

Biodiversity Applications for Airborne Imaging Systems

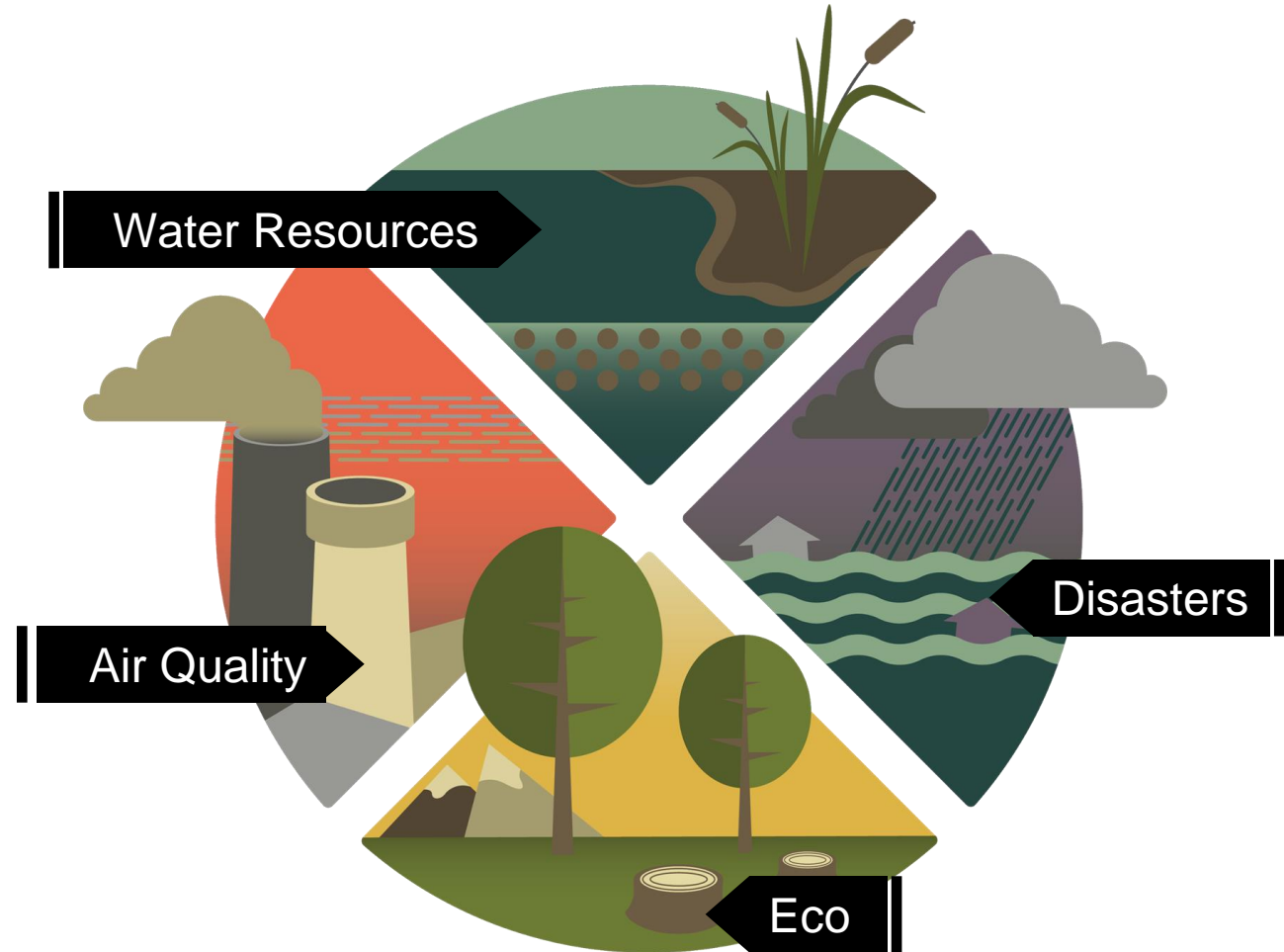
Juan L. Torres-Pérez, Britnay Beaudry, Sativa Cruz, Amber McCullum

March 27, 2023

NASA's Applied Remote Sensing Training Program (ARSET)

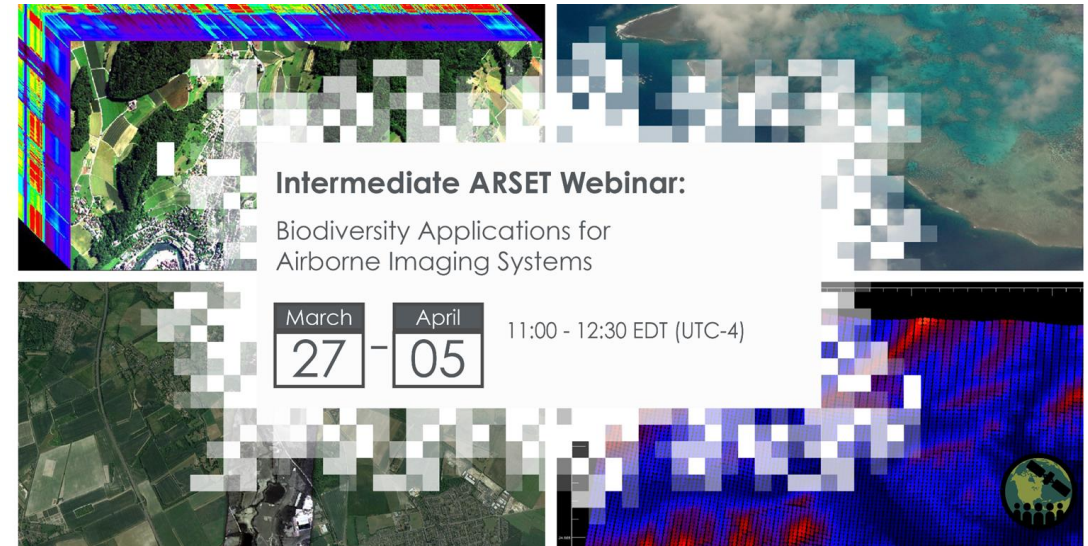
<https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset/about-arset>

- Part of NASA's Applied Sciences Program
- Empowering the global community through remote sensing training
- Seeks to increase the use of Earth science in decision-making through training for:
 - Policy makers
 - Environmental managers
 - Other professionals in the public and private sector



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)



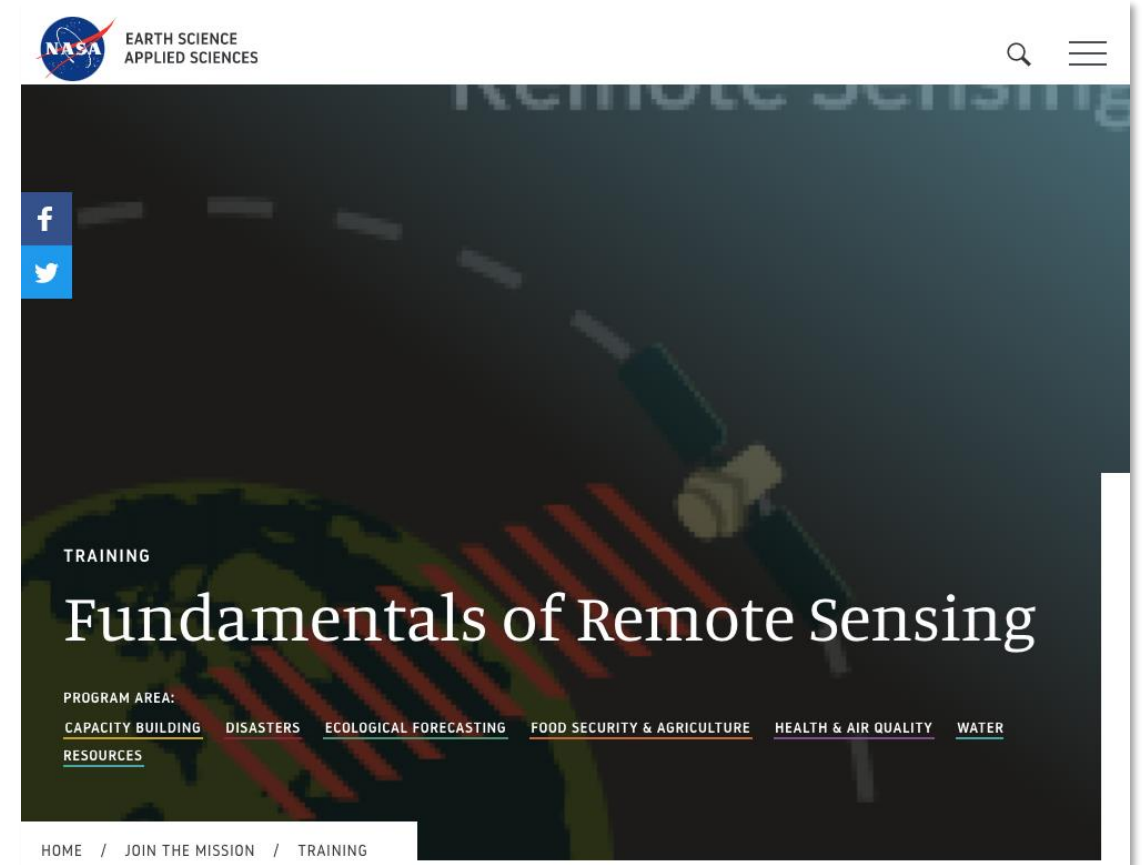
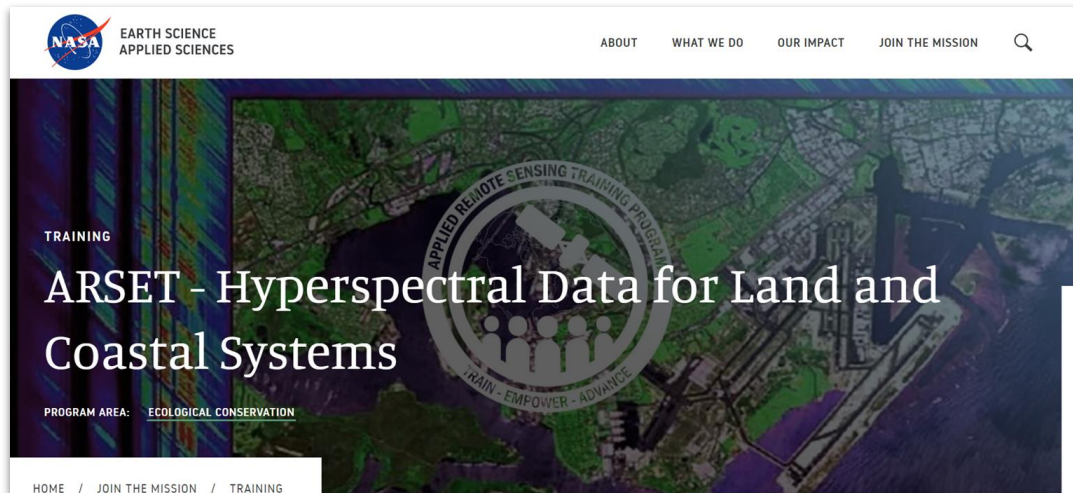
Intermediate ARSET Webinar:
Biodiversity Applications for
Airborne Imaging Systems

March 27 - April 05 11:00 - 12:30 EDT (UTC-4)



Prerequisites

- Prerequisites:
 - [Fundamentals of Remote Sensing](#)
 - [Hyperspectral Data for Land and Coastal Systems](#)
 - or equivalent experience

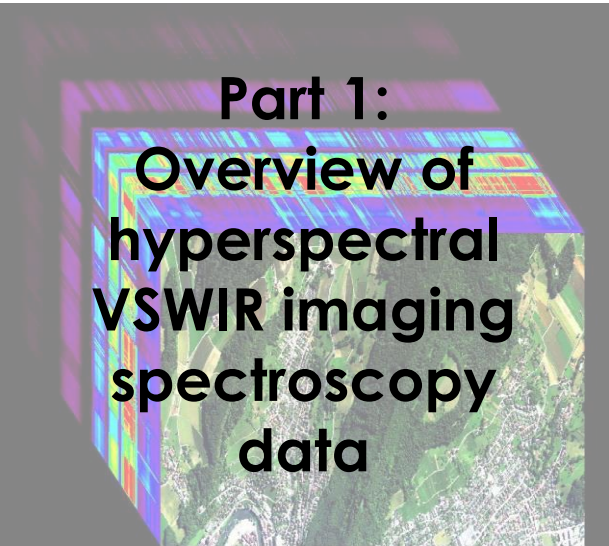


Homework and Certificates

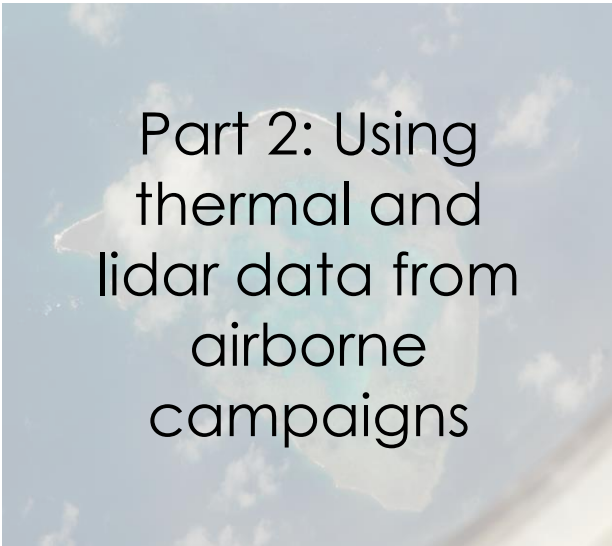
- **Homework:**
 - One homework assignment (available at the end of session four of this webinar series)
 - Answers must be submitted via Google Forms
 - **HW deadline: April 19th**
- **Certificate of Completion:**
 - Attend all four live webinars
 - Complete the homework assignment by the deadline (access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



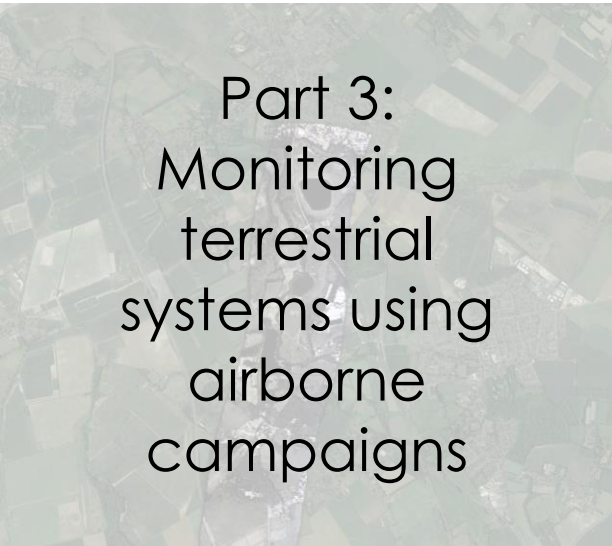
Course Outline




**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



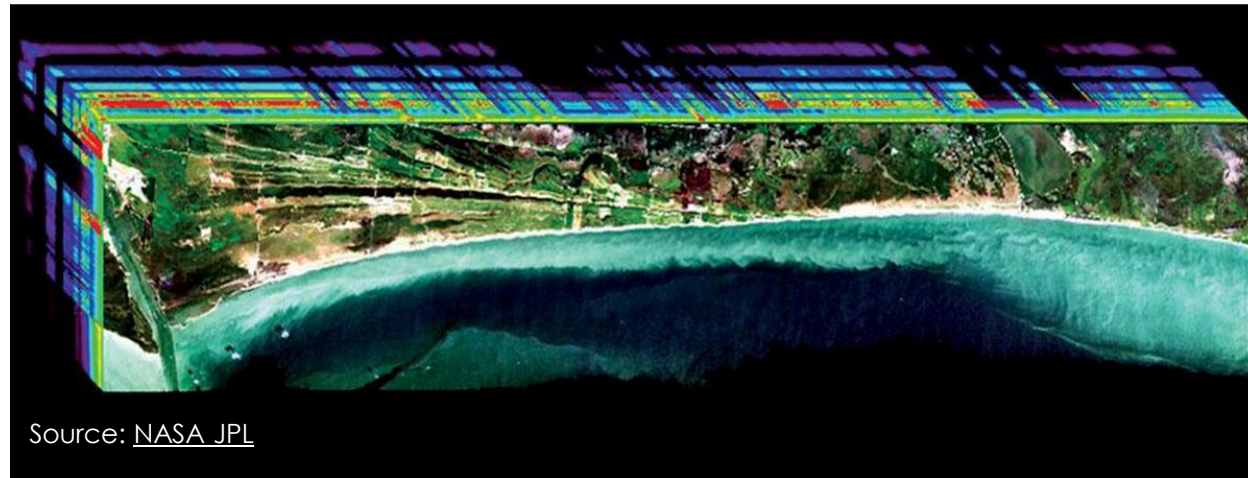
Part 4:
Monitoring
aquatic
systems using
airborne
campaigns



Learning Objectives

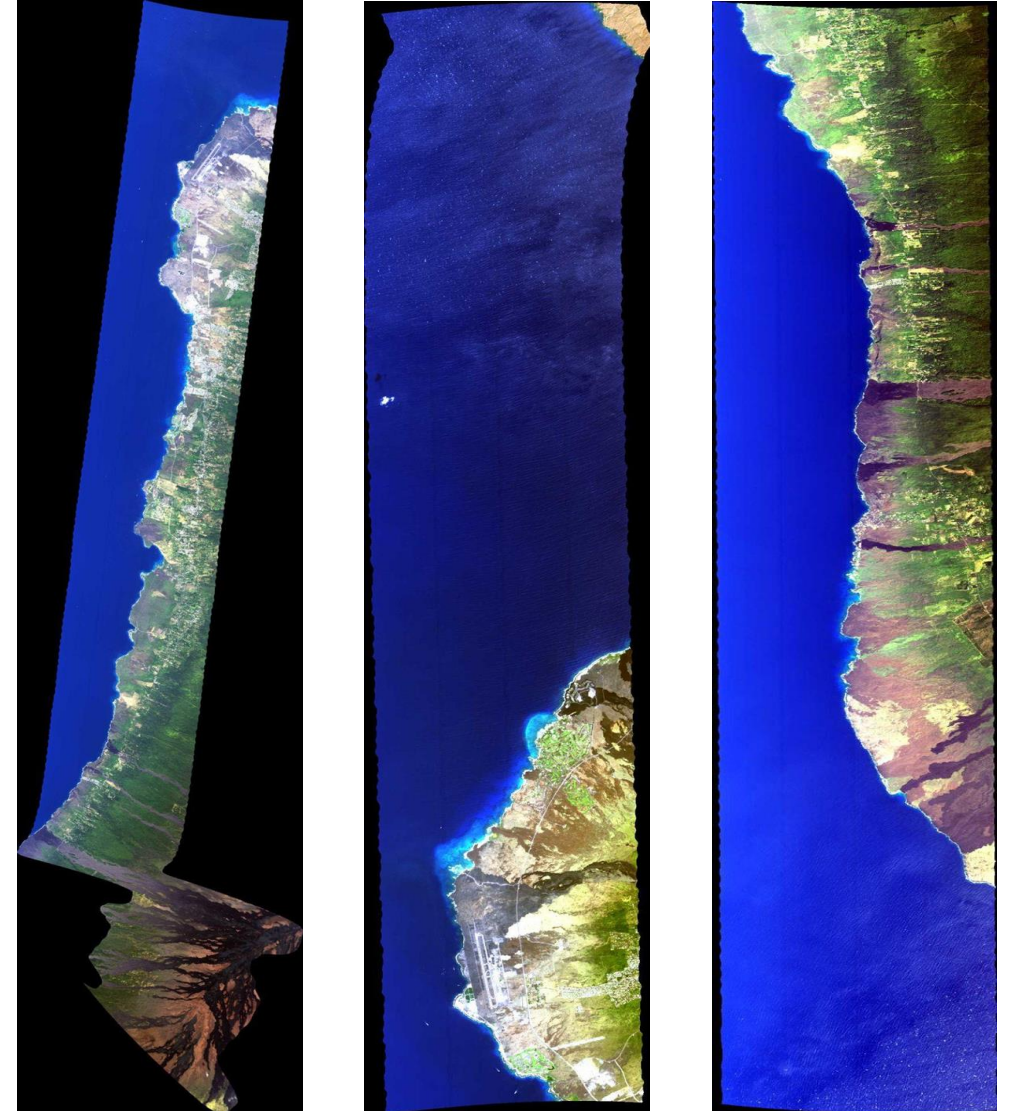
By the end of this training attendees will be able to:

- 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



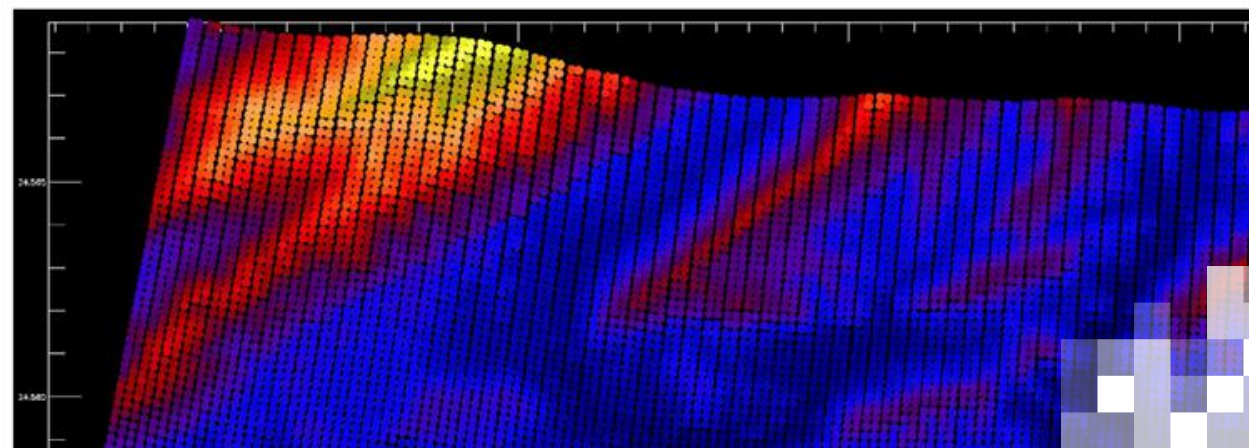
Part 1 Agenda

- Overview of hyperspectral visible to Shortwave Infrared (VSWIR) imaging spectroscopy data
- Highlight of hyperspectral instruments for measuring and monitoring terrestrial and aquatic biodiversity, in particular AVIRIS-NG and PRISM
- Highlight upcoming mission development such as the Surface Geology and Biology (SBG) mission and the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission
- Q&A Session

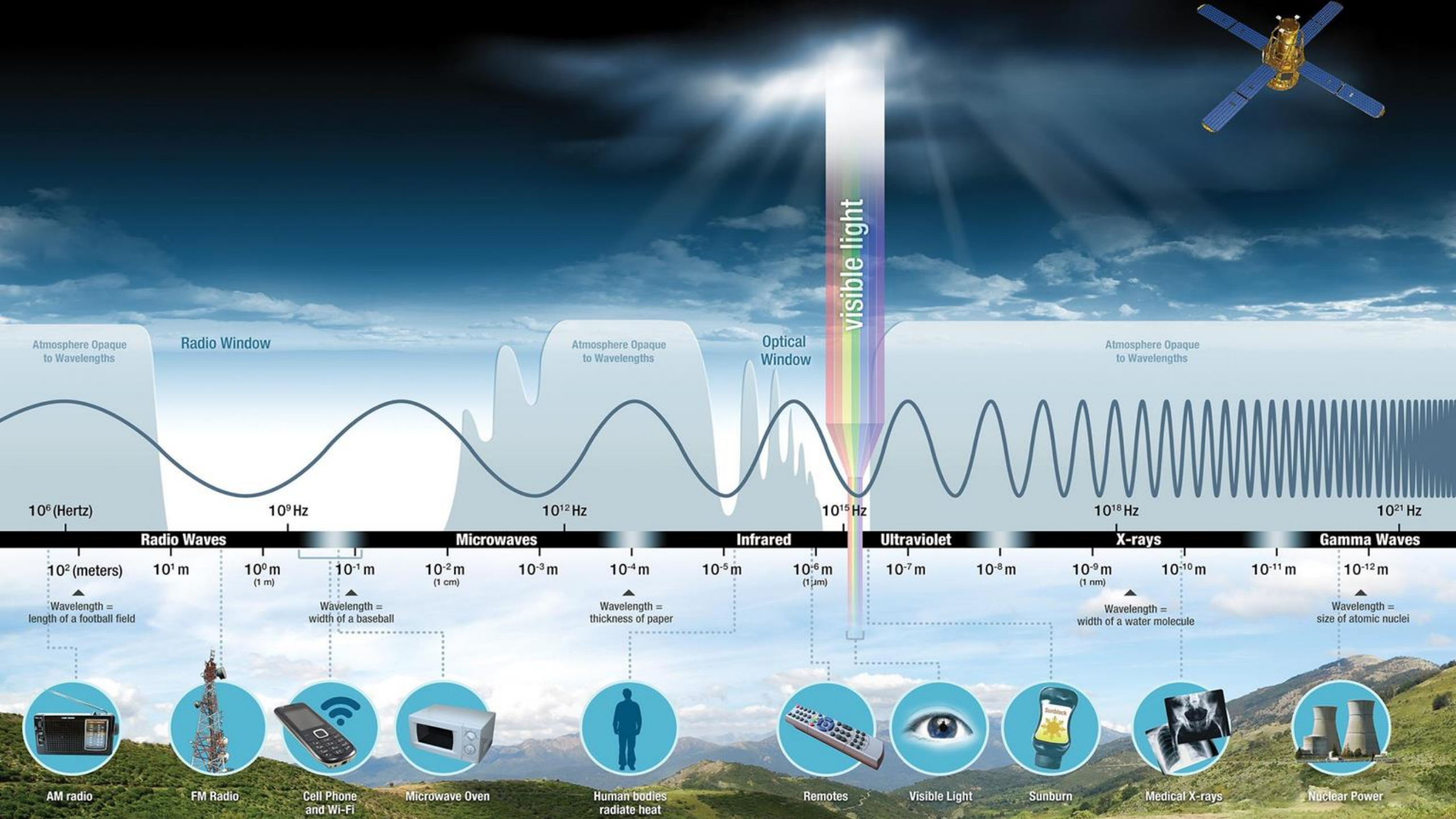


Source: [NASA JPL](#)





Overview of Hyperspectral Visible to Shortwave Infrared (VSWIR) imaging spectroscopy



visible light

Atmosphere Opaque to Wavelengths

Radio Window

Atmosphere Opaque to Wavelengths

Optical Window

Atmosphere Opaque to Wavelengths

10^6 (Hertz)

10^9 Hz

10^{12} Hz

10^{15} Hz

10^{18} Hz

10^{21} Hz

Radio Waves

Microwaves

Infrared

Ultraviolet

X-rays

Gamma Waves

10^2 (meters)

10^1 m

10^0 m (1 m)

10^{-1} m

10^{-2} m (1 cm)

10^{-3} m

10^{-4} m

10^{-5} m

10^{-6} m (1 μ m)

10^{-7} m

10^{-8} m

10^{-9} m (1 nm)

10^{-10} m

10^{-11} m

10^{-12} m

Wavelength = length of a football field

Wavelength = width of a baseball

Wavelength = thickness of paper

Wavelength = width of a water molecule

Wavelength = size of atomic nuclei



AM radio

FM Radio

Cell Phone and Wi-Fi

Microwave Oven

Human bodies radiate heat

Remotes

Visible Light

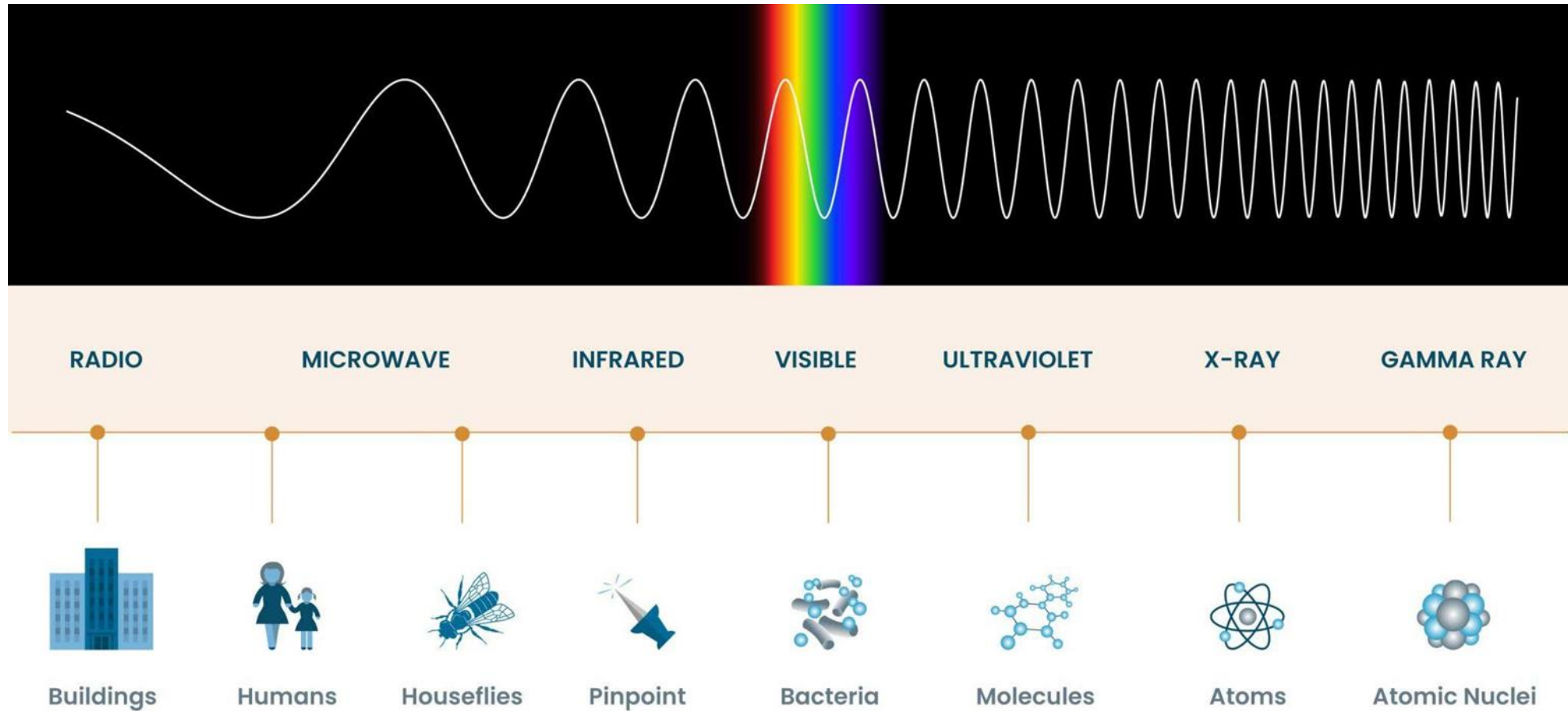
Sunburn

Medical X-rays

Nuclear Power

Visible to Shortwave Infrared (VSWIR)

2500 nm - 380 nm



What is hyperspectral remote sensing?

- The acquisition of imagery in **hundreds of contiguous spectral bands** such that a radiant spectrum can be derived for each pixel.
 - Measuring reflectance at close intervals on the electromagnetic spectrum
 - Bands are usually spaced 10 nm or less from one another

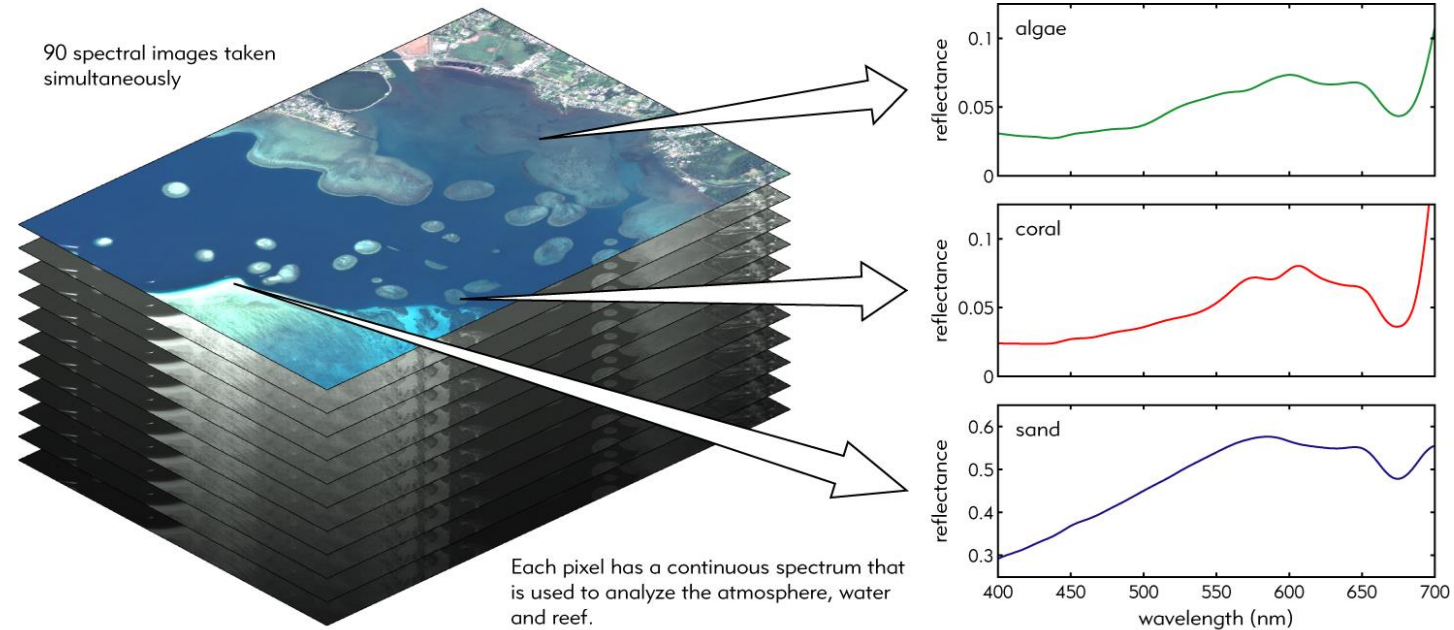
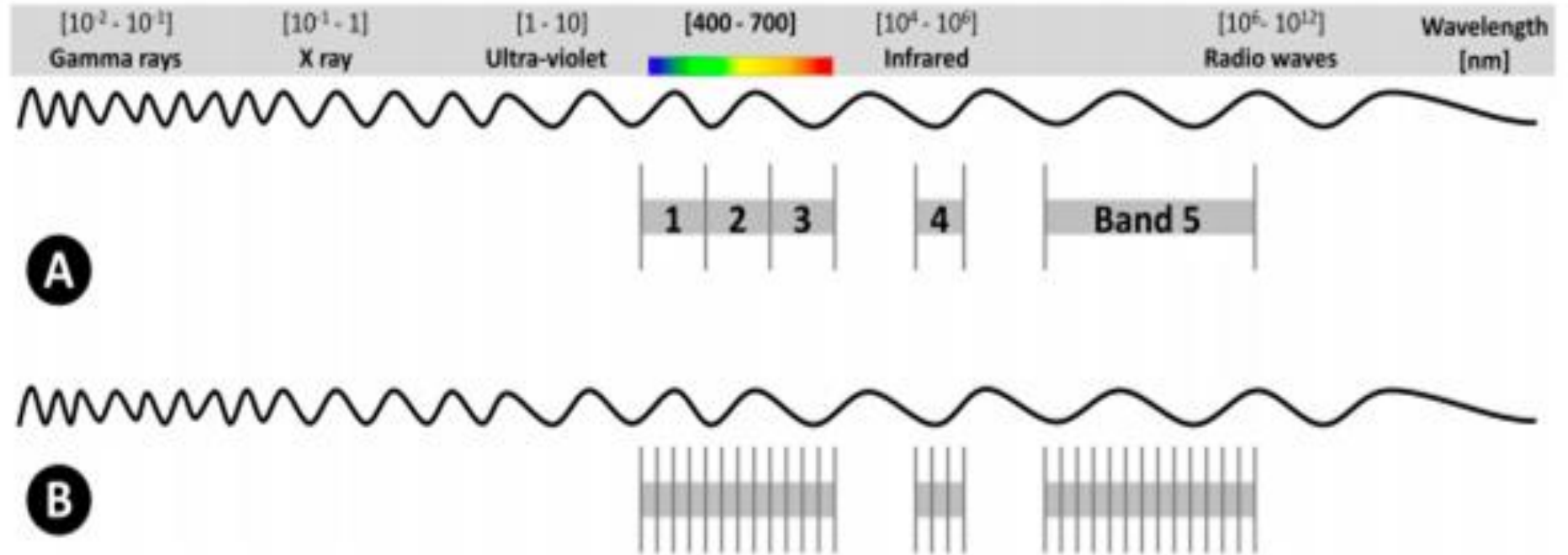
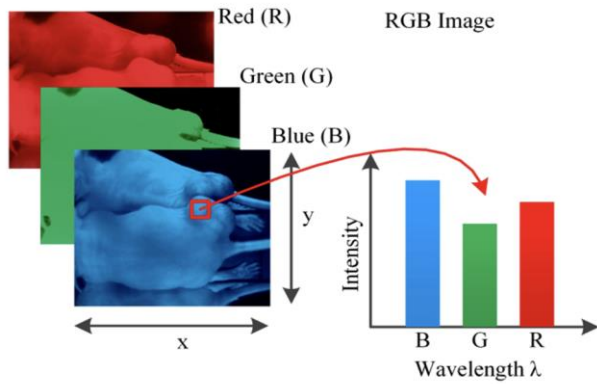


Image Credit: Eric Hochberg (CORAL PI)



Multispectral vs. Hyperspectral Data

Multispectral



Hyperspectral

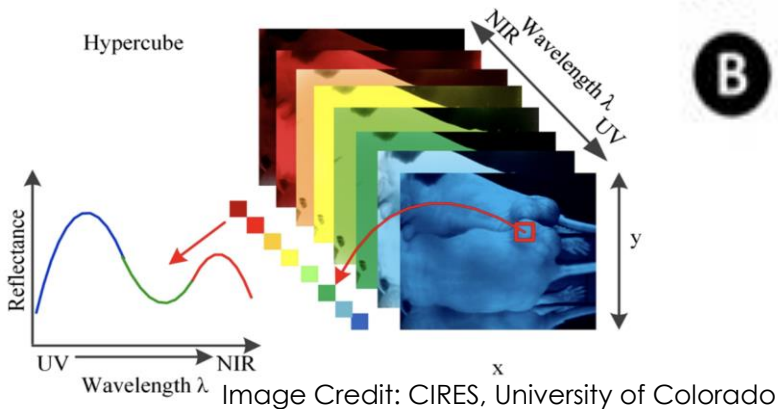
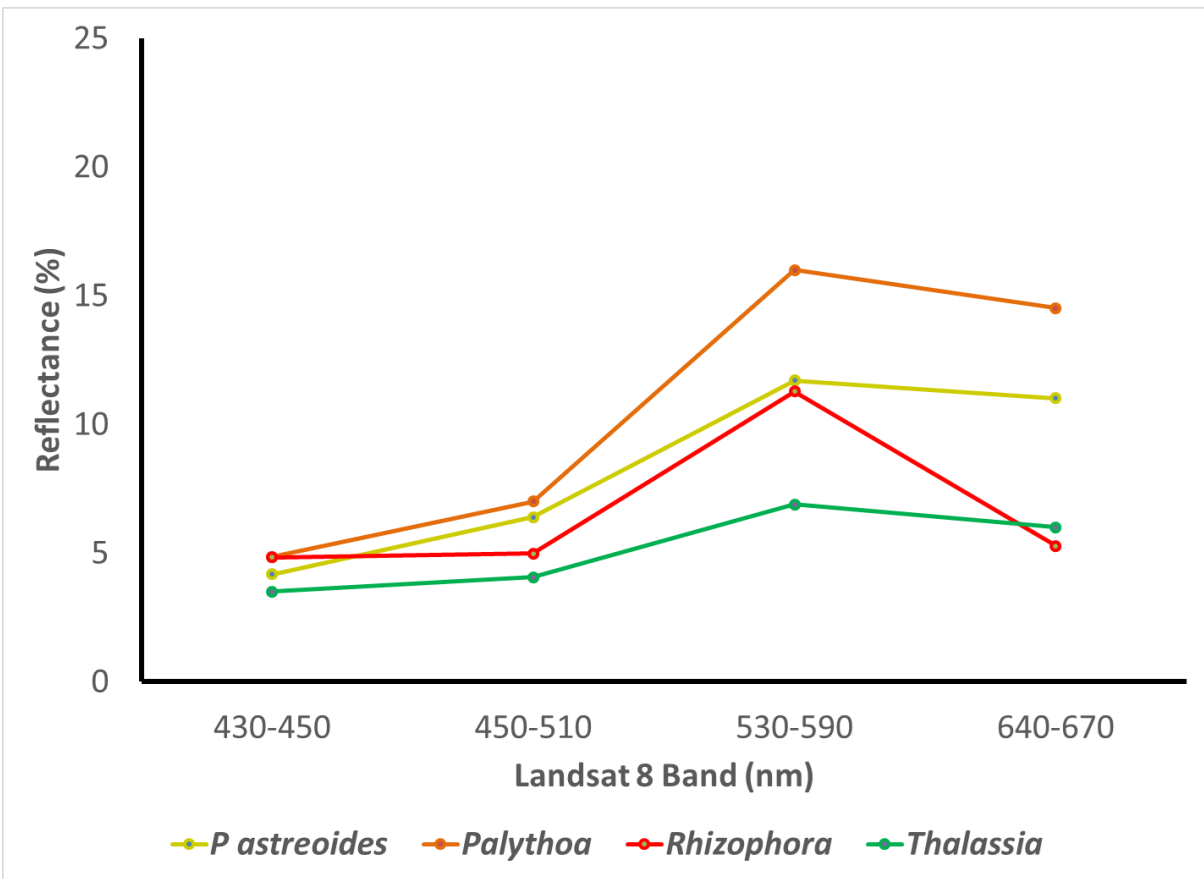
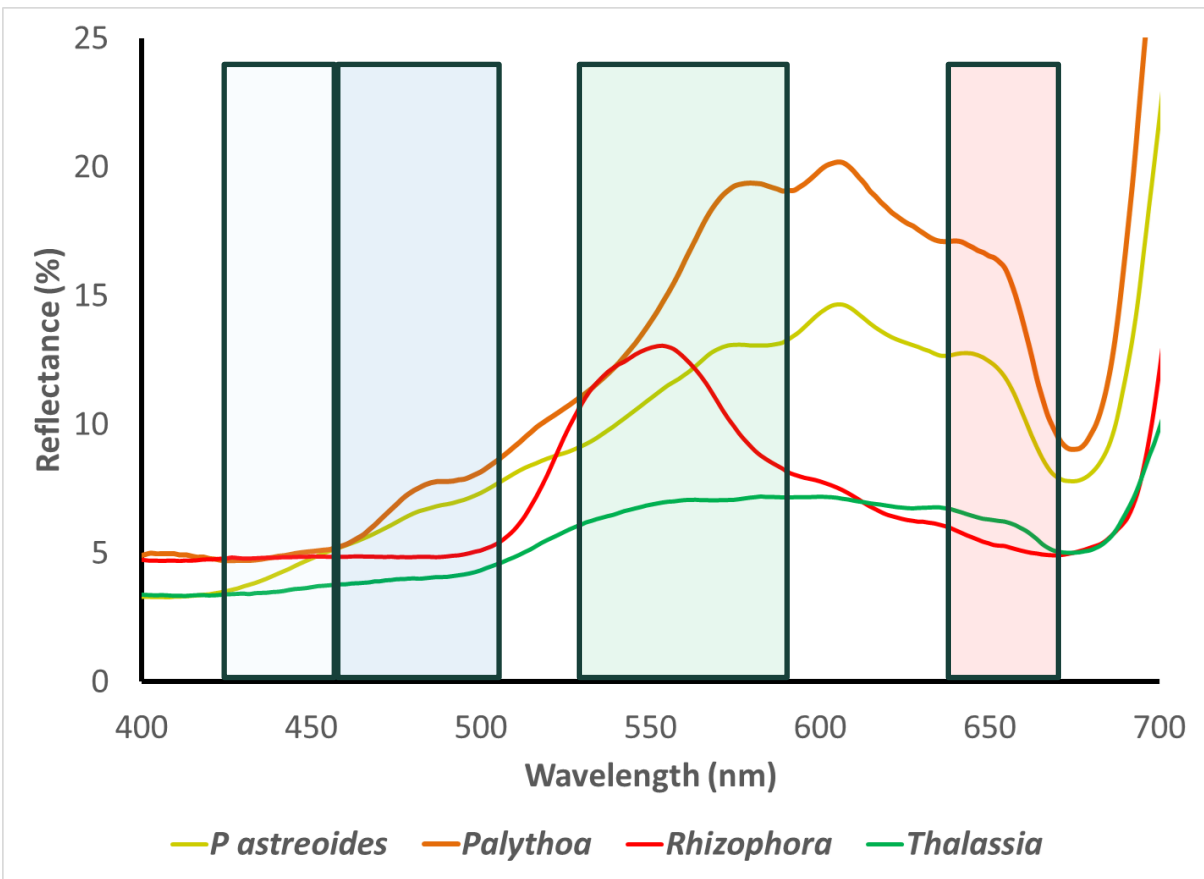


Image Credit: Adao, et al., 2017

Image Credit: CIRES, University of Colorado



Spectral Comparison of Different Coastal Marine Components (Hyperspectral vs. Multispectral)



Torres-Pérez (Unpublished)



NASA Hyperspectral Imagers

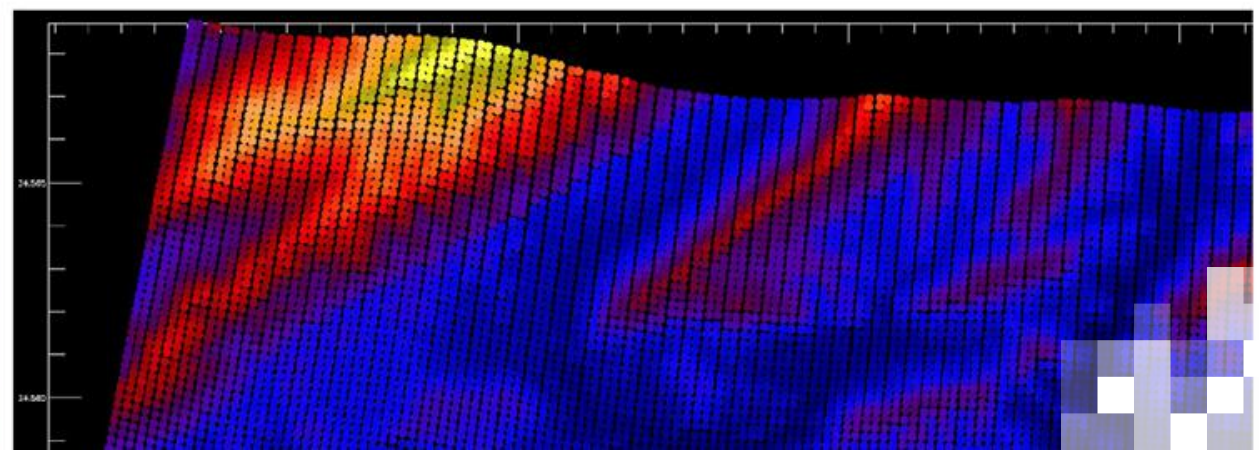
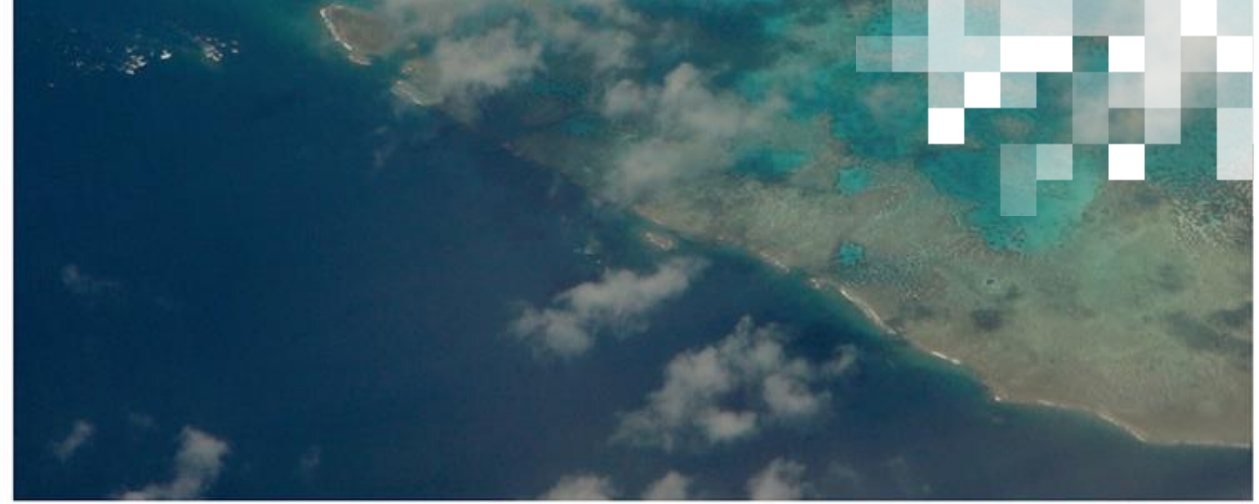
Satellite/Space-Based

- EO-1 Hyperion
- Test missions onboard the International Space Station (ISS):
 - Hyperspectral Imager for the Coastal Ocean (HICO)
 - ECOSystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)*
 - Thermal imagery prototype for future hyperspectral missions

Airborne

- Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)
 - Campaigns flown around the world
 - Proof of concept for future hyperspectral satellite sensors
- Portable Remote Imaging Spectrometer (PRISM)
 - COral Reef Airborne Laboratory (CORAL)
 - Mission flown 2016-2019 to analyze coastal ecosystems and reef conditions





Applications and Sources of Airborne VSWIR data



AVIRIS-NG



PRISM



DESI



Landsat-8



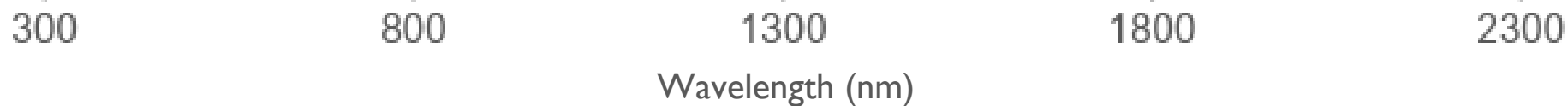
MODIS



Sentinel-3



Sentinel-2



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

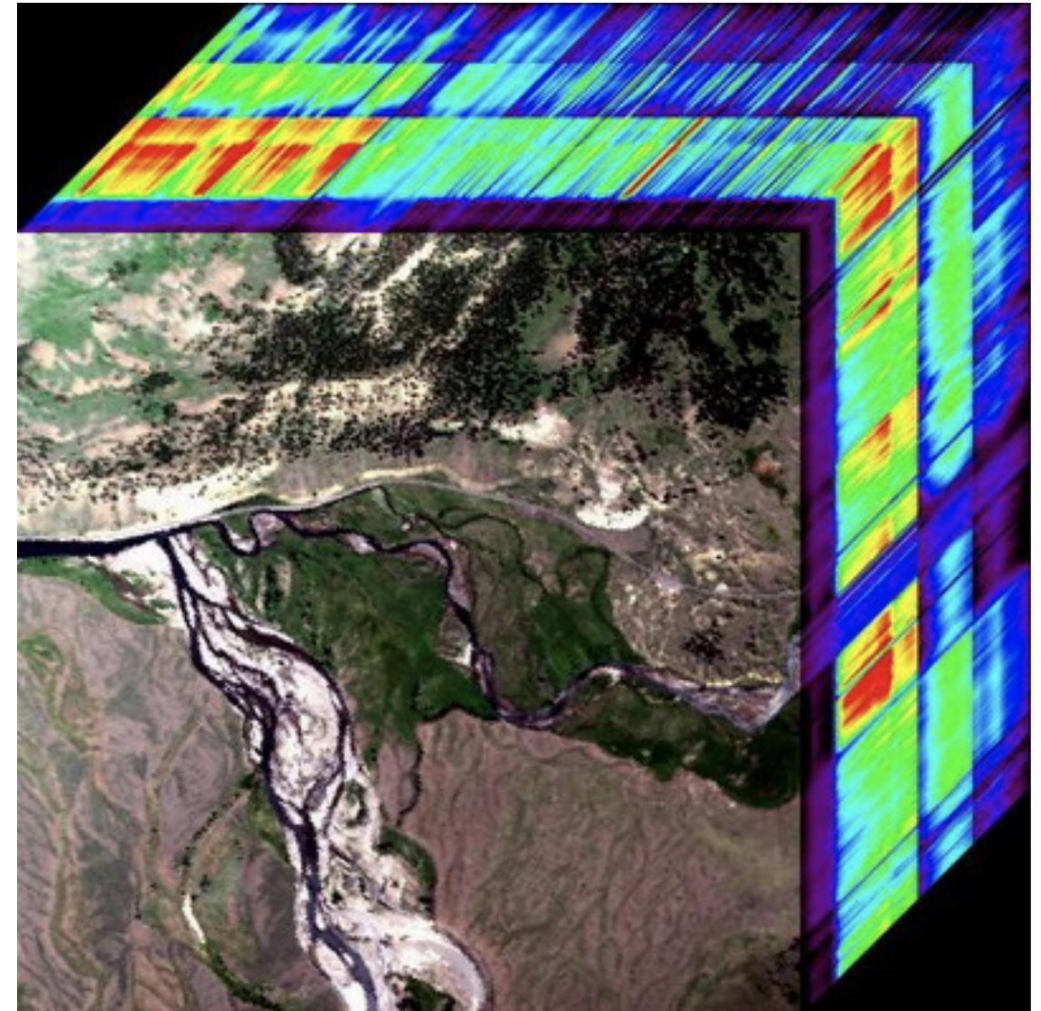


Source: [NASA JPL](#)



Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)

- Objective: Identify, measure, and monitor constituents of Earth's surface and atmosphere based on molecular absorption and particle scattering signatures
- Sometimes referred to as AVIRIS-C "Classic"
- Flown in North America, Europe, portions of South America, and Argentina
- Flown on four aircraft platforms: NASA's ER-2 jet, Twin Otter International's Turboprop, Scaled Composites' Proteus, and NASA's WB-57
- Active since 1986



Source: [Lu et al., 2020](#)



Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)

AVIRIS: Key West, Florida 921119

Red= 646.7 nm Green= 547.6 nm Blue= 449.1 nm



Source: [NASA JPL](#)

- 224 continuous spectral bands
- Spectral coverage: 380 to 2500 nm
- Bandwidth: < 10 nm
- Pixel size based on altitude:
 - 20 km Above Ground Level (AGL) for 20 m pixel resolution
 - 4 km AGL for 4 m pixel resolution



Accessing and Using AVIRIS-C Data

AVIRIS Data Portal 2006-2021

Map | Data Table | Additional Info

AVIRIS Classic Data Portal

Download KML Layers by Year: 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021

Data Table

Click the filter icon to filter columns.
Choose **File** -> **Download** to save a local copy.
Open table in new window

ID	Name	E	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
1	Name	Site Name	NASA Log	Investigator	Comments	FlightScene	Date	REN Ver	Score	GEO Ver	SV																
2	69042981p20001	Red Lake Pass 1 (07010)		Thomas Palmer	Alt = 2163m-5 69042981p20001		4/26/00	c	ac01	int																	
3	69042981p20004	Red Lake Pass 2 (07010)		Thomas Palmer	Alt = 2163m-5 69042981p20001		4/26/00	c	ac01	int																	
4	69042981p20005	Red Lake Pass 3 (07010)		Thomas Palmer	Alt = 2163m-5 69042981p20001		4/26/00	c	ac01	int																	
5	69042981p20006	Red Lake Pass 4 (07010)		Thomas Palmer	Alt = 2163m-5 69042981p20001		4/26/00	c	ac01	int																	
6	69042981p20007	Red Lake Pass 5 (07010)		Thomas Palmer	Alt = 2163m-5 69042981p20001		4/26/00	c	ac01	int																	
7	69042981p20008	Red Lake Pass 1 (07010)		Thomas Palmer	Alt = 2163m-5 69042981p20001		4/26/00	c	ac01	int																	
8	69042981p20003	Commanche Pass, CA		Eastwood	Alt = 1148m-5 69042981p20001		4/26/00	c	ac02	int																	
9	69042981p20005	Sierra Nevada 2 (07010)		Thomas Palmer	Alt = 2148m-5 69042981p20001		4/26/00	c	ac02	int																	
10	69042981p20006	Sierra Nevada 1 (07010)		Thomas Palmer	Alt = 2148m-5 69042981p20001		4/26/00	c	ac05	int																	
11	69050381p20001	Mojave Airport	(07301)	Robert D. Green	Sea level with 6% 69050381p20001		5/23/00	c	ac01	int																	
12	69050381p20004	Capria 1, NV	(07301)	Robert D. Green	Alt = 17.5 km/hr 69050381p20001		5/23/00	c	ac01	int																	
13	69050381p20005	Capria 2, NV	(07301)	Robert D. Green	Alt = 17.5 km/hr 69050381p20001		5/23/00	c	ac01	int																	
14	69050381p20006	Capria 3, NV	(07301)	Robert D. Green	Alt = 17.5 km/hr 69050381p20001		5/23/00	c	ac01	int																	
15	69050381p20007	Capria 4, NV	(07301)	Robert D. Green	Alt = 17.5 km/hr 69050381p20001		5/23/00	c	ac01	int																	
16	69050381p20008	Capria 5, NV	(07301)	Robert D. Green	Alt = 17.5 km/hr 69050381p20001		5/23/00	c	ac02	int																	
17	69050381p20009	North Commanche, UT308		Klaus	Alt = 17.5 km/hr 69050381p20001		5/23/00	c	ac01	int																	
18	69050681p20004	Min Pass 2, CA	(07301)	Robert D. Green	Alt = 15 km/hr-5 69050681p20001		5/6/00	c	ac01	int																	

- 2006 - 2021 data is available to download from [AVIRIS Data Portal](#)
 - Many filtering options
 - Each flightline uses a specific base filename prefix
- To access pre-2006 data, users must fill out a request form
- Data types:
 - .KML
 - .JPEG
 - .dat
- Compatible ENVI, QGIS, ESRI products, etc.
- Preprocessing tutorial is provided



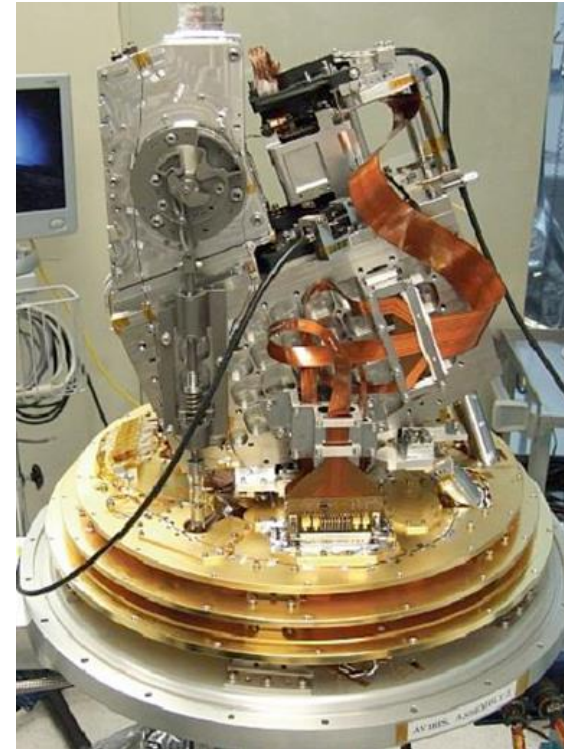
Previous AVIRIS Campaigns

2006-2021 Campaigns



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

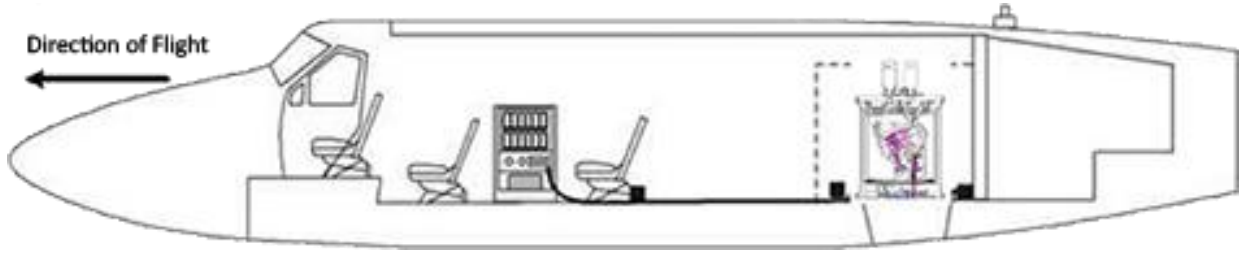
- Objective: To support NASA science and applications by measuring spectra as images that record the interaction of light with matter. These spectra are used to identify, measure, and monitor constituents of the Earth's surface and atmosphere.
- Flown on several aircraft platforms: NASA's ER-2 jet, the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



Source: [NASA JPL](#)



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



- 481 contiguous spectral bands
- Spectral coverage: 380 to 2510 nm
- Spectral resolution: 5 nm \pm 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

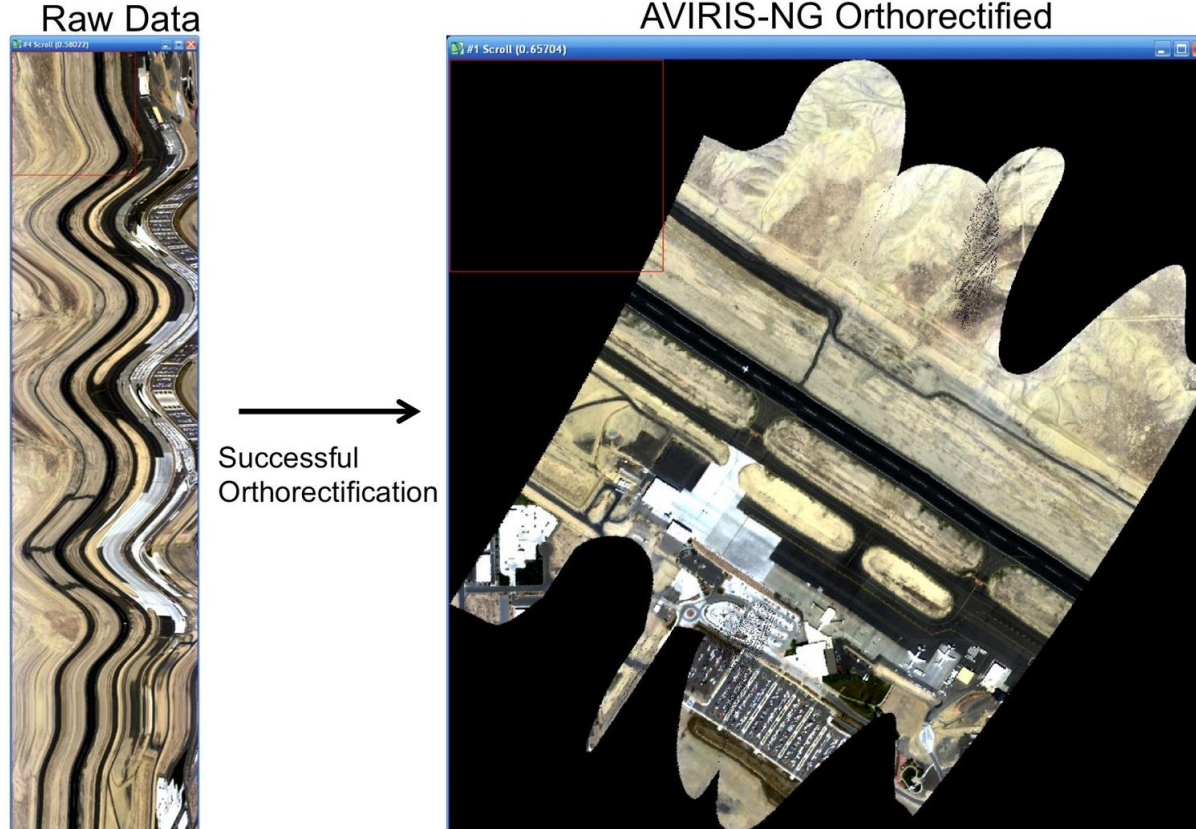


Source: [NASA JPL](#)

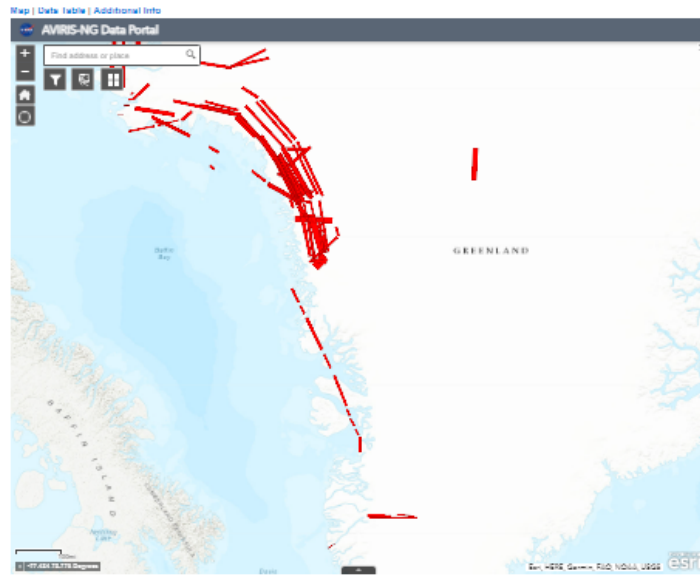


AVIRIS-NG Data Products

Product Name	Product Description
L1B	Resampled calibrated data in units of spectral radiance as well as observational geometry and illumination parameters.
L2	Orthorectified and atmospherically corrected reflectance data (32-bit floating point quantities from 0 to 1) as well as retrieved column water vapor and optical absorption paths for liquid H ₂ O and ice.



Accessing and Using AVIRIS-NG Data



Download KML Layers by Year: 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021

Data Table

Click the filter icon to filter columns
Choose File → Download to save a local copy
Open table in new window

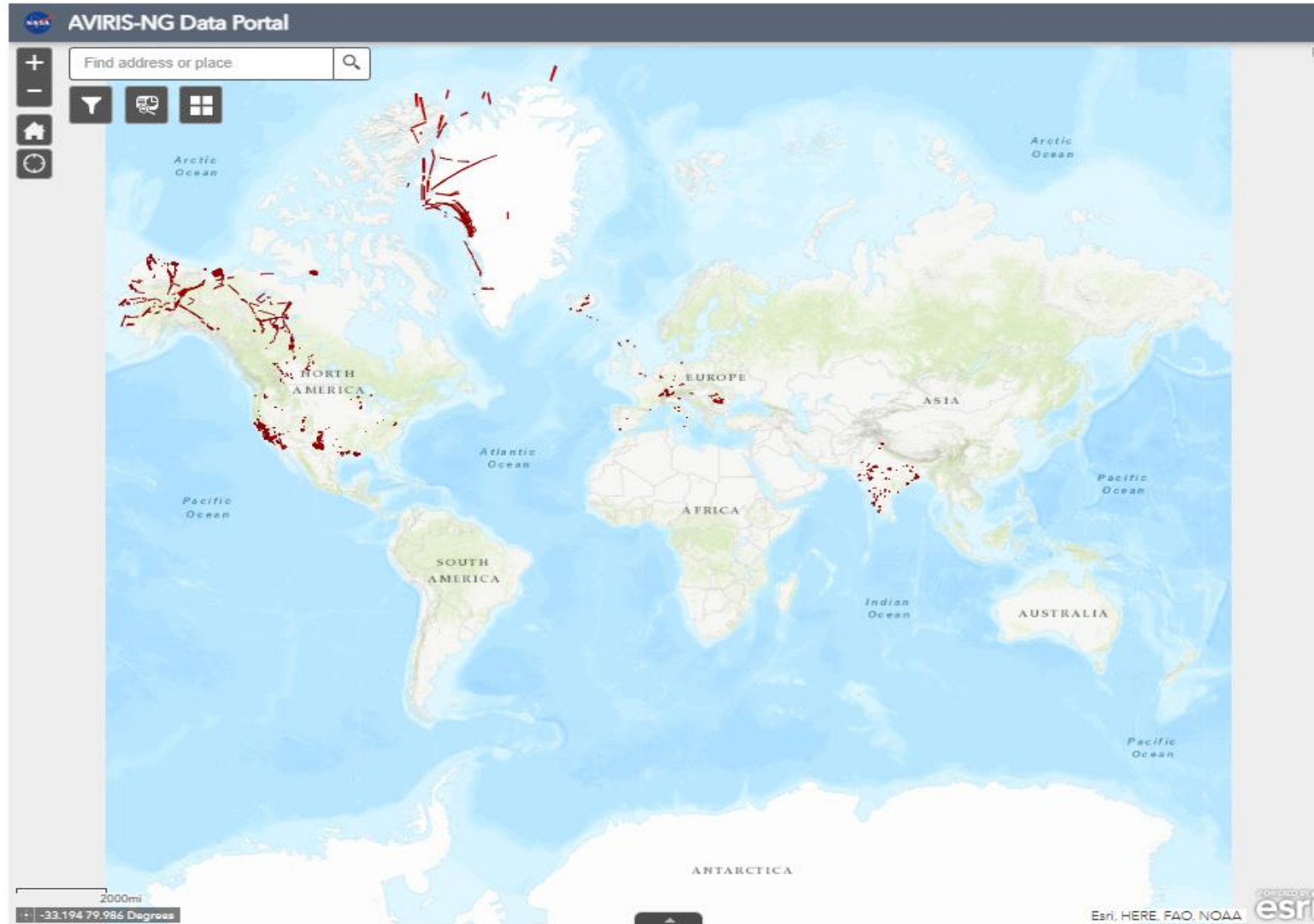
ID	Name	Site Name	NASA Log	Investigator	Comments	FlightSwath
1	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-Clouds * Clear, low haze-br-SGG = 80 kft-br-Direction = 188 deg	ang014053001000
2	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-Clouds * Clear, low haze-br-SGG = 73 kft-br-Direction = 188 deg	ang014053001007
3	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-Clouds * Clear, low haze-br-SGG = 73 kft-br-Direction = 188 deg	ang014053001007
4	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-Clouds * Clear, low haze-br-SGG = 80 kft-br-Direction = 188 deg	ang0140530010054
5	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-Clouds * Clear, low haze-br-SGG = 80 kft-br-Direction = 248 deg	ang0140530010050
6	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-Clouds * Clear, low haze-br-SGG = 70 kft-br-Direction = 168 deg	ang0140530010050
7	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-Clouds * Clear, low haze-br-SGG = 80 kft-br-Direction = 248 deg	ang0140530010050
8	ang014053001	Saqaq Playa 0	142010	Robert Green	Alt = 10 kft-br-SGG = 80 kft-br-Clouds * Clear, low haze-br-Direction = 248 deg	ang0140530010050
9	ang014053001	Mt. Pass (FL17)	142010	Robert Green	Alt = 10 kft-br-SGG = 80 kft-br-Clouds * Clear, low haze-br-Direction = 248 deg	ang0140530010050
10	ang014053001	Mt. Pass (FL17)	142010	Robert Green	Alt = 10 kft-br-SGG = 80 kft-br-Clouds * Clear, low haze-br-Direction = 248 deg	ang0140530010050
11	ang014053001	Mt. Pass (FL17)	142010	Robert Green	Alt = 10 kft-br-SGG = 80 kft-br-Clouds * Clear, low haze-br-Direction = 85 deg	ang0140530010050
12	ang014053001	Mt. Pass (FL17)	142010	Robert Green	Alt = 10 kft-br-SGG = 80 kft-br-Clouds * Clear, low haze-br-Direction = 307 deg	ang0140530010050
13	ang014053001	Mt. Pass (FL17)	142010	Robert Green	Alt = 10 kft-br-SGG = 80 kft-br-Clouds * Clear, low haze-br-Direction = 34 deg	ang0140530010050
14	ang014060201	Saqaq Barbas 0	142011	Phil Townsend	Alt = 15.5 kft-br-SGG = 70 kft-br-Clouds * Clear (phase towards coast-br-Direction = 107 deg	ang0140602010000
15	ang014060201	Saqaq Barbas 0	142011	Phil Townsend	Alt = 15.5 kft-br-SGG = 70 kft-br-Clouds * Clear (phase towards coast-br-Direction = 107 deg	ang0140602010000
16	ang014060201	Saqaq Barbas 0	142011	Phil Townsend	Alt = 15.5 kft-br-SGG = 70 kft-br-Clouds * Clear (phase towards coast-br-Direction = 107 deg	ang0140602010000
17	ang014060201	Saqaq Barbas 0	142011	Phil Townsend	Alt = 15.5 kft-br-SGG = 80-73 kft-br-Clouds * Clear with haze-br-Direction = 107 deg	ang0140602010000
18	ang014060201	Saqaq Barbas 0	142011	Phil Townsend	Alt = 15.5 kft-br-SGG = 70-80 kft-br-Clouds * Clear with haze-br-Direction = 107 deg	ang0140602010000

- 2014 - 2021 data is available to download from [AVIRIS-NG Data Portal](#)
 - Many filtering options
 - Each flightline uses a specific base filename prefix
- Data types:
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 - .dat
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Previous AVIRIS-NG Campaigns

2014-2021 Campaigns



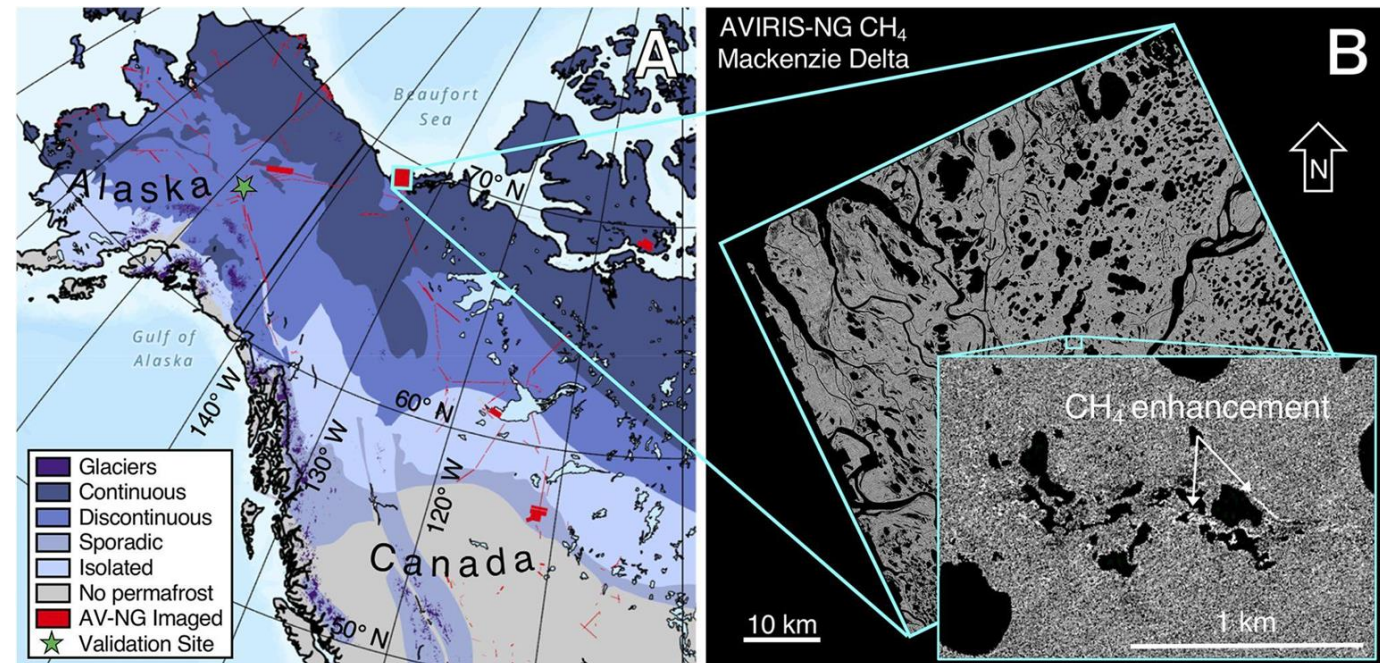
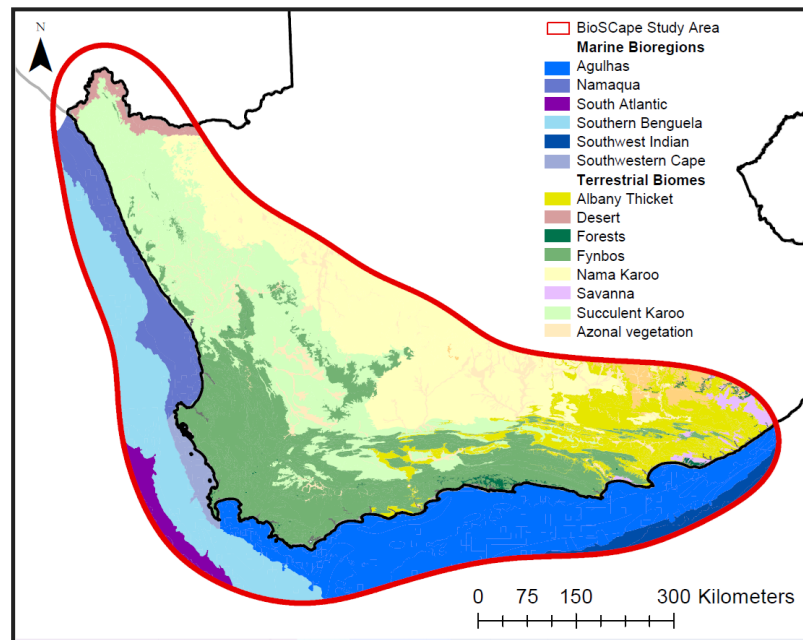
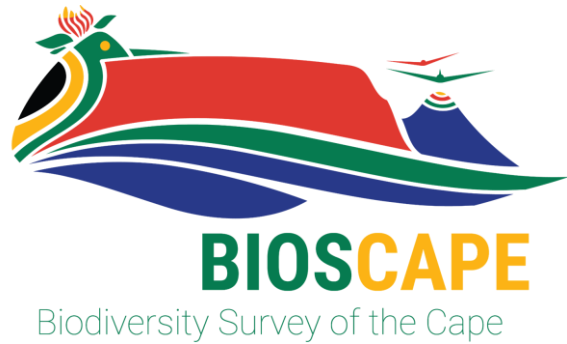
Current and Upcoming AVIRIS and AVIRIS-NG Campaigns

Campaign	Location	Timeframe	Aircraft	Sensor
Carbon Mapper	South America	2023 Jan-March	B200 King Air	AVIRIS-NG
SnowEx/ABoVE	Alaska	2023 April	B200 King Air	AVIRIS-NG
NASA STAQS	New York & Los Angeles	2023 June-Aug	LaRC G-III	AVIRIS-NG
AVIRIS-3 test flights	CONUS	2023 May	B200 King Air	AVIRIS-3
NASA BioSCAPE	South Africa	2023 Oct-Dec	LaRC G-III	AVIRIS-NG
NASA FireSense	Western US	2023 Sept	B200 King Air	AVIRIS-3
NASA WDTS	Western US	2023-2026 Summer	AFRC ER-2	AVIRIS Classic
USGS EMRI	Western US	2023-2026 Summer	AFRC ER-2	AVIRIS Classic

Source: [NASA JPL](#)



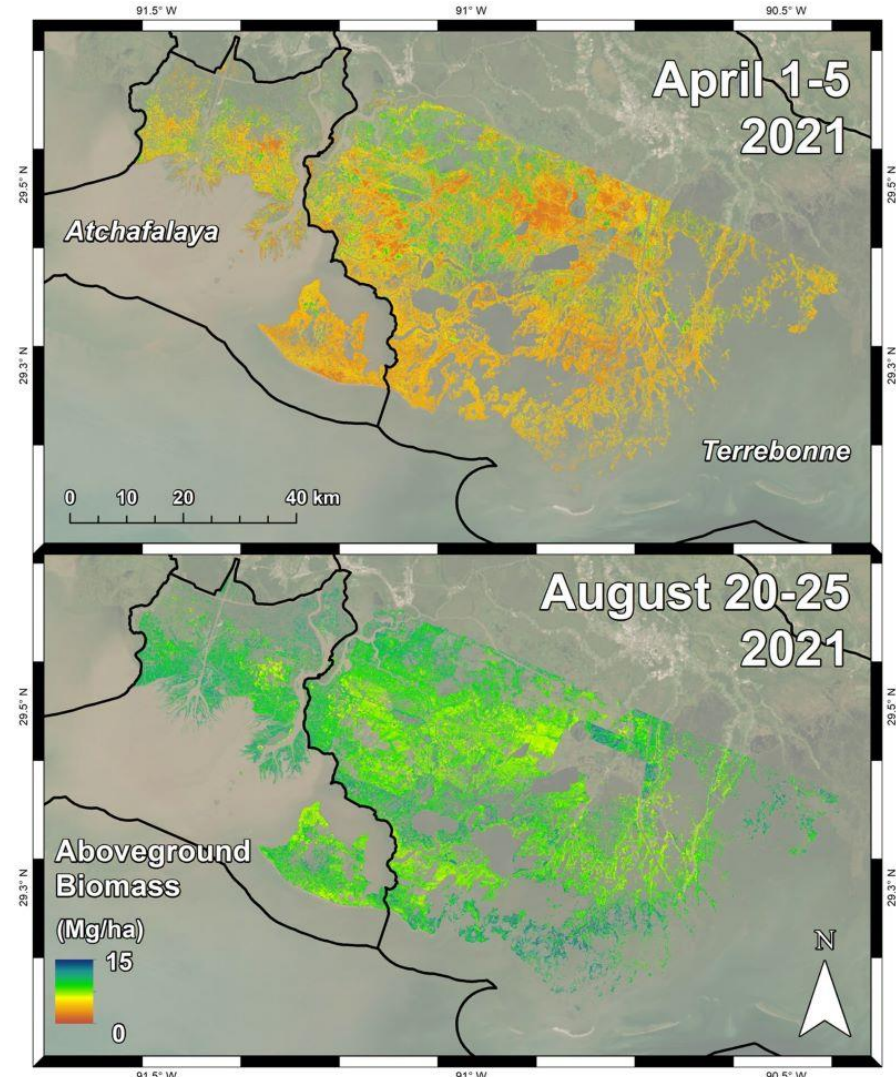
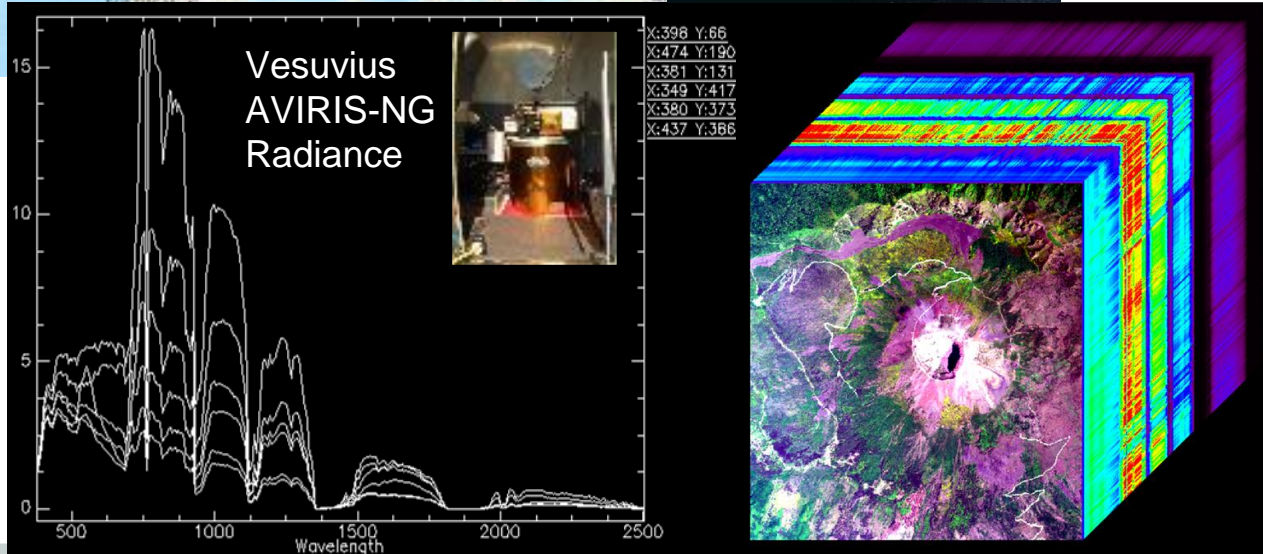
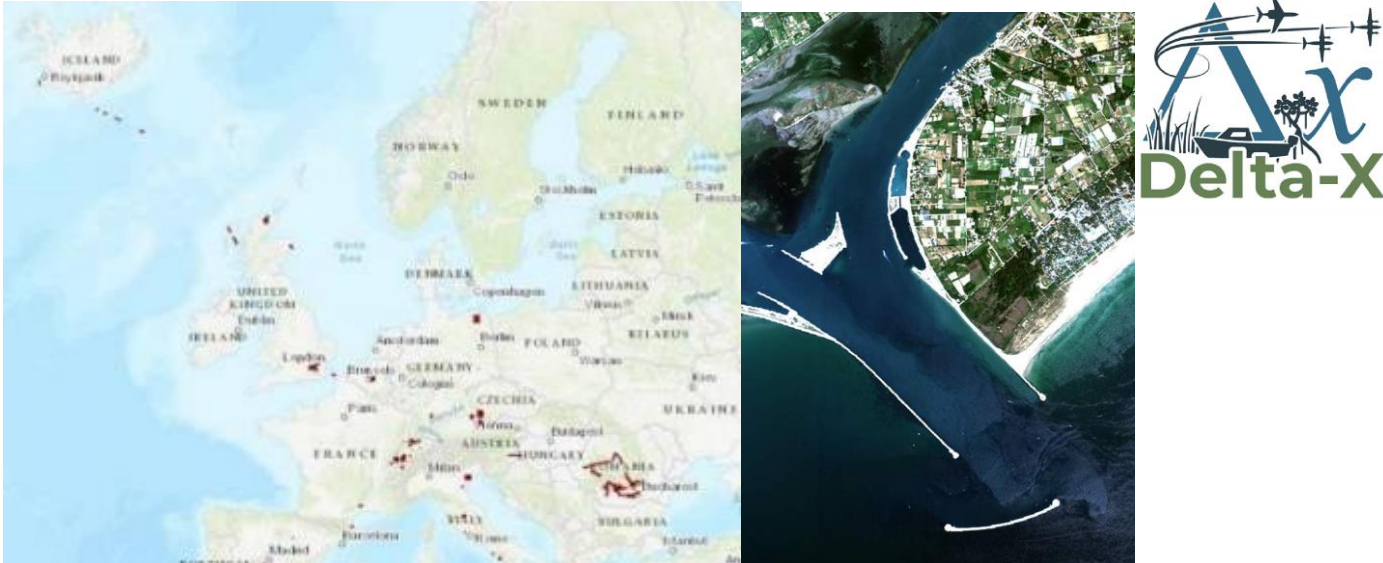
AVIRIS-NG Biodiversity Applications



AVIRIS-NG ABoVE survey and a regional mapping example. Source: [Elder, et al., 2020](#).



AVIRIS-NG Biodiversity Applications

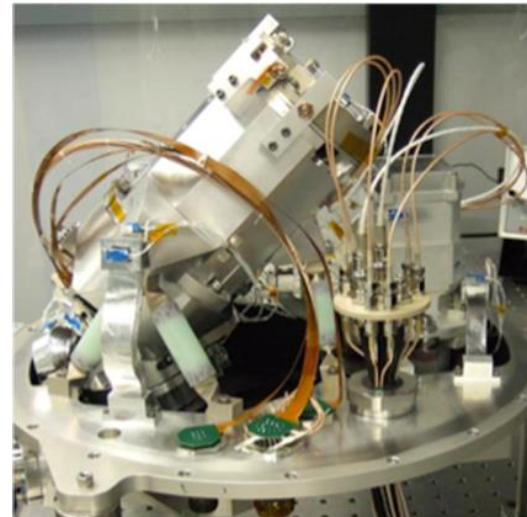


Herbaceous aboveground biomass in coastal Louisiana. Source: [Jensen, et al., 2022.](#)



Portable Remote Imaging SpectroMeter (PRISM)

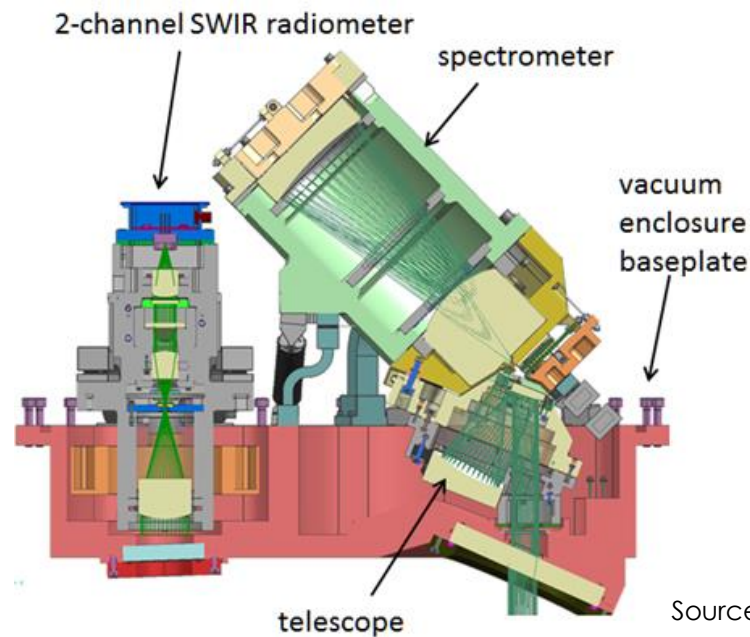
- Application: To serve as a UV-NIR (350 nm to 1050 nm) Coastal Ocean Science Instrument.
- Flown on four aircraft platforms: NASA's ER-2 jet, Twin Otter aircraft, Gulfstream GIII and GV
- Flown in Western United States, South America, and the Southern Ocean
- Active since 2012



Source: [NASA JPL](#)



Portable Remote Imaging SpectroMeter (PRISM)

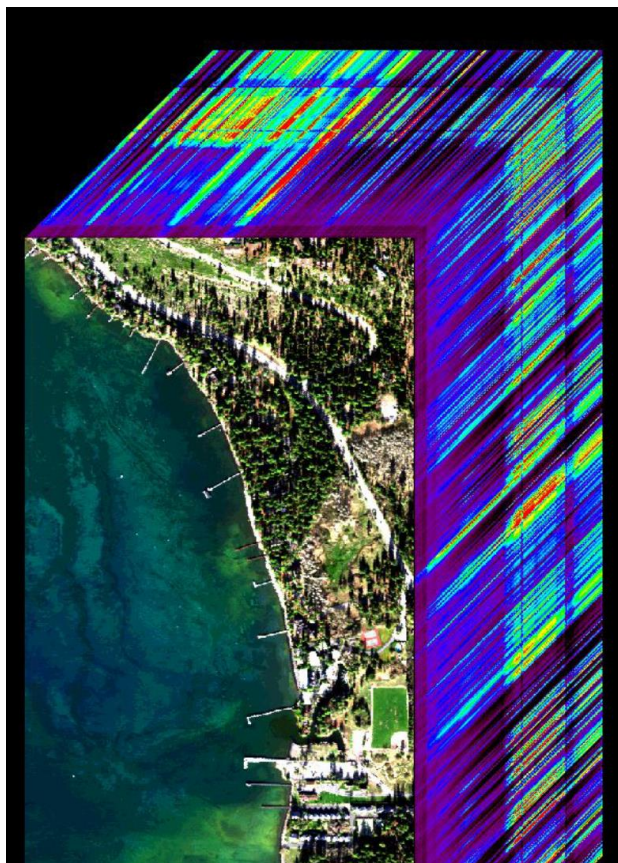


Source: [NASA JPL](#)

- Pushbroom imaging spectrometer with 246 contiguous spectral bands
- Spectral coverage: 350 -1050 nm
- Spectral resolution: 3.5 nm
- Two short wave infrared (SWIR) bands at 1240 and 1610 nm
 - Bandwidth: 22 nm and 56 nm
- The spatial resolution depends on the altitude and plane speed but ranges from 0.3 to 16 m.



PRISM Data Products



Source: [NASA JPL](#)

Product Name	Product Description
L1B	Resampled calibrated data in units of spectral radiance as well as observational geometry and illumination parameters.
L2	Orthorectified and atmospherically corrected reflectance data (32-bit floating point quantities from 0 to 1) as well as retrieved column water vapor and optical absorption paths for liquid H2O and ice.

L1B Data Products

- [Grass Line, FL - View quicklook](#) | [Download data \(4.5 GB\)](#)
- [Island Line, FL - View quicklook](#) | [Download data \(4 GB\)](#)
- [Elkhorn, CA - View quicklook](#) | [Download data \(9 GB\)](#)
- [Elkhorn, CA - View quicklook](#) | [Download data \(10 GB\)](#)
- [Elkhorn, CA - View quicklook](#) | [Download data \(10 GB\)](#)

L2 Data Products

- [Grass Line, FL - View quicklook](#) | [Download data \(4.8 GB\)](#)
- [Island Line, FL - View quicklook](#) | [Download data \(4.1 GB\)](#)
- [Elkhorn, CA - View quicklook](#) | [Download data \(7.4 GB\)](#)
- [Elkhorn, CA - View quicklook](#) | [Download data \(8.2 GB\)](#)
- [Elkhorn, CA - View quicklook](#) | [Download data \(8.1 GB\)](#)



Accessing and Using PRISM Data

PRISM Data Portal 2014-2018

Map | Data Table | Additional Info

Click on red polygons to get flight line details including download links, HGS quickbooks, and KMLs.
Expand map legend (F10 icon) to hide and show layers by year. (NOTE: Additional map-based search and filter features coming soon!)
Shift + CTRL to zoom in and out.
Additional map-based search and filter features can be found here. Navigate to the Contents tab and select the PRISM icon.

Filter layer by applying values

PRISM Flights

Of the following expressions must be true:
PRISM Year (Year):
2014
2015
Flight Year:
Apply

Data Table

Click the filter icon to filter columns.
Choose **File** → **Download** to save a local copy.
Open table in new window

Line#	Site Name	NASA Lag	Investigator	Comments	Flight Science	Date	Yr	Day	Flight ID	Flight
1	Green Line 48	Green Line 48	Green Line 48	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
2	Green Line 58	Green Line 58	Green Line 58	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
3	Green Line 57	Green Line 57	Green Line 57	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
4	Green Line 56	Green Line 56	Green Line 56	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
5	Green Line 55	Green Line 55	Green Line 55	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
6	Green Line 51	Green Line 51	Green Line 51	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
7	Green Line 52	Green Line 52	Green Line 52	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
8	Green Line 51	Green Line 51	Green Line 51	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
9	Green Line 52	Green Line 52	Green Line 52	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
10	Green Line 51	Green Line 51	Green Line 51	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
11	Green Line 52	Green Line 52	Green Line 52	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
12	Green Line 51	Green Line 51	Green Line 51	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
13	Green Line 52	Green Line 52	Green Line 52	Alt = 2.5 kft (m)	prism201401281	11/13/14	14	14	prism20140128	2014C
14	Airport no village (hohot)	Airport no village (hohot)	Green Line 48	Alt = 15 kft (m)	prism201404181	4/16/14	14	14	prism20140418	2014C
15	Saturn March 6 PM - ABCRTE2	Saturn March 6 PM - ABCRTE2	Mark, Robert	prism201403282	4/26/14	14	14	prism20140328	2014C	
16	Saturn March 6 PM	Saturn March 6 PM	Alt = 10 kft (m)	prism201403282	4/26/14	14	14	prism20140328	2014C	
17	Saturn March 6 PM	Saturn March 6 PM	Alt = 10 kft (m)	prism201403282	4/26/14	14	14	prism20140328	2014C	
18	Saturn March 7 PM	Saturn March 7 PM	Altitude = 10 kft	prism201403282	4/26/14	14	14	prism20140328	2014C	

- 2014 - 2018 data is available to download from [PRISM Data Portal](#)
 - Many filtering options
 - Each flightline uses a specific base filename prefix
- Data types:
 - .KML
 - .JPEG
 - .dat
- Compatible ENVI, QGIS, ESRI products, etc.



Previous PRISM Campaigns

2012 - 2018 Campaigns

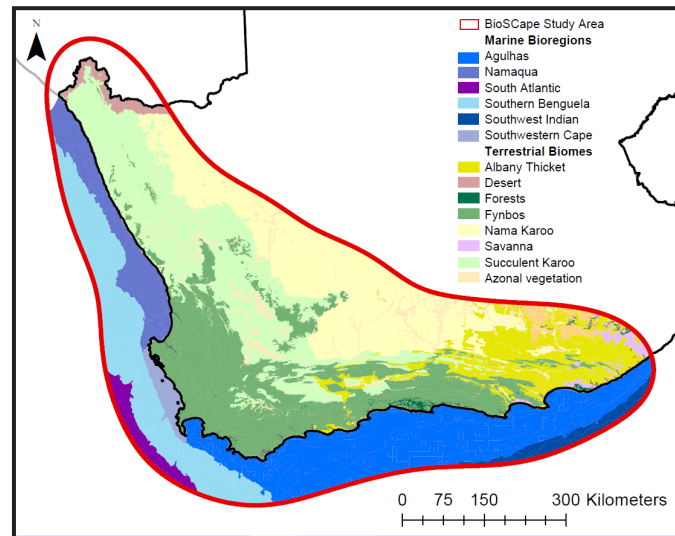


PRISM Biodiversity Applications



BIOSCAPE

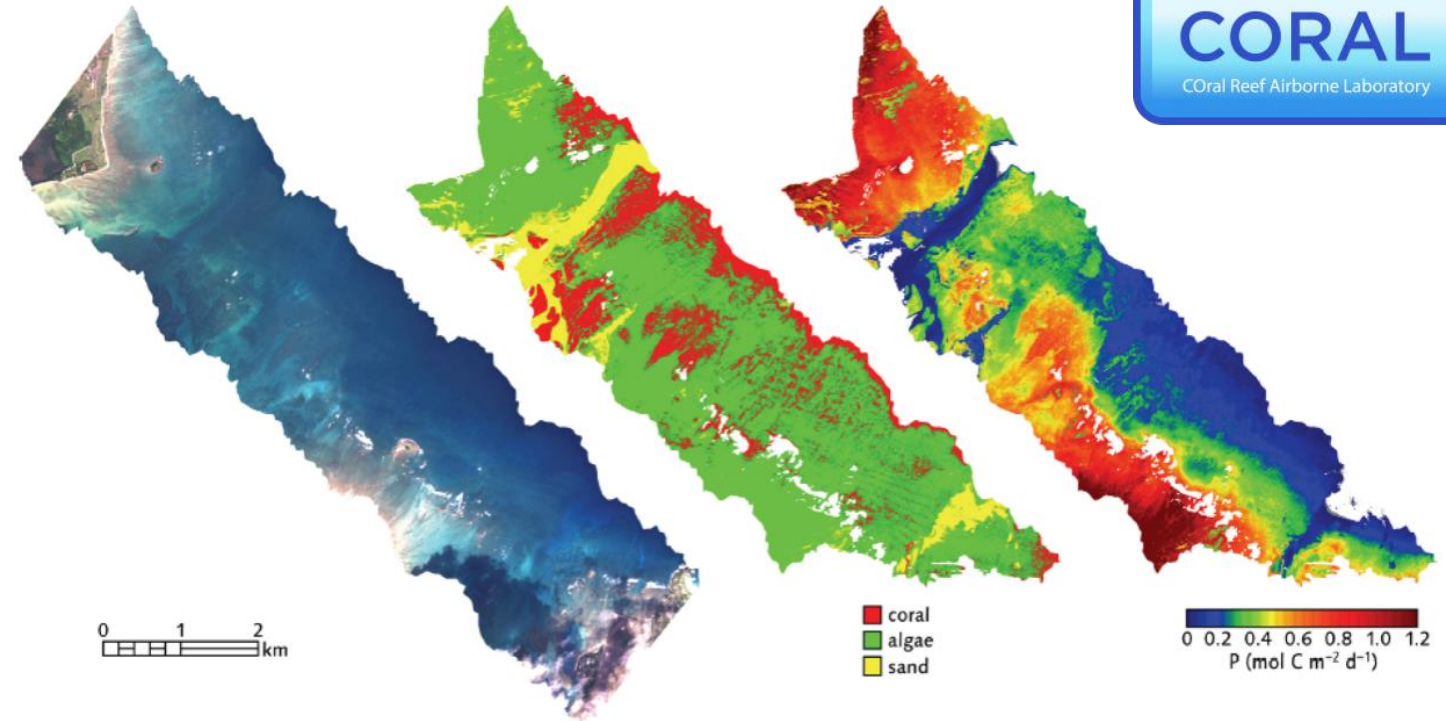
Biodiversity Survey of the Cape



Original Image

Reef Composition

Reef Productivity

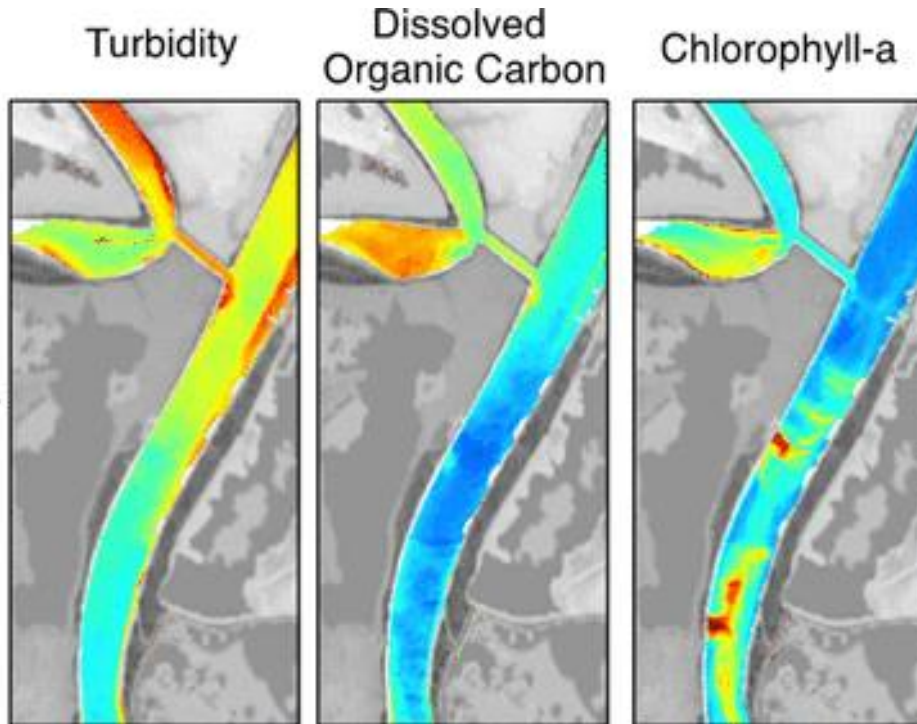


Sources: BioScape, Eric Hochberg (CORAL PI)



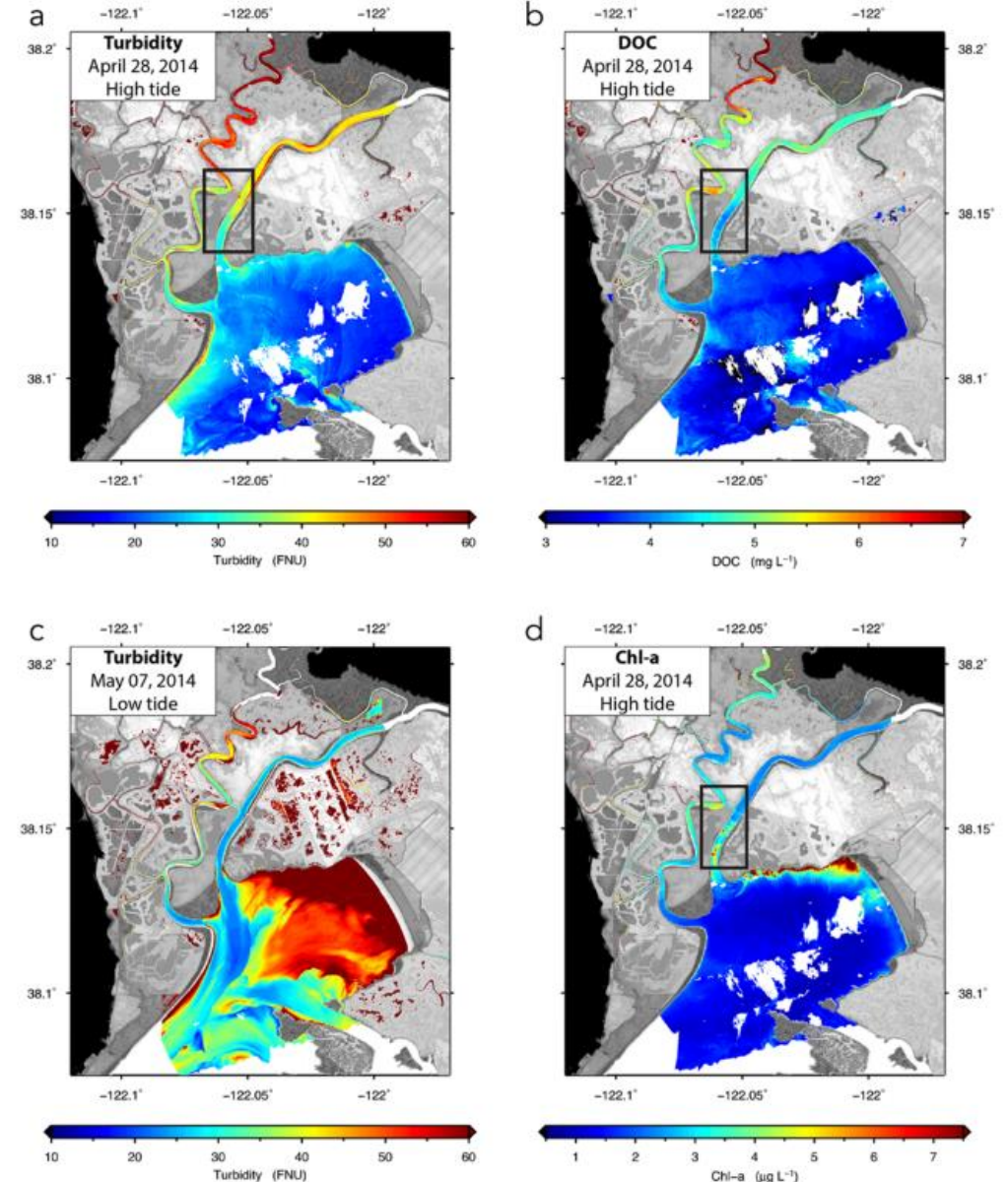
PRISM Biodiversity Applications

Remote-sensing
Reflectance



Above: Distributions of turbidity, dissolved organic carbon (DOC) and chlorophyll-a concentrations in the San Francisco Bay–Delta Estuary.

Right: Maps of turbidity, DOC, and chl-a in Suisun Bay (Grizzly Bay) and Suisun Marsh. Source: [Fichot et al., 2016](#).



Comparing Airborne Systems: Specifications



AVIRIS-C

- Active since 1986
- 224 continuous spectral bands
- Spectral coverage: 380 to 2500 nm
- Spectral resolution: 10 nm
- Spatial resolution: 4 - 20 m



AVIRIS-NG

- Active since 2009
- 481 contiguous spectral bands
- Spectral coverage: 380 to 2510 nm
- Spectral resolution: 5 nm
- Spatial resolution: 2 - 6 m



PRISM

- Active since 2012
- 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



Comparing Airborne Systems: Access and Use

AVIRIS-C



- Data Access:
 - Data portal
 - 2006 - 2021
 - Pre-2006 form
- Data products:
 - Up to Level 1B for 1993 to 2012
 - Up to Level 2 for data collected 2013 to present
- Data types:
 - .KML
 - .JPEG
 - .dat

AVIRIS-NG



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

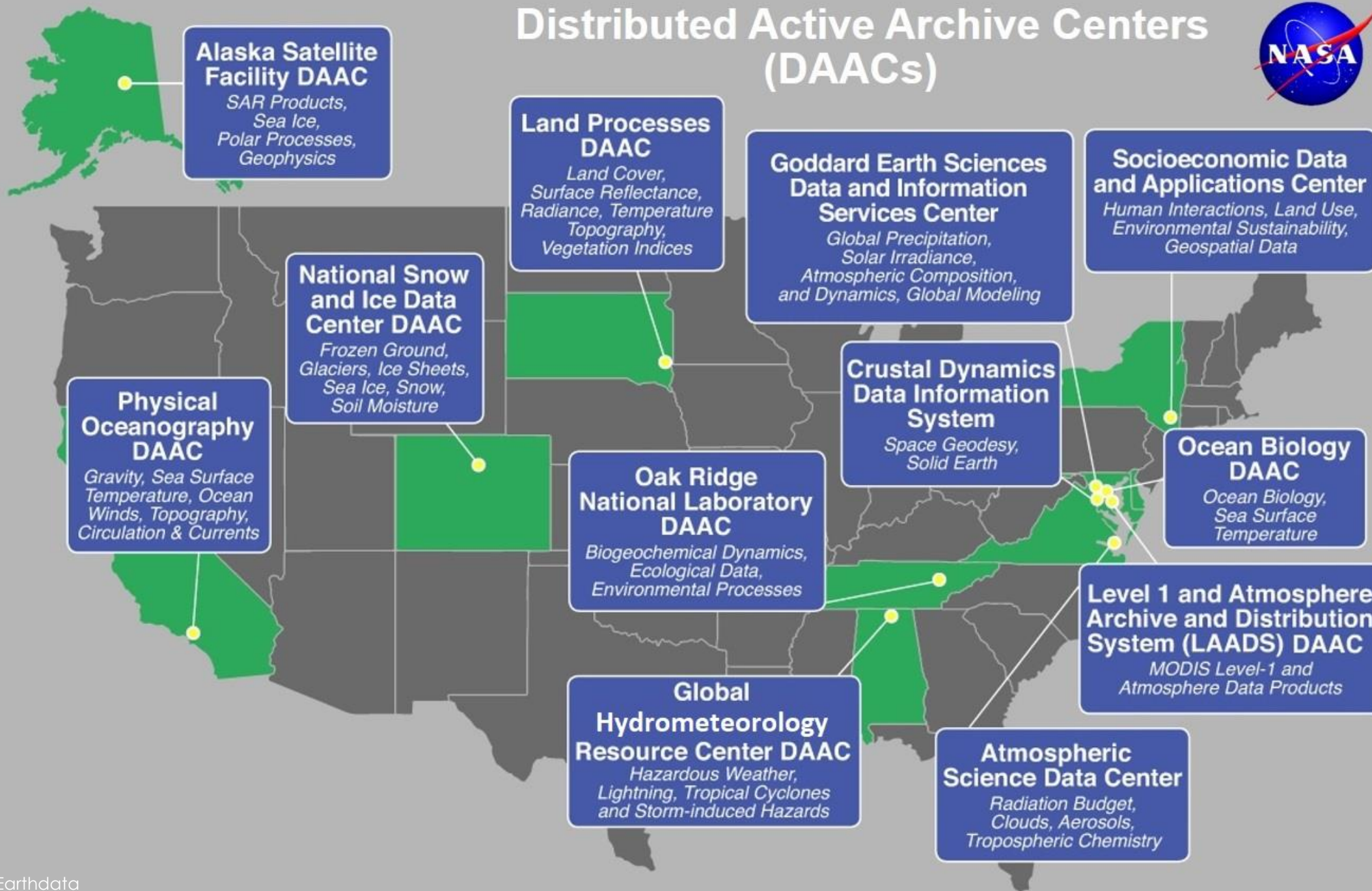
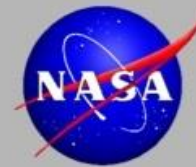
PRISM

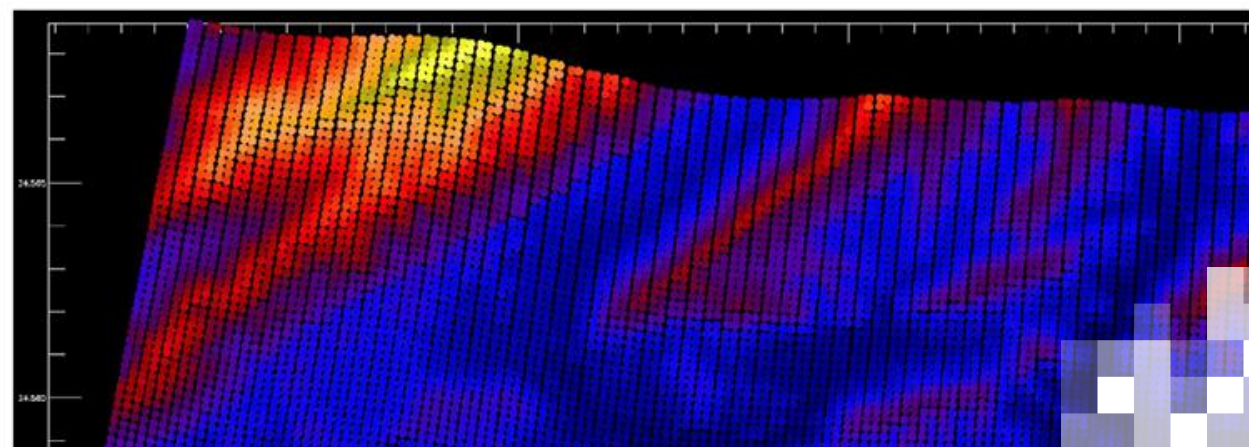


- Data Access:
 - Data portal
 - 2014 - 2018
- Data products: Level 1B and L2
- Data types:
 - .KML
 - .JPEG
 - .dat



Distributed Active Archive Centers (DAACs)



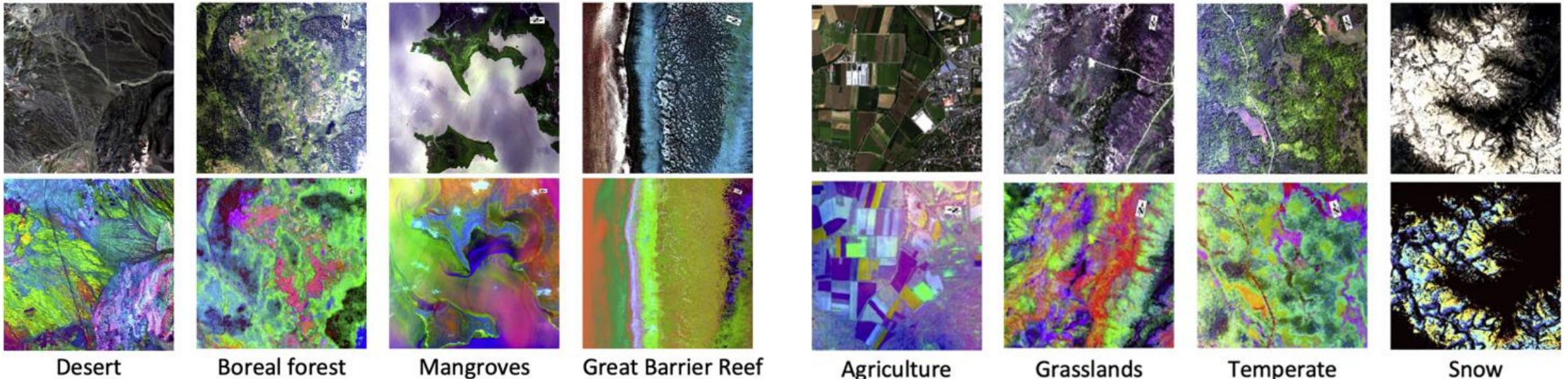


Upcoming Mission Highlights

Paving the Way for Future Missions

The design and data from these airborne instruments have been essential in the development of upcoming satellite missions and future science initiatives.

- Mission objectives and spectrometer specifications are based off of the successful implementation of previous airborne campaigns.



Imagery from HyTES, AVIRIS-NG, AVIRIS-C, and PRISM campaigns used for the development of NASA's SBG mission. Credit: [Cawse-Nicholson, et al., 2021](#).



Upcoming NASA Hyperspectral Satellite Initiatives

- **Plankton, Aerosol, Cloud, and Ocean Ecosystem (PACE)**
 - Observations of the global oceans, atmosphere, and terrestrial ecosystems
 - Ultraviolet through the visible and into the shortwave infrared region of the electromagnetic spectrum, specifically from 340-890 nm sampled at every 2.5 nm with 5 nm resolution
- **Surface Biology and Geology (SBG)**
 - Applications across a variety of focus areas
 - Precursor to SBG: Hyperspectral Infrared Imager (HyspIRI) mission concept activity (2007-2018)
 - Imaging spectrometer measuring from the visible to short wave infrared (VSWIR: 380 nm - 2500 nm) in 10 nm contiguous bands

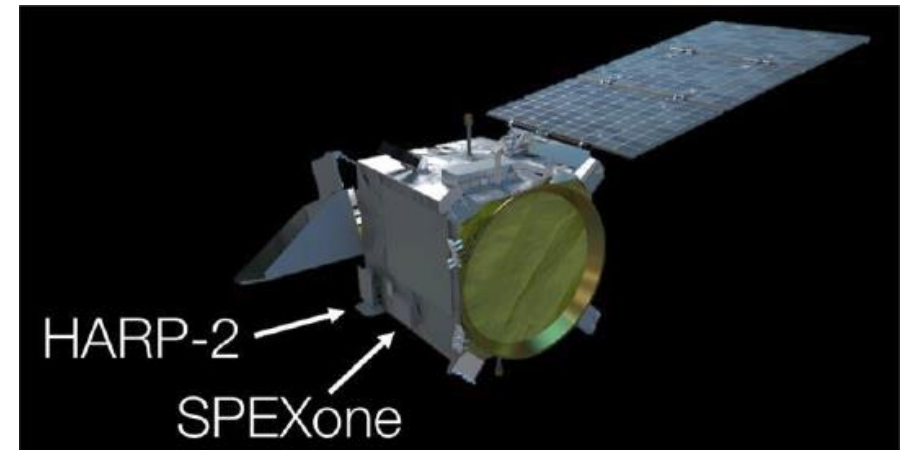


Plankton, Aerosol, Cloud, and Ocean Ecosystem (PACE)



PACE is NASA's next great investment in hyperspectral earth imagery and multi-angle polarimetry.

- Launch Date: **Jan. 2024**
- 3-year design life; 10-year propellant
- Hyperspectral Imager: **Ocean Color Instrument (OCI)**
 - Spectral Resolution: UV to SWIR (340-890 nm every 2.5 nm, with 940, 1038, 1250, 1378, 1615, 2130, & 2250 nm)
 - Temporal Resolution: 2 days
 - Spatial Resolution: 1-km² at nadir
- Two Multi-Angle Polarimeters
 - **HARP-2**: Wide swath, hyper-angular, 4 bands across the VIS & NIR
 - **SPEXone**: Narrow swath, hyperspectral (UVNIR), 5 viewing angles



Extend key systematic **ocean** biological, ecological, & biogeochemical climate data records, as well as **cloud & aerosol climate data records**

Make **new global measurements of ocean color** that are essential for understanding the global carbon cycle & ocean ecosystem responses to a changing climate

Collect **global observations of aerosol & cloud properties**, focusing on reducing the largest uncertainties in climate & radiative forcing models of the Earth system

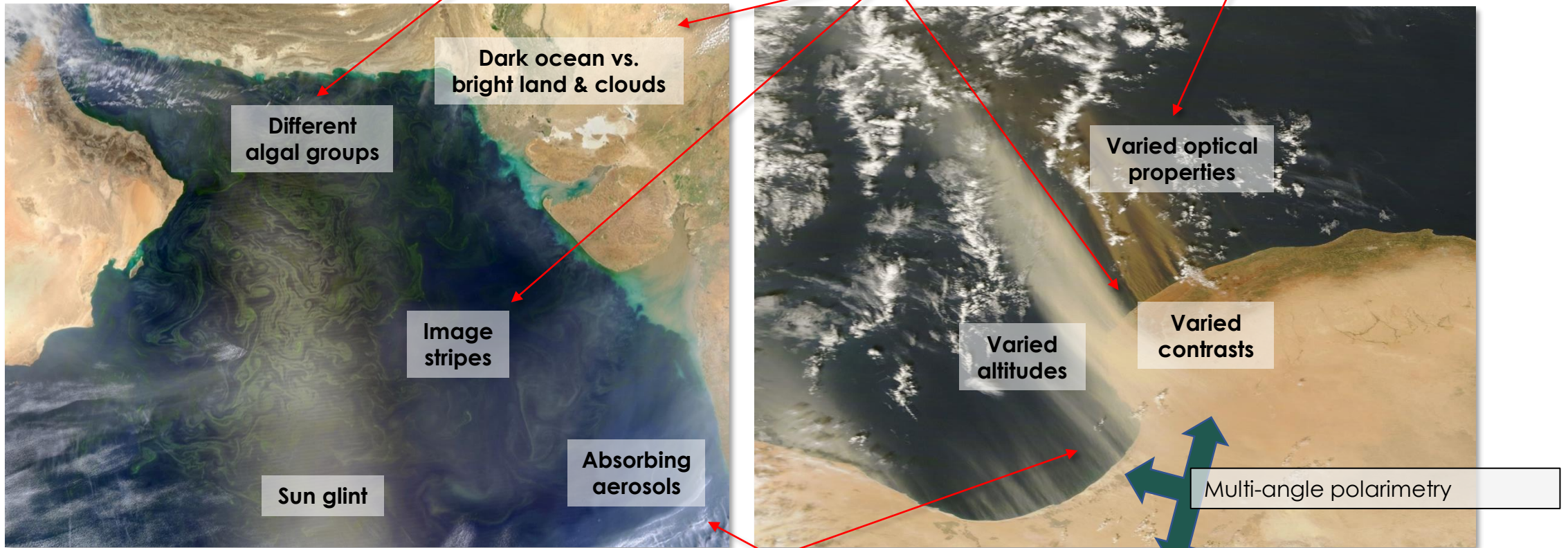
GSD of $1 \pm 0.1 \text{ km}^2$ at nadir

Twice-monthly lunar calibration & onboard solar calibration (daily, monthly, dim)

Spectral range from 350-865 @ 5 nm

940, 1038, 1250, 1378, 1615, 2130, 2260 nm

Instrument performance requirements



Tilt $\pm 20^\circ$

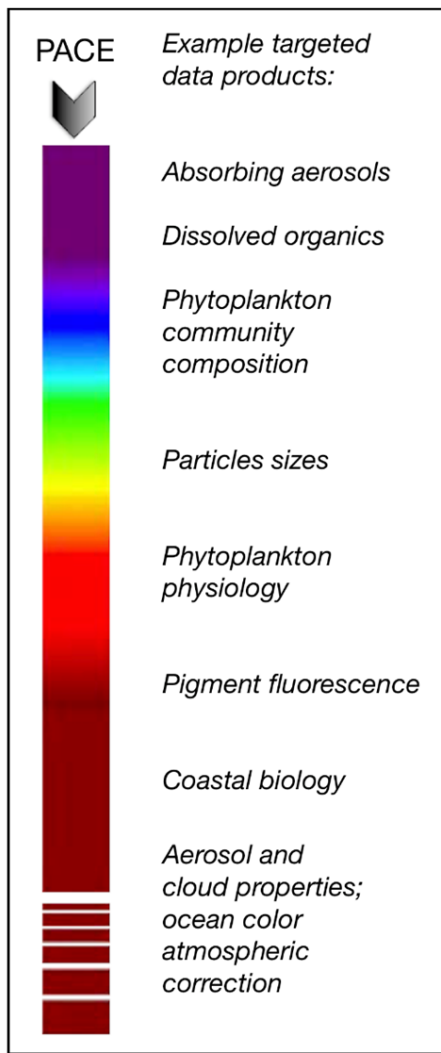
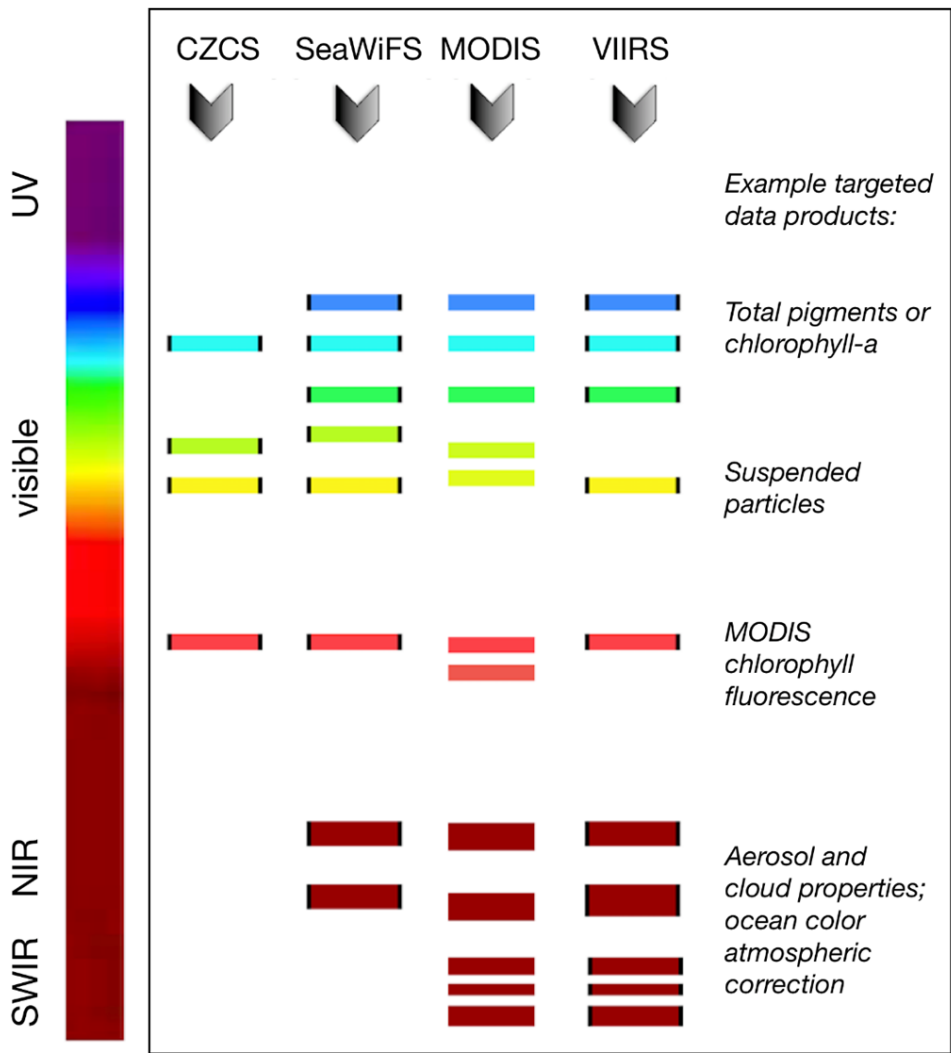
Spectral range goal of 320-865 @ 5 nm

Improve our understanding of how **aerosols influence ocean ecosystems & biogeochemical cycles** and how **ocean biological & photochemical processes affect the atmosphere**



Moving from multi-spectral radiometry to spectroscopy

1978-1986 1997-2010 1999-pres. 2012-pres.

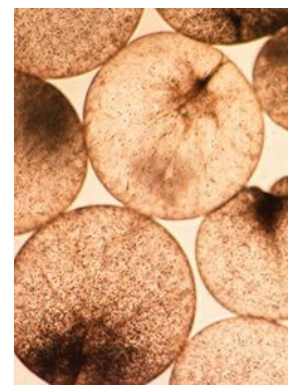


Example diatom

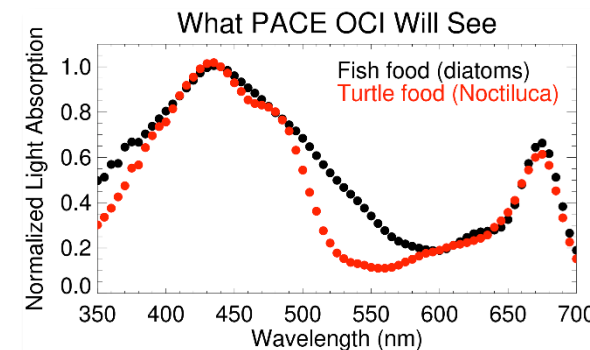
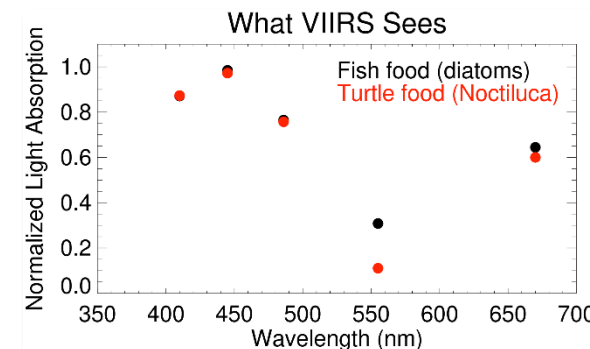


Linda Ambrecht, abc.com.au

Example Noctiluca



Signals from the ocean are small & differentiating between constituents requires additional information relative to what we have today



PACE: Interdisciplinary Applied Science Objectives

fisheries biodiversity HABs oil leaks food security wetlands terrestrial ecosystems land use & change



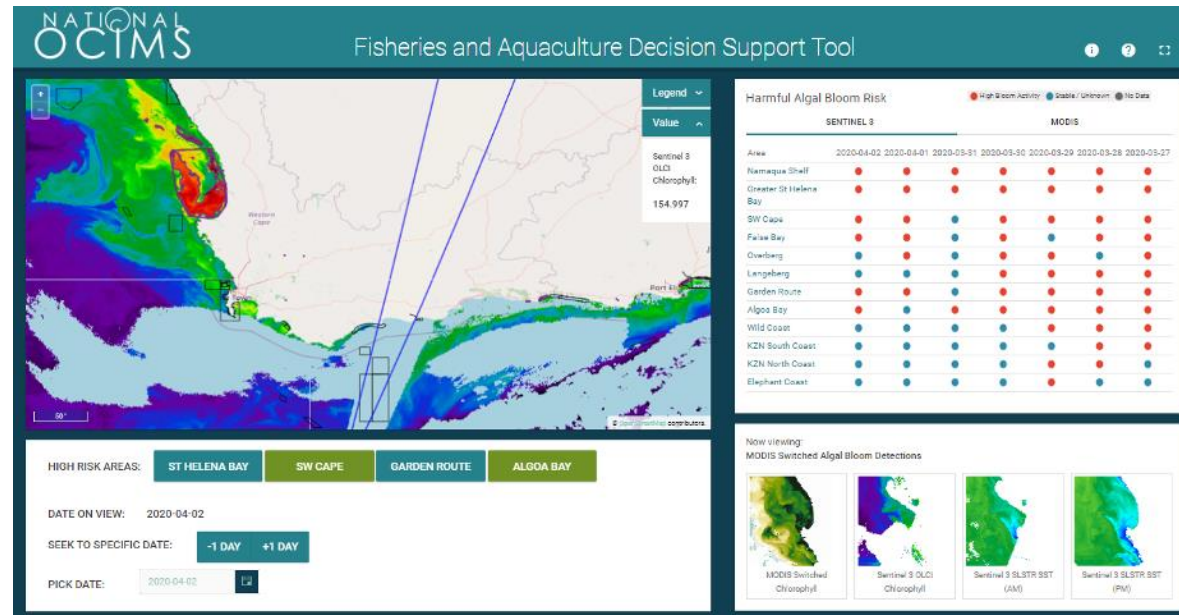
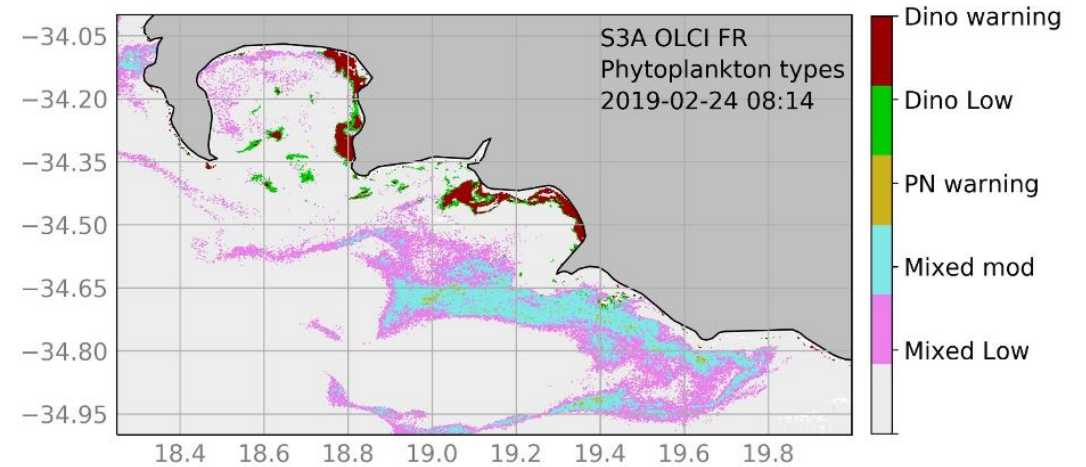
air quality human health disasters climate resource management ecological forecasting pathogens water quality



Informing Applications with PACE Data: Monitoring and Managing Marine Ecosystems

PACE will provide phytoplankton community composition data for understanding ocean ecosystems, which can benefit and/or inform:

- Fisheries and aquaculture
- Marine food webs
- Aquatic biodiversity
- Ecosystem health



Top: Existing phytoplankton type products for potential HAB detection in the southern Benguela will be improved by PACE.
Middle: The National Oceans and Coastal Information Management System (OCIMS) Fisheries and Aquaculture Decision Support Tool will incorporate PCC from PACE.
Left: HAB conditions discolor coastal waters. (Photo courtesy of Wolfgang Volgelbein, VIMS)



Informing Applications with PACE Data: Monitoring and Managing Terrestrial Ecosystems

PACE will provide data on surface vegetation, including surface reflectance, BRDF, and NDVI, which can benefit and/or inform:

- Wetland ecosystem health
- Forest health
- Agriculture
- Understanding impacts from land to coastal environments

Get Involved with PACE:
https://pace.oceansciences.org/app_involved.htm



PACE Applications Program



Air Quality



Water Resources



Disasters



Ecological Forecasting



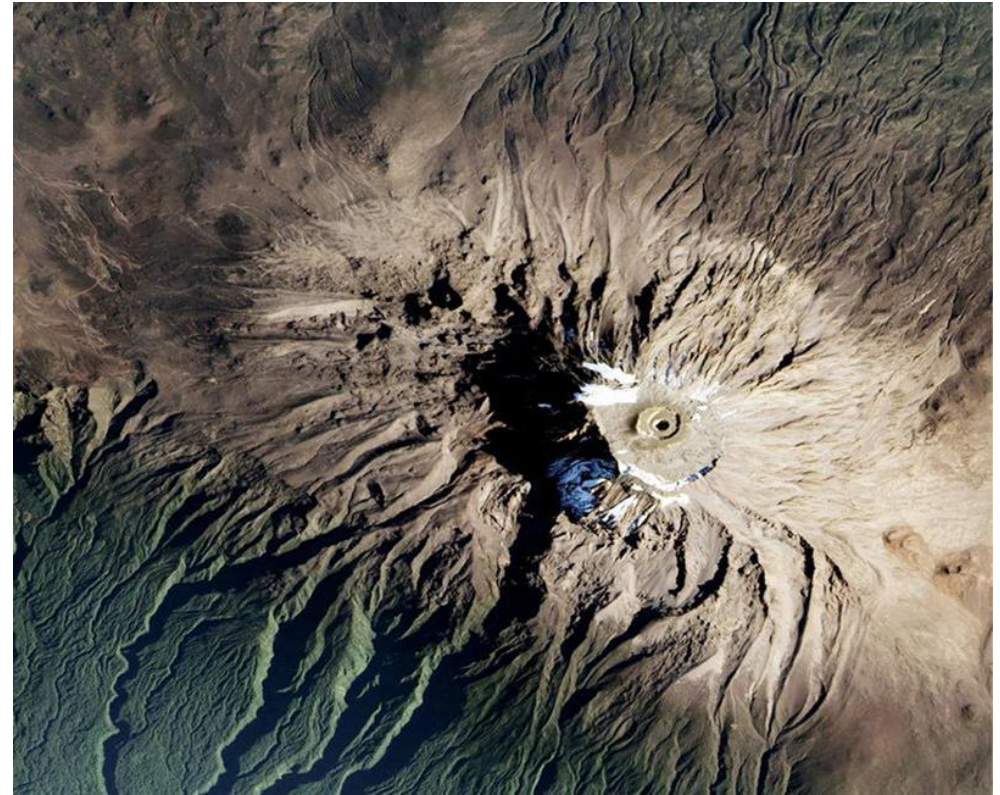
Climate



Surface Biology and Geology (SBG) Mission

<https://sbg.jpl.nasa.gov/>

- In development via guidance from the 2018 Decadal Survey
- Potential Parameters:
 - Visible to Shortwave Infrared Bands:
 - Spectral Range: 350 or 400 to 2500 nanometers
 - Spectral Resolution: 10 nm or better
 - Global with 2- to 16-day revisit times
 - Thermal Bands:
 - Spectral Range: 8000 to 12000 or 3000 to 5000 nanometers
 - Spectral Resolution: Greater than 5 bands
 - Global with 1- to 70-day revisit times



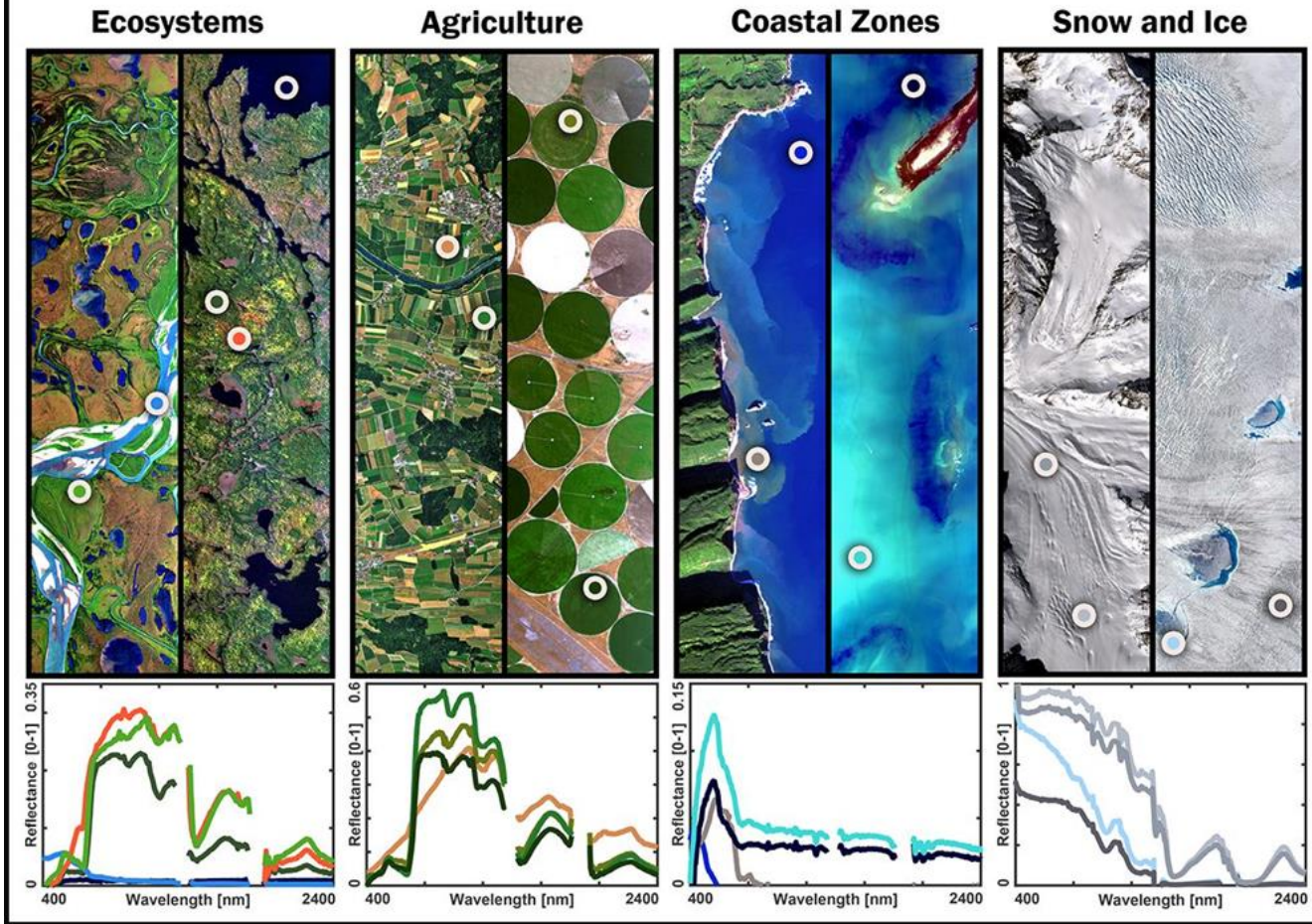
Mount Kilimanjaro Image Credit: [JPL SBG](#)



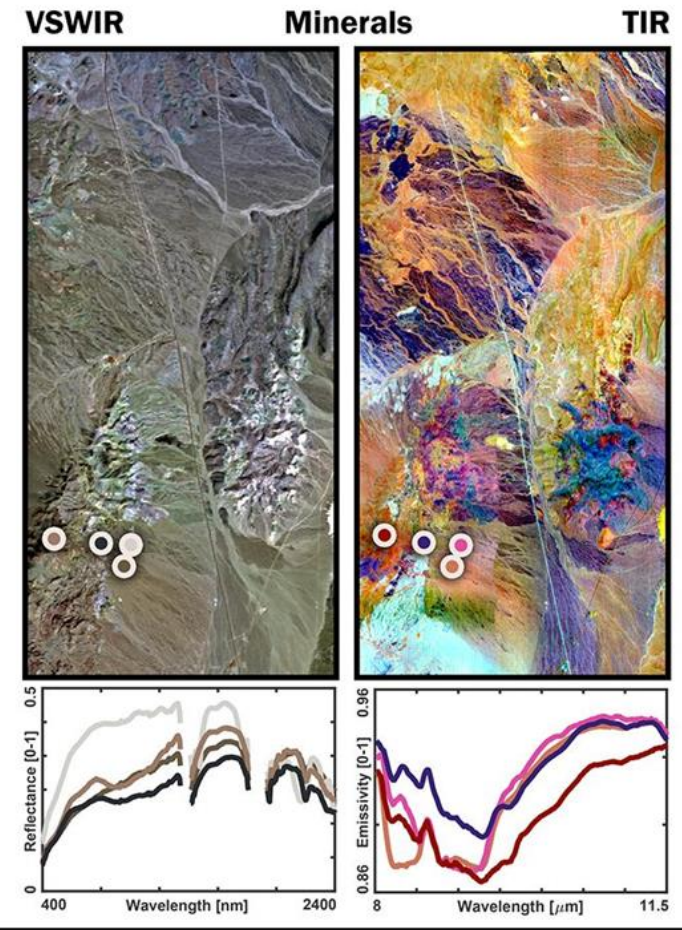
SBG Mission



SBG provides data for many focus areas ...



... and will see the world in two critical spectral regions

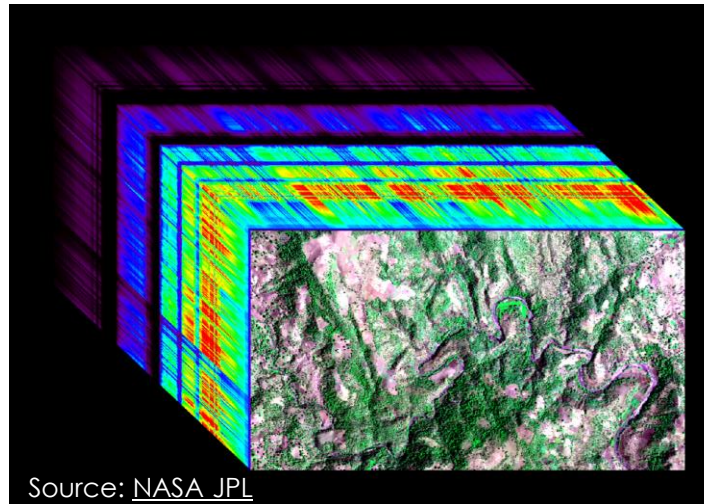


SBG Potential Applications; Image Credit: [JPL SBG](#)



Summary

- Hyperspectral visible to short wave infrared (VSWIR) data refers to wavelengths within the visible and infrared portions of the electromagnetic spectrum (380- 2500 nm).
- The increased spectral resolution from hyperspectral data can provide users with additional data that multispectral data cannot measure.
- Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG) and Portable Remote Imaging SpectroMeter (PRISM) airborne campaigns provide us with hyperspectral VSWIR data.
- Future hyperspectral missions include Airborne Visible InfraRed Imaging Spectrometer 3 (AVIRIS-3), Plankton, Aerosol, Cloud, and Ocean Ecosystem (PACE), and Surface Biology and Geology (SBG).



Resources



<https://airbornescience.nasa.gov/>

<https://aviris.jpl.nasa.gov/>

<https://prism.jpl.nasa.gov/>

<https://www.bioscape.io/>

<https://airbornescience.jpl.nasa.gov/campaign/coral>

<https://sbg.jpl.nasa.gov/>

<https://pace.gsfc.nasa.gov/>



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 - Amber McCullum: amberjean.mccullum@nasa.gov
 - Britnay Beaudry: britnay.beaudry@nasa.gov
 - Sativa Cruz: sativa.cruz@nasa.gov
- Training Webpage: <https://appliedsciences.nasa.gov/mission/training/english/arset-biodiversity-applications-airborne-imaging-systems>
- ARSET Webpage: <https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset>

Consult Our Sister Programs:



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Thank You!

