GOCI In-Orbit Test and Cal/Val Plan

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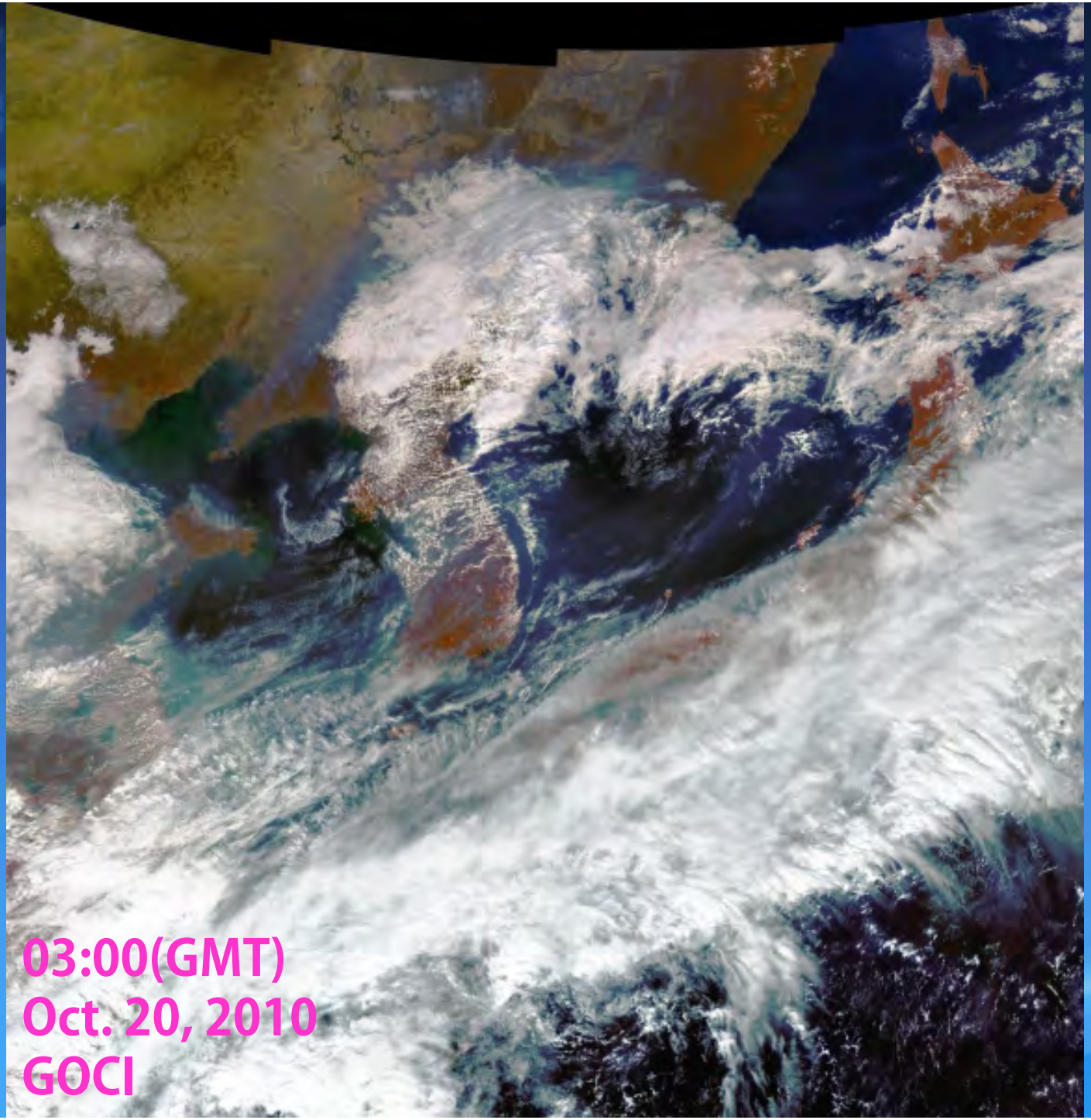
Contribution from : KOSC colleaques

Oct. 21, 2010

Korea Ocean Satellite Center
Korea Ocean Research & Development Institute

World' 1st GOCI/COMS Launch Campaign

- **Launch Date : June 27 2010**
- **Launch Vehicle : Ariane-V (ESA)**
  - **Location : Kourou Space Center, French Guiana**


03:00(GMT)
Oct. 20, 2010
GOCI

A brief overview of GOCI

★ **GOCI : G**eostationary **O**cean **C**olor **I**mager
★ **COMS** : **C**ommunication **O**cean and **M**eteorological **S**atellite

★ It shall be operated in a **staring-frame capture** mode onboard its COMS.

★ The mission concept includes eight visible-to-near-infrared bands, **500 m spatial resolution**, and a **coverage region of 2,500*2,500 km** centered at Korea.

★ The instrument is expected to provide SeaWiFS quality observations for a single study area with imager frequency of **1 hour from 9 am to 4 pm (8 times a day)**.

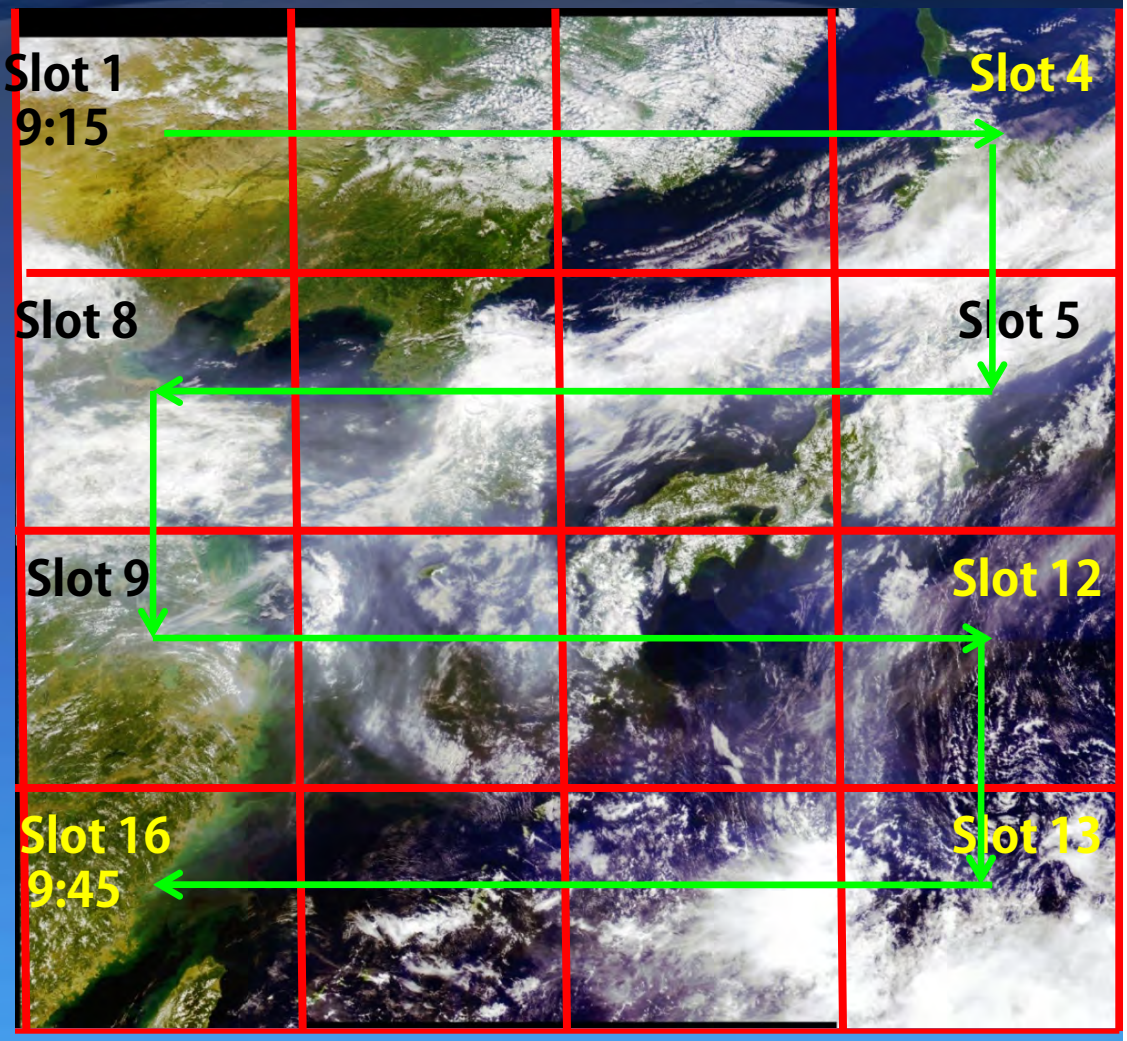
★ GOCI Application : LEO mission **+ Operational mission**
harmful algae bloom (HAB), health of marine ecosystem, movement of suspended sediment and current, and to produce marine fisheries information for fishing communities **+ ocean forecasting (with modeling)**

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	
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

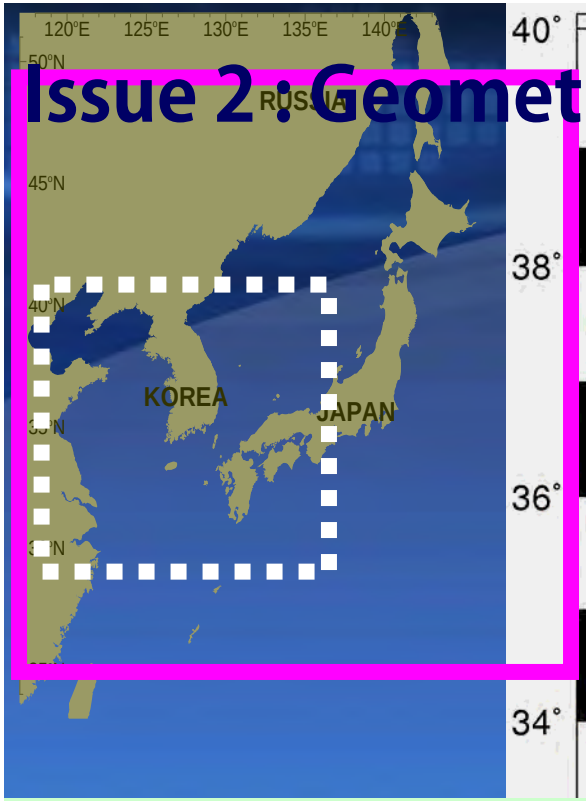
GEO is about 50 times farther from the Earth than LEO
GEO spatial resolution is 4 times better than that of LEO
GEO temporal resolution is 8 times better
To be considered and prepared sensor type, geometry & local coverage for overcoming GEO characteristics

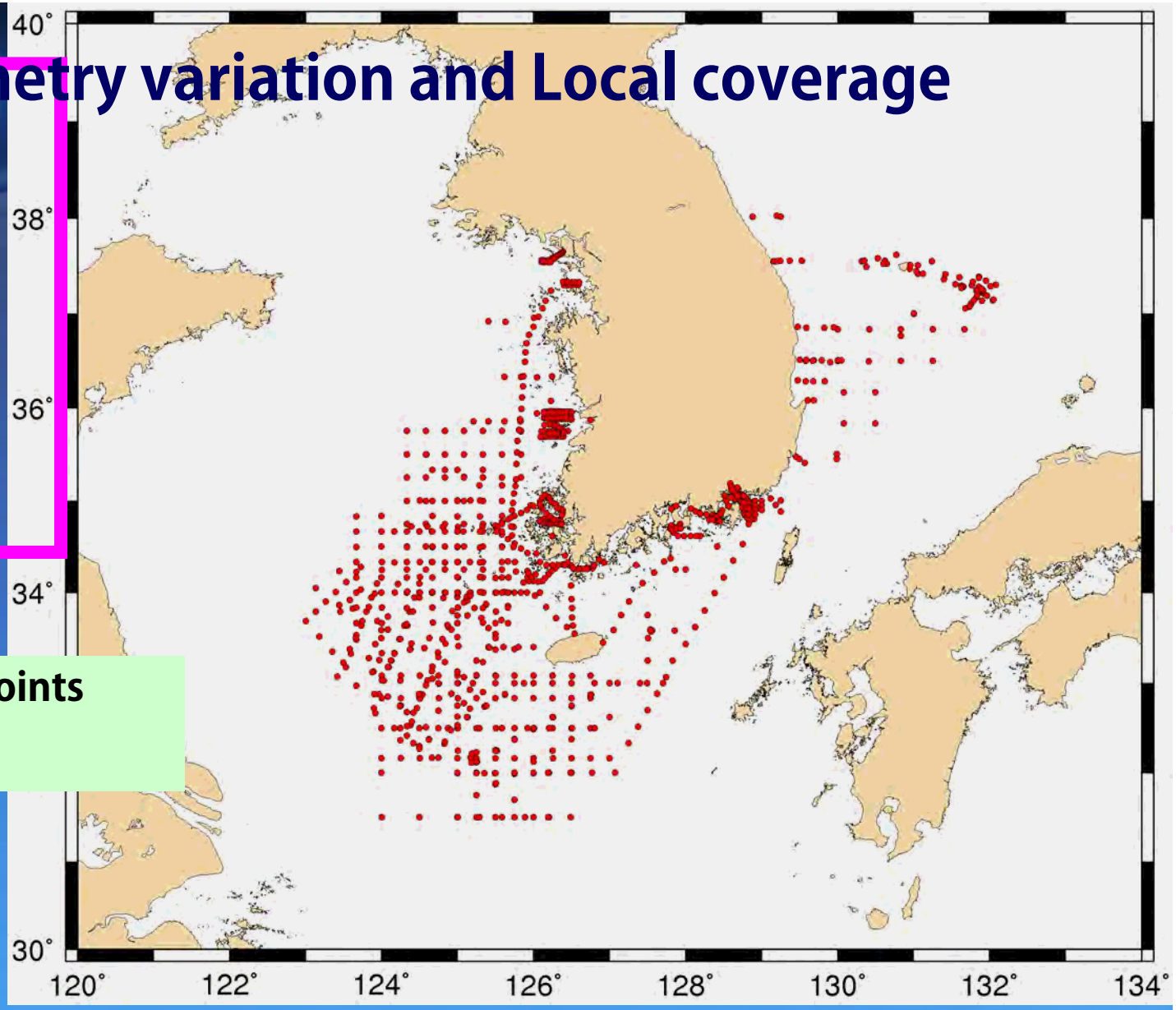
Issue 1 : Sensor type



GOCI uses the staring-frame capture method
It takes 30 min to acquire one set of whole coverage
Time interval is induced between upper and lower lines
The zigzag type of capture line brings about non-homogenous time interval

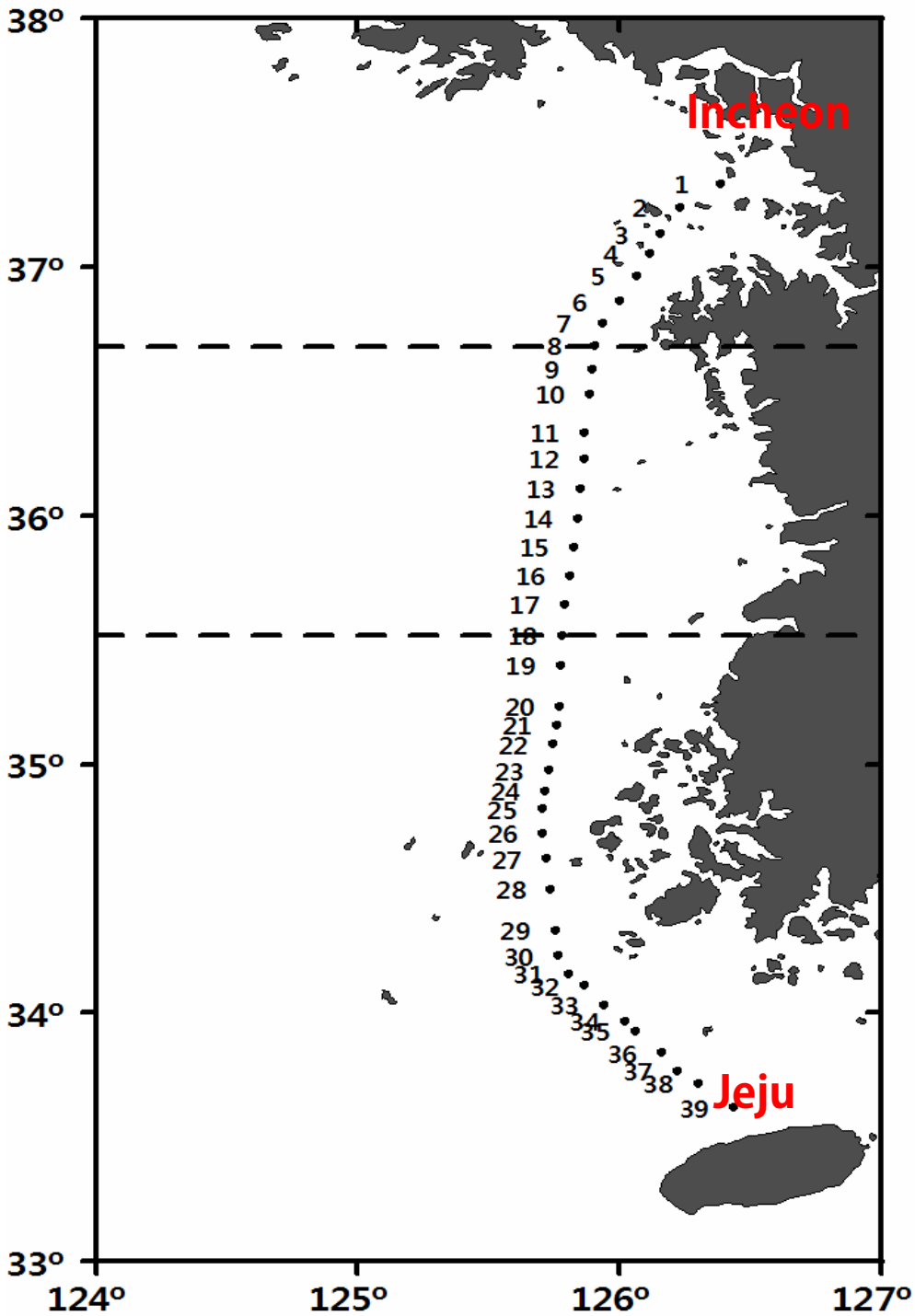
Issue 2 : Geometry variation and Local coverage





- **Total points: 1348 points**
- ***IOP and AOP***

***In situ* measurement** were performed **during a lot of cruises** in **the Korean terrestorial seas and neighboring waters through the years 1998-2010 onboard the KORDI research vessel and fisher boats.**

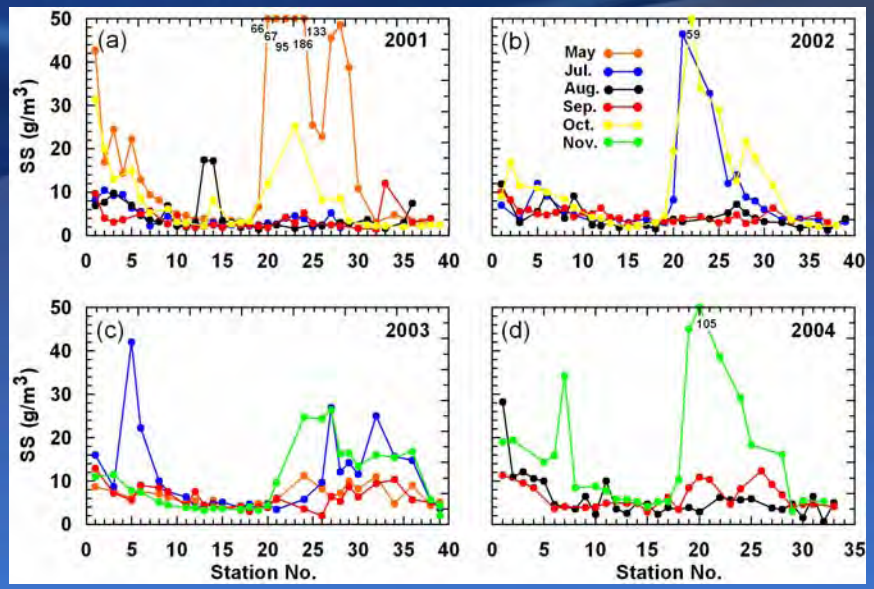


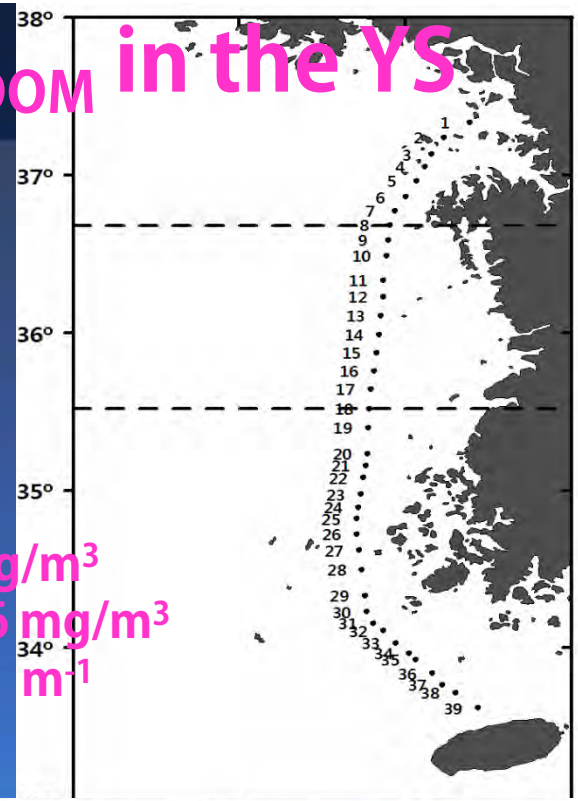
Ferrybox

- 18 times during 4 years
- Operation time : 19:00-10:00(next day)
- Instruments : YSI(SS, chl, T, S, DO), ChelSea(chl), SeaPoint(chl), McVan(SS)
- Water sample : about 40 (every 20 min after departure) <SS>, <chl>, a_{dom}

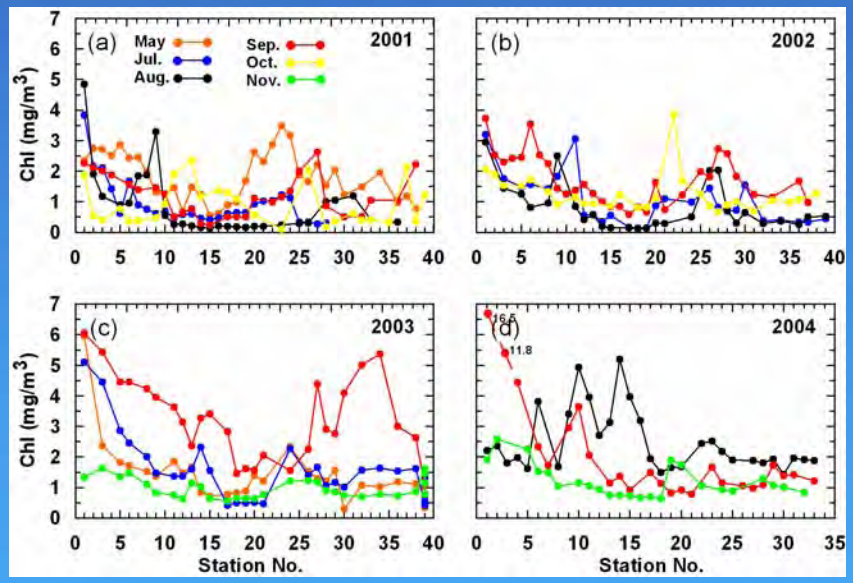
Year	Month	Vessel
2001	5,7,8,9,10	Chunghaejin
2002	6,7,8,9,10	Chunghaejin
2003	5,7,9,10,11	Chunghaejin
2004	8,9,11	Ohamana

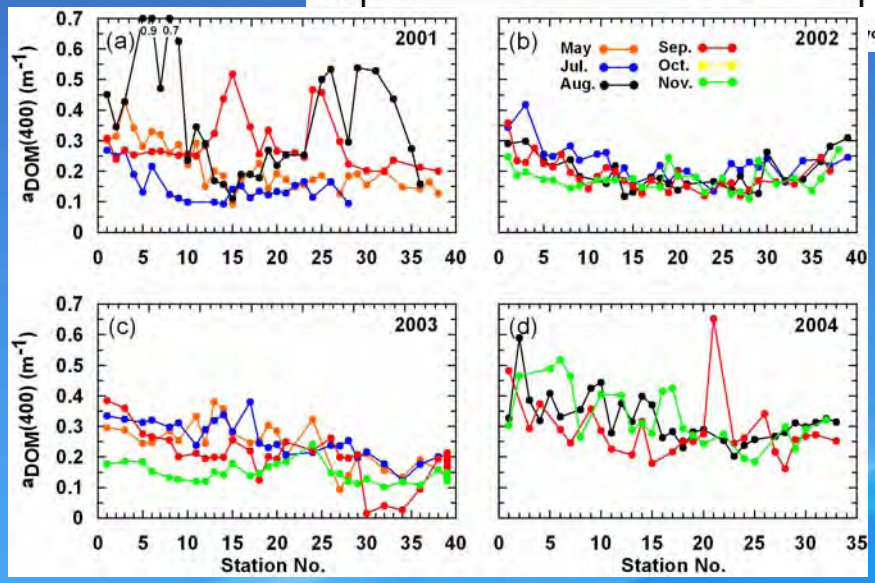
Concentration of SS, <chl>, a_{DOM} in the YS



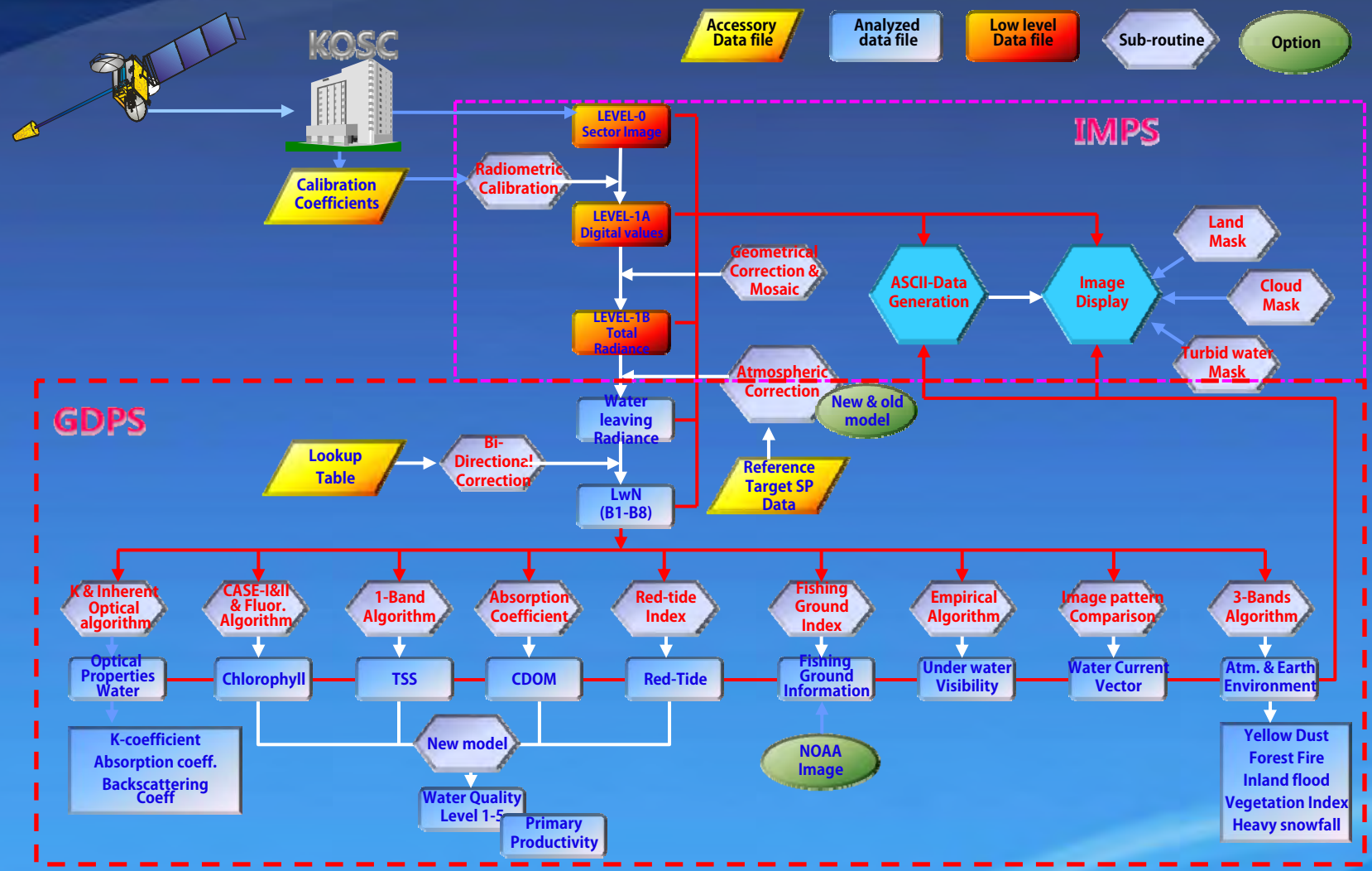


SS : 0-186 g/m^3
<chl> : 0 – 16 mg/m^3
adom : 0-0.9 m^{-1}

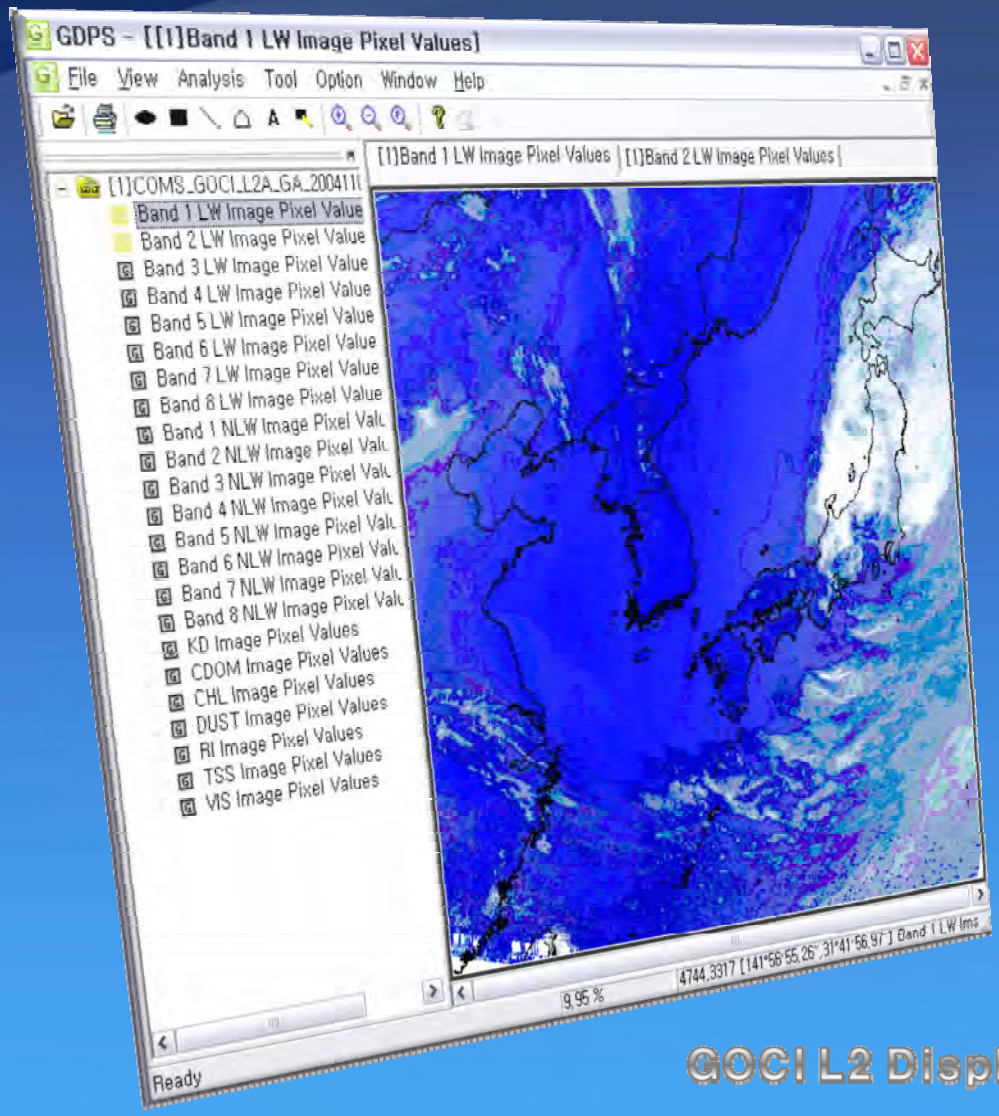




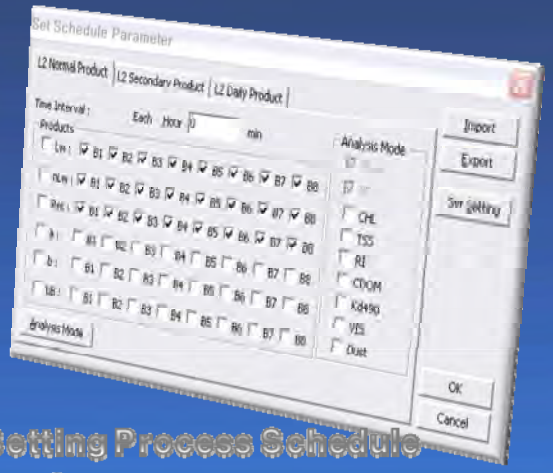
GOCI Data Processing System



GDPS GUI



GOCI L2 Display



Setting Process Schedule

Band-math

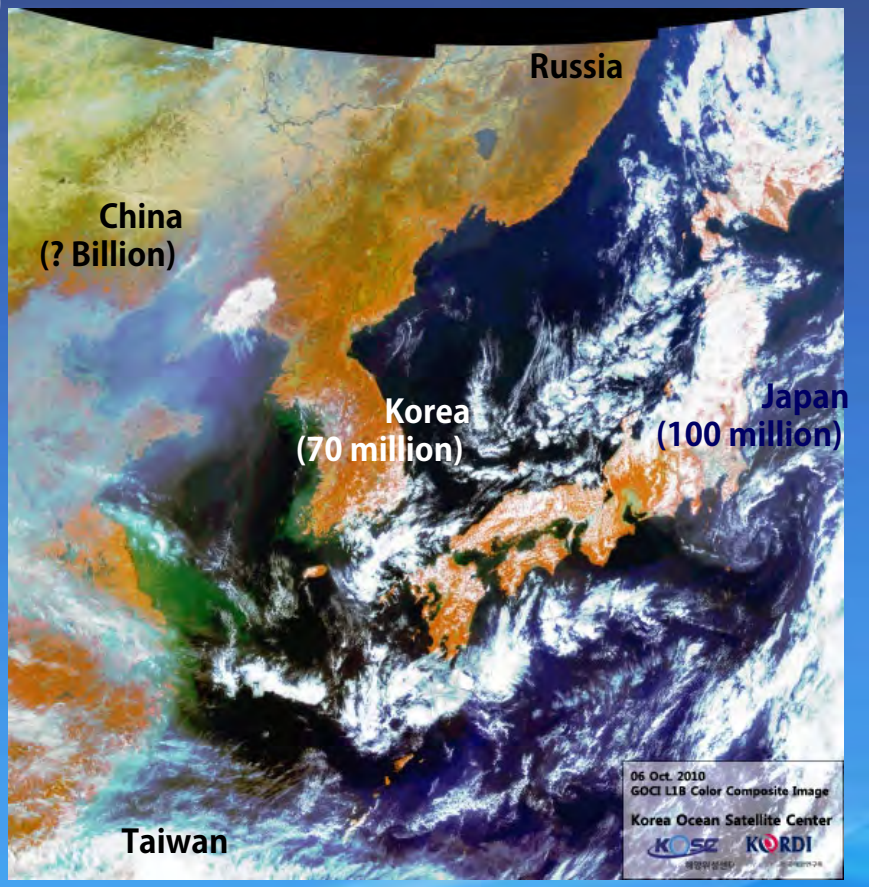
coastcolour

GOCI coverage

→ GOCI coverage / Earth surface = 6,250,000 / 520,000,000 km^2 = 1.2 %
(Considering the geographical size, coverage area is very small)

→ East Asia : South and North Korea, China, Japan, Russia, Taiwan

- ❑ Population : large (a heavily populated district)
- ❑ Economy, Commerce : big (container traffic)
- ❑ Defense, Military : important
- ❑ Environments : variable, changeable
- ❑ Climate change : serious



Issue 3 : No international Cal/Val site

Issues on GOCI

- Problems
  - Staring-capture frame : slot radiometric correction
  - Geometry variation and local coverage : BRDF correction, new local algorithm
  - No international Cal/Val site : new one

- Solutions :
  - to understand geometry and make radiometric, BRDF and atmospheric corrections
  - to understand optical properties of the Seas around Korean peninsula
  - to develop new bio-optical algorithms suitable for complex optical properties considering Case-1/2 waters
  - to make and update GOCI Data Processing System (GDPS)
  - to continuously do Cal/Val by using all kind of methods

GOCI IOT (during 6 months) items and result

- **GOCI HW all functional test : KARI & ASTRIUM**

  - Solar power, activators, system vibration and stability
    Orbit & attitude control, Temperature trend/Parts
    Data transmission, Telemetric control….
    All Optical, mechanical & electronic problems
    => is done by KARI, All GOCI Sub-systems are fully operational

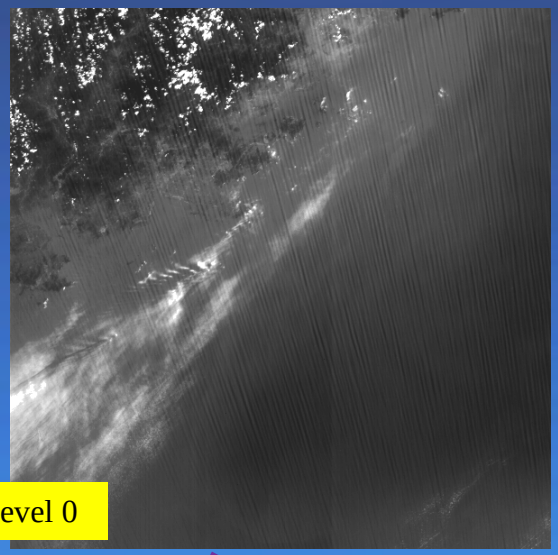
- **Ground test**

  - S/N, MTF(are on going) , wavelength, band registration, polarization…..
  - Image pre-processing test : KARI & KORDI
    - Radiometric calibration :
      initial value(lab test), updated with value obtained by space using solar diffuser
    - Image Mosaic function
    - Geometric calibration
  - Image post processing (GDPS) test : KORDI
    - Atmospheric correction
    - BRDF correction
    - Level-2 production (underwater algorithms)

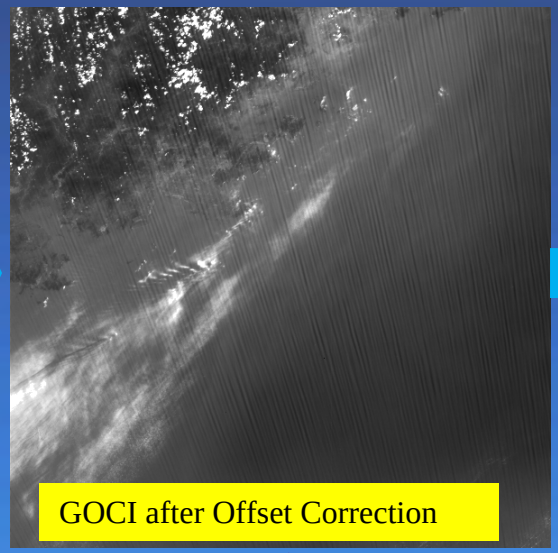
KORDI

Initial Test Result of GOCI

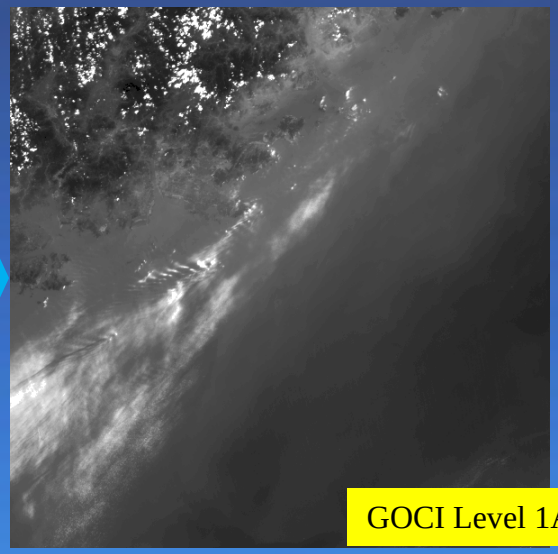
- **GOCI Radiance Restitution Process**
  - 2010. 08. 01 – Band 01



GOCI Level 0



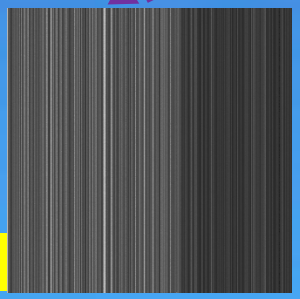
GOCI after Offset Correction



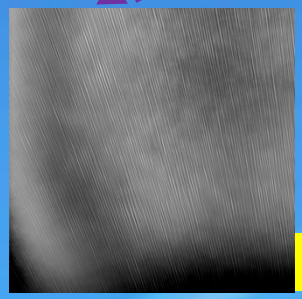
GOCI Level 1A

Offset Correction

GOCI Radiance Restitution for Level 1A



GOCI Dark current Image



GOCI Gain Image

GOCI IOT / HW

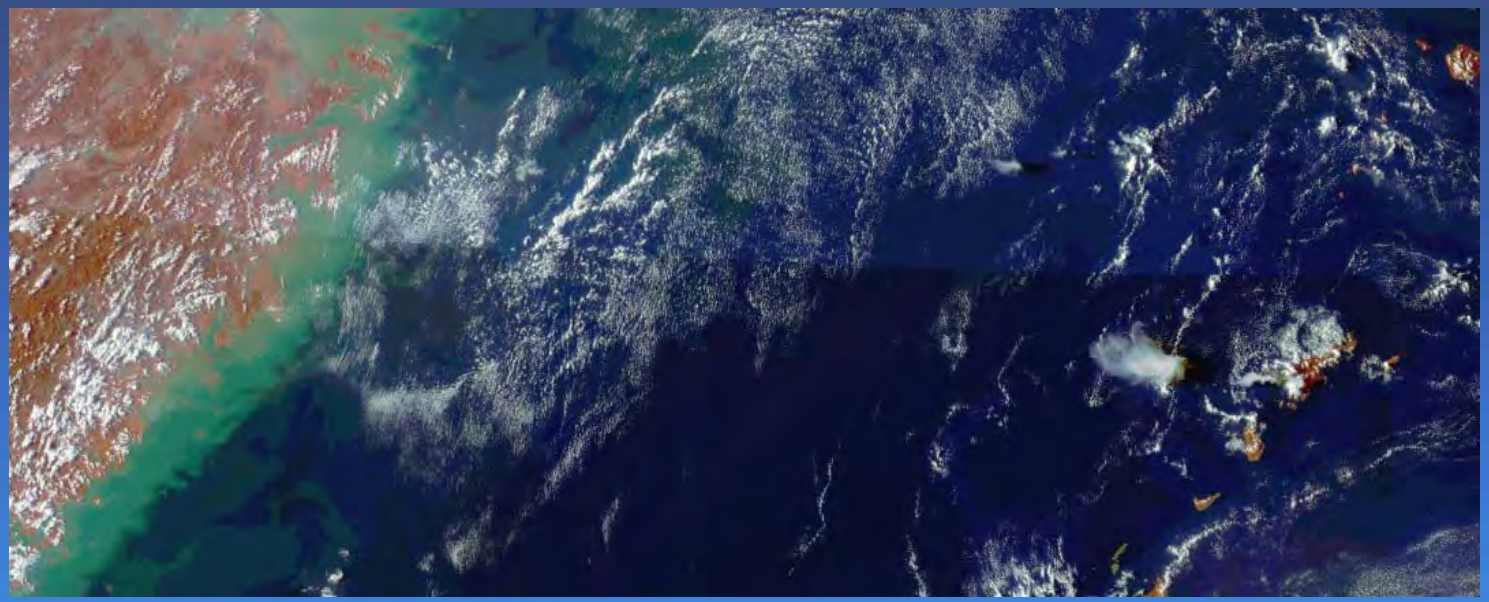
- **GOCI Sensor Status and Performance Tests**
  - **All GOCI Sub-systems are fully operational.**

Functional test		IEU A	T start	T end	Status	IEU B	T start	T end	Status
Stand-By + Thermal	GOCI_01	13/07/2010	00:05:00	00:54:00	OK	15/07/2010	00:21:00	01:06:00	OK
Mechanism activation	GOCI_02	13/07/2010	00:56:00	03:13:00	OK	15/07/2010	00:56:00	03:41:00	OK
Reference positionning	GOCI_03	13/07/2010	03:32:00	04:03:00	OK	15/07/2010	03:45:00	04:12:00	OK
Imaging in darkness	GOCI_04	13/07/2010	04:05:00	05:14:00	OK	15/07/2010	04:50:00	05:28:00	OK
Complete image	GOCI_05	13/07/2010	06:15:00	06:45:00	OK	15/07/2010	06:15:00	06:45:00	OK
Thermal during night	GOCI_06	13/07/2010 to 16/07/2010							OK
Duration	GOCI_DUR	13/07/2010	06:15:00	06:45:00	OK	15/07/2010	06:15:00	06:45:00	OK
Performance test		**IEU A**	**T start**	**T end**	**Status**	**IEU B**	**T start**	**T end**	**Status**
Dark signal & Noise	GOCI_DRK	13/07/2010	07:40:00	08:40:00	OK	15/07/2010	07:40:00	08:40:00	OK
Radiance response	GOCI_RRF 1&2	16/07/2010	13:25:00	14:10:00	OK	NA			
	GOCI_RRF 3&4	17/07/2010	13:25:00	14:10:00	OK	NA			
Calibration	GOCI_CAL S1	18/07/2010	13:25:00	14:10:00	OK	20/07/2010	13:25:00	14:10:00	OK
	GOCI_CAL S2	19/07/2010	13:25:00	14:10:00	OK	21/07/2010	13:25:00	14:10:00	OK
DAMD Acquisitions	GOCI_DAMD	22/07/2010	13:25:00	14:10:00	OK	NA			
	GOCI_DAMD	23/07/2010	13:25:00	14:10:00	OK	NA			
Parameter set	GOCI_PAR	13/07/2010	06:15:00	06:45:00	OK	15/07/2010	06:15:00	06:45:00	OK
Radiometric stability	GOCI_STAB								
MTF	GOCI_MTF	INRSM				INRSM			
GOCI SNR	GOCI_SNR								
Coverage	GOCI_COV	INRSM				INRSM			
Duration	GOCI_DUR	13/07/2010	06:15:00	06:45:00	OK	15/07/2010	06:15:00	06:45:00	OK
Ground sampling distance	GOCI_GSD	INRSM				NA			
Overlap	GOCI OVP	INRSM				INRSM			
Focal Plane parameter	GOCI FPP	22/07/2009	01:15:00	01:45:00		NA			

KORDI

GOCI slots images

Between Slot Radiometric discrepancy <4%



Bright difference between Upper & low slots
We don't know exactly this mechanism yet.
- Solar elevation angle change?
- Stray light effect ?
  * Time interval between adjacent 2 slot : 2min

=> Impact in Level-2 data production

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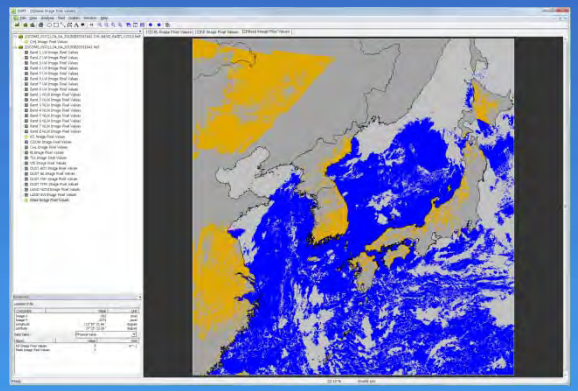
GDPS test

Preliminary L2 Generation Performance Check

- Source code level analysis is performed to improve the reliability.
- Level-2 timeliness is satisfied less than 20 -30min.
- Cloud/land mask, atmospheric algorithm. underwater algorithms are inspected.
- We have found some errors & are under the correction and improving in many parts.

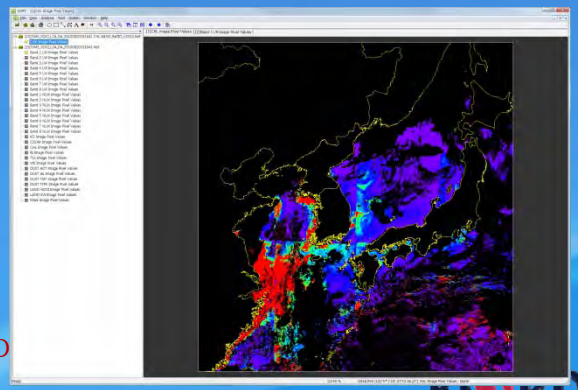
Source Error Summary

Item	Implementation Error Summary	Current Stat us
SSMM atmos correction	- No land mask before correction - The characteristics of GOCI is not reflected in the parameter f ile from the it of SeaWiFS.	Fixed
BRDF algorithm	- BF factor for band 7,8 was not demonstrated.	To be fix
SGCA algorithm	The standard time to calc solar angle was different between S GCA and SSMM. -Insert fill value as basis number.	Fixed
Remote sensing reflectance(Rrs)	- Using wrong solar irradiance for each band.	Fixed
IOP Analysis	-Equation implementation error. -Analysis for valid band	Fixed
Kd490	- Equation implementation error. - trigonometrically miscalculation by degree unit-> radian unit.	Fixed
Chlorophyll concentration	No issue	
Total suspended sediment	No issue	
Disolved organic matter	No issue	
Visibility(horizontal)	No issue	
Red-tide Index	No issue but its algorithm is depend on 1 band.	comment
Water current vector	No issue	
Fishing Ground Index	No issue	
Water Quality Grade Index	No issue	



L2 Cloud
Land Mask

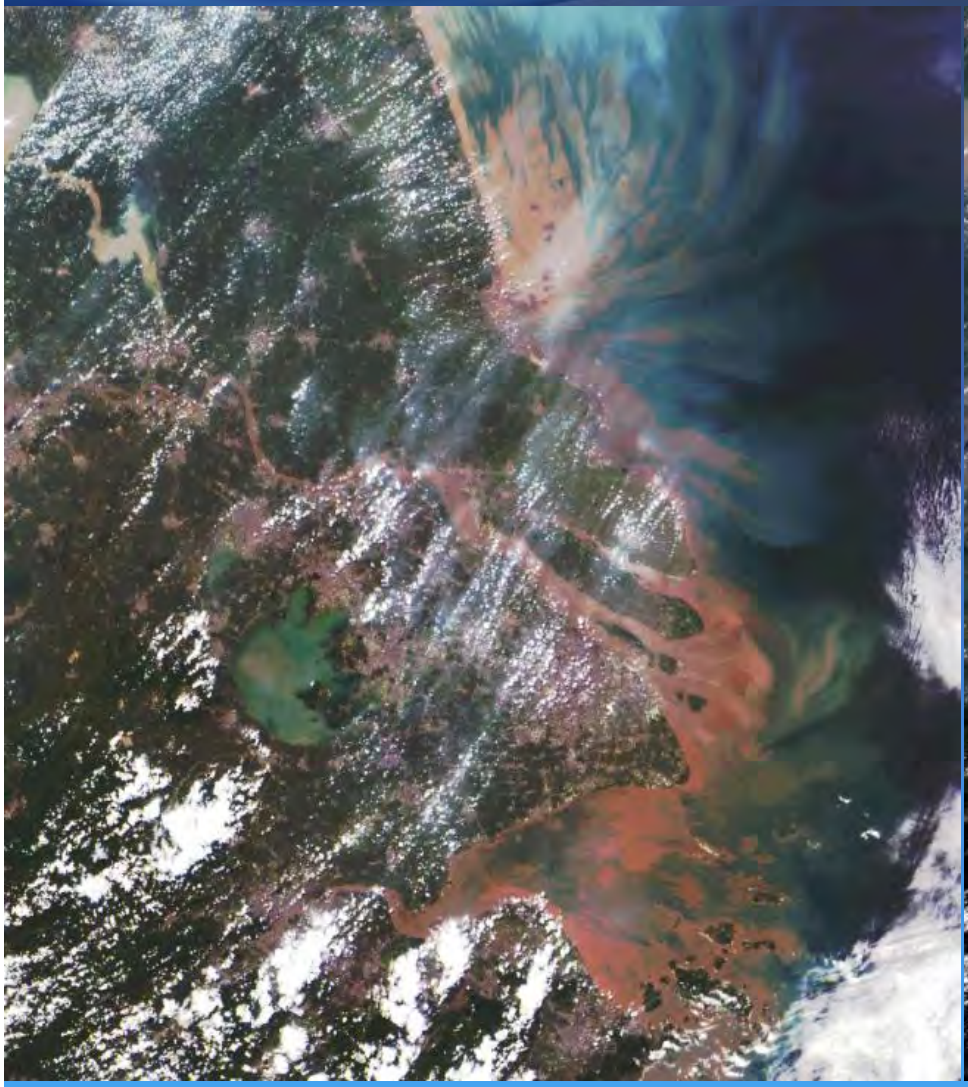
Yellow : land
Blue : sea
Gray : Cloud



L2 CHL
Band Ratio

GOCI Image quality

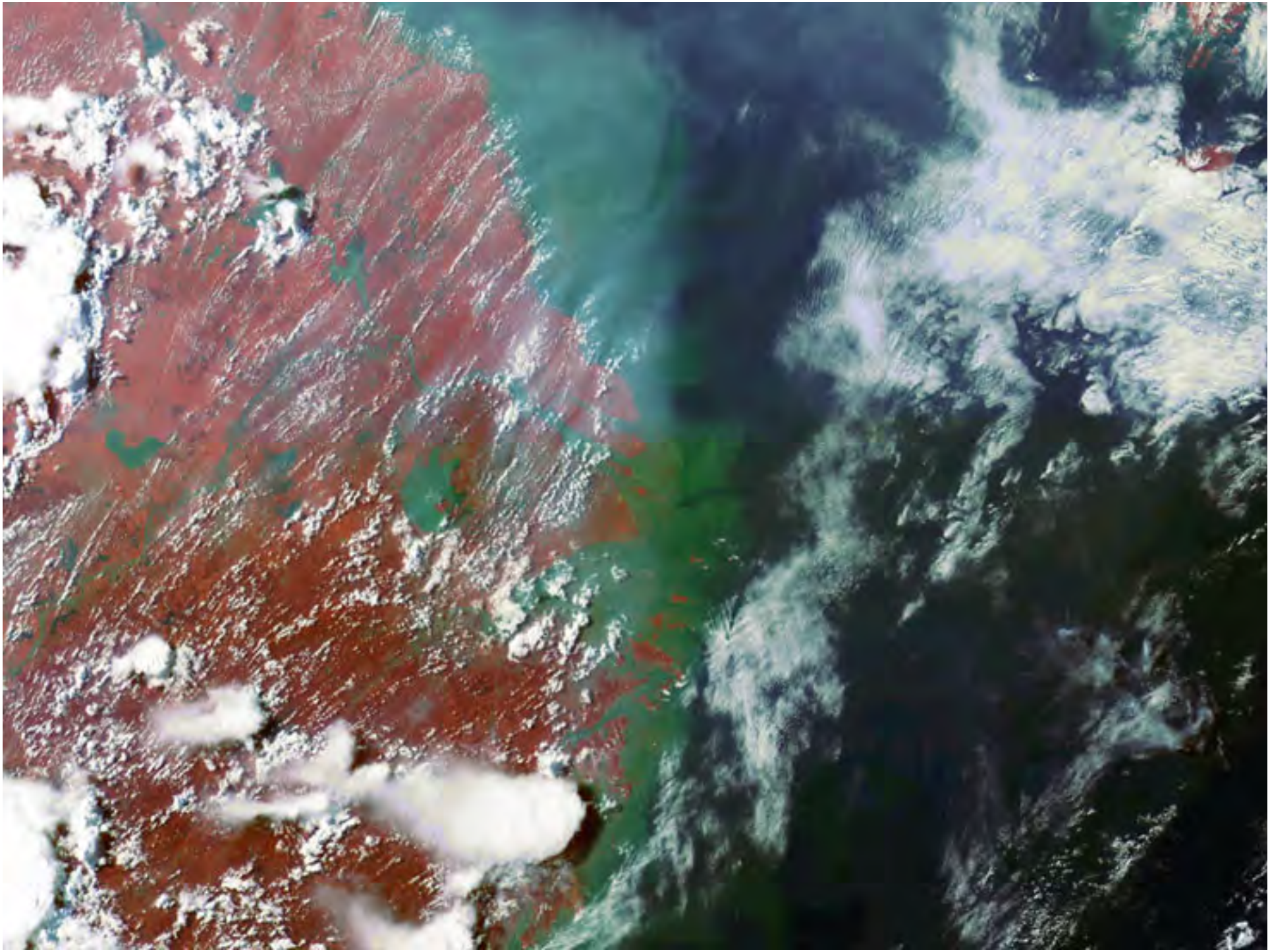
Image Comparison between GOCI and MODIS Aqua

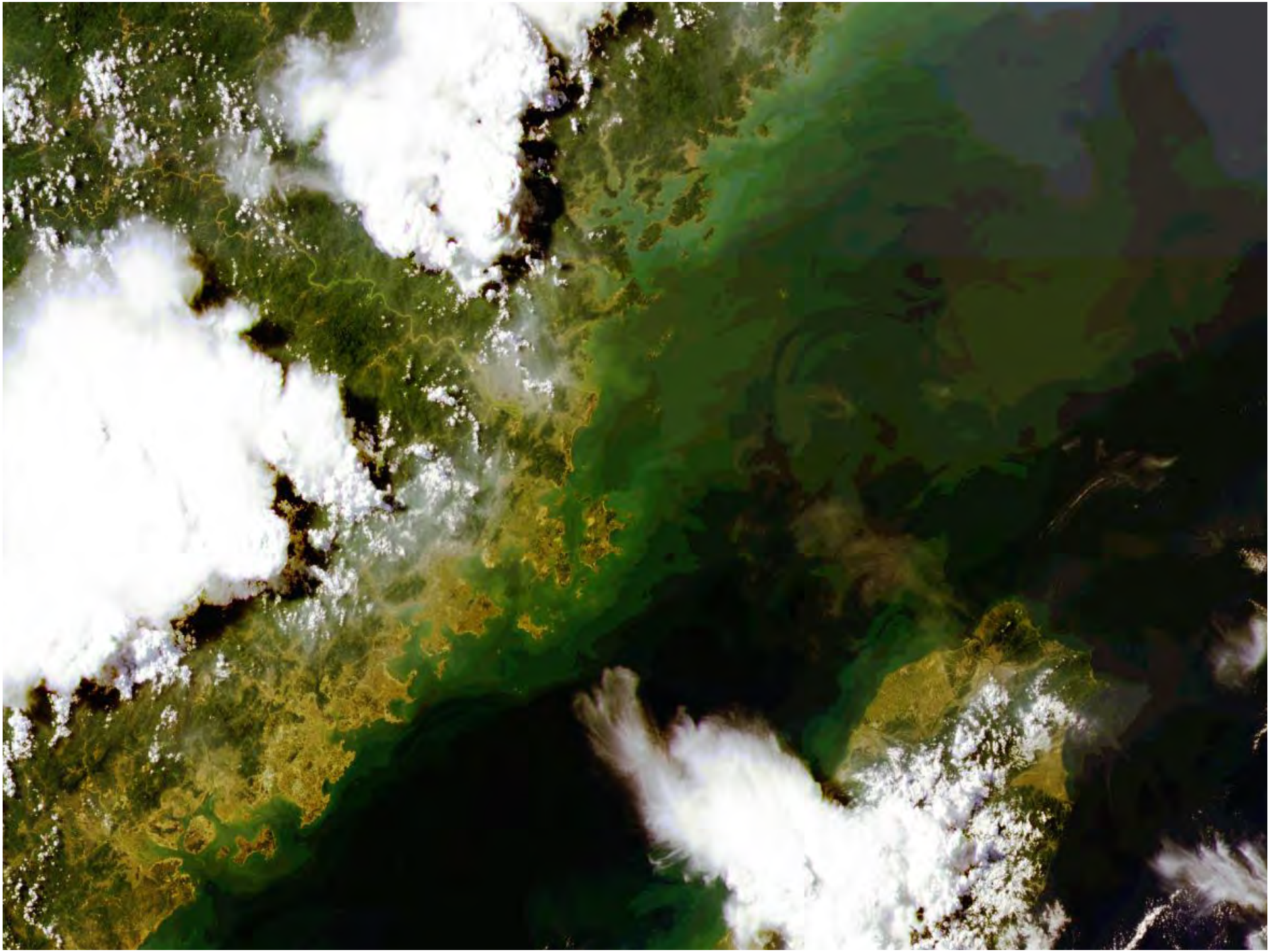


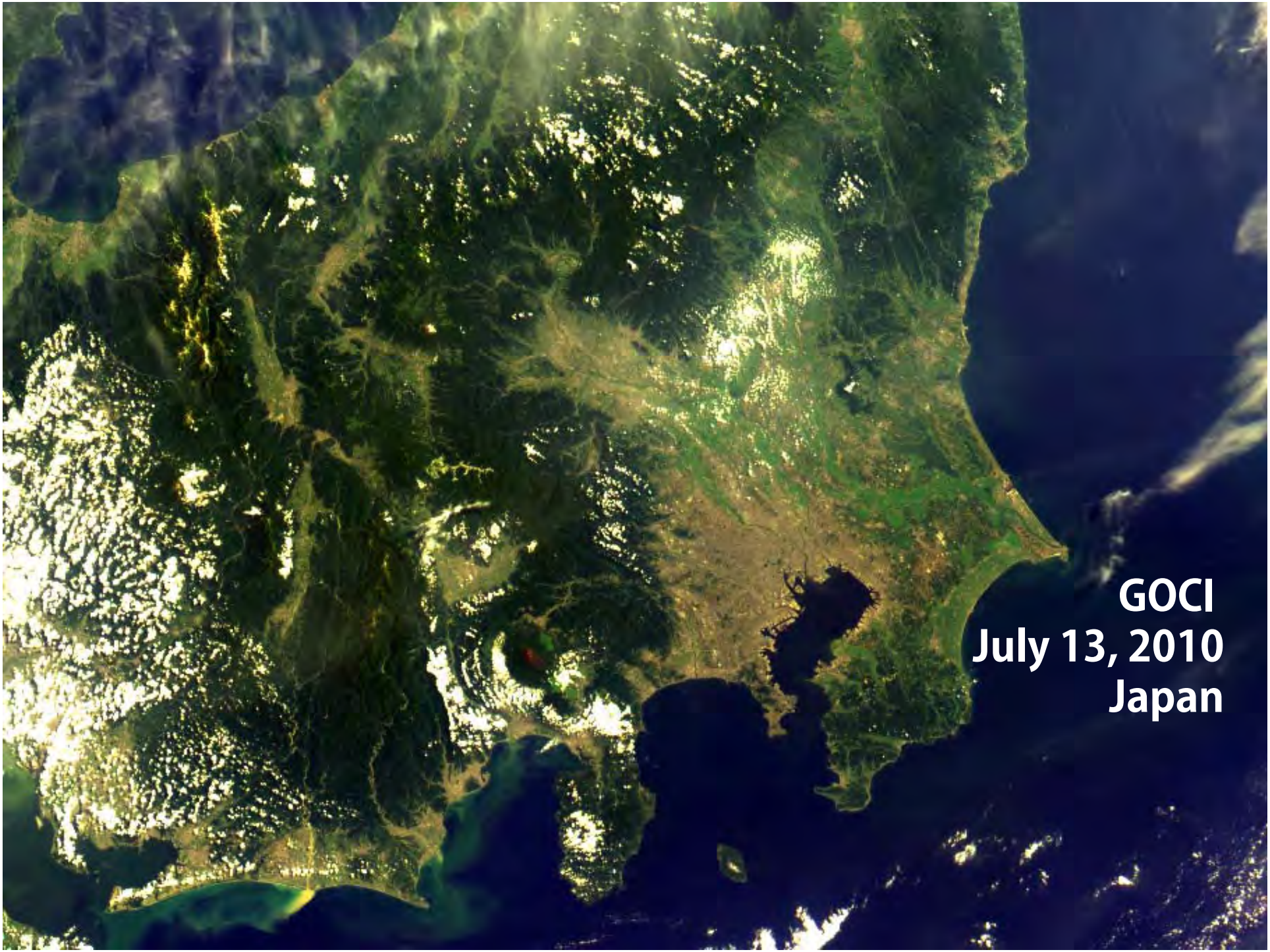
Yangtze River, China (GOCI, 20100731)
R: 660 G: 555 B:490

Yangtze River, China (MODIS Aqua, 20100731)
R: 645 G: 555 B:469

KORDI






GOCI
July 13, 2010
Japan

GOCI IOT Discussion

- Fully successful launch campaign of GOCI/COMS
- All functional tests for GOCI was successful.
- GOCI IOT for geometric performance verification is on-going
- Slot level radiometric discrepancy has been found during in-orbit test
- We need more fine tuning of all algorithms
- GDPS Should be corrected/improved in some parts. (Atmospheric correction, BRDF, under water algorithms)

KORDI

Cal/Val plan

- *in situ* measurements
  - Research vessel, Ferrybox(with KORDI), Glider(with KORDI)
  - 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

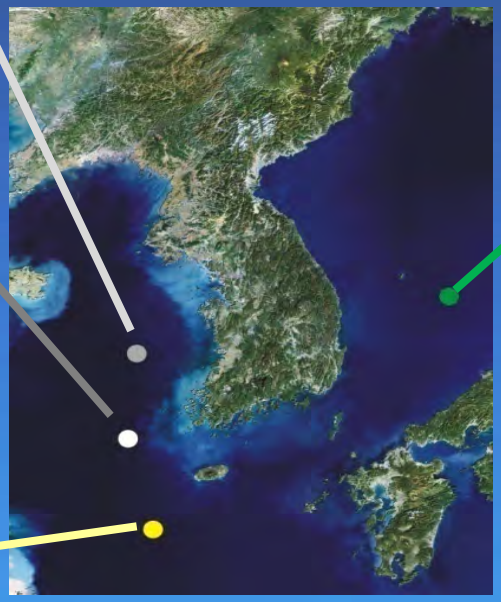
- Uniform land Cal/Val site
  - Desert, Ice, Playa

Korea Operational Oceanography Network

Yellow Sea Buoy (2007)

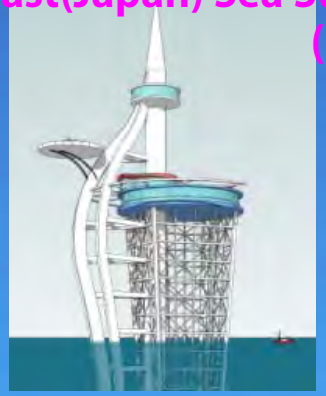
Gageocho Station (2009)

Ieodo Station (2003)



Dokdo Buoy (2009)

East(Japan) Sea Station (2012)



Two buoys and two ocean stations have already been constructed by KOON

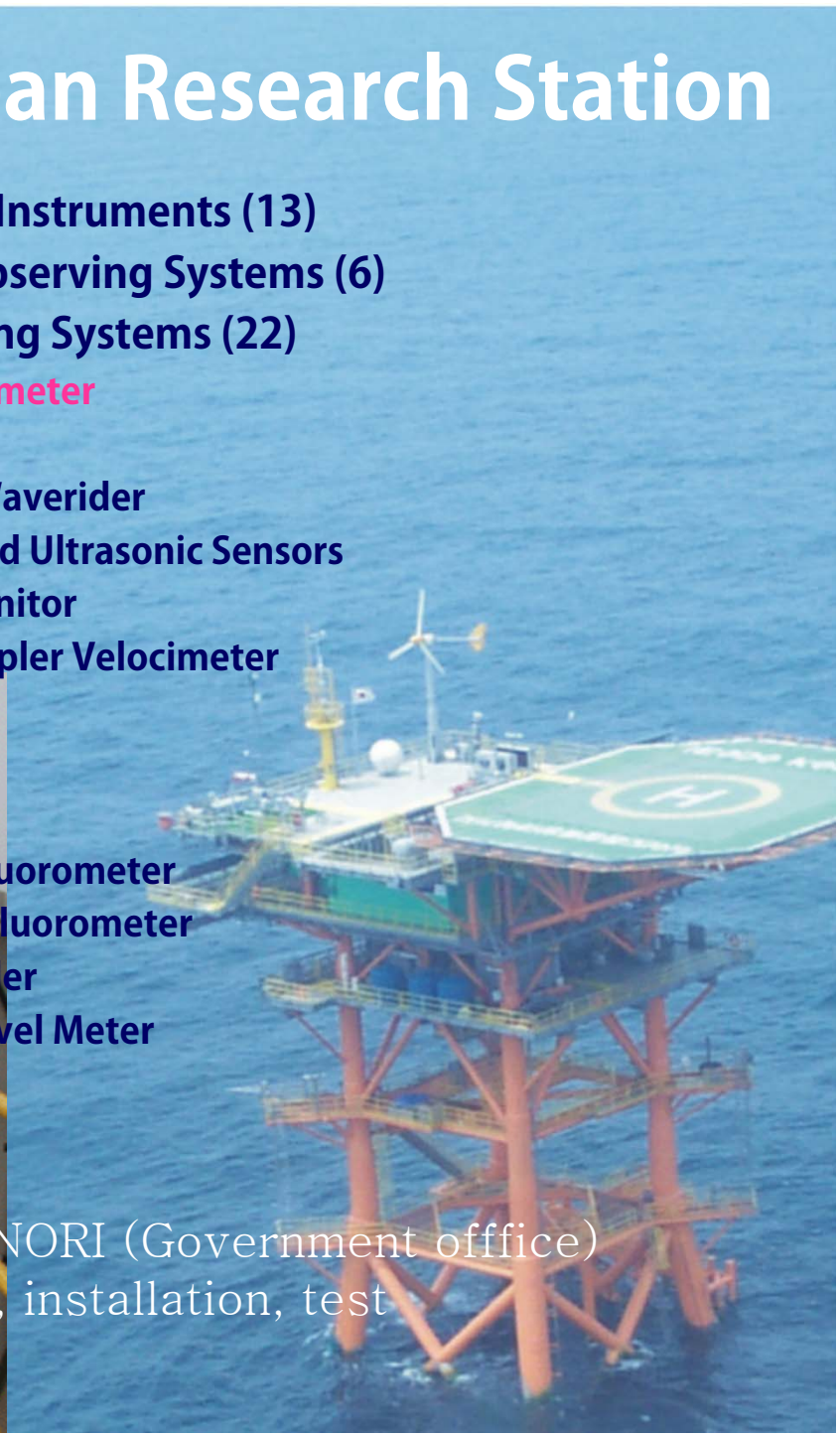
Korea Operational Oceanography Network

Ieodo Station (2003)	• Case-1/2 • Depth : 41m • 33 instruments	• Satlantic HyperSAS • 2003-2004 • Managed by Government Office
Gageocho Station (2009)	• Case-1/2 • Depth : 15m • 31 instruments	• Aeronet-OC(2011) • TriOS(2010) : broken • Fluorometry(2010) • Turbidimeter(2010)
Dokdo station (2012)	• Case-1 • 2012 (plan)	• Aeronet-OC(2013) • Fluorometry(2013) • Turbidimeter(2013)
Yellow Sea buoy (2007)	• Case-1/2 • Depth : 80m • Diameter : 10m • Weight : 50ton	• Fluorometry • Turbidimeter
Dokdo buoy (2009)	• Case-1 • Depth : 300m	• Fluorometry : lost

These systems are not for remote sensing only

Ieodo Ocean Research Station

- Meteorological Instruments (13)
- Environment Observing Systems (6)
- Ocean Monitoring Systems (22)
  - Spectroradiometer
  - Wave radar
  - Directional Waverider
  - Self Contained Ultrasonic Sensors
  - Sea Level Monitor
  - Acoustic Doppler Velocimeter
  - ADCP
  - CTD
  - CTR7
  - Ultraviolet Fluorometer
  - Chlorophyll Fluorometer
  - Current Profiler
  - Ultrasonic Level Meter
  - etc.

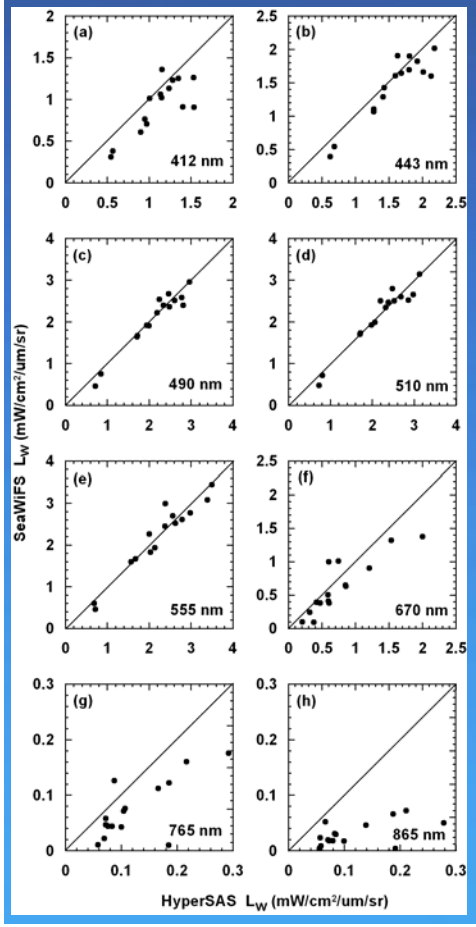


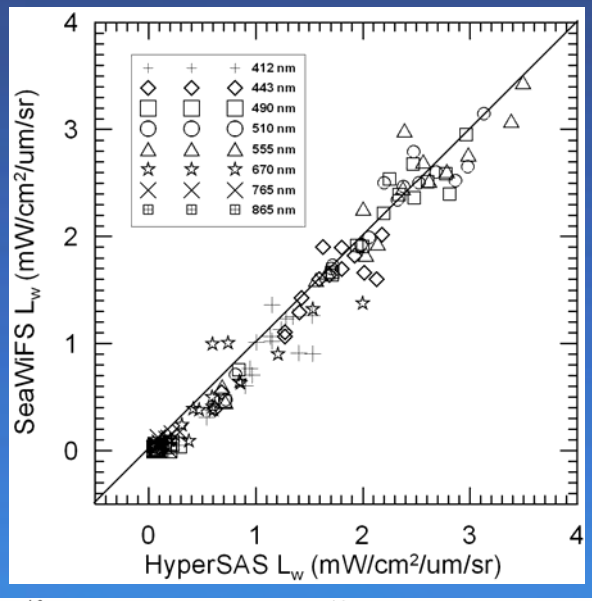
Ieodo station is managed by NORI (Government offfice)
KORDI : design, construction, installation, test
NORI : operational work

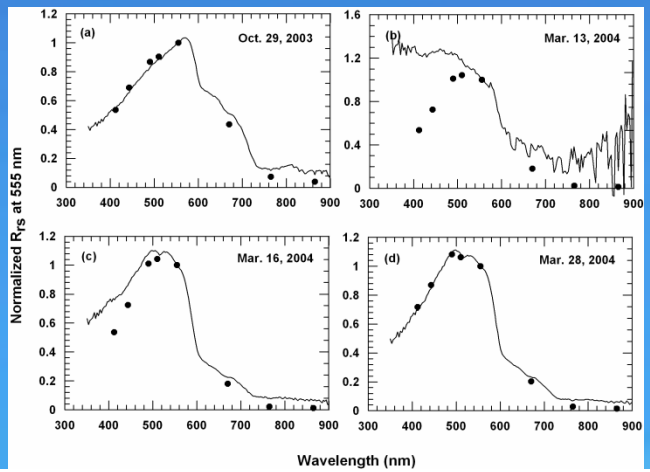
Satlantic HyperSAS OCR-3000

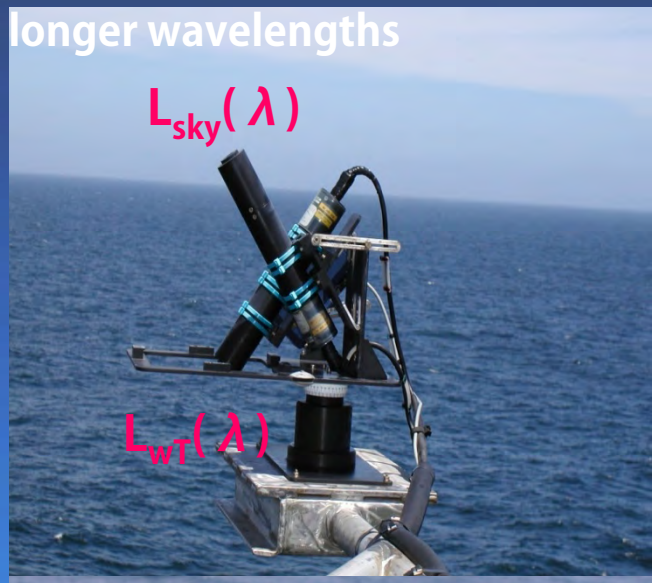
Comparison between HyperSAS and SeaWiFS water-leaving radiance in each band

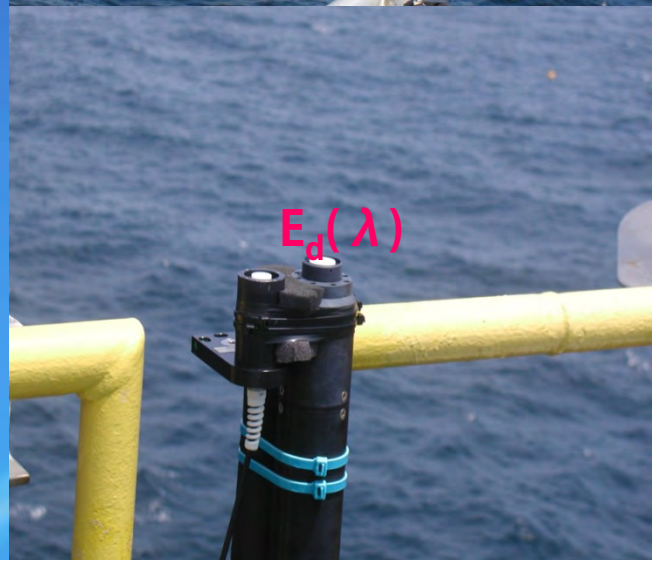
All visible bands were well correlated with SeaWiFS excepted at longer wavelengths



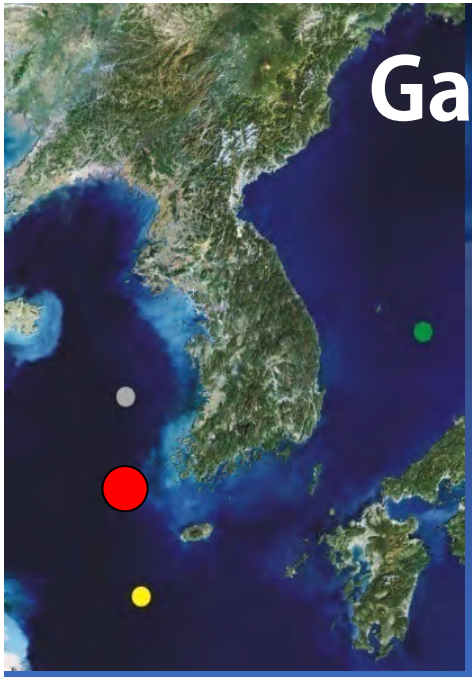






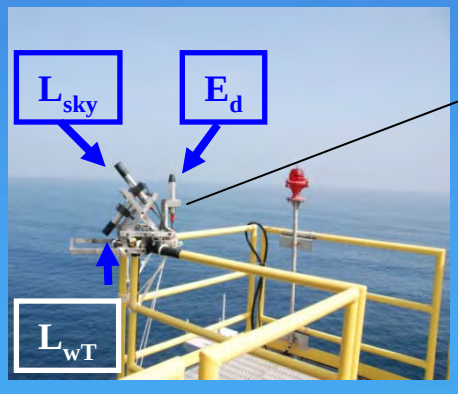


Gageocho Ocean Research Station

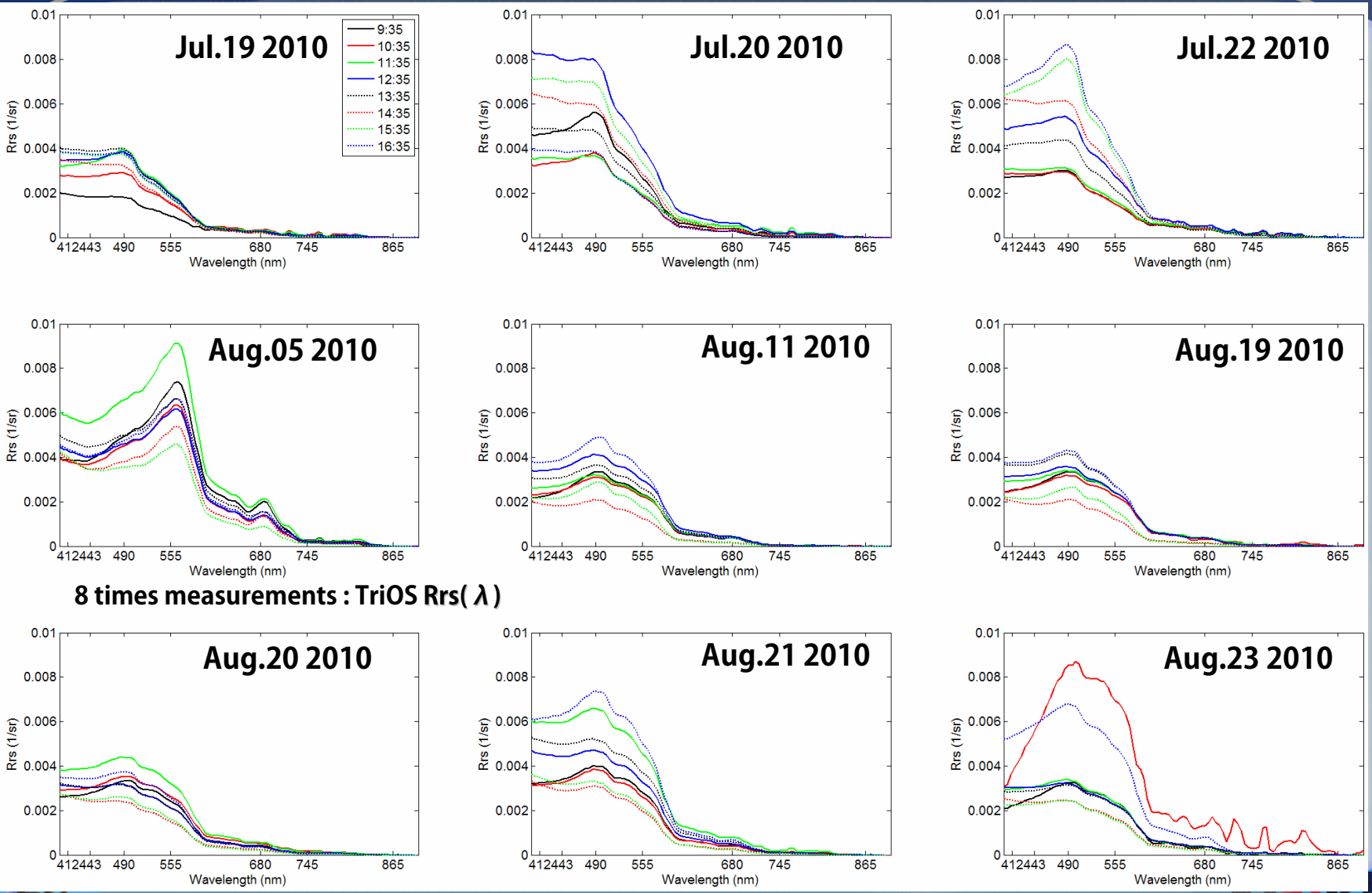


- Meteorological Instruments (12)
- Environment Observing Systems (7)
- Ocean Monitoring Systems (12)
  - TriOS (installed on Jul. 6, 2010)

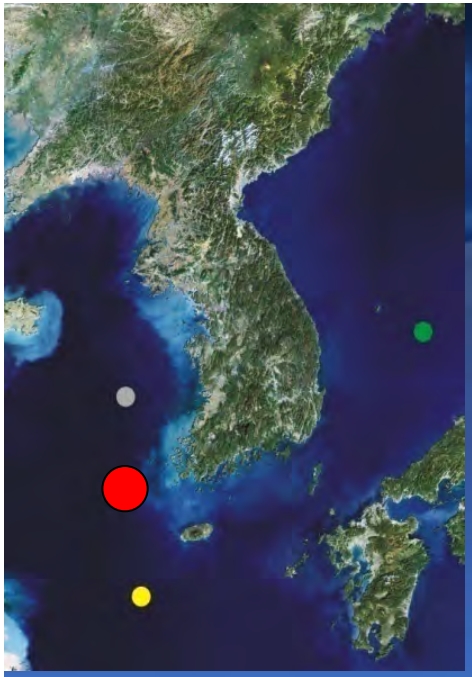
  : taken as 1-min acquisition sequences every 15min from 8 am to 5 pm
  - Aeronet-OC (will be installed at 2011)

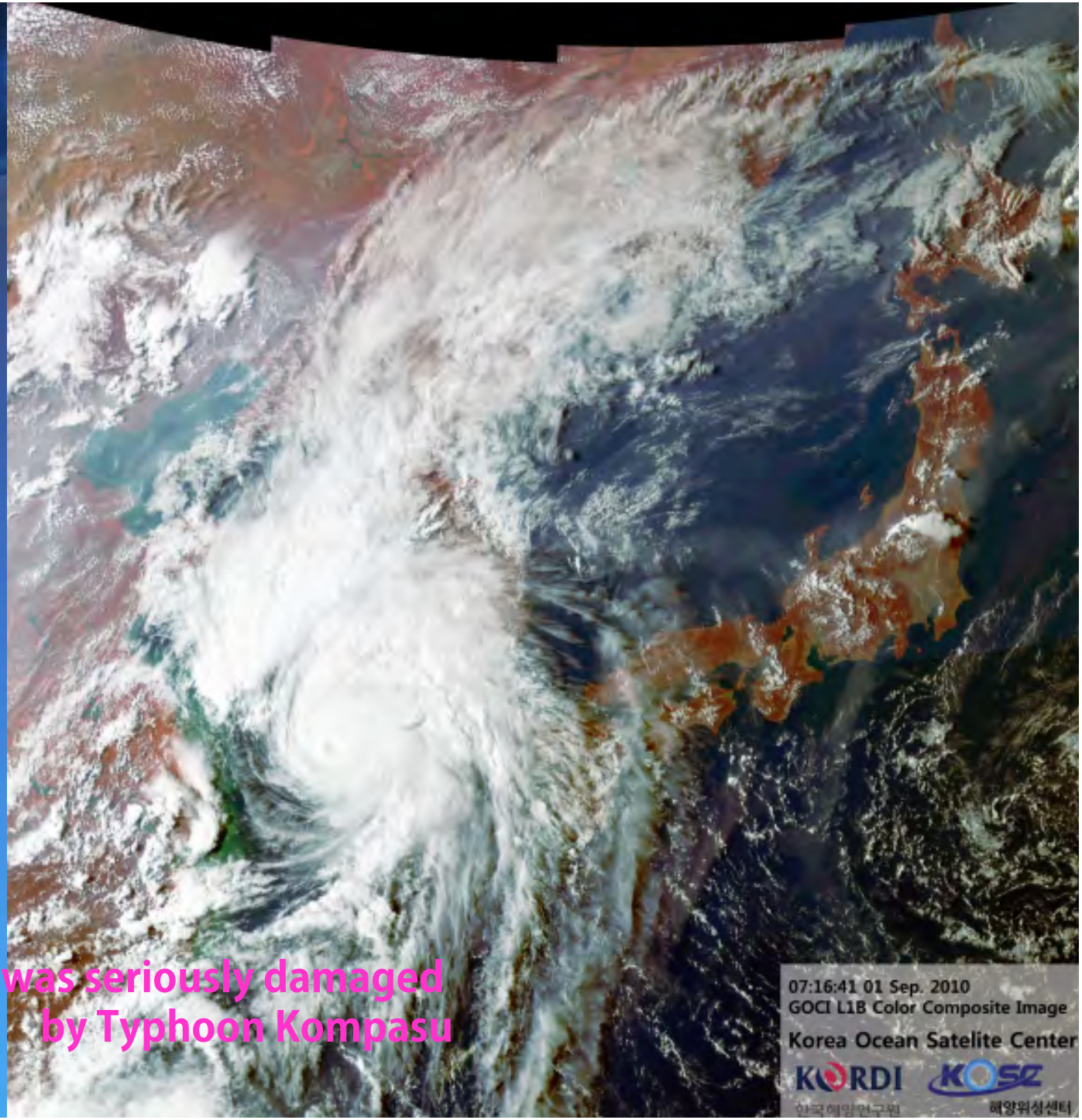


TriOS data (Jul.-Aug. : rainy season)



8 times measurements : TriOS Rrs(λ)

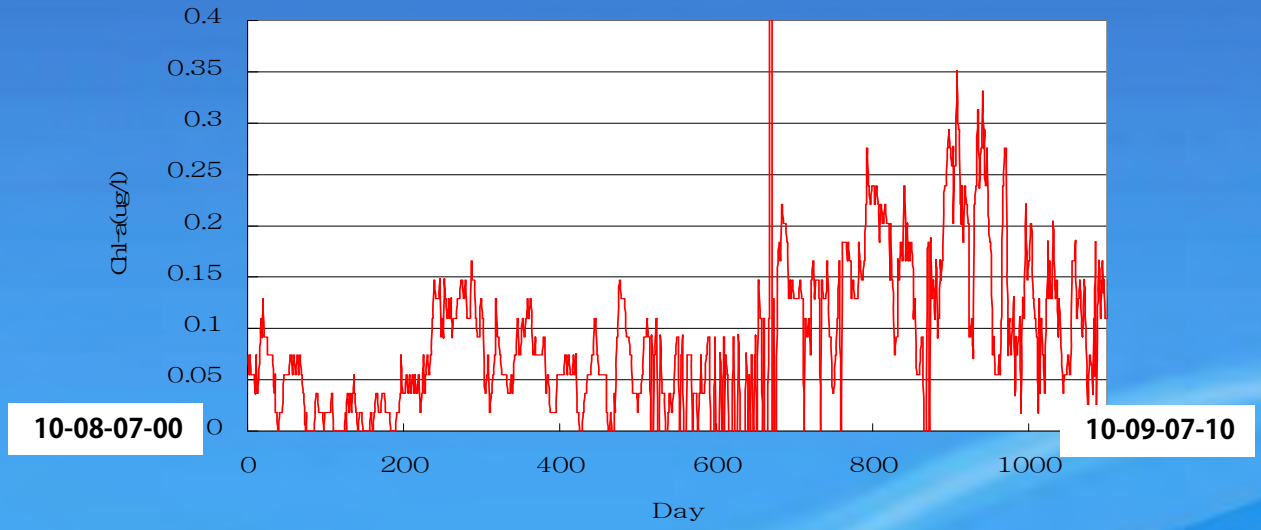




Gageocho Station was seriously damaged by Typhoon Kompasu

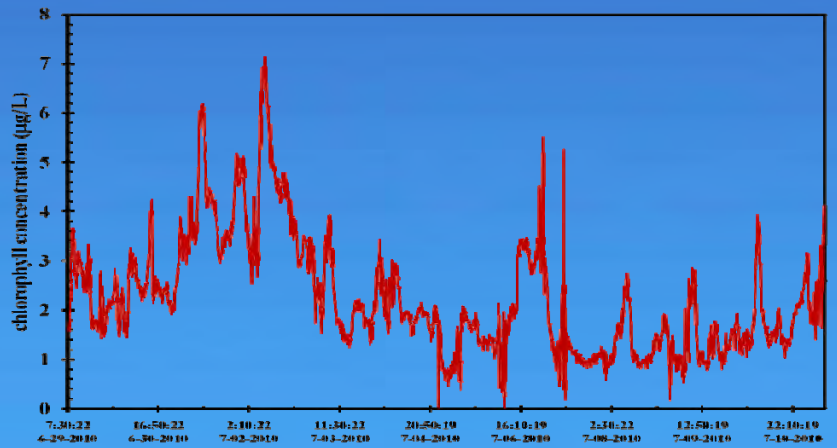
Yellow Sea Buoy

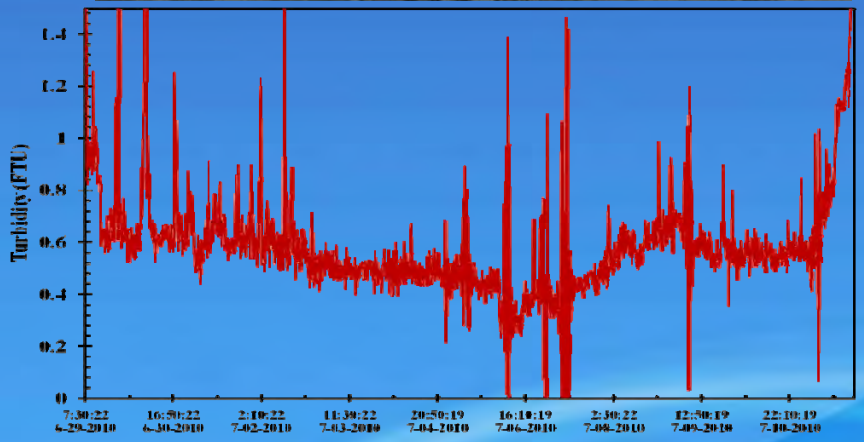
1. Re-mooring on Aug. 7, 2010
2. Real-time measurements for Chlorophyll-a, Turbidity



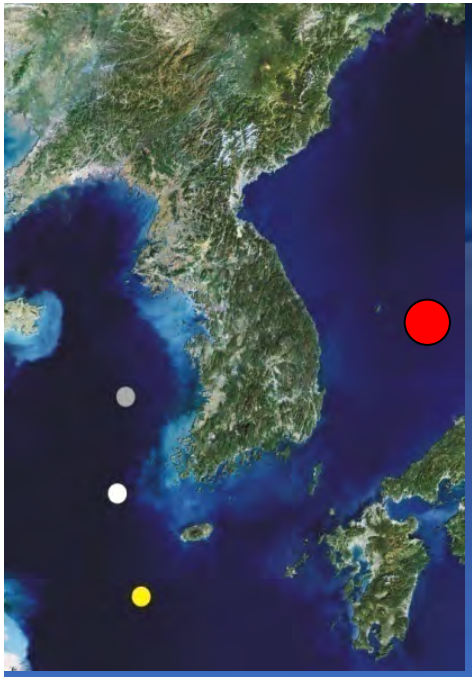
Eocheongdo Buoy : test system(temporal)

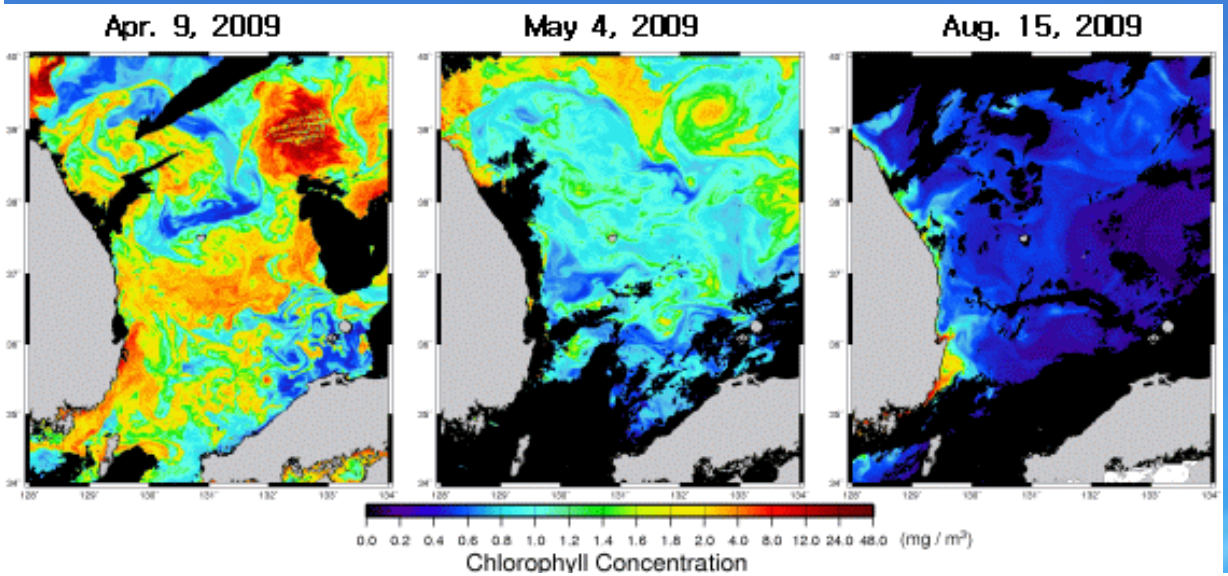
1. Mooring around Eocheongdo on Jun. 28, 2010
2. Real-time measurements of Chlorophyll-a, Turbidity, CDOM (Chelsea Inc.)

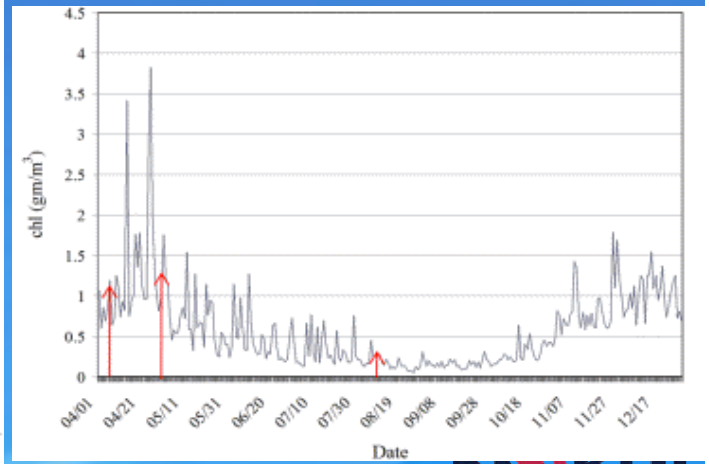




Dokdo Buoy : lost last year(monsoon)







Cross Calibration with LEO Ocean Color Sensors

Comparison of Spectral Channels

SeaWiFS	MODIS	GOCI	HICO	MERIS	Application
	411nm	412 nm	Hyperspectral 380 –1000 nm at 5.2 nm	412.5 nm	CDOM
443 nm	442 nm	443 nm		442.5 nm	chlorophyll
	487 nm	490 nm		490 nm	Chl and other pigments
520 nm	530 nm		Can match	510 nm	turbidity
550 nm	547 nm	555 nm	Any GOCI	560 nm	Chl, suspended sediments
			channel	620 nm	Suspended sediments
670 nm	665 nm	660 nm		665 nm	Chl absorption
	677 nm	680 nm		681.25 nm	Chl fluorescence
				705 nm	Blooms, Red edge
750	746 nm	745 nm		753.75 nm	O_2 abs. ref., ocean aerosols
Beyond				760 nm	O_2 abs.
Planned				775 nm	Aerosols, vegetation
Lifetime.	866 nm	865 nm		865 nm	Aerosols over the ocean
Little data				890 nm	Water vapor reference
In 2008				900 nm	Water vapor absorption

By D. Curtiss

Inter-satellite Cal : GOCI vs. HICO (by D. Curtiss)

HICO Image
Pusan, South Korea: Nov.18, 2009

Ferrybox (Container ship box)

Hanjin Co.	2,821ton 4,538ton	Length ; 93.3m Width ; 15.6m Draft ; 5.60m Speed ; 11 knot	Incheon→Kwangyang→Pusan→Incheon

GOCI Cal/Val Discussion

- No international OC Cal/Val site in GOCI coverage
  - Indirect method : Inter-satellite Cal
- Existing sites need to be stabilize for GOCI Cal/Val
  - Our efforts (with KORDI)
  - Supporting of International groups
- AERONET-OC site selection : Gageocho Station (with TriOS)
  - Already registered to NASA
  - "Once started, termination is irreversible" from David Antoine
- No land Cal/Val site in GOCI coverage
  - No desert, ice, playa : uniform, wide, long term-radiometric stability
  - Tidal flat (if possible) : uniform(except SMC), wide
- Hope to show you quantitative results in near future

KORDI

Planed GOCI Data Distribution at KOSC

- Developed GOCI Public Website at KOSC using published and approved for distribution data, publications and presentations.
- KOSC GOCI Web site would be portal for data requests and distribution
  - Data requests require proposal and data agreement signed by the requestor and their institution and approved by MLTM.
- **http://kosc.kordi.re.kr**

Thank you