

ARSET

Applied Remote Sensing Training

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

 @NASAARSET

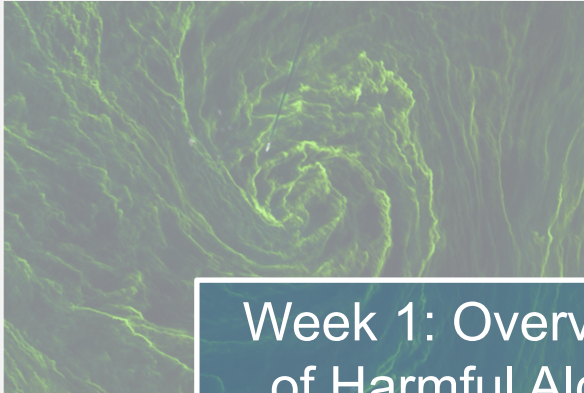
Platforms and Sensors for Ocean Observations, Data Access, and Processing Tools

Week 2, September 12, 2017

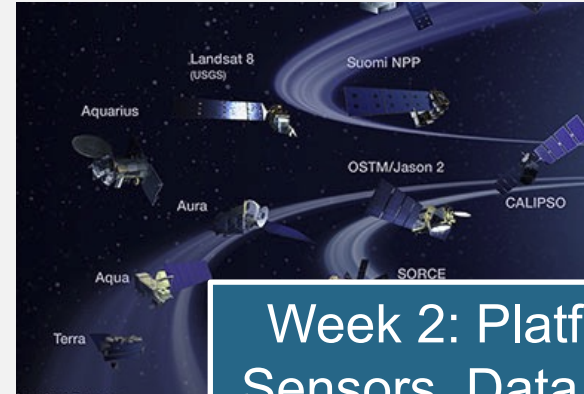
Trainers: Sherry Palacios

Amita Mehta

Course Outline



Week 1: Overview
of Harmful Algal
Blooms

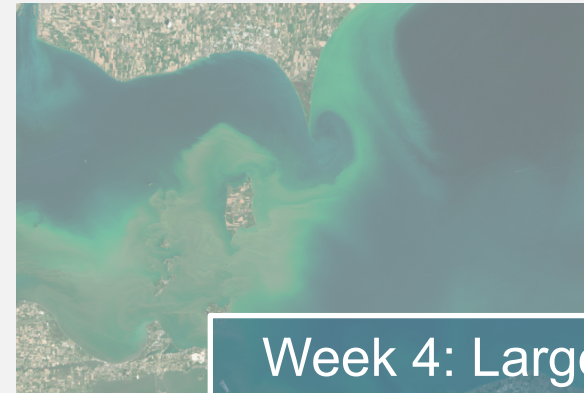


Week 2: Platforms &
Sensors, Data Access,
and Processing



Week 3: HABs in
the Coastal
Environment

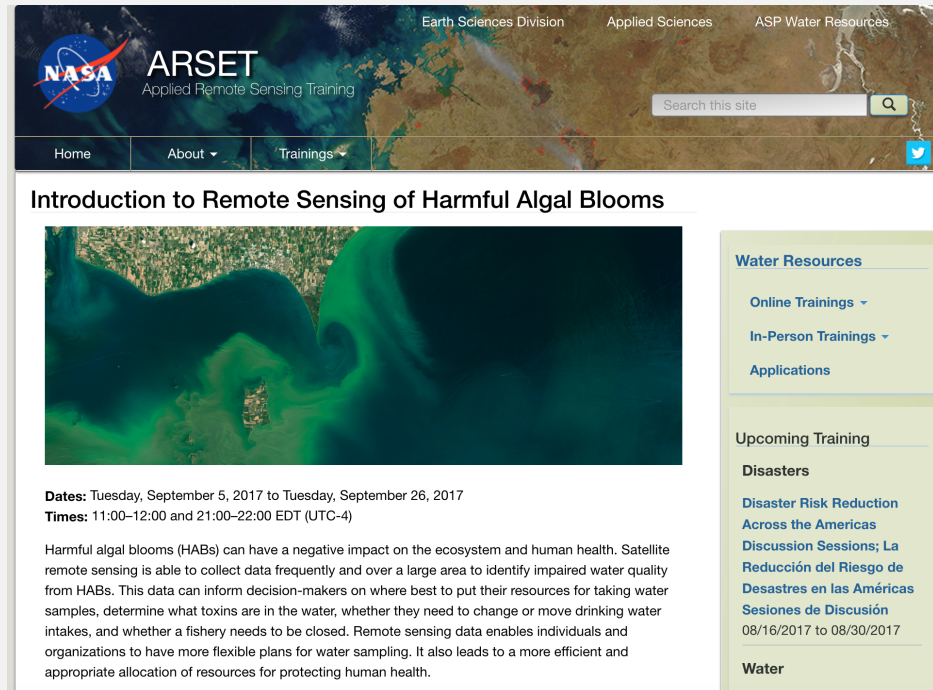
Credit: Paul
Hillman/NOAA



Week 4: Large Scale
Monitoring

Course Material

Webinar recordings, presentations, in class exercises, and homework are available at: <https://arset.gsfc.nasa.gov/water/webinars/HABs17>



The screenshot shows the ARSET (Applied Remote Sensing Training) website. The header includes the NASA logo, 'ARSET Applied Remote Sensing Training', and navigation links for 'Home', 'About', and 'Trainings'. A search bar is also present. The main content area features a satellite image of a coastal area with a large green algal bloom. Below the image, the course title 'Introduction to Remote Sensing of Harmful Algal Blooms' is displayed. The dates are 'Tuesday, September 5, 2017 to Tuesday, September 26, 2017' and the times are '11:00-12:00 and 21:00-22:00 EDT (UTC-4)'. A paragraph of text describes the impact of Harmful Algal Blooms (HABs) and how satellite remote sensing can be used to monitor and manage them. On the right side of the page, there are navigation menus for 'Water Resources' (including Online Trainings, In-Person Trainings, and Applications), 'Upcoming Training' (listing 'Disasters' and 'Disaster Risk Reduction Across the Americas Discussion Sessions; La Reducción del Riesgo de Desastres en las Américas Sesiones de Discusión' from 08/16/2017 to 08/30/2017), and 'Water'.

Learning Objectives:

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

- identify NASA's Earth Science remote sensing data products for the identification and monitoring of HABs
- describe how coupled remote sensing and modeling approaches are used in decision support tools
- use a selection of NASA Earth Science data tools to monitor HABs

Course Format:

- Four, one hour sessions
- Sessions will be held on Tuesdays in September: September 5, 12, 19, and 26 at 11:00 a.m. -12:00 p.m. or 21:00-22:00 p.m. EDT (UTC-4)
 - [Convert to your local time »](#)
- A certificate of completion will be provided to participants that attend all live webinars and complete all homework assignments

Prerequisites:

Complete [Session 2C: Fundamentals of Aquatic Remote Sensing](#) or have equivalent experience. Attendees that do not complete prerequisites may not be properly prepared for the pace during the training.

Audience:

Local, regional, state, federal, and international organizations interested in using satellite imagery for coastal and ocean applications. Governmental and non-governmental organizations in the public and private sectors engaged in environmental management and monitoring will be given preference over organizations focused primarily on research.

Registration Information:

There is no cost for the webinar, but you must register. Space is limited, and preference will be given to...

Introduction to Remote Sensing of Harmful Algal Blooms

09/05/2017 to 09/26/2017

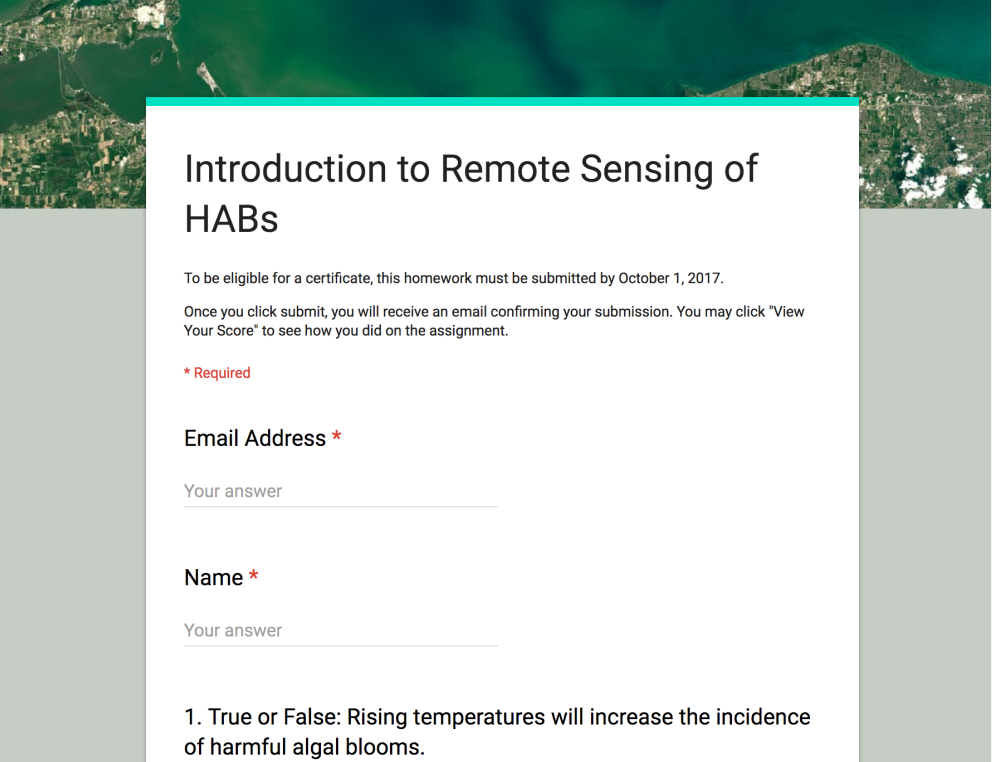
Land

Introduction to Remote Sensing for Scenario-Based Ecoforecasting

09/07/2017 to 09/28/2017

Homework and Certificates

- Homework
 - **Answers must be submitted via Google Form**
- Certificate of Completion:
 - Attend all webinars
 - Complete homework assignments by the deadline (access from ARSET website)
 - **HW Deadline: August 2nd**
 - You will receive certificates approx. two months after the completion of the course from: marines.martins@ssaihq.com



The image shows a screenshot of a Google Form titled "Introduction to Remote Sensing of HABs". The form is set against a background of a satellite-style map of a coastal area. The text on the form includes instructions on submission deadlines and email confirmation, followed by two required input fields: "Email Address" and "Name". At the bottom, a question is partially visible: "1. True or False: Rising temperatures will increase the incidence of harmful algal blooms."

Introduction to Remote Sensing of HABs

To be eligible for a certificate, this homework must be submitted by October 1, 2017.

Once you click submit, you will receive an email confirming your submission. You may click "View Your Score" to see how you did on the assignment.

*** Required**

Email Address *

Your answer

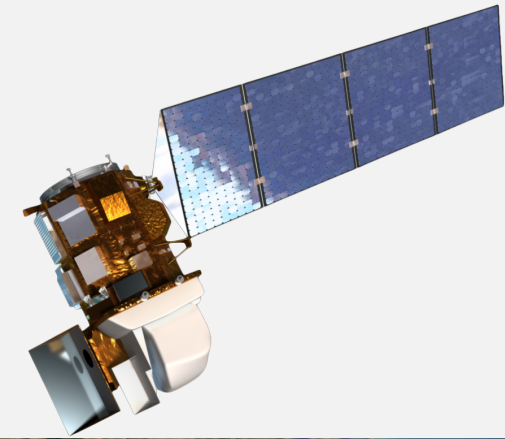
Name *

Your answer

1. True or False: Rising temperatures will increase the incidence of harmful algal blooms.

Outline: Session 2

- Week 1 Review
- HAB Detection Using Remote Sensing
- Overview of Satellites and Sensors for Monitoring HABs
- Overview of Satellite-Based Ocean Color Data Access Tools
- Examples of HAB Monitoring Tools



A Landsat 8 image acquired on Aug. 1, 2014 showing algal blooms in Lake Erie just north of Toledo, Ohio.

Image credit: USGS/[NASA Earth Observatory](#)

An aerial photograph of a river delta, likely the Mississippi River delta, showing a complex network of channels and distributaries. The water is a deep blue-green color. The surrounding land is a patchwork of green and brown fields, with some urban areas visible. A semi-transparent grey rectangle is overlaid on the center of the image, containing the text 'Week 1 Review' and a horizontal line below it.

Week 1 Review

What is a Harmful Algal Bloom?

“Harmful algal blooms, or HABs, occur when colonies of algae — simple plants that live in the sea and freshwater — grow out of control and produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds. The human illnesses caused by HABs, though rare, can be debilitating or even fatal.”

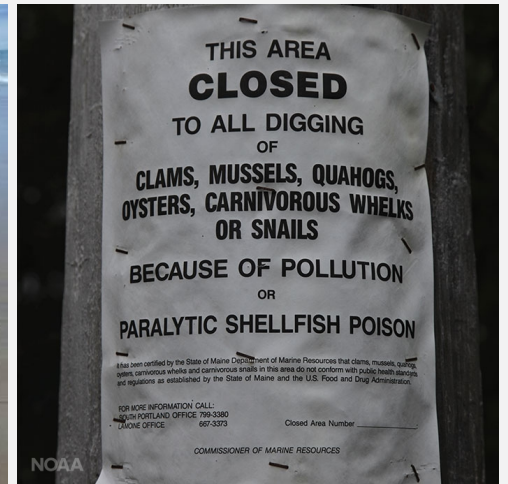
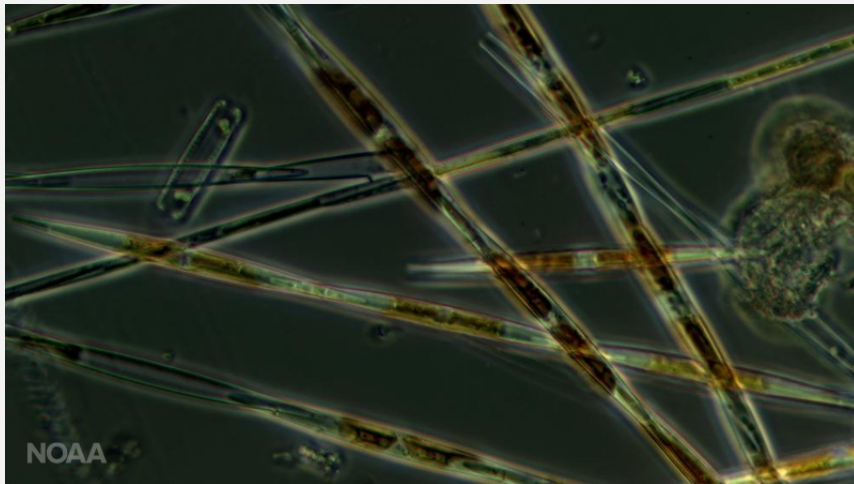


Image credit: <http://www.noaa.gov/what-is-harmful-algal-bloom>

How HABs Can Be Harmful

- Produce toxins
- Cause economic losses
- Impair drinking water
- Smother benthic organisms
- Deplete oxygen
- Impede visual predators
- Attenuate light to benthic submerged aquatic vegetation or corals

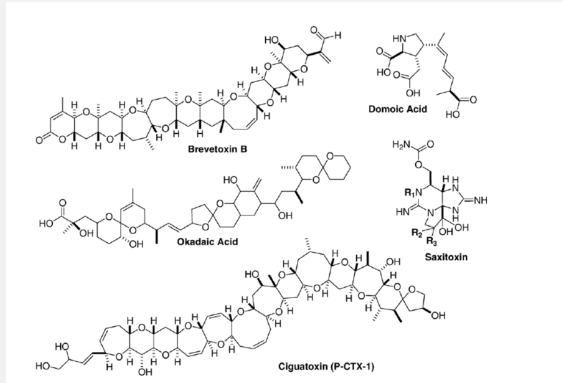


Photo Credits (clockwise from top left) Karina Cardozo (Cardozo et al., 2007); NASA Earth Observatory; NOAA Northwest Fisheries Science Center; Linda Preskitt

What Causes HABs?

- Nutrient loading “eutrophication”
- Pollution
- Warm water
- Food web changes
- Introduced species
- Changes in water flow
 - e.g., after major events like hurricanes, drought, or floods
- Other, yet unknown, factors

Optical Properties of HABs

- Some HAB species have unique properties that affect their optics – and therefore the remote sensing of blooms (e.g., *Microcystis aeruginosa* and *Karenia brevis*)
- HABs can sometimes change the color of the water (e.g., red tides), but not all red tides are harmful and not all harmful blooms discolor the water
- Chlorophyll anomalies can be used to detect and monitor HAB events for blooms that produce high biomass

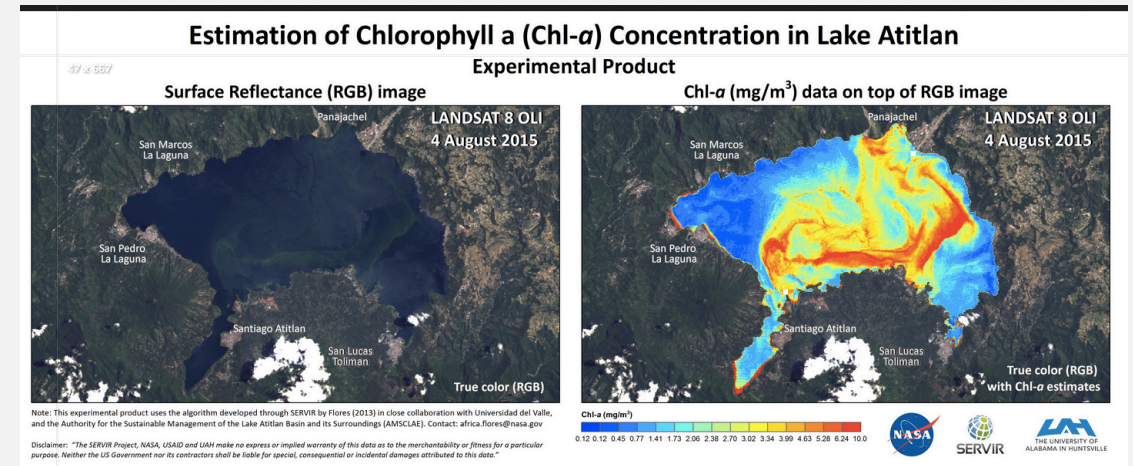


HAB Detection Using Remote Sensing

Parameters Relevant for HAB Detection

- The following parameters, available from remote sensing observations, are commonly used to detect the presence of algal blooms:
 - Chlorophyll-a Concentration (Chl-a)
 - Chlorophyll-a Concentration Anomalies*
 - Sea Surface Temperature (SST)
 - Optical Characteristics (absorption, backscattering)

*Usually taken with respect to 2-3 months means Chl-a can help detect new HABs



Source: [SERVIR](#)

Remote Sensing for HAB Detection

- Reflected solar radiation in various visible to near-infrared (NIR) bands are used to derive the properties of optically-active water constituents, including Chl-a

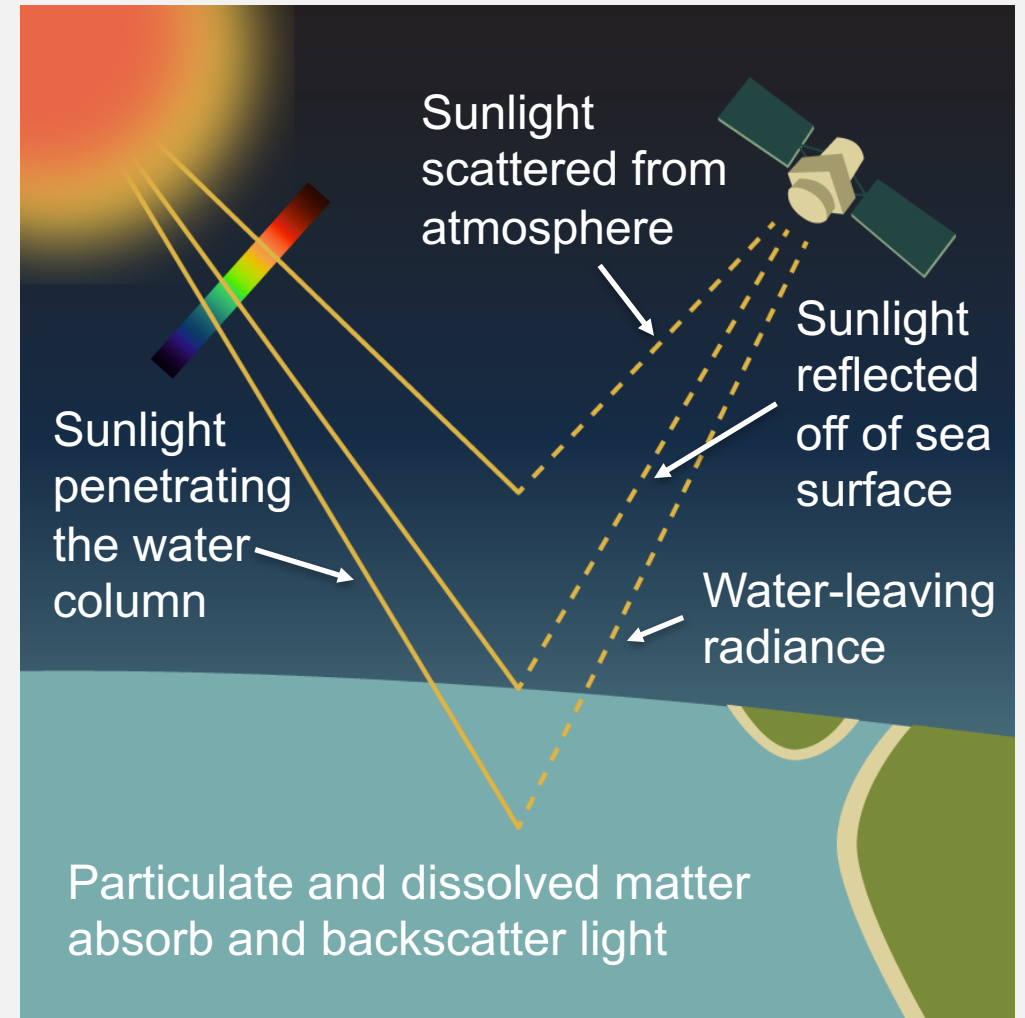
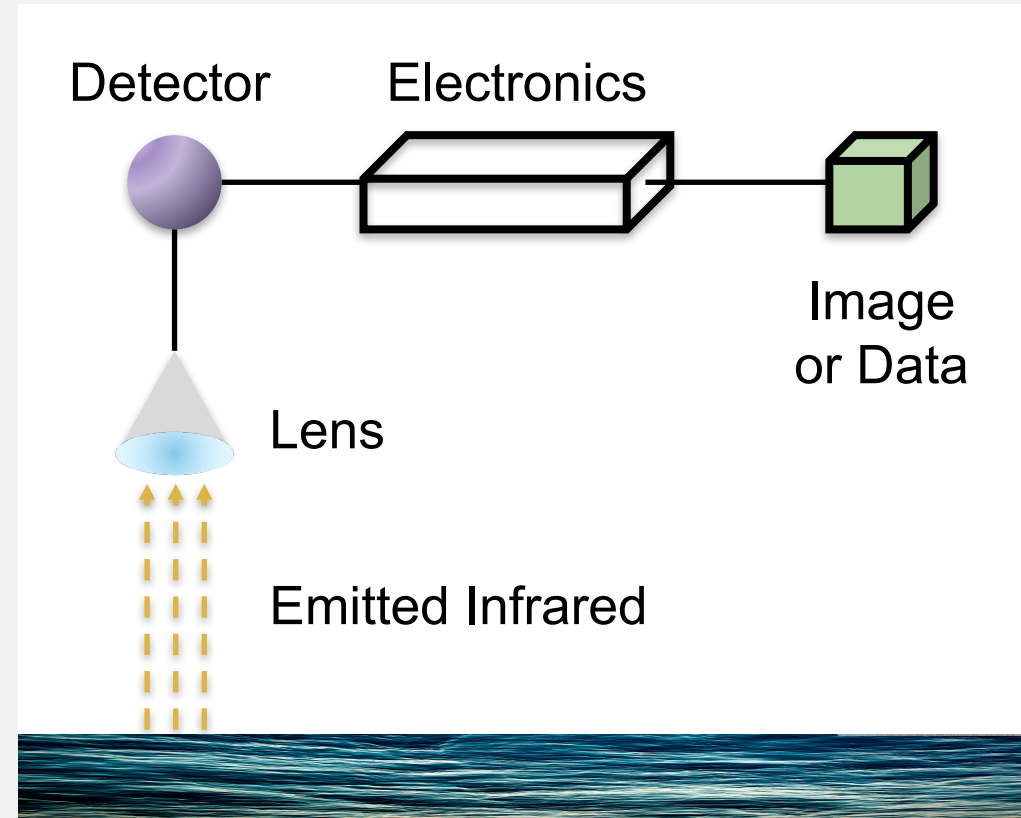


Image based on image from X

Remote Sensing for HAB Detection

- Emitted thermal infrared radiation (TIR) is used to derive surface temperature of water bodies
- A number of NASA & European Space Agency (ESA) satellites carry sensors that measure reflected radiation in VIS-NIR (band reflectance) and emitted TIR



Based on an image from CCRS/CCT

A satellite image of a coastal region. The top half shows a large body of water, likely a bay or estuary, with a prominent river or inlet flowing into it from the top center. The surrounding land is a mix of urban development (dense grid patterns) and agricultural fields (patchwork of green and brown). The bottom half of the image shows a large, bright green area, possibly a mangrove wetland or a large body of water with high chlorophyll content. A semi-transparent grey box is overlaid on the center of the image, containing the title text.

Overview of Satellites and Sensors for Monitoring HAB

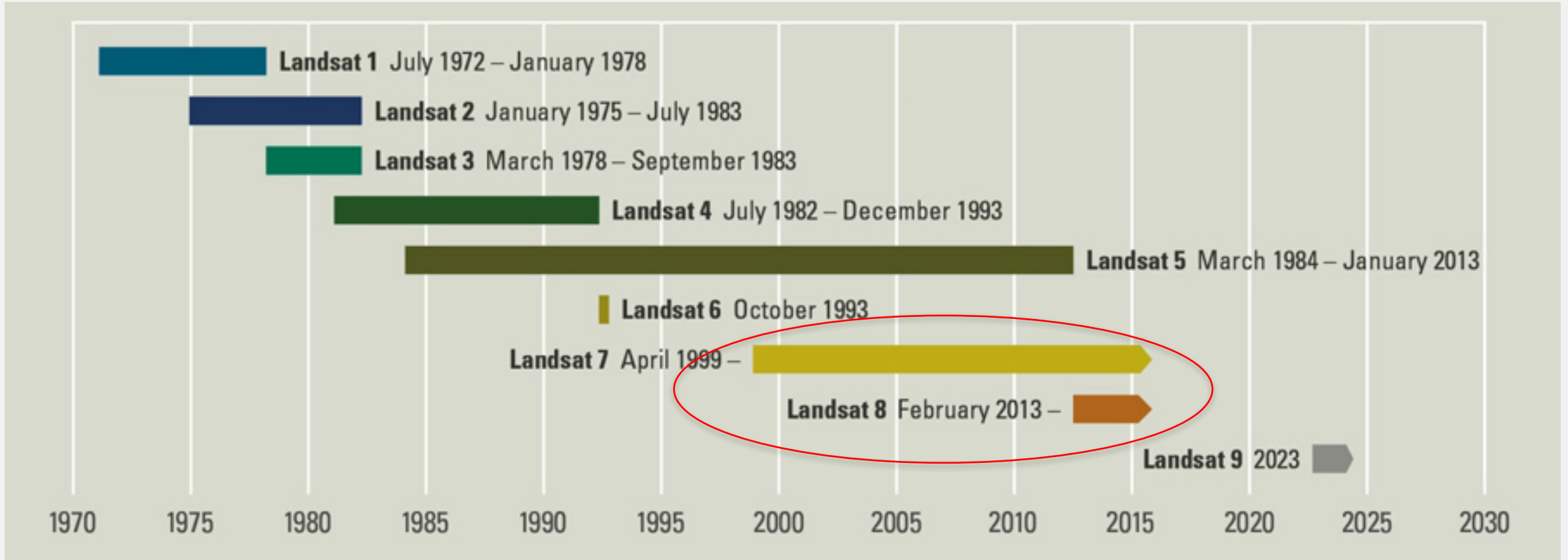
Satellites for HAB Monitoring

- Current Satellite Missions:
 - Landsat 7 & Landsat 8
 - Terra
 - Aqua
 - Suomi National Polar Partnership (SNPP)
 - Sentinel-2 and Sentinel-3



Landsat Satellites and Sensors

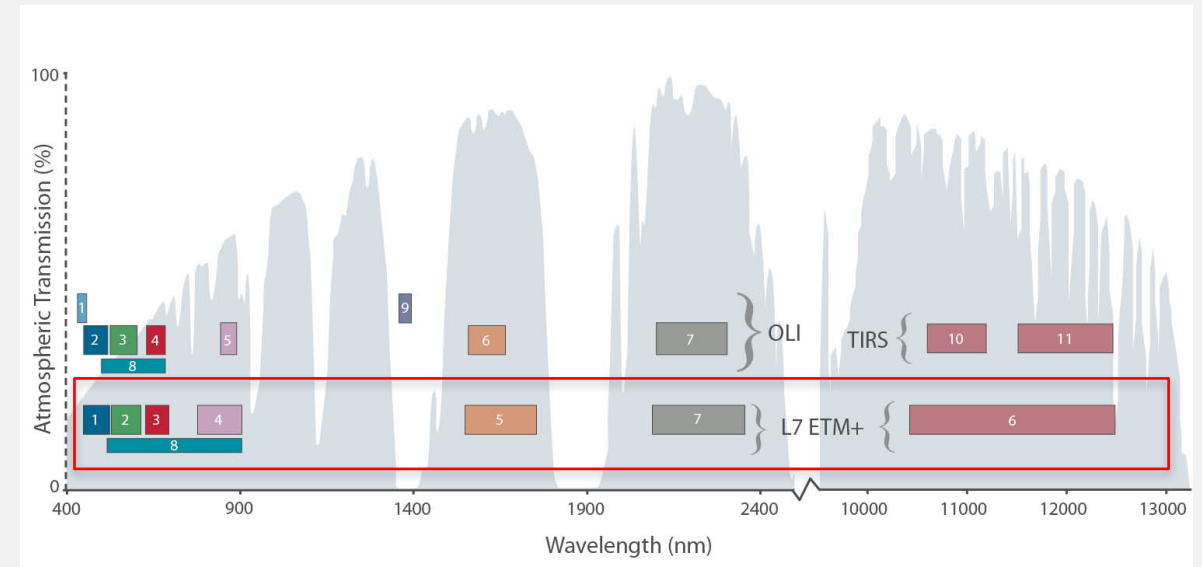
<http://landsat.gsfc.nasa.gov/>



Enhanced Thematic Mapper (ETM+)

<http://landsat.gsfc.nasa.gov/landsat-7/>

- Onboard **Landsat 7**
- Polar orbiting satellite
- 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



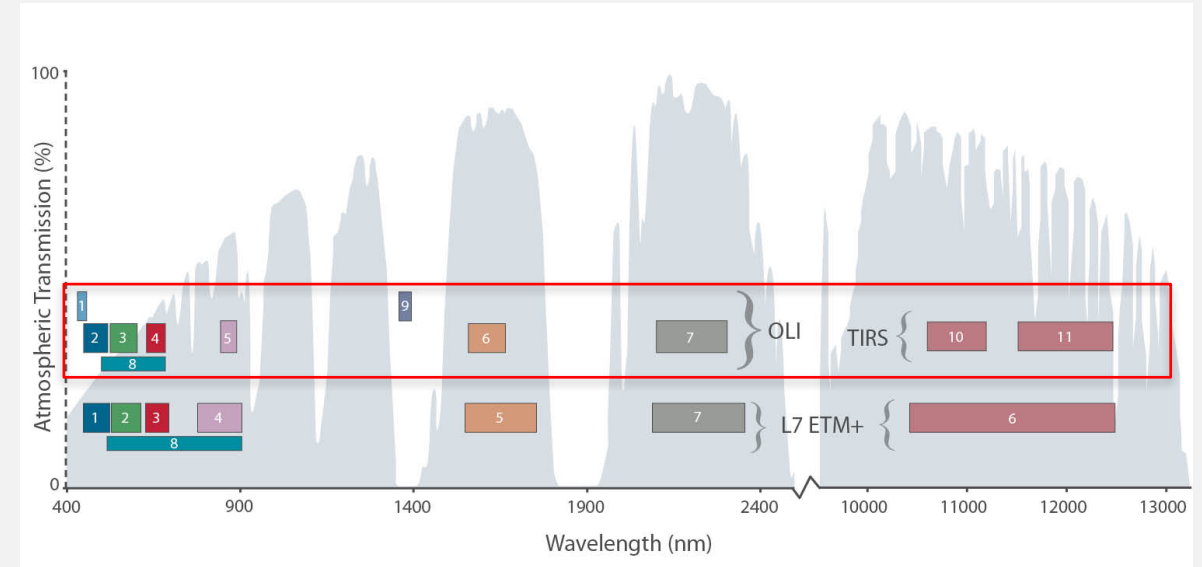
Spectral Bands: 8

- Major Bands: blue-green, green, red, thermal IR, panchromatic
- Bands 1-5, 7: 30 m; Band 6: 60 m; Band 8: 15 m

Operational Land Imager (OLI)

<http://landsat.gsfc.nasa.gov/landsat-8/>

- Onboard **Landsat 8**
- Polar orbiting satellite
- Spatial Coverage and Resolution
 - Global, Swath: 185 km
 - Spatial Resolution: 15 m, 30 m
- Temporal Coverage and Resolution:
 - Feb 11, 2013 – present
 - 16-day revisit time



Spectral Bands: 9

- Major Bands: blue, blue-green, red, near IR, shortwave, panchromatic
- Bands 1-7, 9: 30 m
- Band 8: 15 m

Landsat Bands

Landsat 7 ETM+

Band	Band Range (μm)	Spatial Resolution (m)
1	0.45 – 0.515	30
2	0.525 – 0.605	
3	0.63 – 0.69	
4	0.775 – 0.90	
5	1.55 – 1.75	
6	10.4 – 12.5	60
7	2.08 – 2.35	30
8	0.52 – 0.9	15

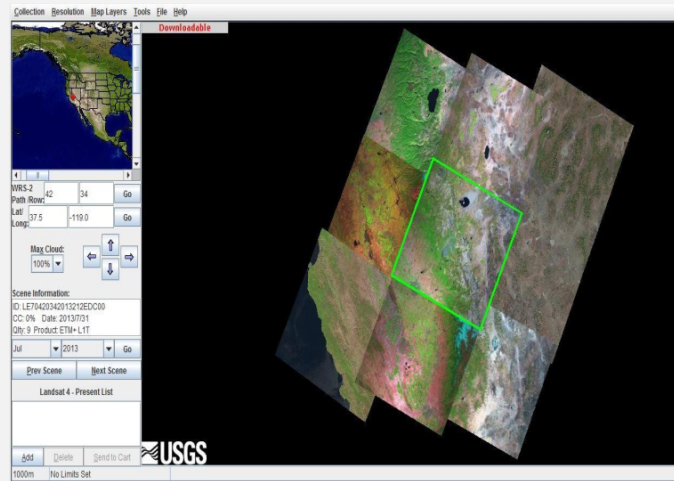
Landsat 8 OLI

Band	Band Range (μm)	Spatial Resolution (m)
1	0.433 – 0.453	30
2	0.450 – 0.515	
3	0.525 – 0.60	
4	0.630 – 0.680	
5	0.845 – 0.885	
6	2.10 – 2.30	
7	0.500 – 0.680	
8	2.08 – 2.35	15
9	1.36 – 1.39	30

Get Landsat Images and Band Reflectance Data



Earth Explorer:
<http://earthexplorer.usgs.gov/>



GloVis
<http://glovis.usgs.gov/>



LandsatLook Viewer:
<http://landsatlook.usgs.gov/>

Terra and Aqua Satellites and Sensors

Terra, <http://terra.nasa.gov>

- 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

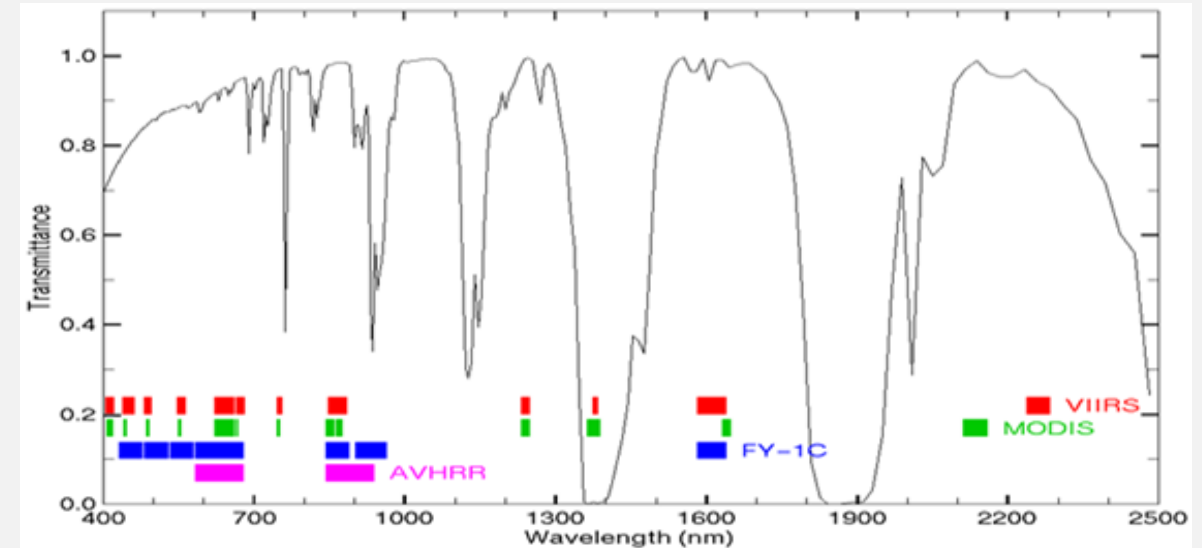
Aqua, <http://aqua.nasa.gov/>

- 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/>

- Onboard **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
 - 1–2 times per day



Spectral Bands: 36

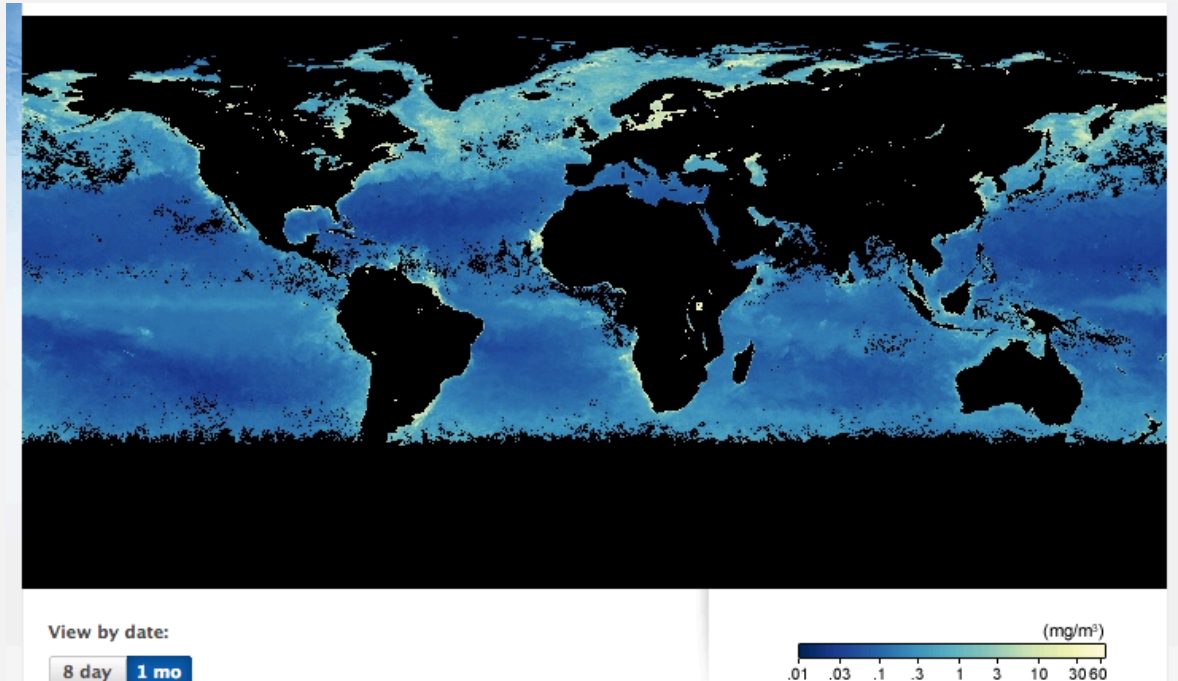
- Reflection and Emission Bands (Major Bands: red, blue, IR, NIR, MIR)
- Bands 1-2: 250 m; Bands 3-7: 500 m; Bands 8-36: 1,000 m

MODIS Bands Relevant for HAB Monitoring

Band	Band Range μm
8	0.405-0.420
9	0.438-0.448
10	0.483-0.493
11	0.526-0.536
12	0.546-0.556
13	0.662-0.672
14	0.673-0.683
15	0.743-0.753

Spatial resolution: 1 km

Chlorophyll Concentration from Aqua MODIS, June 2017



Get MODIS Band Reflectance Data

Land Processing Distributed Active
Archive Center

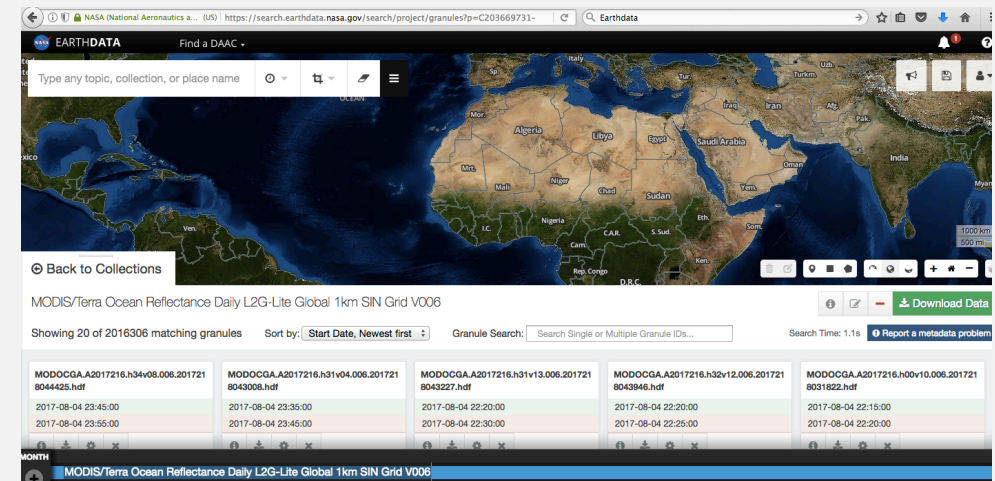
http://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/

Name	Dataset	Product	Pixel Size	Temporal Granularity
MOD09A1	Terra MODIS	Reflectance	500	Composites
MOD09CMG	Terra MODIS	Reflectance	5600	Daily
MOD09GA	Terra MODIS	Reflectance	500, 1000	Daily
MOD09GQ	Terra MODIS	Reflectance	250	Daily
MOD09G1	Terra MODIS	Reflectance	250	Composites
MODOCGA	Terra MODIS	Reflectance	1000	Daily
MOD1BGA	Terra MODIS	Reflectance	1000	Daily
MYD09A1	Aqua MODIS	Reflectance	500	Composites
MYD09CMG	Aqua MODIS	Reflectance	5600	Daily
MYD09GA	Aqua MODIS	Reflectance	500, 1000	Daily
MYD09GQ	Aqua MODIS	Reflectance	250	Daily
MYD09G1	Aqua MODIS	Reflectance	250	Composites
MYDOCGA	Aqua MODIS	Reflectance	1000	Daily
MYD1BGA	Aqua MODIS	Reflectance	1000	Daily

MODIS Band Reflectance for Oceans, Bands 8-16
Product Name: MODOCGA (Terra), MYDOCGA (Aqua)

NASA Earthdata

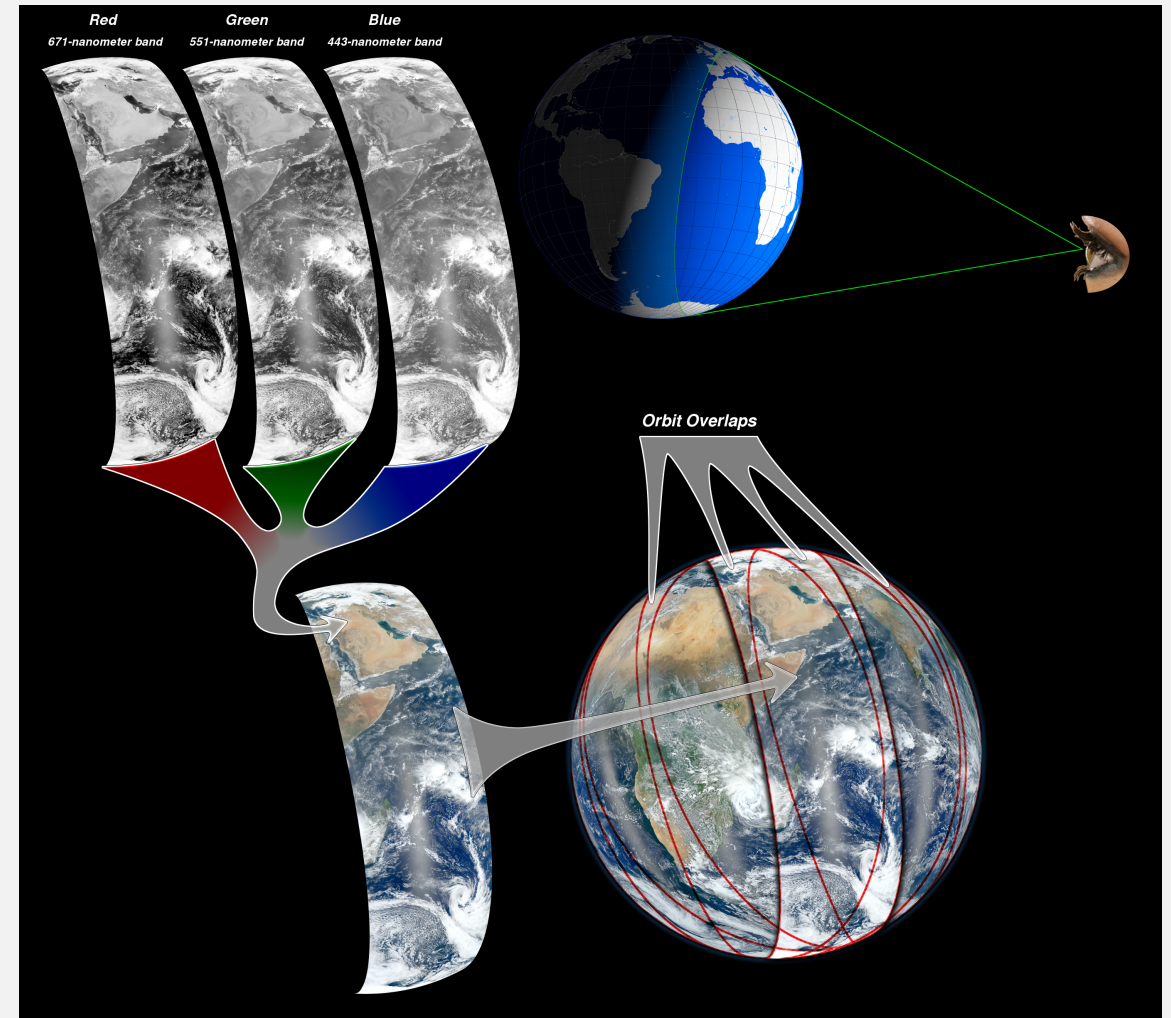
<http://earthdata.nasa.gov/>



Suomi National Polar Partnership (SNPP)

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

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



Visible Infrared Imaging Radiometer Suite (VIIRS)

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

- Onboard **Suomi NPP**
- Polar orbiting satellite
- Functionality similar to MODIS
- Spatial Coverage and Resolution:
 - Global, Swath Width: 3,040 km
 - Spatial Resolution: 375 – 750 m
- Temporal Coverage and Resolution:
 - Oct 2011 – present
 - 1-2 times per day

VIIRS True Color Image Showing Algae in the Caspian Sea, May 18, 2014

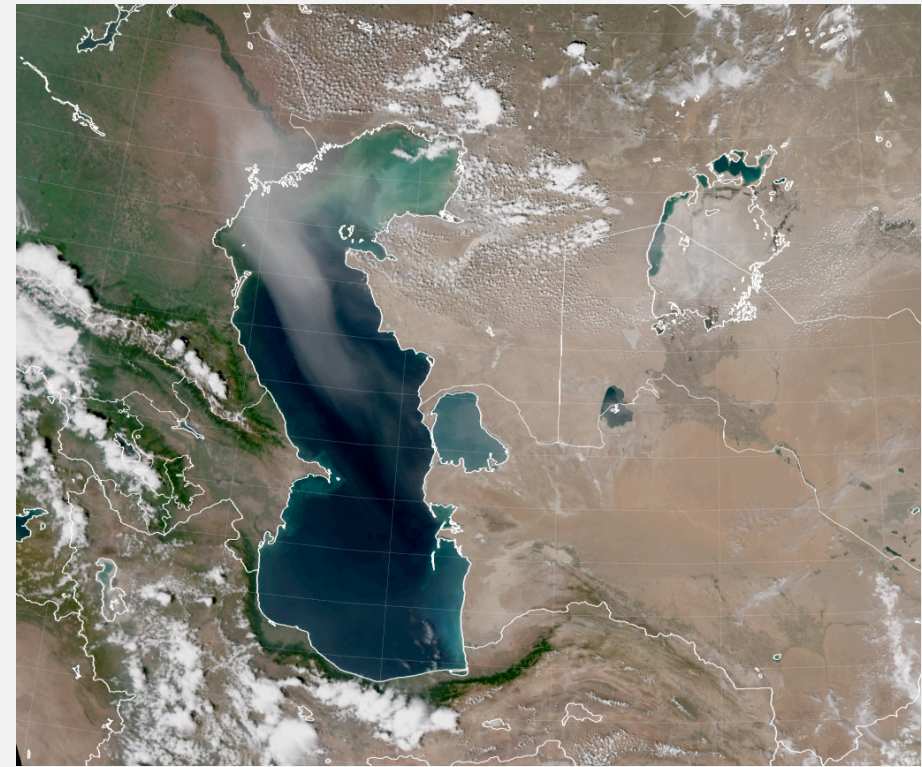


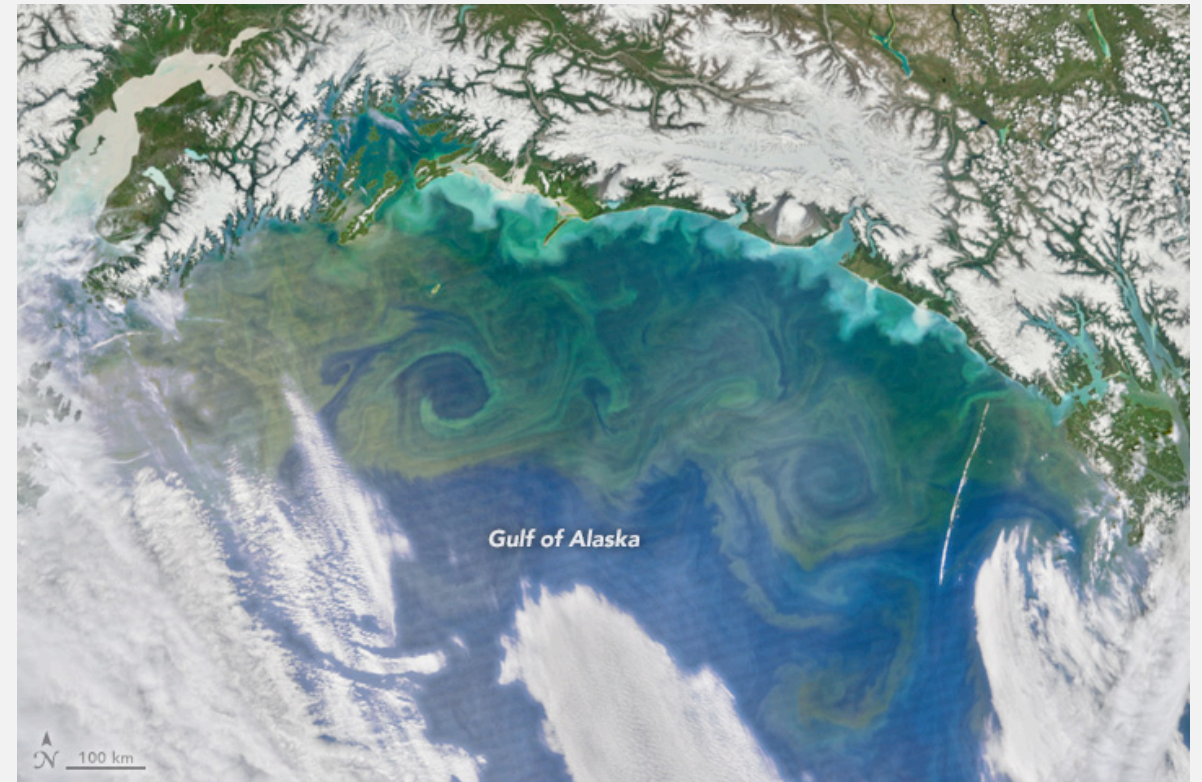
Image Credit: [VIIRS Imagery and Visualization Team Blog](#)

VIIRS Bands Relevant for HAB Monitoring

Band	Band Range μm
M1	0.402-0.422
M2	0.436-0.454
M3	0.478-0.488
M4	0.545-0.565
M5	0.662-0.682
M6	0.739-0.745

Spatial Resolution: 750 m

Phytoplankton Bloom in the Gulf of Alaska, from VIIRS, June 9, 2016



Get VIIRS Band Reflectance Data

LP DAAC
LAND PROCESSES DISTRIBUTED ACTIVE ARCHIVE CENTER

Home About Dataset Discovery Citing Our Data Tools User Resources User Services Site Search Login with Earthdata

Home > Dataset Discovery > VIIRS > VIIRS Products Table

VIIRS Products Table

These links will direct you to specific information and access points for each of the VIIRS Land Products distributed from LP DAAC.

✦ Radiation Budget Variables

Full List

Version 1

Search:

	Dataset	Pixel Size	Product	Temporal Granularity
VNP09A1 V001	S-NPP VIIRS	1000	Reflectance	Composites
VNP09CMG V001	S-NPP VIIRS	5600	Reflectance	Daily
VNP09GA V001	S-NPP VIIRS	500, 1000	Reflectance	Daily
VNP09H1 V001	S-NPP VIIRS	500	Reflectance	Composites

Showing 1 to 4 of 4 entries

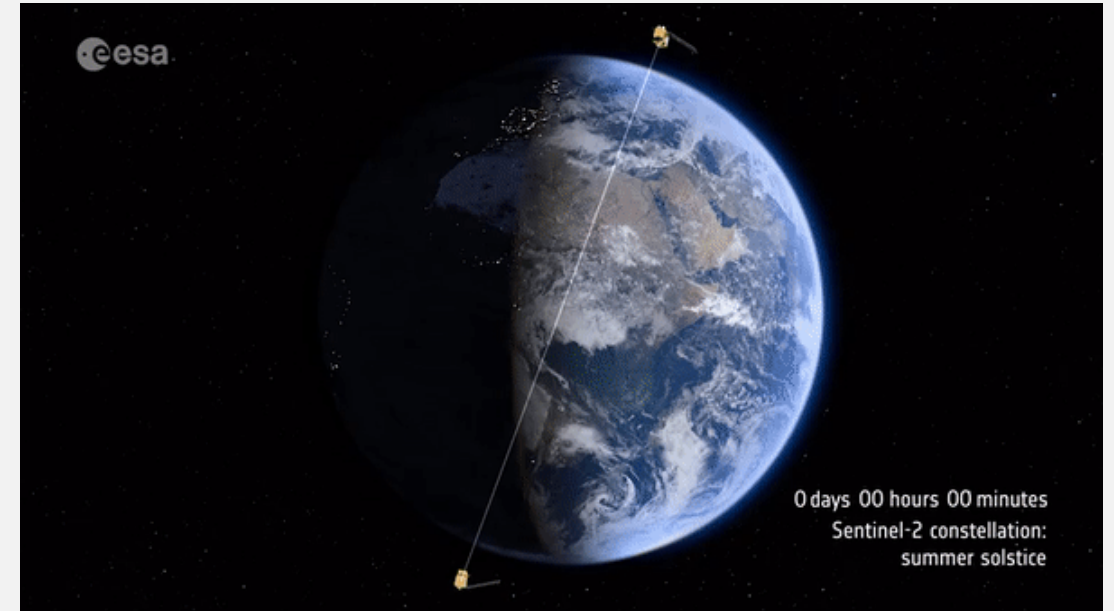
Land Process Distributed Active Archive Center

- https://lpdaac.usgs.gov/dataset_discovery/viirs/viirs_products_table
- Product Name:
VNP09GA_V001

Sentinel-2A and Sentinel-2B

http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2/

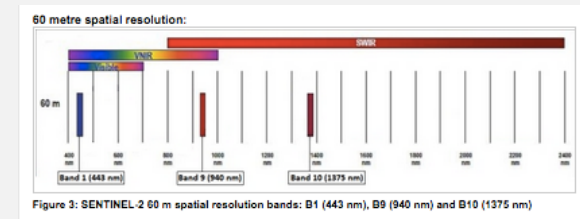
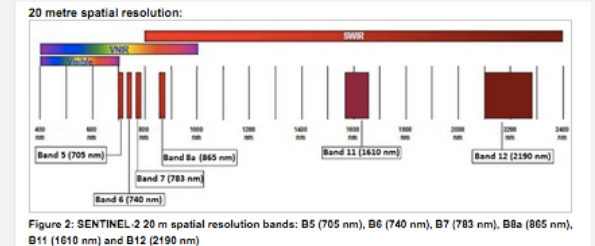
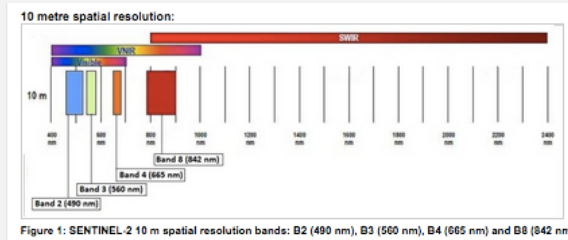
- Launched **by ESA**
- Two satellites, 180° apart, both in polar orbit
- Global coverage
- Temporal Coverage:
 - Sentinel-2A: June 23, 2015 – present
 - Sentinel-2B: March 7, 2017 – present
- 5 day revisit time
- Sensors
 - Multispectral Imager (MSI)



Multispectral Imager (MSI)

<https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi>

- Onboard **Sentinel-2**
- Designed for land and ocean surface observations
- Spatial Coverage and Resolution:
 - Global, swath: 290 km
 - Spatial resolution varies with bands: 10 m, 20 m, 60 m
- Temporal Coverage and Resolution:
 - June 2015 & March 2017 – present
 - 5 day revisit time



Spectral Bands: 13

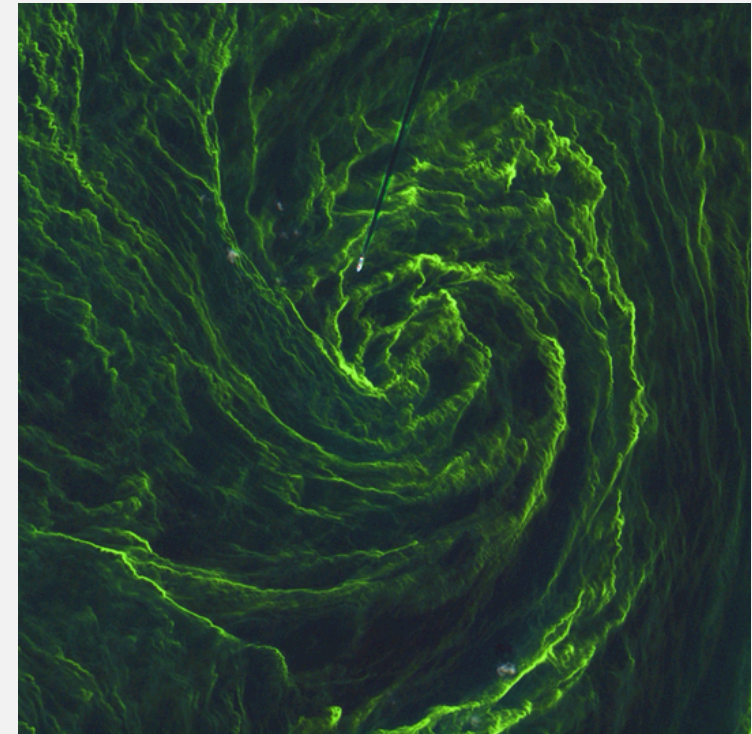
- 4 visible and NIR: 10 m
- 6 red-edge/shortwave infrared: 20 m
- 3 atmospheric correction: 60 m

MSI bands

<https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi>

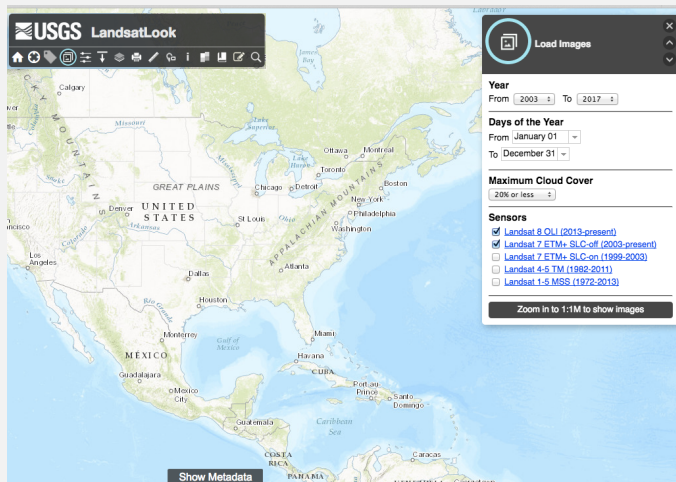
Band Number	S2A		S2B		Spatial resolution (m)
	Central wavelength (nm)	Bandwidth (nm)	Central wavelength (nm)	Bandwidth (nm)	
1	443.9	27	442.3	45	60
2	496.6	98	492.1	98	10
3	560.0	45	559	46	10
4	664.5	38	665	39	10
5	703.9	19	703.8	20	20
6	740.2	18	739.1	18	20
7	782.5	28	779.7	28	20
8	835.1	145	833	133	10
8a	864.8	33	864	32	20
9	945.0	26	943.2	27	60
10	1373.5	75	1376.9	76	60
11	1613.7	143	1610.4	141	20
12	2202.4	242	2185.7	238	20

Algal Bloom in the Middle of the Baltic Sea, Sentinel-2 MSI, Aug 7, 2015



Copernicus data (2015)/ESA

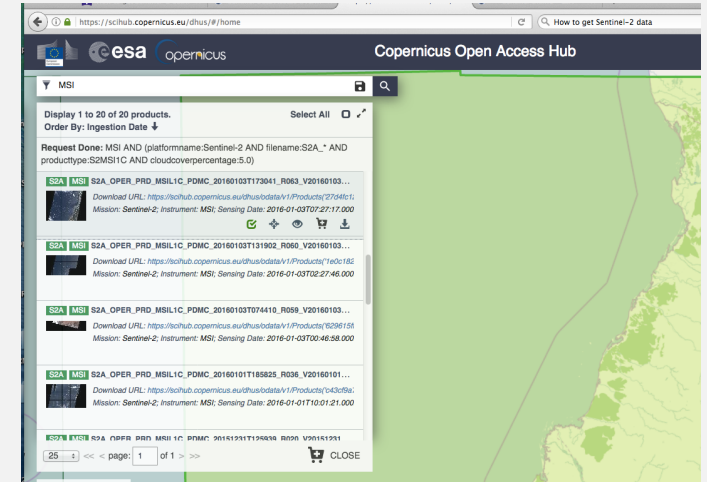
Get MSI Data



USGS Sentinel-2
Look Viewer
<https://landsatlook.usgs.gov/sentinel2/viewer.html>



Earth Explorer:
<http://earthexplorer.usgs.gov/>

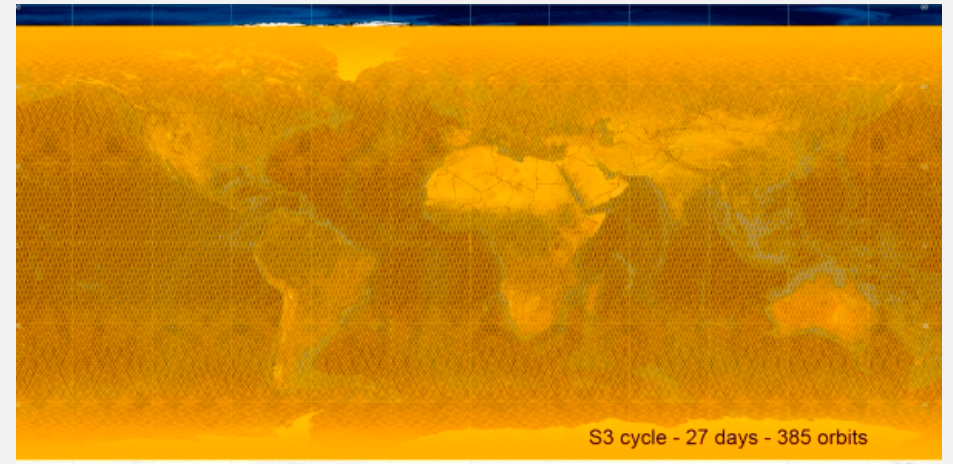


ESA Copernicus
Open Hub
<http://sentinel.esa.int/web/sentinel/sentinel-data-access>

Sentinel-3

www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-3/

- Launched by **ESA**
- Will consist of a two satellite system
 - Sentinel-3A: Feb 16, 2016 - present
 - Sentinel-3B: To be launched
- Global coverage
- 27 day revisit time
- Sensors:
 - **OCLI**, SLSTR, SRAL, MWR



Ocean and Land Color Instrument (OLCI)

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci>

- Onboard **Sentinel-3**
- Based on heritage from ENVISAT satellite Medium Resolution Imaging Spectrometer (MERIS)
- Spatial Coverage and Resolution:
 - Global, swath: 1,270 m
 - Spatial resolution: 300 m, also available at 1.2 km
- Temporal Coverage
 - Feb 2016 – present
 - 27 day revisit time

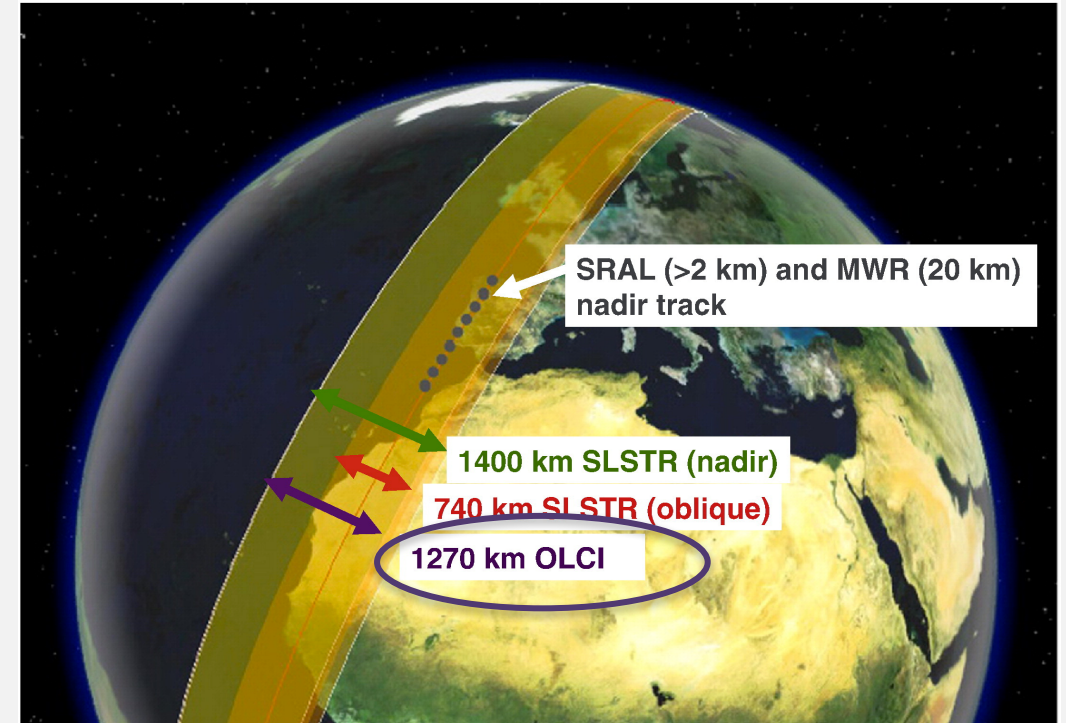


Image Credit: ESA

Spectral Bands: 21

- 4 visible to near-infrared: 300m

OLCI Bands

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci>

Band	λ centre (nm)	Width (nm)	Band	λ centre (nm)	Width (nm)
Oa1	400	15	Oa13	761.25	2.5
Oa2	412.5	10	Oa14	764.375	3.75
Oa3	442.5	10	Oa15	767.5	2.5
Oa4	490	10	Oa16	778.75	15
Oa5	510	10	Oa17	865	20
Oa6	560	10	Oa18	885	10
Oa7	620	10	Oa19	900	10
Oa8	665	10	Oa20	940	20
Oa9	673.75	7.5	Oa21	1 020	40
Oa10	681.25	7.5			
Oa11	708.75	10			
Oa12	753.75	7.5			

Sentinel-3 OCL-Based Chlorophyll Concentration

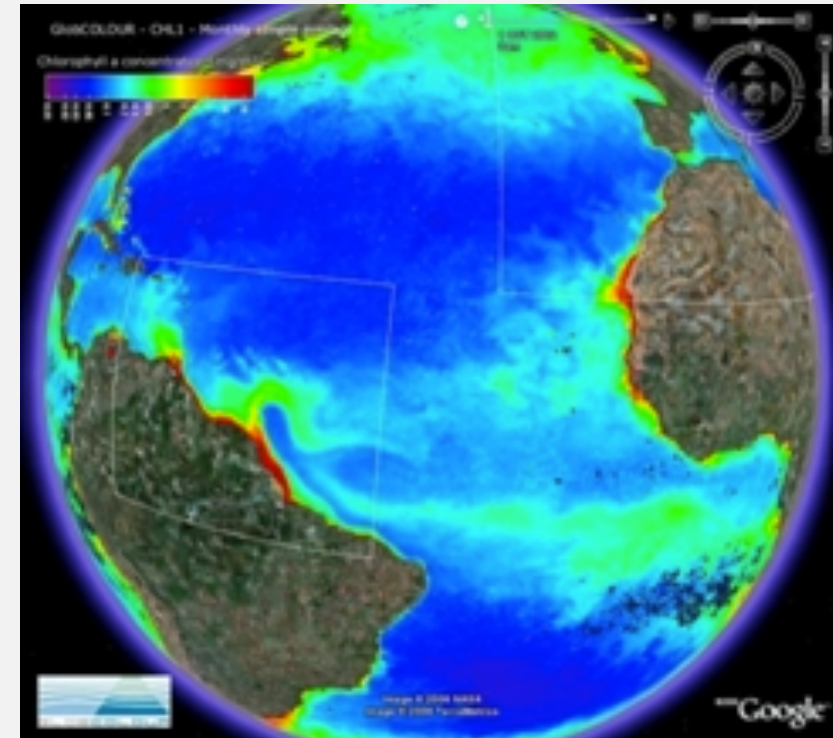


Image Credit: ESA/ACRI-ST

Get OLCI Data

The NOAA CoastWatch granule selector enables a user to select a Level-1 or Level-2 dataset by selecting a date and clicking on the granule that covers the user's area of interest. For VIIRS near real-time data is available for the last 15 days and science quality data is available from 2012 up to near real-time coverage. Clicking a granule will open an information window containing a link to the preview image and/or data file. If multiple files are desired (each file can be 18 to 550 MB), clicking on the download icon (⊕) will add the selected granule to a list that can be downloaded and used to retrieve files using local software.

Sensor: Layers: MGRS Grid for S-2 regions CoastWatch Regions

Date: 2017-08-08 Time: 1348
 Download Data:

NOAA CoastWatch

https://coastwatch.noaa.gov/cw_html/cw_granule_selector.html?sensor=OLCI

SELECT PRODUCT

Search Term:

Products **Sentinel 3 DataSets**

- Meteosat Surface Albedo - MFG - 0 degree
- Meteosat Surface Albedo - MFG - Atlantic Ocean 50 W
- Meteosat Surface Albedo - MFG - Atlantic Ocean 75 W
- Meteosat Surface Albedo - MFG - Indian Ocean 57 E
- Meteosat Surface Albedo - MFG - Indian Ocean 63 E
- Multi-Sensor Precipitation Estimate (GRIB) - MFG - Indian Ocean
- Multi-Sensor Precipitation Estimate (GRIB) - MSG - 0 degree
- Multi-Sensor Precipitation Estimate (GRIB) - MSG - Indian Ocean
- Multi-Sensor Precipitation Estimate (JPEG) - MSG - 0 degree
- Multi-Sensor Precipitation Estimate (JPEG) - MSG - Indian Ocean
- Multi-Sensor Precipitation Estimate in GRIB - Reprocessed
- NAR Sea Surface Temperature in NetCDF
- Near Surface Wind Speed
- Normalised Difference Vegetation Index - MSG - 0 degree
- Normalised Difference Vegetation Index - MSG - Indian Ocean
- Normalised Difference Vegetation Index Decadal - MSG - 0 degree
- Normalised Difference Vegetation Index Decadal - MSG - Indian Ocean
- North Atlantic and Regional Sea Surface Temperature (NAR SST) - NOAA
- OLCI Level 1B Full Resolution in NTC - Sentinel-3
- OLCI Level 1B Reduced Resolution in NTC - Sentinel-3
- OLCI Level 1B Reduced Resolution in NTC - Sentinel-3
- OLCI Ocean Colour Full Resolution in NTC - Sentinel-3
- OLCI Ocean Colour Full Resolution in NTC - Sentinel-3
- OLCI Ocean Colour Reduced Resolution in NTC - Sentinel-3
- OLCI Ocean Colour Reduced Resolution in NTC - Sentinel-3
- OSCAT Winds at 50 km Swath Grid - OceanSat

Thematic Filter

- Marine
- Land
- Atmosphere
- Aerosol
- Analysis
- Cloud
- Fire
- Forecast
- Humidity
- Model
- Observation
- Ocean
- Precipitation
- Pressure
- Radar Backscatter NRCS
- Radiation
- Soil Moisture Index
- Sea Ice
- Sea Surface Temperature
- Snow and Ice
- Temperature
- Vegetation
- Wave
- Wind

Selected Product
 OLCI Level 1B Reduced Resolution in NTC - Sentinel-3

OLCI (Ocean and Land Colour Instrument) Reduced resolution: 1200m at nadir. All Sentinel-3 Non Time Critical (NTC) products are available at pick-up point in less than 30 days. Level 1 products are calibrated Top Of Atmosphere radiances values at OLCI 21 spectral bands. Radiances are computed from the instrument digital counts by applying geo-referencing, radiometric processing (non-linearity correction, smear correction, dark offset correction, absolute gain calibration adjusted for gain evolution with time), and stray-light correction for straylight effects in OLCI camera's spectrometer and ground imager. Additionally, spatial resampling of OLCI pixels to the 'ideal' instrument grid, initial pixel classification, and annotation at tie points with auxiliary

EUMETSAT

<http://archive.eumetsat.int/usc/#sp;;delm=O;noti=1;udsp=OPE;qqov=ALL;seev=0>

Limitations of Remote Sensing Observations for HAB Monitoring

- For accurate and quantitative HAB monitoring analysis of spatially and temporally co-located, *in situ* measurements and satellite observations is required
- Difficult to separate ocean color changes from sediments, dissolved matter, and Chl-a when all are present
- It is not possible to characterize algal types or toxins only from remote sensing observations
- Feasibility of HAB monitoring in coastal and inland water bodies depends on spatial, temporal, and spectral resolutions of remote sensing observations
- Remote sensing reflectance has to be corrected to account for contributions from atmospheric constituents such as aerosols
- Optical remote sensing observations cannot view the surface in the presence of clouds

A satellite image of a coastal region, likely the Chesapeake Bay area, showing a mix of urban development, agricultural fields, and water bodies. A semi-transparent grey rectangular box is overlaid on the image, containing the title text. The text is in a large, black, sans-serif font. Below the title, there is a solid black horizontal line.

Overview of Satellite-Based Ocean Color Data Access Tools

Chl-a and SST Data Access for HAB Monitoring

- These tools enable data search, spatial and temporal subsetting, analysis, and visualization:
 - OceanColor Web:
<https://oceancolor.gsfc.nasa.gov/>
 - Giovanni:
<http://giovanni.gsfc.nasa.gov/giovanni/>
- Image Processing and Visualization Software:
 - SeaDAS:
<http://seadas.gsfc.nasa.gov/>

OceanColor Web

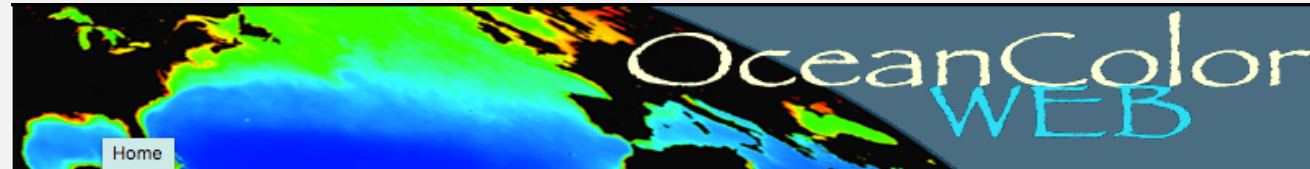
<https://oceancolor.gsfc.nasa.gov/>

- Developed for collection, processing, validation, and distribution of ocean related products from remote sensing and in situ observations
- Useful for monitoring coastal and inland water bodies and estuaries
- Provides visual data browsing capability for L1, L2, and L3 data (Chlorophyll Concentration, Sea Surface Temperature) from selected sensors
- Advances the capability of processing remote sensing images by using SeaDAS



OceanColor Web: Data Search and Access

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



A screenshot of the OceanColor WEB navigation menu. The "MISSIONS" tab is highlighted with an orange box. Below it, a list of satellite missions is shown, with "MODIS Terra", "OCTS", "OLCI-S3A", "VIIRS-SNPP", and "SeaWiFS" also highlighted with orange boxes. Other missions listed include Aquarius, CZCS, GOCI, HICO, MERIS, and MODIS Aqua.

A screenshot of the OceanColor WEB "DATA" page. The "DATA" tab is highlighted with an orange box. The page lists several options for data access, with "Overview", "Direct Data Access", "Data File Search", "Data Subscription", "Data Browsers", and "Level 3 Browser" highlighted with orange boxes. There are also two small inset images: one showing a world map with data overlays and another showing a detailed data visualization.

OceanColor Web: L1 Images and L2 Data Visualization

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

Parameter Selection

Zoom on a Region

Pre-Defined Regions

Time Selection (Month and Day)

Time Selection (Year)

Area and Swath Size Selections

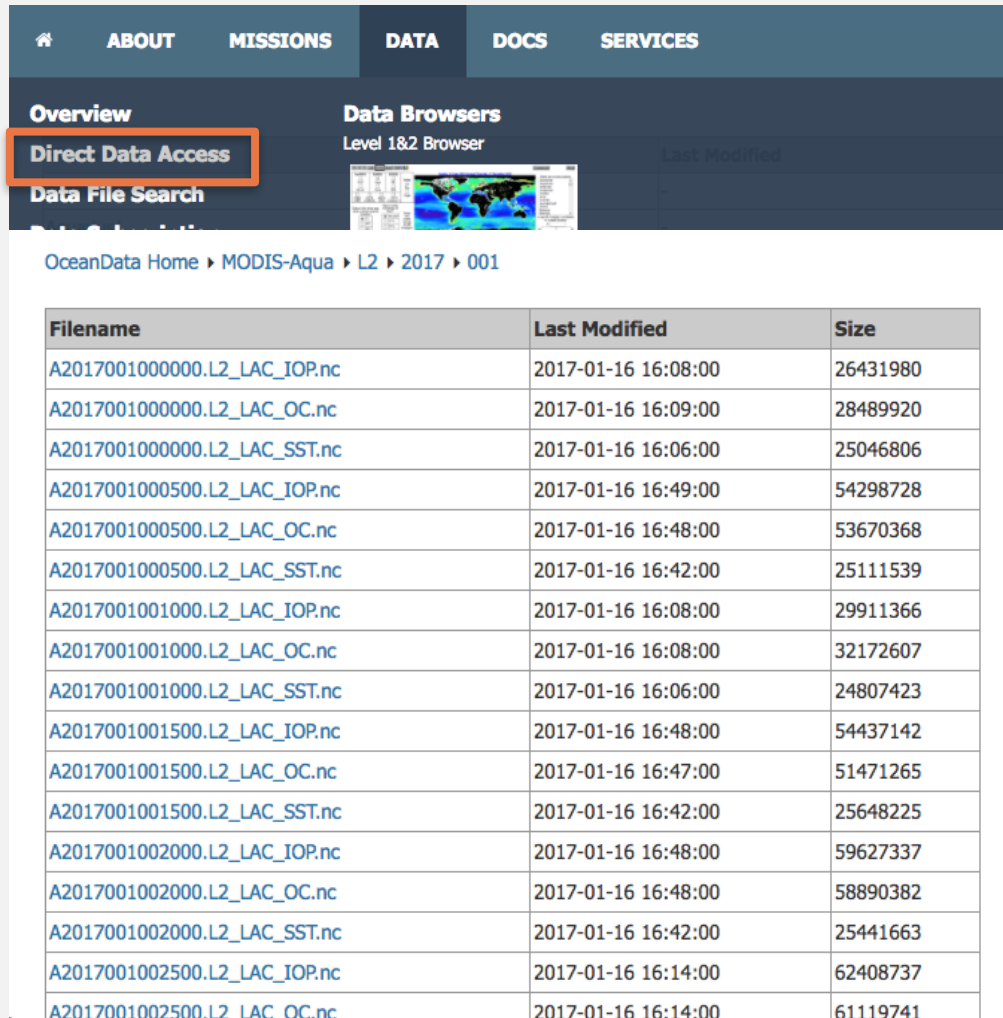
MODIS and VIIRS Near Real-Time and Past Chlorophyll Data

Screenshot details: The interface shows a navigation bar with 'TC', 'CHL', '99T', and '99T4'. A world map displays chlorophyll data for 'Sunday, 23 June 2002 through Wednesday, 20 April 2016'. A 'Pre-Defined Regions' list includes AdriaticSea, AegeanSea, Antarctica, ArabianSea, AralSea, Arctic, Australia, AustraliaCoast, Azores, Bahamas, and BalticSea. A 'Time Selection' calendar shows data availability for 2002-2016. A 'Parameter Selection' panel includes sensors like SeaWiFS, MODIS, MERIS, VIIRS, OCTS, HICO, and CZCS, along with options for radius and swath selection.

[gene_cari.feldman \(gene.c.feldman@nasa.gov\)](mailto:gene_c.feldman@nasa.gov) (301) 286-9428

OceanColor Web: L1 Images and L2 Data Download

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



OceanData Home > MODIS-Aqua > L2 > 2017 > 001

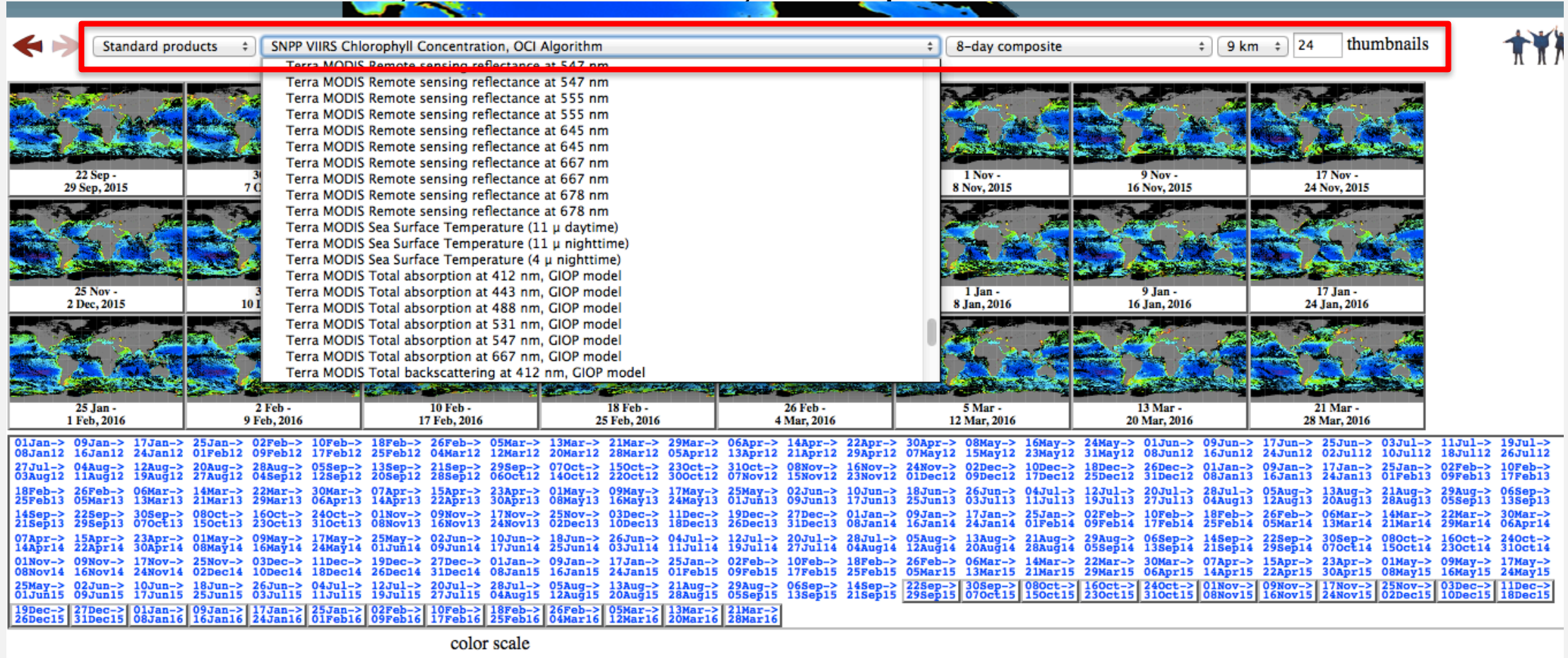
Filename	Last Modified	Size
A2017001000000.L2_LAC_IOP.nc	2017-01-16 16:08:00	26431980
A2017001000000.L2_LAC_OC.nc	2017-01-16 16:09:00	28489920
A2017001000000.L2_LAC_SST.nc	2017-01-16 16:06:00	25046806
A2017001000500.L2_LAC_IOP.nc	2017-01-16 16:49:00	54298728
A2017001000500.L2_LAC_OC.nc	2017-01-16 16:48:00	53670368
A2017001000500.L2_LAC_SST.nc	2017-01-16 16:42:00	25111539
A2017001001000.L2_LAC_IOP.nc	2017-01-16 16:08:00	29911366
A2017001001000.L2_LAC_OC.nc	2017-01-16 16:08:00	32172607
A2017001001000.L2_LAC_SST.nc	2017-01-16 16:06:00	24807423
A2017001001500.L2_LAC_IOP.nc	2017-01-16 16:48:00	54437142
A2017001001500.L2_LAC_OC.nc	2017-01-16 16:47:00	51471265
A2017001001500.L2_LAC_SST.nc	2017-01-16 16:42:00	25648225
A2017001002000.L2_LAC_IOP.nc	2017-01-16 16:48:00	59627337
A2017001002000.L2_LAC_OC.nc	2017-01-16 16:48:00	58890382
A2017001002000.L2_LAC_SST.nc	2017-01-16 16:42:00	25441663
A2017001002500.L2_LAC_IOP.nc	2017-01-16 16:14:00	62408737
A2017001002500.L2_LAC_OC.nc	2017-01-16 16:14:00	61119741

- Data Available
 - Chl-a
 - SST
 - Inherent Optical Properties

OceanColor Web: L3 Data Visualization

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

Data Product, Time Selections, and Spatial Resolution Selections



Giovanni: Geospatial Interactive Online Visualization ANd aNalysis Infrastructure

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

The screenshot displays the GIOVANNI web interface. At the top, there is a navigation bar with 'EARTHDATA' and several menu items: 'Data Discovery', 'DAACs', 'Community', and 'Science Disciplines'. Below this is the 'GIOVANNI' logo and the tagline 'The Bridge Between Data and Science v 4.23', along with links for 'Release Notes', 'Browser Compatibility', and 'Known Issues'. A yellow banner indicates a 'MODIS OPeNDAP server continuing problem ... [1 of 2 messages] Read More'. The main interface is divided into several sections: 'Select Plot' with radio buttons for 'Maps: Time Averaged Map', 'Comparisons', 'Vertical', 'Time Series', and 'Miscellaneous'; 'Select Date Range (UTC)' with input fields for 'YYYY-MM-DD.' and 'HH:mm' and a 'Valid Range: 1948-01-01 to 2017-08-10' note; 'Select Region (Bounding Box or Shape)' with a text input field and a 'Format: West, South, East, North' note; 'Select Variables' with a list of categories: 'Disciplines' (Aerosols, Atmospheric Chemistry, Atmospheric Dynamics, Cryosphere, Hydrology, Ocean Biology, Oceanography, Water and Energy Cycle) and 'Measurements' (Aerosol Index, Aerosol Optical Depth, Air Pressure Anomaly, Air Pressure, Air Temperature, Albedo, Altitude, Angstrom Exponent, Atmospheric Moisture, Black Carbon, Buoyancy, CH4, CO, CO2, Canopy Water Storage, Chlorophyll, Cloud Fraction, Cloud Properties, Component Aerosol Optical Depth, Diffusivity). A search bar with 'Number of matching Variables: 0 of 1679' and 'Total Variable(s) included in Plot: 0' is also present. At the bottom right, there are buttons for 'Help', 'Reset', 'Feedback', and a prominent green 'Plot Data' button.

Giovanni: Geospatial Interactive Online Visualization ANd aNalysis Infrastructure

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

The screenshot shows the GIOVANNI web interface with several key sections highlighted by callouts:

- Analysis and Plot Selection:** A callout box points to the 'Select Plot' section, where 'Time Series: Hovmoller, Longitude-Averaged' is selected.
- Start and End Date, and spatial selection by map, latitude-longitude, and shapefile:** A callout box points to the 'Select Date Range (UTC)' and 'Select Region (Bounding Box or Shape)' sections. The date range is set from 2010-01-01 to 2017-06-30, and the region is defined by the bounding box -86.6602,24.8145,-80.332,31.4941.
- Search data by a keyword:** A callout box points to the search bar where 'Chlorophyll' is entered, resulting in a list of 11 variables.

Select Variables

- Disciplines**
 - Ocean Biology (10)
 - Oceanography (9)
- Measurements**
 - Chlorophyll (11)
 - Organic Carbon (3)
 - Phytoplankton (6)
- Platform / Instrument**
- Spatial Resolutions**
- Temporal Resolutions**
- Wavelengths**
- Portal**

Number of matching Variables: 11 of 1679 Total Variable(s) included in Plot: 1

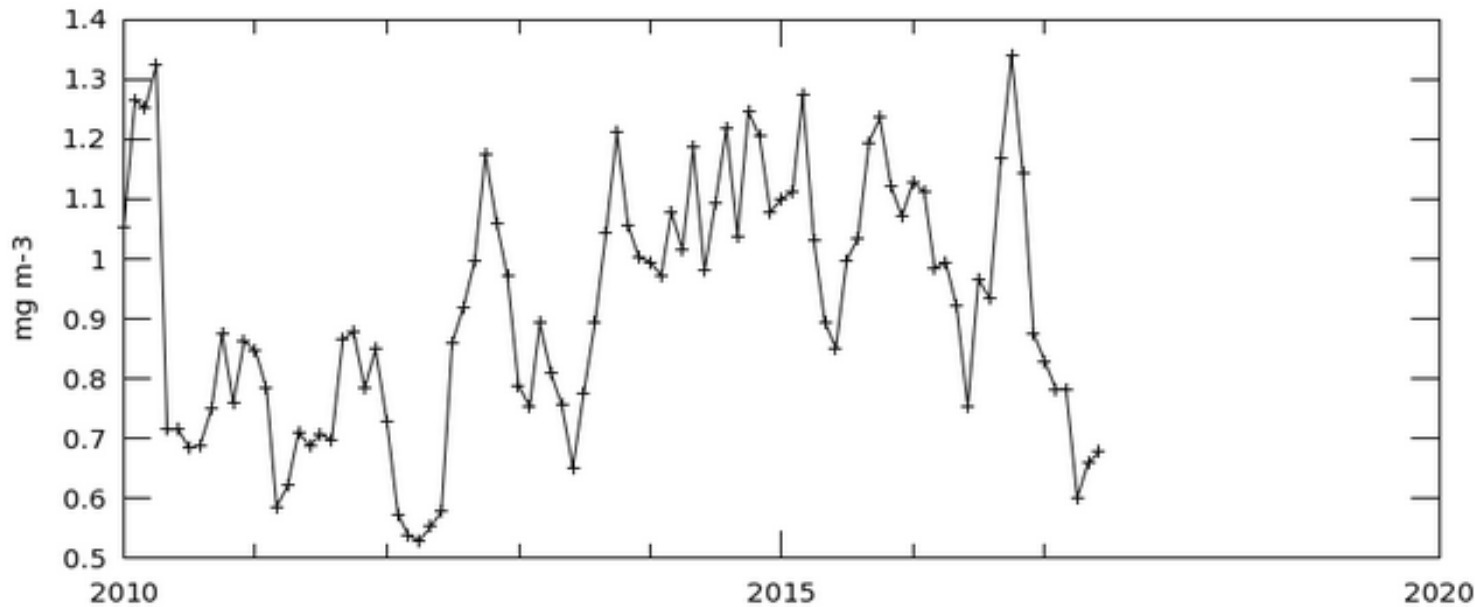
Keyword:

Variable	Source	Temp.Res.	Spat.Res.	Start Date	End Date	Units
<input type="checkbox"/> Chlorophyll a Concentration (OCTS L3m_CHL v2014)	OCTS	Monthly	9 km	1998-01-01	2012-12-31	mg chlorophyll/m ³
<input type="checkbox"/> Chlorophyll a Concentration (NOBM Model)	NOBM Model	Daily	0.667 x 1.25 °	1998-01-01	2012-12-31	mg chlorophyll/m ³
<input type="checkbox"/> Chlorophyll a Concentration (NOBM Model)	NOBM Model	Monthly	0.667 x 1.25 °	1998-01-01	2012-12-31	mg chlorophyll/m ³
<input type="checkbox"/> Normalized fluorescence line height (MODISA L3m_FLH v2014)	MODIS-Ac	Monthly	4 km	2002-07-04	2017-06-30	mW cm ⁻² um ⁻¹ sr ⁻¹
<input checked="" type="checkbox"/> Chlorophyll a concentration (MODISA L3m_CHL v2014)	MODIS-Ac	Monthly	4 km	2002-07-04	2017-06-30	mg m ⁻³
<input type="checkbox"/> Chlorophyll a Concentration (SeaWiFS L3m_CHL v2014)	SeaWiFS	Monthly	9 km	1997-09-04	2010-12-11	mg m ⁻³
<input type="checkbox"/> Chlorophyll Concentration, OC3 Algorithm (OCTS L3m_CHL v2014)	OCTS	Monthly	9 km	1996-11-01	1997-06-30	mg m ⁻³
<input type="checkbox"/> Concentration of Particulate Organic Carbon (OCTS L3m_POC v2014)	OCTS	Monthly	9 km	1996-11-01	1997-06-30	mg m ⁻³
<input type="checkbox"/> Concentration of Particulate Organic Carbon (MODISA L3m_POC v2014)	MODIS-Ac	Monthly	4 km	2002-07-04	2017-06-30	mg m ⁻³
<input type="checkbox"/> Absorption coefficient due to phytoplankton (aph) at 443 nm (SeaWiFS L3m_IOP v2014)	SeaWiFS	Monthly	9 km	1997-09-04	2010-12-11	10 ⁻³ m ² m ⁻¹

Giovanni: Chlorophyll Concentration in the Gulf of Mexico

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

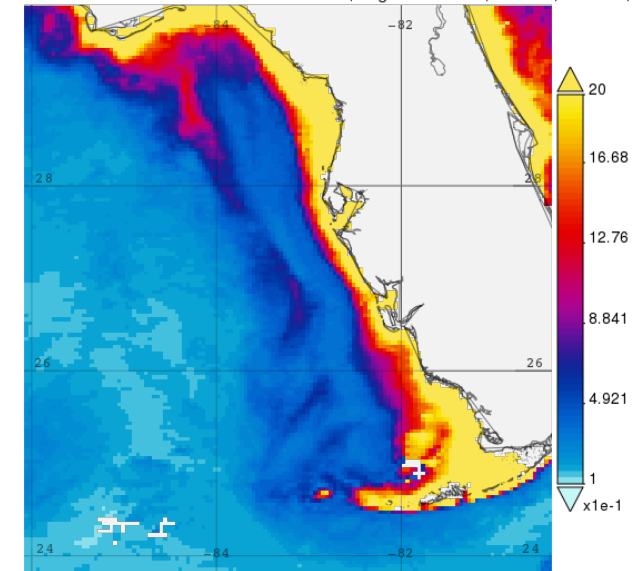
Time Series, Area-Averaged of Chlorophyll a concentration monthly 4 km
[MODIS-Aqua MODISA_L3m_CHL v2014] mg m-3 over 2009-12-31 22:25:08Z -
2017-07-01 02:45:10Z, Region 86.0889W, 23.811N, 80.376W, 29.9634N



- Selected date range was 2010-Jan - 2017-Jul. Title reflects the date range of the granules that went into making this result.

January 2017

Time Averaged Map of Chlorophyll a concentration monthly 4 km [MODIS-Aqua MODISA_L3m_CHL v2014] mg m-3
over 2017-01-01 00:25:11Z - 2017-02-01 02:50:09Z, Region 86.0889W, 23.811N, 80.376W, 29.9634N



Giovanni: Data Download

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

MODIS OPeNDAP server continuing problem ... [1 of 2 messages] [Read More](#)

Browse History

2. Time Averaged Map

- [User Input](#)
- [Plots](#)
- [Plot Options](#)
- **[Downloads](#)**
- [Lineage](#)

1. Time Series, Area-Averaged

- [User Input](#)
- [Plots](#)
- [Plot Options](#)
- **[Downloads](#)**
- [Lineage](#)

Click on file links to download. Files contain data portrayed in the plot images.

NetCDF:

[g4.timeAvgMap.MODISA_L3m_CHL_2014_chlor_a.20170101-20170131.85W_24N_79W_31N.nc](#)

PNG:

[MODISA_L3m_CHL_2014_chlor_a.20170101-20170131.85W_24N_79W_31N.png](#)

GEOTIFF:

[MODISA_L3m_CHL_2014_chlor_a.20170101-20170131.85W_24N_79W_31N.geotif](#)

KMZ:

[MODISA_L3m_CHL_2014_chlor_a.20170101-20170131.85W_24N_79W_31N.kmz](#)

Options for
multiple formats

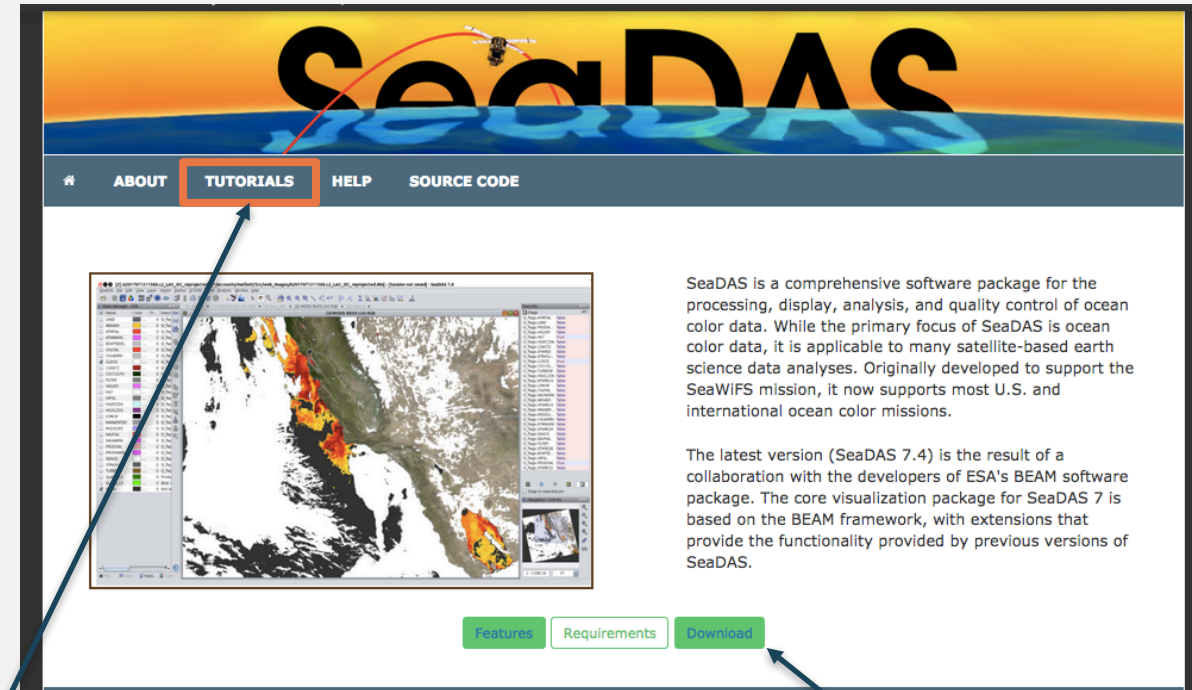
Click to
download files

SeaDAS: Data Analysis Package

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

- SeaDAS is a comprehensive image analysis package developed for the processing, display, analysis, and quality control of ocean color data
- The latest version (SeaDAS 7.4) is developed in a collaboration with the developers of ESA's BEAM software package

Video tutorial and presentations about SDAS



Software download

SeaDAS: Features

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

Visualization

- Very fast image display and navigation even of giga-pixel images
- Advanced layer management allows adding and manipulation of new overlays such as images of other bands, images from WMS servers or ESRI shapefiles
- Rich region-of-interest definitions for statistics and various plotting functions
- Easy bitmask definition and overlay
- Flexible band arithmetic using arbitrary mathematical expressions
- Accurate reprojection and ortho-rectification to common map projections
- Geo-coding and rectification using ground control points
- Coastline, land/water masking for navigated data
- Store and restore the current session including all opened files, views and layers

Data Processing

SeaDAS offers the ability for users to process satellite data from a number of ocean color missions (both U.S. and International) through the various processing levels:

- Level 0 to Level 1 processing is offered for the MODIS sensors onboard the Terra and Aqua spacecraft
- Level 1 to Level 2 (l2gen)
- Level 2 to Level 3 binned (l2bin)
- Temporal binning of Level 3 (l3bin)
- Mapping of Level 1 data (l1mapgen)
- Mapping of Level 2 data (l2mapgen)
- Mapping of Level 3 binned data (smigen)
- Browse file creation (l1brsgen,l2brsgen)

SeaDAS: System Requirement

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

- Visualization-only version
- Visualization and data processing version
- Multiple mission data can be analyzed
- SeaDAS download, installation, and usage require advance training

SeaDAS Configuration and Requirements

SeaDAS is currently available for Linux, Mac OS X, and Windows. The Windows version currently does not support the science data processing code. The SeaDAS [source code](#) is publicly available.

Suggested Hardware Requirements:

Platforms:	Linux Intel Mac OS X
Memory:	256MB minimum, 1GB+ suggested
Disk:	SeaDAS software package (display only version): ~200MB SeaDAS software package (with processing capabilities for all sensors): ~5GB 10GB of free space is also suggested for rudimentary data processing and storage.
Display:	15" Console or X-terminal with 20MB memory 1280x1024 resolution 24-bit X display plane depth 256 colors display minimum

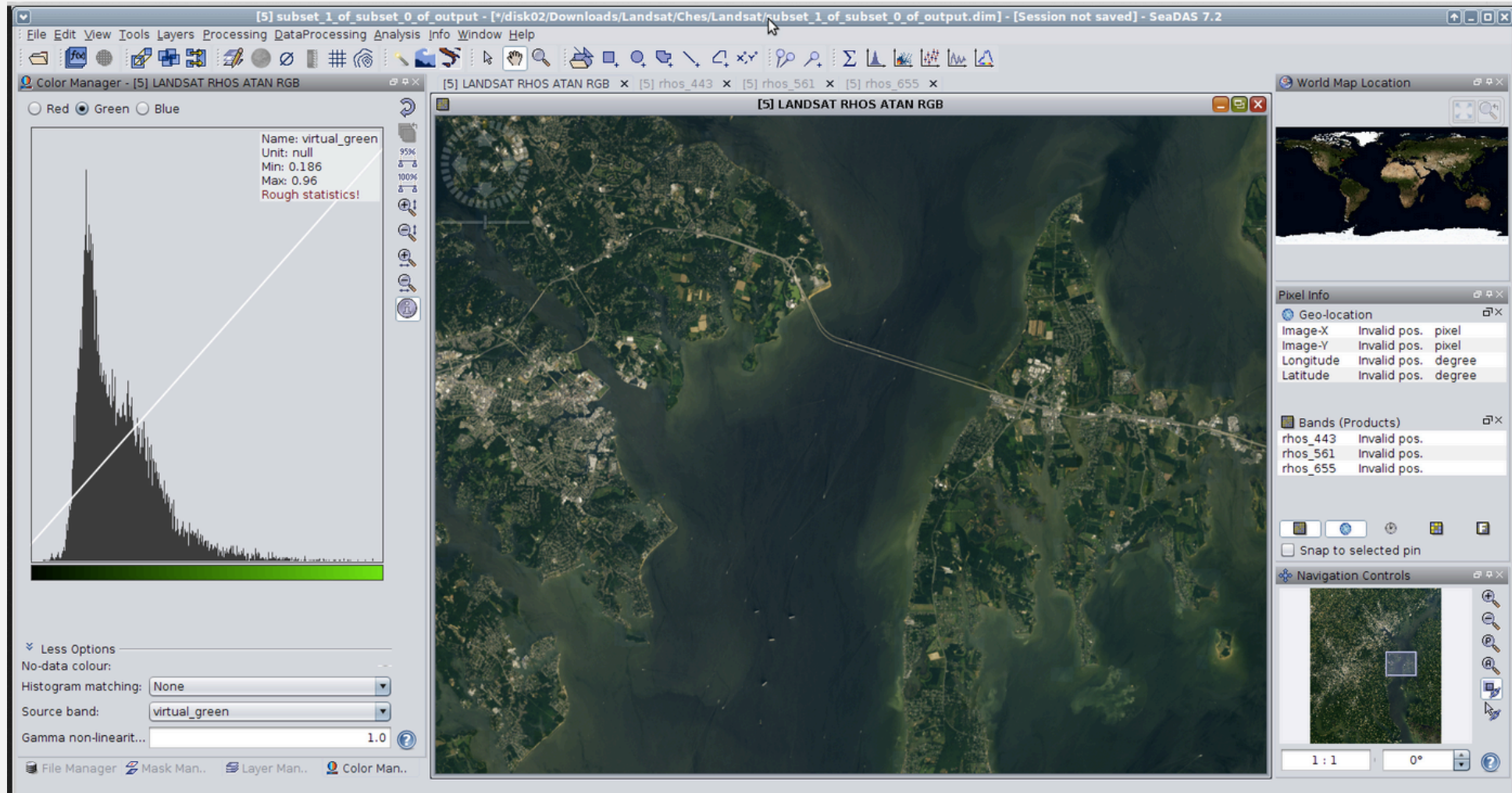
Requirements:

The core visualization package of SeaDAS is written in Java. A minimum Java JRE of version 1.7 is required. A suitable JRE is packaged with the Windows and MacOSX distributions. Linux users will need to separately install a suitable JRE.

Operating Systems:	Linux: tested on various versions of CentOS, Fedora, and Ubuntu Intel Mac: OS X 10.10	
Optional Compilers:	gcc/g++/gfortran (version 4.5 or higher) or Intel Compilers	
Program	Version	Notes
Java	JRE 1.7 or above	Windows and MacOSX distributions come with a suitable JRE Linux users will need to separately install a suitable JRE
Bash	4.x	version 3.x should work, but not tested necessary only for science code, thus not required for Windows distributions
Python	2.6.5 or above	necessary only for science code, thus not required for Windows distributions; not (yet) compatible with version 3 and above
Git	1.7.9 or above	necessary only for science code install/update option, thus not required for Windows distributions
cURL	7.x or above	necessary only for science code install/update option, thus not required for Windows distributions

SeaDAS: Example

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





Examples of HAB Monitoring Tools

Chl-a and SST Monitoring Using MODIS and Landsat 8

<http://optics.marine.usf.edu/>

The screenshot shows the website for the University of South Florida's College of Marine Science, specifically the Optical Oceanography Laboratory. The page features a navigation menu on the left and a main content area on the right. The menu includes sections for 'Home', 'People', 'Projects', 'Satellite Data Products', 'Virtual Buoy Products', 'Publications', 'Events', 'Links', and 'Contact'. The 'Satellite Data Products' section is expanded, showing a list of regions: Caribbean, East Asia, North America, South America, South Pacific, West Africa, and Persian Gulf. The 'Virtual Buoy Products' section is also expanded, showing a list of buoy locations: Big Bend, Cape Cod, Central West Florida, Florida Keys, Mobile Bay, and North Persian Gulf. The 'Landsat 8' section is highlighted with an orange box, and an arrow points to a sub-menu for 'Landsat 8' which includes 'Guadeloupe' and 'Martinique'. Another arrow points from the 'Virtual Buoy Products' section to the 'Virtual Buoy Products' sub-menu.

USF UNIVERSITY OF SOUTH FLORIDA

USF Home | A-Z Index | Directory | myUSF
Marine Science Home | USF St. Pete | Search

College of Marine Science

Optical Oceanography Laboratory

Home

Menu

- Home
- + People
- + Projects
- Satellite Data Products
 - + Caribbean
 - + East Asia
 - + North America
 - + South America
 - + South Pacific
 - + West Africa
 - Persian Gulf
- + Landsat 8
- + Virtual Buoy Products
- + Publications
- + Events
- + Links
- + Contact

Landsat 8

- Landsat 8
 - Guadeloupe
 - Martinique

Virtual Buoy Products

- Virtual Buoy Products
 - + Big Bend
 - + Cape Cod
 - + Central West Florida
 - + Florida Keys
 - + Mobile Bay
 - + North Persian Gulf

- Ocean color data available from MODIS and Landsat 8 for selected areas
- Satellite-derived ocean color data at buoy locations in Gulf of Mexico and Persian Gulf

Ocean Color Data from Aqua and Terra MODIS

http://optics.marine.usf.edu/cgi-bin/optics_data?roi=ECARIB¤t=1/

USF UNIVERSITY OF SOUTH FLORIDA

USF Home | A-Z Index | Directory | myUSF
Marine Science Home | USF St. Pete | Search

College of Marine Science

Optical Oceanography Laboratory

Eastern Caribbean Region & Data Description ? Tips Animate

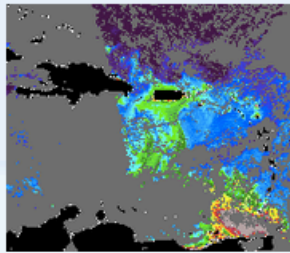
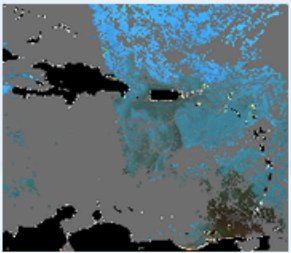
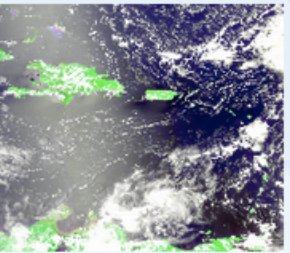
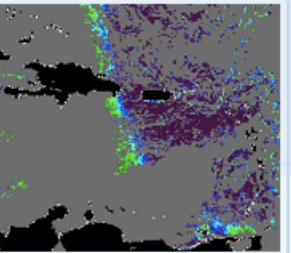
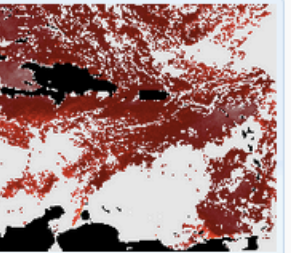
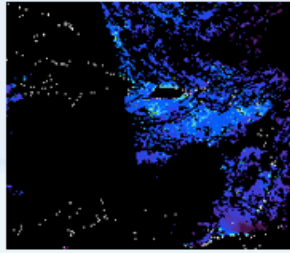
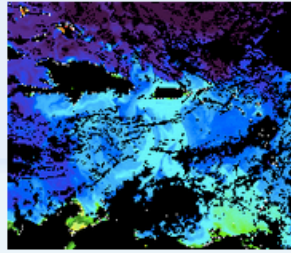
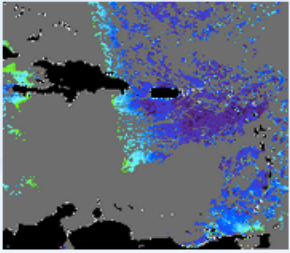
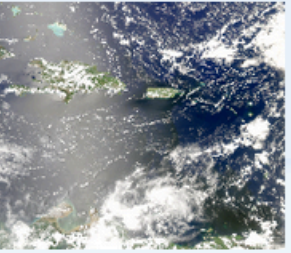
Aug 2017

Su	Mo	Tu	We	Th	Fr	Sa
		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		

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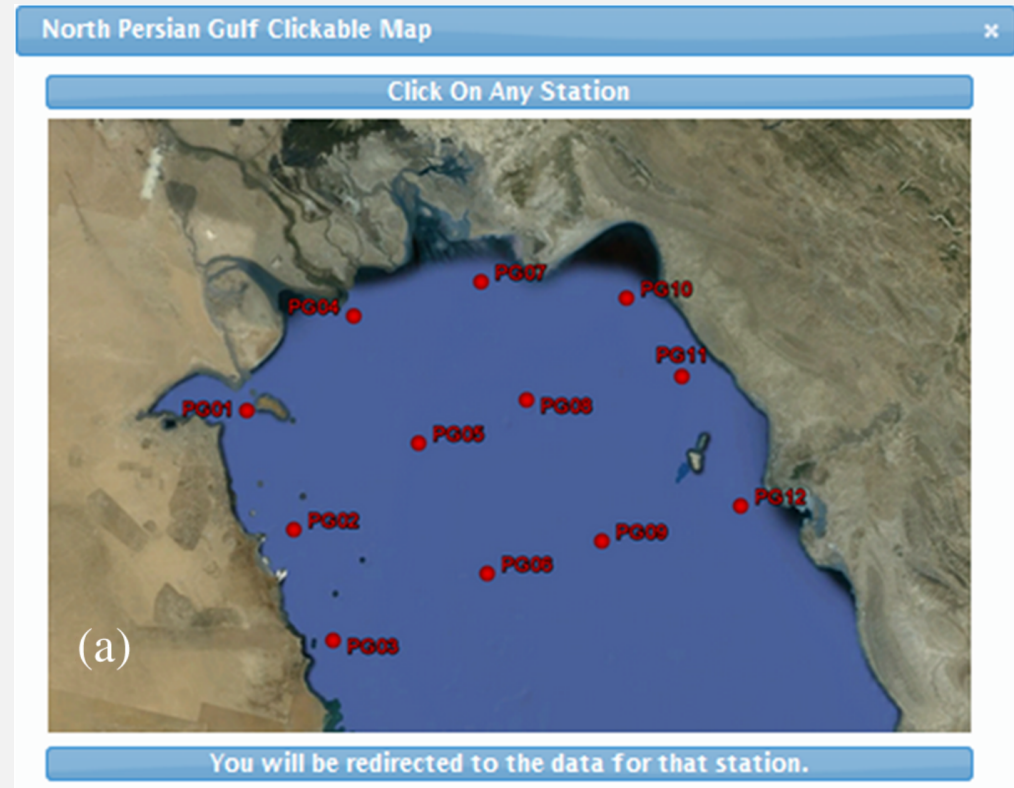
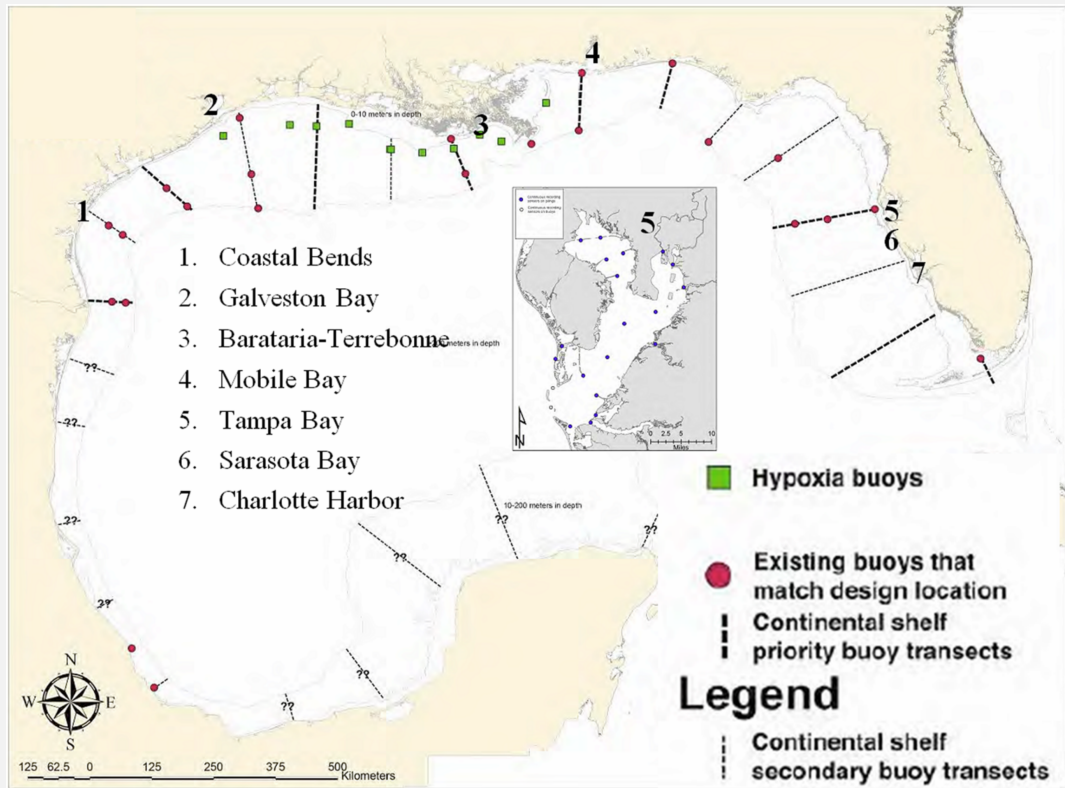
MODIST 14:50 GMT MODISA 17:55 GMT

 <p>CHL L3D Information Get Link Here GE</p>	 <p>ERGB L3D Information Get Link Here GE</p>	 <p>FRGB L3D Information Get Link Here GE</p>	 <p>NFLH L3D Information Get Link Here GE</p>	 <p>SST L3D Information Get Link Here GE</p>
 <p>AFAI L3D_RRC Information Get Link Here GE</p>	 <p>CI L3D_RRC Information Get Link Here GE</p>	 <p>FLH L3D_RRC Information Get Link Here GE</p>	 <p>RGB L3D_RRC Information Get Link Here GE</p>	

Chl-a and SST Monitoring Using MODIS and Landsat 8

<http://optics.marine.usf.edu/>

Buoy Locations in the Gulf of Mexico and Persian Gulf from Hu et al. (2014)



Reference: Hu et al. 2014, Satellite-based virtual buoy system to monitor coastal water quality, Opt. Eng. 2013;53(5):051402. doi:10.1117/1.OE.53.5.051402.

Ocean Color Data from MODIS

<http://optics.marine.usf.edu/>

At a Buoy Location in Tampa Bay

Station Name: TB 01 [Tampa Bay Clickable Map](#)

Latitude: 27.9002

Longitude: -82.5920

Depth in Meters: 2.5

Current Imagery: /cgi-bin/optics_data?roi=CWFL¤t=1

The table below shows the current conditions (most recent weekly and monthly means) at station TB 01, derived from MODIS data. Also included are conditions for the current week and month from last year, as well as the long term means (climatologies).

Current conditions which exceed one standard deviation from the climatological mean are considered "anomalies" and are color coded. Positive chlorophyll anomalies, for example, may indicate phytoplankton bloom conditions at the station. Negative SST anomalies in winter might adversely affect several marine organisms (e.g., manatees, fish, corals, and sea turtles).

This table is intended to provide a visual guide to current and developing conditions at this station. However, caution must be used in interpreting anomaly data. Due to limitations of MODIS measurements, the normal climatological conditions for certain stations or time spans may not be fully characterized. As such, truly anomalous conditions may not be identified. Alternatively, detected anomalies may actually be within the climatological norm.

Current week number 31 in the table below is 7/30/2017 through 8/5/2017, current month is July of 2017.

Product	Weekly Mean	Monthly Mean	Weekly Last Year	Monthly Last Year	Weekly Climatology	Monthly Climatology
SST (C°)	27.56	29.94	29.80	30.11	30.41	29.85
Chlorophyll-a (mg m ⁻³)	No Data	3.72	No Data	6.67	7.31	5.43
Turbidity (NTU)	No Data	1.47	No Data	3.18	2.58	2.60
Secchi Disk Depth (m)	No Data	1.91	No Data	1.51	1.12	1.44
K _d (488) (m ⁻¹)	No Data	0.50	No Data	0.65	1.13	0.73
Light Penetration (%)	No Data	28.32	No Data	19.17	5.62	15.43

Summary Table Guide

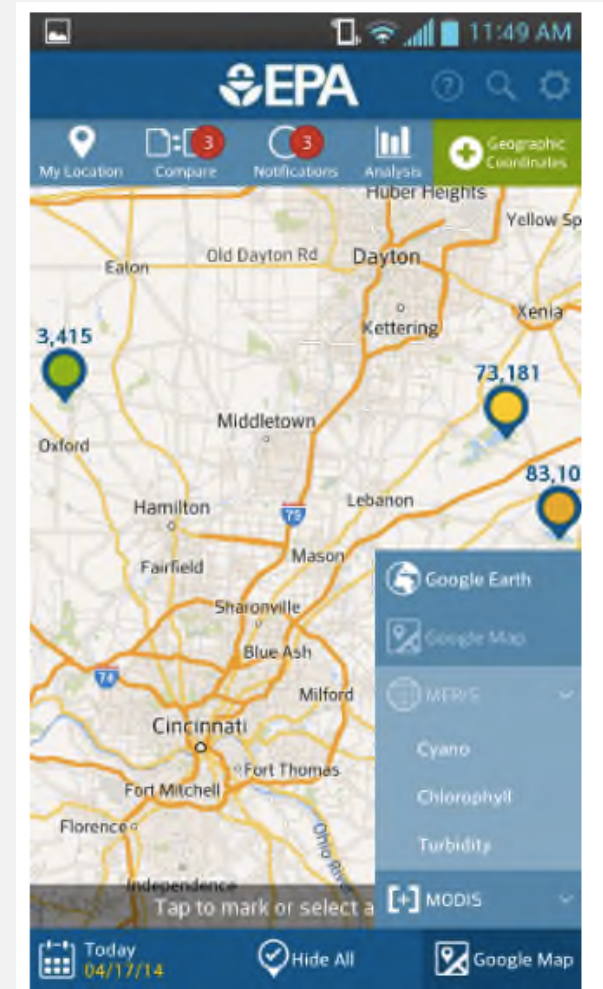
Severe Positive Anomaly	Current data ≥ 2 st. dev. above climatology
Moderate Positive Anomaly	Current data ≥ 1 st. dev. above climatology
No Anomaly	Current data within 1 st. dev. of climatology
Moderate Negative Anomaly	Current data ≤ 1 st. dev. below climatology
Severe Negative Anomaly	Current data ≤ 2 st. dev. below climatology

Cyanobacteria Assessment Network (CyAN)

<https://www.epa.gov/water-research/cyanobacteria-assessment-network-cyan#decision%20support>

- A collaborative program among EPA, NOAA, NASA, and USGS
- Focused on an early and uniform approach to algal bloom identification using satellite remote sensing from Landsat, Sentinel-2, and Sentinel-3
- Develop a decision support system for stakeholders

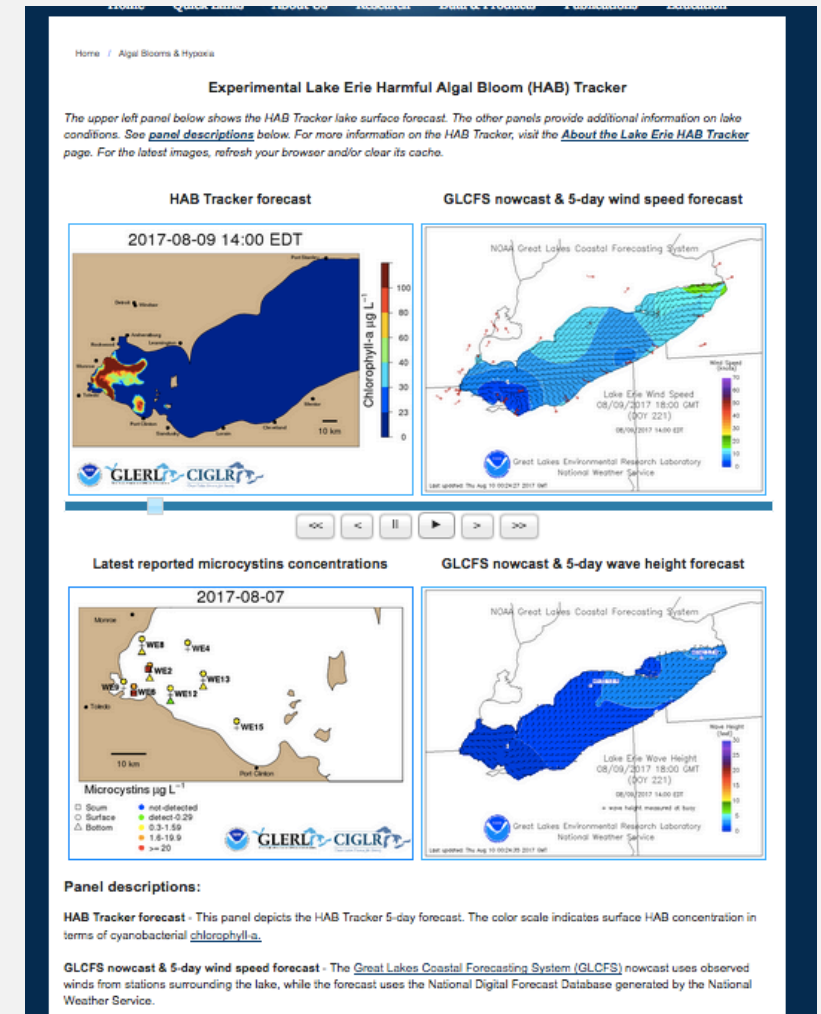
More information about CyAN will be presented in week 4



Lake Erie HAB Tracker

https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habTracker.html

- A forecast model based on:
 - MODIS satellite images
 - Weather forecast information
 - Modeled currents in Lake Erie
- Provides:
 - HAB measurements based on in situ water sample collection
 - Near real-time and 5 day HAB forecasts in terms of cyanobacterial chl-a



Lake Erie HAB Tracker

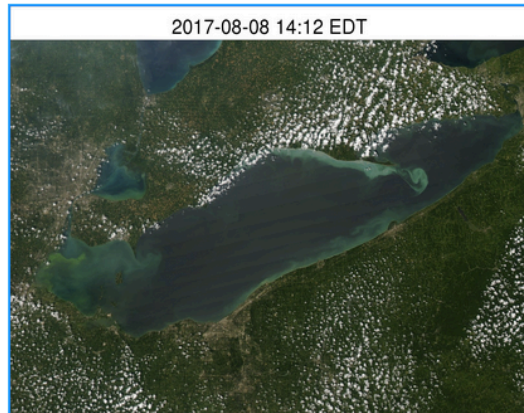
https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habTracker.html

MODIS-Derived Cyanobacterial Density

Latest satellite-derived data used by the HAB Tracker

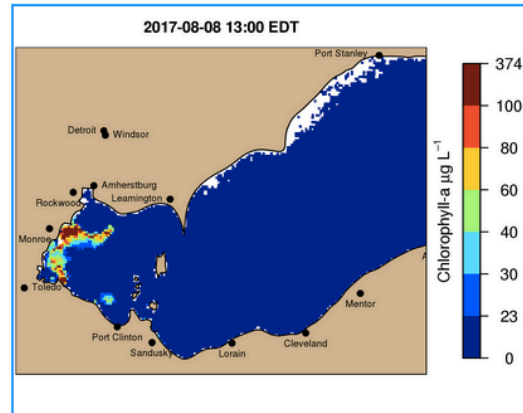
Sensors attached to satellites gather data, which is processed into the cyanobacterial index, an indicator of the abundance, or biomass, of the cyanobacteria associated with HABs. Processed satellite imagery is provided by the [NOAA HAB Operational Forecasting System](#). The cyanobacterial index scale is converted to a cyanobacterial chlorophyll scale for use in the HAB Tracker, a similar indicator of cyanobacterial abundance.

True-color satellite image of Lake Erie



Latest usable (relatively cloud-free) satellite image of Lake Erie. For additional satellite imagery of Lake Erie, visit the [NOAA Great Lakes CoastWatch](#) webpage.

HABs extent analysis



Latest HAB extent analysis from valid satellite imagery above used to update the bloom location in the model.



Photo Credit: NOAA GLERL

NOAA Coast Watch

https://coastwatch.noaa.gov/cw_html/index.html

Multi-sensor sea surface temperature product (March 14, 2017)

Atmospheric Administration
U.S. Department of Commerce

NOAA CoastWatch • OceanWatch

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Need Help?
(301) 683-3335

Latest News

- S-NPP VIIRS Life-of-Mission Science Quality Level-2 Ocean Color product reprocessing MSL12 v1.21.
- EUMETSAT OLCI-Sentinel-3A data now available.

Satellite data products for understanding and managing our oceans and coasts

Satellite Data Products

Nodes

How our data are used

Field Observations

Emily's Post

New Tools

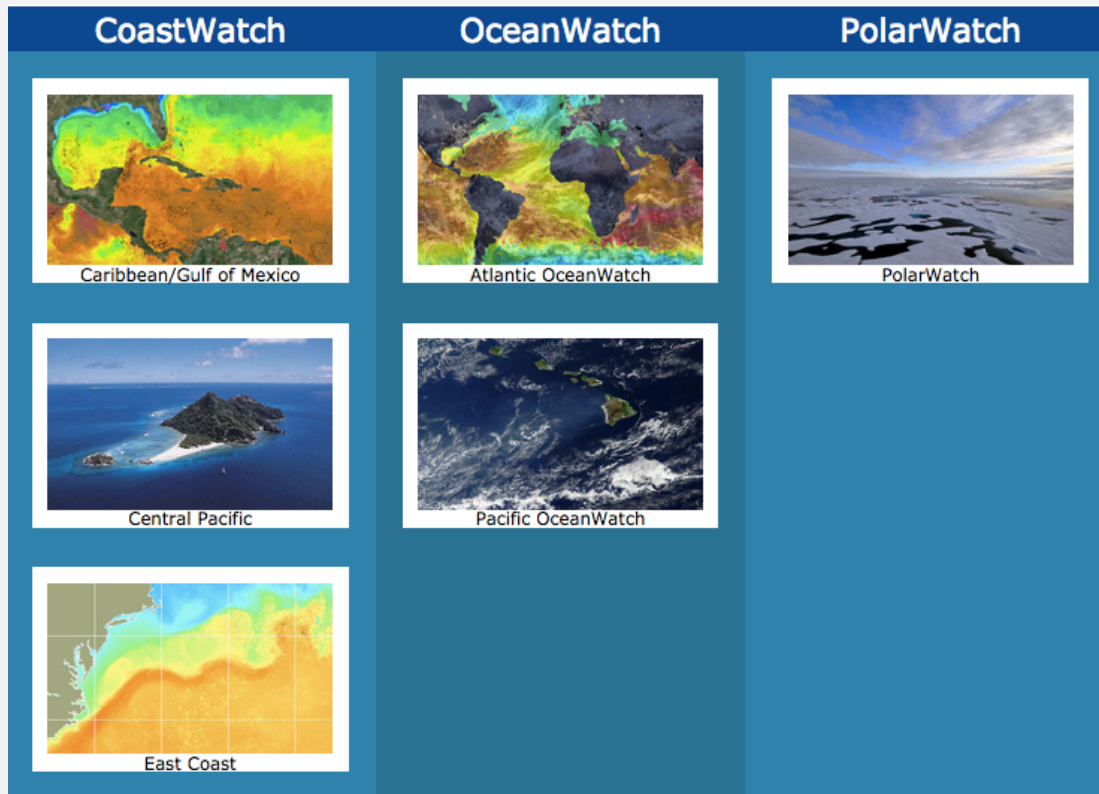
- Using remote sensing for understanding and managing oceans
- Provides HAB monitoring over coastal oceans

NOAA Coast Watch

https://coastwatch.noaa.gov/cw_html/index.html

- Information provided for multiple coastal areas

- Satellite products used
 - True-color Imagery
 - Ocean Color – Radiances and Chlorophyll-a Concentration
 - Sea Surface Temperatures
 - Sea Surface Height
 - Sea Surface Salinity
 - Sea Surface Winds



NOAA Coast Watch

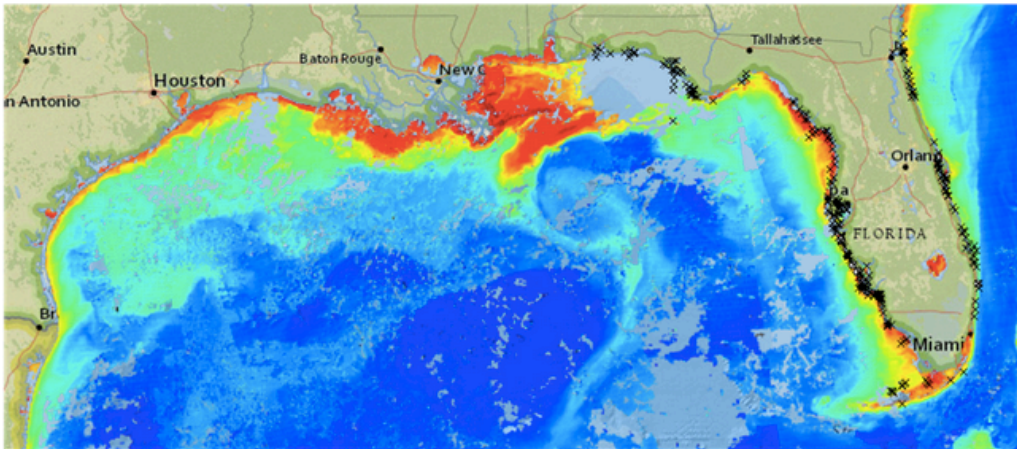
https://coastwatch.noaa.gov/cw_html/OceanColor.html

▼ Harmful Algal Bloom Monitoring and Forecasting in the Gulf of Mexico - 02/17

Harmful Algal Bloom Monitoring and Forecasting in the Gulf of Mexico - 02/17

Harmful algal blooms are a common occurrence in the Gulf of Mexico. Red tide blooms of the neurotoxin producing alga *Karenia brevis* are of particular concern. NOAA's National Ocean Service uses Coast Watch ocean color data along with cell counts and other environmental information to produce a Harmful Algal Blooms Observing System (HABSOS) and a Harmful Algal Bloom Operational Forecast System (HAB-OFS).

HABSOS is a combined data product distributed on an ArcGIS powered map. The system serves as a harmful algal bloom data resource for managers, scientists and the public. CoastWatch data available for visualization in HABSOS include chlorophyll-3 day composite data and chlorophyll anomaly data.



CoastWatch chlorophyll 3-day composite viewed on NOAA's HABSOS.

- Satellite-based HAB monitoring
- Near real-time remote sensing data used from:
 - MODIS Aqua
 - VIIRS S-NPP
 - OLCI Sentinel-3

Copernicus Marine Environment Monitoring Service

<http://marine.copernicus.eu/>

- Combined MODIS & VIIRS observations are used for monitoring HABs in:
 - North Atlantic
 - Arctic Ocean
 - Baltic Sea
 - Black Sea
 - Mediterranean Sea

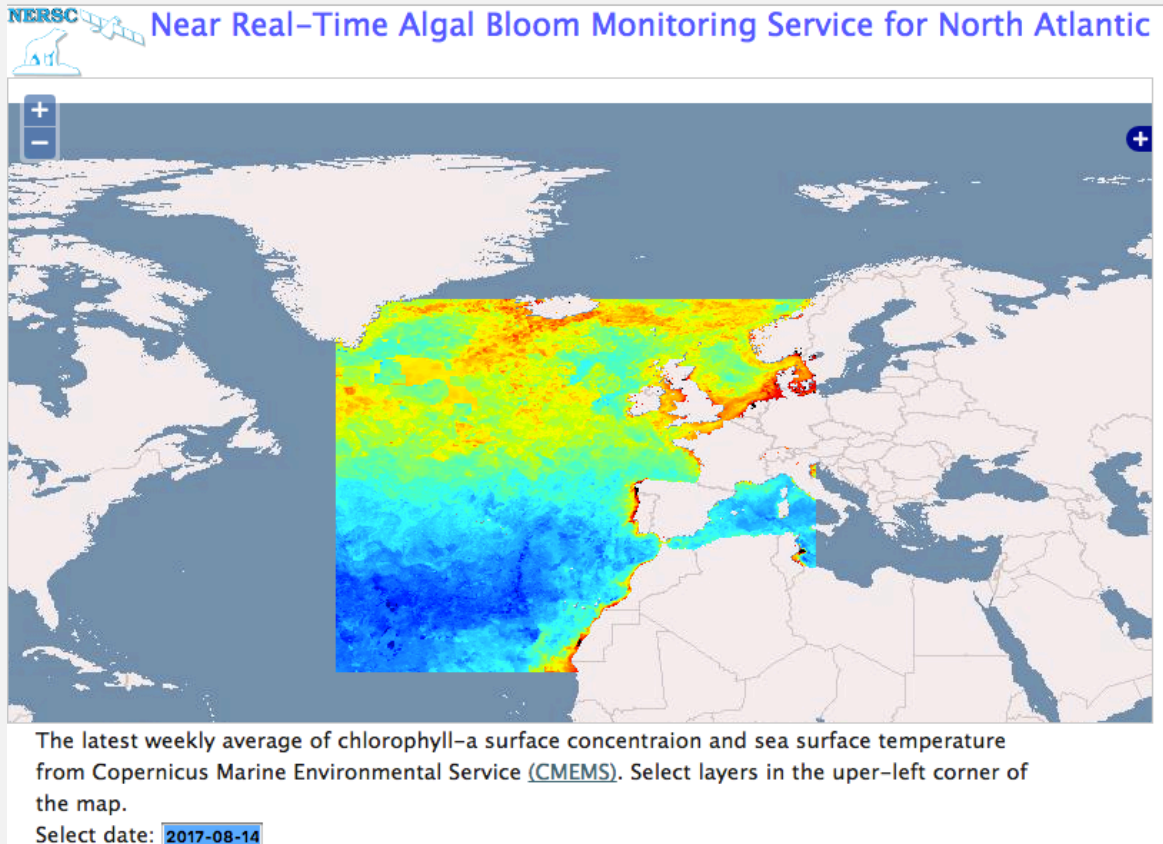
The screenshot displays the Copernicus Marine Environment Monitoring Service (MEMS) website interface. At the top, the European Commission logo and the MEMS title are visible, along with a search bar and navigation menu. The main content area features an 'ONLINE CATALOGUE' section with a search filter sidebar on the left. The sidebar includes options for 'REGIONAL DOMAIN' (All areas), 'PARAMETERS', 'TEMPORAL COVERAGE' (From 1992-01-01 to 2017-08-26), and 'PRODUCT WITH DEPTH LEVEL'. The search results show two product listings:

- GLOBAL_ANALYSIS_FORECAST_PHY_001_024**: GLOBAL OCEAN 1/12° PHYSICS ANALYSIS AND FORECAST UPDATED DAILY. Includes a world map visualization.
- GLOBAL_ANALYSIS_FORECAST_BIO_001_014**: GLOBAL OCEAN BIOGEOCHEMISTRY ANALYSIS AND WEEKLY FORECAST. Includes a world map visualization.

At the bottom, there are links for 'ABOUT US', 'PARTNERS & STAKEHOLDERS', 'BENEFITS', and a 'ANY QUESTIONS?' chat button.

Near Real-Time Algal Bloom Monitoring Services in the North Atlantic

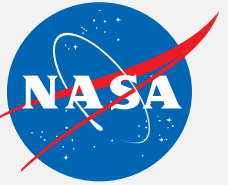
<http://hab.nersc.no/>



- Based on ocean color data from Copernicus Marine Environment Monitoring Service

Summary

- Remote sensing provides continuous global coverage with consistent observations compared to limited point measurements from surface or ship-based water sampling
- Optical and NIR remote sensing observations from Landsat, Terra/Aqua MODIS, SNPP VIIRS, Sentinel-2 MSI and Sentinel-3 OLCI are used operationally for qualitative and quantitative HAB (Chl, and SST) monitoring



ARSET

Applied Remote Sensing Training

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

 @NASAARSET

Thank you!

Next Week:

Understanding HABs in the Coastal Environment