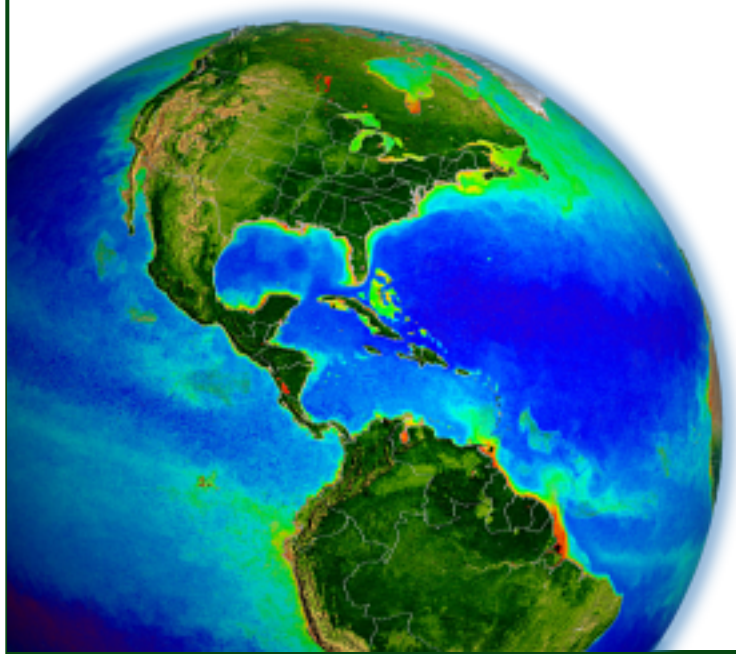
Ocean Discipline Break-out



MODIS/VIIRS Science Team Meeting

18-21 November 2019, College Park, MD

Agenda

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

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

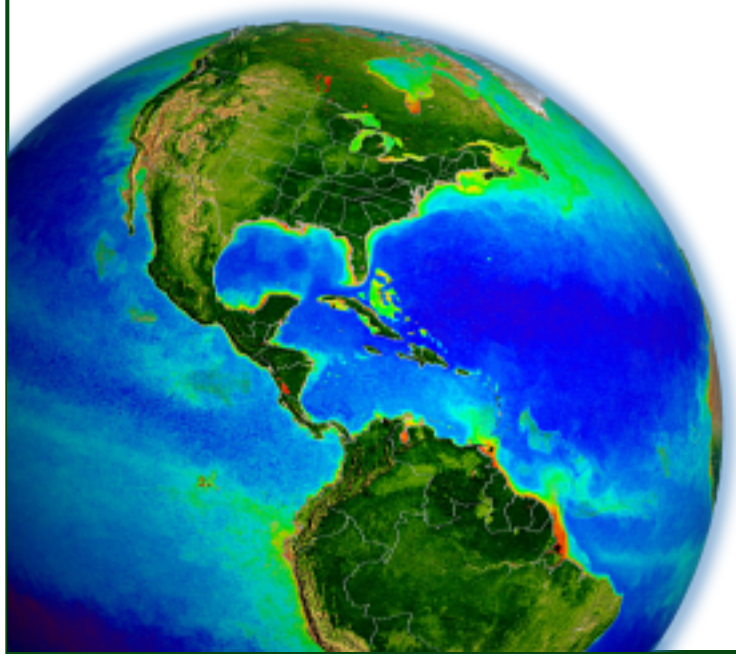
PI	Title	Products
W. Balch	Particulate Inorganic Carbon	PIC
B. Franz	Remote Sensing Reflectance, Chlorophyll, Diffuse Attenuation	Rrs, Chl, Kd490
R. Frouin	Photosynthetically Available Radiation	PAR
P. Minnett	Sea Surface Temperature	SST
T. Westberry	Fluorescence Line Height	FLH

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 Color Processing Status & Plans



MODIS/VIIRS Science Team Meeting

18-21 November 2019, College Park, MD

Contents

1. Standard and Provisional Ocean Products
2. Status of MODIS & VIIRS SST processing
3. Status of MODIS & VIIRS Ocean Color processing
4. Plans for the next multi-mission Ocean Color reprocessing

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*	*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*

* 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 would 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), 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)

ESD 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

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

SST Reprocessing Status

VIIRS/SNPP

- MODIS continuity algorithm (PI Minnett)
- **R2016.0** (Mid 2016) – first processing of SST for VIIRS, new quality flag approach based on alternating decision trees, VIIRS-specific algorithm coefficient and SSES 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 (GHRSST 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

PDSST Implementation Status

- Physical Deterministic SST (PDSST) algorithm (PI Koner)
- Algorithm description provided
- Prototype code and sample products provided
- Integration in progress (conversion from MATLAB to C++, incorporation of additional 3rd-party library dependencies (CRTM), ancillary dependencies)

Ocean Color Reprocessing R2018.0

Completed

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

Purpose

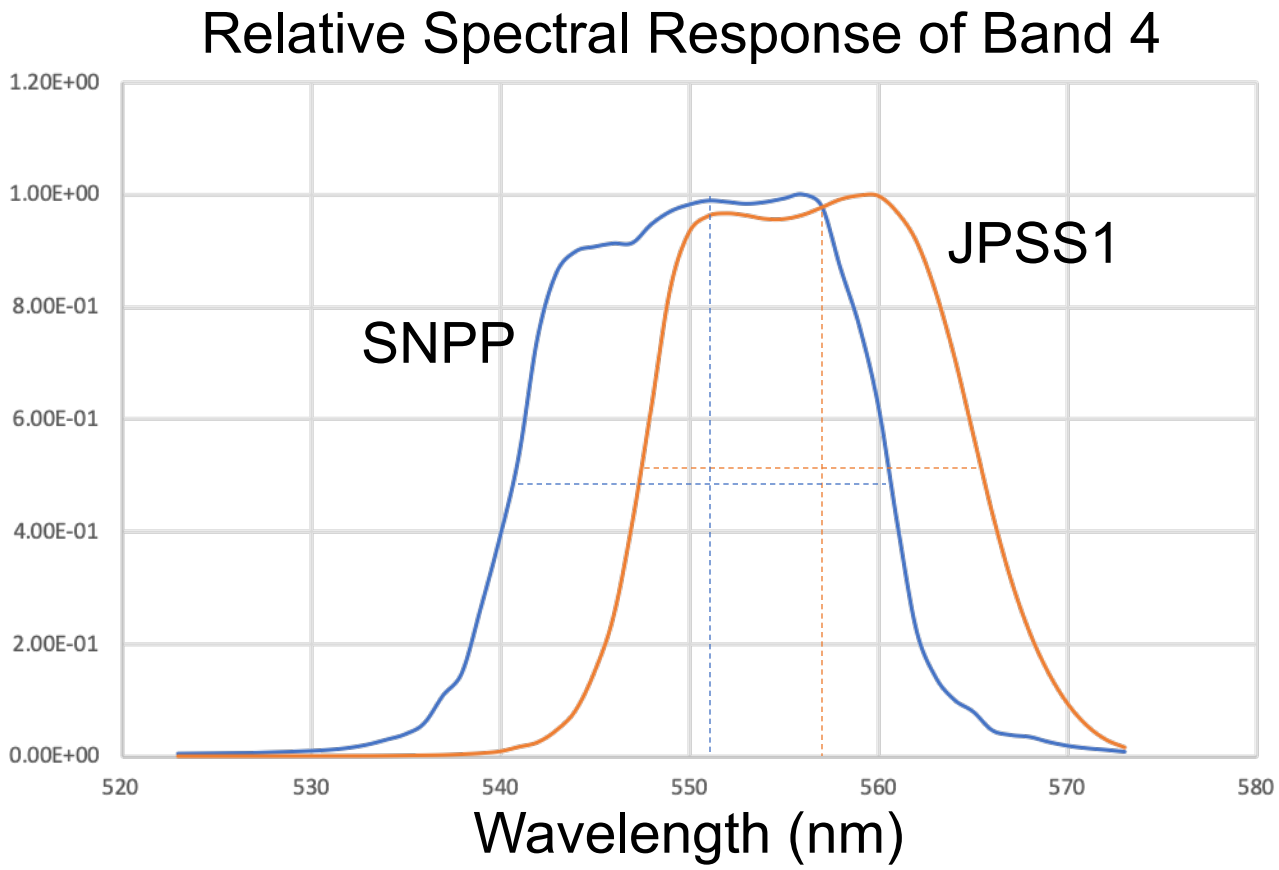
- incorporate updates to vicarious calibration due to revised MOBY time-series
- incorporate updates to instrument calibration
- no algorithm changes since R2014.0

- **first processing for VIIRS on JPSS-1**
  - algorithms identical to SNPP VIIRS
  - instrument calibration as-is (no temporal calibration)
  - used SNPP for vicarious cal

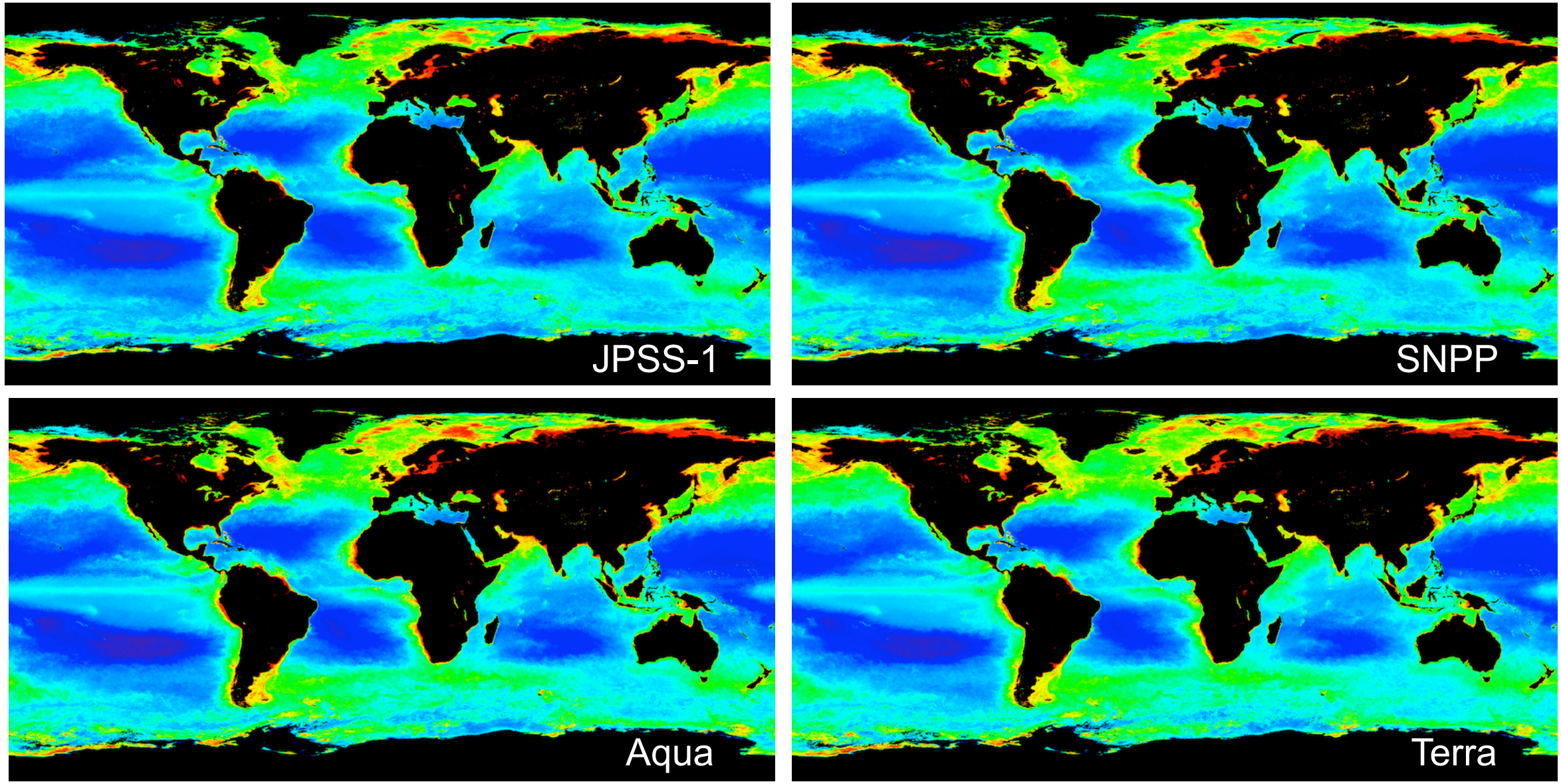
VIIRS Spectral Band Centers and Widths

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)



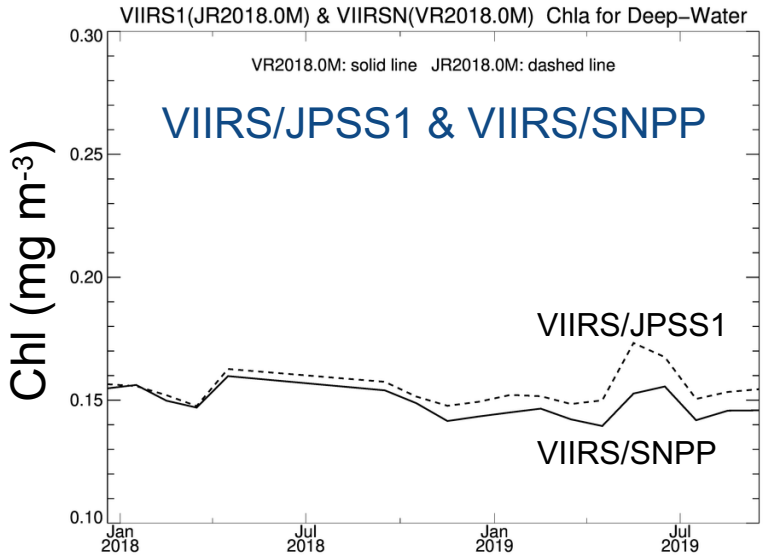
Annual Mean Chlorophyll Concentration for 2018

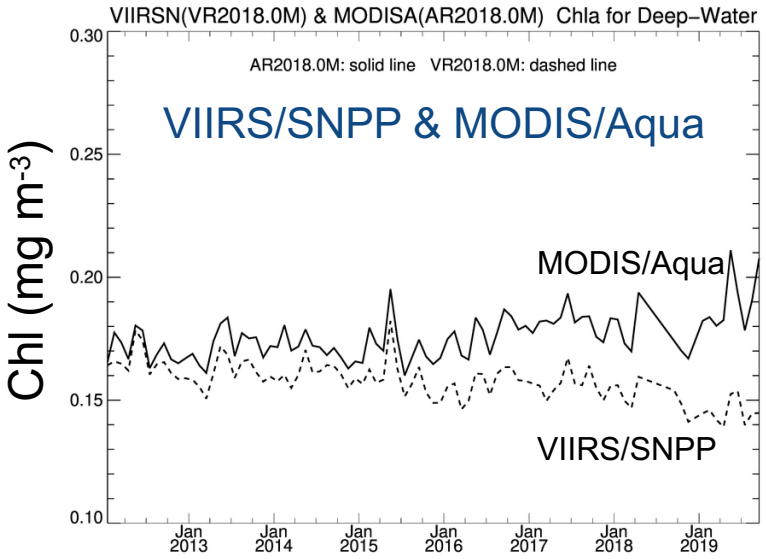


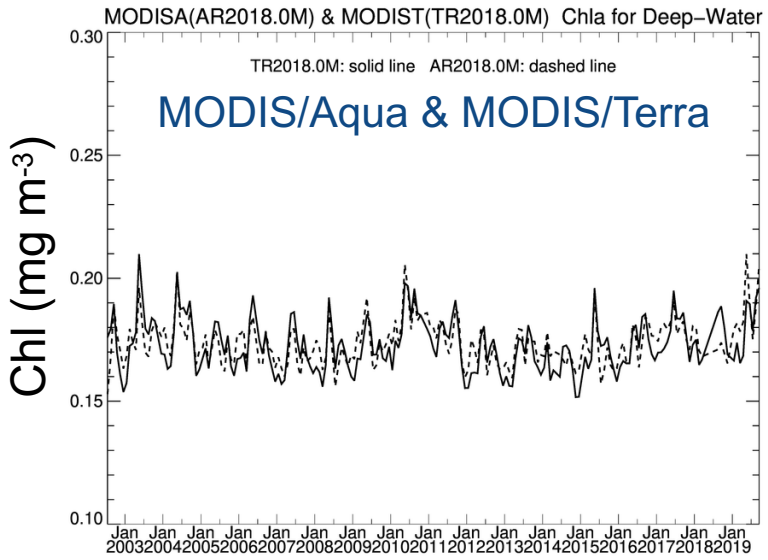
Global Deep-Water Chlorophyll Trends

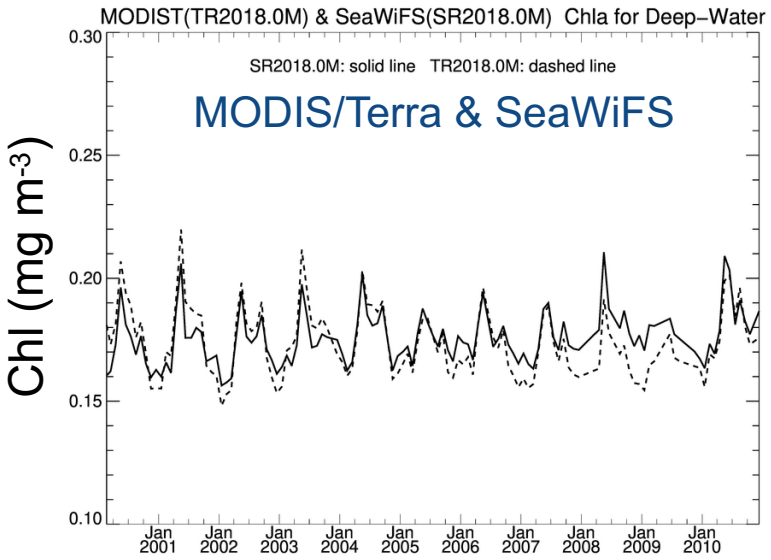
Comparison trends over common mission lifetime

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





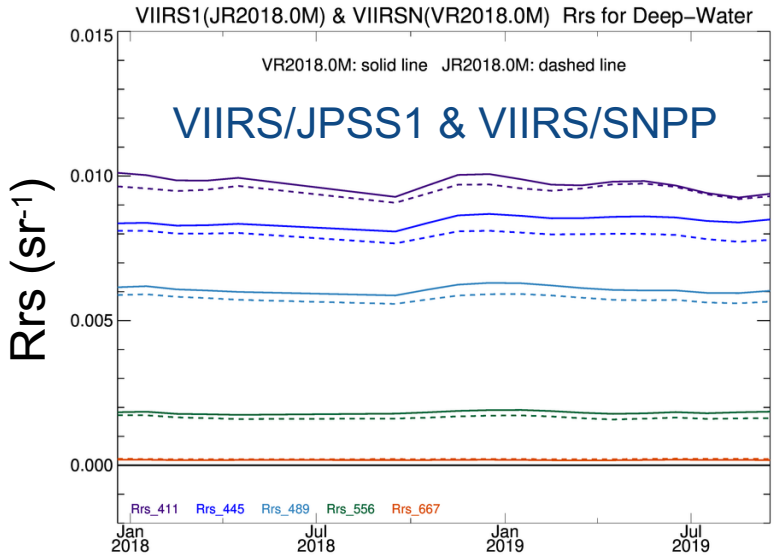


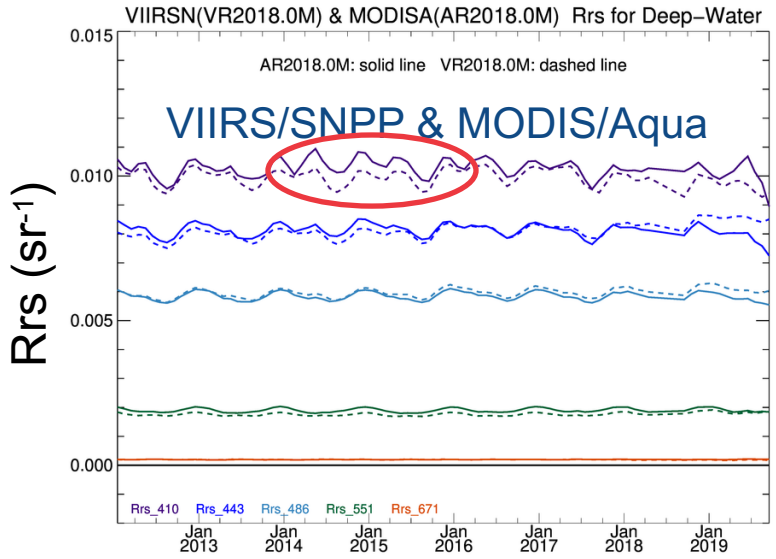


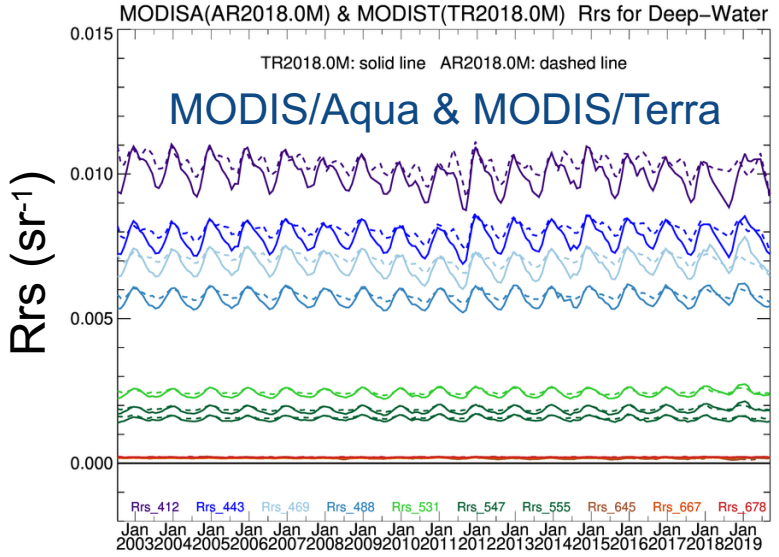
Global Deep-Water Rrs Trends

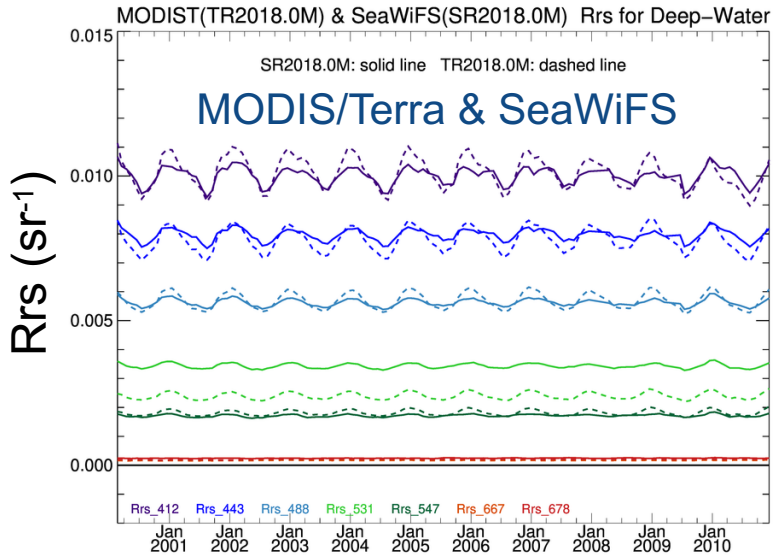
Comparison trends over common mission lifetime

- SeaWiFS, MODIS/Aqua, and MODIS/Terra show good agreement.
- VIIRS/SNPP shows bias and trends in blue relative to MODIS/Aqua and VIIRS/JPSS1





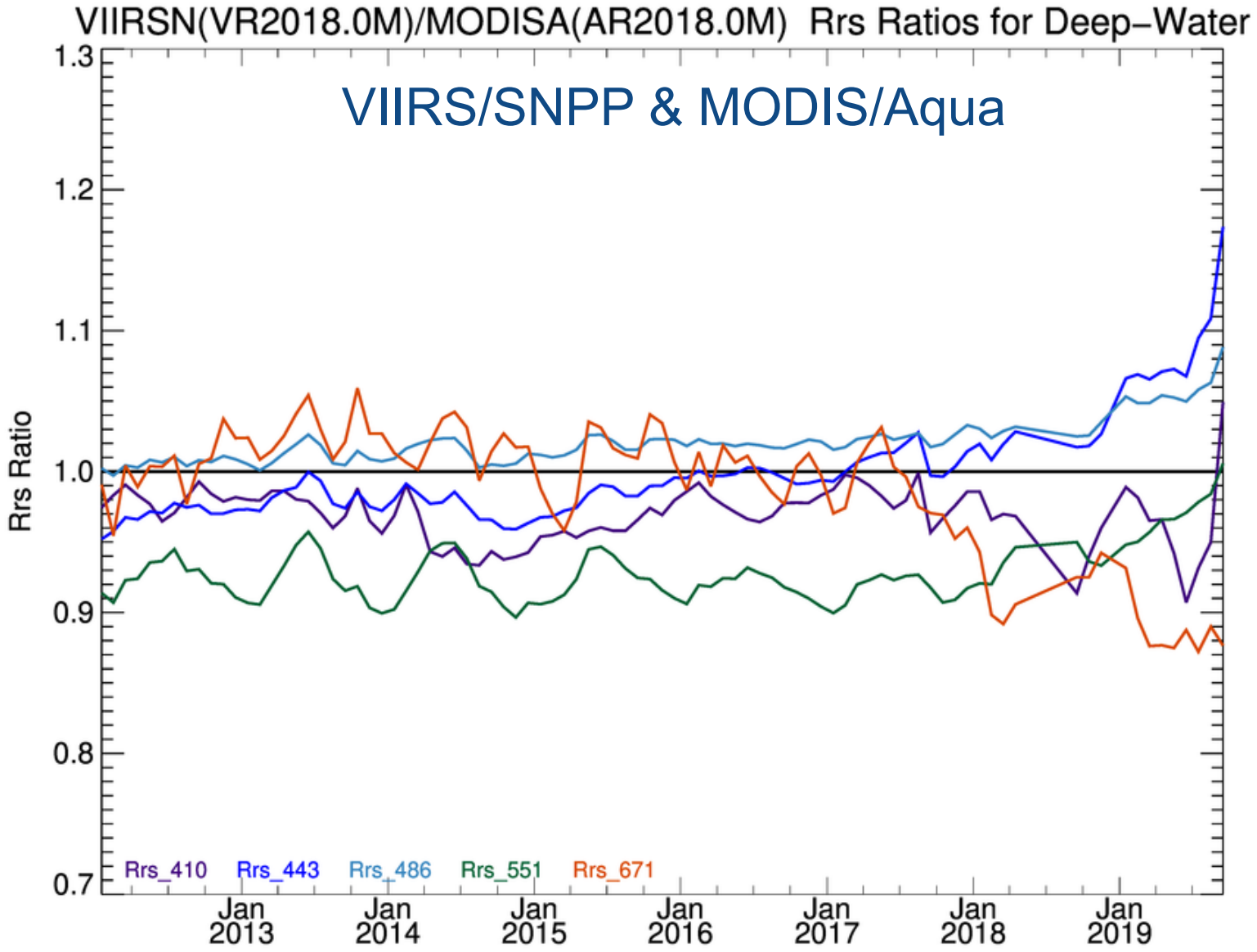




VIIRS/SNPP & MODIS/Aqua R2018.0 Rrs Ratios

Comparison trends over common mission lifetime

- positive trends in 443, 486, and 551,
- negative trends in 412 and 671



VIIRS/SNPP Calibration Update

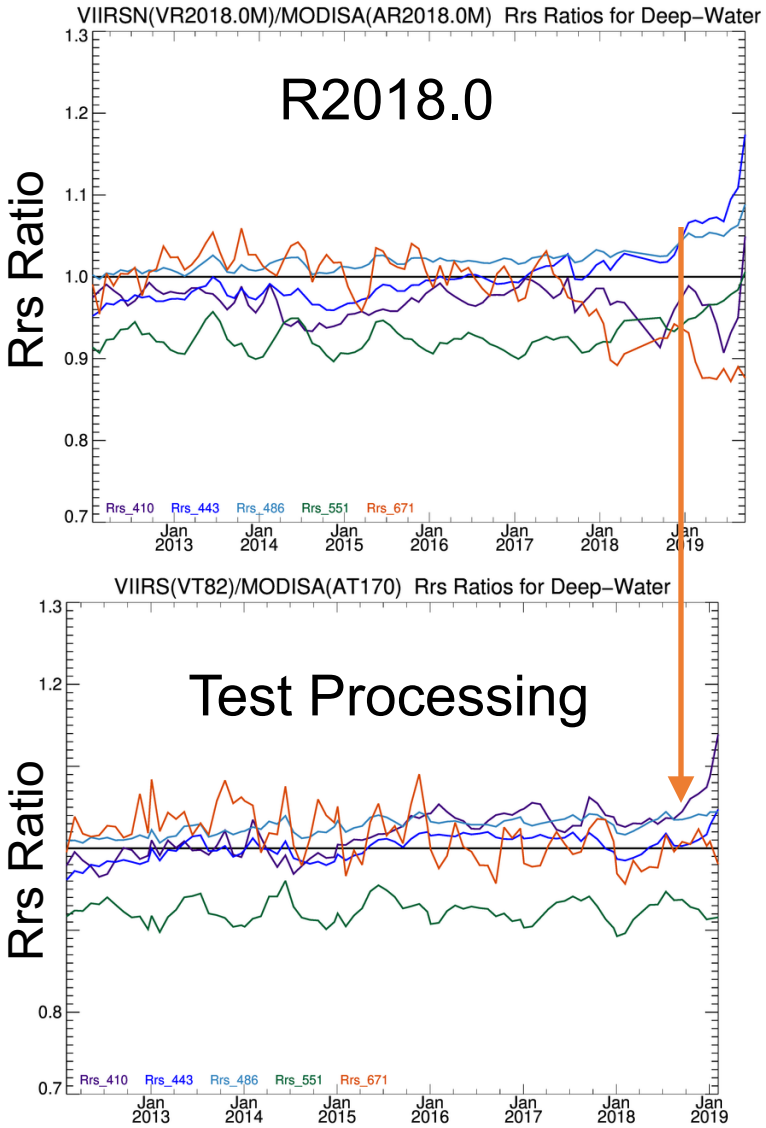
Calibration Changes for Next Reprocessing

- extension of lunar/solar time-series with new measurements
- revised model for temporal fit to lunar time-series (exponential in time + linear with libration), used to correct the solar time-series
- no lunar correction applied to M6 (no detectable trend above noise)
- temporal gain adjustments for impact of modulated RSRs on ocean/atmosphere signal, for bands M1-M7

Impact to Rrs Timeseries

- reduces trends in blue relative to MODIS/Aqua (and J1 VIIRS)
- brings 412 into family with other blue bands (443, 486)
- testing/refinements on-going in preparation for reprocessing

VIIRS/SNPP & MODIS/Aqua



VIIRS R2018.0 Validation

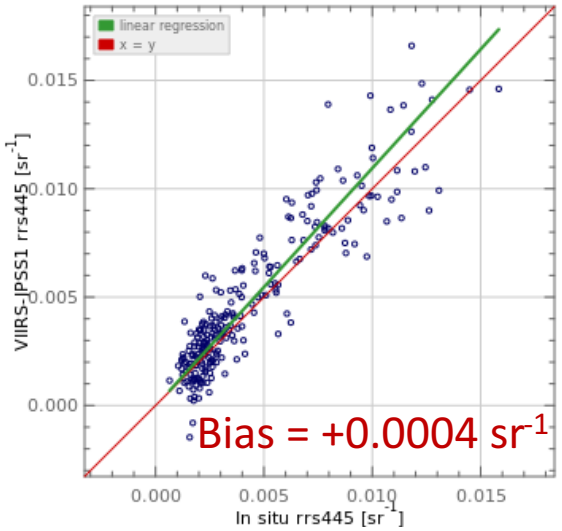
Match-ups to SeaBASS and AERONET-OC

- 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

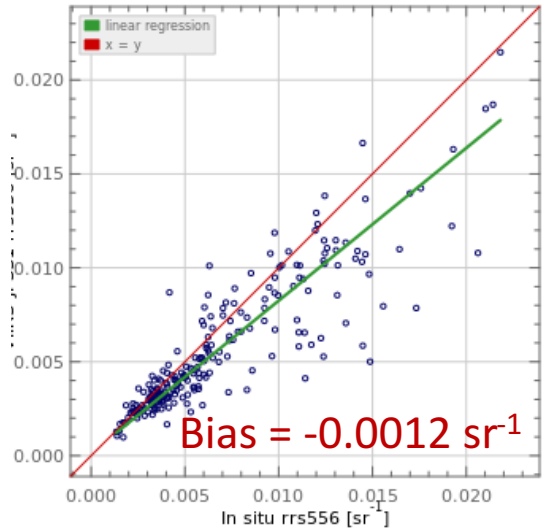
VIIRS/SNPP showed significant reduction in bias from R2014 to R2018 (not shown)

JPSS1

Rrs(445)

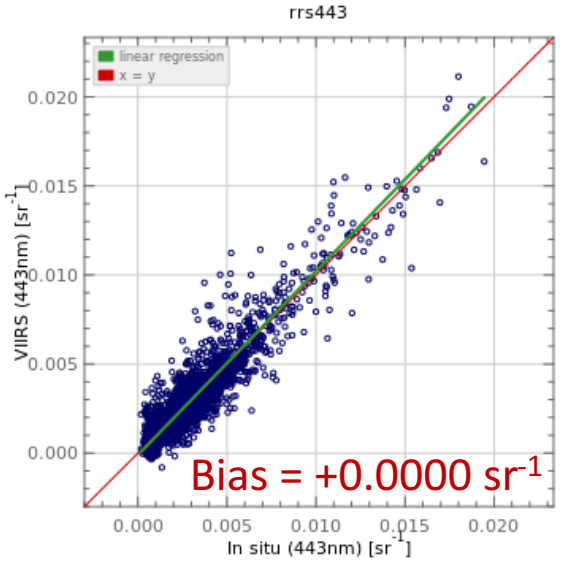


Rrs(556)

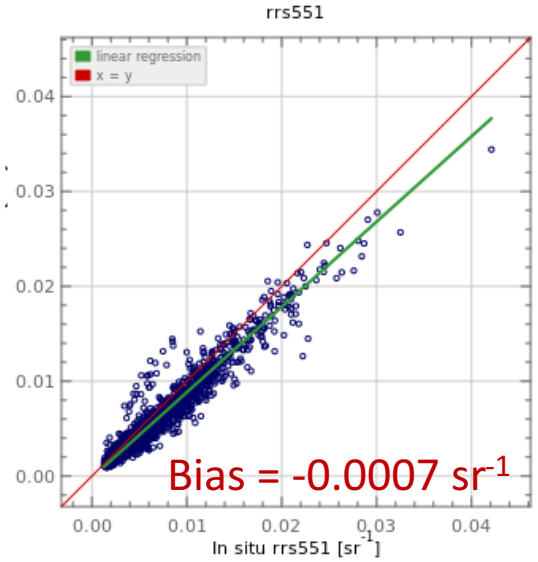


SNPP

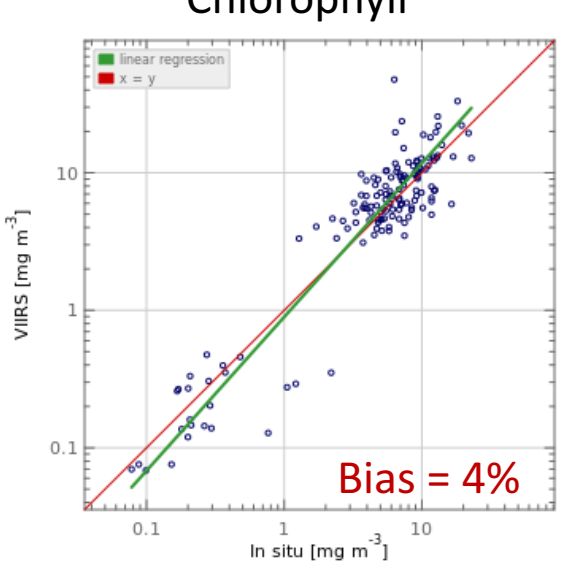
rrs443



rrs551



Chlorophyll

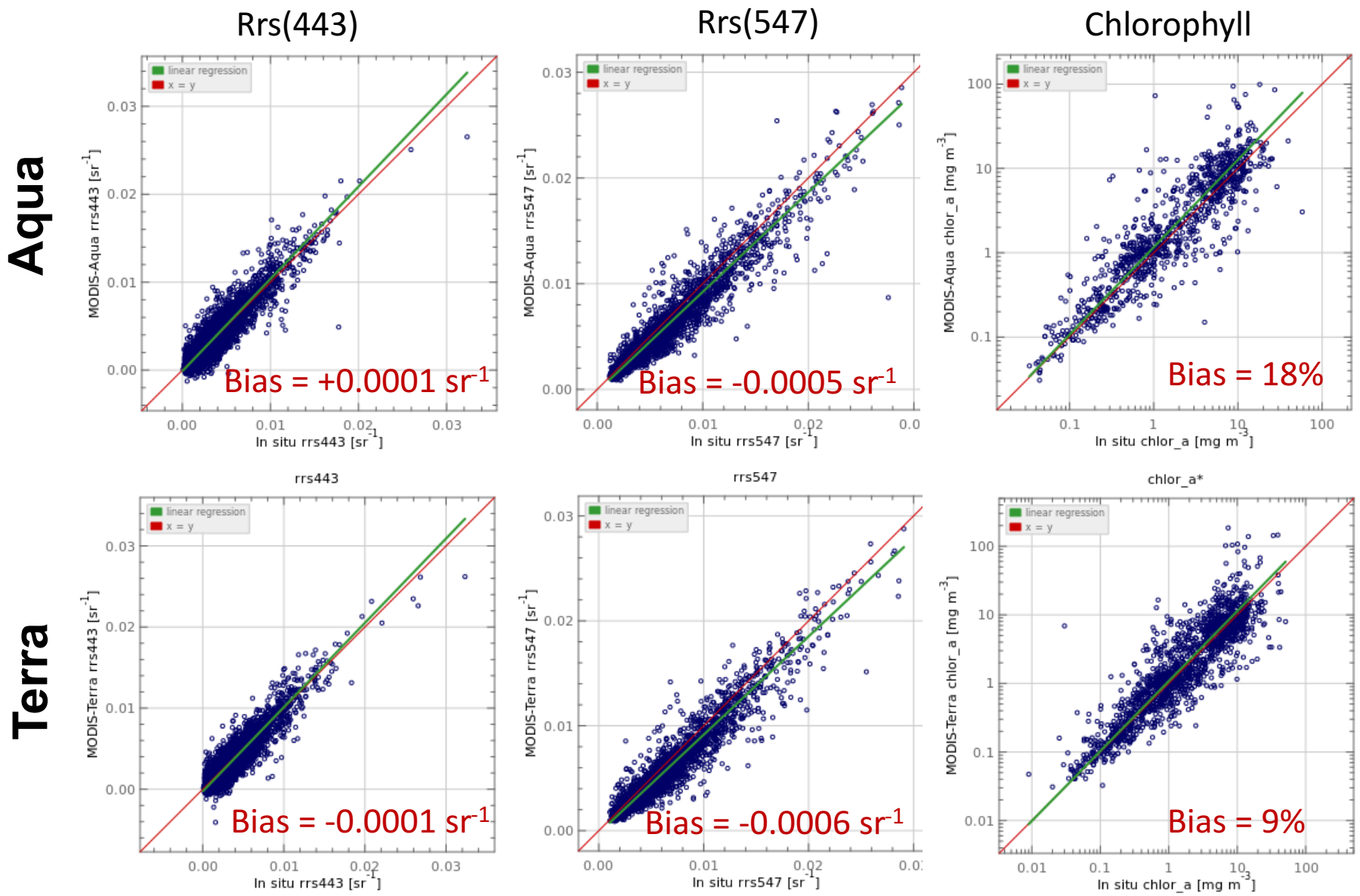


MODIS R2018.0 Validation

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)



In situ Rrs Match-up Statistics

field data from AERONET-OC and SeaBASS

λ (nm)	Mean Bias (sr^{-1})		MAE (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

λ (nm)	Mean Bias (sr^{-1})		MAE (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

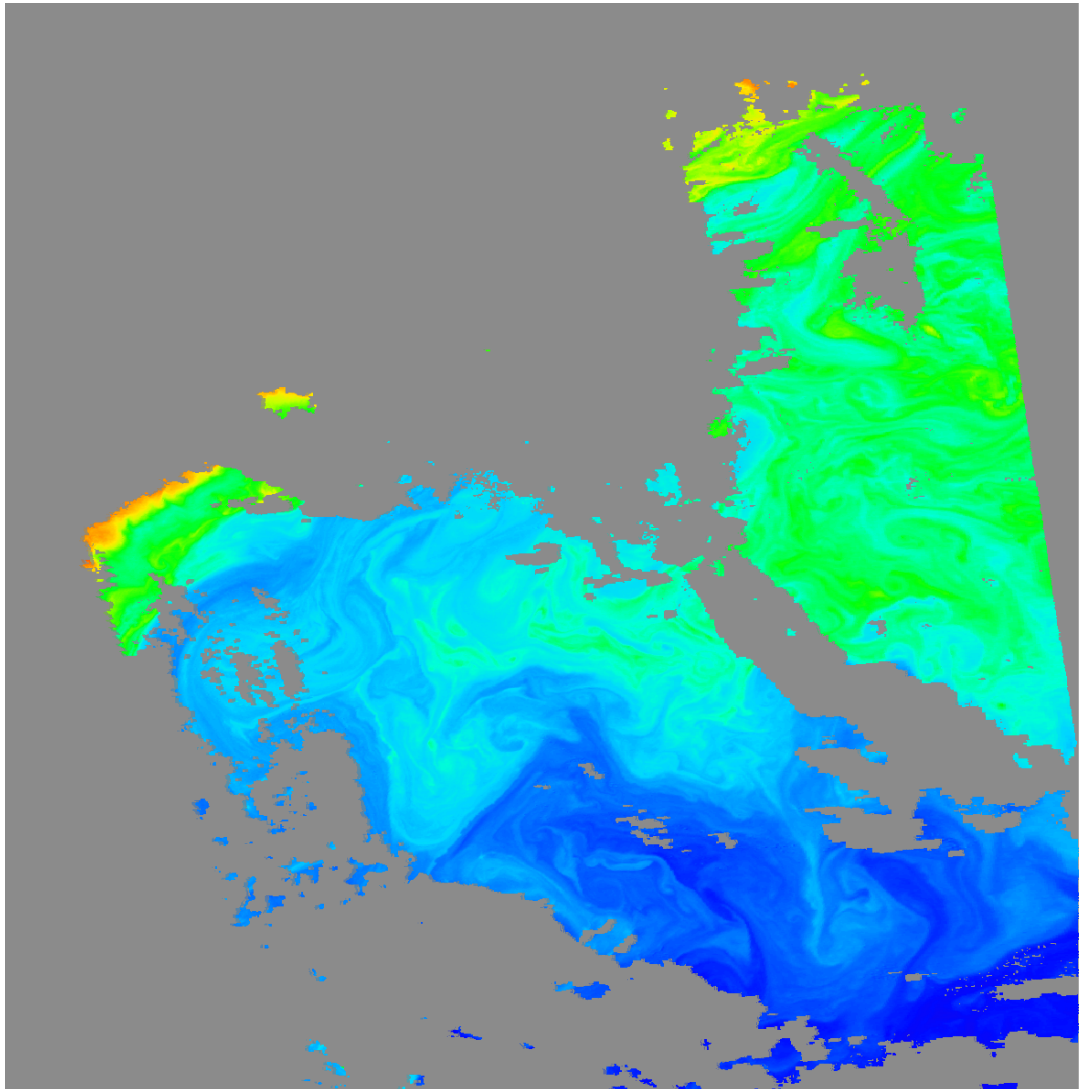
- MODIS (Aqua & Terra) and VIIRS/SNPP show very similar agreement with in situ measurements
- MODIS/Terra does shows larger biases in blue bands relative to MODIS/Aqua
- VIIRS/JPSS1 shows larger Mean Bias and MAE, based on limited match-ups, with no temporal calibration and no vicarious cal to MOBY

NASA Ocean Color Reprocessing 2020.0

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

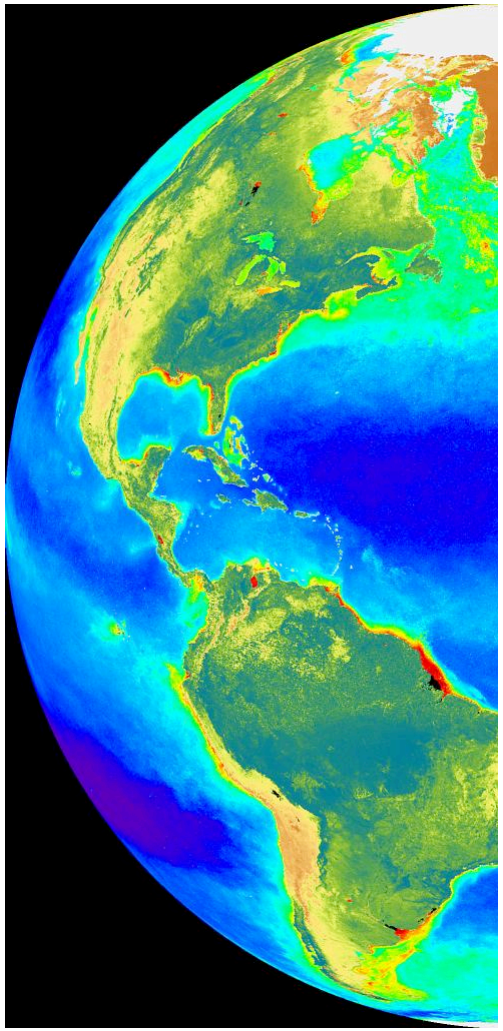
1. updates to ancillary data sources
   - from NCEP/TOMS-OMI/etc. to MERRA-2 assimilation product
2. updates to atmospheric correction methods and tables
   - multi-scattering aerosol selection, potential use of NIR-SWIR (Ibrahim et al. 2019, Frontiers), improved gas corrections (H2O), bug in Rayleigh 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), pic tables, etc.
6. new products
   - Rrs uncertainties (TBD), new standard products (TBD)

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.

Other Stuff



Full processing and distribution of OLCI (S3A & S3B) with standard NASA algorithms coming soon.

HICO Level-2 hyperspectral ocean color products are available from the ocean color web (Ibrahim et al. 2017).

PACE is happening!

- Now in Phase C, with launch readiness date of 11/2022
- Project Science and Science Data Segment within GSFC Ocean Ecology Lab

Questions?