International Ocean Colour Science Meeting 2019 | Advancing Global Ocean Colour Observations

Breakout WS 2: Going beyond HPLC: Coming to rapid consensus on science requirements for assessing phytoplankton composition from satellite imagery

Co-chairs: Astrid Bracher (AWI), Ryan Vandermeulen (NASA-GFSC), Stewart Bernard (CSIR)

Agenda

14:00-14:05 **Scope of BO, former efforts and overview**

14:05-14:25: **Minimum requirements for lab and field work and measurements for sufficient PFT algorithm evaluation**:
Colleen Mouw + Discussion

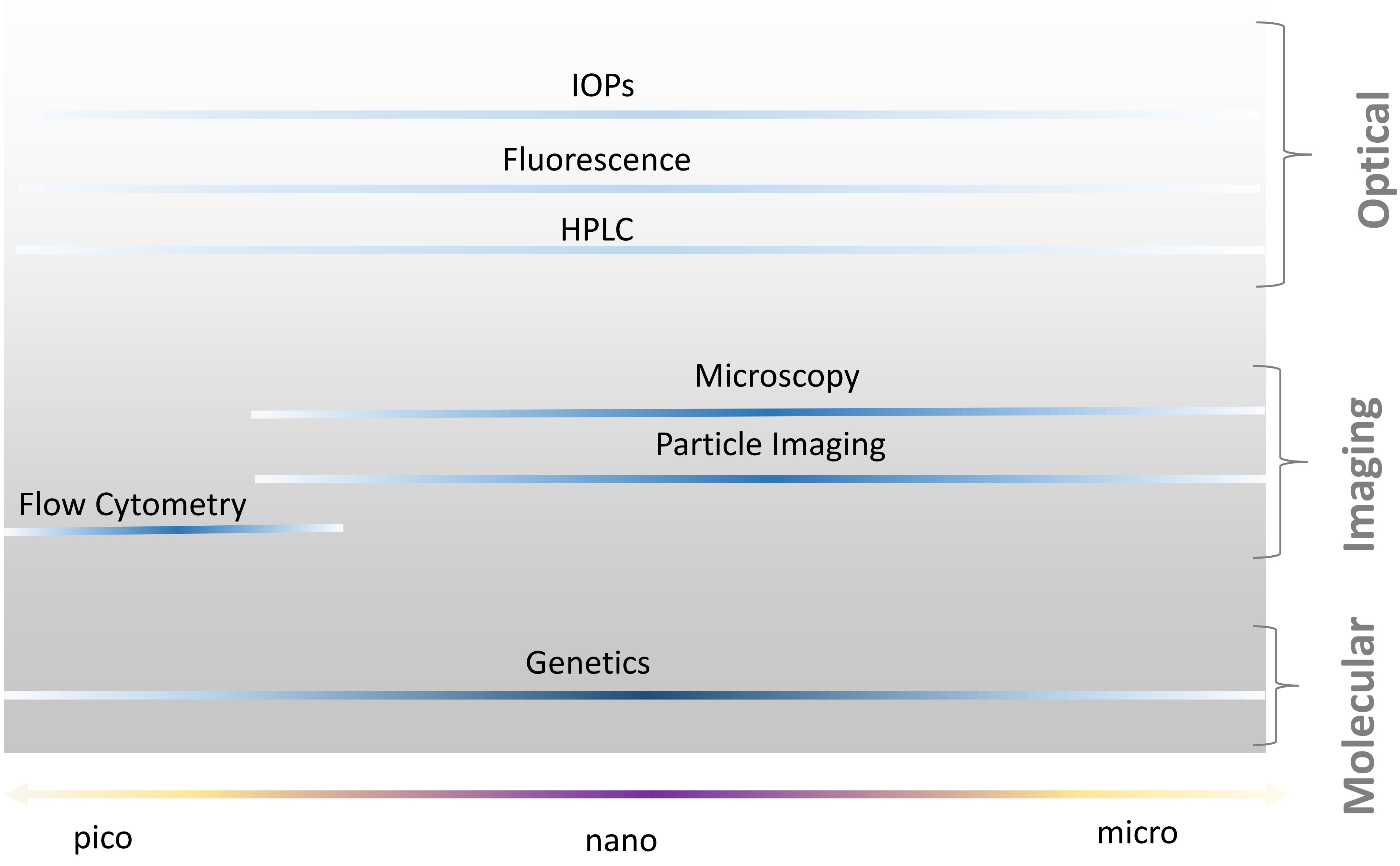
14:25-15:15: **Detection of phytoplankton blooms of specific groups and species – current achievements, gaps and next steps**:
Arnold Dekker, Shaoling Shang, Wonkook Kim, Ana Dogliotti, Tit Kutser, Tiho Kostadinov + Discussion

15:15-15:30: **Role of synthetic data sets and IOP/radiative transfer modelling for development and evaluation of hyperspectral vs multi-spectral detection for phytoplankton groups**
Hongyan Xi, Jianwei Wei + Discussion

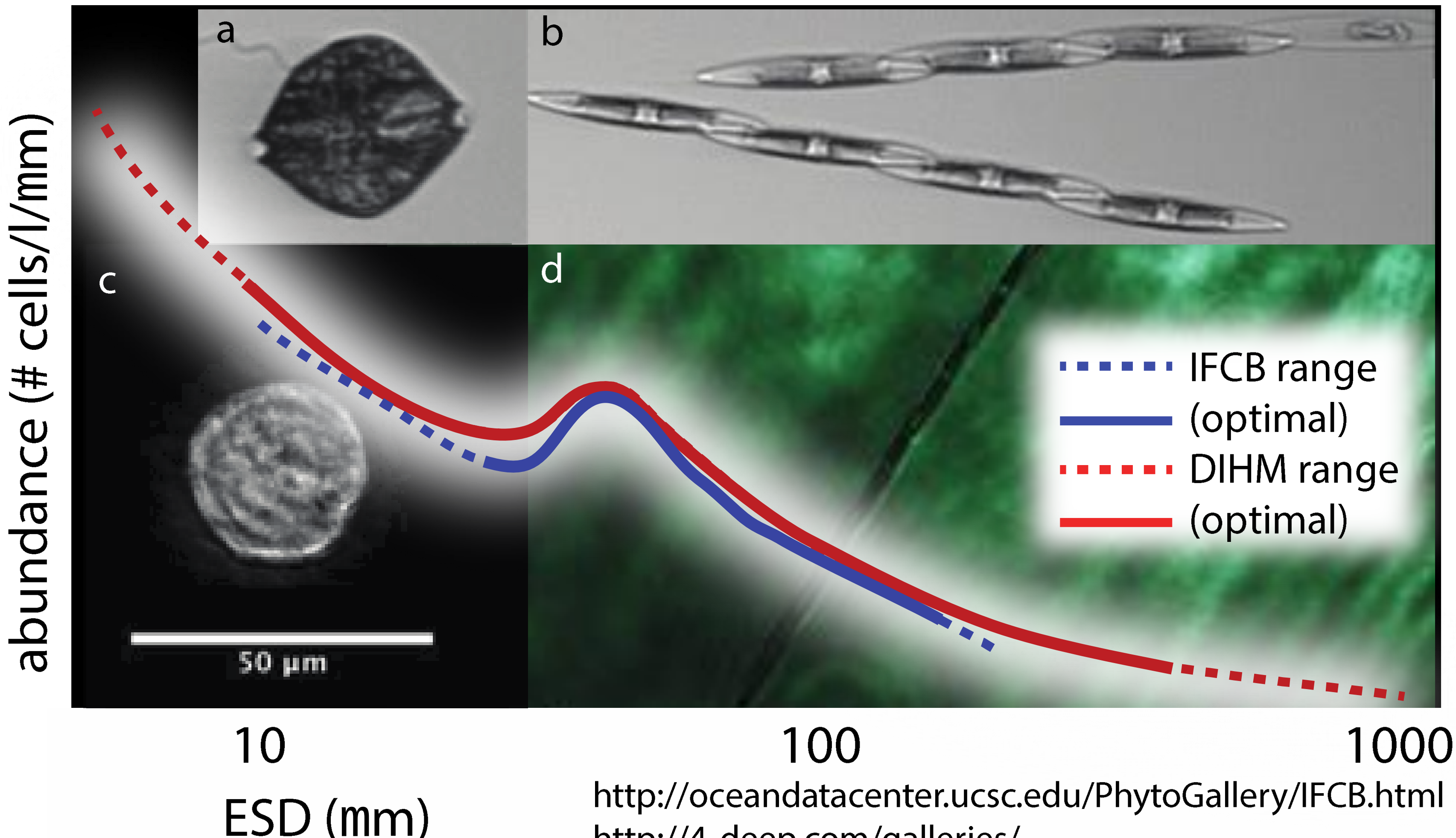
15:30-16:15 **How do we best utilise existing or recommend new programs to validate satellite approaches for detecting ephemeral blooms in the sea?**
Lesley Clementson, Ryan Vandermeulen, Shaoling Shang, Wonkook Kim, Astrid Bracher + Discussion

16:15-16:30: **Final discussion, summary and recommendations**

Range of Characterization & Level of Derivation from R_{rs}



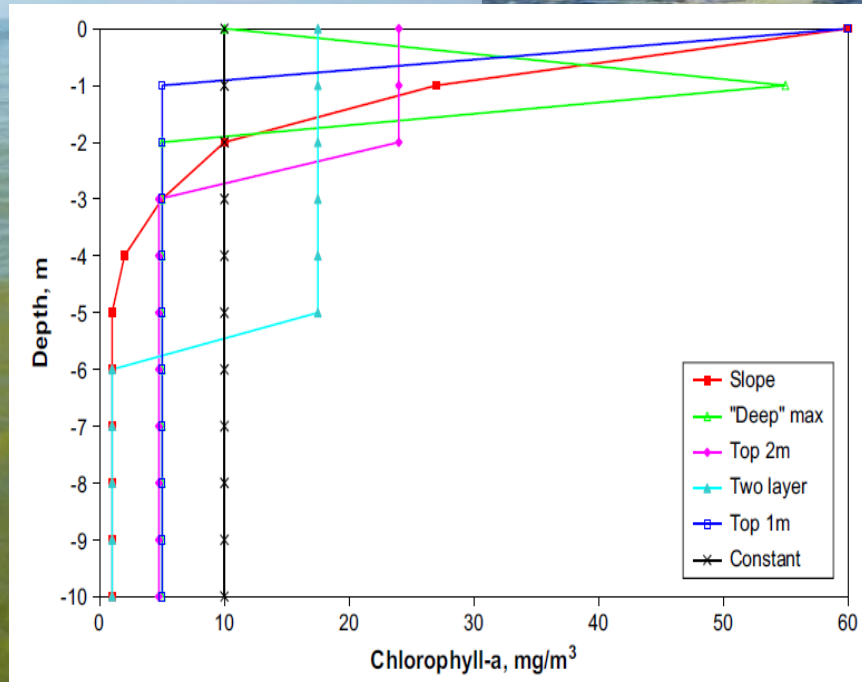
Particle Imaging – Instrumentation Differences

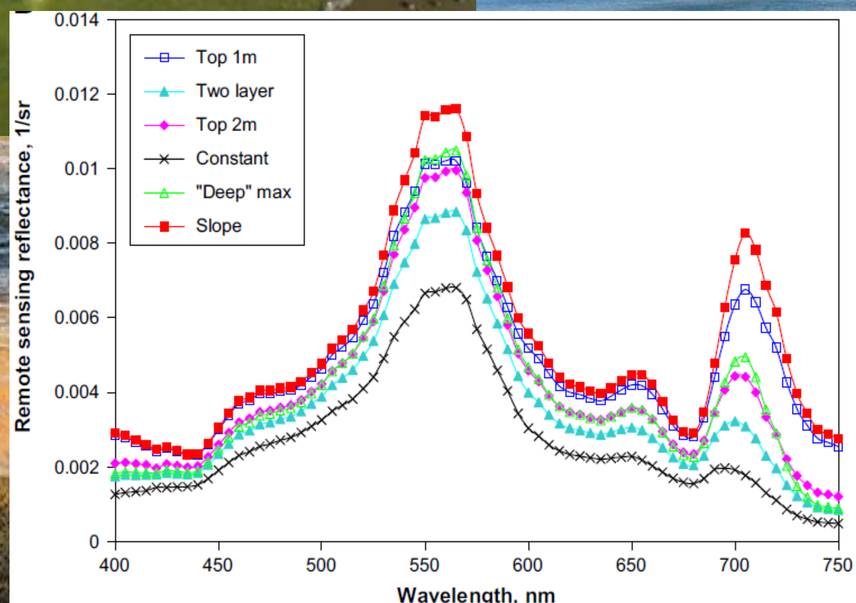


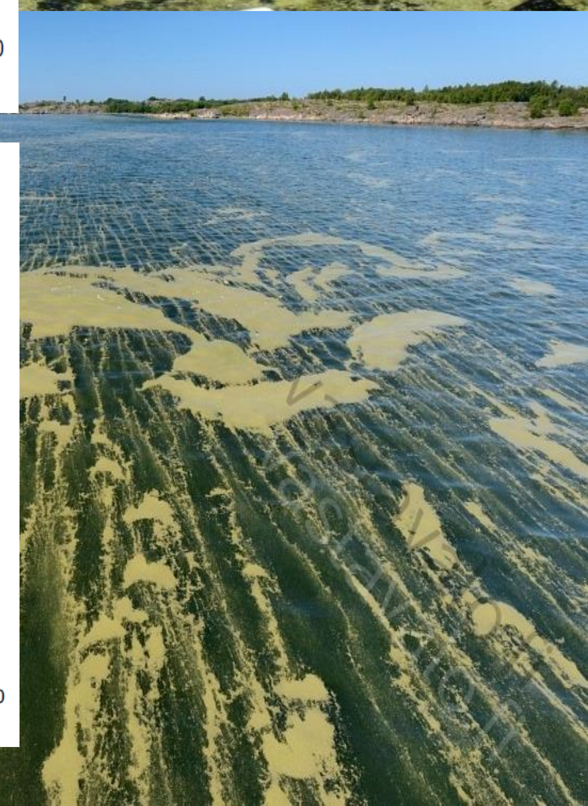
http://oceandatacenter.ucsc.edu/PhytoGallery/IFCB.html
http://4-deep.com/galleries/

Figure: Courtesy of Melissa Omand

Tit.Kutser@ut.ee







High biomass and only one species dominating, easy discrimination

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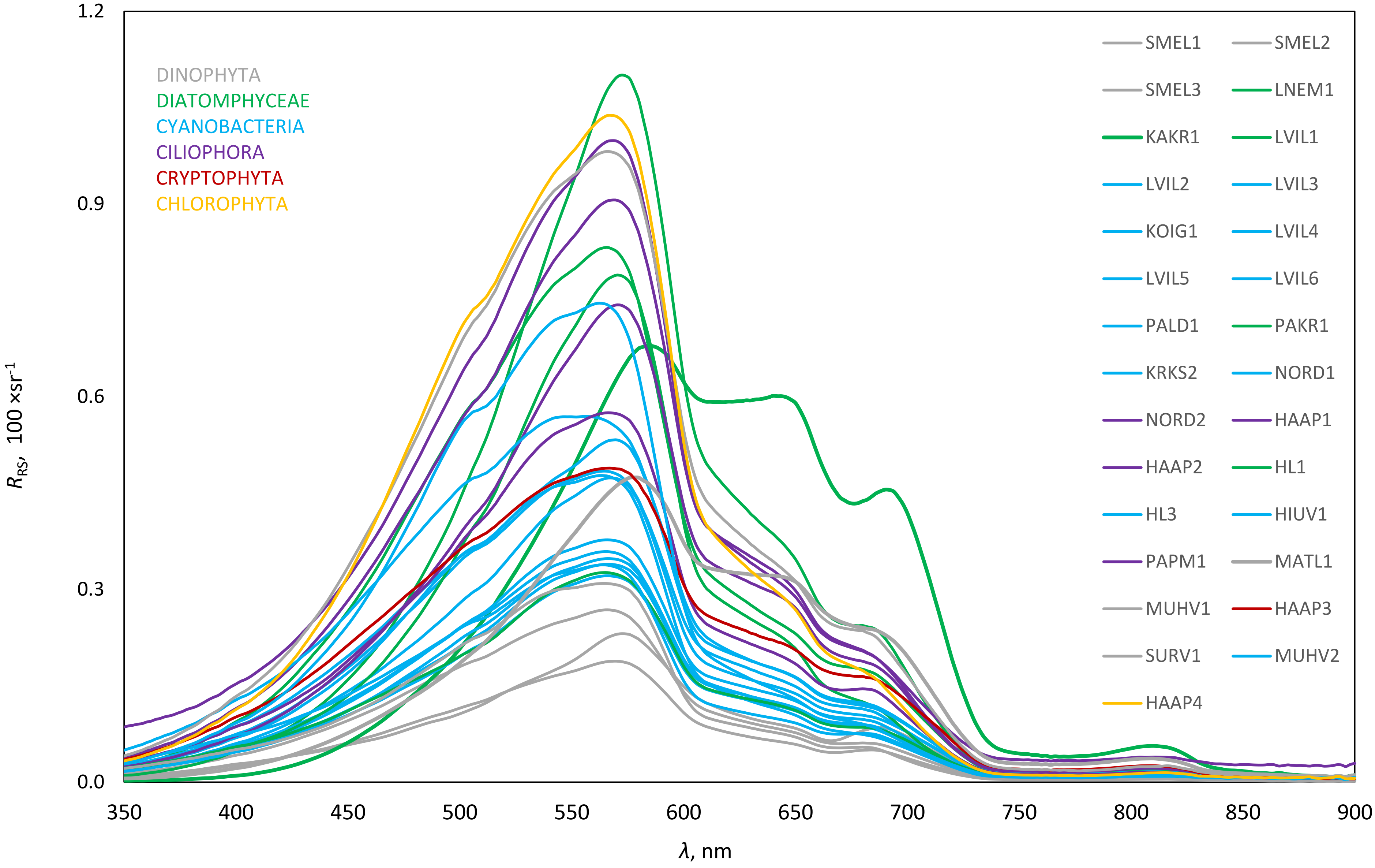
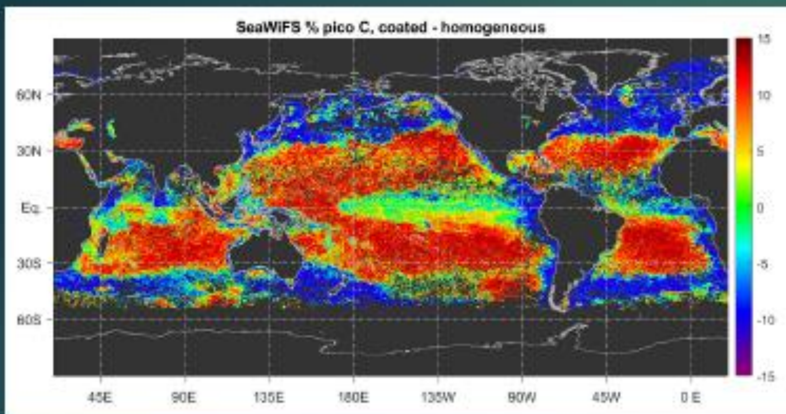
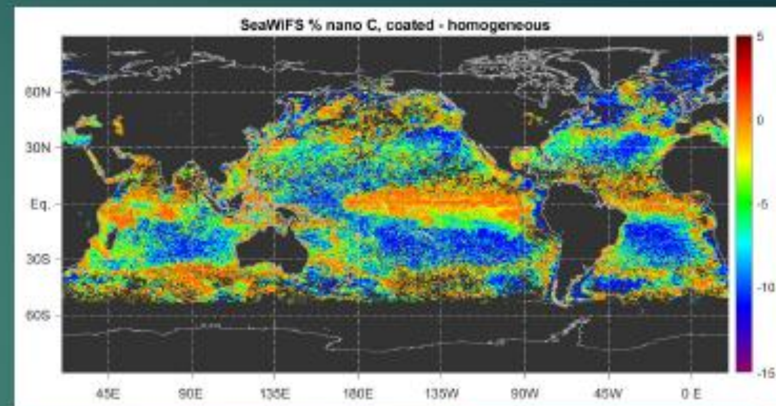
Pigment signal confusing



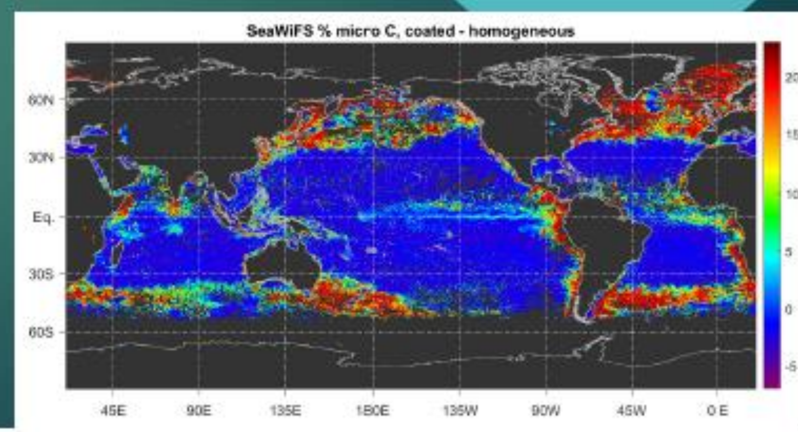
Tihomir.Kostadinov@csu-sm.edu

Differences in retrievals for the fractional C-based PSCs – coated vs. homogeneous spheres





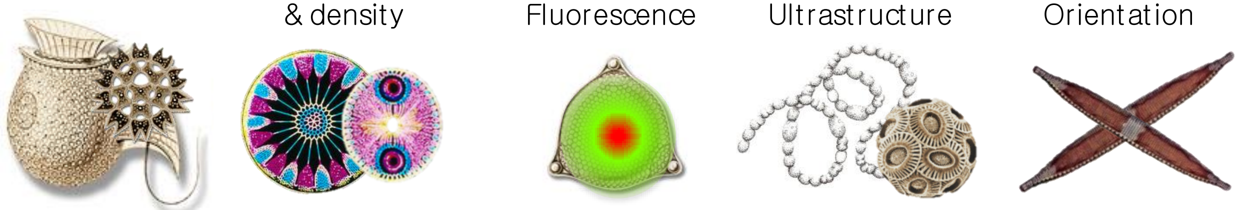
Fractional PSCs are a function of the PSD slope, allometric coeffs, and Dmin/Dmax chosen. So this change reflects the change in the PSD slope LUT – higher slopes retrieved for high values, lower slopes for low values.



The properties of the phytoplankton community that affect ocean colour…

In theory….

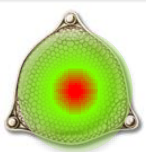
Size	Pigment content & density	Spectral Fluorescence	Vacuoles & Ultrastructure	Shape & Orientation



At high biomass…

Signal from large changes in mean population size

Signal from substantial differences in spectrally distinct accessory pigments

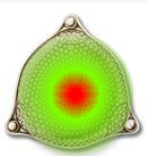


Signal from chlorophyll & accessory pigment fluorescence

Signal from vacuoles & highly scattering cellular components

At low biomass….

Signal from vacuoles & highly scattering cellular components



Signal from chlorophyll fluorescence

In Case 2 type waters…

Highly dependent on the relative IOP contribution….

…from the IOCCG HAB WG draft monograph….

Important to understand that phytoplankton biomass and the relative phytoplankton contribution to the IOP budget are critical to assessing second-order community-structure related effects on the spectral light field….

Systematic Analysis!

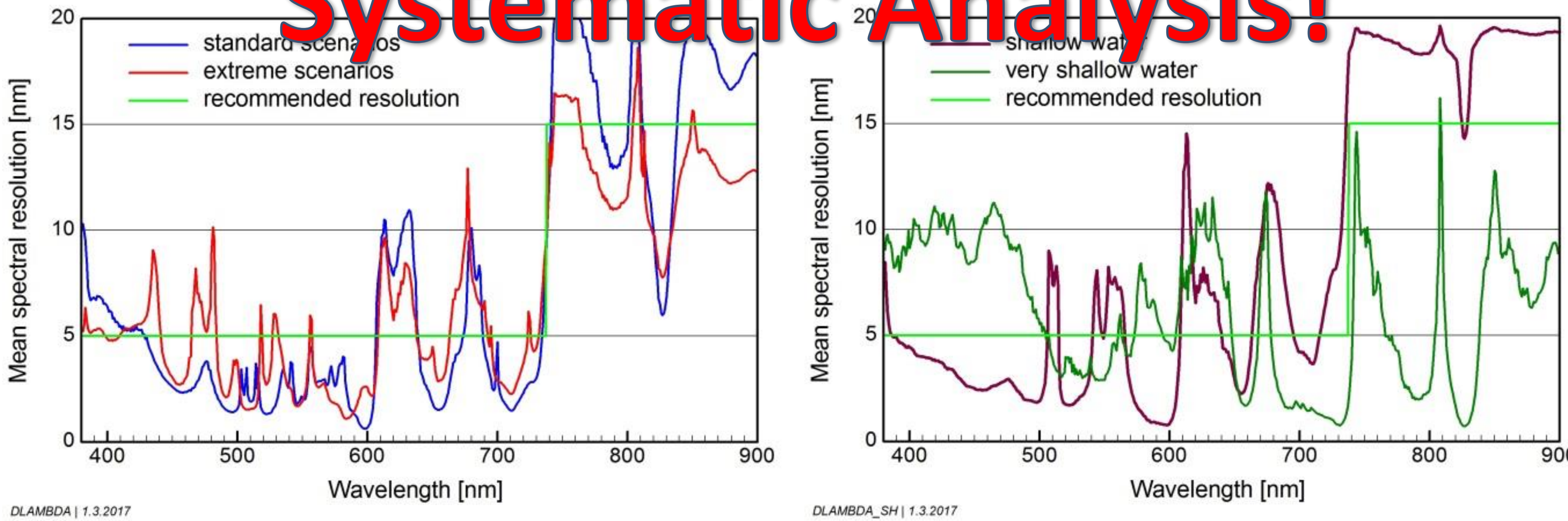
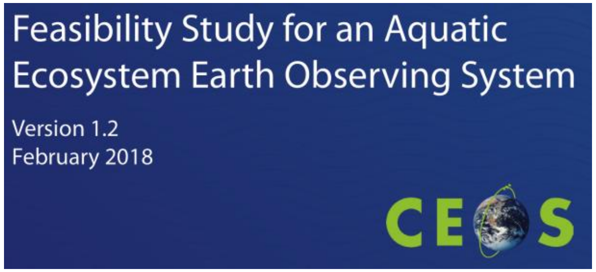


Figure 34: Averages of optimal spectral resolutions. Left: for optically deep water. Right: for optically shallow water.

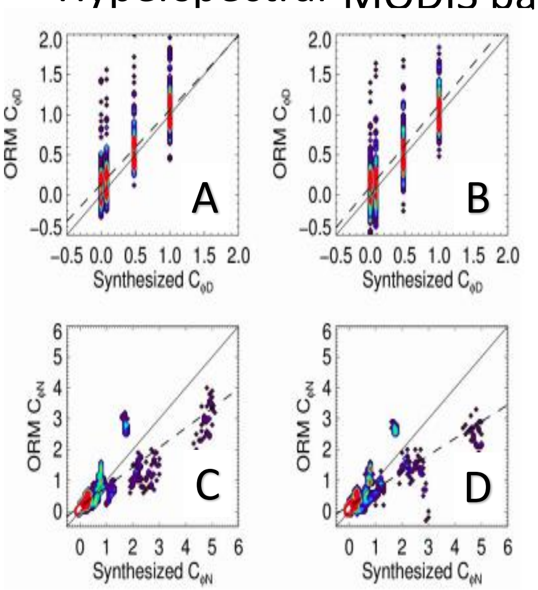
The quantitative hyperspectral vs mutispectral case is a complex one, requiring systematic evaluation over a wide range of water types, focusing on a matrix of co-varying target variables, using both multi-spectral and spectrally dense analyses. An example focusing on spectral resolution requirements - how spectrally dense must the hyper be to offer quantitative advantage? Dekker et al 2018.



GIOP – Ocean color inversion models for PFT retrieval with synthetic Rrs (hyper- / multi-spectral)

GIOP for retrieving diatoms and noctiluca (Werdell et al. (2014)

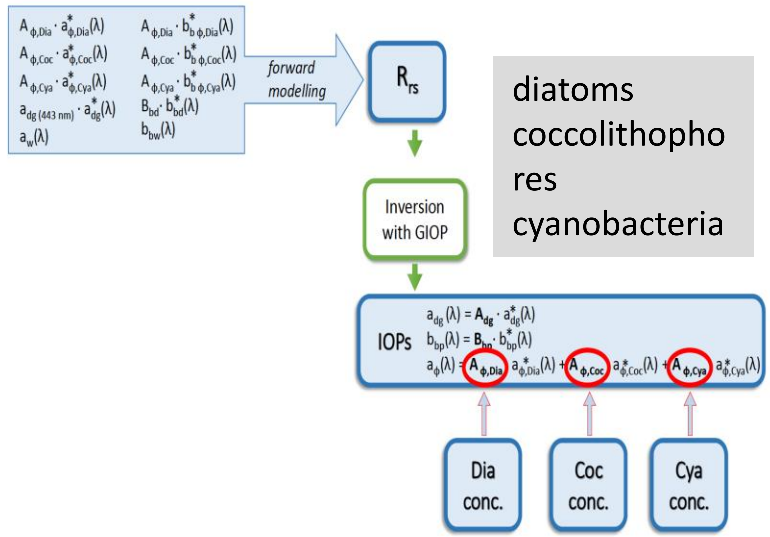
Hyperspectral MODIS bands



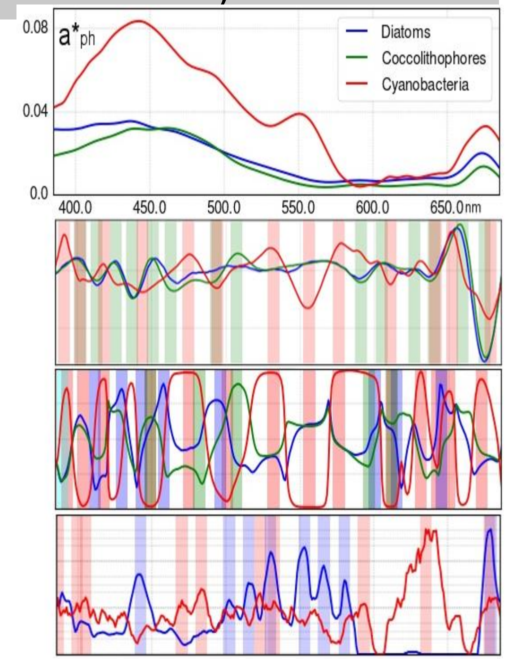
Ground truth (synthesized) versus GIOP retrieved concentrations of Diatom and Noctiluca

- Able to separate the N. miliaris and diatoms;
- Biased absolute estimates even under perfectly controlled conditions.

Spectral band requirements for PFT retrievals (Wolanin et al. 2016)



diatoms
coccolithophores
cyanobacteria



1. Hyperspectral data most beneficial for multiple PFTs
2. Sensors: MERIS best for diatoms & cyano., SeaWiFS for cocco.
3. No single bands setting led to best retrievals for all PFTs.
4. Adding bands to OLCI to enable optical retrievals of this 3 PFTs
5. Choice of band settings depends on chosen

Existing programs

Several databases – SeaBASS, MERMAID, PANGAEA, PACE, OC-CCI, International PFT etc

NASA

PACE Plankton, Aerosol, Cloud, ocean Ecosystem

esa
European Space Agency

Satellite Phytoplankton Functional Type Algorithm Intercomparison Project

IMOS
Integrated **Marine Observing** System

BOUSSOLE
Buoy for the acquisition of long-term optical time series

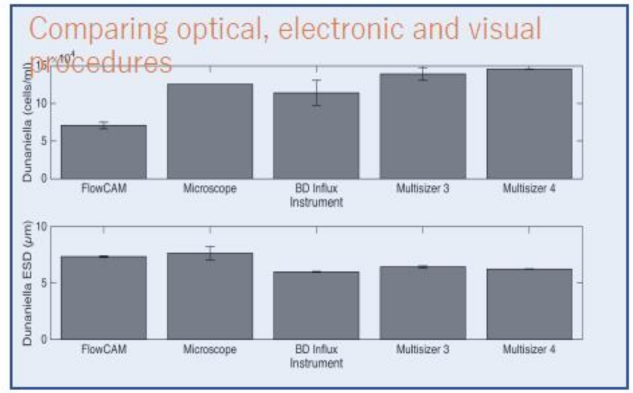
Marine Optical BuoY (MOBY)
Provides vicarious calibration of ocean color satellites

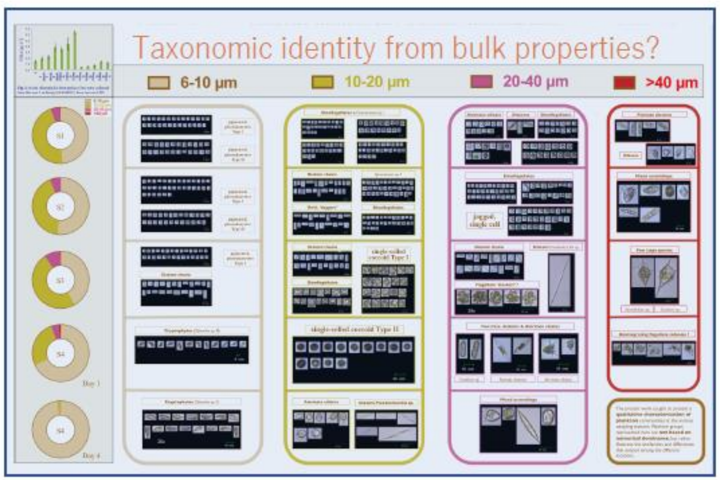
André Valente, et al (2019). A compilation of global bio-optical in situ data for ocean-colour satellite applications – version two. Submitted to Earth System Science Data

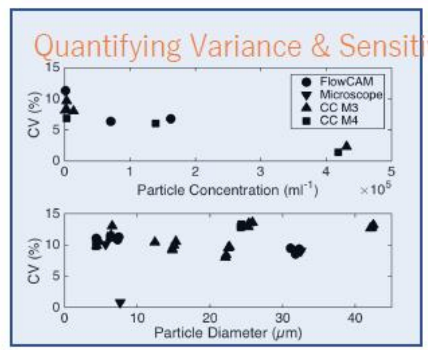
Future Parameters

EXPORTS:
Inter-comparison to link remotely & in situ determined plankton abundance,
size and taxonomy

- at sea and in the lab, whole seawater and mono-specific cultures
- particle abundance, taxonomic identity, size and abundance/size spectra
- instrument sensitivity and measurement variance







Courtesy of Susanne Menden-Deuer
(Export PSD collaborative)

Development of portal with standards, tools, and services, both for users and data centres

for pulse shape recording flow cytometer (ex: Cytosense):

1. New FCM Standardized Common Vocabulary (F02): *12 identifier*

2. New Parameter Usage Vocabulary (P01)

3. Data flow

Data providers: own database or DOI data

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Recommendations (I) = Science requirements for assessing phytoplankton group composition (PG) from space: in-situ data

- **Phytoplankton community observations**: promote use & develop standardised methods & protocols for new generation of imaging particle counters and flow cytometry to allow routine phytoplankton taxonomy resolving size distribution observations & key community metric products (– need to OCB Taxon Resolving Group); enhance usage of data sets for validation from ongoing science initiative repositories and monitoring program efforts provided by flowctometry, imaging and microscopic technique
- **PG into models**: need quantitative framework linking phyto community measurements to biogeochemistry & IOPS (& then onwards to optics). Community based IOP models act as integrative & comparative mechanisms for ranges of data, also allowing QC. These models also facilitate much needed systematic analyses
- **Measured IOPS**: Spectral backscattering identified as major gap in community capability, with large uncertainties & poor ability to resolve phytoplankton specific backscattering. Single angle instruments and/or inappropriate chi factors identified as issues that need attention> Currently sub-optimal phytoplankton specific angular/backscattering measurement capability IOP gap and constraining further systematic analysis…
- **Systematic analysis**: needed at both IOP and reflectance level to understand PG signal across wide ranges of water types – biomass and IOP ranges and including uncertainties (high quality synthetic RTM based data sets).