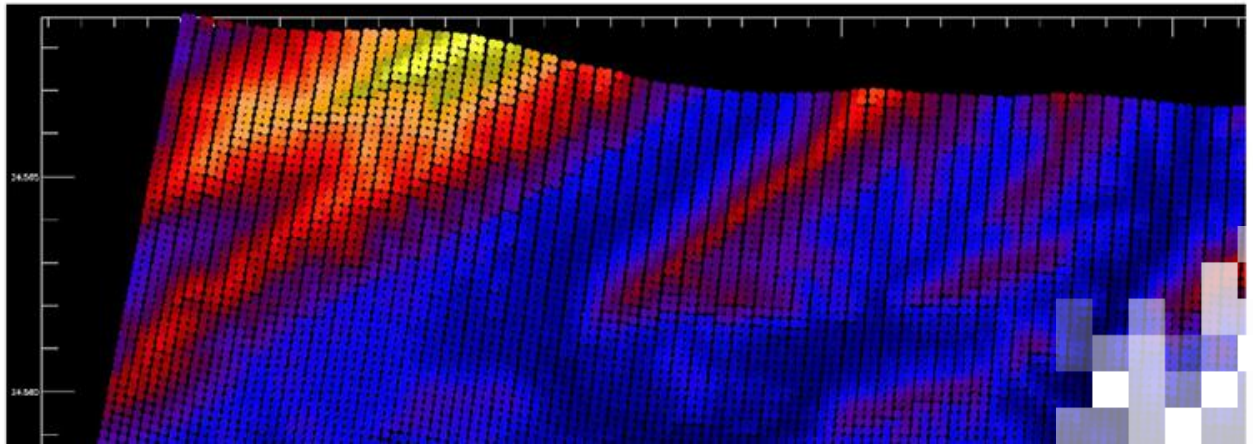




Biodiversity Applications for Airborne Imaging Systems

Juan L. Torres-Pérez, Britnay Beaudry, Sativa Cruz, Amber McCullum
Guest Speaker: Adam Wilson; University at Buffalo, BioSCape

March 29, 2023

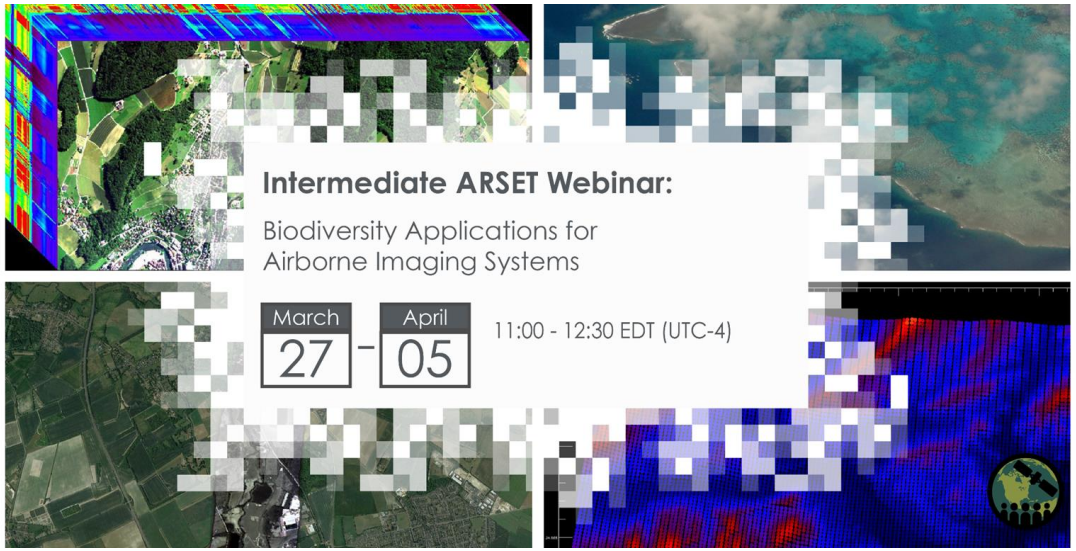
Course Structure and Information

- Four, 1.5-hour sessions on March 27, 29 & April 3, 5
  - 11:00 am - 12:30 pm EDT (UTC-4:00)

- Each session will feature a lecture and a Q&A session where instructors will be online to answer questions.

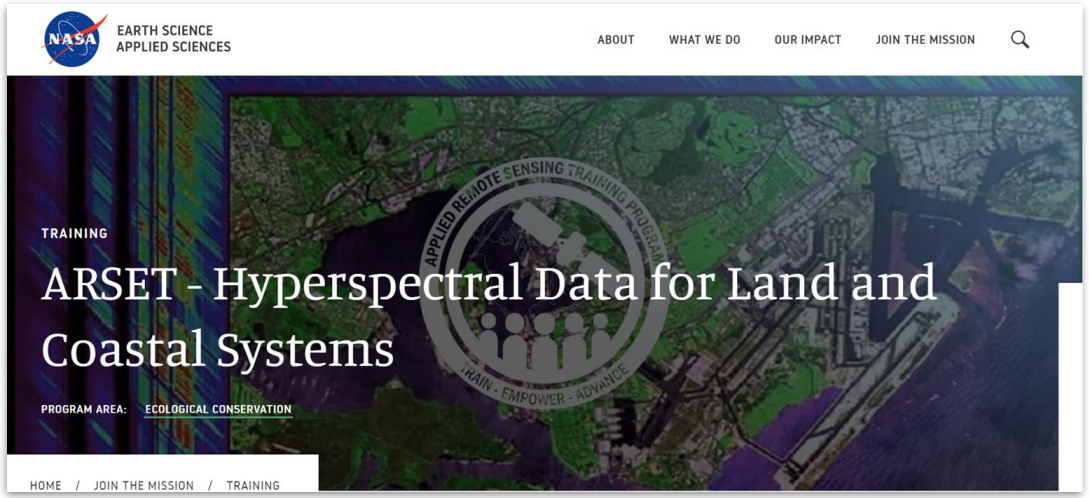
- Webinar recordings and PowerPoint presentations can be found after each session at: https://appliedsciences.nasa.gov/join-mission/training/english/arset-biodiversity-applications-airborne-imaging-systems

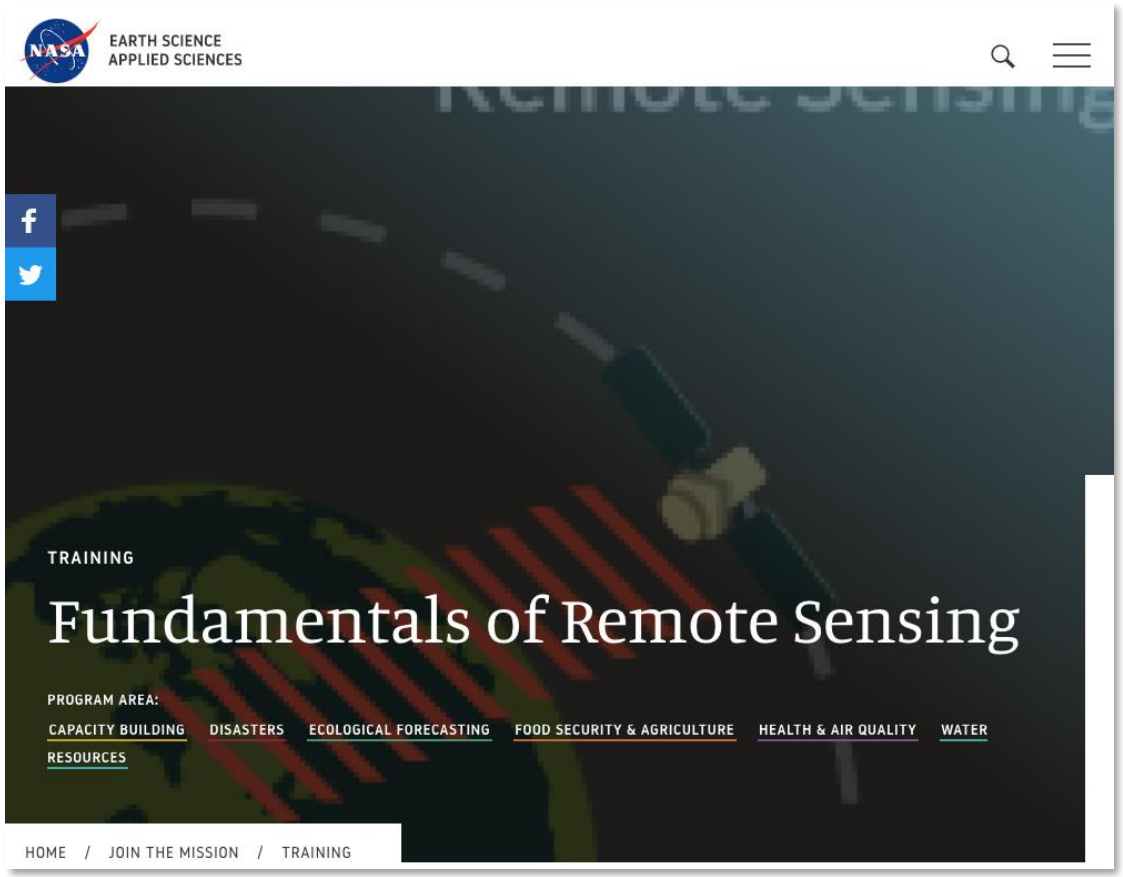
- For additional questions please email:
  - Juan L. Torres-Pérez (juan.l.torresperez@nasa.gov)
  - Amber McCullum (amberjean.mccullum@nasa.gov)
  - Britnay Beaudry (britnay.beaudry@nasa.gov)
  - Sativa Cruz (sativa.cruz@nasa.gov)



Prerequisites

- Prerequisites:
  - Fundamentals of Remote Sensing
  - Hyperspectral Data for Land and Coastal Systems
    - or equivalent experience





Homework and Certificates

- **Homework:**
  - One homework assignment (available at the end of session four of this webinar series)
  - Answers must be submitted via Google Forms
  - **HW deadline: April 19th**
- **Certificate of Completion:**
  - Attend all four live webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
  - You will receive certificates approximately two months after the completion of the course from: marines.martins@ssaihq.com

Course Outline

Part 1: Overview of hyperspectral VSWIR imaging spectroscopy data

Part 2: Using thermal and lidar data from airborne campaigns

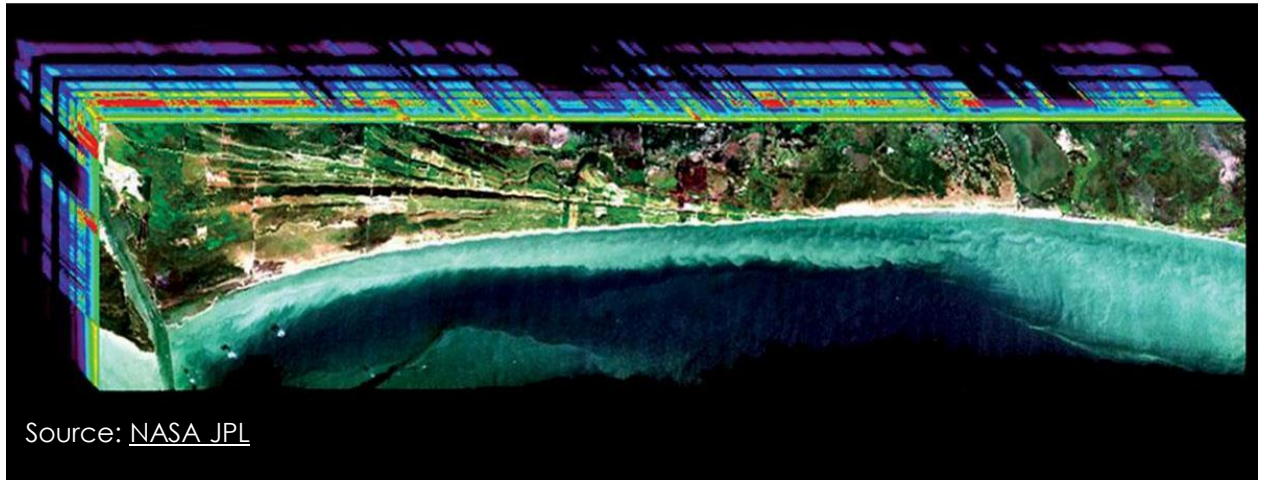
Part 3: Monitoring terrestrial systems using airborne campaigns

Part 4: Monitoring aquatic systems using airborne campaigns

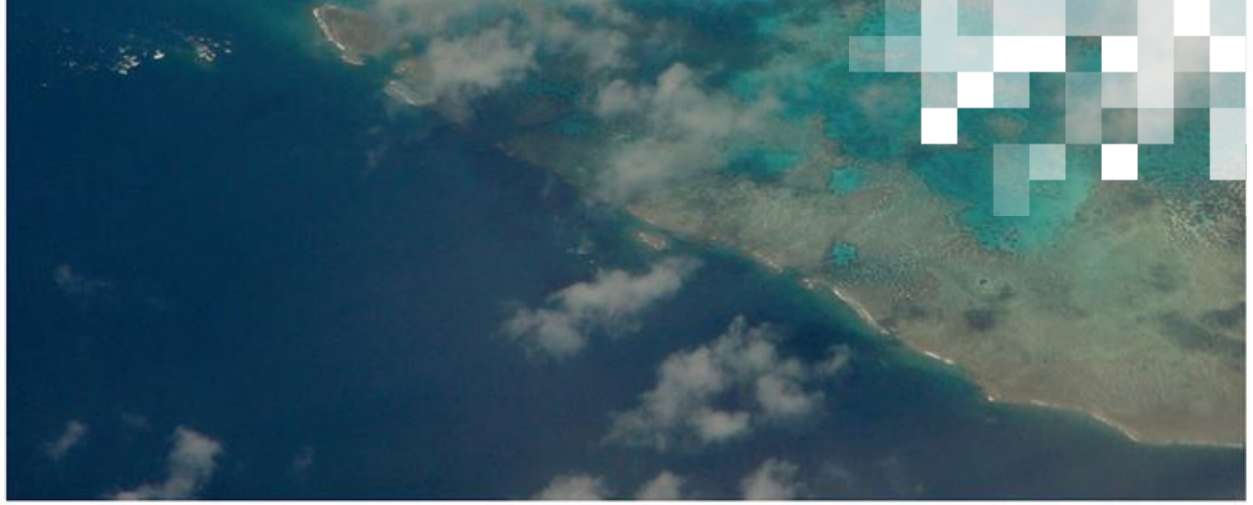
Learning Objectives

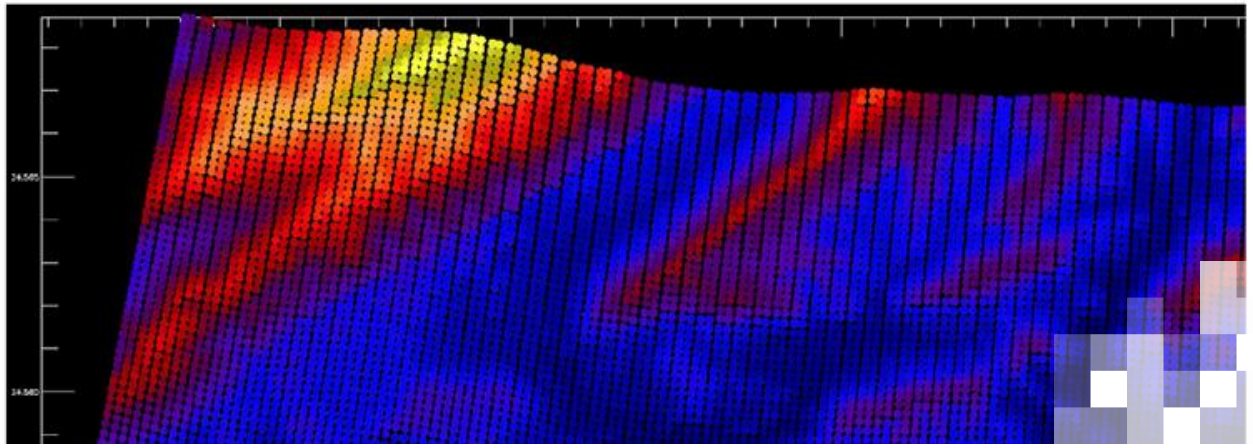
By the end of this training attendees will be able to:

- Understand the applications of hyperspectral data, multispectral data, and LiDAR data for biodiversity monitoring and analysis
- Compare case studies that have used these datasets in preparation for upcoming NASA satellite missions and airborne campaigns



Source: NASA JPL

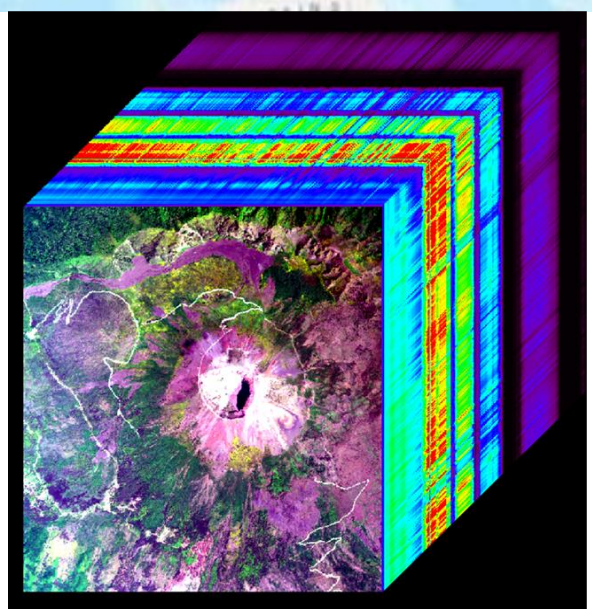





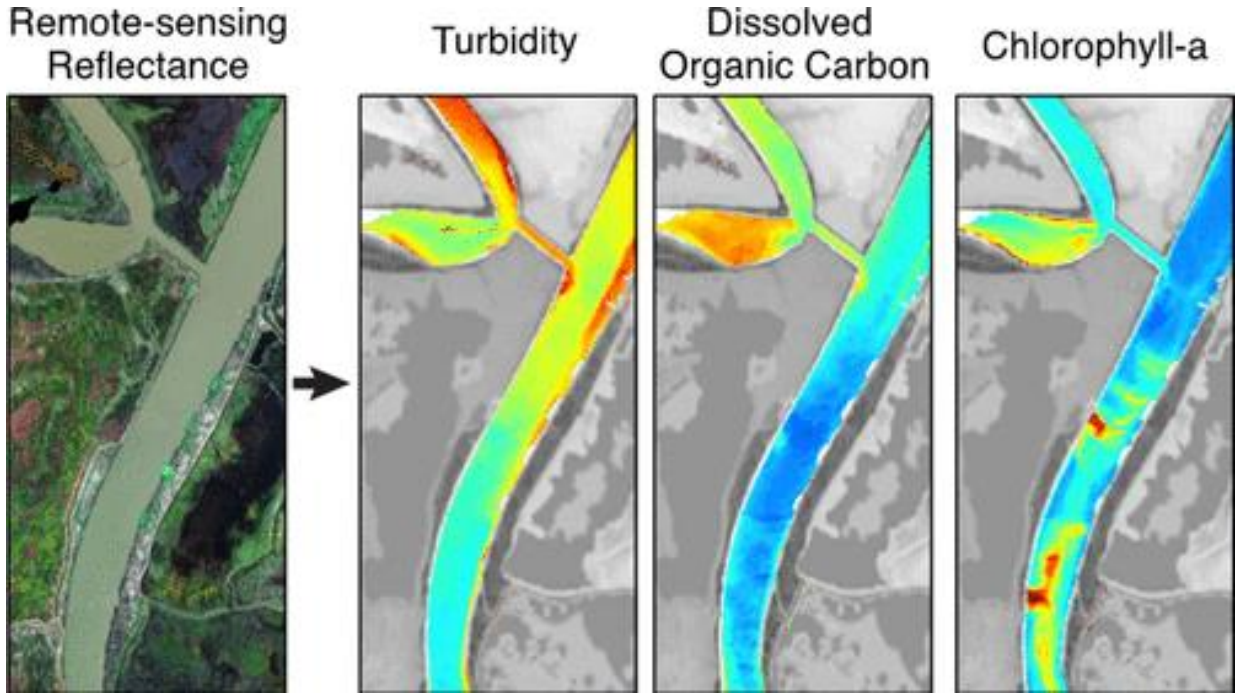
Part 1 Review: Overview of Airborne Hyperspectral VSWIR Instruments

Part 1 Review: Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG)

- VSWIR spectrometer
- Active since 2009
- Flown in North America, Europe, and India
- 481 contiguous spectral bands
- Spectral coverage: 380 to 2510 nm
- Spectral resolution: 5 nm
- Spatial resolution: 2 - 6 m
- Data products: Level 1B and L2



Part 1 Review: Portable Remote Imaging SpectroMeter (PRISM)

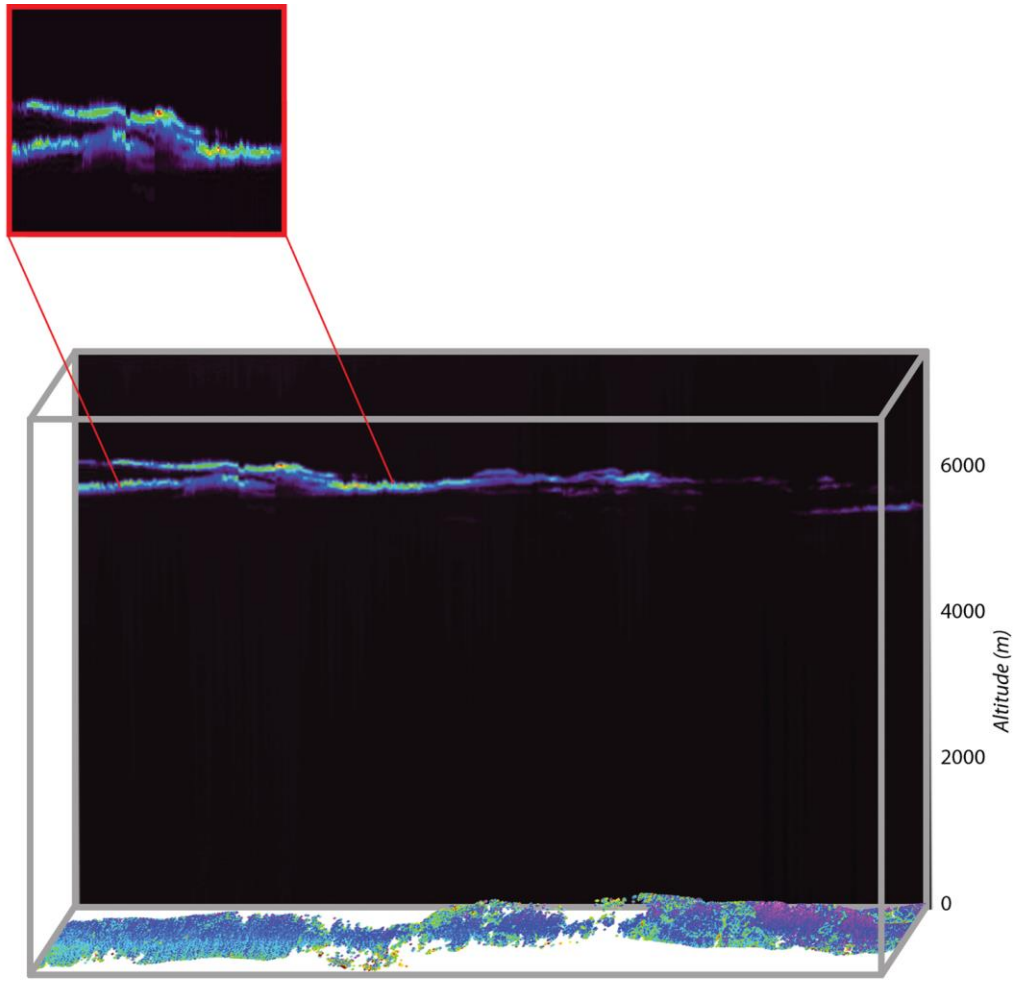


Distributions of turbidity, and dissolved organic carbon (DOC) and chlorophyll-a concentrations in the San Francisco Bay−Delta Estuary. Source: Fichot et al., 2016.

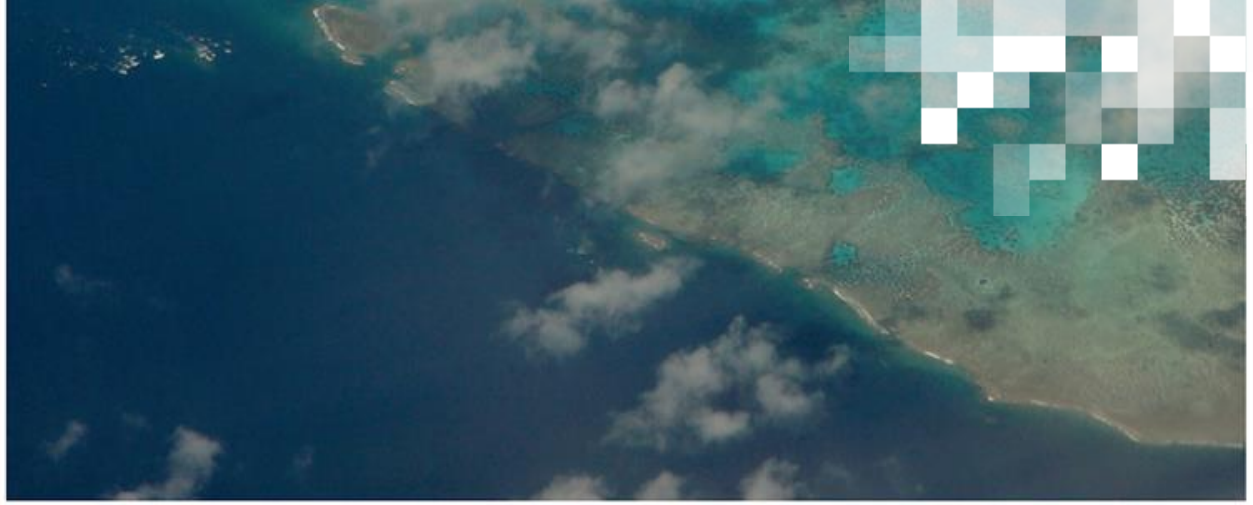
- VSWIR spectrometer
- Active since 2012
- Flown in Western United States, South America, and the Southern Ocean
- 256 contiguous spectral bands and 2 SWIR bands: 1240 and 1610 nm
- Spectral coverage: 350 -1050 nm
- Spectral resolution: 3.5 nm
- Spatial resolution: 0.3 to 16 m
- Data products: Level 1B and L2

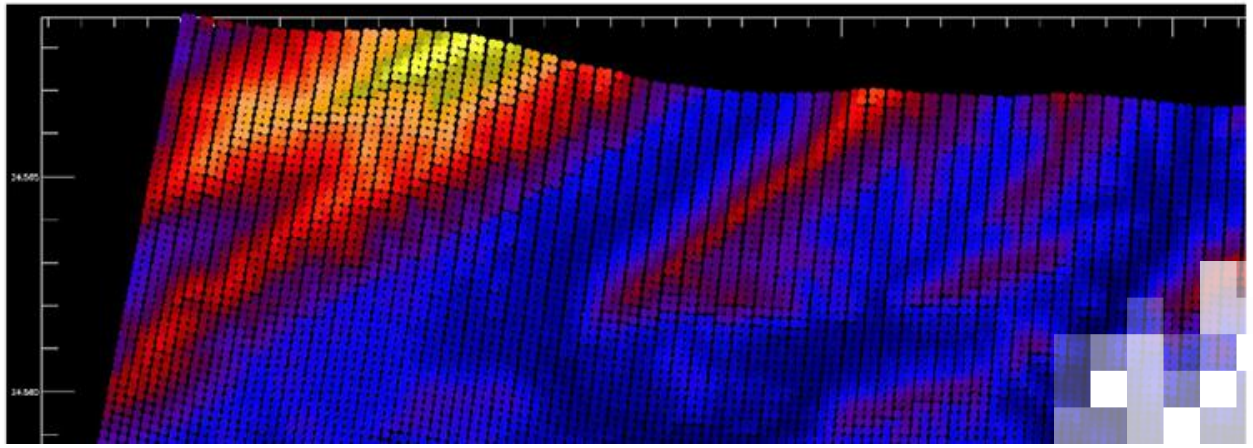
Part 2 Agenda

- Overview of thermal and LiDAR data for characterizing the structure and function of ecosystems using airborne campaigns
- Highlight of thermal and LiDAR missions such as the Hyperspectral Thermal Emission Spectrometer (HyTES) and NASA's Land, Vegetation, and Ice Sensor (LVIS)
- Highlight of the upcoming NASA Biodiversity field campaign in the Greater Cape Floristic Region of South Africa (BioSCape)
- Q&A Session



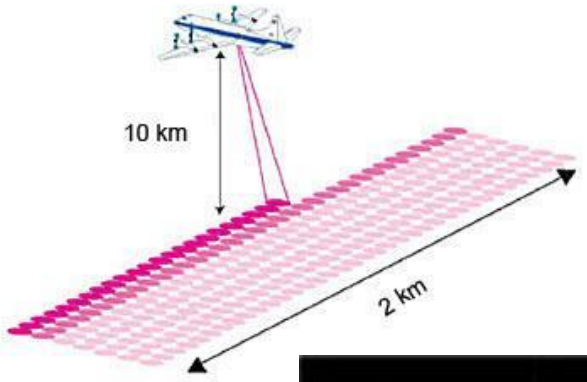
Source: NASA GSFC

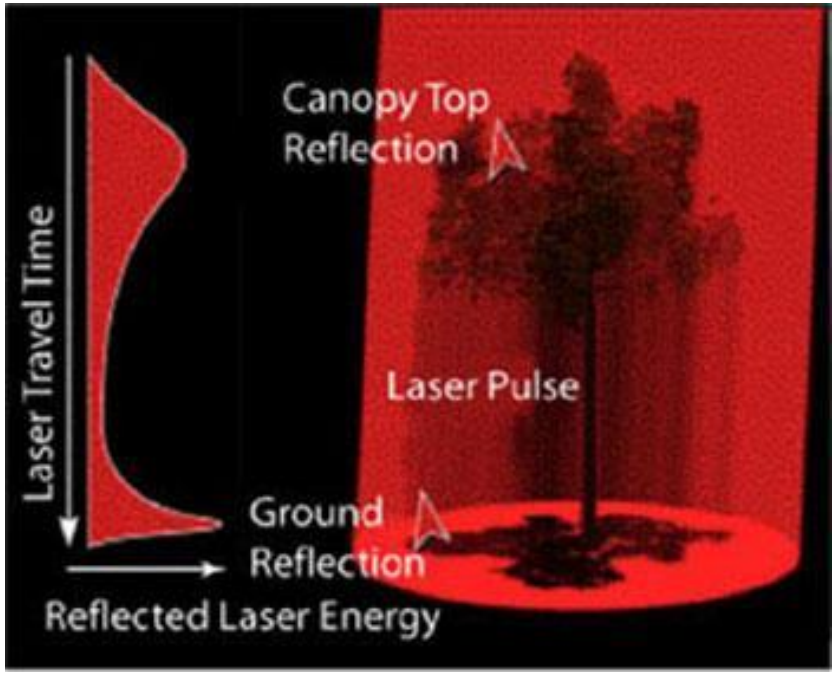




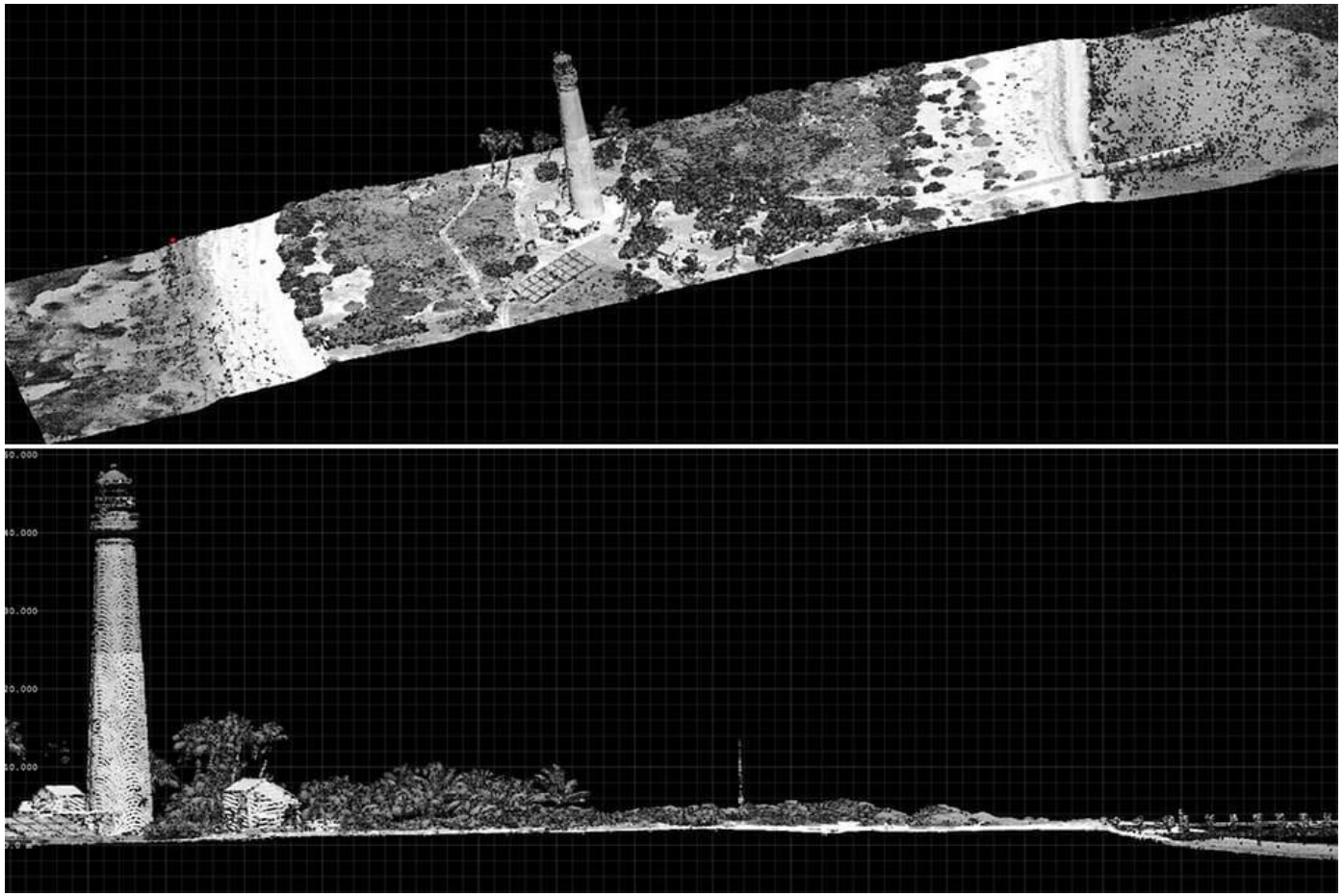
Overview of Thermal and LiDAR Data

Light Detection and Ranging (LiDAR)



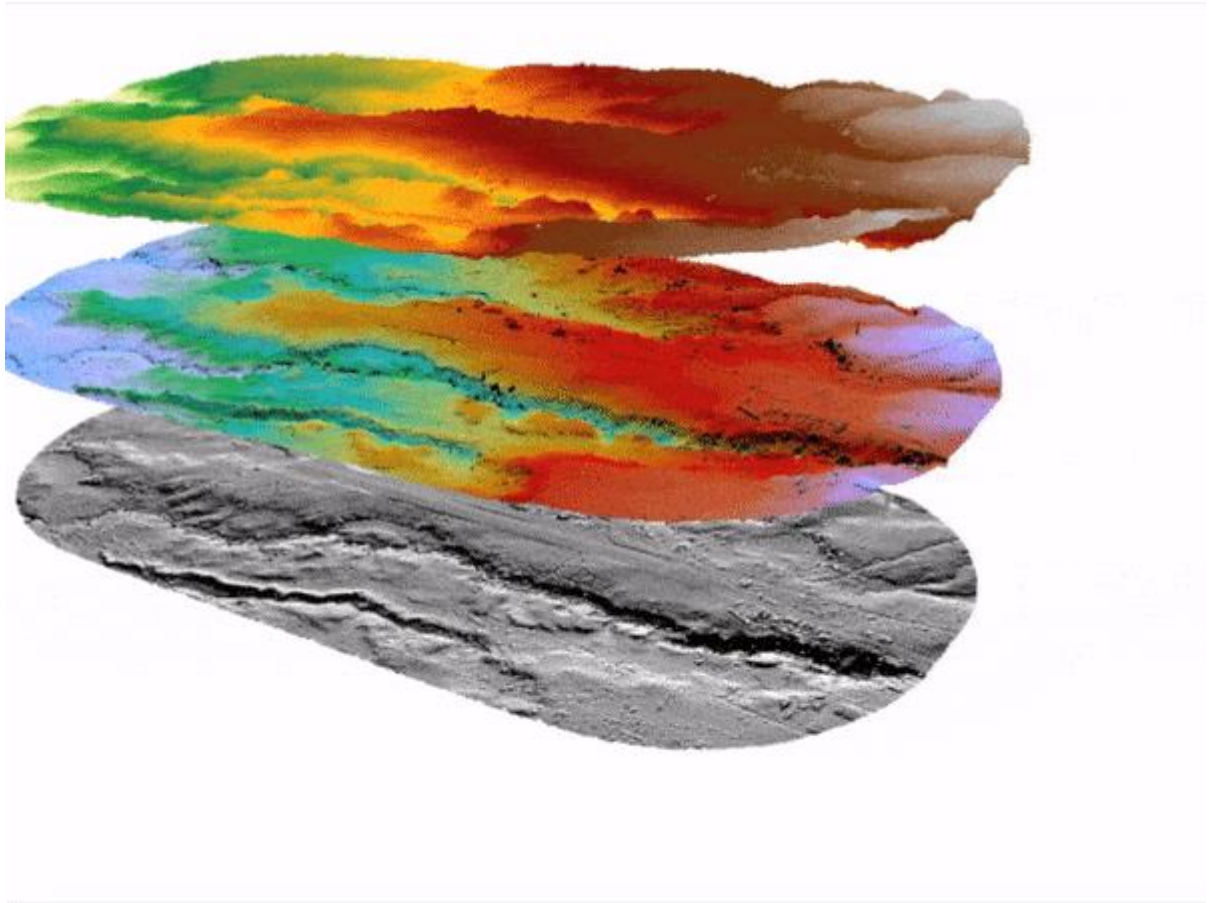


Source: NASA GSFC

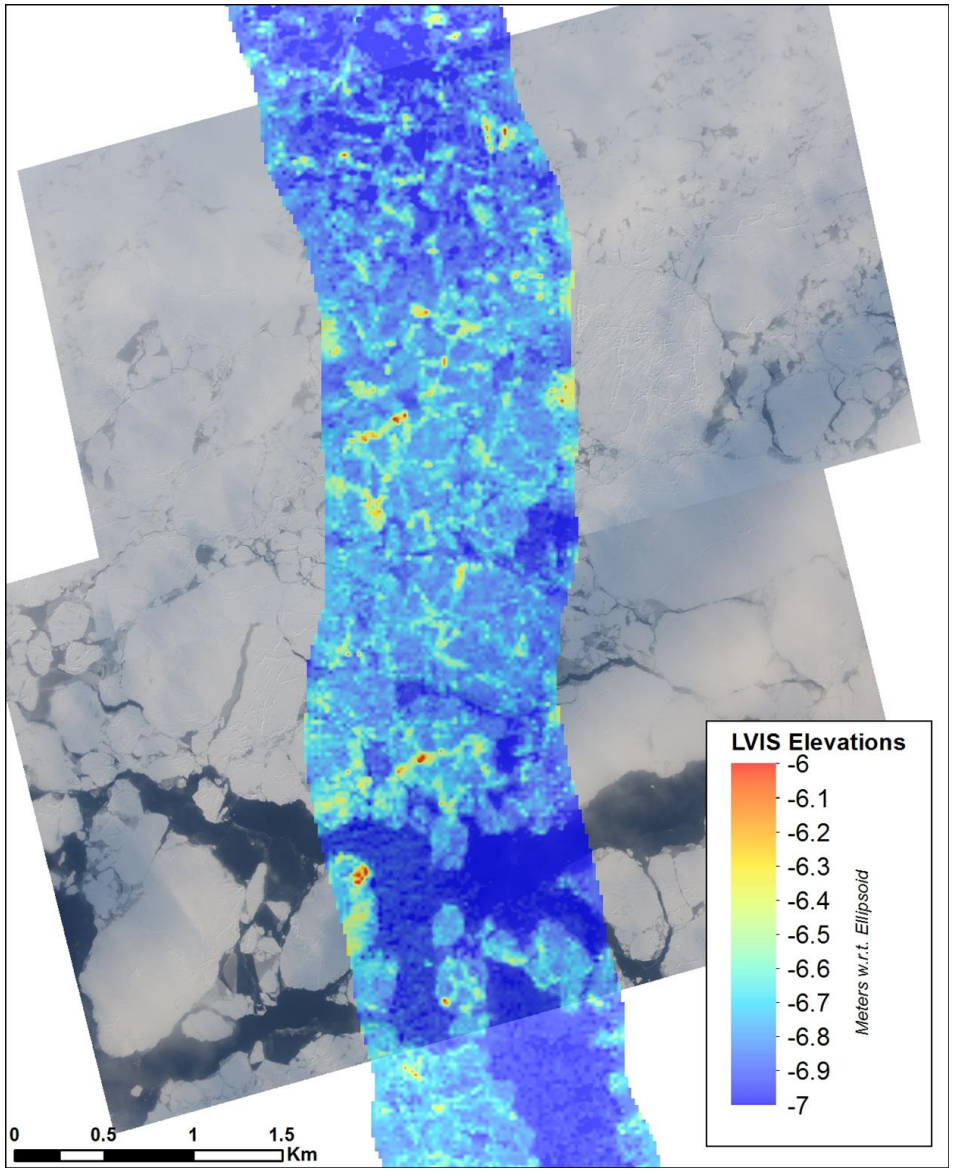


Source: NOAA Ocean Service

Using LiDAR to monitor elevation

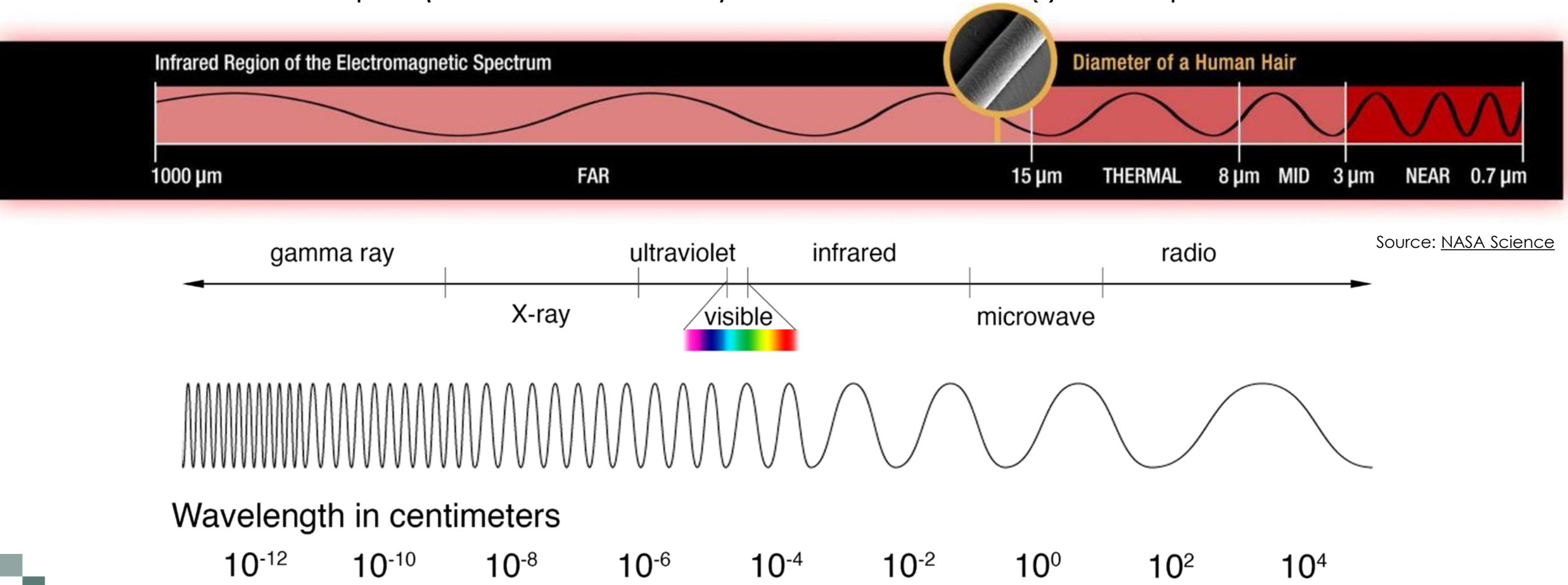


Source: NASA GSFC



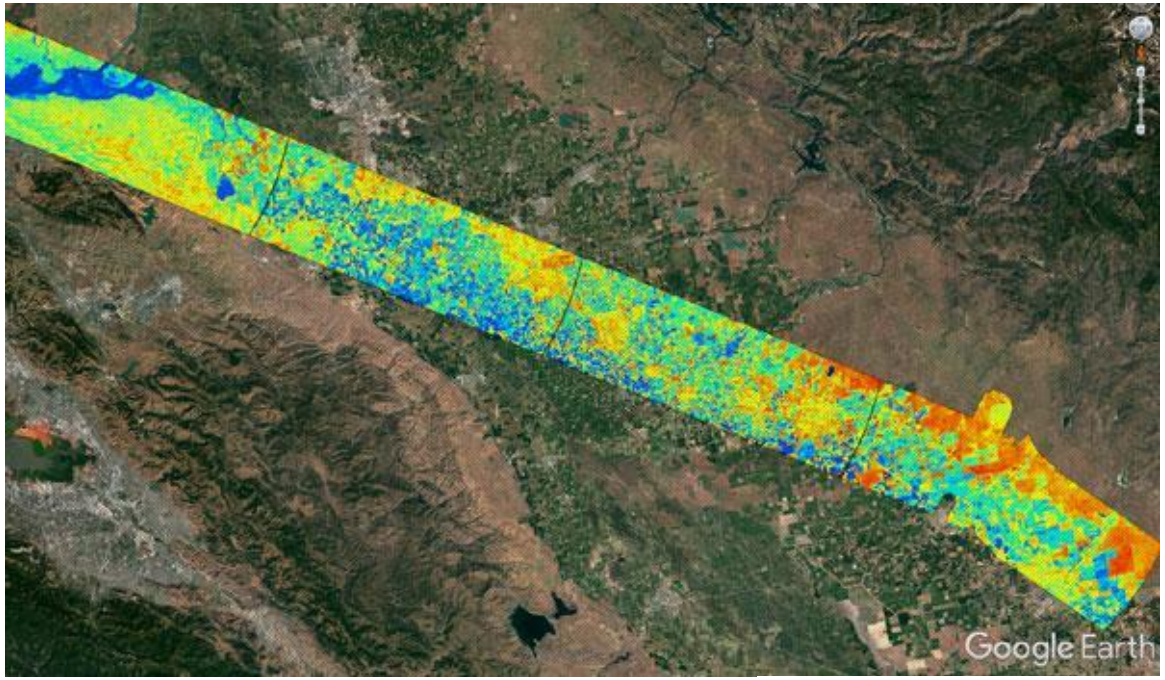
Thermal Infrared (TIR)

8 - 15 µm (8000 - 15000 nm) in the electromagnetic spectrum

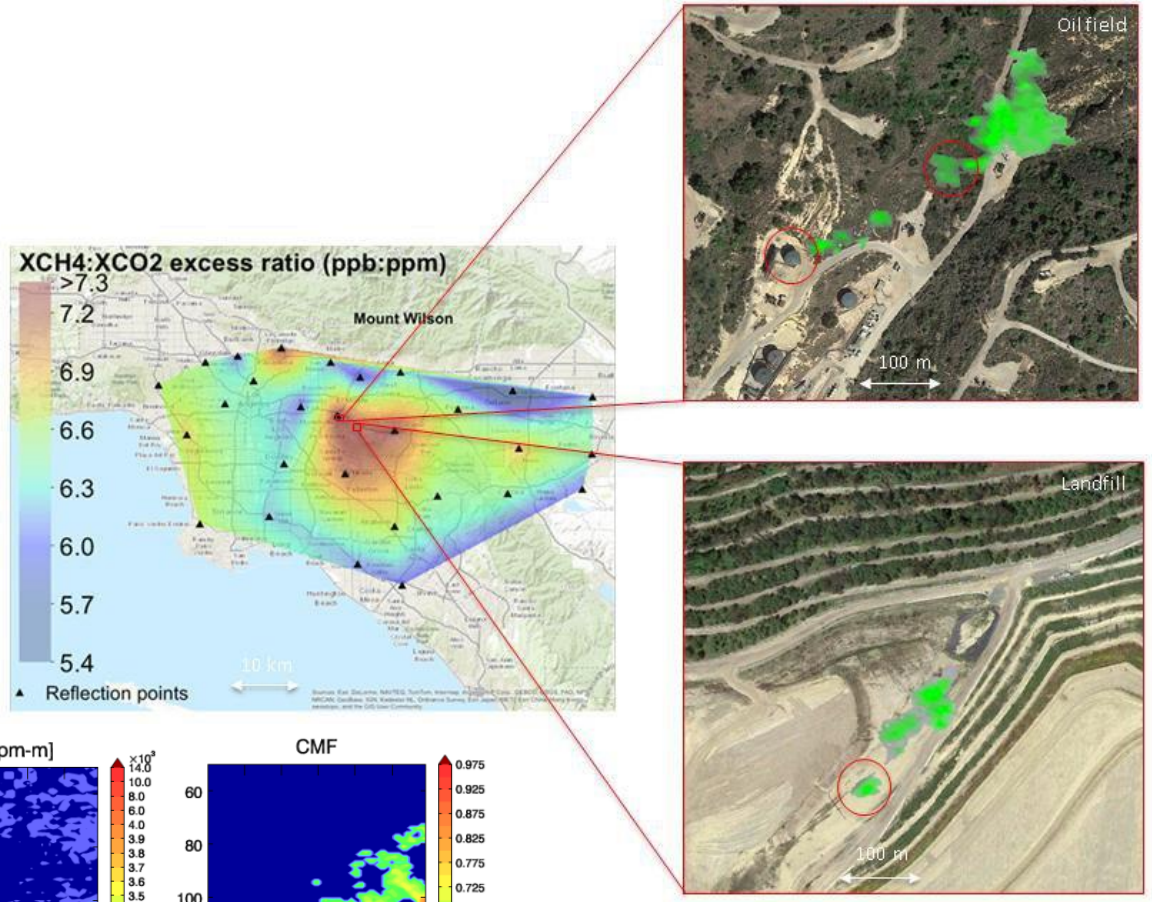


Source: NASA Science

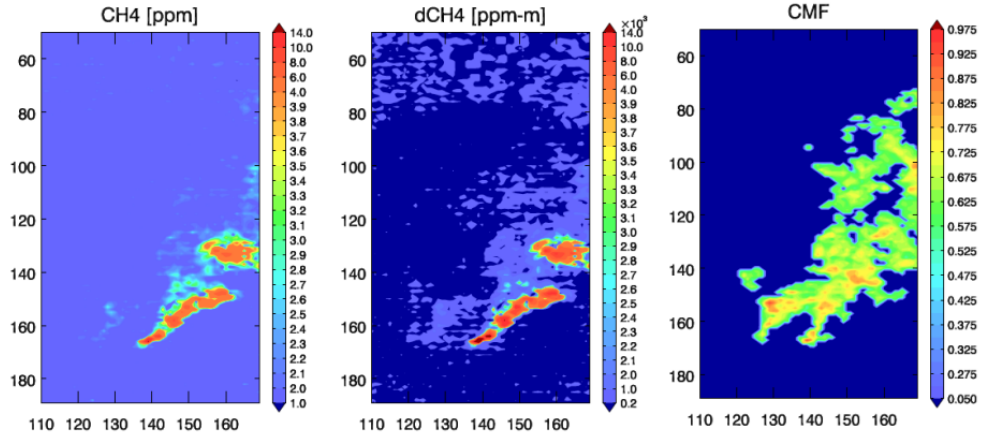
Using TIR to monitor thermal differences



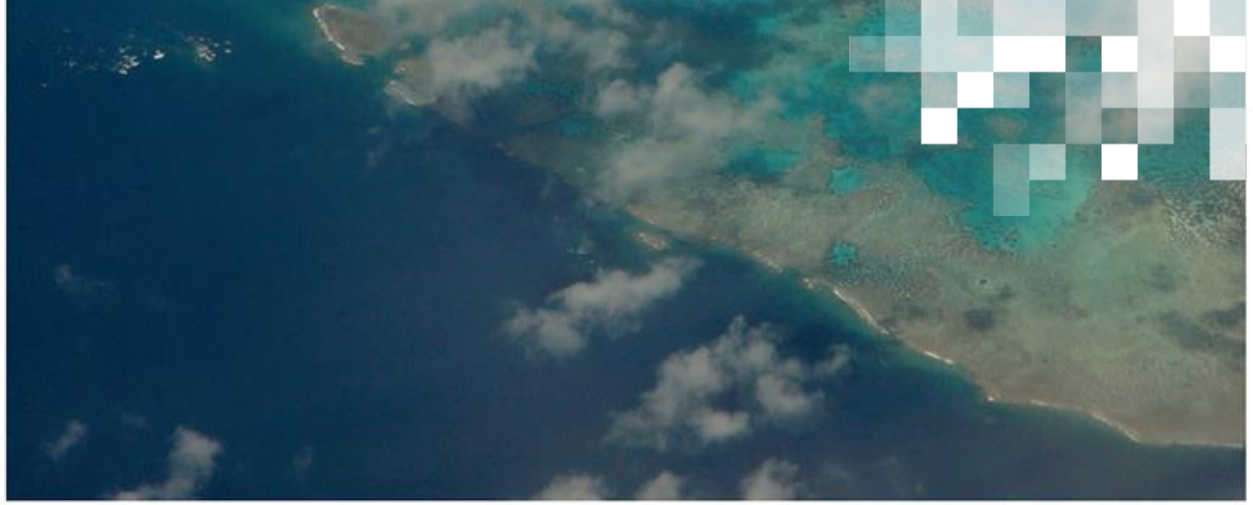
Source: NASA JPL

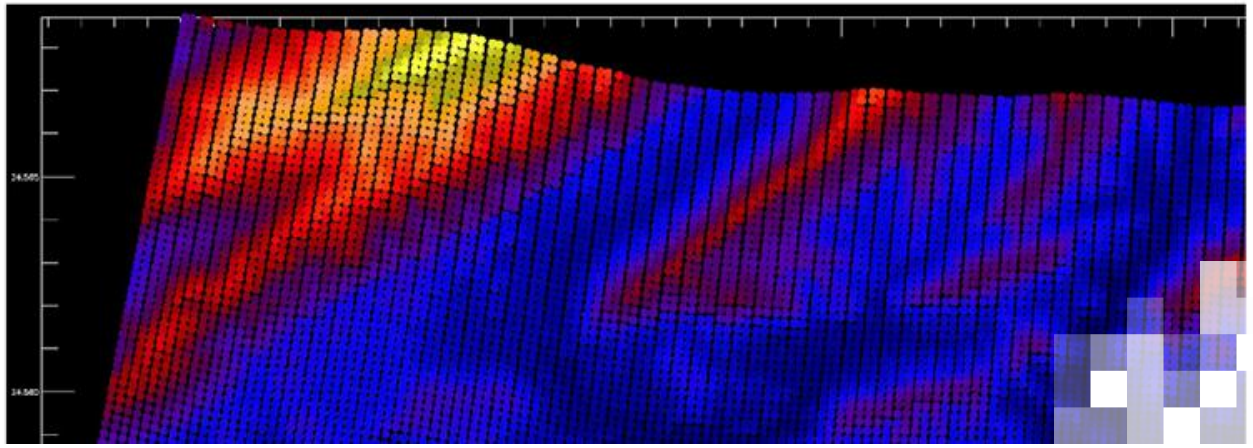


Source: NASA JPL

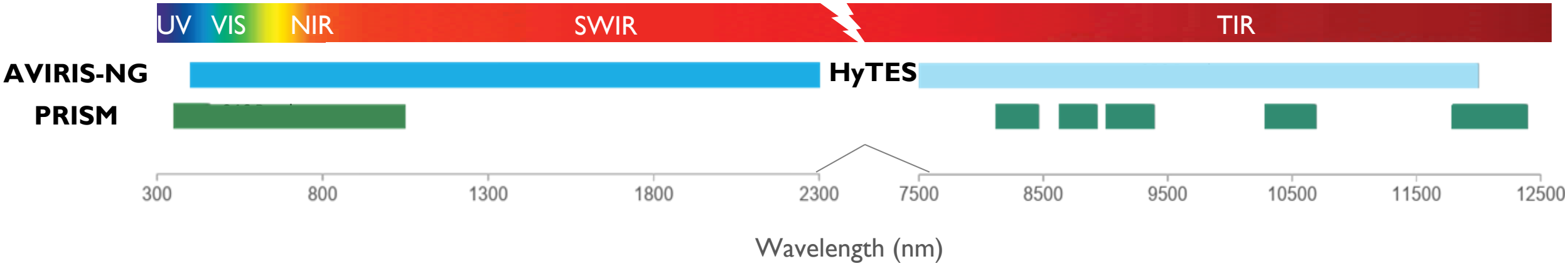


Source: NASA JPL





Aerial Thermal and LiDAR Missions

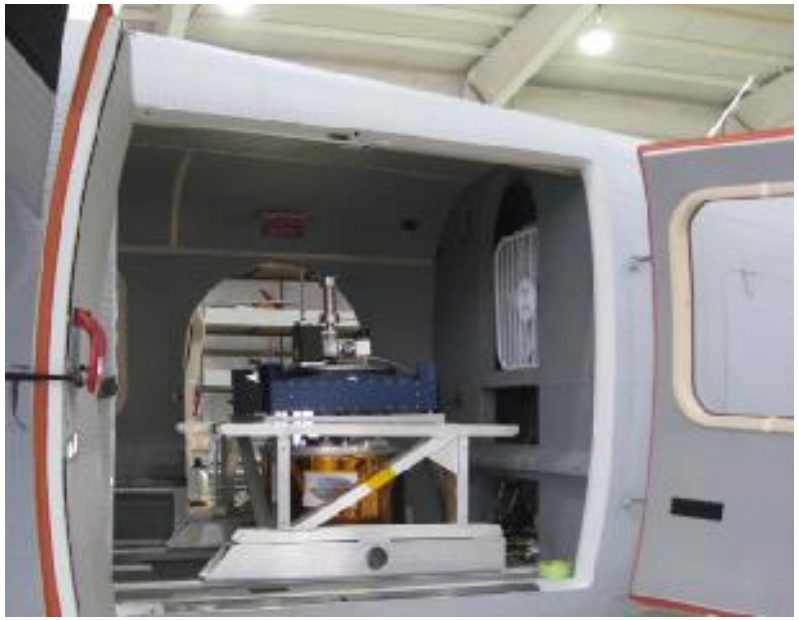


Adapted from: Wilson, A., Hestir, E., Slingsby, J., Cardoso, A. (2022). Biodiversity Survey of the Cape (BioSCape).

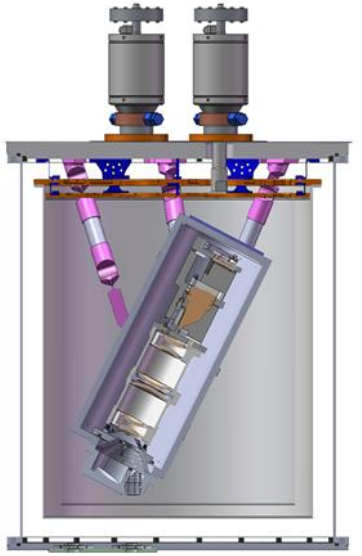
Hyperspectral Thermal Emission Spectrometer (HyTES)

- Objective: To provide precursor high spectral and spatial resolution thermal infrared data to determine the optimum band positions for the TIR instrument on HyspIRI.
- Flown on Twin Otter and ER2 aircraft
- Flown in United States and Europe
- Active since 2012

Source: NASA JPL

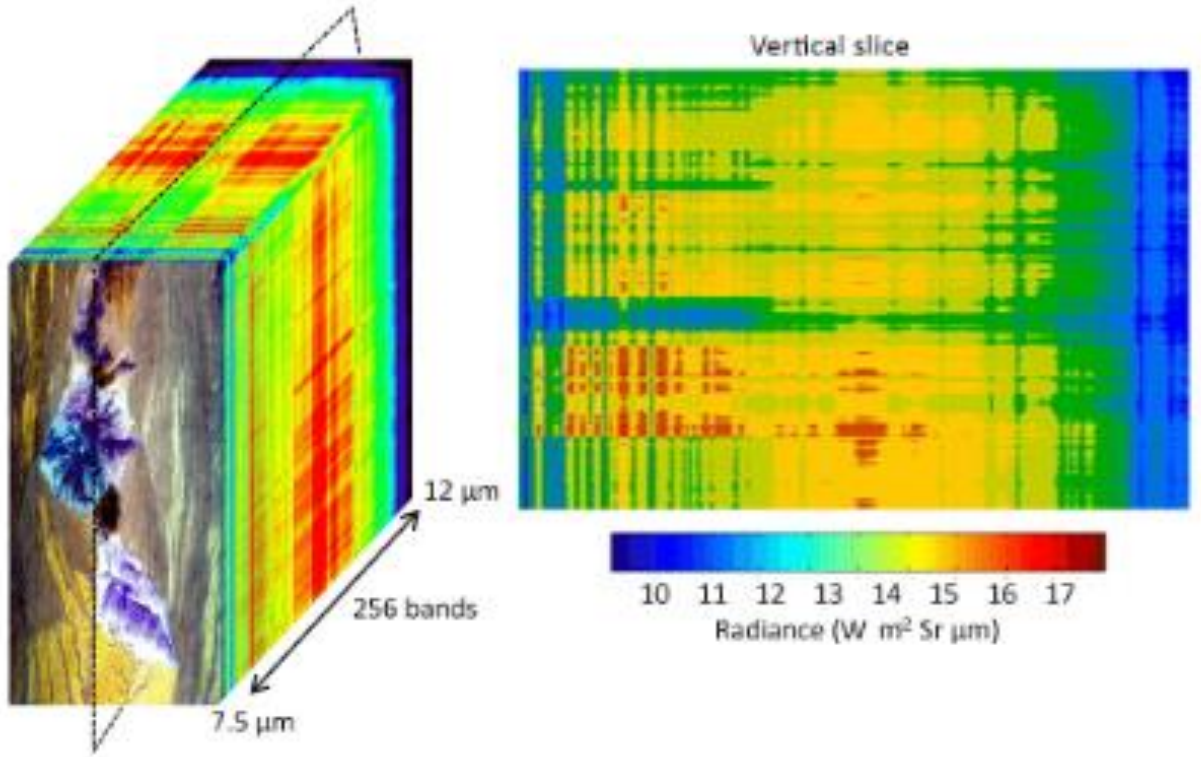


Source: NASA ESTO



Source: NASA JPL

Hyperspectral Thermal Emission Spectrometer (HyTES)

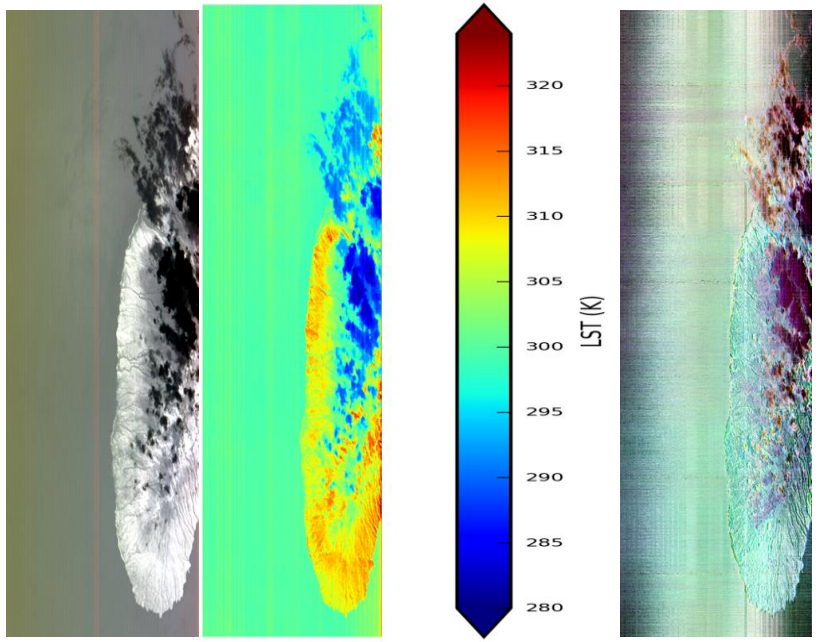


Source: NASA JPL

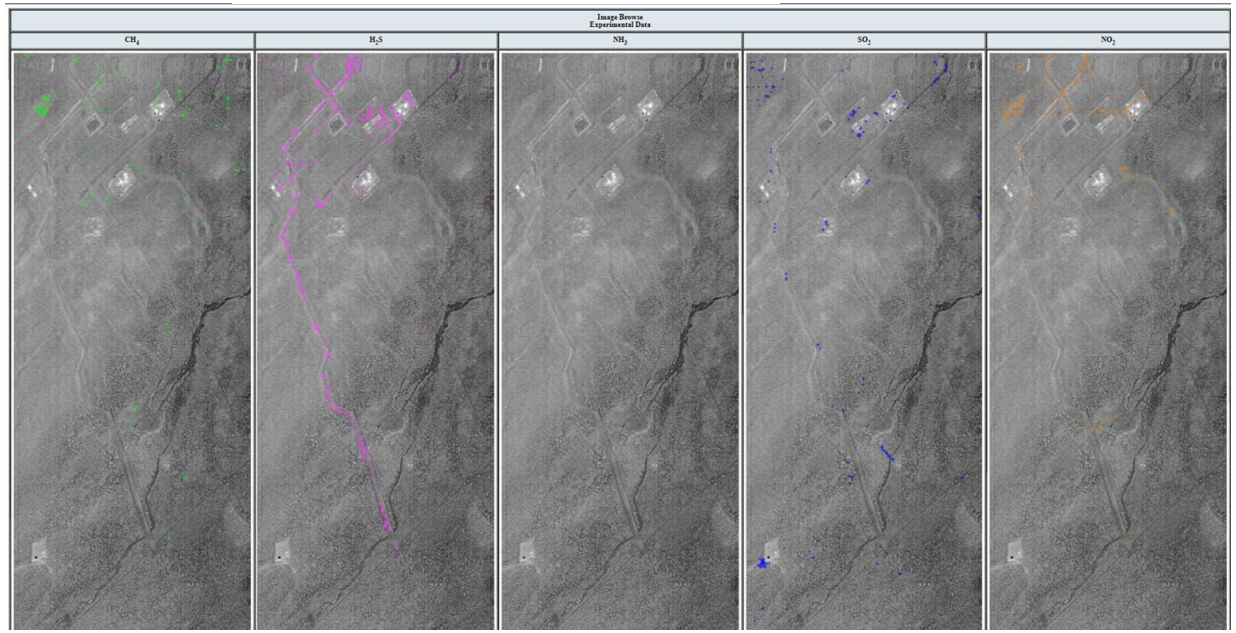
- 256 spectral bands
- Spectral range: 7.5 - 12 µm
- Spectral resolution: 4.5µm (17 nm)
- Spatial resolution:
  - 3.41m at 2,000 m AGL
  - 34.13m 20,000 m AGL

HyTES Data Products

- Level 1a - Calibrated but not geocoded Level 1 Brightness Temperature at Sensor
- Level 1b - Calibrated and geolocated Level 1 Brightness Temperature at Sensor
- Level 2 - Temperature and Emissivity (geolocated)
- Level 3 - Multi-species gas products (geolocated) CH4, H2S, NH3, S02, N02



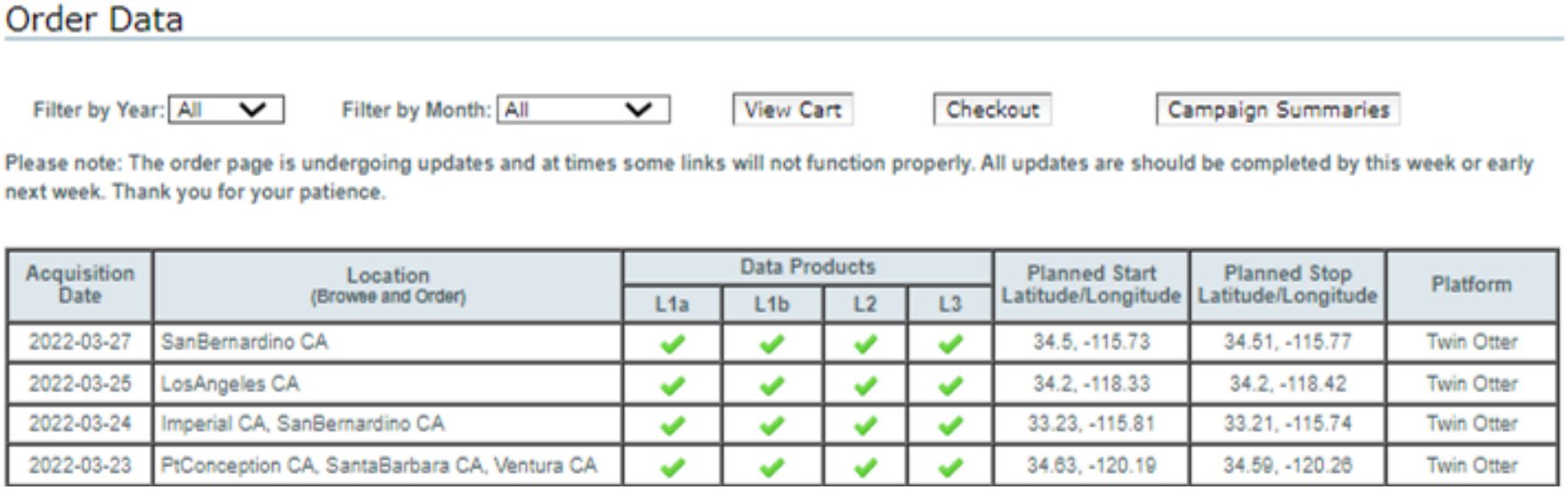
Source: NASA JPL



Accessing and Using HyTES Data

- 2013 - 2022 data is available to download from HyTES Data Portal
  - Filter by month and year
- Data types:
  - .dat
  - .png
  - .hdf5
  - .kmz

- Website provides guides for:
  - HyTES File Description/Naming Information
  - L3 Data Product User Guide
  - Creating a GLT in ENVI user guide



Order Data

Filter by Year: All Filter by Month: All View Cart Checkout Campaign Summaries

Please note: The order page is undergoing updates and at times some links will not function properly. All updates are should be completed by this week or early next week. Thank you for your patience.

Acquisition Date	Location (Browse and Order)	Data Products				Planned Start Latitude/Longitude	Planned Stop Latitude/Longitude	Platform
		L1a	L1b	L2	L3			
2022-03-27	SanBernardino CA	✔	✔	✔	✔	34.5, -115.73	34.51, -115.77	Twin Otter
2022-03-25	LosAngeles CA	✔	✔	✔	✔	34.2, -118.33	34.2, -118.42	Twin Otter
2022-03-24	Imperial CA, SanBernardino CA	✔	✔	✔	✔	33.23, -115.81	33.21, -115.74	Twin Otter
2022-03-23	PtConception CA, SantaBarbara CA, Ventura CA	✔	✔	✔	✔	34.63, -120.19	34.59, -120.26	Twin Otter

Source: NASA JPL

Upcoming HyTES Deployments

2022 WDTS Campaign:

- August 8-15th - install on ER2
- September 1-16th - campaign on ER2

2022 G5 checkout campaign:

- November 14th-18th - install on GV
- November 21st-25th - test flights on GV

2023 European campaign:

- Mid April - May

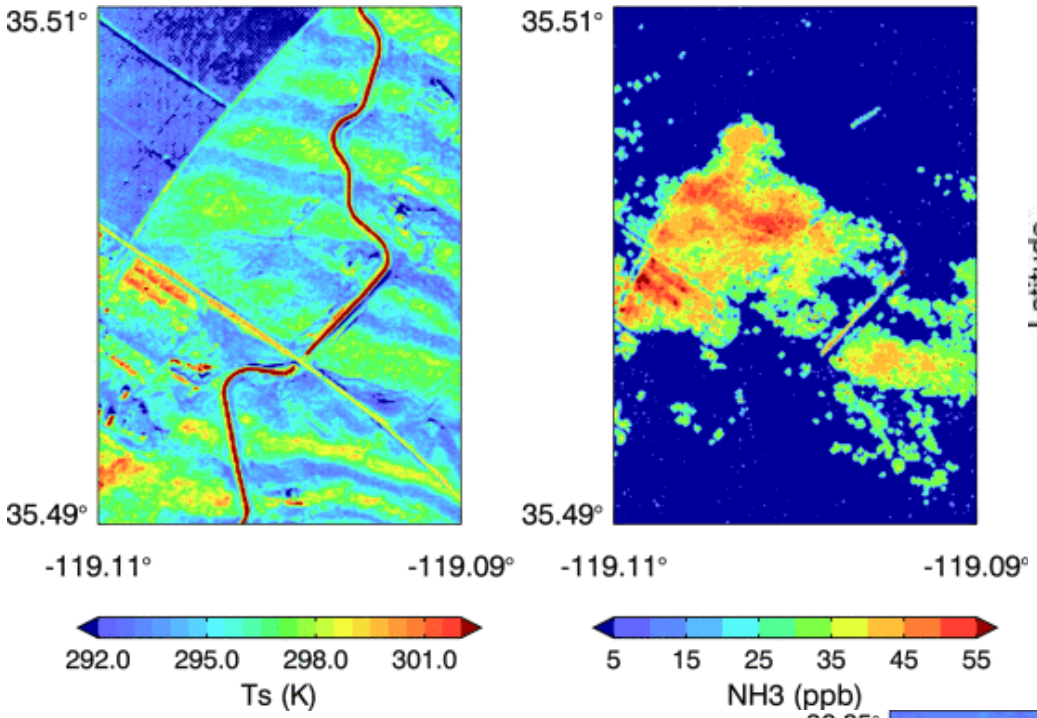
2023 Bioscape campaign

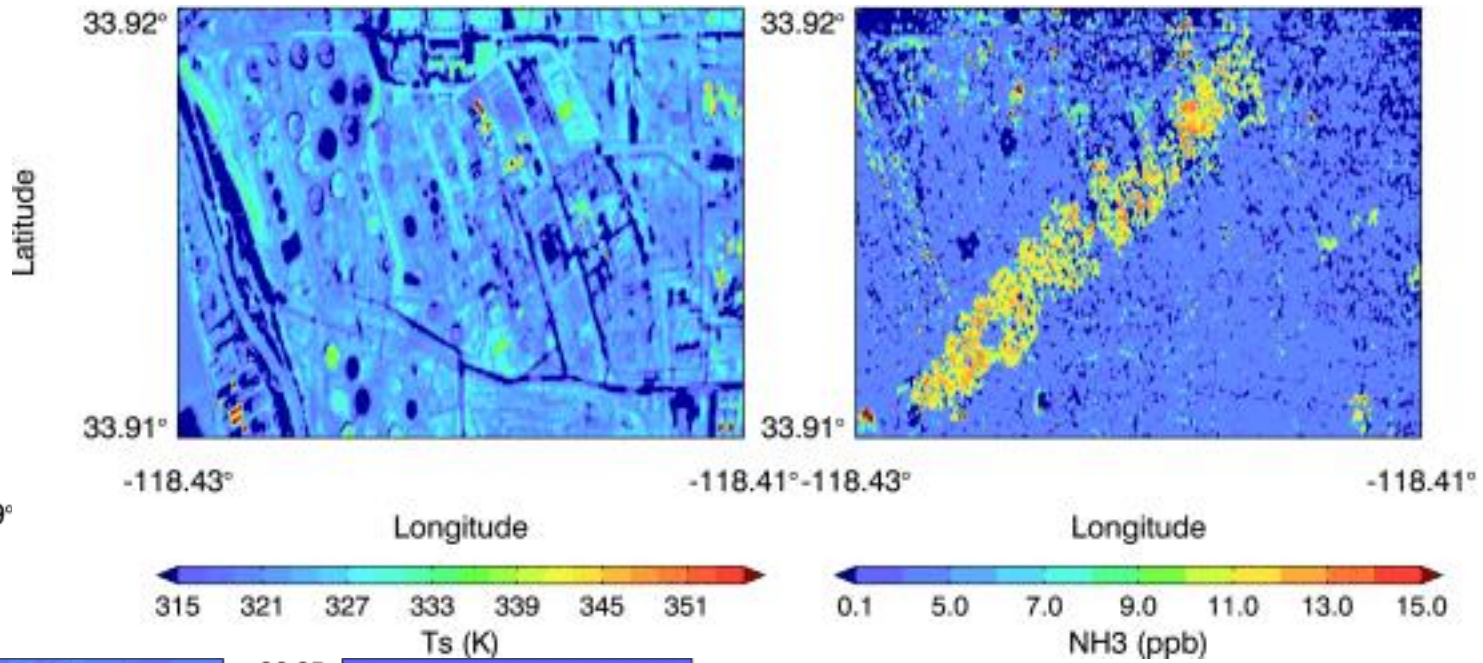
- Mid October - November

Source: King's College London

Source: NASA JPL

HyTES Biodiversity Applications





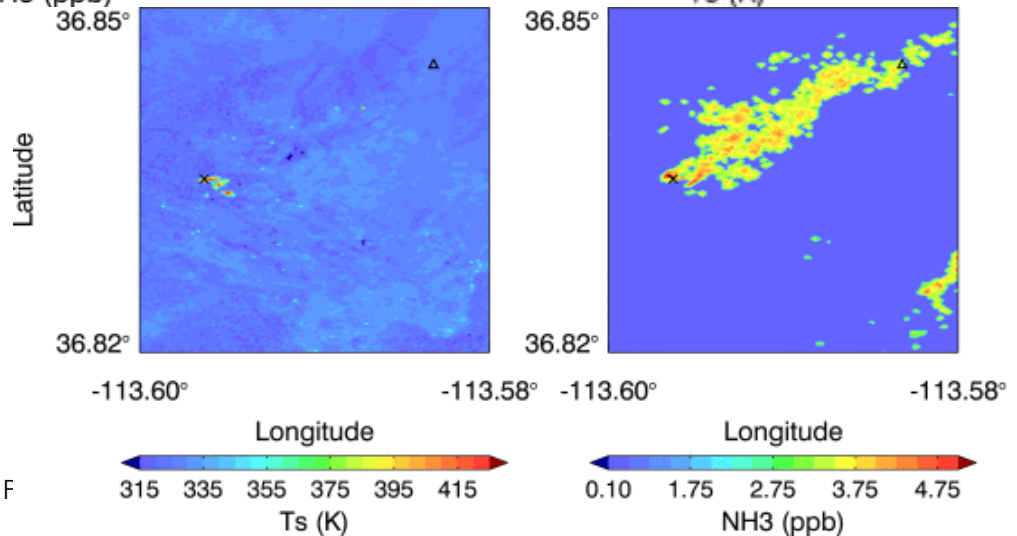
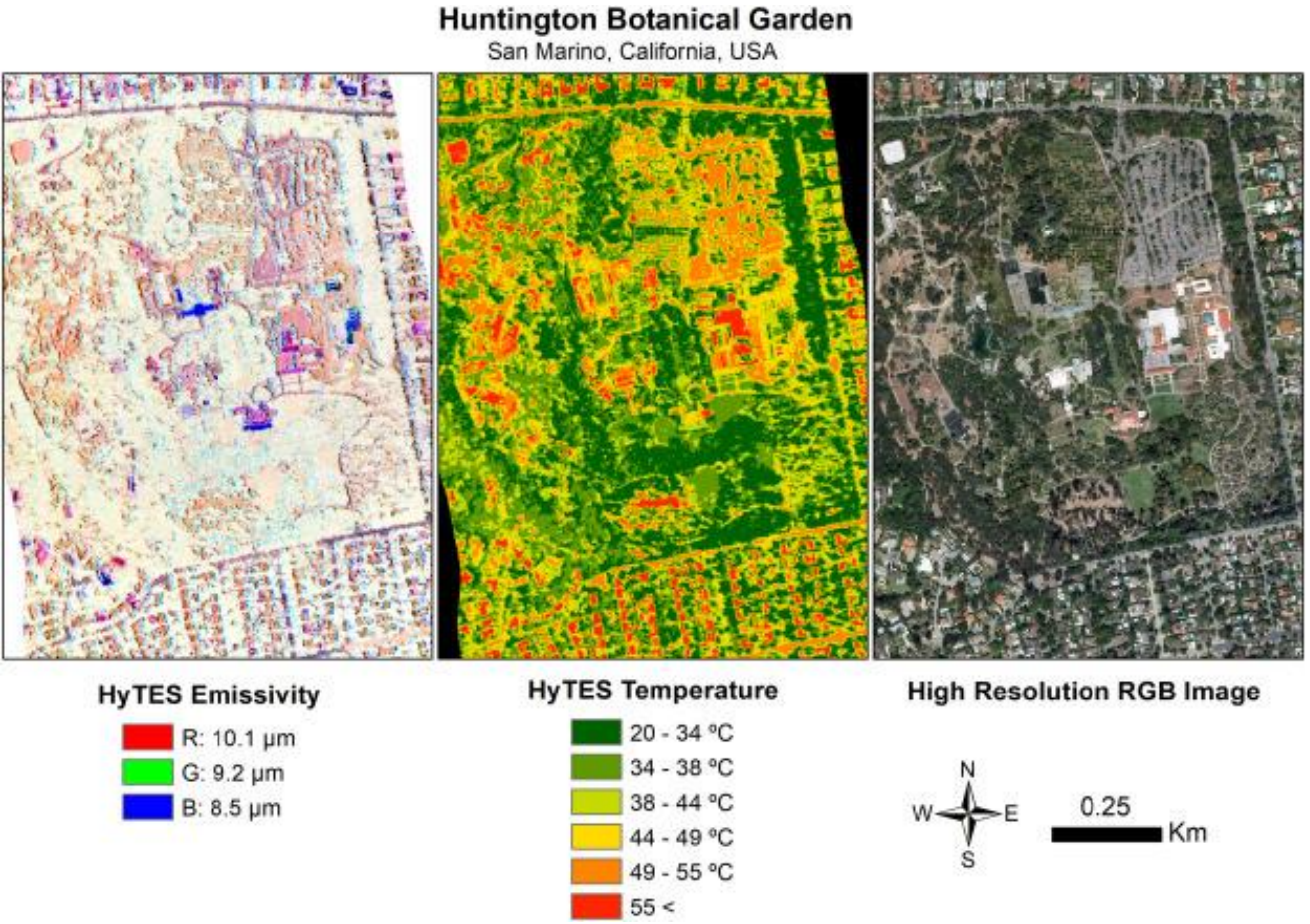
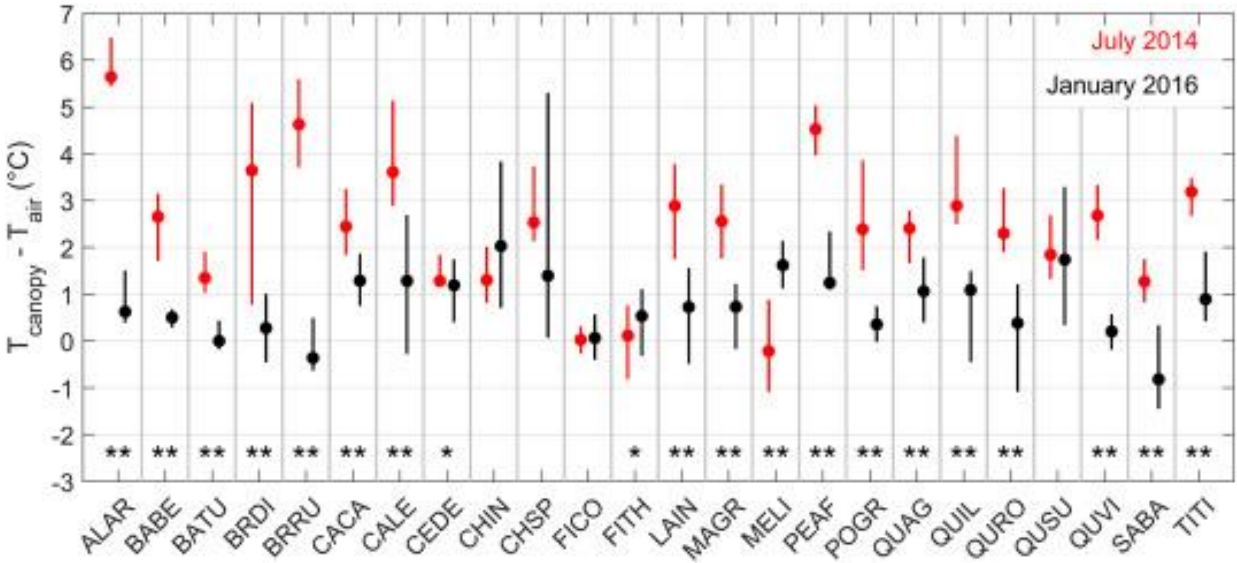


Image top left: Surface temperature (left) and NH3 (right) over a cattle feedlot in Kern County, near Bakersfield, CA, USA.
Image Top right: Surface temperature and NH3 over the power plant facility in the City of El Segundo, located in Los Angeles County, CA, USA.
Image bottom: Surface temperature and NH3 enhancements over the Gulch fire in Arizona.
Source: Kuai et al., 2019.

HyTES Biodiversity Applications



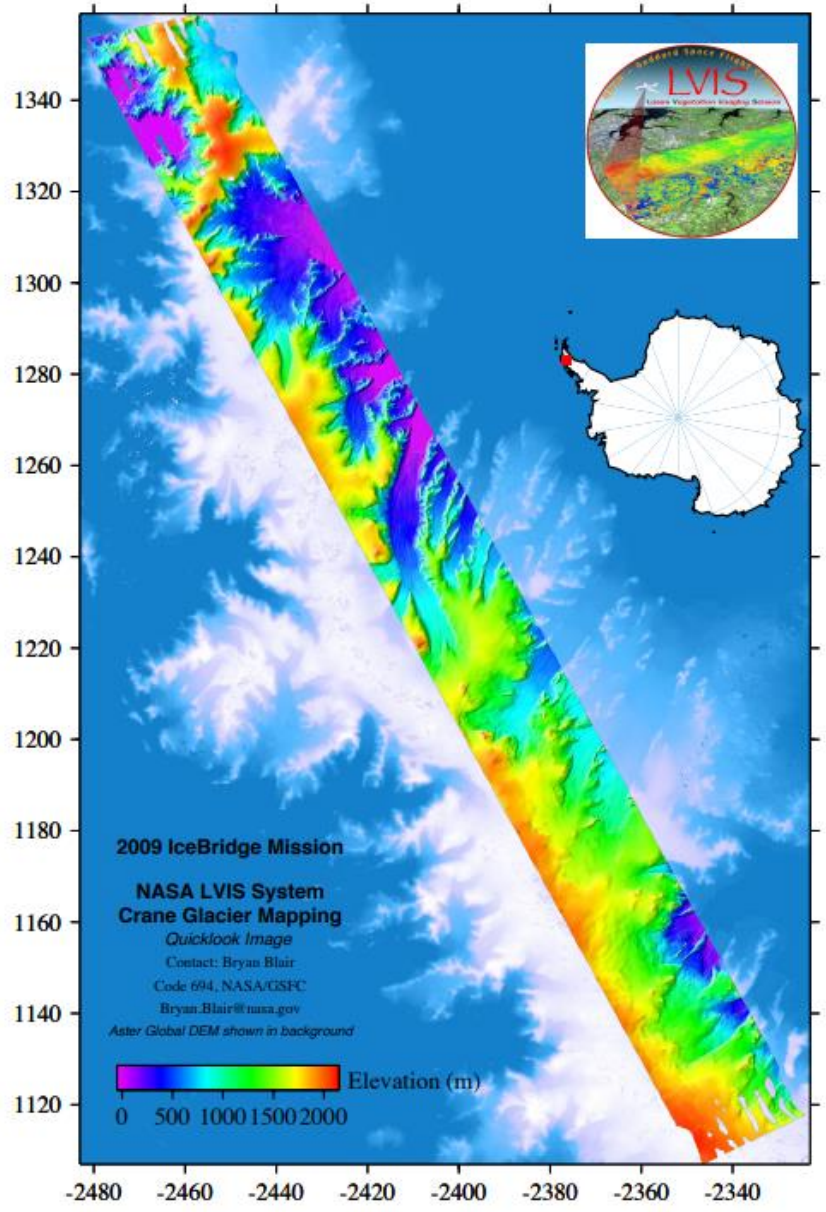


2014 and 2016 canopy LST distributions for 24 plant species within the botanical garden.

Source: Meerdink et al., 2019.

Land, Vegetation, and Ice Sensor (LVIS)

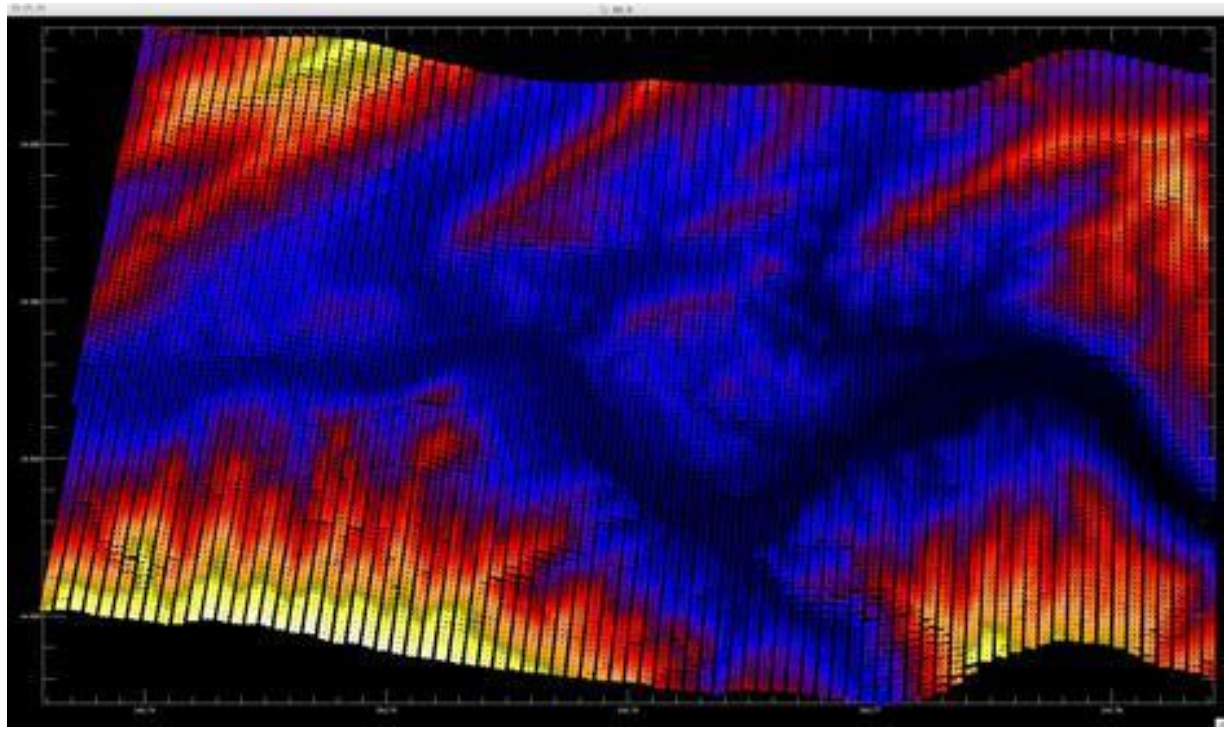
- Objective: To provide elevation and surface structure measurements.
- LVIS has flown on 12 different types of aircraft.
- Flown in the Arctic (Greenland, Alaska, and Canada), the Antarctic, the continental United States, Africa, and Costa Rica
- Active since 1998



Source: NASA GSFC

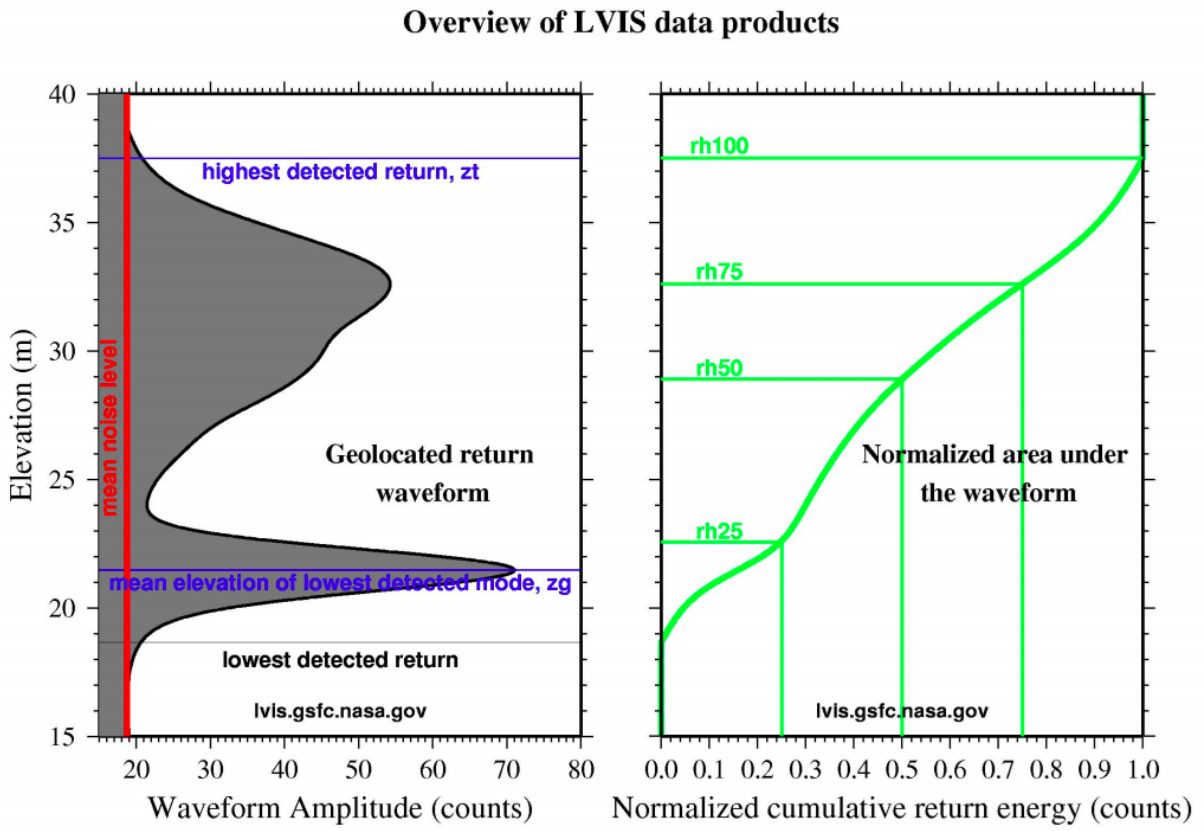
Land, Vegetation, and Ice Sensor (LVIS)

- 1064 nm laser and 3 detectors
- Operates at altitudes up to 20 km
- Scan angle of ~12 degrees and can cover 2 km swaths of surface from an altitude of 10 km



Source: NASA GSFC

LVIS Data Products



Source: NASA GSFC

- Products levels include Level-1A, Level-1B, and Level-2A.
- The Level-1B data files contain the geolocated laser waveform data for each laser footprint.
- The Level-2A data files contain canopy top and ground elevations and relative heights derived from the Level-1 data.

Accessing and Using LVIS Data

- 2006 - 2021 data is available to download from the LVIS Data Portal
- Data types:
  - .HDF5
  - ASCII
  - JPG
  - .PDF
  - .kmz
  - .shp
- LVIS website has a data use section, a FAQ section, and a tutorial for LVIS data products from all levels.

Data Locations

Since 1998, LVIS has flown in several regions around the world including the Arctic (Greenland, Alaska, and Canada), the Antarctic, the continental United States, Africa, and Costa Rica.

Below is a list of all of LVIS's missions organized by region with the most recent missions on top. Click a mission's "Year" to view a thumbnail containing all trajectories for that mission.

Greenland

LVIS has flown over Greenland numerous times between 2007 and 2017 for Operation IceBridge.

Canada and Alaska

LVIS has flown over Canada and Alaska in 2010, 2014, 2017, and 2019 for missions including ARISE, IceBridge, and ABoVE.

Africa

LVIS flew over Africa in 2016 for AfriSAR.

Antarctica

LVIS has flown over Antarctica several times between 2009 and 2015 for Operation IceBridge.

Mission	Year	Platform	Data
IceBridge	Fall 2015	NSF/NCAR G-V	View Data
IceBridge	Fall 2011	NSF/NCAR G-V	View Data
IceBridge	Fall 2010	DC-8	View Data
IceBridge	Fall 2009	DC-8	View Data
	All		

United States

LVIS has extensive data from the United States.

Costa Rica and Panama

LVIS has flown over Costa Rica in 1998, 2005, and 2019. The 1998 deployment included a flight over Panama.

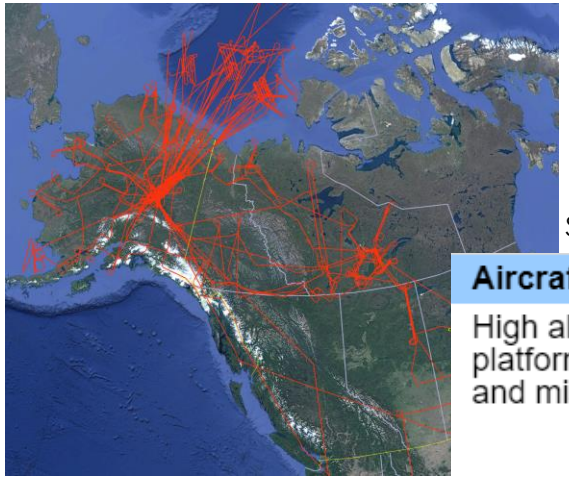
French Guiana

LVIS has flown over French Guiana in 2021.

Previous LVIS Campaigns

Since 1998, LVIS has flown in several regions around the world, including:

- Africa
- Alaska
- Antarctica
- Canada
- Costa Rica
- French Guiana
- Greenland
- United States

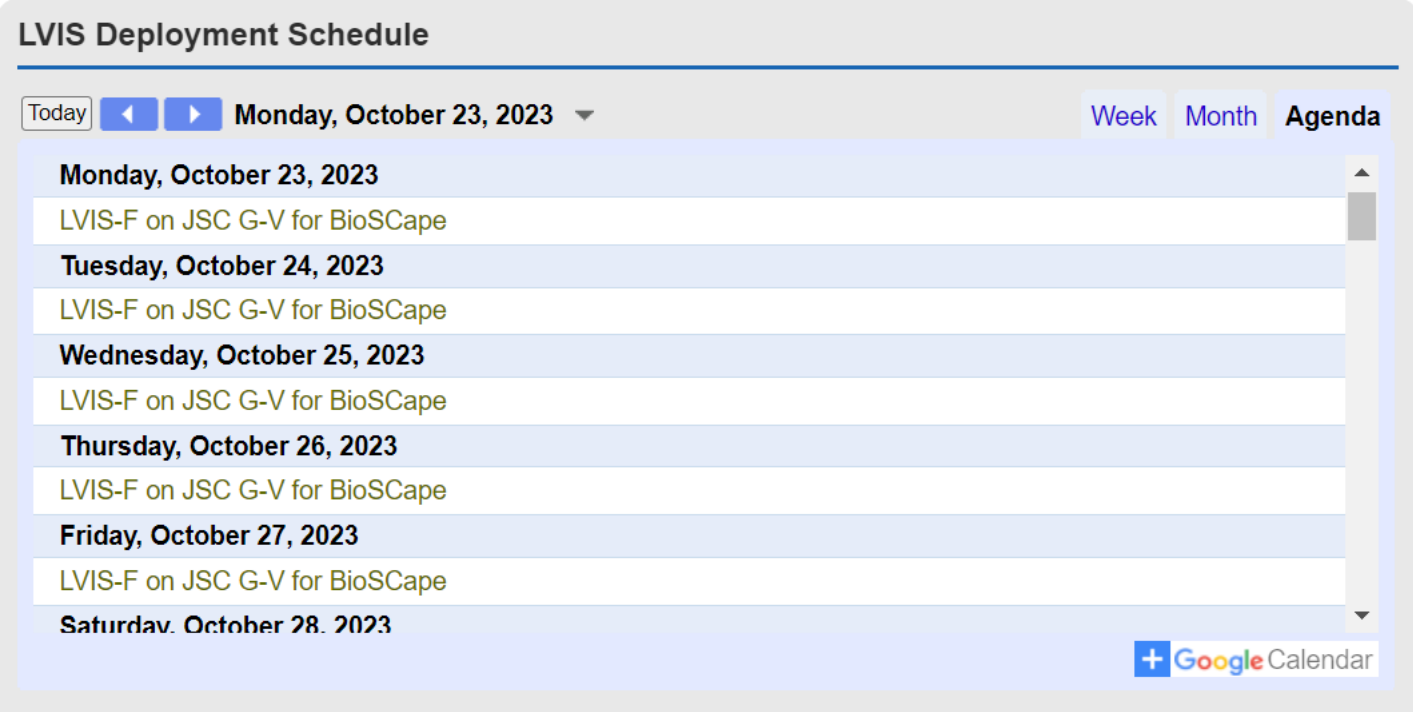


Source: NASA GSFC

Aircraft		Install Dates
High altitude, long endurance platforms for maximum coverage and mission flexibility	NASA JSC Gulfstream V	2019, 2021, 2022
	NSF Gulfstream V	2011, 2015
	NASA LaRC Gulfstream III	2022
	NASA LaRC HU-25 Guardian	2012
	NOAA Cessna Citation	2003, 2005, 2006
	NASA Global Hawk	2013
Widely-deployed, high-availability, lower-cost aircraft	NASA LaRC King Air B200	2011, 2013, 2016, 2018, 2019
	DOE King Air B200	2003, 2004, 2005, 2006, 2009
	Dynamic Aviation King Air B200	2004, 2017
Large, multi-instrument platforms	NASA P-3	2007, 2011, 2022
	NASA DC-8	2010, 2011
	NASA C-130	1998, 1999, 2013, 2014

Source: NASA GSFC

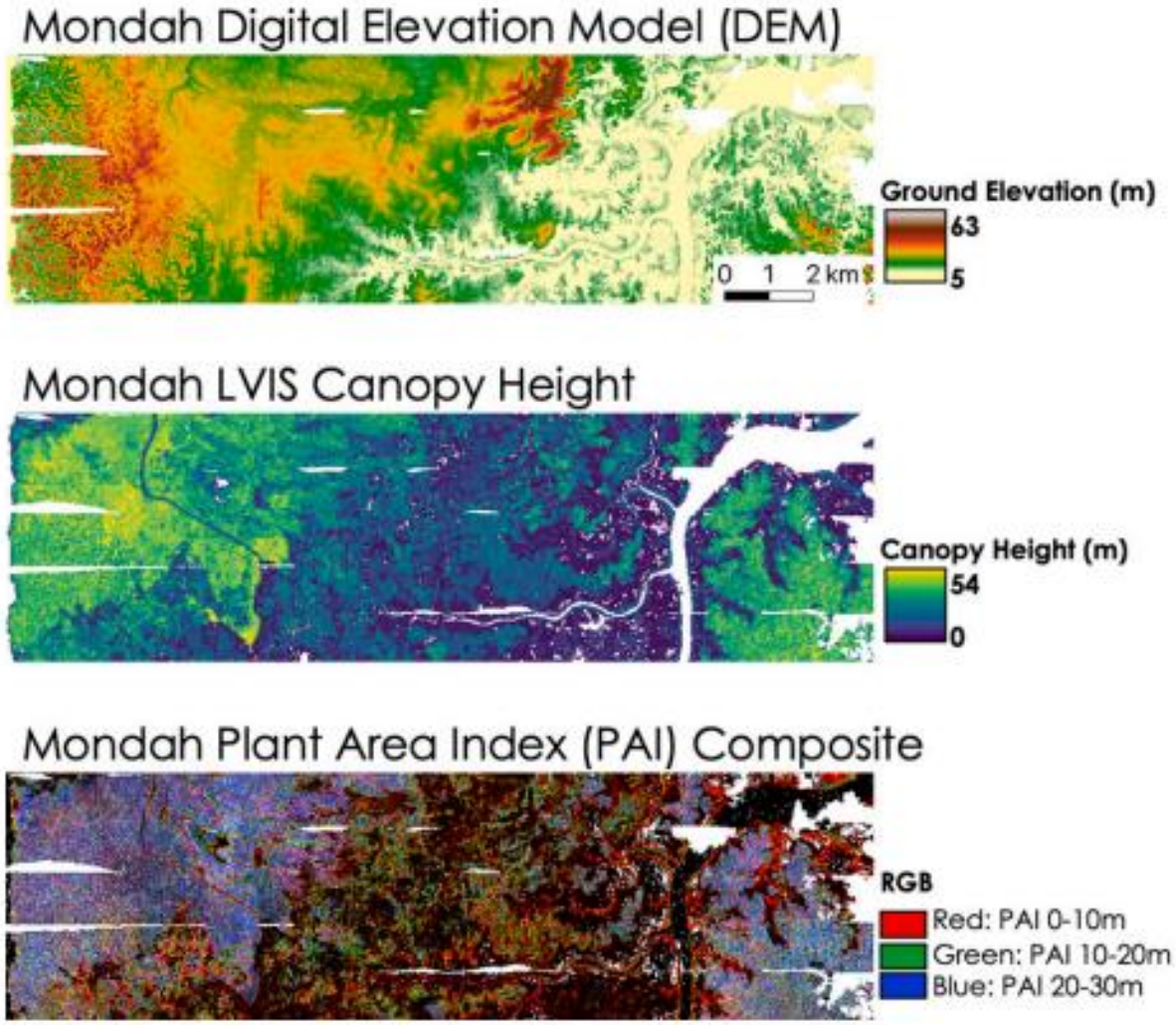
Upcoming LVIS Deployments



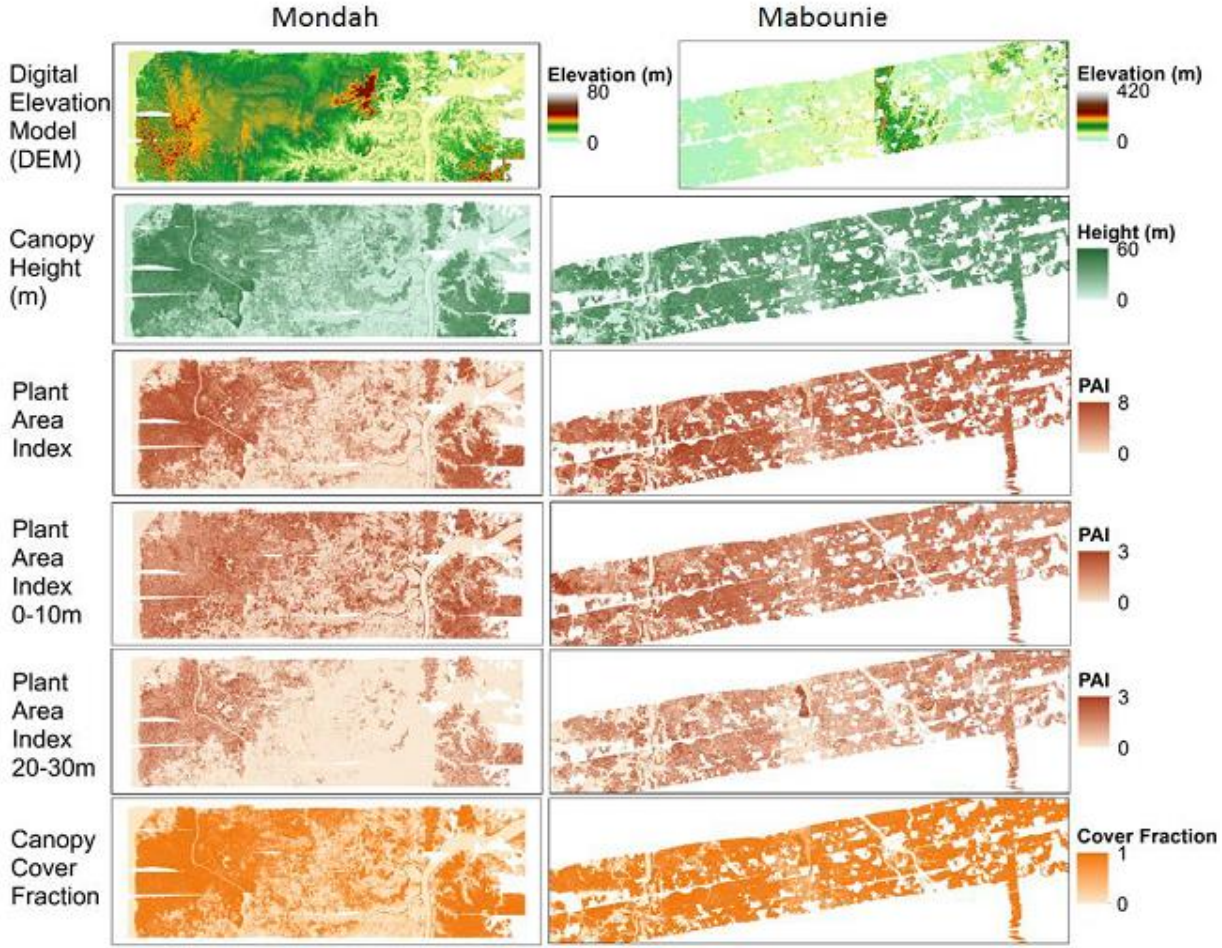
Source: NASA GSFC

- LVIS will be flying for BioSCape from late October through December 2023.
- You can see all their upcoming campaigns on the LVIS website.

LVIS Biodiversity Applications



AfriSAR

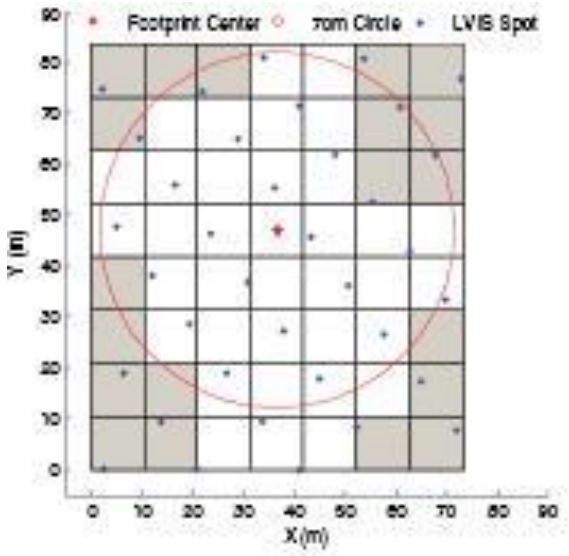


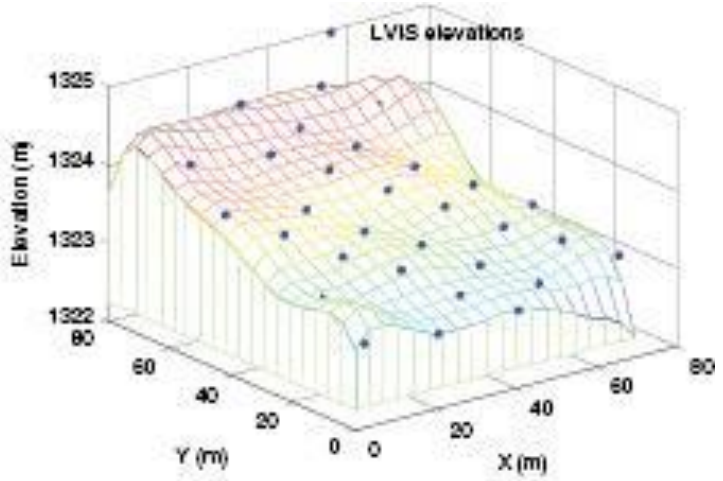
Source: Fatoyinbo, et al., 2021.

Source: J. Armston

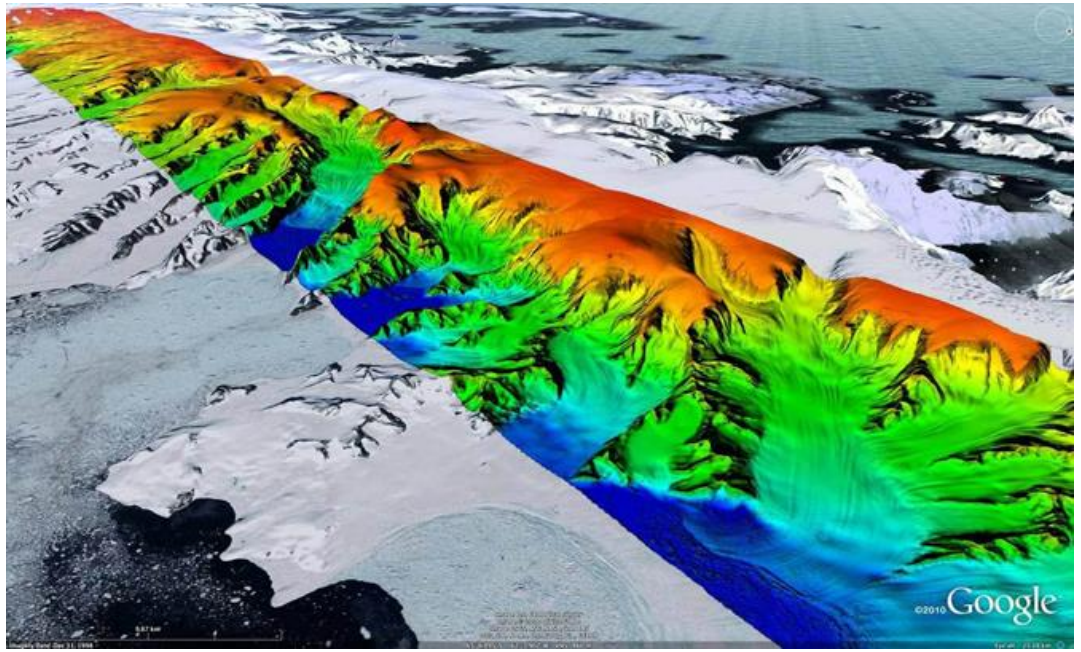
LVIS Biodiversity Applications

Source: NASA GSFC





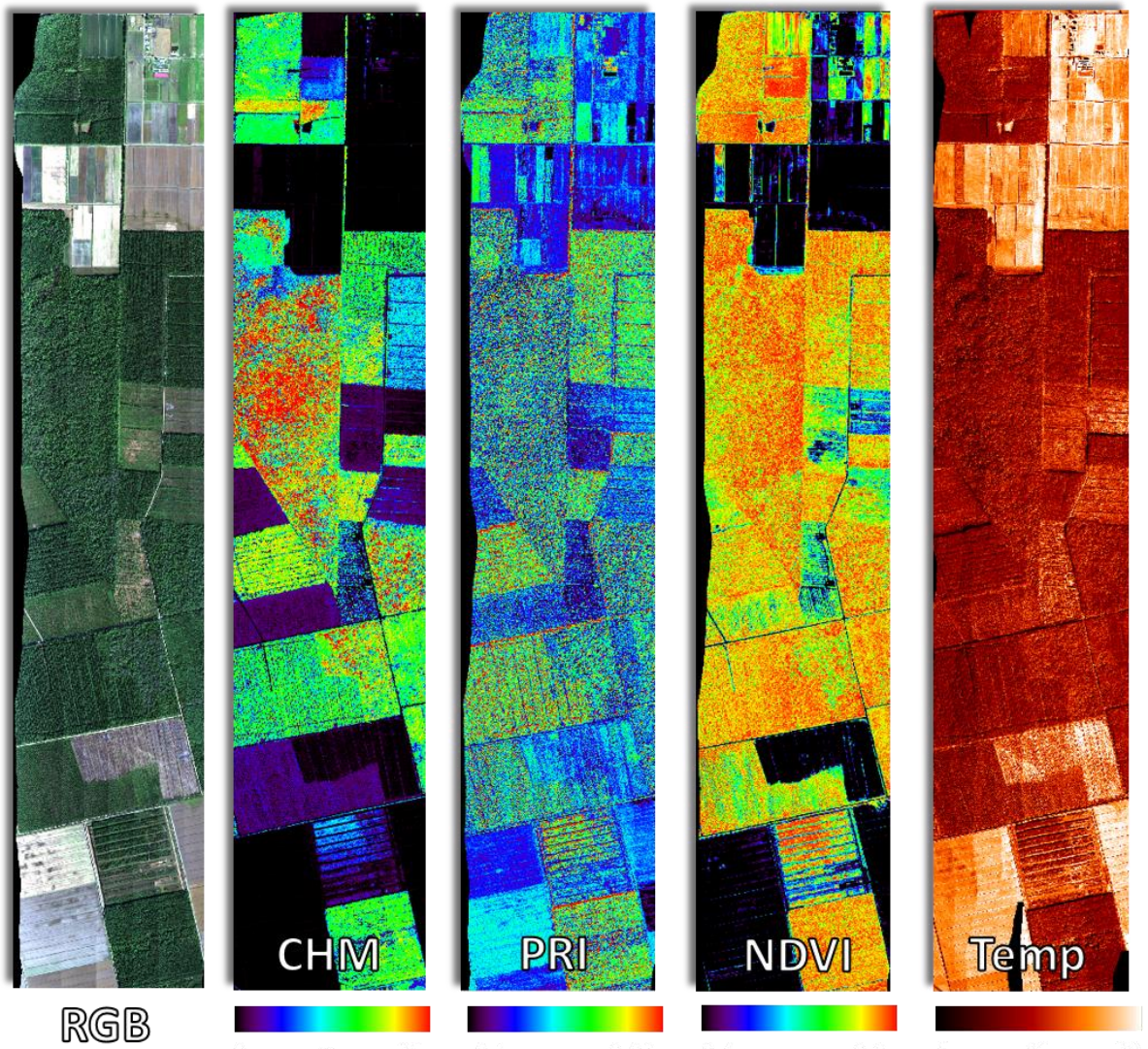
Source: Xiaolu, Li et al., 2016



Source: NASA GSFC

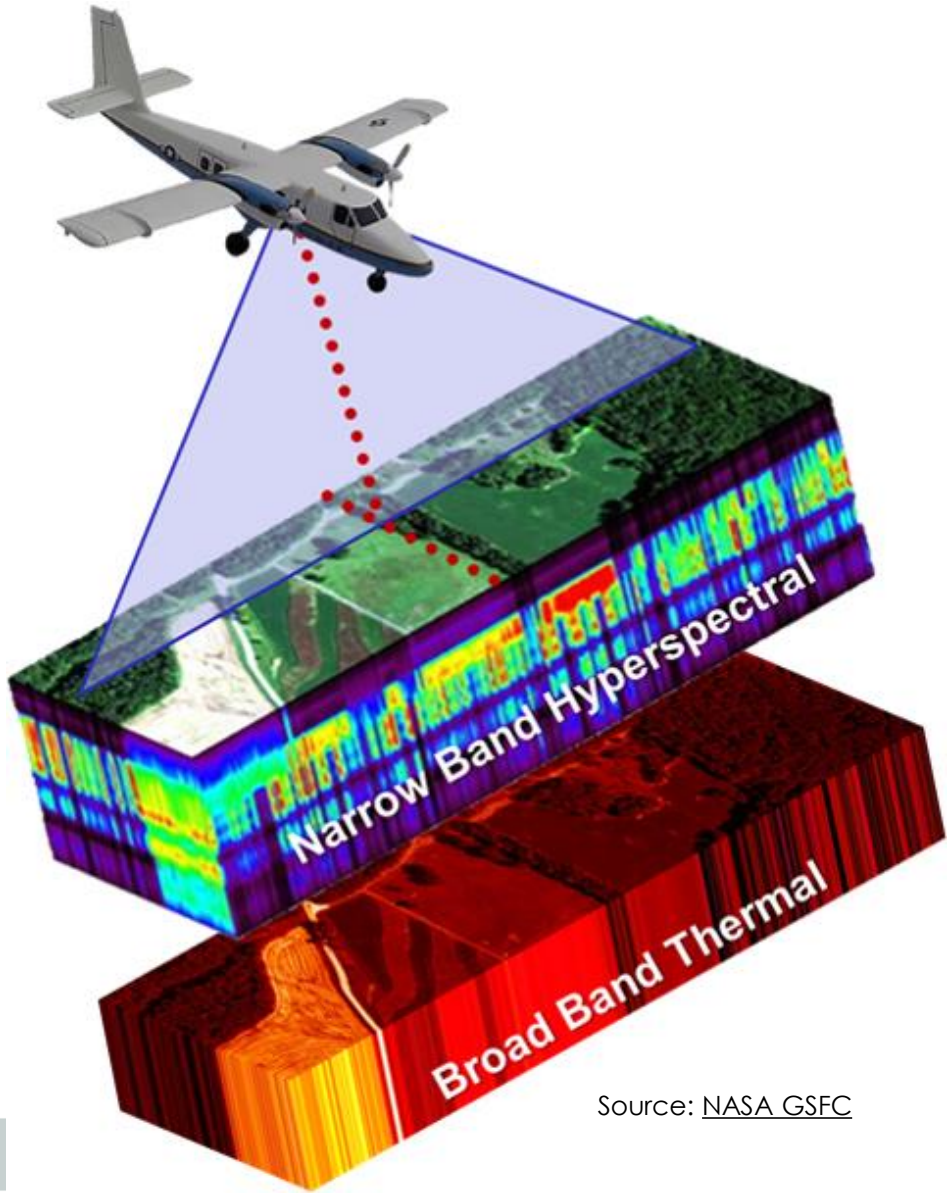
Goddard's LiDAR, Hyperspectral & Thermal Imager (G-LiHT)

- Objective: To provide simultaneous measurements of vegetation structure, foliar spectra and surface. temperatures at very high spatial resolution (~1 m) on a wide range of airborne platforms.
- Flown in US and Mexico
- Cessna, Piper, Twin Otter; 12/28 VDC aircraft compatibility
- Active since 2011



Source: NASA GSFC

Goddard's LiDAR, Hyperspectral & Thermal Imager (G-LiHT)



Source: NASA GSFC

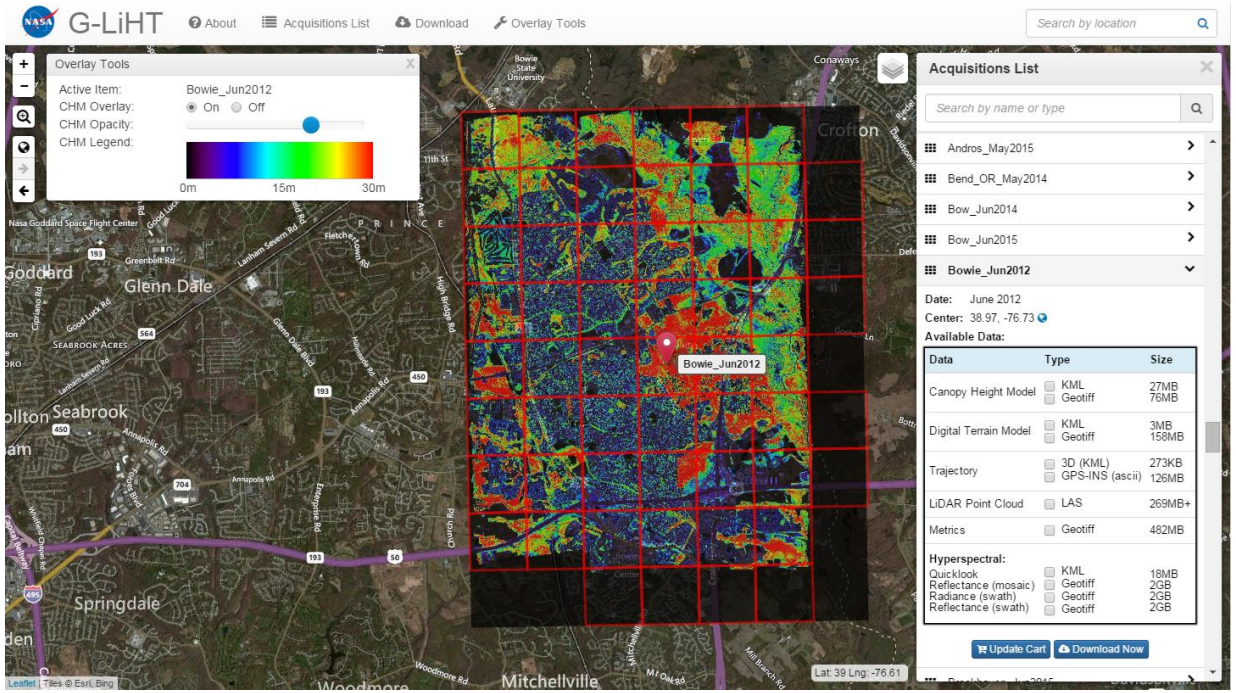
- LiDAR:
  - NIR 1550 nm Laser
  - Point Density up to 12 pt/m2
- VNIR Imaging
  - Micro-Hyperspec E-Series
    - Up to 375 spectral bands w/o binning
    - Spectral range: 400nm-1000nm sampled at 1.6nm w/o binning
    - Spectral resolution: 5nm
  - FIREFLY
    - 2160 spectral bands
    - Spectral range: 670nm-780nm sampled at 0.05nm
    - Spectral resolution: ≤ 0.18nm
- Broad Band Thermal Imaging
  - Spectral Band 8 to 15 µm
- High Resolution Aerial Photos
  - Ground Sampling Distance: 4cm

G-LiHT Products Levels

Instrument	L1	L2	L3
Oxford RT-4041 GPS-INS 250 Hz measurement rate	Trajectory data (coordinates, roll, pitch, yaw)	• Aircraft elevation • Aircraft altitude AGL • Geographic Look-Up Table (GLT)	• Aircraft elevation • Aircraft altitude AGL • View angle • View azimuth
Riegl VQ-480 Scanning Lidar 1550 nm laser discrete returns (≤8 pulse^{-1}) 150 kHz measurement rate	Return data (coordinates, scan angle, return number, apparent reflectance)	• Classified return data (ground, non-ground) • AGL heights	• LiDAR returns (“point clouds”) • DTM • CHM • LiDAR metrics
Headwall Hyperspec Imaging Spectrometer 417 to 1,007 nm 402 bands, ≤5 nm FWHM 1,004 pixels per line 50 Hz measurement rate	At-sensor radiance spectra ($W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$)	• At-sensor reflectance computed with observed irradiance • Surface reflectance computed with atmospheric correction • Fluorescence [experimental]	• At-sensor reflectance computed w/observed irradiance • Surface reflectance computed w/atmospheric correction • Common vegetation indices • Fluorescence [experimental]
Ocean Optics USB 4000 Irradiance Spectrometer cosine diffuser 346 to 1,041 nm 1.5 nm FWHM 1 Hz measurement rate	Solar irradiance spectra ($W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$)	• Incoming PAR • Cloudiness index • Modeled solar zenith angle • Modeled solar azimuth angle	• Incoming PAR • Cloudiness Index • Modeled solar zenith angle • Modeled solar azimuth angle
Xenics Gobi 384 Thermal Camera 8 to 14 µm 25 Hz measurement rate	Temperature data (°C)	• Atmospherically corrected surface temperature	• Atmospherically corrected surface temperature

Accessing and Using G-LiHT Data

- 2011 - 2021 data is available to download from the G-LiHT Data Center Webmap.
- Data can also be downloaded from the Land Processes Distributed Active Archive Center (LP DAAC).
- Data Types:
  - AGL
  - KML
  - GeoTIFF
  - ASCII
  - ENVI
  - ASPRS LAS 1.1
- G-LiHT website has links and instructions for various software tools compatible with G-LiHT data.
- LP DAAC also has a FAQ page for G-LiHT data.



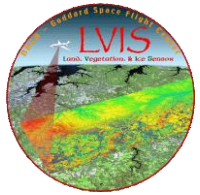
Source: NASA GSFC

Comparing Airborne Systems: Specifications

HyTES

- Active since 2012
- TIR
- 256 spectral bands
- Spectral coverage: 7.5 - 12 µm
- Spectral resolution: 4.5µm (17 nm)
- Spatial resolution:
  - 3.41m at 2,000 m AGL
  - 34.13m 20,000 m AGL

LVIS



- Active since 1998
- LiDAR
- 1064 nm laser and 3 detectors
- Operates at altitudes up to 20 km
- Scan angle of ~12 degrees and can cover 2 km swaths of surface from an altitude of 10 km

G-LiHT

- Active since 2011
- LiDAR
  - NIR 1550 nm Laser
  - Point Density up to 12 pt/m2
- VNIR
  - Micro-Hyperspec E-Series
    - Up to 375 spectral bands w/o binning
    - Spectral range: 400nm-1000nm sampled at 1.6nm w/o binning
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- Broad Band Thermal
  - Spectral Band 8 to 15 µm
- High Resolution Aerial Photos
  - Ground Sampling Distance: 4cm

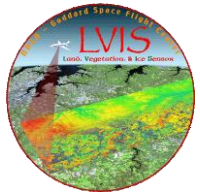
Comparing Airborne Systems: Access and Use

HyTES

- Data Access:
  - Data portal
  - 2013 - 2022
- Data products:

  Level 1a, L1b, L2, L3
- Data types:
  - .dat
  - .png
  - .hdf5
  - .kmz

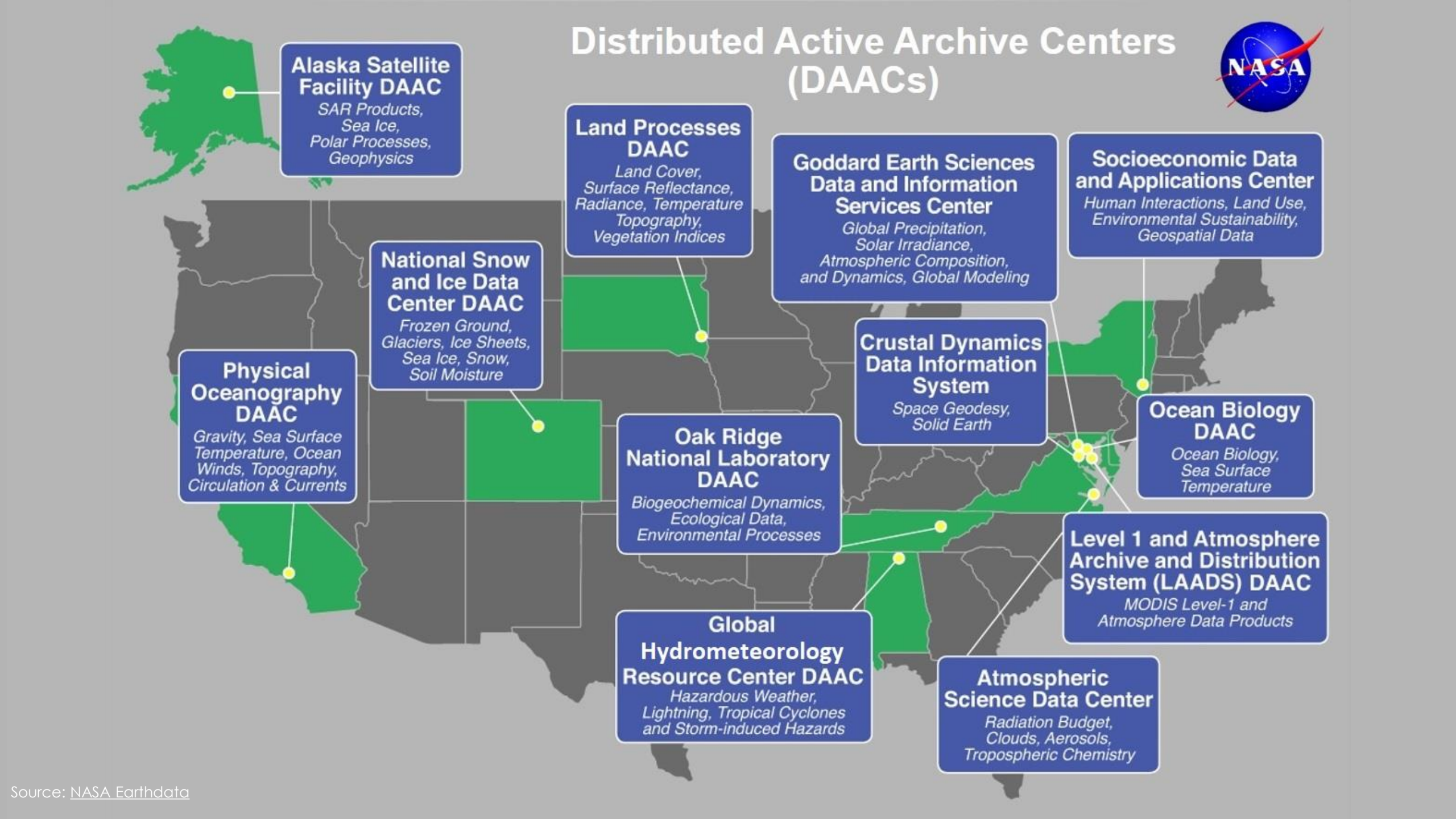
LVIS



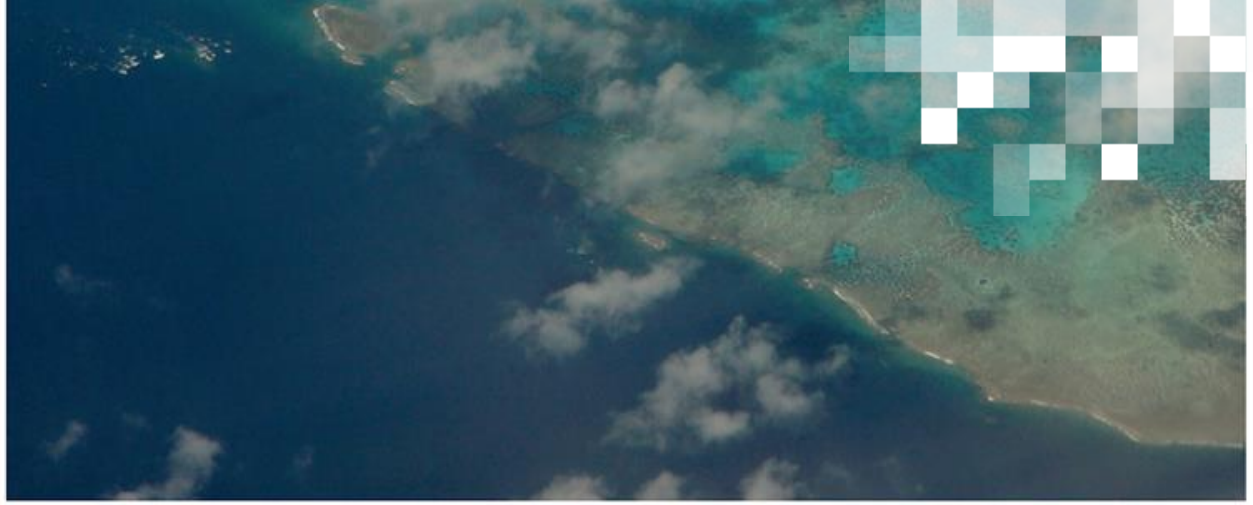
- Data Access:
  - Data portal
  - 2014 - 2021
- Data products:
  Level 1B, L2
- Data types:
  - .KML
  - .JPEG
  - .dat
  - ASCII

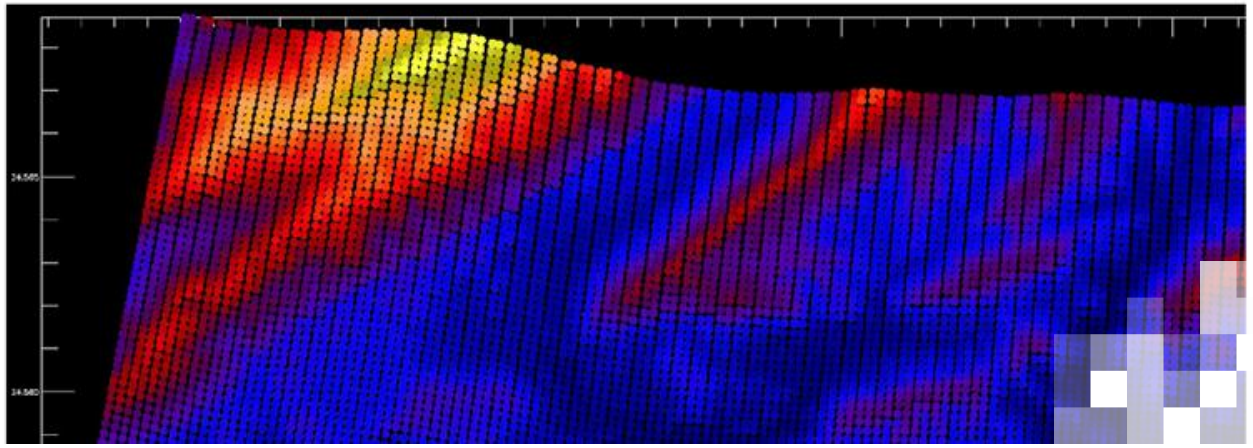
G-LiHT

- Data access:
  - Data portal
  - 2011 - 2021
- Data products
  - L1, L2, L3
- Data types:
  - AGL
  - KML
  - GeoTIFF
  - ASCII
  - ENVI
  - ASPRS LAS 1.1



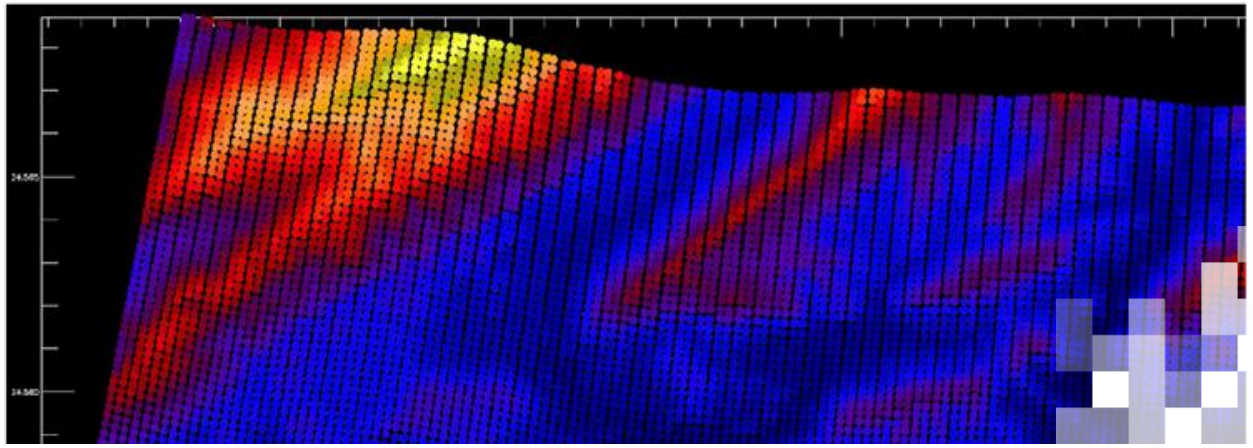
Source: NASA Earthdata



Guest Speaker: Adam Wilson, BioSCape





Biodiversity Applications for Airborne Imaging Systems

Case Study: BioSCape - A Field Campaign in South Africa

March 27, 2023

An Exciting Time for Remote Sensing and Biodiversity

- Technology is advancing.
  - LiDAR and Imaging Spectroscopy from space

- Biodiversity Conservation Challenges:
  - Human Development Pressure
  - 6th Mass Extinction

- The time is right for a biodiversity-focused airborne campaign.

An Exciting Time for Remote Sensing and Biodiversity

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  - LiDAR and Imaging Spectroscopy from space

- Biodiversity Conservation Challenges:
  - Human Development Pressure
  - 6th Mass Extinction

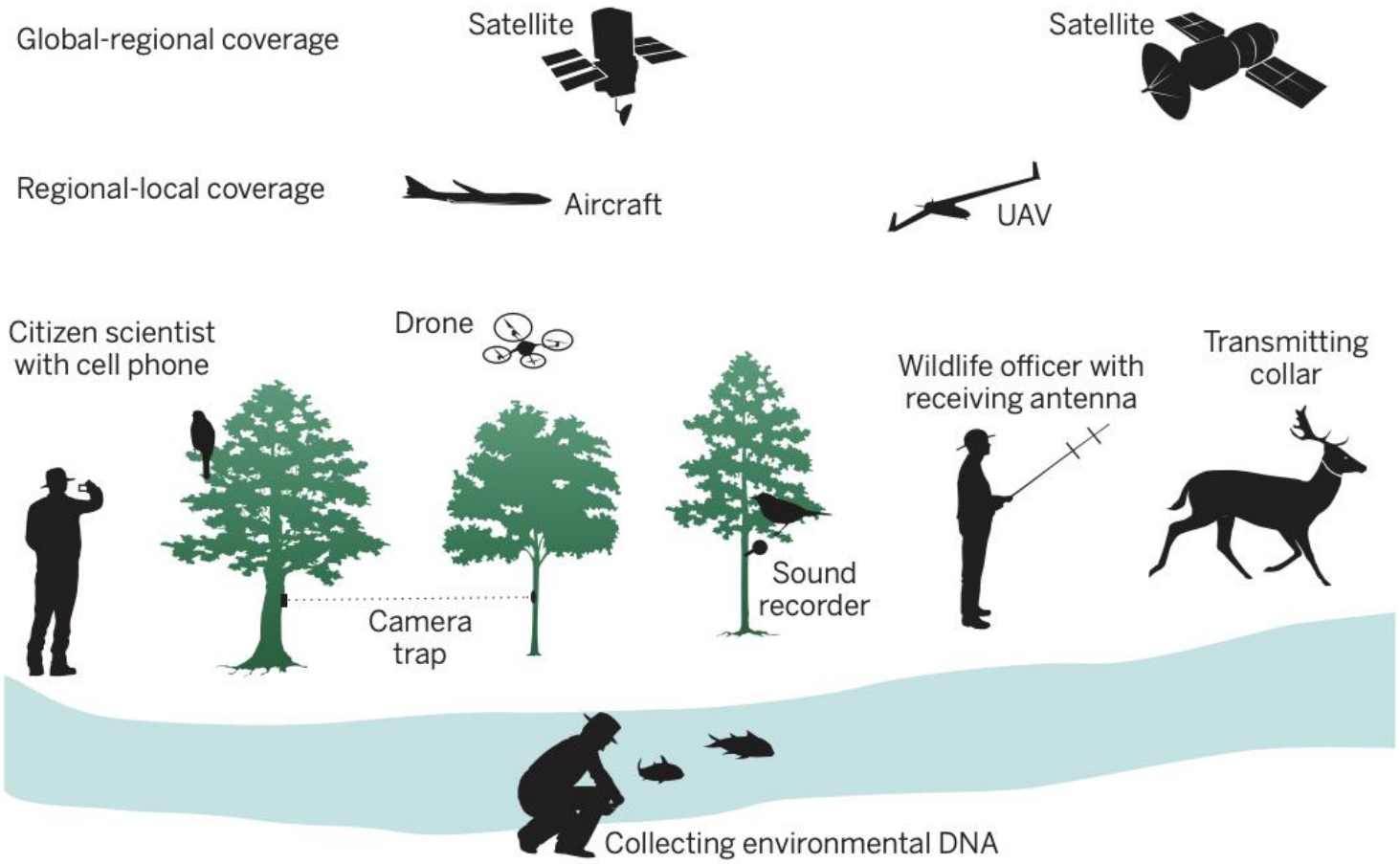
- The time is right for a biodiversity-focused **airborne campaign**.

What is an "airborne campaign"?

Integrating Field and Remotely Sensed Observations

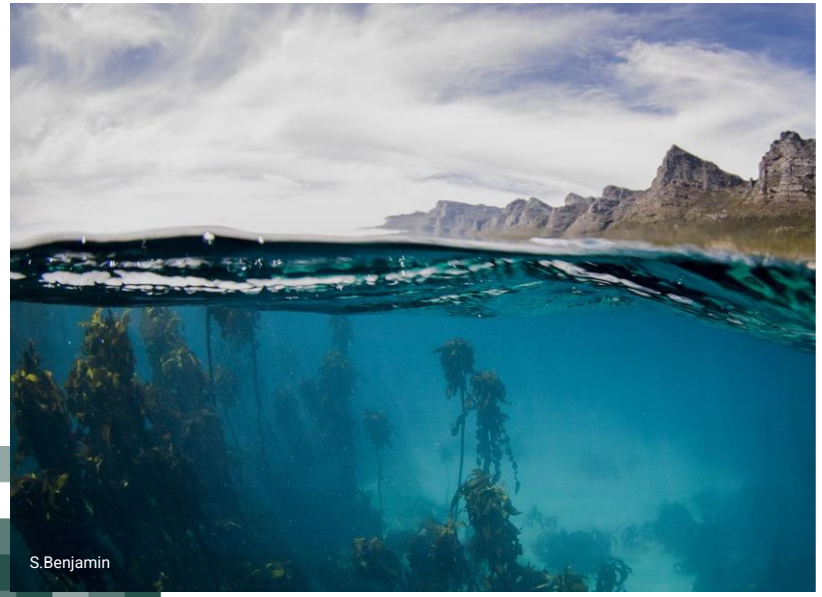
"Inclusive integration of remote sensing with field-based ecology and evolution is needed to fully understand and preserve Earth's biodiversity."

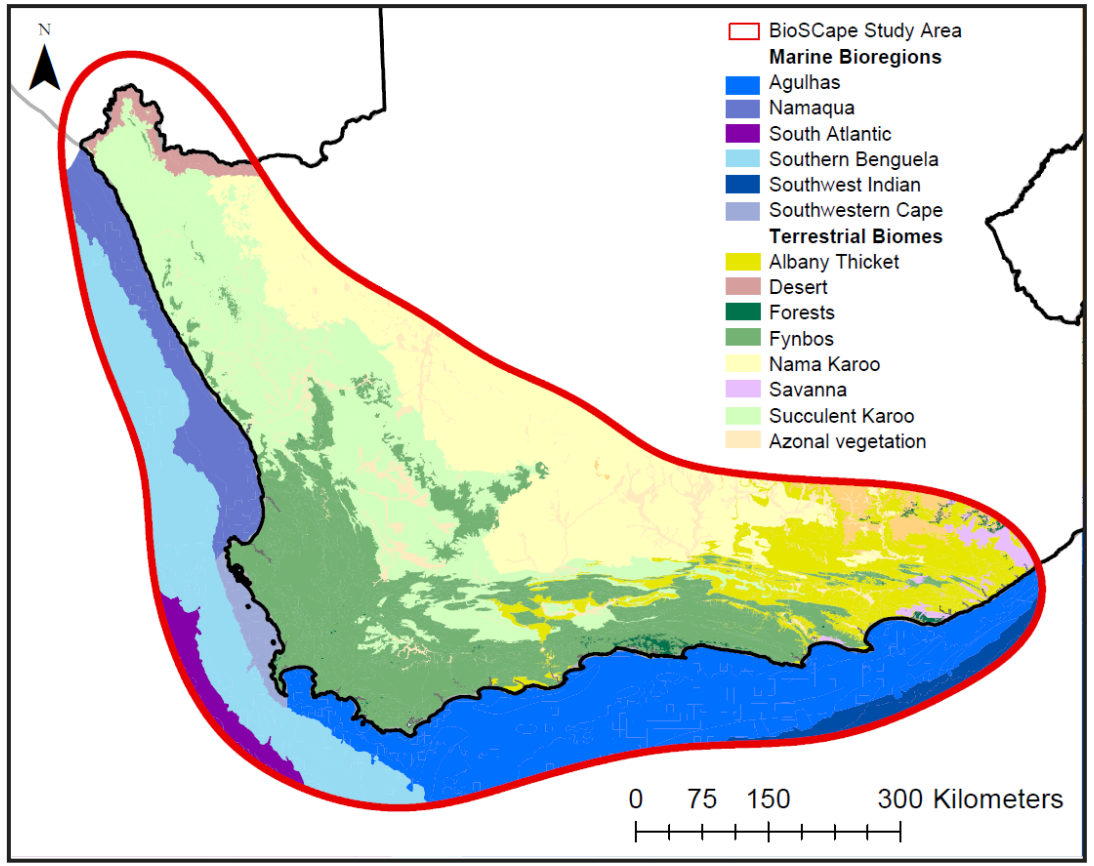
Cavender-Bares et al., 2022, Nat Ecol Evol



Turner, 2014, *Science*

BioSCape: Testing Our Abilities in a Biodiversity Hotspot





≈90,000km^2
(~1% Africa's area)

≈9,000 vascular plants
(~20% Africa's Plants)
with 65% endemic

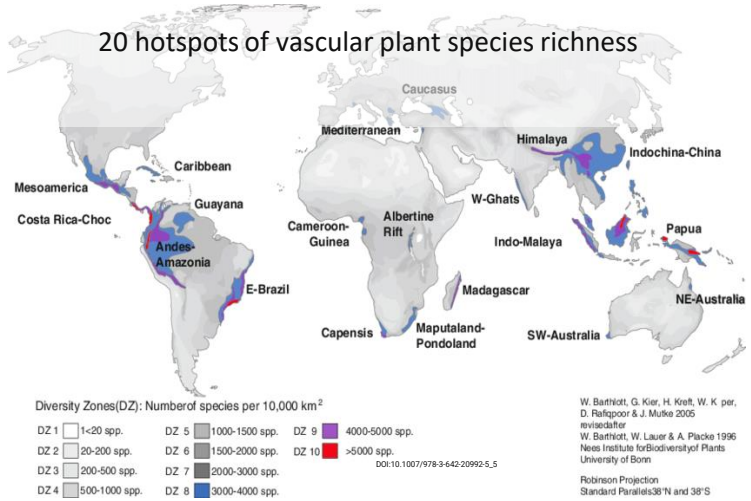
3rd highest marine endemism in the world

Biodiversity Hotspot:

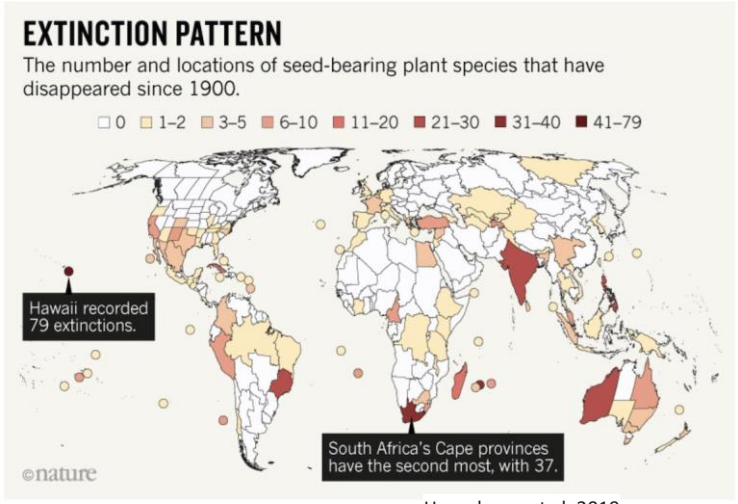
- 7 Terrestrial Biomes
- 4 Marine Bioregions
- Important Freshwater Systems

South Africa: A Microcosm of Global Challenges

Global Biodiversity Hotspot



Global Extinction Hotspot



Humphreys et al. 2019

Complex history and ongoing social challenges

Development + Environmental Change + Biodiversity

We need to map, monitor, and understand biodiversity in this complex socio-economic environment.

Key Themes for BioSCape

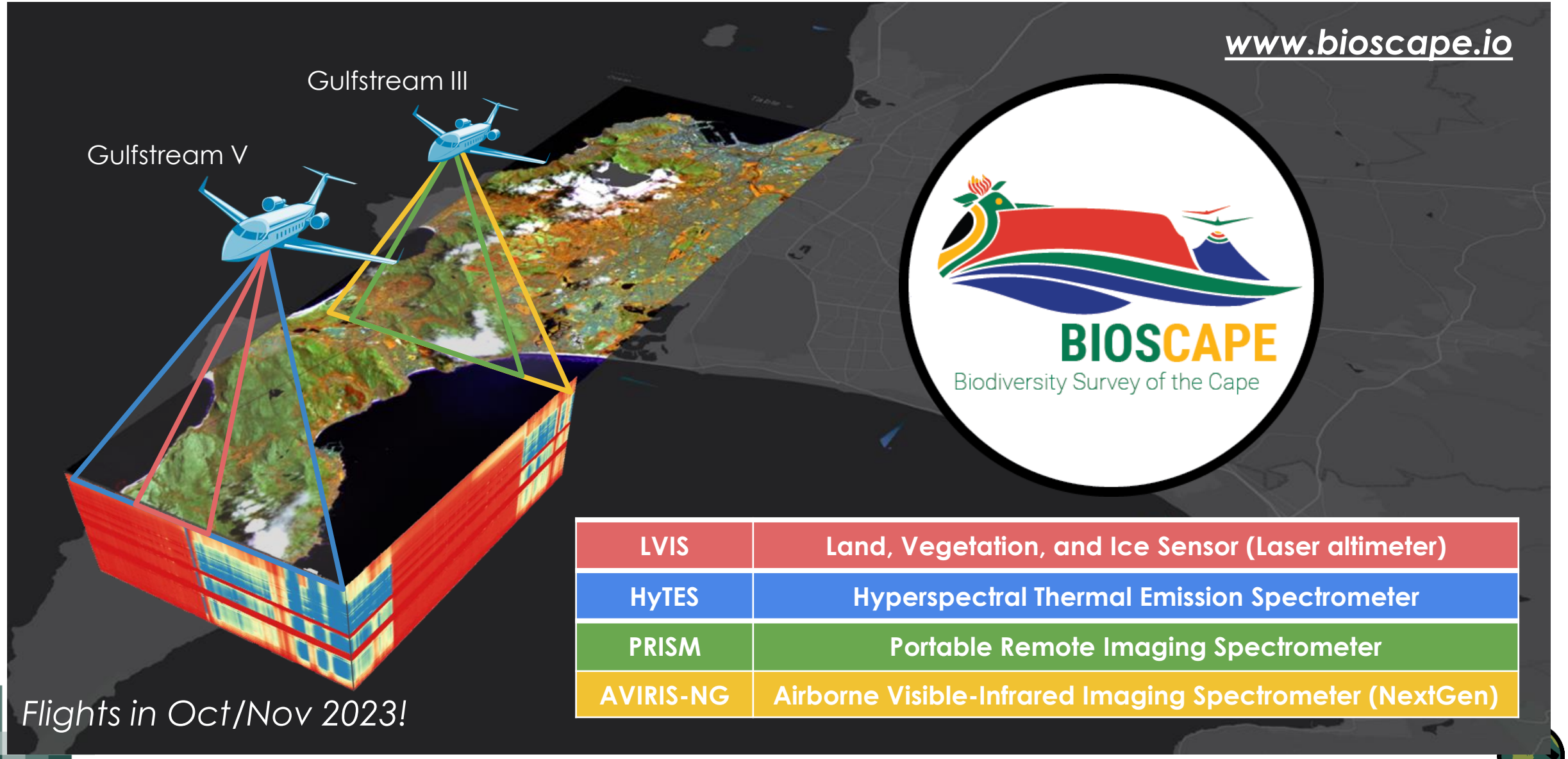
1. The distribution and abundance of biodiversity,

2. The role of biodiversity in ecosystem functions, and

3. The feedbacks between global change, biodiversity change, and ecosystem services.

Where is biodiversity,
what is it doing,
and why does it matter?

BioSCape: A Biodiversity Survey of the Cape in South Africa



LVIS	Land, Vegetation, and Ice Sensor (Laser altimeter)
HyTES	Hyperspectral Thermal Emission Spectrometer
PRISM	Portable Remote Imaging Spectrometer
AVIRIS-NG	Airborne Visible-Infrared Imaging Spectrometer (NextGen)

BioSCape: An Integrated Airborne Campaign

Satellite Data:
MODIS, Landsat, Sentinel, EMIT, ECOSTRESS

Hyperspectral Airborne Data:
AVIRIS-NG & PRISM

Thermal Emission and Laser
Altimeter Data: HyTES & LVIS

Remote Sensing Data

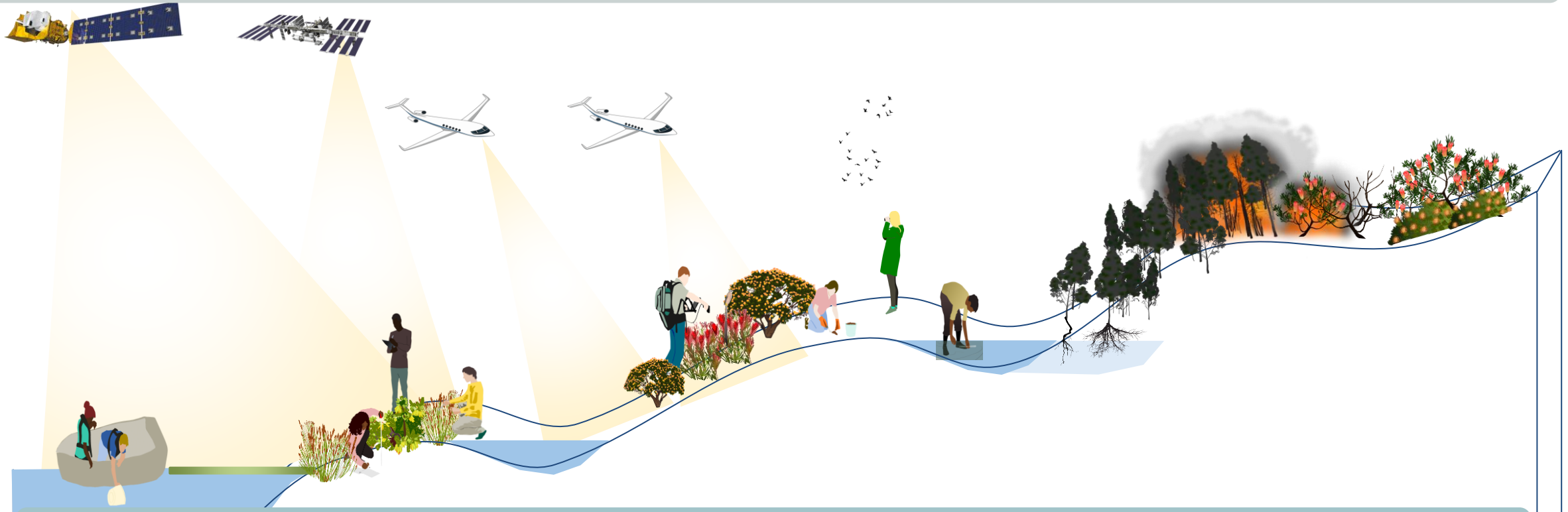
BioSCape: An Integrated Airborne Campaign

Satellite Data:
MODIS, Landsat, Sentinel, EMIT, ECOSTRESS

Hyperspectral Airborne Data:
AVIRIS-NG & PRISM

Thermal Emission and Laser Altimeter Data: HyTES & LVIS

Remote Sensing Data



Phytoplankton Functional Types

Plant Functional Traits and Species Composition

Leaf and Canopy Reflectance

Animal Point Counts

DNA and eDNA Samples

Lidar

Field Data

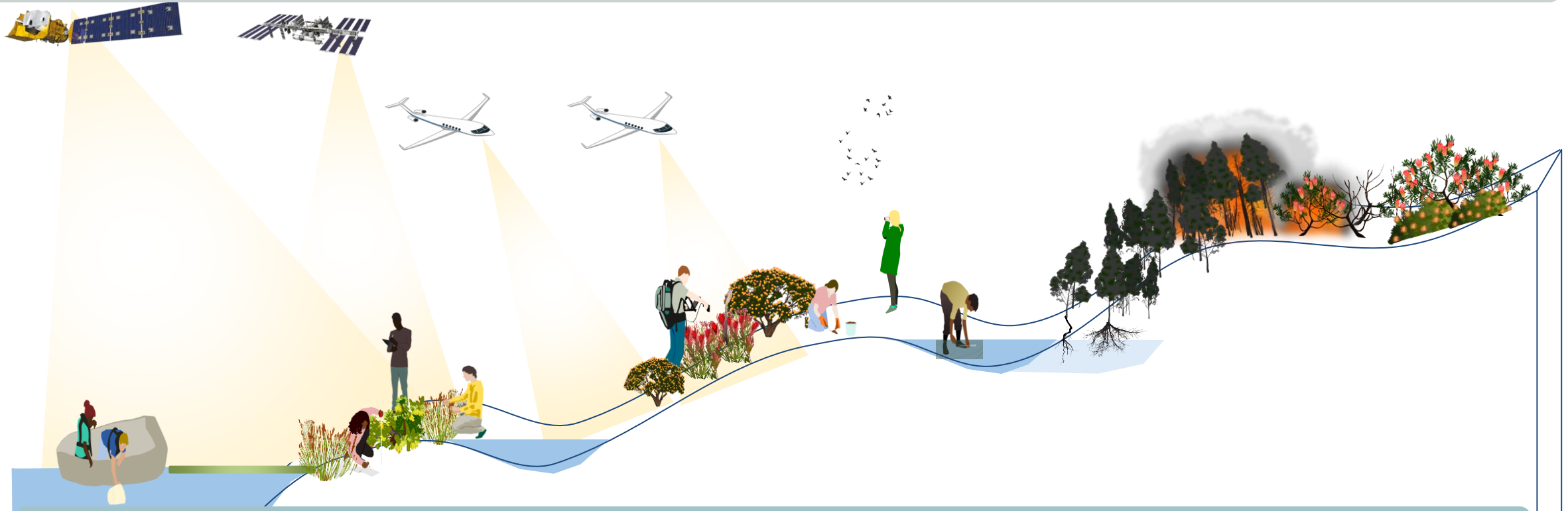
BioSCape: An Integrated Airborne Campaign

Satellite Data:
MODIS, Landsat, Sentinel, EMIT, ECOSTRESS

Hyperspectral Airborne Data:
AVIRIS-NG & PRISM

Thermal Emission and Laser Altimeter Data: HyTES & LVIS

Remote Sensing Data



Phytoplankton Functional Types

Plant Functional Traits and Species Composition

Leaf and Canopy Reflectance

Animal Point Counts

DNA and eDNA Samples

Lidar

Field Data

Models and Algorithms

Functional Diversity

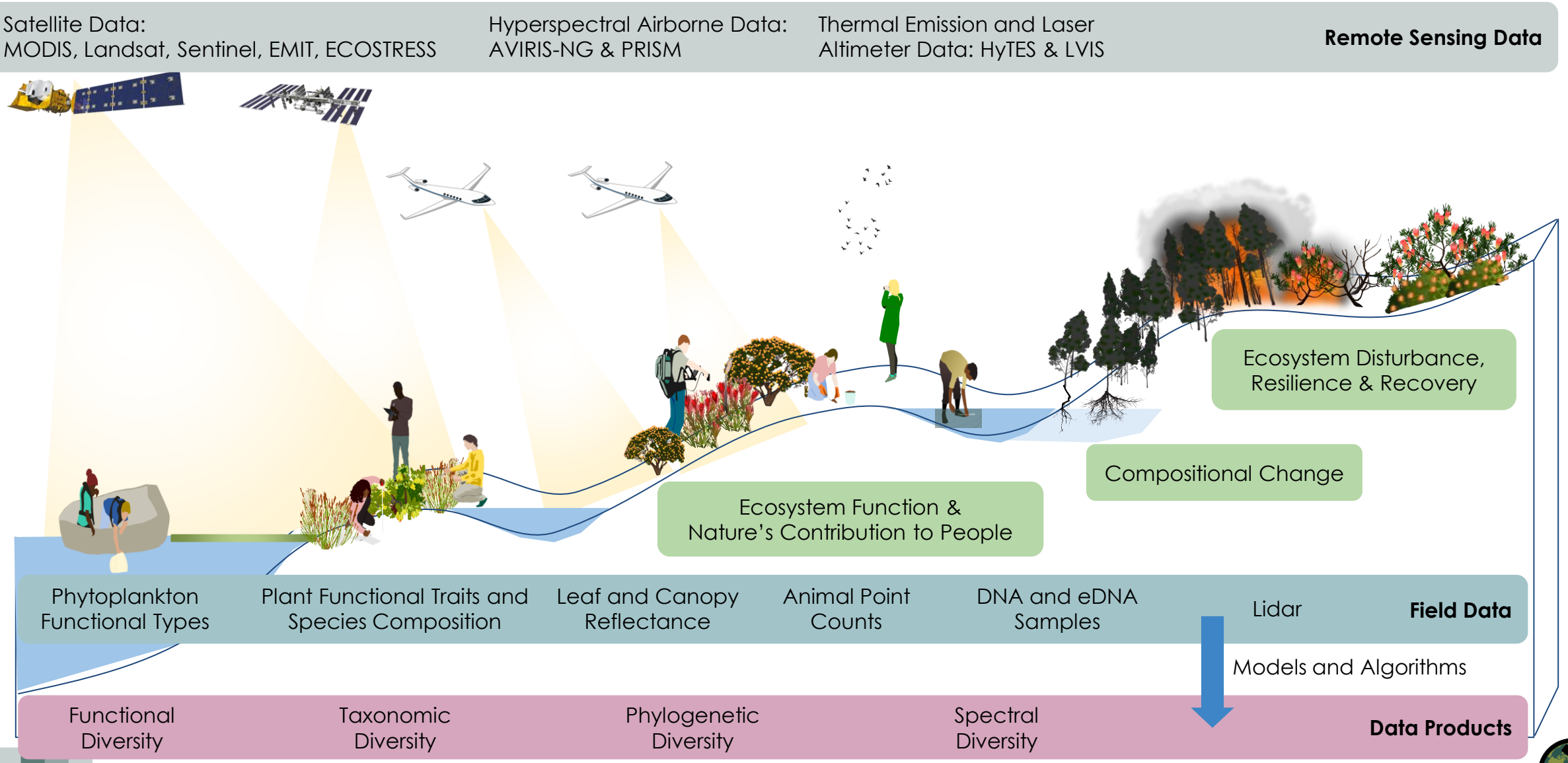
Taxonomic Diversity

Phylogenetic Diversity

Spectral Diversity

Data Products

BioSCape: An Integrated Airborne Campaign



Advancing Radiative Transfer Modeling on Land and In the Water

- Generating Synthetic Hyperspectral Datasets For:
  - Various Ecosystems
  - Agricultural Lands
  - Aquatic Environments
  - The Atmosphere

- Uses:
  - Identifying phytoplankton functional types and floating aquatic vegetation
  - Link spectral and structural plant traits, especially those used in biodiversity indicators

Push the Limits of Our Ability to Measure Plant Diversity Remotely

- Mapping Diversity:
  - Taxonomic
  - Phylogenetic
  - Functional
  - Structural
  - Spectral

- Evaluating essential biodiversity variables

- Assessing relationships between diversity metrics and how this changes across spatial scales and environmental gradients

Use Novel Data Products for Biodiversity Applications

- Effect of alien plant invasion on diversity and ecosystem function
- How fire, drought, and invasion affect the relationship between diversity and:
  - Evapotranspiration
  - Primary Productivity
  - Water Use Efficiency
- Post-fire recovery of vegetation
- Distribution of groundwater-dependent plant communities
- Drivers of estuarine biodiversity

Test Novel Field Methods for Measuring Biodiversity and Answering Evolutionary Questions

- Environmental DNA (eDNA) as a proxy for phylogenetic, taxonomic, and functional biodiversity
- Automated analysis of an ecosystem's sounds (i.e., soundscape) to assess biodiversity distribution and habitat condition
- Using spectral data to understand long-term evolutionary and community assembly processes

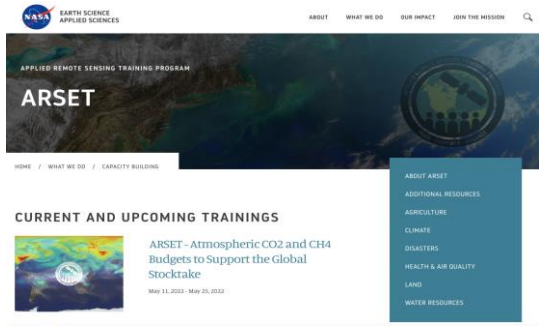
A Campaign with Diverse Metrics of Success

- **Equitable Science**
- **Applications**
- **Capacity Building**
- **Outreach**
- **Education**

Learn more at BioSCape.io

Avoiding Parachute Science

Encouraging US-SA collaboration through international teams, workshops, and joint-funding.

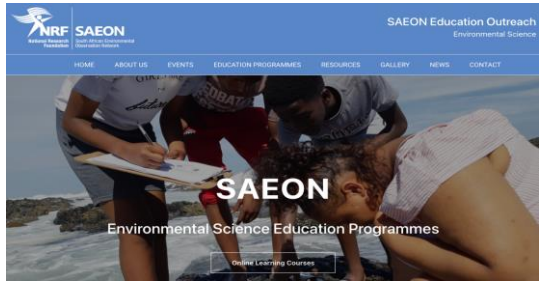


Applied Courses for Practitioners

NASA Applied Remote Sensing Training (ARSET) Program to develop new BioSCape-related trainings and a potential in person workshop in 2023-2024.

Reaching 'Broader' Audiences

Two South African (PhD) filmmakers to document BioSCape including time in the field with most teams and interviews following the campaign (fishwaterfilms.com).



Science Education

BioSCape 'open house' for kids to meet scientists, possibly visit the planes, and see field work (under development).

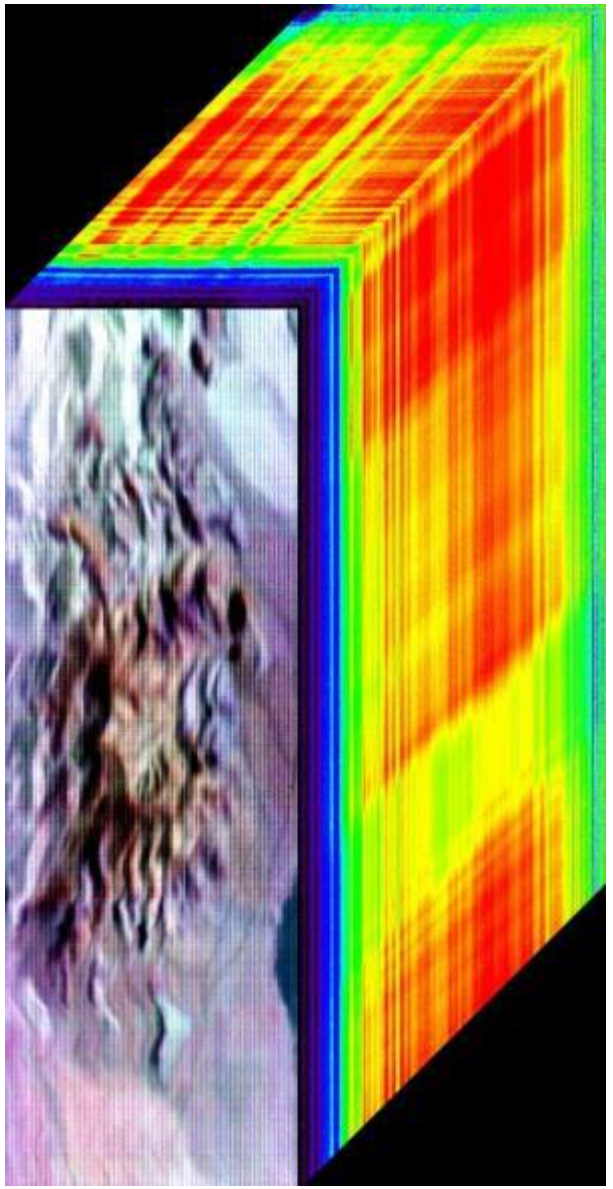
Coming Up in this Course

An Overview of Airborne LiDAR and Imaging Spectroscopy for Biodiversity

- **Atticus Stovall** *University of Maryland | NASA Goddard Space Flight Center* - LVIS
- **Natasha Stavros** *University of Colorado Boulder* - HyTES, AVIRIS-NG, and eDNA
- **Phil Townsend** *University of Wisconsin–Madison,* AVIRIS-NG for Plant Functional Traits
- **Liane Guild** *NASA*, PRISM Opportunities in Aquatic Systems

Summary

- Light Detection and Ranging (LiDAR) is a form of remote sensing that uses a laser to measure distance.
- Thermal Infrared (TIR) is the spectral range of 8 - 15 µm in the electromagnetic spectrum. We can use data from this spectral range to monitor various environmental parameters.
- NASA's Hyperspectral Thermal Emission Spectrometer (HyTES), Goddard's LiDAR, Hyperspectral & Thermal Imager (G-LiHT), and Land, Vegetation, and Ice Sensor (LVIS) are airborne campaigns that provide us with thermal and LiDAR data.



Source: NASA ESTO

Resources

https://airbornescience.nasa.gov/

https://hytes.jpl.nasa.gov/

https://lvis.gsfc.nasa.gov/Home/index.html

https://gliht.gsfc.nasa.gov/

https://www.bioscape.io/

Contacts

- Trainers:
  - Juan L. Torres-Pérez: juan.l.torresperez@nasa.gov
  - Amber McCullum: amberjean.mccullum@nasa.gov
  - Britnay Beaudry: britnay.beaudry@nasa.gov
  - Sativa Cruz: sativa.cruz@nasa.gov

- Training Webpage: https://appliedsciences.nasa.gov/join-mission/training/english/arset-biodiversity-applications-airborne-imaging-systems

- ARSET Webpage: https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset

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TRAIN - EMPOWER - ADVANCE

Thank You!