In-Orbit Radiometric Calibration and Characterization Issue of Geostationary Ocean Color Imager

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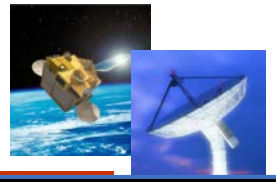
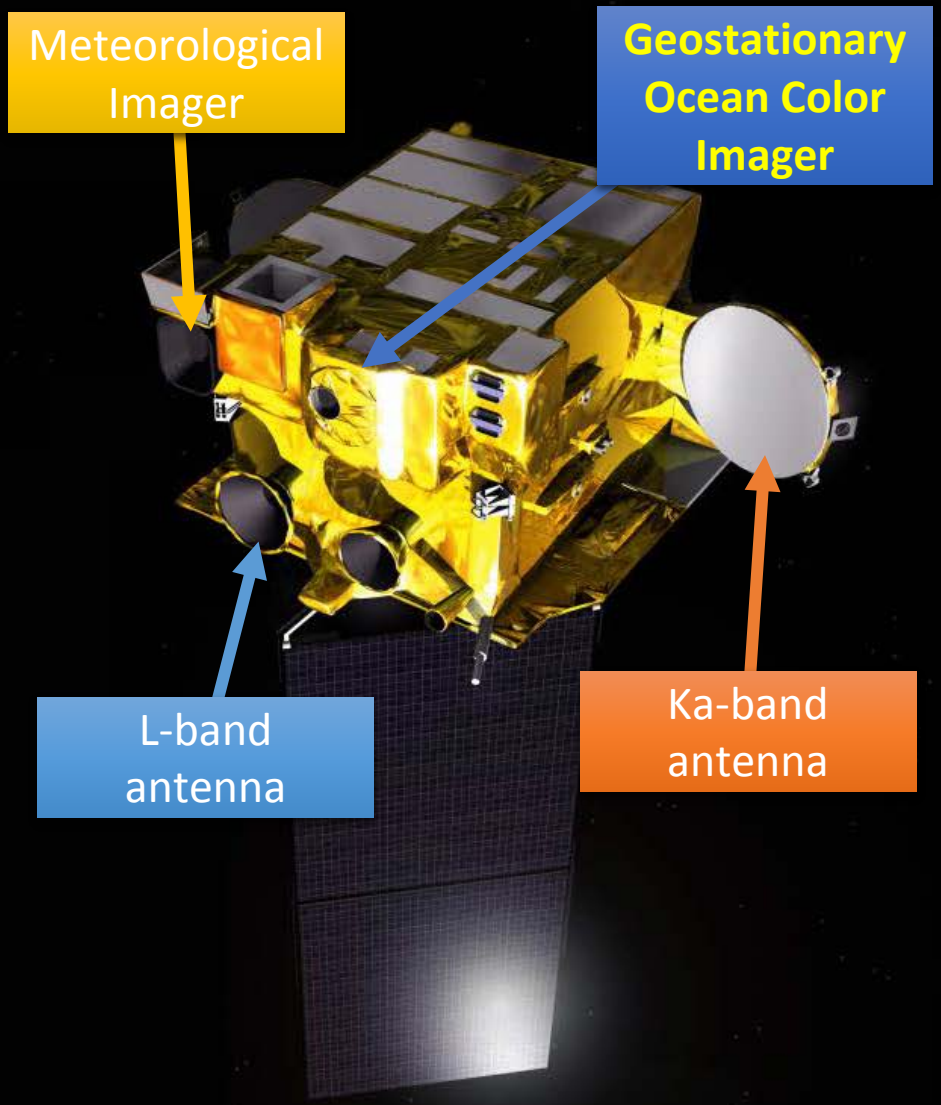
COMS (a.k.a. Chollian)

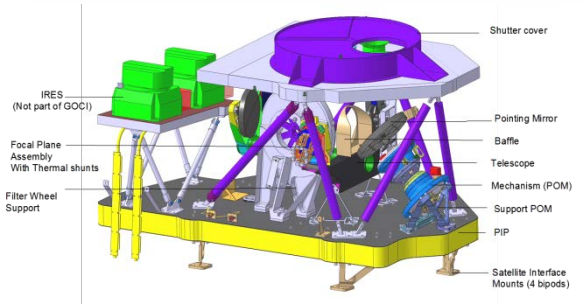


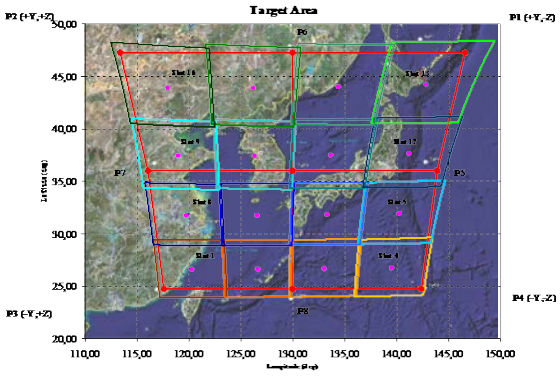


- COMS : Communication, Ocean & Meteorological Satellite
  - Development Period : 2003~2010
  - Mission and Operational Agency
    : Satellite System – msip.go.kr
    : Ocean – mof.go.kr
    : Meteo . – kma.go.kr
    : Telecomm.(Ka-Band) – kcc.go.kr
  - The first Korean Geostationary multipurpose Satellite
  - Launch date : June 27 2010
  - Lifetime : 7 years
  - Payloads (3 Missions)
    - **Geostationary Ocean Color Imager (GOCI)**
    - Meteorological Imager
    - Ka-band Communication Antenna

GOCI : Overview

- Geostationary Ocean Color Imager
  - **VIS/NIR Multispectral Imager for Ocean Monitoring**
  - GSD(Ground Sampling Distance) : 500m@130°E 36°N, ~390m@nadir
  - Target Area : 2,500km * 2,500km (Center : 130°E 36°N; Pohang-Si, Korea)
  - Temporal Resolution : 1hour (8 times at 1 day)



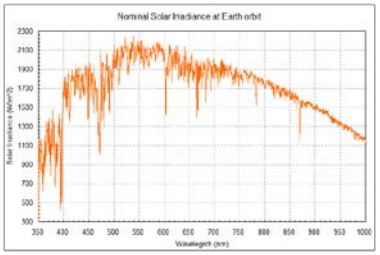


Spectral Bands Characteristics of GOCI

Band	*Band Center*	*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

Calibration Radiance Calculation

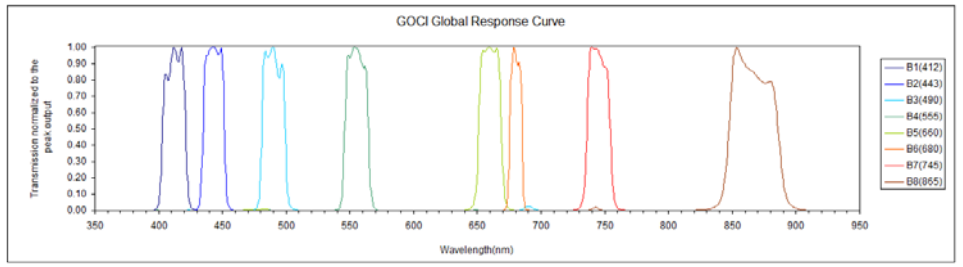
Solar Irradiance Reference Spectra



(Ref. Thuillier, 2004)

Solar Irradiance

GOCI Instrument Spectral Model



Sun-Earth Distance Model

$$D_{es} = 1.00011 + 0.034221\cos(\Phi_{day}) + 0.00128\sin(\Phi_{day}) + 0.000719\cos(2\Phi_{day}) + 0.000077\sin(2\Phi_{day})$$

(Ref. Spencer, 1971)

Calibration Radiance Calculation

Sun-Earth Distance Model

Instrument Spectral Model

In-Band Instrument Solar Irradiance

Solar Incident Angle

Solar Diffuser BRDF Model

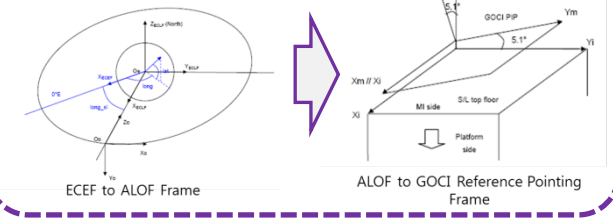
Calibration Radiance

Solar Incident Angle Calculation

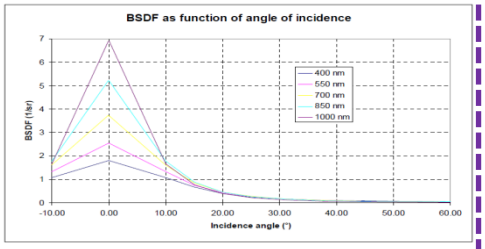
Orbital Position of Sun

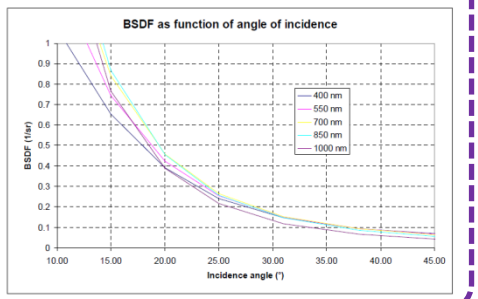
– VSOP82 Model **(Ref. P. Bretagnon, 1982)**

Frame Conversion



GOCI Diffuser BRDF Model

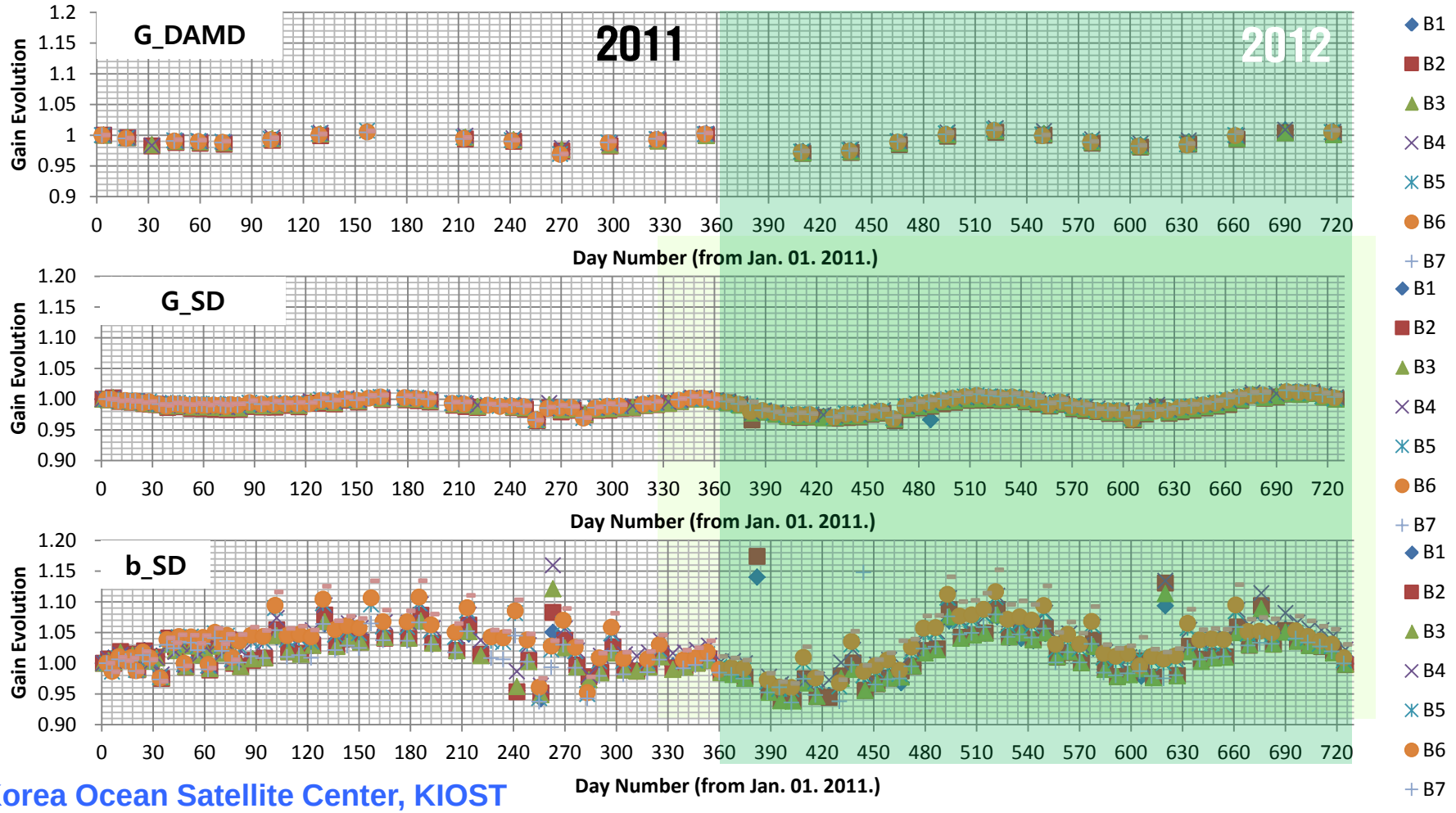




- **VSOP: Variations Séculaires des Orbites Planétaires**
- **ECEF: Earth Centered Earth Fixed Frame**
- **ALOF: AOCS Local Orbital Frame**

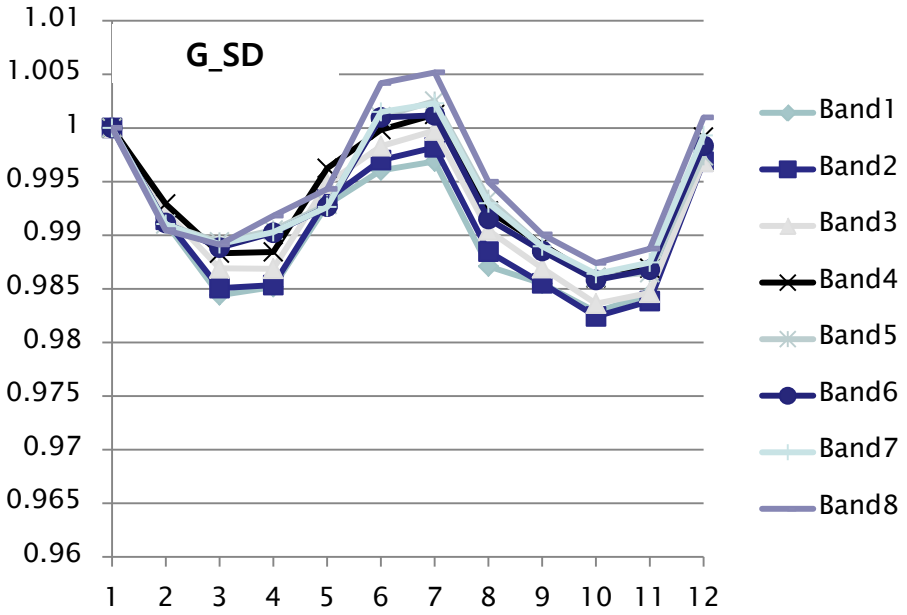
In-Orbit Calibration Results

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

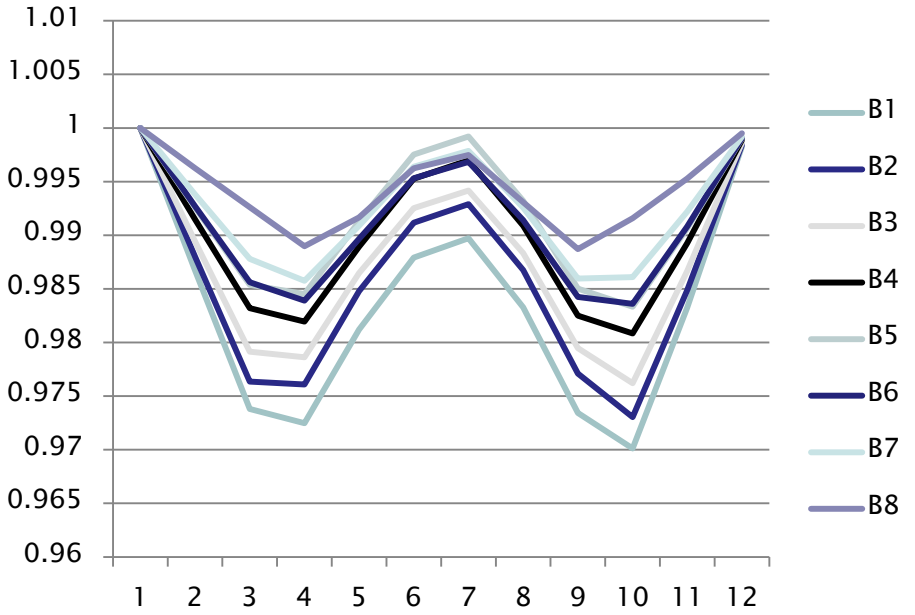


Discussion for Gain Evolution (1 /3)

- **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)



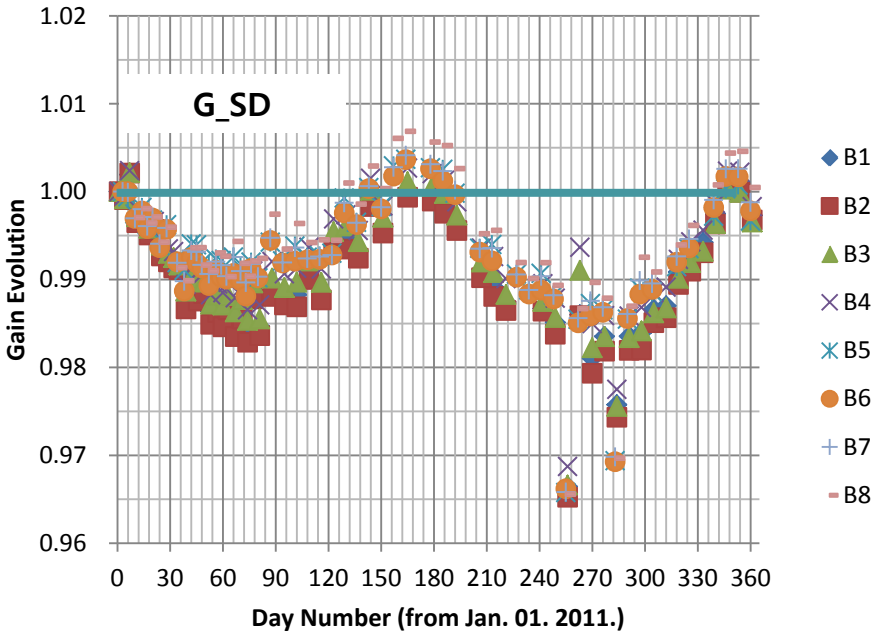
Evolution of Radiometric Gain (2011)



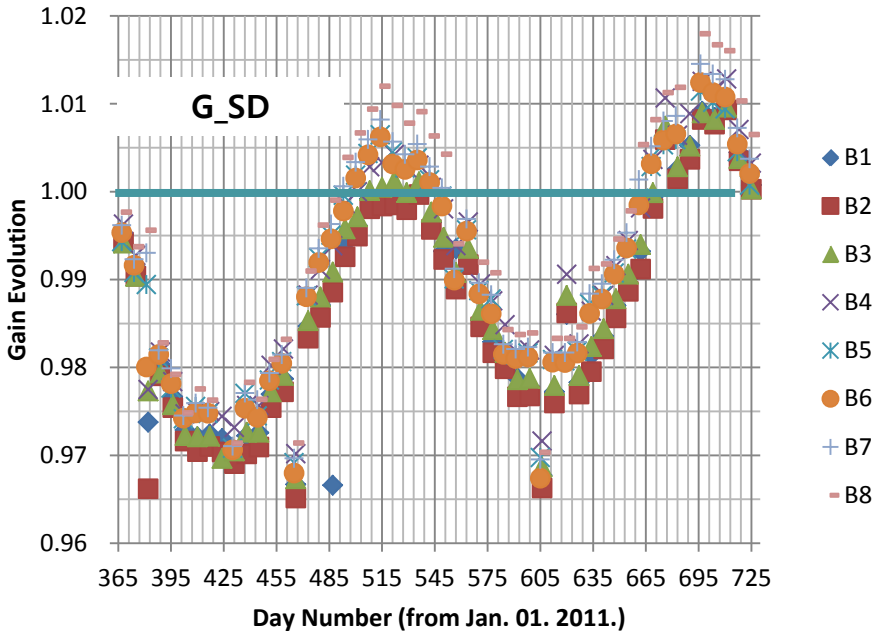
Diffusion Factor Variation
w.r.t. Solar azimuth **angle measured in pre-flight test**

Discussion for Gain Evolution (2/3)

- **Evolution of Radiometric Gain (2011. vs. 2012.)**
  - Radiometric Gain Variation(2012) : ~ 4% (from '11./01./01.)
  - Amplitude of variation is larger than year of 2011.
    - Required S/W code debugging for diffuser BRDF model
    - Might be the contribution of aging of diffusion factor



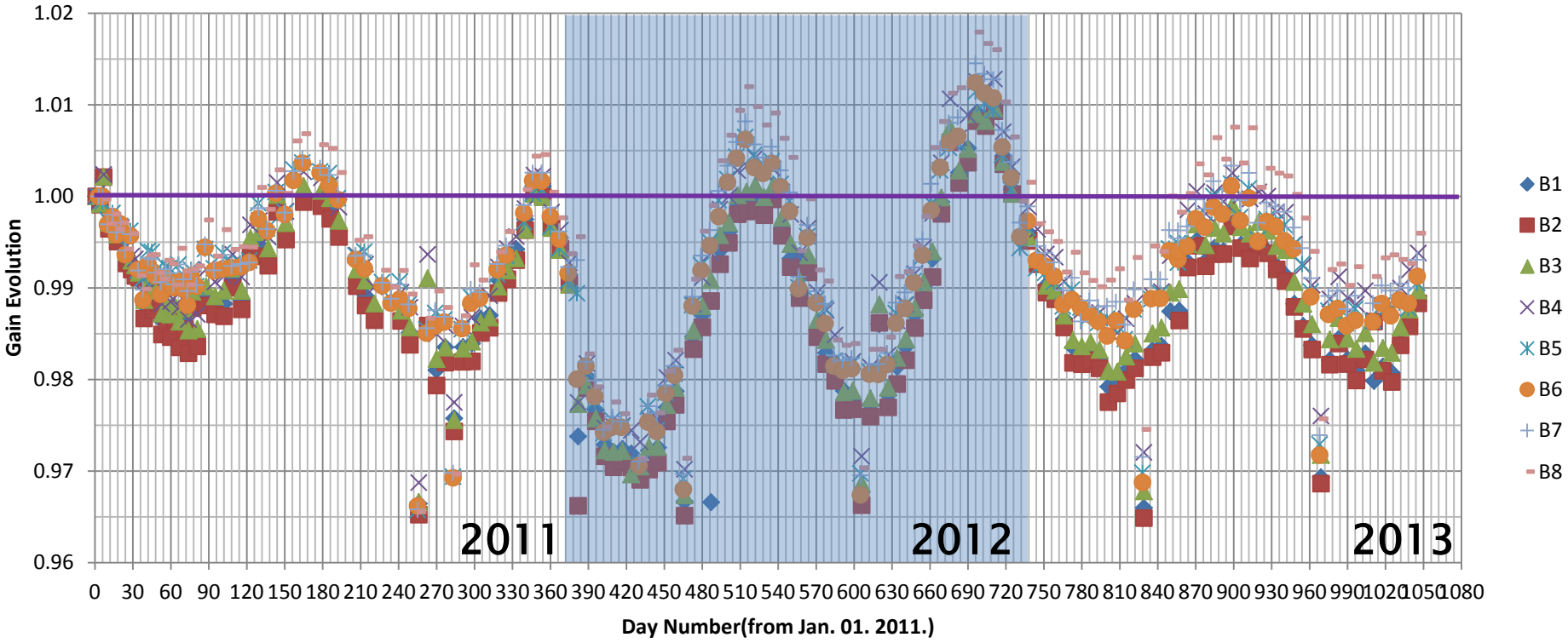
Evolution of Radiometric Gain (2011)



Evolution of Radiometric Gain (2012)

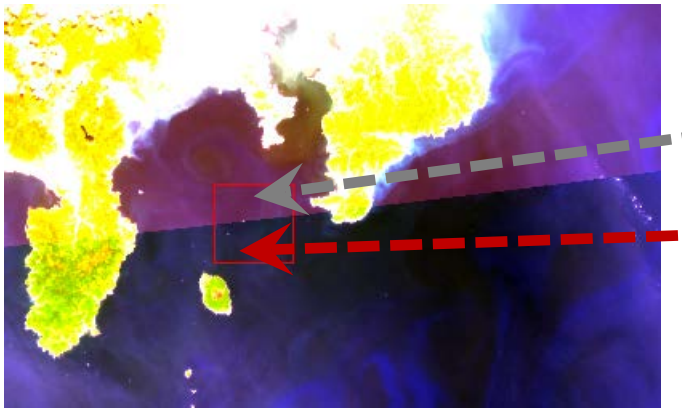
Discussion for Gain Evolution (3/3)

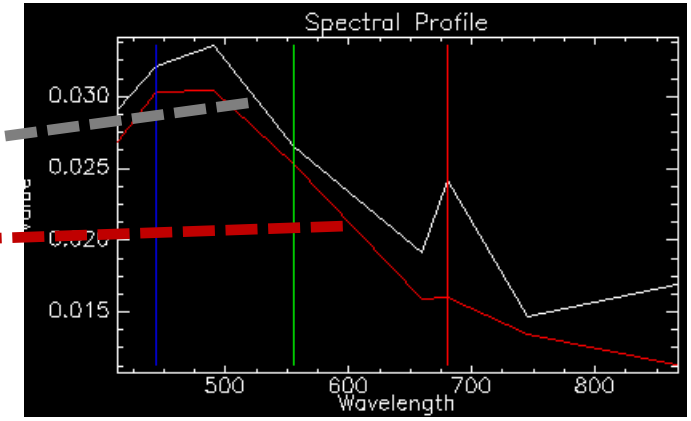
- **Evolution of Radiometric Gain (2011~2013)**
  - Gain Variation is stabilized in 2013
  - At same Solar incident(az/el) angle, Gain evolution between 2011 to 2013 is ~0.25% (incl. diffuser aging)



Inter-Slot Radiometric Discrepancy

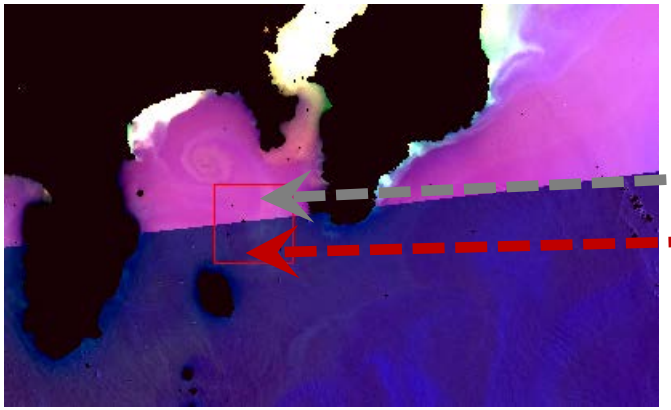
TOA RGB

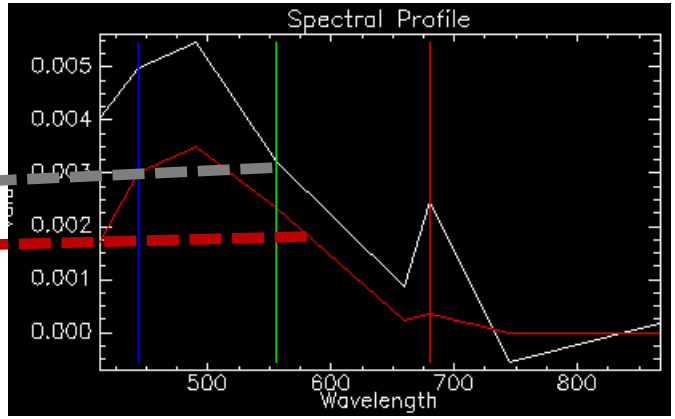




Atmospheric correction

Lw RGB

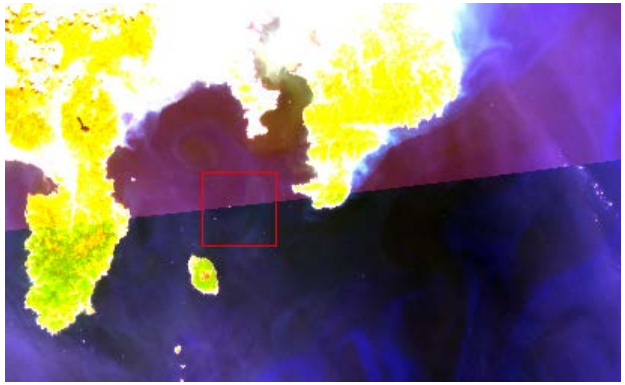




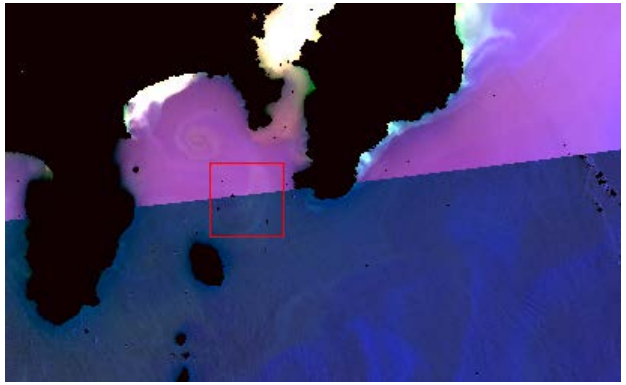
(Courtesy of Dr. Youngje Park)

Inter-Slot Radiometric Discrepancy

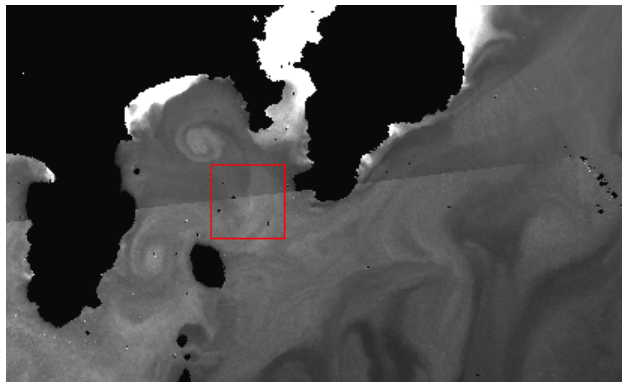
◆ ISRD Correction Algorithm developed by Dr. Park



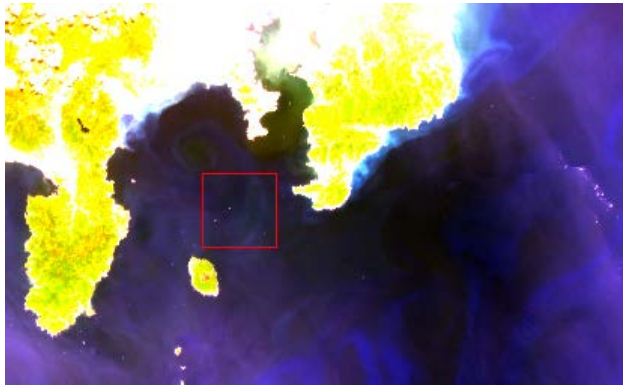
TOA RGB

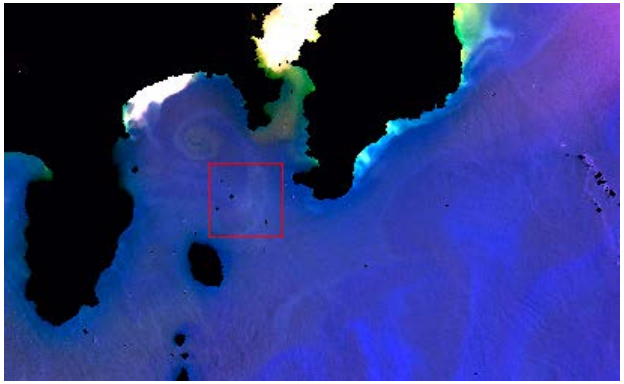


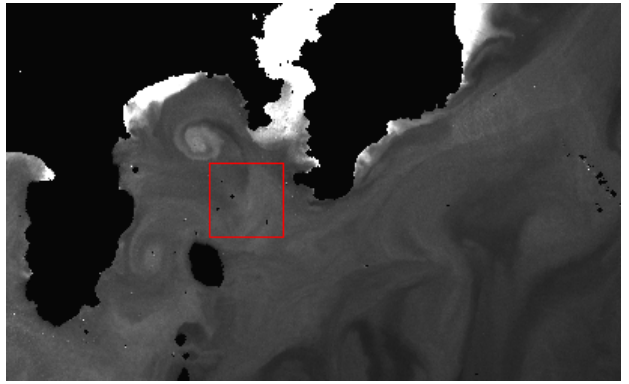
Lw RGB



Chla



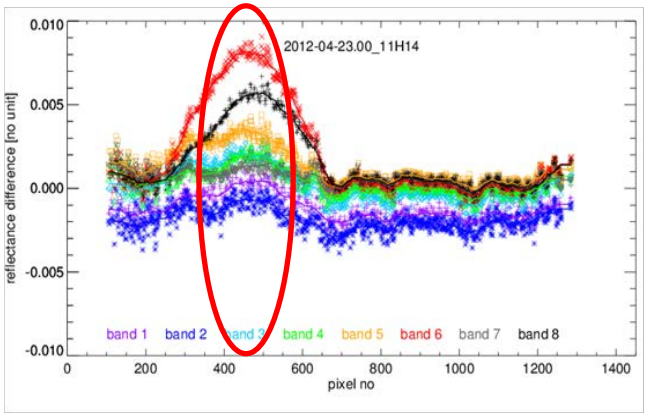


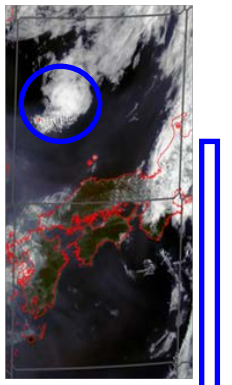


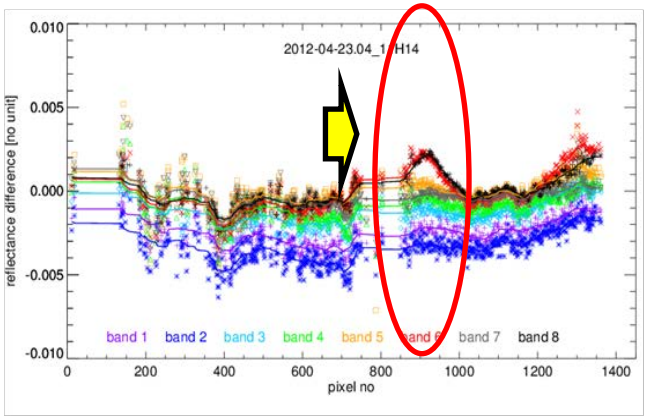
(Courtesy of Dr. Youngje Park)

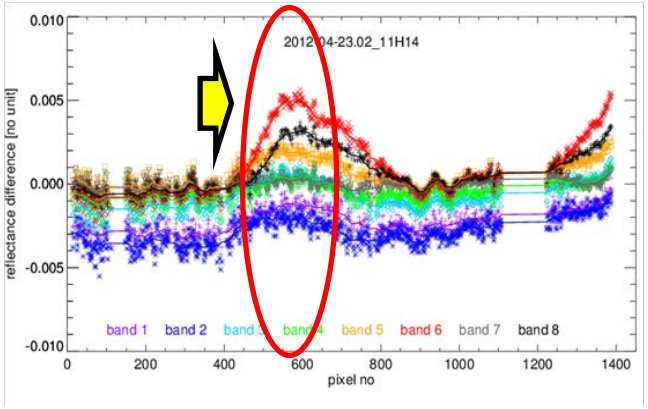
Inter-Slot Radiometric Discrepancy

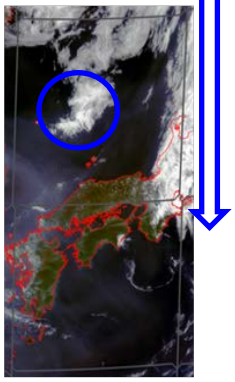
- ISRD caused by the cloud, straylight and sensor calibration irregularities

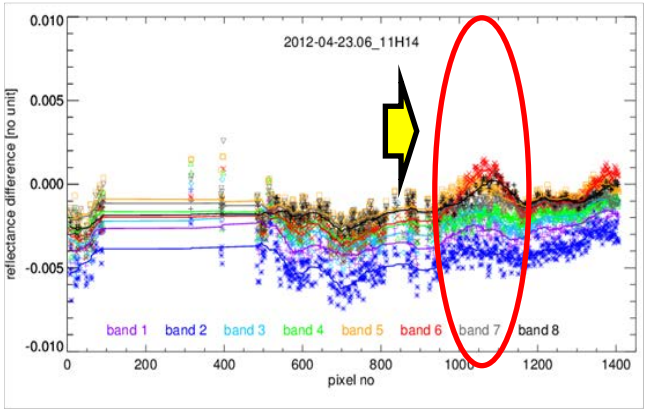












(Courtesy of Dr. Youngje Park)

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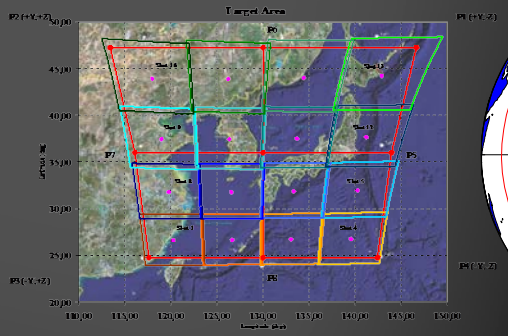
In-Orbit Calibration Concept of GOCI-II

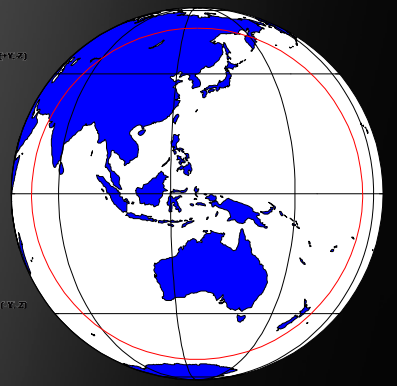
GOCI-II

- 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 2013, and will be launched in 2018.
- The user requirements of GOCI-II will have higher spatial resolution, 250m×250m, 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 or twice is planned for GOCI-II.

Items	GOCI Specs	GOCI-II Specs
Increased band number	8 bands	12+1 bands
Improved spatial resolution	500m	250m
More observations	8 times/day	10 times/day
Pointable & Full Disk coverage	Local Area	Local Area + Full Disk



LA (Reference Local Area)



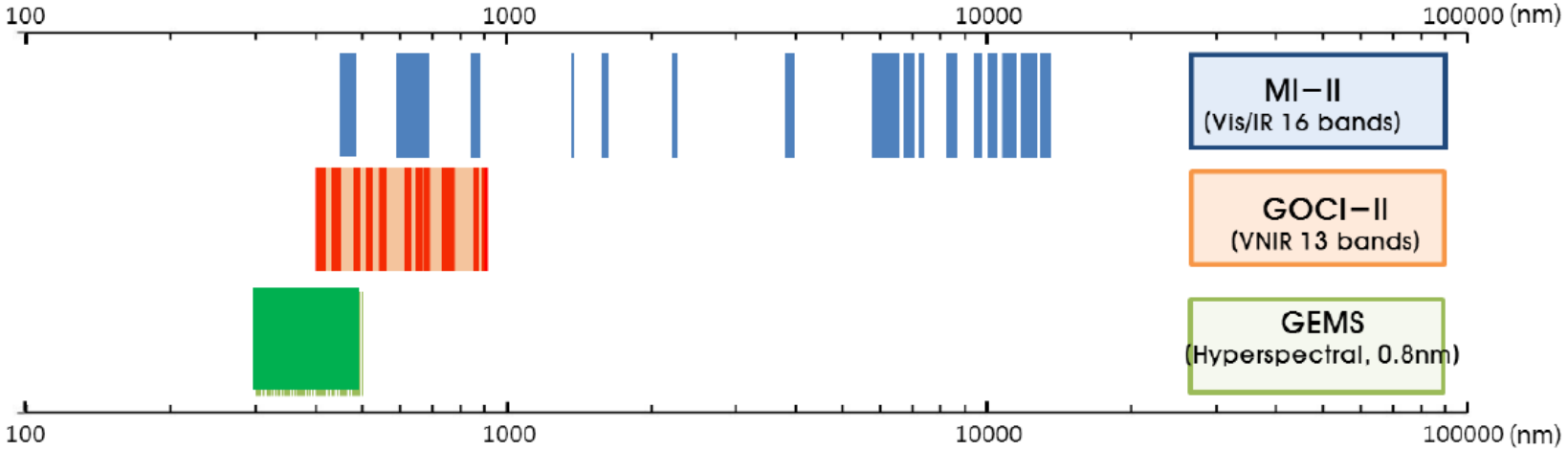
FD (Red Circle)

- **Spectral Bands Requirements (TBD)**
  - 13 Bands (GOCI : 8 Bands)
  - Phytoplankton type verification, Nighttime Observation, 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)

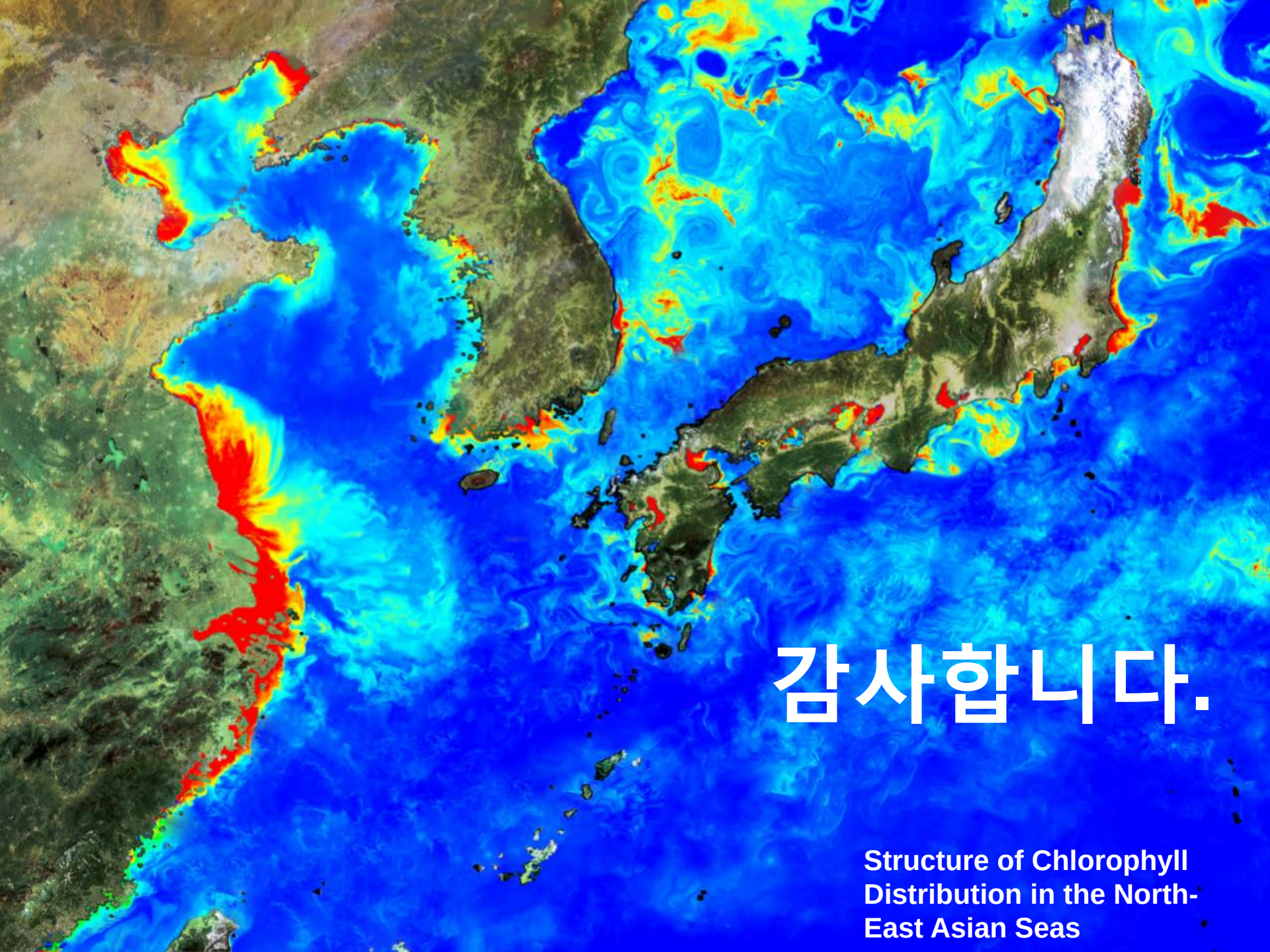
GEOKompsat-2 Payloads Requirements



	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

Concluding Remarks

- **In-Orbit Calibration of GOCI**
  - After 3-year operation, GOCI can be regarded as stabilized status in terms of in-orbit radiometric performance.
- **ISRD issue on GOCI**
  - Verified that residual discrepancy of GOCI comes from instrument level optical ghost
  - Pre-launch characterization such as straylight/ghost is quite important for the QC of satellite data
  - For GOCI-II, instrument level design to minimize straylight/ghost are taking into account
    - Enhanced Optical Design implementing intermediate focal plane with quasi field stop, and etc.
    - Dedicated prelaunch test campaign for ISRD characterization
- **Lunar Calibration for GOCI-II**
  - Expected to have more reliability of in-orbit calibration results



Structure of Chlorophyll Distribution in the North-East Asian Seas