Spatial and Temporal Uncertainty of satellite ocean color : Real time Satellite and Aeronet _OC Matchup

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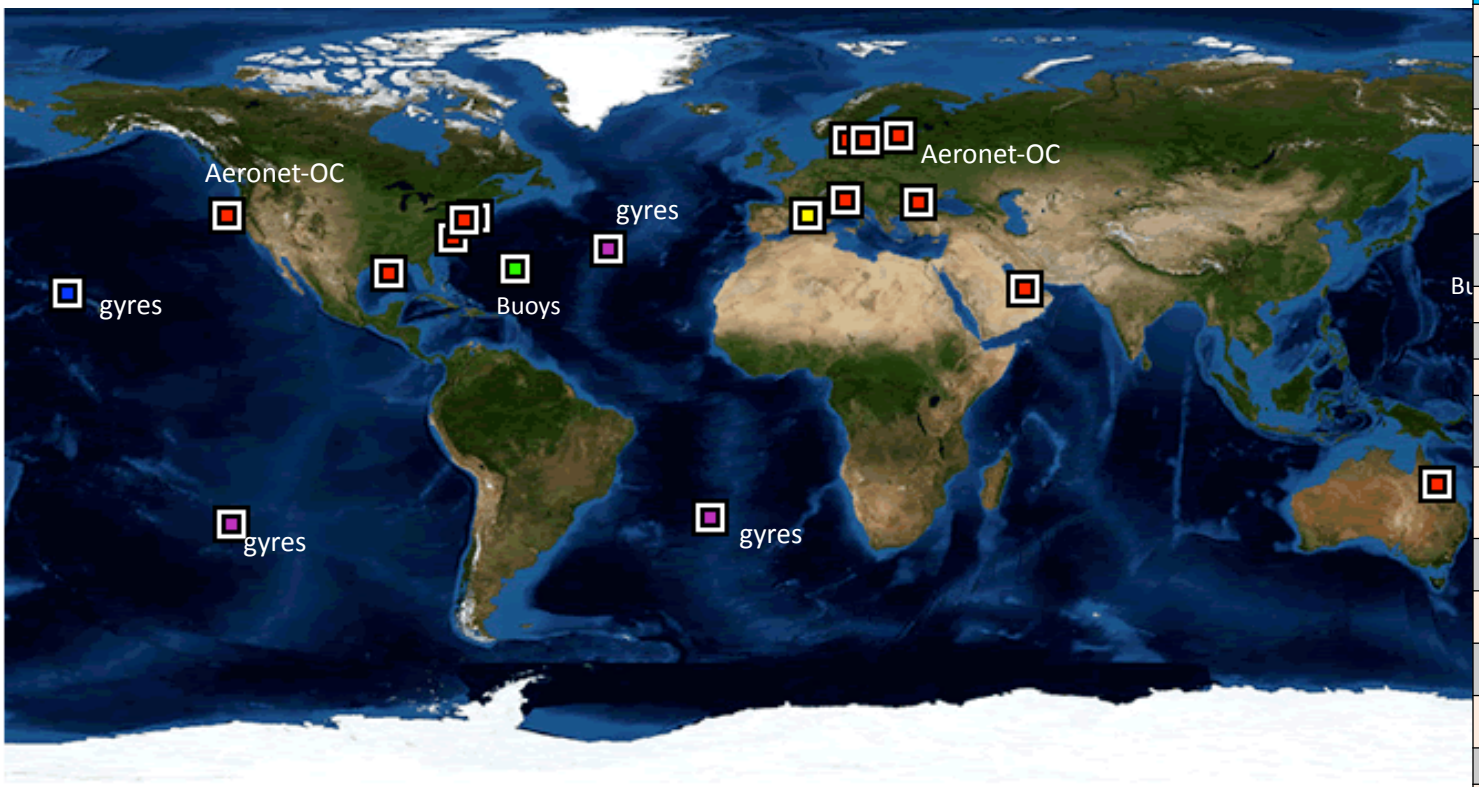
Aeronet – site Stakeholders

Global Network Monitoring Satellite products
"Real time monitoring capability"



Real time Observations
Real time Satellite products

MODIS, MERIS, Proxy NPP

Product evaluation
Tracking Algorithm
Stability &Satellite calibration

Product Uncertainty

Golden regions		
	Areas	**Data**
1	Long Island	Aeronet
2	Venice	Aeronet
3	MVCO	Aeronet
4	WaveCIS (Gulf)	Aeronet
5	Lucinda	Aeronet
6	COVE (Chesapeake)	Aeronet
7	Gustav_Dalen	Aeronet
8	Helsinki	Aeronet
9	Gloria	Aeronet
10	MOBY - Buoy	cal val Mooring
11	Boussole Buoy france	cal val Mooring
12	South pacific	Gyre
13	North Pacific	Gyre
14	North Atlantic	Gyre
15	South Atlantic G	Gyre
16	West Coast US - Aeronet	Aeronet
17	Abu_Al Bukhoosh	Aeronet
18	Palgrunden	Aeronet
19	HOTS	Time Series
20	BATS	Rime Series
21	CalCOFI	Time Series

Data access underway

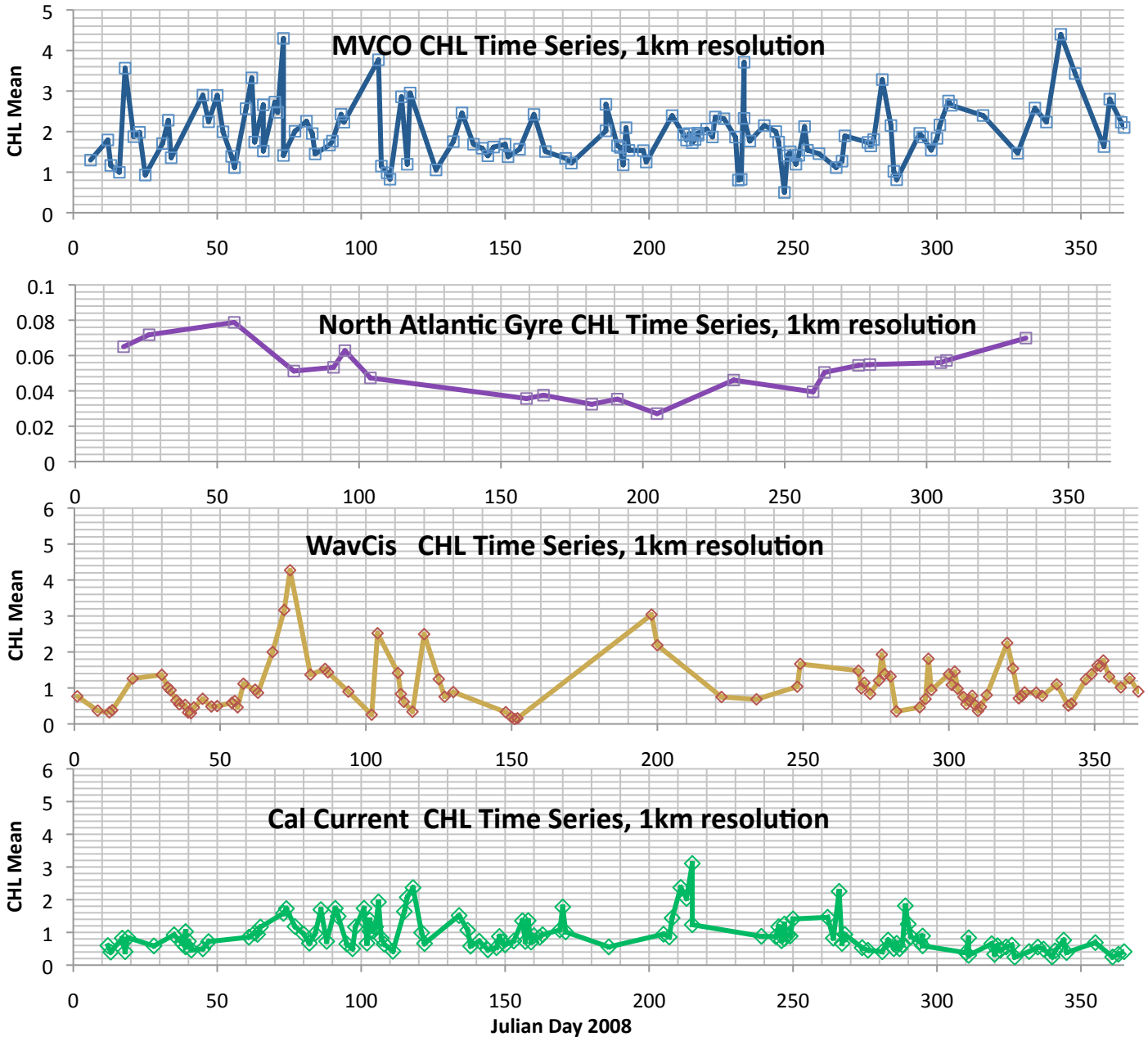
Status (Feb 17, 2011)

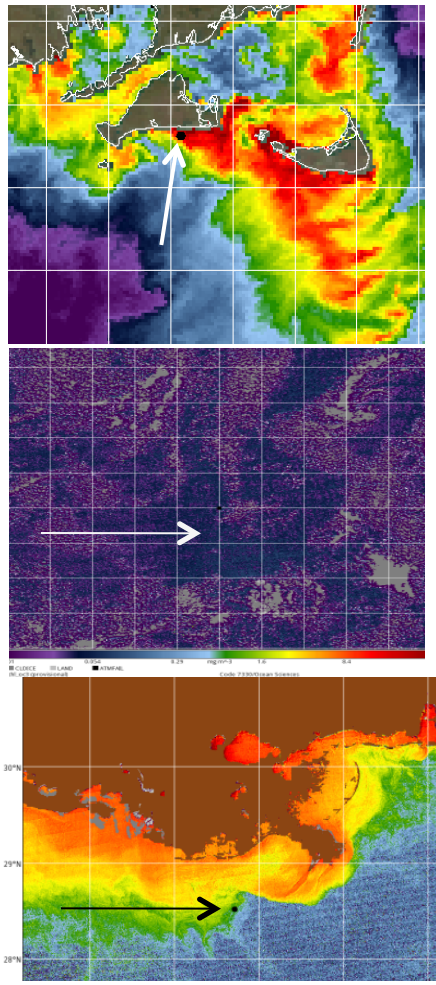
Back to Jan 2010

Golden Regions

	Areas	Data	Map	Lat/Lon (Rounded)	Date Online	SeaWiFS 1Km	MODIS 1km	MODIS 250m	MERIS 1km	MERIS 300m	NPP Proxy
1	Long Island Sound	AERONET_OC	MVCOX (MVX)	N/S 40; E/W -73	Jan 2010	X	x	X	X	X	X
2	Venice	AERONET_OC	AAOT (AOT)	N/S 45; E/W 12	Jan 2010	X	x	X	X	X	X
3	MVCO	AERONET_OC	MVCOX (MVX)	N/S 41; E/W -70	Jan 2010	X	x	X	X	X	X
4	Wave_CIS (Gulf)	AERONET_OC	WaveCIS (WCS)	N/S 29; E/W -90.5	Jan 2010	X	x	X	X	X	X
5	Lucinda	AERONET_OC	LucindaJetty (LJY)	N/S -18; E/W 146.4	Jan 2010	X	x	X	X	X	X
6	COVE (Chesapeake)	AERONET_OC	COVE (COV)	N/S 36.9; E/W -75.7	Jan 2010	X	x	X	X	X	X
7	Gustav_Dalen	AERONET_OC	GDAT (GDT)	N/S 58.6; E/W 17.5	Jan 2011	Na	x	X	X	X	X
8	Helsinki	AERONET_OC	Helsinki (HLH)	N/S 59.9; E/W 24.9	Jan 2011	Na	x	X	X	X	X
18	Gloria	AERONET_OC	Gloria (GAS)	N/S 29.36; E/W 44.6	Jan 2011	Na	x	X	X	X	X
9	MOBY - Buoy	Cal/Val Mooring	MOBY (M	N/S 20.5; E/W -157.19	Jan 2011	Na	x	X	X	X	X
17	Boussole Buoy	Cal/Val Mooring	Boussole Buoy (BOB)	N/S 42.37; E/W 7.9	Jan 2011	Na	x	X	X	X	X
10	South Pacific	Gyre	SouthPacific Gyre (SPG)	N/S -26.5; E/W -135.5	Jan 2011	Na	x	X	X	X	X
11	North Pacific	Gyre	NorthPacific Gyre (NPG)	N/S 32.1; E/W 178.1	Jan 2011	Na	x	X	X	X	X
12	North Atlantic	Gyre	NorthAtlantic Gyre (NAG)	N/S 25; E/W -42	Jan 2011	Na	x	X	X	X	X
13	South Atlantic	Gyre	SouthAtlantic Gyre (SAG)	N/S -36.5; E/W-20.1	Jan 2011	Na	x	X	X	N/A	X
14	West Coast US – Eureka (spring 2011)	AERONET_OC	Eureka	N/S 33; E/W 118	Feb 2011	Na	x	X	X	X	X
15	Abu_Al Bukhoosh	AERONET_OC	AbuAlBukhoosh (AAB)	N/S 25.5; E/W 53.1	Jan 2011	Na	x	X	X	N/A	X
16	Palgrunden	AERONET_OC	Palgrunden (PAL)	N/S 58.75; E/W 13.15	Jan 2011	Na	x	X	X	N/A	X
19	HOTS	Time Series	HOTS	N 23.75; S 23.5; W -158.75 ; E -157.5	Jan 2011	Na	X	X	X	N/A	X
20	BATS	Time Series	BATS (BI	N 34; S 30; W -66; E -62	Jan 2011	Na	X	X	X	X	X
21	CalCOFI	Time Series	CalCOFI (C	N 34; S 29; W -124.5; E -118.5	Jan 2011	Na	X	X	X	X	X

Examples MODIS – Chlorophyll 1 km Time series (5x5 box mean)
All Golden Regions satellite products running Now - Feb 2011



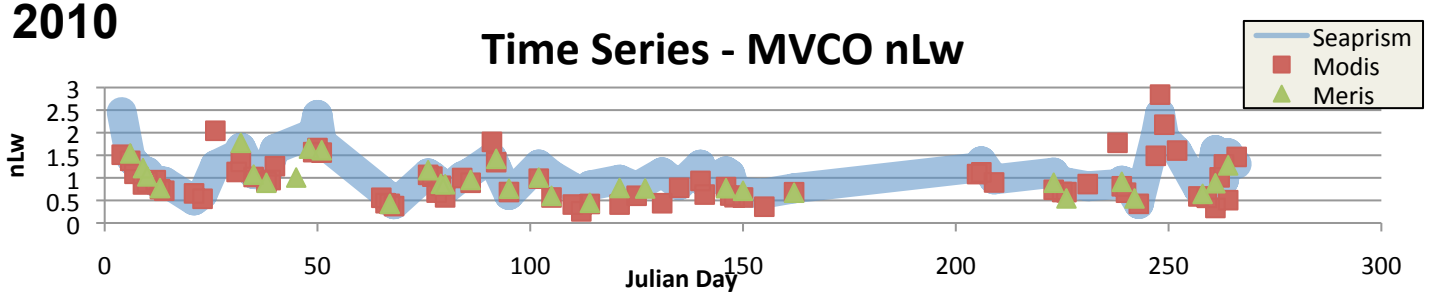


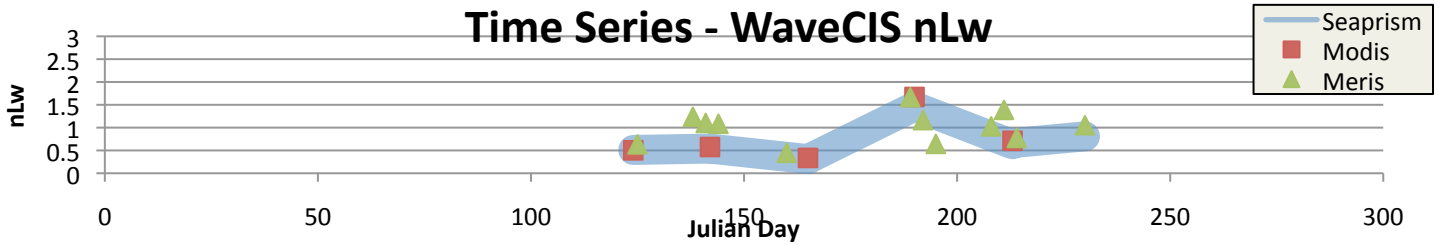
Additional, satellite Bio-optical Products, Aerosol Properties

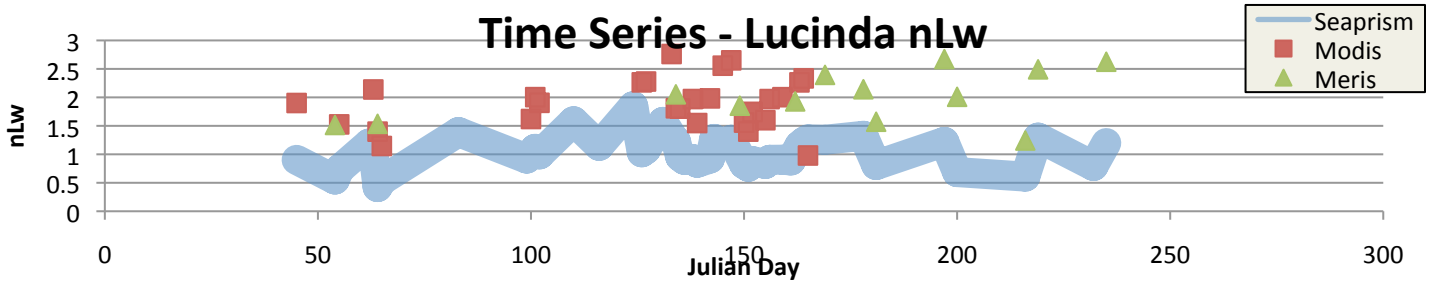
All satellites .

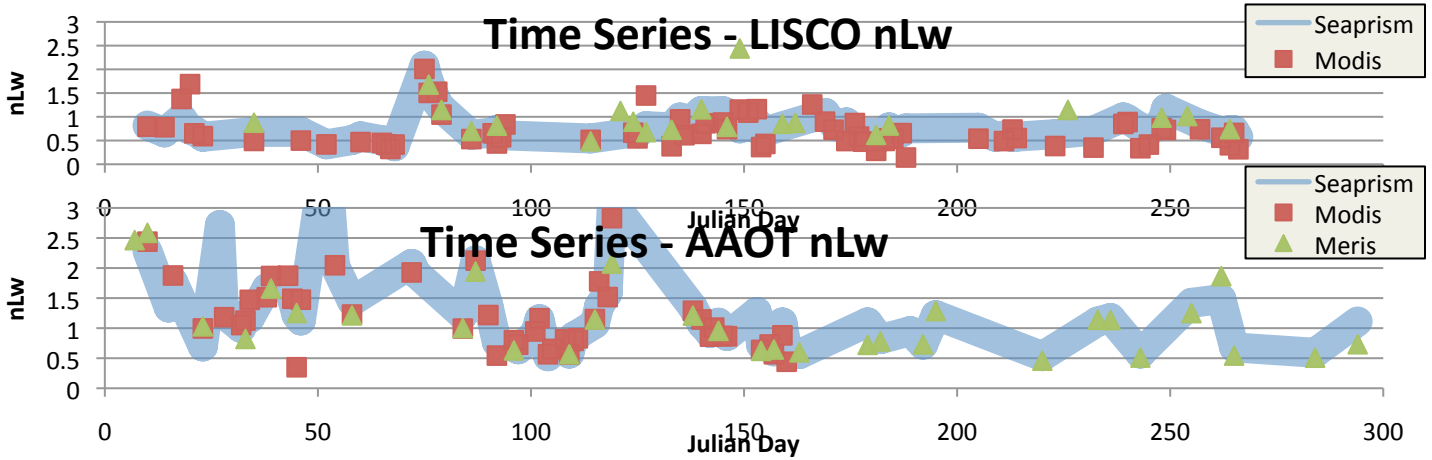
Daily updates from Aeronet –OC and Satellite - Running Now – Feb 2011!

2010









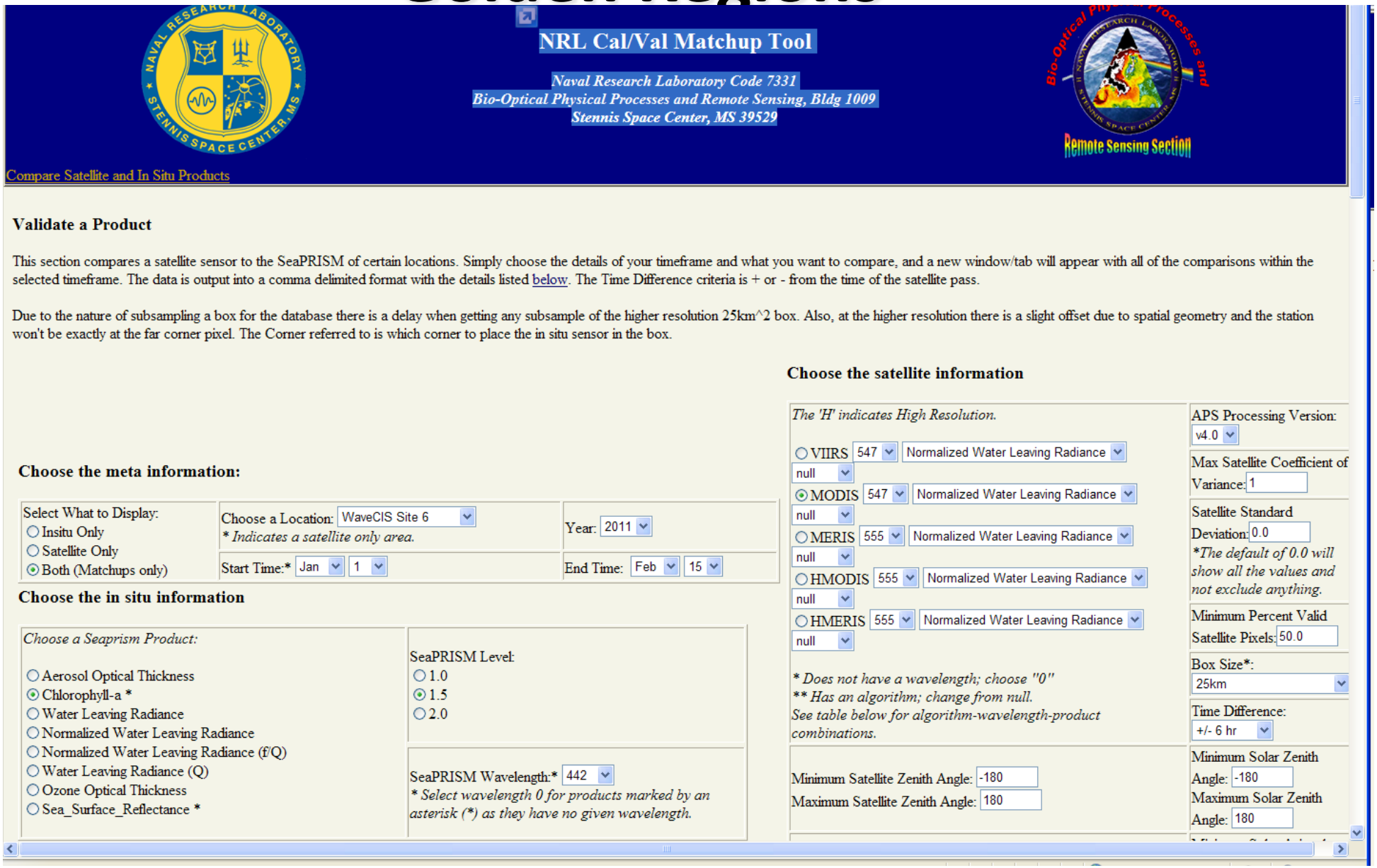
Aeronet –OC
MODIS 1 km
MERIS 1 km

Matchup Constraints

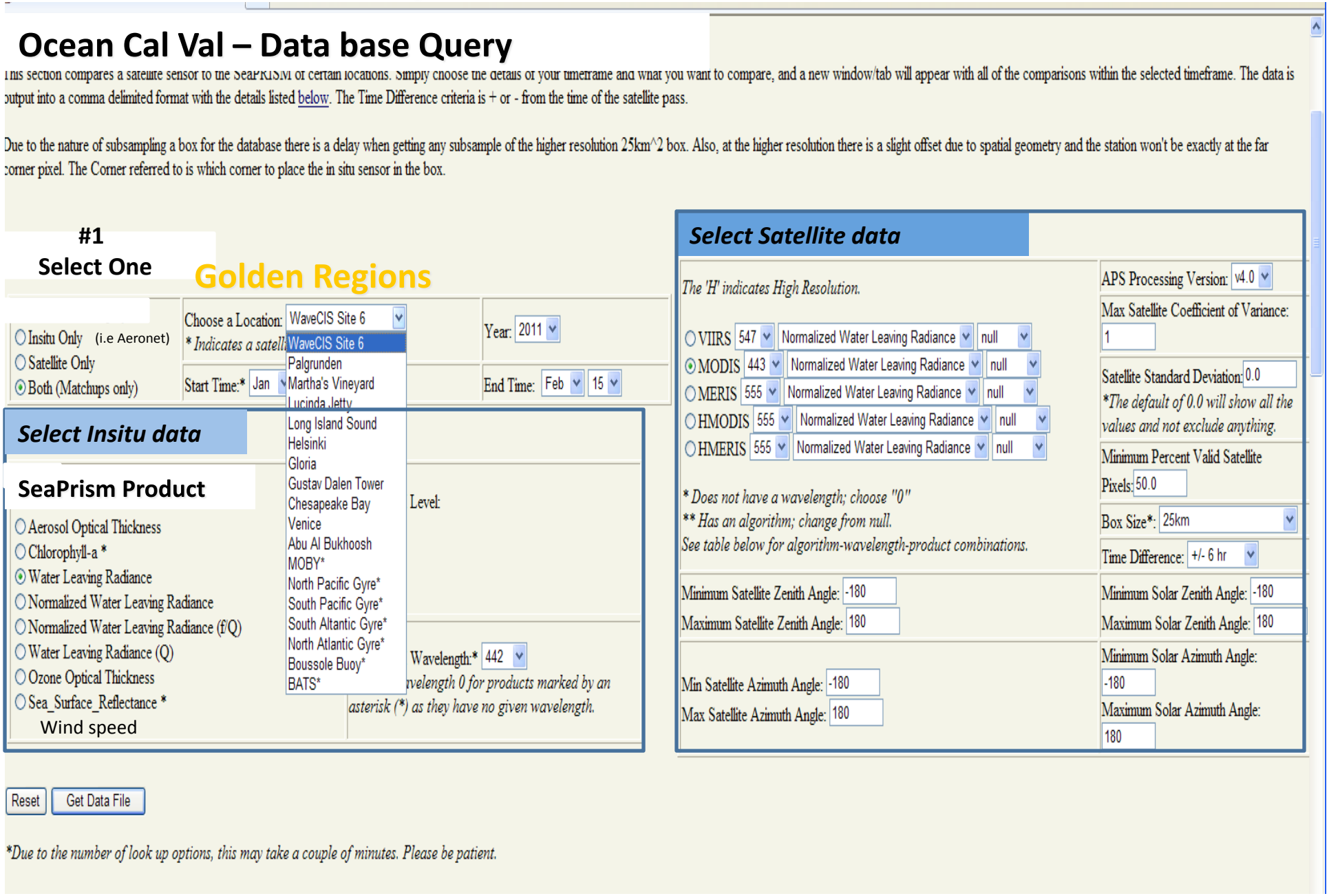
-+ 1 hour
- 5x5 box (25 km)
-Mean nLw
-Std- 0.02
- 50% valid
-SAngle – 30°
-SpAngle - <30°
- LV1.5
- Start 1/1/2010
- End 1/10/2010
-Wind – NA

-No spectral shift

Matchup Tool for Golden Regions

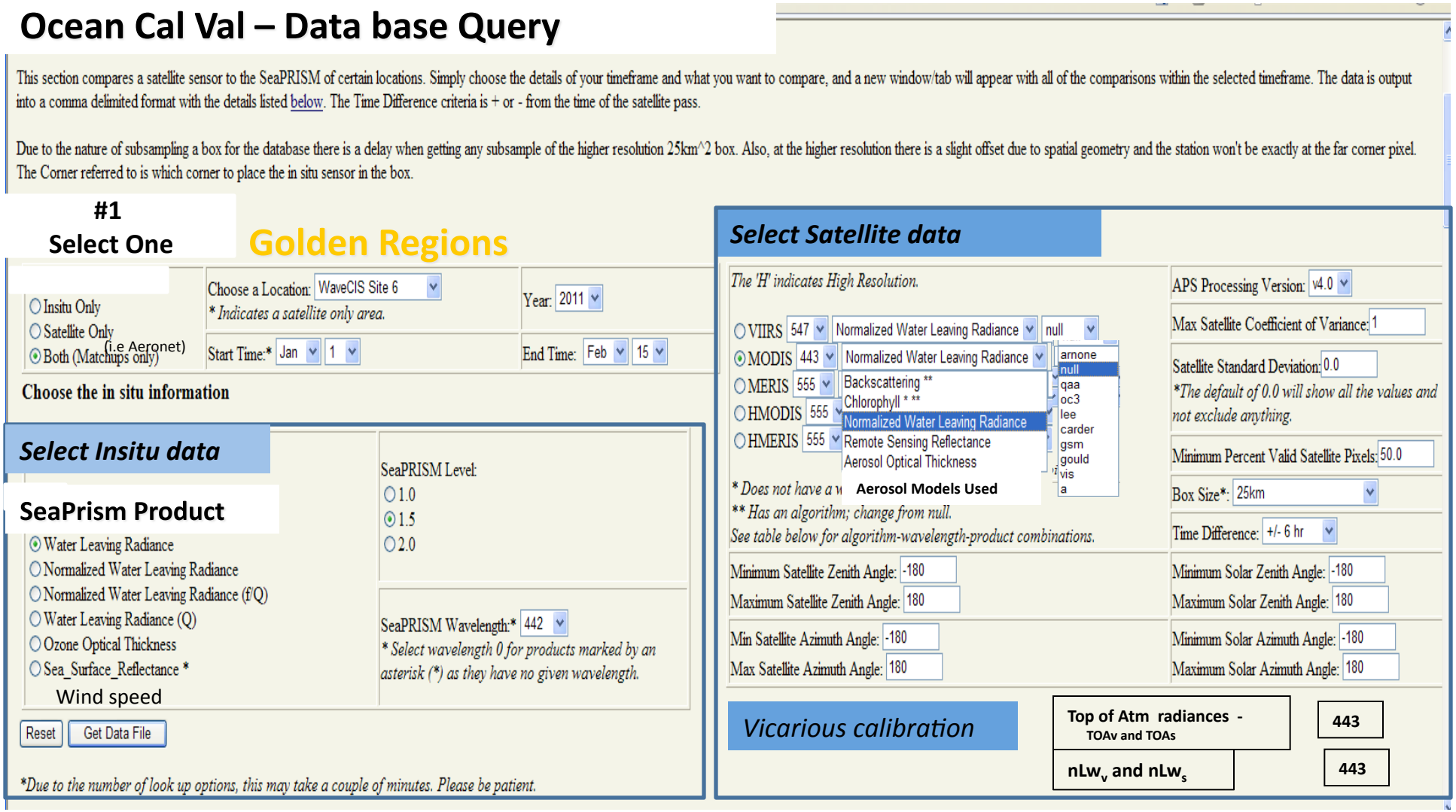


Matchup Tool for Golden Regions



Web page Matchup Tool for Golden Regions

Ocean Cal Val – Data base Query



Satellite products

- **Chlorophyll** — Oc3, Oc4
- **Absorption (total) (l)** –
- **Backscattering (l)** — **Arnone, Qaa ,Carder, Gsm**
- **nLw (l)** — **n ,QAA , Carder, gsm**
- **Rrs (l)**
- **Aerosol Optical Depth (l)**
- **2 Aerosol Models**

Spatial Uncertainty

Martha's Vineyard

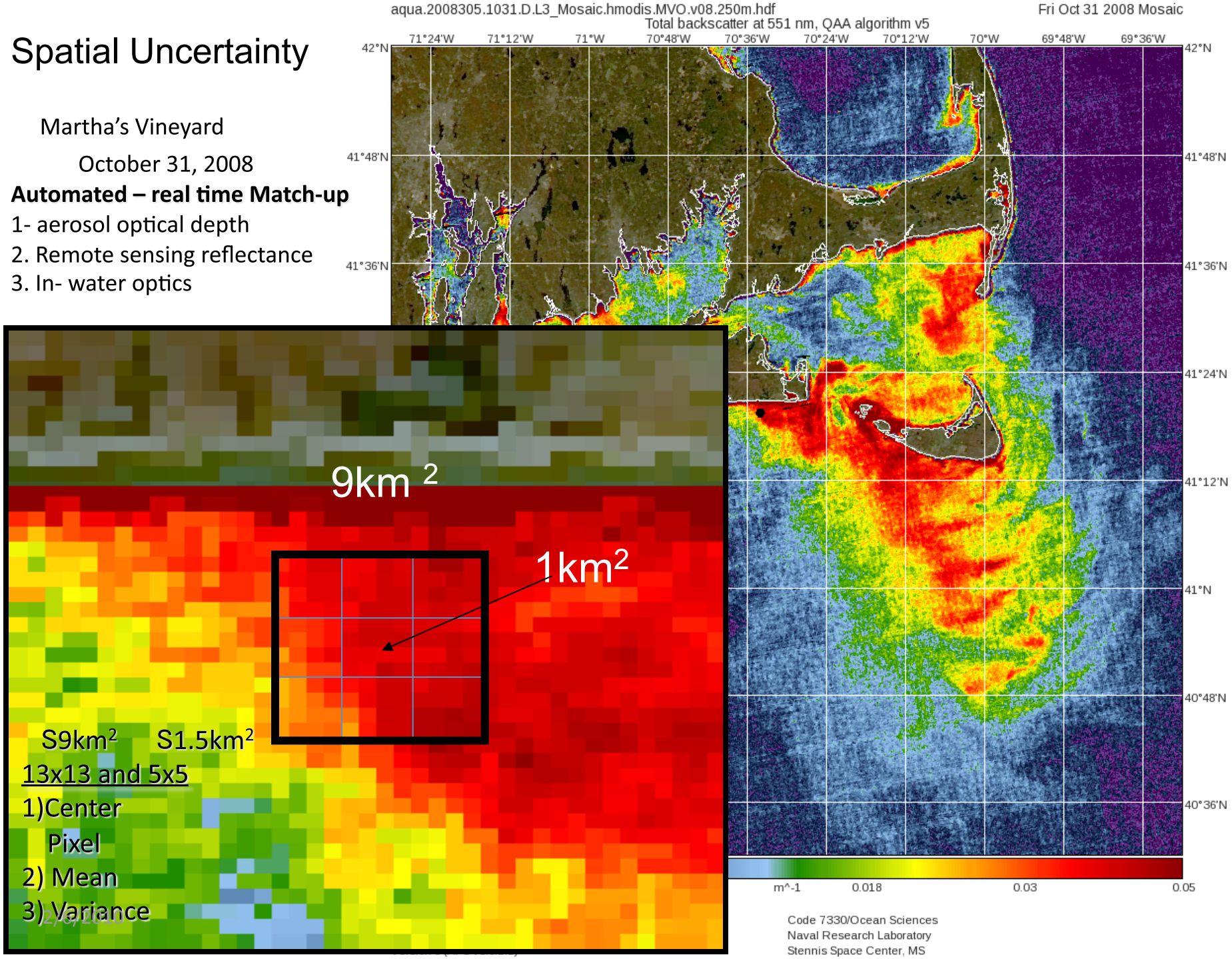
October 31, 2008

Automated – real time Match-up

1- aerosol optical depth

2. Remote sensing reflectance

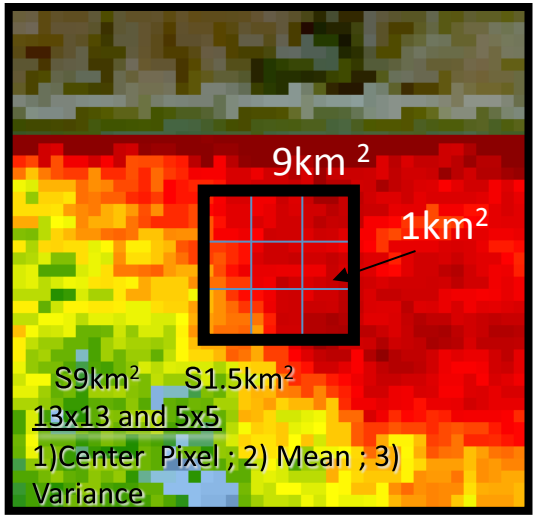
3. In- water optics



Satellite Product - Spatial Uncertainty

Spatial analyses in data base

Information Given	Details/Definition
Year	The year of the comparison.
Wavelength	The wavelength of the SeaPRISM in nanometers.
Julian Day	The day of the SeaPRISM observation.
Observation Time	The time the SeaPRISM observation was taken, given in hours:minutes format.
Value	The value from the SeaPRISM observation.
Number of Observations in a Day	The total number of valid observations the SeaPRISM took for the given julian day.
Daily Mean	The mean of the SeaPRISM's valid observations for the specified julian day.
Daily Standard Deviation	The standard deviation of the SeaPRISM's valid observations for the specified julian day.
Satellite Wavelength	The wavelength of the specified satellite in nanometers.
Satellite Julian Day	The julian day of the satellite.
Observation Time	The time of the satellite observation, given in hours: minutes format.
Number of Valid Pixels	From a 5x5 box with the center pixel being the location of the SeaPRISM, the number of good, unflagged pixels from the satellite data.
Center Pixel Value	The center pixel from the 5x5 box. It is the satellite's value at the specified SeaPRISM location.
5x5 Box Mean	The average of all the valid, unflagged pixels from the 5x5 box of the satellite pass.
Standard Deviation	The standard deviation of all the valid, unflagged pixels from the 5x5 box of the satellite pass.



Matchup Tool for Golden Regions

Reports back ASCI file of the matchup → Excel and plot generation

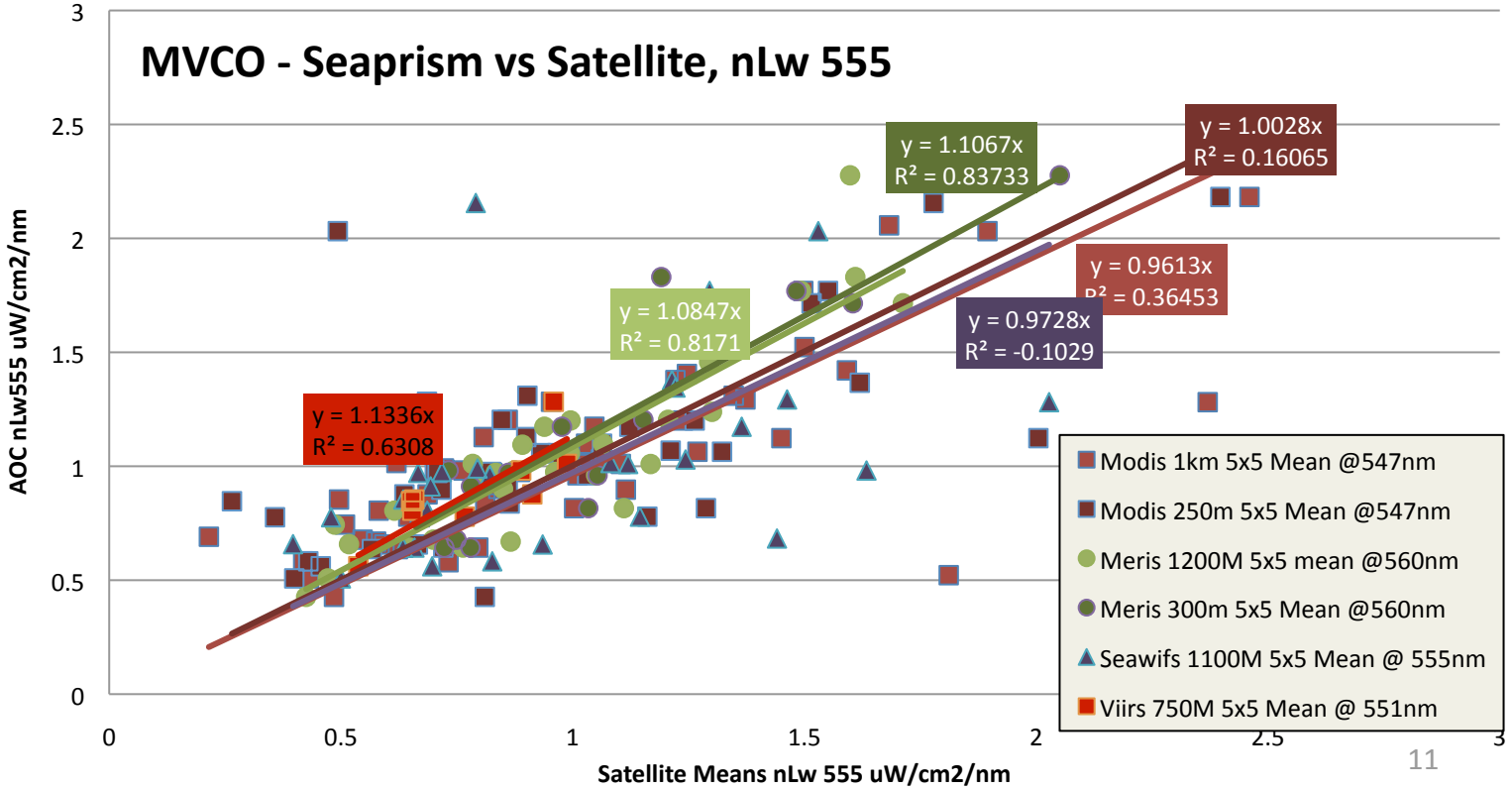
Lwn_fQ Data for Martha's Vineyard at Wavelength 412 (nm)

Julian Day, # Valid Observations, Daily Mean, Daily Standard Deviation,MODIS Julian Day, # Valid Pixels, Center Pixel Value, 5x5 Mean, Standard Deviation

4, 2, 0.578622, 0.003854, 4, 26, 0.3437, 0.40483076923077, 0.15546920488842
6, 2, 0.491799, 0.000222, 6, 26, 0.7656, 0.75851538461538, 0.17793221201066
7, 5, 0.5070244, 0.021958018695684, 7, 26, 0.6048, 0.68447307692308, 0.18241960622884
9, 2, 0.398855, 0.076868, 9, 26, 0.2927, 0.33406153846154, 0.064745335899276
10, 8, 0.333815, 0.08307959790466, 10, 26, 0.5162, 0.6037, 0.20081583985946
11, 11, 0.27754890909091, 0.057774160878143, 11, 5, 0.5162, 1.75342, 0.31868344418874
12, 4, 0.29243025, 0.033045384574665, 12, 26, 1.0465, 1.2163346153846, 0.39995732747604
32, 2, 0.203186, 0.051745, 32, 30, 1.5637, 0.56688333333333, 0.40575648286736

Matchup Constraints

-+ 1 hour
-5x5 box mean
-Std- 0.02
- 50% valid
-SAngle – 30°
-SpAngle - <30°
- LV1.5
- Start 1/1/2010
- End 1/10/2010
-Wind – NA

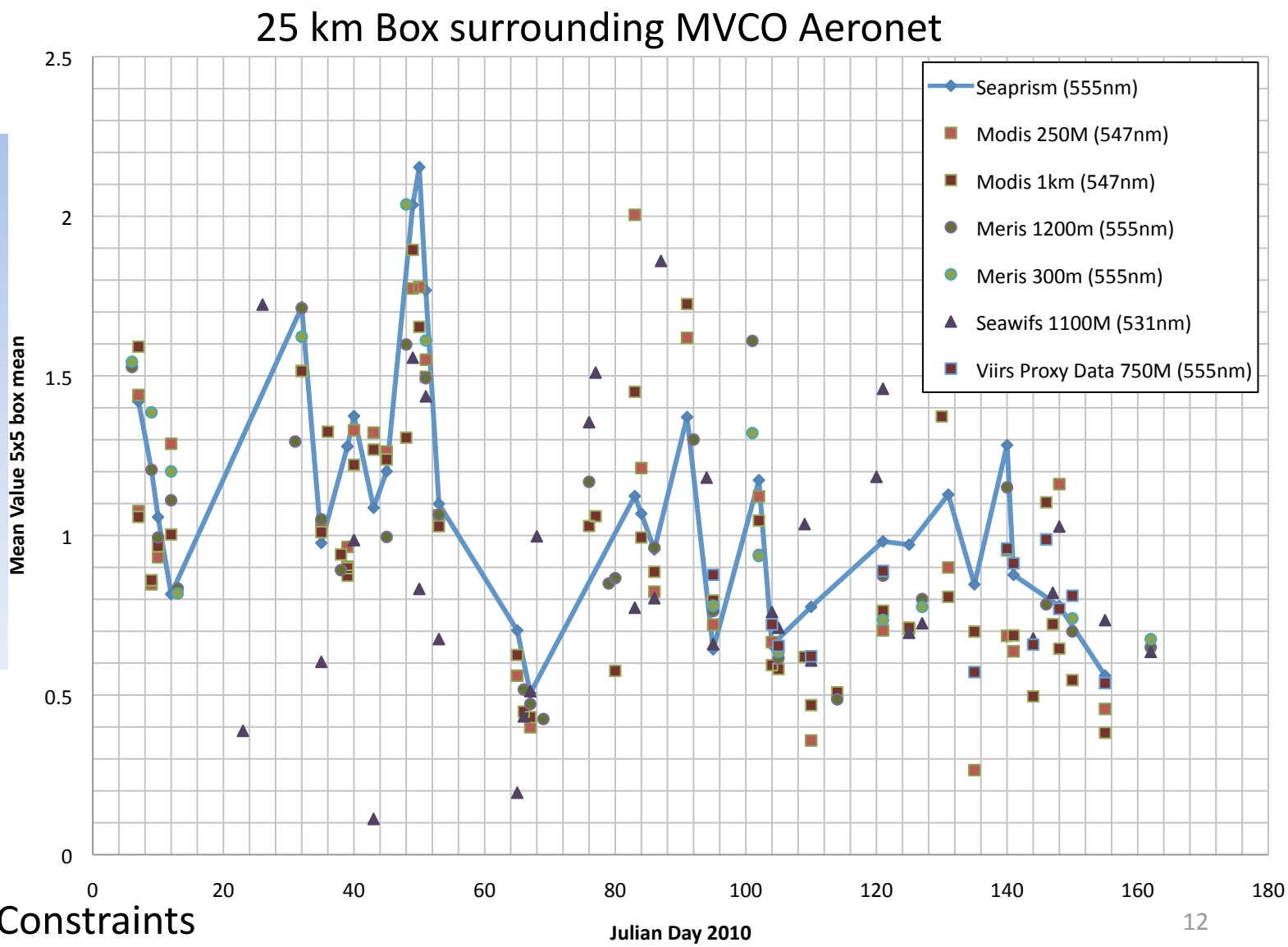


Spatial uncertainty from different satellites

Matchup Constraints

-+ 1 hour
- 5x5 box (25 km)
-Mean nLw
-Std- 0.02
- 50% valid
-SAngle – 30°
-SpAngle - <30°
- LV1.5
- Start 1/1/2010
- End 1/10/2010
-Wind – NA

-No spectral shift



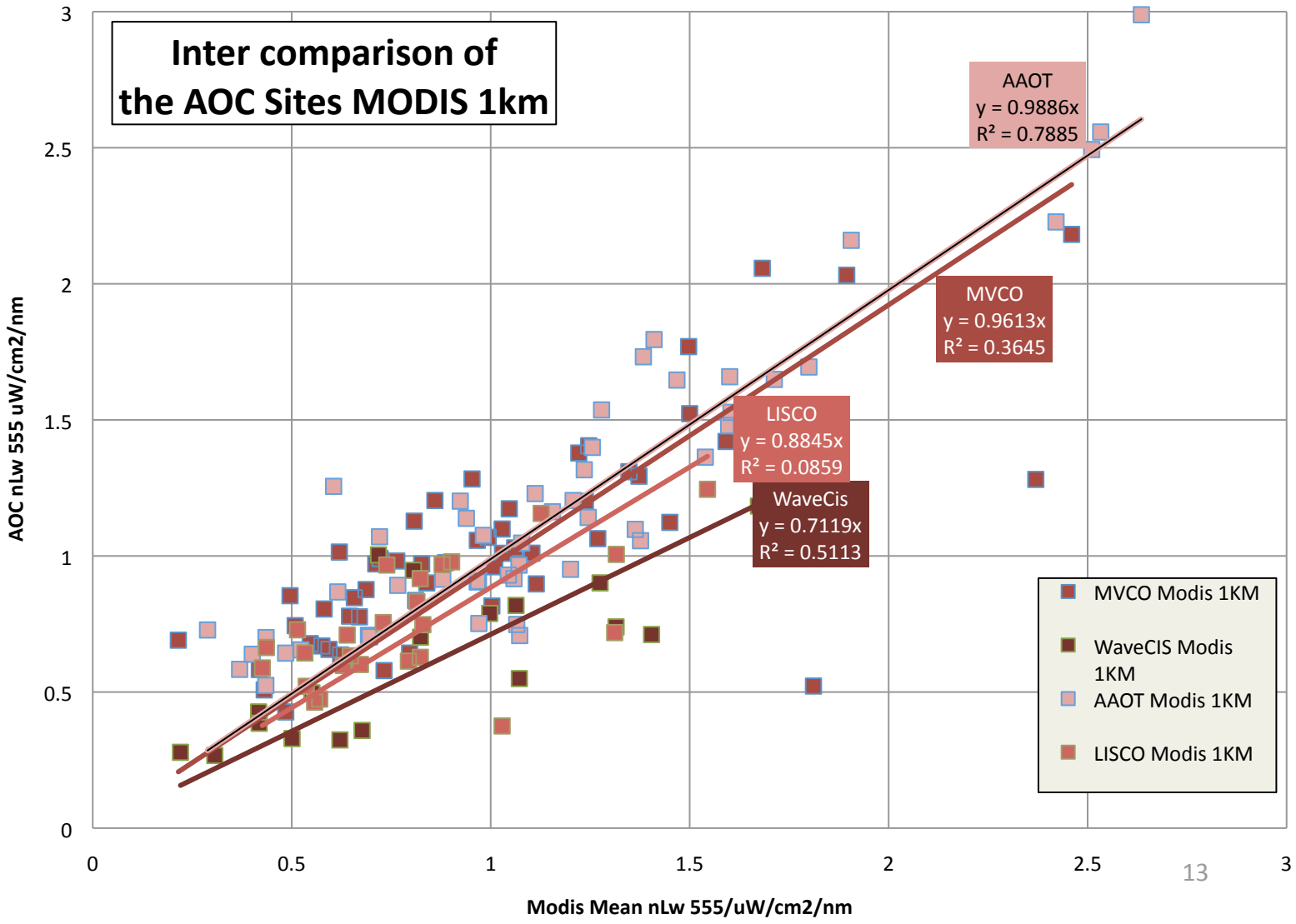
Tighten the Constraints

Comparison of different sites for MODIS nLw 550

Matchup Constraints

-+ 1 hour
- 5x5 box (25 km)
-Mean nLw
-Std- 0.02
- 50% valid
-SAngle – 30°
-SpAngle - <30°
- LV1.5
- Start 1/1/2010
- End 1/10/2010
-Wind – NA

-No spectral shift

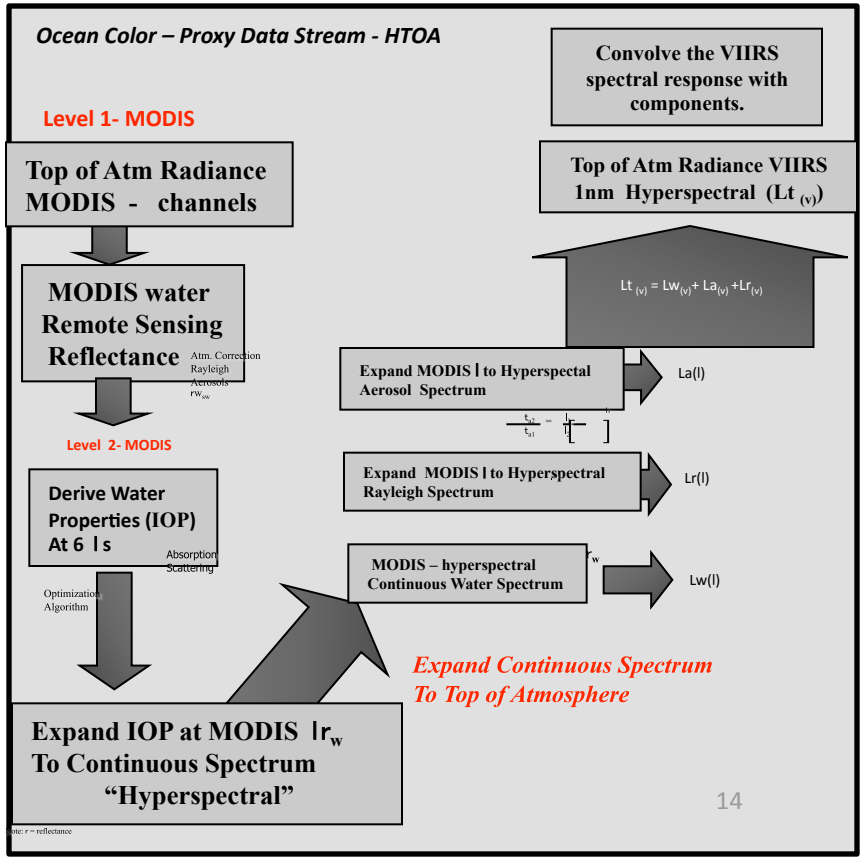


Matchup requires the Spectral Shift

Adjust the SeaPrism channels to the Satellite Channels

Similar problem with the VIIRS proxy data took MODIS TOA

NPP data



Use this for the Spectral shift

Lee et al, 2011

Hyperspectral Rrs (Lw)

Step 1: From Aeronet Rrs, calculate parameter _ equivalent Chlorophyll Conc "Z":

$$x = \log\left(\frac{Rrs(443)+Rrs(488)}{Rrs(557)+Rrs(667)}\right);$$

$$y = 10^{-0.407-1.574x+0.531x^2};$$ ← total absorption at 443 nm - **at**

$$z = \left(\frac{y-0.00635}{0.110}\right)^{\frac{1}{0.672}}.$$ ← equivalent chlorophyll conc.

Step2: Total Absorption coefficient: Using "z", generate (hyperspectral and MODIS bands)

$$a(H) = a_w(H) + K(H)\,z^{e(H)}$$

Values of K and e are based on Morel et al (2001)
H = Hyperspectral B= Band

Step 3: Backscattering - Using a(B) and Aeronet Rrs at each band, Rrs(B), calculate $b_{bp}(B)$

$$b_{bp}(B) = R_{rs}(B)\,a(B)/0.05 - b_{bw}(B)$$

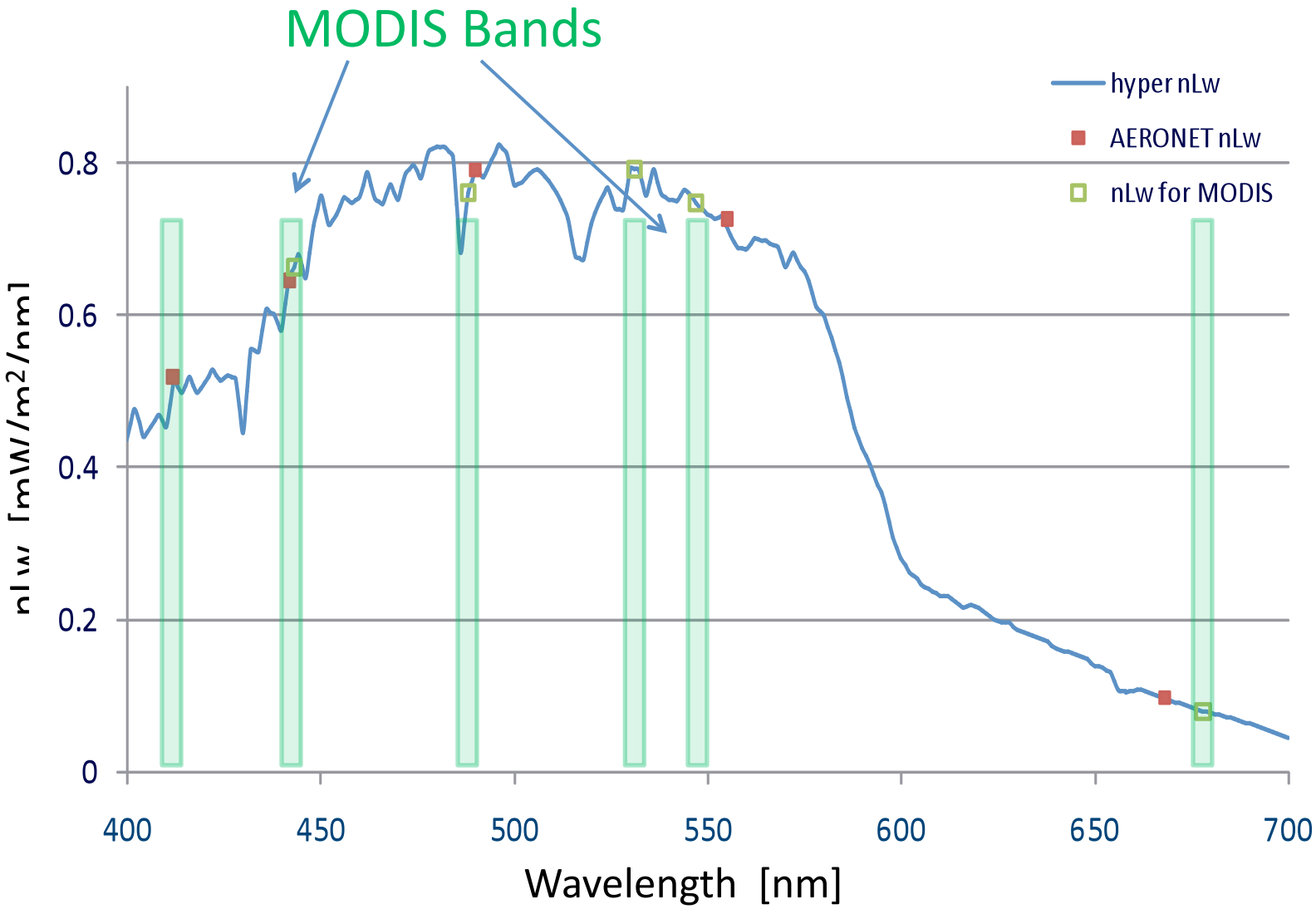
Hyperspectral backscattering $b_{bp}(H)$
Interpolate the above (every 1 nm)

Step 4: From the above a(H) and $b_{bp}(H)$, calculate hyperspectral Rrs(H):

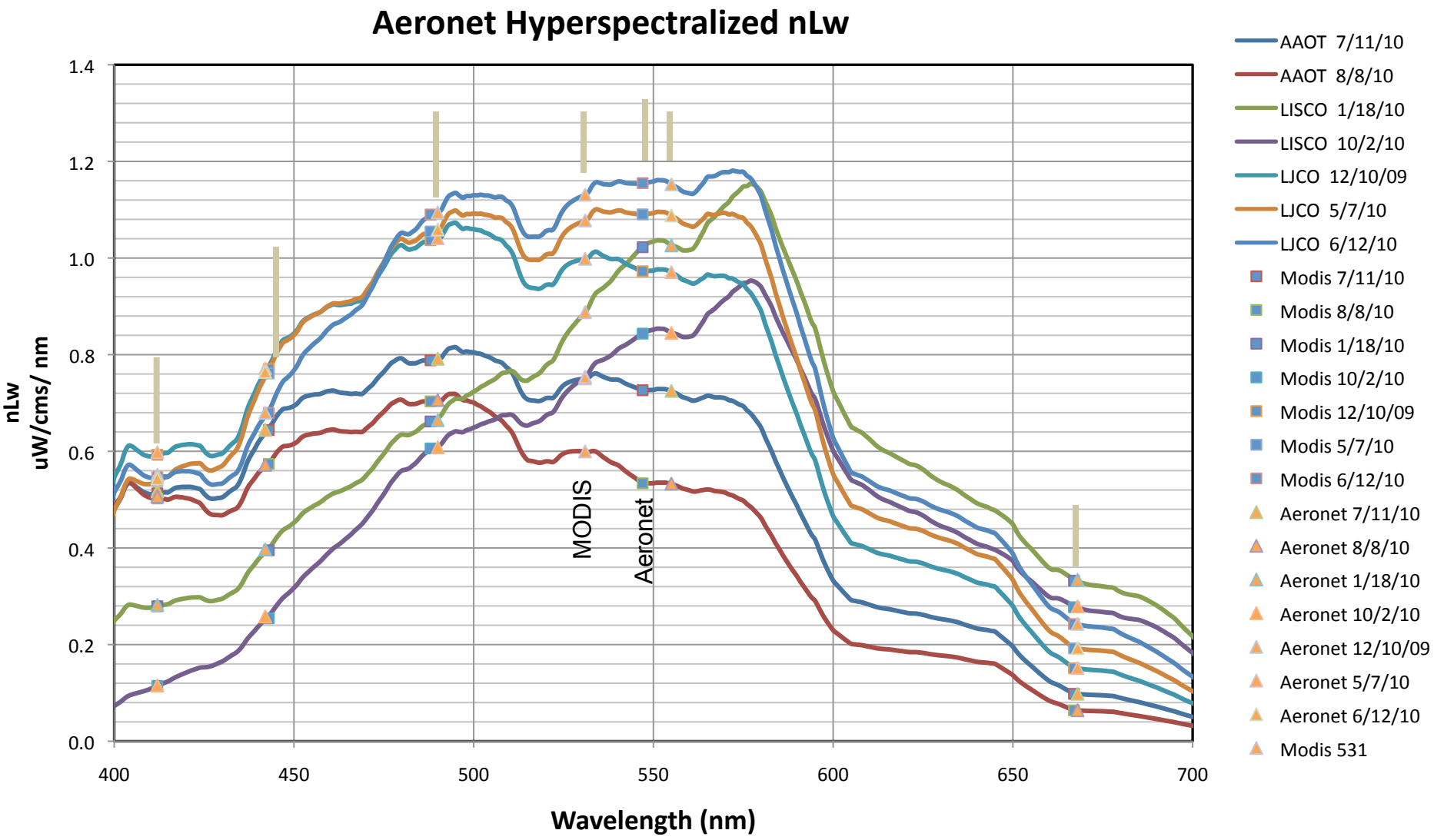
$$R_{rs}(H) = 0.05\frac{b_{bw}(H)+b_{bp}(H)}{a(H)}$$

Hyperspectral Rrs !!!

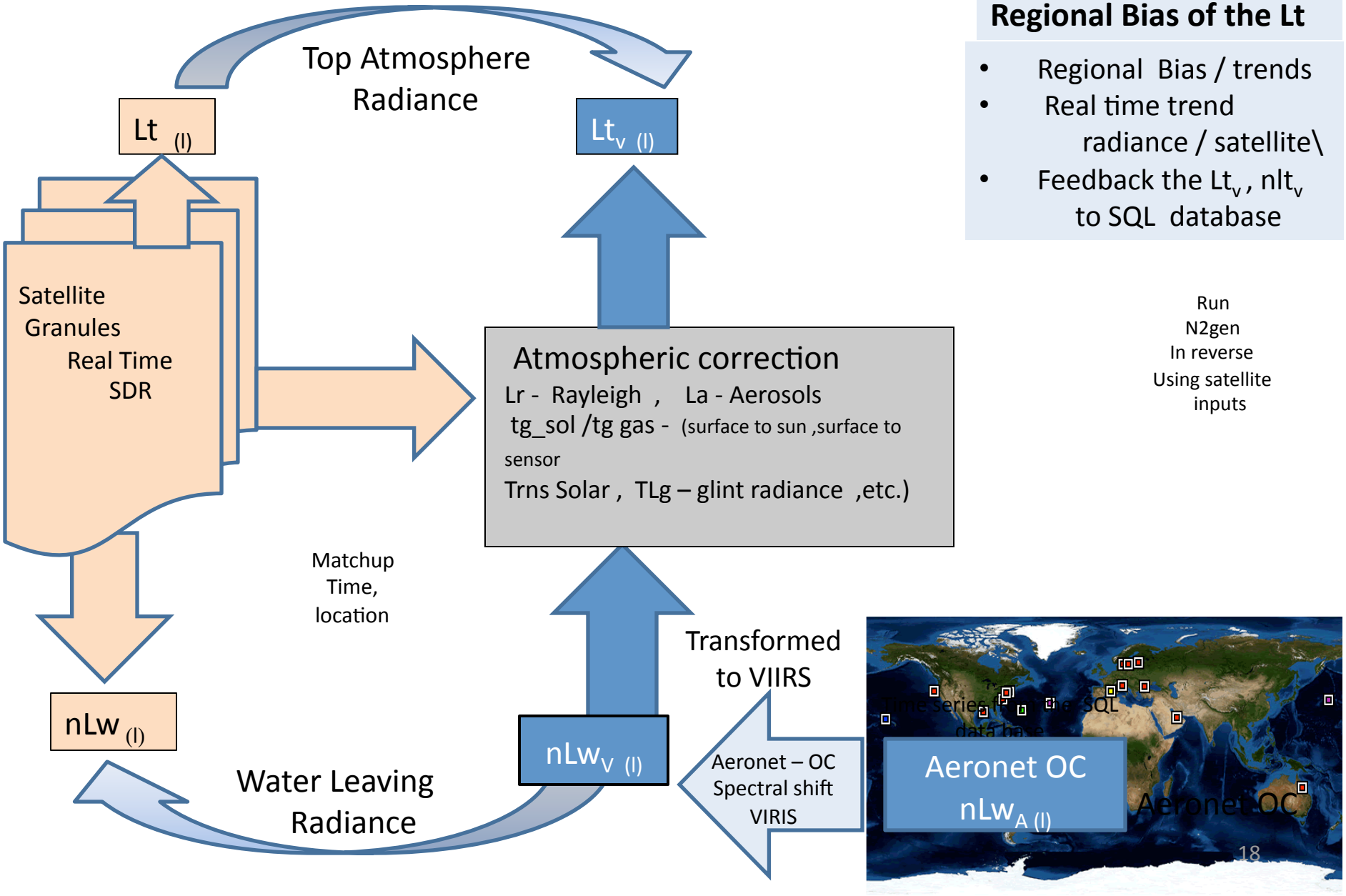
Example of band shift of Aeronet nLw



Spectral Shift of water leaving radiance



Monitoring a Vicarious Regional matchup Lt and nLw



Regional Bias of the Lt

- Regional Bias / trends
- Real time trend radiance / satellite\
- Feedback the Lt_v , nlt_v to SQL database

Run N2gen In reverse Using satellite inputs

Vicarious Matchup → Lt

$$vLt = [(TL_g + L_a)t_{o2} + tL_f + L_r]polcor\ tg_{sol}\ tg_{sen} + vnL_w / brdf_{sensor}\ polcor\ t_{sen}\ t_{sol}\ tg_{sol}\ tg_{sen}\ \cos(\theta) f_{sol}$$

- TL_g - TOA Glint Radiance
- La - Aerosol Radiance
- tL_f - White-cap Radiance
- L_r - Rayleigh Radiance
- t_{o2} - Total Oxygen Transmittance
- t_{sol}- Rayleigh-Aerosol Diff. Trans., Sun to Surface
- t_{sen} - Rayleigh-Aerosol Diff. Trans., Surface to Sensor
- tg_{sol} - Gaseous Transmittance, Sun to Surface
- tg_{sen} - Gaseous Transmittance, Surface to Sensor
- brdf - Bi-directional
- θ - Solar Zenith Angle
- f_{sol} - Earth-Sun distance correction
- polcor - polarization correction

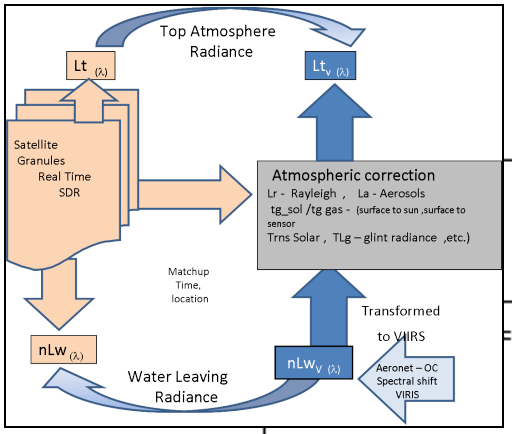
Parameters integrated into the SQL data base
Plus: file, date, Level-2 flags, aeronet instrument, data level

Automated Regional Vicarious Matchup at "vLt"

Script to produce vicarious matchups.

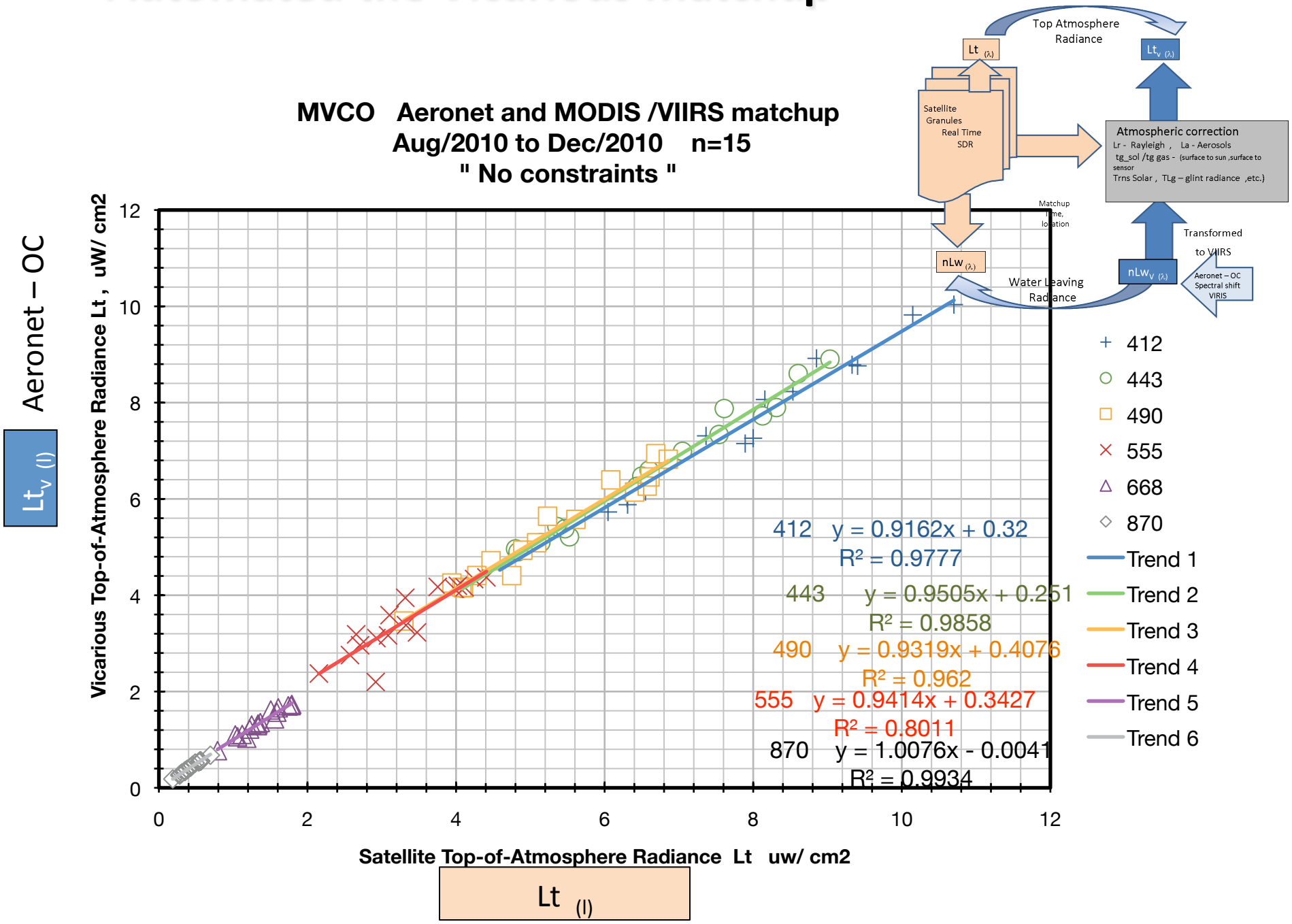
1. Input is configuration file and list of satellite file(s).
2. Time, wavelengths are extracted from satellite.
3. Aeronet database queried for all matching locations and time.
4. For each aeronet-site and satellite match:
   a. Find closest aeronet record and satellite based on time.
   b. Get nLw from aeronet record
   c. Create vicarious matchup parameter file (Lt, vLt, La, Lr, etc.)
   d. Run vicarious mode to get vLt (see next slide)
   e. Pull results from file
   f. Push results back to database (Lt, vLt, La, Lr, solzen, etc.)
5. Generate Plots of gain ratios (Lt/vLt)
6. Perform regression to obtain vicarious gains/offsets (use quality checks)

Example from LISCO Aeronet using VIIRS Proxy Scene.

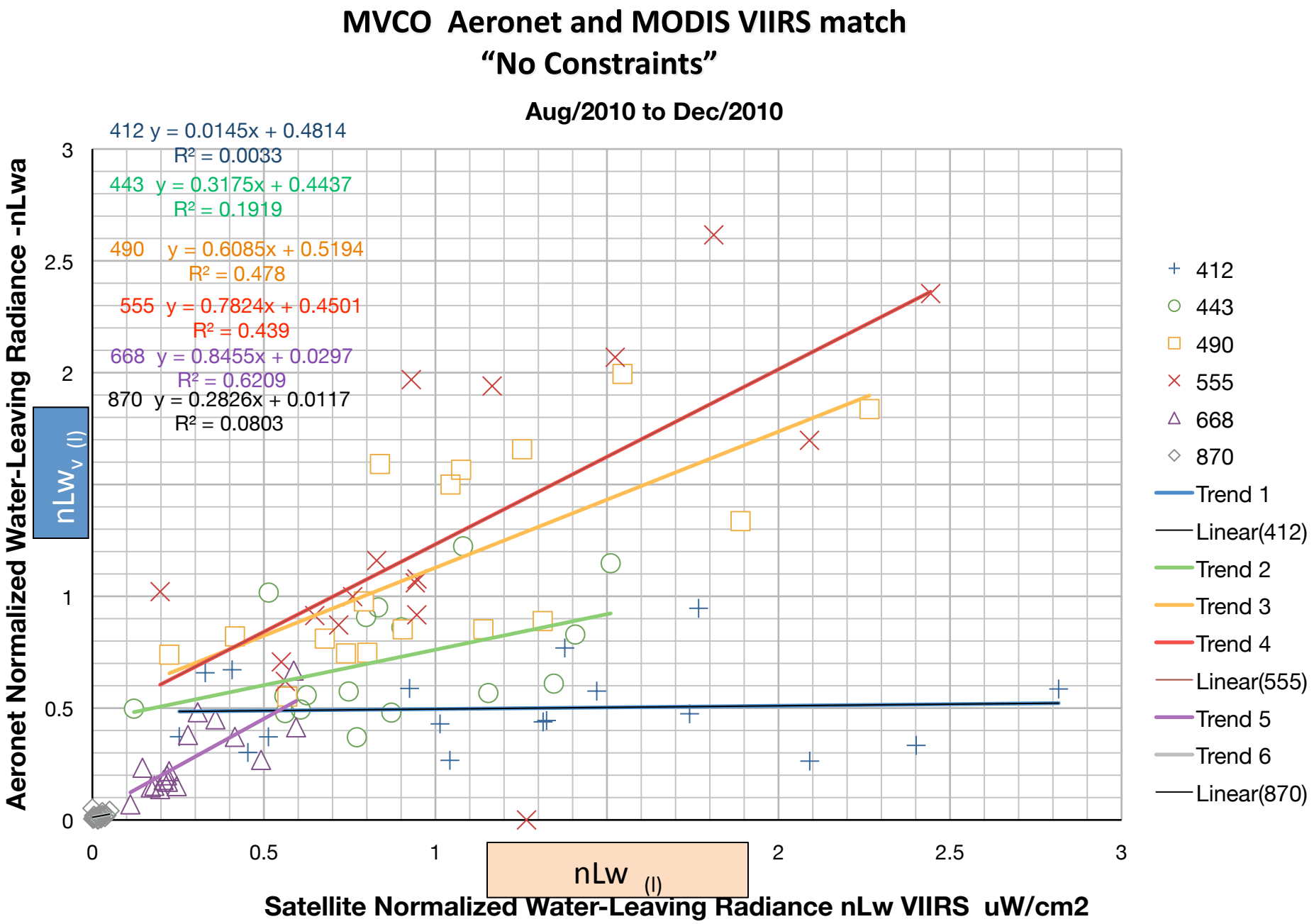


No Spectral Shift applied !

Automated the Vicarious Matchup --



Automated the Vicarious Matchup --



Applications for monitoring the "Golden Regions"

- **Determine satellite product trending both seasonally and in different coastal and open ocean regions**
- **Examine in real time (2 weeks) vicarious matchups - track regional validation**
  - **Assess the regional Bias at different sites (globally)**
  - **Determine the impact of new LUT using the matchup**
    - **Maintain "golden site" reprocessing .**
      - **Demonstration in Summner.**

Spatial and Temporal Uncertainty of satellite ocean color : Real time Satellite and Aeronet _OC Matchup

Summary

- Aeronet – OC and observation data streams being assembled with satellite data streams
- Developing real time Match –up
  - Satellite products validation
  - Inter- satellite comparison and product consistency
  - Spatial and temporal uncertainty in coastal areas being addressed, using "constraints"
- Coordinate with national and international collaborators

Questions ?

- Golden Regions Satellite Processing -

NPP – VIIRS proxy data processing

1-	AAOT/	11-Feb-2011 15:01	
2-	AbuAlBukhoosh/	22-Jan-2011 06:49	
3-	BATS/	21-Jan-2011 14:07	
4-	BoussoleBuoy/	22-Jan-2011 09:46	
5-	CalCOFI/	21-Jan-2011 19:21	
6-	ChesapeakeBay/	14-Feb-2011 11:35	
7-	Cove/	14-Feb-2011 11:22	
8-	GDAT/	22-Jan-2011 10:57	
9-	Gloria/	22-Jan-2011 08:12	
10-	Gomex/	14-Feb-2011 11:26	
11-	GreatLakes1km/	14-Feb-2011 12:40	
12-	GulfOfMaine/	11-Feb-2011 15:04	
13-	Helsinki/	22-Jan-2011 10:57	
14-	HelsinkiLH/	11-Feb-2011 15:04	
15-	LigurianSea/	11-Feb-2011 15:04	
16-	LucindaJetty/	22-Jan-2011 02:49	
17-	MOBY/	21-Jan-2011 21:23	
18-	MVCO/	14-Feb-2011 11:23	
19-	MVCOX/	14-Feb-2011 11:21	
20-	MissBight/	14-Feb-2011 11:24	
21-	NYBight/	14-Feb-2011 11:24	
22-	NorthAtlanticGyre/	21-Jan-2011 14:31	
23-	NorthEastAustralia/	11-Feb-2011 15:08	

24	NorthEastAustralia/	11-Feb-2011 15:08	-
25-	NorthPacificGyre/	23-Jan-2011 00:42	-
26-	Palgrunden/	22-Jan-2011 10:57	-
27-	PersianGulf/	11-Feb-2011 15:08	-
28-	SouthAtlanticGyre/	21-Jan-2011 12:30	-
29	SouthPacificGyre/	21-Jan-2011 20:58	-
30	WaveCIS/	14-Feb-2011 11:22	-

Reprocessing

-Level 0 –

-Level 1b –

-

-Level 3 - daily imagery

-And mosaics

-Level 4 – composites daily,

Weekly , months

7 day latest pixel