NOAA Okeanos Ocean Color Operational Production System: Status and Prospective

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AMS Meeting, 01/08/2015

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

(Reference: http://www.noaa.gov/organizations.html)

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

(Courtesy of Matthew Seybold)

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

NSOF

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

(Courtesy of Matthew Seybold and John Paquette)

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)

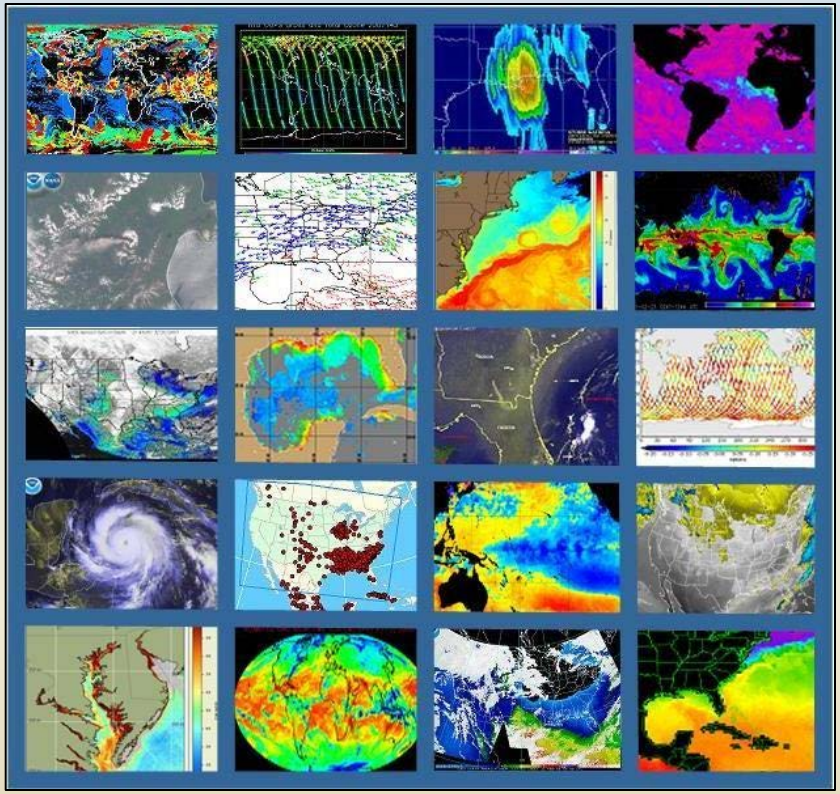
Fire and Smoke

Hurricane Intensity and Position

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

Volcanic Ash

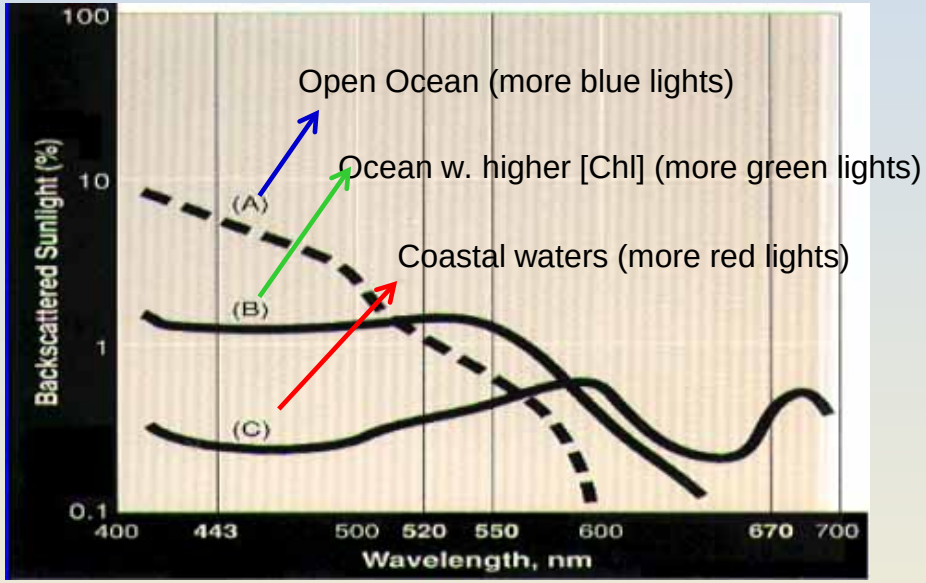
And many more



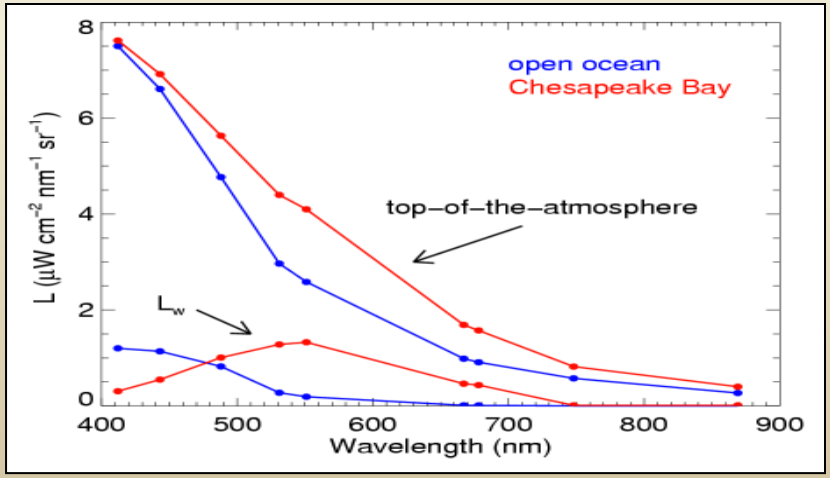
(Reference: http://www.ospo.noaa.gov/Products/index.html)

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



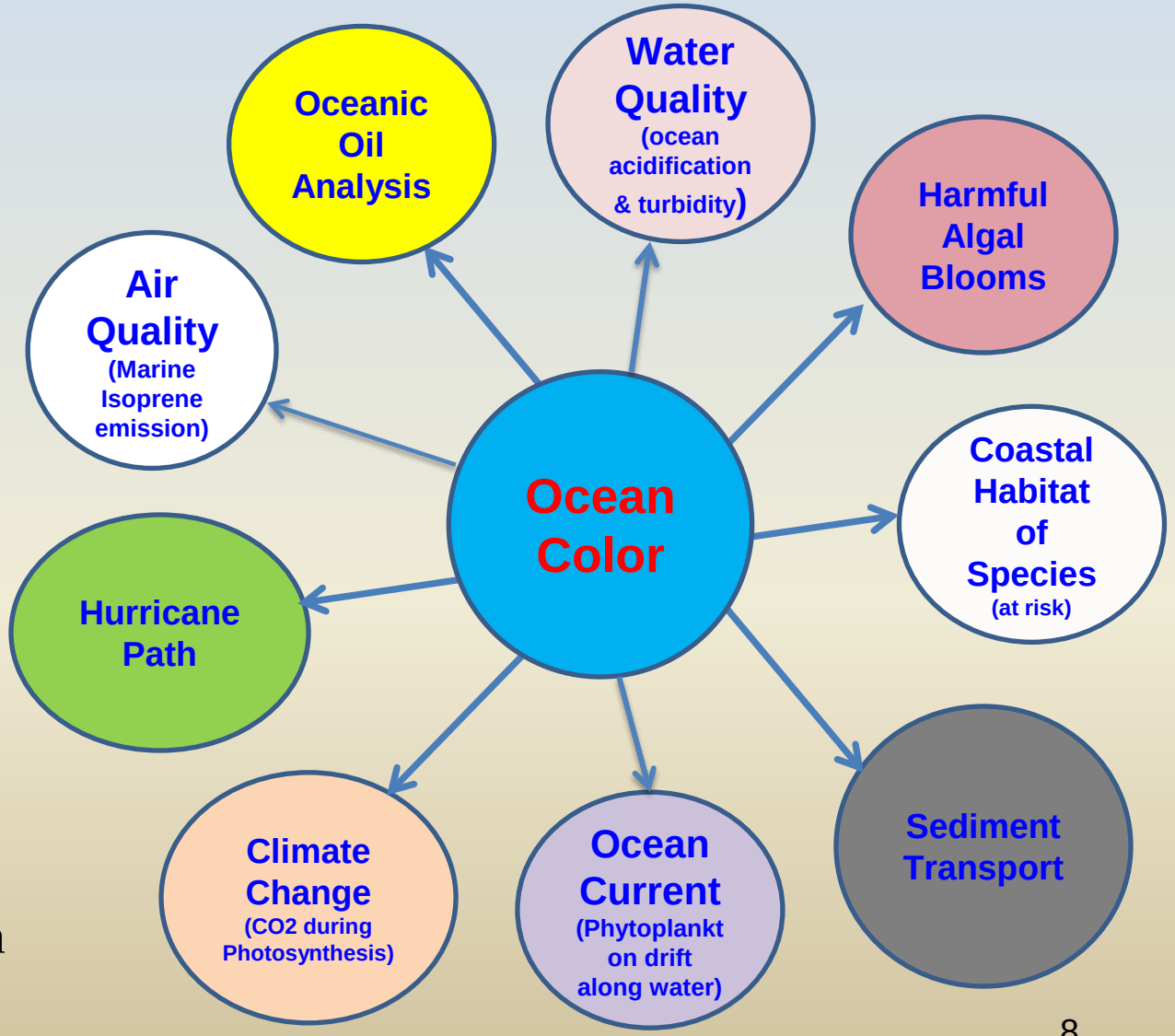
(Reference: https://www.eeb.ucla.edu/test/faculty/nezlin/OceanColor.htm)



(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

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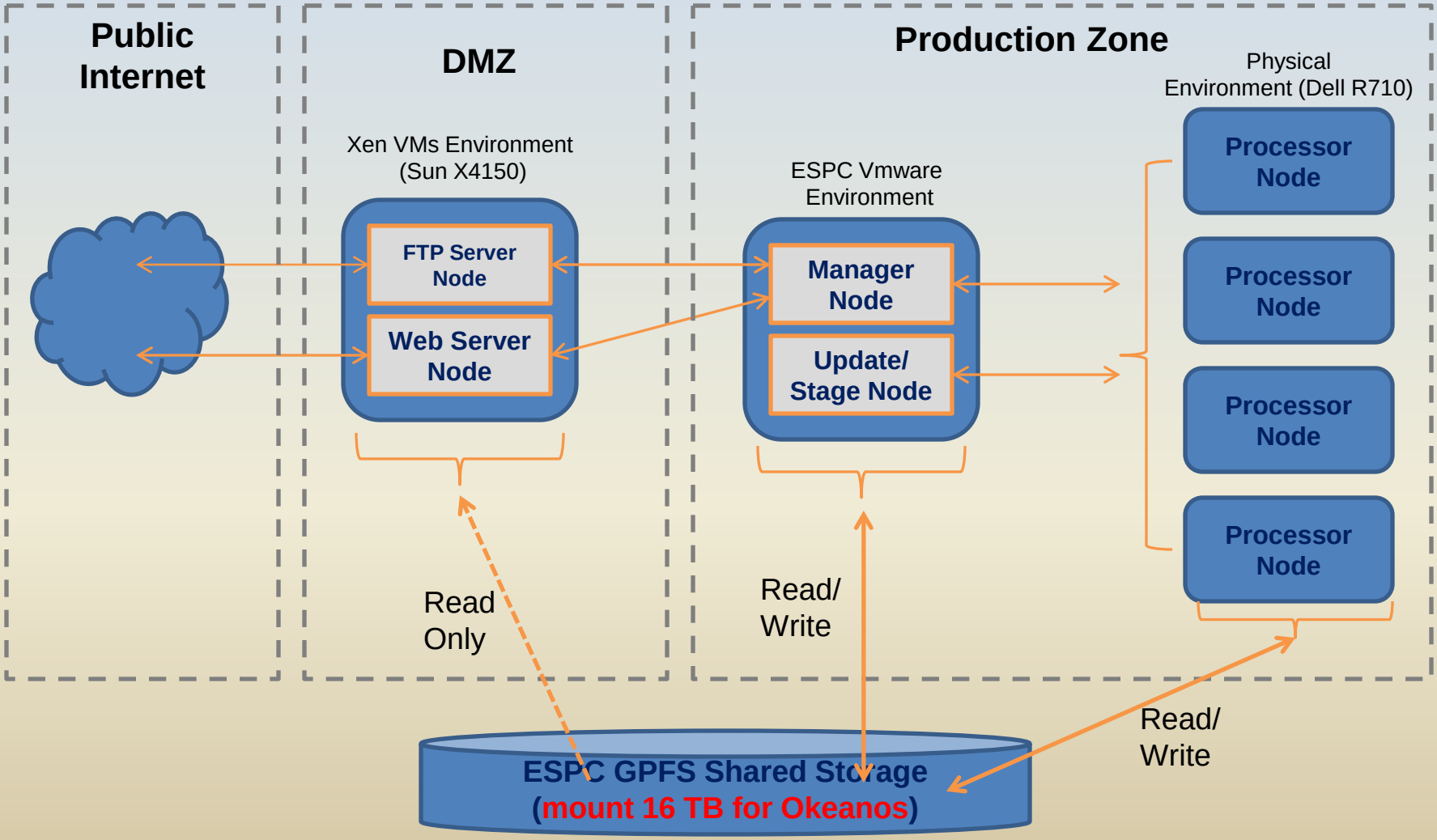
Current Okeanos Operational Production System for MODIS OC Processing, Operating Environment



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**

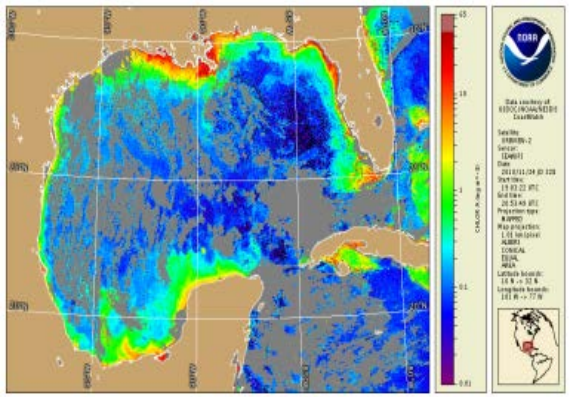
    (MODIS/Aqua, BOA-SNRA method)
- **Spatial Resolution**: 1Km
- **Timeliness**: 12 hours for daily products
- **Format:** HDF, GeoTiff, PNG, NetCDF

Okeanos Data Access Information

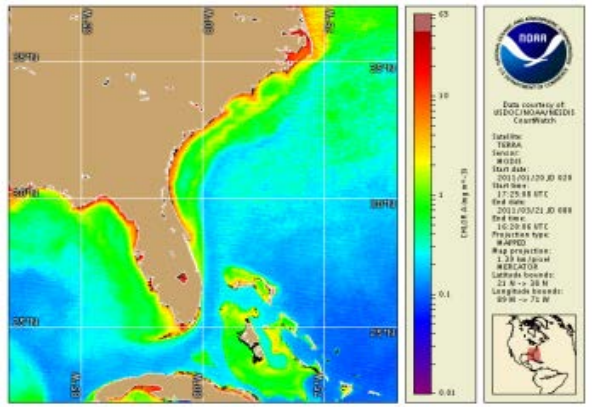
- Okeanos public ftp site (3 ~ 6 months): ftp://cw-okeanos.noaa.gov/pub/
- Okeanos OC product imagery (png, ≤10 days) web site: NOAA OSPO OC Web
- Okeanos OC products (short-term, ≤ 1 year): NOAA CoastWatch Web
- Okeanos OC products (long-term, only granule level chlorophyll products): CLASS

Okeanos Operational Ocean Color Products Type

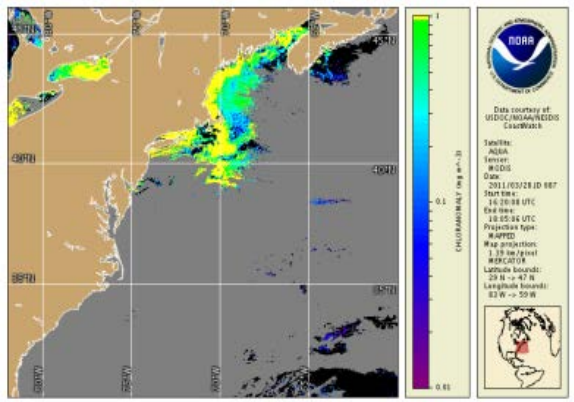
Daily chlorophyll concentration



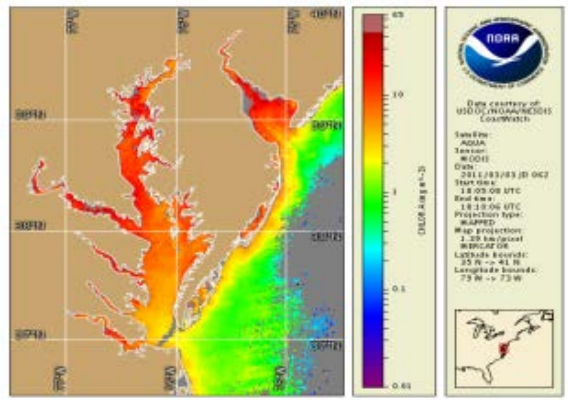
Bimonthly-mean chlorophyll concentration



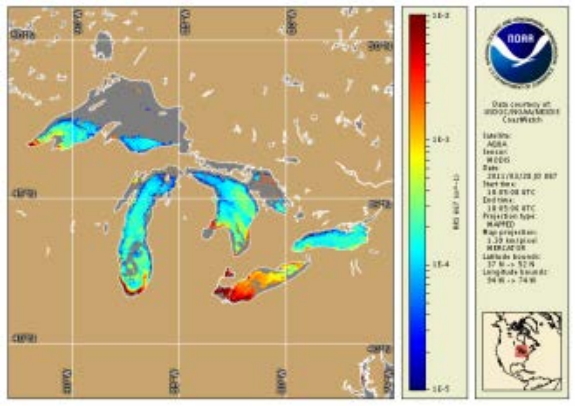
New algal growth (Positive chlorophyll concentration anomaly)



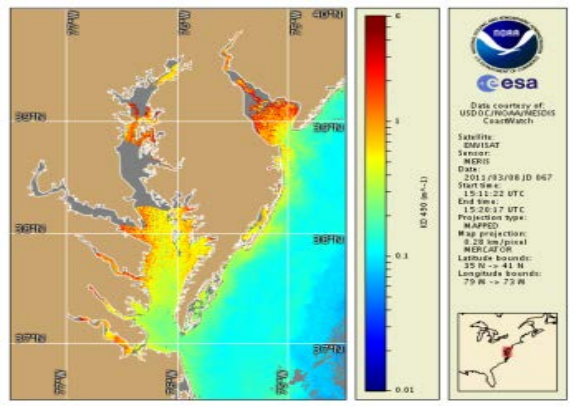
Chesapeake Bay daily chlorophyll concentration



Suspended sediment proxy (Remote sensing reflectance at 667 nm)

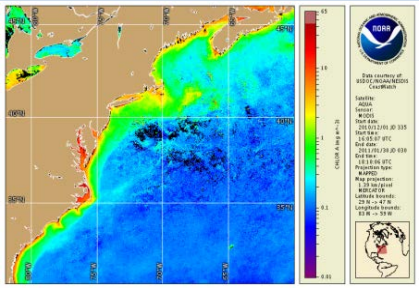


Water turbidity (Diffuse attenuation coefficient at 490 nm)

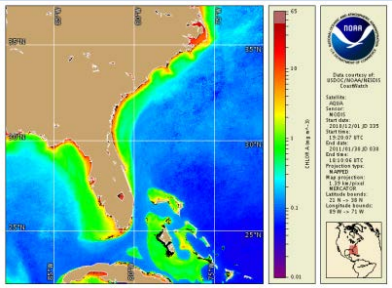


MODIS/Aqua OC Product Coverage

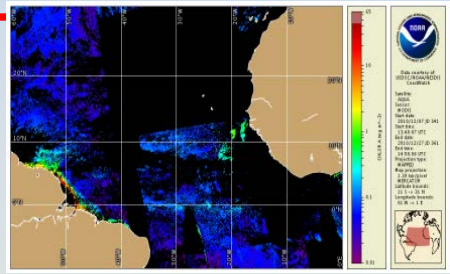
Northeast



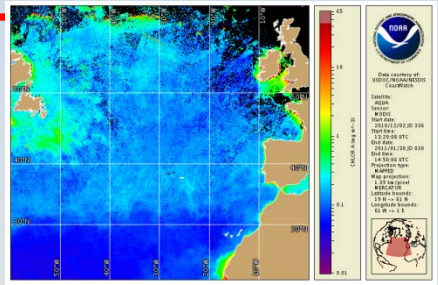
Southeast



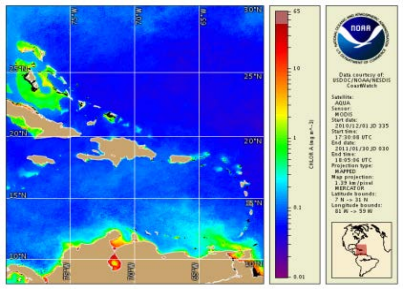
Equatorial Atlantic



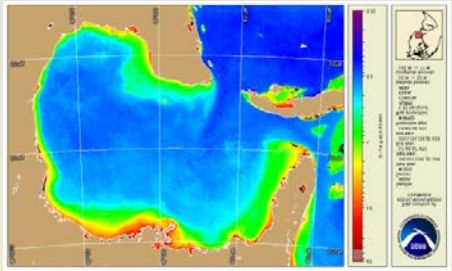
North Atlantic



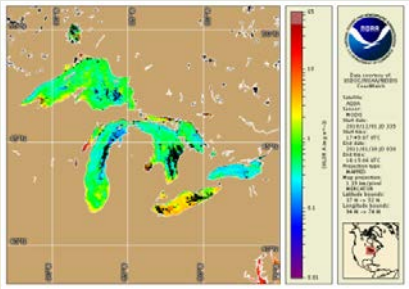
Caribbean



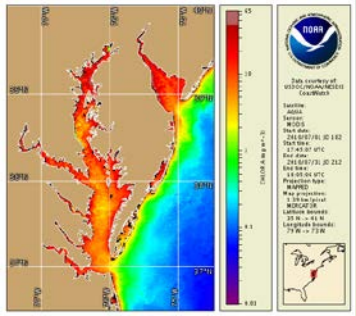
Gulf of Mexico



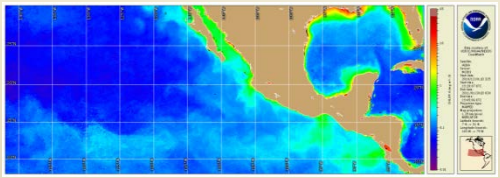
Great Lakes



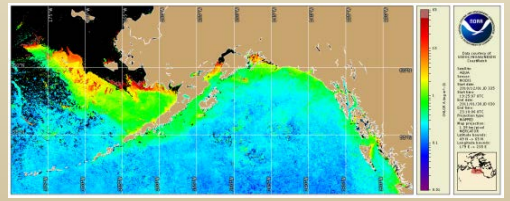
Chesapeake Bay



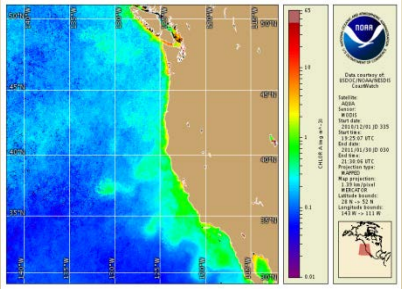
Eastern Tropical Pacific



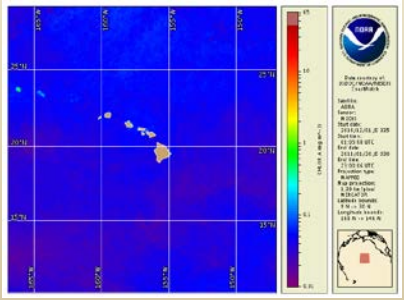
Alaska



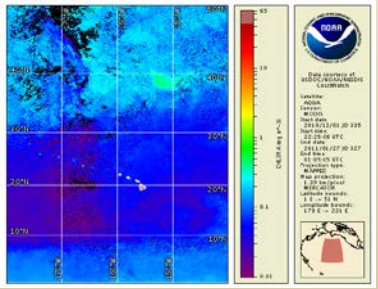
West



Hawaii



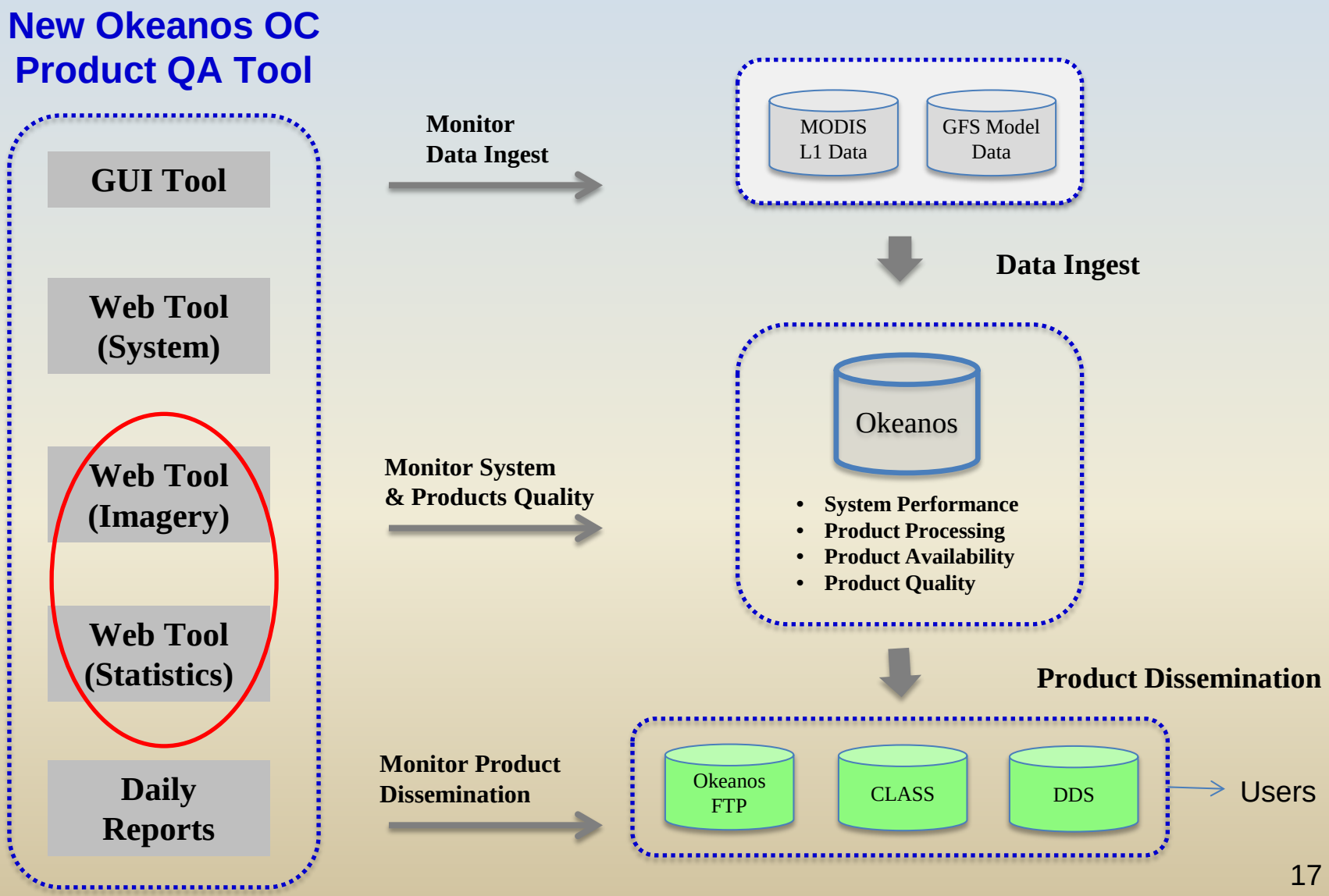
Pacific Basin



Okeanos OC Product QA Monitoring Tool

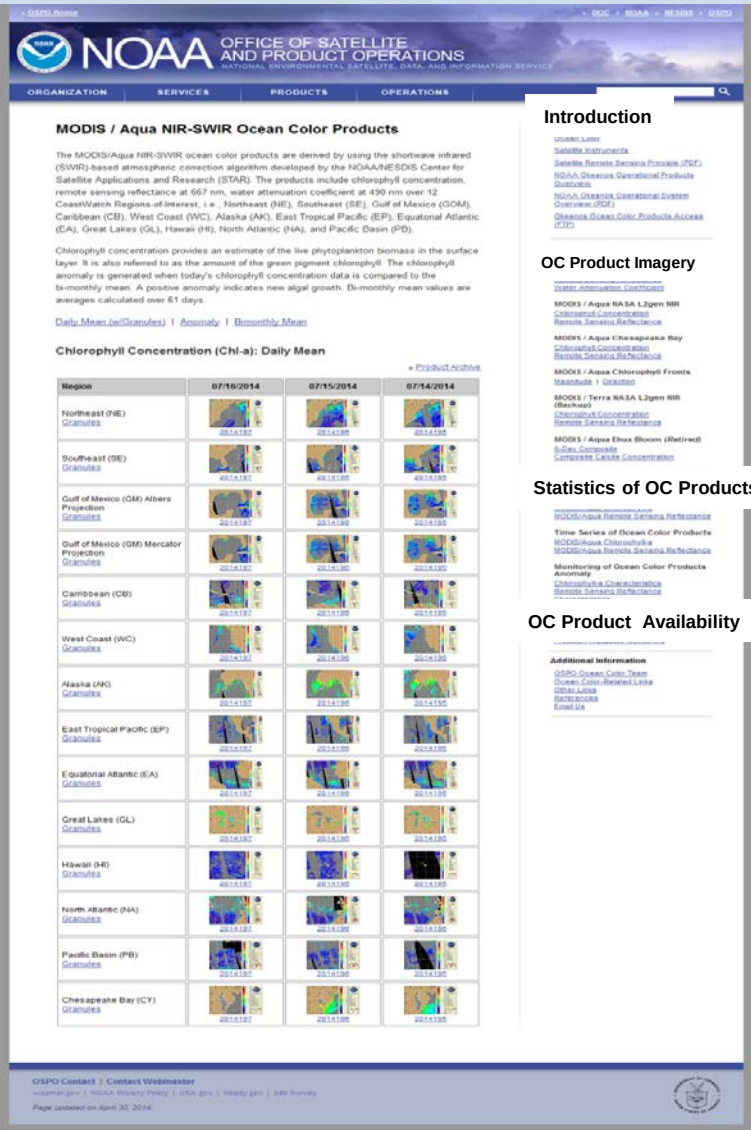
- **Objective: Develop a new Okeanos ocean color (OC) products QA monitoring tool along with the following capabilities**
  - Monitoring Okeanos system ingest, process, generation, and distribution in near real time
  - Monitoring availability and quality assurance of products in near real time
  - Monitoring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

Okeanos OC Products QA Tool Overview



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)



(Refer to OC Web Site)

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_4Imgery.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)***

(Refer to 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

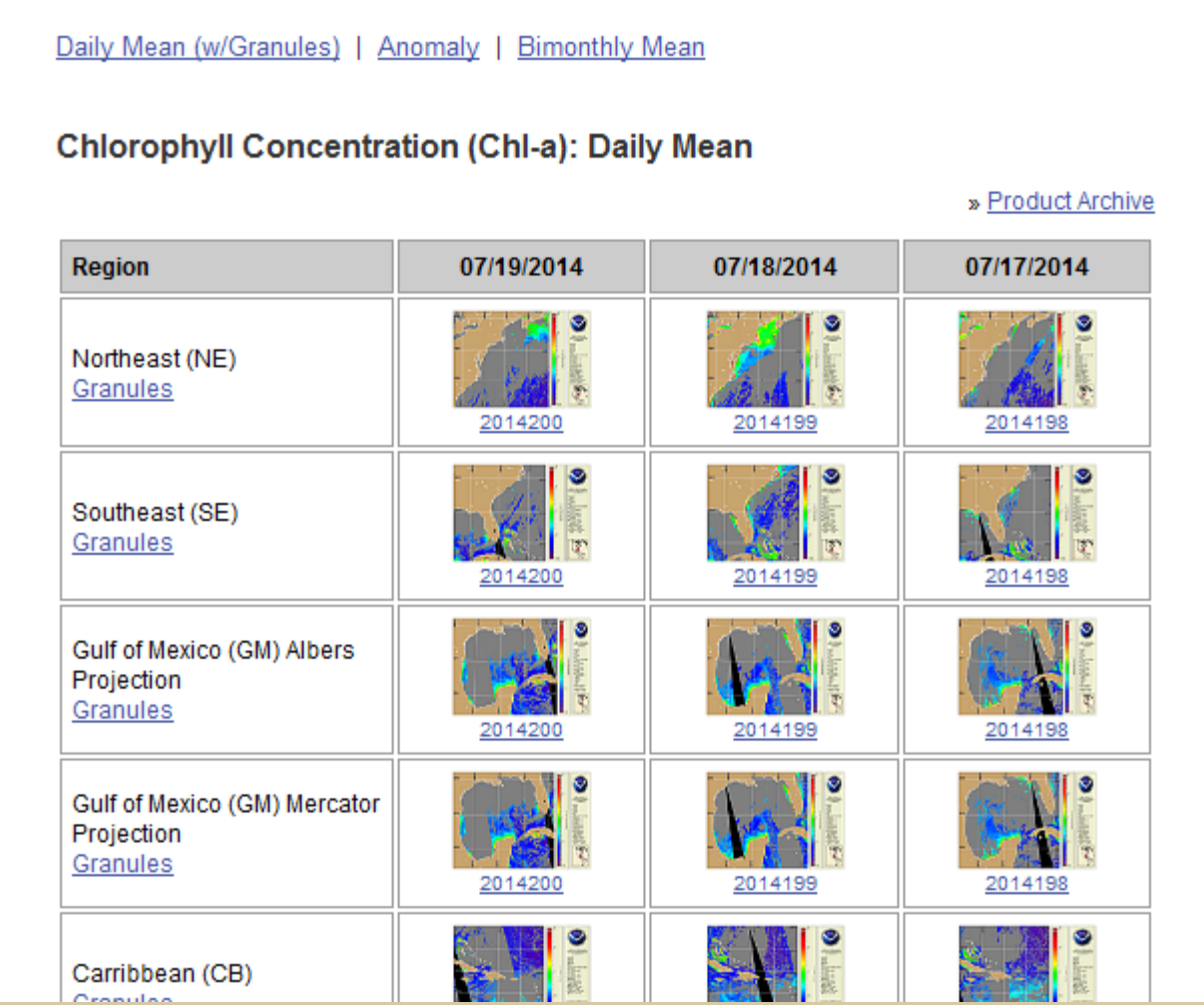
MODIS / Aqua NASA L2gen NIR
- Chlorophyll Concentration
- Remote Sensing Reflectance

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

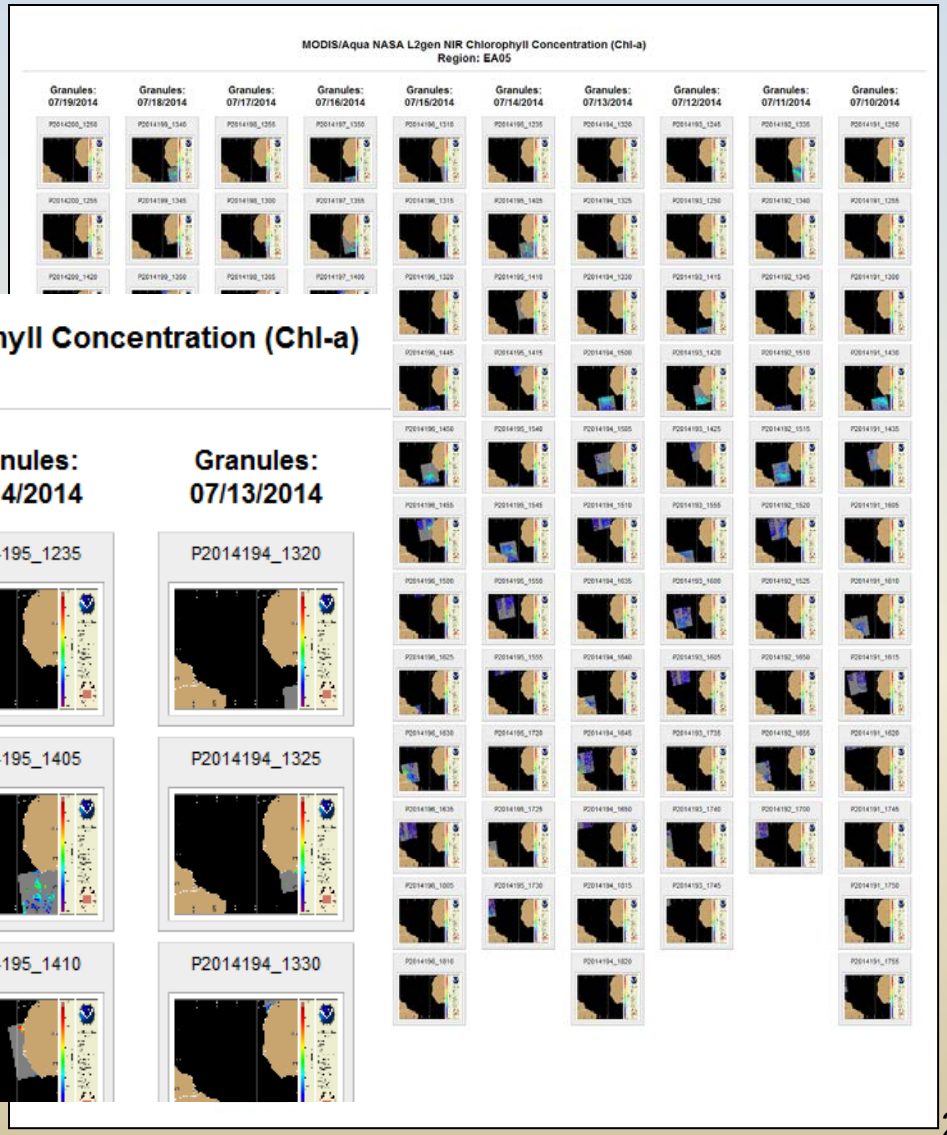
MODIS / Aqua Chlorophyll Fronts
- Magnitude | - Direction

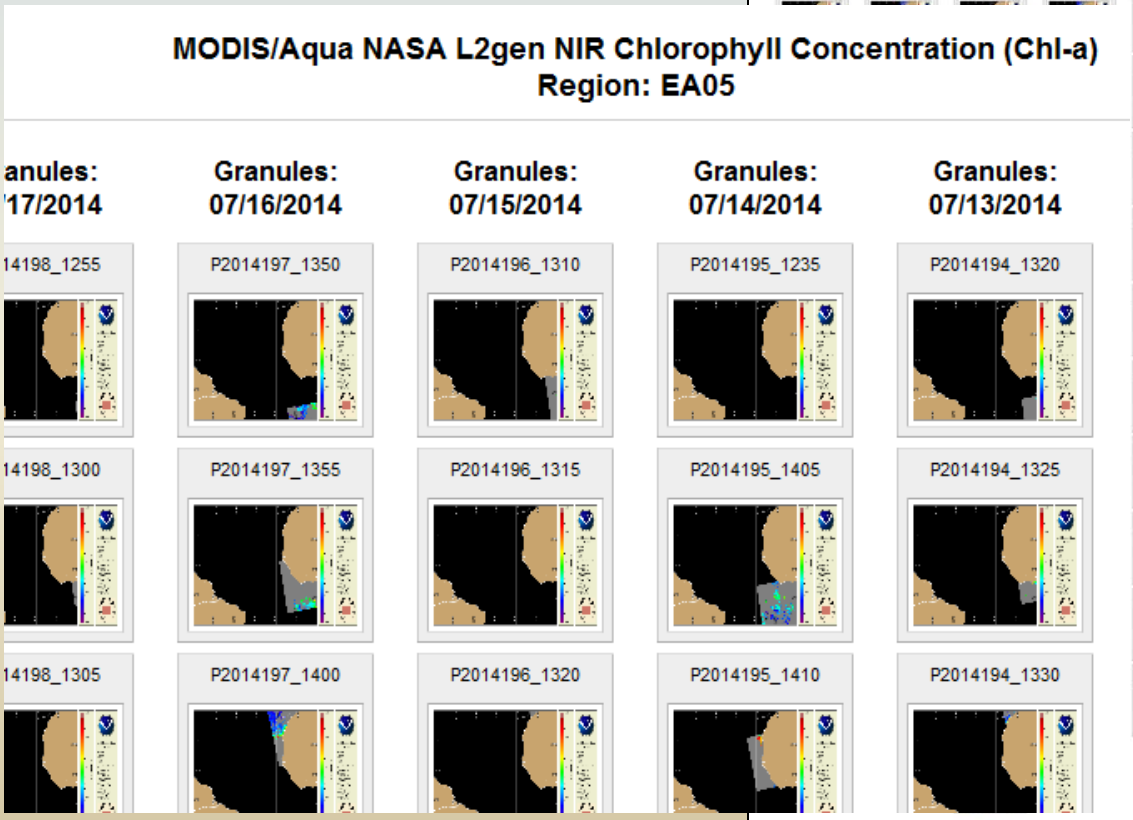
MODIS / Aqua Ehux Bloom *(Retired)*
(No granules shown)
- (Also) 8-Day Composite
- Composite Calcite Concentration



Example 2: Archived OC Products (Granules)

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





Okeanos QA Tool: Okeanos OC Products Statistics Monitoring

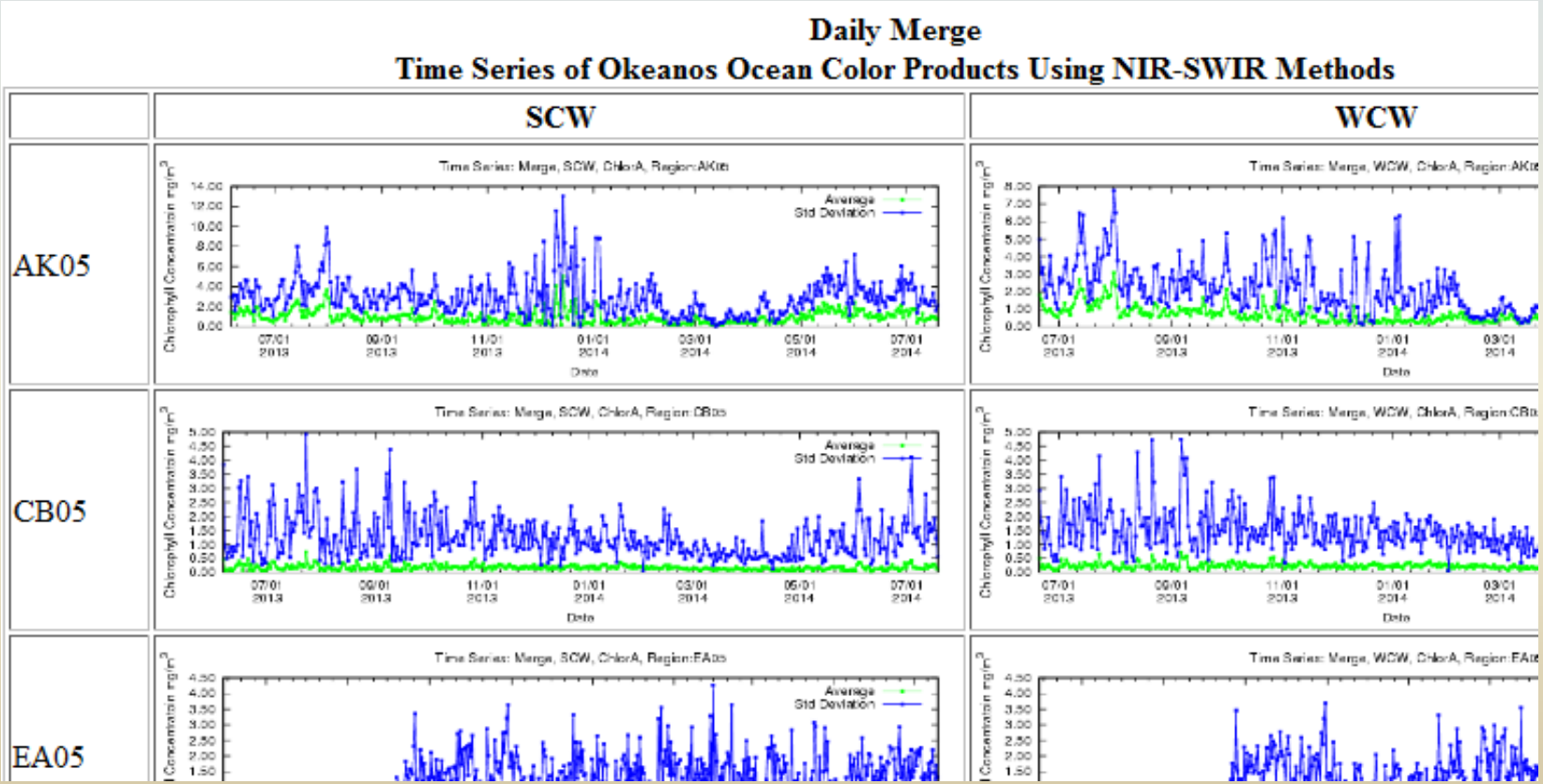
- **Histogram of Ocean Color Products**
  - MODIS/Aqua Chlorophyll-a
  - MODIS/Aqua Remote Sensing Reflectance
- **Time Series of Ocean Color Products**
  - MODIS/Aqua Chlorophyll-a
  - MODIS/Aqua Remote Sensing Reflectance
- **Monitoring of Ocean Color Products Anomaly**
  - Chlorophyll-a Characteristics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

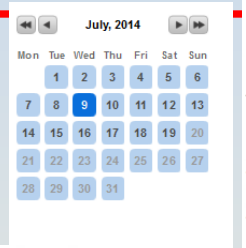
- All CW regions
- NIR and NIR-SWIR Methods
- Daily and Bi-Monthly Chl and Rrs Products

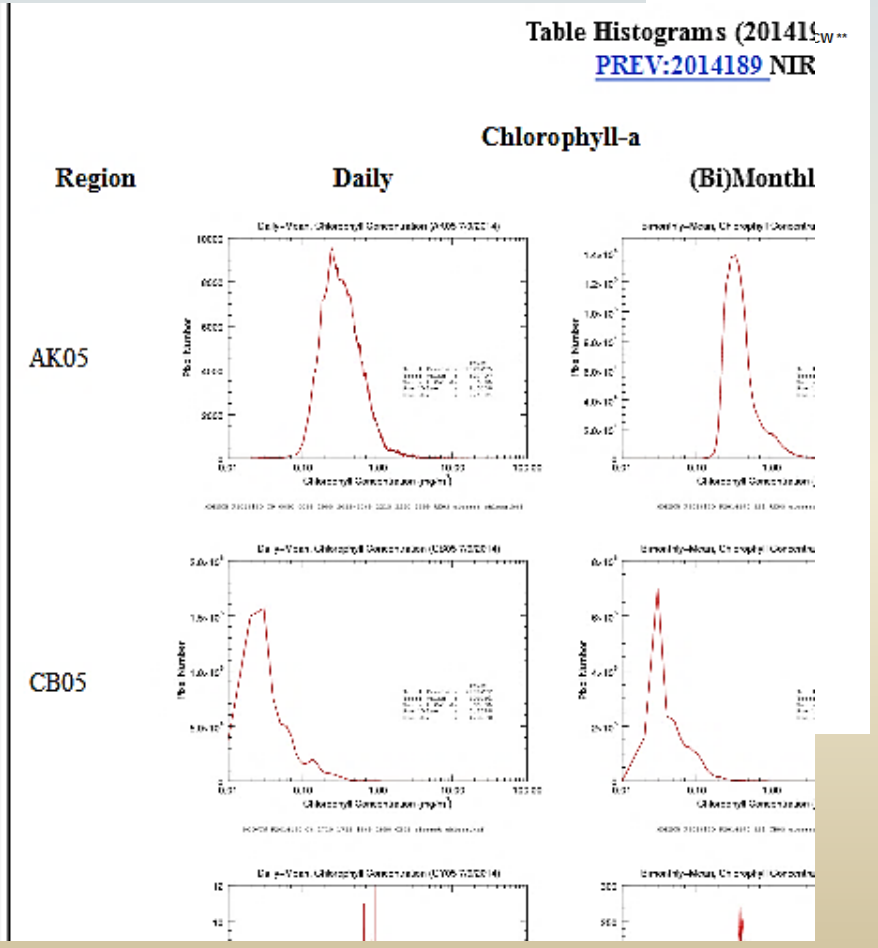


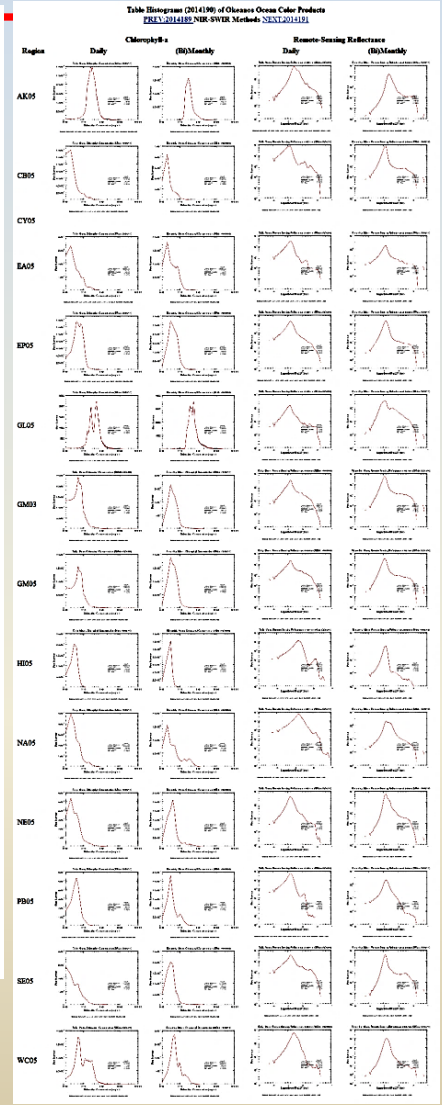
OC Product Statistics-Histogram Table

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

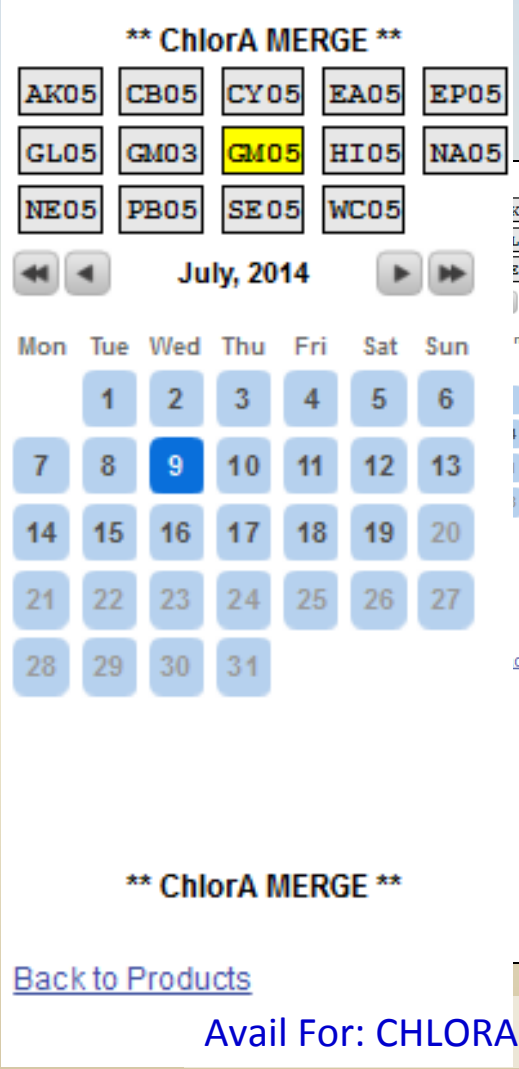
(Chl and Rrs667, bimonthly & daily merges NIR and NIR-SWIR Products)



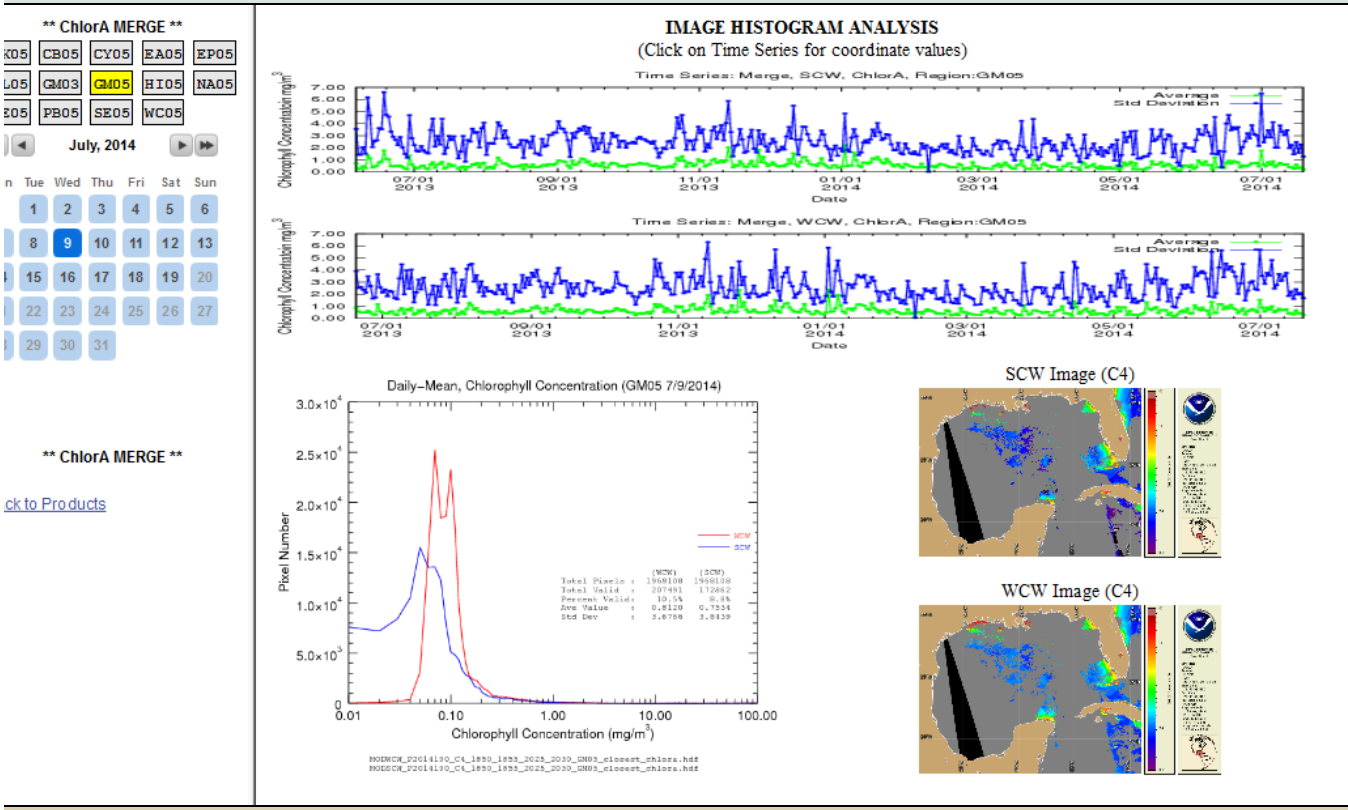




Okeanos OC Products Statistics Monitoring: Product Anomaly?

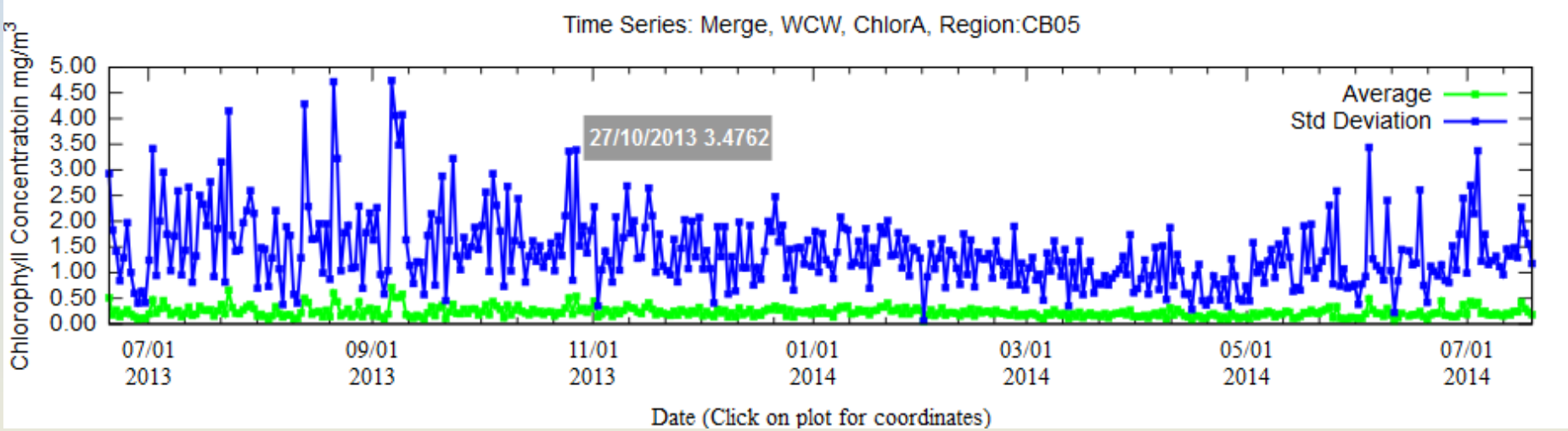


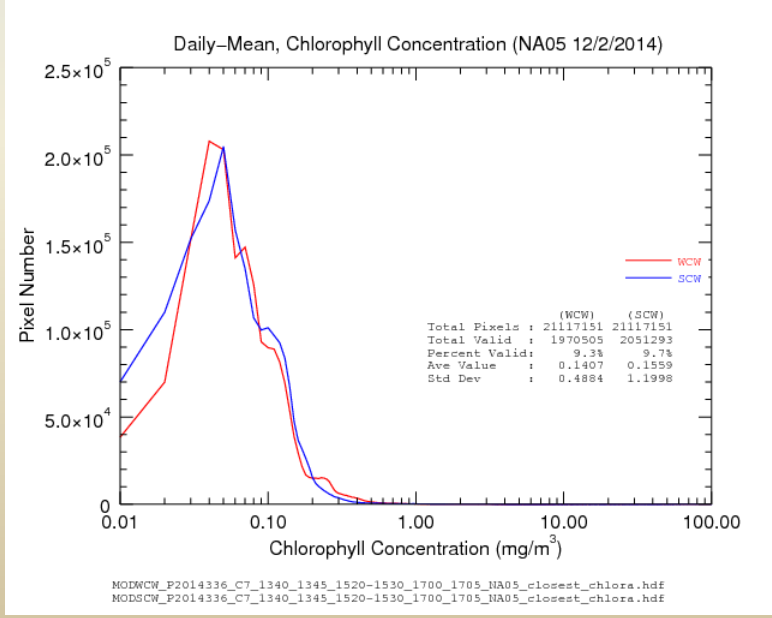
Monitor suspicious product anomaly? **Interactive Date and Region shows Time Series, Histogram and Images for selected options.**



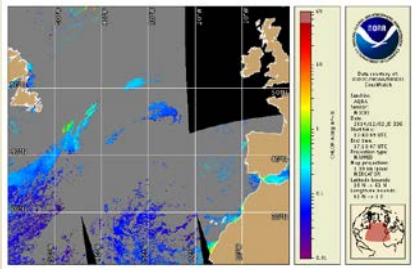
Avail For: CHLORA MERGE, CHLORA BIMONTH, Rrs667 MERGE, Rrs667 BIMONTH

Example Image for Time Series and Histogram

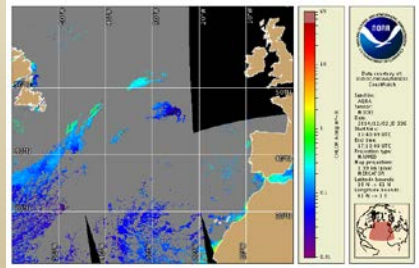




SCW Image (C7)

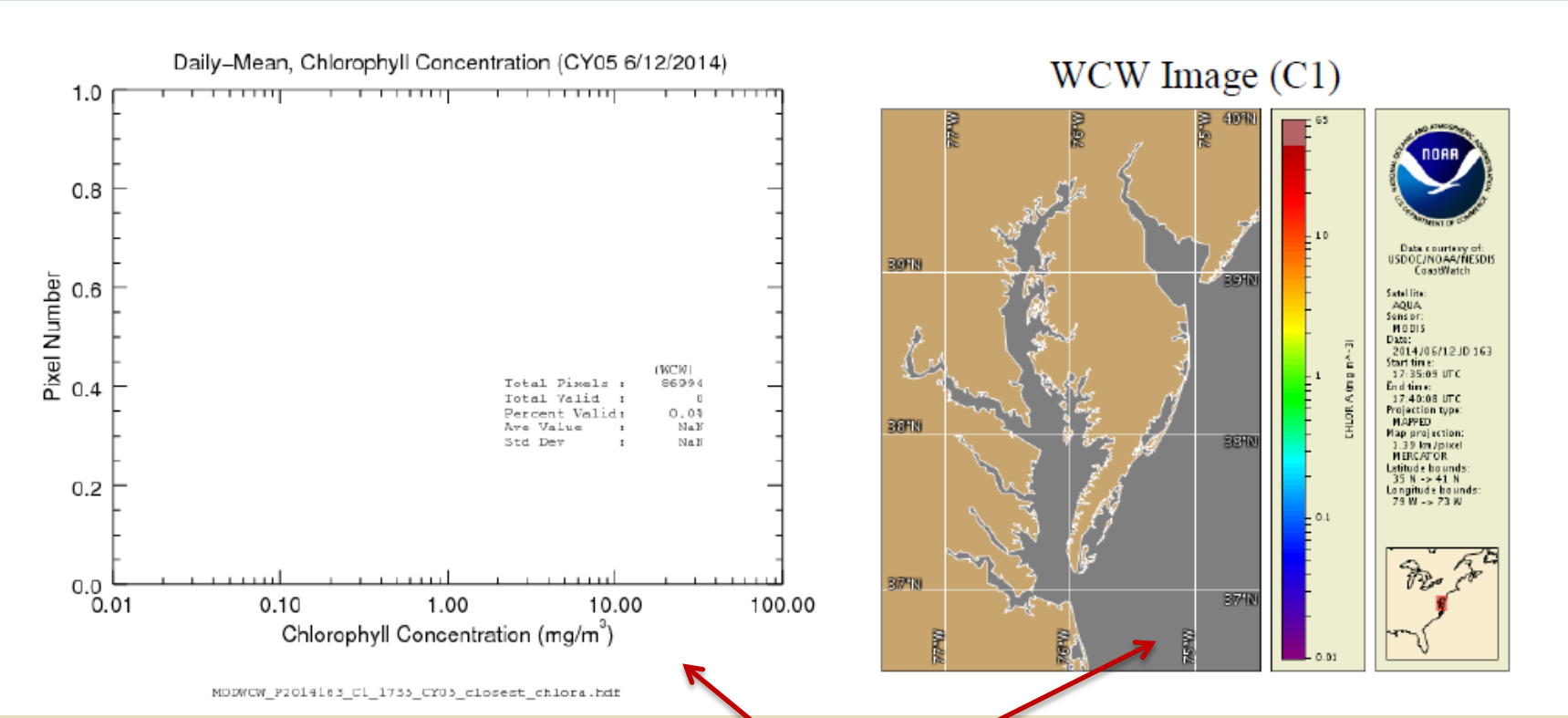


WCW Image (C7)



Okeanos OC Products Suspicious Features Detection: Example 1

Identify Chlorophyll Products with Zero or Low Valid Pixels

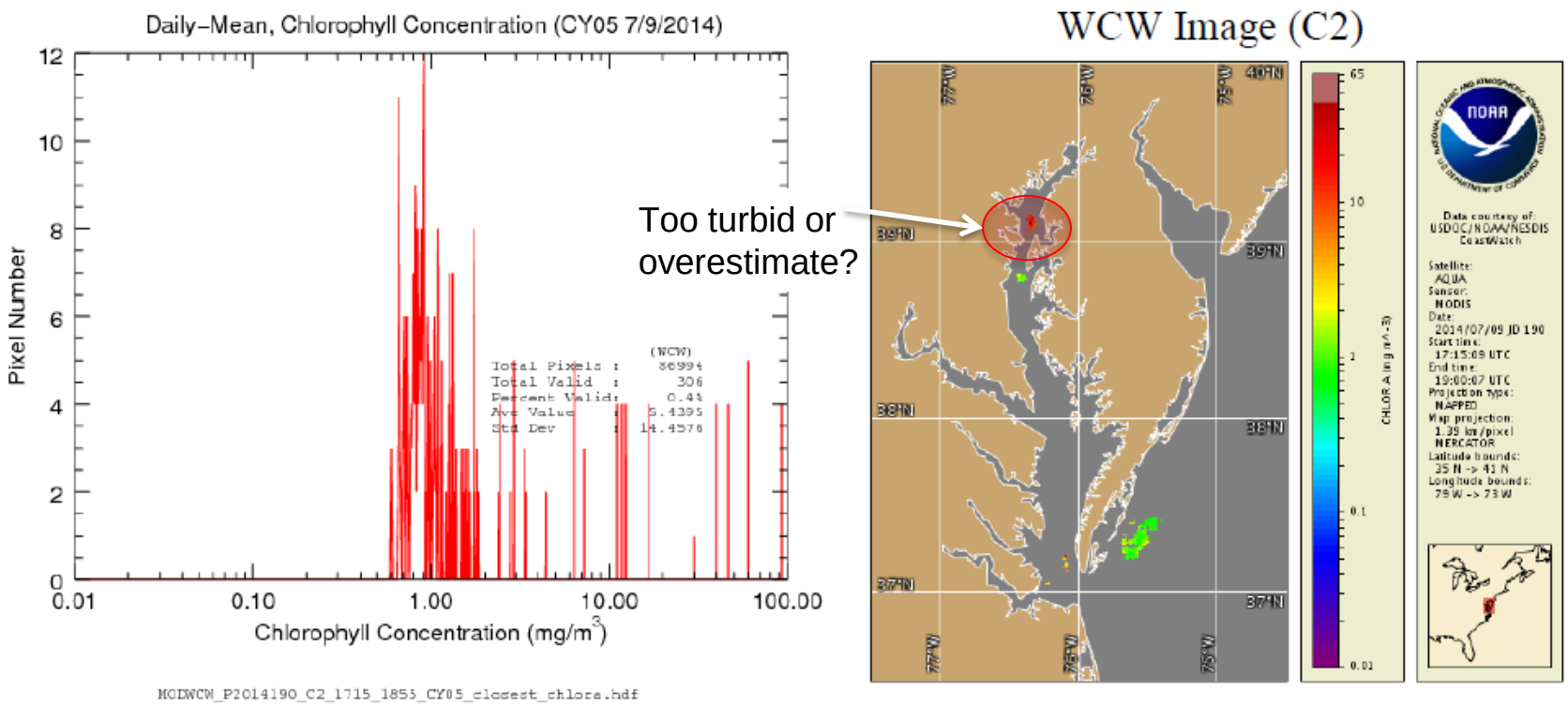


No valid pixels!

- **Detection Criteria:**
  - Valid pixel (Vpixel): 0.001 < [chl] < 100 mg/m^3
  - Vpixel # < 1000.0

Okeanos OC Products Suspicious Features Detection: Example 2

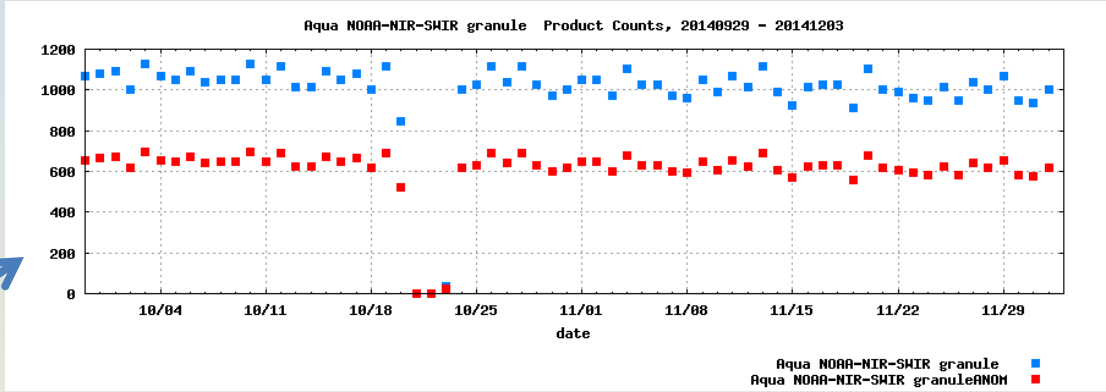
Identify Extremely Turbid Ocean or Anomalous Ocean Color Products?

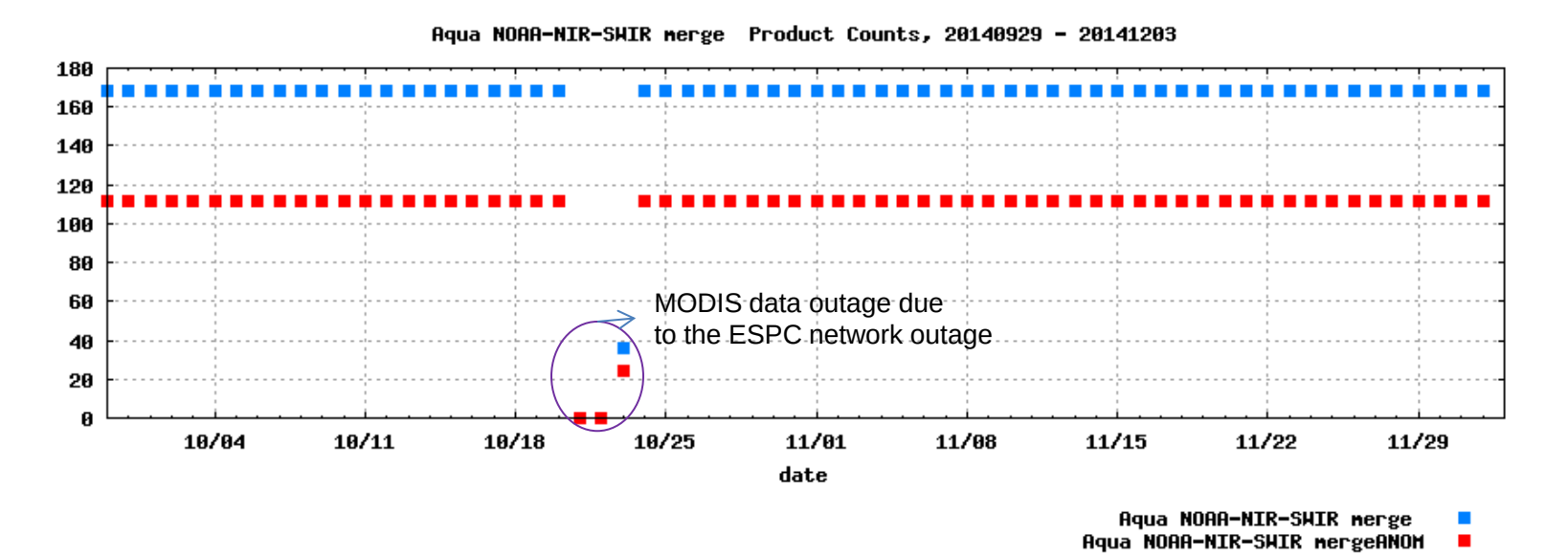


- Detect Criteria for extremely turbid ocean or anomalous ocean color products:
  - –Non-CY regions: mean > 0.2 and σ (standard deviation) > 8.0*mean
  - –CY region: σ > 2.0*mean

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





Refer to http://www.ospo.noaa.gov/Products/ocean/color/count_plots.html

Upcoming Activities

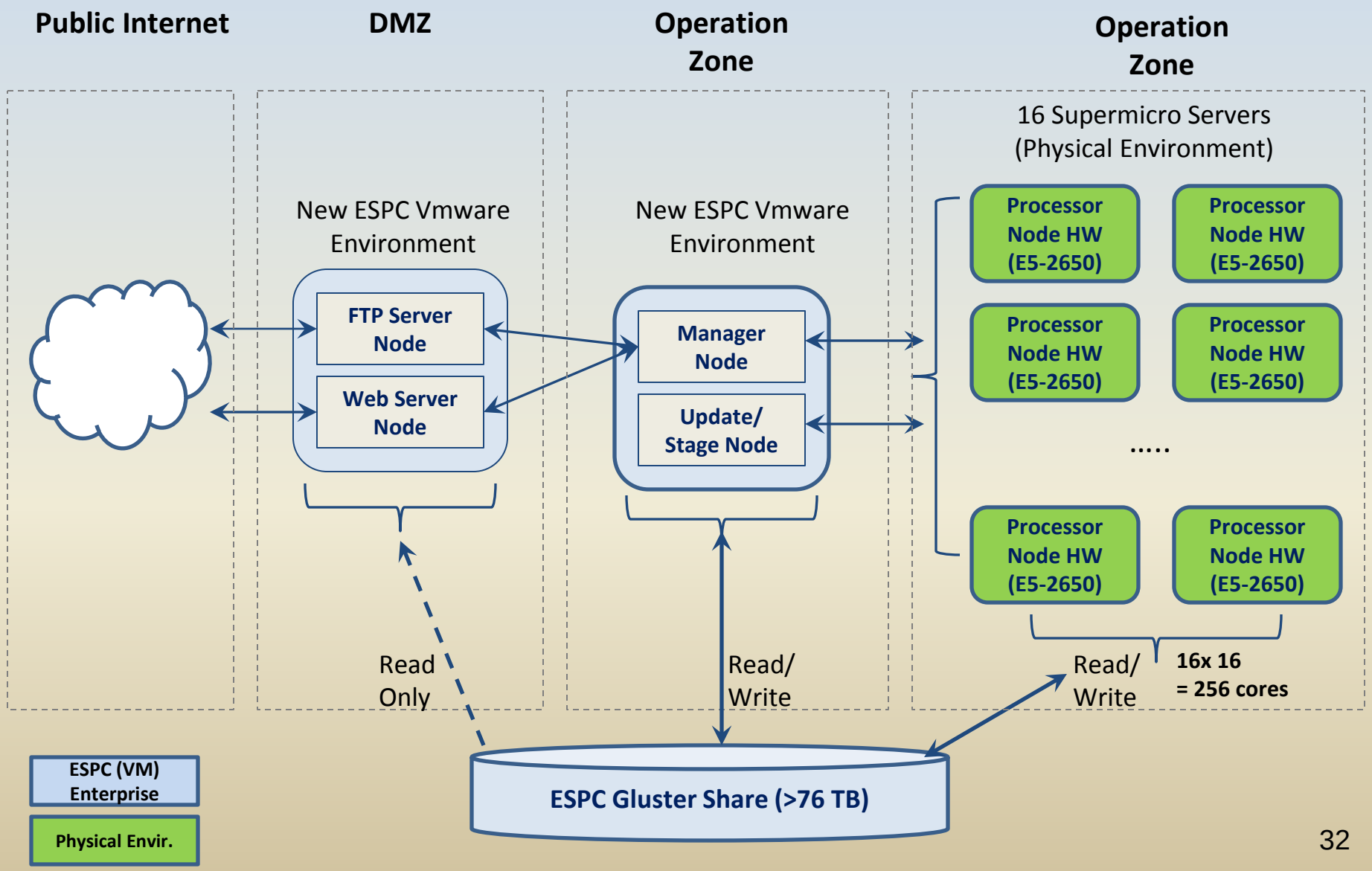
- Develop new-generation Okeanos ocean color Parallel Test System in support to SNPP VIIRS ocean color product processing and dissemination: Target May 2015

- Develop new-generation Okeanos ocean color production system in support to SNPP VIIRS ocean color product processing and dissemination: Target 2016

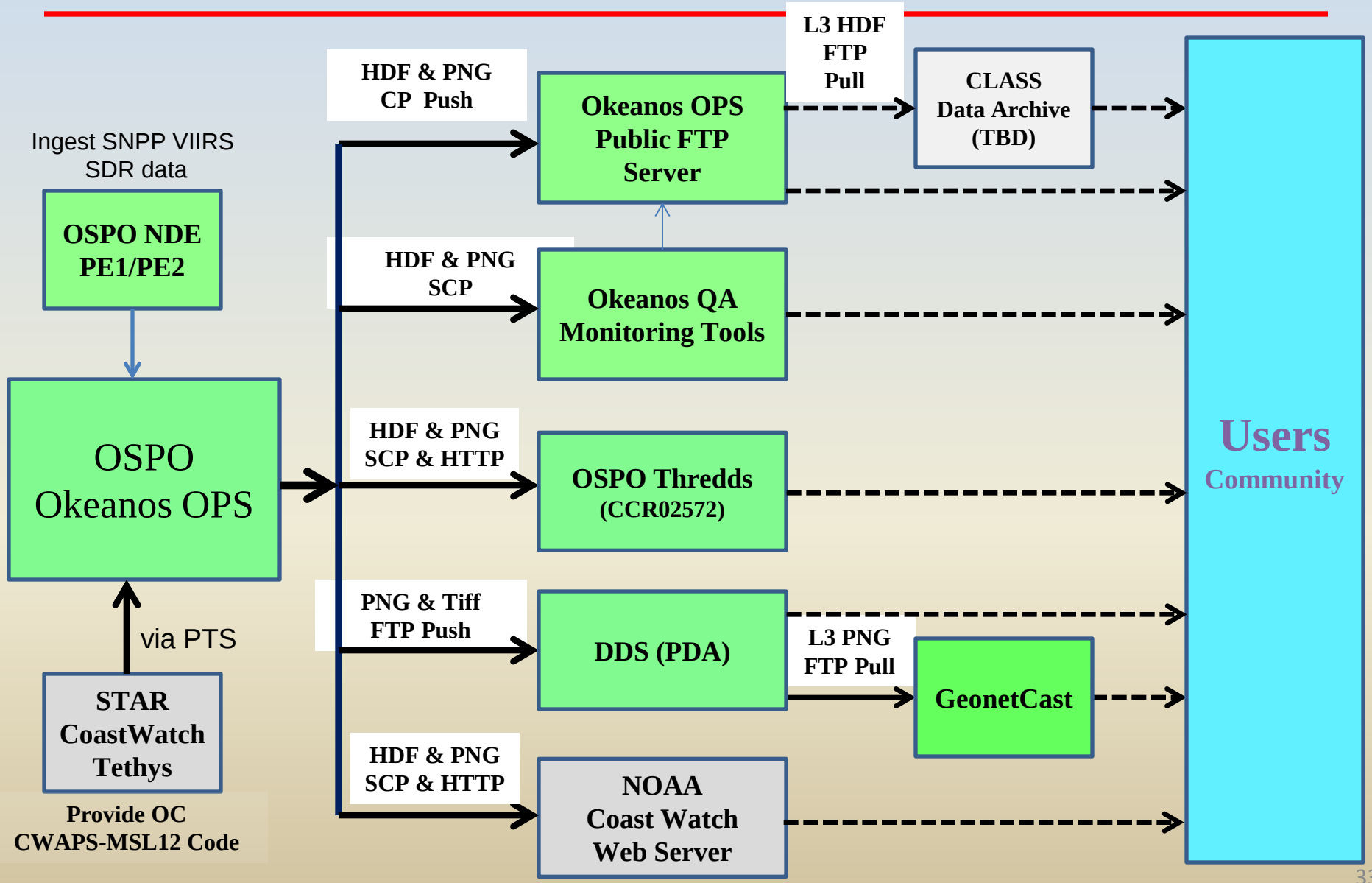
- Deliver SNPP VIIRS ocean color NOAA pre-operational products to user community: Target summer 2015

- 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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