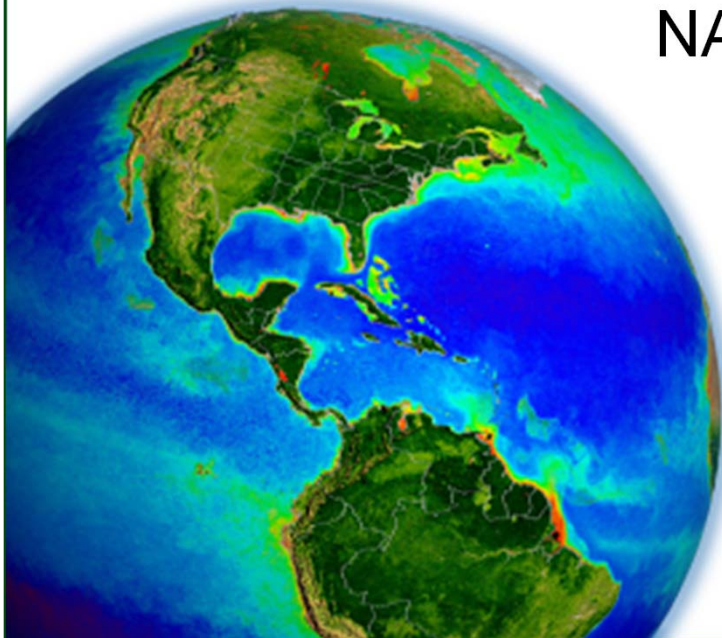


NASA ocean color processing and data analysis support for SGLI

Bryan Franz

Ocean Biology Processing Group
NASA Goddard Space Flight Center



JAXA GCOM-C PI Workshop. January 2014

Collaborators

Ziauddin Ahmad	<i>radiative transfer, aerosol models</i>
Sean W. Bailey	<i>software development, SeaDAS</i>
Gerhard Meister	<i>instrument calibration</i>
Jeremy Werdell	<i>bio-optical algorithms, SeaBASS</i>

and the NASA Ocean Biology Processing Group



We have no progress to report!

NASA Ocean Biology Processing Group

calibration, validation, algorithm development, processing, and distribution

OceanColor WEB

Missions ▾ Data ▾ Documents ▾ Analyses ▾ People ▾ Forum ▾ Services ▾ Links

Data Access

Level 1 and 2 Browser
Visually search the ocean color data archive. Directly download or order data from a single file to an entire mission. Data from the Aquarius mission is also available.

Level 3 Browser
Browse the entire global ocean color, sea surface temperature and sea surface salinity data sets for many parameters and time periods and download PNG images or digital data in HDF format.

Data Archive
Access to the complete data archive. Retrieval of data in bulk is possible.

Ocean Productivity
Ocean Net Primary Productivity data products derived from MODIS and/or SeaWiFS data available from Oregon State University.

Giovanni
An easy-to-use, Web-based interface for the visualization and analysis of Earth Science data provided by the GES DISC DAAC.

MEaSUREs Ocean Color Project
This project creates a variety of established and new ocean color products for evaluation as candidates to become Earth Science Data Records.

Ocean Color Feature

Southeastern Atlantic Color

Different sorts of information can be derived from the ocean color data collected by orbiting radiometers. The above pseudo-color image represents chlorophyll concentration around South Africa. If one computes the reflectance of the ocean at different wavelengths measured by the radiometer, one can form a multiband composite that reveals differences in phytoplankton community structure which are not apparent just from the chlorophyll concentration.

Image Gallery
NOTE: All SeaWiFS images presented here are for research and educational use only. All commercial use of SeaWiFS data must be coordinated with GeoEye

Ocean Color Distribution Statistics

Support Services

SeaDAS
A comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data.

SeaBASS
An archive of *in situ* oceanographic and atmospheric data for use in algorithm development and satellite data product validation.

Registration for support services:

- Data access and Subscriptions
- Forgotten password
- Email change

Near Real-Time (NRT) Services:

- NRT Data Subscriptions
Subscriptions allow users to specify regions for NRT data to be continually staged on our FTP server for download.

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- Ocean Color Forum
- Ocean Color Mailing List
- Ocean Color Data Processing

Other Services:

- Satellite Overflight Predictions
- Data subscription status
- L1/L2 browser order status
- Locate Ancillary Files
- File Search Utility
Search for satellite and ancillary data archived by the ocean color data production system.

Global Processing & Distribution

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

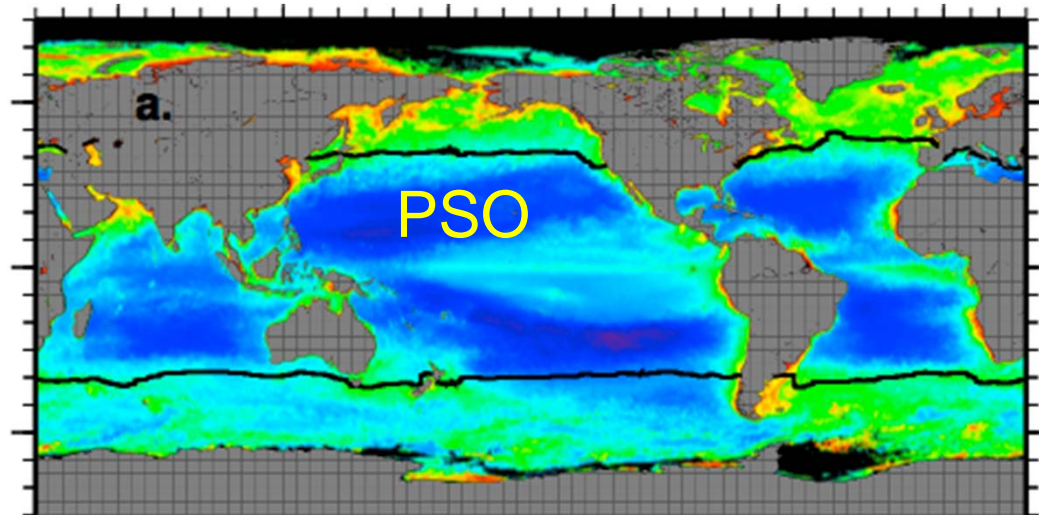
Regional Missions Supported

- GOCI (Korea)
- HICO (USA)
- OCM-1/2 (India)
- MOS (Germany)

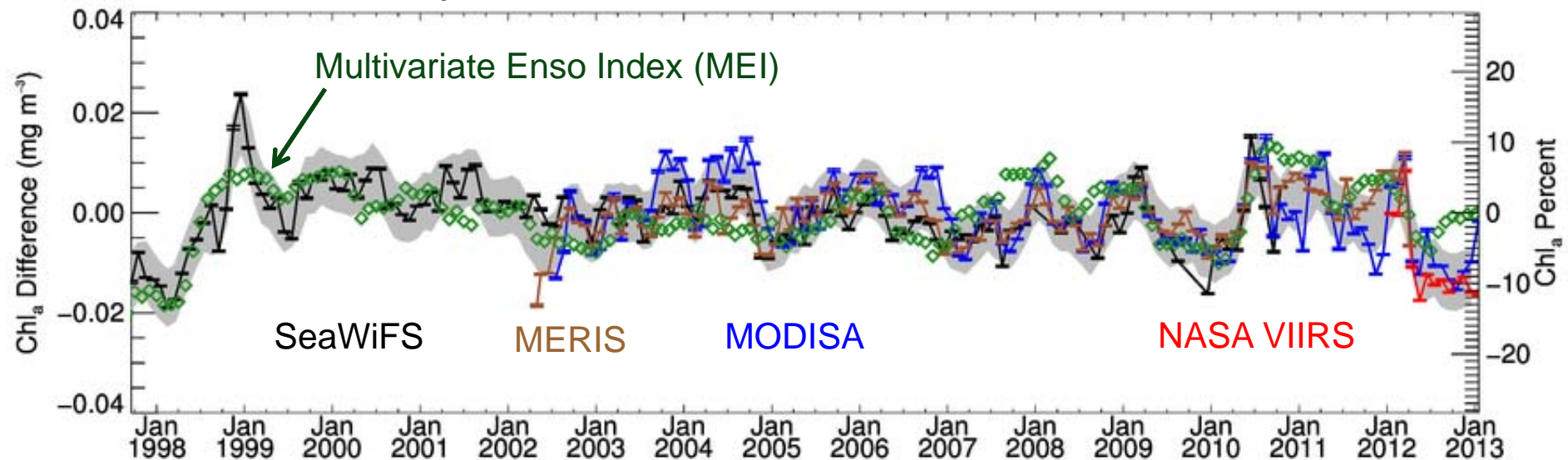
<http://oceancolor.gsfc.nasa.gov/>

we want to produce high quality data records of sufficient length,
consistency, and continuity to support climate and ecosystem research

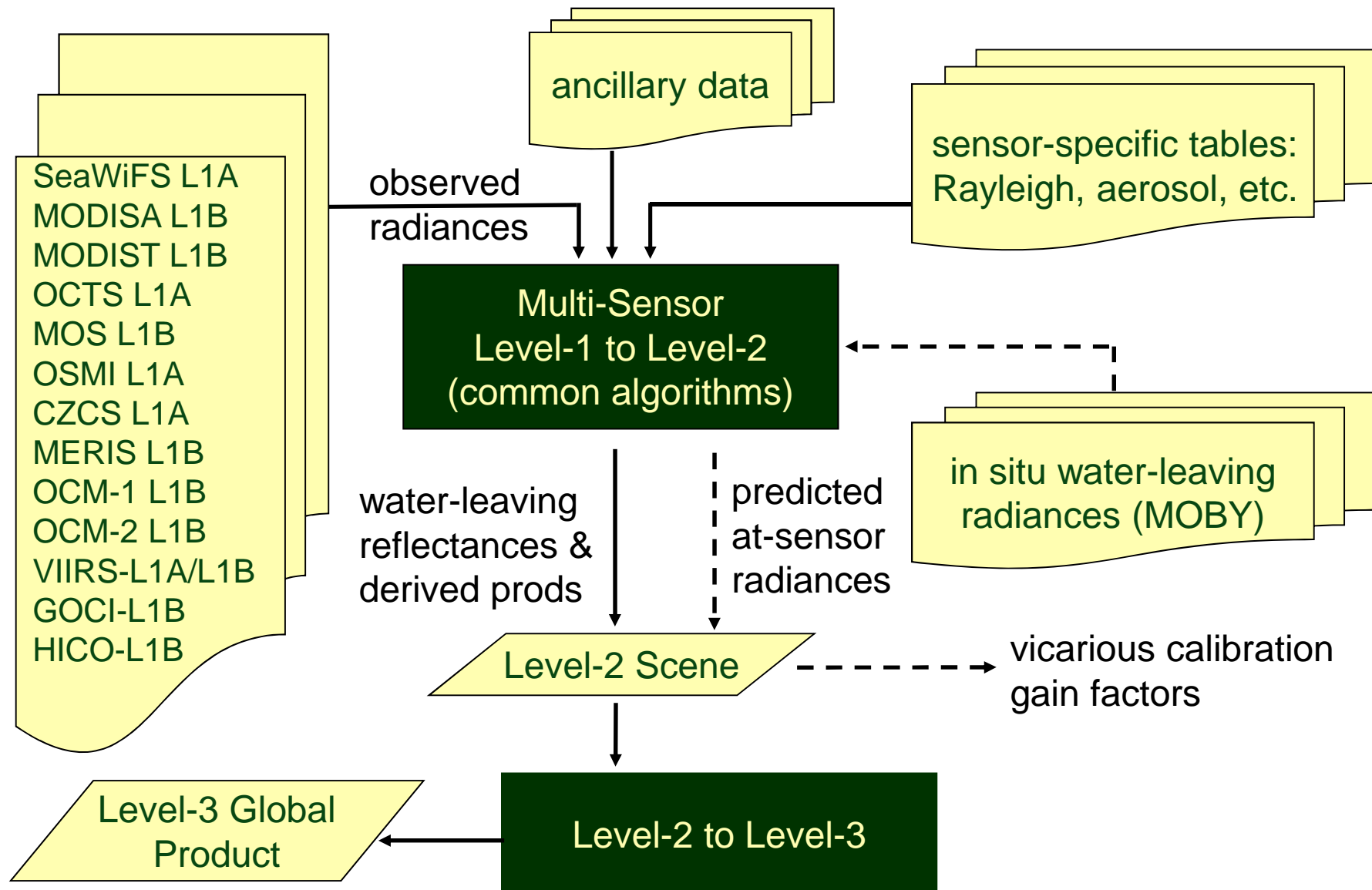
Following
Berenfeld et al. 2006
Mean SST > 15C



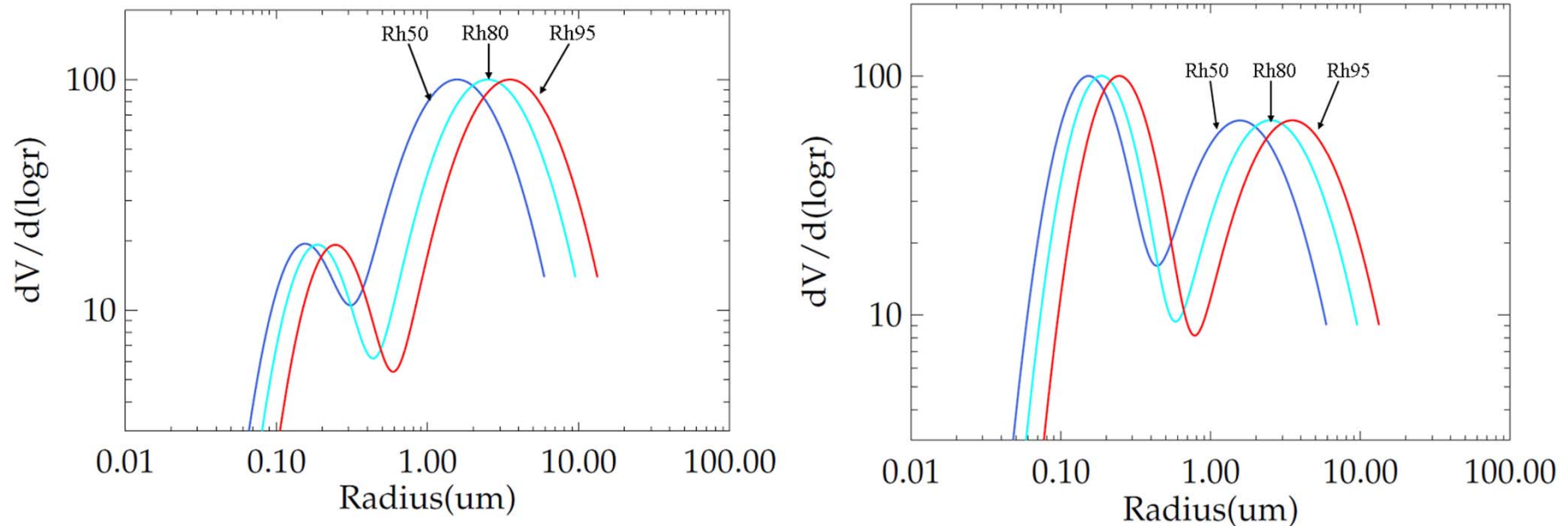
PSO Anomaly



Common Processing Approach



Generate SGLI-specific Aerosol & Rayleigh Tables



- NASA using 80 weakly absorbing aerosol models based on bi-modal size distributions that vary by modal fraction and relative humidity
- look-up tables (aerosol and Rayleigh) will be generated for SGLI band-passes using Ahmad-Fraser vector radiative transfer code
- need SGLI spectral response functions

Ahmad, Z., B.A. Franz, C.R. McClain, E.J. Kwiatkowska, J. Werdell, E.P. Shettle, and B.N. Holben (2010). New aerosol models for the retrieval of aerosol optical thickness and normalized water-leaving radiances from the SeaWiFS and MODIS sensors over coastal regions and Open Oceans, *Appl. Opt.*, 49(29).


Research & Development Plan

1. implement L1 to L3 processing support for SGLI in our multi-sensor ocean color processing software

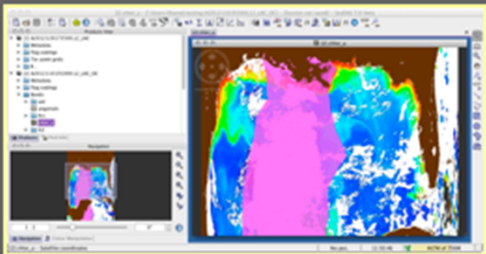
Current NASA OC Products Relevant to SGLI

Level-2 OC Product	Algorithm Reference
1. $R_{rs}(\lambda)$	
2. Ångstrom	<i>Ahmad et al. 2010, Gordon and Wang 1994.</i>
3. AOT	
4. Chlorophyll a	<i>O'Reilly et al. 1998 (OC3) updated by Werdell</i>
5. $K_d(490)$	<i>Werdell (KD2) algorithm (similar to OC3)</i>
6. POC	<i>Stramski et al. 2008</i>
7. PIC	<i>Balch et al. 2005, Gordon et al. 2001</i>
8. PAR	<i>Frouin et al. 2003</i>
9. IOPs (GIOP)	<i>Werdell et al. 2013.</i>
10. IOPs (QAA)	<i>Lee et al. 2002</i>
11. IOPs (GSM)	<i>Maritorena et al. 2002</i>
	and many more

SeaDAS: free open-source multi-sensor processing, image display, and analysis tool



General Description



The SeaWiFS Data Analysis System (SeaDAS) is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data. The latest version (SeaDAS 7) is the result of a collaboration with the developers of ESA's **BEAM** software package. The core visualization package for SeaDAS 7 is based on the BEAM framework, with extensions that provide the functionality provided by previous versions of SeaDAS..

Features
Requirements
Download

Supported Missions	User Support	Other
<ul style="list-style-type: none">◦ MODIS◦ SeaWiFS◦ CZCS◦ VIIRS◦ HICO◦ Aquarius	<ul style="list-style-type: none">◦ MERIS◦ OCTS◦ OCM◦ OCM-2◦ OSMI◦ MOS	<ul style="list-style-type: none">◦ SeaDAS FAQ◦ Online Help◦ Ocean Color Web◦ Ocean Color Forum◦ Ocean Mailing Lists
		<ul style="list-style-type: none">◦ SeaDAS Visualization Source Code◦ Processing Binaries and Source Code◦ SeaDAS version 6.4◦ MODISL1DB 1.8

<http://seadas.gsfc.nasa.gov/>

SeaDAS Product Generation

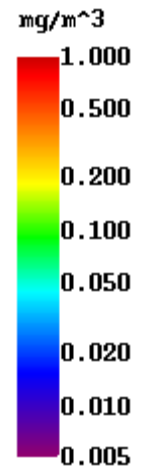
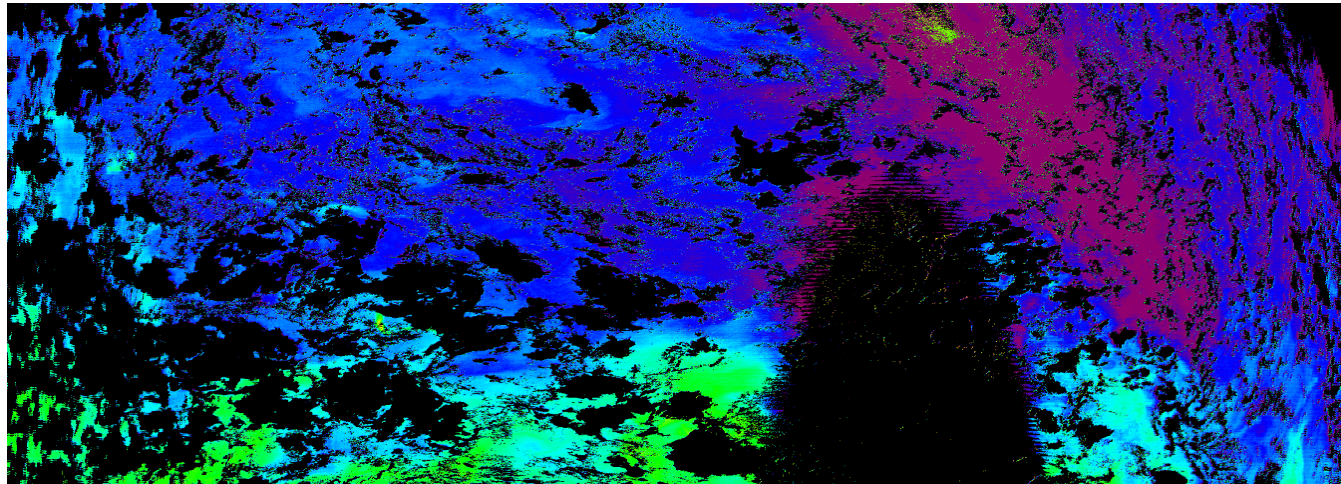
many additional products + alternate correction algorithms

- **Atmospheric Correction Options**
 - alternate band pairs
 - aerosol model suites
 - model selection methods
 - turbid-water corrections
 - absorbing gases (e.g., NO₂)
 - ancillary data sources
 - flag & mask thresholds
- **Intermediate Products**
 - aerosol and Rayleigh radiances
 - derived transmittances
 - polarization state
 - glint and whitecap radiances
 - co-located ancillary inputs
 - etc.
- **Additional Derived Products**
 - alternate C_a algorithms
 - regionally-tuned coefficients
 - Zeu, KPAR, spectral K_d
 - water classification
 - inherent optical properties
 - a, bb, adg, aph, bbp
 - full suite of published models
 - generic IOP model
 - etc.
- **Community Algorithm Development**
 - full source distribution with build environment and user support

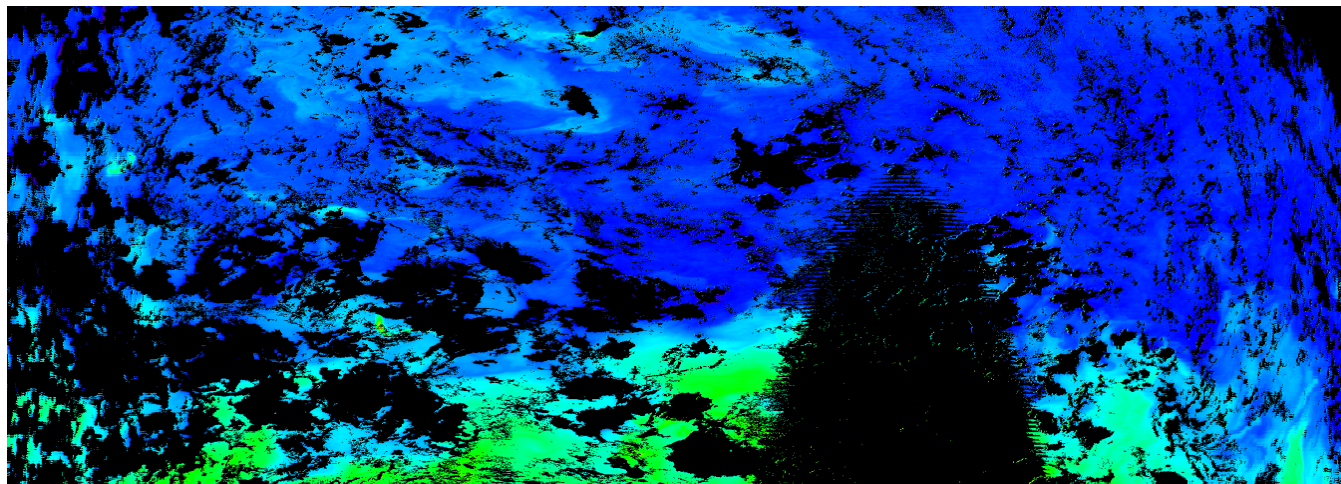
Alternative Chlorophyll Algorithm OCI

more robust in glint retrieval in presence of Sun glint

Chl_{OC3}
Flags off



Chl_{OCI}
Flags off



Hu, C., Z. Lee, and B. Franz (2012), Chlorophyll a algorithms for oligotrophic oceans: A novel approach based on three-band reflectance difference, J. Geophys. Res., 117.

Research & Development Plan

1. implement L1 to L3 processing support for SGLI in our multi-sensor ocean color processing software
2. implement processing, display, and analysis support for SGLI in SeaDAS

SeaBASS In Situ Validation Tool

Support Services

SeaDAS

A comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data.

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Other Services:

- Satellite Overflight Predictions
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 - File Search Utility
- Search for satellite and ancillary data archived by the ocean color data production system.

Search Type:

Bio-optical Pigment Validation

The validation search allows visitors to search for match-ups between water measurements and coincident satellite products. Water leaving values are calculated by SeaBASS staff using select data files that were submitted to SeaBASS. For more information on how match-ups were performed, refer to: S.W. Bailey and P.J. Werdell, "A multi-sensor approach for the on-orbit Rem. Sens. Environ. 102, 12-23 (2006).

Compare:

☐ MODIS Aqua vs. In situ
☒ MODIS Aqua vs. MODIS Terra

Water Depth:

Minimum: 0.0 Maximum: 10000

Exclusion Criteria:

Minimum Valid satellite pixels (in %):
 Maximum Solar Zenith Angle:
 Maximum Satellite Zenith Angle:
 Maximum Time Difference between satellite and in situ (in hours):
 Maximum Coefficient of Variation of satellite pixels:
 Maximum difference between measured and modeled Irradiance (in %):
 Maximum Windspeed:

Satellite Version(s):

aqsa: operational
 terra: operational

Products:

☐ a ☐ adg ☐ aot ☐ aph ☐ bbp ☐ chl a
☐ kd ☐ par ☐ pic ☐ poc ☐ Rrs
☐ Zeu ☐ Zsd

Data Sources:

☐ SeaBASS Only ☒ All* ☐ AERONET-OC Only* ☐ MOBY Only*
 *MOBY and AERONET results are preliminary.
 Data acquired from the Aerosol Robotic Network - Ocean Color (AERONET-OC) web site. Details. Additional data usage policies apply.

Search

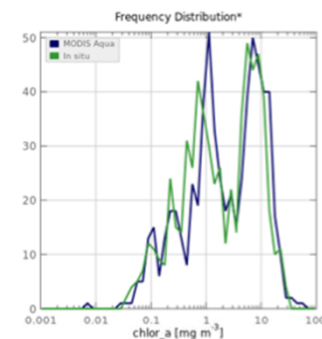
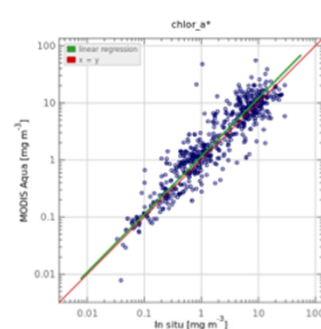
chlor_a Download Stats/Plots Generate CSV Download CSV

Statistics Data

Product Name	MODIS Aqua Range	In situ Range	#	Best Fit Slope*	Best Fit Intercept*	R ² *	Median Ratio	Abs % Difference	RMSE*
chlor_a	0.03340, 29.04500	0.00781, 55.23780	631	1.01529	0.06471	0.86487	0.86773	32.88839	0.27831

* statistical calculations based on log10

The linear regression algorithm has been changed to reduced major axis.



<http://seabass.gsfc.nasa.gov/>

Research & Development Plan

1. implement L1 to L3 processing support for SGLI in our multi-sensor ocean color processing software
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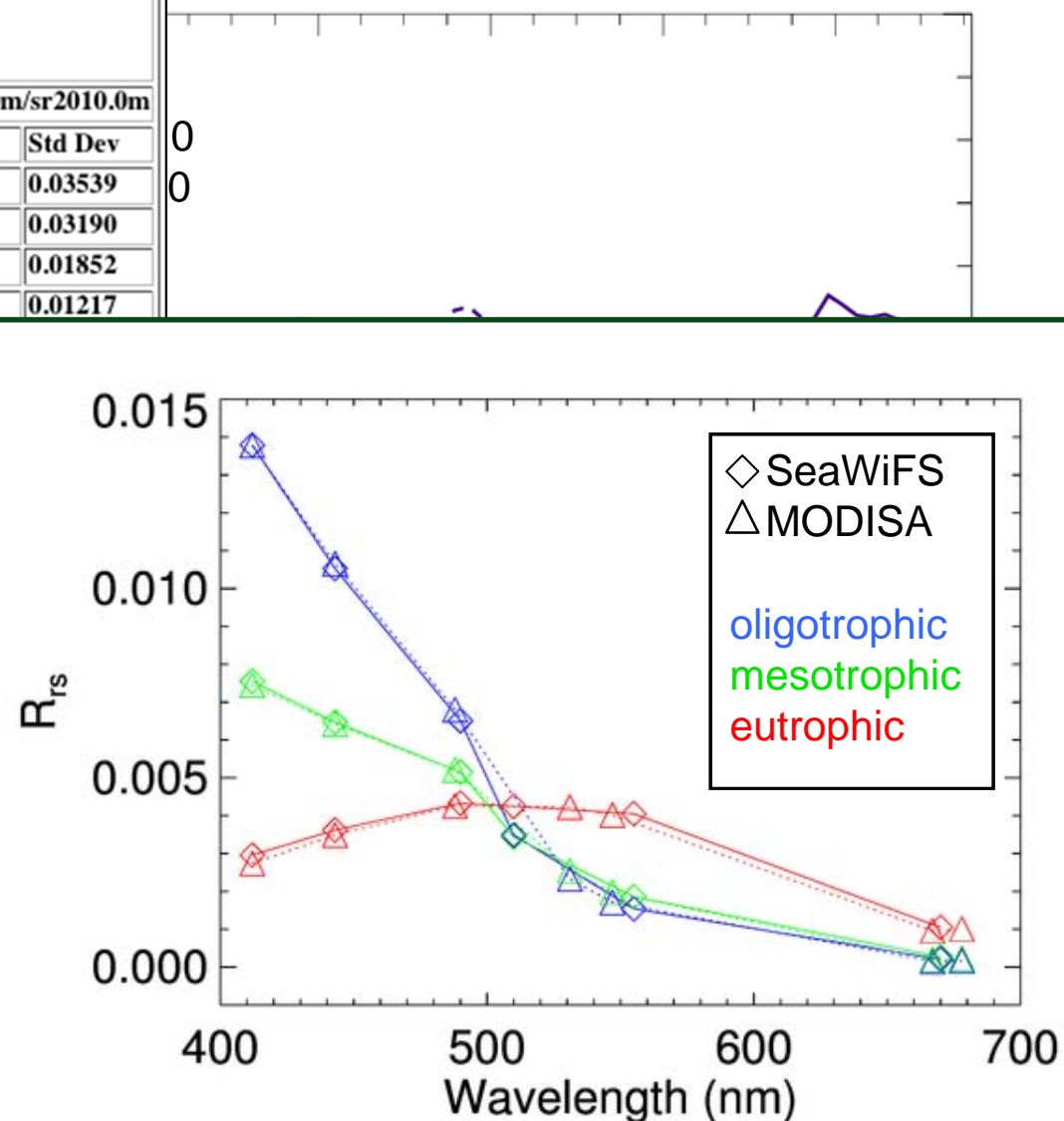
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4. develop tools for timeseries comparison of SGLI standard products and SGLI products processed with NASA standard algorithms, and coincident products from MODIS and/or VIIRS and/or OLCI

Radiometric Consistency of MODISA & SeaWiFS

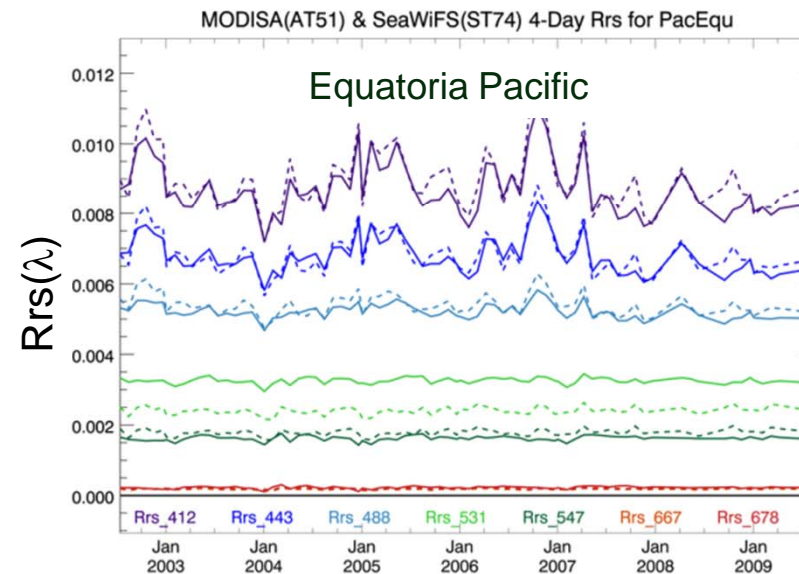
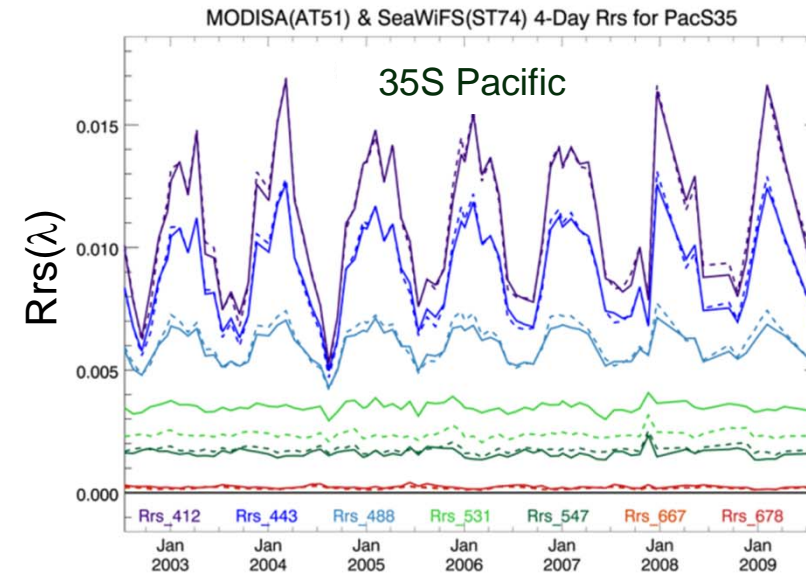
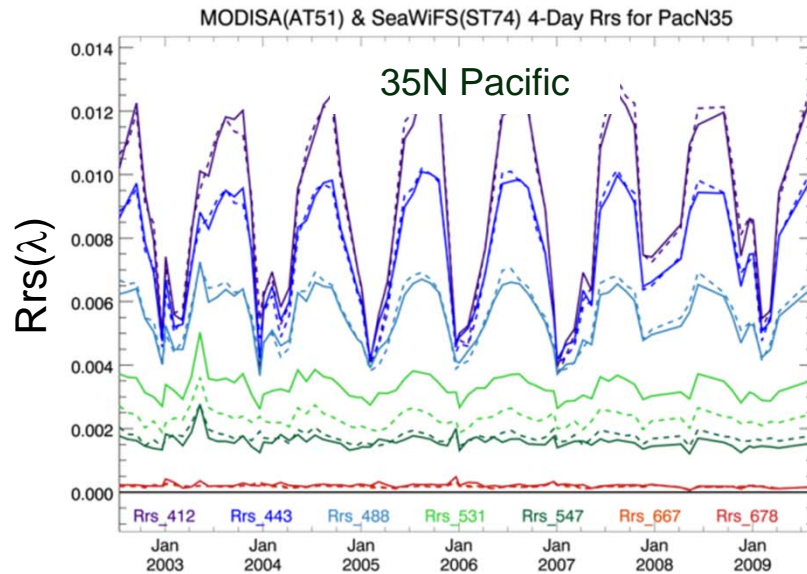
Deep-Water

Deep-Water						
	sr2010.0m		ar2013.0m		ar2013.0m/sr2010.0m	
Prod	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
chlor_a	0.17947	0.00910	0.17367	0.01064	0.96779	0.03539
Rrs_412	0.00987	0.00029	0.00981	0.00034	0.99417	0.03190
Rrs_443	0.00797	0.00019	0.00799	0.00021	1.00225	0.01852
Rrs_490,Rrs_488	0.00564	0.00013	0.00578	0.00015	1.02507	0.01217
Rrs_510,Rrs_531	0.00345	0.00008	0.00245	0.00006	0.7106	
Rrs_555,Rrs_547	0.00173	0.00005	0.00186	0.00005	1.0756	
Rrs_670,Rrs_667	0.00025	0.00001	0.00019	0.00001	0.7367	
Rrs_670,Rrs_678	0.00025	0.00001	0.00021	0.00001	0.8224	
aot_865,aot_869	0.07316	0.00303	0.08322	0.00303	1.1384	
angstrom	0.83233	0.08118	0.83383	0.05318	1.0096	
Oligotrophic						
	sr2010.0m		ar2013.0m		ar2013.0m/sr2010.0m	
Prod	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
chlor_a	0.06091	0.00637	0.05776	0.00532	0.9505	
Rrs_412	0.01379	0.00060	0.01378	0.00065	0.9998	
Rrs_443	0.01053	0.00037	0.01066	0.00042	1.0126	
Rrs_490,Rrs_488	0.00651	0.00012	0.00680	0.00017	1.0446	
Rrs_510,Rrs_531	0.00349	0.00005	0.00233	0.00004	0.6681	
Rrs_555,Rrs_547	0.00154	0.00004	0.00171	0.00003	1.1083	
Rrs_670,Rrs_667	0.00021	0.00001	0.00016	0.00001	0.7567	
Rrs_670,Rrs_678	0.00021	0.00001	0.00017	0.00001	0.7866	
aot_865,aot_869	0.06858	0.00397	0.07764	0.00408	1.1338	
angstrom	0.79744	0.09358	0.80293	0.07993	1.0169	



MODISA & SeaWiFS Water-Leaving Reflectance

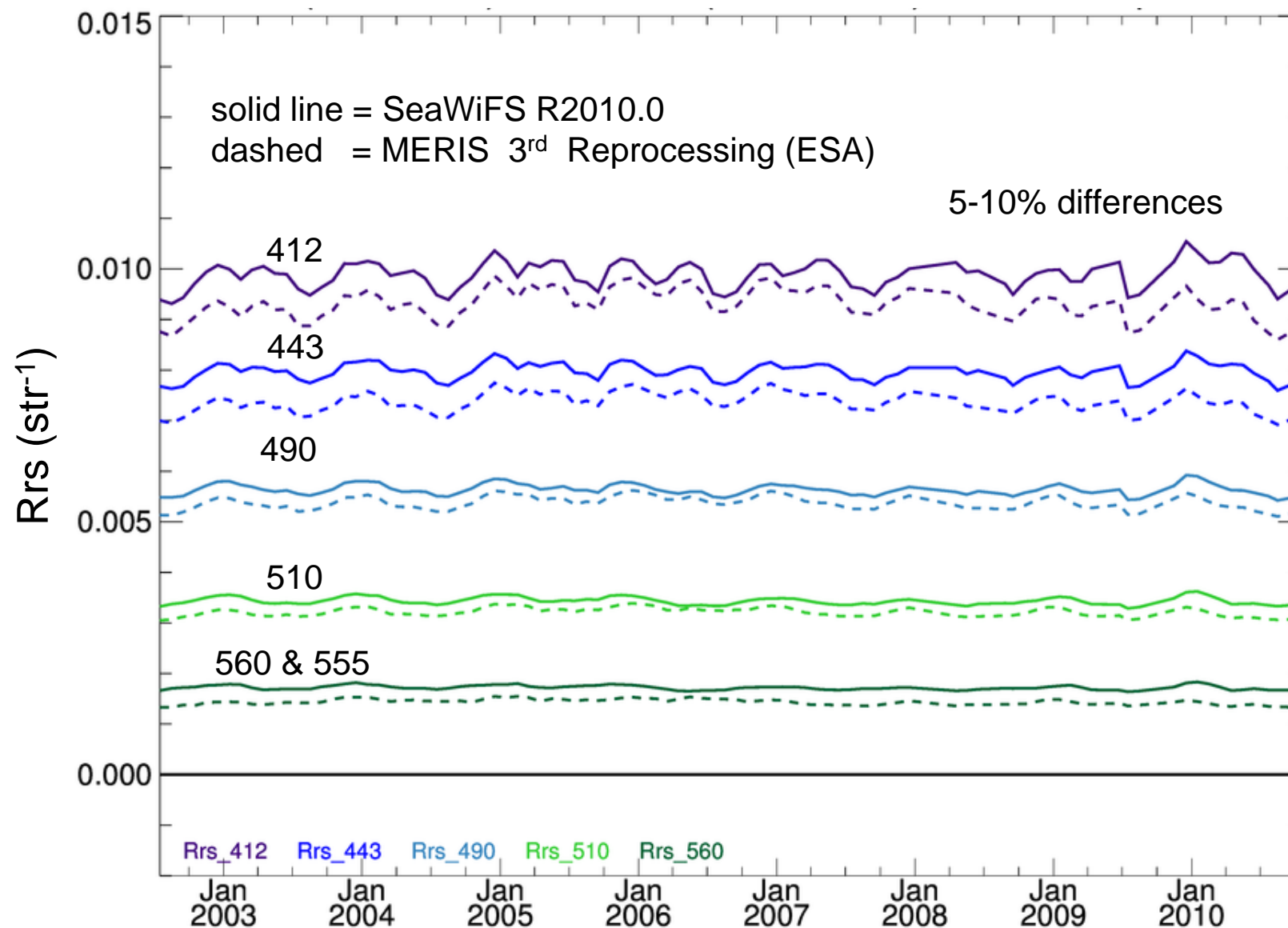
zonal analysis over duration of mission overlap



Challenges atmospheric models and polarization corrections.

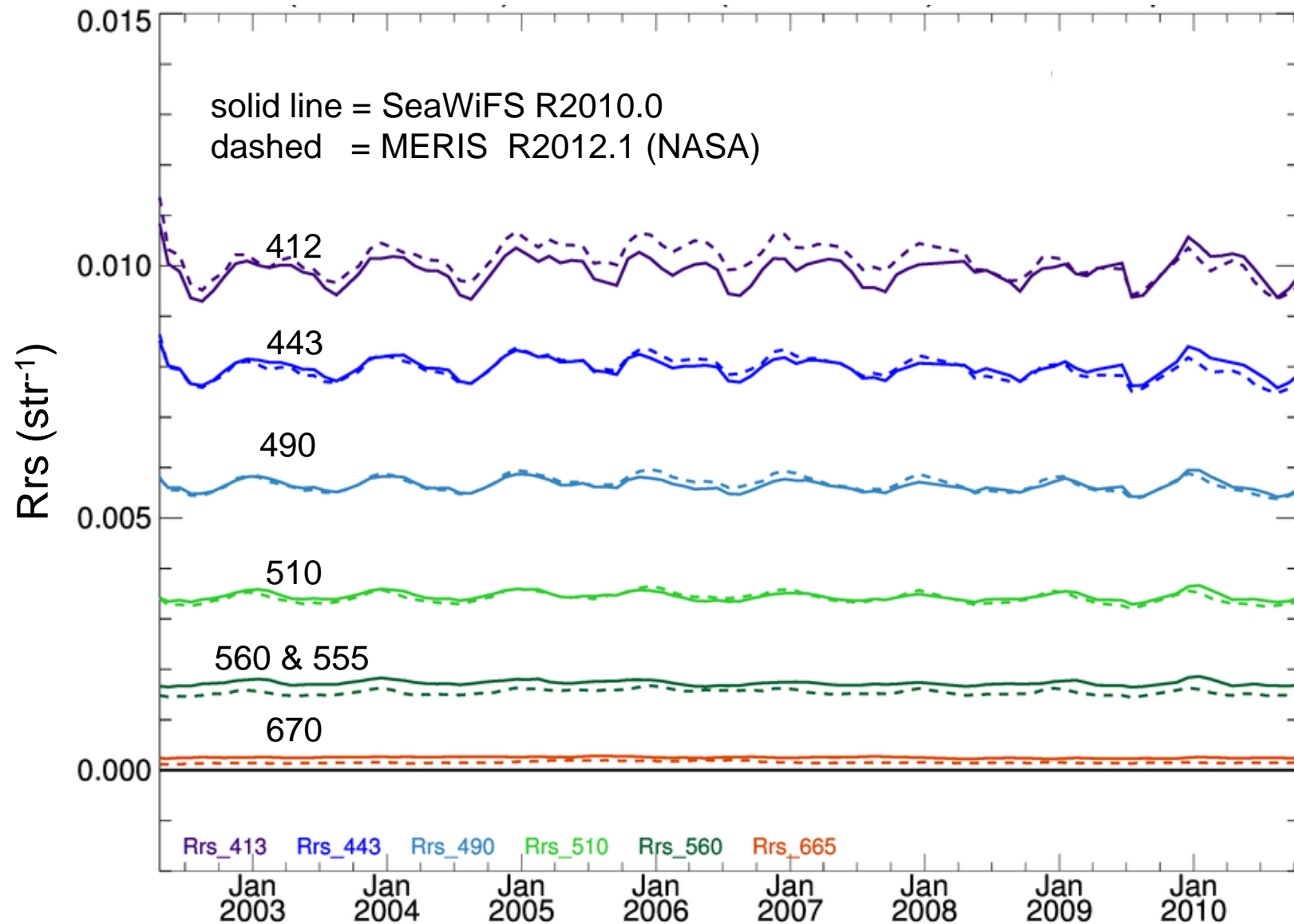
Radiometric (in)Consistency of MERIS & SeaWiFS

Deep-Water



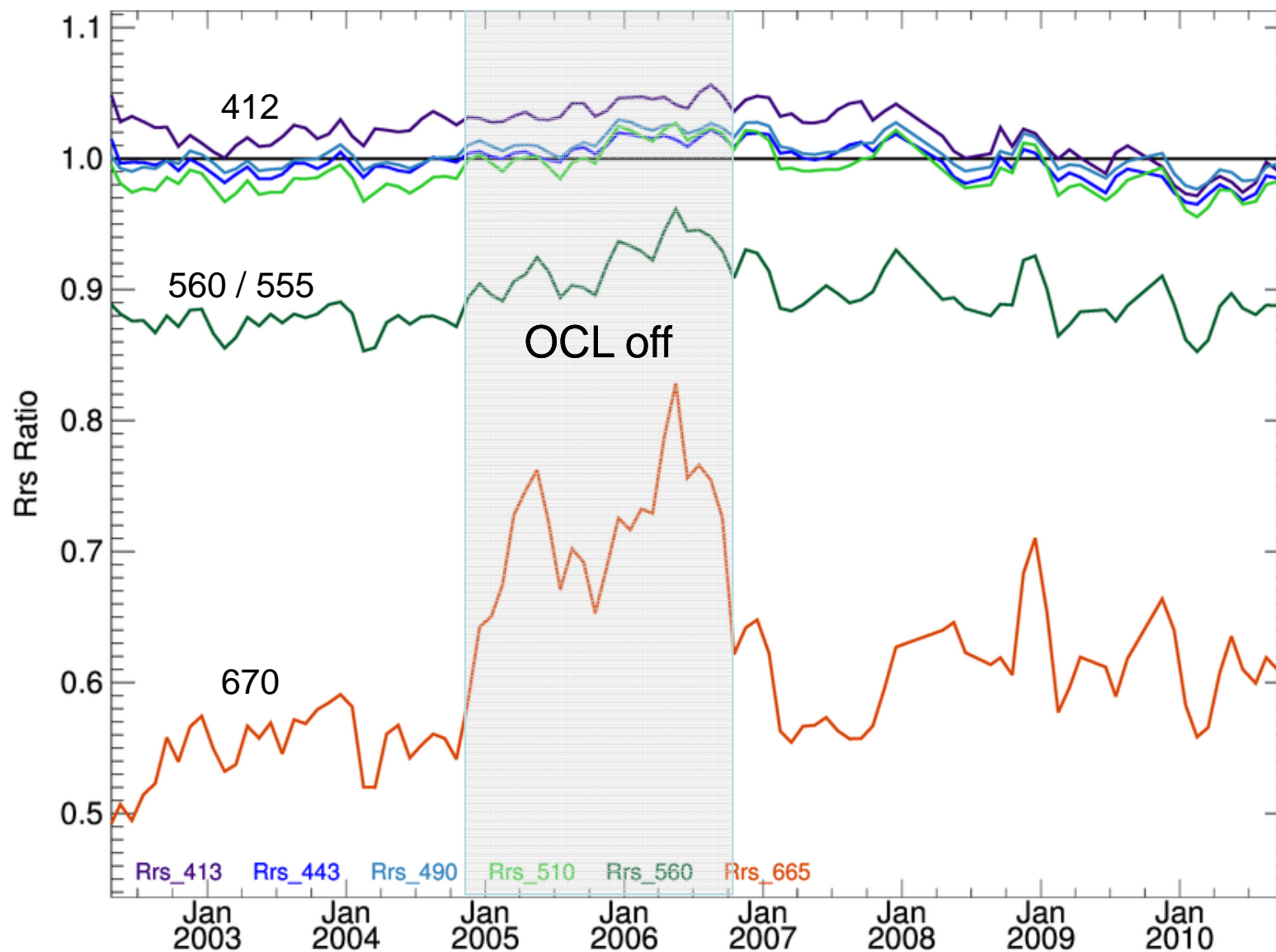
Radiometric Consistency of MERIS & SeaWiFS

Deep-Water



MERIS/SeaWiFS Rrs Ratios

Deep-Water



SGLI Data Requirements

- Prelaunch

- relative spectral response functions
- sample Level-1 data
- sample Level-2 data
- sample Level-3 data

- Postlaunch

- global, full mission Level-1(A?) at 1-km resolution
- global, full mission Level-3

Anticipated Benefits

- SeaDAS support will provide the international science community with a familiar tool to readily access and exploit the capabilities of SGLI for earth system science and applications
- freely-distributed open-source processing software will facilitate community-based application development to maximize the value & impact of SGLI
- comparative analyses of SGLI time-series relative to other sensors using common algorithms can identify instrument calibration issues
- comparative performance assessment of SGLI processed with different algorithms helps to advance the state of the art

Final Thought

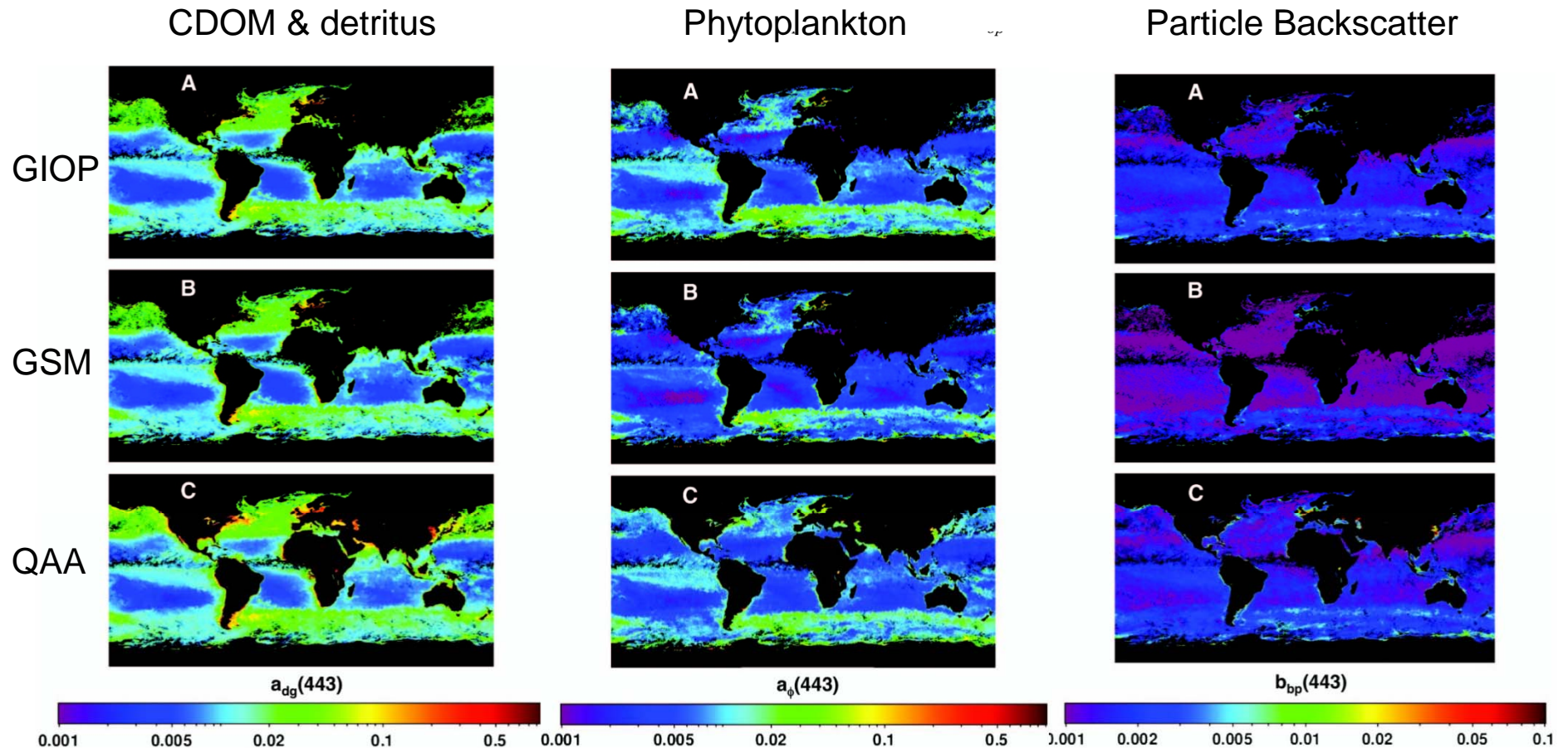
Fundamentally, we wish to

share lessons learned from NASA ocean color experience
to contribute to the value and success of the SGLI mission.



Thank You

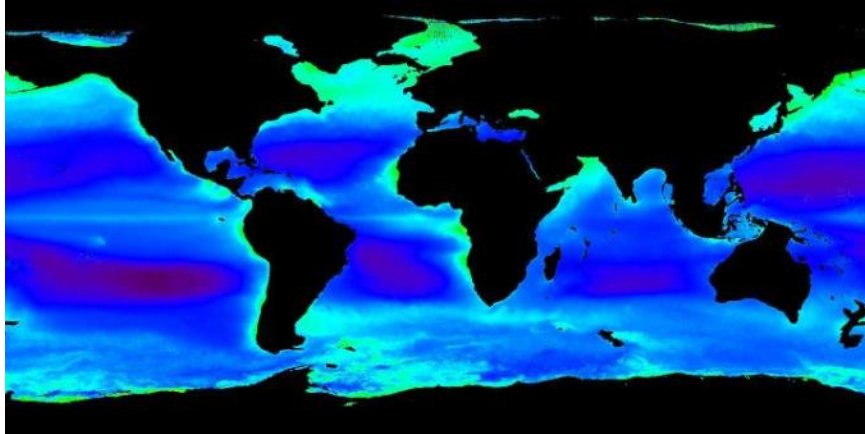
Inherent Optical Properties



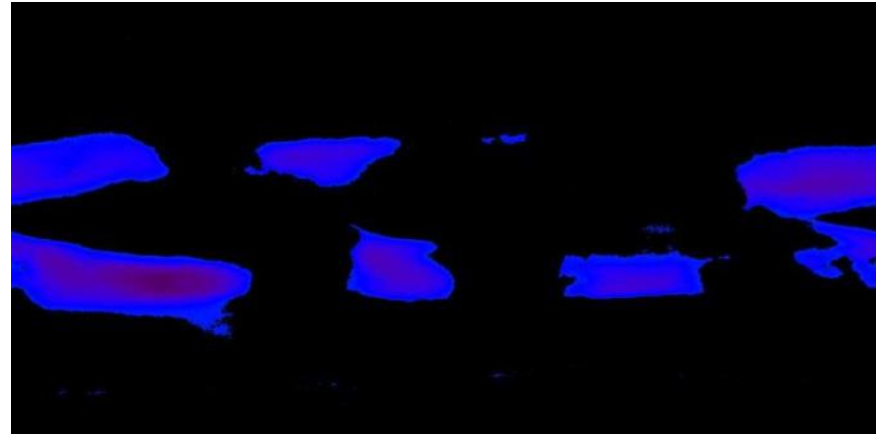
Werdell, P.J., B.A. Franz, S.W. Bailey, G.C. Feldman and 15 co-authors (2013). Generalized ocean color inversion model for retrieving marine inherent optical properties, *Applied Optics* 52, 2019-2037.

Global Trophic Subsets

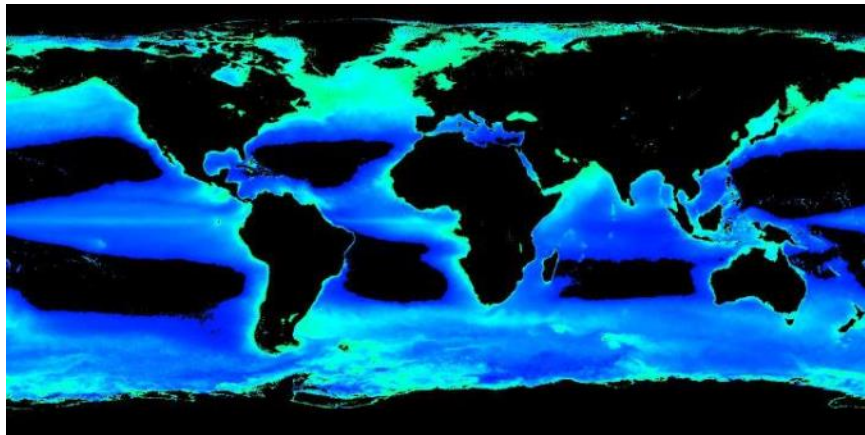
Deep-Water (Depth > 1000m)



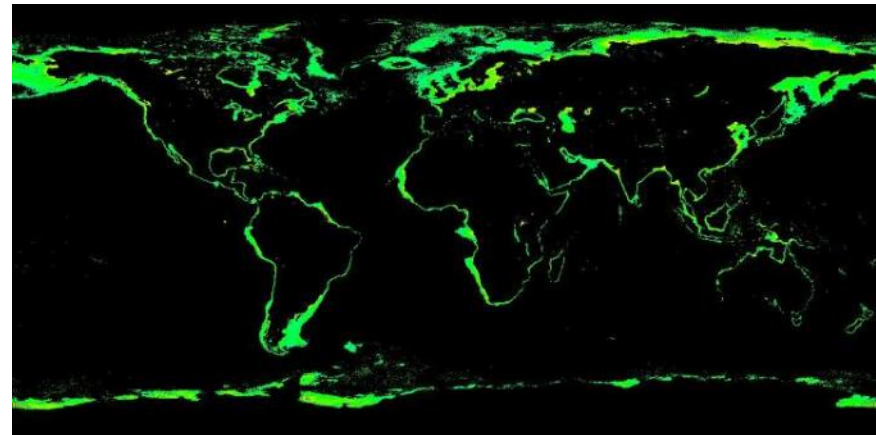
Oligotrophic (Chlorophyll < 0.1)



Mesotrophic (0.1 < Chlorophyll < 1)

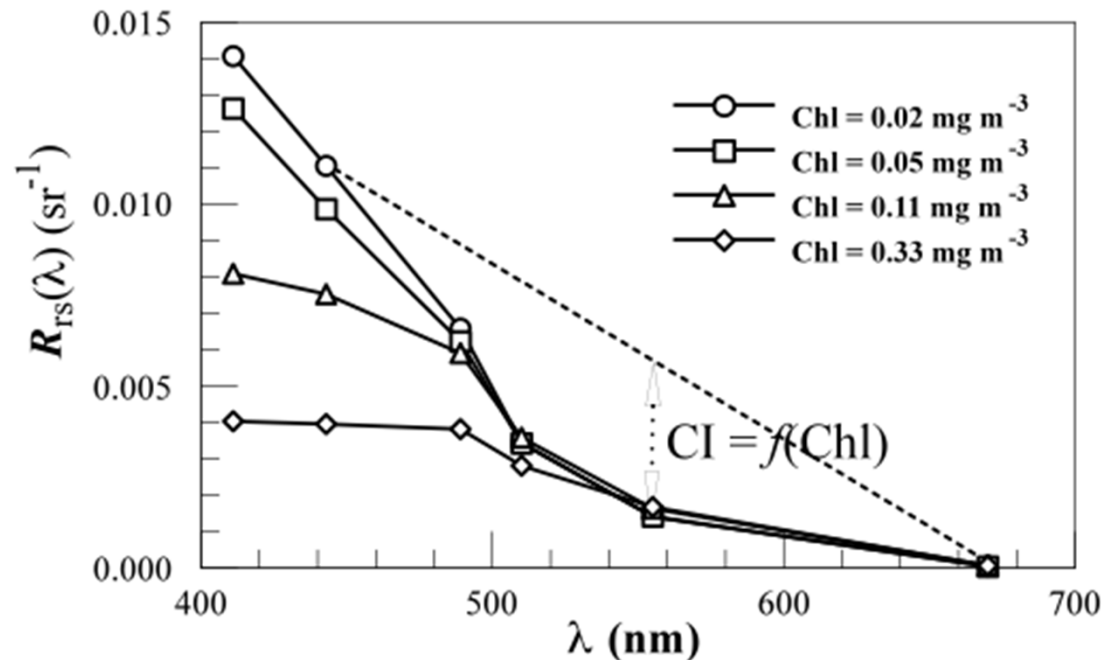


Eutrophic (1 < Chlorophyll < 10)



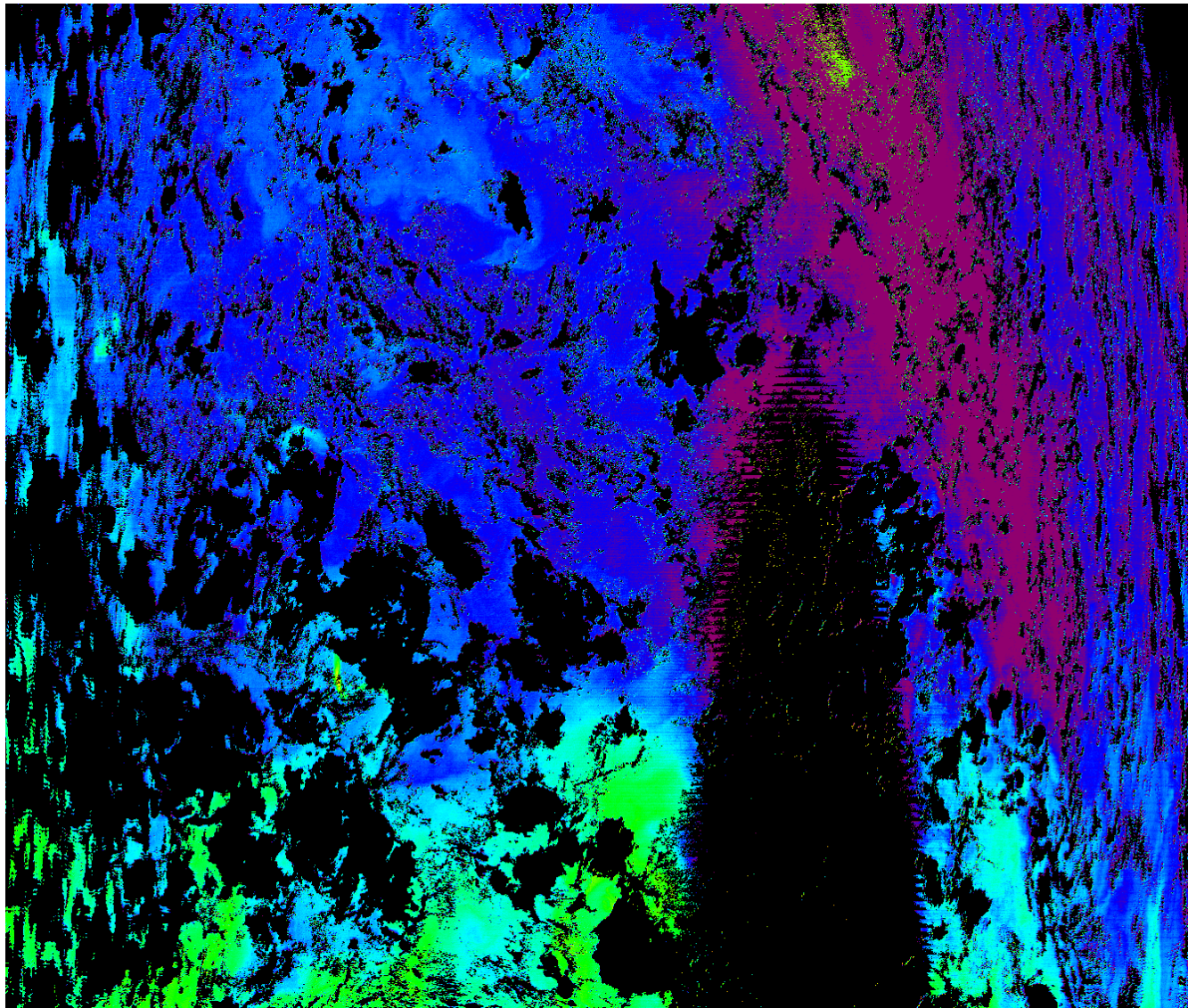
OCI Chlorophyll Algorithm

Line height algorithm for chlorophyll $< 0.25 \text{ mg m}^{-3}$, merged with OC3/OC4 max band ratio algorithm for chlorophyll $> 0.3 \text{ mg m}^{-3}$.

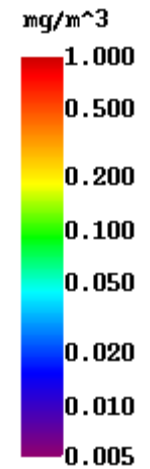


Hu, C., Z. Lee, and B. Franz (2012), Chlorophyll a algorithms for oligotrophic oceans: A novel approach based on three-band reflectance difference, J. Geophys. Res., 117, C01011, doi:10.1029/2011JC007395.

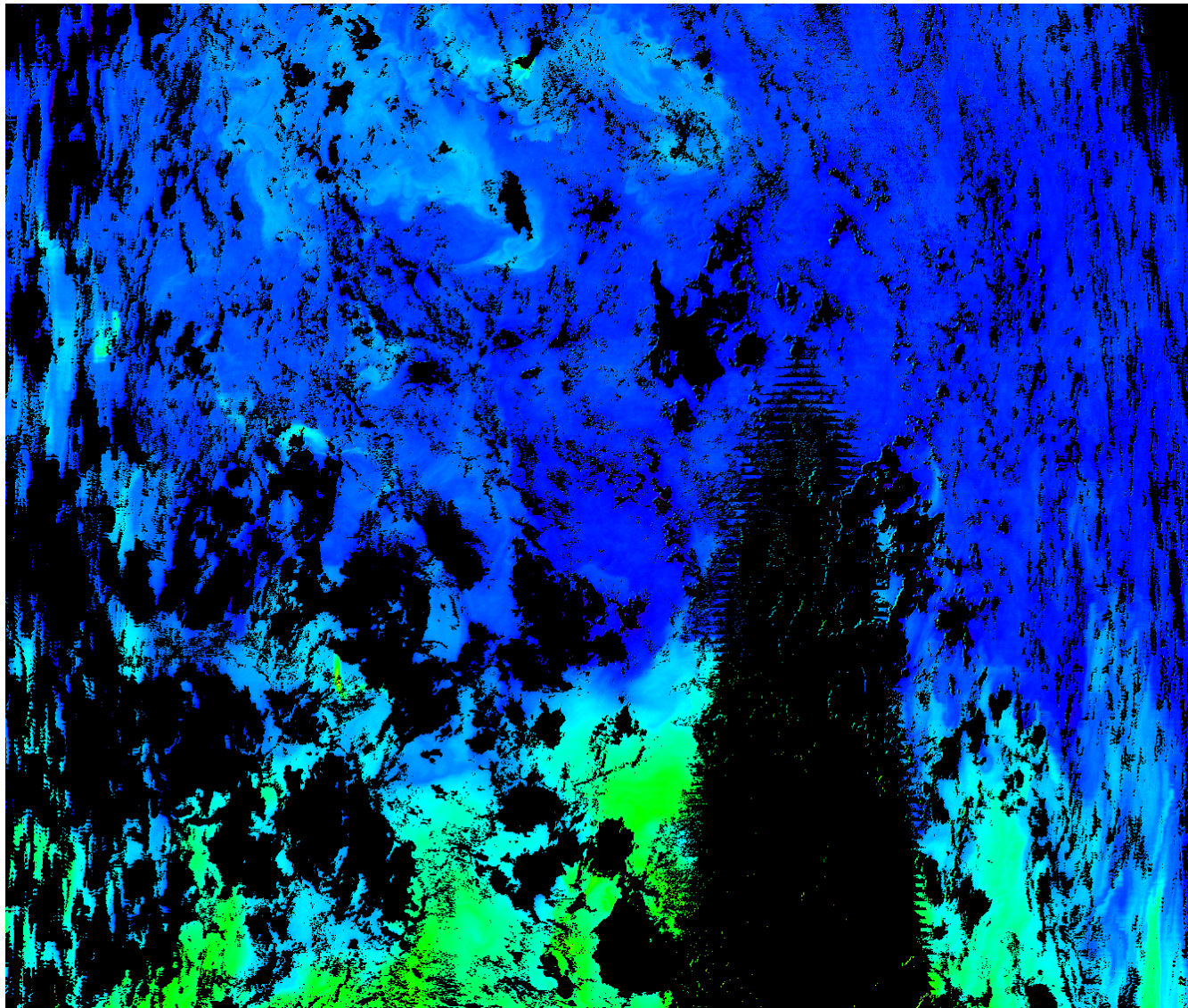
MODIS/Aqua, March 4, 2003, 21:10 GMT



Chl_{OC3}
Flags off



MODIS/Aqua, March4, 2003, 21:10 GMT



Chl_{CI}
Flags off

