

Satellite Ocean Color at NOAA: From Data to Decision-making

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NOAA OCEAN COLOR EDR TEAM AND CAL/VAL TEAM



Advancing Global Ocean Colour Observations

Busan, South Korea, 9-12 April 2019



Outline: Ocean Color "End-to-End"

Ocean Color Environmental Data Records (see Wang et al. poster)

In situ validation activities (see Lance et al. poster)

Data discovery, monitoring, distribution, training and outreach through NOAA CoastWatch/OceanWatch/PolarWatch (*see Gu et al. poster*)

Downstream applications – Users

International collaboration – leveraging data and services to mutual benefit



Mission Agnostic, Measurement-based approach in support of users: Ensuring continuity & coverage







• 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 <u>I1 (638 nm)</u>
- 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 (PAR)
- (<u>QA Score</u> 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., <u>Chl-a anomaly</u> and <u>Chl-a anomaly ratio</u>)
- 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)





Experimental Ocean Color Product Image (Selected) SNPP (2012–2018)



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



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









Global daily NRT Chl-a anomaly and anomaly ratio are routinely produced



High Chl-a Anomaly Linked to HAB in the West Coast of Florida (July 26, 2018)

2

1.5

1

L 0 0 0 Chlorophyll-a anomaly (mg m⁻³)

-1.5





Chl-a Anomaly



Chl-a Anomaly Ratio

Global NRT Chl-a anomaly and anomaly ratio are routinely produced



VIIRS-SNPP and NOAA-20 Chl-a Images

(January 6, 2018)









VIIRS SNPP and NOAA-20 Merged Global Chl-a (August 14, 2018)



VIIRS SNPP, NOAA-20, Sentinel-3A OLCI Merged Global Chl-a (August 14, 2018)



VIIRS SNPP + NOAA-20 + Sentinel-3A OLCI



Complete Daily Chl-a Coverage Using DINEOF Method (Example: The US West Coast, VIIRS-SNPP May-Oct 2015)





Menghua Wang,

Complete Daily Chl-a Coverage from SNPP/NOAA-20 Merged Data with the DINEOF

(Example: The US West Coast, VIIRS-SNPP May-Oct 2015)



Difference of Chl-a (Merged – VIIRS-SNPP)

-0.1

0.1

(Liu and Wang, 2019)



In Situ Validation Activities



- MOBY
- Dedicated VIIRS Cal/Val cruises - Annual on NOAA ships; supported by JPSS
- Cruises of opportunity in collaboration with other NOAA programs and outside
- AERONET-OC support









Dedicated VIIRS Cal/Val Cruise IV NOAA Ship *Okeanos Explorer* 9-18 May 2018

The fourth Cal/Val cruise report will be published soon!

NOAA

The fifth dedicated OC Cal/Val cruise will be in May 2019!



Data Distribution: NOAA

CoastWatch OceanWatch PolarWatch

≡ CoastWatch Data Portal | Intera OceanWatch Monitor (OM) PP VIIRS L3 Chl, Day , Global Ocean tra-thematic Plots

http://coastwatch.noaa.gov

- Regional nodes established in multiple NOAA line offices (NMFS, NOS, OAR) covering geographic regions (Ocean basins, coasts, high latitudues)
- Data portals for interactive image preview, data search and file download; automated downloads supported
- Ocean remote sensing online monitoring tool
- Product quality monitor in development

HelpDesk

 Intermediate between Ocean Color Science Team and NOAA line office and outside user community

Application of VIIRS Ocean Color: Model global isoprene emissions incorporate into air quality monitor (NWS NAQFC)

JPSS PGRR PI: Daniel Tong

Since June 2018, VIIRS Isoprene product has been incorporated into ARL emission data to support NWS NAQFC operation. **Global Isoprene** from VIIRS Area Isoprene Emission (No VIIRS Data) Isoprene Emission with VIIRS Data 261 0.000060 235 0.000052 209 204 0.000045 183 157 0.000038 mole/s 146 131 0.000030 117 105 88 0.000022 79 59 0.000015 53 0.000008 0.000000 74 147 220 293 366 4२0 74 147 220 293 366 439 July 1, 2017 00:00:00 UTC July 1, 2017 00:00:00 UTC Min (1, 1) = 0.000, Max (45, 121) = 0.004 Min (381, 5) = 0.000000, Max (338, 52) = 0.006023

JPSS offers unique marine emission products derived from VIIRS-SNPP ocean color data;

VIIRS isoprene product has been incorporated into OAR/ARL emission data to support NWS NAQFC operations; Marine emission products, including isoprene, dimethyl sulfide (DMS), organic aerosols, are needed to support NWS Next-Generation Global Prediction System (NGGPS).

Using inputs: VIIRS-derived Chl-a and K_d (490)









Lake Erie Harmful Algal Bloom Bulletin 04 September, 2018, Bulletin 22

Analysis

The Microcystis cyanobacteria bloom continues in the western basin of Lake Erie. Recent satellite imagery (9/3) shows the bloom extending north along the Michigan coast to Point Mouillee State Game Area, east along the Ohio coast to Sandusky Bay, and through the Bass Islands extending up to 15 miles east of Pelee Island. Calm winds observed over the weekend (8/31-9/3) may have promoted scum formation of Microcystis concentrations. Toxin concentrations are present at most sampling sites but are below the recreational threshold. Keep pets and yourself out of the water in areas where scum is forming. The persistent cyanobacteria bloom in Sandusky Bay continues

Forecasts

Winds (3-8 kn) forecast today and tomorrow (9/4-5) will promote scum formation where surface Microcystis concentrations are greatest. Winds will promote the eastward transport of Microcystis concentrations from the Michigan coast and northeastward transport of Microcystis concentrations around the Bass Islands and Pelee Island today through Friday (9/4-7). -- Davis, Lalime

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/xReTC for instructions on viewing longitude and latitude.

Lake Erie HAB **Bulletin**



Figure 1. Cyanobacterial Index from NASA MODIS-Terra data collected 03 September, 2018 at 11:07 EST. Grey indicates clouds or missing data. The estimated threshold for cyanobacteria detection is 20,000 cells/mL.

40

35

2 30

§ 25

E 20 8 15 <u>ه</u>10

30.

NOAA/NOS/CO-OP

water column at wind speeds greater than 15 knots (or 7.7 m/s).



Figure 2. Cyanobacterial Index from NASA MODIS-Terra data collected 03 September, 2018 at 11:07.

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



Figure 3. Nowcast position of bloom for 04 September, 2018 using LEOFS modelled currents to move the bloom from the 03 September,



Figure 4. Forecast position of bloom for 07 September, 2018 using LEOFS modelled currents to move the bloom from the 03 September,



For more information and to subscribe, please visit the NOAA HAB Forecast page: https://tidesandcurrents.noaa.gov/hab/lakeerie.html

Courtesy of Rick Stumpf and NOAA-**COOPS**

18 02:00 FD1



Optimization of phytoplankton functional type algorithms for VIIRS ocean color data in the Northeast U.S. Continental Shelf Ecosystem



Project Summary: Optimize remote sensing phytoplankton functional type/size class (PFT/PSC) algorithms for the Northeast U.S. Continental Shelf for applications in fisheries management and ecosystem modeling.

JPSS PGRR PI: Kim Hyde, NOAA/NMFS/Northeast Fisheries Science Center





EcoCast Map

EcoCast Explorer

About EcoCast



NOAA ECOCAST

mark conlin - NOAA Fisheries / Mark Conlin

An Eco-Informatic Tool for Sustainable Fisheries

What is EcoCast?

EcoCast is a real-time data tool to help fishers and managers allocate fishing effort to optimize the harvest of target fish while minimizing bycatch of protected species.

View details »

Finding a good place to fish

The EcoCast Map product combines the predicted distributions of target catch species and bycatch species into a single map that suggests better and poorer locations to fish off the US West Coast.

View the map »

Scenario analysis

EcoCast Explorer tool gives users an opportunity to explore how species are responding to changing ocean conditions, and how that can influence the EcoCast Map product. Users are able to generate predictive maps for specific dates and species, and can change the species weightings.

JPSS PGRR PI: Elliott Hazen, NOAA/NMFS/SouthWest Fisheries Science Center





Age-O Pollock in the Gulf of Alaska

Kevin Siwicke, AFSC/ABL 2019 WCN CoastWatch Satellite Course, Juneau, AK

W 2011 E 2011 60 -58.5 70 58.0 59 -Latitude 57.5 57.0 Latitude 56.5 56.0 55 60 W 2012 E 2012 60 . 58.5 58.0 55 59 Latitude 57.5 -160 -150 -140 Longitude 58 57.0 56.5 log(chl-a) 56.0 1.5 1.0 55 0.5 W 2013 E 2013 0.0 60 58.5 -0.5 -1.0 58.0 59 --1.5 Latitude 57.5 A0 Pollock (CPUE^{1/4}) 58 57.0 56.5 56.0 15 55 -150 -149 -148 -139 -138 20 -153 -152 -151 -137 Longitude Longitude

Question: Does chlorophyll-a concentration in April and May influence age-0 pollock abundance and condition in the Gulf of Alaska?

Objective: Use satellite ocean color to explore spatial and temporal relationships between spring bloom and age-0 Pollock.

Ongoing: Mean chlorophyll-a concentration that has been log-transformed for April/May from 2011-2013 in the east and west Gulf of Alaska with fourth-root-transformed CPUE of age-0 pollock (right).

- Samples in EGOA collected in July.
- Samples in WGOA collected in August.
- Include condition and RNA/DNA ratios.





NOAA Satellite and Information Service V



DOC > NOAA > NESDIS > STAR > CRW



Coral Reef Watch Home

Products Overview

Near-Real-Time Data <u>5-km Resolution</u> 50-km Resolution

Experimental Products Daily Global 5km Products Disease Outbreak Risk Light Stress Damage Doldrums Ocean Color Bleaching Outlook (CFS) Thermal History Larval Connectivity Ocean Acidification Add'I Free Online Data

Research Activities

Outreach/Education

Research Partnerships

Publications Cite CRW Data & Products

About Us

Daily 750m VIIRS Satellite Ocean Color Monitoring (Version 1.0, released on 10 May 2018)

Click on an image below for region-specific ocean color products: Chlorophyll-a and Kd(490)

a (ma

Chlorophyll-

Main Hawaiian Islands

Puerto Rico





Product Description

<u>NOAA Coral Reef Watch and NOAA/National Environmental Satellite, Data, and Information Service (NESDIS)</u> <u>Ocean Color Team</u> are working closely with partners in the U.S. Coral Reef Task Force (USCRTF) Watershed Working Group (WWG) to develop satellite ocean color products for use over coral reefs. Data are from the <u>Visible Infrared</u> <u>Imaging Radiometer Suite (VIIRS)</u> onboard the <u>Suomi National Polar-orbiting Partnership (S-NPP) satellite</u> operated by the <u>NOAA Joint Polar Satellite System (JPSS)</u>.

Coral Reef Watch

NOAA

JPSS PGRR PI: Avichal Mehra NWS/NCEP/Environmental Modeling Center



Initial biogeochemical modeling at **NOAA/NCEP: Using VIIRS** ocean color data for validation and data assimilation

OCEAN COLOR IN OCEAN MODELING



NESDIS Science-quality Chlorophyll-a significantly outperforms NRT and BASE in ocean model simulations; GODAS analyses used as observations; BASE is model run with SeaWiES 4-yr monthly climatology, SCI is run with VIIRS science-quality OC, NRT is run with VIIRS NRT OC

(all based on 4 year experiments 2012-2015)



International Collaboration

Leveraging international data and services for mutual benefit:

NOAA is primary US distributor for Copernicus Marine Data from Sentinels

NOAA OCView

 Hosts OLCI ocean color (EUMETSAT& true color (L1 from ESA)

NOAA CoastWatch

- Produces routine L3 for Mediterranean for EUMETSAT operational use
- Hosts OLCI ocean color and true color

NOAA/STAR just began routine pull of SGLI GCOM-C data to be routinely served

Co-hosting with EUMETSAT the 1st International Operational Satellite Oceanography Symposium (see next slide)



Including:

VIIRS SNPP, NOAA-20, OLCI Sentinel-3A, Sentinel-3B, SGLI-GCOM-C, and GOCI

1st International Operational Satellite Oceanography Symposium

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...

REGISTRATION AND ABSTRACT SUBMISSION: OSOS WEBSITE LINK

EUMETSAT



18 TO 20 JUNE 2019 WASHINGTON, DC AREA First International OPERATIONAL SATELLITE OCEANOGRAPHY Symposium And pre-meeting data workshop training day **17 June 2019**

Link to PDF Flyer available at NOAA CoastWatch

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

