Recent ocean color satellite vicarious calibration activities

Jeremy Werdell

NASA Ocean Color Research Team Meeting

11 April 2007, Seattle, WA

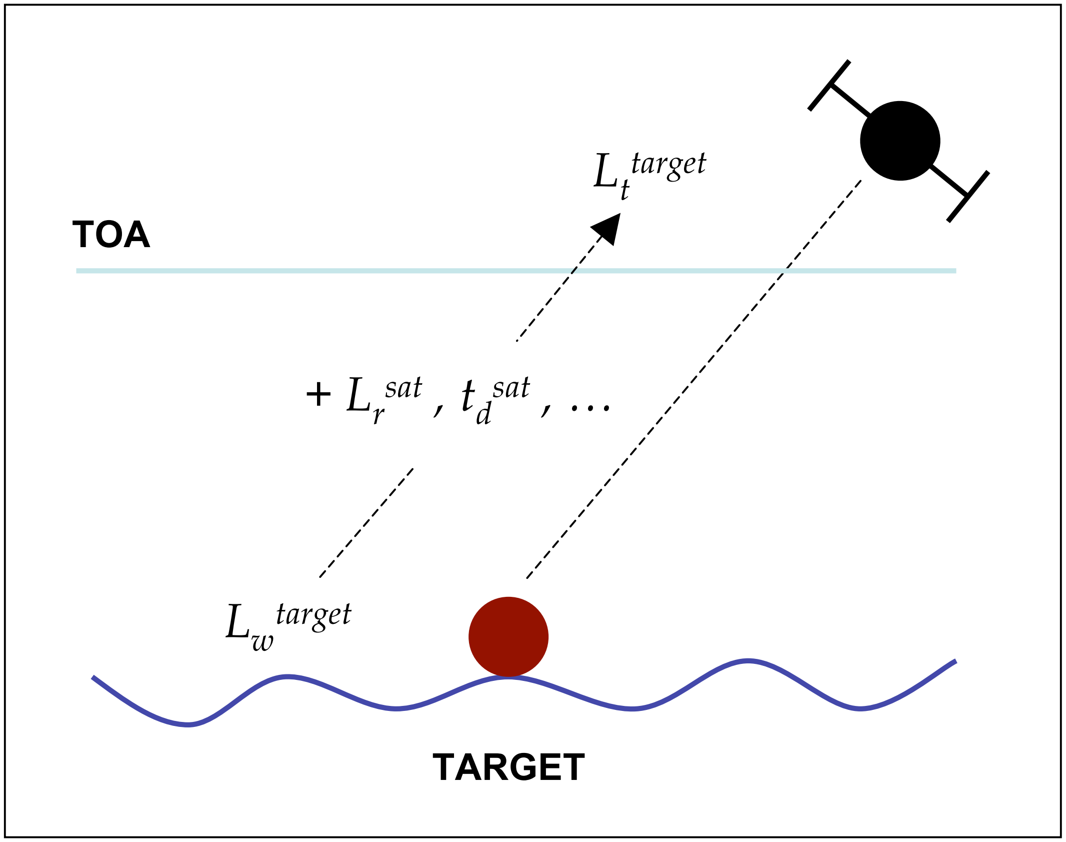
Operational calibration of SeaWiFS and MODIS

Bryan Franz, Sean Bailey, and Jeremy Werdell

MOBY Operations Team

the operational OBPG vicarious calibration approach has (finally) been documented

B.A. Franz, S.W. Bailey, P.J. Werdell, and C.R. McClain, "Sensor independent approach to the vicarious calibration of satellite ocean color radiometry," *Applied Optics (in press).*



the operational OBPG vicarious calibration approach has (finally) been documented:

B.A. Franz, S.W. Bailey, P.J. Werdell, and C.R. McClain, “Sensor independent approach to the vicarious calibration of satellite ocean color radiometry,” *Applied Optics (in press).*

highlights:

independent of sensor to be calibrated and source of ground-truth

specific to Gordon and Wang (1994)

describes both NIR and VIS calibration

demonstrates use of MOBY for VIS calibration

discusses outstanding issues and required assumptions

provides (some) associated uncertainties with approach

software support via SeaDAS

one particular analysis will be revisited in a few moments …

Retrospective calibration of CZCS and OCTS

Jeremy Werdell, Sean Bailey, Bryan Franz, André Morel, and Chuck McClain

OCEAN SURFACE REFLECTANCE MODEL (ORM)

$$R(0^-) = f'(C_a)\frac{b_b(C_a)}{a(C_a)+b_b(C_a)}$$

$$L_{wn} = \Re\, F_0 \frac{R(0^-)}{Q(C_a)}$$

b_b, a, f', and Q estimated using C_a

R and F_o are constants

in Case-1 water, plausible estimates of L_{wn} can be derived from C_a using an ocean surface reflectance model

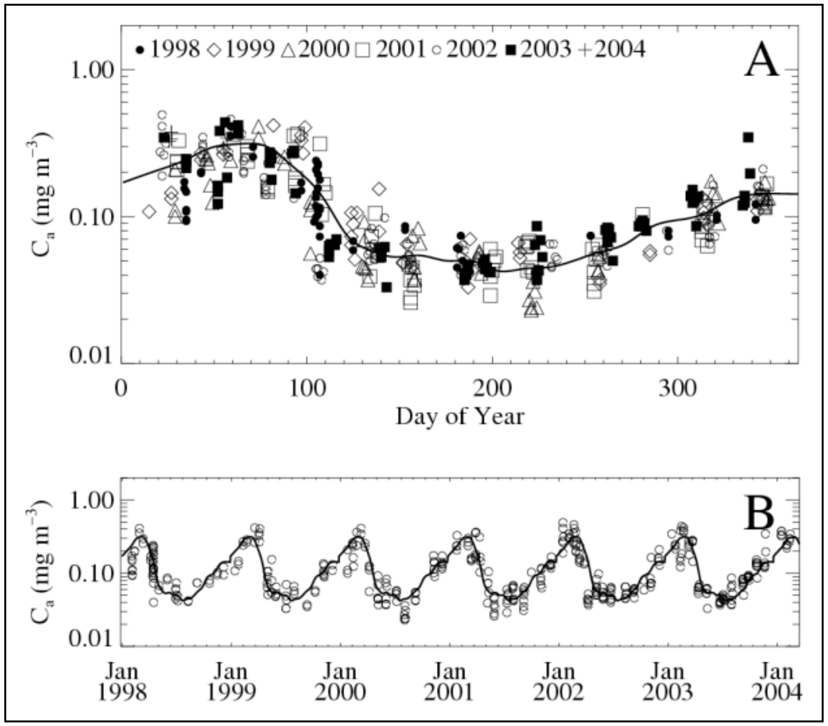
Morel and Maritorena (2001)

Morel, Antoine, and Gentili (2002)

Ciotti, Cullen, and Lewis (1999)

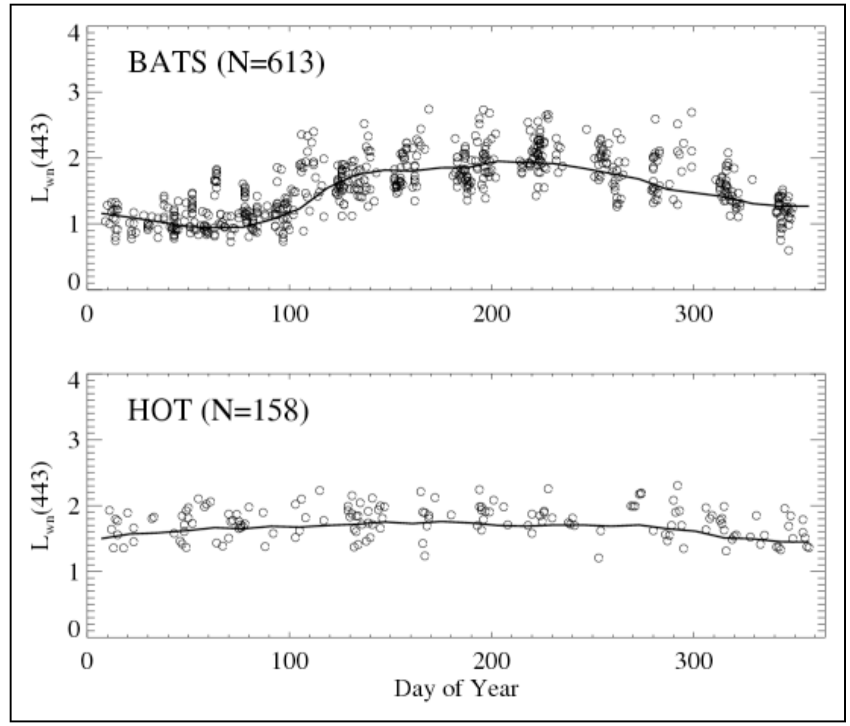
general C_a expressions developed for BATS and HOT

here is the expression for BATS fluorometric C_a:



verified the "ORM-C_a model" combination

through comparisons with in situ L_{wn}



use the C_a expressions as input into the ORM

estimate L_{wn} for every day of the year at both BATS and HOT

input these L_{wn} into the vicarious calibration system consistent SeaWiFS gains retrieved at both sites:

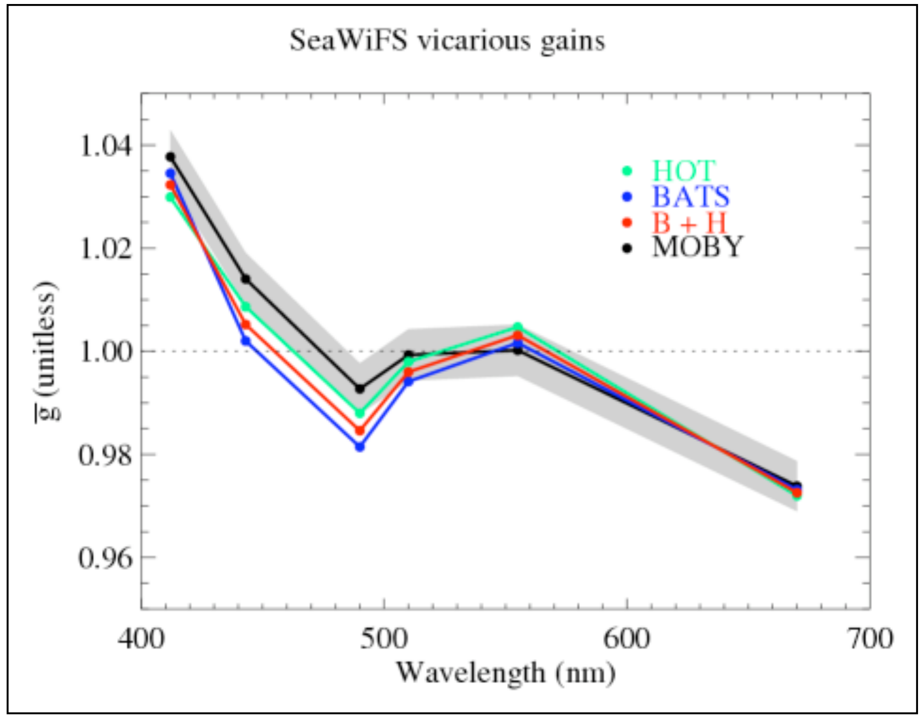
Table 4. Percent differences[a] between the HOT and BATS ORM $\bar{g}$.

412	443	490	510	555	670
-0.44	0.66	0.66	0.38	0.30	-0.13

[a] Calculated via $(\bar{g}_{HOT} - \bar{g}_{BATS}) * 100\% / \bar{g}_{BATS}$.

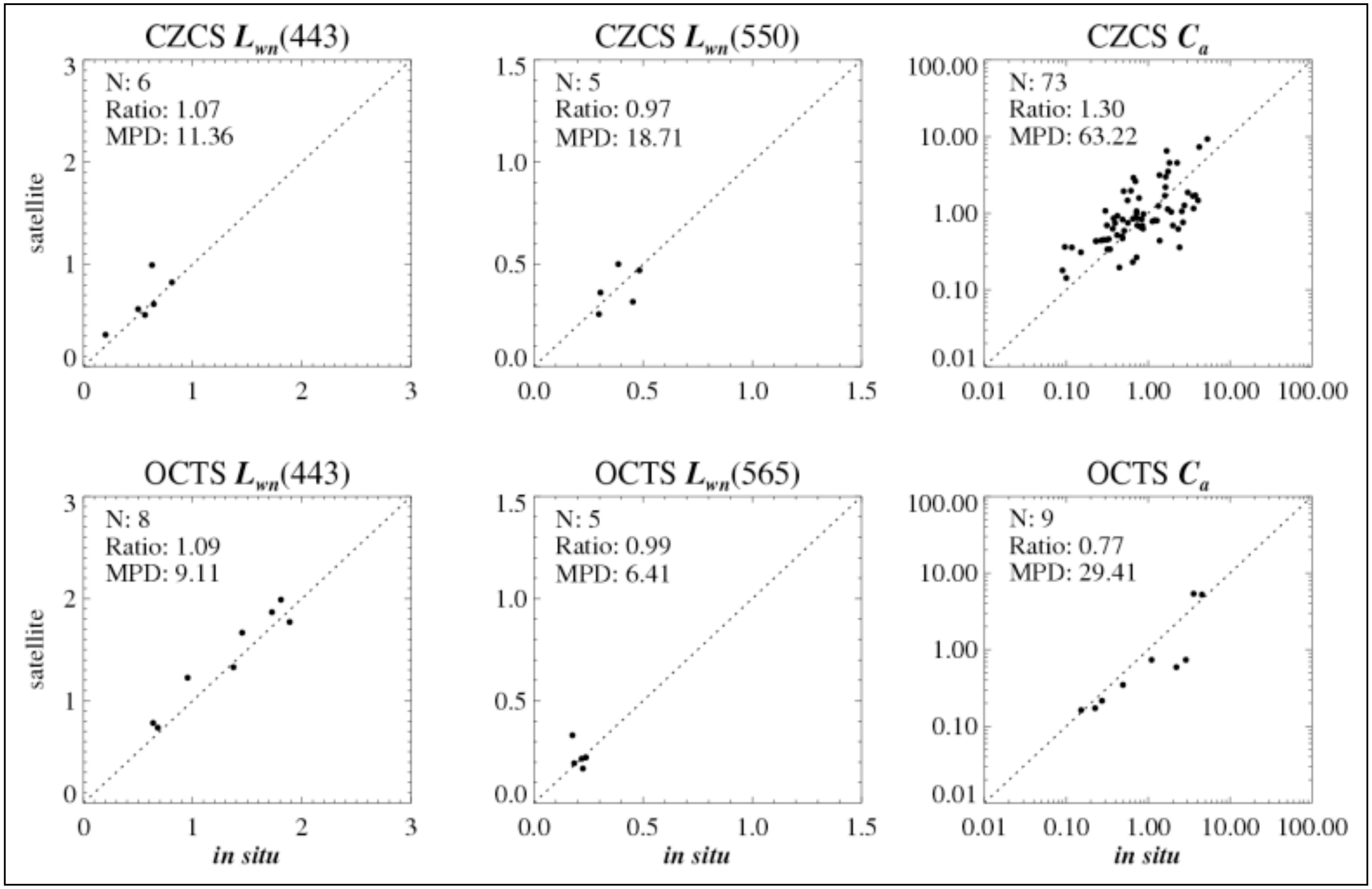
the approach has been documented:

P.J. Werdell, S.W. Bailey, B.A. Franz, A. Morel, and C.R. McClain, "On-orbit vicarious calibration of ocean color satellites using a ocean surface reflectance model," *Applied Optics (in review, Mar 2007)*.



CZCS and OCTS validation results using the ORM-based gains

CZCS-era C_a data courtesy of the NODC World Ocean Database 2005



Complementary calibration sources to support future missions

Sean Bailey, Stanford Hooker, Jeremy Werdell, Bryan Franz, and David Antoine

MOBY has provided 1,450 contemporaneous match-ups for SeaWiFS over 9-years

150 pass the satellite screening process (approximately 17 per year)

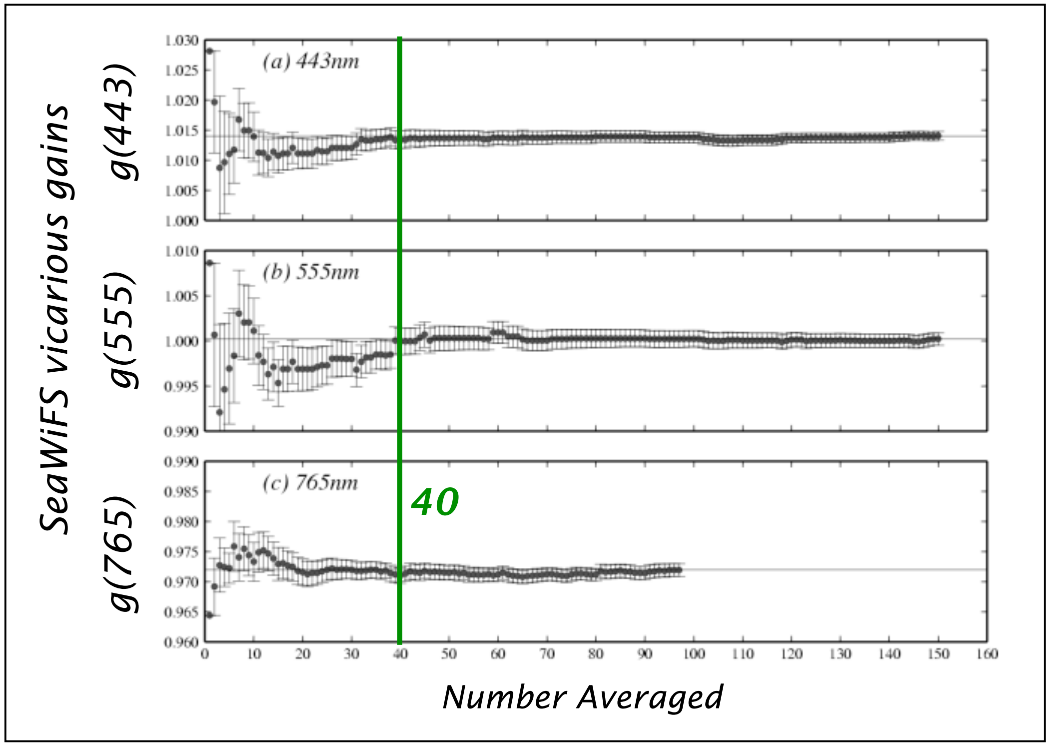


figure 6 from Franz et al. (2007)

for this specific scenario … 2 to 3-years to achieve adequate sample size for reliable gain estimation using a single ground-truth target

verified statistically using variance estimates and desired confidence intervals

suggested requirements for vicarious calibration sites & sources

spatially homogeneous location

low C_a (< 0.2 mg m^{-3})

low aerosols ($\tau(865) < 0.15$)

hyperspectral L_{wn} for convolution with satellite spectral bandpass

extremely well-characterized in situ radiometer

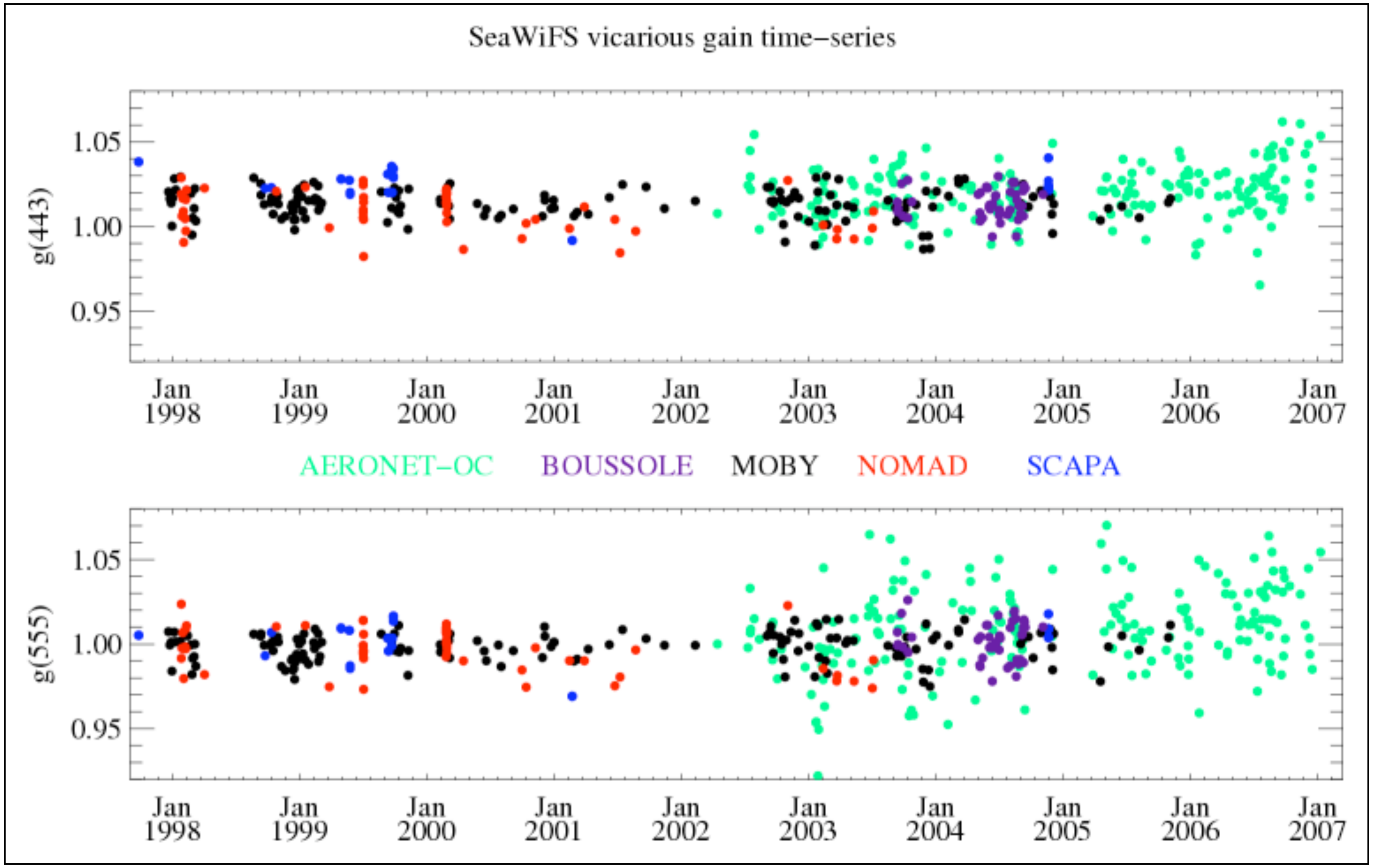
limited geophysical dynamic range

Clark et al. (1997), Gordon (1998), Clark et al. (2003)

(some) available in situ calibration targets

SOURCE	FEATURES	REFERENCE
MOBY (buoy)	well-calibrated, daily hyperspectral sampling, ideal location, expensive, bio-fouling, self-shading, discrete depths	Clark et al. (1997,2003)
AERONET-OC (SeaPRISM)	COTS instrumentation, global above-water network, daily sampling, coincident AOT, complex locations, multispectral	Zibordi et al. (2006)
BOUSSOLE (buoy)	COTS instrumentation, daily sampling, limited self-shading, bio-fouling, discrete depths, multispectral	Antoine et al. (2007)
NOMAD (profiles)	COTS instrumentation, continuous vertical profiles, global observations, hyperspectral above-water observations, irregular shipboard sampling, multispectral, varied sources	Werdell and Bailey (2005)
SCAPA (profiles)	COTS instrumentation, continuous vertical profiles, global observations, irregular shipboard sampling, multispectral	S.B. Hooker / GSFC
SIMBAD(A) (hand-held)	portable above-water radiometer & sun photometer, global observations, irregular shipboard sampling, multispectral	Deschamps et al. (2004)

preliminary results …

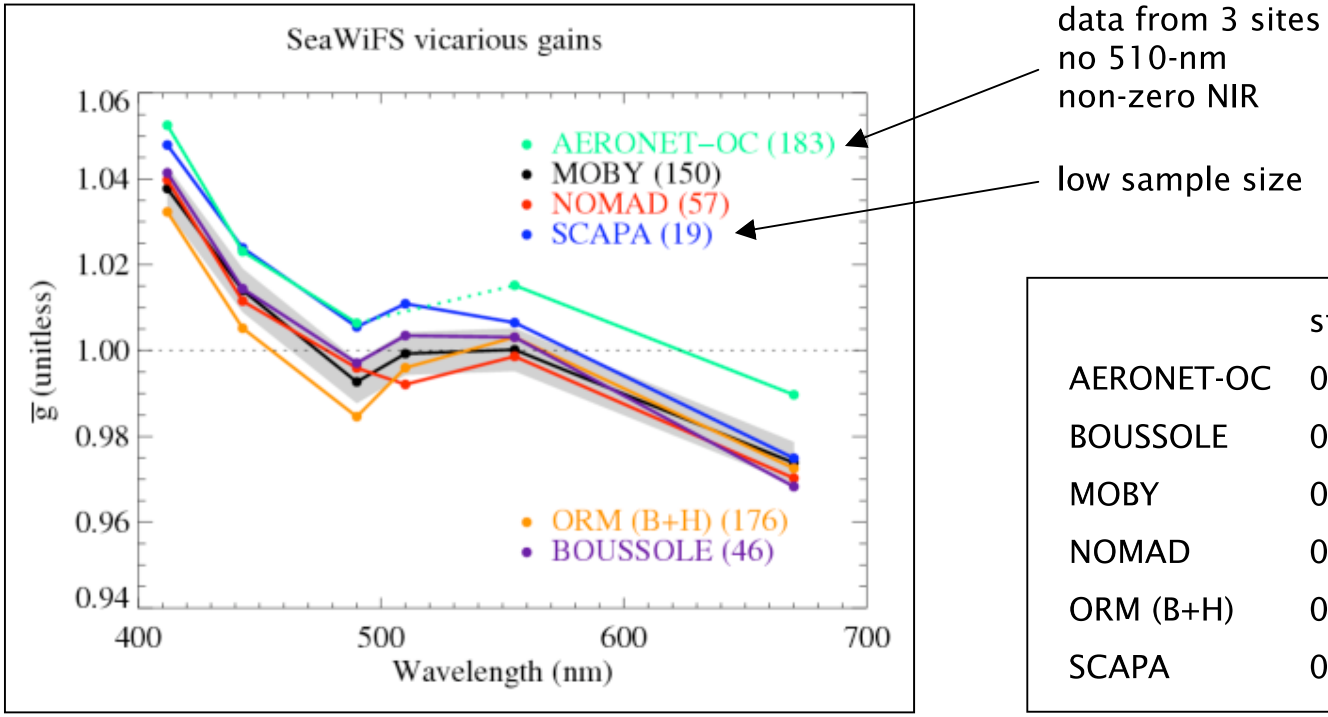


standard exclusion criteria applied to MOBY, NOMAD, and SCAPA

C_a restriction increased to 0.3 mg m^{-3} for BOUSSOLE

C_a restriction increased to 2 mg m^{-3} for AERONET-OC, which includes AAOT, COVE, and MVCO sites

preliminary results …



	std dev (avg)
AERONET-OC	0.025
BOUSSOLE	0.010
MOBY	0.009
NOMAD	0.012
ORM (B+H)	0.014
SCAPA	0.014

evaluation metrics TBD (define “truth”)

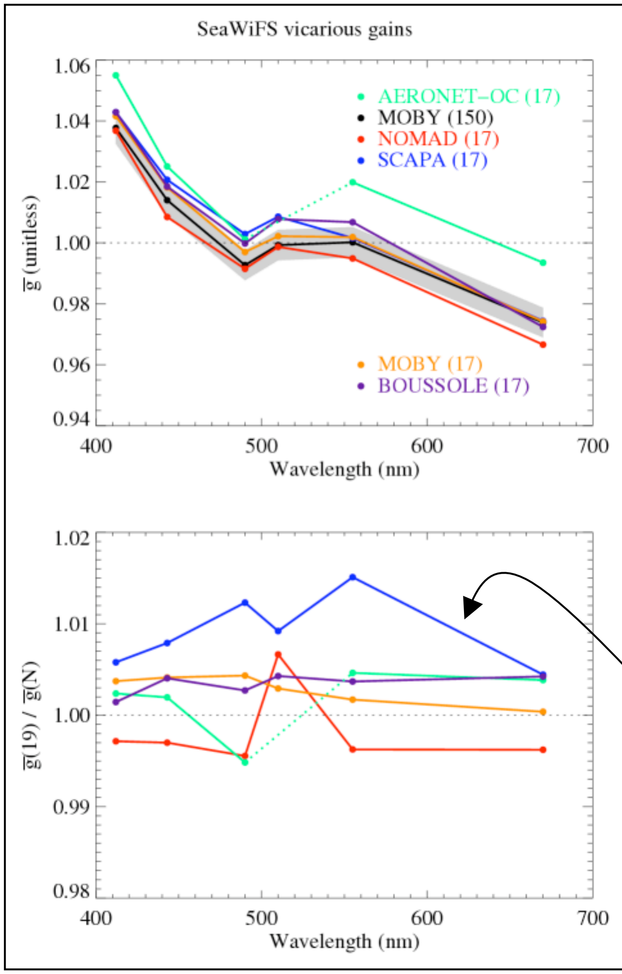
spectral shape reproduced by all sources, magnitudes vary

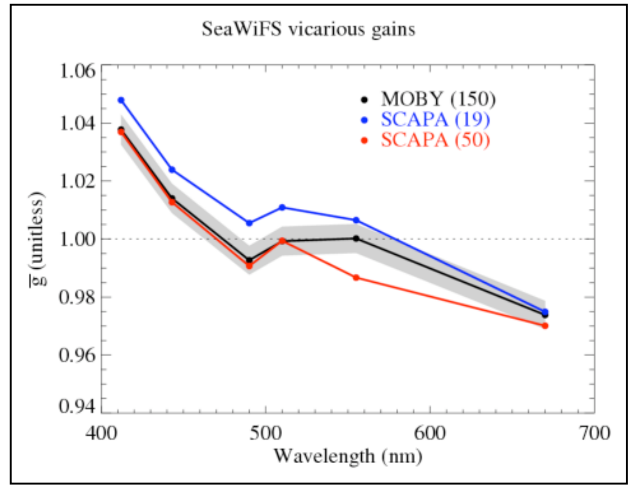
sensitivity of requirements TBD

preliminary results …

gains recalculated with N = 17

N increased by relaxing exclusion criteria





C_a restriction increased to 0.5 mg m^{-3}

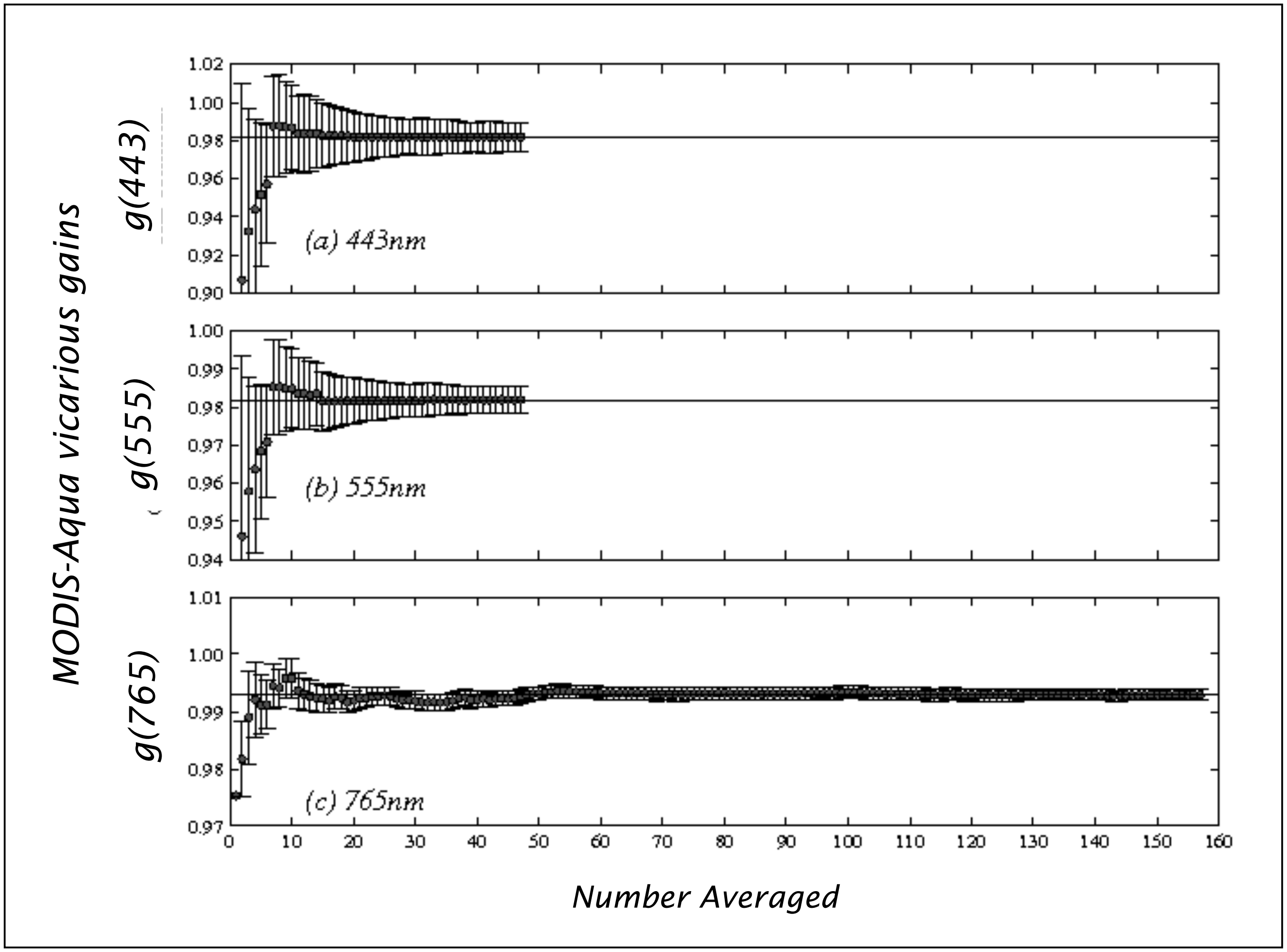
#-valid-pixels restriction reduced to 13

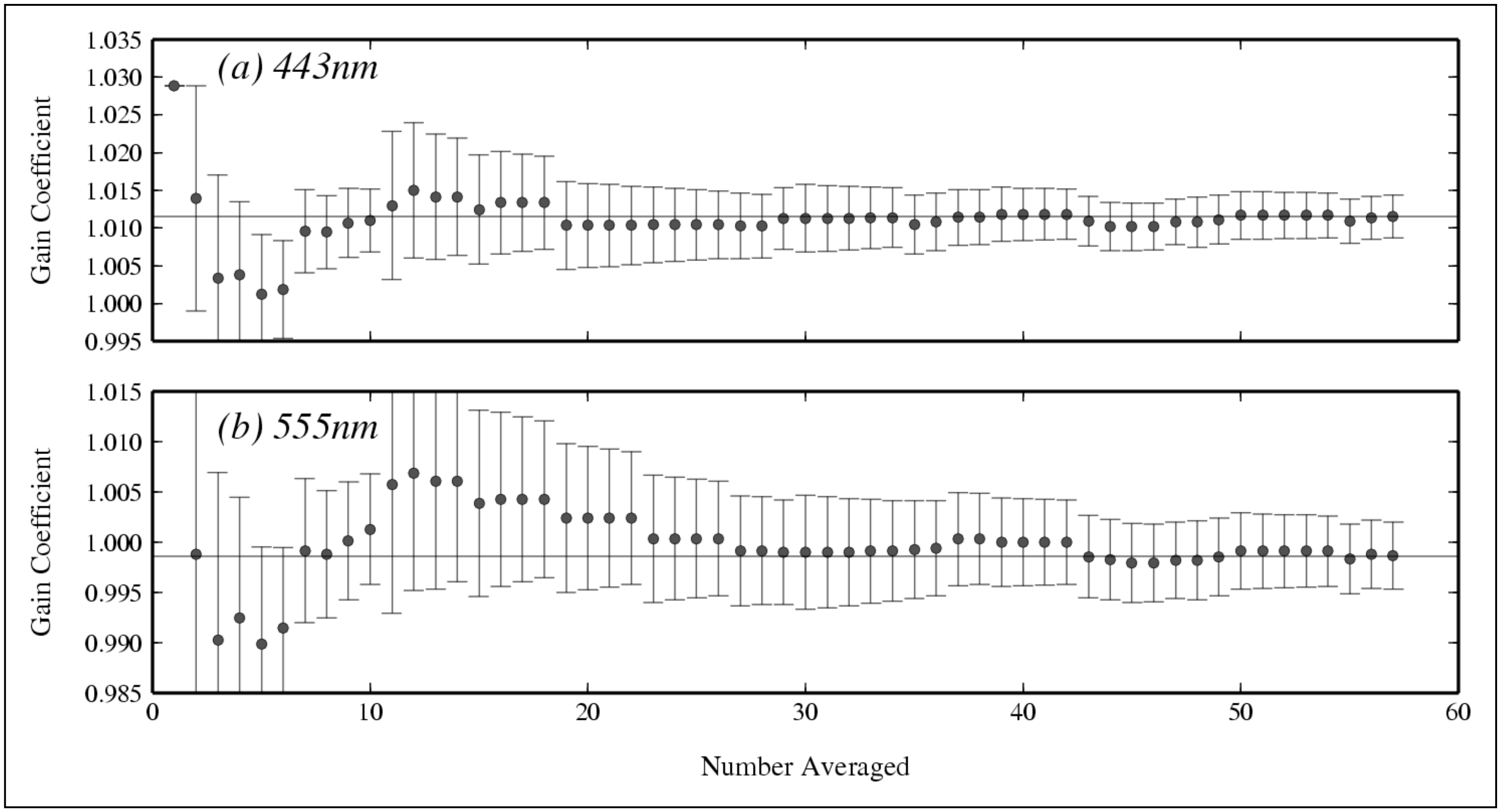
ratio of N=19 to N=50 from left figure

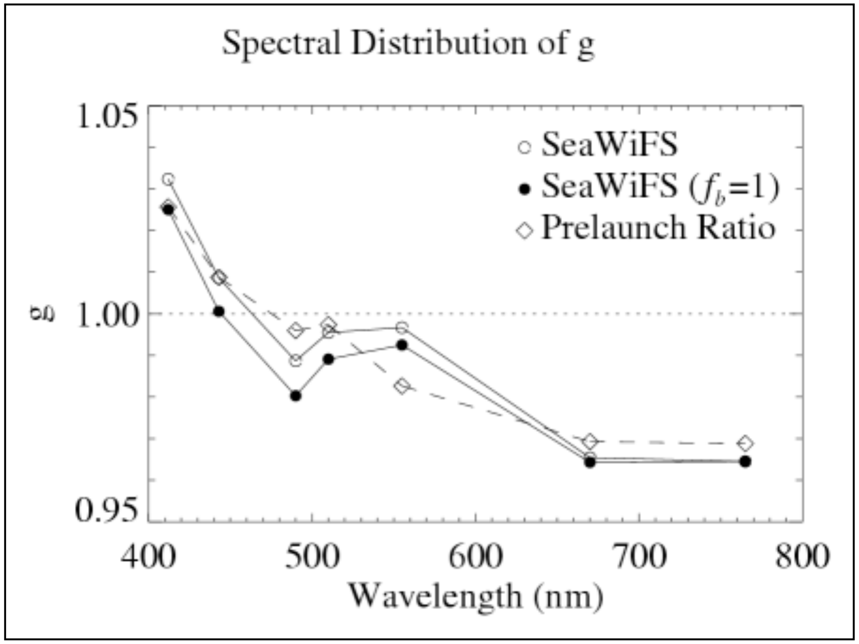
comments and suggestions always welcome

jeremy@seawifs.gsfc.nasa.gov

http://oceancolor.gsfc.nasa.gov


MODIS-Aqua vicarious gains
g(443)
g(555)
g(765)
(a) 443nm
(b) 555nm
(c) 765nm
Number Averaged


(a) 443nm
(b) 555nm
Gain Coefficient
Gain Coefficient
1.035
1.030
1.025
1.020
1.015
1.010
1.005
1.000
0.995
1.015
1.010
1.005
1.000
0.995
0.990
0.985
0
10
20
30
40
50
60
Number Averaged


Spectral Distribution of g
1.05
1.00
0.95
g
400
500
600
700
800
Wavelength (nm)
SeaWiFS
SeaWiFS (f_b=1)
Prelaunch Ratio