MODIS and VIIRS
Discipline Summary Report - Oceans

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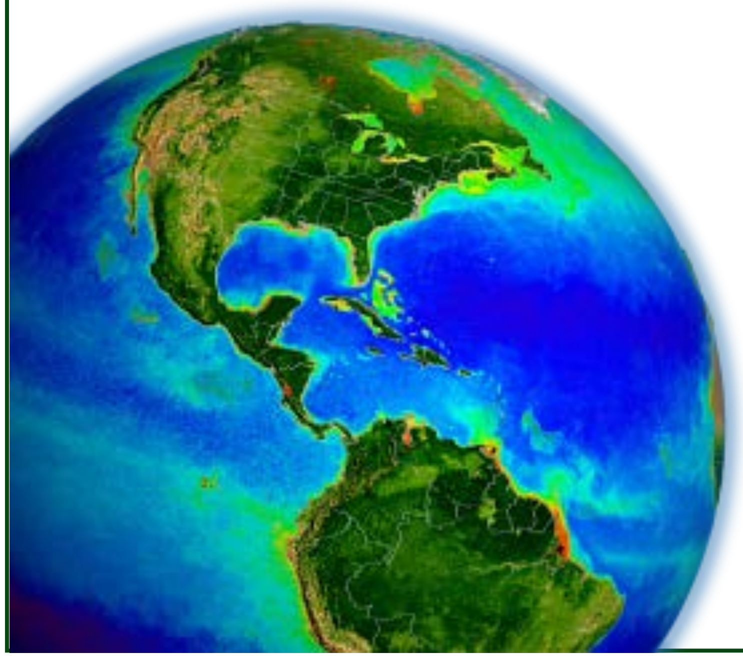

MODIS/VIIRS Science Team, 15-19 October 2018, Silver Spring, MD

Team Telecon

- Held 1st Team Telecon on 16 July 2018
- Full participation of all PIs + Program Management
- Plan is to repeat on ~6 month intervals, or as needed.

Telecon Agenda

1. Programmatic Business
2. Ocean Team Overview and Organization
3. Procedures and Responsibilities
4. PI Proposals Summaries
5. Open Discussion/Questions

Terra/Aqua/SNPP Selected Ocean Proposals

PI	Proposal Title	Notes
M. Behrenfeld	Merging Active and Passive Ocean Observations to Advance Understanding of Climate Impacts on Global Carbon Stocks and Phytoplankton Physiology	Multi-platform science
B. Franz	Advancing the Quality and Continuity of Marine Remote Sensing Reflectance and Derived Ocean Color Products from MODIS to VIIRS	Rrs, Chl, Kd490
R. Frouin	Estimating the Fraction of Photosynthetically Available Radiation Absorbed by Live Phytoplankton from MODIS and VIIRS Data	fPAR
W. Gregg	Combining Data Assimilation with an Algorithm to Improve the Consistency of SeaWiFS, MODIS and VIIRS Chlorophyll: Continuing a Multidecadal, Multisensor Global Record	Chl (Level-4)
K. Knobelspiesse	Joint MISR/MODIS Ocean Color Atmospheric Correction with a New Algorithm that Utilizes Reflected Sun Glint	Multi-platform algorithm
P. Koner	Physical Deterministic Sea Surface Temperature from MODIS and VIIRS Radiances	SST
T. Kostadinov	Carbon Based Phytoplankton Size Classes Using Multi Platform Ocean Color Observations and Earth System Models: inter Annual Variability and Trend Power Analysis	Multi-platform science
A. Mannino	Support of NASA MODIS and VIIRS Ocean Science Teams and Research with Quality Assured HPLC Pigment Analysis	Chl (in situ)
P. Minnett	Merging Optimal Estimation and Multi Channel Atmospheric Corrections for Accurate Sea Surface Temperatures from MODIS and VIIRS	SST (Level-4?)
L. Remer	Understanding Airborne Fertilization of Oceanic Ecosystems from Analysis of MODIS, VIIRS and CALIOP Observations	Multi-platform science
D. Stramski	Refinement, Evaluation, and Application of an Improved POC Ocean Color Product for Continuity of Climate Data Records	POC
F. Wentz	Improved Air Sea Essential Climate Variables (AS-ECV) from AQUA AMSR-E and S-NPP VIIRS	SST correction
J. Werdell	Advancing the Retrieval of Marine Inherent Optical Properties from Mult-Sensor, Multi-Spectral Satellite Ocean Color Radiometry	IOPs

MODIS SR Product Maintenance Proposals

maintenance of standard products

PI	Title	Products
W. Balch	Particulate Inorganic Carbon	PIC
B. Franz	Remote Sensing Reflectance, Chlorophyll, Diffuse Attenuation	Rrs, Chl, Kd490
R. Frouin	Photosynthetically Available Radiation	PAR
P. Minnett	Sea Surface Temperature	SST
T. Westberry	Fluorescence Line Height	FLH

in situ data for validation and algorithm development

PI	Title	Products
A. Mannino	HPLC pigments	
N. Nelson	BBOP	
D. Siegel	Plumes & Blooms	

Total
21 Funded Proposals
18 Unique PIs

MODIS/VIIRS Ocean SIPS Status

Ocean SIPS is currently producing Ocean Color and SST from MODIS (Terra & Aqua) and VIIRS (S-NPP)

Ocean Color for MODIS and VIIRS reprocessed in 2018 (R2018.0) with updated instrument and vicarious calibrations only

- next reprocessing (Spring 2018), will incorporate algorithm updates and any new products “approved” for standard production

SST for MODIS (Terra & Aqua) reprocessed in 2017 (R2014.0.1) for minor quality flag updates only

- next MODIS reprocessing (TBD), will incorporate updates to quality flag algorithm consistent with updated VIIRS algorithm

SST for VIIRS (S-NPP) processing initiated in 2016 (R2016.0) with heritage MODIS algorithm, updated quality algorithm, and sensor-specific tuning of algorithm coefficients (from PI Minnett)

Standard Products

Product	POC	Sensor
$R_{rs}(\lambda)$, AOT, Angstrom	*Franz*	*MODIS, VIIRS*
Chlorophyll a	*Franz (Werdell, Hu)*	*MODIS, VIIRS*
$K_d(490)$	*Franz (Werdell)*	*MODIS, VIIRS*
POC	*Stramski (Franz)*	*MODIS, VIIRS*
PIC	*Balch*	*MODIS, VIIRS**
PAR	*Frouin*	*MODIS, VIIRS*
nFLH	*Westberry*	*MODIS*
SST (11um)	*Minnett (Kilpatrick)*	*MODIS, VIIRS**
SST (4um)	*Minnett (Kilpatrick)*	*MODIS*

* orphaned product (no PI selected in current science team)

The Ocean SIPS will continue to produce all products, and the OB.DAAC will continue to distribute, regardless of orphan status.

Future Standard Products?

Product	POC	Sensor	Status
IOPs (GIOP)	*Werdell*	*MODIS, VIIRS*	*Provisional Distribution*
nKd	*Lee*	*MODIS*, VIIRS**	*Implemented*
PDSST	*Koner*	*MODIS, VIIRS*	*Implementation in progress*
SST3	*Minnett*	*VIIRS**	*Provisional Distribution*

* orphaned product (no PI selected in current science team)

How does a product become "standard"?

- The Ocean Team Lead, Ocean SIPS, and OB.DAAC have been in discussion with Program Management (Paula B, Kevin M) about the need for a modern, more dynamic process.
- The concept is to establish a standing review board for the Ocean SIPS (Science Operations Board, SOB).
- The SOB would include representation from the Science Team(s), SIPS Management, DAAC Management, Program Science, and ESDIS Program Management.
- The SOB would be responsible for maintaining the "approved" list of standard products and associated algorithms, and approving any changes to that list.
- The SOB review would consider science value, sufficiency of documentation, and availability of sufficient production and distribution resources.
- In practice, the review process could be managed through a CM system (CCR process) to ensure traceability and transparency.

What constitutes sufficient documentation?

- The end-user needs a Product User's Guide, and it needs to be up-to-date.

- The Ocean SIPS developed the concept of a Product and Algorithm Description Document, PADD).

- The PADD is a living document that includes:
  - a brief description of the product and it's purpose
  - a brief description of the algorithm with links to associated publications for more details
  - details of implementation differences for each sensor
  - direct links to source code for even more details (live links)
  - product validation results (live links)

Ocean Product Status and Documentation

https://oceancolor.gsfc.nasa.gov/product_status/

Ocean SIPS/OB.DAAC enhanced product documentation page.

Table provides

- links to the PADDs for each product
- product status (Standard, Provisional, Test, Special)
- links to the Mission Description pages
- links to the DOI landing pages per product and product level

Product Status & Algorithm Documentation

The Ocean Biology Processing Group (OBPG) produces and distributes a standard suite of ocean color products for all compatible sensors at Level-2 and Level-3, plus sea surface temperature (SST) products from MODIS and VIIRS. The OBPG also produces a suite of provisional products for evaluation. Provisional products have been approved for large-scale production, but they have not yet been accepted as standard products. The descriptions and references for these standard and provisional products are provided below. The product names link to the associated Product and Algorithm Description Document (PADD), which serves to satisfy the Algorithm Theoretical Basis Document (ATBD) requirement as defined by the NASA Earth Observing System Project Science Office.

Product Status

Key: Standard Provisional Test Special No DOI TBD N/A (Not generated for this mission)

		Sensor										
		CZCS	SeaWiFS	MODIS Aqua	MODIS Terra	OCTS	VIIRS SNPP	VIIRS J1	GOCI	HICO	MERIS	OLCI S3A
Product	Rrs	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	TBD	L2	L1	L2 L3B L3M	L2
	Chlor_a	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	TBD	L2	L1	L2 L3B L3M	L2
	Kd_490	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	TBD	L2	L1	L2 L3B L3M	L2
	POC	N/A	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	TBD	L2	L1	L2 L3B L3M	L2
	PIC	N/A	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	TBD	L2	L1	L2 L3B L3M	L2
	PAR	N/A	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	L2 L3B L3M	TBD	L2	L1	L2 L3B L3M	L2
	iPAR	N/A	N/A	L3B L3M	L3B L3M	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	nFLH	N/A	N/A	L3B L3M	L3B L3M	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	SST	N/A	N/A	L2 L3	L2 L3	N/A	L2 L3B L3M	N/A	N/A	N/A	N/A	N/A
							L2					

What About JPSS-1 VIIRS?

Ocean SIPS has been funded to:

- acquire J1/VIIRS Level-0
- produce Level-1B & Level-2/3 continuity products

Science Team has NOT been funded to support J1/VIIRS

Ocean Science Team is supporting J1/VIIRS on a best-effort basis

- atmospheric correction LUTs generated
- vicarious calibration performed

OB.DAAC is currently distributing J1/VIIRS Level-1B and Level-2/3 Ocean Color products produced by the Ocean SIPS

Questions?

PI Proposal Overviews

MODIS SR Product Maintenance Proposals

maintenance of standard products

PI	Title	Products
W. Balch	Particulate Inorganic Carbon	PIC
B. Franz	Remote Sensing Reflectance, Chlorophyll, Diffuse Attenuation	Rrs, Chl, Kd490
R. Frouin	Photosynthetically Available Radiation	PAR
P. Minnett	Sea Surface Temperature	SST
T. Westberry	Fluorescence Line Height	FLH

Balch Proposed Work

- *Maintenance of NASA standard 2-band/3-band PIC algo [Balch et al., 2005; Gordon et al., 2001]* (re-deriving look-up table and coefficients, based on latest ocean PIC measurements in new areas of the world ocean- such as those we are making now aboard R/V Endeavor at this very moment in the Mid-Atlantic Shelf, Slope and Sargasso Sea)
- *Working with the DAAC as well as the community to address user inquiries concerning the algorithm/product*- this has involved updating the algorithm code with the Ocean SIPS for product reprocessing.
- *Comparisons of standard NASA PIC algorithm and new differencing algorithm:*
  - By using band differences instead of band ratios, the PIC differencing algorithm is less sensitive to atmospheric correction errors. *(*Mitchell C, Hu C, Bowler BC, Drapeau DT, Balch WM, 2017. Estimating particulate inorganic carbon concentration from ocean color data using a reflectance difference approach. Journal of Geophysical Research - OceansDOI: 10.1002/2017JC013146)
  - More comparisons between the 2B/3B algorithm and the PIC differencing algorithm are planned.

Maintenance and Quality Assessment of Remote Sensing Reflectance, Chlorophyll, and Diffuse Attenuation Products to Support MODIS Ocean Color Science

B. Franz, S. Bailey, G. Meister

- Maintenance of Rrs retrieval from MODIS
  - MODIS (Terra & Aqua) instrument calibration, cross-calibration
  - vicarious calibration updates (alg updates, inst cal, or MOBY reproc)
  - on-going quality assessment (match-ups, time-series)
- Maintenance of key derived products (Chl, Kd)
  - algorithm re-tuning for any updates to NOMAD
  - on-going quality assessment (match-ups, time-series)
- User support

SST from MODIS, Terra and Aqua

PI: Peter Minnett. Co-I's: Kay Kilpatrick, Goshka Szczodrak. RSMAS, University of Miami.

Objectives:

- To assess accuracies of SSTs derived from MODIS – SST from Bands 31 & 31 (11&12 µm), day and night, and SST4 from Bands 22 & 23 (3.96 & 4.04 µm), at night.
- May lead to algorithm improvement if resources allow.
- Provide foundation for SST CDR through SI-traceable calibration of ship radiometers used to assess accuracies.

Data:

Subsurface temperatures from drifting buoys – iQUAM (NOAA)
Ship radiometers – 4 x M-AERI's: 3 on Royal Caribbean Cruise Limited ships. 1 on research vessels.

Collaborations:

OB.DAAC & GSFC: Match-up extractions and SST processing using our algorithms.

PO.DAAC & JPL: Generation of GHRSST L2P files, distribution and archiving (MODIS SSTs are some of most-downloaded data sets).

NCEI (NOAA): GHRSST Long-term stewardship and distribution.

See: Kilpatrick, K.A., Podestá, G., Walsh, S., Williams, E., Halliwell, V., Szczodrak, M., Brown, O.B., Minnett, P.J., & Evans, R. (2015). A decade of sea surface temperature from MODIS. *Remote Sensing of Environment 165*, 27-41. http://dx.doi.org/10.1016/j.rse.2015.04.023

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Maintenance and ongoing evaluation of MODIS-Aqua chlorophyll Fluorescence Line Height (FLH) product

PI: Toby Westberry, Oregon State University

- Especially sensitive to sensor performance (e.g., RVS changes in Bands 13-15)
- Past reprocessing has brought about significant changes in FLH product (see below)

The proposed work will focus on 4 main areas: 1) evaluation of biases in the Aqua mission FLH time series at both the global and regional level, 2) evaluation of calibration impacts on geophysical interpretation (e.g., iron stress) of FLH product, 3) continued evaluation of uncertainty in FLH product (very little direct validation exists for this property), and 4) work with the Ocean Data Processing SIPS to incorporate findings into successive Aqua MODIS reprocessing

Fig.1 Temporal trends in FLH anomaly in oligotrophic subset before (A) and after (B) R2009

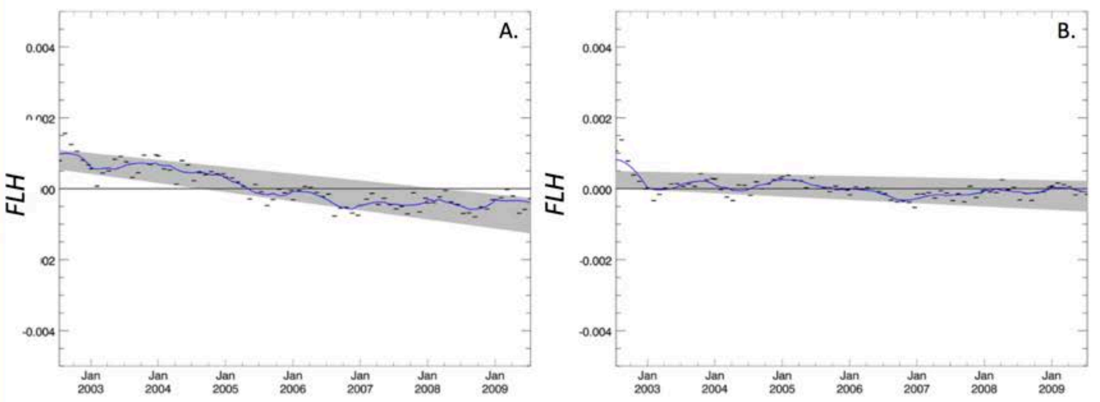
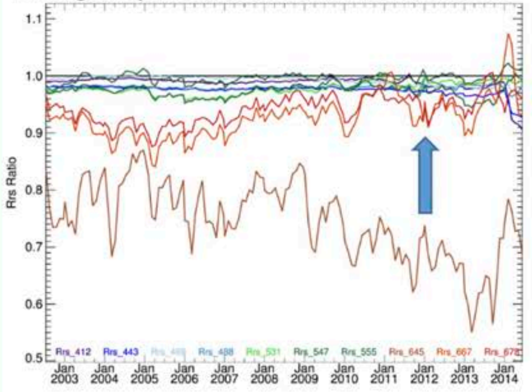


Fig 2. Ratio of mean R_{rs}678 (red/orange lines) in oligotrophic subset from R2014/R2013.



MODIS SR Product Maintenance Proposals

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A. Mannino	HPLC pigments	
N. Nelson	BBOP	
D. Siegel	Plumes & Blooms	

Support of NASA MODIS and VIIRS Ocean Science Teams and Research with Quality-Assured HPLC Pigment Analysis

PI: Antonio Mannino (NASA/GSFC)
Co-Is: Crystal Thomas (SSAI, NASA/GSFC) and Jeremy Werdell (NASA/GSFC)

Three main objectives:

1. Enable refinement of existing Chl *a* algorithms through continuation of high-quality HPLC pigment measurements (3000 samples/year)

    -includes making minor improvements to current methodology (no new hardware or technology needed)

2. Research the utility and practicality of adding LC-MS as part of routine HPLC analysis

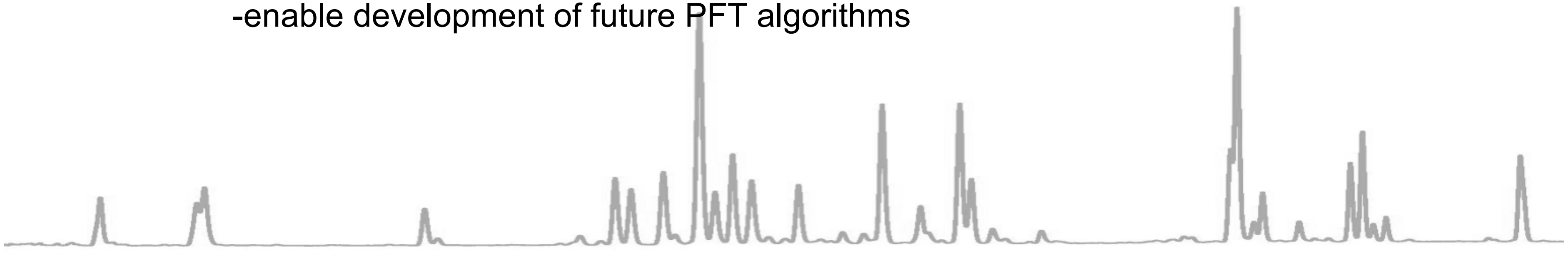
    -to further reduce uncertainties in pigment measurements in field samples

    -which could in turn reduce uncertainties in Chl *a* and PFT satellite data products

3. Research and implement phycobilin (phycoerythrin and phycocyanin) analysis

    -application with existing PFT algorithms

    -enable development of future PFT algorithms



In situ research in support of ocean color science: Bermuda Bio-Optics Project

Norm Nelson, Dave Siegel: Earth Research Institute, UC Santa Barbara

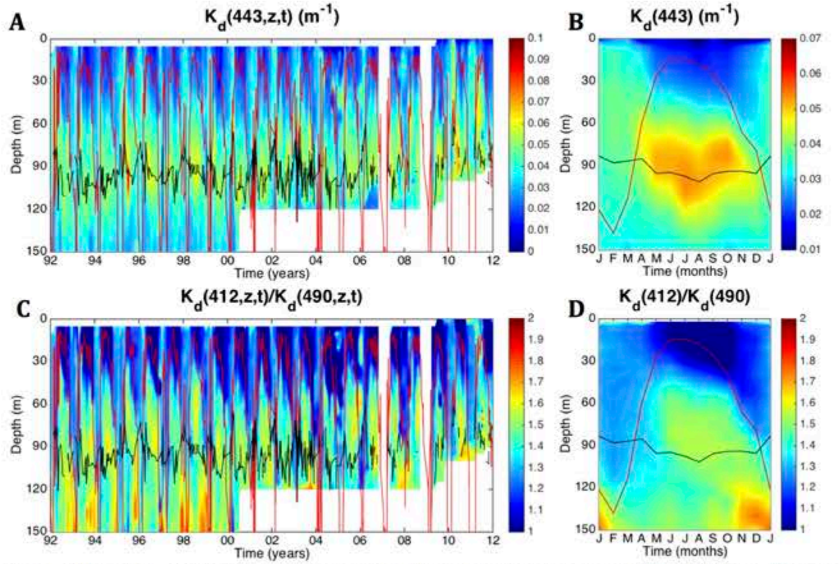
Subcontractor: Nick Bates, BIOS

Principal Activities

- **Since 1992 Monthly** to 2x monthly at the BATS site 65 miles SE of Bermuda, piggybacking on BATS cruises
  - Multichannel spectroradiometer profiles (Ed, Lu, Es)
  - Bottle sample component absorption spectra (ag, ap, ad, aph)
- Annual meridional sections across Sargasso Sea

Science Goals

- **Climate - ecosystem connections**
  Decadal - scale changes in optical observables (CDOM, phytoplankton) related to local and regional processes, climate oscillators
- **Ocean color product validation**
  Reflectance, chlorophyll, absorption
- **Technology development**
  New optical sensors and methods tested at BATS



From Allen et al. 2017: Time-space distributions of (a) the diffuse attenuation coefficient for downwelling irradiance of 443nm, $K_d(443,z,t)$ (m^{-1}), (b) the monthly mean $K_d(443,z,t)$ (m^{-1}), (c) the ratio of $K_d(412,z,t)$ to $K_d(490,z,t)$, and (d) the monthly mean ratio of $K_d(412,z,t)$ to $K_d(490,z,t)$. The red line signifies the mixed layer depth, while the black line signifies the 1% PAR isolume.

Table 1 Allen et al. 2017 Deep-Sea Res I 119: 58-67

Linear regression for anomalies at 20m depth

Parameter	Annual Change ± 95% CI	Percent Annual Change ± 95% CI	r^2 (%)	p
Temperature	0.017 ± 0.0057	0.075% ± 0.025%	78	< 0.005
Chl a	0.0015 ± 0.0009	1.24% ± 0.78%	77	< 0.005
$a_{ph}(443)$	0.00003 ± 0.00005	0.61% ± 0.86%	82	0.17
$a_g(325)$	-0.00004 ± 0.00005	0.31% ± 0.62%	91	0.33
$K_d(443)$	0.00027 ± 0.0001	0.99% ± 0.37%	79	< 0.005
$K_d(412)/K_d(490)$	0.00005 ± 0.0017	0.004% ± 0.15%	79	0.95
MLD	0.283 ± 0.074	0.48% ± 0.13%	71	<0.005
1% PAR depth	-0.614 ± 0.121	-0.66% ± 0.13%	86	<0.005

Plumes & Blooms – Ocean Color Algorithm Maintenance for a Case II Ocean

David Siegel – UC Santa Barbara

Plumes & Blooms (PnB) focuses on the understanding ocean color variability in highly variable coastal environment with the goal of maintaining coastal satellite ocean color observations. PnB makes near-monthly cross-channel surveys and collaborates with the SBC-LTER and SBC-MBON on studies of oceanographic variability, phytoplankton community structure, HABs, C cycle dynamics, etc.

Monthly Sampling of Optical, Physical & Biogeochemical Parameters

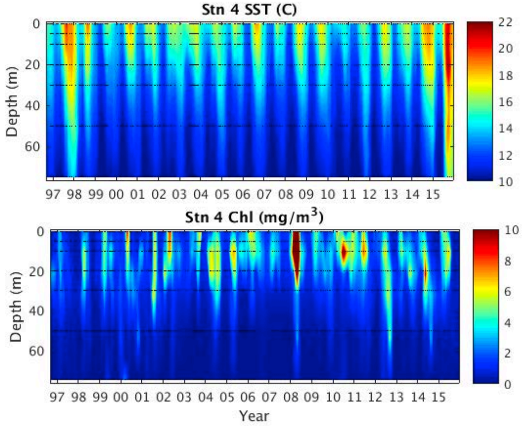
Monthly 7 station transect on NOAA's R/V Shearwater

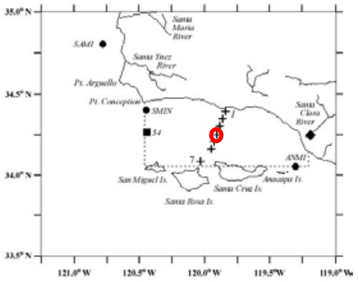
In situ Profile Parameters Sampled
- Ocean color spectra (profiling radiometer – C-OPS)
- Total absorption & scattering spectra (AC-9)
- Backscatter spectra (Hydroscat-6) & Particle size spectra (LISST-900)

Bottle sample Parameters Sampled
- Phytoplankton, dissolved organic & detrital absorption spectra (spectrophotometry)
- Nutrients (NO_3, PO_4, SiO_4), Particulate silica (biogenic & lithogenic), POC & DOC
- Phytoplankton pigments by HPLC (run by NASA)
- Water for other investigators especially student projects

PnB In Situ Time Series Observations

Time-depth contours at PnB Station 4



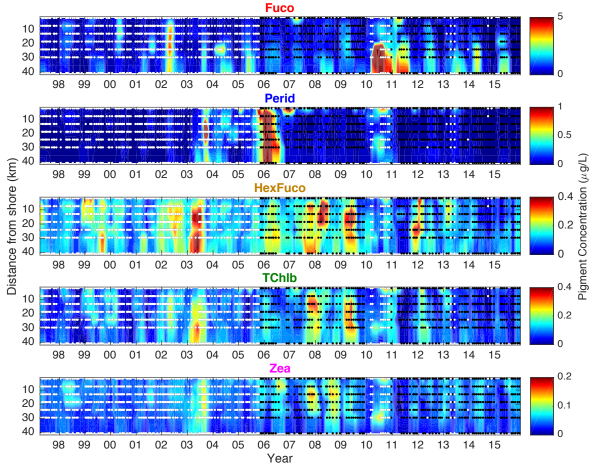


- Highly dynamic ecosystem driven by seasonal upwelling & weather
- Large warming events (ENSOs & "the blob")
- Starting our third decade of sampling
- No statistically significant long-term trends (yet)

Reconstruction of Pigments from $a_{ph}(\lambda)$

Spectral derivative analyses are used to model missing surface ocean pigment observations (white points)

- R values > 0.8 (except Zea/pico's)
- Shows altering dominance of diatoms (Fuco) & dinos (Perid)
- Metacommunity genomic analyses underway (SBC MBON $'s)



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K. Knobelspiesse	Joint MISR/MODIS Ocean Color Atmospheric Correction with a New Algorithm that Utilizes Reflected Sun Glint	Multi-platform algorithm
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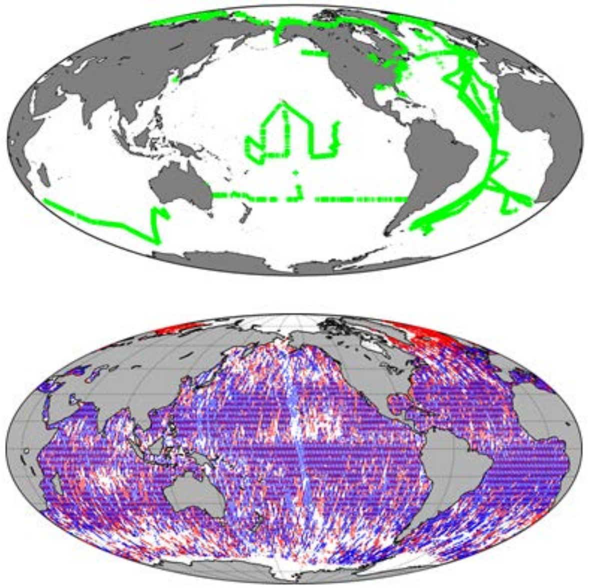
P. Minnett	Merging Optimal Estimation and Multi Channel Atmospheric Corrections for Accurate Sea Surface Temperatures from MODIS and VIIRS	SST (Level-4?)
L. Remer	Understanding Airborne Fertilization of Oceanic Ecosystems from Analysis of MODIS, VIIRS and CALIOP Observations	Multi-platform science
D. Stramski	Refinement, Evaluation, and Application of an Improved POC Ocean Color Product for Continuity of Climate Data Records	POC
F. Wentz	Improved Air Sea Essential Climate Variables (AS-ECV) from AQUA AMSR-E and S-NPP VIIRS	SST correction
J. Werdell	Advancing the Retrieval of Marine Inherent Optical Properties from Mult-Sensor, Multi-Spectral Satellite Ocean Color Radiometry	IOPs

Merging active and passive ocean observations to advance understanding of climate impacts on global carbon stocks and phytoplankton physiology



(TOP) Location of field b_{bp} data available in the SeaBASS archive. (BOTTOM) Location of valid CALIOP b_{bp} retrievals for May 2010. Red symbols = daytime data. Blue symbols = nighttime data.

- Satellite remote sensing data from MODIS-AQUA and CALIOP
- Merger of passive and active data to improve ocean inherent optical property (IOP) retrievals
- CALIOP provides a global, spatially- and temporally-unbiased algorithm training data set
- Resultant optimized IOP algorithm generates improved global fields of particulate backscatter coefficients (b_{bp}), phytoplankton absorption coefficient (a_{ph}), non-algal absorption (a_{dg})
- a_{ph} and b_{bp} converted to phytoplankton chlorophyll (*Chl*) and carbon biomass (C_{phyto})
- Re-evaluate temporal anomalies in chlorophyll with respect to light, nutrient, and biomass changes.

Advancing the Quality and Continuity of Marine Remote Sensing Reflectance and Derived Ocean Color Products from MODIS to VIIRS

B. Franz, S. Bailey, A. Ibrahim, G. Meister, J. Werdell

- Consistency of Rrs retrieval from MODIS and VIIRS
  - VIIRS instrument calibration, vicarious calibration, atmospheric correction, normalization
- Advancing the heritage MODIS/VIIRS atmospheric correction
  - from 2-band, single-scattering epsilon approach of Gordon & Wang to multi-band, multi-scattering optimization (NIR to SWIR)
- Development of per-pixel uncertainties for Rrs
  - combining propagated instrument noise, estimated systematic error, and algorithm error terms

Estimating the Fraction of Photosynthetically Available Radiation Absorbed by Live Phytoplankton from MODIS and VIIRS Data (R. Frouin, PI)

-An algorithm will be developed to estimate *APAR* from water reflectance, after atmospheric correction. Instead of using chlorophyll concentration or absorption coefficients, which are all estimated from water reflectance via empirical relations or inversion schemes, the *APAR* algorithm will use directly water reflectance, or more exactly the ratio of irradiance reflectance just below the surface normalized by the pure seawater value, in an optimum multi-linear combination.

-This optimum combination will be obtained by systematically examining the statistical performance of possible combinations (based on available spectral bands) on a realistic ensemble of *APAR* and associated (noisy and not noisy) multi-spectral water reflectance.

-Uncertainty metrics will be generated for pre-determined water classes using estimated and prescribed *APAR* data sets. Then fuzzy membership to the classes will be used to calculate the *APAR* uncertainty for each pixel.

-The algorithm will be applied to MODIS and VIIRS imagery and evaluated against in situ measurements. A complete processing line, with code and ATBD, will be developed and delivered to the ODPS at NASA GSFC for implementation, testing, and generation of *APAR* L2 and L3 products.

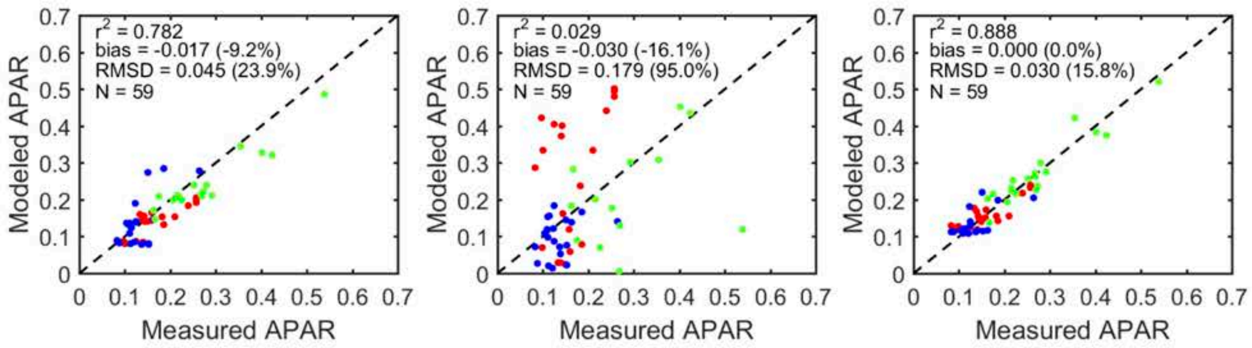
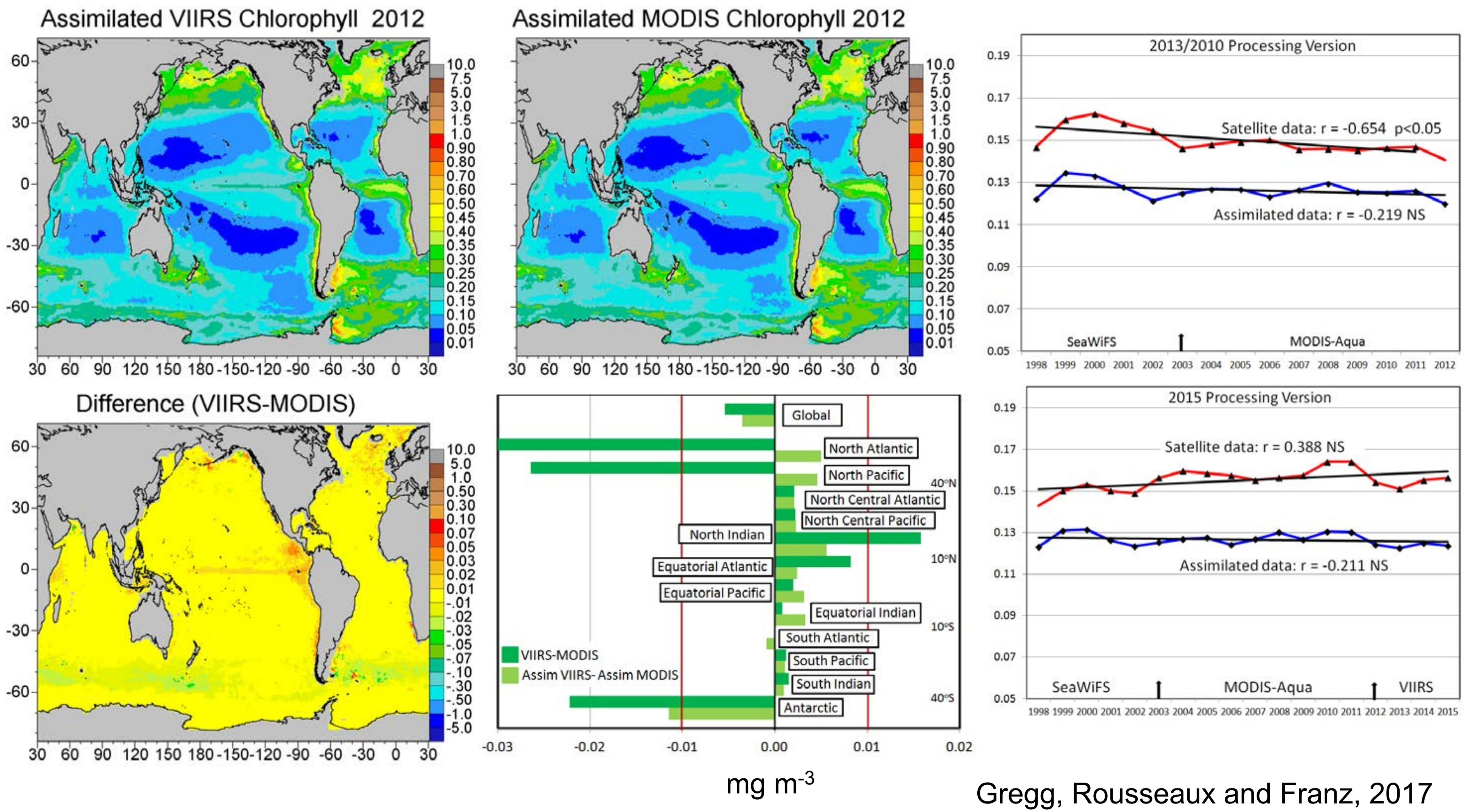


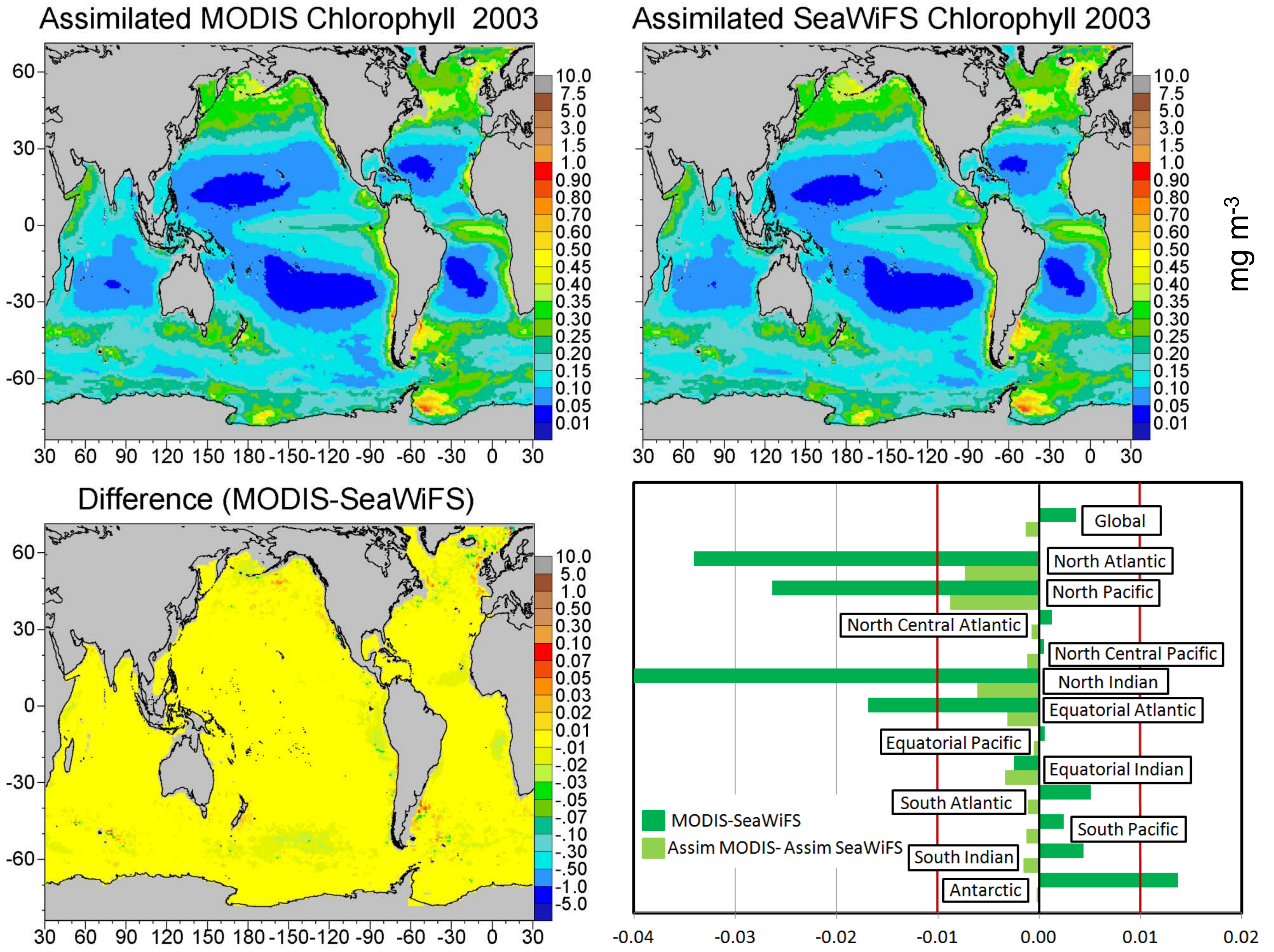
Figure 1*: Comparison of estimated and "measured" APAR using field data collected during OUTPACE (red), BIOSOPE (blue) and MV1102 (green) cruises: Left - using OC3M derived [chl], Middle - using QAA derived a_{ph} and a_{tot}, Right - using R_w/R_{w0} ratios.*

Combining Data Assimilation with an Algorithm to Improve the Consistency of SeaWiFS, MODIS-Aqua, and Suomi NPP-VIIRS Chlorophyll: Toward a Multidecadal, Multisensor Global Record

Watson Gregg and Cecile Rousseaux, NASA/GMAO



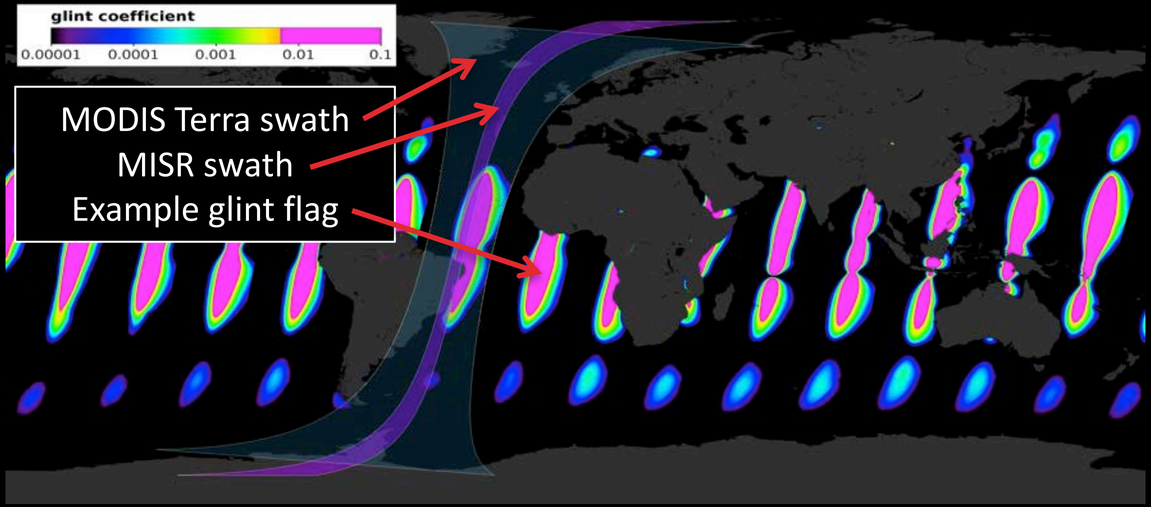
Gregg, Rousseaux and Franz, 2017

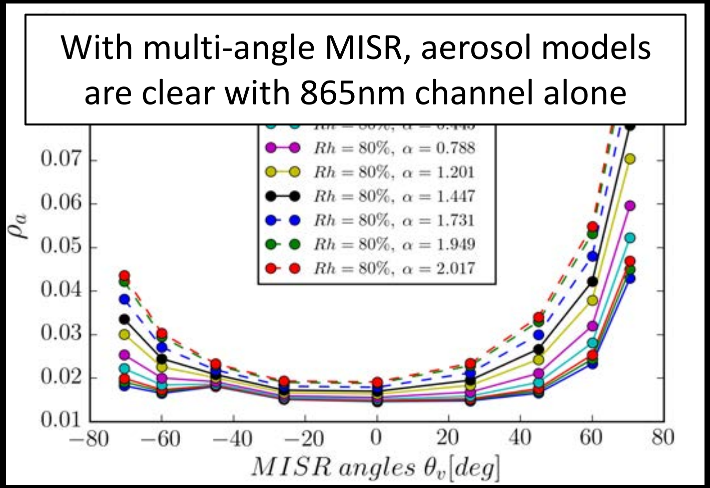


Assimilated OCI-ESRID MODIS chlorophyll for 2003, Assimilated OCI-ESRID SeaWiFS, difference. Assimilated and satellite differences summarized for the 12 major oceanographic basins.

MOCMAC: MODIS Ocean Color with MISR Atmospheric Correction

Kirk Knobelspiesse (PI), Amir Ibrahim, Zia Ahmad, Sean Bailey, Bryan Franz, Joel Gales, Mike Garay, Olga Kalashnikova, Rob Levy; GSFC & JPL





For coincident MISR and MODIS (Terra) observations:

- solve for atmosphere using multi-angle MISR observations (including glint)
- use this to atmospherically correct MODIS data; apply ocean color algorithms

First steps:

- ingesting MISR data into GSFC Ocean Biology Processing Group systems
- information content assessment to guide LUT structure

Contact: Kirk.knobelspiesse@nasa.gov

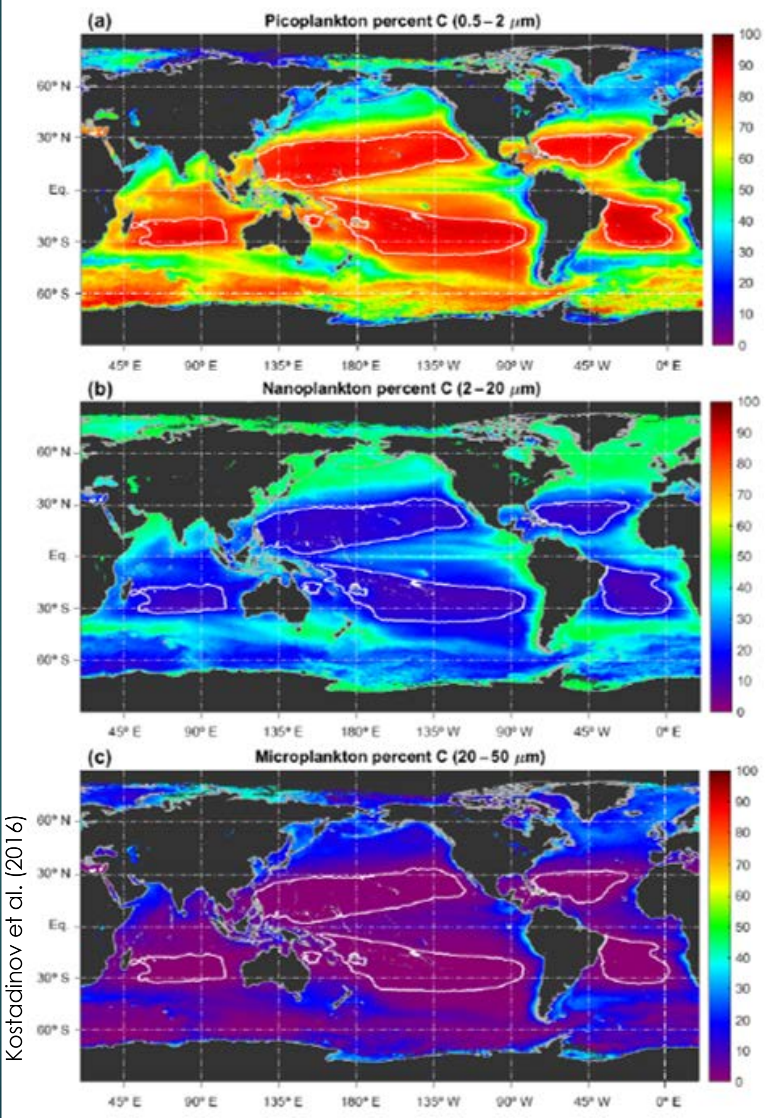
Physical deterministic sea surface temperature from MODIS and VIIRS radiances

PI: Prabhat Koner & Co-I: Andy Harris

- PDSST suite is combination of the SST retrieval and cloud detection using RTM (CRTM)
- Research shows 3-4 time information gain as compared to operational MODIS SST product for the night time.
- Challenges for daytime:
  - A preliminary study has been already conducted for daytime SST retrieval using 3.9 & 4 μm with success as a part of PDSST. It is also found that the fast forward model for 3.7 μm channels is suboptimal at the present status of CRTM.
  - SWIR channels for daytime SST retrieval is completely new initiative and needs thorough investigation.
  - Can it be SWIR channels modelled for regression based daytime SST?
  - Will it be useful for daytime the excellent nighttime double difference test between 3.9 & 4 μm for cloud detection? If not, what is the alternative?

Carbon-based phytoplankton size classes using multi-platform ocean color observations and Earth System Models: satellite algorithm development and interannual variability

PI: T. KOSTADINOV (CSU SAN MARCOS); CO-PIS: I. MARINOV (U. PENN) & S. MARITORENA (UCSB)



Kostadinov et al. (2016)

The **PSD** represents a critical link between:

A) Ocean ecology (master trait that influences ecosystem function, e.g. biological pump), and

B) Ocean optics (influences IOPs and thus RS retrievals)

The KSM09 bbp-based algorithm retrieves the assumed power-law PSD parameters, and the TK16 algorithm uses those to retrieve C-based PFTs (left, SeaWiFS climatology).

Here, we propose:

- Improving the KSM09 PSD algorithm
- Comparing with absorption-based Roy et al. (2013) algorithm
- Producing a merged multi-platform PSD/PFT ocean color data set
- Investigating biology-physics connections in the satellite data using mixing length scales (heat fluxes, winds, MLD) & light level indices
- Exploring ENSO variability: validating and comparing biological signals in the CMIP6 model suite and the merged satellite data product

Merging Optimal Estimation and Multi-Channel Atmospheric Corrections for Accurate Sea-Surface Temperatures from MODIS and VIIRS

PI: Peter Minnett. Co-PI: Goshka Szczodrak. Co-I's: Kay Kilpatrick. RSMAS, University of Miami.

<u>Objectives:</u>

- To demonstrate that a new hybrid method which combines the Non-Linear SST algorithm and the Optimal Estimation approach can improve accuracy and error characteristics of the skin sea-surface temperature (SST_{skin}) retrieved from MODIS and VIIRS top-of-atmosphere brightness temperature (BT) measurements.
- Should lead to a new atmospheric correction algorithm.

<u>Data:</u>

MODIS and VIIRS L2 TOA radiance data and SST retrieval; and MODIS and VIIRS MUDB data.

ECMWF atmospheric fields.

Ship radiometers – 4 x M-AERI's: 3 on Royal Caribbean Cruise Limited ships. 1 on research vessels.

<u>Collaborations (for new algorithm implementation):</u>

OB.DAAC at GSFC: SST processing using new algorithm(s).

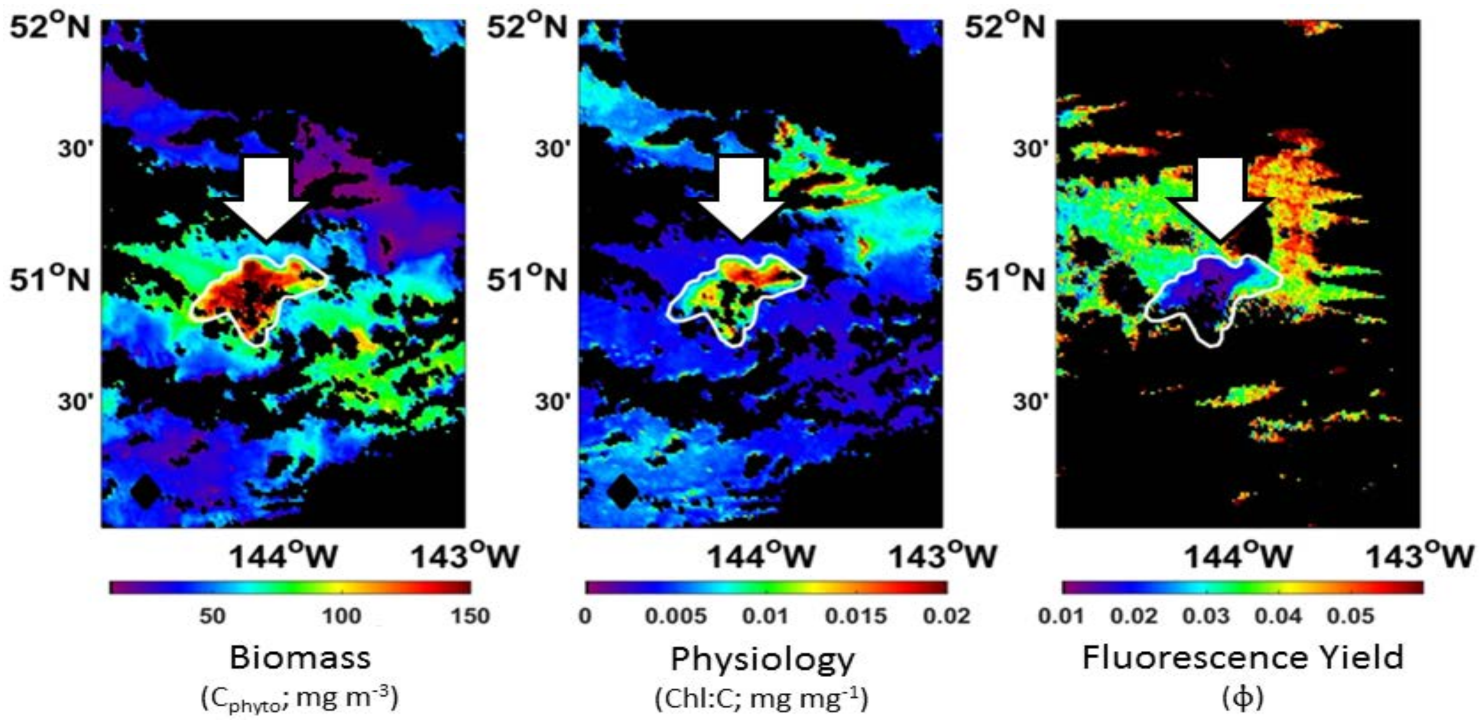
PO.DAAC at JPL: Generation of GHRSST L2P files, distribution and archiving.

NCEI (NOAA): GHRSST Long-term stewardship and distribution.

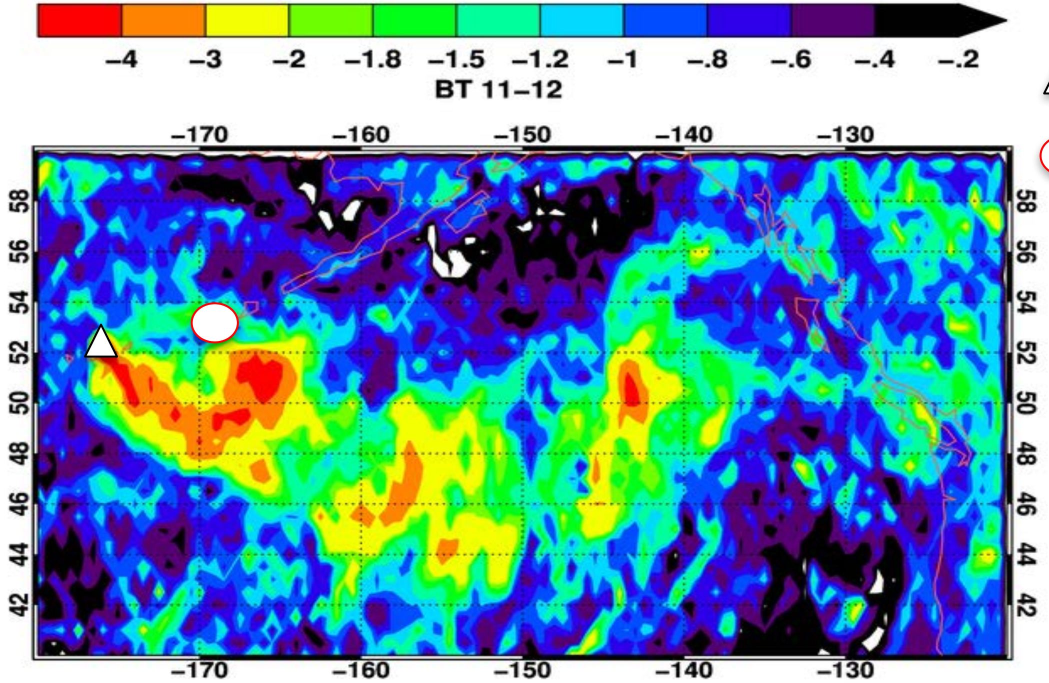
Understanding airborne fertilization of oceanic ecosystems using MODIS, VIIRS and CALIPSO

Lorraine Remer, Hongin Yu, Yingxi Shi (the atmospheric scientists)
Michael Behrenfeld and Toby Westberry (the oceanographers)

Artificially adding iron to ocean (a) increases biomass, (b) changes physiology and (c) cranks up carbon engine. But… what about adding iron from aerosols?



Westberry et al. (2013)

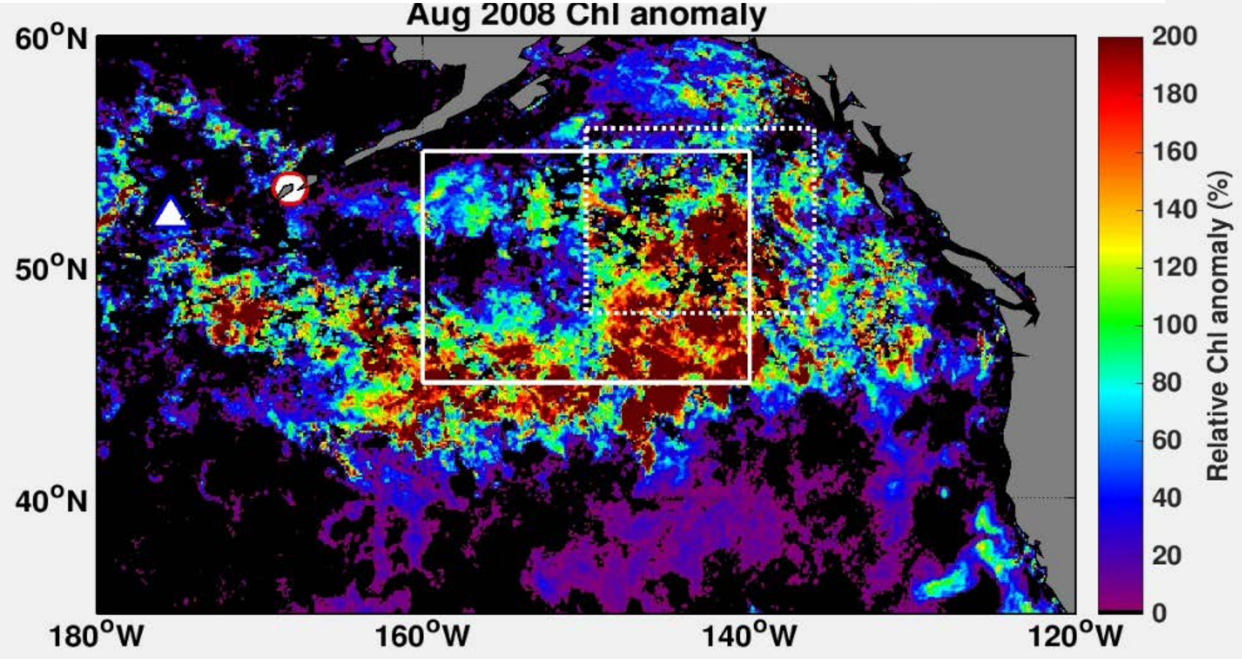


△ Kasatochi eruption 7-8 Aug 2008

◯ Okmok eruption 12 Aug 2008

Atmosphere
Volcanic ash plumes
Composite BT 11-12
8-12 August 2008

(Yingxi Shi)



Ocean
Chl Aug 2008
anomaly

Monthly mean, but heavily influenced by latter half of the month.

(Toby Westberry)

Refinement, Evaluation, and Application of an Improved POC Ocean Color Product for Continuity of Climate Data Records

PI: Dariusz Stramski, Co-PI: Rick A. Reynolds, Co-PI: Dale Robinson

PRIMARY MOTIVATION

- Currently the standard global POC data product utilizes the algorithm developed by our lab a decade ago with a limited number of in situ observations

OVERALL GOAL

- Refine and evaluate the instrument-specific (SeaWiFS, MODIS-Aqua, and VIIRS) POC algorithms on the basis of much larger datasets including marine environments that were underrepresented in earlier algorithm formulations and validation

SPECIFIC OBJECTIVES AND TASKS

- Assembly and quality control of field datasets for POC algorithm refinement and validation
- Analysis and evaluation of candidate approaches to establish and implement refined Level-2 instrument-specific global algorithms for continuity of standard global POC data record
- Evaluation of algorithm performance and quantification of uncertainties in standard POC data product
- Intercomparisons of the POC product provided by SeaWiFS, MODIS-Aqua, and VIIRS observations globally, and within specific geographical regions
- Develop and evaluate novel algorithms for generating an experimental POC product for optically-complex coastal and shelf sea environments
- Analysis of global and basin-scale POC data record from satellite observations over a period of >20 years, providing reference baseline profile of POC and a critical look at possible trends in the long-term record in support of global change and ecosystem characterization research

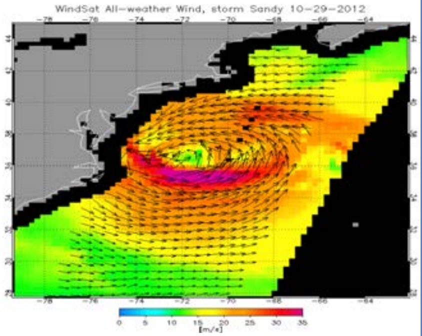
Remote Sensing Systems
www.remss.com

Improved Air-Sea Essential Climate Variables from AQUA AMSR-E and S-NPP VIIRS

P.I. Frank Wentz   Co.I. Richard Lindsley

- Sea-surface temperature (T_S, °C)
- Sea-surface wind speed (W, m/s)
- Total water vapor above the ocean (V, mm)
- Total liquid cloud water above the ocean (L, mm)
- Sea-surface rain rate (R, mm/hr)

AMSR-E Improvements
Consistent V8 Calibration
Winds through Rain
RFI Mitigation
Sun Glitter Mitigation



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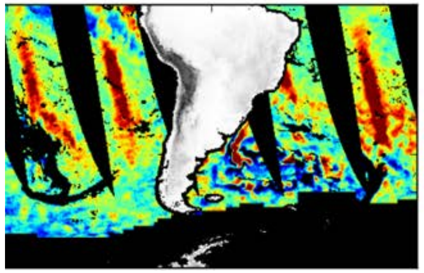
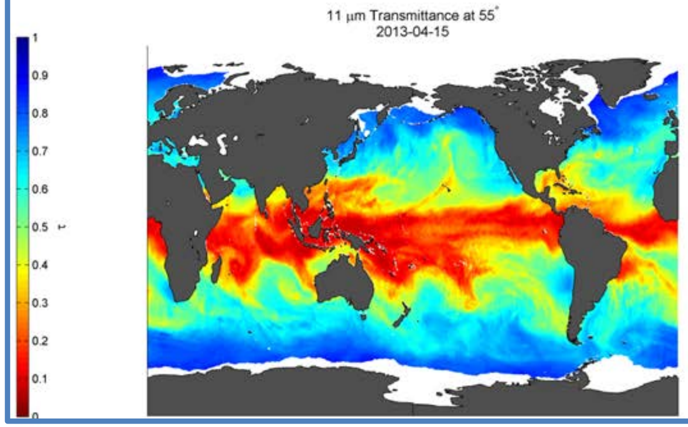
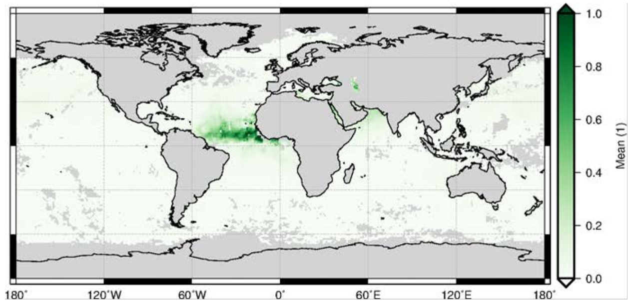
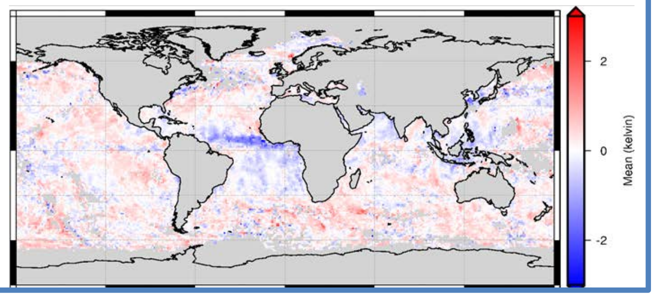


V8 Calibration: AMSR-2, TMI, and GMI
WindSat V8 is being done as part of OVWST
AMSR-E V8 will complete the 2-decade time series
(SSM/I V8 is being proposed to extend back to 1987)

MW Vs. VIIRS SST Comparisons
Effects of Vapor and Aerosols







Advancing the retrieval of marine inherent optical properties from multi-sensor, multi-spectral satellite ocean color radiometry

Jeremy Werdell (PI), Lachlan McKinna (Co-I), Cecile Rousseaux (Co-I), Bryan Franz (Co-I), Zhongping Lee (Collaborator)

Data products

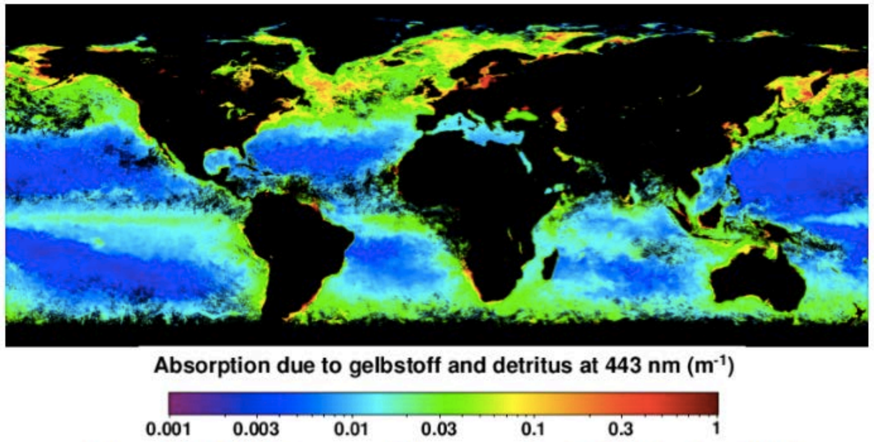


Figure 1. MODIS-Aqua monthly $a_{dg}(443)$ from GIOP for June 2017

Spectral marine inherent optical properties (IOPs):
- Absorption due to phytoplankton
- Absorption due to gelbstoff (CDOM) + detritus
- Backscattering by particles

To be related to light penetration & biogeochemistry

Proposed work

Derive IOPs using the GIOP framework (Werdell et al. 2013)

(1) Implement alternative approaches to:
- relate remote-sensing reflectances to IOPs
- partition total absorption into its subcomponents
- parameterize backscattering by particles

(2) Derive analytical data product uncertainties

(3) Reveal & resolve inherent differences in MODIS & VIIRS
- limit to common wavelengths
- empirical band adjustment to common wavelengths
- bio-optical band shifting to common wavelengths

(4) Validate products & distribute software via SeaDAS

(5) Become core EOS and Suomi NPP data products