

# Climate Quality Ocean Color Time Series: MODIS-SeaWiFS MOBY Vicarious Calibration

**Dennis Clark & Robert Evans**

with

**MOCE/MOBY Team Members**

**NOAA/NESDIS**

**Office of Research and Applications**

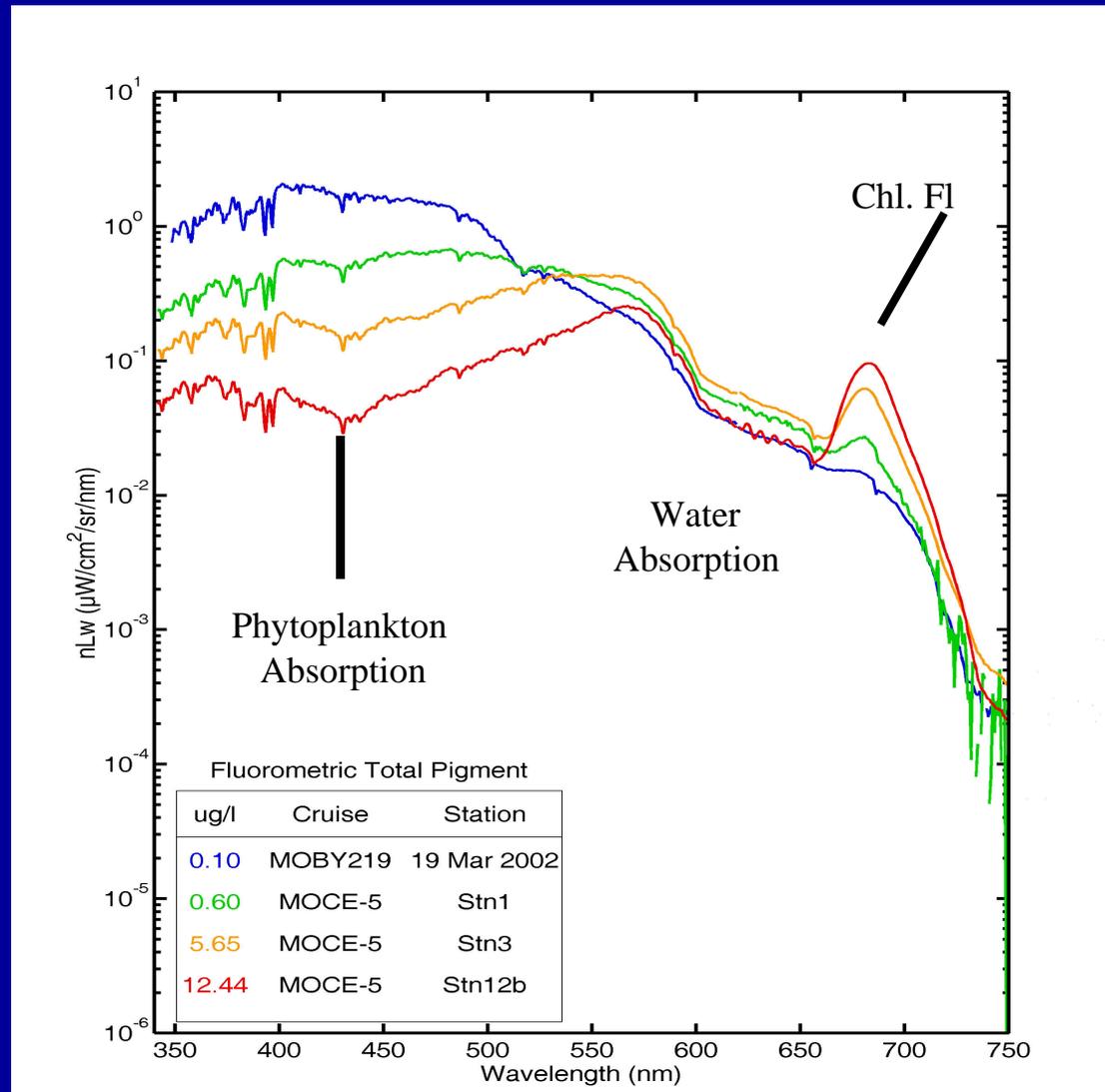
**E. Kearns and K. Kilpatrick**

**Rosenstiel School of Marine and Atmospheric Science  
University of Miami**



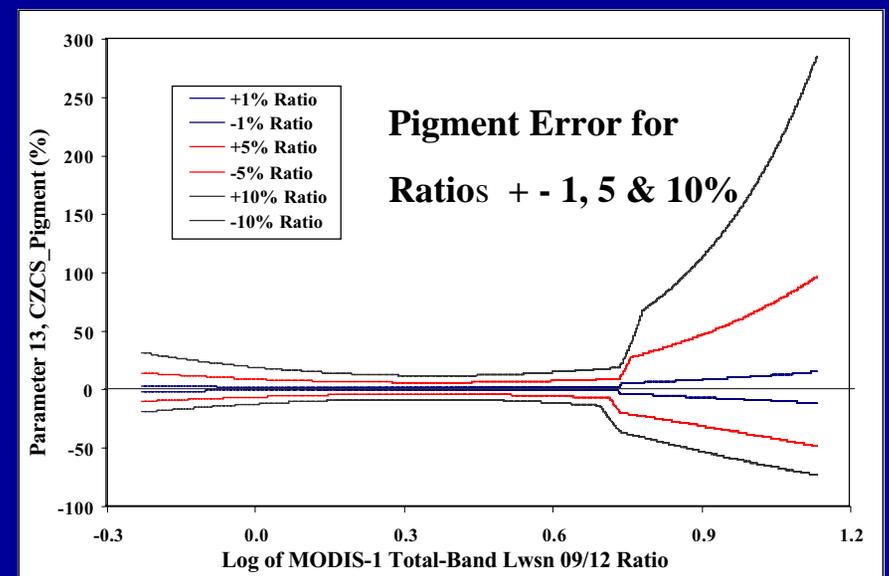
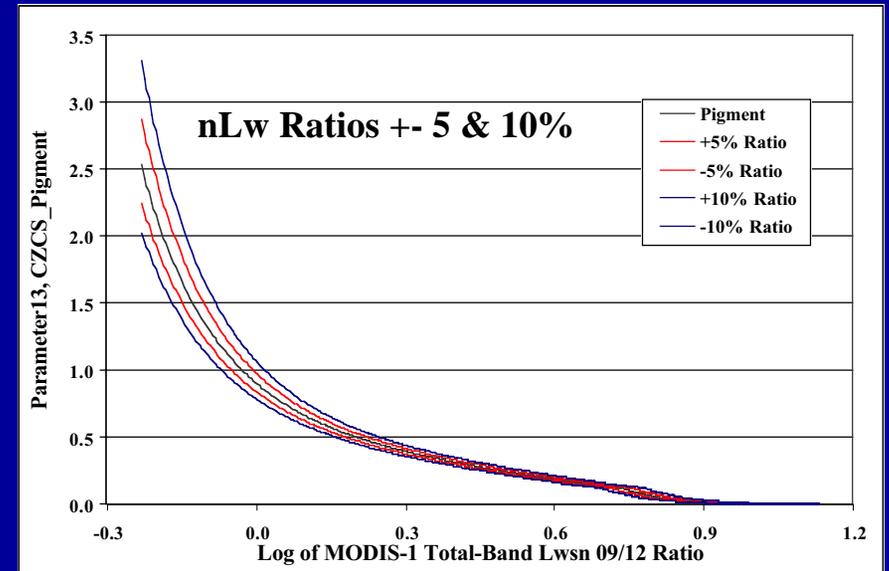
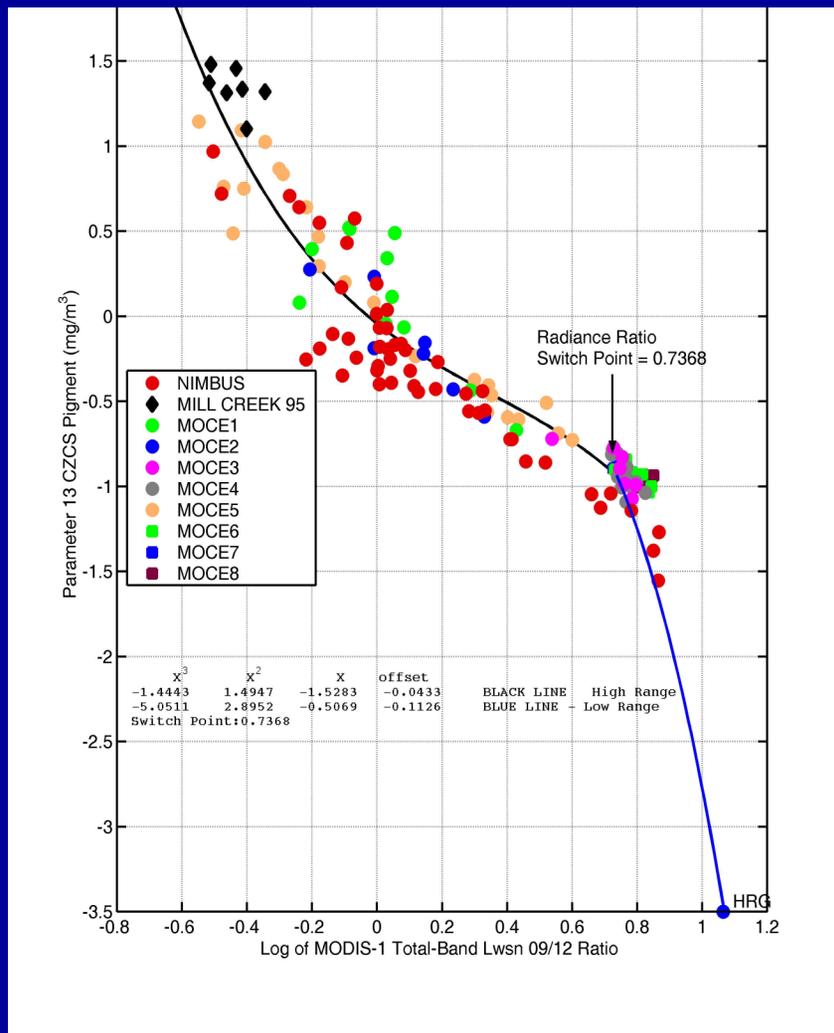
**IWG Meeting 18 November 2002**

# Water-leaving Spectral Radiance Distributions “Ocean Color”



Ocean Color Variability is Dominated by the Suspended and Dissolved Matter of Biogenic Origin.

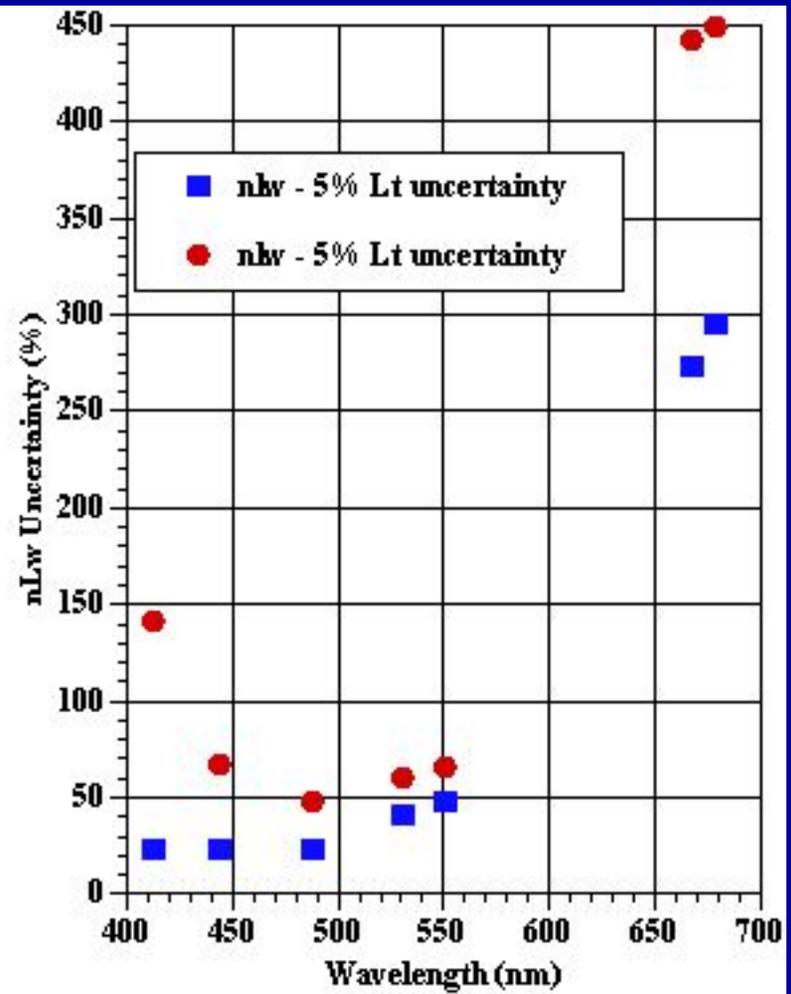
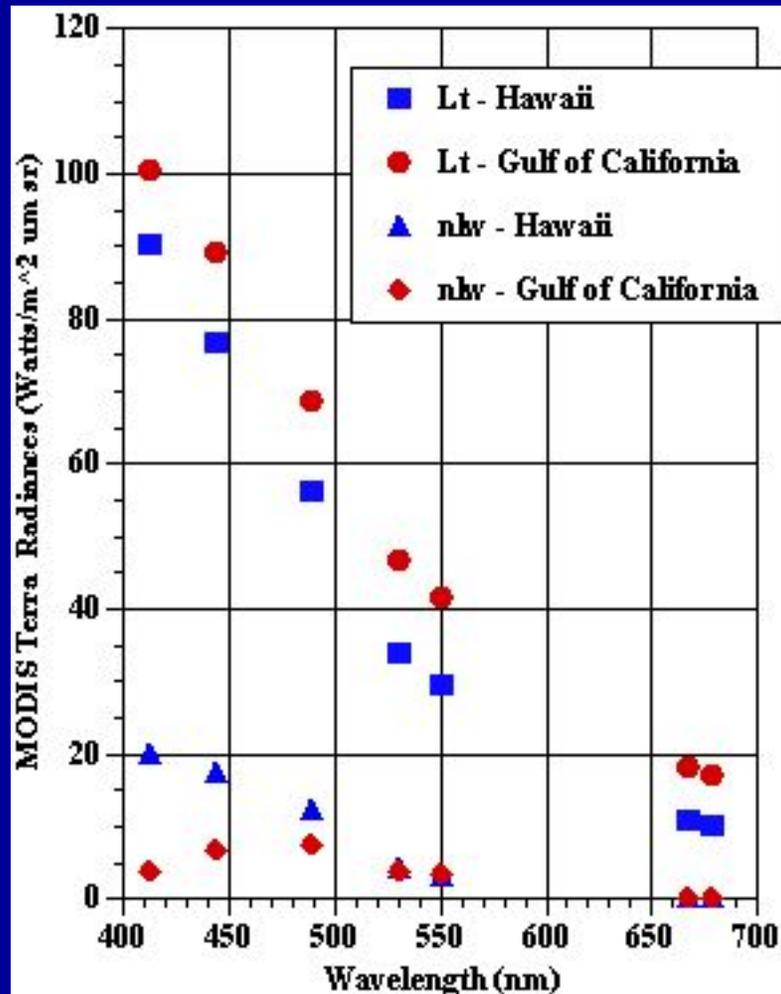
# Empirical Pigment Product - Ratio Uncertainty



# Water-leaving Radiance Retrieval Uncertainty

SeaWiFS - NIST Calibration 4% MODIS  $\leq 5\%$

Assume Atmospheric Correction is Perfect

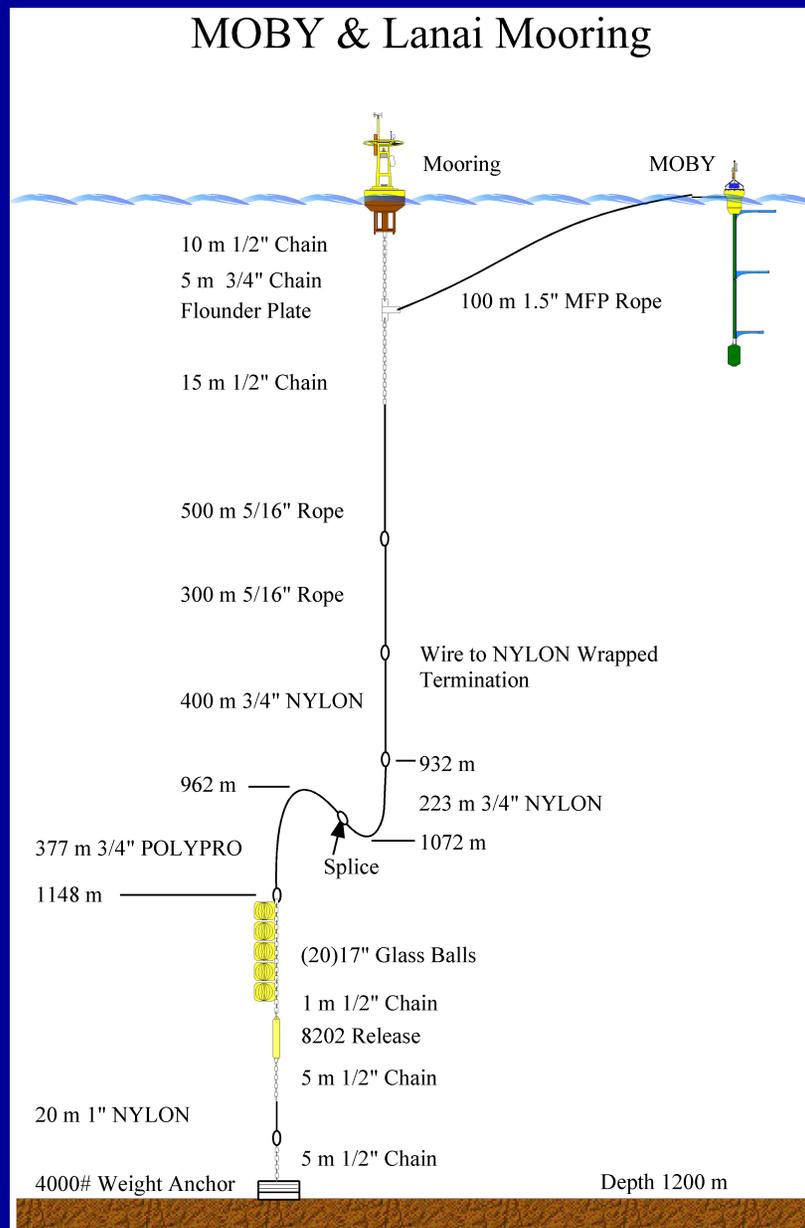
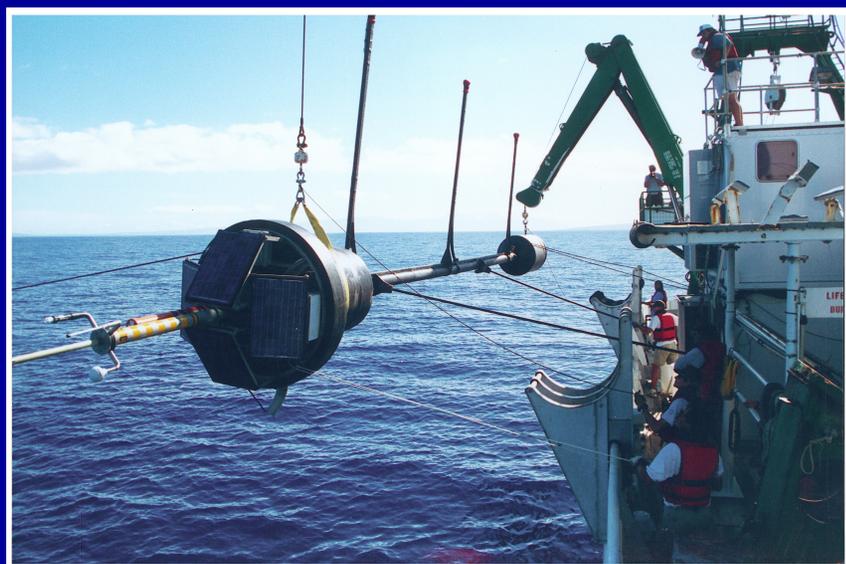
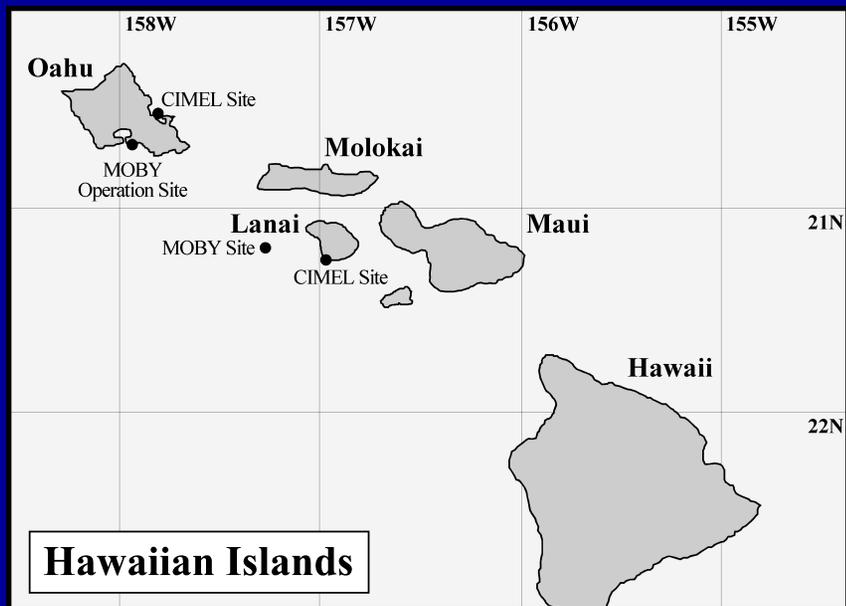


# Vicarious Calibration Required for Ocean Color Science

**Laboratory and On-board Sensor Calibrations  
Cannot Meet the Accuracy Requirements  
for this Science Application.**

**A Minimum of an Order of Magnitude  
Improvement in Calibration Accuracy is Required.**

# MOBY Mooring Site



# MOBY Operations Site - Univ. Hawaii



**Pier Side - 30,000 sq. ft**

## **16 Portable vans/tent**

offices, shops, storage, labs (calibration, optics assembly, filtration)

## **6 Shipboard Vans**

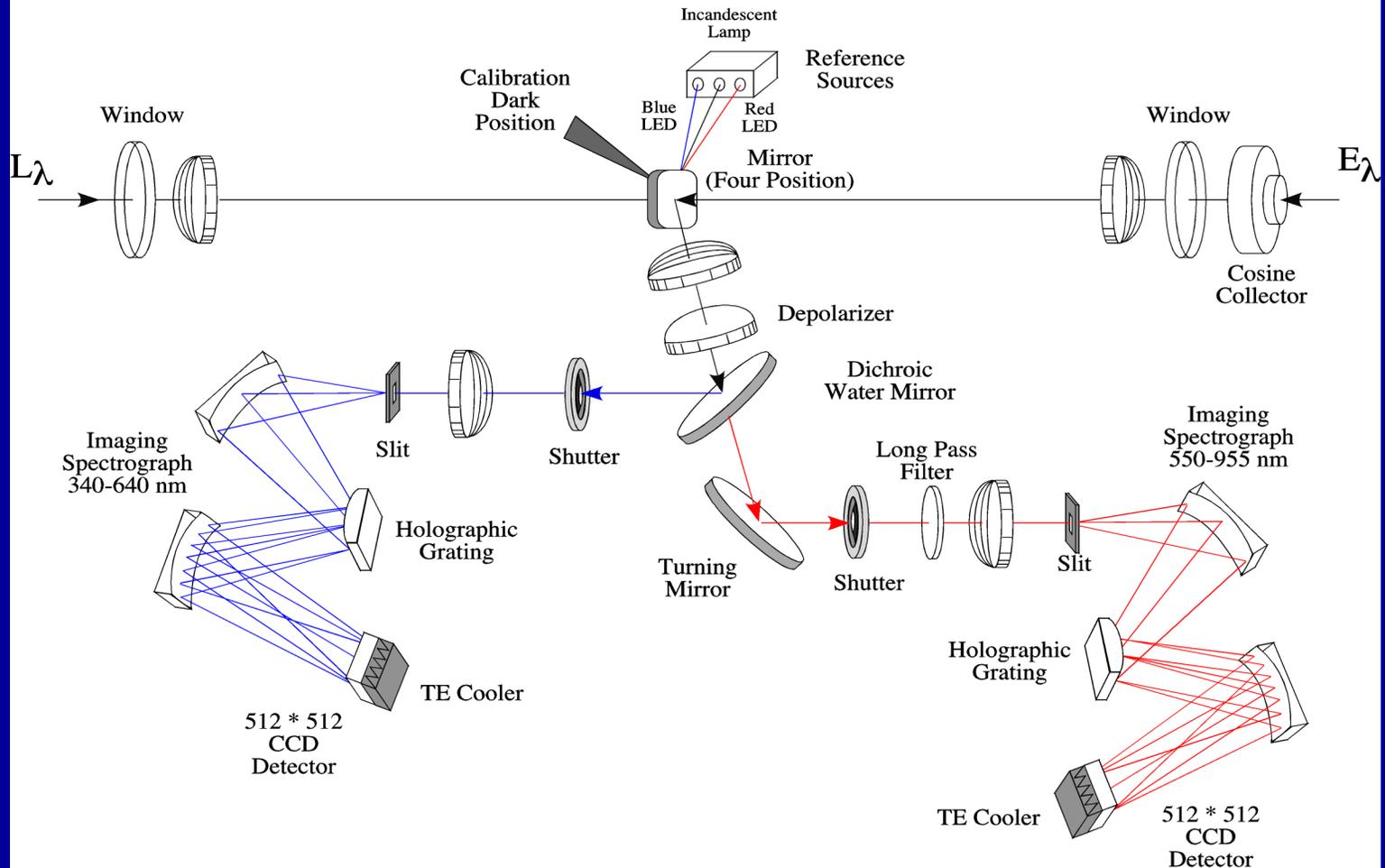
3 labs - (wet, optics, data acquisition) power, storage, & office

**Pier side Support - cranes, machine shop.**



# MOBY Optical System

## Marine Optical System - Dual Spectrographs



# MOBY Spectral Radiances

MODIS Marine Optical Buoy NOAA/MLML

MOBY2 DEPLOYMENT: 13 CONFIG: 01

TOP 1 m

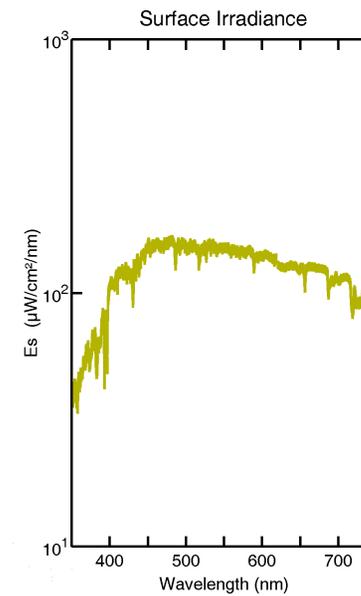
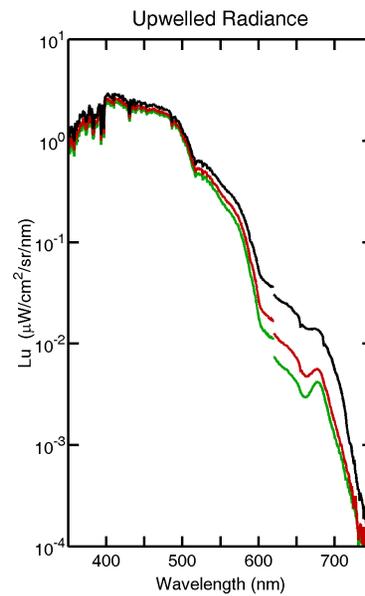
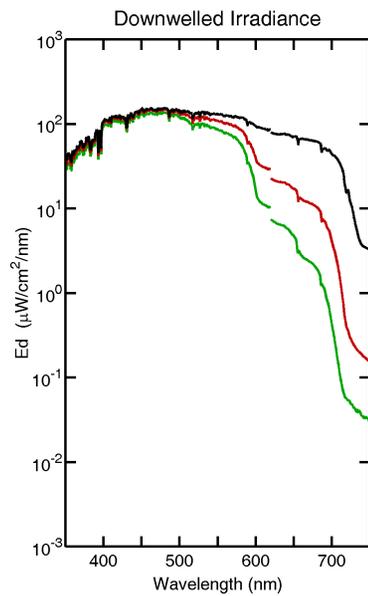
MID 5 m

BOT 9 m

POSITION: 20° 49.57' N 157° 11.74' W

STATION: Lanai Mooring

DATE: 21:05 (GMT) 24 Jun 2000



# MOBY Attenuation Coefficients & Water-leavings Radiances

MODIS Marine Optical Buoy NOAA/MLML

MOBY2 DEPLOYMENT: 13 CONFIG: 01

T-M 1 to 5 m

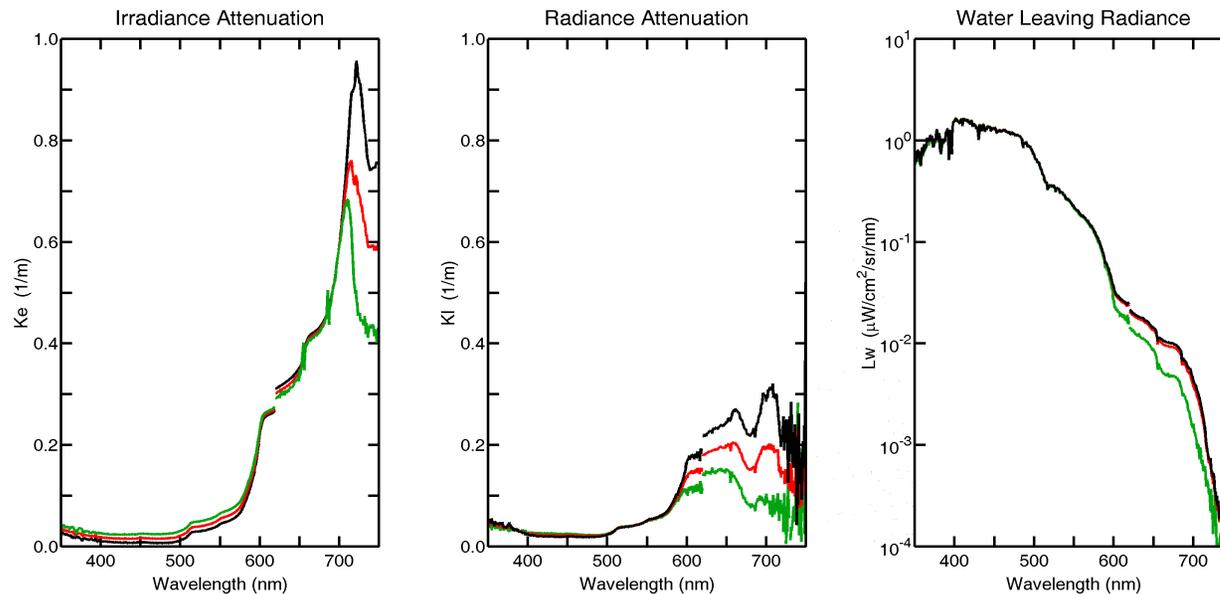
POSITION: 20° 49.57' N 157° 11.74' W

STATION: Lanai Mooring

T-B 1 to 9 m

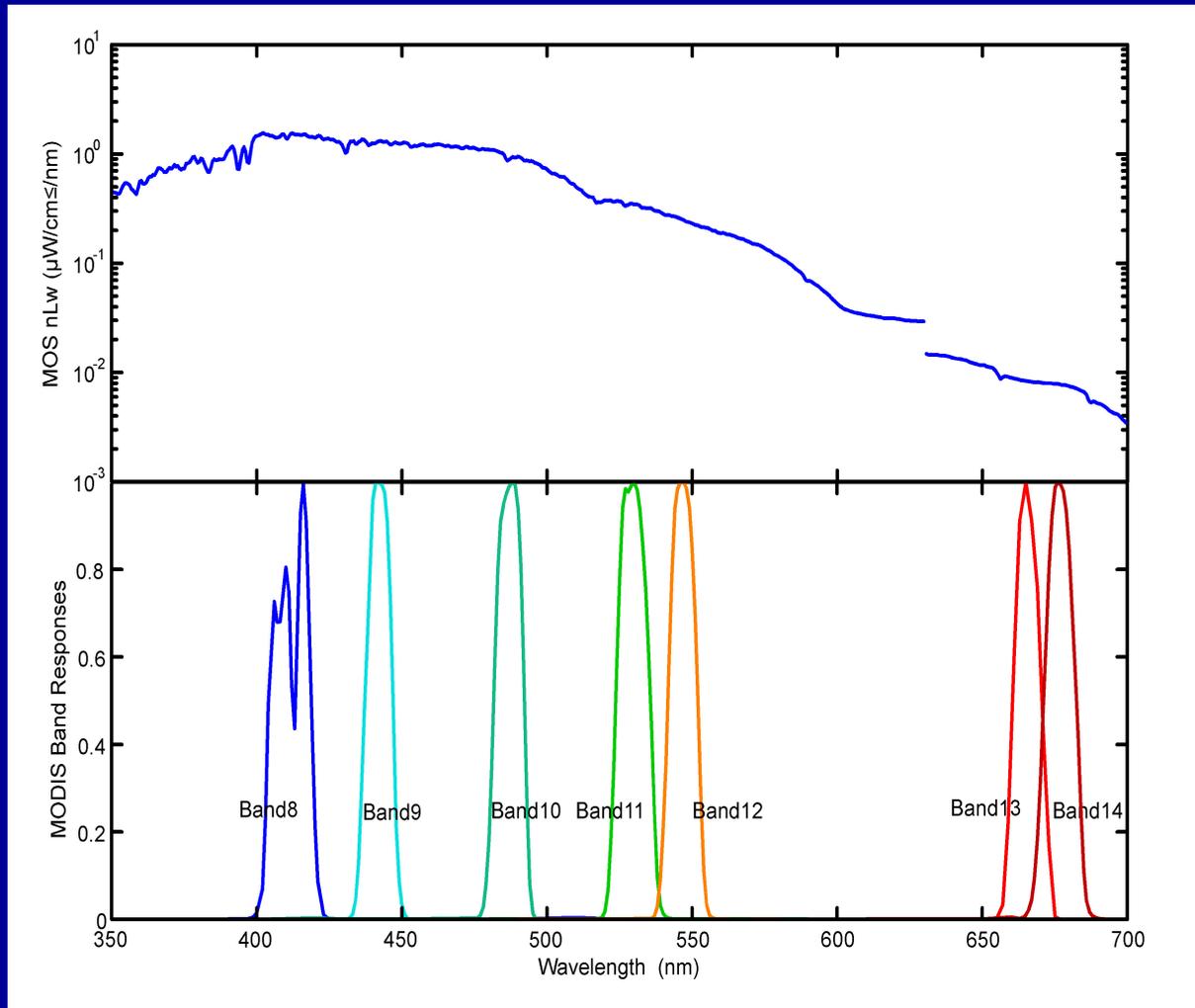
DATE: 21:05 (GMT) 24 Jun 2000

M-B 5 to 9 m



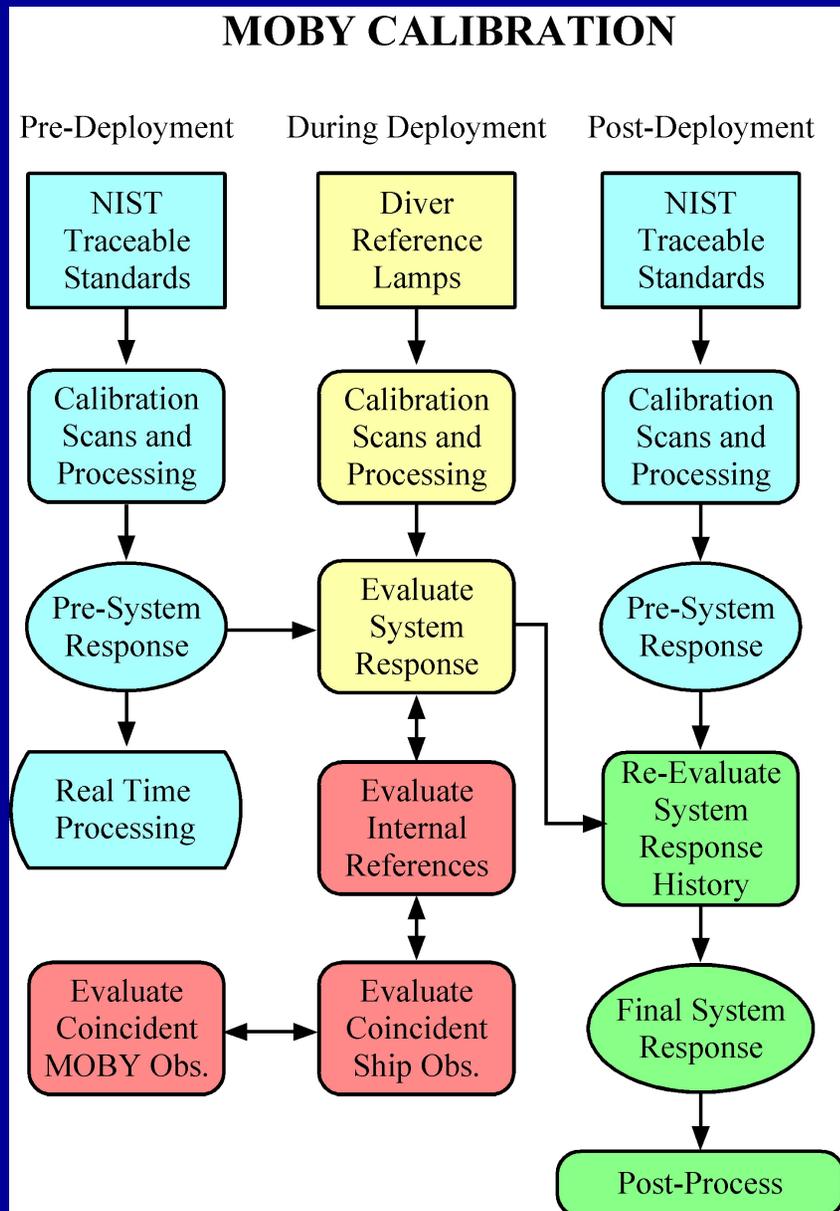
# Spectral Band Pass Matching

High Resolution Spectra Convolved to Sensor's Spectral Band Pass





# MOBY Calibration Process



## NIST Collaborations

### Training

NIST Primary Lamb Standards

Annual On Site Calibration Systems Check

Pre/Post Cal. System monitoring with NIST Cal. Radiometers

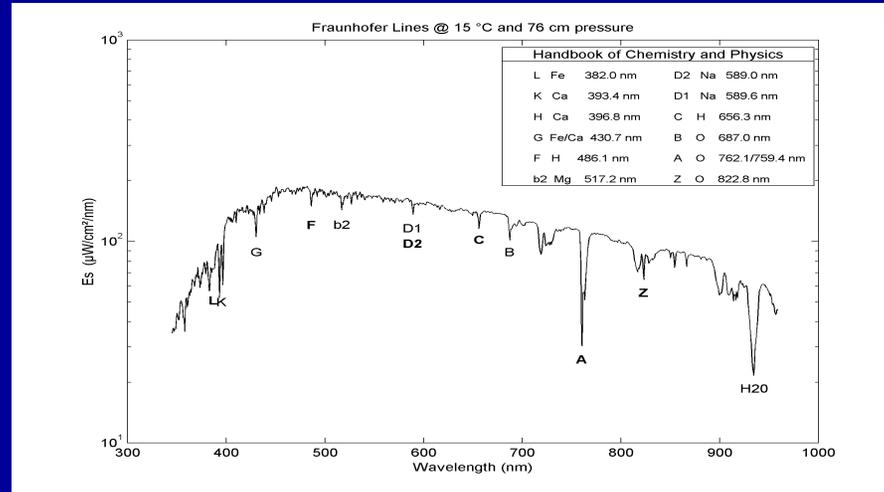
SIRCUS - Stray Light Characterizations on MOBY and Shipboard Spectrometers

MOCE Calibration Systems (OL420 & OL425) now Calibrated at NIST

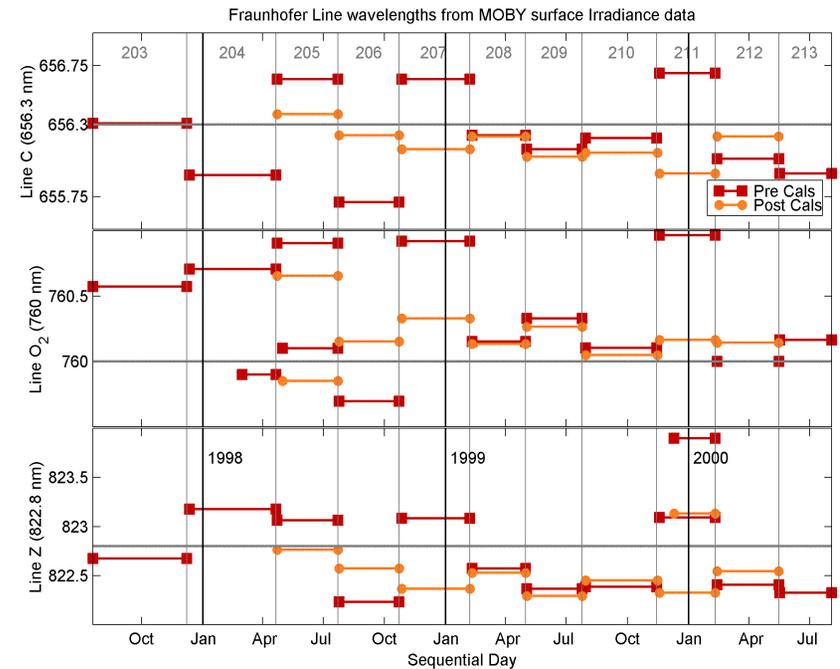
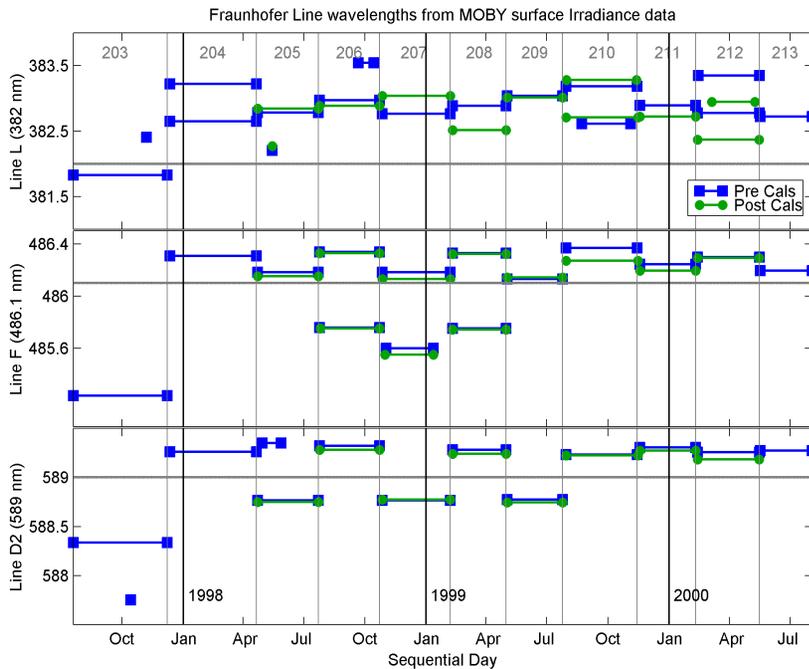
Initiating the development of new Radiometric Calibration Sources for Oceans

# Spectral Calibration QC-Solar

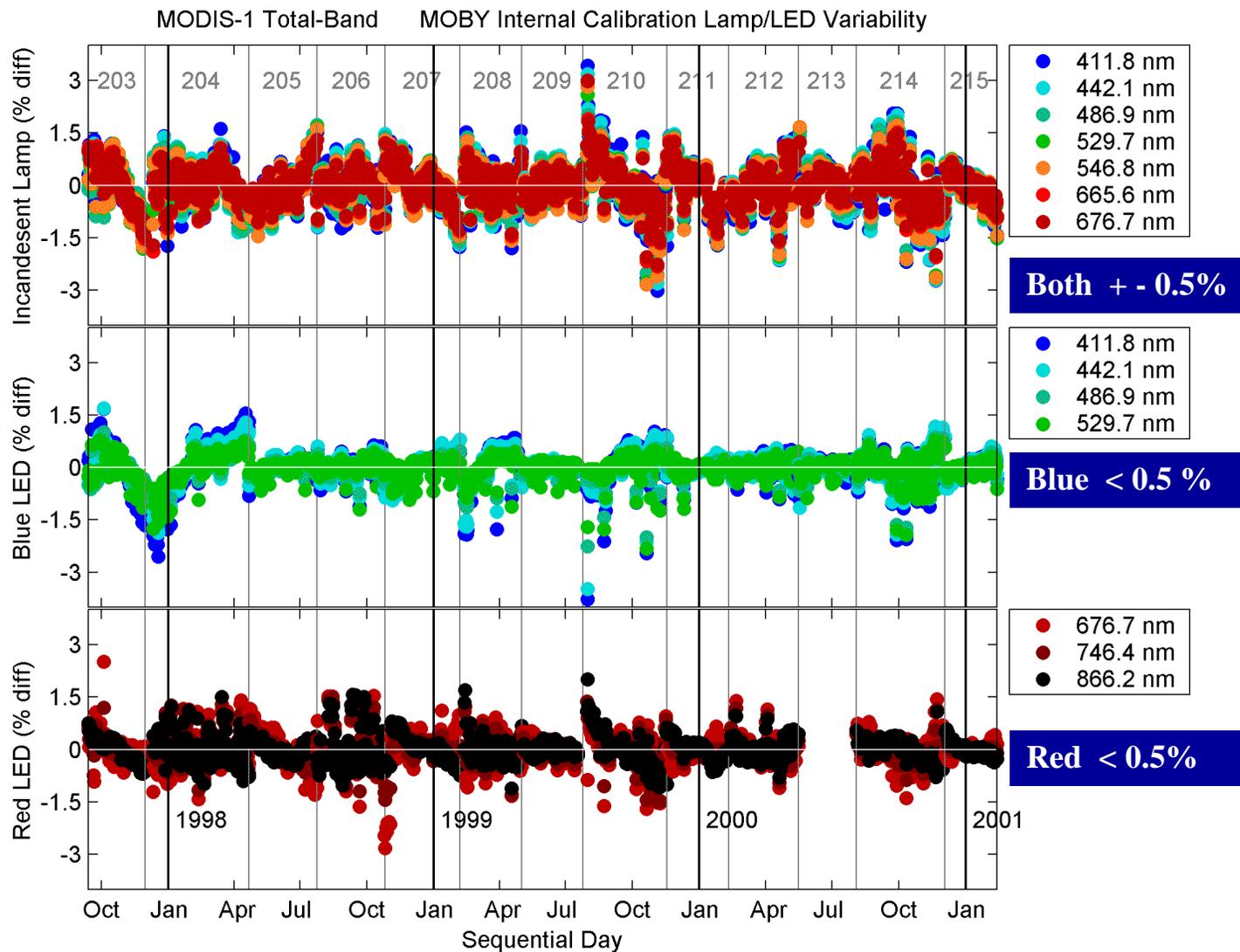
**Blue Spectrograph**  
2.5 years  
Approx. +/- 0.6nm



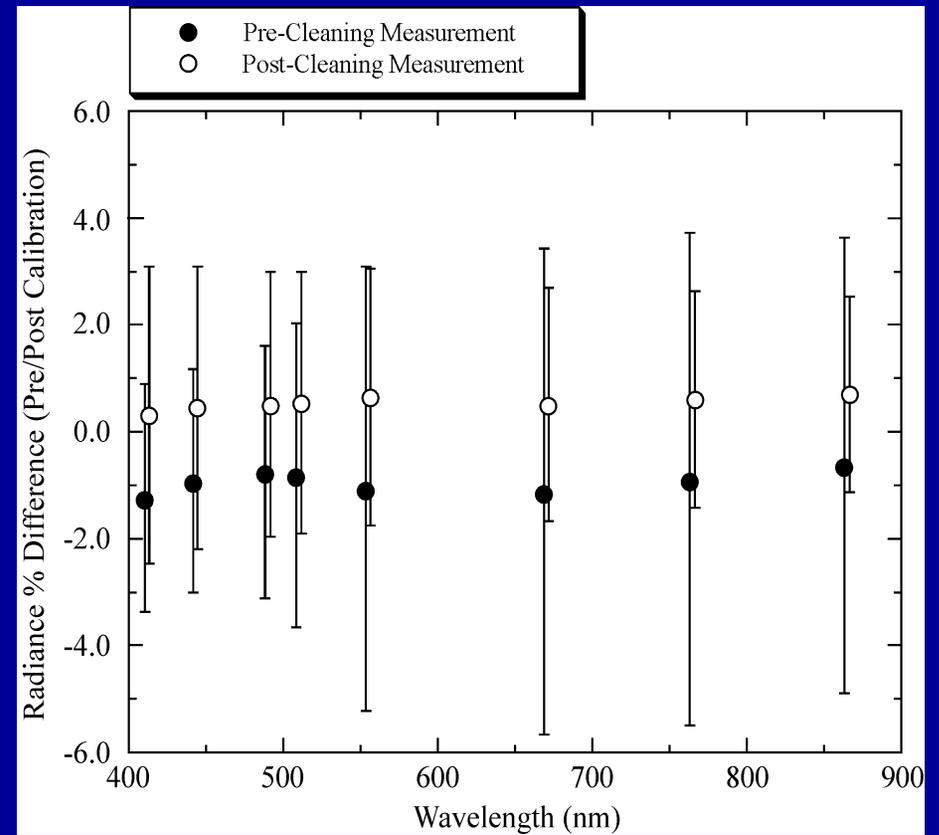
**Red Spectrograph**  
2.5 years  
Approx. +/- 1nm



# Internal Reference Lamps - Stability QC

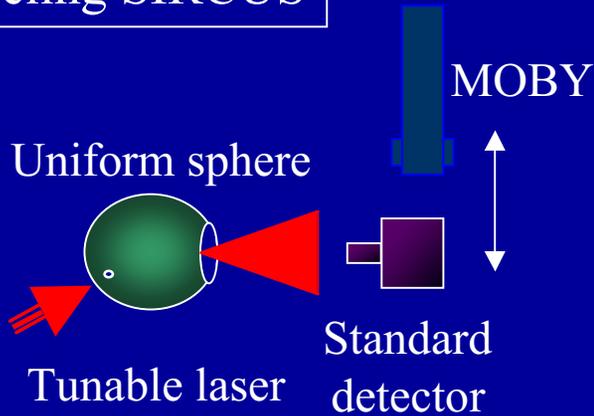


# Diver Reference Lamp - Pre/Post Cleaning QC

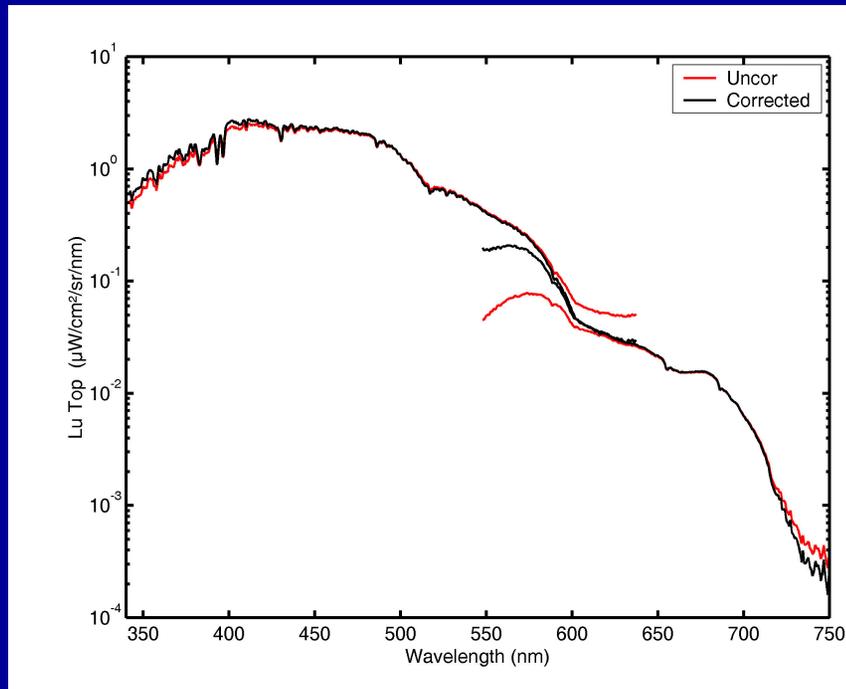
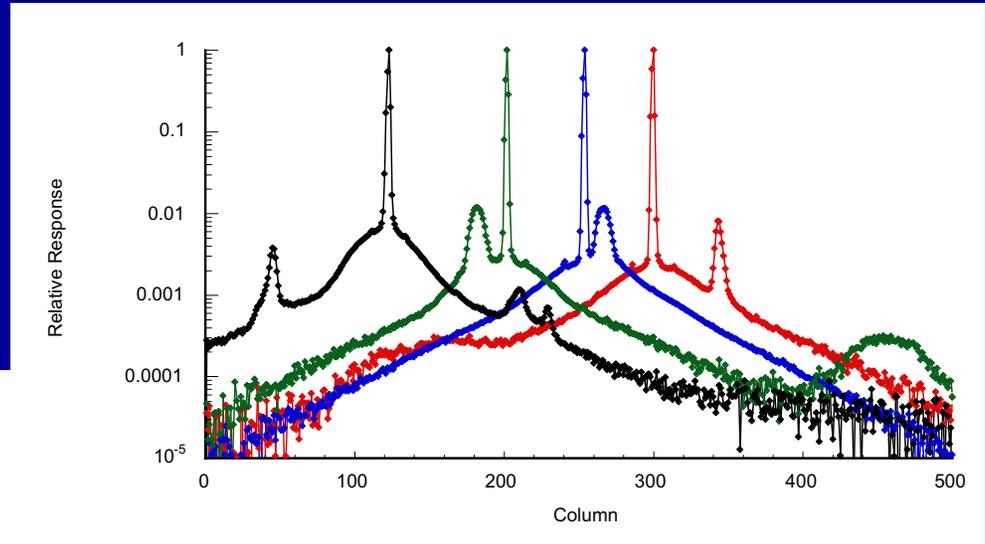


# Stray Light & MOBY

Traveling SIRCUS

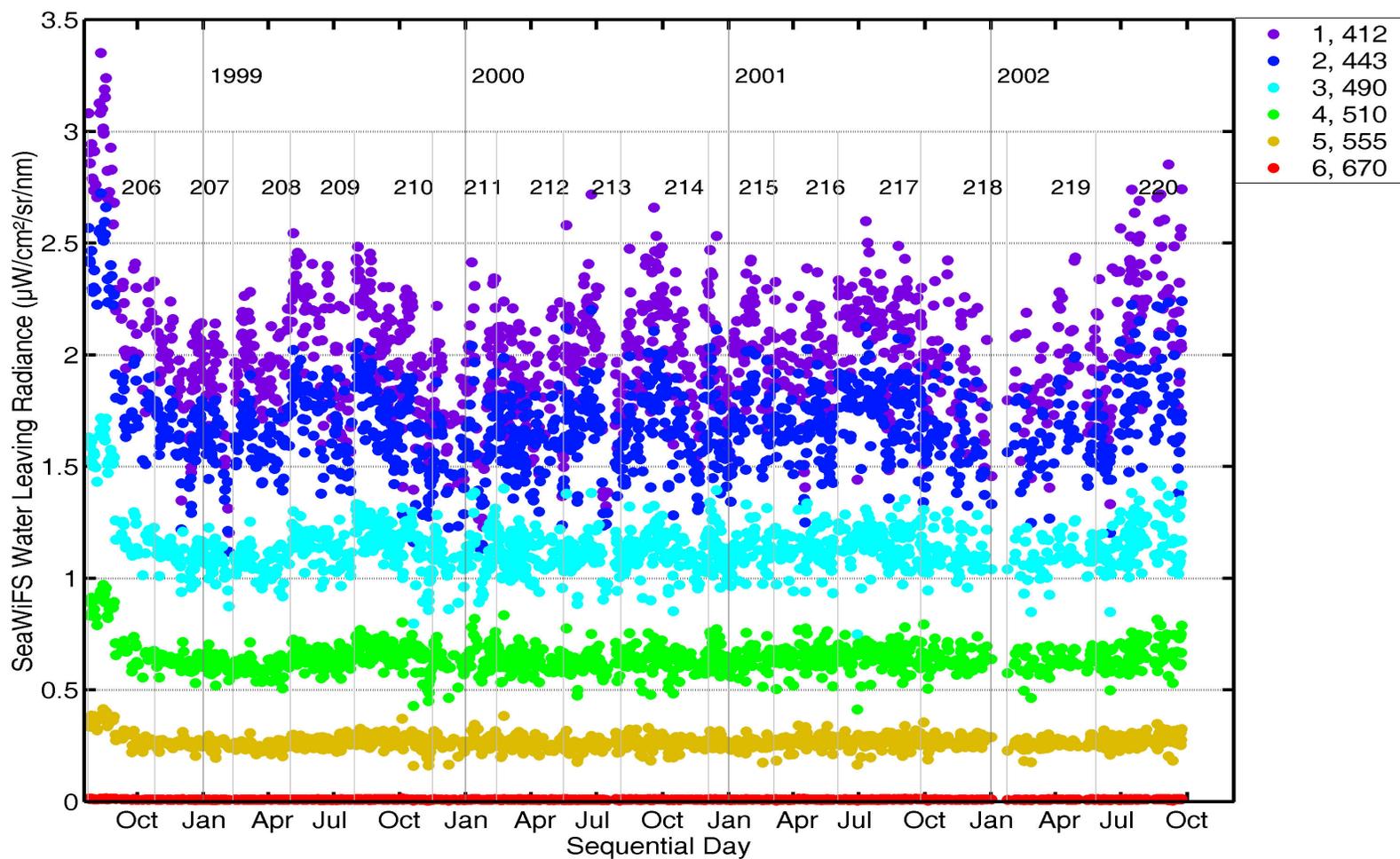


Response found at many wavelengths

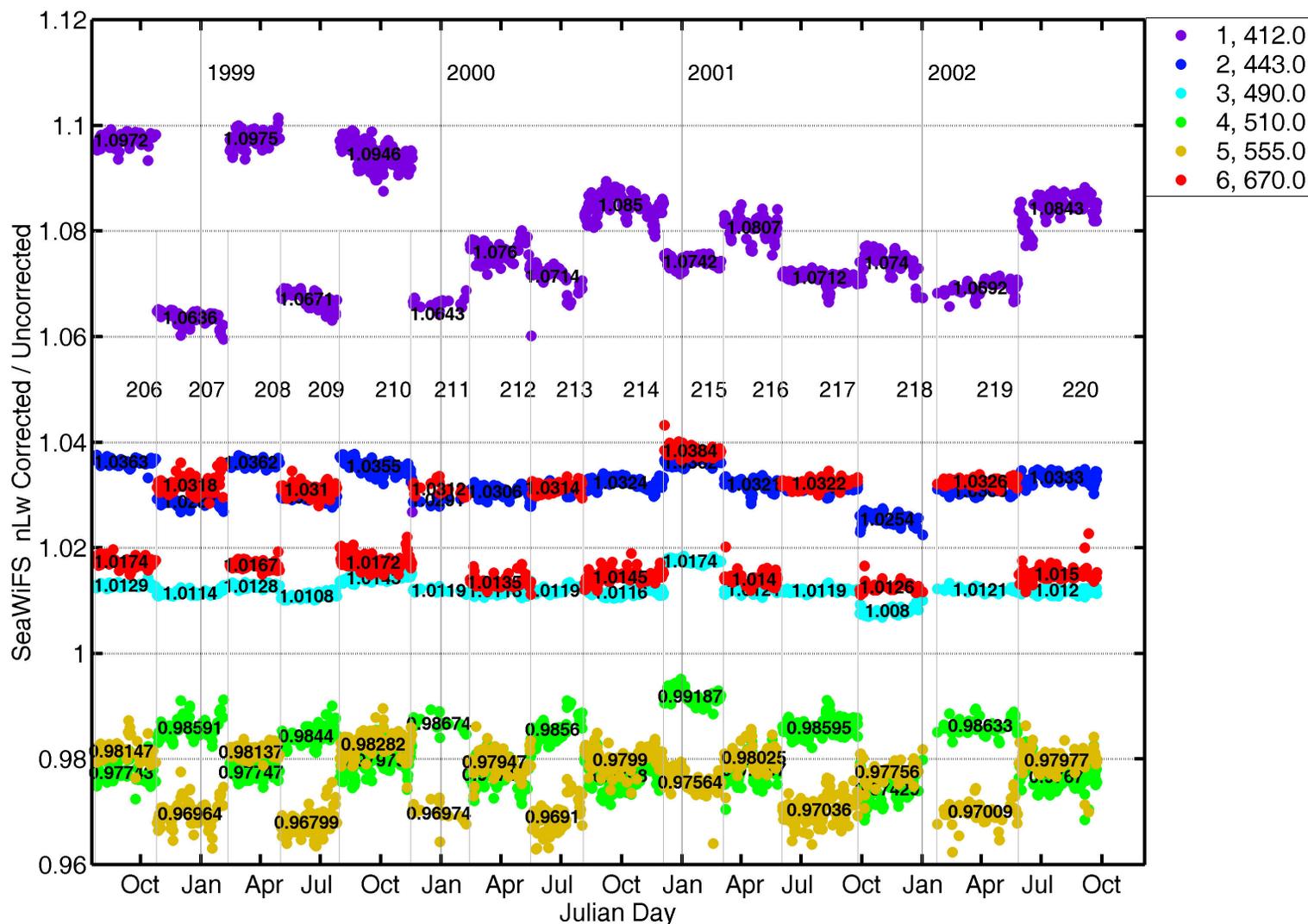


Corrected Lu's  
-increase in UV  
-better agreement in overlap region

# MOBY Stray Light Corrected Time-Series - SeaWiFS Bands



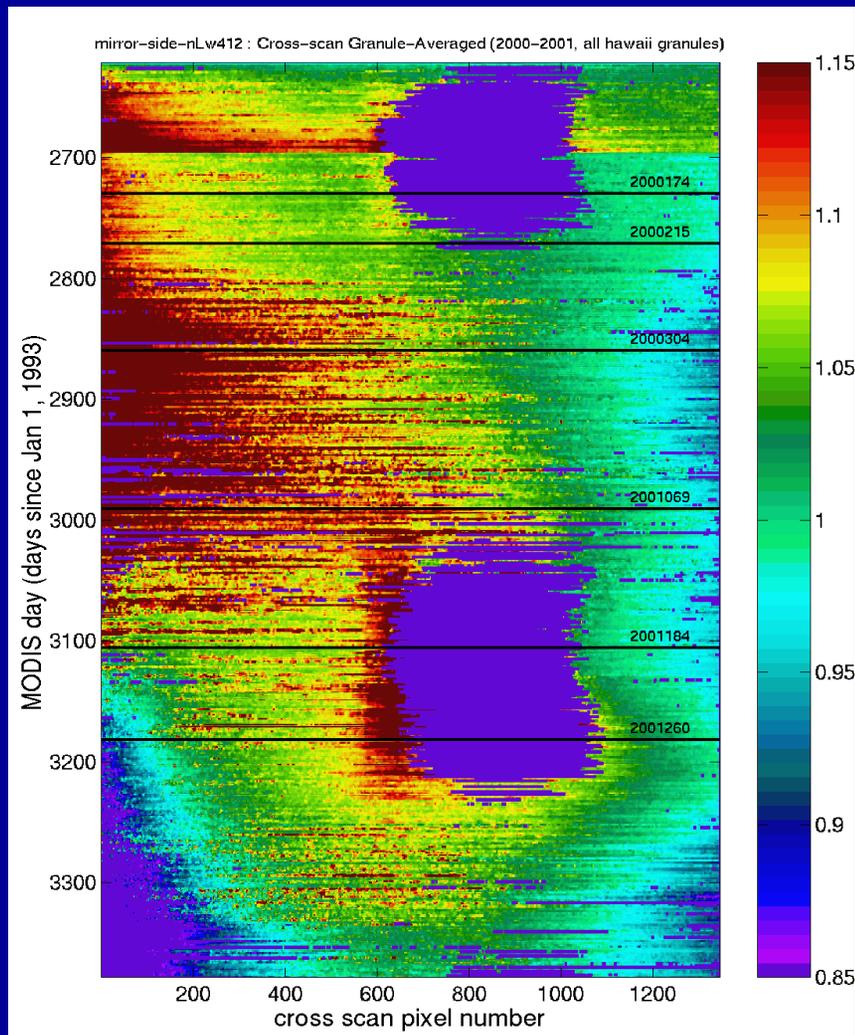
# SeaWiFS Stray Light Time Series Corrections



# Terra Mirror Side 1 to Mirror Side 2 Ratio Cross-scan vs Time Gain Change (Percent Error)

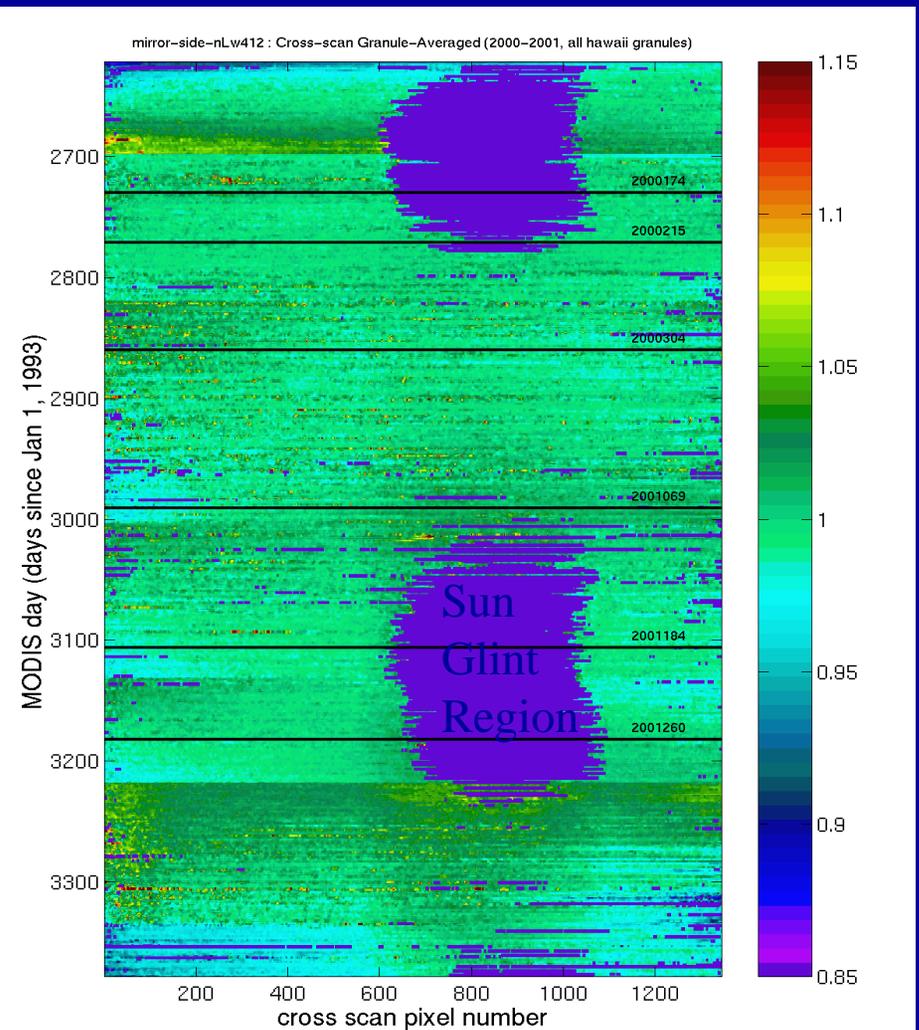
**NOTE: Calibration is an ongoing process,  
instrument character changes ~ every 3 months**

412 nm uncorrected



Correction reduces mirror and detector effects by a factor of 5

412 nm corrected



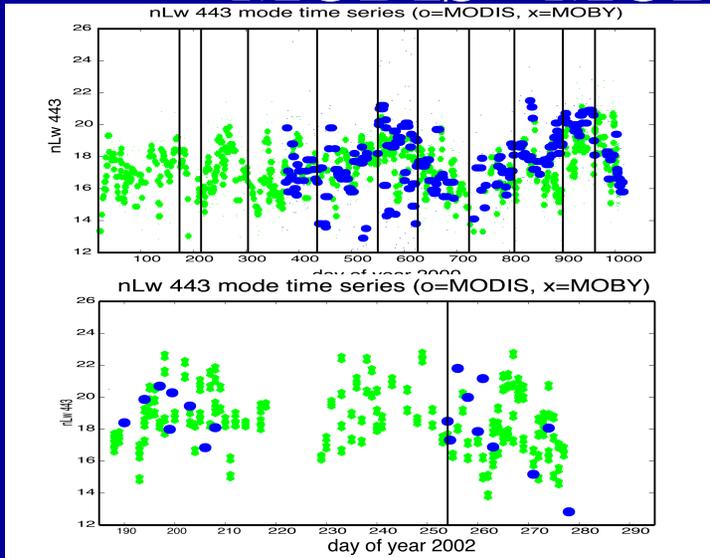
# nLw443 Modal & Match up **Terra-Aqua** MODIS - MOBY Time Series

Match up Statistics - MODIS - MOBY residuals by wavelength, final bias adjustment in progress for Version 4 L1b

Terra

Modal  
nLw443

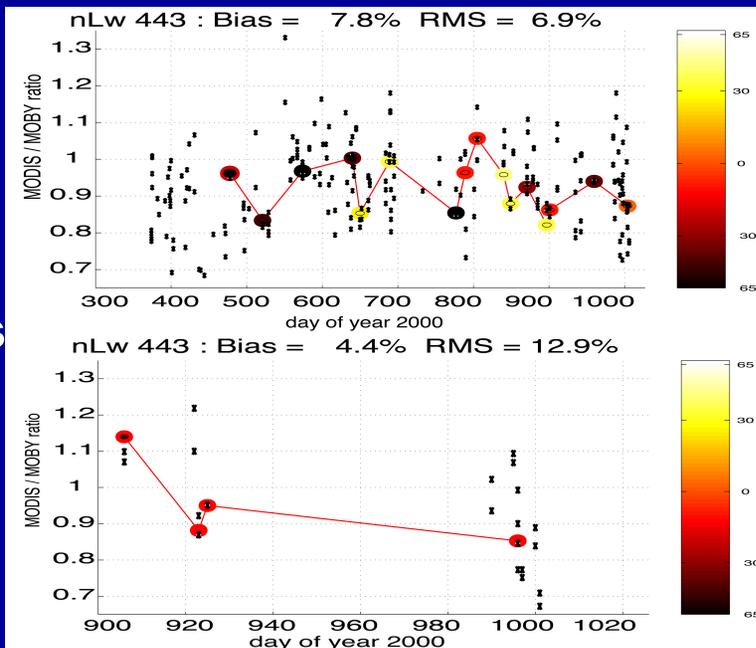
Aqua



Terra

Match-ups  
nLw443

Aqua

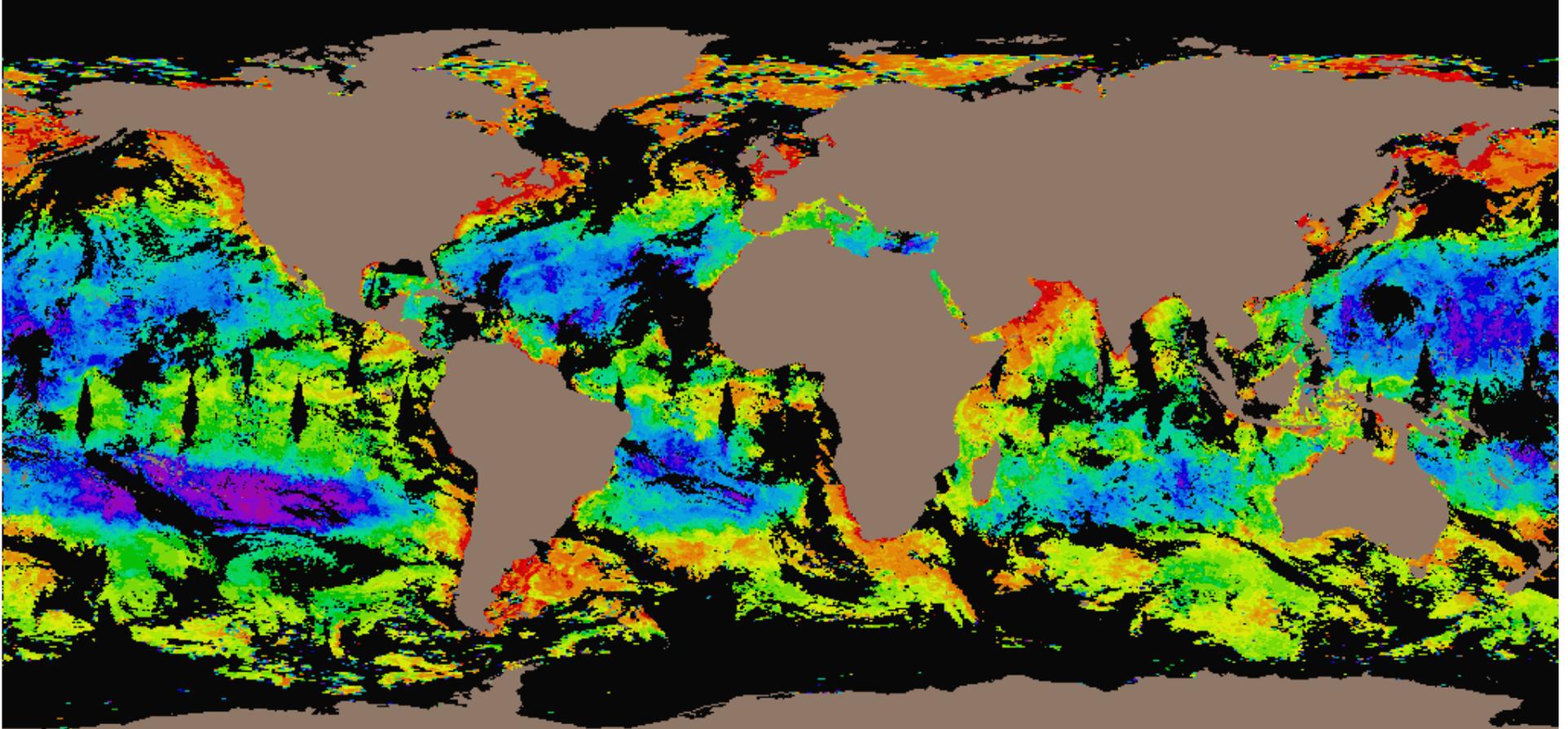


Wave-length	Terra		Aqua	
	Bias	Std. Dev.	Bias	Std. Dev.
412	0.915	0.115	0.974	0.199
443	0.922	0.069	0.956	0.129
488	0.948	0.051	0.973	0.092
531	0.927	0.103	1.033	0.093
551	0.921	0.105	1.023	0.101

Top Left - Modal Plots of **MODIS** and **MOBY**  $L_w$  vs time used to compute time corrections

Bottom Left - MODIS/MOBY point matchups, used to compute bias corrections

**Merged Aqua, Terra Chlor\_MODIS  
Global Chlorophyll  
Sept 29, 2002**

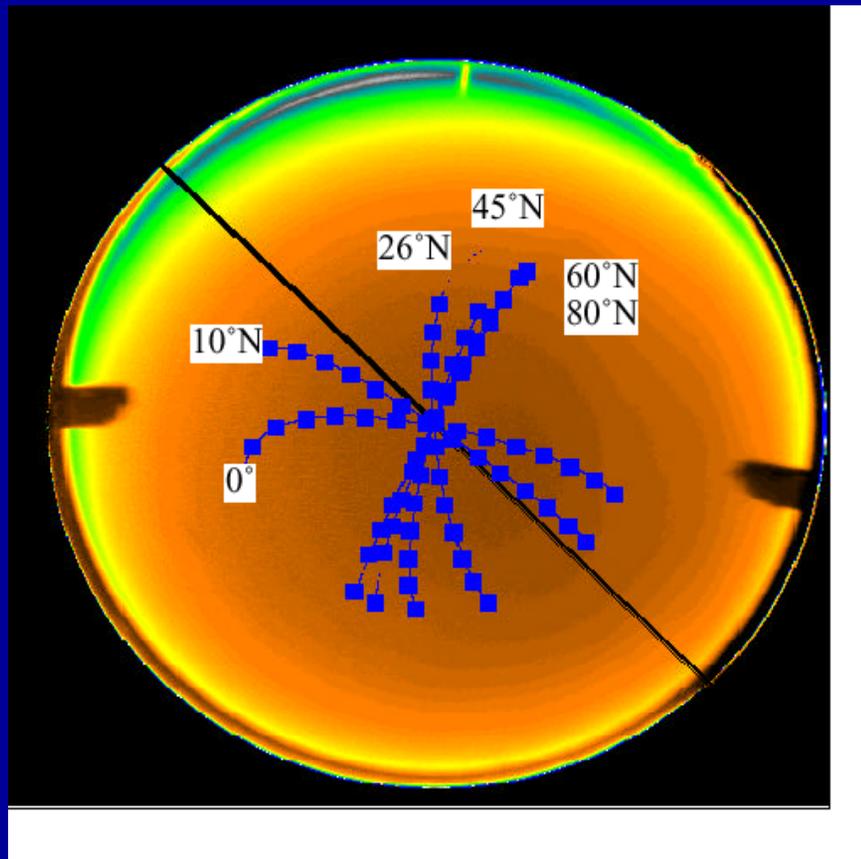


# Radiance distribution vs. azimuth and solar zenith angles (Ken Voss)

Scan line geometry, variation with Latitude, 0° to 80°N

MODIS

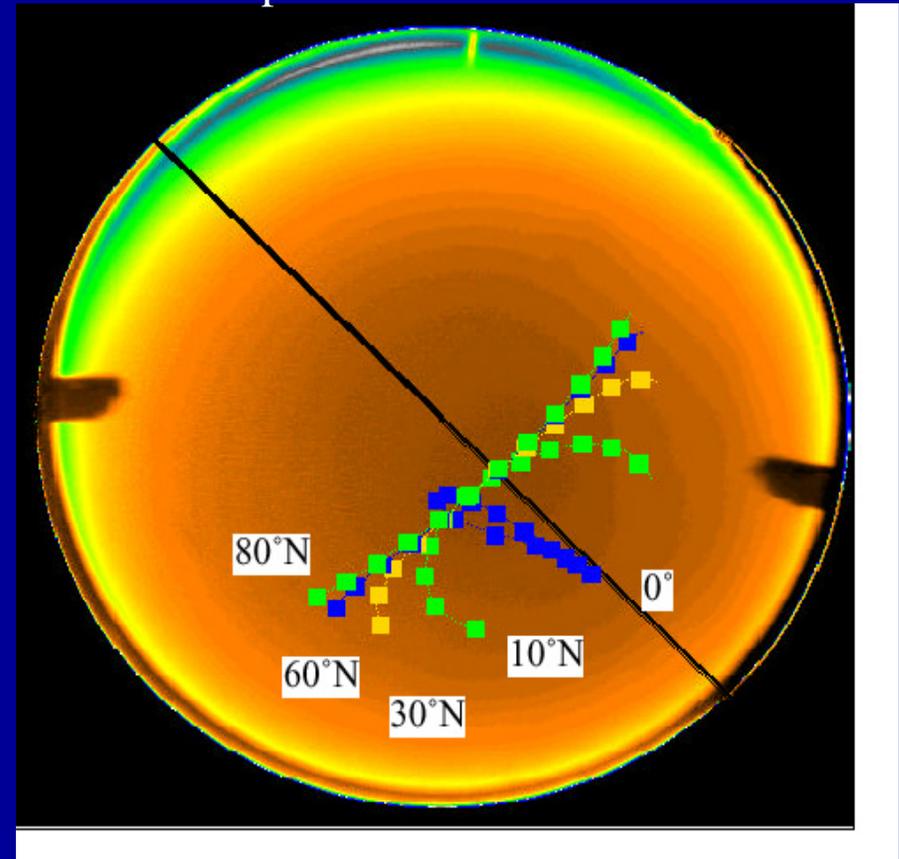
Black intrusions mark orientation of Sun.



Satellite scan changes from near parallel to perpendicular along orbit track

SeaWiFS

Black line represents orbit track

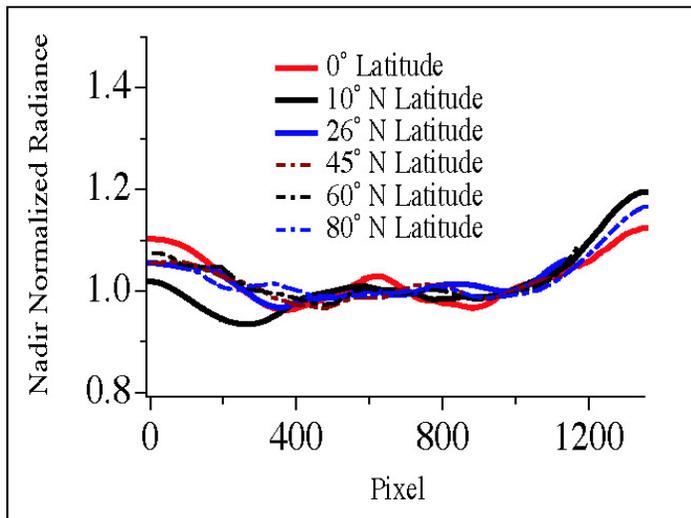


Satellite scan perpendicular to orbit track

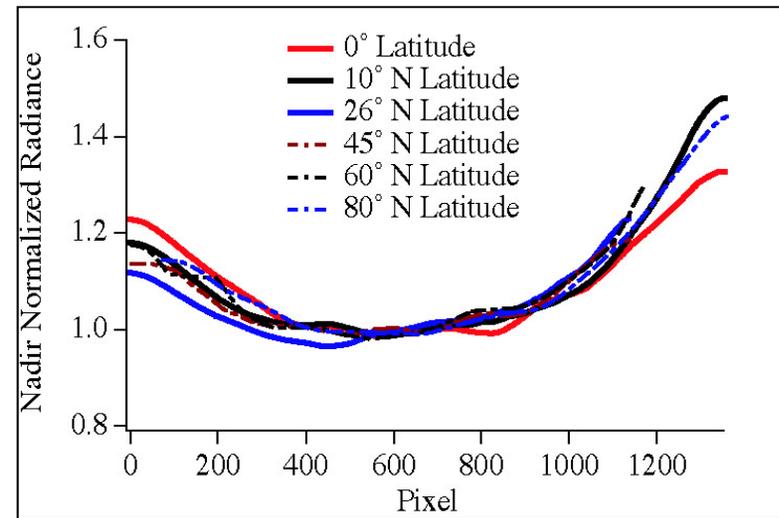
# Terra -MODIS Scan Angle Relative To Nadir Lu

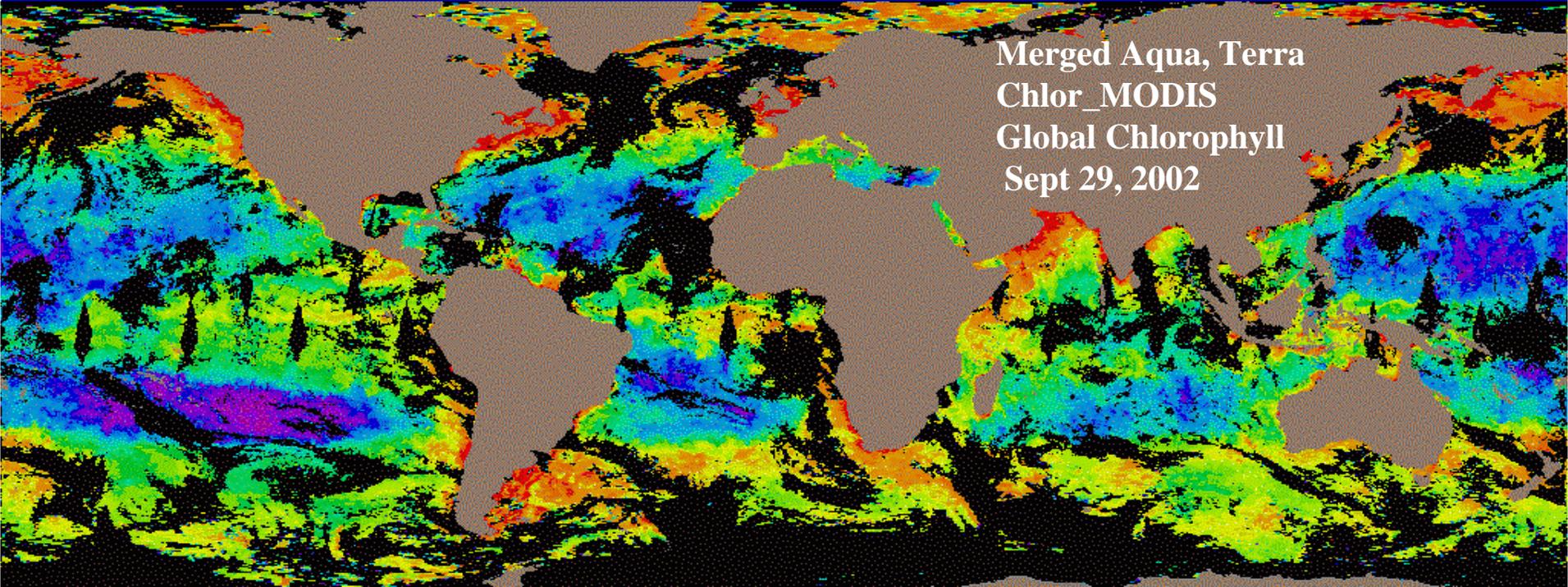
MODIS, 440 nm

Low Chl (0.3 mg/m<sup>3</sup>)



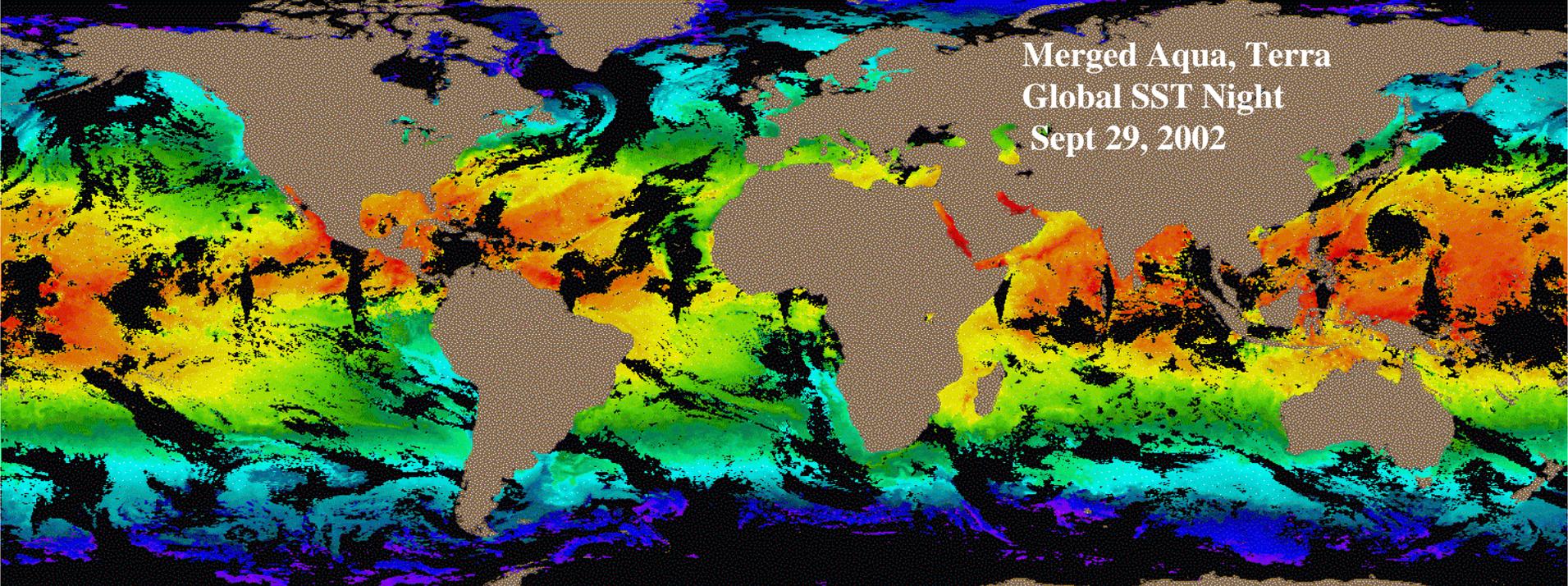
High Chl (5 mg/m<sup>3</sup>)





Merged Aqua, Terra  
Chlor\_MODIS  
Global Chlorophyll  
Sept 29, 2002

This figure is a global map showing the concentration of chlorophyll in the ocean's surface layer. The map uses a color scale where blue and cyan represent low concentrations, green and yellow represent moderate concentrations, and orange, red, and purple represent high concentrations. High concentrations are visible in the North Atlantic, the North Pacific, and the Indian Ocean. The map is a composite of data from the Aqua and Terra satellites.



Merged Aqua, Terra  
Global SST Night  
Sept 29, 2002

This figure is a global map showing the Sea Surface Temperature (SST) at night. The map uses a color scale where blue and cyan represent cooler temperatures, green and yellow represent moderate temperatures, and orange, red, and purple represent warmer temperatures. The warmest waters are concentrated in the tropical regions, particularly in the Indian Ocean and the western Pacific. The map is a composite of data from the Aqua and Terra satellites.

The background of the slide is a photograph showing a diver in the upper right quadrant and a sensor mounted on a ship's deck in the lower left quadrant. The sensor is a cylindrical device with a green top and a black bottom, connected to a metal pole. The water is a deep blue color.

# MOBY/MOCE

## Five Year + Time-Series

### 7/20/97 to Present

- NIST Radiometric Scale & Overview
- NIST Stray Light Characterizations
- Sensor Spectral Band Matching
- Ocean Color Sensors Supported
  - Japan's OCTS
  - SeaWiFS
  - MODIS Terra and Aqua
  - Japan's GLI (Fall 2002)
- Primary Reference Standard for Climate Quality Ocean Color Time-Series