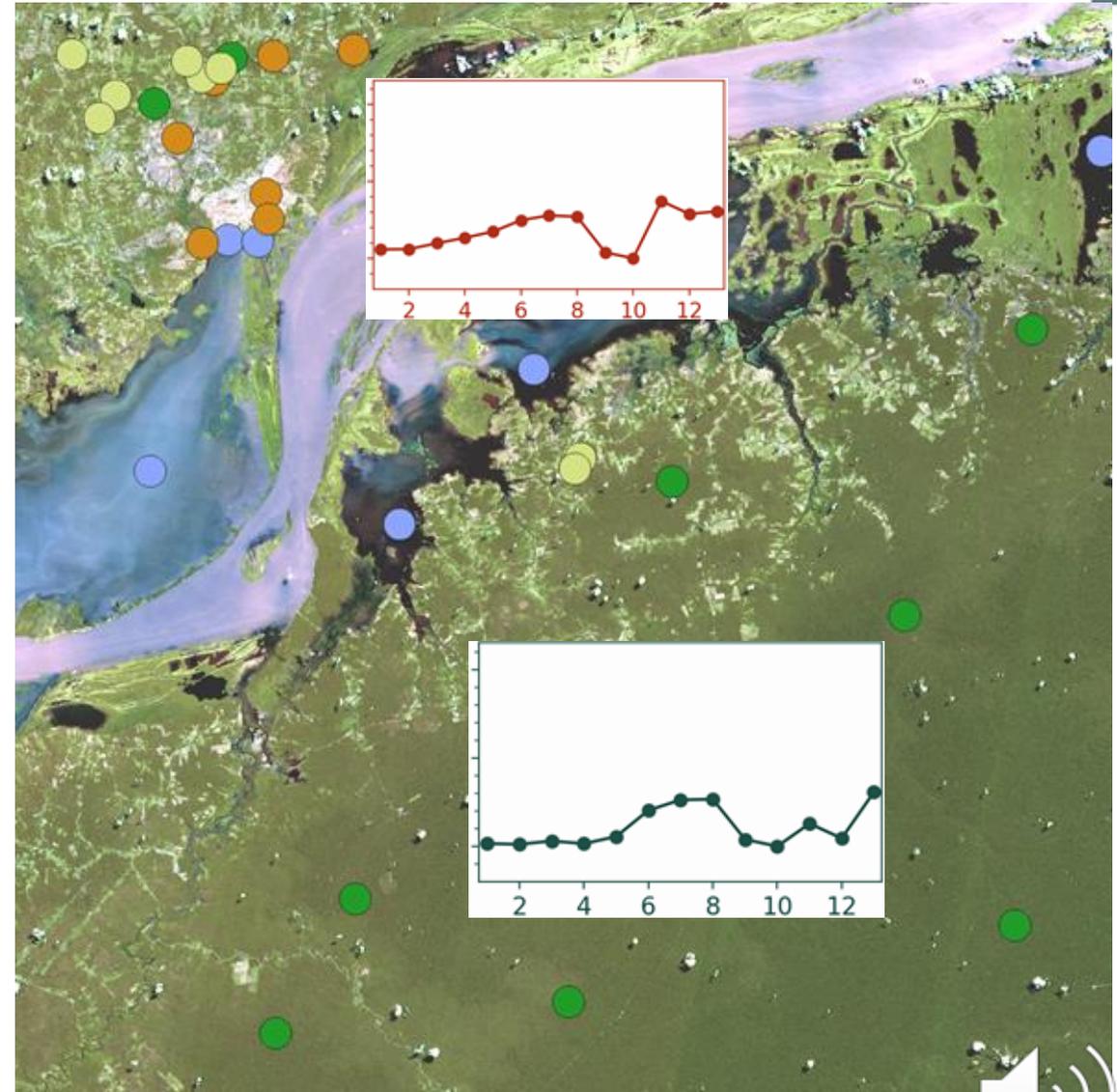
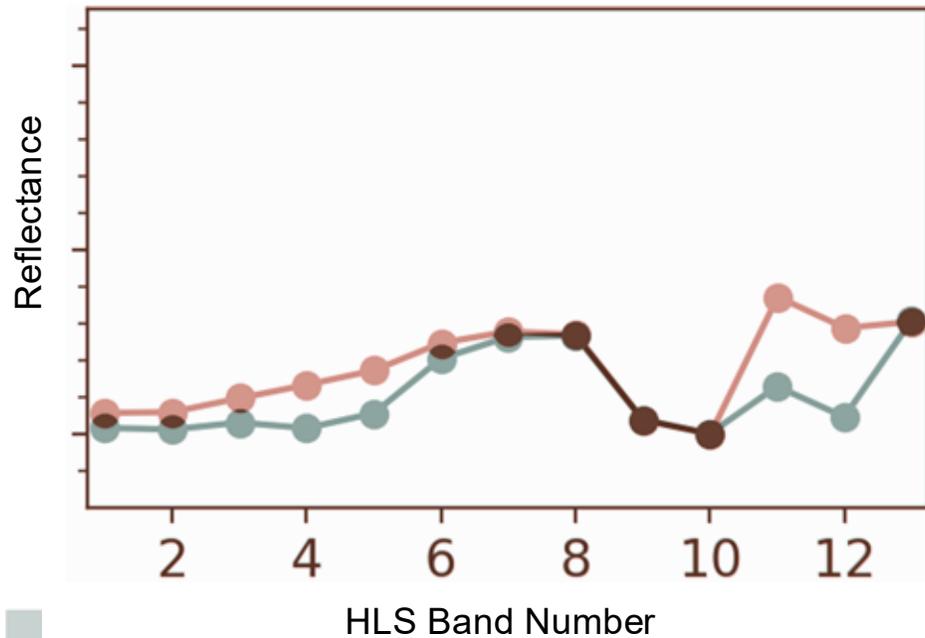
Classification: Training Data

- Training data for remote sensing imagery classification can consist of:
 - Points
 - Lines
 - Polygons
- The extracted pixel value(s) under each training data feature give a profile of the spectral response
- This response corresponds to how much light is being reflected in the wavelengths of each band



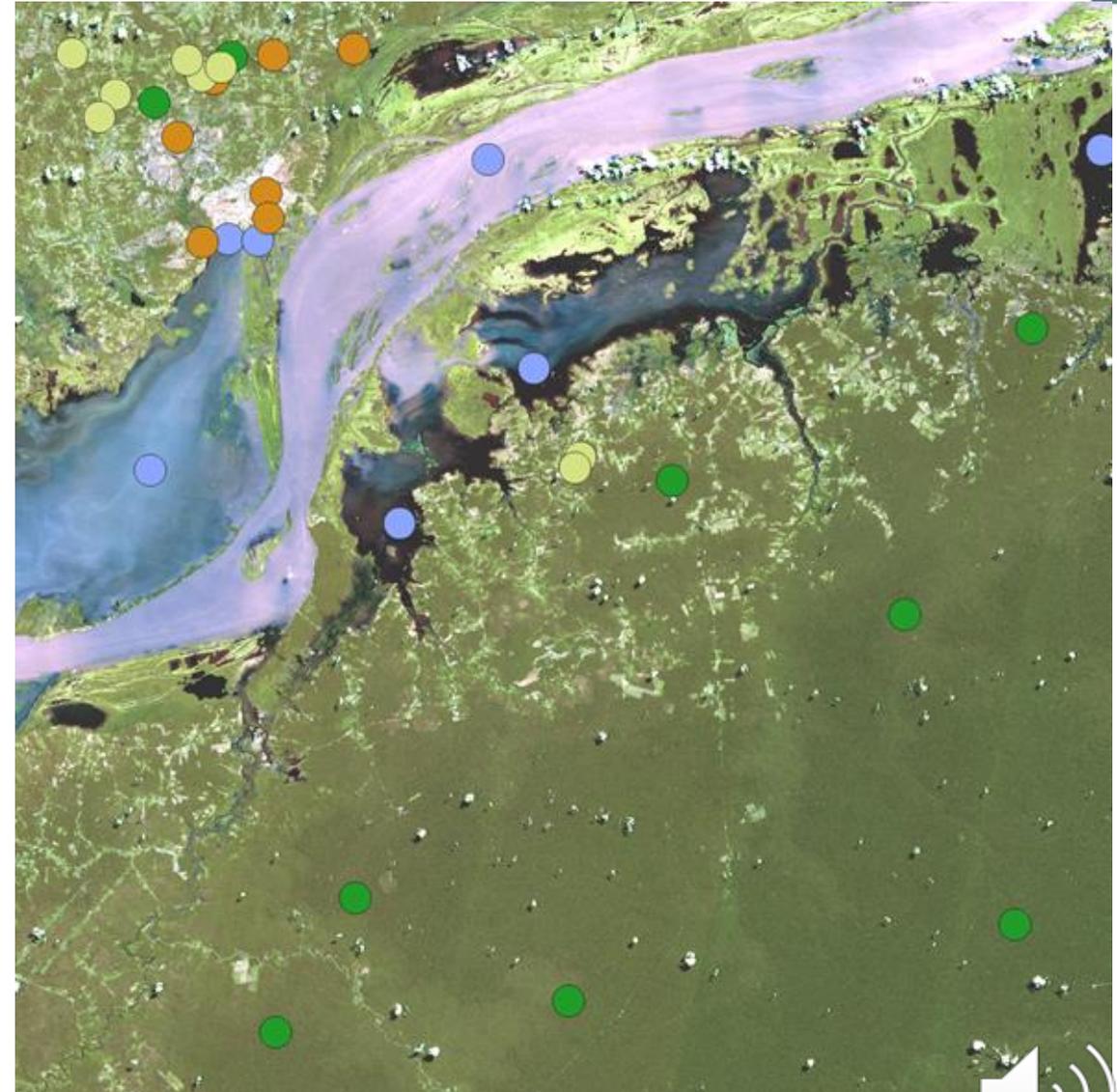
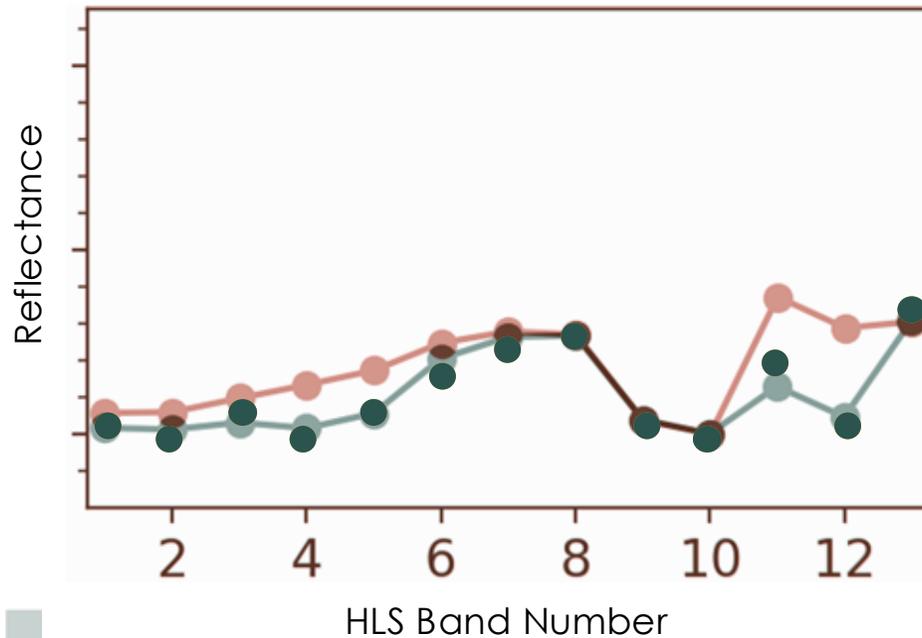
Classification: Spectral Differences

- Here are two examples for:
 - Barren land (top)
 - Forests (bottom)
- We can overlay the two for a better idea of their differences



Classification: Prediction by Similarity

- In a supervised classification, the model builds up an average curve for each LC class
- When presented with an unknown curve the model can attempt to pair it with the **known** curve it most closely matches



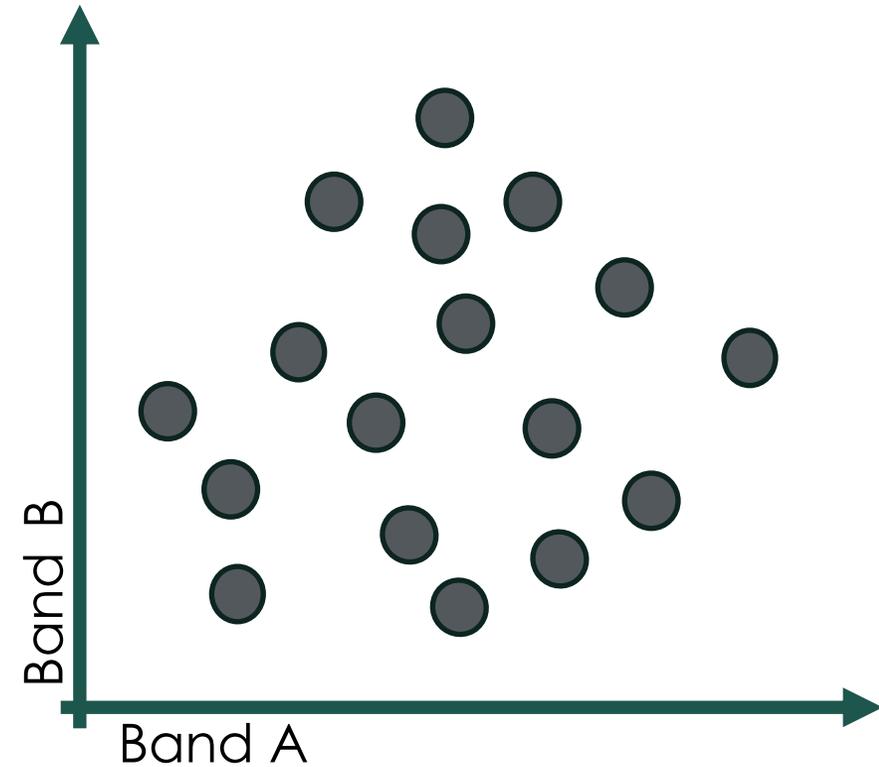


Overview of Selected Classification Methods



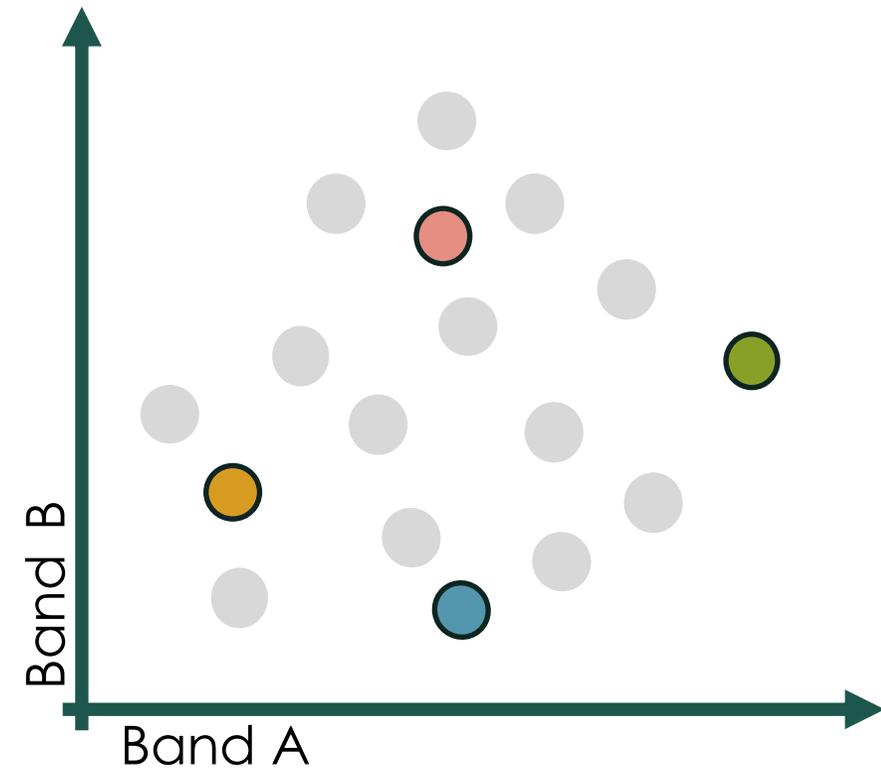
K-Means Clustering (Simplified)

- Start with each pixel projected into feature space
- In feature space each dimension (band) is a measurement (reflectance)
 - The feature space is usually hyperdimensional, but I'm only using 2 here for simplicity



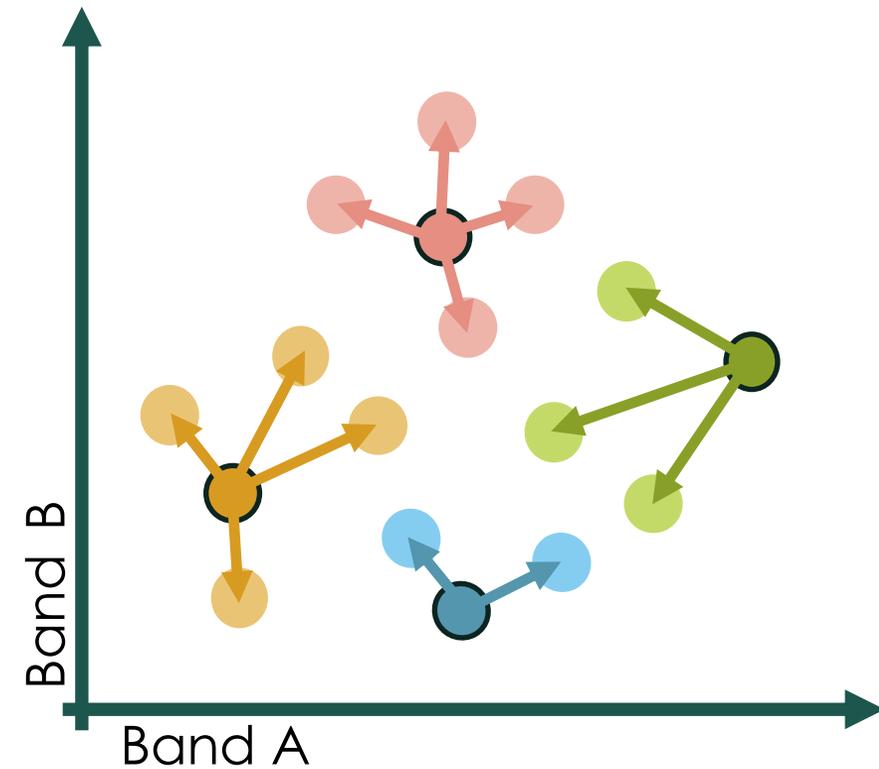
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- **Select K random points in feature space**
 - **These are the centers for each class**



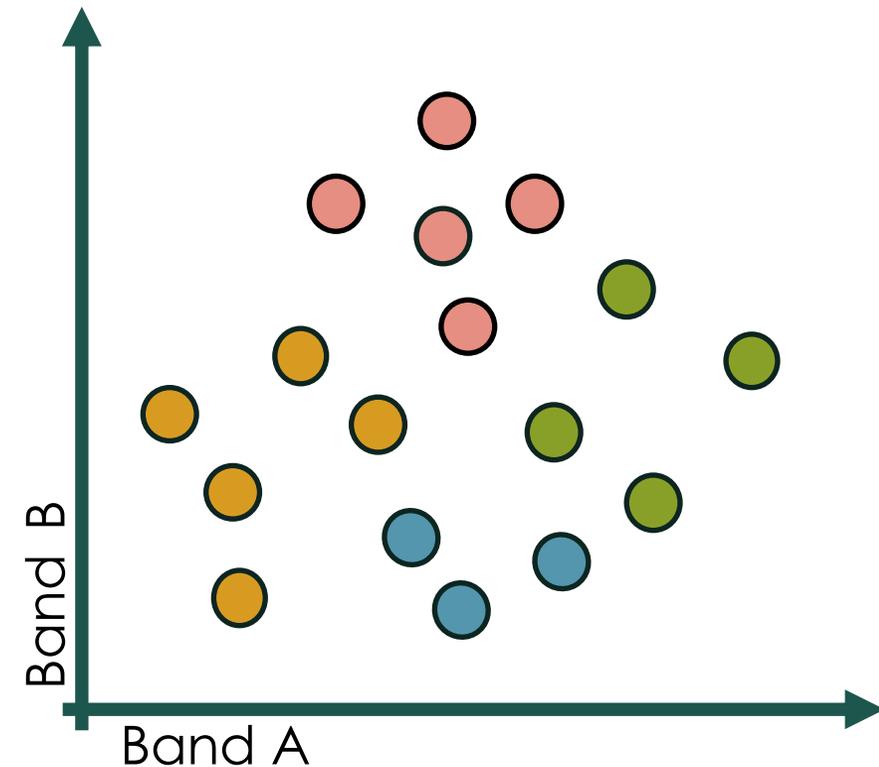
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 - These are the centers for each class
- **Group each point by distance to the closest center**



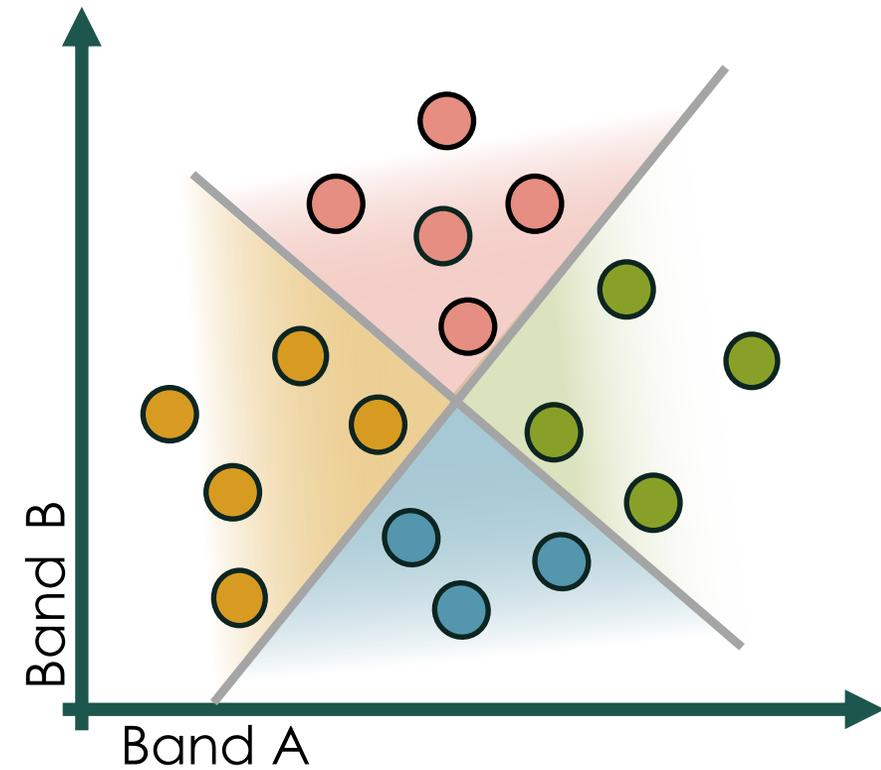
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- Group each point by distance to the closest center
- **Assign a class to each point based on its nearest center**



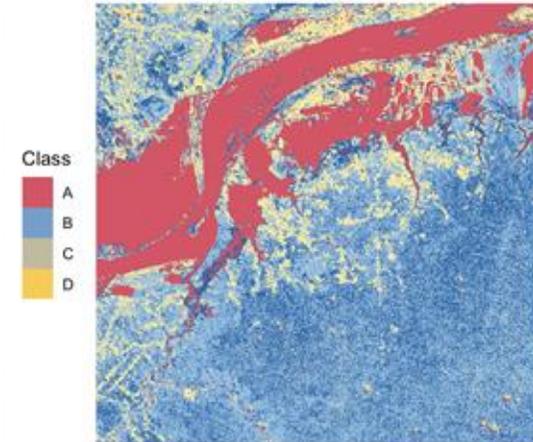
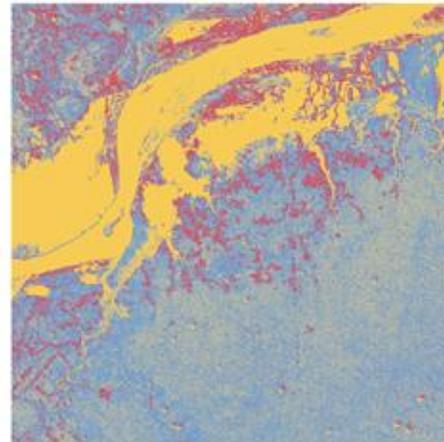
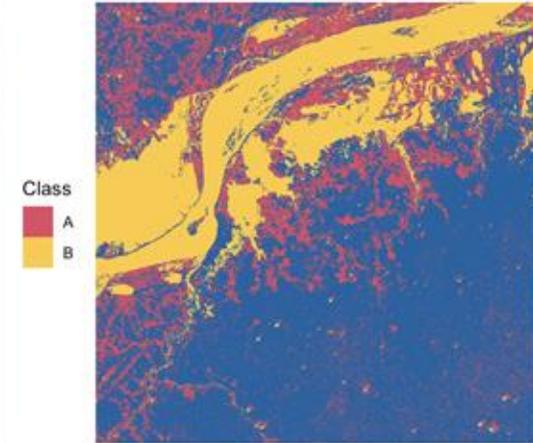
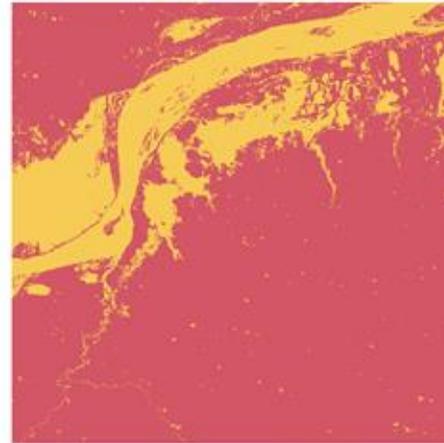
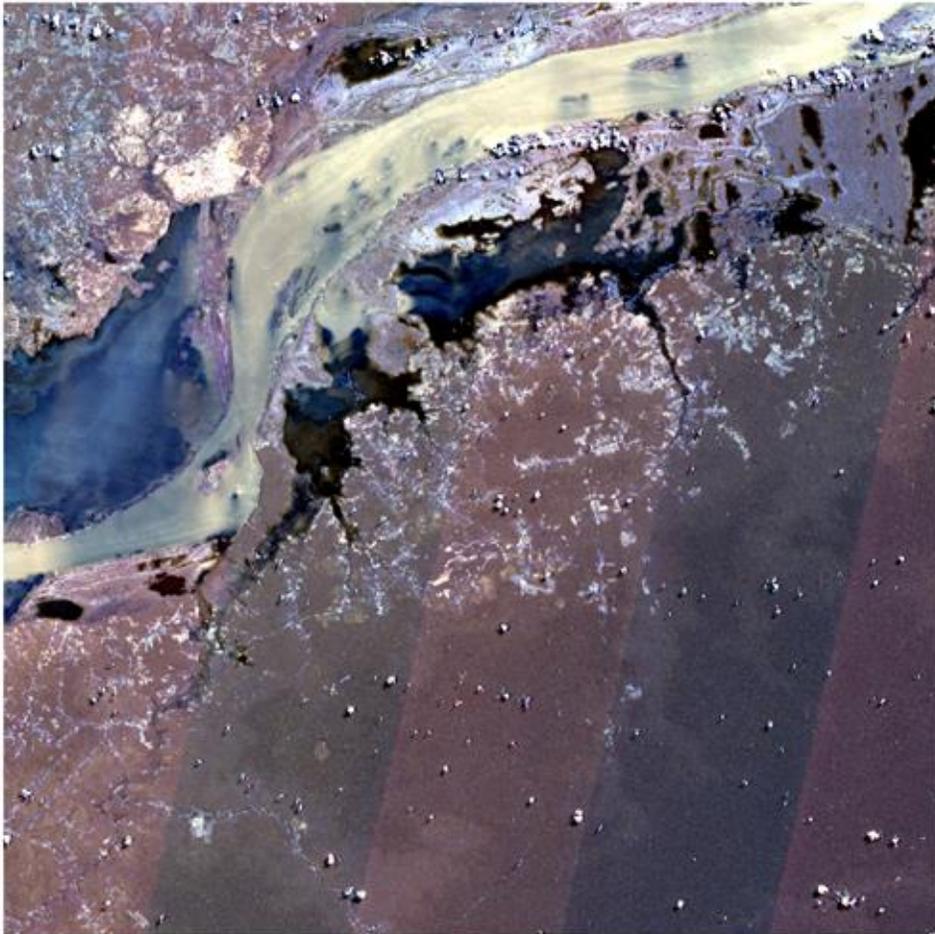
K-means Clustering: Interpretation

- Which LCLU classes do these clusters correspond to?



K-means Clustering (Simplified)

This is where we are headed today, **a decent classifier that doesn't use any training data**



Accessing HLS Imagery with Earthdata Search

- Let's take a very quick diversion to look at how I downloaded the data for this training

Here's a condensed version of the process:

- Define the area of interest
- Search for HLS data
- Select imagery for two dates
- Download the selected imagery



🔍 HLS

Search

📅 Temporal ▾

📍 Spatial ▾



My Project 📁 | 🗄️ | ? | Justin ▾

📍 Spatial



SW:

NE:

🔼 Filter Collections

Features ^

- Available in Earthdata Cloud
- Customizable ⚙️
- Map Imagery

Keywords ▾

Platforms ▾

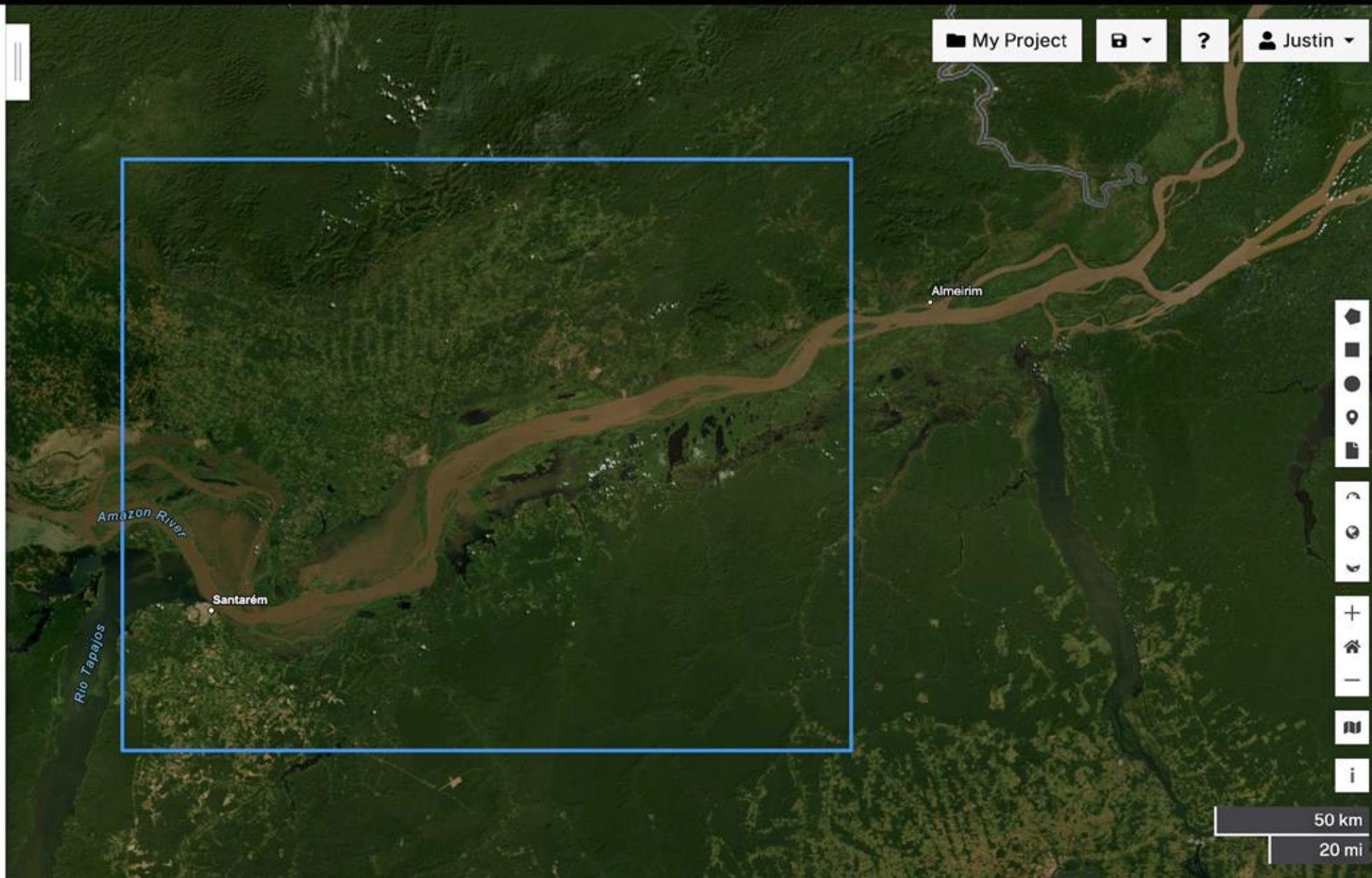
Instruments ▾

Organizations ▾

Projects 1 Selected ^

- ECOSTRESS 15
- HLS 4
- SNWG/OPERA 4

Processing Levels ▾



Map navigation controls: Home, Full Screen, Layers, Location, Map Style, Refresh, Home, Zoom In, Zoom Out, Home, Full Screen, Info

50 km
20 mi

🔍 HLS Search

📁 My Project 🔒 ▾ ? ▾ 👤 Justin ▾

📅 Temporal ▾ 📍 Spatial ▾ ☰ 🗑️

Spatial Rectar

- Polygon
- 📐 Rectangle
- Circle
- Point
- File (KML, KMZ, ESRI, ...)

SW: NE:

⌵ Filter Collections

Features ⌵

- Available in Earthdata Cloud
- Customizable
- Map Imagery

Keywords ⌵

Platforms ⌵

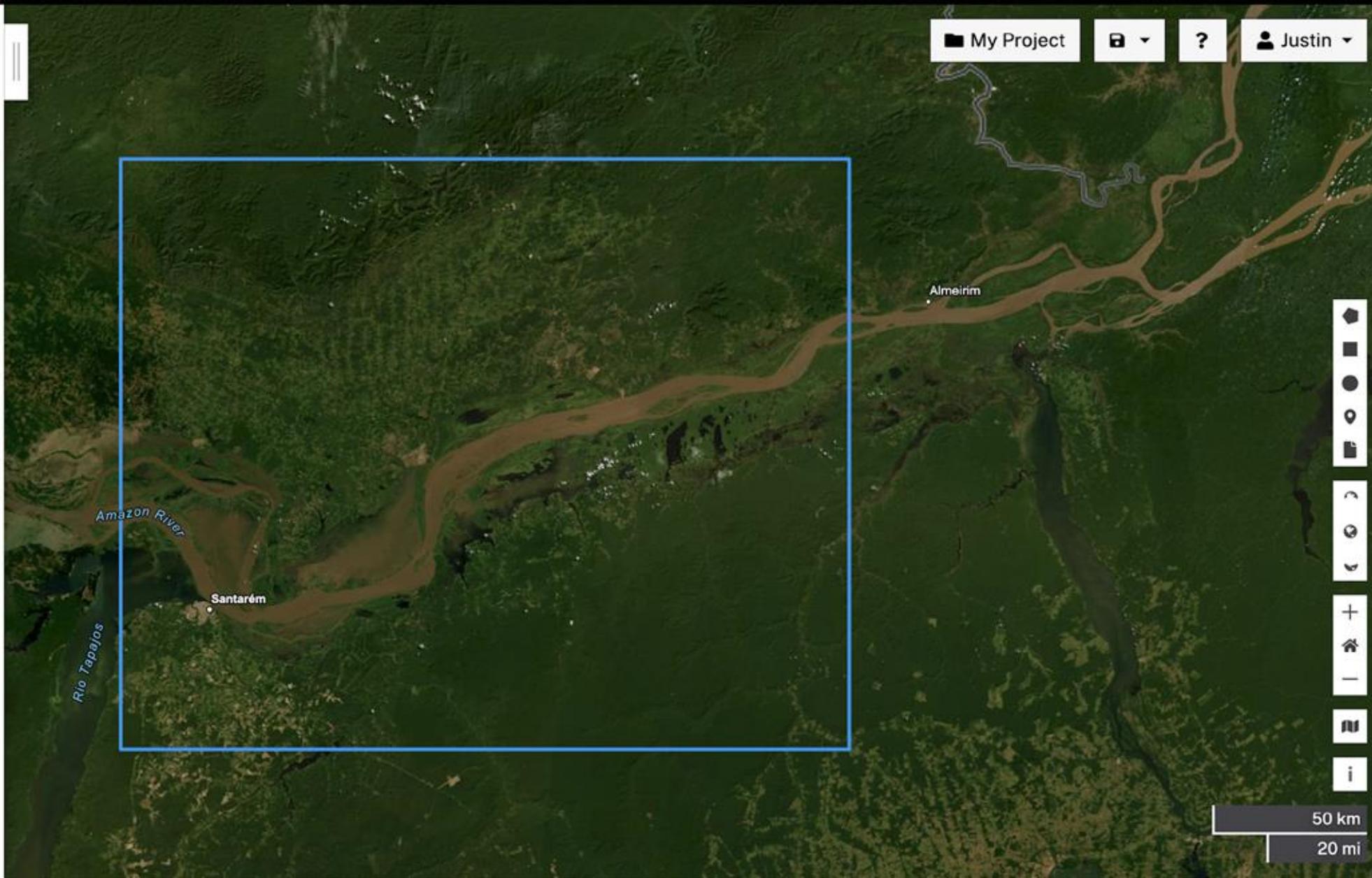
Instruments ⌵

Organizations ⌵

Projects 1 Selected ⌵

- ECOSTRESS 15
- HLS 4
- SNWG/OPERA 4

Processing Levels ⌵



HLS Search

Temporal ▾ Spatial ▾

- Spatial
- Rectangle
- SW: -2.85517
- NE: -1.1003,-5
- Polygon
- Rectangle
- Circle
- Point
- File (KML, KMZ, ESRI, ...)

Filter Collections

Features

- Available in Earthdata Cloud
- Customizable
- Map Imagery

Keywords

Platforms

Instruments

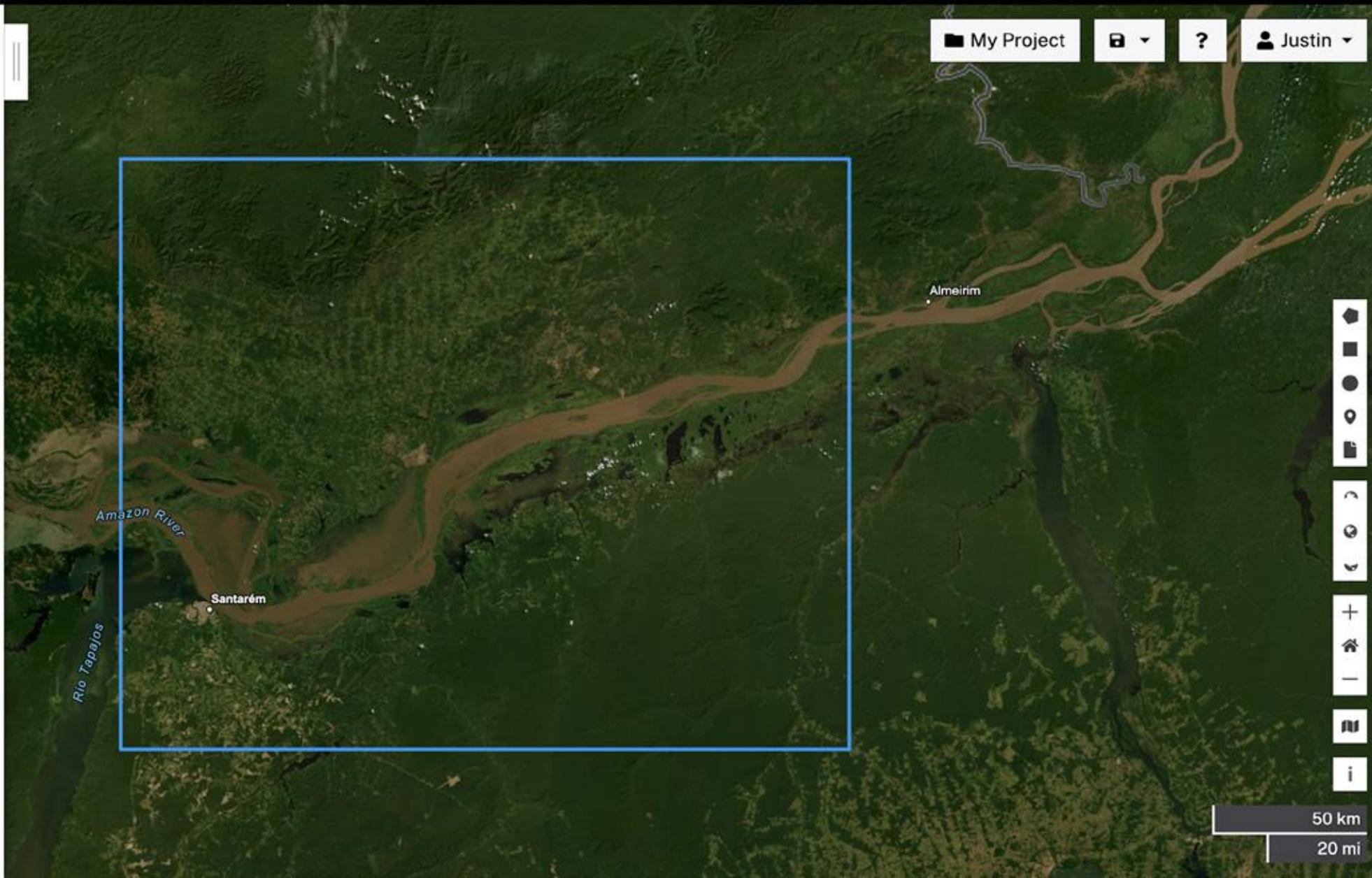
Organizations

Projects 1 Selected

- ECOSTRESS 15
- HLS 4
- SNWG/OPERA 4

Processing Levels

My Project ? Justin ▾



Map navigation controls including pan, zoom, and layer management icons.

50 km
20 mi

HLS Search

4 Matching Collections

Temporal Spatial

Showing 4 of 4 matching collections Sort: Usage View: List

Spatial Rectangle SW: -2.85517,-54.96316 NE: -1.1003,-52.80851

HLS Sentinel-2 Multi-spectral Instrument Surface Reflectance Daily Global 30m v2.0

6,834 Granules 2015-11-28 to Present

The Harmonized Landsat Sentinel-2 (HLS) project provides consistent surface reflectance data from the Operational Land Imager (OLI) aboard the joint...

GEOSS · HLSS30 v2.0 - LP DAAC

HLS Landsat Operational Land Imager Surface Reflectance and TOA Brightness Daily Global 30m v2.0

5,083 Granules 2013-04-11 to Present

The Harmonized Landsat Sentinel-2 (HLS) project provides consistent surface reflectance (SR) and top of atmosphere (TOA) brightness data from a virtual...

GEOSS · HLSS30 v2.0 - LP DAAC

HLS Sentinel-2 Multi-spectral Instrument Vegetation Indices Daily Global 30 m V2.0

3,340 Granules 2015-11-28 to Present

The Harmonized Landsat and Sentinel-2 (HLS) project provides consistent data products from the Operational Land Imager (OLI) aboard the joint NASA/USGS...

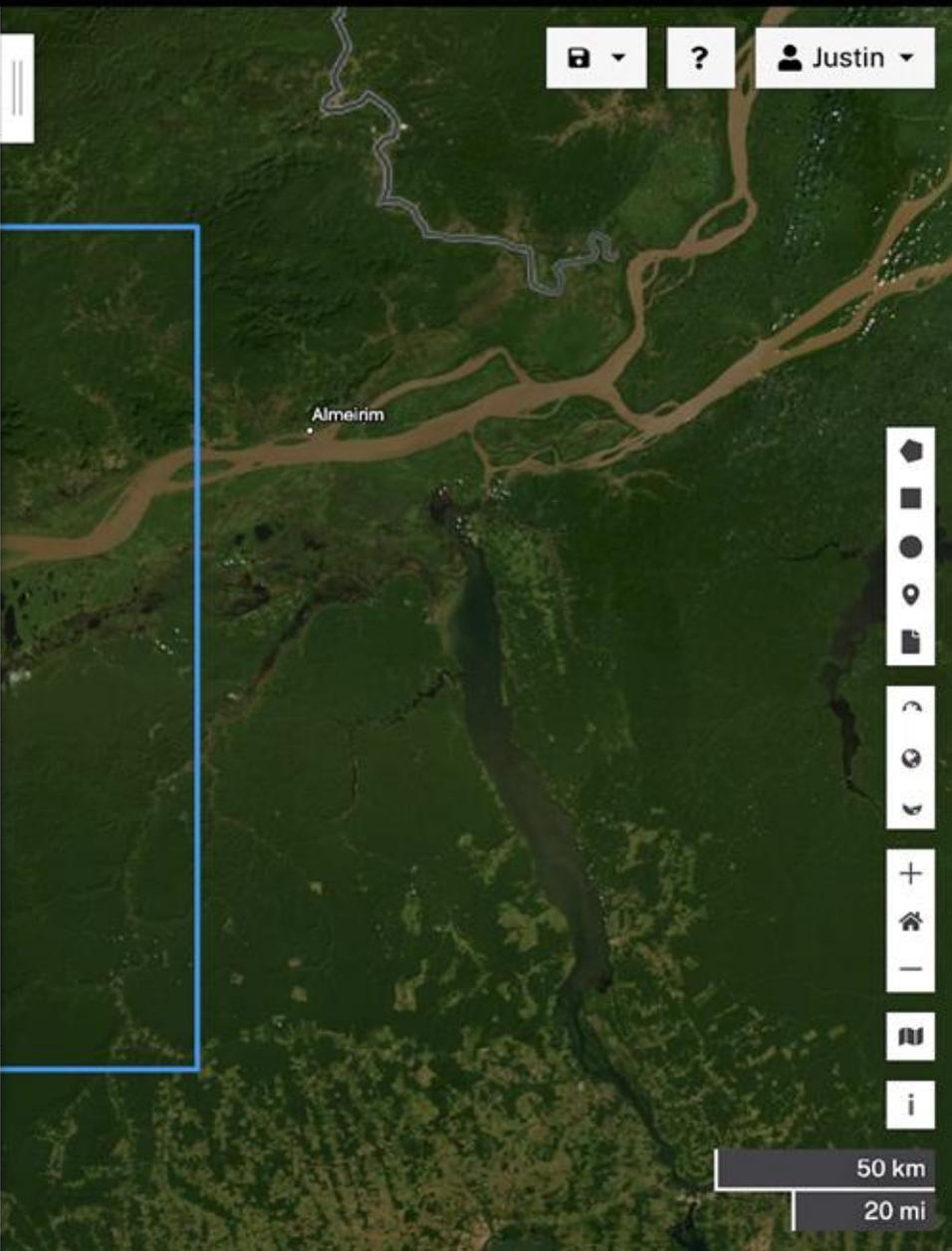
GEOSS · HLSS30_VI v2.0 - LP DAAC

HLS Operational Land Imager Vegetation Indices Daily Global 30 m V2.0

2,826 Granules 2013-04-11 to Present

Subscriptions

- Organizations
- Projects 1 Selected
- ECOSTRESS 15
 - HLS 4
 - SNWG/OPERA 4
- Processing Levels
- Data Format
- Tiling System
- Horizontal Data Resolution
- Latency
- Additional Filters**
- Include collections without granules
 - Include only EOSDIS collections



HLS

Search

Search Results (4 Collections)

HLS Sentinel-2 Multi-spectral Instrument Surface Reflectance Daily Global 30m v2.0

Showing 20 of 556 matching granules

Sort: Start Date (Newest)

View: List

HLS.S30.T21MYT.2026003T14071

1



START 2026-01-03 14:13:15

END -



HLS.S30.T21MYU.2025340T14110

1



START 2025-12-06 14:13:09

END -



HLS.S30.T21MYU.2025340T1356

59



START 2025-12-06 14:02:55

END -



HLS.S30.T21MYT.2025320T14110

1



START 2025-11-16 14:13:24

END -



HLS.S30.T21MYU.2025313T14065

9



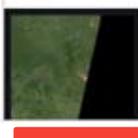
START 2025-11-09 14:12:50

END -



HLS.S30.T21MYU.2025308T14110

1



START 2025-11-04 14:13:06

END -



Search Time: 0.7s

Subscriptions

Add

Download All 556

Temporal ▾ Spatial ▾

Spatial Rectangle

SW: -2.85517,-54.96316

NE: -1.1003,-52.80851

Spatial Rectangle

SW: -2.85517,-54.96316

NE: -1.1003,-52.80851

Temporal

Start

Type or click to select a date

YYYY-MM-DD HH:mm:ss

End

Type or click to select a date

YYYY-MM-DD HH:mm:ss

Use a recurring date range

Day/Night

Find granules captured during the day, night or anytime.

Anytime

Visualization Layers

Reflectance (Nadir BRDF-Adjusted)

Almeirim

50 km

20 mi

HLS Sentinel-2 Multi-spectral Instrument S...

2000

2010

2020

2030

2040

HLS

Search

Search Results (4 Collections)

Temporal Spatial

Spatial Rectangle

SW: -2.85517,-54.96316

NE: -1.1003,-52.80851

Find granules captured during the day, night or anytime.

Anytime

Data Access

- Find only granules that have browse images
- Find only granules that are available online

Cloud Cover

Find granules by cloud cover percentage.

Minimum 0

Maximum 20

HLS Sentinel-2 Multi-spectral Instrument Surface Reflectance Daily Global 30m v2.0

Showing 20 of 556 matching granules

Sort: Start Date (Newest)

View: List

HLS.S30.T21MYT.2026003T14071
1

START 2026-01-03 14:13:15

END -

Download

HLS.S30.T21MYU.2025340T14110
1

START 2025-12-06 14:13:09

END -

Download

HLS.S30.T21MYU.2025340T1356
59

START 2025-12-06 14:02:55

END -

Download

HLS.S30.T21MYT.2025320T14110
1

START 2025-11-16 14:13:24

END -

Download

HLS.S30.T21MYU.2025313T14065
9

START 2025-11-09 14:12:50

END -

Download

HLS.S30.T21MYU.2025308T14110
1

START 2025-11-04 14:13:06

END -

Download

Search Time: 0.7s

Subscriptions

Remove

Download All 556

My Project

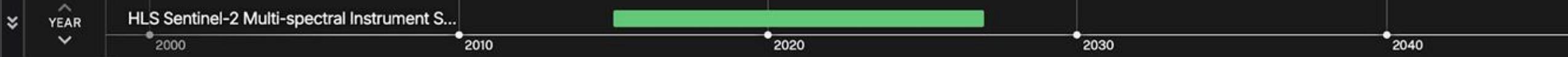
Justin

Visualization Layers

Reflectance (Nadir BRDF-Adjusted)



50 km 20 mi





HLS Data for ARSET LCLUC Cla...

326 Granules 1 Collection 0.0 MB

HLS Sentinel-2 Multi-spectral Instrument Surface Reflectance Daily Global 30m v2.0

326 Granules Est. Size 0.0 MB

Edit Options

Click "Edit Options" to select options for each collection in your project.

Download Data



50 km
20 mi



HLS Sentinel-2 Multi-spectral Instrument S...





Building a K-means Classifier in R



Part 1: Summary

Summary

- How to access HLS data with EarthData Search
- Why LCLU classification and LCLUC analysis is important to our understanding of the Earth
- What training data is and how it relates to supervised classification
- How an unsupervised (K-means) model classifies land cover
- How to apply a K-means classification to remote sensing imagery



Looking Ahead to Part 2

- In the next session we will cover Part 2 of this training which includes
 - A review of models for supervised classification
 - An explanation of Random Forest models
 - How to implement Random Forest for classification in R
 - How to evaluate and interpret model results
 - How to create maps to show LCLU change over time



Homework and Certificates

- **Homework:**
 - One homework assignment
 - Opens on 26/02/2026
 - Access from the [training webpage](#)
 - Answers must be submitted via Google Forms
 - **Due by 12/03/2026**
- **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

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Contact Information

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- [ARSET Website](#)
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Thank You!

