Remote Sensing of Phytoplankton Composition – Possibilities, Applications and Future Needs

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Objectives

- How current satellite phytoplankton composition products are and could be used in modeling (climate, ecosystem, optical) activities and ecosystem and fisheries management.

- *In situ* observational needs and opportunities to support forthcoming satellite capabilities leading to expanded satellite phytoplankton composition algorithm approaches and products.

Phytoplankton groups (PFT or PSC) from space: former and on-going efforts of community

2006-2014 IOCCG PFT working group & IOCCG report (#15)

2008-2010: 1st PFT algorithm intercomparison (focus on global dominance)

2011- : 2nd intercomparison round on global PFT algorithms (quantitative assessment - status shown today)

May 2013: IOCS Splinter Meeting on “PFTs from space” with recommendations to agencies

Oct 2014: IOCCG WS on “Phytoplankton Composition from Space: towards a validation strategy for satellite algorithms”
NASA TM #217528_01-22-15 - action items & recommendations

Action Items from breakout-group I: activities for current satellite PFT intercomparison and validation

In Progress:

- Intercomparison of algorithm phenology
- Database development
- Invitation for more PFT algorithms to take part
- User's Guide

Planned Validation:

- SeaWiFS level-2 and level-3 and SCIAMACHY match-ups
- Output from algorithm developers including output from various steps: IOPs , chl-a, …
- Characterizations based on regions, output (fraction, conc.) and type
- **Find ways for funding**

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Breakout-group II: work plan to prepare for validation of future missions

Recommendations:

1. Establish a number of validation sites that maintain measurements of a key set of variables (pigments, cell counts, volume, IOPs, AOPs, PSD, genetic / -omics data)
2. Undertake intercomparison of methods / instruments over several years at a few sites to understand algorithm capabilities to fully characterize the phytoplankton community.
3. More engagement with User groups

Action:

1) Propose splinter meeting at the IOCCG-IOCS

Focus at splinter meeting:

a) which locations are possible, what efforts have to be taken to reach that and specify round-robins among sites to secure measurement standards and calibration
b) Link with users

2) Find resources for workshops (partial support by space agencies and others)

Techniques for particle characterization, classification
Modeling and end user requirements
Data storage & management, standards for data, data challenges…

Agency readiness for PFT Algorithms

- ESA:
  - SynSenPFT Project using MERIS and SCIAMACHY, preparing for Copernicus (Sentinel-3 2015)
  - OC-CCI Mk2 – user requirements survey
- EUMETSAT:
  - User requirements being considered for PFTs from Sentinel-3e onwards following Ocean Optics consultation
- JAXA:
  - PFT dominance products specified (incl. red tides) for GCOM-C (2016/17)
  - Proposal to be sought for post-launch field validation campaign
- KIOST:
  - Testing of algorithms for PFTs from GOCI is underway
- NOAA NESDIS:
  - NESDIS STAR working with users to develop PFT requirements and products
  - VIIRS Cal/Val Field Campaigns will collect validation data for PFTs
- NASA:
  - PFTs will be major focus of PACE hyperspectral mission (~2023)
  - 1st stage PACE science team defined, focus on in situ observations
  - EXPORTS carbon export research program – prospective
  - Also relevant to Geo-CAPE and HyspIRI missions

Initial user product scoping from OOXXII

Product type	Application	Product specification	Units	Uncertainty (user requirement)	Examples of algorithms
Phytoplankton size structure	Open ocean: productivity assessments, trophic energy flows, fisheries, climate and ocean acidification assessments	• large (micro), medium (nano) and small (pico) phytoplankton • continuous phytoplankton size spectrum	• Dominant size class • Proportion of total population (% Chl or carbon) • Concentration (mg m^{-3} Chl or C)		• Uitz et al. 2006 • Hirata et al. 2008 • Brewin et al. 2010 • Devred et al. 2010 • Ciotti & Bricaud
	Coastal: as above	• As above	• As above		• Pan et al.2010
Biogeochemical functional types	Earth system, climate and ocean acidification assessments	• Multiple-functional types to characterise whole phytoplankton community • Coccolithophores (calcifiers) • Trichodesmium (N2 fixers) • Diatoms (carbon export) • Haptophytes (DMS producers) • Cyanobacteria	• Presence • Dominant type • Proportion of total population (% Chl or carbon) • Concentration (mg m^{-3} Chl or C) • Liths per m^{-3} (coccolithophores only) • Trichomes per m^{-3} (Trichodesmium only)		• Alvain et al. 2005 • Aiken et al. 2007 • Hirata et al. 2011 • Brown et al. • Shutler et al. • Dupuy et al. • McKinna et al.
HABs	Water quality	• High intensity blooms • Specific spectral signatures of known HAB types	• Presence/absence • Concentration (mg m^{-3} Chl or toxin, cells m^{-3})		

User's Guide Summary

- Focus on taxonomic classes, size classes and particle size distribution algorithms
- 4 algorithm types
    - Abundance, radiance, absorption and scattering

- Algorithm development inputs
- Satellite input/output products
- Validation data sources and metrics
- Summary of assumptions, strengths and limitations of the four algorithm types
- The aim is a digestible resource for non-algorithm developers who desire to use these products. Reduce the boundary of expert knowledge needed to make a sound selection with confidence by a variety of user groups

Guiding Questions

- Many of the approaches are globally focused; where as users often have a local interest. With the current validation and detection capabilities, how to we best serve interested users? How best can we communicate strengths and limitations so the appropriate products are matched with a given use?

- What is most valuable for users?

- What coordinated efforts in future satellite PFT algorithm development would have the most impact?

Actions to Address User Requirements

Gap Analysis			
	Existing	Needed	Desired
In situ Observations			
Algorithm Strengths/ Limitations			

Prioritized Implementation			
	Immediate	Near-term	Long-term
1			
2			
3			