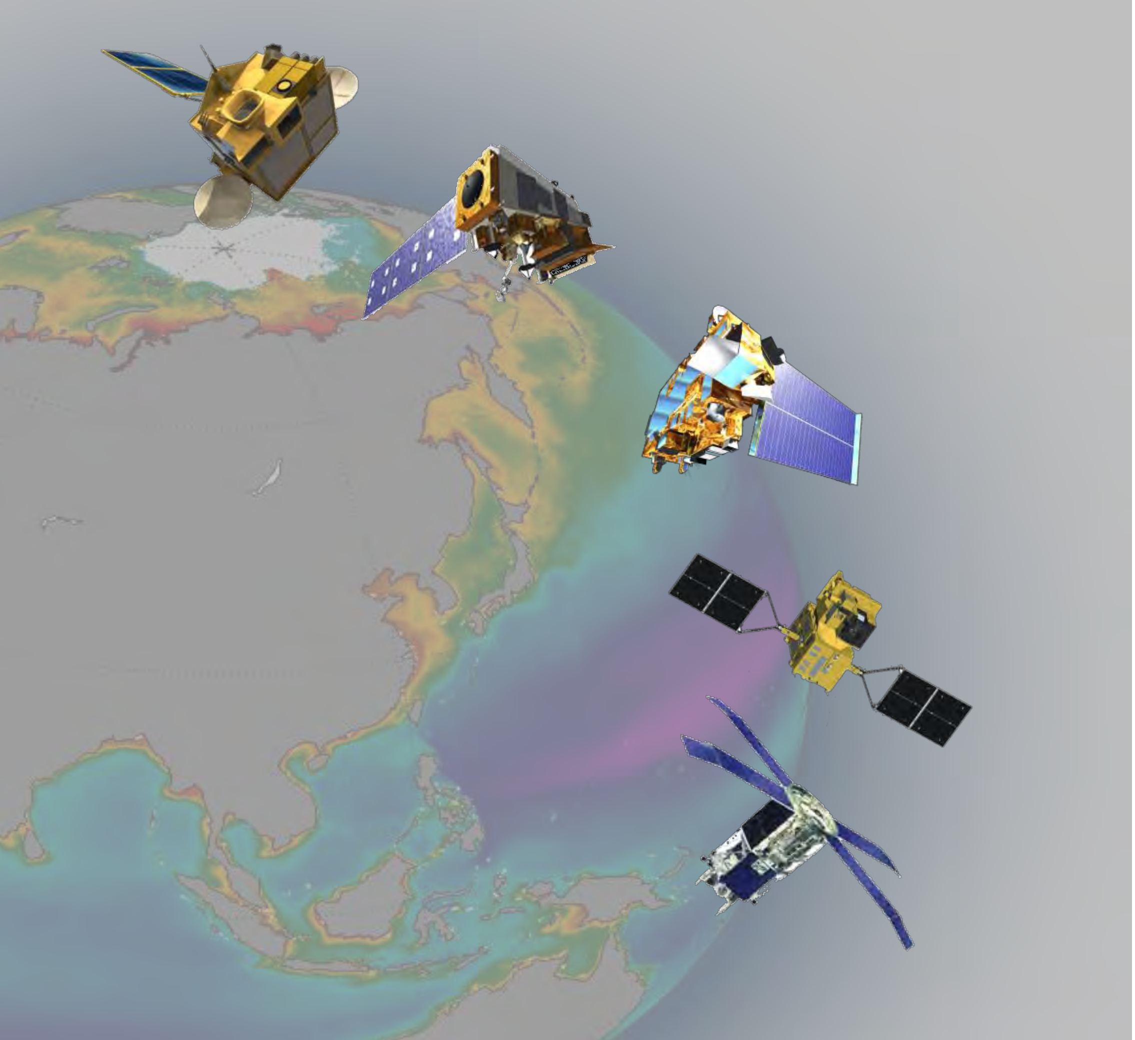
THE 3rd ASIAN / 12th KOREA-JAPAN WORKSHOP ON OCEAN COLOR

8 – 10 December 2015

Miyoshi Memorial Hall
Yokohama Institute for Earth Sciences
Japan Agency for Marine-Earth Science & Technology
(JAMSTEC)



JAMSTEC
Department of Environmental and Geochemical Cycle Research

APN
Asia-Pacific Network for Global Change Research

NAGOYA UNIVERSITY
ISEE
INSTITUTE FOR SPACE-EARTH ENVIRONMENTAL RESEARCH

KIOST
KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

KOSC
KOREA OCEAN SATELLITE CENTER

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Overview

Since 2003, Joji Ishizaka (Nagasaki University, presently Nagoya University, Japan) and Yu-Hwan Ahn (Korea Ocean Research and Development Institute, presently Korea Institute of Ocean Science and Technology, Korea) started an annual workshop on ocean color called as the Korea-Japan Workshop on Ocean Color (KJWOC), which has been held either in Japan or Korea, and attended mostly by Japanese and Korean ocean color community. Later, the community has agreed and decided to hold the Asian Workshop on Ocean Color (AWOC) once in several years of KJWOC series. By also inviting scientists and students from other Asian/southeast Asian countries, the AWOC is held to promote the application of ocean color remote sensing technology especially in the Asian/southeast Asian regions by initiating and/or establishing bilateral/international research collaborations. The 1st AWOC in 2011, which was also the 8th series of KJWOC, was held in Hokkaido University, Japan by the efforts of Taka Hirata. The 2nd AWOC 2013 was held in National Cheng Kung University, Taiwan and chaired by Cheng-Chien Liu. Here, in December 8-10, 2015, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) will host the 3rd AWOC 2015 or the 12th KJWOC series. Acknowledgement has to be addressed to the Institute for Space-Earth Environmental Research-Nagoya University (ISEE), Korea Ocean Satellite Center-Korea Institute of Ocean Science & Technology (KOSC), Japan Agency for Marine-Earth Science & Technology (JAMSTEC), and the Asia-Pacific Network for Global Change Research (APN) for their financial and in-kind supports.

Welcome Message

Asian marine environments have been changing as results of human activities and climate changes. Ocean color satellite with synoptic observation has been widely applied to monitor and study marine environmental changes. The launching of next generations Korean GOCI-II and Japanese GCOM-C/SGLI in the near future with high spatiotemporal resolution will definitely provide unprecedented observation system to understand more precisely the changes in the marine especially coastal water environments of the Asian regions.

For the purpose of facilitating the application of satellite ocean color technology to address the Asian marine environmental issues, collaborations among the Asian countries have been initiated during the 1st Asian Workshop on Ocean Color (AWOC) 2011 in Hokkaido University. Since then the collaborations have been intensified and the new collaborations have also been established.

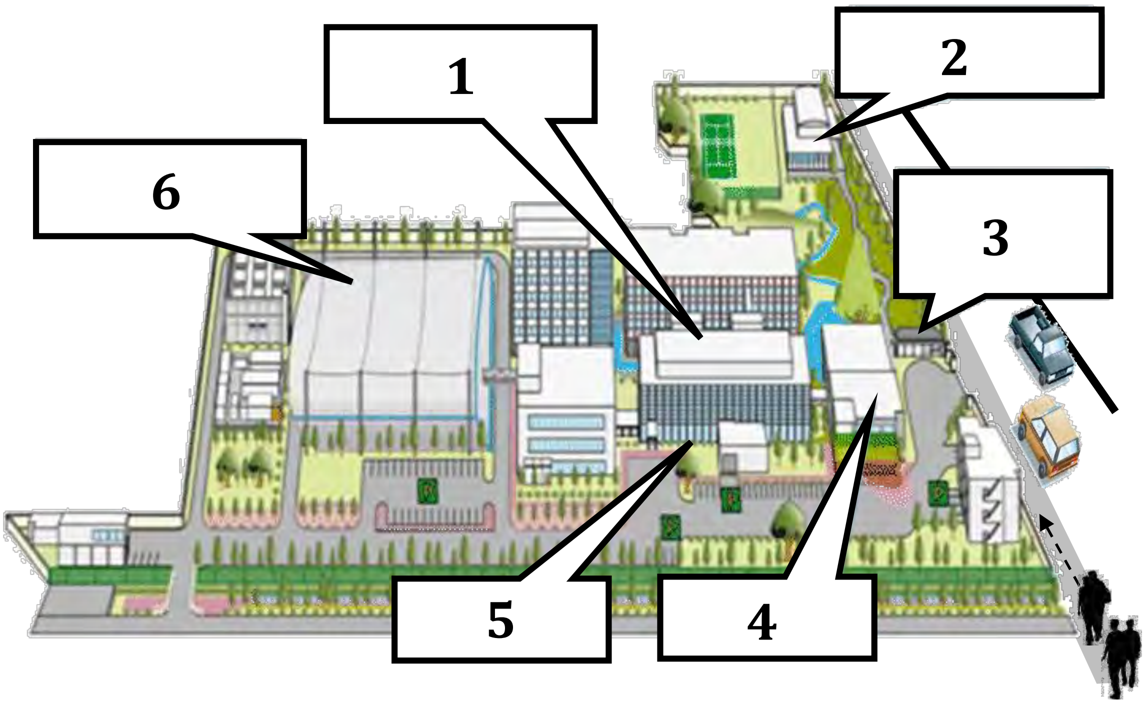
With the theme of "Application of Ocean Color Remote Sensing for Asian Marine Environment", the 3rd AWOC 2015 will present 36 oral and 13 poster presentations, covering a wide range of ocean color remote sensing application from various expertise of physical oceanography, biological oceanography, ecosystem modeling, and atmospheric-ocean optics. As a broad purpose, the workshop will strengthen the Asian ocean color community and to foster strong research collaborations among the Asian universities/research institutes. Besides identifying and/or offering solutions to current marine environmental problems by presenting/reporting relevant case studies and knowledge gaps, the workshop is also expected to be able to materialize bilateral/international new research collaborations among the participating countries.

On behalf of the organizing committee and Department of Environmental and Geochemical Cycle Research-JAMSTEC, it is my great pleasure to invite you to participate the 3rd AWOC/12th KJWOC 2015.

I look forward to seeing you in JAMSTEC, Yokohama, Japan.

Eko Siswanto
Chairman of the 3rd AWOC/12th KJWOC 2015
Department of Environmental and Geochemical Cycle Research (DEGCR)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Layout of Yokohama Institute for Earth Sciences (YES), JAMSTEC



[Address]
3173-25, Showa-machi, Kanazawa-ku, Yokohama-city, Kanagawa, 236-0001, Japan
PHONE:+81-45-778-3811
FAX : +81-45-778-5498

1.Miyoshi Memorial Hall

2.Guest House

3.Security Guard

4.Earth Science Museum

5.Cafeteria

6.Earth Simulator

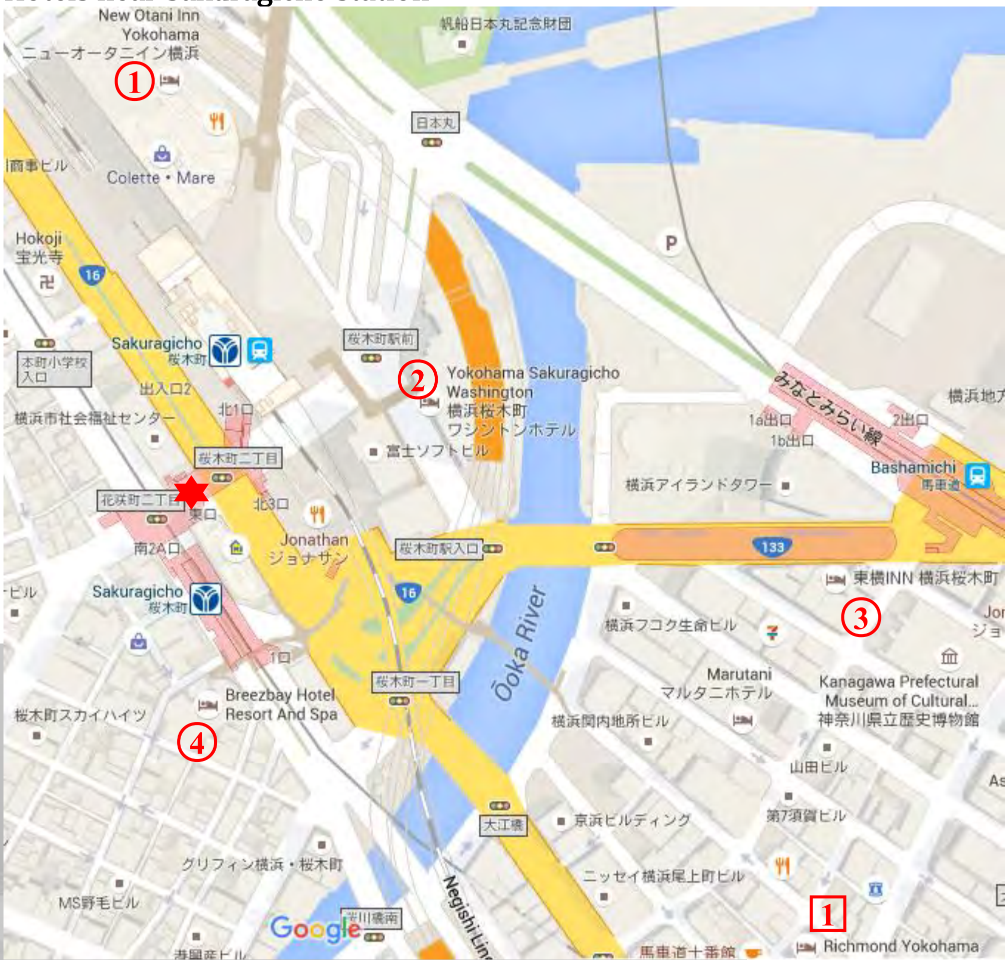
Transportation and Accommodation

❖ Hotels around Yokohama downtown area

We recommend hotels near 2 Japan Railways (JR) or subway stations i.e., Sakuragicho and Kannai stations. We have not contacted any hotel below, so the hotel rates shown here are based on internet booking sites, including VAT. Free Wi-Fi is available in all hotels on the list.

Basically, JAMSTEC does not book the hotel room for participant. So, please kindly make a room reservation by yourself.

Hotels near Sakuragicho station



1 Richmond Hotel (see hotels near Kannai st. below)
★ Sakuragicho st. Japan Railway (JR) Line gate Subway Blue Line gate

① New Otani Inn Yokohama

1 min. from Sakuragicho station
14,000-23,000 JPY per one night, single room, incl. breakfast
http://www.newotani.co.jp/en/innyokohama/index.html?GRP
(Official site is available in English, Korean, Chinese, and Japanese)

② Washington hotel Yokohama Sakuragicho

1 min. from Sakuragicho station
7,000-12,000 JPY per one night, single room, incl. breakfast
http://yokohama-s.washington-hotels.jp/
(Official site is available in English, Korean, Chinese, and Japanese)

③ Toyoko INN Yokohama Sakuragicho

5 min. from Sakuragicho station
6,800-8,500 JPY per one night, single room, without breakfast
http://www.toyoko-inn.com/hotel/00050/index.html
(Official site is available only in Japanese)

④ Breezebay Hotel Resort&Spa

3min. from Sakuragicho station
7,200-30,000 JPY per one night, single room, incl. breakfast
http://www.breezbay.co.jp/
(Official site is available only in Japanese)

Hotels near Kannai station

Sakuragicho st.
Japan Railway (JR) Line gate
Subway Blue Line gate

1 Richmond Hotel Yokohama Bashamichi

5 min. from Kannai station (7 min. from Sakuragicho)
6,600-12,000 JPY per night, single room, incl. breakfast
http://yokohama.richmondhotel.jp/
(Official site is available in English and Japanese)

2 Daiwa Roynet Hotel Yokohama Kannai

3 min. from Kannai station
7,500-14,000 JPY per night, single room, incl. breakfast
http://www.daiwaroynet.jp/english/yokohama-kannai/
(Official site is available in English, Korean, Chinese, and Japanese)

3 APA Hotel Yokohama Kannai

3 min. from Kannai station
6,000-14,000 JPY per night, single room, incl. breakfast
http://www.apahotel.com.e.ju.hp.transer.com/language/shutoken/08_yokohamakannai.html
(Official site is available in English, Korean, Chinese, and Japanese)

4 Comfort Hotel Yokohama Kannai

3 min. from Kannai station
7,000 JPY per night, single room, without breakfast
http://www.comfortinn.com/hotel-yokohama-japan-JP043#listpos1
(Official site is available in English and Japanese)

❖ Transportations for Airports–Yokohama station–Sakuragicho station/Kannai stations

1. Airports to Yokohama station

1a. Haneda International Airport – Yokohama station

Although you can take railway to Yokohama station, we recommend you to take Keihin Kyuko (Keikyu) bus that departs from platform/pole no.7 of Haneda Airport International Terminal, and please get off at the last stop, Yokohama City Air Terminal (YCAT). It will take around 40 minutes to reach YCAT. Keikyu bus is more convenient than railways especially for participants who have large/much luggage.

Please visit the links below (available in English, Chinese, Korean, and Japanese):
http://www.ycat.co.jp/en/route/haneda/ for bus fare;
http://www.ycat.co.jp/en/route/haneda/haneda2ycat.php for bus timetable; and
http://www.ycat.co.jp/en/route/haneda/movie.php the movie for getting on the bus to YCAT.
From YCAT, please follow the link below to reach Yokohama station by walk.
http://www.ycat.co.jp/en/access/ycat2station.php

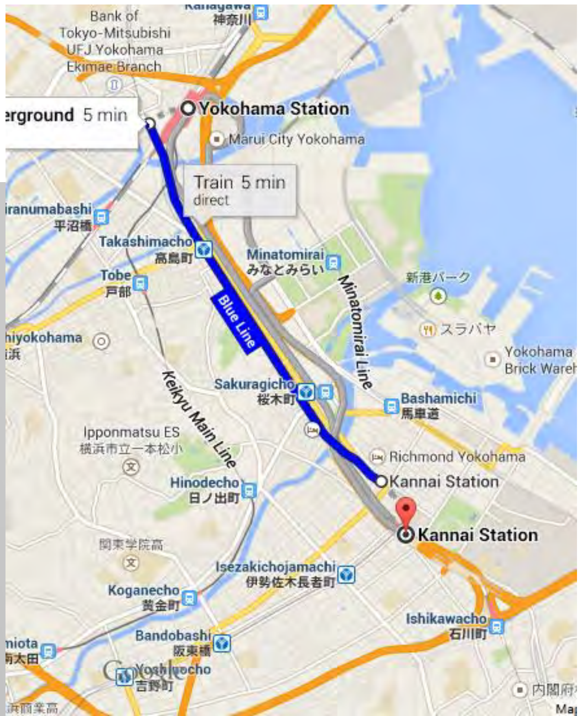
1b. Narita International Airport – Yokohama station

You can take either Narita Express Railway (NEX) or bus (Keikyu or Keisei buses), both are convenient. The NEX will bring you to Yokohama Station and take around 100-110 minutes. Please visit the following link (in English, Chinese, Korean, and Japanese), http://www.jreast.co.jp/e/nex/ for NEX detail information and http://www.eki-net.com/pc/jreast-shinkansen-reservation/english/wb/common/timetable/e_nex_u/index.html for NEX timetable.

The bus will connect Narita Airport to YCAT in approximately 85 minutes. Please visit the following links (available in English, Chinese, Korean, and Japanese):
http://www.ycat.co.jp/en/route/narita/ for bus fare;
http://www.ycat.co.jp/en/route/narita/narita2ycat.php for timetable, platform or pole no; and
http://www.ycat.co.jp/en/route/narita/movie.php the movie for getting on the bus to YCAT.
From YCAT, please follow the link below to reach Yokohama station by walk.
http://www.ycat.co.jp/en/access/ycat2station.php

2. Yokohama station to Sakuragicho or Kannai stations

From Yokohama station, please take either **JR Negishi Line** (~140 JPY) or **Subway Blue Line** (~210 JPY) to reach Sakuragicho or Kannai stations. It takes around 5 minutes. JR Negishi Line is also called as JR Keihin-Tohoku Line.

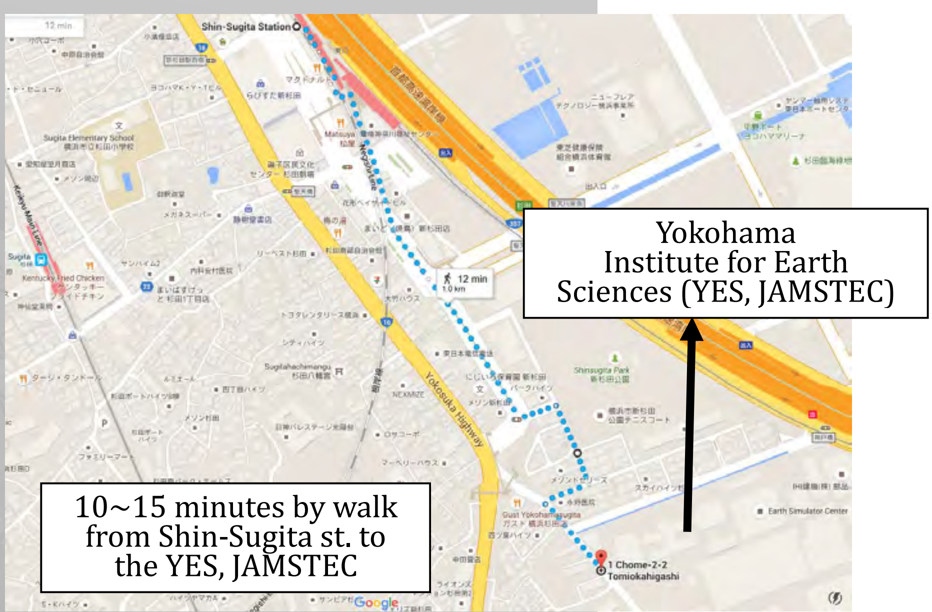


The link below is useful to find timetable from Yokohama st. to Sakuragicho or Kannai st.:

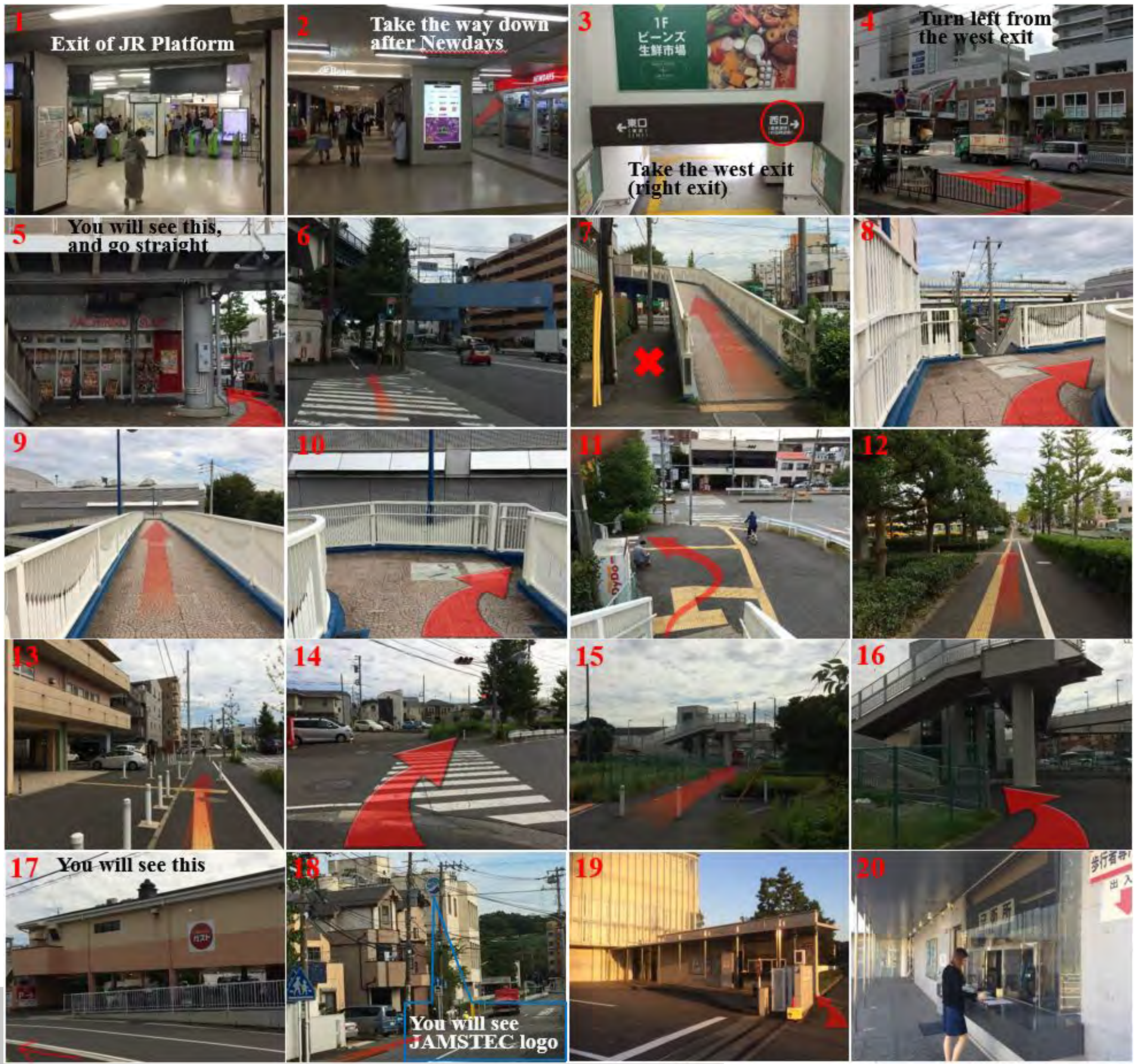
http://www.hyperdia.com/cgi/en/search.html?dep_node=YOKOHAMA&arv_node=KANNAI&via_node01=&via_node02=&via_node03=&year=2015&month=10&day=13&hour=10&minute=00&search_type=0&search_way=&transtime=undefined&sort=0&max_route=10&faretype=0&ship=off&lmlimit=null&search_target=route&facility=reserved&sum_target=7

❖ Transportation/guide for Sakuragicho station/Kannai station–Yokohama Institute for Earth Sciences (YES, JAMSTEC)

1) From Sakuragicho or Kannai st., please take JR Negishi Line (towards Ofuna) to reach JR Shin-Sugita st (around 15 minutes, cost: 170 JPY). Subway is not available to Shin-Sugita st. Click the link below to search JR timetable: http://www.hyperdia.com/cgi/en/search.html?dep_node=KANNAI&arv_node=SHIN-SUGITA&via_node01=&via_node02=&via_node03=&year=2014&month=02&day=03&hour=08&minute=30&search_type=1&search_way=&transtime=undefined&sort=0&max_route=5&ship=off&lmlimit=null&search_target=route&facility=reserved&sum_target=7



2) It will take 10~15 minutes by walk from Shin-Sugita station to Yokohama Institute for Earth Sciences (YES, JAMSTEC). Pictures below may help you find YES, JAMSTEC.



3) You will report to JAMSTEC security guards at the JAMSTEC gate, so they will check your name on the participant list.

Cafeteria

There is a cafeteria for lunch break in the 1st floor (below the Miyoshi Hall). Lunches can be purchased from the vending machine that accepts 10, 50, 100, 500 JPY coins and 1,000, 2,000, 5,000, and 10,000 JPY notes. Although, cafeteria will serve lunch from 11:30 to 13:30, it is recommended to finish the lunch by 12:30. Other vending machines for snack and beverage are also available.

Presentation Instructions

Instructions for oral presentation

In order to ensure a smooth workshop program, we kindly ask you to follow the following instructions.

Please kindly adhere strictly to **20 minutes** allocated to each presentation. Plan for **15 minutes** presentation followed by **5 minutes** for Q&A. Follow any additional instructions given by your session chairpersons.

Chairperson may ring the bell once at the first **10 minutes** and twice when **15 minutes** have passed. Chairperson will ring the bell three times **just before the end of presentation time** to signal the presenters that they have to stop the presentation, to allow smooth transition to the next presenter.

Instructions for poster presentation

Please prepare your poster to fit the following dimensions. The poster boards are portrait in orientation, and the dimensions are **170 cm high x 120 cm wide**.

Posters can be mounted from 09:00 on the first day (8 December) and should be removed before 14:00 on the last day (10 December). Short pins for the mounting of posters will be available at the Poster Help Desk in the Poster area.

Your poster numbers will be attached on poster boards. Please refer to the Final Program book that you will receive upon arrival at the venue for the poster board number assigned to you.

Poster presenters are requested to stand by their posters during the Poster Session between 16:00 and 17:00 on 9 December for informal discussion.

Workshop Program

DAY-1, 8 December 2015

Time	Program/Session/Title — *Speaker/Co-authors/Chairperson*	Page
09:15~10:00	Registration	
10:00~10:05	Announcements	
10:05~10:10	Welcome remarks *Eko Siswanto*	
10:10~11:30	**Session I : Ocean Color Programs (1)** *Chair: Young-Je Park, Co-chair: Eko Siswanto*	
10:10~10:30	Review of the last 10 years KJWOC activities *Yu-Hwan Ahn*	1
10:30~10:50	Update to GOCI & GOCI-II projects *Young-Je Park, KOSC members*	2
10:50~11:10	Preparation status of GCOM-C *Hiroshi Murakami*	3
11:10~11:30	User requirements and development status of the next Geostationary Ocean Color Imager, GOCI-II *Seongick Cho, Ki-Beom Ahn, Eunsong Oh, YoungJe Park*	4
11:30~12:30	Lunch break	
12:30~13:00	Group photo	
13:00~14:40	**Session II : Optical Color Programs (2)** *Chair : Hiroshi Murakami, Co-chair: Wonkook Kim*	
13:00~13:20	Version 1.4 update in GOCI Data Processing System (GDPS) *Hyun Yang, Nam-Su Kim, Jeung-Mi Ryu, Hee-Jeong Han, Young-Jae Park, Yu-Hwan Ahn*	5
13:20~13:40	Cluster based ocean color data processing system *Yunsoo Choi, Sangwhan Lee, Kyungseok Park, Hyun-cheol Kim, Young Baek Son, Sinjae Yoo*	6
13:40~14:00	A new web-based service of pathlines derived from GOCI data *Cheng-Chien Liu*	7
14:00~14:20	VIIRS ocean color research and applications *Menghua Wang, Xiaoming Liu, Lide Jiang, SeungHyun Son, Junqiang Sun, Wei Shi, Liqin Tan, Karlis Mikelsons, Xiao-long Wang, Veronica Lance*	8
14:20~14:40	Atmospheric correction updates for GDPS v.1.4 *Jae-Hyun Ahn, Youngje Park, Boram Lee, Wonkook Kim*	9
14:40~15:00	Tea/coffee break	
15:00~16:20	**Session III : Optical Properties & Ocean Color Algorithms (1)** *Chair : Sinjae Yoo, Co-chair: Mitsuhiro Toratani*	
15:00~15:20	A proposal for GOCI near-cloud flags in consideration to fast-moving clouds *Hajime Fukushima, Kazunori Ogata, Mitsuhiro Toratani, Jae-Hyun Ahn, Wonkook Kim, Young-Je Park*	10

Time	Program/Session/Title *Speaker/Co-authors/Chairperson*	Page
15:20~15:40	Analysis of the particle size distribution and optical properties in the Korean seas *Boram Lee, Young-Je Park, Kwangseok Kim, Jae-Hyun Ahn, Wonkook Kim, Jeong-Eon Moon, Sang-Wan Kim*	11
15:40~16:00	Optical properties of four harmful algal bloom (HAB) species in Korean waters *Yeseul Kim, Sinjae Yoo, Young Baek Son*	12
16:00~16:20	Seasonal and spatial variability in the absorption properties of the Korean waters and its influence for the ocean color algorithms *Jee-Eun Min, Joo-Hyung Ryu, Young -Je Park*	13
16:20~16:40	Tea/coffee break	
16:40~17:40	**Discussion on the new activities under the APN Climate Adaptation Framework** *Chair: Eko Siswanto*	
18:00~20:00	Gathering at the JAMSTEC guest house	

DAY-2, 9 December 2015

Time	Program/Session/Title *Speaker/Co-authors/Chairperson*	Page
09:50~11:30	**Session IV : Optical Properties & Ocean Color Algorithms (2)** *Chair : Young Baek Son, Co-chair: Amane Fujiwara*	
09:50~10:10	Estimation error of chlorophyll-a concentration in Tokyo Bay *Mitsuhito Toratani, Masaya Kometani*	14
10:10~10:30	Evaluation of GOCI chlorophyll algorithms for ocean waters around Korea and Japan *Wonkook Kim, Jeong-Eon Moon, Young-Je Park, Joji Ishizaka*	15
10:30~10:50	Diffuse attenuation coefficient of the photosynthetically available radiation K_d(PAR) for global open ocean and coastal waters *SeungHyun Son, Menghua Wang*	16
10:50~11:10	Ocean color detected features of phytoplankton bloom in Greenland Sea *Dae-hyuk Lee, Hyun-cheol Kim*	17
11:10~11:30	Detection and classification of red-tide outbreaks using big database (*in situ*, model, satellite data) around Korean Peninsular *Young Baek Son, Yeseul Kim, Soonmi Lee, Kyongseok Park, Sanghwan Lee, Sinjae Yoo*	18
11:30~12:30	Lunch break	
12:30~13:50	**Session V: Phytoplankton Functional Type** *Chair: Joji Ishizaka, Co-chair: SeungHyun Son*	
12:30~12:50	Influence of timing of sea ice retreat on phytoplankton size during marginal ice zone bloom period in the Chukchi and Bering shelves *Amane Fujiwara, Toru Hirawake, Koji Suzuki, Lisa Eisner, Ichiro Imai, Shigeto Nishino, Takashi Kikuchi, Sei-Ichi Saitoh*	19

12:50~13:10	High-resolution shipboard measurements of phytoplankton functional types and photosynthetic competency – a way forward for enhancing the utility of satellite Chlorophyll and SST for mapping coastal microscale features and frontal zones *Joaquim I. Goes, Christy A. Jenkins, Helga do R. Gomes, Robert Arnone, Joji Ishizaka*	20
13:10~13:30	Responses of phytoplankton functional types to changing winter vertical mixing: a modeling study *Soonmi Lee, Sinjae Yoo*	21
13:30~13:50	Remote sensing of taxon-specific primary productivity and quantum yield of photosynthesis *Taka Hirata, Koji Suzuki*	22
13:50~14:00	Tea/coffee break	
14:00~15:30	**JAMSTEC facility tour** *Guides: Kyoko Takeuchi, Fumie Nishida, Akiko Suzaki, Masako Wallwork*	
15:30~16:00	Tea/coffee break	
16:00~17:00	**Poster session**	

DAY-3, 10 December 2015

Time	Program/Session/Title *Speaker/Co-authors/Chairperson*	Page
09:30~11:30	**Session VI: Phytoplankton Biomass & Primary Productivity** *Chair: Joaquim I. Goes, Co-chair: Jonson Lumban-Gaol*	
09:30~09:50	Evaluation of the primary productivity algorithms for the Yellow Sea, East China Sea, and East Sea LMEs *Christina Eunjin Kong, Sinjae Yoo, Young Baek Son*	23
09:50~10:10	A rapid decline of annual primary production in the East/Japan Sea *HuiTae Joo, SeungHyun Son, Jung-Woo Park, Jae Jung Kang, Jin-Yong Jeong, Chung Il Lee, Chang-Keun Kang, Sang Heon Lee**	24
10:10~10:30	Monitoring of surface chlorophyll-a around the laver cultivation area of the Seto Inland Sea using GOCI data *Yuji Sakuno, Zuomin Wang*	25
10:30~10:50	Spatial and temporal variations of chlorophyll.*a* in the Seto Inland Sea using AQUA MODIS data *Miwa Nakagawa, Xinyu Guo, Naoki Yoshie*	26
10:50~11:10	Seasonal and inter-annual variability of satellite chlorophyll-a in Ise-Mikawa Bay, Japan *Masataka Hayashi, Joji Ishizaka, Mitsuhiro Toratani, Yo-ichi Maekawa, Toru Nakamura, Yasuo Nakashima, Satoshi Yamada*	27
11:10~11:30	The role of the Aleutian Low Pressure System in regulating phytoplankton production and carbon export in the North Pacific Ocean – results from a decade and half of satellite ocean color observations *Joaquim I. Goes, Helga do R. Gomes, Joji Ishizaka*	28
11:30~12:30	Lunch break	

Time	Title	Authors	Page
12:30~13:50	**Session VII: Phytoplankton Dynamic (1)**	*Chair : Iskhaq Iskandar, Co-chair: Md. Latifur Rahman Sarker*	
12:30~12:50	El Nino footprint on the South China Sea phytoplankton biomass at different time-lags	*Eko Siswanto, DanLing Tang, Ye Haijun*	29
12:50~13:10	Annual variations in plankton blooming in the upper Gulf of Thailand	*Anukul Buranapratheprat, Akihiko Morimoto, Atsushi Kaneda, Yoshihisa Mino, Vichaya Gunboa, Pachoenchoke Jintasaeranee, Joji Ishizaka*	30
13:10~13:30	Sea surface chlorophyll-a variations in the Upper Gulf of Thailand (UGoT) based on remotely sensed data analysis	*Prasarn Intacharoen, Songkot Dassananona, Anukul Buranapratheprat*	31
13:30~13:50	Long-term change of ocean productivity: A case study in the Bay of Bengal	*Md. Latifur Rahman Sarker, Noor Saadah Sabarudin*	32
13:50~14:10	Tea/coffee break		
14:10~15:30	**Session VIII: Phytoplankton Dynamic (2) & Other Applications**	*Chair: Xinyu Guo, Co-chair: Anukul Buranapratheprat*	
14:10~14:30	Examining features of enhanced phytoplankton biomass in the Bay of Bengal using a coupled physical-biological model	*Helga do Rosário Gomes, Joaquim I. Goes, Sergio deRada, Fei Chai ,Joji Ishizaka*	33
14:30~14:50	Boreal summer-fall surface chlorophyll bloom in the southeastern tropical Indian Ocean based on MODIS data	*Iskhaq Iskandar, Bruce Monger*	34
14:50~15:10	Change in coral cover detected by using multi temporal LANDSAT imagery data in Pangkajene Islands, Spermonde Archipelago, South Sulawesi, Indonesia	*La Ode Muhammad Yasir Haya, Masahiko Fujii*	35
15:10~15:30	Ocean color data for *Sardinella lemuru* management in Bali Strait	*Jonson Lumban-Gaol, Bonar P. Pasaribu, Kedarnath Mahapatra, Yoshihiro Okada, Toshiro Osawa*	36
15:30~16:00	**Closing remarks**		

Poster Presentations

DAY-2, 9 December 2015 (16:00~17:00)

Schedule for JAMSTEC Facility Tour

Time and date : 14:00 – 15:30, December 9, 2015
Venue : JAMSTEC Yokohama Institute for Earth Sciences
3173-25 Showa-machi, Kanazawa-ku, Yokohama City,
Kanagawa, 236-0001, Japan
Guests : AWOC/KJWOC 2015 attendees
Guides :

- Kyoko Takeuchi, Public Relations Division, Public Relations Department
- Fumie Nishida, Public Relations Division, Public Relations Department
- Akiko Suzaki, Public Relations Division, Public Relations Department
- Masako Wallwork, Research Support Department

Timetable :

Time	Facility
14:00~14:20	Briefing on JAMSTEC in Miyoshi Memorial Auditorium of Conference Building
Group A (Tour is offered in English)	
14:20~14:40	Simulation images on hemispheric simulation screen and 3D video on Drilling Vessel CHIKYU in Earth Science Museum
14:40~15:00	Water Pressure Experiment
15:00~15:20	Super computer system, Earth Simulator in Earth Simulator Building
15:20~15:30	Question and answer session in Miyoshi Memorial Auditorium of Conference Building
Group B (Tour is offered in Japanese)	
14:20~14:40	Super computer system, Earth Simulator in Earth Simulator Building
14:40~15:00	Simulation images on hemispheric simulation screen and 3D video on Drilling Vessel CHIKYU in Earth Science Museum
15:00~15:20	Water Pressure Experiment
15:20~15:30	Question and answer session in Miyoshi Memorial Auditorium of Conference Building

Review of the last 10 years KJWOC activities

Yu-Hwan Ahn
Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology

Corresponding e-mail: yhahn@kiost.ac.kr

The Korea-Japan Workshop on Ocean Color (KJWOC) begun in 2004 through the cooperation between Nagasaki University, Japan (Prof. J. Ishijaka) and KORDI (now KIOST) (Dr. YH Ahn & Dr. SJ Yoo). The main objectives of this series of meetings are to enhance research cooperation and discuss common research activities between Japan and Korea. The JKWOC meetings are financially supported by the national R&D projects from both the countries. We consider this kind of long-run annual meeting as a very good model for enhancing research collaboration and promoting the ocean color science. It is now 11 years and the program is still very active and inspiring many researchers in our two countries. During the last 10 years, many young students who participated in KJWOC meetings have now become regular research scientists in various institutions in Asia.

In 2013, we organized KJWOC meeting with the AWOC (Asian Workshop on Ocean Color) in Taiwan and it was extended to participants from the Asian countries. The outcome was encouraging as we had a large number of scientists within Asia. Hence, it's time to think about if we could make this meeting as a regular and open, international ocean color workshop like the one organized for the Asia-Pacific region (PORSEC meeting).

More activities are needed since we already have a Geostationary Ocean Color Satellite (GOCI series, GOCI-II is scheduled for launch 2018) in Korea and GCOM-C in Japan.

Update to GOCI & GOCI-II projects

Young-Je Park, and all the members of Korea Ocean Satellite Center
Korea Ocean Satellite Center, Korea Institute of Ocean Science and Technology

Corresponding e-mail: youngjepark@kiost.ac.kr

The Geostationary Ocean Color Imager (GOCI), the only ocean color sensor currently operated on a geostationary orbit since July, 2010. This presentation provides brief updates to the missions of the GOCI and follow-on sensor, GOCI-II.
The GOCI instrument appears very stable, showing less than 1% degradation per year in the calibration for all bands. GOCI data processing software (GDPS) has been updated, where the atmospheric correction was improved significantly. GOCI imagery, again this year, showed the spatial extent of the harmful algal blooms, which is an important information for the HAB study but difficult to obtain by using field observation only. GOCI was also able to detect the floating Sargassum in early 2015, massive floating Sargassum washed ashore in Jeju island and islands in southwestern corner of Korea.

The GOCI-II, planned to launch in the first half of 2019, has undergone the detailed design phase without a critical issue. The ground processing system for GOCI-II is currently in preliminary design phase.

Preparation status of GCOM-C

Hiroshi Murakami
Earth Observation Research Center (EORC), Japan Aerospace Exploration Agency (JAXA)

Corresponding e-mail: murakami.hiroshi.eo@jaxa.jp

For the launch in JFY2016, GCOM-C satellite and sensor are being tested in Tsukuba Space Center this year. Sensor characterization (gain, linearlity, polarization sensitivity, and straylight) and the calibration algorithm development are undergoing. GCOM-C ground system is being tested by simulation data, prototype algorithms, which are developed by PIs and JAXA, and the operation control system.

SGLI has 250m spatial resolution with 1050-km swath, which is expected to improve the coastal monitoring. We have developed ocean color algorithms for the SGLI bands and estimated their errors.

There are problems in the atmospheric correction, retrieval of water composition in the presence of optically complex waters and absorbing aerosols. We have started characterization study of coastal in-water optical properties (spectral absorption and back scattering) and aerosol characteristics in some coasts mainly around Japan, e.g, Mutsu, Tokyo, and Ariake Bays, and so on. The obtained optical properties will be analysed by a consistent way, and the characterization results will be used in the satellite data retrievals (atmospheric correction and inversion of in-water optical properties) in each area. The analysis requires measurements in various (typical) coastal areas. The observations will be conducted in collaboration with our GCOM-C science team, other collaborative research organizations, and international partners.

The PI team has been organized in summer 2009 as the first research period (Sep. 2009 - Mar. 2013), followed by the second research period (Apr. 2013 - Mar. 2016), and will be continued as the third research period (Apr. 2016 - Mar. 2019) which will include launch time and the initial Cal/Val phase.

User requirements and development status of the next Geostationary Ocean Color Imager, GOCI-II

Seongick Cho[1,2], Ki-Beom Ahn[1,2], Eunsong Oh[1,2], YoungJe Park[1]
[1] Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology, Korea
[2] Space Optics Laboratory, Dept. of Astronomy, Yonsei University, Korea

Corresponding e-mail: youngjepark@kiost.ac.kr

Geostationary Ocean Color Imager (GOCI), the first Earth observation instrument in geostationary orbit, is successfully launched and operated from 2010. The necessity of the next generation satellite is gradually increasing into the international ocean color remote sensing users as well as domestic users in Korea. As a successor of GOCI, development of GOCI-II has been started in 2012 with a scheduled launch in 2019. The mission and user requirements of GOCI-II are defined by Korea Institute of Ocean Science and Technology (KIOST) and international GOCI PI (Principal Investigators).

GOCI-II will be operated in same orbital location, at 128.2 degrees Eastern Longitude in geostationary orbit, with GOCI. The GSD (Ground Sample Distance) 250m spatial resolution at nadir and the spectral bands are 12 bands from visible to NIR (370~885nm). Additional 4 spectral bands are added to improve the accuracy of data products such as chlorophyll concentration, total suspended sediments, dissolved organic matters, enhancement of atmospheric correction, and to have a novel capability such as PFT (Phytoplankton Functional Type) which enables to discriminate harmful algae bloom. Newly implemented panchromatic band with 402~885nm bandwidth is expected to enable star imaging for the geometric correction of GOCI-II images. GOCI-II will perform 10 LA observations per day, it fully contain the current GOCI image acquisition schedule (8 times per day with one hour interval from 09:15AM KST, Korea Standard Time). The observation region of LA can be freely definable by user. Full Disk (FD) and user-definable local area observation mode to be implemented for GOCI-II will satisfy the user requests such as special ocean event area over specific region in anytime and anywhere.

Additionally, a daily global observation is planned for GOCI-II for the research of long-term climate change in ocean. In order to develop the GOCI-II with the full satisfaction of user requirements and to develop the data processing technique based on the actual GOCI-II on-ground test results, KIOST research scientists are working together as Joint Development Team (JDT) with Airbus Defence & Space, and KARI (Korea Aerospace Research Institute). Airbus DS is the GOCI-II main developer according to the contract signed in July 2013. Critical Design Review for GOCI-II has been held in Oct. 2015.

Version 1.4 update in GOCI Data Processing System (GDPS)

Hyun Yang[1,*], Nam-Su Kim[2], Jeung-Mi Ryu[1], Hee-Jeong Han[1], Young-Jae Park[1], Yu-Hwan Ahn[1]

[1] Korea Ocean Satellite Center (KOSC), Korea Institute of Ocean Science and Technology (KIOST)
[2] Saeasoft

**Corresponding e-mail: yanghyun@kiost.ac*

The Geostationary Ocean Color Imager (GOCI) Data Processing System (GDPS) is an exclusive software system to process the GOCI data in real-time and interactively. In this paper, the summary of the next GDPS version 1.4 was explained. The main purpose of this update was applying the software modularization to GDPS. The software modularization means a software design technique separating each function into mutually independent modules.

The main problem of the existing GDPS was that the processing functions were not separated. This causes inefficient processing environments. For example, we were able to process chlorophyll concentration estimation algorithm only after the atmospheric correction, although we want to obtain just a chlorophyll concentration product. Therefore, we are planning to provide each separated modules for all of ocean color products of GDPS to end users, in order to improve the processing efficiency. Another purpose of this work was to update user interfaces for GDPS. Especially we refined the usability for the FLAG analysis. Finally, trivial bugs were fixed correctly.

Cluster based ocean color data processing system

Yunsoo Choi[1], Sangwhan Lee[2], Kyungseok Park[2], Hyun-cheol Kim[3*], Young Baek Son[4], Sinjae Yoo[4]

[1] *Biomedical Convergence Technology Lab, Korea institute of Science and Technology Information, Daejeon, South Korea, 34141*

[2] *Scientific Data Research Center, Korea institute of Science and Technology Information, Daejeon, South Korea, 34141*

[3] *Department of Polar Remote Sensing, Korea Polar Research Institute, Incheon, South Korea, 21190*

[4] *Jeju International Marine Science Research and Logistics Center, Korea Institute of Ocean Science and technology, Jeju, South Korea, 15627*

**Corresponding e-mail: kimhc@kopri.re.kr*

We faced with huge amount of Ocean Color data due to its accumulation during last couple of decades and newly added satellite data for monitoring the Earth. In addition to, sophisticated spatiotemporal resolution require extra processing time then before. That is, the satellite remote sensing is in the era of data analysis.

A complicated natural phenomenon requires a wider range and type of satellite data and accurate analysis techniques. Since last three years we have developing ocean color data processing system to improve processing performance, speed up and intuitive use. Clustering platform can it possible to reduce processing time on a massive big volume of data and is easy use for end-user even though he/she is not export on computer system.

Our cluster consists of a single master and 9 slaves for job execution. Each node in the cluster is equipped with Intel Xeon E7-4860 with 2.26GHz CPU cores, 18GB main memory, and 7200RPM 1TB HDD. All nodes are connected by a Gigabit switching hub. We evaluated performance comparison by testing average image converting time for 288 MODIS level 1-A images, each of which size is about 417 MB in average, both in a single machine and in our cluster. In a single machine environment, converting the level-1A images to level-2 images was taken 392.76 seconds for each image in average and 113,114 seconds for all 288 images. On the other hands, only 8.36 seconds in average were required for the same converting process in our cluster, meaning that our cluster system is 47.98 times faster than when working on a single machine.

Our proposed platform provides researchers with a more efficient way to treat a massive volume of scientific data to be analyzed as we significantly reduced the total elapsed time for data loading and query processing. Consequently, our platform could lead researchers to see their results of their scientific studies more quickly.

A new web-based service of pathlines derived from GOCI data

Cheng-Chien Liu[1,2*]

[1] Department of Earth Sciences, National Cheng Kung University, No 1, Ta-Hsueh Road, Tainan, Taiwan 701 R.O.C.

[2] Global Earth Observation and Data Analysis Centre, National Cheng Kung University, No 1, Ta-Hsueh Road, Tainan, Taiwan 701 R.O.C.

**Corresponding e-mail: ccliu88@mail.ncku.edu.tw*

This paper reports a new web-based service of pathlines derived from Geostationary Ocean Colour Imager (GOCI) data. To assist the users to quickly browse the large archive of all GOCI data via internet and select the appropriate time frame and location of concerns, three modules were integrated and operated on line. The first module is an auto-generated mask of cloud and shadow, based on the technique developed for Landsat TM and ETM+ images. The second module separates water body from those regions contaminated by clouds or shadows. A lot of details of the fine structures of eddies and fronts near the coast can be revealed from these contrast-enhanced images. The third module uses the technique of superoverlay to generate a standard set of image pyramid that completely conforms with Google Earth and Google Map.

An animation file can be generated to display the full-temporal and full-spatial resolution of GOCI data at any location within any time frame. For each set of two masked GOCI images, the normalized cross correlation (NCC) coefficient is used as an index to search all co-registered/matched points (C/M Pts). The problematic pairs of C/M Pts are filtered out by applying the phase-correlation (PC) approach to the template and matched images, as well as varying their sizes to double check the amount of shifts. The pathlines are derived by processing all eight consecutive images collected by GOCI within one day. This new value-added product of pathlines is now made available by Global Earth Observation and Data Analysis Centre.

VIIRS ocean color research and applications

Menghua Wang[1], Xiaoming Liu[1,2], Lide Jiang[1,2], SeungHyun Son[1,2,*], Junqiang Sun[1,3], Wei Shi[1,2], Liqin Tan[1,2], Karlis Mikelsons[1,3], Xiao-long Wang[1,2], Veronica Lance[1,3]

[1] *NOAA/NESDIS, Center for Satellite Applications and Research (STAR), E/RA3, 5830 University Research Ct., College Park, MD, USA*
[2] *CIRA, Colorado State University, Fort Collins, CO, USA*
[3] *Global Science & Technology, Greenbelt, MD, USA*

**Corresponding e-mail: seunghyun.son@noaa.gov*

We provide evaluations and assessments of the Visible Infrared Imaging Radiometer Suite (VIIRS) ocean color products, including normalized water-leaving radiance spectra *nLw*(λ) at VIIRS five spectral bands, chlorophyll-a concentration (Chl-a), water diffuse attenuation coefficients at the wavelength of 490 nm, *Kd*(490), and at the domain of photosynthetically available radiation (PAR), *Kd*(PAR). Specifically, VIIRS ocean color products derived from the NOAA Multi-Sensor Level-1 to Level-2 (MSL12) ocean color data processing system are evaluated and compared with in situ data from the Marine Optical Buoy (MOBY) and measurements from the Moderate Resolution Imaging Spectroradiometer (MODIS).

In general, VIIRS ocean color products are matched well with MOBY in situ measurements, and are also consistent with those from MODIS-Aqua. Ocean color products were found to be highly sensitive to some operational sensor calibration issues. We have improved sensor calibration by combining the lunar calibration into the current calibration method. Here, the ocean color products based on the new sensor calibration are evaluated. Our results show that VIIRS is capable of providing high-quality global ocean color products in support of the scientific research and operational applications.

Atmospheric correction updates for GDPS v.1.4

Jae-Hyun Ahn[1,2,*], Youngje Park[1], Boram Lee[1,3], Wonkook Kim[1]

[1] *Korea Institute of Ocean Science & Technology, Korea Ocean Satellite Center, Ansan, South Korea*

[2] *Ocean Science &Technology School, Department of Convergence Study on the Ocean Science and Technology, Busan, South Korea*

[3] *Sejong University, Geoinformation Engineering, Seoul, South Korea*

**Corresponding e-mail: brtnt@kiost.ac.kr*

Geostationary Ocean Color Imager (GOCI) records the total radiance exiting the top-of-atmosphere (TOA) at 6 visible bands (centered at 412, 443, 490, 555, 660, and 680nm) and 2 near-infrared (NIR) bands (centered at 745 and 865nm) bands with a moderate spatial resolution and a high temporal frequency. The current GOCI standard atmospheric correction method that is included in the GDPS ver.1.3 is theoretically based on the SeaWiFS/MODIS standard approach (Gordon and Wang, 1994), however, its implementation is partially different (Ahn et al., 2012; Ahn et al., 2015).

In this study, we describes the updated atmospheric correction schemes for GDPS ver.1.4 including 1) water vapor absorption correction, 2) sun-glint correction, 3) modified white-cap correction, 4) modified Rayleigh scattering correction, and 5) correlated adjustments of vicarious gains and turbid water NIR correction model coefficients. These scheme updates significantly impact on the oligotrophic region of GOCI observation.

A proposal for GOCI near-cloud flags in consideration to fast-moving clouds

Hajime Fukushima[1,*], Kazunori Ogata[1], Mitsuhiro Toratani[1], Jae-Hyun Ahn[2], Wonkook Kim[2], and Young-Je Park[2]
[1] Tokai University
[2] Korea Institute of Ocean Science and Technology

**Corresponding e-mail: hajime@tsc.u-tokai.ac.jp*

The Global Ocean Color Imager (GOCI) aboard the Korean COMS geostationary satellite observes ocean reflectance at 8 bands over visible to near-infrared region. One full GOCI scene is made by 16 (i.e. 4 by 4) slot-wise observations, each of which takes about 50 seconds to complete the spectral scan with the rotating filter wheel. Due to this inter-band time difference of 6~50 seconds, travelling cloud/aerosol would appear at slightly different position in each band-wise image data to affect the image quality of Level 2 products. Since the maximum wind speed of high altitude (cirrus cloud level) could reach as high as 100m/s, the spatial scale of this contamination could extend up to 10 pixels.

To cope with this, we have been studying efficient and realistic methodology to indicate those pixels affected by moving cloud/aerosol. In this talk we are to propose a set of near-cloud quality tests, named GOCI spectral consistency (GOSPEC) test set, reporting updates and improvements since the prior presentations given in KJWOC 2014 and in ISRS 2015.

The proposed test set consists of three tests: (1) Rrs Consistency (RRSC) test that checks spectral relationship over satellite-derived Rrs in 443, 490 and 550 nm bands against a standard relation derived from NOMAD in situ data set, (2) Local Coherency (LC) test that evaluates coherency of difference of the Rayleigh-corrected reflectance between 660 and 680 nm bands over 3 by 3 and 5 by 5 local window, and (3) the same LC test but over 745 and 865 nm bands. A suggested set of the thresholds or parameter values for different warning levels (to flag/mask L2 or L3 products) will be presented. The talk will also include the results of statistical performance evaluation over limited number of GOCI data set.

Analysis of the particle size distribution and optical properties in the Korean seas

Boram Lee[1,2], Young-Je Park[1,*], Kwangseok Kim[1], Jae-Hyun Ahn[1], Wonkook Kim[1], Jeong-Eon Moon[1], Sang-Wan Kim[2]

[1] Korea Ocean Satellite Center (KOSC), Korea Institute of Ocean Science and Technology (KIOST)

[2] Geoinformation Engineering, Sejong University

**Corresponding e-mail:youngjepark@kiost.ac.kr*

The Particle Size Distribution (PSD) is the mathematical function that defines the number of particles according to size and has been widely used to characterize marine particles (Buonassissi and Dierssen, 2010). The PSD can aid in the comprehension of phytoplankton community dynamics and sediment transport (Slade and Boss, 2015). Based on theoretical derivation (assuming nonabsorbing spherical particle), the exponent of the PSD (ξ) and the exponent of the particulate attenuation spectrum (the hyperbolic exponent, γ) as a function of wavelength are linearly related (Boss et al., 2001).

Here, we conduct (1) the measurement of the PSD using Coulter counter analysis in laboratory and (2) post-processing of AC-S raw data with correcting the effects of temperature and salinity. Field measurements of the PSD and inherent optical properties (IOP) which includes absorption, scattering and attenuation were carried out in 2015 near East/Japan sea and Yellow sea. According to previous studies, (3) we derive relationship between the PSD slope (ξ) and particulate attenuation slope (γ) and then analyze the results.

Optical properties of four harmful algal bloom (HAB) species in Korean waters

Yeseul Kim[1,2,*], Sinjae Yoo[1,2], Young Baek Son[1]
[1] *Korea Institute of Ocean Science and Technology (KIOST), Jeju, R Korea*
[2] *Ocean Science and Technology School, Korea Maritime and Ocean University/Korea Institute of Ocean and Science Technology Joint Program, Busan, R Korea*

**Corresponding e-mail: yees0408@kiost.ac.kr*

Harmful algal blooms (HABs) have continuously occurred around the coastal waters of Korean peninsula since the late 1980s. Satellite remote sensing has been used to detect and monitor the temporal and spatial distributions of widespread HABs. To use satellite remote sensing more effectively in detecting HABs, we should understand optical characteristics such as absorption and remote sensing reflectance of HAB causative species.

In this study, we analyzed the characteristics of absorption coefficients and simulated remote sensing reflectance (R_{rs}) of the four dinoflagellate HAB species (*Cochlodinium polykrikoides, Akashiwo sanguinea, Alexandrium tamarense and Scrippsiella trochoidea*) which are among the major HAB species in Korean waters. We calculated the absorption coefficients (a_{ph}) of four HAB species using culture samples. The absorption spectrums of the four dinoflagellate HAB species show similar patterns at major and minor peaks near 440, 680 nm and 460nm, respectively. However, the shapes and magnitudes of these spectrums show clear differences. Next, we used the HydroLight (version 5.2; Mobley, 1995) to simulate the remote sensing reflectance under dynamic optical conditions. For HydroLight simulations, we used the absorption coefficients measured from the samples and absorption and backscattering coefficients of other optical constituents from International Ocean-Color Coordinating Group database (IOCCG Report 5, 2006). We compare the simulated R_{rs} and in-situ R_{rs} observed during HAB outbreaks in August 2014 and 2015.

Seasonal and spatial variability in the absorption properties of the Korean waters and its influence for the ocean color algorithms

Jee-Eun Min, Joo-Hyung Ryu*, Young -Je Park
Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology, Korea

**Corresponding e-mail: jhryu@kiost.ac.kr*

Understanding for the light field of sea water is very important in Ocean Color Remote Sensing (OCRS) because it brings immense information concerning the ocean environmental properties. The signal recorded on the sensor is an energy leaving from the sea surface after incidence light has been absorbed and scattered by sea water constituents. The amount of scattering is a lot smaller than that of absorption relatively, so the influence of absorption is more critical. Many studies have been accomplished in various seas around the world, but we found only a few investigations in optically more complex waters around the Korea.

Thus, in this study we analyze the absorption coefficient of sea water constituents, phytoplankton (chlorophyll), Suspended Particulate Matter (SPM) and Dissolved Organic Matter (DOM) for the various Korean Waters. About 1300 water samples have been collected from 2003 to 2014 around the Korean waters. It should be noted that sea areas around the Korea have different characteristics separately, so we analyzed the optical properties of each separated sea waters and compared each other results. The absorption spectral shape of SPM and DOM showed exponentially decreasing pattern toward longer wavelength. Slope for the each spectrum represented the information of absorption characteristics. Using this result, we modeled the remote sensing reflectance (R_{rs}) spectra and simulated ocean color algorithms for the SPM and chlorophyll concentration.

Estimation error of chlorophyll-a concentration in Tokyo Bay

Mitsuhito Toratani*, Masaya Kometani
School of engineering, Tokai University

Corresponding e-mail: tora@keyaki.cc.u-tokai.ac.jpl

Tokyo bay is one of inner bay of high eutrophication. Red tide occurs frequently 98 days per year and blue tide occers sometimes. The ocean color remote sensing is expected to monitor them. However, satellite-estimated chorophyll-a concentarion has error in Tokyo Bay.

In this study, we compare the satellite-estimated chlorophyll-a concentration and in-situ data, to investigate the chlorophyll a concentration estimation error of Tokyo Bay.

MODIS/Aqua data was processed to estimate chlorophyll-a concentration using atmospheric program l2gen in SeaDAS7. On the other hand, we use ship observation data and automatic marine observation data at Kawasaki artificial island and Chiba light beacon. Satellite-estimated chlorophyll-a concentration was underestimated generally. We report the cause of errors such as impact on the remote sensing reflectance of atmospheric correction, fluctuations in aerosol optical thickness and Angstrom exponent of aerosol, etc.

Evaluation of GOCI chlorophyll algorithms for ocean waters around Korea and Japan

Wonkook Kim[1,*], Jeong-Eon Moon[1], Young-Je Park[1], Joji Ishizaka[2]
[1] Korea Institute of Ocean Science and Technology, 787 Haean-ro, Ansan, Korea
[2] Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Japan

**Corresponding e-mail: wkkim@kiost.ac*

Estimation of chlorophyll concentration in marine biosphere has been the central topic of ocean color remote sensing since its advent. Although various estimation algorithms were proposed in the literature so far and tested for oceanic waters of optically complex waters, an independent algorithm evaluation is needed for the local ocean waters that have dynamic variation in optically active water constituents such as colored dissolved organic matters (CDOM) and suspended sediment (SS).

This paper evaluates the performance of chlorophyll algorithms for Geostationary Ocean Color Imager (GOCI) radiometric data, using *in situ* measurements collected over 588 stations around Korea Peninsula during 2010-2014 (287 match-up data with GOCI). To enable evaluation for the areas with large variability in the constituents, water samples were first classified into mutually exclusive water types based on the levels of CDOM and suspended particulate matters (SPM). The candidate algorithms were then evaluated for each type of water, using the *in situ* and GOCI data. Traditional band ratio algorithms (e.g. OC algorithms and Tassan's algorithm, fluorescence line height algorithm, and NIR-to-red band ratio approach were tested in the study.

The evaluation results for the coincident *in situ* data showed that the best mean uncertainty is less than 40% with the correlation greater than 0.7 with either the OC3 or Tassan's algorithm. For the GOCI match-ups, the best overall uncertainty for all types of waters is around 50% with correlation around 0.4 which is achievable with Tassan's algorithm, while for clear waters in open oceans the best uncertainty is around 40% with correlation around 0.8 when estimated with either the OC3 or Tassan's algorithm.

Diffuse attenuation coefficient of the photosynthetically available radiation K_d(PAR) for global open ocean and coastal waters

SeungHyun Son[1,2,*], Menghua Wang[1]
[1] *NOAA/NESDIS, Center for Satellite Applications and Research (STAR) E/RA3, 5830 University Research Ct., College Park, MD 20740, USA*
[2] *CIRA, Colorado State University, Fort Collins, CO, USA*

**Corresponding e-mail: seunghyun.son@noaa.gov*

Satellite-based observations of the diffuse attenuation coefficient for the downwelling spectral irradiance at the wavelength of 490 nm, K_d(490), and the diffuse attenuation coefficient for the downwelling photosynthetically available radiation (PAR), K_d(PAR), in the ocean can play important roles for ocean-atmospheric circulation model, biogeochemical model, and ecosystem models. Since existing K_d(PAR) models for the satellite ocean color data have wide regional variations, we need to improve K_d(PAR) model for the global ocean applications. In this presentation, we propose a new blended K_d(PAR) model from satellite measurements.

The new method has been assessed using in situ optical measurements from the NASA SeaBASS database, and is applied to the MODIS and VIIRS to derive K_d(PAR) products and compared with in situ measurements. Results show that there are significant improvements in model-derived K_d(PAR) values using the new approach, compared to those from some existing K_d(PAR) algorithms. In addition, matchup comparisons between MODIS-derived and in situ-measured K_d(PAR) data for the global ocean show a good agreement. Synoptic maps of MODIS- and VIIRS-derived K_d(PAR) data generated using the new method provide very similar and consistent spatial patterns in the US east coastal region. Monthly maps of VIIRS-derived K_d(PAR) data for the global ocean are also generated using the new K_d(PAR) model, and provide spatial and temporal K_d(PAR) distributions, showing consistent results with those from the previous studies. Thus, our results show that satellite-derived K_d(PAR) data can be used as an important input for ocean-atmospheric circulation, biogeochemical, and ecosystem models.

Ocean color detected features of phytoplankton bloom in Greenland Sea

Dae-hyuk Lee[1] and Hyun-cheol Kim[1*]

[1] Department of Polar Remote Sensing, Korea Polar Research Institute, Incheon, South Korea 21990

**Corresponding e-mail: kimhc@kopri.re.kr*

The aim of this study is to understand phytoplankton bloom dynamics in Greenland Sea using ocean color satellite data. Greenland Sea is a section of the southern Arctic Ocean off the eastern coast of Greenland, and just a small part of global ocean. However, a recent study revealed that Greenland Sea has warmed 10 times faster than global ocean on average and can be a leading indicator of climate change.

Inter-annual and seasonal variability of chlorophyll a concentration in the Greenland Sea can be identified spatially by ocean color remote sensing. For extrapolation of bloom of past years, MODIS (Moderate Resolution Imaging Spectroradiometer), SeaWiFS (Sea-viewing Wide Field-of-view Sensor) and CZCS (Coastal Zone Color Sensor) 8-day chlorophyll a data were fitted to Gaussian function of time (Yamada et al., 2006). Parameters obtained from the Gaussian fit are start timing, end timing of the bloom, peak concentration, peak timing and bloom duration. The bloom timing and its magnitude were spatially varying.

Satellite data indicate that the blooms of northward of Jan Mayen were the largest and most intense, with chlorophyll a concentration often exceeding 10 mg m^{-3}. The bloom started at the west coast of Spitsbergen in May, northward of Jan Mayen in June and continued through June and July, respectively. The bloom in the Greenland Sea in 2004 appeared one month earlier than others and was the largest in 2007. We also investigated sea ice concentration percent observed by SSM/I (Special Sensor Microwave Imager) and SSMIS (Special Sensor Microwave Image Sounder) satellite sensors for the same period. The results show that bloom timing seemed to be related with the anomalous variations of sea ice extent in northern Greenland Sea, ocean currents and variability of global climate index.

Detection and classification of red-tide outbreaks using big database (*in situ*, model, satellite data) around Korean Peninsular

Young Baek Son[1,*], Yeseul Kim[1], Soonmi Lee[1], Kyongseok Park[2], Sanghwan Lee[2], Sinjae Yoo[1]

[1] *Jeju International Marine Science for Research & Education, Korea Institute of Ocean Science and Technology (KIOST), Jeju, 940-3 Haengwon-ri, Gujwa-eup, Jeju-si, Jeju-do, Korea*
[2] *Software Research Center, Korea Institute of Science & Technology Information (KISTI) 245 Daehak-ro, Yuseong-gu, Daejeon 305-806, Korea*

**Corresponding e-mail: sonyb@kiost.ac.kr*

Satellite remote sensing has been successfully employed to monitor and detect the increasing incidence of harmful algal blooms (HABs) under various water conditions. To expand our understanding of how red tide blooms clarify non-red tide water in various water conditions, we used the available data set for a continuous and systematic study of algal bloom such as *in situ* (hydrographic data and red-tide incubation data), Hydrolight simulation, and MODIS satellite data (included temporal and spatial information of red tide events from 2002 to 2015). The spectral characteristics of HAB species were identified with wide range of absorption and backscattering spectra and compared with *in situ* and satellite spectra. We distinguished true red tide water from non-red tide water and compared user accuracy with various red-tide detection algorithms.

The spectral characteristics of red-tide species were that increased phytoplankton absorption at 443 nm and pigment backscattering 555 nm. However, *C. polykrikoides* red tide blooms showed discolored waters with enhanced pigment concentrations, high chlorophyll, fluorescence, and absorption at 443 nm resulted in a steeper slope between 488 and 555 nm with a hinge point at 488 nm in MODIS bands. On the other hand, non-red tide water and/or other red-tide species typically were presented by broader radiance spectra between the blue and green bands were associated with relatively reduced pigment absorption and backscattering. Most red tide detection algorithms found a large number of false positive but only a small number of true positive areas(<30 % accuracy). These proposed algorithms are not useful to distinguish true red tide water from complex non-red tide water. Our proposed method substantially reduces the false signal rate (false positive) from strong absorption at short wavelengths and provide a more reliable and robust detection of *C. polykrikoides* blooms in the SCK from the space.

Influence of timing of sea ice retreat on phytoplankton size during marginal ice zone bloom period in the Chukchi and Bering shelves

Amane Fujiwara[1,*], Toru Hirawake[2], Koji Suzuki[3], Lisa Eisner[4], Ichiro Imai[2], Shigeto Nishino[1], Takashi Kikuchi[1], Sei-Ichi Saitoh[2]

[1] *Institute of Arctic Climate and Environment Research (IACE), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)*
[2] *Faculty/Graduate School of Fisheries Sciences, Hokkaido University*
[3] *Faculty of Environmental Earth Science, Hokkaido University*
[4] *Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA*

**Corresponding e-mail: amane@jamstec.go.jp*

Extremely high primary production in the shelf region of the Bering and Chukchi Seas supports large biomass of higher trophic level organisms. Not only phytoplankton biomass during spring bloom but also its size structure can affect energy use of higher trophic levels through pray-predator body size relationship. The timing of sea ice retreat should also take into account because it is tightly coupled with timing of spring bloom. In order to assess the influence of sea ice melt timing on phytoplankton community size structure, we investigated inter-annual and spatial variability of phytoplankton community size structure during spring and timing of sea ice retreat using satellite remote sensing.

Satellite remote sensing data used for this study was collected over a period of 1998–2013: remote sensing reflectance (R_{rs}), sea-surface temperature, and sea ice concentration (SIC). Proportion of larger phytoplankton (%Chl$a_{>5\mu m}$) and primary production (PP) were calculated from R_{rs}, and onset date of sea ice retreat was calculated from SIC. Surface heat flux during the sea ice retreat season was also obtained from NCEP/NCAR reanalysis data to infer the variability of mixed-layer depth. We examined pixel-by-pixel relationship between inter-annual variability of phytoplankton related variables (%Chl$a_{>5\mu m}$ and PP) and environmental variables (SST, onset date of sea ice retreat and surface heat flux) to assess the influence of variability of sea ice retreat timing.

Significant negative relationship between proportion of larger phytoplankton during sea ice retreat season and onset date of sea ice retreat was found in the most part of the shelf region. That is to say, earlier sea-ice retreat causes larger %Chl$a_{>5\mu m}$ during spring. It can be suggested that nutrients were utilized before sea ice retreat by sub-ice algae and/or under-ice phytoplankton bloom in the lately retreated years. On the other hand, we found not only length of ice-free season but also annual mean %Chl$a_{>5\mu m}$ positively correlated with annual net primary production. Thus, both phytoplankton community composition and growing season are important for annual primary production at least in the study area. Our findings would contribute to comprehend the mechanism of recent changings of ecosystem structure in the shelf region.

High-resolution shipboard measurements of phytoplankton functional types and photosynthetic competency – a way forward for enhancing the utility of satellite Chlorophyll and SST for mapping coastal microscale features and frontal zones

Joaquim I. Goes[1,*], Christy A. Jenkins[1], Helga do R. Gomes[1], Robert Arnone[2], Joji Ishizaka[3]

[1] *Lamont Doherty Earth Observatory at Columbia University, Palisades, New York, USA, 10964*

[2] *Dept. of Marine Sciences, University of Mississippi, Stennis Space Centre, Mississippi, USA, 39529*

[3] *Division for Land-Ocean Ecosystem Research, Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Nagoya, Japan*

**Corresponding e-mail: jig@ldeo.columbia.edu*

Eddies, frontal zones and microscale oceanographic features are easily observable from satellite measurements of SST and Chl *a* in coastal waters. Enhancing the utility of these measurements of fine oceanographic features for biological productivity, biogeochemical cycling and fisheries studies associated are challenging and demand that we begin to develop novel bio-optical methods capable of providing in-situ information of phytoplankton at horizontal spatial scales that are compatible with satellite data.

In this presentation, we will attempt to highlight the importance of high-resolution in-situ measurements, by showcasing data from a recent (Nov. 2014) validation cruise in support of NOAA's Suomi Visible Infrared Imaging Suite (VIIRS) ocean color sensor. High-resolution shipboard measurements of sea water hydrography (SeaBird CTD®), CDOM (WetLabs ALF®), phytoplankton functional types (PFTs, FlowCam®), biomass (bbe Moldaenke AlgaeOnlineAnalyzer® and WetLabs ALF®) and phytoplankton photosynthetic competency (Satlantic FIRe®) when mapped against binned daily, Level 2 satellite images of Chl *a*, K_d490 and SST over the cruise period, allow for identification of PFTs and water types associated with distinct coastal microscale features and fronts seen from space.

Large assemblages of phytoplankton communities comprising of diatoms and diatom-diazotroph associations (DDAs), were found in mesohaline frontal zones. Despite their high biomass, these populations were characterized by low photosynthetic competency, indicative of a bloom at the end of its active growth possibly due to nitrogen depletion in the water. Other prominent PFTs such as *Trichodesmium* spp., *Synechococcus* spp. and Cryptophytes, were also associated with specific water masses offering the promise that ocean remote sensing reflectance bands when examined in the context of water types also measurable from space, could greatly enhance the potential of satellite measurements for ecological, productivity, biogeochemical cycling and fisheries studies.

Responses of phytoplankton functional types to changing winter vertical mixing: a modeling study

Soonmi Lee, Sinjae Yoo*
Jeju International Marine Science Center for Research and Education, Korea Institute of Ocean and Science, Gujwa Iljudongro 2670, Jeju, South Korea

**Corresponding e-mail: sjyoo@kiost.ac.kr*

Using the zero-dimensional European Regional Seas Ecosystem Model (ERSEM) for 2001-2012, we investigated the impacts of varying winter vertical mixing and atmospheric deposition on the lower trophic level ecosystem in the Ulleung Basin, East Sea. The model results show that as the winter maximum mixed layer depth (MMLD) changes, the growth and grazing loss of phytoplankton functional types (PFTs) are affected differently resulting in an altered succession process of PFTs in the upper mixed layer.

Diatoms preempt the early spring growth by better utilization of light and nitrate. Diatoms' advantages lessen as MMLD decreases. Flagellates and picophytoplankton show mixed responses to decreased MMLD. Their net primary productivity (NPP) and peak biomass decrease but their annual biomass increases due to decreased grazing. Dinoflagellates are always doing better when MMLD decreases. Taken together, if warming continues and winter vertical mixing decreases, the total NPP and peak biomass will decrease although the yearly biomass of flagellate, pico-, and dinoflagellate will increase.

Remote sensing of taxon-specific primary productivity and quantum yield of photosynthesis

Taka Hirata[1,2,*], Koji Suzuki[1]
[1] Faculty of Environmental Earth Science, Hokkaido University
[2] Space Mission Center, Creative Research Institution, Hokkaido University

**Corresponding e-mail: tahi@ees.hokudai.ac.jp*

Taxon-specific primary productivity and quantum yield of photosynthesis of diatoms, haptophytes and cyanobacteria were estimated for the greater Kuroshio region (22-44°N and 120-160°E), using satellite ocean colour remote sensing. A novel statistical inversion methodology, which integrates a multi-pixel image processing and a bio-optical model, was developed, taking an advantage of instantaneous sampling of bulk spatial data by the satellite remote sensing. This novel methodology also allowed derivation of spatio-temporal distribution of the chlorophyll-a specific absorption coefficients of the three taxonomic groups as a by-product.

The bio-optical model used here utilized the observational fact that magnitude of a spectral average of the optical absorption coefficient of total phytoplankton community can be represented by the coefficient at a single wavelength band carried by the current ocean color satellite sensor. The derived taxon-specific primary productivity showed that haptophytes and cyanobacteria dominate primary productivity at lower latitudes, and diatoms at higher latitudes, in the greater Kuroshio region. Variation in diatom productivity in the region was mainly controlled by its biomass throughout year, whereas that in cyanobacteria productivity was by its photophysiology. For haptophytes, influences of both of its biomass and photophysiology on their productivity varied seasonally: physiological effects largely surpassed that of biomass in the northern winter whereas they were comparable to each other in the northern summer. Time series of relative contributions of biomass- and photophysiology-control on the taxon-specific primary productivity led us to the scientific hypothesis that the biomass-control on the productivity had been decreasing over the decade of 1998-2010 for diatoms and haptophytes in the region.

Evaluation of the primary productivity algorithms for the Yellow Sea, East China Sea, and East Sea LMEs

Christina Eunjin Kong*, Sinjae Yoo, Young Baek Son
Jeju Environment Research Section, Korea Institute of Ocean Science and Technology (KIOST)

**Corresponding e-mail: cejkong@kiost.ac.kr*

Despite many efforts to accurately estimate the global primary productivity from the satellite ocean color data, the uncertainty in the analytical algorithms still remains high at a range of temporal and spatial scale. Among the algorithms of primary productivity applied to the Large Marine Ecosystems (LMEs), photosynthetic rate (P^{B}opt), attenuation coefficient of photo-synthetically active radiation (PAR) associated with euphotic depth (Zeu), and sea surface chlorophyll-a concentration (SSC) are found to be most important, yet its predictability still needs further refinement. Previously, we evaluated regional algorithms for the SCC and P^{B}opt estimate. In this study, we assessed the Zeu algorithm using the in-situ data, which shows that Zeu also can be problematic.

Global analysis of primary production is sometimes based on a set of standard algorithms of the three variables. Here, we conducted a comparison of primary productivity using different combinations of the three algorithms for Yellow Sea, East China Sea, and East Sea. Using the SeaWiFS, MODIS, and MERIS data (1998-2014), we conducted a comparative analysis of the following algorithms: OC4v4, OC4v6, and YOC algorithms for SCC, BF-VGPM versus KI algorithm for P^{B}opt, and K490 versus QAA for Zeu. The estimate of primary productivity by different algorithm combinations can differ by more than 100 percent.

A rapid decline of annual primary production in the East/Japan Sea

HuiTae Joo[1], SeungHyun Son[2], Jung-Woo Park[1], Jae Jung Kang[1], Jin-Yong Jeong[3], Chung Il Lee[4], Chang-Keun Kang[5], Sang Heon Lee[1,*]

[1] *Department of Oceanography, Pusan National University, Geumjeong-gu, Busan 609-735, Korea*

[2] *CIRA, Colorado State University, Fort Collins, CO, USA*

[3] *Korea Institute of Ocean Science and Technology, Ansan 426-744, Korea*

[4] *Department of Marine Bioscience, GangneungWonju National University, Korea*

[5] *School of Environmental Science and Engineering, Gwangju Institute of Science and Technology, Gwangju 500-712, Korea*

**Corresponding e-mail: sanglee@pusan.ac.kr*

The East/Japan Sea is highly dynamic in its physical phenomena and biological characteristics. Over the recent decades, substantial changes in the physical structure and vertical distribution of chemical properties have been reported in the East/Japan Sea. Recently, some biological changes in lower trophic levels also have been reported. In this study, a recent decadal trend of primary productivity in the East/Japan Sea was analyzed based on Moderate-Resolution Imaging Spectroradiometer (MODIS)-derived monthly values to detect any long-term change.

The daily primary productivities averaged from different seasons from 2003 to 2012 were 719.7 mg C m^{-2} d^{-1} (S.D. ± 48.2 mg C m^{-2} d^{-1}) and 632.3 mg C m^{-2} d^{-1} (S.D. ± 37.4 mg C m^{-2} d^{-1}) for the southern and the northern areas in the East/Japan Sea, respectively. Based on the daily productivities, the average annual primary production in the East/Japan Sea was 246.8 g C m^{-2} y^{-1}, which was substantially higher when compared to those previously reported in deep oceans. However, a significant decreasing trend (13 %) in the annual primary production was observed in the East/Japan Sea. The decline in the East/Japan Sea was approximately three times faster than that in the North Pacific region. The increased temperature and shallower mixed layers could be a potential cause for the decline in annual production. However, this decline could be a part of an oscillation pattern strongly governed by PDO phases.

Monitoring of surface chlorophyll-a around the laver cultivation area of the Seto Inland Sea using GOCI data

Yuji Sakuno*, Zuomin Wang
Graduate School of Engineering Hiroshima University

**Corresponding e-mail: sakuno@hiroshima-u.ac.jp*

The Seto Inland Sea is one of the most popular laver culture areas in Japan; however, noticeable color fade of the laver has become a problem in recent years. This color fade occurs because of the lack of nutrient salts such as DIN (dissolved inorganic nitrogen) that are mainly brought in from rivers. Therefore, the monitoring of DIN around the laver farm is very important. Knowledge of the DIN outflow mechanism from the rivers is desired, particularly by fish farmers. Although the direct measurement of DIN from satellites is very difficult, as of 2010, a Korean geostationary satellite with a 500 m resolution "COMS GOCI" was capable of monitoring Chl.a (chlorophyll a) every hour as an alternative to DIN monitoring.

The objective of this study is to monitor Chl.a using GOCI data around the laver farm in the Seto Inland Sea. The LCI (Linear Combination Index) algorithm proposed by Frouin et al. (2006) was applied to the estimation of Chl.a by GOCI. The LCI algorithm is a method to easily estimate Chl.a by removing aerosol information from a linear combination of Rayleigh scattering correction reflectance using several theoretical bands. The LCI and Chl.a calculated from MODIS data at the 500 m resolution from the Japanese coast are highly precise for this method. A significant correlation was already obtained between the LCI using GOCI and in-situ data around the Ariake Sea.

The above LCI method was applied off the Fukuyama City coast included in the Seto Inland Sea in this study. Seven hours of data (from 0900 to 1600) from GOCI was synchronized with high-resolution Landsat-8 data (clear day) in the winter (from December to February) for the laver culture season. The high Chl.a waters from the Nuta River located in Mihara City to the laver farm off Tajima was caught by time series images of GOCI Chl.a on January 3, 2014, as an example of the results. On the other hand, the high Chl.a water brought from a different route from the Nuta River (Kurushima Strait and northeast straits of the strait) to the laver farm at Momoshima Island located in a border between Hiroshima and Ehime prefectures was expected.

Spatial and temporal variations of chlorophyll.*a* in the Seto Inland Sea using AQUA MODIS data

Miwa Nakagawa, Xinyu Guo*, Naoki Yoshie
Center for Marine Environmental Studies, Ehime University

Corresponding e-mail: guo.xinyu.mz@ehime-u.ac.jp

The Seto Inland Sea in Japan is divided into several regions (basins, straits and channels), and these regions respectively have different features of water temperature and current. For example, in the Kii channel and Bungo channel, cold and nutrient-rich water intrudes from offshore area of the Pacific Ocean in the bottom layer. On the other hand, terrestrial nutrients are supplied from the river to the basin regions called 'nada' in Japanese. Since most previous studies focused on only individual region such as the Osaka-Bay or the Harima-nada, the relation of phytoplankton between all the regions in the Seto Inland Sea is still not well documented. In this study, we focus on all the regions in the Seto Inland Sea, and compare the spatial and temporal variations of phytoplankton between the regions.

We used daily chlorophyll.*a* concentration of AQUA MODIS with a horizontal resolution of 500 m during a period from April 2006 to March 2015 provided by JAXA. We calculated monthly mean from daily data and monthly climatology from monthly mean in different years. We selected 12 representative regions (6 basins, 4 straits and 2 channels). The satellite chlorophyll.*a* presents a clear seasonal variation that is high from autumn to winter and low in summer. Comparing with the chlorophyll.*a* observed by ship, the satellite chlorophyll.*a* is apparently overestimated during winter in the all regions of the Seto Inland Sea. The spatial variation of satellite chlorophyll.*a* is also large: lower in the western region than in the eastern and central regions. In the recent years, the interannual variations of the satellite chlorophyll.*a* showed a significant reduction trend in entire of the Seto Inland Sea. This trend might be caused by the long-term reduction of nutrient associated with the severe limitation of nutrient emissions. In this study, although we clarified the spatiotemporal variations of chlorophyll.*a* in the entire Seto Inland Sea using the satellite data, we have to note that the accuracy of satellite chlorophyll.*a* in the winter in the coastal regions needs to be improved in the future.

Seasonal and inter-annual variability of satellite chlorophyll-a in Ise-Mikawa Bay, Japan

Masataka Hayashi[1,*], Joji Ishizaka[2], Mitsuhiro Toratani[3], Yo-ichi Maekawa[4], Toru Nakamura[4], Yasuo Nakashima[5], Satoshi Yamada[5]

[1] *Graduate School of Environment Studies, Nagoya University, Japan*
[2] *Institute for Space-Earth Environmental Research, Nagoya University, Japan*
[3] *School of Engineering, Tokai University, Japan*
[4] *Graduate School of Faculty of Bioresources, Nagoya University, Japan*
[5] *Aichi Fisheries Research Institute, Japan*

**Corresponding e-mail: hayashi.masataka@f.mbox.nagoya-u.ac.jp*

Phytoplankton has a very important role as a primary producer in the marine coastal region, but red tide and hypoxia caused by phytoplankton damage fisheries, especially in semi-enclosed and eutrophic bay like Tokyo Bay, Seto Inland Sea and Ise-Mikawa Bay. In those regions, local governments have taken a policy since 2002, which they restrict nutrients loading from the rivers to decrease the occurrence of the red tide and the hypoxia. But this effect still is not clear. *In-situ* data based on the ship board is important, however, the frequency and numbers of station are very limited. On the other hand, Satellite-based ocean color sensor can get data frequently and synoptically.

In this study, we analyzed seasonal and inter-annual variability of satellite chlorophyll-a (chl.a) using improved atmospheric correction and in-water algorithms by Hayashi et al. (2015) in Ise-Mikawa Bay. From analysis of 15 years monthly area average, there is clear seasonal variability of satellite chl.a which is high in summer and low in winter. And, in detail, it is much higher in the northern region than in southern region of Ise Bay. This is corresponding to river discharge from Kiso, Ibi and Nagara Rivers located on the northern region, which is high discharge in summer and low discharge in winter. We will also present inter-annual variability of satellite chl.a, especially how much change between before and after 2002.

The role of the Aleutian Low Pressure System in regulating phytoplankton production and carbon export in the North Pacific Ocean – results from a decade and half of satellite ocean color observations

Joaquim I. Goes[1,*], Helga do R. Gomes[1], Joji Ishizaka[2]

[1] Lamont Doherty Earth Observatory at Columbia University, Palisades, New York, USA, 10964

[2] Division for Land-Ocean Ecosystem Research, Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Nagoya, Japan

**Corresponding e-mail: jig@ldeo.columbia.edu*

The North Pacific Ocean experiences strong climate-modulated seasonal, interannual to decadal variations in meteorological and physical oceanographic conditions, which have a profound influence on biological processes and carbon cycling in the region. Inorganic nitrate, a major nutrient controlling phytoplankton growth is key to understanding the export of organic matter out of the euphotic zone. Its supply to the region is driven largely, by winter convective mixing.

Using satellite data for a 15 year period beginning in 1997, we provide evidence of strong interannual variations in the supply of inorganic nitrate and new production in the subarctic Pacific the amplitude of which appears to be linked to El Niño/La-Niña events in the Equatorial Pacific. These satellite-based climatologies allow us to make a compelling case that the primary driver for the observed interannual variations in biological production across the subarctic Pacific is the intensity of the winter monsoonal winds, which experiences sharp changes in response to El Niño/La-Niña-mediated shifts in the position and strength of the Aleutian Low Pressure System. This presentation will attempt to establish the mechanistic connections between the onset of El Niño/La-Niña and changes in the west-east gradient in biological production and carbon export in the North Pacific Ocean through the use of satellite data.

El Nino footprint on the South China Sea phytoplankton biomass at different time-lags

Eko Siswanto[1,*], DanLing Tang[2], Ye Haijun[2]
[1] Department of Environmental and Geochemical Cycle Research (DEGCR), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
[2] State Key Laboratory of Tropical Oceanography (LTO), South China Sea Institute of Oceanology (SCSIO)

**Corresponding e-mail: ekosiswanto@jamstec.go.jp*

The El Nino is known to decrease phytoplankton biomass (Chl) in the South China Sea (SCS) east of the Vietnamese coast during the summer due to weakened Ekman pumping associated with weakened summer southwesterly winds (Zhao and Tang, 2007; Lan et al., 2012). Recently, utilizing empirical orthogonal function analysis (EOF), Liao et al. (2013) however mentioned that decreasing biological productivity also occurs over the SCS basin four months following the canonical El Nino. The EOF however is not able to trace detail succession of time-lag between El Nino and its footprints on the SCS Chl and phytoplankton productivity in detail spatial features.

Here, we conducted regression analysis of satellite Chl and physical data against Nino3.4 as El Nino/La Nina index with different time-lags to understand the detail spatial and temporal changes of El Nino footprints on ocean physical environments and Chl. Consistent with Zhao and Tang (2007), a remarkable decrease in Chl east of Vietnamese coast was already observed almost at no time-lag. Such a Chl decrease was likely caused by weakened zonal winds.

The decrease in Chl east of Vietnamese coast during El Nino however expanded with increasing time-lags. The most remarkable decrease in Chl with the largest area over the center of the SCS was observed at 7-month time-lag (Nino3.4 leading Chl by 7 months). The most remarkable decrease in Chl east of Vietnamese coast and northwest of Luzon Island at 4-month time-lag was consistent with Liao et al.'s (2013) EOF analysis. On the other hand, SST east of Vietnamese coast increased with no time-lag, but the area showing SST increases expanded almost over the SCS basin at 7-month time-lag. The aforementioned spatiotemporal associations between Chl decrease and SST increase over the SCS basin indicated that a reduction of nutrient supply occurred not only over the limited area nearby the Vietnamese coast, but also over the SCS basin.

By correlating zonal and meridional winds against Nino3.4 (data not mentioned), we suggested that the decrease (increase) in Chl (SST) over the SCS during El Nino was associated with anti-cyclonic anomalous wind circulation in the SCS with almost no time-lag from the El Nino time. Our result on wind circulation anomaly was consistent with that reported by Kuo et al. (2008). Other physical oceanographic data such as surface circulation, sea surface height anomaly are however needed to be analyzed to confirm whether Ekman convergence occurred over the SCS basin during El Nino.

Annual variations in plankton blooming in the upper Gulf of Thailand

Anukul Buranapratheprat[1,*], Akihiko Morimoto[2], Atsushi Kaneda[3], Yoshihisa Mino[4], Vichaya Gunboa[1], Pachoenchoke Jintasaeranee[1], Joji Ishizaka[4]

[1] *Department of Aquatic Science, Faculty of Science, Burapha University, Thailand*

[2] *Center for Marine Environmental Studies (CMES), Ehime University, Japan*

[3] *Department of Marine Bioscience, Faculty of Marine Bioscience, Fukui Prefectural University, Japan*

[4] *Institute for Space-Earth Environmental Research, Nagoya University, Japan*

**Corresponding e-mail: anukul@buu.ac.th*

Red tide incidents in the upper gulf of Thailand (UGoT) has long been reported. This semi-enclosed coastal area is eutrophic because of exceeded nutrients and organic substances both delivered by river discharges and accumulated in the area. Phytoplankton blooming occurs year round but in different locations, mostly near the northern coast where the major rivers locate. Previous investigations based on numerical modeling and remote sensing data revealed that seasonal winds and currents play a crucial role to the movement of phytoplankton blooming areas, in the northeast and the northwest during the southwest and the northeast monsoons, respectively. Evidences suggested that discharged water from the Chaopraya River may be the most important trigger to strong blooming and hypoxia in the river mouth vicinity in the northern area. Phases, courses and distributions of the blooming are able to deteriorate water qualities and coastal ecosystems where the influences of the blooming extend. Problem becomes more serious if the blooming areas were transported nearshore where tourism or aquaculture activities are intense.

Bangsaen Beach, locating in the northeast of UGoT, is one of a popular tourist attraction especially for local Thai people because it is not far from Bangkok, the capital of Thailand. Once in many years, strong blooming of green *Noctiluca scintillans* hit the beach, resulting in environmental deterioration seen as sticky green water, low dissolved oxygen, marine organism mortality and unplesant odor, for examples. Strong blooming occurred again at least twice in this year of 2015, in early July and in mid-August. The evidences raise two key questions about annual variations in plankton blooming in UGoT. Are the blooming in this year and some others that can cause sticky green wave in Bangsaen Beach abnormally stronger in UGoT than other normal years? Or is the blooming intensity still the same as other years, but wind and wave conditions transport blooming water mass from offshore to the beach in some years including this year? Both issues will be thoroughly discussed. The outcomes of this analysis may be useful for predicting the risk of red tide in key important areas to reduce economic damages.

Sea surface chlorophyll-a variations in the Upper Gulf of Thailand (UGoT) based on remotely sensed data analysis

Prasarn Intacharoen[1,2,*], Songkot Dassananona[1], Anukul Buranapratheprat[2]
[1] *School of Remote Sensing, Institute of Science, Suranaree University of Technology, Muang, Nakhon Ratchasima 30000, Thailand*
[2] *Department of Aquatic Science, Faculty of Science, Burapha University, Chonburi 20131, Thailand*

**Corresponding e-mail: prasarni@buu.ac.th*

Chlorophyll-a (Chl-a) in seawater is typically regarded as a key component for marine ecosystem assessment. It is normally acquired through costly and highly time-consuming in-situ measurements. To overcome these stated difficulties, we propose here the determination of Chl-a concentration in the Upper Gulf of Thailand (UGoT) based on satellite data. The Performances of six global and one local algorithms applied on MODIS level 2 reflectance data on sea surface Chl-a estimation were evaluated before further data analysis.

The results suggested that global OC3M and local Chula (Matsumura et al., 2006) algorithm equally provide the best Chl-a estimation with correlation coefficient (R) of 0.71, root mean square error (RMSE) of 2.57 and mean absolute percentage error (MAPE) of 82.86. The resulted instantaneous Chl-a data were then combined to produce weekly and yearly data and used for time series analysis. This study focuses on the spatial and temporal variations of sea surface Chl-a in UGoT during great flooding years of 2010-2012 based on harmonic analysis and local maximum fitting algorithm (LMF) (Wada and Ohira, 2004). The results revealed unusual spatial and temporal high sea surface Chl-a which will be used for the analysis of Geographical Information System (GIS) to investigate the controlling factors of such variations in the near future.

Long-term change of ocean productivity: A case study in the Bay of Bengal

Md. Latifur Rahman Sarker[1,2,*], Noor Saadah Sabarudin[1]
[1] Department of Geoinformation and Real Estate, Universiti Teknologi Malaysia, Malaysia
[2] Department of Geography and Environmental Studies, University of Rajshahi, Bangladesh

**Corresponding e-mail: lrsarker@yahoo.com; sarker@utm.my*

The understanding of ocean phytoplankton or chlorophyll-a concentration is an important issue to address in several scientific disciplines since it is a key component of the Earth's biogeochemical carbon cycles, as well as in predicting the response of marine biota to possible changes in radiative or other physical forces due to global warming. The productivity of the ocean, which is mostly indicated by the concentration of phytoplankton or chlorophyll-a (Chl-a) has been declining throughout the sea. Recent studies found that the rate of decrease of ocean productivity is more evident in some parts of the ocean such as in the Bay of Bengal which is probably due to effect of global warming and anthropogenic (human activities) distortions, although many other factors (such as wind speed, ocean currents, upwelling activities, monsoon changes, disaster events, sea surface salinity, and sea level changes) can contribute to the change of Chl-a concentration. Despite all these, there are still considerable uncertainties in local ocean primary productivity especially in the Bay of Bengal where long term ocean primary productivity still remains a mystery.

Therefore, considering the importance of Chl-a concentration, this study is going to investigate the long-term change of ocean productivity/Chl-a concentration in the Bay of Bengal, the largest bay in the world with a unique semi-enclosed tropical basin which observes tropical climate, high rainfall, and monsoon variation predominantly. A simple methodology with several steps of image processing was used to perform spatial and temporal analysis of long-term MODIS Aqua Chl-a concentration data (from 2003 to 2014). Spatial analysis was performed by dividing the coastal and offshore areas and by drawing the transect lines with a selected interval. The extracted information was compared with respect to different locations. While, the temporal analysis was performed by using change detection analysis from one specific period to another.

Preliminary results from spatial and temporal analysis indicate that there is a significance variation of Chl-a concentration over the entire region which attributed, mostly depending on the location of the bay, seasonal variation, sea surface temperature, river discharge, ocean current and other factors. For the spatial analysis, in general, this study found that variation of Chl-a concentration is higher at coastal areas, and this variation of Chl-a concentration is reduced almost steadily with the increase of distance from the coastal areas to offshore areas. However, this variation is not stable for all over the bay, especially in the coastal regions, probably due to the different anthropogenic activities nearby the coastal areas as well as river discharge from big rivers. While the temporal analysis figured out that Chl-a concentration in the Bay of Bengal varied with respect to time as well. This temporal variation of Chl-a concentration mostly occurred from season to season within a year probably due to the variation of sea surface temperature and rainfall. However, the variation of Chl-a concentration with respect to the seasons is not sable in all parts of the bay. Nevertheless, from the spatial and temporal analysis, it can be concluded that the overall trend of ocean productivity was almost the same over the decade although fluctuation of Chl-a concentration from one to another year was observed for parts of the bay but very little accumulative effect from the starting period to ending period of the study was observed, and no constant rate of change of ocean productivity from year to year has been observed.

Examining features of enhanced phytoplankton biomass in the Bay of Bengal using a coupled physical-biological model

Helga do Rosário Gomes[1]*, Joaquim I. Goes[1], Sergio deRada[2], Fei Chai[3], Joji Ishizaka[4]

[1] *Lamont Doherty Earth Observatory at Columbia University, Palisades, New York, USA, 10964*

[2] *Dept. of Marine Sciences, University of Mississippi, Stennis Space Centre, Mississippi, USA, 39529*

[3] *University of Maine, Orono, ME 04469, USA*

[4] *Division for Land-Ocean Ecosystem Research, Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Nagoya, Japan*

**Corresponding e-mail: helga@ldeo.columbia.edu*

A coupled bio-physical ocean model is used to describe areas of enhanced phytoplankton biomass, seen in *in situ* and remotely sensed observations, in the otherwise oligotrophic environment of the Bay of Bengal. The model is based on the Naval Coastal Ocean Model (NCOM) which is coupled to a 13-component Carbon, Silicate, and Nitrogen Ecosystem (CoSiNE) model and configured for the Indian Ocean. Model results are compared and evaluated against a set of *in-situ* shipboard observations as well as ocean color data acquired from several remote sensing platforms.

The model is shown to successfully simulate the seasonal cycle of phytoplankton, the markedly contrasting scenarios of phytoplankton distribution in the north versus the south Bay of Bengal, and the biological impact from the 1997/1998 Indian Ocean Dipole (IOD) event. The model simulation provides us with vertical cross sections of phytoplankton biomass from summer and winter blooms in the southwest of the bay; information not found in remotely sensed data. It also successfully reproduces the timing of the onset of the blooms and their spatial extent, thereby providing a measure of its potential for augmenting *in situ* and remotely sensed observations to improve understanding of the dynamics of primary producers and carbon cycling in one of the most poorly sampled regions of the world's oceans.

Boreal summer-fall surface chlorophyll bloom in the southeastern tropical Indian Ocean based on MODIS data

Iskhaq Iskandar[1,3,*], Bruce Monger[2]

[1] *Department of Physics, Faculty of Mathematics and Natural Sciences, University of Sriwijaya, Inderalaya, Ogan Ilir, Sumatra Selatan, 30662, Indonesia*

[2] *Department of Earth and Atmospheric Sciences, Cornell University, Ithaca, NY 14853*

[3] *Also at Center for Geo-hazard and Climate Change Study, Faculty of Mathematics and Natural Sciences, University of Sriwijaya, Inderalaya, Ogan Ilir, Sumatra Selatan, 30662, Indonesia*

**Corresponding e-mail: iskhaq@mipa.unsri.ac.id*

The southeastern tropical Indian Ocean (SETIO) region experiences significant seasonal and interannual variations in wind forcing. The seasonal reversal of the monsoon winds is shown to generate strong seasonal upwelling along the southern coast of the Lesser Sunda Islands. Moreover, interannual variations associated with the Indian Ocean Dipole (IOD) are shown to cause anomalously strong upwelling off of Sumatra-Java. An empirical orthogonal function (EOF) analysis was applied on the seasonal time series of the satellite observed surface chlorophyll concentration (SCHL), sea surface temperature (SST) and surface winds. Spatial eigenfunctions of the first EOF mode reveal broad areas that exhibit coherent temporal variation in SCHL, SST and Ekman pumping in the SETIO region. The corresponding principal component time series reveals a robust seasonal variation and relatively weak interannual variation. The second EOF mode exhibited strong interannual variation in SCHL, appearing mostly off Sumatra-Java, and co-located with 180° out of phase variation in SST and in phase variations in both Ekman pumping and wind-induced mixing.

EOF analysis of the interannual variability for a given season reveals interesting spatial and temporal patterns. The leading EOF mode for June-July-August (JJA) phytoplankton bloom season revealed strong interannual variability for SCHL during this season along the southern coast of Java, Nusa Tenggara Islands and within the eastern Indonesian seas. Similar EOF analyses reveled that Ekman pumping variation was in phase with SCHL, and SST variation was 180° out of phase with SCHL.

The principal component time series of the SCHL was significantly correlated with Ekman pumping, but it does not significantly correlated with the Dipole Mode Index (DMI). It suggests that the SCHL during JJA bloom season (development phase of the IOD event) is mostly associated with the seasonal upwelling favorable winds. On the other hand, the leading EOF mode for September-October-November (SON) season reveals strong SCHL variability confined to the southern coast of Java and 180° out of phase with variations in SST. Its corresponding principal component time series shows significant correlation with that of the DMI, but it does not correlate with that of the Ekman pumping. Thus, we may suggest that SCHL bloom magnitude is significantly affected by the IOD and generated principally by the alongshore upwelling-favorable winds in the preceding season.

Change in coral cover detected by using multi temporal LANDSAT imagery data in Pangkajene Islands, Spermonde Archipelago, South Sulawesi, Indonesia

La Ode Muhammad Yasir Haya[1,2], Masahiko Fujii[3]*

[1] Graduate School of Environmental Science, Hokkaido University
[2] Faculty of Fisheries and Marine Science, Halu Oleo University
[3] Faculty of Environmental Earth Science, Hokkaido University

**Corresponding e-mail: mfujii@ees.hokudai.ac.jp*

Pangkajene Islands (PANGKEP) in Spermonde Archipelago is a stretch of coral reef islands, situated at the west coast of South Sulawesi, Indonesia. Native people in this region have long regarded the coral reefs as sources of livelihood. Unfortunately, the pressure and threat to the coral reef has been increasing due to population growth. However, the current data and information regarding the status of coral reefs is not comprehensively available to be set as reference for management purpose. This study aims to assess the status of coral reefs and to visualize the change of coral reefs for 20 years (1994-2014) by using the multi-temporal LANDSAT Imagery integrated with field observation data in 2014.

The methodology includes the Lyzenga (1981)'s transformation with the blue and green bands employed as an input, while the percentage of live coral cover was deduced from Point Intercept Transect (PIT) data observed at sites. The results of LANDSAT image classification and spatial analysis show that the area of live coral reefs decreased from 7,716 hectares in 1994 to 6,885 hectares in 2002 and then to 4,236 hectares in 2014. This indicates that for last 20 years coral reefs have been degraded by 3,479 hectares or by 174 hectares per year. Analysis of coral transect data at several sites come with "poor" category results with average percentage of live coral cover approximately 24%.

Ocean color data for *Sardinella lemuru* management in Bali Strait

Jonson Lumban-Gaol[1]*, Bonar P. Pasaribu[1], Kedarnath Mahapatra[2], Yoshihiro Okada[2], Toshiro Osawa[3]

[1] *Department of Marine Science and Technology, Bogor Agricultural University, Bogor 16680, Indonesia*

[2] *Scholl of Marine Science and Technology, Tokai University, 3-20-1 Orido, Shimizu, Shizuoka 424-8610, Japan*

[3] *Center for Remote Sensing and Ocean Sciences (CReSOS), Udayana University Bali, Indonesia, and Yamaguchi University, Yamaguchi, Japan*

**Corresponding e-mail: jonson_lumbangaol@yahoo.com*

The time series chlorophyll-a (Chl-a) concentration derived from ocean color data clearly indicated the unnual and interannual variabilities in Bali Strait. The unnual and interannual variability of Chl-a in Bali Strait were affected by monsoon winds, and El Niño Southern Oscillation (ENSO)/Indian Ocean Dipole (IOD) respectively. During southeast monsoon between May and August, the wind blows from the southeast towards the north-west along the southern coast of Java-Bali-Nusa Tenggara (eastern Indian Ocean), producing seasonal upwelling, and is more intense during El Niño/IOD positive phase.

The upwelling process brings deep-water mass with nutrient-rich cold water to the surface, and increases the fertility of waters. Cross-correlation analyses between monthly Chl-a concentration and *Sardinella lemuru* production shows that the Chl-a concentration has significant effects on variability of *Sardinella lemuru* production in Bali Strait. This correlation is maximal when Chl-a concentration leads sardine production by 4 months, with a positive anomaly of Chl-a concentration corresponding to a high Sardinella lemuru production. Otherwise, the *Sardinella lemuru* production has declined sharply when the Chl-a concentration is lowest. Thus, the abundance of phytoplankton sustained the stock of sardines in the Bali Strait.

During 1997/98 and in 2006/07 the sardine production increased by 100-200 per cent. This was due to phytoplankton blooming in those years, and this actually produced a negative impact on the fishermen due to a sharp drop in fish prices. The increase in the abundance of sardines in the Bali Strait can be predicted from the trend in Chl-a concentrations four months earlier. If the anomaly is positive, the next four months is expected to see an abundance of sardines. Therefore, appropriate management is needed such as adjusting the number of vessels to catch fish so that fish production will not be excessive, keeping some excess production for further fish processing, or distributing the excess fish to other areas. In contrast, during a negative anomaly of Chl-a concentration, *Sardinella lemuru* production can be expected to decline so that it is necessary to arrange a supply from other regions. The time series Chl-a concentration derived from ocean color data can be used as an indicator to predict the abundance of *Sardinella lemuru* in Bali Strait, to assist fishermen in fisheries management.

Operation of in-situ optical instruments calibration laboratory

Ki-Beom Ahn[1,2], Seongick Cho[1,2], Eunsong Oh[1,2], YoungJe Park[1]
[1] Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology, Korea
[2] Space Optics Laboratory, Dept. of Astronomy, Yonsei University, Korea

Corresponding e-mail: youngjepark@kiost.ac.kr

After the launch of GOCI (Geostationary Ocean Color Imager) in 2010, KOSC has been performed the in-situ observations for vicarious calibration and measured the optical characteristics of the in-situ instruments, such as Analytical Spectral Devices FieldSpec3, TriOS and RAMSES. Because the vicarious calibration depends on the collection of ground truth data, in-situ spectroradiometers should be calibrated each time in the laboratory. The optical laboratory in KOSC (Korea Ocean Satellite Center) has established for three aspects. The first is the optical performance characterization of the in-situ ocean optical instruments such as ASD Fieldspec Spectroradiometer. The second is the quantification of the variation between before and after field work, and the last is the relative correction of them. The laboratory is equipped with a 20 inches integrating sphere (USS-2000S, LabSphere) and KRISS (Korea Research Institute of Standards and Science) calibration lamp (Tungsten Halogen, 250~1050 nm) that are traceable to the National Institute of Standards Technology (NIST-traceable) for the standard light source, a reference spectrometer (MCPD9800, Photal) for the relative calibration, and an optical table having a flatness of ± 0.1 mm.

In this study, we suggest that the continuous monitoring of the in-situ instruments should be performed for more accurate calibration and validation of GOCI. The ASD instruments, calibrated in this laboratory, are expected to collect more consistent and reliable radiance data. These are used for the validation of remote sensing data. On the basis of the achievement of this research, we have a plan to provide the CAL/VAL service to GOCI CAL/VAL community members. It is expected to bring a variety of academic accomplishment of the ocean color remote sensing.

Effect analysis of cold water the East Sea using satellite data

Suk Yoon*, Hyun Yang, Jong-kuk Choi, Young-Je Park
Korea Ocean Satellite Center, Korea Institute of Ocean Science and Technology, 787 Haeanro, Ansan 426-744,South Korea

**Corresponding e-mail: syoon@kiost.ac.kr*

This study investigates various environment change during cold water events in the summer season in the east sea. Cold water in coastal waters refers to areas whose average SST is 5°C colder than surrounding SST. When Cold water expands and changes its extract direction, NFRDI (National Fisheries Research & Development Institute) issues an upwelling cold water warming. This study was performed based on the various environment factors using satellite data and in-situ data. The period of the study is from summer to fall of 2011∼2015. We used NOAA of max daily composite satellite data for SST analysis, the Geostationary Ocean color Imager (GOCI) level2 mean daily composite data for analysis of Chl-a and ocean current, wind of in situ.

We calculated the cold water area when it is 5°C colder than in SST data. The spatial resolution of NOAA satellite is 1.1km, and data are acquired 1∼2 times in one day. GOCI nominal spatial resolution is 500m, and re acquired data 8 times in one day, In-situ data used each time in one day. The appearing season mainly begins at the end of June, repeats the cycle of creation and extinction, and Cold water ends at the end of August. We think that chl-a increased from September to November as it still maintained some influence of cold water after summer season in the cold water area. We compared SST, surface currents, wind vector for analysis of environment change. Data showed similar pattern that chl-a, SST. We hope to predict the movement and spread form an analysis of cold water.

An estimation method for blue tide distribution based on the light-scattering of turbidity

Hiroto Higa[1], Yoshiyuki Nakamura[1], Yoji Tanaka[2], Mitsuhiro Toratani[3], Hiroshi Kobayashi[4], Hikaru Ito[1], Takayuki Suzuki[1]

[1] Department of Civil Engineering, Yokohama National University
[2] Facility of Engineering, Tokyo City University
[3] School of Engineering Department of Optical and Imaging Science and Technology, Tokai University
[4] Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi

Corresponding e-mail: higa@ynu.ac.jp

Blue tide is a serious environmental problem in Tokyo Bay, a representative eutrophication area in Japan. The occurrences of blue tide cause mass mortality and damage to fishery. Hence, there is the urgent need to suggest the mitigation measures elucidating the occurrence mechanism of blue tides and their behavior by continuous monitoring. A monitoring method of blue tides has been reported, turbidity can be used as a blue tide index based on high backscattering properties of sulfide contained in the blue tide water (Tanaka et al., 2015). However, it is difficult to monitor the spatial behavior of blue tides when using a turbidity sensor. In this study, the optical properties of blue tide were elucidated in terms of apparent optical properties and inherent optical properties. The blue tides estimation model was suggested based on the previous turbidity estimation model by Nechad et al., (2009).

In order to elucidate the optical properties of blue tide, field observations were carried out on September, 27th, 2011 and August, 24th, 2015. Remote sensing reflectance (R_{rs}) was derived from the measured upward radiance and downward irradiance. Turbidity and backscattering coefficient (b_b) were also measured in the field observations. Furthermore, absorption coefficients were measured from collected water sample.

The R_{rs} of the blue tide was a peak of the spectrum at around 570nm and was decreasing at short wavelength lower than around 500nm and at long wavelength higher than 700nm from the results of the calculated R_{rs}.

Furthermore, the estimation model for blue tides was considered based on the simple band turbidity estimation model by Nechad et al. (2009) using the R_{rs}. According to Nechad et al. (2009), the simple band turbidity estimation model is based on the assumption of $\rho_w(\lambda) << C(\lambda)$. Hence, the variation of $\rho_w(\lambda)/C(\lambda)$ was considered by calculating back scattering coefficient for the particle (b_{bp}) and was calibrated using the measured b_{bp}. As a result, $\rho_w(\lambda)/C(\lambda)$ was below 0.23 from long wavelength higher than 660nm, therefore, the blue tides estimation model was effective from red to near-infrared region of wavelength when $\rho_w(\lambda)/C(\lambda)$ is small. In addition, the relationship between $\rho_w(\lambda)$ and turbidity was validated assuming GOCI bands. As a result, the correlation coefficients were 0.94 and 0.95 at ρ_w (660) and ρ_w (680), respectively. Therefore, it was found that these wavelengths are effective to estimate blue tides. Furthermore, the application of blue tides estimation model to the GOCI images using ρ_w (660) can emphasize the back scattering of blue tides.

Characterization of remote sensing reflectance spectra for the red tide detection in Ariake Bay

Mengmeng Yang[1]*, Joji Ishizaka[2], Katsuya Saitoh[3]
[1] *Graduate School of Environmental Studies, Nagoya University, Japan*
[2] *Institute for Space-Earth Environmental Research, Nagoya University, Japan*
[3] *Japan Fisheries Information Center*

**Corresponding e-mail: yang.mengmeng@i.mbox.nagoya-u.ac.jp*

Red tides in Ariake bay is a severe phenomenon in recent years and negatively affect economies of this area. Especially, diatom blooms in winter cause serious damage for Nori culture, which contributes the largest portion of Nori production in Japan. To detect and monitor red tides timely and widely, satellite remote sensing has been proved to be an efficient way. In this study, in situ optical datasets during 2001-2010 and 2015 as well as red tide maps from 2004 to 2015 will be used. Preliminary investigation of the red tide Rrs in August 2003 indicated some discrepancies, both underestimate and overestimate at the short wavelength.

We will investigate more on the comparison of in situ and MODIS Rrs and evaluate the atmospheric correction error. Then, red tide detection method will be developed based on the characteristics of remote sensing reflectance (Rrs) spectra from MODIS data in comparison to red tide map.

Strong blooming of *Noctiluca scintillans* in Bangsaen beach, Chonburi province, Thailand in early July 2015

Vichaya Gunbua, Anukul Buranapratheprat, Natthira Muentarawat, Siraporn Tong-u-dom*, Suphachai Yuenyong, Parattagon Phromkot, Dudsadee Leenawarat, Benjamas Meesub
Department of Aquatic science, Faculty of Science, Burapha University, Thailand.

Corresponding e-mail: aommy_se7en@hotmail.com

Bangsaen beach is located in the eastern part of the Upper Gulf of Thailand (UGoT). It is one of popular sightseeing places for local Thai people because it is near, approximately 100 kilometers, from Bangkok. This area is strongly influenced by freshwater discharge and its delivered organic and inorganic substances from major rivers located along the northern coast of UGoT. This is therefore the major cause of red tide frequently occurring in this area.

Marine Environmental Monitoring and Protection Program on Red Tide in the Coastal waters of Chonburi Province (2006) reported the occurrences of red tide for 8 out of 16 cases at Bangsaen beach during January 2005 and October 2006. The dominant blooming species is a dinoflagellate *Noctiluca scintillans* that makes water color to be dark green due to a green symbiont *Pedinomonas noctilucae* living inside the *Noctiluca* cell. Because of high ammonia concentration in *Noctiluca* cell, this can deteriorate water quality when the cells are massively die and release ammonia to surrounding environment. The situation becomes worse with water hypoxia resulting from the decomposition of dead cells by bacteria.

A strong red tide of *Noctiluca* occurred again in Bangsaen beach this year between 6 and 13 July 2015. The blooming supposedly started in the northeast of UGoT and moved to Bangsaen Beach and Bangpra bay, reveled by ocean color satellite imageries. The mass of blooming remained near the beach for many days supposedly induced by coastal current systems. This red tide afterwards headed to Bangpra bay located in the south of Bangsaen beach by seasonal residual current.

Detection of potential eutrophic zones in the Northwest Pacific region using remotely sensed chlorophyll-*a*

Genki Terauchi[1]*, Yongjiu Xu[2]
[1] *Northwest Pacific Region Environmental Cooperation Center*
[2] *Zhejiang Ocean University*

**Corresponding e-mail: terauchi@npec.or.jp*

The Northwest Pacific region, which includes parts of northeast China, Japan, Korea and southeast Russia, is one of the most densely populated areas of the world. Eutrophication is an emerging environmental problem in this region, where a significant number of red tides and hypoxic conditions have been reported in coastal waters - possibly due to anthropogenic influences such as extensive chemical fertilizer use and sewage effluent. Although no international legislation has been passed in this region to address the problem, the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) of the United Nations Environmental Program (UNEP) has been implemented by China, Japan, Korea and Russia since 1994.

Within the framework of NOWPAP, the Special Monitoring and Coastal Environment Assessment Regional Activity Centre (CEARAC) has developed "Procedures for assessment of eutrophication status including the evaluation of land-based sources of nutrients for the NOWPAP region" (NOWPAP Common Procedures) (NOWPAP CEARAC 2009). The NOWPAP Common Procedures suggest assessing eutrophication with the level and trend of water quality parameter data, categorized into 4 groups: the degree of nutrient enrichment as well as the direct, indirect and other possible effects of nutrient enrichment. Chlorophyll-*a* concentration (Chl-*a*) can be categorized as one parameter, among others, that directly reflects nutrient enrichment, since one of the responses to eutrophication is an increase of phytoplankton biomass. Chl-*a*, as a proxy for phytoplankton biomass, can be utilized as a useful indicator of eutrophication.

Satellite data of two ocean color sensors, the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on board the Orbview-2 satellite and Moderate Resolution Imaging Spectroradiometer on board the Aqua satellite (MODIS-A) were obtained from NASA Ocean Color Website. Monthly Chl-*a* data processed by an empirical algorithm developed by Yellow Sea Large Marine Ecosystem Ocean Color Work Group (YOC).

Three year mean Chl-*a* processed by the YOC algorithm from 2012 to 2014 was used to divide the study area into ''high'' or ''low'' Chl-*a* areas based on a reference condition of 5 mg m^{-3} as a value for early warning. The annual maximum monthly mean Chl-*a* trend was estimated pixel-wise and its significance was examined by the Sen slope test at a 90 % confidence level. Then, by combining the level and trend of monthly Chl-*a* from 1998 to 2014, the Northwest Pacific was classified into six eutrophication states: high-increasing, high-no trend, high-decreasing, low-increasing, low-no trend and low-decreasing. It is suggested that the detected high-increasing and high-no trend state of satellite Chl-*a* indicates potential eutrophic zones in the Northwest Pacific region. Validation of the obtained results with *in situ* Chl-*a*, COD trend and frequencies of hypoxia and red tides will be done by the workshop.

Estimation of transparency in the Ise-Mikawa Bay from ocean color data

Risa Ibuki[1]*, Joji Ishizaka[2], Akiko Mizuno[3], Masataka Hayashi[4], Yo-ichi Maekawa[5]
[1,4] Graduate School of Environment Studies, Nagoya University, Japan
[2,3] Institute for Space-Earth Environmental Research, Nagoya University, Japan
[5] Graduate School of Faculty of Bioresources, Mie University, Japan

Corresponding e-mail: ibuki.risa@e.mbox.nagoya-u.ac.jp

Ocean transparency is a useful index of water quality or productivity and is widely used in many environmental studies. In the present study, ocean color data are used to estimate the Secchi disk depth (SD), which is a well-known indicator of ocean transparency. There are many SD studies in Case1 waters, but few in Case 2 waters because it is difficult to estimate water transparency in complex waters which are a mixture of colored dissolved organic matter (CDOM), inorganic mineral particles and phytoplankton.

The aim of this study is to estimate SD using satellite data in the Ise-Mikawa Bay, a complex system influenced by rivers. In-situ data has been collected by the Aichi Fisheries Research Institute since 2002 and by our laboratory since 2011. Measurement include SD, chlorophyll *a* concentrations (Chla), absorption coefficient of non-phytoplankton (a_{nph}) and CDOM (a_y), and remote sensing reflectance (Rrs). These dataset are divided at random for independent calibration and validation. MODIS L2 LAC data since 2002 are obtained from the NASA Ocean Color site.

Firstly, I studied the relation between the in-situ measured SD and Chla, a_{nph} and a_y to identify which components influence SD in this area. Estimating SD using Chla, a_{nph} and a_y (R^2=0.67, RMSE=1.21) gave better results than using only Chla (R^2=0.45, RMSE=1.36) as evidenced from the R^2 values. This indicates that transparency in the Ise-Mikawa Bay is influenced by these three components. Secondly, I developed a wavelength algorithm using the available in-situ SD and in-situ Rrs ratio (Chla $\propto$ Rrs488/Rrs547, $a_{nph}412+a_y412 \propto$ Rrs443/Rrs531). This model was validated using an independent data set of in-situ Rrs as well as satellite Rrs. The predictive precision of wavelength model using one in-situ Rrs ratio (Rrs488/Rrs547) or two Rrs ratios (Rrs488/Rrs547, Rrs443/Rrs531) are not so different (R^2=0.70, RMSE=1.04 and R^2=0.74, RMSE=0.94). This suggests that SD in this area can be estimated using a single ratio (Rrs488/Rrs547). However when the single ratio algorithm was applied to satellite data, the precision decreased drastically (R^2=0.46 RMSE=3.15). I will plan to estimate SD using semi-analytical algorithm by the workshop.

Validation of GOCI Chl a using in-situ data in East China Sea and Ise Bay, Japan

Akina Matsushima[1]*, Joji Ishizaka[2]
[1] *Graduate School of Environmental Studies, Nagoya University, Japan*
[2] *Institute for Space-Earth Environmental Research, Nagoya University, Japan*

**Corresponding e-mail: matsushima.akina@b.mbox.nagoya-u.ac.jp*

GOCI (Geostationary Ocean Color Imager) is the world's first ocean color sensor to be launched in a geostationary orbit in June, 2010. The GOCI provides images with high spatial resolution of 500 m at hourly intervals up to 8 times a day. Therefore, it is possible to obtain more ocean color data around cloud by GOCI compared to SeaWiFs and Aqua MODIS, and to observe the short-term changes of chlorophyll *a* concentration (Chl *a*).

Kusunoki (2014) evaluated the accuracy of the GOCI data by using in-situ Chl *a* in East China Sea. As a result of processing with GDPS (Geostationary Ocean Color Imager Data) ver. 1.2, satellite Chl *a* and in-situ Chl *a* using OC2v2 algorism indicated significant positive correlation. When satellite remote sensing reflectance (Rrs) was validated, the absolute value showed error, but the Rrs ratio showed relatively good correlation. On the other hand, satellite Chl *a* using YOC algorism indicated no significant correlation with in-situ Chl *a*. This result indicated the possibility that the method of calculation for YOC algorism was not correct.

On January 13th, 2015, the latest GDPS (ver. 1.3) was released and some new functions were added to it. Moreover, it is said that Chl *a* by using the ver. 1.3 is able to be estimated more exactly than ver. 1.2. When the data set used by Kusunoki (2014) was used to evaluate an accuracy of ver. 1.3, in the OC2v2 algorism the correlation between satellite Chl *a* and in-situ Chl *a* was almost same as the result obtained by ver. 1.2; whereas, in the YOC algorism the correlation by ver. 1.3 was higher than ver. 1.2, and the accuracy was comparable to the result estimated from the OC2v2 algorism. In our further study, we will evaluate the accuracy of satellite Chl *a* using other data set in East China Sea and in Ise Bay, Japan.

Improvement of satellite chlorophyll-a in the upper Gulf of Thailand

Jutarak Luang-on[1]*, Joji Ishizaka[2], Anukul Buranapratheprat[2]
[1] Graduate School of Environmental Studies, Nagoya University, Japan
[2] Institute for Space-Earth Environmental Research, Nagoya University, Japan
[3] Department of Aquatic Science, Faculty of Science, Burapha University, Thailand

**Corresponding e-mail: jutarak.lua@gmail.com*

Seawater in the upper Gulf of Thailand (UGoT) is referred as case II water because of high turbidity and CDOM delivered by river discharges from four main rivers located along the northern coast. These water compositions and their seasonal variations affects the optical properties of seawater and satellite-derived chlorophyll-a (Chl-a) in this area. NASA has been providing a number of standard satellite Chl-a products through the internet, but unfortunately those data were reportedly overestimated.

The local empirical algorithm, named Chula algorithm (Matsumura, 2006), was therefore established and then applied on MERIS data for higher accuracy to investigate the dynamics of Chl-a in UGoT (Buranapratheprat, 2008). These local algorithms, however, are not applicable for useful and easy-accessed MODIS and VIIRS data due to wavelength discrepancy. This study is therefore focused on developing local empirical algorithms, based on PRR data, for Chl-a estimation suitable for those satellite sensors. The algorithms are based on a mathematical function of the satellite reflectance (R*rs*) ratios on the wavelengths of 443/555 nm and 488/555 nm. Established algorithm were then applied on MODIS and VIIRS data for Chl-a estimation and validated with *in situ* Chl-a data. Based on the correlation coefficient, root-mean-square error and bias, the best estimated Chl-a will be used for further studies on red tide phenomena in UGoT.

Phenology of phytoplankton blooms in the East Sea (Sea of Japan): remote sensing analysis

Soonmi Lee*, Sinjae Yoo, Young Baek Son
Jeju International Marine Science Center for Research & Education, Korea Institute of Ocean and Science, Jeju, South Korea

**Corresponding e-mail: byelggi@kiost.ac.kr*

The timing of phytoplankton blooms, known as phenology, is tightly linked to the recruitment success of higher trophic levels. It has been considered as an important ecological indicator, because it can respond sensitively to climate change. Long-term time series of chlorophyll-*a* concentration derived from satellite ocean color data were used to map the timing of phytoplankton blooms in the East Sea (Sea of Japan) for the years 1998-2014.

To estimate the bloom timing metrics (bloom initiation, peak timing, bloom duration, bloom termination and peak magnitude), we used a shifted gaussian function, taking into account uncertainty in bloom detection. In the East Sea, the bloom timing metrics show spatially different patterns. In spring, the bloom starts from the area in southern subpolar front and moves to northern or southern areas. The spatial distributions of peak timing and bloom termination are very similar with that of bloom initiation. However, the spatial distribution of bloom duration is the opposite to that of bloom initiation. In autumn, the bloom starts from the southwestern area and moves northward. The spatial distribution of bloom termination is very similar with that of peak timing. We discuss the implication of the changes in the timing of phytoplankton blooms in light of climate change.

Application of FRRf for net primary productivity estimation : Cases in Ariake Bay and East China Sea

Yuanli Zhu[1], Joji Ishizaka[2]*, Sarat Tripathy[3], Yoshihisa Mino[2], David Suggett[4]

[1] Graduate School of Environmental Studies, Nagoya University, Nagoya 464-8601, Japan

[2] Institute for Space-Earth Environmental Research, Nagoya University, Japan

[3] National Centre for Antarctic and Ocean Research, Earth System Science Organization, Ministry of Earth Sciences, Vasco-Da-Gama, Goa 403804, India

[4] Plant Functional Biology and Climate Change Cluster, University of Technology Sydney. P.O.Box 123, Broadway, NSW 2007, Australia

**Corresponding e-mail: joji.ishizaka@gmail.com*

Fast Repetition Rate fluorometry (FRRf) potentially provides a means to examine marine primary productivity free from limitations associated with carbon uptake measurements; however FRRf-based productivity estimates require knowledge of the electron requirement of C-uptake $(\Phi_{e,C})$ to fully scale electron transfer rate (ETR) to CO_2 uptake rates. Most studies derived $\Phi_{e,C}$ have inter-compared parallel measures of ETR with CO_2 uptake with relatively short time (tens of minutes-hours) incubation. However, how these measurements compare with longer, daily incubation has not been examined.

Here we determined $\Phi_{e,C}$ (hereafter, net $\Phi_{e,C}$) by comparing depth-specific daily integrated ETRs and 24-hours ^{13}C-uptake rates from seven cruises in Ariake Bay (AB) Japan, 2008-2010 and six cruises in East China Sea (ECS) from 2008 to 2011,2013. Our goal was to determine the extent of variability of net $\Phi_{e,C}$ and to evaluate the environmental factors for controlling this variability. Overall, daily ETR and net $\Phi_{e,C}$ varied considerably, in both areas throughout the entire dataset. The maximum net $\Phi_{e,C}$ in two study areas were found ca. 30 mol e^- (mol C)$^{-1}$in AB and 50 mol e^- (mol C)$^{-1}$ in ECS under high light condition. It indicated very low sun energy usage efficiency for carbon fixation. Finally, light intensity was found that can explain most variation of net $\Phi_{e,C}$ (ca. 95% in AB and 72% in ECS) and the daily irradiance dependent algorithms for net $\Phi_{e,C}$ estimation were made for both areas. Our approach demonstrates the first potential application of FRRf to estimate regional net primary production (NPP, daily integrated CO_2 uptake).

Sixteen-year phytoplankton biomass trends in the northwestern Pacific Ocean observed by the SeaWiFS and MODIS ocean color sensors

Eko Siswanto*, Makio C Honda, Kazuhiko Matsumoto, Yoshikazu Sasai, Tetsuichi Fujiki, Kosei Sasaoka, Toshiro Saino
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

**Corresponding e-mail: ekosiswanto@jamstec.go.jp*

Using multisensor/platform biophysical data collected from 1997 to 2013, we investigated trends of phytoplankton biomass concentration (Chl) and the probable causative factors in the northwestern Pacific Ocean (NWPO). The trend of rising sea surface temperature (SST) was likely responsible for the increasing trends of overall and seasonal means of Chl at high latitudes (roughly north of 45°N), with the spatial extent changing meridionally during different seasons.

Trends of rising SST at low latitudes (south of 45°N, east of 160°E), however, led to trends of decreasing Chl, the underlying factor being reduction of nutrient inputs caused by shoaling of the mixed layer. The climate change associated with the weakening of the Aleutian Low pressure since late 2007, as indicated by the large negative phase of the Pacific Decadal Oscillation index likely superimposed on the observed 16-year trends of satellite Chl in the NWPO. Long-term climate changes will then be expected to modify the low-trophic marine organisms and hence bring ecological consequences on high-trophic level marine organisms, as well as on the biogeochemical cycle processes in the NWPO.

Atmospheric deposition—Another source of nutrients enhancing primary productivity in the eastern tropical Indian Ocean during positive Indian Ocean Dipole phases

Eko Siswanto
Department of Environmental and Geochemical Cycle Research (DEGCR), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Corresponding e-mail: ekosiswanto@jamstec.go.jp

High phytoplankton primary productivity (PP) west of Sumatra, Indonesia during the positive Indian Ocean Dipole (hereafter +IOD) is generally accepted to be attributed to the elevated nutrients due to anomalously southwesterly wind-driven upwelling. Besides coastal upwelling, +IOD is also associated with Sumatra wildfires, whose aerosol depositions may also be potent to supply nutrients for ocean phytoplankton.

This study used in situ and multisensor satellite data and combinations of various PP and surface nitrate models to assess the contributions of upwelling and atmospheric deposition to modulating PP in the eastern tropical Indian Ocean (ETIO) during +IOD. Surprisingly, atmospheric deposition of nutrients from wildfires accounted for a higher portion of enhanced PP during +IODs than wind-driven nutrient upwelling.

Substantial atmospheric nutrient deposition likely also maintains high PP post-upwelling and post-wildfire. Multiple regression analysis further supported the importance of atmospheric deposition in determining ETIO PP with a significantly large partial regression coefficient for aerosol optical thickness. It is possible that aerosols from major wildfire areas worldwide contribute nutrients that also nontrivially modulate PP in the oceans' main upwelling systems.