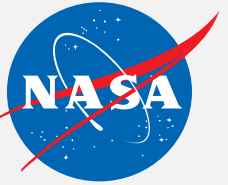


National Aeronautics and
Space Administration



ARSET

Applied Remote Sensing Training

<http://arset.gsfc.nasa.gov>

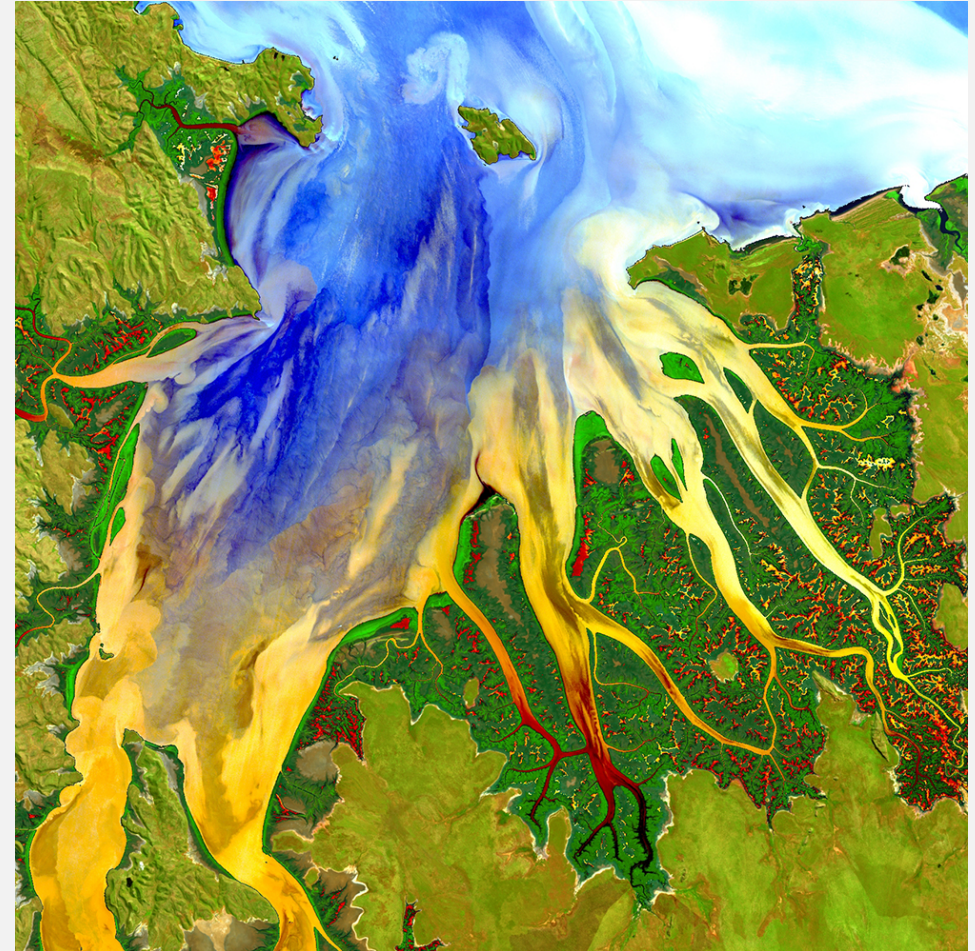
 @NASAARSET

Fundamentals of Aquatic Remote Sensing

Sherry L. Palacios, Ph.D.

Course Objective

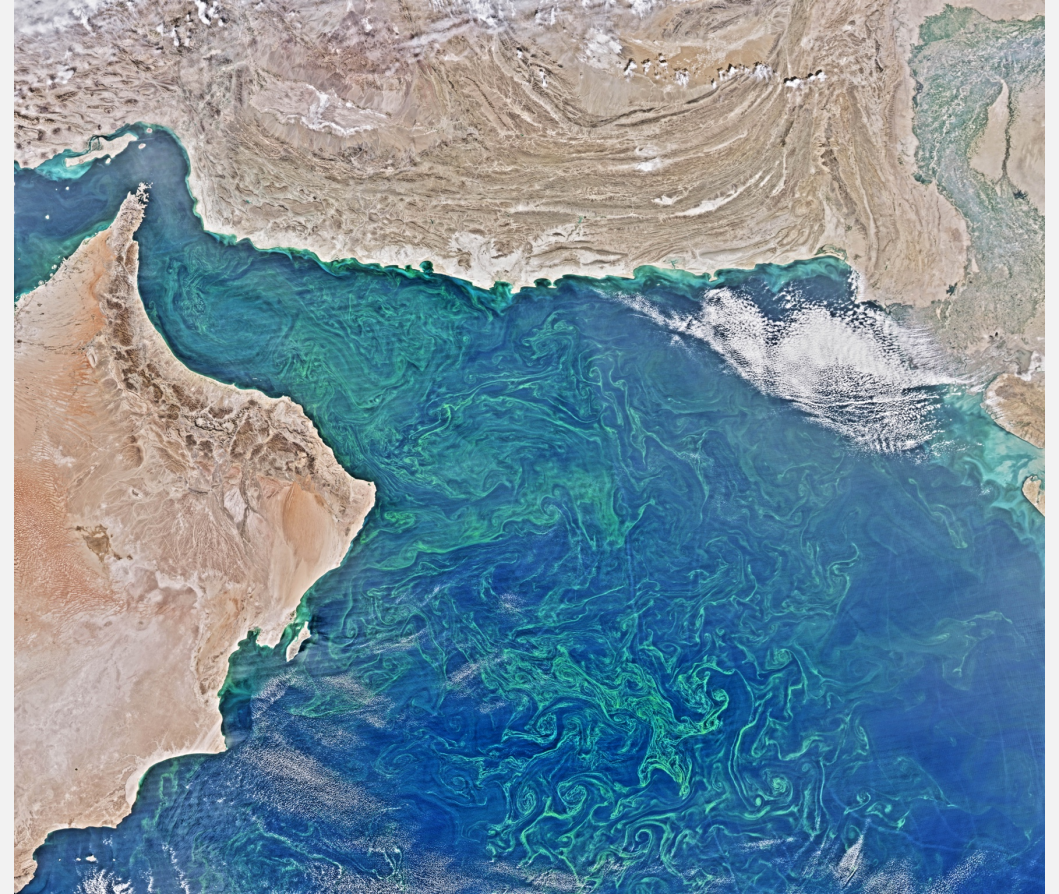
- Provide an overview of aquatic optics, the remote sensing of water targets, and NASA Earth observation resources available for aquatic applications.



Credit: NASA/USGS Landsat; Geoscience Australis

Agenda

- Light and Water
- Fundamentals of Remote Sensing
- Aquatic Remote Sensing Data Products and Their Uses
- Accessing NASA Satellite Imagery
- NASA Satellite Data Processing Tools

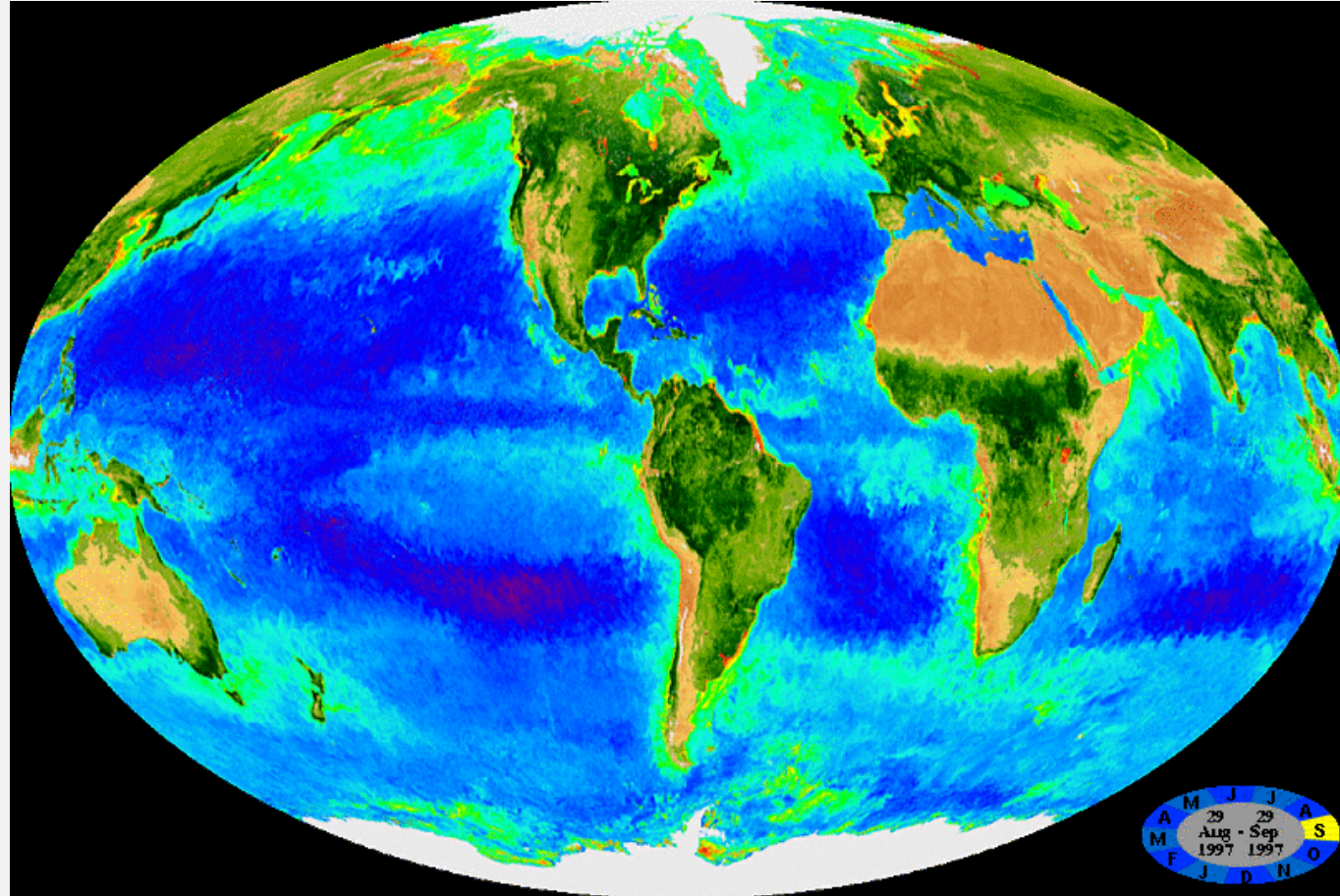


Phytoplankton Bloom in the Arabian Sea

Credit: N. Kuring, <http://earthobservatory.nasa.gov/IOTD/view.php?id=85718>

Why Do We Observe from Space?

To Understand Earth's Processes on a Global Scale



SeaWiFS Chlorophyll
Credit: OBPG, NASA Goddard

Advantages of Remote Sensing of Aquatic Environments

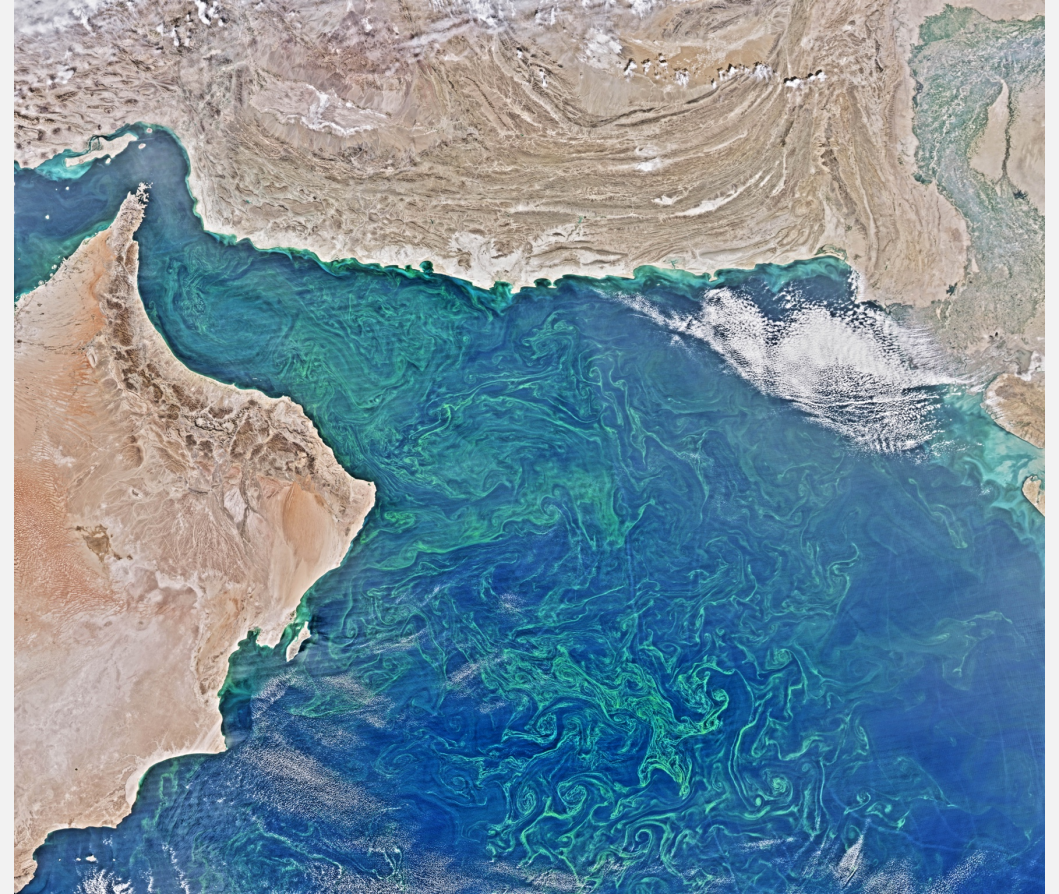
- Synoptic coverage
- Temporal frequency needed to capture dynamic aquatic processes
- Observations of remote ocean locations, infrequently accessed by sea-based platforms

An aerial photograph of a coastal region. A river with a light-colored, sandy delta flows into the sea. The water near the shore is a vibrant turquoise, while the deeper ocean is a dark blue. The land is green with some brown patches, possibly indicating a forest or agricultural area. A semi-transparent white rectangle is overlaid on the image, containing the text 'Light and Water' and a horizontal line.

Light and Water

Agenda

- Light and Water
 - How light propagates through the atmosphere and water column, and back to sensor
 - Constituents of the water column and their inherent optical properties
- Fundamentals of Remote Sensing
- Aquatic Remote Sensing Data Products and Their Uses
- Accessing NASA Satellite Imagery
- NASA Satellite Data Processing Tools

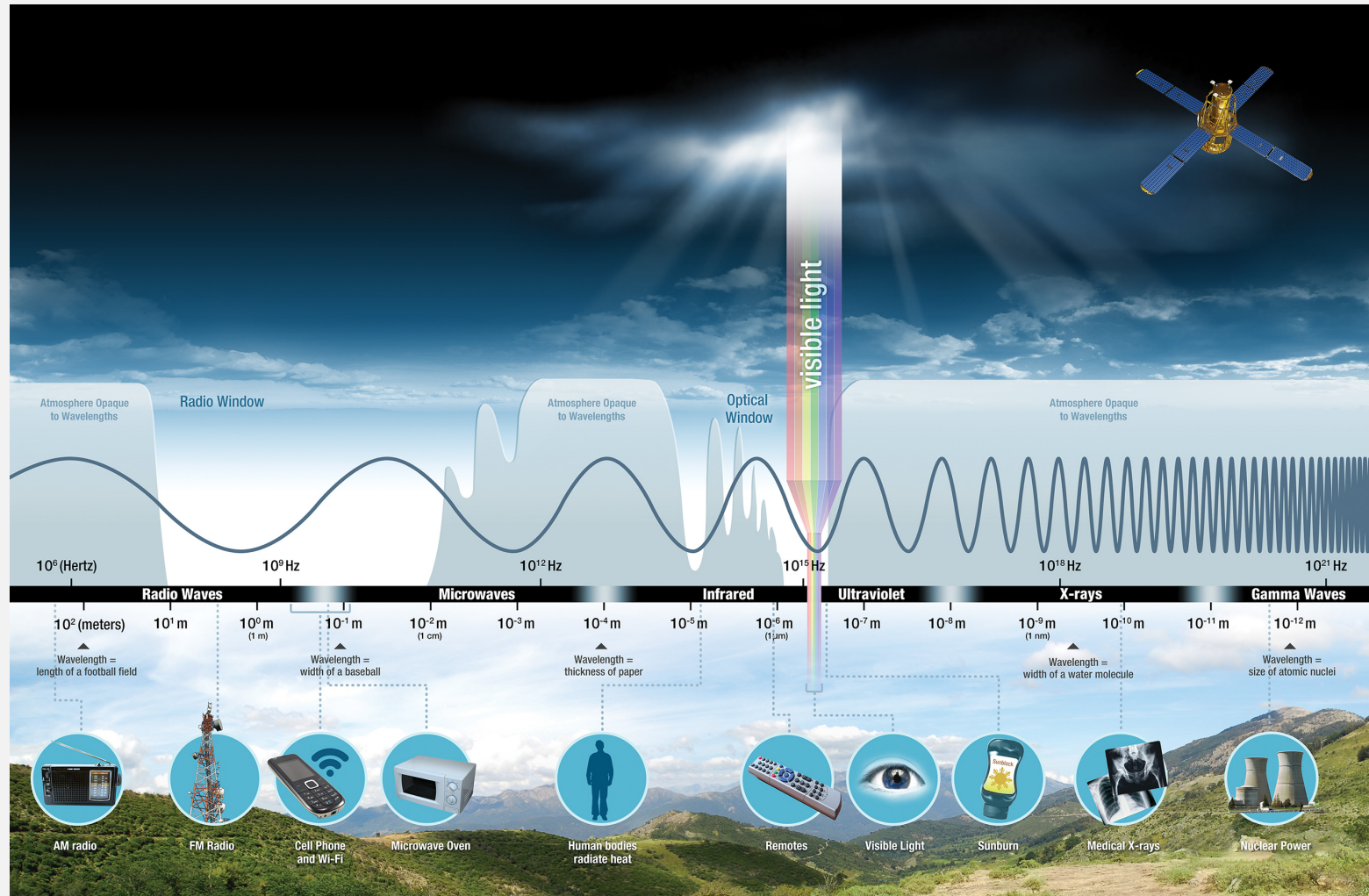


Phytoplankton Bloom in the Arabian Sea

Credit: N. Kuring, <http://earthobservatory.nasa.gov/IOTD/view.php?id=85718>

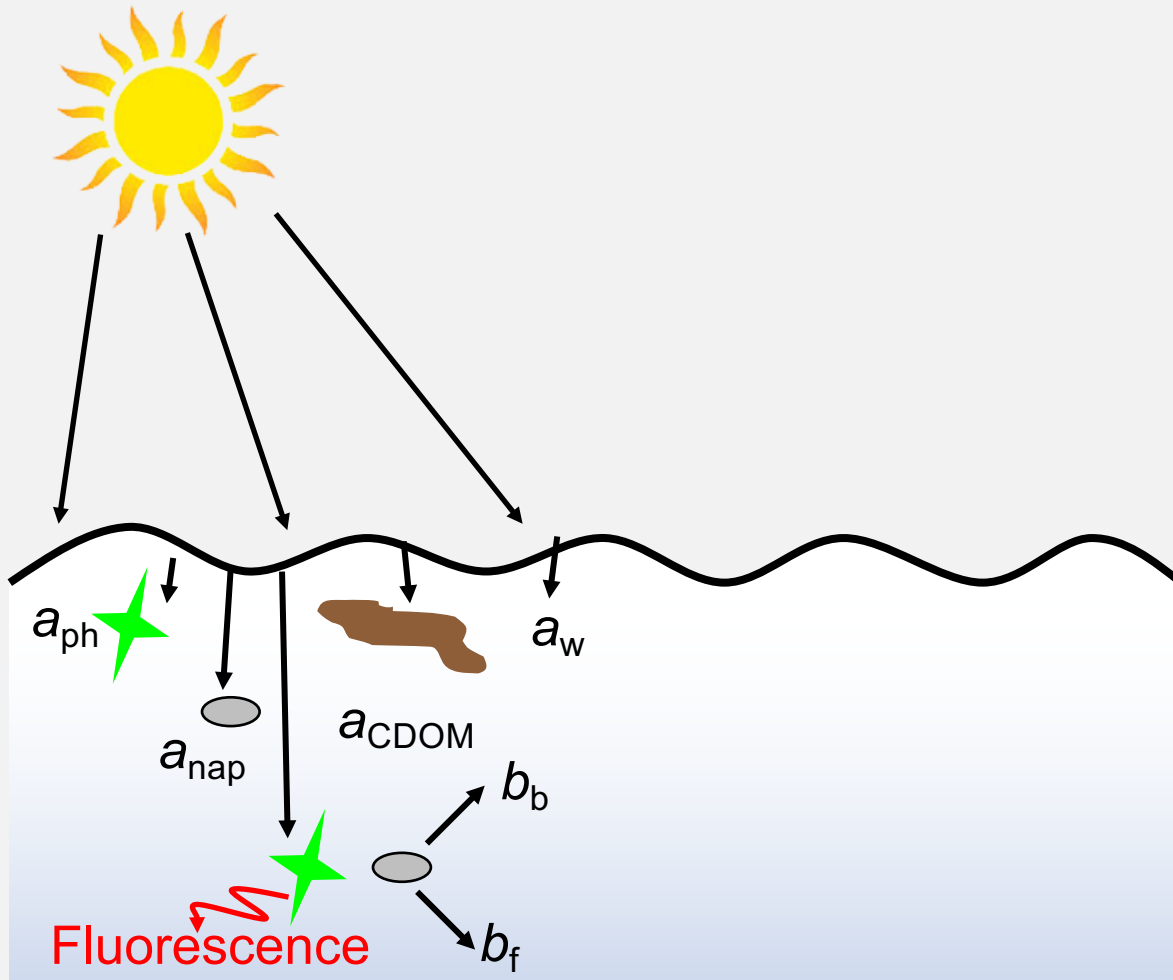
First, an Aquatic Optics Primer...

The Electromagnetic Spectrum



How Light Interacts with Water

Defining Remote Sensing Reflectance (R_{rs}) – or ‘Ocean Color’



$$R_{rs}(\lambda, 0^+) \cong C \frac{b_b(\lambda)}{a(\lambda) + b_b(\lambda)}$$

Inherent Optical Properties

a = absorption by...

phytoplankton (ph)

non-algal particles (nap)

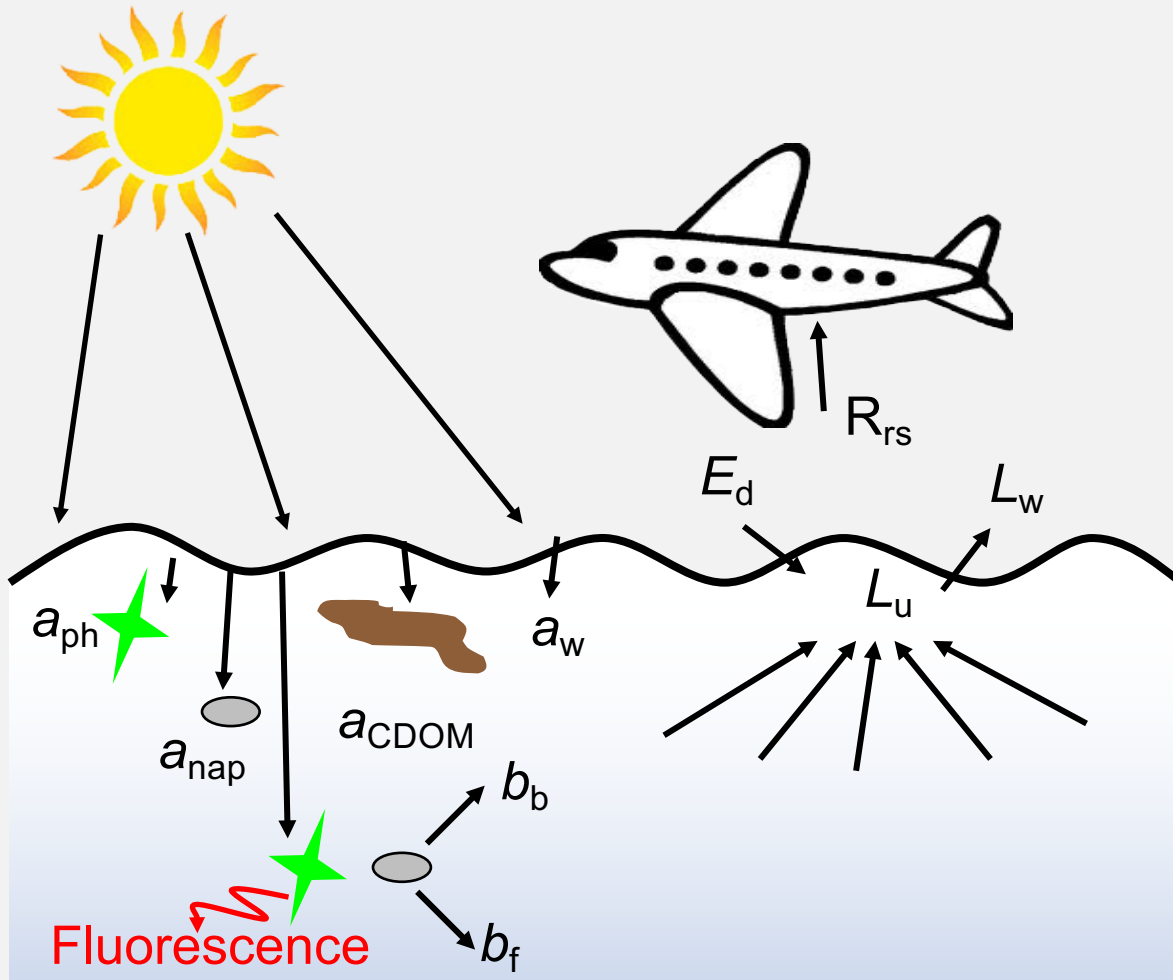
colored dissolved organic matter (CDOM)

water (w)

b = scattering in forward (f) and backward (b) directions

How Light Interacts with Water

Defining Remote Sensing Reflectance (R_{rs}) – or ‘Ocean Color’



$$R_{rs}(\lambda, 0^+) \cong C \frac{b_b(\lambda)}{a(\lambda) + b_b(\lambda)} = \frac{L_w(\lambda)}{E_d(\lambda, 0^+)}$$

Inherent Optical Properties

a = absorption

b = scattering

Apparent Optical Properties

L_w = water leaving radiance

L_u = upwelling radiance

E_d = downwelling irradiance

R_{rs} = remote sensing (rs) reflectance

Inherent Optical Properties (IOPs) and the 'Color' of Water

$$R_{rs}(\lambda, 0^+) \cong C \frac{b_b(\lambda)}{a(\lambda) + b_b(\lambda)}$$

Light absorption (a) by phytoplankton (ph), non-algal particles (nap), water (w), and colored dissolved organic matter (CDOM)

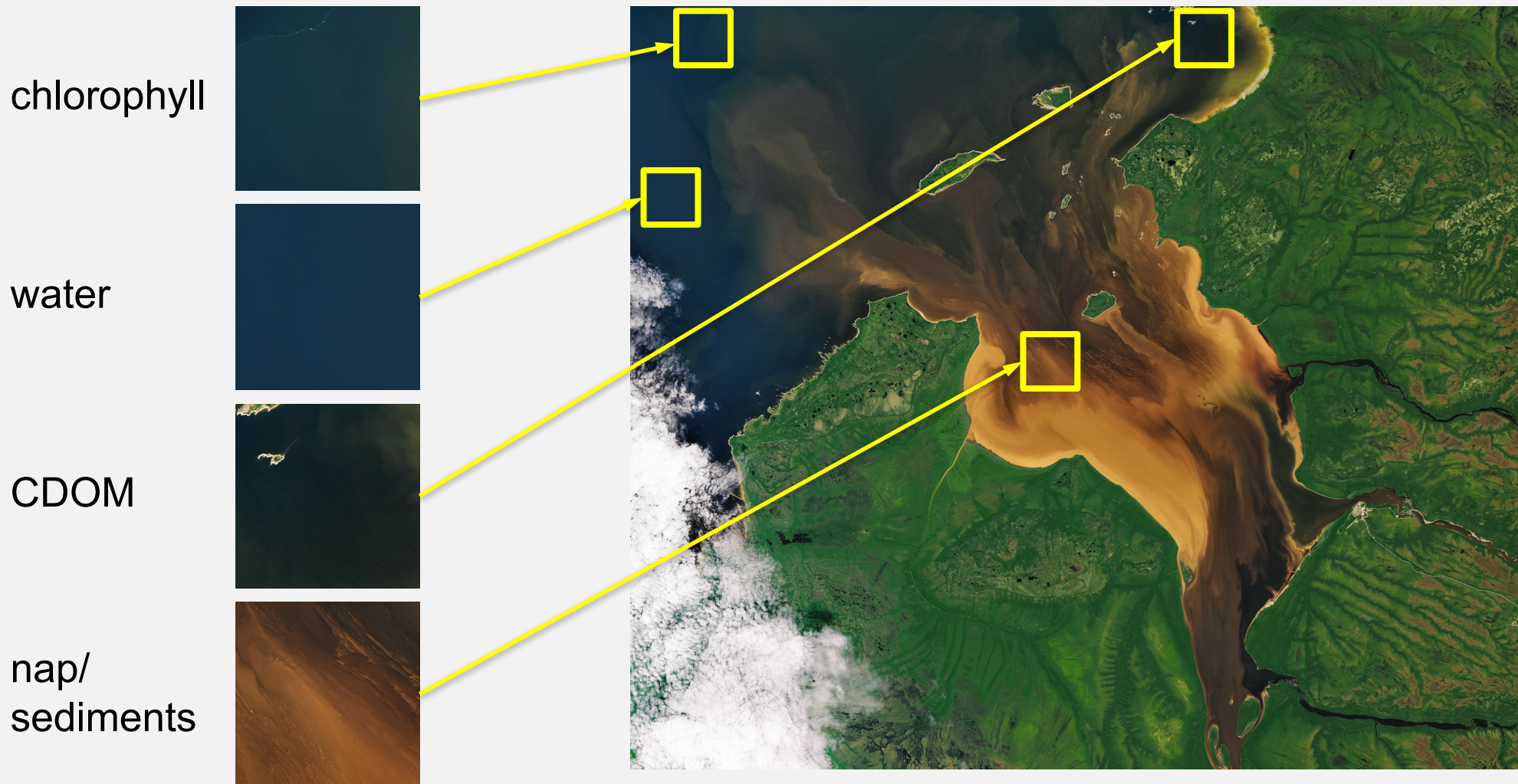
$$a = a_{ph} + a_{nap} + a_{CDOM} + a_w$$

Light scattering (b) by particles in forward (b_f) and backward (b_b) direction

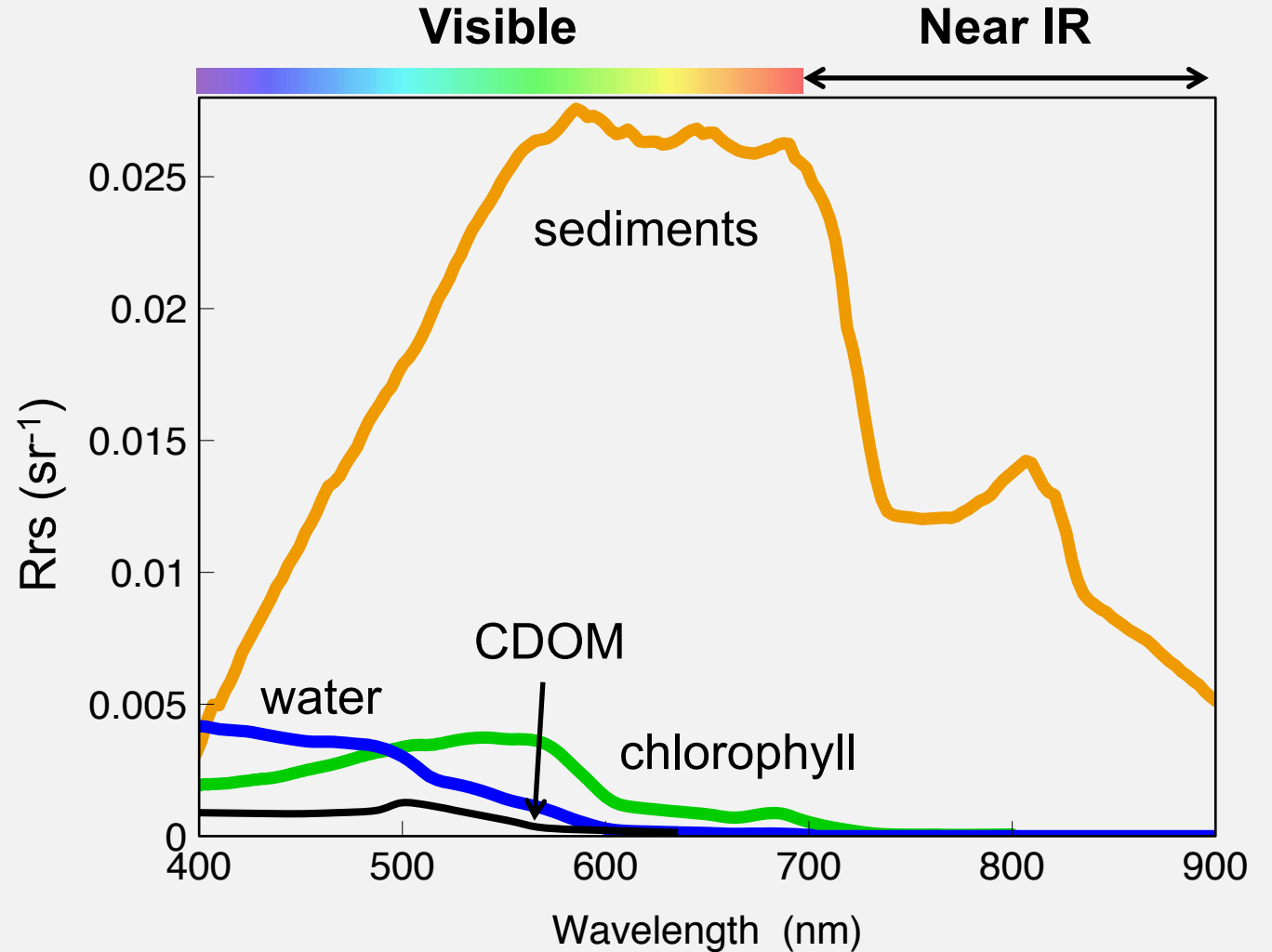
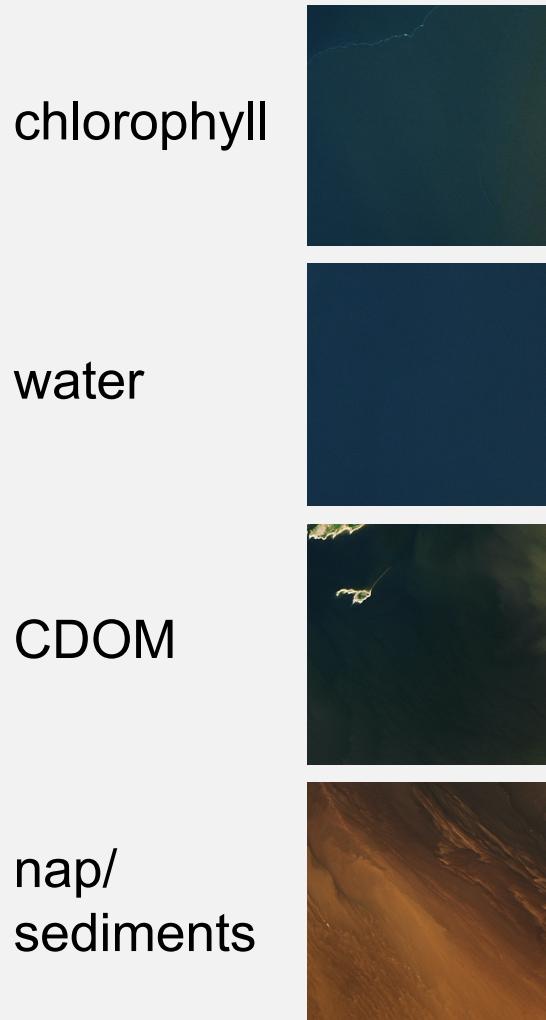
$$b = b_f + b_b$$



Inherent Optical Properties (IOPs) and the 'Color' of Water

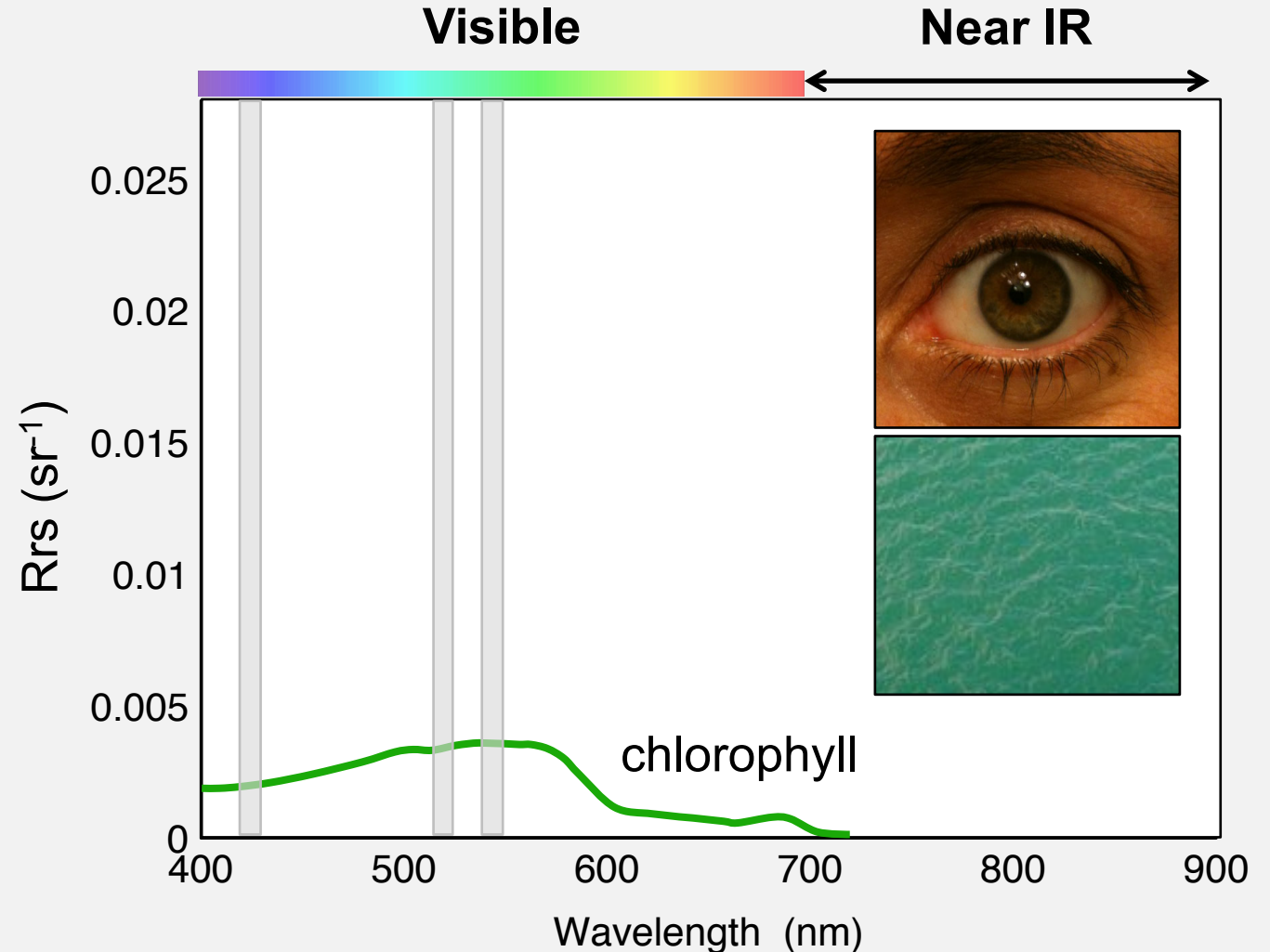


Inherent Optical Properties (IOPs) and the 'Color' of Water



Inherent Optical Properties (IOPs) and the 'Color' of Water

- The typical human eye has color-detecting receptors that sense light at:
 - 420-440 nm 'blue'
 - 534-555 nm 'green'
 - 564-580 nm 'red'
- Water with high chlorophyll content looks green because it reflects strongly in the green part of the spectrum

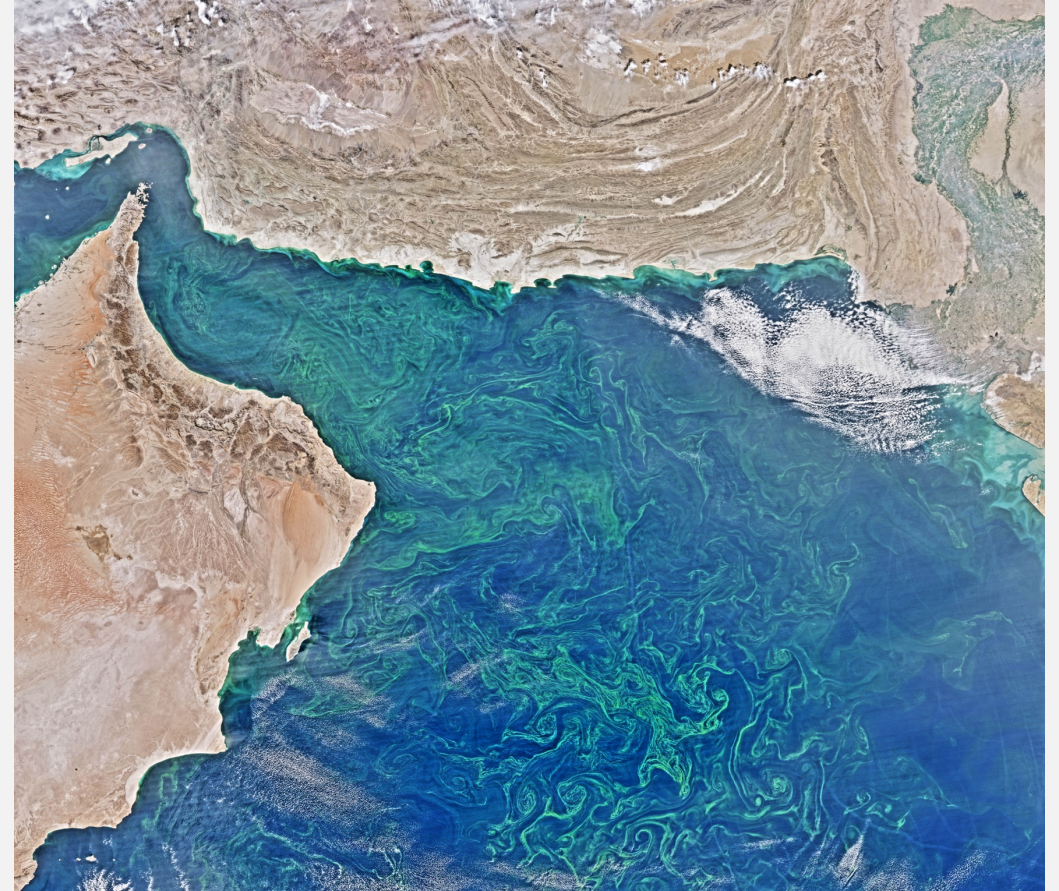


An aerial photograph showing a river delta with multiple channels flowing into a body of water. The land is green and brown, while the water is a mix of turquoise and deep blue. A semi-transparent white rectangular box is overlaid on the right side of the image, containing the title text.

Fundamentals of Remote Sensing

Agenda

- Light and Water
- Fundamentals of Remote Sensing
 - Spatial, Temporal, Spectral Resolution
 - NASA Satellites and Sensors for Aquatic Applications
 - Image “Correction”
 - Satellite Data Processing Levels
- Aquatic Remote Sensing Data Products and Their Uses
- Accessing NASA Satellite Imagery
- NASA Satellite Data Processing Tools



Phytoplankton Bloom in the Arabian Sea

Credit: N. Kuring, <http://earthobservatory.nasa.gov/IOTD/view.php?id=85718>

Types of Resolution

Spatial Resolution

- Decided by its pixel size
- Pixel: smallest unit measured by a sensor

Temporal Resolution

- How frequently a satellite observes the same area of the Earth

Spectral Resolution

- Ability of a sensor to define fine wavelength intervals
- Finer spectral channels enable remote sensing of different parts of the atmosphere

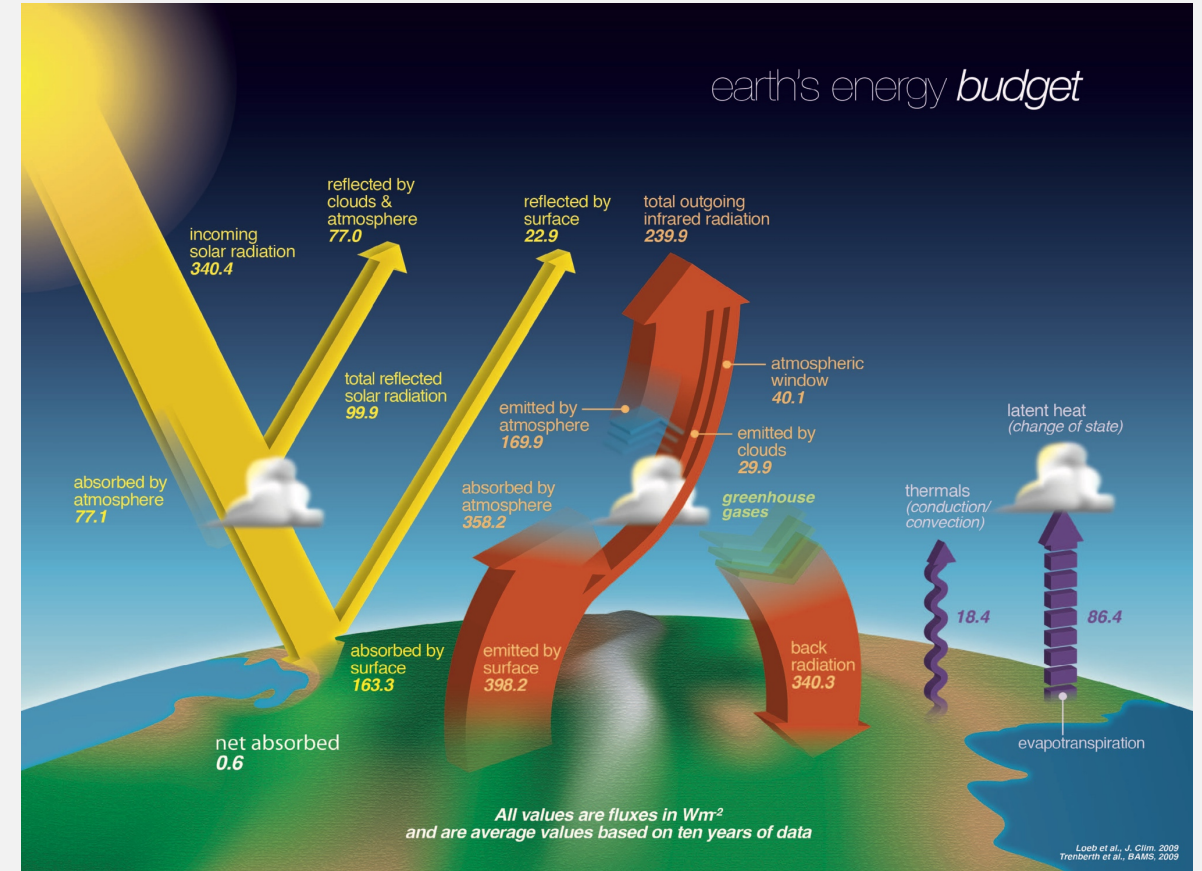
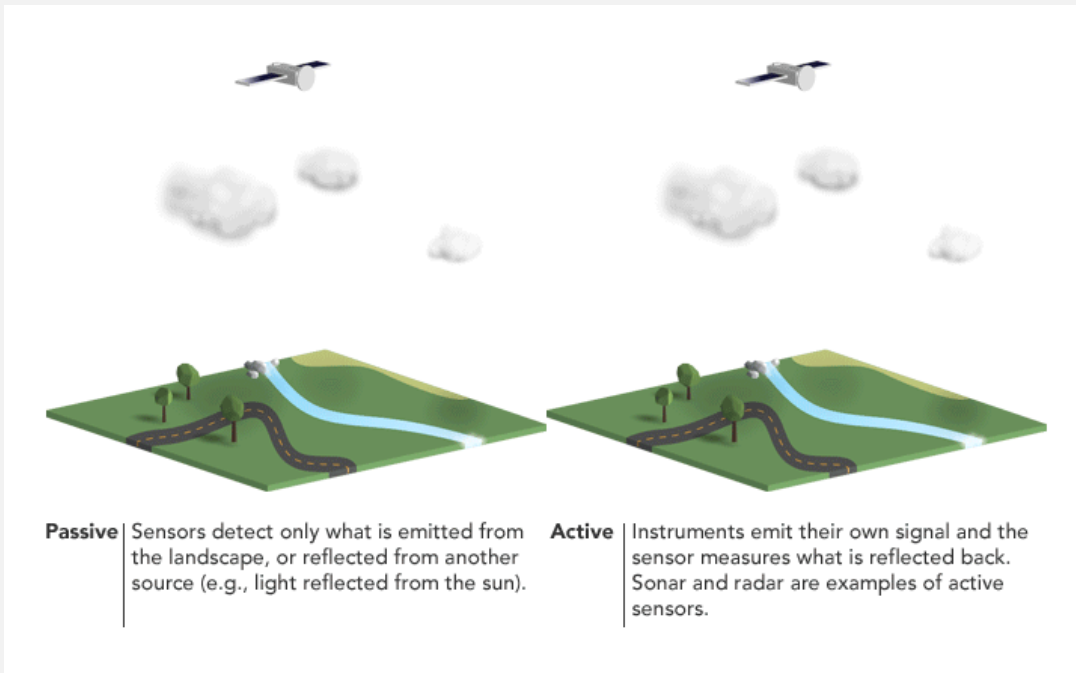
*Credit: Natural Resources Canada

Satellite (Sensor)	Spatial Resolution	Temporal Resolution	Spectral Bands
Landsat 8 (OLI)	15 m, 30 m	16 day revisit	9 bands (blue-green, green, red, near IR, shortwave and thermal IR)
Terra, Aqua (MODIS)	250 m – 1 km	2 times per day	36 bands (red, blue, IR, NIR, MIR)

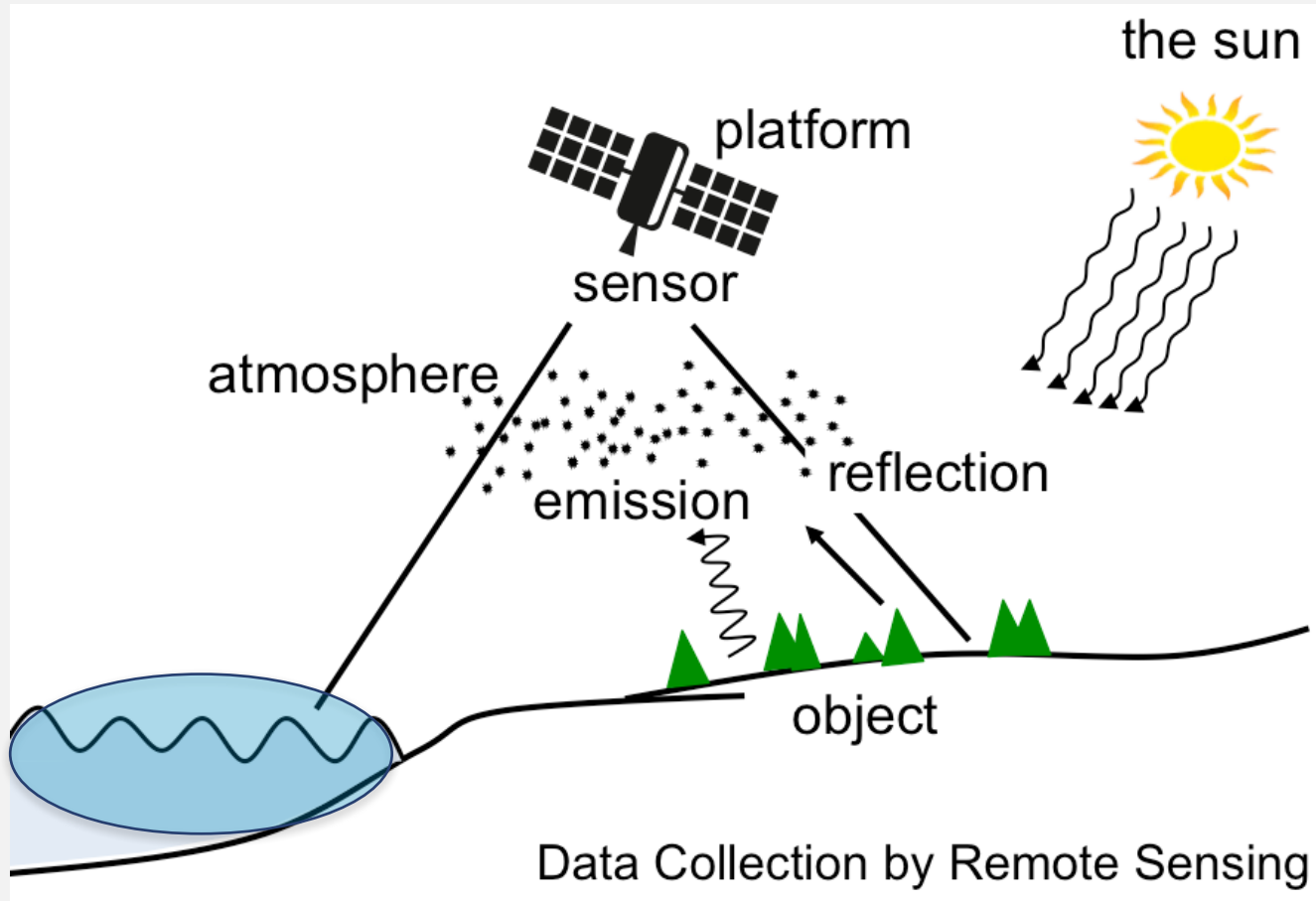
How Do We Observe From Space?

Overview of Active & Passive Remote Sensing

- Satellites carry instruments and sensors to measure:
 - reflected solar radiation
 - emitted infrared and microwave radiation



Data Collection by Satellites



Atmosphere

- Clouds
- Aerosols
- Gases

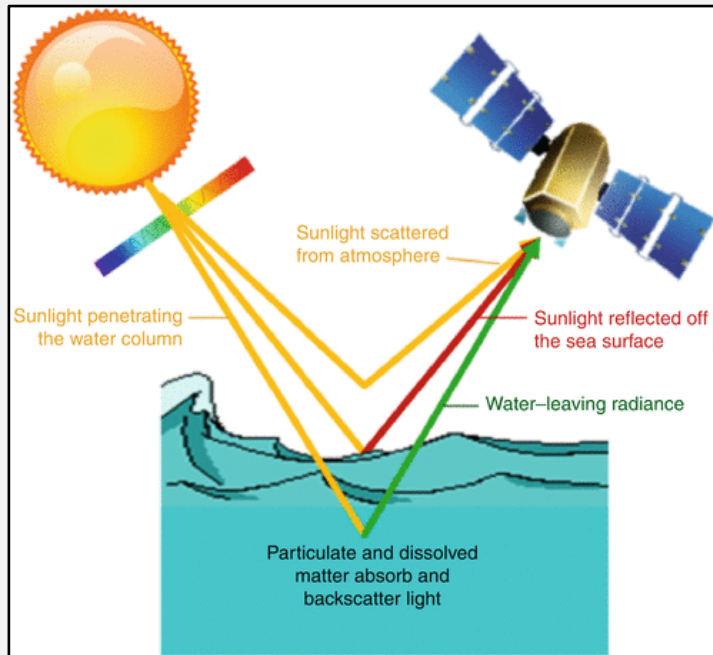
Earth's Surface

- Snow/Ice
- Land (land use, vegetation)
- **Water**

Remote Sensing of Water Bodies

Reflected Solar Radiation (~color of water)

- Measured by satellite sensors
- Used to derive the properties of optically-active water constituents



- Suspended Sediments
- Algae
- Colored Dissolved Organic Matter
- Detrital Organic Matter
- Submerged or floating vegetation
- Oil

- Contaminants
- Pathogens

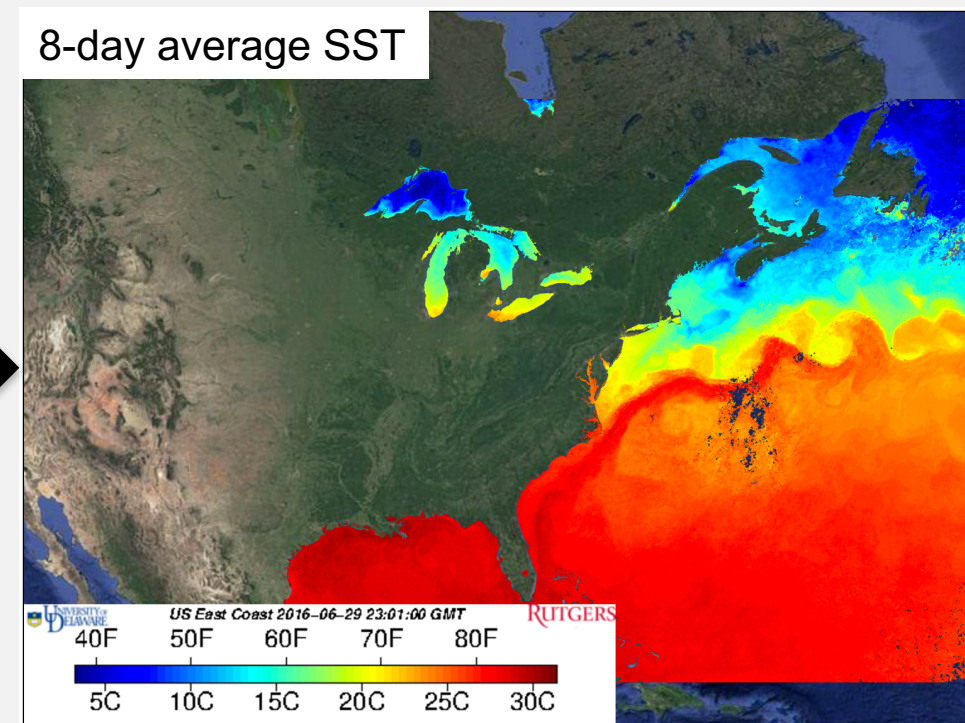
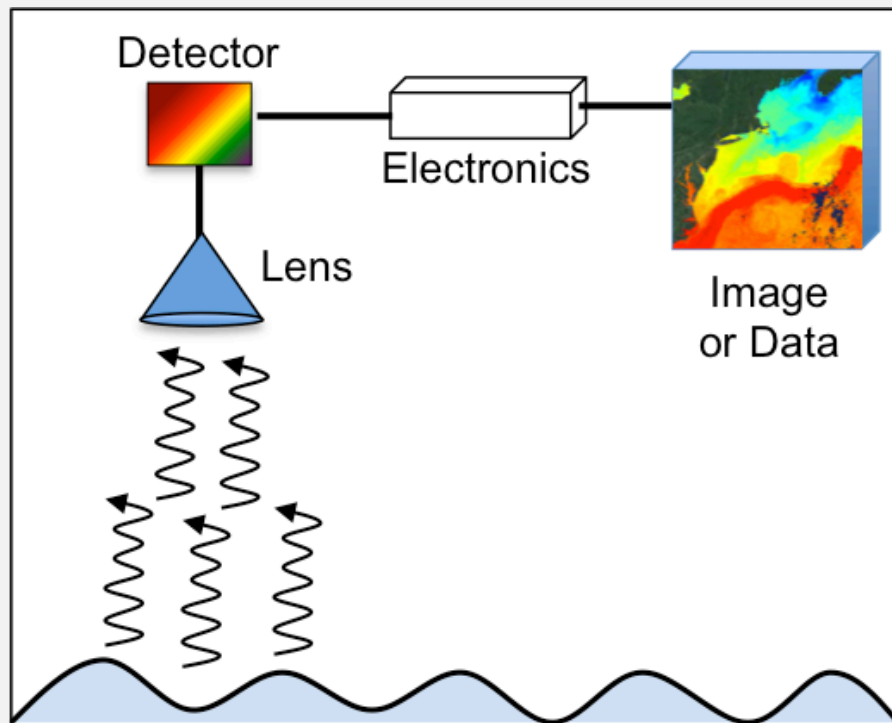


Coccolithophore Bloom, Norway

Remote Sensing of Water Bodies

Emitted Thermal Radiation

- Used to derive the surface temperature of water bodies



MARACOOS, ORB Lab, courtesy M. Oliver

An aerial satellite-style photograph showing a river delta with multiple channels flowing into a large body of water. The land is green and brown, while the water is a mix of light blue and dark blue. A semi-transparent white box is overlaid on the image, containing the title text.

NASA Satellites and Sensors for Aquatic Applications

Overview of NASA Satellites & Sensors for Water Quality Monitoring

- Currently several satellites observe water surface properties in:
 - the open ocean
 - coastal oceans and estuaries
 - many inland lakes
- A number of water quality parameters are operationally available from these satellites
 - e.g. temperature, chlorophyll-a



NASA Satellites & Sensors for Ocean and Coastal Systems

Satellite	Sensor	Parameter
Landsat Series (7/1972 - present)	<ul style="list-style-type: none"> • Thematic Mapper (TM) • Enhanced Thematic Mapper (ETM+) • Operational Land Imager (OLI) 	<ul style="list-style-type: none"> • Spectral Reflectance
Terra (12/1999 - present)	Moderate Resolution Imaging Spectroradiometer (MODIS)	<ul style="list-style-type: none"> • Spectral Reflectance • Chlorophyll-a Concentration • Temperature • Colored Dissolved Organic Matter (CDOM) • Turbidity • Euphotic Depth
Aqua (5/2002 - present)		
Terra (12/1999 – present)	Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	<ul style="list-style-type: none"> • Spectral Reflectance • Temperature

NASA Satellites & Sensors for Ocean and Coastal Systems

Satellite	Sensor	Parameter
National Polar Partnership (NPP) (11/2011-present)	Visible Infrared Imaging Radiometer Suite (VIIRS)	<ul style="list-style-type: none"> • Spectral Reflectance • Chlorophyll Concentration
International Space Station	Hyperspectral Imager for the Coastal Ocean (HICO) (2009 – 2014)	<ul style="list-style-type: none"> • Spectral Radiance • Spectral Remote Sensing Reflectance
Plankton, Aerosols, Clouds, ocean Ecosystems (PACE) (proposed for 2022 or 2023)	Ocean Color Instrument	<ul style="list-style-type: none"> • Spectral Reflectance • Optional Polarimeter being considered

Landsat Satellites and Sensors

<http://landsat.gsfc.nasa.gov/>

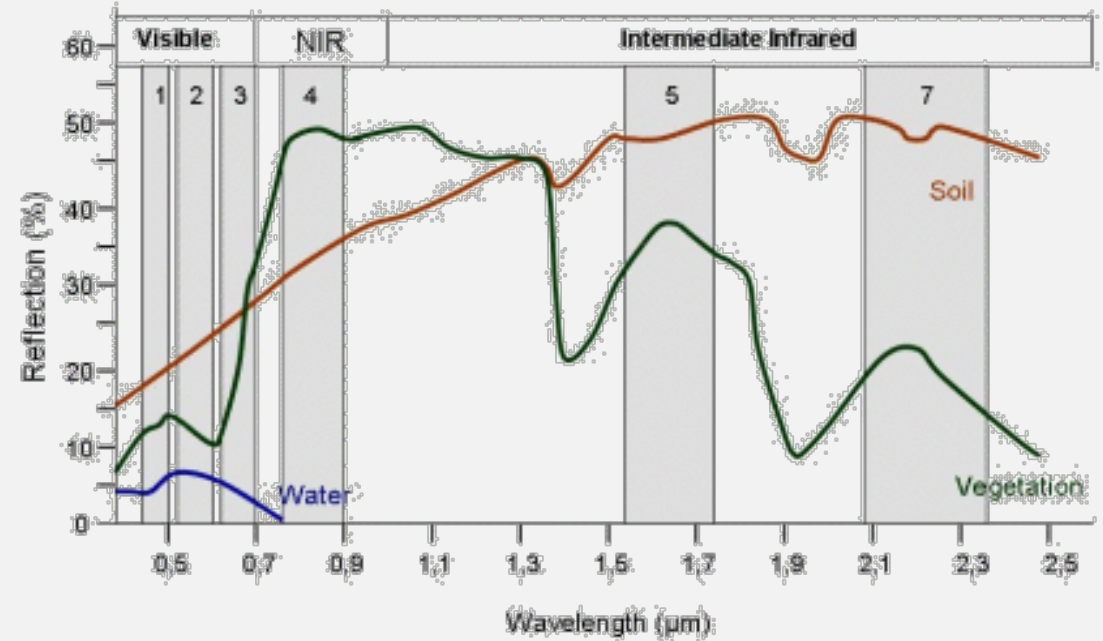
- Near-polar orbit
- 10 a.m. equator crossing time
- Global coverage
- July 1972 – present
- 16 day revisit time
- Sensors:
 - MSS
 - TM
 - ETM+
 - OLI
 - TIRS



Landsat-7 Enhanced Thematic Mapper (ETM+)

<http://geo.arc.nasa.gov/sge/landsat/l7.html>

- Flying on-board Landsat 7 polar orbiting satellites
- Spatial Coverage and Resolution:
 - Global, swath 185 km
 - Spatial Resolution: 15 m, 30 m, 60 m
- Temporal Coverage and Resolution
 - April 15, 1999 – present
 - 16 day revisit time
- Spectral Bands
 - 8 bands (major bands include: blue-green, green, red, reflected and thermal IR, and panchromatic)

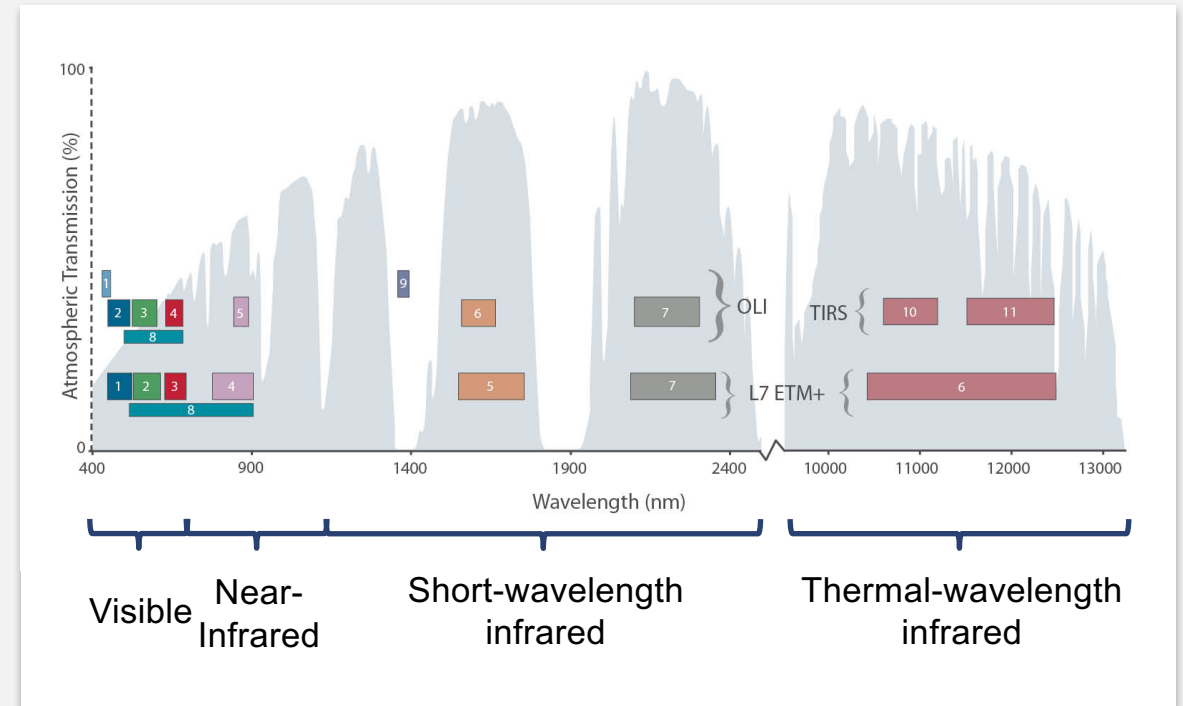


- Spectral Bands
 - Bands 1-5, 7: 30 m
 - Band 6: 60 m
 - Band 8: 15 m

Landsat-8 Operational Land Imager (OLI)

<http://landsat.usgs.gov/landsat8.php>; <http://landsat.gsfc.nasa.gov/?p=5779>

- Flying on-board Landsat 8 (Landsat Data Continuity Mission – LDCM) polar orbiting satellite
- Spatial Coverage & Resolution:
 - Global, Swath 185 km
 - Spatial Resolution: 15 m, 30 m
- Temporal Coverage & Resolution:
 - February 11, 2013 – present
 - 16 day revisit time
- Spectral Bands
 - 9 bands (major bands include blue-green, red, near IR, shortwave and thermal IR, panchromatic)

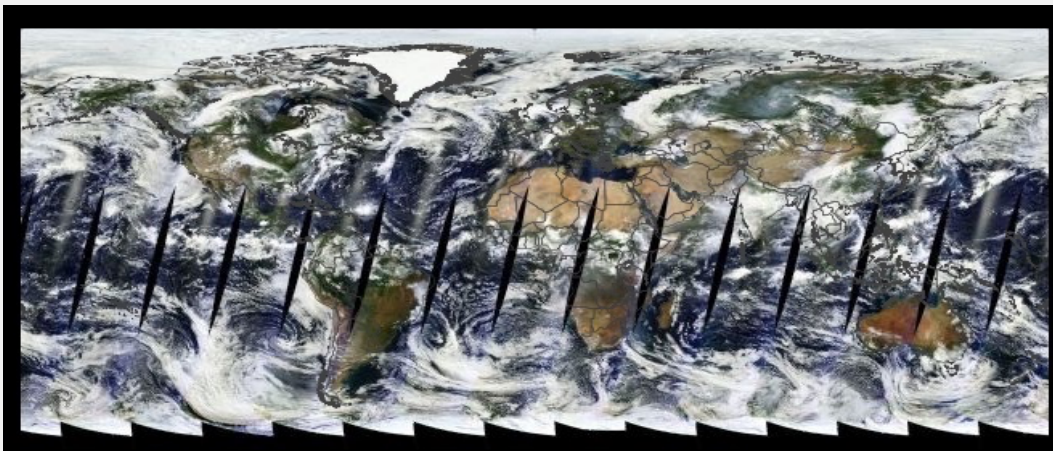


Terra and Aqua

<http://terra.nasa.gov/>; <http://aqua.nasa.gov/>

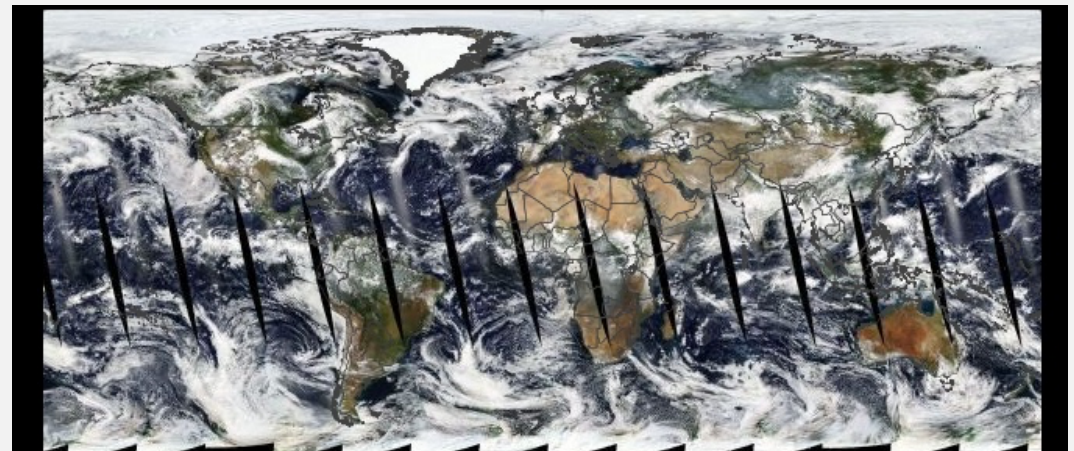
Terra

- Polar orbit, 10:30 a.m. equator crossing time
- Global Coverage
- December 18, 1999 – present
- 1-2 observations per day
- Sensors:
 - ASTER, CERES, MISR, MODIS, MOPITT



Aqua

- Polar orbit, 1:30 p.m. equator crossing time
- Global Coverage
- May 4, 2002 – present
- 1-2 observations per day
- Sensors:
 - AIRS, AMSU, CERES, MODIS, AMSR-E



MODerate Resolution Imaging Spectroradiometer (MODIS)

<http://modis.gsfc.nasa.gov>

- On board Terra and Aqua
- Designed for land, atmosphere, ocean, and cryosphere observations
- Spatial Coverage and Resolution:
 - Global, Swath: 2,330 km
 - Spatial Resolution Varies: 250 m, 500 m, 1 km
- Temporal Coverage and Resolution:
 - 2000 – present
 - 2 times per day

Spectral Bands

- 36 bands (red, blue, IR, NIR, MIR)
 - Bands 1-2: 250 m
 - Bands 3-7: 500 m
 - Bands 8-16: 1000 m

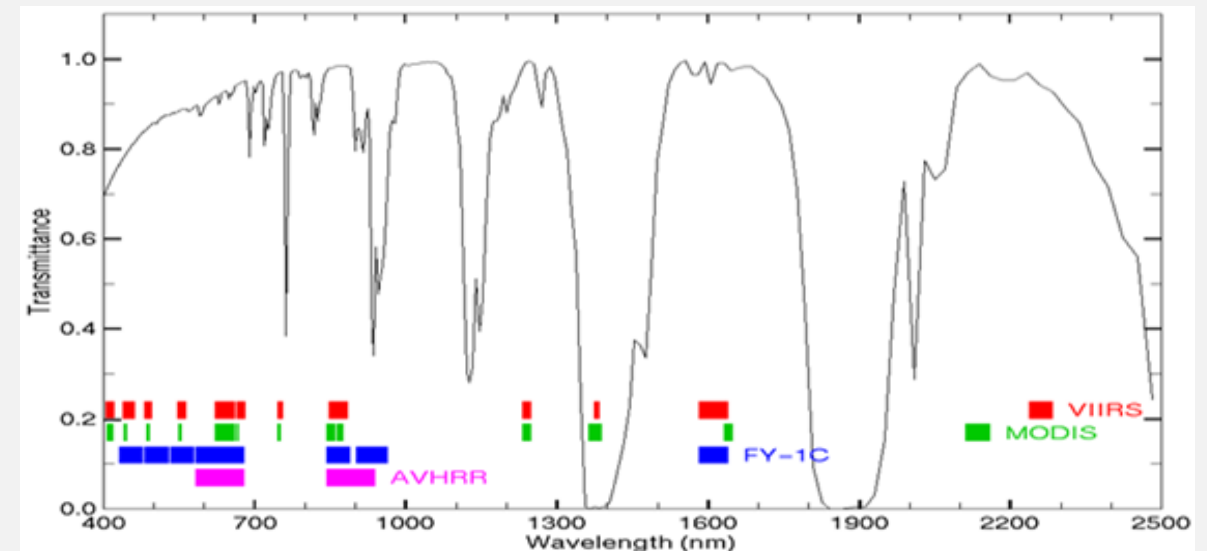
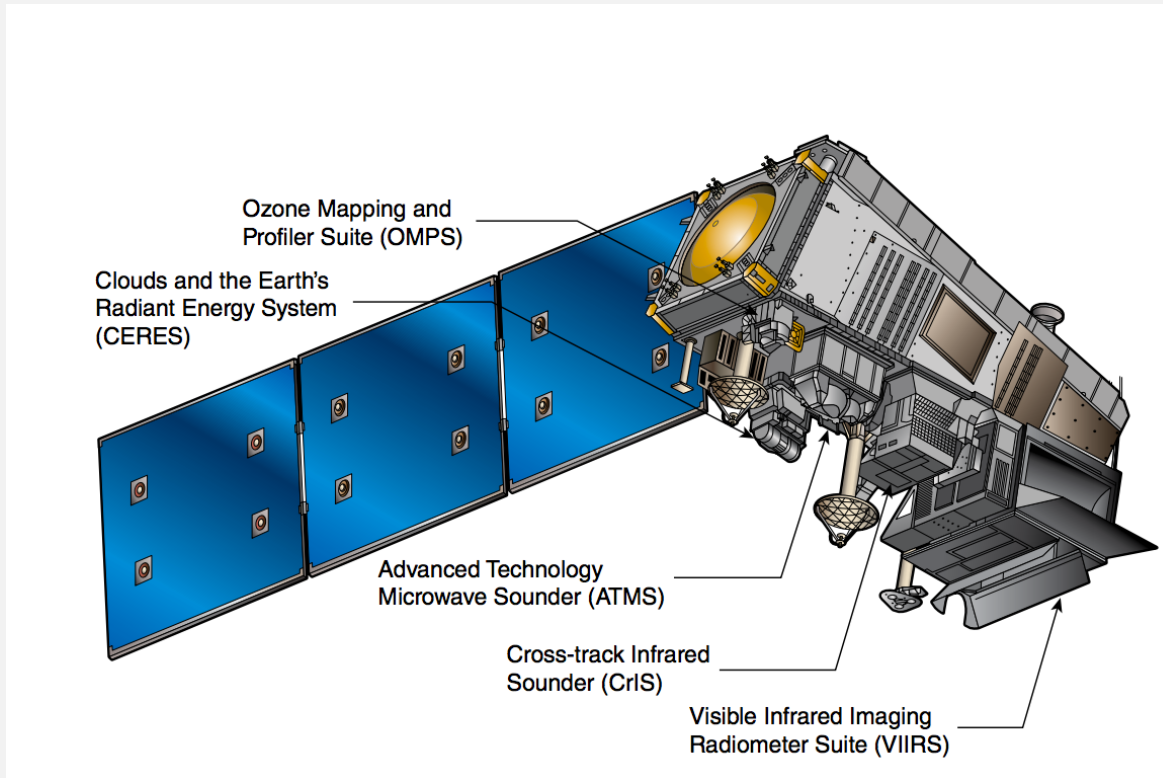


Image Credit: <http://cimss.ssec.wisc.edu/>

National Polar Partnership (NPP)

http://www.nasa.gov/mission_pages/NPP



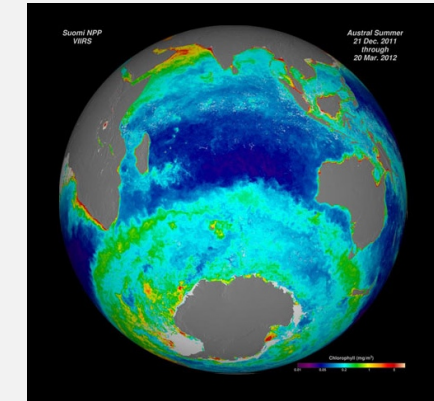
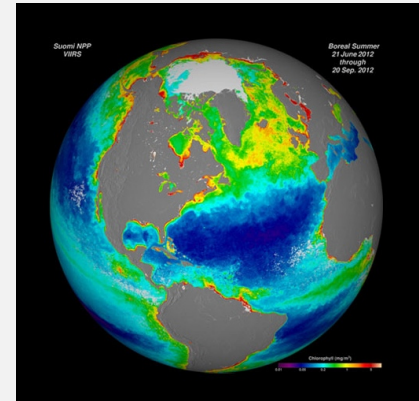
NASA/NOAA

- Polar orbit
- 1:30 p.m. equator crossing time
- Global coverage
- November 21, 2011 – present
- 1-2 observations per day
- Sensors:
 - VIIRS
 - ATMS
 - CrIS
 - OMPS
 - CERES

Visible Infrared Imaging Radiometer Suite (VIIRS)

<http://npp.gsfc.nasa.gov/viirs.html>

- Flying on-board NPP, polar-orbiting satellite
- Designed to collect measurements of clouds, aerosols, ocean color, surface temperature, fires, and albedo
- Spatial Coverage and Resolution:
 - Global, swath width: 3,040 km
 - Spatial resolution: 375 m – 750 m
- Temporal Coverage
 - October 2011 – present
 - 2 times per day

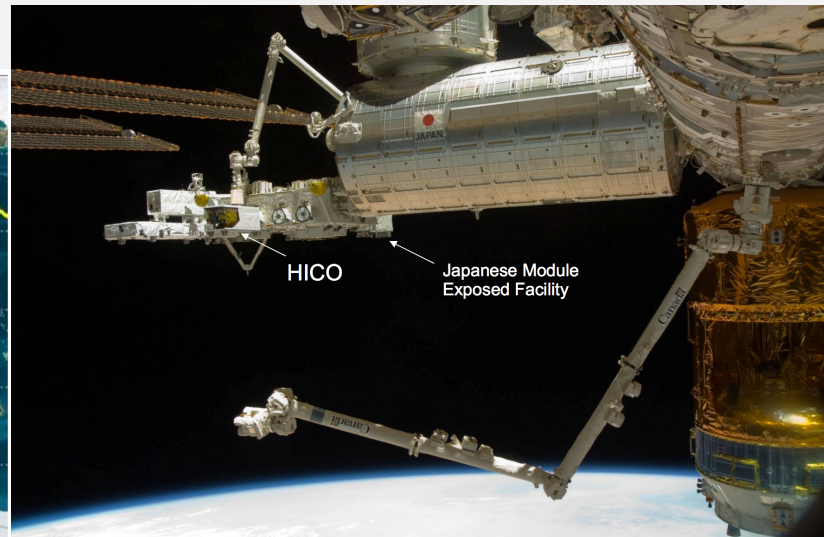


- Spectral Bands
 - 15 bands (major bands include visible, red, blue, green, short, middle, and long-wave IR)
 - Ocean Color Bands 1-7: 0.402 - 0.682 μm
 - Sea Surface Temperature Bands 12-13: 3.660 - 4.128 μm

Hyperspectral Imager for the Coastal Ocean (HICO)

<http://hico.coas.oregonstate.edu/>; <http://oceancolor.gsfc.nasa.gov/cms/data/hico>

- Partnership with U.S. Naval Research Lab, Office of Naval Research, Oregon State University, and NASA
- Active 2009 – 2014 aboard the International Space Station (ISS)
- 380 nm to 960 nm at 5.7 nm spectral resolution
- 90 m² spatial resolution
- Targeted data collection



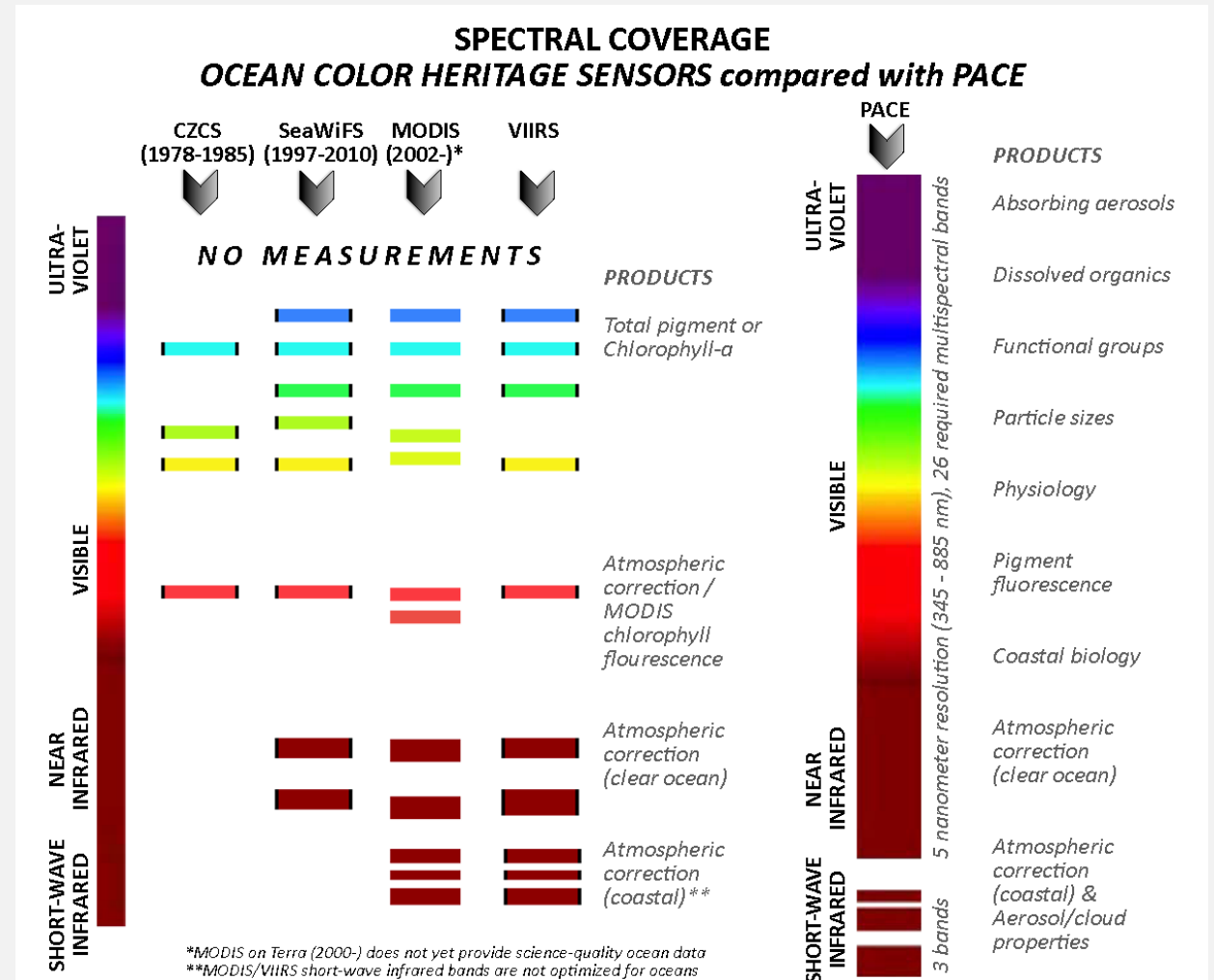
Davis, C. O. (n.d.). *The Hyperspectral Imager for the Coastal Ocean (HICO): Sensor and Data Processing Overview* [PDF]. International Ocean Colour Coordinating Group.

Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE)

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



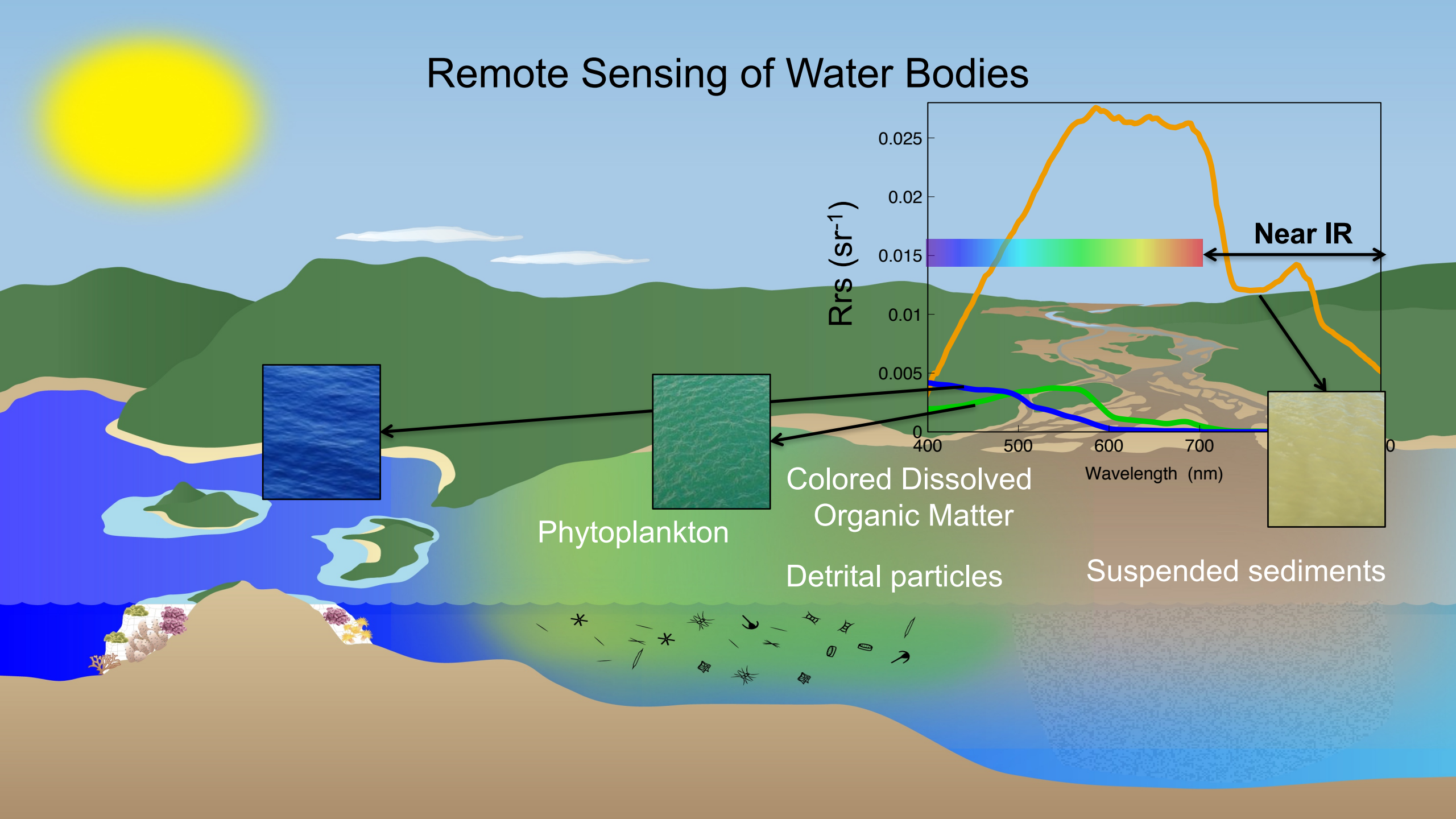
- Polar orbiting, 2-day revisit
- High spectral resolution
- 1 km ground sample distance
- Optional polarimeter being considered for cloud and aerosol study and to aid in atmospheric correction
- Anticipated launch 2022



An aerial photograph of a coastal region. A river with a light-colored, sandy delta flows into the sea from the top left. The coastline is visible, with a mix of green land and blue water. A semi-transparent white rectangular box is overlaid on the right side of the image, containing the text 'Image "Correction"' and a horizontal line below it.

Image "Correction"

Remote Sensing of Water Bodies



R_{rs} (sr^{-1})

Near IR

Colored Dissolved Organic Matter

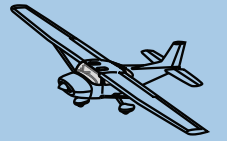
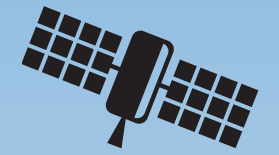
Phytoplankton

Detrital particles

Suspended sediments

Wavelength (nm)

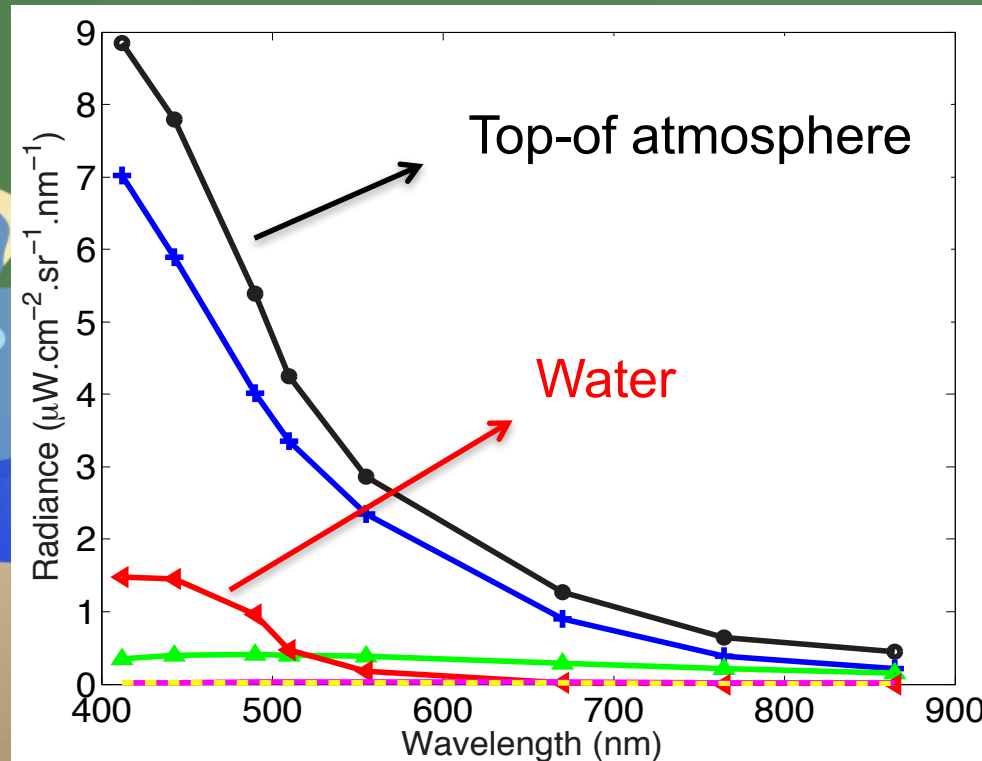
Atmospheric Correction



$$L_t(\lambda) = L_r(\lambda) + L_a(\lambda) + L_{ra}(\lambda) + T(\lambda, \theta)L_g(\lambda) + t(\lambda, \theta)L_{wc}(\lambda) + t(\lambda, \theta)L_w(\lambda)$$

>90%

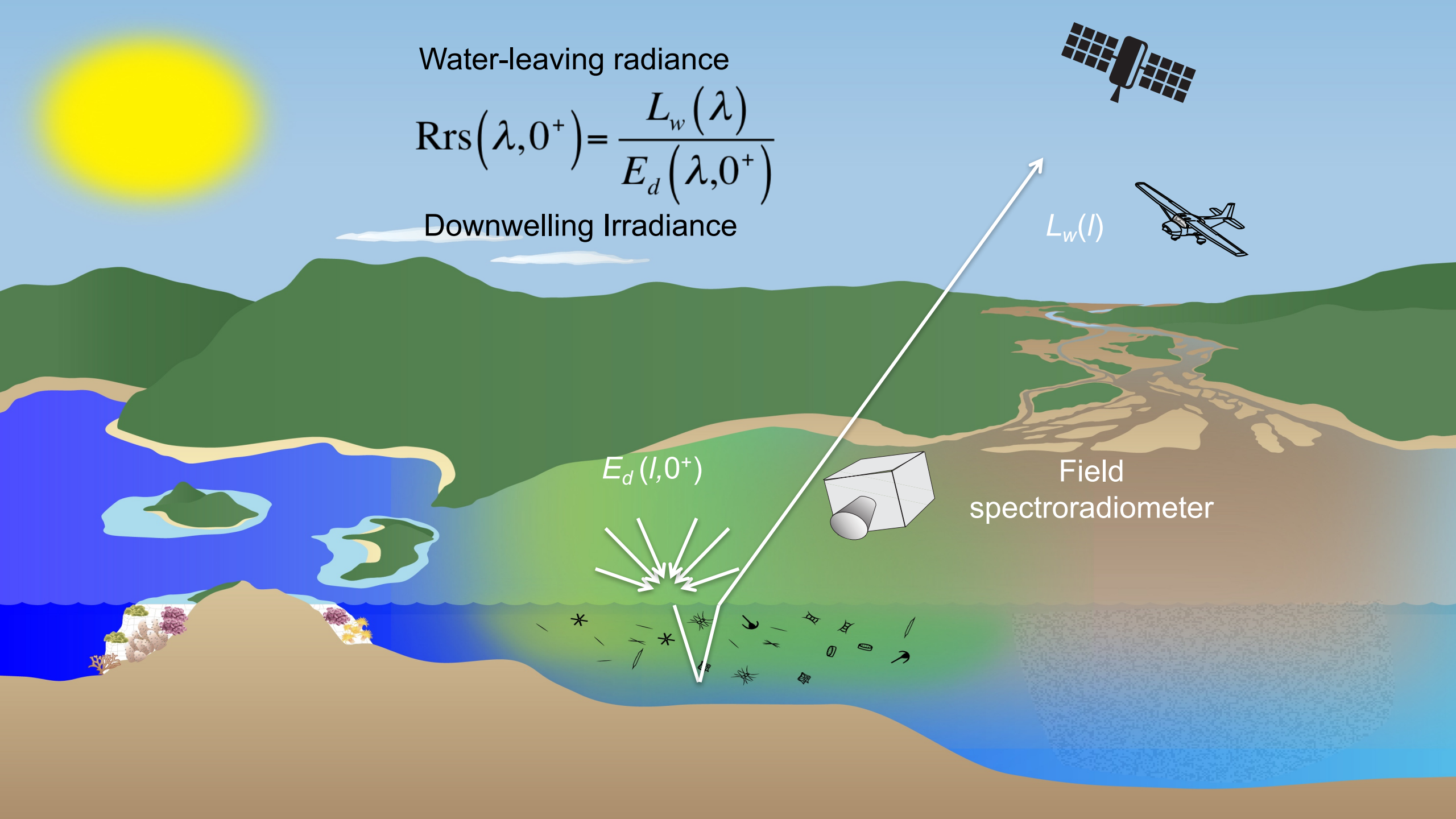
<10%



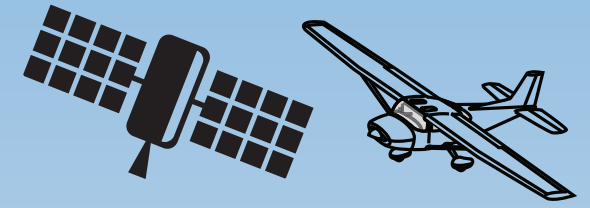
Water-leaving radiance

$$R_{rs}(\lambda, 0^+) = \frac{L_w(\lambda)}{E_d(\lambda, 0^+)}$$

Downwelling Irradiance



Atmospheric Correction



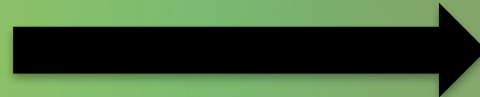
$$L_t(\lambda) = L_r(\lambda) + L_a(\lambda) + L_{ra}(\lambda) + T(\lambda, \theta)L_g(\lambda) + t(\lambda, \theta)L_{wc}(\lambda) + t(\lambda, \theta)L_w(\lambda)$$

>90%

<10%



Atmospheric correction



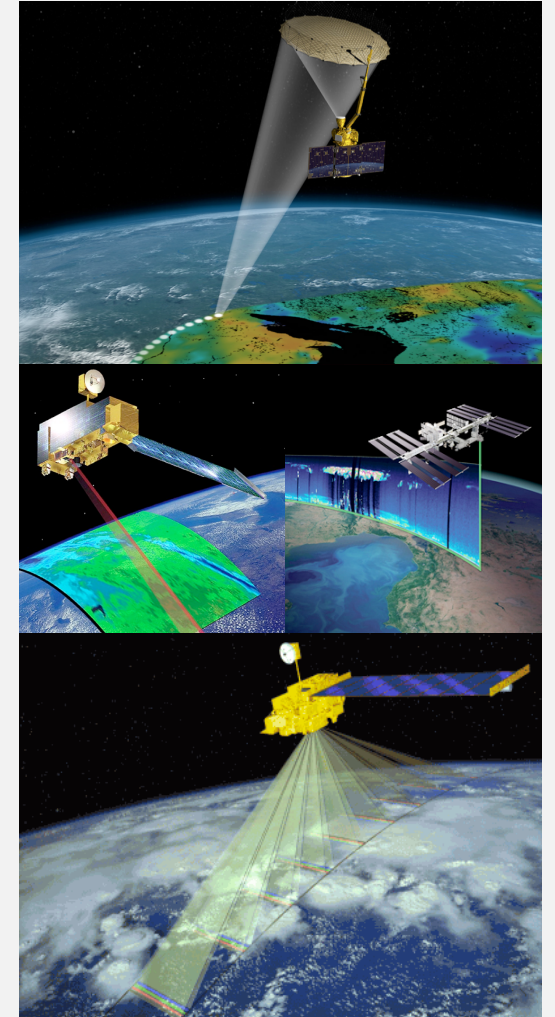
A satellite image of a coastal region. On the left, a river with a light-colored, silty delta flows into the sea. The water near the coast is a vibrant turquoise, transitioning to a deep blue further out. The land is green with some brown patches, possibly indicating agricultural fields or bare earth. A semi-transparent white rectangular box is overlaid on the right side of the image, containing the title text.

Satellite Data Processing Levels

Levels of Data Processing

<http://oceancolor.gsfc.nasa.gov/cms/products>

- Level 0: unprocessed instrument data at full resolution, rawest format available
- Level 1A: reconstructed and unprocessed instrument data at full resolution
- Level 1B: L1A data with instrument/radiometric calibrations applied
- Level 2: Derived geophysical variables at same resolution as L1 data
- Level 3: L2 projected onto a well defined spatial grid over a well-defined time period
- Level 4: model output or results from analyses of lower level data
 - e.g., Primary Productivity



Data Processing Levels

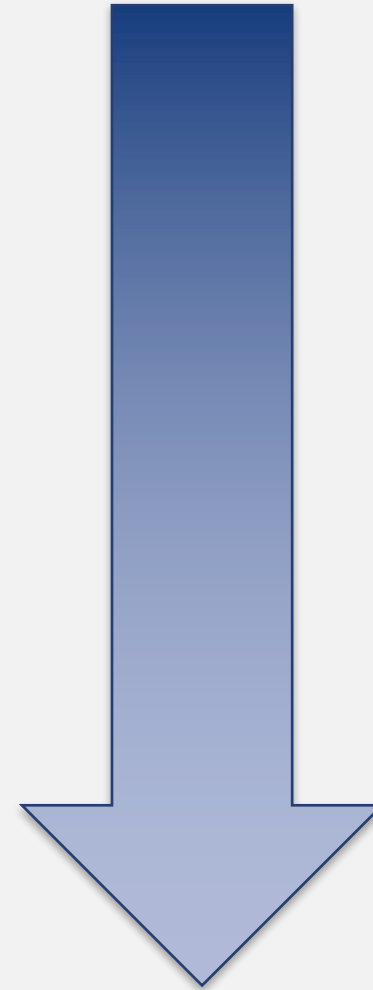
L0: Raw instrument data

L1: Geolocated and calibrated

L2: Products derived from L1B


L3: Gridded and quality controlled

L4: Model output: derived variables



Harder to Use

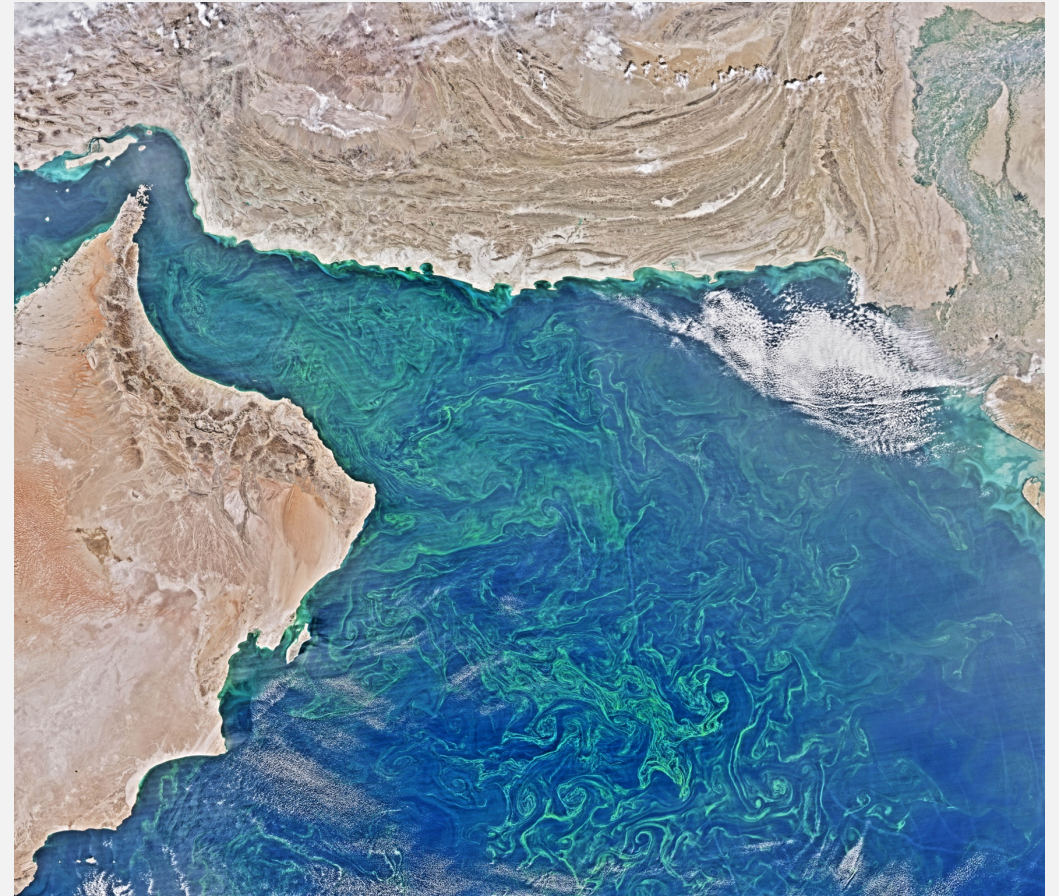
Easier to Use

An aerial photograph of a river delta, likely the Amazon, showing a complex network of channels and a large body of water. A semi-transparent white rectangular box is overlaid on the image, containing the title text. The background shows the river's path through green and brown terrain, meeting a large body of water with varying shades of blue and green.

Aquatic Remote Sensing Data Products and Their Uses

Agenda

- Light and Water
- Fundamentals of Remote Sensing
- Aquatic Remote Sensing Data Products and Their Uses
- Accessing NASA Satellite Imagery
- NASA Satellite Data Processing Tools



Phytoplankton Bloom in the Arabian Sea

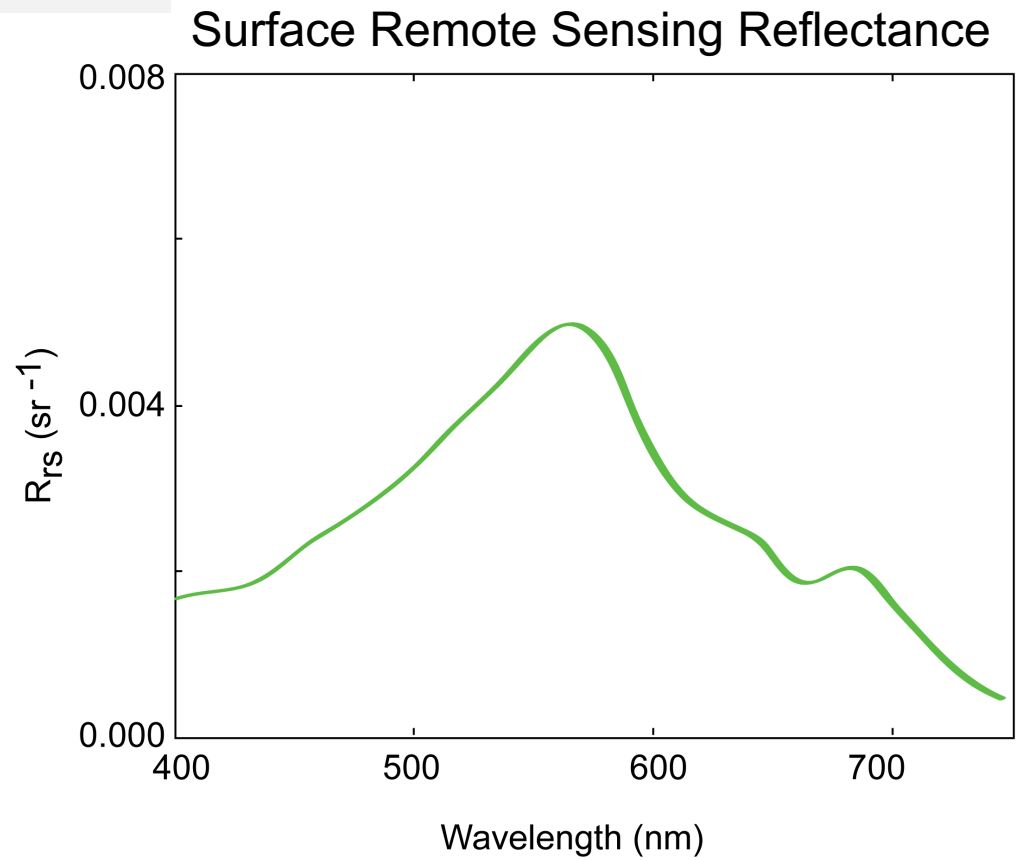
Credit: N. Kuring, <http://earthobservatory.nasa.gov/IOTD/view.php?id=85718>

What Can We Observe from Space?

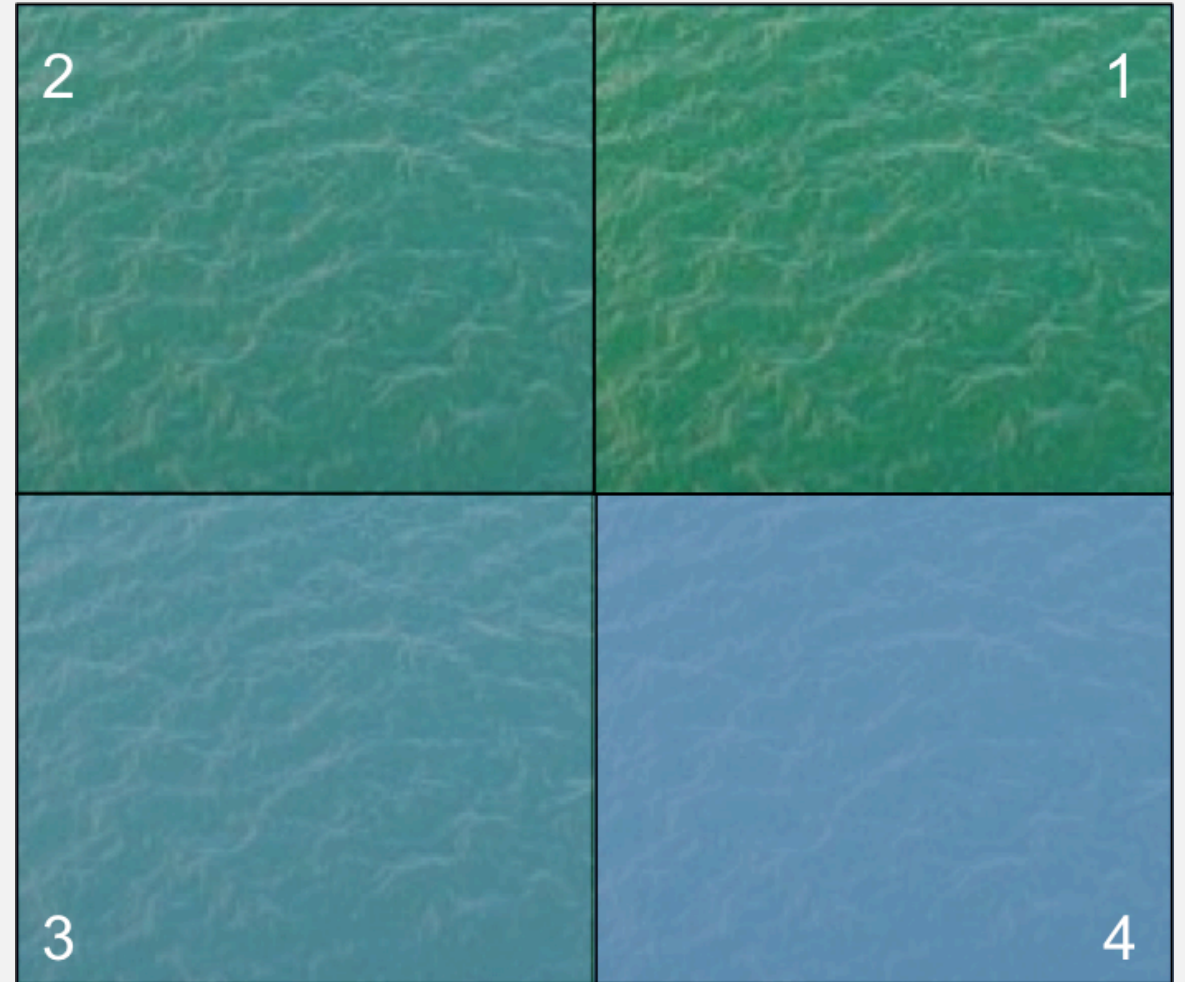
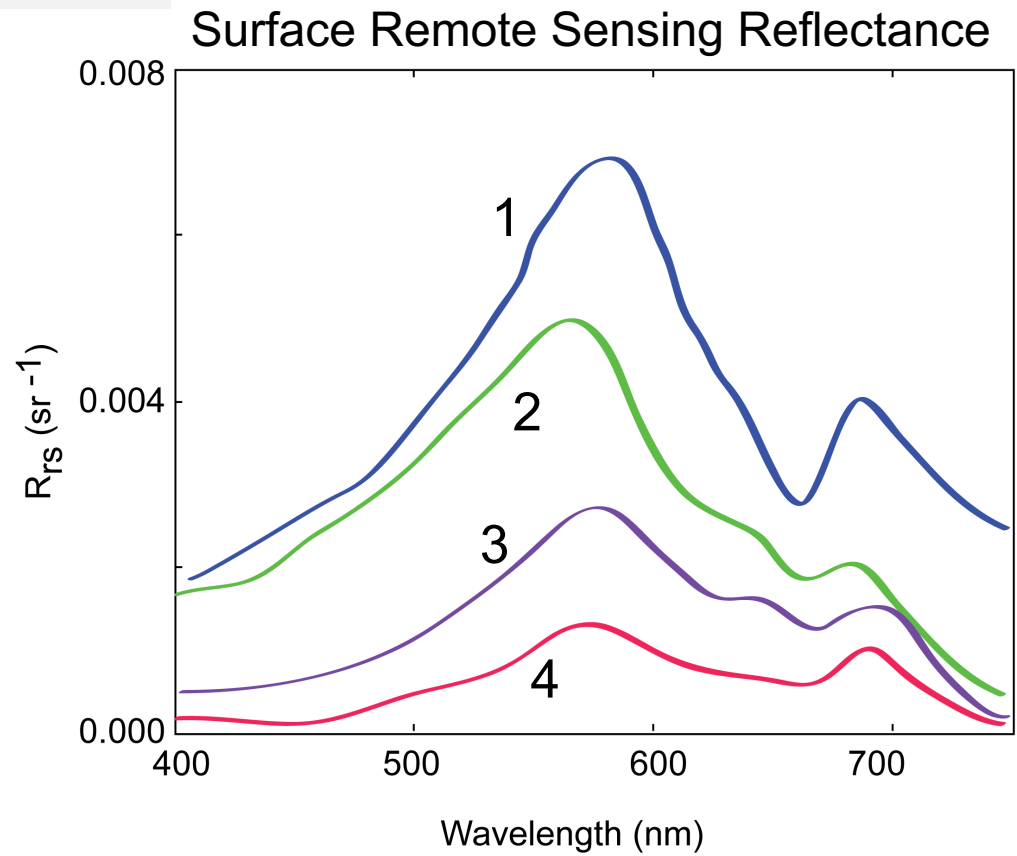
Ocean Properties Derived from Remote Sensing Imagery

Observation	Application
Chlorophyll-a	Phytoplankton biomass, primary productivity, biogeochemical cycling
Water Turbidity	Water quality, human and ecosystem health
Colored Dissolved Organic Matter (CDOM)	Water quality, biogeochemical cycling, human and ecosystem health
Sea Surface Temperature (SST)	Currents, primary productivity, climate studies, biogeochemistry, temperature flux
Surface winds	Currents, mixing, air-sea flux of gases
Salinity	Mixing, air-sea flux of gases, geostrophic currents, salt flux

Chlorophyll-a from Remote Sensing Reflectance (Rrs)

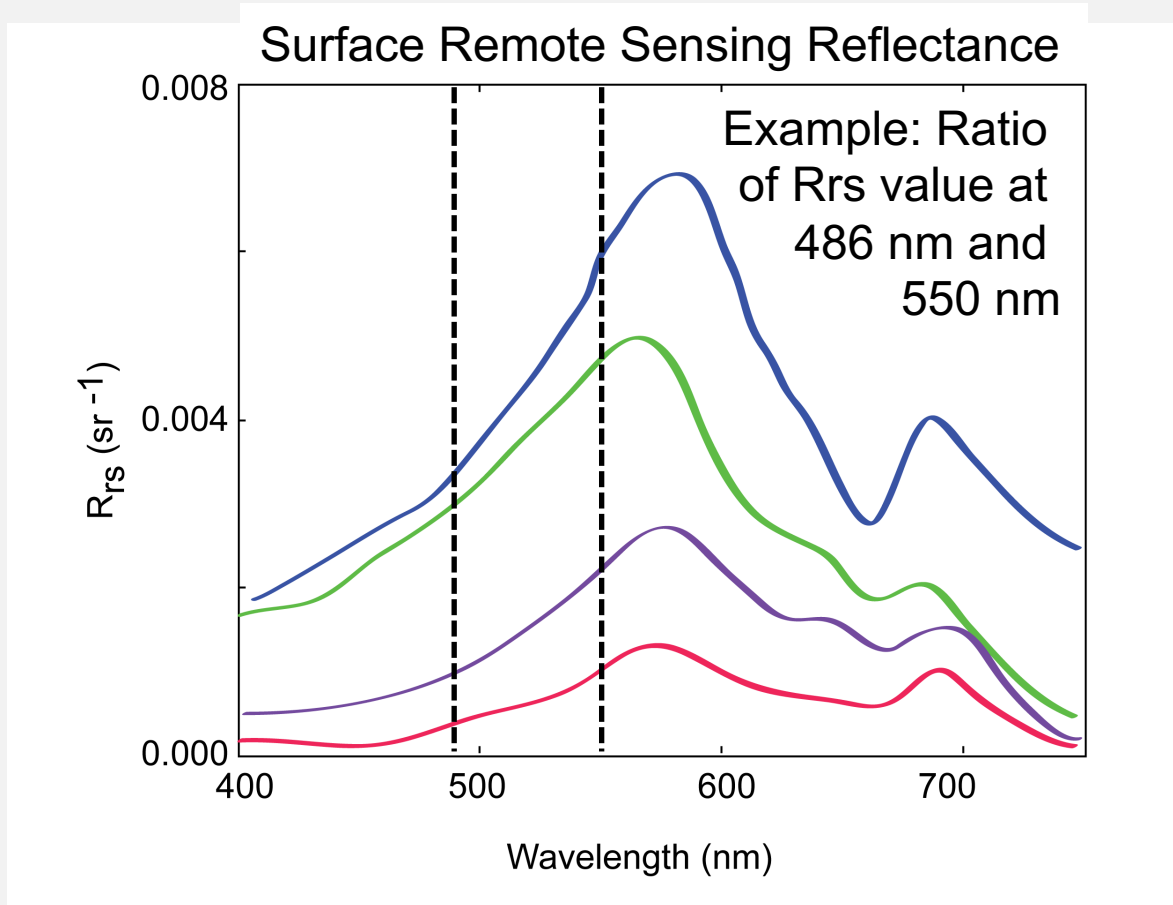


Rrs at Different Chlorophyll-a Concentrations

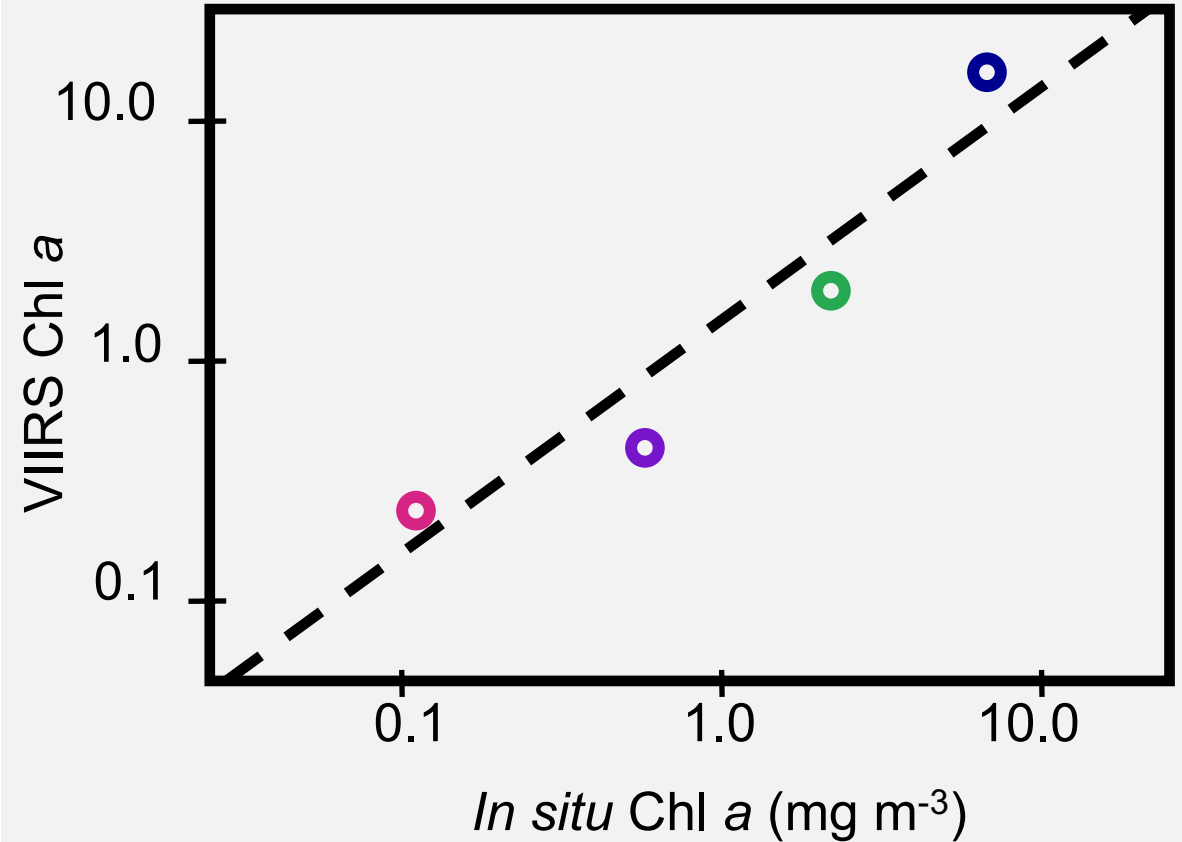


Chlorophyll-a Estimates

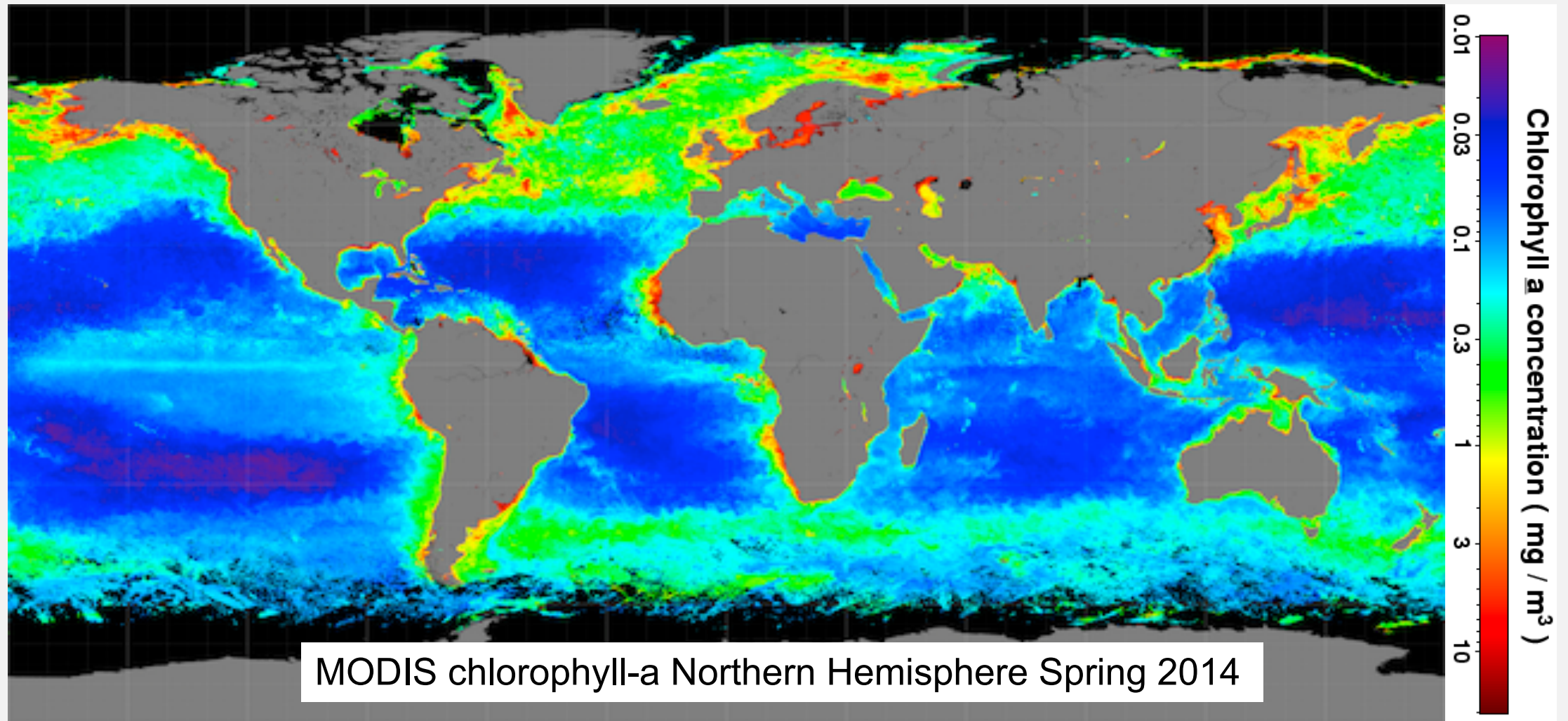
Estimations are a function of the ratios of Rrs values



Algorithm description: http://oceancolor.gsfc.nasa.gov/cms/atbd/chlor_a



Chlorophyll-a from Space

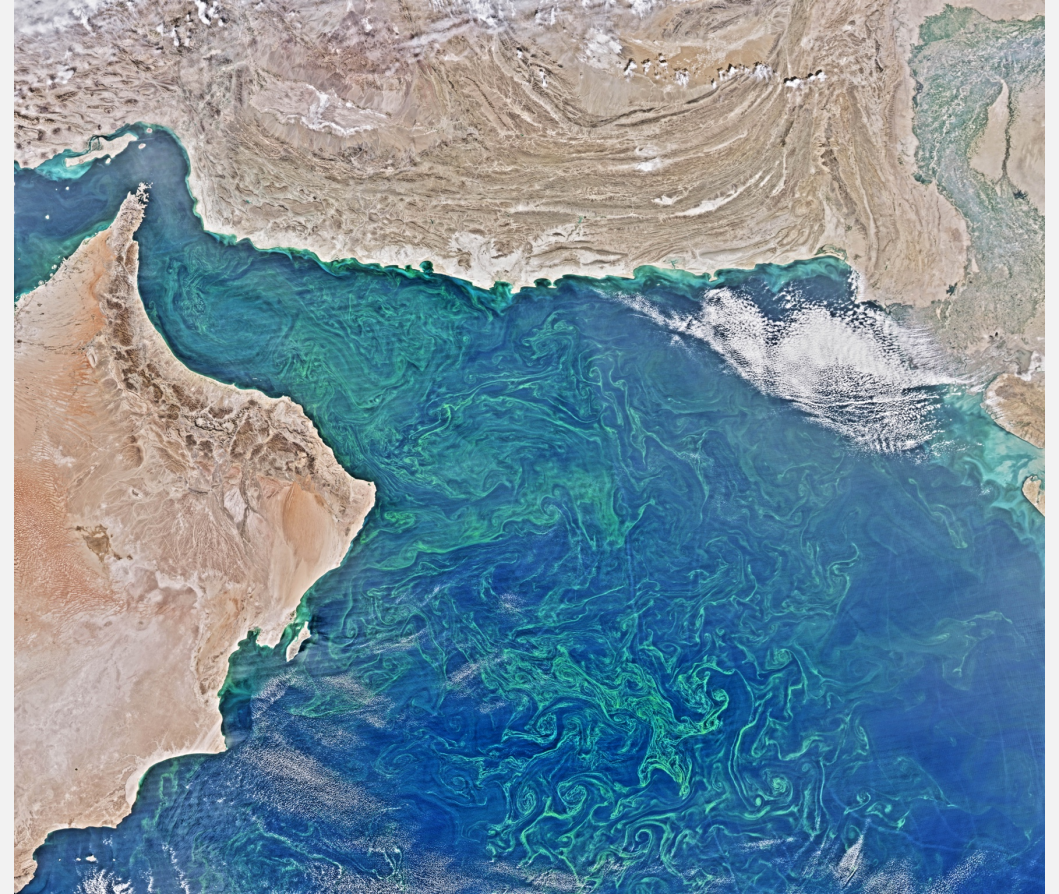


The background of the slide is a high-resolution satellite image. It shows a coastal area with a prominent river delta system on the left side, where the river branches out into several smaller channels. The water in the delta and the surrounding coastal waters is a vibrant turquoise color, contrasting with the deep blue of the open ocean on the right. The land is a mix of green and brown, indicating vegetation and possibly agricultural or natural terrain. A semi-transparent white rectangular box is overlaid on the image, containing the title text.

Accessing NASA Satellite Imagery

Agenda

- Light and Water
- Fundamentals of Remote Sensing
- Aquatic Remote Sensing Data Products and Their Uses
- Accessing NASA Satellite Imagery
 - Worldview
 - OceanColor Web Data Browsers
 - Other Data Access Tools
- NASA Satellite Data Processing Tools

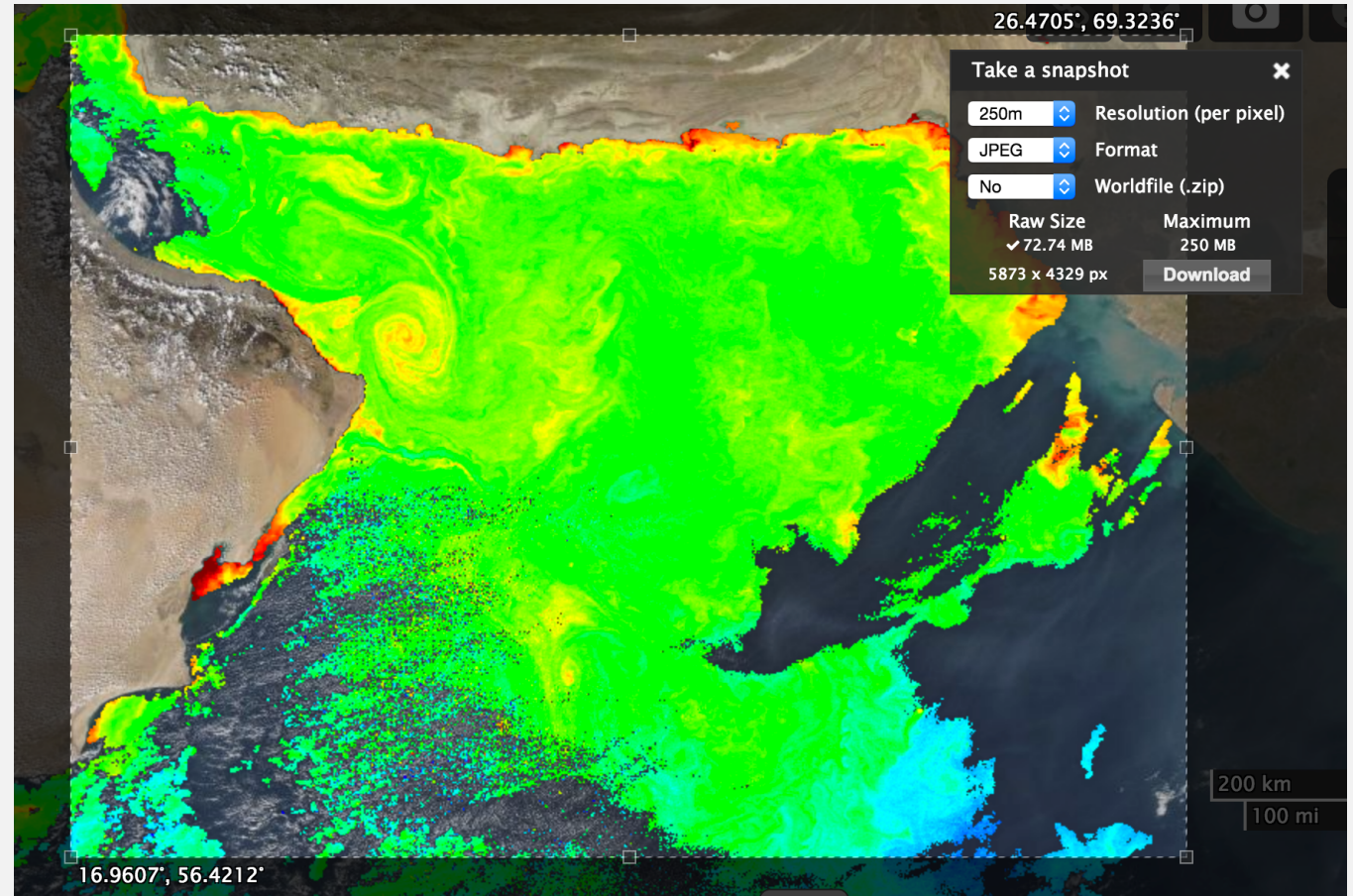


Phytoplankton Bloom in the Arabian Sea
Credit: N. Kuring, <http://earthobservatory.nasa.gov/IOTD/view.php?id=85718>

NASA Worldview

<https://worldview.earthdata.nasa.gov/>

- Interactive web-based tool for browsing satellite imagery
- Imagery is generally available within four hours of observation
- Daily imagery from May 2012 to present
- Data can be downloaded
- Image output in JPEG, PNG, GeoTIFF, and KML formats



NASA OceanColor Web – Data Access

<http://oceancolor.gsfc.nasa.gov/cms/dataaccess>

- Level 1 & 2 Browser
- Level 3 Browser
- Direct Data Access
- Data File Search
- SeaBASS Field Data

Data Access

The Ocean Biology Processing Group (OBPG) serves as the Distributed Active Archive Center (DAAC) for all Ocean Biology (OB) data produced or collected under NASA's Earth Observing System Data and Information System (EOSDIS). This website thus serves as the primary data access portal to the NASA OB.DAAC. The links below provide a variety of methods to access the holdings of the OB.DAAC, including visual browsers that enable point-and-click access by [data levels](#) and direct access for bulk download. In agreement with partner organizations, some data access requires [user registration](#) to enable better tracking of usage metrics.

Data Management

The data management plan describes the acquisition, generation, management, archive and distribution of science data products generated by the Ocean Data Processing System (ODPS). For a detailed description of science data products, data flows, supported sensors, and data availability, archiving and distribution, please refer to the [plan document](#).

Data Access Tools

[Level 1 & 2 Browser](#) - visual browse, download and data order access to all supported satellite data for Level-1 and Level-2 scenes at observed geographic scale and temporal granularity including cross satellite and *in situ* data search capabilities.

[Level 3 Browser](#) - visual access to global composites at various spatial and temporal scales.

[Direct Data Access](#) - direct access to all available data through http protocols suitable for [bulk download](#).

[Data File Search](#) - direct access via filename search, including support for wildcard search on partail filenames.

[SeaBASS Field Data](#) - community archive of field data relevant to ocean color research, algorithm development, and validation.

[Other Resources](#) - links to partners that also distribute OB.DAAC products or other products derived from OB.DAAC holdings.

NASA OceanColor Web – Level 1 & 2 Browser

<http://oceancolor.gsfc.nasa.gov/cgi/browse.pl>

TC **Chl** SST SST4

Comment **Help**

SeaWiFS <input type="checkbox"/> GAC <input type="checkbox"/> MLAC	MODIS <input checked="" type="checkbox"/> Aqua <input type="checkbox"/> Terra	MERIS <input type="checkbox"/> RR <input type="checkbox"/> FRS
<input type="checkbox"/> VIIRS (Suomi-NPP) <input type="checkbox"/> OCTS (ADEOS) <input type="checkbox"/> HICO (ISS) <input type="checkbox"/> GOCI (COMS) <input type="checkbox"/> CZCS (Nimbus-7)	Select <input checked="" type="checkbox"/> Day <input type="checkbox"/> Night	

Radius (km) about map click or about typed-in location:

<input checked="" type="radio"/> 72
<input type="radio"/> 400
<input type="radio"/> 800
<input type="radio"/> 1200
<input type="radio"/> 1500

Select swaths containing (at least):

<input checked="" type="radio"/> any part
<input type="radio"/> 25 %
<input type="radio"/> 50 %
<input type="radio"/> 75 %
<input type="radio"/> all

Select only scenes having in situ matchups.

Sunday, 23 June 2002 through Saturday, 9 July 2016

Chlorophyll

Display results 10 at a time. Reconfigure page

Select one or more regions:

- AdriaticSea
- AegeanSea
- Antarctica
- ArabianSea
- AralSea
- Arctic
- Australia
- AustraliaCoast
- Azores
- Bahamas
- BalticSea

or specify boundary coordinates or a single location:

N:

W: :E

S:

Mission	2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2003	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2005	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2007	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2009	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2015	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

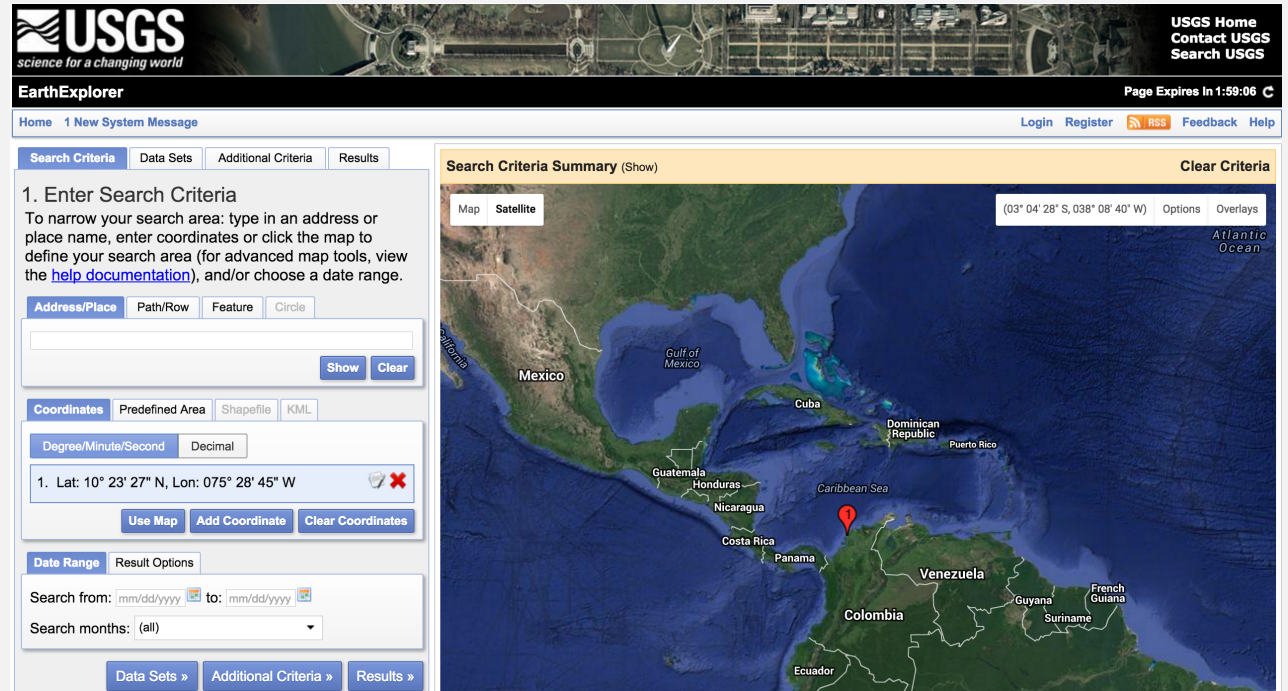
May 2016						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June 2016						
S	M	T	W	T	F	S
				1	2	3
				4	5	6
				7	8	9
				10	11	12
				13	14	15
				16	17	18
				19	20	21
				22	23	24
				25	26	27
				28	29	30

July 2016						
S	M	T	W	T	F	S
					1	2
					3	4
					5	6
					7	8
					9	10
					11	12
					13	14
					15	16
					17	18
					19	20
					21	22
					23	24
					25	26
					27	28
					29	30
					31	

Some Other Data Access Tools

- NOAA CoastWatch
 - <http://coastwatch.noaa.gov/>
- NASA Giovanni
 - <http://giovanni.gsfc.nasa.gov/giovanni/>
- USGS Earth Explorer
 - <http://earthexplorer.usgs.gov/>



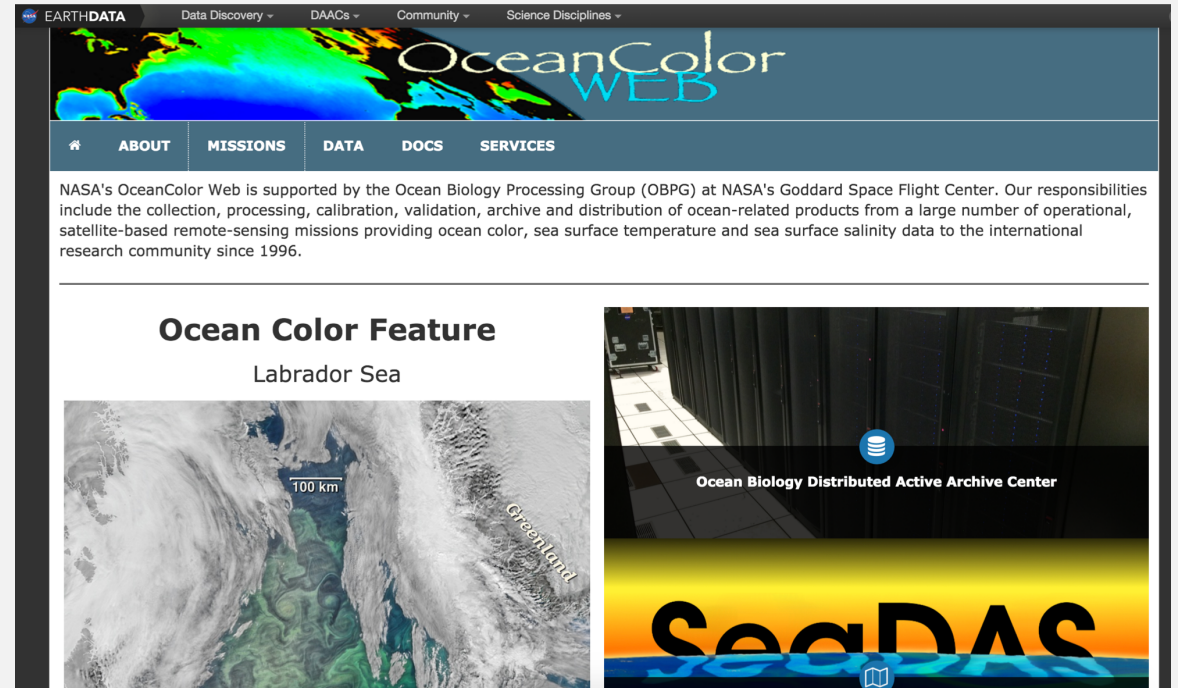
An aerial satellite image of a coastal region. A large river delta flows into the ocean, creating intricate patterns of water and land. The water is a vibrant turquoise color, while the surrounding land is green and brown. The sky is a deep blue with some white clouds. A semi-transparent white box is overlaid on the image, containing the title text.

NASA Satellite Data Processing Tools

NASA OceanColor Web

<http://oceancolor.gsfc.nasa.gov/>

- OceanColor Web is supported by the Ocean Biology Processing Group (OBPG) at NASA Goddard
- OBPG's duties include collection, processing, calibration, validation, archive, and distribution of ocean-related data products from a large number of satellite missions



SeaWiFS Data Analysis System (SeaDAS)

<http://seadas.gsfc.nasa.gov/>

- Image analysis package for the processing, display, analysis, & quality control of ocean color data
- Originally developed for SeaWiFS, but supports most U.S. and international ocean color missions
- Online tutorials, help pages, and an active user community in the Ocean Color Forum
- Attentive & friendly support team based at NASA Goddard

Missions ▾ **Data** ▾ **Documents** ▾ **Analyses** ▾ **People** **Forum** ▾ **Services** ▾ **Links**

SeaDAS

General Description

SeaDAS is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data. While originally developed to support the SeaWiFS mission, it now supports most US and international ocean color missions. The primary focus of SeaDAS is ocean color data, but it is applicable to many satellite-based earth science data analyses.

The latest version (SeaDAS 7.3.1) is the result of a collaboration with the developers of ESA's BEAM software package. The core visualization package for SeaDAS 7 is based on the BEAM framework, with extensions that provide the functionality provided by previous versions of SeaDAS..

Features
Requirements
License
Download

Supported Missions

- MODIS
- SeaWiFS
- CZCS
- VIIRS
- HICO
- Aquarius
- Landsat8/OLI
- MERIS
- OCTS
- OCM
- OCM-2
- OSMI
- MOS
- GOCI

User Support

- SeaDAS Video Tutorials and Demos
- SeaDAS FAQ
- SeaDAS Help Pages
- Other SeaDAS Tutorial Material
- Ocean Color Web
- Ocean Color Forum
- SeaDAS Mailing List

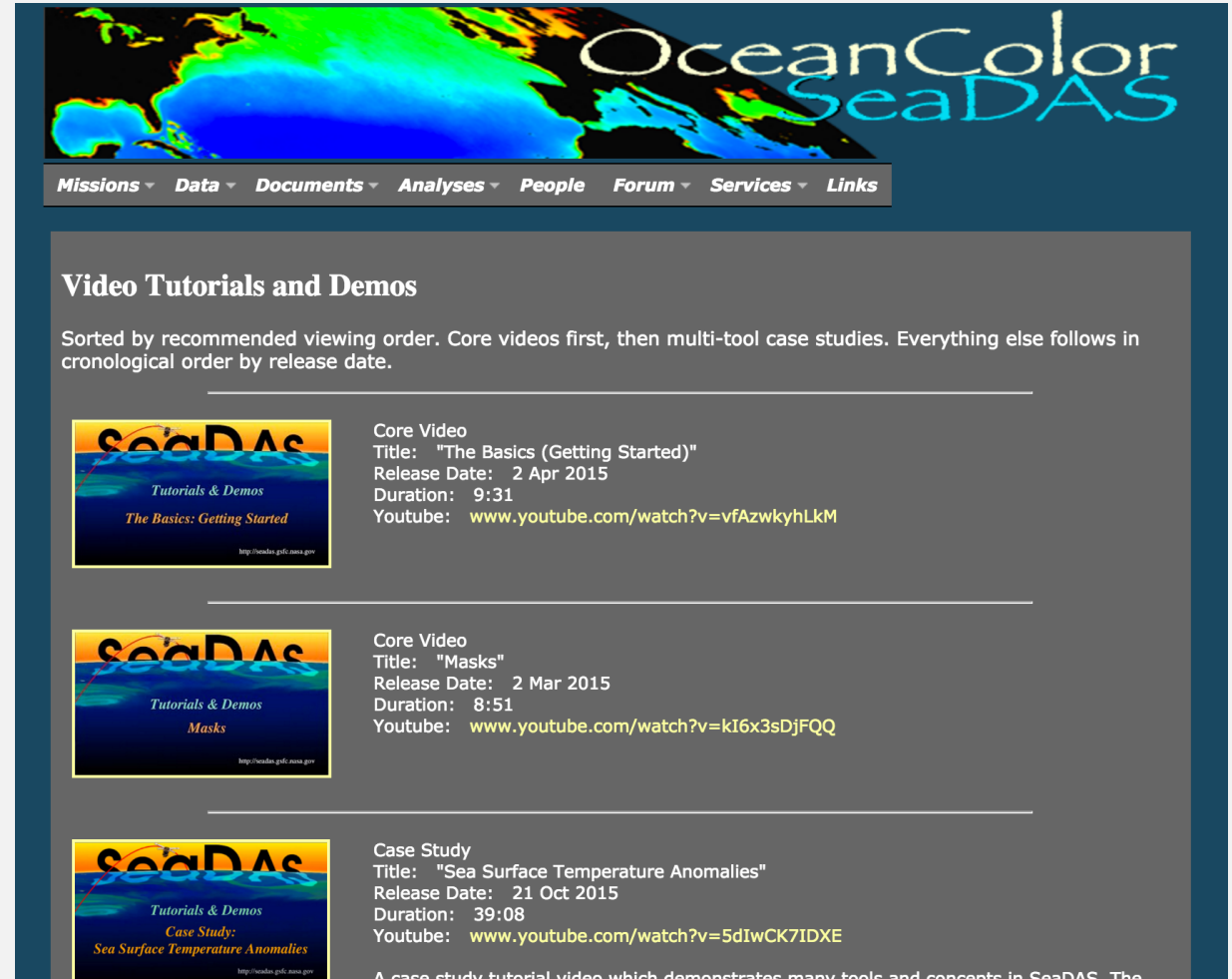
Other

- SeaDAS Visualization Source Code
- Processing Binaries and Source Code
- SeaDAS version 6.4
- MODISL1DB 1.8




Online Tutorials and Webinars for SeaDAS

<http://seadas.gsfc.nasa.gov/tutorial/>

- Strongly recommend completing all of the on-demand tutorials listed on this webpage
- SeaDAS supports a wide variety of satellite sensors so your investment in learning it will be time well spent
- Check out this SeaDAS webinar from June 15, 2016:
 - <https://earthdata.nasa.gov/user-resources/webinars-and-tutorials>



The screenshot shows the SeaDAS website interface. At the top, there is a header with a satellite image of the ocean and the text "OceanColor SeaDAS". Below the header is a navigation menu with links: Missions, Data, Documents, Analyses, People, Forum, Services, and Links. The main content area is titled "Video Tutorials and Demos" and includes a sorting instruction: "Sorted by recommended viewing order. Core videos first, then multi-tool case studies. Everything else follows in chronological order by release date." There are three video entries listed:

Thumbnail	Category	Title	Release Date	Duration	Youtube Link
	Core Video	"The Basics (Getting Started)"	2 Apr 2015	9:31	www.youtube.com/watch?v=vfAzwkyhLkM
	Core Video	"Masks"	2 Mar 2015	8:51	www.youtube.com/watch?v=kI6x3sDjFQQ
	Case Study	"Sea Surface Temperature Anomalies"	21 Oct 2015	39:08	www.youtube.com/watch?v=5dIwCK7IDXE

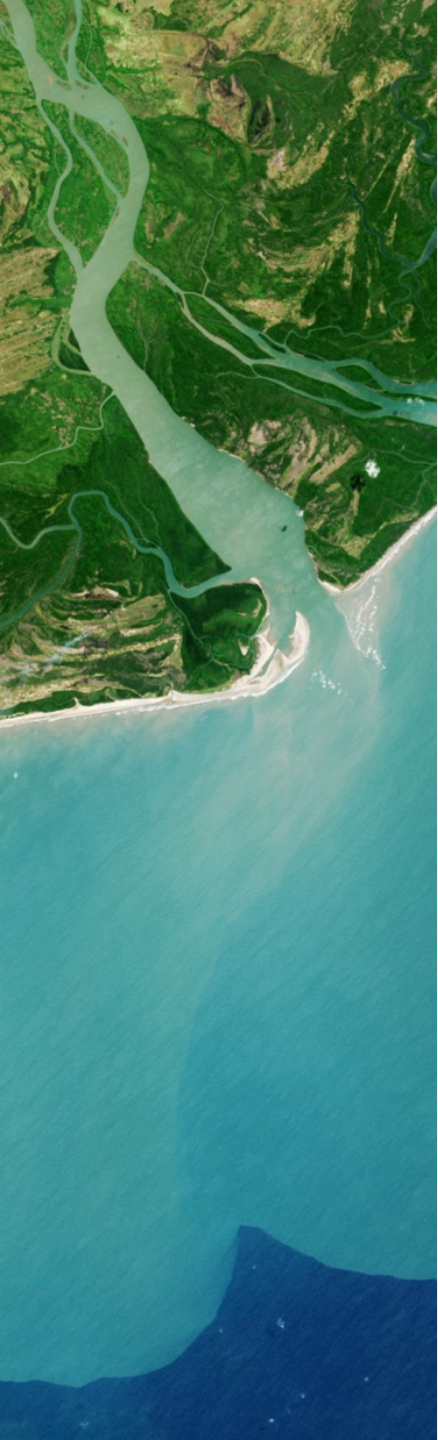
Below the third entry, there is a partial sentence: "A case study tutorial video which demonstrates many tools and concepts in SeaDAS. The"

Interested in a More In-Depth Understanding of Aquatic Optics and Remote Sensing Imagery?

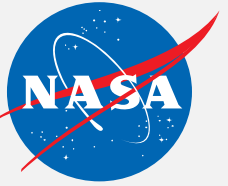
- For a more solid foundation in aquatic optics:
 - Ocean Optics Web Book: <http://www.oceanopticsbook.info/>
 - IOCCG Summer Lecture Series, 2016: <http://ioccg.org/what-we-do/training-and-education/ioccg-summer-lecture-series-2016/#lectures>
- For remote sensing imagery information, data access, and processing tools:
 - NASA's OceanColor Web: <http://oceancolor.gsfc.nasa.gov/cms>

Summary

- Light and Water
 - How light propagates through the atmosphere and water column, and back to sensor
 - Constituents of the water column and their inherent optical properties
- Fundamentals of Remote Sensing
 - Spatial, Temporal, Spectral Resolution
 - NASA Satellites and Sensors for Aquatic Applications
 - Image “Correction”
 - Satellite Data Processing Levels
- Aquatic Remote Sensing Data Products and Their Uses
- Accessing NASA Satellite Imagery
 - Worldview
 - OceanColor Web
 - Other Data Access Tools
- NASA Satellite Data Processing Tools
 - SeaDAS



National Aeronautics and
Space Administration



ARSET

Applied Remote Sensing Training

<http://arset.gsfc.nasa.gov>

 @NASAARSET

Thank you!

<http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>