National Aeronautics and Space Administration

Visualizing Land Cover and Land Use Change with NASA Satellite Imagery

Part 2: Visualizing Land Cover Change

Justin Fain (NASA/BAERI)

February 24-26, 2026

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About ARSET

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- Trainings include a variety of applications of satellite data and are tailored to audiences with a variety of experience levels.

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EARTH SCIENCE APPLIED SCIENCES

CAPACITY BUILDING

Visualizing Land Cover and Land Use Change with NASA Satellite Imagery

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 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

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 Today – 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 2: Visualizing Land Cover Change

Part 2 – Trainers

Justin Fain

Research Scientist

NASA Ames / BAERI

Part 2 Objectives

By the end of Part 2, participants will be able to:

- Apply a random forest model to NASA imagery to create LCLU maps at two different time periods
- Analyze (numerically and visually) the change in LCLU over time

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 2:
Introduction

Important Terms and Acronyms

- Land Cover (LC)
  – what is on the ground

- Land Use (LU)
  – Depends on the functional use; not the ground itself

- Land Cover and Land Use (LCLU)
  – Terms often paired together
  – sometimes reversed as "LULC"

- LCLU Change (LCLUC)
  – measured over time
  – Left image has example of LC Change

- Classification
  – dividing things into categories or classes
  – Example: water, vegetation, etc.

- Classifier
  – Tool that assigns classes (i.e., person, model, process)

LC Change
- barren
- forest
- veg
- water
- NA
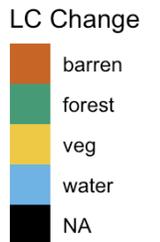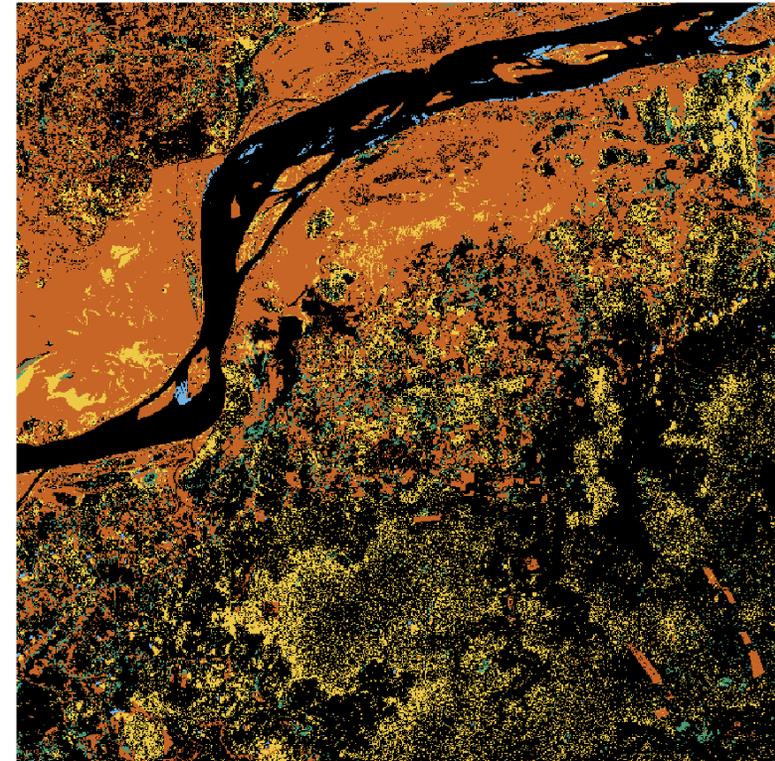
Classification Methods (Continued)

Supervised Classification

	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

Supervised Classification: KNN Overview

- K-nearest neighbor (KNN, supervised) uses the class labels of other known samples (the training data) to decide how to classify new samples

- K-means (unsupervised) has no pre-determined classes for new samples; just looks for similarities

- How KNN works:
  - Given an unclassified sample, check the K-number of nearest points in the training data
  - K is any integer greater than 1
    - An odd number helps avoid ties
  - The majority vote wins
    - The unclassified sample becomes the class with the most known samples nearby
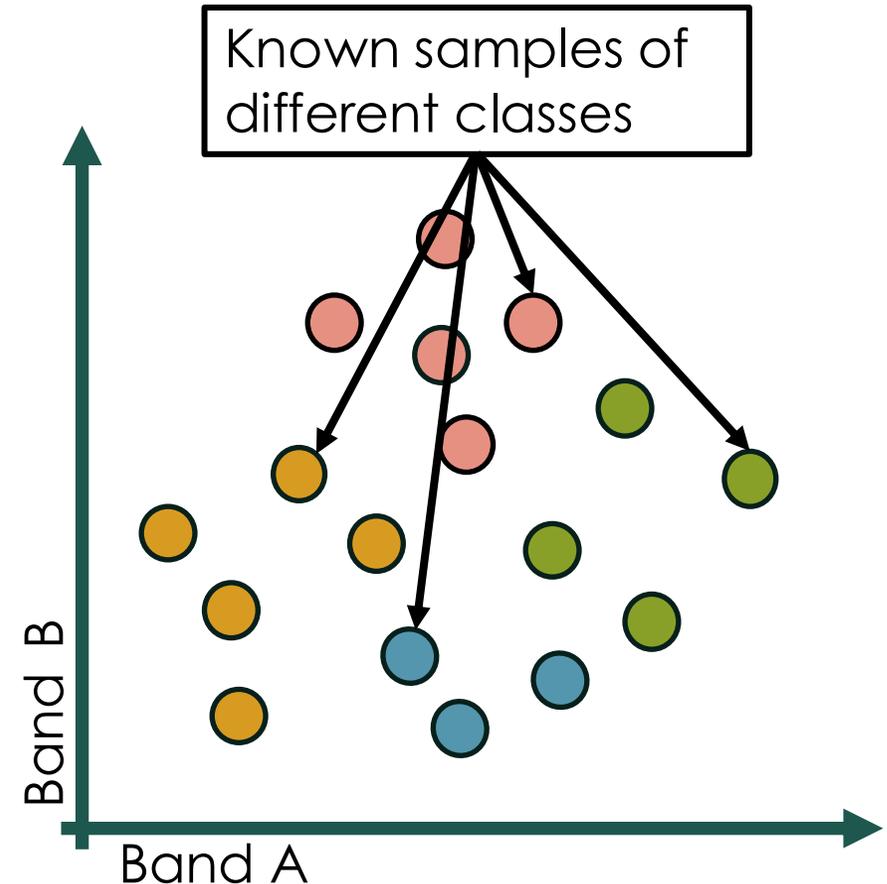
"everything is related to everything else, but near things are more related than distant things"

- Waldo Tobler's "First Law of Geography"

Supervised Classification: KNN Step-by-Step

Watch how KNN classifies a new point:

- We will set K equal to 3

- Find the K (3) closest known points

- Tally the votes
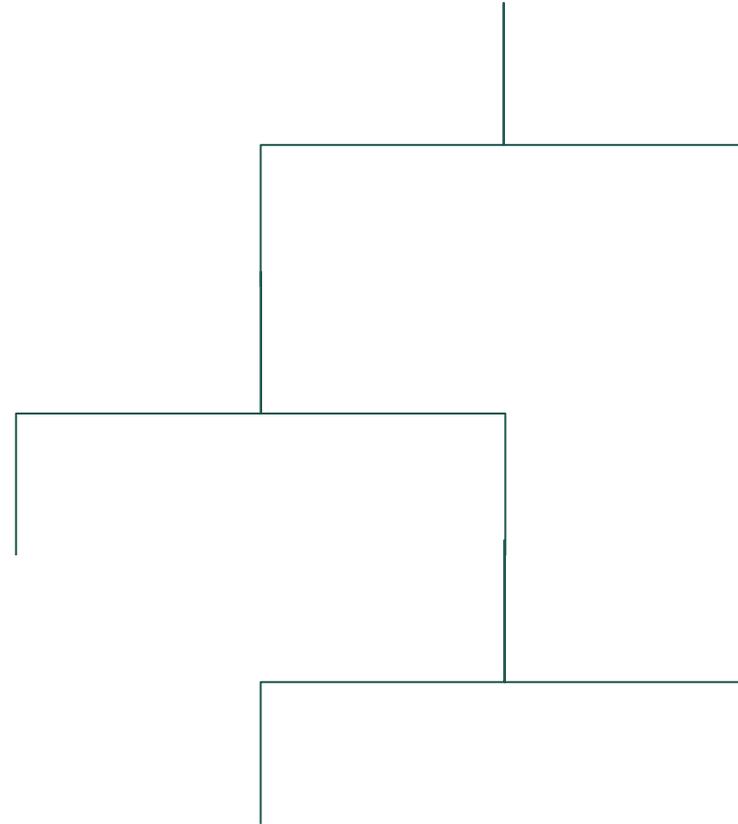
- Assign the new point to the winning class

K = 3


Band B

Band A
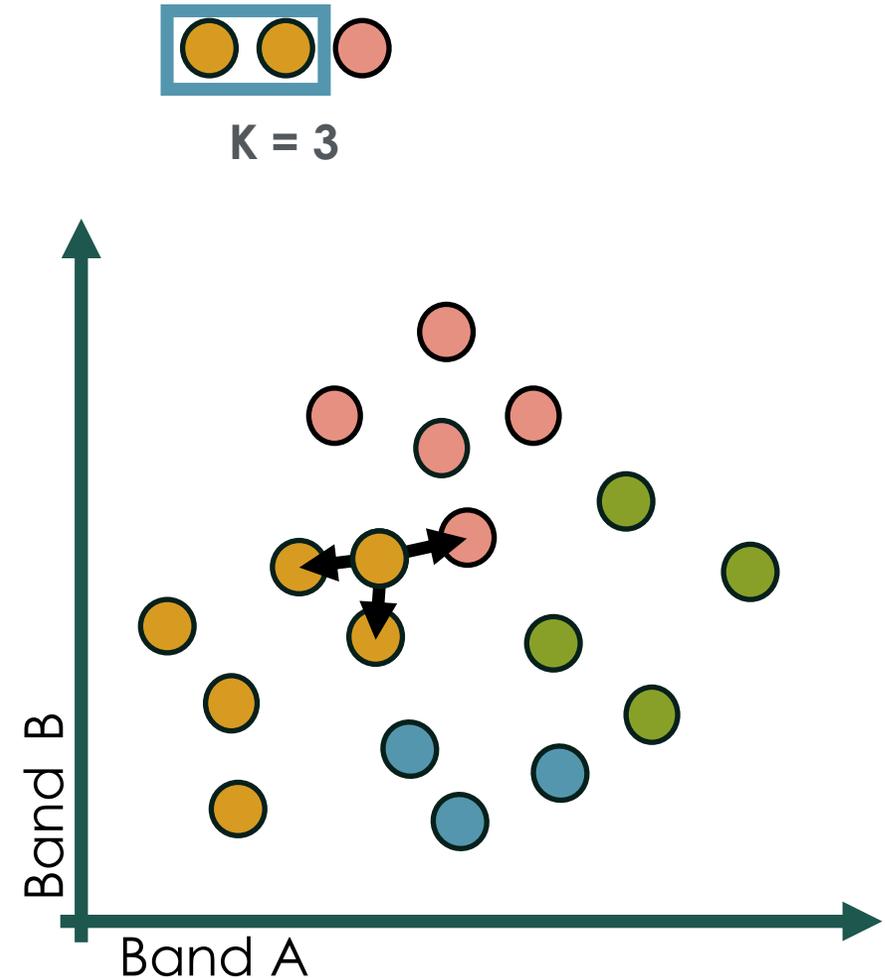
Random Forest

Random Forest: Overview

- Random Forest is a tree-based model

- It builds an array of decision trees

- The decision trees each give a possible solution for dividing the training data

- New data is classified by applying the decision tree(s)

Random Forest: Training Data

- Let's assume we have a training data set consisting of aliens and acorns

- Random Forest knows they are different, because we have labeled this training data

- There are a few features that separate aliens and acorns
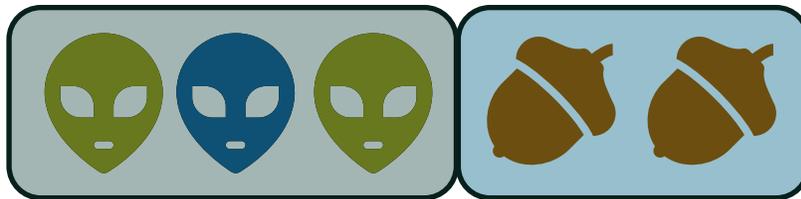
- Aliens can be blue or green
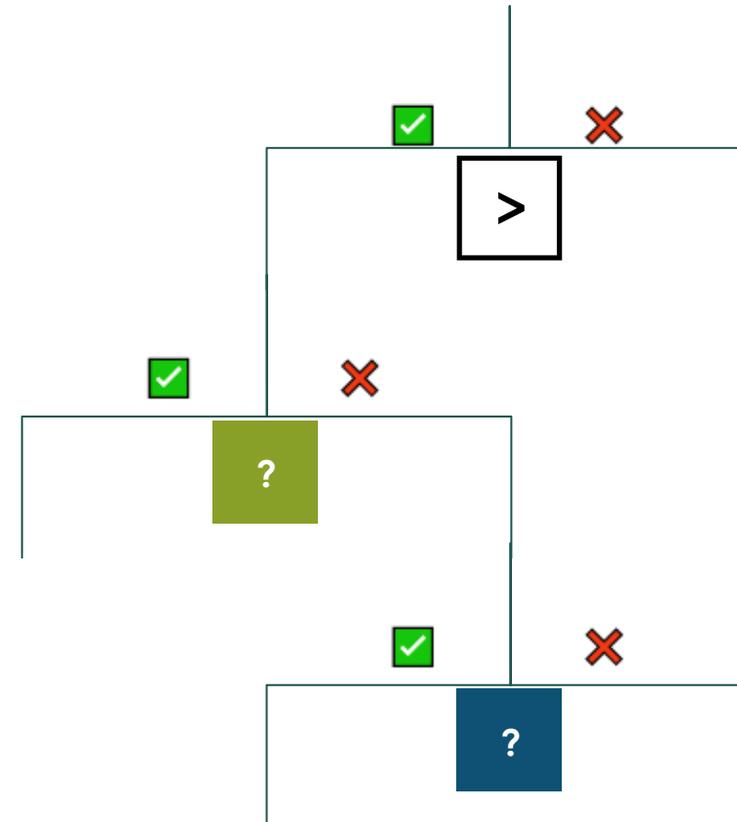- Acorns are smaller than aliens
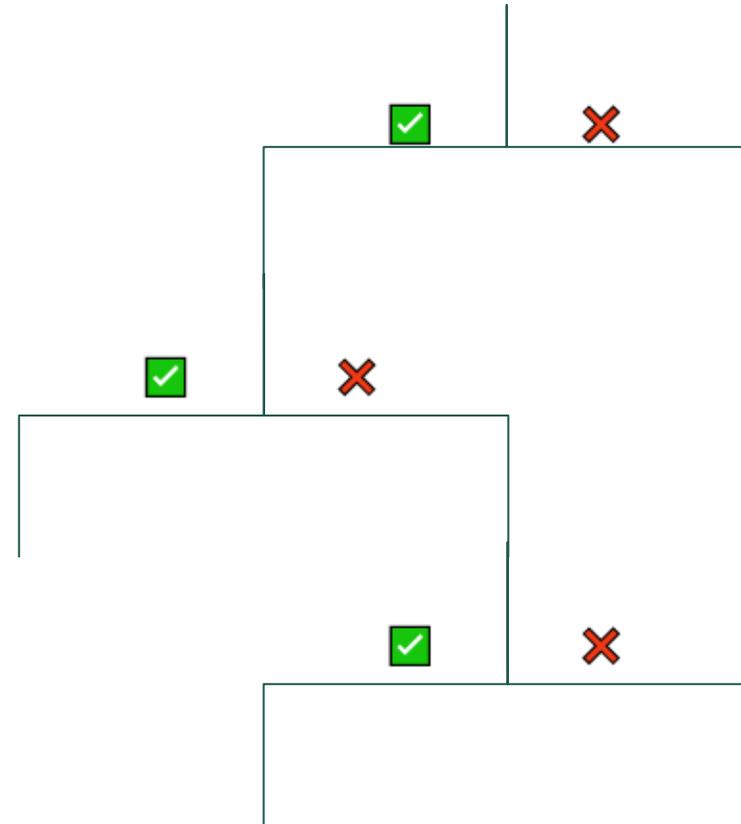
Random Forest: Decision Tree

- Each split in the decision tree represents a binary (T/F)
- The first might be, "Is it larger than some size?"
- Next might be, "Is it green?
- Finally, "Is it blue?"
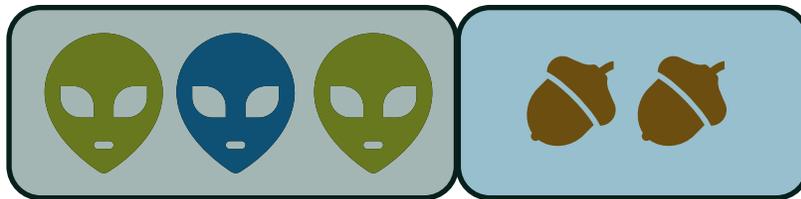
- Aliens can be blue or green
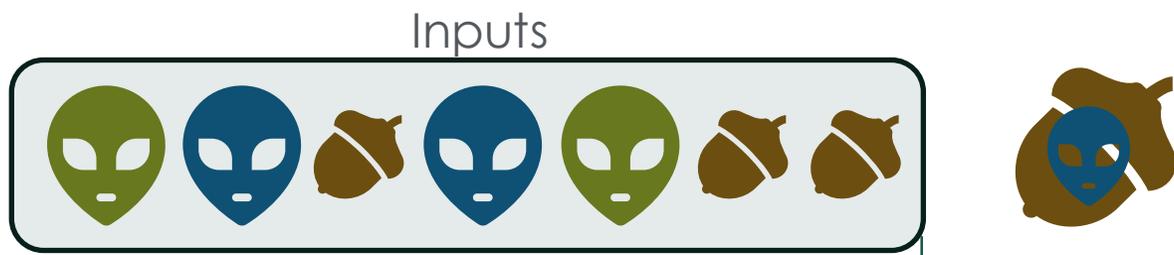- Acorns are smaller than aliens

Random Forest: Defining Classes

- Now we have a tree which can sort objects into aliens and acorns

- Anything which gets sorted into the left-hand side is more likely to be an alien than an acorn

- Conversely, things which are sorted to the right are more likely to be acorns than aliens
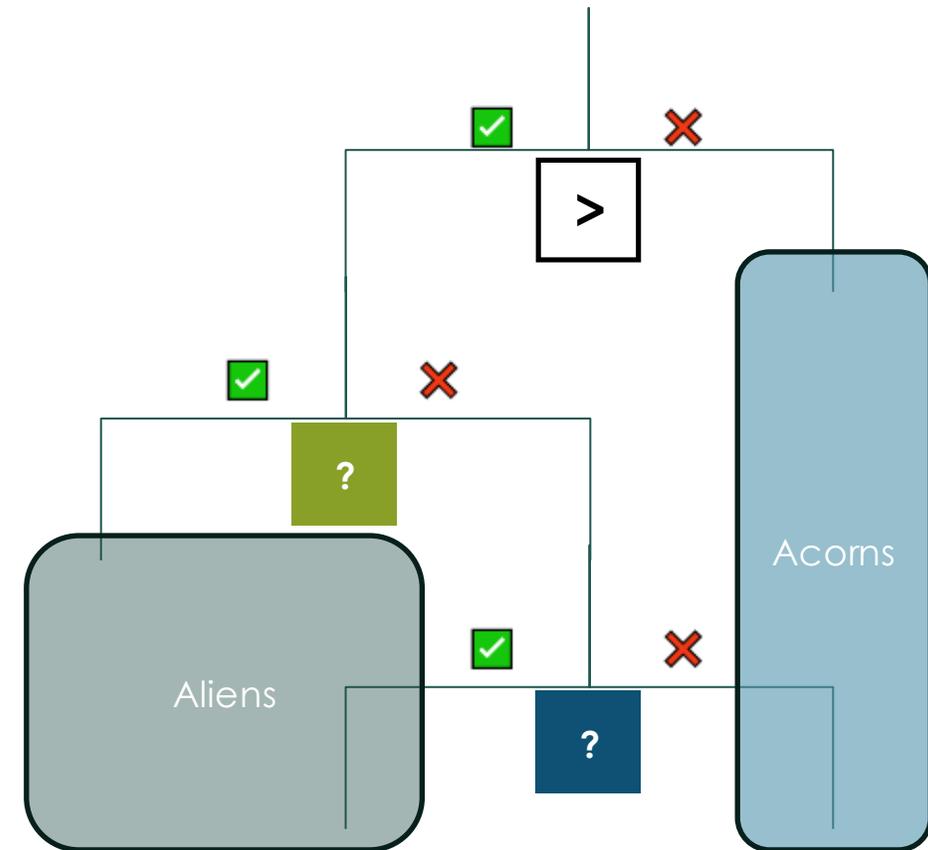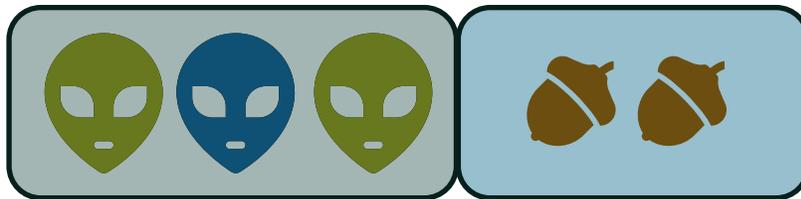
Random Forest: Step-by-Step

- Now we can apply this to some data that the model hasn't seen before and observe what happens.

- The decision tree correctly sorted all the objects

- There is a pathway that was never used
  - This would represent acorns that are bigger than aliens
  - In this case we got lucky and the big acorn is still being correctly classified

- We might also ask, "What about small aliens?"
  - And now we see that we have a problem
  - There were no small aliens in the training data, so our model didn't classify it correctly

>

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Acorns

Aliens

?
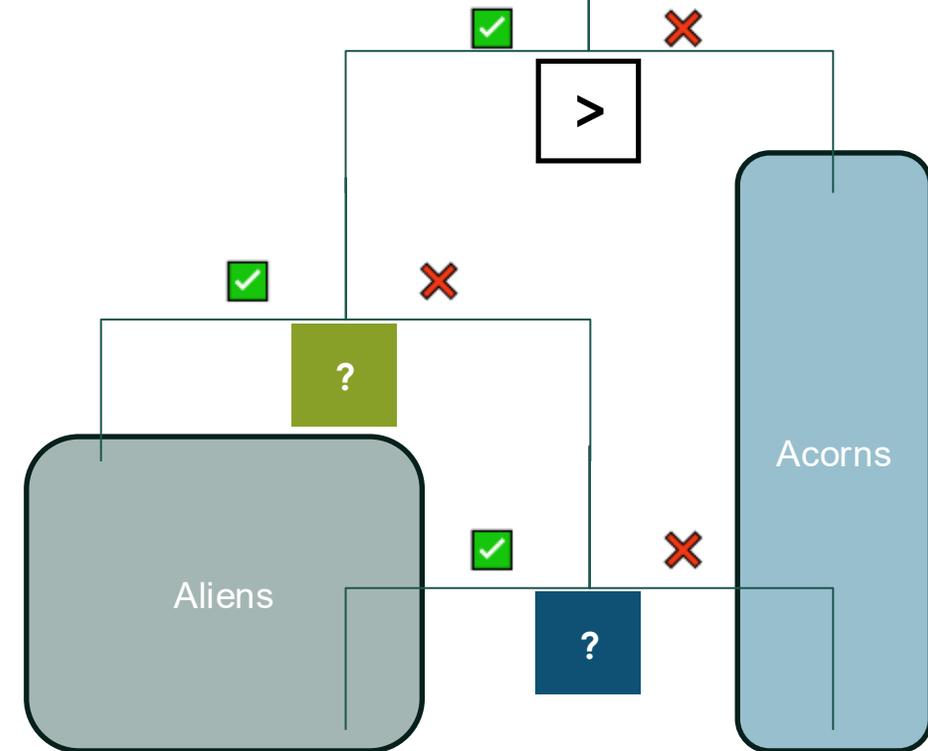
Training Data Quality

- Good training data is:
  - high-quality (accurate)
  - representative (varied)
- A model trained on good data:
  - Is more robust to variations in the LC itself
    (like water turbidity)
  - Is more robust to errors introduced between the LC and the sensor
    (like atmospheric effects)
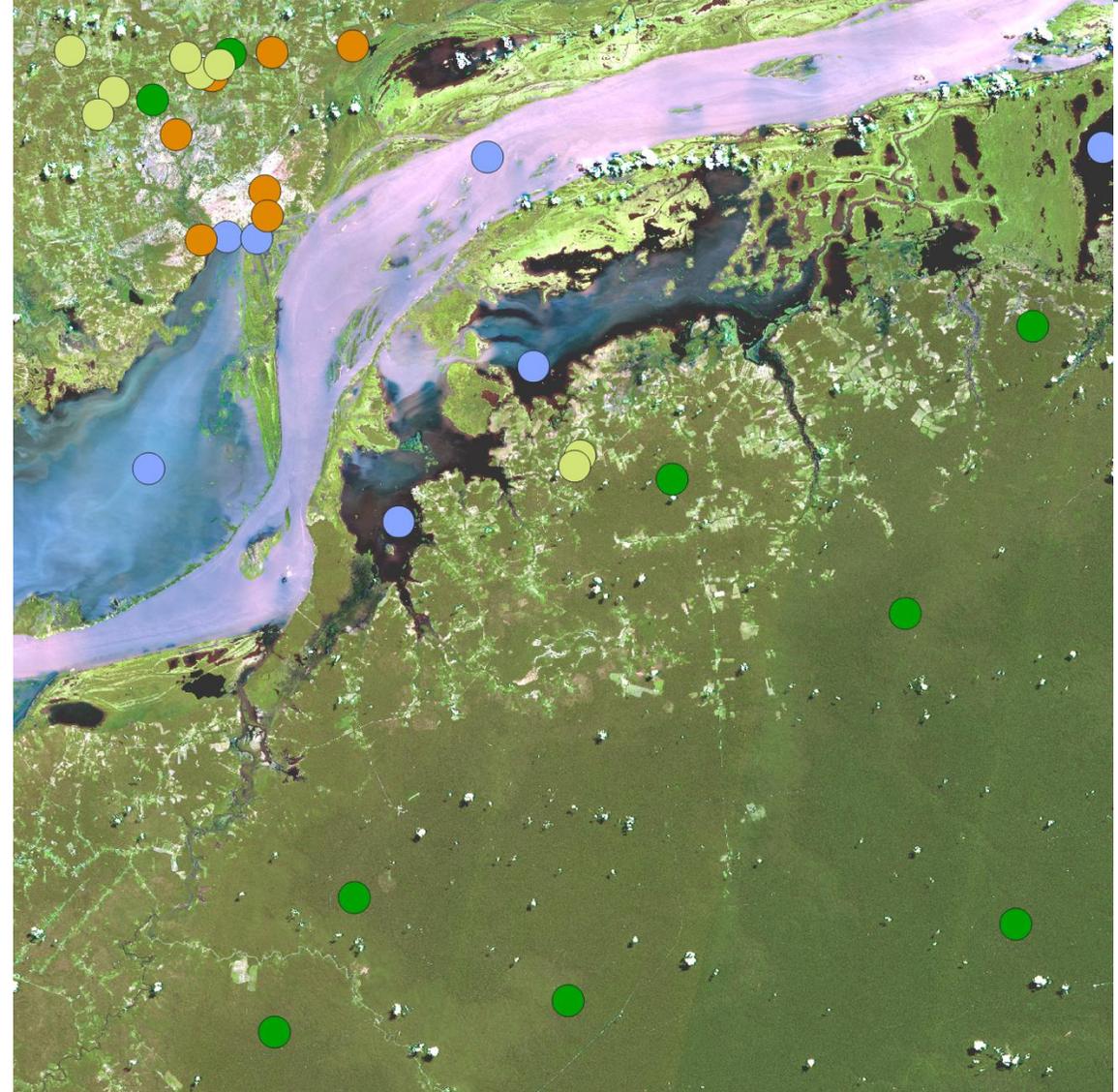
Spectral Differences

- Here is an example of two of the reflectance curves for turbid and clear water

- You can see that there are large differences which might degrade the classification
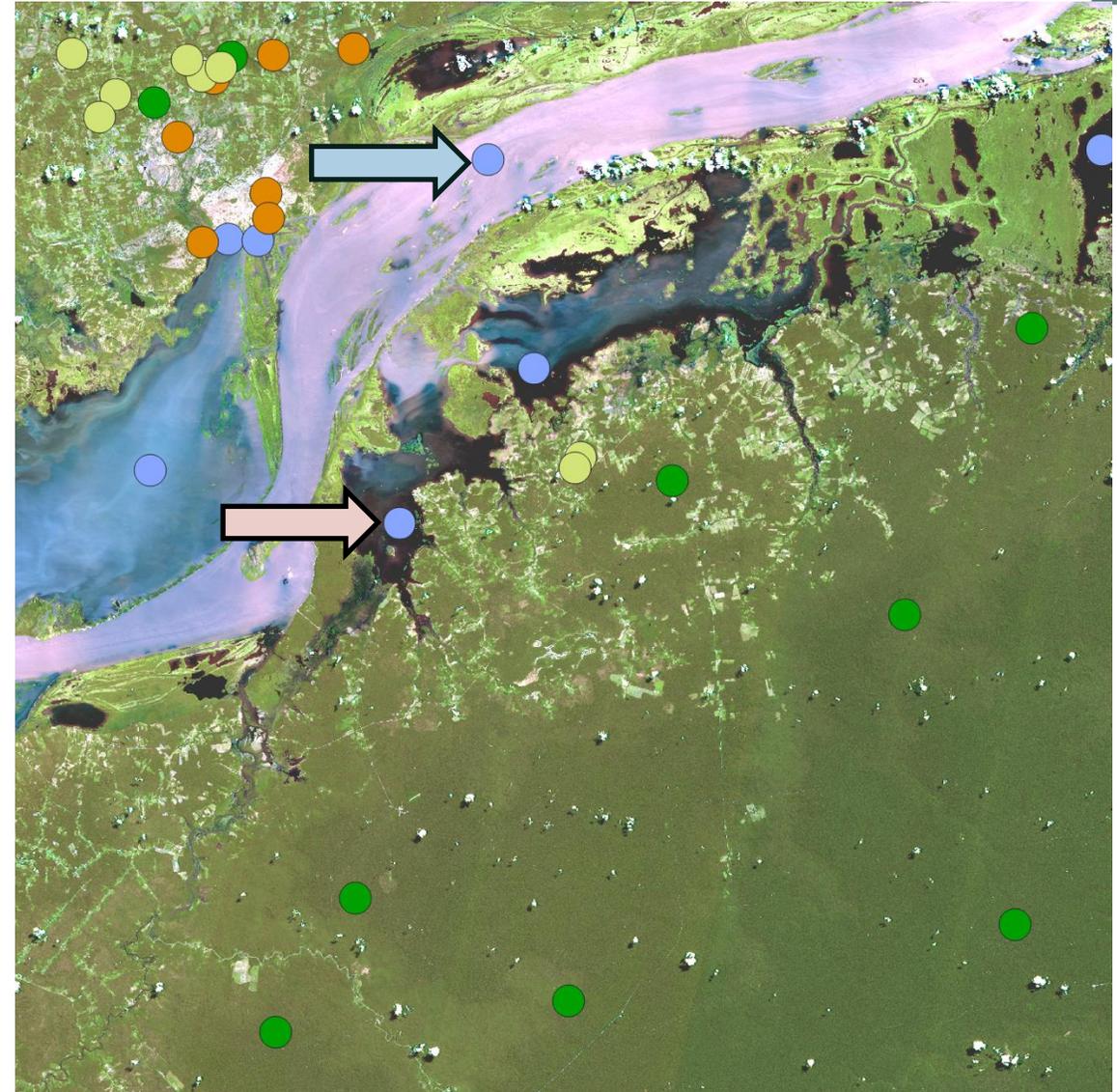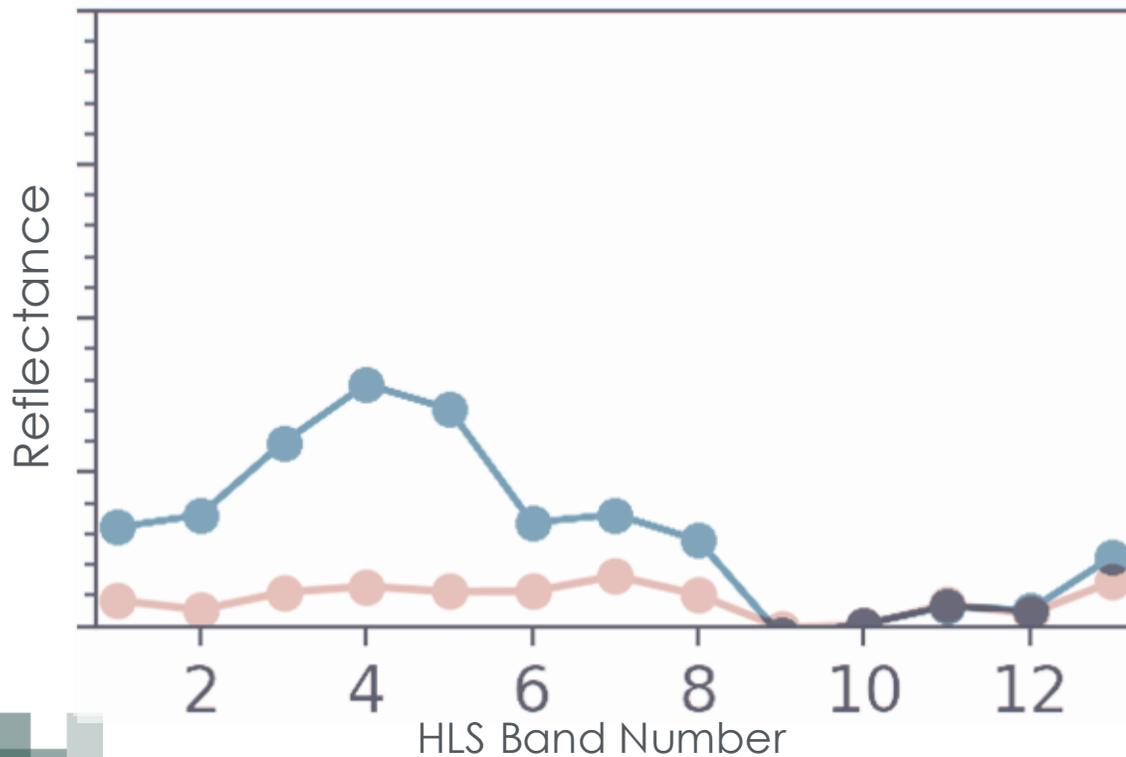
Building a Random Forest Model in R

Roadmap for the following demo

Load imagery data (2017, 2024) → Load training data points → Merge training data with imagery → Train an RF model → Apply the trained model to imagery

Quantifying Land Cover Change in R

Roadmap for the following demo

Apply the trained model

Compare model results for two dates

Compute a change matrix

Interpret the overall changes

Mapping LCLUC

Mapping LCLUC: Where Change Happened

- We can use simple mathematical and logical operations to monitor the changes in LC from two classified LC maps

- The most common and simplest method is inequality
  - Boolean NOT EQUAL or ≠
  - In R syntax that is written !=
  - Output is T/F or 1/0

- These operations are applied cell-by-cell
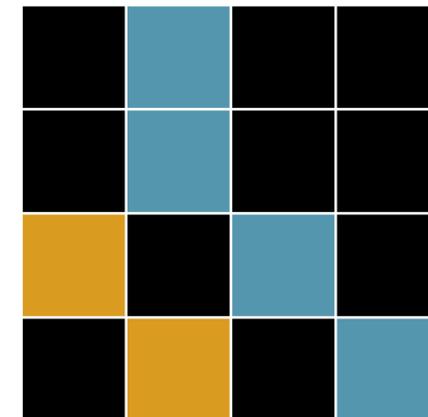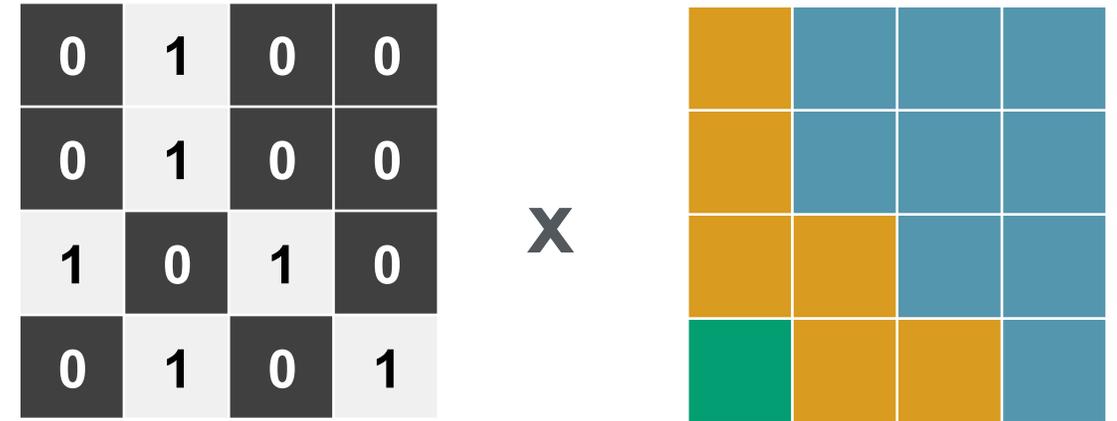 - Highlights which of the cells have changed LC over time
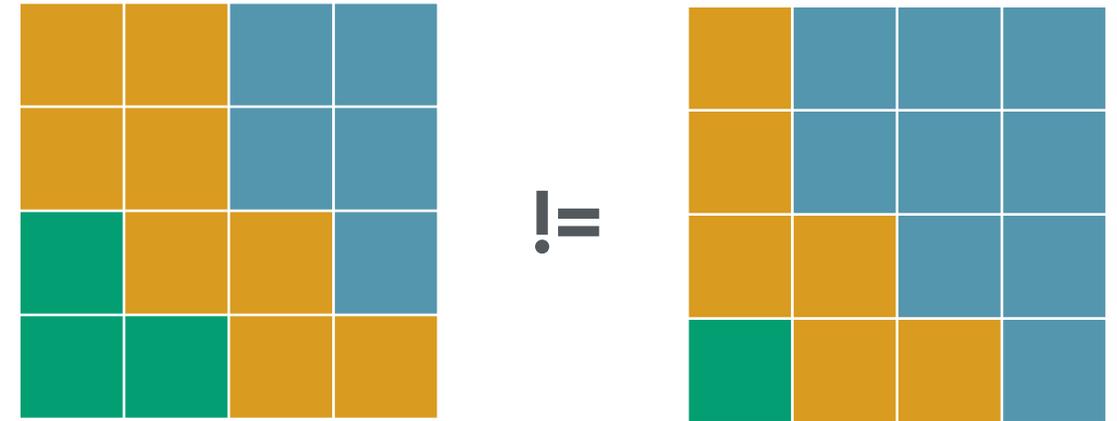
Mapping LCLUC: Type of Change

- The change map can be applied as a mask to one of the previous LC maps
- Since the values in the change mask are only ever 0 and 1 we can simply multiply the two maps together
  - Changed pixels keep their original class
  - Unchanged pixels are set to 0

Part 2:
Summary

Summary

- Recognize the importance of training data for supervised classification.

- Compare K-means and KNN methods for clustering and classification.

- Construct decision trees as used in random forest models.

- Apply a random forest model to NASA imagery to create LCLU maps at two different time periods.

- Analyze (numerically and visually) the change in LCLU over time.

Visualizing Land Cover and Land Use Change with NASA Satellite Imagery
Summary

Training Summary

- 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 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.

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 both 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.
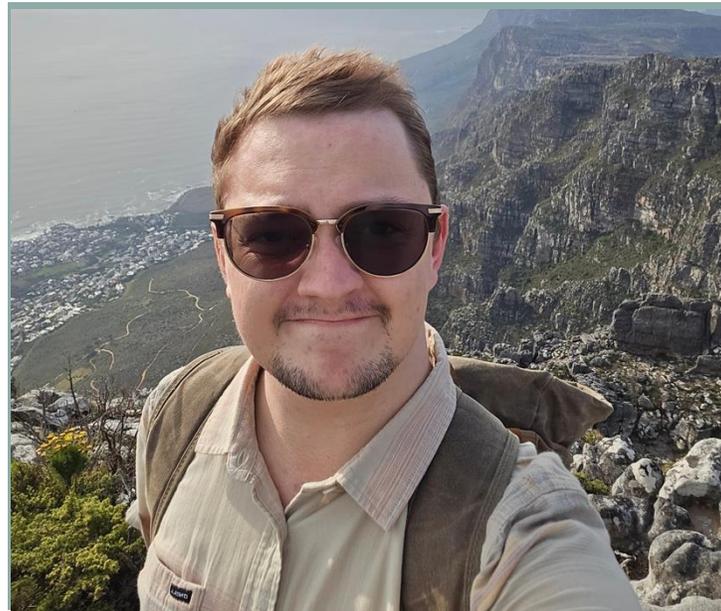
Acknowledgements

Justin Fain

Research Scientist

NASA Ames / BAERI

Contact Information

Trainers:

- Justin Fain
    - justin.j.fain@nasa.gov

- ARSET Website
- ARSET YouTube

For questions, comments, or to share how you have applied our trainings to your work or studies, email nasa.arset@gmail.com.

Join our quarterly newsletter to stay up-to-date on our latest trainings:

1. Send an email with no subject line to arset-join@lists.nasa.gov.
2. Follow the instructions sent in response.

Resources

- GeeksforGeeks Random Forest Algorithm

- IBM's Guide Machine Learning

- Spatial data science with {terra} in R

- Josh Starmer's StatQuest videos

Thank You!