Report on improvement of the NOWPAP Eutrophication Assessment Tool (NEAT) for assessment and monitoring of eutrophication using satellite chlorophyll-a

1. Background

NOWPAP CEARAC developed a Common Procedure for eutrophication assessment—a methodology for the assessment of eutrophication status including the evaluation of land-based sources of nutrients—for the NOWPAP region (NOWPAP CEARAC 2009). During the following biennia, the suitability of the developed procedure was tested in selected sea areas (NOWPAP CEARAC 2011) and refined accordingly (NOWPAP CEARAC 2014). The Common Procedure uses a two-step process in eutrophication assessment. The first step is “Screening Procedure” with minimum required parameters, including satellite derived chlorophyll-a (satellite CHL), to detect symptoms of eutrophication while the second step is “Comprehensive Procedure” which is applied for further assessment when symptoms of eutrophication are detected in the first step. Thus, by applying the former, it is easier to effectively focus on areas with symptoms of eutrophication.

The use of satellite CHL in the Screening Procedure has been defined as NOWPAP Eutrophication Assessment Tool (NEAT) and it has been recognized at the second CEARAC Expert Meeting on Eutrophication Assessment in the NOWPAP region held on 22nd March 2019 in Vladivostok, Russia. The experts in the meeting also emphasized the importance of continued improvement of the NEAT. In line with the discussion of development of indicator for the Sustainable Development Goal 14.1.1, the NEAT has been featured in a web-story on the UNEP website and it was recognized as an important step towards monitoring of eutrophication globally.

Here, CEARAC proposes a refinement of the NEAT, especially the procedures used in creating continuous satellite CHL data set for eutrophication assessment. The activity will take advantage of newly launched sensors with higher accuracy and finer spatial resolution while simultaneously ensuing data continuity for eutrophication assessment and monitoring. Consequently, this activity will enable operational eutrophication assessment in coastal waters and estuaries in the NOWPAP region.

2. Objective

Objective of this activity is to revaluate the use of the NEAT with satellite CHL products from newer sensors. This will ensure continuous eutrophication assessment and monitoring. Moreover, the activity also aims to improve the procedures presently used to create continuous seamless satellite CHL used in the NEAT. This improvement is meant to cover newer satellite sensors so that data continuity can be assured and maintained with better spatial resolution and higher accuracy.

3. Tasks

3.1. Development of a tool for online match-up of satellite data

CEARAC developed an online tool for match-up of in-situ data with satellite CHL and Rrs (remote sensing reflectance). The tool is available for the public to use at the Marine Environmental Watch website of NPEC. A working prototype is already available at https://ocean.nowpap3.go.jp/smat/, and it is expected to be finalised within July, 2021. With this tool users can do the match-up online without the need to download large (and many) satellite files sometimes to obtain only a single-point match-up. Further, the tool helps CEARAC collect validation data for satellite products in the NOWPAP region. Figure 1 shows the interface of the online match-up tool. An example of the output from the match-up is also shown in Figure 2.

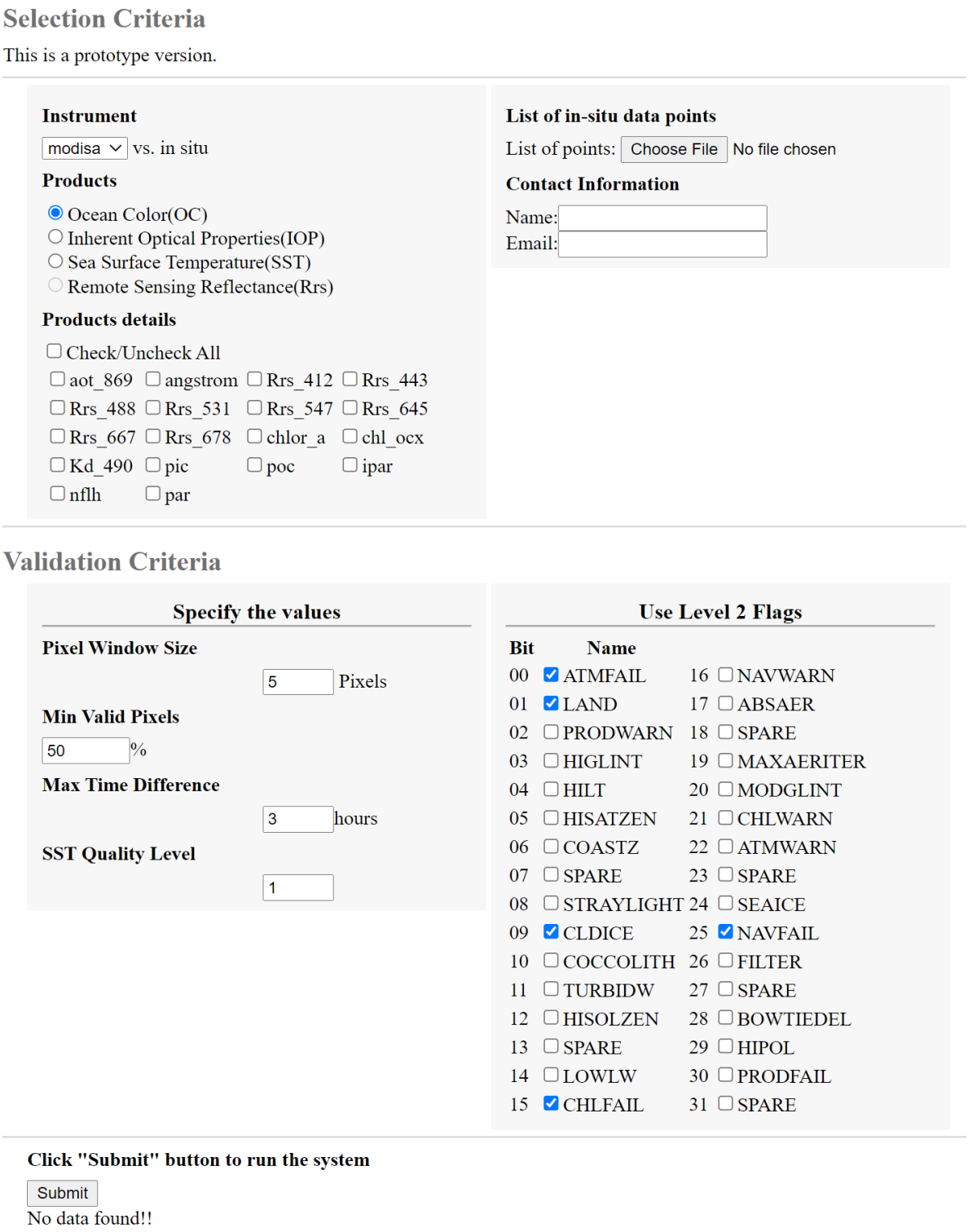

Figure 1. The web user interface of the online match-up tool (prototype version).

:BeginHeader
Using satellite data from MODIS/AQUA
Match-up generation datetime: 2021-06-11T12:45:10
VALIDATION CRITERIA applied to this match-up
-Box size of satellite extract: 5 x 5 = 25 pixels
-Minimum percent valid satellite pixels: 25.0
-Maximum time difference between satellite and in situ: 3 h
-Level-2 flags considered for data screening: ATMFAIL+LAND+CLDICE+CHLFAIL+NAVFAIL
:EndHeader

cruise	datetime	lat	lon	id	etopo2	chl	Filename	Variable [Units]	StartDatet	EndDatetime	ValidPixels	InvalidPixels	Min	Max	Mean	STD	Median	PointValue	PixelValue	PixelValue	PixelValue	Pixe
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_412 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.00575	0.00635	0.00612	0.00013	0.00616	0.00621	0.00598	0.00608	0.006	0.0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_443 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.00459	0.00504	0.00489	0.00012	0.00491	0.00485	0.00484	0.00495	0.00485	0.0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_488 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.00401	0.0043	0.0042	7.3E-05	0.00423	0.00416	0.00419	0.00423	0.00418	0.0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_531 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.002	0.00215	0.00208	3.4E-05	0.00208	0.00204	0.002	0.00204	0.00206	0.0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_547 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.00157	0.00169	0.00163	3.1E-05	0.00163	0.00158	0.00157	0.0016	0.00161	0.0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_645 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.00011	0.00025	0.00019	3.3E-05	0.00019	0.00018	0.00017	0.00021	0.00017	0.0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_667 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.00015	0.00022	0.00018	1.6E-05	0.00018	0.00017	0.00015	0.00016	0.00017	0.0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	Rrs_678 [sr^-1]	2003-02-2	2003-02-22T	25	0	0.00017	0.00023	0.0002	1.4E-05	0.0002	0.0002	0.00017	0.0002	0.00019	0
bats173	2003-02-2	32.1844	-64.4933	462	3013	0.382	A2003053	chlor_a [mg m^-3]	2003-02-2	2003-02-22T	25	0	0.18249	0.22369	0.19178	1.04818	0.18931	0.18527	0.18421	0.18249	0.18867	0.1
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_412 [sr^-1]	2003-04-0	2003-04-02T	25	0	0.00688	0.00746	0.00709	0.00013	0.00708	0.00692	0.00746	0.00707	0.00712	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_443 [sr^-1]	2003-04-0	2003-04-02T	25	0	0.00541	0.00604	0.00568	0.00014	0.00568	0.00551	0.00596	0.00572	0.00572	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_488 [sr^-1]	2003-04-0	2003-04-02T	25	0	0.00439	0.00478	0.00454	9.1E-05	0.00455	0.00445	0.00465	0.00452	0.00455	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_531 [sr^-1]	2003-04-0	2003-04-02T	25	0	0.00195	0.00221	0.00206	5.8E-05	0.00206	0.00201	0.00214	0.00203	0.00206	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_547 [sr^-1]	2003-04-0	2003-04-02T	25	0	0.00145	0.00168	0.00155	5.8E-05	0.00154	0.00149	0.00164	0.00153	0.00154	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_645 [sr^-1]	2003-04-0	2003-04-02T	25	0	3.4E-05	0.00018	1E-04	3.9E-05	9.8E-05	6.8E-05	0.00012	0.00008	0.00012	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_667 [sr^-1]	2003-04-0	2003-04-02T	25	0	6.6E-05	0.00015	0.00011	2.6E-05	0.00011	7.6E-05	0.00014	9.4E-05	8.4E-05	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	Rrs_678 [sr^-1]	2003-04-0	2003-04-02T	25	0	8.4E-05	0.00016	0.00012	2.3E-05	0.00012	0.0001	0.00016	0.00012	0.00011	0.0
bats174a	2003-04-0	32.2519	-64.2636	472	4054	0.269	A2003092	chlor_a [mg m^-3]	2003-04-0	2003-04-02T	25	0	0.15202	0.16111	0.15725	1.01376	0.15716	0.15716	0.15566	0.1555	0.15641	0.1
bats174a	2003-04-0	32.1689	-64.5003	476	3106	0.144	A2003094	Rrs_412 [sr^-1]	2003-04-0	2003-04-04T	15	0	0.00778	0.00872	0.00826	0.0003	0.00832	0.00809	0.00782	0.00803	0.0079	0.0
bats174a	2003-04-0	32.1689	-64.5003	476	3106	0.144	A2003094	Rrs_443 [sr^-1]	2003-04-0	2003-04-04T	15	0	0.00671	0.00746	0.00704	0.00025	0.00708	0.00686	0.00674	0.00688	0.00675	0
bats174a	2003-04-0	32.1689	-64.5003	476	3106	0.144	A2003094	Rrs_488 [sr^-1]	2003-04-0	2003-04-04T	15	0	0.0051	0.00556	0.00533	0.00015	0.00538	0.00522	0.0051	0.00518	0.00517	0.0
bats174a	2003-04-0	32.1689	-64.5003	476	3106	0.144	A2003094	Rrs_531 [sr^-1]	2003-04-0	2003-04-04T	15	0	0.00196	0.00224	0.00211	8.7E-05	0.00208	0.00202	0.00196	0.00208	0.00204	0.0

Figure 2. Sample of the output text from the online match-up tool.

3.2. Evaluation of satellite CHL from new sensors

The NEAT currently uses seamless (sensor independent) satellite CHL from two ocean colour sensors (SeaWiFS and MODIS on board Aqua) for the screening procedure. As the MODIS sensor is becoming old after 16 years of continuous observation since July 2002, evaluation of satellite CHL data from recent sensors such as JAXA's SGLI (Second generation GLobal Imager), the ESA's OLCI (Ocean and Land Colour Instrument), the KOPRI's GOCI (Geostationary Ocean Color Imager) and the NOAA/NASA's VIIRS-SNPP (Visible and Infrared Imager/Radiometer Suite) is necessary to guarantee the continuity of seamless CHL product. To check the usefulness of these sensors in the NOWPAP region, intercalibration of sensors and cross-validation with in-situ data will be conducted by nominated experts in the NOWPAP member states.

CEARAC have requested CEARAC FPs to nominate experts in the NOWPAP member states to collaborate in in-situ data collection for evaluation of satellite CHL in July. Parameters to be collected are mostly those obtained in routine water quality monitoring in national institutes such as CHL, suspended sediments, nutrient concentration and coloured dissolved organic matter. Rrs will be collected if conditions allow. The collected parameters are invaluable for uncertainty estimation in satellite CHL. Following the compilation of evaluation results, the 3rd CEARAC expert meeting on eutrophication assessment will be organised online. Discussion from the expert meeting will contribute towards the development of a seamless satellite CHL product (3.3).

The activities in this section are currently ongoing. While awaiting the starting of the data

collection activity after the online match-up tool is finalised and open, CEARAC has started working on data inter-comparison between different sensors. Currently, data processing of SGLI, GOCI, VIIRS-SNPP and MODIS-Aqua CHL are ongoing.

3.3. Update of the sensor independent satellite CHL for the NEAT operational monitoring

CEARAC with collaboration of nominated experts of the NOWPAP member states will develop a seamless satellite CHL product aimed at two main points: first, guarantee data continuity and second, apply the satellite CHL to operational monitoring of eutrophication. This activity will be started after completion of task 3.2.

4. Expected outcomes

With this project CEARAC expects first, to guarantee data continuity to use in the NEAT while taking advantage of CHL data from many concurrent sensors. Second, make the NEAT operational in eutrophication assessment and monitoring. Operational eutrophication monitoring contributes to the SDGs, especially 14.1 which is aimed at preventing and significantly reducing marine pollution of all kinds, specially from land-based activities and to 6.3 (about Monitoring Ambient Water Quality) which sets out to improve ambient water quality. Third, with the online match-up system available to a wider public, CEARAC will be able to gather a lot of ground truth data. The collected data will be useful in future activities such as satellite data validation, and update of the YOC algorithm (to use newer sensors like SGLI) that is currently used to produce better quality satellite CHL for the Yellow and East China Seas, etc.

5. Schedule

The timeline of this activity is shown below.

Time		Action	Main body
2019	September	17th CEARAC FPM Proposal and approval of the workplan	CERAC and CEARAC FPs
2020	May	Proposal and approval of NOWPAP workplan and budget at IGM24	National FPs
	August	17th CEARAC FPM Review of workplan	CEARAC and CEARAC FPs
2021	Q1-Q2	Implementation of the online match-up tool	CEARAC
	Q3	Collection of information for application of the NEAT in operational assessment and monitoring of eutrophication (Satellite CHL and in-situ data)	CEARAC
		Evaluation of the SGLI and other sensors for operational eutrophication monitoring	CEARAC
		Compilation of evaluation results	CEARAC
	Q4	Organisation of the 3rd CEARAC expert meeting on eutrophication assessment (online)	CEARAC and Nominated Experts
		Development of a seamless (sensor independent) satellite CHL for data continuity and operational eutrophication monitoring using the NEAT	CEARAC
		Implementation of operational eutrophication monitoring web-map based on the NEAT	CEARAC

6. Budget

Task	Timing	Output	To be completed	Main body (experts)	Budget (US$)
Development of an online match-up tool	2021 Q1	Online match-up tool	2020 Q2	CEARAC	4,000
Evaluation and development of satellite CHL product for use in the operational NEAT	2021 Q3	Evaluation results summary (data submitted as spreadsheet)	2021 Q3	China	4,000
				Japan	0
				Korea	4,000
				Russia	4,000
Operational eutrophication monitoring web-map (NEAT)	2021 Q4	Interactive NEAT monitoring web-map for the NOWPAP region (updating data sets)	2021 Q4	CEARAC	4,000
Total					20,000