



- 5th NOWPAP Remote Sensing Training Course 2021
- **Webinar 2: Monitoring and Assessment of Water Quality by Ocean Color Remote Sensing**

Prerequisites

- Install Jupyter Notebook:
 - <https://jupyter.org/install>
- Best and simple option is to use **ANACONDA**
 - <https://www.anaconda.com/products/individual>

Anaconda Installers

Windows 	MacOS 	Linux 
Python 3.9 64-Bit Graphical Installer (510 MB) 32-Bit Graphical Installer (404 MB)	Python 3.9 64-Bit Graphical Installer (515 MB) 64-Bit Command Line Installer (508 MB)	Python 3.9 64-Bit (x86) Installer (581 MB) 64-Bit (Power8 and Power9) Installer (255 MB)

- **Optionally, have access to Google Earth Engine**
 - <https://code.earthengine.google.com/>


Training Outline

- Day 1 (~2 h):
 - Application of ocean color products ([global eutrophication watch](#))
 - Working with satellite swath imagery
 - Introduction to OC data products and [online match-up tool](#)
- Day 2–3 (~2 h):
 - **Time-series analysis**
 - Browse and download NOWPAP-[Marine Env. Watch](#) data
 - Generate monthly [composites](#) from daily images
 - Create [animations](#) from monthly images
 - Extract [annual max](#) from monthly images
 - Extract [point/region](#) of interest
 - Perform [trend detection](#)

Certificate

- **A certificate of completion will be awarded to those who:**
 - Attend most of the lectures and hands-on sessions
 - Complete the feedback form by the deadline
- The certificate of completion will be sent approximately two weeks after the completion
- Any questions direct to: cearac@npec.or.jp
 - In the subject put: **5th NOWPAP Training Course: Webinar 2**

Outline for Day 1

- Application of ocean color products (H) 50 mins
 - Introduction to the global eutrophication watch
- Working with satellite swath imagery (H) 60 mins
 - Introduction to the online match-up tool
- **Resource page**
 - <https://github.com/npec/5th-NOWPAP-Training-Course-on-Remote-Sensing-Data-Analysis>
 - **Download training materials**  <https://github.com/npec/5th-NOWPAP-Training-Course-on-Remote-Sensing-Data-Analysis/archive/refs/heads/main.zip>

Introduction to the global eutrophication watch

Article | [Open Access](#) | [Published: 22 October 2021](#)

Globally consistent assessment of coastal eutrophication

[Elígio de Raús Maúre](#) , [Genki Terauchi](#), [Joji Ishizaka](#), [Nicholas Clinton](#) & [Michael DeWitt](#)

[Nature Communications](#) **12**, Article number: 6142 (2021) | [Cite this article](#)

1657 Accesses | [Metrics](#)

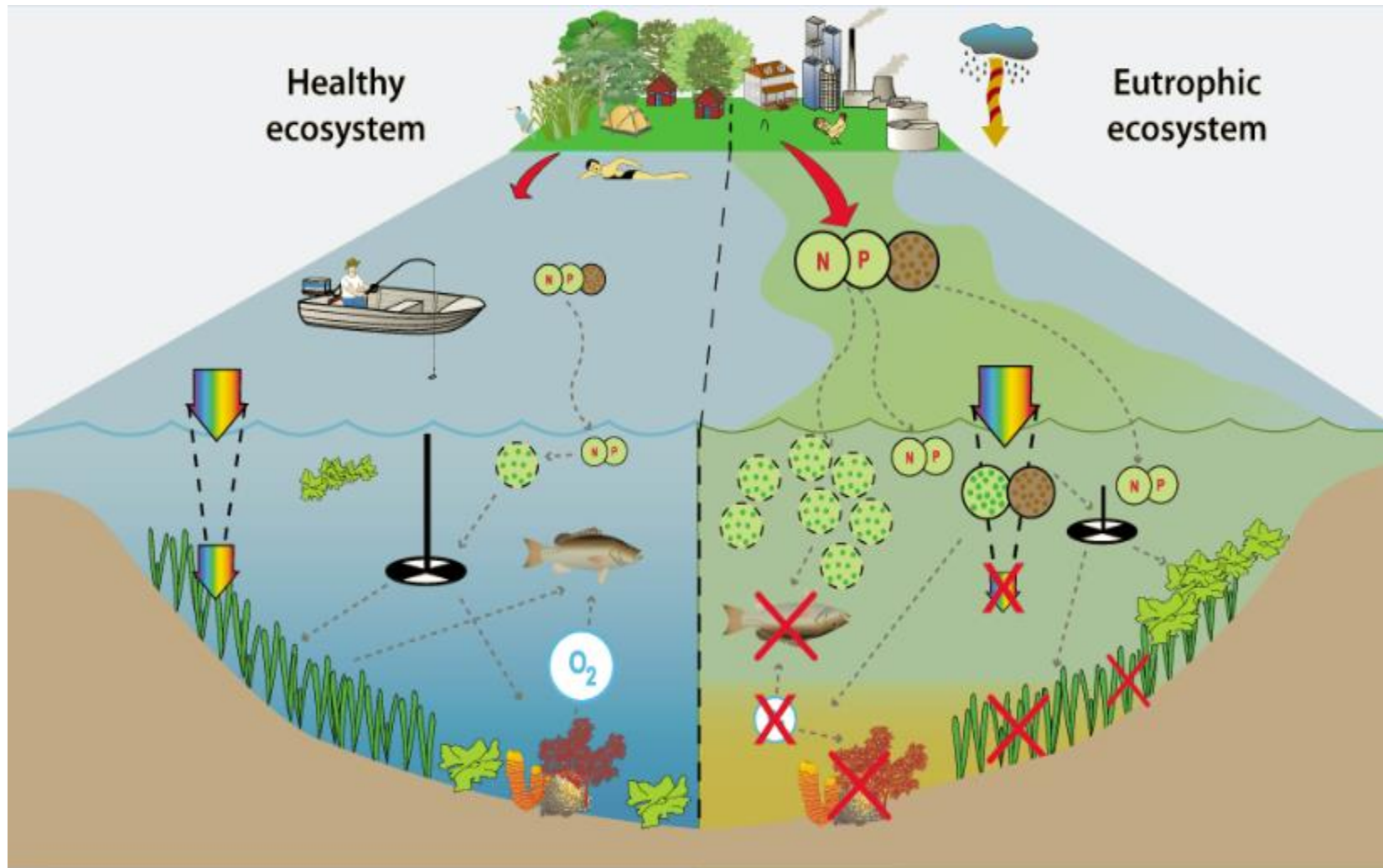


Eligio Maure

Northwest Pacific Region Environmental Cooperation Center

Coastal Eutrophication

Also known as cultural eutrophication: accelerated degradation of coastal ecosystems associated with increasing anthropogenic nutrient loading.

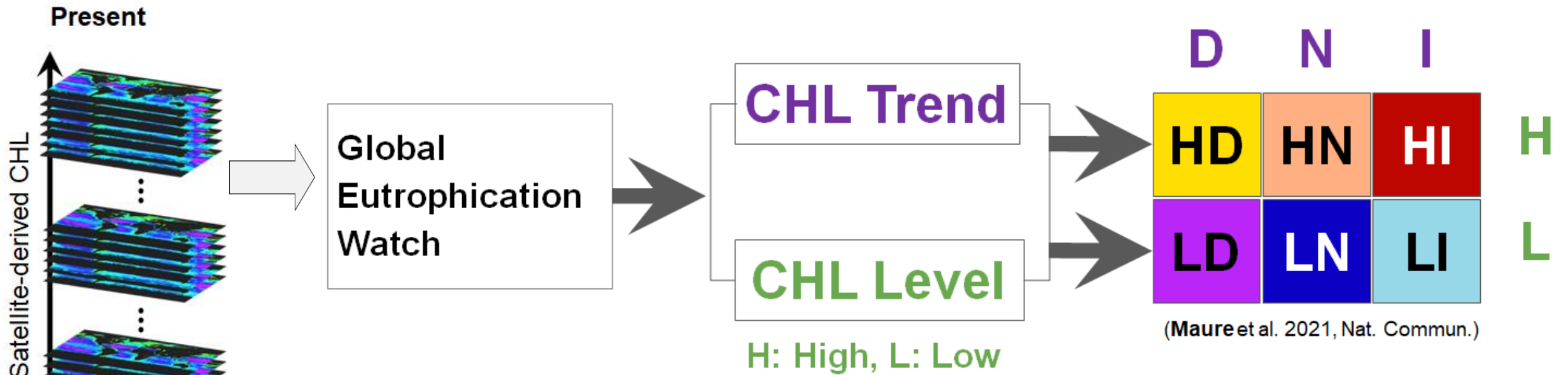


- High Nutrients loads (industrial & household)
- Red Tide (Harmful Algal Blooms)
- Low Bottom Oxygen (Hypoxia and anoxia)
- Low Transparency (Less submerged vegetation)
- Global Coastal Problem
- SDG 14.1.1a: (Index of coastal eutrophication)

Global Eutrophication Watch

A planetary scale tool for eutrophication assessment

Global Eutrophication Watch: a Google Earth Engine tool for coastal eutrophication assessment using the **NEAT** methodology
It detects symptoms of coastal eutrophication using only satellite-derived chlorophyll-a (CHL) concentration



Eutrophic potential waters: HD, HN and HI

Eutrophication potential waters: HI and LI

NOWPAP: Northwest Pacific Action Plan

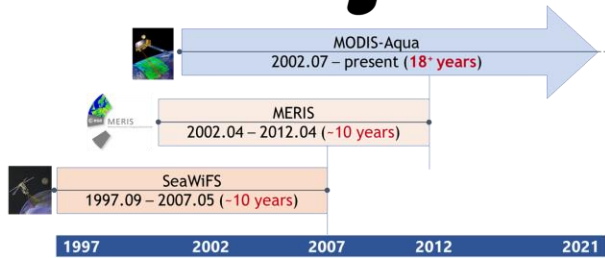
NEAT: NOWPAP Eutrophication Assessment Tool (Terauchi et al. 2014, 2018)

Global Eutrophication Watch: Trend in Annual CHL Max

CHL time series (Monthly)

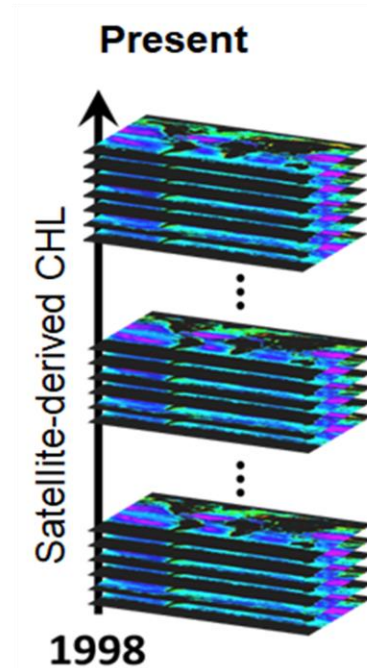
Annual CHL max

CHL trend

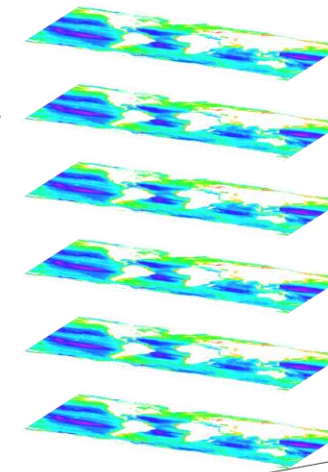


Global assessment based on combined **SeaWiFS, MERIS** and **MODIS-Aqua** derived CHL at 1 km spatial resolution

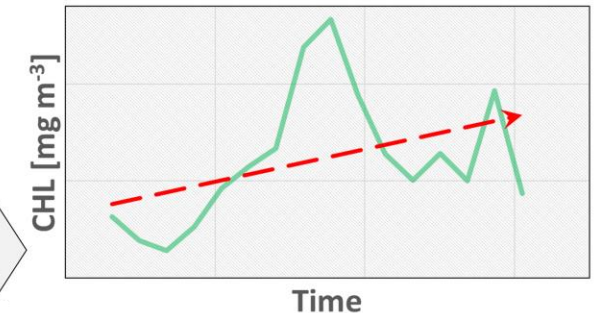
- Long-term consistent CHL time series (1998-2018, **20+ years**)



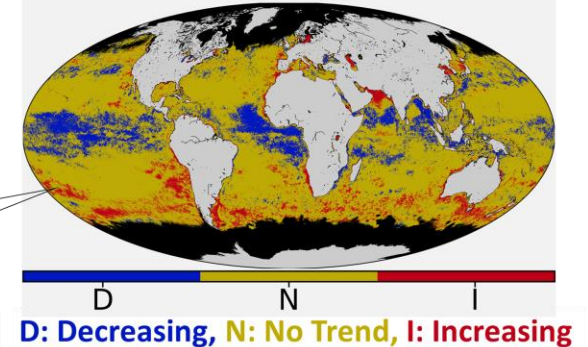
Annual CHL Max



— Annual CHL Max. → CHL trend



Trend in Annual CHL Max



Trends in annual CHL max based on Sen's slope method (Sen, 1968) at 90% significance level. Polar regions with a few observations (< 70% of the study period) were masked.

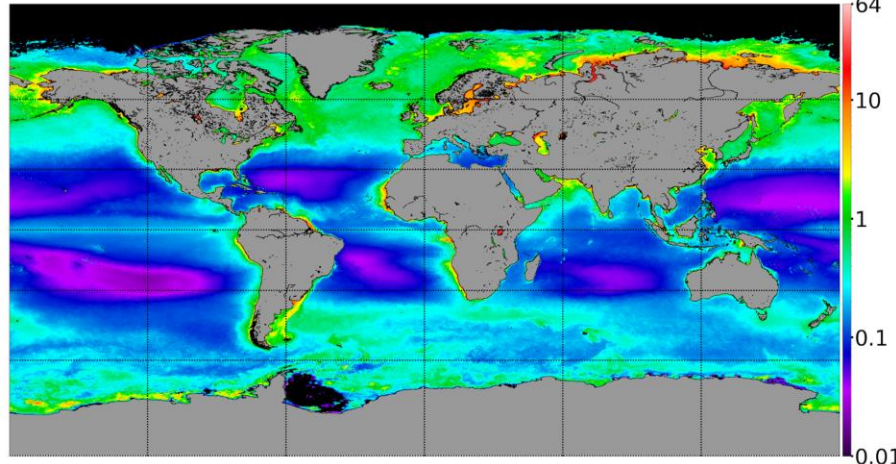
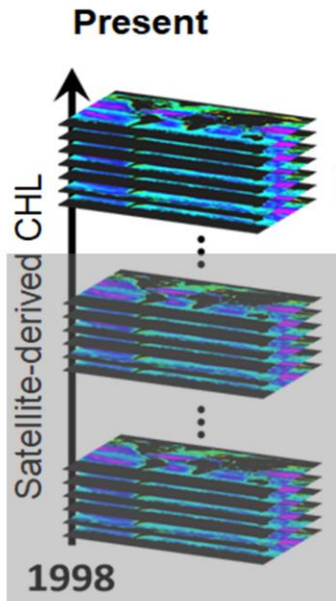
Global assessment: MODIS-Aqua CHL data with 4 km spatial resolution
NOWPAP region: combined above three sensors at 1 km spatial resolution

Global Eutrophication Watch: 3-year Mean CHL

CHL time series (Monthly)

3-year Mean CHL

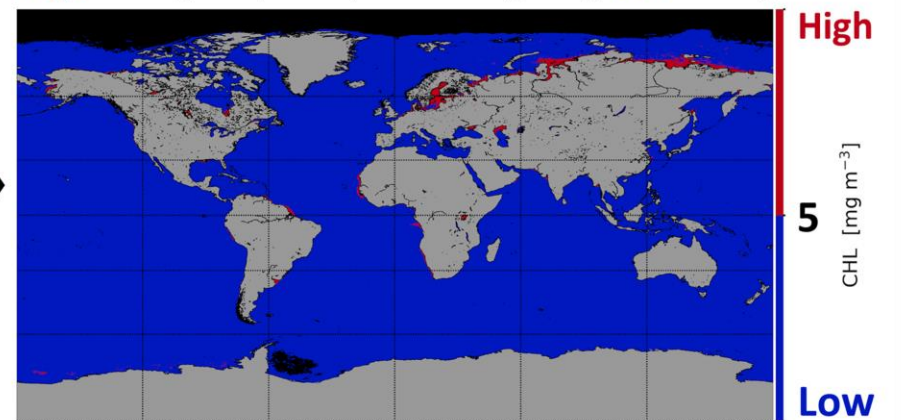
CHL threshold



Composite of most recent 3-year of the analysis period

CHL Threshold (Cut-off level)

High $\geq 5 \text{ mg m}^{-3}$ (mostly coastal regions); Low $< 5 \text{ mg m}^{-3}$



Blue: CHL $< 5 \text{ mg m}^{-3}$ (open ocean mostly)

Red: CHL $\geq 5 \text{ mg m}^{-3}$ (coastal waters mostly)

Citation:
de Raais Maïre, E., Terauchi, G., Ishizaka, J. et al. Globally consistent assessment of coastal eutrophication. Nat Commun 12, 6142 (2021). <https://doi.org/10.1038/s41467-021-26391-9>

Global Eutrophication Watch

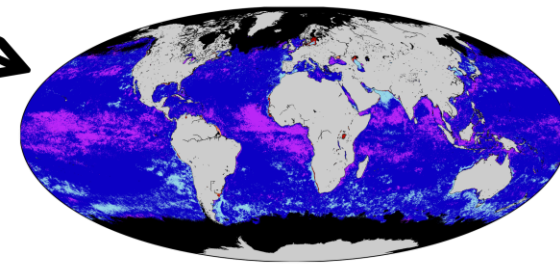
CHL Trend

CHL Level

H: High, L: Low

	D	N	I
H	HD	HN	HI
L	LD	LN	LI

(Maure et al. 2021, Nat. Commun.)



Eutrophic potential waters: HD, HN and HI

Eutrophication potential waters: HI and LI

The Global Eutrophication Watch App: Global Assessment

Earth Engine Apps Experimental

Search places

Global Eutrophication Watch

Dataset Specification

Specify the path to your monthly CHL asset below. The dataset should contain a variable named "chlor_a".

Enter asset path here 1

Use YOC Product (Regional)

default: MODIS/Aqua Level-3 (Global)

Trend Detection Interval

Select the start/end year interval for trend detection.

Start year:

End year: 2

Toggle map views, comparative assessment!

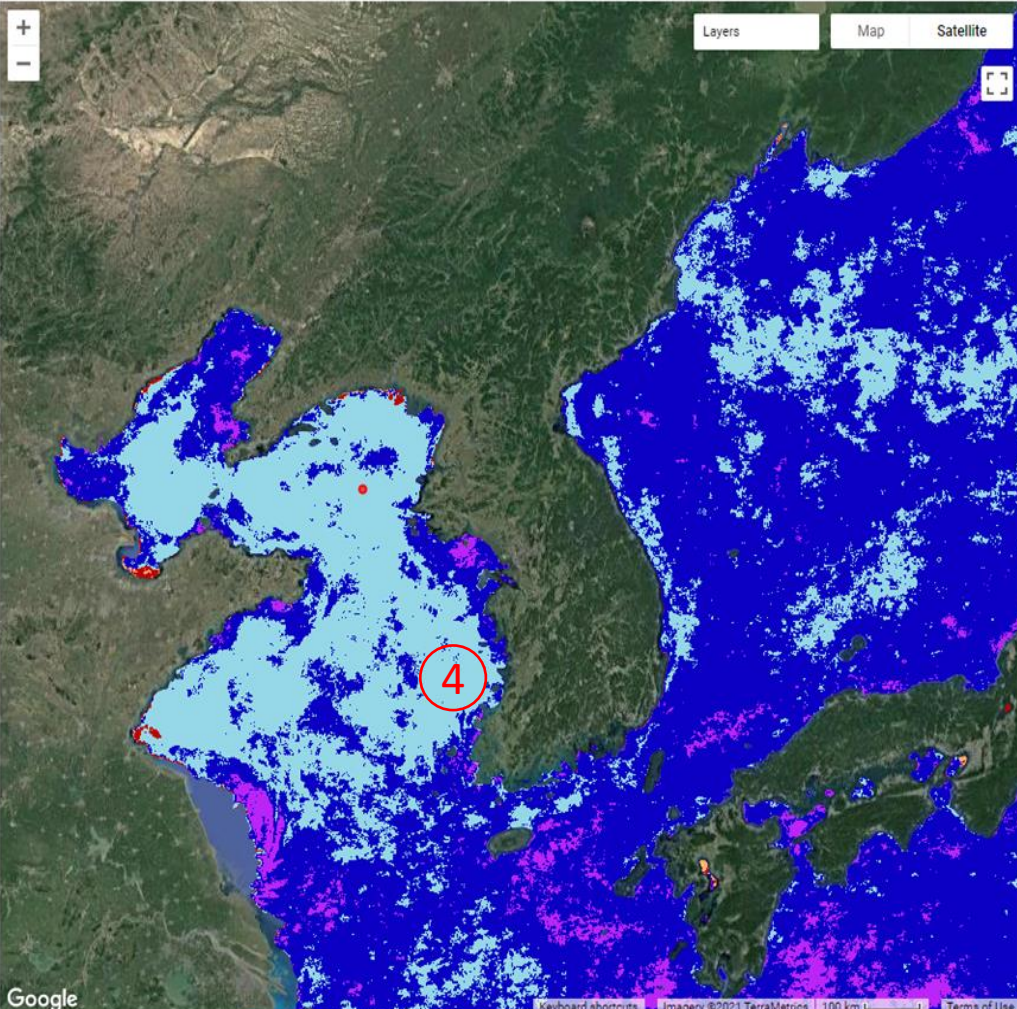
CHL Composite Interval

The start/end date for computing the temporal composite of CHL.

Start date: 3

End date:

Select cutoff level: [mg/m³]



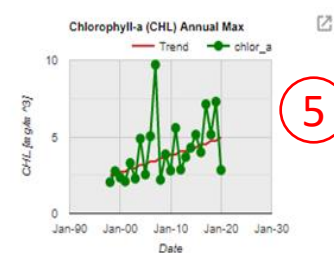
Layers Map Satellite

Click a point on the map to update the chart.

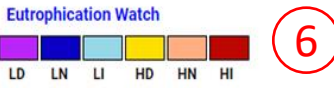
Latitude: 38.41 Longitude: 123.73

Point Status :: LI

Chlorophyll-a (CHL) Annual Max



Eutrophication Watch



LD LN LI HD HN HI

The Global Eutrophication Watch is designed to allow users to perform a preliminary screening of coastal eutrophication using satellite-derived chlorophyll (CHL) data. A default MODIS/Aqua-derived CHL product is bundled with the App. However, users can also provide a link to their own asset of monthly CHL. In addition to that, the YOC CHL product (a regional dataset in the Northwest Pacific region) is also provided with the App.

The article for this app, accessible from the link: <https://doi.org/10.1038/s41467-021-26391-9>, introduces the terms eutrophic potential, eutrophication potential, and oligotrophication potential for waters with high CHL levels (HD, HN, and HI), with increasing CHL trends (LI and HI), and with decreasing CHL trends (LD and HD), respectively. LI and HI are of a particular interest as they indicate waters in a process of becoming eutrophic (LI) or a progression of an already eutrophic (HI) water body.

Fields in the App

1. Specification of dataset for eutrophication assessment
2. Definition of assessment interval for trend detection
3. Definition of chlorophyll (CHL) level parameters (CHL threshold)
4. Eutrophication assessment map
5. Time series of a select point on the map
6. Assessment colour codes

The Global Eutrophication Watch App: Regional Assessment

Earth Engine Apps Experimental

Global Eutrophication Watch

Dataset Specification
Specify the path to your monthly CHL asset below. The dataset should contain a variable named "chlor_a".

Enter asset path here
 Use YOC Product (Regional)
 default: MODIS/Aqua Level-3 (Global)

Trend Detection Interval
Select the start/end year interval for trend detection.

Start year:
 End year:

Toggle map views, comparative assessment!
 Different start/end year interval can be specified to compare trends in different periods.

Start year:
 End year:

CHL Trend
 D: Decreasing Trend
 N: No Trend
 I: Increasing Trend

CHL Composite Interval
The start/end date for computing the temporal composite of CHL.

Start date

Eutrophication assessment in NOWPAP region using a regional dataset

The dataset is based on a local algorithm developed to improve CHL retrievals in coastal regions highly influenced by coloured dissolved organic matter and suspended sediments (Siswanto et al. 2011)

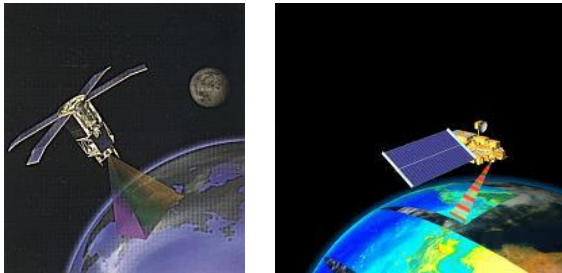
<https://eutrophicationwatch.users.earthengine.app/view/global-eutrophication-watch>

The Global Eutrophication Watch is designed to allow users to perform a preliminary screening of

Regional Satellite-derived CHL in the NOWPAP

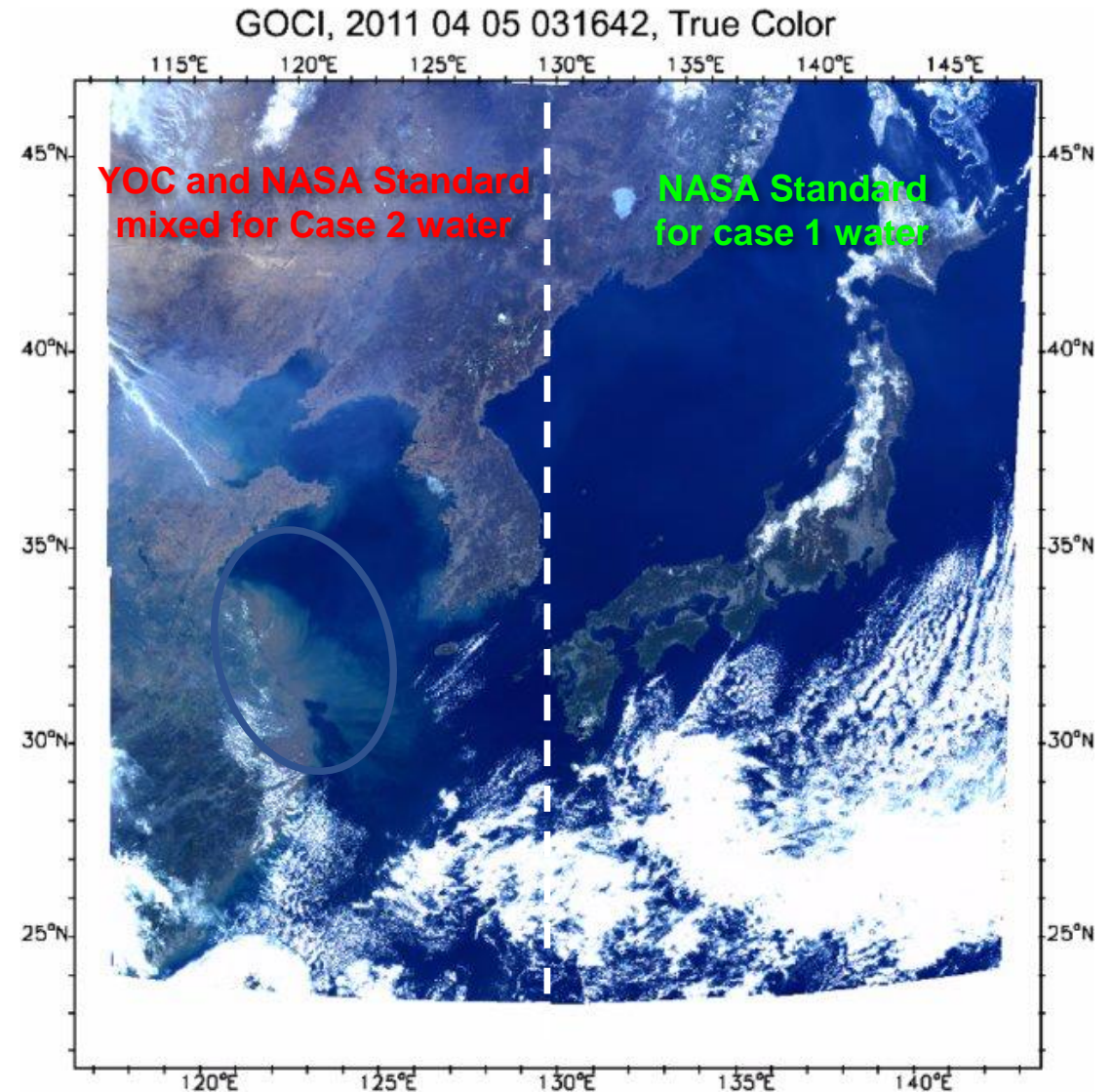
Satellite Sensors

- SeaWiFS (1998-2007)
- MERIS (2002-2012)
- MODIS-Aqua (2002-present)

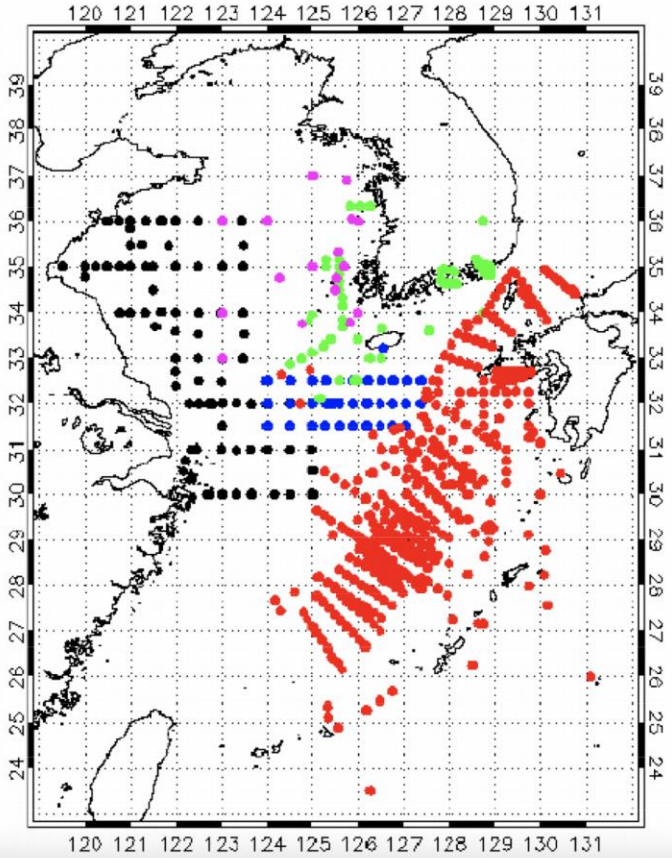


Algorithm to estimate chlorophyll-a

- NASA Standard
- Yellow Sea Large Marine Ecosystem Ocean Color Project Algorithm (YOOC)



Regional efforts to improve satellite derived CHL



YOC (2007-2009)

Leader: Kawamura

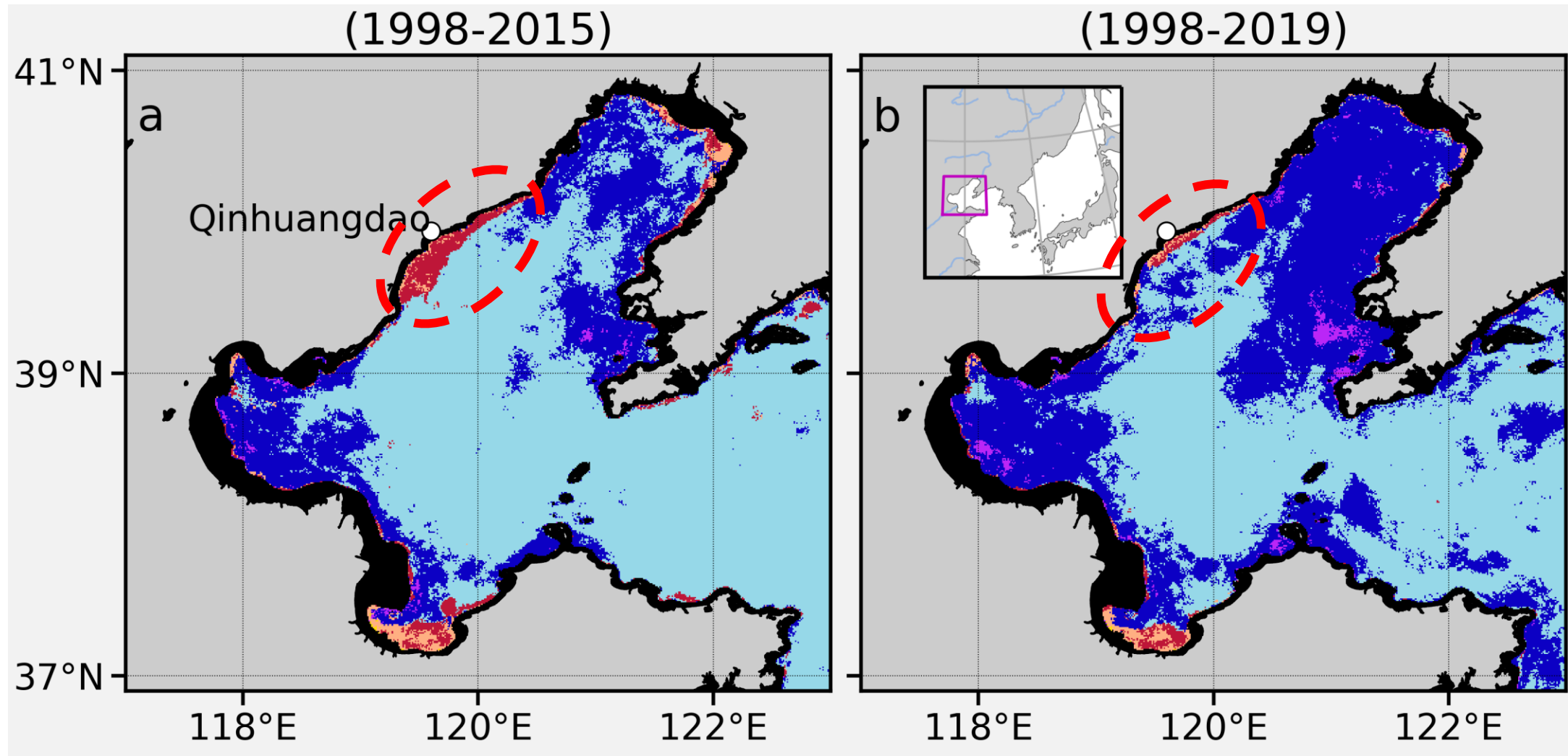
- Ahn (KORDI)
- Ishizaka (NU, SNFRI)
- Tang (NSOAS)
- Yoo (KORDI)
- Kim (NFRDI)

**Yellow Sea
Large Marine
Ecosystem
Regional Ocean
Color Algorithm
Development**

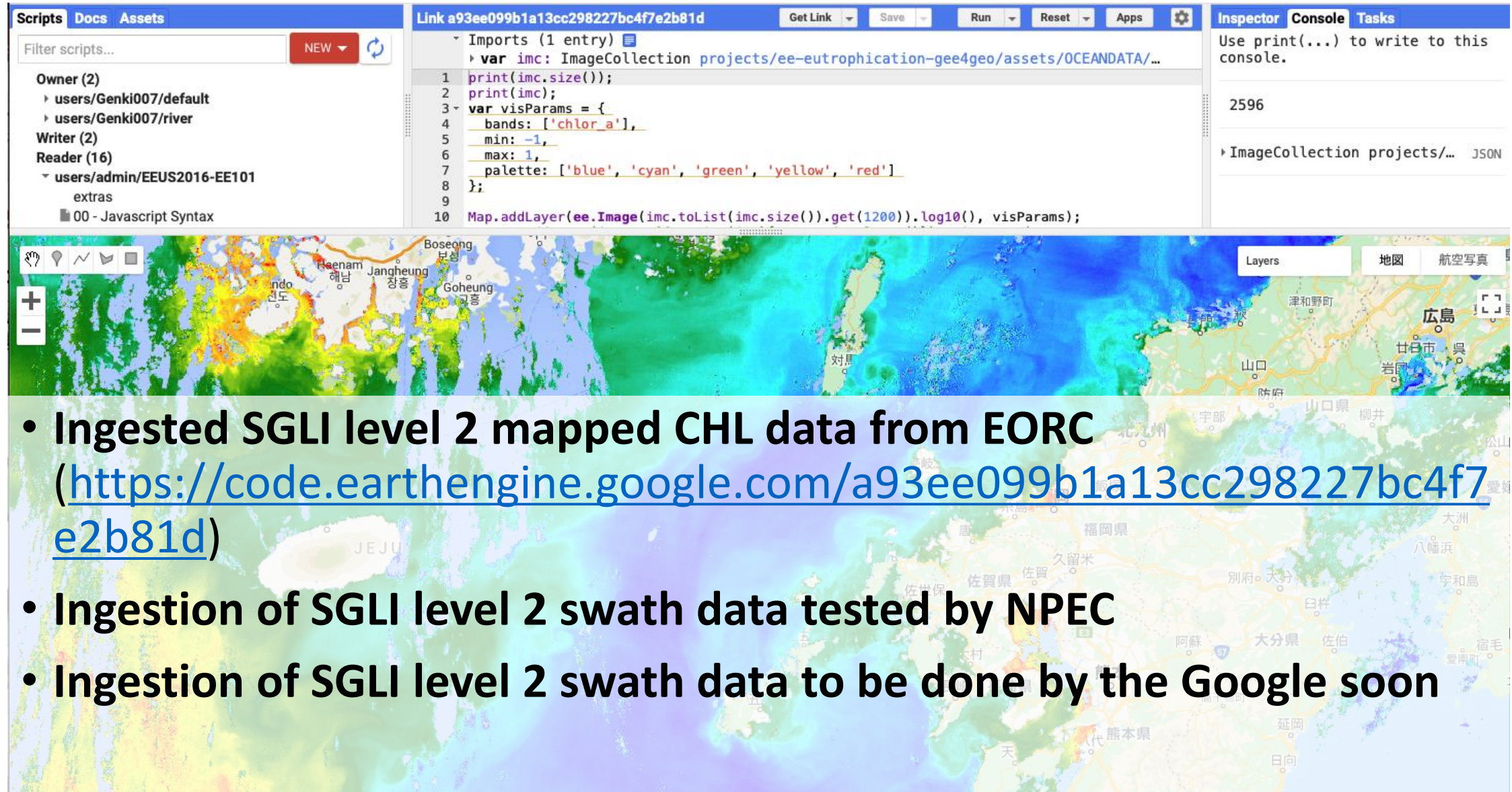


Regional Satellite-derived CHL in the NOWPAP

Highlights improving water quality with decreasing CHL trends



SGLI data ingesting in Google Earth Engine



The screenshot displays the Google Earth Engine interface. The top panel shows a script editor with the following code:

```
Link a93ee099b1a13cc298227bc4f7e2b81d
Imports (1 entry)
  var imc: ImageCollection projects/ee-eutrophication-gee4geo/assets/OCEANDATA/...
1 print(imc.size());
2 print(imc);
3 var visParams = {
4   bands: ['chlora'],
5   min: -1,
6   max: 1,
7   palette: ['blue', 'cyan', 'green', 'yellow', 'red']
8 };
9
10 Map.addLayer(ee.Image(imc.toList(imc.size()).get(1200)).log10(), visParams);
```

The right panel shows the Inspector and Console. The Console displays the output of the script:

```
Use print(...) to write to this console.
2596
ImageCollection projects/... JSON
```

The bottom panel shows a map visualization of the SGLI data, with a color scale ranging from blue (low values) to red (high values). The map covers the region around Jeju Island and the Korean Peninsula.

- Ingested SGLI level 2 mapped CHL data from EORC (<https://code.earthengine.google.com/a93ee099b1a13cc298227bc4f7e2b81d>)
- Ingestion of SGLI level 2 swath data tested by NPEC
- Ingestion of SGLI level 2 swath data to be done by the Google soon

Summary

- **We introduced the global eutrophication watch**
 - It can be used for rapid and cost-effective screening of eutrophication
 - Can help identify areas in need of eutrophication management or with improving water quality
 - Ideal for awareness raising and education

- **For assessment in coastal waters**
 - High resolution data with suitable data quality are needed
 - The global eutrophication watch user to specify region-specific dataset
 - Existing and future ocean colour missions (e.g. SGLI/GCOM-C (250m) and OLCI/Sentinel-3 (300m)) are enabling coastal water monitoring and global eutrophication watch will play a key role

Acknowledgments

- We thank the NPEC Team: Genki Terauchi & Mihoko Nagamori, for their help and support.
- We also acknowledge the help received from the Nagoya University and Pusan University in preparing the lectures.
- Organizer:
 - [NOWPAP CEARAC](#)
- Supporter:
 - IOC/Sub-Commission for the Western Pacific ([WESTPAC](#))
 - North Pacific Marine Science Organization ([PICES](#))