GOCI-I and II mission updates since last meeting

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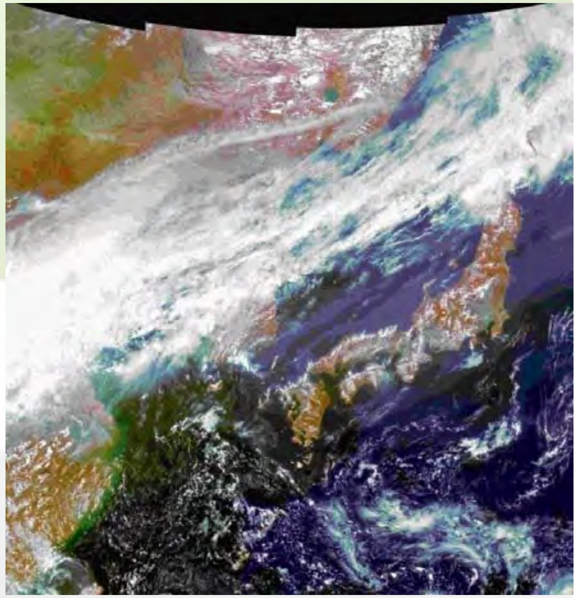
Korea Ocean Satellite Center

Korea Ocaen Research & Development Institute

GOCI Current Status



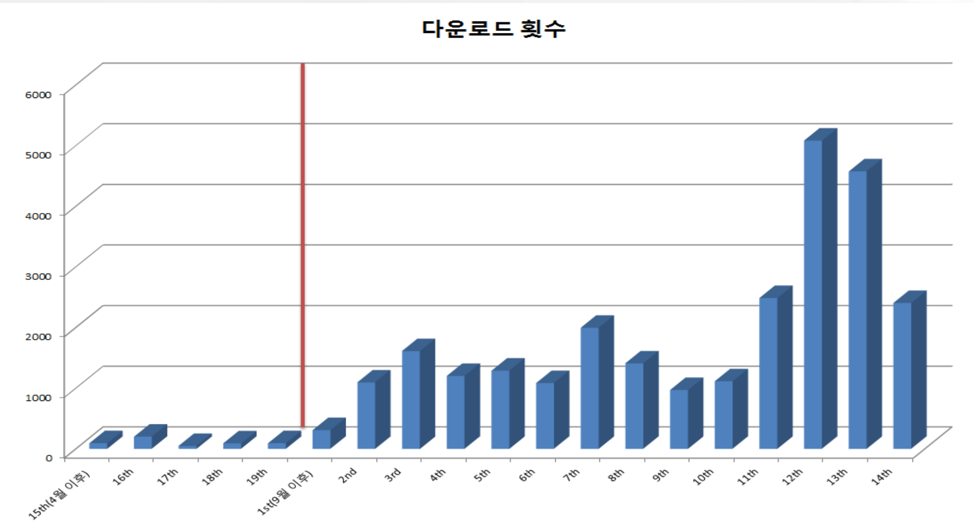
- Start of projects
  - Developments of COMS(H/W) and GDPS(S/W) : 2003
  - Establishment of KOSC (Ground System) : 2005
- Launch : June 27, 2010
- First image acquisition : July 13, 2010
- **IOCCG 16 meeting : Feb. 2011**
- **In-Orbit Test : ~ Apr. 2011**
- **GOCI data(Level 1B) and GDPS viewer service : Apr. 20, 2011**
- **GOCI data(Level 2) and GDPS service : Sep. 2, 2011**
- **GOCI PI Workshop : Jan. 2012**
- **IOCCG 17 meeting : Feb. 2012**

GOCI data distribution service

Status of Distribution Service (2011.4.20~)

* Satellite data DB (for distribution) : 7,971
* Downloads(in 2011) : 29,552
* Users : 690 people (Korea : 468, Others : 222)
•near-real-time data service : 16 domestic institutes and departments

Spread of GOCI Users



Status of GOCI data service

2nd GOCI PI Workshop + 1st GOCI-II Development Workshop

1st : Oct. 29-30, 2008 in Jeju, Korea

2nd : Jan. 11-12, 2012 in KORDI, Korea. After the official distribution of GOCI.

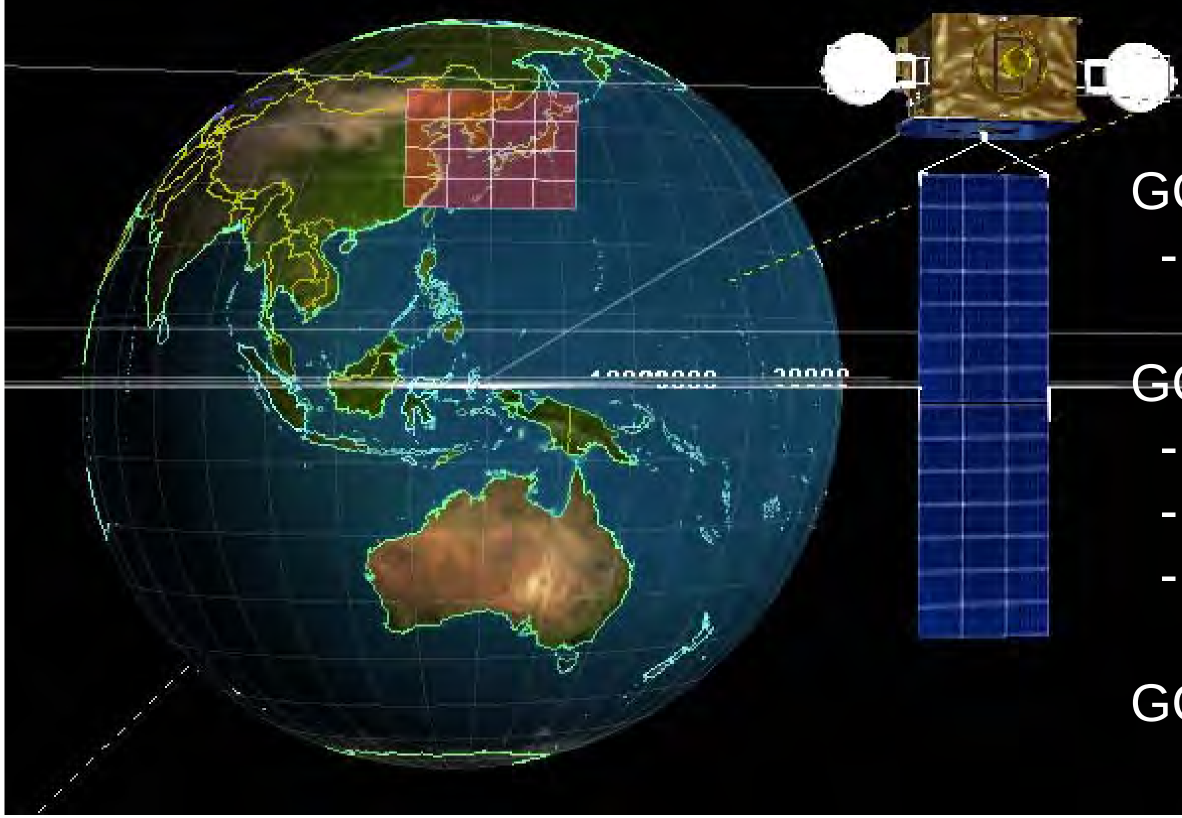
More than 150 persons, 29 PIs attended

	Name	Institution	Nationality
1	Saitoh, Sei-Ichi	Hokkaide University	Japan
2	Tufillaro, Nicholas	Oregon State University	USA
		light Center	USA
		tor Business Developme	France
		ation Agency	Japan
			France
		or Natural Sciences (RBI	Belgium
		eanography	China
			France
			Japan
		ersity	China
			Japan
		niversity	Taiwan
			Japan
			Japan
			Japan
		ute of Far Seas Fisheries	Japan
			Japan
			Japan
			Japan
			France
		University	Taiwan
		da	USA
			USA
		y	Vietnam
		anography, State Oceanic	China
		ormation Science & Tech	China
		eanography	USA
		etts	USA

World's first …

Geostationary (orbit) + Ocean Color Imager (mission)

GOCI Characteristics



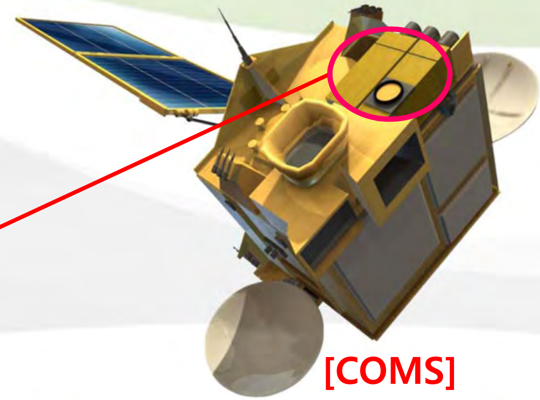
GOCI characteristics
- strengths and weaknesses

GOCI application fields
- GDPS
- Cal/Val
- applications

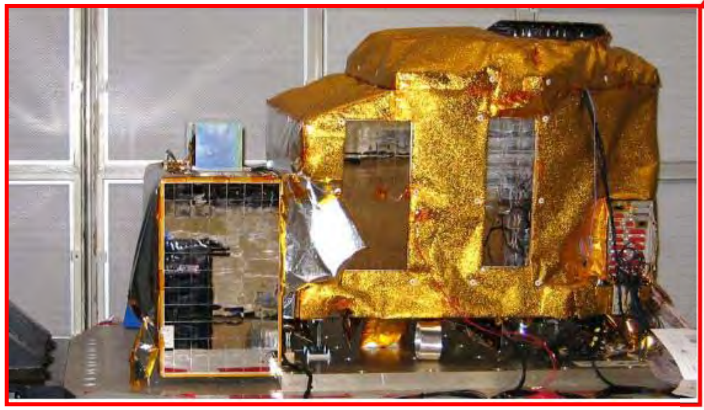
GOCI-II mission concept

Introduction of COMS

- COMS : Communication, Ocean & Meteorological Satellite
  - The first Korean Geostationary multipurpose Satellite
  - Launch date : June 27 2010
  - Lifetime : 7 years
  - Payloads (3 Missions)
    - Geostationary Ocean Color Imager
    - Meteorological Imager
    - Ka-band Communication



[COMS]



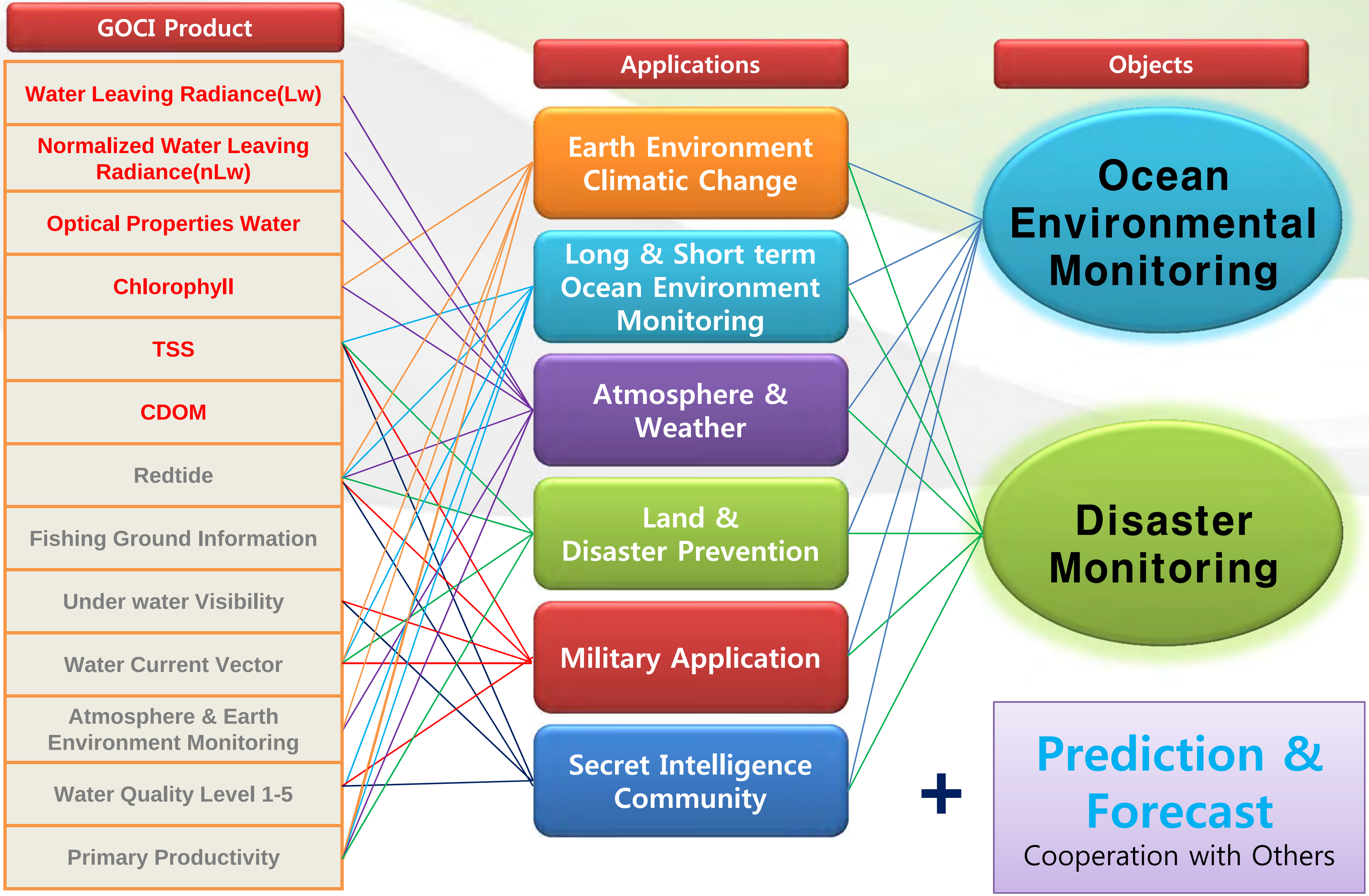
[Geostationary Ocean Color Imager]

GEO vs. LEO

	GEO/GOCI	LEO/SeaWiFS	
Altitude	**35,857 km**	705 km	about 50 times-far
Sensor type	**Staring-frame capture**	1-axis scanning	Slot discrepancy
Spatial resolution	**500 m**	1000 m	4 times better
Spectral range	**400-900 nm**	400-900 nm	Almost same
Temporal resolution	**1 hour**	1 day	8 times better
Sun-Satellite position	**variable**	stable	BRDF
Coverage	**local**	global	limitation
Bio-optical algorithm	**local**	global	New local algorithm

GOCI is about 50 times farther from the Earth than LEO.
GOCI's spatial and temporal resolutions are 4 times and 8 times better than that of LEO.
To be considered and prepared sensor type, geometry & local coverage for overcoming GEO characteristics

Mission of GOCI

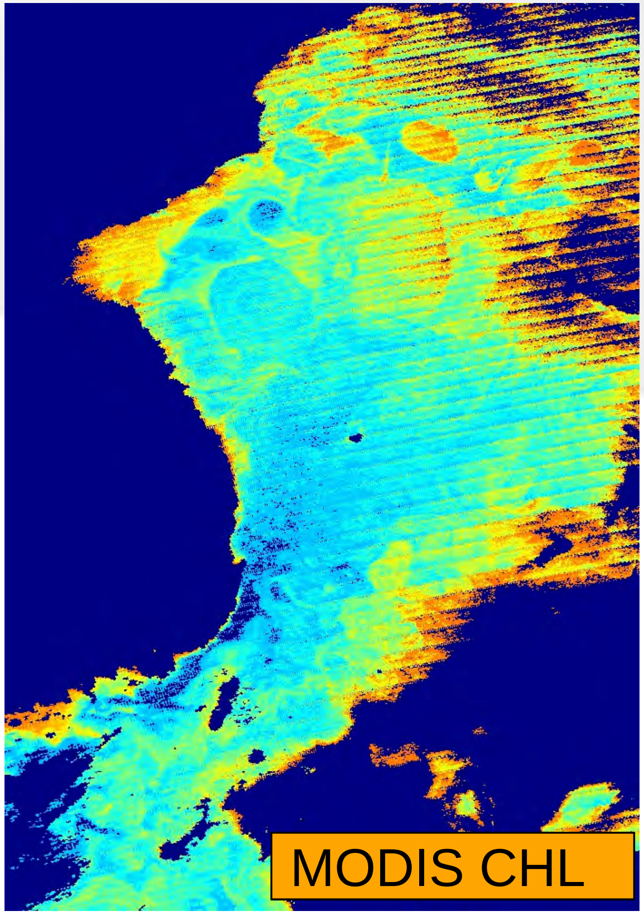


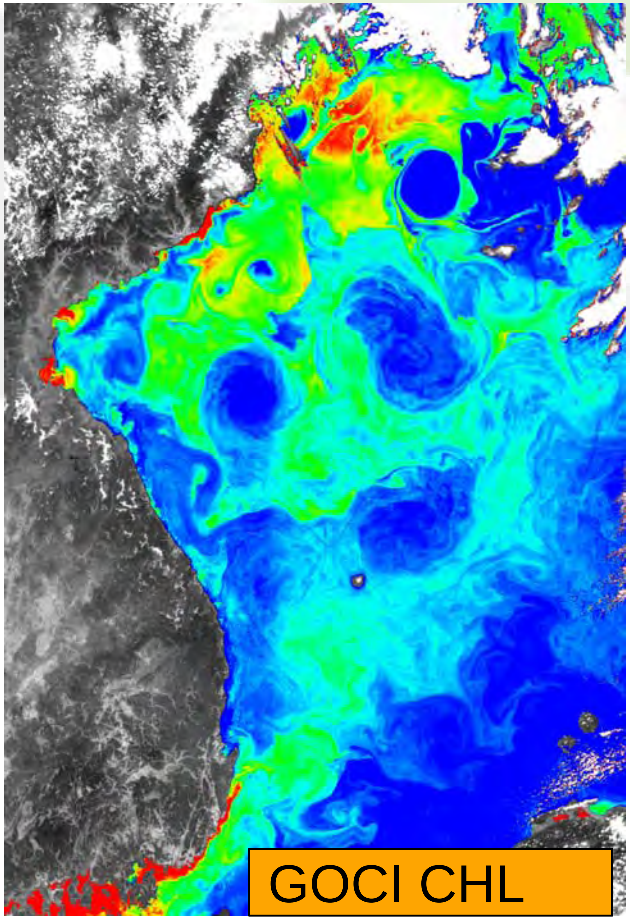
GOCI updates

- Slot discrepancy (2011 ~)
- Atmospheric correction (2011)
- Bio-optical algorithm (2012)
- GDPS

Topic 1 : Accomplishments for “High performance”

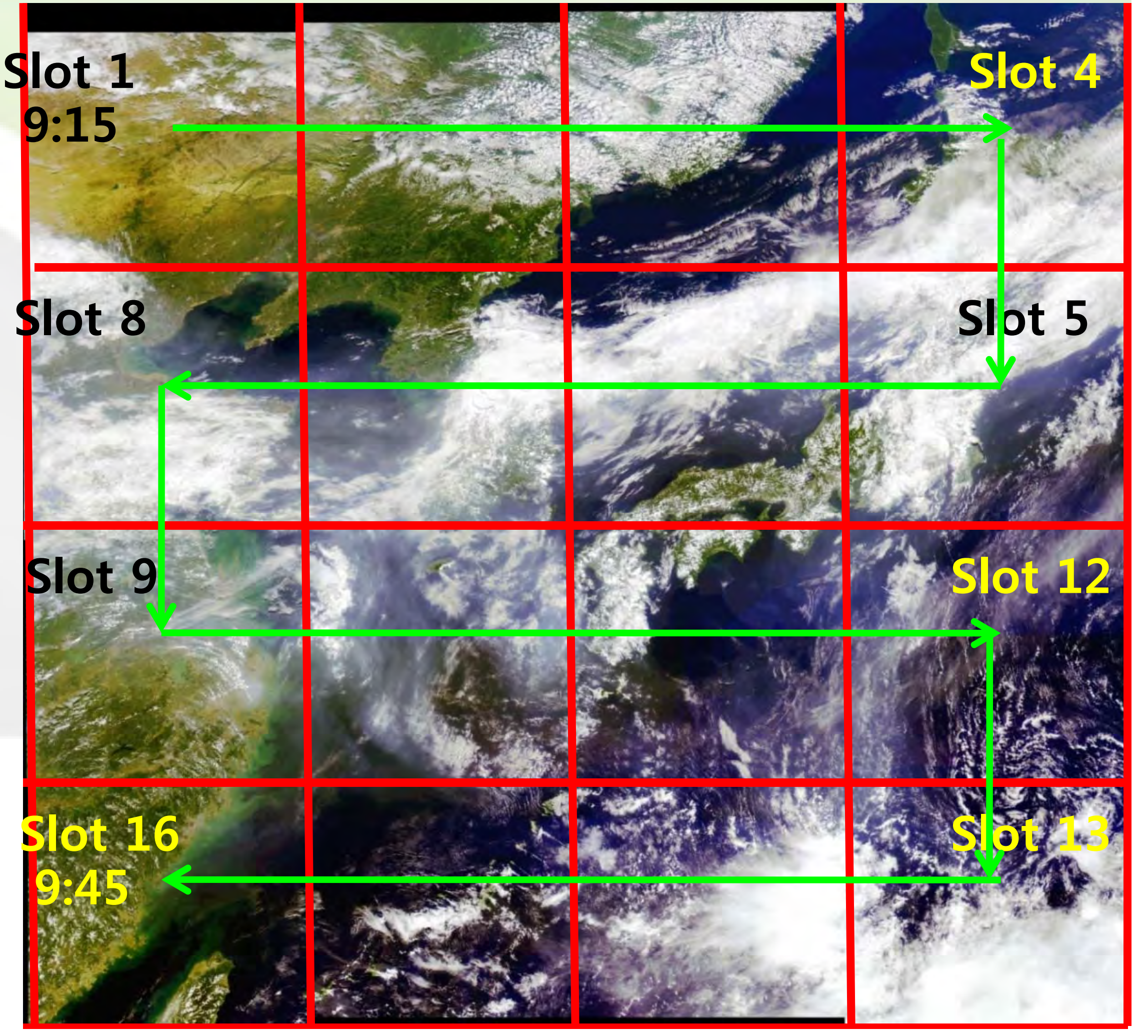
– 2D Staring frame-capture mode can achieve the high optical performance (SNR and MTF etc) and high spatial resolution(GSD 500m) in GEO





Sensor type : Inter-Slot Radiometric Discrepancy (ISRD)

- Interval between bands = ~ 8 seconds
- Interval between consecutive L1a slots = ~ 103 seconds
- Duration for acquiring one GOCI image = ~ 103*16 seconds = 27 minutes
- Interval between consecutive GOCI images = one hour
- Interval between the adjacent slots in L1B scene = up to ~103*7 seconds or 12 minutes => sun angle difference??

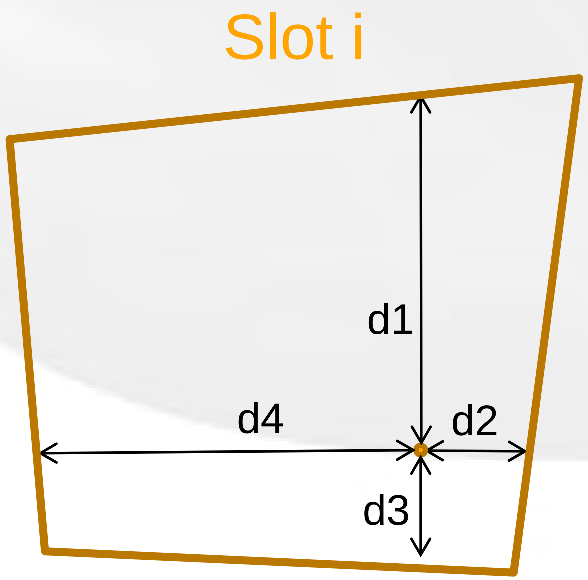


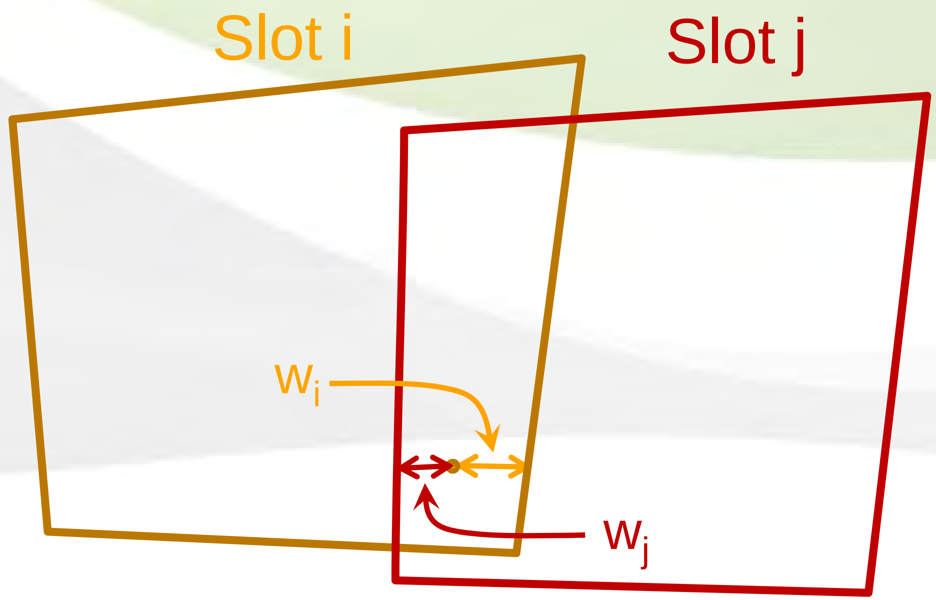
Because GOCI equips 2D CMOS, GOCI IFOV corresponds to the FOV of the GOCI slot area.
It takes 30 min to acquire one set of whole coverage.
The zigzag type of capture line brings about non-homogenous time interval
Time interval is induced between upper and lower lines

Outline

- Overview of the GOCI optical system and image acquisition sequence
- ISRD in GOCI L1B images
  - Spectral dependence
  - variability within a slot border, across different slot borders
  - variability with observation hours (0, 3, 7 hours): image vs RT simulations
  - Along East-West slot borders
- Image smoothing technique
- Simple ISRD correction model

Brute-force smoothing
Distance-to-border weighted average





$w_i = \min(d1,d2,d3,d4)$

where is number of pixels to the k-th border

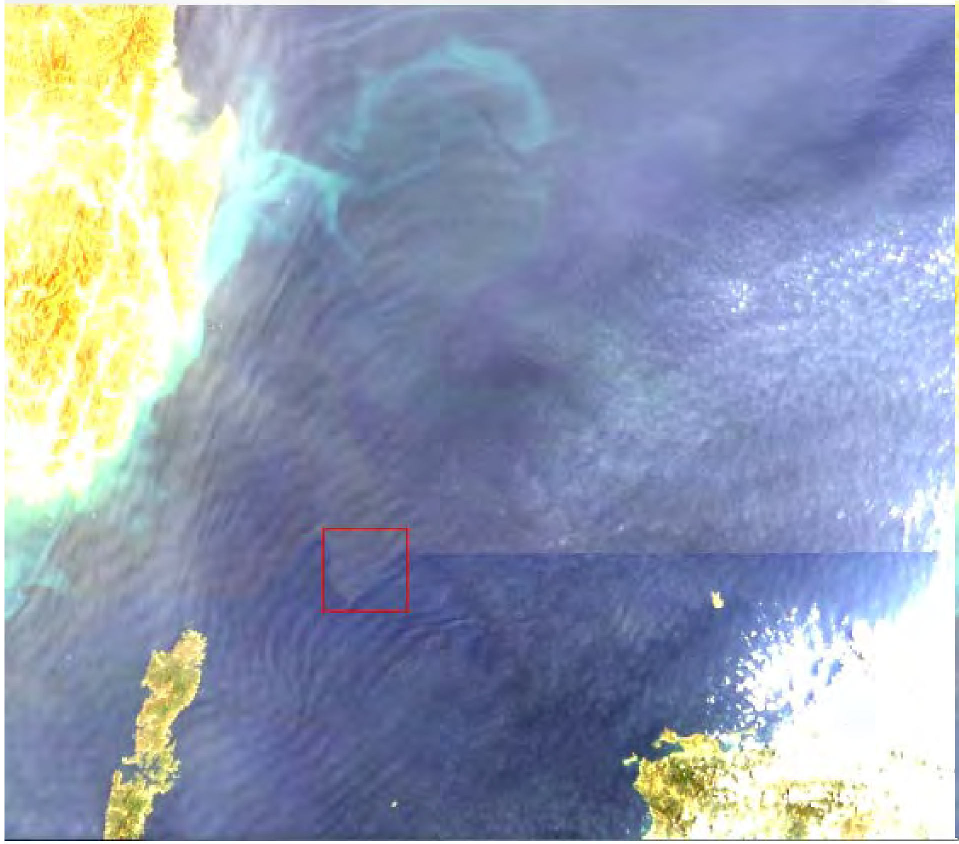
$N' = \sum(w_i \times N_i) / \sum w_i$

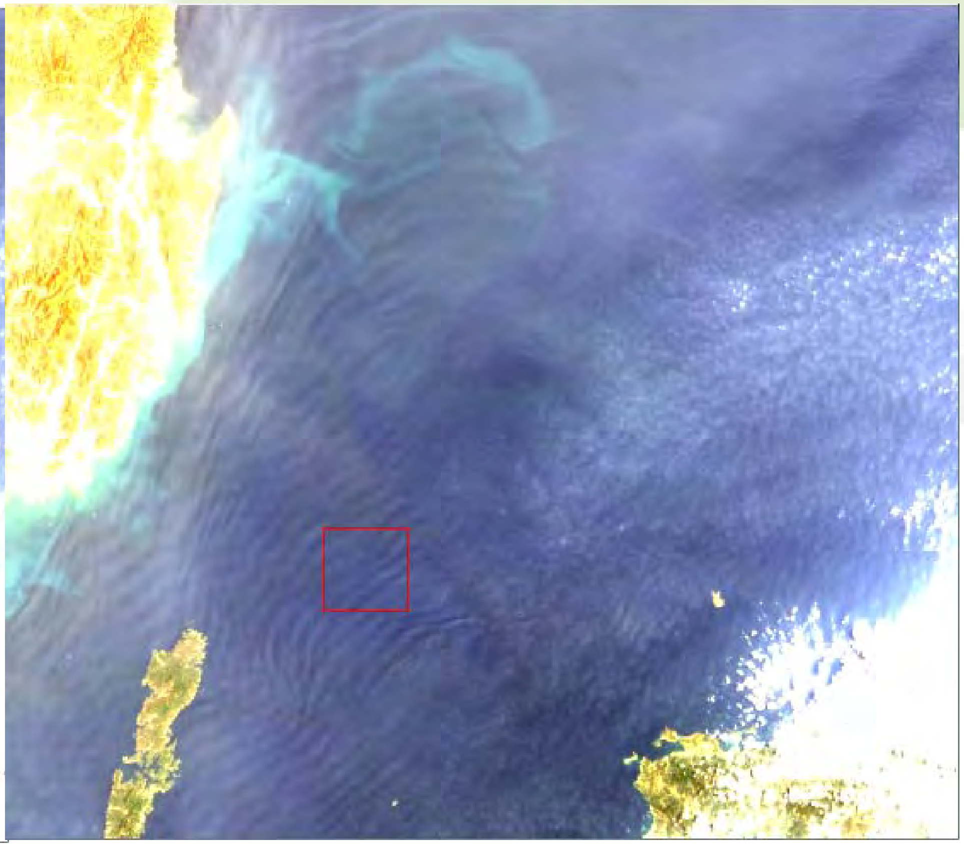
N': weighted average

N_i: reading from the ith slot

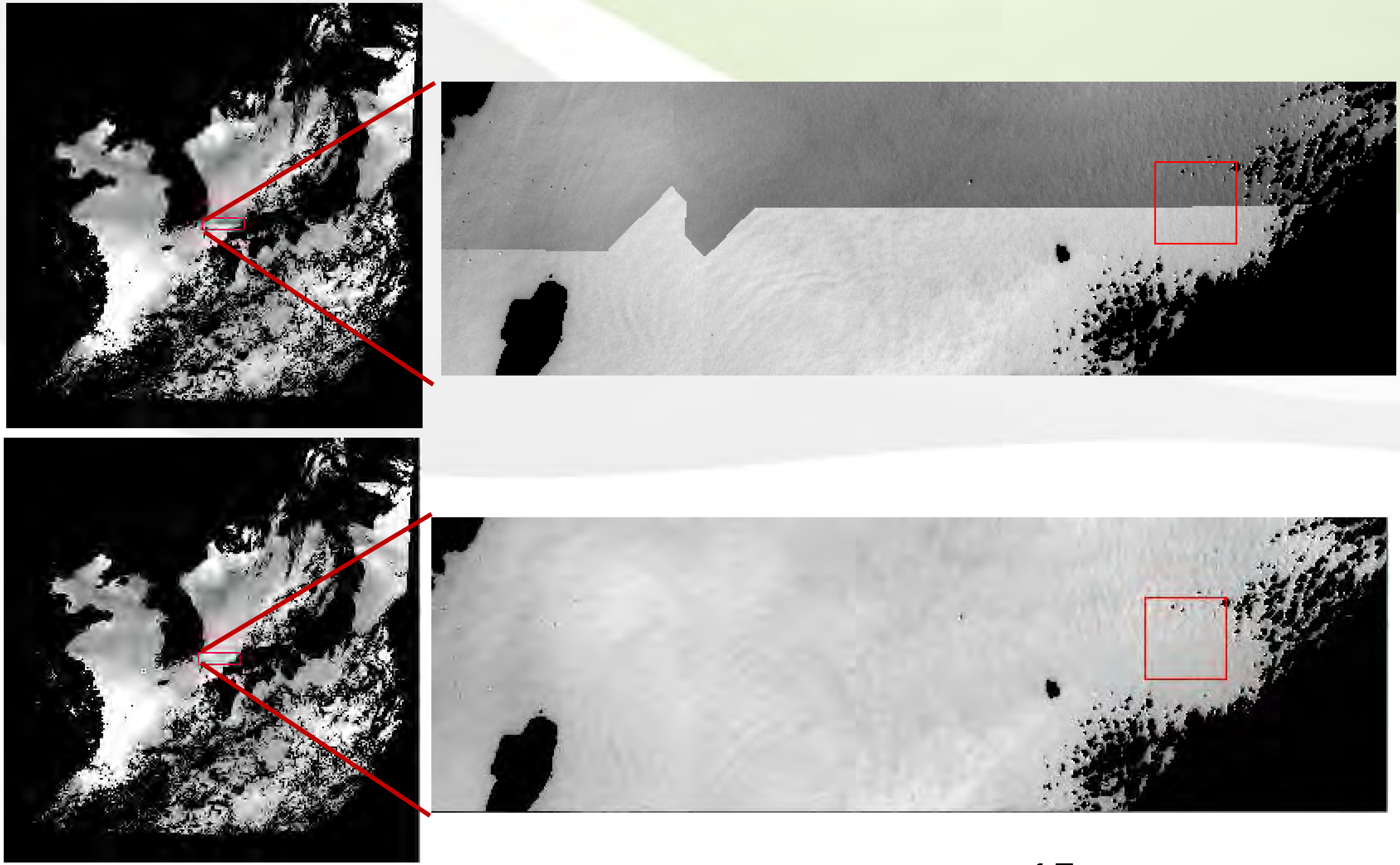
Example image: before and after correction

- Left: before correction, Right: after correction





where correction did apply



Radiance Discrepancy at slot borders

Example 1 (Original)

GOCI image captured at 07h Apr 12, 2011

Radiance Discrepancy at slot borders

Example 1 (Weighted averaging)

ISRD Conclusions

- ISRD is an image quality issue visible in GOCI images
  - Difference between north-south slots is large although east-west slot difference is significant for band 1
  - Magnitude: -0.003~0.005 in the 20110330_0h image
  - Variability across bands
  - Variability within a slot border and across different slot borders
- 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.

Topic 2 : GOCI CAL/VAL activities

Level-0

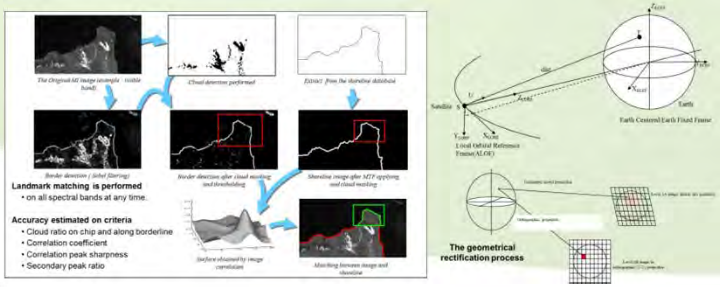
Raw data

Level-1

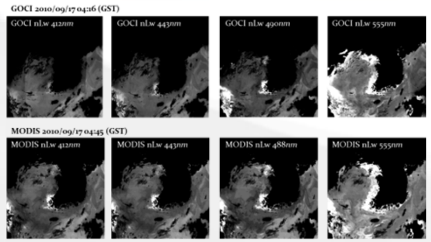
Radiance
(L_w, L_{wN})

Level-2

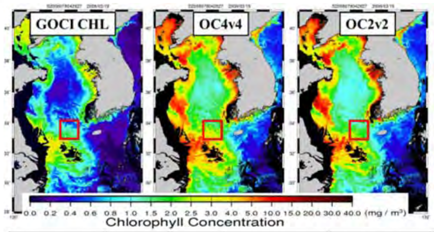
Products
(R_{rs}, chl, SS, DOM, Red-tide, Fishing ground information, Under water visibility, water current vector, and so on.)



Radiometric / Geometric Calibration

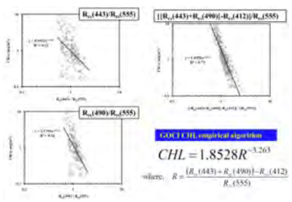


Atmospheric correction CAL/VAL

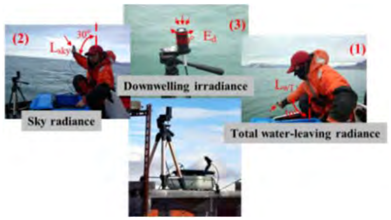


	GOCI CHL	OC4v4	OC2v2
평균값	1.18 mg/m³	2.48 mg/m³	1.96 mg/m³
vs. OC4v4	53 % 감소		
vs. OC2v2	40 % 감소		

Selection Area: Lat. 33 – 34, Long. 124 – 125 (Red Box)



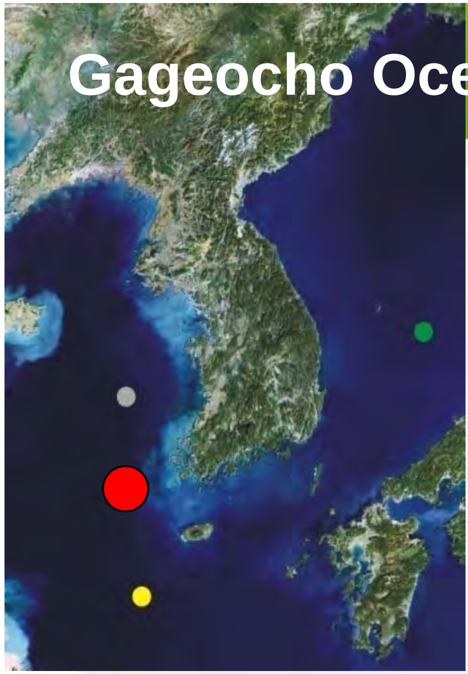
In-water algorithm CAL/VAL



Cal/Val plan

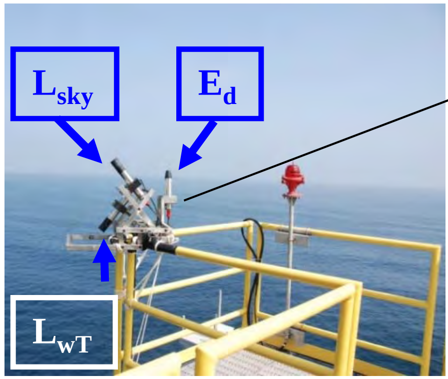
- In situ measurements
  - Research vessel
  - Buoy, Ocean research station
    - To use Korea Operational Oceanography Network(with KORDI)
    - To cooperate neighboring countries (with Japan, China, Taiwan)
    - To join International Group (with IOCCG, OCR-VS, Aeronet-OC)
- Inter-satellite Cal.
  - Existing OC : MODIS, MERIS
  - HICO (with D. Curtiss)
- New System
  - Kite, aerostat, airborne(with KARI)
  - Argo-type buoy
- Uniform land Cal/Val site
  - Desert, Ice, Playa

Gageocho Ocean Research Station

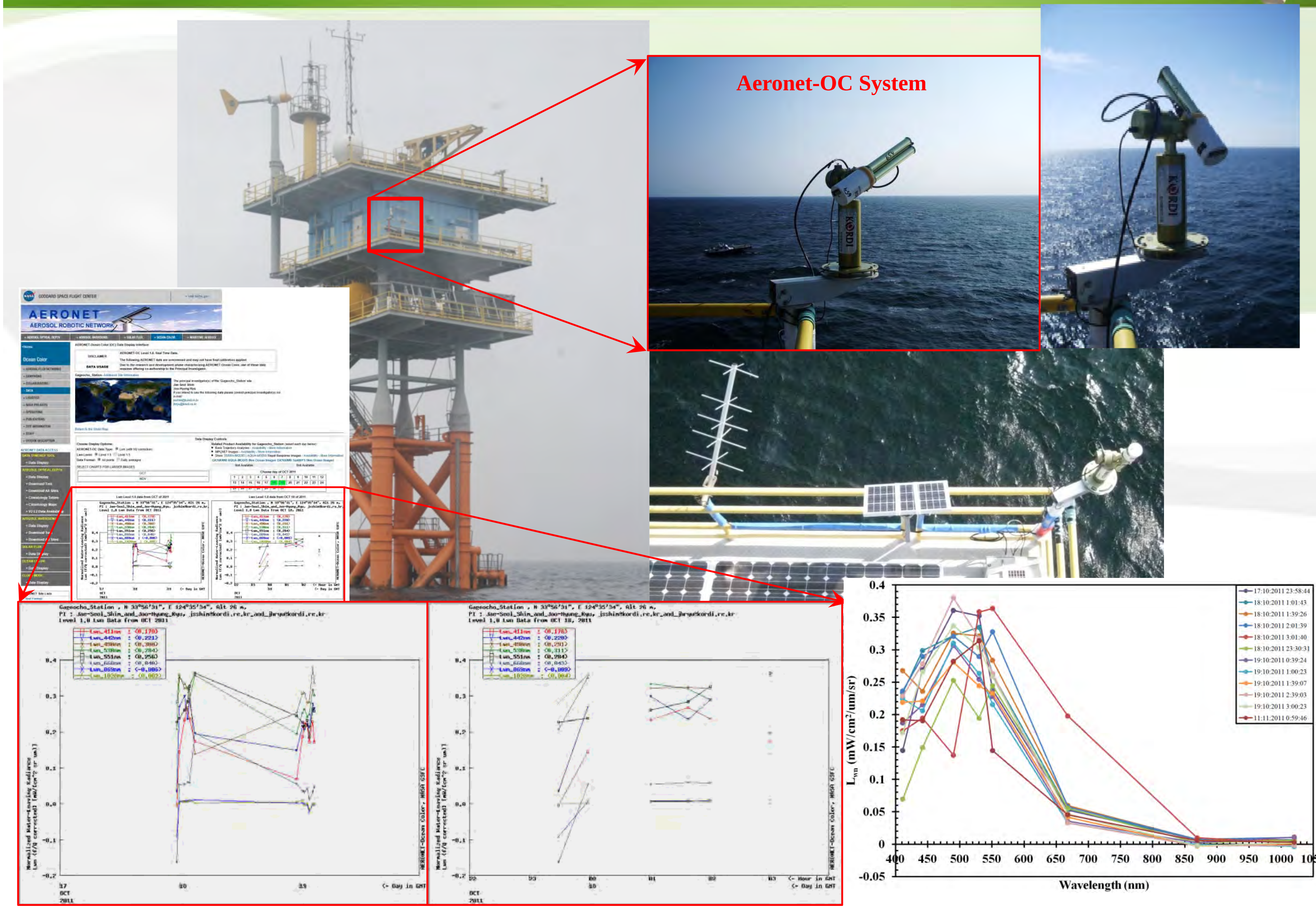


- ► Meteorological Instruments (12)
- ► Environment Observing Systems (7)
- ► Ocean Monitoring Systems (12)
  - ► TriOS (installed on Jul. 6, 2010)

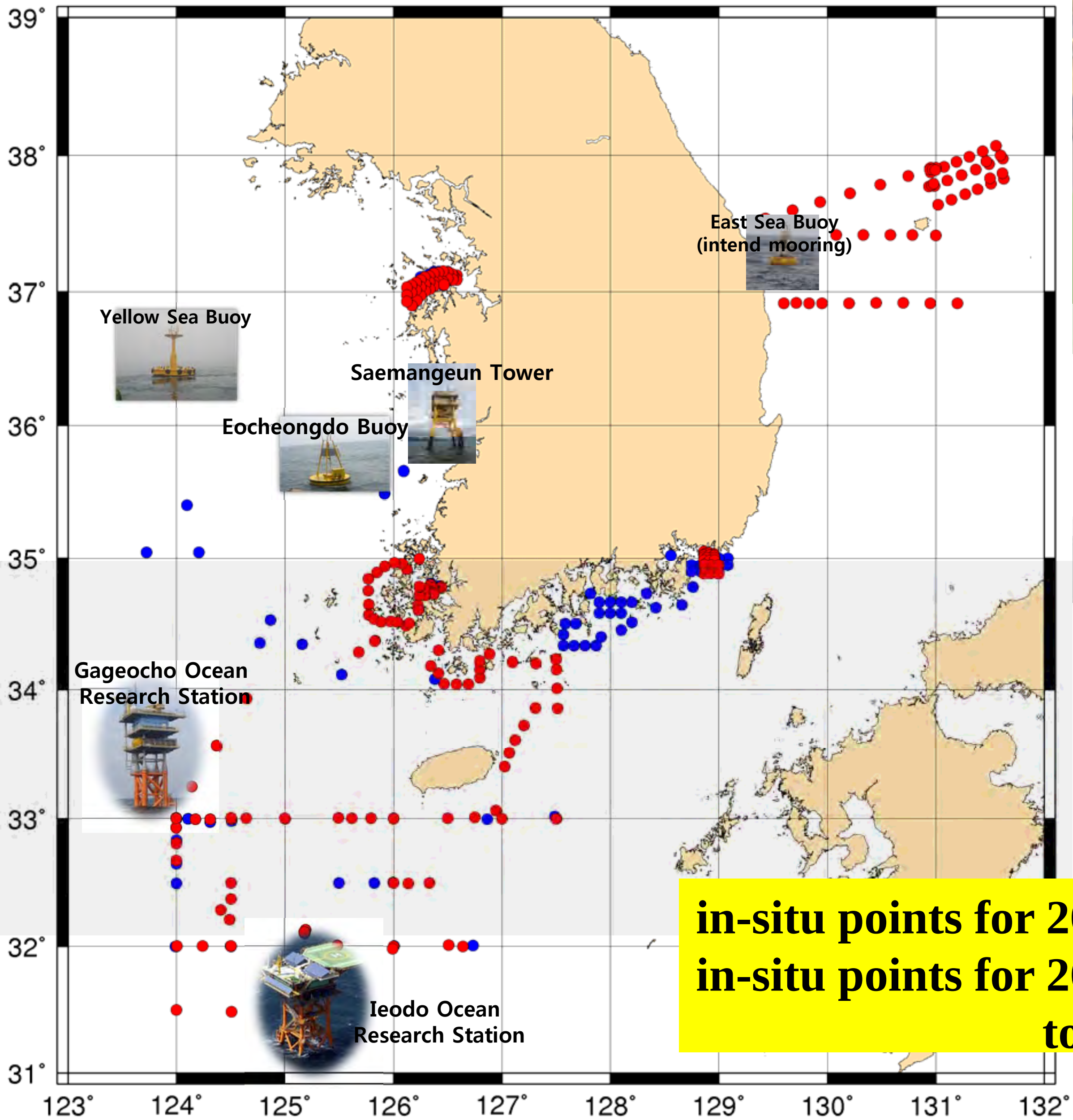
  : taken as 1-min acquisition sequences every 15min from 8 am to 5 pm
  - ► Aeronet-OC (was installed at 2011)



Aeronet-OC system on Gageocho station



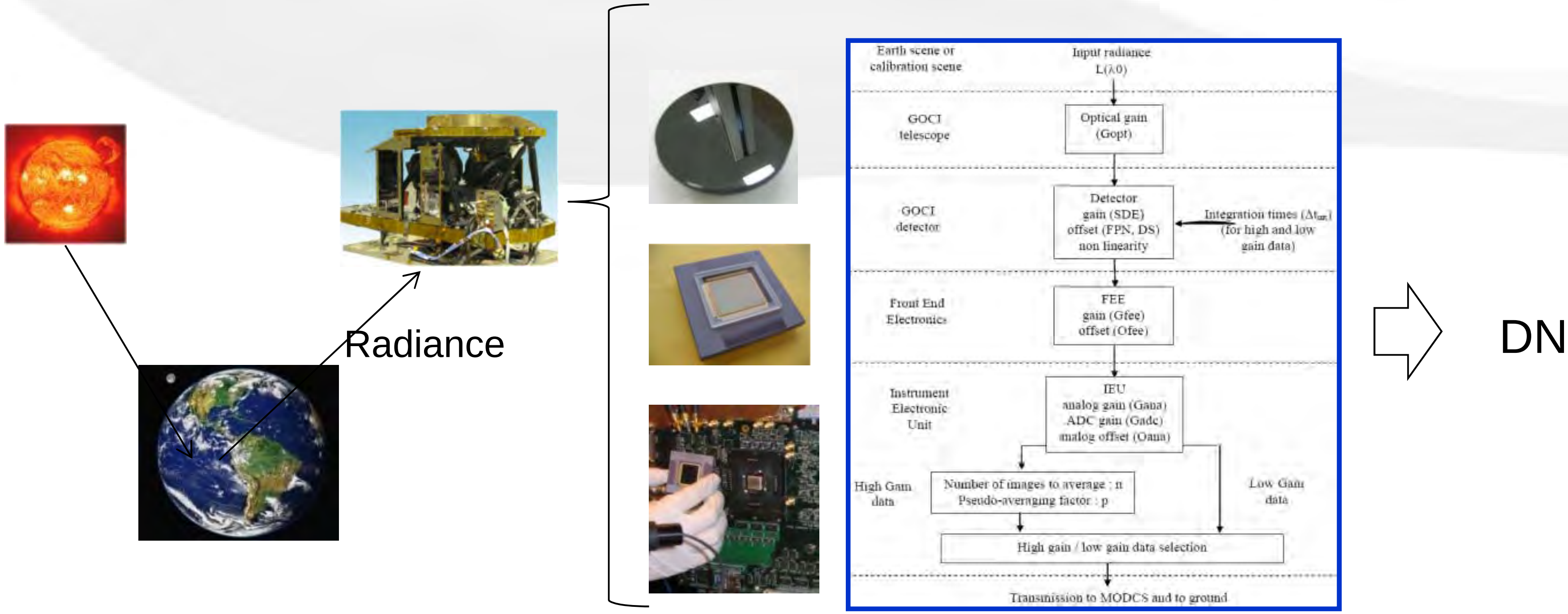
in situ Locations in 2011



in-situ points for 2010: 133 (blue)
in-situ points for 2011: 229 (red)
total: 362

Radiometric Calibration Concept

- **Radiometric Calibration (Sensor Calibration)**
  - GOCI data (DN) shall be converted to values in physical unit(i.e. radiance).
  - Every Sensor sub-unit has its own characteristics(gain, offset).
    - Optical gain, detector gain/offset, Electronics gain/offset
  - Sensor Model characterization(Gain, Offset) is required.

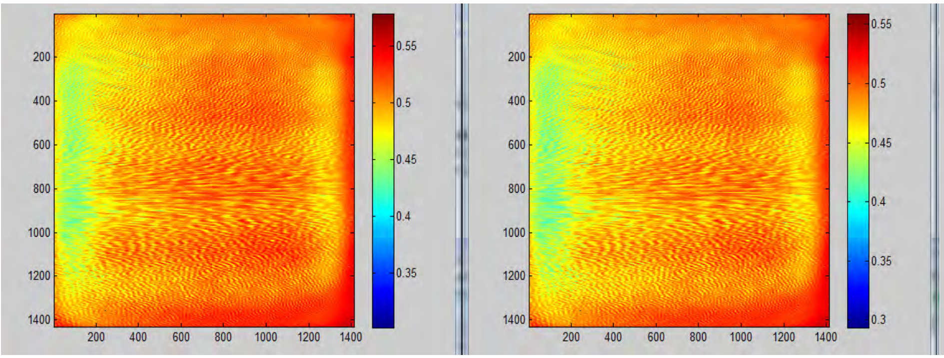


GOCI Radiometric Model

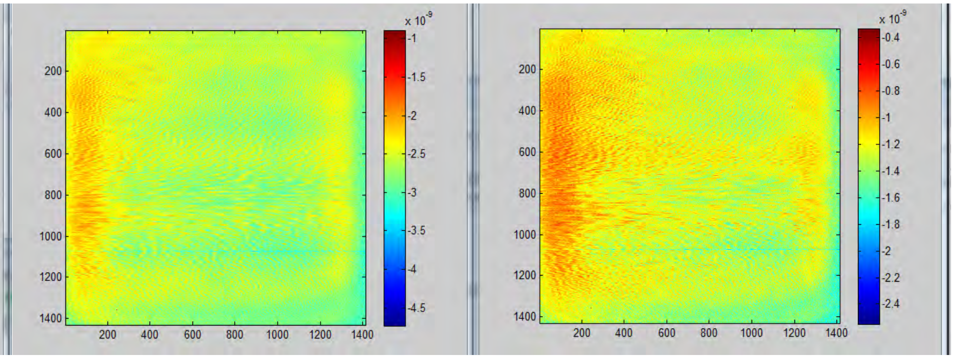
- GOCI Radiometric Model : 3rd-Order Polynominal

$$S = G \times T_{\text{int}} \times L + b \times T_{\text{int}}^3 \times L^3 + T_{\text{int}} \times O + F$$

- L : Spectral Radiance(W/m^2/um/sr) measured by GOCI
- G, b : Linear & Non-linear Gain of GOCI, respectively
- Tint : Integration Time
- O, F : Offset parameters (i.e. dark signal)



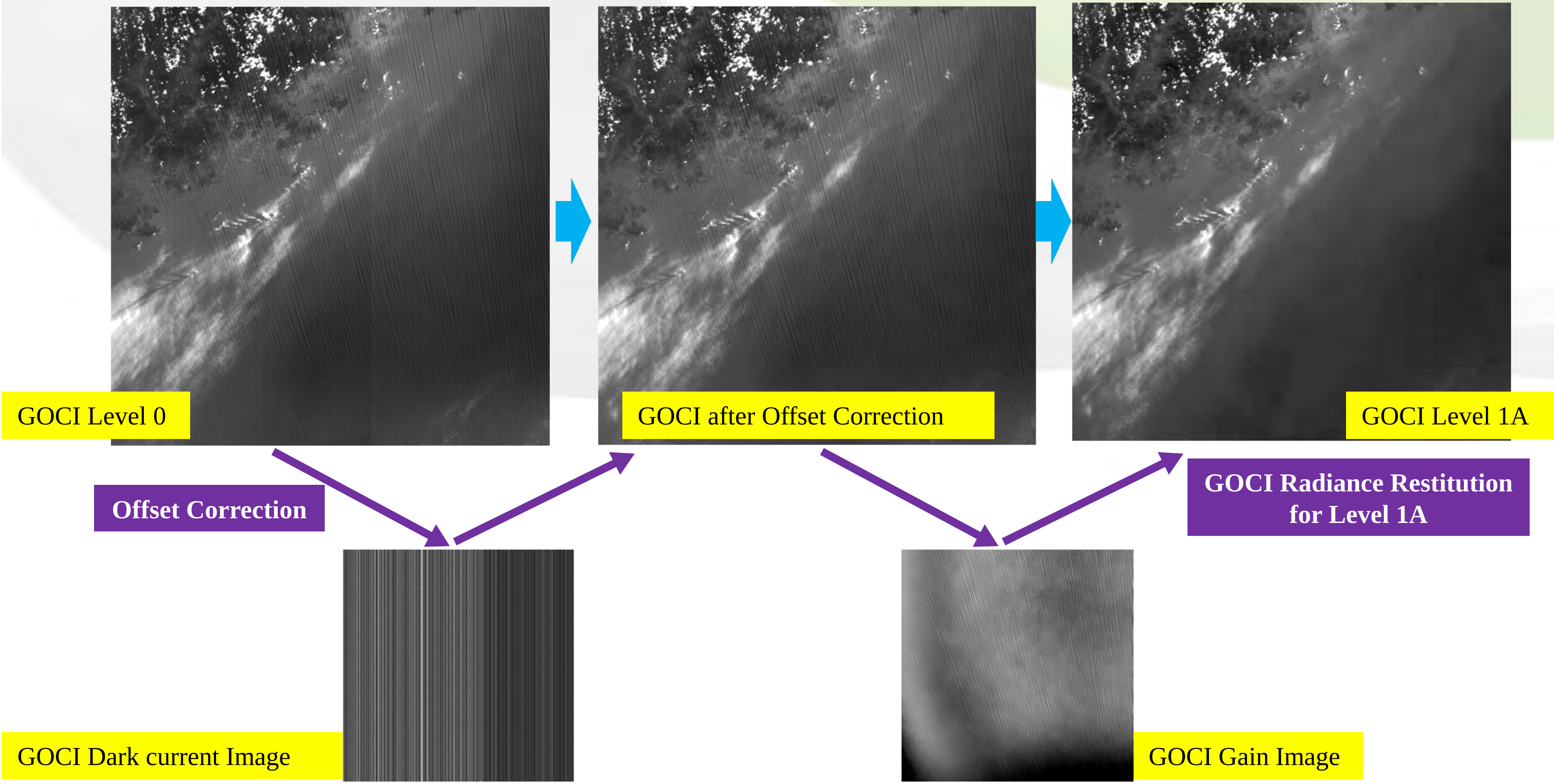
Linear Gain(G)



Non-linear Gain(b)

GOCI Radiometric Calibration

- GOCI Radiance Restitution Process
  - 2010. 08. 01 – Band 01



Monitoring : Dark Signal Variation

* Diurnal

Operation error :
Increased FEE temperature

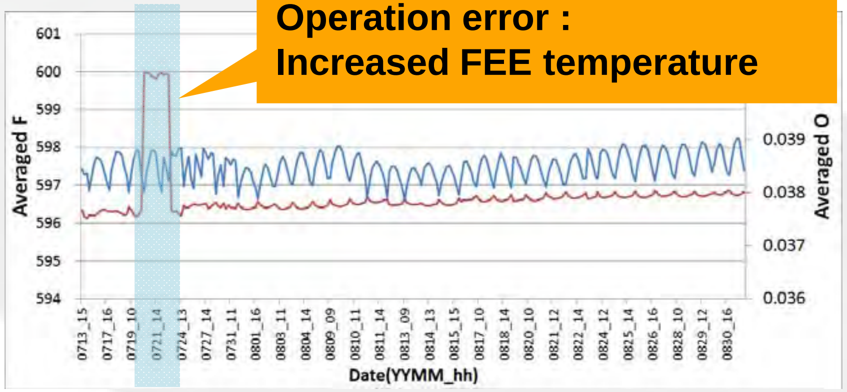


Fig 1. The time series of O and F averaging 16slots from 17th Jul 2010 06:15 UTC to 31th Aug 2010 07:15 UTC

* Monthly

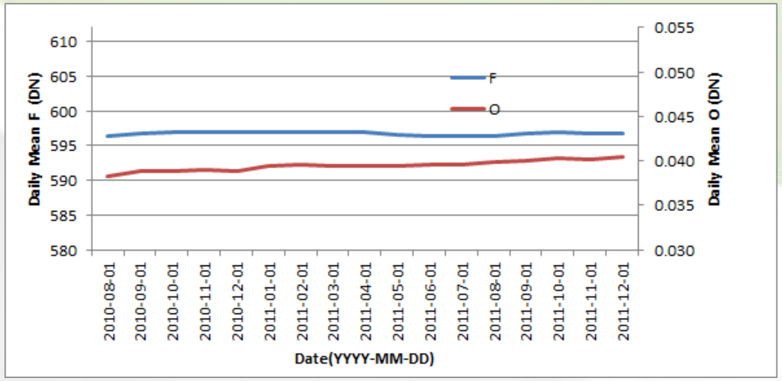


Fig 2. The time series of daily mean O and F for 1st day from Aug. 2010 to Dec. 2011.

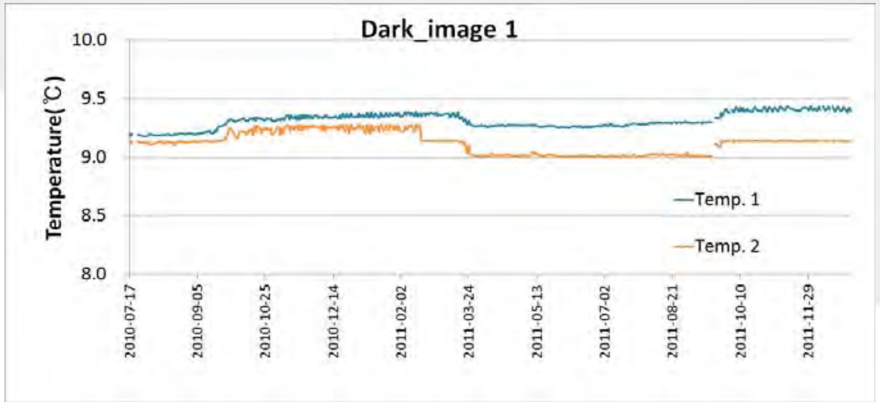
The averaged O is sensitive to temperature variation of sensor by increasing the integration time. Though integration time is not changed, the diurnal variation is found in fig. 2. (Cf. O ∝ 1/F)
(max : 03 or 04 UTC, min : 00 and 07 UTC)
The pattern of 'O' seems to be related with diurnal solar energy variation. The uptrend shown in fig. 1 is also found in fig. 2.

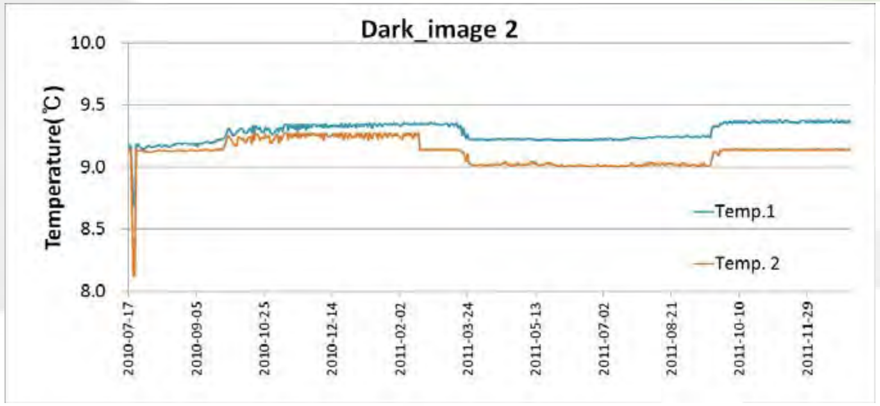
Daily mean F and O are about 596±16 and 0.04±0.013
Only, the daily mean O is increasing slightly. But the variation is very small.

GOCI detector has been operated *in stable*

GOCI FPA Temperature

The GOCI detector(2D CMOS) includes internal temperature acquisition which are part of the image data and correspond to the first(0) and last columns(1431) of the detector.

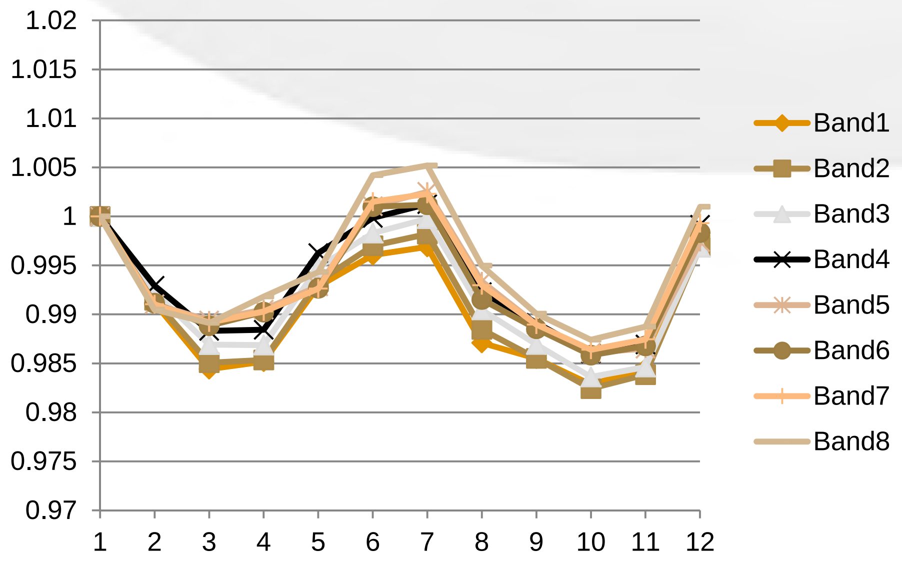




Temperature of GOCI FPA is stable.

GOCI Radiometric Gain

- **Evolution of GOCI Radiometric Gain (2011)**
  - Radiometric Gain Variation : ~ 1.8%
  - Sinusoidal variation
    - Solar incident angle model might be required to update.
  - Sensor Model characterization(Gain, Offset) is required.



Evolution of Radiometric Gain (2011)

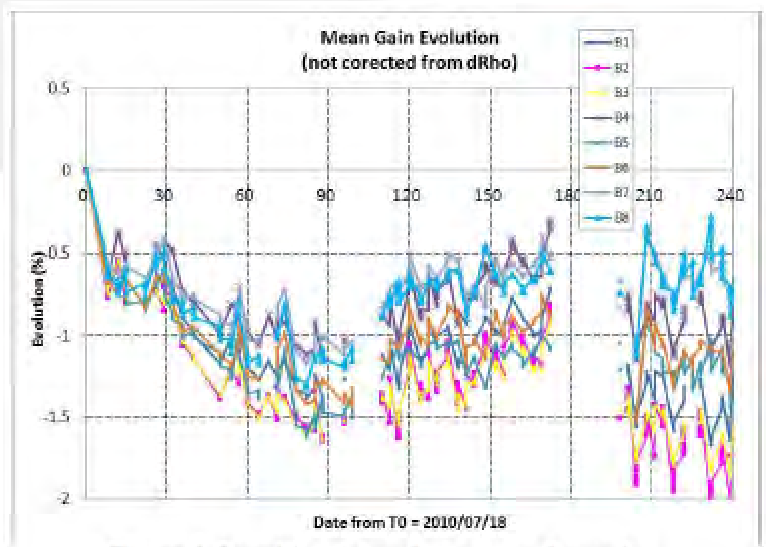
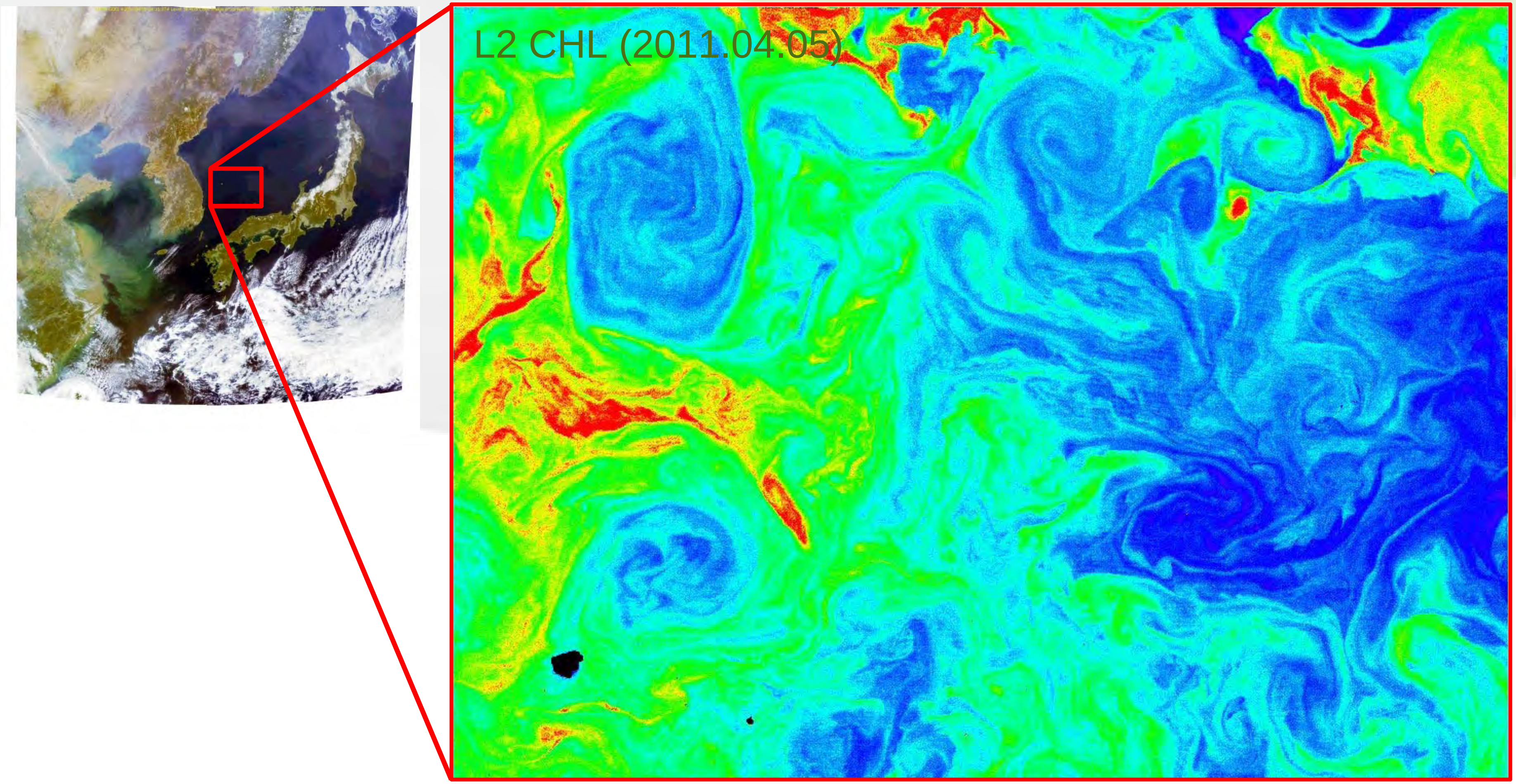


Figure 4. In-orbit gain evolution over 8 months

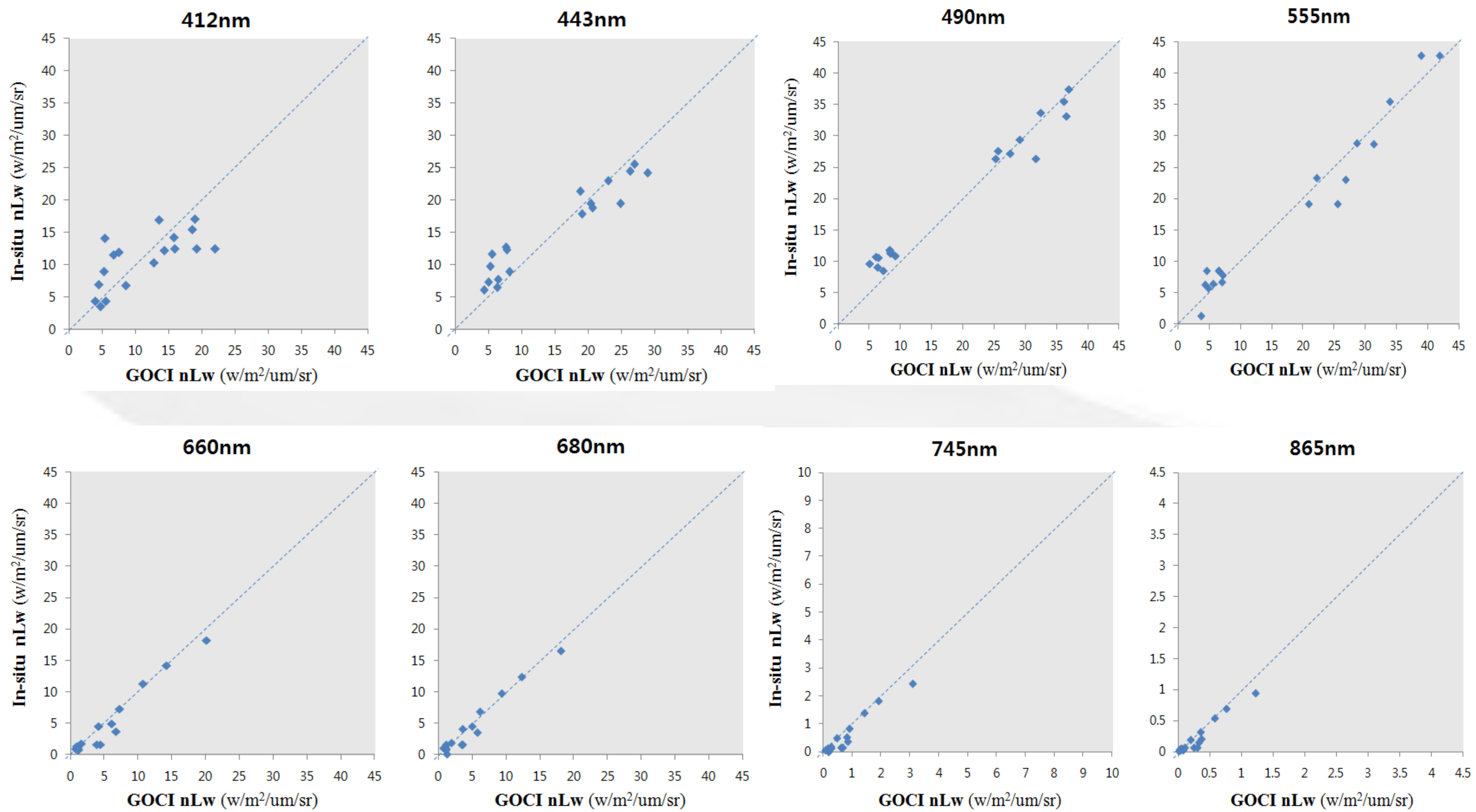
Evolution of Radiometric Gain (2010)
(G. Kang & H. Youn, 2011)

Local Atmospheric correction

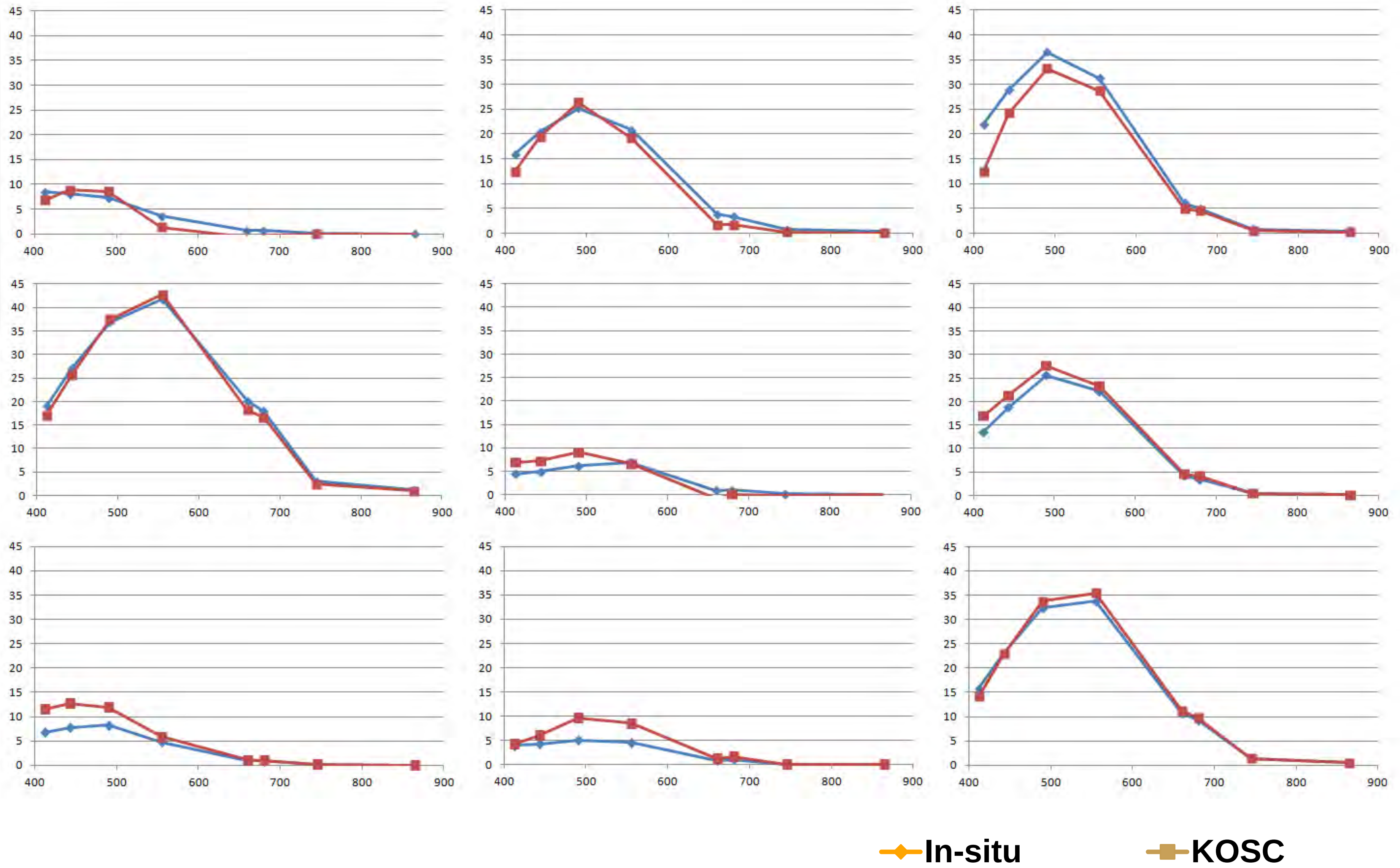
To add modified NASA standard atmospheric correction in GDPS



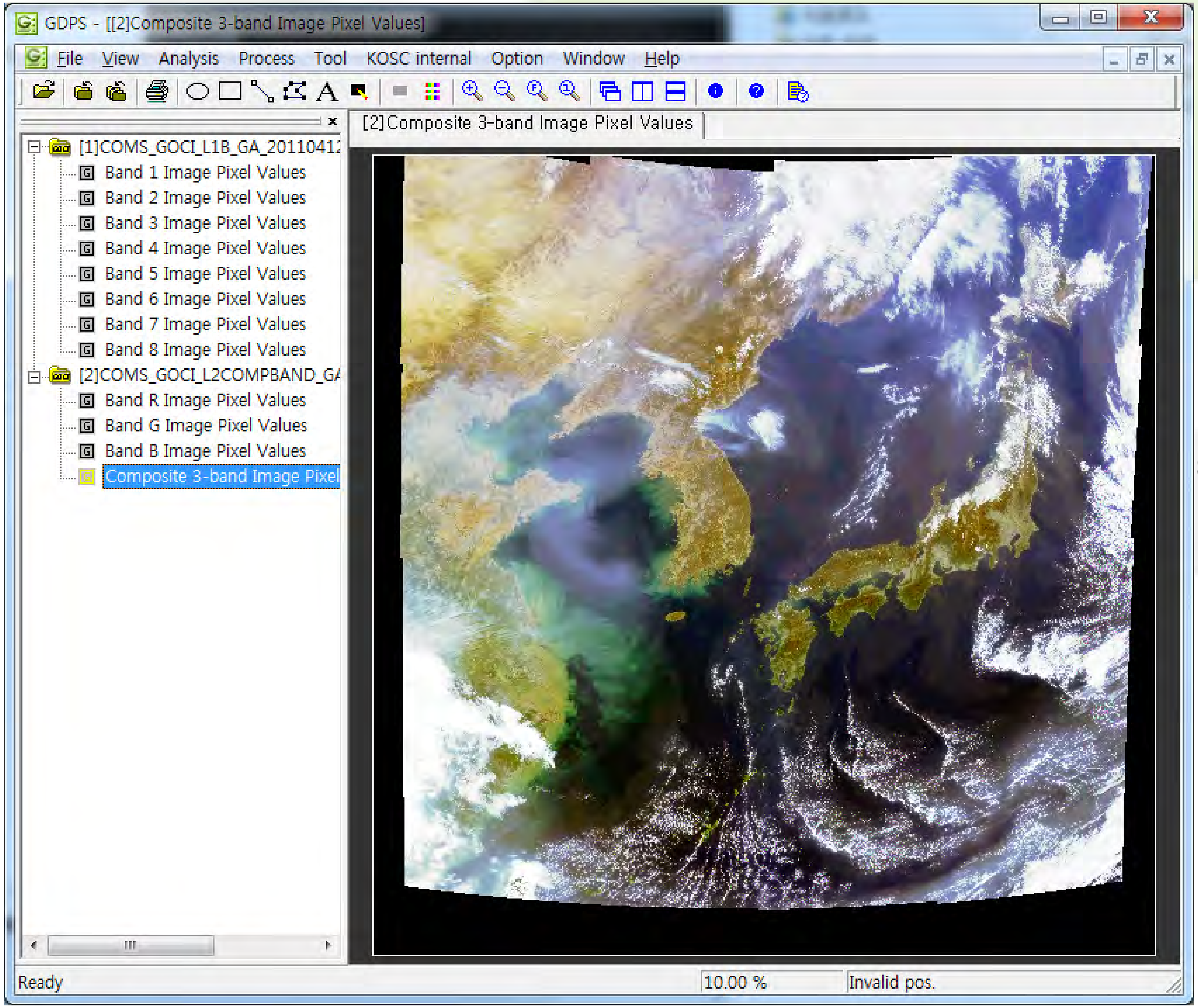
In-situ validation



In-situ validation

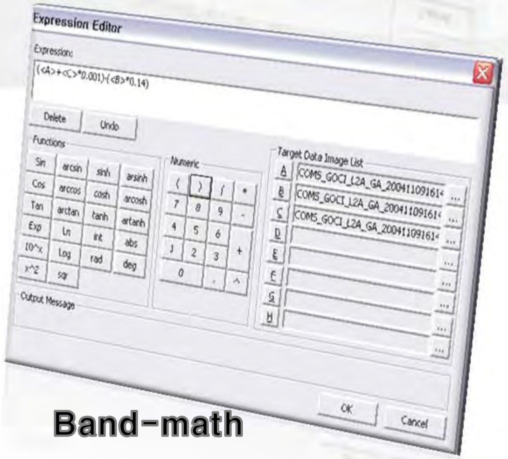


GDPS GUI



GOCI L2 Display

Setting Process Schedule



Band-math

Improvement of GDPS(2011~2012)

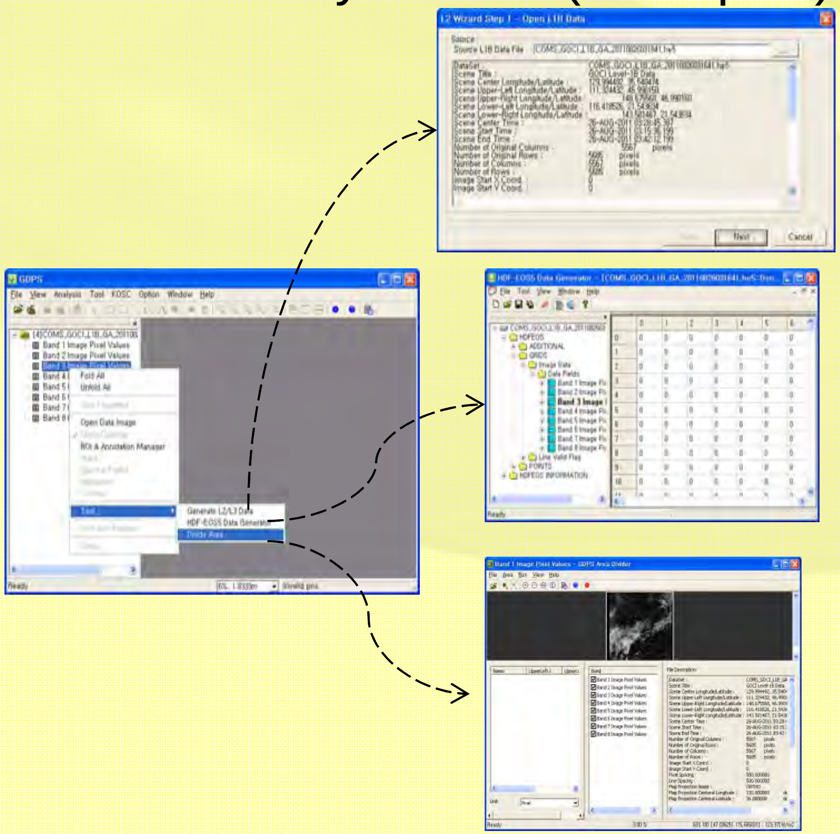
1. Improvement Trend
 - to improve GOCI level 2 data quality
 - to make user oriented GOCI data processing and analysis system

2. Content of Main Improvement
 - User friendly function
 - Efficient memory management
 - Extension of data analysis functions

3. SW Release
 - GDPS Ver 1.0 was released in Sep. 2011
 - GDPS Ver 1.1 will be released in Apr. 2012

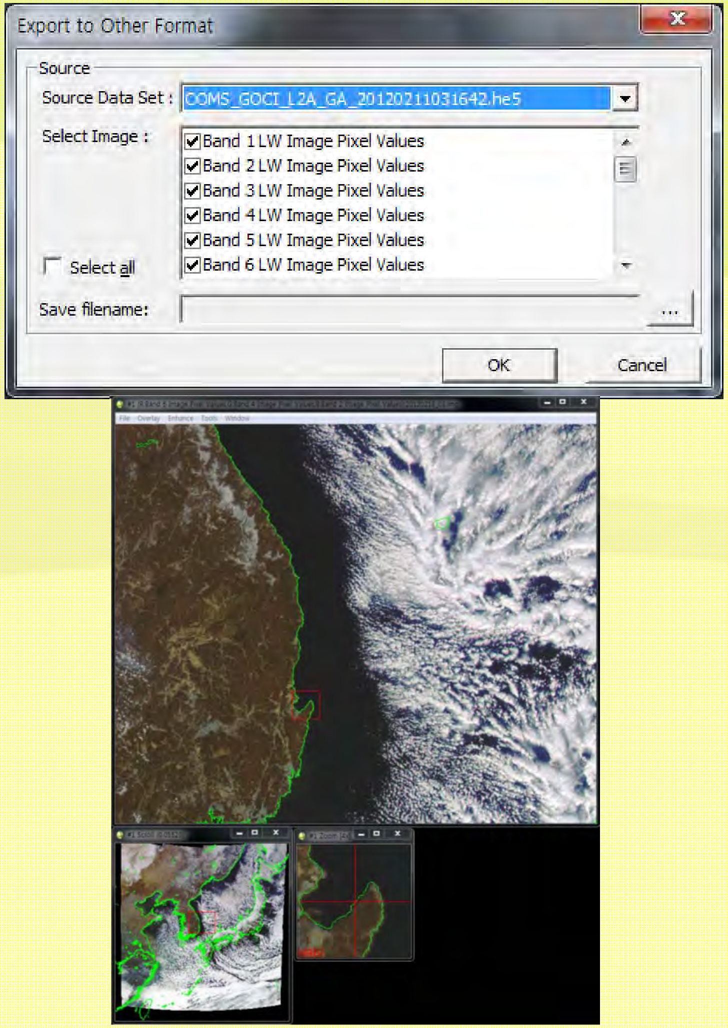
Improvement of GDPS

-User friendly function(Examples)



Link the selected file as input file of Tool process

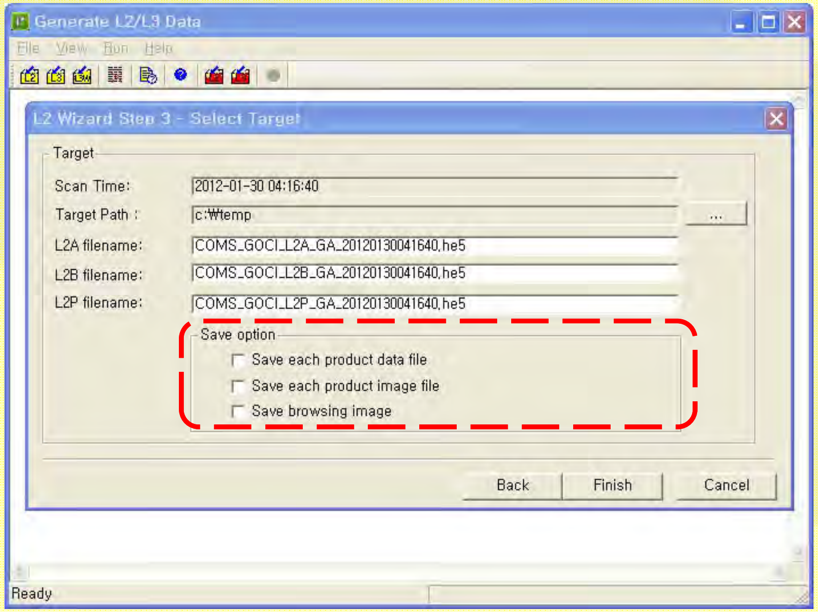
(Generate L2/L3 Data, HDF-EOS5 Data Generator, Divide Area)



Export other format including geo-information (Export to ENVI)

Improvement of GDPS

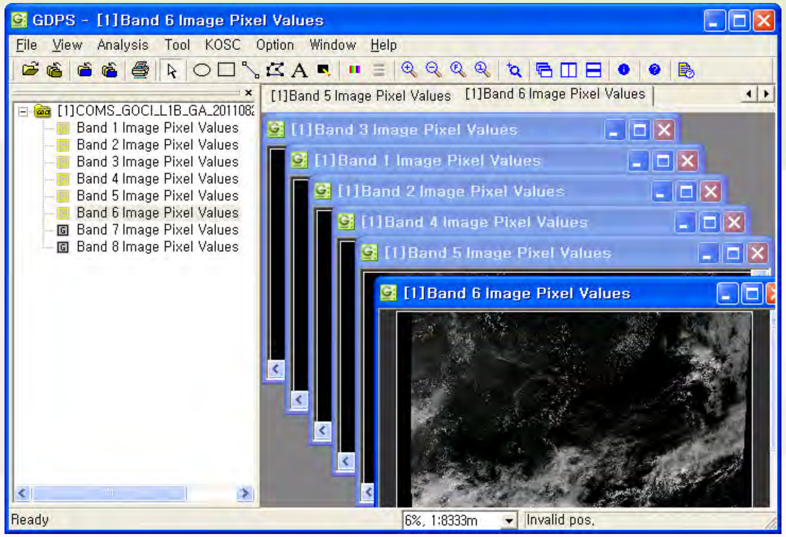
-User friendly function(Examples)



Minimizing numbers of L2 data file

- Adding option to ask to save each product or not

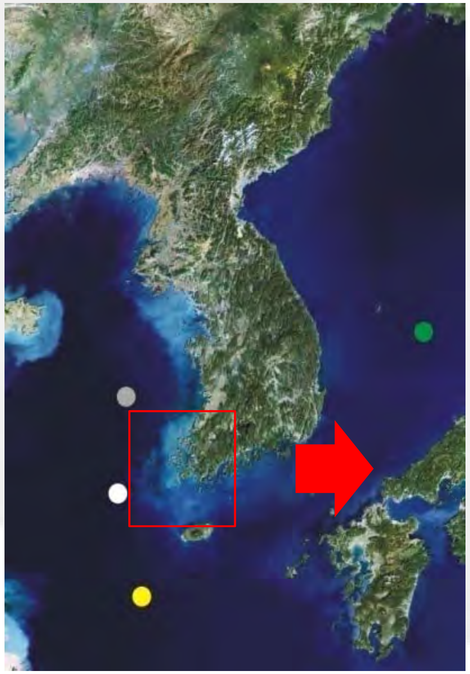
- Efficient memory management

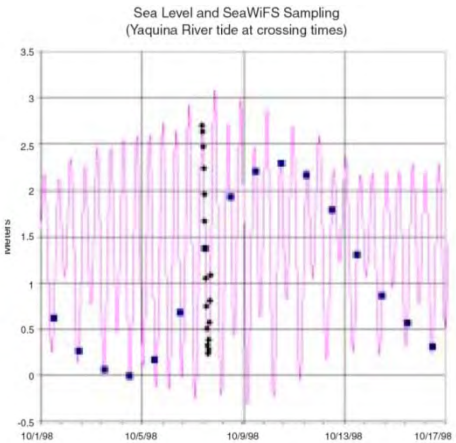


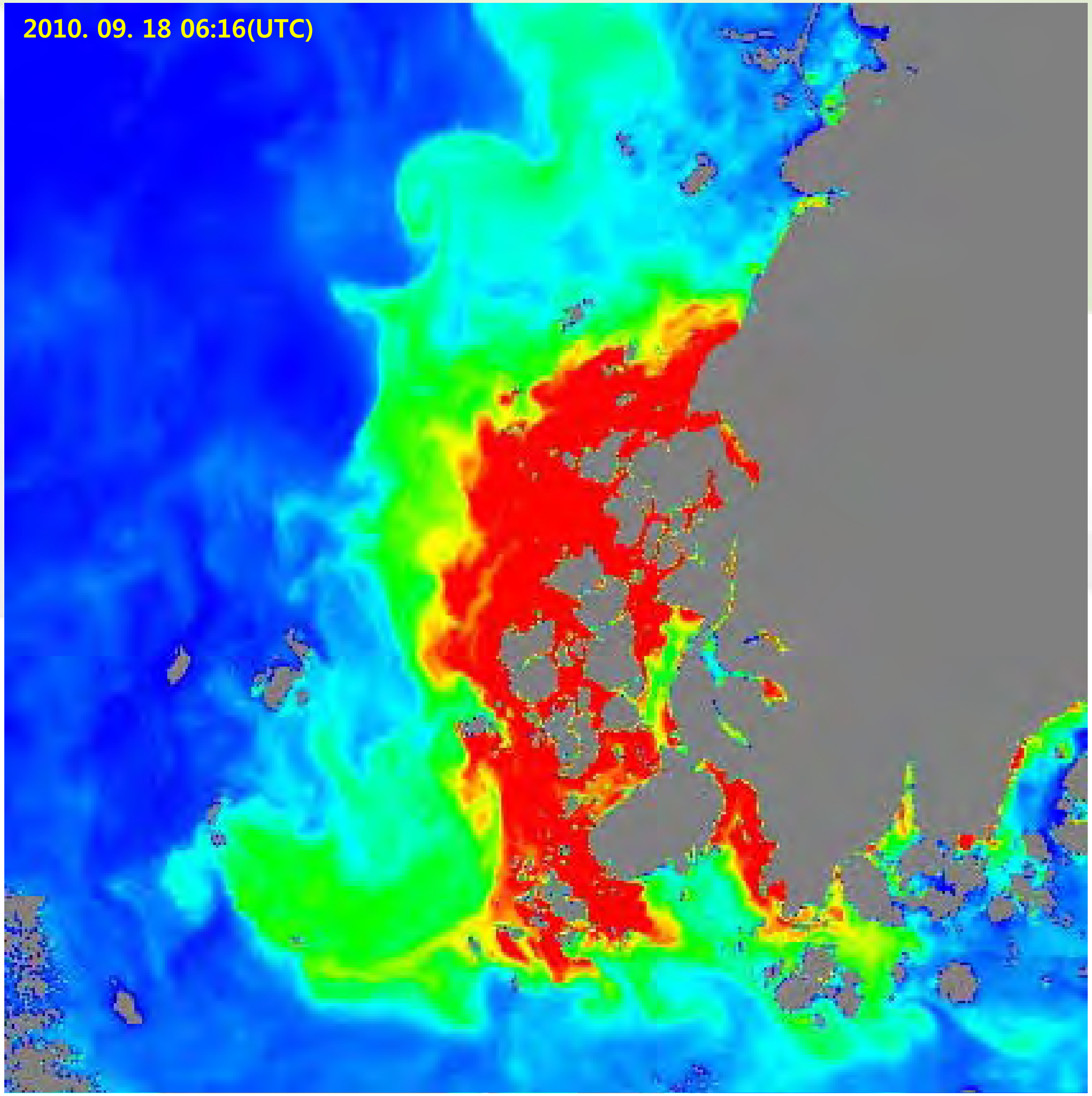
Maximize to open viewer
-Can open 6 viewers

GOCI Applications

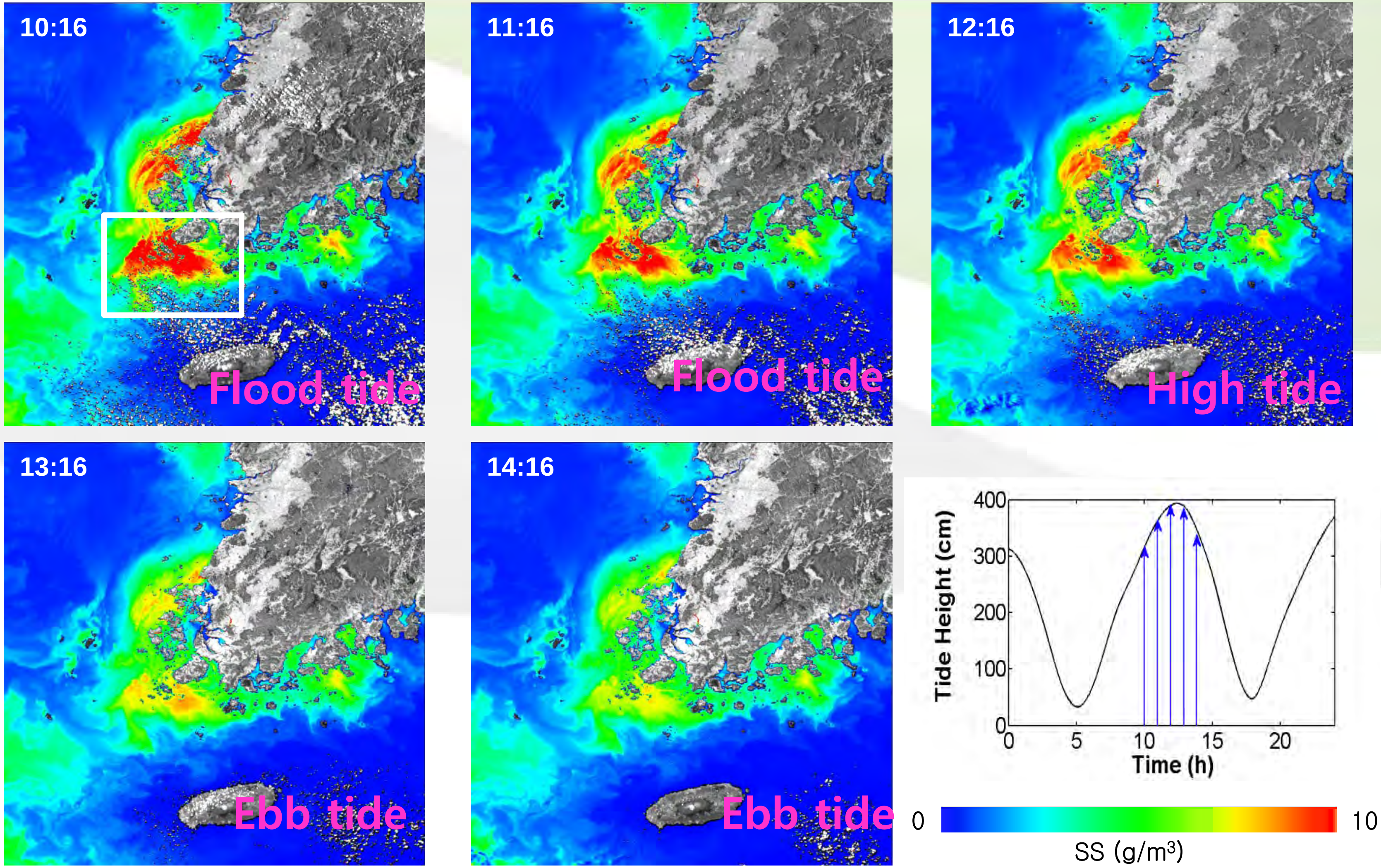
SSC monitoring







Hourly SS variations



There is no notable difference over the study area from 10:30 to 12:30. However, white box area is gradually decreased time after time until high tide and then suddenly decreased.

Bohai Bay Oil Spill(by Chosunilbo)

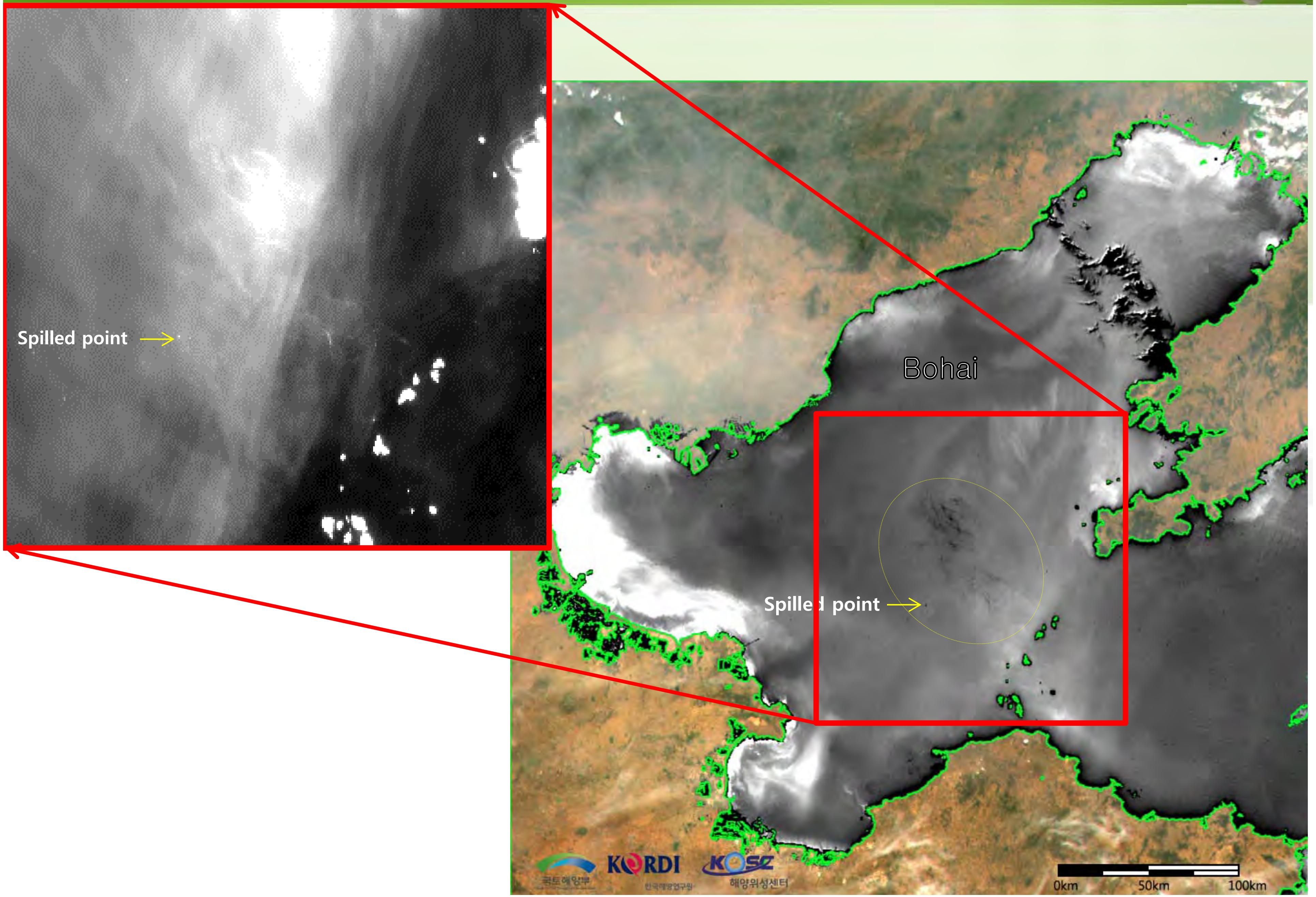
- The sea area polluted in an oil spill in China's Bohai Bay was five times as large as Beijing previously announced. A probe conducted by the Chinese State Oceanic Administration found that some 4,240 sq.km of water, or seven times the size of Seoul, were polluted by oil leaks from the Peng Lai 19-3 oilfield in Bohai Bay, the daily Xin Jing Bao reported Wednesday.

  Beijing admitted the oil spill for the first time on July 5, a month after two oil leaks occurred at China's largest marine oilfield on June 4 and 17, saying only 840 sq.km were polluted. But the water quality of a 3,400 sq.km area nearby dropped from Grade 1 to Grade 3.

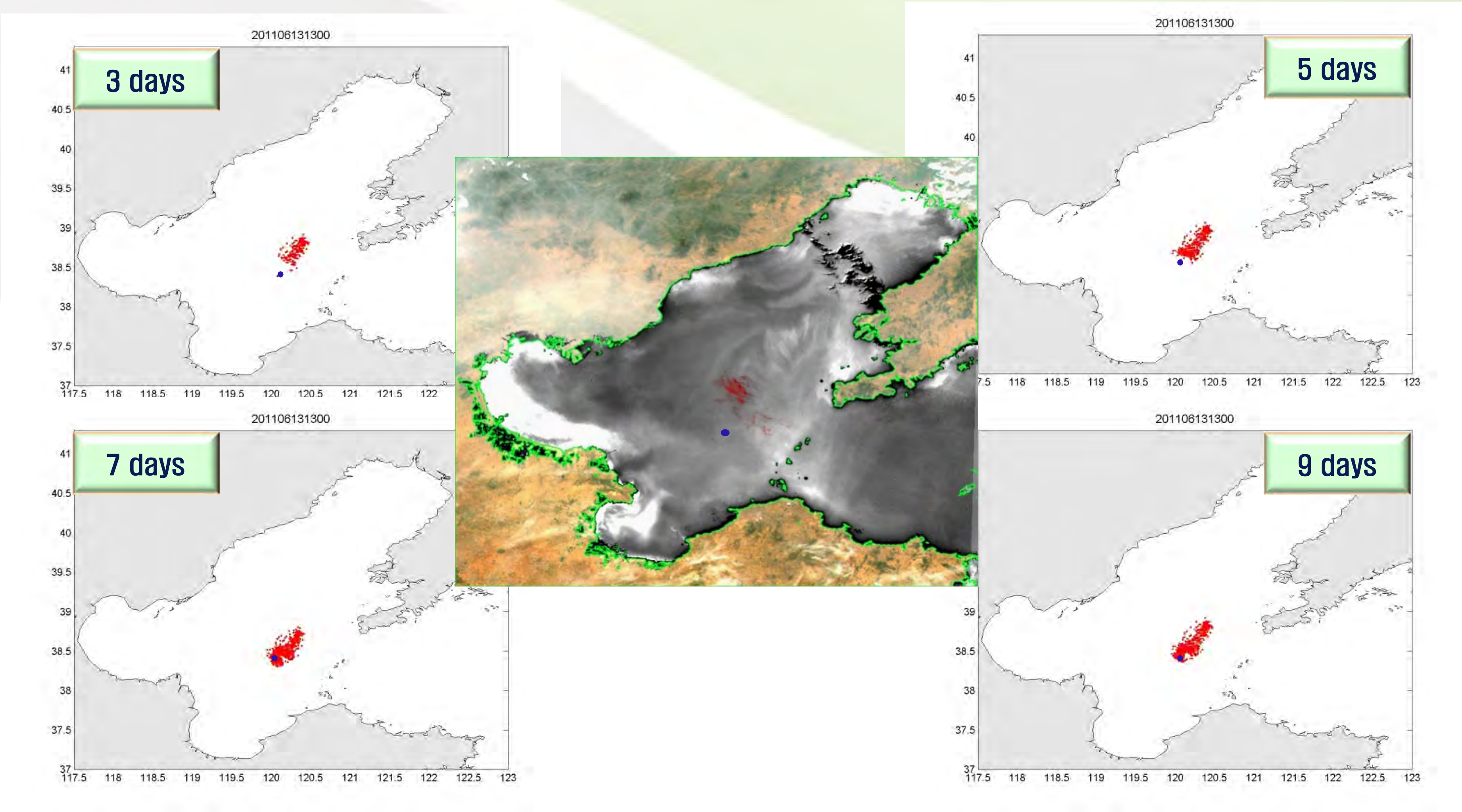
  China National Offshore Oil Corp. and ConocoPhillips, the joint operators of the oilfield, said the oil spill was quickly contained and cleaned up, but earlier this week Beijing admitted that oil continues to leak out.

  The Chinese government on Wednesday ordered the operators to suspend production until there is no more danger of further spills. Concern is increasing about the safety of seafood from the West Sea. The city of Yantai in Shandong Province near the ill-fated oilfield has set up an observation post on the coast to check for pollution.

Oil Spill estimation (GOCI June 13, 2011)



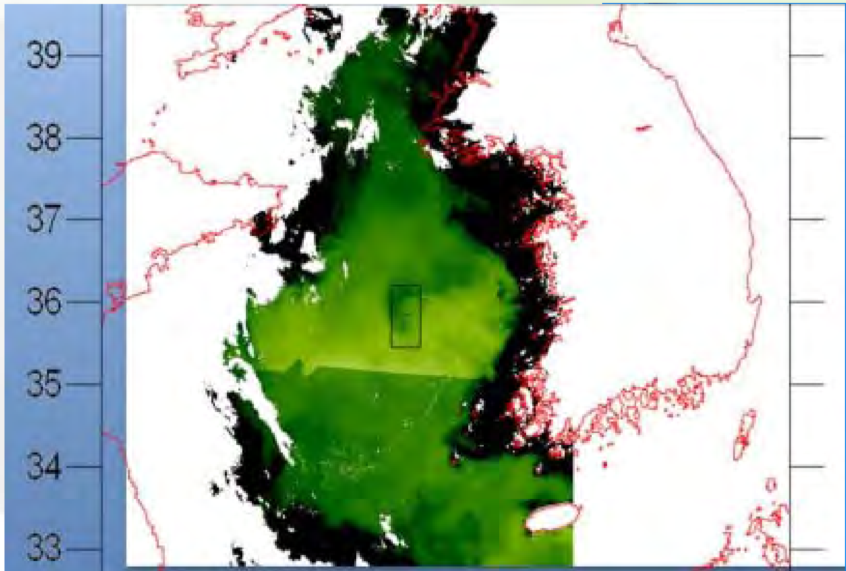
GOCI and Model comparison

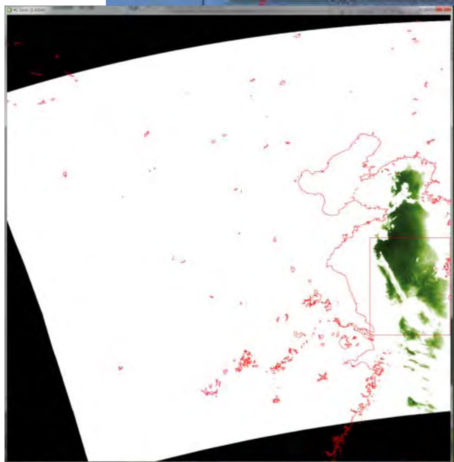


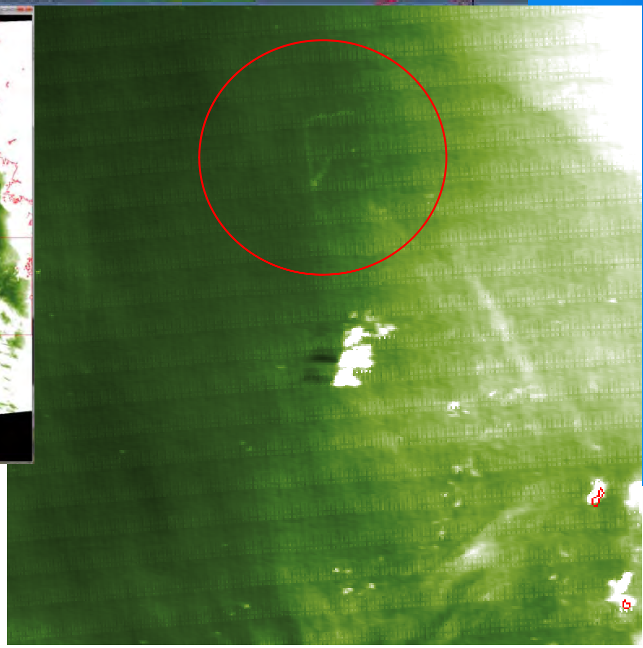
Dumping ship monitoring

- 2011.07.19
- Ship velocity measurement

: 8~9 knot

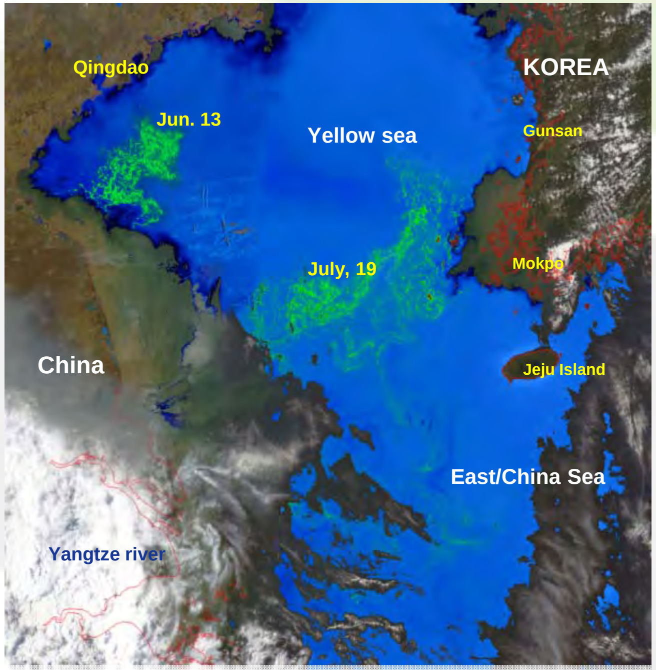


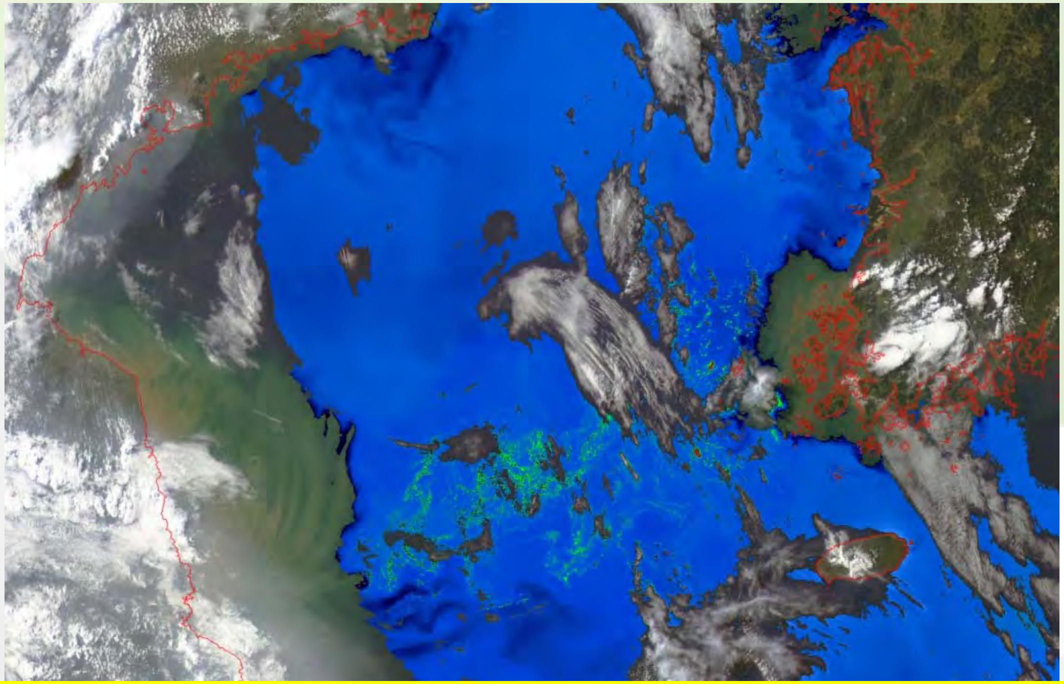




MODIS Aqua
2011.07.19. 02:00(UTC)

Monitoring Green tide





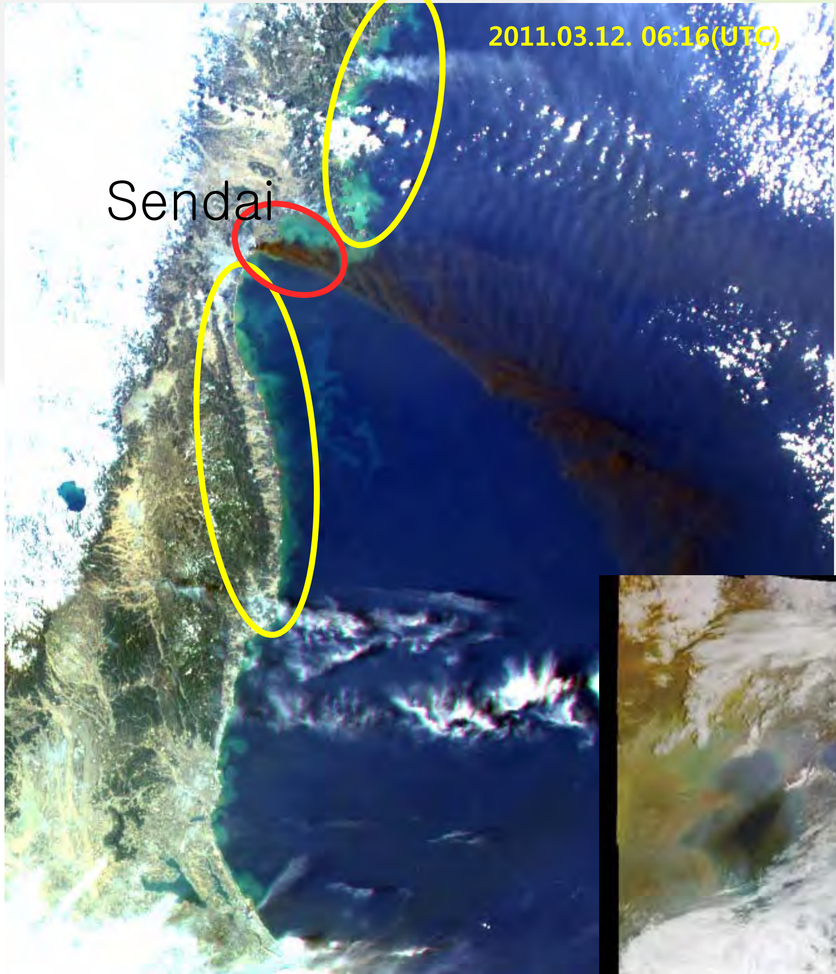
(a) June. 10, 2011 in south sea of Korea
Picture by Onnuri research ship of KORDI

(b) June. 16, 2011 : West south sea
Location: 31N, 125E
Picture by KORDI and Nagasaki Univ.

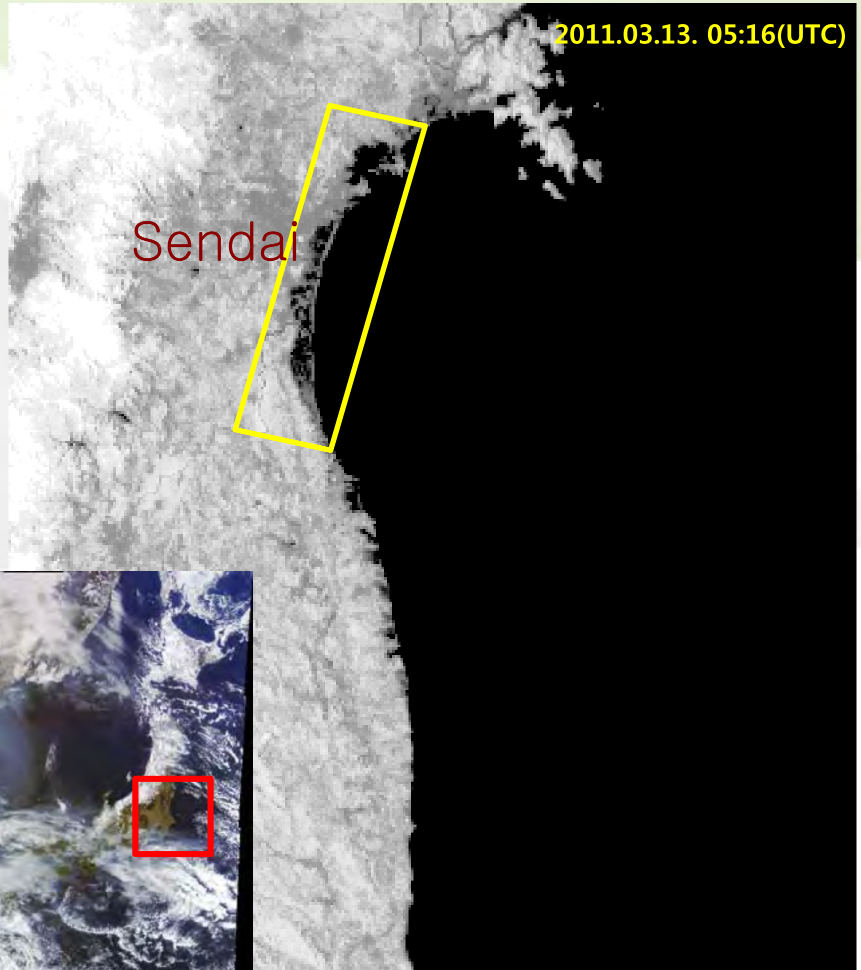
(c) June. 21, 2011
Location : (34N°31.9, 125E°27.8)
Picture by Mugunghwa -2 ship of Jeonnam Univ.

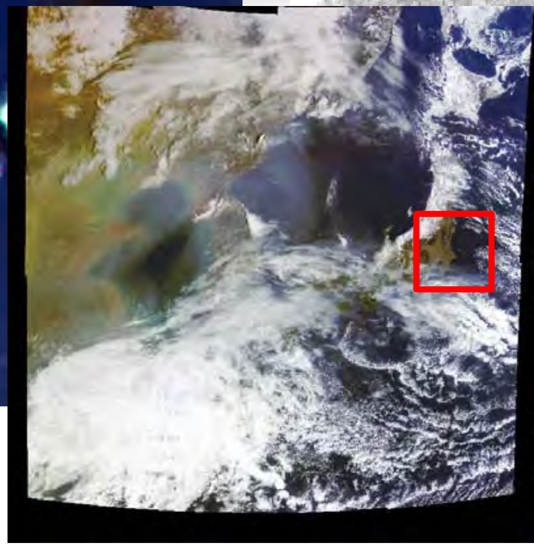
Tsunami

Changing of Coastal Suspended Sediments and Fire Monitoring

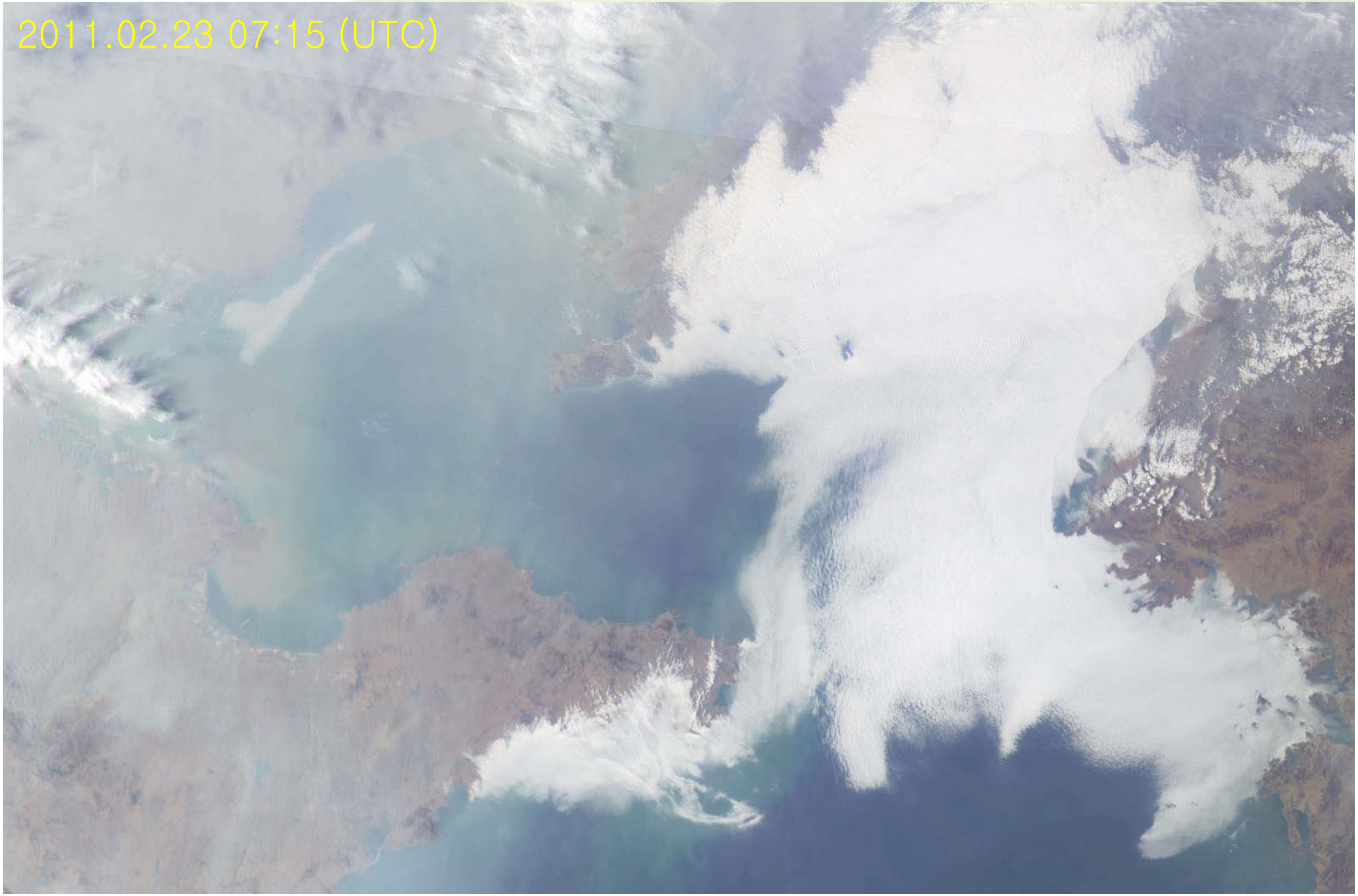


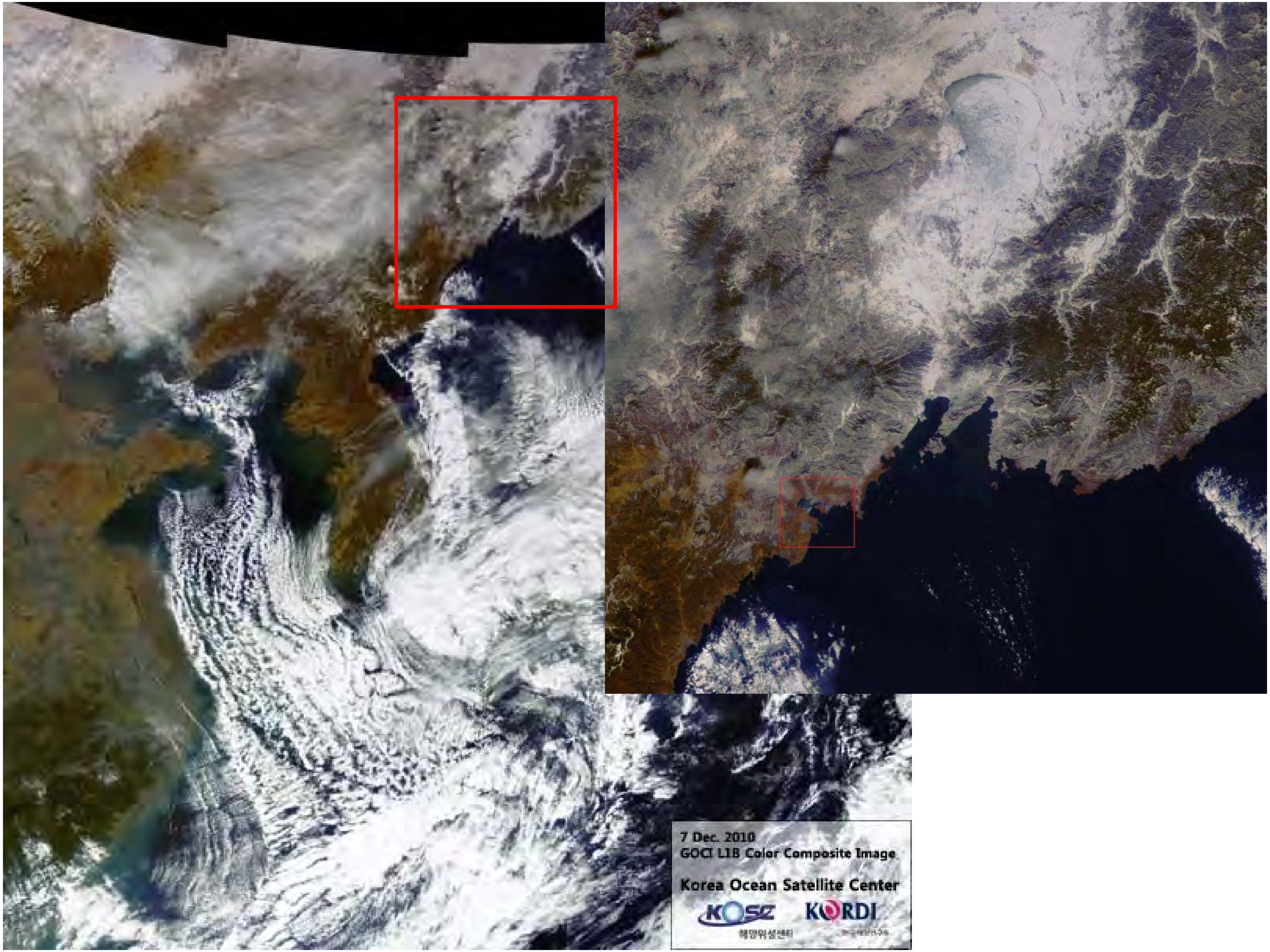
Changing of Coastal Line before and after tsunami



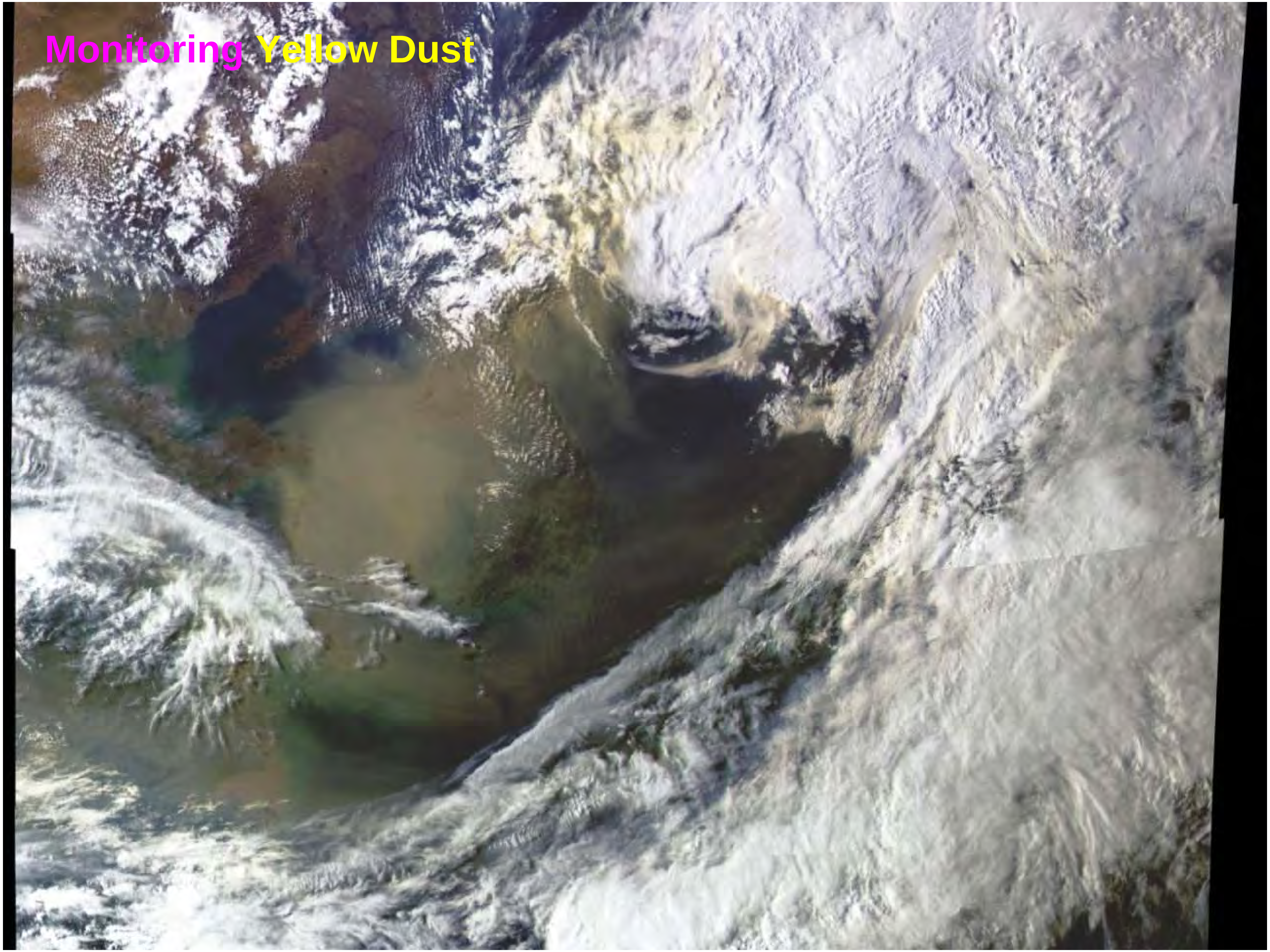


Sea Fog (Feb 19–23,2011)



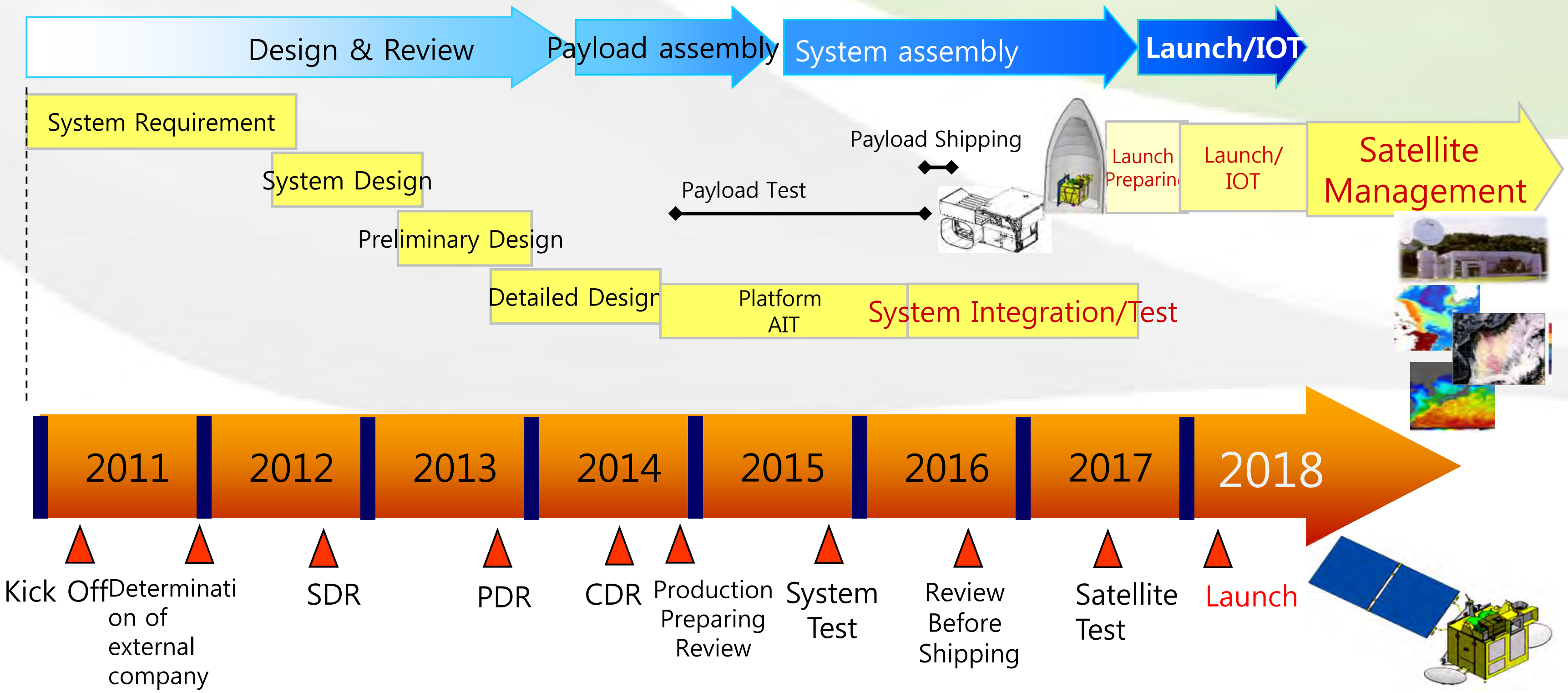

7 Dec. 2010
GOCI L1B Color Composite Image
Korea Ocean Satellite Center
KOSC
KORDI

Monitoring Yellow Dust



GOCI-II : Next Generation

(2012~2018)

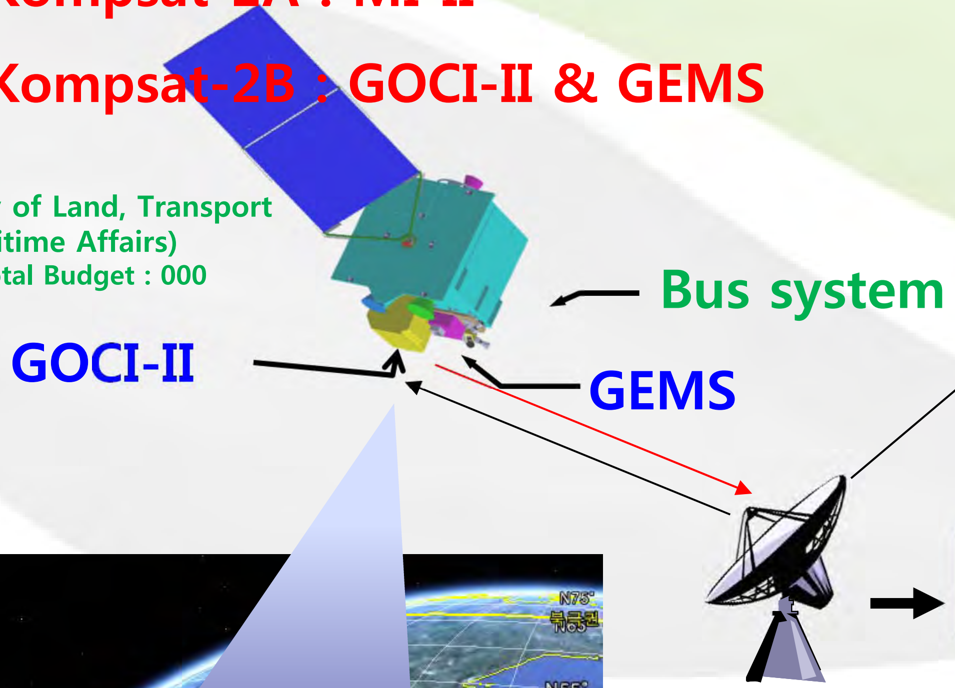


GOCI-II development
(Ministry of Land, Transport and Maritime Affairs)

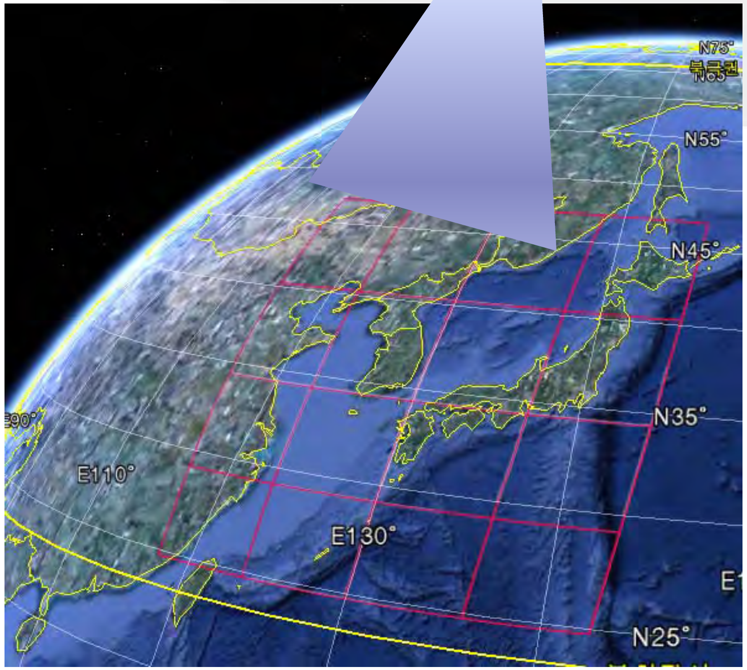
GeoKompsat-2A : MI-II

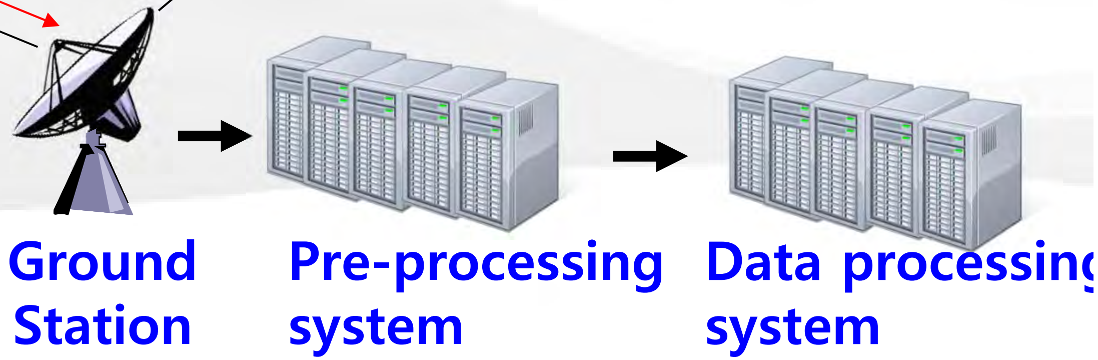
GeoKompsat-2B : GOCI-II & GEMS

GOCI-II
(Ministry of Land, Transport and Maritime Affairs)
Total Budget : 000



Ground Station
- Primary Station
- Remote Backup Station



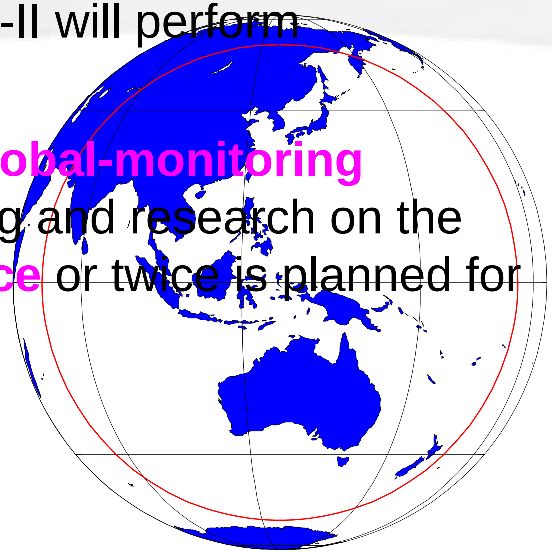


Ground Station & Data processing system Development
(Ministry of Land, Transport and Maritime Affairs)
- Performing precedent study (2012)
- Project Period (2013 ~ 2018)

Pre-processing system
(Ministry of Education, Science and Technology)
- Algorithm : KORDI and KARI
- S/W Development : KORDI

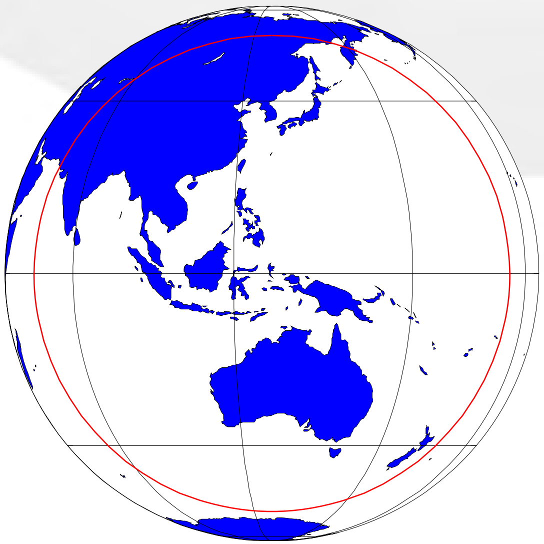
GOCI-II

- 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 is planned to **start the development in 2012**, and will be launched in 2018.
- The user requirements of GOCI-II will have higher spatial resolution, **250m×250m, and 12-15 spectral bands(TBD)** 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** or twice is planned for GOCI-II.

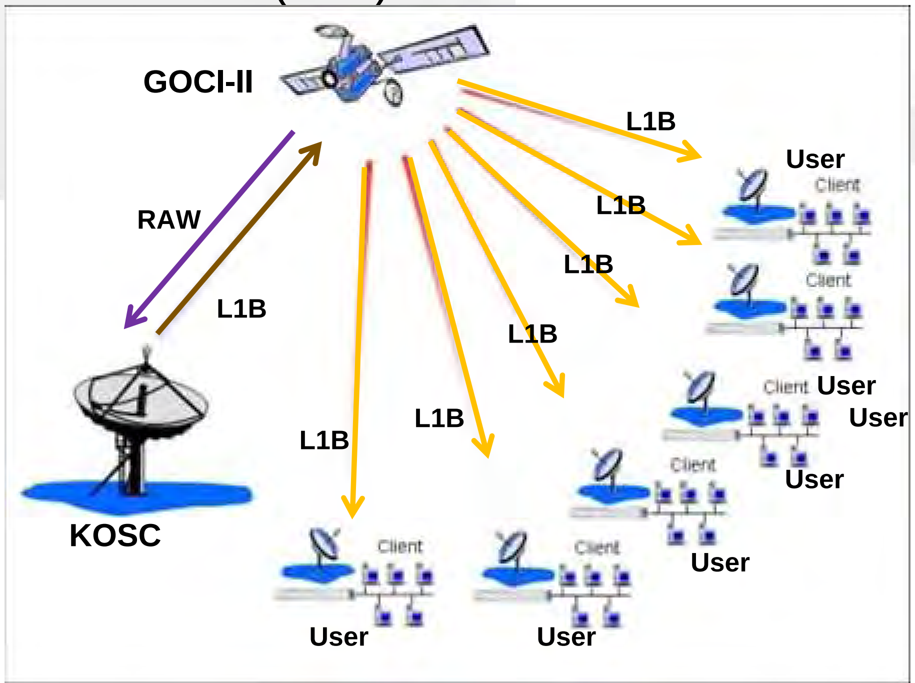


Direct Broadcast Service

- User Requirements for GOCI-II Direct Broadcasting
  - Data Rate : 23Mbps
  - Service Coverage : ~ Full Disk Area
  - Data Format : (TBD)
  - Receiving Antenna on Ground Station : < 5m (Dim)

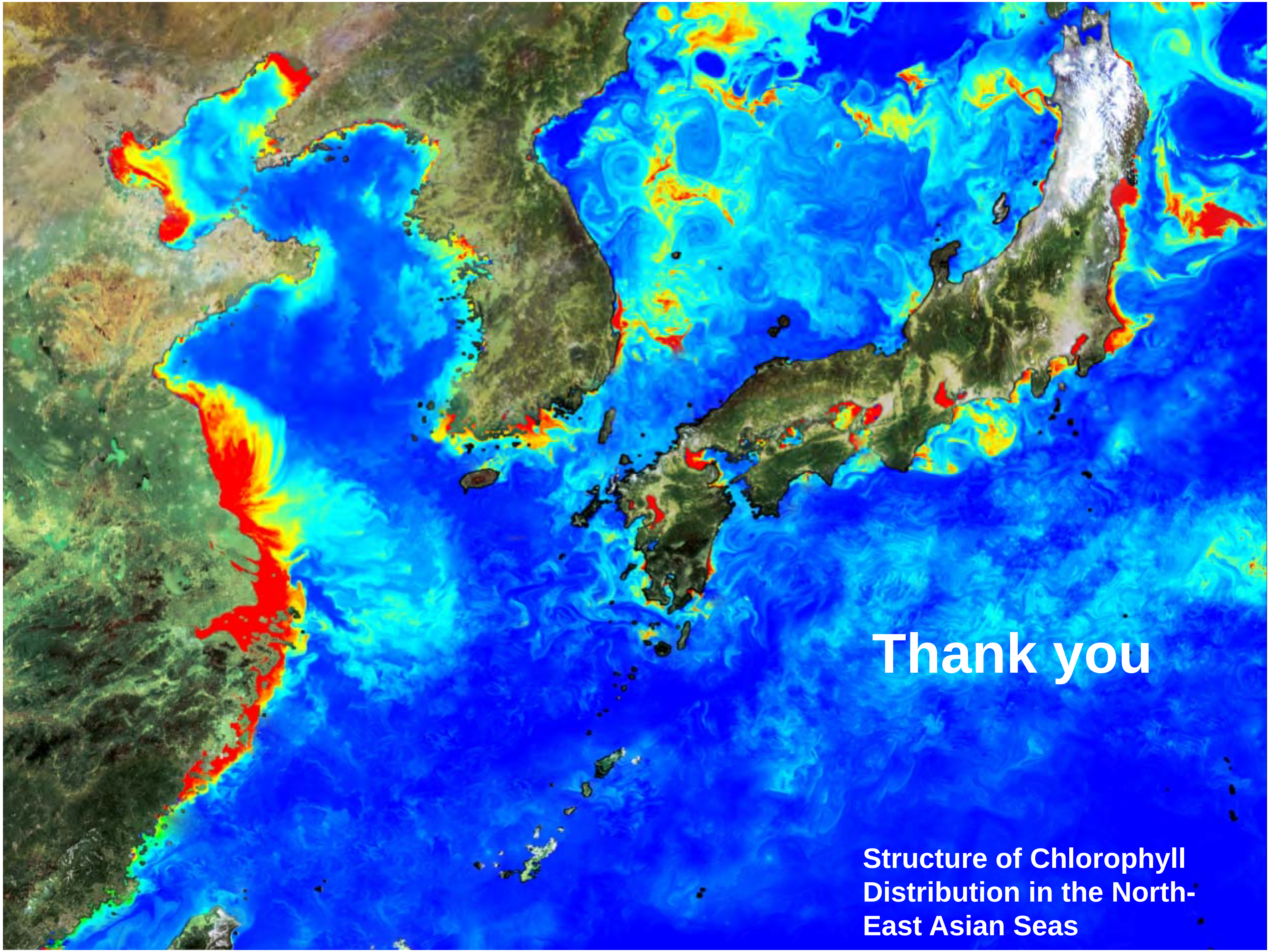


Service Area (Red Circle)



Summary

- There is no significant technical issue for GOCI operation.
- Enhanced temporal resolution and high performance of GOCI show better effectiveness than we expected especially operational use.
- GOCI has an excellent capability to monitor ocean, atmosphere, land and disaster.
- After solving ISRD and approval of government, we will distribute 8 times images of GOCI to user.
- We would like to make a international mirror sites for fast download this year.


Thank you
Structure of Chlorophyll Distribution in the North-East Asian Seas