<u>Splinter Session 5:</u> Operational Ocean Colour Data in Support of Research, Applications and Services

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1. Redefining "operational"

We are experiencing the rise of operational ocean colour as countries and continents invest in sustained long-term and routine ocean colour observations. However, the general perception of operational data services has to be updated because the core requirements for ocean colour include the need for 24/7 data delivery but also extend far beyond it. The reason is that users and applications of ocean colour data are very diverse. NOAA, the European MyOcean programme, and global partners from Brazil, China, Korea, South Africa and India have applications as varied as marine ecosystem monitoring (also, for oil and gas exploration); services like fisheries, aquaculture, water quality, harmful algal blooms, marine disaster monitoring, turbidity and eutrophication; as well as climate, science, and marine and costal management. The timescales for most of these applications are much longer than the standard near-real time operational paradigm. User needs and applications vary regionally and across the globe. An operational service therefore has to deliver NRT data as well as routine consistent long-term time series of ocean colour observations.

Most importantly, the principal requirement is data quality. The experience from NOAA Fisheries, HAB forecasting and from MyOcean is that data accuracy and long term stability are crucial. These goals are particularly challenging in the operational scenario. Their realization hinges on a continuous calibration effort, monitoring of data quality in NRT and over time series, and on the immediate resolution of instrument and processing issues. Calibration, validation and monitoring in turn rely on on-orbit activities, such as lunar looks for NPP VIIRS, on ground cal/val resources and infrastructure, and on capabilities for frequent mission data reprocessings.

The process of transitioning ocean colour from research to operations is therefore challenging. Operations require a parallel research programme as maintaining the data quality is far from routine.

<u>Recommendation 1</u>: The quality of operational ocean colour data is of critical importance. Operational agencies should develop and maintain infrastructure and scientific and technical activities to ensure that the accuracy and long-term stability requirements are met across regions.

<u>Recommendation 2</u>: Define long-term data stability goals for operational ocean colour applications.

<u>Recommendation 3</u>: Assure data continuity and sustainability of product delivery via operational missions. Operational services require satellite data from two operational data streams and one experimental stream as a backup, or three streams in the optimal case, to provide robust services.

Recommendation 4: Distribute regional and global data to marine service and cal/val users early in the mission, even if the data are not well calibrated.

Recommendation 5: Ensure that operational capabilities are achieved soon after launch.

2. Scientific and technological innovation in support of evolving applications and user needs

Ocean colour applications and services have significant potential to meet a range of societal needs and challenges. The experience from the UK MetOffice is that operational assimilation of ocean colour data in ecosystem and carbon cycle models can reduce model errors by 50% in the chlorophyll field and by 20% in unobserved model variables, such as pCO2. Hence, the integration of ocean colour in biogeochemical models has the potential to advance the global operational observation network as well as to be a powerful tool for monitoring the marine environment. However these capabilities are still underused. Modellers require products that include chlorophyll, SPM, Kd490, IOPs, PFTs and carbon which are not all core ocean colour products from the providers such as European Sentinel-3 OLCI and NOAA's NPP VIIRS. Routine exploitation of the data by end-users is lagging. Results from an ICES WGOOFE survey revealed that fisheries managers require primary production, chlorophyll, phytoplankton phenology (timing of algal blooms) and SPM products, half of which are not core products, and they need time series of monthly averages in simple data formats, where corresponding Level-3 data are, once more, not core for Sentinel-3 OLCI.

A compilation of user surveys conducted by the Sentinel-3 Mission Advisory Group and by ESA's Ocean Colour Climate Change Initiative emphasized that open and easy access to data at all levels, open source software, and user tools are prerequisites to broad data usage. Feedback from MyOcean, Brazil and South Africa confirms the need to empower the users by distributing open source modular software for all data levels (with the highest priority for L1 to L2 code) so that the operational algorithms can be adapted to regional conditions, new ad hoc algorithms and processing chains can be developed, and data can be processed locally. Software that works with multiple ocean colour sensors is recommended. The availability of L3 data products was deemed critical by many users during this splinter and the plenary sessions. Access to L1A uncalibrated radiances (and calibration tables) is also recommended so that the users can create their local data archives and reprocess the time series locally each time the calibration changes. The CCI survey indicated that Earth Observation users choose L1/L2 data whereas modellers prefer L3 data. Harmonization of data formats among ocean colour missions was emphasized.

Ocean colour data download using ftp (wget) is the most favoured method in the science and modelling communities for both NRT and historical data, followed by data access via web-browser and OPeNDAP (for the modelling community). Users from South America and Africa additionally benefit from NRT access via EUMETCast, particularly where internet access is poor. A typical NRT timeliness of less than 12 hours from the time of satellite data acquisition is requested.

The provision of ocean colour data analysis tools is considered critical. The non-specialist users want easy on-line tools such as NASA's GIOVANNI. Other examples include tools based on Open Geospatial Consortium web services that enable flexible web visualization and processing, data subsetting in time and space, and data aggregation.

Recommendation 6: Produce and distribute Level-3 data.

Recommendation 7: Provide open source modular software that matches the operational processor and that can be run in batch mode on local user computers; preferably multi-mission software.

Recommendation 8: Disseminate data in NRT via dedicated interfaces, internet and broadcast (by means such as EUMETCast), where the acceptable NRT timeliness is less than 12 hours. Distribute reprocessed consolidated data within a few days, where a maximum of 4 days is adequate.

Recommendation 9: Provide all data online for downloading (instead of a limited rolling archive).

Recommendation 10: Distribute Level-1A uncalibrated radiances with calibration tables.

Recommendation 11: Expand the core product suite to satisfy the modellers and end-users.

Recommendation 12: Provide NRT information on the status of service provision, data stream continuity and quality.

Recommendation 13: Support outreach to and empowerment of all stake holders, including commercial users.

3. Community organization to support the implementation of its goals and recommendations

At present, the international ocean colour community is organized around IOCCG, CEOS Ocean Colour Radiometry Virtual Constellation, GEO Blue Planet, ChloroGIN, GOOS / GODAE, as well as a variety of programmes linked to specific applications or agencies. The IOCCG's IOCS meeting is the first to bring together the international community at large –agencies, scientists and data users– to formulate common goals and to jointly address the practical implementation of solutions from a wide scientific, technical, and programmatic perspective. These objectives match the OCR-VC purpose, which aims to produce long time series of calibrated ocean colour products from multi-mission measurements in an operational and non-operational manner by focusing on calibration, validation, algorithms and standardized products/formats, applications and services, and on training and outreach.

The wider ocean colour community, from data producers, scientists, to end-users, can be organized by following the GHRSST model as it brings together international expertise around specific topics common to all. However, the organization also has to address the diversity of ocean colour applications and regional specificities. Clear vision and goals are needed. These currently exist for global ocean science and climate, but are not as well specified for services, marine ecosystems, and marine and coastal management.

Recommendation 14: Define ocean colour requirements for services, ecosystem and management applications. Involve international data users, other stakeholders and the scientific community and draw on existing information on user requirements gathered by various projects and agencies.

Recommendation 15: Create a framework within which the wider international community can collaborate through permanent working groups on specific topics identified by the IOCCG/IOCS meeting and the stakeholder community. Support harmonization where appropriate, accounting for the regional diversity in the methodological/algorithmic requirements, user needs and societal challenges.

Splinter agenda

Topic 1: Redefining "Operational" (sustained long-term, routine provision of quality satellite data)

- Emerging perspective - Cara Wilson, NOAA
- Marine services view - Rosalia Santoleri, EC MyOcean
- Diverse applications and their needs - Stewart Bernard, CSIR

Topic 2: Scientific and technological innovation in support of evolving applications and user needs

- Emerging applications, modelling/data assimilation - Rosa Barciela, UK MetOffice
- Data access and tools - Steve Groom, PML

Topic 3: Community organisation to support the implementation

- International Ocean Colour Community view and OCR-VC - Mark Dowell, EC JRC