IOCS 2017 Breakout Workshop 9: Carbon in Ocean Colour

F. Montagner, S. Sathyendranath
H. Evers-King, J. Shutler, C. Rousseaux, H. Loisel

With thanks to all Breakout participants

Breakout Goals

- Goal 1:

  To assess the performance and limitations of the current relevant carbon products.
  - approaches towards **validation** of these products
  - approaches towards consistent **implementation** of these products in global **operational processing systems** across missions.
- Goal 2:

  To liaise with the modellers to understand the requirements for further Carbon products, including **chlorophyll:carbon ratio** and **dissolved organic carbon**.

Seed Questions

- Where are the critical shortcomings and needs ?
- What is ready for operational agencies to pick up ?
- Algorithms development and validation: what actions are needed ?
- What is needed from in situ observations ?
- What are the priority directions ?
- Where are your needs evolving ?

Particulate vs. phytoplankton carbon

- POCO study outcomes were presented by H. Evers-King
- POC algorithms perform well when compared to in situ data. There is more variability in phytoplankton carbon (C_{phy}).
- POC products in the open ocean are ready for operational implementation.
- At least initially more than one algorithm should be implemented and tried with the user community.
- Users would be satisfied with uncertainties between 10-25%.
- Need to understand better the causes for the variability of C_{phy}
  - Impact of the assumptions made in the bio-optical algorithms
  - Better, more *in situ* measurements of C_{phy}
- … leading to look at semi-analytical model approaches
- Variety of approaches remains important
- Need to strengthen involvement of modelling community

Closing the carbon budget

- Presentation by J. Shutler
- Sizing the ocean and atmosphere sinks in the Carbon cycle are crucial to narrowing the uncertainty on the land sink
- A carbon-product oriented international community effort is recommended above a discipline approach. OC observations need to be complemented by salinity, SST, etc.
- DOC – of terrestrial or marine origin – is accessible to OC: terrestrial DOC covaries with CDOM, influenced by salinity. Regional algorithms exist.
  - Priority on DOC from estuarine and coastal discharge
  - UV observations are recommended to improve DOC
- DIC (largest contributor) escapes OC but can be deduced from salinity-alkalinity relationship
  - More regional algos are called for based on e.g GLODAP
  - An accurate enough assessment of salinity from OC has been demonstrated
- Recommendation to promote routine carbon assessments including expression of land-ocean fluxes

Climate Models Needs and Priorities

- Presentation by C. Rousseaux
- Key issue for climate projections: understand the capacity of the Ocean as a sink for excess anthropogenic carbon
- Assimilation of in situ data and RS products in models
  - Allows filling gaps (time /space /variable) in observations
  - Reduce uncertainty on model output variables
  - Thus contributing to RS product validation
  - Requires uncertainty on each RS parameter
  - Requires compatibility between properties observed by satellite and model variables
- Current focus on Chl, PIC, DOC
- Needs: Surface fields of Primary production, C_{phy}, POC.

Carbon in Coastal Waters

- Presentation by H. Loisel
- Coastal waters contribution to C cycle is well above proportion to their extent
  - Limited understanding of sources, sinks / stocks, fluxed of DOC, POC
- Specific issues
  - Atmosphere corrections : recent improvements from e.g SWIR based, POLYMER
  - Bio-physical variability of the bio-optical algorithms
  - Validation strategy
- Recommends optical classification-based approach to reduce the complexity
- Requires global in situ data bases organised along optical class
  - Further include vertical profiles
- Promotes satellite – in situ synergy and integration in products.
- Product specific issues
  - Chl retrieval : OC5 mature, sensitive to turbidity
  - DOC retrieval : importance of UV observations for terrestrial and for marine DOC
  - Noting that DOC is a lead to pCO2 (with Temperature, salinity)
  - POC: related to SPM (which is mature) but high variability

Community Priorities

- Top priority to improve the contents, coverage, consistency of *in situ* measurement databases
  - Apply standardised best practices and protocols to establish high quality *in situ* measurements as Fiducial Reference Measurements
  - Ongoing update of the IOCCG technical reports on protocols
  - Key parameters: **C contents of phytoplankton** (developments needed- flow cytometry ? (H. Sosik's talks)), POC, DOC, pCO_2 (existing SOCAT atlas).
  - Associated measurements: particle size distribution (needs a typology /classification scheme), spectrofluorometry for DOC assessment
- Recommendation to the Agencies to implement relevant aspects in *e.g.* SeaBASS, FRM4SOC.

Recommendations & Actions (1)

- Action to IOCCG : support the establishment of an IOCCG Task Force on Carbon
  - Potential leads: H. Sosik (TBC), C. Rousseaux, J. Shutler,
  - Reach out to organic chemistry (L. Santoleri, C. Fichot) and non-OC remote sensing experts
  - Liaise with international groups *e.g.* CLIVAR, SOLAS, GEOTRACES
  - Initial focus on
    - Disentangling the complexity of the optical <-> C relationship: Regional vs. Classification based approaches
    - Multiple vs. blended algorithms
    - Support and build on existing initiatives e.g. NASA in situ protocols for *e.g.* C_{phy}, POC, pCO_2
    - Global in situ database assembly
  - Additional ToR to be developed by the Community

Recommendations & Actions (2)

- Recommendation to Agencies to implement quasi / pre operational RS products:
  - POC in Open ocean
  - SPM in Coastal waters
  - As “research” or “experimental” as needed
  - Carrying clear indication of uncertainty or at least fitness for purpose
- Recommendation to develop user engagement and training
- Importance of temporal resolution of satellite obs in coastal waters -> interest of geostationary mission with UV-VIS coverage
- Importance of vertical profile resolution
  - In situ e.g. BioArgo
  - Airborne lidar
  - Lidar on Satellite

Dicussion /Findings

- “terrestrial” DOC in coastal / inland waters
  - Mature algorithms exist,
  - regional or optical classification-based
  - Comparison / reconciliation of approaches needed

Please stay engaged as a Community and keep C moving forward !

Thank You !