Aeronet-OC Cal/Val

- 1) Define a VIIRS Proxy Data Stream
- 2) Define the required in situ data stream for Cal/Val
- 3) Tuning of algorithms and LUTS (Vicarious calibration and SDR feedback)
- 4) Ocean Algorithm, stability evaluation and uncertainty
- 5) Product validation and product long-term stability
- 6) Satellite inter-comparisons, robustness, seasonal and product stability

Presenter/Affiliation: Carol Johnson, Optical Technology Division, NIST, Gaithersburg, MD

Performers: Carol Johnson, Dennis Clark, Al Parr, & NIST OTD staff members

Thrust area: 2, In situ data collection (6, 7, & 11); 3, vicarious calibration (12); 4, algorithm performance (19)

Award date: April 1, 2010

Total Man-Months Effort:

FY09	FY10	FY11
1.5		

Establishing a SeaPRISM site on the West Coast of the United States

Project Objectives

Assessment of the uncertainty of the Aeronet / SeaPrism Sites for Ocean Color in Coastal Waters

Supports: Ocean cal/val plan elements 2, 3, 4

Milestones / Deliverables

		FY 10 1 2 3 4	FY11 1 2 3 4	FY12 1 2 3 4
1.	**Aeronet-OC uncertainty budget**	**S**	**C**	
2.	Study the Aeronet-OC protocols as developed by Giuseppe Zibordi and evaluate the application at the new sites.	S	C	

Major FY10 Challenges/Issues

Schedules need to be worked out. Plans need to be discussed and finalized. This is one year funding, but would like to extend to 3 years.

Major Progress

Very successful workshop in February 2010; literature review / study has begun

Establishing a SeaPRISM site on the West Coast of the United States

Collaboration and Coordination with Inside and Outside Activities

Inside this team
G. Fargion, SeaPrism site team leads

Outside – to NIST
IPO (VIIRS calibration, characterization)
NOAA, MLML (MOBY)
NASA OBPG (potential)
NASA Aeronet (suggested)

Transition Partners

Leveraged RDT&E Projects

Related programs at NIST
- Climate Initiative
- Carbon Cap and Trade
- Internal Oceans Funding Opportunity

IPO funded NPP/NPOESS (VIIRS, CrIS...)
Hollings Marine Institute
Other efforts in remote sensing support

International Partnerships

JRC – G. Zibordi – for this project

JRC and NIST have opportunity for formal MOUs

CEOS WGCV IVOS – Johnson participates in WGCV and IVOS (infrared and visible subgroup); is the WGCV liason to the Ocean Color Radiometry Virtual Constellation (OCR-VC)

Aeronet-OC Cal/Val

FY10 Milestones are In Progress

- Aeronet / SeaPrism Uncertainty Budget
  - extend Zibordi's Aeronet-OC uncertainty work
- Report on Aeronet / SeaPrism Protocols for coastal waters
  - in particular at the new sites (Long Island, Gulf of Mexico, US West Coast)

Uncertainty Approach

- Measurement Equation Approach
  - an example is for water-leaving radiance from the measured sea (T) and sky (i) radiance:

$$L_{\mathrm{W}}(\lambda,\theta,\phi) = L_{\mathrm{T}}(\lambda,\theta,\phi) - \rho(\lambda,\theta,\phi,\theta_0,W)\, L_{\mathrm{i}}(\lambda,\theta',\phi)$$

- Follow ISO Guide to the *Expression of Uncertainty in Measurement*
  - Propagate uncertainties, determining sensitivity coefficients and degree of correlation
  - Identify as Type A or Type B

Basic Method

- Aeronet sun photometers are Gershun tube radiometers, FOV ~ 1.5°
  - Solar disk is 0.5°; direct solar viewing is irradiance mode, used for determining aerosol optical depths at selected channels, leading to calculation of diffuse spectral transmittances
  - Aeronet-OC augments the standard atmospheric sky radiance set with a set of sky/sea radiance measurements at defined geometry
- Lwn is the data product (normalized water-leaving radiance)

Factors that Enter Lwn

- sky and sea radiance measurements;
- solar zenith angle, Earth-sun distance, spectral diffuse transmittance of atmosphere;
- sea surface reflectance, which is modeled and depends on geometry, solar zenith angle, and wind speed;
- the degree of anisotropy of the in water light field and corrections for the irradiance reflectance
  - these corrections are model dependent and at the present time Aeronet-OC uses LUT values developed for Case 1 waters & AOT of 0.2 at 550nm (there are dependencies on wavelength, solar zenith angle, viewing geometry AOT, IOPs)

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Joint Research Centre

Uncertainties

Source	L_{WN}				
	412	**443**	**488**	**551**	**667**
Absolute calibration	2.7	2.7	2.7	2.7	2.7
Sensitivity change	0.4	0.2	0.2	0.2	0.2
Correction	1.6	2.0	2.8	2.9	1.9
t_d	1.5	1.5	1.5	1.5	1.5
ρ	1.8	1.3	0.7	0.6	2.5
W	1.1	0.8	0.4	0.4	0.4
Environmental effects	3.1	2.1	2.1	2.1	6.4
Quadrature sum	**5.1**	**4.5**	**4.7**	**4.7**	**7.8**

~5% (400-600 nm)

G.Zibordi, B.Holben, I.Slutsker, D.Giles, D.D'Alimonte, F.Mélin, J.-F. Berthon, D. Vandemark, H.Feng, G.Schuster, B.Fabbri, S.Kaitala, J.Seppälä. AERONET-OC: a network for the validation of Ocean Color primary radiometric products. *Journal of Atmospheric and Oceanic Technology* , 26, 1634-1651, 2009.

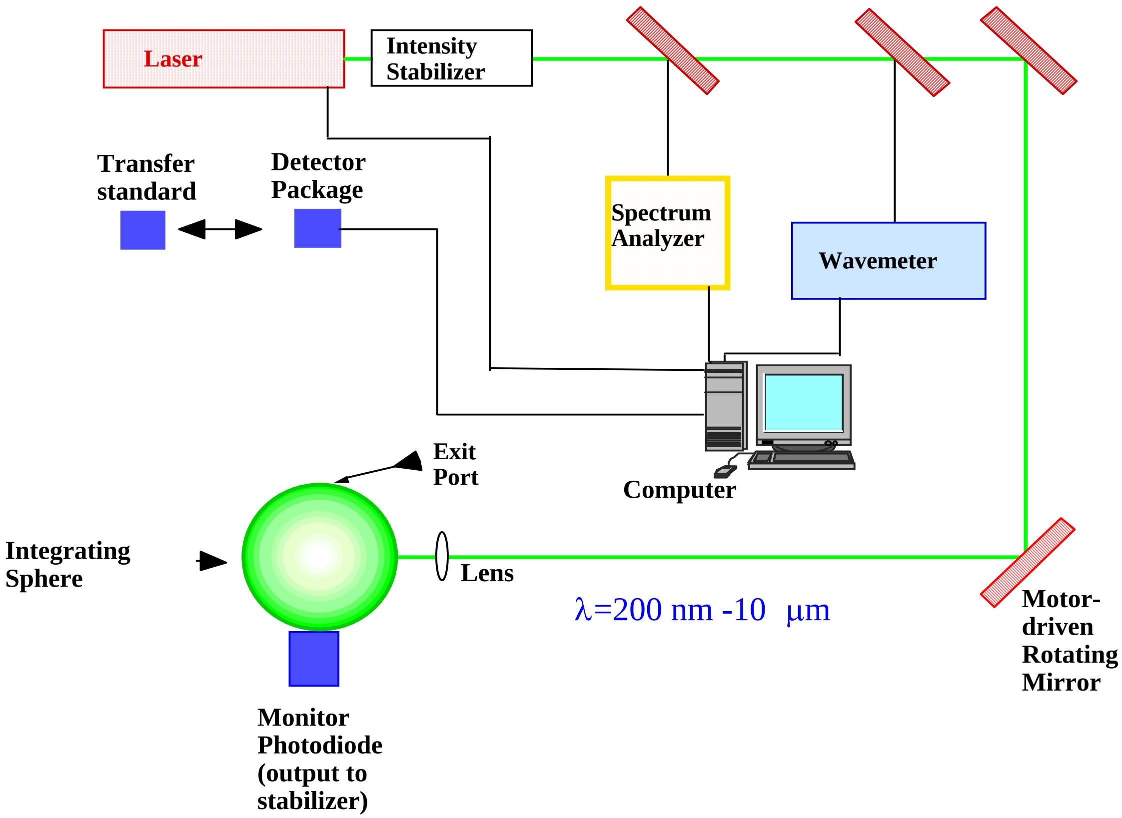
Joint Research Centre

FY10 Plans

- Additional characterizations of one CIMEL sun photometer
  - Absolute spectral irradiance and radiance responsivities, uncertainty ~0.1% using NIST SIRCUS
  - Temperature dependence on irradiance and radiance responsivity, chamber covers ~5°C to ~90°C
  - Linearity & NEΔL for the irradiance and radiance modes
  - Long term stability
  - Geometric factors (spatial response, invariance with distance)
- Study and review Aeronet-OC protocols in relation to their application at the new sites (with site team members and Giuseppe Zibordi)

SIRCUS

Spectral Irradiance and Radiance Responsivity using Uniform Sources

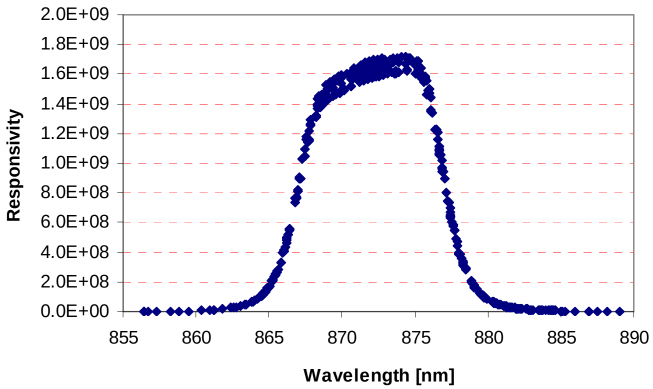


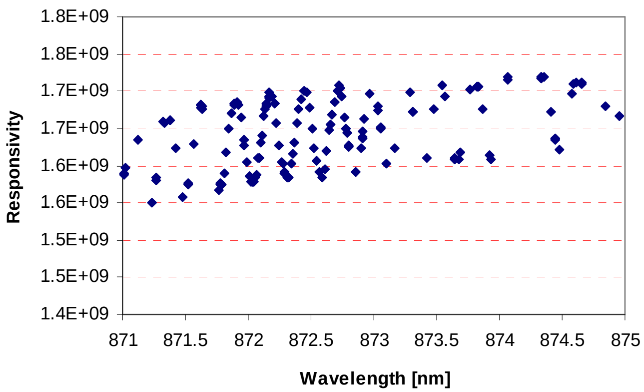
Irradiance or Radiance Mode;
Monochromatic flux;
Large dynamic range;
Low uncertainties

Spectral Characterization

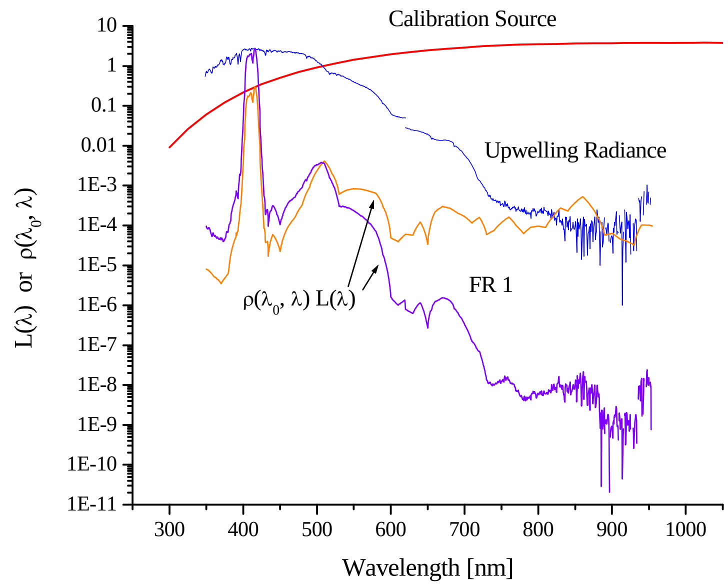
Characterization on SIRCUS will provide accurate wavelength calibration, bandpass/shape information, and spectral out of band values.

Any measured biases (measurement compared to specification) in λ_0 or $\Delta\lambda$ are part of the uncertainty budget in τ_a and τ_d





SIRCUS results for CIMEL sun photometer



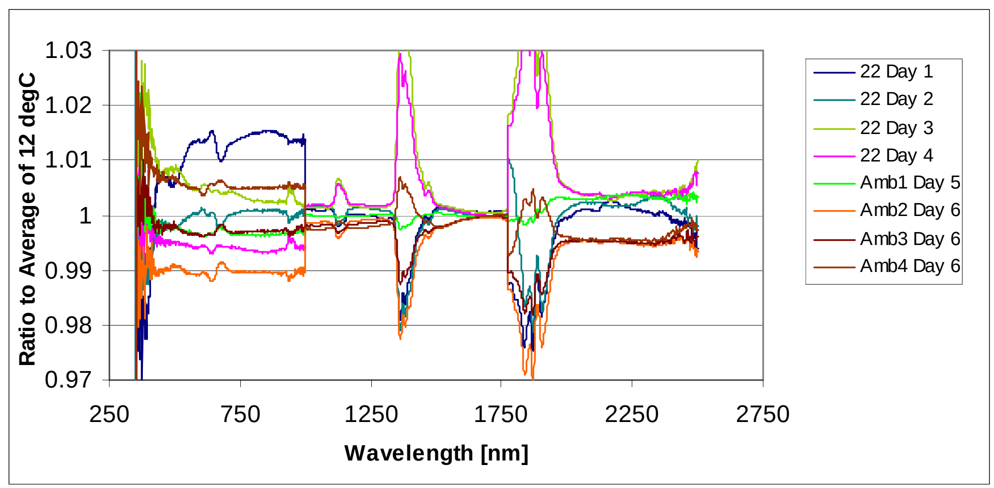
Spectral out of band is a source of bias when the calibration and measured source differ in relative spectral shape

Environmental Chamber

Achievable Values:
Dry Bulb Temperatures 4.4°C to 85°C for
Dew Point Temperatures -29°C to 93°C
and RH from 5% to 100%

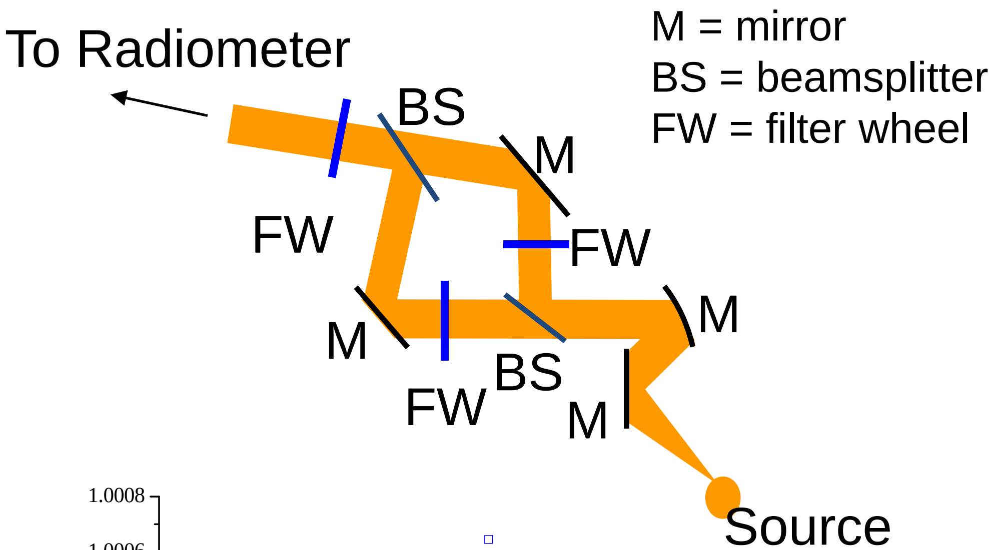
Internal dimension of ~1mx1mx1m
Ports for coupling sources to radiometer

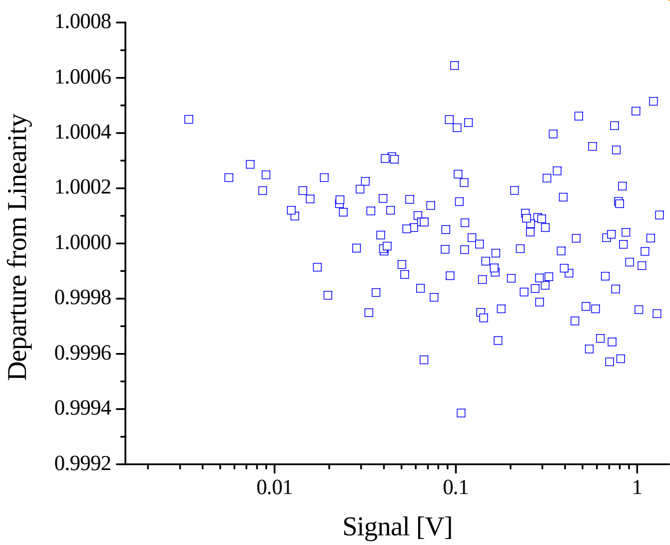
E_s channels calibrated outdoors; L channels calibrated in lab and used outdoors



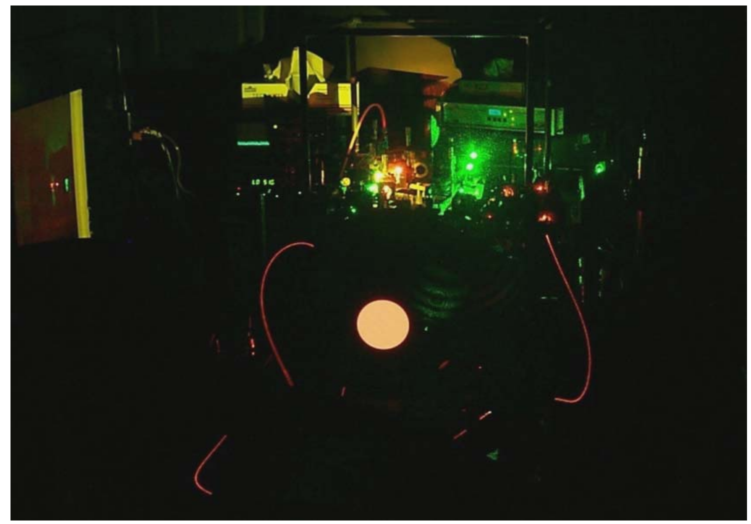
Example: Characterization of ASD

Linearity and SNR





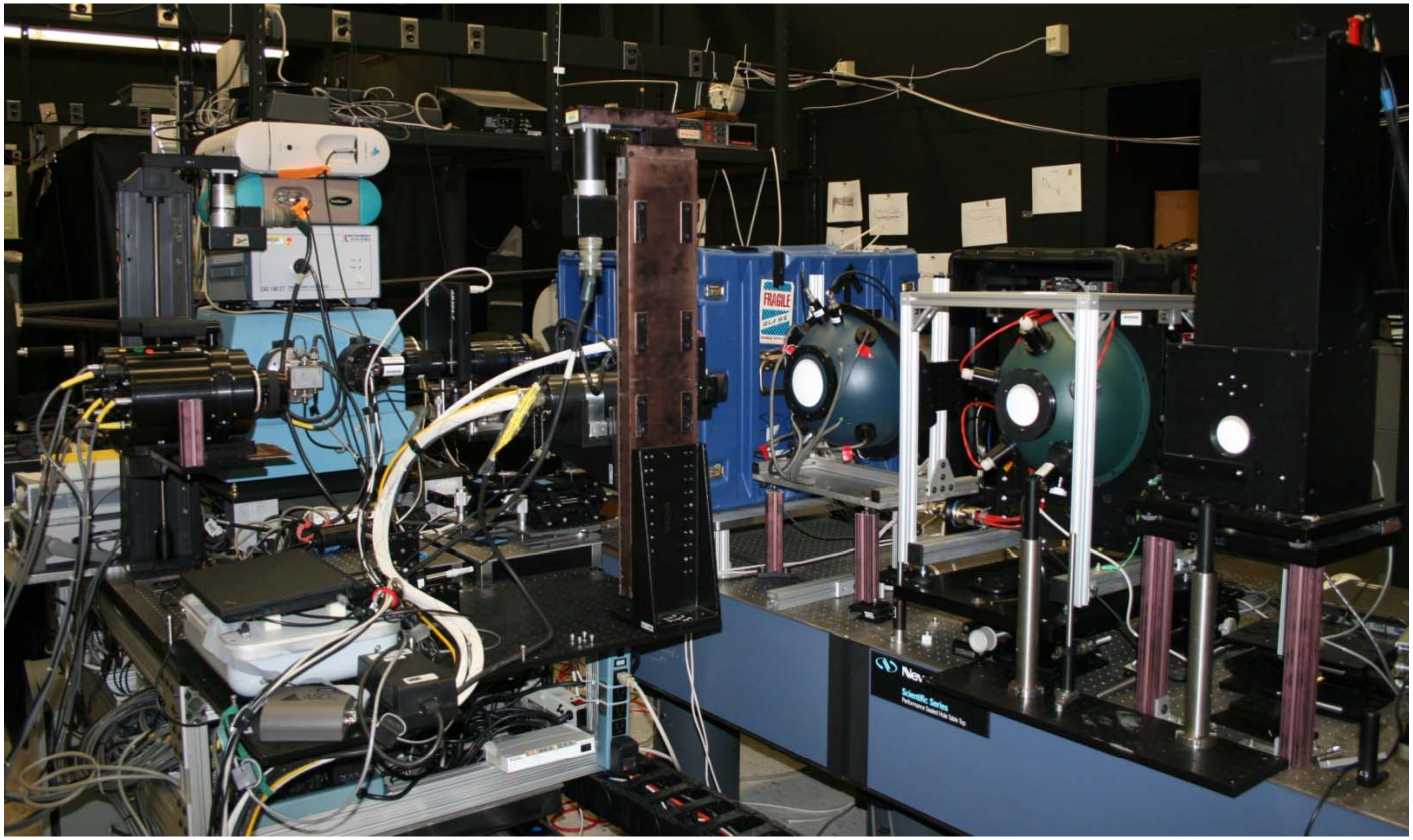
Beamconjoiner (additive method)



SIRCUS (reference monitor photodiode)

E and L channels required to cover wide dynamic range

Stability and Validation



The Remote Sensing Laboratory has sphere and lamp/plaque sources, filter radiometers, scanning monochromators and spectrographs for performance testing, validation, and comparison activities.

[1]Use simultaneous acquisition for channels (requires instrument redesign)

Uncertainty Budget, 1/2

Uncertainty Component	Description and Comments
Radiometric Reference Source	
GSFC integrating sphere for Radiance	As realized at GSFC using NIST FEL irradiance lamps
Stability	Of the sphere source with time
Sun Photometry at GSFC for Irradiance	Systematic effects must be included
Transfer to the CIMELs (either E or L)	
Spectral interpolations	Radiometric reference values; CIMEL channel’s spectral response
Reproducibility	“Changed” conditions of measurement
Wavelength and bandpass	Sensitivity on retrievals is complicated, includes band-shifting if necessary
Spectral out of band	Amount of bias depends -- if sun or sky/sea
Temperature	Correction applied for NIR channel, but AΩ and electronics is a concern
Instrument Stability during the Deployment	
System response	No in situ data, estimate from pre/post calibration
Fouling and degradation	No in situ data, estimate from pre/post calibration

Uncertainty Budget, 2/2

Uncertainty Component	Description and Comments
Environmental	
Cloud contamination	Es channels (threshold values)
Wave effects	Compare independent Lwn values
Natural variability	Compare independent Lwn values
Platform shadow	Mitigate with instrument mounting
Temperature	Characterize and correct
Analysis and Model Sensitivity	
Filtering of sea radiances	High values erroneous because of glint
Calculation of Lw from Lsky & Lsea	Measurement uncertainty, geometry, reflectance, wind speed, time differences in solar zenith angle
Calculation of Lwn from Lw	R/Q and f/Q are dependent on site optical properties and the diffuse transmittance τ_d
Quality assurance, control, screening	Non-physical results removed statistically

The Plan is to produce uncertainty budgets for the three new sites following the methods of Giuseppe Zibordi and extend using the additional instrument characterization data. The specific instrument tests are being discussed at this time.

Protocol Topics

- Site Suitability
  - adjacency effects (satellite sensor dependent)
  - bottom effects
  - adequate characterization of atmosphere
- Instrument limitations
  - sequential measurements of physical variables
  - filter sets result in band-shifting corrections
- Optical properties of site
  - need local band ratio algorithm for Chl a estimates
  - in-water values for Chl a, and IOPs a, b, and bb is desirable
- Theoretical efforts for f/Q in Case 2 (not in scope of this project)
- Investigate concept of field "stability" source

The Plan is to apply the Aeronet-OC protocols as developed by Giuseppe Zibordi and evaluate the application at the new sites.

Aeronet-OC Cal / Val

Status and Issues:

- Deliverable: Uncertainty Budget
  1. February 2010 attended Workshop at AGU (with Parr)
  2. Discussions with Zibordi
  3. Finalize plans March 2010
  4. Major technical issues and their impacts: None
- Deliverable: Protocols at the new sites
  1. March 2010 literature study, discussions with Zibordi
  2. Further advance plans during this review meeting team discussions
  3. Major technical issues and their impacts: None

Aeronet-OC Cal / Val

Summary : Impact of Deliverables on Program:

Additional in situ validation data is required for VIIRS initialization and mission, especially in complex coastal waters. This work will leverage off the tremendous efforts by Zibordi and his team and add new sites to the global network. The involvement of NIST aids in establishing and assessing traceability for the measurements.

Role of the milestones on IPO efforts (SDR/ EDR): SeaPRISM data and related ancillary data will be essential for validating VIIRS Remote Sensing reflectance and chlorophyll and other data products.

Role of efforts on other partners: Collaborating and sharing results and procedures for using the SeaPRISM data and ancillary data to validate satellite ocean color data products will be of great benefit.

Relationship to VIIRS Launch Schedule:

This is one year money. I hope to see the project extended, with NIST support and involvement in areas such as during deployment source stability tests, development or application of new technologies such as the simultaneous hyperspectral sensor we are developing as a MOBY-C sensor.

Aeronet-OC Cal / Val

Schedule with Major Deliverables

Red background indicates delays and green indicates on or ahead of schedule (as compared to FY09 DD1498)

Title Establishing a SeaPRISM site on the West Coast of the United States																				
Milestones	FY08				FY09				FY10				FY11				FY12			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Uncertainty Budget										**S**				**C**						
2. Aeronet OC protocols										**S**				**C**						

Note: Timeliness of deliverables science and transition (i.e., documents/demo/software, etc). Indicate changes from FY09 1498 by highlighting original planned time in red. <u>You can use this table legend:</u>
S – Start, C – Complete, D – Demo, P – Products (data) I-Issues, M - Manual/Documentation, R – Final Report, T- Transition

on the West Coast of the United States

1) Define a VIIRS Proxy Data Stream

2) Define the required in situ data stream for Cal/Val

3) Tuning of algorithms and LUTS (Vicarious calibration and SDR feedback)

4) Ocean Algorithm, stability evaluation and uncertainty

5) Product validation and product long-term stability

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Questions ?