CoastWatch/OceanWatch: Background, OceanWatch Evolution, Ocean Color Use and User Readiness

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NOAA/NESDIS CoastWatch

June 18, 2013
JPSS Proving Ground Science Seminar

Background and Mission

BACKGROUND: CoastWatch began in 1987 by providing near real-time SST for the Mid-Atlantic following several outbreaks of Harmful Algal Bloom (Red Tide) along the coast of North Carolina.
CoastWatch has evolved from providing high resolution data from the NOAA's Polar Orbiter satellites to providing data from multiple satellites from different government organizations. Regular funding (research) was established for CoastWatch in 1990 under the Coastal Ocean Program. NOAA CoastWatch became operational in 1991. Efforts are ongoing to expand CoastWatch into OceanWatch.

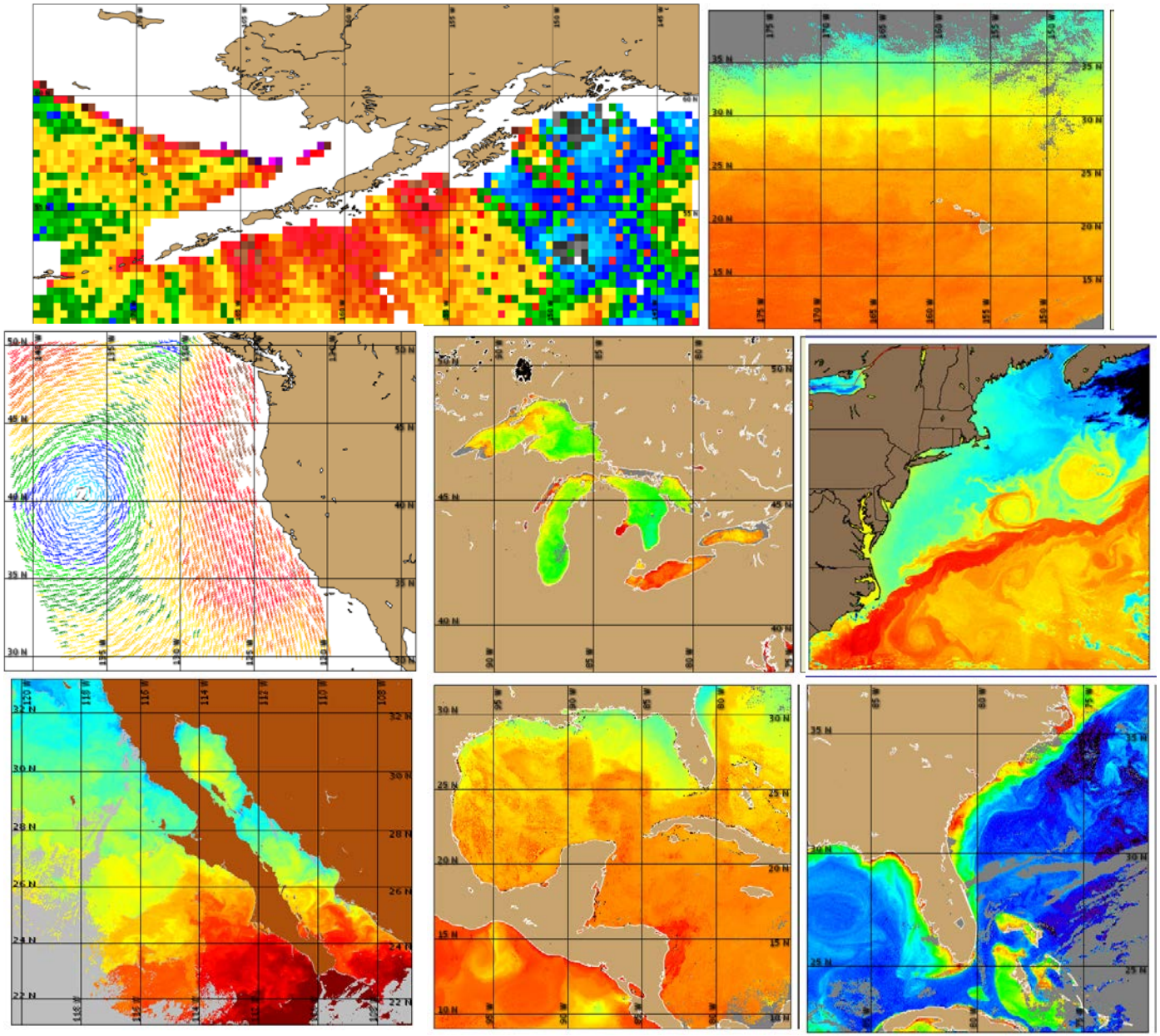
MISSION STATEMENT: to provide and ensure timely access to near real-time satellite data to protect, restore, and manage U.S. coastal ocean resources, and understand climate variability and change to further enhance society's quality of life. Our primary users include Federal, State, and local marine scientists, coastal resource managers, and the general public.

Overview

1. ***Satellite ocean remote sensing products:***
   - **Ocean Color: OrbImage/ SeaWiFs, Aqua and Terra/ MODIS.**
   - **Sea Surface Temperature: POES/ AVHRR and GOES/ Imager, Aqua and Terra/ MODIS.**
   - **Ocean Surface Winds: DMSP SSM/I and QuikSCAT SeaWinds.**
2. ***National distribution:*** **Six regional nodes**
3. ***Line Office Partners:***
   - **NOS, NMFS, OAR, NWS**
4. ***National Center Partners:***
   - **Coastal Services Center/Charleston, National Centers for Coastal Ocean Science/NOS, and National Centers for Environmental Prediction/NWS**

CoastWatch Regional Nodes

Ocean Remote-Sensing Products



<u>Ocean Color:</u> Aqua/ MODIS

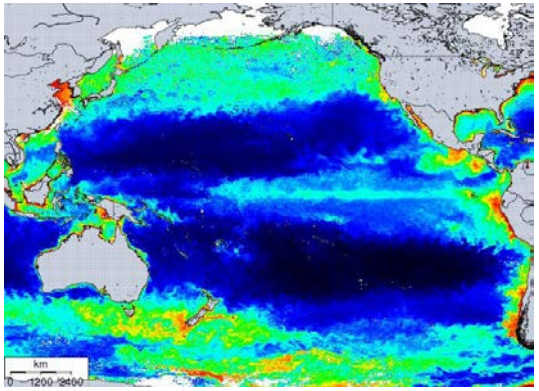
<u>SST:</u> POES/ AVHRR and GOES/ Imager

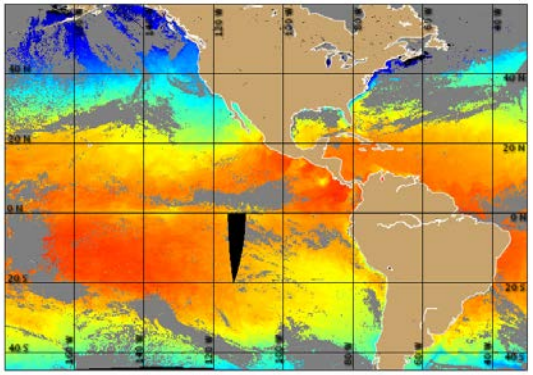
<u>Ocean Surface Winds:</u> DMSP SSM/I and SAR Winds

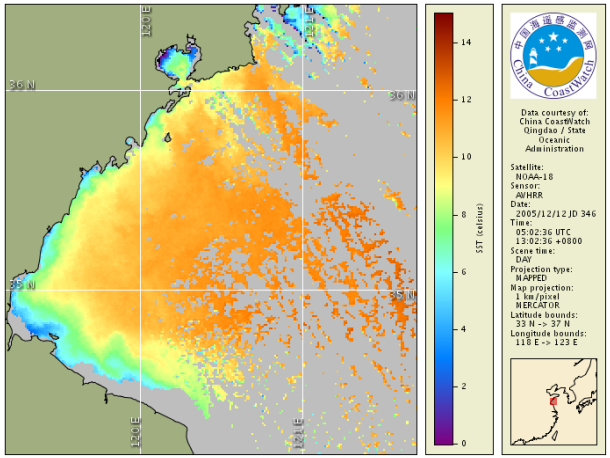
Evolution of OceanWatch

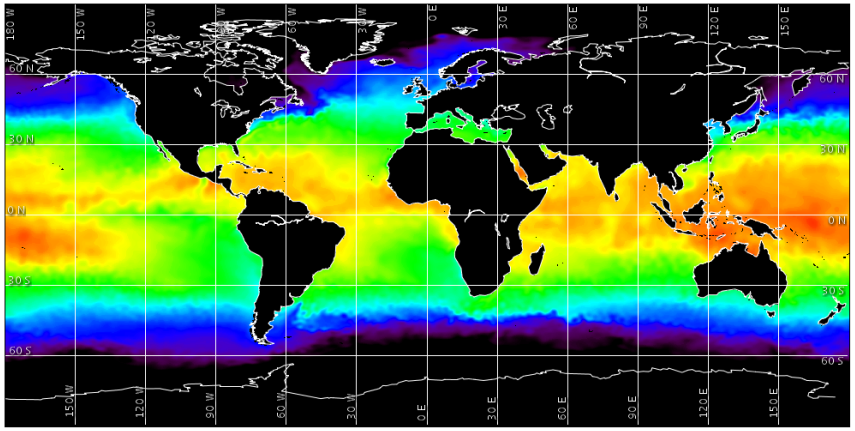
CoastWatch into OceanWatch:

1. Global, science / climate quality, retain active regional support.
2. Pacific Center (NMFS / Honolulu), Atlantic Center (AOML/Miami), National Center (NCWCP/College Park) .
3. DoC supported for 2003 BY w/o funding.









CoastWatch VIIRS Ocean Color Proving Ground

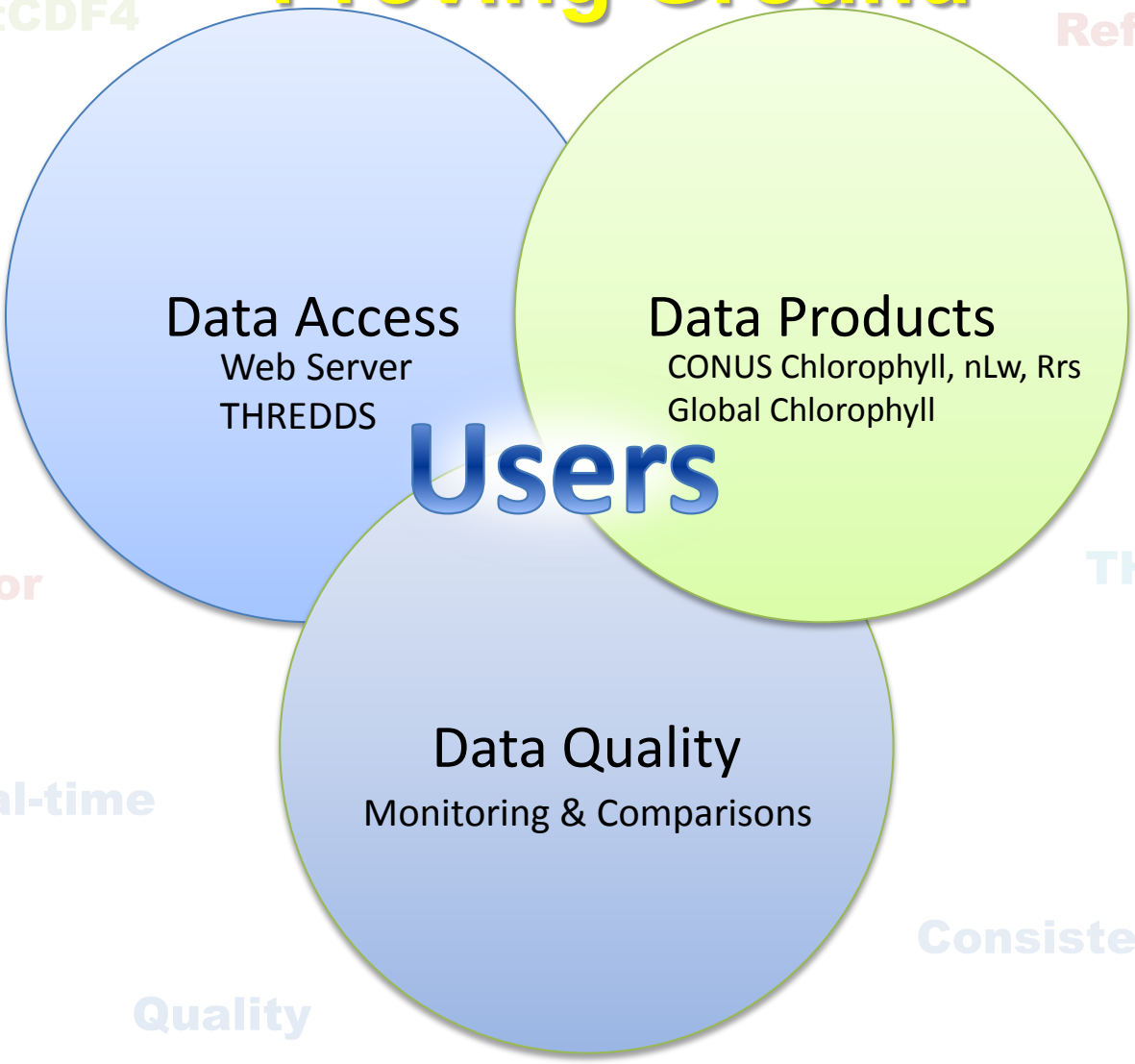
NetCDF4

Reflectance

Protocols

Chlorophyll

GeoTIFF



True Color

THREDDS

HTTP

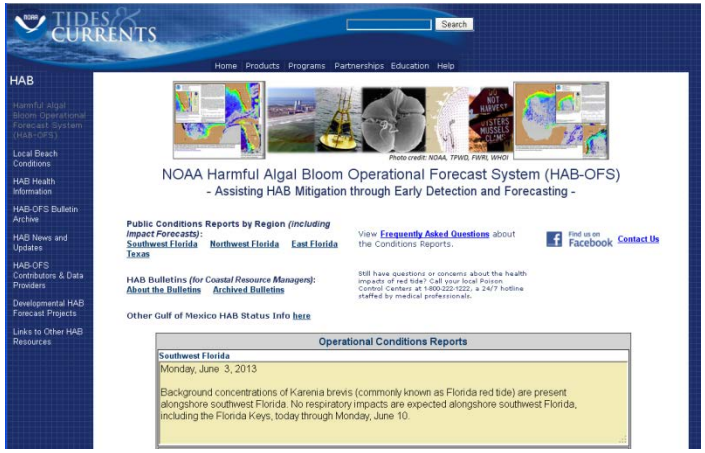
Near real-time

Consistency

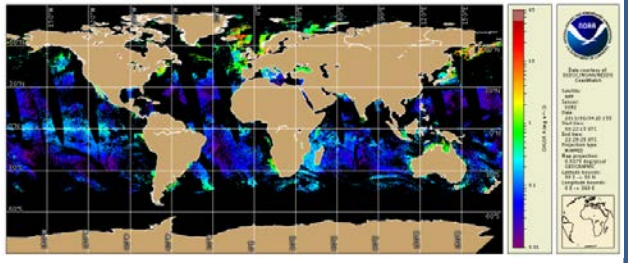
Quality

VIIRS OCEAN COLOR USE

Operational HAB Forecasts

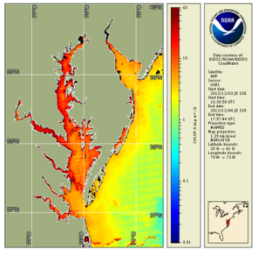


NCEP EMC Modeling



Ecological Forecast Modeling

VIIRS satellite chlorophyll → Georeferenced grid → Ecosystem model grid



S-NPP VIIRS chlorophyll
CoastWatch 2-day avg (Dec 3-4, 2012)
Raster data: UTM coordinates

Chesapeake Bay Program
Georeferenced polygonal grid
8,282 polygons

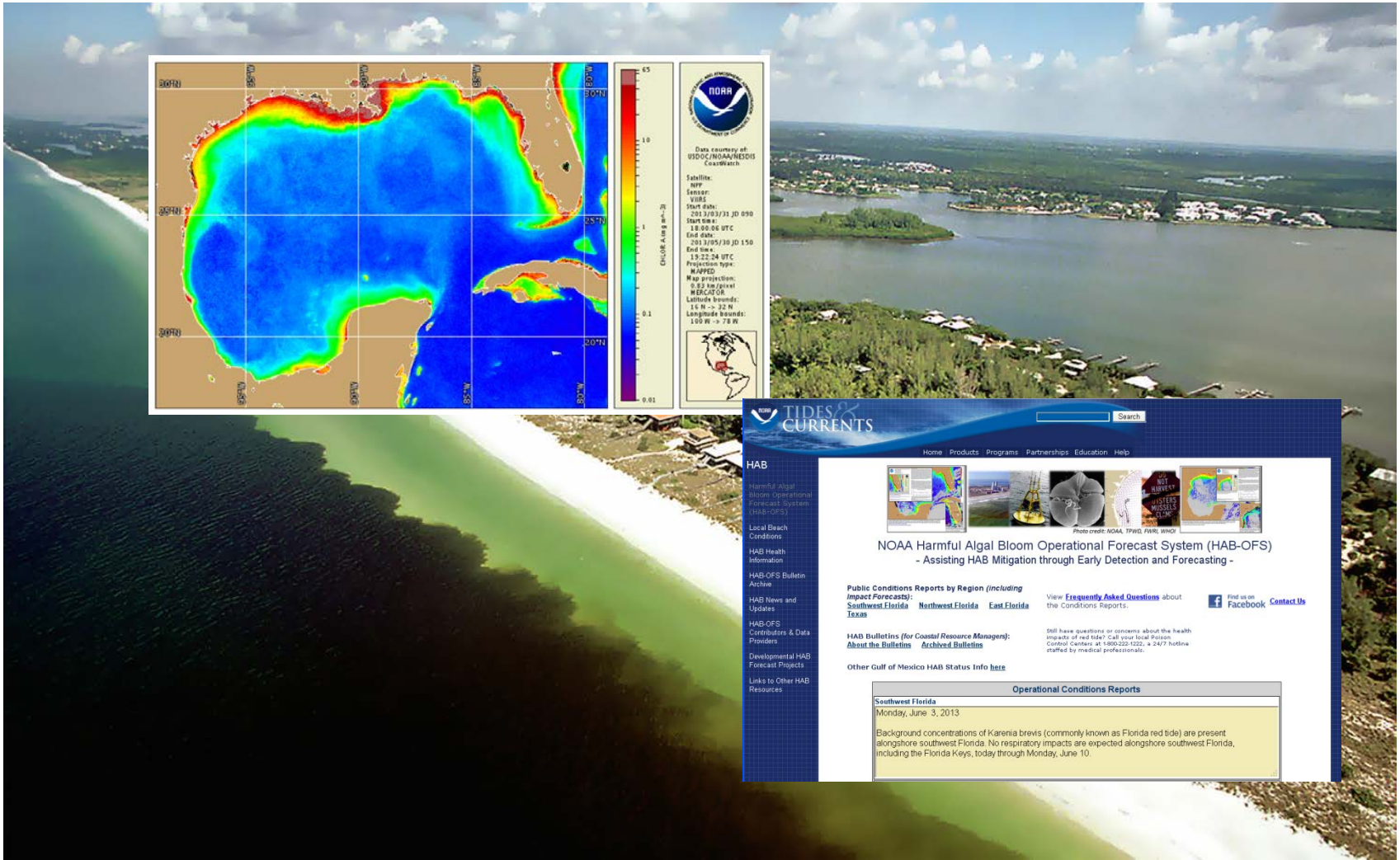
NOAA/NMFS/NCBO
Atlantis Ecosystem Model
97 polygons
Aggregated from 8,282

Commercial

VIIRS Operational Ocean Color User: NOS & NWS/OPC

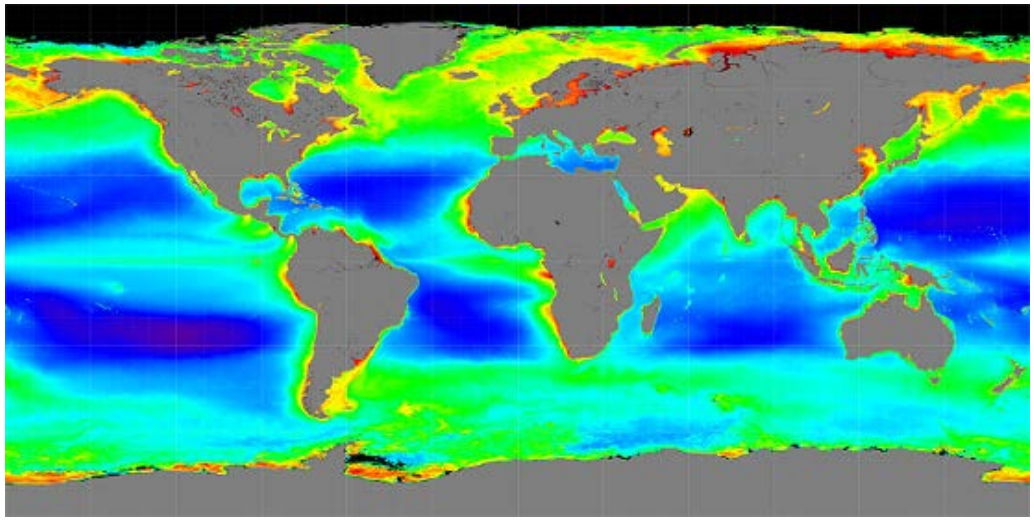
Harmful Algal Bloom Monitoring and Forecasting

NOS issues twice-weekly HAB Bulletins



VIIRS Operational Ocean Color User: NWS/EMC

- Phytoplankton alter the penetration of solar radiation in the upper layers of the ocean, affecting:
  - vertical distribution of heat
  - near surface heat content
  - surface heat flux
- Current NCEP ocean models use a very limited climatology of SeaWiFS chlorophyll (1998-2001)



Chlorophyll Global Distribution (SeaWiFS, NASA)

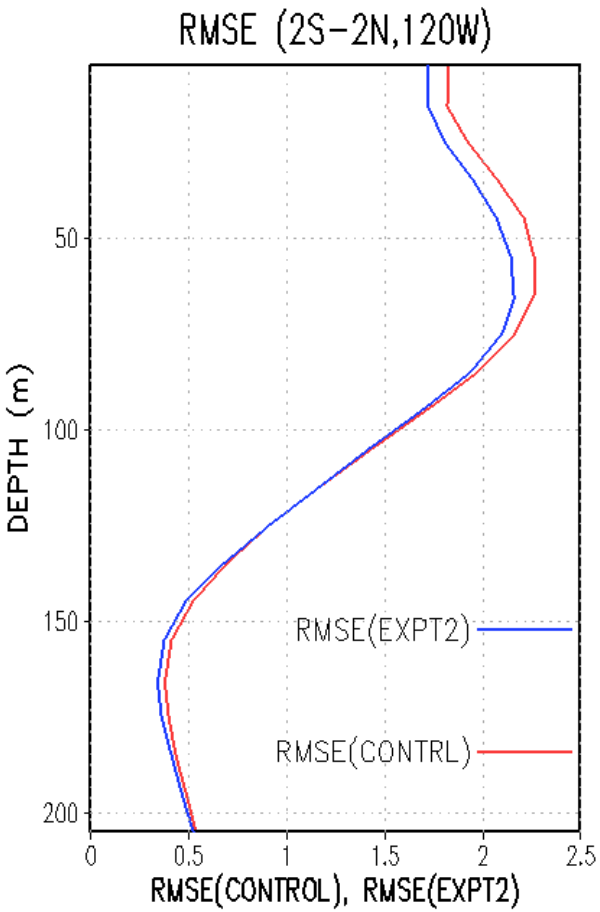
- Operational near real-time use of VIIRS chlorophyll will properly represent temporal change of upper ocean heat distribution
- Improvements to:
  - Ocean forecasts:

    Real-time Ocean Forecast System (RTOFS)
  - Coupled ocean-atmosphere forecasts:

    Global Ocean Data Assimilation System / Coupled Forecast System (GODAS / CFS)

NWS/EMC Results: GODAS/CFS Improvement
(MOM4 Ocean Model, currently with SeaWiFS climatology)

Near-surface ocean temperature error reduction of ~10% (~0.2 C)
(Equatorial Pacific "Cold Tongue" 2S – 2N)

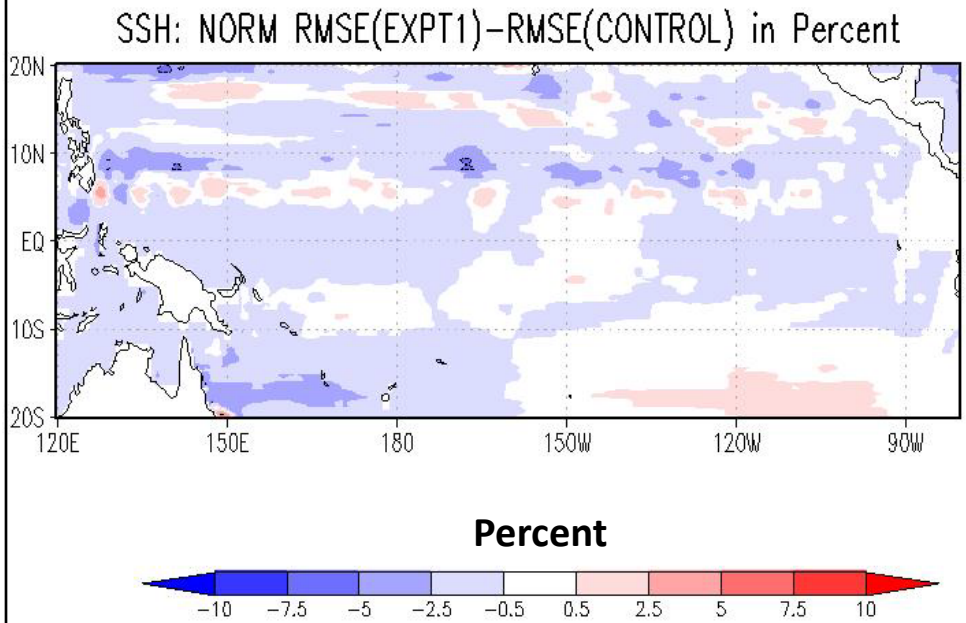


Expt2 = SeaWiFS monthly chl 1998- 2010

Control = SeaWiFS chl climatology (1998-2001)

Reference = CFS Reanalysis

Sea Surface Height percent error reduction of ~5-10%
(Equatorial Pacific Basin 20S – 20N)



Expt1 = SeaWiFS chl climatology (1998- 2010)
Control = SeaWiFS chl climatology (1998-2001)
Reference = CFS Reanalysis

Source: E. Bayler, S. Nadiga, A. Mehra, D. Behringer

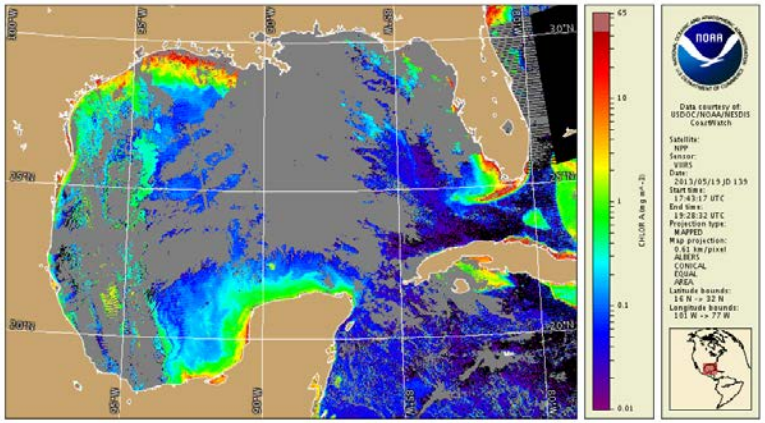
CoastWatch NPP/VIIRS User Engagement: User Interviews and Outcomes

Line Office	Sub-Element	Program Area/Products	Interviewees and Date(s)	Outcome
National Ocean Service (NOS)	NCCOS	Imagery support for operational product: Harmful Algal Bloom Forecasts and Warnings	Stumpf and Tomlinson February 26, 2013	1. Major concern re masking of West Florida shelf area during major HAB. L2gen renders area satisfactorily. 2. Do not shut down MODIS until end of life, but VIIRS should be ready. 3. Parallel operations: MODIS and VIIRS 4. Require at least one back up platform 5. Continue independent quality assessment. 6. Desire regeneration of HAB products using NASA science quality data. 7. Lack of inland waters (lakes) makes IDPS product unacceptable.
National Weather Service (NWS)	EMC and OPC	Incorporation of near realtime chl a into regional and global models. Input of chl into AWIPS to support Ecological Forecast System	Avichal Mehra and Dave Behringer. Anthony Siebers	1. Lack of Great Lakes data makes IDPS product unacceptable. 2. Consistency AND quality are important. In that order. 3. Difference between science quality (NASA) and NOAA of 10% is acceptable. Parallel operations with science quality is important. 4. Consistent delivery of data, i.e., from constellations is important.
National Marine Fisheries Service (NMFS)	Honolulu Laboratory / Pacific Island Fisheries Science Center	Basin scale resource management on decadal / interdecadal timescales and cruise support – Pacific Basin	Polovina and Moxey March 21, 2013	1. Require NRT high resolution for cruise support as well as long time period basin scale for resource management. 2. Desire data from various missions “stitched” together. 3. Historically relied on OBPG but would use NOAA data if quality were assessed, sustained and conveniently delivered.

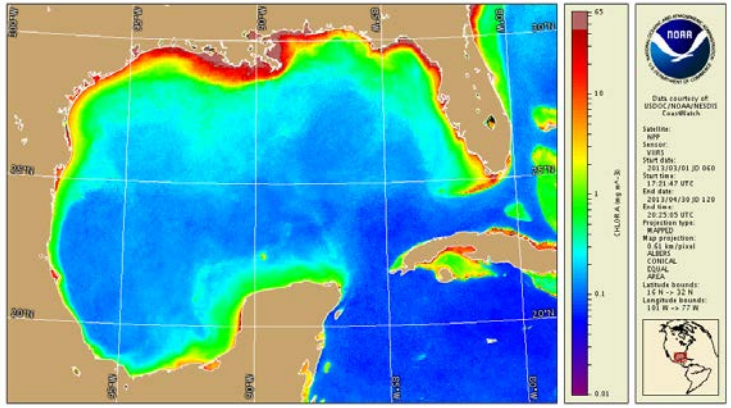
CoastWatch Data Processing (STAR/Tethys) to support users' requirements

- VIIRS OC Processing from IDPS EDR
  - EDR swath mapped to CONUS Regions and Full-Resolution Global 'Sectors'
  - Reformat as CW-HDF
- Separate processing instances for Global and CONUS
  - Global (to support NWS/EMC)
    - Chlorophyll only
    - Globe is divided into 24 sectors at full resolution (750m)
    - Sector daily composites are assembled into a 4 km global product
  - CONUS (to support NOS & NWS/OPC)
    - Chlorophyll
    - Normalized Water-Leaving Radiance, nLw (QA, NOS evaluation)
    - Suspended Matter Reflectance, Rrs_672 (resuspended chl correction to HAB)
    - Regions processed are Hawaii (HI05), Gulf of Mexico (GM03 and GM05), Northeast (NE05), Great Lakes (GL05), Caribbean (CB05), Southeast (SE05) and West Coast (WC05)
    - Mapped granules, daily composite, 61-day median composite, and HAB anomaly products.

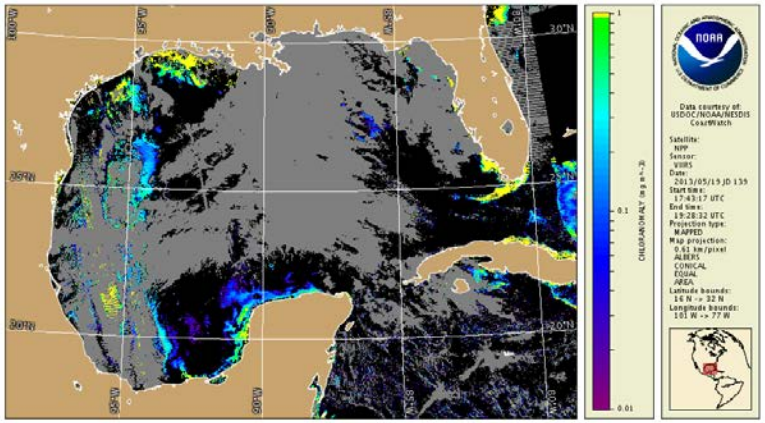
Gulf of Mexico HAB Products for NOS



Daily Image



61-Day Baseline

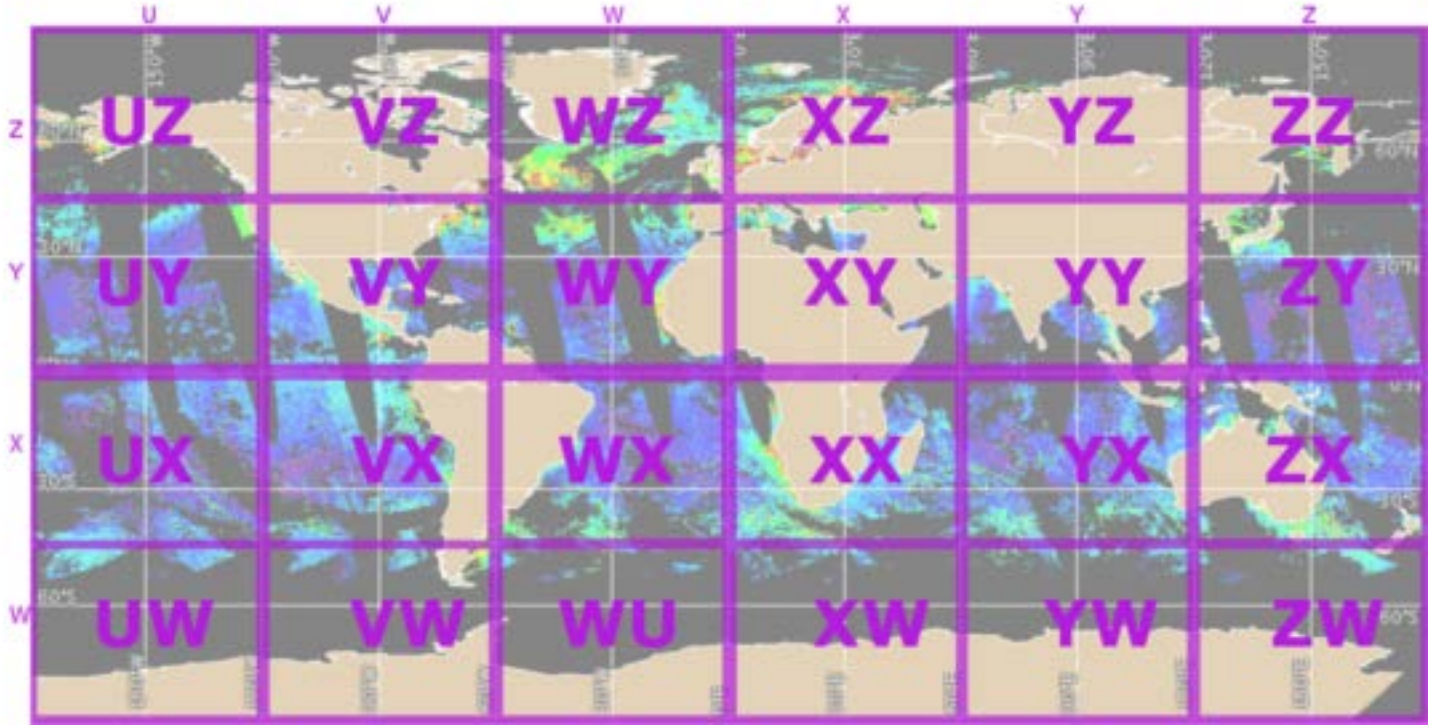


Anomaly

All CONUS regions are being generated to support **NWS / OPC** operational HAB detection and forecasting

Full-Resolution (750m) Global Sectors

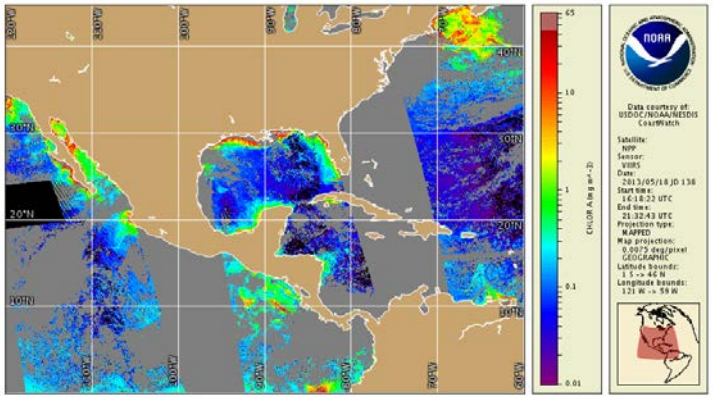
first time full-res global ocean color available to the user community



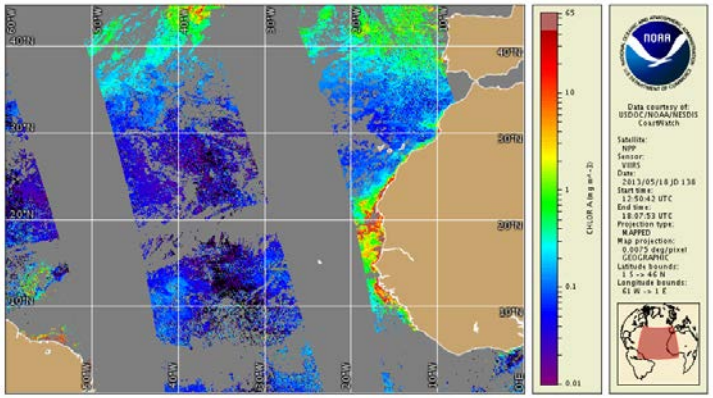
U – Z in longitude
W – Z in latitude
WU is used instead of WW

750m Sectors: Daily Composite

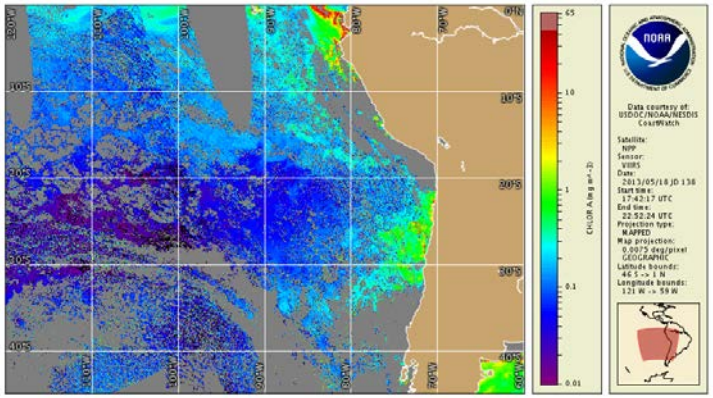
chlorophyll



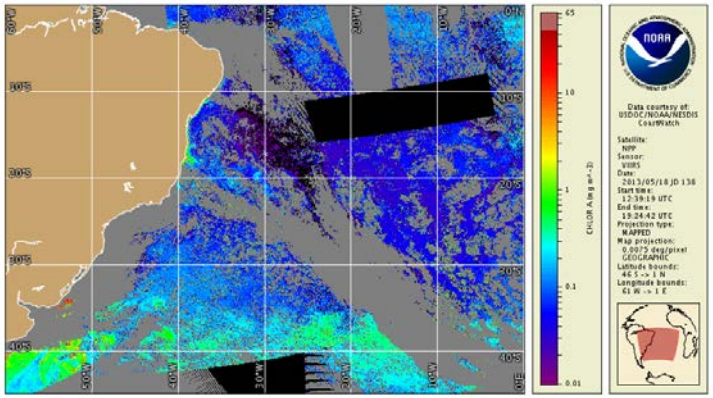
VY



WY

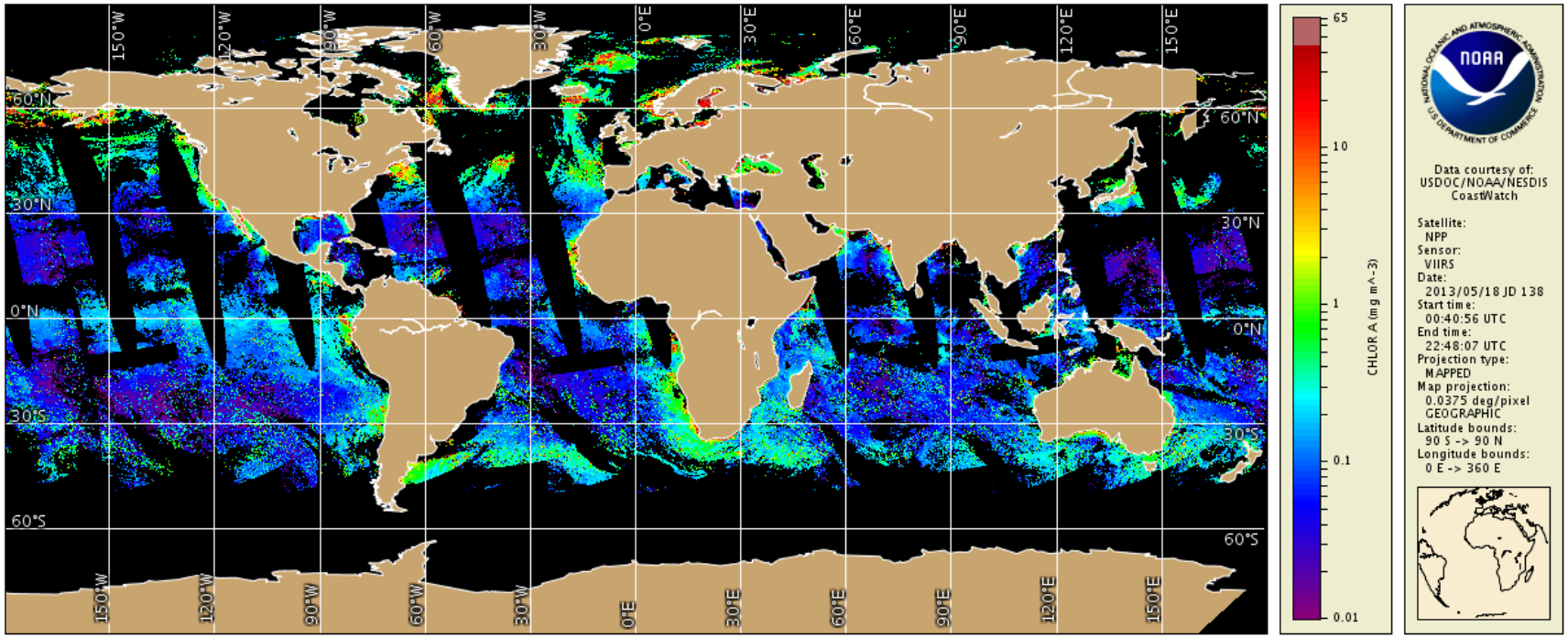


VX



WX

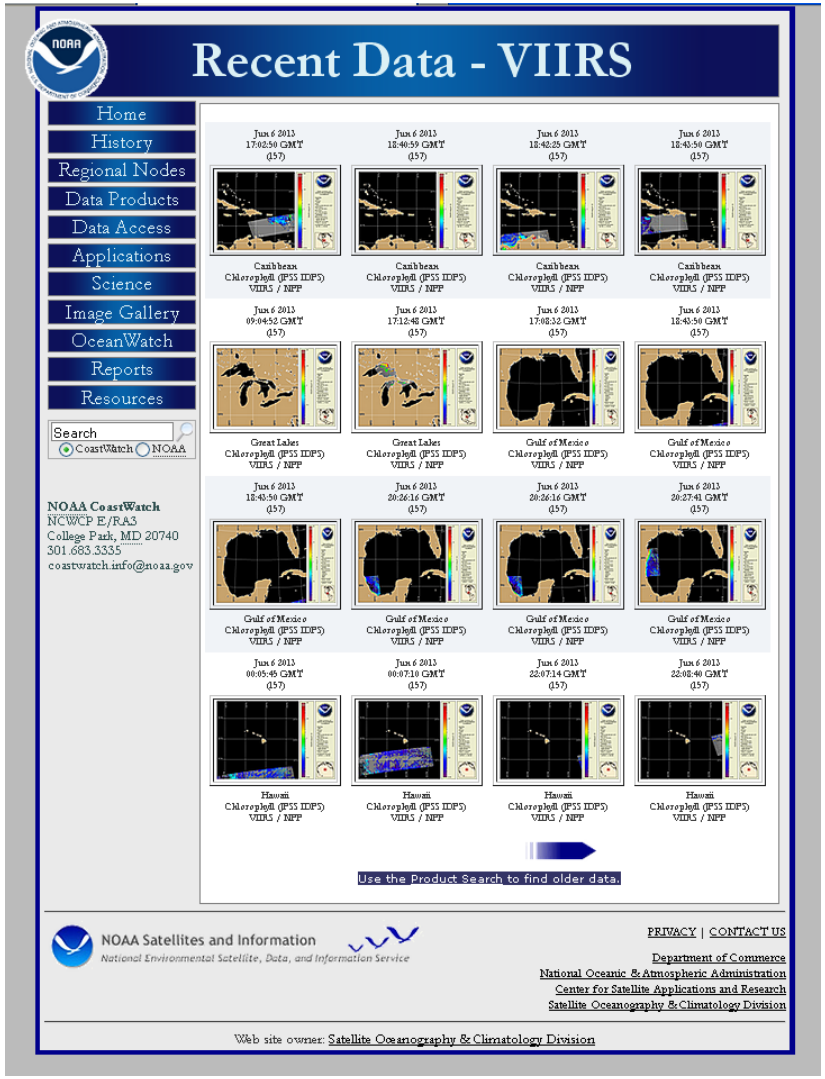
Global Daily Composite (4km)



VIIRS Chlorophyll, May 18, 2013

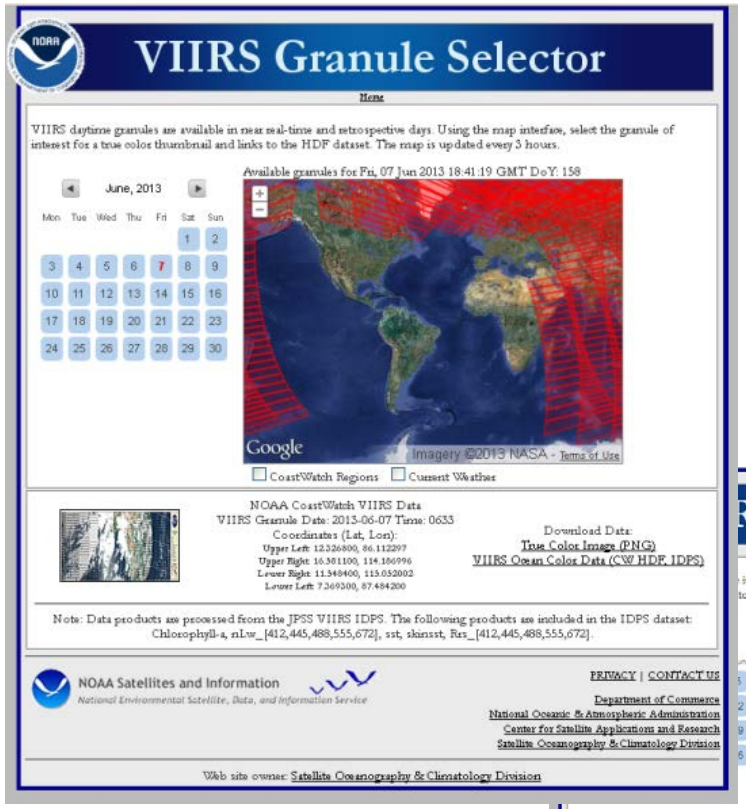
Data Distribution Portal

- CoastWatch webserver
  - Product/Region search for all CW products
    - VIIRS CONUS 750m
    - VIIRS Global 4km
  - VIIRS Granule Selector
  - Data available for 7 days (images available longer)
- THREDDS data server
  - VIIRS Global 750m sectors
  - VIIRS Global 4km
  - netCDF format
  - THREDDS services for mapping, spatial subsetting, data visualization



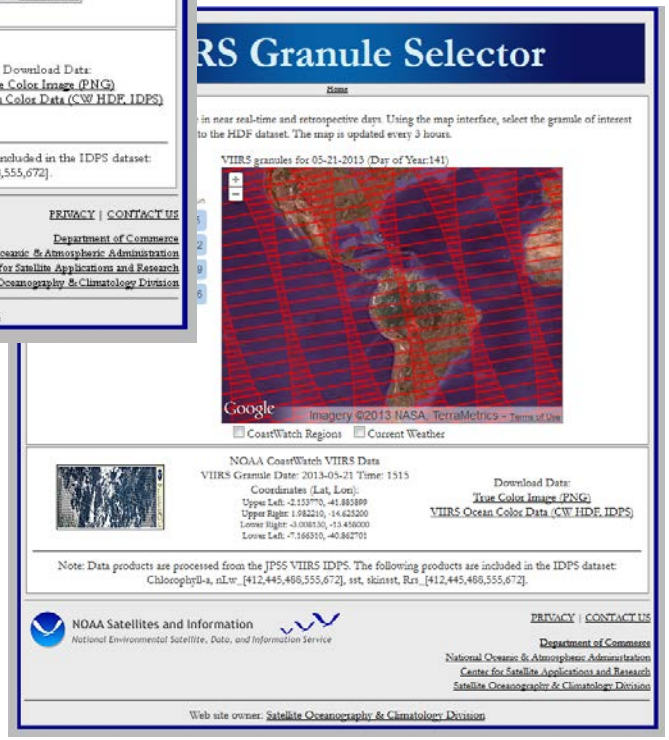
Data Portal Enhancements

- VIIRS granules can be selected from a map:
  - True color image shown to indicate cloud-free coverage
  - Link to the IDPS-processed EDR in CW HDF format
- Product search "No Results" augmented with date ranges of actual data holdings
- Operational vs. experimental search



Near real-time granule processing shown on map

Calendar to select data for any date

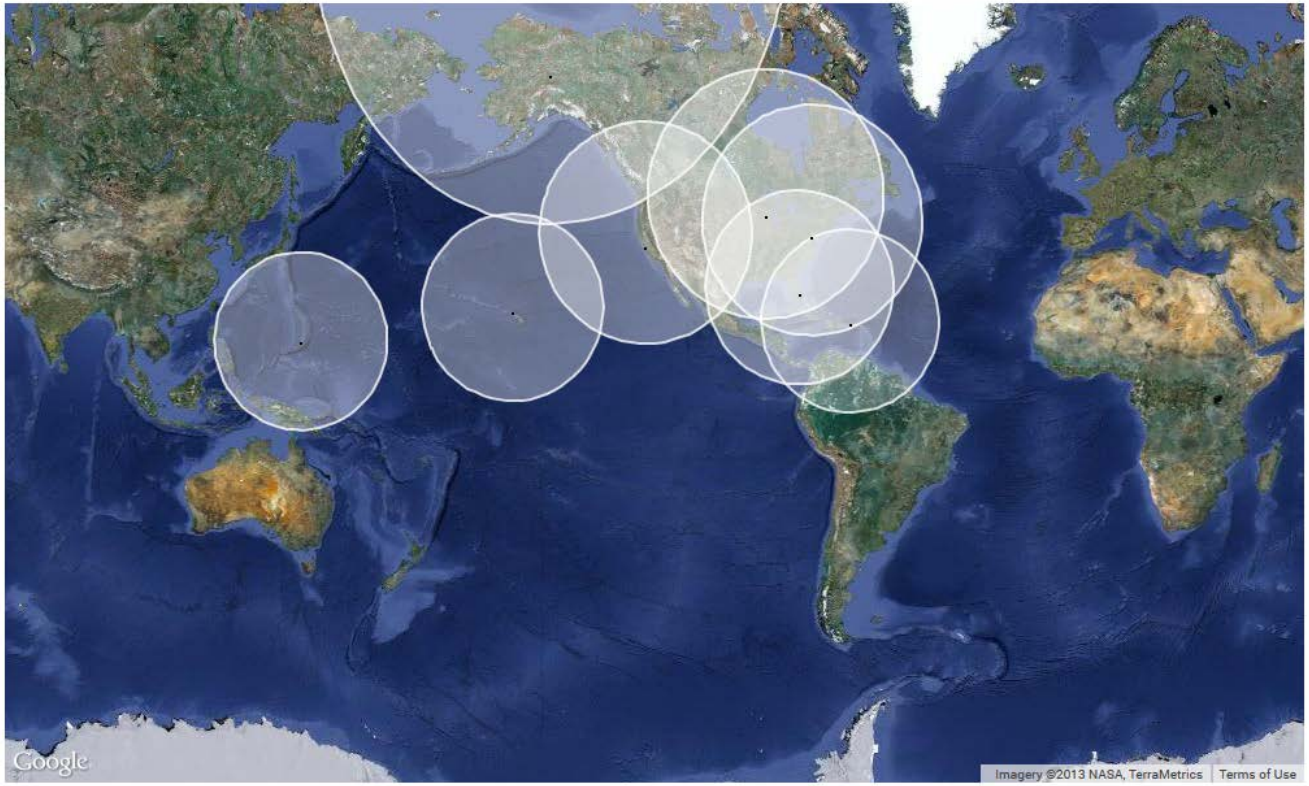


Google-Map zoom into granules

Select true color image and download data

JPSS Supported X-band Sites

Proposed JPSS X-Band Station Coverage



Guam - Honolulu,HI - Fairbanks,AK - Monterey,CA - Madison,WI - Suitland,MD - Miami,FL - Puerto Rico

CoastWatch NPP/VIIRS Ocean Color: Independent Quality Assessment and Algorithm Recommendation

Sathya Ramachandran

Results

- Chlorophyll
  - IDPS looks good in comparison with heritage and Climatology for open ocean waters.
  - L2gen is doing better than IDPS for high chlorophyll coastal waters.

- nLw
  - 443 & 488 bands are closer to corresponding Climatology values for L2gen (< 5%), it is more like 10-15% for IDPS
  - However 551 band is sitting with a large bias (~ 30%) for L2gen when compared to IDPS product (<10%) at this time.

NRT-QA links

Inter-sensor plots :

http://www.star.nesdis.noaa.gov/sod/mecb/coastwatch/NRT-QA/OC-timeseries-DynamicInterSensor-CW_v4.html

Comparison with MODIS Climatology

Filter by Chlorophyll value:

http://www.star.nesdis.noaa.gov/sod/mecb/coastwatch/NRT-QA/OC-DailyClimTimeSeriesStats-DynamicInterSensor-filterbyChlor.html

Filter by distance from Coast:

http://www.star.nesdis.noaa.gov/sod/mecb/coastwatch/NRT-QA/OC-DailyClimTimeSeriesStats-DynamicInterSensor-filterbyCoastal.html

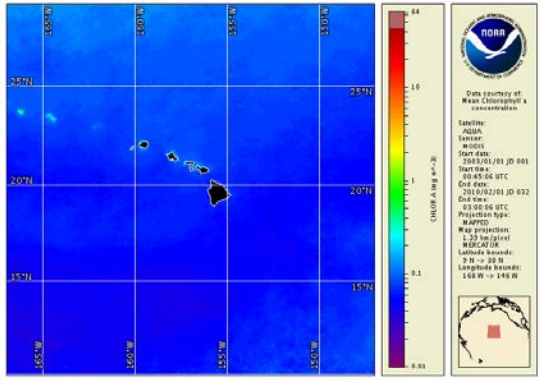
Filter by Bathymetry:

http://www.star.nesdis.noaa.gov/sod/mecb/coastwatch/NRT-QA/OC-DailyClimTimeSeriesStats-DynamicInterSensor-filterbyBathy.html

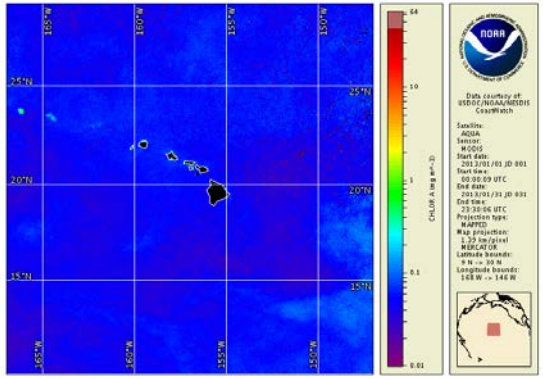
Background Slides

Monthly Chlorophyll

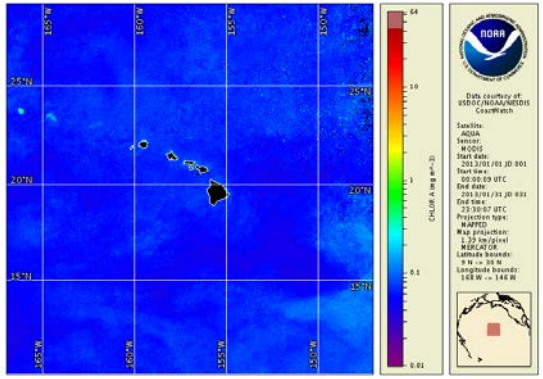
MODIS Climatology for January



MODIS (L2gen) NRT for January

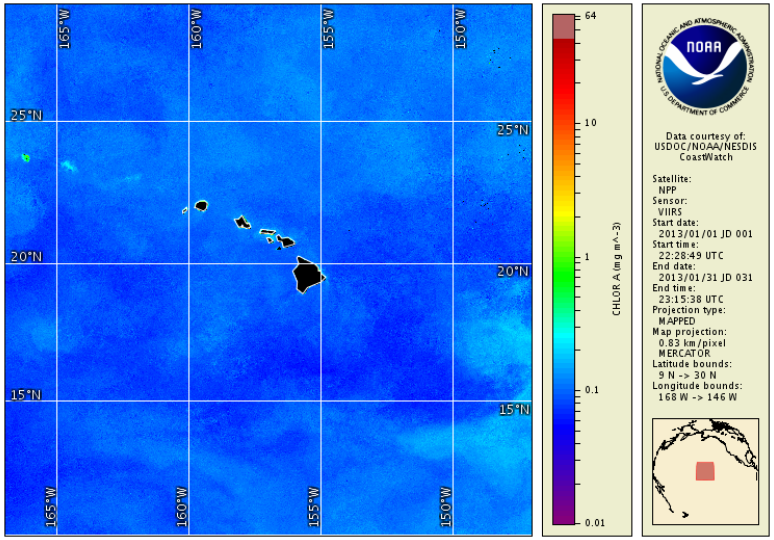


MODIS (SWIR) NRT for January

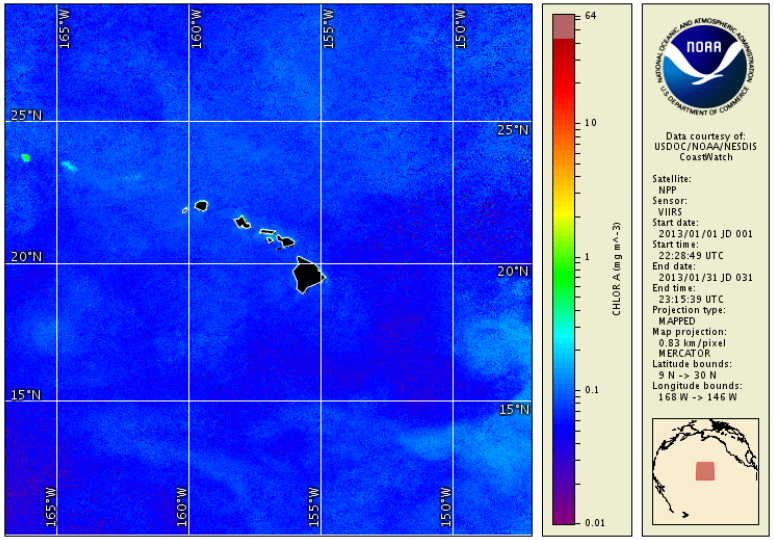


- VIIRS Flavors
  - IDPS (Ingest IDPS EDRs and create CWhdf L3 files; VRSCW)
  - L2gen (Ingest IDPS SDR, use L2gen to create EDR and then L3 CWhdf; VRSSCW)

VIIRS(L2gen) for January

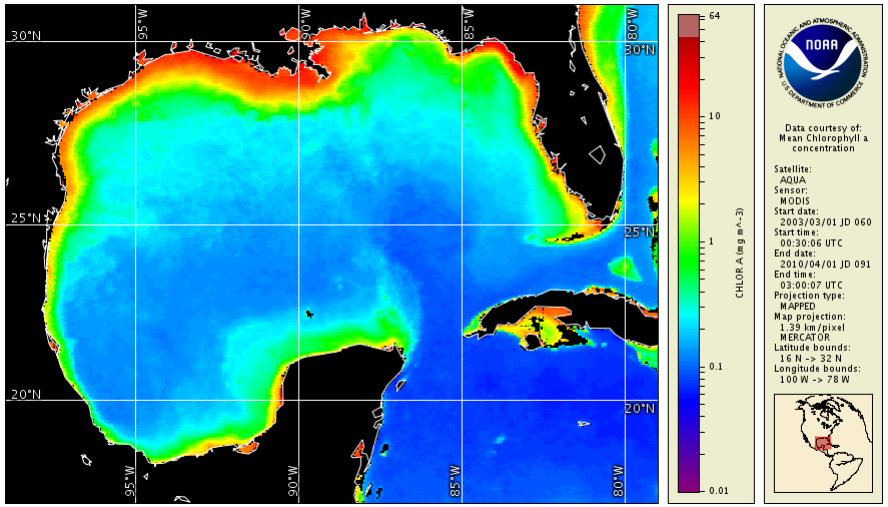


VIIRS(IDPS) for January

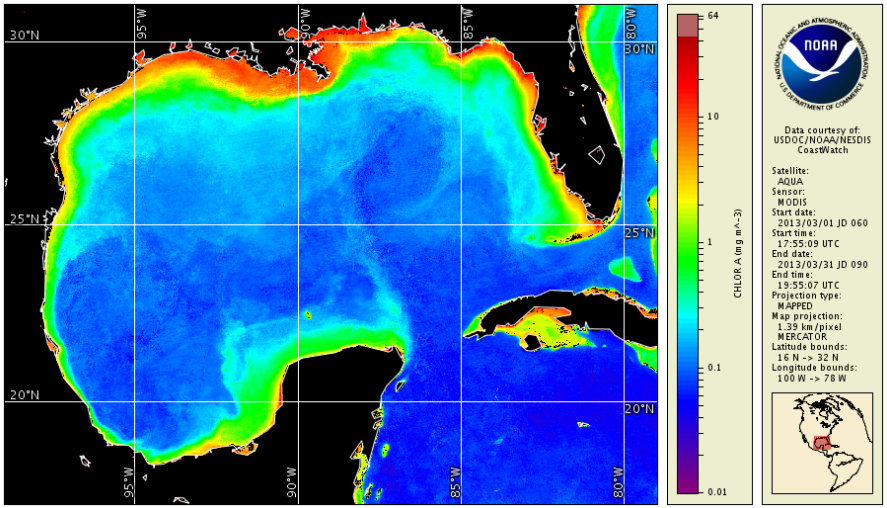


Chlorophyll Images from various algorithms

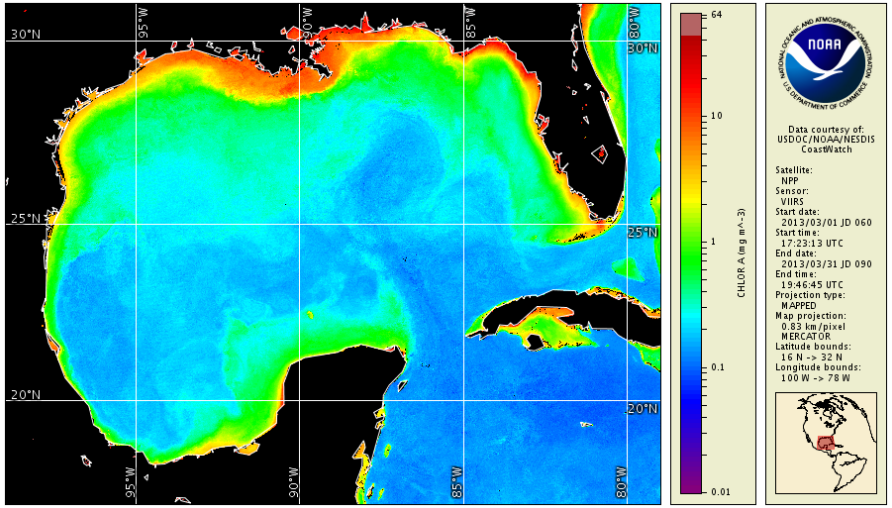
MODIS Climatology For March



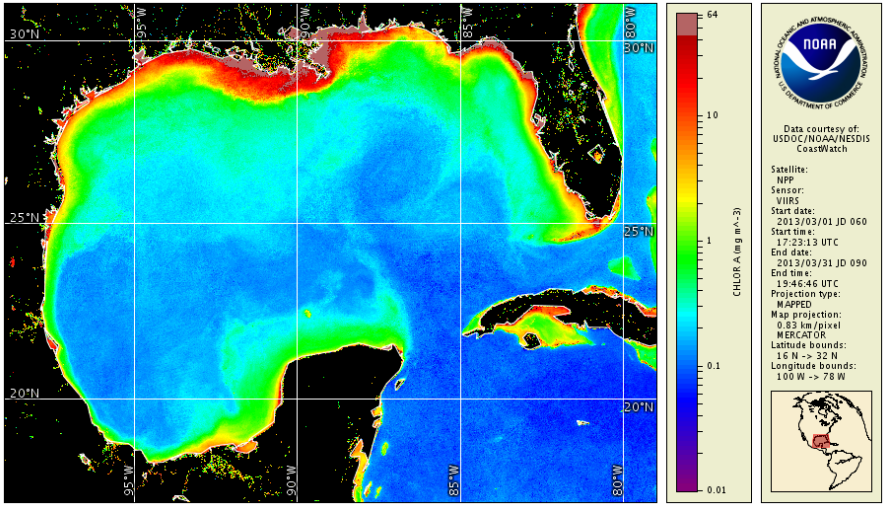
MODIS (L2gen) Monthly for Mar 2013



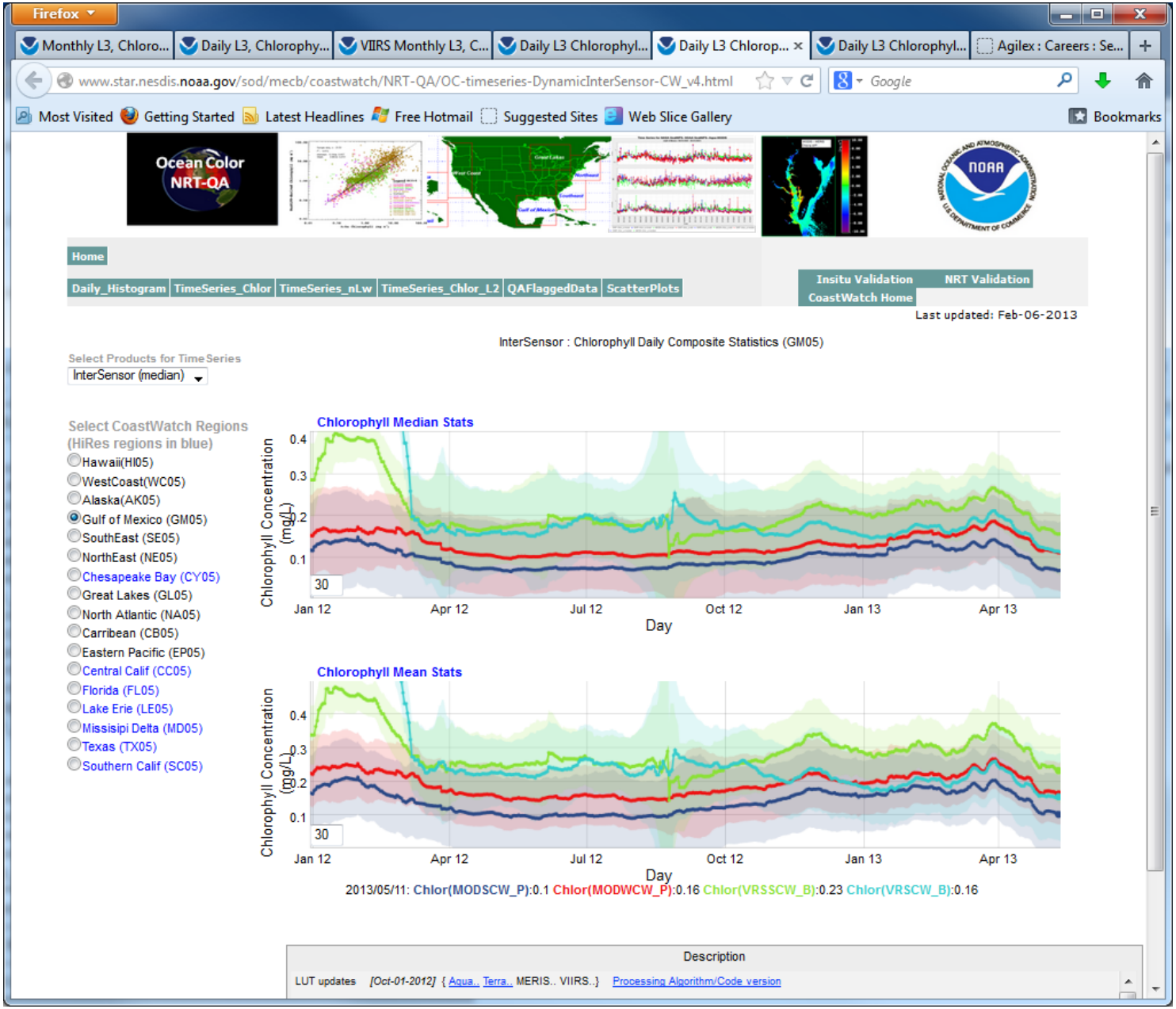
VIIRS (L2gen) monthly for Mar 2013



VIIRS (IDPS) monthly for Mar 2013



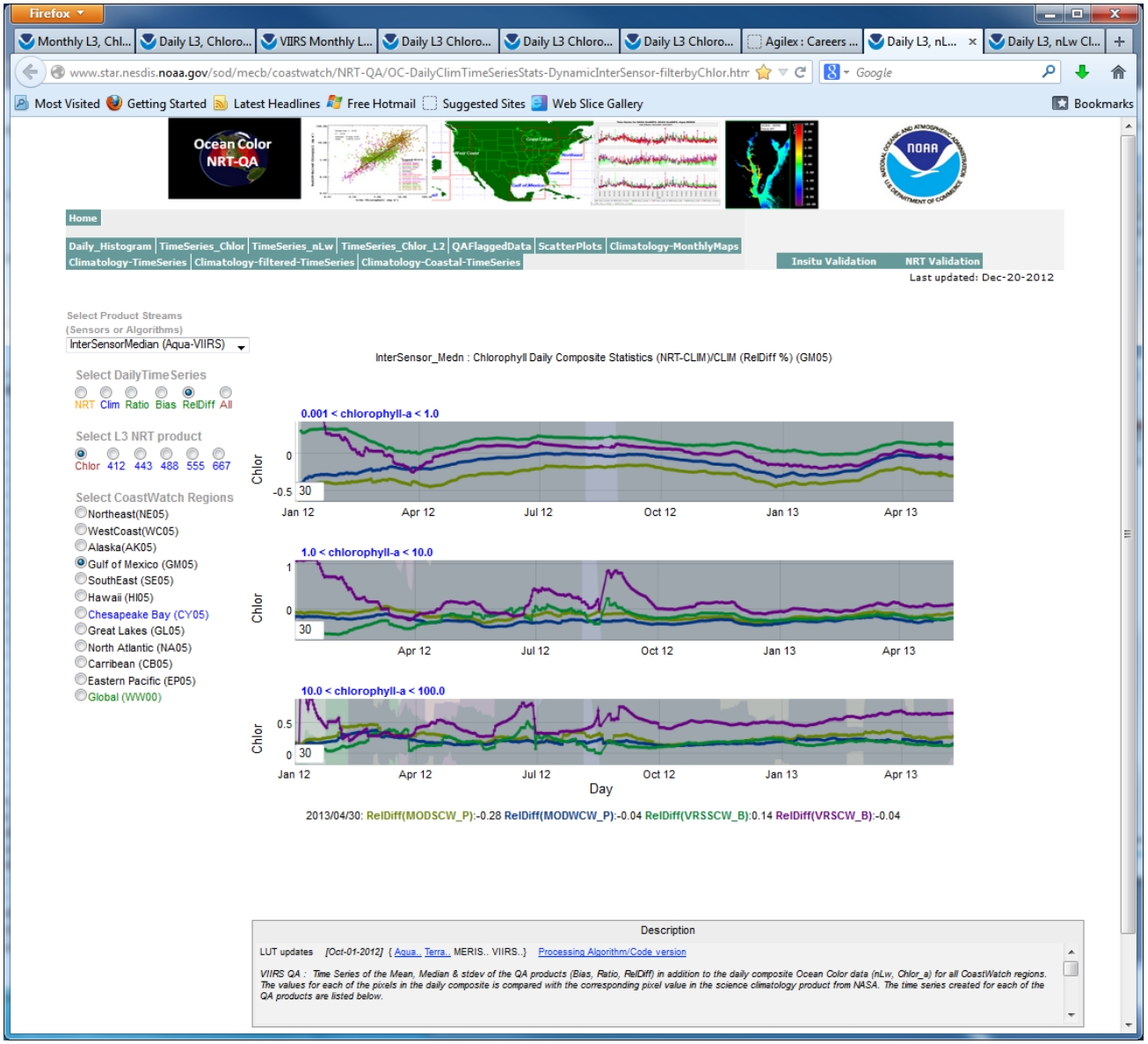
CoastWatch region Chlorophyll averages (Mean & Median) for GM05



VIIRS
L2gen
IDPS

MODIS
SWIR
L2gen

Relative Difference with Climatology GM05
Stratified by Chlorophyll values

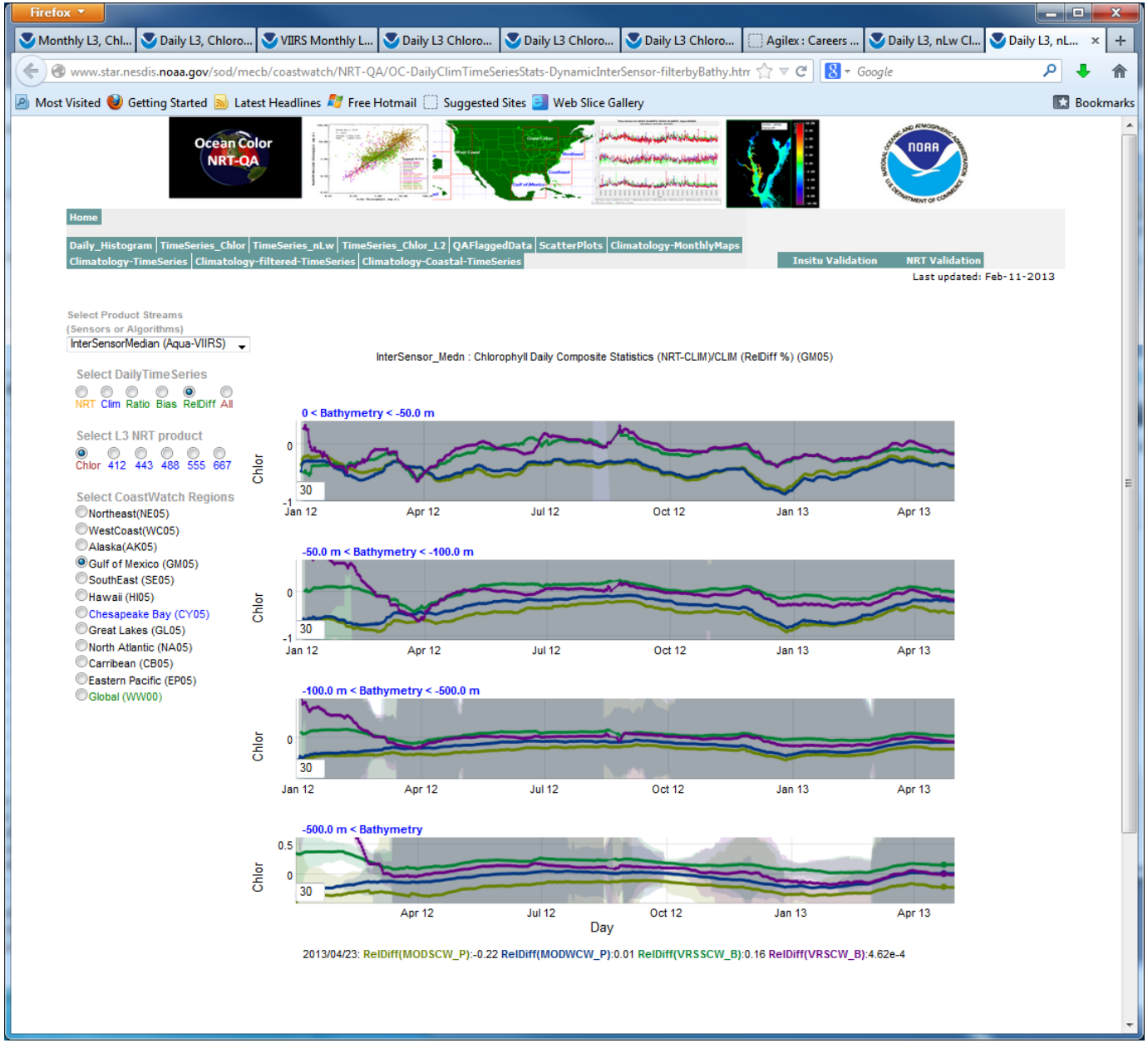


VIIRS
L2gen
IDPS

MODIS
SWIR
L2gen

Note: L2gen(NOAA) returns higher values for Chlorophyll in open ocean and IDPS does the same for high (coastal) values compared to MODIS multi-year Climatology

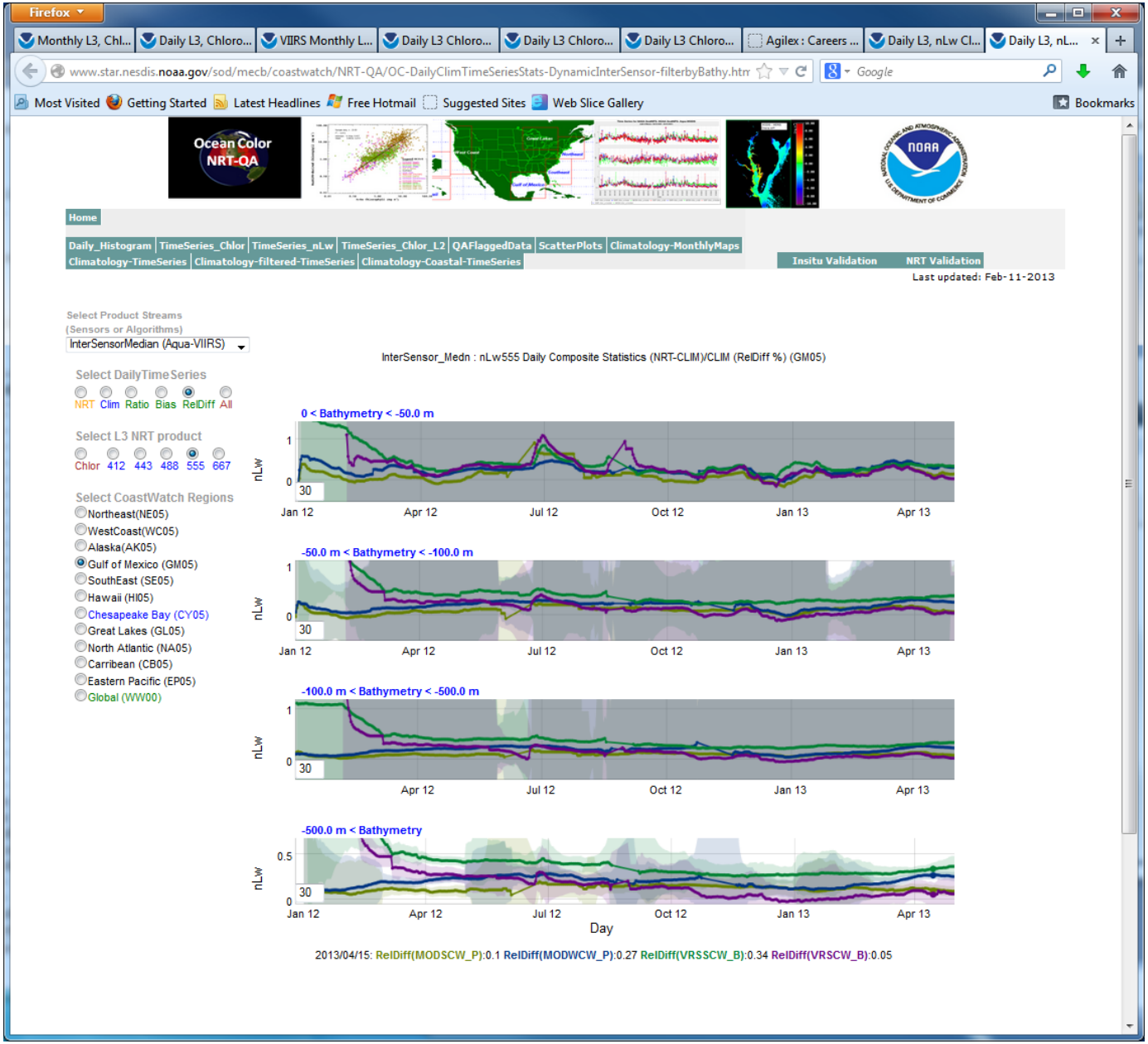
Chlorophyll Relative Difference GM05 Stratified by Bathymetry



VIIRS
L2gen
IDPS

MODIS
SWIR
L2gen

nlw555 Relative Difference GM05 stratified by Bathymetry



VIIRS
L2gen
IDPS

MODIS
SWIR
L2gen