National Aeronautics and Space Administration

Airborne Data Applications for Invasive Species Mapping

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Sativa Cruz[2,3], Justin Fain[2,3], Juan Torres-Perez[2],Savannah Cooley[2,3]
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September 30, 2025

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.

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.

Prerequisites

- Biodiversity Applications for Airborne Imaging Systems
- Basic Python programming experience
- Supplemental Materials
  - Fundamentals of Machine Learning for Earth Science
  - Introduction to Invasive Species Monitoring with Remote Sensing
  - Hyperspectral Data for Land and Coastal Systems

Training Outline

Airborne Data Applications for Invasive Species Mapping

September 30, 2025

11:00-13:00 EDT

15:00-17:00 EDT

Homework

Opens September 30 – Due October 14 – 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.

Trainers

Michele Thornton

Airborne Data Lead

Oak Ridge National Laboratory

Rupesh Shrestha

Remote Sensing Scientist

Oak Ridge National Laboratory

ARSET Eco Team

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BAER/NASA Ames Research Center

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.

Training Learning Objectives

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

- Recognize how image classification of airborne imaging spectroscopy and labeled field data can be used to map invasive species.
- Use a Jupyter Notebook to access NASA JPL AVIRIS-NG data located on the NASA Earthdata cloud for a spatial and temporal region of interest.
- Apply a cloud based workflow in a provided Jupyter Notebook to classify species using a trained machine learning model for the Greater Cape Floristic Region, South Africa.
- Identify key considerations for interpreting machine learning end products for invasive species mapping for land management decisions.

NASA Earthdata Cloud

NASA Earthdata Cloud

- NASA's cloud-based archive of its Earth Observations
- Hosted by Amazon Web Services (aws)

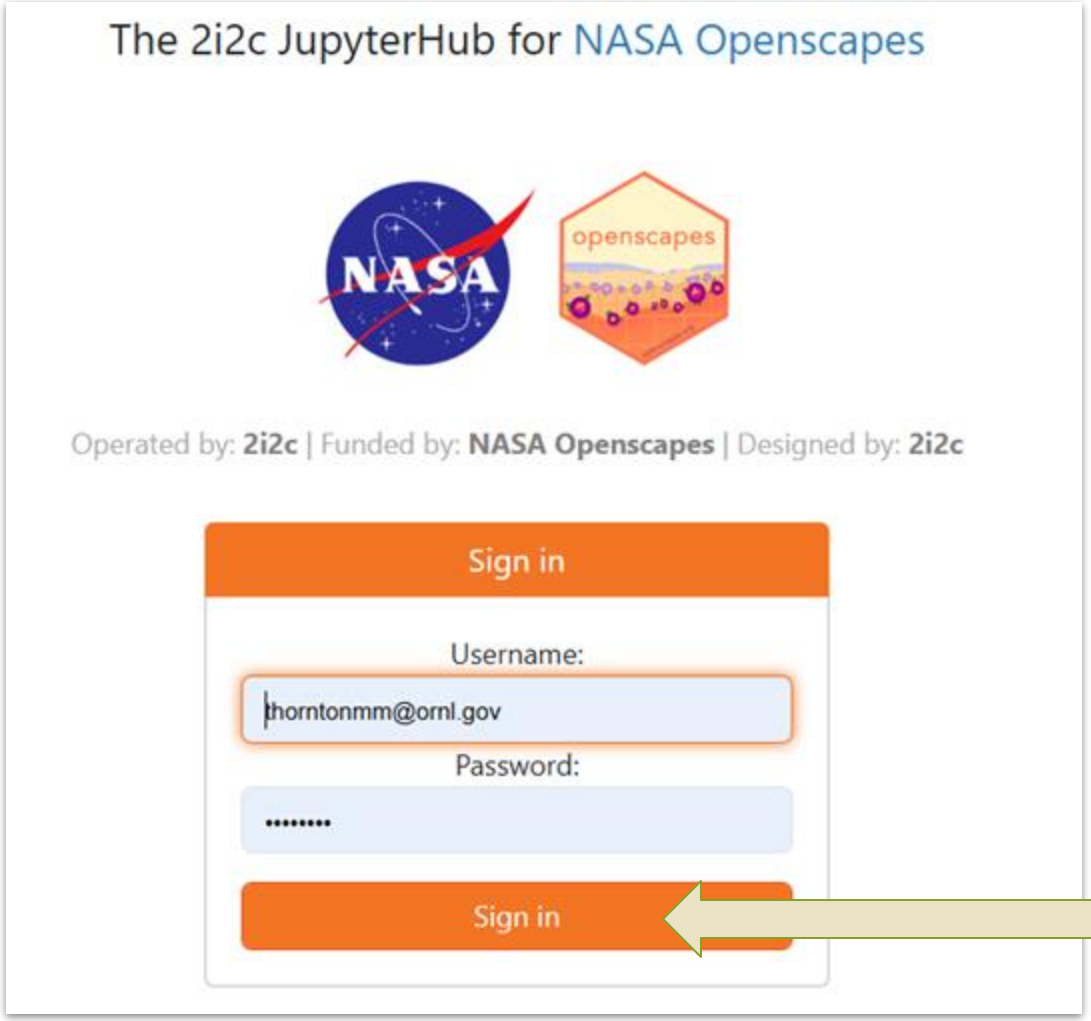
NASA Earthdata Cloud Supports

- NASA's Open-Source Science Initiative
- Eases access to data: data are co-located
- Re-focuses user data access methods: data analysis-in-place
- Toward providing a common suite of NASA Earthdata tools and services
- Allows multi-disciplinary multi-mission science

Learn More: https://www.earthdata.nasa.gov/learn/earth-observation-data-basics/cloud-computing

NASA Openscapes and JupyterHub Workshop Environment

Navigate to the Hub: https://workshop.openscapes.2i2c.cloud/

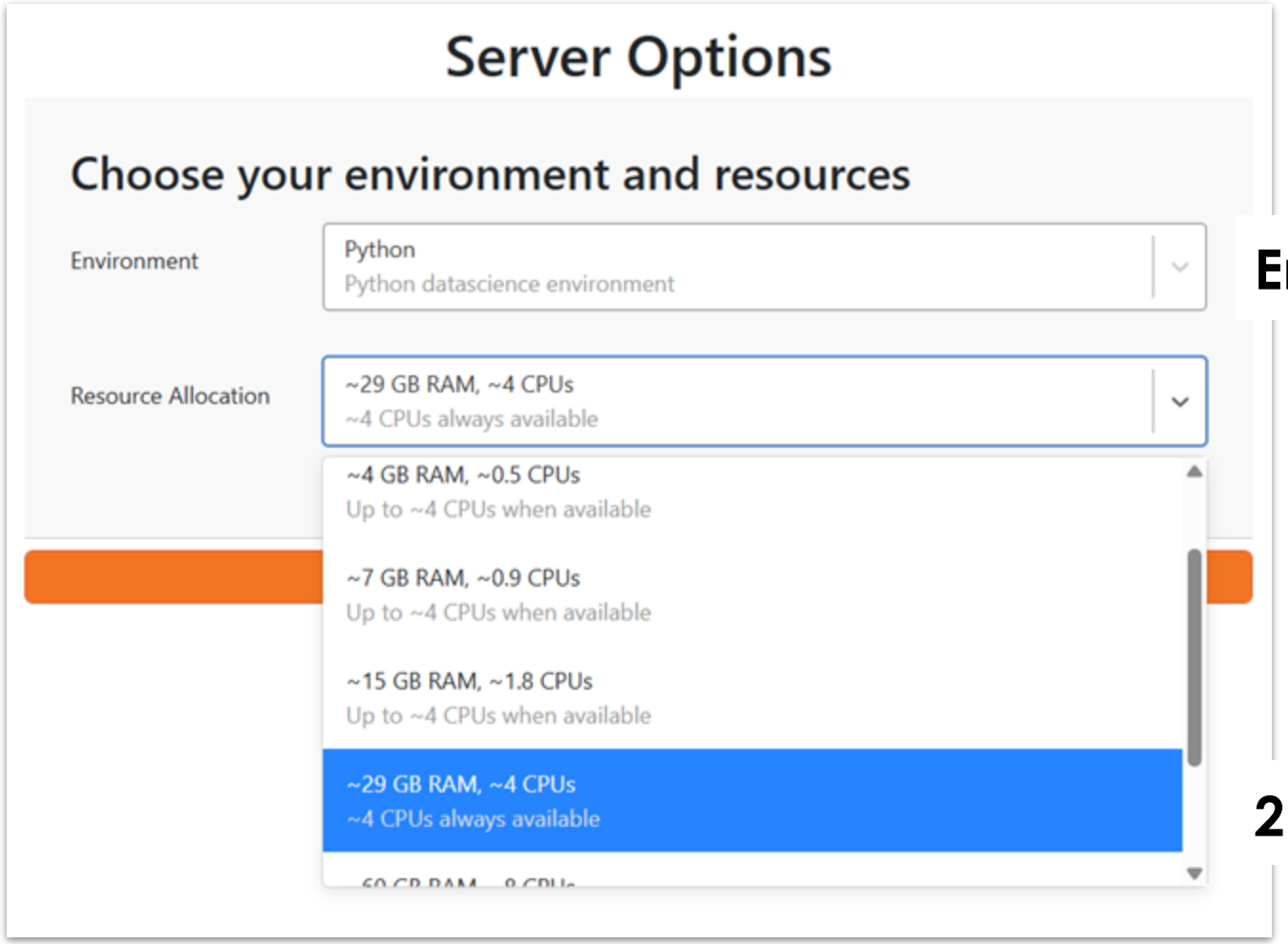


Managed Cloud Service

Each participant will have their own managed environment for the Notebook tutorial

Participants in the live presentation were provided login information.

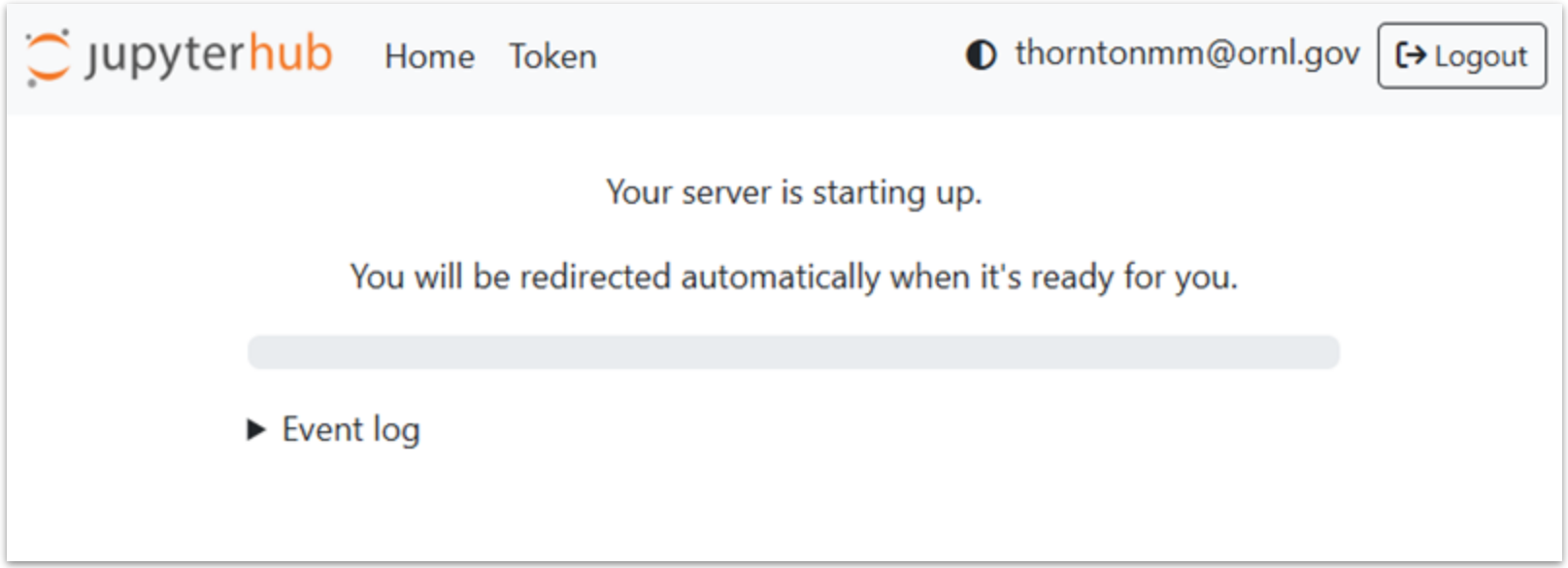
NASA Openscapes and JupyterHub Workshop Environment



Environment: Python

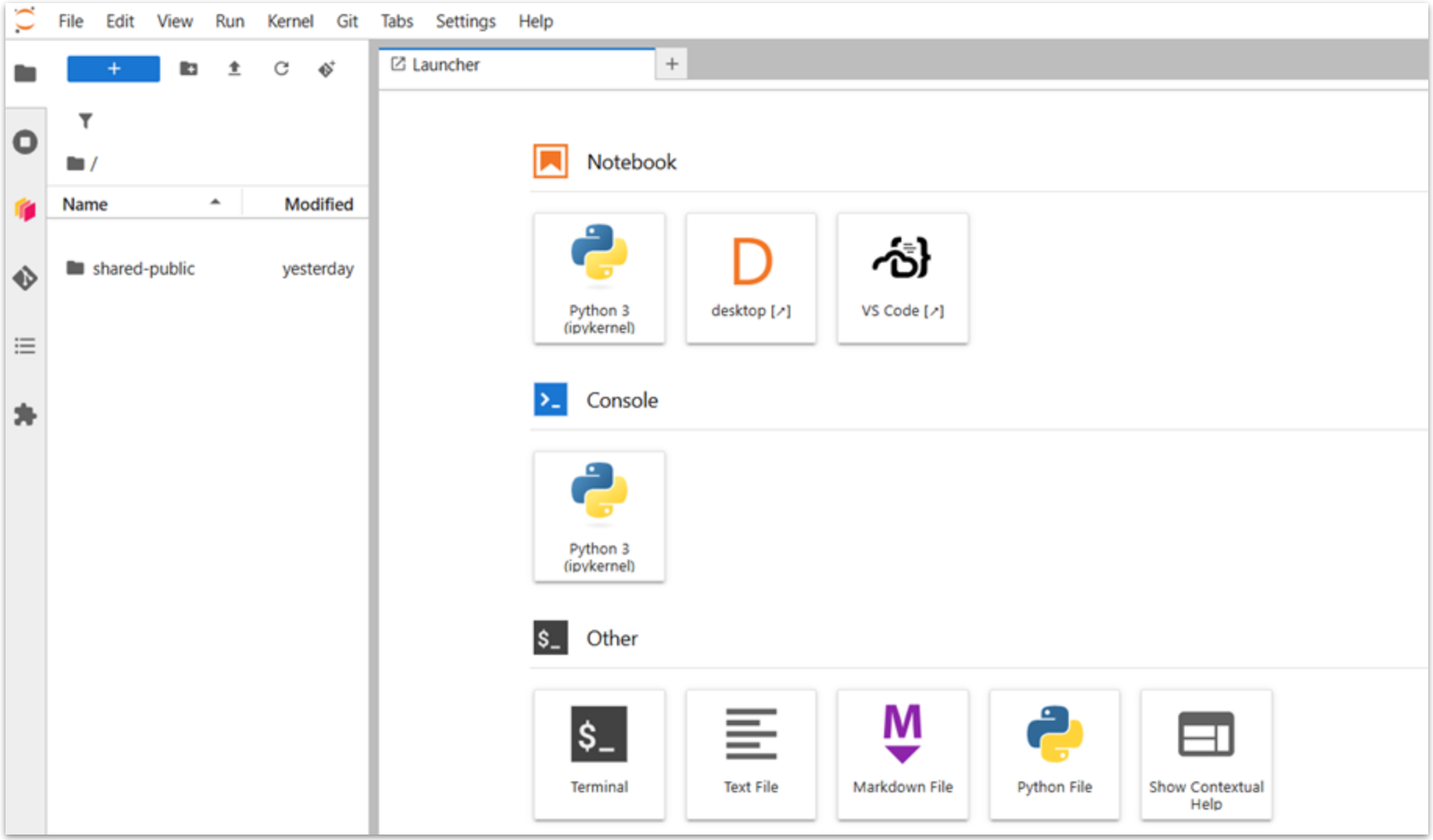
29 GB RAM, ~4 CPUs

NASA Openscapes and JupyterHub Workshop Environment



Keep trying if you get an error !!

NASA Openscapes and JupyterHub Workshop Environment



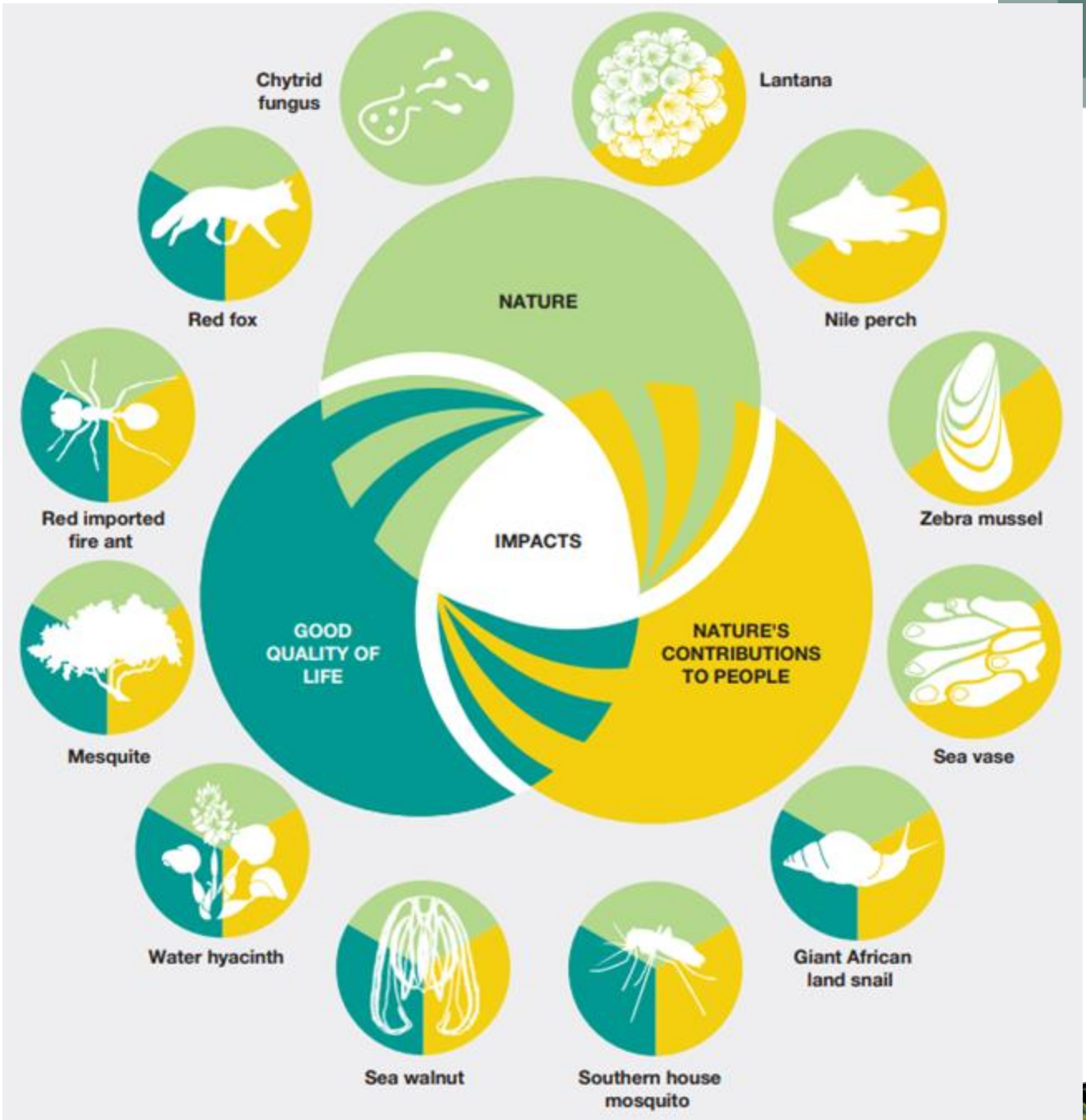
Airborne Data Applications for Invasive Species Mapping Overview

Impact of Invasives Species

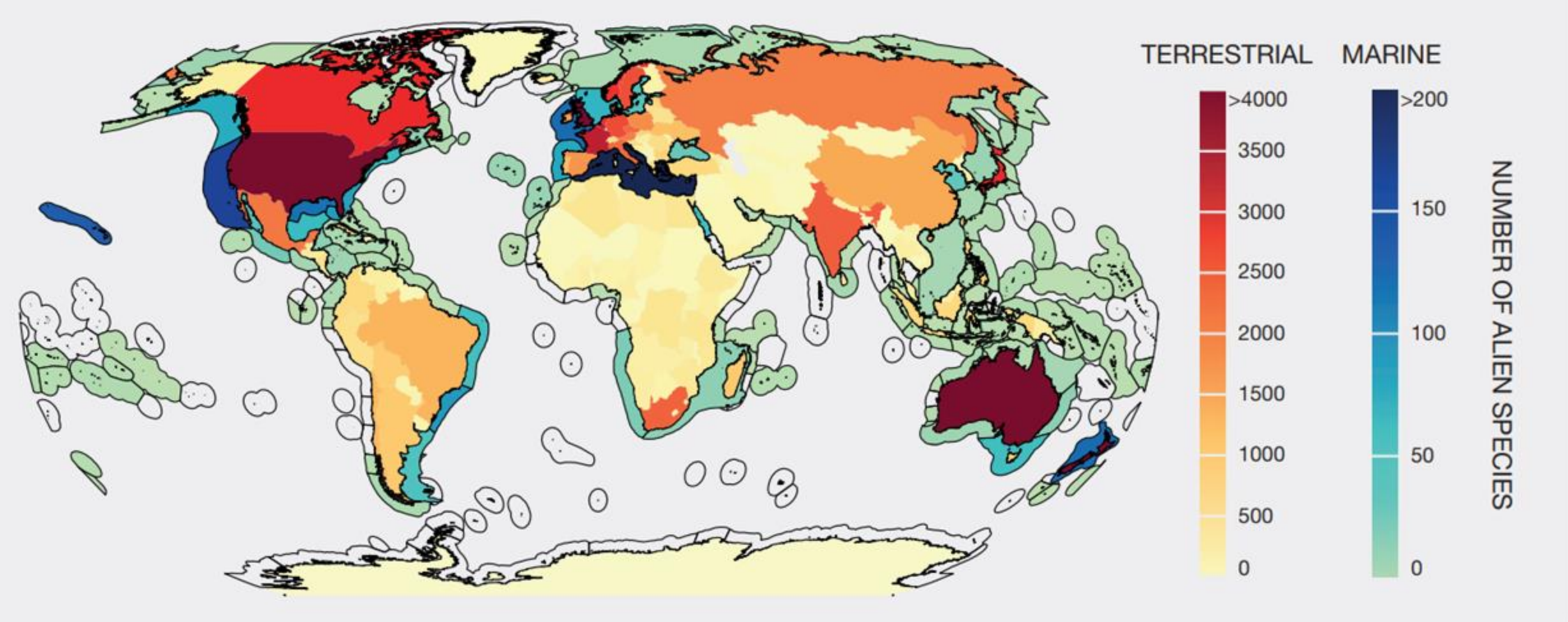
"Invasive alien species are a significant factor that directly or indirectly caused **60 percent** of documented global animal and plant extinctions"

Estimated economic impact of **$423 Billion Dollars**.

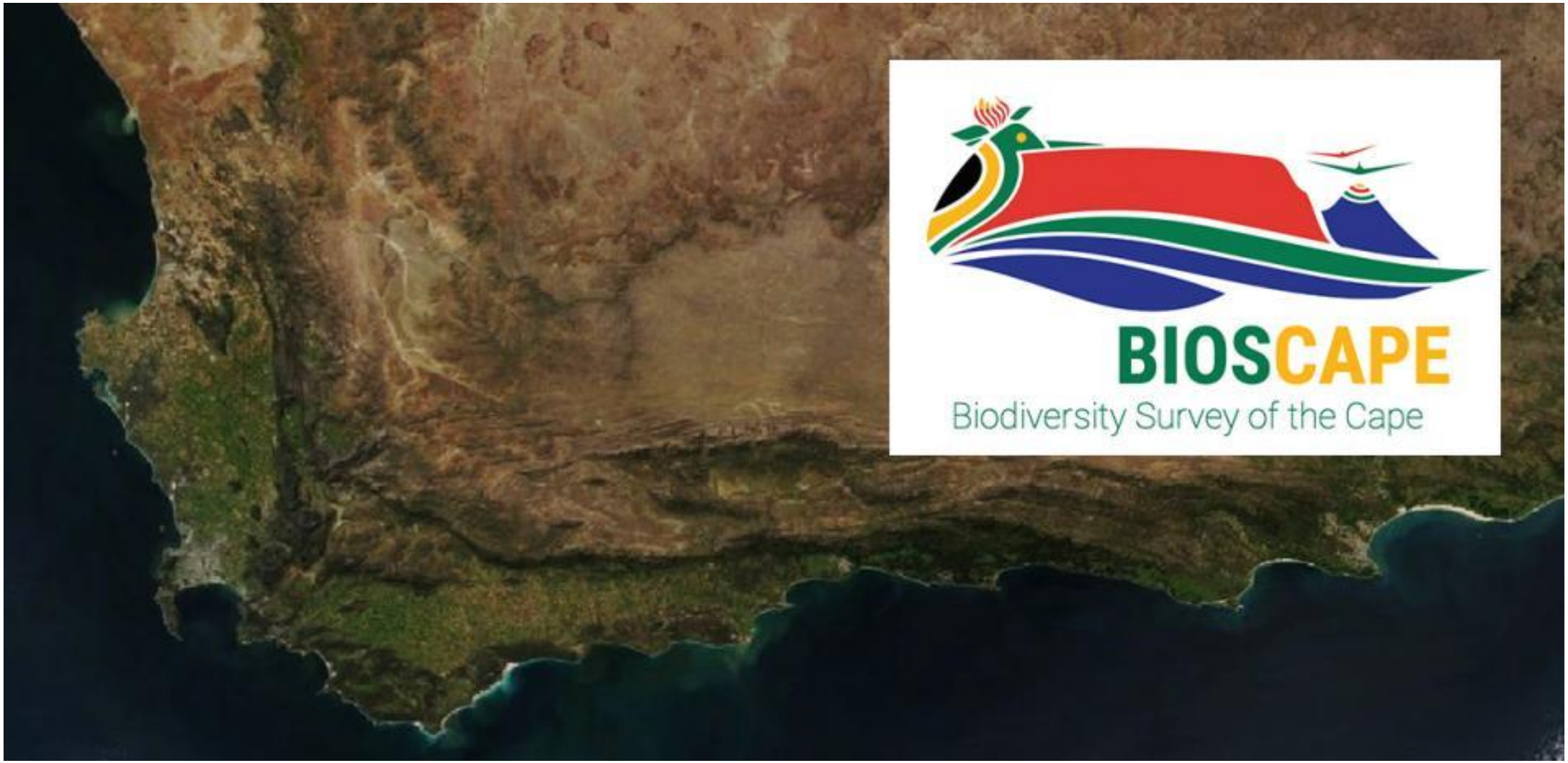
[IPBES Report]

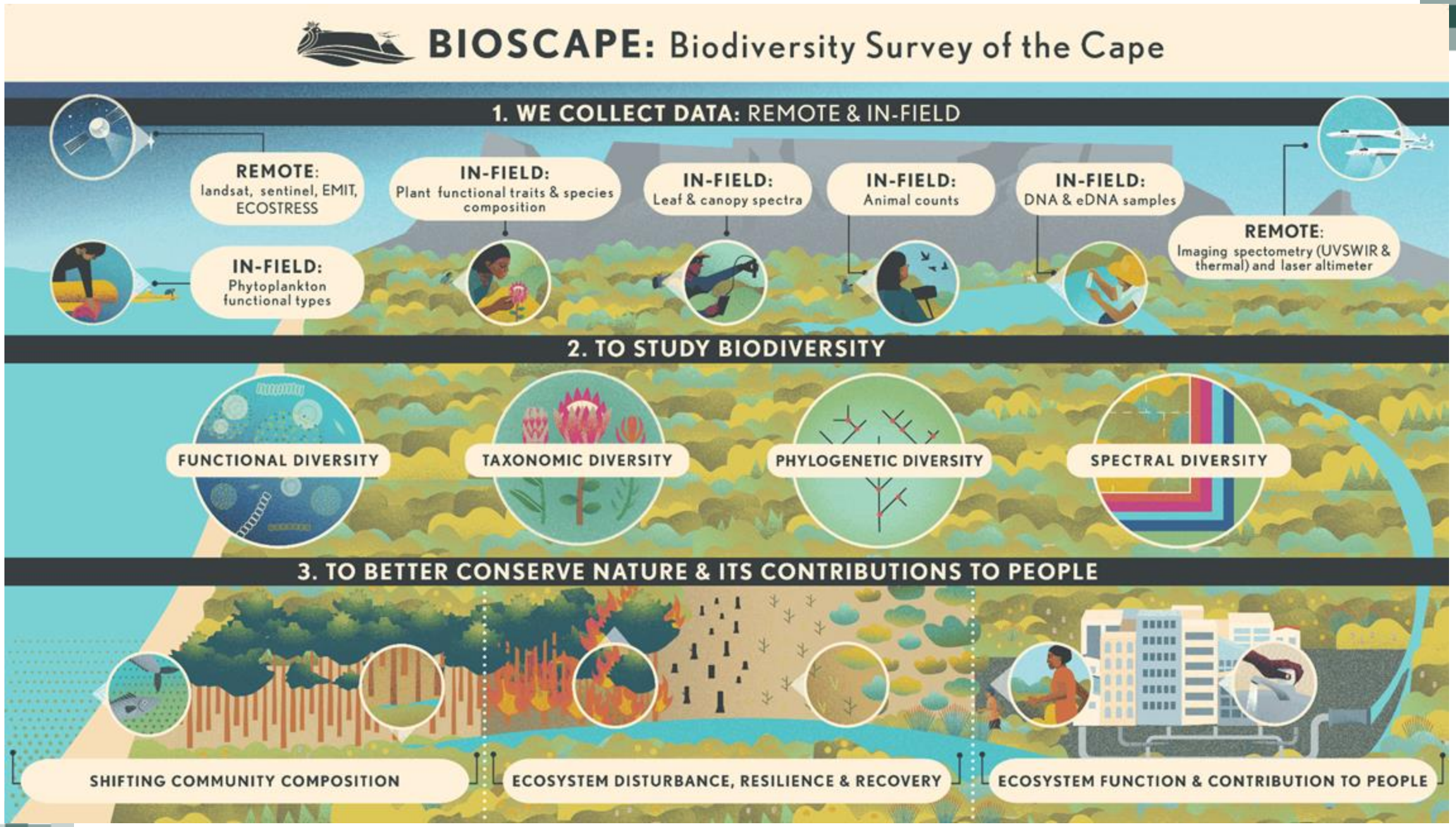


Invasive Species Around the World



Biodiversity Survey of the Cape (BioSCape)




BIOSCAPE: Biodiversity Survey of the Cape
1. WE COLLECT DATA: REMOTE & IN-FIELD
REMOTE: landsat, sentinel, EMIT, ECOSTRESS
IN-FIELD: Phytoplankton functional types
IN-FIELD: Plant functional traits & species composition
IN-FIELD: Leaf & canopy spectra
IN-FIELD: Animal counts
IN-FIELD: DNA & eDNA samples
REMOTE: Imaging spectometry (UVSWIR & thermal) and laser altimeter
2. TO STUDY BIODIVERSITY
FUNCTIONAL DIVERSITY
TAXONOMIC DIVERSITY
PHYLOGENETIC DIVERSITY
SPECTRAL DIVERSITY
3. TO BETTER CONSERVE NATURE & ITS CONTRIBUTIONS TO PEOPLE
SHIFTING COMMUNITY COMPOSITION
ECOSYSTEM DISTURBANCE, RESILIENCE & RECOVERY
ECOSYSTEM FUNCTION & CONTRIBUTION TO PEOPLE

South Africa's Greater Cape Floristic Region

Biodiversity Hotspot

~ 2/3 of the estimated 9,000 species that grow there are endemic

Most of the region is treeless and covered in a type of evergreen shrubland called fynbos

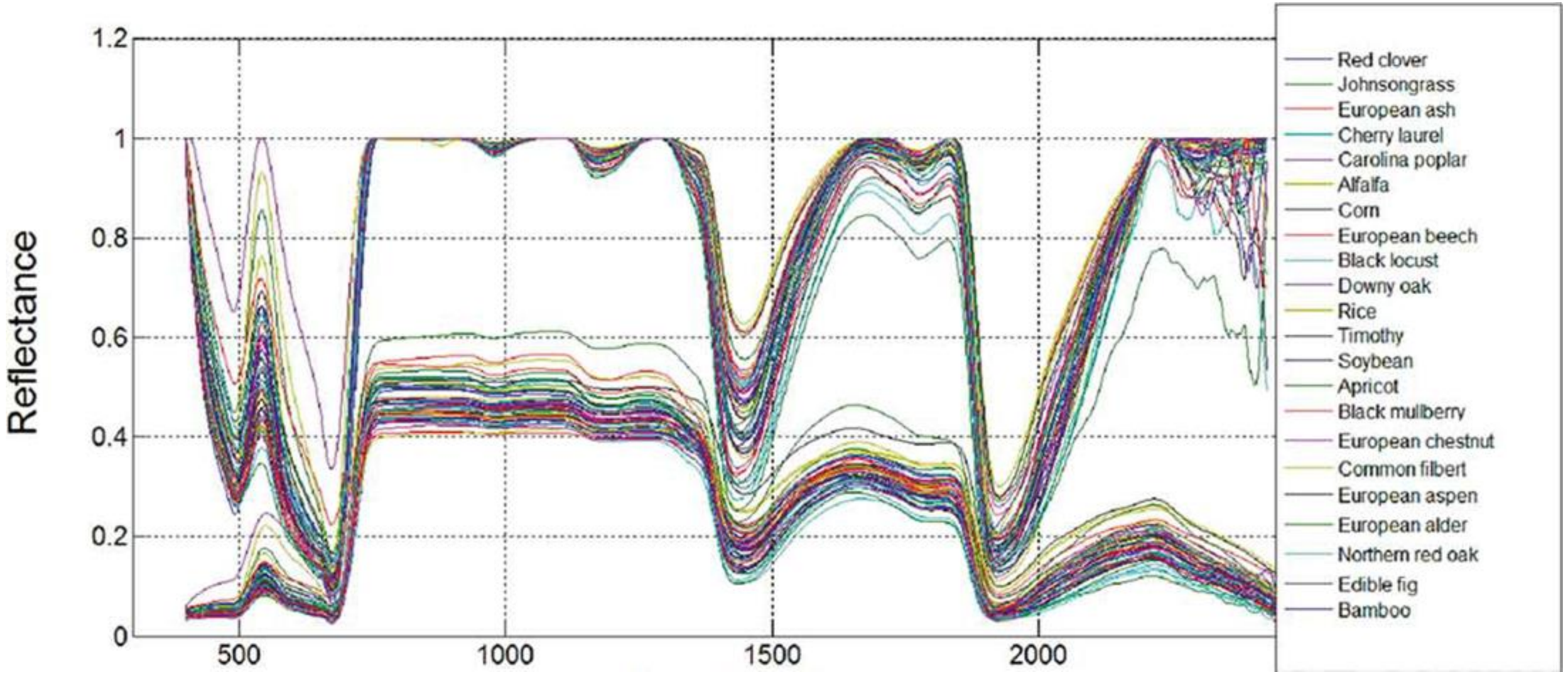
Non-native trees (acacia, pine, and eucalyptus) have spread into the floristic region, threatening endemic species and using more water than native plants

[NASA Earth Observatory October 2, 2023]

Classification

- Differences in spectral signatures are used to differentiate between surfaces through a process called classification
- With enough information it is sometimes possible to tell the difference between species of plants

Remote Sensing Detection by Spectral Differences



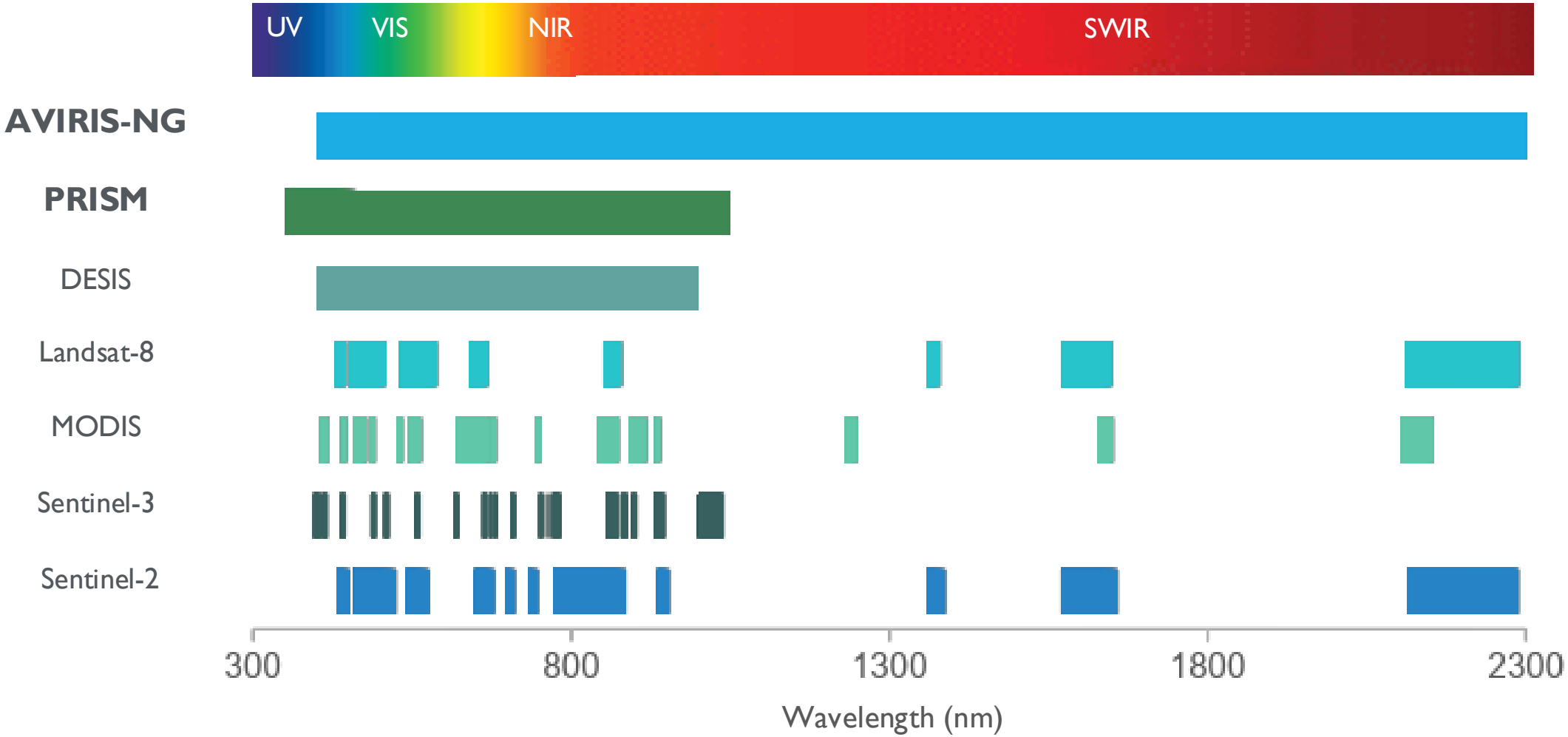
Wavelength in nm

Bahrami, M., & Mobasheri, M. R. (2020).

Applications of Airborne VSWIR Data

- Hyperspectral visible to shortwave infrared imaging spectroscopy data can be used to monitor and measure a wide array of environmental parameters such as climate variability, land cover distribution, seasonal cycles, and much more.
- Common sources of this data include AVIRIS-NG and PRISM.

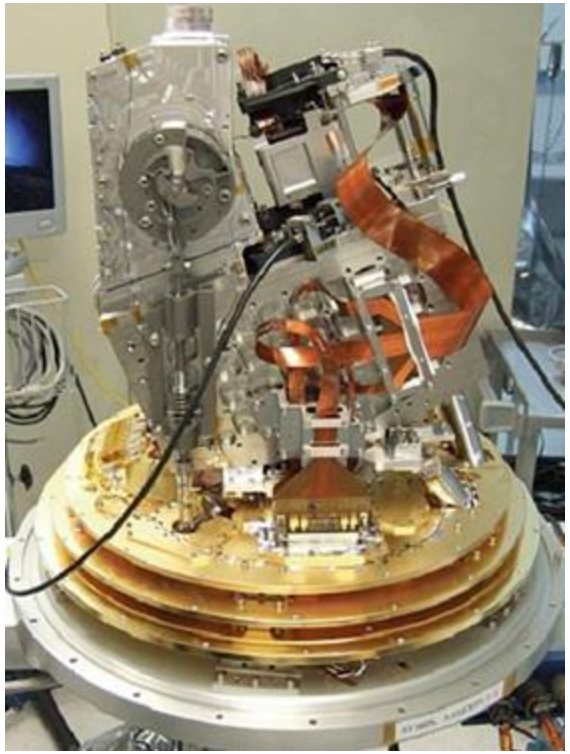
Source: NASA JPL



Adapted from: Wilson, A., Hestir, E., Slingsby, J., Cardoso, A. (2022). Biodiversity Survey of the Cape (BioSCape).

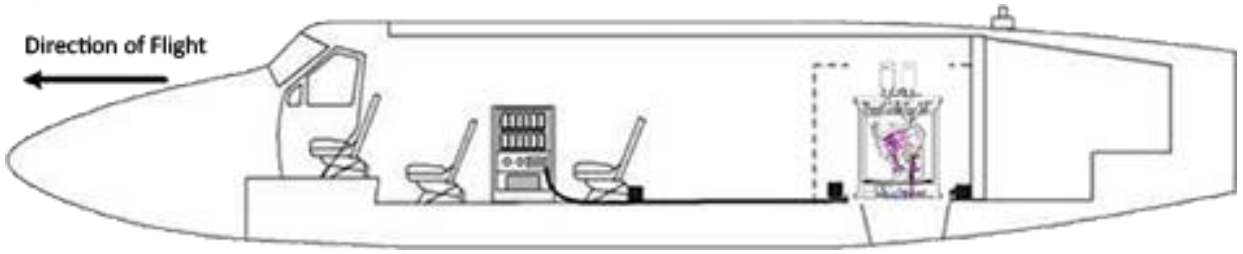
Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG)

- Objective: To support NASA science and applications by measuring spectra as images that record the interaction of light with matter. These spectra are used to identify, measure, and monitor constituents of the Earth's surface and atmosphere.
- Flown on several aircraft platforms: NASA's ER-2 jet, the Twin Otter turboprop, B200 King Air, and NASA's Gulfstream III and V
- Flown in North America, Europe, India and South Africa
- Active since 2009



Source: NASA JPL

AVIRIS-NG Resolution



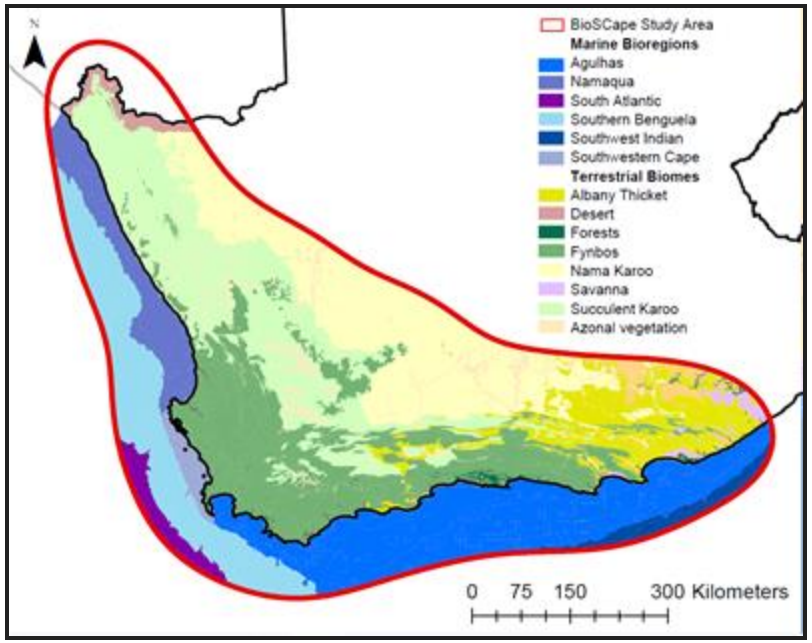
Source: NASA JPL

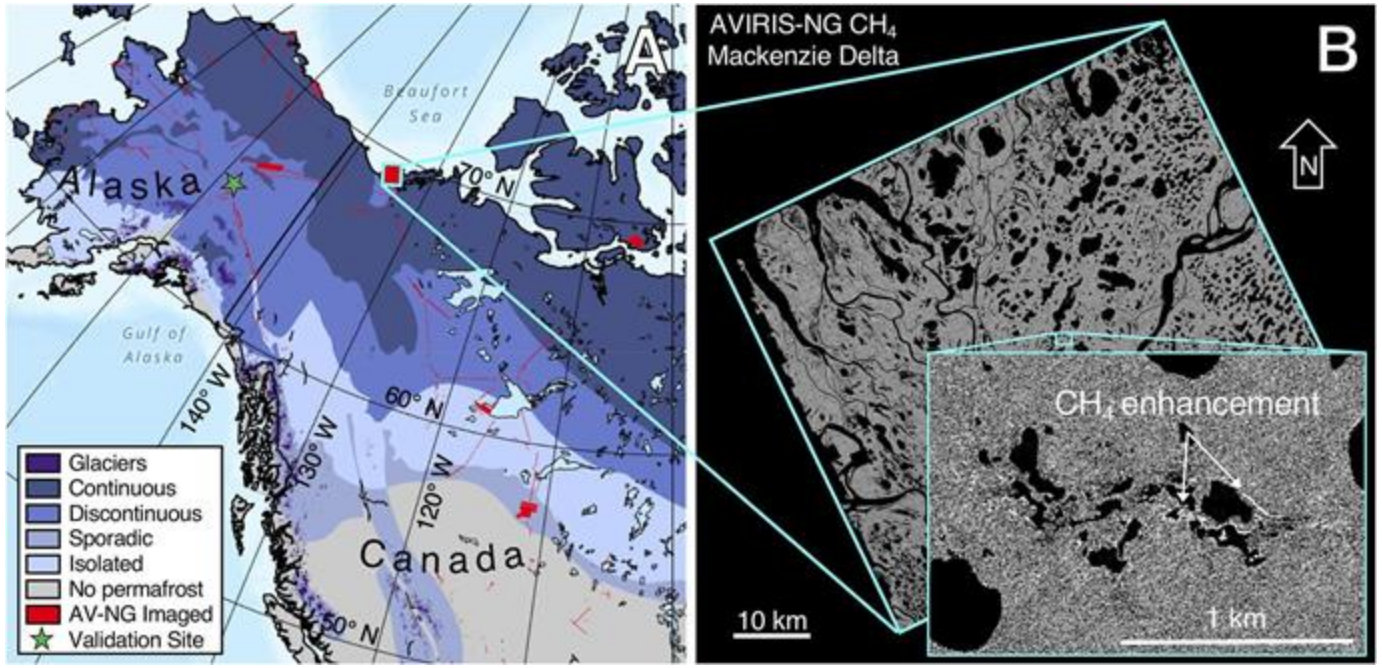
- 425 contiguous spectral bands
- Spectral coverage: 380 to 2510 nm
- Spectral resolution: 5 nm ± 0.5 nm
- Pixel size based on altitude:
  - 6,500 ft AGL for 2 m pixel resolution
  - 13,000 ft AGL for 4 m pixel resolution
  - 20,000 ft AGL for 6 m pixel resolution
  - 65,000 ft AGL for 18m pixel resolution

AVIRIS-NG Biodiversity Applications

BIOSCAPE
Biodiversity Survey of the Cape

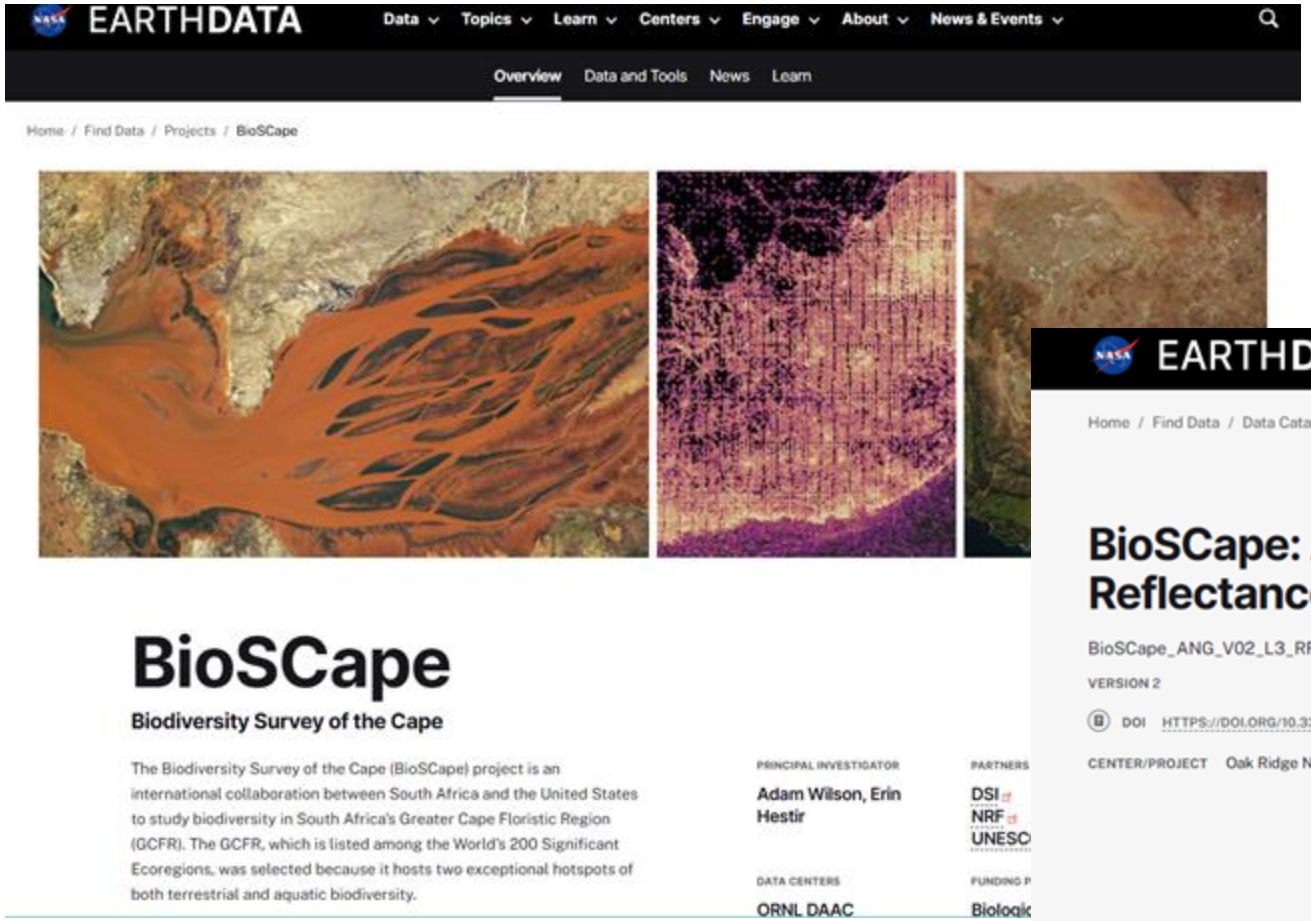
ABoVE
ARCTIC - BOREAL VULNERABILITY EXPERIMENT



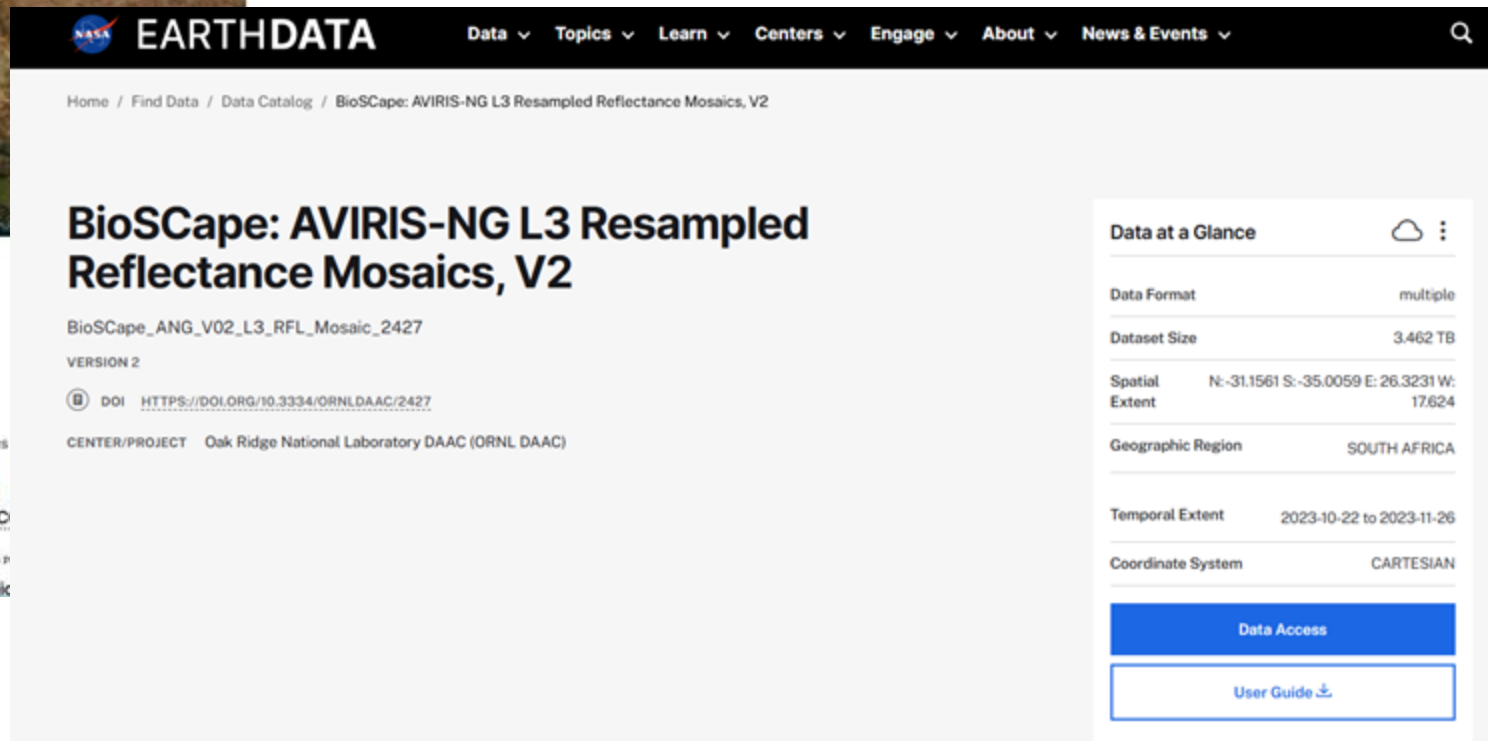


AVIRIS-NG ABoVE survey and a regional mapping example. Source: Elder, et al., 2020.

BioScape on EARTHDATA



[Bioscape](#) on EARTHDATA



[AVRIS-NG BIOSCAPE Data](#)

For a review of data processing levels [click here](#).

Fundamentals of Machine Learning for Earth Science
Overview

Machine Learning in Earth Science

- Problems in Earth science are often complex.
- It is difficult to apply well-known and described mathematical models to the natural environment:
  - ML is commonly a better alternative for such non-linear problems.
- A number of researchers found that machine learning outperforms traditional statistical models in Earth science, such as in:
  - Characterizing forest canopy structure,
  - Predicting climate-induced range shifts, and
  - Delineating geologic facies.

Benefits of Utilizing Machine Learning

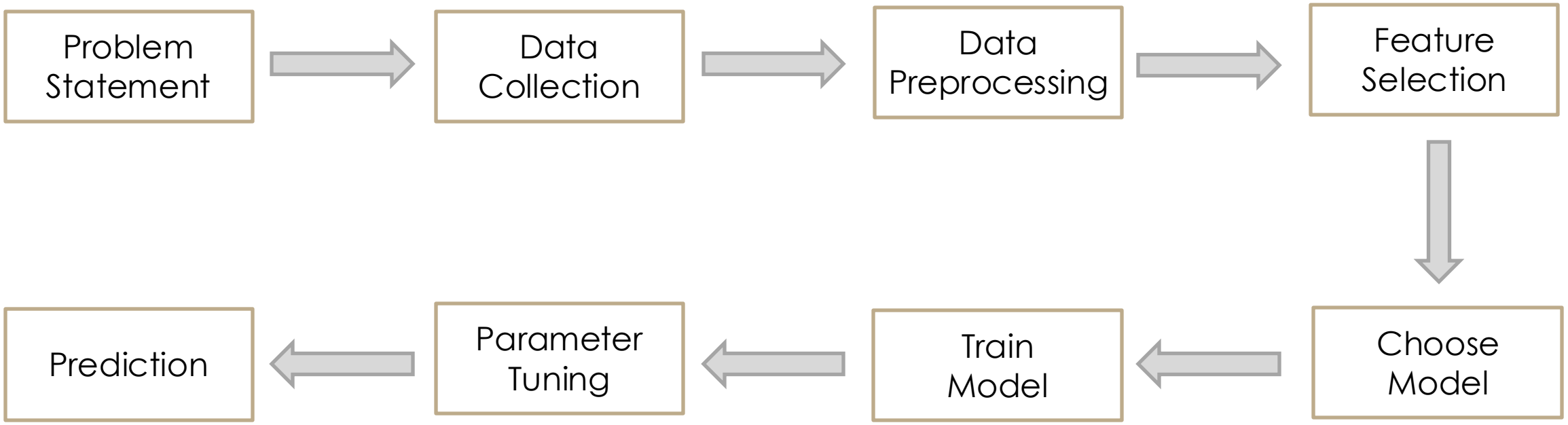
There are numerous ways in which ML can accelerate scientific research, such as:

- **Increased Efficiency:** Machine learning can help automate the analysis of large and complex datasets, allowing scientists to quickly process and analyze large amounts of data.

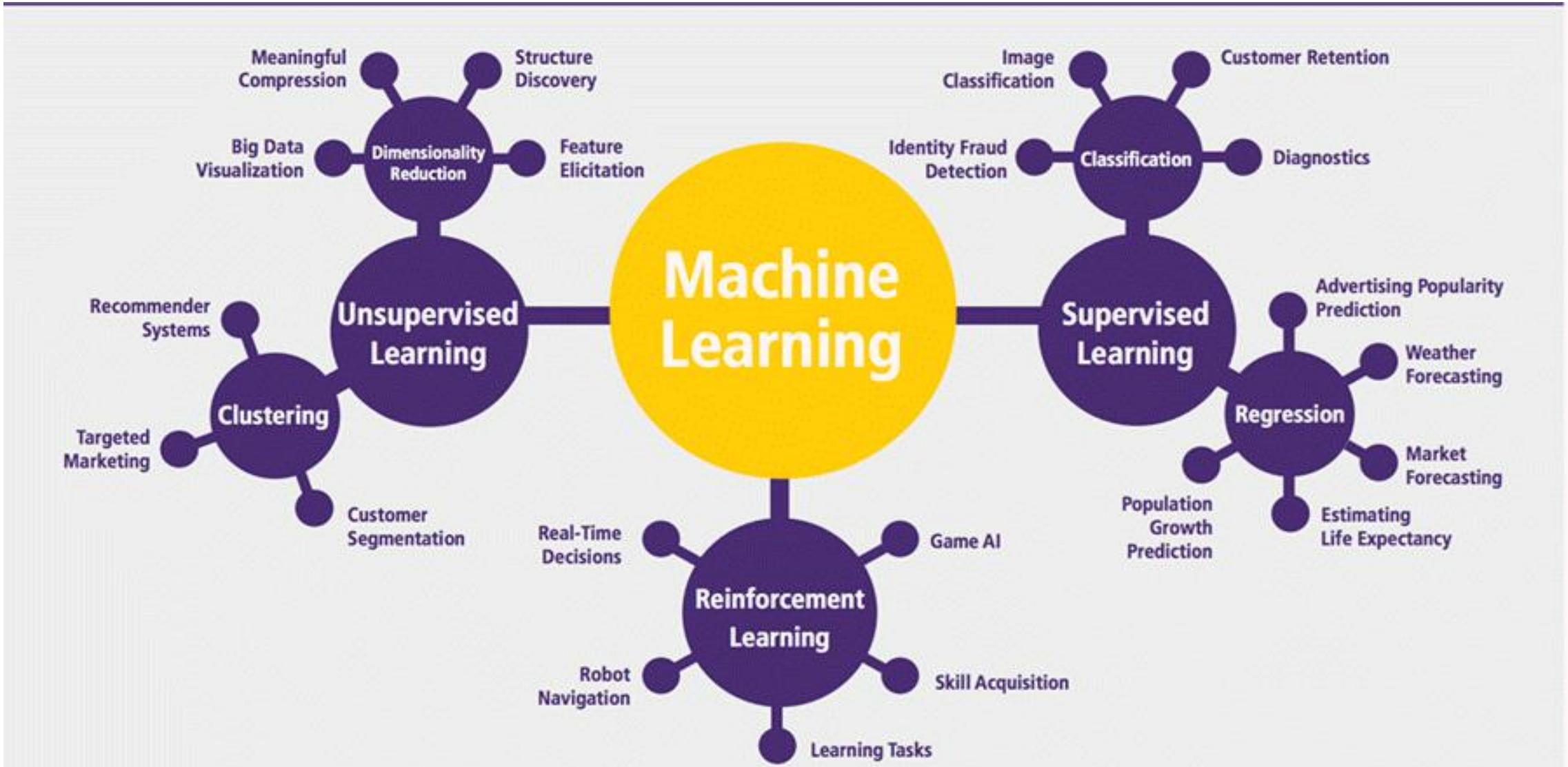
- **New Insights and Discoveries:** Machine learning can help scientists identify new patterns and relationships in complex datasets, leading to new insights and discoveries in Earth Science research.

- **Improved Predictive Modeling:** Machine learning algorithms can be used to build accurate predictive models that can help scientists better understand complex Earth Science phenomena.

Machine Learning Steps



Machine Learning Algorithms



Source

Machine Learning Tools

Source

Software to Support Machine Learning

Python: Python is the most used language for Machine Learning. One of the main reasons Python is so popular within AI development is that it was created as a powerful data analysis tool and has always been popular within the field of big data.

Jupyter Notebook: Open-source, web-based application which allows us to create and share documents that contain code, equations, visualizations, and text. Its uses include data cleaning and transformation, statistical modeling, data visualization, machine learning, etc.

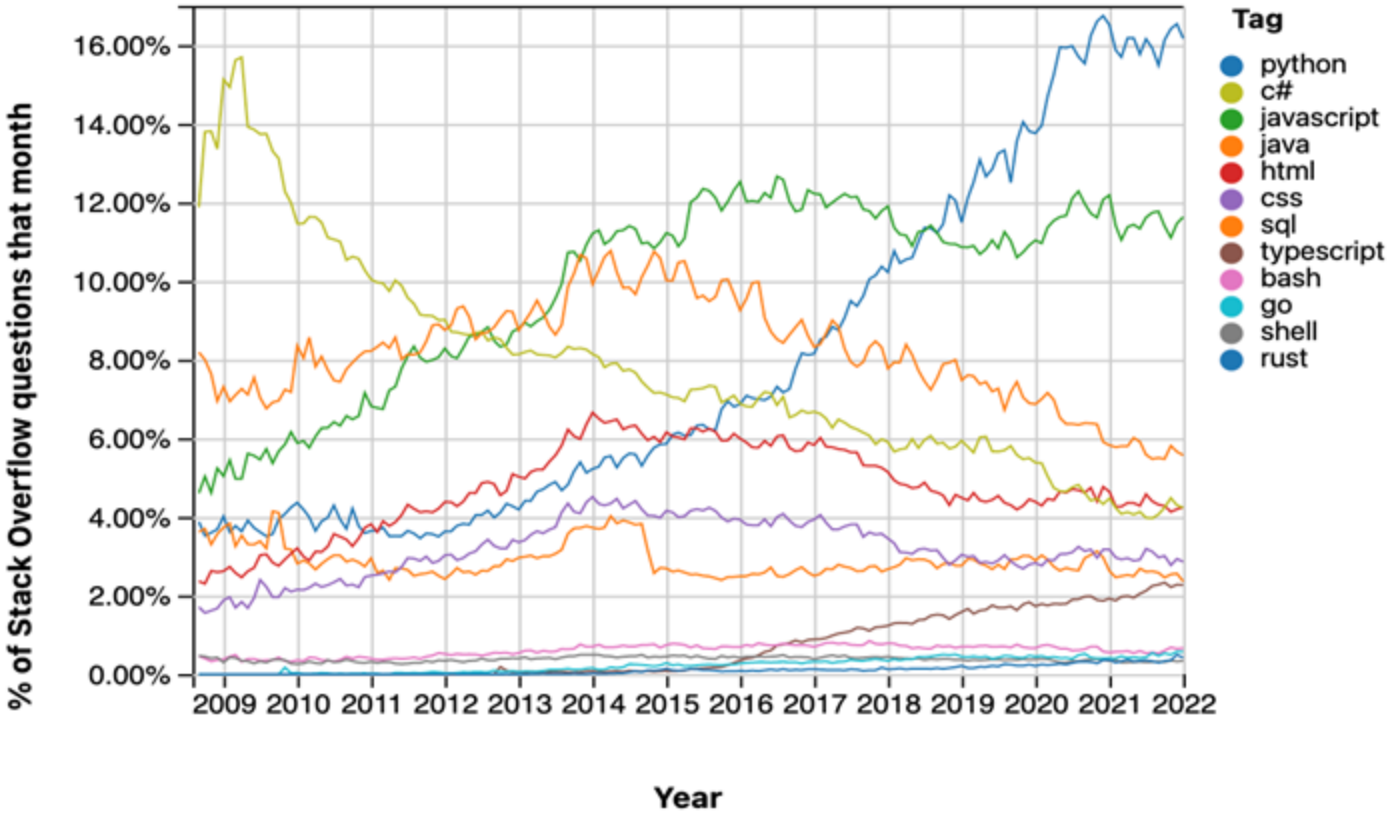
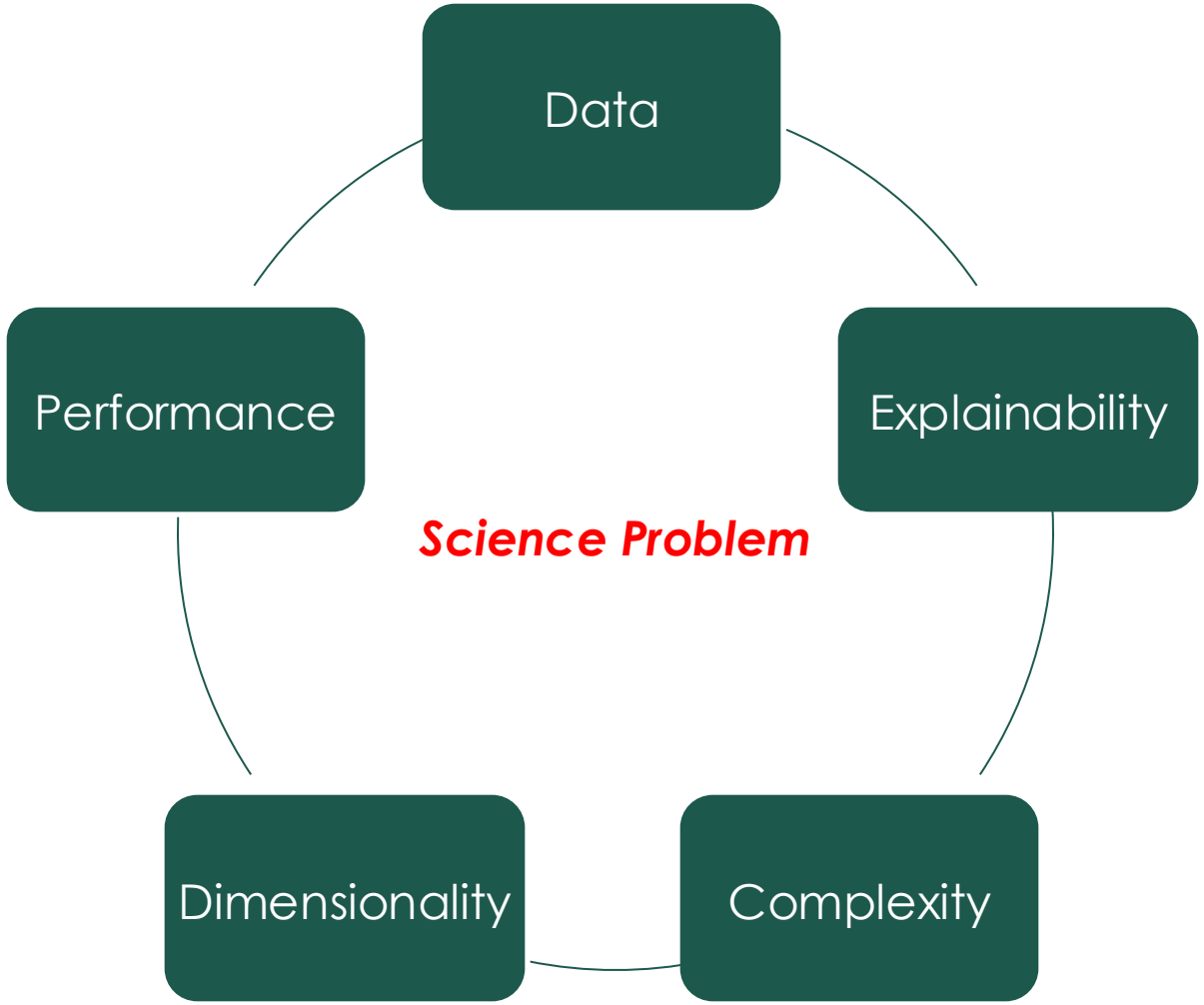


Image Source: Stack Overflow 2022

Machine Learning Algorithms: Science Problem

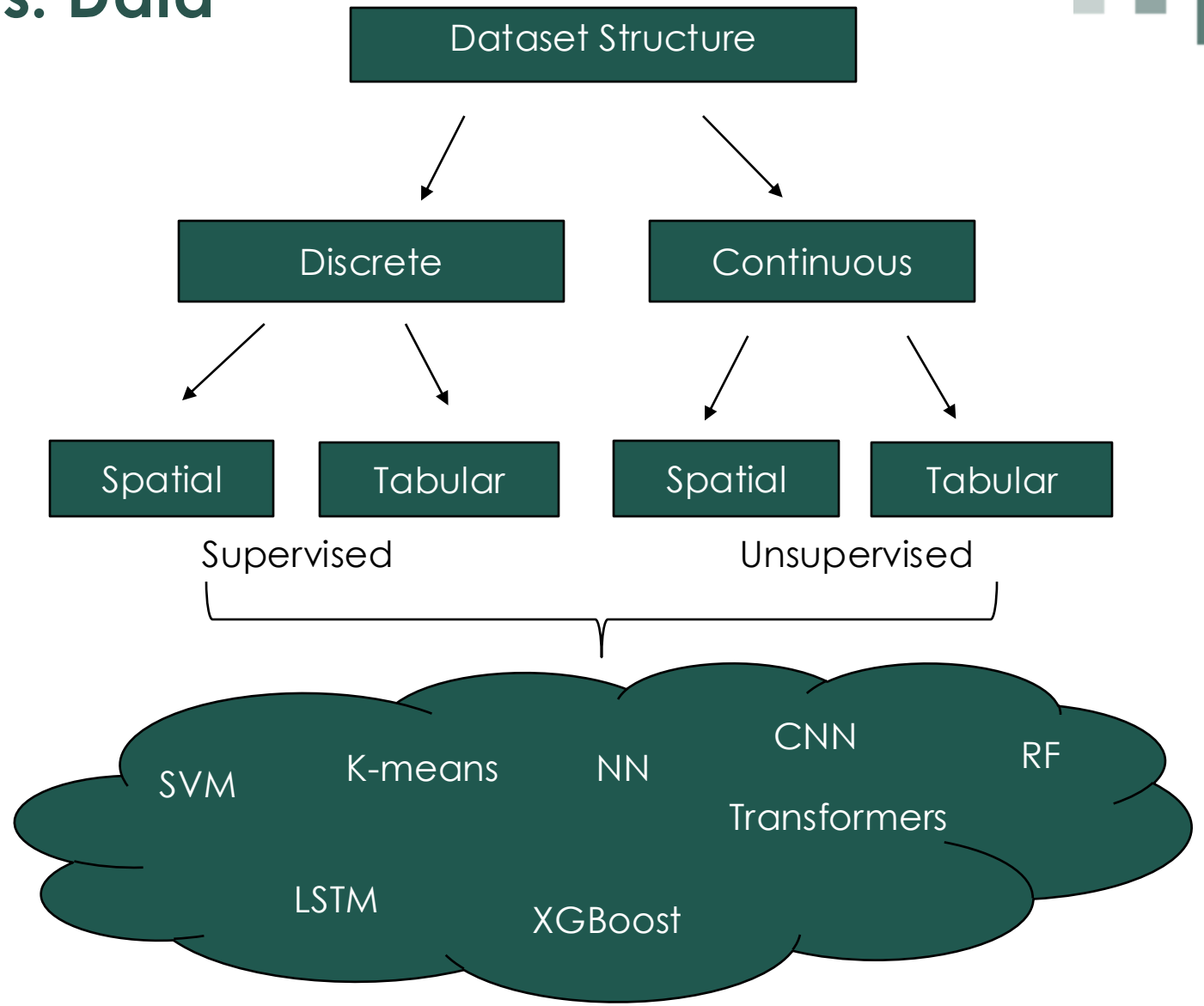
- Which scientific question would you like to address?
- What information is missing to answer this question?



Components to aid the selection of your ML algorithm.

Machine Learning Algorithms: Data

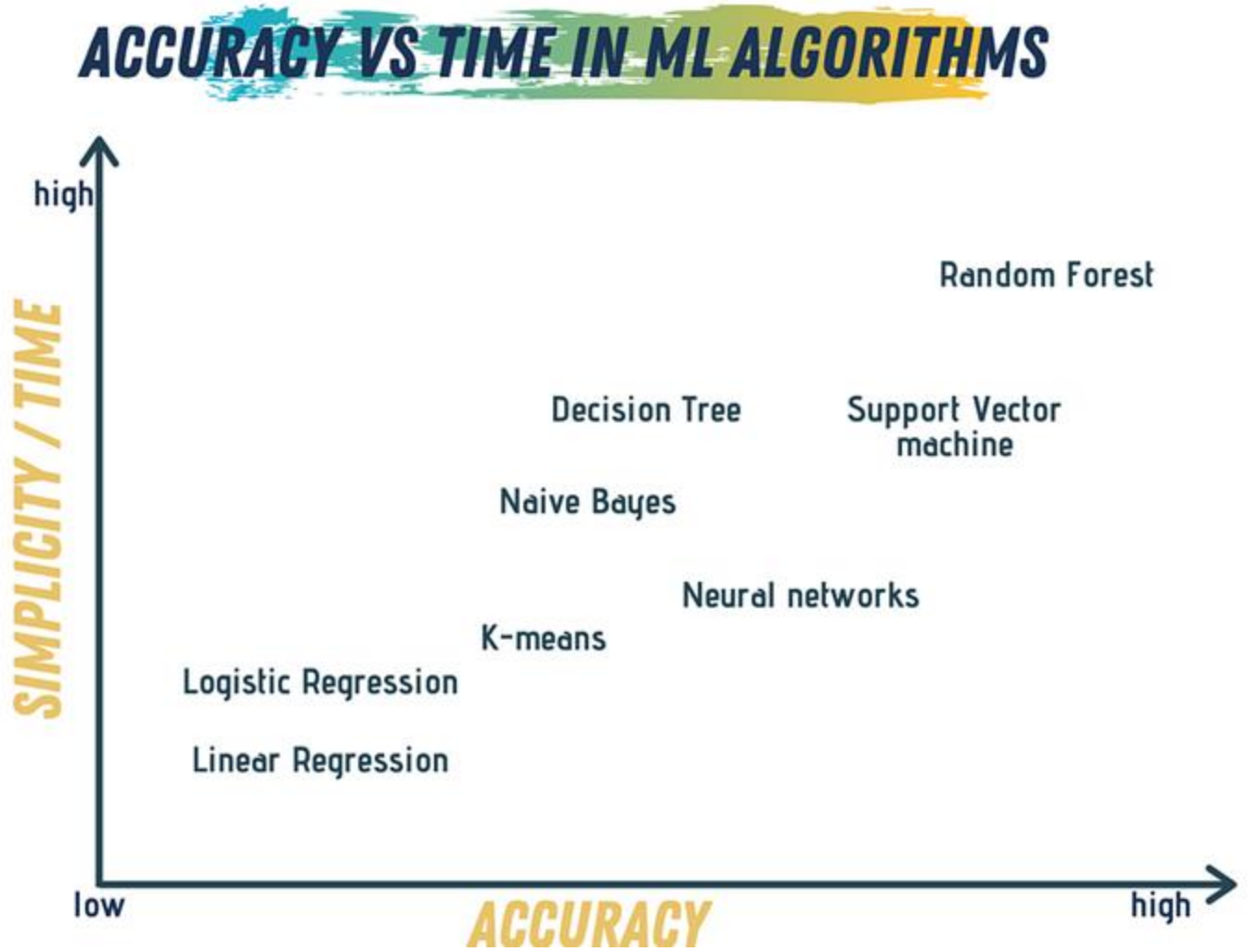
- What data do you have available?
- Do you have training data available?
- What is the structure of your data?
- Is your dependent variable a continuous or discrete problem?



Algorithm decision branch based on data structure.

Machine Learning Algorithms: Performance

- Are there any performance requirements based on your science question (e.g., real time vs. static)?
- Is your software going to run on on-premise, cloud, or embedded hardware?
- What is more important for your project: inference time or model performance?



Trade off between speed and accuracy.
Source

Demonstration

Summary

Considerations

There are many factors to consider when undertaking a remote sensing approach to monitoring invasive species. Many factors will be unique to your study, but these are some general considerations to keep in mind.

- Cost
- Scale mismatch
- Temporal resolution
- Spectral signatures
- Availability
- Complexity

Training Summary

In this training we:

- Provided an overview of the impacts invasives and introduced the BIOSCAPE Campaign
- Highlighted Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG) biodiversity applications and data
- Used a Jupyter Notebook to access NASA AVIRIS-NG data located on the NASA Earthdata cloud.
- Demonstrated the classification of invasive tree species using a machine learning model for the Greater Cape Floristic Region in South Africa.
- Discussed how image classification of airborne imaging spectroscopy and labeled field data can be used to map invasive species.
- Reviewed key considerations for interpreting machine learning end products for invasive species mapping for land management decisions.

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 09/30/2025
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 10/14/2025**

- **Certificate of Completion:**
  - Attend live webinar (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.

Contact Information

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- Juan Torres-Perez
  - juan.l.torresperez@nasa.gov
- Savannah Cooley
  - savannah.cooley@nasa.gov

- ARSET Website
- ARSET YouTube

For questions, comments, or to share how you have applied our trainings to your work or studies, email 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

NASA Earthdata Cloud

Earthdata Login

Notebook Tutorial

https://ornldaac.github.io/airborne/events/2025-ARSET/README.html

https://ornldaac.github.io/airborne/notebooks/AVIRIS-NG_L3_invasive_species.html

Tutorial AVIRIS-NG L3 Dataset Citation

Brodrick, P. G., Chlus, A. M., Eckert, R., Chapman, J. W., Eastwood, M., Geier, S., Helmlinger, M., Lundeen, S. R., Olson-Duvall, W., Pavlick, R., Rios, L. M., Thompson, D. R., & Green, R. O. (2025). BioSCape: AVIRIS-NG L3 Resampled Reflectance Mosaics, V2 (Version 1). ORNL Distributed Active Archive Center. https://doi.org/10.3334/ORNLDAAC/2427

BioSCape

https://www.bioscape.io/

https://popo.jpl.nasa.gov/mmgis-aviris/?mission=BIOSCAPE

https://www.earthdata.nasa.gov/data/projects/bioscape


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!