Proposal for development of a cloud-based bio-optical database for satellite water quality monitoring in NOWPAP coastal waters

1. Background

The Common Procedure for eutrophication assessment developed by NOWPAP CEARAC includes a Screening Procedure that is applied to detect symptoms of eutrophication using chlorophyll-a (CHL) from satellite observations (NOWPAP CEARAC, 2009, 2011). This procedure has been termed NEAT (NOWPAP Eutrophication Assessment Tool). It is supported by the NOWPAP member and the UNEP (United Nations Environment Programme) as an important step towards monitoring of eutrophication globally. Currently, a project to develop a global eutrophication watch tool on GEE (Google Earth Engine)—a cloud-based platform for planetary scale computing—is ongoing. This project is one of the 32 projects to tackle the world's greatest challenges using open Earth data like CHL and was approved by the GEO (Group on Earth Observations). However, before the value of satellite CHL can be fully realized validation and sophisticated algorithm development are extremely important, particularly in NOWPAP coastal waters where global CHL algorithms are unable to account for all the optical complexities of these coastal waters.

In the 2020-2021 biennium, CEARAC with support from NOWPAP members states worked on the NEAT refinement project. A cloud-based online match-up tool of satellite and in-situ data was developed under that project. Ground truth data in NOWPAP coastal waters was also collected. For the initial work with the online match-up tool, in-situ CHL data was collected and used to evaluate satellite CHL. This preliminary work mostly focused on identifying the characteristics of each available satellite CHL relative to in-situ data in NOWPAP coastal waters.

In this project, CEARAC proposes to extend the previous project by developing a database of bio-optical data for water quality monitoring using satellite derived information from recent sensors with improved spatial coverage in nearshore environments. These bio-optical data sets, which are composed of IOPs (inherent optical properties) and AOPs (apparent optical properties), will allow not just the characterization of individual satellite derived products such as CHL, but also the derivation of important water quality parameters using satellite optical data. One of these parameters is water transparency or clarity often measured with the depth of visibility of Secchi disk (SD). The SD value is an easy to measure AOP parameter that has been widely used as an indicator of water quality for over 100 years. So, making a link between NEAT—currently used for water quality monitoring—and SD-based maps will provide important water quality information that is easily understood by the public. The database from this project should also help space agencies in developing or improving their bio-optical algorithms of satellite products. Therefore, this activity will contribute to the implementation of the NEAT and help NOWPAP track the progress against SDG 14.1.1a within its coastal ecosystems.

2. Objective

The prime objective of this project is to develop a cloud-based bio-optical database. This database will be developed using the online match-up tool constructed in the previous biennium. Specific objectives of the project are threefold.

- First, collect bio-optical data for database construction in NOWPAP coastal waters.
- Second, evaluate the accuracy of satellite derived water quality products (such as CHL) in NOWPAP coastal waters.
- Third, create SD maps of NOWPAP coastal waters and relate them with NEAT based maps of water quality assessment.

3. Tasks

The main tasks in this project are (1) in-situ bio-optical data collection for building the online database, (2) evaluation of satellite bio-optical products, and (3) development of satellite-based SD map for the NOWPAP region. The collected in-situ bio-optical data will support the characterization of optical properties of NOWPAP coastal waters. Moreover, it will support the development and improvement of satellite product algorithms as well as the creation of water quality maps such as those of SD.

3.1. In situ bio-optical data collection in NOWPAP coastal waters

In this activity, water quality parameters such as chlorophyll-a (CHL) concentration, AOPs and IOPs will be collected to build the cloud-based bio-optical database. AOPs include spectral remote sensing reflectance (Rrs), whereas IOPs include the spectral absorption and scattering properties of seawater. Particulate backscattering combined with absorption defines the Rrs used in ocean colour algorithms to derive parameters of water constituents. The table below summarises those parameters. NOWPAP members states will support this activity by nominating local experts to assist in the data collection.

List of bio-optical parameters to be collected

Parameter	**Unit**	**Description**
CHL	[mg m^{-3}]	Chlorophyll-*a* concentration
TSM	[g m^{-3}]	Total suspended matter
$\mathrm{Rrs}(\lambda)$	[nm]	Remote sensing reflectance
$a_{ph}(\lambda)$	[m^{-1}]	Absorption coefficient of phytoplankton
$a_{nap}(\lambda)$	[m^{-1}]	Absorption coefficient of detrital (non-phytoplankton) particulate matter
$a_{cdom}(\lambda)$	[m^{-1}]	Absorption coefficient of coloured dissolved matter (or gelbstoff)
$b_{bp}(\lambda)$	[m^{-1}]	Particulate backscattering coefficient
SD	[m]	Secchi depth disk

3.2. Evaluation of satellite bio-optical products

The in-situ collected parameters in (3.1) will be used to evaluate the accuracy of satellite derived products. Those products mostly include CHL, TSM, Rrs and SD. The focus will be placed on satellite data from high-resolution sensors, SGLI (Second generation GLobal Imager) with 250 m spatial resolution, OLCI (Ocean and Land Colour Instrument) with 300 m spatial resolution, and GOCI (Geostationary Ocean Color Imager)—a regional sensor in the NOWPAP region—with 500 m spatial resolution. These sensors can retrieve data in nearshore waters including estuaries, small bays, etc. Preliminary evaluation results will be discussed during CEARAC expert meetings. The discussion from the expert meetings should guide on the best practices for water quality monitoring using satellite data in the NOWPAP region. Moreover, they will also contribute knowledge to combining different sensors for improved spatial and temporal coverage that cannot be achieved with a single sensor.

3.3. Development of satellite-based SD map

In addition to the evaluation of satellite derived products (3.2), CEARAC plans to use the bio-optical database to create maps of SD. The use of satellite information to create water quality parameters such as SD provides an alternative for routine monitoring of water quality. This is useful not just in the NOWPAP region but also in other regional seas programmes, especially those lacking routine monitoring of water quality. Given its long history and easy of measuring, the SD continues to play an important role in the characterization of the optical properties of water bodies up to this date. Thus, making the link between the NEAT-based eutrophication map and SD map is essential for making satellite information more accessible to the public.

4. Expected outcomes

With the creation of this database, CEARAC expects to continue its water quality monitoring programme with improved satellite derived information. The bio-optical database with allow better characterization of the bio-optical characteristics of the NOWPAP coastal waters. This has the potential of also contributing data to space agencies to improve their bio-optical algorithms of satellite products.

Besides, with the creation of SD maps and linking them to NEAT-based maps CEARAC will be able to make the NEAT more accessible to the public. SD is an important water quality parameter with long history. As such, it is relatively well understood by the public as compared to other satellite-derived information. So, making the link between the two will be useful for communicating water quality information to the public in general.

Further, this project will also help CEARAC promote the use of newly developed online match-up tool. The benefits of creating a cloud-based tools include, but not limited to, collaboration efficiency. For example, non-experts in satellite ocean colour can now collaborate with CEARAC in evaluating the accuracy of satellite derived information by submitting their water quality monitoring data and retrieving the results processed by the online matchup tool. This is an especially important step forward as it makes satellite information more accessible. Also, it has the potential of boosting the use of satellite derived information for monitoring of water quality. Satellite derived information has higher data collection frequency and covers wider areas as compared to the conventional in-situ observations. Overall, CEARAC expects this activity to contribute towards continuous application of satellite data in water quality monitoring and to the achievement of SDGs, precisely the SDG 14.1.1a.

5. Schedule

The timeline of this activity is shown below.

Time		Action	Main body
2021	August	Proposal and approval of the workplan at FPM18	CEARAC and CEARAC FPs
	Q4	Proposal and approval of NOWPAP workplan and budget at IGM24	National FPs
2022	Q2	Preparations of Memorandum of Understanding for collection of in-situ bio-optical data for building the “cloud-based database for validation of satellite chlorophyll-a in coastal waters of NOWPAP”	CEARAC
	Q2-Q4	Collection of in-situ bio-optical data for building the NOWPAP database	Nominated Experts and CEARAC
2023	Q1-Q2	Evaluation of satellite bio-optical products	CEARAC
	Q3-Q4	Creation and evaluation of SD maps, and comparison with NEAT maps of water quality monitoring	CEARAC
	Q3	Organisation of the 3rd Expert Meeting on eutrophication assessment	Nominated Experts and CEARAC
	Q4	Compilation of evaluation results	CEARAC

6. Budget

Task	Time	Output	To be completed	Main body (experts)	Budget (US$)
In-situ data collection	2022 Q2	Collection of bio-optical data shown in (Table 1) submitted through the online match-up tool (link)	2022 Q4	China	4,000
				Japan	4,000
				Korea	4,000
				Russia	4,000
Evaluation of satellite bio-optical products	2023 Q1	Results of comparison between in-situ and ocean colour derived bio-optical properties	2023 Q2	CEARAC	4,000
Creation and evaluation Secchi depth information using satellite data	2023 Q2	Results of comparison between Secchi depth maps and NEAT maps water quality assessment	2023 Q4		
Total					20,000