

NOAA Okeanos Ocean Color Operational Production System: Status and Prospective

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NOAA/NESDIS/OSPO/Satellite Products Branch

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OUTLINE

- Who Are We?
- NOAA Okeanos Ocean Color Operational Production System
- NOAA Okeanos Ocean Color Products Quality Monitoring Tool
- Upcoming Activities
- Acknowledgement

National Oceanic and Atmospheric Administration (NOAA) Line Offices

- National Environmental Satellite, Data, and Information Service (NESDIS)
 - **Office of Satellite and Product Operations (OSPO)**
 - *Center for Satellite Applications and Research (STAR)*
 - *Joint Polar Satellite System (JPSS)*
 - *Office of Systems Development (OSD)*
 - *Geostationary Operational Environmental Satellite R-Series (GOES-R)*
 - *International and Interagency Affairs Division (IIAD)*
 - *Office of Space Commercialization (OSC)*
 - *Commercial Remote Sensing Regulatory Affairs (CRSRA)*
 - *National Oceanographic Data Center (NODC)*
 - *National Climate Data Center (NCDC)*
 - *National Geophysical Data Center (NGDC)*
- National Marine Fisheries Service
- National Ocean Service
- National Weather Service
- Office of Oceanic and Atmospheric Research
- Office of Program Planning and Integration

NESDIS Office of Satellite and Product Operations (OSPO)

- Locations at four facilities housing about 700 OSPO staff
- NOAA Satellite Operations Facility (NSOF) in Suitland, MD
 - **Mission Operations Division (MOD)**
- NOAA Center for Weather & Climate Prediction (NCWCP) in College Park, MD
 - **Satellite Product and Services Division (SPSD)**
- Command and Data Acquisition (CDA) in AK and VA
- NOAA Ice Center (NIC)

NSOF



Fairbanks CDA



NCWCP



Wallops CDA

NESDIS Office of Satellite and Product Operations (OSPO) Key Roles

Ground System Command & Control, Ingest, Product Generation and Distribution for the nation's 15 environmental satellites

- 3 Geostationary (GOES) by NOAA
- 5 Polar-Orbiting (POES) by NOAA
- 5 Defense Meteorological Satellite Program (DMSP) operated by NOAA
- 1 OSTM Jason-2 (Ocean Surface Topography Mission) Joint NOAA, NASA, CNES, EUMETSAT effort
- 1 Suomi National Polar-orbiting Partnership (SNPP) by NOAA & NASA

(Courtesy of Matthew Seybold and John Paquette)



NSOF

- Pre-Launch and Post-Launch Testing
- Operational Testing, Validation, and Verification
- User Readiness
- Long-Term Continuity of Products and Services

Supporting Products in Satellite Products Branch

Ocean Color

Ocean Heat Content

Coral Bleaching

Sea Lake Ice

Sea Surface Temperature

Ozone & Atmospheric Chemistry

Precipitation (Rain & Snow)

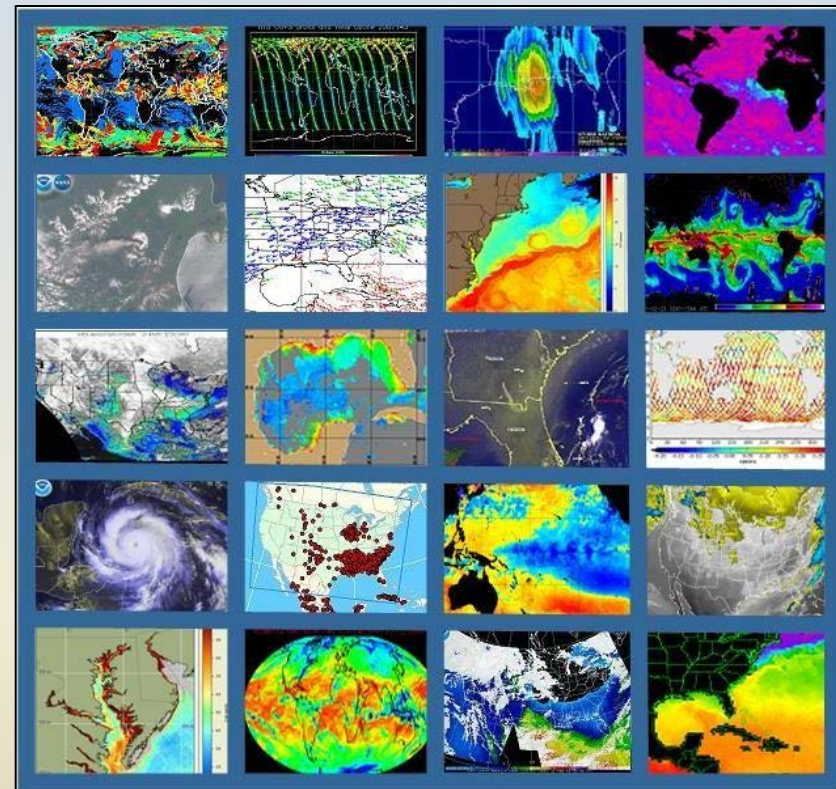
Fire and Smoke

Hurricane Intensity and Position

Imagery (e.g. Visible, IR, WV)

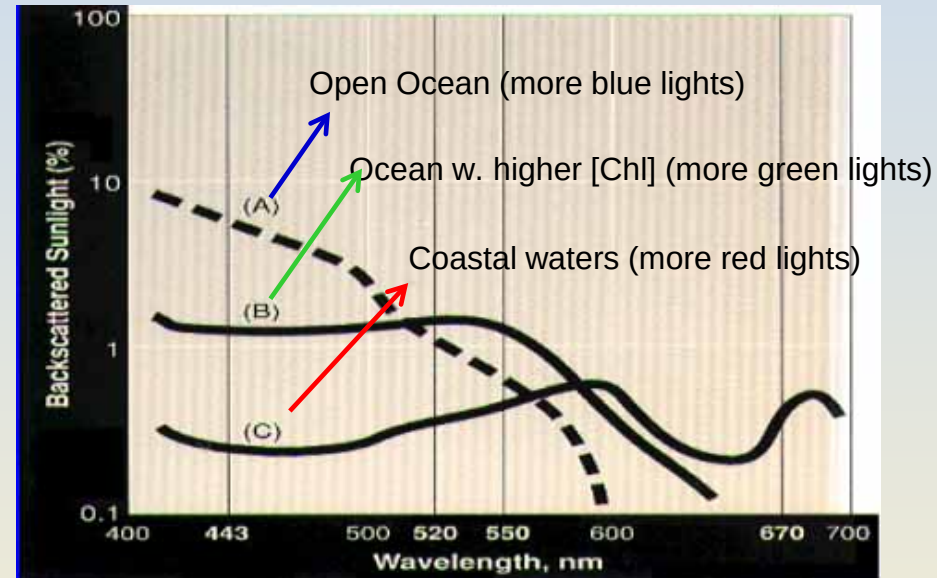
Volcanic Ash

And many more

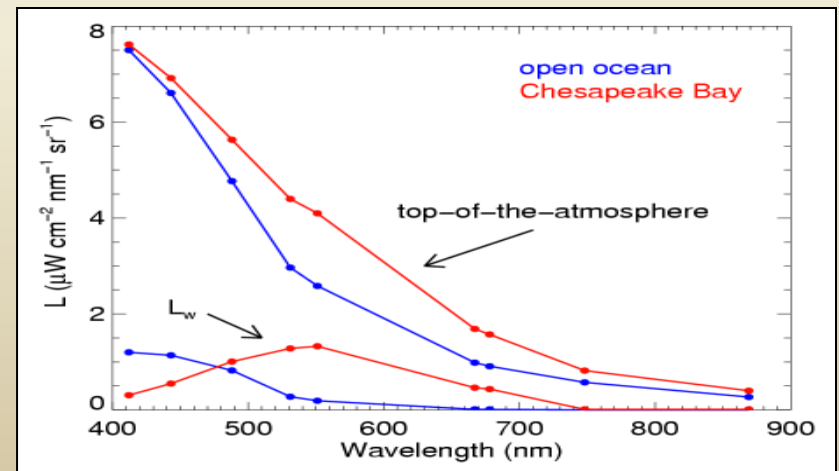


What Is Ocean Color?

- Ocean color (OC) is the water hue due to the presence of tiny plants containing the pigment chlorophyll, sediments, and colored dissolved organic material.
- OC is the water-leaving radiance in the visible wavelengths emanating from the ocean due to scattering by the above oceanic particles.
- Water-leaving radiance in blue – green wavelength (400 – 600 nm) is at most 10 % (open ocean) ~ 20 % (coastal or turbid waters) of the total TOA radiance



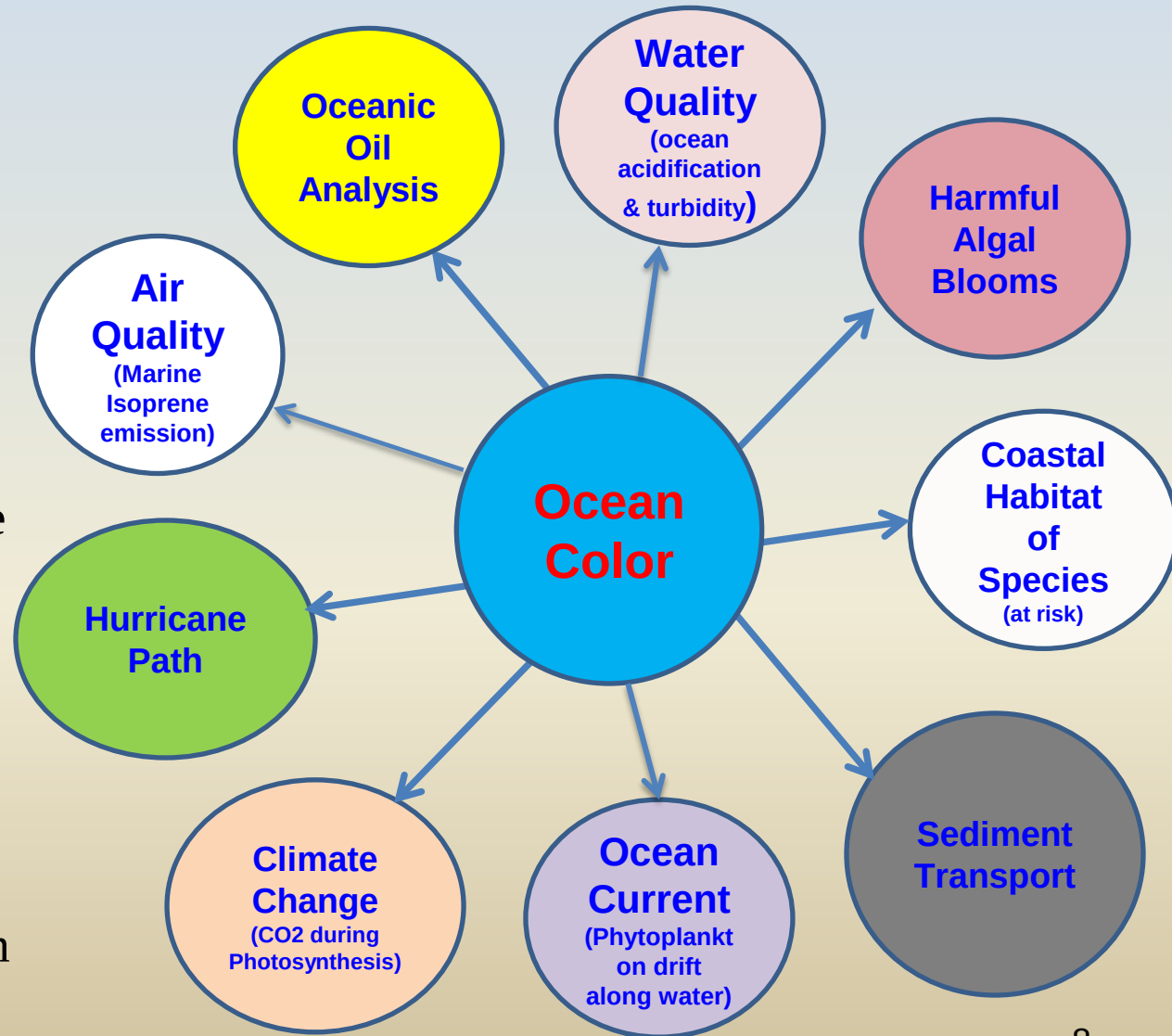
(Reference: <https://www.eeb.ucla.edu/test/faculty/nezlin/OceanColor.htm>)



(Reference: NASA SeaDAS Training)

Why Is Ocean Color So Important?

- Retrieve chlorophyll concentration from satellite observation of ocean color;
- Estimate the amount and general type of phytoplankton from chlorophyll;
- Phytoplankton, the base of the oceanic food web, use sunlight and carbon dioxide to produce organic carbon (photosynthesis);
- Monitor health of oceanic ecosystem from phytoplankton, etc.



Okeanos Ocean Color System Concept

- The Okeanos system is a flexible, expandable Linux-based system capable of processing multiple satellite streams to produce multiple CoastWatch ocean color products.

–**Hardware Components:**

- Process manager nodes
- Update and stage nodes
- Processor nodes
- Shared storage
- FTP servers

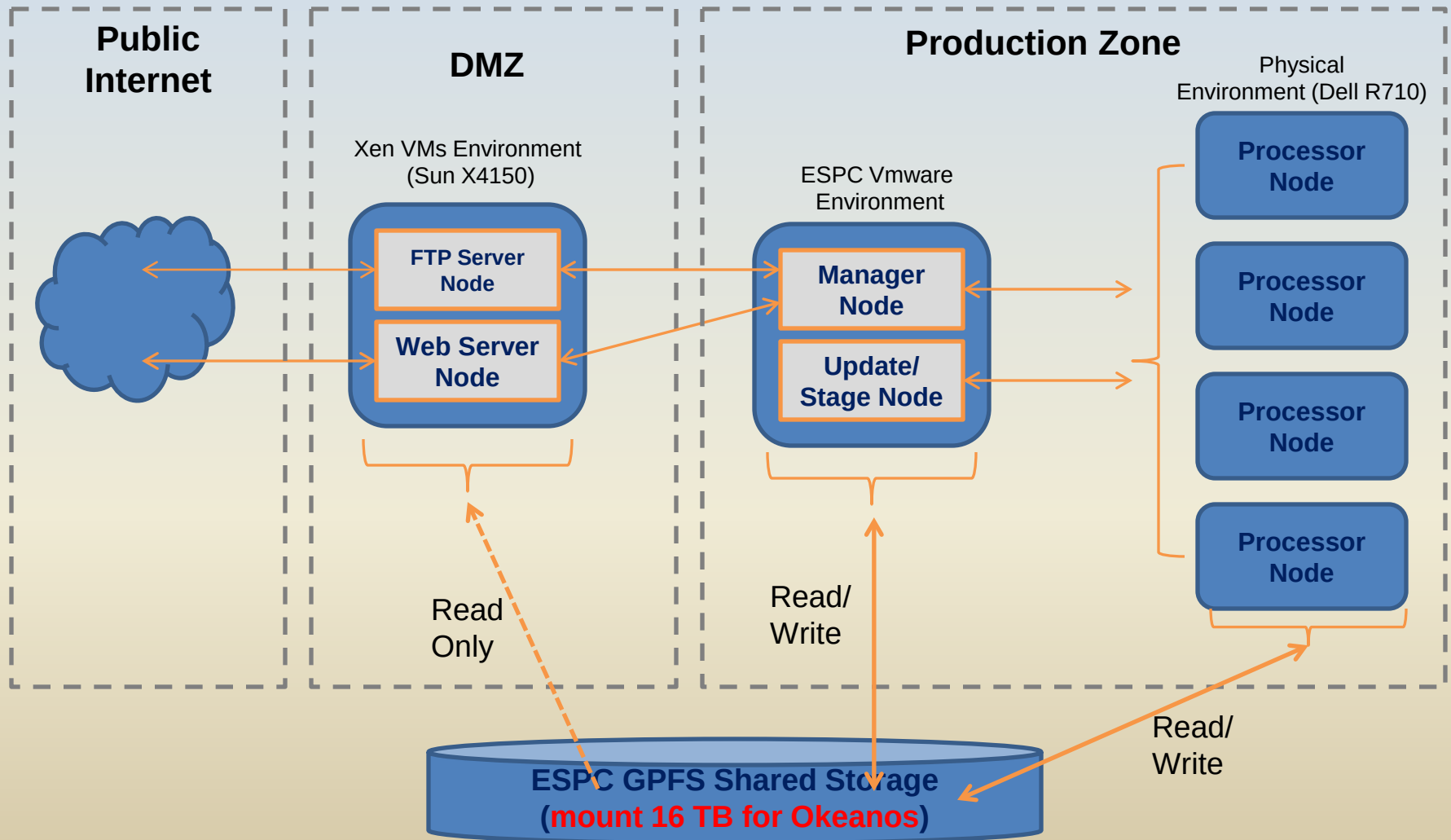
–**Software Modules:**

- CoastWatch Automatic Processing Software (CWAPS) module
- Process manager and control module
- File ingest module
- Merge module
- Update and stage module
- Disk space control module
- Publications module I (transfer products to the CW web server)
- Publication module II (transfer products to ftp servers)

Okeanos Ocean Color Systems

- **Okeanos Parallel Test System (PTS)**
 - Provide software compiler, CWAPS source code test and product validation before the code is promoted to the OPS
 - Provide backup capability of part of the products in the OPS
 - Does not provide access to users
- **Okeanos Operational Production System (OPS)**
 - Run the CWAPS code that has been tested on PTS
 - Produce products with required quality and latency
 - Distribute products to users
 - Provide 8x5 support

Current Okeanos Operational Production System for MODIS OC Processing, Operating Environment



Okeanos Ocean Color Operational Products

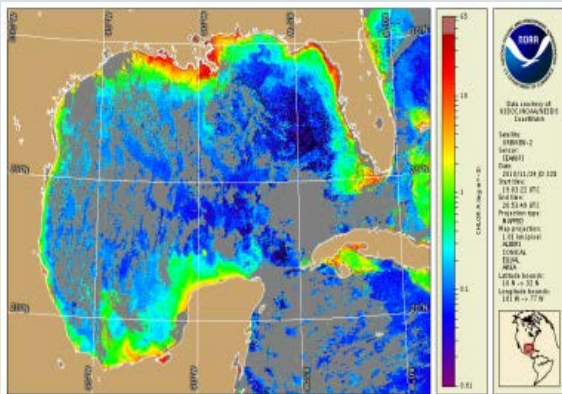
- **Product Category:**
 - **Daily mean, bi-monthly mean and anomaly of chlorophyll concentration**
(MODIS/Aqua, NASA L2gen & NOAA NIR-SWIR methods)
 - **Daily, bi-monthly mean and anomaly of remote sensing reflectance at 667 nm**
(MODIS/Aqua, NASA L2gen & NOAA NIR-SWIR methods)
 - **Water turbidity (diffuse attenuation coefficient at 490 nm)**
(MODIS/Aqua, NIR-SWIR method)
 - **Granule and daily-merged chlorophyll frontal products**
(MODIS/Aqua, BOA-SNRA method)
- **Spatial Resolution:** 1Km
- **Timeliness:** 12 hours for daily products
- **Format:** HDF, GeoTiff, PNG, NetCDF

Okeanos Data Access Information

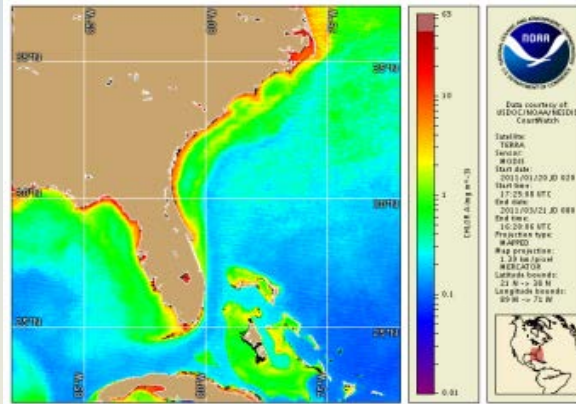
- Okeanos public ftp site (3 ~ 6 months): <ftp://cw-okeanos.noaa.gov/pub/>
- Okeanos OC product imagery (png, ≤ 10 days) web site: [NOAA OSPO OC Web](#)
- Okeanos OC products (short-term, ≤ 1 year): [NOAA CoastWatch Web](#)
- Okeanos OC products (long-term, only granule level chlorophyll products): [CLASS](#)

Okeanos Operational Ocean Color Products Type

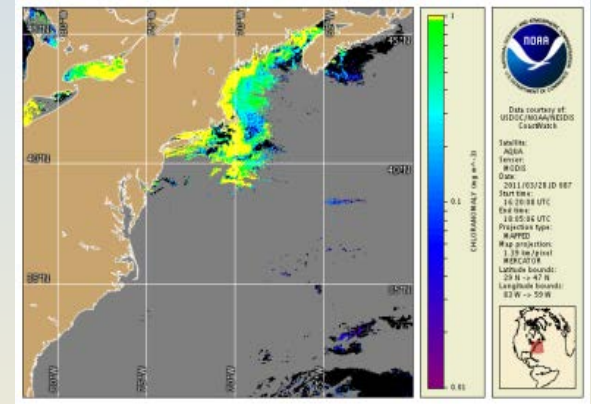
Daily chlorophyll concentration



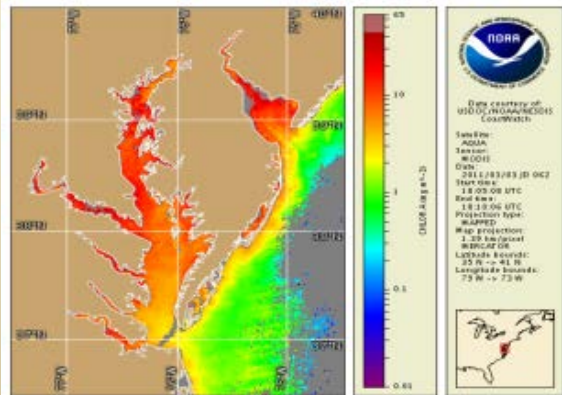
Bimonthly-mean chlorophyll concentration



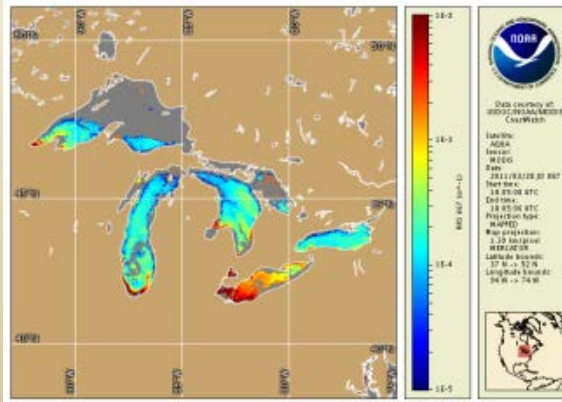
New algal growth (Positive chlorophyll concentration anomaly)



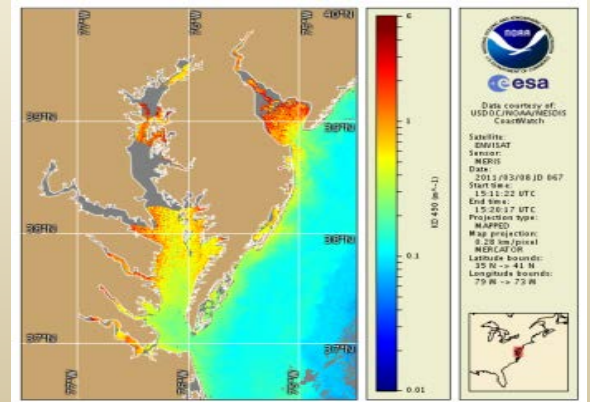
Chesapeake Bay daily chlorophyll concentration



Suspended sediment proxy (Remote sensing reflectance at 667 nm)

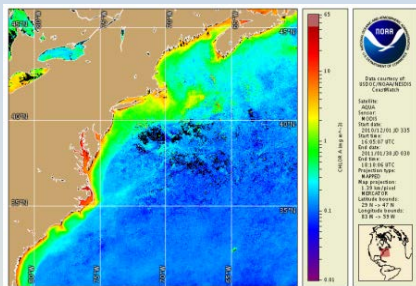


Water turbidity (Diffuse attenuation coefficient at 490 nm)

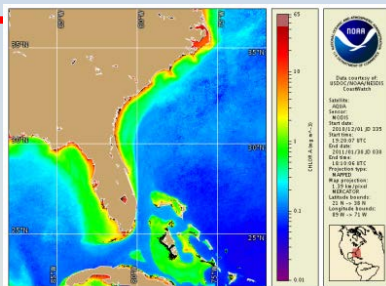


MODIS/Aqua OC Product Coverage

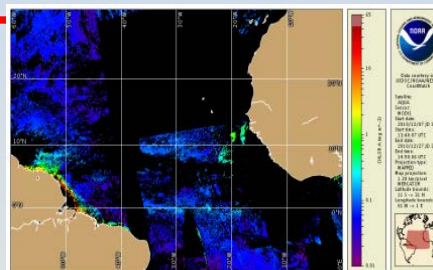
Northeast



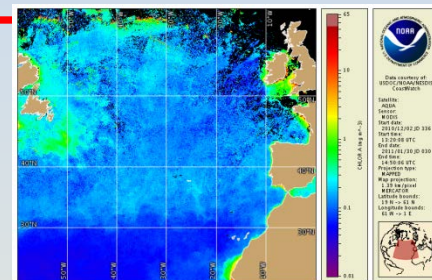
Southeast



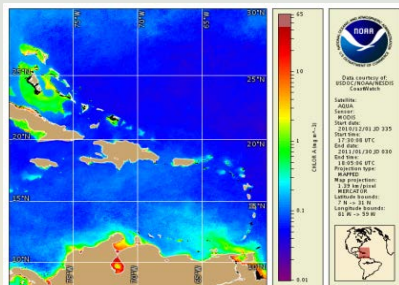
Equatorial Atlantic



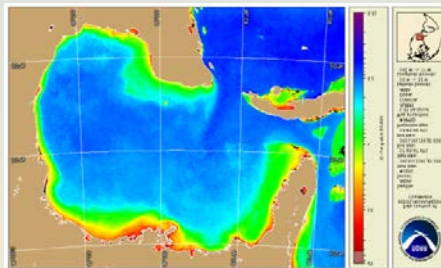
North Atlantic



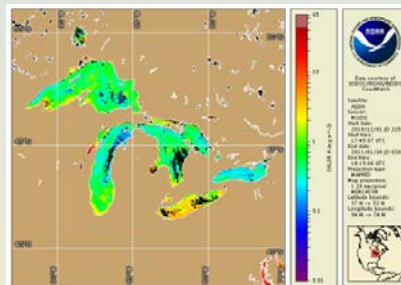
Caribbean



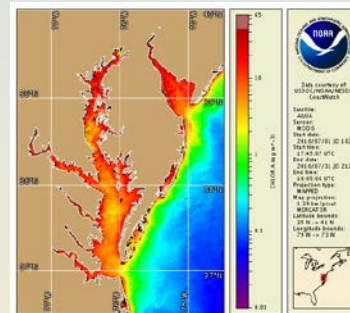
Gulf of Mexico



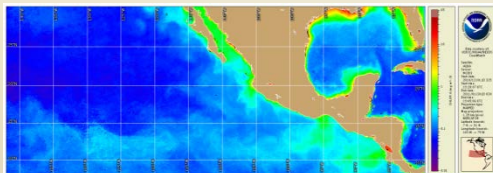
Great Lakes



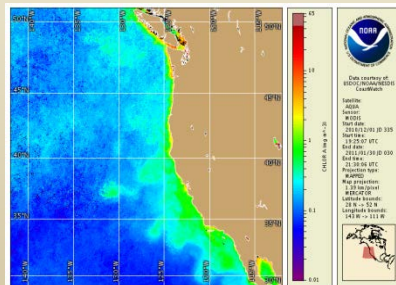
Chesapeake Bay



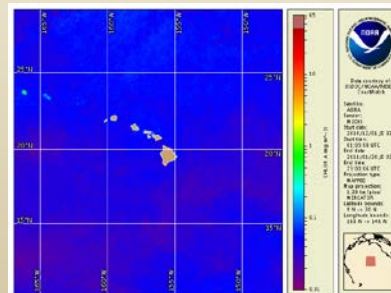
Eastern Tropical Pacific



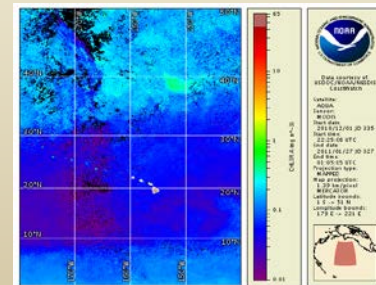
West



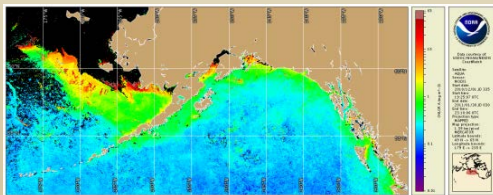
Hawaii



Pacific Basin



Alaska

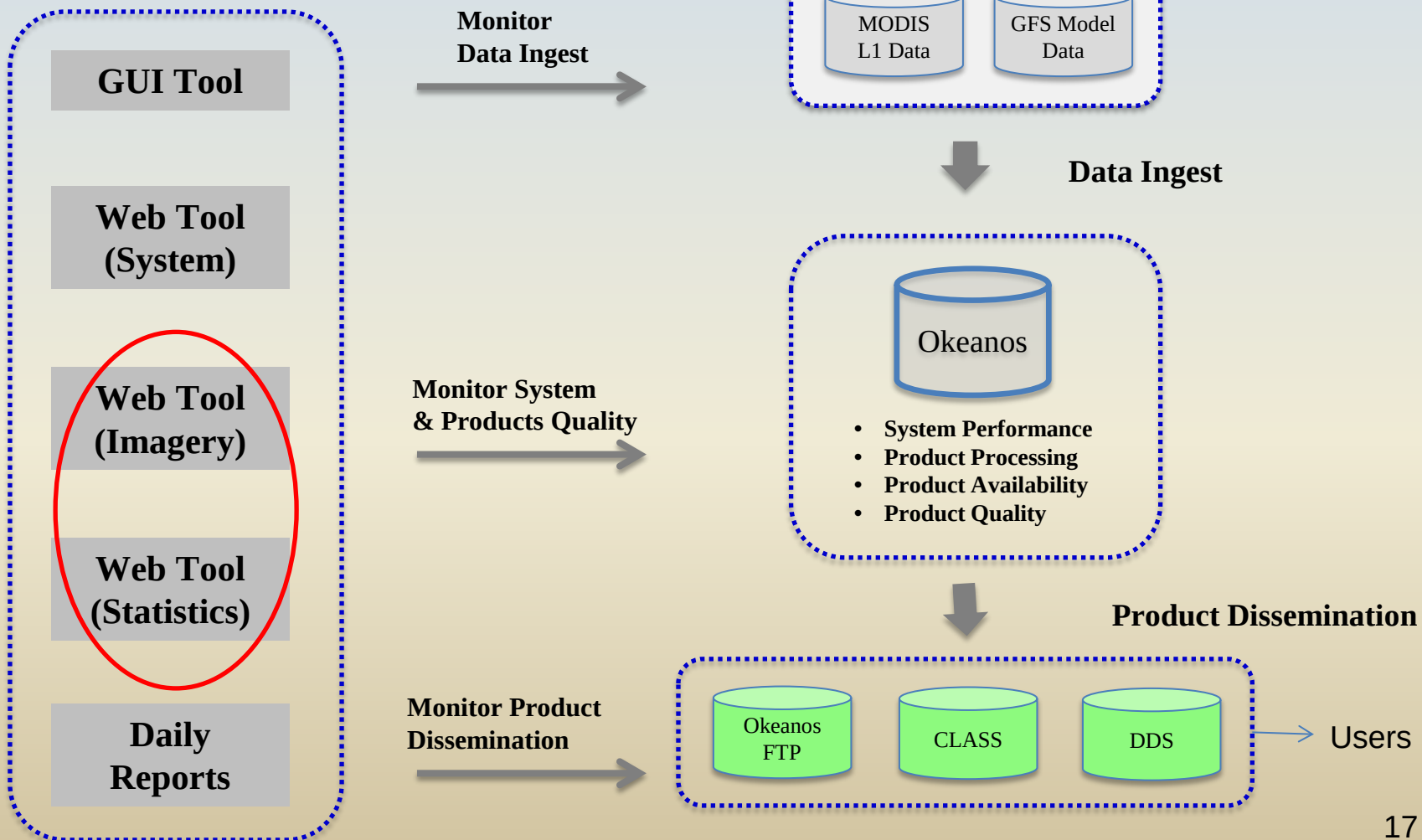


Okeanos OC Product QA Monitoring Tool

- **Objective: Develop a new Okeanos ocean color (OC) products QA monitoring tool along with the following capabilities**
 - Monitoring Okeanos system ingest, process, generation, and distribution in near real time
 - Monitoring availability and quality assurance of products in near real time
 - Monitoring performance and stability of system in near real time
 - Detecting suspicious or anomalous ocean color products

Okeanos OC Products QA Tool Overview

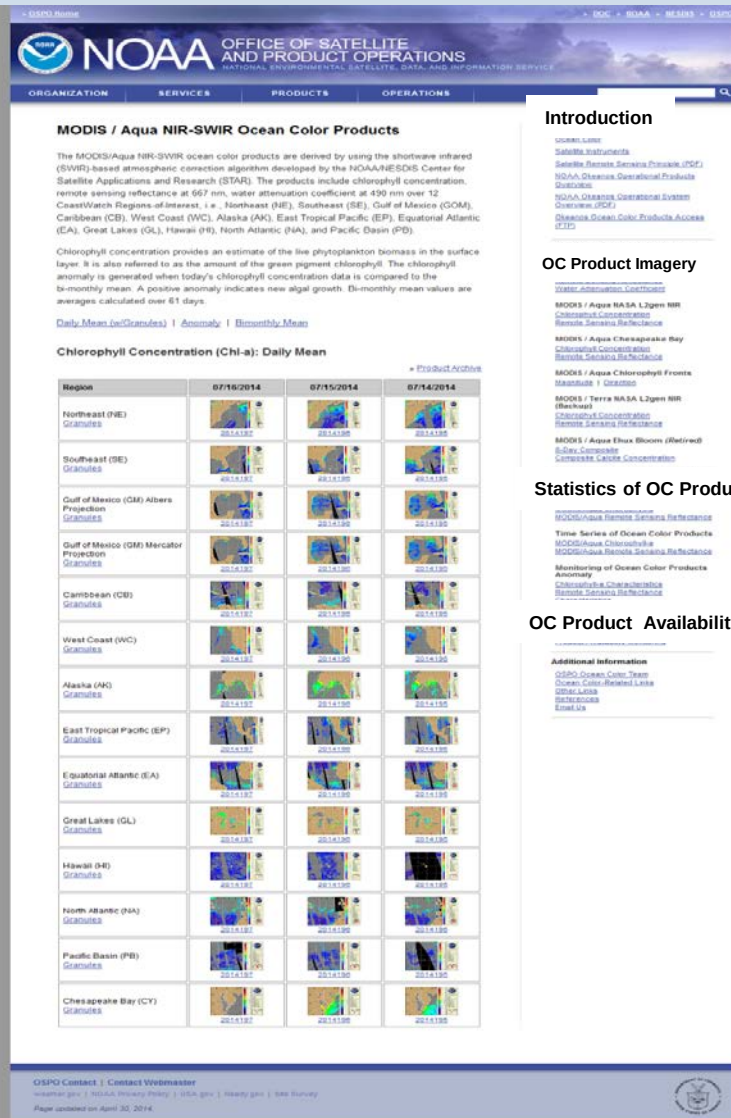
New Okeanos OC Product QA Tool



Okeanos Web-Based QA Monitoring Tool: Home Page

Regions

- Northeast (NE)
- Southeast (SE)
- Gulf of Mexico (GM)
- Albers Projection
- Gulf of Mexico (GM)
- Mercator Projection
- Carribbean (CB)
- West Coast (WC)
- Alaska (AK)
- East Tropical Pacific (EP)
- Equatorial Atlantic (EA)
- Great Lakes (GL)
- Hawaii (HI)
- North Atlantic (NA)
- Pacific Basin (PB)
- Chesapeake Bay (CY)



STREAMS

- MODIS / Aqua NIR-SWIR (WCW)
- MODIS / Aqua NASA L2gen NIR (SCW)
- MODIS / Aqua Chesapeake Bay
- MODIS / Aqua Chlorophyll Fronts
- MODIS / Terra NASA L2gen NIR
- MODIS / Aqua Chlorophyll Fronts
- MODIS / Aqua Ehux Bloom (Retired)

Products (images)

- Chlorophyll Concentration
- Remote Sensing Reflectance
- Water Attenuation Coefficient
- Chlorophyll Front
- Calcite Concentration (retired)

Products (Statistics)

Time Series and Histograms

- Chlorophyll Concentration
- Remote Sensing Reflectance

Okeanos QA Tool: Introduction

- [Ocean Color](#)
- [Satellite Instruments](#)
- [Satellite Remote Sensing Principle \(PDF\)](#)
- [NOAA Okeanos Operational Products Overview](#)
- [NOAA Okeanos Operational System Overview \(PDF\)](#)
- [Okeanos Ocean Color Products Access \(FTP\)](#)
- [Okeanos Documents \(FTP\)](#)



<ftp://cw-okeanos.noaa.gov/pub/data1/doc/>

[NOAA CoastWatch_Okeanos_OCProducts_Overview.pdf](#)

[NOAA Okeanos Prds Web QA Monitoring Tool 4Imrgery.pdf](#)

[NOAA Okeanos Prds Web QA Monitoring Tool 4Statistics.pdf](#)

[NOAA Okeanos QA GUI Monitoring Tool.pdf](#)

[README.txt](#)

etc.

Okeanos pub FTP directory /pub/data1/ at cw-okeanos.noaa.gov

```
Directory CLASS
Directory CPC
Directory CW
Directory EHUX data experimental
Directory FRONTAL
Directory GUI
Directory HAB
README.txt
Directory Temp
Directory data products
Directory dds geonet
Directory doc
Directory modis
    Directory L1
    Directory L2
    Directory L3
    Directory L4
        Directory browse
        Directory hdf \(Chl anomaly files etc\)
        Directory thumb
        Directory tiff
Directory png archive
Directory products by type
```

Okeanos QA Tool: Okeanos OC Products

Imagery Monitoring

- MODIS / Aqua NIR-SWIR
 - [Chlorophyll Concentration](#)
 - [Remote Sensing Reflectance](#)
 - [Water Attenuation Coefficient](#)
- MODIS / Aqua NASA L2gen NIR
 - [Chlorophyll Concentration](#)
 - [Remote Sensing Reflectance](#)
- MODIS / Aqua Chesapeake Bay
 - [Chlorophyll Concentration](#)
 - [Remote Sensing Reflectance](#)
- MODIS / Aqua Chlorophyll Fronts
 - [Magnitude](#) | [Direction](#)
- MODIS / Terra NASA L2gen NIR (Backup)
 - [Chlorophyll Concentration](#)
 - [Remote Sensing Reflectance](#)
- MODIS / Aqua Ehux Bloom (*Retired, for Demo only*)

http://www.ospo.noaa.gov/Products/ocean/color/swir_chla_daily.html

Example 1: Daily Mean Image Products

Daily Mean Image

Posting for three days, or
archived for 10 days

MODIS / Aqua NIR-SWIR

- Chlorophyll Concentration
- Remote Sensing Reflectance
- Water Attenuation Coefficient

MODIS / Aqua NASA L2gen NIR

- Chlorophyll Concentration
- Remote Sensing Reflectance

**MODIS / Aqua Chesapeake Bay
(1 Region)**

- Chlorophyll Concentration
- Remote Sensing Reflectance

**MODIS / Terra NASA L2gen NIR
(Backup) (Currently 3 Regions)**

- Chlorophyll Concentration
- Remote Sensing Reflectance

MODIS / Aqua Chlorophyll Fronts

- Magnitude | - Direction

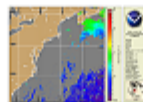
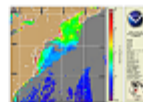
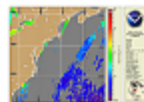
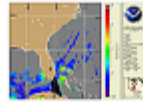
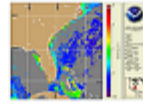
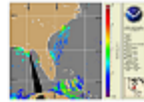
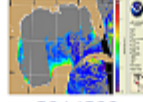
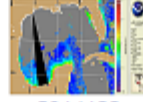
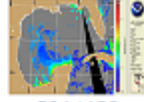
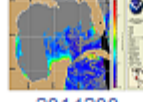
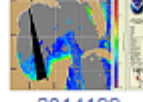
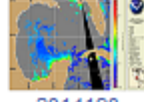
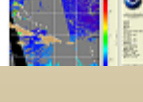
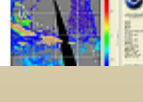
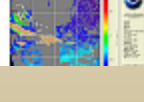
**MODIS / Aqua Ehux Bloom (Retired)
(No granules shown)**

- (Also) 8-Day Composite
- Composite Calcite Concentration

[Daily Mean \(w/Granules\)](#) | [Anomaly](#) | [Bimonthly Mean](#)

Chlorophyll Concentration (Chl-a): Daily Mean

» [Product Archive](#)

Region	07/19/2014	07/18/2014	07/17/2014
Northeast (NE) Granules	 2014200	 2014199	 2014198
Southeast (SE) Granules	 2014200	 2014199	 2014198
Gulf of Mexico (GM) Albers Projection Granules	 2014200	 2014199	 2014198
Gulf of Mexico (GM) Mercator Projection Granules	 2014200	 2014199	 2014198
Caribbean (CB) Granules	 2014200	 2014199	 2014198

Daily Chl and frontal products have Granule Archives available for (latest) 10 days.



Okeanos QA Tool: Okeanos OC Products Statistics Monitoring

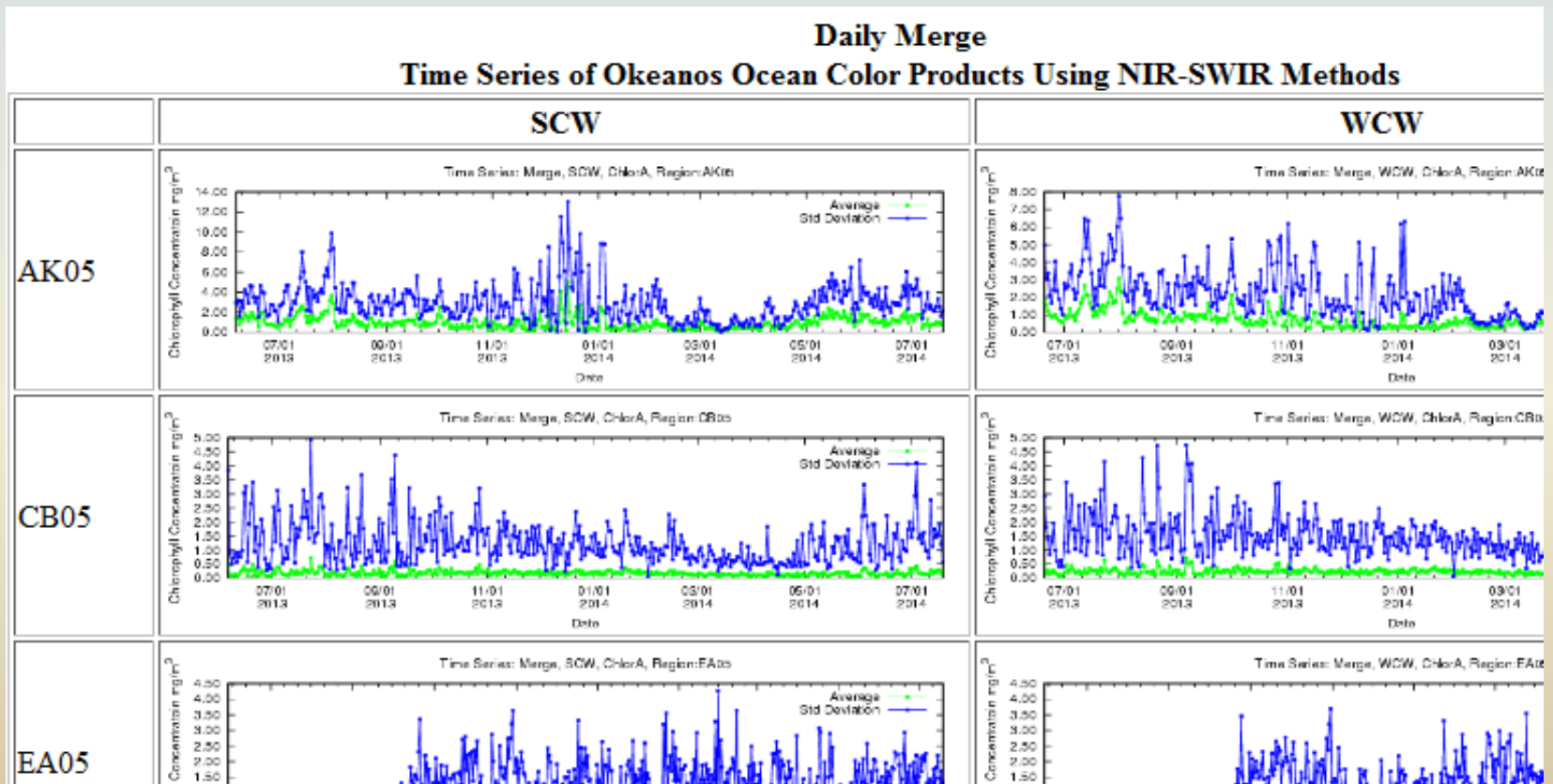
- **Histogram of Ocean Color Products**
 - [MODIS/Aqua Chlorophyll-a](#)
 - [MODIS/Aqua Remote Sensing Reflectance](#)
- **Time Series of Ocean Color Products**
 - [MODIS/Aqua Chlorophyll-a](#)
 - [MODIS/Aqua Remote Sensing Reflectance](#)
- **Monitoring of Ocean Color Products Anomaly**
 - [Chlorophyll-a Characteristics](#)
 - [Remote Sensing Reflectance Characteristics](#)

Refer to: <http://www.ospo.noaa.gov/data/ocean/okeanos/STATS/html/HSocp.html>

Statistics Daily-Merge Chlorophyll and Rrs667: Histogram, Time Series and Anomaly Monitoring

Time Series graphs (Mean & Standard Deviations):

- All CW regions
- NIR and NIR-SWIR Methods
- Daily and Bi-Monthly Chl and Rrs Products



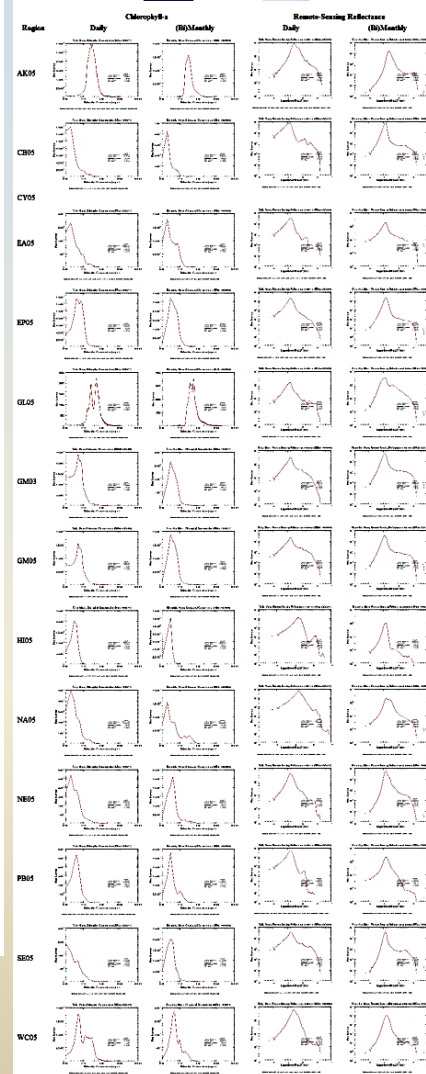
OC Product Statistics-Histogram Table

For **selected day**, display histograms of the products for all CW regions.

(Chl and Rrs667, bimonthly & daily merges NIR and NIR-SWIR Products)



Table Histogram (2014198) of Oceanic Ocean Color Products
PREV:2014189 NIR-SWIR Merge NEXT:2014121



**** HISTOGRAM TABLE WCW ****

[NIR Products](#)

[NIR-SWIR Products](#)

[Back to Products](#)

Table Histograms (2014198) of Oceanic Ocean Color Products
PREV:2014189 NIR

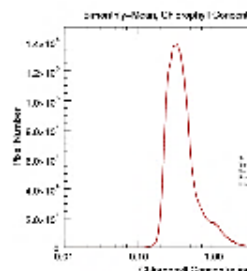
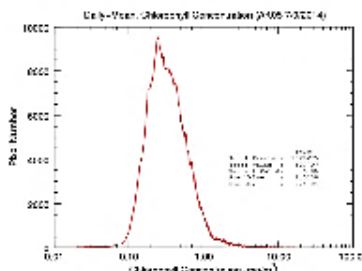
Chlorophyll-a

Region

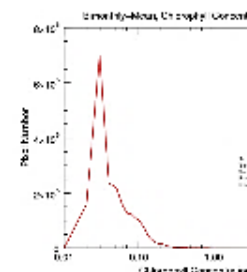
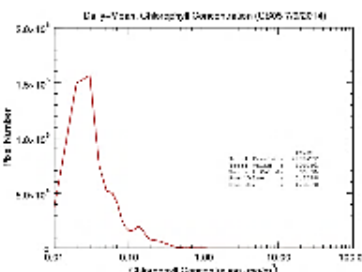
Daily

(Bi)Monthl

AK05



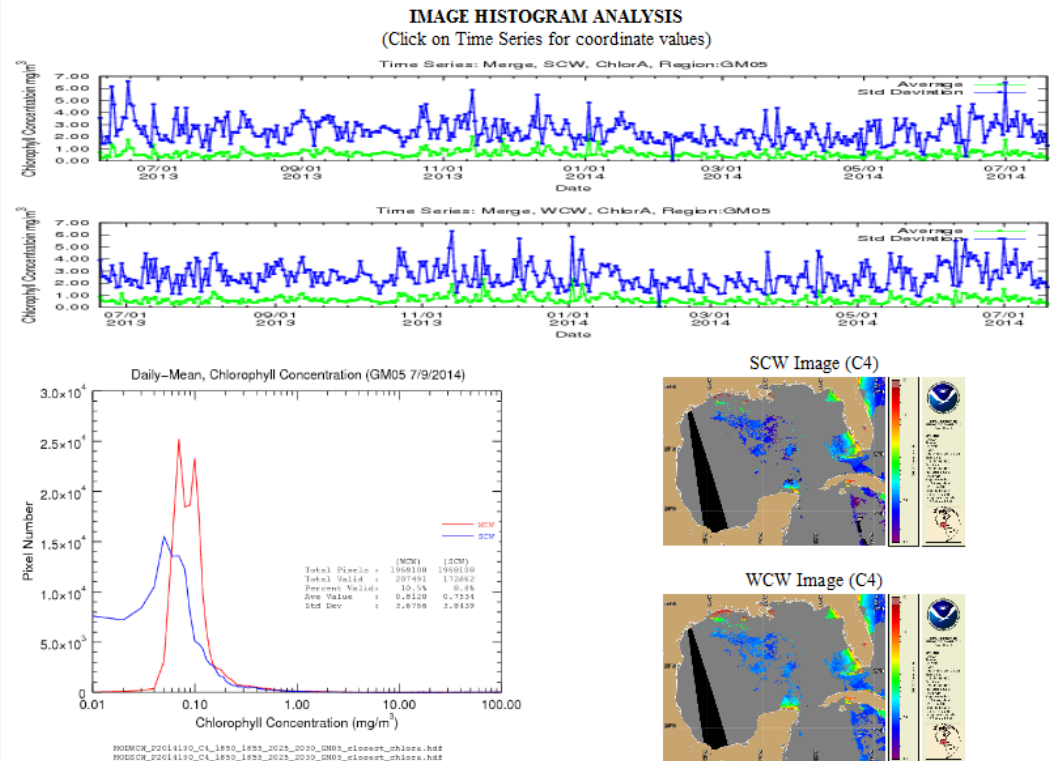
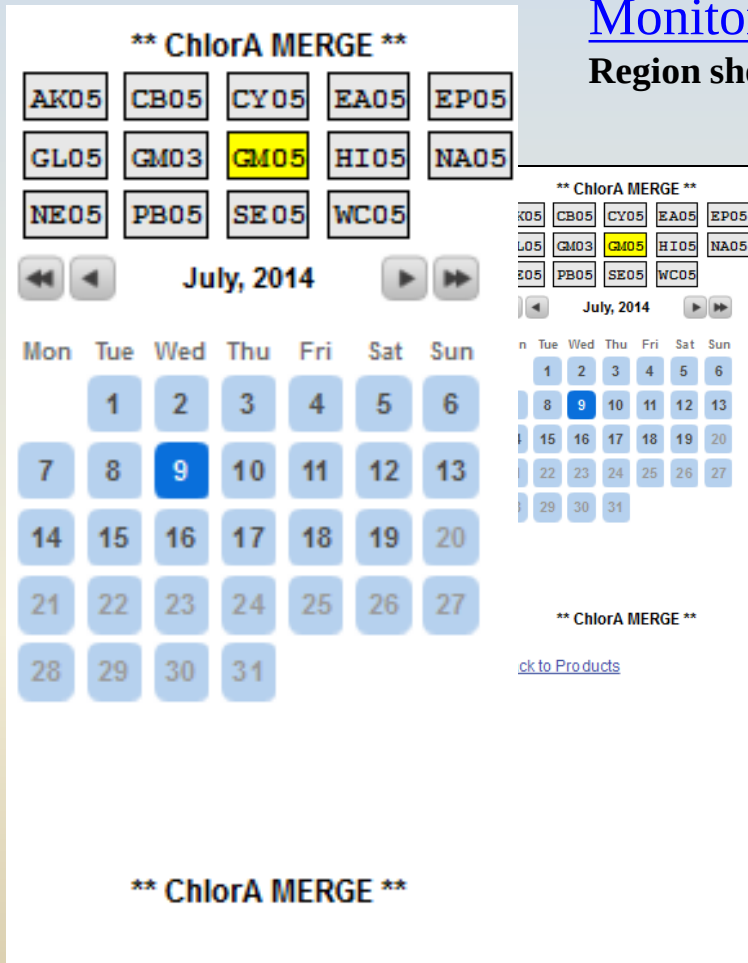
CB05



Okeanos OC Products Statistics

Monitoring: Product Anomaly?

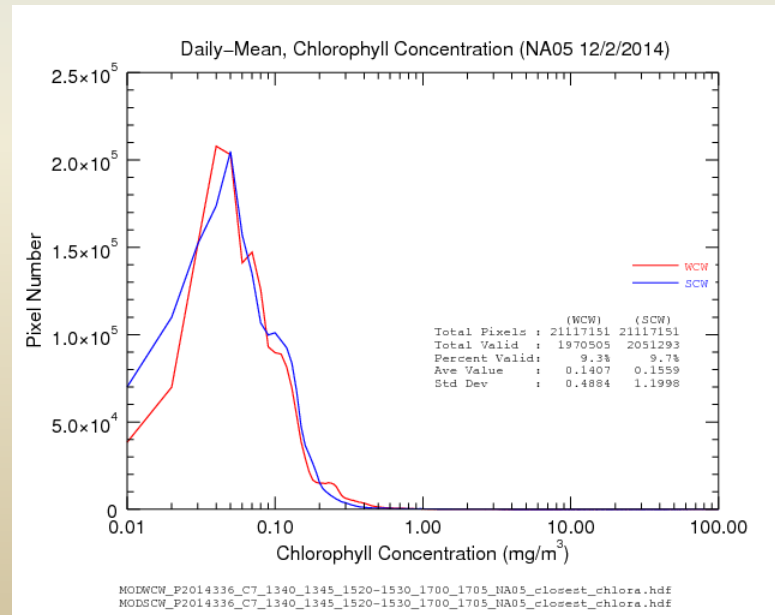
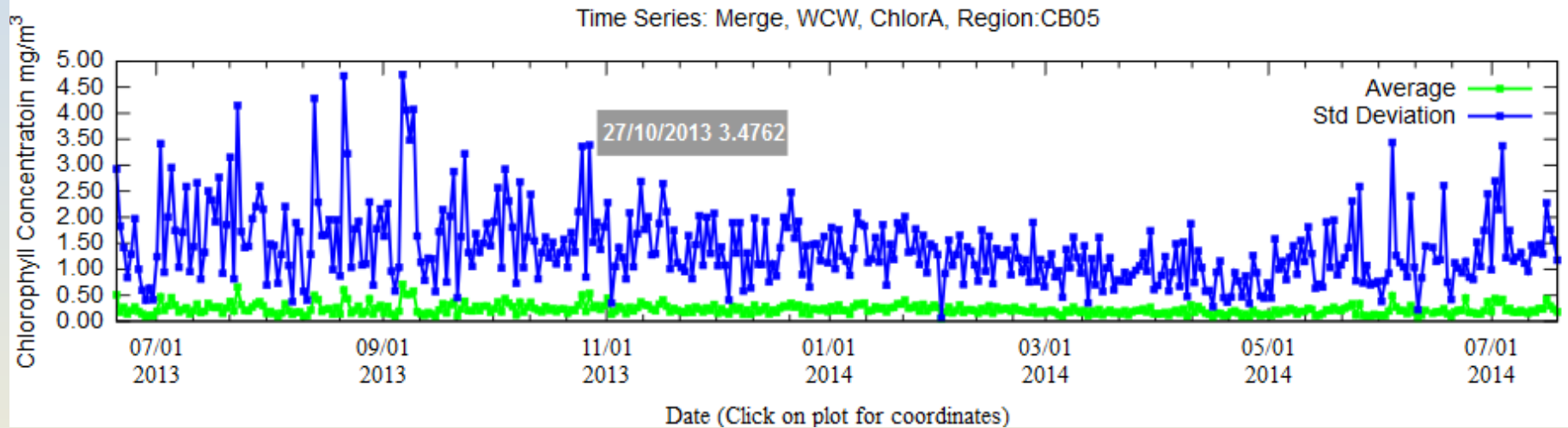
Monitor suspicious product anomaly? Interactive Date and Region shows Time Series, Histogram and Images for selected options.



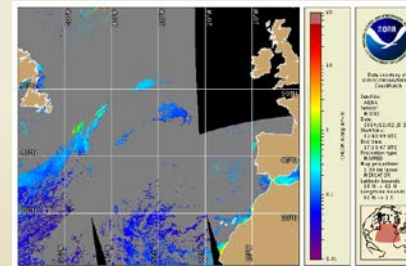
[Back to Products](#)

Avail For: CHLORA MERGE, CHLORA BIMONTH, Rrs667 MERGE, Rrs667 BIMONTH

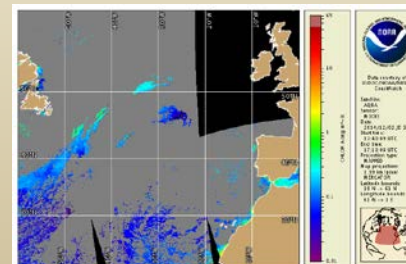
Example Image for Time Series and Histogram



SCW Image (C7)



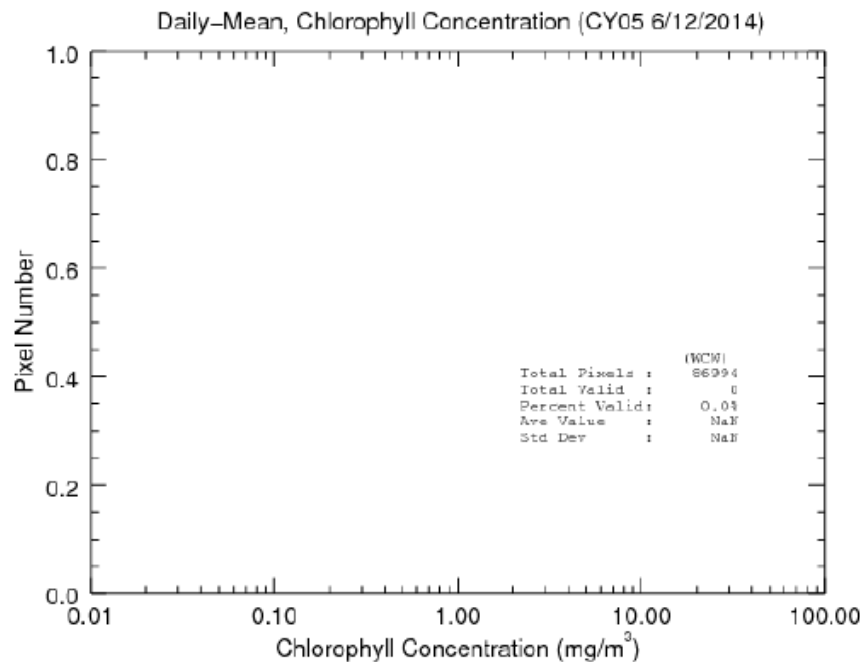
WCW Image (C7)



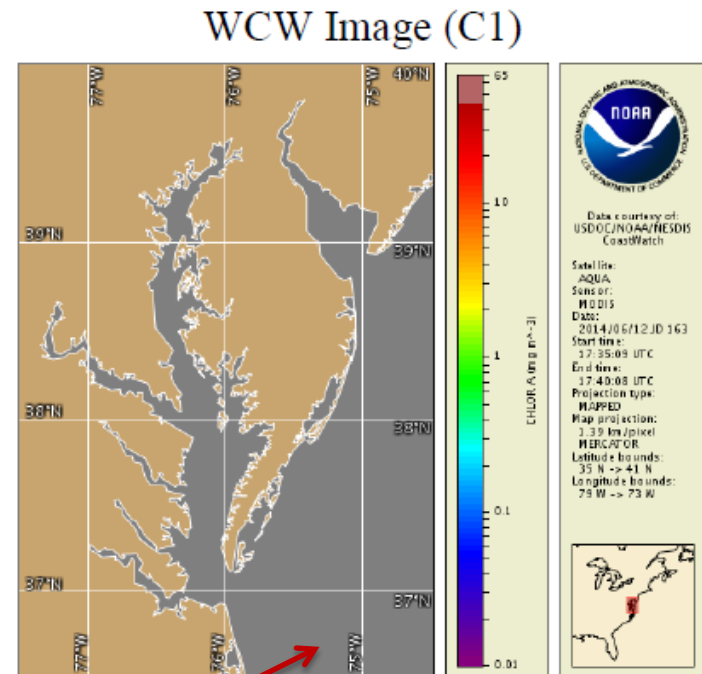
Okeanos OC Products Suspicious Features

Detection: Example 1

Identify Chlorophyll Products with Zero or Low Valid Pixels



MODISWCW_F2014163_C1_1735_CY05_closest_chlora hdf



No valid pixels!

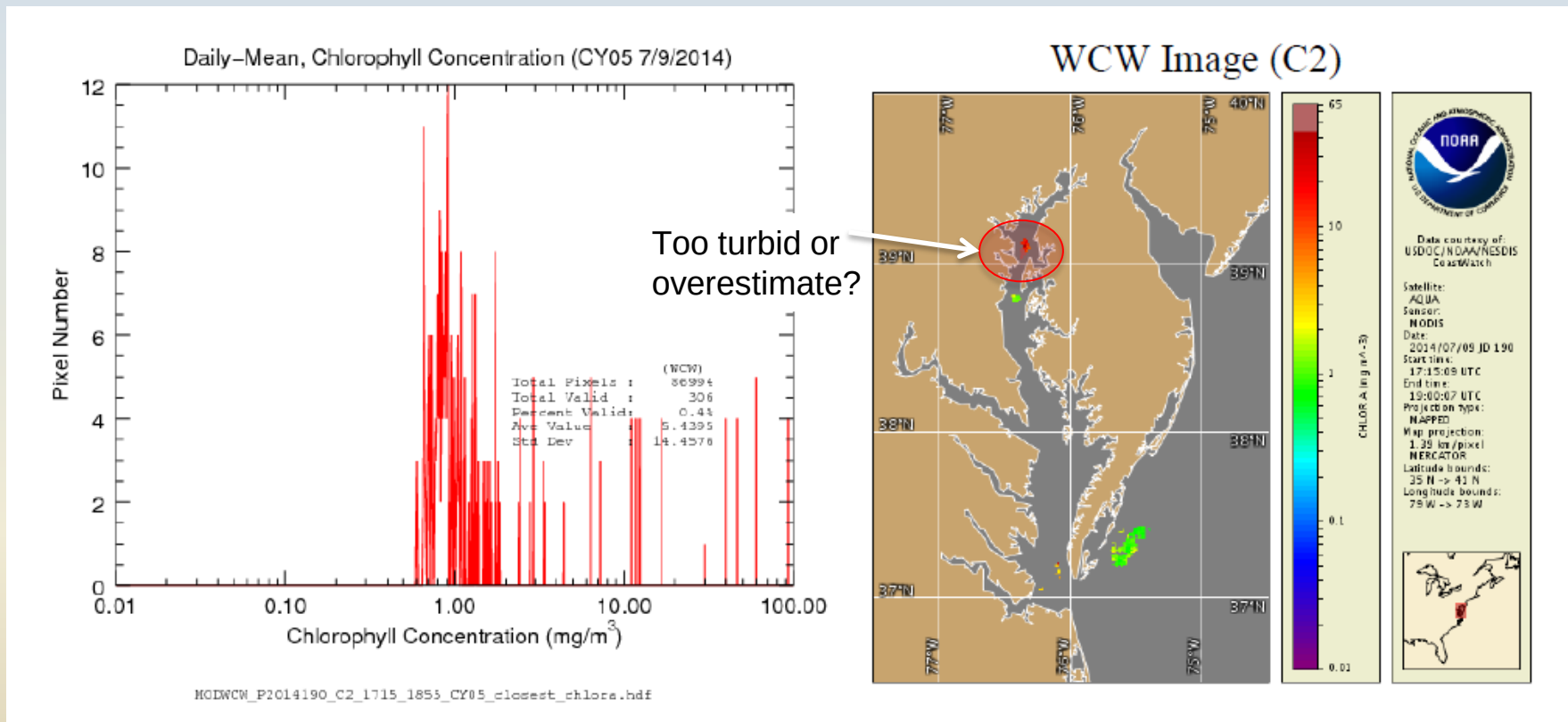
- **Detection Criteria:**

- Valid pixel (Vpixel): $0.001 < [\text{chl}] < 100 \text{ mg/m}^3$
- Vpixel # < 1000.0

Okeanos OC Products Suspicious Features

Detection: Example 2

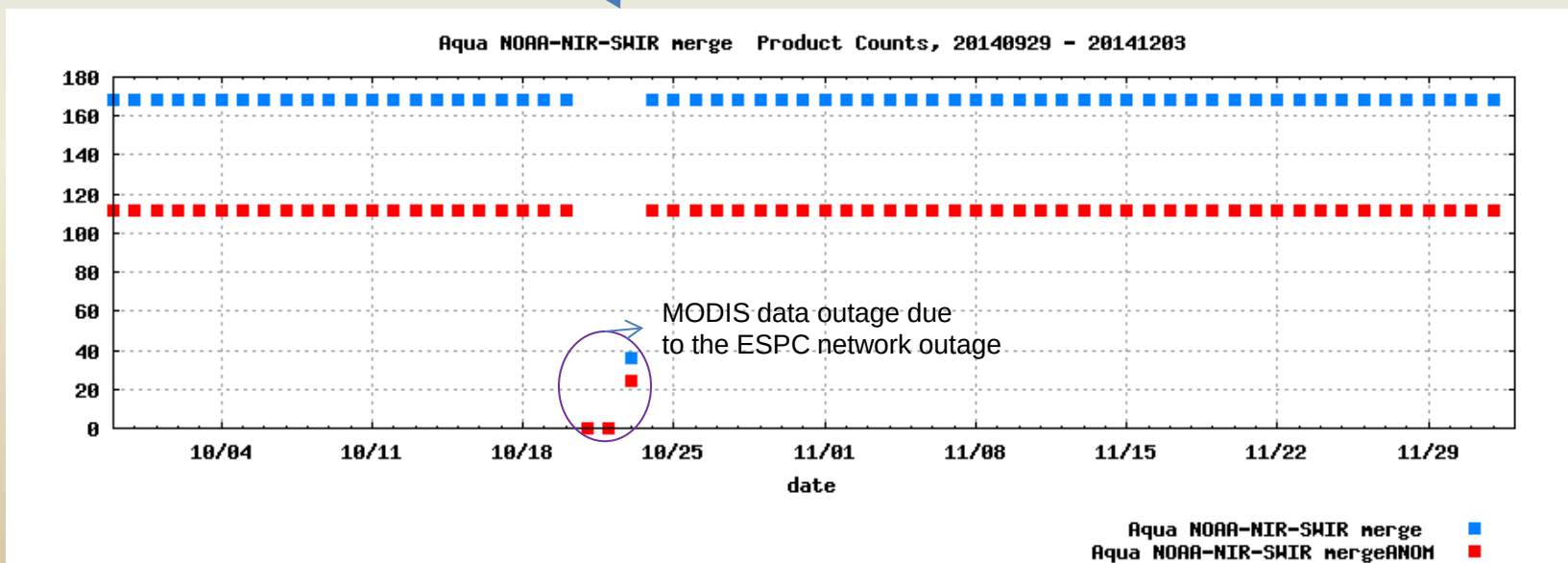
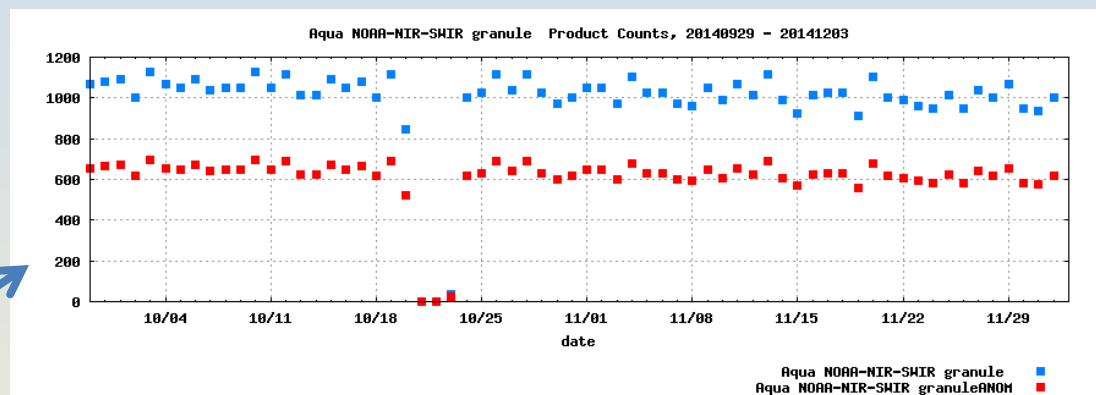
Identify Extremely Turbid Ocean or Anomalous Ocean Color Products?



- Detect Criteria for extremely turbid ocean or anomalous ocean color products:
 - Non-CY regions: mean > 0.2 and σ (standard deviation) $> 8.0 \times \text{mean}$
 - CY region: $\sigma > 2.0 \times \text{mean}$

Okeanos QA Tool: OC Product Availability Monitoring

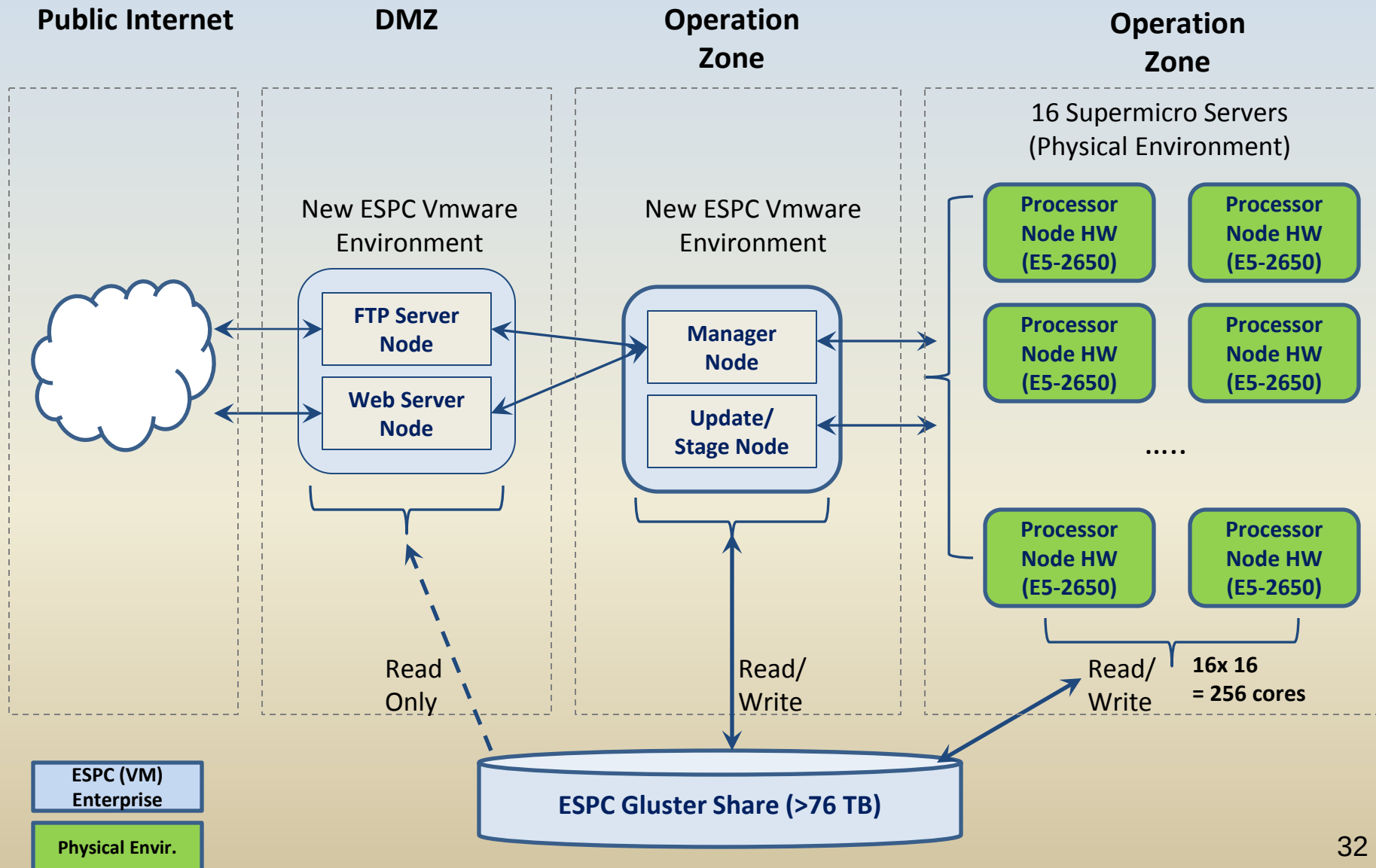
- Aqua Chesapeake Granule
- Aqua Chesapeake Merge
- Aqua Frontal Granule
- Aqua Frontal Merge
- Aqua NASA NIR Granule
- Aqua NASA NIR Merge
- Aqua NOAA NIR-SWIR Granule
- Aqua NOAA NIR-SWIR Merge



Upcoming Activities

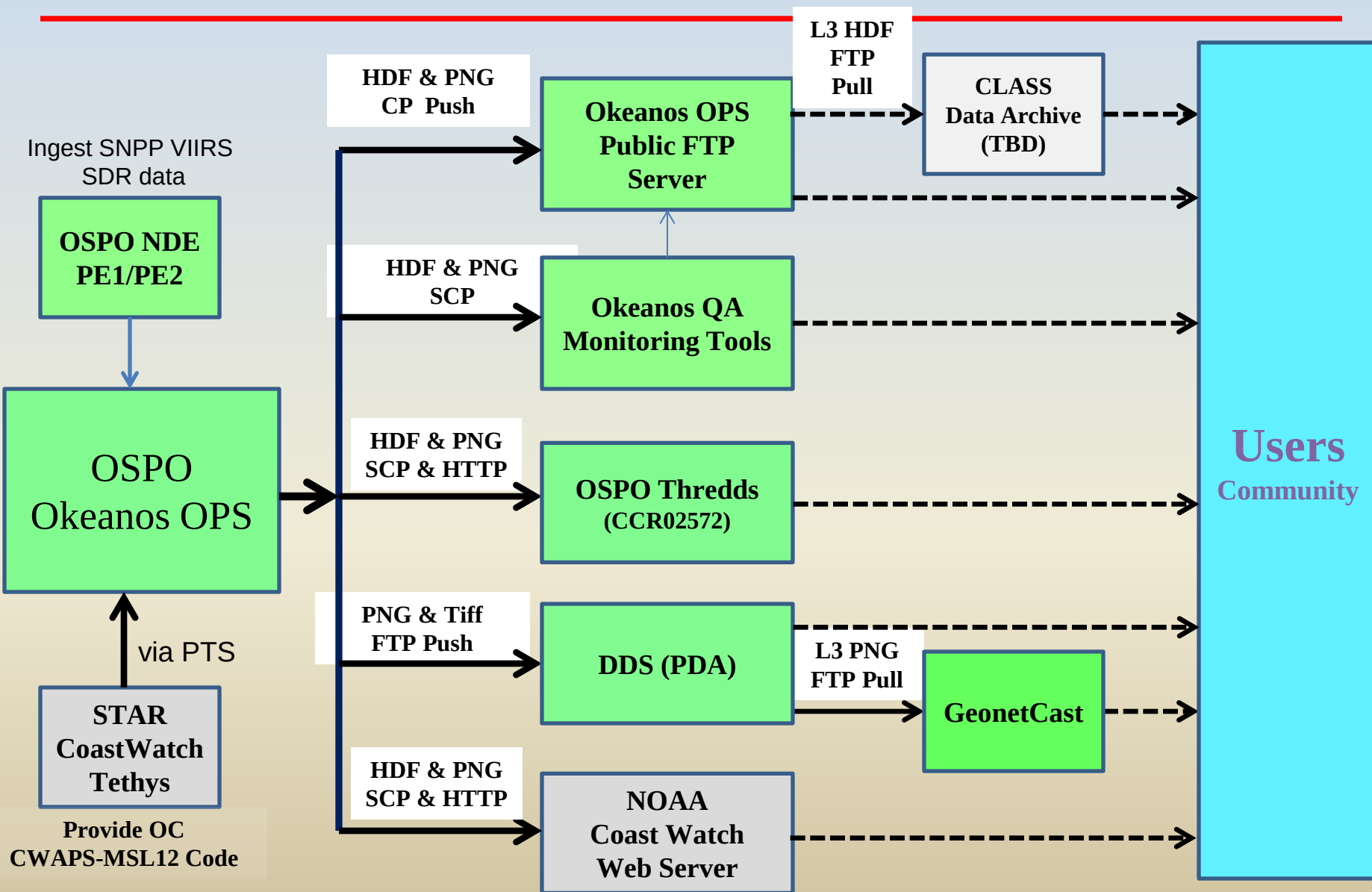
- Develop new-generation Okeanos ocean color Parallel Test System in support to SNPP VIIRS ocean color product processing and dissemination: Target May 2015
- Develop new-generation Okeanos ocean color production system in support to SNPP VIIRS ocean color product processing and dissemination: Target 2016
- Deliver SNPP VIIRS ocean color NOAA pre-operational products to user community: Target summer 2015
- Deliver SNPP VIIRS ocean color NOAA operational products to user community: Target 2016

Upcoming New-Generation Okeanos Operational Production System in Support of VIIRS/MODIS OC Processing



NOAA Okeanos Data Flow Chart

in Support to VIIRS Operational Ocean Color Products



Okeanos Ocean Color Products

Access Information

Welcome to visit our NOAA ocean color operational product web site:

<http://www.ospo.noaa.gov/Products/ocean/color/index.html>

Welcome to visit our NOAA ocean color operational product data access:

<ftp://cw-okeanos.noaa.gov/pub/data1/>

Welcome to contact with Banghua.Yan@noaa.gov for any questions of the Okeanos products.

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 - Edmond Rodriguez, Derek Van Pelt, and Sterling Spangler: development of the Okeanos ocean color products QA monitoring tools
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- Collaborators: NOAA CoastWatch team, leading the development of CWAPS ocean color products processing software; Drs. Brown, C. , Wang, M., and Belkin, leading development of a series of ocean color products NOAA algorithms; MODIS/Aqua NIR products: NASA's Ocean Biology Processing Group (OBPG)

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