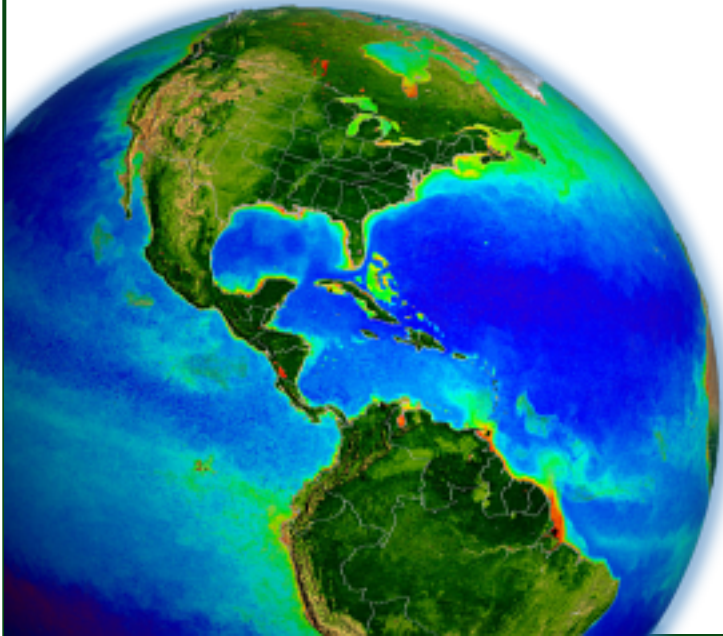


# MODIS and VIIRS Discipline Summary Report - Oceans



MODIS/VIIRS Science Team Meeting  
18-21 November 2019, College Park, MD

# Ocean Breakout Agenda

- 1:30 MODIS/VIIRS Ocean Processing Status and Plans B. Franz
- 2:30 Ocean Optics and Biogeochemical Protocols A. Mannino
- 3:30 SeaBASS Data Submission C. Proctor/V. Sanjuan
- 4:00 Open Discussion

# Update and Expansion of Ocean Optics Protocols

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

Volume 1: Inherent Optical Property Measurements and Protocols: Absorption Coefficient (v1.0)

**Vol. 1.0  
Absorption  
(particles)**

**COMPLETED  
Nov. 2018**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

Volume 2: Beam Transmission and Attenuation Coefficients: Instruments, Characterization, Field Measurements and Data Analysis Protocols (v2.0)

**Vol. 2.0 Beam-c**

**COMPLETED  
April 2019**

May 2019

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

**Vol. 3.0  
Radiometry for  
Validation**

**~COMPLETED  
Nov. 2019**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

Volume 4: Inherent Optical Property Measurements and Protocols: Best Practices for the Collection and Processing of Ship-Based Underway Flow-Through Optical Data (v4.0)

**Vol. 4.0  
Inline Flow-  
Through IOPs**

**COMPLETED  
Nov. 2019**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

**CDOM  
Absorption**

**Posted for public  
comment**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

**Particulate  
Organic Carbon**

**Posted for  
public comment**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

**Phytoplankton  
Taxonomy WG  
Data Reporting**

**Final writing  
coming 2020**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

**Scattering  
Properties**

**Writing Stage  
late 2020 ?**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

**Primary  
Productivity**

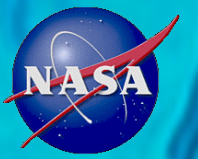
**Writing Stage  
2020-2021**

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

**Noteworthy &  
Supplemental  
Topics on Ocean  
Colour Radiometry**

**Writing Stage  
2020-2021**



## Future Protocols (for consideration)

- Suspended Particulate Matter (in house lit. review?)
- Dissolved Organic Carbon (in house lit. review?)
- Phytoplankton community enumeration, identification, biovolume
- Phytoplankton Carbon
- HPLC Pigments update
- Phycobilin Pigments
- Particle Size Distribution
- Particulate Inorganic Carbon
- Fluorescence properties

# Ocean Breakout Agenda

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4:00 Open Discussion

# Standard Products

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

\* 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.

Inherent Optical Property (IOP) suite has been in standard production for many years, selected through multiple science team iterations, documented, validated.

# SST Reprocessing Status

## VIIRS/SNPP

- MODIS continuity algorithm (PI Minnett, not reselected)
- **R2016.0** (Mid 2016) – first processing of SST for VIIRS, new quality flag based on alternating decision trees, VIIRS-specific algorithm coefficient and error tables.
- **R2016.1** (July 2018) – updated SSES tables, revised ice masking, minor fixes (changes only implemented for forward-stream).
- **R2016.2** (in progress) – new reference SST (GHRSSST L4 CMC)

## MODIS (Aqua and Terra)

- **R2019.0** (pending) – incorporates algorithm changes associated with VIIRS R2016.x, adds dust correction, updates to algorithm coefficient and error tables

Reprocessing of SNPP/VIIRS nearly complete, with algorithms and updates developed in previous Science Team cycle. Reprocessing of MODIS to follow soon, with algorithm refinements. No J1 VIIRS SST is being produced.

# PDSST Implementation Status

- Physical Deterministic SST (PDSST) algorithm (PI Koner)
- Algorithm description provided
- Prototype code and sample products provided
- SIPS integration in progress (conversion from MATLAB to C++, incorporation of additional 3<sup>rd</sup>-party library dependencies (CRTM), ancillary dependencies)
- anticipated to become a provisional product for distribution by OB.DAAC

Ocean SIPS is working on implementation of the PDSST algorithm, with expectation of full production and distribution as a Provisional Product. Computationally expensive, but potential for much improved coverage with equal or better validation results.



# Ocean Color Reprocessing R2018.0

## Completed

- VIIRS/SNPP (Dec 2017), MODIS/Aqua (Jan 2018), MODIS/Terra (April 2018), and **VIIRS/JPSS1** (Sep 2018)

## Purpose

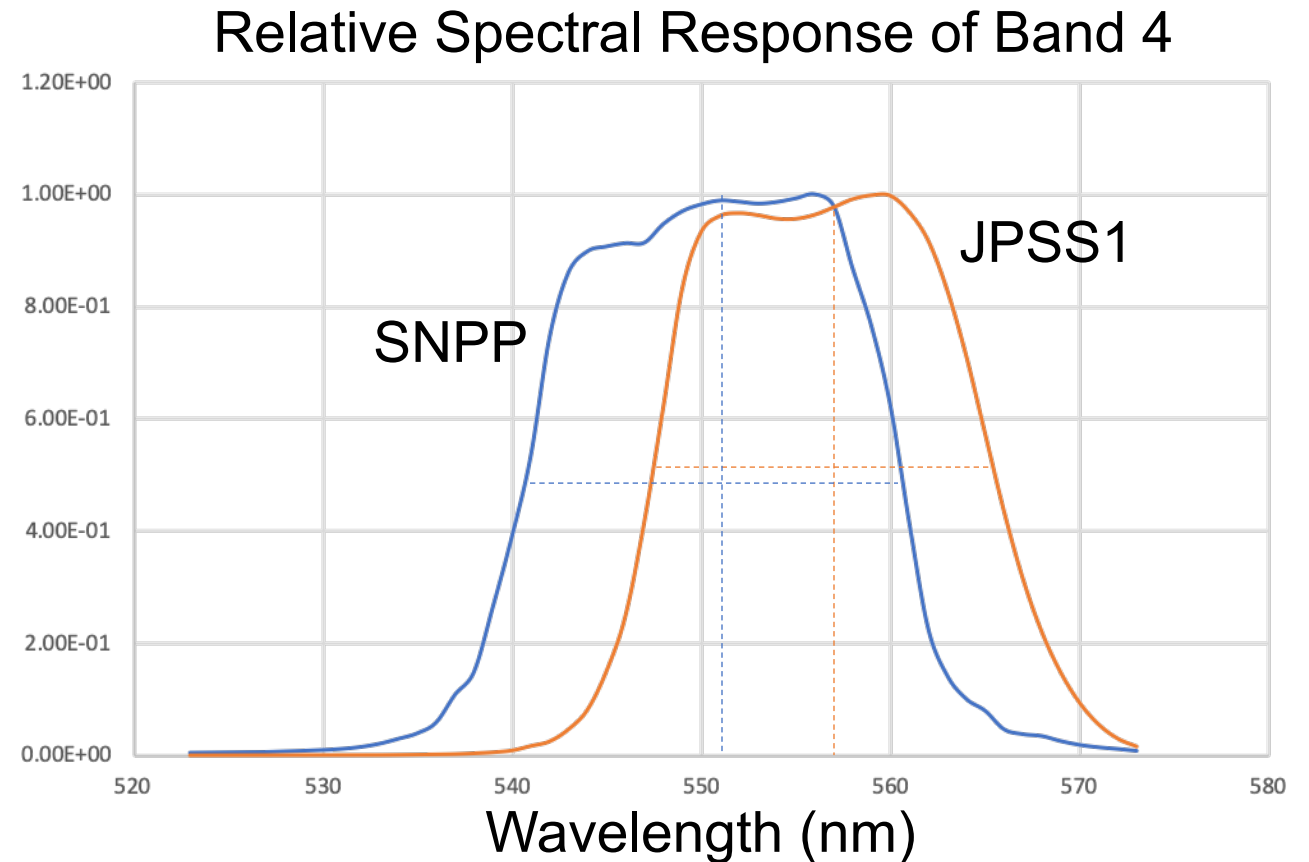
- incorporate updates to vicarious calibration due to revised MOBY time-series
- incorporate updates to instrument calibration
- no algorithm changes since R2014.0
- **first processing for VIIRS on JPSS-1**

JPSS-1 VIIRS has been fully integrated into the current ocean color processing (R2018.0) and OBPG product validation system. Vicarious cal to SNPP, no temporal cal.

# VIIRS Spectral Band Centers and Widths

Band Center and FWHM (nm)

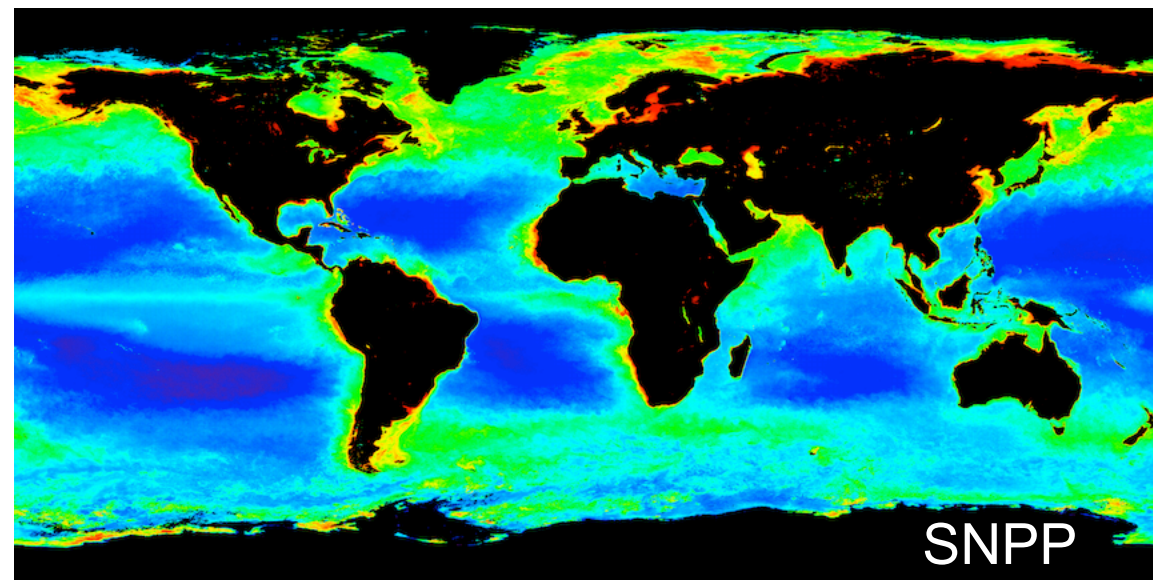
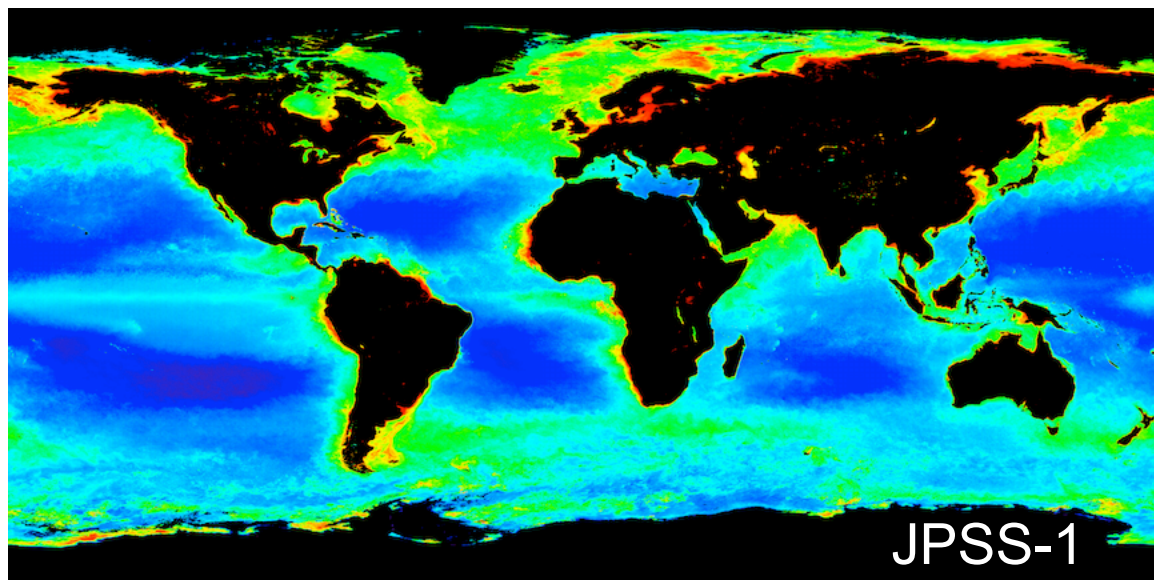
SNPP VIIRS	J1 VIIRS
410 (20)	411 (18)
443 (15)	445 (17)
486 (19)	489 (19)
551 (20)	556 (18)
671 (19)	667 (19)
745 (14)	746 (13)
862 (38)	868 (36)
1238 (26)	1238 (26)
1601 (60)	1604 (60)
2257 (46)	2258 (52)



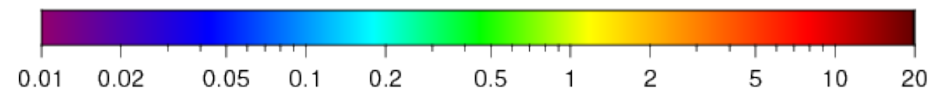
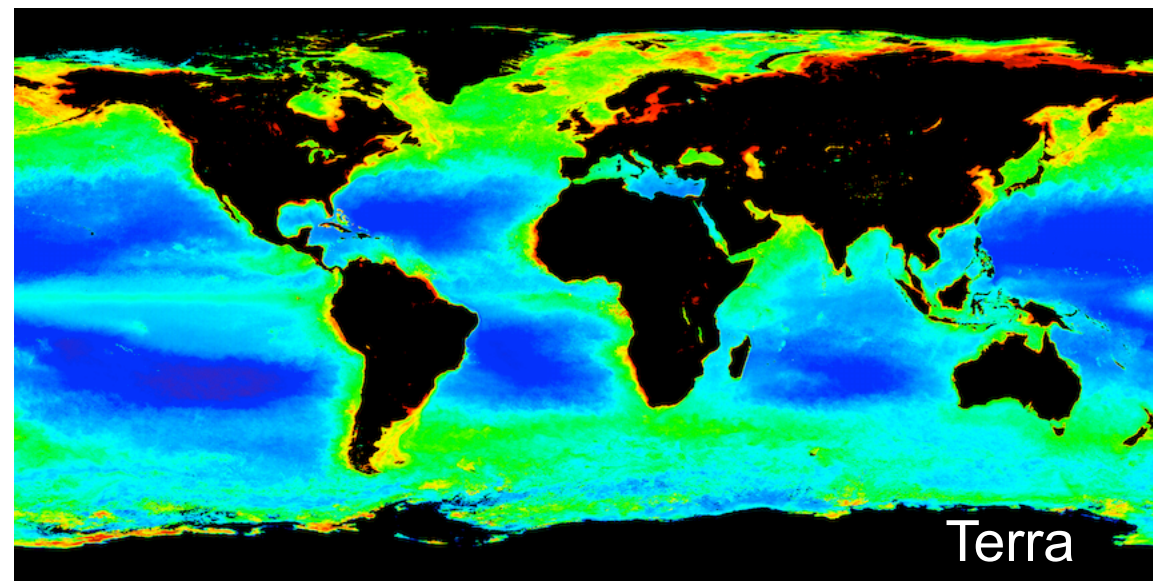
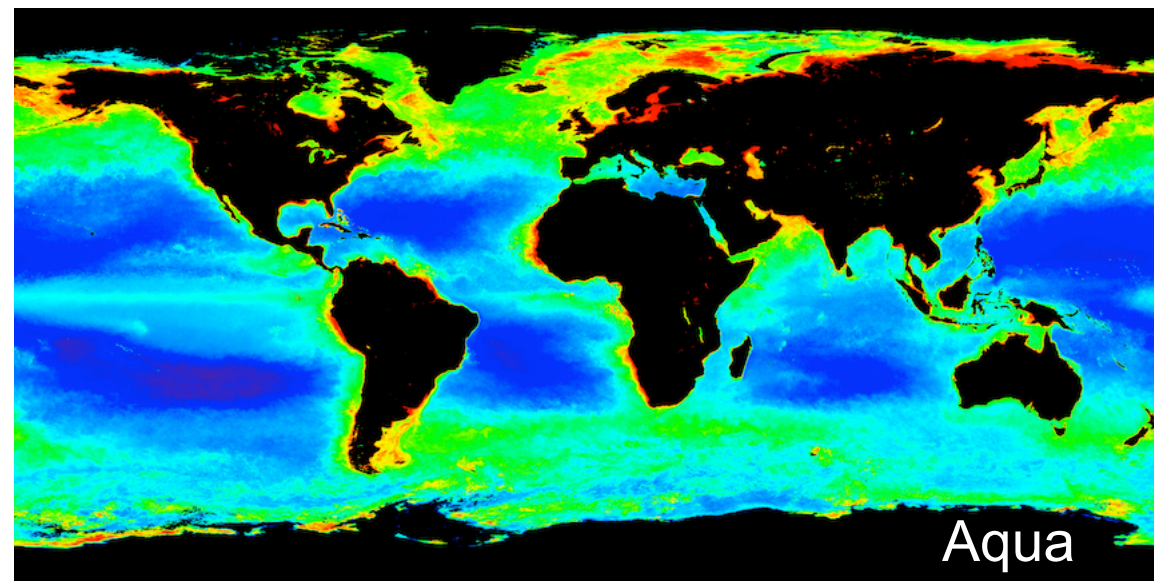
The two VIIRS instruments are not created equal. Significant differences in spectral bands. note: Rrs is reported at the nominal spectral band centers, based on the measured SRF.

# Annual Mean Chlorophyll Concentration for 2018

VIIRS



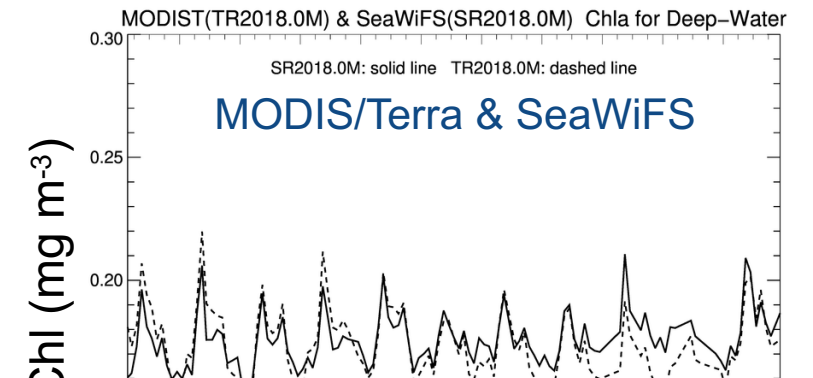
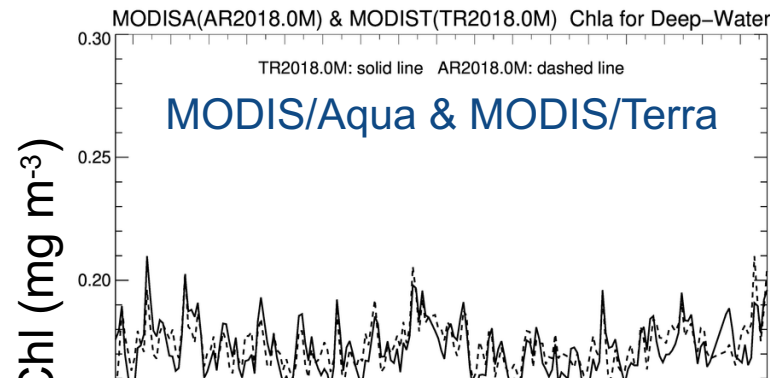
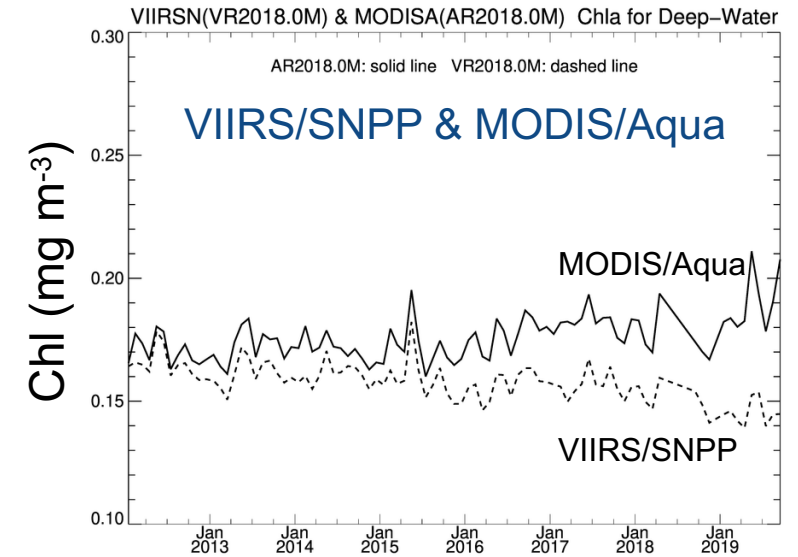
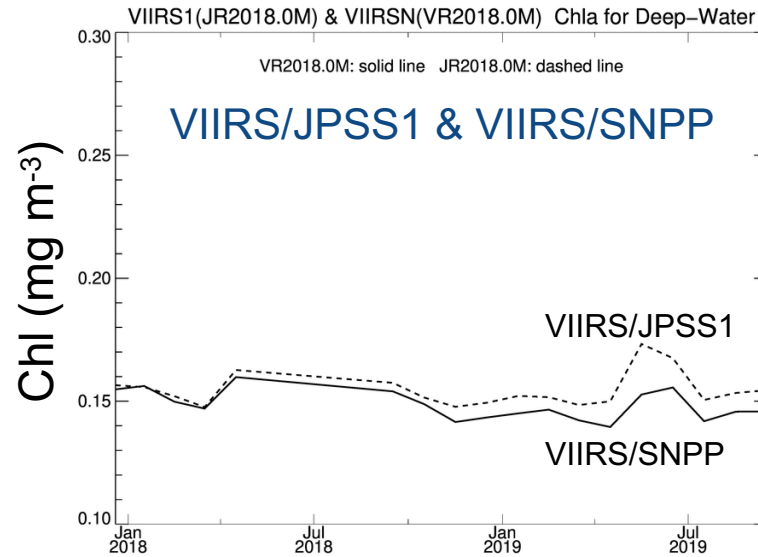
MODIS



# Global Deep-Water Chlorophyll Trends

Comparison trends over common mission lifetime

- SeaWiFS, MODIS/Terra, MODIS/Aqua in good agreement, with short-term deviations
- VIIRS/SNPP shows negative trend relative to VIIRS/JPSS1 & MODIS/Aqua



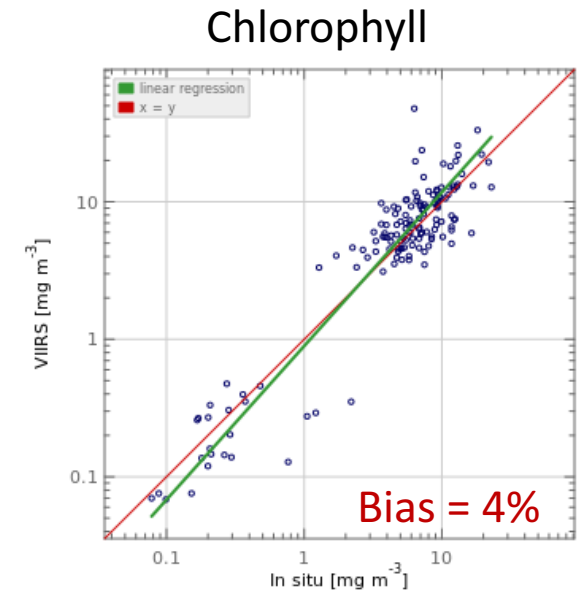
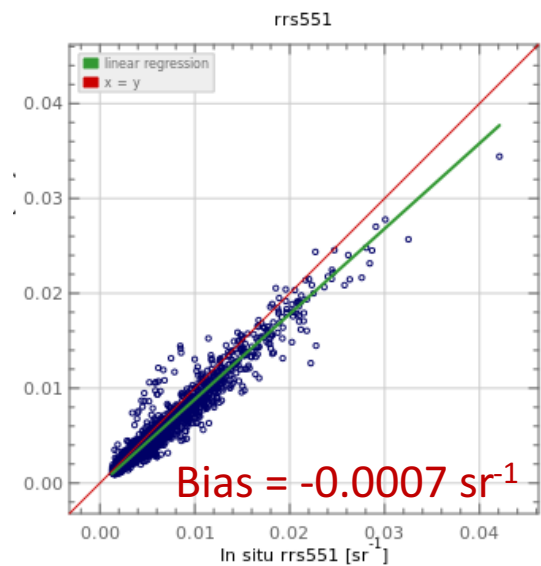
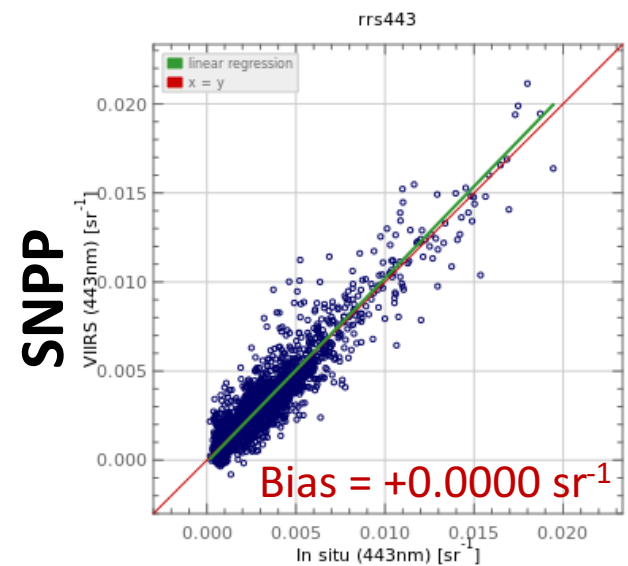
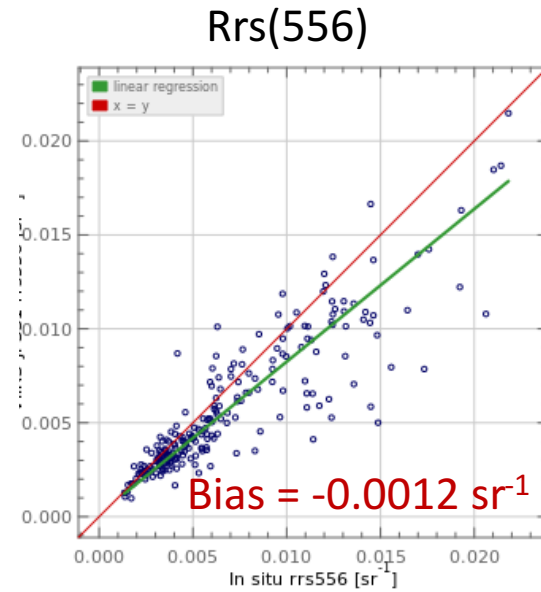
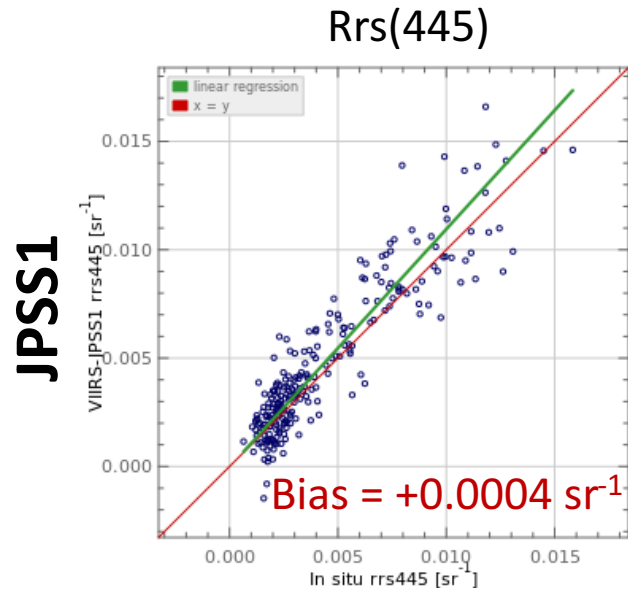
SNPP VIIRS current products showing suspect drift in blue bands (445, 486). Presentation by Eplee on Monday described our efforts to resolve through improved modeling of lunar and solar calibration and corrections for modulated SRF.

# VIIRS R2018.0 Validation

Match-ups to SeaBASS and AERONET-OC

- VIIRS/SNPP Rrs and Chlorophyll in very good agreement with in situ
- VIIRS/JPSS1 Rrs in good agreement, but with larger differences based on limited match-ups

*VIIRS/SNPP showed significant reduction in bias from R2014 to R2018 (not shown)*



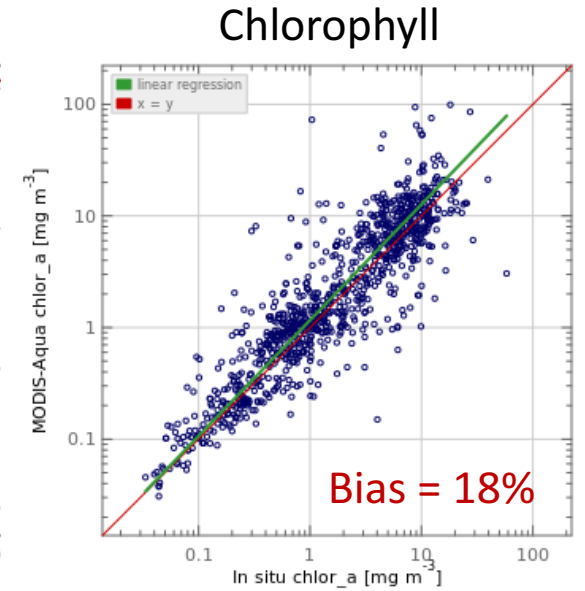
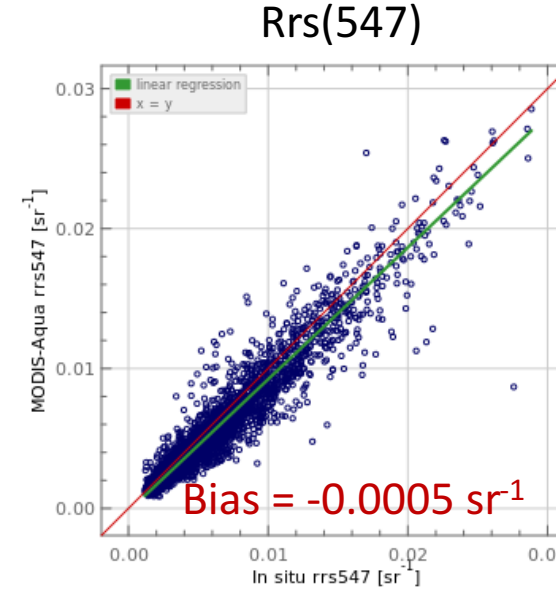
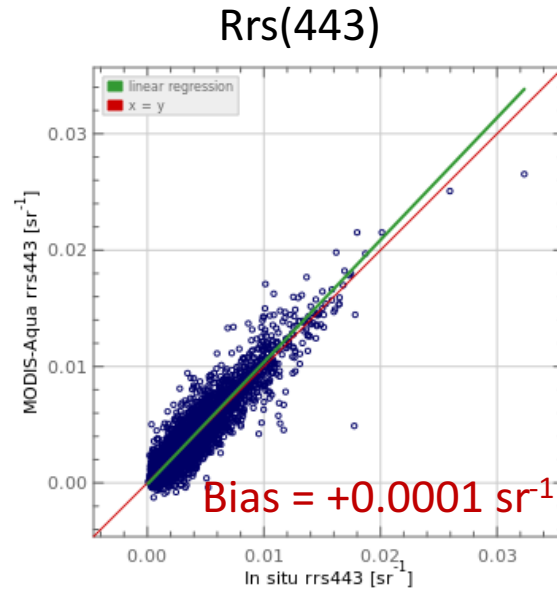
# MODIS R2018.0 Validation

Match-ups to SeaBASS and AERONET-OC

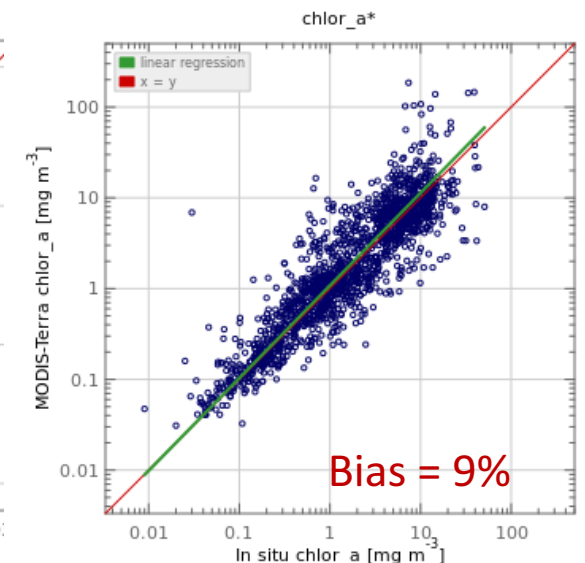
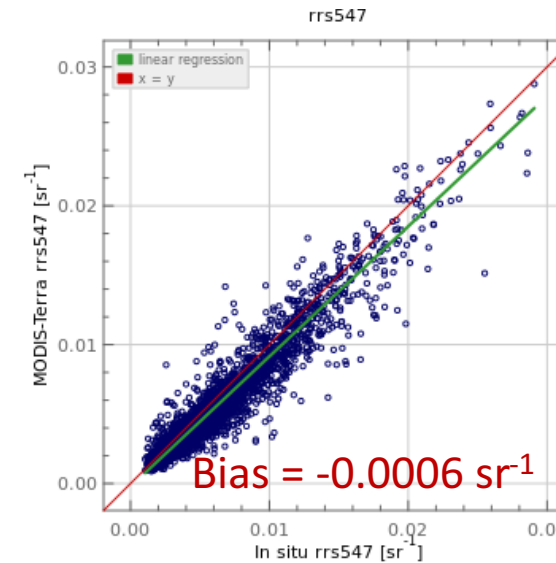
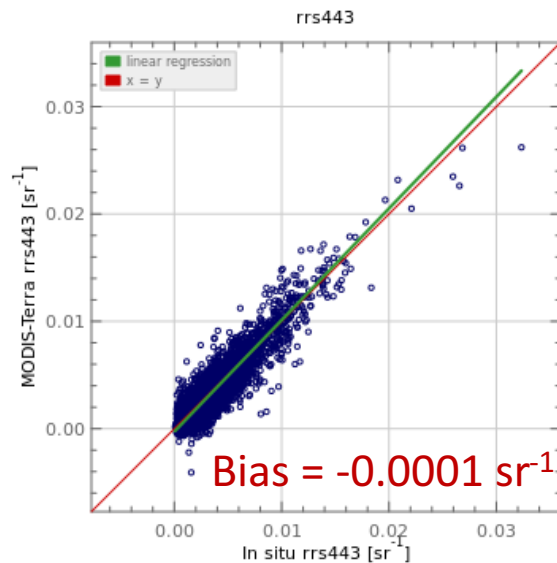
- MODIS Rrs and Chl from Aqua and Terra in good agreement with in situ
- Mean bias in Rrs remains near zero

*MODIS showed significant reduction in bias from R2014 to R2018 (not shown)*

**Aqua**



**Terra**



# In situ Rrs Match-up Statistics

field data from AERONET-OC and SeaBASS

$\lambda$ (nm)	Mean Bias ( $\text{sr}^{-1}$ )		MAE ( $\text{sr}^{-1}$ )	
	Aqua	Terra	Aqua	Terra
412	0.00001	-0.00031	0.00102	0.00106
443	0.00005	-0.00014	0.00077	0.00079
488	-0.00054	-0.00053	0.00079	0.00078
531	-0.00055	-0.00053	0.00078	0.00076
547	-0.00050	-0.00055	0.00078	0.00079
555	-0.00079	-0.00080	0.00094	0.00094
667	-0.00017	-0.00018	0.00029	0.00030
678	-0.00016	-0.00019	0.00033	0.00036

$\lambda$ (nm)	Mean Bias ( $\text{sr}^{-1}$ )		MAE ( $\text{sr}^{-1}$ )	
	JPSS1	SNPP	JPSS1	SNPP
410	-0.00072	-0.00036	0.00130	0.00105
443	0.00041	0.00002	0.00110	0.00077
486	-0.00062	-0.00063	0.00108	0.00088
551	-0.00115	-0.00071	0.00150	0.00088
671	-0.00034	-0.00020	0.00050	0.00029

- MODIS (Aqua & Terra) and VIIRS/SNPP show very similar agreement with in situ measurements
- VIIRS/JPSS1 shows larger Mean Bias and MAE, based on limited match-ups, with no temporal calibration and no vicarious cal to MOBY

# NASA Ocean Color Reprocessing 2020.0

Planning for Spring 2020, first major update of algorithms since R2014.0

1. updates to ancillary data sources
  - from NCEP/TOMS-OMI/etc. to MERRA-2 assimilation product
2. updates to atmospheric correction methods and tables
  - multi-scattering aerosol selection, potential use of NIR-SWIR (Ibrahim et al. 2019, Frontiers), improved gas corrections (H<sub>2</sub>O), bug in Rayleigh tables at extreme solar zenith, error propagation
3. updates to pure seawater optical properties (nw, aw, bbw)
  - apply temperature & salinity dependence (e.g., Werdell et al. 2013), bug in pure-water aw/bbw (off by few nm)
4. updates to masks and flags
  - reduced straylight masking (Hu et al. 2019, JGRO), absorbing aerosol flag based on MERRA-2 transport model
5. updates to derived product algorithms
  - chlor-a coefficient update (Hu et al. 2019, JGRO; O'Reilly and Werdell, 2019)
6. new products
  - Rrs uncertainties (TBD), new standard products (TBD)

CHL algorithm refinements

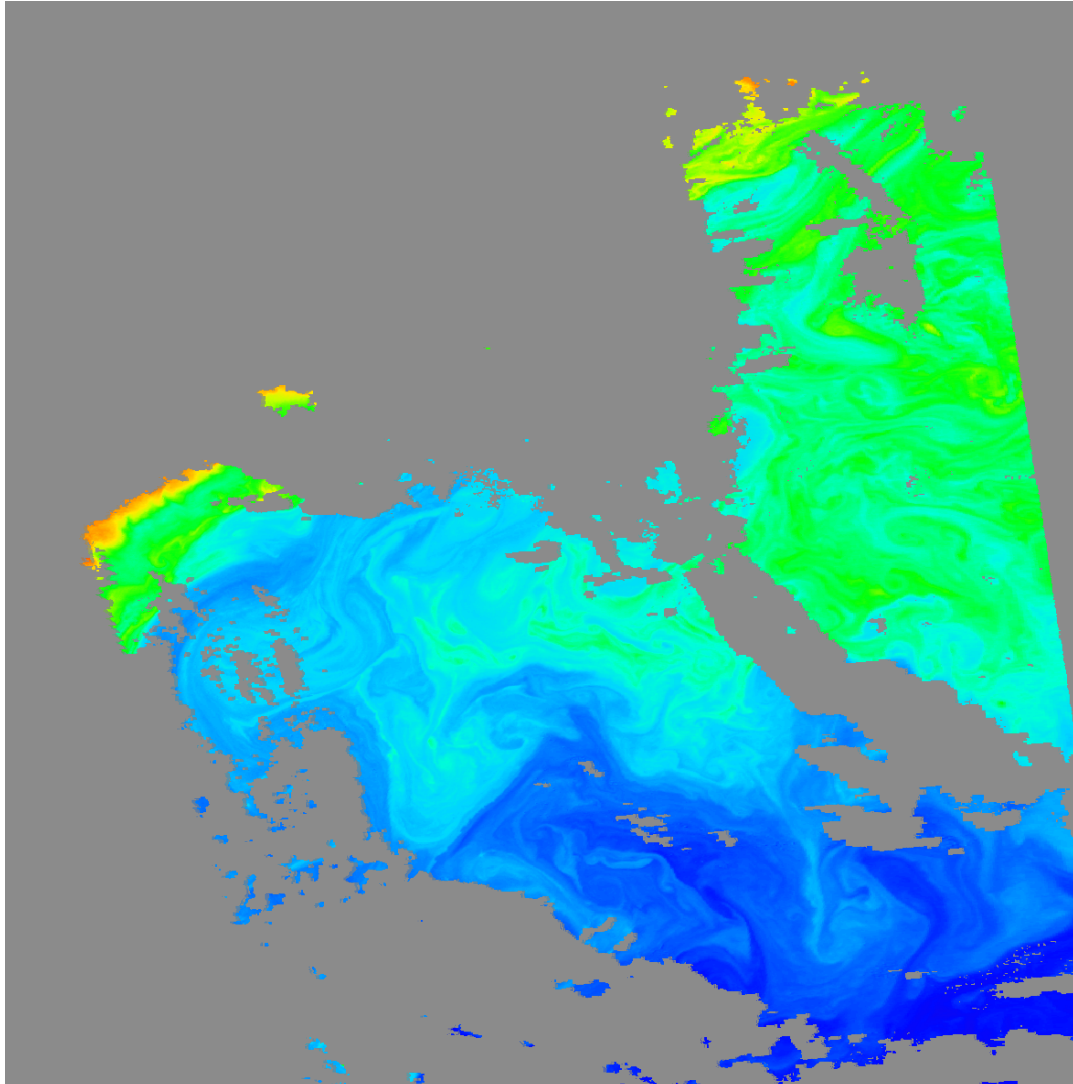
PIC updates, bb\*

POC algorithm refinement

PAR uncertainties



# Higher Spatial Resolution Level-3 Products



- Standard Level-3 products are based on binning from Level-2 native resolution into quasi-equal-area bins at 4.6x4.6km, using the center location of the observation.
- Users frequently ask for higher resolution binned/mapped data products, or produce them with the standard binner in SeaDAS.
- Result is poor quality imagery and invalid statistics due to pixel growth from nadir to scan edge.
- OBPG developed an efficient mechanism to approximate the observational footprint of each pixel and weight the contribution into the fixed geographical bins.
- Updated binner will be distributed with SeaDAS, and may be utilized in next reprocessing to produce higher-resolution standard products.

Questions?

# Product 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), a living document that includes:
  1. a brief description of the product and it's purpose
  2. a brief description of the algorithm with links to associated publications for more details
  3. details of implementation differences for each sensor
  4. direct links to source code for even more details (live links)
  5. product validation results (live links)

ESDS has responded with initiation of an on-line tool for development of algorithm documentation, called the NASA Algorithm Publication Tool (APT).

[https://docs.google.com/presentation/d/1i\\_jw2ilrFc0VPWmbIHLbVfY-5SHu-e3iwY25h0fo2VA/edit#slide=id.p](https://docs.google.com/presentation/d/1i_jw2ilrFc0VPWmbIHLbVfY-5SHu-e3iwY25h0fo2VA/edit#slide=id.p)

The Ocean SIPS has been participating in requirements development and testing.