IOCCG Working Groups

- Address technical and scientific issues related to remote sensing of ocean colour and its application
- Small, international working groups (~ 10-15 members) convened and sponsored by IOCCG
- Each group consists of leading experts in the field (not necessarily members of the IOCCG), chaired by a specialist
- Each group holds a mini-workshop (3-5 days) to discuss the topic and agree on approach
- End product: an IOCCG Report (written by members of the working group, reviewed by IOCCG Committee)
- Reports are freely available to the scientific community and agencies

IOCCG Report No. 1 (1998)

Minimum Requirements for an Operational Ocean-Colour Sensor for the Open Ocean

By

A. Morel (Chair), V. Barale, A. Bricaud, J. Campbell, N. Hoepffner, M. Kishino, M. Lewis, S. Sathyendranath and J. Yoder

- Long-term goal: continuous, unbroken, satellite ocean-colour observations into the indefinite future

- Is it possible to meet requirements for an operational ocean-colour mission based on a simple sensor?

- If so, this minimal band an set should be carried on all future sensors regardless of their other capabilities and number of channels

- Advantages:
  - easy intercomparison between sensors
  - compatibility of operational algorithms
  - meaningful data merging
  - continuity of ocean-colour observations based on comparable parameters
  - coherent data base for biogeochemical studies, physical models and climatological studies

Bands required for ocean colour observations

- Ocean colour is modelled as a simple function of the absorption and backscattering coefficients
- Most important pigment is chlorophyll-*a* – absorbs in the blue and red
- High absorption coefficient of water at wavelengths > ~590 nm
- Changes in blue (443 nm)-green (550-580 nm) ratio of reflectance interpreted as changes in chl-*a*
- Alternatively, use 490 nm (instead of 443 nm) at high pigment concentrations (also better atmospheric correction)
- Accurate atmospheric correction is essential for interpretation of data
- At least 2 wavebands in the NIR required
- For detection of yellow substances, additional channel at 410 nm

Recommendations

To monitor a pigment index in Case 1 waters, detect sediments in coastal environments and assess aerosols, **a minimal set of 5 channels** should be adopted (2 for atmospheric correction and aerosol monitoring and 3 for oceanic variables):

Visible	438-448 nm (low-medium chl concentration)
	485-495 nm (medium-high chl concentration)
	550-565 nm (all chl /sediment turbidity)
NIR	744-757 nm (aerosol characterization)
	855-890 nm (aerosol characterization)

Additional channel recommended at 407-417 nm (detection of yellow substances)

Other requirements

- High signal-to-noise ratio in all channels
- Radiometric stability (in-flight calibration, inter-calibration between sensors)
- Adequate dynamic range

IOCCG Report No. 2 (1999)

Status and Plans for Satellite Ocean Colour Missions: Considerations for Complementary Missions

By

J. Yoder (Editor), W. Gregg, N. Hoepffner, J. Parslow, T. Platt, M. Rast, S. Sathyendranath, T. Tanaka

Objective: To provide Space Agencies with the information necessary for them to begin developing an internationally-coordinated plan for the uninterrupted delivery of ocean-colour data into the indefinite future.

- Utility of ocean-colour data
- Technical requirements for global-scale, remote sensing of ocean colour in both Case 1 and Case 2 waters
- Issues of complementarity (more than one sensor with similar capabilities in orbit at the same time)

IOCCG Report No. 2

Utility of Ocean Colour Data

- **Quantifying carbon flux**.
  Primary production calculated from distribution of chl-*a*. Principal users are global change programmes (*e.g*. JGOFS)

- **Upper Ocean Processes**
  Upper ocean heat flux calculations, numerical models, effects of climate and other large-scale phenomena (*e.g*. El Niño)

- **Management of the coastal zone**
  Water quality parameters, erosion/sediment transport, toxic blooms, fisheries information

Technical Requirements for Satellite Ocean-Colour Sensors

Ocean-colour mission should meet the following 5 technical requirements:

(i) sensors with appropriate number and placement of spectral bands, SNR performance and swath characteristics
(ii) calibration programmes (sensor stability)
(iii) appropriate algorithms to calculate data products
(iv) validation programmes
(v) mechanisms for timely delivery of data products

Report Number 2 deals with key requirements within criterion (i)

Technical Requirements for Open Ocean, Global Missions:

- Global coverage every 3-5 days
- 4- to 5-km pixel resolution (minimum 10-km pixels)
- Minimum set of 5 bands (Report No. 1)
- Minimum of 3 global satellites operating simultaneously to achieve 60% ocean coverage in 4 days (1 satellite observes only 15% of the ocean per day - sun-glint, clouds)

Technical Requirements for Coastal Applications:

- One-day coverage
- 0.1 – 0.5-km pixel resolution
- Increased spectral resolution required: bands at 410 nm for yellow substances, triplet for chl-*a* fluorescence (660-680-710), 620 nm for water turbidity, additional channels in NIR for aerosol correction (MODIS, MERIS, GLI).

IOCCG Report No. 2 ….3

Assessment of Sensors up to 2005

Sensors that meet all 5 criteria for open-ocean missions:

SeaWiFS
MODIS-AM
MERIS
GLI and POLDER-2
MODIS-PM

Other missions:

MOS – does not provide global coverage
OCM – proof of concept mission
OCI – only covers subtropical latitudes, does not have 2 NIR bands
OSMI - proof of concept mission, does not have 2 NIR bands
NEMO, ARIES – hyperspectral sensors for coastal applications

The 3-satellite requirement: can be met by MODIS-AM, MERIS and GLI for the period 1999-2002

Backups: Sea WiFS in early part of this period, MODIS-PM at the end till 2005 (launch delays, mission failures etc.)

Strategy for post-2005 timeframe

- Multiple, well-coordinated missions are required for continuous global coverage
- Combined data from missions with complementary swath widths, equatorial crossing times and tilt capability can vastly improve coverage
- Cooperation required at mission planning stage: a strategic plan should be developed (consistent data processing, calibration, phasing of missions, complementarity of performances, data merging)
- IOCCG is willing to assist the agencies

IOCCG Report No. 3 (In Prep.)

Applications of Ocean-Colour Data in Case 2 Waters

By

**S. Sathyendranath (Editor), R. Arnone, M. Babin, R. Bukata,
J. Campbell, C. Davis, R. Doerffer, M. Dowell, N. Hoepffner,
J. Kirk, M. Kishino, H. Krawczyk, A. Neumann,
J. Parslow, P. Schlittenhardt**

Overview: Report reviews the progress in remote sensing of Case 2 waters, and provides recommendations for the future (algorithm development, sensor design).

- ♦ Composition and optical properties of Case 2 waters are more complex than Case 1 waters (contributions from phytoplankton, suspended sediments, yellow substances and perhaps bottom reflectance)
- ♦ Multi-waveband algorithms are required to unravel non-linear, spectrally-varying interactions among at least three variables
- ♦ Technical requirements of ocean-colour sensors for Case 2 waters are more stringent (spectral resolution, radiometric accuracy).

Some of the questions addressed

- ♦ What additional wavebands are required to distinguish among phytoplankton, yellow substances and suspended sediments?
- ♦ Can universal algorithms deal with all possible conditions and combinations, or is it better to develop regional algorithms optimized for local conditions?
- ♦ Do the atmospheric correction algorithms developed for Case 1 waters hold in Case 2 waters?
- ♦ How to determine if the signal is influenced by bottom reflectance?

Algorithms for Case 2 waters

- Desired products: suspended sediments, yellow substances, chl-*a*, bottom depth and type
- Inversion of semi-analytical models
- Iterative techniques
- Neural network approach
- Empirical approach
- Regional versus generic algorithms

Requirements for Case 2 waters

- Sensor requirements
- *In situ* data for model parameterisation and validation
- Protocols and standards for *in situ* data collection

Secondary Products and Applications

- Primary production
- Fisheries management
- Aquaculture
- Environmental monitoring
- Harmful or unusual algal blooms

IOCCG Report No. 4

Absolute Calibration of Ocean Colour Sensors to Common Standards
(Meeting 16 September, 1999)

A. Neumann (Chair), R. Barnes (SIMBIOS), P-Y. Deschamps, R. Frouin, H. Fukushima, O. Kopelevich, H. Krawczyk, H-W. Li, A. Lifermann, J-M. Nicolas, M. Rast, G. Zibordi, G. Zimmermann…….

Aim:

To investigate the calibration of ocean-colour instruments to a common standard (will include absolute scale calibrations as well as radiometric intercalibration of sensors).

Composition of Working Group:

The working group will include at least one representative from each agency operating or planning an ocean-colour sensor, as well as experts in field and laboratory measurements (SIMBIOS representatives).

Topics to be covered by Report:

- **Pre-launch (laboratory) calibration**
  - Radiance and irradiance standards (intercomparisons of different national standards)
  - Geometrical and spectral problems w.r.t. sensor principals
  - Recommendations on laboratory procedures

- **In-orbit stability monitoring**
  - Relative calibration procedures using internal (lamps, LEDs) and external (moon) light sources

- **Absolute in-orbit calibration**
  - Sun calibration
  - Diffuser related problems, degradation…

- **Intercalibration of ocean-colour sensor**
  - Based on sun/moon measurements
  - Based on nadir measurements

- **Vicarious calibration**
  - calibration link between spaceborne and groundbased instruments
  - influence of atmospheric correction
  - other errors
  - test site selection

IOCCG WG: Establishment of a Standard Validation Data Set

J. Ishizaka, J. Yoder…..

(Conceptual stage)

Aim: To identify a source of sea truth data for Space Agencies and Users, which can be used to:

- confirm the calibration of new sensors
- ensure the accuracy of satellite data (validation)
- detect the bias of each sensor (merging data sets)
- detect regional bias

Approach:

Locate major data bases of past (CZCS period) and present sea truth data including:

- chlorophyll-*a* and phaeopigments
- water leaving radiance?
- attenuation?
- other optical properties?

Strategy:

- Request oceanographic community to support this effort
- Create a web-site to provide information for agencies and users
- Produce a brief report elaborating various points, including protocols on how to collect the data.

IOCCG WG: Data Merging

J. Campbell, T. Tanaka, P. Schlittenhardt

(Preliminary meetings, proposals etc.)

Aim: To examine the steps required to produce a merged long-term, global, chlorophyll data set, taking into account issues such as atmospheric correction.

The IOCCG recognizes that it should take responsibility for ensuring a long-term data series at a global scale and that there should be some liaison with CEOS, SIMBIOS, Agencies etc. While the IOCCG does not have the resources to produce a large, merged, data set, it could implement a strategy to achieve this.

Approach:

- Establish points of contact at each of the three major agencies that provide ocean-colour data (NASA, NASDA, ESA)
- Submit proposals to NASA/SIMBIOS and EC for funding
- Examine steps required to merge Level 2 data from different sensors…

IOCCG WG: International Ocean Colour Cruise

(Conceptual stage)

R. Frouin, O. Kopelevich…

Objectives of the Cruise:

- To support the satellite missions during their operational phase (vicarious calibration, evaluation of algorithms, intercalibration of instruments etc.)
- To educate students/scientists in marine optics, satellite remote sensing, and ocean bio-geochemistry
- To publicize ocean colour on a world-wide scale

Outline:

- Cruise would consist of six 1-month legs on a research vessel from the Shirshov Institute of Oceanology (Russia) , starting in Fall 2000
- Formal courses for graduate students in marine optics, oceanography, *in situ* measurement techniques, and remote sensing on board
- Cal/Val activities on board (scientists and students)
- Public lecturers/conferences in Port

Approach:

- Planning Committee to be selected (responsible for science, education, logistics, public relations, finance etc.)
- Set up a Project Office at Scripps?
- Solicit funding (from agencies, education and capacity building programmes, other organisations)