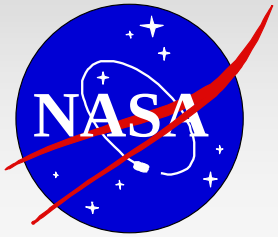
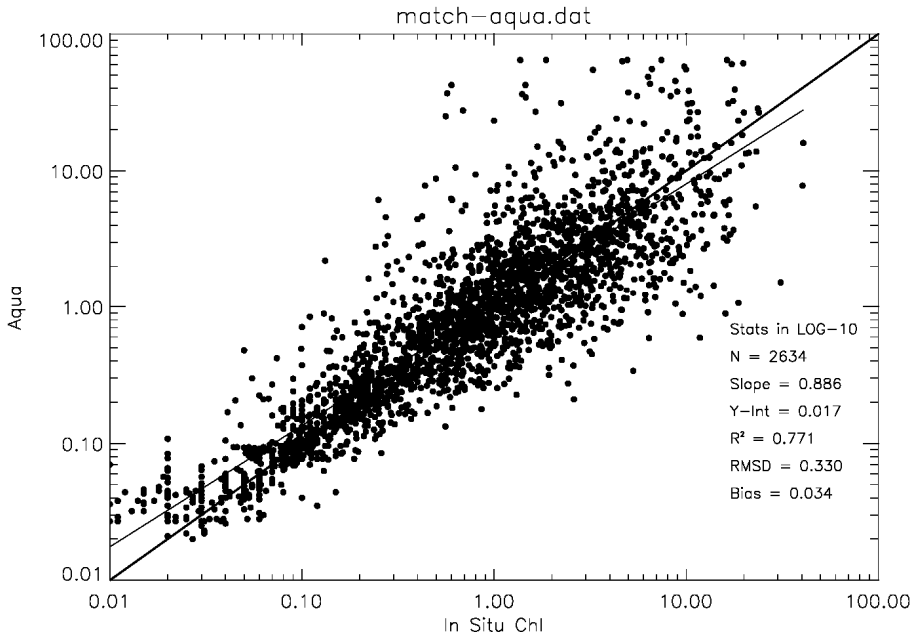
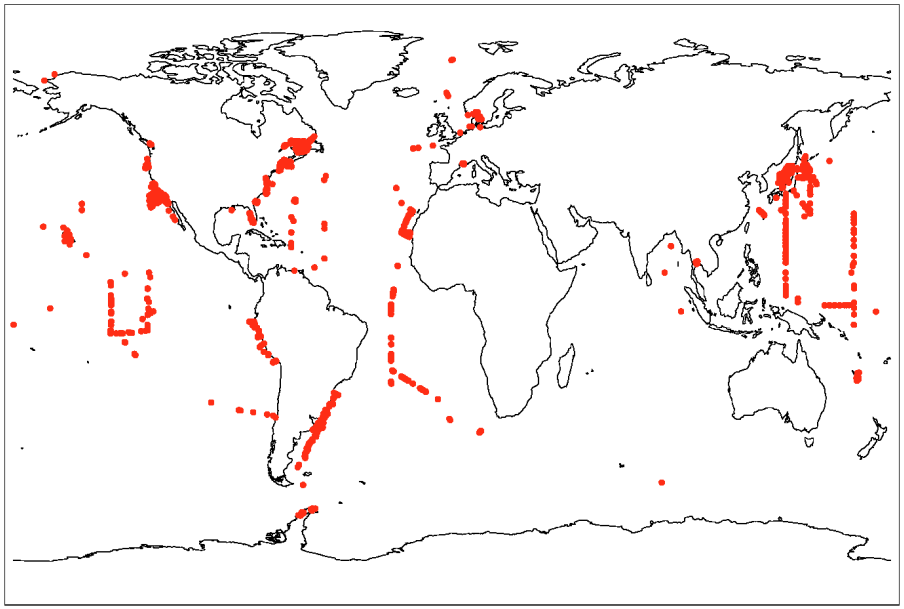
In Situ Data for Improving Satellite Data and Models: Beyond Validation



Watson Gregg
NASA/Global Modeling and Assimilation Office

Supporting data and publications: Google gmao, click Research, then Ocean Biology Modeling (http://gmao.gsfc.nasa.gov/research/oceanbiology)

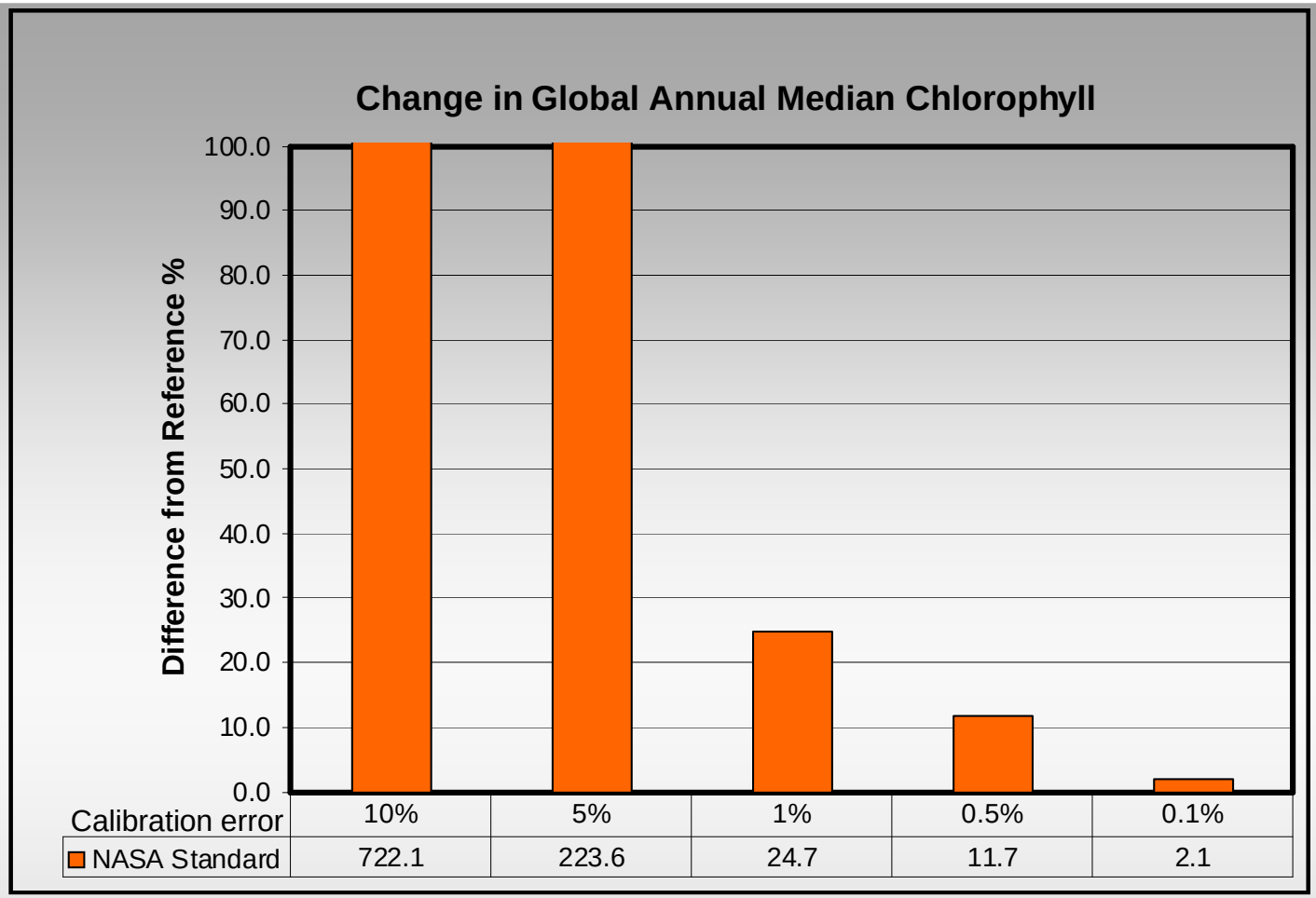

match−aqua.dat
100.00
10.00
1.00
0.10
0.01
Aqua
0.01
0.10
1.00
10.00
100.00
In Situ Chl
Stats in LOG−10
N = 2634
Slope = 0.886
Y−Int = 0.017
R² = 0.771
RMSD = 0.330
Bias = 0.034

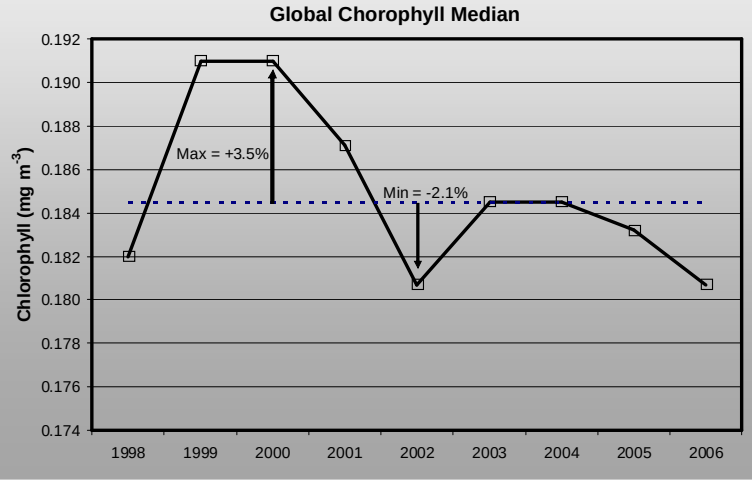


Seek to Unify the Description of Global Ocean Biology

using satellite and in situ data:

Beyond Validation





Maximum interannual variability for SeaWiFS = ±3%

Empirical Satellite Radiance-In situ Data (ESRID)

Derive empirical relationships between

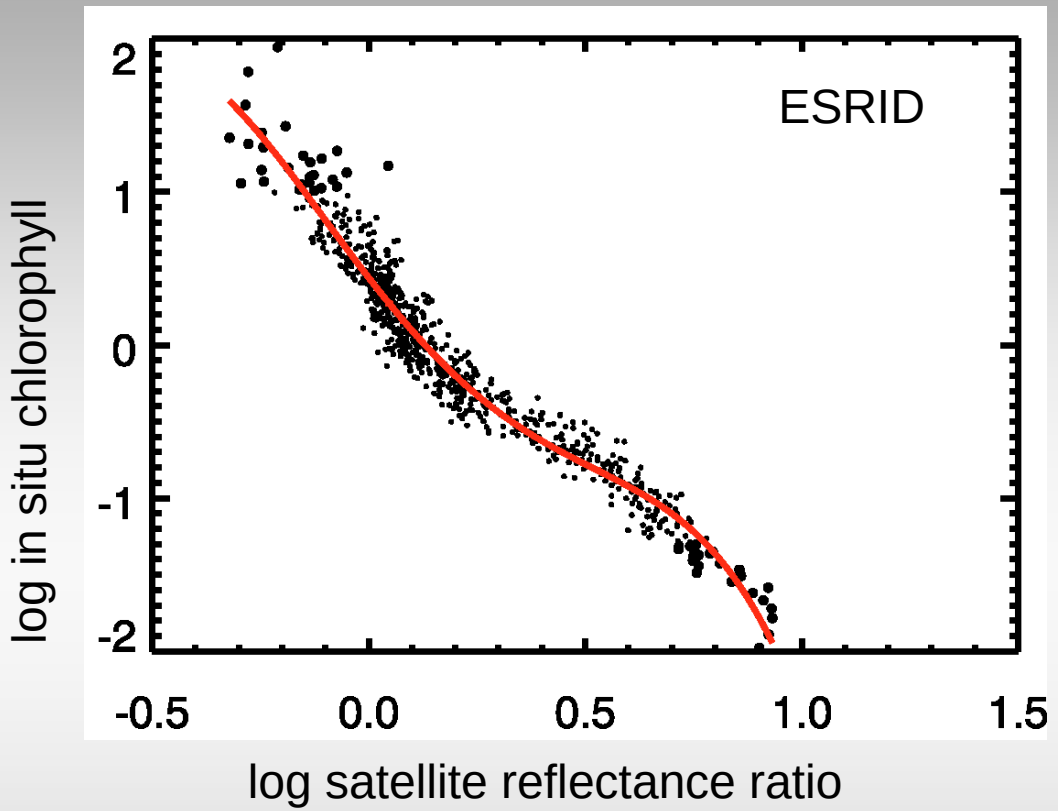
Satellite radiances (at Level 3)

and

In situ geophysical data

Requires that sensor-related spatial and temporal variability be removed prior to application

In principle not limited to chlorophyll

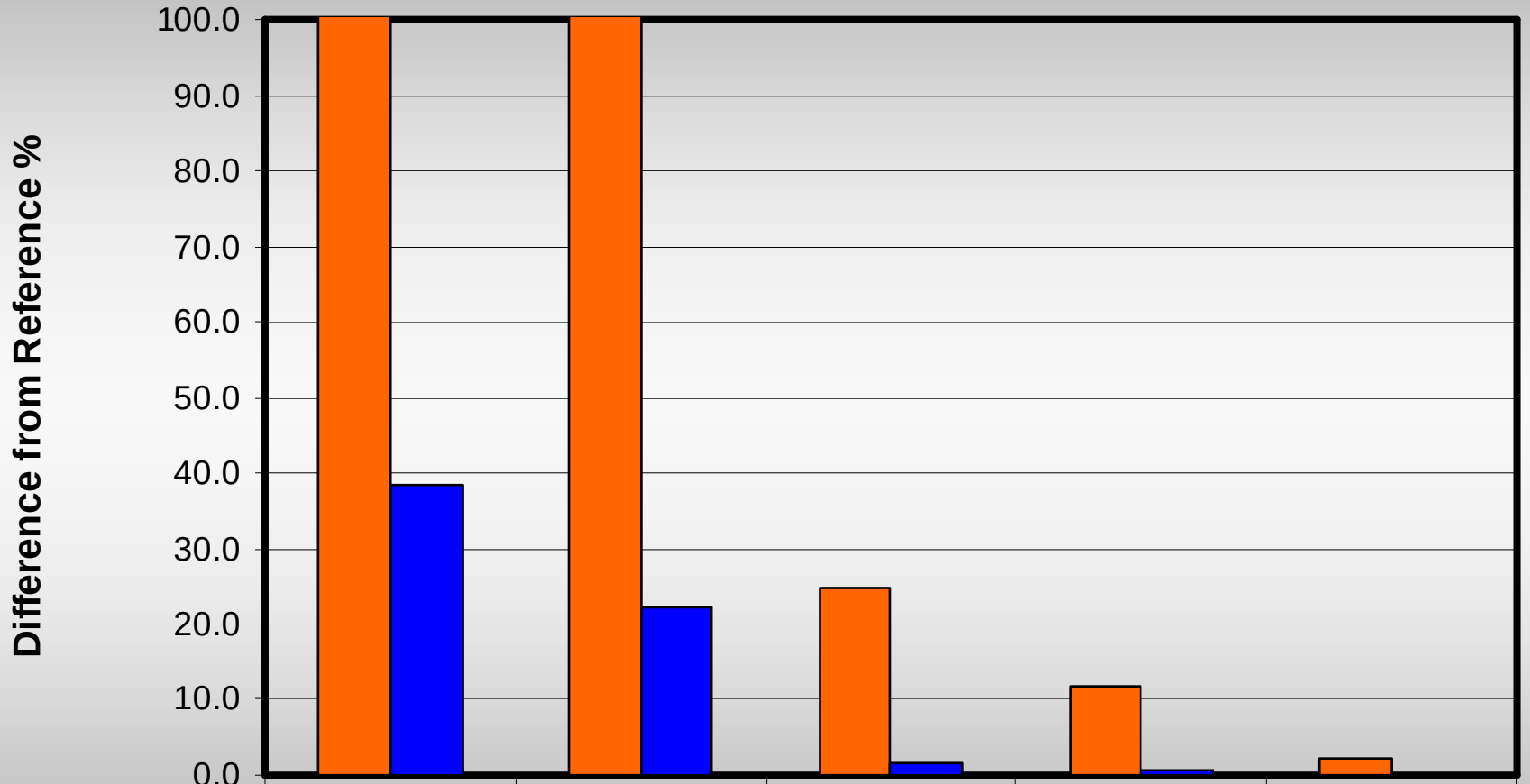


OC4 bio-optical algorithm

$\log chl = a_0 + a_1 R + a_2 R^2 + a_3 R^3 + a_4 R^4$

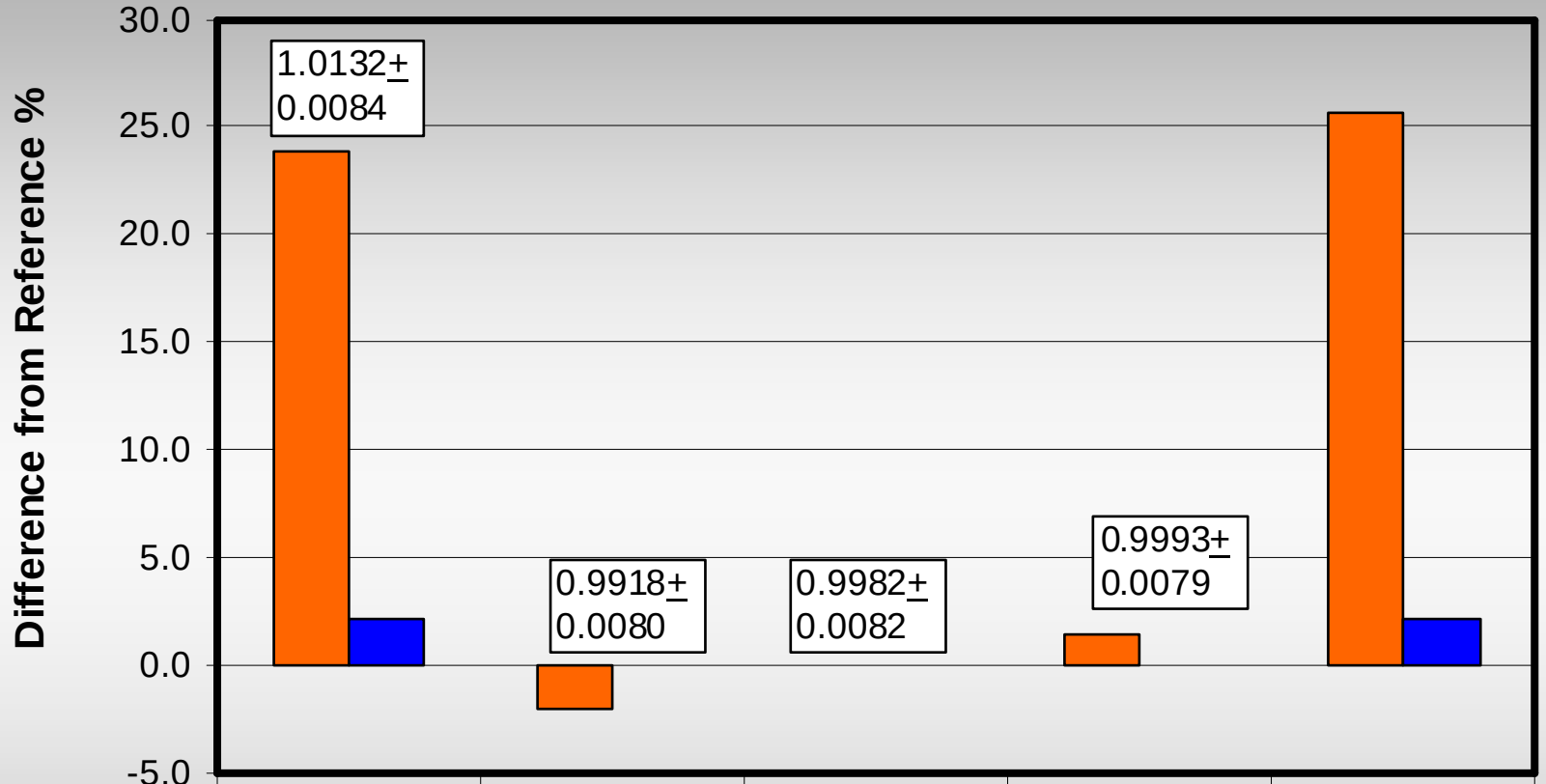
$R = \log (Rrs1/Rrs5)$

Change in Global Annual Median Chlorophyll



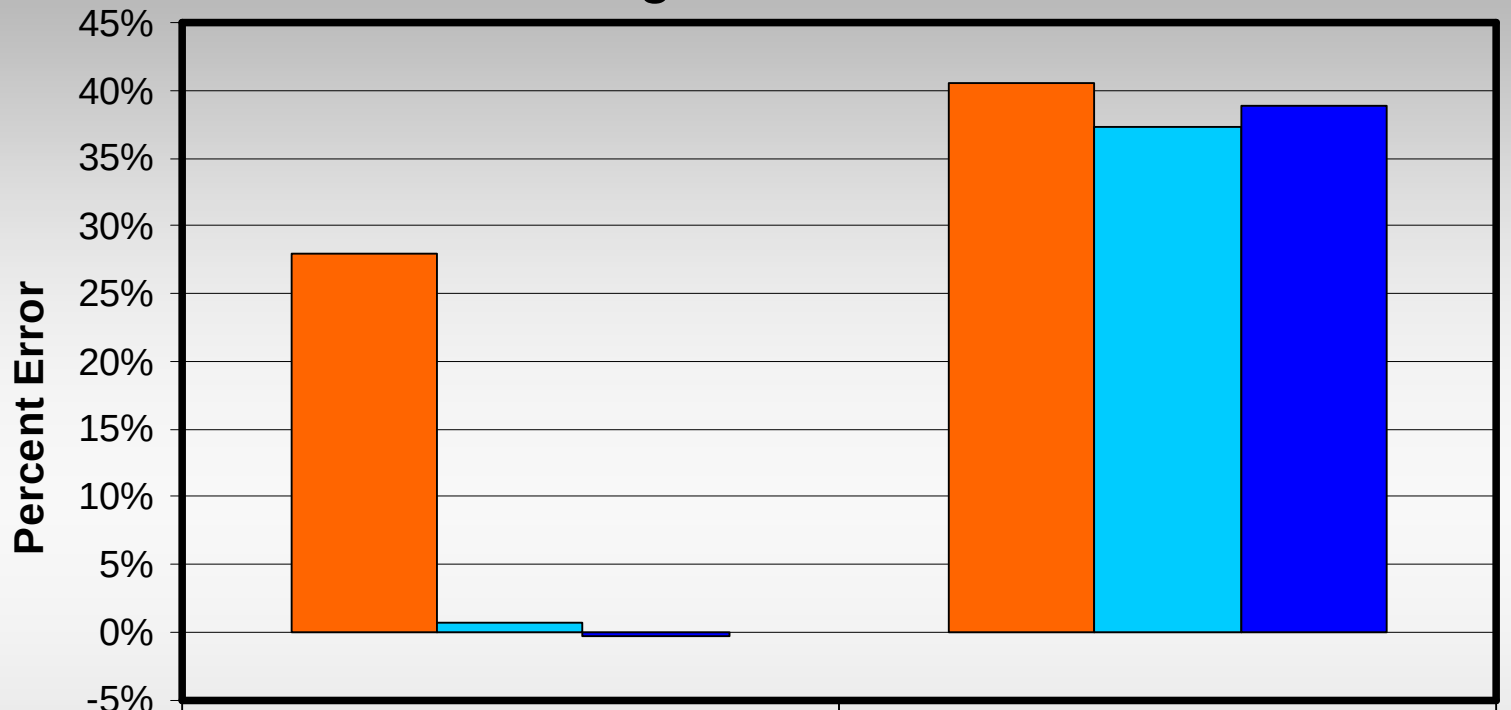
Calibration error	10%	5%	1%	0.5%	0.1%
NASA Standard	722.1	223.6	24.7	11.7	2.1
ESRID	38.4	22.2	1.4	0.7	0.0

Changes in Global Annual Median Chlorophyll Not Using Re-Calibration Factors

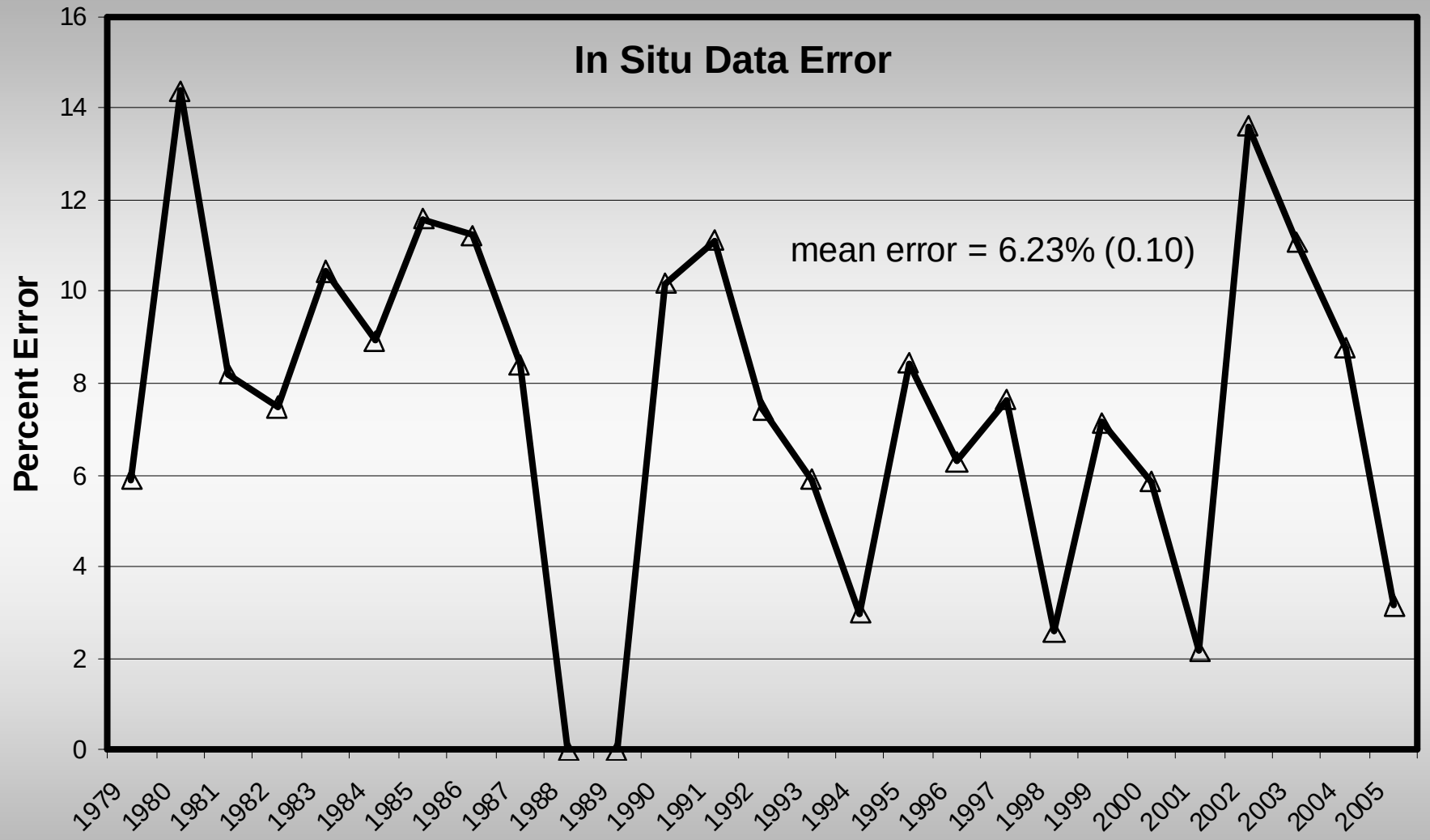


	443nm	490nm	510nm	555nm	All
NASA Standard	23.9	-2.0	0.0	1.4	25.6
ESRID	2.1	0.0	0.0	0.0	2.1

Satellite-Weighted Error: Global Ocean



	Bias			Uncertainty	
SeaWiFS	N=5994	28.0%	(0.130)	40.6%	(0.298)
ESRID 0% w/h	N=5920	0.7%	(0.020)	37.3%	(0.291)
ESRID 50% w/h	N=2922	-0.3%	(0.028)	38.9%	(0.291)



In situ data error estimated as the SIQR in percent at all 9km grid locations where 2 or more observations occurred. The Mean error over all years is shown with log RMS error in parentheses. N = 27.

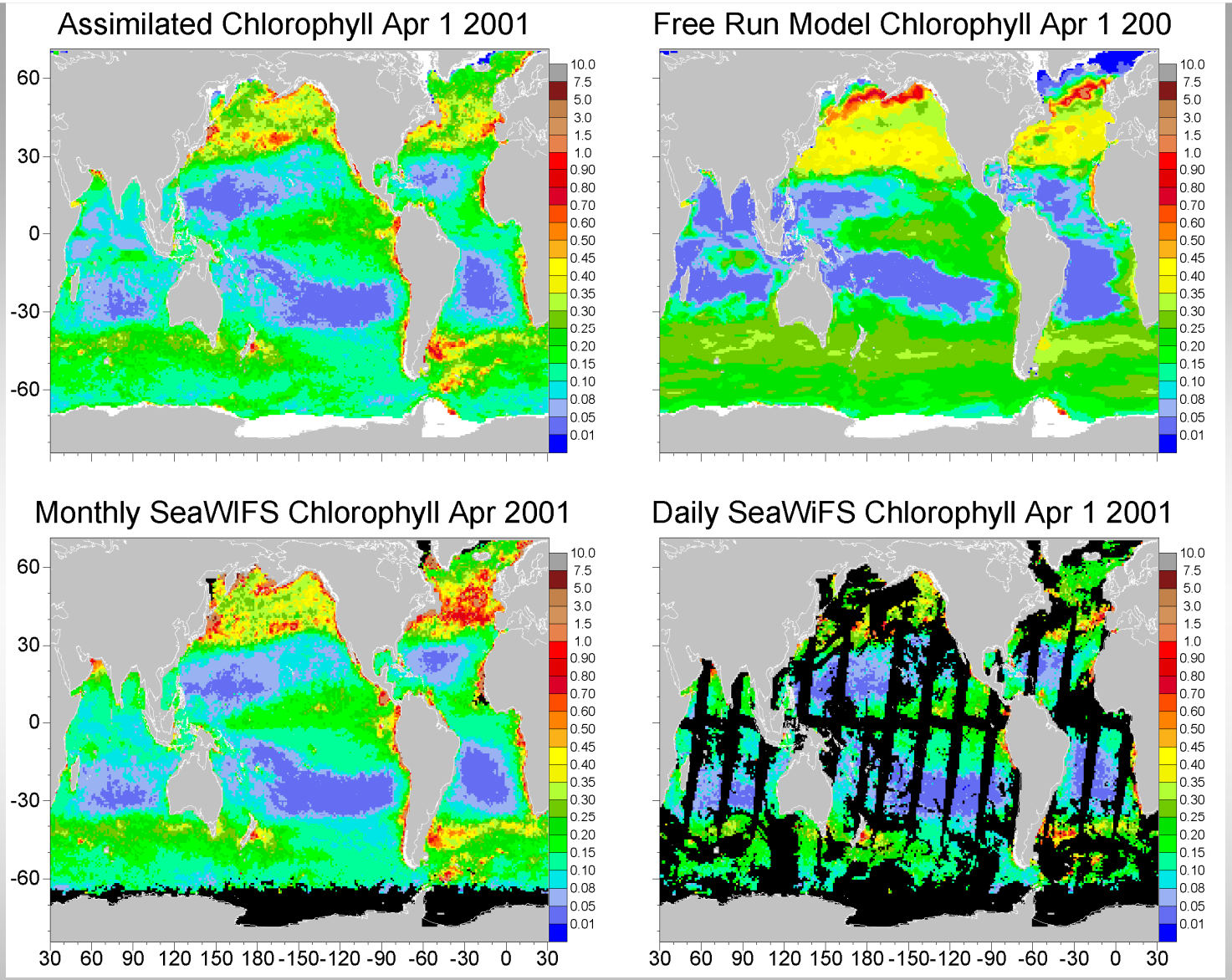
Data Assimilation at NASA

Routinely assimilating SeaWiFS and Aqua Data

Assimilated data sets available through GES-DISC

Recently implemented multi-variate assimilation:

- Nitrate
- Silica
- Iron

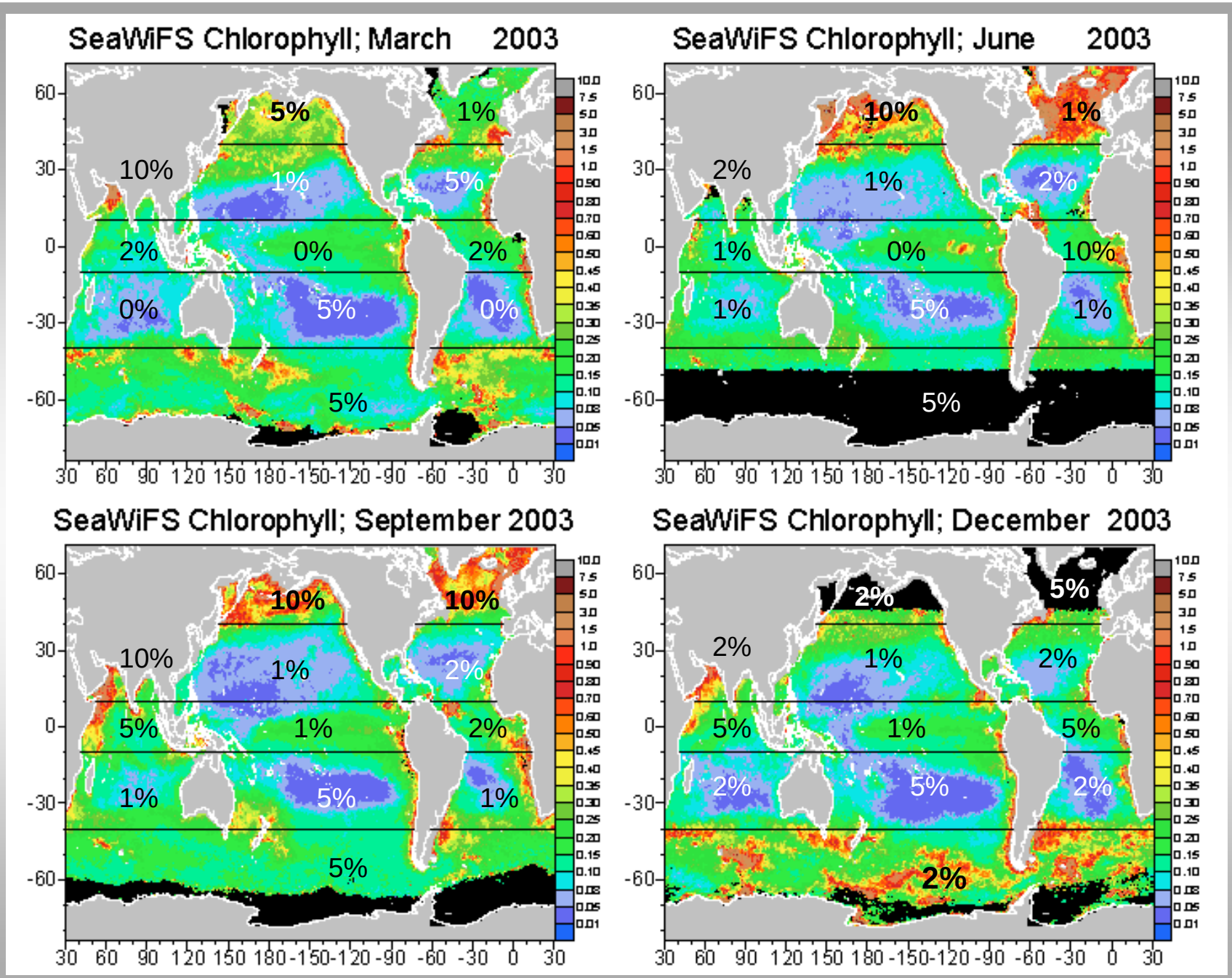


	Bias	Uncertainty	N
SeaWiFS	**-1.3%**	**32.7%**	**2086**
Free-run Model	**-1.4%**	**61.8%**	**4465**
Assimilation Model	**0.1%**	**33.4%**	**4465**

Can we fill a gap in satellite data using enhanced ship observations and data assimilation?

Goal: < 3% difference in Global Means using in situ assimilation (from satellite assimilation) <10% difference for any ocean basin

Sampling %	Global Difference	Maximum difference by basin
10% sampling (about 1500 obs/day)	-2.3%	-7.6% North Pacific
1% sampling (about 150 obs/day)	1.4%	-21.9% North Indian



Targeted regional (but systematic) sampling requirements for <10% difference in regional mean

Conclusions

The NASA standard algorithm is highly sensitive to radiometric calibration errors.

ESRID is insensitive to radiometric calibration error,
providing stable global mean estimates despite radical errors,
well within the interannual variability of the 9-year SeaWiFS record

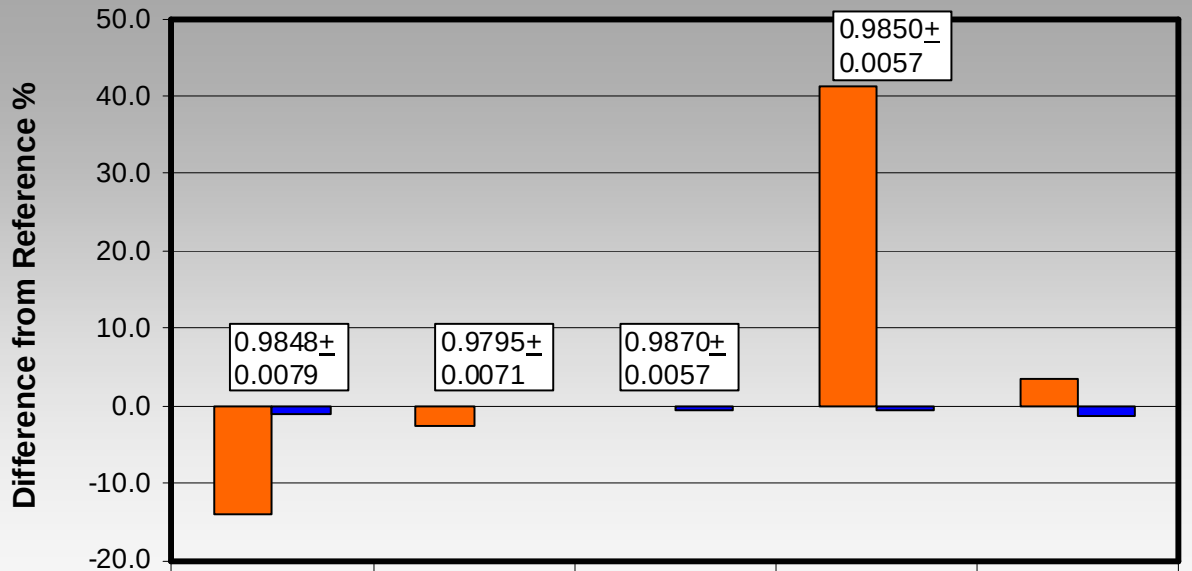
ESRID drastically reduces bias of satellite-derived ocean chlorophyll

ESRID reduces need for high radiometric calibration accuracy:
suggests intensified effort for in situ data sampling of biologically meaningful variables

ESRID promotes a unified description of ocean biology with satellite and in situ data

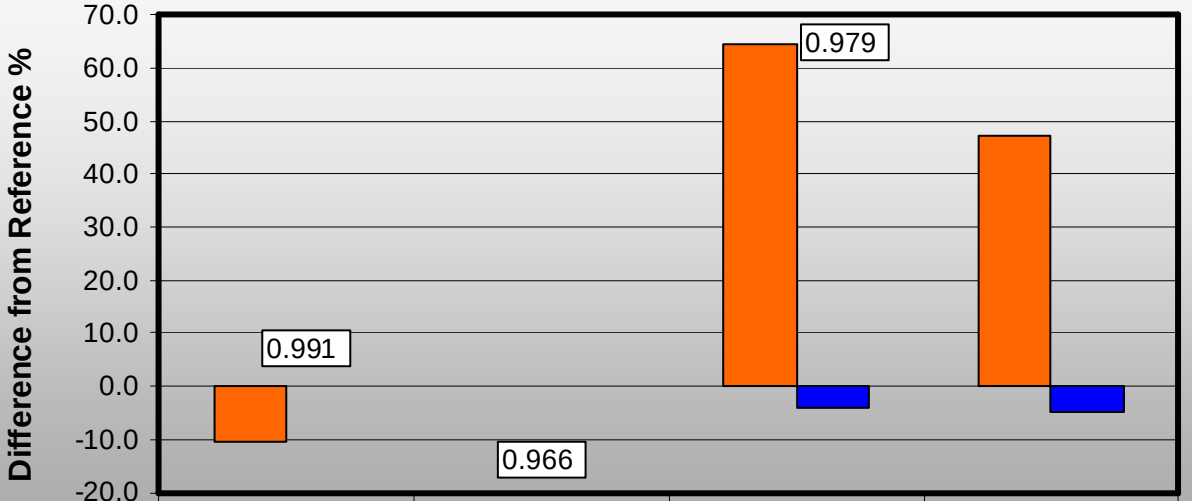
Data assimilation can assist in targeting in situ observations to maximize the effectiveness of field campaigns

Re-Calibration Factors from MODIS-Aqua

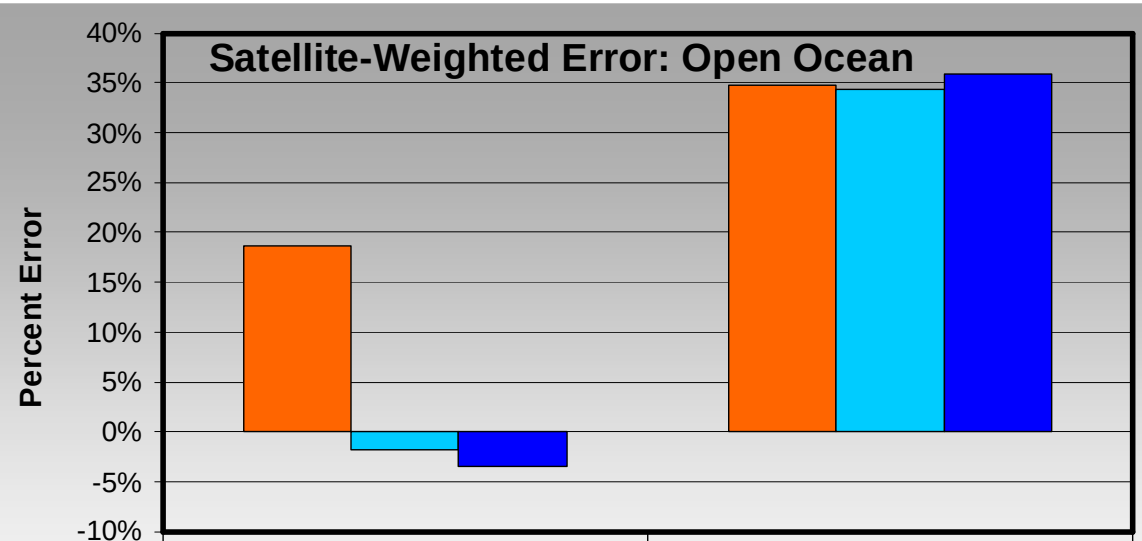


	443nm	490nm	510nm	555nm	All
NASA Standard	-14.1	-2.7	0.0	41.3	3.5
ESRID	-1.0	0.0	-0.7	-0.7	-1.4

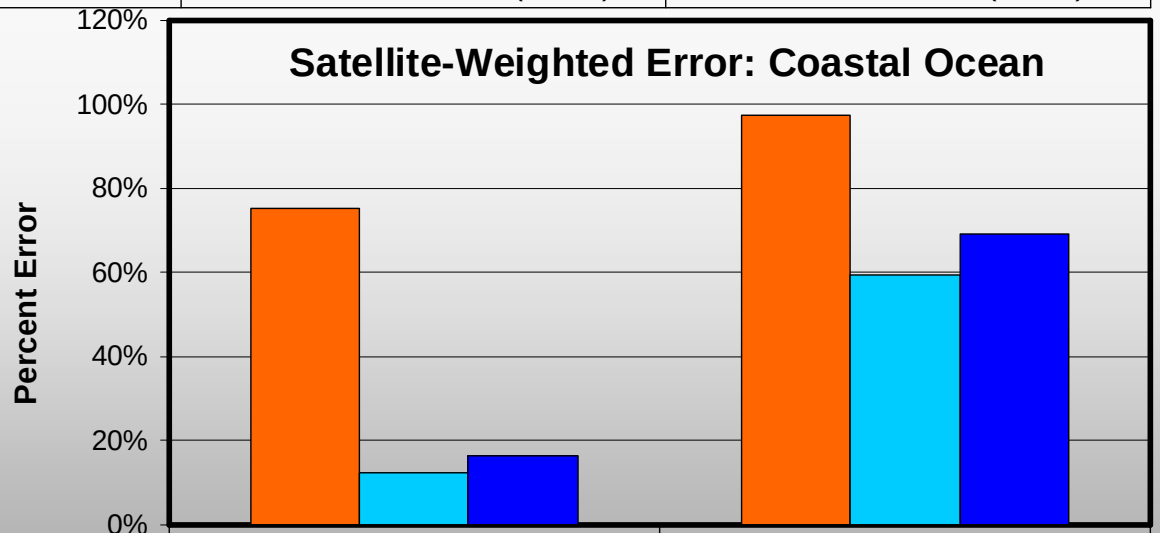
Re-Calibration Factors from CZCS



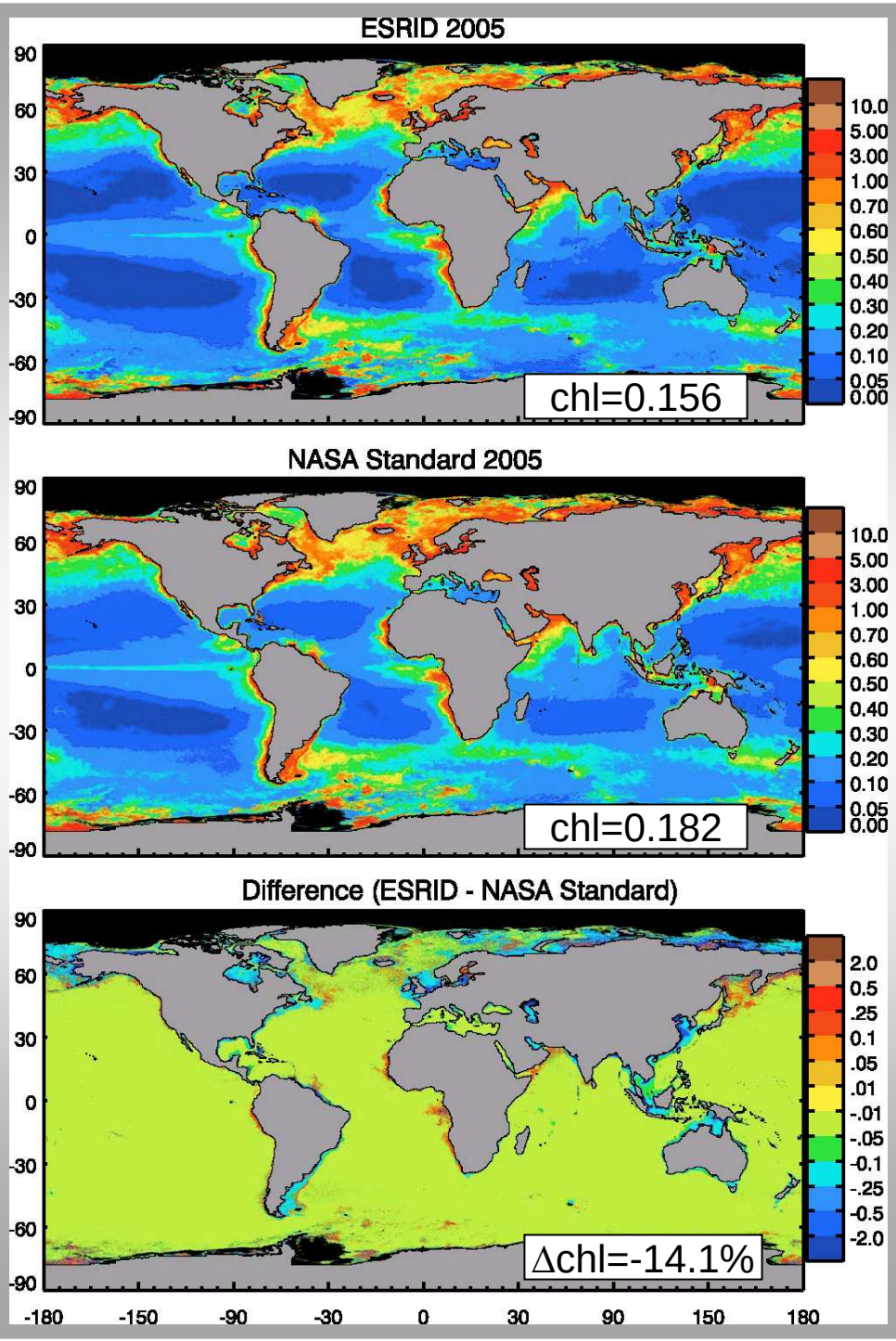
	443nm	510nm	555nm	All
NASA Standard	-10.5	0.0	64.5	47.2
ESRID	0.0	0.0	-4.1	-4.7

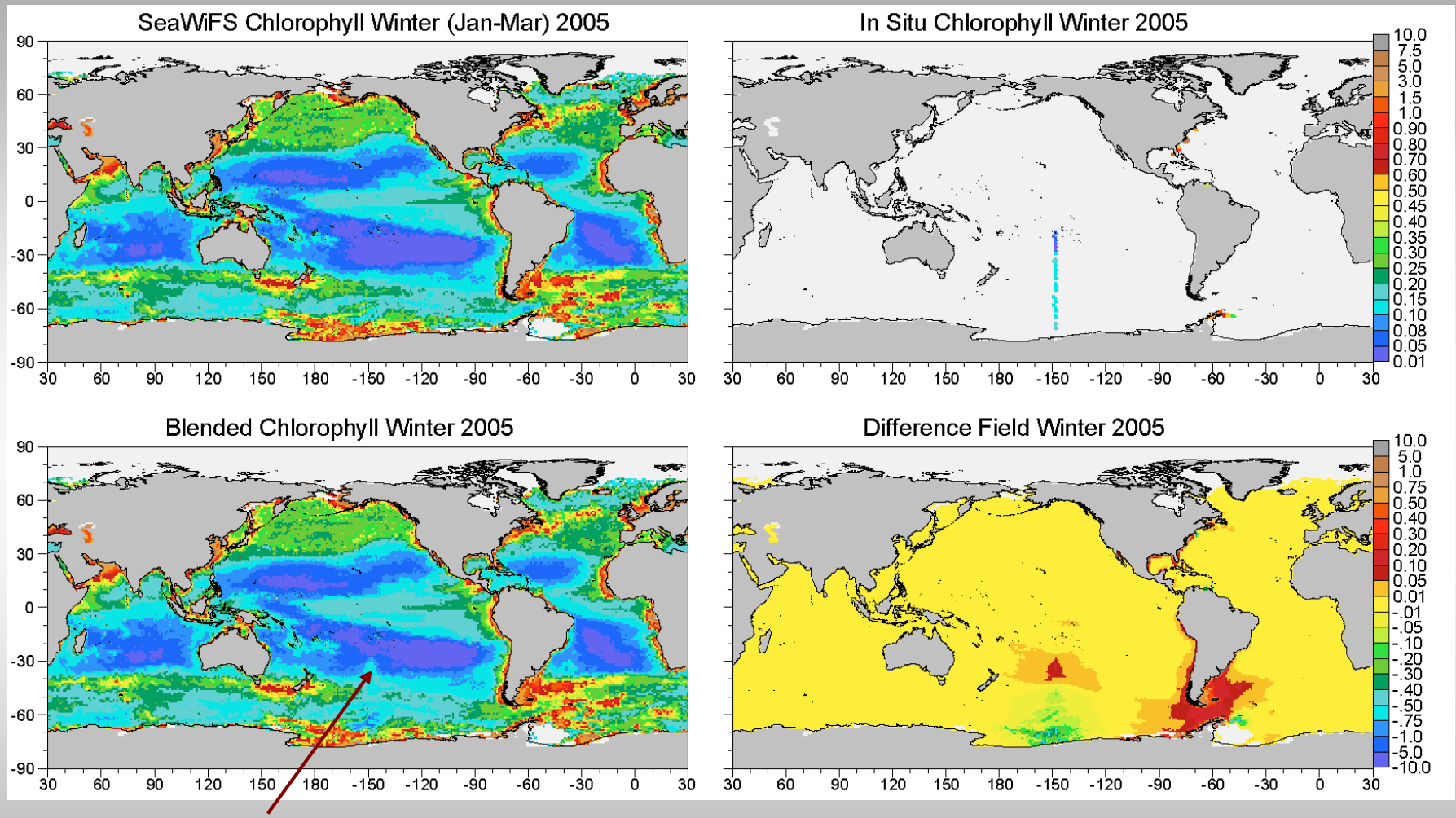


	Bias			Uncertainty	
SeaWiFS	N=3216	18.6%	(0.077)	34.8%	(0.249)
ESRID 0% w/h	N=3161	-1.8%	(-0.006)	34.3%	(0.261)
ESRID 50% w/h	N=1558	-3.4%	(0.001)	35.8%	(0.262)



	Bias			Uncertainty	
SeaWiFS	N=2778	75.0%	(0.314)	97.3%	(0.471)
ESRID 0% w/h	N=2751	12.4%	(0.132)	59.5%	(0.414)
ESRID 50% w/h	N=1364	16.4%	(0.134)	69.1%	(0.394)


ESRID 2005
90
60
30
0
-30
-60
-90
10.0
5.00
3.00
1.00
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.05
0.00
chl=0.156
NASA Standard 2005
chl=0.182
Difference (ESRID - NASA Standard)
2.0
0.5
.25
0.1
.05
.01
-.01
-.05
-0.1
-.25
-0.5
-2.0
Δchl=-14.1%
-180
-150
-90
-30
0
30
90
150
180


SeaWiFS Chlorophyll Winter (Jan-Mar) 2005
In Situ Chlorophyll Winter 2005
Blended Chlorophyll Winter 2005
Difference Field Winter 2005
90
60
30
0
-30
-60
-90
30 60 90 120 150 180 -150 -120 -90 -60 -30 0 30
10.0
7.5
5.0
3.0
1.5
1.0
0.90
0.80
0.70
0.60
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.08
0.05
0.01
10.0
5.0
1.0
0.75
0.50
0.40
0.30
0.20
0.10
0.05
0.01
-.01
-.05
-.10
-.20
-.30
-.40
-.50
-.75
-1.0
-5.0
-10.0