

# Integrating Remote Sensing into a Water Quality Monitoring Program

Sherry L. Palacios & Amita Mehta

5, 12, 19 June 2019



# Training Objectives

Learn to:

- Understand which data products are used for water quality monitoring
- Follow rigorous practices for obtaining and processing aquatic remote sensing data
- Build skills in image processing for water quality monitoring for coastal and inland water bodies using NASA's SeaDAS image processing software

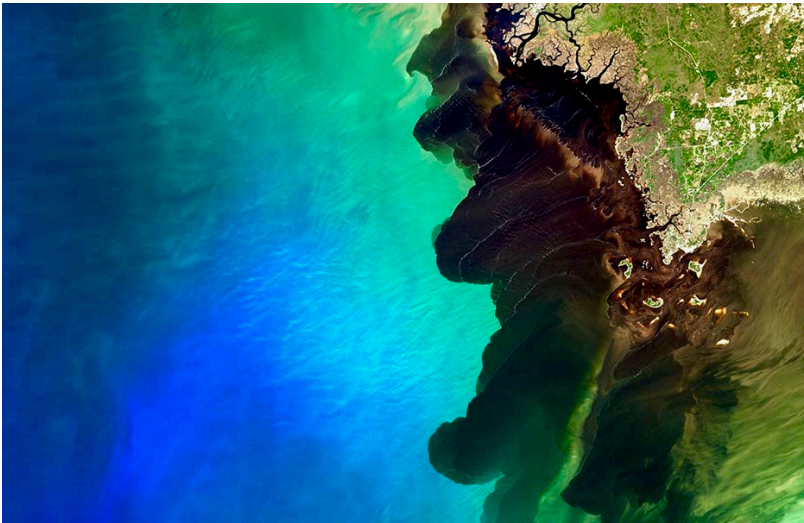
# Prerequisites

- Fundamentals of Remote Sensing, Session 2C:
  - <http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>
- Advanced Webinar: Processing Satellite Imagery for Monitoring Water Quality;  
Capacitación en Línea Avanzada: Procesamiento de Imágenes Satelitales para el Monitoreo de la Calidad del Agua
  - <https://arset.gsfc.nasa.gov/water/webinars/wq-image-processing>
- Download and install NASA's SeaDAS software. Ensure the software is working:
  - <https://seadas.gsfc.nasa.gov/>

# Training Outline

June 5

Water Quality in the Coastal Zone



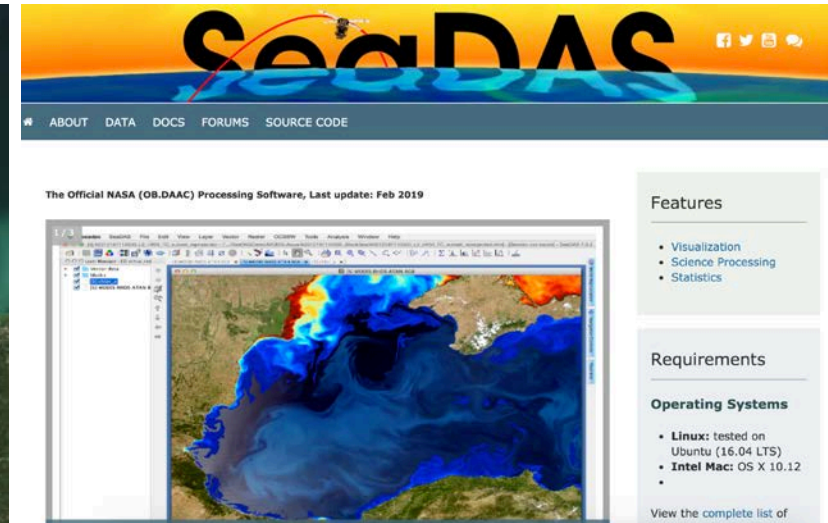
June 12

Water Quality of Larger Inland Water Bodies



June 19

Aquatic Remote Sensing  
Skill Development and  
Best Practices

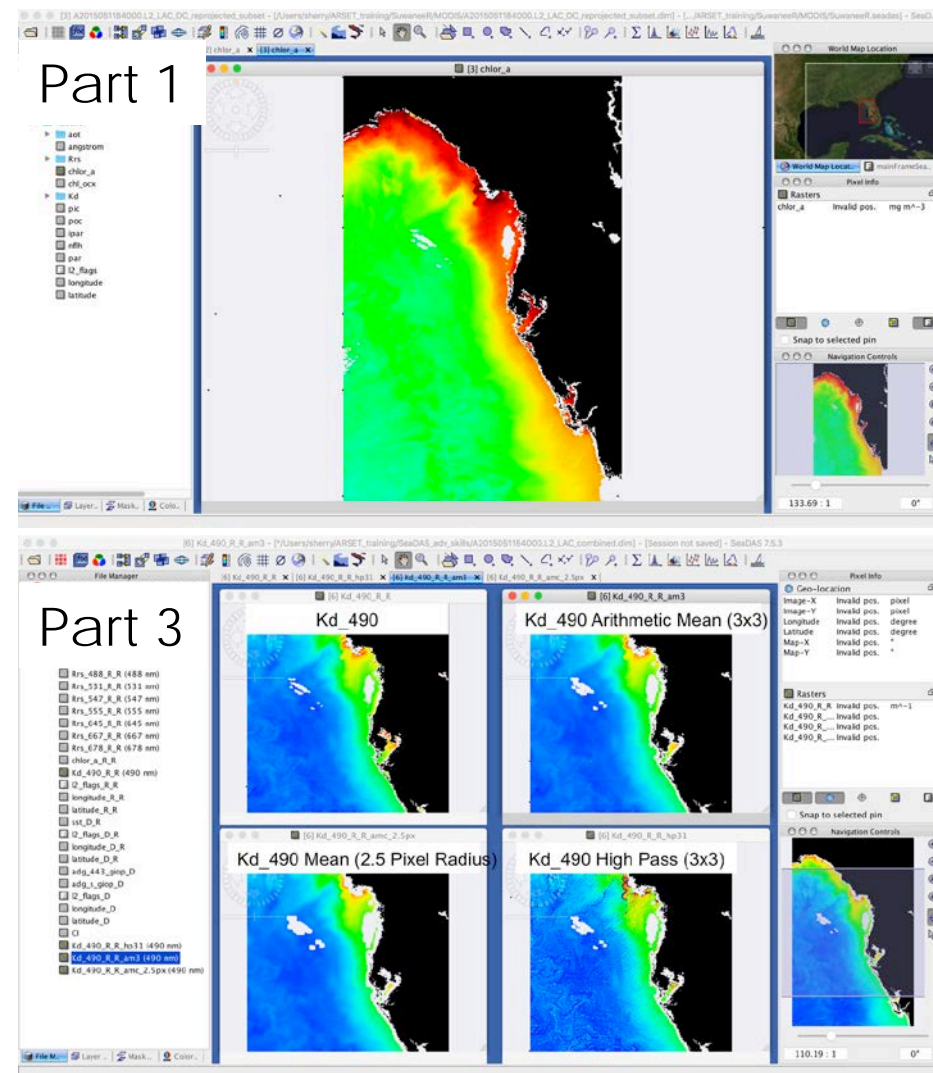


# Outline for Part 1

- About ARSET
- Remote Sensing of Water Quality (WQ)
- Aquatic Remote Sensing Overview
- Examples of WQ Monitoring Programs
- Demonstration of MODIS & Landsat 8 OLI Image Data Access
  - OceanColor: <https://oceancolor.gsfc.nasa.gov/>
  - EarthExplorer: <https://earthexplorer.usgs.gov/>
- Exercise: Basic Skills in SeaDAS

# Homework & Certificates

- Homework:
  - 3 homework assignments
  - Answers to homework from Parts 1 & 3 must be submitted via Google Forms
  - There is no form to complete for Part 2 homework
- Certificate of Completion
  - Attend all live webinars
  - Complete the homework assignments by June 21
- You will receive certificates approximately 2 months after the completion of the course from: [marines.martins@ssaihq.com](mailto:marines.martins@ssaihq.com)





## About ARSET

# NASA's Applied Remote Sensing Training Program (ARSET)

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

- 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
- Training topics focus on:
  - air quality
  - land
  - disasters
  - water

Helping Professionals Solve Problems Including...





# ARSET Team Members

## Program Support

- Ana Prados, Program Manager (GSFC)
- David Barbado, Spanish Translator (GSFC)
- Brock Blevins, Training Coordinator (GSFC)
- Annelise Carleton-Hug, Program Evaluator (Consultant)
- Elizabeth Hook, Technical Writer/Editor (GSFC)
- Selwyn Hudson-Odoi, Training Coordinator (GSFC)
- Marines Martins, Project Support (GSFC)
- Stephanie Uz, Program Support (GSFC)

## Disasters & Water Resources

- Sean McCartney, Instructor (GSFC)
- Amita Mehta, Instructor (GSFC)
- Sherry Palacios, Instructor (ARC)
- Erika Podest, Instructor (JPL)

## Land & Wildfires

- Cynthia Schmidt, Lead (ARC)
- Amber Jean McCullum, Instructor (ARC)

## Health & Air Quality

- Pawan Gupta, Lead (MSFC)
- Melanie Cook, Instructor (GSFC)

**Acknowledgement:** We wish to thank Nancy Searby for her continued support

# ARSET Trainings



110+ trainings



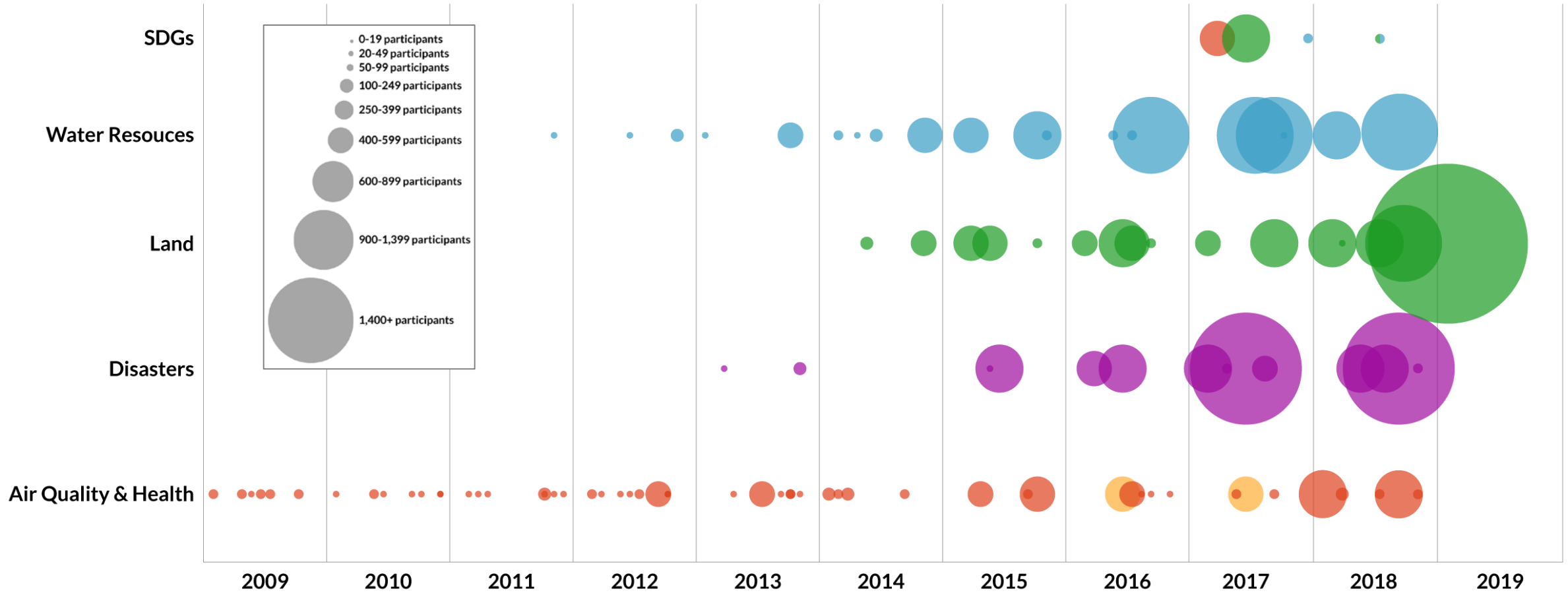
19,400+ participants



160+ countries



5,000+ organizations



\* size of circle corresponds to number of participants



# ARSET Water Quality Trainings

<https://arset.gsfc.nasa.gov/water/>

- Advanced Webinar: Processing Satellite Imagery for Monitoring Water Quality
  - <https://arset.gsfc.nasa.gov/water/webinars/wq-image-processing>
- Introduction to Remote Sensing of Harmful Algal Blooms:
  - <https://arset.gsfc.nasa.gov/water/webinars/HABs17>
- Introduction to Remote Sensing for Coastal & Ocean Applications:
  - <https://arset.gsfc.nasa.gov/land/webinars/coastal-oceans-2016>
- Water Quality Monitoring Using Remote Sensing Measurements:
  - <https://arset.gsfc.nasa.gov/water/water-quality-2014>

# Learn More About ARSET

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

The screenshot displays the ARSET website interface. At the top, it features the NASA logo and the text "ARSET Applied Remote Sensing Training". Navigation links for "Earth Sciences Division", "Applied Sciences", and "Capacity Building Program" are visible. A search bar is present with the text "Search this site". A main navigation menu includes "Home", "About", and "Trainings". The "Trainings" dropdown menu is open, listing categories: "Fundamentals", "Disasters", "Health & Air Quality", "Land", and "Water Resources". The main content area features a large image of a satellite map with the text "Advanced Webinar: Water Quality Monitoring" and "Sensing into a". Below this, a sidebar titled "Water Resources" contains links for "Online Trainings" and "In-Person Trainings". The "Upcoming Training" section lists a webinar on "Remote Sensing for Disasters Scenarios" with dates from April 16 to April 30, 2019. At the bottom, there is a registration notice for a webinar on June 5, 12, and 19, 2019, with registration closing on June 4, 2019.





# Remote Sensing of Water Quality

# What Do We Mean by 'Water Quality'?

Water quality describes the condition of the water, including chemical, physical, and biological characteristics, usually with respect to its suitability for a particular purpose such as ecosystem function or human health

# Examples of Some *In Situ* Water Quality Observations

- Water Temperature
- Salinity
- Dissolved Oxygen
- Alkalinity
- pH
- Color
- Nutrients (E.G., Nitrogen)
- Tests for Specific Pollutants (e.g., Industrial Organic Compounds)
- Heavy Metals
- Colored Dissolved Organic Matter
- Suspended Solids - Turbidity
- Bacteria (e.g., E. Coli)
- Water Clarity
- Cyanobacteria
- Pathogens and Pathogen Indicators
- Algae-Produced Toxins
- Plastic Microbeads
- Chlorophyll
- Chlorophyll Anomaly
- Algal Pigments

# Water Quality Affects Water Optical Properties

Natural water contains material that is optically active. Remote sensing of this material may indicate the quality of the water.

Examples of two common constituents that influence water quality:

- Colored dissolved organic matter (CDOM) which is a mixture of organic compounds like lignins and tannins
- Suspended matter includes particles of clay, undissolved minerals, plankton, and algal blooms



Confluence of the Rio Negro and Rio Solimoes, Brazil, CDOM on the left, Sediments on the Right

Image Credit: Pant, A. A. (2014, October 21). Rivers that meet but do not mix. Retrieved from Awesci - Science Everyday website: <http://awesci.com/rivers-that-meet-but-do-not-mix/>



# Some Water Quality Indicators Satellites Can Observe

- Turbidity and Sediments
- Colored Dissolved Organic Matter (CDOM)
- Sea Surface Temperature (SST)
- Chlorophyll-a (phytoplankton)
- Salinity
- Total Suspended Solids (TSS)
- Fluorescence Line Height
- Euphotic Depth
- Diffuse Attenuation of Light



Image Credit: A blackwater river meets the sea [Text.Article]. (2018, October 27). Retrieved from <https://earthobservatory.nasa.gov/images/144147/a-blackwater-river-meets-the-sea>

# How *In Situ* and Satellite Observations Roughly Correspond

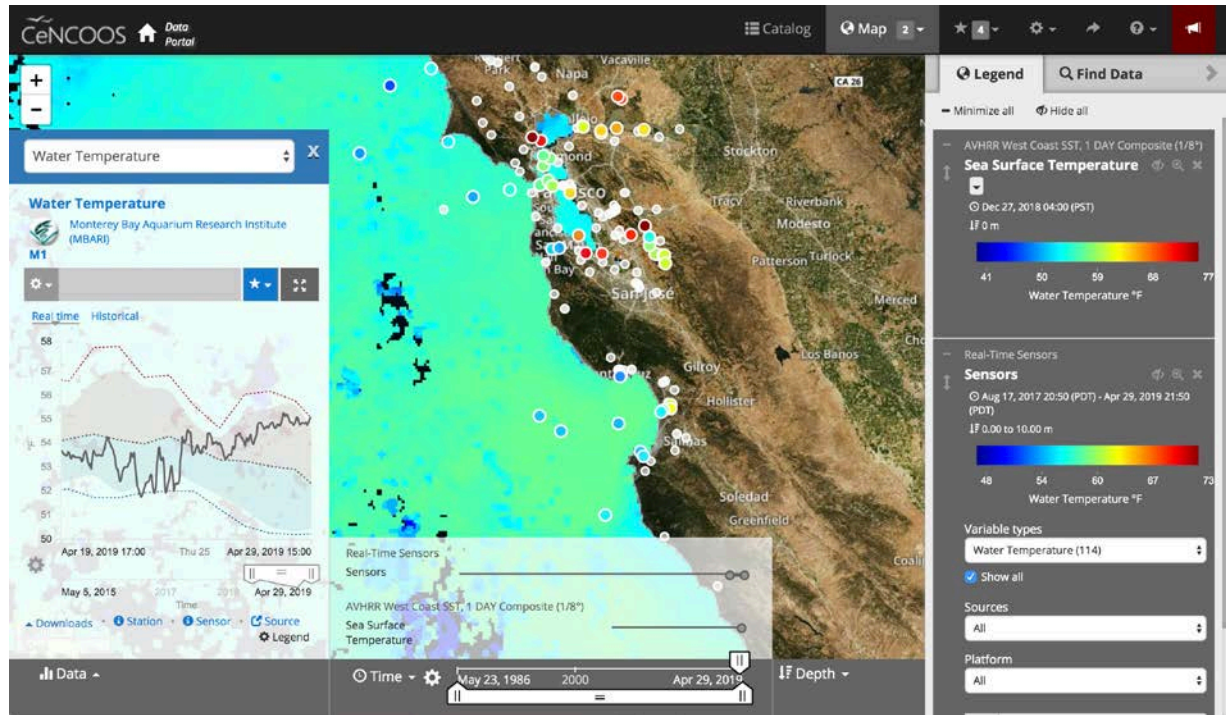
<i>In Situ</i>	Satellite
Water Temperature	Sea Surface Temperature (SST)
Colored Dissolved Organic Matter (CDOM)	Absorption by CDOM ( $a_{dg}$ )
Suspended Solids – Turbidity	Diffuse attenuation of light at 490 nm ( $K_d$ )
Water Clarity	Chlorophyll-a, Normalized Fluorescence Line Height (nFLH)
Cyanobacteria	Cyanobacteria Index (CI)
Algal Pigments	Euphotic Zone Depth ( $Z_{eu}$ )
	Experimental Phytoplankton Functional Type Algorithms

# Which Factors Influence Water Quality?

- Nutrient loading “eutrophication”
  - agricultural runoff
  - septic leaching
- Pollution
  - industrial point sources
  - deposition from the atmosphere
- Climate change
  - rising temperatures stimulate cyanobacterial blooms
  - ocean acidification from elevated CO<sub>2</sub>
- Food web changes
- Introduced species
- Changes in water flow
  - dams
  - natural events like hurricane, drought, or flood

# Why Use Satellites?

- Regular and consistent observations over a large area
- Consistent revisit rate for well structured time series analyses
- Large number of data products available
- Complements *in situ* sampling
- Mostly free and open access



Sea Surface Temperature from the AVHRR Sensor

Image Credit: CeNCOOS Data Portal, <https://data.cencoos.org/>



# Aquatic Remote Sensing Review

# How Light Interacts with Water

## Remote Sensing Reflectance (Rrs) 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 by...
  - phytoplankton (ph)
  - non-algal particles (nap)
  - colored dissolved organic matter (CDOM)
  - water (w)
- $b$  = scattering in forward (f) and backward (b) directions

### 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

- Light absorbed ( $a$ ) is a combination of:
  - Phytoplankton ( $a_{ph}$ )
  - Non-Algal Particles ( $a_{nap}$ )
  - Water ( $a_w$ )
  - Colored Dissolved Organic Matter (CDOM)

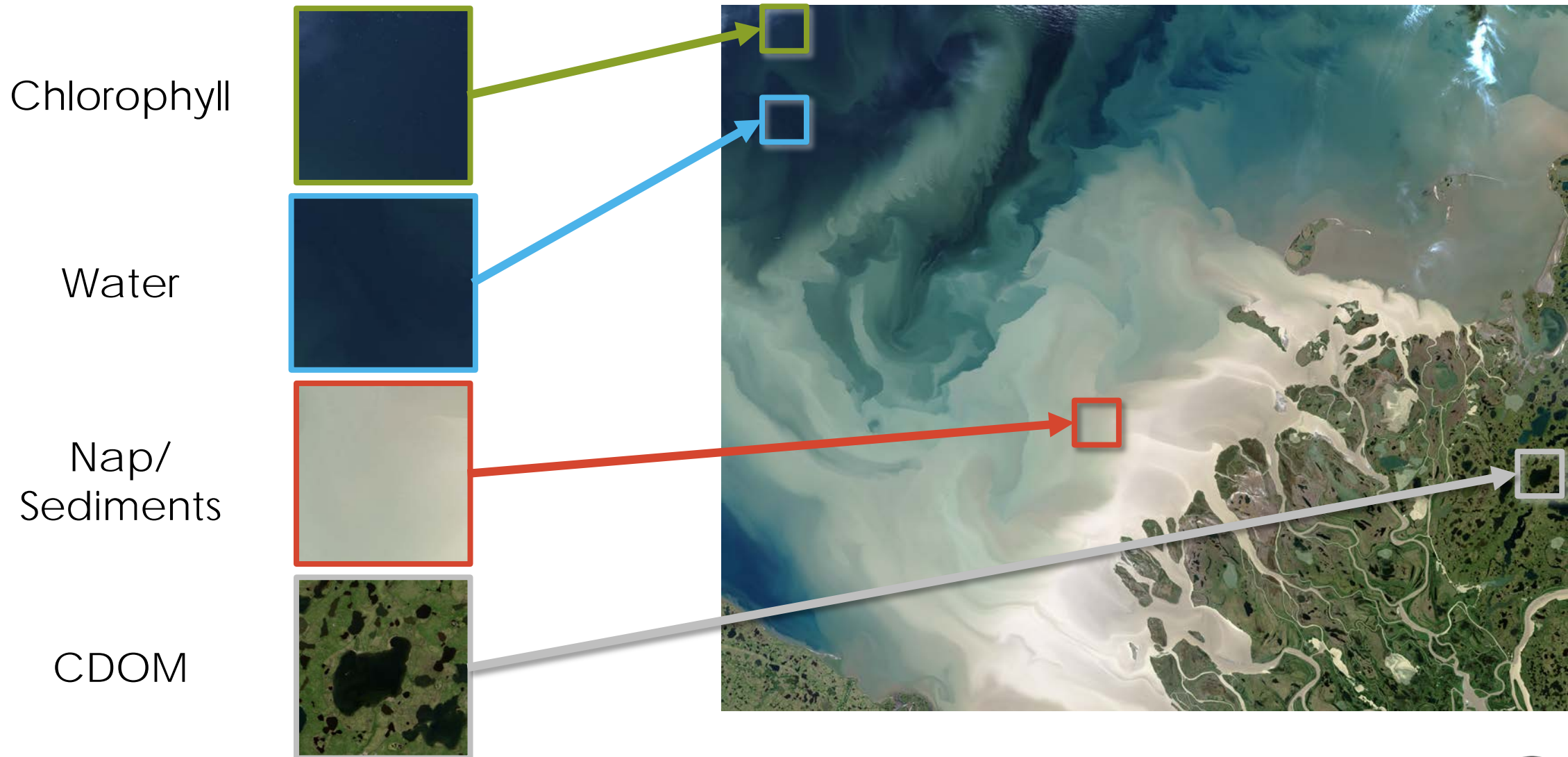
$$a = a_{ph} + a_{nap} + a_{CDOM} + a_w$$

- Light scattered ( $b$ ) is a combination of particles in forward ( $b_f$ ) and backward ( $b_b$ ) directions

$$b = b_f + b_b$$

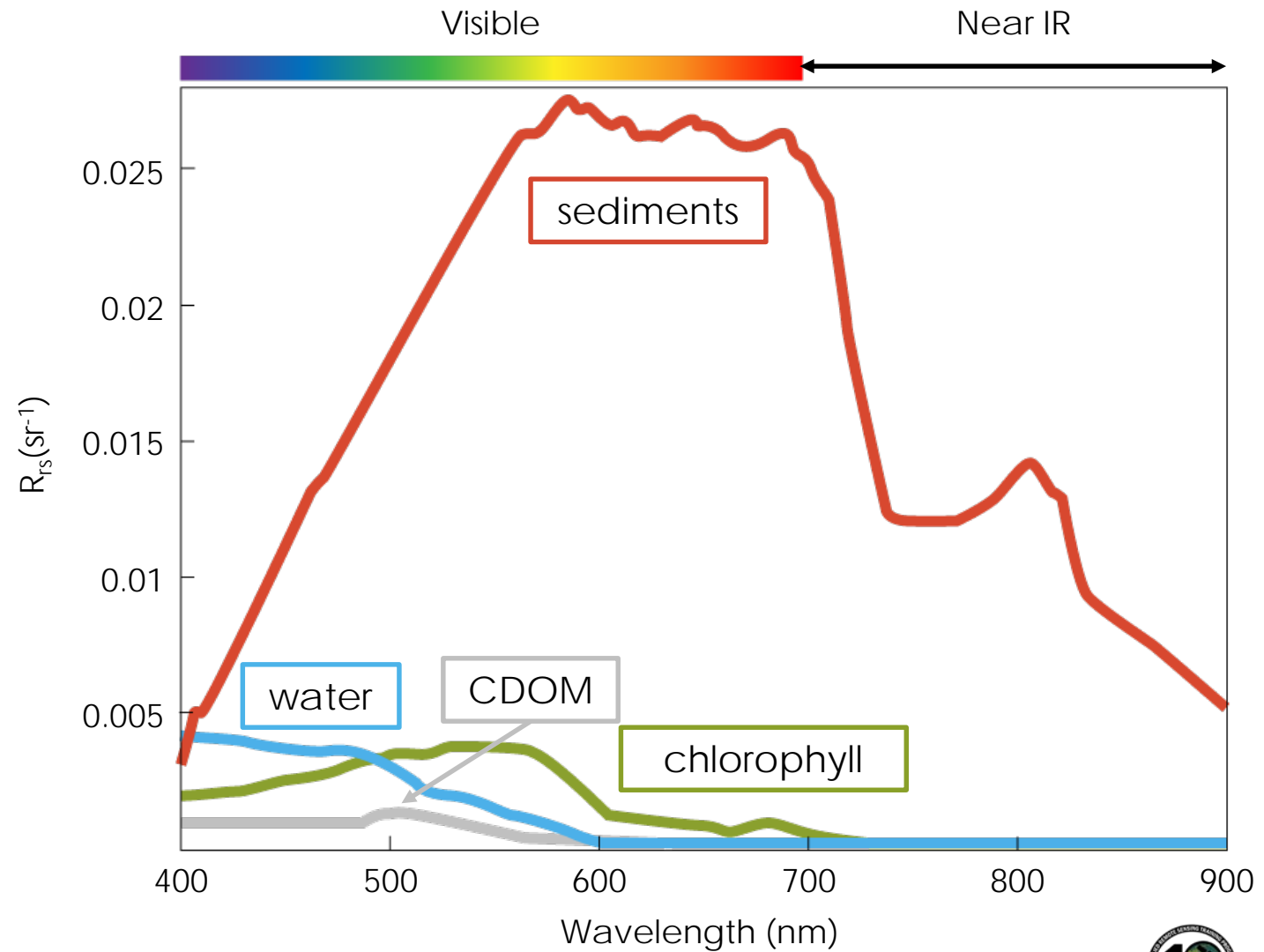
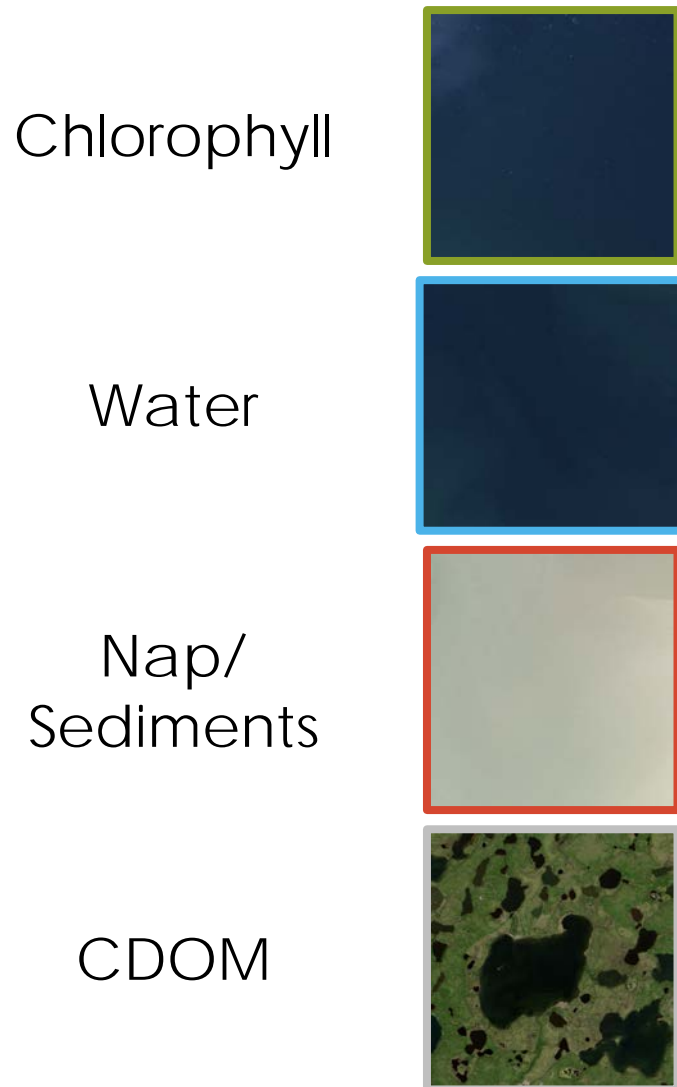


# Inherent Optical Properties (IOPs) and the 'Color' of Water



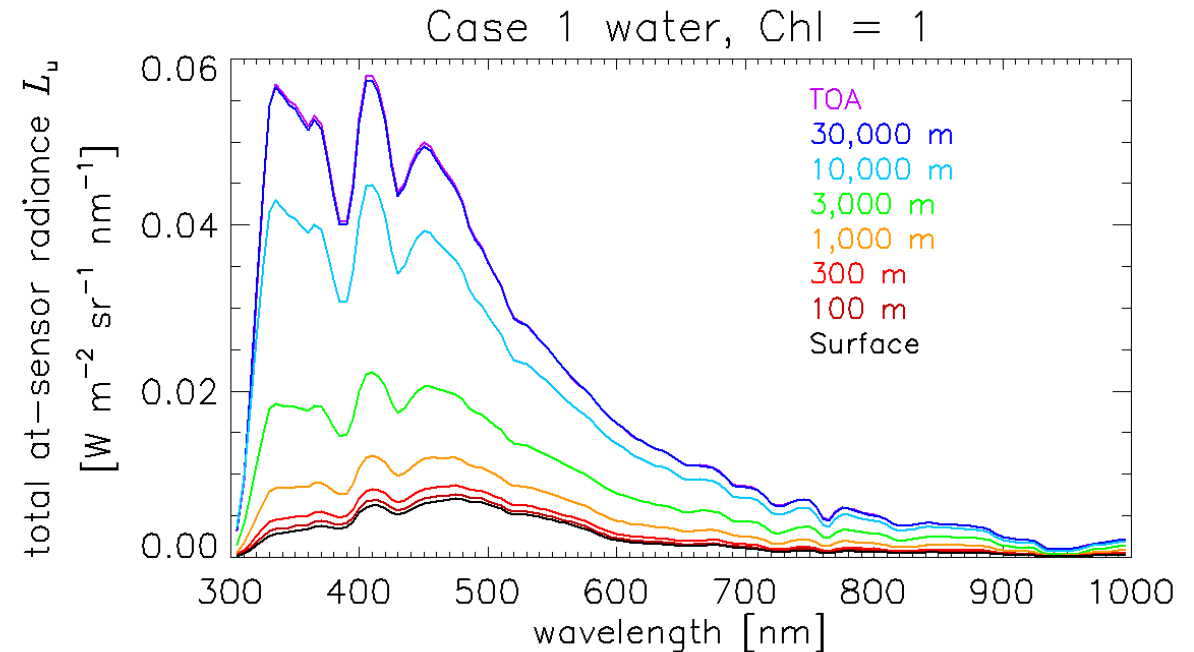


# Inherent Optical Properties (IOPs) and the 'Color' of Water



# Atmospheric Correction for Water Quality Monitoring

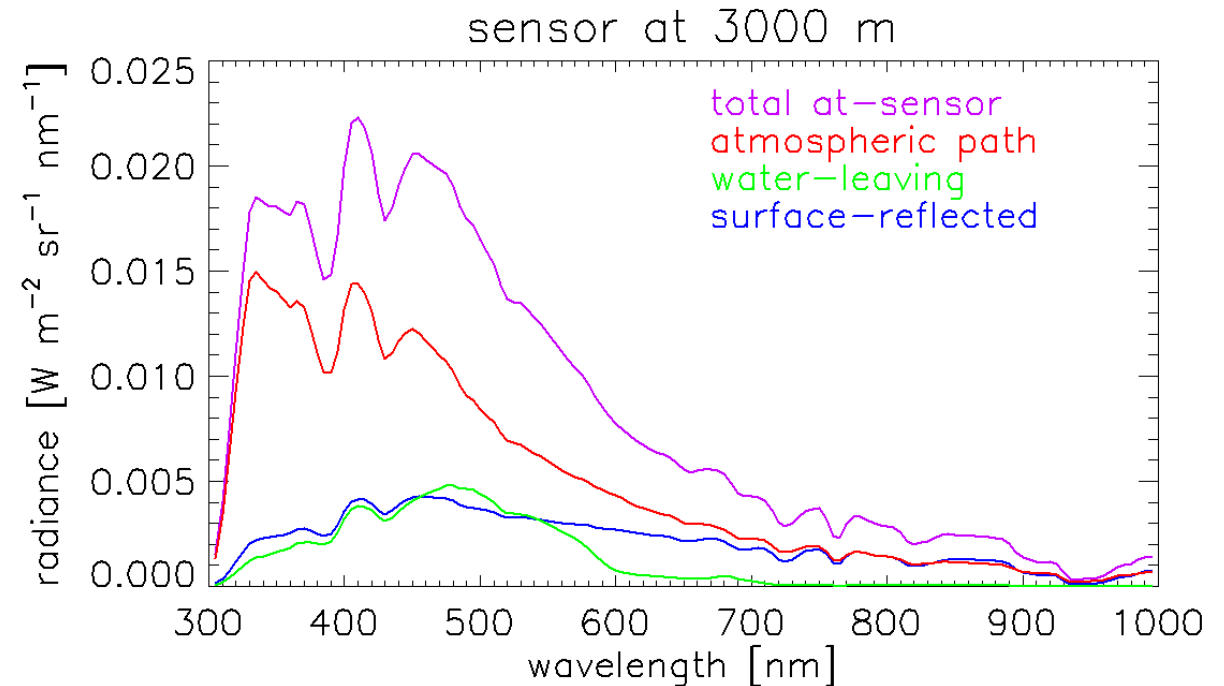
- Satellite sensors measure top-of-atmosphere (TOA) radiances
- The TOA radiances result from a combination of surface and atmospheric conditions, including effects of water vapor, relative humidity, gases, aerosol particle type and size distribution, aerosol hygroscopy
- The effect of sky radiance can be seen in at-sensor radiance spectra modeled for different altitudes



Examples of at-sensor radiance spectra for different sensor altitudes, assuming the same surface reflectance

# Atmospheric Correction for Water Quality Monitoring

- The goal is to subtract the atmospheric path and surface-reflected spectra from the total at-sensor spectrum to arrive at the water-leaving radiance spectrum
- Requires radiative transfer modeling along with atmospheric conditions, clouds, and aerosol information
- Various techniques exist for atmospheric correction (e.g., 6S, ACOLITE, ATREM, FLAASH)



# Atmospheric Correction

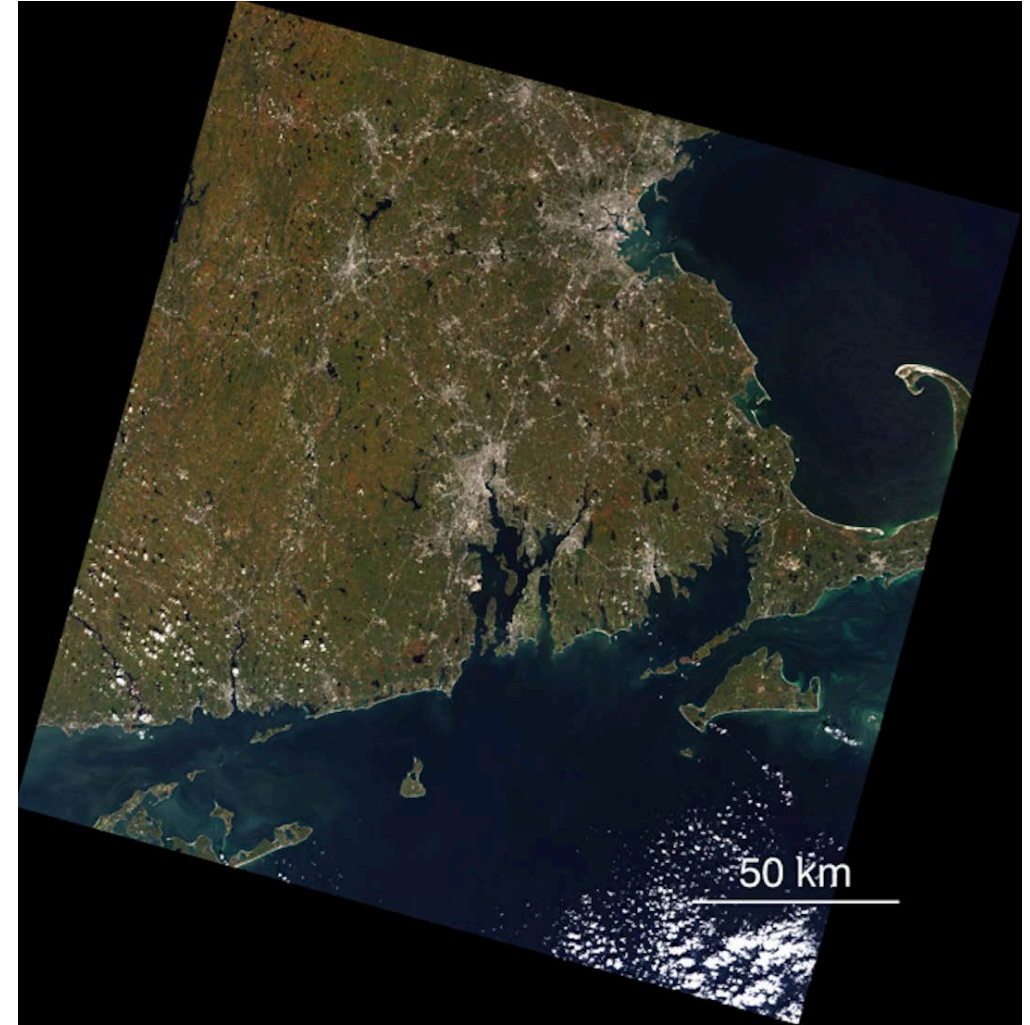
"Top of Atmosphere"



Atmospheric  
correction



"Surface Reflectance"



# 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

# Data Processing Levels

Greater Skill  
Needed

Less Skill  
Needed



Processing Level	Description
Level 0	Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts (e.g., synchronization frames, communications headers, duplicate data) removed.
Level 1A	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (e.g., platform ephemeris) computed and appended but not applied to Level 0 data.
Level 1B	Level 1A data that have been processed to sensor units (not all instruments have Level 1B source data).
Level 2	Derived geophysical variables at the same resolution and location as Level 1 source data. Data are atmospherically corrected prior to deriving these geophysical variables.
Level 3	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements).

# Satellites & Sensors for Water Quality Monitoring

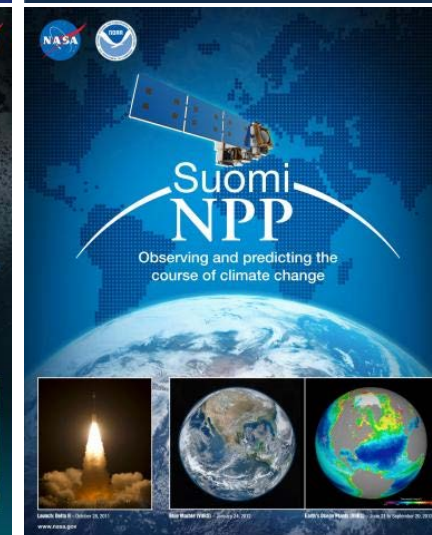


Satellites	Sensors	Resolution
Landsat 7	Enhanced Thematic Mapper (ETM+)	185 km swath; 15 m, 30 m, 60 m; 16 day revisit
Landsat 8	Operational Land Imager (OLI)	185 km swath; 15 m, 30 m, 60 m; 16 day revisit
Terra & Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	2330 km swath; 250 m, 500 m, 1 km; 1-2 day revisit
Suomi NPP	Visible Infrared Imaging Radiometer Suite (VIIRS)	3040 km swath; 375 m – 750 m; 1-2 day revisit
Sentinel 2A and 2B	Multi Spectral Imager (MSI)	290 km swath; 10 m, 20 m, 60 m; 5 day revisit
Sentinel 3A	Ocean and Land Color Instrument (OLCI)	1270 km swath; 300 m; 27 day revisit



# Current Satellite Missions for Water Quality Monitoring

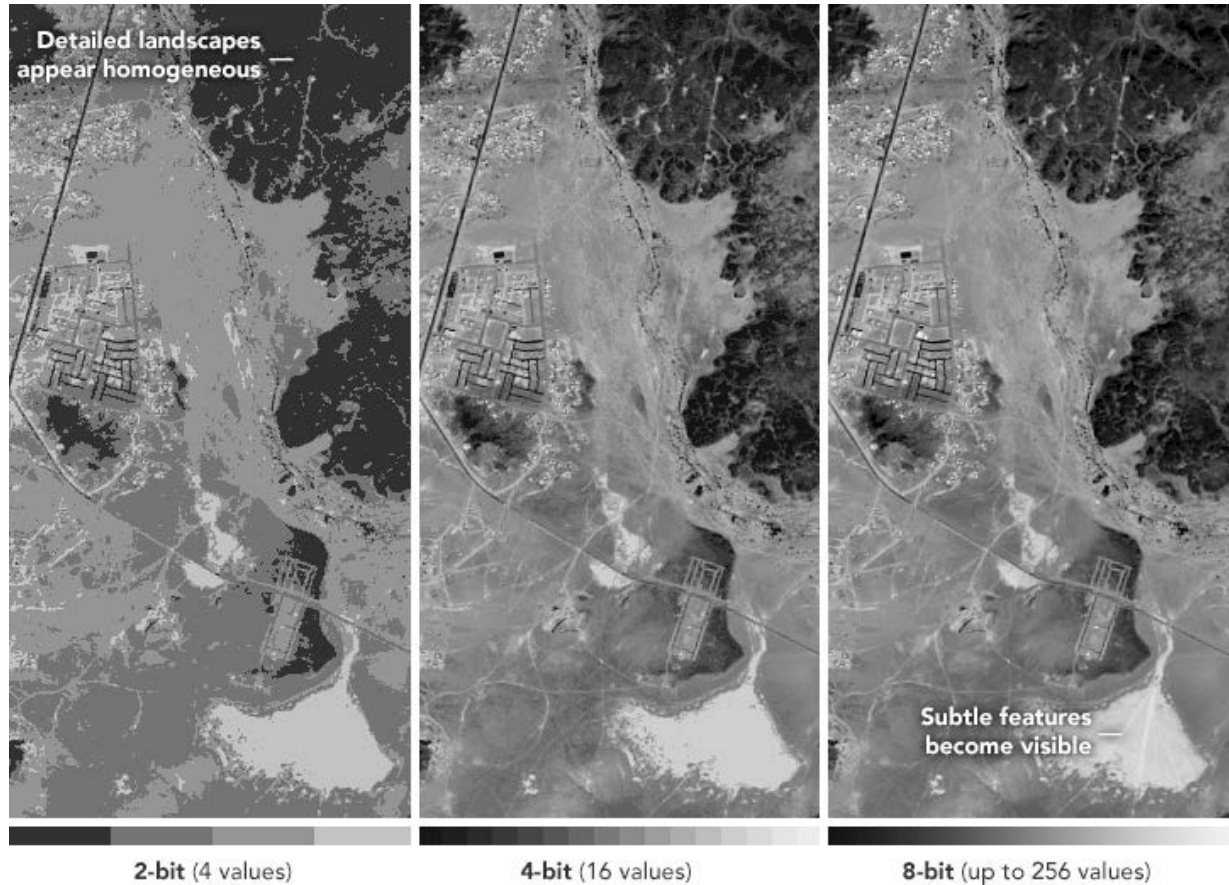
- Landsat 7 (4/15/1999 – present)
- Landsat 8 (2/1/2013 – present)
- Terra (12/18/1999 – present)
- Aqua (5/4/2002 – present)
- Suomi National Polar Partnership (SNPP) (11/21/2011 – present)
- Sentinel-2A (6/23/2015 - present)
- Sentinel-2B (3/7/2017 – present)
- Sentinel-3A (2/16/2016 – present)





# Radiometric Resolution & Signal to Noise Ratio (SNR)

- Radiometric resolution is the amount of information in a pixel
- Radiometric resolution is also dependent on the signal-to-noise ratio of the sensor
- In our tables, we use signal-to-noise (SNR) – the higher the SNR, the better for water



# Landsat 7 ETM+ Resolution

Band	Spectral Range (μm)	Spatial Resolution (m)	SNR
1	0.45 – 0.515	30	32
2	0.525 – 0.605		35
3	0.63 – 0.69		26
4	0.775 – 0.90		32
5	1.55 – 1.75		25
7	2.08 – 2.35		17
8	0.52 – 0.9		15

Temporal Resolution 16 Days

Credit: [eoPortal Directory](#)

# Landsat 8 OLI Resolution

Band	Spectral Range (μm)	Spatial Resolution (m)	SNR	
1	0.433 – 0.453	30	238	
2	0.450 – 0.515		364	
3	0.525 – 0.60		302	
4	0.630 – 0.680		227	
5	0.845 – 0.885		204	
6	2.10 – 2.30		265	
7	0.500 – 0.680		334	
8	2.08 – 2.35		15	149
9	1.36 – 1.39		30	165

Temporal Resolution 16 Days

# MODIS Resolution

Band	Spectral Range (μm)	Spatial Resolution (m)	SNR
8	0.405-0.420	1000	880
9	0.438-0.448		838
10	0.483-0.493		802
11	0.526-0.536		752
12	0.546-0.556		750
13	0.662-0.672		910
14	0.673-0.683		1087
15	0.743-0.753		586

Temporal Resolution 1- 2 Days

# VIIRS Resolution

Band	Spectral Range (μm)	Spatial Resolution (m)	SNR
M1	0.402-0.422	750	352
M2	0.436-0.454		380
M3	0.478-0.488		416
M4	0.545-0.565		362
M5	0.662-0.682		342
M6	0.739-0.745		199

Temporal Resolution 1- 2 Days

Credit: [STAR JPSS](#)



# Sentinel-2A MSI Resolution

Band	Central Wavelength (nm)	Spatial Resolution (m)	SNR
1	442.7	60	129
2	492.4	10	154
3	559.8	10	168
4	664.6	10	142
5	704.1	20	117
6	740.5		89

Band	Central Wavelength (nm)	Spatial Resolution (m)	SNR
7	782.8	20	105
8	832.8	10	174
8a	864.7	20	72
9	945.1	60	114
10	1373.5		50
11	1613.7	20	100
12	2202.4		100

Temporal Resolution 5 – 7 Days

# Sentinel-3 OLCI Resolution

Band	Central Wavelength (nm)	Spatial Resolution (m)	SNR
Oa1	400	300 & 1200	2420
Oa2	412.5		2398
Oa3	442.5		2161
Oa4	490		200
Oa5	510		1979
Oa6	560		1776
Oa7	620		1591
Oa8	665		1547
Oa9	673.75		1329
Oa10	681.25		1320
Oa11	708.75		1420

Band	Central Wavelength (nm)	Spatial Resolution (m)	SNR
Oa12	753.75	300 & 1200	1127
Oa13	761.25		502
Oa14	764.375		663
Oa15	767.5		558
Oa16	778.75		1514
Oa17	865		1243
Oa18	885		823
Oa19	900		691
Oa20	940		535
Oa21	1020		346

Temporal Resolution 27 Days



## Examples of Water Quality Monitoring Programs

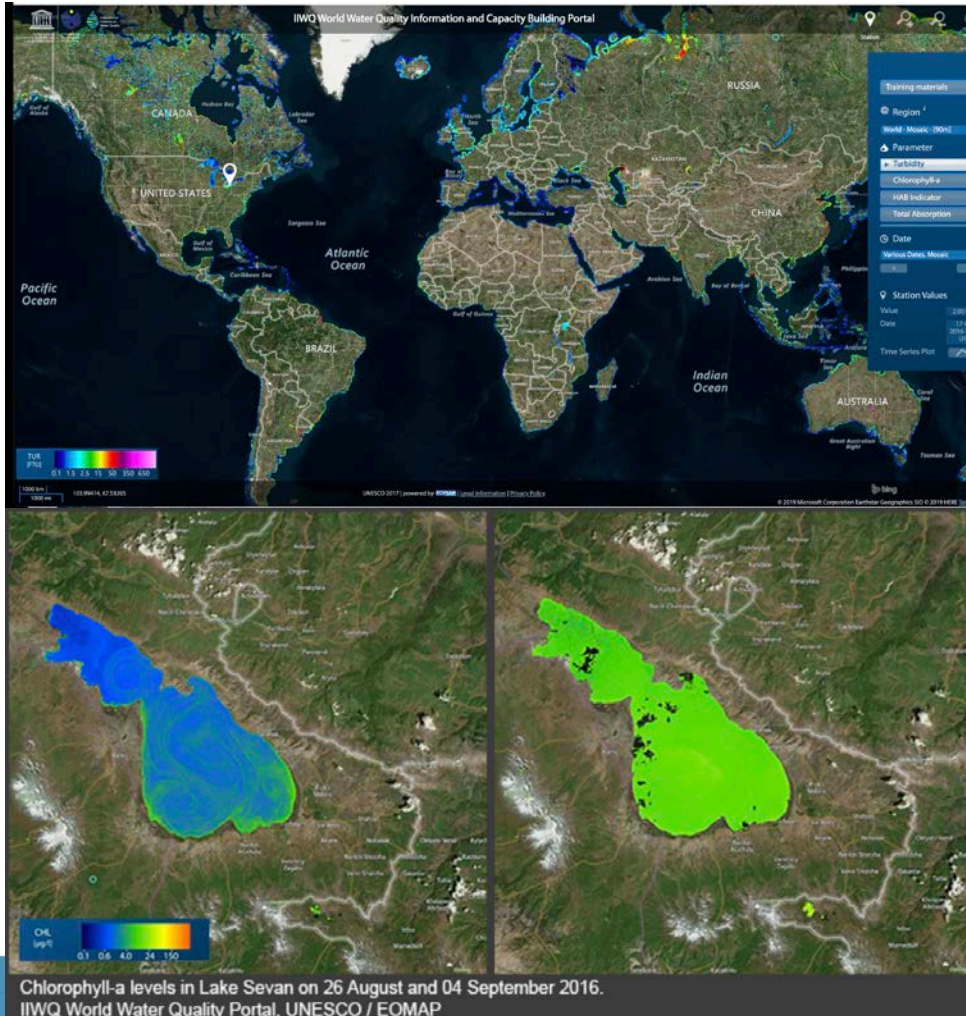


# Water Quality Monitoring Program Examples

- UNESCO
  - Water Quality Information and Capacity Building Portal
- European Space Agency (ESA)
  - Earth Observation for Sustainable Development: Water Quality Monitoring
- Finnish Environment Institute
  - Monitoring Water Quality in Baltic Seas and Finnish Lakes
- UN-SPIDER Knowledge Portal
- Florida Fish & Wildlife Conservation Commission
  - Evaluating Suwannee River Discharge Effects on Water Quality in Big Bend Region

# UNESCO Water Quality Information & Capacity Building Portal

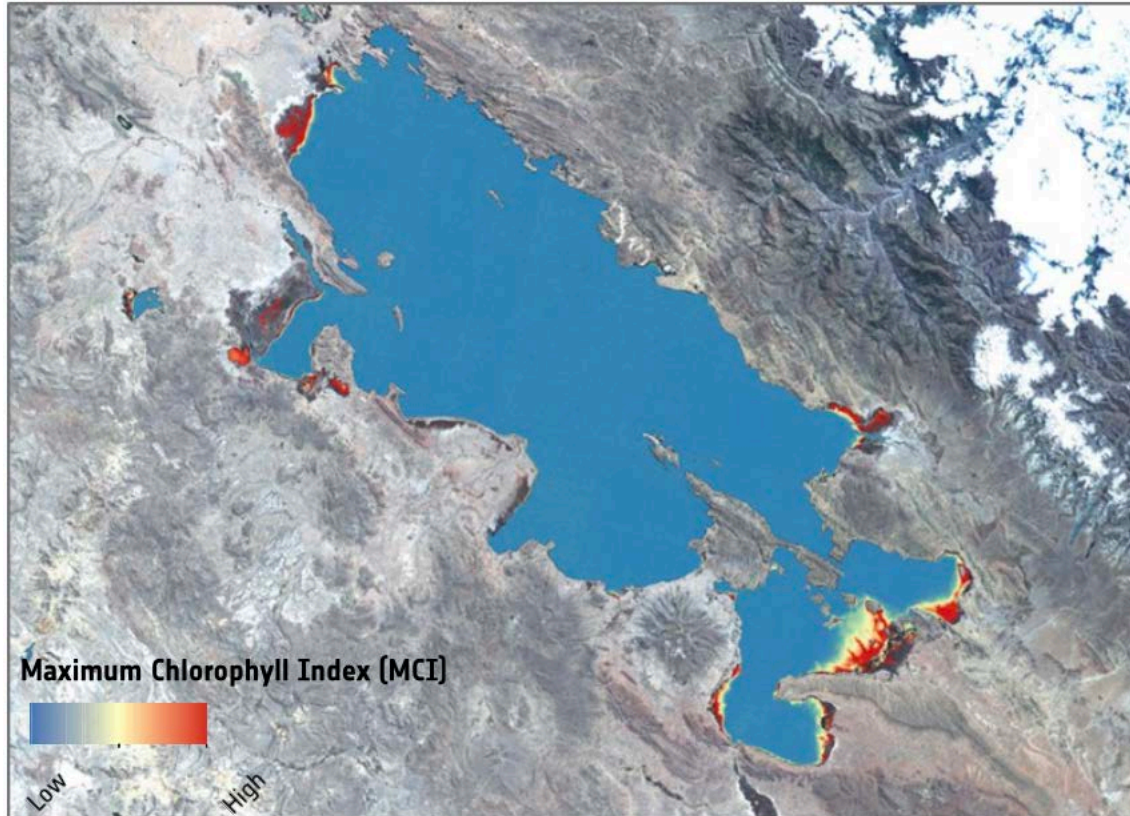
<http://www.worldwaterquality.org/>



- A portal based on optical data from Landsat and Sentinel-2 satellites, and a computational system, developed by EOMAP, Germany
- Provides Turbidity, Chlorophyll-a, HAB Indicator, Total Absorption, Surface Temperature

# Earth Observation for Sustainable Development: WQ Monitoring

<http://eo4sd-water.net/portfolio/product/water-quality-monitoring>



Example of a chl map derived from satellite data in 10m resolution over Lake Titicaca on the border of Bolivia & Peru. © Copernicus Sentinel data/DHI GRAS

- Planned by European Space Agency
- Will Monitor Chlorophyll concentrations, Total Suspended Matter (TSM), and water temperature from satellite observations
- Will use Sentinel-2 MSI and Sentinel-3 OLCI data, and Landsat8 OLI data

# Monitoring Water Quality in Baltic Seas and Finnish Lakes

<http://bit.ly/2LwYIhd>

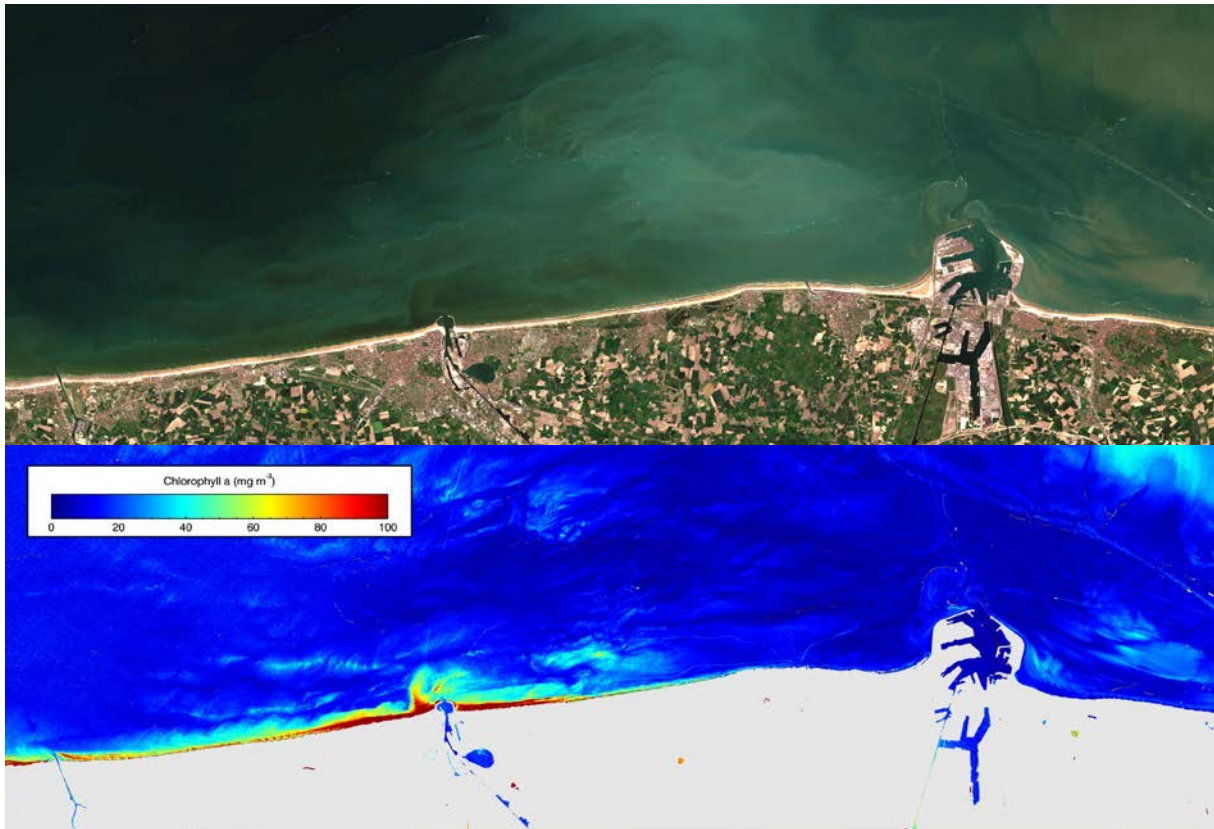


Sentinel-2 satellite image from 27/8/2016, the west coast of Finland. ESA Sentinel Program, processed by SKYE.

- A program by Finnish Environment Institute
- Utilization of data from Sentinel series of satellites and Landsat to monitor
  - chlorophyll a
  - Turbidity
  - Colored Dissolved Organic Matter (CDOM)
  - Secchi disk depth

# UN-SPIDER Knowledge Portal

<http://www.un-spider.org/links-and-resources/data-sources/daotm-water-quality>



- Provides an overview of satellites, sensors, and spectral bands used for water quality monitoring

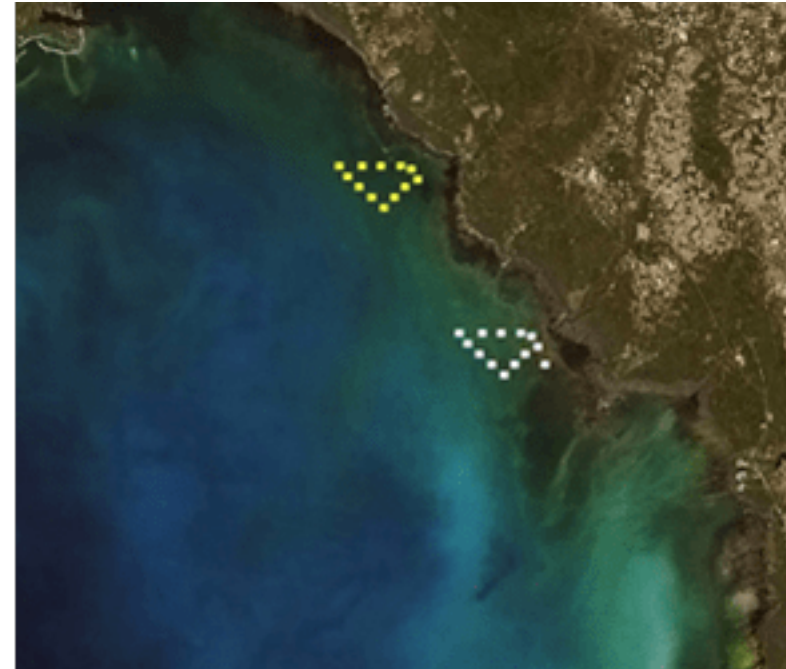
Algal bloom close to Belgium's coast. Captured by Sentinel-2A on 1 May 2016. Images contain modified Copernicus Sentinel data (2016) processed by RBINS

# Evaluating Suwannee River Discharge Effects on Water Quality in Big Bend Region

- A study to link water quality to suitable habitat for seagrasses using in situ observations of nutrient load and other optical properties and remotely sensed imagery
- Build a regional algorithm for water quality parameters like water transparency, CDOM, chlorophyll, turbidity
- Relate historical seagrass distribution and abundance data to imagery-derived water quality parameters



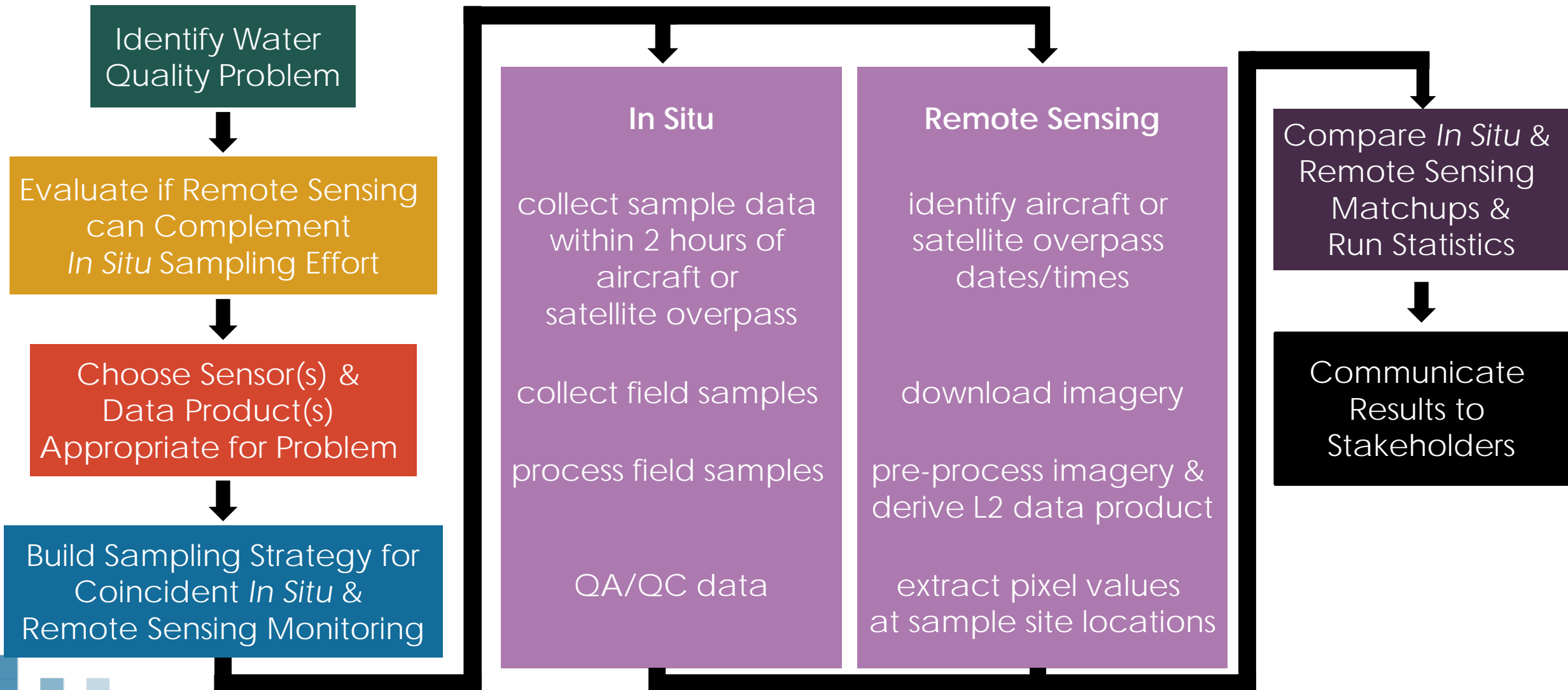
**Florida Fish and Wildlife  
Conservation Commission**



MODIS satellite image showing sampling sites near the mouths of the Suwannee (white) and Steinhatchee (yellow) rivers.

Credit: [Florida Fish & Wildlife Conservation Commission](#)

# Water Quality Monitoring Program Workflow





## Exercise: Basic Skills in SeaDAS





## Demonstration of MODIS & Landsat 8 OLI Image Data Access

# NASA Earth Observatory - A Blackwater River Meets the Sea

- The Suwannee River, a naturally occurring “blackwater river”, has its headwaters in boggy Okefenokee Swamp (Georgia, USA)
- It flows through Florida (USA) and drains into the Gulf of Mexico
- Its tannin- and lignin- rich water is dark brown from the colored dissolved organic matter
- When it meets the Gulf, the contrast in color is stark



Credit: [Earth Observatory](#)

# Download Satellite Imagery

- **Location:** Western Florida, USA & Gulf of Mexico

- **Boundary Coordinates:**

29  
-84            81  
25

- **Date:** 20 February 2015

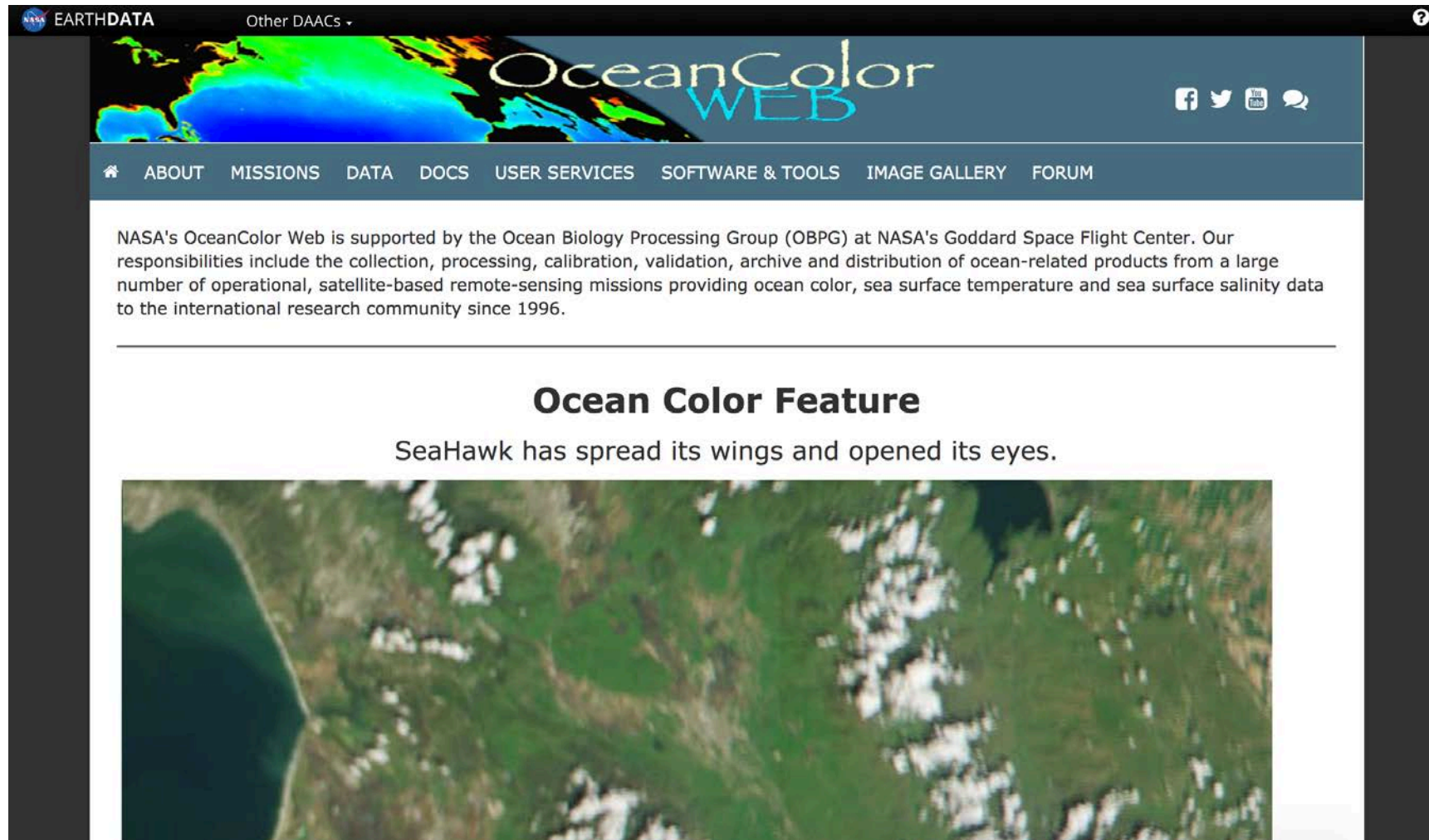
- **Sensors:**

- Aqua (MODIS)
- Landsat 8 OLI



# NASA OceanColor Web

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



**EARTHDATA** Other DAACs

## OceanColor WEB


Facebook Twitter YouTube

HOME ABOUT MISSIONS DATA DOCS USER SERVICES SOFTWARE & TOOLS IMAGE GALLERY FORUM

NASA's OceanColor Web is supported by the Ocean Biology Processing Group (OBPG) at NASA's Goddard Space Flight Center. Our responsibilities include the collection, processing, calibration, validation, archive and distribution of ocean-related products from a large number of operational, satellite-based remote-sensing missions providing ocean color, sea surface temperature and sea surface salinity data to the international research community since 1996.

### Ocean Color Feature

SeaHawk has spread its wings and opened its eyes.



# NASA OceanColor Web

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

**DATA**

- Overview
- Direct Data Access
- Data File Search
- Data Subscription
- OPeNDAP
- SeaBASS Field Data
  - Search
  - Browse
  - Submit
- How to Cite
- Other Resources

**Data Browsers**

- Level 1&2 Browser
- Level 3 Browser

**Quality Assessment**

- Product Validation
- Global L3 Trends
- Level-3 Time Series Plotter

**Overpass Predictor**

**OceanColor Forum**

# NASA OBPG Level 1 & 2 Browser for MODIS Imagery

<https://oceancolor.gsfc.nasa.gov/cgi/browse.pl?sen=am>

▲ ◀ ▶ TC **CHL** SBT SSTA

Comment

Help

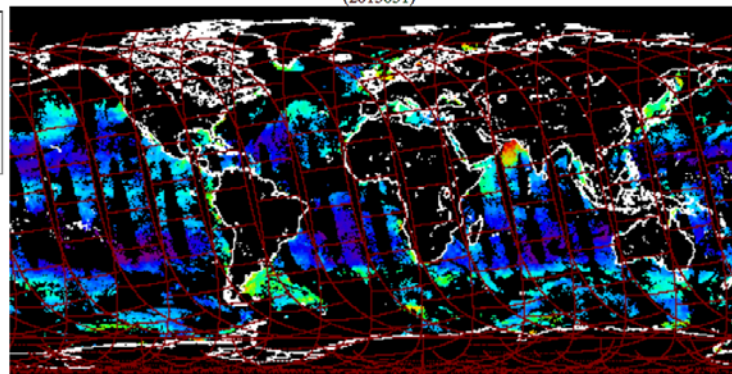
SeaWiFS <input type="checkbox"/> GAC <input type="checkbox"/> MLAC	MODIS <input checked="" type="checkbox"/> Aqua <input type="checkbox"/> Terra	VIIRS <input type="checkbox"/> Suomi-NPP <input type="checkbox"/> JPSS1	MERIS <input type="checkbox"/> RR <input type="checkbox"/> FRS	Select <input checked="" type="checkbox"/> Day <input type="checkbox"/> Night
OLCI (Sentinel-3A) <input type="checkbox"/>	OCTS (ADEOS) <input type="checkbox"/>	HICO (ISS) <input type="checkbox"/>	GOCI (COMS) <input type="checkbox"/>	

Radius (km) about map click or about typed-in location: Select swaths containing (at least):

72  
 400  
 800  
 1200  
 1500

any part  
 25 %  
 50 %  
 75 %  
 all

Select only scenes having in situ matchups.



Friday, 20 February 2015  
(2015051)

Chlorophyll

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: 29  
 W: -85 -81 :E  
 S: 25

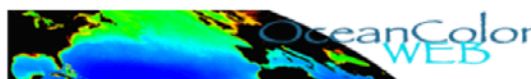
Click on:  
MODIS Aqua  
Feb 2015  
February 20  
& enter  
Boundary  
Coordinates

Display results 10 at a time.

Reconfigure page

	2015													
	January				February				March					
	S	M	T	W	T	F	S	S	M	T	W	T	F	S
2002														
2003														
2004														
2005														
2006														
2007														
2008														
2009														
2010														
2011														
2012														
2013														
2014														
2015														
2016														
2017														
2018														
2019														

Click on  
"Find Swaths"  
After Selecting  
Options



gene carl feldman (gene.c.feldman@nasa.gov) (301) 286-9428

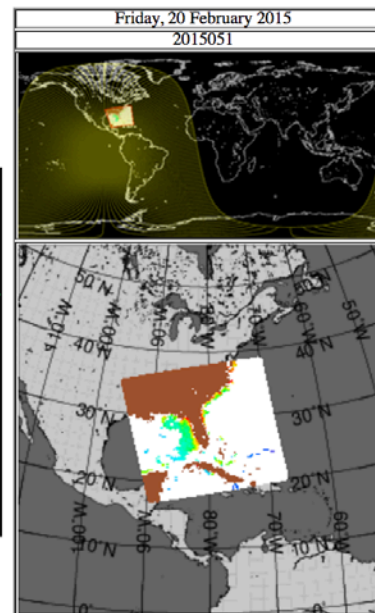
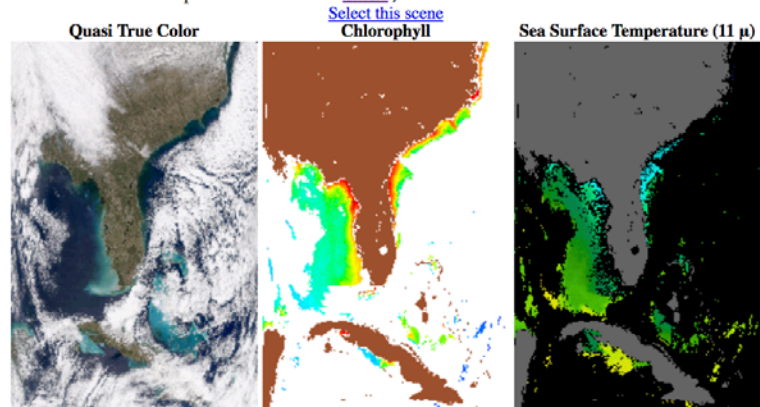


# NASA OBPG Level 1 & 2 Browser Search Results

TC SST

[A2015051184000.L0\\_LAC](#) 244,429,948 bytes  
[A2015051184000.L1A\\_LAC](#) 238,353,367 bytes  
[A2015051184000.L2\\_LAC\\_OC.nc](#) 47,342,390 bytes  
[A2015051184000.L2\\_LAC\\_IOP.nc](#) 54,601,840 bytes  
[A2015051184000.L2\\_LAC\\_SST](#) 25,063,922 bytes

(The above hyperlinks point to [compressed files](#).  
Documentation on these products can be found [HERE](#).)



Search Criteria  
Time Period: Friday, 20 February 2015 (daytime)  
Sensors: Aqua  
Area of Interest: region bounded by 29.0N and 25.0N and 85.0W and 81.0W



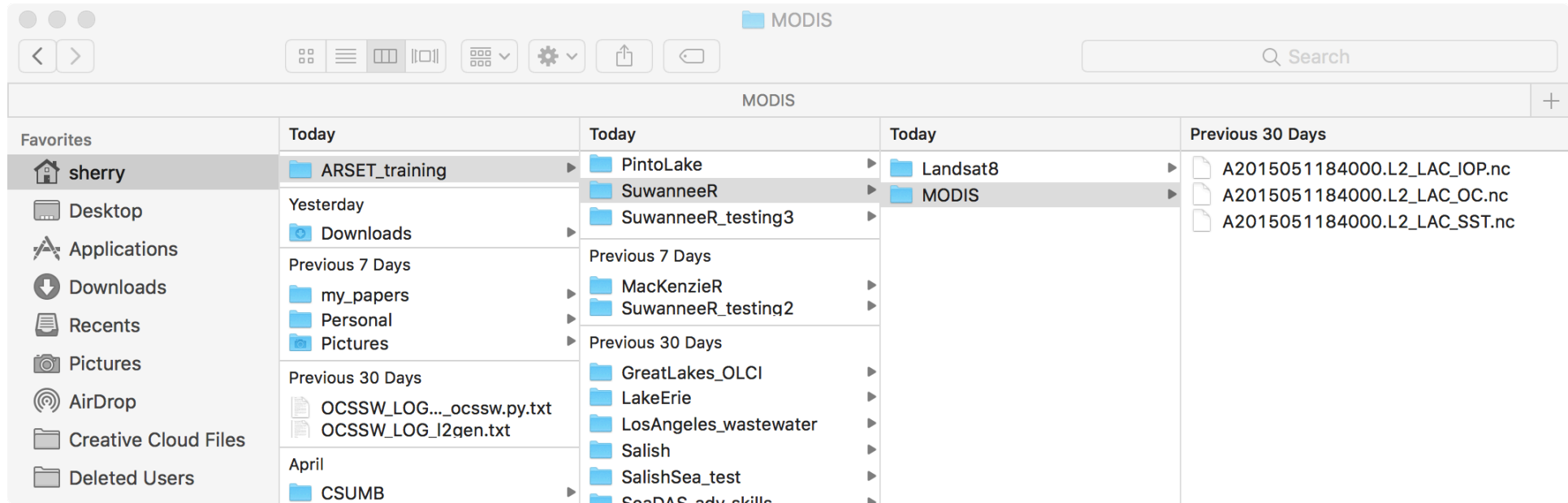
Percentage of AOI that swaths must include: 0

Number of swaths: 1 swath found

Click on

[A2015051184000.L2\\_LAC\\_OC.nc](#)  
[A2015051184000.L2\\_LAC\\_IOP.nc](#)  
[A2015051184000.L2\\_LAC\\_SST.nc](#)  
to begin downloading image files

# Save Files to a Meaningful Location





# Find and Download the Landsat 8 OLI Imagery

<https://earthexplorer.usgs.gov/>

Set up  
a free  
account  
and  
log in

The screenshot displays the USGS EarthExplorer homepage. The top navigation bar includes the USGS logo, the text "EarthExplorer - Home", and a page expiration timer. Below the navigation bar, there are tabs for "Search Criteria", "Data Sets", "Additional Criteria", and "Results". The "Search Criteria" tab is active, showing a search form with the following sections:

- 1. Enter Search Criteria:** Instructions to narrow the search area by address, coordinates, or map.
- Address/Place:** A text input field containing "suwanee, fl" with "Show" and "Clear" buttons.
- Coordinates:** A section with "Predefined Area", "Shapefile", and "KML" tabs. The "Degree/Minute/Second" tab is selected, showing "1. Lat: 29° 19' 43" N, Lon: 083° 08' 39" W" with "Use Map", "Add Coordinate", and "Clear Coordinates" buttons.
- Date Range:** A section with "Date Range" and "Result Options" tabs. The "Date Range" tab is selected, showing "Search from: 02/01/2015" to "02/28/2015" and "Search months: (all)".

On the right side of the search form, there is a "Search Criteria Summary (Show)" section with a "Clear Criteria" button. Below this is a map interface with "Map" and "Satellite" tabs. The "Satellite" tab is active, showing a satellite view of the United States with a red location pin in the Southeast. A tooltip above the pin displays the coordinates "(52° 55' 57" N, 029° 39' 10" W)" and "Options" and "Overlays" buttons.

# Find and Download Landsat 8 OLI Imagery











<https://earthexplorer.usgs.gov/>

## 2. Select Your Data Set(s)

Check the boxes for the data set(s) you want to search. When done selecting data set(s), click the *Additional Criteria* or *Results* buttons below. Click the plus sign next to the category name to show a list of data sets.

Use Data Set Prefilter ([What's This?](#))


Data Set Search:

- EO-1
  - Global Fiducials
  - HCMM
  - ISERV
  - Land Cover
  - Landsat 
    - Landsat Collection 1 Level-3
    - Landsat Analysis Ready Data (ARD)
    - Landsat Collection 1 Level-2 (On-Demand) 
    - Landsat Collection 1 Level-1
      -   Landsat 8 OLI/TIRS C1 Level-1
      -   Landsat 7 ETM+ C1 Level-1
      -   Landsat 4-5 TM C1 Level-1
      -   Landsat 1-5 MSS C1 Level-1
    - Landsat Legacy

## 3. Additional Criteria (Optional)

If you have more than one data sets selected, use the dropdown to select the additional criteria for each data set.

Data Sets:

Landsat 8 OLI/TIRS C1 Level-1 

### Day/Night Indicator

All  
Day  
Night

### Sun Elevation

to

### Date L-1 Generated (Ex. YYYY/MM/DD)

to

### Geometric RMSE Model (meters)

to

### Nadir/Off Nadir

All  
Nadir  
Off Nadir

### Landsat Scene Identifier (Legacy)

Search Criteria


Data Sets

Additional Criteria


Results


## 4. Search Results

If you selected more than one data set to search, use the dropdown to see the search results for each specific data set.

Show Result Controls 

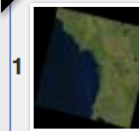
Data Set

[Click here to export your results](#) 

Landsat 8 OLI/TIRS C1 Level-1 

« First < Previous 1  Next > Last »

Displaying 1 - 2 of 2 



1

ID:LC08\_L1TP\_017040\_20150220\_20170301\_01\_T1  
Acquisition Date:20-FEB-15  
Path:17  
Row:40



2

ID:LC08\_L1TP\_017040\_20150204\_20170302\_01\_T1  
Acquisition Date:04-FEB-15  
Path:17  
Row:40



« First < Previous 1  Next > Last »

# Find and Download Landsat 8 OLI Imagery

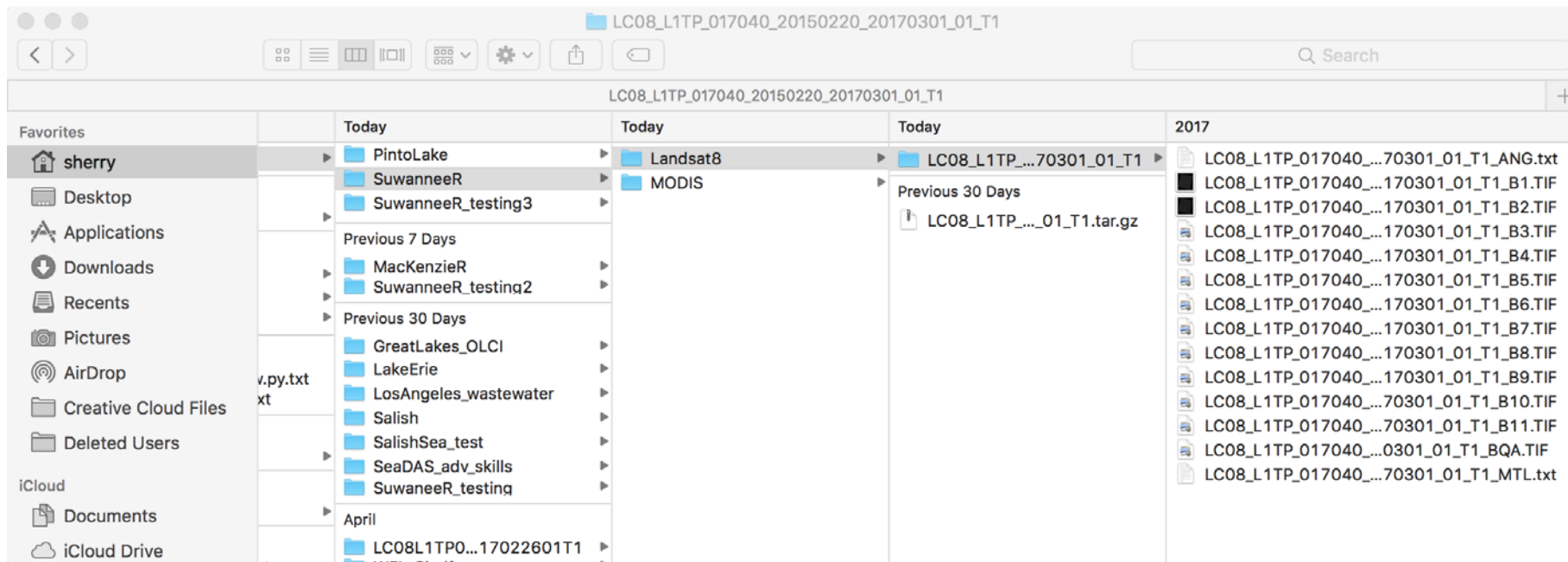
<https://earthexplorer.usgs.gov/>

The screenshot displays the Earth Explorer USGS interface. At the top, there are tabs for 'Search Criteria', 'Data Sets', 'Additional Criteria', and 'Results'. Below these, a '4. Search Results' section provides instructions and a 'Show Result Controls' dropdown. The 'Data Set' section lists 'Landsat 8 OLI/TIRS C1 Level-1'. Two data sets are shown, each with a thumbnail and metadata (ID, Acquisition Date, Path, Row). A 'Download Options' dialog box is overlaid on the right, listing five download options with their file sizes. The 'Level-1 GeoTIFF Data Product (822.3 MB)' option is circled in red. The background shows a satellite map of the Jacksonville, Florida area with a search criteria summary and a 'Clear Criteria' button.

Download Option	File Size
Download LandsatLook Natural Color Image	6.3 MB
Download LandsatLook Thermal Image	2.5 MB
Download LandsatLook Quality Image	398.2 KB
Download LandsatLook Images with Geographic Reference	9.2 MB
Download Level-1 GeoTIFF Data Product	822.3 MB

# Extract and Save Files to a Meaningful Location

(not too deep in your directory structure)





## Exercise: Basic Skills in SeaDAS