Update on NOAA Ocean Color Activities: VIIRS et al.

Cara Wilson, NOAA-NMFS
Menghua Wang & Paul DiGiacomo, NOAA-NESDIS

International Ocean Color Science Meeting
Darmstadt, Germany, 6 May 2013

NMFS: National Marine Fisheries Service
NESDIS: National Environmental Satellite, Data & Information Services

Outline

Three themes:

- VIIRS data – access & quality

- Products & Applications

- International Collaborations

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VIIRS Overview

- Suomi National Polar-Orbiting Partnership (NPP) Mission, launched 28 October 2011

- Bridge to the Joint Polar Satellite System (JPSS)

- JPSS Program is a collaborative effort between NOAA and NASA, with NOAA having overall responsibility, and NASA acting as NOAA's acquisition agent and system integrator

- The VIIRS (Visible Infrared Imager Radiometer Suite) sensor on NPP, future JPSS-1 etc, provides ocean color and SST

- Global coverage; resolution, 750m (M bands)/375m (I bands)

- Official NPP Mission data is archived and distributed by the NOAA National Data Centers

VIIRS Ocean Color Data Access Summary

- A detailed presentation on NPP/VIIRS data access by A. Graumann et al. is available at the 2012 NASA Ocean Color Research Team Meeting Website: http://oceancolor.gsfc.nasa.gov/MEETINGS/OCRT_Apr2012/

- NOAA's Comprehensive Large Array-data Stewardship System (CLASS) serves as the official repository of NPP mission data, including VIIRS. On-line search, order, and distribution of all archived VIIRS mission data (along with tutorials) is available through CLASS: www.class.noaa.gov

- VIIRS RDR (Level 0) and SDR (Level 1B) data from the JPSS *Interface Data Processing Segment* (*IDPS*) available via CLASS since 2012

- VIIRS Ocean Color EDR (Level 2) data from the IDPS were declared "Beta" status in Jan 2013, and are available via CLASS.

- Daily global merged VIIRS ocean color (1 & 4 km) data available on a rolling basis from NOAA CoastWatch by summer 2013

- **Reprocessing of IDPS ocean color data expected to occur by early 2014**

1. Beta
   - early release product, minimally validated
   - versioning not established until a baseline can be determined
   - product not appropriate for quantitative scientific studies
   - data available to users to gain familiarity with data formats

2. Provisional
   - product quality may not be optimal
   - version control is in effect
   - ready for operational evaluation

3. Validated
   - product is well-defined over a range of different conditions
   - ready for use in scientific publications
   - three separate validation stages

1. ✔ Beta   VIIRS OC EDR Beta status declared Jan 2013

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Provisional status anticipated ~Fall 2013 will include vi-cal gains

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VIIRS OCC EDR Algorithms

- **Inputs**: VIIRS M1-M7 bands SDR data, terrain-corrected geo-location file, SST EDR data (not used for current OC3V chlorophyll-a algorithm), cloud mask Intermediate Product (IP), on-board calibrator IP, 7 ancillary data files, 7 lookup tables, and 1 configurable parameter file.

- **Outputs**:
  - chlorophyll-a (Chl-a) concentration
  - normalized water-leaving radiance (nLw's) at bands M1-M5
  - Inherent Optical Properties (IOP-a and IOP-s) at VIIRS bands M1-M5
  - quality flags

- Three sets of algorithms in the IDPS OCC-EDR data processing:
  - The Gordon & Wang (1994) atmospheric correction algorithm: including corrections for ozone, Rayleigh (molecules) and aerosols, ocean surface reflection, sun glint, whitecap, and sensor polarization effects.
  - chlorophyll-a algorithm: currently with OC3V algorithm (heritage algorithm), with option to switch between the OC3V and Carder chlorophyll-a algorithms.
  - IOP algorithm: Carder IOP algorithm.

Comparison with MODIS in global deep waters

Global Deep-Water Daily Chlorophyll-a
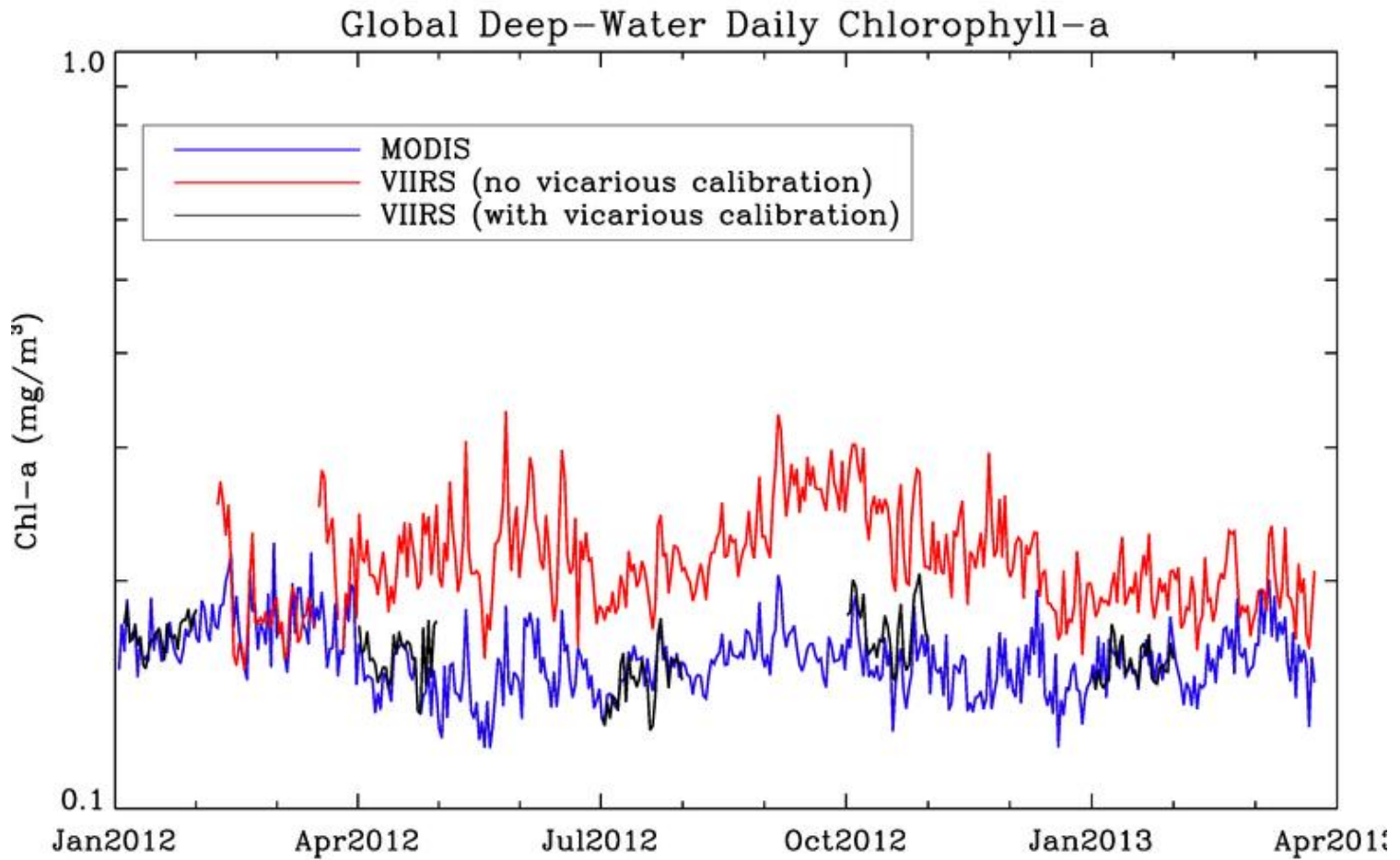
More details in **poster** by *Wang et al.*, "Vicarious calibration efforts for VIIRS operational ocean color EDR"
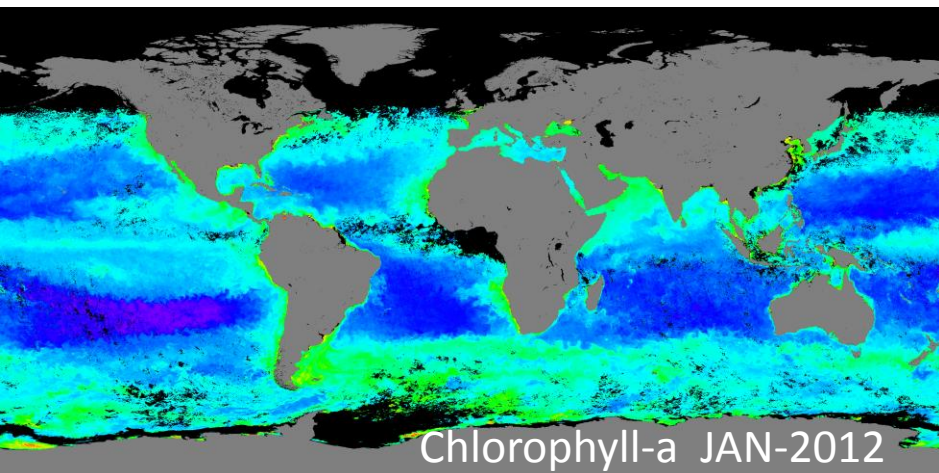
Comparison with MODIS in global deep waters
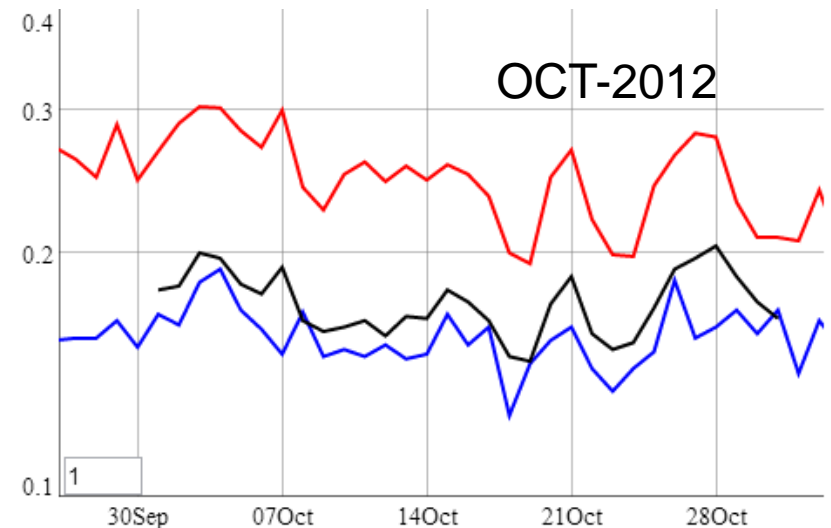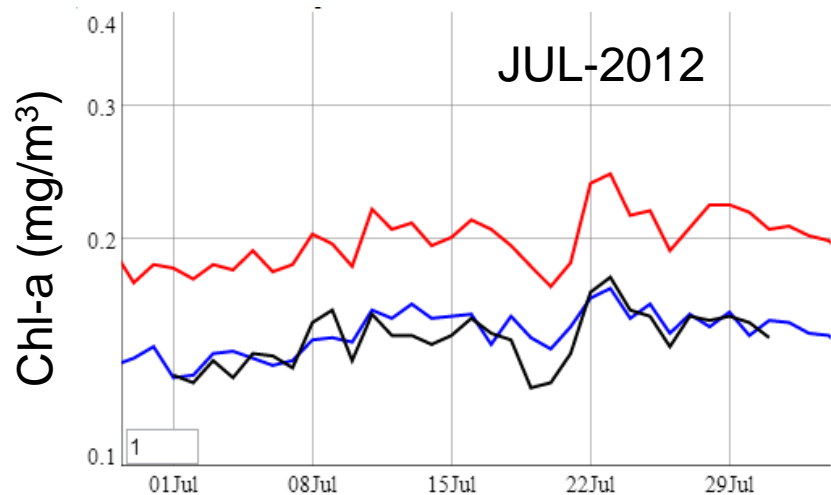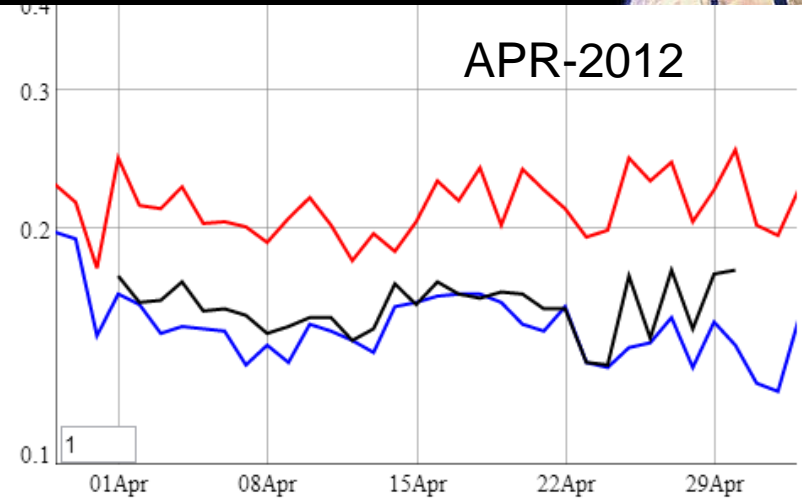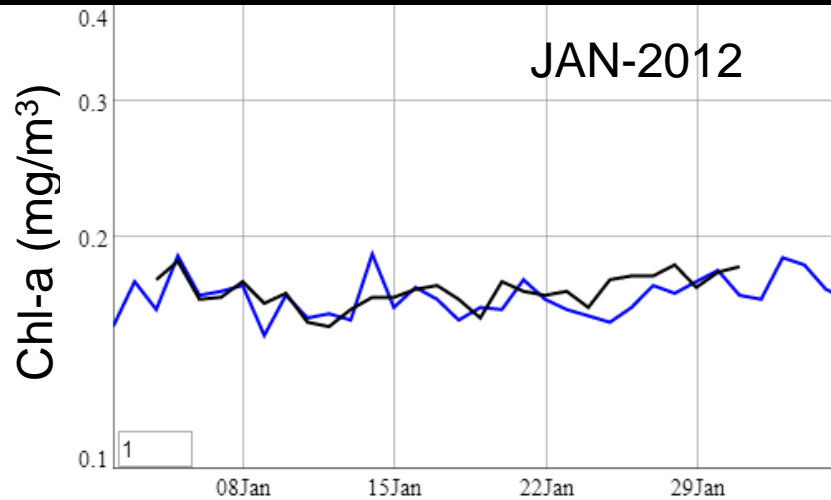
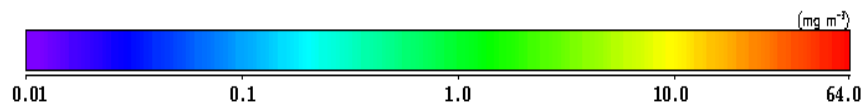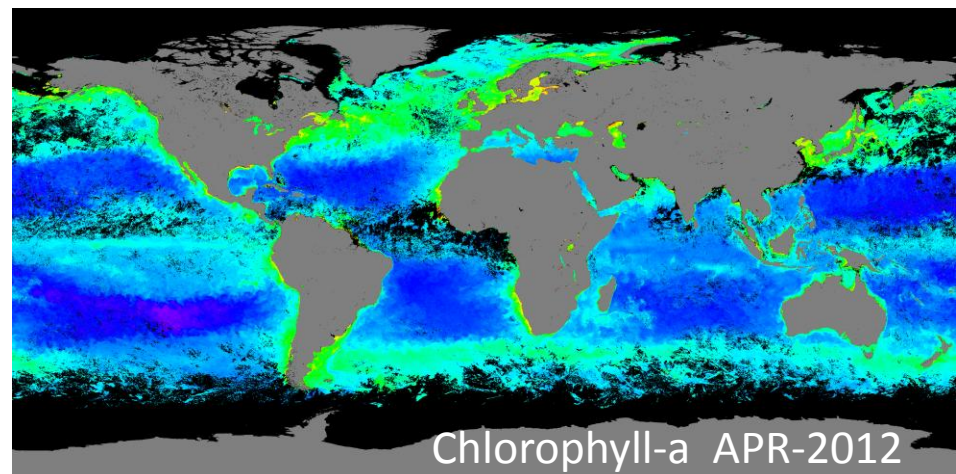Blue: MODIS;   Red: VIIRS no v-calibration;   Black: VIIRS with v-calibration
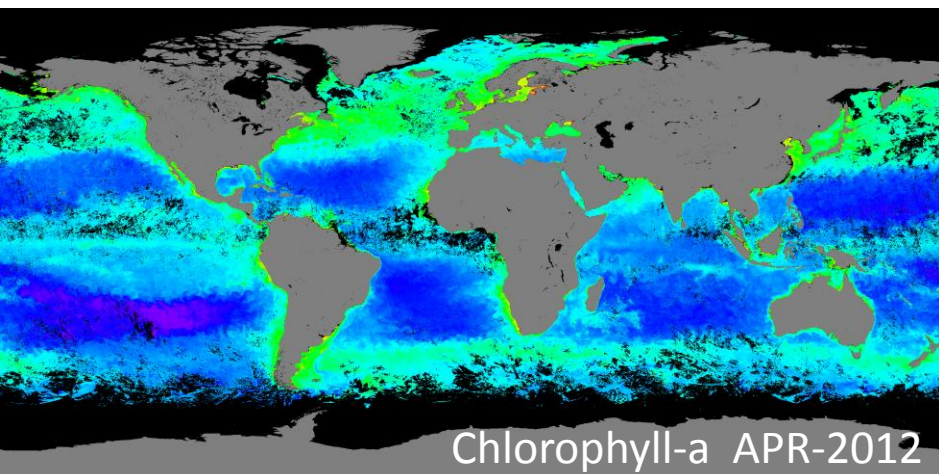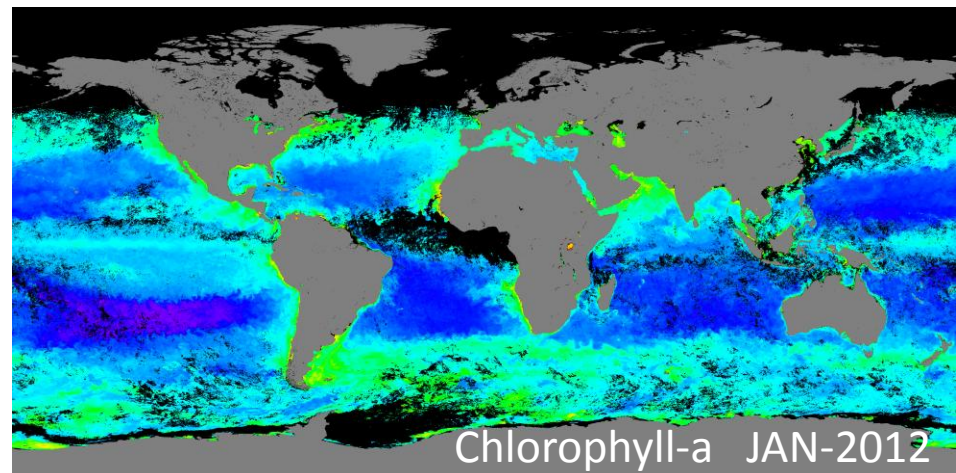
Global image comparison with MODIS-Aqua
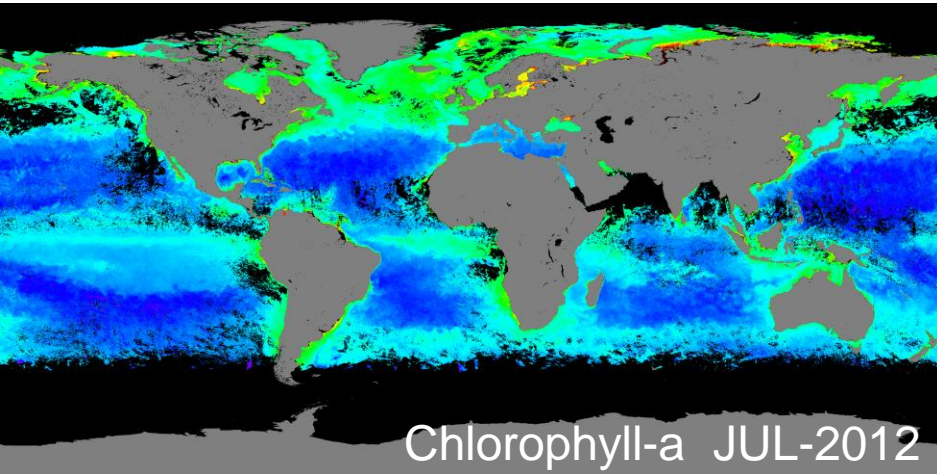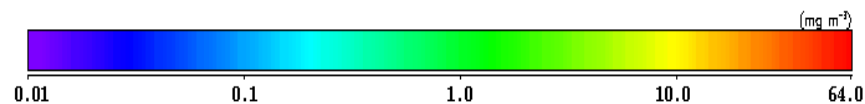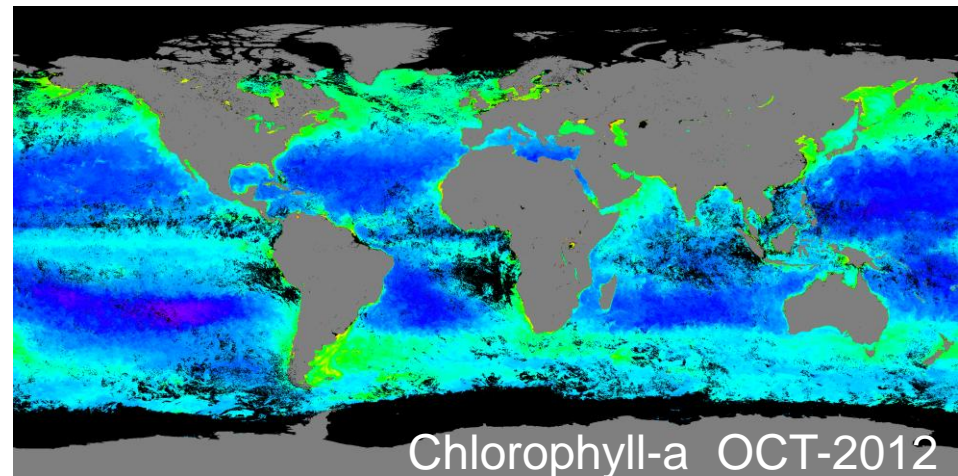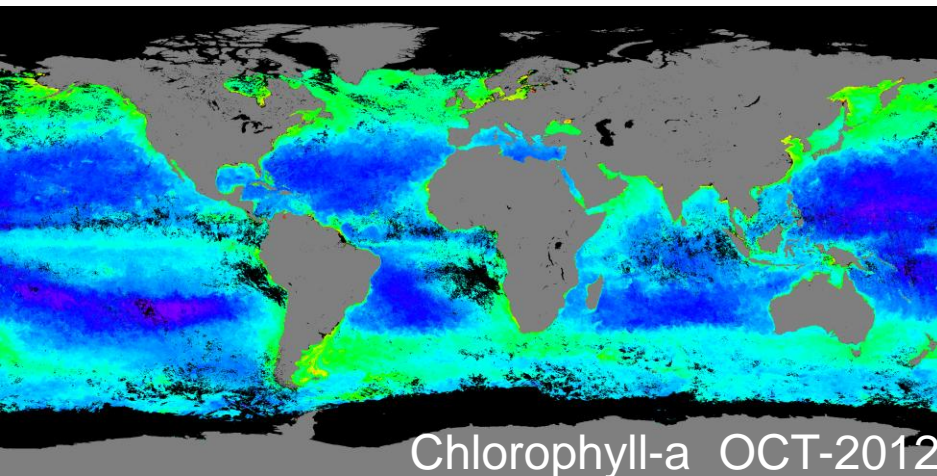
VIIRS with vicarious calibration

MODIS-Aqua

Chlorophyll-a JAN-2012

Chlorophyll-a JAN-2012

Chlorophyll-a APR-2012

Chlorophyll-a APR-2012

(mg m⁻²)

0.01   0.1   1.0   10.0   64.0

Global image comparison with MODIS-Aqua

VIIRS with vicarious calibration

MODIS-Aqua

Chlorophyll-a JUL-2012

Chlorophyll-a JUL-2012

Chlorophyll-a OCT-2012

Chlorophyll-a OCT-2012

(mg m⁻²)

0.01   0.1   1.0   10.0   64.0
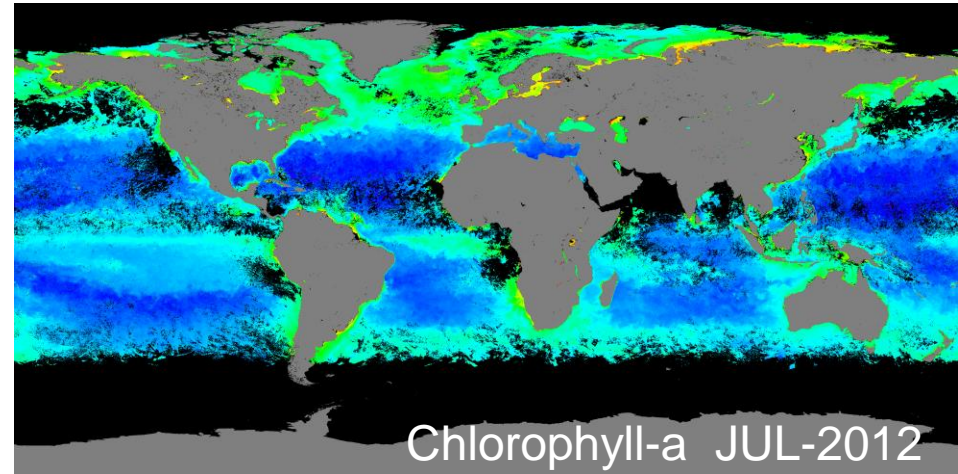
Upcoming Plans

- Apply vicarious calibration gain coefficients for VIIRS IDPS ocean color data processing (on going).
- Continue Cal/Val activities for VIIRS OCC EDR.
- Continue working with the SDR team to improve SDR and OCC EDR products, in particular, the issue with significant sensor NIR & SWIR bands degradation.
- Evaluate and improve data quality flags.
- Algorithms refinements and improvements, e.g., sun glint masking and correction, etc.
- Algorithms improvements for coastal turbid and inland waters.
- The NOAA Observing Systems Council (NOSC) has tasked NESDIS to form a tiger team to address user requirements for JPSS ocean color data reprocessing; a plan will be presented later this month.
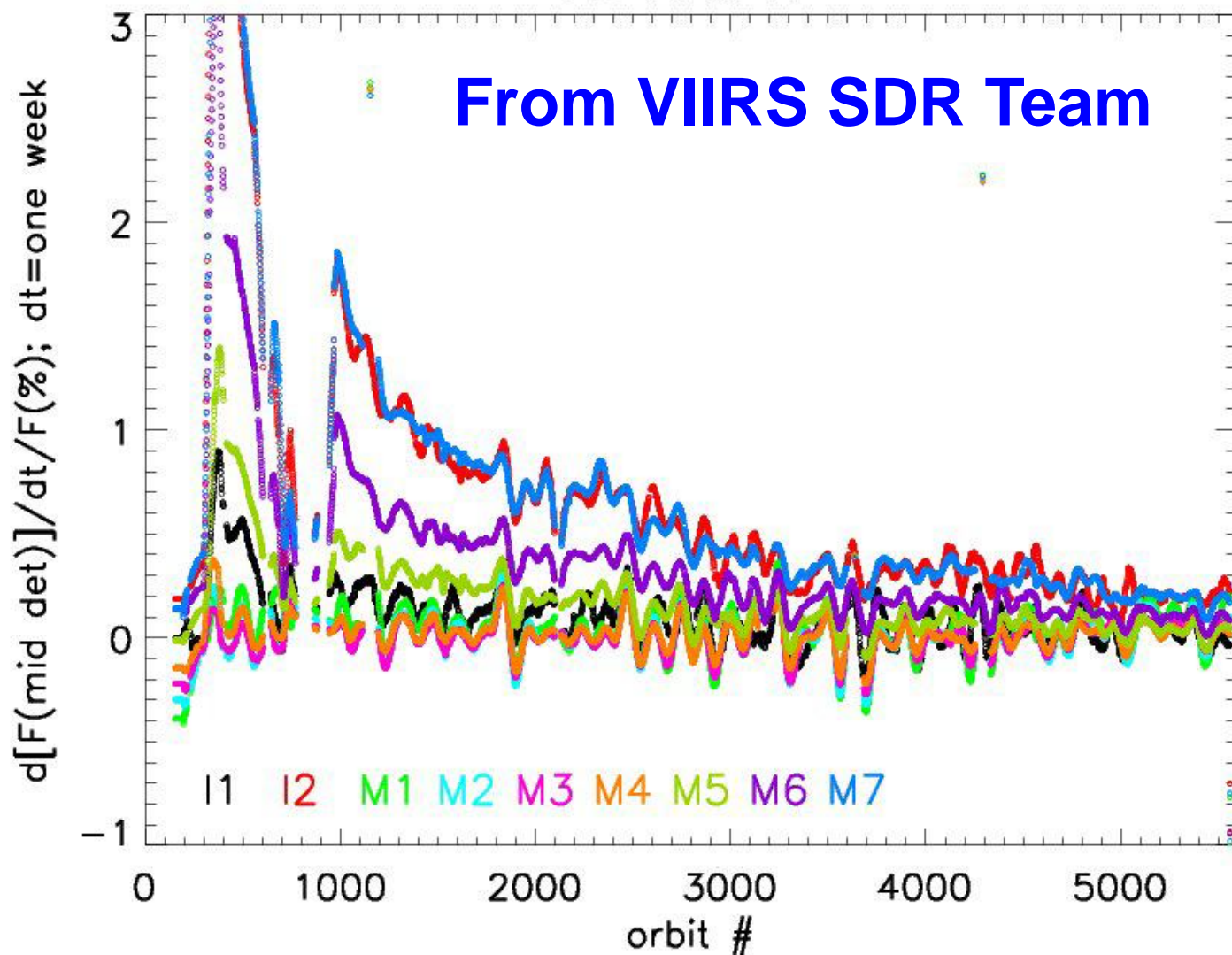
From VIIRS SDR Team

Assessment of VIIRS OC Data Quality

- In Jan 2013 VIIRS OCC EDR was declared as beta status for data from Feb. 6, 2012 onward.

- VIIRS OCC EDR data is now available to the public from CLASS.

- Significant VIIRS sensor NIR degradation is now back to normal, i.e., about 0.1-0.2% per week.

- There are a number of issues that will be resolved in the next IDPS build (e.g. vi-cal, negative nLw's , and High Sensor Zenith Angle flags), and identification and resolution of issues will be ongoing as part of the product maturation process.

- VIIRS can potentially provide high-quality global ocean color products in support of research and operational applications.

MOBY Status & Tech Refresh Plans

- MOBY operations are being funded by the JPSS Program; it has been functioning extremely well with no issues since the launch of VIIRS

- Data are available at coastwatch.noaa.gov/moby2

- However, MOBY, including main optical parts, is 20 year old technology.

- Funding request has been submitted to JPSS Program to replace MOBY optics & control system with current technology

- New system would be an imaging spectrometer system, providing more frequent measurements and reducing measurement uncertainty by having simultaneous measurements at each arm depth, provide full spectral resolution, and other improvements.

- Plan was to start the technology refresh process sometime in 2013, with test deployments starting in 1.5 years, and full operational deployment in approximately 4 years; however, funding provided for FY13 does not include support for the refresh activity (nor presently supported in the out years)

- Going forward, current instrument operation will become increasingly risky w/o refresh due to system age & reliability issues.

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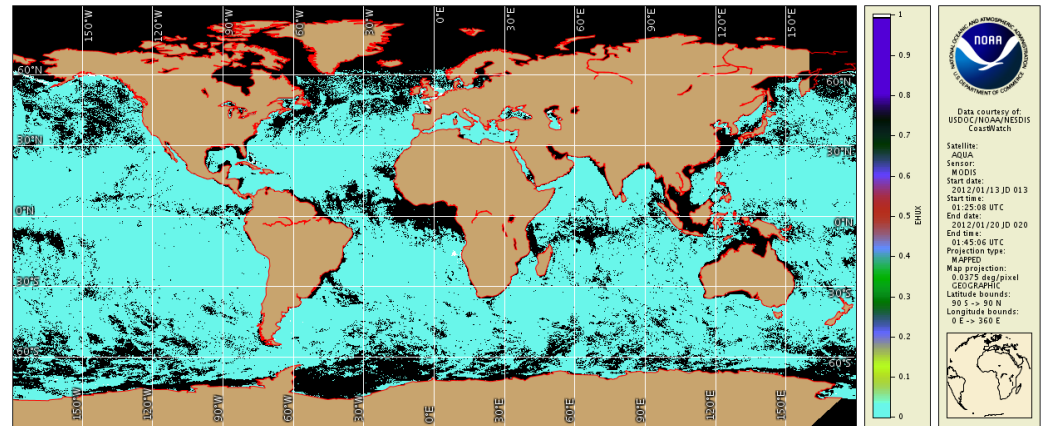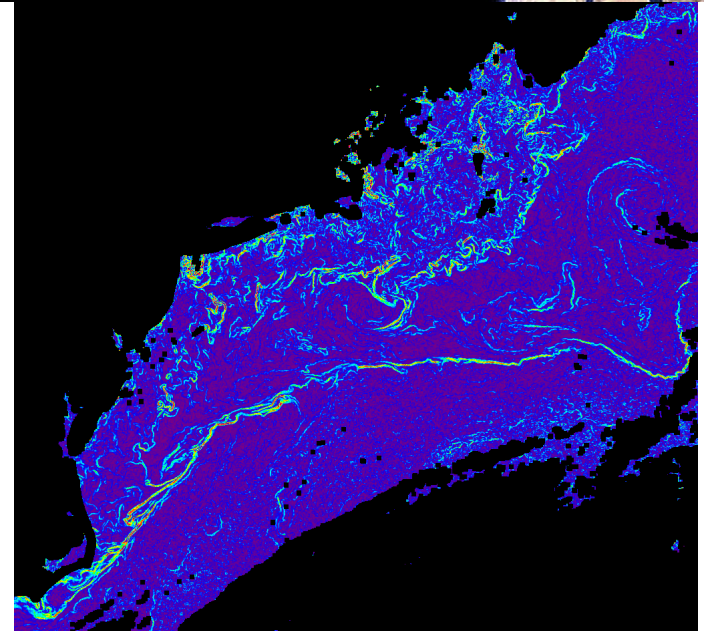- Products & Applications

- International Collaborations

Recent & Upcoming NOAA Operational OC Radiometry Products

MODIS/Aqua Chlorophyll Frontal Product
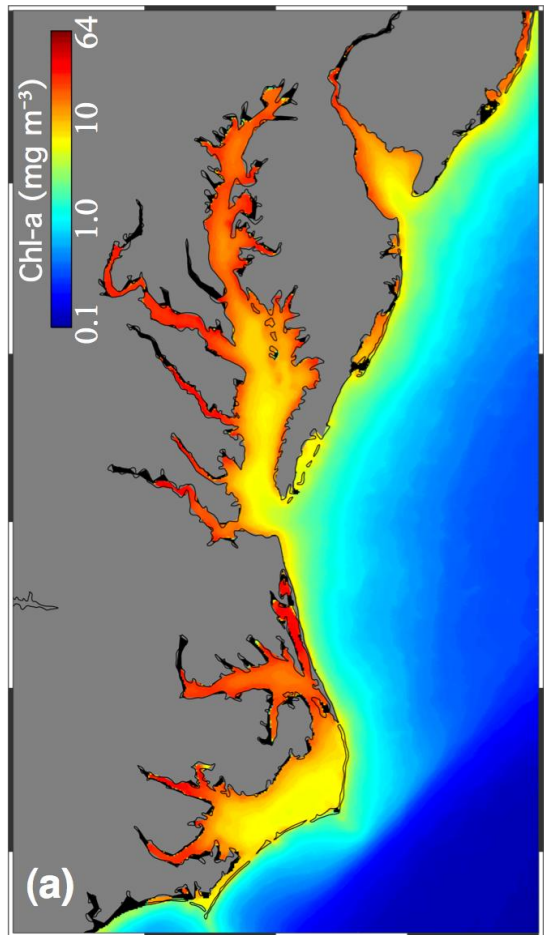
MODIS/Aqua SWIR Coastal Ocean Color Products

MODIA/Aqua Global *Emilliania huxleyi* Bloom Map

NOAA CoastWatch/OceanWatch

- CoastWatch will support the eventual transition of VIIRS ocean color data into operations following established NESDIS processes

- Enhanced coverage: CoastWatch will distribute global VIIRS data (including via THREDDS server) to users by summer 2013, and continue to distribute MOBY data.

- JPSS Proving Ground projects underway to ensure continuity of heritage and other NOAA unique products using VIIRS OCR data; independently assess data/product quality & ensure end user utilization.

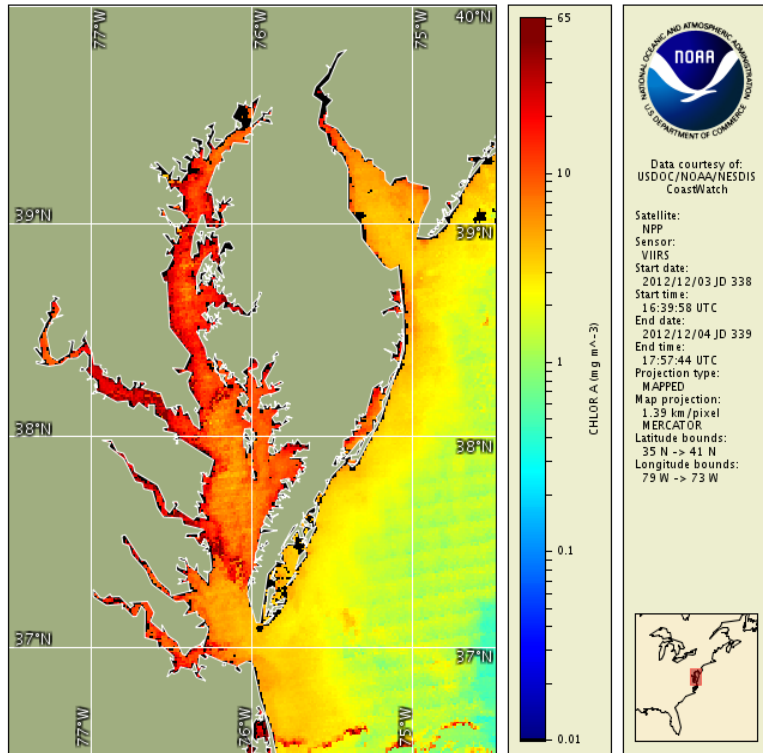# VIIRS data in Chesapeake Atlantic Model

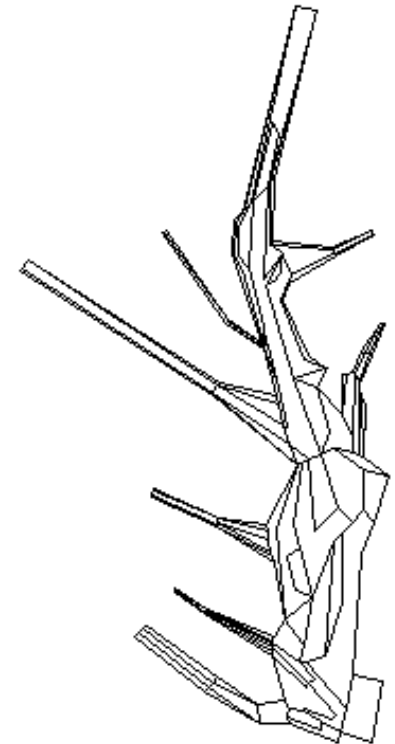**VIIRS satellite chlorophyll** → **Georeferenced grid** → **Ecosystem model grid**

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

Chesapeake Bay Program
Georeferenced polygonal grid
8,282 polygons

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

"Operational": What does it mean?

As Ocean Color data moves from being the product of "research" missions to being the product of "operational" missions it has become evident that there are ambiguities in what the word "operational" means or implies.

- In the world of (meteorological) satellite data, "operational" is often assumed to mean a near-real time (NRT) 24/7 application.

- For fisheries and marine resource managers, interannual and decadal timescales are often more relevant than NRT 24/7.

- It is likewise often assumed that "operational" means any quality of data will suffice – this is definitely not the case for ocean color data….

More details in **talk** in Splinter Session 5 by *Wilson*, Redefining "Operational": Emerging Paradigms

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# Recent International Collaborations

- NOAA/NESDIS/STAR submitted a proposal (P. DiGiacomo, PI) to the Sentinel-3 Validation Team (S3VT) call, supporting ocean color, sea-surface and land-surface temperature. Status: accepted

- Ongoing efforts within NESDIS and between NESDIS and Eumetsat to facilitate exchange of VIIRS as well as Sentinel data

- NESDIS/STAR submitted a proposal (M. Wang, PI) to the Global Change Observation Mission (GCOM) Fourth Research Announcement. Status: accepted

- Active collaboration continues with Korea on GOCI data (see following slides)

- Continued participation in the GEO Inland and Near-Coastal Water Quality Working Group (Steve Greb et al.)
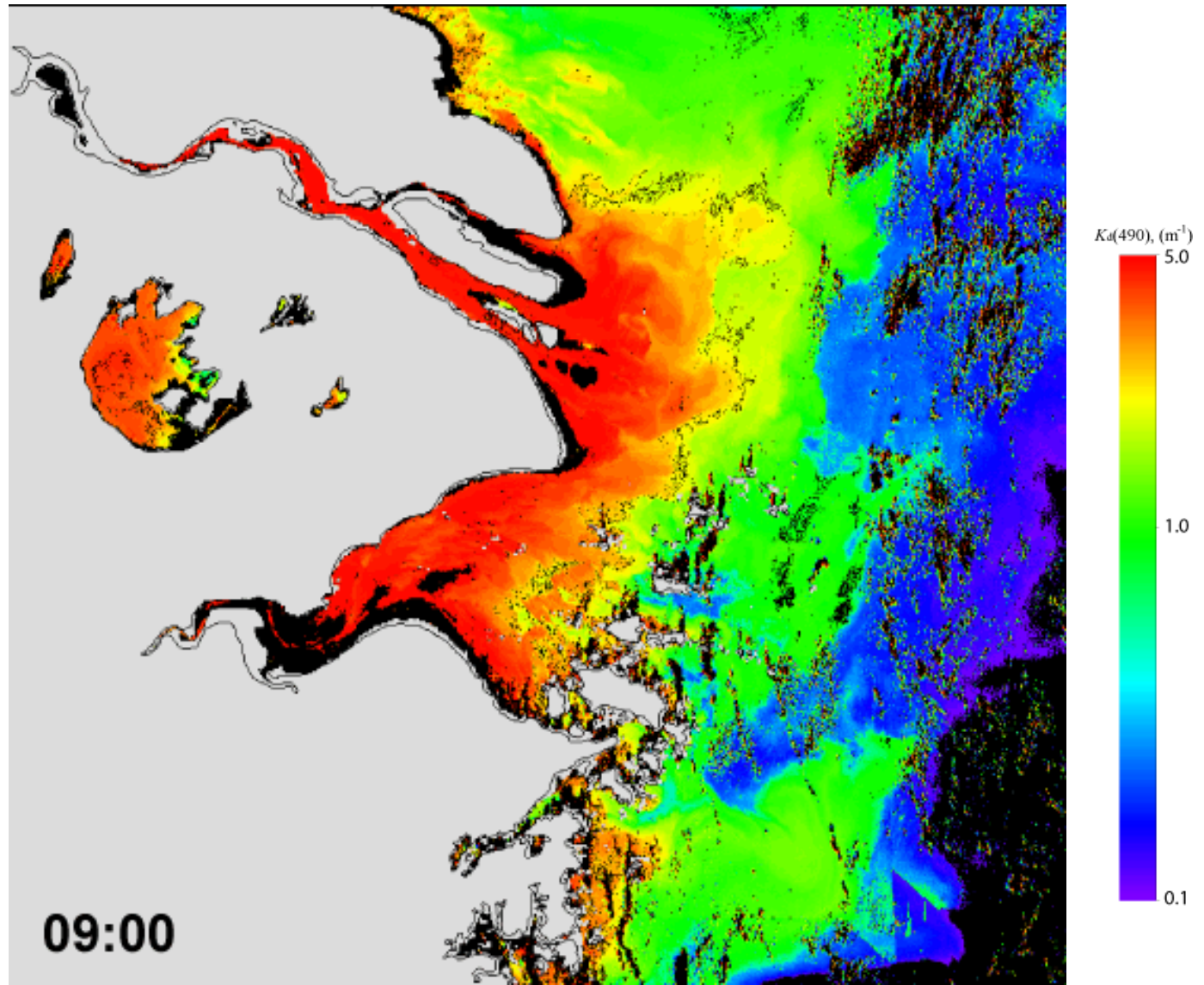
GOCI NOAA-MSL12 $K_d(490)$ (2012-03-25)
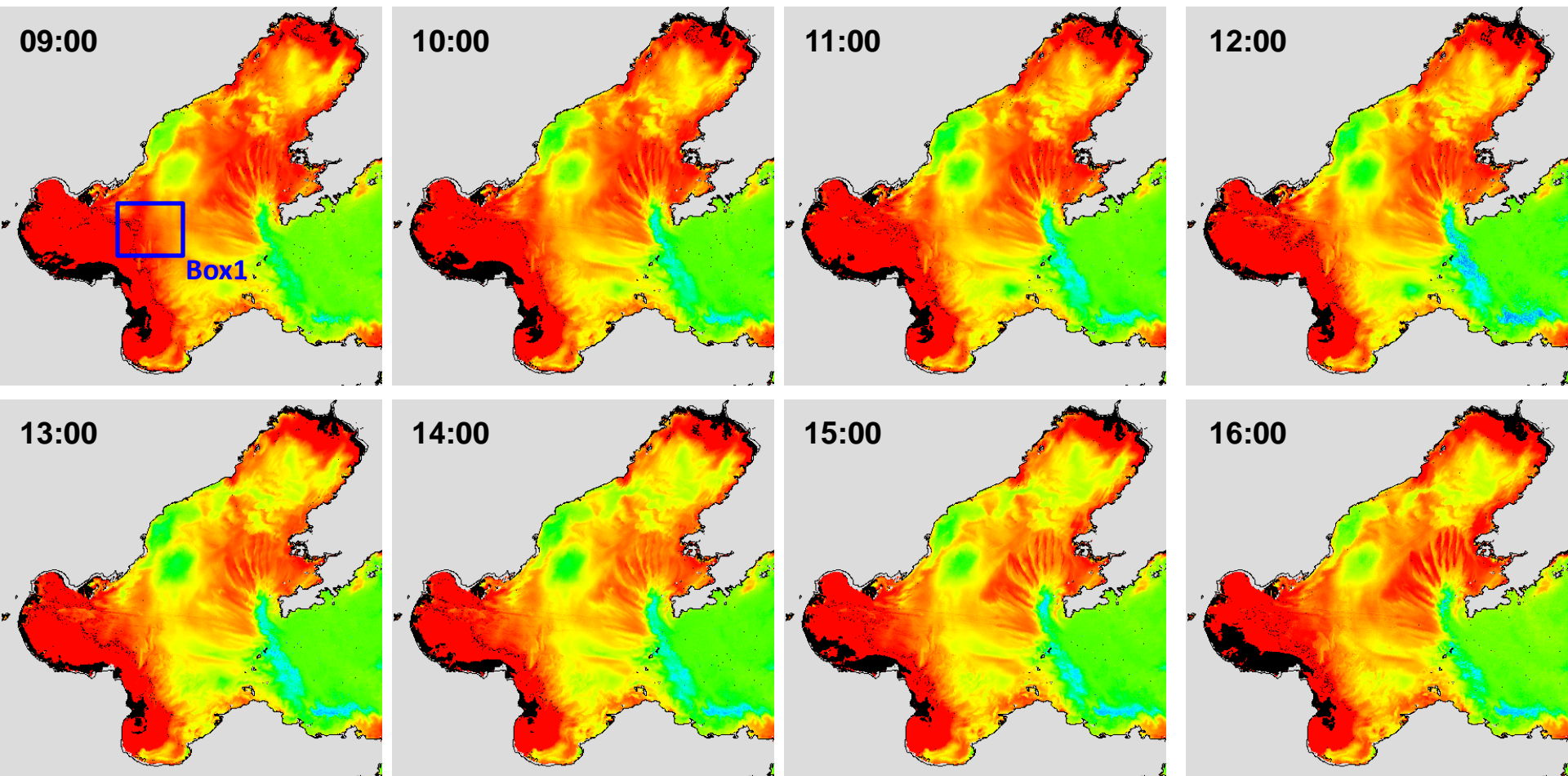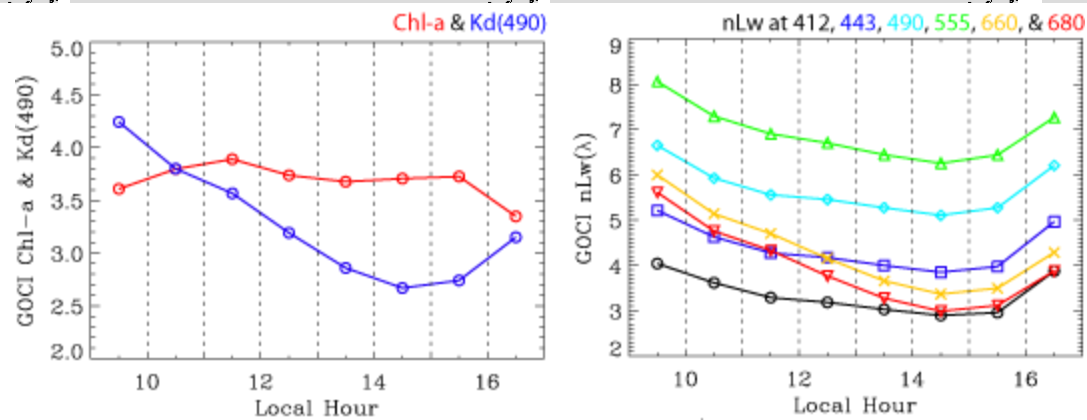
Wang et al. (2012; 2013)

GOCI NOAA-MSL12 $K_d(490)$ (2012-07-29)

More details in **poster** by *Wang et al.*, "Ocean diurnal variations measured by the Korean Geostationary Ocean Color Imager"

2011-008
08 September 2011
National Ocean Service
Great Lakes Environmental Research Laboratory
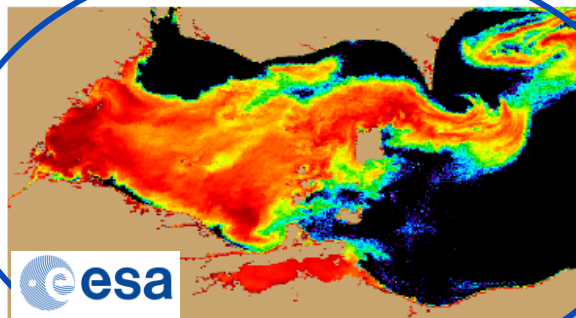Last bulletin: 22 July 2011

Bloom from MERIS

Figure 1. MERIS image from the European Space Agency. Imagery shows the spectral shape at 681 nm from September 03, where colored pixels indicate the likelihood of the last known position of the *Microcystis* spp. bloom (with red being the highest concentration). *Microcystis* spp. abundance data from shown as white squares (very high), circles (high), diamonds (medium), triangles (low) , + (very low) and X (not present).
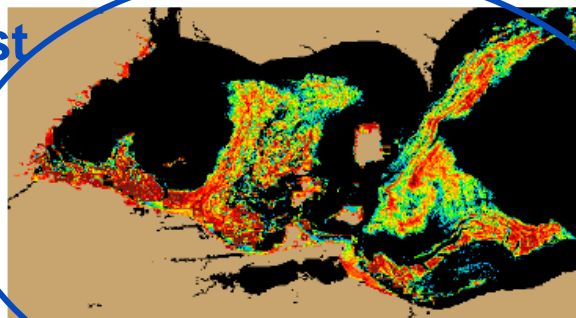
forecast

Figure 2. Nowcast position of *Microcystis* spp. bloom for September 08 using GLCFS modeled currents t move the bloom from the September 03 image.

Analysis: As indicated in satellite imagery from Saturday (9/3/2011), an enormous *Microcystis* bloom was present in western Lake Erie. The southern extent of the bloom was remotely observed along the coast of Ohio from Maumee Bay to Catawba Island. The northern extent of the bloom was observed to be consistent along the Michigan coast from Northern Maumee Bay to the mouth of the Detroit River. The eastern-most portion of the bloom was observed past Point Pelee and to the northeast up in to Rondeau Provincial Park.

At the mouth of the Detroit River, a five day nowcast shows a southward suppression of the western-most portions of the bloom. However, the bloom is likely to still persist in much of the Western Basin. The nowcast also suggest the bloom has spread to the east of Sandusky and into the Cleveland area. **(Note: Due to a lack of clear imagery the bloom has not been remotely observed in the Cleveland area.)** A three day forecast also suggests that the bloom will persist to the north of Cleveland through the weekend. Water temperatures remain above 20 degrees Celsius and are forecast to decrease into the weekend; however, conditions remain favorable for bloom growth.

Briggs, Wynne
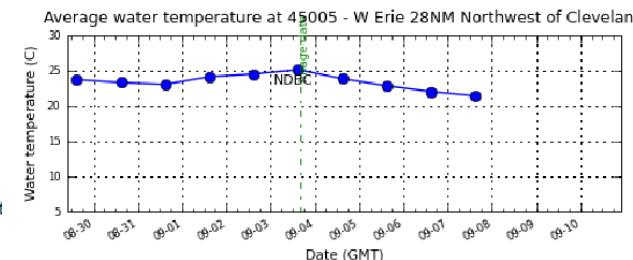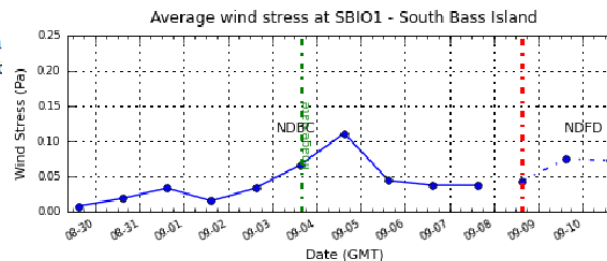
MODIS is a poor substitute: interested in OLCI data

Eagerly awaiting data from Sentinal 3!

Conclusions

VIIRS data is still in the beginning stages of maturity (beta status), but should provide high-quality global ocean color products

More information about NOAA's work with ocean color will be presented:

Splinter Session 3 (Monday afternoon): *Geostationary ocean color*, Seunghuyn Son

Splinter Session 4 (Monday afternoon): *VIIRS data policy*, Wei Shi

Splinter Session 5 (Tuesday morning): *Redefining "Operational"*, Cara Wilson

Poster session - Application, Users Service & Products: *Ocean Diurnal Variations Measured by the Korean Geostationary Ocean Color Imager (GOCI)*, Seunghyun Son (Menghua Wang)

Poster Session - Application, Users Service & Products: *VIIRS data now accessible via ERDDAP and with EDC for ArcGIS*, Cara Wilson

Poster Session - Application, Users Service & Products: *Status and Prospective of Operational Ocean Color Products from the NOAA CoastWatch Okeanos System*, Banghua Yan

Poster session - Algorithms & Products*: Vicarious Calibration Efforts for VIIRS Operational Ocean Color EDR*, Wei Shi (Menghua Wang)
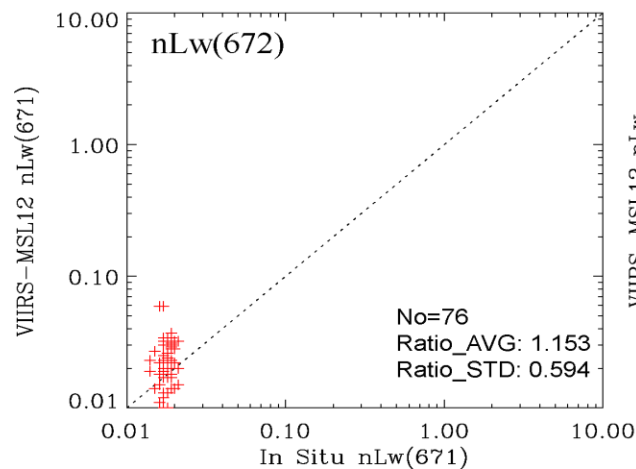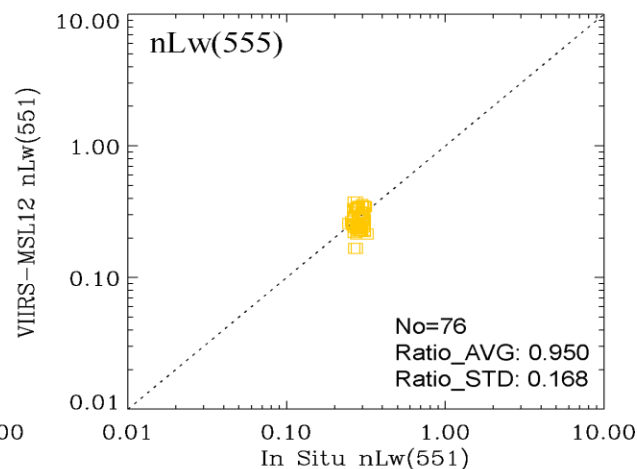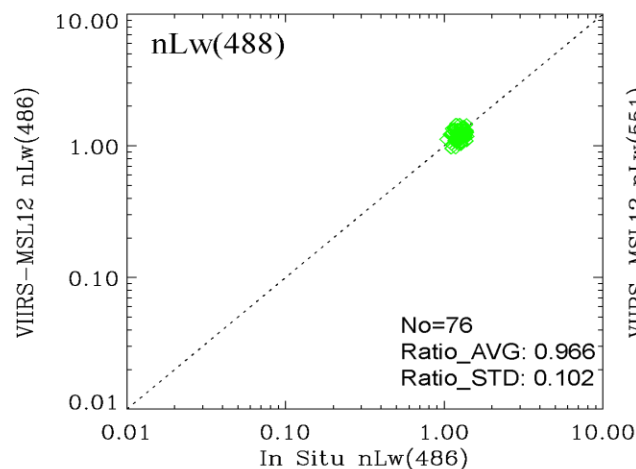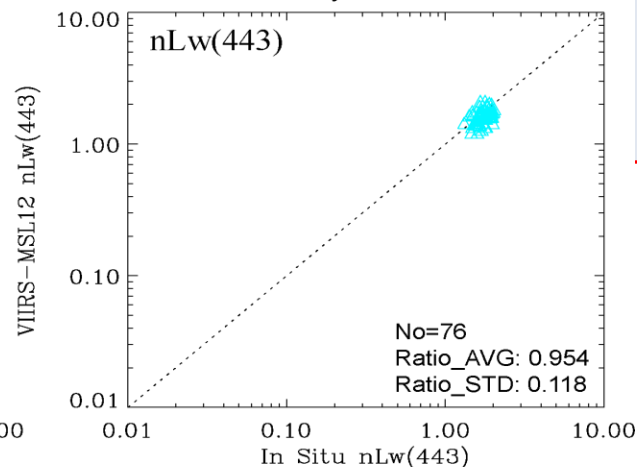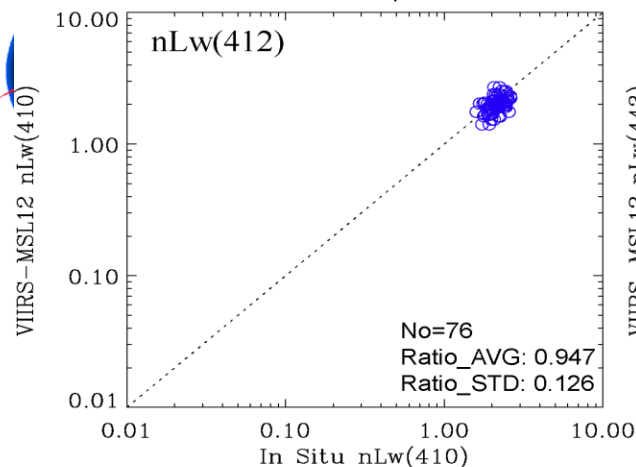
Poster session - Algorithms & Products: *Sea ice properties in the Bohai Sea measured by MODIS Aqua: Satellite Algorithm and Study of Sea Ice Seasonal and Interannual Variability*, Wei Shi

Dankeschön!

Matchup between MOBY In-Situ vs VIIRS MLS12 DailyF-LUT
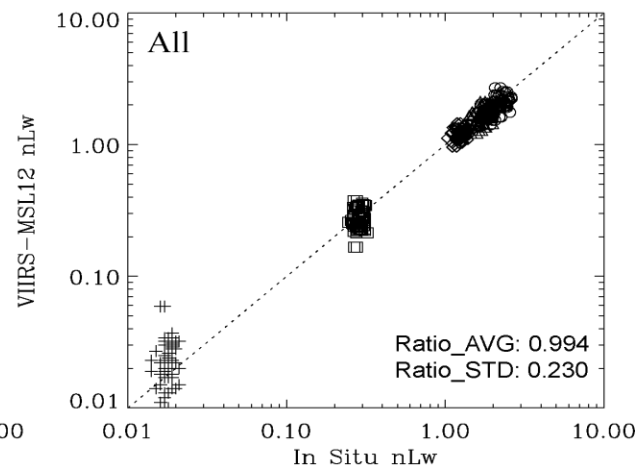
Scatter plots of NOAA-MSL12 Level-2 data (reprocessed from RDR with daily F-LUT) match-up with MOBY in situ data.

Note:
Vicarious calibration gains applied. Thus, they are used as verification.
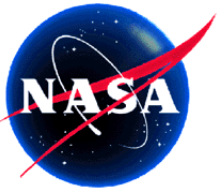
- Changed chlorophyll-a algorithm from Carder algorithm to OC3V algorithm (heritage algorithm) with updated coefficients.

- Retrieval and output of Chl-a and IOPs when M5 remote-sensing reflectance is negative.

- Processing Chl-a and IOPs for pixels with negative normalized water-leaving radiance nLw (or remote-sensing reflectance Rrs) at some of the VIIRS ocean color bands (M1-M5) (fixes to be implemented).

- Retrieval and output of OCC over coastal and inland waters (fixes to be implemented).

- Changed Ocean Color Horizontal Reporting Interval (HRI) from sensor-zenith angle of 53° to 60° for more data coverage (fixes to be implemented).

- Updated OCC operational software to enable ocean color data processing up to solar-zenith angles of 80° instead of 70° (note: the high solar-zenith angle is still at 70°) (fixes to be implemented).

Matchup between MOBY In-Situ vs VIIRS EDR NoGain

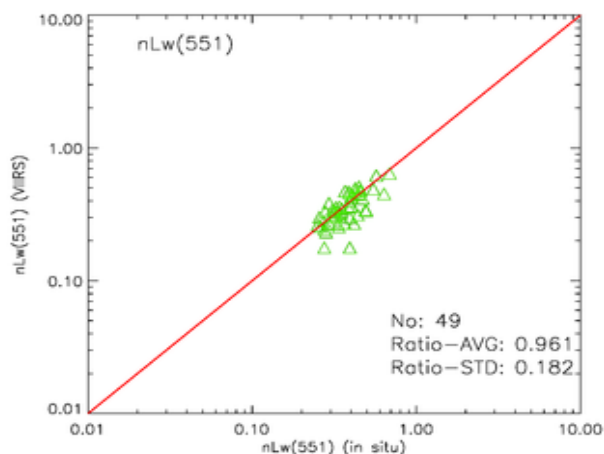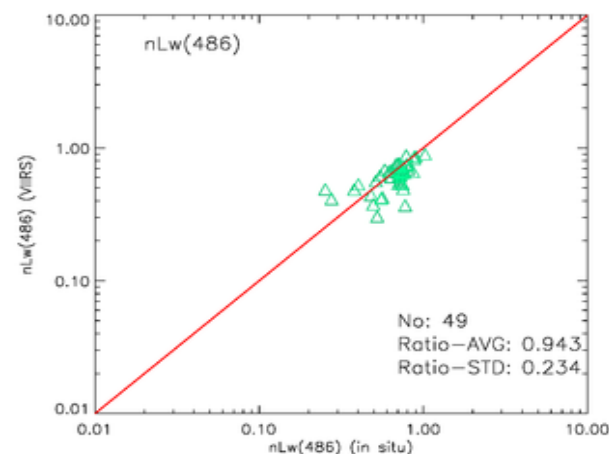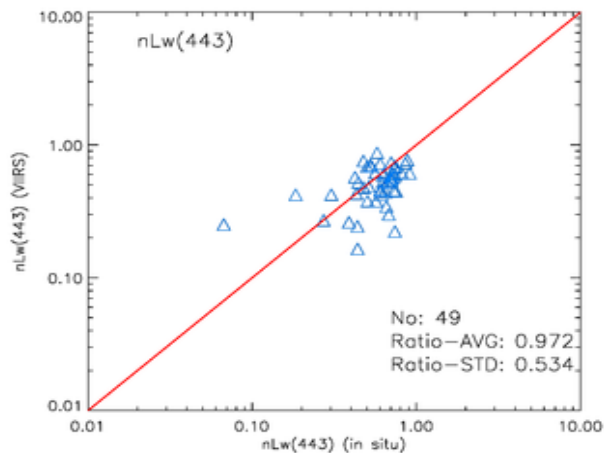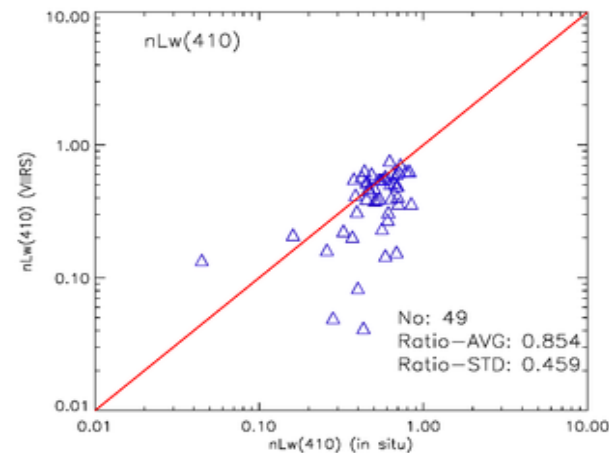**VIIRS vs. MOBY Quantitative Comparisons**
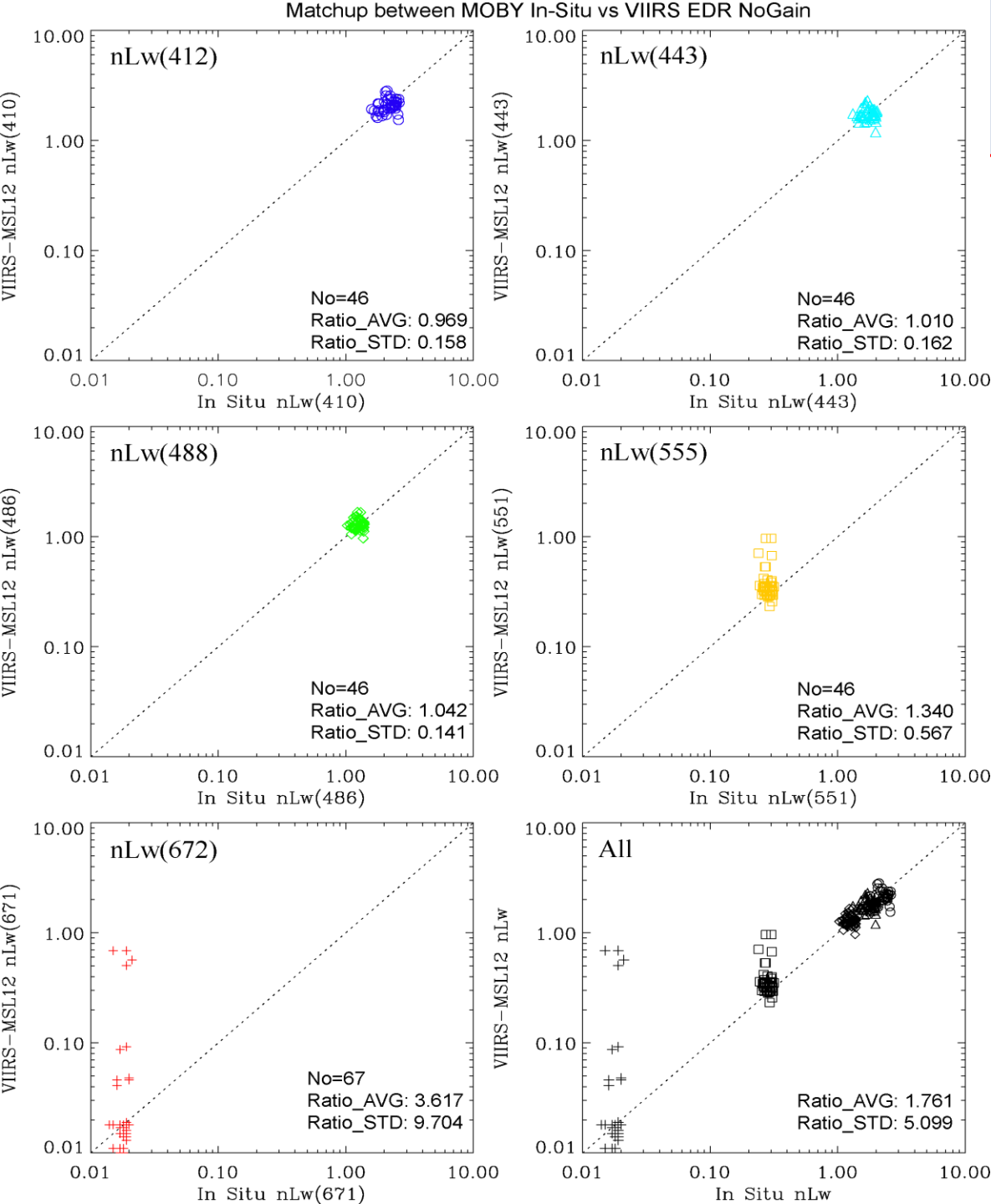
Scatter plots of VIIRS IDPS OCC EDR data match-up with MOBY in situ data since Feb. 6, 2012.

Note:
No vicarious calibration gains applied in IDPS OCC EDR.

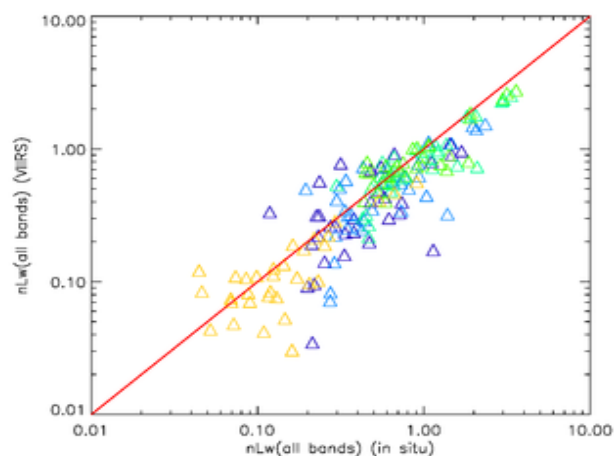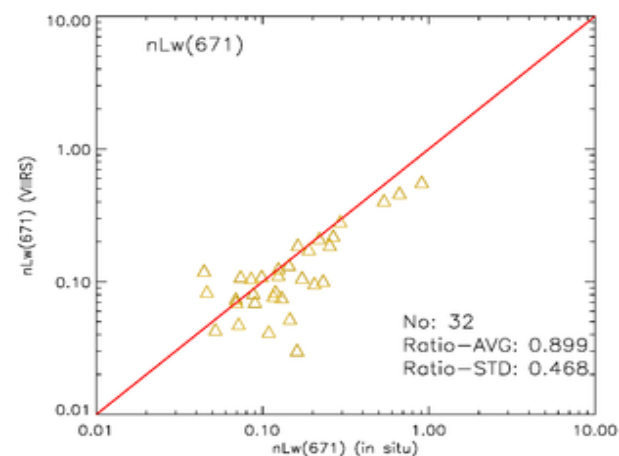## VIIRS vs. AERONET-OC
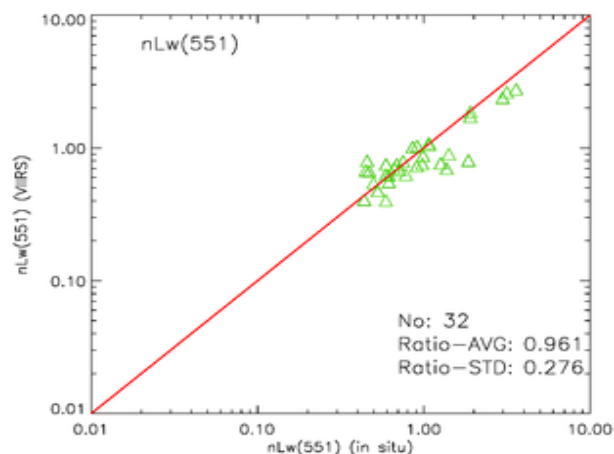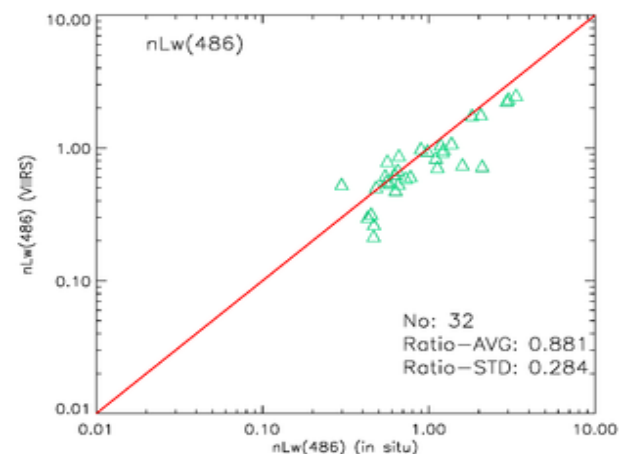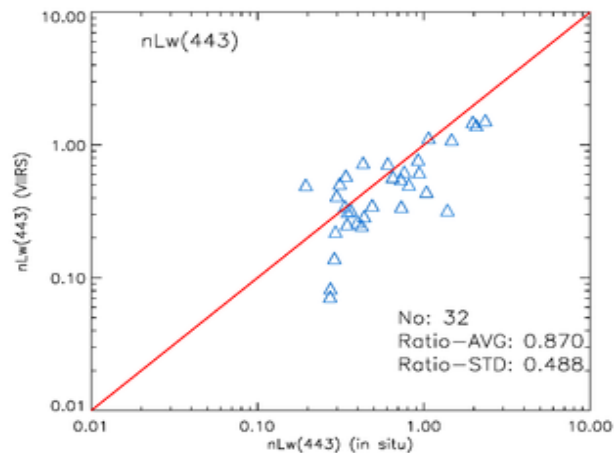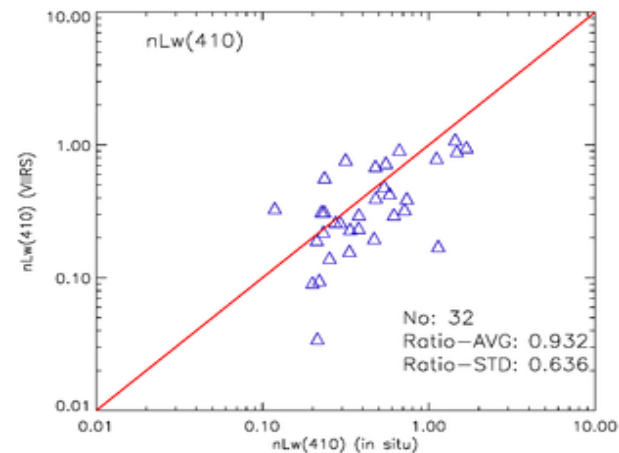USC Site, PI: Burton Jones
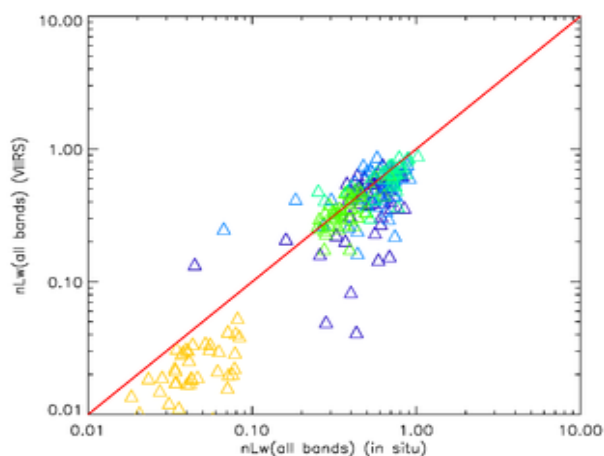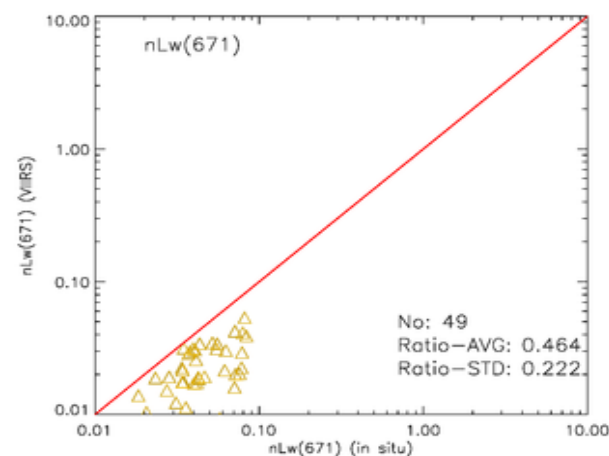
Scatter plots of VIIRS IDPS OCC EDR data match-up with in situ AERONET-OC data at USC site (Newport Beach, CA) since Feb. 6, 2012.

Note:
No vicarious calibration gains applied in IDPS OCC EDR.

VIIRS vs. AERONET-OC
CSI Site, PI: Bill Gibson

Scatter plots of VIIRS IDPS OCC EDR data match-up with in situ AERONET-OC data at CSI site (Gulf of Mexico) since Feb. 6, 2012.

Note:
No vicarious calibration gains applied in IDPS OCC EDR.

Characterization of Water Turbidity in Florida's Lake Okeechobee Using MODIS-Aqua Measurements

Wang *et al.* (2012), Characterization of turbidity in Florida's Lake Okeechobee and Caloosahatchee and St. Lucie estuaries using MODIS-Aqua measurements, *Water Research,* **20,** 741-753.