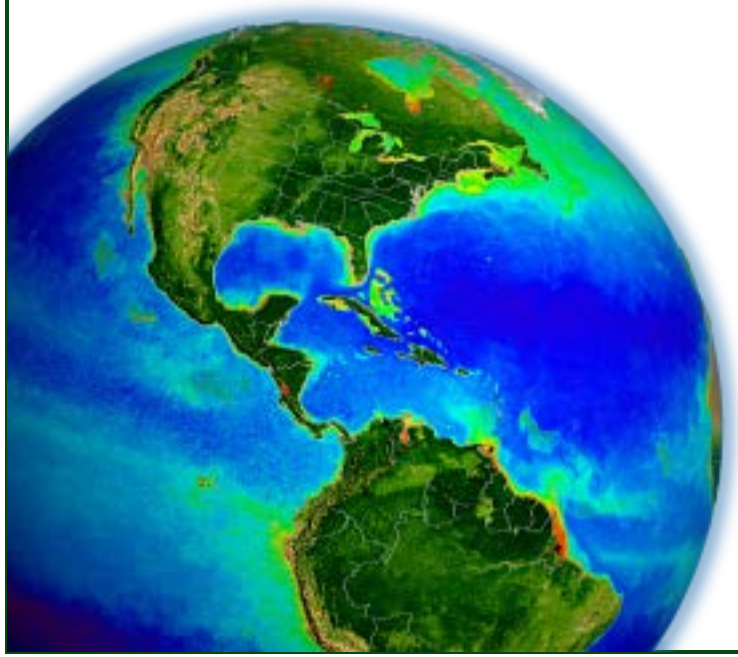
NASA OBPG
Satellite Ocean Color Update



Bryan Franz

and the

Ocean Biology Processing Group
NASA Goddard Space Flight Center

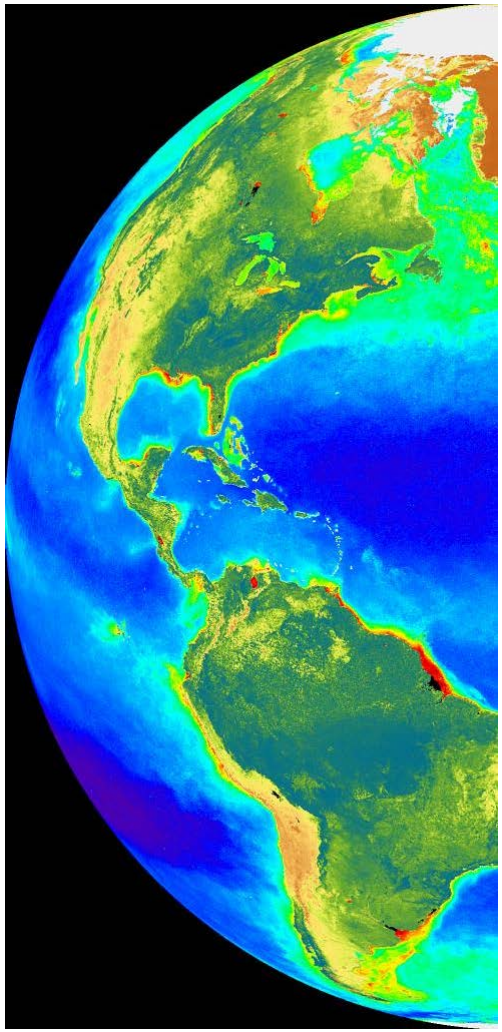
IOCS Meeting

Ocean Color Research Team Meeting

18 May 2017, Lisbon, Portugal

NASA Ocean Biology Processing Group

currently supporting calibration, validation, software development, (re)processing, and distribution for a multitude of ocean color missions & sensors.



Global Processing & Distribution

- **VIIRS/NPP** (USA)
- **MODIS/Aqua** (USA)
- **MODIS/Terra** (USA)
- **OLCI/S3A** (Europe)
- SeaWiFS (USA)
- CZCS (USA)
- MERIS (Europe)
- OCTS (Japan)

Regional Processing & Distribution

- **GOC**I (Korea)
- HICO (USA)

Limited Mission Support

- Landsat-8/OLI (USA)
- Sentinel-2/MSI (Europe)
- OCM-1/2 (India)
- OSMI (Korea)
- MOS (Germany/India)

Ocean Color Reprocessing

All global missions are now at version R2014.0 (with the exception of MERIS).

Reprocessing R2014.0 included:

- updates to instrument and vicarious calibrations
- updates to standard algorithms (e.g., OCI Chlorophyll)
- expansion of standard products to include suite of inherent optical properties (GIOP).
- switch to NetCDF4 file formats (Level-2 and Level-3)

We have **not** reprocessed any ocean color missions in the past year!

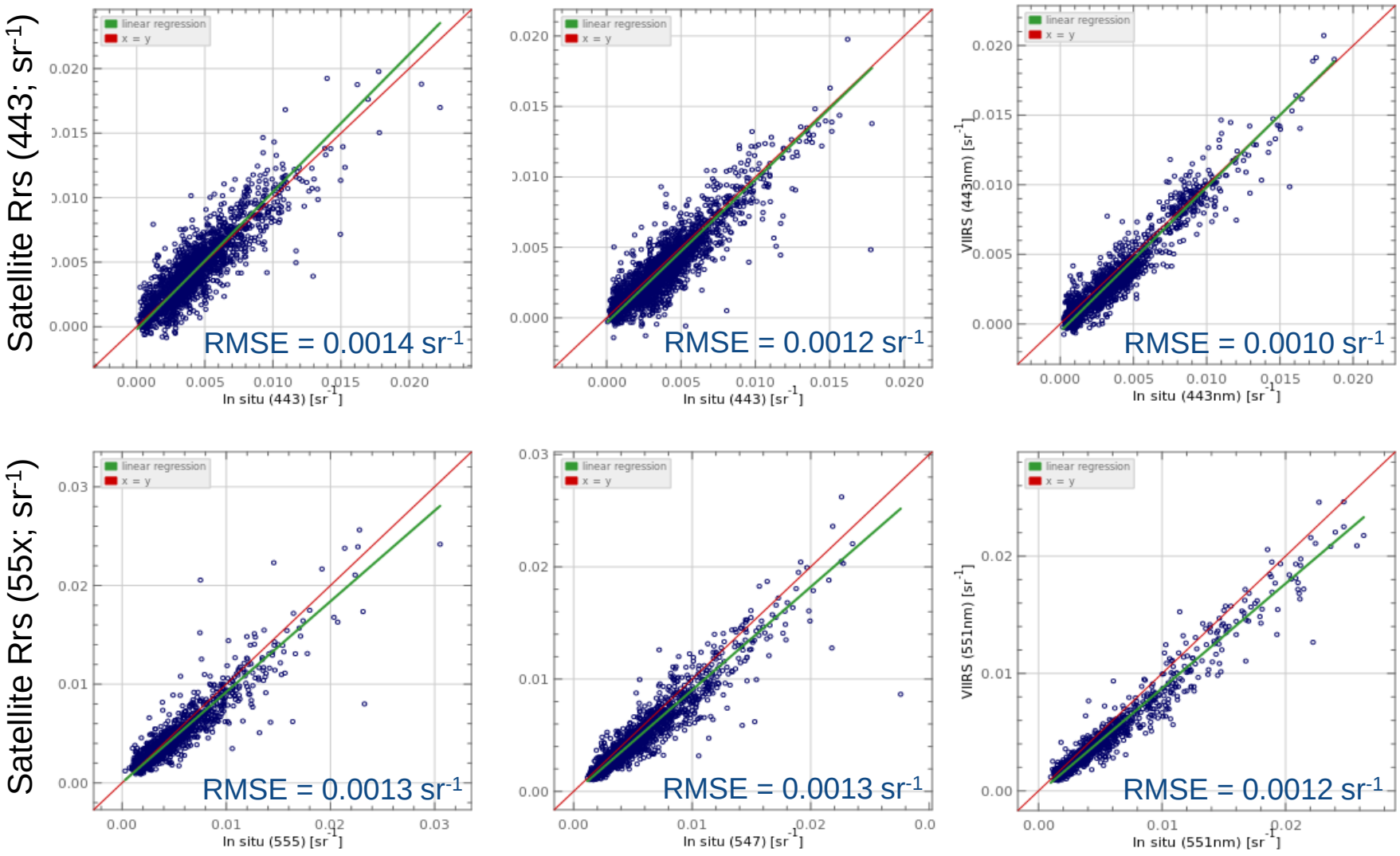
Rrs(λ) Validation

all available in situ match-ups from SeaBASS & AERONET-OC

SeaWiFS

MODISA

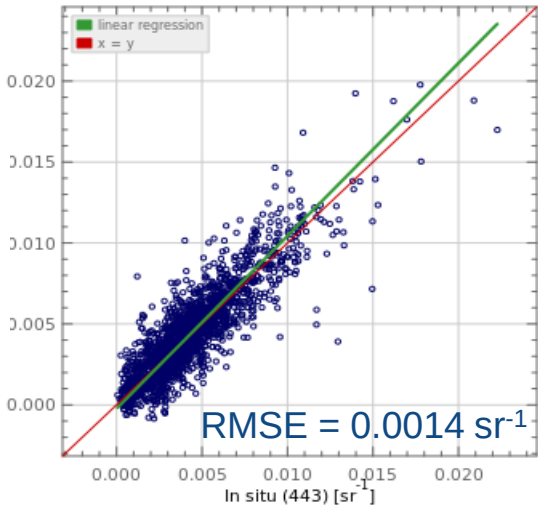
VIIRS

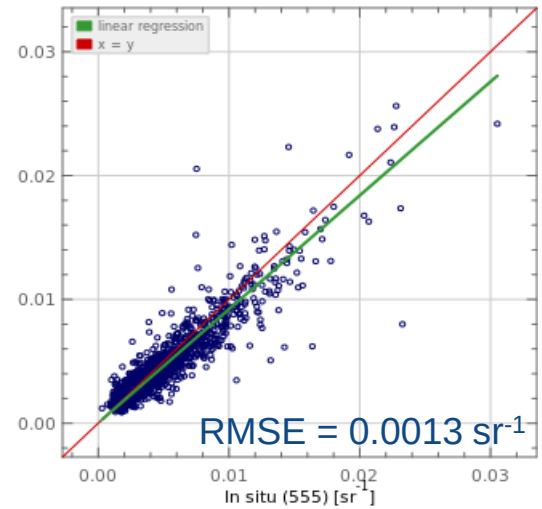


Rrs(λ) Validation

all available in situ match-ups from SeaBASS & AERONET-OC

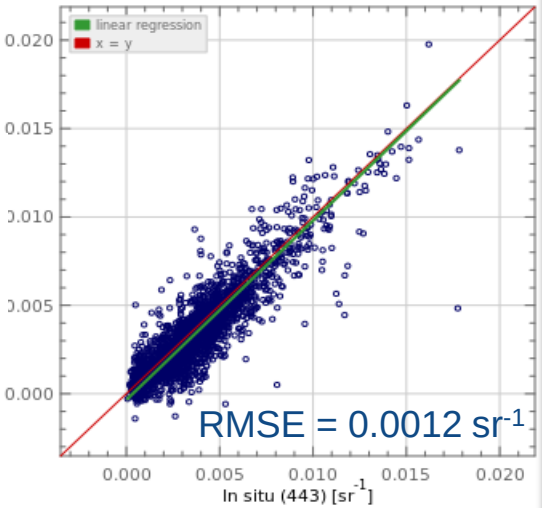
SeaWiFS

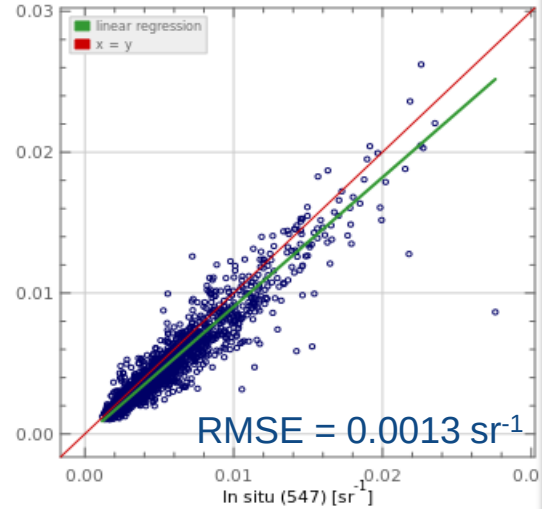




Satellite Rrs (55x; sr^{-1})

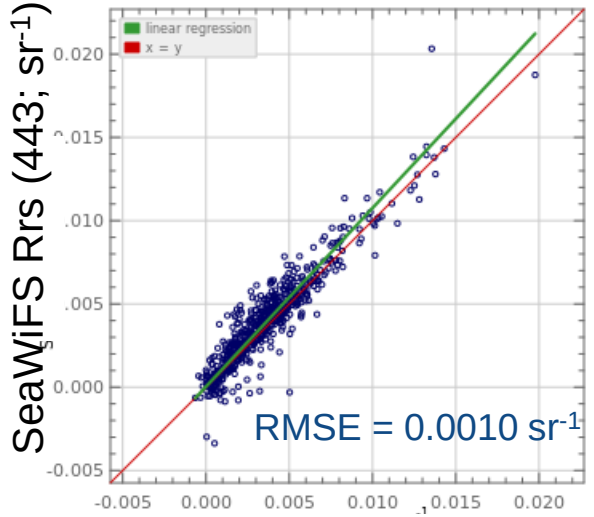
MODISA



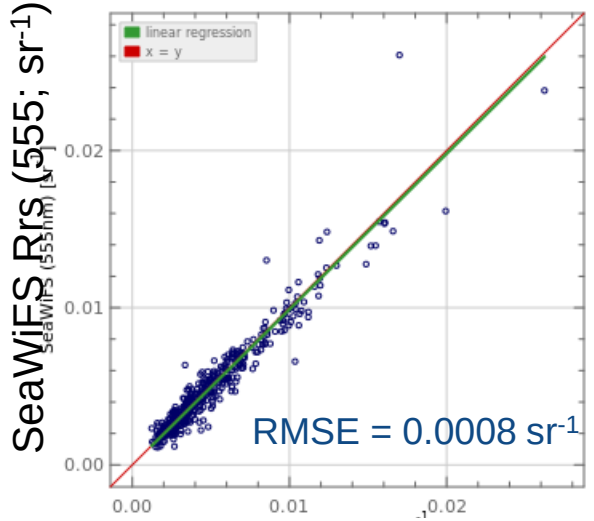


In situ Rrs(λ)

SeaWiFS v MODISA



SeaWiFS Rrs (443; sr^{-1})



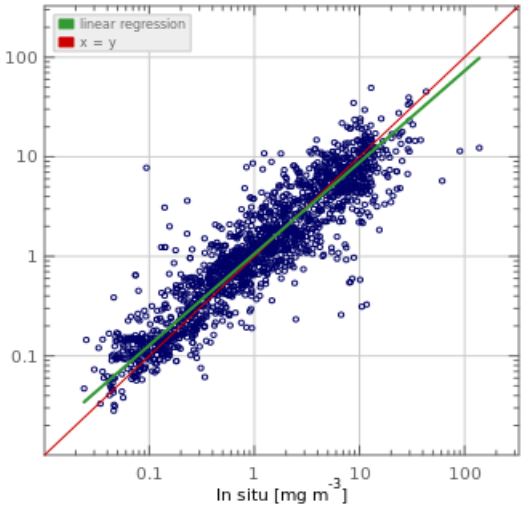
SeaWiFS Rrs (555; sr^{-1})

MODISA Rrs(λ)

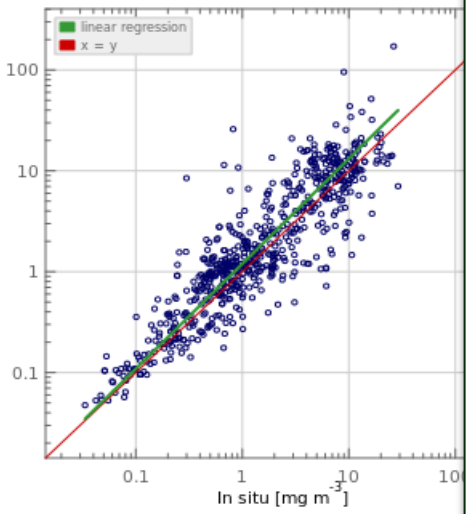
Chlorophyll-a Validation

all available in situ match-ups from SeaBASS

SeaWiFS



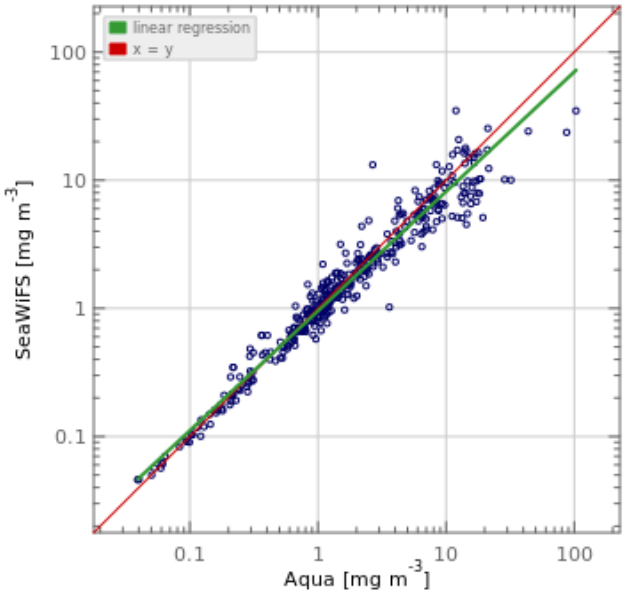
MODISA



Satellite Chla (mg m^{-3})

In situ Chla

SeaWiFS v MODISA

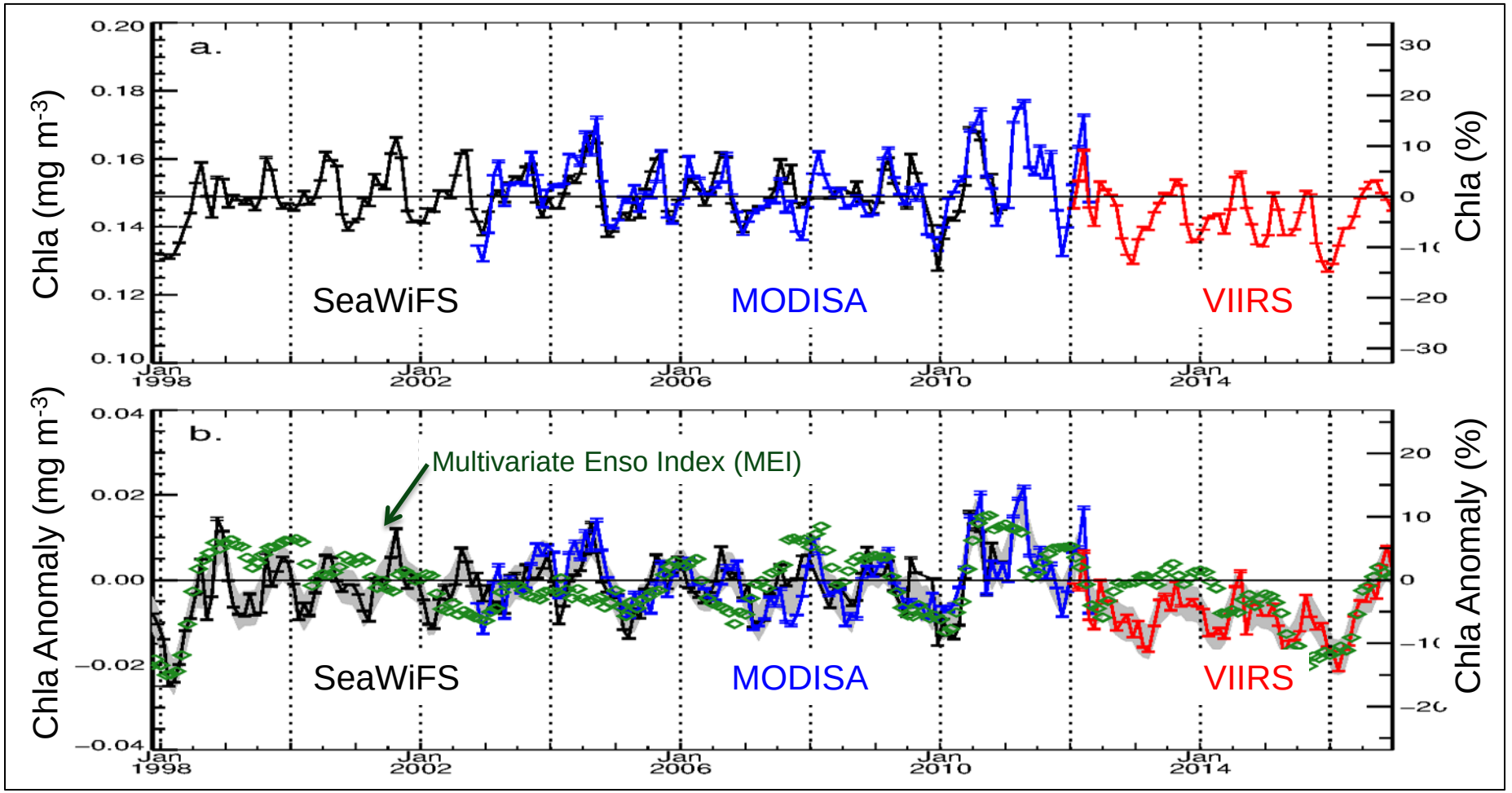


in VIIRS era

- heavy reliance on AERONET-OC for radiometric validation
- need more 2012-2017 chlorophyll in SeaBASS!

Long-term (19-year) Chlorophyll Record

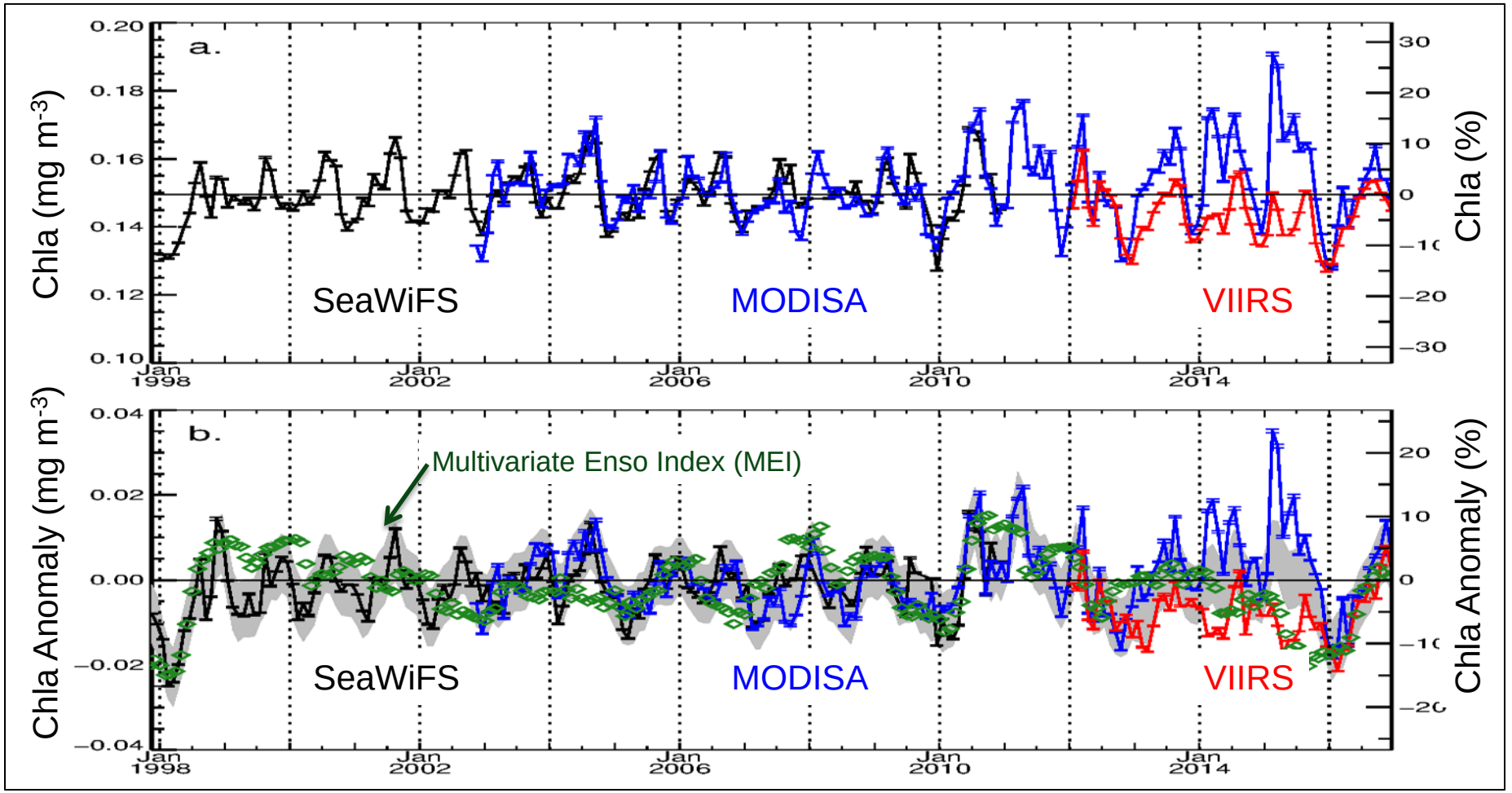
multiple missions, consistently processed



Franz, B.A., M. J. Behrenfeld, D.A. Siegel, S.R. Signorini, 2017: Global ocean phytoplankton [in "State of the Climate in 2016"]. Bulletin of the American Meteorological Society, submitted.

Long-term (19-year) Chlorophyll Record

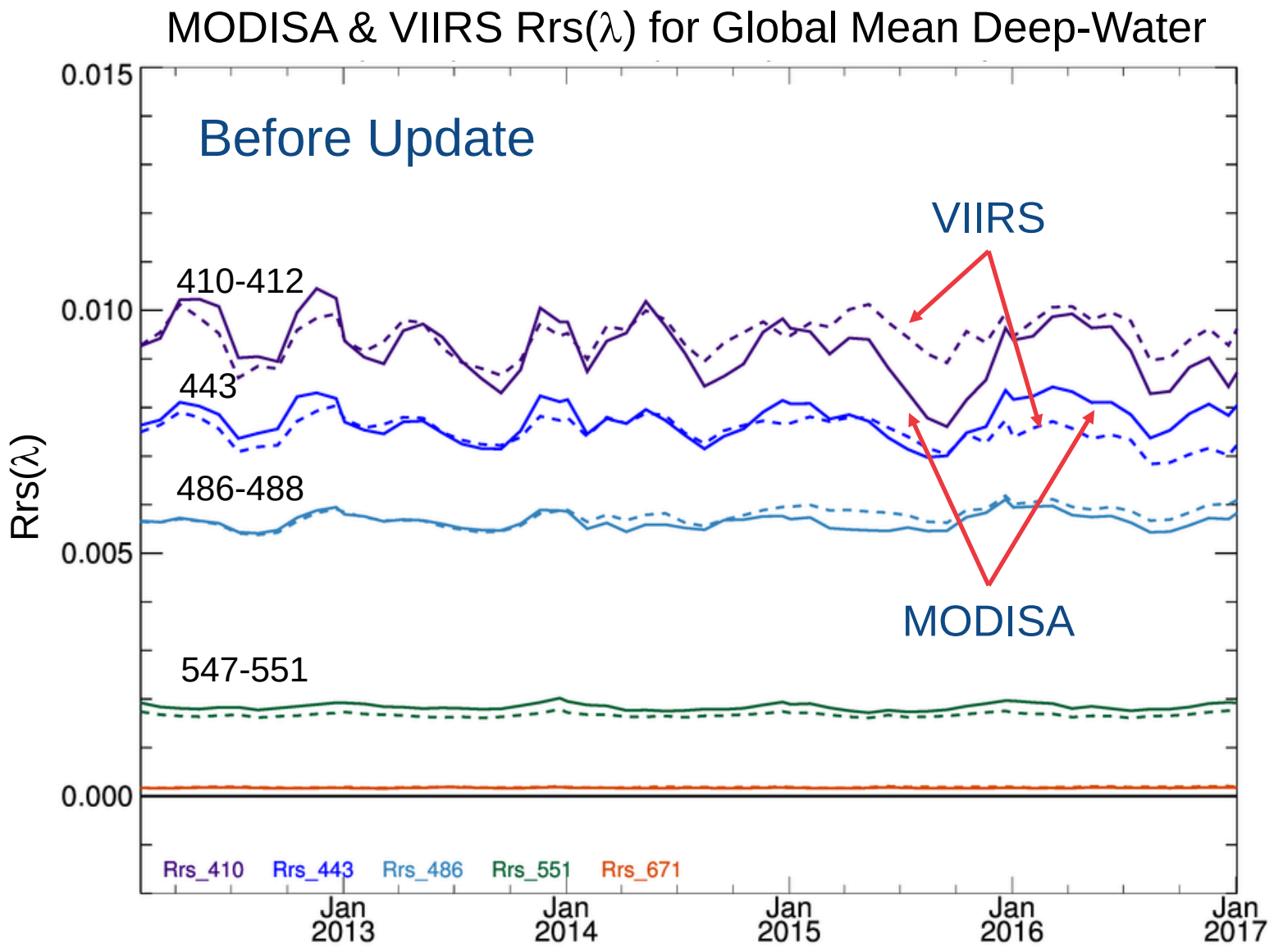
multiple missions, consistently processed



known issues with MODIS/Aqua data quality after 2012

MODIS/Aqua Calibration Update

comparison of OC trends to VIIRS 2012-2017



MODIS/Aqua Calibration Re-analysis

complete in-house end-to-end assessment

1) Instrument Calibration

- Solar diffuser (SD) and SD stability monitor (SDSM) screen transmission, and SD BRF derived from yaw maneuver data
- SD degradation corrected using SDSM
- SD calibration used to determine detector gain changes
- Lunar Calibration to determine RVS for 488 – 869nm
- Desert / Lunar Cal to determine RVS for 412, 443nm
- Calibration LUT created using smoothed SD gains & RVS values

2) Residual Artifact Corrections

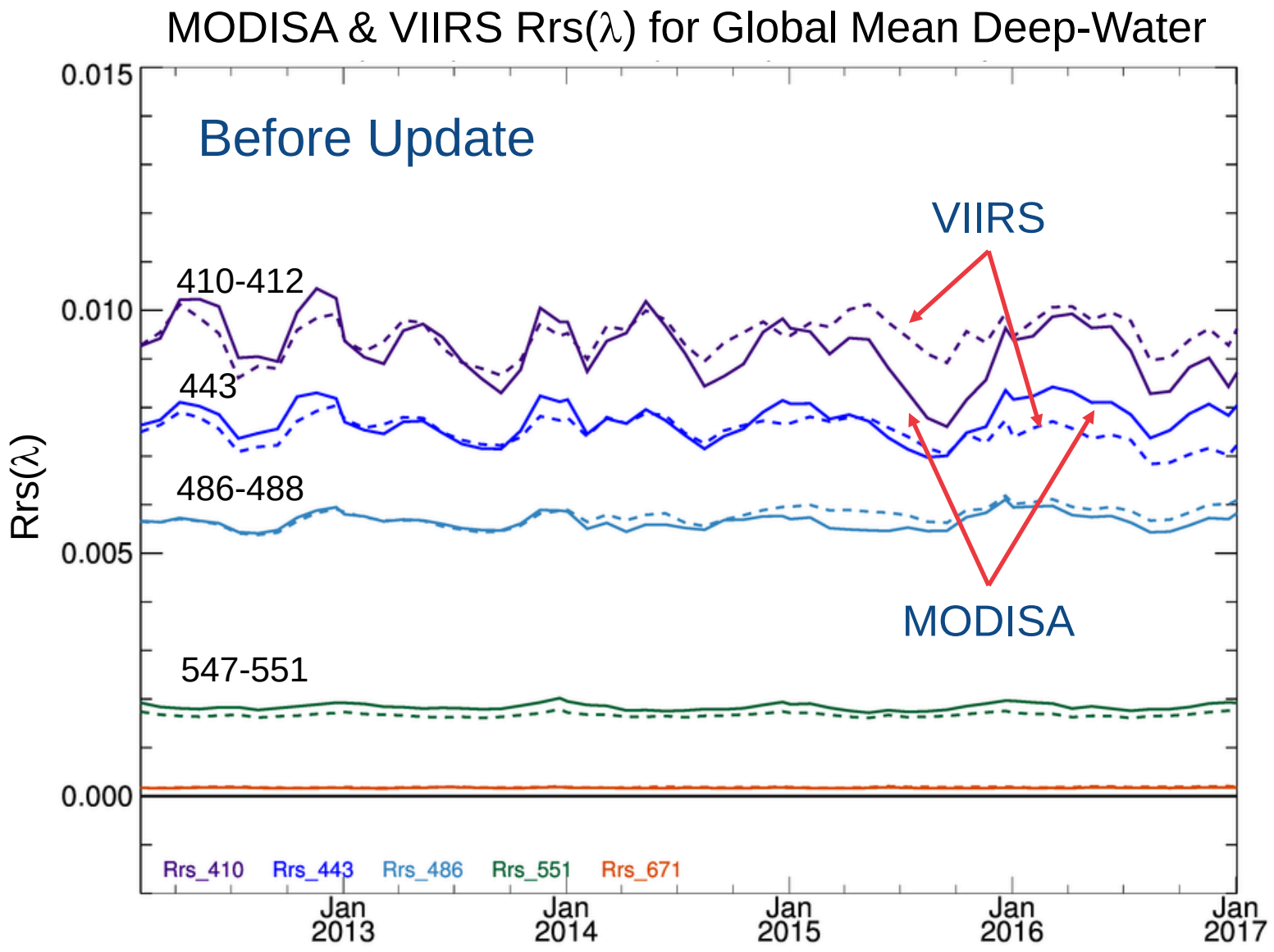
- additional corrections derived from calibrated radiances to further reduce detector striping and cross-track artifacts

3) Vicarious calibration to MOBY

see Shihyan Lee or Gerhard Meister

MODIS/Aqua Calibration Update

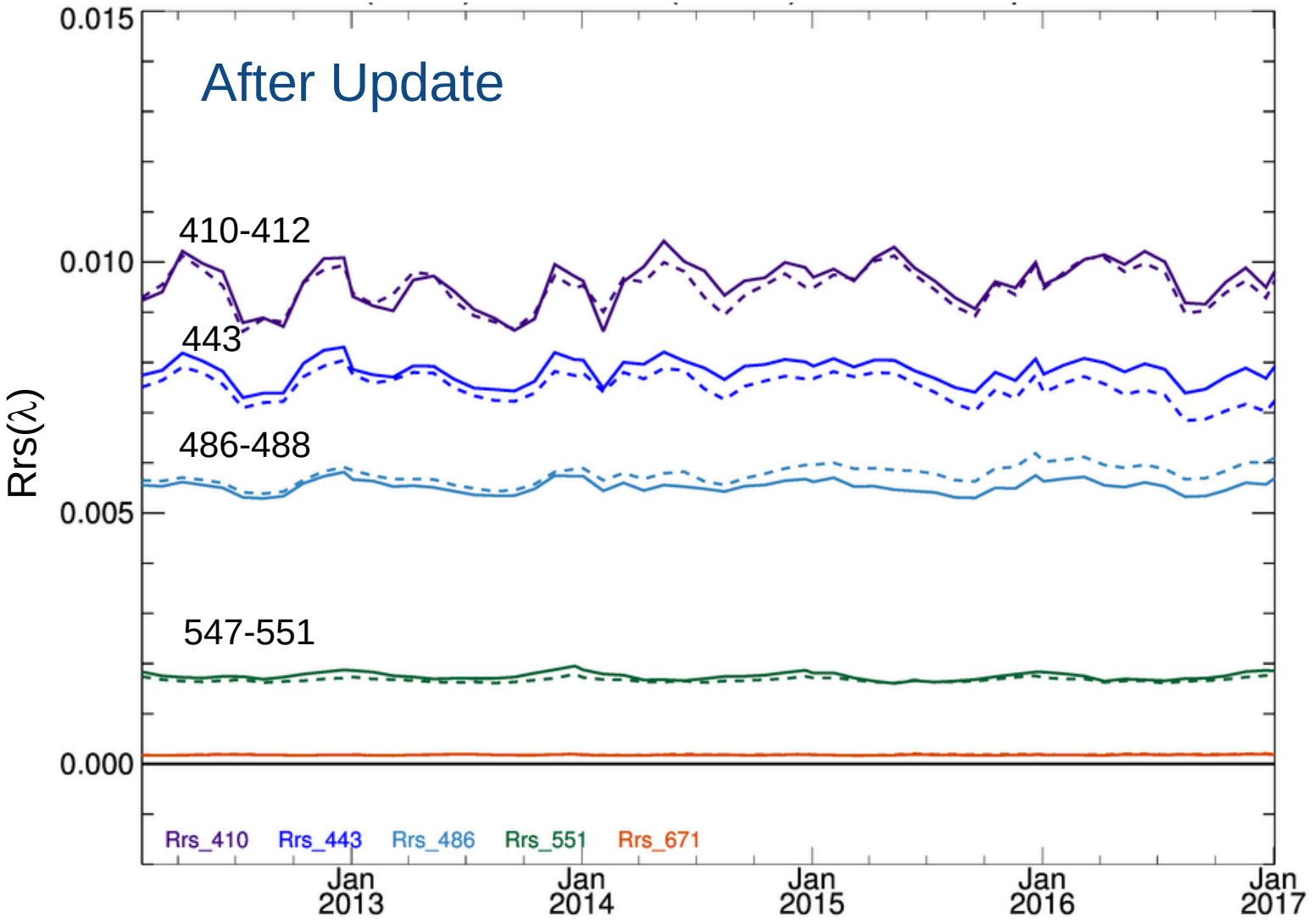
comparison of OC trends to VIIRS 2012-2017



MODIS/Aqua Calibration Update

comparison of OC trends to VIIRS 2012-2017

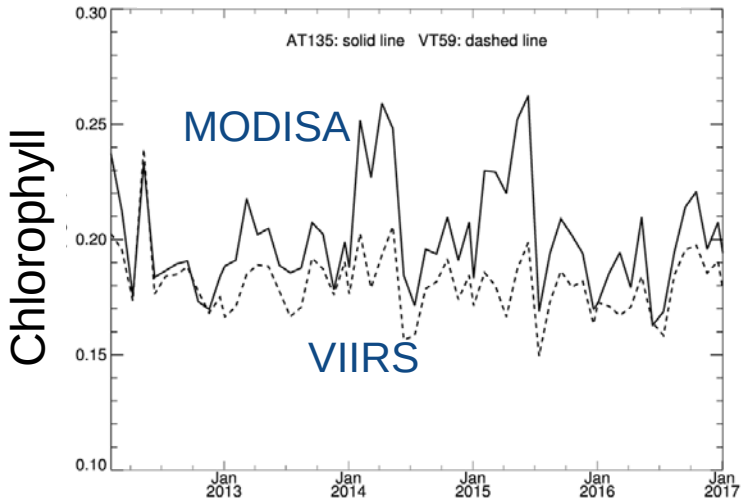
MODISA & VIIRS Rrs(λ) for Global Mean Deep-Water



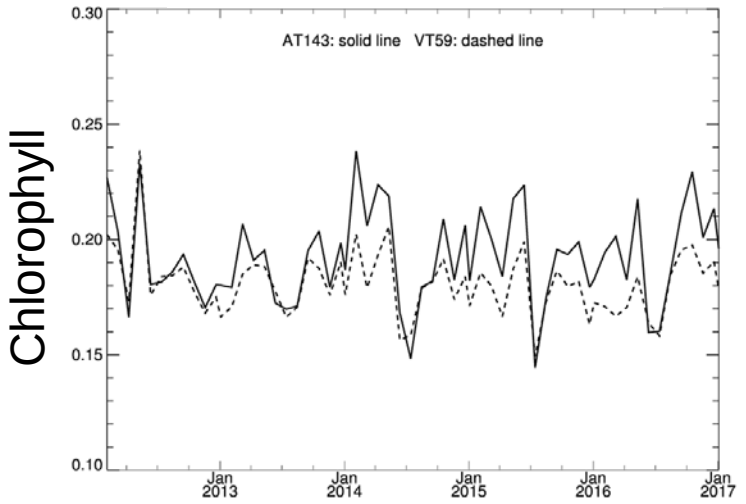
MODIS/Aqua Calibration Update

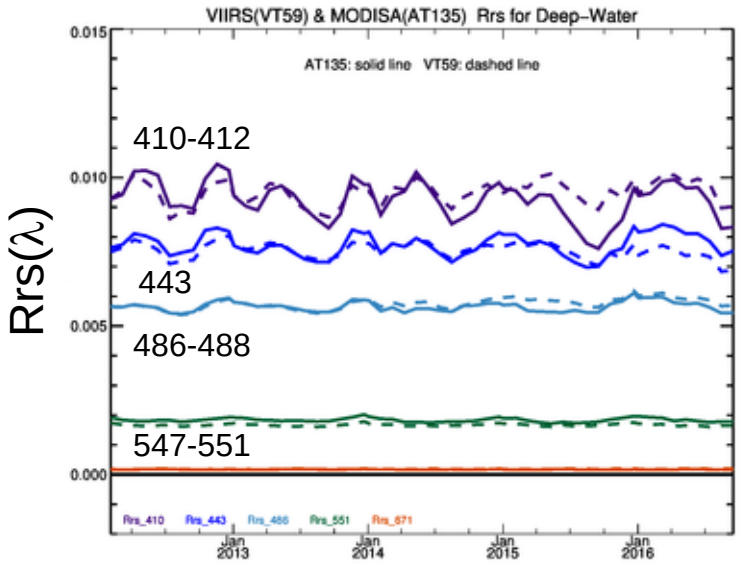
comparison of OC trends to VIIRS 2012-2017

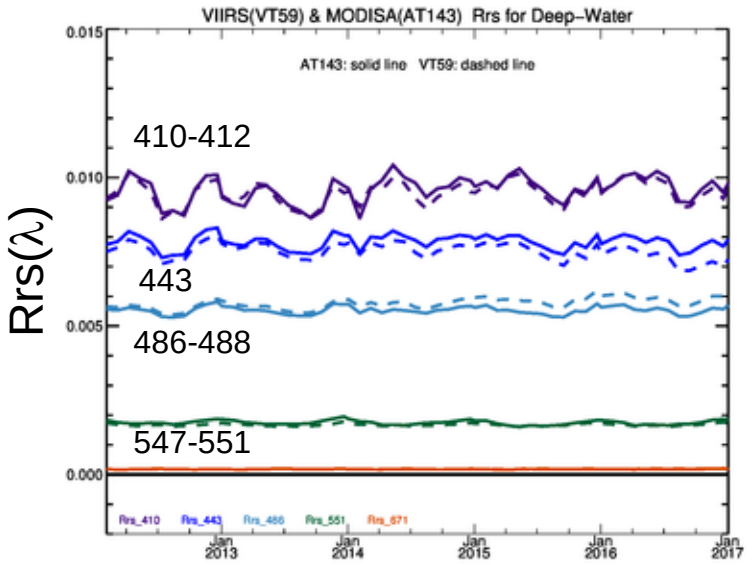
Before



After

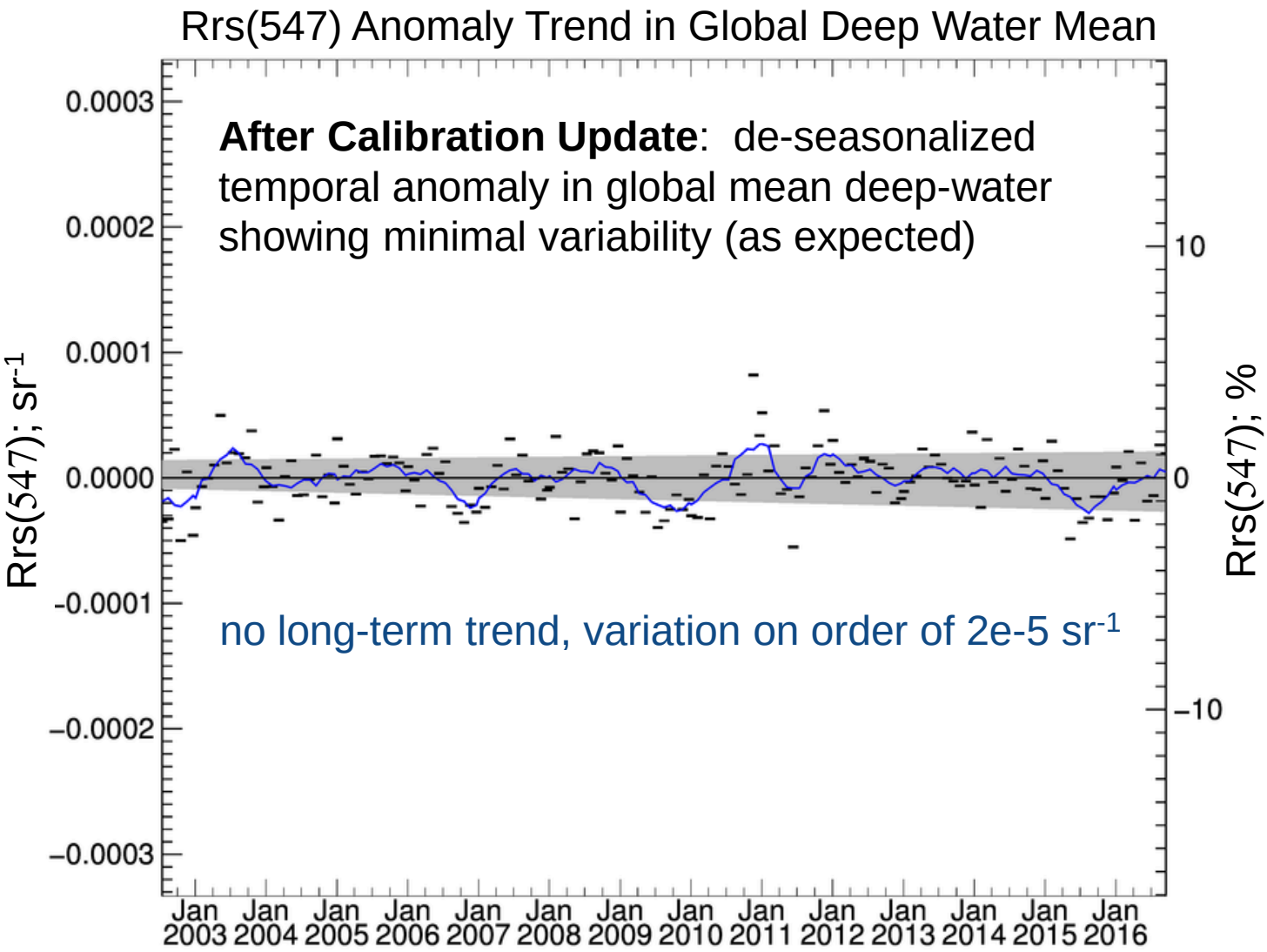






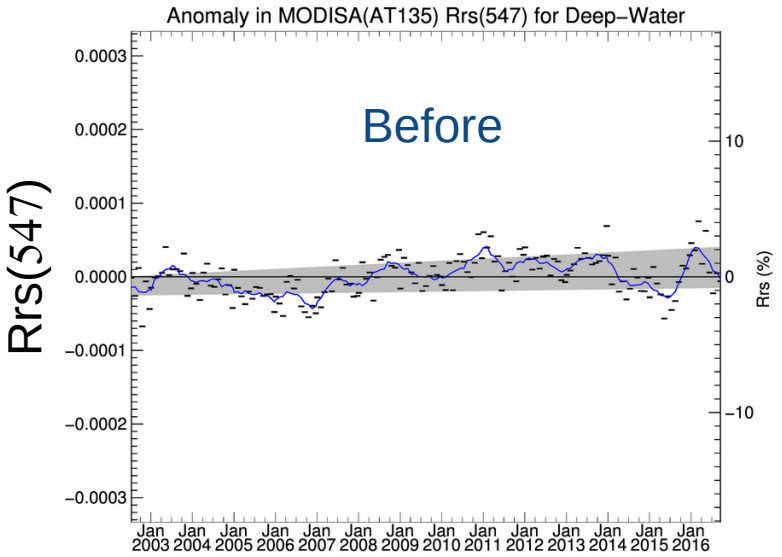
MODIS/Aqua Calibration Update

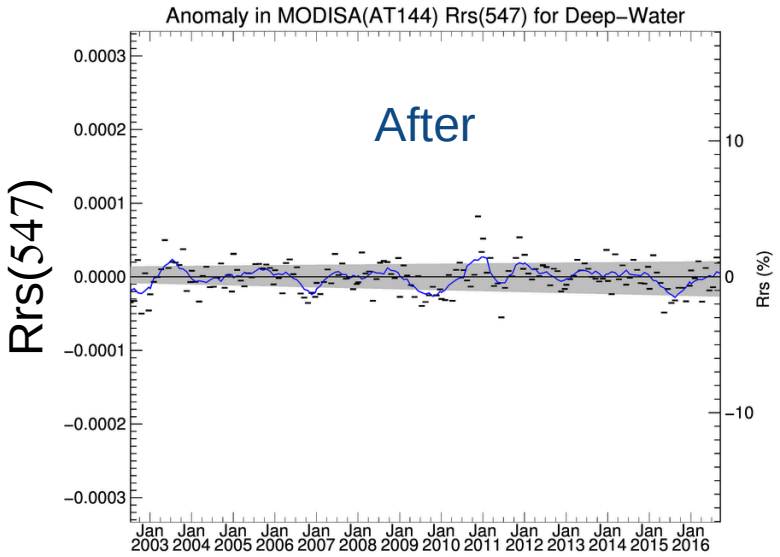
Temporal Anomaly Trend

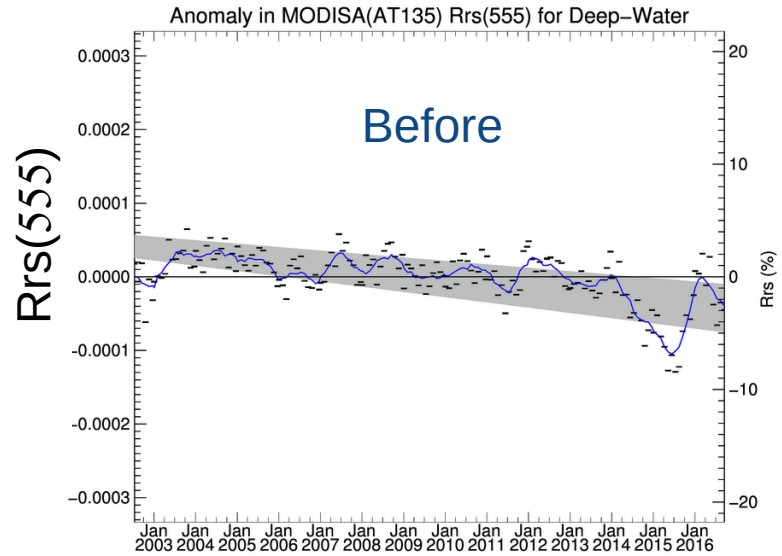


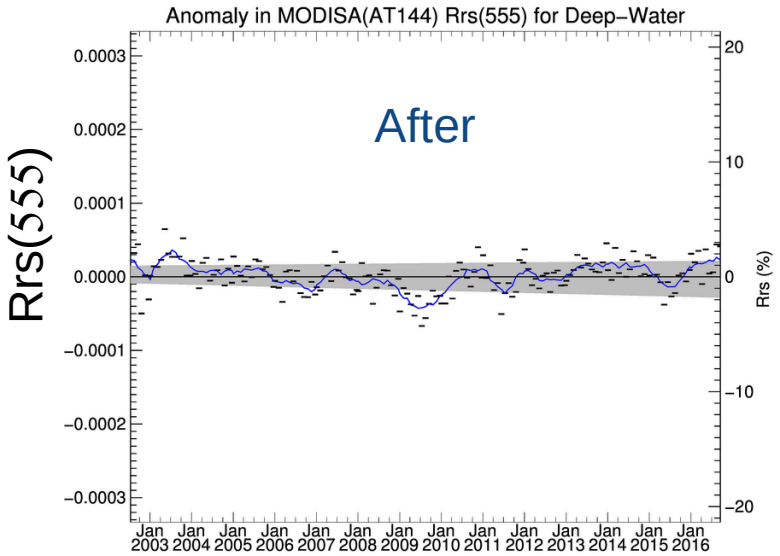
MODIS/Aqua Calibration Update

Temporal Anomalies in Green Bands in Clear Water









Coming Soon!

MODISA/Aqua Reprocessing

(version 2014.1)

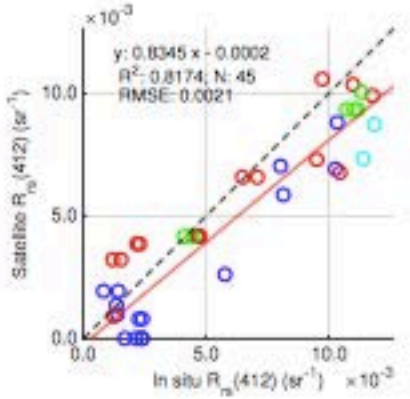
GOCI Support (KIOST)

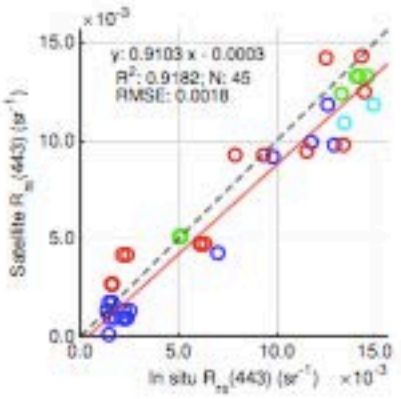
- Processing capability
  - standard NASA ocean color processing codes have been augmented to support GOCI
  - ocean color processing capability from Level-1B with NASA algorithms is supported in current SeaDAS

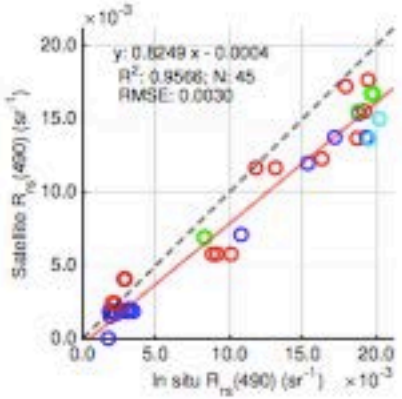
- Data distribution
  - OBPG is acquiring full GOCI mission at Level-1B, through ongoing collaboration with KIOST
  - Level-1B (mirror) and Level-2 products (NASA algorithms) are available via ocean color web portal
  - Anticipating an update to the Level-1B mission archive from KIOST to mitigate slot artifacts (ISRD), which will precipitate a NASA Level-2 reprocessing as well.

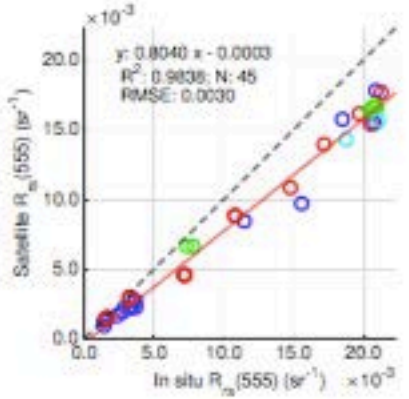
GOCI Results

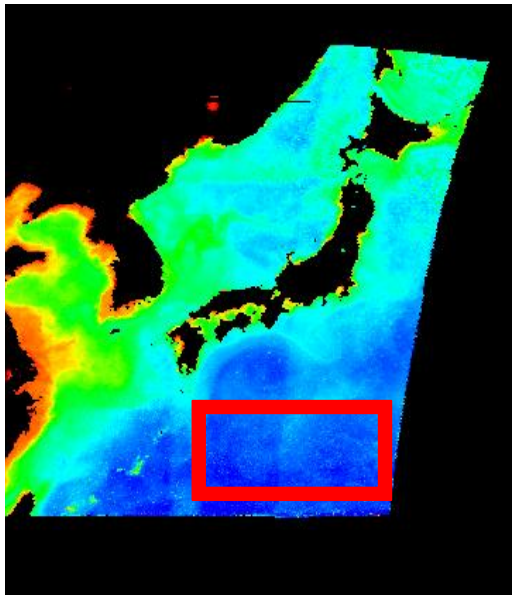
validation to AERONET-OC sites at varying times of day

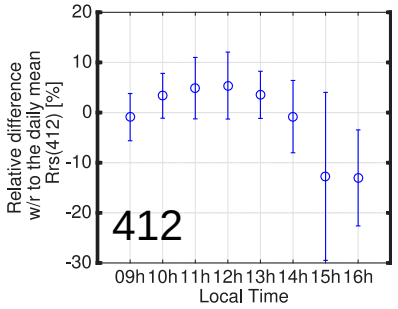


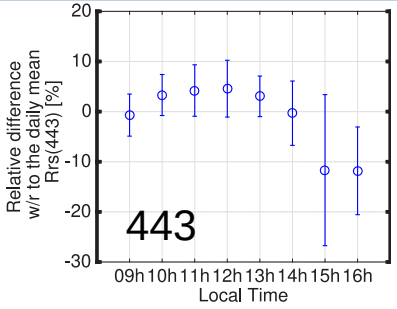


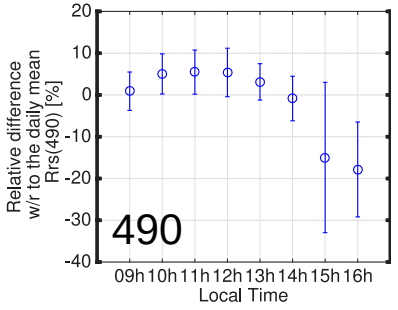


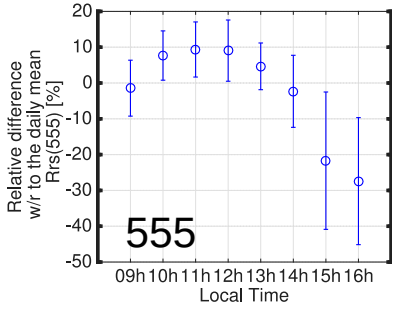


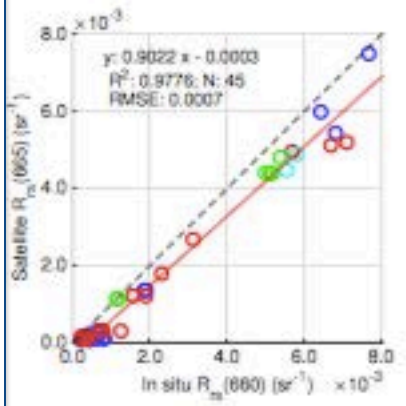


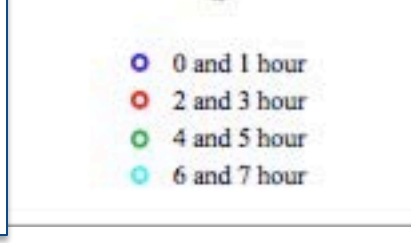












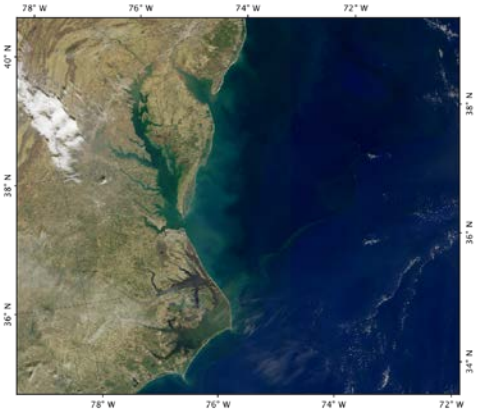
J. Concha, A. Mannino, B.A. Franz, and W. Kim (2017). *Assessing Diurnal Variability of Biogeochemical Processes using GOCI,* ***Poster at this meeting****.*

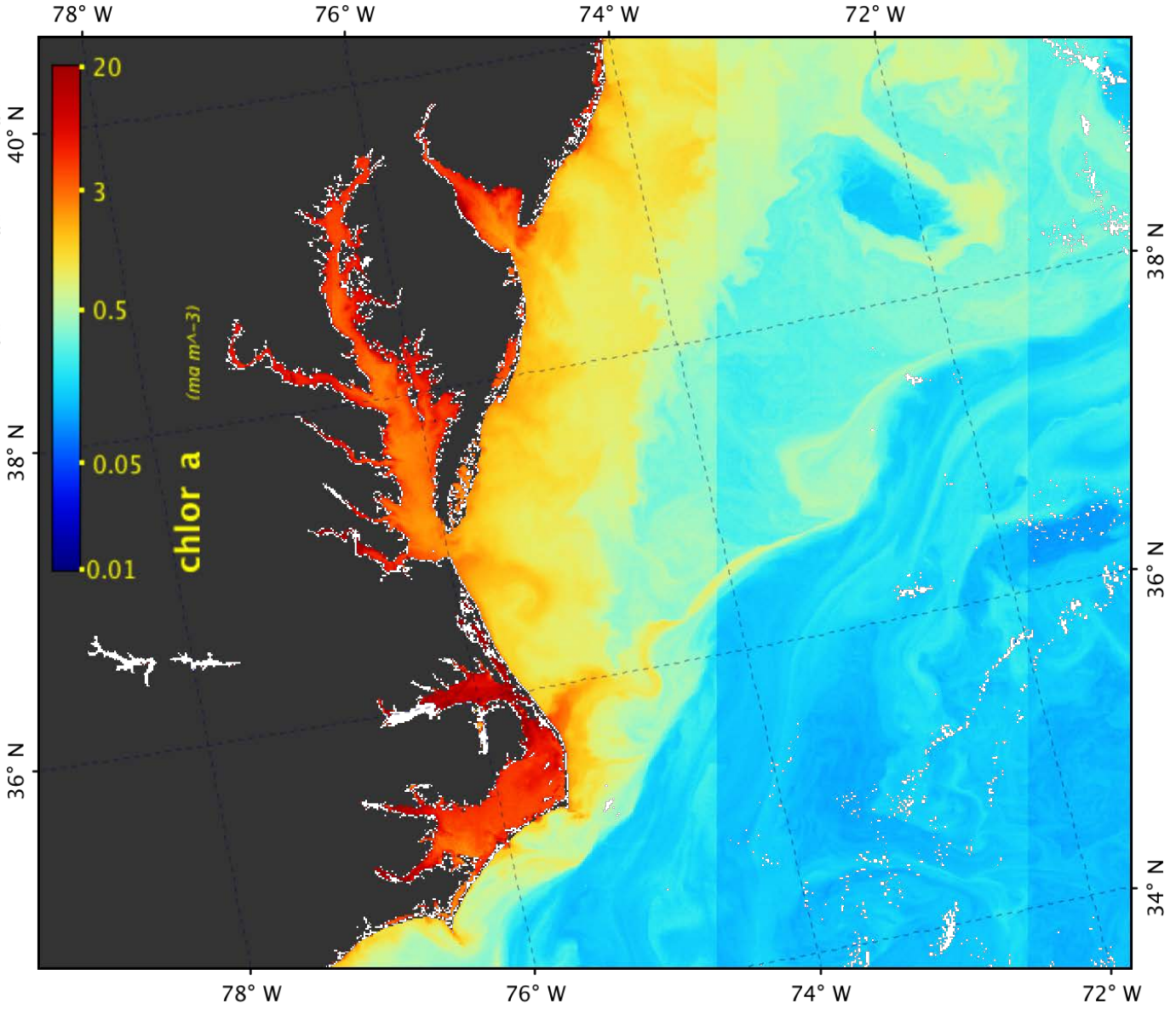
Sentinel-3 OLCI Support (ESA)

- Processing capability
  - standard NASA ocean color processing codes have been augmented to support OLCI
  - processing capability from Level-1B with NASA algorithms is supported in current SeaDAS
  - refinements to incorporate updated spectral response and implement smile correction in progress

OLCI Processed with SeaDAS

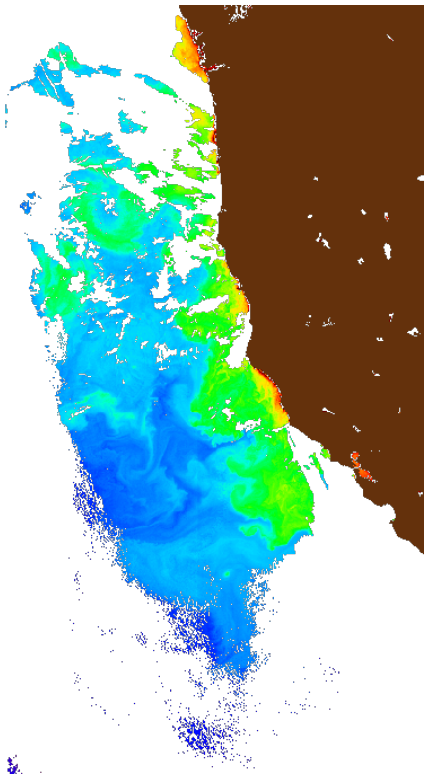
using standard NASA algorithms



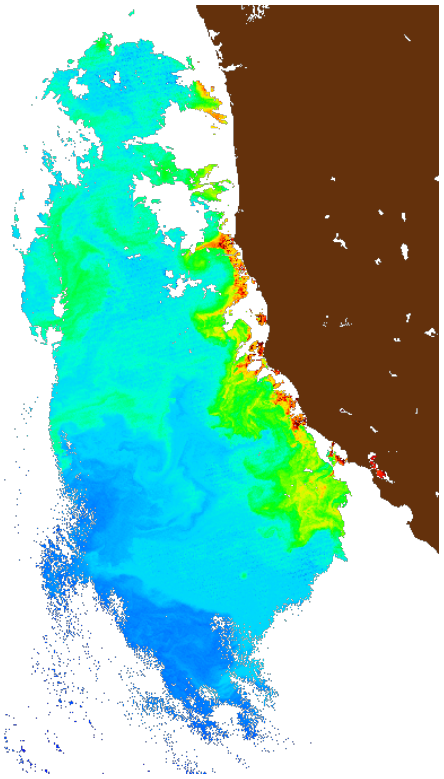


Chlorophyll-a Comparison of VIIRS and OLCI

using standard NASA algorithms



OLCI

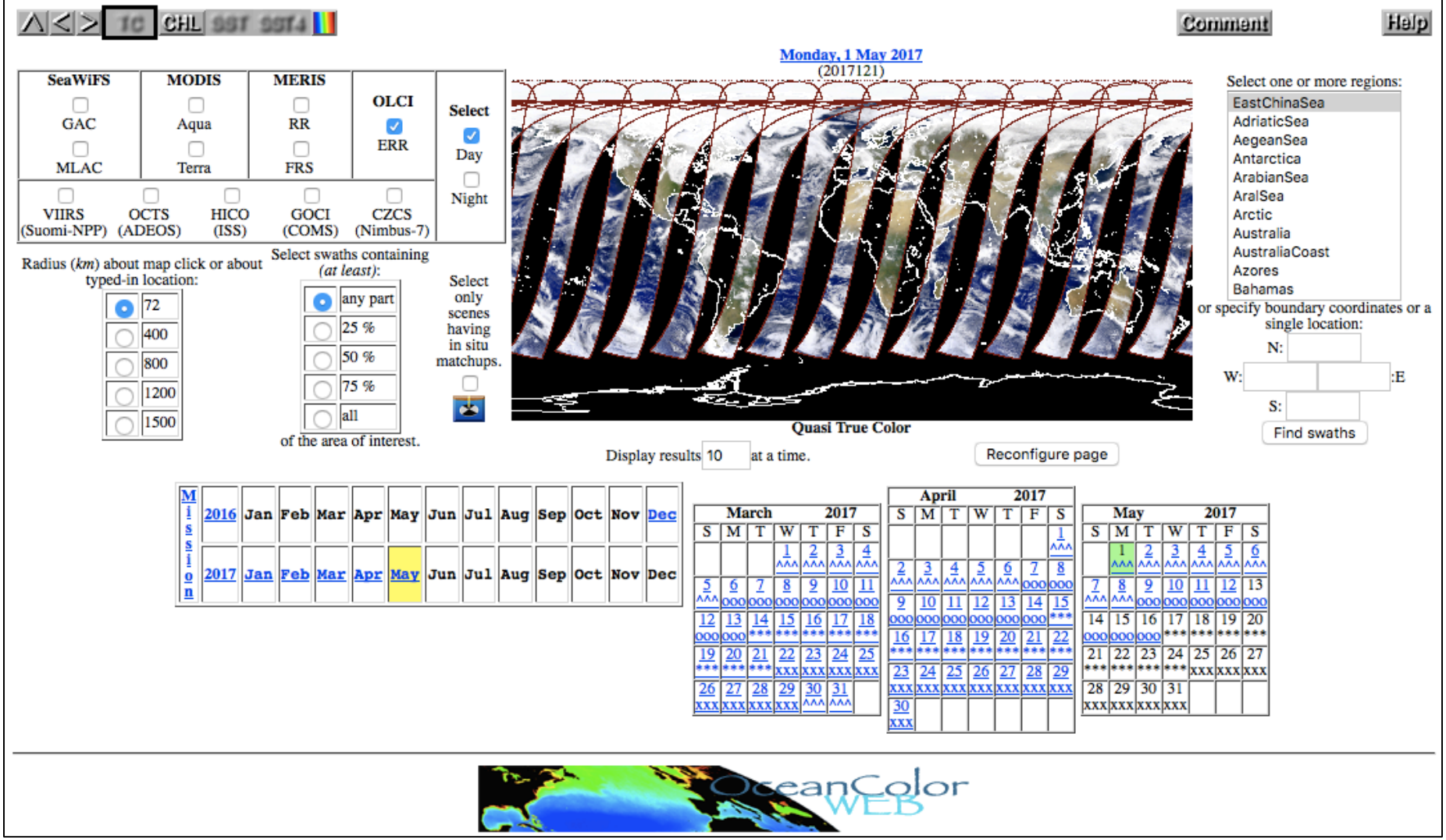


VIIRS

*no vicarious calibration performed on OLCI yet

OLCI Level-1B Data Distribution

https://oceancolor.gsfc.nasa.gov/cgi/browse.pl



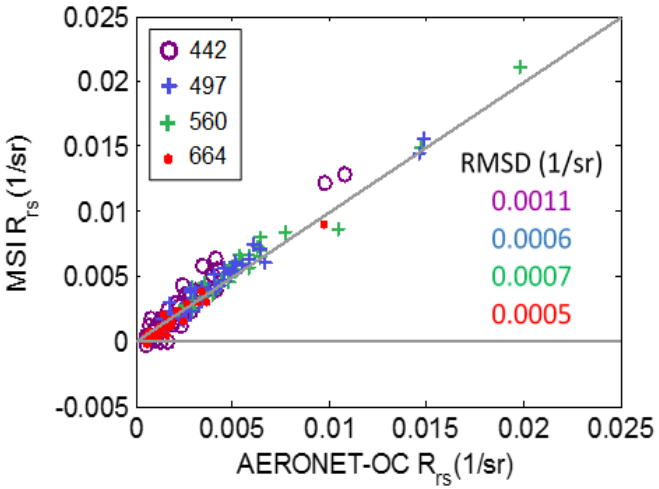
Sentinel-3 OLCI Support (ESA)

- Processing capability
  - standard NASA ocean color processing codes have been augmented to support OLCI
  - processing capability from Level-1B with NASA algorithms is supported in current SeaDAS
  - refinements to incorporate updated spectral response and implement smile correction in progress
- Data distribution
  - OBPG is acquiring full OLCI mission at Level-1B, through ESA-NASA gateway (FR/RR, archived from start of commissioning)
  - distribution (mirror) of RR Level-1B via ocean color web portal, with FR coming soon
  - **anticipating full mission Level-1B update from ESA**
  - production & distribution of NASA Level-2 is TBD

Sentinel-2 Support (ESA)

- Sentinel-2 MSI ocean color retrieval capability implemented in NASA processing code, for future release in SeaDAS.
- Challenging due to varying resolutions of spectral bands, variable viewing geometry per band, lack of sufficient sampling in geometry.

Nominal band centers (nm)											
MSI	444	497	560	664	704	740	783	843	865	1613	2200
OLI	443	482	561	665	NA	NA	NA	NA	865	1609	2201
Spatial resolution (m)											
MSI	60	10	10	10	20	20	20	10	20	20	20
OLI	30	30	30	30	NA	NA	NA	NA	30	30	30



Validation to AERONET-OC after vicarious calibration to BOUSSOLE

Band	*RD (%)*	*RMSD*	Slope	Intercept	Bias (1/s)	R^2
442	-0.009	0.0011	1.35	-0.0007	0.0003	0.91
497	0.049	0.0006	1.04	4.0E-05	0.0002	0.96
560	0.052	0.0007	1.05	3.2E-05	0.0003	0.97
664	-0.215	0.0005	1.02	-0.0003	-0.0002	0.93

N. Pahlevan, S. Sarkar, B.A. Franz, and J. He (2017). *Sentinel-2 MultiSpectral Instrument (MSI) data processing for aquatic science applications: Demonstrations and preliminary validations, Rem. Sens. Env., submitted.*

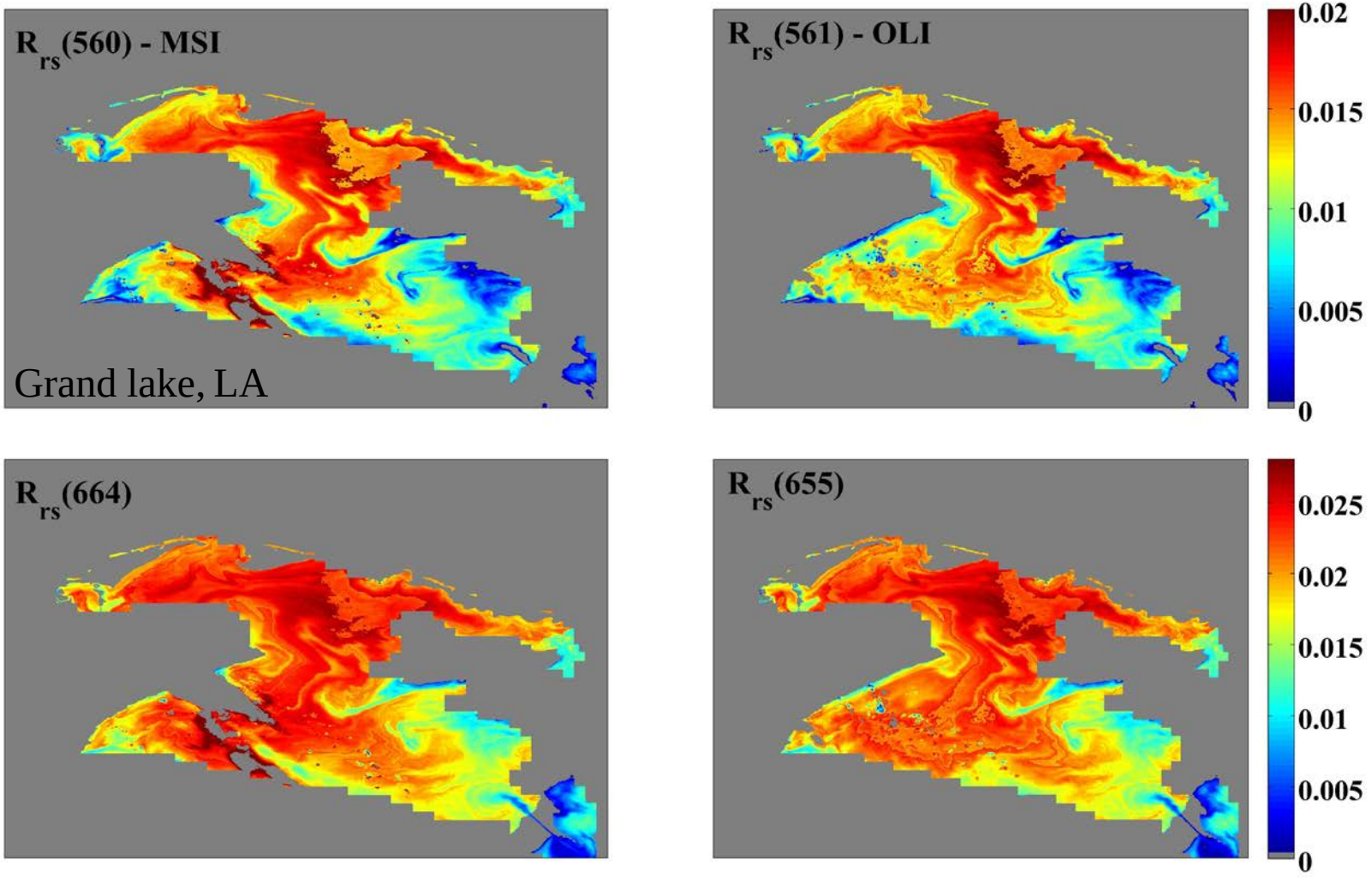
Sentinel-2 Results

Sentinel-2 MSI

Landsat-8 OLI

$R_{rs}(560)$

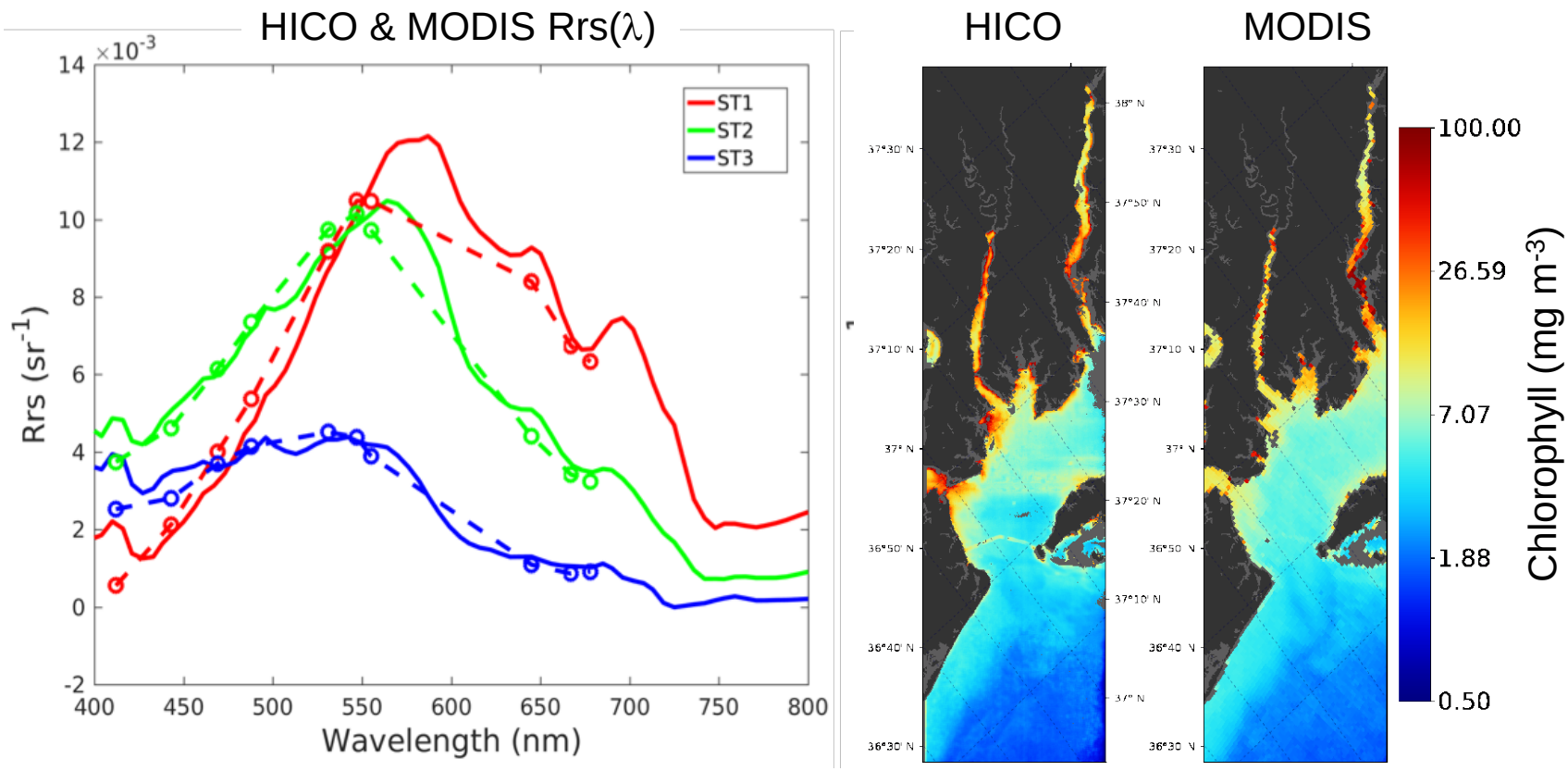
$R_{rs}(664)$



N. Pahlevan, S. Sarkar, B.A. Franz, and J. He (2017). *Sentinel-2 MultiSpectral Instrument (MSI) data processing for aquatic science applications: Demonstrations and preliminary validations, Rem. Sens. Env., submitted.*

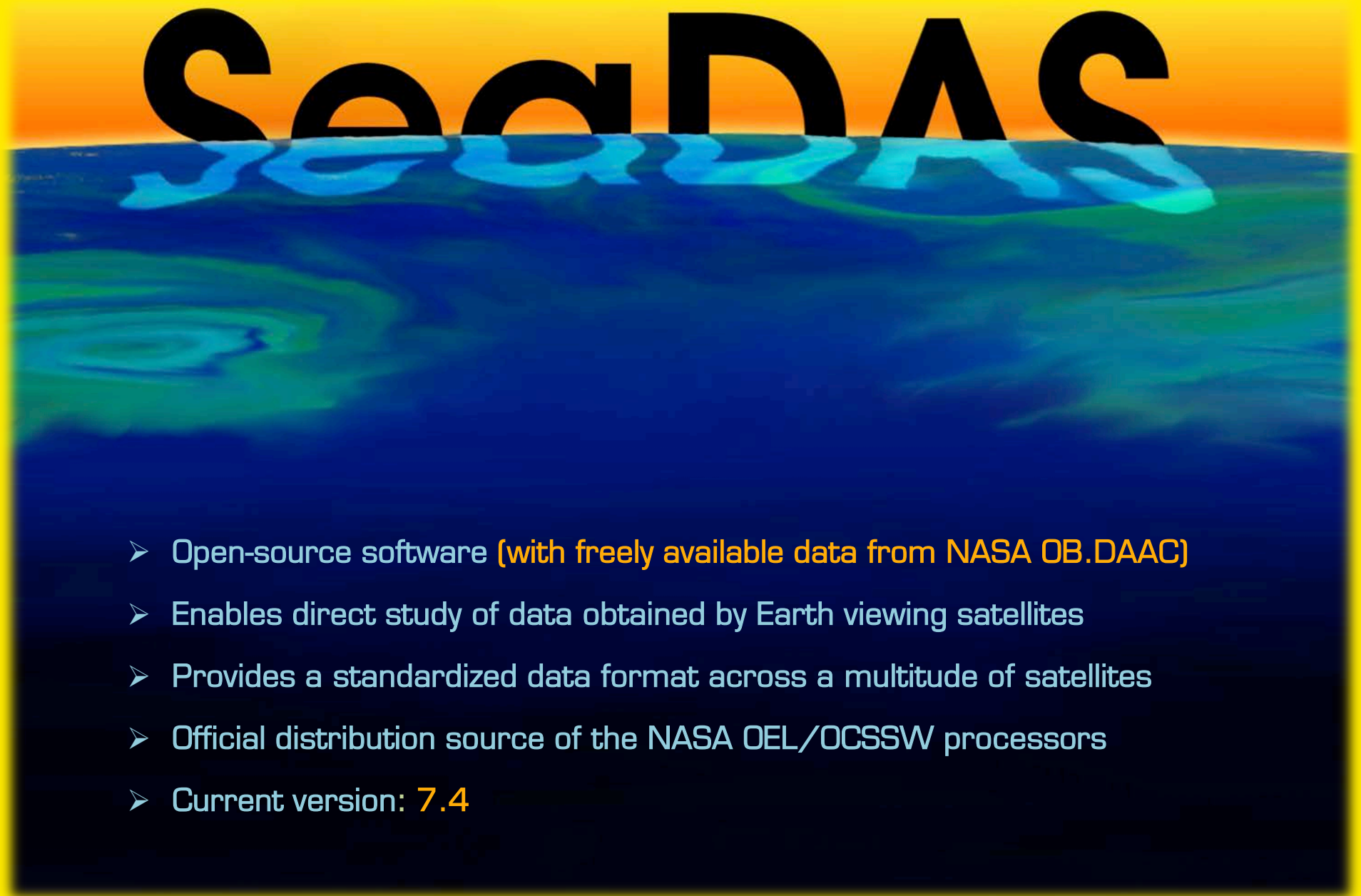
HICO Support (Hyperspectral Retrievals)

SeaDAS/l2gen code has been modified to support hyperspectral Rrs(λ) retrieval, including line-by-line absorbing gas corrections with dynamic water vapor retrieval and correction based on ATREM code (B-C Gao et al.)



A. Ibrahim, B.A. Franz, Z. Ahmad, R. Healy, K. Knobelspiesse, B-C. Gao, C. Proctor, and P. Zhai (2017). Atmospheric Correction for Hyperspectral Ocean Color Retrieval with Application to the Hyperspectral Imager for the Coastal Ocean (HICO), *Rem. Sens. Env., submitted.*

SeaDAS: The Official NASA (Ocean Ecology Lab) Processing Software



- Open-source software (with freely available data from NASA OB.DAAC)
- Enables direct study of data obtained by Earth viewing satellites
- Provides a standardized data format across a multitude of satellites
- Official distribution source of the NASA OEL/OCSSW processors
- Current version: 7.4

Status & Changes over past 2 Years

SeaDAS version 7.4 released March 6, 2017 (IOCS 2015 was version 7.2)

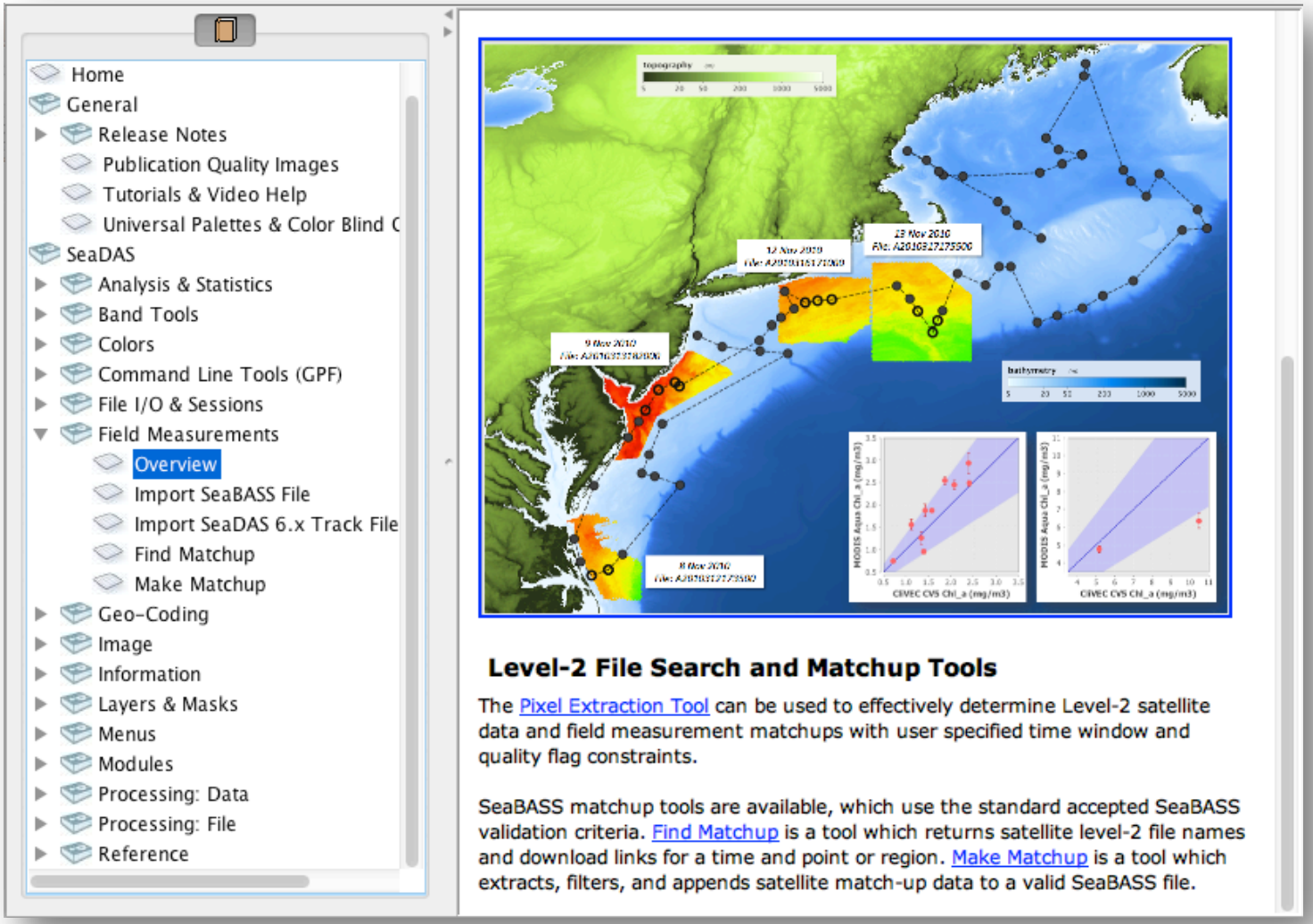
SeaDAS - OCSSW Processing Components

- **Level-2 Matchup Tools**
- Level-3 Mapping "l3mapgen"
- Support for Satellite Missions
  - VIIRS: SST
  - LANDSAT-8 OLI
  - Sentinel-3A: OLCI
  - HICO: full hyperspectral

GUI Visualization & Analysis Components

- Color Palettes & Color Bar (revised)
- Map Gridlines (revised)
- RGB Color Image (revised)
- Command Line Tools (GPF): WriteImage (new)

New Commandline Match-up Tool



Projected Status & Changes next 2 Years

SeaDAS Version 7.x (The "7" series is a heavily modified integration of BEAM)

SeaDAS Version 8 (Integration with SNAP)

SeaDAS - OCSSW Processing Components

- **Processing Support on Windows**
- Support of Satellite Missions
  - Sentinel-3A OLCI (revision)
  - Sentinel-2 MSI
  - GCOM-C SGLI

GUI Visualization & Analysis Components

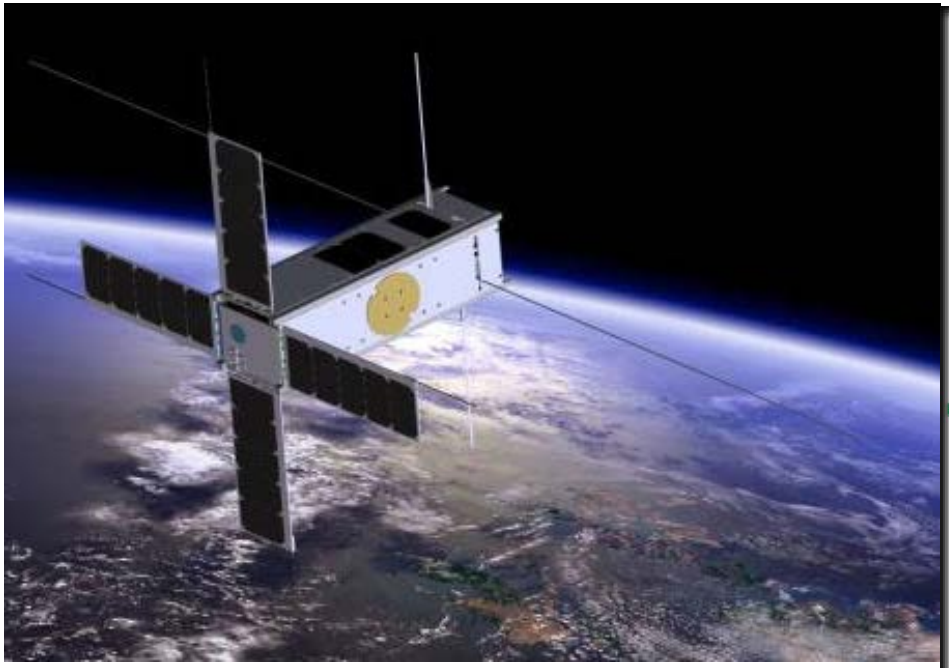
- Statistics Tool

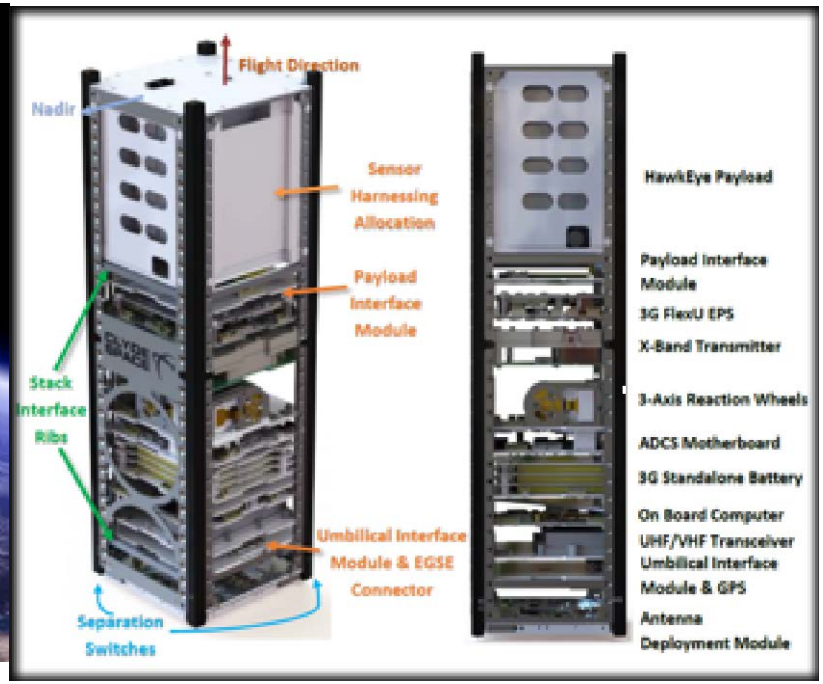
SOCON

Sustained Ocean Color Observations from Nanosatellites

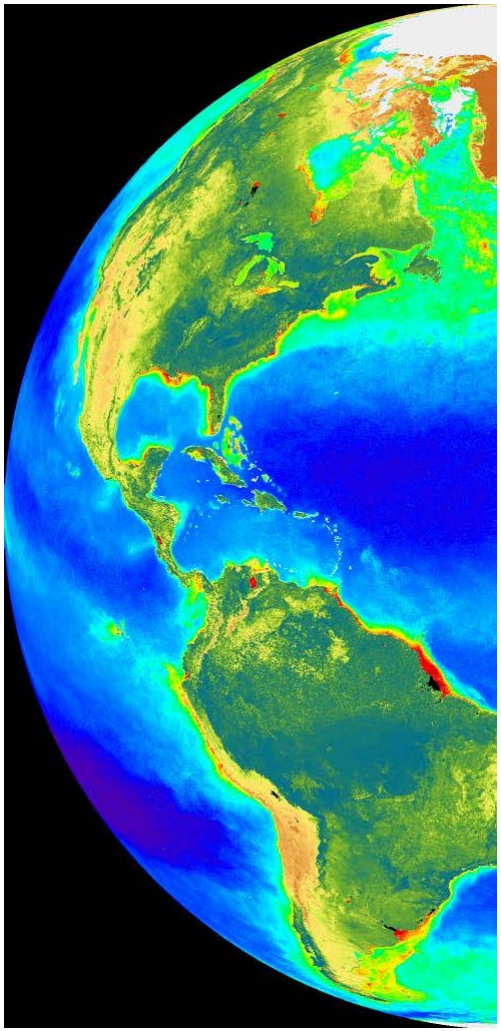
http://uncw.edu/socon/

- Seahawk spacecraft (3U Cubesat)
- Hawkeye ocean color instrument: 8-bands, ~120-m resolution
- Two copies to be launched in early 2018 and 2019





Future Plans



MERIS reprocessing

HICO Level-2 processing

JPSS1 VIIRS processing and distribution

GCOM-C SGLI processing capability

Sentinel-2 processing capability

and of course …

PACE