Satellite Oceanography at NOAA: Research, Applications and Services

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NOAA/NESDIS Center for Satellite Applications & Research

University of Maryland
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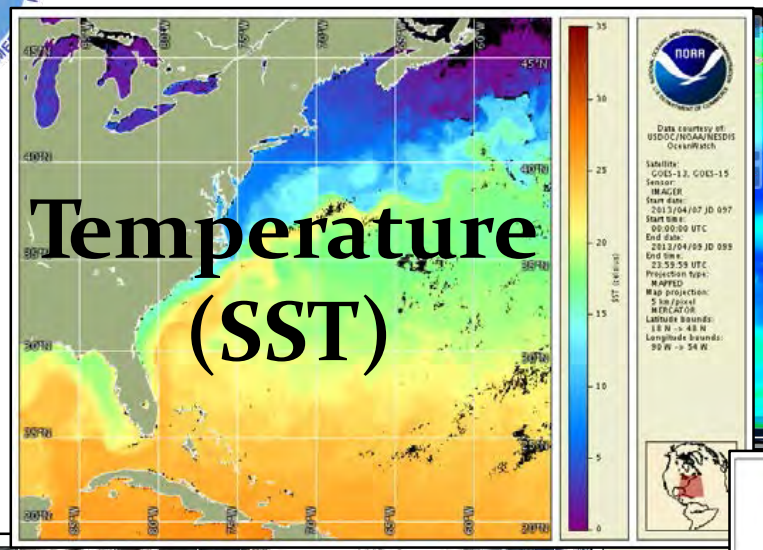
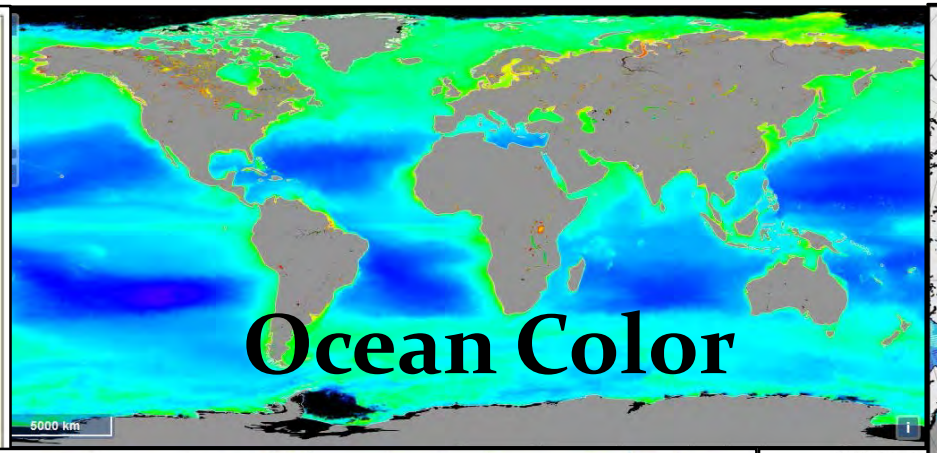
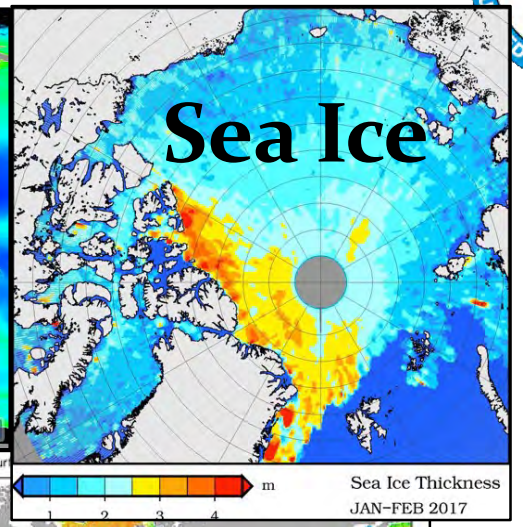
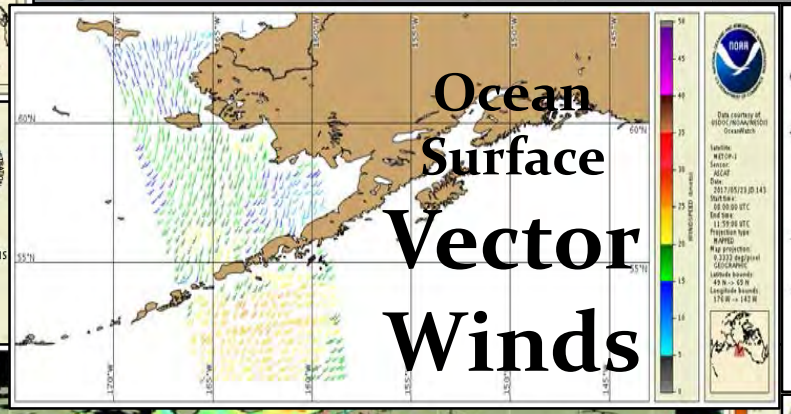
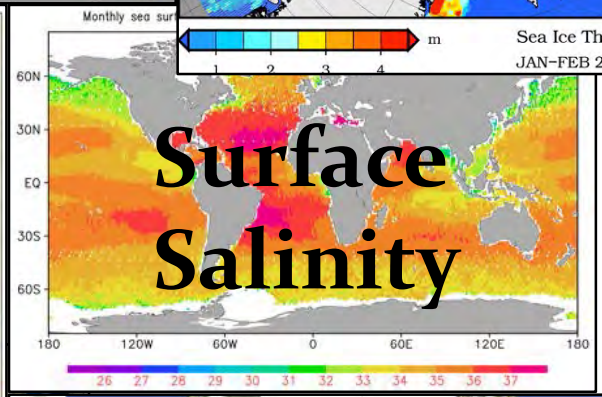
Ocean Observations from SPACE

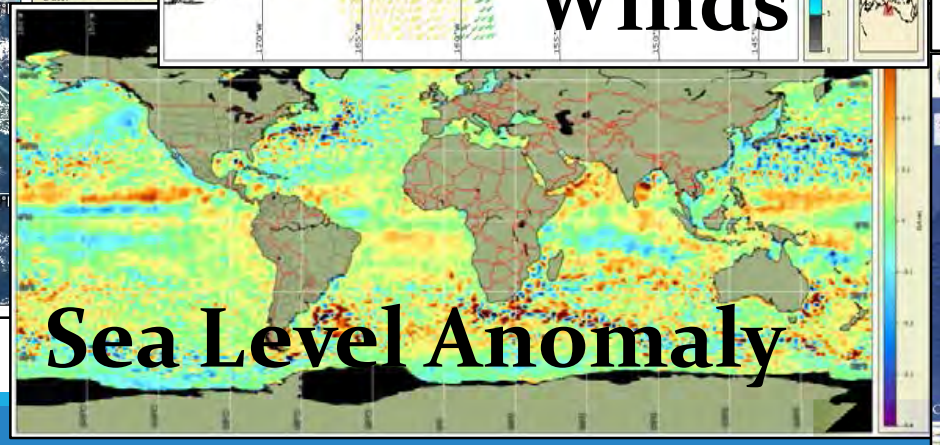


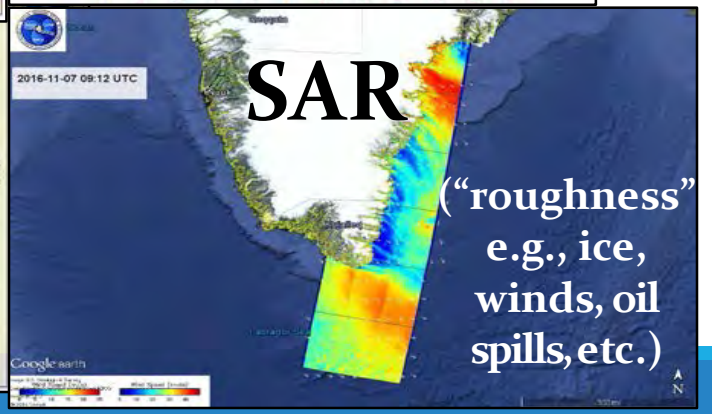






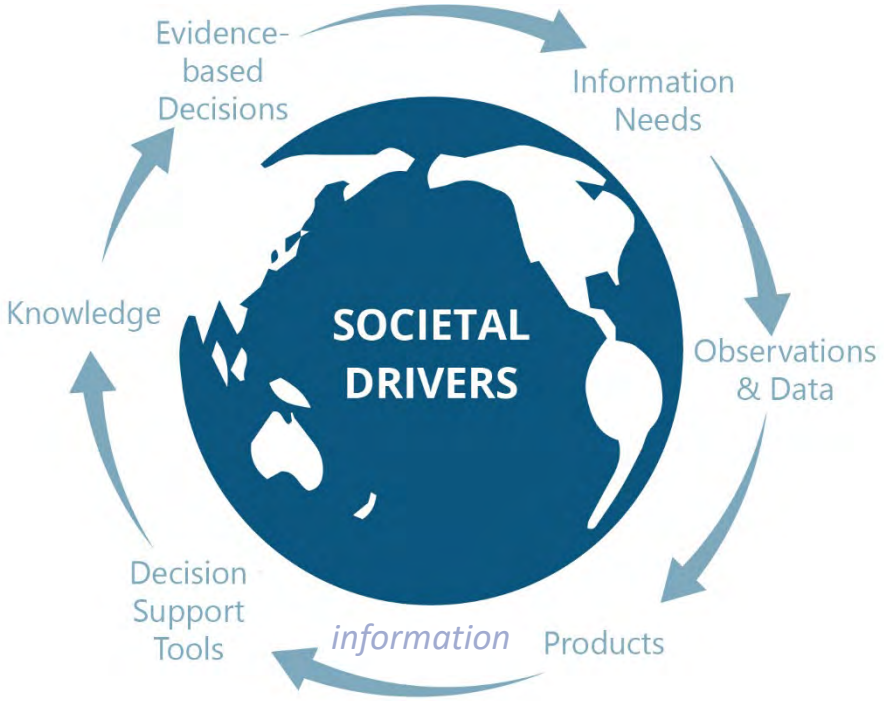






User-driven Value Chain: Observations, Data, Products, Information, Services, Knowledge

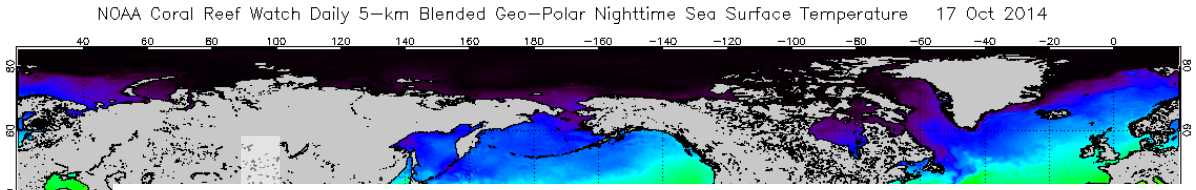
- Satellite Ocean Observations/Data
  - ~from bits & bytes to geophysical parameters
- Satellite Ocean Data Products
  - ~from swath/granule to mapped, merged, anomalies, etc.
- Information
  - integrate data types, model output etc, for more holistic picture
- Tools and Services
- Knowledge (***to inform actions and decisions***)
- Coral Reef Watch example

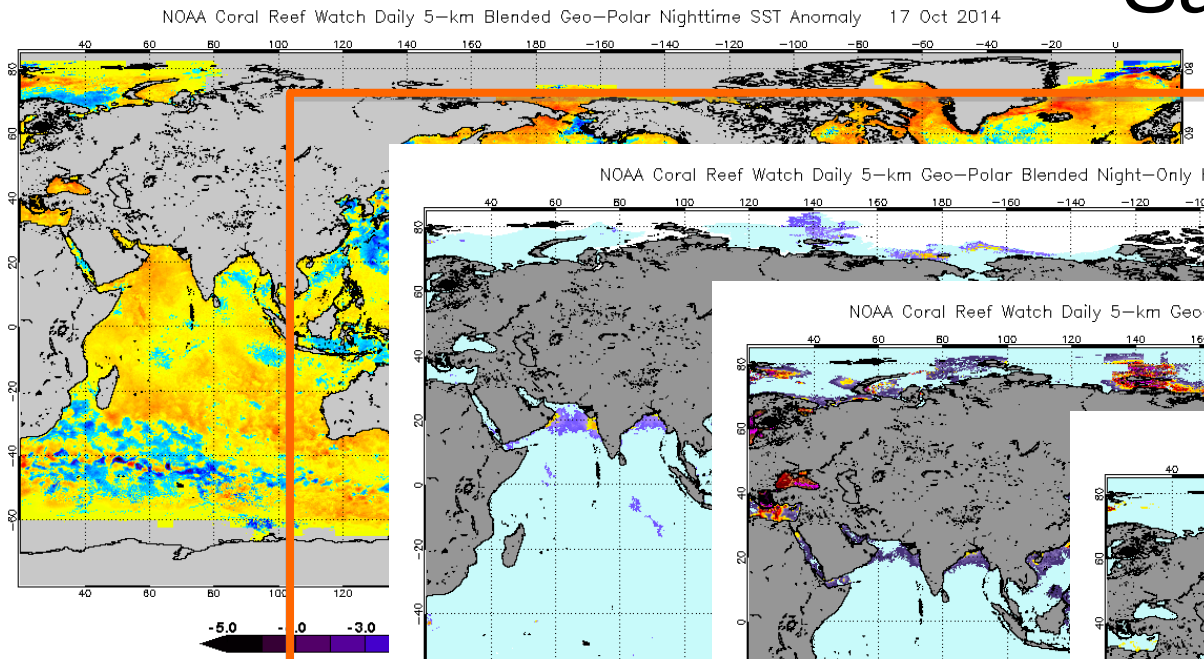


NOAA Coral Reef Watch Satellite-Based Products

Mark Eakin, Lead

Coralreefwatch.noaa.gov





Coral – specific

Our perspective is:

- We are now entering into a "Golden-Age" of *Operational* Satellite Oceanography
- As such, significant opportunities exist to facilitate increased and more diverse use of these data in support of societal needs and the Blue Economy
- That said, ocean satellite data are currently under-utilized by information providers & end-users, and there is a crucial need to distill ever expanding amounts of data into information
- The "*Operational*" paradigm is expanding - not just need for NRT data, but also the need for routine & sustained, high quality delayed-mode data (e.g., multi-mission, long term time-series)
- There are evolving data assurance, service models and services to better serve user needs
- In this context, NOAA is expanding satellite data availability, access & support for all users

So, what does “Operational” mean?

Expanding the "Operational" paradigm

Despite maturity and availability, challenges (real and perceived) remain to achieving more-routine, effective, and sustained applications of satellite oceanographic data by a diverse suite of users

Challenge: Shifting Perceptions about what "operational" actually means

Operational:
= Near-Real Time (NRT)
= 99.99% ground system reliability and operational availability 24x7
= 24x7 human in the loop operations
= Continuity of Operations capability (system redundancy/op backups)
= High-impact/resiliency IT security

Operational:

- **Routine and sustained provision of accurate, consistent and fit for purpose quality oceanographic satellite observations**
- **Span the different time-scales** (i.e., NRT to climate) of operational mission user interest,
- Can be **high assurance/high-service <u>OR</u> moderate assurance/moderate-service**
- **Consider all applications including research**

Operational Satellite Oceanography

OPERATIONAL: Routine and sustained provision of mature, fit for purpose quality data and products in support of both near real time and delayed mode research, applications and services...

Operational Satellite Oceanography

OPERATIONAL: Routine and sustained provision of mature, fit for purpose quality data and products in support of both near real time and delayed mode research, applications and services...

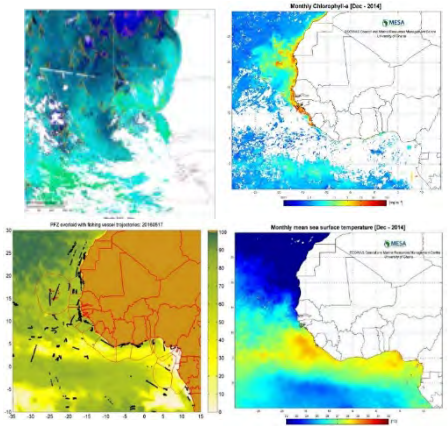
Another Key Challenge:

*Don't let perfect be the enemy of the good (*Voltaire*)*

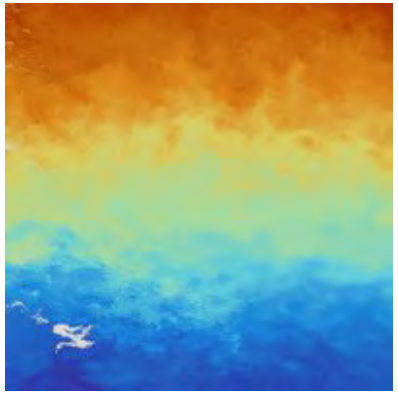
Global Constellation of Earth Observing Satellites

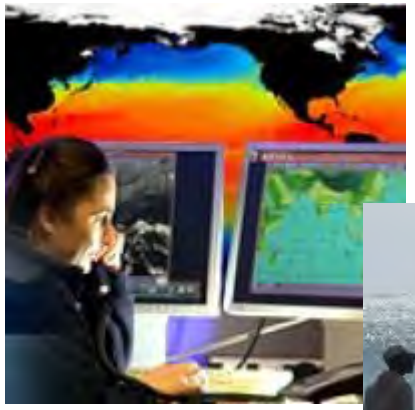
Main Challenges to Overcome

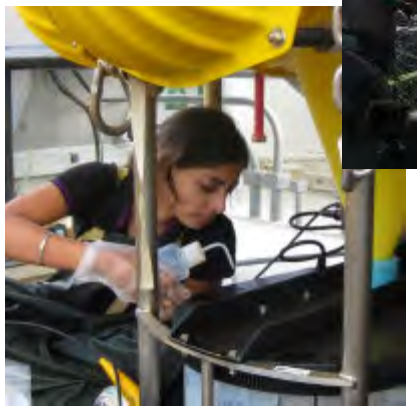
Increasing quantity of datasets and data portals → Stakeholders need better resources for data access, discovery and use

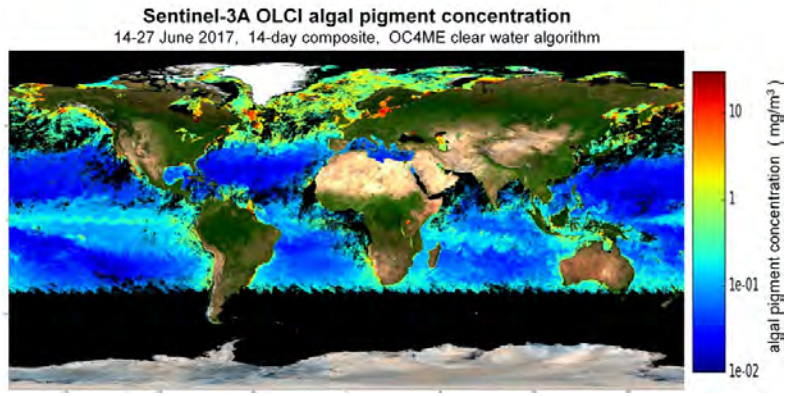


Courtesy of MESA/Kwame Adu Agyekum, ECOWAS Coastal & Marine Resources Management Centre



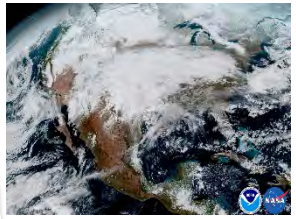
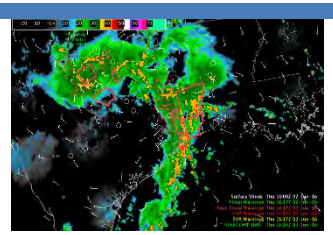
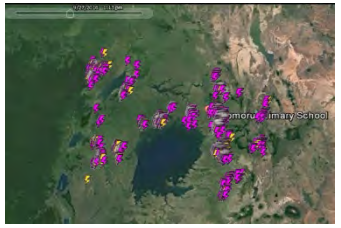
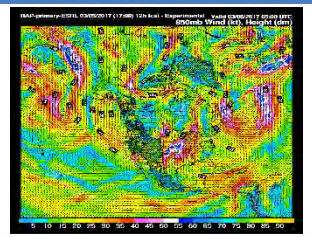




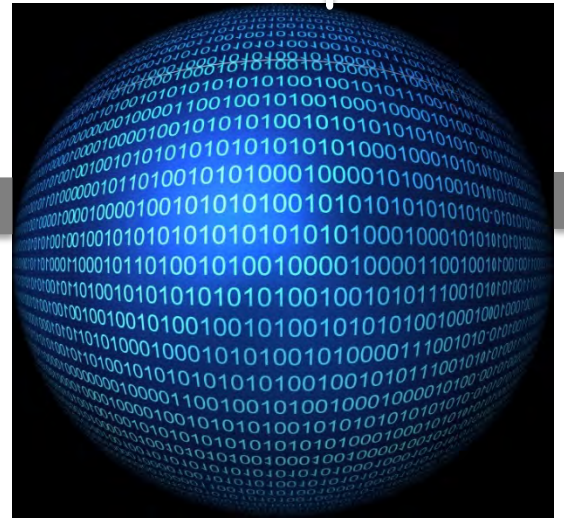


BLUE PLANET Oceans and Society a GEO Initiative

Extract Higher Information Content

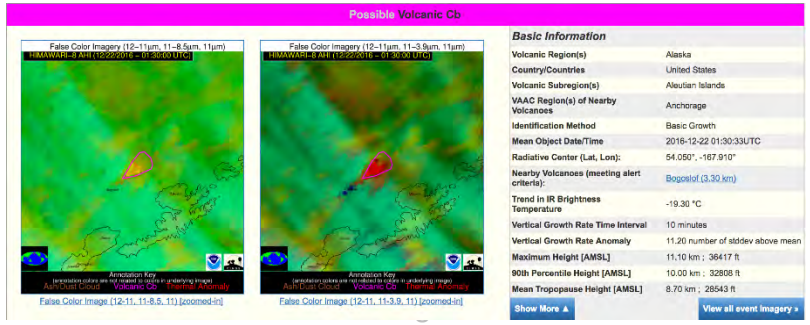





Operational applications require "Big Data" to be automatically transformed into information and insight for decision making



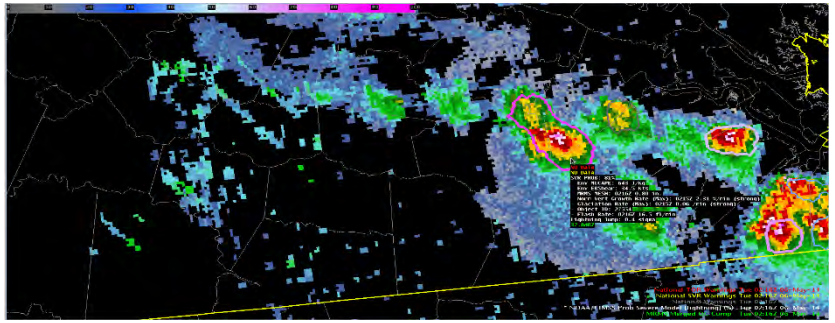
Volcat

Volcanic Eruption Detected!



Probsevere

Severe Weather Likely

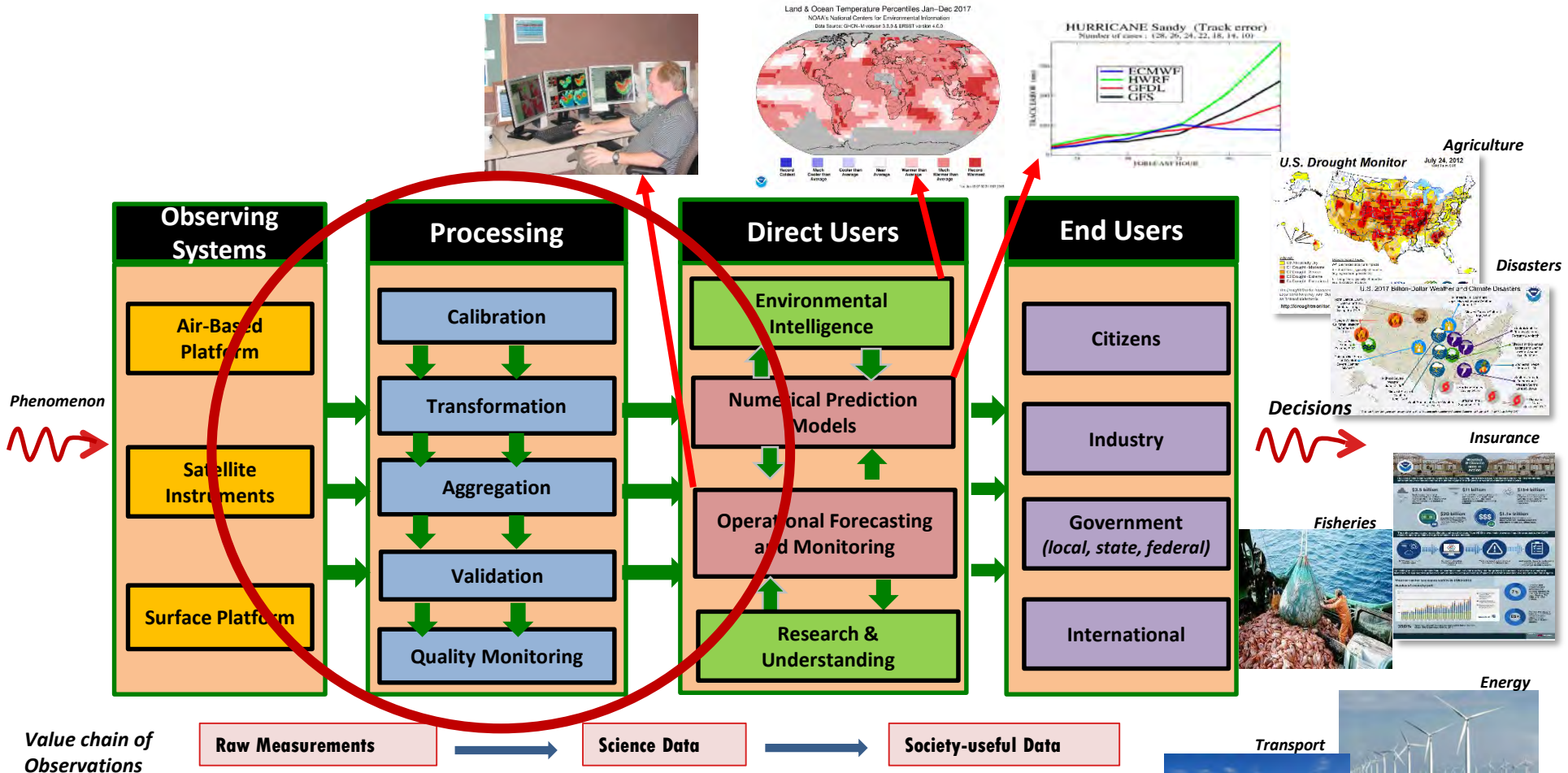


Focus on consistent, fit-for-purpose data, end-to-end value chain, and partnerships:

- Enable end-to-end value chain of observations <> data <> products <> information <> knowledge; ensuring result is fit for purpose for user needs - one size does NOT fit all!
- *Routine & sustained provision of consistent, high-quality,* source agnostic (i.e., multi-sensor) multi-parameter ocean satellite data and products *through enterprise algorithms, global and regional product validation, data integration (merged and blended products), assimilation etc.*
- Working to remove barriers and provide greater value for more users through new/improved products and enhanced product discovery, education & training (NB: increasing focus on near-shore coastal and inland water products and applications)
- Success requires domestic and international partnerships, communication, and coordination and sustained user engagement, support and product evolution and enhancements

NOAA/NESDIS Center for Satellite Applications and Research (STAR)

STAR provides the satellite remote sensing science and technical basis for transforming satellite observations into data / information products for the processing chain from observation to decisions



STAR bridges between instrument providers and NOAA/external users

STAR/Satellite Oceanography & Climatology Division (SOCD)

SOCD Organization

SOCD Chief: *Dr. Paul M. DiGiacomo*

Ocean Sensors Branch

Chief: *Dr. Alexander (Sasha) Ignatov*

- Sea Surface Temp, Ocean Winds, Ocean Optics & Water Quality (e.g. Chesapeake Bay)

Marine Ecosystems & Climate Branch

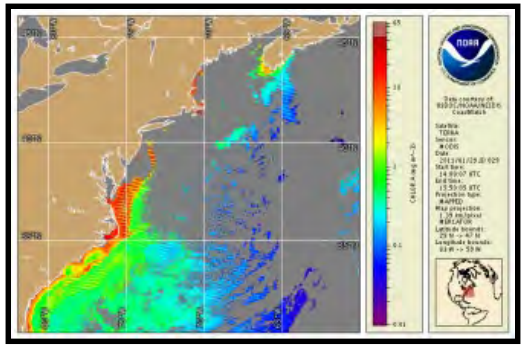
Chief: *Dr. Menghua Wang*

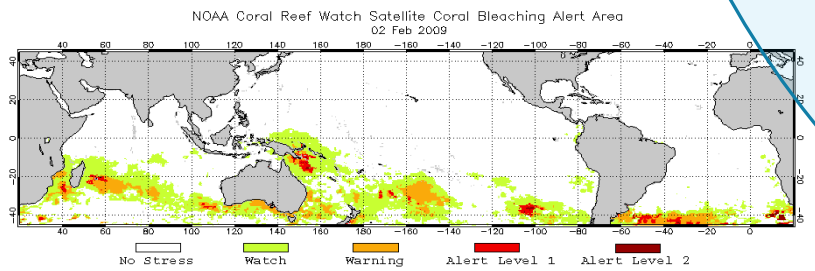
- Ocean Color, Coral Reefs, Sea Ice, Synthetic Aperture Radar, Blended SST

Laboratory for Satellite Altimetry

Chief: *Dr. Eric Leuliette (acting)*

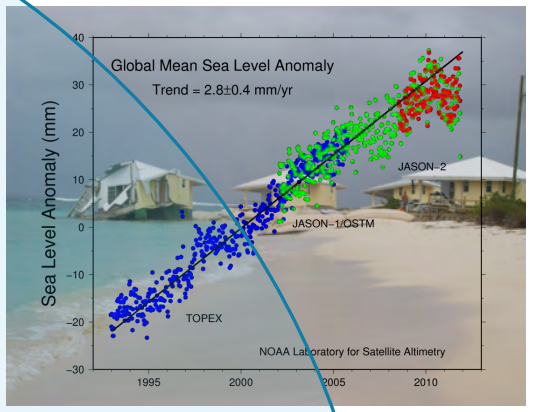
- Sea Level, Bathymetry, Waves, Sea Ice/Climate





Science Teams: R&O

- Sea Ice
- Sea Surface Height
- Sea Surface Roughness
- Sea Surface Salinity
- Sea Surface Temperature
- Ocean Color Radiometry
- Ocean Surface Vector Winds
- CoastWatch/OceanWatch
- PolarWatch
- Coral Reef Watch



Major Programs & Activities

- *Users*: All NOAA; extensive inter/national users
- *Approach*: Source-agnostic, measurement-based
- *Fit for purpose*: NRT & science-quality data
- *Enterprise*: Ocean algorithms/processing systems
- Sat ocean data assimilation for environmental modeling
- GEOSS: AquaWatch (Water Quality) & Blue Planet (Oceans/Coasts) Initiative
- JASON Satellite Radar Altimeter Program
- JPSS: Ocean Color & SST EDR leads
- GOES-R: SST lead; GCOM-W: Project Lead
- Marine Optical BuoY (MOBY) Project

Focusing on the user-driven end-to-end value chain: Observations <> Data <> Products <> Information <> Knowledge

Ocean Obs and Data Providers & Stewards

NESDIS

Operational Satellite Data
NOAA & non-NOAA assets
STAR (Mod. Assurance/Service)
OSPO (High Assurance/Service)

Archived Satellite Data
NOAA & non-NOAA assets
NCEI

Non-NESDIS Satellite Data Providers

Other Observations & Data
Sub/surface, Airborne, Sub-orbital
NOAA (e.g., IOOS, CPO) & non-NOAA

Ocean Product and Information Generators & Providers

NOAA

Tailored Satellite Products
CoastWatch/OceanWatch
Coral Reef Watch
PolarWatch

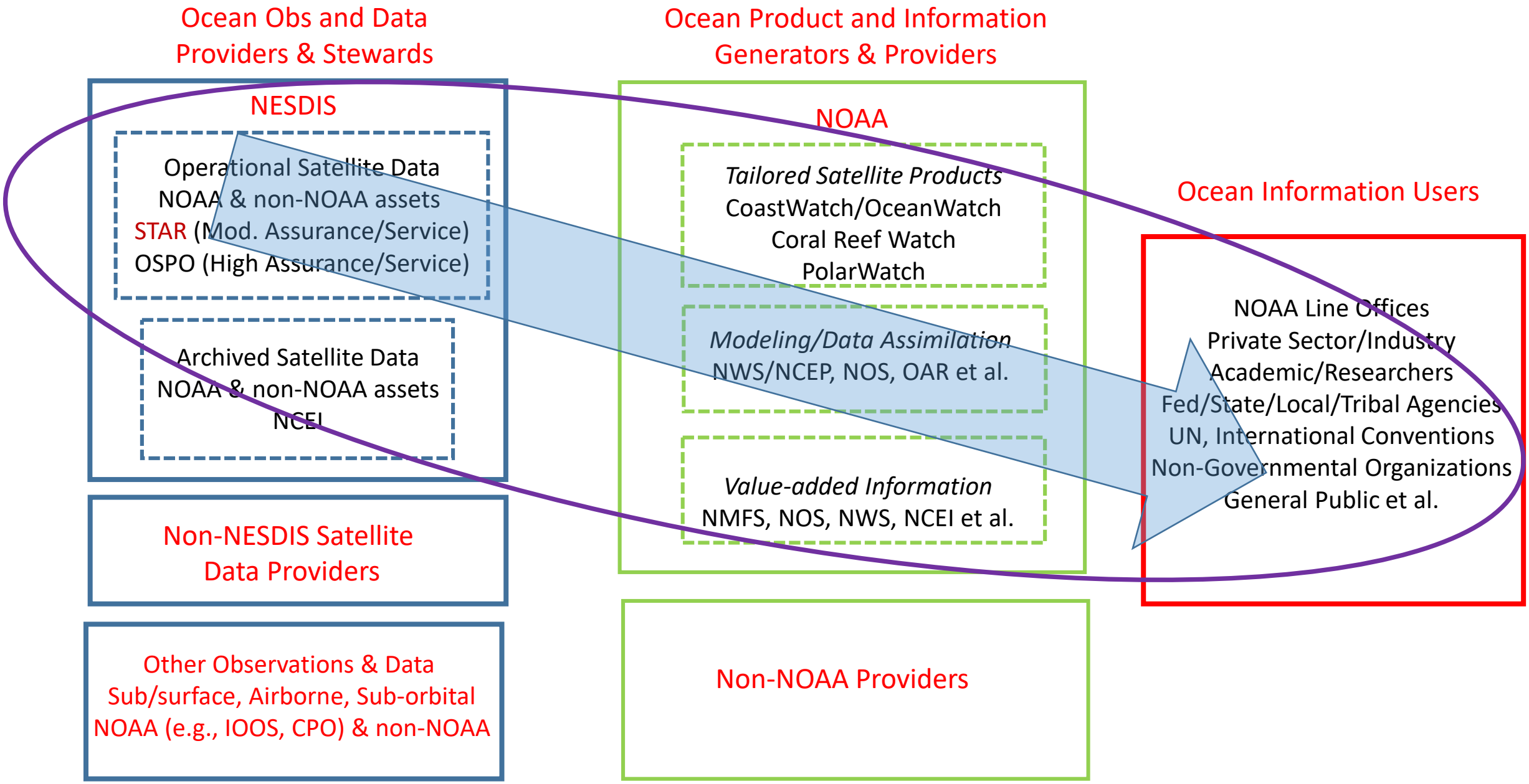
Modeling/Data Assimilation
NWS/NCEP, NOS, OAR et al.

Value-added Information
NMFS, NOS, NWS, NCEI et al.

Non-NOAA Providers

Ocean Information Users

NOAA Line Offices
Private Sector/Industry
Academic/Researchers
Fed/State/Local/Tribal Agencies
UN, International Conventions
Non-Governmental Organizations
General Public et al.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Ocean Remote Sensing at the NOAA Center for Satellite Applications and Research (STAR)

Ocean Color (e.g., VIIRS, OLCI)

Sea Surface Temperature (e.g., VIIRS, ABI, AHI)

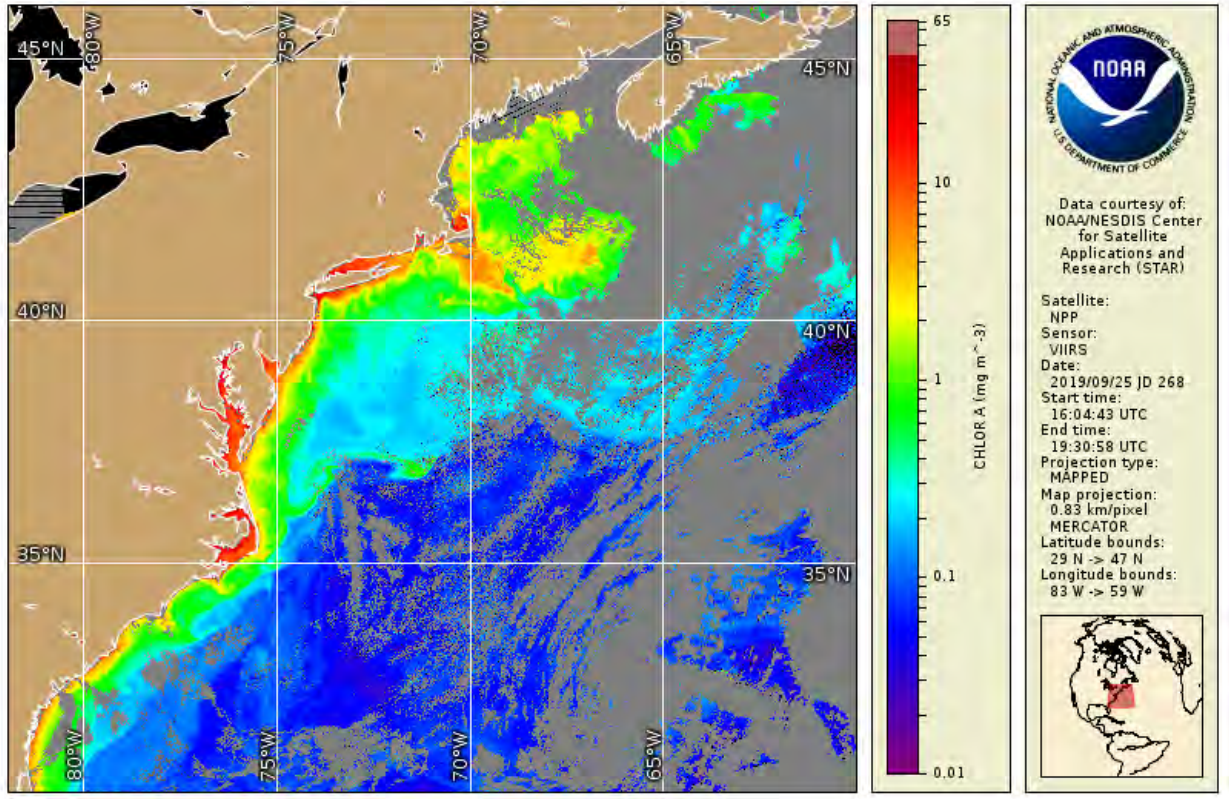
Sea Surface Height (e.g., Jason-3, Sentinel-3)

Ocean Surface Vector Winds (e.g., ASCAT, SCATSAT)

Sea Surface Roughness (e.g., Sentinel-1; RCM)

Sea Surface Salinity (SMOS, SMAP)

Sea Ice (e.g., Cryosat-2, Sentinel-1)



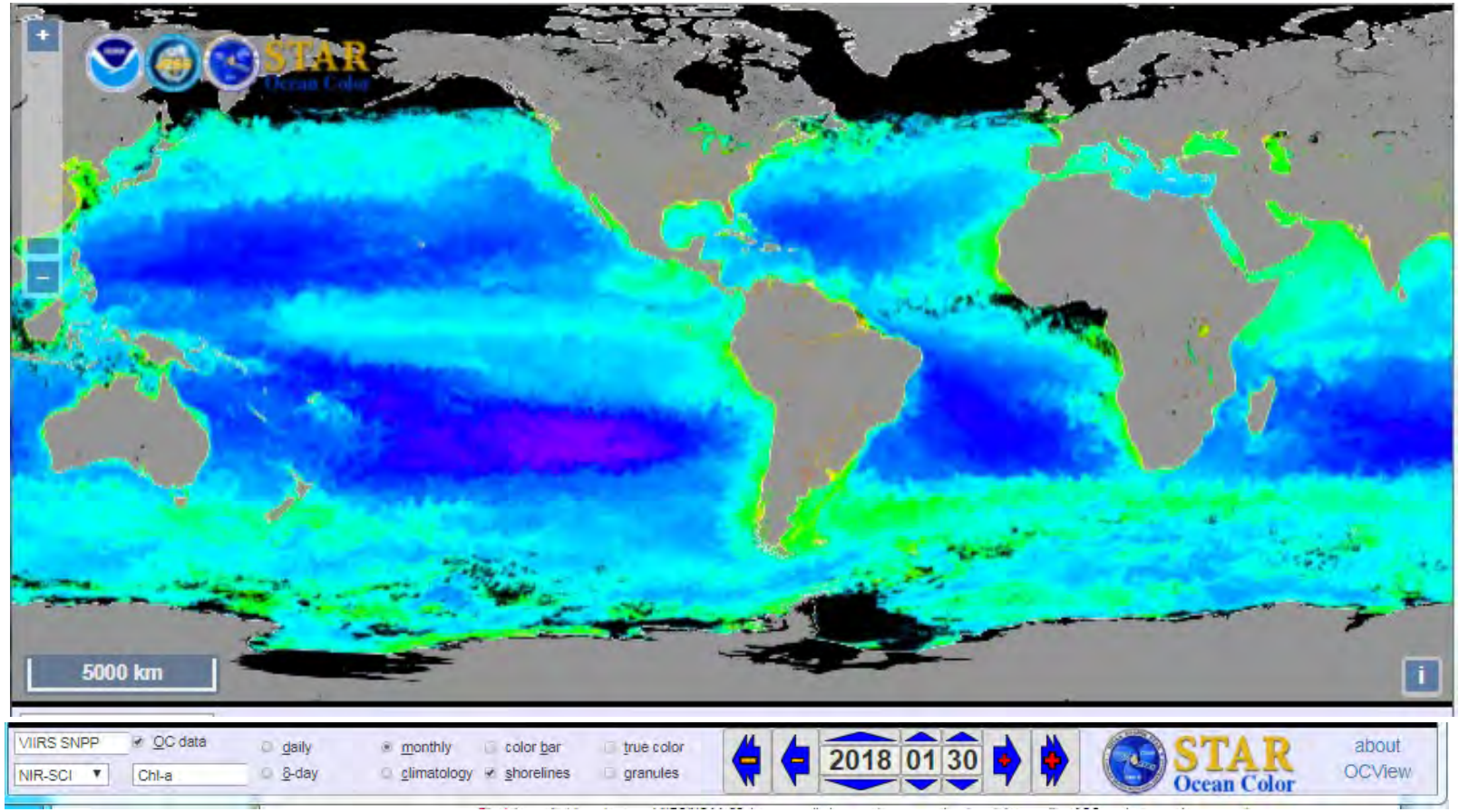
Ocean/Aquatic Color Radiometry

Lead: Menghua Wang

Enterprise processing: NOAA Multi-sensor Level 1 to Level 2 processing system (NOAA-MSL12)

- Radiances
- Chlorophyll
- Kd490, KdPAR
- QA Score
- Other experimental products

OCView



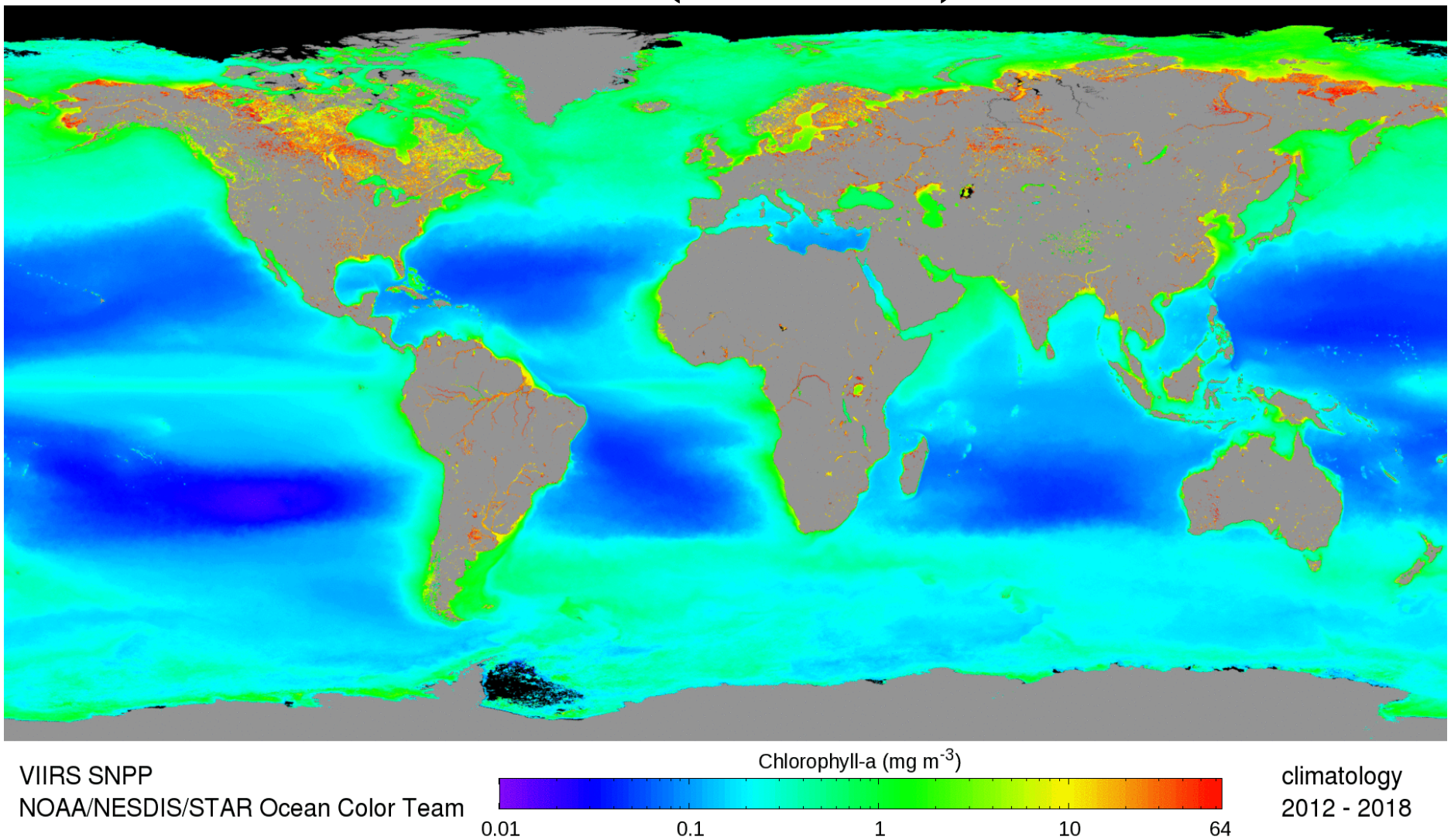
Summary of VIIRS Ocean Color EDR Products (Updates-Based on Users Input)

- **Inputs**:
  - VIIRS M1-M7, I1, and the **SWIR** M8, M10, and M11 bands SDR data
  - Terrain-corrected geo-location file
  - Ancillary meteorology and ozone data
- **Operational (Standard) Products (10)**:
  - Normalized water-leaving radiance (nL_w's) at VIIRS visible bands M1-M5, and **I1 (638 nm)**
  - Chlorophyll-a (Chl-a) concentration
  - Diffuse attenuation coefficient for the downwelling spectral irradiance at the wavelength of 490 nm, $K_d(490)$
  - Diffuse attenuation coefficient of the downwelling photosynthetically available radiation (PAR), $K_d(\mathrm{PAR})$
  - **QA Score** for data quality ($nL_w(\lambda)$ spectra) (*Wei et al.*, 2016)
  - Level-2 quality flags
- **Experimental Products (29):**
  - Inherent Optical Properties (IOP-a, IOP-a_{ph}, IOP-a_{dg}, IOP-b_b, IOP-b_{bp}) at VIIRS M2 or other visible bands (M1-M5) from the Quasi-Analytical Algorithm (QAA) (*Lee et al.*, 2002)
  - Photosynthetically Available Radiation (PAR) (*R. Frouin*)
  - Chl-a from ocean color index (OCI) method (*Hu et al.*, 2012; *Wang and Son*, 2016)
  - Others, e.g., user specific products (e.g., **Chl-a anomaly** and **Chl-a anomaly ratio**)

➢ Data quality of ocean color EDR are extremely sensitive to the SDR quality. It requires **~0.1%** data accuracy (degradation, band-to-band accuracy…)!

VIIRS Climatology Ocean Color Product Image

SNPP (2012–2018)



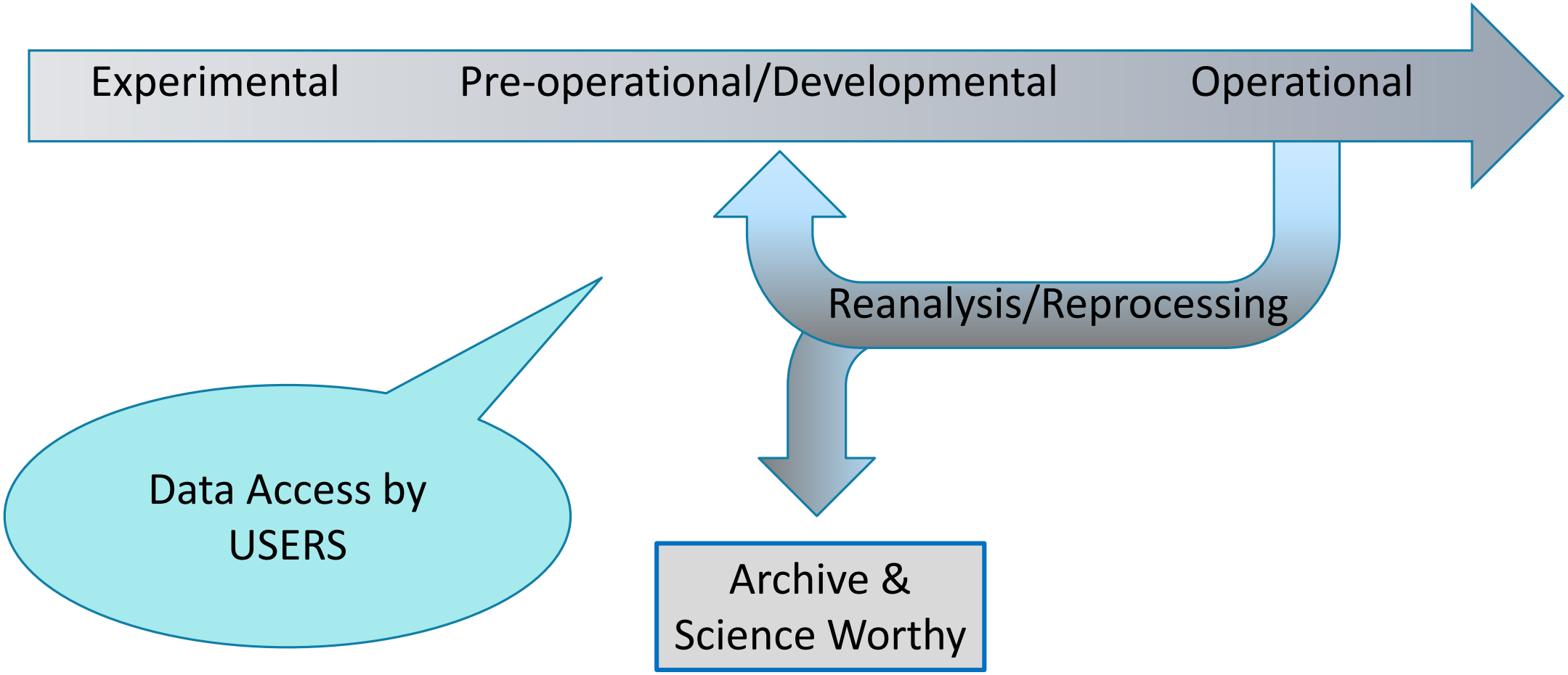
The NOAA MSL12 *enterprise* processing system with the NIR-SWIR Algorithm is used for VIIRS ocean color

Menghua Wang, NOAA/NESDIS/STAR

Consistent NRT & Science Quality
Example from NOAA MSL12 VIIRS Ocean Color

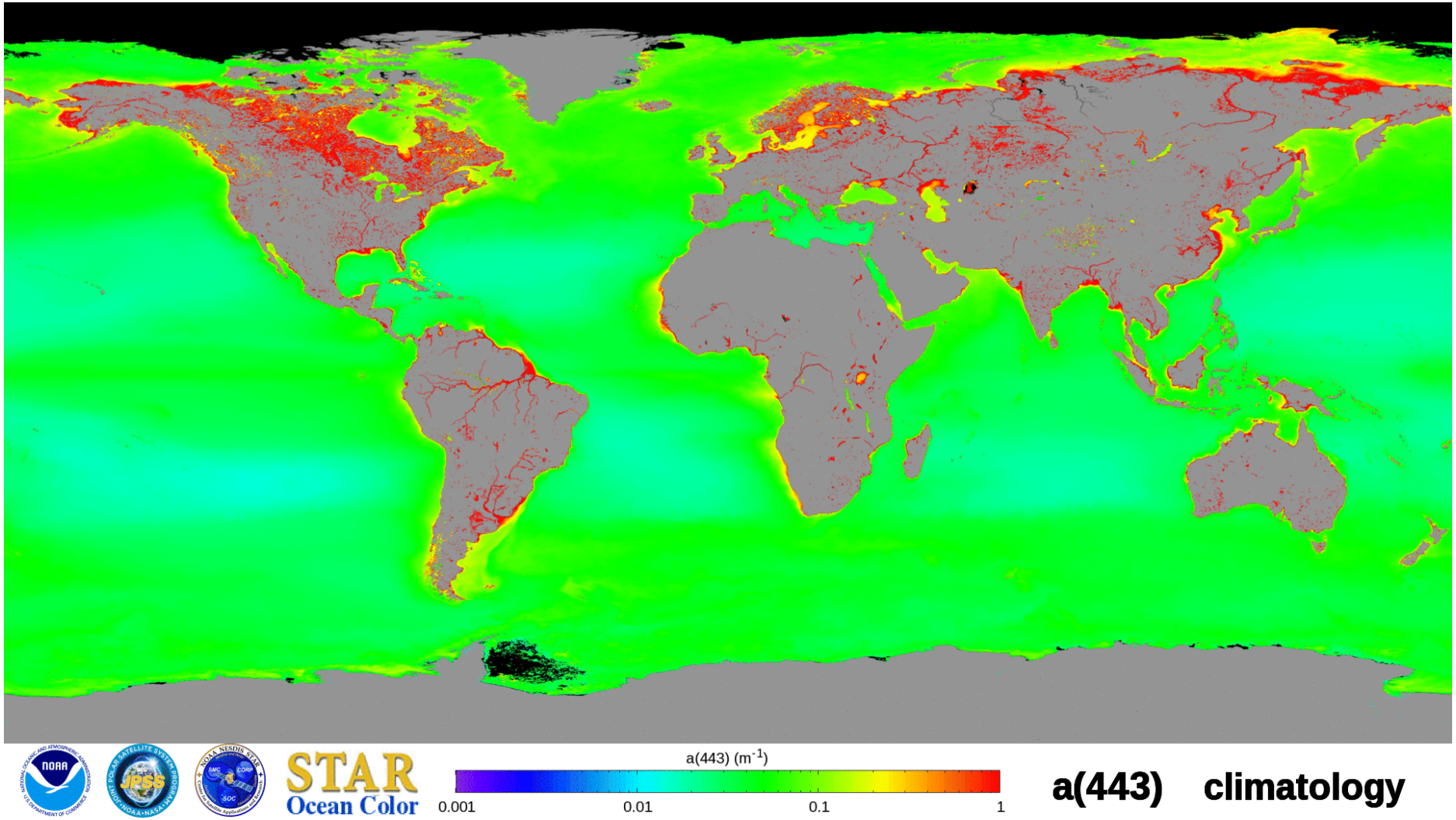
Attribute	Near-Real Time	Delayed-Mode/Science-Quality
Latency:	Best effort, as soon as possible (~12-24h)	Best effort, on a 2-week delay
Processing System:	**MSL12** (v1.01; will transition to v1.2x)	**MSL12** (v1.2x)
SDR:	**IDPS Operational SDR**	**OC-improved SDR**
Ancillary Data:	Global Forecast System (GFS) Model	Science quality (assimilated; GDAS) from NCEP
Spatial Coverage:	May be gaps due to various issues	Complete global coverage
Processed by:	OSPO (operational)	NOAA/STAR
Distributed by:	CoastWatch , OSPO	CoastWatch, NCEI
Archive Plans:	Yes, from OSPO to NCEI	Yes, from CoastWatch to NCEI
Full Mission Reprocessing:	No	Yes, every ~2-3 years or as needed

Typical Product Lifecycle



Experimental Ocean Color Product Image (Selected)

SNPP (2012–2018)



NOAA MSL12 with the NIR-SWIR data processing system is used for VIIRS

Menghua Wang, NOAA/NESDIS/STAR

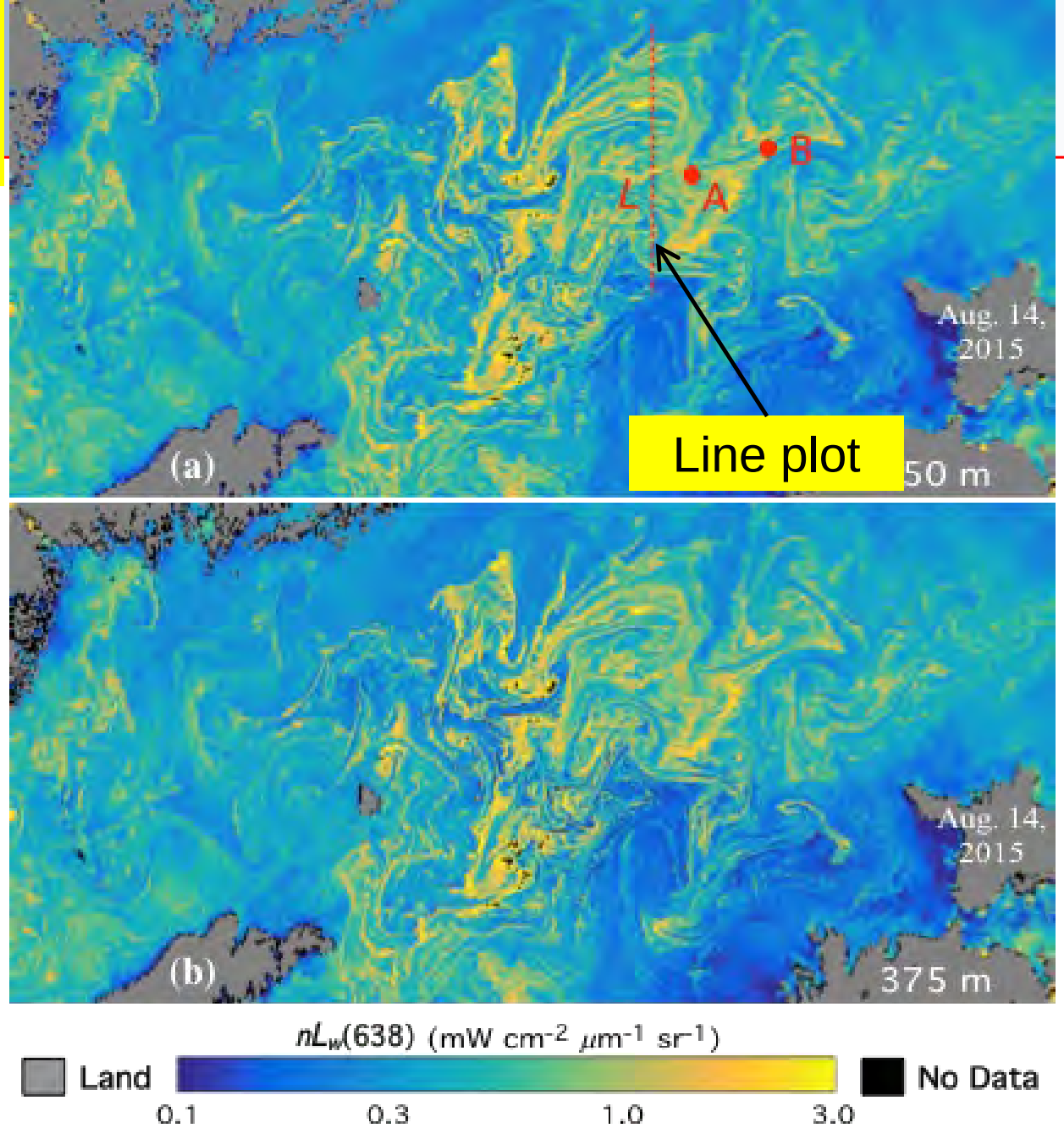
New VIIRS $nL_w(638)$ with Imaging Bands

(Resolution at 375 m)

Example:

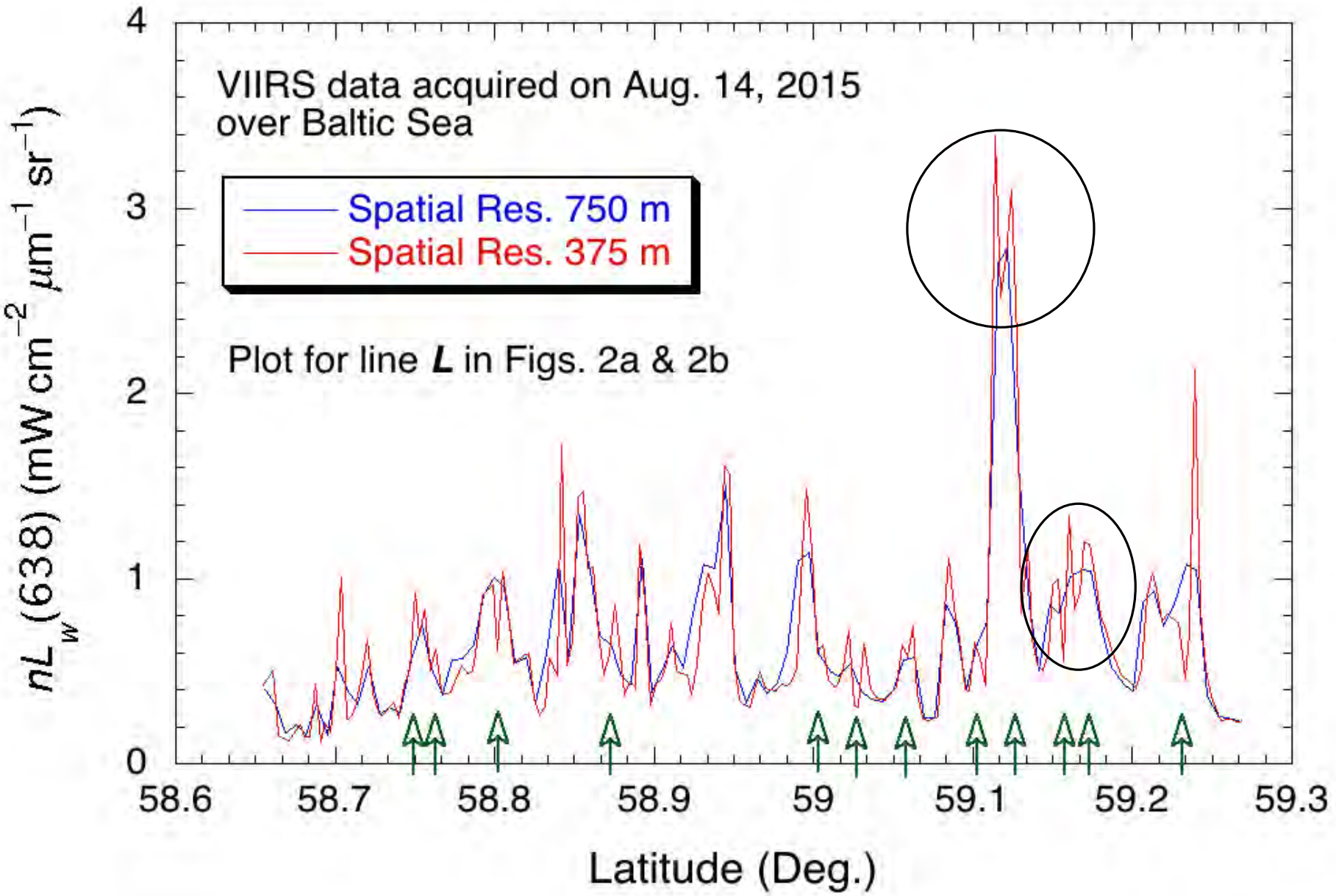
Algae Bloom in the Baltic Sea on August 14, 2015

One can see differences between two images for bloom size < ~500 m, showing high spatial resolution data providing more details for bloom spatial distribution/features

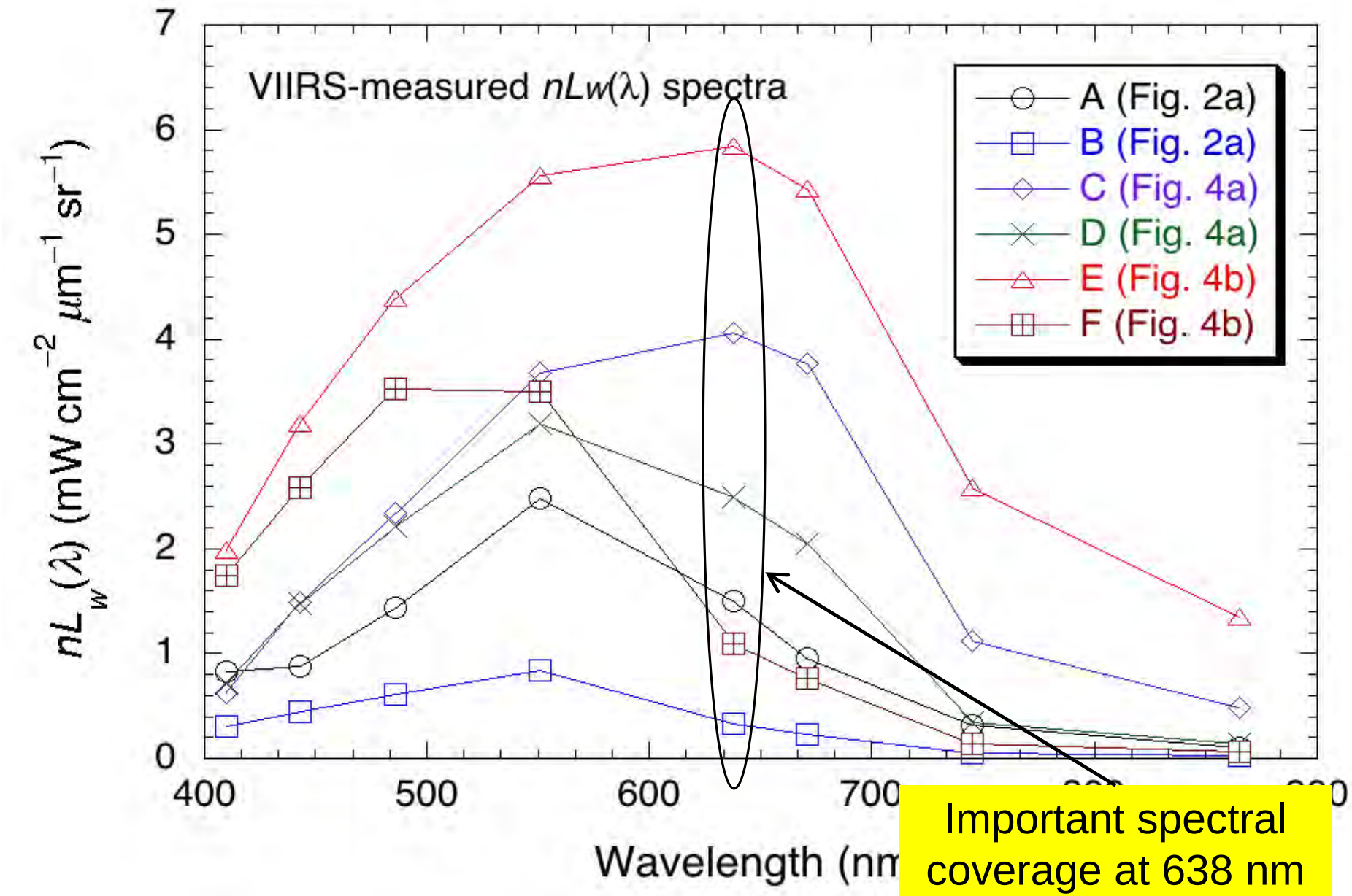


Wang, M. and L. Jiang (2017), "VIIRS-derived ocean color product using the imaging bands", *Remote Sen. Environ.*, **206,** 275–286, 2018. http://dx.doi.org/10.1016/j.rse.2017.12.042

More Detailed Algae Bloom Information Provided by VIIRS High Spatial Resolution (375 m) $nL_w(638)$ Data



Increased spectral coverage with VIIRS new $nL_w(638)$ data, providing important spectral information



MOBY at NOAA

on CoastWatch.NOAA.gov

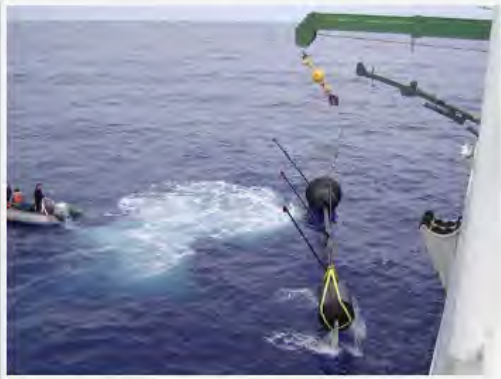
Ocean Color Radiances from MOBY

The following list highlights the various data product types available from NOAA CoastWatch:

The Marine Optical BuoY (MOBY) is a NOAA funded project to provide vicarious calibration of oce (SeaWiFS, MODIS, and VIIRS NPP, VIIRS NOAA-20, OLCI Sentinel-3A, SGLI GCOM-C, and mo

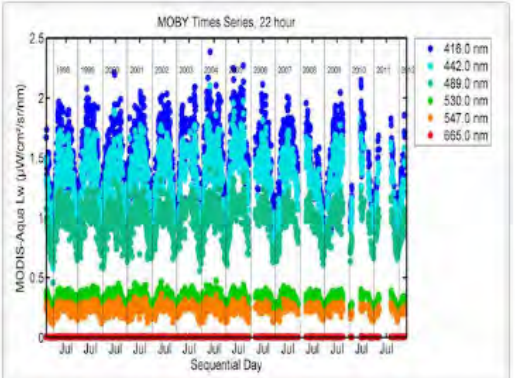
MOBY is an autonomous optical buoy which is moored off the island of Lanai in Hawaii. The syste measuring sunlight incident on and scattered out of the ocean.

These measurements are provided in near real time for the vicarious calibration procedures condu scientists.



Deployment Information
Operational at the Lanai site since July 1997.
Daily data collection.
Four month deployment.
Deployment Record: July 1997 to current.

View Deployment Information ›



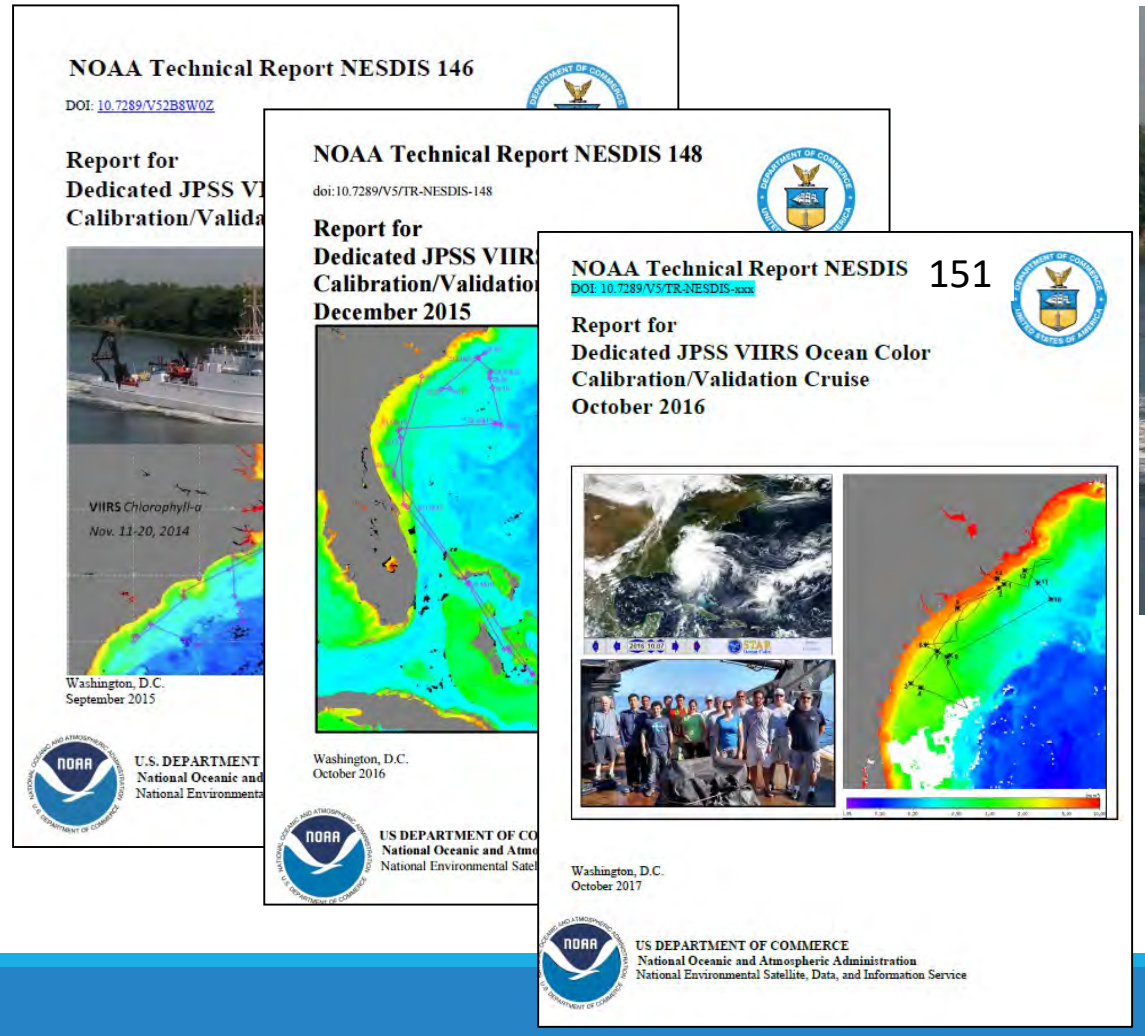
Gold Directory
Satellite weighted data; SeaWiFS, MODIS, VIIRS NPP, VIIRS NOAA-20, OLCI Sentinel-3A, SGLI GCOM-C, and more.
No bad observations.

View Gold Directory ›

MOBY Spectral Data Lis
All observed raw data.
Filename Font Color indi
1. Good
2. Bad
3. Questionable
4. Bad and Cloudy

View

NOAA Ocean Color Annual Dedicated Cal/Val Cruises (5 completed to date, next in Spring 2020, Hawaii)



NOAA STAR CENTER FOR SATELLITE APPLICATIONS AND RESEARCH

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VIIRS/SNPP Ocean Color Product Calibration / Validation

Data Source: Science Quality (NIR)

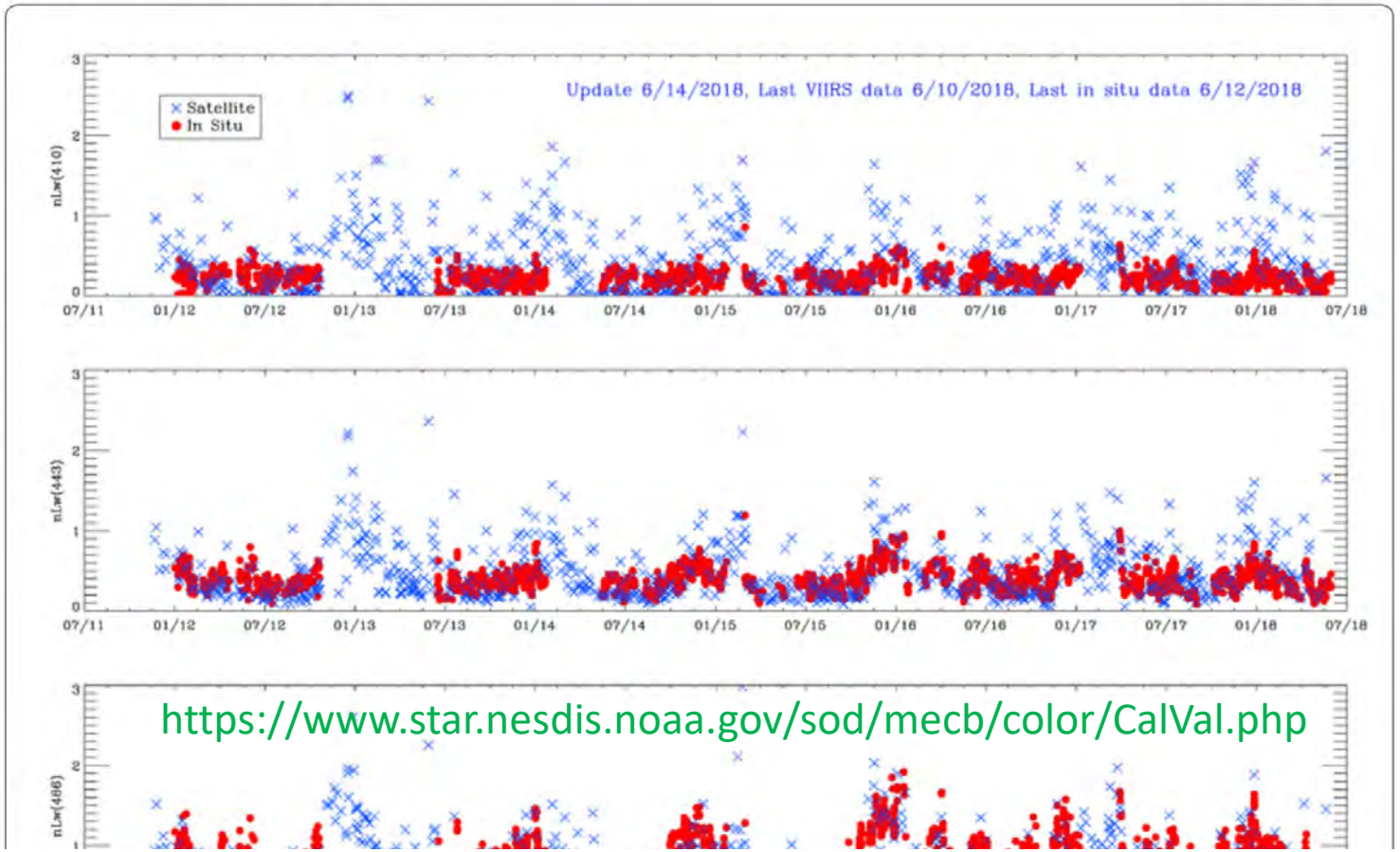
Location: AERONET-LISCO data matchup

View Site Locations On Map

Science Quality (NIR): AERONET LISCO Site Ocean Color Data Matchup

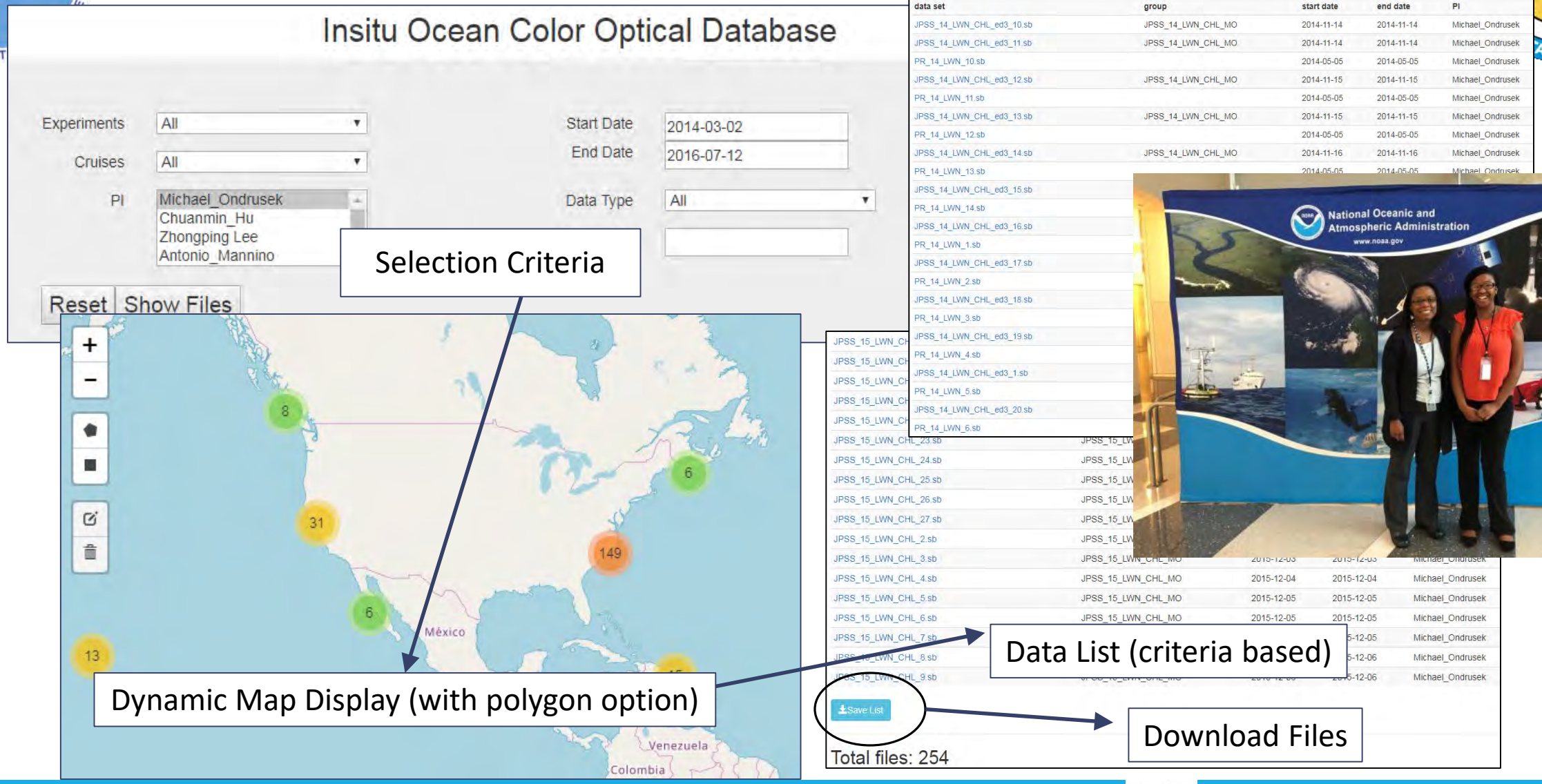
Select a parameter for interactive plot: none

View Scatter Plot



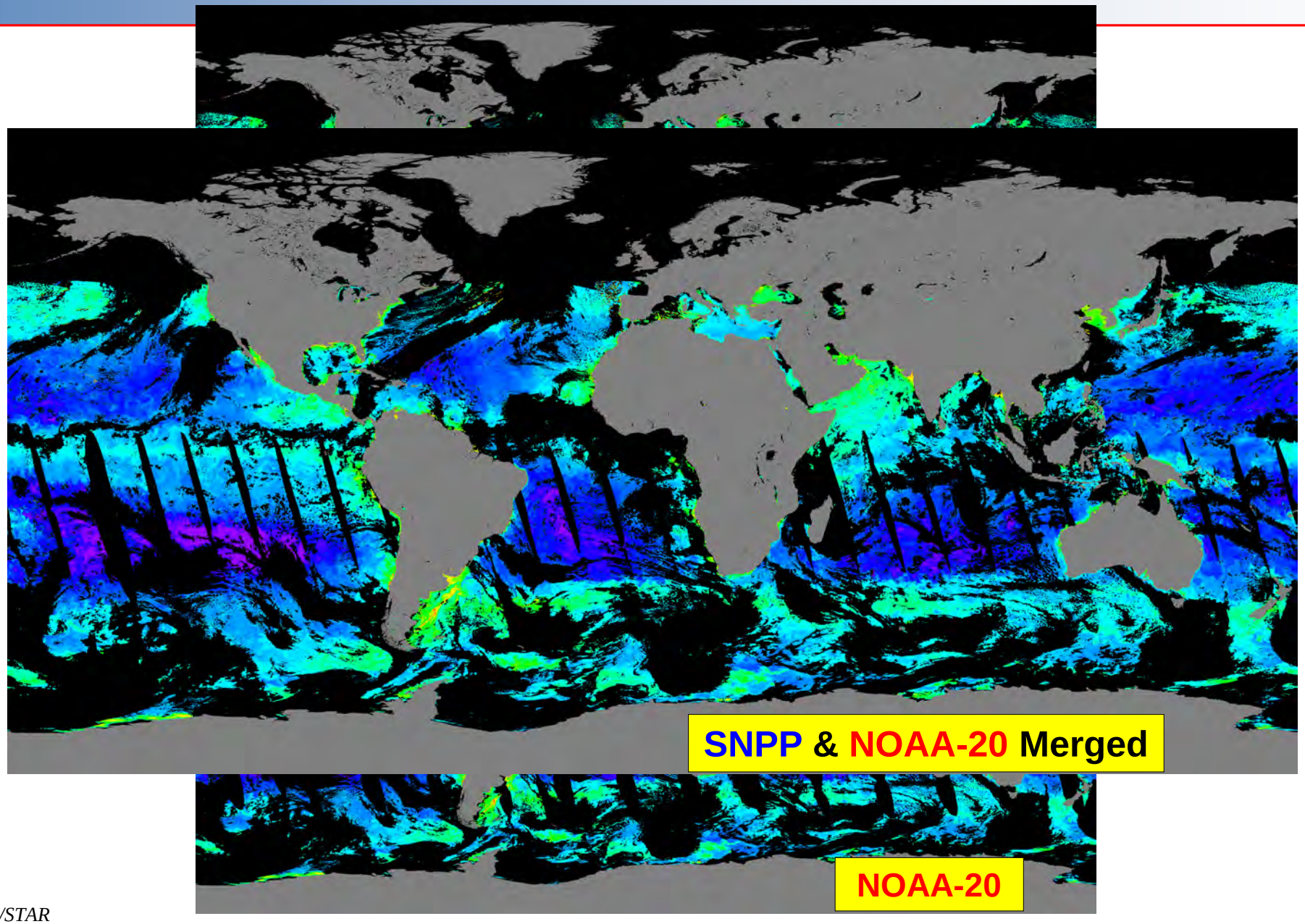
https://www.star.nesdis.noaa.gov/sod/mecb/color/CalVal.php

In situ Ocean Color Database



VIIRS-SNPP and NOAA-20 Chl-a Images

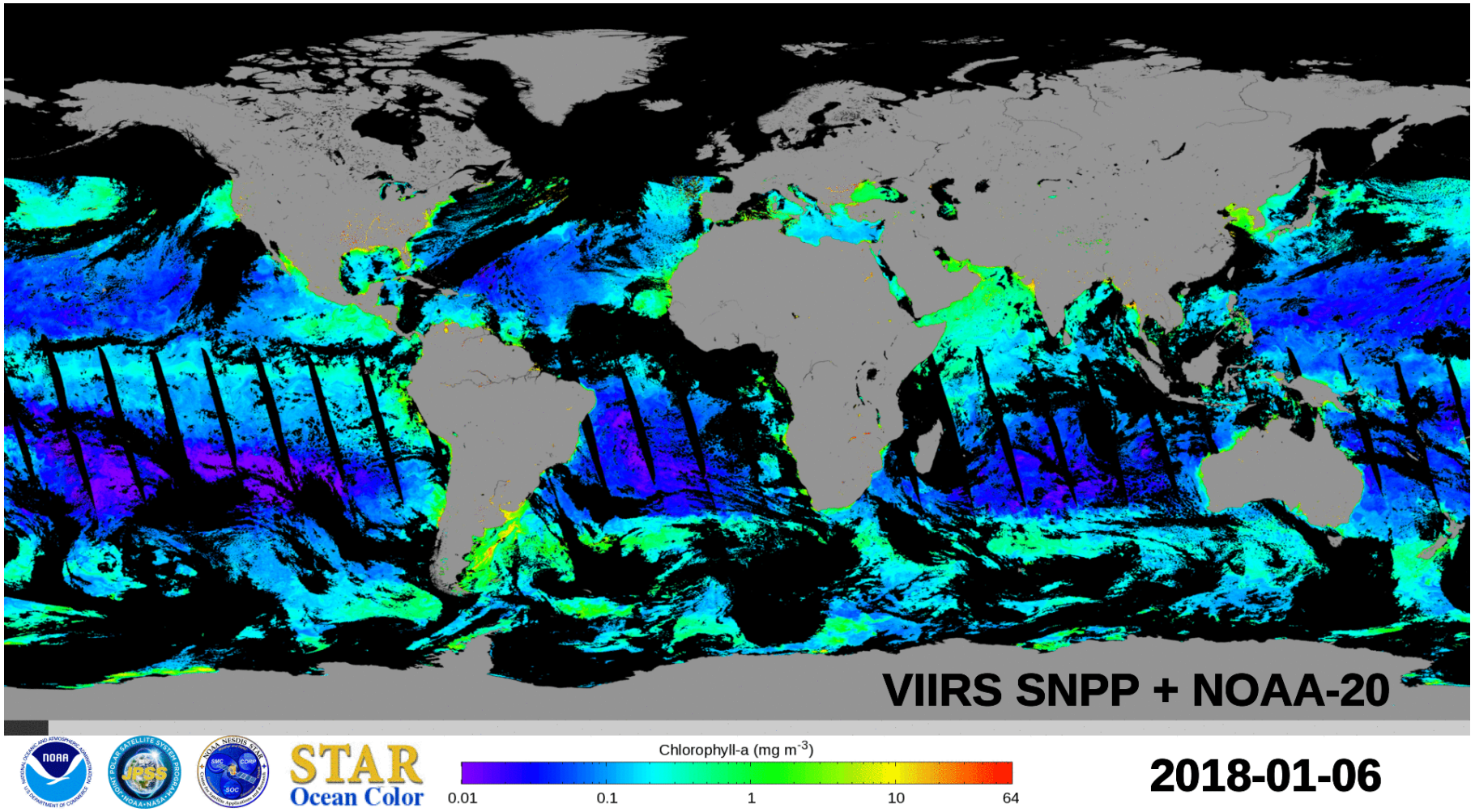
(January 6, 2018)



Menghua Wang, NOAA/NESDIS/STAR

VIIRS-SNPP and NOAA-20 Merged Chl-a Images

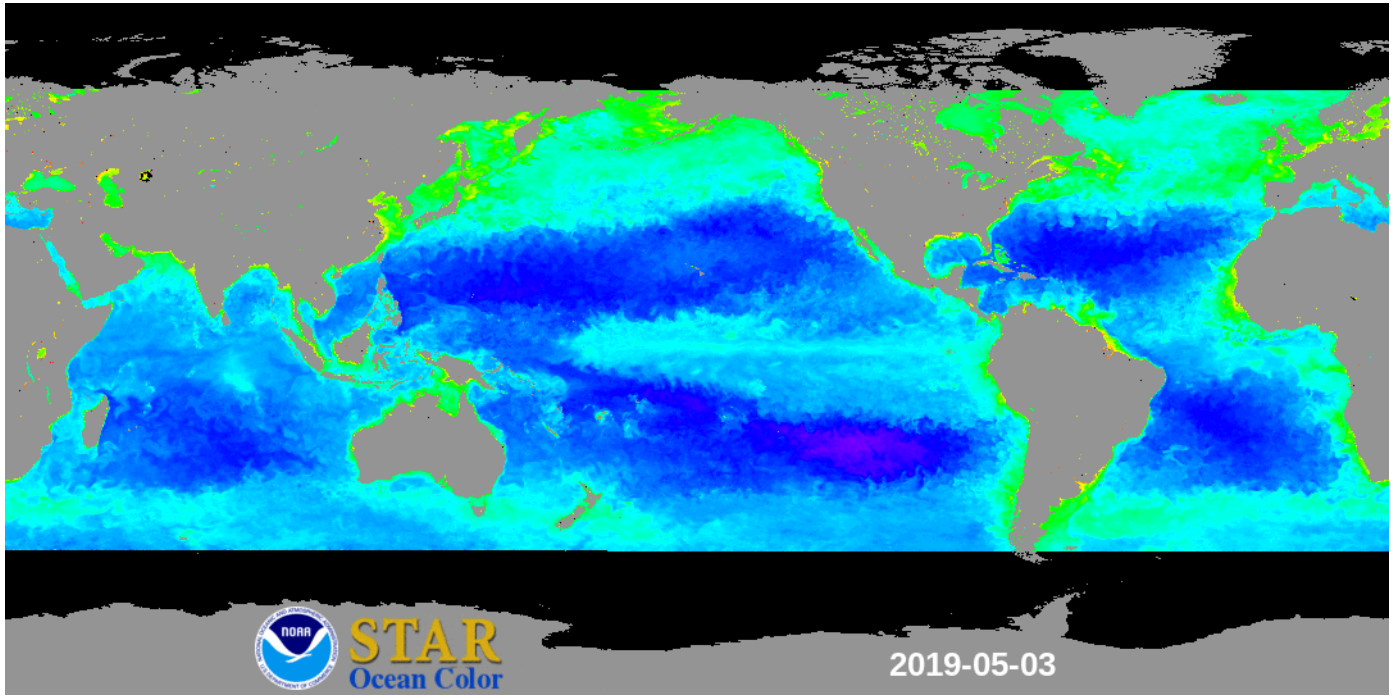
(January 6-February 7, 2018)

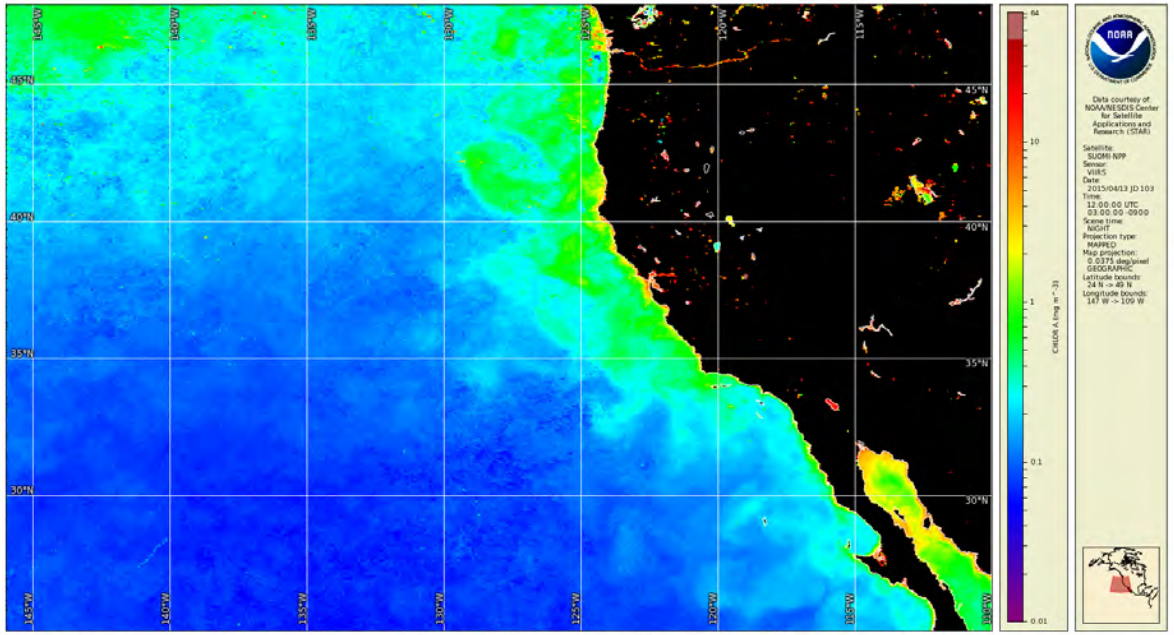


Courtesy of Menghua Wang and team, NESDIS/STAR/SOCD

Animation

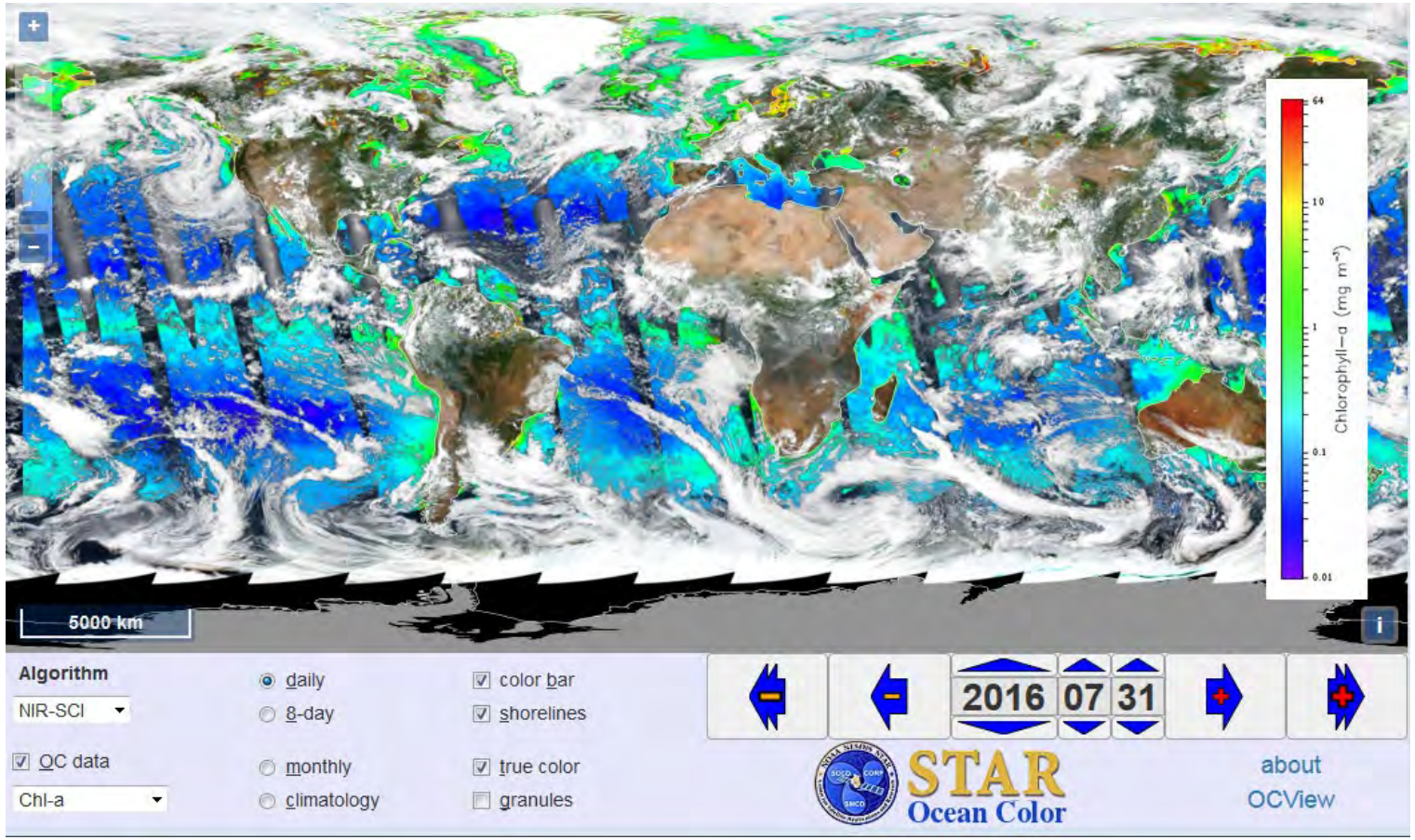
NOAA/STAR VIIRS Merged & Gap-Filled Chl-a Product





NOAA/STAR Ocean Color

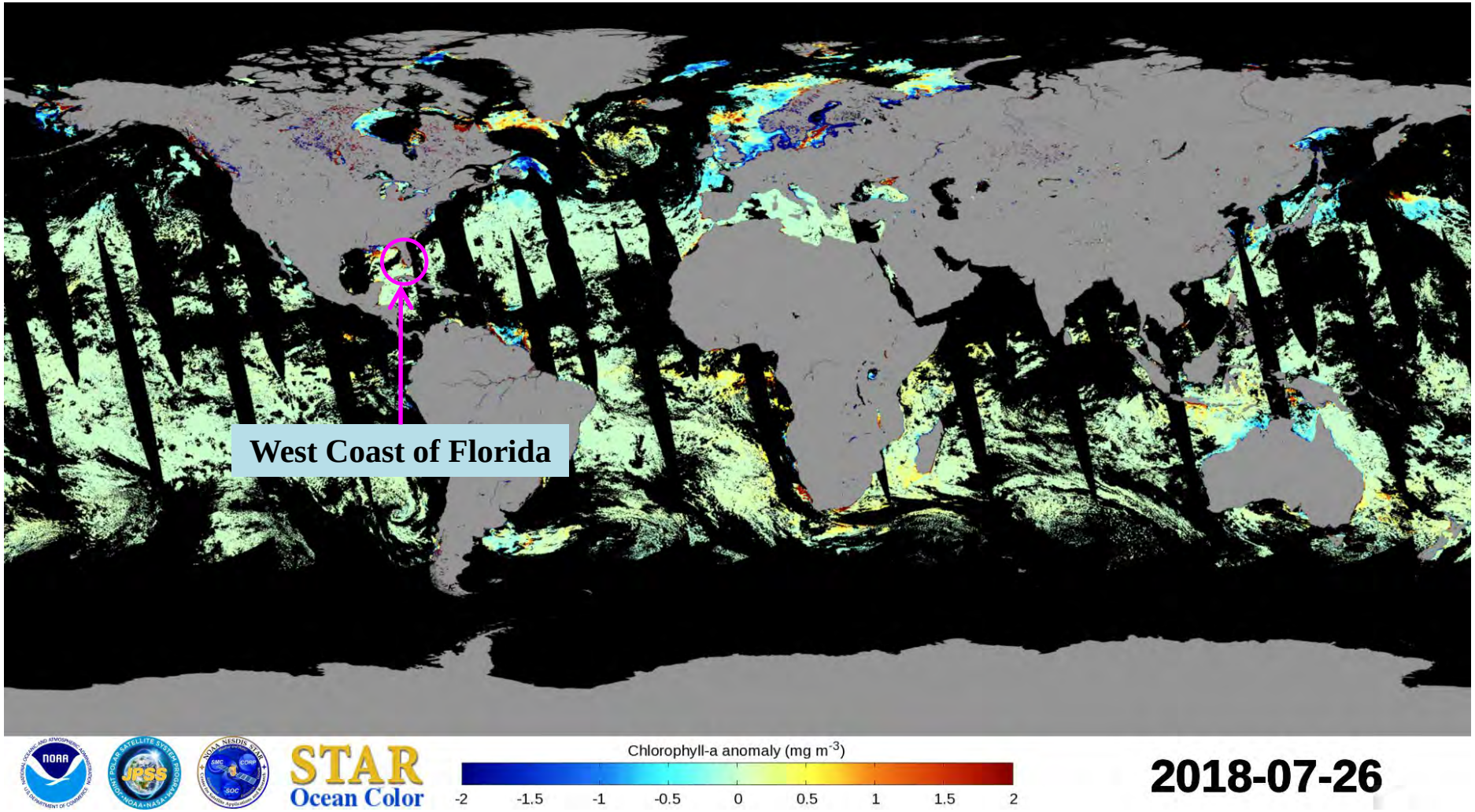
NOAA VIIRS Ocean Color Team: Introduced OCView tool for easy, interactive image monitoring



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

See AGU EOS article: https://eos.org/project-updates/interactive-online-maps-make-satellite-ocean-data-accessible

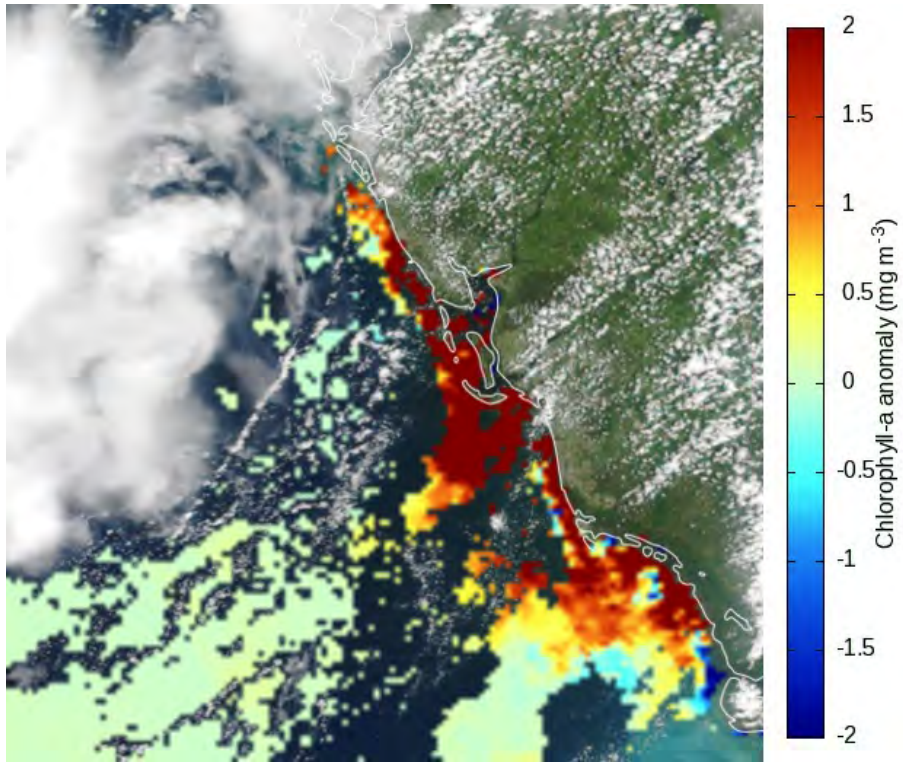
VIIRS-SNPP Chl-a Anomaly
(July 26, 2018)



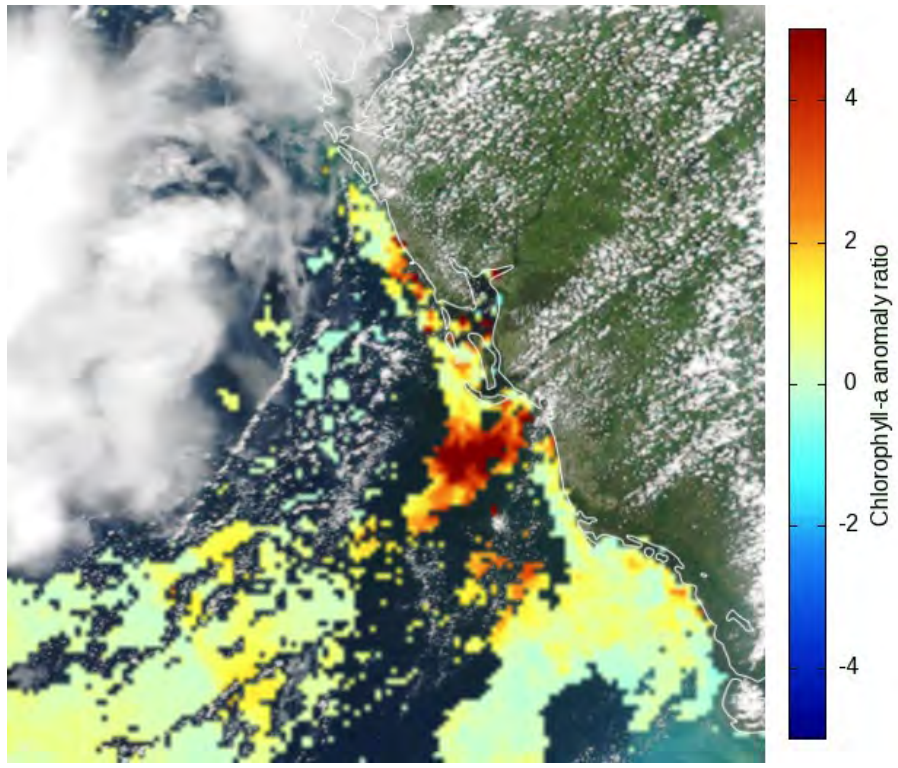
Global daily NRT Chl-a anomaly and anomaly ratio are *Routinely* produced

Menghua Wang, NOAA/NESDIS/STAR

Harmful Algal Bloom Detection and Prediction



Chl-a Anomaly



Chl-a Anomaly Ratio

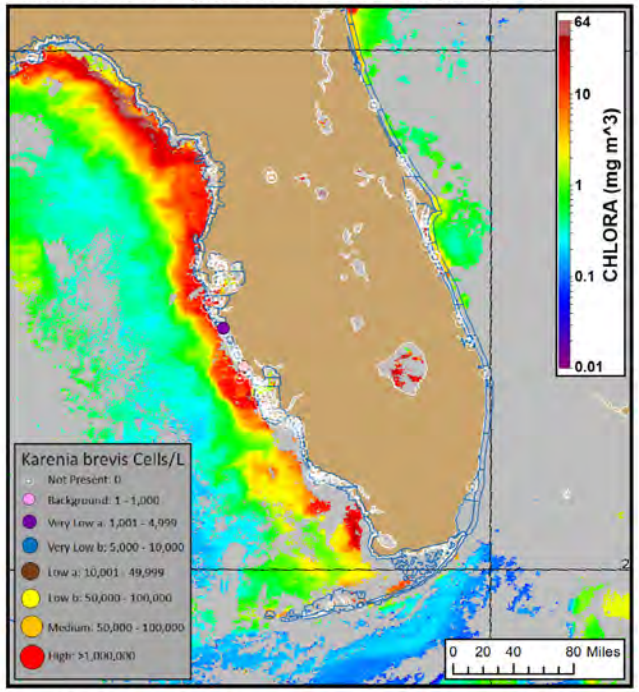
High chlorophyll-a anomaly linked to HAB presence in waters off the Gulf Coast of Florida. Global NRT Chl-a anomaly and anomaly ratio are routinely produced

Gulf of Mexico Harmful Algal Bloom Bulletin

Monday, August 26, 2019
NOAA National Ocean Service
NOAA Satellite and Information Service
NOAA National Weather Service

Region: Southwest Florida

Instructions for viewing this geospatial pdf are available at: https://go.usa.gov/xn9g2.



Karenia brevis cell concentration sampling data from: 08/16/19 through 08/23/19. Cell count data are provided by Florida FWC Fish and Wildlife Research Institute. For a list of sample providers and a key to the cell concentration categories, please see the HAB-OFS bulletin guide: https://tidesandcurrents.noaa.gov/hab/hab_publication/GOMX_HAB_Bulletin_Guide.pdf. Detailed sample information can be obtained through the Florida FWC Fish and Wildlife Research Institute: http://myfwc.com/REDTIDESTATUS.

MODIS Aqua satellite chlorophyll image (08/24/19) with possible *K. brevis* HAB areas shown by red polygon(s).

Conditions Report

No respiratory irritation associated with *Karenia brevis* (commonly known as red tide) is expected in this region.

Analysis

Imagery:

***Due to the upcoming federal holiday, the next bulletin will be issued on Tuesday, September 3.*

Recent ensemble imagery (MODIS Aqua, 8/24) is partially obscured by clouds alongshore the Florida coast, limiting analysis. Patches of very high chlorophyll (2 to >20 µg/L) with some of the optical characteristics of *K. brevis* are visible from Pinellas to Lee counties.

Forecasts:

Harmful algal bloom formation at the coast of southwest Florida is not expected today through Tuesday, September 3.

Keeney, Davis

https://tidesandcurrents.noaa.gov/hab/gomx.html

Lake Erie Harmful Algal Bloom Bulletin

03 September, 2019, Bulletin 19

Analysis

The *Microcystis* cyanobacteria bloom continues in the western basin of Lake Erie. Recent satellite imagery (9/2) shows the bloom extending from Maumee Bay north along the Michigan coast, to Brest Bay; east along the Ohio coast to the Marblehead Peninsula, offshore through the Bass Islands, and up to 10 miles east of Pelee Island. Observed conditions (8/27-9/2) promoted mixing and eastern transport of surface bloom concentration, now present in the central basin. Measured toxin concentrations are below recreational thresholds throughout most of the bloom extent. *Keep pets and yourself out of the water in areas where scum is forming.* The persistent cyanobacteria bloom in Sandusky Bay continues. No other blooms are present in Lake Erie.

Forecasts

Winds (9-26 kn) forecast today through Thursday (9/2-5) will promote mixing and eastern transport of surface *Microcystis* concentrations along the Michigan coast. Keeney, Ilima

Additional Resources

To find a safe place for recreation, visit the Ohio DOH "BeachGuard" site: *http://publicapps.odh.ohio.gov/beachguardpublic/*
Ohio EPA's site on harmful algal blooms: *http://epa.ohio.gov/HAB-Algae*
NOAA's GLERL provides additional HAB data here: *http://www.glerl.noaa.gov/res/HABs_and_Hypoxia*

The images below are "GeoPDF". Please visit https://go.usa.gov/xkeTC for instructions on viewing longitude and latitude.

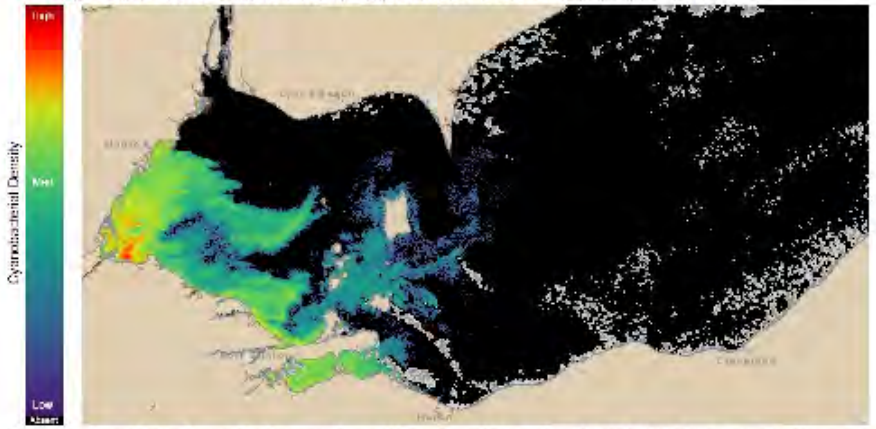


Figure 1. Cyanobacterial index from modified Copernicus Sentinel 3 data collected 02 September, 2019 at 11:49 EST. Grey indicates clouds or missing data. The estimated threshold for cyanobacteria detection is 20,000 cells/mL.

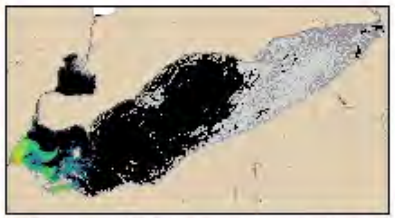
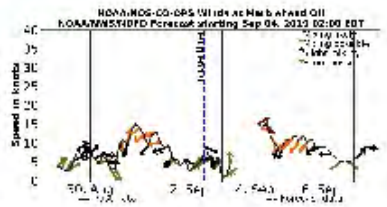


Figure 2. Cyanobacterial index from modified Copernicus Sentinel 3 data collected 02 September, 2019 at 11:49.



Wind speed and direction from Marblehead, OH. Blooms mix through the water column at wind speeds greater than 15 knots (or 7.7 m/s).

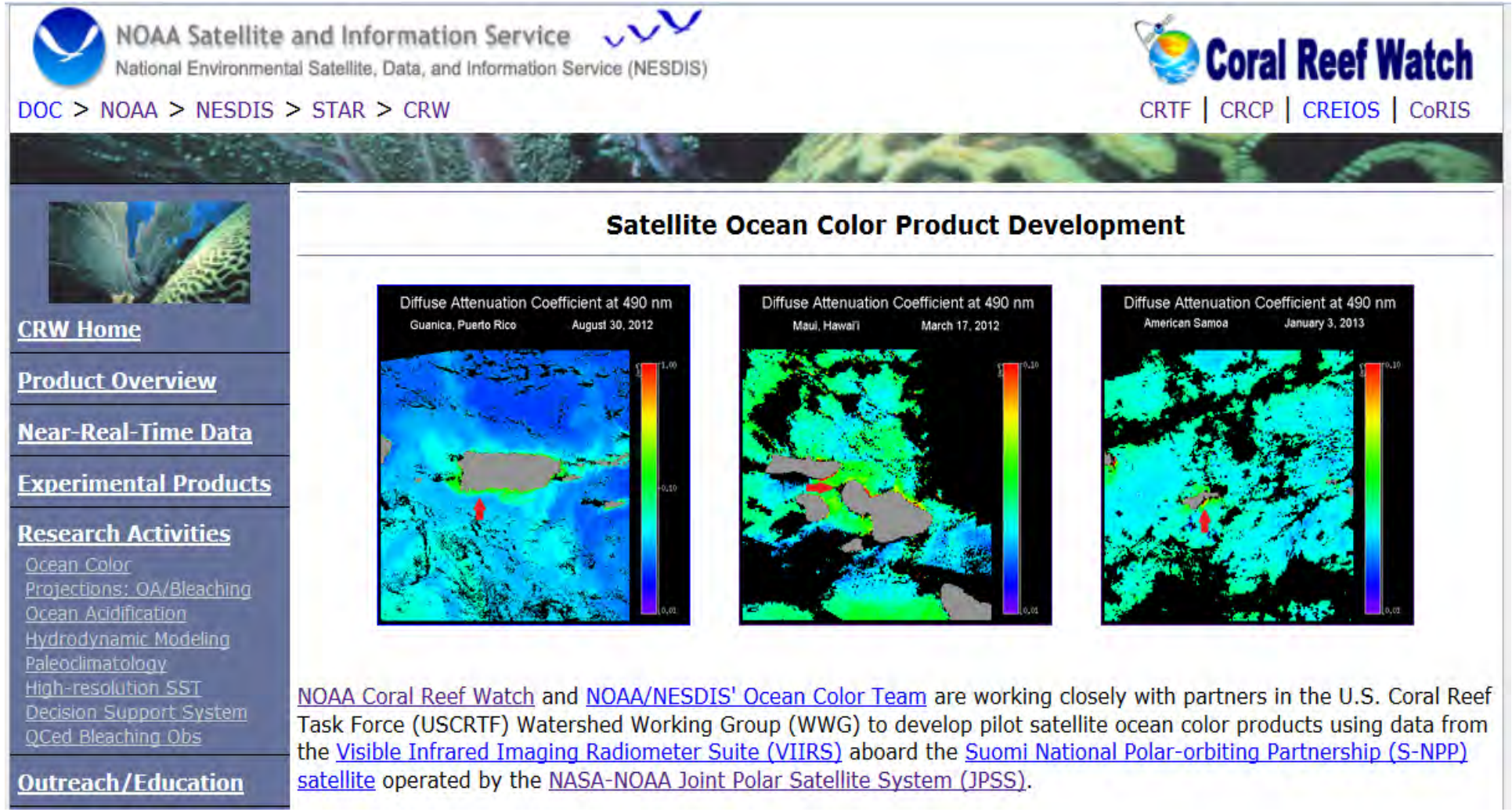
For more information and to subscribe to this bulletin, go to: https://tidesandcurrents.noaa.gov/hab/lakeerie.html

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

NOAA Harmful Algal Bloom Bulletins

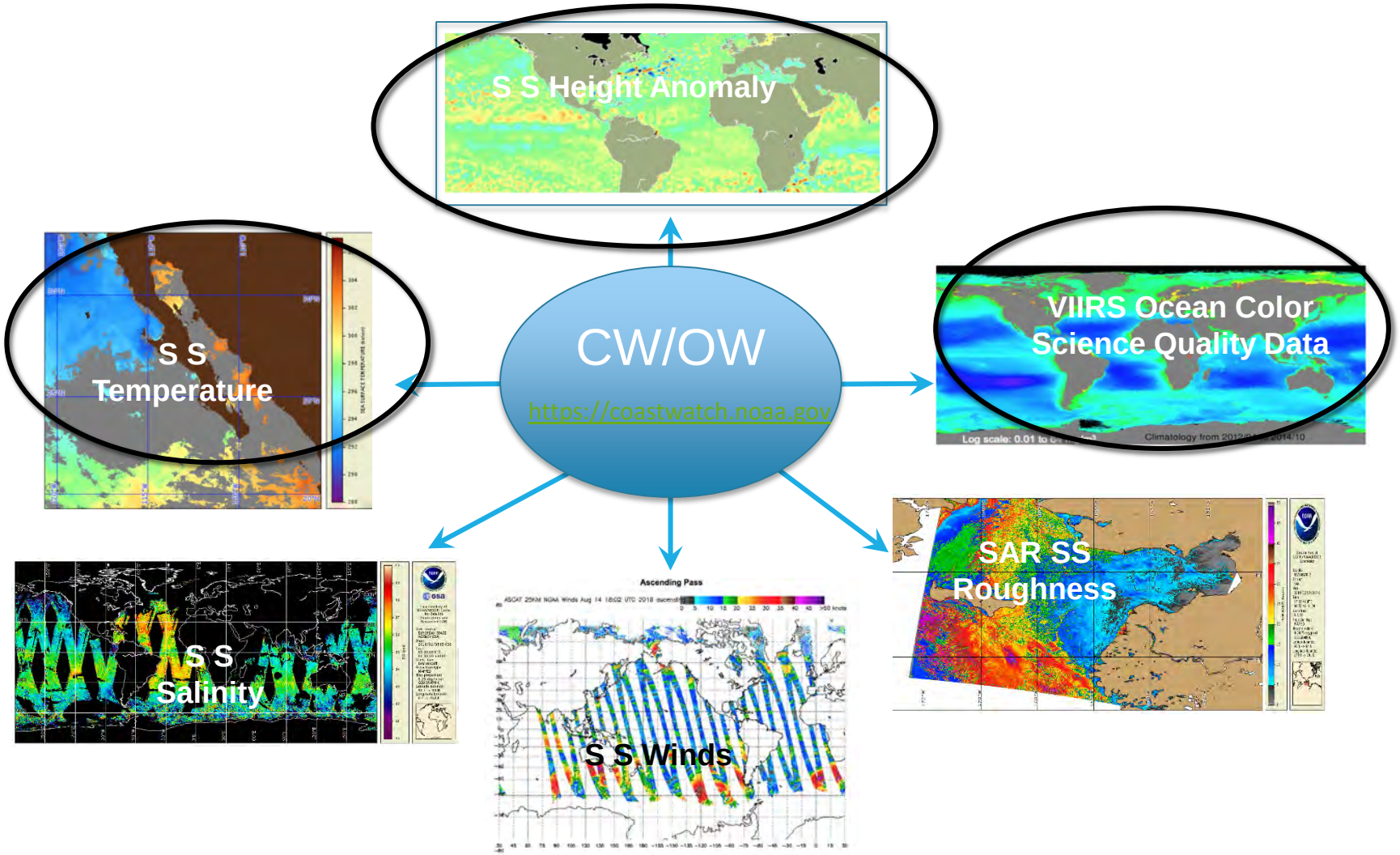
Ocean Color Tools for Reef Managers

http://coralreefwatch.noaa.gov/satellite/research/oceancolor.php



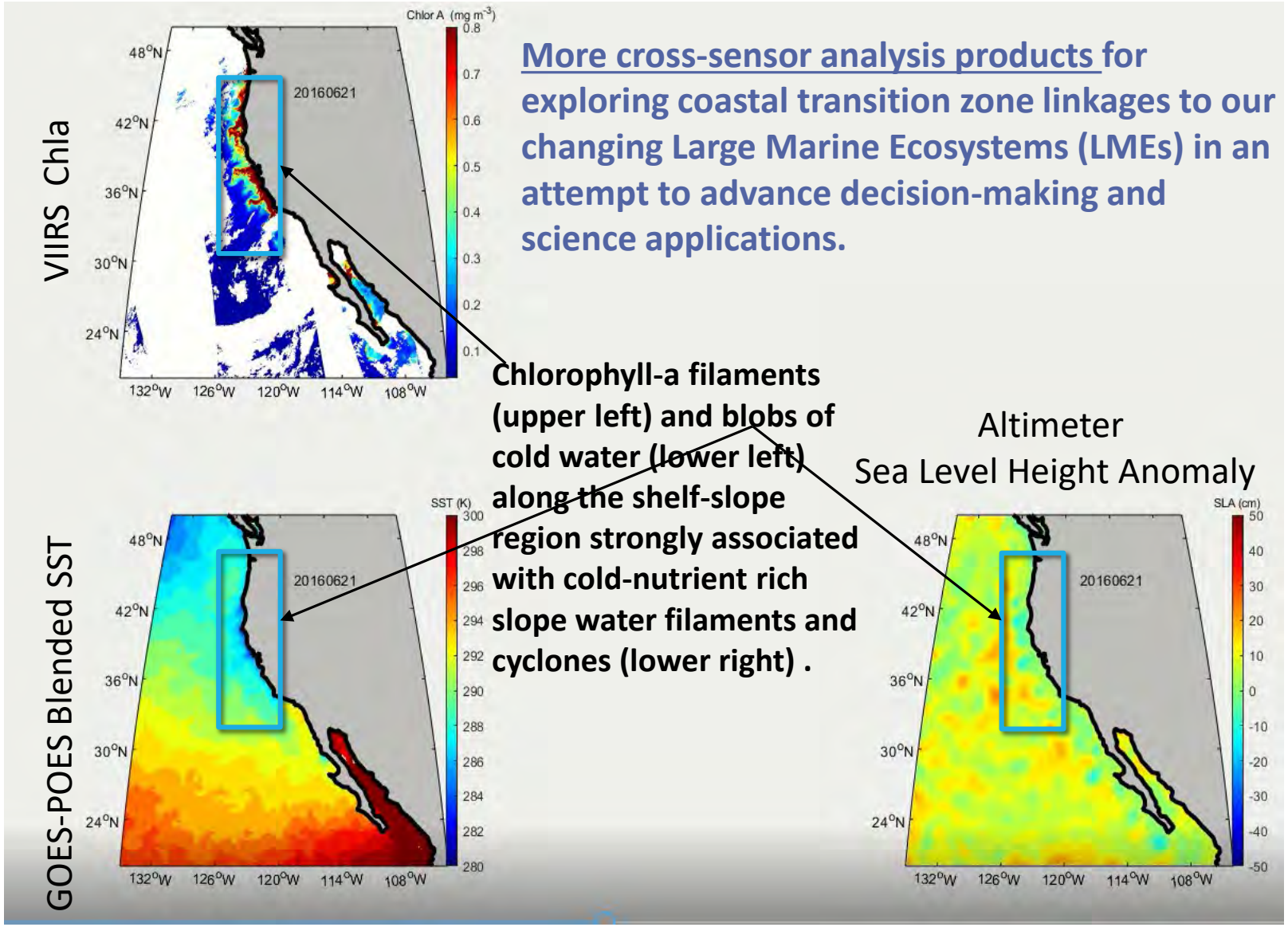
*From **Coral Reef Watch***

On the Need for Combined Cross-Sensor Analysis



Data from CW/OW through STAR Science Teams

Ongoing & Further Applications using multi-sensor satellite data



More cross-sensor analysis products for exploring coastal transition zone linkages to our changing Large Marine Ecosystems (LMEs) in an attempt to advance decision-making and science applications.

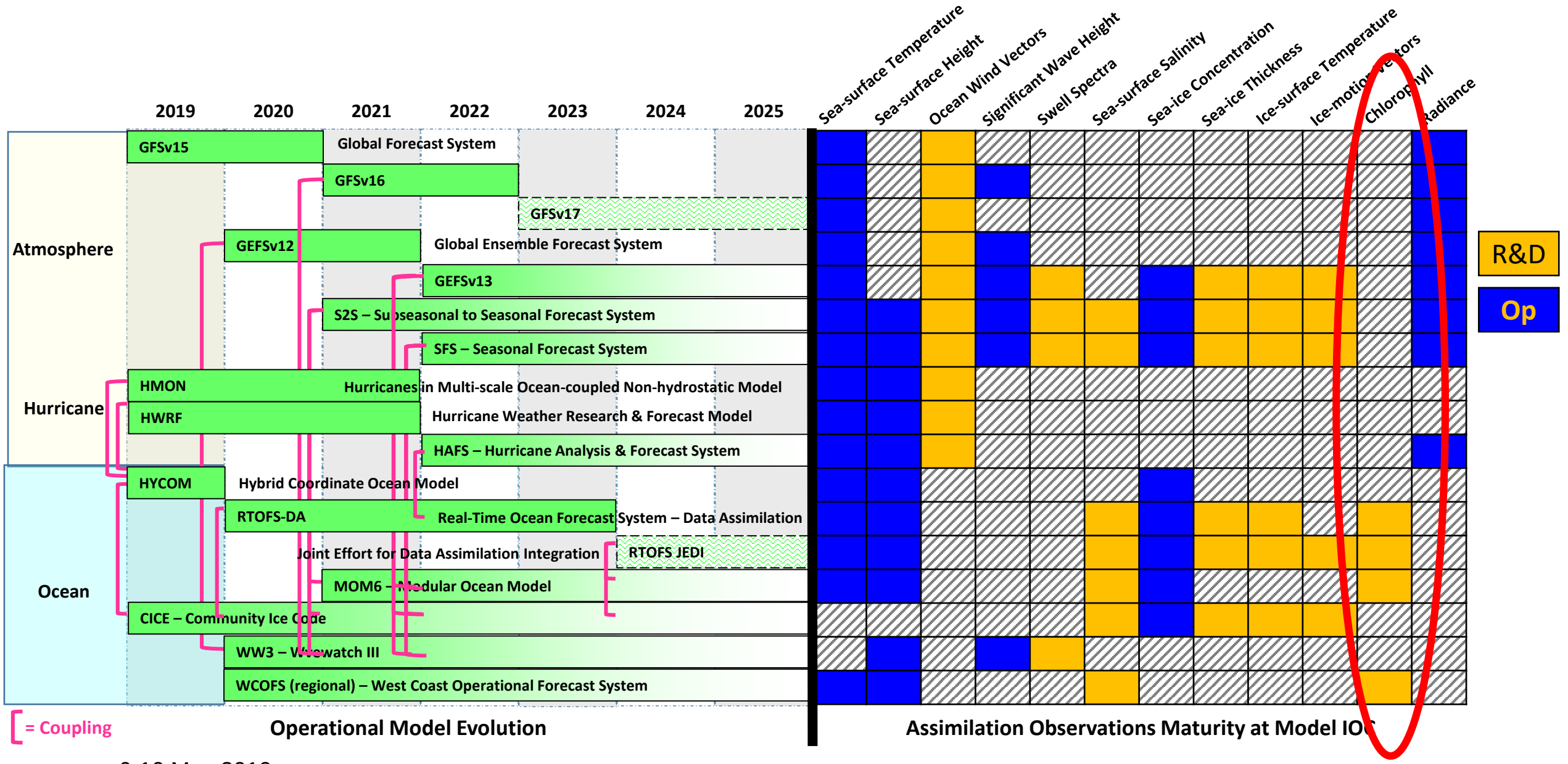
Chlorophyll-a filaments (upper left) and blobs of cold water (lower left) along the shelf-slope region strongly associated with cold-nutrient rich slope water filaments and cyclones (lower right) .

Satellite Observations in Numerical Prediction

- **Current NOAA ocean prediction operations:**
  - Sea-surface temperature
  - Sea-surface altimetry (sea-surface height anomaly)
  - Sea-ice concentration/edge
  - Sea-surface roughness (ocean vector winds, ocean wind speed)

- **Research and development (R&D) targeting ocean prediction:**
  - Sea-surface salinity
  - Sea-ice thickness
  - Ice-surface temperature
  - Ice-motion vectors
  - Ocean radiometry (color)
  - Swell spectra
  - Significant wave height
  - Radiances

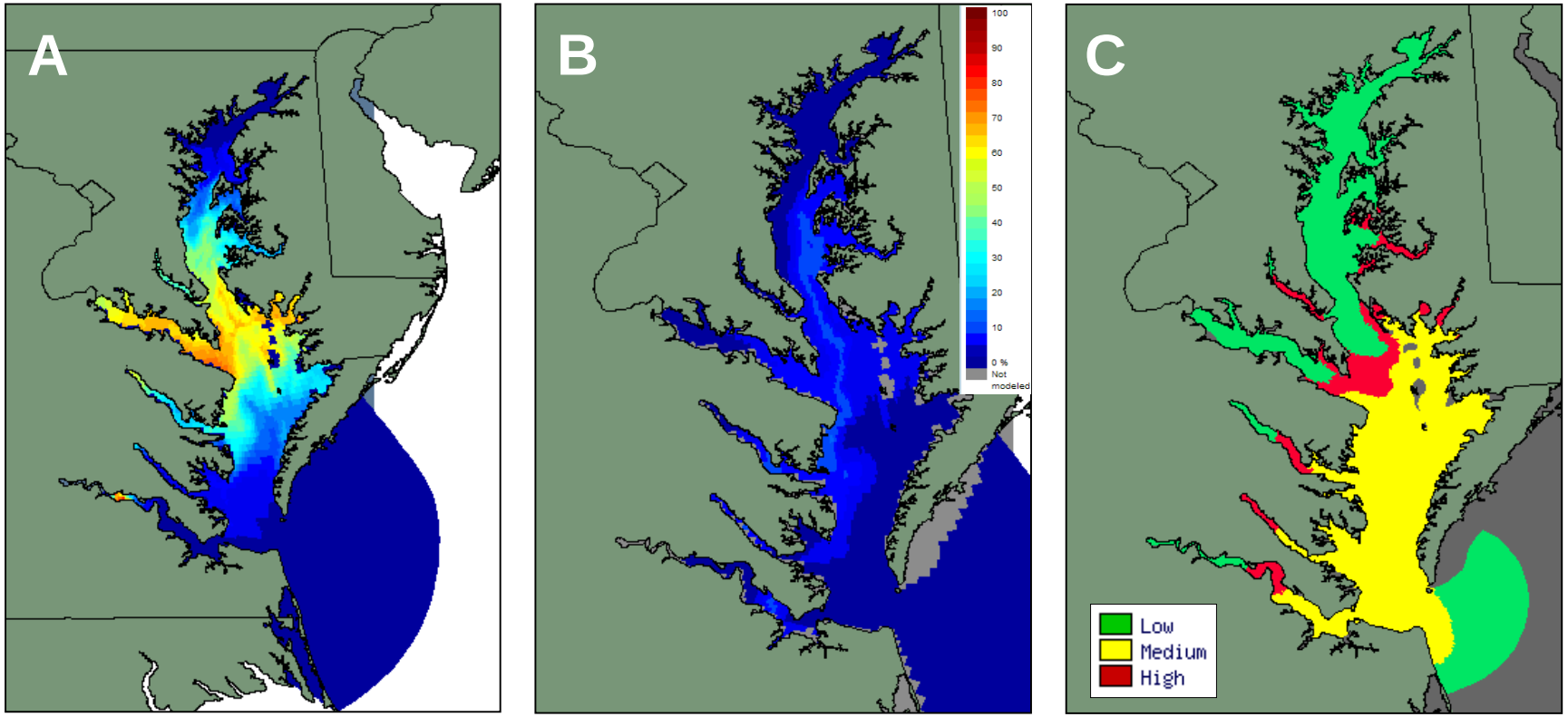
Satellite Ocean Data for Operational Environmental Modeling



Ecological Forecasting

- **Data Assimilation**
  - Satellite-derived chlorophyll, Kd_{PAR}, and bio-optically-active reflectance for improving HAB, biogeochemical, and SST model predictions
    - Component development effort for pending NOAA operational West Coast regional model
    - California-Harmful Algae Risk Mapping (C-HARM)
    - NOAA's EcoCast, which provides fishing guidance to minimize bycatch
  - Neural network methodology demonstrated for filling data spatial/temporal gaps and providing forecasted values
- **Habitats**
  - **NOAA Coral Reef Watch Program provides:**
    - Current and upcoming reef environmental conditions using POES-GOES Blended SST product to provide to quickly identify areas at risk for coral bleaching
    - Weekly predictions of the likelihood of coral bleaching heat stress based on NOAA's Climate Forecast System to up to four months in the future
- **Water Quality**
  - **NOAA's Ocean Service generates operational and experimental Harmful Algal Bloom (HAB) Forecasts** using satellite ocean color derived products (chl-a anomaly; cyanobacterial index) and associated wind/transport forecasts
    - Includes New product development efforts are underway to optically discriminate water mass constituents using satellite ocean color data
    - Improved detection, tracking and forecasting of coastal plumes and blooms
    - Discrimination of phytoplankton functional taxa and size in support of fisheries management and other applications
  - **NOAA CoastWatch/OceanWatch satellite ocean observations and tools support monitoring:**
    - Risk index for bacteria (multiple health issues, including seafood contamination)
    - Turbidity and visibility
    - Floating algae index
    - Ocean acidification

Ecological Forecasting



Examples of species forecasts generated by the Chesapeake Bay Ecological Prediction System. (A) Likelihood of encountering sea nettles, *Chrysaora quinquecirrha* on 17 August 2007. (B) Likelihood of *Vibrio vulnificus* on 20 April 2011. (C) Relative abundance of *K. veneficum* on 20 April 2005. Legend: low: 0-10, med: 11-2000 cells/ml, high: > 2000 cells/ml. Color bar for likelihood is the same for both A and B.

Water Quality Monitoring and Forecasting

Progress in Oceanography 159 (2017) 45–72

Contents lists available at ScienceDirect

Progress in Oceanography

journal homepage: www.elsevier.com/locate/pocean

Review

Uncertainties and applications of satellite-derived coastal water quality products

Guangming Zheng[a,b,*], Paul M. DiGiacomo[a]

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ARTICLE INFO

Keywords:
Light absorption
Light scattering
Light backscattering
Water-leaving radiance
Remote-sensing reflectance
Water quality

ABSTRACT

Recent and forthcoming launches of a plethora of ocean color radiometry sensors, coupled with increasingly adopted free and open data policies are expected to boost usage of satellite ocean color data and drive the demand to use these data in a quantitative and routine manner. Here we review factors that introduce uncertainties to various satellite-derived water quality products and recommend approaches to minimize the uncertainty of a specific product. We show that the regression relationships between remote-sensing reflectance and water turbidity (in terms of nephelometric units) established for different regions tend to converge and

https://doi.org/10.1016/j.pocean.2017.08.007

Satellite Monitoring of Post-Storm Coastal Sediment Plumes

Sediment plume in Chesapeake Bay following 2011's Tropical Storm Lee

- Satellites can measure concentration of sediment in the surface water
- Red indicates high sediment concentration as a result of storm runoff from land

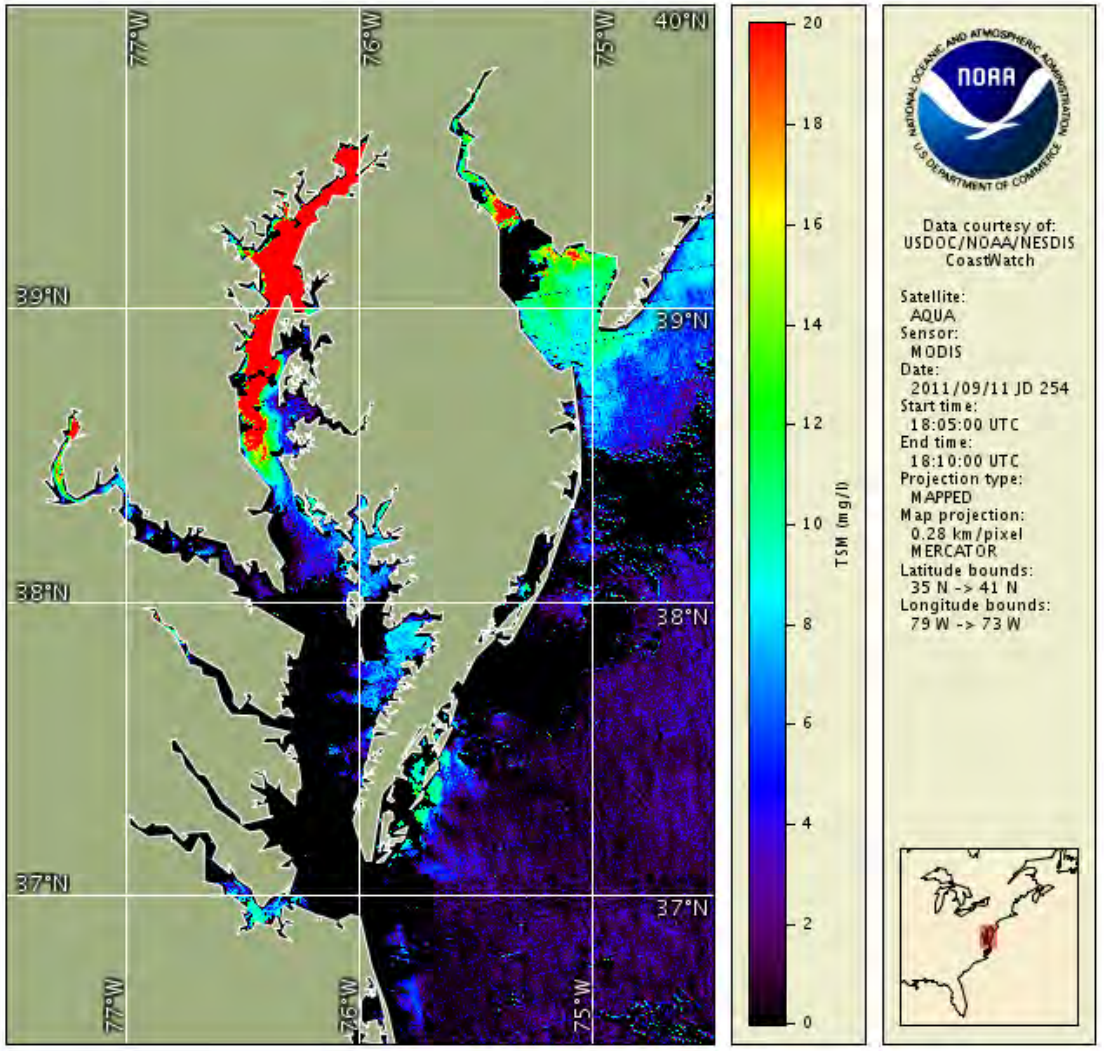
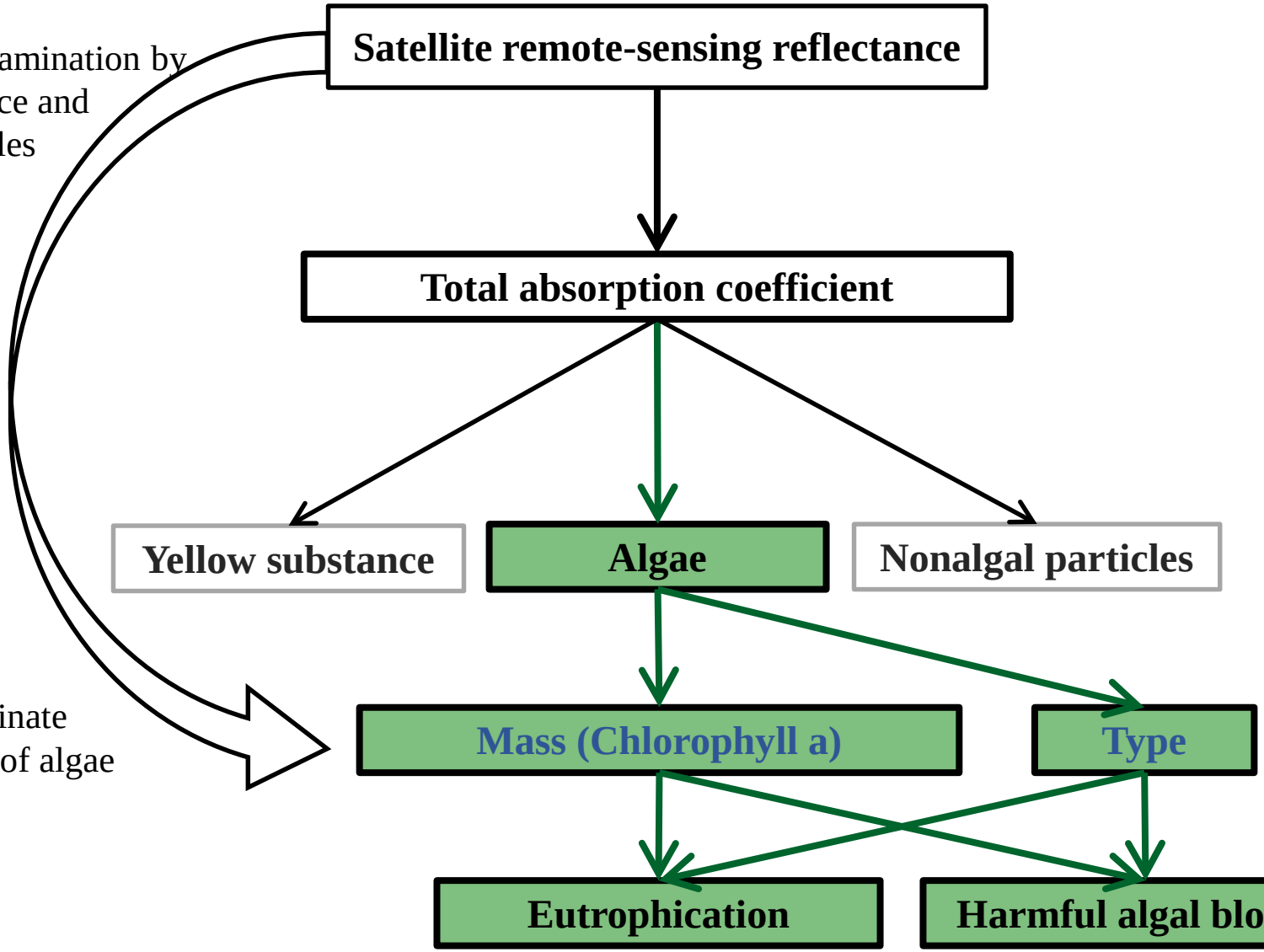


Figure Caption: Ron Vogel of NESDIS/STAR's CoastWatch East Coast Node explains the use of NOAA's satellite water turbidity data to understand the water clarity impacts resulting from NOAA/NMFS's large-scale oyster restoration in the Choptank River and its potential socioeconomic benefits. Dr. Jacobs (right), acting NOAA Administrator, looks on with members of his staff and NCBO personnel while on the NOAA/NMFS R/V Potawaugh acoustic mapping vessel.

Approaches on algal water quality proxies

Existing approaches

- Subject to contamination by yellow substance and nonalgal particles



- Do not discriminate different types of algae

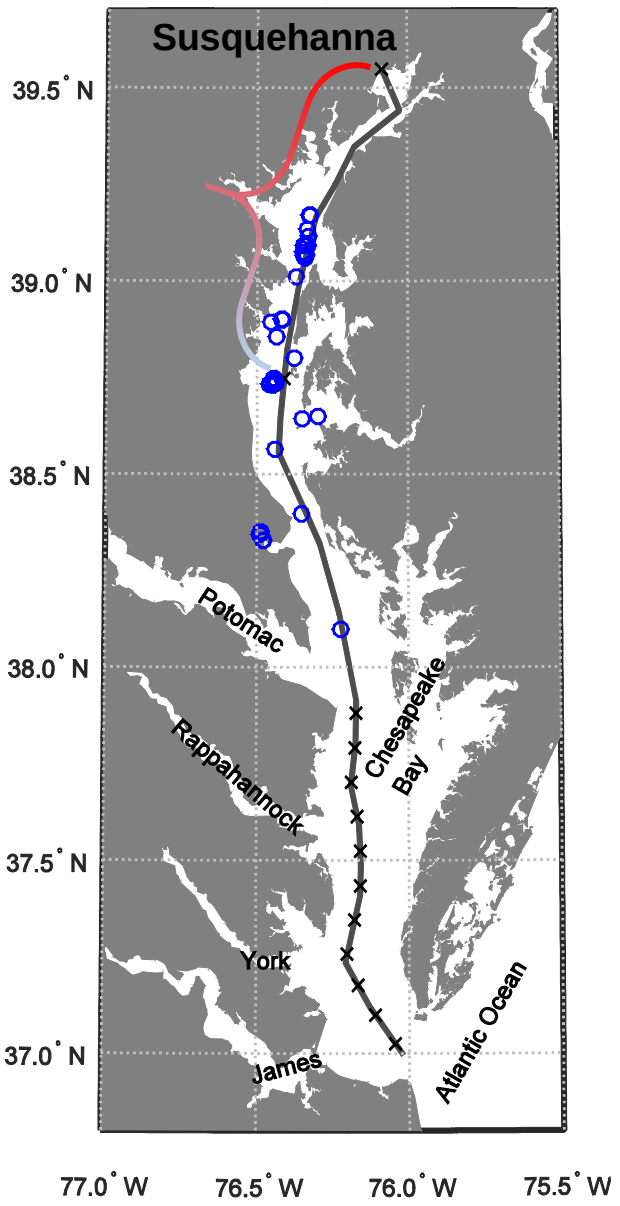
Our approach

- Singles out the light absorption contributed only by algae
- Derives not only **algal mass** but also **algal type**

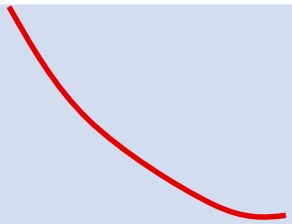
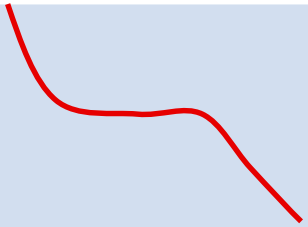
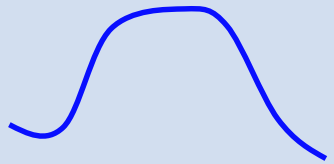
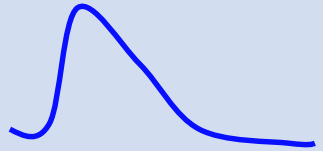
Different types of algae

- Have different pigment composition – making it possible to discriminate them optically
- May respond to nutrient pulses differently – so the capability to detect algal type can facilitate the detection of eutrophication in addition to HABs

Suspended sediment water quality proxies

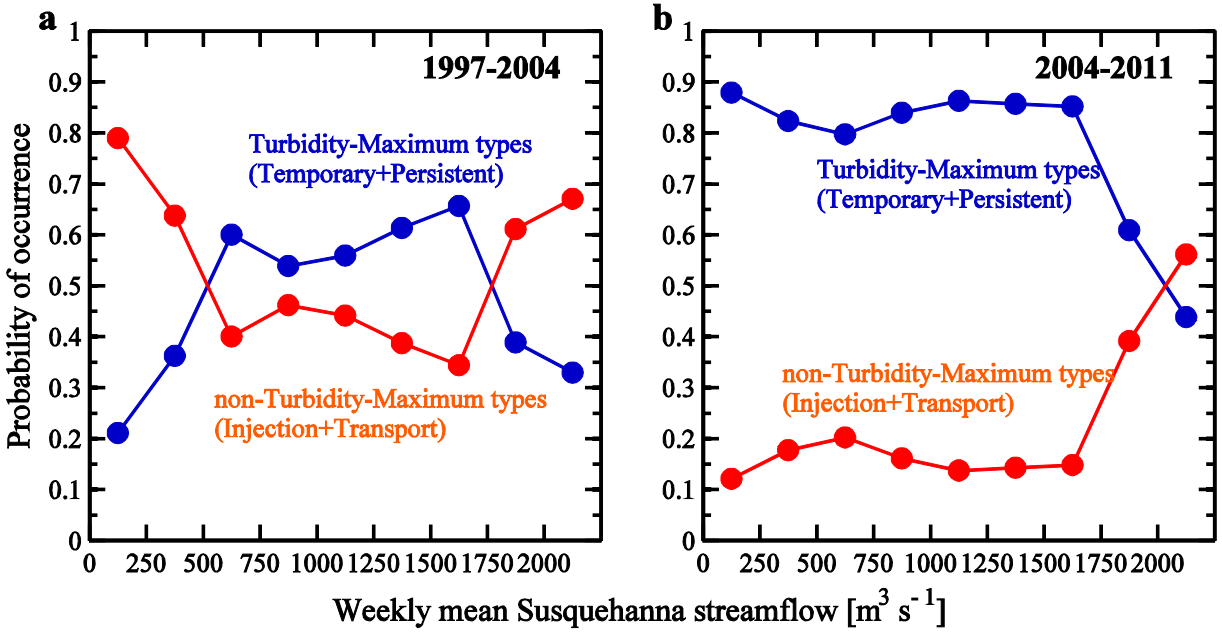


Sediment plume typology

Four types	Injection	Transport	Temporary Turbidity Max	Persistent Turbidity Max
Spatial distribution of suspended sediment concentration				
Timing (days)	0–5	3–10	5–30	>13

Long-term regime shift of typology after 2004, likely associated with Hurricane Ivan which triggered a discharge of large amounts of sediments.

[Zheng et al., *Environ. Sci. Tech.*, 2017]



Regional Product Development and Case Studies: Chesapeake Bay and Water Quality (1/2)

Phytoplankton Functional Types – research & algorithm development

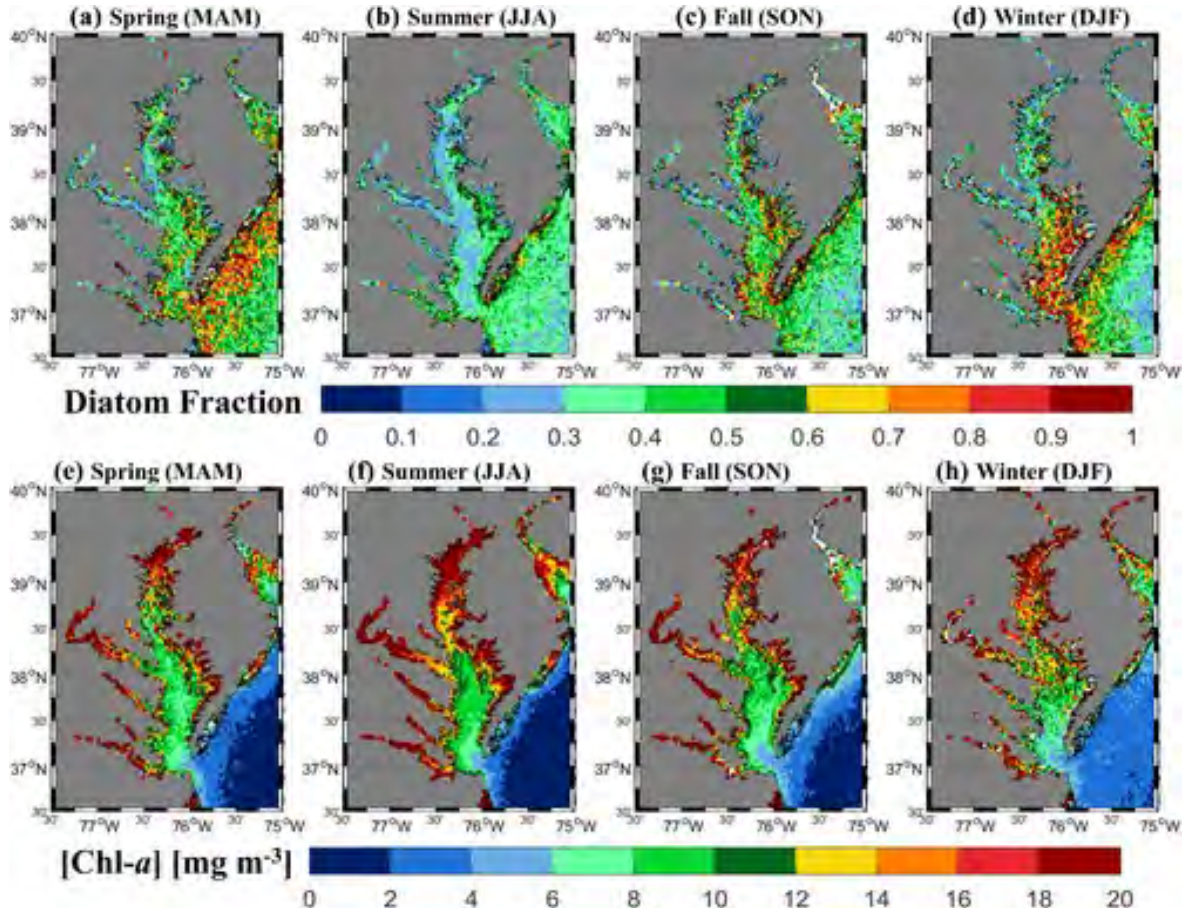
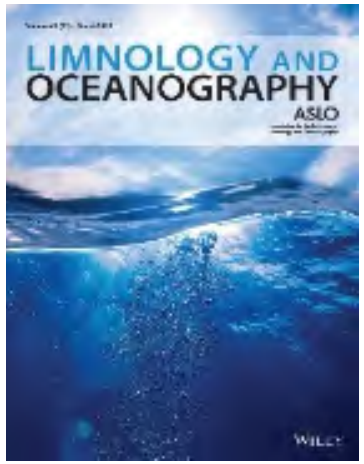


Fig. 5 from Zheng and DiGiacomo, Detecting phytoplankton diatom fraction based on the spectral shape of satellite-derived algal light absorption coefficient, March 2018 Volume: 63, Issue: S1, S85-S98, DOI: (10.1002/lno.10725)
Limnology & Oceanography



Regional Product Development and Case Studies: Chesapeake Bay and Water Quality (2/2)

- *Optical constituents*: Zheng, G., D. Stramski, and P. M. DiGiacomo, 2015: A model for partitioning the light absorption coefficient of natural waters into phytoplankton, nonalgal particulate, and colored dissolved organic components: A case study for the Chesapeake Bay, *J. of Geophysical Research-Oceans*

- *Sediments*: Zheng, G., DiGiacomo, P. M., Yuen-Murphy, M. A., et al., 2015: Evolution of Sediment Plumes in the Chesapeake Bay and Implications of Climate Variability. *Environmental Science & Technology*

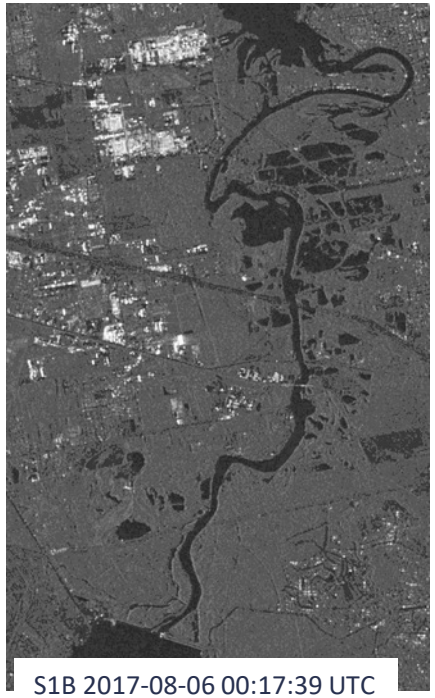
- *Chlorophyll:* Zheng, G. and P.M. DiGiacomo, 2017: Remote sensing of chlorophyll-a in coastal waters based on the light absorption of phytoplankton. *Remote Sensing of Environment*

- *Water quality:* Zheng G. and P.M. DiGiacomo, 2017: Uncertainties and applications of satellite-derived coastal water quality products. *Progress in Oceanography*

- *Hypoxia:* Zheng, G. and P.M. DiGiacomo, 2019: Linkages between surface algae and bottom oxygen in the Chesapeake Bay. Under revision. *Journal of Geophysical Research-Oceans*

Upcoming SAR Based Coastal Products

SAR Flood mapping After Hurricane Harvey



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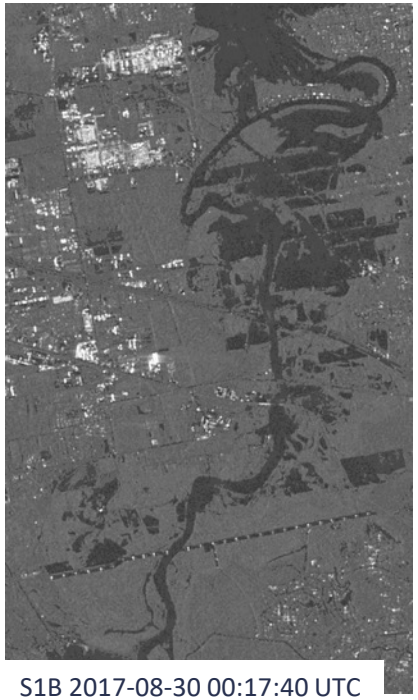
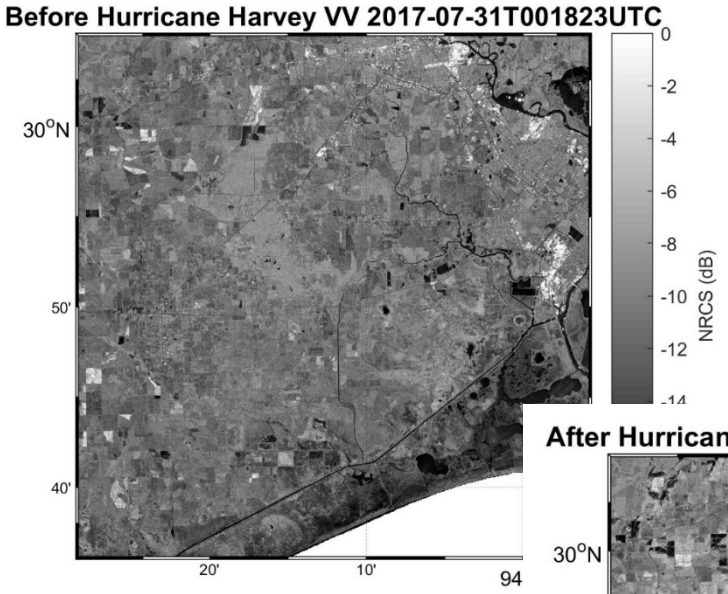
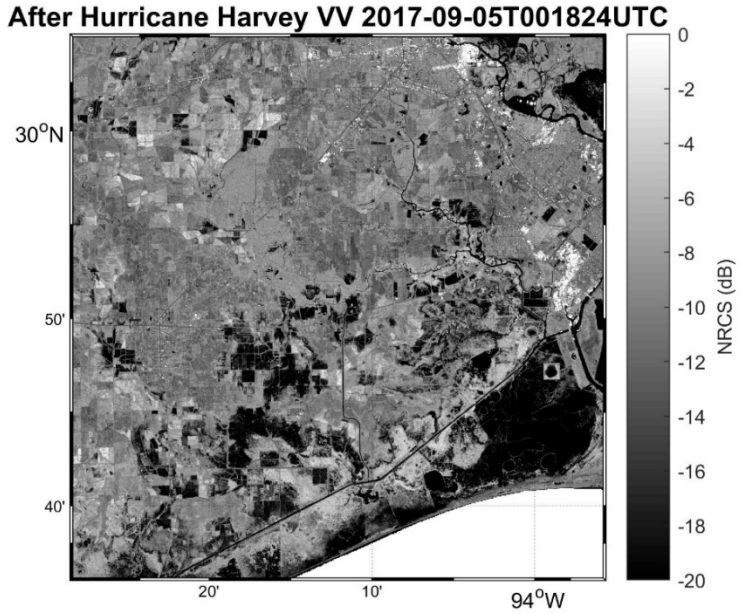


S1B 2017-08-30 00:17:40 UTC

COASTAL FLOOD MAPPING

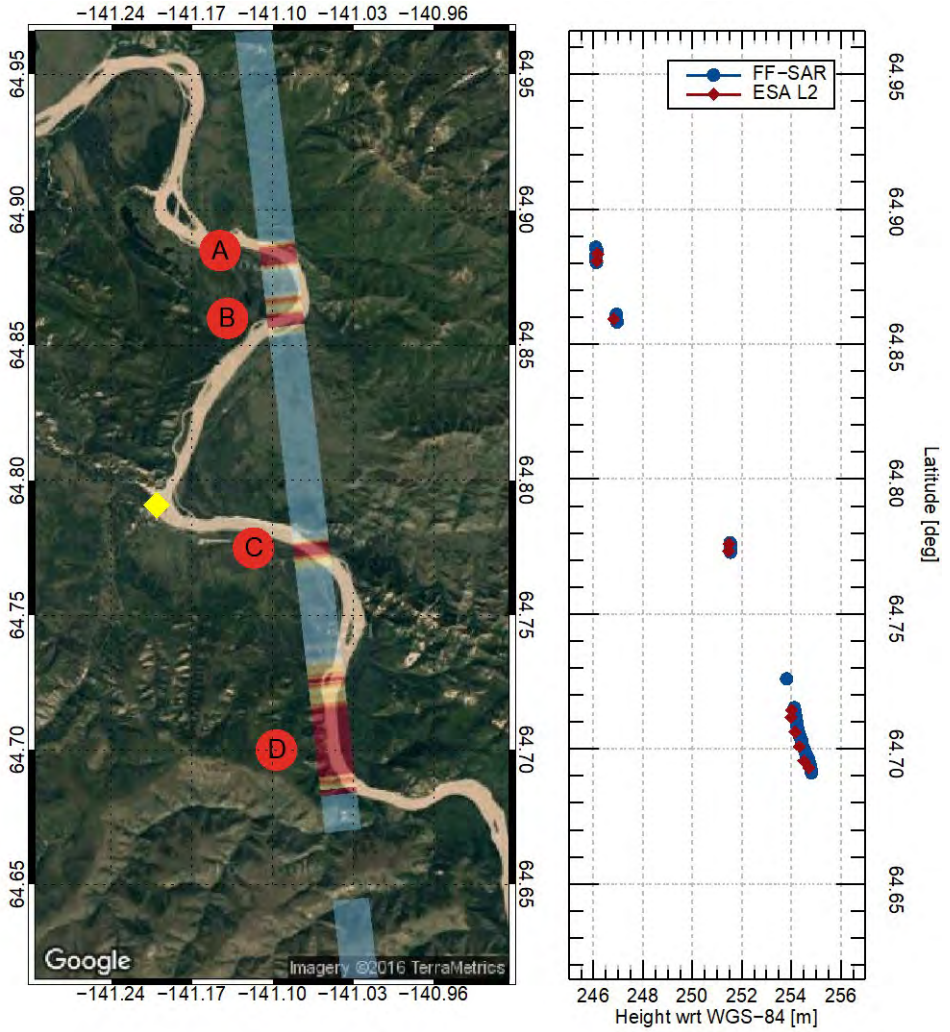




Fully-Focused SAR: Hydrology Applications

River Level Monitoring

- Fully Focused (FF) SAR and delay-Doppler processing applied to track crossing the Yukon River, Alaska, US, close to the Eagle Station, represented as the yellow diamond:
  - FF-SAR at 0.5 meters resolution
  - Multilooking at 80 meters.
- In the figure the CryoSat track is shown overlaid on the Google Earth image, with the waveform power in color scale.
- The height was estimated based on a simple primary peak retracker.
- The estimations are fully consistent with ESA L2 product but at a much higher resolution.

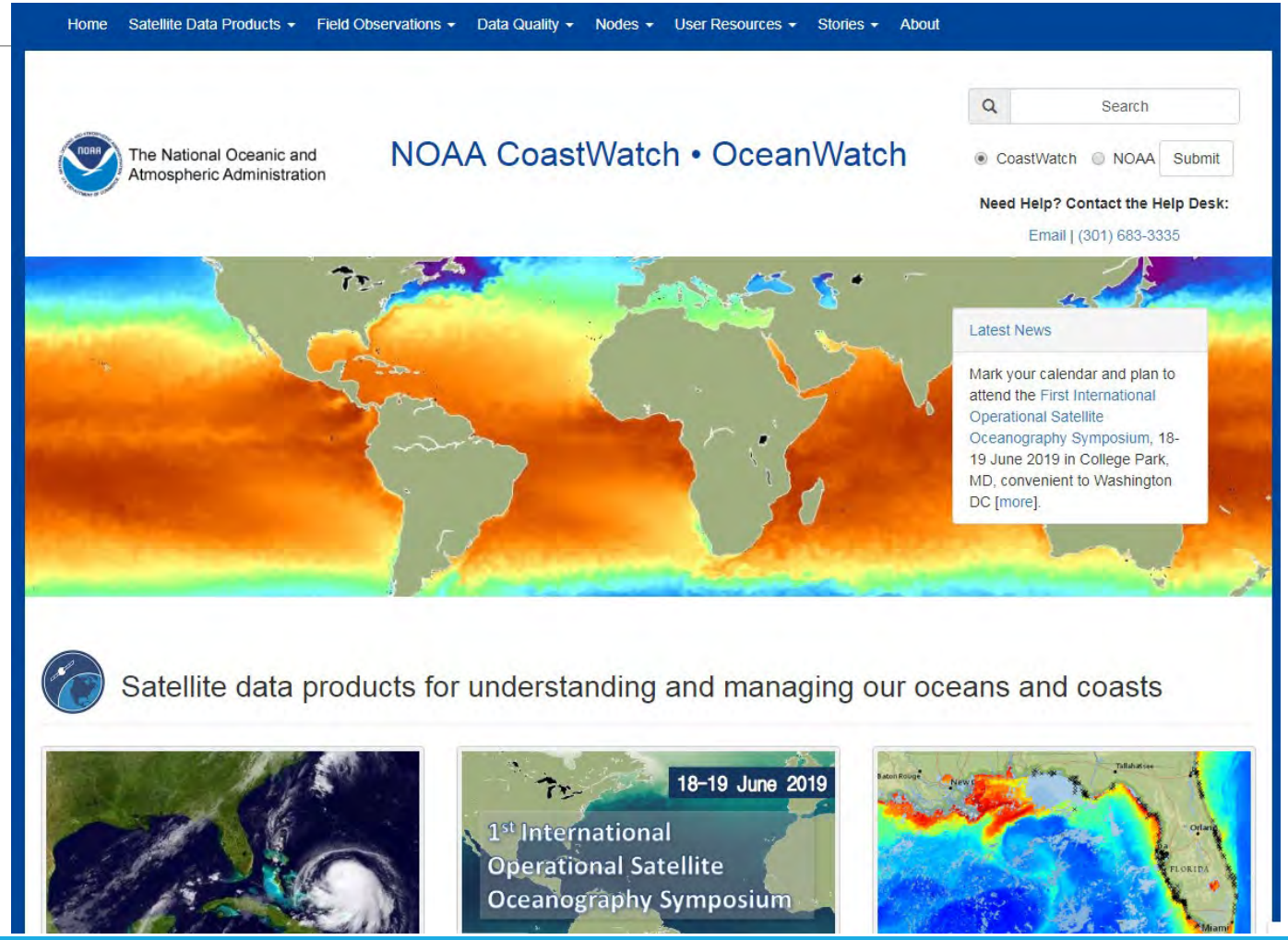


NOAA CoastWatch/OceanWatch/PolarWatch

CoastWatch.NOAA.gov

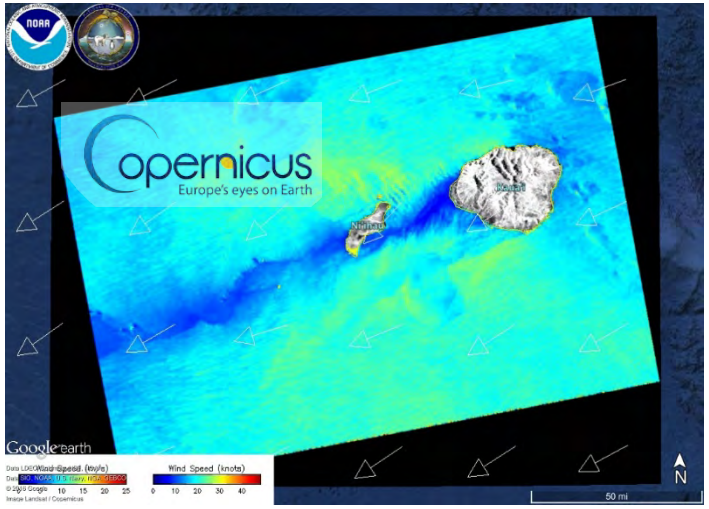
Facilitating the discovery & use of ocean, coastal & aquatic satellite data along the value chain from observations to information to decision-making

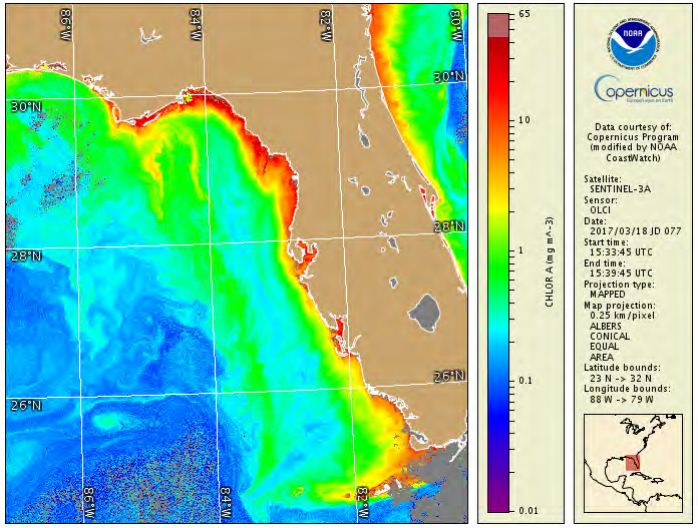
- Multi-sensor data discovery and access
- Tailored products (regions, formats etc.)
- Product assurance and quality monitoring
- Value-added product distribution (nodes)
- User engagement and training
- Outreach and education
- Feedback to science/product developers



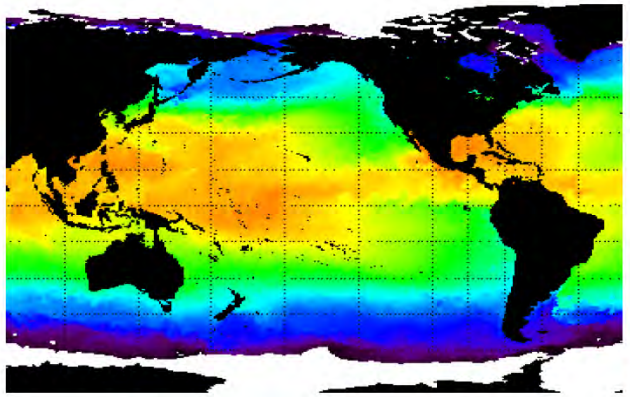
NOAA CoastWatch / OceanWatch Program: Copernicus Engagement

Examples of Copernicus support for marine/ coastal ecosystem management, water quality, harmful algal blooms, fisheries et al. within the NOAA CoastWatch/OceanWatch Program





1st Operational Satellite Oceanography Symposium: June 2019, NOAA, College Park, MD, USA



18 to 20 June 2019
Washington, DC Area
FIRST INTERNATIONAL OPERATIONAL SATELLITE OCEANOGRAPHY SYMPOSIUM

Satellite remote sensing of ocean properties is a technology of continuously increasing maturity and scope. Sea surface temperature, sea surface height, ocean color, sea ice, ocean winds, roughness-derived parameters (e.g., oil spills) and other measurements are now available on a routine and sustainable basis. Some of these products are integral to operational applications for routine and event-driven environmental assessments, predictions, forecasts and management. Yet ocean satellite data are still underutilized and have a huge potential for contributing further to societal needs and the "blue economy".

The First Operational Satellite Oceanography Symposium aims to enable the understanding the barriers (perceived or actual) and facilitate the widespread incorporation of satellite ocean observations into the value chain from data to useful information across the range of operational applications. In this symposium, an international community of satellite operators, information producers and users will exchange facts and ideas to 1) understand user needs and expectations, and 2) develop interoperability standards and establish best practices that will lead to more universal use of ocean satellite data.

Training sessions to facilitate use of satellite data products will be offered.

NOAA EUMETSAT

NOAA Center for Weather and Climate Prediction

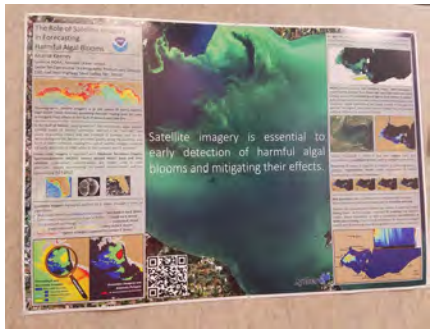
18 to 20 June 2019
College Park, MD
USA

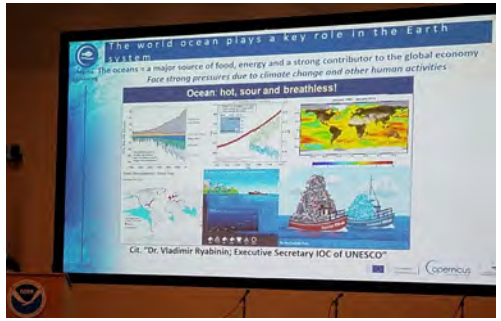
Convenient access from Washington DC

HTTPS://CoastWatch.NOAA.gov/OSOSymposium

STEERING COMMITTEE
Bojan Bojkov (EUMETSAT)
Christopher Brown (NOAA)
Paul DiGiacomo (NOAA)
Veronica Lance (NOAA)
Francois Montagner (EUMETSAT)

Posted 20 September 2018 with extended dates. Details to follow.





First OSO Symposium Presentations available at:
https://www.star.nesdis.noaa.gov/star/meeting_2019OSOS_presentations.php

Second International Operational Satellite Oceanography Symposium will be hosted by EUMETSAT in Spring 2021 in Germany

1st OSO Symposium Highlights

Attendees: >160 scientists, stakeholders and users from over 30 countries, bringing together data and information providers as well as end-users and practitioners

Keynotes and Plenaries: Neil Jacobs (NOAA), Steve Volz (NESDIS), Francois Montagner (EUMETSAT), Antonio Repucci (Mercator Ocean), Paul DiGiacomo (NESDIS), Estelle Obligis (EUMETSAT), Veronica Lance (UMD), Tom Cuff (NWS), Anne O'Carroll (EUMETSAT), Helen Beggs (BOM), Karen St Germain (NESDIS), Bojan Bojkov (EUMETSAT), Craig McLean (NOAA/IOC), Ralph Rayner (London School of Economics), Chris Lauer (NOAA Chief Economist Office)

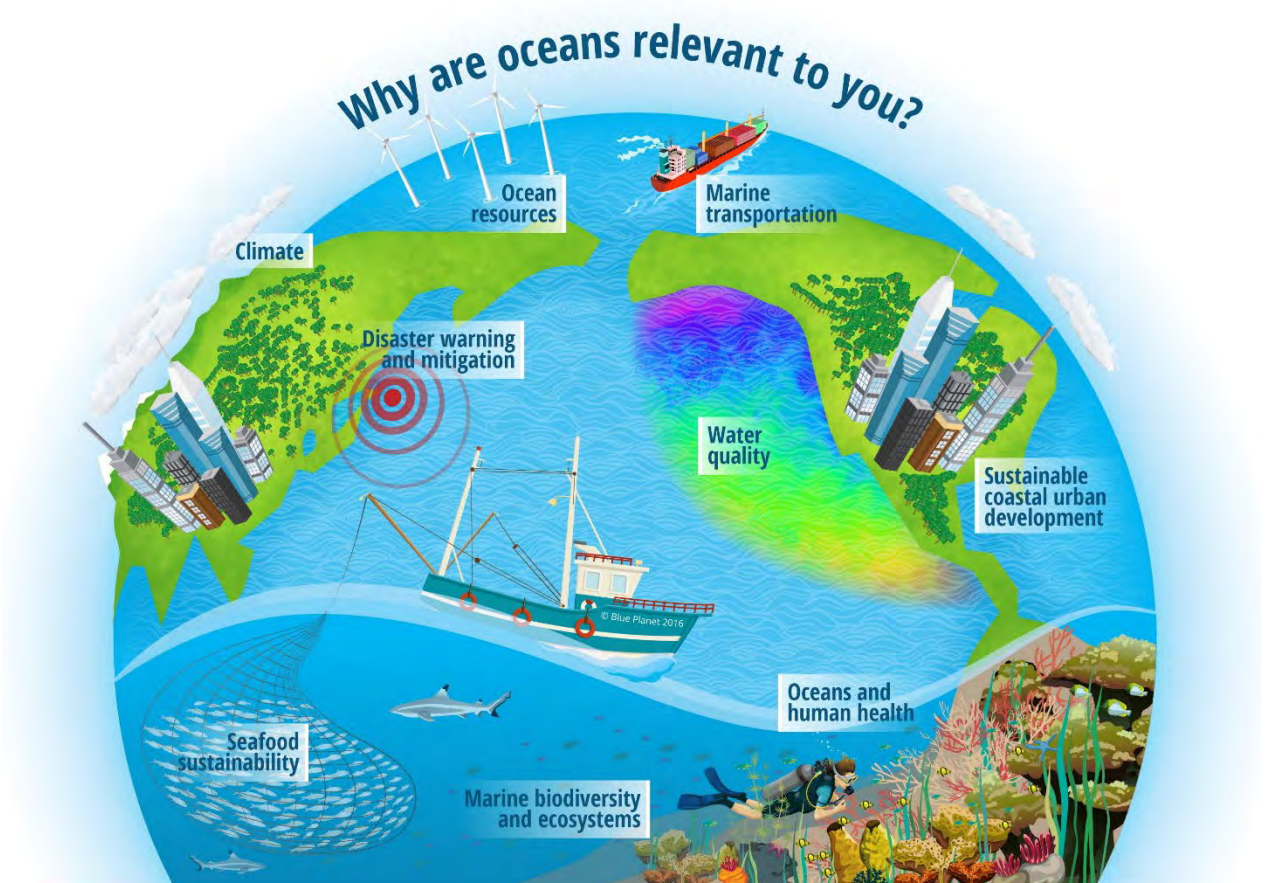
Featured: Community presentations and posters**;** Day-long Joint NOAA-EUMETSAT User Training, Commercial Providers Feedback Forum, Product/Tool demos

Outputs: Community recommendations and priorities to be captured in Symposium Report; planning for dedicated special issue of Journal of Operational Oceanography

Oceans and Society: GEO Blue Planet Initiative

Oceans and Society: Blue Planet is an Initiative within GEO that focuses on coastal and ocean observations and information for societal benefit

www.geoblueplanet.org

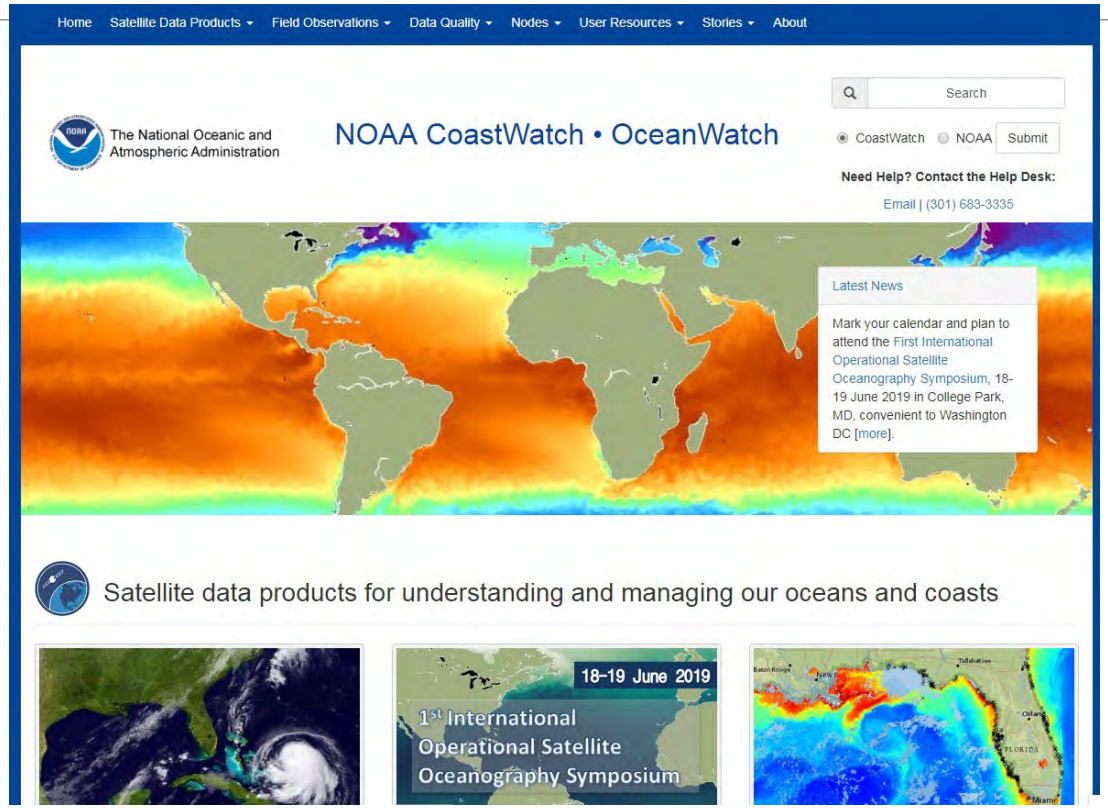


Take Home Messages

- We are now entering a "golden-age" of ocean remote sensing, particularly a significant expansion and availability of satellite oceanography data for operational utility, supporting diverse applications, services & research – Blue Economy et al.
- As data providers we are actively reaching out to users to demonstrate, facilitate and expand usage of fit for purpose operational satellite oceanography data & derived-products
- Given the rapid evolution of modeling and data assimilation for operational forecasting et al. needs, ocean satellite data are becoming increasingly important to improve skill/benefits
- Significant improvements are still to come with recent and upcoming satellite sensors and associated new and improved satellite-based and integrated sat-in situ-model products
- Particular foci over the next several years include inland and coastal water products, as well as linking environmental and socio-economic data and indicators.

THANKS!

CoastWatch.NOAA.gov



Paul.DiGiacomo@noaa.gov