"SUPPORTING *IN SITU* & SPACE BASED MEASUREMENTS" NASA Workshop

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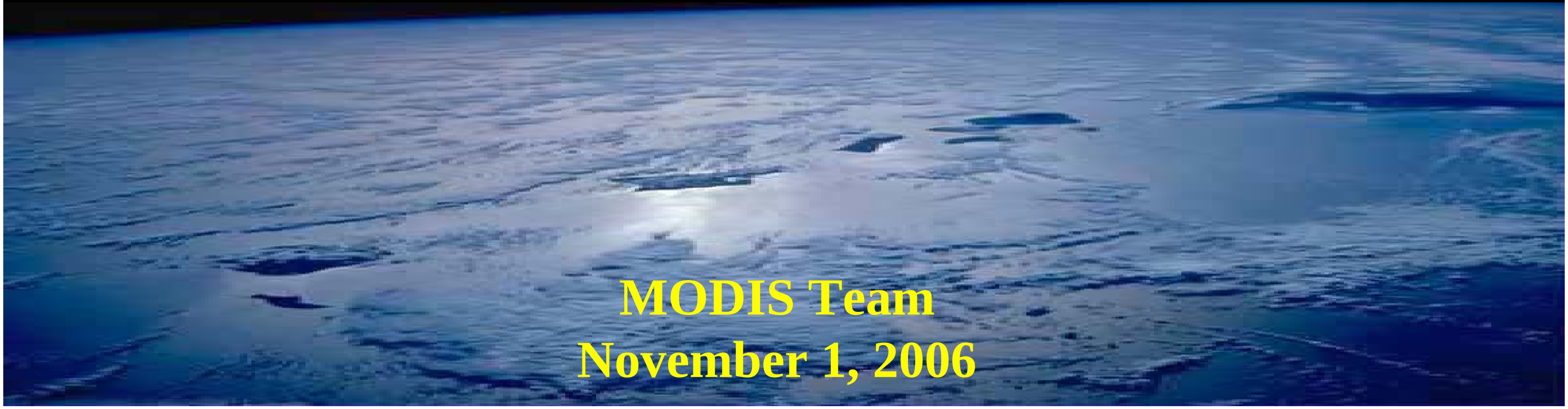

MODIS Team
November 1, 2006

Workshop Participants:

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Paula Bontempi, NASA Headquarters
Francisco Chavez, MBARI
Giulietta S. Fargion, San Diego State University,
Bryan A. Franz, SAIC, Ocean Biology Processing Group
Ricardo M Letelier, Oregon State University
Stéphane Maritorena, UCSB
Charles R. McClain, GSFC, NASA
B. Greg Mitchell, Scripps Institution of Oceanography
Andre Morel, Observatoire Océanologique de Villefranche
Cyril Moulin, Laboratoire des Sciences du Climat et de l'Environnement
Alexander Smirnov, AERONET, GSFC
Dariusz Stramski, Scripps Institution of Oceanography
Kenneth J. Voss, Physics Department University of Miami
P. Jeremy Werdell, SSAI, Ocean Biology Processing Group
J. Ronald V. Zaneveld, WetLabs

Agenda:

October 6, 2006

14:10 Welcome. P. Bontempi
14:20 Opening Remarks and Goals. G. Fargion
14:40 AERONET & Upcoming Measurements Over the Oceans. A. Smirnov
14:45 Phytoplankton Functional Types. C. Moulin
15:05 Road Map for Integrating Ocean Color into Models. B. Arnone
15:25 European Ocean Color Climate Data Sets. A. Morel
15:50 Open discussion focusing on scientific questions, observational requirements, satellite missions and other
18:30 Adjourn

October 7, 2006

8:15 Open discussion focusing on which *in situ* parameters, possible ranking as required, recommended,
13:30 Lunch
14:30 Break out group discussion: focusing on feasibility/accuracy of the in situ measurement methods for each parameter; the time frame within which we can hope to have "reliable" measurements (immediate, short- mid- long-term) for the parameters.
16:00 Group reporting & discussion
16:30 Closing comments. P. Bontempi
17:25 Adjournment

Emerging Scientific Questions for NASA OBB Program

How are ocean ecosystems and the biodiversity they support influenced by climate or environmental variability and change, and how will these changes occur over time?

How do carbon and other elements transition between ocean pools and pass through the Earth System, and how do these biogeochemical fluxes impact the ocean and Earth's climate over time?

How (and why) is the diversity and geographical distribution of coastal marine habitats changing, and what are the implications for the well-being of human society?

How do hazards and pollutants impact the hydrography and biology of the coastal zone? How do they affect us, and can we mitigate their effects?

Define the Scientific Questions

Observational Requirements & Strategies:

Carbon missions considered by the group were:

- MODIS and SeaWiFS
- VIIIRS
- Advanced

  multi-spectral LEO UV to SWIR
  hyperspectral GEO, high spatial resolution

- LIDAR, mixed layer

- What measurements do we need (including the priorities)?
- What can be measured with current or future sensors or *in situ* programs;
- What observational strategy?
- What kind of spatial and temporal resolution do we need in order to "measure" it?
- What do we need to develop?

What we expected from this workshop :

A revised straw man list of parameters grouped by time (1-5, 5-10 & 10+ years). The list should include:

- the targeted goal;
- the parameters needed to develop/validate algorithms or models for that goal;
- the feasibility/accuracy of the *in situ* measurement methods for each parameter;
- the time frame within which we can hope to have "reliable" measurements (immediate, short- mid- long-term) for the parameters.

If there are measurement issues (protocol, accuracy, instrument maturity, etc.), then we should not be out collecting data until they are addressed. This will help prioritize what measurements get funded early and which will need to be deferred to later.

The group made the following overall recommendations:

- Collect a_cdom with all chlorophyll samples;
- Collect species counts with HPLC pigments;
- Collect AOPs and IOPs into the UV (300-800nm);
- Need full radiance distributions; and
- Need volume-scattering functions.

All in situ data collected must be submitted to the NASA database holdings (SeaBASS)

The group discussed and identified the following straw man parameter list:

- Chlorophyll, PP, POC, PIC, DOC, carbon export, TSM and TOM, T, S, oxygen, PAR, PFTs (phyto and non-algal) – diatoms, pico, cocco, tricho, dino. CDOM, pCO2 – DIC/alkalinity, land-ocean exchange, beam-c particles, PSD, nutrients and non-living PFTs

The participants broke-up into three groups:

1) AOP and IOP measurements,
2) Primary Production and
3) Characterizing standing stocks of seawater constituents including particle functional types.

Each group discussed the feasibility/accuracy of the *in situ* measurement methods for each parameter; and the time frame within which we can hope to have "reliable" measurements (immediate, short- mid- long-term) for the parameters.

AOP and IOP Measurements Group

Contributions from

Arnone, Maritorena, McClain, Morel, Stramski, Voss and Zaneveld

Recommendations:

- apparent and inherent optical properties be measured in the 300-900 nm range with the highest possible spectral resolution to take advantage of:
  - the better separability of absorption components in the UV;
  - the use of NIR in coastal waters; and
  - to support advanced atmospheric correction schemes.
- vertical profiles are measured rather than just sub-surface measurements;
- Protocols should be updated (in particular for acdm, acdom, sensitivity in oligotrophic waters and derivation of slopes)

AOP and IOP Measurements Group

Contributions from
Arnone, Maritorena, McClain, Morel, Stramski, Voss and Zaneveld

Recommendations (cont.):

- NASA organize a workshop on backscattering instruments and measurement protocols. During such a workshop the participants should look into VSF and PSD measurements;
- operational definitions of the component absorption terms and backscattering should be revisited to take into account the fact that the filtering techniques involved in these determinations are not fully consistent.

The recommended IOPs and AOPs to be measured are listed below:

- AOPs
  - Lu, Ed, Es, Eu, Kd, KPAR. KPAR can be obtained with either a PAR sensor with a cosine collector or by integrating the Ed spectra if the spectral resolution of the measurements is sufficient; and
  - the upward spectral radiance distribution is also required to address BRDF issues and to validate existing BRDF correction schemes.

- IOPs:

IOP	Instrument/method	Issues - comments
a total	AC-9 AC-S Spectrophotometry Integrating cavity	* Calibrations * Post-processing information (Salinity, temperature, corrections, volume filtered,....) must be in SeaBASS metadata * Ver tical distribution (spectrophotometry covers the whole wavelength range from UV to NIR but samples at discrete depths. AC-9 like instruments do not cover the whole spectral range but make complete vertical profiles).
ap, aphy, ad	AC-9 (w/ filter) AC-S (w/ filter) Spectrophotometry Integrating cavity	* Methods for ad: Kishino, Tassan and spectral decomposition. * Beta value or correction scheme, filtered volume must be in SeaBASS metadata
Acdom	Fluorometry Capillary waveguide Spectrophotometry AC-9 (w/ filter) AC-S (w/ filter) Integrating cavity	* Calibration. * Protocols. * Sensitivity in oligotrophic waters * Pure water * Slope calculation, zero value, how far in the UV.
B	AC-9 (w/ filter) AC-S (w/ filter) Transmissometer	* Calibrations * It is recommended that VSF and/or PSD is also measured with b or bb. * Pathlengths * Post-processing information (Salinity, temperature, corrections, volume filtered,....) must be in SeaBASS metadata
Bb	Hydroscat ECoVSF VST (?) B. Balch's method LIST (?)	* Calibrations * It is recommended that VSF and/or PSD is also measured with b or bb. * Spectral characteristics, measurement angle(s) should be specified.
c	AC-9 AC-S Transmissometer	* Calibrations * Pathlengths

Primary Production Group

Contributions from
Balch, Behrenfeld, Chavez, Letelier and Mitchell.

Improvements to modeling production will require information on, or observations of:

- Mixed layer light levels, which are a function of the physiological mixing depth, spectral downwelling sunlight, and spectral attenuation,
- Phytoplankton absorption,
- Temperature, and
- Nutricline depth, which is helpful for describing changes in photosynthetic efficiencies, subsurface structure of phytoplankton pigment and biomass, and export or 'new' production

Primary Production Group

Contributions from

Balch, Behrenfeld, Chavez, Letelier and Mitchell.

- Field observations should aim to measure all of the presented properties simultaneously and should obviously be accompanied by measurements of carbon fixation (14C).
- **Recommendations:** consideration/measurements should be given/made of the photosynthetic energy invested into calcium carbonate structures - which influence 14C measurements and are an important factor in carbon export from the photic zone to depth.

Primary Production Group

Contributions from
Balch, Behrenfeld, Chavez, Letelier and Mitchell.

- Solar simulated fluorescence or variable fluorescence measurements were also recommended in support of developing productivity algorithms and for understanding observed physiological variability.
- Was not recommended that such measurements be used in a quantitative manner to estimate photosynthetic performance, but rather as an index for identifying regional differences in nutrient constraints.

Primary Production Group

Contributions from

Balch, Behrenfeld, Chavez, Letelier and Mitchell.

- Was recommended that field productivity studies supporting satellite carbon-based algorithm development include measurements of particle size distributions and, to the degree possible, observations that help resolve the contribution of different light scattering constituents.
- Work is also needed on developing new approaches for measuring phytoplankton carbon biomass in the field.

Parameters for Characterizing Standing Stocks of Seawater Constituents Including Particle Functional Types

Contributions from Stramski and Moulin

Standing Stock Parameters considered:

- 1) Chlorophyll a and Other Pigments;
- 2) DOC (Dissolved Organic Carbon)
- 3) POC (Particulate Organic Carbon)
- 4) PIC (Particulate Inorganic Carbon)
- 5) TSM (Total Suspended Matter)
- 6) PIM (Particulate Inorganic Matter defined as a non-combustible fraction of TSM);
- 7) POM (Particulate Organic Matter derived as a difference TSM-PIM);
- 8) DIC (Dissolved Inorganic Carbon) and Alkalinity;
- 9) PSD (Particle Size Distribution); and
- 10) PFTs (Particle Functional Types).

Parameters for Characterizing Standing Stocks of Seawater Constituents Including Particle Functional Types

Contributions from Stramski and Moulin

- We recommend to broaden the concept of PFTs from Phytoplankton Functional Types to Particle Functional Types.
- The enhanced concept of Particle Functional Types includes not only the Phytoplankton Functional Types but also Non-Phytoplankton Particle Types (such as various kinds of non-living particle types, heterotrophic microorganisms, and viruses).

Parameters for Characterizing Standing Stocks of Seawater Constituents Including Particle Functional Types

Contributions from Stramski and Moulin

- We expect that the report that is now being prepared by the IOCCG Working Group on PFTs will provide a useful synthesis of concepts related to Phytoplankton Functional Types, measurement methods for characterizing or quantifying these types, and the present status of our capabilities for retrieving information about these types from ocean color.
- Non-phytoplankton particle types will not be addressed in the IOCCG report, however.

Parameters for Characterizing Standing Stocks of Seawater Constituents Including Particle Functional Types

Contributions from Stramski and Moulin

- Status of Measurement Techniques and Protocols:
  - to parameters (1) through (8), the measurement techniques are available and have been used for a number of years.
  - Parameter 9 (PSD) the current status of measurement methodology appears not to be standardized. We recommend a NASA workshop to examine PSD measurements and methods with these different instruments in conjunction with the use of different instrumentation/methods for light scattering measurements
  - Parameter 10 (i.e., the suite of yet undefined or poorly/incompletely defined parameters for characterizing PFTs)

Parameters for Characterizing Standing Stocks of Seawater Constituents Including Particle Functional Types

Contributions from Stramski and Moulin

- At this time we do not suggest the submission of information about Phytoplankton Functional Types derived from HPLC pigments to the NASA database because there is no unified or unambiguous methodology for converting pigment data into PFTs.
- We also suggest considering data obtained with various instrumentation such as flow cytometer, FlowCam, or microscopes as an important source of information on PFTs, and possibly initiating the submission of these data to the NASA database.