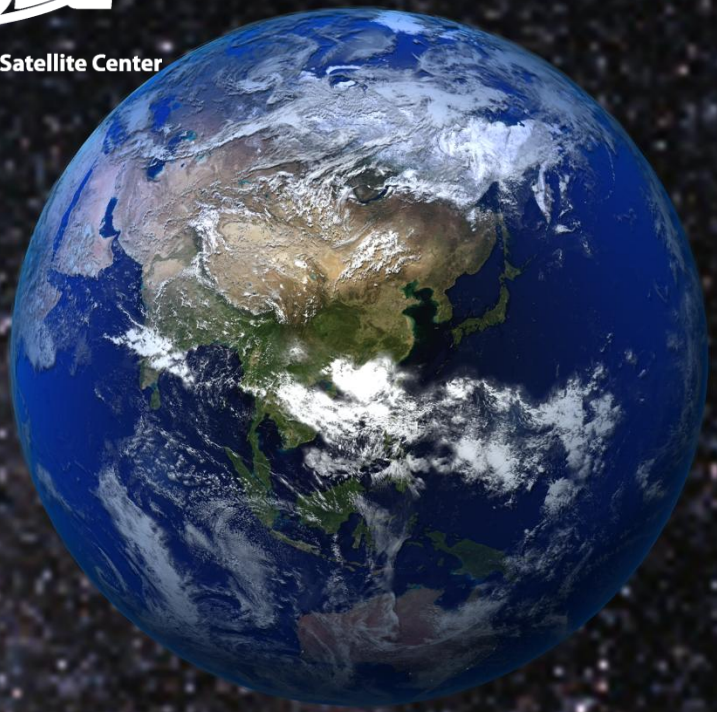
Korea Ocean Satellite Center



GOCI Status and GOCI-II Plan

Joo-Hyung Ryu
On behalf of Korea Ocean Satellite Center

- KIOST/KOSC
- GOCI status
- GOCI applications
- GOCI-II plan

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- “Geostationary ocean colour will not be available for at least another decade”…IOCCG Report1, 1998.
- NOAA or Eumetsat require approximately 10 years, from design to launch, to complete a geostationary platform. Little or no chance exists of adding ocean-colour bands on GOES-P, which is planned for launch in 2007 (launch readiness: 2006). Time is available, however, to justify and incorporate *Other operational aspects* 30 an ocean-colour requirement on the next GOES platform, Q, which is planned for launch in 2010 (launch readiness: 2008)

- 12 years later, GOCI has been successfully launched in 2010 and …1st IOCS in 2103.

Introduction of KIOST

Function : R&D
MEST(Ministry of Edu. Sci. & Tech.)

Function : R&D+Education
MOF(Ministry of Oceans and Fisheries)

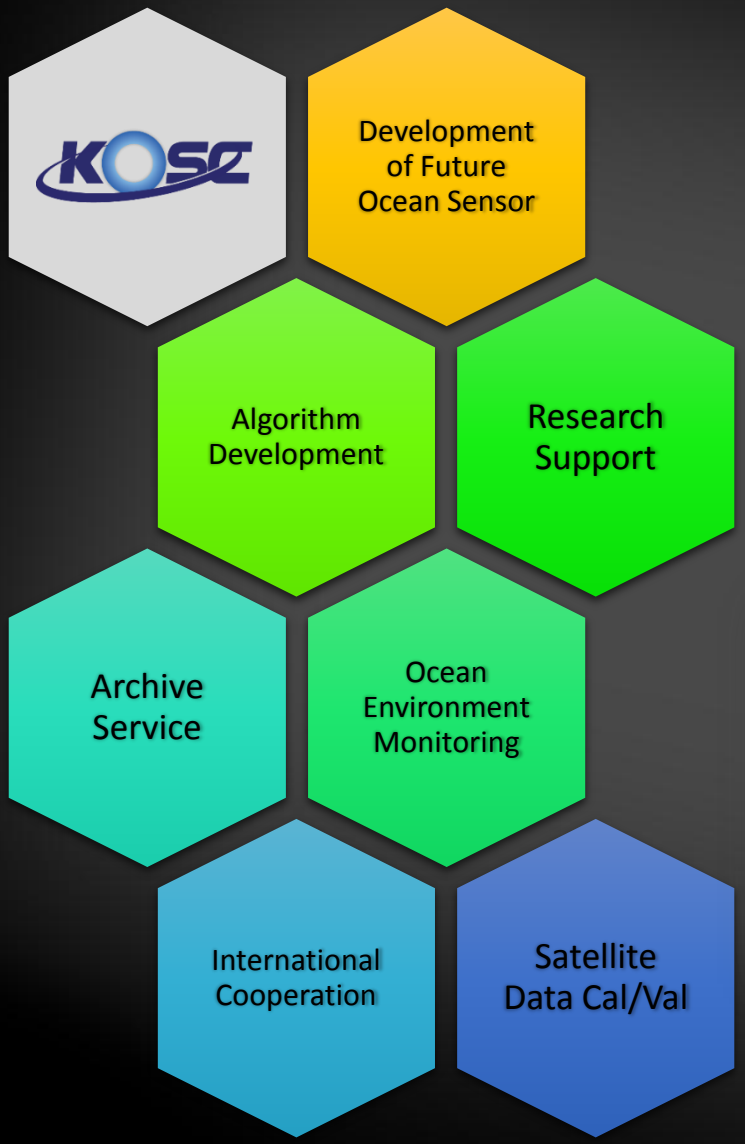
KORDI has set sail to the broader world of marine sciences and technology as **KIOST**.

Vision : **A global leadership in advanced marine sciences and technology**

KIOST Goals : Providing solutions to global agendas and pursues technology R&D to develop the national competency in marine sciences and technology

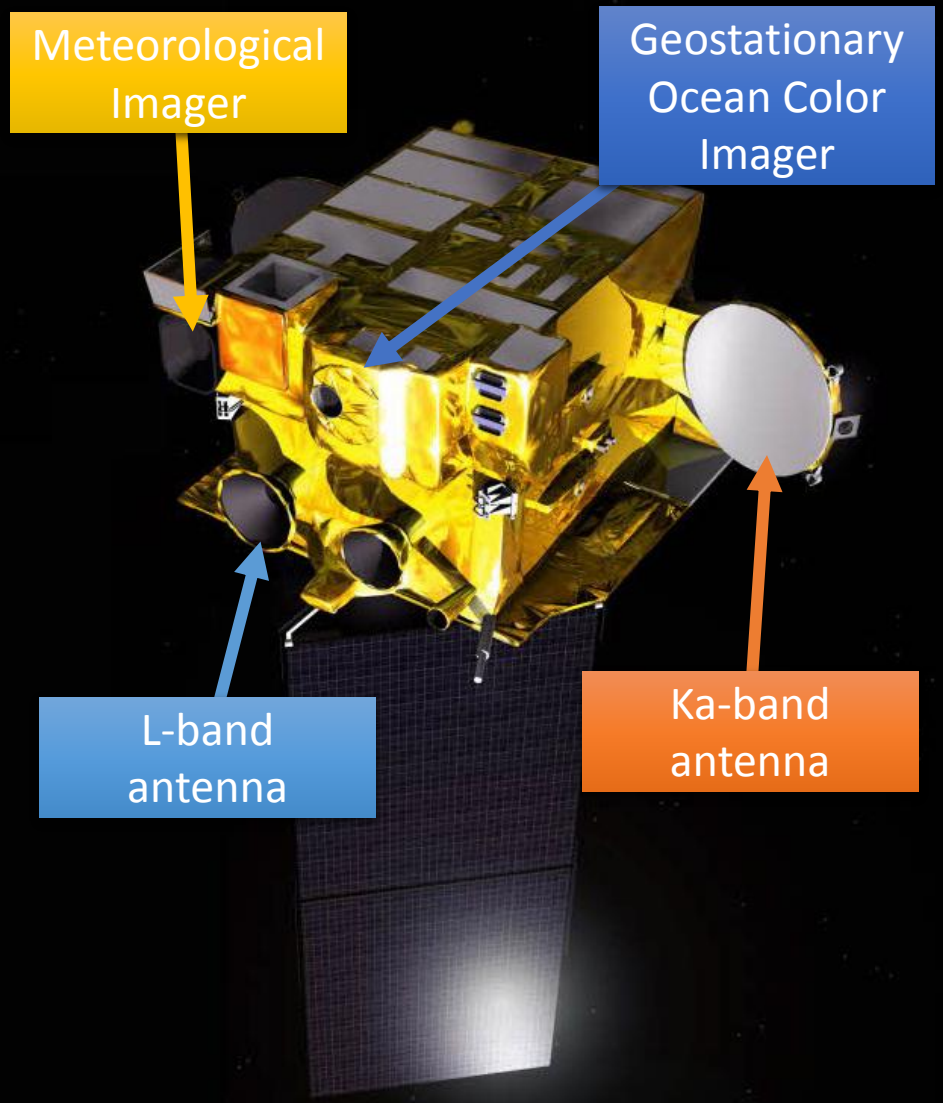
- Researches on basic marine sciences
- Researches on application and commercialization of marine technologies
- Researches for responses to national issues
- Researches on ocean and polar region policies

Introduction of KOSC



- GOCI Operation Agency
- MISSION
  - Ocean remote sensing satellite development /operation
  - Ocean/Coastal remote sensing technique development
  - Satellite data calibration and validation
  - Data distribution service and research support
  - Application research
  - Operational use (?)

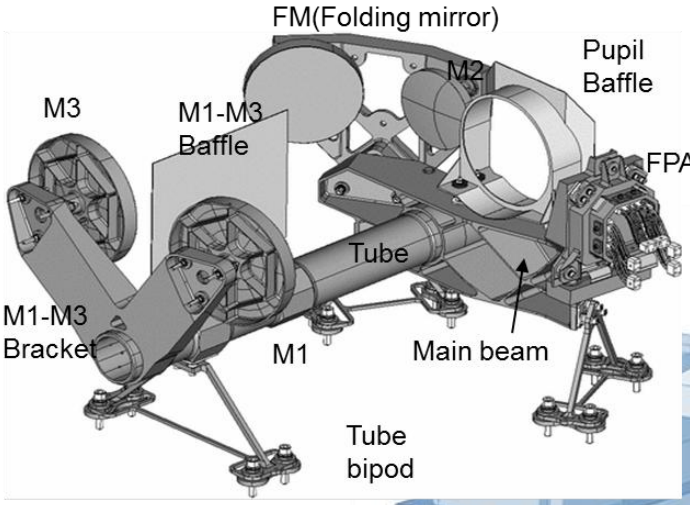
Introduction of COMS

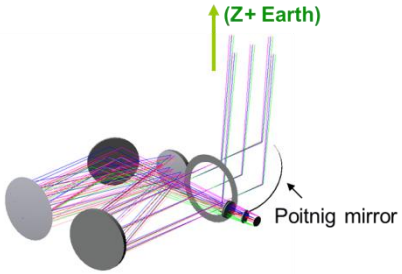


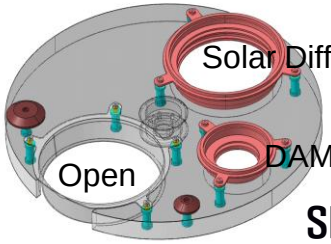
- COMS : Communication, Ocean & Meteorological Satellite
  - Developments of COMS(H/W) and GDPS(S/W) : 2003
  - Establishment of KOSC (Ground System) : 2005
  - The first Korean Geostationary multipurpose Satellite
  - Launch date : June 27 2010
  - Lifetime : 7 years
  - Payloads (3 Missions)
    - Geostationary Ocean Color Imager (GOCI)
    - Meteorological Imager
    - Ka-band Communication

GOCI overview

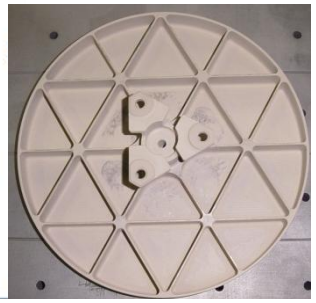
Telescope





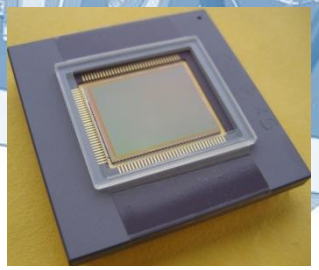


Shutter wheel

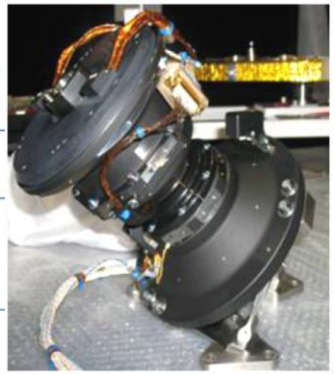


PM (Pointing mirror)

Filter Wheel

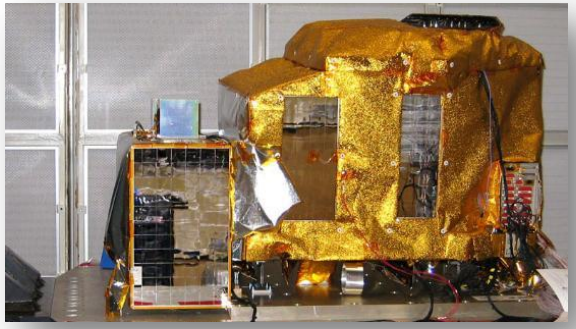


FPA(2D CMOS)

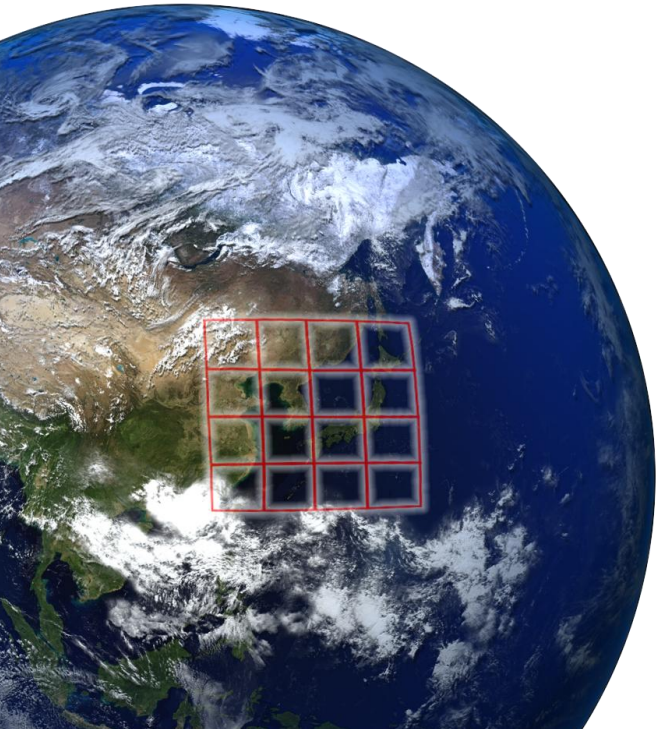


Pointing Mechanism

Introduction of GOCI



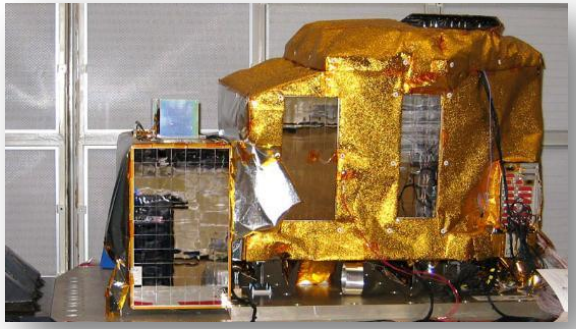
- Geostationary Ocean Color Imager
  - GSD(Ground Sampling Distance) : 500m * 500m
  - Target Area : 2,500km * 2,500km (Center : 130°E 36°N)
  - Included Nations : Korea, China, Taiwan, Japan, Russia, etc.
  - Temporal Resolution : 1hour (8 times at 1 day)

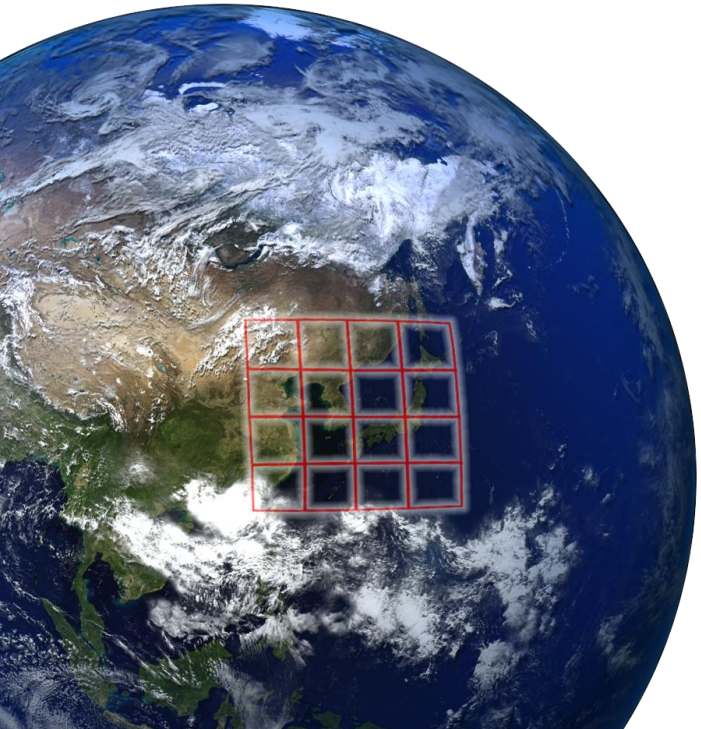


Spectral Bands Characteristic and Requirements of GOCI

Band	*Central wavelengths*	*Band Width*	*SNR*	*Type*	*Primary Application*
B1	412 nm	20 nm	1,000	Visible	Yellow substance and turbidity
B2	443 nm	20 nm	1,090	Visible	Chlorophyll absorption maximum
B3	490 nm	20 nm	1,170	Visible	Chlorophyll and other pigments
B4	555 nm	20 nm	1,070	Visible	Turbidity, suspended sediment
B5	660 nm	20 nm	1,010	Visible	Baseline of fluorescence signal, Chlorophyll, suspended sediment
B6	680 nm	10 nm	870	Visible	Atmospheric correction and fluorescence signal
B7	745 nm	20 nm	860	NIR	Atmospheric correction and baseline of fluorescence signal
B8	865 nm	40 nm	750	NIR	Aerosol optical thickness, vegetation, water vapor reference over the ocean

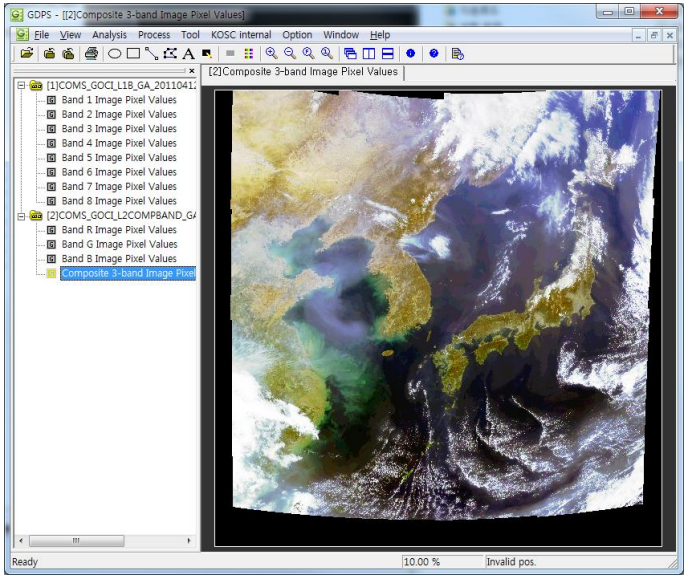
Progress of GOCI Operation





- Progress of GOCI Operation
  - Start of Project
    - Developments of COMS(H/W) and GDPS(S/W) : 2003
    - Establishment of KOSC (Ground System) : 2005
  - Launch : June 27, 2010
  - First image acquisition : July 13, 2010
  - In-Orbit Test : ~ Apr. 2011
  - GOCI data(Level 1B) and GDPS viewer service : Apr. 20, 2011
  - GOCI data(Level 2) and GDPS Ver.1.0 service : Sep. 2, 2011
  - GOCI 2nd PI Workshop : Jan. 2012
  - GDPS Ver.1.1 service : Jul. 2012
  - Ocean Science Journal GOCI Special Issues : 13 papers included
  - GOCI-II project started : Oct. 2012
  - GDPS Ver.1.2 release : Apr. 2013

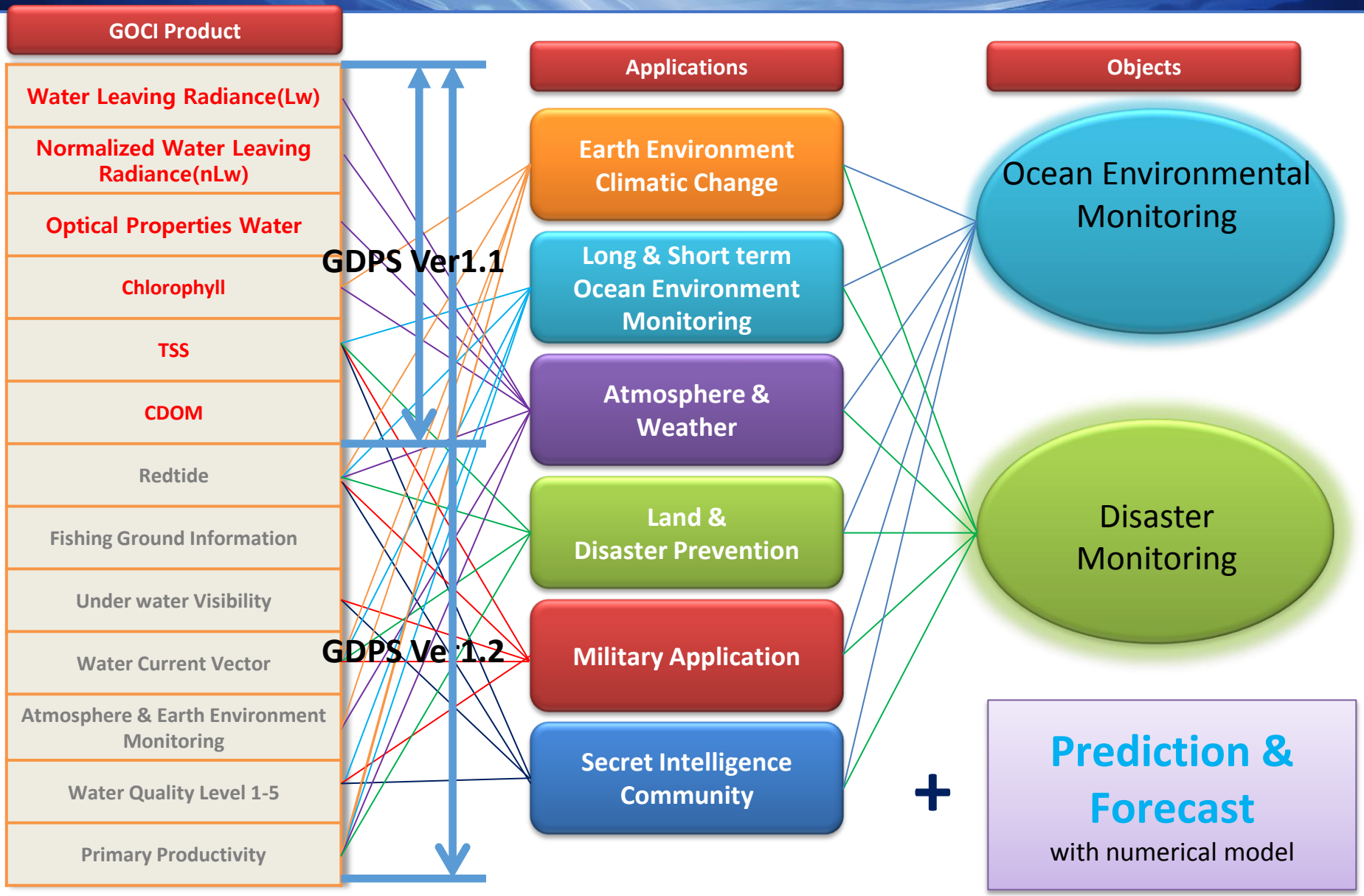
GOCI Data Processing Software



- GOCI Data Processing System
- Ver1.1 distributed July 2012
  - More accurate atmospheric correction
  - Improvement of User Interface
- Ver1.2 (April 2013)
  - Including more products
  - 64bit Windows OS supported

PRODUCTS	DESCRIPTION
Water-leaving radiance	The radiance assumed to be measured at the very surface of the water under the atmosphere
Normalized water leaving radiance	The water leaving radiance assumed to be measured at nadir, as if there was no atmosphere with the Sun at zenith
Optical properties of water	K-coefficient Absorption coefficient Backscattering coefficient
Chlorophyll	Concentration of phytoplankton chlorophyll in ocean water
TSS	Total suspended sediment concentration in ocean water
CDOM	Colored dissolved organic matter concentration in ocean water
Red tide	Red tide index information
Fishing ground information	Fishing ground probability index, fishing ground prediction
Underwater visibility	Degree of clarity of the ocean observed by the naked eye
Sea surface current vector	Sea surface current direction/speed
Atm. & earth environment	Yellow dust, Vegetation Index
Water quality level	Coastal water quality level estimation
Primary productivity	The production of Organic compounds from carbon dioxide, principally through the process of photosynthesis

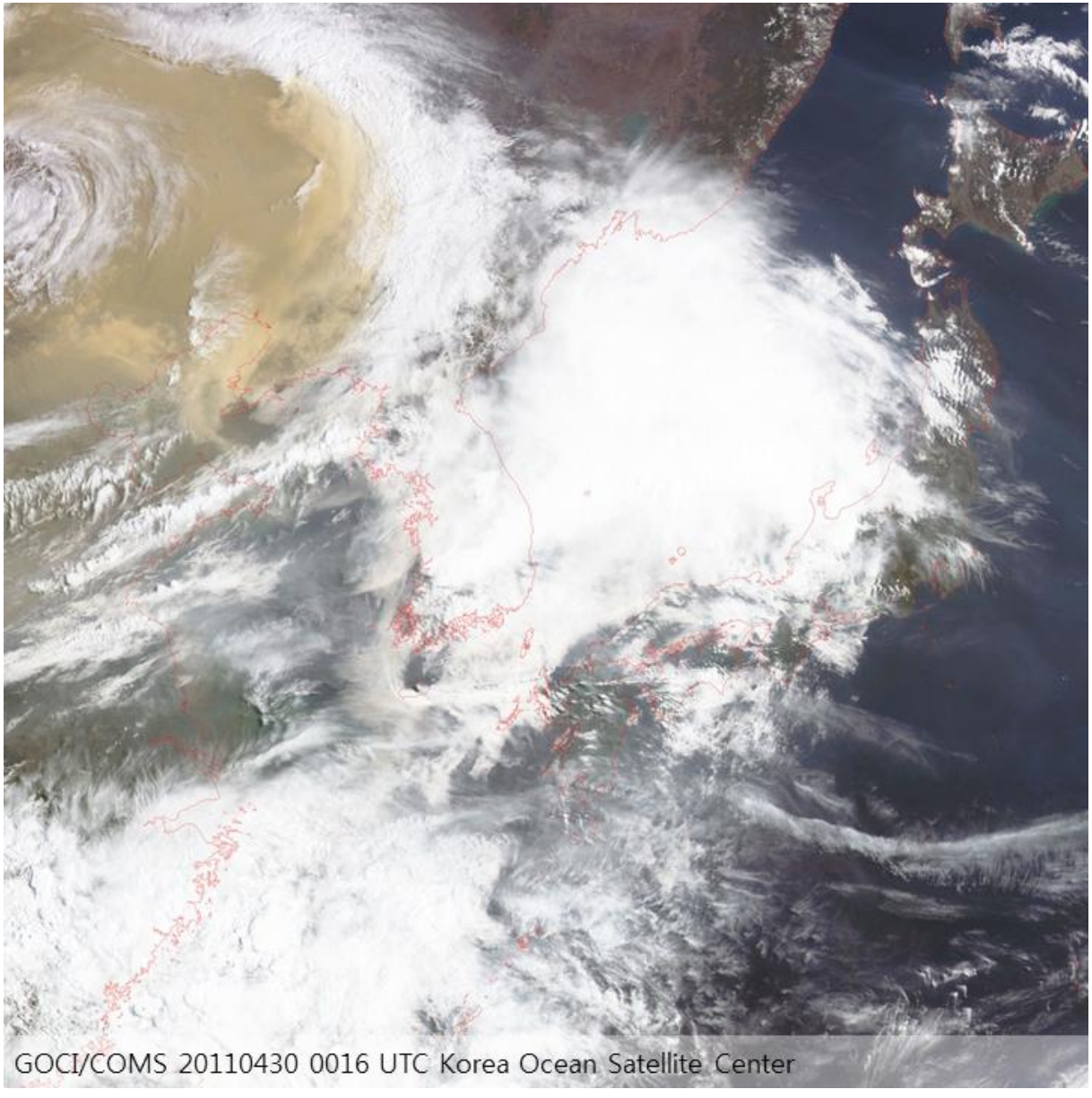
GOCI mission and GDPS version



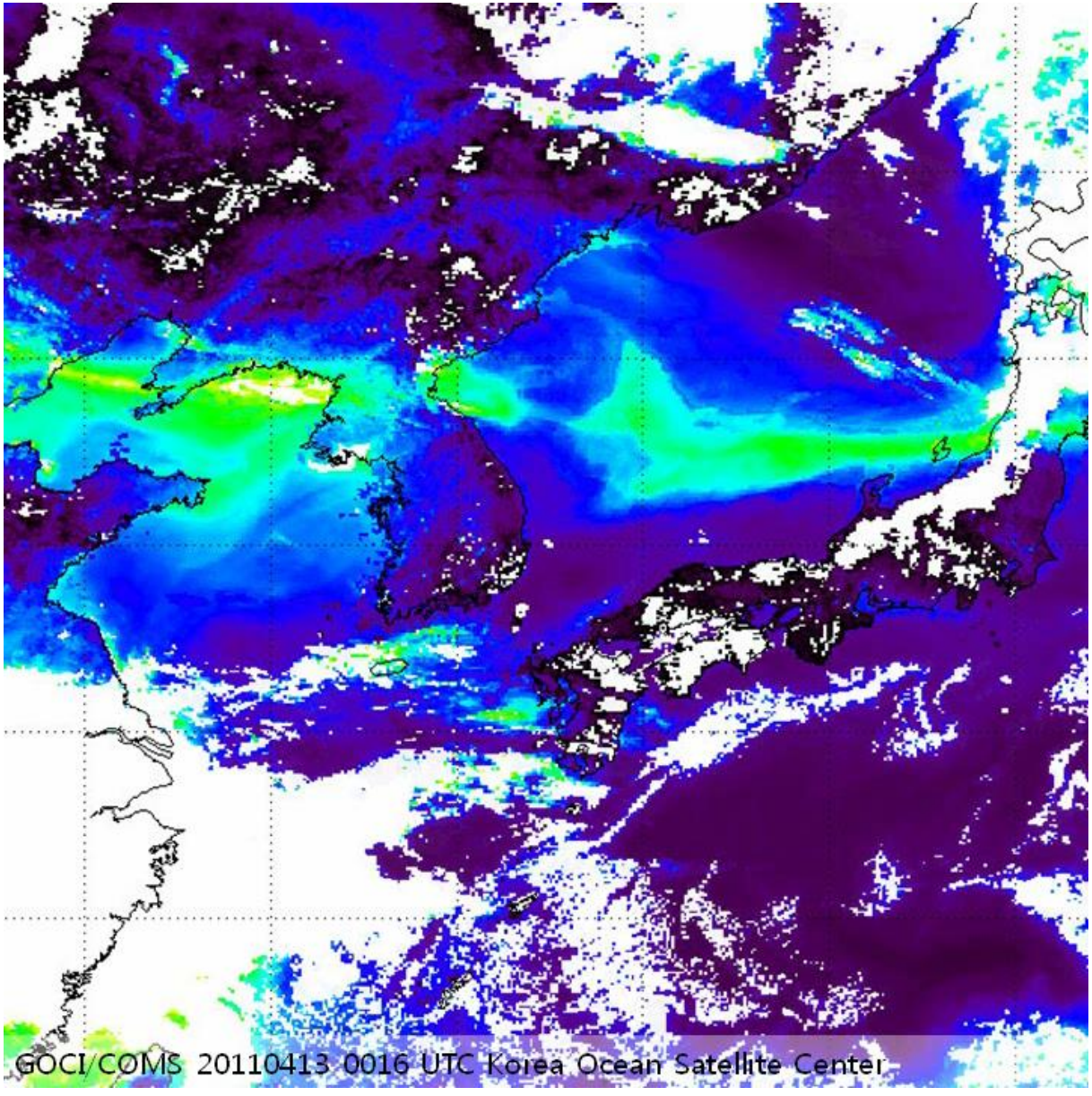
GDPS version 1.2

64 bit GDPS	1. Because of extending memory available - Improvement of processing speed - Improvement of program stability - Increasing number of window in GDPS
New Products	1. Rayleigh Corrected Reflectance for land user 2. Water current vector 3. Fish ground index 4. Yellow dust in ocean
Batch processing	1. When changed product algorism - processing maximum 1000 image 2. Applied batch processing in variety function - Subset image, L2 processing, L3 processing, Exporting image, Extracting pixel value of filed measurement point
User Interface	1. Developing user- friendly GUI in Combine Area, Combine Time-series/Animation, Dividie Area

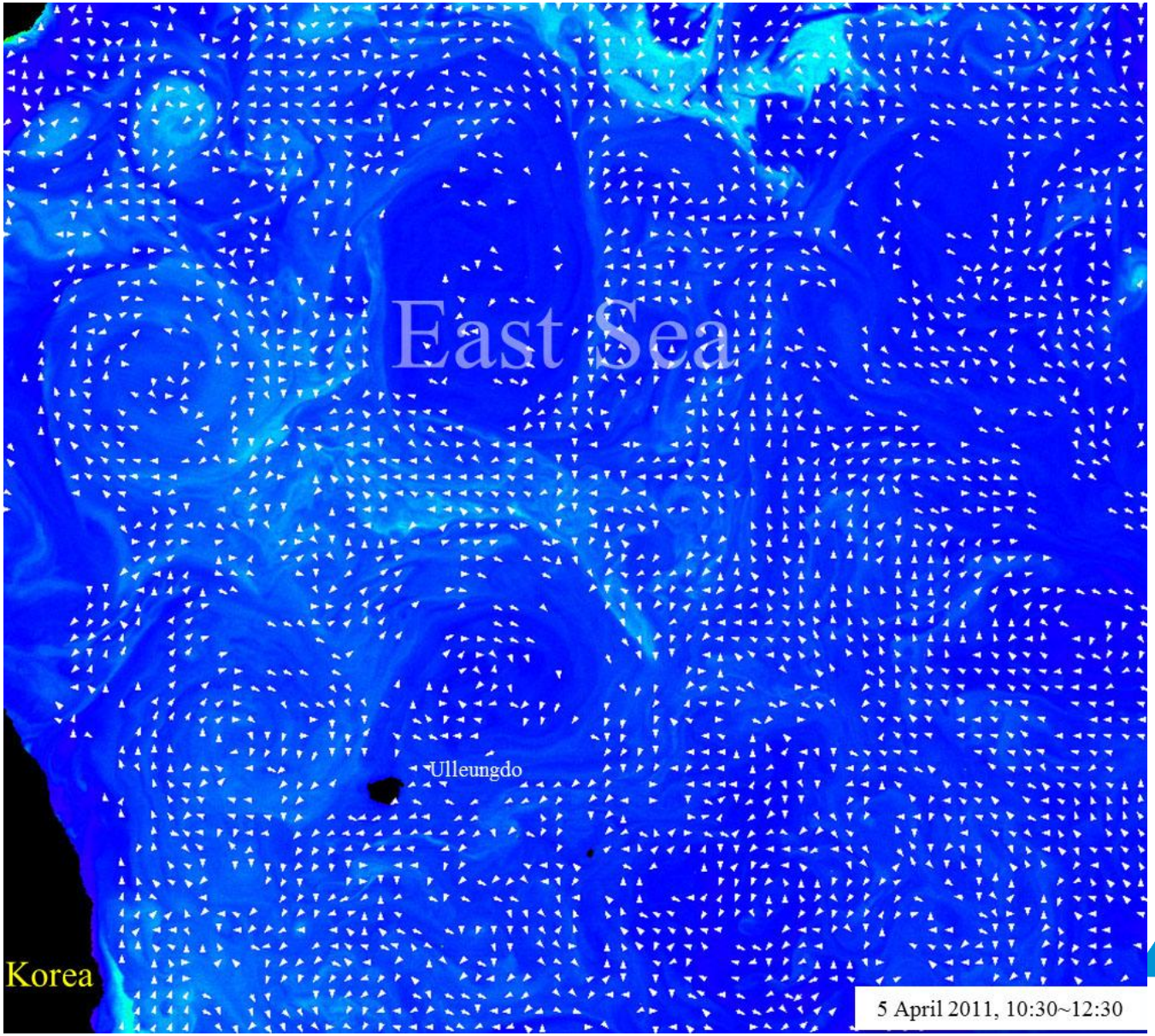
GOCI APPLICATIONS : Yellow Dust



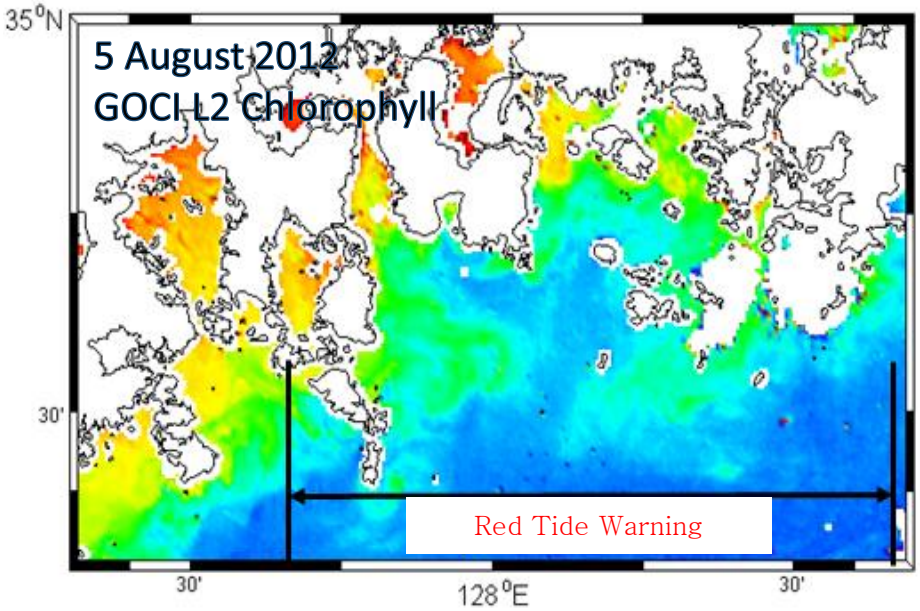
GOCI APPLICATIONS : Aerosol Optical Depth

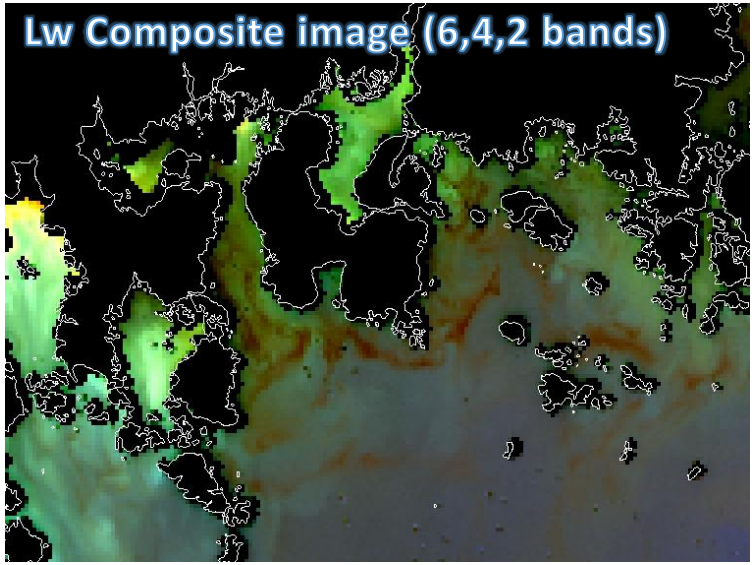


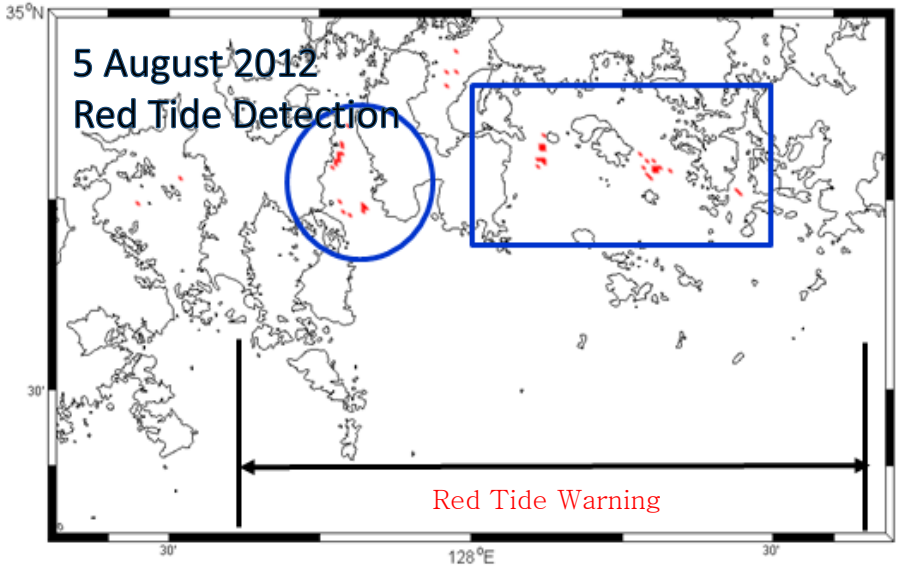
GOCI APPLICATIONS : Water Currents Vector

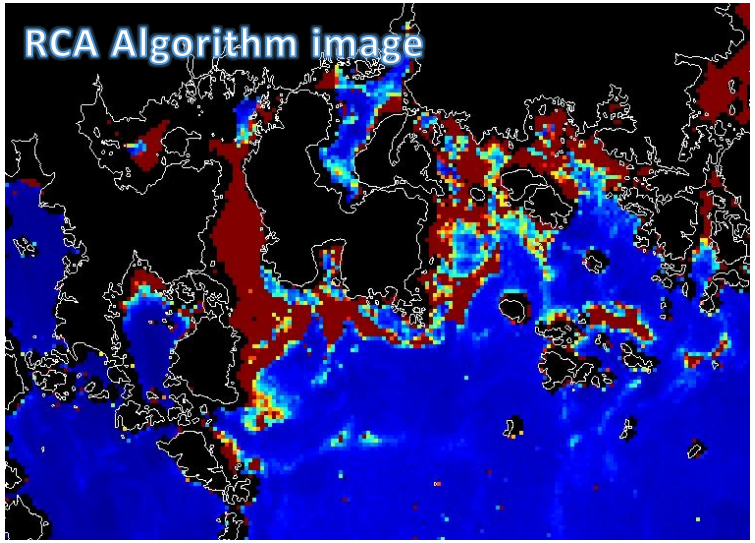


GOCI APPLICATIONS : Red Tide Detection



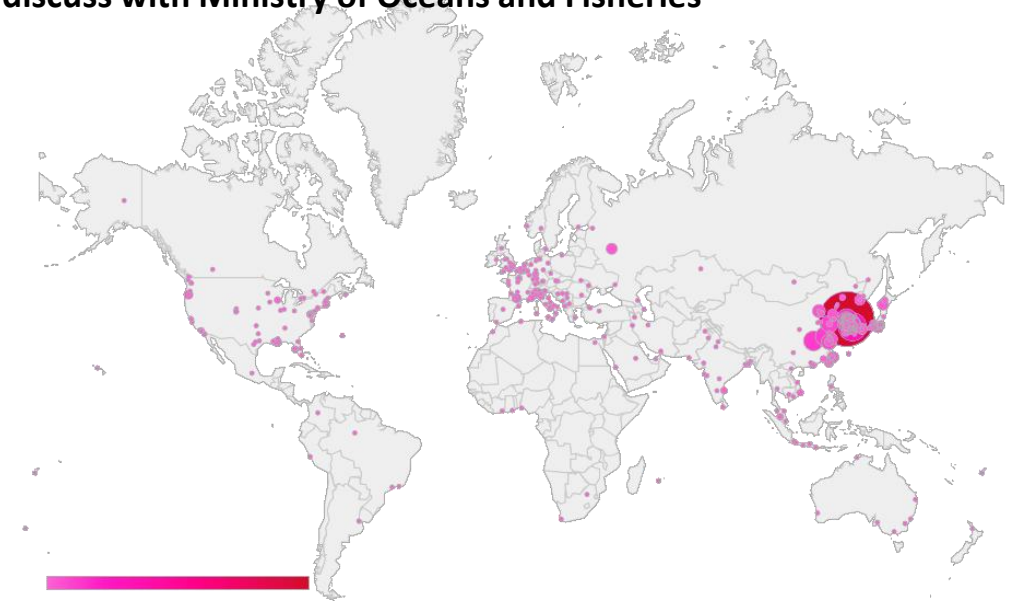






GOCI Data distribution

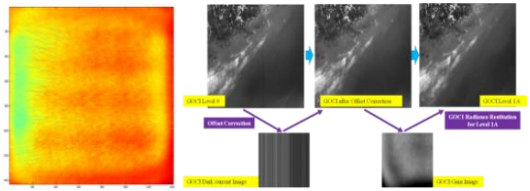
- Status of Distribution Service(20 Apr. 2011~)
- Satellite data DB (for distribution) : 42,000
- Downloads(~2012) : 113,400
- Scientific Users by web : 1006 people (Korea : 649, Others : 357)
- Domestic Gov./Inst. User by ftp : 24 (near-real-time data service)
- Public User by portal site
  - Korean portal site(http:// map.naver.com; in Korean)
  - Service : L1B RGB, CHL, CDOM, SS Jpeg image(only)
  - Frequency : 8 times/day
  - Maximum daily visitors: 260,000
- Redistribution site for international scientific users
  - approved by GOCI operation committee (Jan. 2013)
  - discuss with Ministry of Oceans and Fisheries



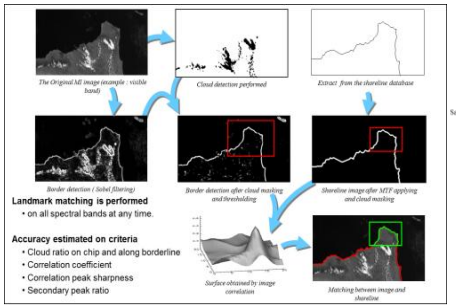
GOCI Data Quality Control (Cal / Val)

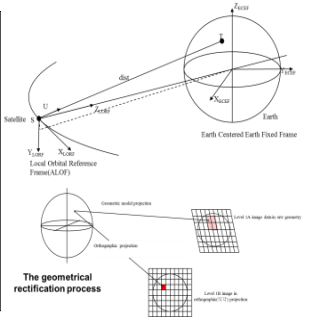
Level-0

Raw data



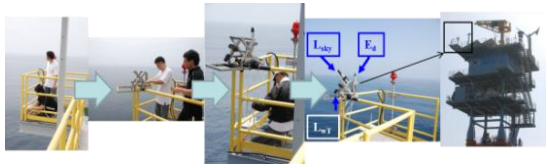
Radiometric / Geometric Calibration



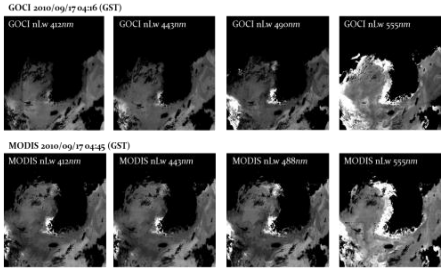


Level-1

Radiance
(L_w, L_{wN})



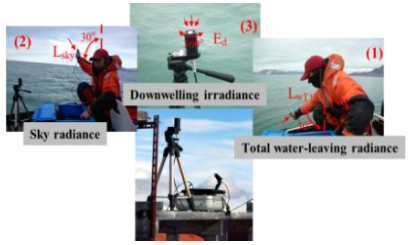
Atmospheric correction CAL/VAL

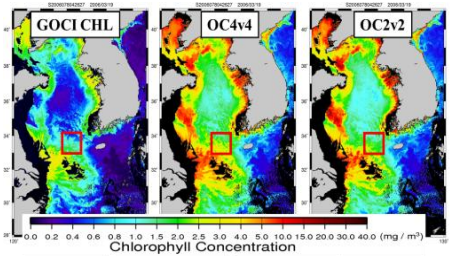


Level-2

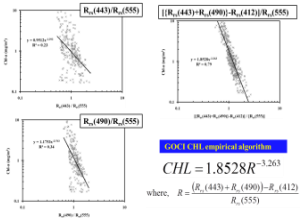
Products
(R_{rs}, chl, SS, DOM, Red-tide, Fishing ground information, Under water visibility, water current vector, and so on.)

Algorithm CAL/VAL





	GOCI CHL	OC4v4	OC2v2
평균값	1.18 mg/m³	2.48 mg/m³	1.96 mg/m³
vs. OC4v4	53 % 감소		
vs. OC2v2	40 % 감소		
Selection Area: Lat. 33 – 34, Long. 124 – 125 (Red Box)			



KOSC

KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY
1973-2013
KIOST

GOCI Data Quality Control (Cal / Val)

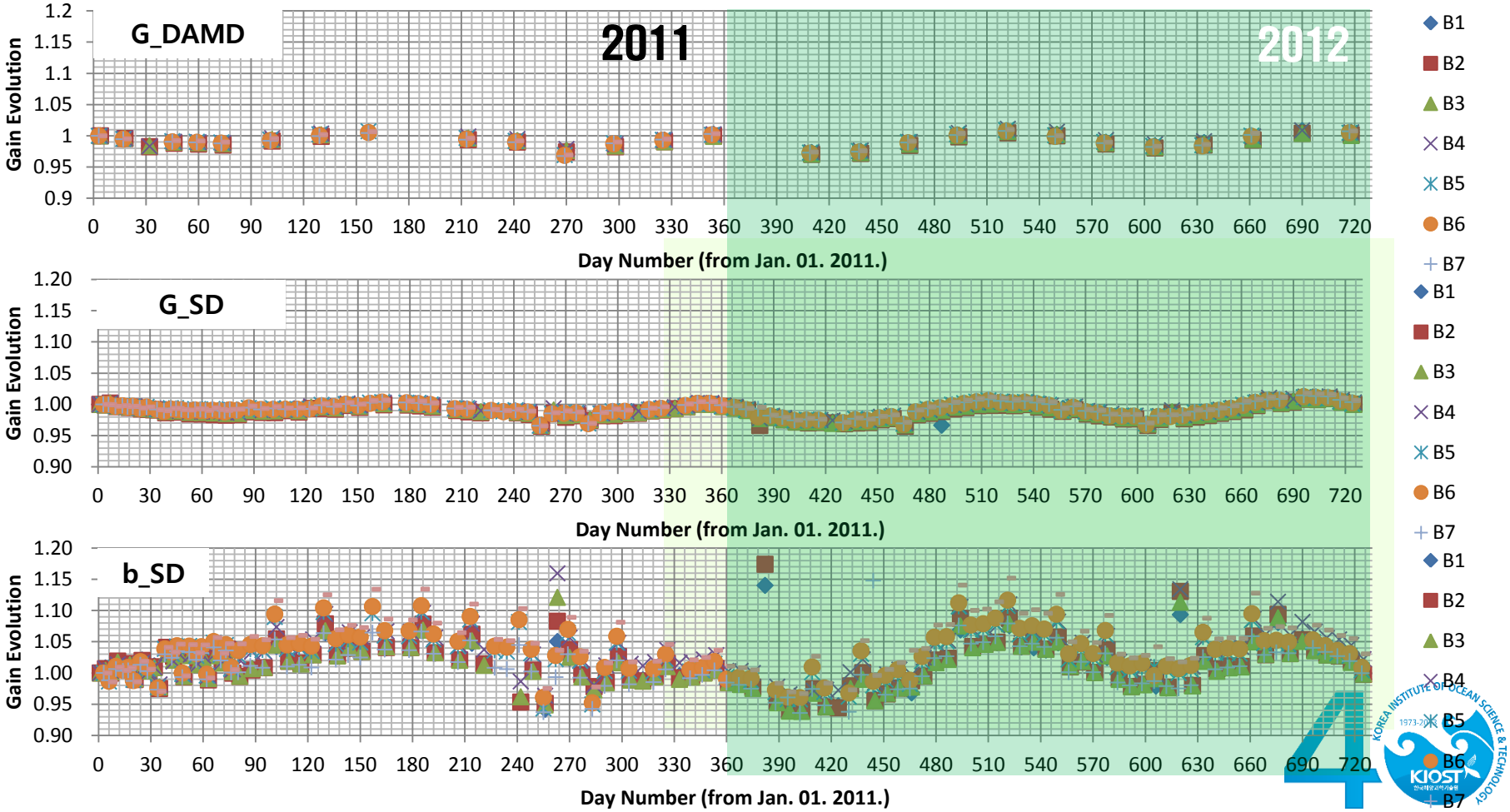
- Radiometric Calibration
  - GOCI Radiance Restitution Process calculated with dark image(offset) and 2D gain matrix correction
  - Dark Signal Variation shows very small changes.
  - GOCI detector has been operated in stable.
- Geometric accuracy(INR) Performance
  - Within-Frame, Frame-Frame, Band-Band Registration performances are satisfied with requirement.
  - In Winter season, a few date cannot be satisfied with requirement. Because of low intensity or poor circumstance, landmark for INR cannot be found enough.
- Inter Slot Radiance Discrepancy(ISRD)
  - The issue by sensor type(2D CMOS, frame capture method)
    - It takes 30 min to acquire one set of whole coverage.
    - The zigzag type of capture line brings about non-homogenous time interval.
  - Need to clarify the cause of ISRD : straylight/ghost image, sensor calibration or polarization sensitivity, etc.
  - A simple ISRD model has been tested and looks promising. Further test and improvement is needed for implementation into processing chain this year.

GOCI Data Quality Control (Cal / Val)

- Atmospheric Correction
  - KOSC standard atmospheric correction algorithm for GOCI has been developed.
  - The result of comparison of GOCI and *in situ* data shows good relationship except 412nm.
  - nLw comparison result with NOAA algorithm & KOSC algorithm is quite similar.
- Level 2 product Validation
  - Building Rrs matchup database for validation of CHL, TSS, CDOM.
  - Initial validation result of TSS is R2=0.87, Δ=35%. That of CHL is 0.34.
  - Results show that the bio-optical algorithms need to be improved. Semi-analytical algorithms should be considered.
- GOCI Cal/Val advisory group meeting
  - 1st meeting has held at Nagoya Univ.(Japan) in Nov. 2012.
  - To discuss for *In situ* database for GOCI validation/vicarious calibration

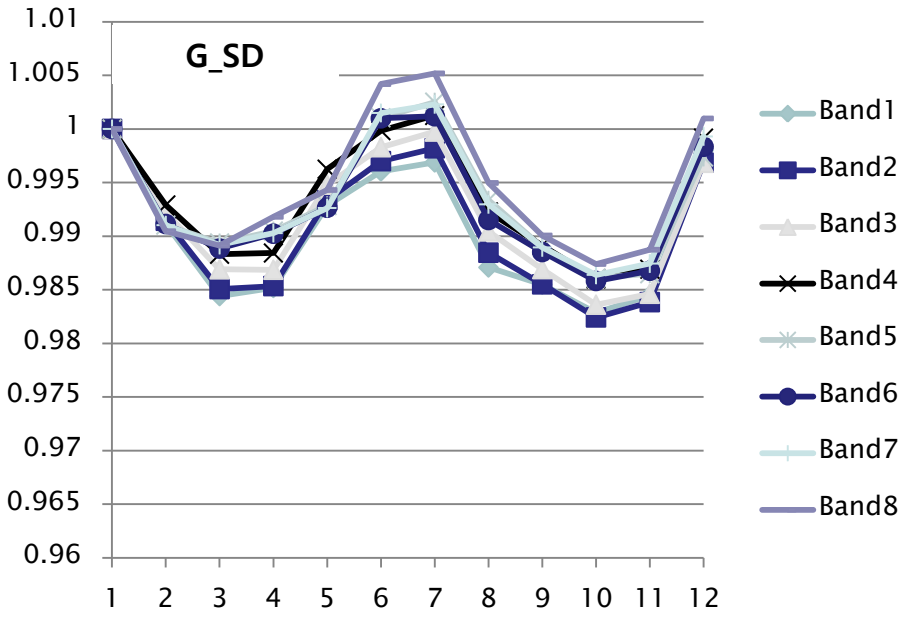
• Evolution of GOCI Radiometric Gain

- Monitoring of Linear Gain(G), Non-linear Gain(b) using SD & DAMD

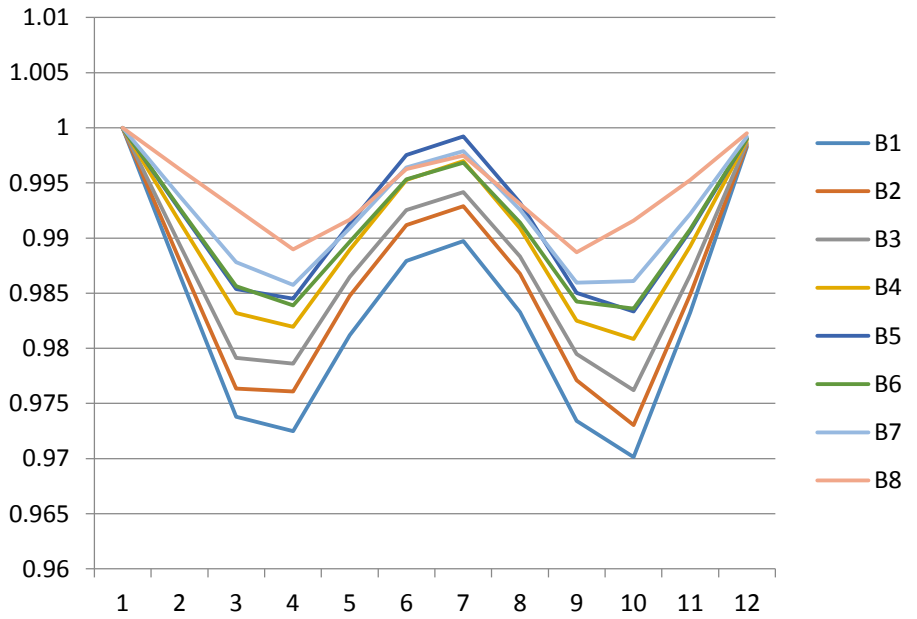


Discussion for gain evolution

- **Evolution of GOCI Radiometric Gain (2011.~2012.)**
  - Sinusoidal Variation of Radiometric Gain : ~ 2.5% (2011.)
  - Gain Evolution with same solar Azimuth/Elevation angle
    - ~0.51% (G_SD, Weekly Obs.) , ~0.14% (G_DAMD, Monthly Obs.)
    - Annual Solar angle variation : 108.4°/10.5° (AZ/EL)
  - Gain Variation(Uniformity) over FPA : ~5% (CV; STDEV/Mean)



Evolution of Radiometric Gain (2011)

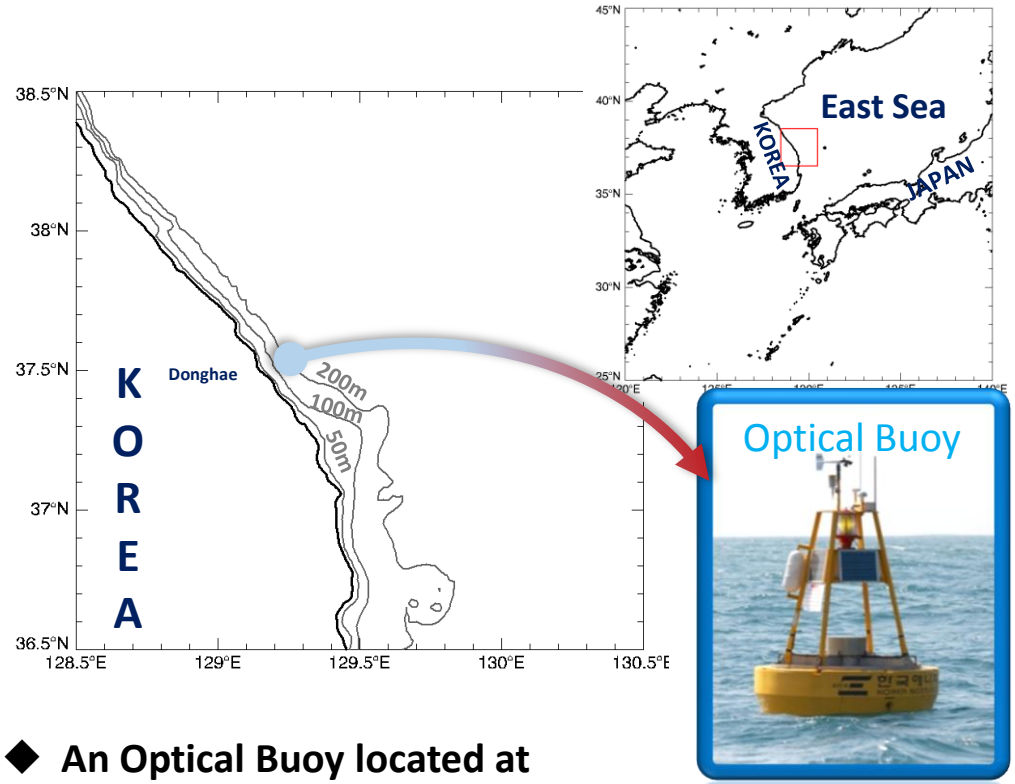


Diffusion Factor Variation
w.r.t. Solar azimuth **angle measured in pre-flight test**

GOCI Cal/Val Plan

◆ **In situ measurements**

- Research vessel, Ferry box(with KIOST), Glider(with KIOST)
- Buoy, Ocean research station
  - To use Korea Operational Oceanography Network(with KIOST)
  - To cooperate neighboring countries (with Japan, China, Taiwan)
  - To join International Group (with IOCCG, Aeronet-OC)



◆ **New System**

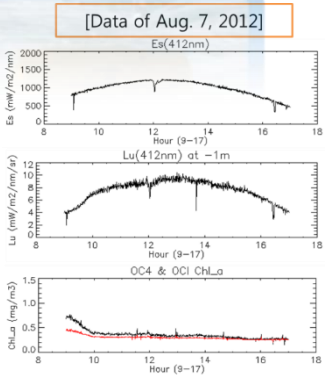
- Kite, aerostat, airborne(with KARI)
- Argo-type buoy

◆ **Uniform land Cal/Val site**

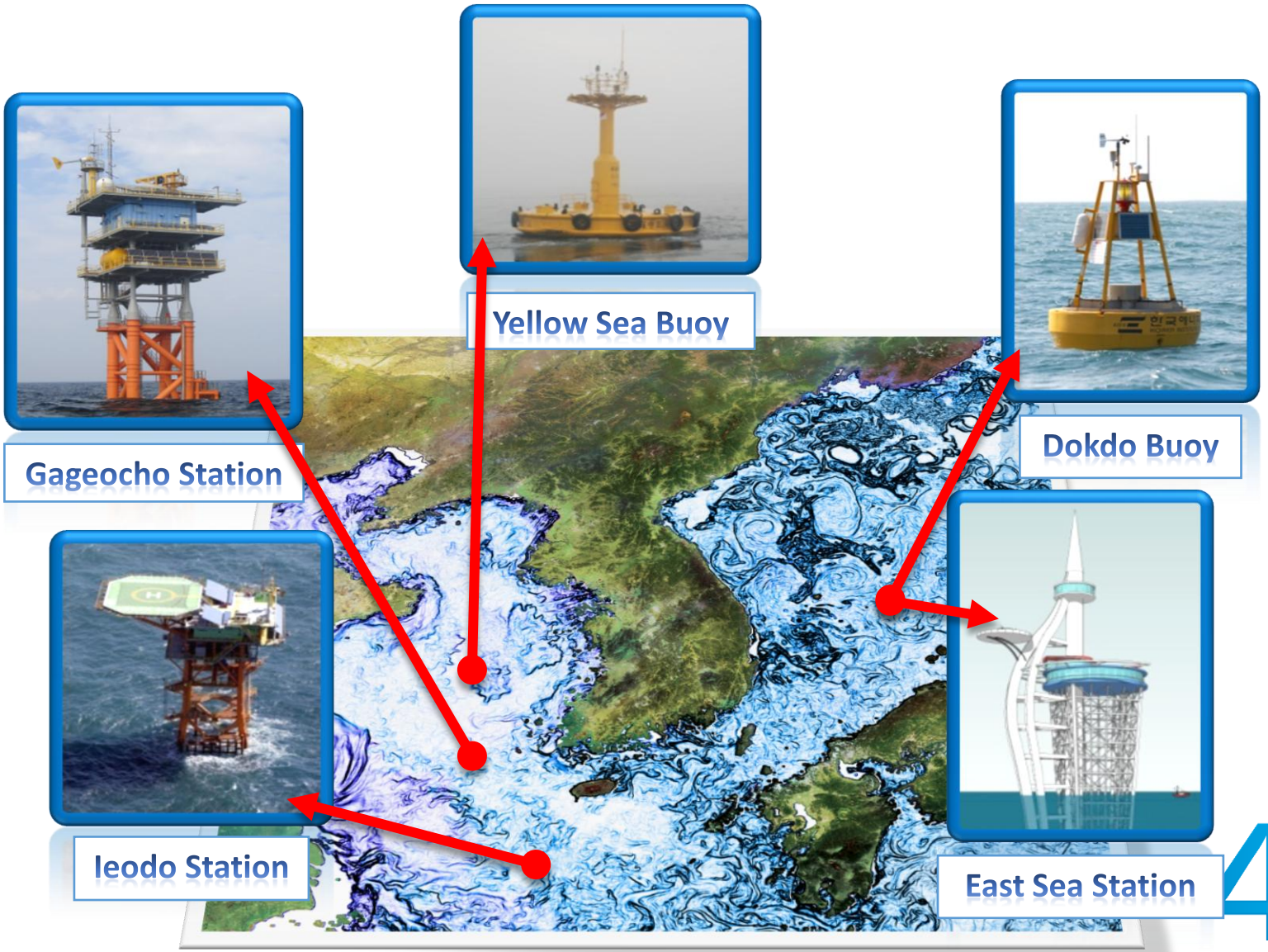
- Desert, Ice, Playa

◆ **An Optical Buoy located at**

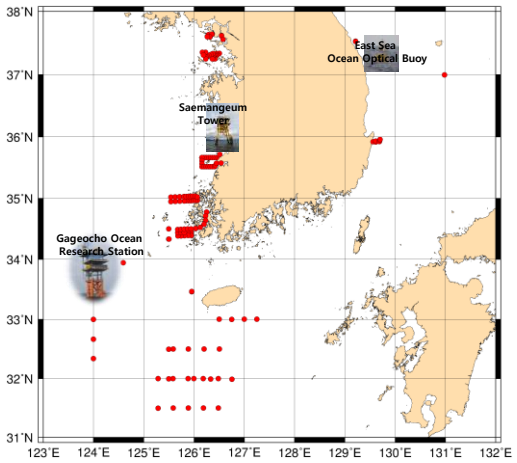
- An area of the convergence of North Korean Cold Current and East Korean Warm Current
- 10 km off Donghae port at a depth of 130m
- Data collected for April 24-Aug 13, 2012



Korea Operational Oceanography Network



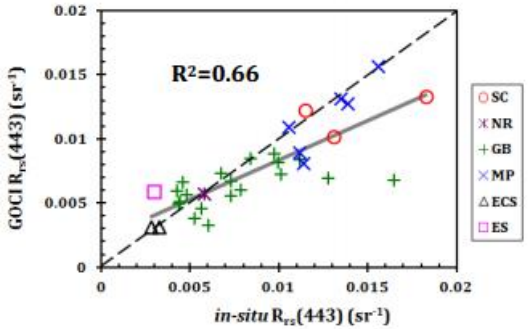
Rrs Matchup Result / L2 Validation Result

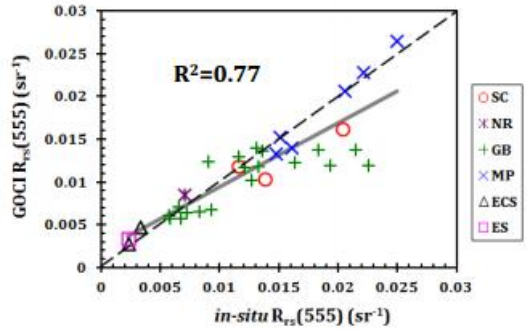


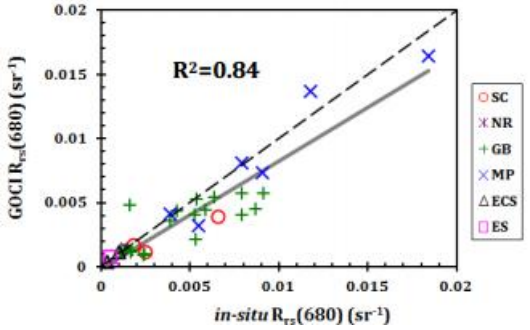
Observation Points : 207

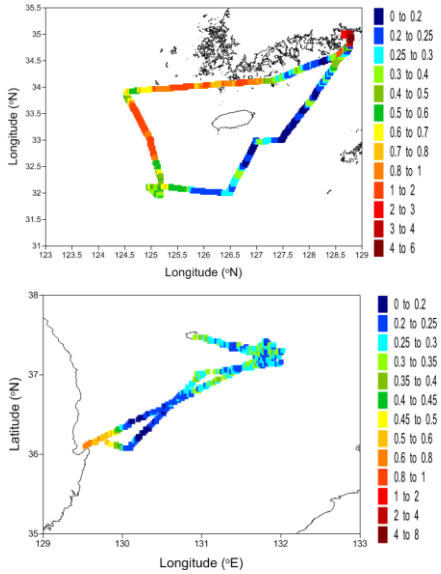
- ◆ initial validation
  - Chla: R2=0.34, Δ=35%
  - SPM: R2=0.87, Δ=35%
  - CDOM: R2= 0.18 Δ =330%
- ◆ Results show that the bio-optical algorithms need to be improved.
  - Semianalytical algorithms should be considered

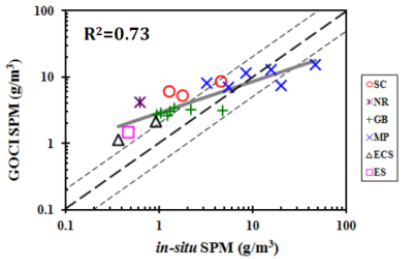
Rrs matchup results

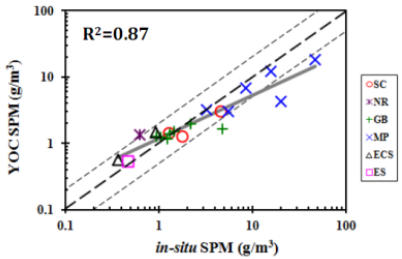


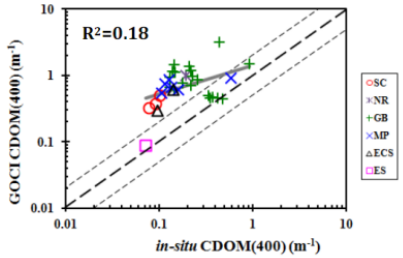


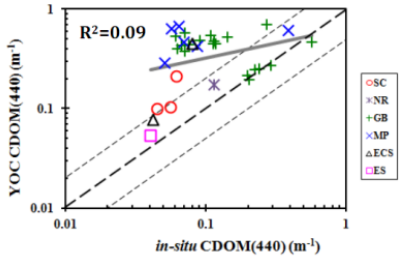












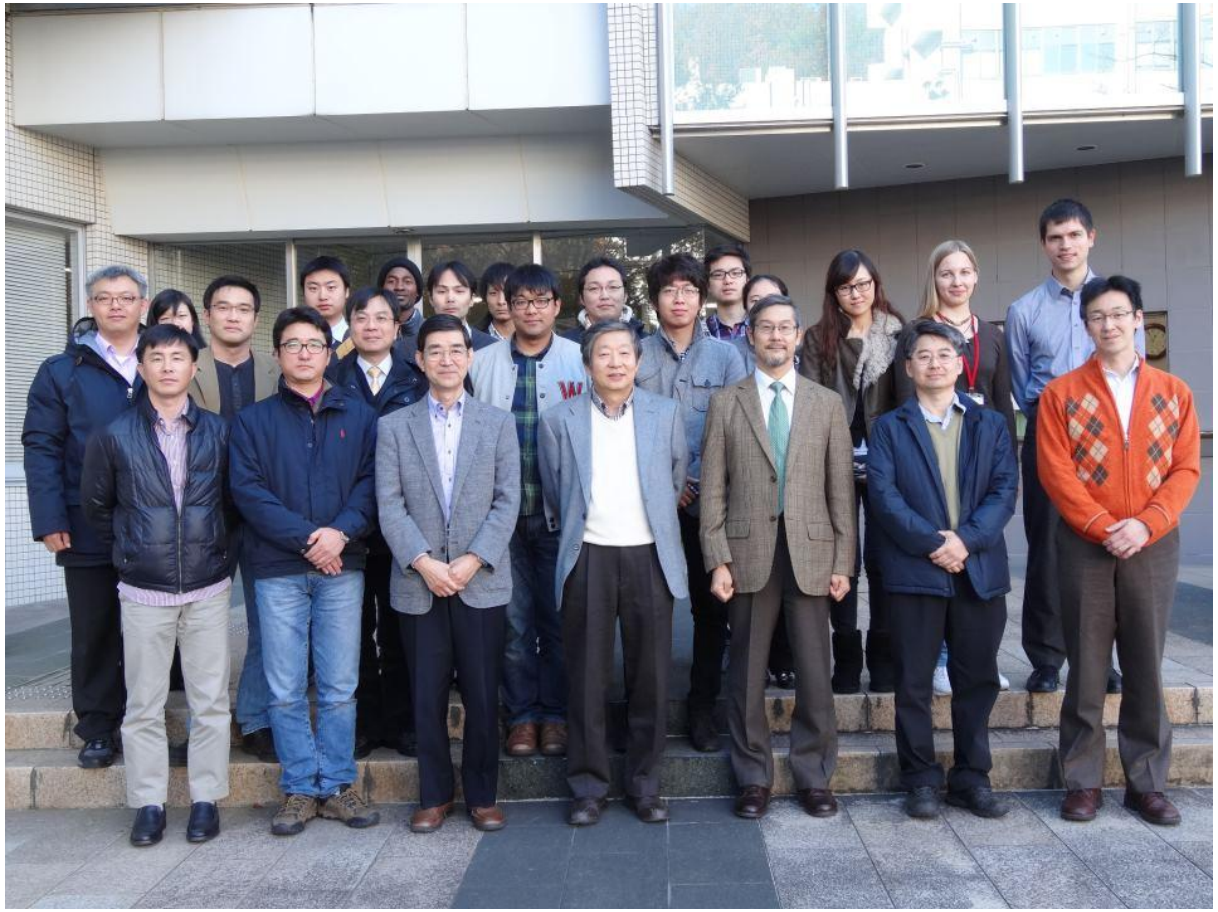
Flow-through fluorometer for Chl_a
(courtesy of J-H Noh, KIOST)

GOCI Calibration / Validation Future Direction

- Continued efforts for ship-based matchup comparison
  - Matchup data in the open ocean
- Feedback for algorithm improvement including
  - Vicarious calibration
  - Bio-optical algorithm
- Annual GOCI validation cruise
  - Foreign scientist participation encouraged
- Autonomous systems
  - Aeronet-OC
  - Validation buoy
  - Flow-through system
- Network/collaboration
  - Promote domestic val activities, e.g. HPLC round-robin exercise
  - International validation advisory group
  - International collaboration

GOCI Cal / Val Advisory Group Meeting

- **Date: Dec, 2012**
- **Location : Nagoya University (Japan)**
- **Attendee**
  - Korea, Japan, Russia, Taiwan + China



International GOCI PI Workshop

- **1st GOCI PI Workshop (Oct. 29~30, 2008)**
  - 72 peoples from 11 organizations, 7 countries(36 PIs)
  - Discussed the collaboration for *Algorithm development, in-situ data acquisition, and application research*

- **2nd GOCI PI Workshop (Jan. 11~12, 2012)**
  - 200 more peoples including 31 PIs, 62 domestic scientists
  - 16 sessions, 57 presentations
  - Shared the result for GOCI and satellite application research
  - Discussed GOCI application and international cooperation
  - Proposed GOCI-II user requirements

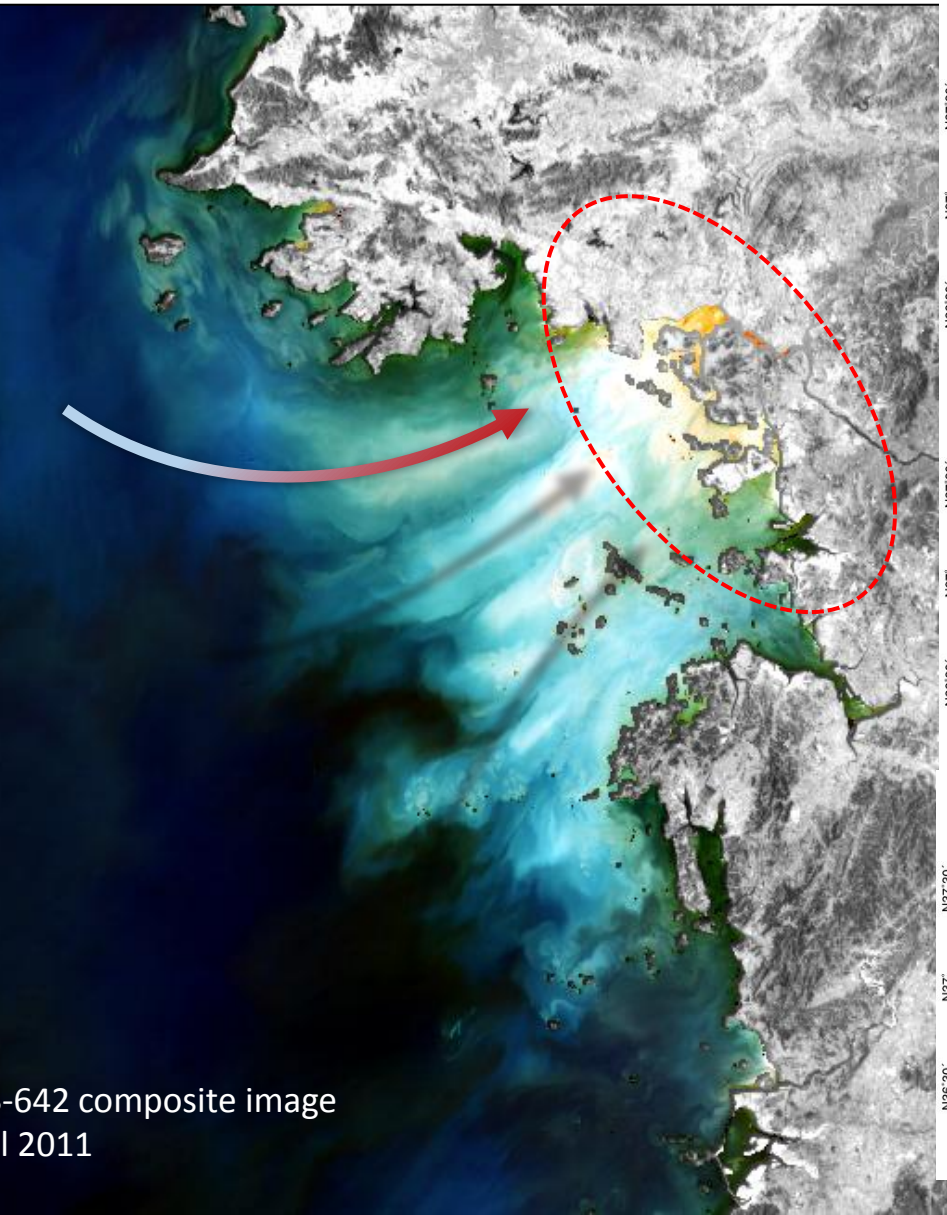
- **3nd GOCI PI Workshop (2014 ?)**
  - will be announced…

KOSC International Collaborations

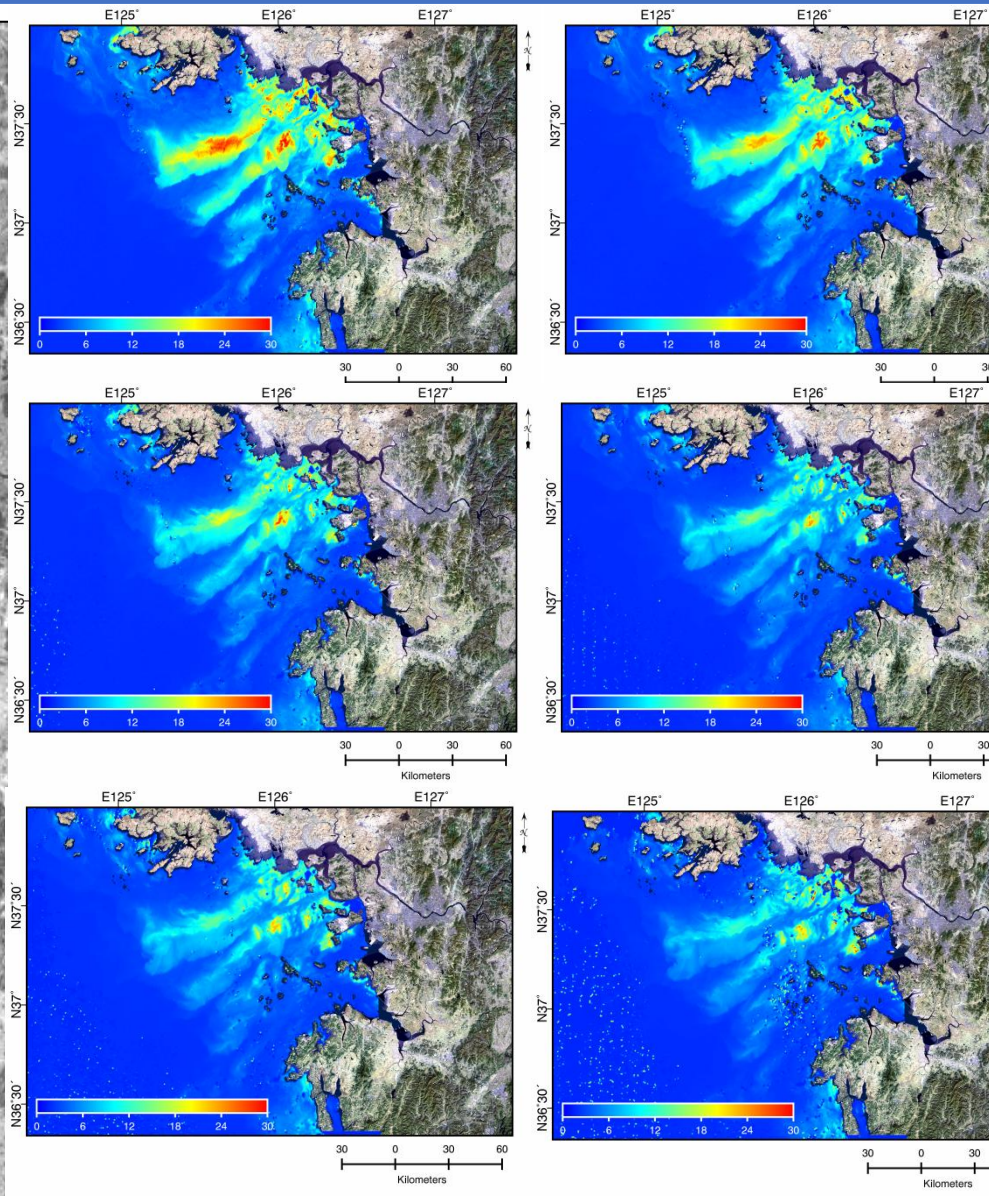
KOSC has many relationship for GOCI cal/val and research collaboration.

- NOAA
- NASA
- LOV
- MUMM
- PML
- JKWOC
- Cal/Val Advisory group
- Japan
- China, Taiwan, Russia
- Aeronet-OC

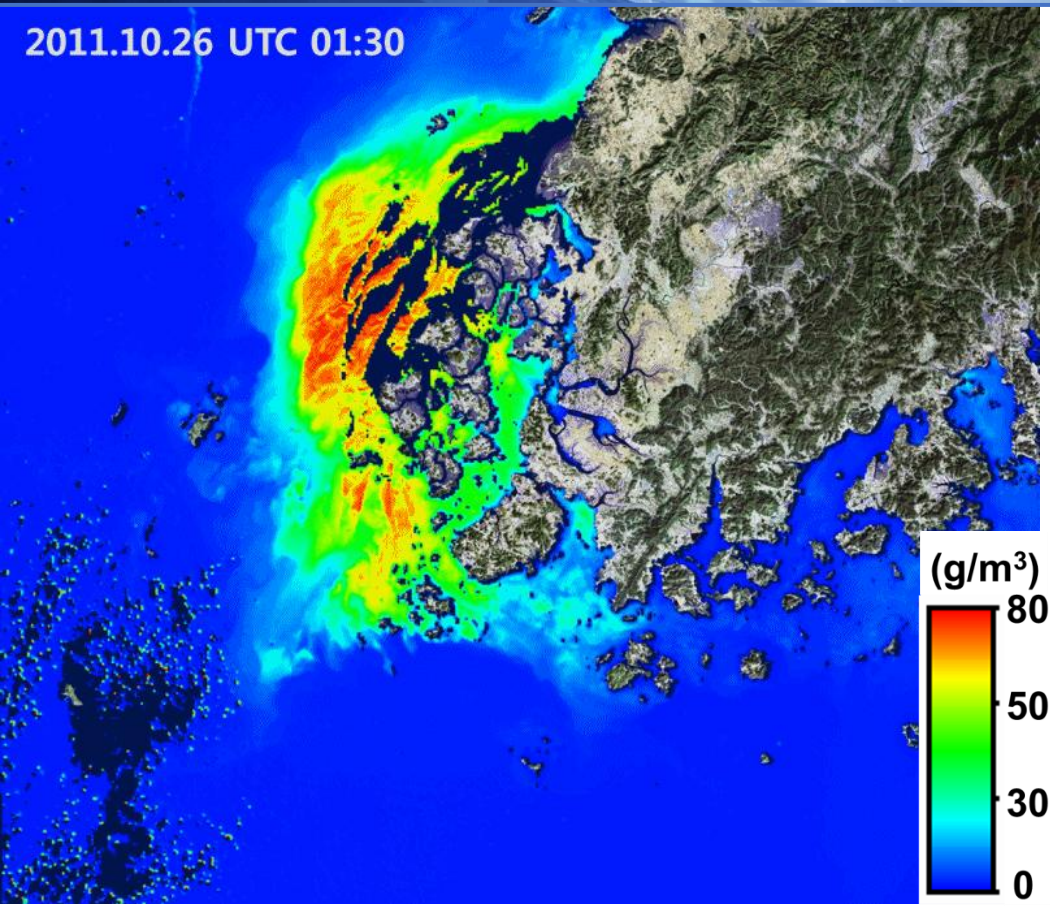
Short-term variability : Tidal Movement

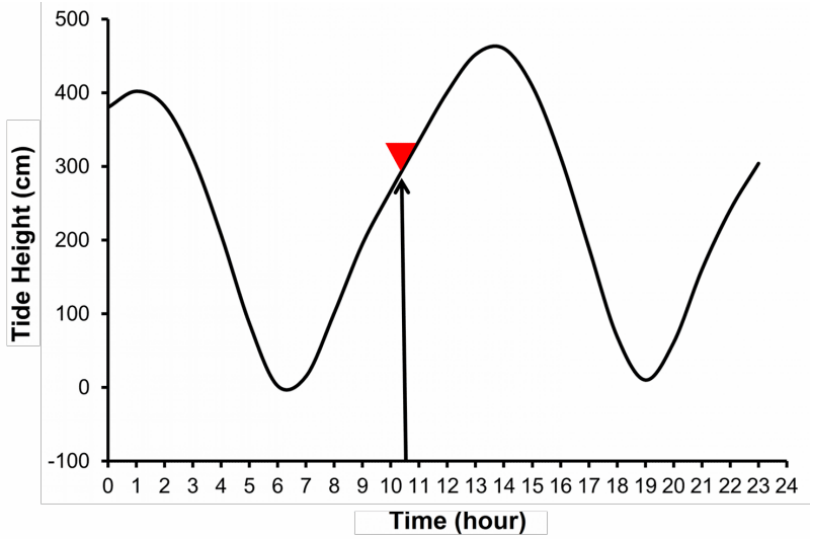


-642 composite image
l 2011



Short-term variability : Tidal Movement





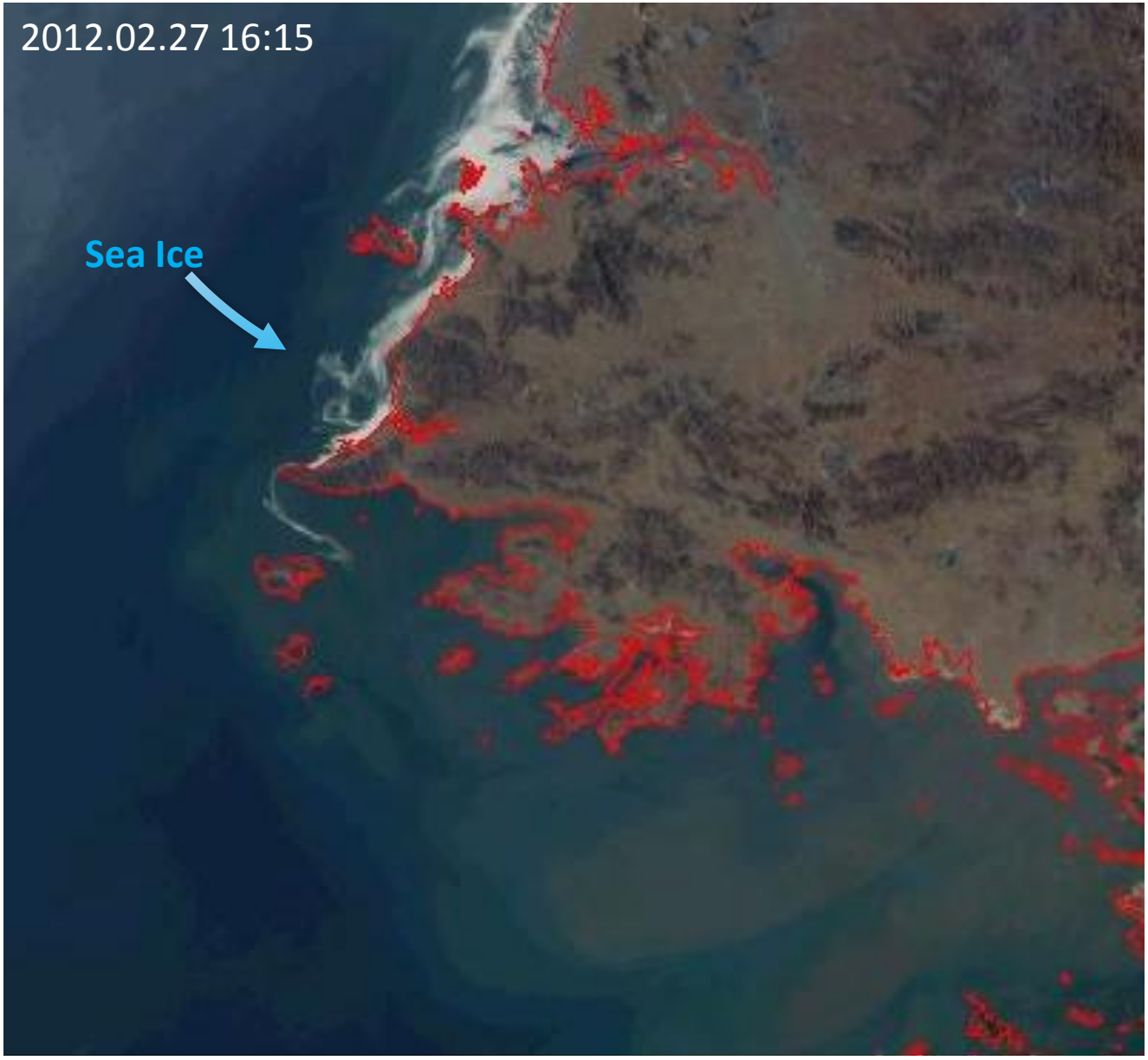
areas of relatively high turbidity (in red) gradually decreased over time

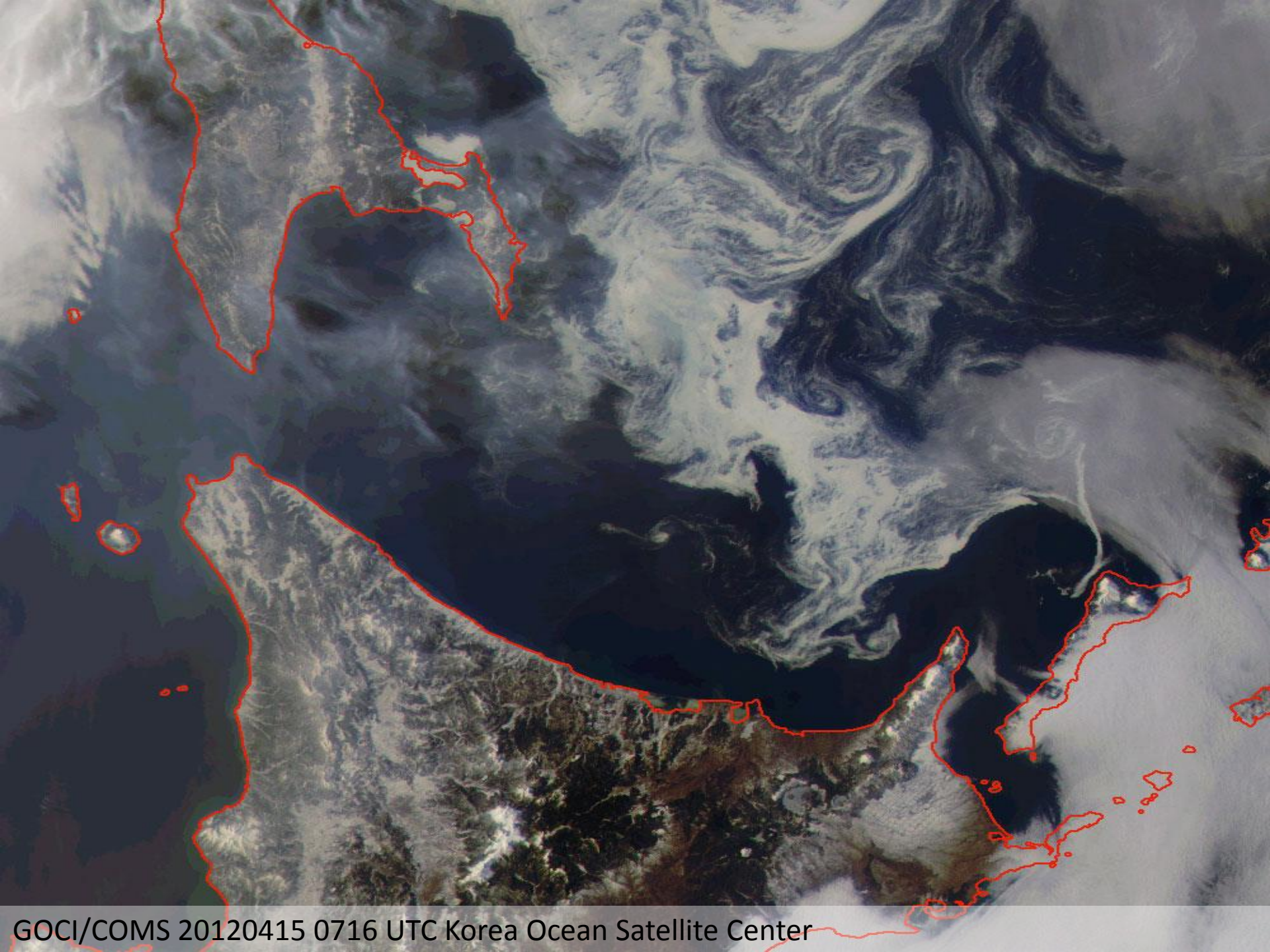
- clear water from open sea suppressed turbidity during flood tide

around the time of high tide, turbidity was remarkably lower

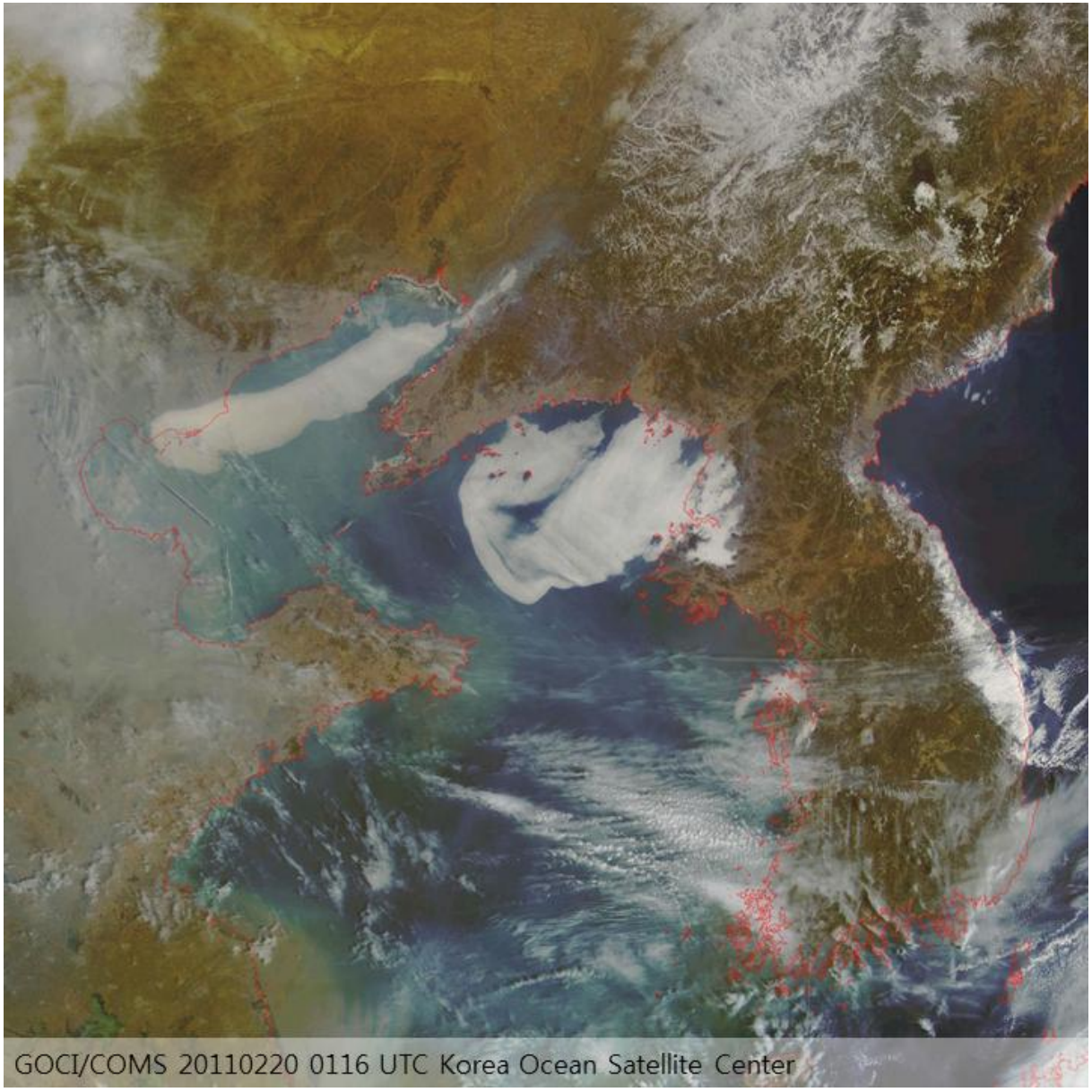
- settlement of suspended particulates during the transition from flood to ebb tide and resulting lull in the tidal current

Short-term variability : Sea Ice

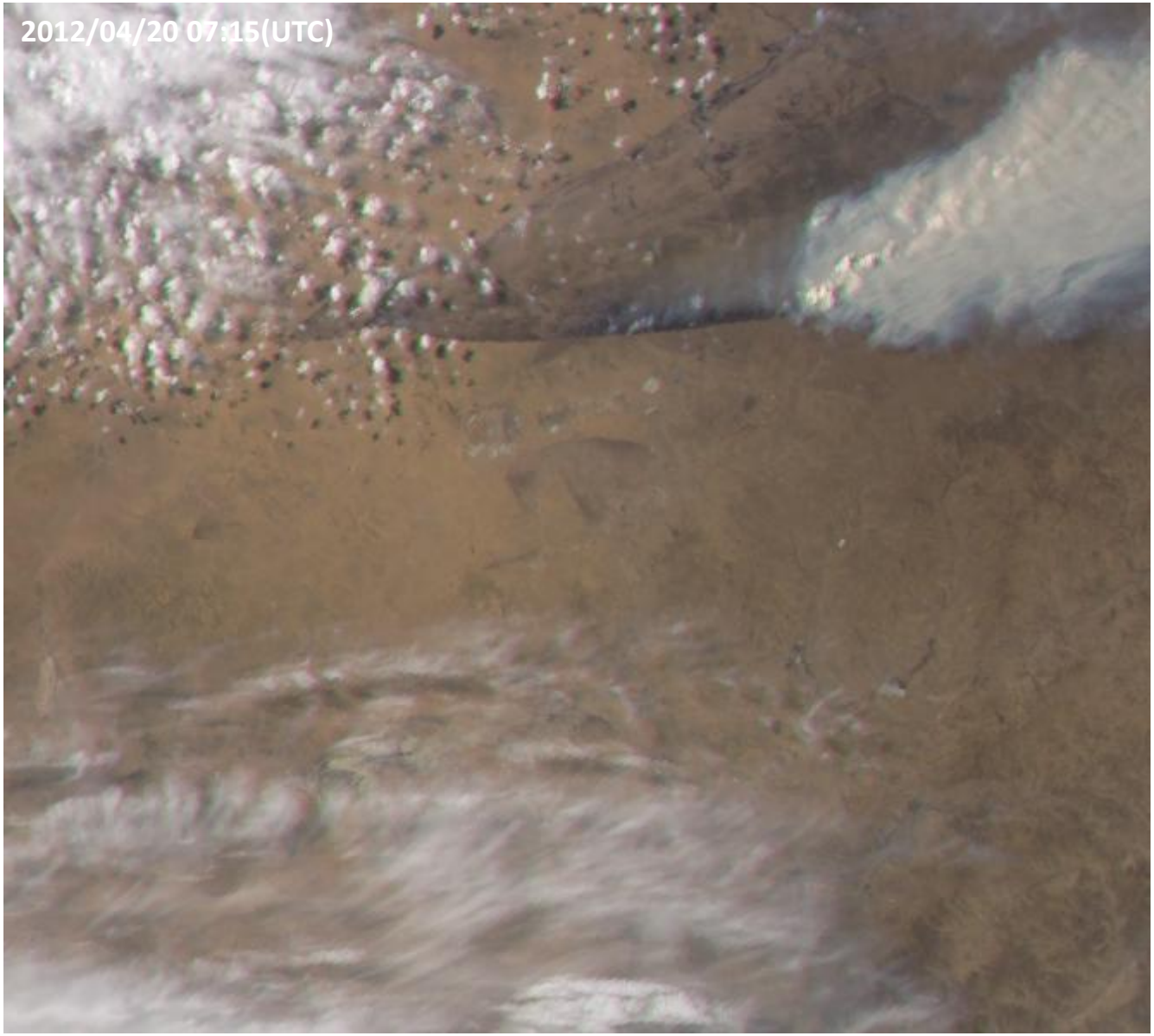



GOCI/COMS 20120415 0716 UTC Korea Ocean Satellite Center

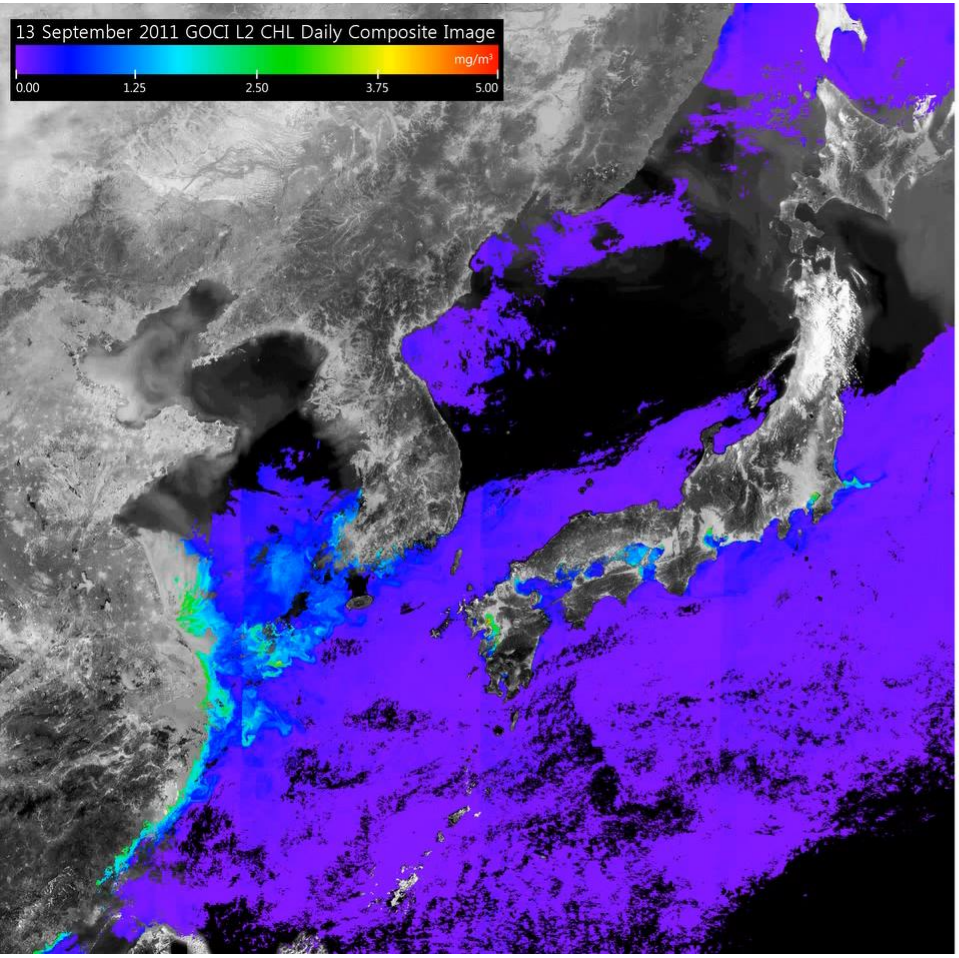
Short-term variability : Sea Fog

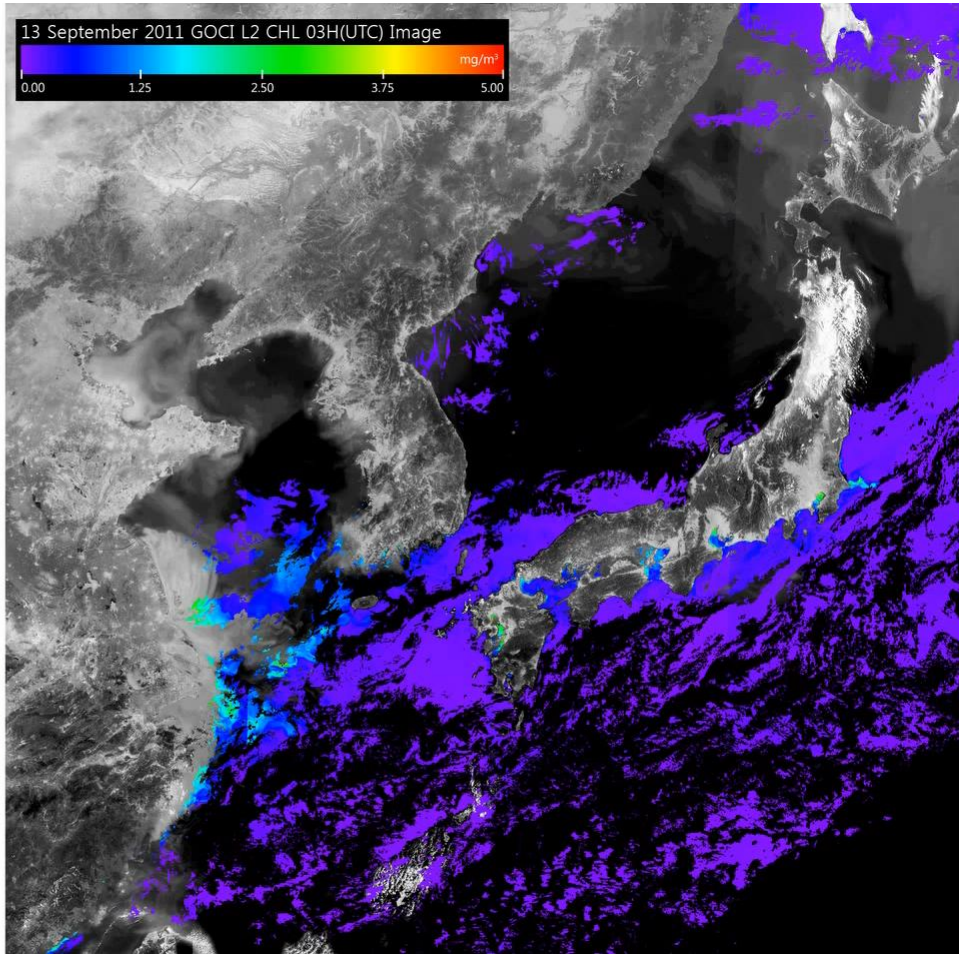


Short-term variability : Fire Detection



OCEAN DATA AVERAGE ACQUISITION RATE





DAILY COMPOSITE
8 SCENES / DAY

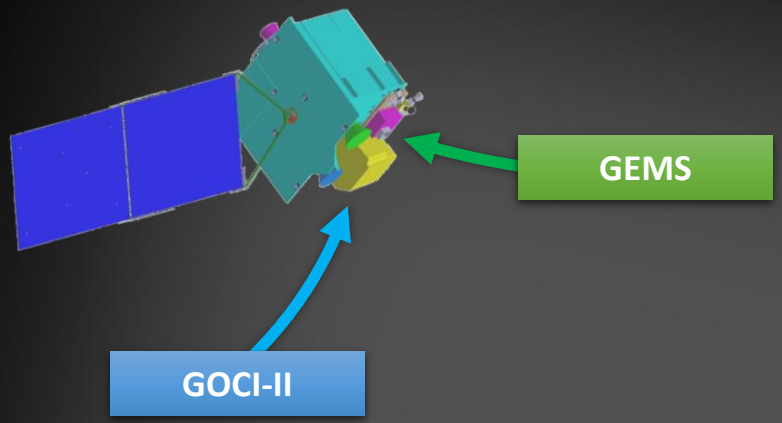
28%

1 SCENE / DAY

10%

GOCI APPLICATIONS : Ocean Fronts

GeoKompsat-2 Development

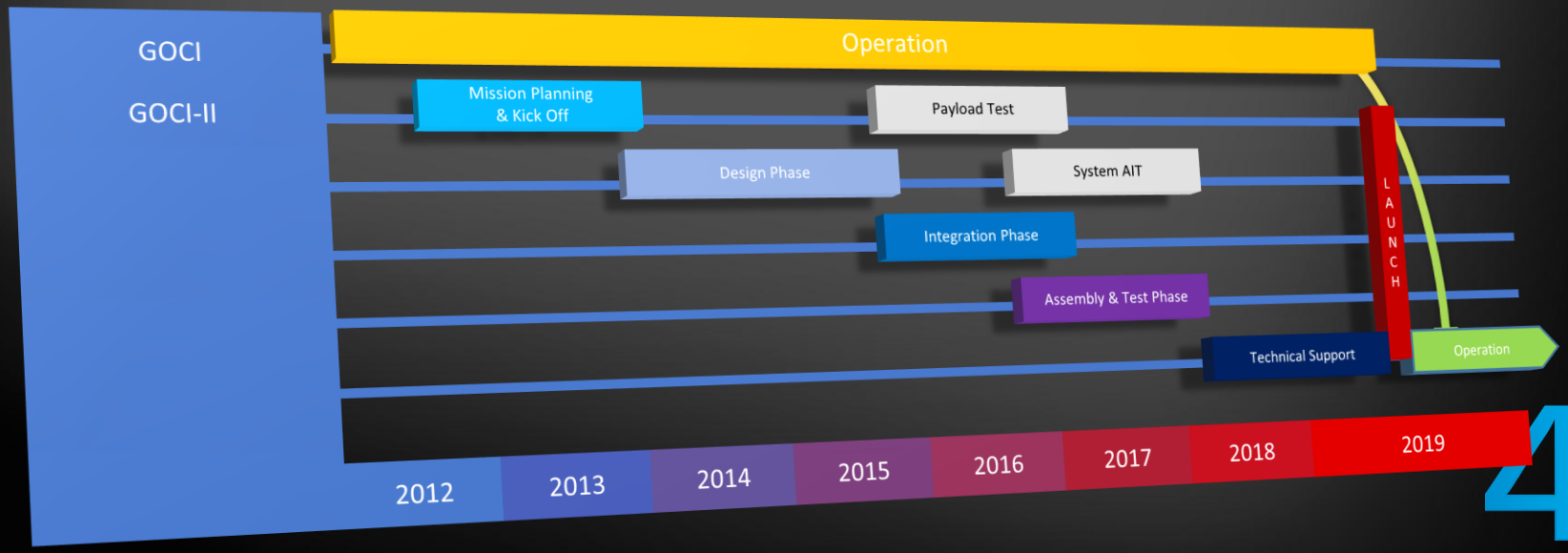


COMS : GOCI-I, MI-I, & Ka-band

GeoKompsat-2A : MI-II (ABI)

GeoKompsat-2B : GOCI-II & GEMS

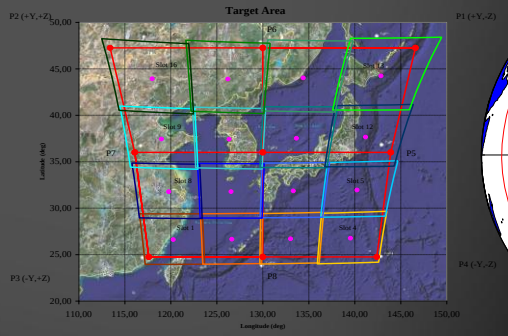
- GOCI Development :
  - KARI & KIOST Cooperation Development
  - Payload system - Development Company(TBD) + KARI/KIOST team
  - Bus system - KARI
- Supervising : KIOST



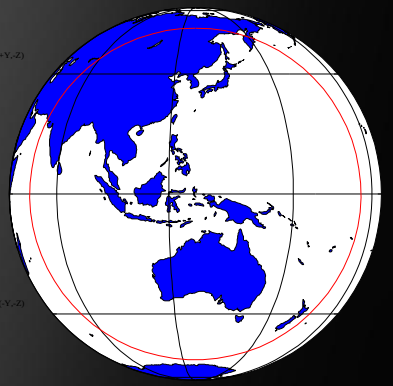
GOCI-II

- GOCI-II is focused on the coastal and global ocean environment monitoring with better spatial resolution and spectral performance for the succession and expansion of the mission of GOCI.
- GOCI-II project started the development in 2012, and will be launched in 2018.
- The user requirements of GOCI-II will have higher spatial resolution, 300m×300m, and 13 spectral bands to fulfill GOCI's user requests, which could not be implemented on GOCI for technical reasons.
- GOCI-II will have a new capability, supporting user-definable observation requests such as clear sky area without clouds and special-event areas, etc. This will enable higher applicability of GOCI-II products. GOCI-II will perform observations 8 times daily, the same as GOCI's.
- The main difference between GOCI-II and GOCI is the global-monitoring capability, which will meet the necessity of the monitoring and research on the long-term climate change. Daily global observation once is planned for GOCI-II.

Items	GOCI Specs	**GOCI-II Specs**
Increased band number	8 bands	**13 bands**
Improved spatial resolution	500m	**300m**
More observations	8 times/day	**10 times/day**
Pointable & Full Disk coverage	Local Area	**Local Area + Full Disk**



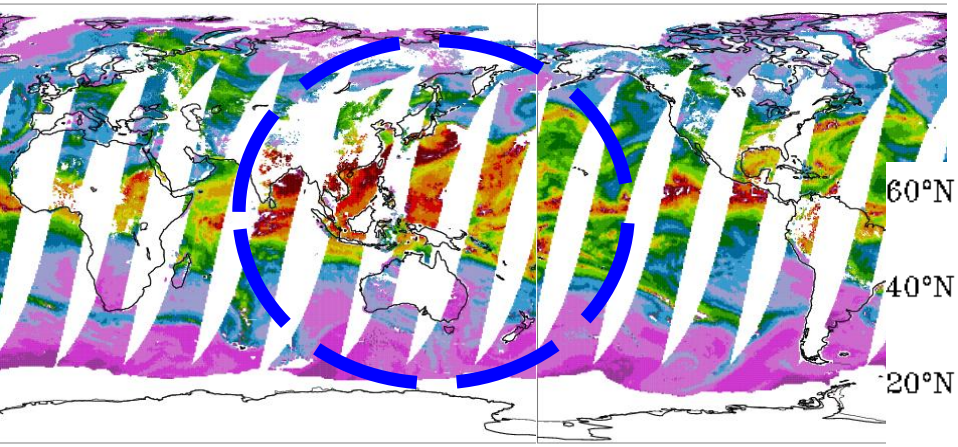
Selected LA



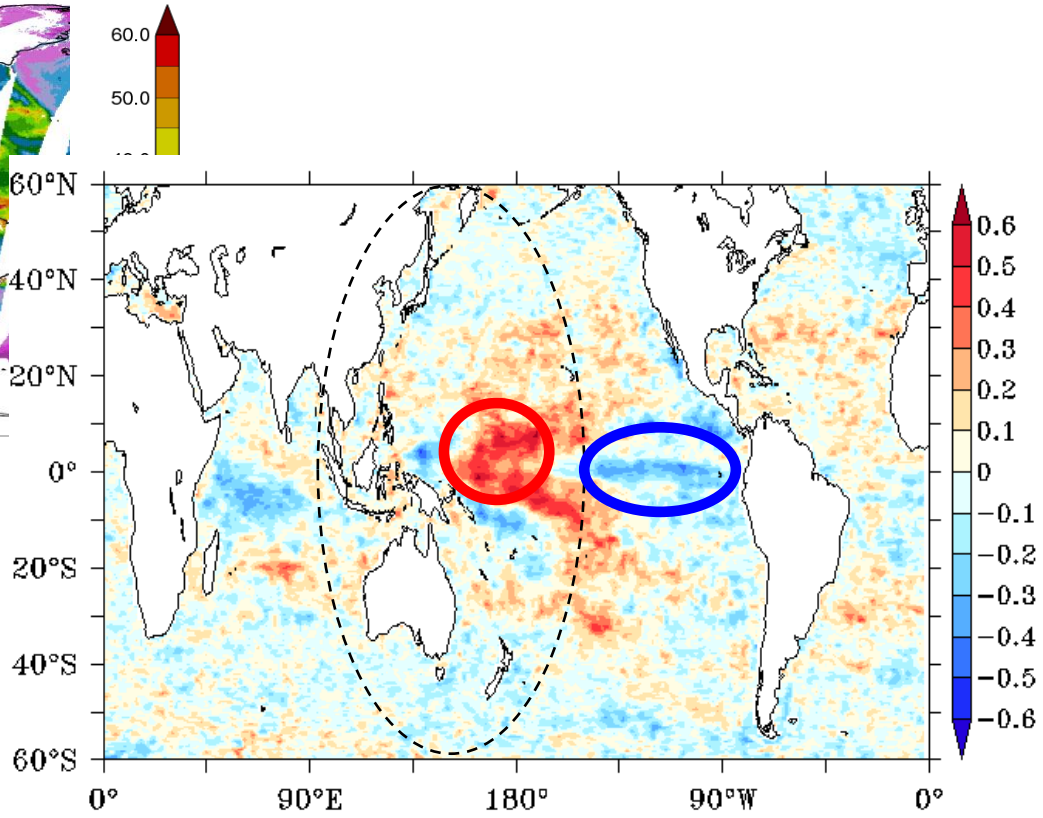
FD (Red Circle)

FD : Global Coverage

- Better Quality in GEO
  - Easy to achieve High SNR with longer Integration time and Noise Reduction with averaging of multiple acquisitions.
  - Effective 1-Day coverage of GEO is larger.
- Necessity of Global Area Observation
  - Global Obs. can enable the ocean climate change research.



1-day Composite Image (MERIS)

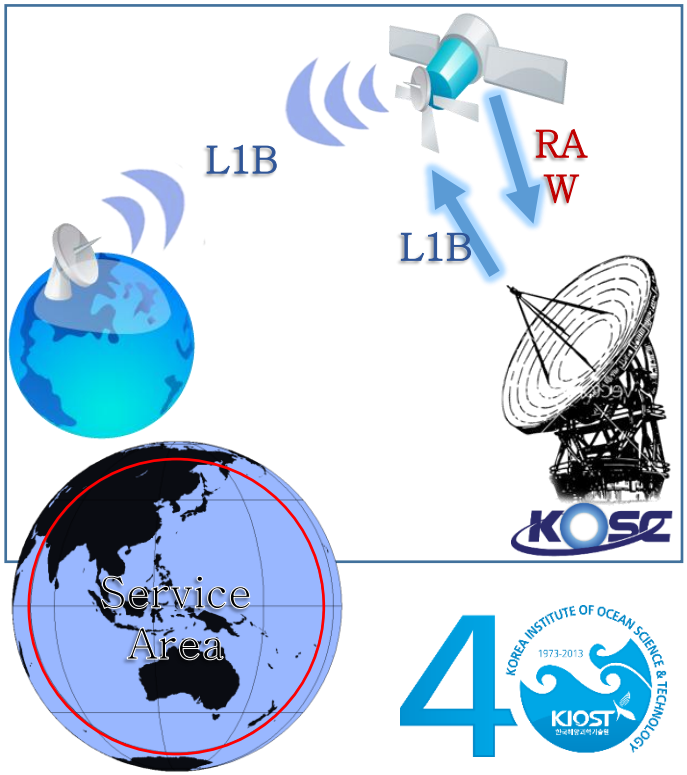


GOCI-II

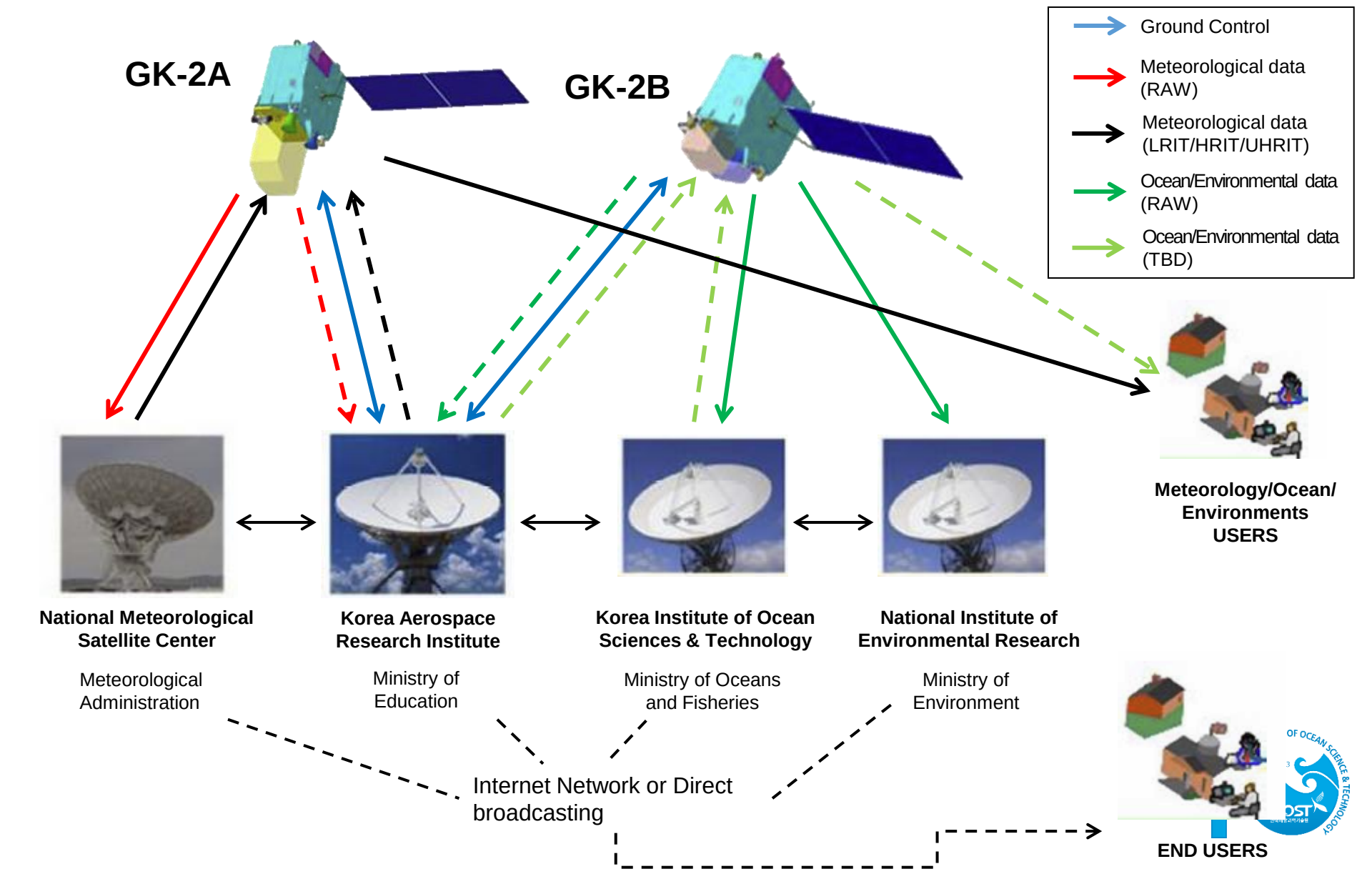
- **Spectral Bands Requirements (TBD)**
  - 13 Bands (GOCI : 8 Bands)
  - Phytoplankton type verification, Enhanced Atmospheric Correction Accuracy

Band	Band Center	Bandwidth	Nominal Radiance	Maximum Ocean Radiance	Saturation Radiance	Maximum Cloud Radiance	SNR @ Nominal Radiance
1	380 nm	20 nm	93	139.5	143.1	634.4	998
2	412 nm	20 nm	100	150	152	601.6	1050
3	443 nm	20 nm	92.5	145.8	148	679.1	1145
4	490 nm	20 nm	72.2	115.5	116	682.1	1228
5	510 nm	20 nm	55.3	85.2	122	665.3	1124
6	555 nm	20 nm	55.3	85.2	87	649.7	1124
7	620 nm	20 nm	40.3	67.8	70.5	616.5	1080
8	660 nm	20 nm	32	58.3	61	589	1060
9	680 nm	10 nm	27.1	46.2	47	549.3	914
10	709 nm	10 nm	27.7	50.6	51.5	450	914
11	745 nm	20 nm	17.7	33	33	429.8	903
12	865 nm	40 nm	12	23.4	24	343.8	788
13	PAN	515 nm	–	–	–	–	-

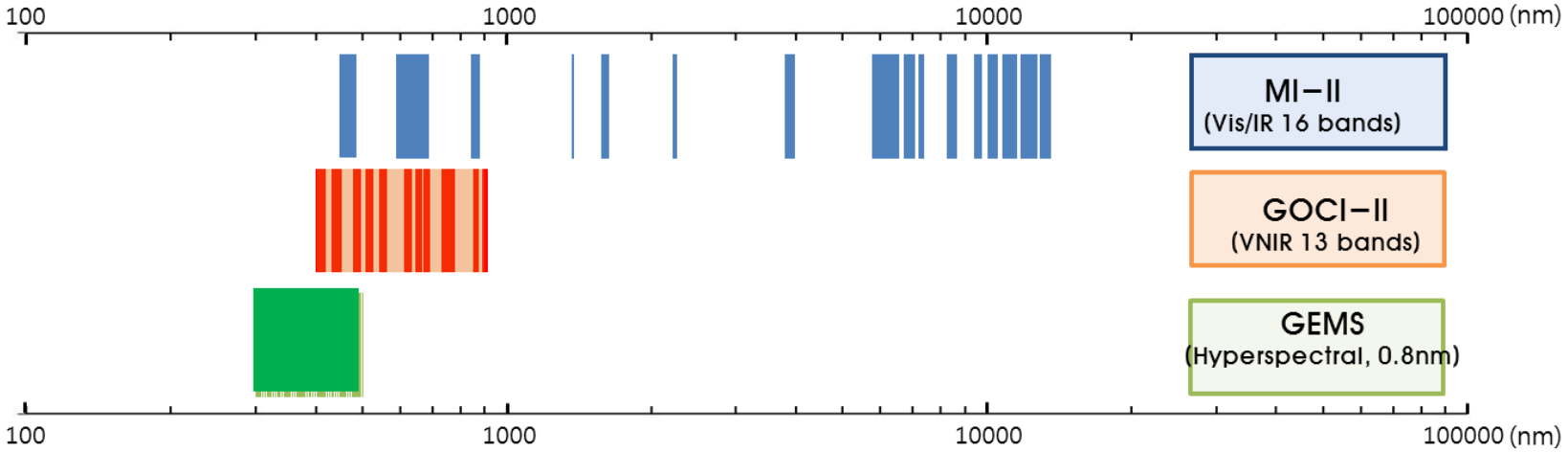
- **User Requirements for GOCI-II Direct Broadcasting**
  - Data Rate : 23Mbps
  - Service Coverage : ~ Full Disk Area
  - Data Format : (TBD)
  - Receiving Antenna on Ground Station : < 6.5m (Diameter, TBD)



GEO-Kompsat2 Configuration



GEOKompsat-2 Payloads Requirements



	MI-II (ABI)	GOCI-II	GEMS
Spectral Range	0.47μm-13.3μm	380-900nm	300-500nm
Spatial Resolution	500m, 1km(VIS), 2km(IR)	300m	7.0 km
Spectral Resolution	400~1,000nm	10~40nm, 500nm	0.8nm
Bands	16	13	Hyperspectral
Coverage	FD, NHFD, North-East Asia, Korea Peninsula (LA)	2,500 x 2,500km(LA), FD	FD, NHFD, North-East Asia, Korea Peninsula (LA)
Observation Period	FD 4 times/hour LA 120 times/hour	10 times/day	8 times/day
Observation Time	FD 15 min, NHFD 5 min, LA 30 sec	< 30 min (LA)	30 min

Necessity & Objectives

Integration & Fusion Science

Various Application of **Geostationary Orbit Satellites** could be constructed with high performance

Planning

What fields can be fused with **GEOstationary** satellite?

What can we obtain the NEW products from integration & fusion science?

Conference

What / How can we do integrate and apply **GEOstationary** satellite?

Cooperation

Ocean
+
Meteorology
+
Environment
+
Communication

Completion

NEW Technology & Synergy

High Quality
High Accuracy
High Speed
Low Cost

Integrated Research Areas of three payloads

Ocean Application

Original application

- Long-term climate change, carbon emissions
- Environmental monitoring for coastal/marine/land
- Real-time marine environmental monitoring (disasters reduction)
- Fishing cost saving for increased production

MI-II

- Fisheries using SST
- Marine numerical weather prediction
- Atmospheric correction precision
- Marine meteorological disasters surveillance(hurricanes, torrential rain)

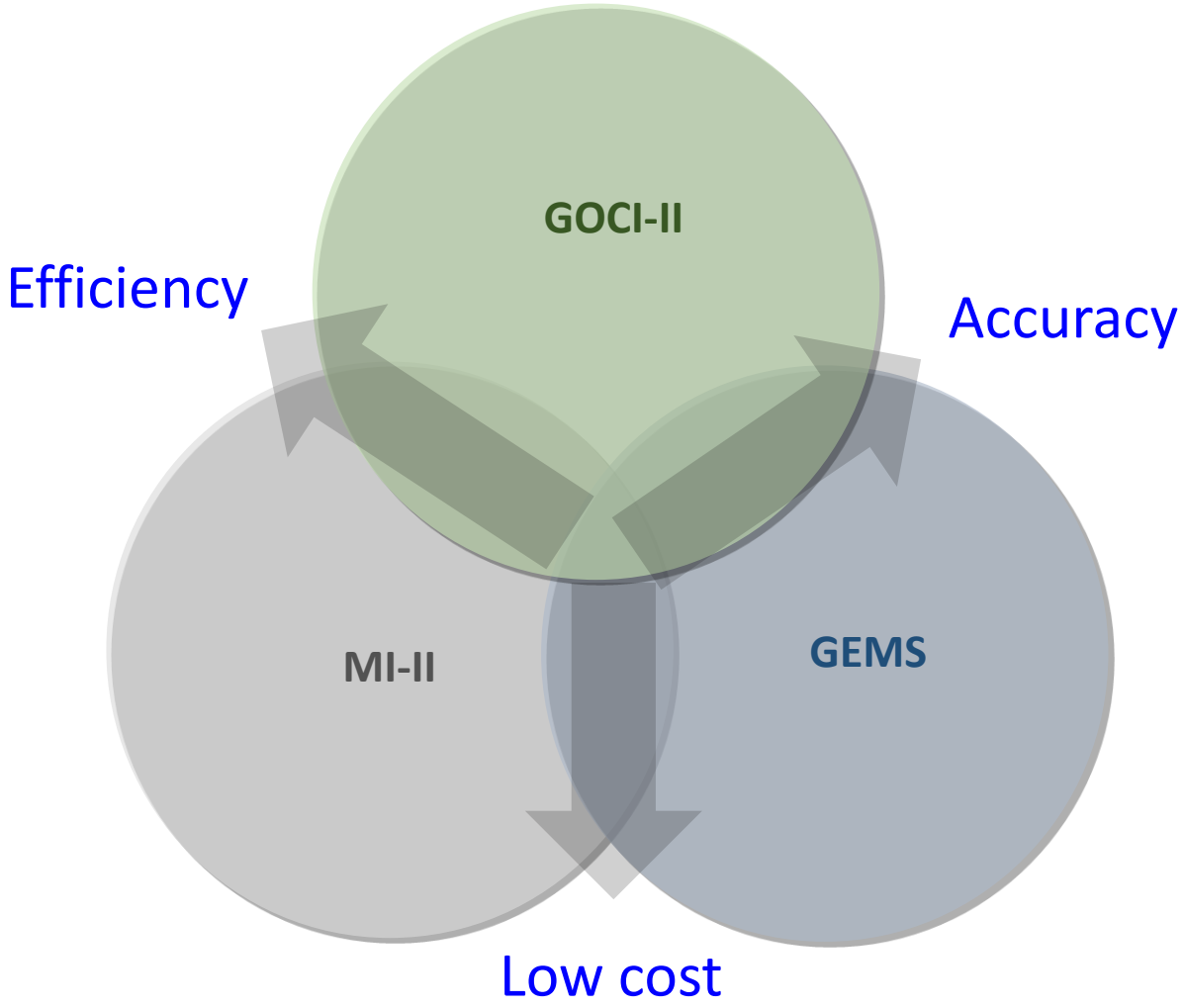
GEMS

- DOM distribution research using UV data
- Improving atmospheric correction accuracy using vertical aerosol data
- Marine environment analysis accuracy improvement removal of NO2

In case of Ocean Application,
Ocean product accuracy will be enhanced with integration of other satellite.

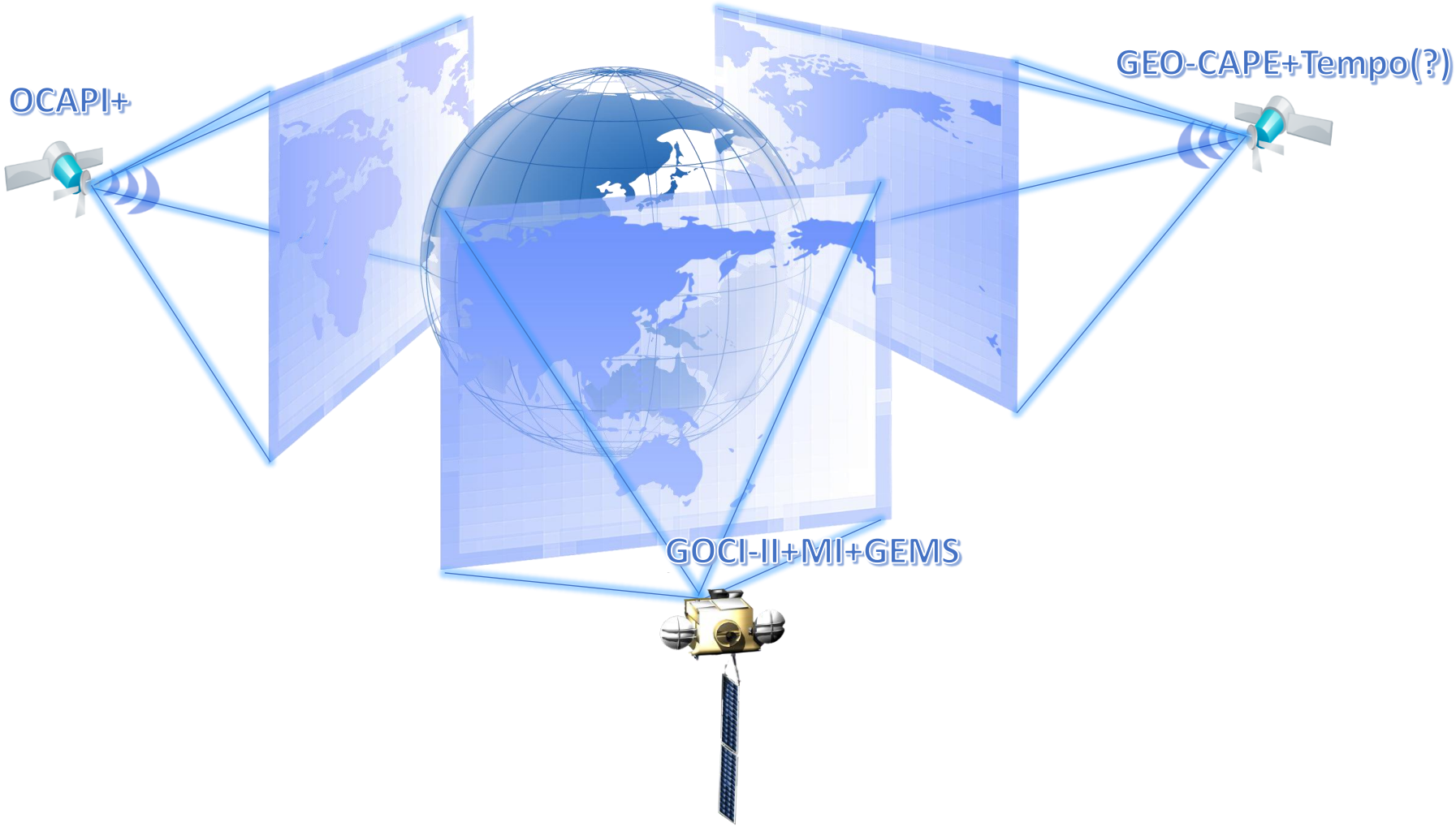
Summary

GEO new mission & Synergy



Multi-sensors fusion algorithm can be installed to GDPS-II(GOCI-II Data Processing System)

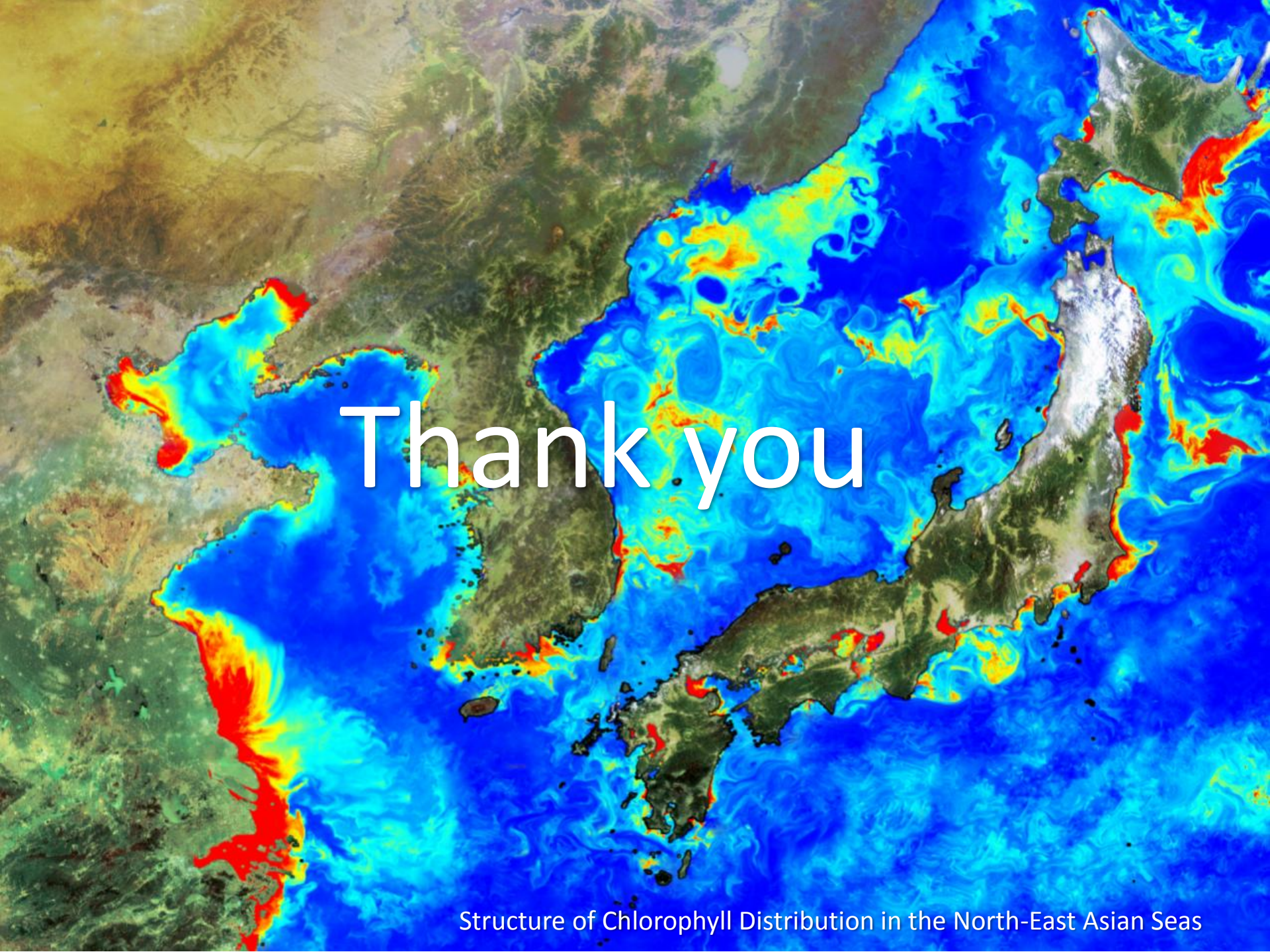
A Constellation of Geostationary Ocean Color Satellites



Summary

- GOCI Operation
  - There is no significant technical issue for GOCI operation.
  - To distribute 8 times GOCI images to user this year
  - To make a international mirror sites for fast download : under discussing the detail conditions
- GOCI Cal/Val and Research
  - To collaborate the GOCI Cal/Val and application
  - To release the GDPS and ATBD Ver1.2
  - To strengthen the operational algorithm (WCV, FGI etc)
- GOCI-II development
  - To select the manufacturing company for GOCI-II this month
  - To propose the integrated research using 3 payloads of GeoKompsat-II

We need more collaborations for blooming the GEO OC potentials



Structure of Chlorophyll Distribution in the North-East Asian Seas