VIIRS Ocean Color Products from Global Open Oceans and Coastal/Inland Turbid Waters

Menghua Wang &

NOAA Ocean Color Team

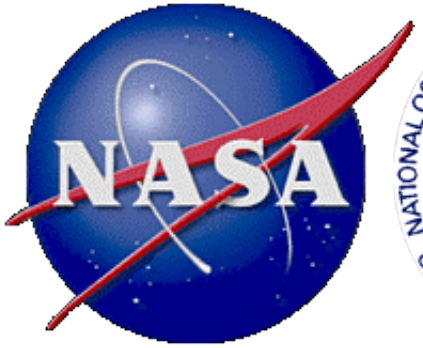
NOAA/NESDIS/STAR
E/RA3, Room 3228, 5830 University Research Ct.
College Park, MD 20740, USA

The NASA Direct Readout Conference (NDRC-9)
Valladolid, Spain, June 21-24, 2016

Website for VIIRS ocean color images and Cal/Val:
http://www.star.nesdis.noaa.gov/sod/mecb/color/

Website for VIIRS ocean color data:
http://coastwatch.noaa.gov/cwn/cw_products_ocLOM.html

Acknowledgements: This work has been supported by JPSS/VIIRS funding. We thank MOBY team for in situ optics data, VIIRS Cal/Val PIs and their collaborators in support of VIIRS Cal/Val activities.



VIIRS Ocean Color EDR & Cal/Val Teams Members

EDR	Name	Organization	Funding Agency	Task
Lead	**Menghua Wang (OC EDR & Cal/Val Lead),** L. Jiang, X. Liu, W. Shi, S. Son, L. Tan, X. Wang, J. Sun, K. Mikelsons, M. Chu, V. Lance, **M. Ondrusek,** E. Stengel	NOAA/NESDIS/ STAR	JPSS/NJO	Leads – Ocean Color EDR Team & Cal/Val Team OC products, algorithms, SDR, EDR, Cal/Val, vicarious cal., refinements, data processing, reprocessing, algorithm improvements, software updates, data validations and analyses
Ocean Color	**Robert Arnone** Sherwin Ladner, Ryan Vandermeulen Adam Lawson, Paul Martinolich, Jen Bowers	U. Southern MS NRL QinetiQ Corp. SDSU	JPSS/NJO	Look Up Tables – SDR-EDR impacts, vicarious calibration Satellite matchup tool (SAVANT) – Golden Regions Cruise participation and support WAVE_CIS (AERONET-OC site) operation
	Carol Johnson	NIST	JPSS/NJO	Traceability, AERONET-OC Uncertainty
	Curt Davis, Nicholas Tufillaro	OSU	JPSS/NJO	Ocean color validation, Cruise data matchup West Coast
	Burt Jones, Matthew Ragan	USC	JPSS/NJO	Eureka (AERONET-OC Site) , Data analysis
	Alex Gilerson, **Sam Ahmed**	CUNY	JPSS/NJO	LISCO (AERONET-OC site), Data analysis Cruise data and matchup
	Chuanmin Hu	USF	JPSS/NJO	NOAA data continuity
	Ken Voss & **MOBY** team	RSMAS –Miami	JPSS/NJO	Marine Optical Buoy (MOBY)
	Zhongping Lee, Jianwei Wei	UMB	JPSS/NJO	Ocean color IOP data validation and evaluation Ocean color optics matchup

Working with: NOAA **CoastWatch**, VIIRS **SDR team**, DPA/DPE, Raytheon, NOAA OC Working Group, NOAA various line-office reps, NOAA NCEI, NOAA OCPOP, NASA OBPG, etc. Collaborators: ESA/EUMETSAT, G. Zibordi (JRC-Italy), D. Antoine (BOUSSOLE), B. Holben (NASA-GSFC), R. Frouin (for PAR), and many others.

Ocean Color Spectra


Lake Taihu


Chesapeake Bay

VIIRS Spectral Bands for Ocean Color

VIIRS (Visible Infrared Imaging Radiometer Suite) on
Suomi National Polar-orbiting Partnership **(SNPP)**
VIIRS-**SNPP**, Oct. 28, **2011**, VIIRS-Joint Polar Satellite System (**JPSS**) **J1**, **2017**, VIIR-**J2**,
2021, and J3 & J4 (up to ~2038)

VIIRS†		MODIS		SeaWiFS
Ocean Bands (nm)	Other Bands (nm)	Ocean Bands (nm)	Other Bands (nm)	Ocean Band (nm)
410 (M1)	638 (I1)	412	645	412
443 (M2)	862 (I2)	443	859	443
486 (M3)	1600 (I3)	488	469	490
—		531	555	510
551 (M4)	*SWIR Bands*	551	*SWIR Bands*	555
671 (M5)	1238 (M8)	667	1240	670
745 (M6)	1601 (M10)	748	1640	765
862 (M7)	2257 (M11)	869	2130	865

†VIIRS-SNPP nominal center wavelength

Spatial resolution for VIIRS M-band: 750 m, I-band: 375 m

Summary of VIIRS Ocean Color EDR Products

- **Inputs**:
  - VIIRS M1-M7 and the **SWIR** M8, M10, and M11 bands SDR data
  - Terrain-corrected geo-location file
  - Ancillary meteorology and ozone data
- **Operational (Standard) Products** (8):
  - Normalized water-leaving radiance (nL_w's) at VIIRS visible bands M1-M5
  - Chlorophyll-a (Chl-a) concentration
  - Diffuse attenuation coefficient for the downwelling spectral irradiance at the wavelength of 490 nm, K_d(490) (New)
  - Diffuse attenuation coefficient of the downwelling photosynthetically available radiation (PAR), K_d(PAR) (New)
  - Level-2 quality flags
- **Experimental Products:**
  - 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 from users requests

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

Multi-Sensor Level-1 to Level-2 (MSL12) Ocean Color Data Processing

➢ Multi-Sensor Level-1 to Level-2 (MSL12)

- ✓ MSL12 was developed during NASA SMIBIOS project (1997-2003) for a consistent multi-sensor ocean color data processing (*Wang*, 1999; *Wang and Franz*, 2000), i.e., it is measurement-based (or Enterprise) ocean color data processing system.
- ✓ It has been used for producing ocean color products from various satellite ocean color sensors, e.g., SeaWiFS, MOS, OCTS, POLDER, MODIS, GOCI, etc.

➢ NOAA-MSL12 Ocean Color Data Processing

- ✓ NOAA-MSL12 is based on SeaDAS version 4.6.
- ✓ Some significant improvements: (1) the SWIR-based data processing, (2) Rayleigh and aerosol LUTs, (3) algorithms for detecting absorbing aerosols and turbid waters, (4) ice detection algorithm, (5) improved straylight/cloud shadow algorithm, & others.
- ✓ Some new improved algorithms, e.g., BMW–new NIR reflectance correction (*Jiang and Wang*, 2014), Destriping (*Mikelsons et al.*, 2014), K_d(PAR) (*Son and Wang*, 2015), OCI Chl-a (*Wang and Son*, 2016), etc.

➢ NOAA-MSL12 for VIIRS (and others) Ocean Color Data Processing

- ✓ Routine ocean color data processing (daily, 8-day, monthly) since VIIRS launch.
- ✓ Turbid coastal and inland waters from other approaches, e.g., the **SWIR-based approaches**, results in the US east coastal regions, Chesapeake Bay, China's east coastal, Lake Taihu, Lake Okeechobee, Aral Sea, etc.
- ✓ Capability for multi-sensor ocean color data processing, e.g., MODIS-Aqua, VIIRS, GOCI, and will also add **JPSS-1**, **OLCI**/Sentinel-3, and **SGLI**/GCOM-C ocean color data processing capability.

End-to-End Ocean Color Data Processing

- NOAA Ocean Color Team has been developing/building the capability for the **End-to-End** satellite ocean color data processing including:
  - Level-0 (or Raw Data Records (RDR)) to Level-1B (or Sensor Data Records (SDR)).
  - Level-1B (SDR) to ocean color Level-2 (Environmental Data Records (EDR).
  - Level-2 to global Level-3 (routine daily, 8-day, monthly, and climatology data/images).
  - Validation of satellite ocean color products (in situ data and data analysis capability).
- Support of in situ data collections for VIIRS Cal/Val activities, e.g., MOBY, AERONET-OC sites, NOAA dedicated cruises (2014, 2015, 2016, ….,)

➢ **On-orbit instrument calibration (solar and lunar) for ocean color data processing:**

- J. Sun and M. Wang, "Visible Infrared Imaging Radiometer Suite solar diffuser calibration and its challenges using solar diffuser stability monitor," *Appl. Opt.,* **53**, 8571-8584, 2014.
- J. Sun and M. Wang, "On-orbit characterization of the VIIRS solar diffuser and solar diffuser screen," *Appl. Opt.*, **54**, 236-252, 2015.
- J. Sun and M. Wang, "On-orbit calibration of Visible Infrared Imaging Radiometer Suite reflective solar bands and its challengers using a solar diffuser," *Appl. Opt.*, **54**, 7210-7223, 2015.
- J. Sun and M. Wang, "Radiometric calibration of the VIIRS reflective solar bands with robust characterizations and hybrid calibration coefficients," *Appl. Opt.*, **54**, 9331–9342, 2015.

➢ **RDR (Level-0) to SDR (Level-1B) data processing** (efficient RDR to SDR processing)**:**

- Sun, J., M. Wang, L. Tan, and L. Jiang, "An efficient approach for VIIRS RDR to SDR data processing," *IEEE Geosci. Remote Sens. Lett.*, **11**, 2037–2041, 2014.
- L. Tan, M. Wang, J. Sun, and L. Jiang, "VIIRS RDR to SDR Data Processing for Ocean Color EDR," *Proc. SPIE* 9261*, Ocean Remote Sensing and Monitoring from Space,* October 13-16, 2014.

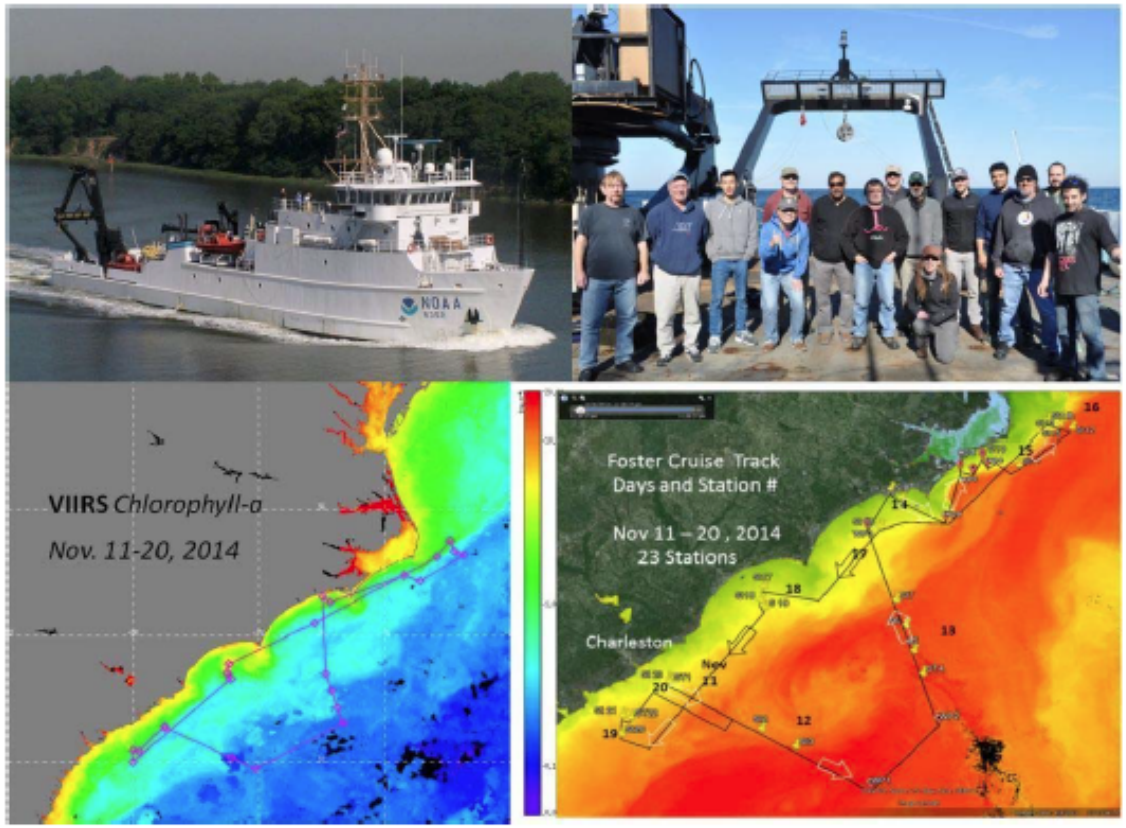
- **O**cean **C**olor **D**ata **A**nalysis and **P**rocessing **S**ystem (**OCDAPS**)—IDL-based VIIRS ocean color data visualization and processing package
  - Wang, X., X. Liu, L. Jiang, M. Wang, and J. Sun, "VIIRS ocean color data visualization and processing with IDL-based NOAA-SeaDAS", *Proc. SPIE 9261*, 8 Nov. 2014.

Report for the 2014 NOAA dedicated Cal/Val cruise has been published!

NOAA Technical Report NESDIS 146

DOI: 10.7289/V52B8W0Z

Report for Dedicated JPSS VIIRS Ocean Color Calibration/Validation Cruise



Washington, D.C.
September 2015

Dedicated VIIRS Cal/Val Cruises

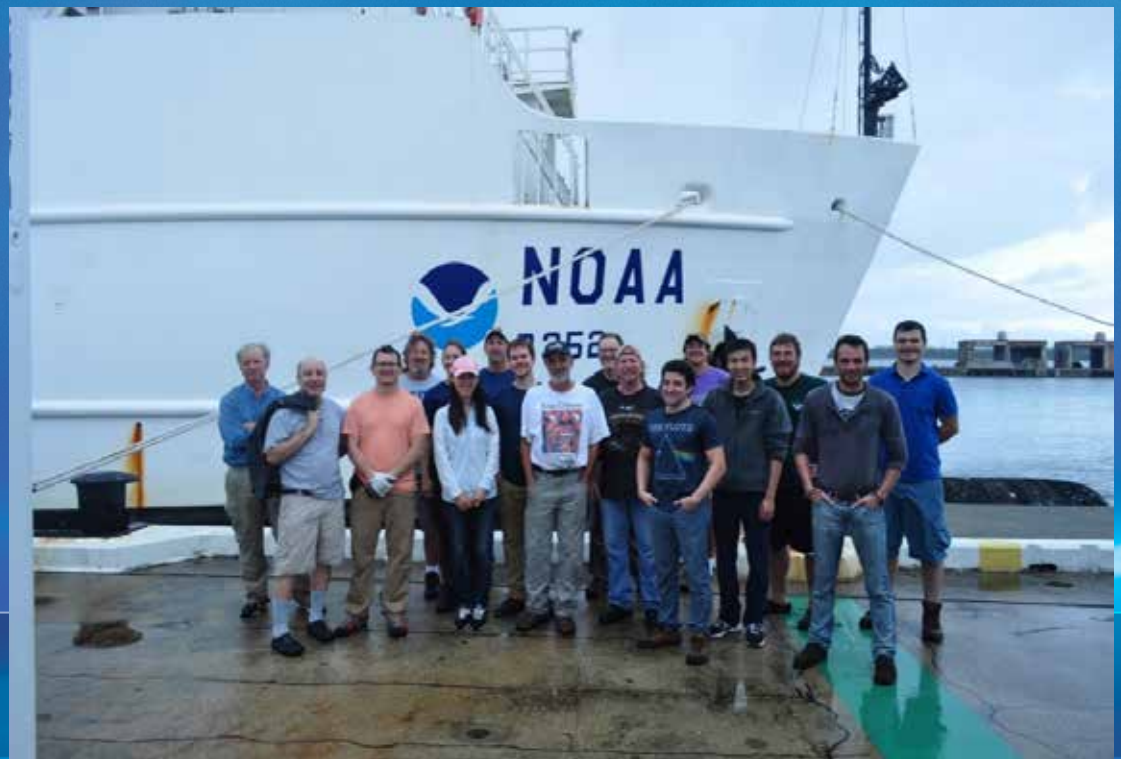
http://dx.doi.org/10.7289/V52B8W0Z

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

Dedicated VIIRS Cal/Val Cruise
NOAA Ship Nancy Foster
2-14 December 2015

Validation Measurements

- **Water-Leaving Radiance** - HyperPro, MicroPro, C-OPS, GER, SBA, TRIOS, HyperSAS, ASD
- **Aerosol Optical Depth** - Microtops
- **Chlorophyll** - HPLC, Fluorometric, (in situ and extracted)
- **Absorption** - ACS, AC9, Spectrophotometric
- **Backscatter** - BB9, BB7, BB3, ECO Puck
- **Bi-directional radiance distribution** - NURADS
- **Phytoplankton Physiology -** FRRF, FIRe, Alf-a
- **Carbon** - POC and DOC water analysis; plus CDOM
- **Total Suspended Matter** - Gravimetric



International, Interagency and Academic Collaborations:

US Agencies

- **NOAA**/NESDIS/STAR (NOAA)
- Naval Research Laboratory, Stennis Space Center (**NRL**)
- NASA/Goddard Space Flight Center (**NASA**)
- National Institute of Standards and Technology (**NIST**)

Universities

- City University of New York, Long Island; CREST
- Lamont-Doherty Earth Observatory, Columbia University
- University of Massachusetts, Boston
- University of Miami
- University of South Florida
- University of Southern Mississippi
- Oregon State University

Two Data Streams for VIIRS Ocean Color EDR

To meet requirements from **All** users (operational, research, modeling, etc.), we proposed and have been routinely producing VIIRS global ocean color products in **two data streams**:

- **Near-Real-Time (NRT) Ocean Color Data Processing (12-24 hours):**
  - Quick turn around with ~12-24 hours latency (operational)
  - Using standard IDPS operational SDR data
  - Ancillary data using the Global Forecast System (GFS) model
  - Data may not be completed due to various issues (SDR missing, computer, etc.)
  - Data will be processed in NOAA CoastWatch and OSPO
- **Science Quality Ocean Color Data Processing (One-two weeks delay):**
  - About one-two weeks delay
  - Reprocessed mission-long ocean color data and continue-forward data stream
  - Using improved SDR (based on IDPS SDR data) (science quality SDR)
  - Science quality (assimilated) NCEP ancillary data
  - Complete global coverage
  - May expand to more experimental products & test with improved algorithms
  - Ocean color EDR will be reprocessed (mission-long) about every two-three years (or as needed, e.g., short-term data reprocessing, error fixing, etc.)
  - Data will be processed in NOAA/STAR and transferred to CoastWatch for distributions

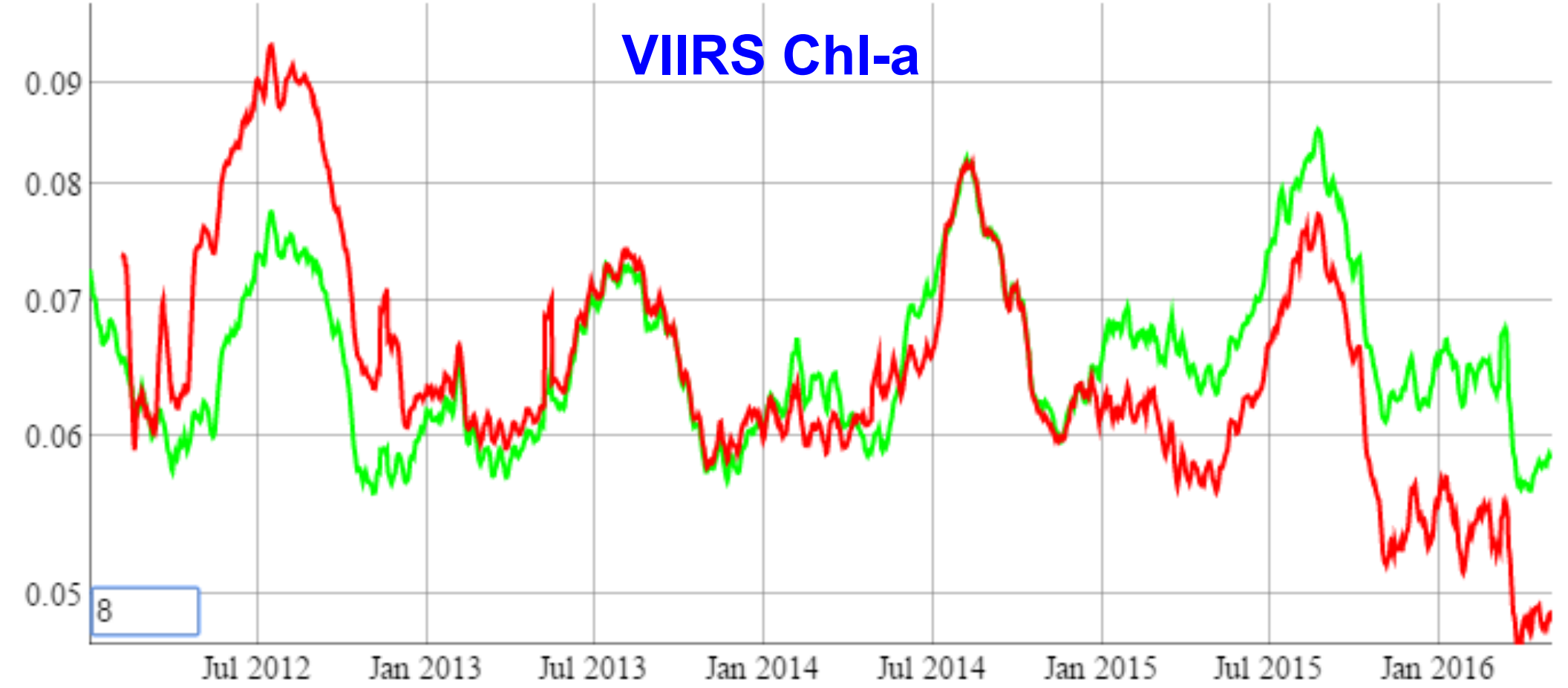
VIIRS Mission-long Ocean Color Data Reprocessing

- ✓ We have successfully reprocessed VIIRS mission-long ocean color data products for the Near-Real-Time data stream in summer 2015 and the Science Quality data stream just recently (May 2016). Both data streams have been going forward routinely.
- ✓ For the Science Quality data stream, VIIRS mission-long SDR has been reprocessed using significantly improved on-orbit calibration (both solar and lunar approaches).
- ✓ For the VIIRS ocean color Science Quality data distribution, we have been working with the NOAA CoastWatch and NCEI teams, making changes to meet their requirements (and NOAA, the community, *et al.*) data format (netCDF), e.g., metadata, etc. The ocean color Science Quality data stream is now distributed through **CoastWatch** at: **http://coastwatch.noaa.gov/cwn/cw_products_ocLOM.html**.
- ➢ The reprocessed VIIRS mission-long Science Quality ocean color data have been significantly improved, providing accurate and consistent ocean color data for science research and applications. **It shows the importance of the lunar data for calibration, particularly in recent years (and forwarding)**.
- ➢ In particular, significant improved VIIRS ocean color data over global **high altitude lakes**, which is a very significant progress for remote sensing of inland water quality.
- ➢ VIIRS chlorophyll-a and $K_d(490)$ data from global oligotrophic waters for two data streams: Near-real-time data stream with IDPS SDR and the recently reprocessed Science Quality data stream with the new OC-SDR. The same **MSL12** ocean color data processing system has been used for both data streams. We also show some global images and quantitative comparisons with MOBY in situ data.

Open Ocean, Coastal and Inland Waters

- Global open ocean
- High Altitude Lakes:
  - Lake Victoria (South Africa, Altitude 1133 m)
  - Lake Tahoe (California/Nevada, Altitude 1897 m)
  - Lake Qinghai (China, Altitude 3205 m)
- Turbid Coastal Regions:
  - US East Coast, including the Chesapeake Bay, Outer banks, etc.
  - China East Coast, including the Bohai Sea, Yellow Sea, East China Sea
  - La Plata Estuary
- Turbid Inland Lakes:
  - Lake Okeechobee (US)
  - Great Lakes (US)
- Couple Applications Using VIIRS Ocean Color Data

Global Oligotrophic Waters

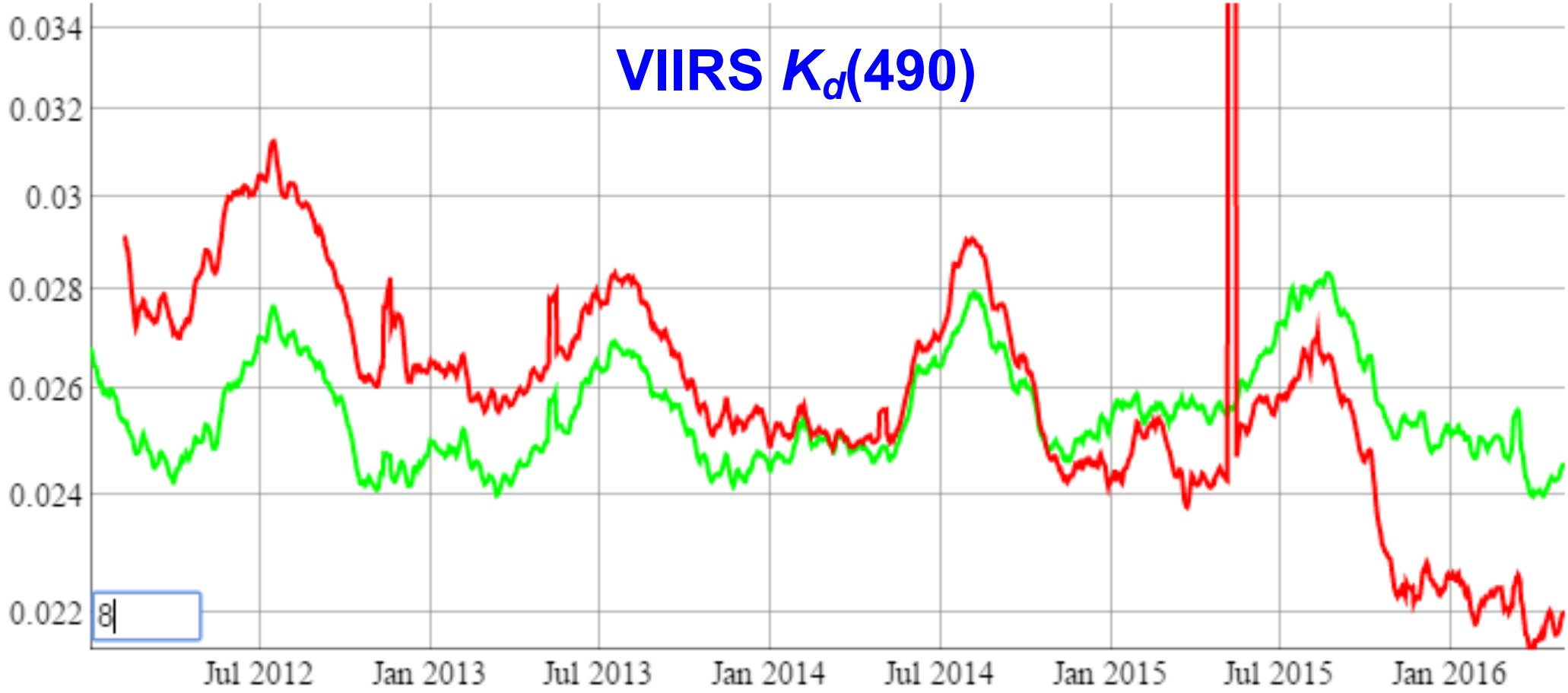


Red: VIIRS **IDPS-SDR**
Near-real-time data

Green: VIIRS **OC-SDR**
Science quality data

Both data are reprocessed using the same MSL12!

Global Oligotrophic Waters

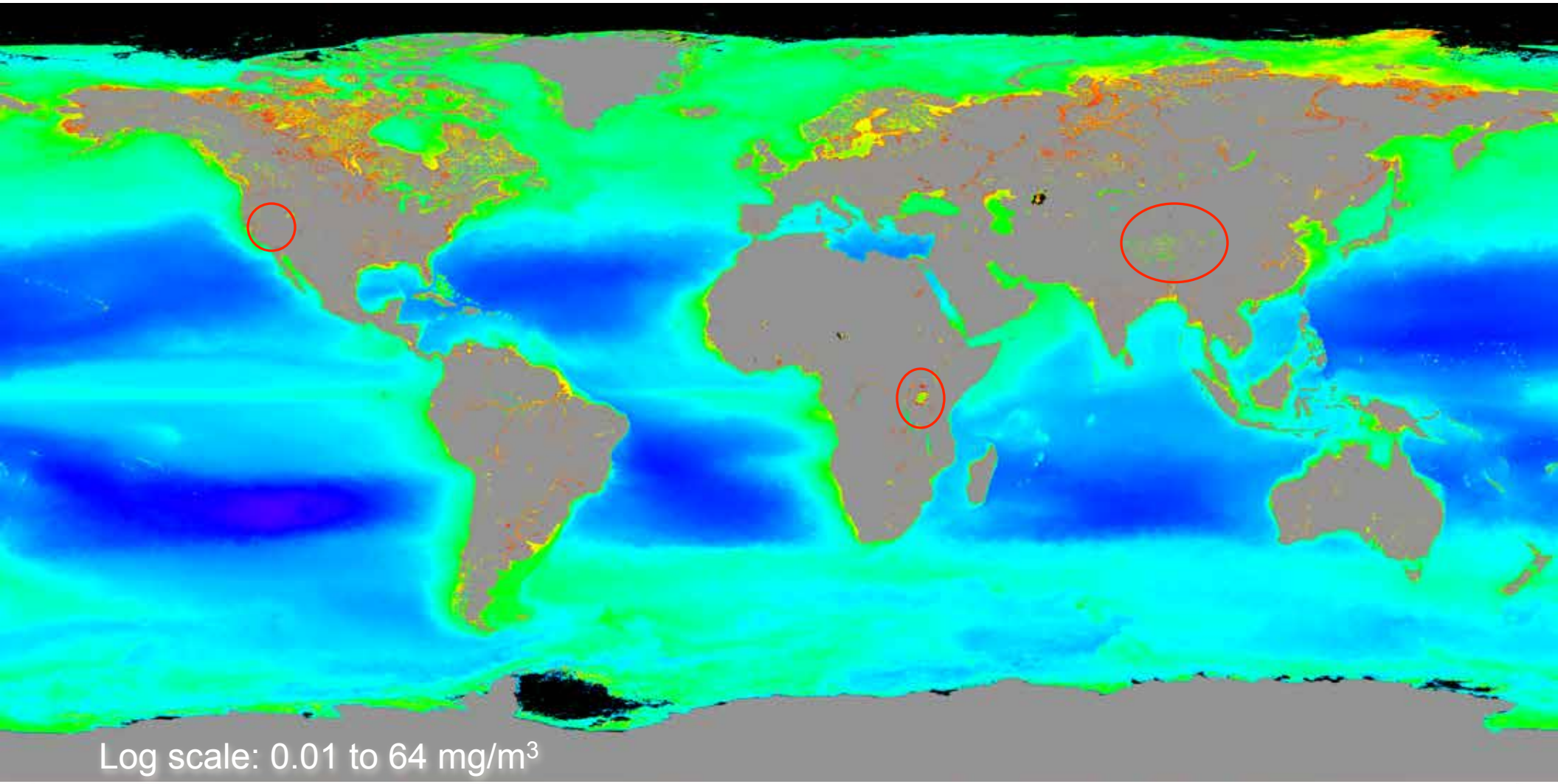


Red: VIIRS **IDPS-SDR**
Near-real-time data

Green: VIIRS **OC-SDR**
Science quality data

Both data are reprocessed using the same MSL12!

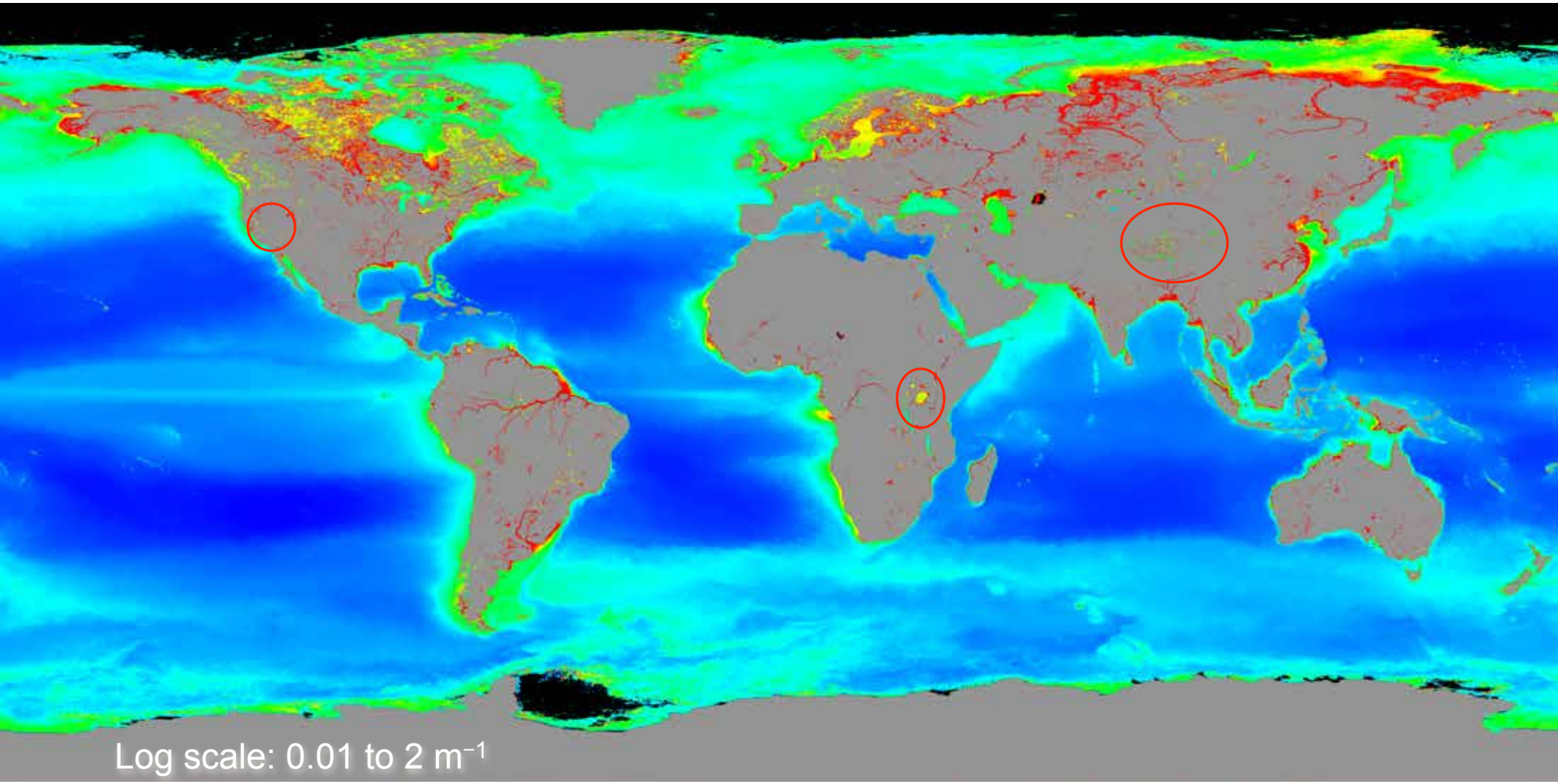
VIIRS Climatology Chlorophyll-a Image
(February 2012 to January 2016)



Generated using MSL12 for VIIRS mission-long ocean color data reprocessing

Wang, M., X. Liu, L. Tan, L. Jiang, S. Son, W. Shi, K. Rausch, and K. Voss, "Impacts of VIIRS SDR performance on ocean color products," *J. Geophys. Res. Atmos.*, **118**, 10,347–10,360, 2013. http://dx.doi.org/10.1002/jgrd.50793

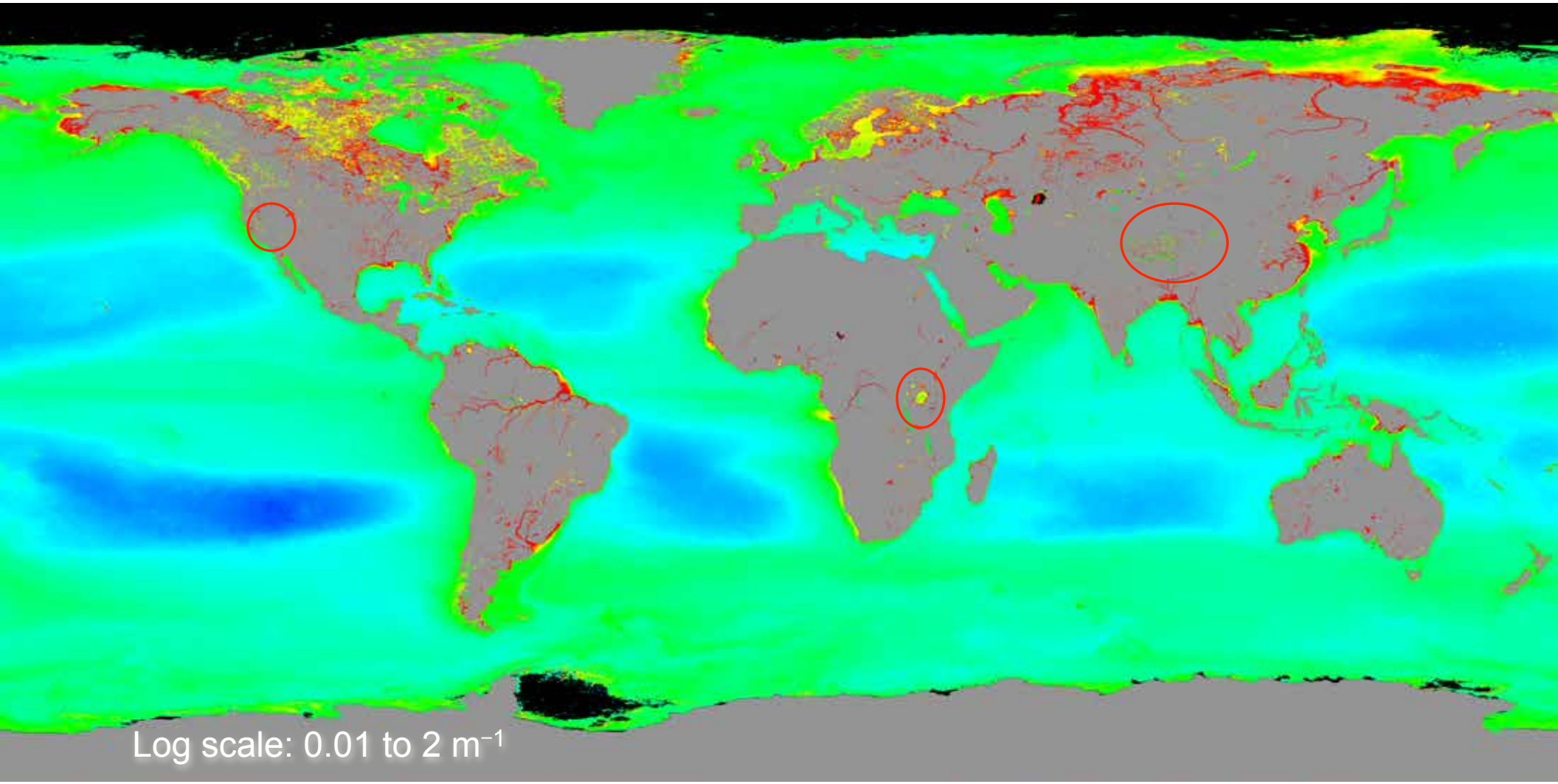
VIIRS Climatology $K_d(490)$ Image
(February 2012 to January 2016)



Generated using MSL12 for VIIRS mission-long ocean color data reprocessing

Wang, M., S. Son, and L. W. Harding Jr., "Retrieval of diffuse attenuation coefficient in the Chesapeake Bay and turbid ocean regions for satellite ocean color applications," *J. Geophys. Res.*, **114**, C10011, 2009. http://dx.doi.org/10.1002/2009JC005286

VIIRS Climatology K_d(PAR) Image
(February 2012 to January 2016)



Generated using MSL12 for VIIRS mission-long ocean color data reprocessing

Son, S. and M. Wang, "Diffuse attenuation coefficient of the photosynthetically available radiation Kd(PAR) for global open ocean and coastal waters," *Remote Sens. Environ.*, **159**, 250–258, 2015. http://dx.doi.org/10.1016/j.rse.2014.12.011

Matchup of

VIIRS-MSL12

&

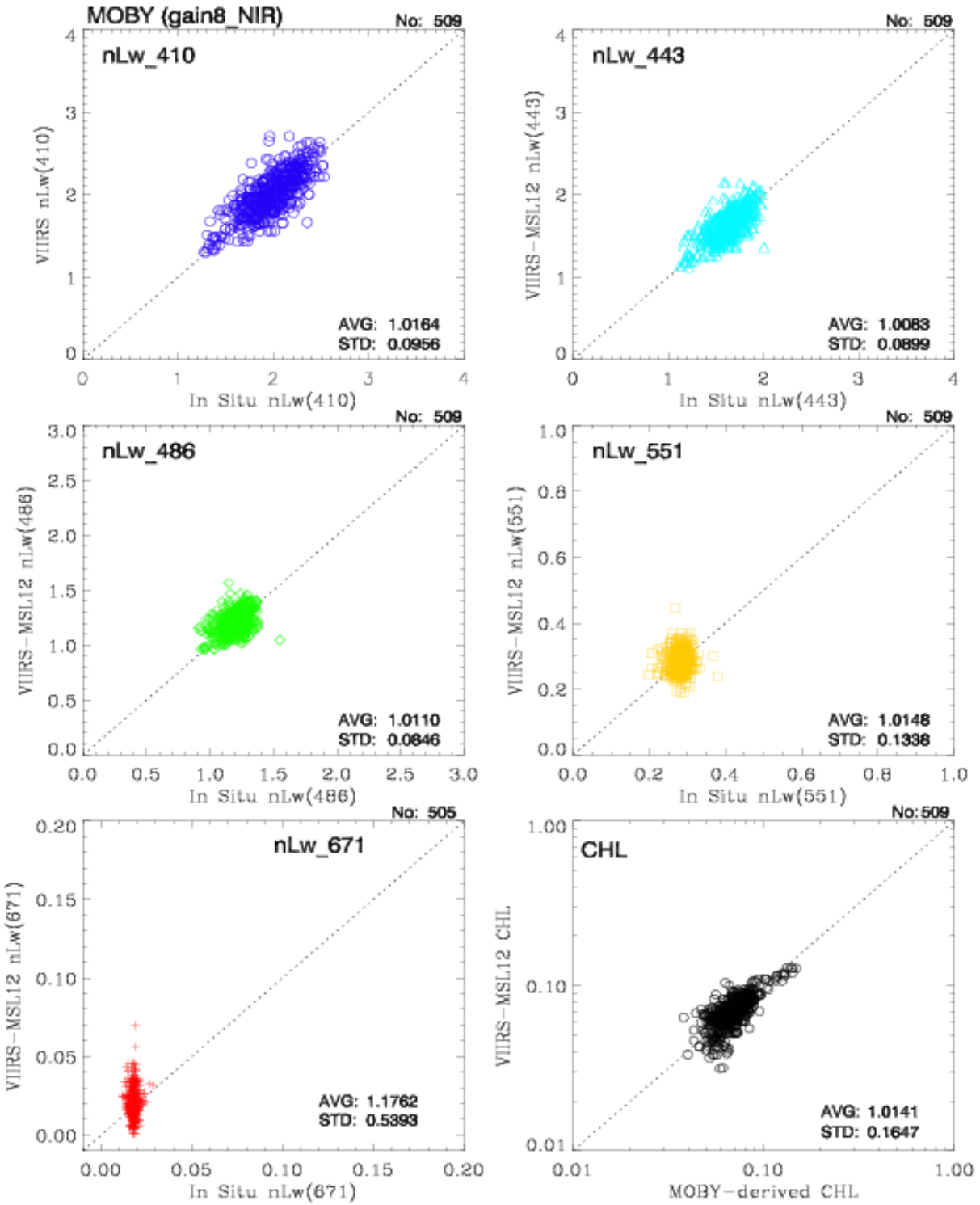
MOBY In Situ

(2016-05-05)

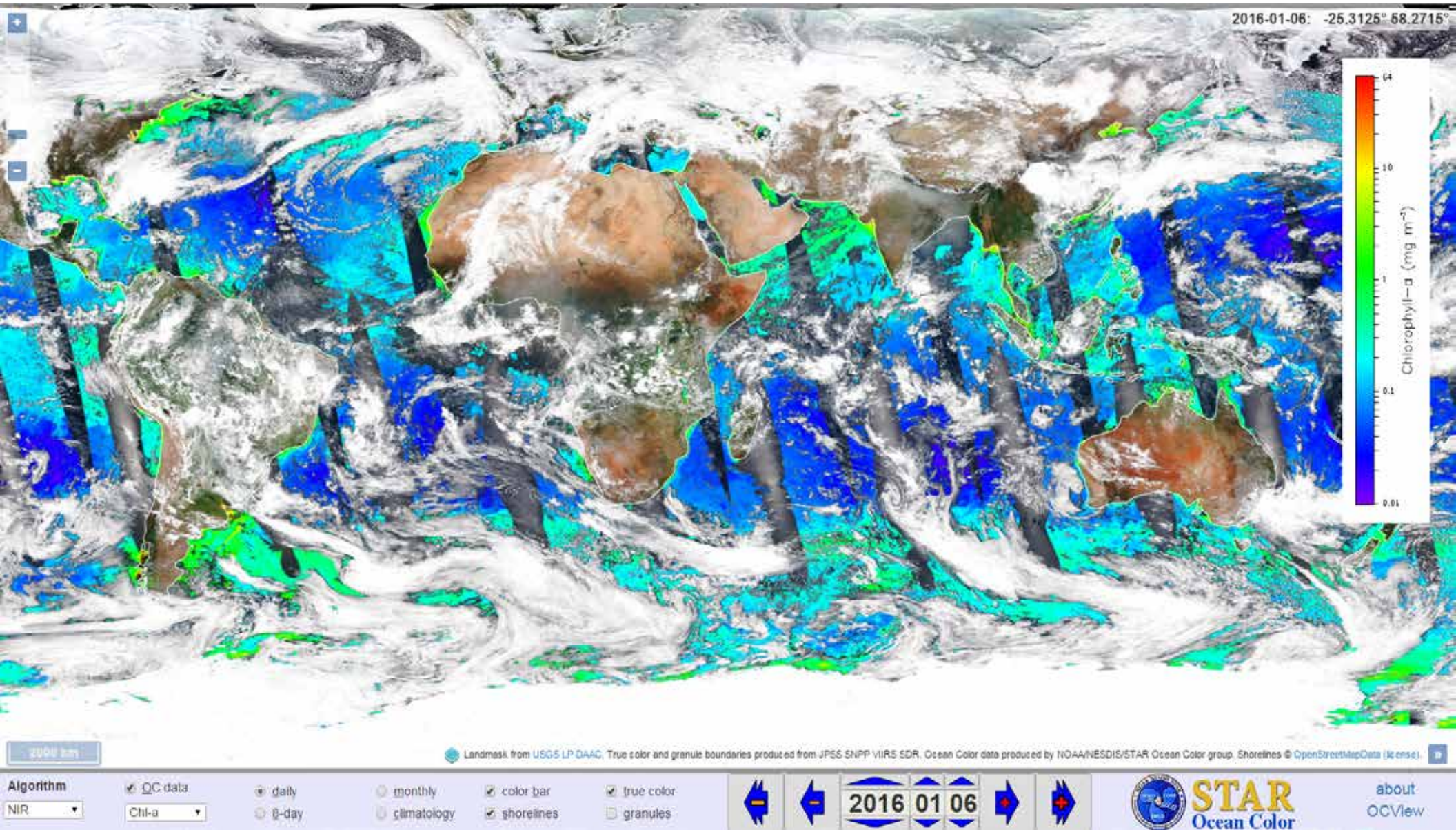
Science Quality Data

MOBY

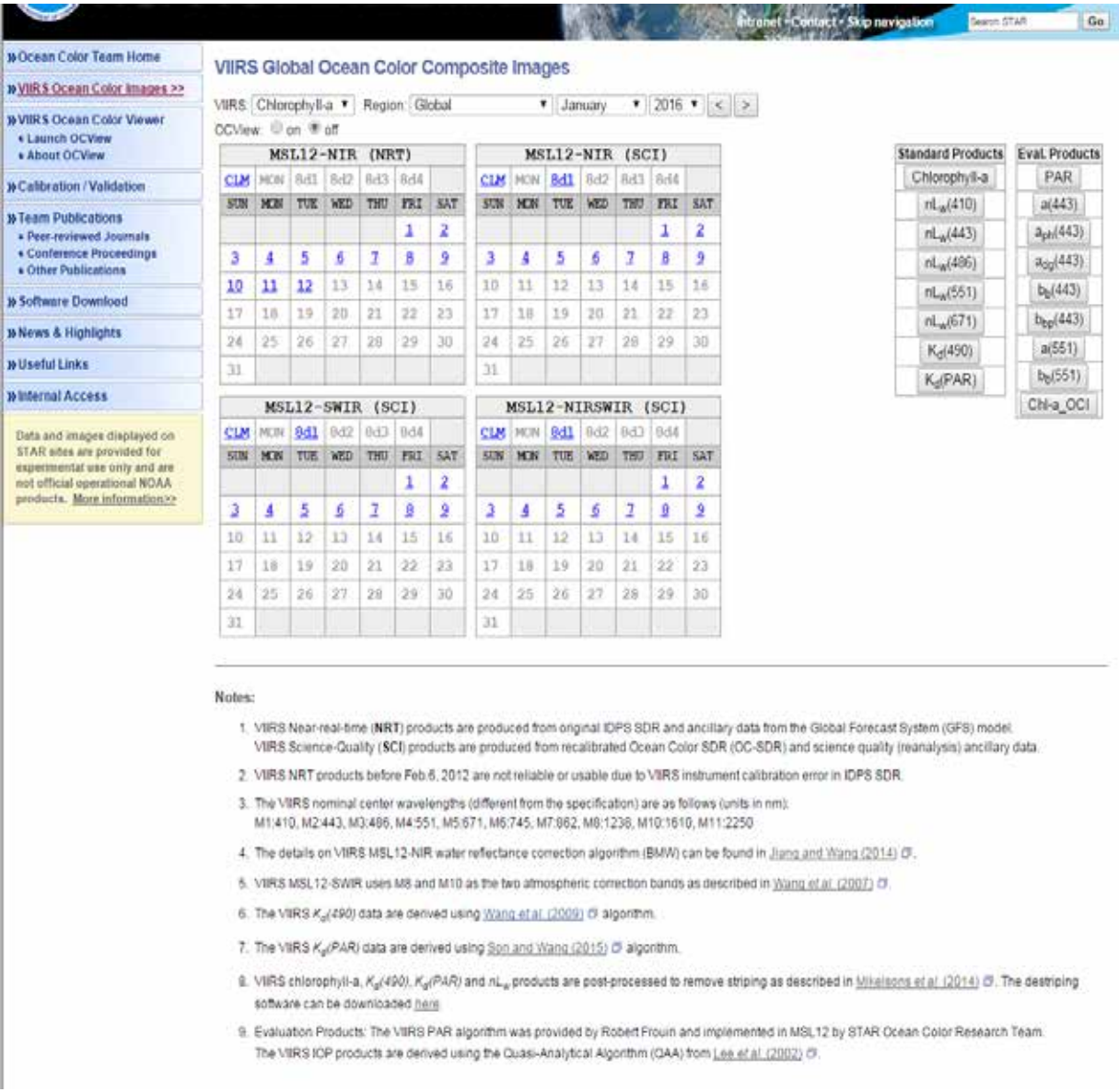
Marine Optical Buoy (MOBY) --- In situ hyperspectral radiometric data measured at water off the island of Lanai in Hawaii.

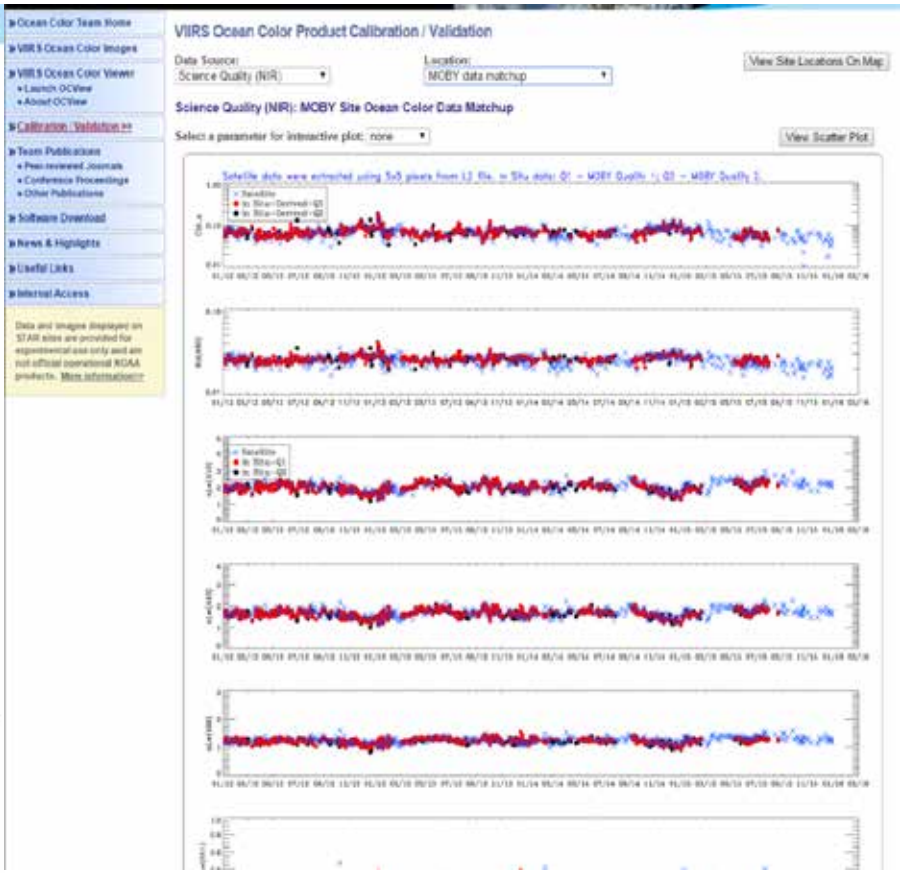


OCView: Seamless Global Coverage



Composite Images & Cal/Val

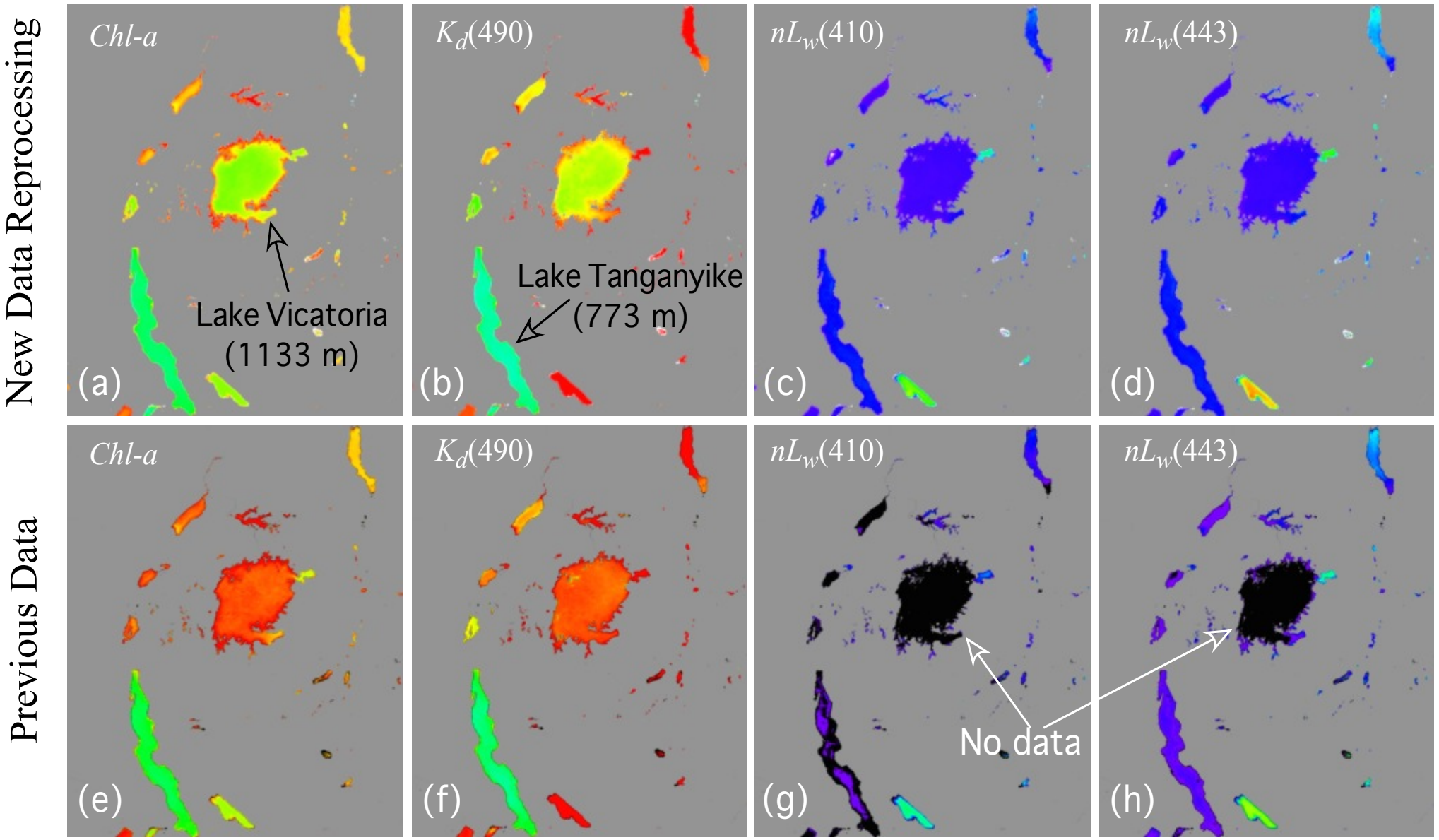




Routinely producing VIIRS global ocean color products (**daily**, **8-day**, **monthly**, **climatology**) using the **MSL12** with the **NIR**, **SWIR**, and **NIR-SWIR** atmospheric correction algorithms.

Significantly Improved Water Property Data Over High Altitude Lakes (1)

High Altitude Lake Vicatoria (1133 m) and Lake Tanganyike (773 m)

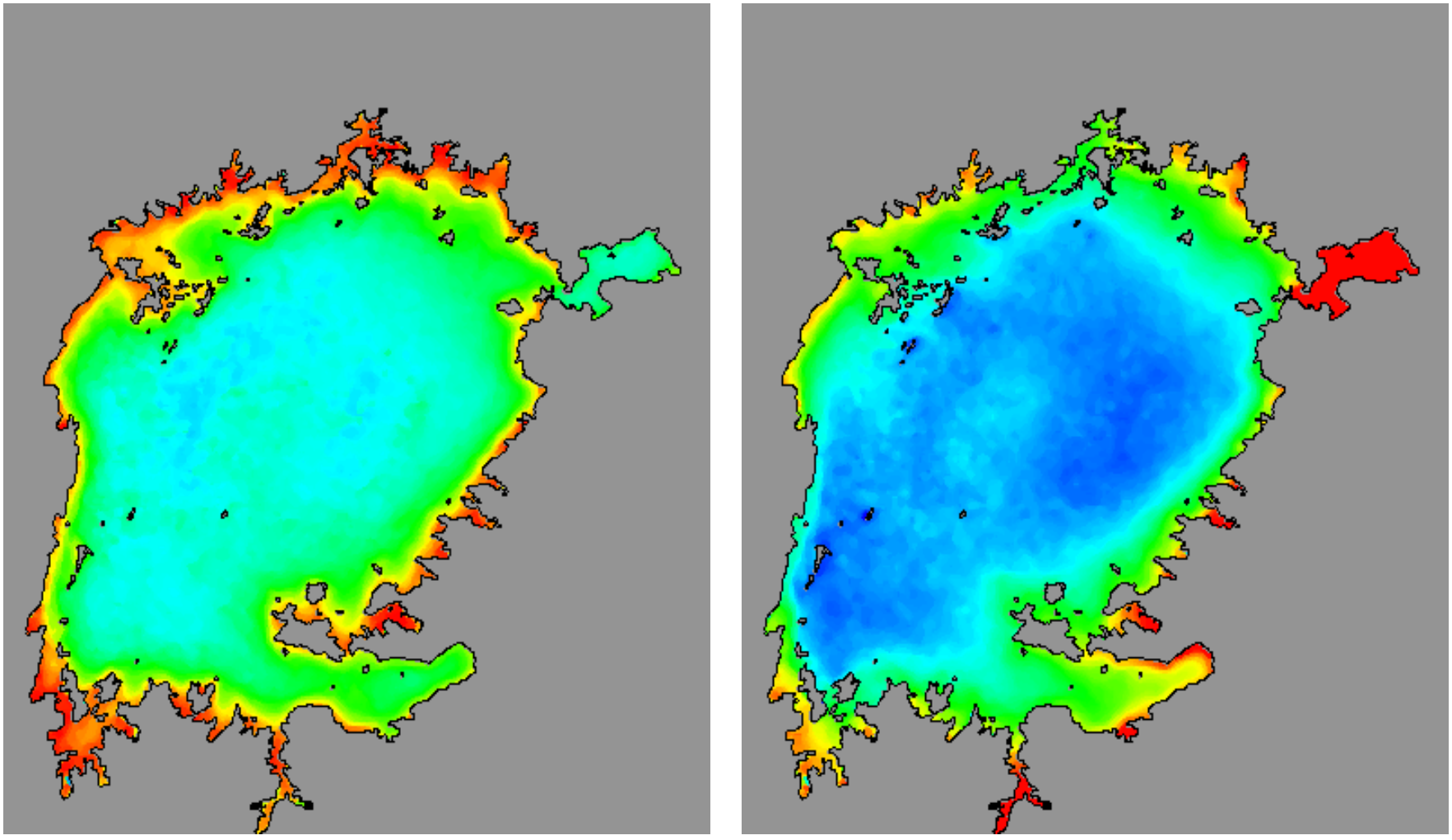


VIIRS mission-long ocean color data have been successfully reprocessed using improved MSL12. VIIRS ocean color data over open oceans and coastal/inland waters have been significantly improved, in particular, over high altitude lakes. This is a significant progress for remote sensing of inland water quality.

Lake Victoria---Fresh water (South Africa, Area: 68,800 km^2, Ave. depth: 40 m)

VIIRS Climatology Images (Jan. 2012–May 2016)

VIIRS *Chl-a* | **VIIRS K_d(490)**



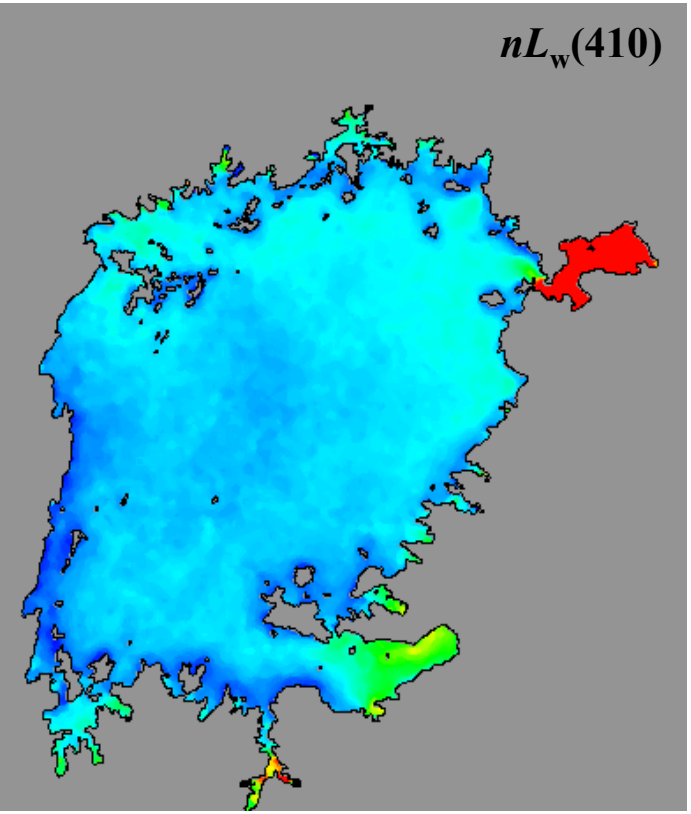
Color scales: Chl-a (1~64.0 mg m^{-3}) & K_d(490) (0.3~2.0 m^{-1}) in log-scale

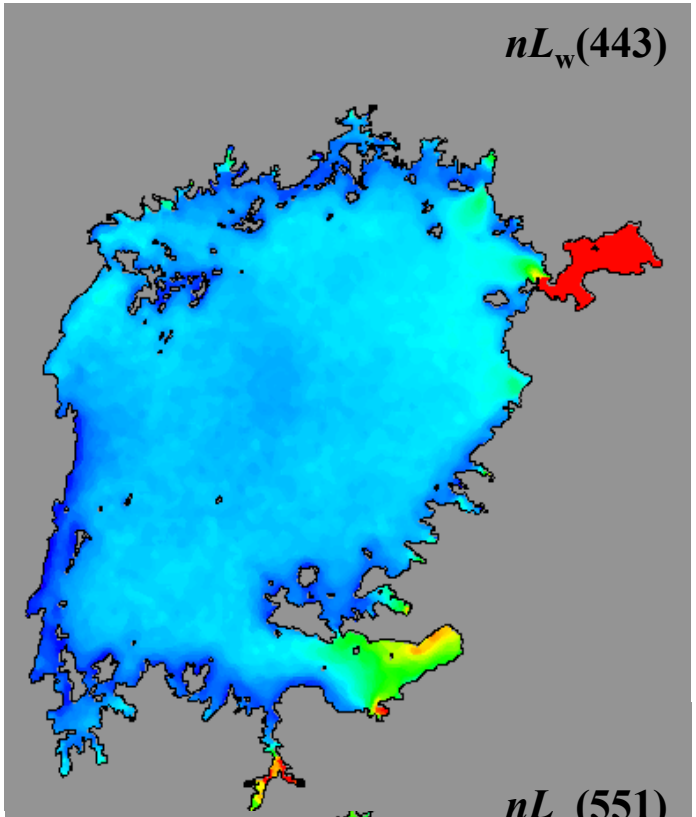
5×5 Median Filter

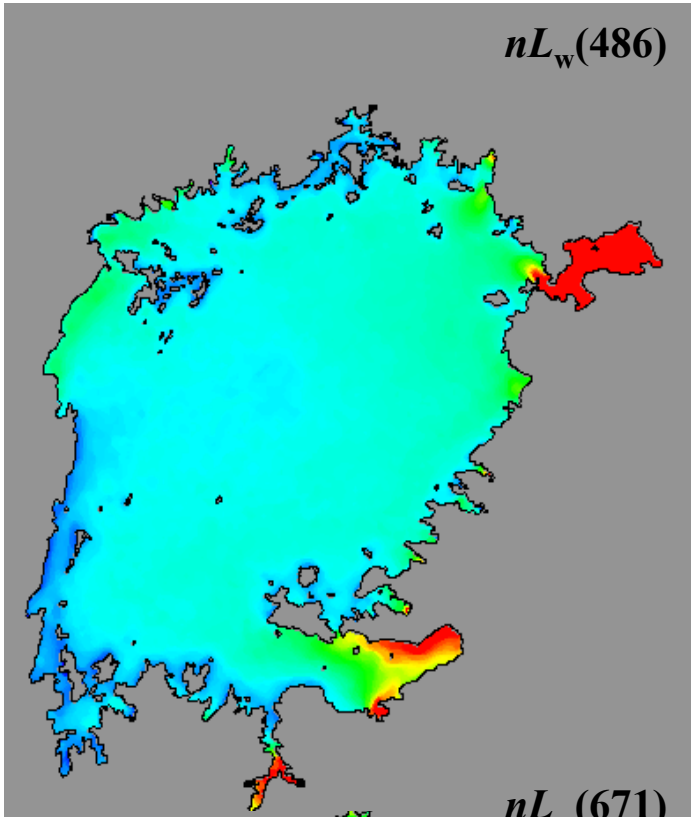
Lake Victoria

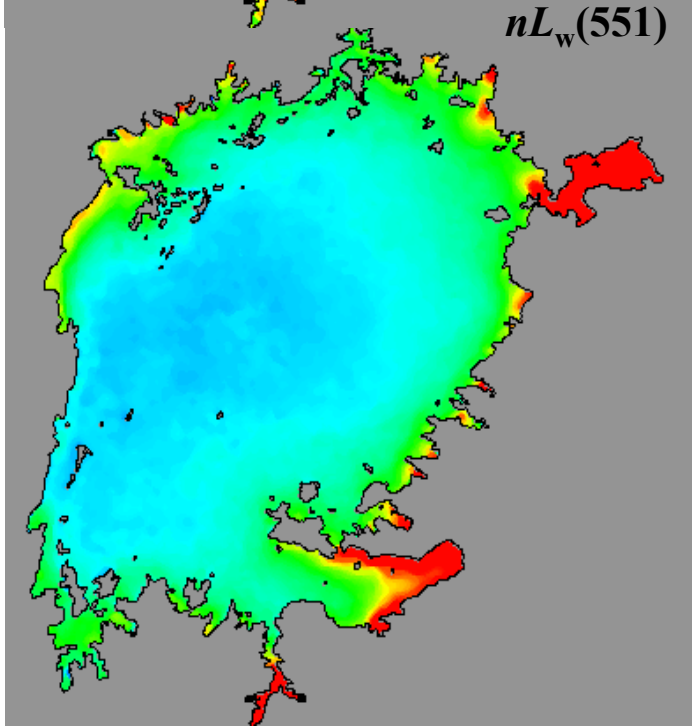
VIIRS Climatology Images (Jan. 2012–May 2016)

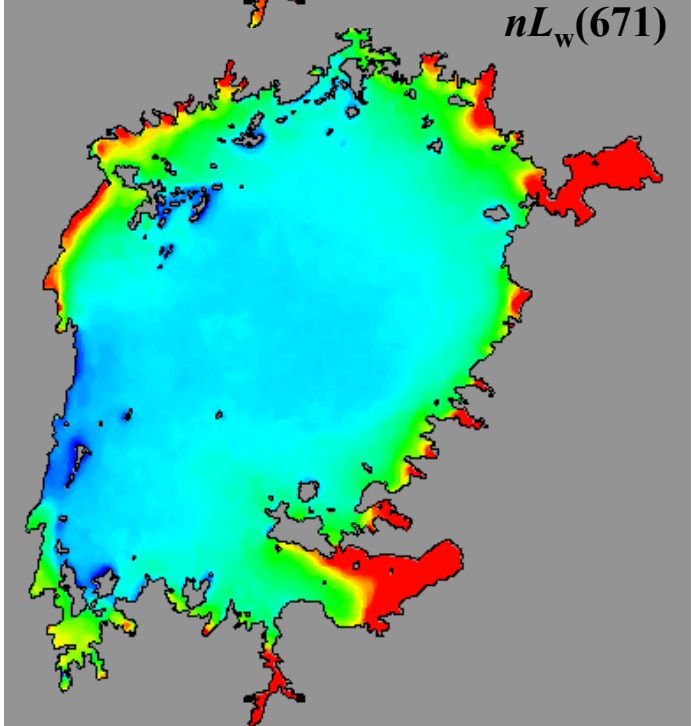
Lake Victoria











Color scales (linear-scale):

$nL_w(410)$: 0 ~ 1.0

$nL_w(443)$: 0 ~ 1.2

$nL_w(486)$: 0 ~ 1.5

$nL_w(551)$: 0 ~ 2.0

$nL_w(671)$: 0 ~ 0.5

Unit: mW cm^{-2} μm^{-1} sr^{-1}

5×5 Median Filter

Histogram of

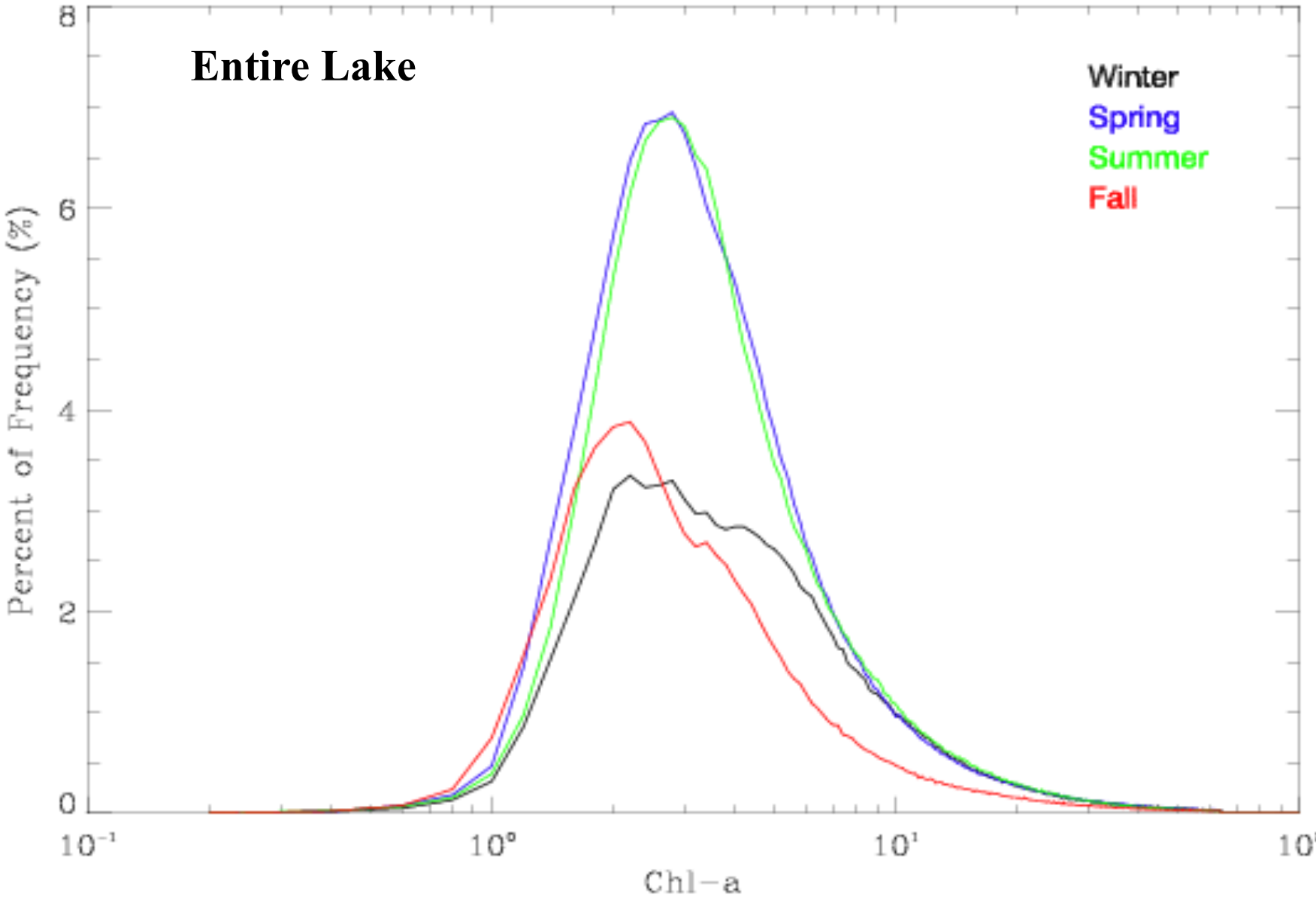
VIIRS-NIR

Seasonal Chl-a

Lake Victoria

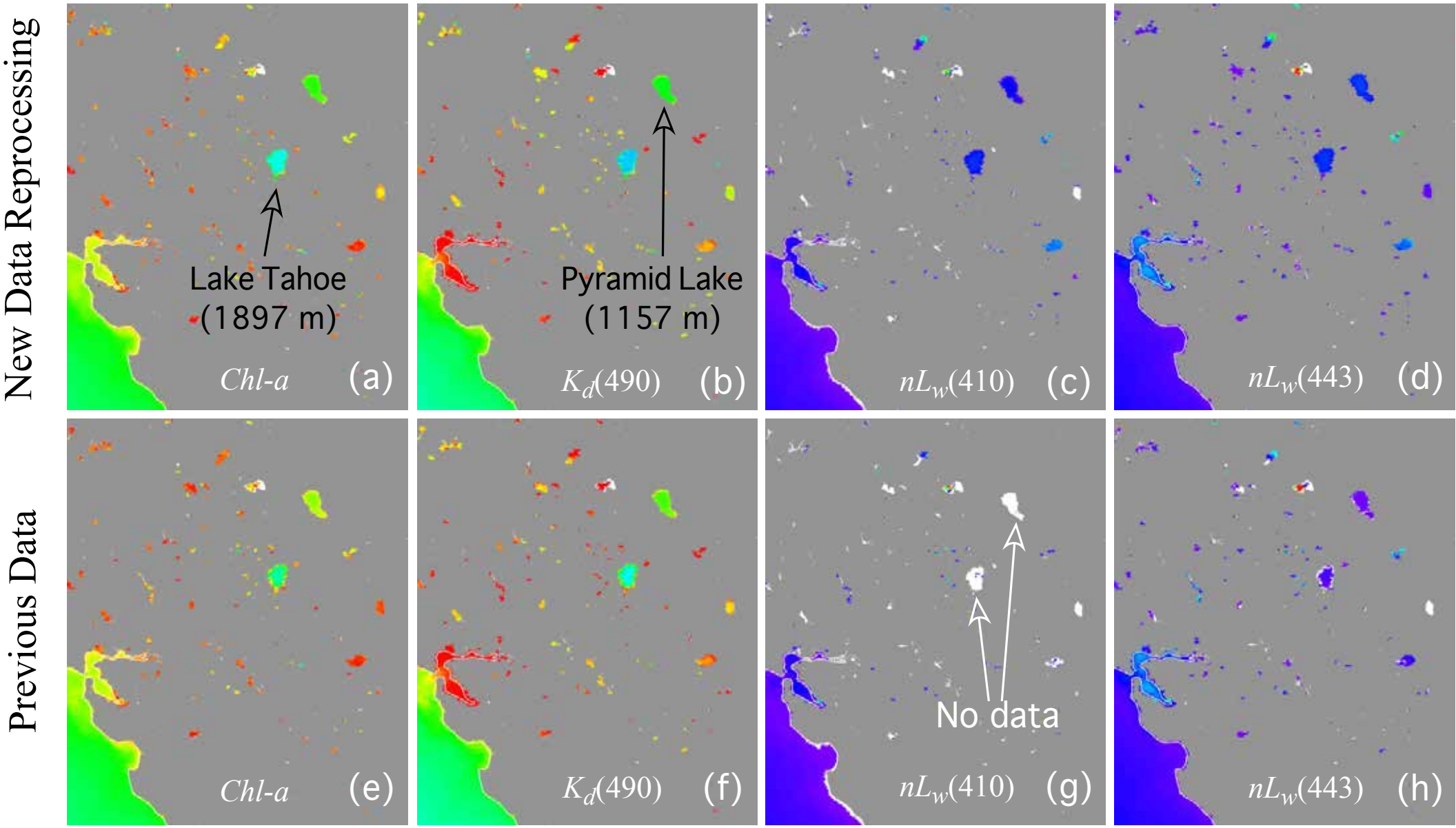
Winter (Dec.–Feb.)
Spring (Mar.–May)
Summer (Jun.–Aug.)
Fall (Sep.– Nov.)

VIIRS Chl-a Data over Lake Victoria (Jan. 2012–May 2016)



Significantly Improved Water Property Data Over High Altitude Lakes (2)

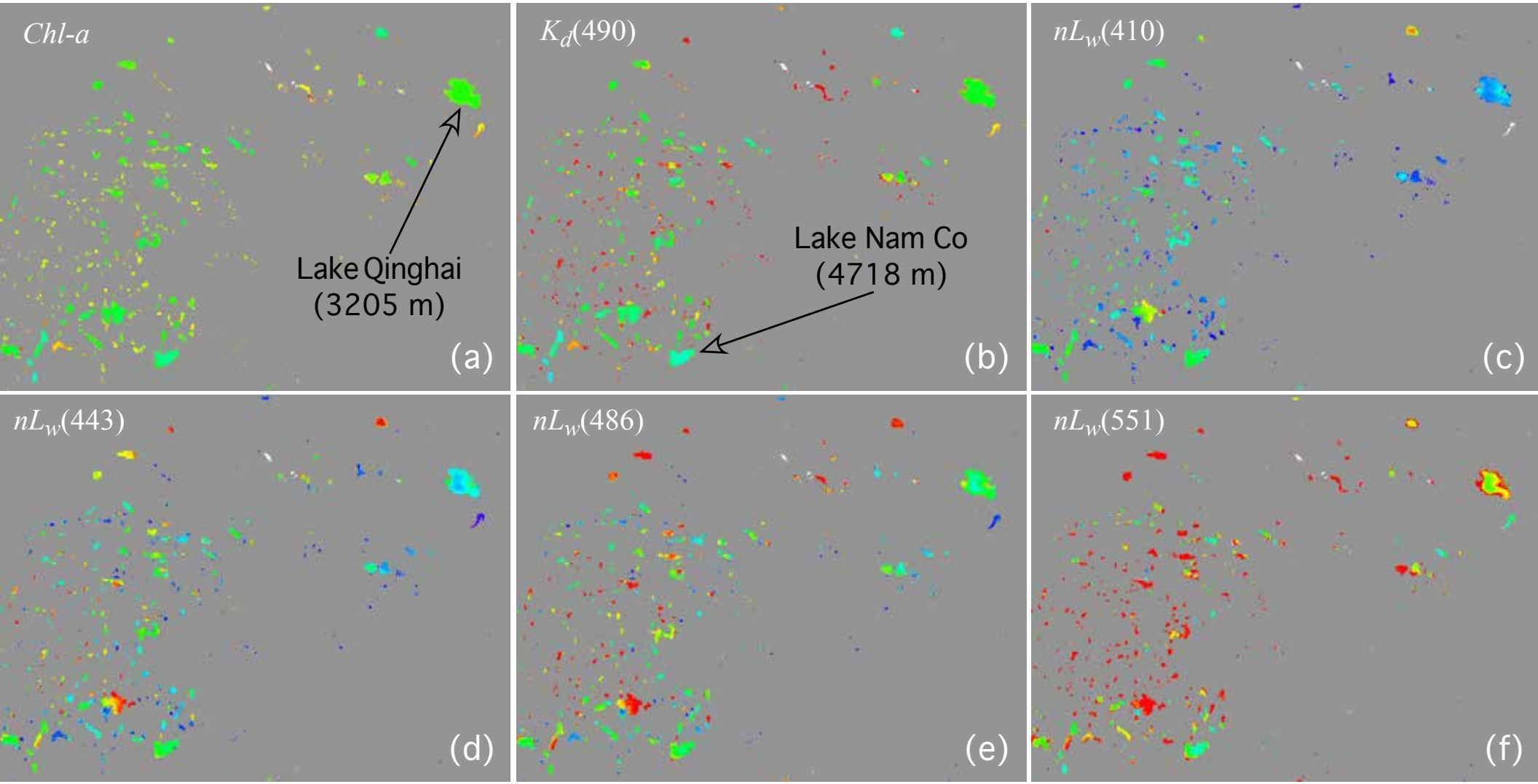
High Altitude Lake Tahoe (1,897 m) and Pyramid Lake (1,157 m)



Lake Tahoe---Fresh water (California/Nevada, Area: 490 km^2, Ave. depth: 300 m)
Pyramid Lake---1/6 salinity (Nevada, Area: 490 km^2, Max. depth: 109 m)

Significantly Improved Water Property Data Over High Altitude Lakes (3)

High Altitude Lake Qinghai (3,205 m) and Lake Nam Co (4,718 m)



Lake Qinghai---Saline lake (Qinghai, China, Area: 4489 km^2, Ave. depth: 21 m)
Lake Nam Co---Saline lake (Tibetan, China, Area: 1920 km^2, Ave. depth: 33 m)

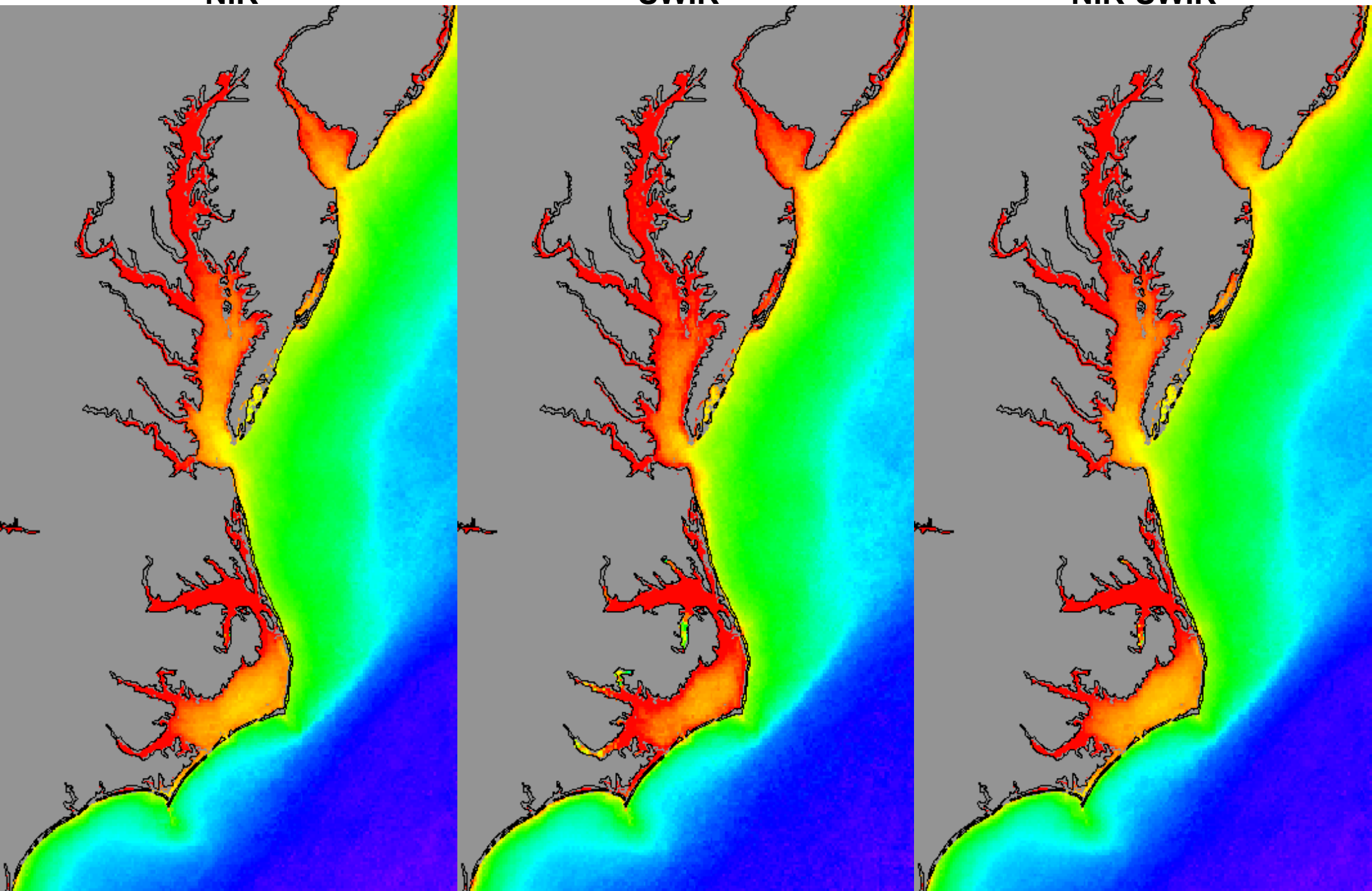
Wang, M., "Rayleigh radiance computations for satellite remote sensing: Accounting for the effect of sensor spectral response function," *Opt. Express*, **24**, 12414–12429, 2016. http://dx.doi.org/10.1364/OE.24.012414.

VIIRS (OC-SDR) Climatology Images (2012–2015)

Chl-a (0.1~16.0 mg/m^3 in log scale)

US East Coast

NIR | **SWIR** | **NIR-SWIR**

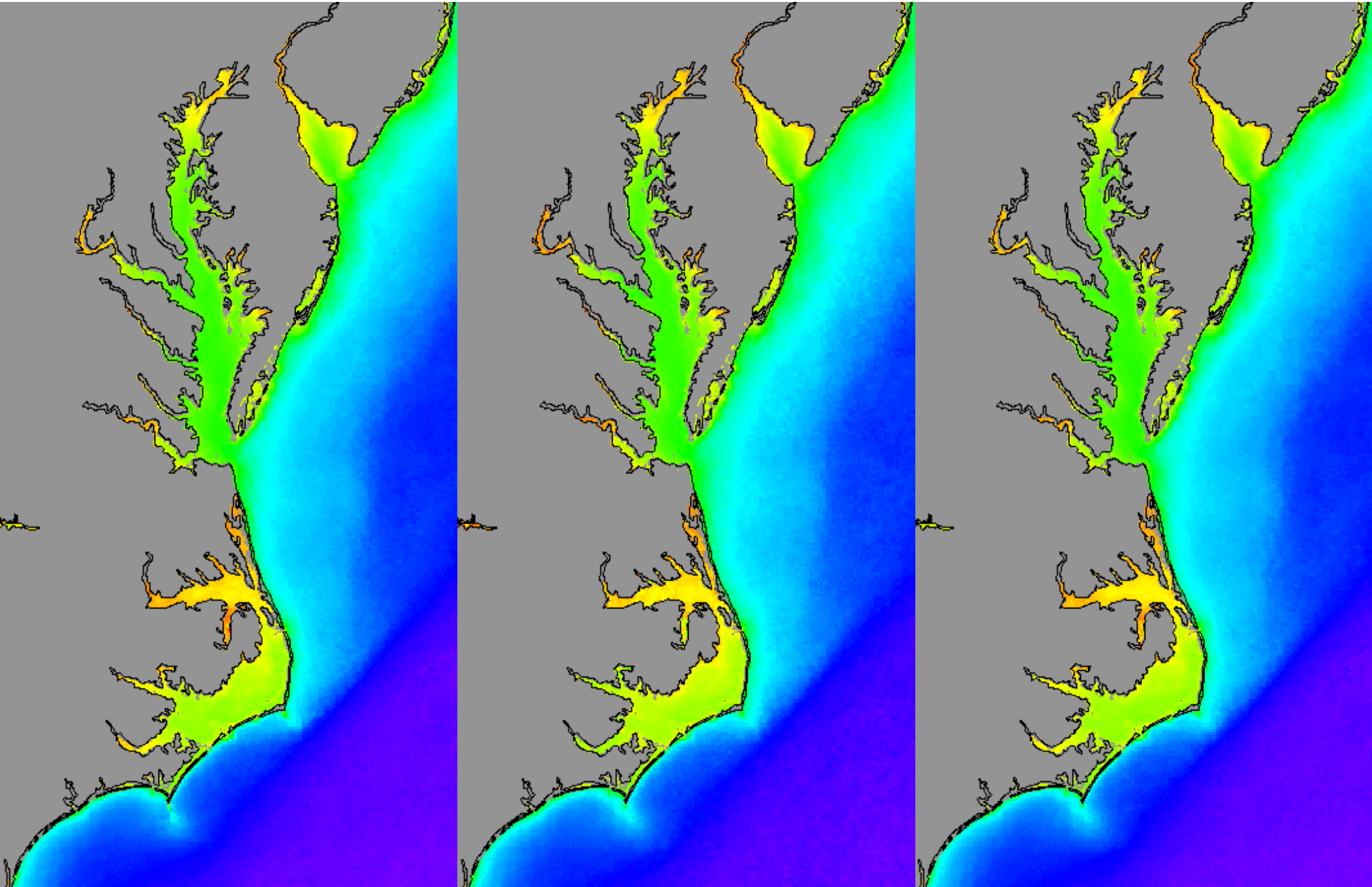


VIIRS (OC-SDR) Climatology Images (2012–2015)

$K_d(490)$ (0.03−8.0 m^{-1} in log scale)

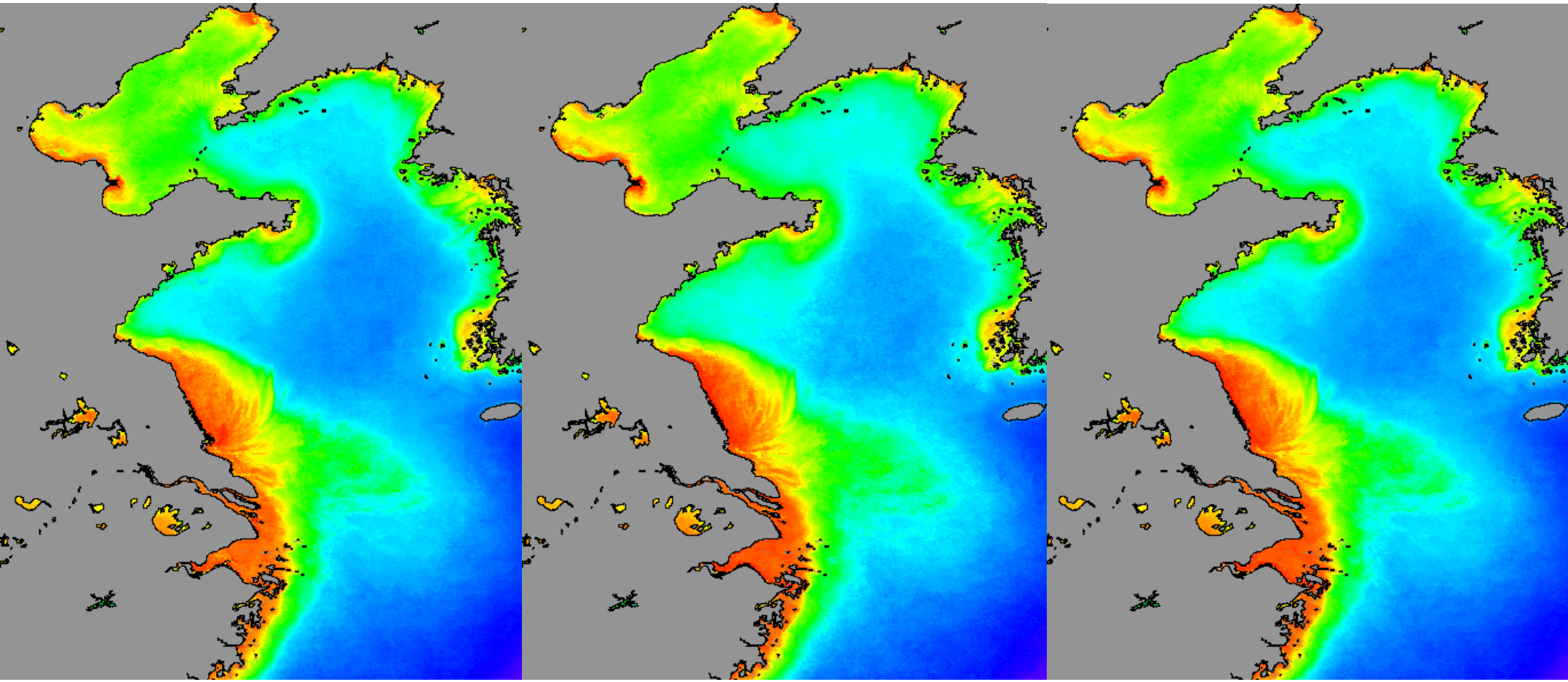
US East Coast

NIR | **SWIR** | **NIR-SWIR**



VIIRS (OC-SDR) Climatology Images (2012–2015)

NIR **SWIR** **NIR-SWIR**

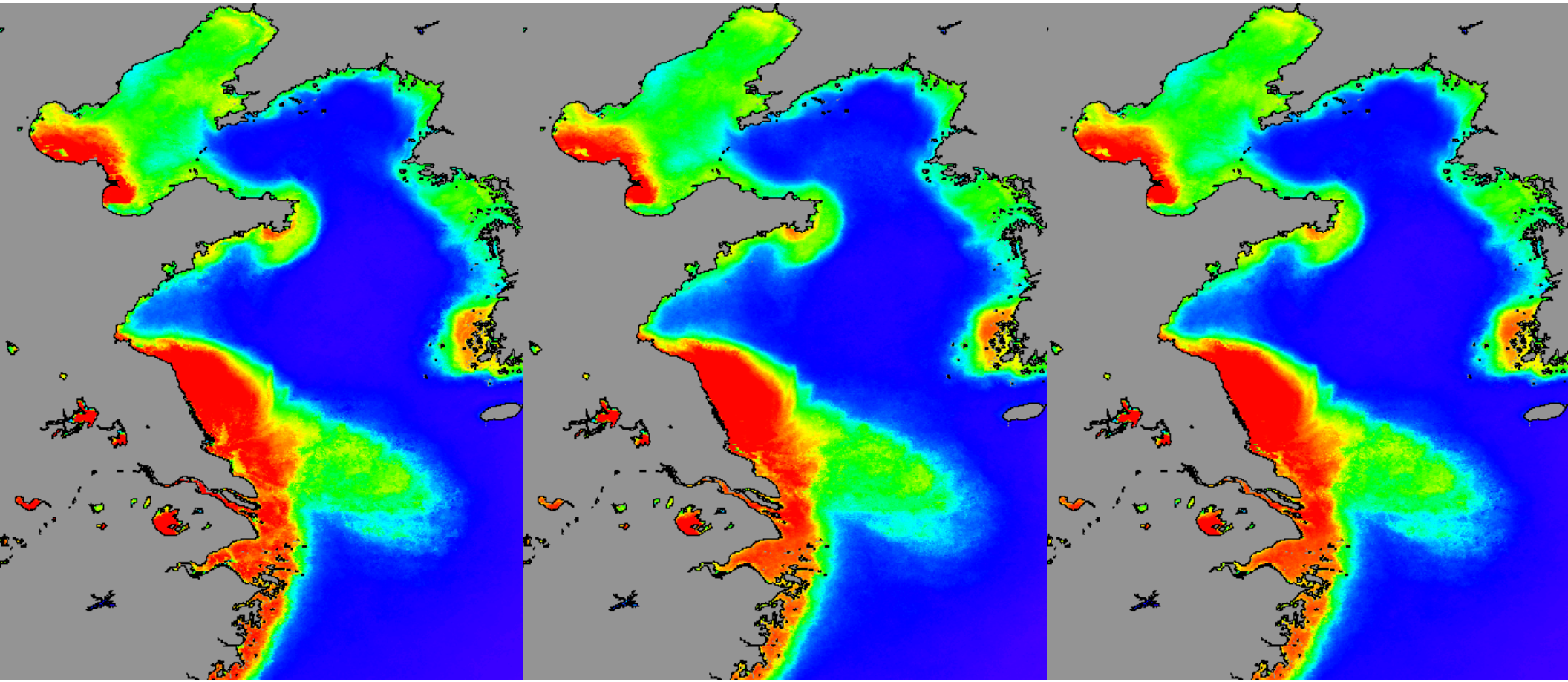


$K_d(490)$ (0.03~8.0 m^{-1} in log scale)

China East Coast

VIIRS (OC-SDR) Climatology Images (2012–2015)

NIR SWIR NIR-SWIR



$nL_w(551)$ (0.0~5.0 mW/cm^2 μm sr in linear scale)

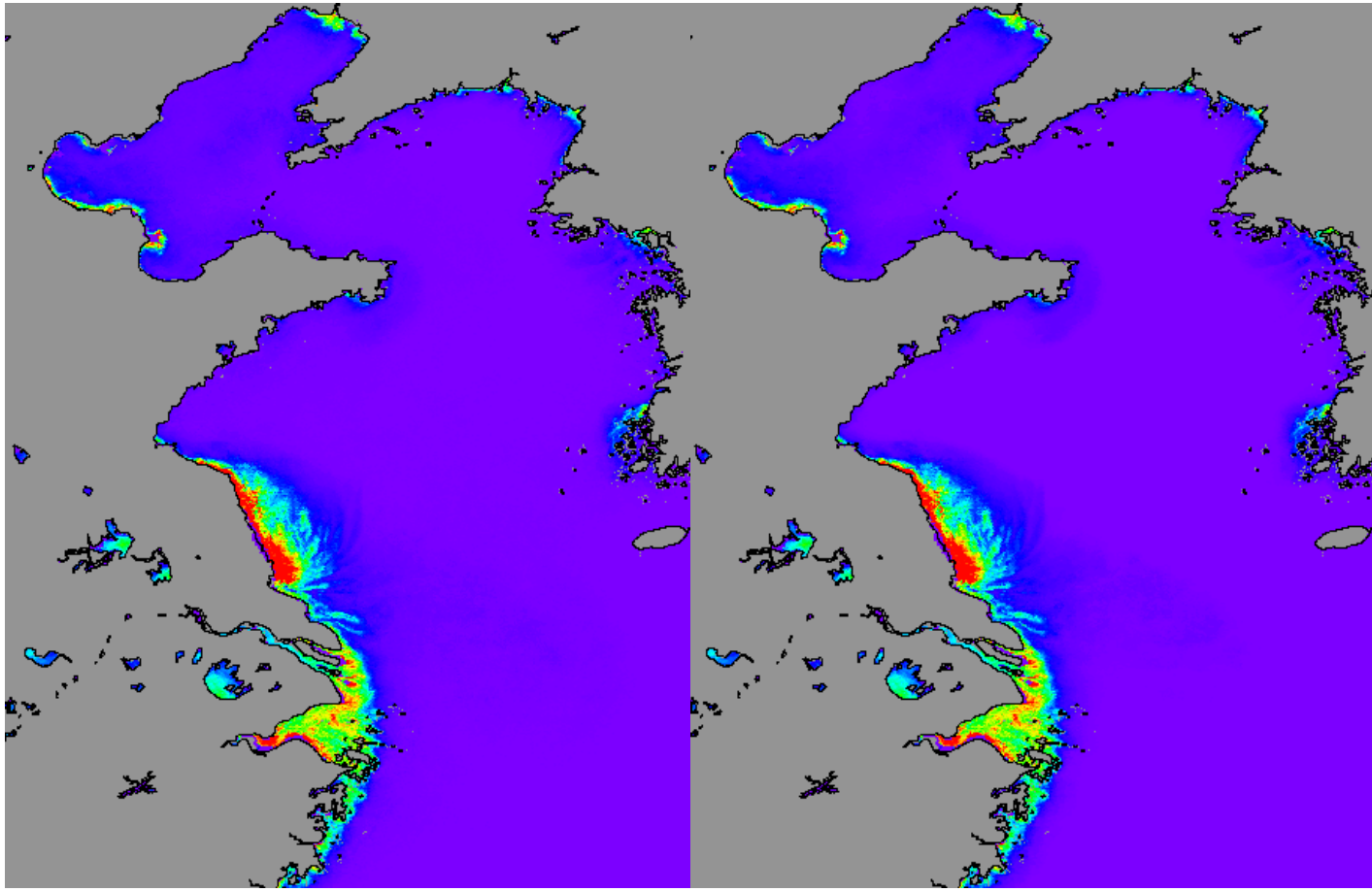
China East Coast

VIIRS (OC-SDR) Climatology Images (2012–2015)

The **NIR** normalized water-leaving radiance contribution in highly turbid coastal regions.

China East Coast

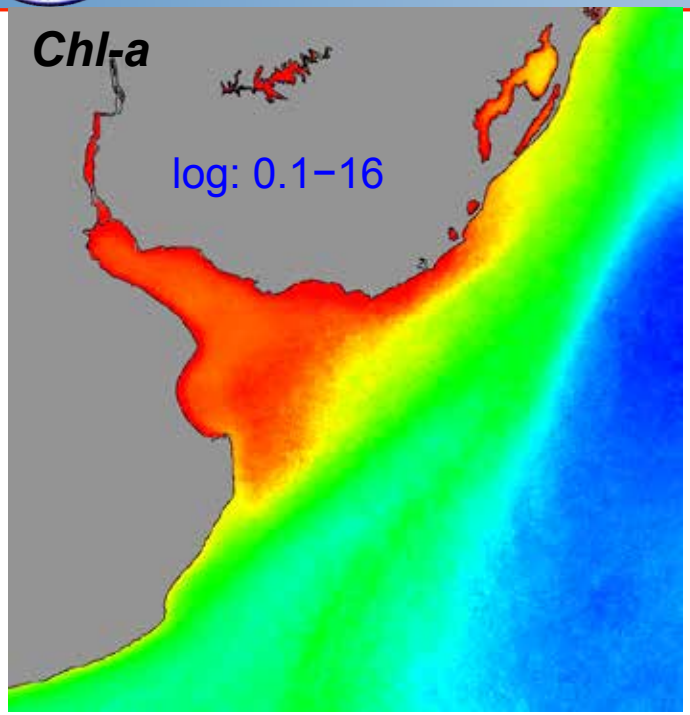
SWIR **NIR-SWIR**

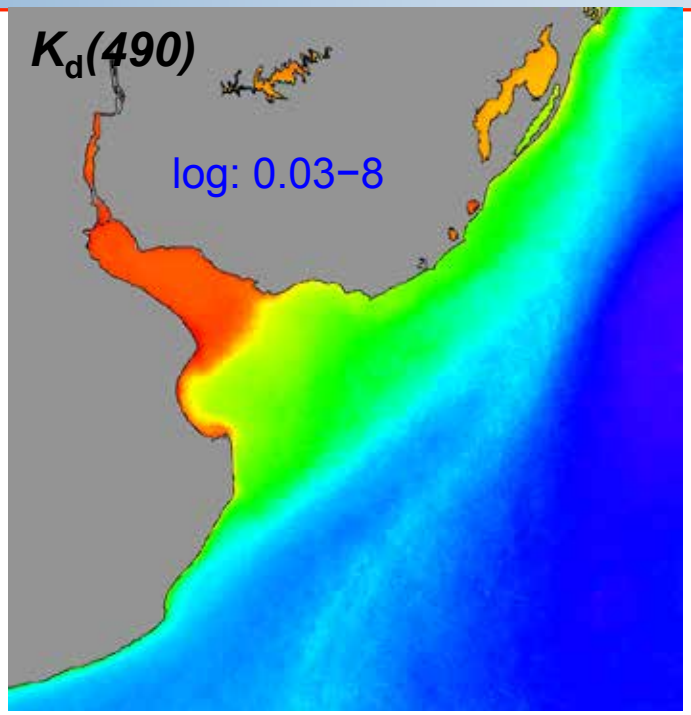


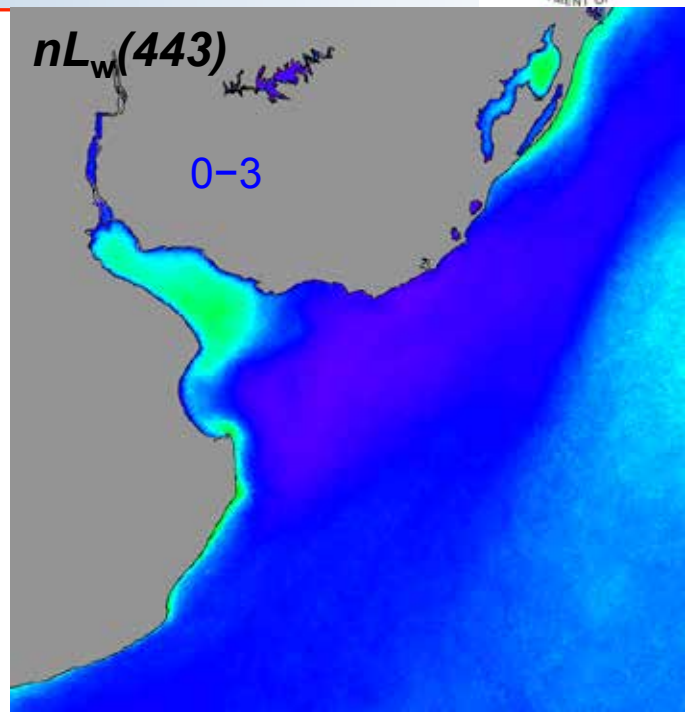
$nL_w(862)$ (0.0~**2**.0 mW/cm^2 μm sr in linear scale)

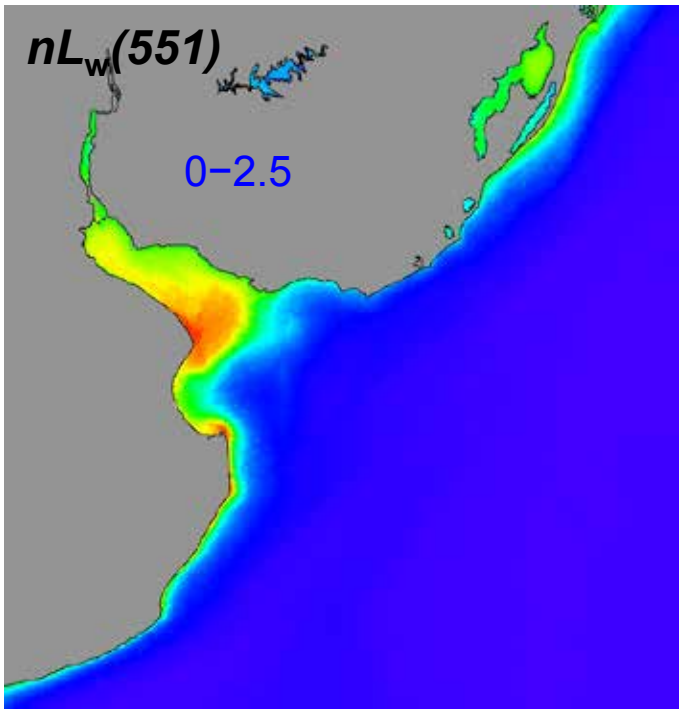
VIIRS Climatology (2012-2015) using the NIR-SWIR Approach

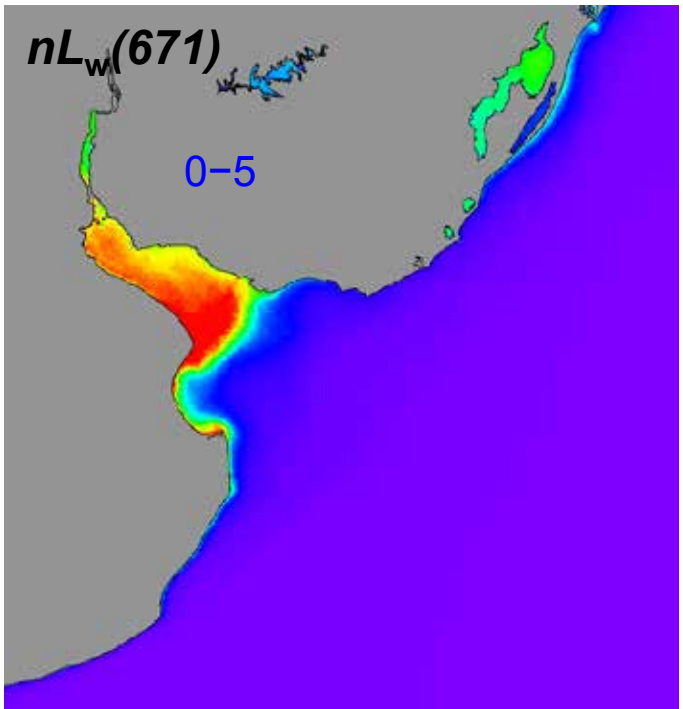
La Plata

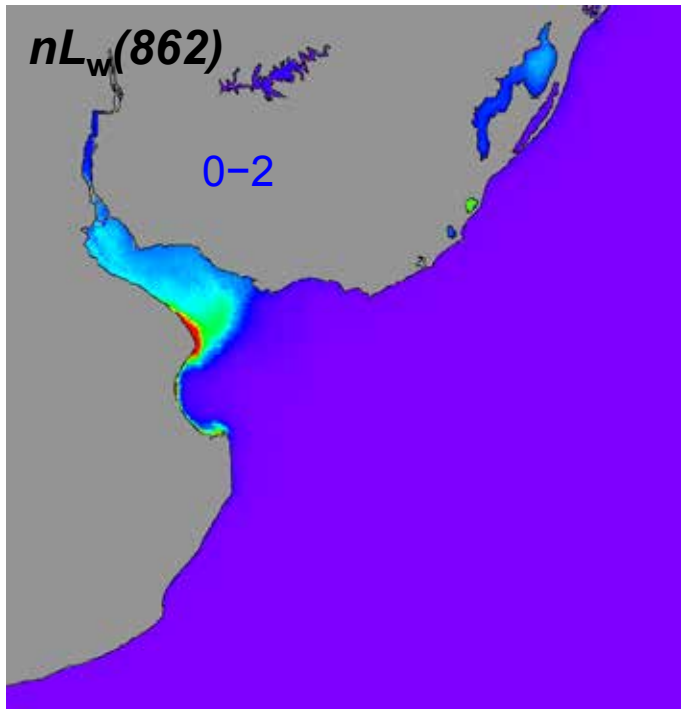






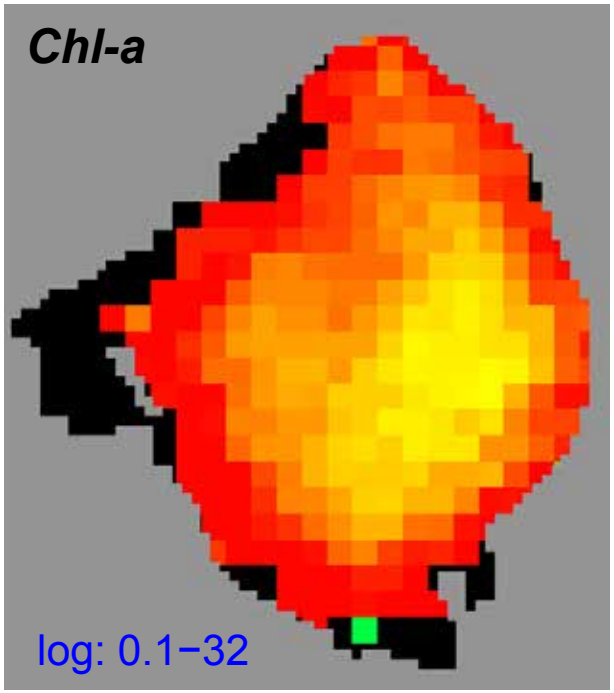


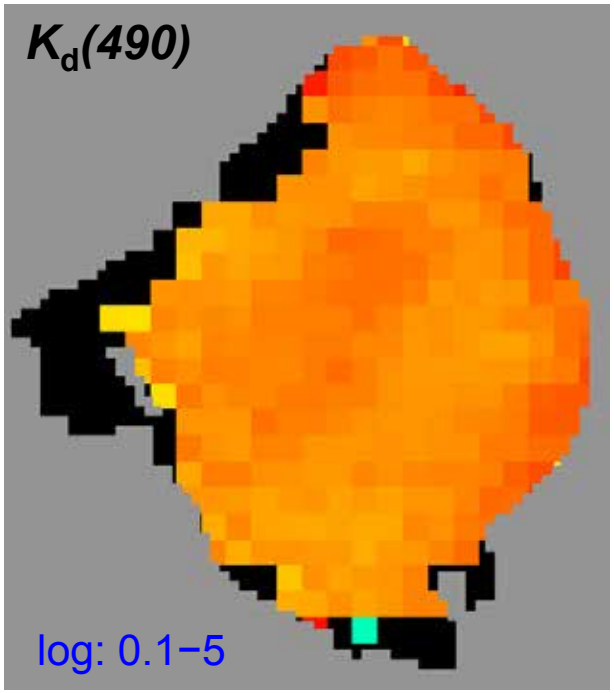


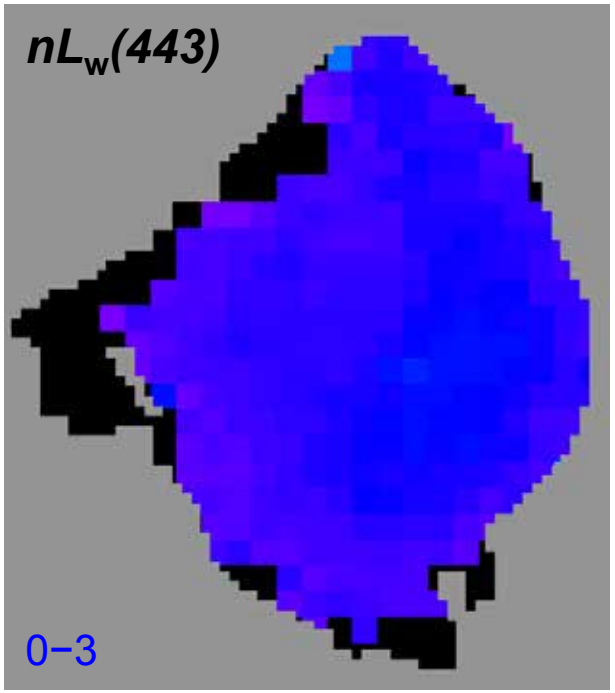


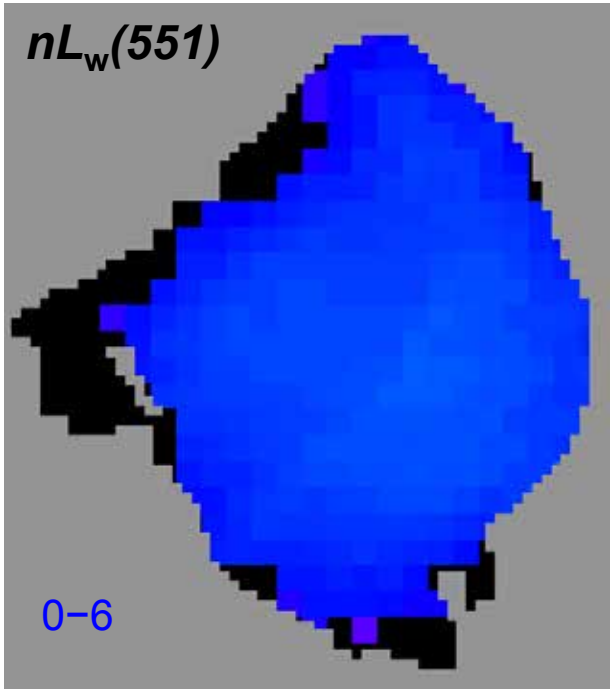
VIIRS Climatology (2012-2015) using the NIR-SWIR Approach

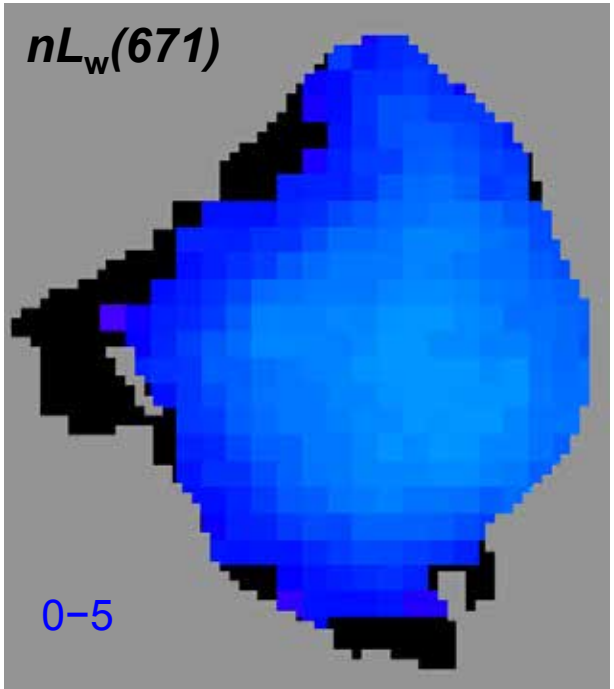
Lake Okeechobee

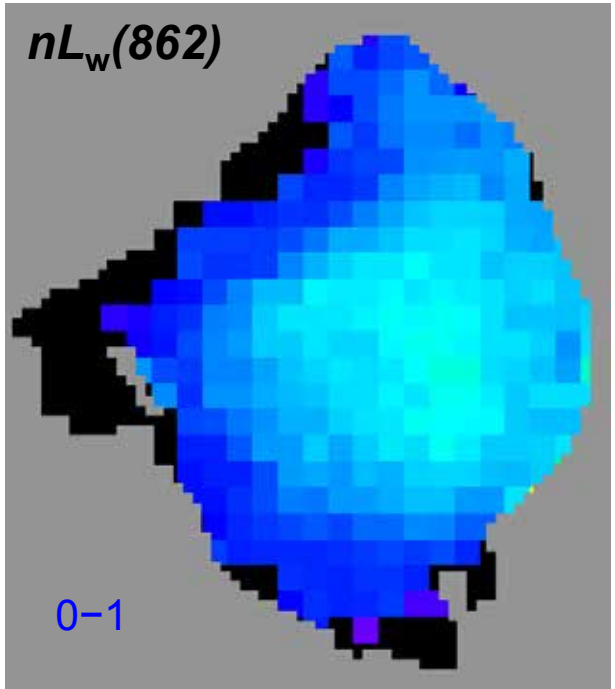


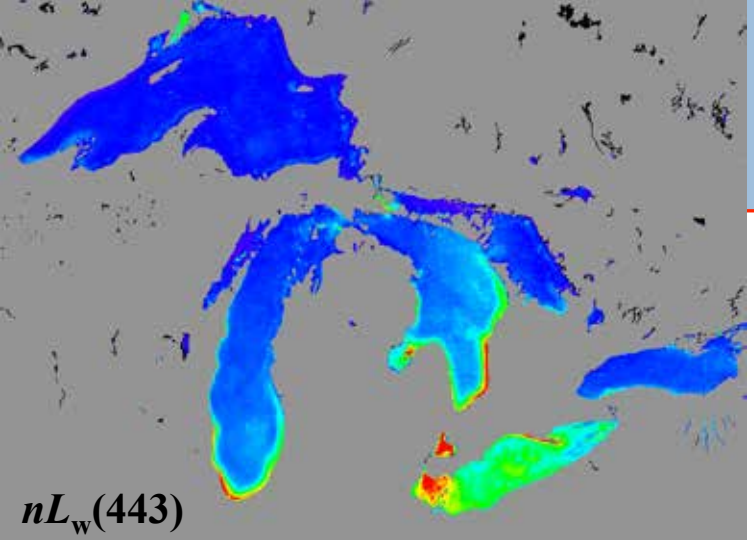


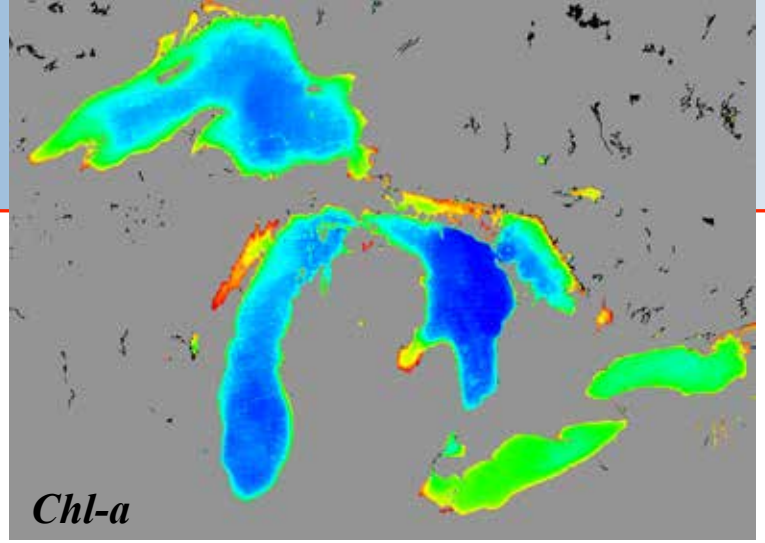


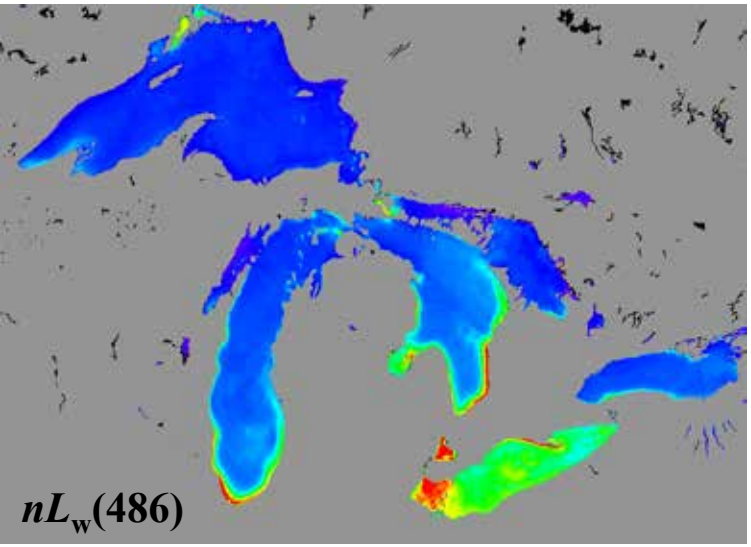


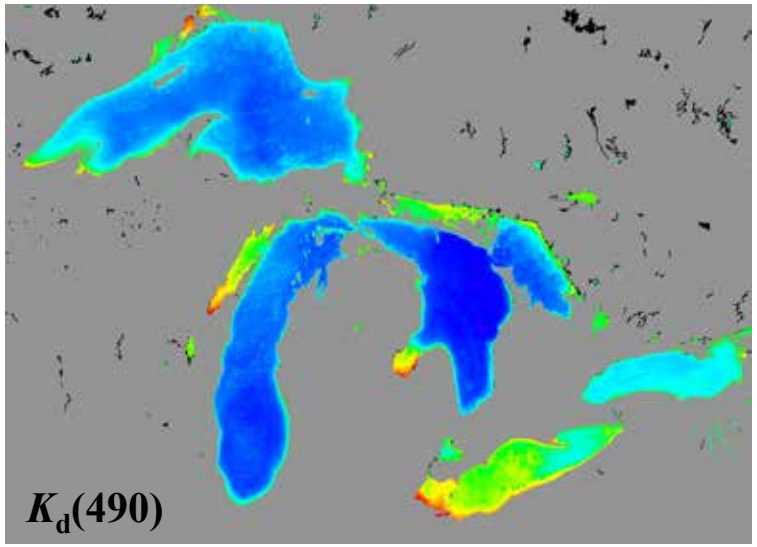


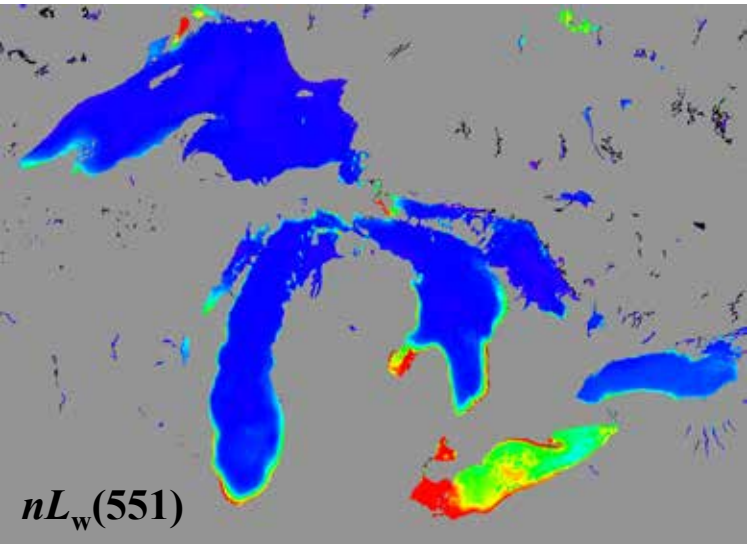


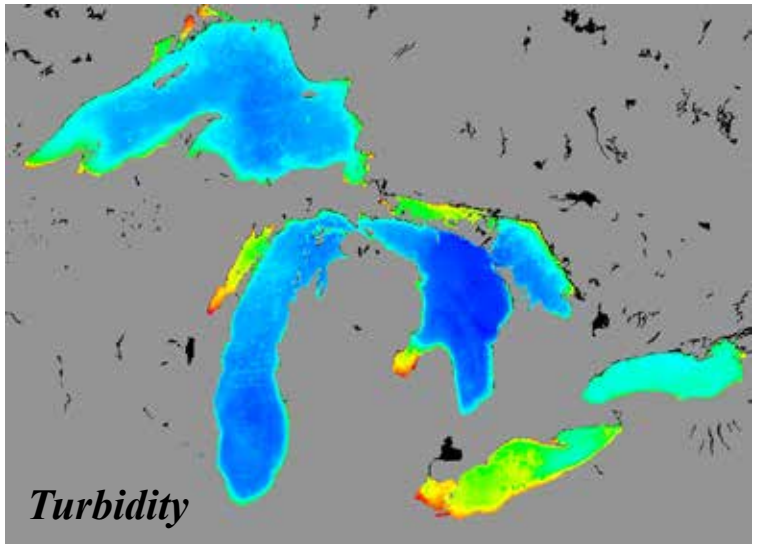












VIIRS NIR-SWIR Climatology Images (from 2012–2015)

Great Lakes

OCEAN COLOR TOOLS FOR REEF MANAGERS

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

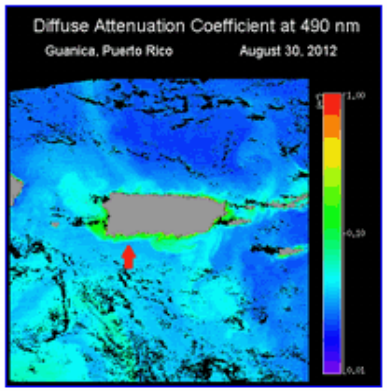
NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

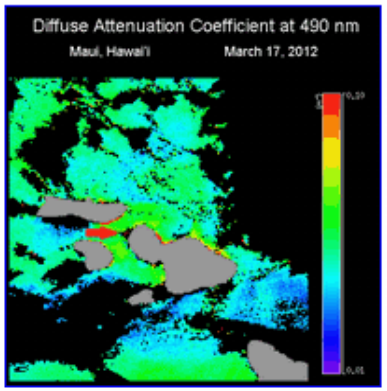
Coral Reef Watch

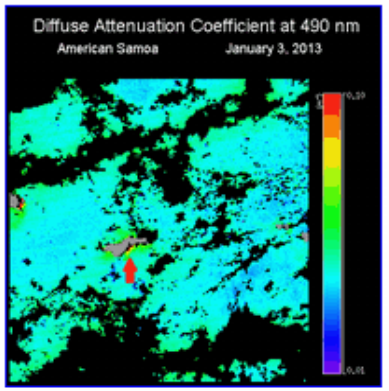
DOC > NOAA > NESDIS > STAR > CRW

CRTF | CRCP | CREIOS | CoRIS

Satellite Ocean Color Product Development







NOAA Coral Reef Watch and NOAA/NESDIS' Ocean Color Team are working closely with partners in the U.S. Coral Reef Task Force (USCRTF) Watershed Working Group (WWG) to develop pilot satellite ocean color products using data from the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the Suomi National Polar-orbiting Partnership (S-NPP) satellite operated by the NOAA Joint Polar Satellite System (JPSS).

The pilot satellite ocean color products are designed to help coral reef ecosystem managers monitor variable water turbidity (diffuse attenuation coefficient at 490 nm, $K_d(490)$). Land-Based Sources of Pollution (LBSP), identifiable by a significant increase in water turbidity, especially following large precipitation events, is one of the major threats to coral reef health typically caused by coastal and upstream land development. Since chlorophyll *a* plays a role, as well, this parameter is also being addressed, but not shown here. Additional VIIRS ocean color measurements (e.g. Colored Dissolved Organic Matter (CDOM) and Total Suspended Solids (TSS)) will be included as they are developed and verified by the team.

Three high priority coral reef sites identified by the USCRTF WWG have been selected for development of the pilot ocean color products. These include, from left to right above: Guánica Bay, Puerto Rico; West Maui, Ka'anapali, Hawai'i; and Faga'alu, Tutuila, American Samoa. (Note that in the VIIRS $K_d(490)$ images above, the exact location of each focal site is pinpointed by a red arrow.) The spatial resolution of the data used for deriving these images is 740 meters.

The pilot satellite ocean color products are being developed by NOAA Coral Reef Watch and NOAA/NESDIS' Ocean Color Team with support from NOAA's Ocean Remote Sensing program.

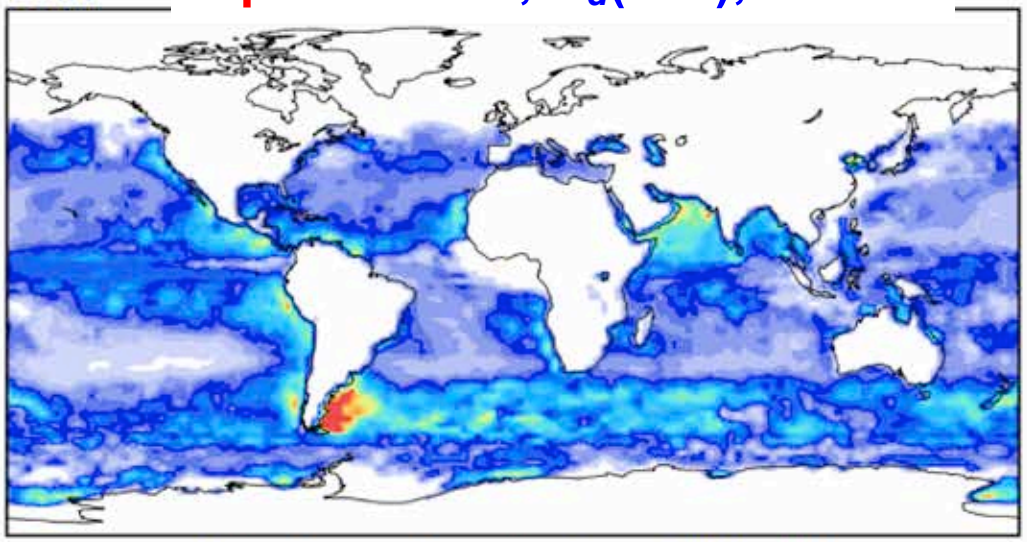
*From **Coral Reef Watch***

Global Distribution of Marine Isoprene Emission

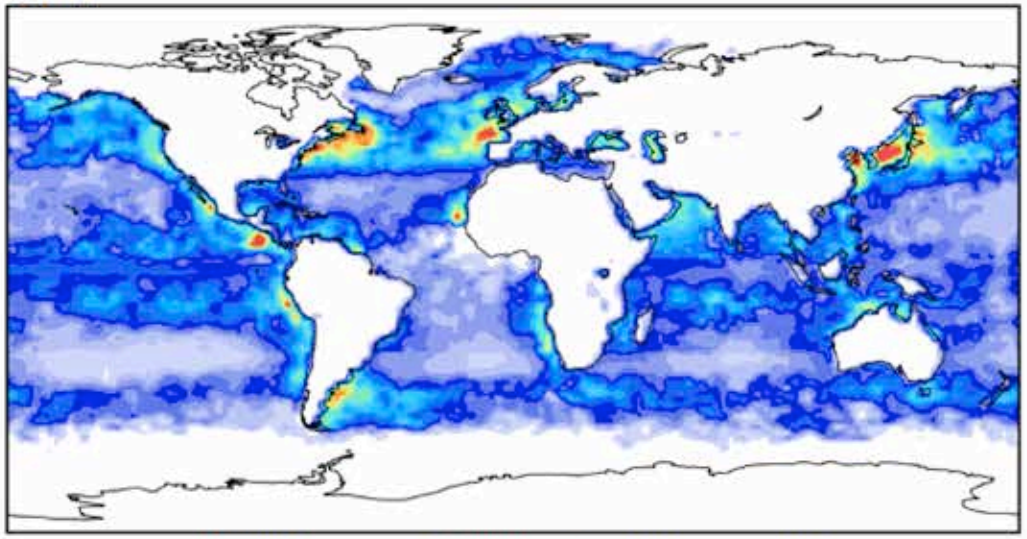
Tong et al. (JPSS Proving Ground Project)

Inputs: Chl-a, K_d(490), PAR

JAN



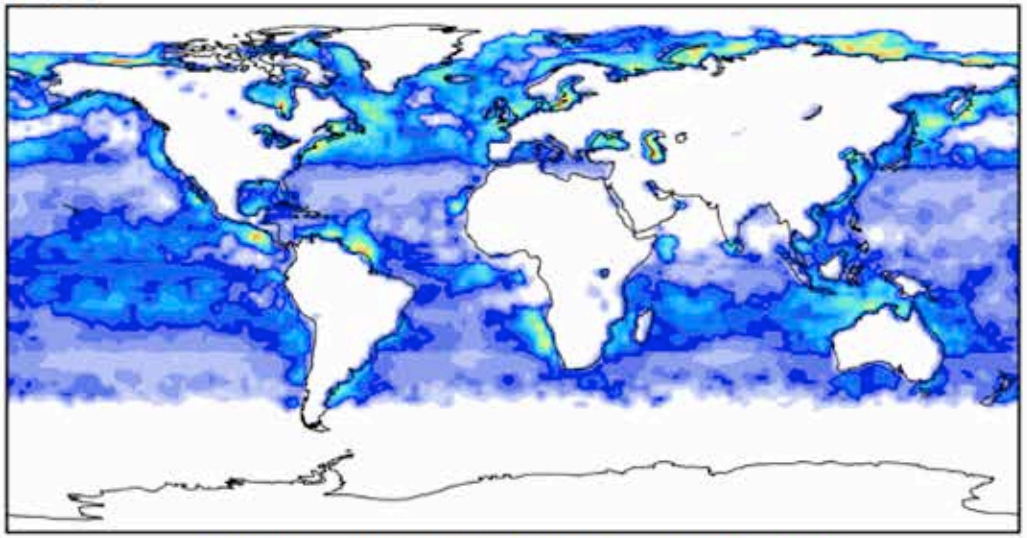
APR



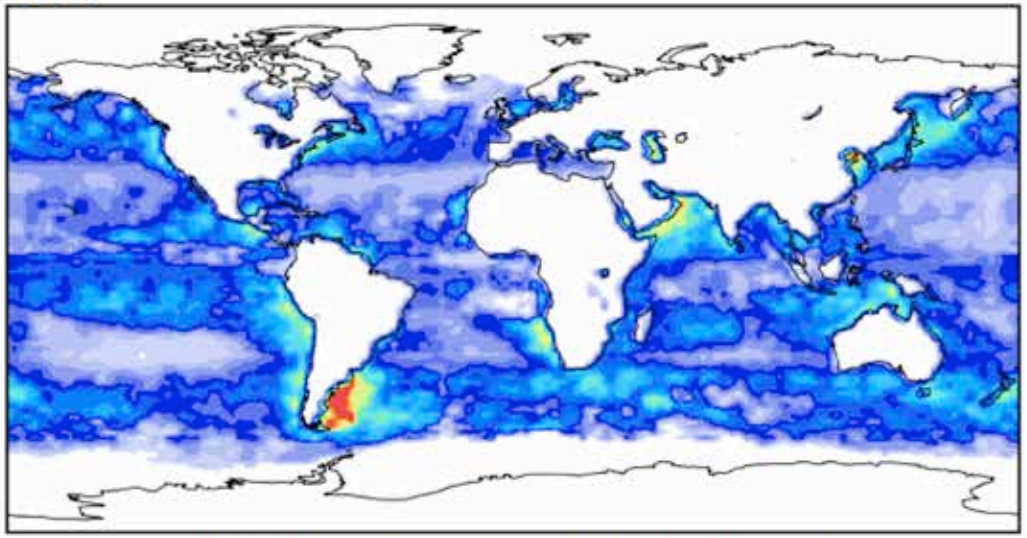
Marine Isoprene Emissions (molecules/cm2/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

JUL



OCT



Marine Isoprene Emissions (molecules/cm2/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

Conclusions

- We have completed VIIRS mission-long science quality ocean color data **reprocessing** (including **SDR** and **EDR**), and the data stream is now going forward. **Two data streams have been routinely produced: near-real-time and science quality ocean color data.**
- We have developed VIIRS instrument calibration capability, and with new calibration LUTs, VIIRS ocean color products are significantly improved.
- VIIRS ocean color products have been significantly improved (**data over global high altitude lakes**) after the implementation of some important updates, new algorithms, and with vicarious calibrations using MOBY data.
- In general, VIIRS **normalize water-leaving radiance** spectra show reasonable agreements with in situ measurements at MOBY, AERONET-OC sites, and various other ocean regions.
- The new NIR ocean reflectance correction algorithm (**BMW**) improves ocean color data over coastal and inland waters.
- VIIRS global ocean color products have been routinely produced using the **NIR**, **SWIR**, and **NIR-SWIR** atmospheric correction algorithms, providing necessary satellite data for various applications in coastal and inland waters, as well as for further improving data quality.
- Our evaluation results show that VIIRS-SNPP is capable of providing high-quality global ocean color products in support of science research and operational applications.

VIIRS Images and Cal/Val:
http://www.star.nesdis.noaa.gov/sod/mecb/color/

VIIRS Ocean Color Data:
http://coastwatch.noaa.gov/cwn/cw_products_ocLOM.html