JPSS STAR Science Team Annual Meeting

12-16 May 2014

Ocean Color Team Report

Menghua Wang

VIIRS EDR Ocean Color Lead

16 May 2014

VIIRS Ocean Color Team Members' Roles & Responsibilities

EDR	Name	Organization	Funding Agency	Task
Lead	**Menghua Wang (EDR Lead), , L. Jiang, X. Liu, W. Shi, S. Son, L. Tan, X. Wang, P. Naik, J. Sun, V. Lance, K. Mikelsons, M. Ondrusek, E. Stengel**	NOAA/NESDIS/ STAR	JPSS/NJO	Leads – Ocean Color EDR Team OC products, algorithms, SDR, EDR, Cal/Val, vicarious cal., refinements, data processing DR- Software updates
Ocean Color	**Robert Arnone** **Sherwin Ladner, Ryan Vandermeulen Adam Lawson, Paul Martinolich,** **Jen Bowers, Giulietta Fargion**	U. Southern MS NRL QinetiQ Corp. SDSU	JPSS/NJO	Coordination Look Up Tables – SDR-EDR impacts, vicarious calibration Satellite matchup tool (SAVANT) – Golden Regions cruise participation . WAVE_CIS (AERONET site)
	Carol Johnson	NIST	JPSS/NJO	Traceability, AERONET 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 Site)
	Sam Ahmed, Alex Gilerson, Soe Hlaing	CUNY	JPSS/NJO	LISCO (AERONET site) Cruise data and matchup
	Chuanmin Hu	USF	JPSS/NJO	NOAA data continuity
	Ken Voss & MOBY team	Univ. 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
	Patty Pratt, J. Ip	NGAS	JPSS/NJO	Detector tool Matchup and DR and IDPS updates

Working with: VIIRS **SDR team**, DPA/DPE (e.g., R. Williamson, Neal Baker), Raytheon (e.g., Marine Hollingshead), NOAA OC Working Group, NOAA various line-office reps, NASA OC Working Group (K. Turpie, B. Franz , et al.), NOAA OCPOP, etc.
Collaborators: D. Antoine (BOUSSOLE), B. Holben (NASA-GSFC), G. Zibordi (JRC-Italy), and others

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 and common ocean color data processing for multiple satellite ocean color sensors (*Wang*, 1999; *Wang and Franz*, 2000; *Wang et al.*, 2002).
- ✓ It has been used for producing ocean color products from various satellite ocean color sensors, e.g., SeaWiFS, MOS, OCTS, POLDER, MODIS, etc.

➢ NOAA-MSL12 Ocean Color Data Processing

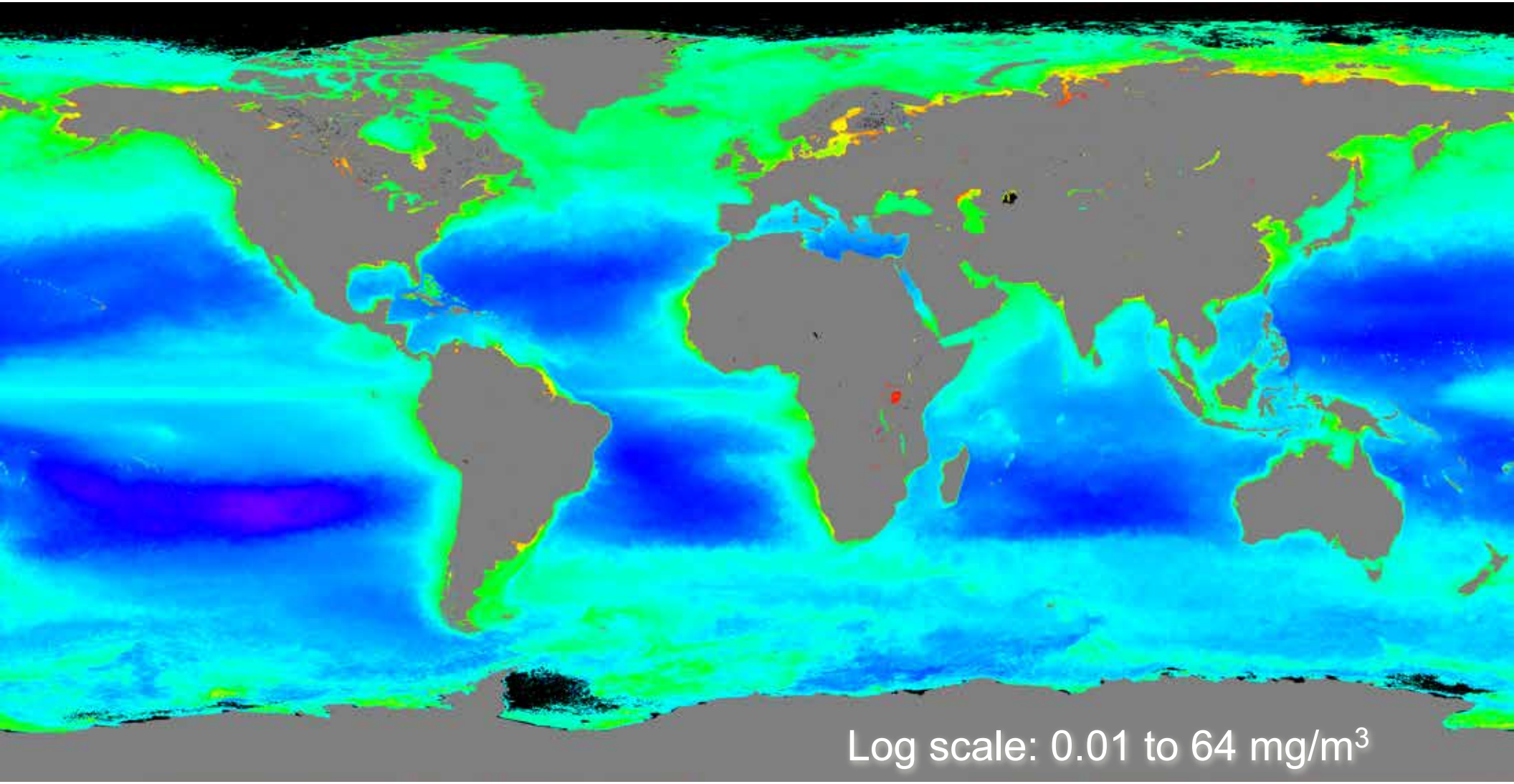
- ✓ NOAA-MSL12 is based on SeaDAS version 4.6.
- ✓ Some significant improvements: (1) the SWIR-based data processing, (2) Rayleigh and aerosol LUTs, (3) detecting absorbing aerosols and turbid waters, (4) ice detection algorithm, (5) improved straylight and cloud shadow algorithm, and others.
- ✓ Capability for multi-sensor ocean color data processing, e.g., MODIS, **VIIRS**, GOCI, and will add OLCI/Stentinel-3, SGLI/GCOM-C, **J-1**, **J-2**, and others.

➢ MSL12 for **VIIRS** Ocean Color Data Processing

- ✓ Standard ocean color products: **normalized water-leaving radiances** ($nL_w(\lambda)$) at VIIRS M1 to M5 bands; **chlorophyll-a** concentration, and water **diffuse attenuation coefficient** at the wavelength of 490 nm ($K_d(490)$).
- ✓ Experimental products: photosynthetically available radiation (PAR), inherent optical properties (IOPs), and others.

Menghua Wang, NOAA/NESDIS/STAR

VIIRS Climatology Chlorophyll-a Image
(April 2012 to December 2013)

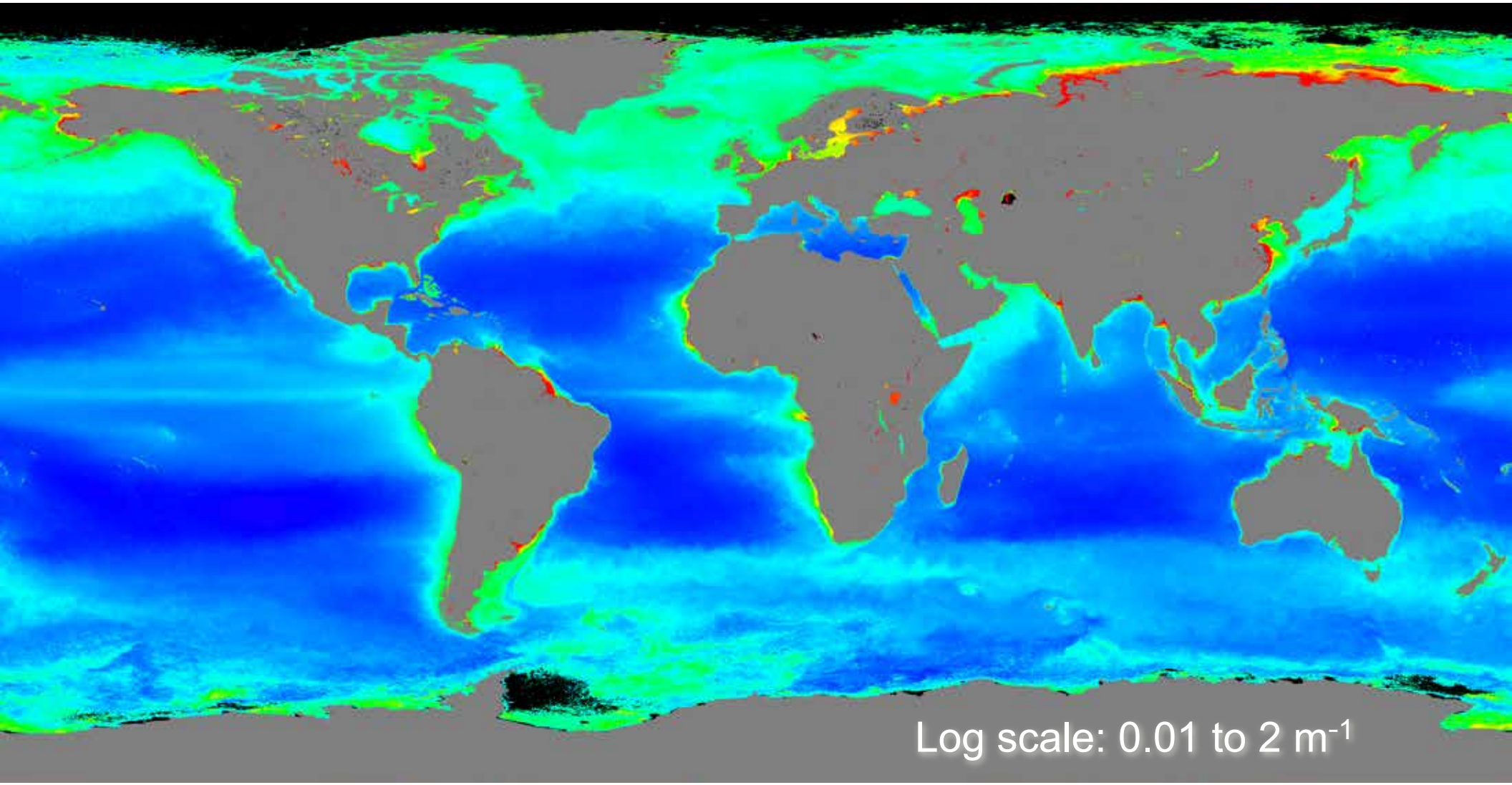


Generated using MSL12 for VIIRS ocean color data processing

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

Menghua Wang, NOAA/NESDIS/STAR

VIIRS Climatology $K_d(490)$ Image
(April 2012 to December 2013)

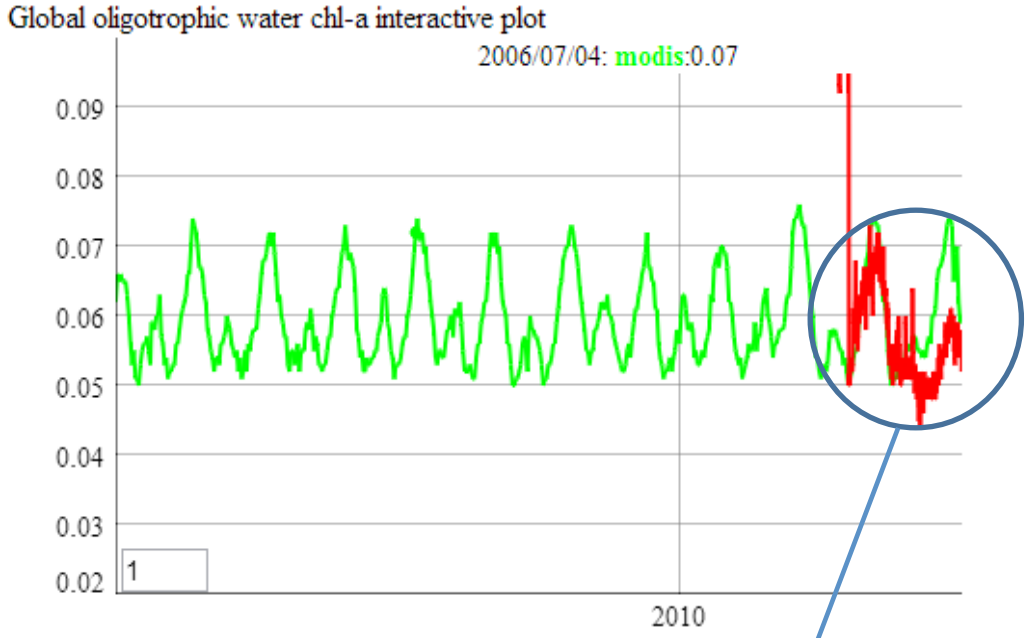


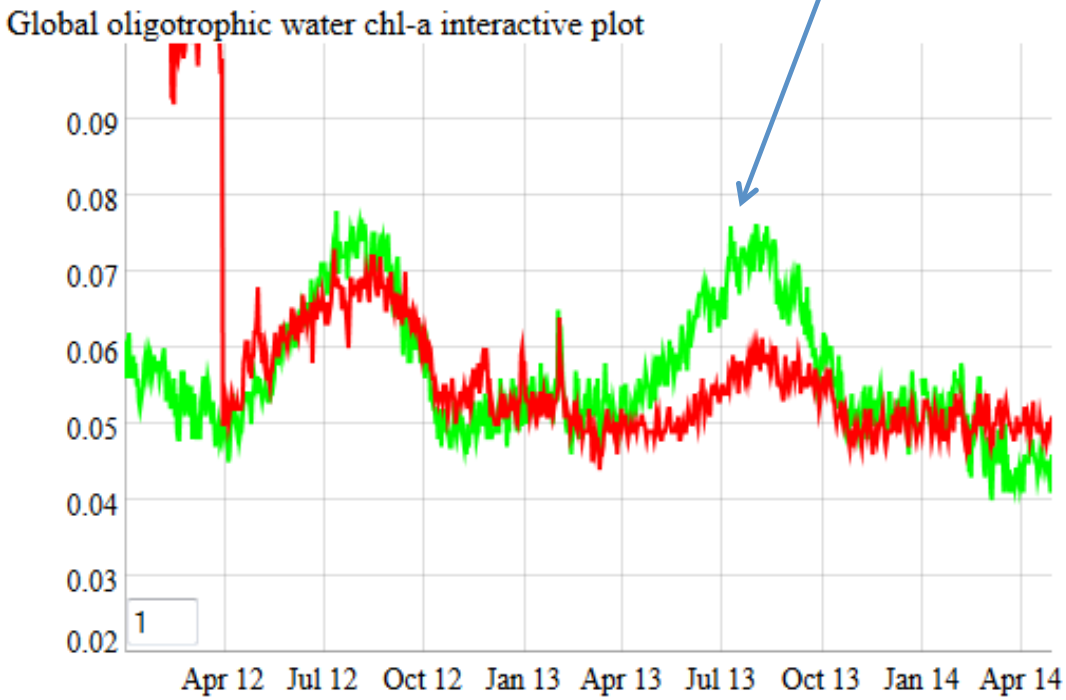
Generated using MSL12 for VIIRS ocean color data processing

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/10.1029/2009JC005286.

Menghua Wang, NOAA/NESDIS/STAR

VIIRS Calibration Issue





MODIS-Aqua global oligotrophic water Chl-a from 2002 to 2013 (green), overplotted with VIIRS data from 2012 to 2013 (red)

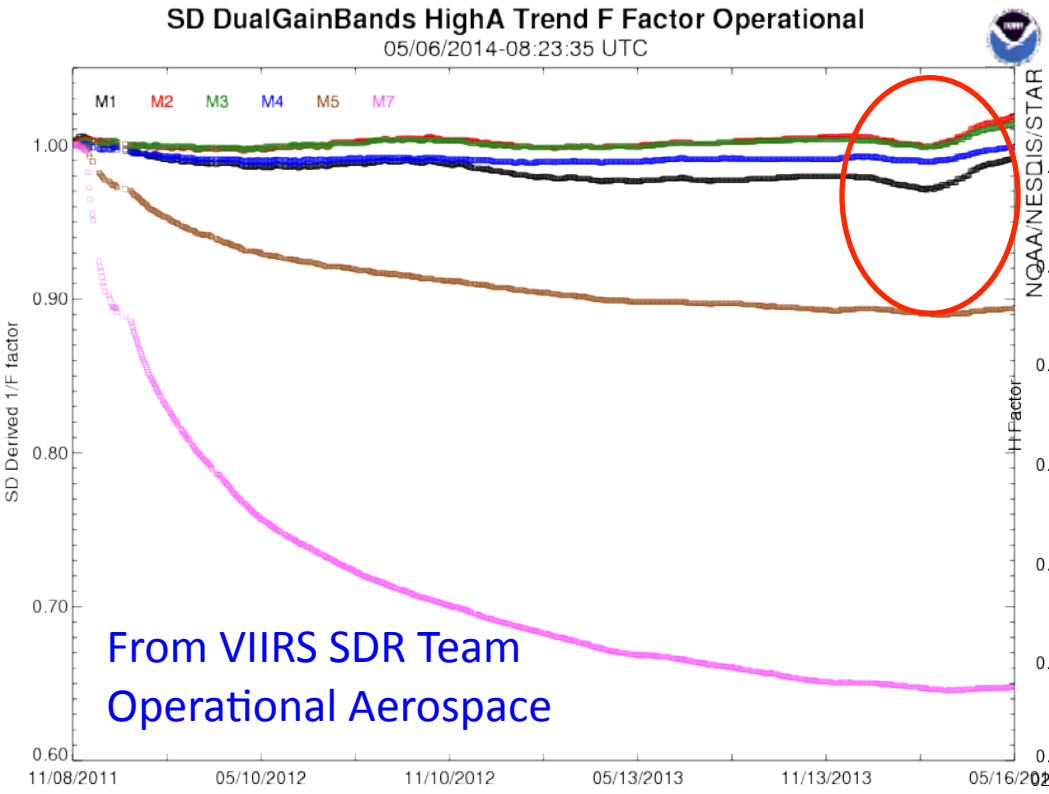
—— MODIS-Aqua

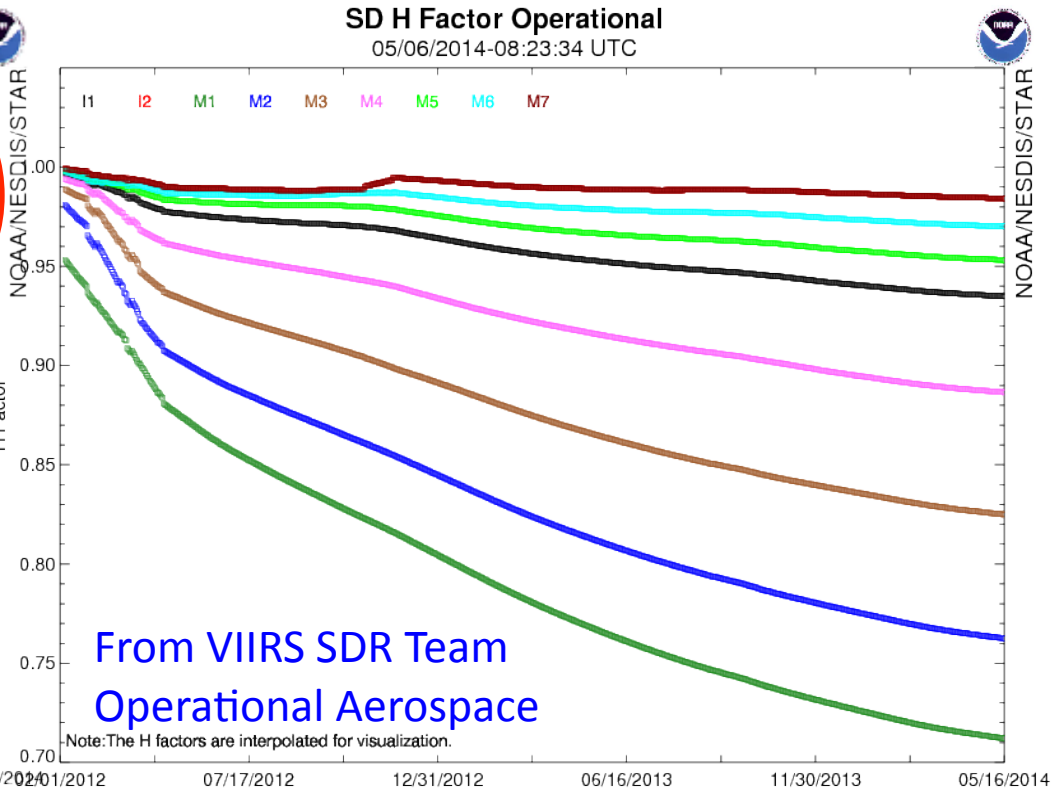
—— VIIRS (NOAA-MSL12)

- VIIRS and MODIS-Aqua match each other quite well in 2012.
- They have noticeable difference in 2013 (biased low from VIIRS).
- Since MODIS-Aqua has a reasonable Chl-a annual repeatability, It is confirmed that VIIRS SDR has calibration issues, in particular, **for the M4 (551 nm) band (biased low), at least for 2013.**

Recent Operational RSB H&F Factors Trends

(More detail this afternoon)



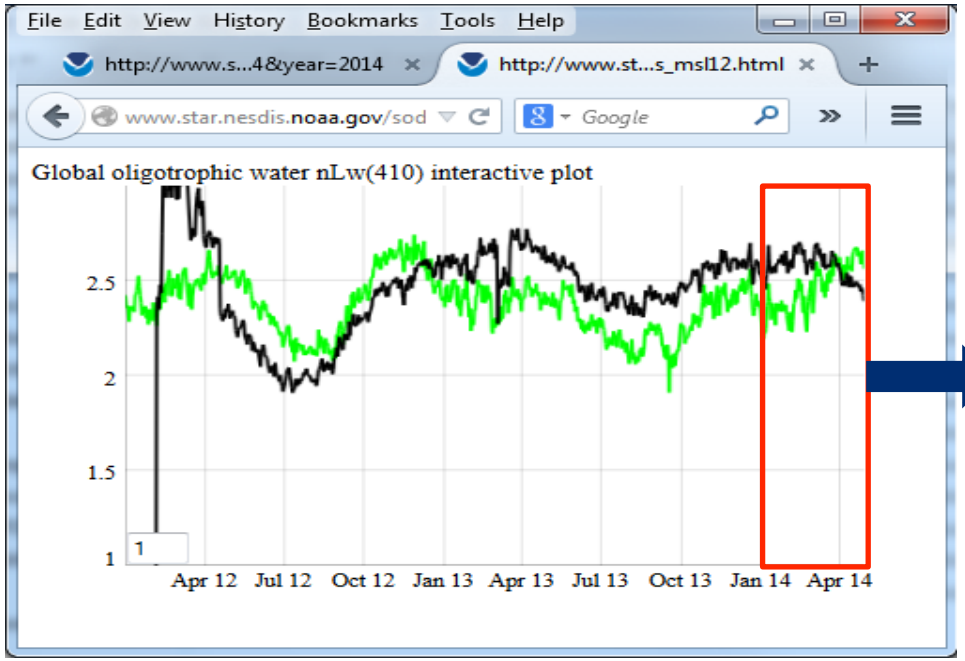


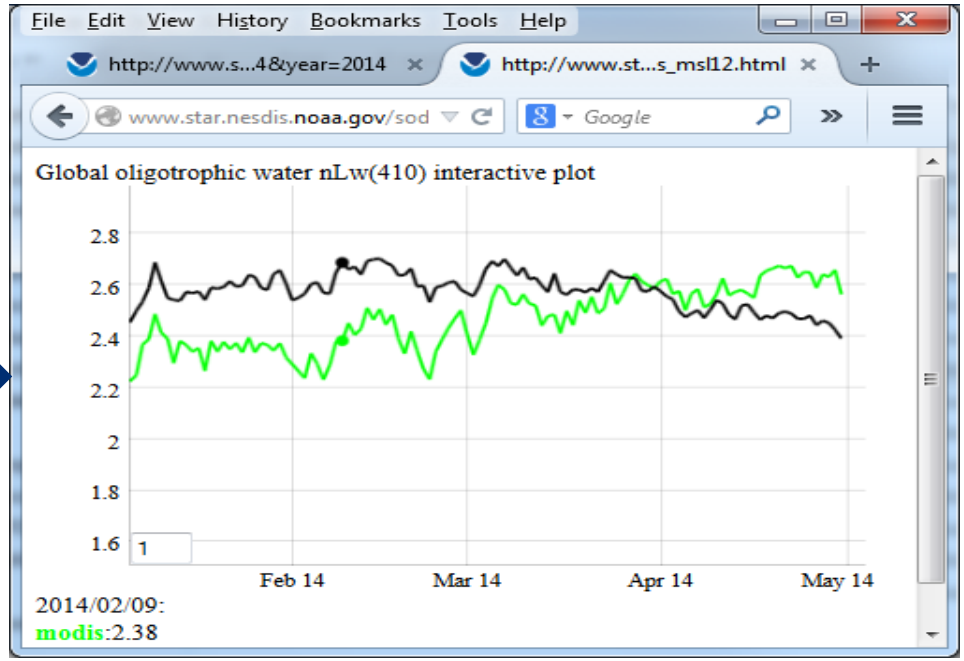
- Recent F-factors (1/F) show significant trend change which suggests that degradation has stopped or even reversed.
- F-lookup tables (1/F) for M1-M4 show significant increase of ~1-2% since early February. F factors for M1 and M2 increased ~2% in 3 months.
- Thus, calibration gains (TOA radiances) are decreased by ~2% for M1 and M2.

Quantitative Evaluation for Global Oligotrophic Waters

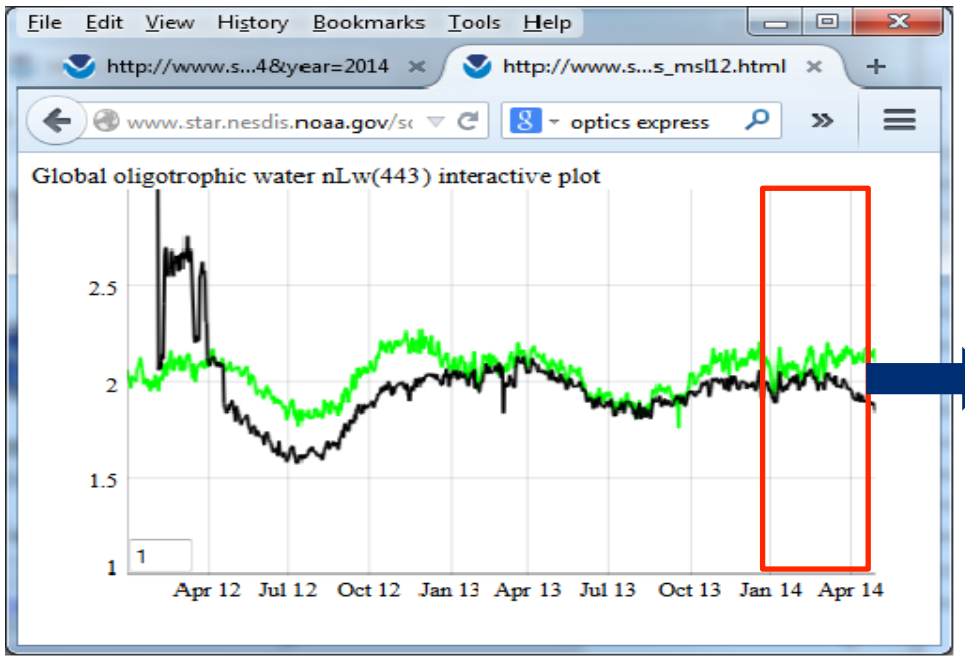
VIIRS MODIS-Aqua

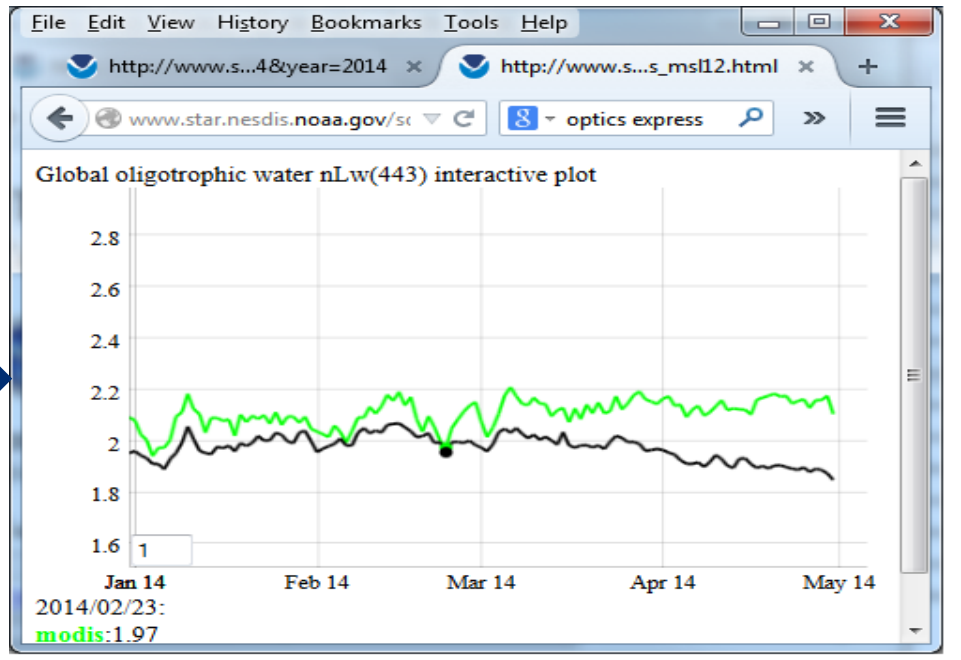
VIIRS vs. MODIS nLw(412)



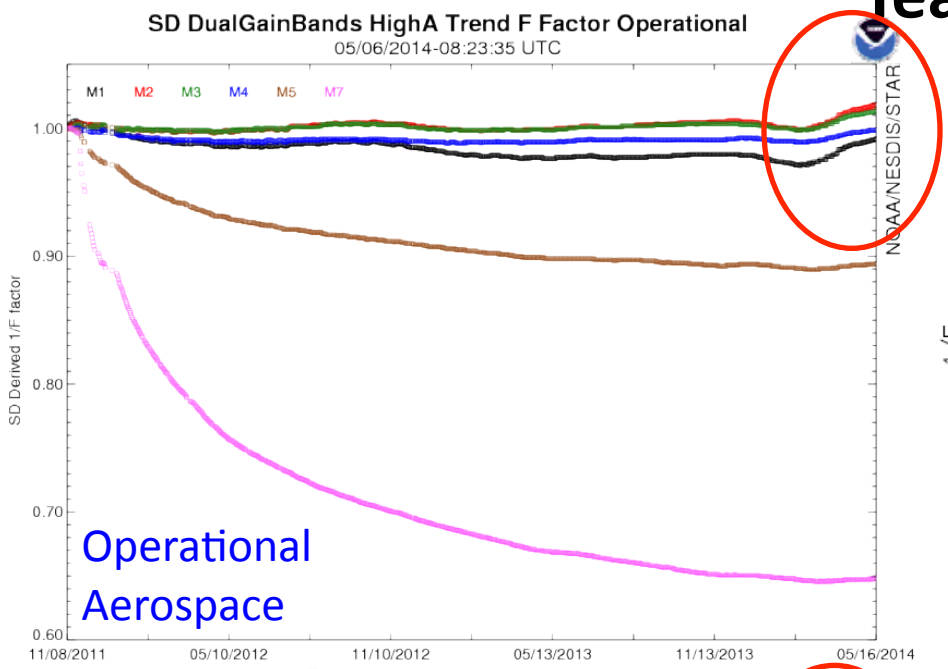


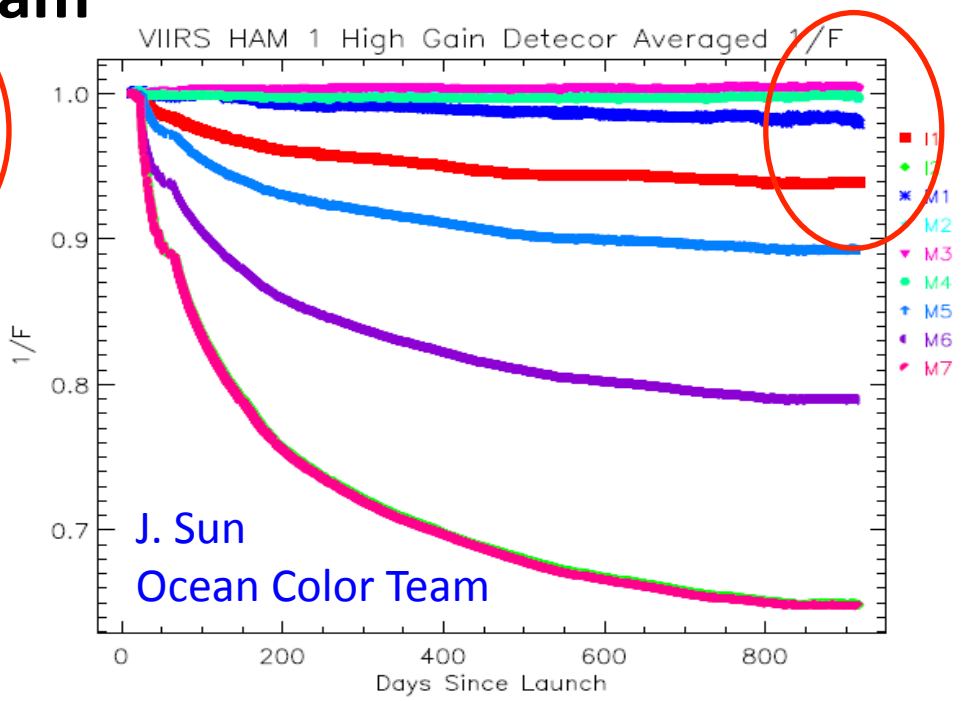
VIIRS vs. MODIS nLw(443)

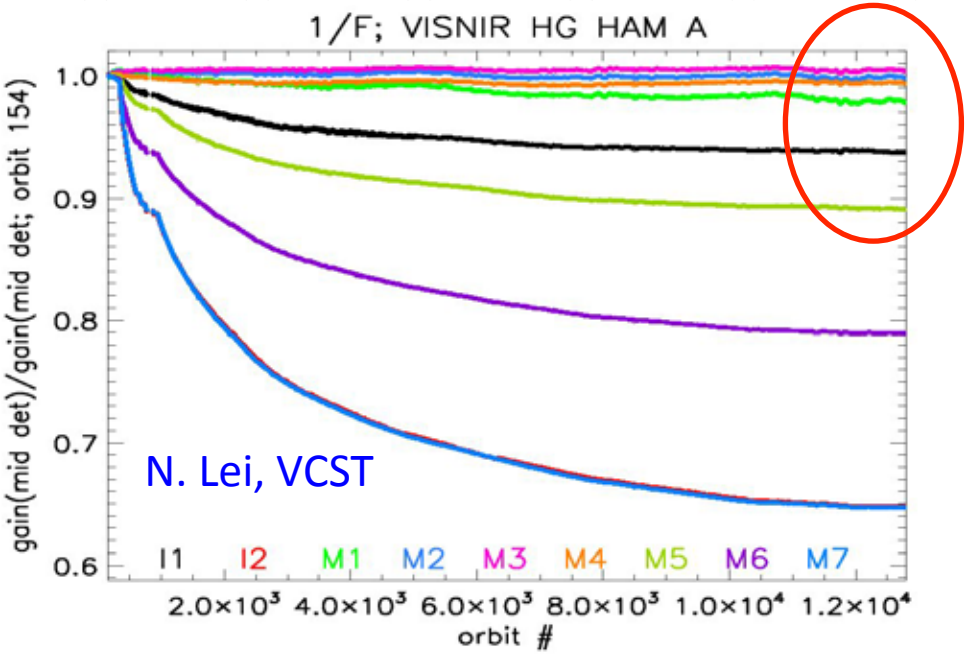




F factors from Operational, VCST, and Ocean Color EDR Team







- **The recently F-factors (1/F) increase (Cal. gains decrease) in short wavelength bands observed in operational F-LUTs is not seen in F factors derived by Ocean Color Team and VCST.**
- **The artificial F-factors increase lead to the EV radiance/reflectance decrease and significantly impacted VIIRS ocean ocean products, leading to biased low nLw values and missing values due to nLw < 0.**

Ocean Color Breakout Discussions

- **Ken Voss** (Univ. Miami): Why MOBY and why MOBY refresh?
- **Kevin Turpie** (NASA/UMBC): Calibration uncertainty and satellite ocean color trends
- **Mike Ondrusek** (STAR): Validation ocean color sensors using a profiling hyperspectral radiometer
- **Puneeta Naik** (STAR): Effective band center wavelengths for MODIS and VIIRS for open ocean waters
- **Discussions**: OC data quality, SDR issues, long-term time series, need lunar calibration, J-1 polarization issue (most impact to OC products), etc.

➢ VIIRS Ocean Color Team contributed **7** posters covering various topics.

Ocean Color Users Feedback

- Participants from
  - **Fisheries**
    - Northeast – **Kim Hyde**
    - Atlantic/Florida – represented by **Ron Vogel**
    - Pacific -- **Cara Wilson**
      - Surveys (NRT)
      - Long term model predictions
  - **NWS** – **Tony Siebers**
    - Ecosystem Forecasting – moving toward operational - **Chris Brown**
    - EMC - **Sudhir Nadiga**, **Eric Bayle**
  - **NOS** – **Rick Stumpf**
    - HAB
    - Sanctuaries
  - **OAR** (e.g., **D. Tong**, Isoprene emission)
  - **NESDIS** ecosystems – Chris Brown
  - **AOML/AOR** (not present but discussed)

PRODUCT Needs & Latency Requirement

- Current Operational products all need to be regularly reprocessed with VIIRS, to provide high quality data **time series** (expressed by ALL users).
- **Required** Products: **nLws**, **Chlorophyll-a**, **Kd(490)**, Kd(PAR) (from EMC). Anomaly products. Global data.
- New products desired
  - Primary Productivity
  - Chromophoric Dissolved (Organic) Matter (CDM or CDOM)
  - Suspended Particulate Material
  - Particulate Inorganic Carbon (PIC)
  - Chlorophyll Frontal Product
- **Data Latency Requirement**: generally 12 hrs, but some applications need 3 hrs or less. Need DB data.

Conclusions

- In general, VIIRS OC normalize water-leaving radiance spectra show reasonable agreements with in situ measurements at MOBY, AERONET-OC sites, and various other ocean regions.

➢ In global deep waters, the VIIRS ocean color products generated from MSL12 were consistent with MODIS-Aqua in 2012, but discrepancy started to become noticeable for IDPS and MSL12 Chl-a data since early 2013. We confirmed that this is a VIIRS calibration problem in 2013, particularly for M4 band.

➢ Following the reverse trends of VIIRS SDR F-LUTs, global VIIRS nL_w data show decreasing trends from February to May of 2014. nL_w(410) (M1) and nL_w(443) (M2) drifted lower ~**15-20**% as of early May 2014, and nL_w(488) (M3) decreased ~**8-10**% for global oligotrophic waters. These are very significant! The nL_w trends are continuing, and the correct F-LUTs should be used now!

- VIIRS ocean color products are critical to NOAA users (also to broad ocean community). High quality time series data are required. Thus, regularly data reprocessing is necessary for both SDR and EDR. The VIIRS OC team will carry out a mission-long data reprocessing when the SDR issues are solved.

- It has been shown in the VIIRS mission that ocean color EDR is extremely sensitive to SDR data quality. Thus, both solar and **lunar** calibrations (require **lunar maneuvers**) are necessary for SNPP, and future **J-1** and **J-2**.