Radiative Coupling in the Oceans using MODIS-Aqua Ocean Radiance Data

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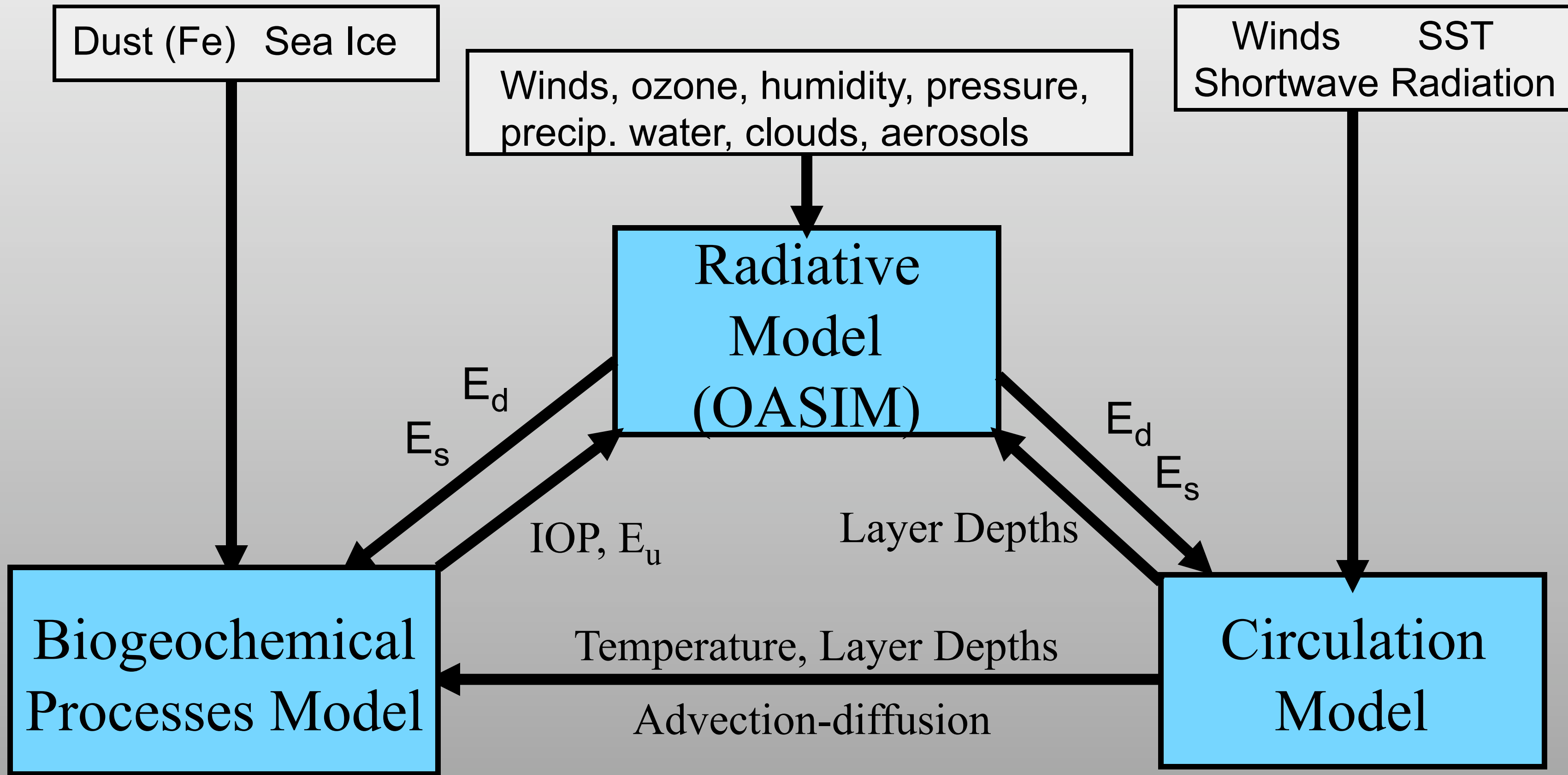
Assimilate MODIS-Aqua Water-Leaving Radiances to:

1) Improve understanding of the propagation of light in the surface layer
   - Primary Production
   - Heat transfer -- Changes in ocean density structure and circulation

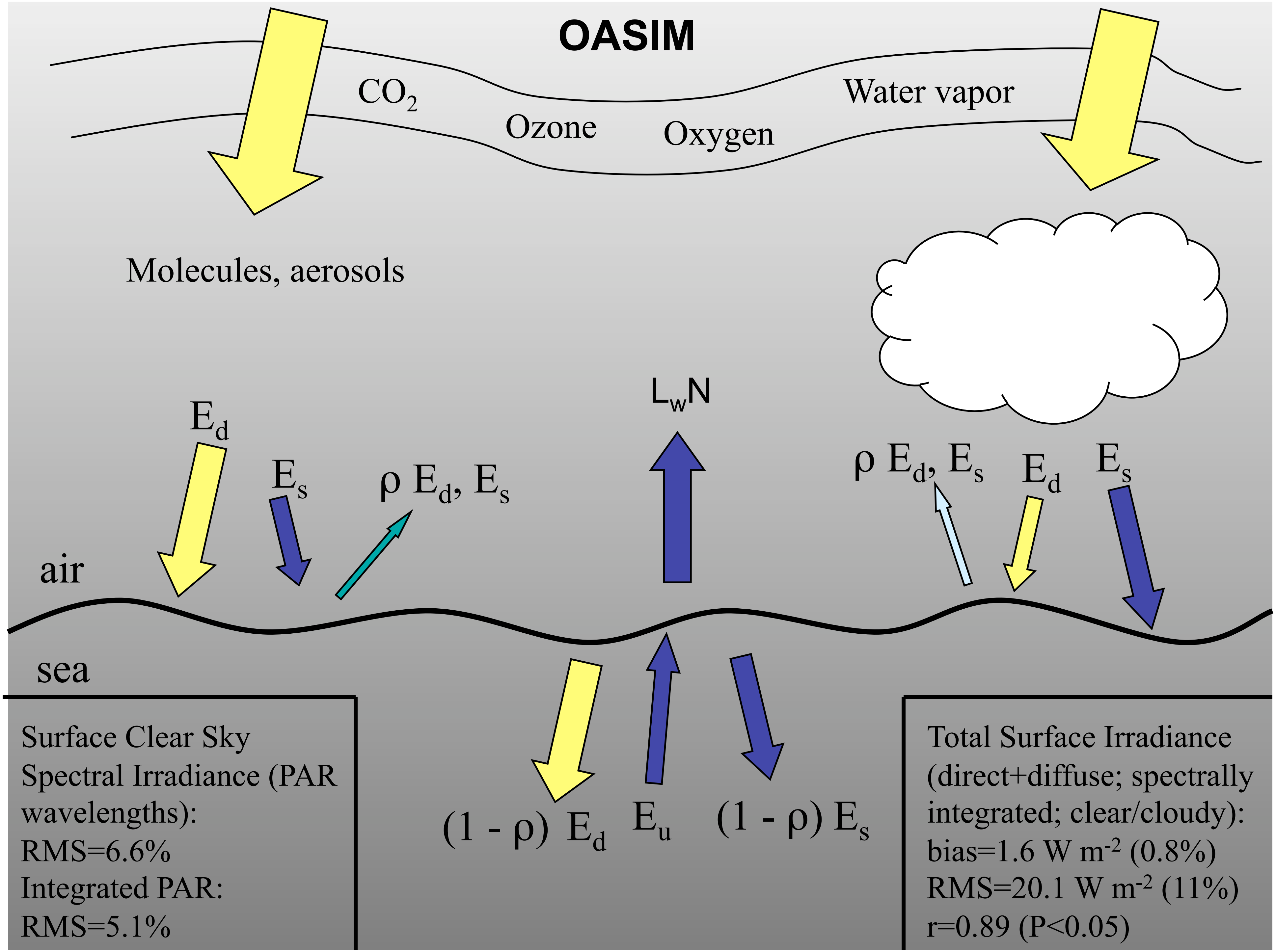
2) Invert the radiance assimilation into new information on model phytoplankton groups, CDOM, and other internal model variables.

NASA Ocean Biogeochemical Model (NOBM)

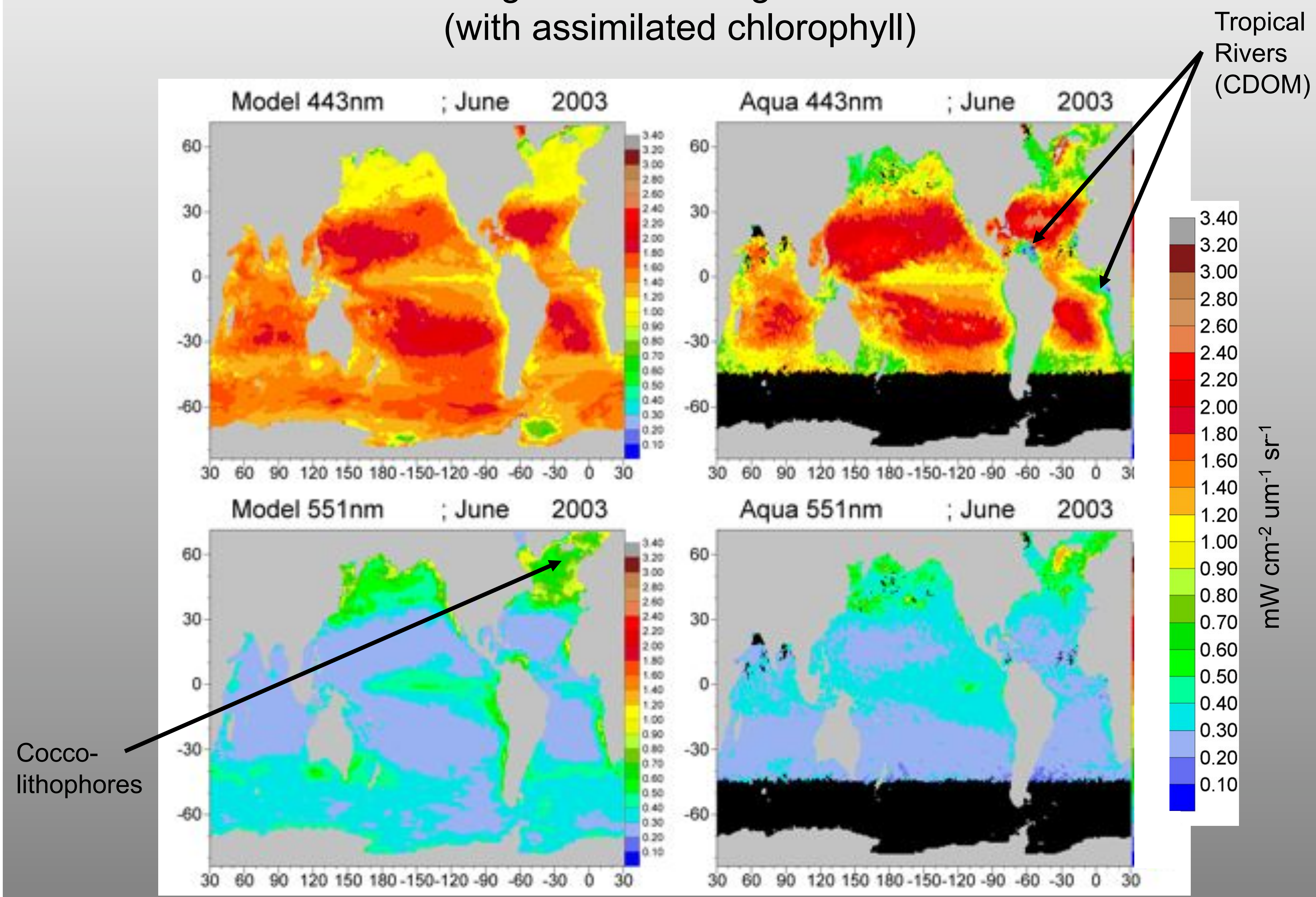


Outputs:

- Chlorophyll, Phytoplankton Groups
- Primary Production
- Nutrients
- DOC, DIC, pCO_2
- Spectral Irradiance/Radiance


OASIM
CO2
Ozone
Oxygen
Water vapor
Molecules, aerosols
Ed
Es
ρ Ed, Es
LwN
ρ Ed, Es
Ed
Es
air
sea
(1 - ρ) Ed
Eu
(1 - ρ) Es
Surface Clear Sky Spectral Irradiance (PAR wavelengths):
RMS=6.6%
Integrated PAR:
RMS=5.1%
Total Surface Irradiance (direct+diffuse; spectrally integrated; clear/cloudy):
bias=1.6 W m-2 (0.8%)
RMS=20.1 W m-2 (11%)
r=0.89 (P<0.05)

Modeling Water-Leaving Radiances (with assimilated chlorophyll)



$$\frac{dE_d(\lambda)}{dz} = -C_d(\lambda)E_d(\lambda) \qquad (1)$$

$$\frac{dE_s(\lambda)}{dz} = -C_s(\lambda)E_s(\lambda) + B_u(\lambda)E_u(\lambda) + F_d(\lambda)E_d(\lambda) \qquad (2)$$

$$\frac{dE_u(\lambda)}{dz} = -C_u(\lambda)E_u(\lambda) - B_s(\lambda)E_s(\lambda) - B_d(\lambda)E_d(\lambda) \qquad (3)$$

$$L_w = (1-\rho)E_u(0^-)/n^2Q$$

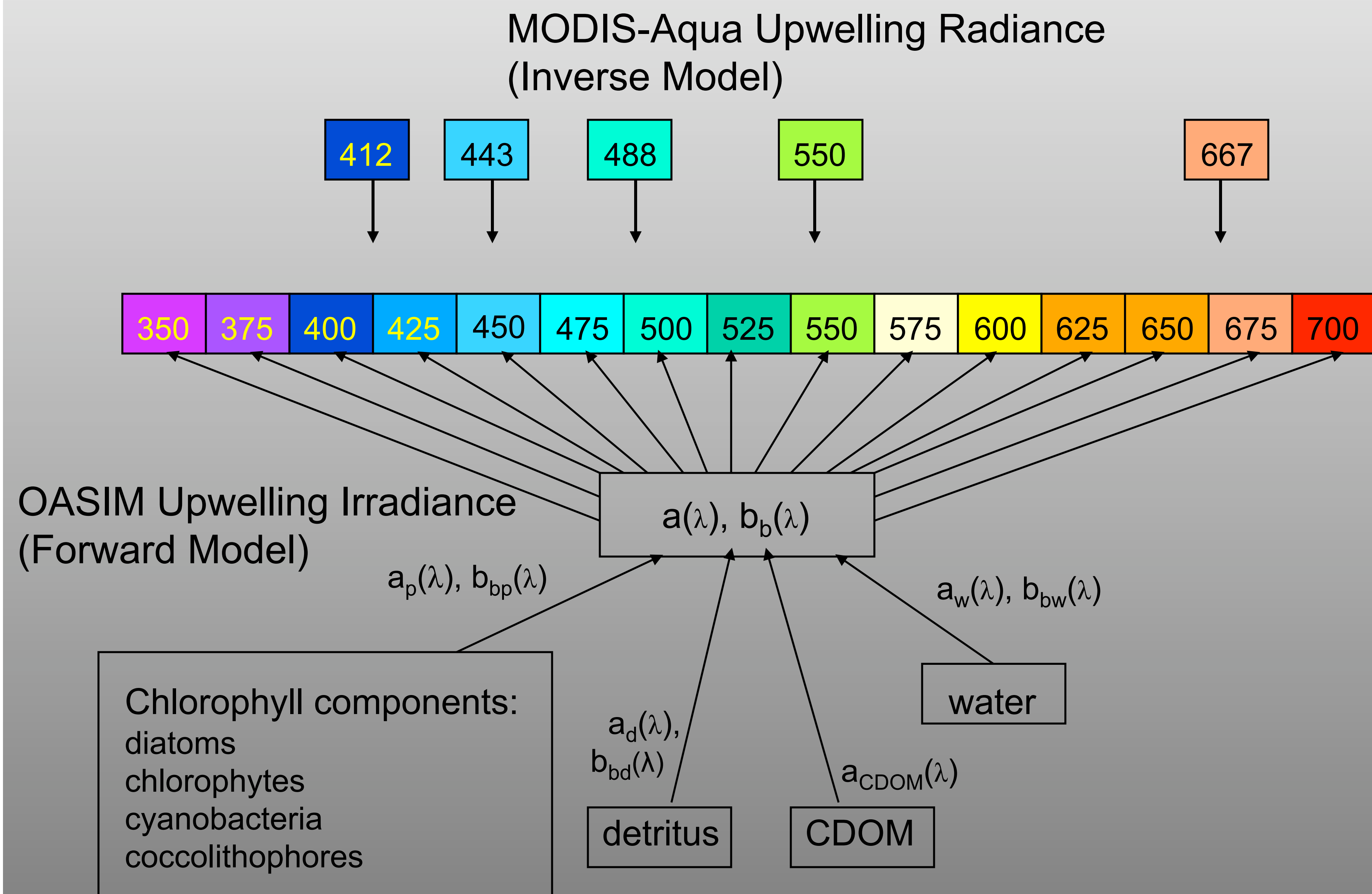
$$R = E_u(0^-)/E_{dt}(0^-)$$

$$\Delta Lw_N = LwN_{assim} - LwN_{model}$$

or

$$L_wN = \frac{tFo}{n^2} \sum g_i \left[\frac{b_b}{a + b_b} \right]^i$$

Objective 2: Invert the radiance assimilation into new information on model phytoplankton groups, CDOM, and other internal model variables.



Consistent Ocean Chlorophyll from NPP/VIIRS

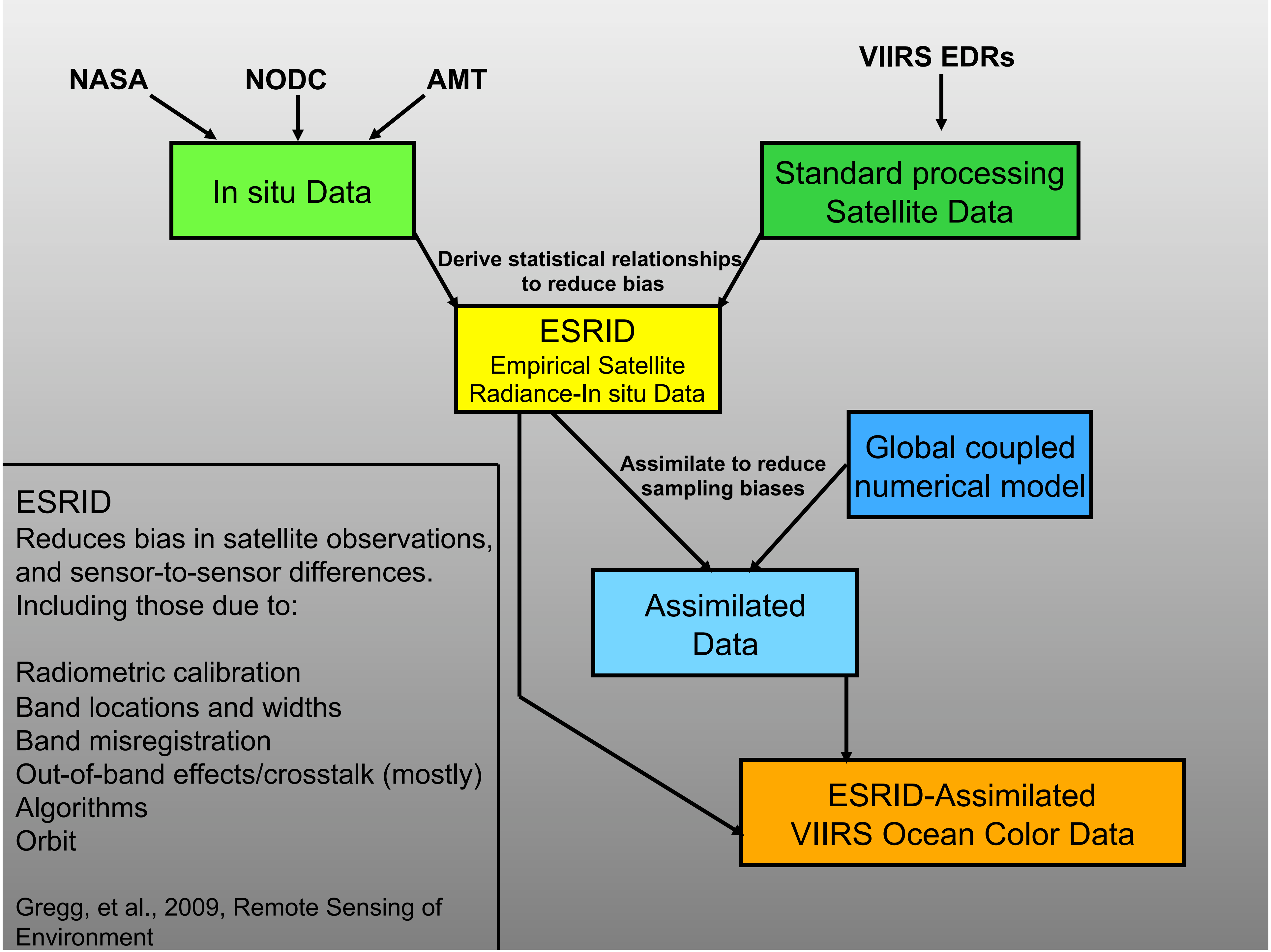
NPP Science Team for Climate Data Records

Watson W. Gregg and
Nancy W. Casey

Investigate the ability of an established approach to improve the consistency of VIIRS ocean color data.

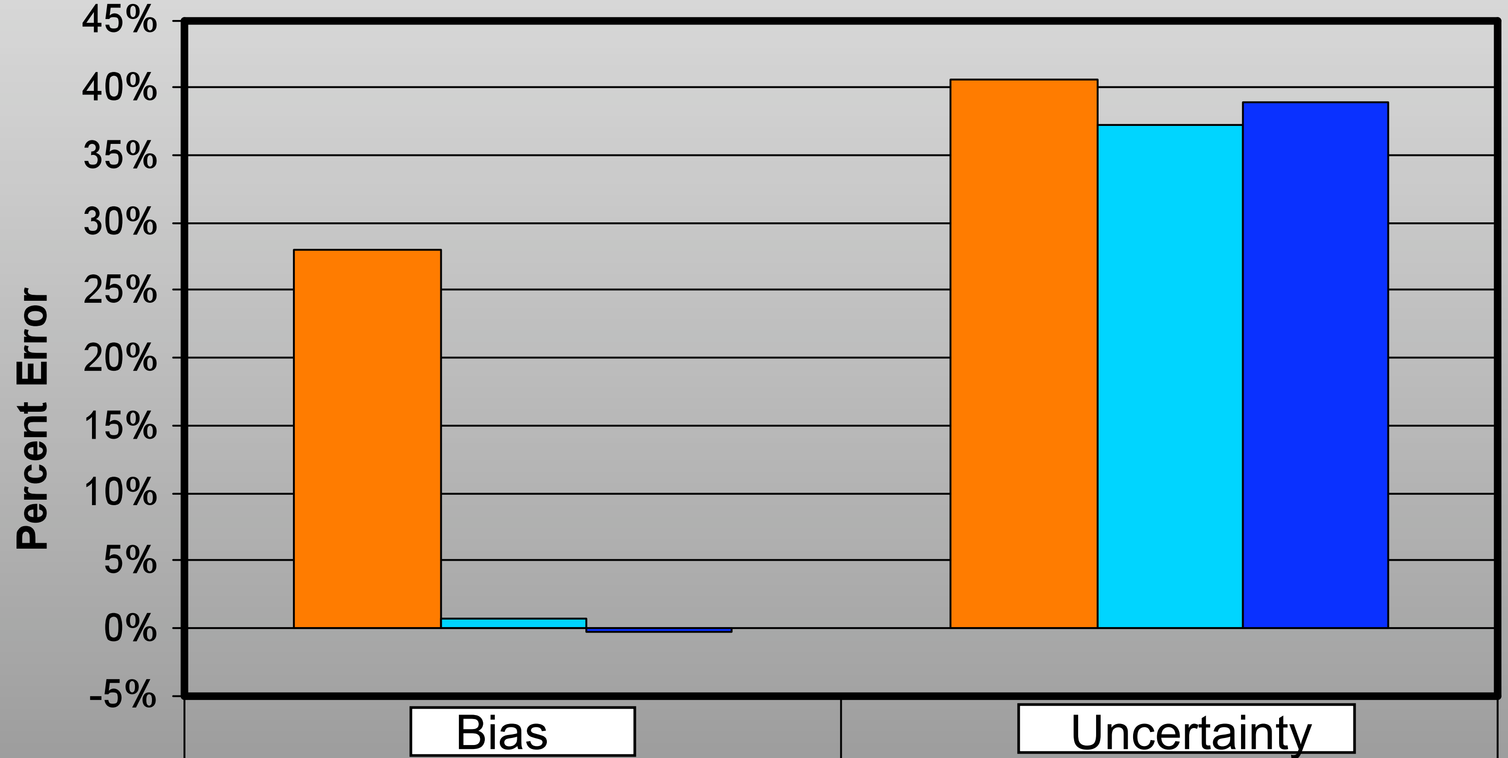
Utilizes completely processed and gridded ocean color data (Level-3 Environmental Data Records):

1) applies in situ data for *a posteriori* correction, and then
2) applies data assimilation to correct sampling problems.


NASA
NODC
AMT
VIIRS EDRs
In situ Data
Standard processing Satellite Data
Derive statistical relationships to reduce bias
ESRID
Empirical Satellite Radiance-In situ Data
Assimilate to reduce sampling biases
Global coupled numerical model
Assimilated Data
ESRID-Assimilated VIIRS Ocean Color Data
ESRID
Reduces bias in satellite observations, and sensor-to-sensor differences.
Including those due to:
Radiometric calibration
Band locations and widths
Band misregistration
Out-of-band effects/crosstalk (mostly)
Algorithms
Orbit
Gregg, et al., 2009, Remote Sensing of Environment

ESRID
Empirical Satellite Radiance-In situ Data Algorithm

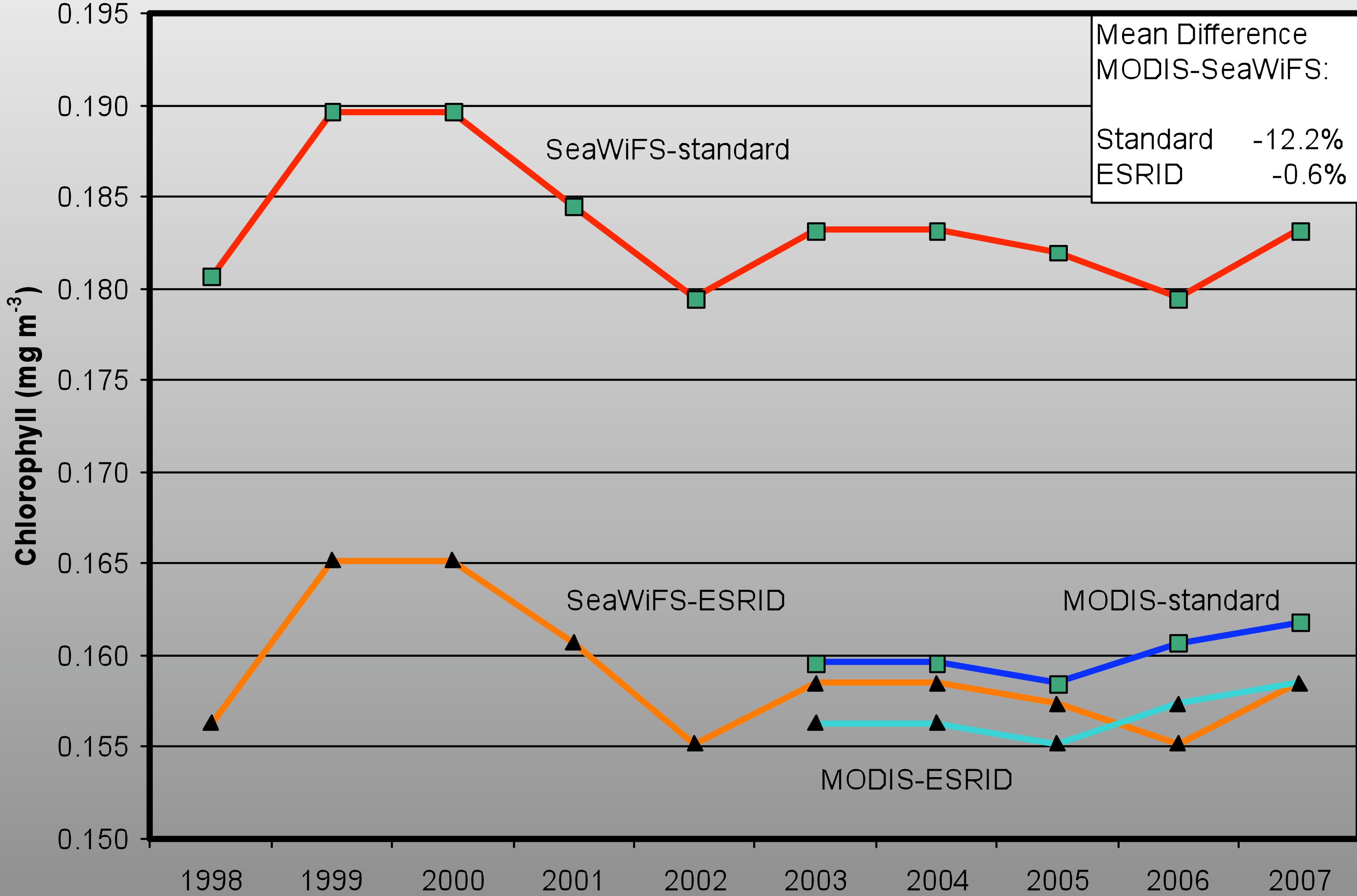
Satellite-Weighted Error: Global Ocean



	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)

w/h = withholding of in situ data
log bias and uncertainty in parentheses

Global Annual Median Chlorophyll circa 2007 Processing

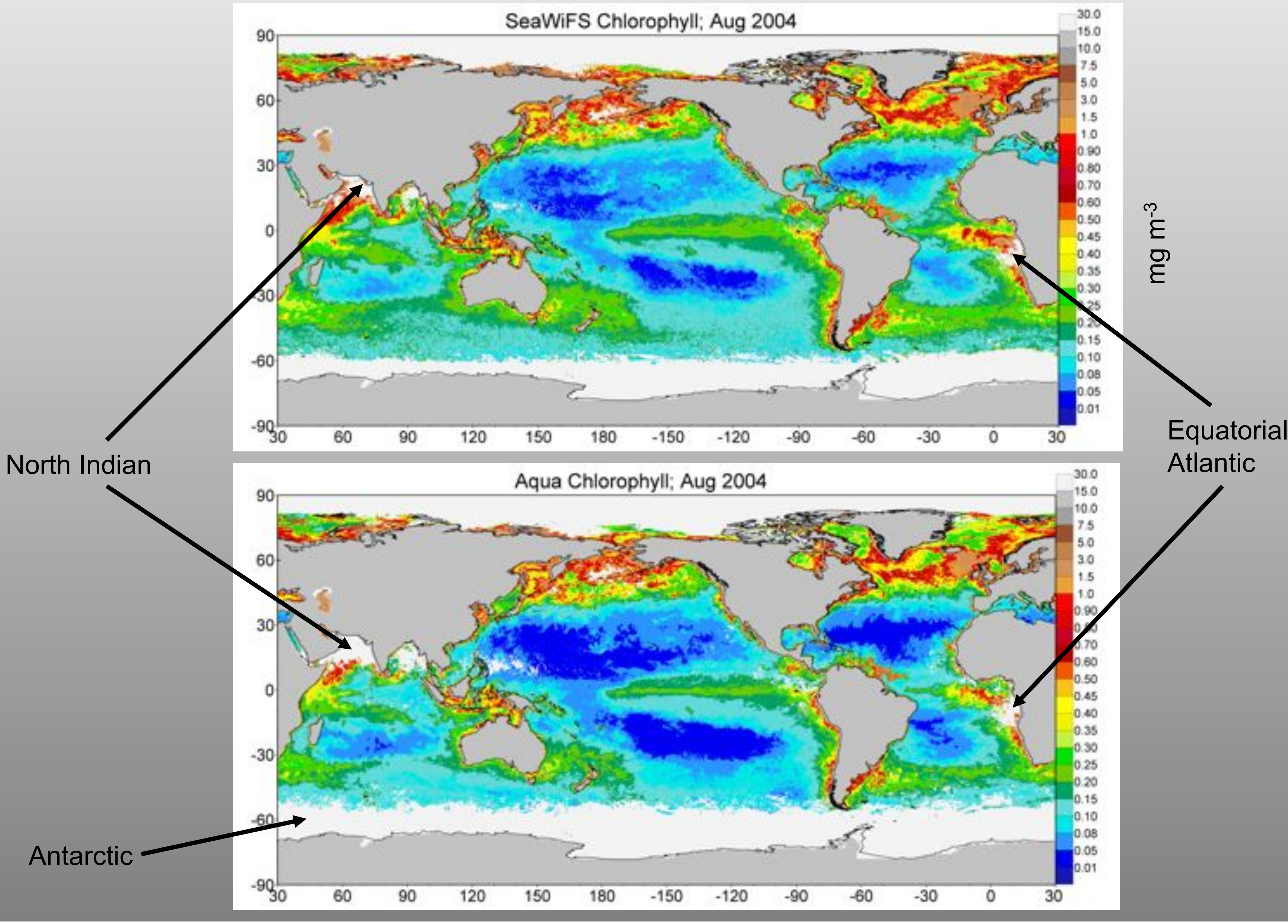


ESRID improves consistency between disparate data sets

Unifies the representation of ocean biology from ships and satellites

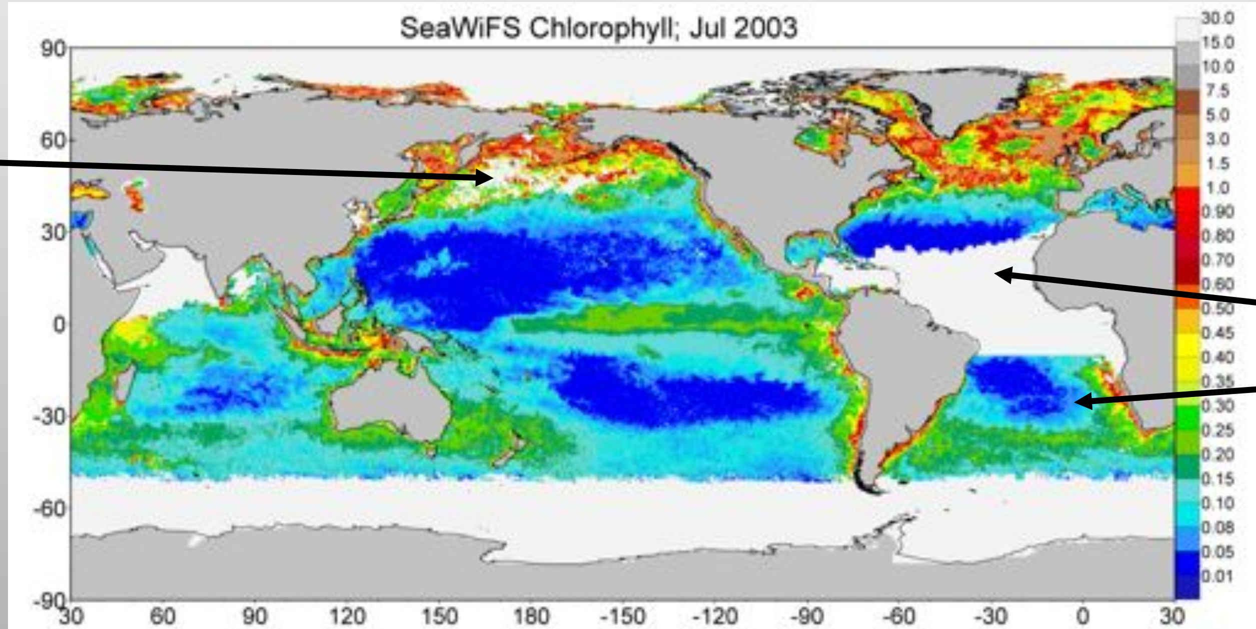
Gregg and Casey, Geophysical Research Letters, 2010

Sampling Differences/Biases



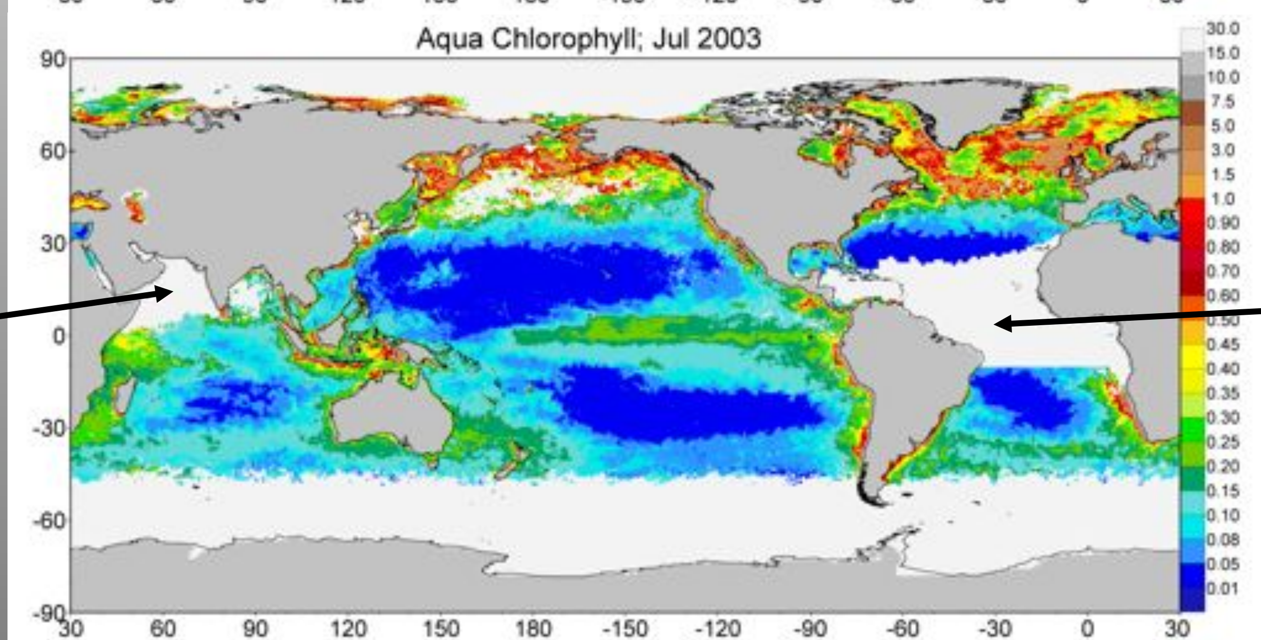
Two-Step Process to Remove Sampling Differences:
1) Remove high aerosol regions and tropical river regions (Equatorial Atlantic)

Aerosol optical thickness limit = 0.4 globally



= 0.3 North Central/ South Atlantic

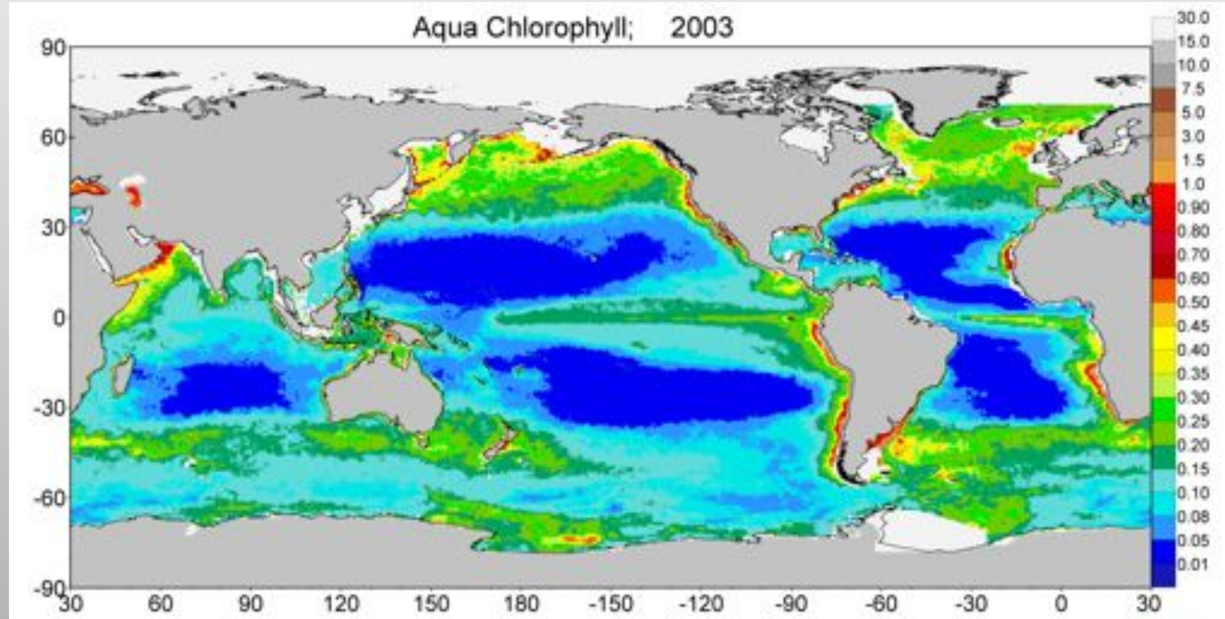
= 0.3 North/ Equatorial Indian



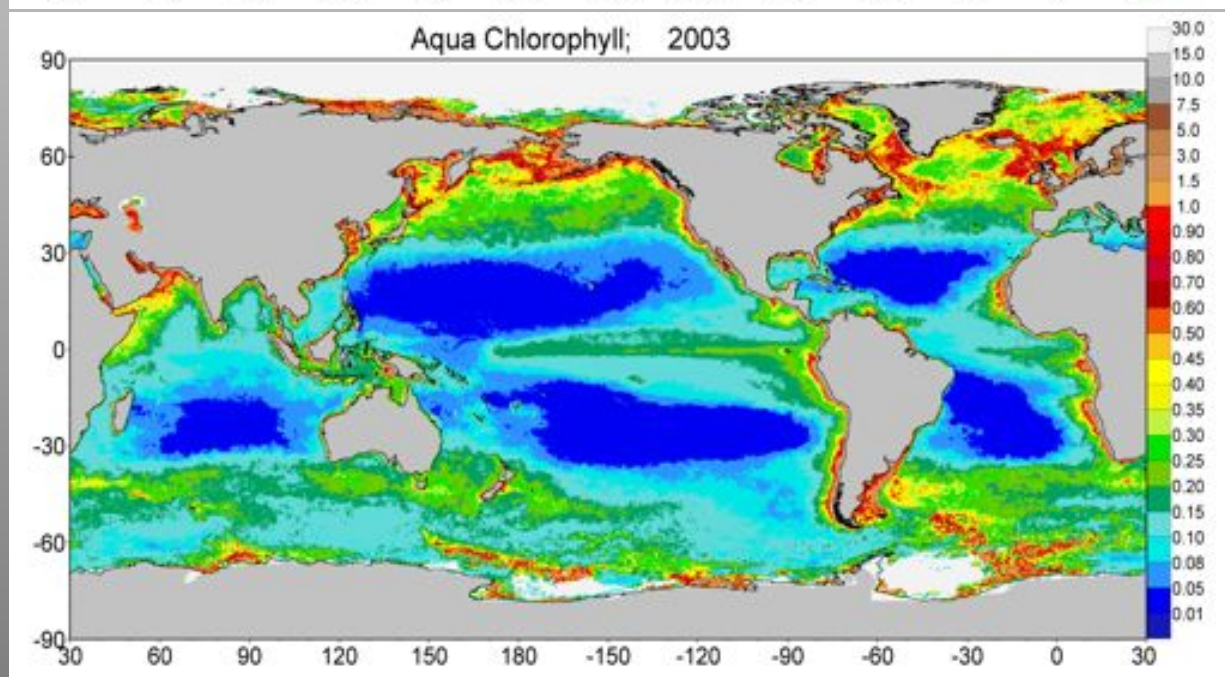
Data eliminated Equatorial Atlantic

Step 2: Assimilate to backfill missing regions/seasons

ESRID-Assimilated Global Annual Median Chlorophyll for MODIS-Aqua



Global Annual Median Chlorophyll for MODIS-Aqua



$mg\ m^{-3}$