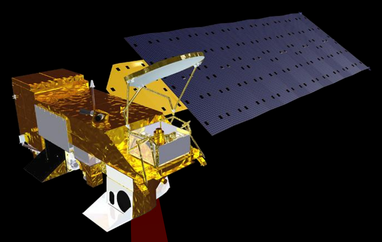

Consensus on aquatic primary productivity field protocols for satellite validation and model synthesis

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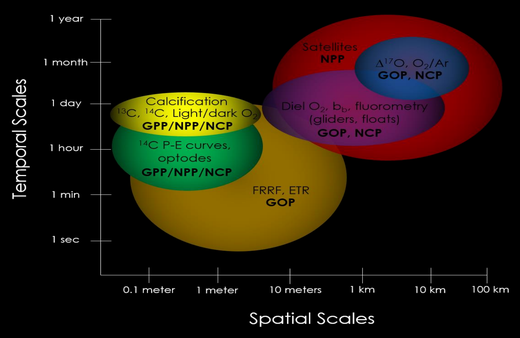
The NASA PACE project, in conjunction with the IOCCG, EUMETSAT, and JAXA, have initiated an Aquatic Primary Productivity working group, with the aim to develop community consensus on multiple methods for measuring aquatic primary productivity used for satellite validation and model synthesis. A workshop to commence the working group efforts was held December 05-07, 2018 at the University Space Research Association headquarters in Columbia, MD U.S.A., bringing together 26 active researchers from 16 institutions. The group discussed the primary differences, nuances, scales, uncertainties, definitions, and best practices for measurements of primary productivity derived from in situ/on-deck/laboratory radio/stable isotope incubations, dissolved oxygen concentrations (from incubations or autonomous platforms such as floats or gliders), oxygen-argon ratios, triple oxygen isotopes, natural fluorescence, and FRRF/ETR/kinetic analysis.

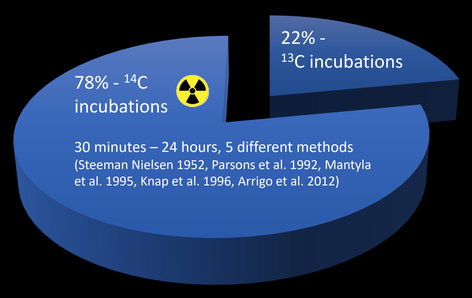


WHY ARE WE DOING THIS?

In spite of the ubiquitous nature of primary productivity measurements in oceanographic research, it is notable that perhaps no single measurement in the suite of significant oceanographic observations exhibits as much methodological diversity as well as interpretive ambiguity. The techniques to quantify the input of reduced carbon into the aquatic biosphere do so on varying time and space scales, are dependent on different assumptions, and measure photosynthetic processes that are linked, but often de-coupled, thus leading to significant biases between measurements. The lack of a standard protocol for primary productivity presents a challenge in attempting to integrate and reconcile measurements to establish a robust validation dataset in a similar manner to other ocean color algorithms.

The necessary preamble for the development of new algorithms for ocean parameters is the establishment of in situ data records, such as those in NASA's SeaWiFS Bio-optical Archive and Storage System (SeaBASS). NASA's mandate to collect and distribute in situ data of the highest quality to support their satellite algorithm development and data product validation activities requires that those field measurements be generated with a documented uncertainty in keeping with established performance metrics for producing climate-quality data records. Lack of uniformed consensus protocols precludes a complete assessment of algorithm uncertainty and the accuracy of satellite data products. The reasons above point to an urgent need to develop community consensus on best practices protocols for various primary productivity measurement approaches, and define the uncertainty associated with each type of measurement. Accurate determination of carbon cycle parameters is central to space agency priorities and is required for the success of current and future programs in producing climate-quality data from sea-going platforms and space borne sensors.

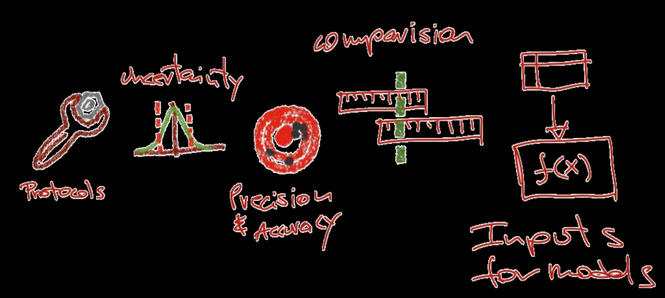
NASA/IOCCG Aquatic Primary Productivity Workshop Participants
Top row, left to right: Solange Duhamel, Mary Jane Perry, Helga Gomes, Maxim Gorbunov, Gemma Kulk, Greg Silsbe, Roo Nicholson, Rachel Stanley, Patrick Neale, John Marra, Mark Brzezinski, Barney Balch, Tomonori Isada, Laurie Juranek, SeungHyun Son, Toru Hirawake; Bottom row, left to right: Joaquim Goes, Ana Fernandez Carrera, Antonio Mannino, Ryan Vandermeulen, Ricardo Letelier, Kimberly Halsey, Priscila Kienteca Lange, Joaquin Chaves. Other participants (not pictured): Joe Salisbury, Susanne Craig, Jeremy Werdell, Paula Bontempi.



NASA SeaBASS Primary Productivity Submissions

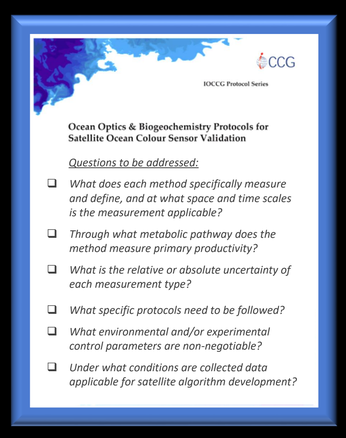
✓ Objectives of the Primary Productivity Working Group:

- Normalize emerging technologies
- Determine consensus on best practices
- Strictly define applicability and uncertainties
- Establish priorities for future science



THE CHALLENGES, IN A NUTSHELL

The combination of modeling efforts with satellite observations, is the only viable path to gauge the rate of marine carbon fixation at a global scale, and thus is critical to evaluate model outputs against accurate in situ measurements from diverse regions. However, the field measurements used to calibrate and validate these models/observations can exhibit large environmental or experimental variability due to temperature, light source/quality, filtration, bottle effects, length and type of incubations, inherent assumptions made about respiration and dissolved losses and the depth of the photic zone, grazing, regenerated production, quantum yield, as well as mixing and air-sea exchange, among others. Rather surprisingly, results from identical samples analyzed at different laboratories have shown an average coefficient of variation on the order of 25-40% (Richardson 1991). Nevertheless, systematic and random biases can be minimized through better understanding of assumptions and limitations of the various available measurement approaches and by promoting best practices.


IOCCG Protocol Series

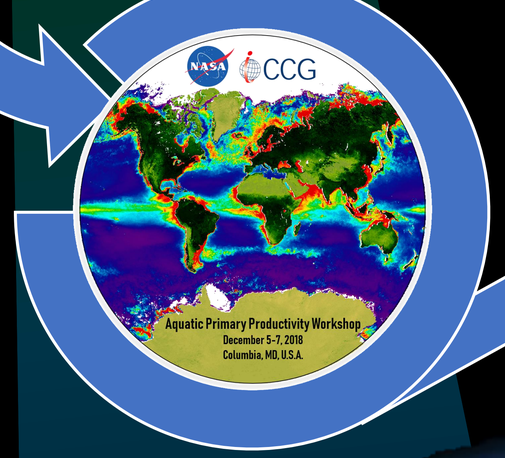
Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

Questions to be addressed:

- *What does each method specifically measure and define, and at what space and time scales is the measurement applicable?*
- *Through what metabolic pathway does the method measure primary productivity?*
- *What is the relative or absolute uncertainty of each measurement type?*
- *What specific protocols need to be followed?*
- *What environmental and/or experimental control parameters are non-negotiable?*
- *Under what conditions are collected data applicable for satellite algorithm development?*

OUTCOMES AND DELIVERABLES:

The discussions initiated by the working group highlighted the necessity to move the community forward towards the establishment of climate-quality primary productivity measurements that follow uniform protocols, which is imperative to ensure that existing and future measurements can be compared, assimilated, and their uncertainties determined for model development and validation. The specific deliverable resulting from of this activity will be a synthesis document, published and distributed in coordination with IOCCG as a report, that will detail the consensus protocols devised by the sub-groups for each of the primary productivity methodologies. Each protocol chapter will review the historical context, development, and application for each technique, identify known biases and artifacts, and provide an assessment of method uncertainty. Each contribution will propose a set of state-of-the-art protocol guidelines. The synthesis document will be posted for public comment peer review for no less than 60 days. Thereafter, the editors and authors will resolve those comments and finalize the report. Our intention is for this report to be a living document that is updated as advances in techniques and technology allow for improved measurement capabilities.



PACE Plankton, Aerosol, Cloud, ocean Ecosystem

STAY UPDATED ON WG ACTIVITIES

Updates on the activities of the Aquatic Primary Productivity working group, including presentations and relevant contributions are provided on the NASA PACE website.

Scan the QR code to find out more on the Working Group's website