Climate Quality Ocean Color Time Series: Vicarious Calibration Requirements - MOBY

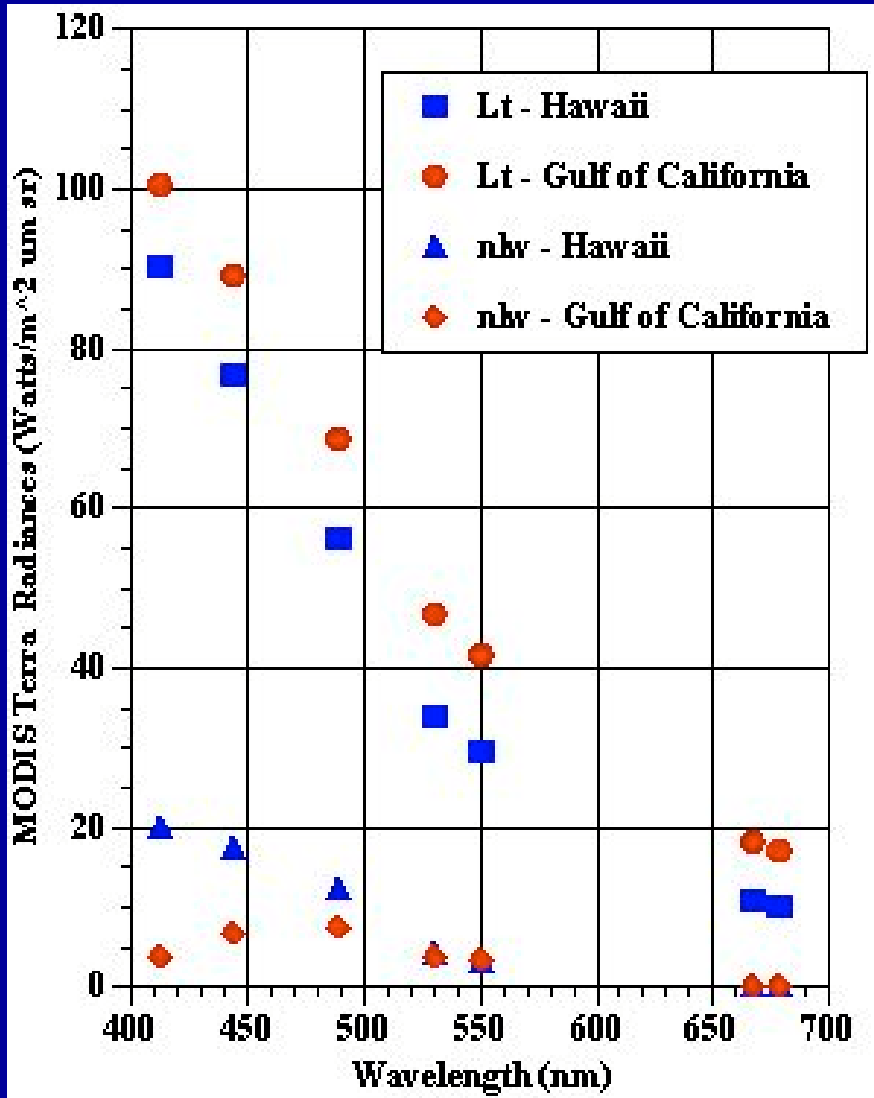
Dennis Clark
NOAA/NESDIS
Office of Research and Applications
with
MOCE/MOBY Team Members

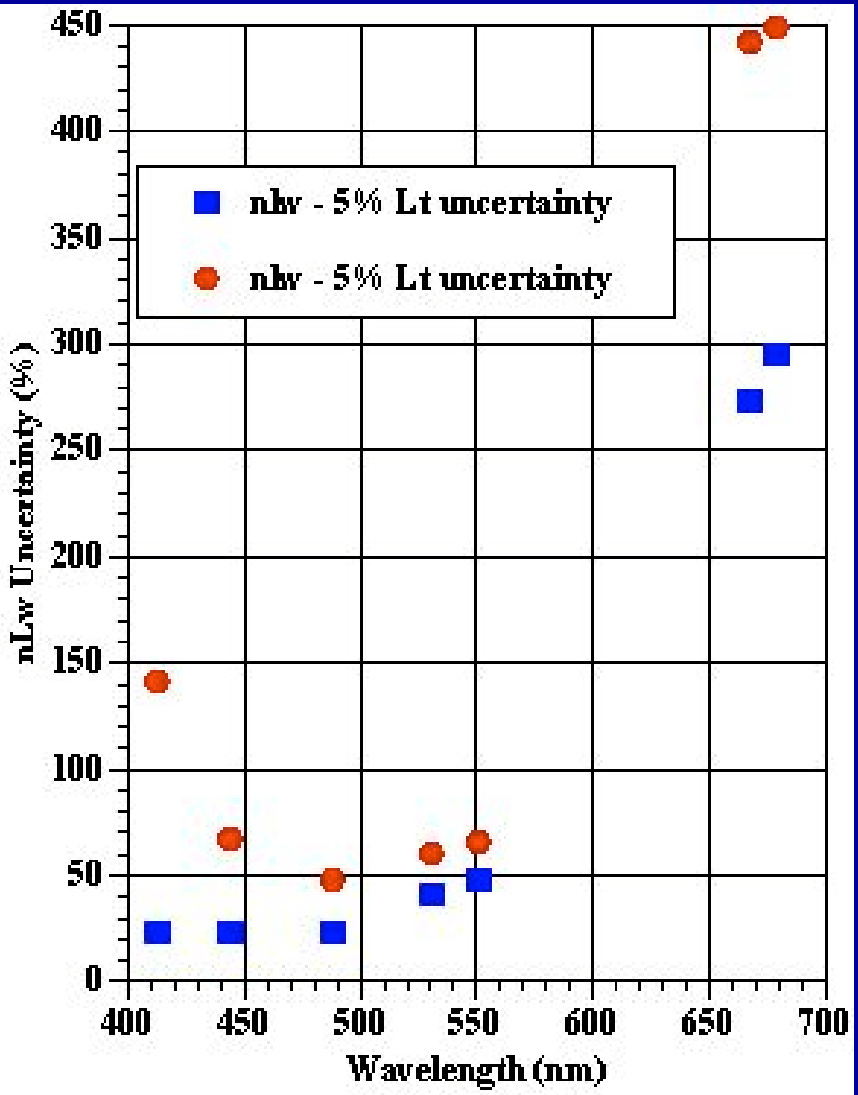
Ocean Color Forum 14 April 2004

Water-leaving Radiance Retrieval Uncertainty

SeaWiFS - NIST Calibration 4% MODIS ¡ 5%

Assume Atmospheric Correction is Perfect





Vicarious Calibration Required for Ocean Color Science

Atmospheric Correction is an Inherent Part of the Calibration Process.

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

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

Vicarious Calibration Site Criteria

Oligotrophic Waters -Stable Target

- Low Horizontal Gradients
- Optically Deep
- High Signal In Blue

Maritime Atmosphere

- Small Aerosol Component
- Avoid Absorbing Aerosol

Characterize

- Physical, Biological, & Optical
- BDRF Measurements & Models

Serviceability

- Convenient Logistic Support
- Safety - Diver & small boat operations

Vicarious Calibration Optical System Criteria

Optical

- High Spectral Resolution (1-2 nm)
- Large spectral range (350 - 900 nm)
- High stray light rejection
- Temperature Stabilization
- Reference lamps for stability monitoring

Calibration

- NIST traceability & overview
- Wavelength calibrations - low pressure lamps and lasers

Characterization

- Stray light
- Thermal
- Linearity

Vicarious Calibration Buoy System Criteria

Buoy

Stable - small tilt angles

Minimized shadowing effects

Data & system status telemetry

Characterization

Shadowing Correction Models

Reliability

Minimize structural degradation for deployment periods of four months.

Minimize bio-fouling and provide for systematic cleaning and *in situ* reference calibrations.

Initial Proposal for MODIS Vicarious Calibration

Based on DOE Ozone Monitoring Program:

A few primary sites instrumented with high-end optical systems (Fastie -eight meter double spectrometers).

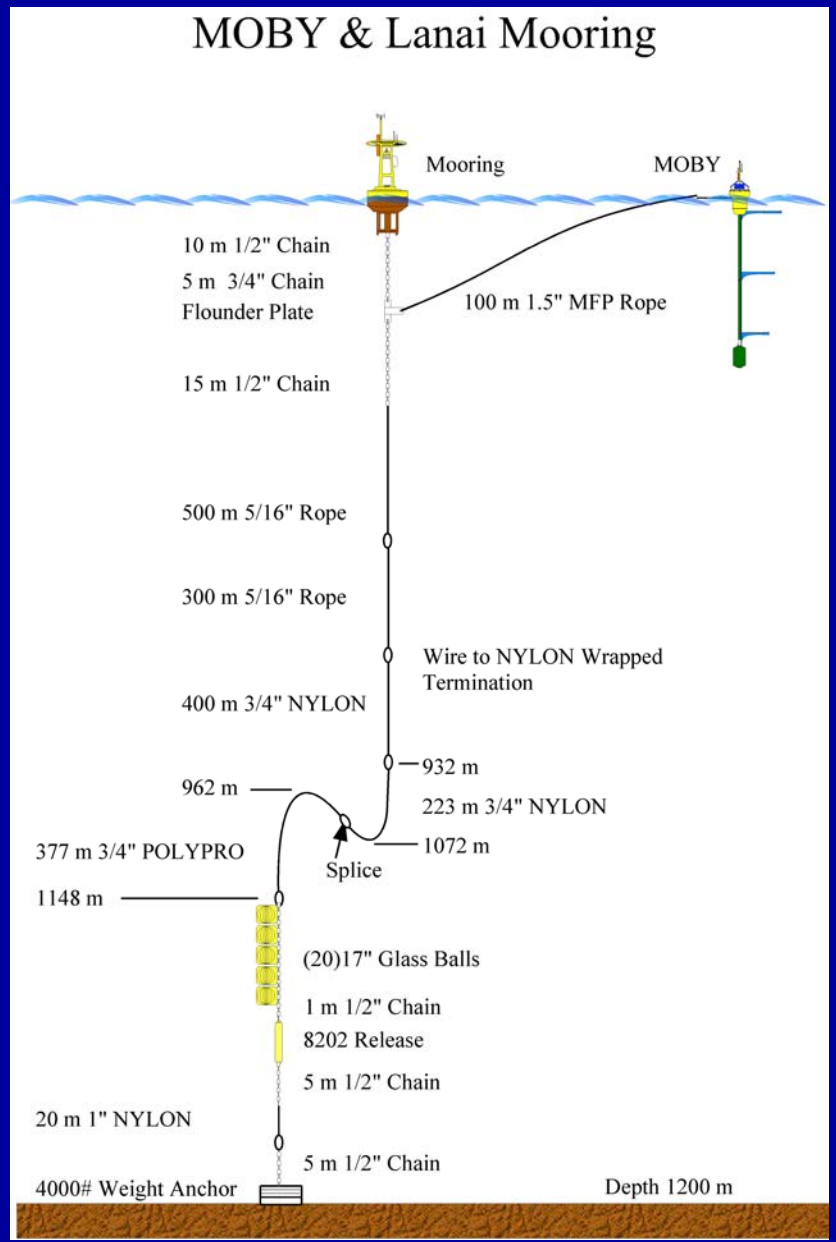
High density geographic coverage with Dobson meters.

MODIS Proposal:

MOBY's at five sites - Hawaii, Bermuda, Mediterranean , Brazil, and Australia.

Optical Drifters and at-sea bio-optical campaigns

MOBY Mooring Site



MOBY Operations Site - Univ. Hawaii

Pier Side - 30,000 sq. ft

16 Portable vans/tent

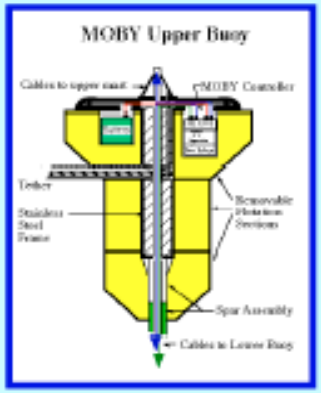
offices, shops, storage, labs (calibration, optics assembly, filtration)

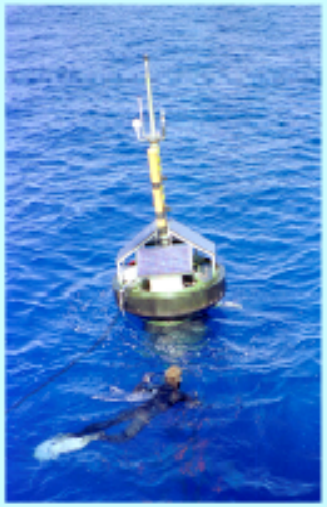
6 Shipboard Vans

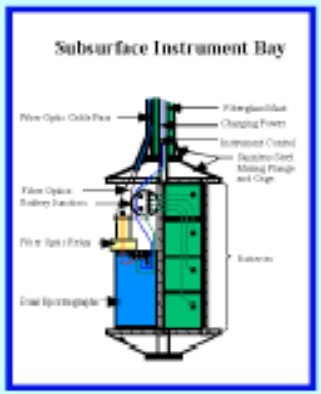
3 labs - (wet, optics, data acquisition) power, storage, & office

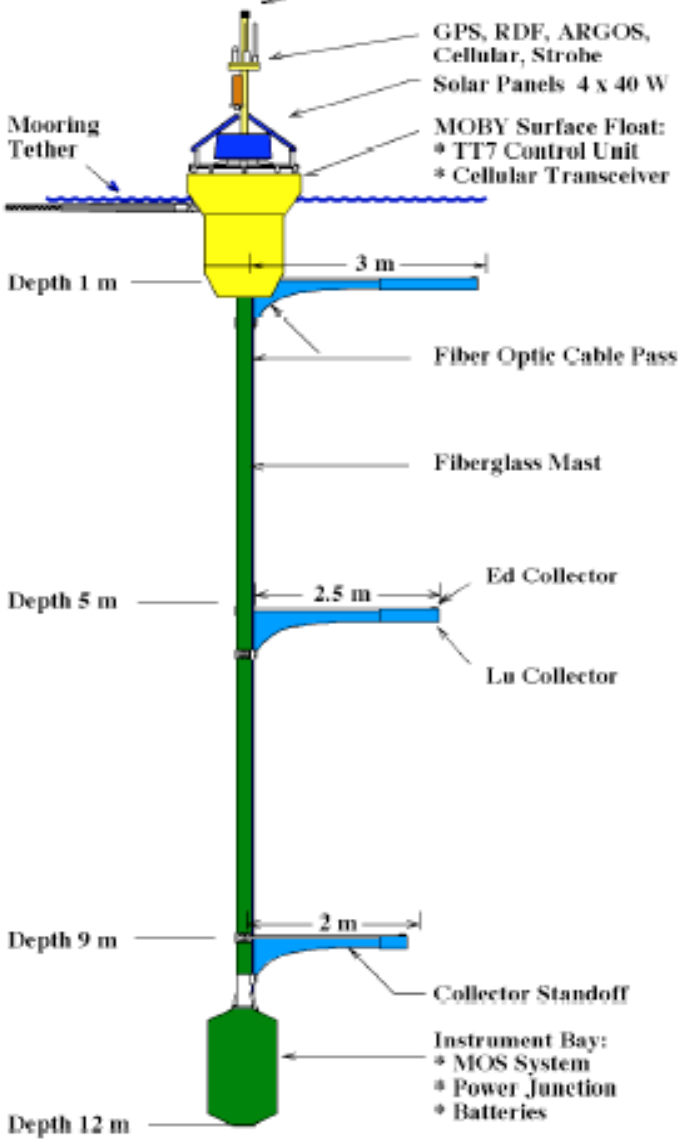
Pier side Support - cranes, machine shop.

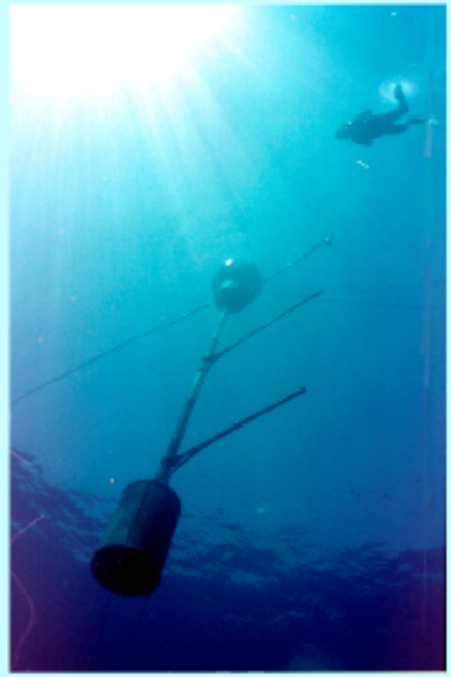
Marine Optical Buoy

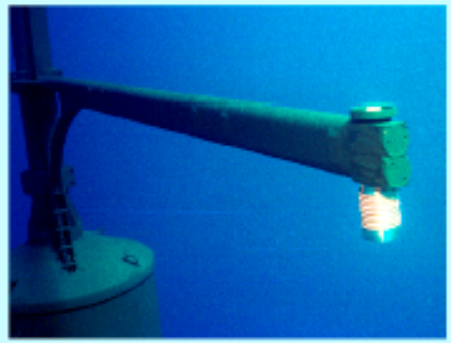


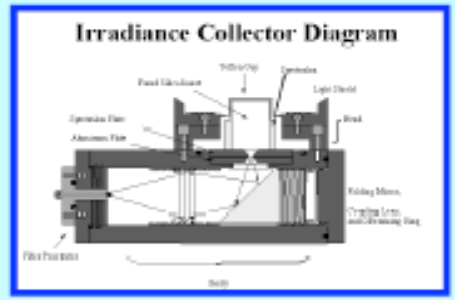




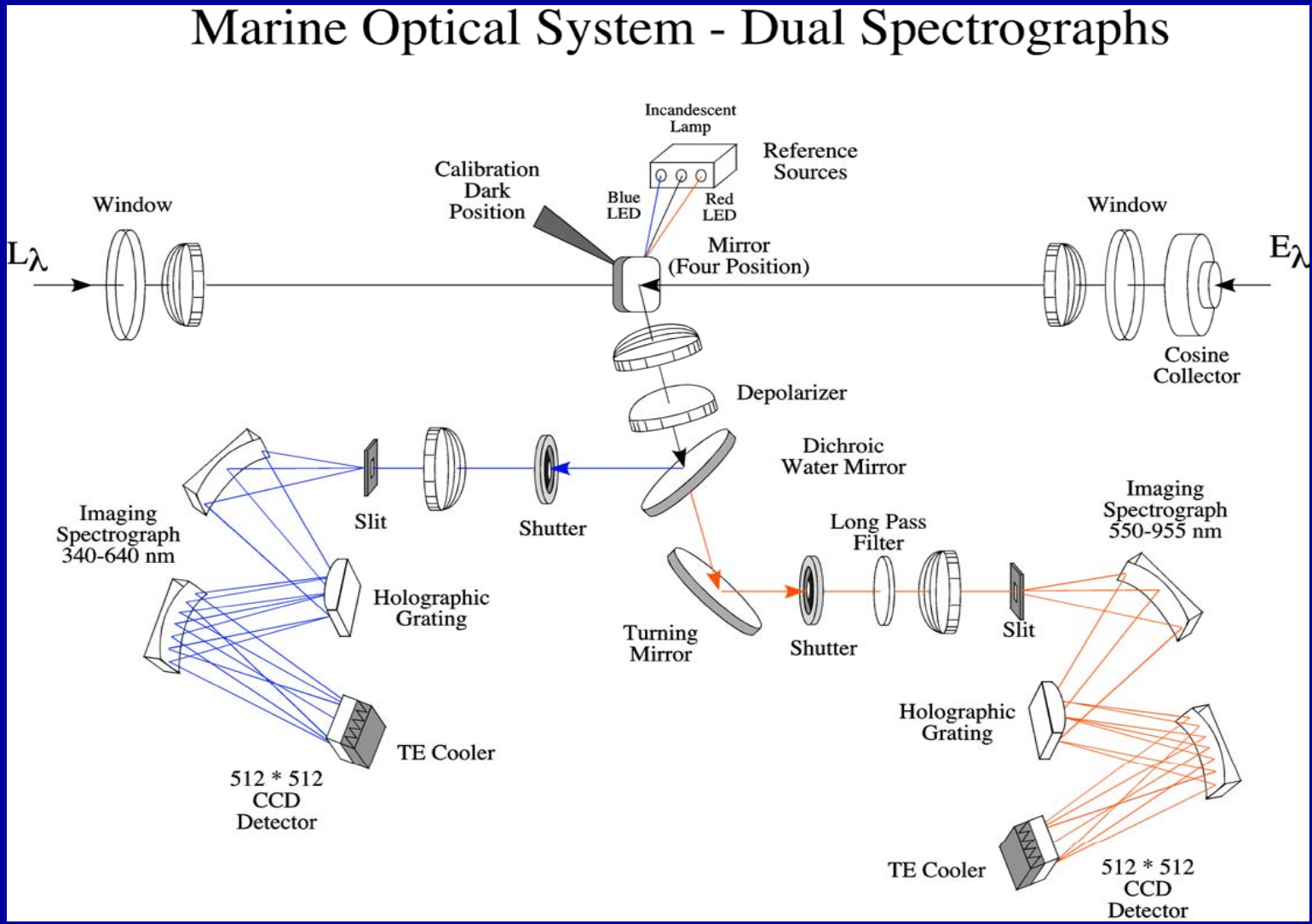




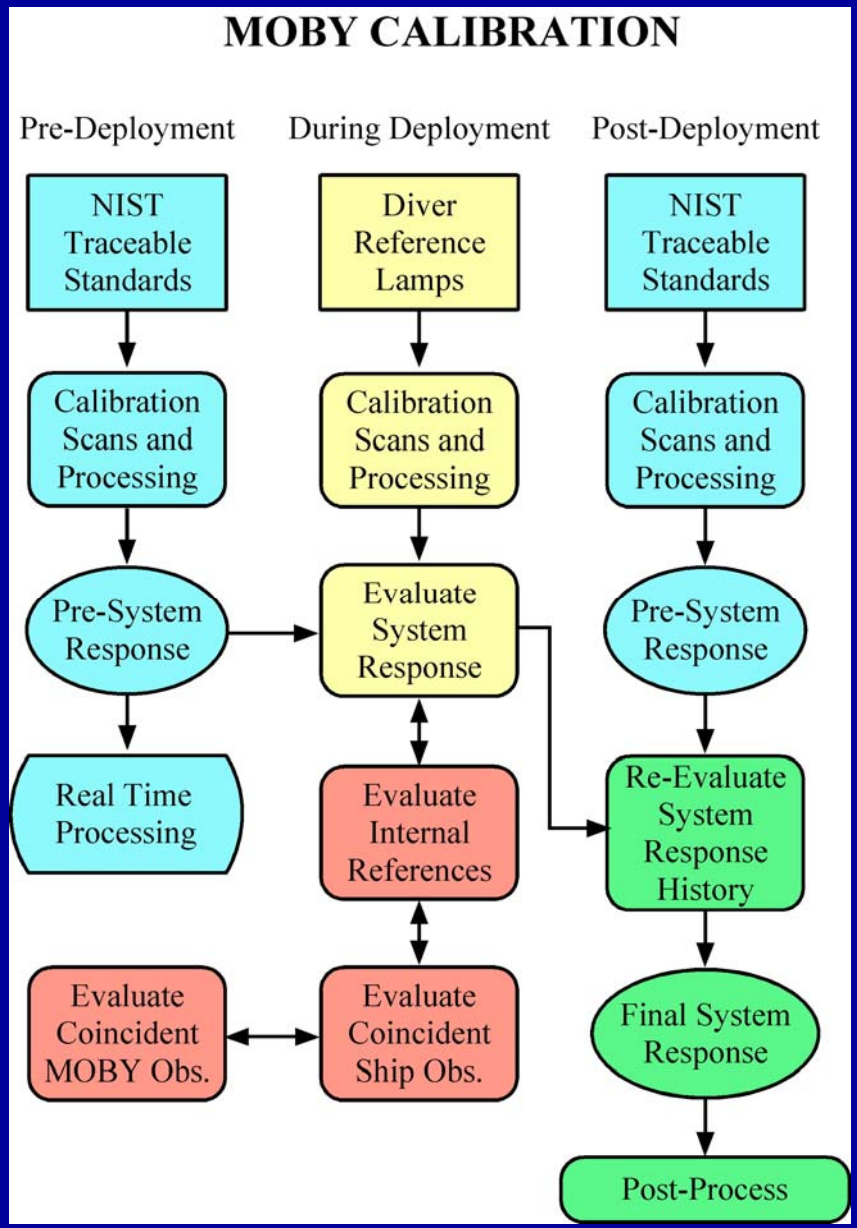




MOBY Optical System



MOBY Calibration Process



NIST Collaborations

Training

NIST Primary Lamb Standards

Annual On Site Calibration Systems Check

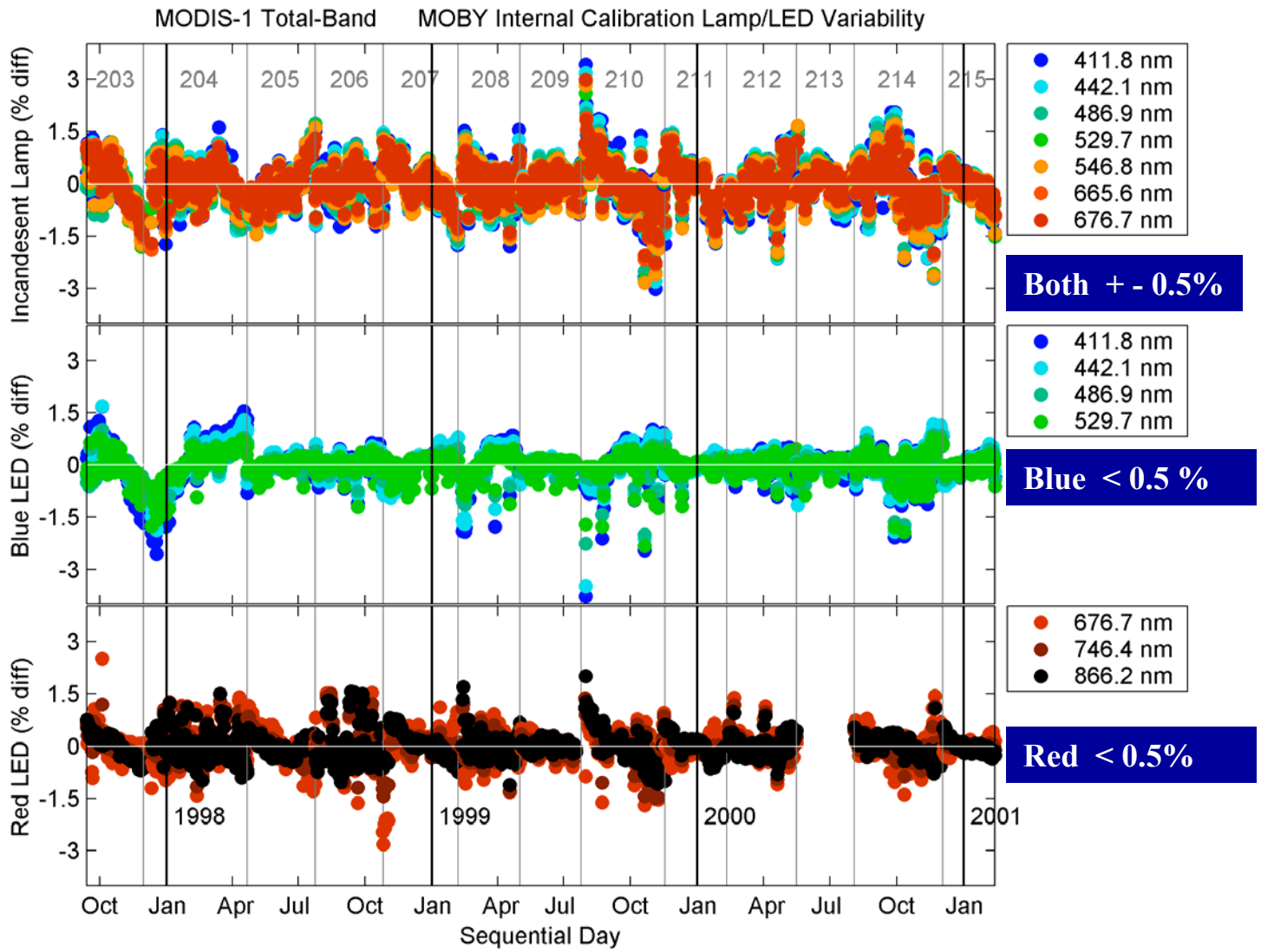
Pre/Post Cal. System monitoring with NIST Cal. Radiometers

SIRCUS - Stray Light Characterizations on MOBY and Shipboard Spectrometers

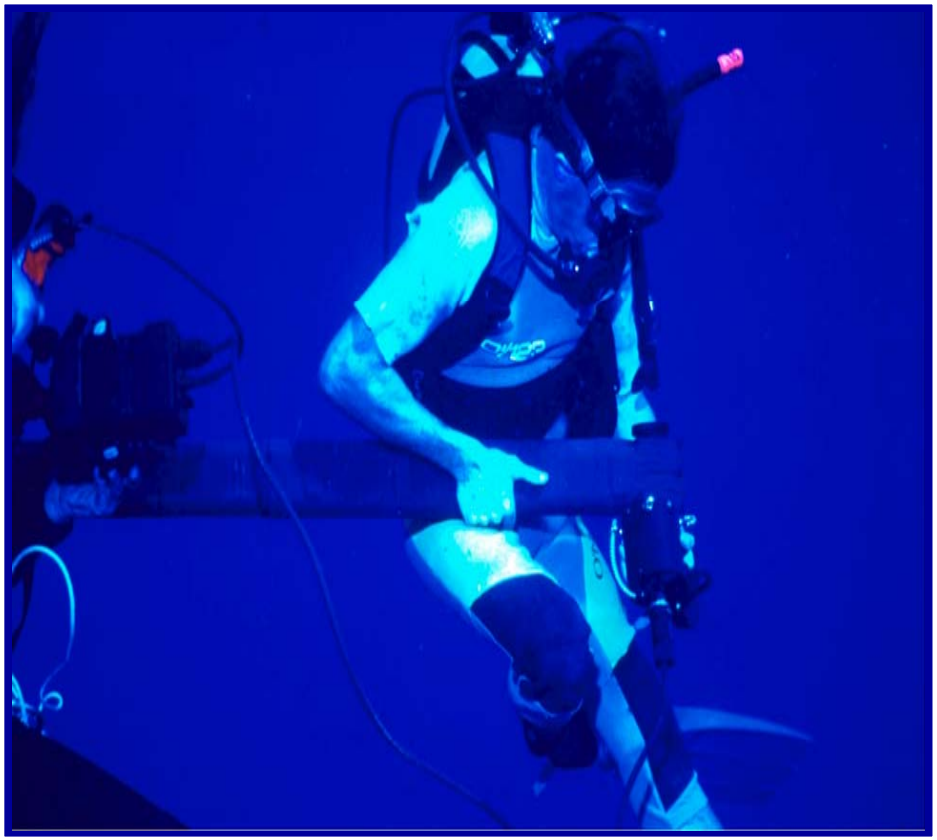
MOCE Calibration Systems (OL420 & OL425) now Calibrated at NIST

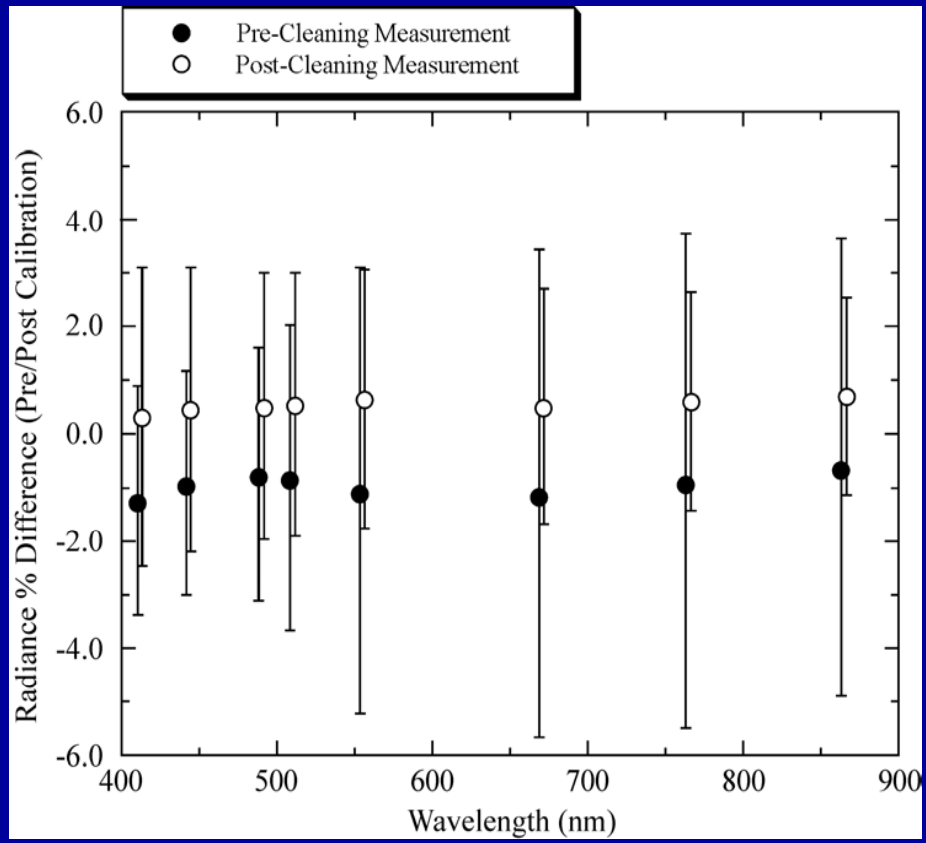
Initiating the development of new LED Radiometric Calibration Sources for Oceans

Internal Reference Lamps - Stability QC



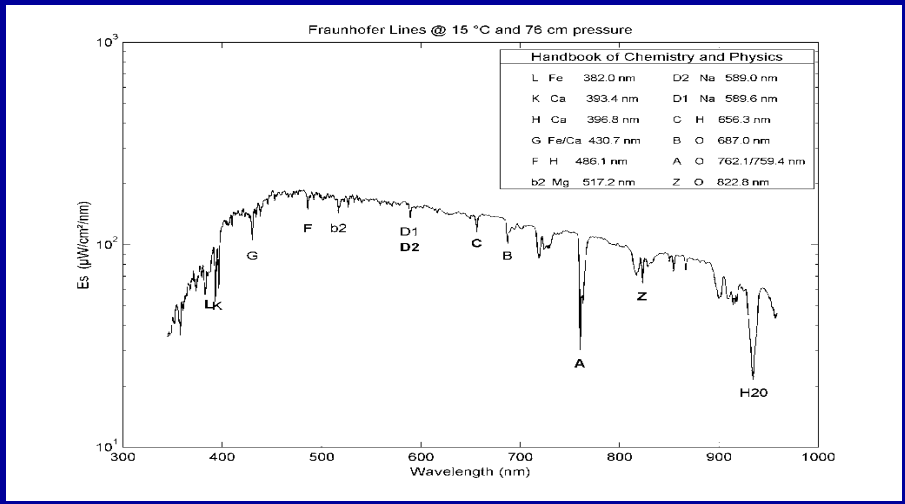
Diver Reference Lamp - Pre/Post Cleaning QC



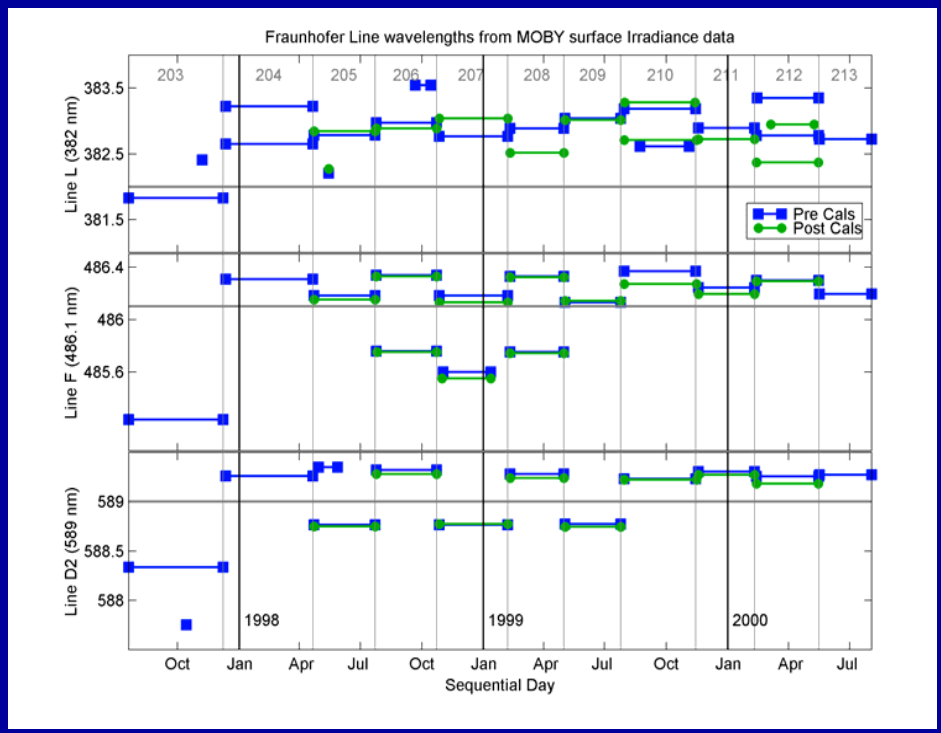


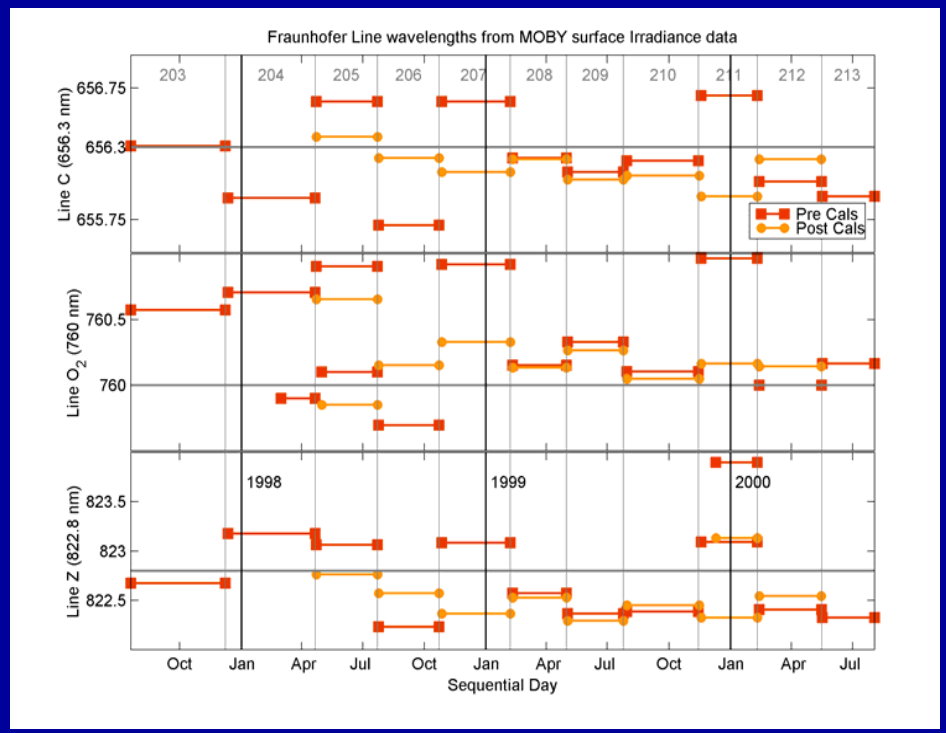
Spectral Calibration QC-Solar

Blue Spectrograph
2.5 years
Approx. +- 0.6nm

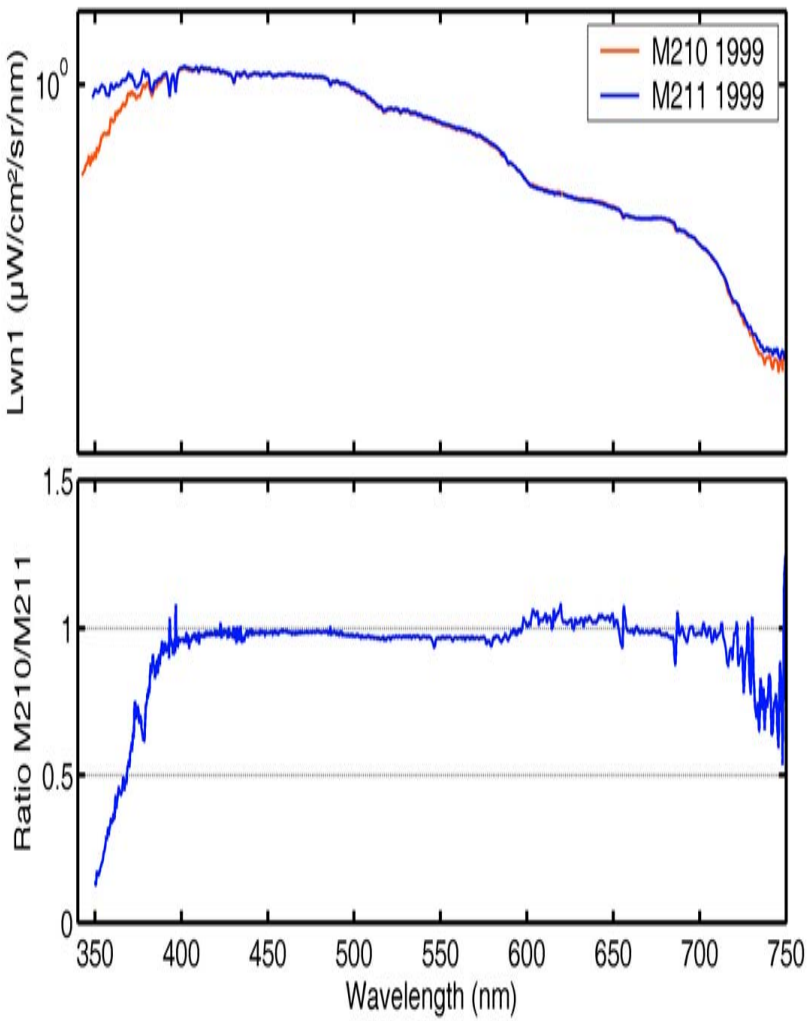


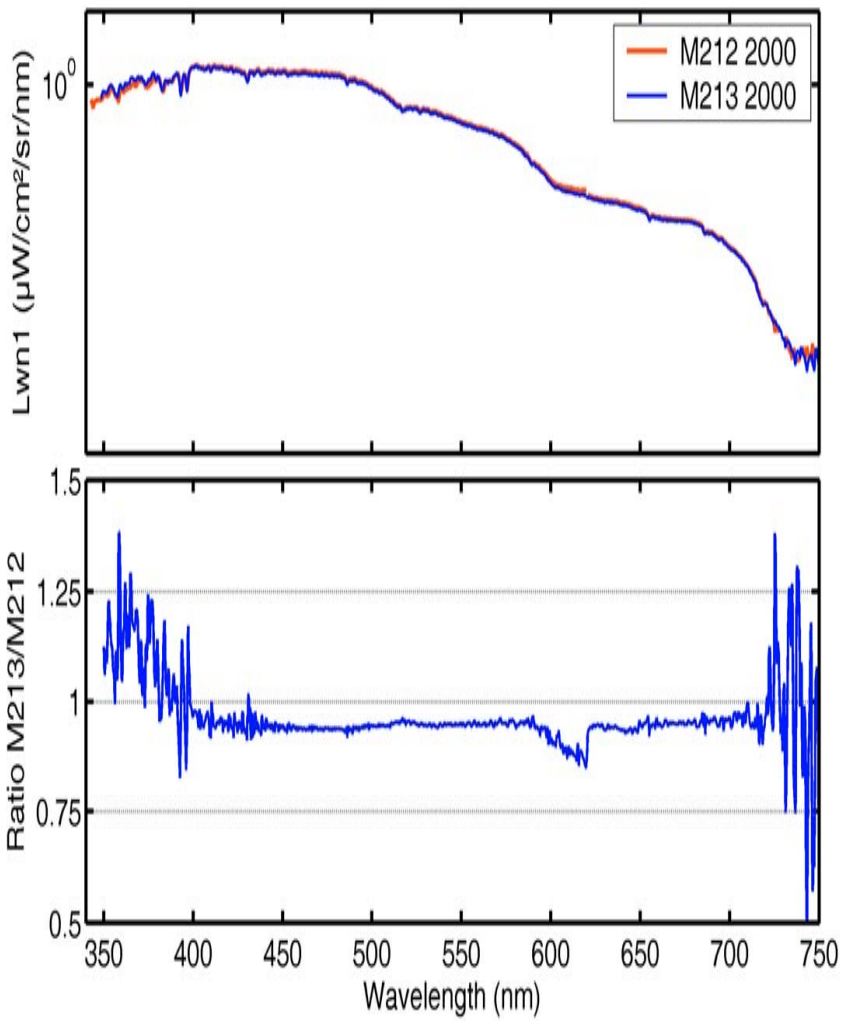
Red Spectrograph
2.5 years
Approx. +- 1nm



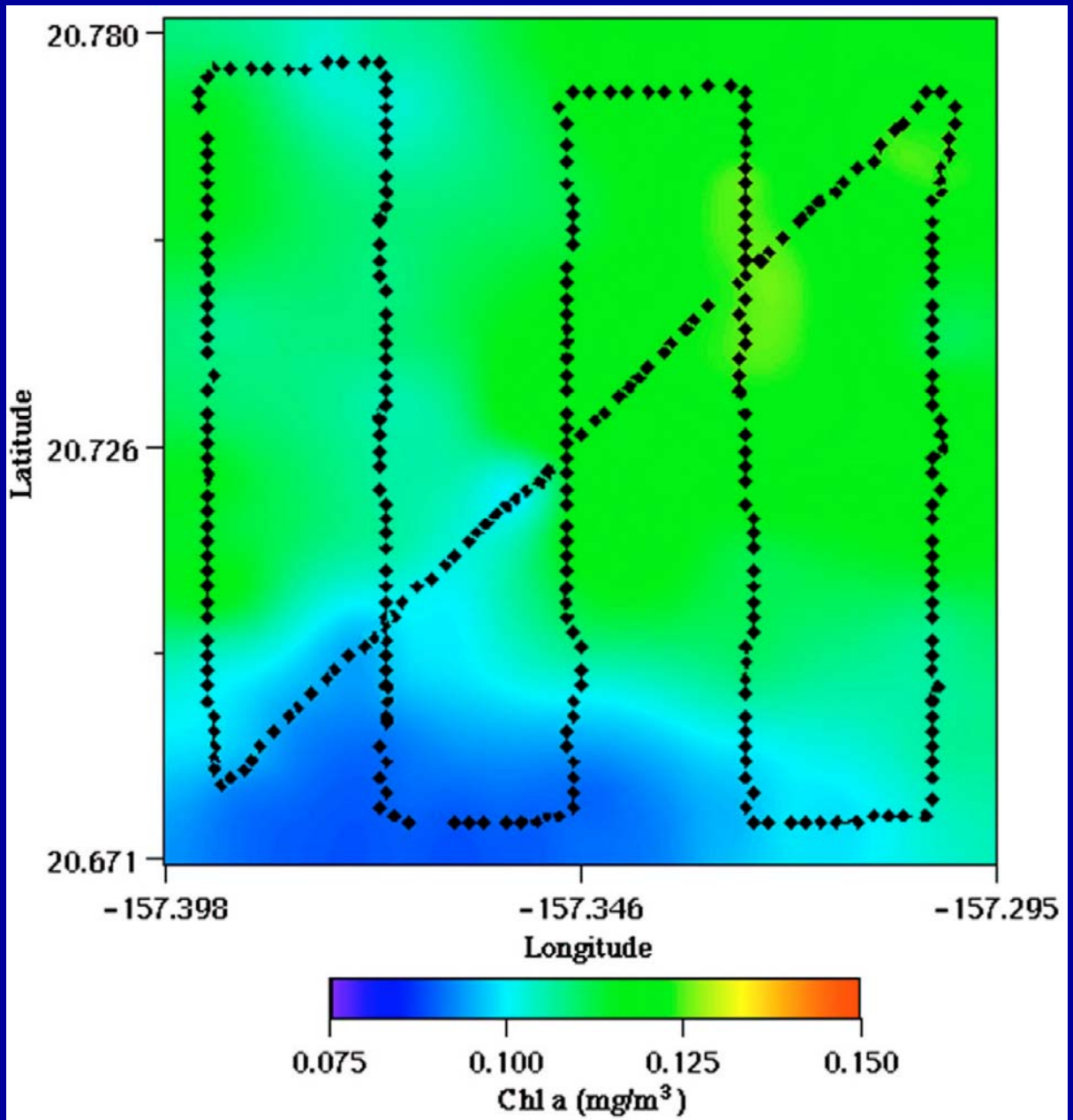


MOBY Crossover Comparisons





Horizontal Chlorophyll-a Variability Survey

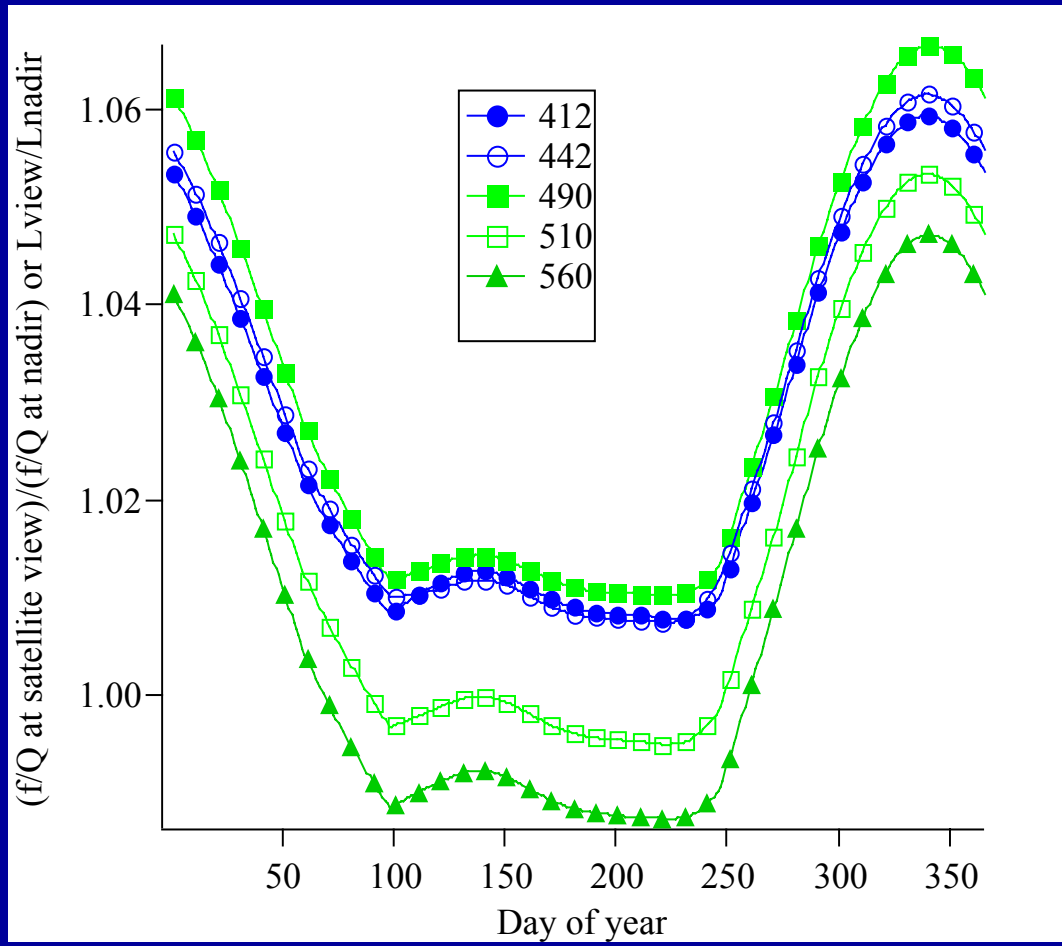


Grid Size:
12x12 Km

Min: 0.089
Max: 0.126
Mean: 0.110
Delta: 0.038

MOBY BDRF Measurements (Ken Voss)

- MODIS views MOBY from 14 specific geometries.
- Sun-MODIS geometry varies in a regular manner throughout the year
- Use NuRADS data to empirically model this variation

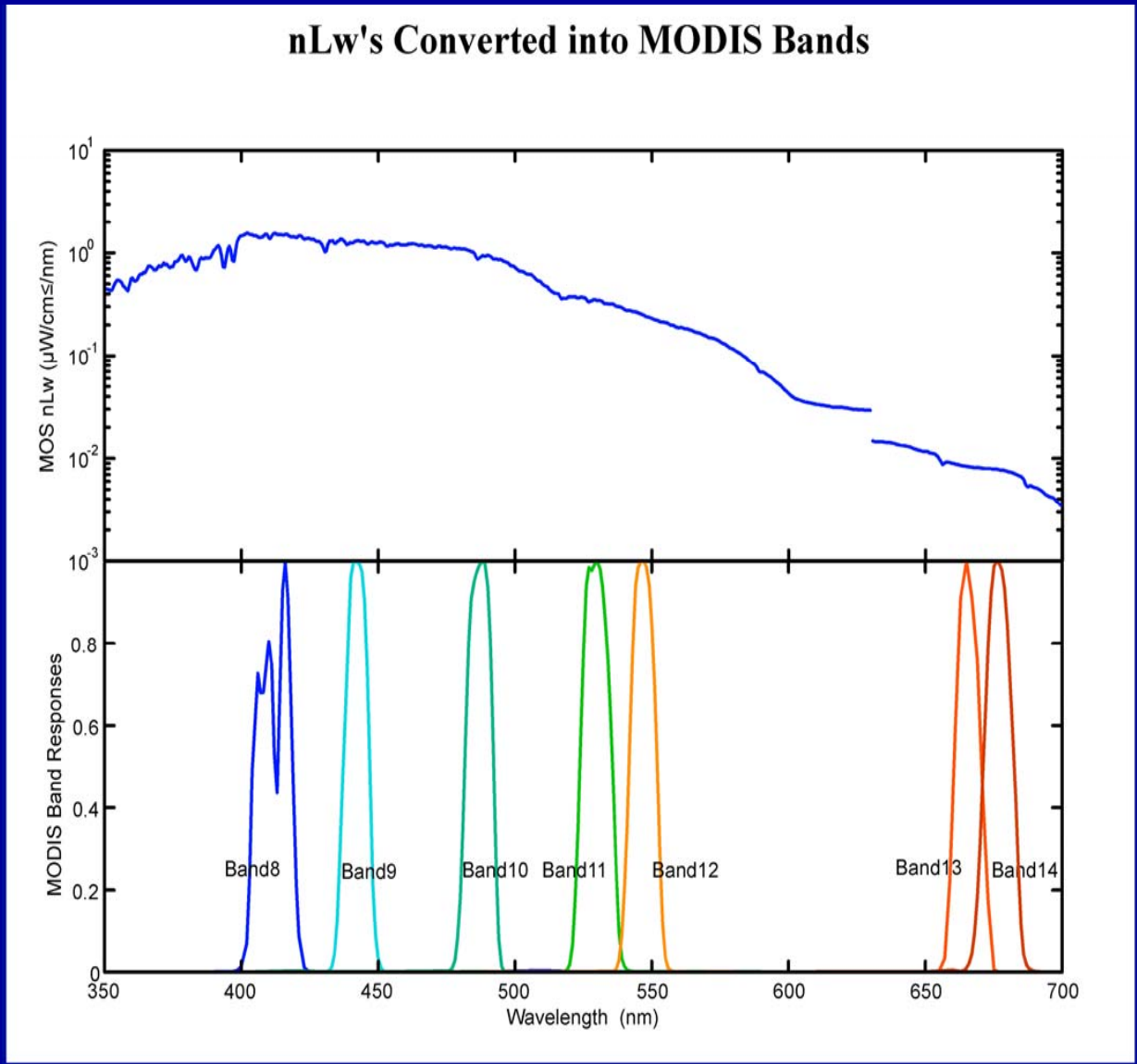


Example for measurement at 22:04 UT., Satellite view is 53 degrees.

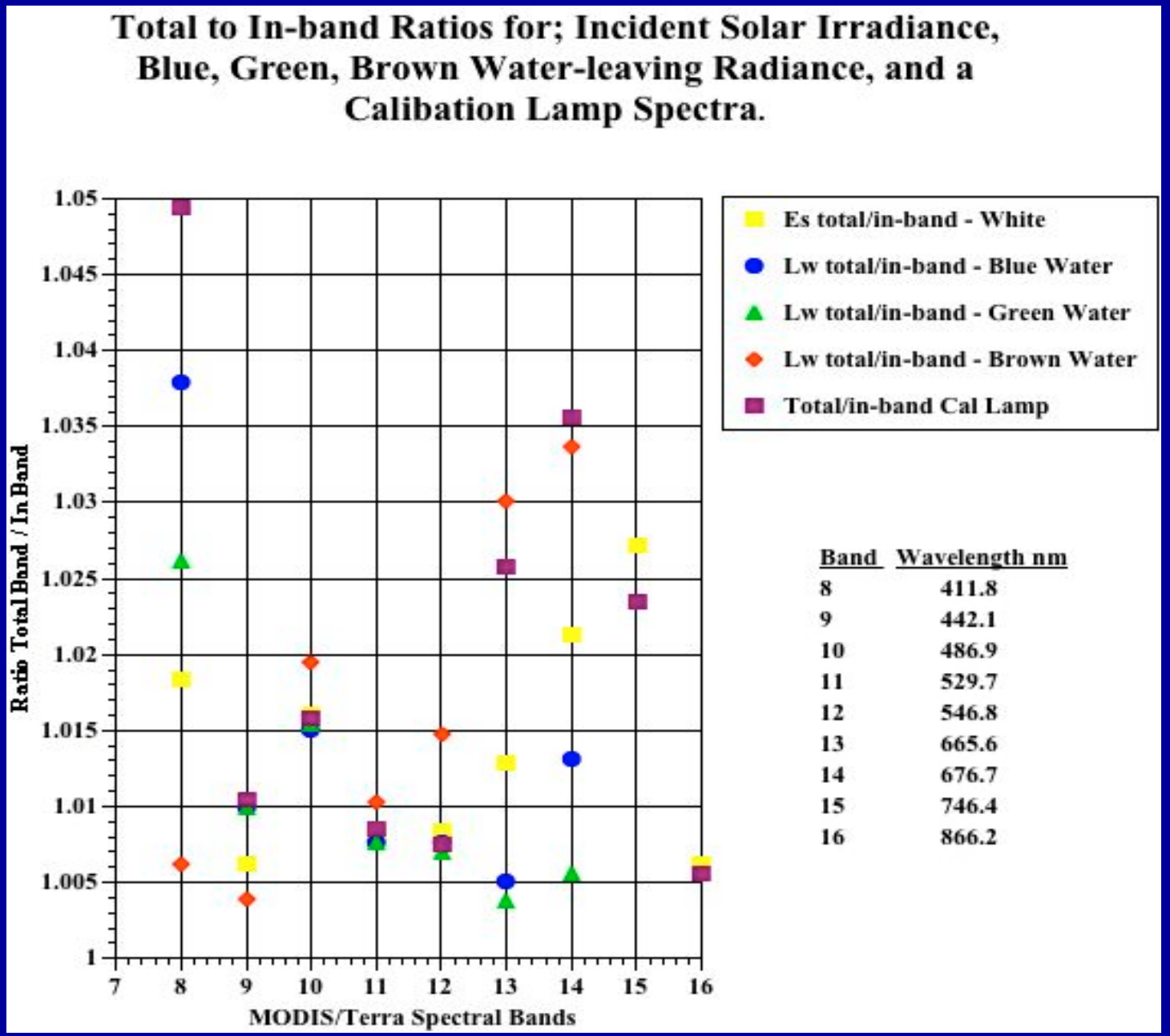
Spectral Band Considerations

Spectral Band Pass Matching

High Resolution Spectra Convolved to Sensor's Spectral Band Pass

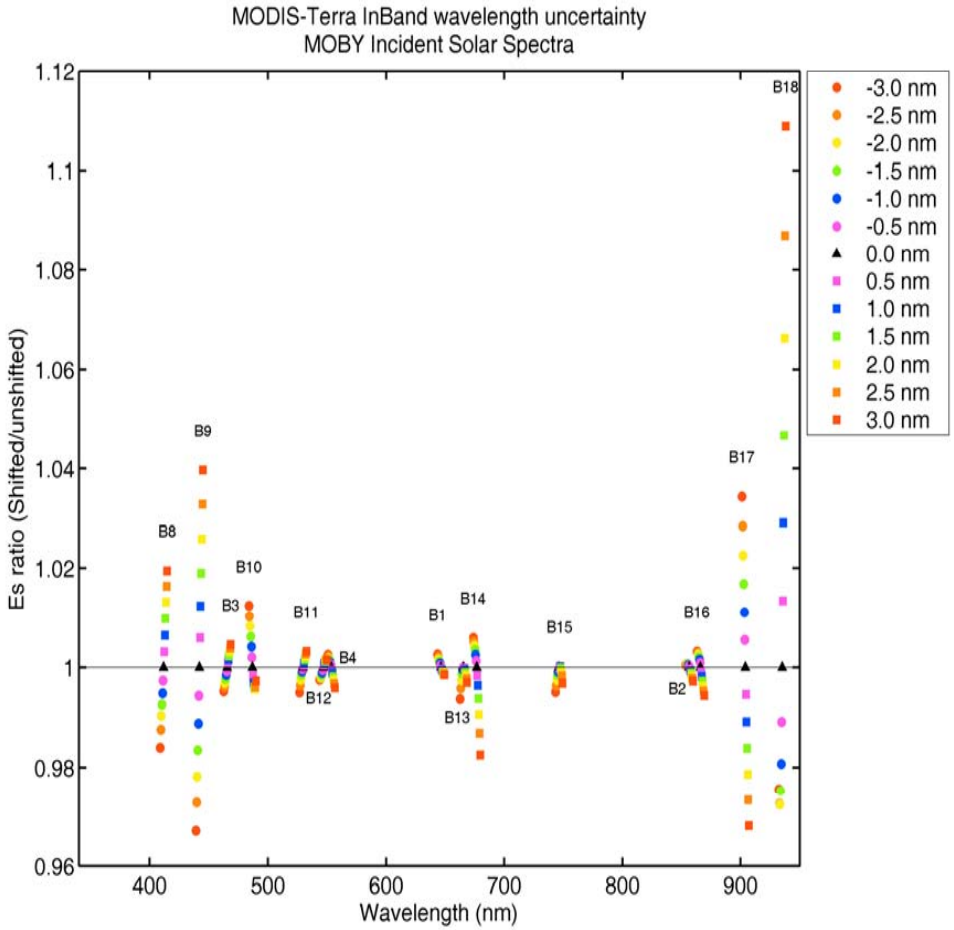


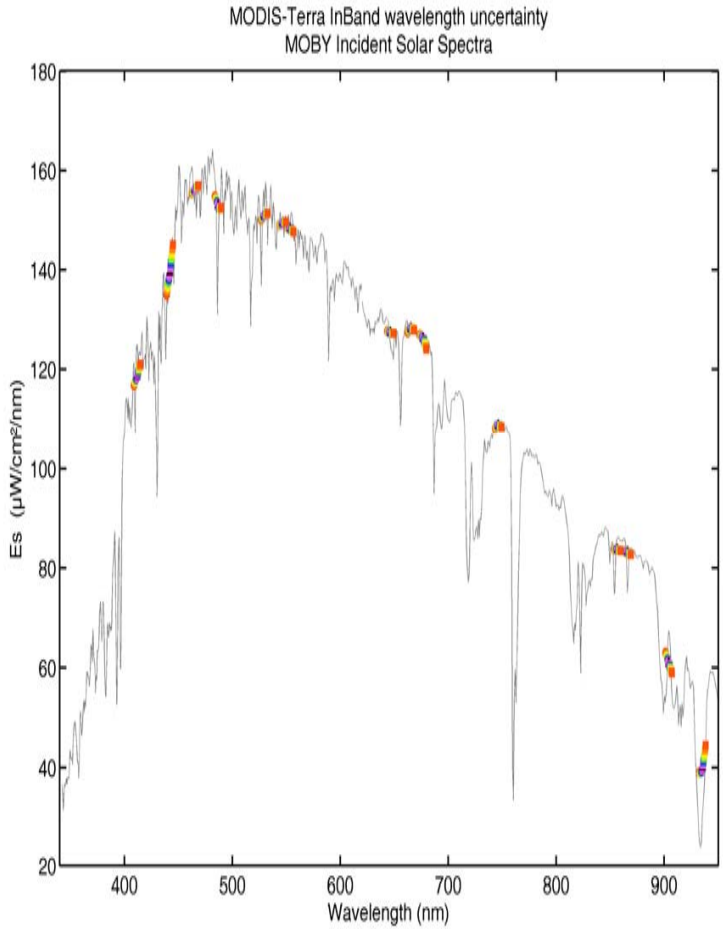
Spectral Band Uncertainties-MODIS Terra



Spectral Band Systematic Uncertainties

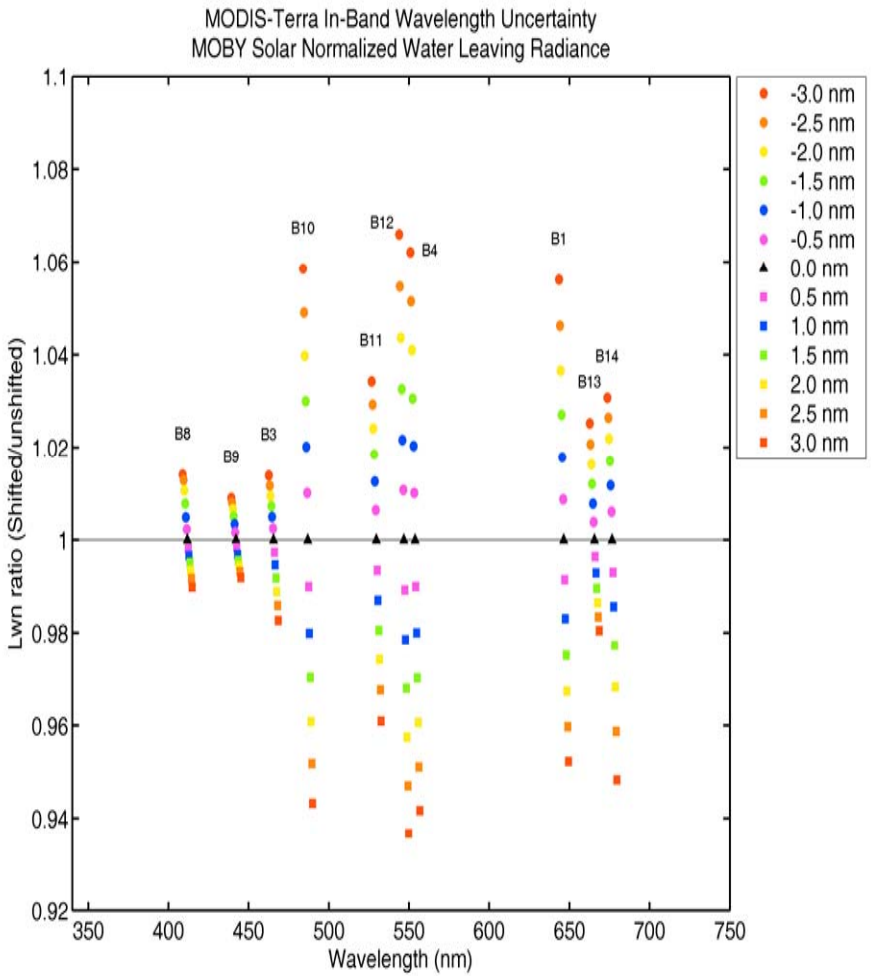
Wavelength Shifts - Es - 0.05nm steps

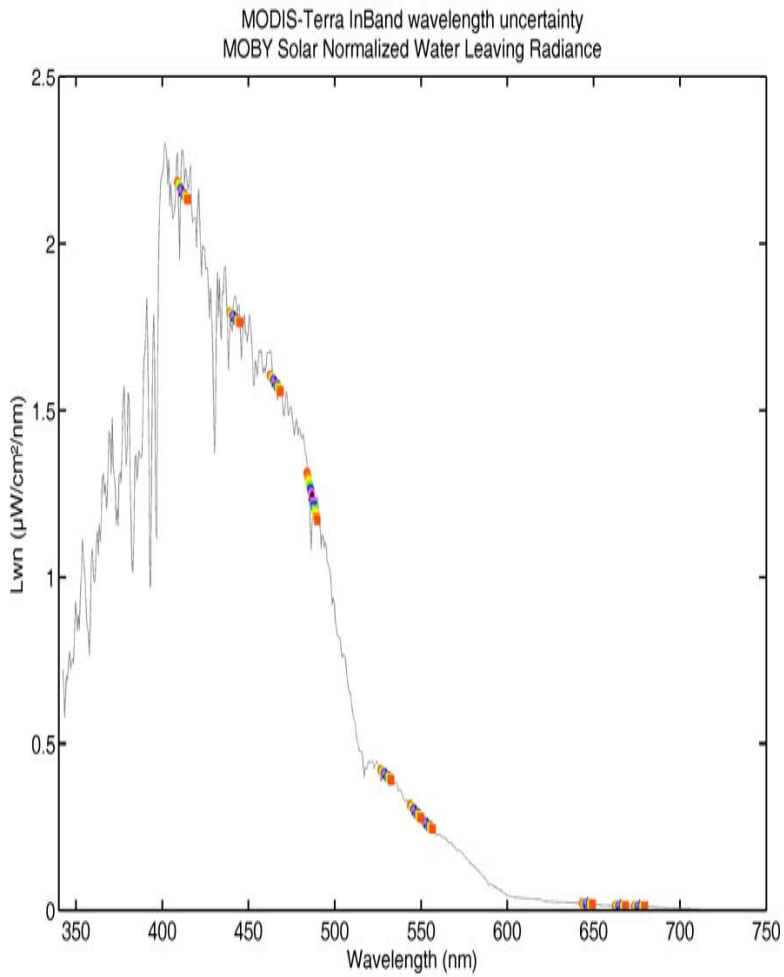




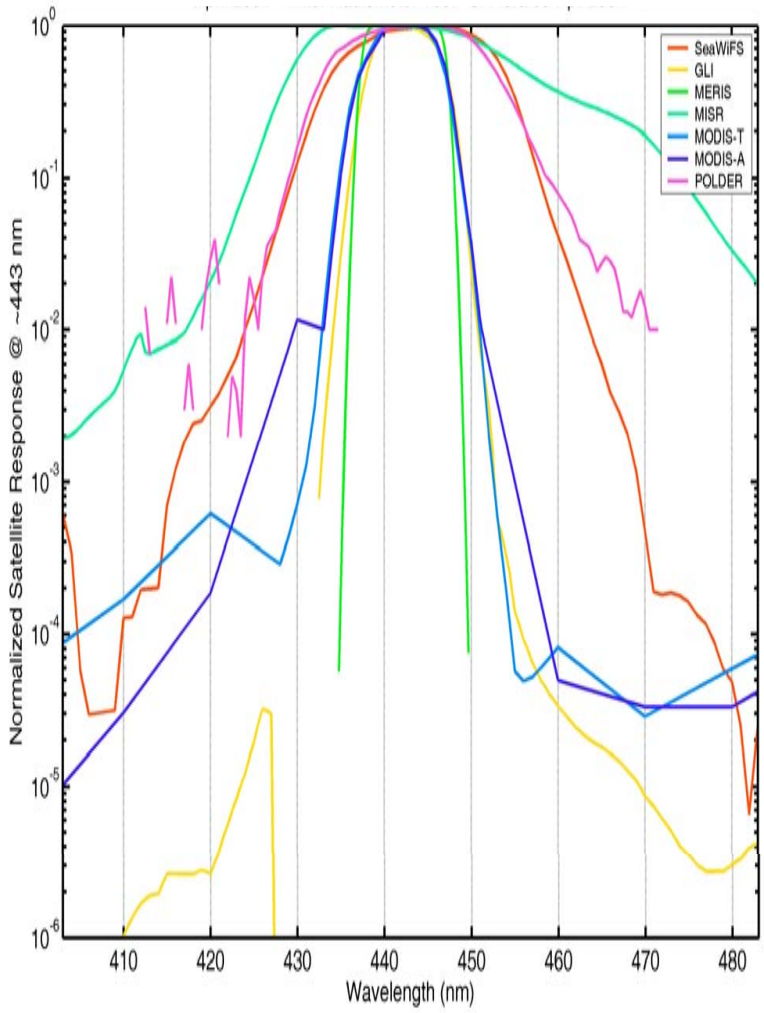
Spectral Band Systematic Uncertainties

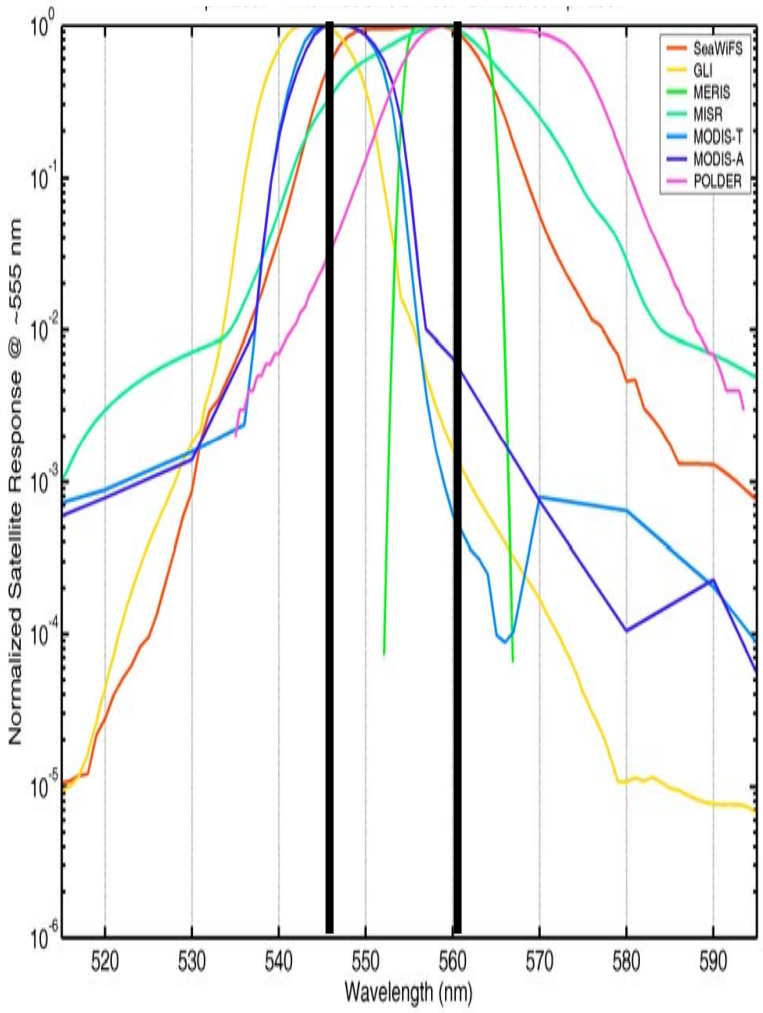
Wavelength Shifts - Lwn - 0.05nm steps





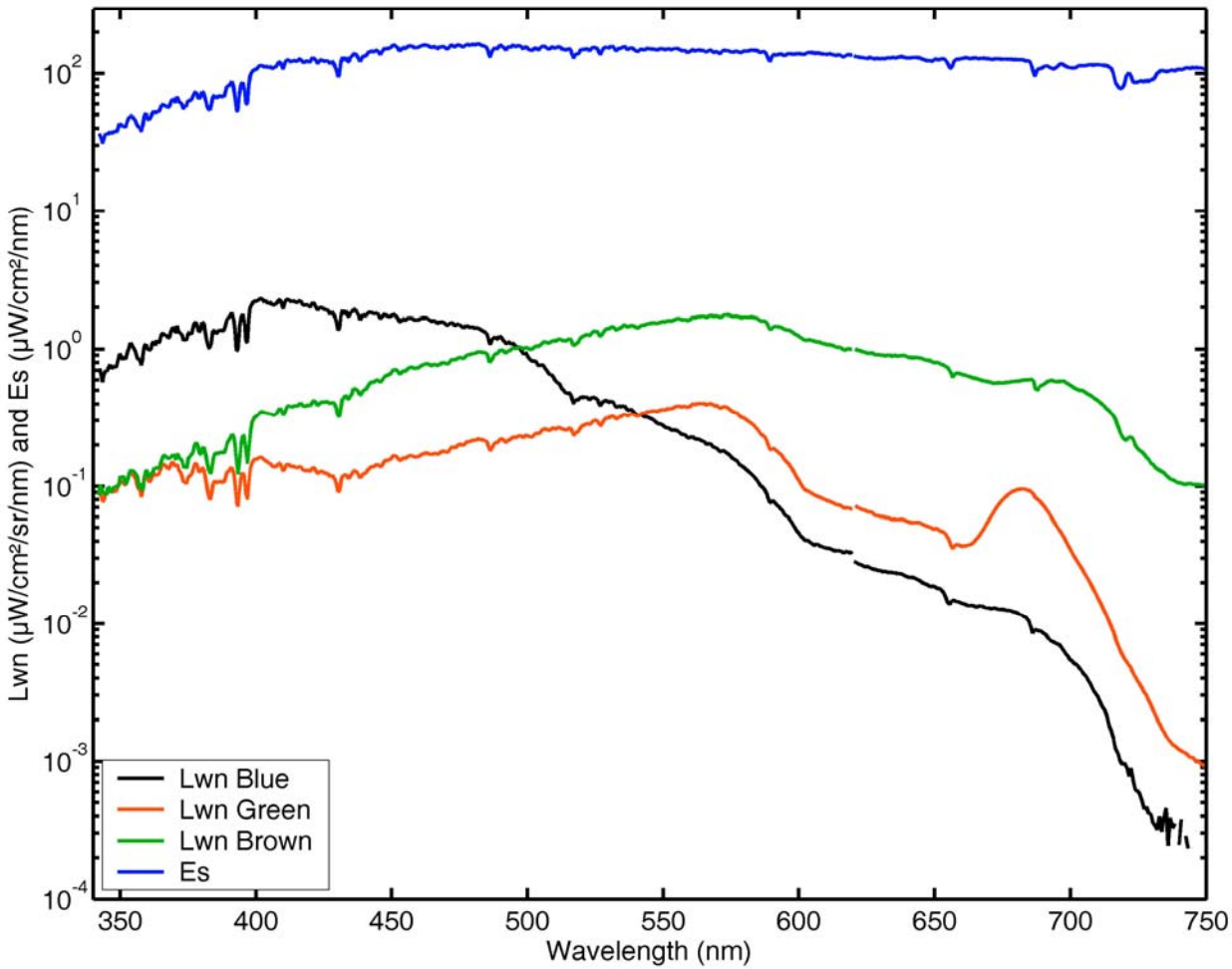
Spectral Band Passes - OC Missions





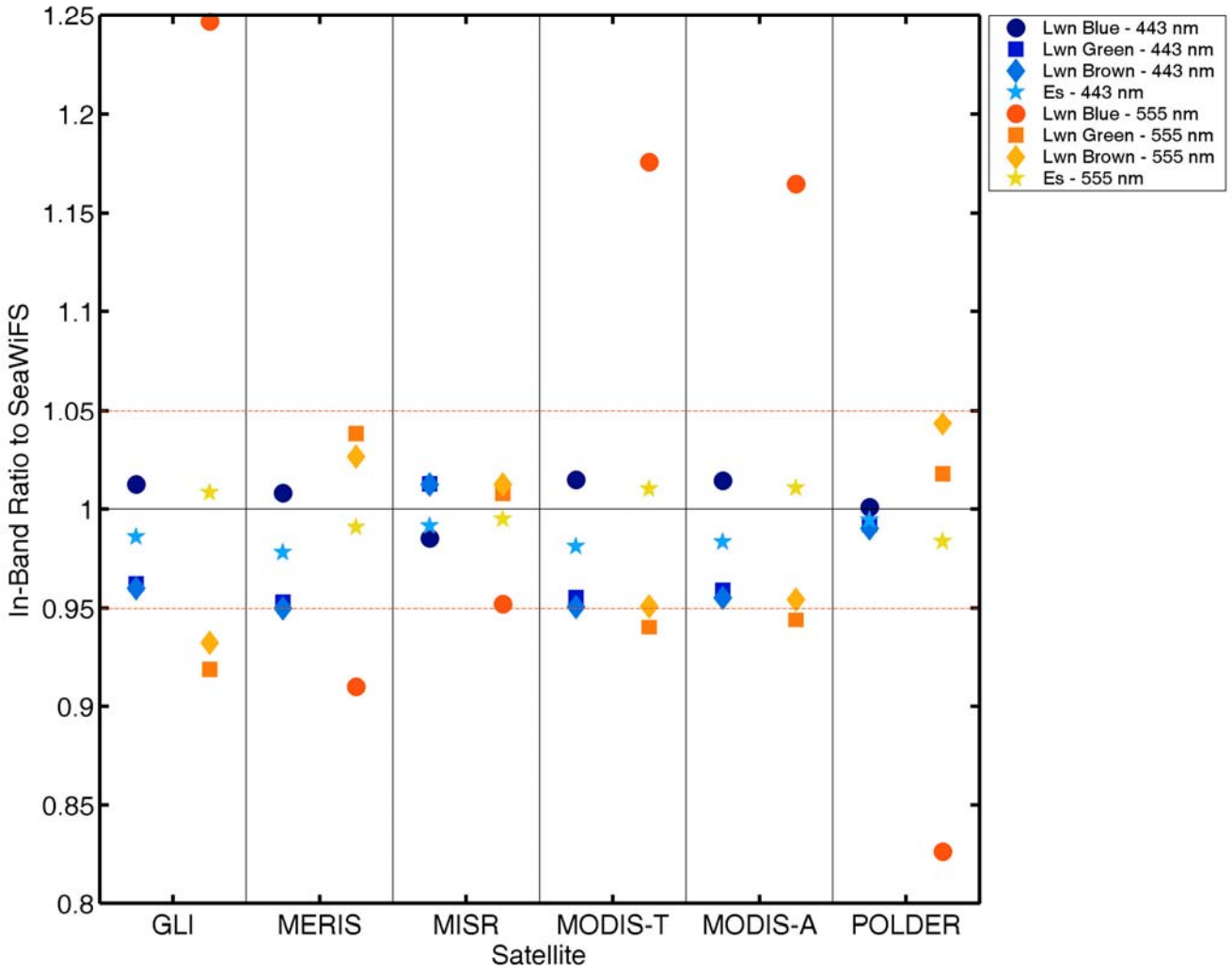
Spectral Band Pass Matching

High Resolution Spectra Convolved to Sensor's Spectral Band Pass



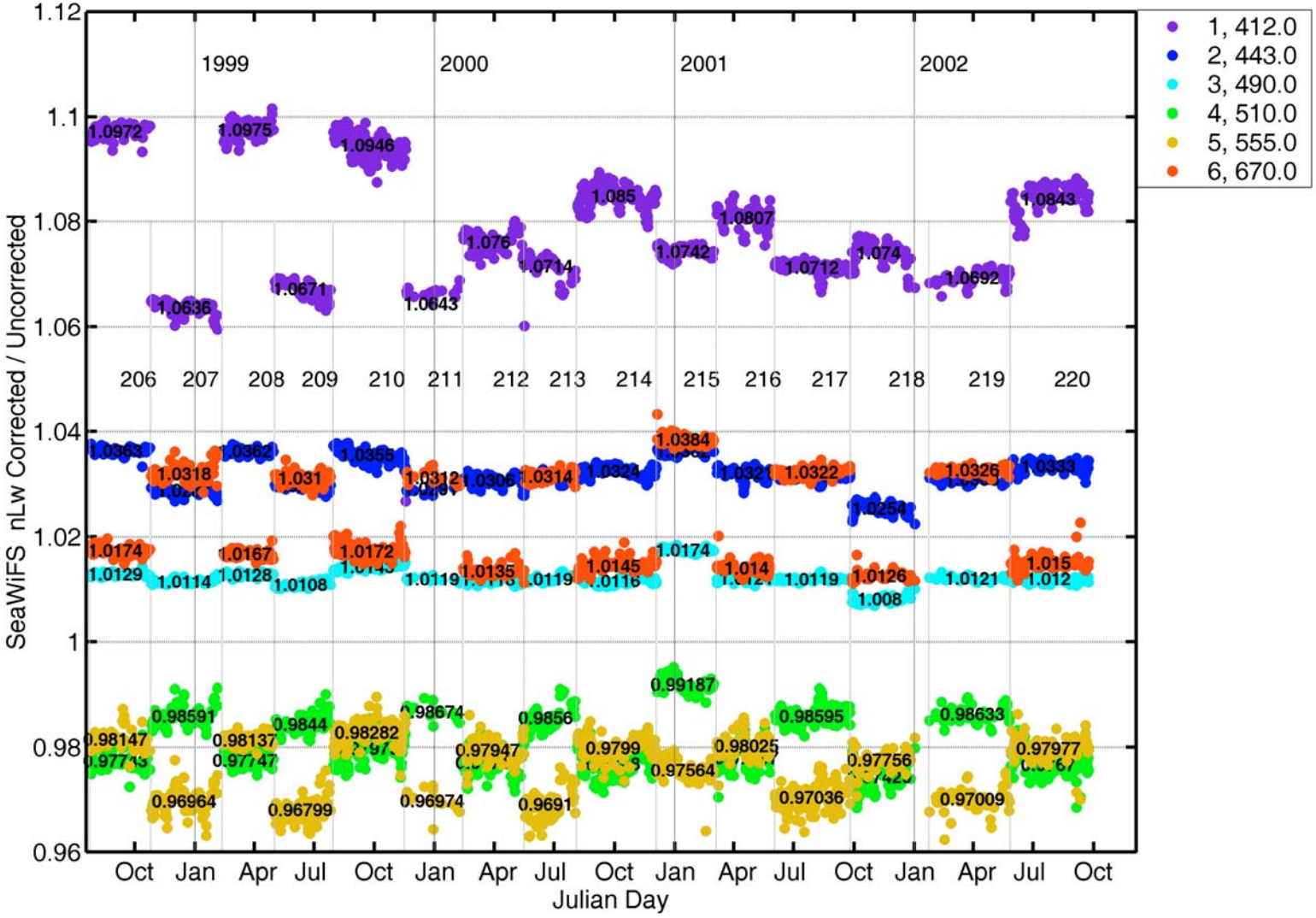
Spectral Band Systematic Uncertainties

SeaWiFS In-Band Response Ratios to Other OC Sensors



Reduction of Systematic Uncertainties - MOBY

SeaWiFS Stray Light Time Series Corrections



Major MOBY Reprocessing Elements

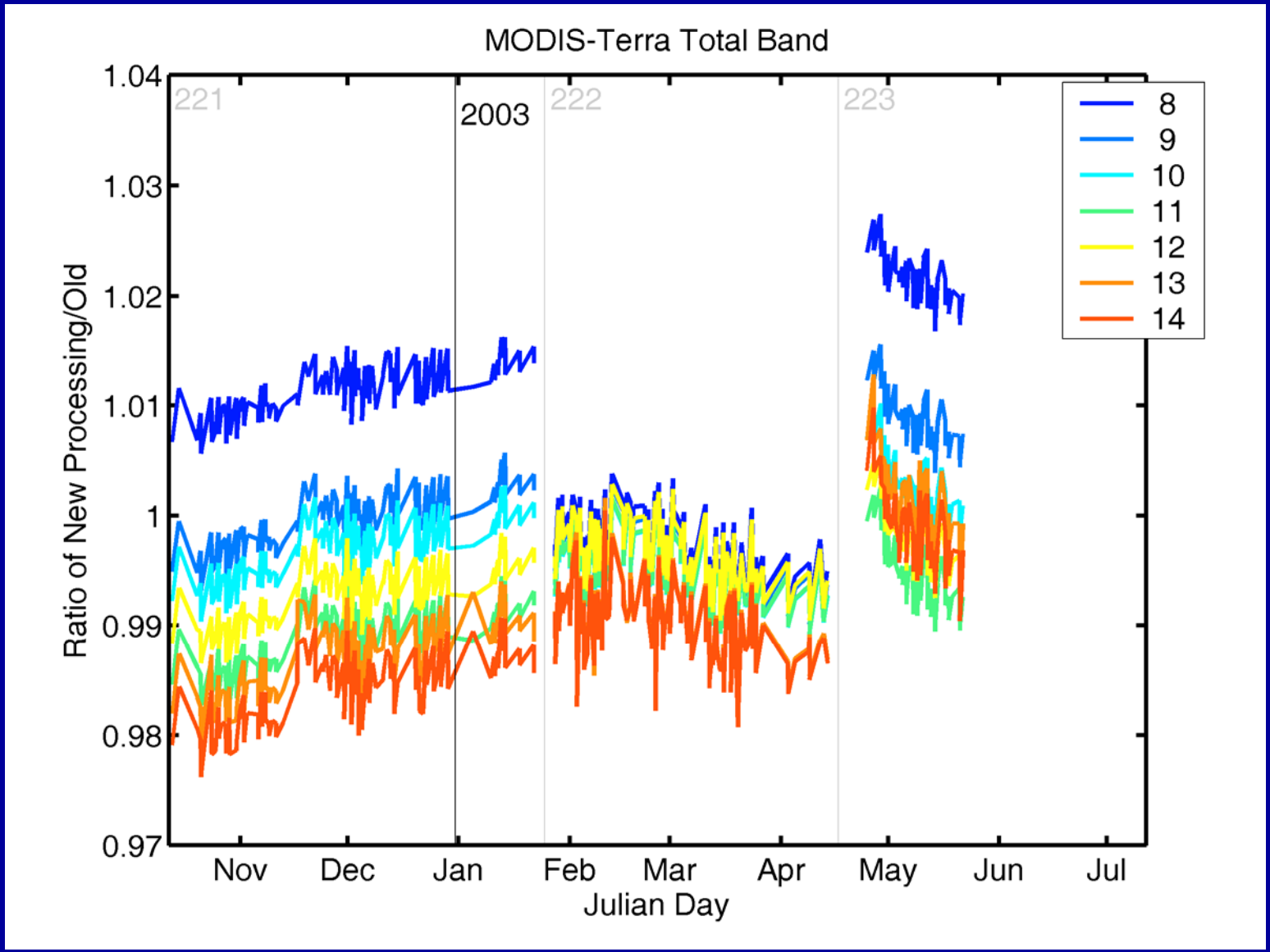
Thermal Corrections - A correction for temperature of approximately 0.5% per degree is being applied to system responses and *insitu* data.

Stray-light Model Version 2 - Implemented an improved characterization of the MOS spectrographs to develop a more detailed model of the instrument slit scatter function. This resulted in a more accurate measure of scattered light in the system and impacted the measured Lu's - primarily at the ends of each spectrograph.

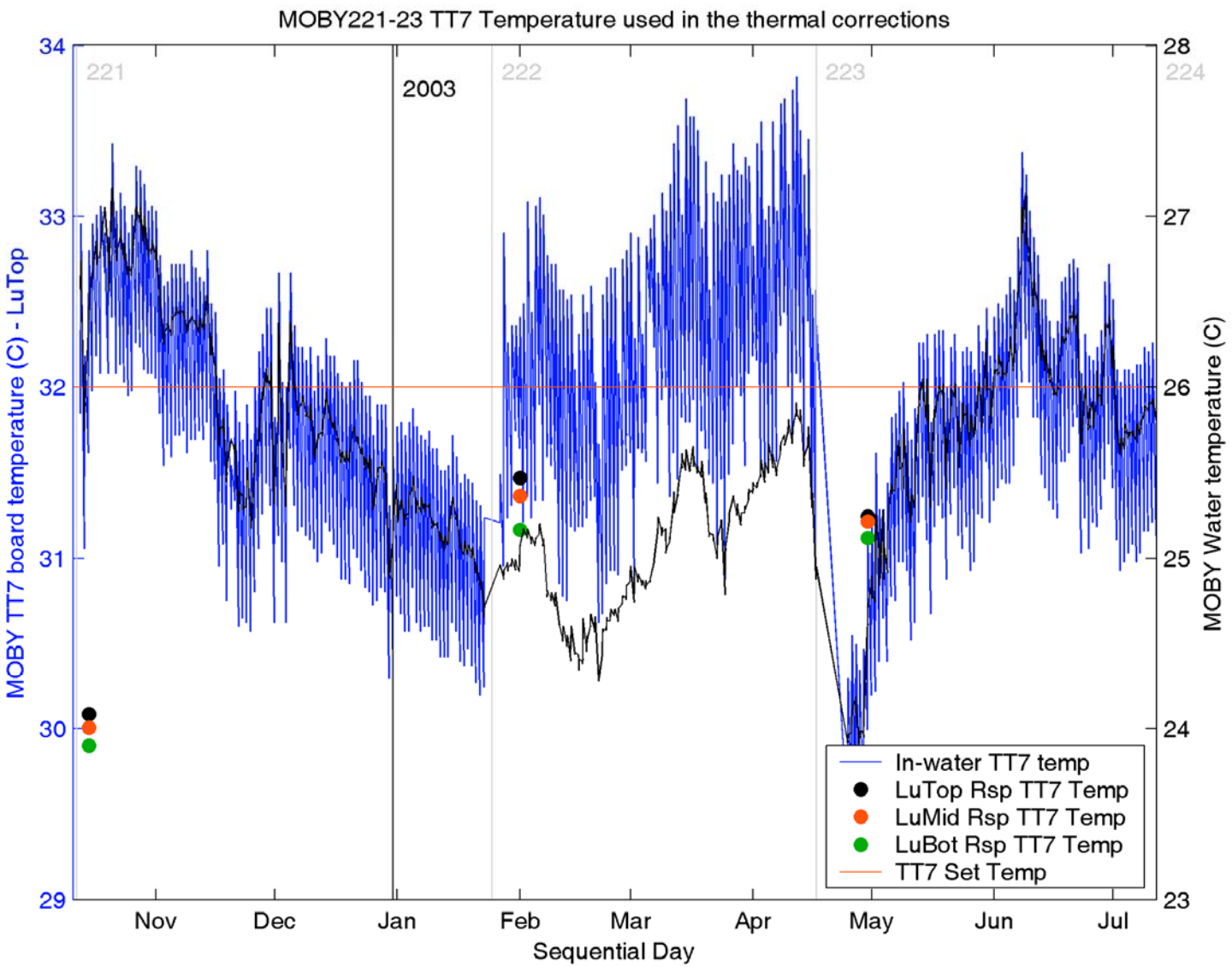
System Responses - The pre and post radiometric and wavelength calibrations are being recomputed with new stray-light and thermal corrections. The average of the pre and post calibrations will applied as the final response functions.

Quality Control - Changed to Mueller pure water Kl's and added a flag for questionable data.

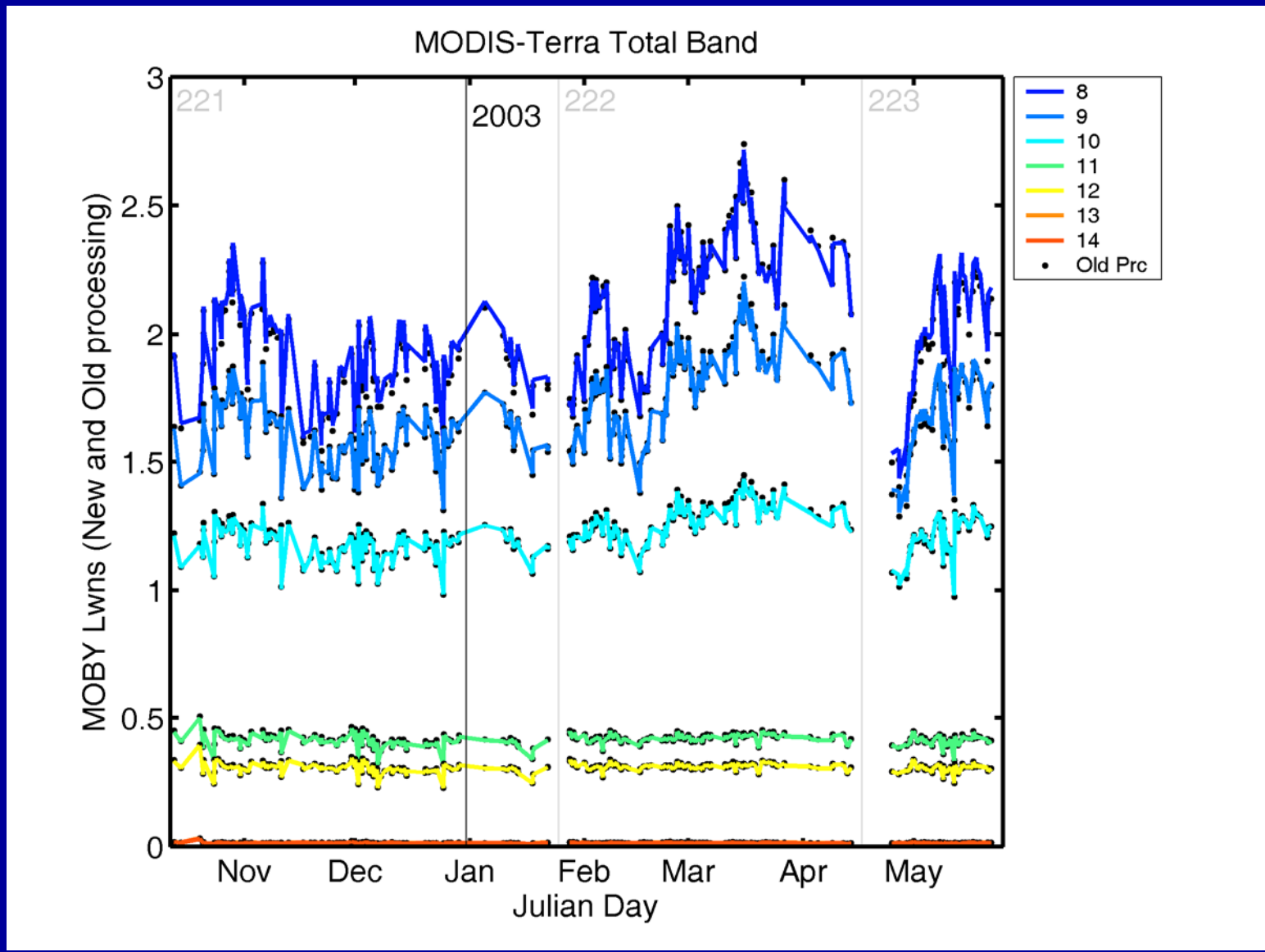
Initial Test Results: MOBY Reprocessing



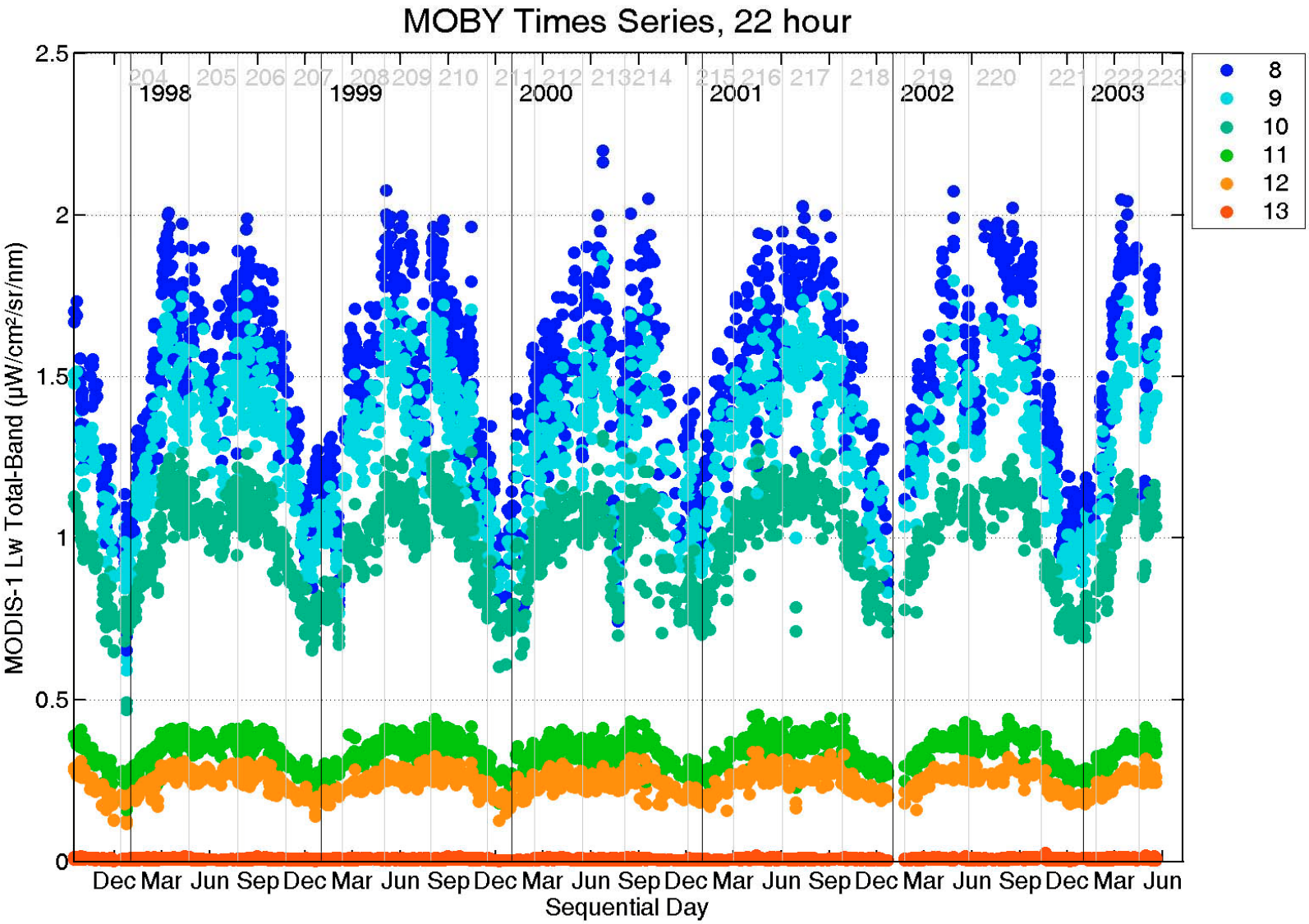
Thermal Corrections



Initial Results: MOBY Reprocessed Lwn



MOBY Lw Time-Series MODIS Terra



Work In Progress - Reprocessing 3 Potential

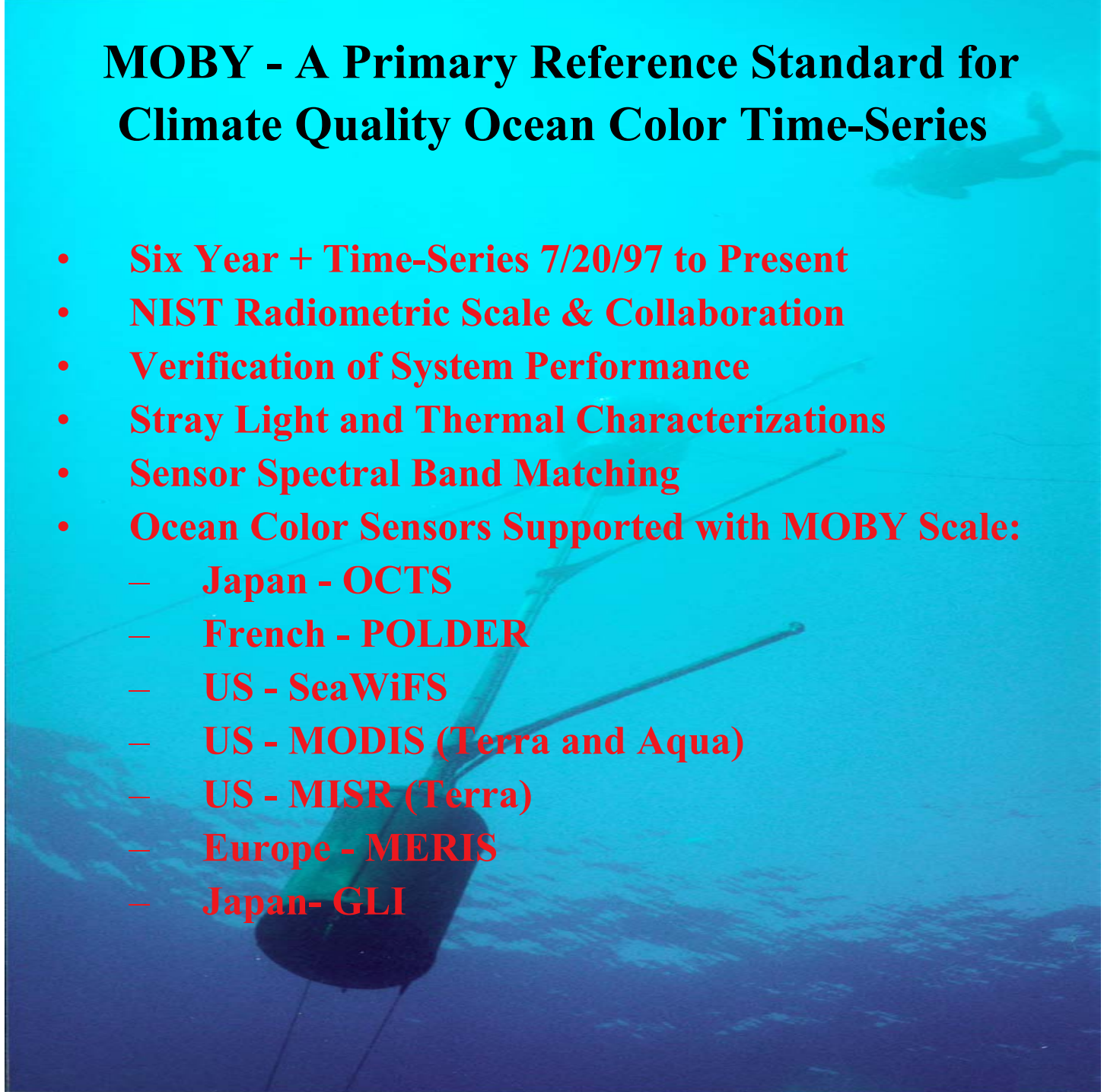
Apply Mueller Shadowing Model Corrections

Improve NIR Lw Computations

Improve UV System Responses with Blue LED Calibration Sources

Reduce Calibration System Uncertainty with NIST SLM's & VXR MOBY Time Series

MOBY - A Primary Reference Standard for Climate Quality Ocean Color Time-Series

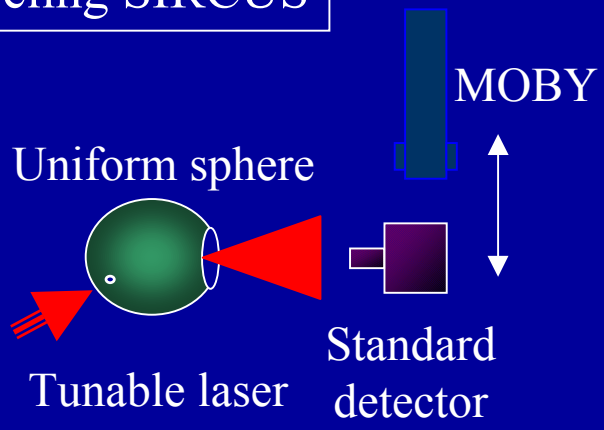


- Six Year + Time-Series 7/20/97 to Present
- NIST Radiometric Scale & Collaboration
- Verification of System Performance
- Stray Light and Thermal Characterizations
- Sensor Spectral Band Matching
- Ocean Color Sensors Supported with MOBY Scale:
  - Japan - OCTS
  - French - POLDER
  - US - SeaWiFS
  - US - MODIS (Terra and Aqua)
  - US - MISR (Terra)
  - Europe - MERIS
  - Japan- GLI

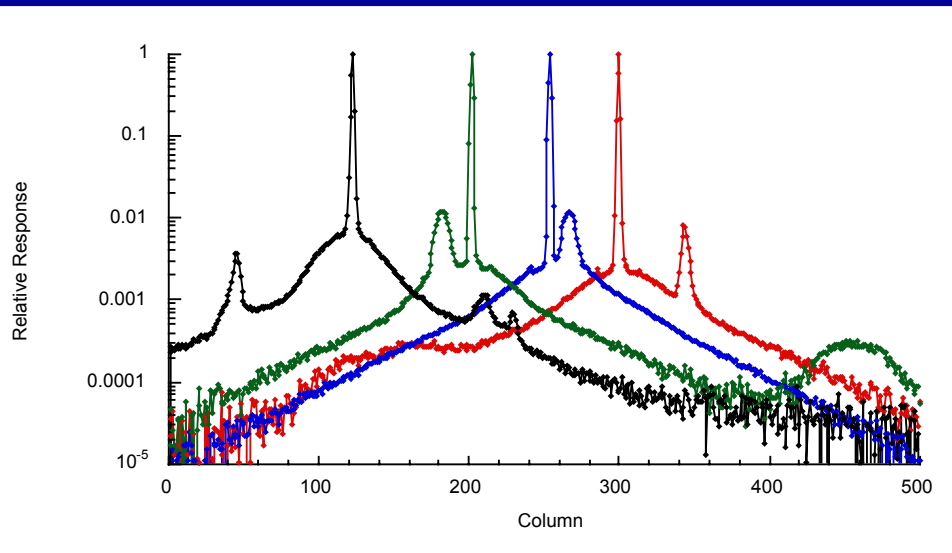
Ancillary slides

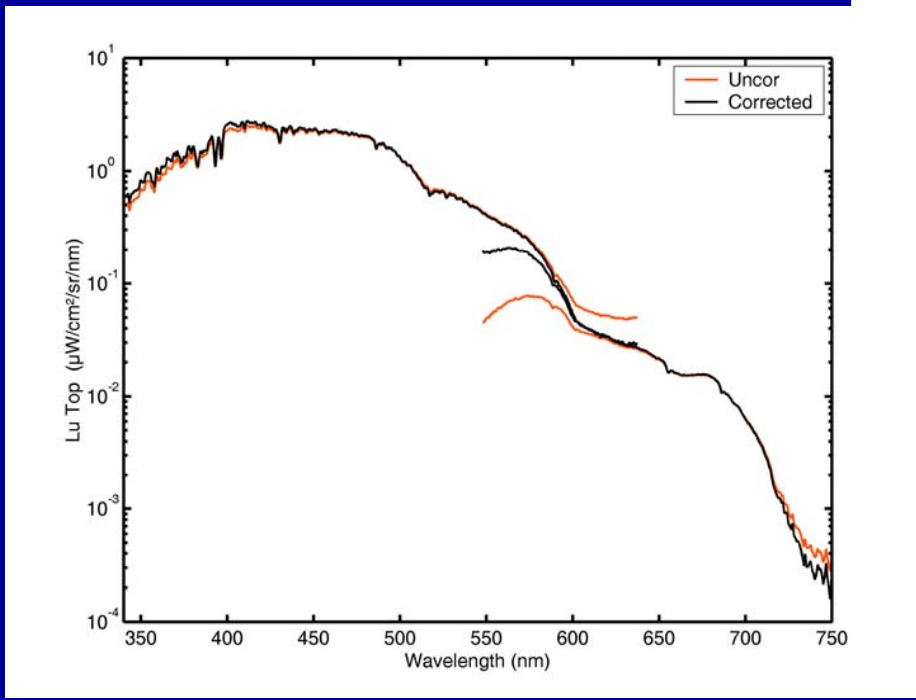
Stray Light & MOBY

Traveling SIRCUS



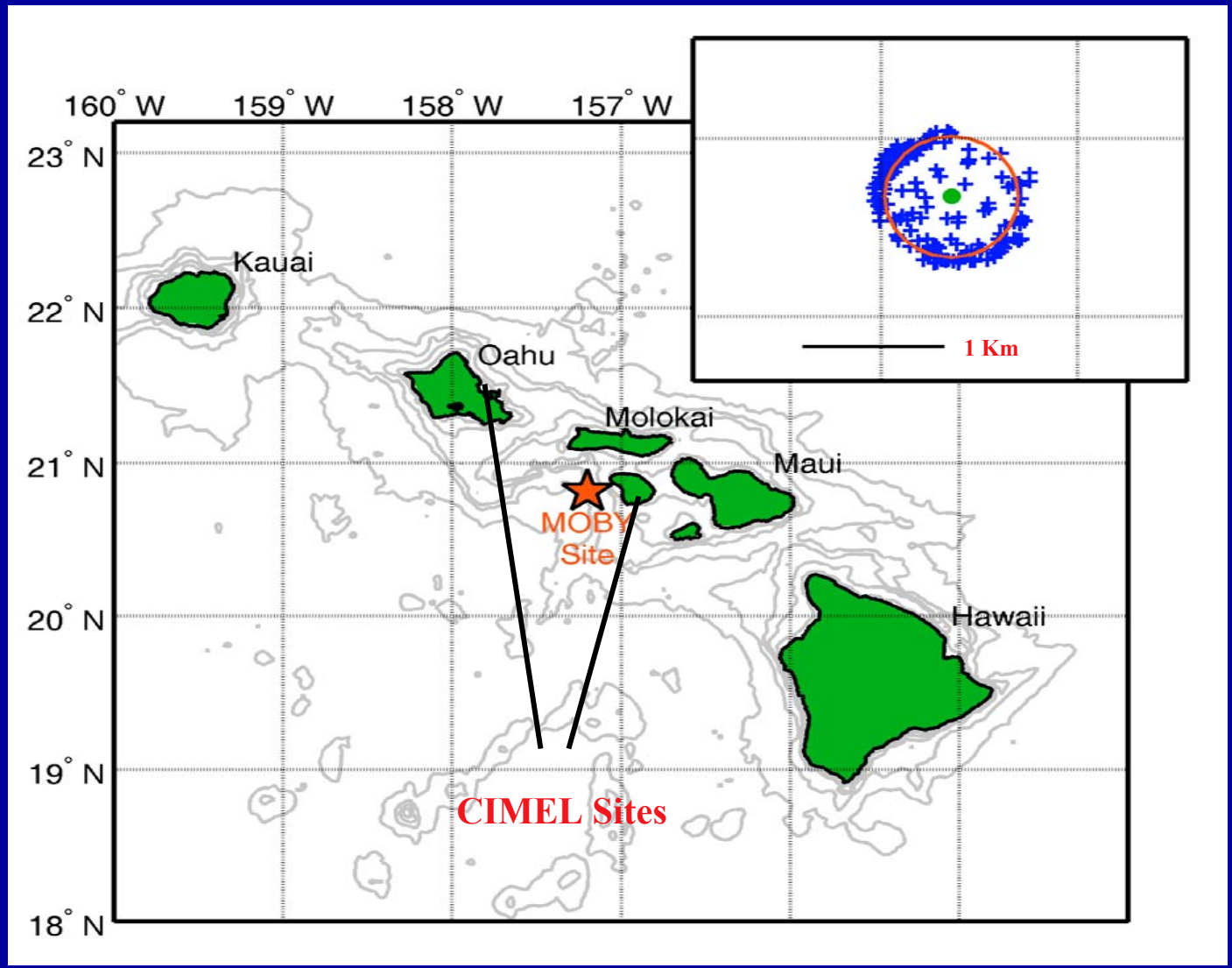
Response found at many wavelengths





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

Site Location & Watch Circle



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