Using ocean observatories to support NASA satellite ocean color objectives

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NASA Goddard Space Flight Center

Ocean Observatories Workshop

Ocean Optics XXI Conference

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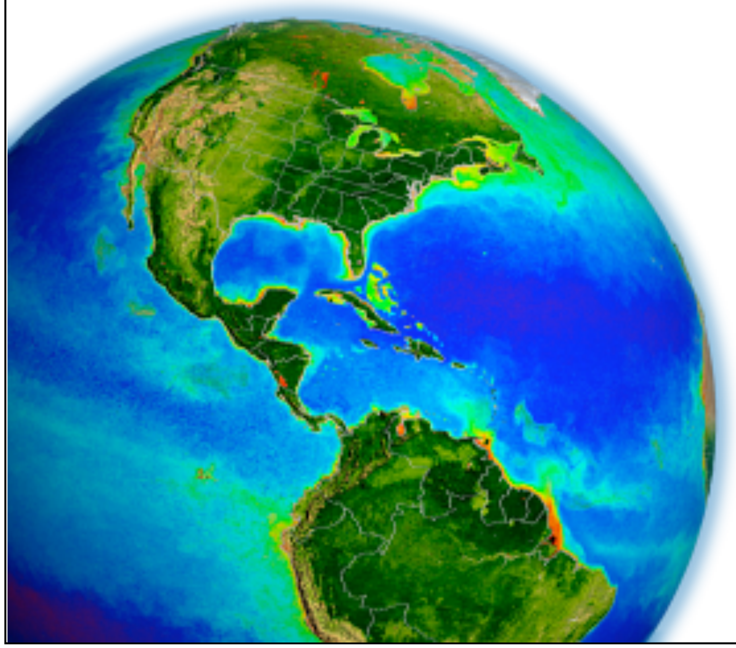


outline

great field data enable great satellite data products

an abundance of field data is hard to come by

ocean observatories can provide rich data streams

QA/QC metrics are essential (or this all falls apart)

NASA Ocean Biology & Biogeochemistry Program

field work funded by OBB Program

QA/QC

by data contributor

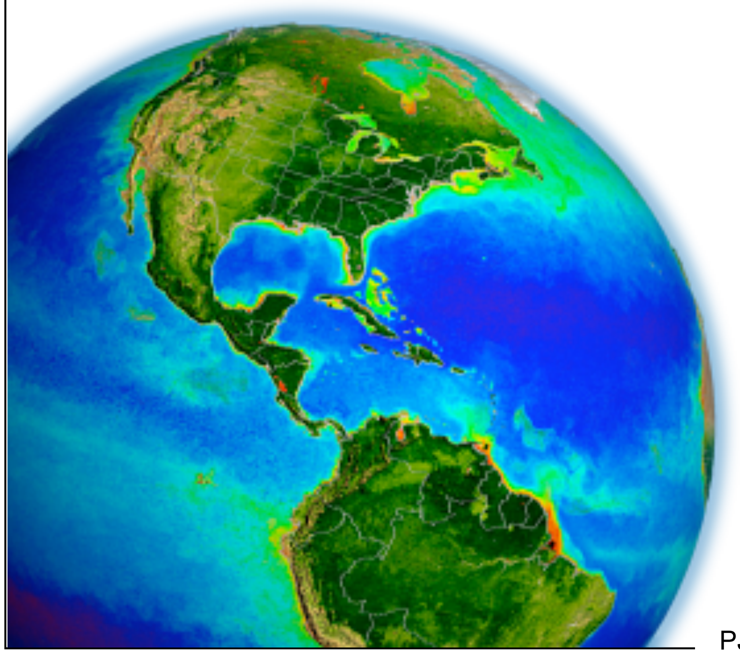
in situ data submitted to NASA SeaBASS (GSFC) within 1-year

by NASA

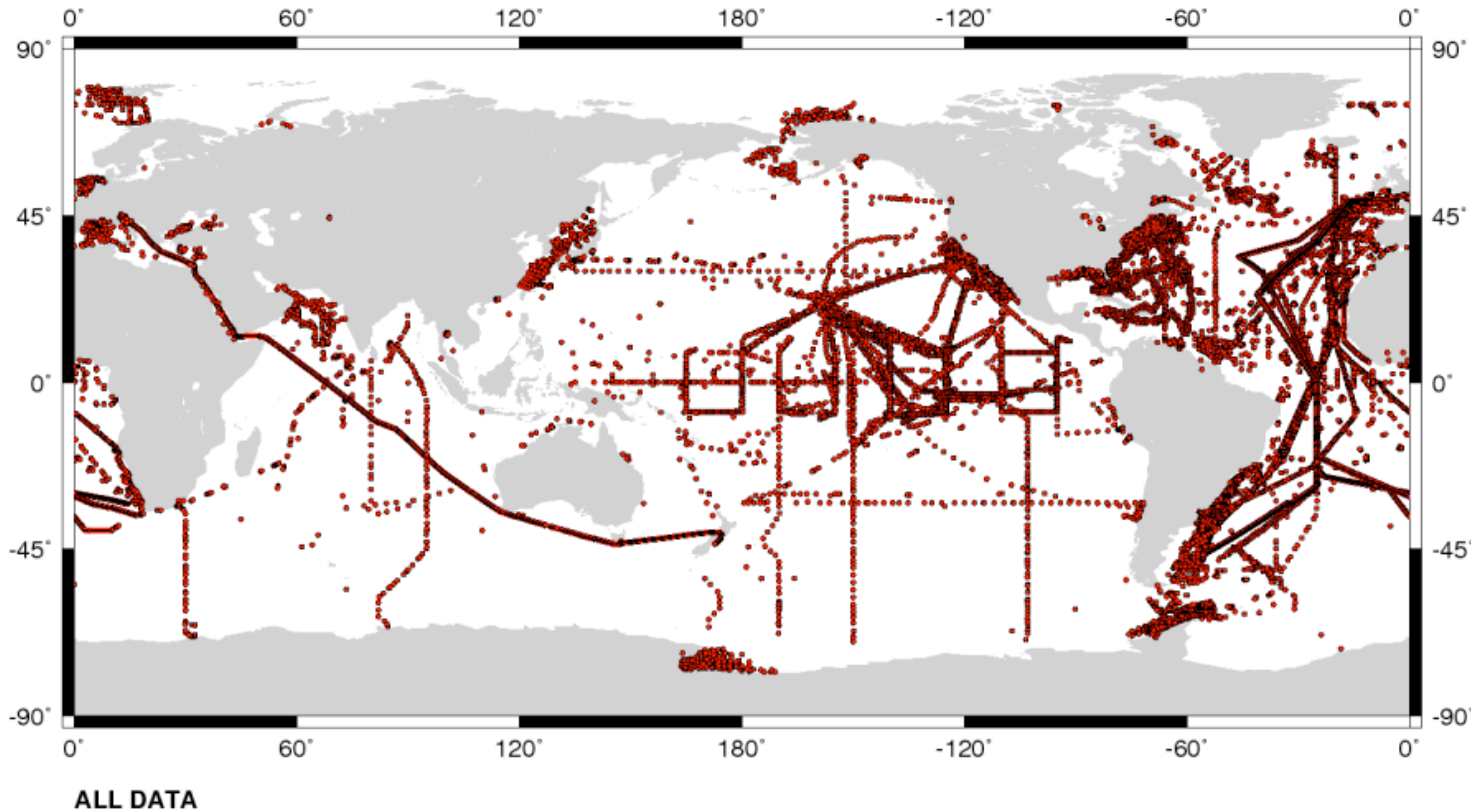
in situ data publicly released

in situ data used to validate satellite data products & to develop / evaluate algorithms

in situ used to calibrate satellite



SeaBASS @ http://seabass.gsfc.nasa.gov



AOPs, IOPs, carbon stocks, CTD, pigments, aerosols, etc.

continuous & discrete profiles; some fixed observing or along-track

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satellite vicarious calibration (instrument + algorithm adjustment)

satellite data product validation

bio-optical algorithm development, tuning, & evaluation

satellite vicarious calibration

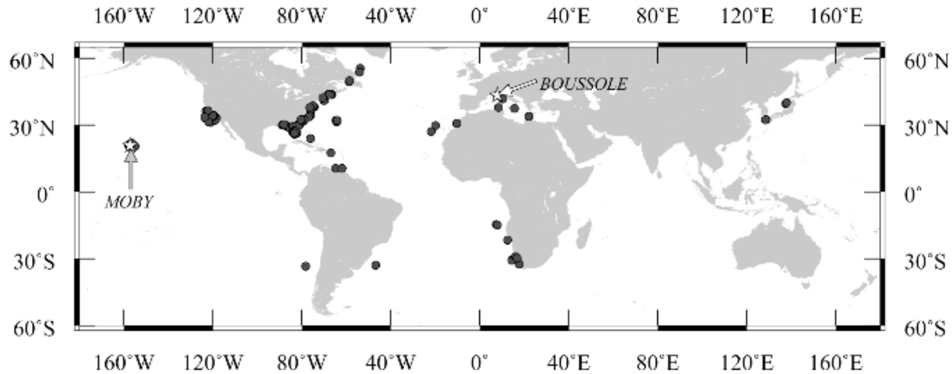


Fig. 1. Map showing the locations for the *in situ* data used in this study.

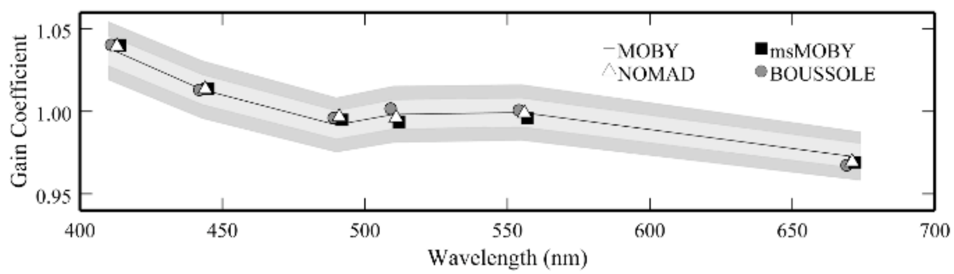


Fig. 3. Vicarious calibration coefficients as a function of wavelength. The standard MOBY-derived $\bar{g}_\lambda{}'$ (solid curve) are overplotted by the msMOBY-, NOMAD-, and BOUSSOLE-derived $\bar{g}_\lambda{}'$. The shaded regions indicate the ranges for the first (light-gray) and second (dark-gray) standard deviations of the mean for $\bar{g}_\lambda{}'$.

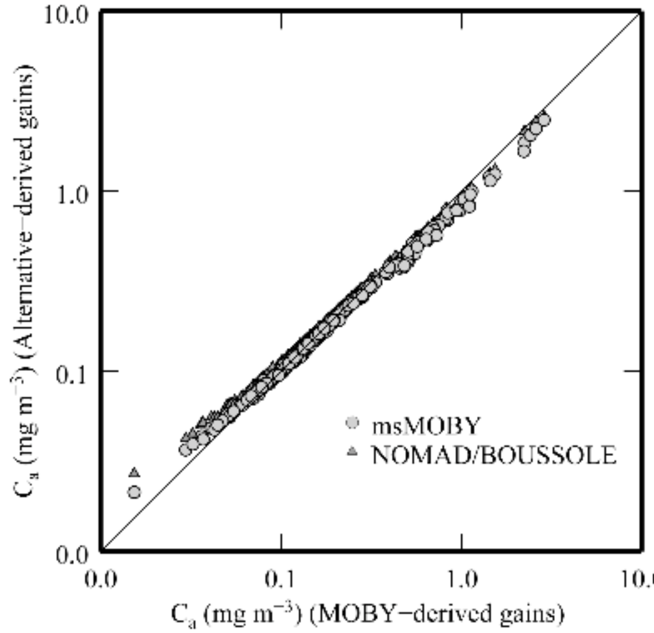


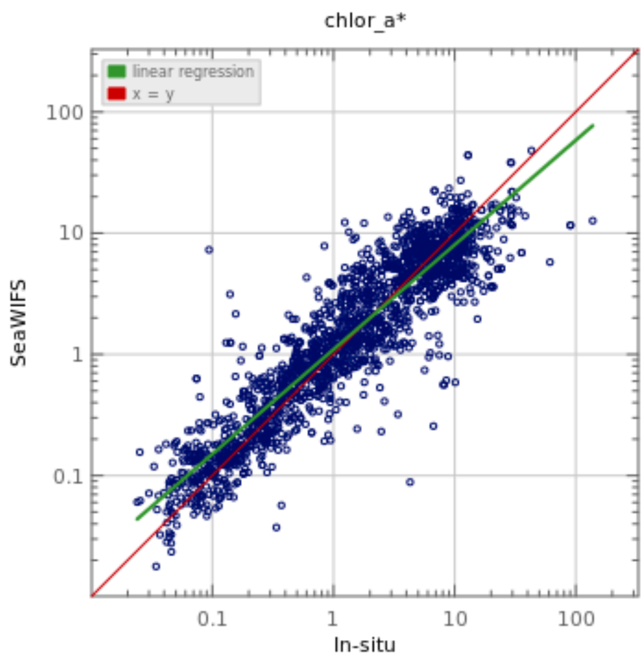
Fig. 7. Satellite-derived chlorophyll estimated from the two alternative $\bar{g}'$ gain sets (msMOBY and NOMAD/BOUSSOLE) plotted versus the corresponding chlorophyll estimated from the standard MOBY $\bar{g}$.

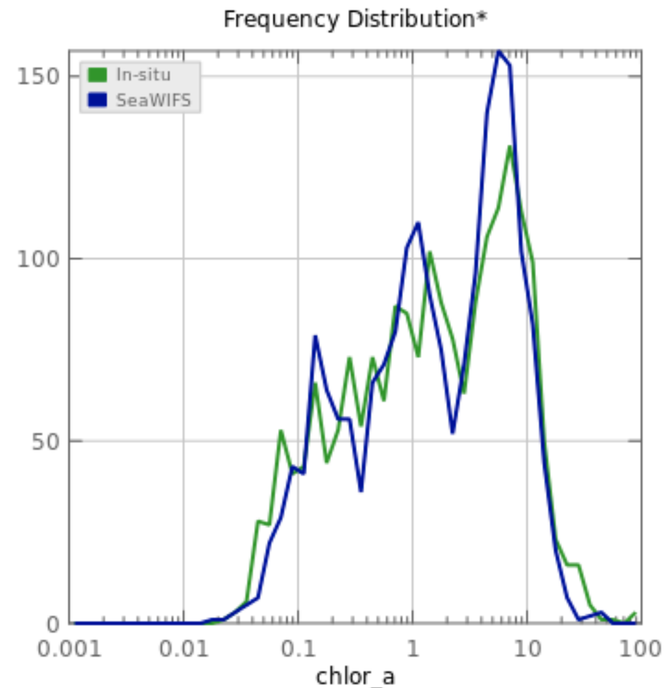
S.W. Bailey, et al. “Sources and assumptions for the vicarious calibration of ocean color satellite observations,” Appl. Opt. 47, 2035-2045 (2008).

satellite data product validation: discrete match-ups

Product Name	SeaWIFS Range	In-situ Range	#	Best Fit Slope*	Best Fit Intercept*	R^2*	Median Ratio	Abs % Difference	RMSE*
chlor_a	0.01782, 48.08236	0.02400, 138.04700	1968	0.86322	0.03969	0.84667	1.05656	36.22945	0.28465

* statistical calculations based on log10

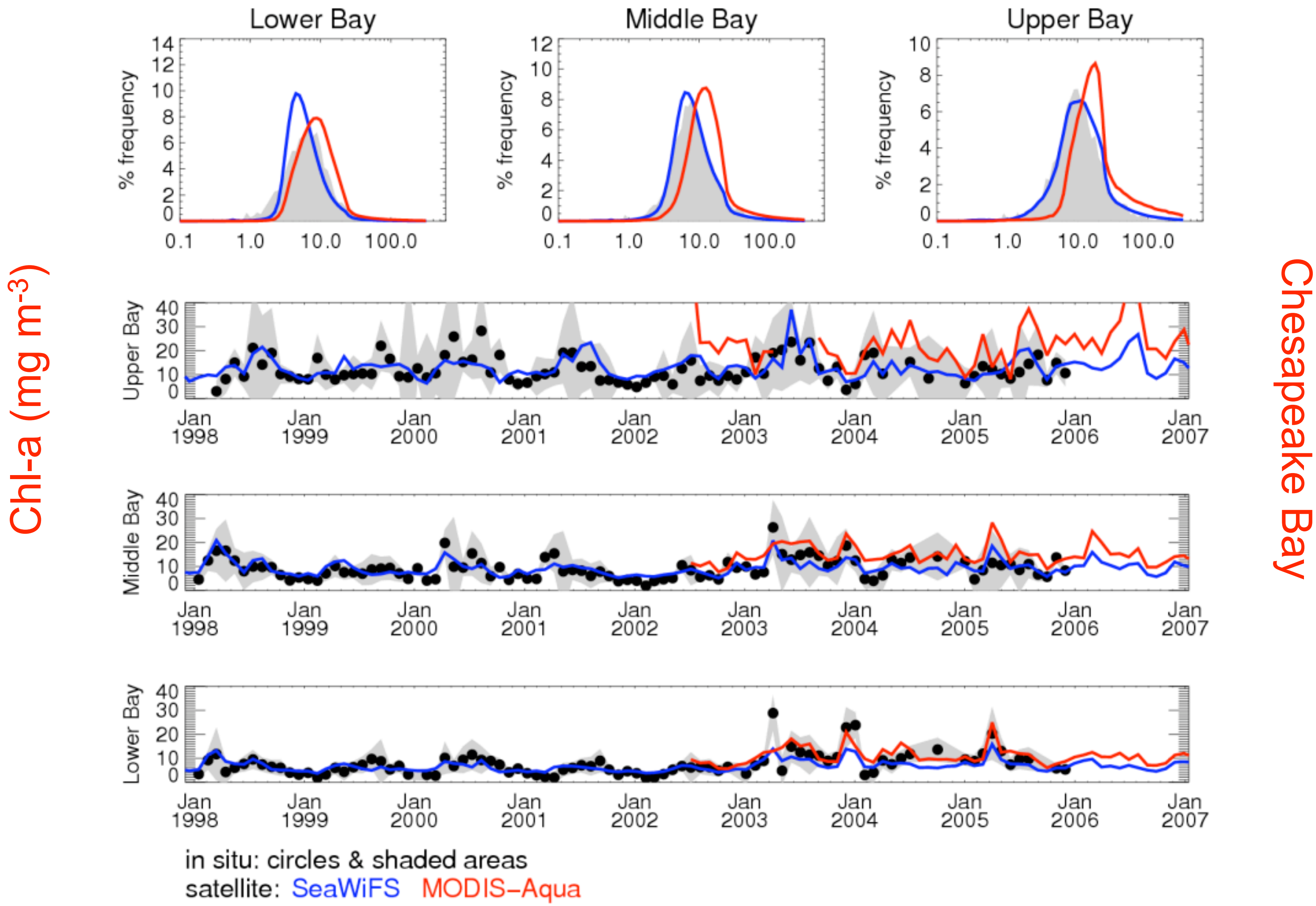




http://seabass.gsfc.nasa.gov/seabasscgi/beta/search.cgi

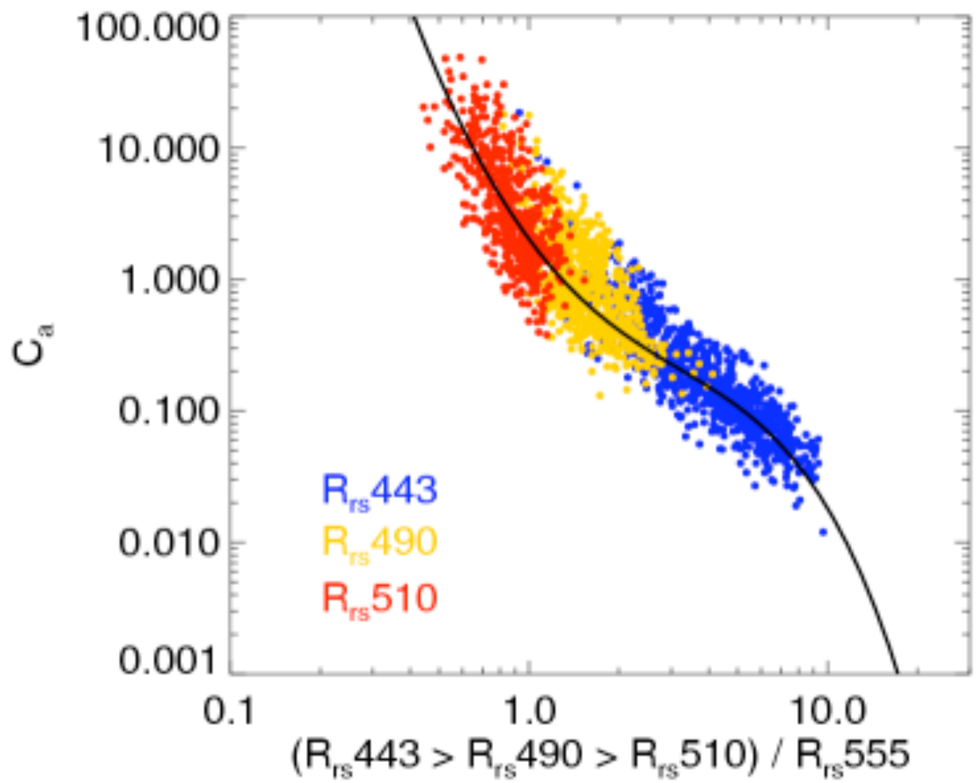
S.W. Bailey and P.J. Werdell, “A multi-sensor approach for the on-orbit validation of ocean color satellite data products,” Rem. Sens. Environ. 102, 12-23 (2006).

satellite data product validation: population statistics



P.J. Werdell et al., "Regional and seasonal variability of chlorophyll-a in Chesapeake Bay as observed by SeaWiFS and MODIS-Aqua," *Rem. Sens. Environ.* 113, 1319-1330 (2009).

bio-optical algorithm development



$\underbrace{R_{rs}}_{\text{what satellite sees}}$ related to $\underbrace{\text{pigments, IOPs, carbon stocks, etc.}}_{\text{what you might want to study}}$

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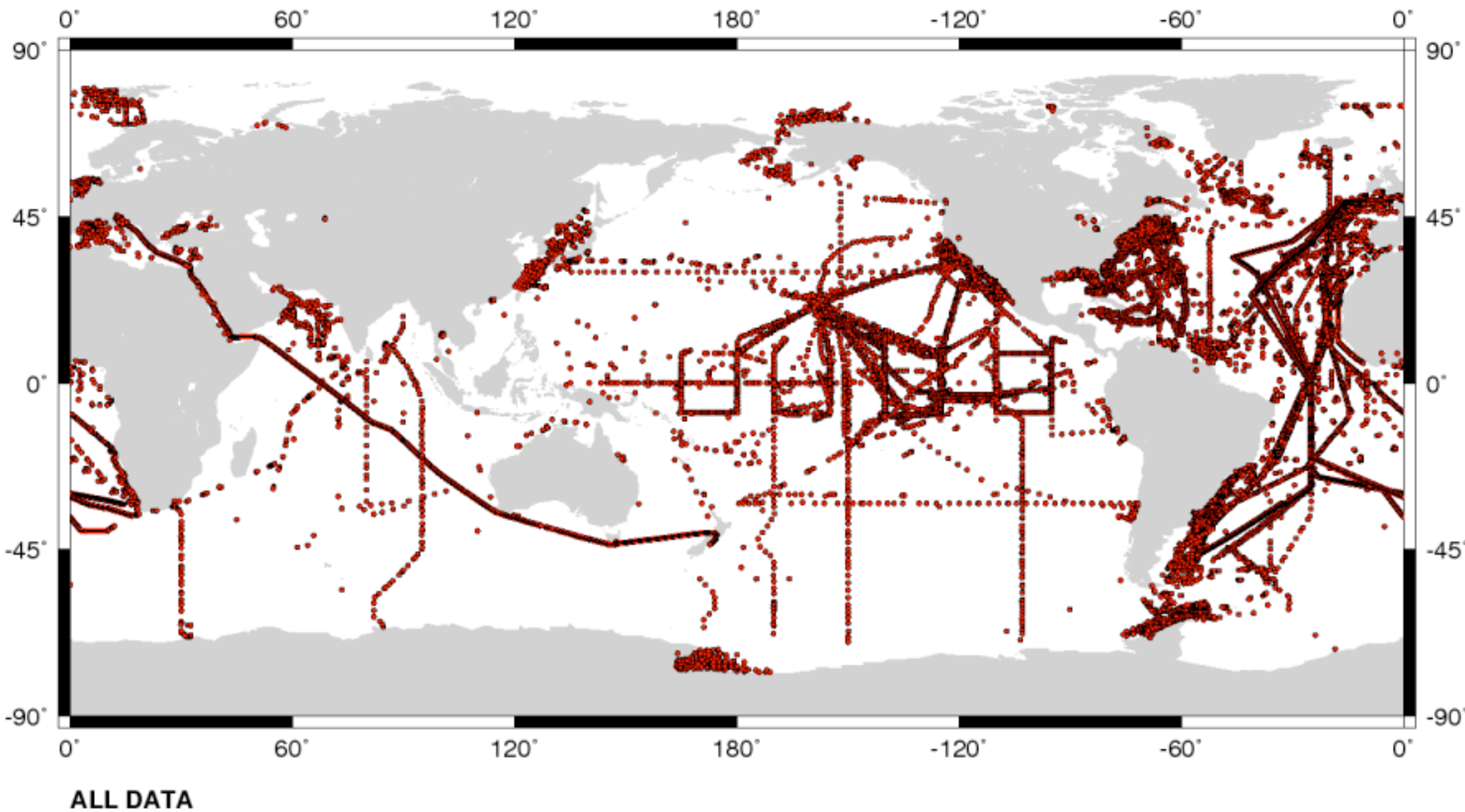
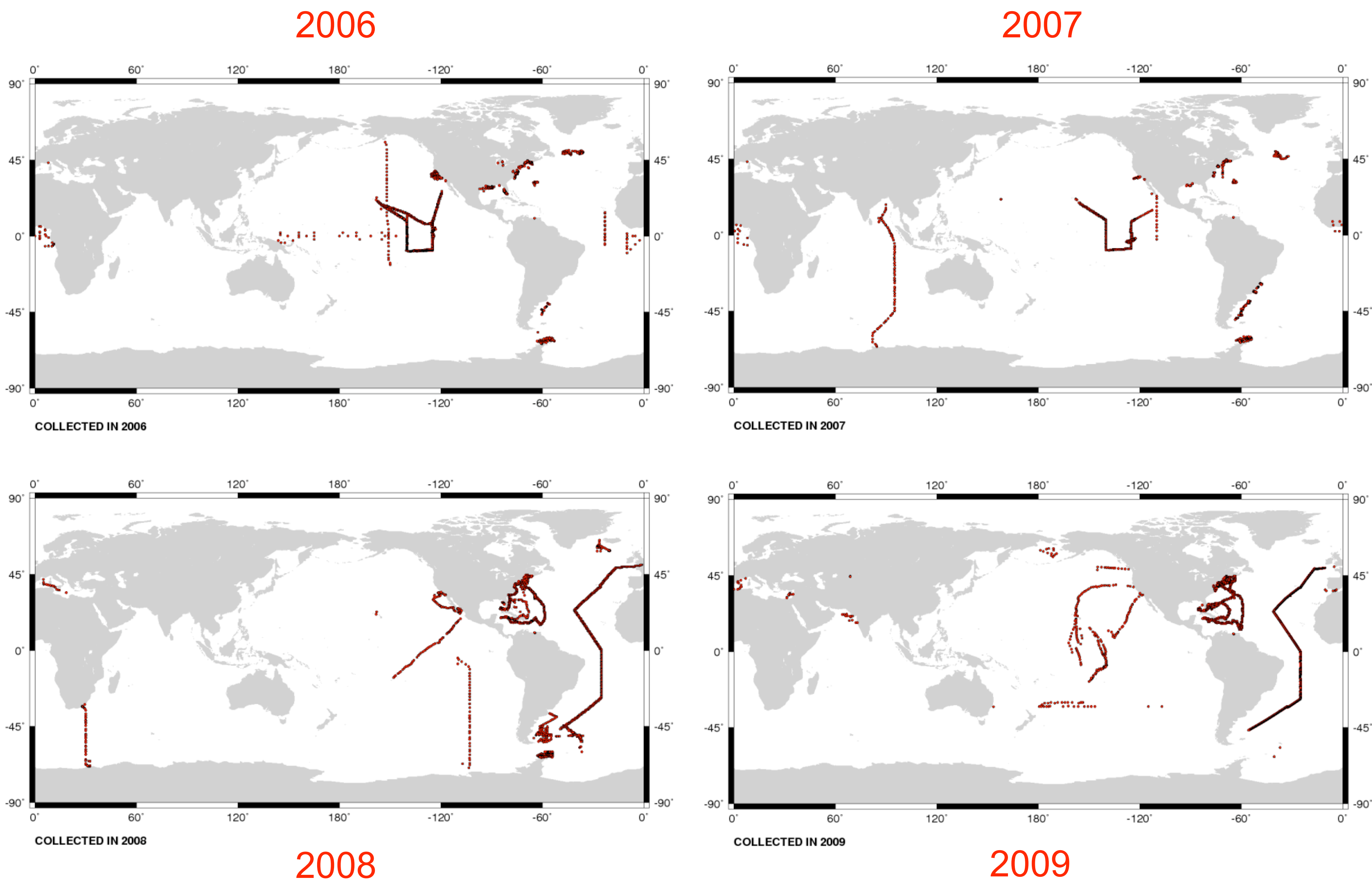
spatial & temporal distributions

“complete” suites of measurements (R_{rs}, IOPs, biogeochemistry)

SeaBASS @ http://seabass.gsfc.nasa.gov



SeaBASS holdings by year: 2006-2009



satellite data product validation: discrete match-ups

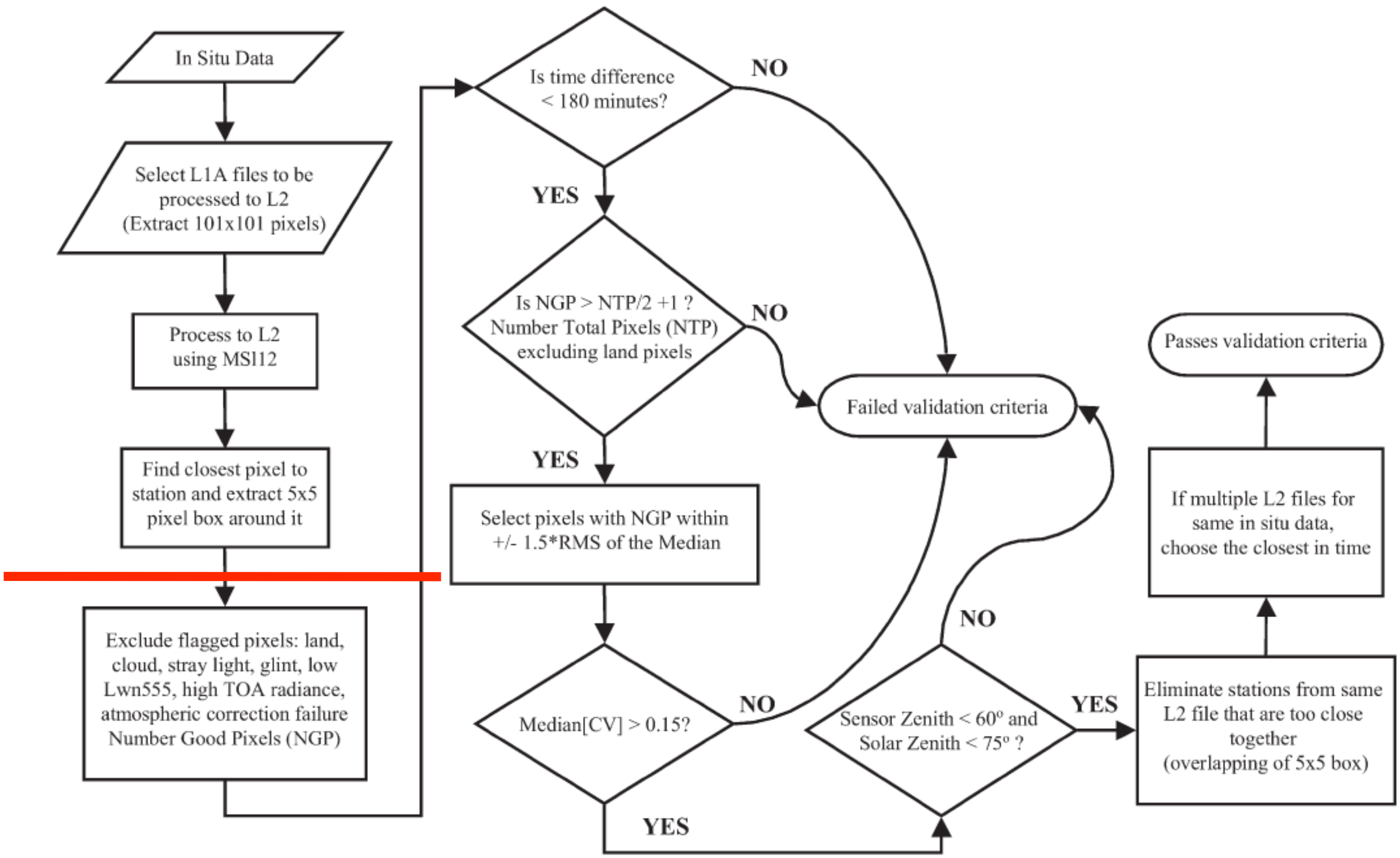
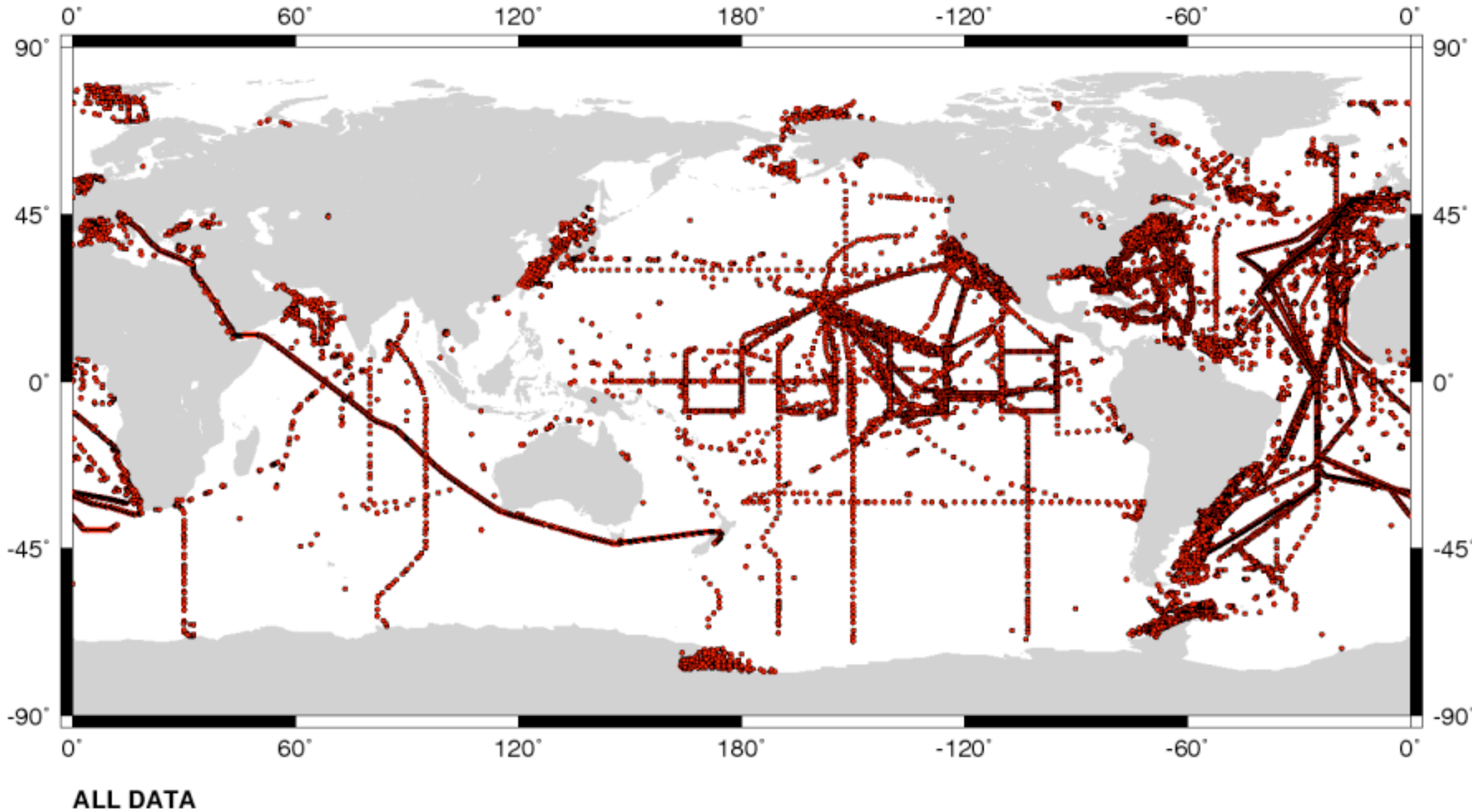


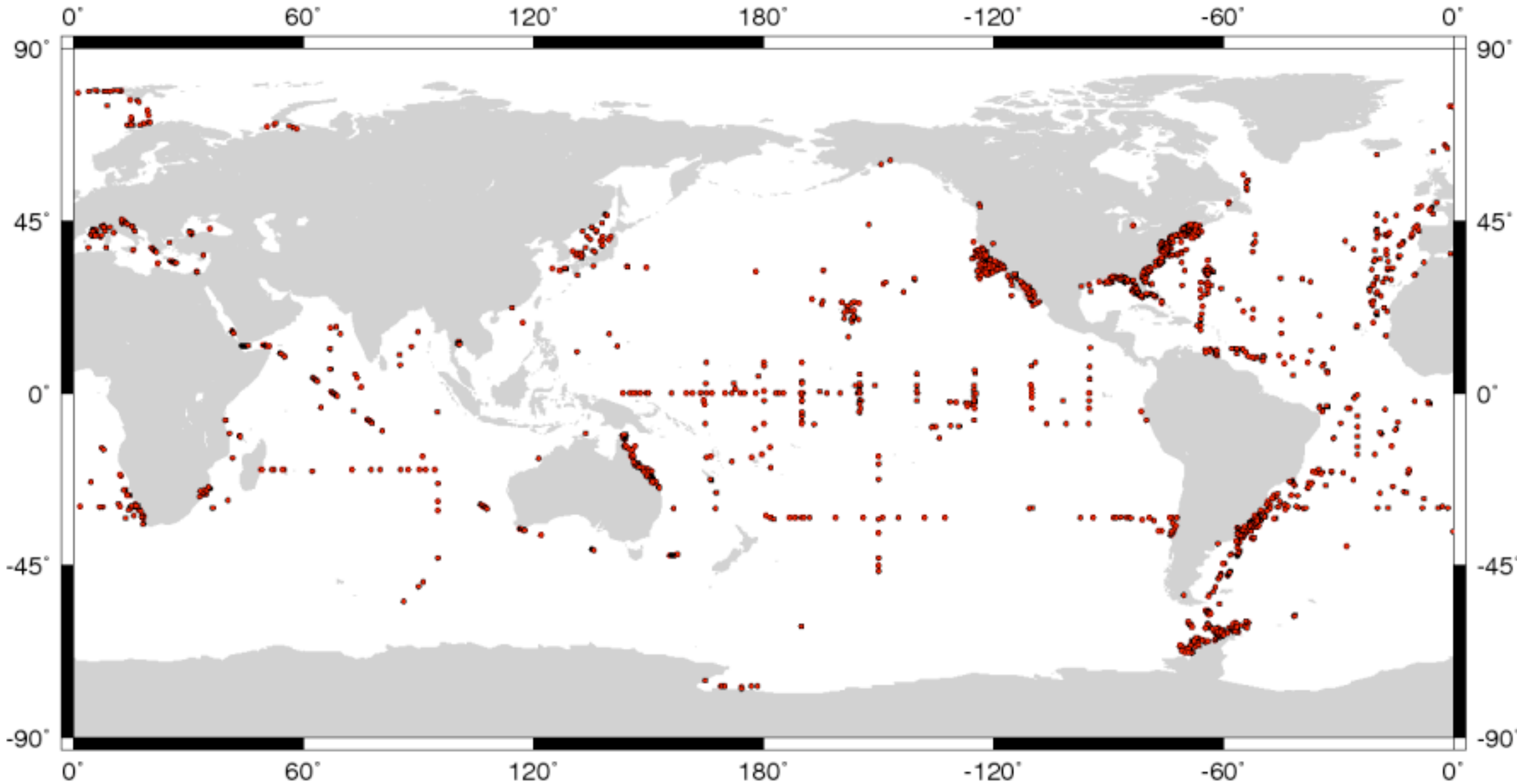
Fig. 1. Flowchart of the validation process highlighting the applied exclusion criteria.

S.W. Bailey and P.J. Werdell, “A multi-sensor approach for the on-orbit validation of ocean color satellite data products,” Rem. Sens. Environ. 102, 12-23 (2006).

SeaBASS @ http://seabass.gsfc.nasa.gov

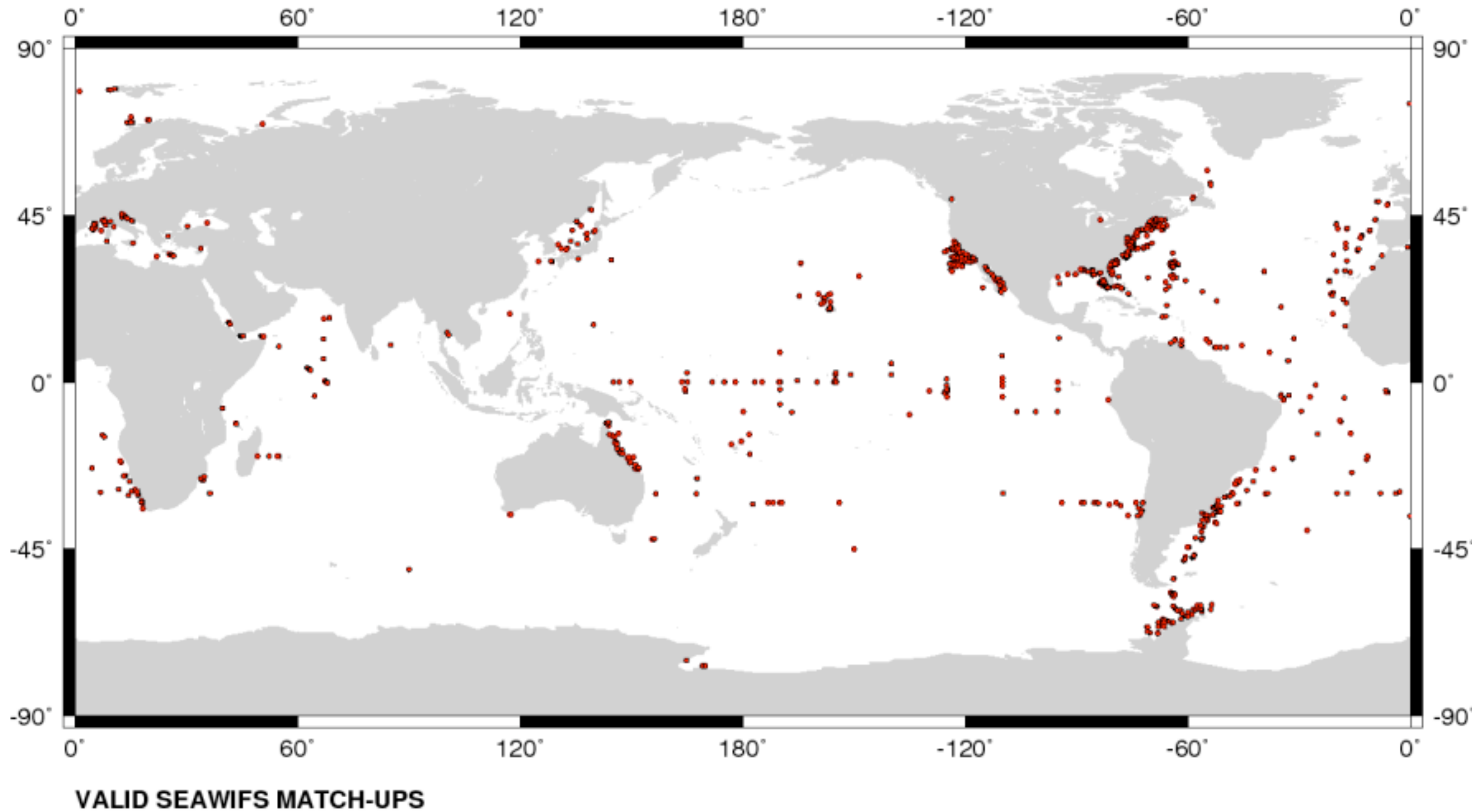


coincident SeaWiFS & *in situ* data



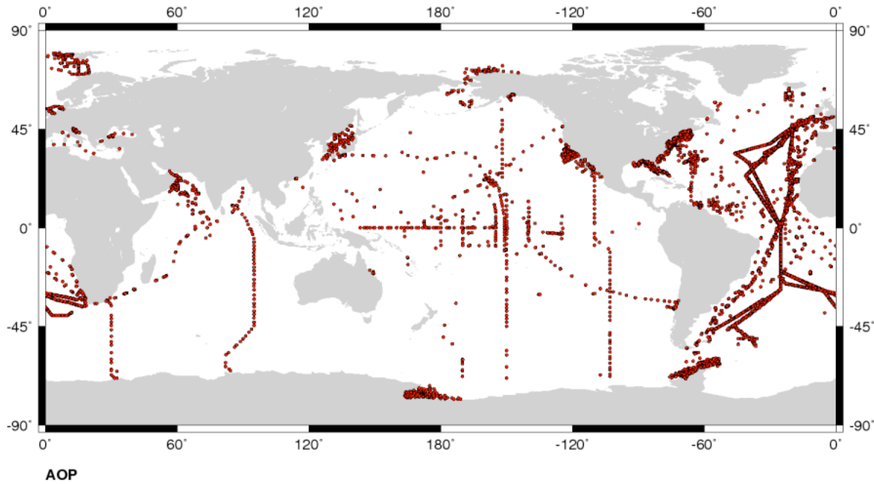
POSSIBLE SEAWIFS MATCH-UPS

valid SeaWiFS-*in situ* match-ups

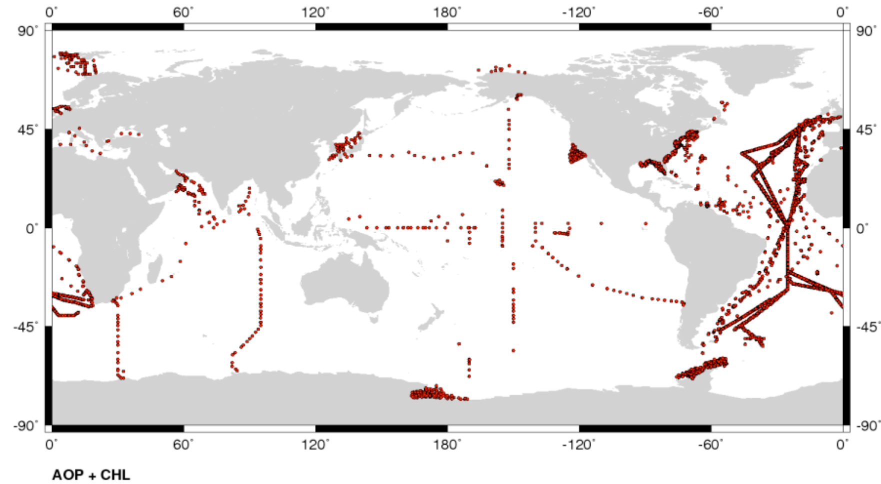


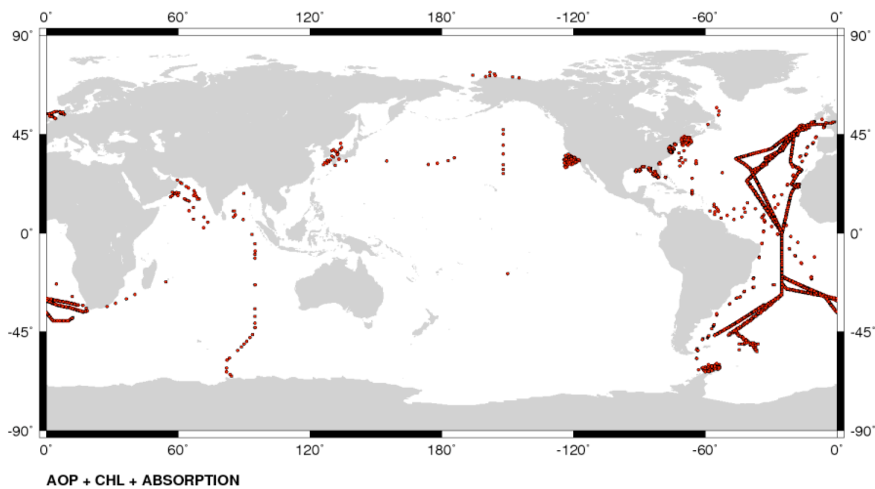
bio-optical algorithm development data sets

R_{rs}

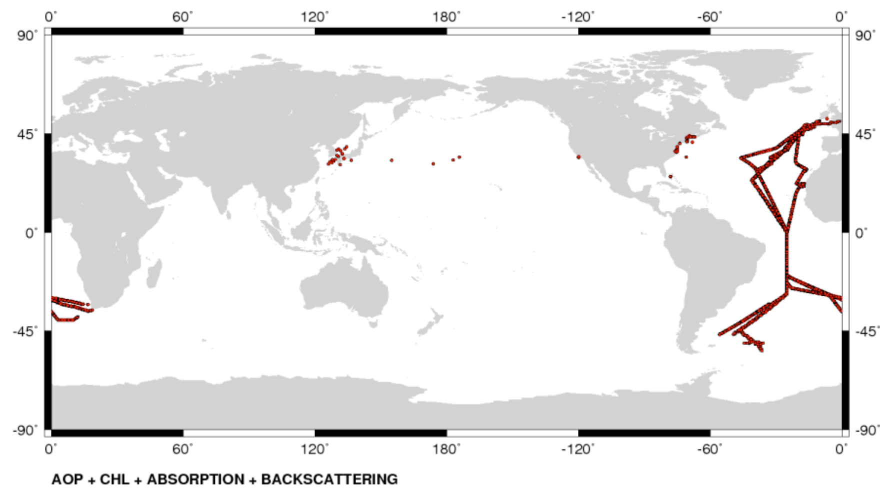


R_{rs} & Chl



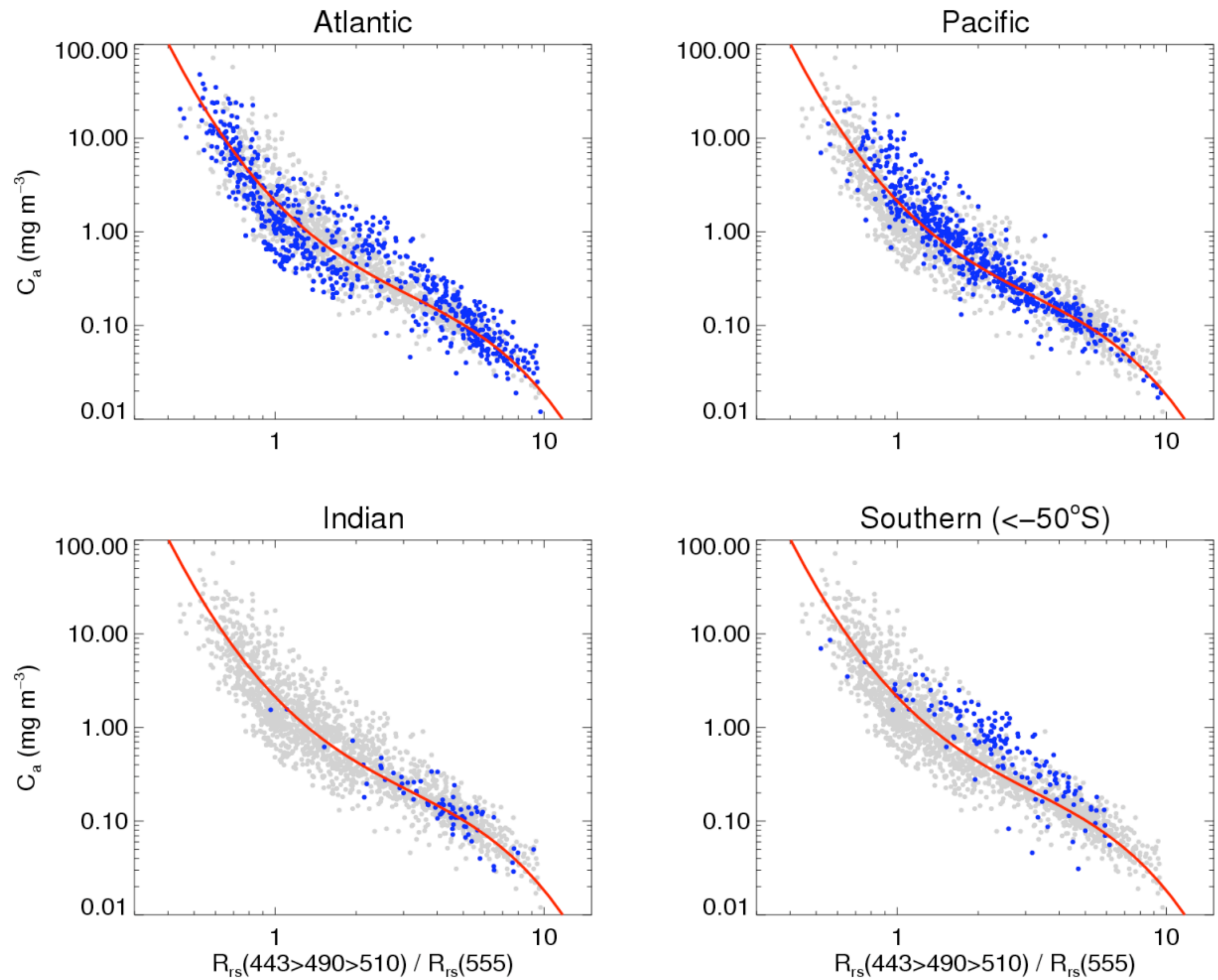


R_{rs} & Chl & absorption



Rrs & Chl & absorption & backscattering

bio-optical algorithm development data sets



new missions, new requirements

new missions

VIIRS: launched Oct 2011, viable data Feb 2012

OLCI (Europe), SGLI (Japan): scheduled for CY12, CY15

PACE: scheduled for CY19

ACE, GEO-Cape: scheduled for ~CY23

dynamic range of problem set is growing

emphasis on research in shallow, optically complex water

emphasis on "new" products (carbon, rates, etc.)

spectral domain stretching to UV and SWIR

immediate, operational requirements

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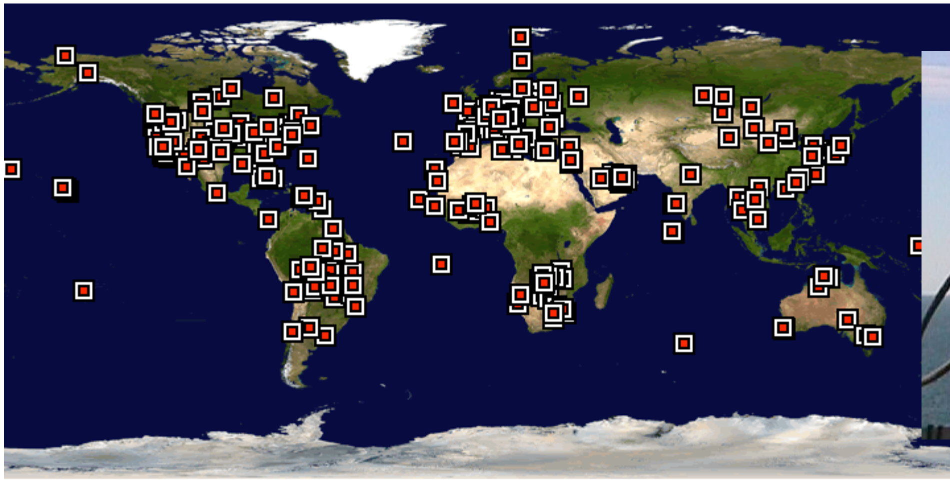
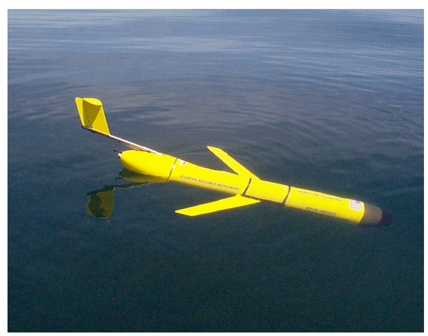
moving forward: community innovations

AERONET (fixed-above water platforms)

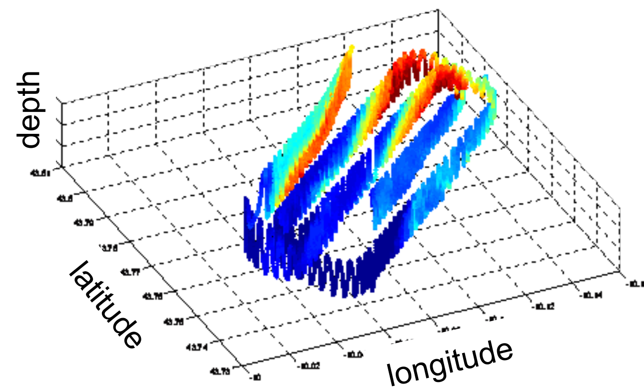


buoy networks



gliders, drifters, & other autonomous platforms

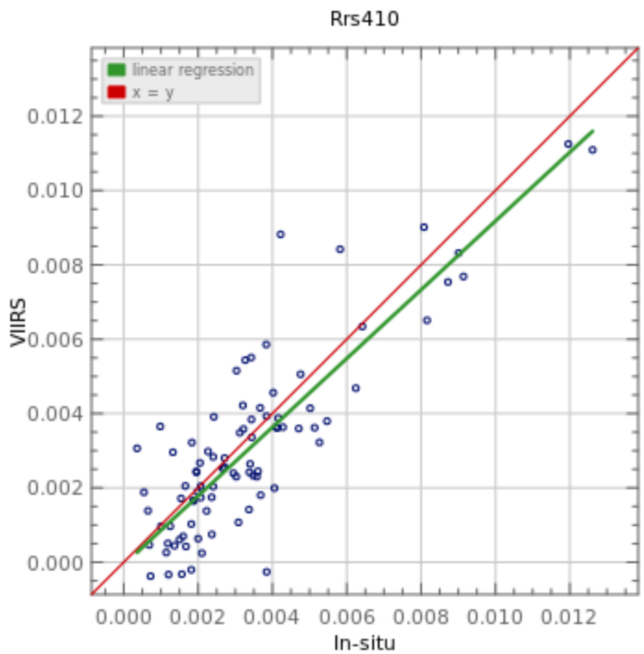
towed & underway sampling

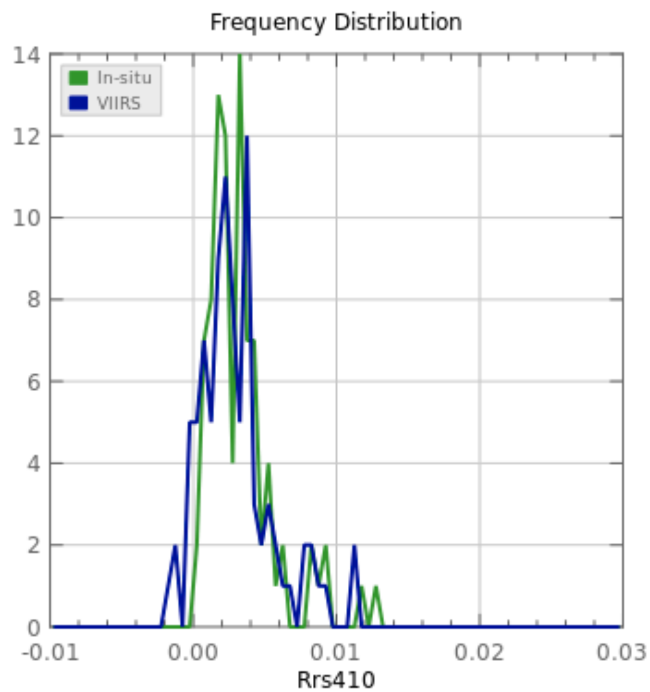


validation exercises with autonomous data

AERONET-OC match-ups with VIIRS (data since Feb 2012)

Product Name	VIIRS Range	In-situ Range	#	Best Fit Slope	Best Fit Intercept	R^2	Median Ratio	Abs % Difference	RMSE
Rrs410	-0.00163, 0.01125	0.00036, 0.01261	90	0.92474	-0.00007	0.72198	0.86896	29.93523	0.00140
Rrs443	-0.00025, 0.01501	0.00057, 0.01618	78	0.93235	0.00007	0.88422	0.95293	19.82360	0.00105
Rrs486	0.00088, 0.01860	0.00137, 0.02078	90	0.84640	-0.00002	0.94259	0.85070	18.37501	0.00132
Rrs551	0.00144, 0.01816	0.00147, 0.02119	90	0.82073	0.00008	0.95628	0.85329	16.06320	0.00130
Rrs671	-0.00001, 0.00217	0.00007, 0.00256	32	0.75027	-0.00006	0.82559	0.61936	38.73894	0.00043





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a single entity (e.g., NASA or equivalent) cannot collect sufficient volumes of *in situ* data to satisfy its operational calibration & validation needs

following, flight projects rely on multiple entities to collect *in situ* data

QA/QC metrics are essential

QA/QC methods vary in maturity – exist for many established instruments & platforms, but not always for newer or autonomous systems

a recent QA/QC workshop

Consortium for Ocean Leadership (COL) & NASA hosted an oceanographic QA/QC workshop in Jun 2012 at the U. Maine Darling Marine Center

25 attendees, 16 institutions, 4 countries (US, Australia, France, Canada)

expertise in a wide variety of oceanographic measurements & platforms (bio-optics, hydrography, buoys, gliders, ARGO floats, fixed platforms, etc.)

a recent QA/QC workshop

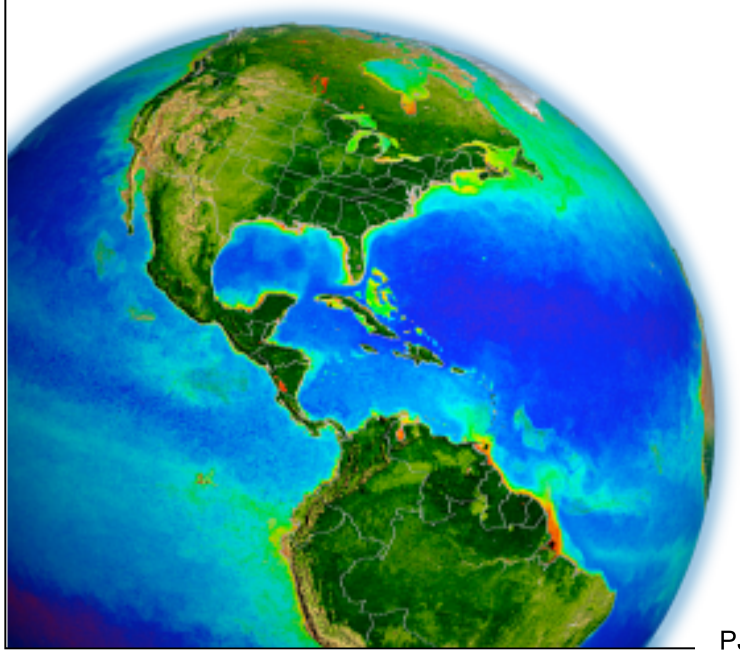
topics of discussion:

system-level QA/QC approaches (vs. sensor-level)
centralized versus distributed approaches
levels of QA/QC and associated effort (workforce) required
laboratory instrument inter-calibration & verification
at-sea instrument inter-calibration
detection of slow drifts against large background variability
bio-fouling: susceptibility, mitigation, identification, correction
utilizing external (field or remote) observations

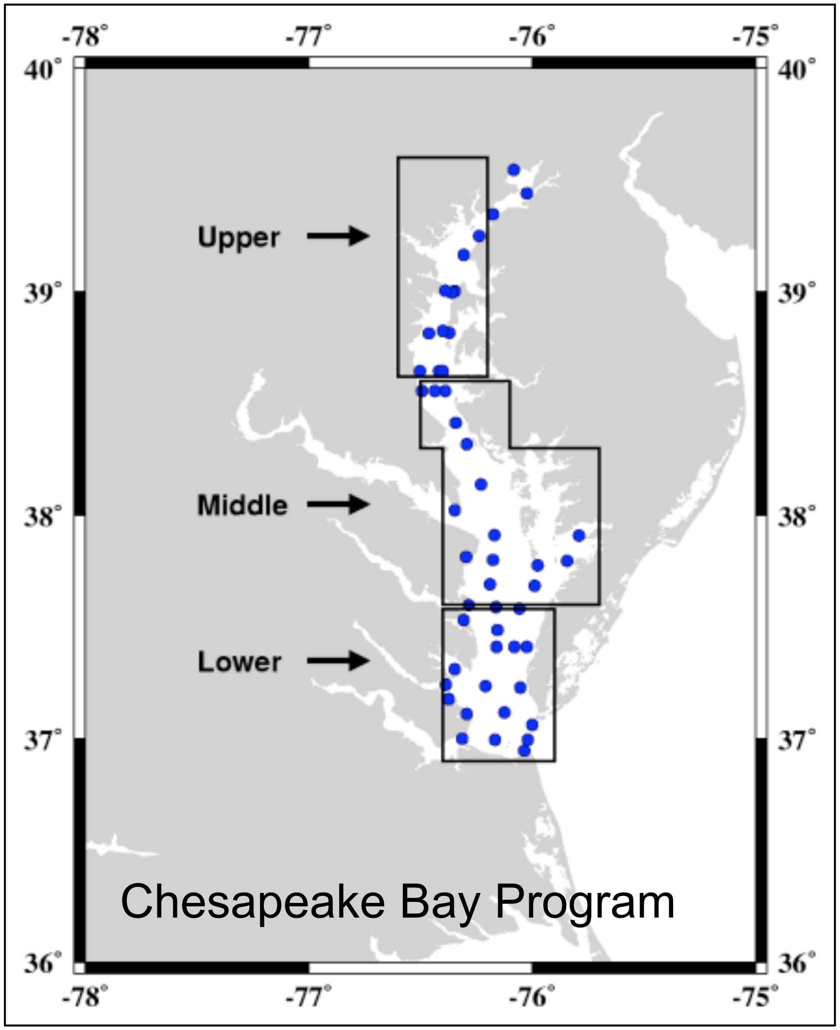
a recent QA/QC workshop

http://www.wordle.net

questions & comments?



satellite data product validation: population statistics



http://www.chesapeakebay.net

routine data collection since 1984
12-16 cruises / year

49 stations
19 hydrographic measurements

algal biomass
water clarity
dissolved oxygen
others