Seasonal to Interannual Variability in Phytoplankton Biomass and Diversity on the New England Shelf:
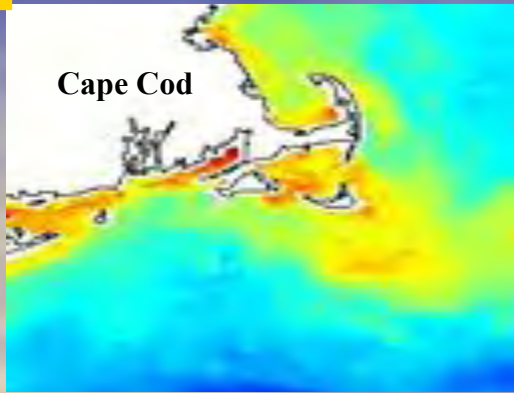## In Situ Time Series for Validation and Exploration of Remote Sensing Algorithms

(The proposal submitted to NASA ROSES (NNH09ZDA001N-TERRAQUA;   recently awarded)

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the MODIS Science Team Meeting, Adelphi, MD (May 18-20, 2011)

Cape Cod

- New England shelf
- Time series approach
- Leverage existing observing assets
  - Martha's Vineyard Coastal Observatory (MVCO – cabled facility)
  - AERONET-OC (i.e. SeaPRISM) for sea surface radiometry (Lwn, aot)
  - In situ flow cytometry to characterize phytoplankton communities
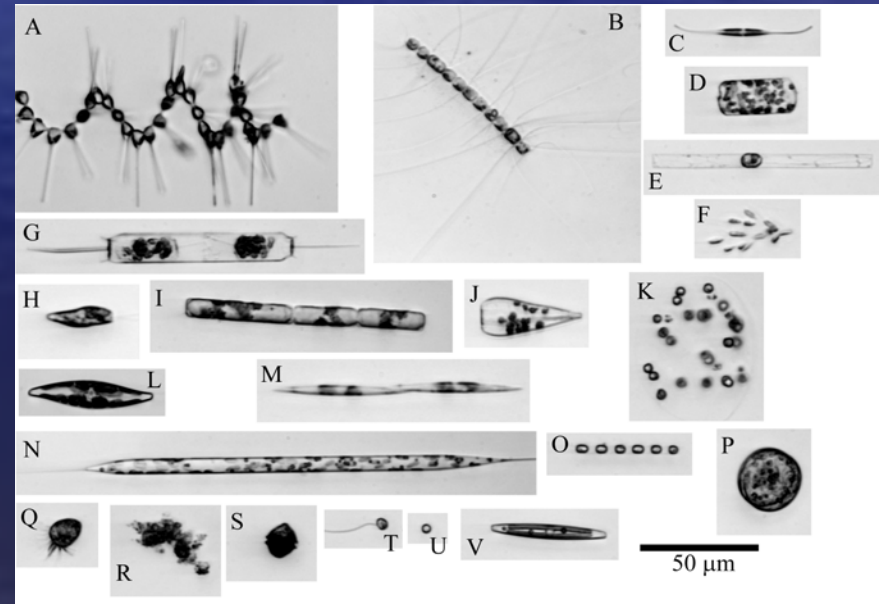

AERONET-OC: nLw(λ), AOT(λ)

Automated submersible flow cytometry

The study site presents important Opportunities and Challenges

- Predictable seasonal switch in phytoplankton dominance
  - large diatoms in winter
  - small cells in summer

- Phytoplankton community changes impact bulk optical properties ((discrete samples)
  - Seasonality strong
  - Interannual variability also evident

- MODIS products influenced by atmospheric correction and other potential issues
  - Well-known for northeast US waters
  - Unique dataset to evaluate new approaches
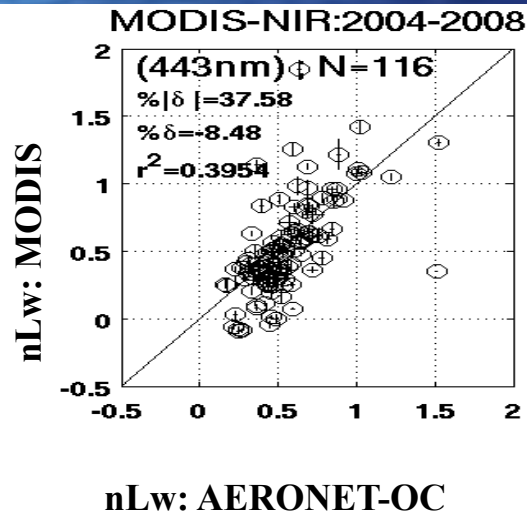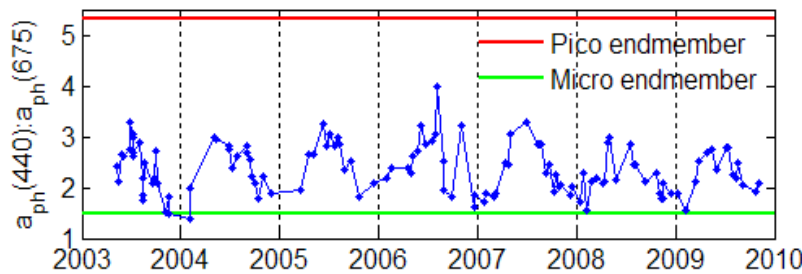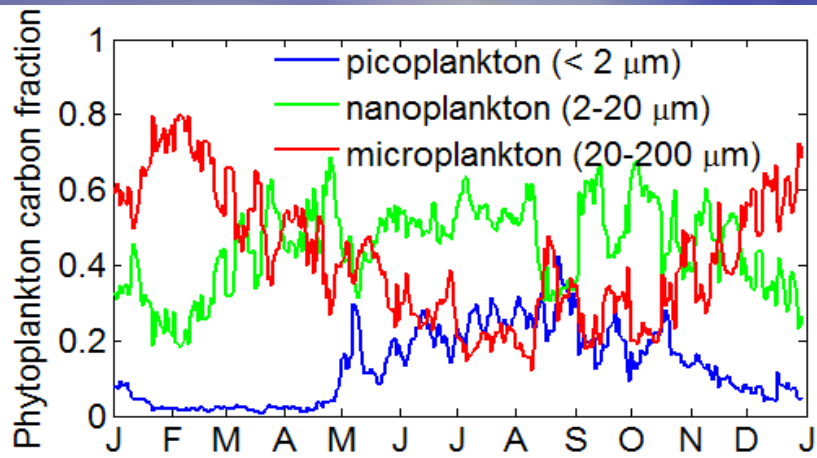
Objectives

- Extend/analyze the existing phytoplankton community time series at MVCO with focus on resolving seasonal to interannual patterns and modes of variability;

- **Extend/analyze the existing AERONET-OC times series at MVCO for coastal ocean color validation for expanded understanding of uncertainty sources for satellite ocean color retrievals (on going; more today) ;**

- Explore (and possibly adapt) published approaches to retrieve phytoplankton functional groups and/or size classes from AERONET-OC / MODIS water-leaving radiances on the basis of comparison with the in situ time series;

- Develop approaches and criteria for extending the spatial / temporal foot print of phytoplankton community characteristics in using MODIS products (existing and exploratory) to beyond the locations of detailed in situ measurements (e.g., MVCO).

Validation of MODIS ocean color and aerosol retrievals in the northeastern US coast using AERONET-OC:

On-going activities

Objectives

- Establish a high-quality observational time series dedicated to satellite ocean color product validation at a NW Atlantic coastal site (MVCO)

- Quantify major uncertainty sources in ocean color retrievals, and understand temporal and spatial variability of these uncertainties

- Examine coastal validation (and/or calibration) approaches

- Explore improvement of satellite ocean color atmospheric correction in coastal waters

AERONET measurement sites along the US NE coastal region
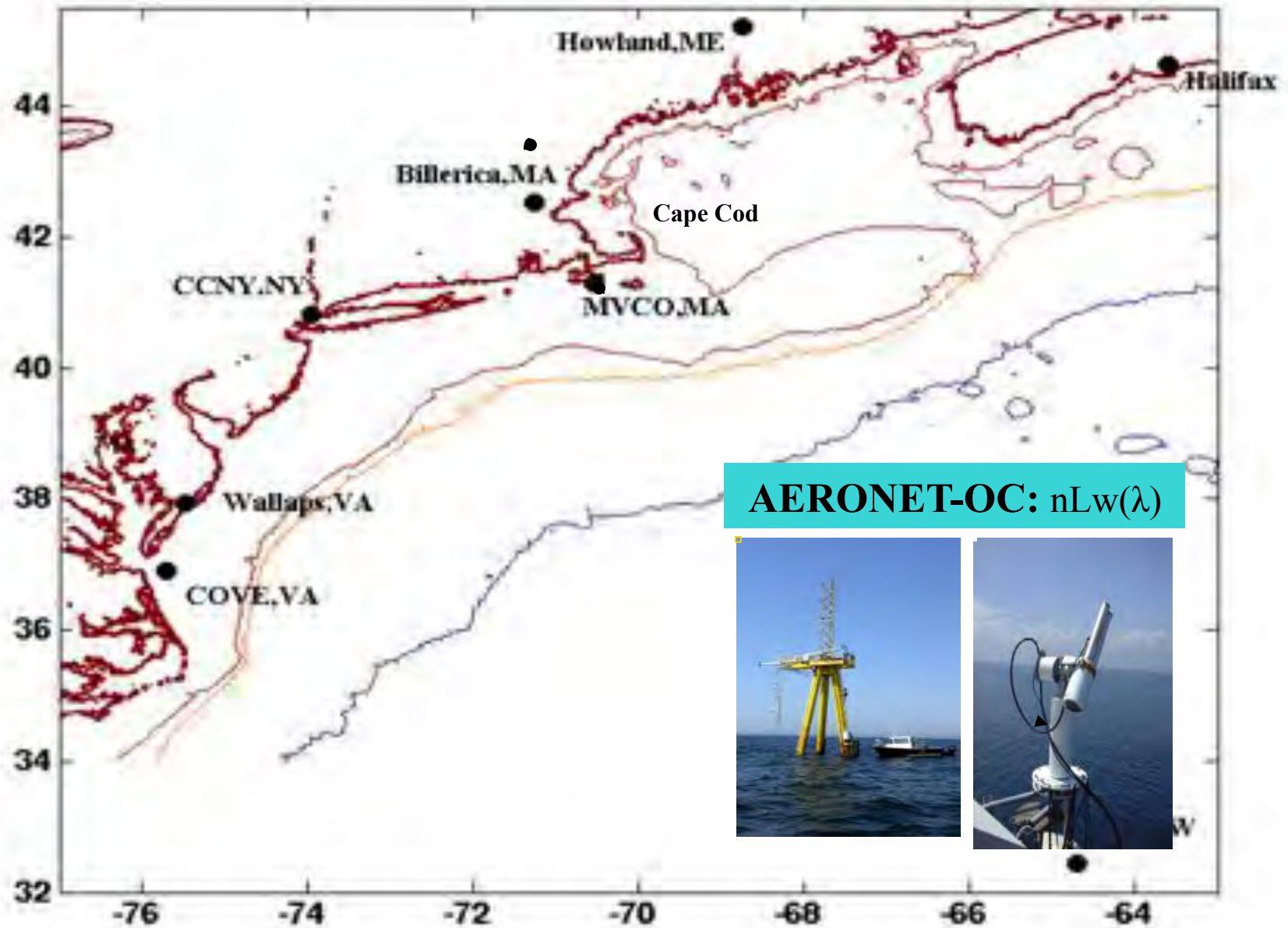
MVCO AERONET-OC Observations

- 2004-present (the 1st deployment in the US coast)
- Spectral Channels:

AERONET-OC (i.e. SeaPRISM)			MODIS-aqua	
2004-2005	2006	2007-	Version 5	Version 6 Reprocessing 2009
412nm	412nm	412nm	412nm	412nm
439nm	442nm	442nm	443nm	443nm
500nm	490nm	490nm	488nm	488nm
		532nm	531nm	531nm
555nm	555nm	555nm	551nm	547nm
674nm	668nm	668nm	667nm	667nm
			748nm	748nm
870nm	870nm	870nm	869nm	869nm

- Operations by UNH/WHOI

nLw(412) underestimated

τ_a(870) overestimated

Angstrom underestimated
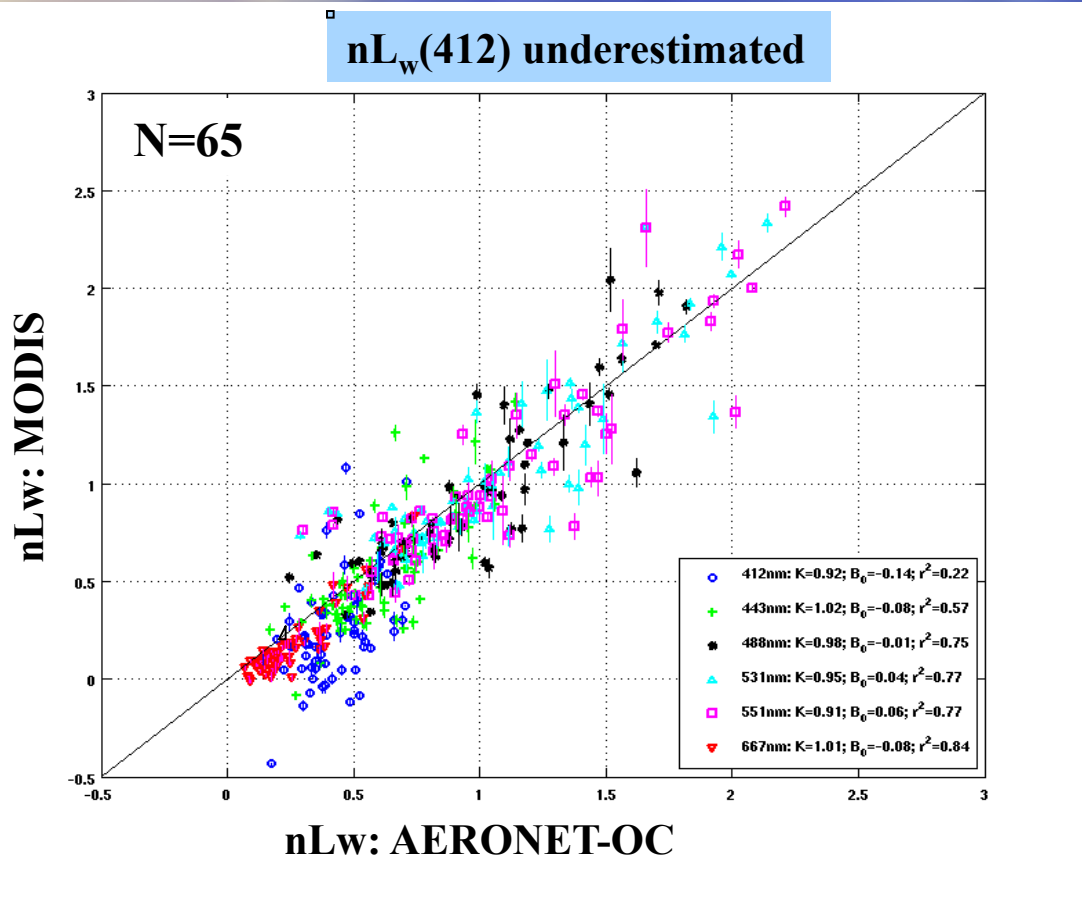
2004-2005 AERONET-OC observations
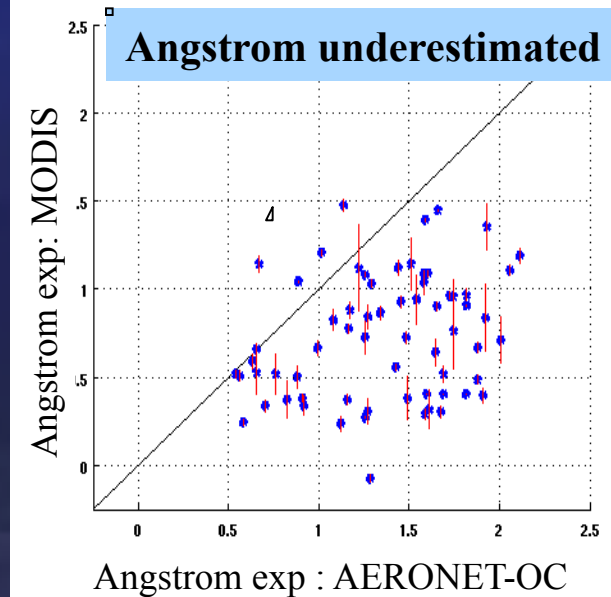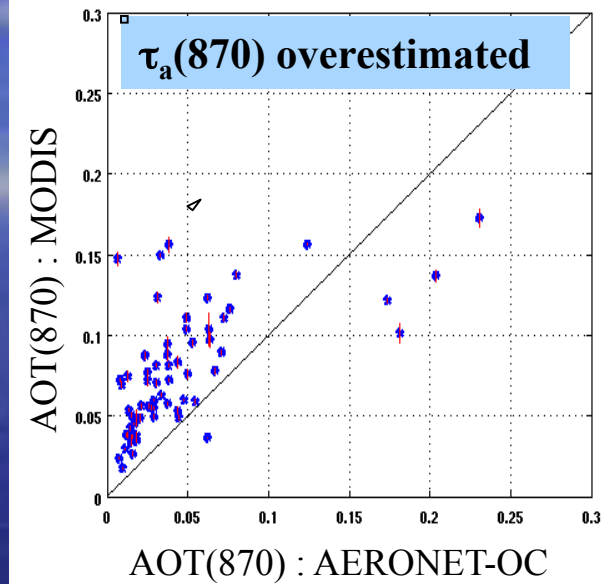
MODIS-Aqua Version 5 validation summary

#1: MODIS- nLw @488, 531, and 551nm performs well.

#2: MODIS-AOT(870) is overestimated systematically
MODIS-Angstrum Exp is underestimated significantly,

?

#3: MODIS $nL_w(412)$ and $nL_w(443)$ is under-estimated significantly with 15-20% negative values

Motivations

A) Is there a linkage between #2 and #3 ?.

B) Is there any inprovement in MODIS Version 6 (Reprocessing 2009) ?

Major changes in Atmosperic Correction Approach
SeaDAS Version 5 vs. SeaDAS Version 6

Version 5: **12** candidate aerosol models (Gordon and Wang, 1994) were used for AC lookup tables: As shown, these models not adequately represent observed aerosal properties

Version 6 (reprocessing 2009):

- **80** new aerosol models are now used in terms of observations of aerosol size distributions and single scattering albedos from various AERONET coastal and island sites (Ahmad et al., 2010).
- In-water IOP models in NIRs are modified (Bailey et al, 2010)
- New Vicarious calibratin coefficients

Validation of oean color nLw

MODIS-V5/MODIS-V6

vs.

AERONET-OC

(2004-2009 AERONET-OC observations)
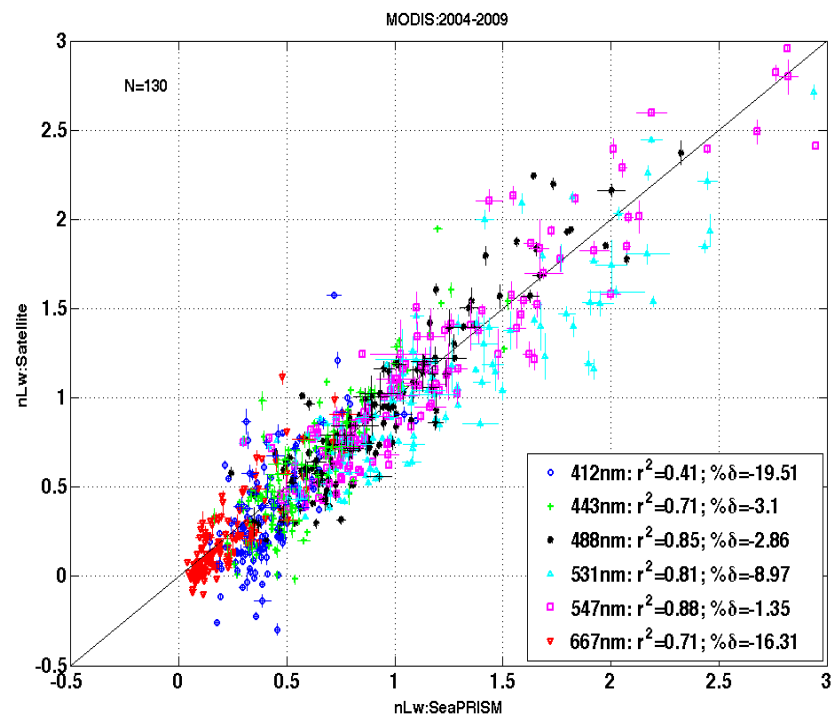
MVCO Matchup Mean nLw spectra
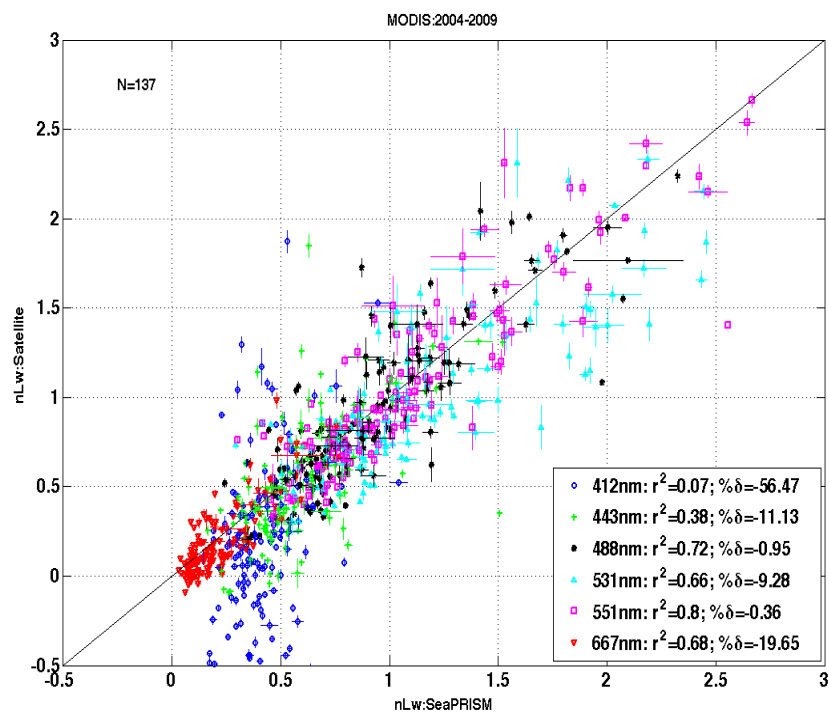
MODIS-Aqua Version 5

MODIS-Aqua Version 6
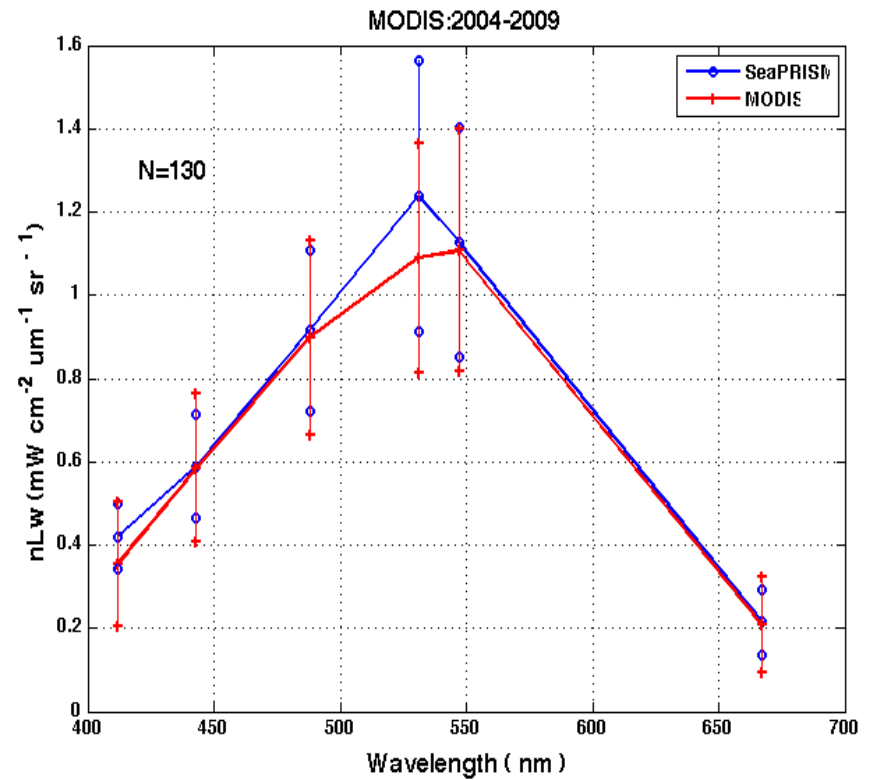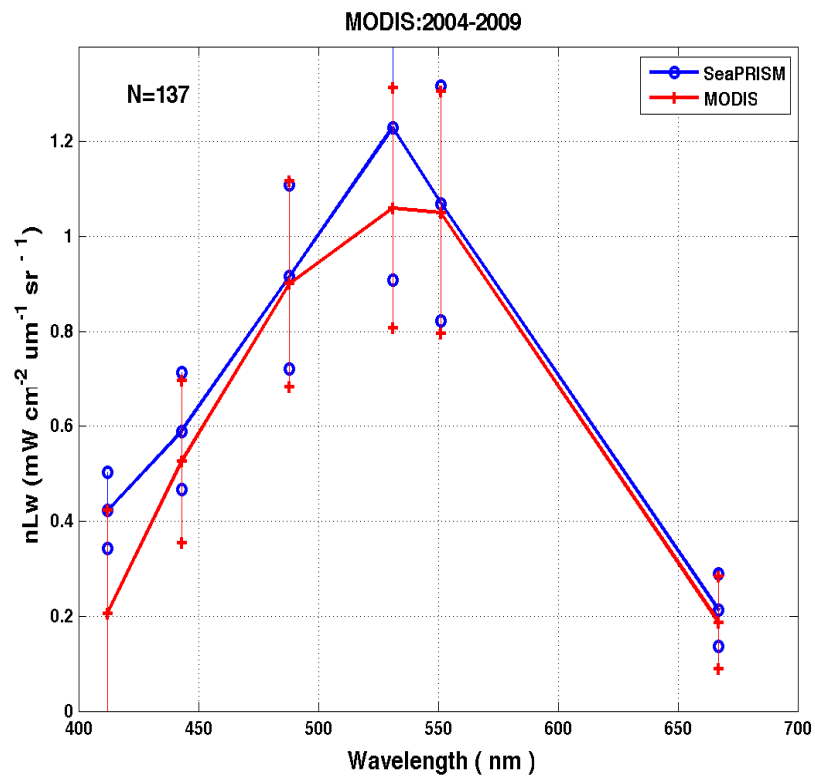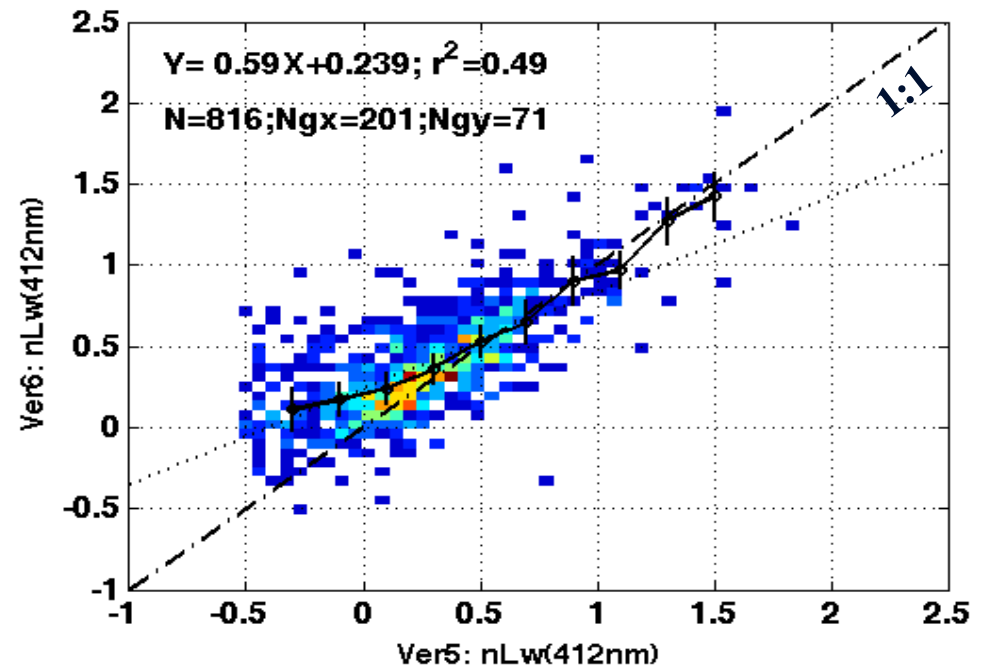
Scatterplot of Matchups in nLw spectra

MODIS-Aqua Version 5
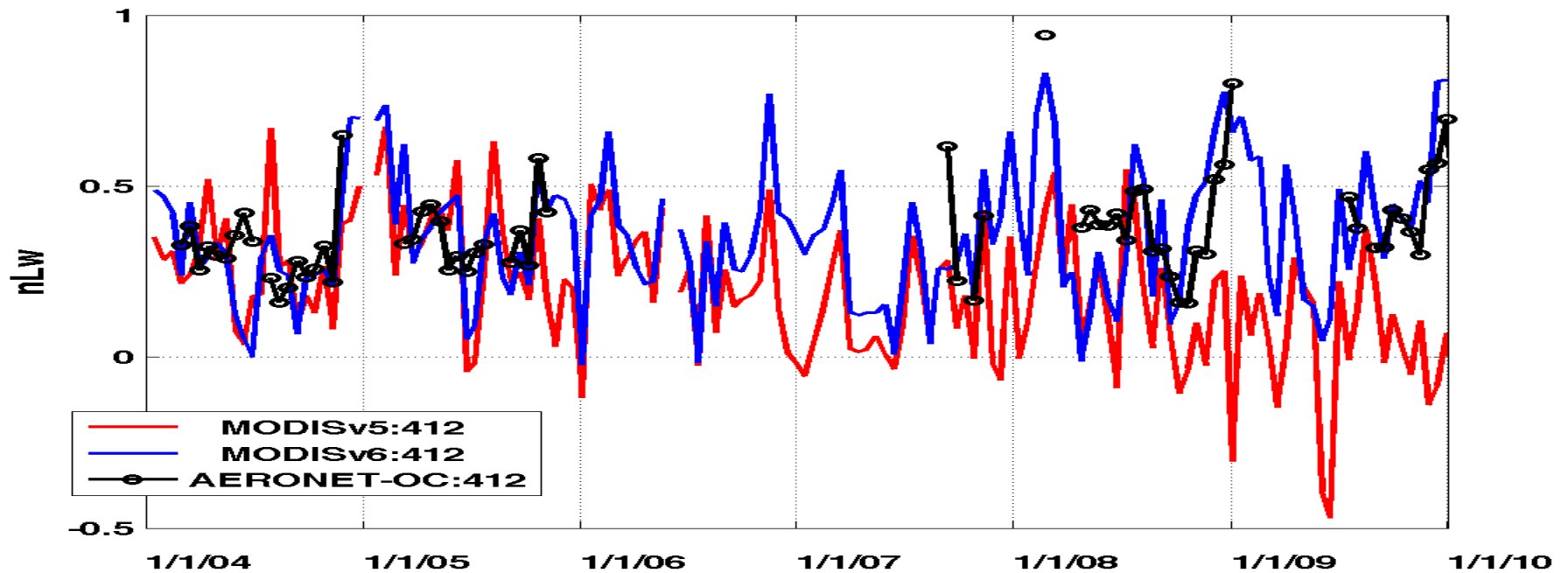
MODIS-Aqua Version 6
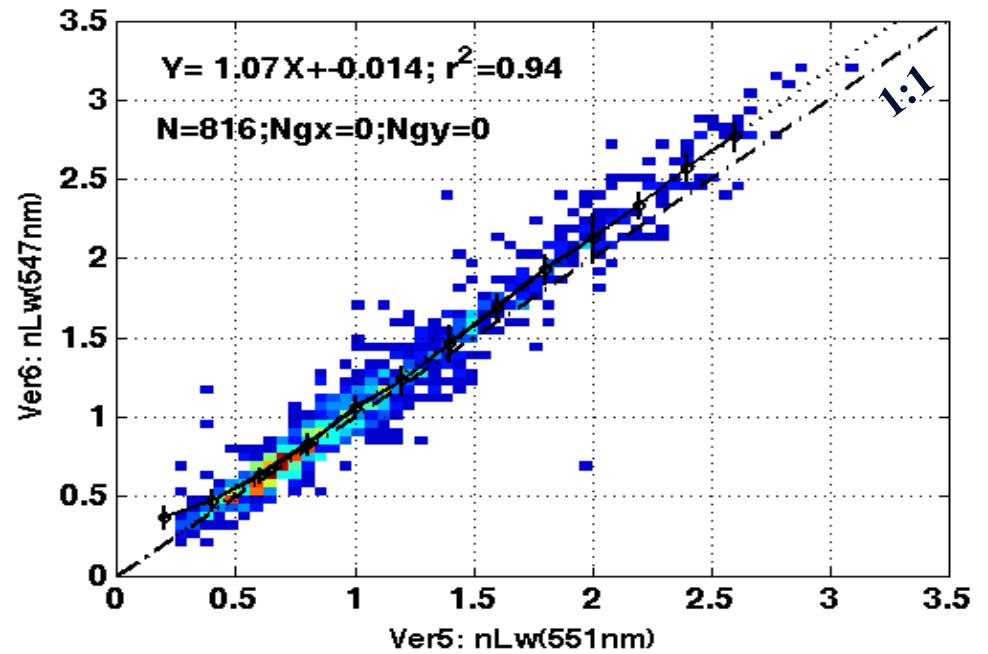## (Reprocessing 2009)

nLw-412m

MODISv5/v6
vs.
AERONET-OC

Y= 0.59 X+0.239; r^2=0.49

N=816; Ngx=201; Ngy=71

15-day bin averaged

MODISv5:412
MODISv6:412
AERONET-OC:412

nLw-551nm

MODISv5/v6
vs.
AERONET-OC

Y= 1.07X+-0.014; r² =0.94

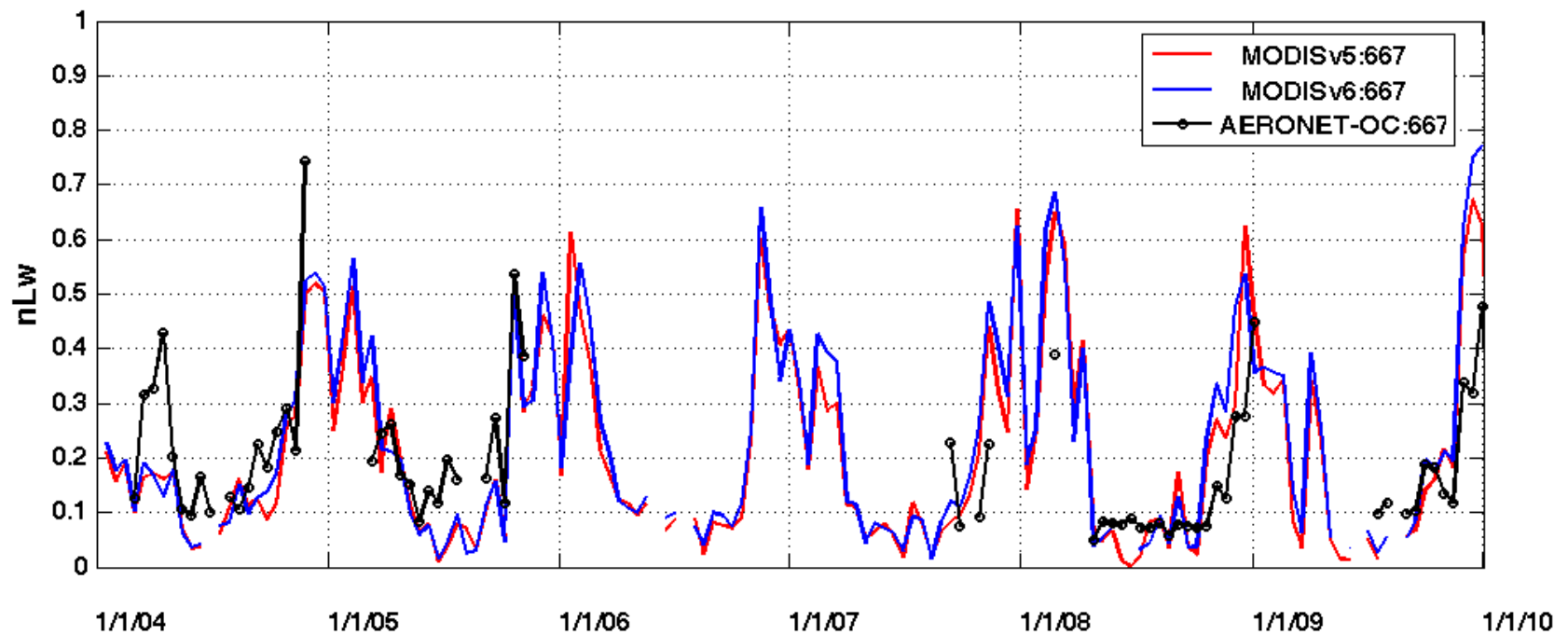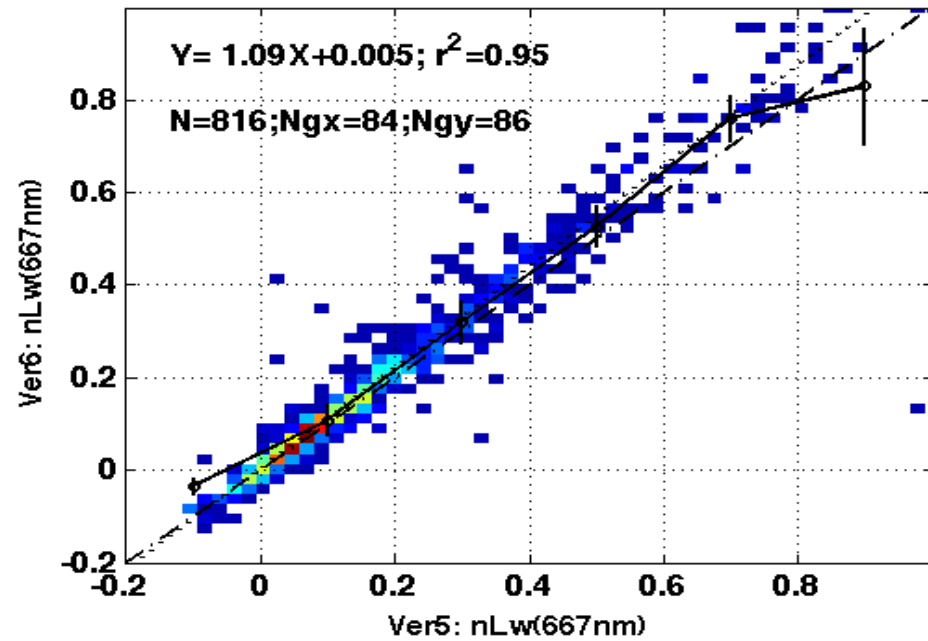N=816;Ngx=0;Ngy=0

15-day bin averaged
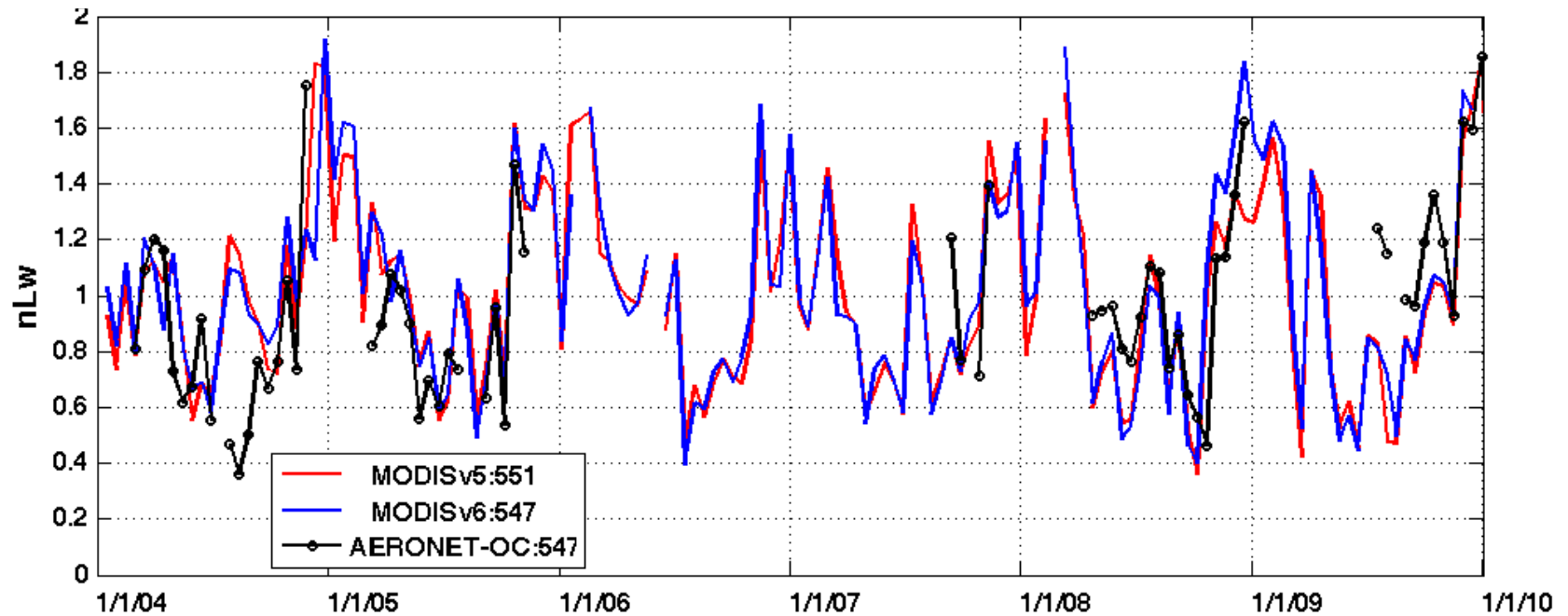
nLw-667nm

MODIS v5/v6
vs.
AERONET-OC

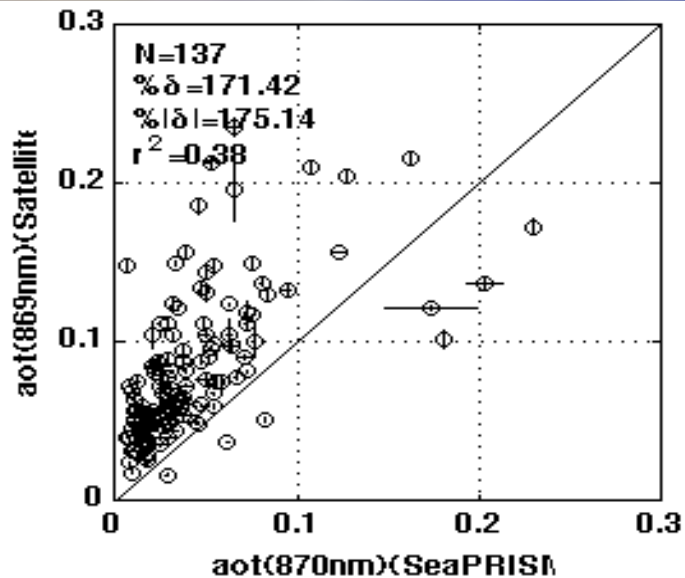# Validation of aerosol properties

MODIS-V5 and MODIS-V6
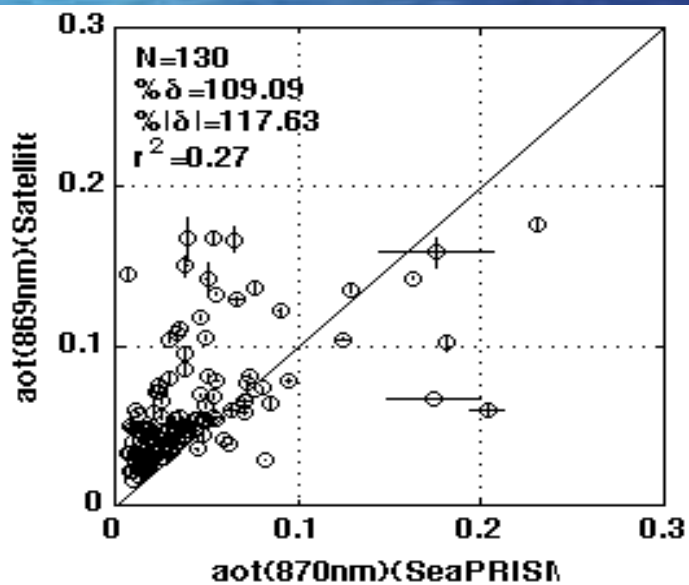
vs.

AERONET-OC
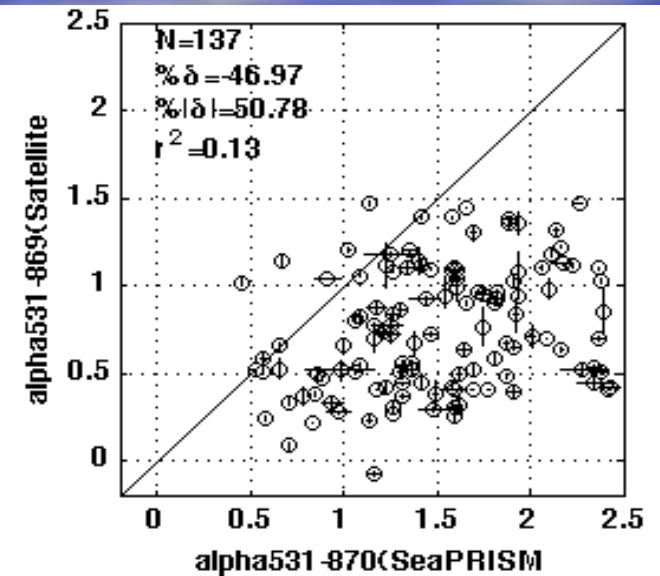
(2004-2009 AERONET-OC observations)

Scatterplot of Matchups

AOT(869)

Angs Exp(531,869)

MODIS-V5
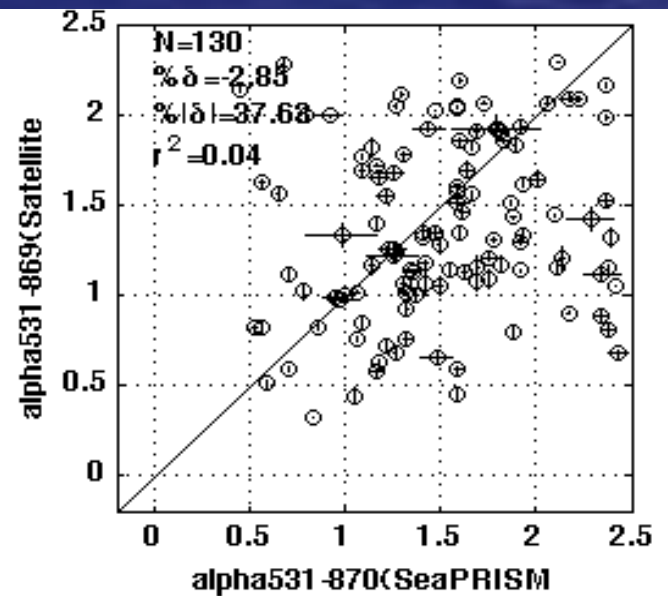
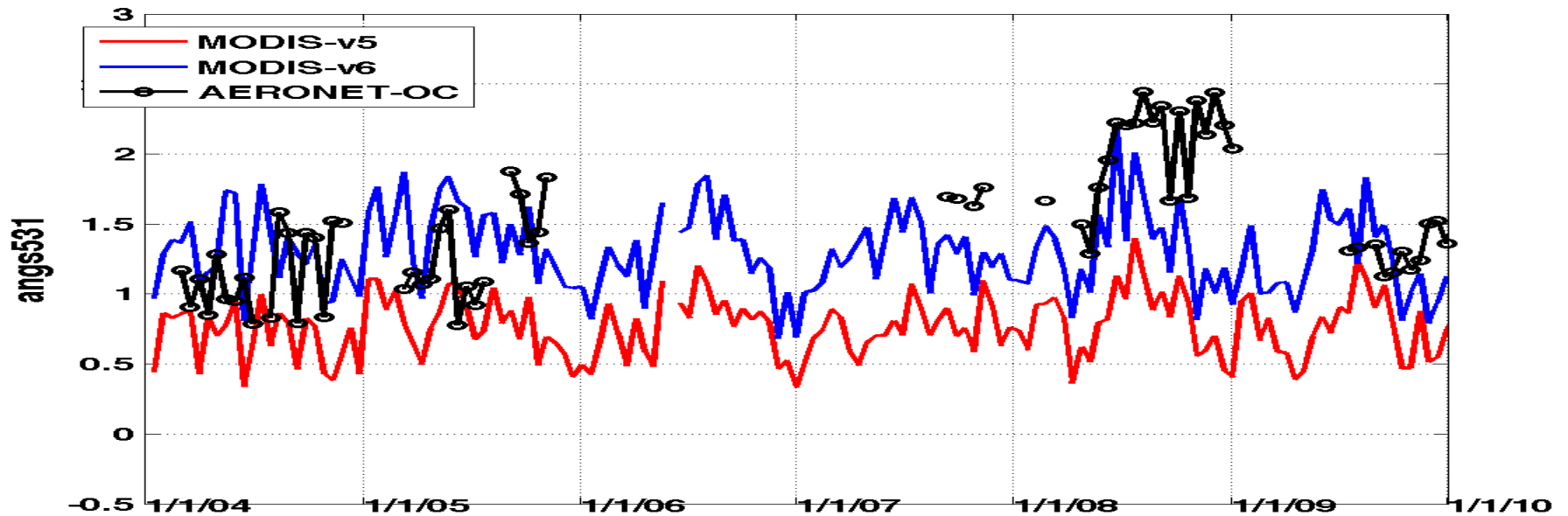**MODIS-V6**

Angstrum Exp (531,869)

MODIS v5/v6
vs.
AERONET-OC

Y= 0.63X+0.821; r^2=0.33

N=816;Ngx=8;Ngy=4
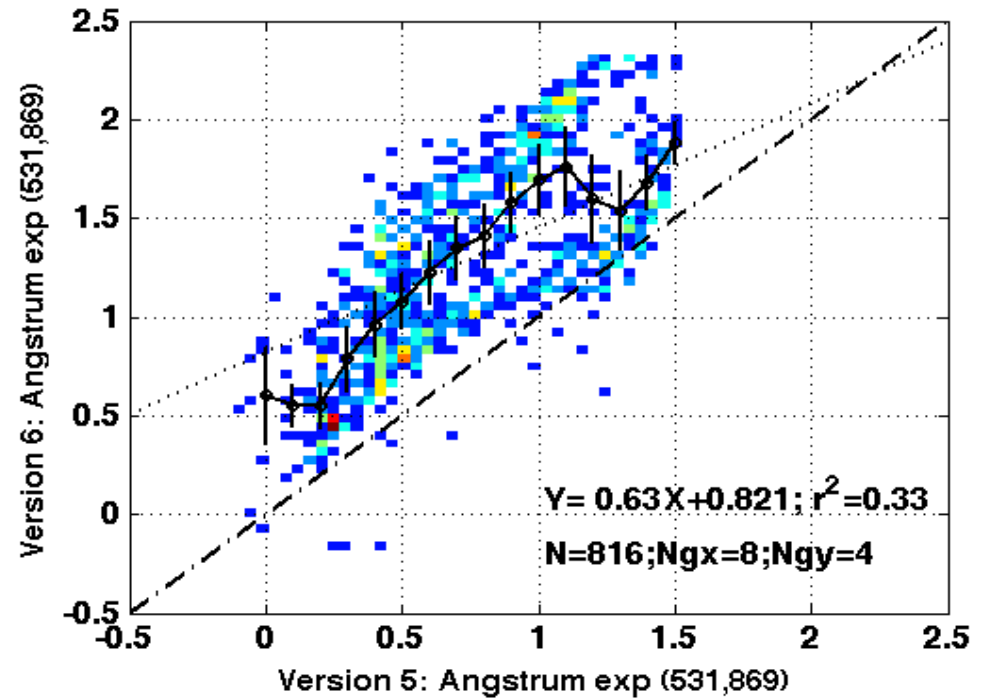
AOT(869)

MODIS v5/v6
vs.
AERONET-OC
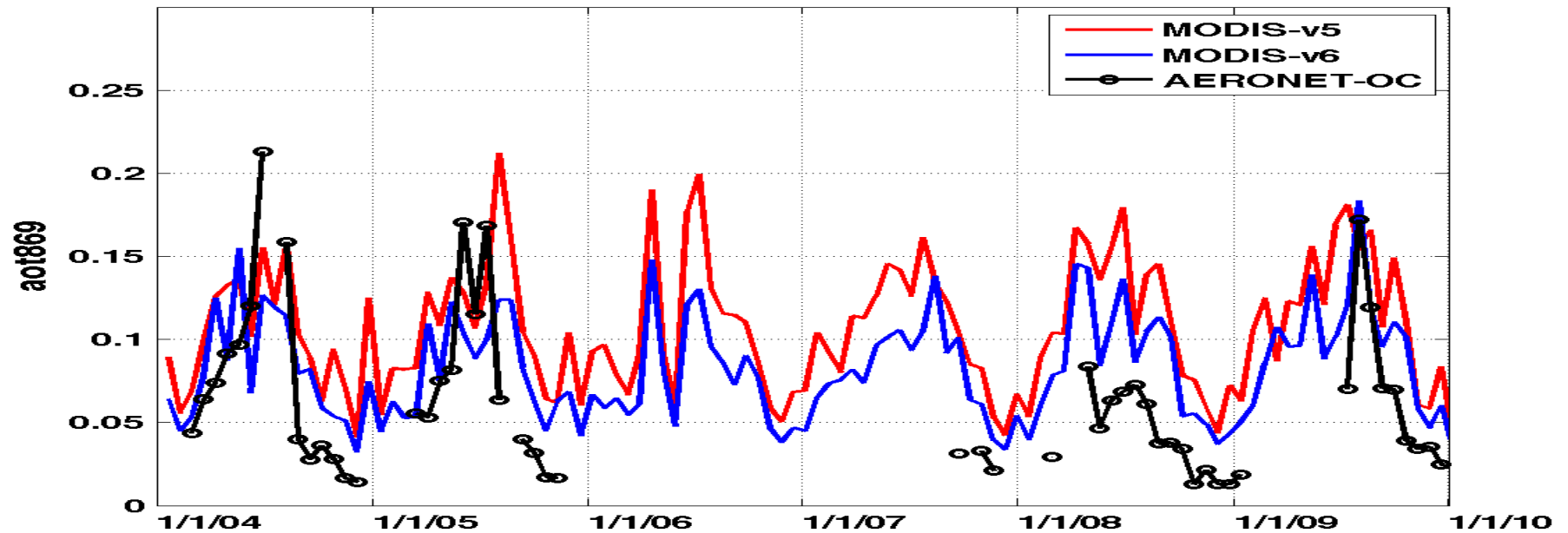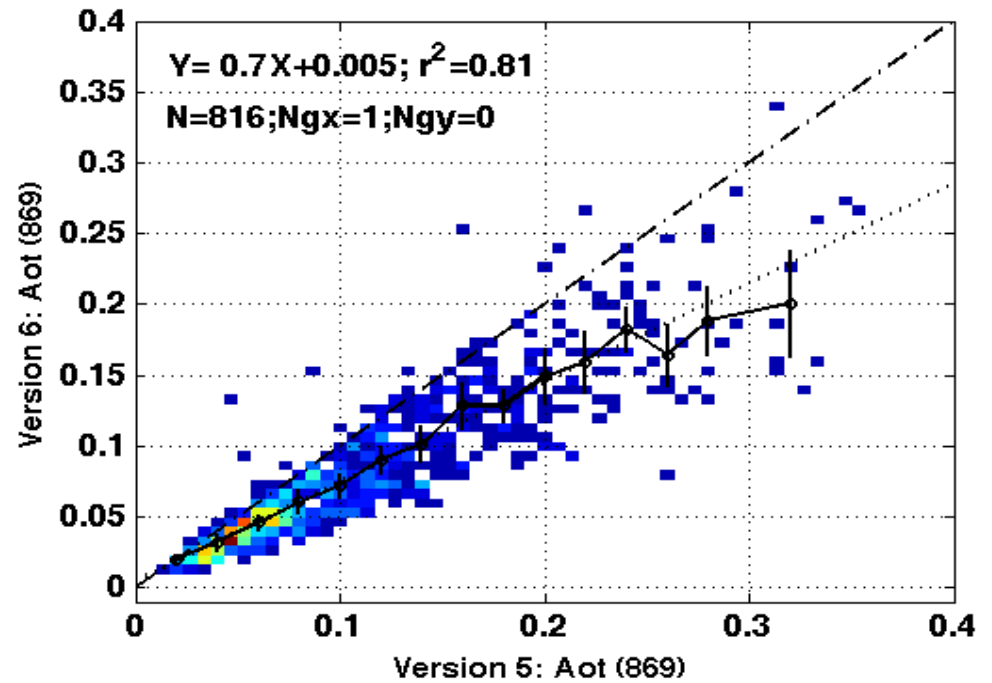
Summary

- The AERONET-OC deployed at MVCO has provided a valuable long time series for coastal ocean color validation efforts.

- The Validation of the MODIS-Aqua ocean color products of Version 5 and Version 6 (reprocessing 2009) in MVCO shows that the MODIS V6 products gives a significant improvement over the Verson 5 ones. Specifically:

  - MODIS-retrieved aerosol propereties, i.e. Angstrum exponent (531,869) and AOT at 869nm, agree with AERONET measurements better in V6 than in V5

  - MODIS-retrieved nLw(412) is significantly improved in terms of
    - that the number of negative values decreases
    - that the mean mode of nLw(412) increases
    - that nLw(412) matches to measurements better

Future Work

- Keep it in a stable/normal operational mode,

- Extend the validation effort to inter-satellite ocean color products from MODIS, SeaWiFS, VIIRS…

- Explore the optimal atmosperic correction and the site vicarious calibration potential to minimize bias and uncertainties,

- Explore approaches to retrieve phytoplankton functional groups and/or size classes from AERONET-OC/Satellite nLw on the basis of comparison with the in situ time series

Acknowledgements

- the UNH/NOAA Center for Coastal Ocean Observation and Analysis (COOA).

- NASA's Science Directorate
  - Ocean Biology Biogeochemistry program
  - New Investigator program
  - AquaTerro team project (newly funded)

- WHOI -MVCO tower operation team

- Data
  - NASA DAAC for MODIS-Aqua data

Thank you