Welcome to
NASA Applied Remote Sensing Training (ARSET)
Webinar Series

Introduction to Water Quality (WQ) Monitoring From Remote Sensing Measurements

Course Dates: 18, 25, November and 2, December 2014
Time: 8 to 9 am Eastern US time

ARSET : Applied Remote SEnsing Training

A project of NASA Applied Sciences

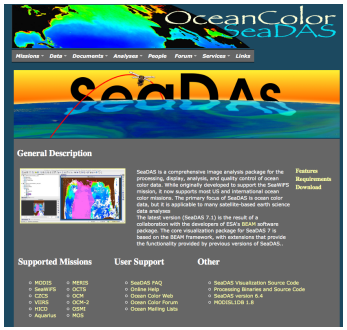
Course Outline

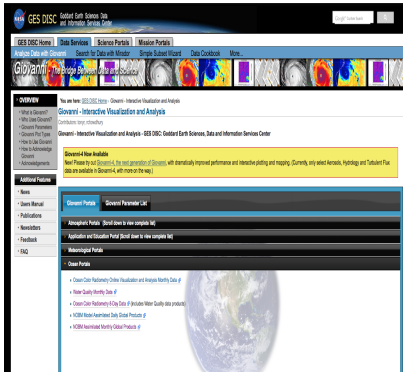
Week 1

Introduction to Remote Sensing of WQ parameters

Week 2

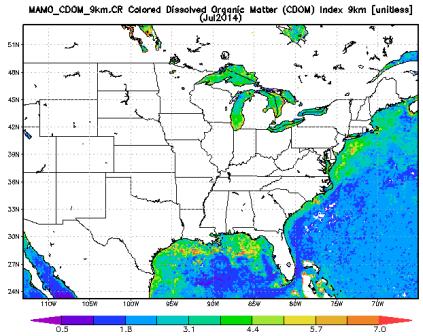
NASA WQ Data, Access, and Tools





Week 3

Overview of WQ Monitoring and
Case Studies of Monitoring WQ in Selected Water Bodies



Webinar Information

Speakers:

Amita Mehta amita.v.mehta@nasa.gov

Ana Prados Ana.I.Prados@nasa.gov

Africa Flores Africa.flores@nasa.gov

Guest Speaker:

Blake Schaeffer (Week-3) Schaeffer.Blake@epa.gov

Webinar Information

Presentation URL: http://arset.gsfc.nasa.gov/webinar

Contact for requesting Certificate and more information about the course material

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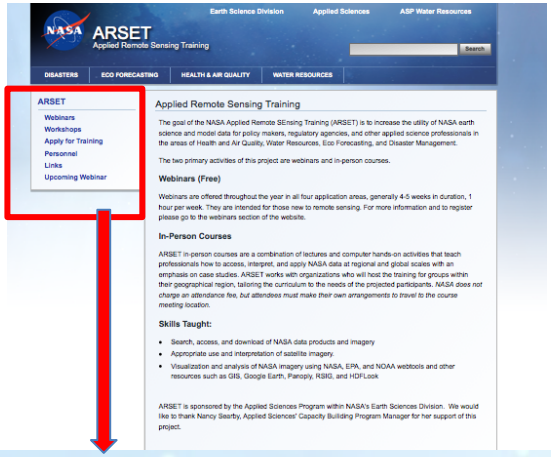
ARSET Web Page

http://arset.gsfc.nasa.gov



Water Quality Monitoring Using Remote Sensing Measurements

11/18/2014 to 12/02/2014

Times: Course-I: 8-9 AM, Course-II: 1-2 PM, Course-III: 10-11 AM (Eastern US time)

There are three identical courses offered at three different times

Courses I and II are in English, and Course III is in Spanish

Please sign up for any ONE course.

Course-I (8-9 AM, English) Information and Registration

Course-II (1-2 PM, English) Information and Registration

Course III (10-11 AM, Spanish) Information and Registration

Course Objective: To introduce remote sensing data, their access, analysis, and applications for water quality (WQ) monitoring in coastal oceans, estuaries, and in-land lakes.

Course Agenda:

Week-1: Introduction to Remote Sensing of WQ parameters

Week-2: NASA WQ Data, Access, and Tools

Week-3: Overview and Future Prospects of Remote Sensing of WQ Monitoring and Case Studies of Accessing WQ Data

A certificate will be awarded to participants who attend all three sessions and submit completed homework assigned during the course.

Agenda: **WQ Webinar Agenda**
GIS: True
Keywords: **Satellite Imagery, Tools**
Instruments: **Aqua, Landsat, MODIS, Terra, VIIRS**

Presentations and Reccordings

Week	Date	Title	Presentation	Recording	H
1	November 18, 2014	Introduction to Remote Sensing of WQ parameters	Session-1 (English) Session-1 (Spanish)	View Week 1 Recording (English) View Week 1 Recording (Spanish)	N/A
2	November 25, 2014	NASA WQ Data, Access, and Tools			
3	December 2, 2014	Overview and Future Prospects of Remote Sensing of WQ Monitoring and Case Studies of Accessing WQ Data			

Session Presentations and Recordings

Sign up to the listserve for more information and program updates

https://lists.nasa.gov/mailman/listinfo/arset

Week 2: Outline

NASA WQ Data, Access, and Tools

- Overview of Satellite and Sensors for WQ Remote Sensing
- Water Quality Data and Tools: SeaDAS, OceanColor Web, Giovanni, LandsatLook, GloVis, EarthExplorer
- Future Satellite Missions: GEO-CAPE, PACE,
- Introduction to NASA Ocean Biogeochemical Model

Review Week-1: Water Quality Parameters

Physical Properties: Color, Temperature, Density, Heat Capacity, Turbidity, Suspended Sediment

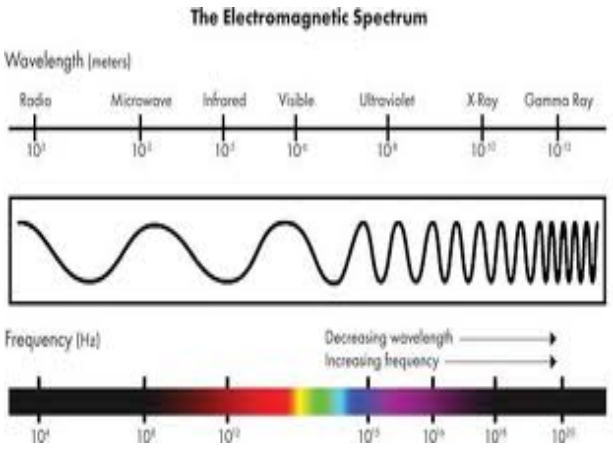
Chemical Properties: pH, Salinity, Dissolved Oxygen, Conductivity, Hardness

Biological Properties: Algal Bloom/Chlorophyll-a, Microorganisms, Dissolved Organic Carbon

WQ Parameters (marked in red) can be obtained from NASA earth observing satellites with multi-year, near-global coverage

Review Week-1 : Remote Sensing Attributes

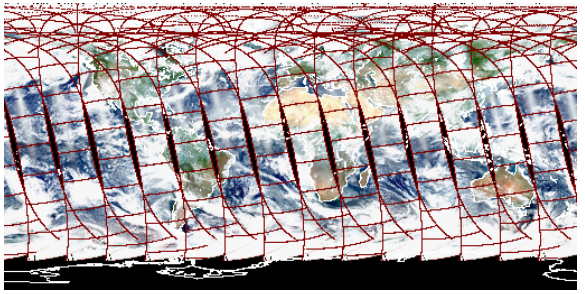
- Satellite Missions/Sensors Used for WQ Information
- Satellite Orbit Configuration: Temporal Resolution, Spatial Coverage (Geostationary and Polar Orbits)
- Sensor Characteristics: Type, Spatial Resolution, Spectral Bands



Landsat-7 Image of Niger River Delta

Spatial resolution: 30 m

Aqua (“ascending” orbit) day time



Review Week-1: Remote Sensing Observations for WQ

	Satellite	Sensor	Parameter
Current Missions	Terra	MODIS	Chlorophyll-a concentration, Temperature, Colored Dissolved Organic Matter (CDOM), Turbidity, Euphotic Depth[1]
	Aqua	MODIS	
	Landsat	TM and ETM+ OLI	Spectral Reflectance
	Terra	ASTER	Spectral Reflectance, Temperature
	NPP	VIIRS	Spectral Reflectance, Chlorophyll Concentration

MODIS: The Moderate Resolution Imaging Spectroradiometer
ASTER: The Advanced Spaceborne Thermal Emission and Reflection Radiometer
TM and ETM: Thematic Mapper and Enhanced Thematic Mapper **OLI:** Operational Land Imaging
VIIRS: Visible Infrared Imaging Radiometer Suit

[1]The euphotic depth is the depth at which light intensity falls to 1% of the value at the surface of a body of water. Euphotic depth is influenced by phytoplankton, colored dissolved organic matter, and suspended particulate matter.

Review Week-1: Remote Sensing Observations for WQ

	Satellite	Sensor	Parameter
Current Research Missions	EO-1	Hyperion ALI	Spectral Reflectance
	International Space Station	HICO	Spectral Reflectance (gathered upon request)
Past Missions	SeaStar/OrbVew	SeaWiFS	Chlorophyll-a, Temperature, Particulate Inorganic Carbon, Particulate Organic Carbon, CDOM Index
	Envisat (ESA)	MERIS	Spectral Reflectance, Chlorophyll concentration

ALI: Advanced Land Imager Spectrometer

MERIS: MEdium-spectral Resolution Imaging

SeaWiFS: Sea-viewing Wide Field-of-view Sensor

HICO: Hyper-spectral Images for Coastal Ocean

WQ Parameters from Remote Sensing Observations

- Landsat (TM, ETM+, OLI), Terra (ASTER), and EO-1 (Hyperion) spectral reflectance and imagery can provide qualitative information about WQ **but** require further processing and algorithms to obtain quantitative WQ parameters

- This session will provide description of current and future satellites/sensors and tools to access available data with focus on readily available WQ parameters from MODIS

Spectral Reflectance and Water Quality Parameters

Spectral Reflectance in different bands change with changing water quality properties such as Suspended Particles, Secchi Disk Depth, Turbidity, and Chlorophyll Concentration

Landsat, MODIS spectral reflectance are widely used to monitor WQ

Example:

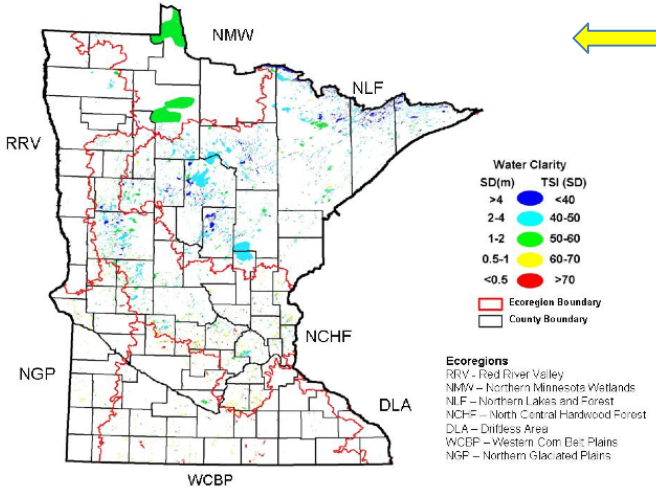


Figure 7. Minnesota 2005 lake clarity with county and ecoregion boundaries.

Landsat TM based TSI of lakes in Minnesota derived from in situ measurements and Landsat

(TSI is measure of nutrients/chlorophyll and SDT)

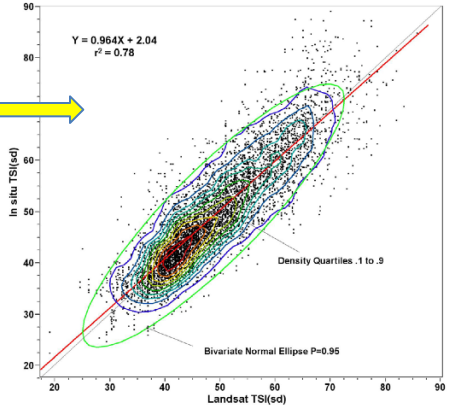
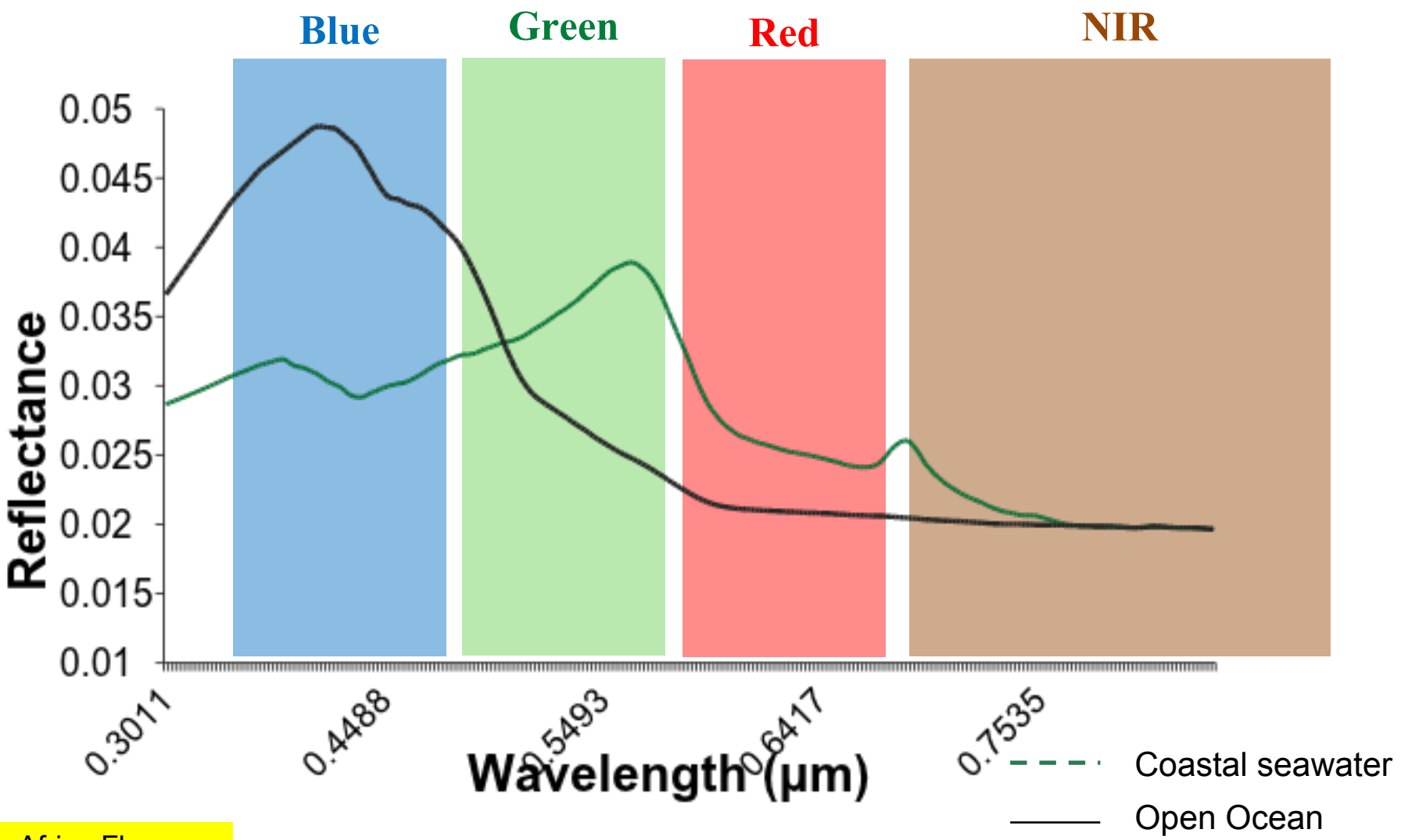


Figure 6. Scatter plot of Landsat TSI(sd) vs. In situ late summer mean TSI(sd) for 6216 lake points.

Reference: A 20-year Landsat Water Clarity Census of Minnesota's 10,000 Lakes
(**http://water.umn.edu/Documents/Olmanson,%20et_al.__RSE--lake_clarity_paper.pdf**)

Spectral Reflectance and Chlorophyll Concentration

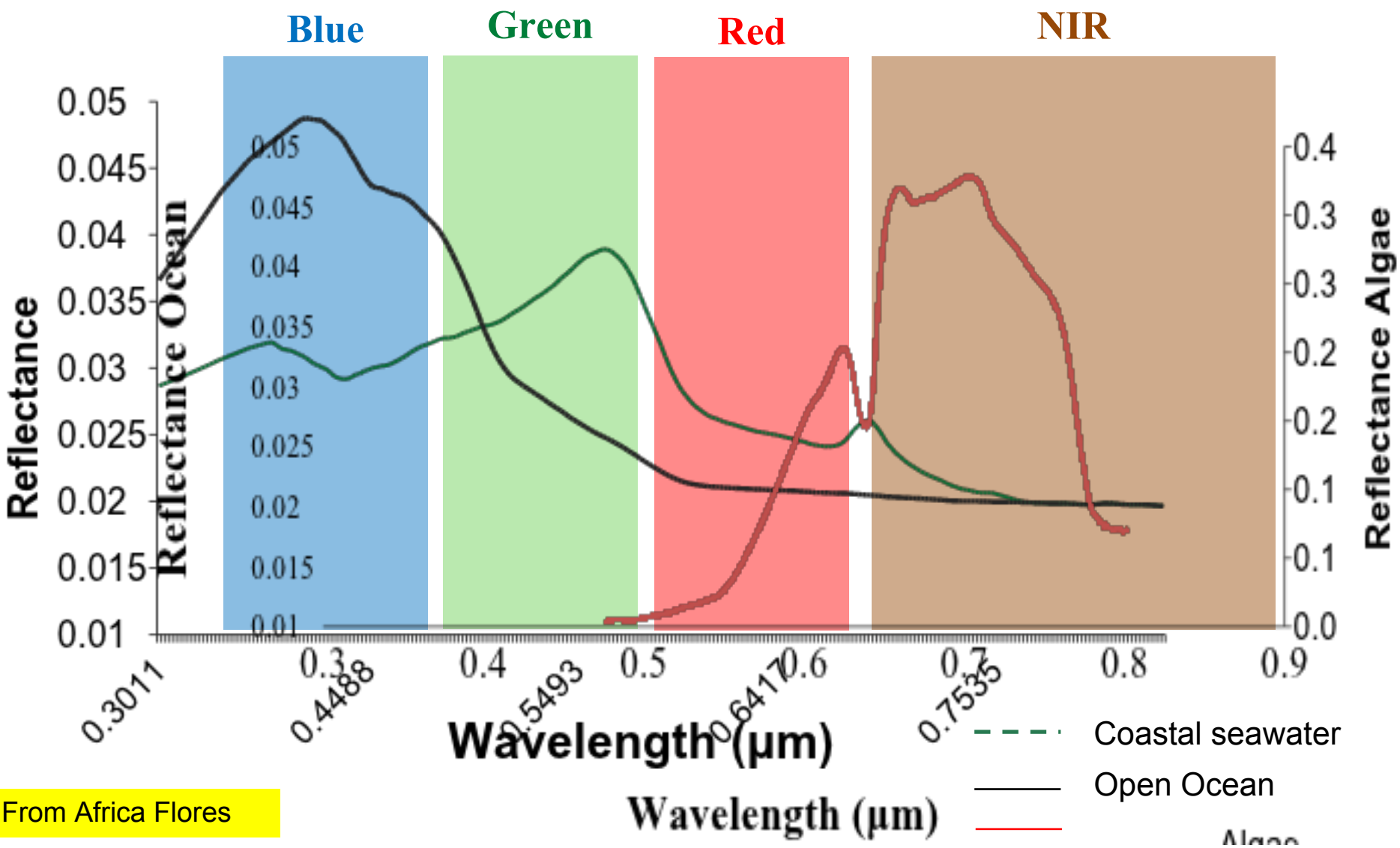
Chl-a < 2mg/m³ 2 – 30 mg/m³ > 300mg/m³



From Africa Flores

Spectral Reflectance and Chlorophyll concentration

Chl-a < 2mg/m³ 2 – 30 mg/m³ > 300mg/m³

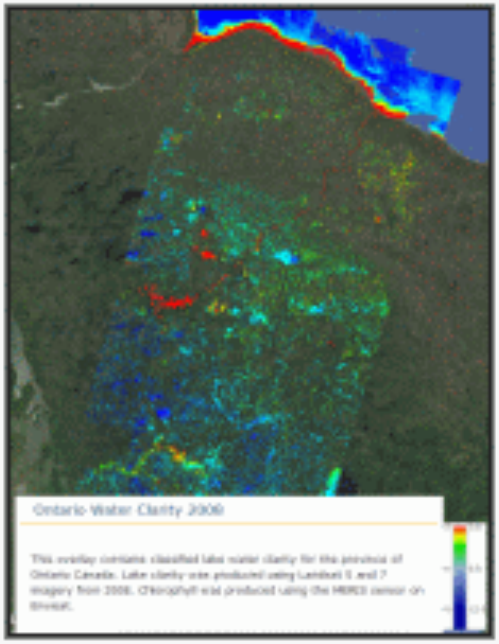


From Africa Flores

http://water.umn.edu/

Use of remote sensing and and situ data in operational water quality monitoring of in-land lakes and streams

Ontario Water Clarity 2008



UNIVERSITY OF MINNESOTA

REMOTE SENSING OF WATER RESOURCES

A collaboration of the University of Minnesota's Remote Sensing and Geospatial Analysis Laboratory and Water Resources Center

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Mapping Stream Quality
Mapping Aquatic Vegetation
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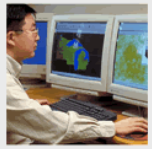
Welcome

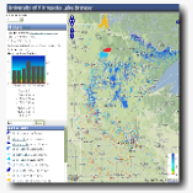
Although water quality protection is a priority for water agencies in lake-rich areas like the Upper Midwest, budgets restrict the number of lakes monitored. As a result, agencies cannot identify and manage all water resource problems.

At the University of Minnesota's Water Resources Center and Remote Sensing Laboratory, analysts are developing a new monitoring approach. With images captured from earth-observing satellites, they're estimating lake and stream water clarity and mapping aquatic vegetation at city, state and regional scales.

3. Process satellite imagery



Find out how clear your favorite Minnesota lake is!



In the News

Measuring Water Clarity and Quality in Minnesota Lakes and Rivers: A Census-Based Approach Using Remote-Sensing Techniques CURA Reporter, summer 2007
by Patrick L. Brezonik, Leif G. Olmanson, Marvin E. Bauer, and Steven M. Kloiber
Read more from the CURA Reporter

Report on Minnesota rivers comes now by air
03/05/2006 - From 11,000 feet, a powerful sensor can detect subtle changes in water quality along the length of a river...
Read more from the Minneapolis Star Tribune

Satellite Tabulation of Impervious Surface Areas
2005 - The past decade has been one of steady growth across many areas of North America including Minnesota, and particularly in our lake regions and associated communities...
Read more from *LakeLine* - A publication of the North American Lake Management Society

Scientists Monitor Water Quality from Air
09/08/2004 - Scientists are testing a new tool for monitoring the health of our rivers: a high-tech contraption that tests water quality from the air...
Read more from Kare 11 News, Minneapolis-St. Paul

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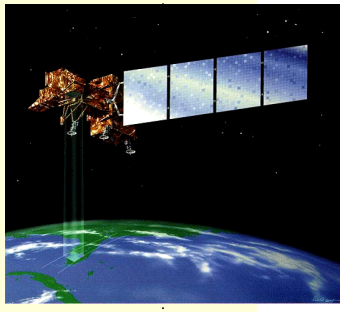
Overview of Satellites and Sensors for WQ Remote Sensing

Landsat

http://landsat.gsfc.nasa.gov/
http://landsat.usgs.gov/

Continuous mission with multiple satellites, Landsat-1 launched in July 23, 1972



Landsat-1 (ERTS)
Landsat-2
Landsat-3
Landsat-4
Landsat-5
Landsat-6
Landsat-7

MSS (79 m, 4 band)
TM (30/120 m, 7 band)
ETM+ (15/30/60 m, 8 band)
Landsat 8 (15/30/90 m, 9 band)

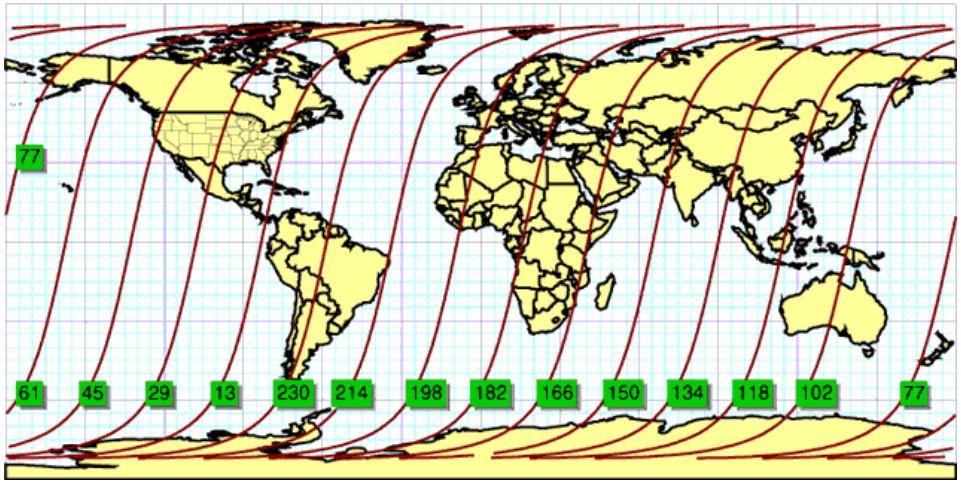
Landsat 8
Launched 11 Feb. 2013

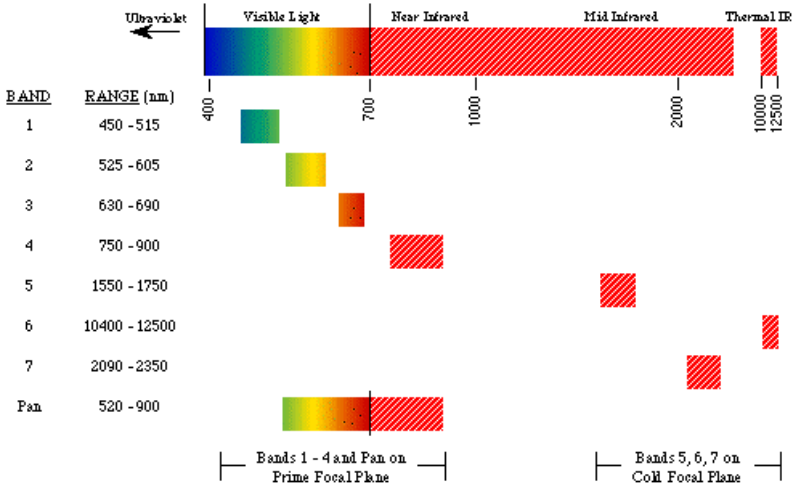
1970 1980 1990 2000 2010

Commercial operations
Government operations

Landsat

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



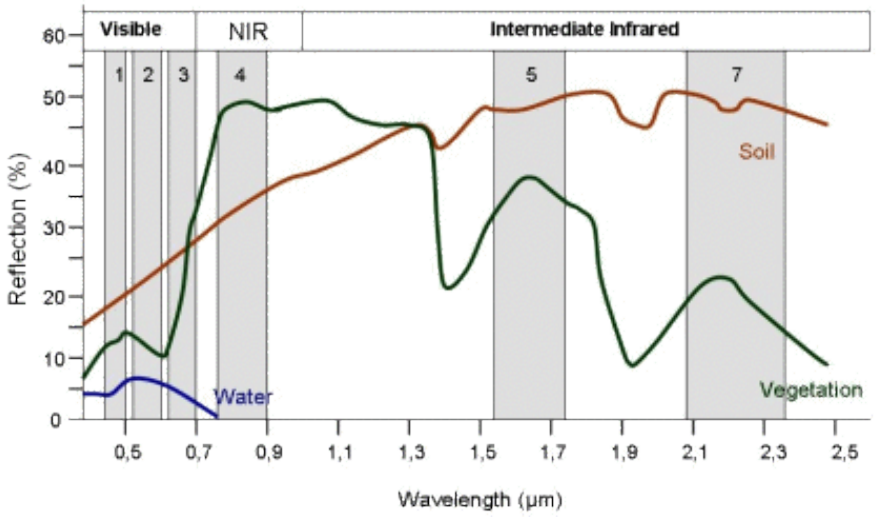


- Near-polar orbit, 10 am equator-crossing time
- Global coverage
- July 1972- Present, 16-day revisit time
- Sensors: MSS,TM, ETM+,OLI, TIRS

Enhanced Thematic Mapper (ETM+)

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

- Flying on-board Landsat-7 polar orbiting satellites.
- **Spatial Coverage and Resolution**: global, Swath 185 km, Spatial resolution 15 m, 30 m, 60 m
- **Temporal Coverage and Resolution**:
  April 15, 1999-present,
  16 day revisit time

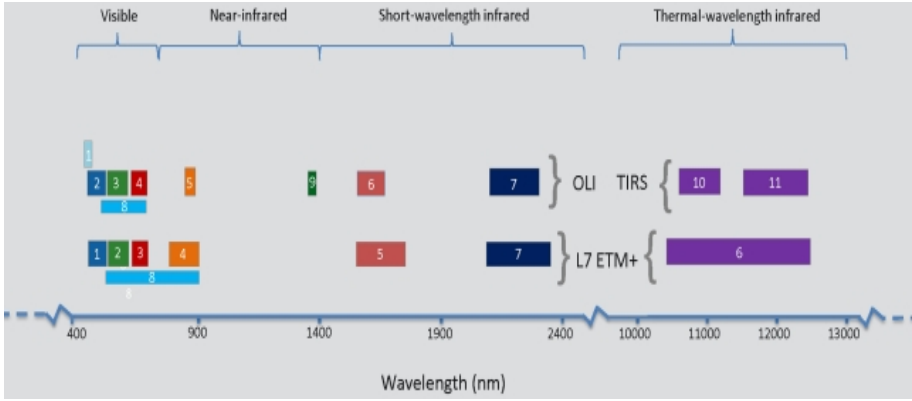


- **Spectral Bands**:
  8 bands (major bands include Blue-green, Green, Red, Reflected and Thermal IR, Panchromatic)

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

Operational Land Imager (OLI)

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



- Flying on-board Landsat-8 (Landsat Data Continuity Mission - LDCM) polar orbiting satellites.

- **Spatial Coverage and Resolution**:
  global, Swath 185 km,
  spatial resolution 15 m, 30 m

- **Temporal Coverage and Resolution**:
  February 11, 2013-present,
  16 day revisit time

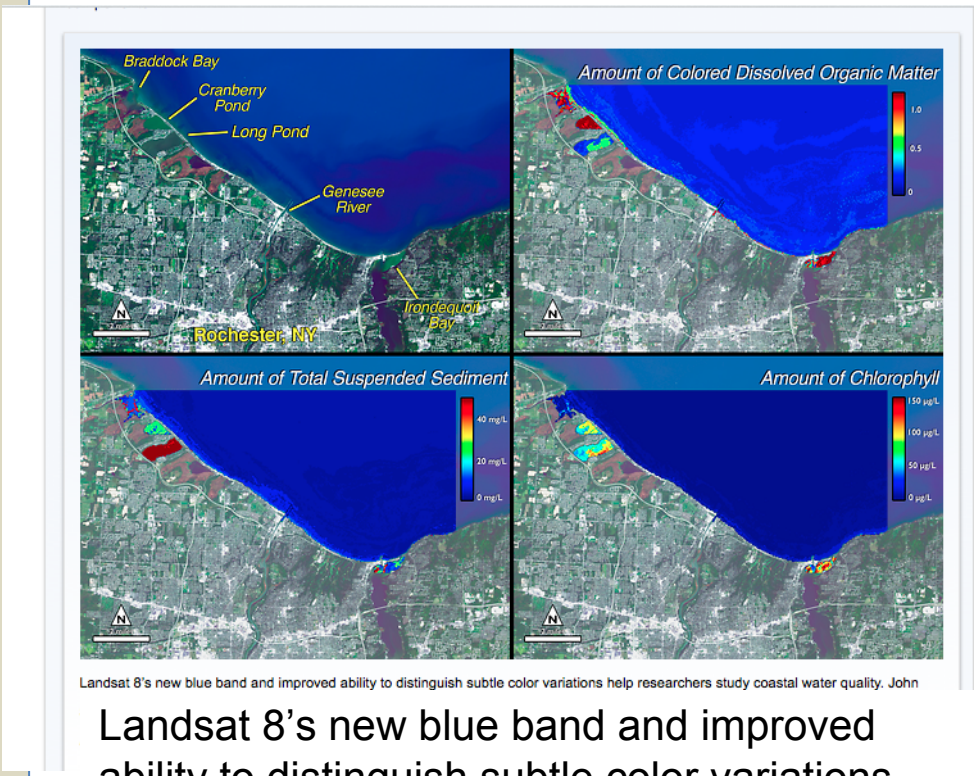
- **Spectral Bands**:
  9 bands (major bands include Blue- Green, Red, Near IR, Shortwave and Thermal IR, panchromatic)

  Bands 1-7,9: 30 m
  Band 8: 15 m

WQ Parameters from Landsat

- Only spectral reflectance and imagery available on-line, numerous studies use these information to get the following parameters over various locations:

  Chlorophyll Concentration, Secchi Disk Depth, Suspended Particles, Turbidity, Colored Dissolved Organic Matter

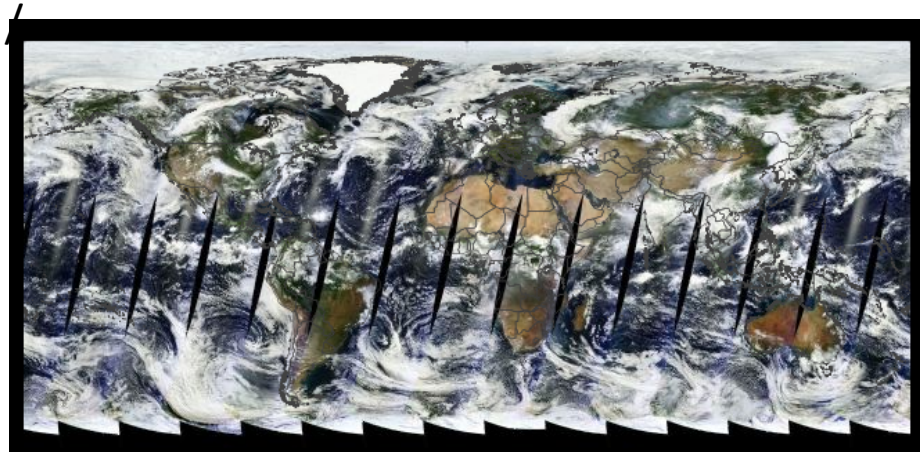


Landsat 8's new blue band and improved ability to distinguish subtle color variations help researchers study coastal water quality. Image Credit: RIT/NASA/USGS

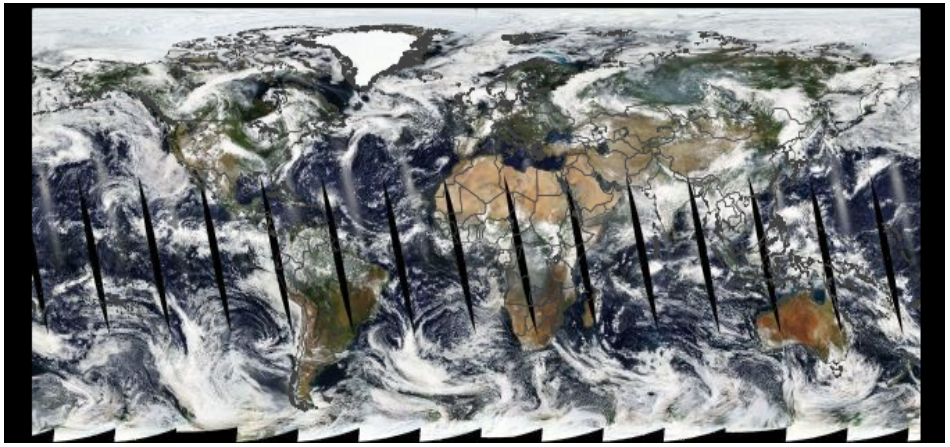
http://www.nasa.gov/content/goddard/taking-nasa-usgs-landsat-8-to-the-beach/#.VG64blfUmIg

Terra and Aqua

http://terra.nasa.gov/



http://aqua.nasa.gov/



Terra:

- Polar orbit, 10:30 am equator crossing time
- Global Coverage
- December 18,1999 – Present
- 1-2 observations per day
- **Sensors:**
  ASTER, CERES, MISR, MODIS, MOPITT

Aqua:

- Polar orbit, 1:30 pm equator crossing time
- Global Coverage
- May 4, 2002 – Present
- 1-2 observations per day
- **Sensors:**
  AIRS, AMSU, CERES, **MODIS,** AMSR-E

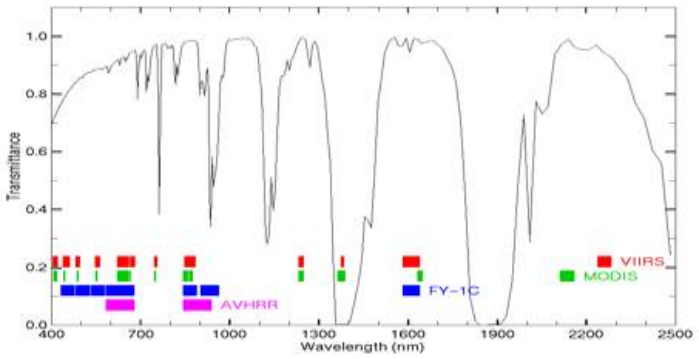
MODerate Resolution Imaging Spectroradiometer (MODIS)

http://modis.gsfc.nasa.gov

- Flying on-board Terra and Aqua – polar orbiting satellites. Designed for Land, Atmosphere, Ocean, Cryosphere observations

- **Spatial Coverage and Resolution**:
  global, swath width 2330 km,
  spatial resolution vary:
  250 m, 500 m,1 km

- **Temporal Coverage and Resolution**:
  2000-present, 2 times per day

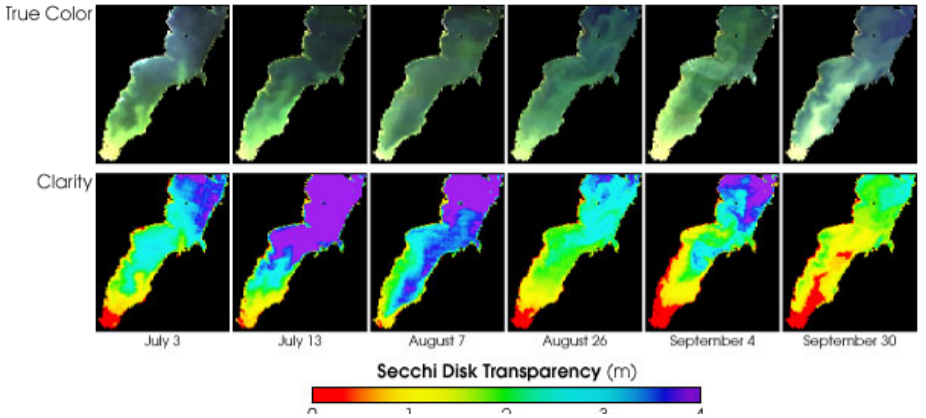


- **Spectral Bands**:
  36 bands (major bands include Red, Blue, IR, NIR, MIR)

  Bands 1-2: 250m
  Bands 3-7: 500m
  Bands 8-36: 1000m

Water Quality Parameters from MODIS

Chlorophyll, Sediments, Chlorophyll Fluorescence, Surface Temperature, Colored Dissolved Organic Matter (CDOM), Turbidity



These images show true-color imagery and water quality data for Green Bay, Wisconsin during the summer of 2001. The MODIS acquires data over a wider area and more frequently than Landsat, allowing researchers to track seasonal water clarity. (Images courtesy Jonathan Chipman, Center for Limnology and Environmental Remote Sensing Center, University of Wisconsin)

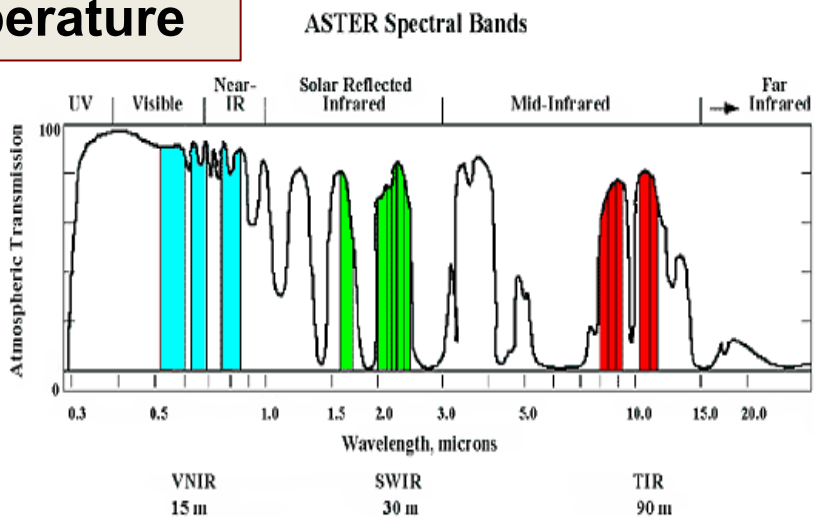
https://lpdaac.usgs.gov/products/modis_products_table/modis_overview

http://earthobservatory.nasa.gov/Features/WaterQuality/water_quality4.php

Advanced Spaceborne Thermal and Reflection Radiometer (ASTER)

http://asterweb.jpl.nasa.gov/

Water Quality Parameter: Surface Temperature



- Flying on-board Terra – polar orbiting satellite

- **Spatial Coverage and Resolution**:

  global, swath width 60 km,

  spatial resolution varies: 15m, 30 m, 90 m

- **Temporal Coverage and Resolution**:

  2000-present, 2 times per day

- **Spectral Bands**:

  14 bands (visible to the thermal I IR Bands)

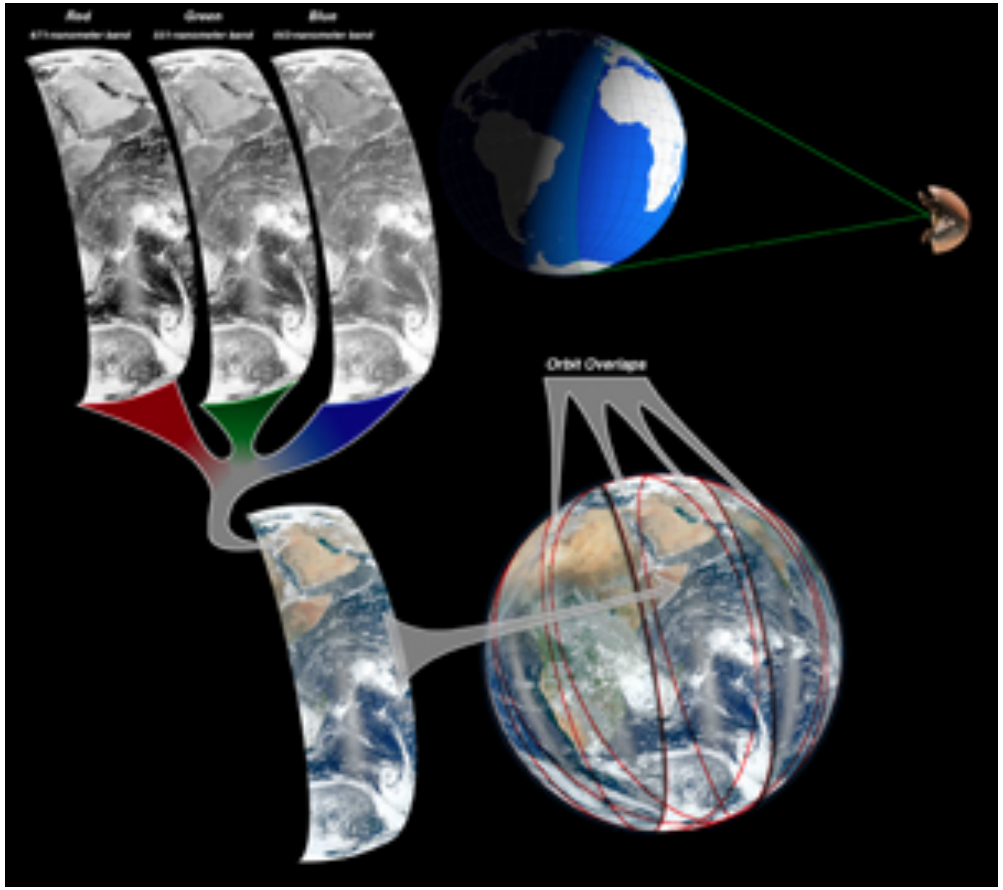
  Bands 1-3: 15 m (VNIR)
  Bands 4-9: 30 m (SWIR)
  Bands 10-14: 90m (TIR)

Status alert: ASTER SWIR data acquired since April 2008 are not useable

National Polar-orbiting Partnership (NPP)

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

Water Quality Parameter Currently Available : Chlorophyll Concentration



- Polar orbit, 1:30 pm equator crossing time
- Global coverage
- November 21, 2011- Present
- 1-2 observations per day
- **Sensors:**
  VIIRS, ATMS, CrIS, OMPS, CERCES

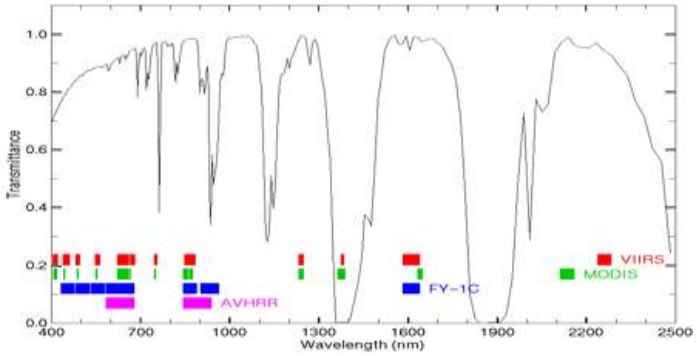
Visible Infrared Imaging Radiometer Suite (VIIRS)

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

- Flying on-board NPP – polar orbiting satellite. Designed to to collect measurements of clouds, aerosols, **ocean color, surface temperature,** fires, and albedo.

- **Spatial Coverage and Resolution**:
  global, swath width 3040 km,
  spatial resolution 375 m to 750 m

- **Temporal Coverage and Resolution**:
  Oct 2011-present, 2 times per day



Spectral Bands:
15 bands (major bands include visible, Red, Blue, Green, Short, Middle and Long -wave IR)

Ocean Color Bands 1-7 (0.402-0.682 μm), Sea Surface Temperature Bands 1, 2-13 (3.660-4.128 μm)

Earth Observing Mission (EO-1)

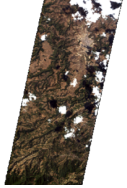
http://eo1.gsfc.nasa.gov/

- A part of the New Millennium Program (NMP)
- Breakthrough technologies designed to enable the development of future earth imaging observatories

- Polar orbit, 10 am equator crossing time ((in formation with Landsat-7)
- November 21, 2000 – Present (extend mission after 2001)
- Data Acquisition within minutes from Landsat-7
- **Sensors:**
  ALI, Hyperion, LEISA

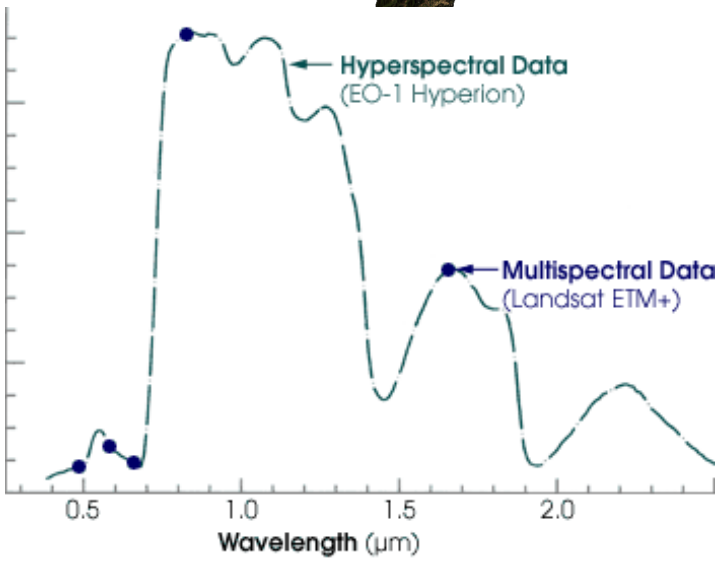
Hyperion

http://eo1.usgs.gov/sensors/hyperion

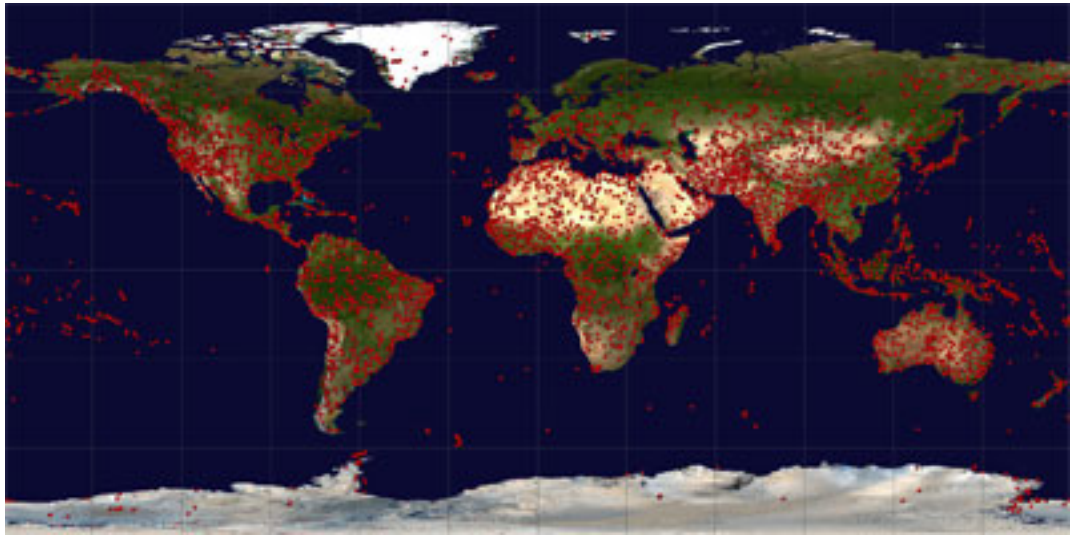


- Flying on-board EO-1 – polar orbiting satellite.
- **Spatial Coverage and Resolution**: Global, 30m
- **Temporal Coverage**

  Since November 2000, available through Data Acquisition Request (DAR)



Available Scenes



- **Spectral Bands**:

  220 Bands (from 400 to 2500 nm)

  About 28 bands between 480 nm to 750 nm useful for water quality monitoring

Hyperspectral imaging has wide ranging applications in mining, geology, forestry, agriculture, and environmental management

Hyperspectral Imager for the Coastal Ocean (HICO)

http://www.nasa.gov/mission_pages/station/research/experiments/689.html#overview

- On-board International Space Station in near-circular orbit
- **Spatial Coverage and Resolution**: Selected Images, Spatial resolution 90 m (varies with altitude and angle)
- Only one image per orbit can be requested (42 km x 192 km scene)
- **Temporal Coverage**
  Since November September 25, 2009
  3-day revisit time

http://hico.coas.oregonstate.edu/datasets/datacharacteristics.shtml

Columbia River Mouth, Oregon
2012-05-12 16:33:42

- **Spectral Bands**:
  87 bands in visible to the near-infrared (VNIR) wavelengths

Data Request: http://hico.coas.oregonstate.edu/collections/collection_process.shtml

Past Ocean Color Missions

http://oceancolor.gsfc.nasa.gov/SeaWiFS/

Seastar/Orbview:

- polar orbit, ~ 12 pm equator-crossing time
- Global coverage
- August 1, 1997 – December 2010
  1-day revisit time
- Sensors: SeaWIFS

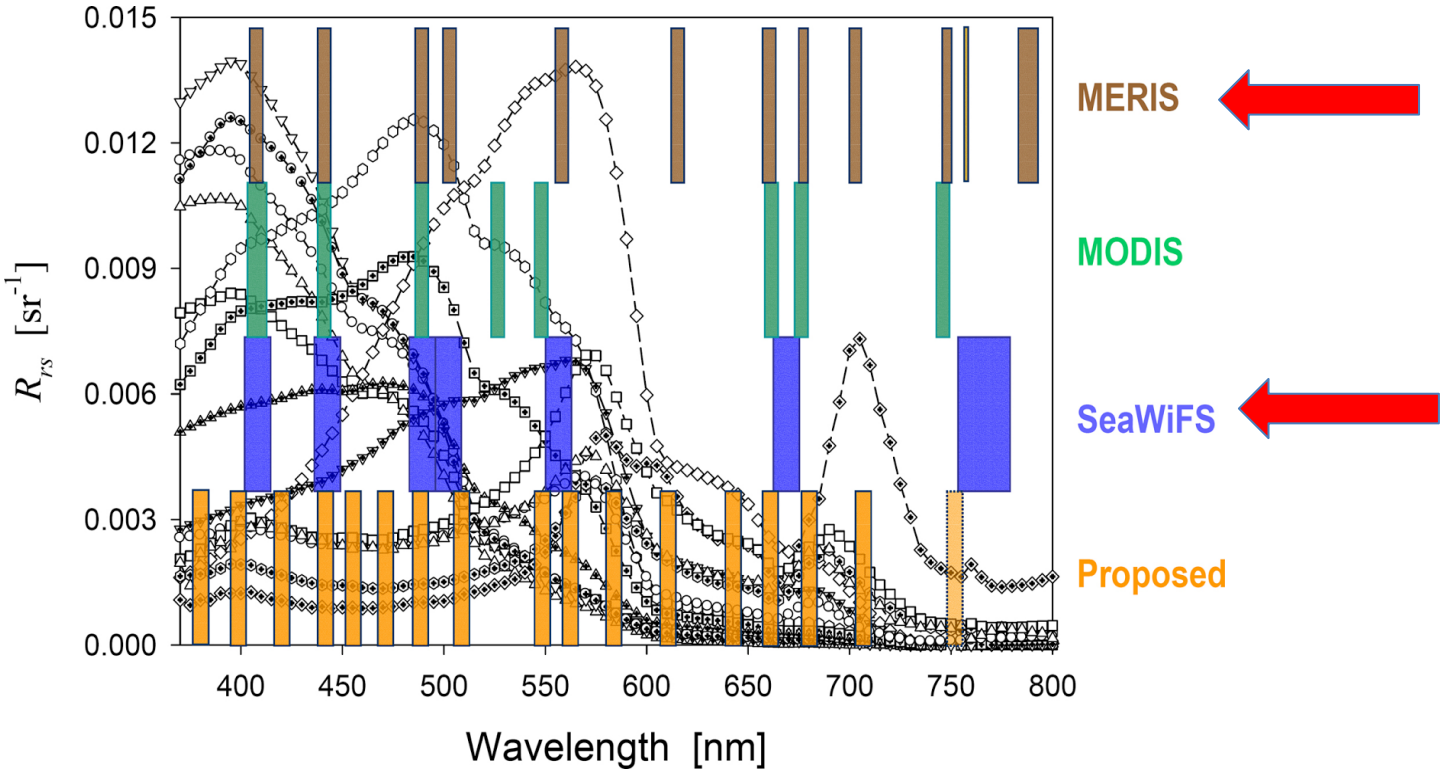
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/envisat

ENVSAT:

- polar orbit, 10 am equator-crossing time
- Global coverage
- March 2002 - April, 2012
  30 day revisit time
- Sensors: AATSR, ASAR, MERIS

Past Ocean Color Missions

Primary objective was to clarify the magnitude and variability of chlorophyll and primary production by marine phytoplankton, and to determine the distribution and timing of algal blooms



SeaWIFS : 8 Spectral Bands, Swath Width 1502 km, Spatial resolution of 4.5 km

MERIS: 15 Spectral Bands, Swath Width 1150 km, Spatial resolution ->Ocean: 1040m x 1200 m, Land & coast: 260m x 300m

Data Processing Levels

Remote Sensing Data Processing

Level 0 Raw Instrument Data

Level 1 Geolocated and Calibrated

Level 2 Geophysical Data Derived from L1 Products

Level 3 Composites Of Level 2 Data Products

Level 4 Model-derived Data Product

Less Processing
Orbital Data

- More user control
- Highest spatial/temporal resolution
- Harder to use

More Processing
Gridded Data

- Less user control
- Lower spatial/temporal resolution but gridded and may be available at multiple spatial/temporal resolutions
- More web-tools available for analysis/ access
- Easier to use

Remote Sensing Data Formats

- **Text/ASCII**

  pros: easy to read and examine the data right away (can read with used tools such as excel and GIS software)

  cons: large data files, not always available.

- **Binary – HDF, NetCDF**

  pros: takes less space, more information (metadata, SDS)

  cons: need specific tools or code to read the data

- **KML or KMZ (zipped KML)**

  pros - easy 2D and 3D visualization of the data through free tools such as Google Earth. Data are very low volume

- **Shapefiles/Geotiff**: GIS Applications. May or may not work with open source

Data Access Tools

NASA Earth Observing System Data and Information System (EOSDIS) has a number of data centers that distribute a variety of NASA remote sensing and other ancillary data and tools

More information can be found from ARSET webinar : http://arset.gsfc.nasa.gov/airquality-disasters-ecoforecasting-water-resources/webinars/introduction-nasa-earth-science-data

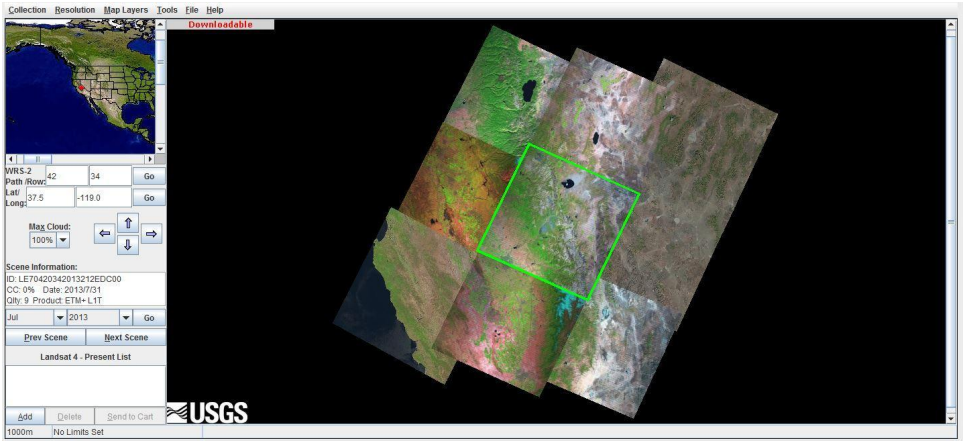
Data and Tools

Satellite/Sensor	Data Access Tool	Source	Coverage	Spatial Resolution
Terra and Aqua MODIS WQ Parameters	Giovanni Seadas/ Oceancolor Web	NASA Goddard Goddard Earth Sciences, Data and Information Services Center	8-day and monthly Composites 2000-present	9 km and 4 km
MODIS Level 1 and 2 Data Level 3 Data	OceanColor Web	NASA	Daily Daily, 3-and 8, day , Monthly, Seasonal 2000-present	250 m 9 km and 4 km
Landsat* Tm, ETM+ EO-1/Hyperion Terra/ASTER Spectral Reflectance	LandsatLook Viewer* GloVIS EarthEXploer	USGS	July 1972-present	30 -60 m (Landsat and EO1-) 15 m (ASTER)
NPP/VIIRS WQ Parameters	STAR	NOAA	October 2011-present	375 m

Tools to acquire Landsat Images

The LandsatLook Viewer

GloVis

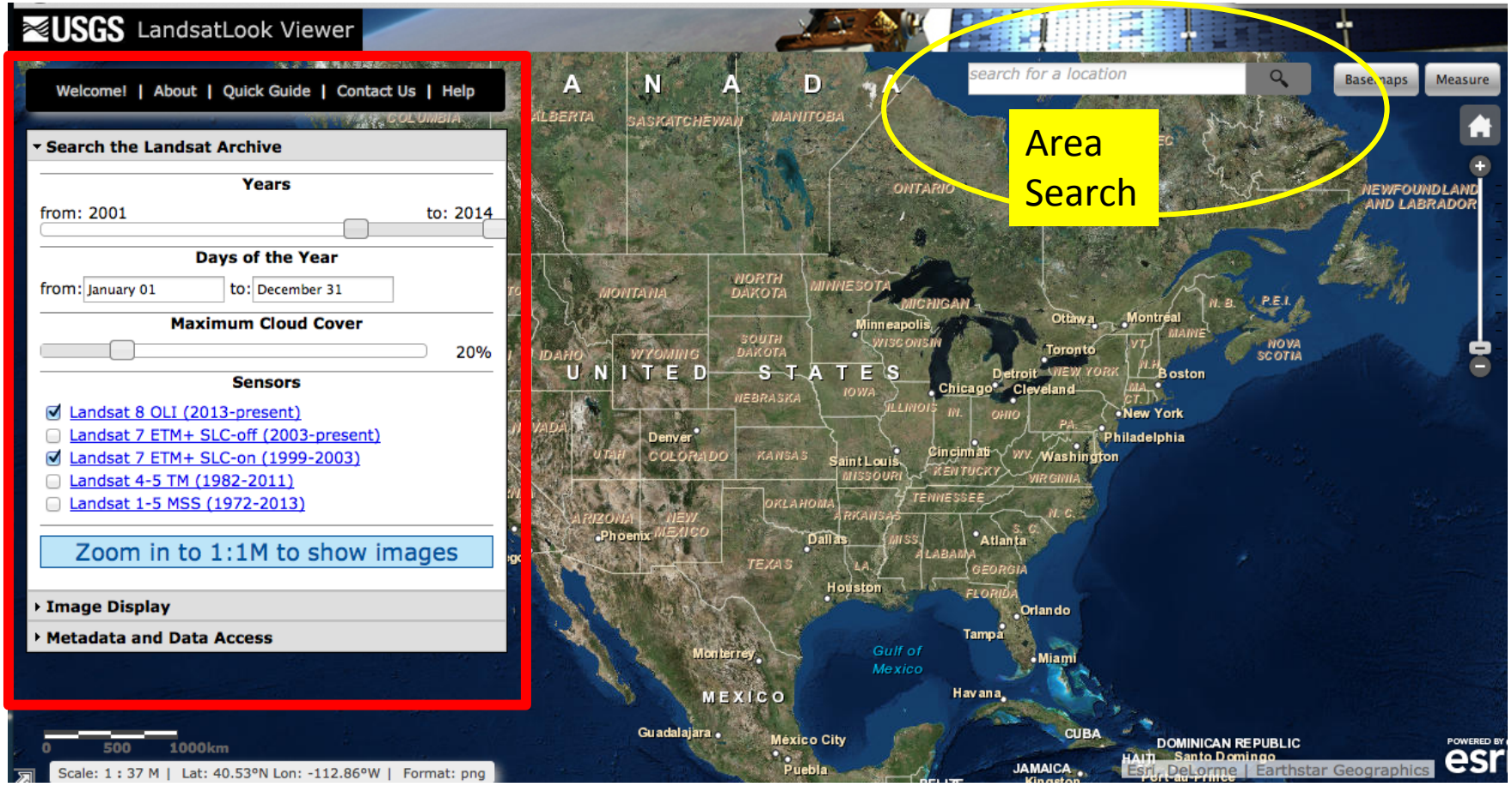


Earth Explorer

Acquiring Landsat Images

The LandsatLook Viewer

http://landsatlook.usgs.gov



- Visualize and Access all full resolution natural color Landsat imagery and Level 1 Data products. Available in GeoTiff format.

Acquiring Landsat and ASTER Images

GloVis

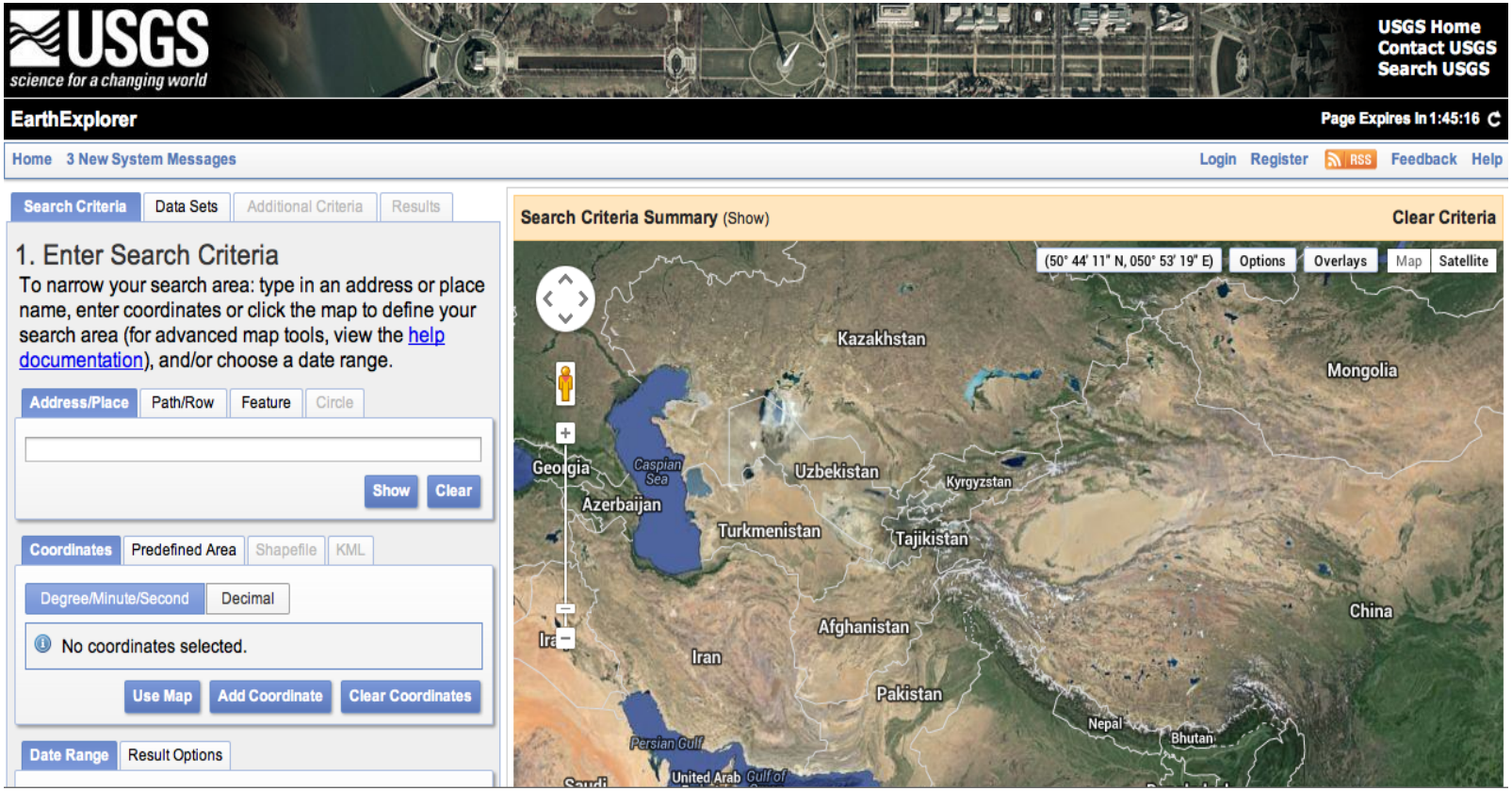
http://glovis.usgs.gov

- **GloVis** is a quick and easy online search and download tool for satellite data

Acquiring Landsat and ASTER Images

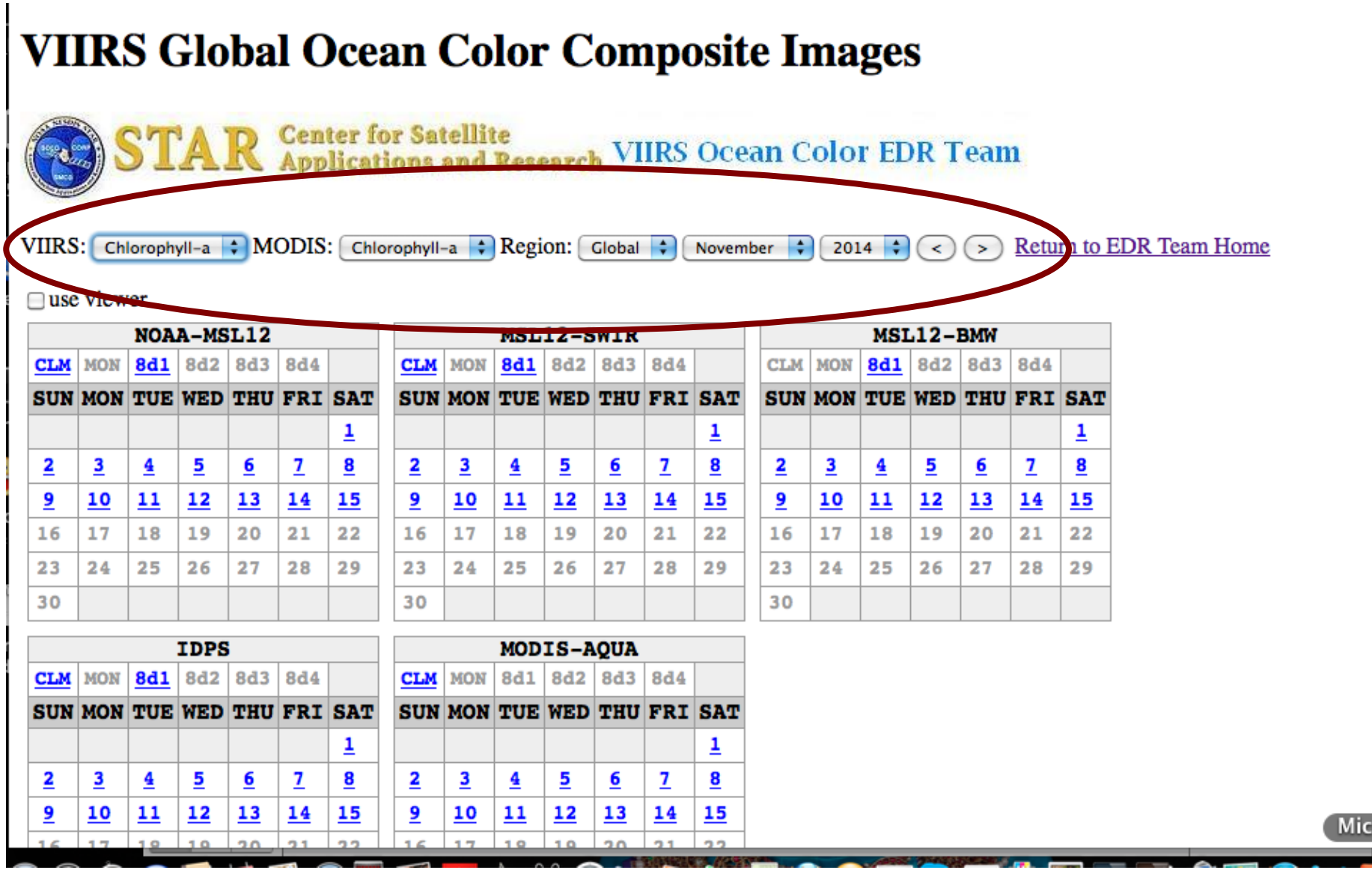
EarthExplorer

http://earthexplorer.usgs.gov



Acquiring VIIRS Images

http://www.star.nesdis.noaa.gov/sod/mecb/color/composite/



VIIRS Global Ocean Color Composite Images

STAR Center for Satellite Applications and Research — VIIRS Ocean Color EDR Team

VIIRS: Chlorophyll-a MODIS: Chlorophyll-a Region: Global November 2014 < > Return to EDR Team Home

use viewer

NOAA-MSL12

CLM	MON	8d1	8d2	8d3	8d4	
SUN	MON	TUE	WED	THU	FRI	SAT
						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						

MSL12-SWIR

CLM	MON	8d1	8d2	8d3	8d4	
SUN	MON	TUE	WED	THU	FRI	SAT
						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						

MSL12-BMW

CLM	MON	8d1	8d2	8d3	8d4	
SUN	MON	TUE	WED	THU	FRI	SAT
						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						

IDPS

CLM	MON	8d1	8d2	8d3	8d4	
SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15

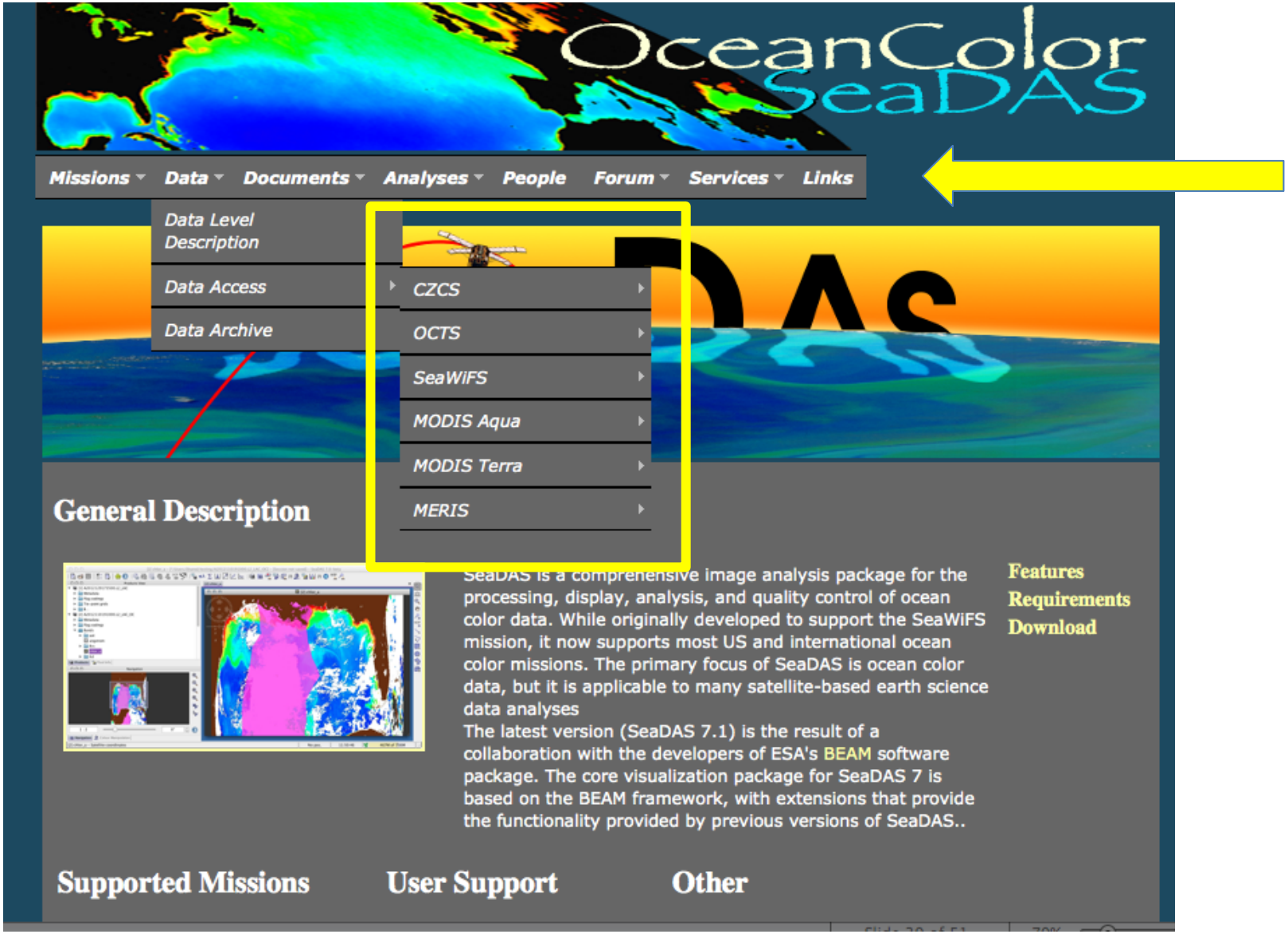
MODIS-AQUA

CLM	MON	8d1	8d2	8d3	8d4	
SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15

Access MODIS WQ Data using SeaDas, OceanColor Web, and Giovanni Tools

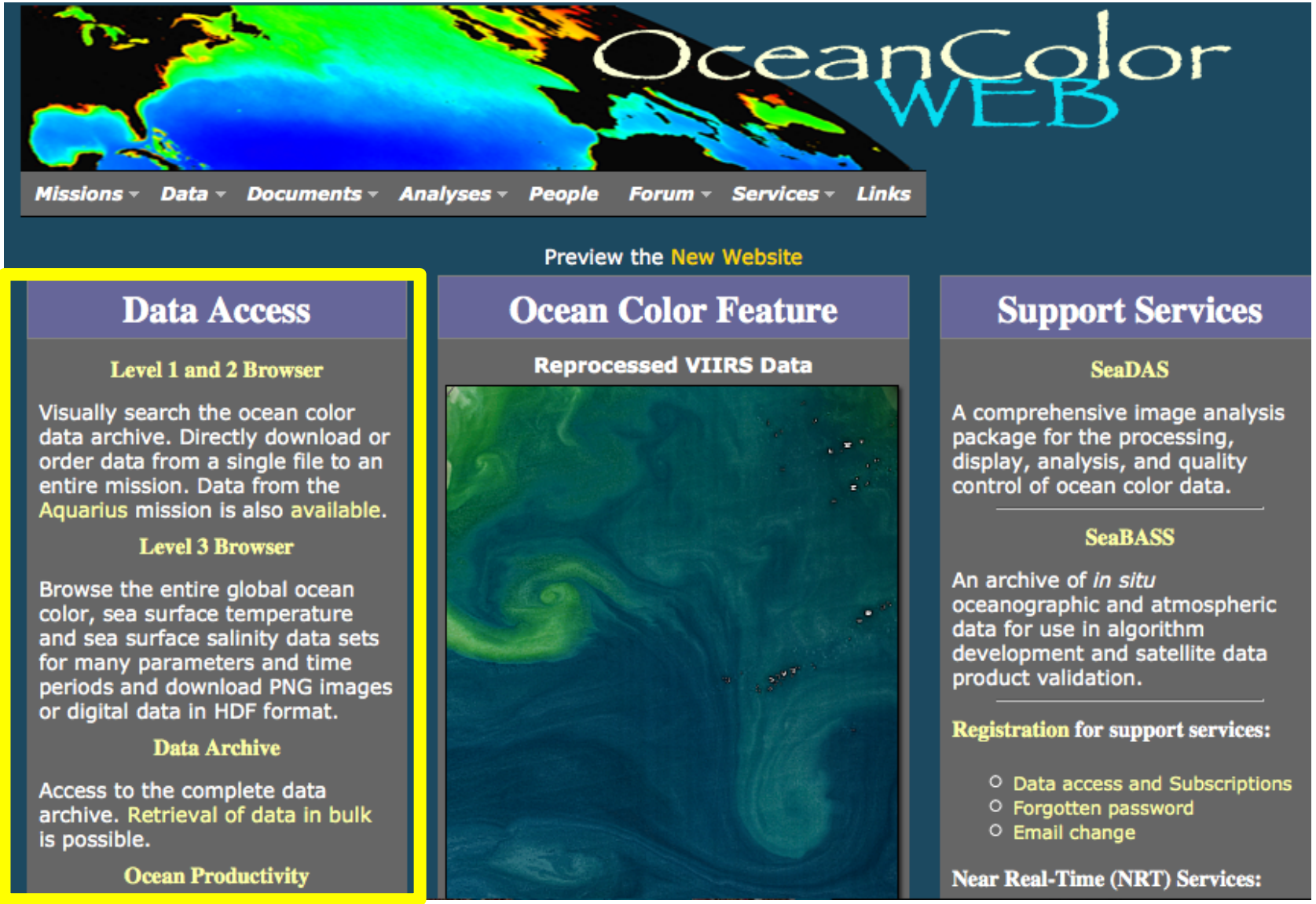
Water Quality Data form SeaDas

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



Water Quality Data form OceanColor Web

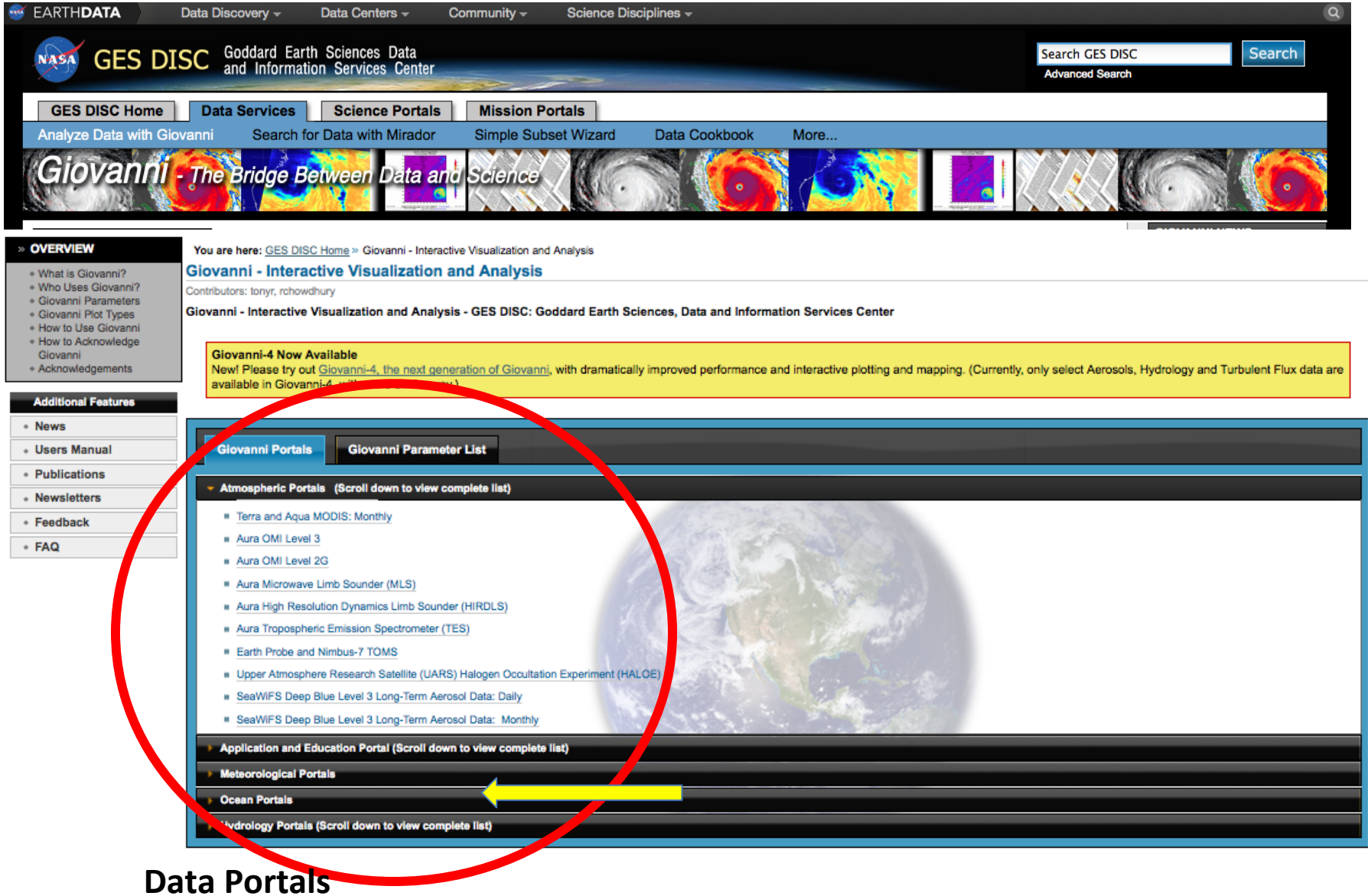
http://oceancolor.gsfc.nasa.gov//



SeaDas &
OceanColor
Web Demo

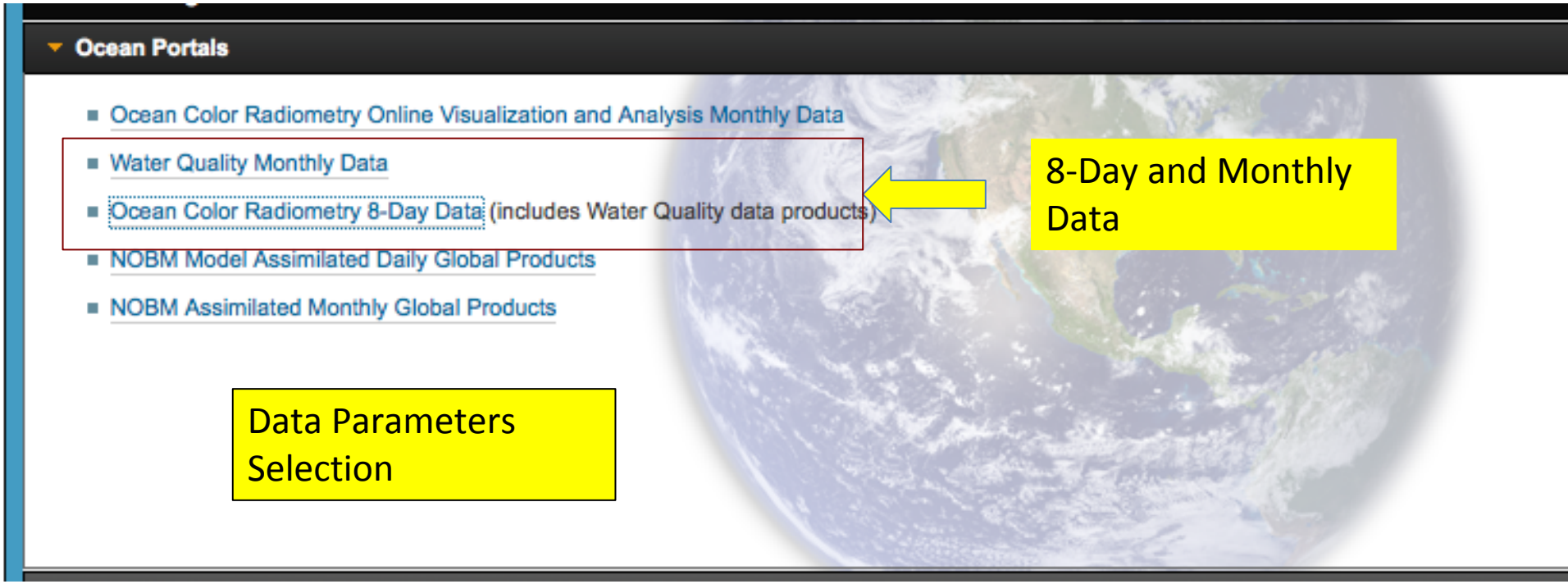
Giovanni

GES DISC: Goddard Earth Sciences, Data and Information Services Center
Interactive Visualization and Analysis



Data Portals

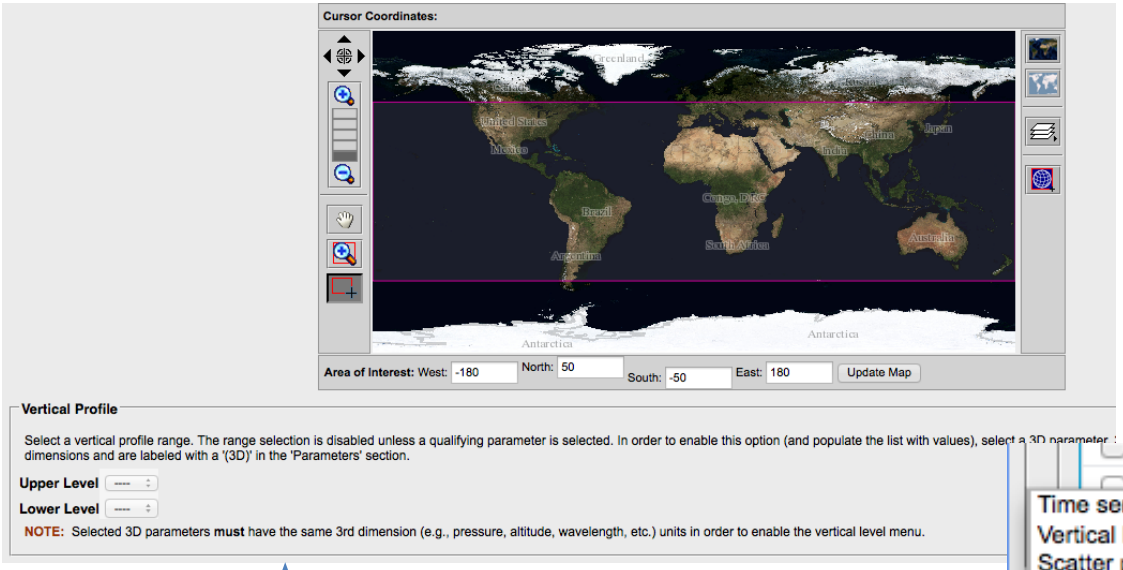
Giovanni Ocean Portal



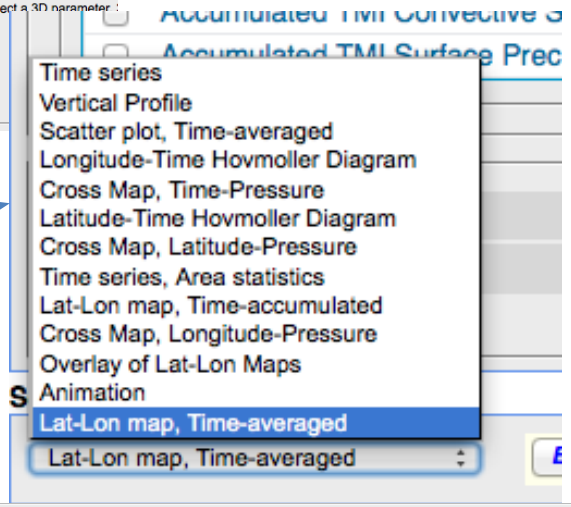
Giovanni

GES DISC: Goddard Earth Sciences, Data and Information Services Center

Interactive Visualization and Analysis



Spatial, Temporal, Analysis and Visualization Selections



Giovanni Ocean Portal Demo

Future NASA Missions for Water Quality Remote Sensing

http://geo-cape.larc.nasa.gov/

GEO-CAPE

Measurement coastal ocean phytoplankton, water quality and biogeochemistry from geostationary orbit, providing multiple daily observations within the field of view

- Planned for 2020 time-frame
- Geostationary orbit
- (95°-100°W), proposed 250 m to 1 km spatial resolution
- Ocean Sensor:
  Coastal Ecosystem Sensor and Imager proposed with ultraviolet to near-infrared plus short-wave infrared (SWIR) bands

http://dsm.gsfc.nasa.gov/PACE.html

PACE:

Global ocean color measurements to provide extended data records on ocean ecology and global biogeochemistry

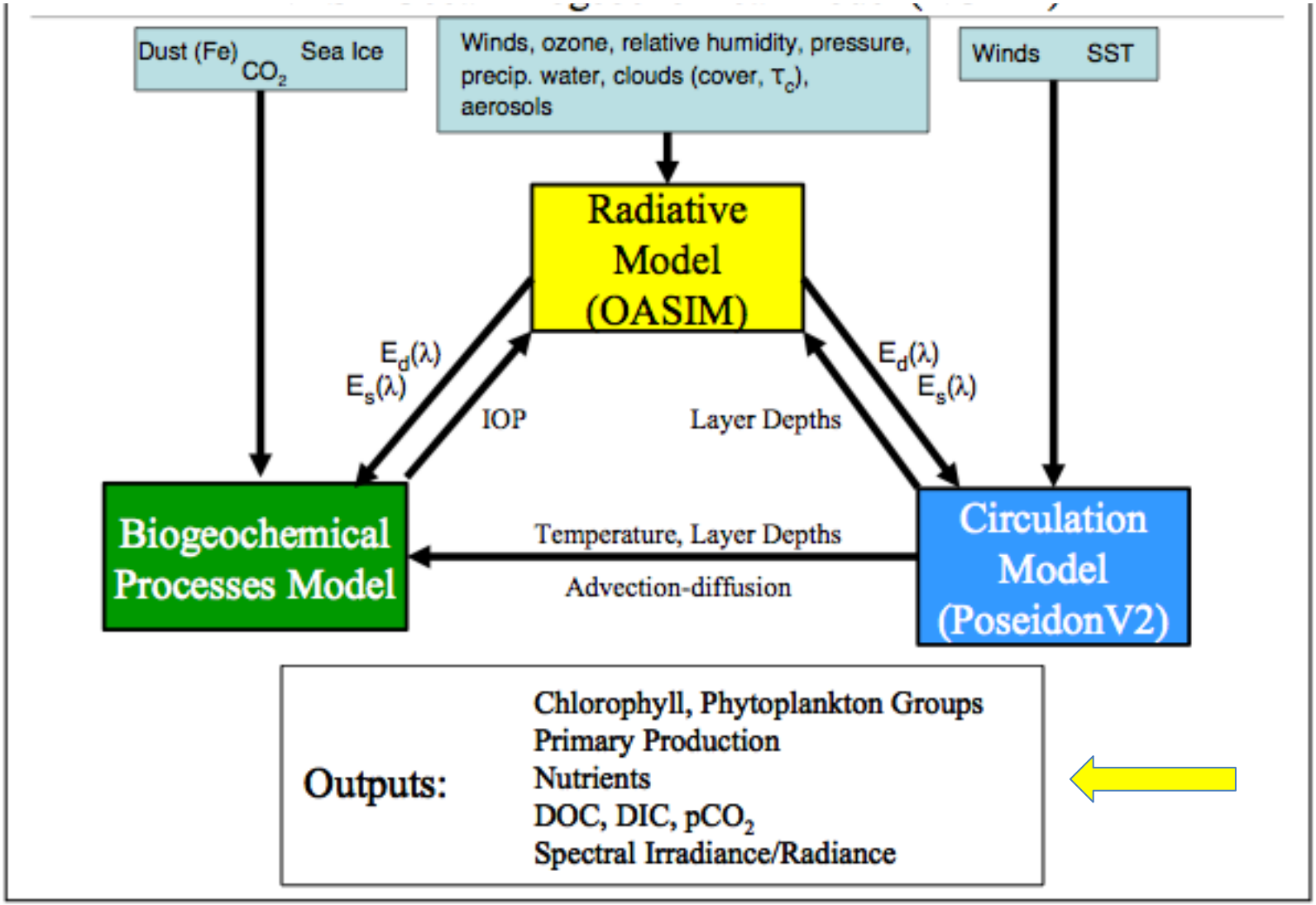
- Planned for 2019 time-frame
- Polar orbit, 2-day global coverage proposed
- Ocean Sensor:
  Ocean Ecosystem Spectrometer/Radiometer with spectra bands in visible/IR range

GEO-CAPE: The GEOstationary Coastal
PACE : Pre-Aerosol, Clouds, and ocean Ecosystem

NASA Ocean Biogeochemical Modeling

NASA Ocean Biogeochemical Model (NOBM)

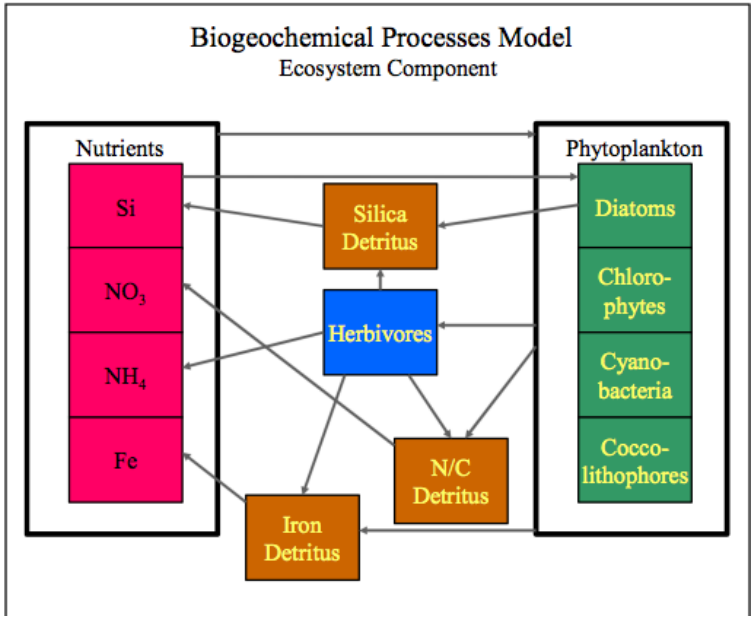
http://gmao.gsfc.nasa.gov/research/oceanbiology/oceanbiology.pdf

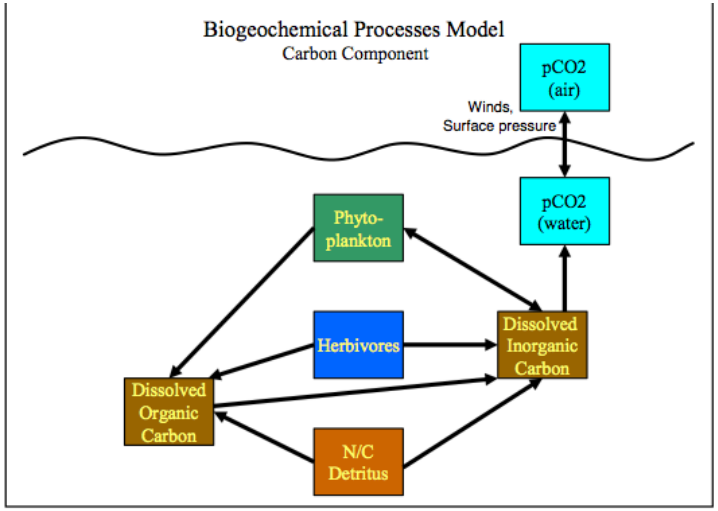


NASA Ocean Biogeochemical Model (NOBM)

http://gmao.gsfc.nasa.gov/research/oceanbiology/oceanbiology.pdf

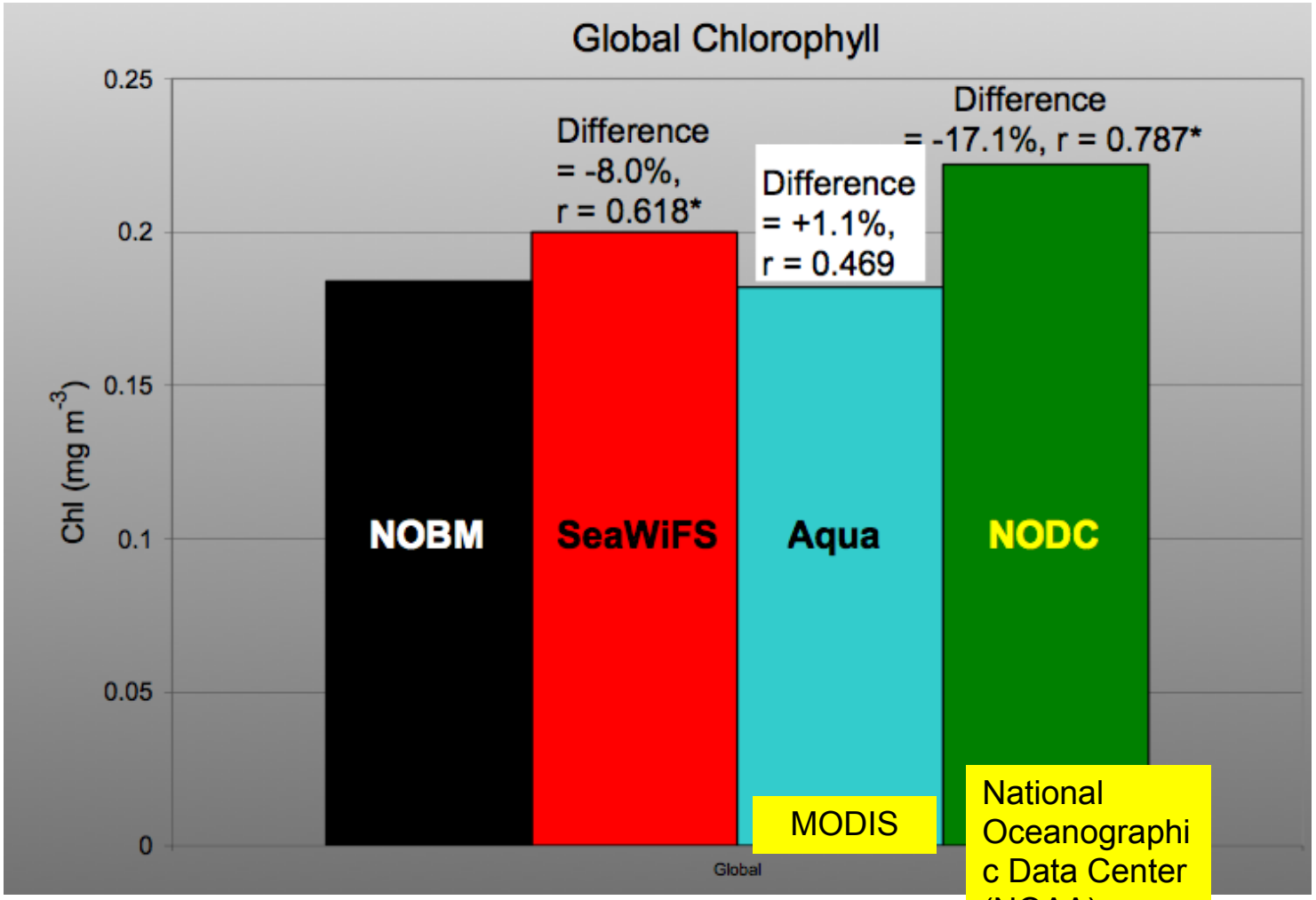
- An Ocean general Circulation Model With Ecosystem and Carbon biogeochemical processes
- Currently being couples with an atmospheric model
- Global Model Grid Domain: 84°S to 72°N at 1.25°lon., 2/3° lat, 14 oceanic layers
- Atmospheric forcing to NOMB information contains information from various satellites/remote sensors
- A version with SeaWIFs data assimilated (merged) in the model





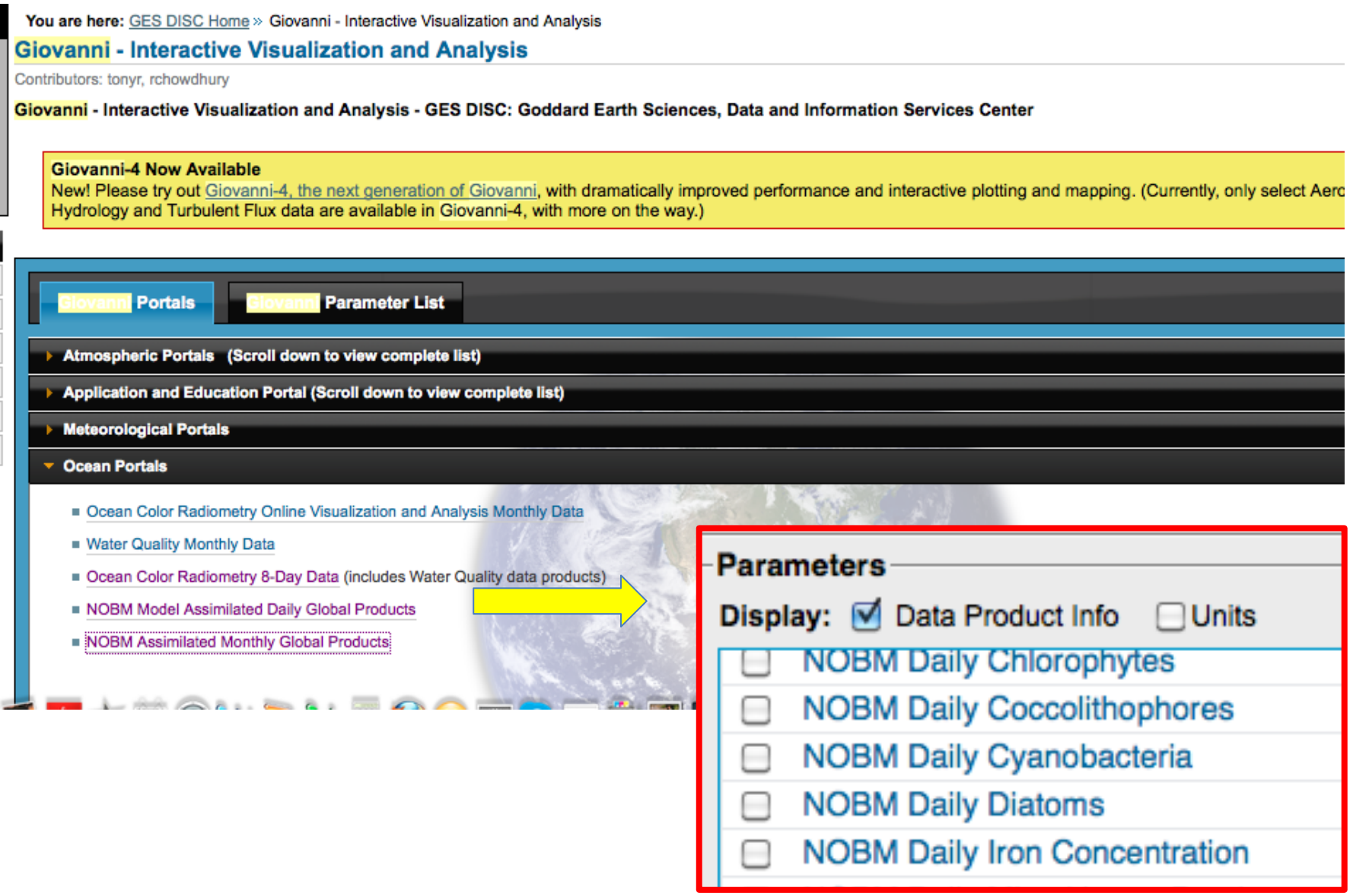
NOBM Chlorophyll Comparison with Other Measurements

http://modis.gsfc.nasa.gov/sci_team/meetings/201205/presentations/plenary/gregg.pdf



For more information:
Watson Gregg, NASA/Global Modeling and Assimilation Office
watson.gregg@nasa.gov

NOBM Data: Available from Giovanni



Coming Up Next Week (December 2, 2014)

- **Invited Talk**

  Dr. Blake Schaeffer from EPA: Review of Water Quality Monitoring from Remote Sensing Observations

- **Case Studies:**

  1) WQ monitoring of Lake Atitlan, Guatemala (Dr. Africa Flores from NASA-SERVIR)

  2) WQ of Lake Victoria : WQ parameters from MODIS and Landsat Imagery

- **Course Summary**

Thank You!

Amita Mehta **email: amita.v.mehta@nasa.gov**

Appendix

Water Quality Models in the US

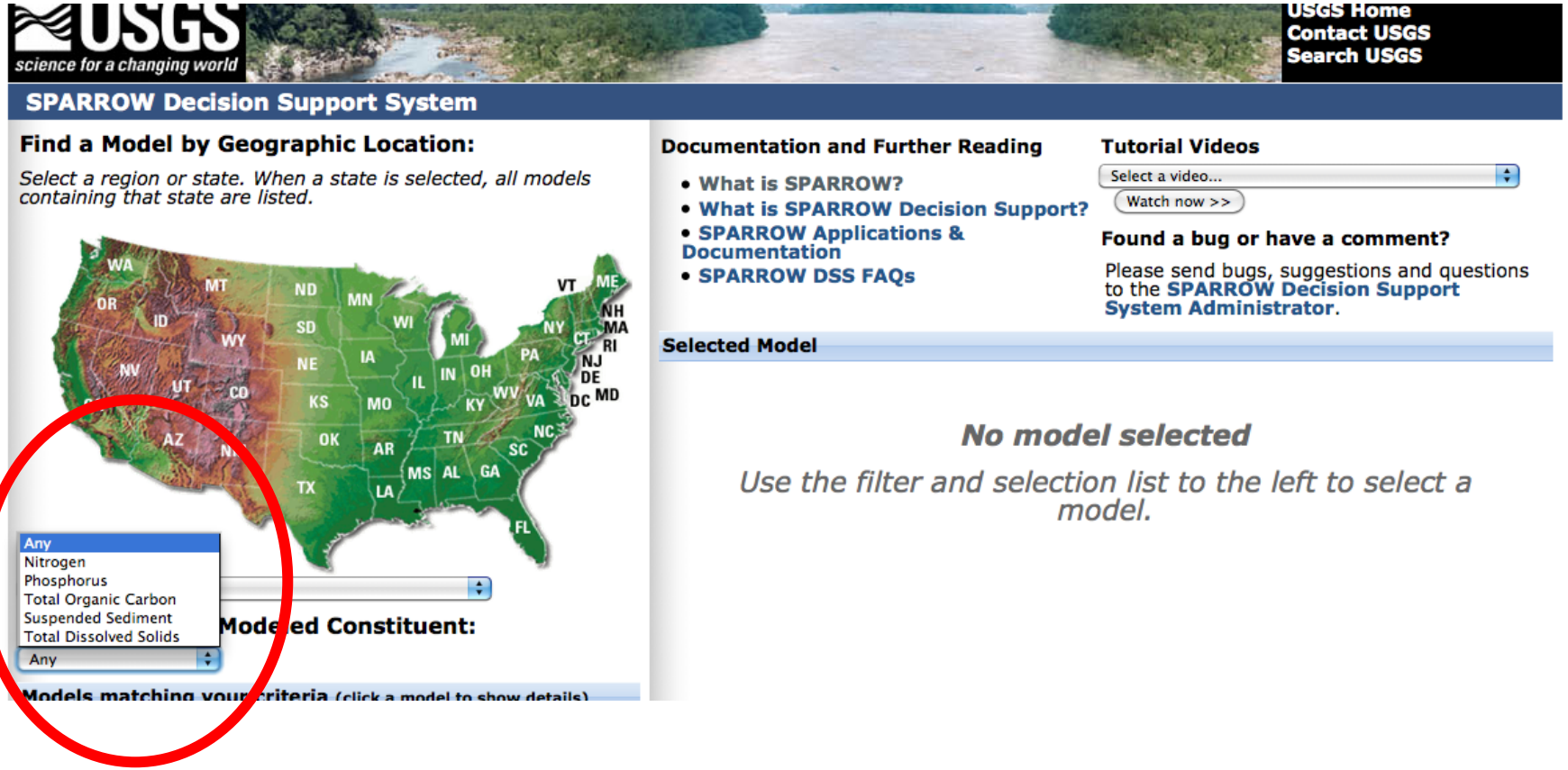
Spectral Bands of Satellite Sensors

USGS SPARROW

http://cida.usgs.gov/sparrow/

(SPAtially Referenced Regressions On Watershed)

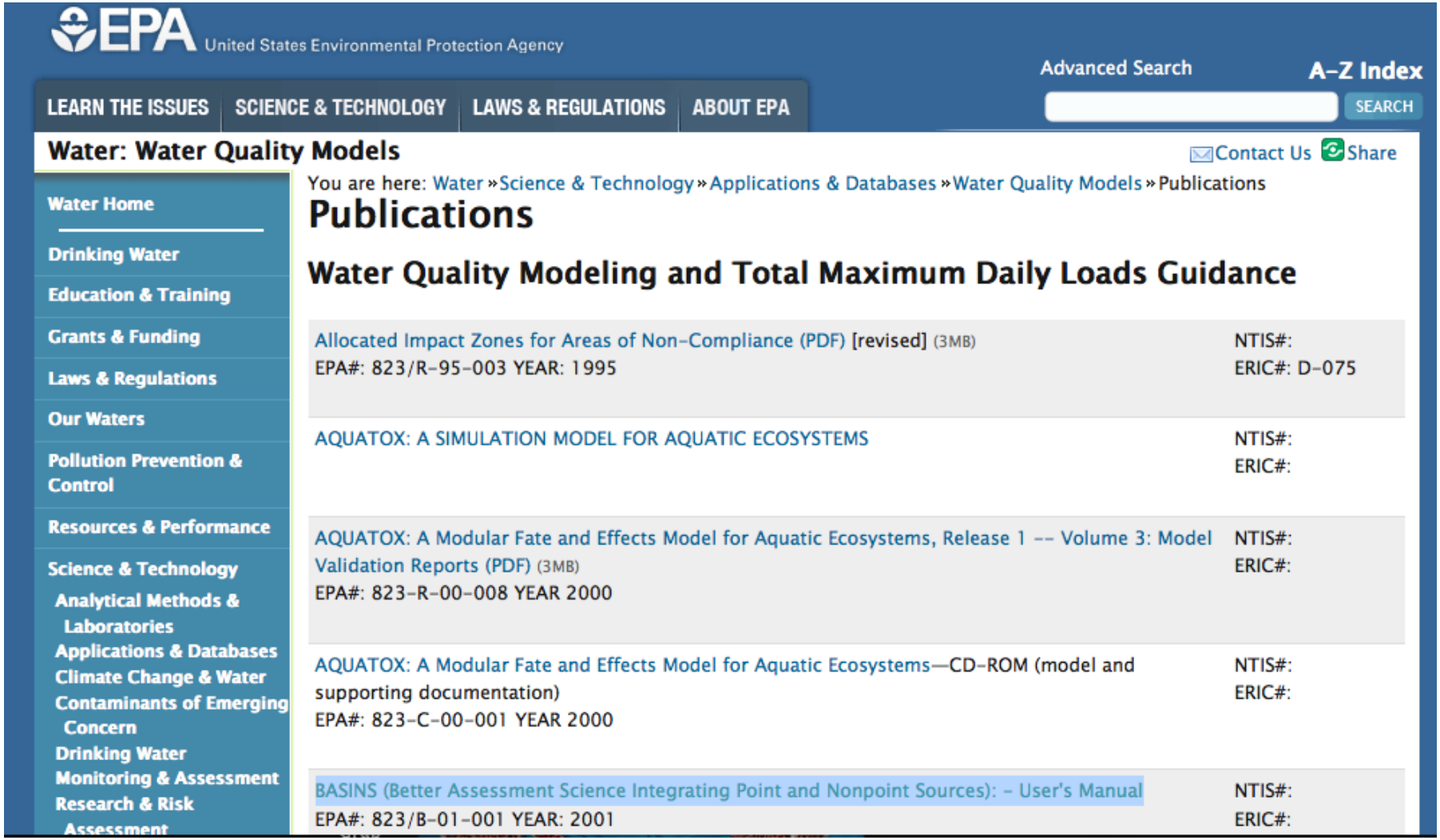
Relates water-quality measurements made at a network of monitoring stations to attributes of the watersheds (contaminant sources and environmental factors)



EPA BASIN* and AQUATOX

(*Better Assessment Science Integrating Point and Nonpoint Sources)

http://water.epa.gov/scitech/datait/models/library_index.cfm



USDA Water Quality Information Center

http://wqic.nal.usda.gov/tools-and-guides/modeling

Home | About WQIC | Databases | Enviro-News | News and Events | Publications | Help | Contact Us | En Español

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Go

- Search all USDA
- Advanced Search
- Search Tips

Browse by Subject

- Agricultural Environmental Management
- Educational Materials
- Irrigation
- Regional Information
- Social and Legal Issues
- Tools and Guides
- Water Availability
- Water Quality

Tools and Guides >

Modeling

Spotlights

Modeling and Water Resources

USDA. NAL. Water Quality Information Center.

Searches for article citations in the NAL catalog (AGRICOLA) on modeling and water resources including hydrologic models for watersheds.

Model Provides Major Advance in Controlling Water Erosion

USDA. Agricultural Research Service.

Article from *Agricultural Research* on the Water Erosion Prediction Project (WEPP) model, a process-based, distributed parameter, continuous simulation, erosion prediction model for use on personal computers.

Modeling Agricultural Areas

NASA. Astrophysics Data System; Harvard Univeristy; Smithsonian Institution.

A search of citations from the Physics and Geophysics set, a component of the ADS databases containing 4.7 million records. Find out more about the system.

SPARROW: SPAtially Referenced Regressions On Watershed Attributes

DOI. United States Geological Survey.

Tools and Guides

- Discussion Lists
- Expertise
- Federal Agencies and Departments
- Funding
- Internet Indexes
- Journals
- Modeling
- Professional Societies
- Water Webinars

Landsat-7 Sensor

ETM+ : Enhanced Thematic Mapper **ETM+**

Scene size: 183m x170 km

Landsat 7	Wavelength (micrometers)	Resolution (meters)
Band 1	0.45-0.52	30
Band 2	0.52-0.60	30
Band 3	0.63-0.69	30
Band 4	0.77-0.90	30
Band 5	1.55-1.75	30
Band 6	10.40-12.50	60 * (30)
Band 7	2.09-2.35	30
Band 8	.52-.90	15

Spatial Resolution

For more details: http://landsat.usgs.gov/band_designations_landsat_satellites.php

Landsat-8 Sensors

OLI: operational Land Imager **TIRS**: Thermal Infrared Sensor

Scene size: 183m x170 km

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal aerosol	0.43 - 0.45	30
Band 2 - Blue	0.45 - 0.51	30
Band 3 - Green	0.53 - 0.59	30
Band 4 - Red	0.64 - 0.67	30
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
Band 6 - SWIR 1	1.57 - 1.65	30
Band 7 - SWIR 2	2.11 - 2.29	30
Band 8 - Panchromatic	0.50 - 0.68	15
Band 9 - Cirrus	1.36 - 1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

For more details: http://landsat.usgs.gov/band_designations_landsat_satellites.php

Water Quality Information from MODIS

Band	Range(nm)	Key use
8	405–420	Chlorophyll
9	438–448	Chlorophyll
10	483–493	Chlorophyll
11	526–536	Chlorophyll
12	546–556	Sediments
13h	662–672	Atmosphere, Sediments
13l	662–672	Atmosphere, Sediments
14h	673–683	Chlorophyll Fluorescence
14l	673–683	Chlorophyll Fluorescence
20	3.660–3.840	Sea Surface Temperature

https://lpdaac.usgs.gov/products/modis_products_table/modis_overview

		Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan)	
					Nadir	End of Scan
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58
		M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58
		I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789
		M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58
		M6	Atmosph. Correct.	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58
		I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789
		M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58
	S/WMIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58
		M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58
		I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789
		M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58
		M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58
Emissive Bands		I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789
		M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58
		M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58
	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58
		M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58
		I5	Cloud Imagery	10.500 - 12.400	0.371 x 0.387	0.80 x 0.789
		M16	SST	11.538 - 12.488	0.742 x 0.776	1.60 x 1.58

Table 1: VIIRS Channels
(courtesy of H. Oudrari)

SeaWiFS Spectral Bands and Seastar/OrbView Features

Instrument Bands	
Band	Wavelength
1	402-422 nm
2	433-453 nm
3	480-500 nm
4	500-520 nm
5	545-565 nm
6	660-680 nm
7	745-785 nm
8	845-885 nm
Mission Characteristics	
Orbit Type	Sun Synchronous at 705 km
Equator Crossing	Noon +20 min, descending
Orbital Period	99 minutes
Swath Width	2,801 km LAC/HRPT (58.3 degrees)
Swath Width	1,502 km GAC (45 degrees)
Spatial Resolution	1.1 km LAC, 4.5 km GAC
Real-Time Data Rate	665 kbps
Revisit Time	1 day

Historical and Current International Satellites and Sensors for Remote Sensing Observations for WQ

PMC full text: Sensors (Basel). 2012; 12(6): 7778–7803.
Published online Jun 7, 2012. doi: 10.3390/s120607778
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Sensors (Basel)

Table 1.

Characteristics of historical and current ocean-color sensors (International Ocean Color Coordinating Group. http: http://www.ioccg.org/sensors).

Sensor	Agency	Satellite	Operating Dates	Spatial Resolution (m)	Bands	Spectral Coverage (nm)	Obit
CZCS	NASA (USA)	Nimbus-7 (USA)	24/10/78–22/06/86	825	6	433–12,500	Polar
SeaWiFS	NASA (USA)	OrbView-2 (USA)	01/08/97–14/02/11	1,100	8	402–885	Polar
MODIS-Terra	NASA (USA)	Terra (EOS-AM1)	Launch 18/12/99	250/500/1,000	36	405–14,385	Polar
MODIS-Aqua	NASA (USA) Ma'an	Aqua (EOS-PM1)	Launch 04/05/02	250/500/1,000	36	405–14,385	Polar
Polder	CNES (France)	ADEOS (Japan)	17/8/96–29/6/97	6,000	9	443–910	Polar
Polder-2	CNES (France)	ADEOS-II (Japan)	14/12/02–24/10/03	6,000	9	443–910	Polar
Polder-3	CNES (France)	Parasol	Launch 08/12/04	6,000	9	443–1,020	Polar
MOS	DLR (Germany)	IRS P3 (India)	21/03/96–31/05/04	500	18	408–1,600	Polar
MERIS	ESA (Europe)	ENVISAT (Europe)	Launch 01/03/02	300/1,200	15	412–1,050	Polar
OCTS	NASDA (Japan)	ADEOS (Japan)	17/08/96–29/06/97	700	12	402–12,500	Polar
GLI	NASDA (Japan)	ADEOS-II (Japan)	14/12/02–24/10/03	250/1,000	36	375–12,500	Polar
OCI	NEC (Japan)	ROCSAT-1 (Taiwan)	27/01/99–16/6/04	825	6	433–12,500	Polar
OSMI	KARI (Korea)	KOMPSAT-1/Arirang-1 (Korea)	20/12/99–31/1/08	850	6	400–900	Polar
GOCI	KARI/KORDI (South Korea)	COMS	Launch 26/6/10	500	8	400–865	Geostationary
CMODIS	CNSA (China)	SZ-3 (China)	25/03/02–15/09/02	400	34	403–12,500	Polar
CZI	CNSA (China)	Hy-1A (China)	15/05/02–01/04/04	250	4	420–890	Polar
COCTS	CNSA (China)	Hy-1A (China)	15/05/02–01/04/04	1,100	10	402–12,500	Polar
CZI	CNSA (China)	Hy-1B (China)	Launch 11/04/07	250	4	433–695	Polar
COCTS	CNSA (China)	Hy-1B (China)	Launch 11/04/07	1,100	10	402–12,500	Polar
OCM	ISRO (India)	IRS-P4 (India)	Launch 26/05/99	360/4,000	8	402–885	Polar
OCM-2	ISRO (India)	Oceansat-2 (India)	Launch 23/09/09	360/4,000	8	400–900	Polar
MMRS	CONAE (Argentina)	SAC-C (Argentina)	21/11/00 – 2009	175	5	480–1,700	Polar
HICO	ONR and DODSpace Test Programme	JEM-EFInt.Space Stn.	Launch 18/09/09	100	124	380–1,000	51.6°,15.8 orbits p/d