Introduction to COMS Geostationary Ocean Color Imager

Gumsil Kang
Korea Aerospace Research Institute (KARI)
45 Eoeun-Dong, Yuseong-Gu, Daejeon, 305-333, Korea
wimikgs@kari.re.kr

Jongah Kim, Hwan-Chun Myung, Jeong-Heum Yeon,
Song-Doug Kang, Heong-Sik Youn
Korea Aerospace Research Institute (KARI)
45 Eoeun-Dong, Yuseong-Gu, Daejeon, 305-333, Korea
kja@kari.re.kr, mhc@kari.re.kr, jhyeon@kari.re.kr, kangs@kari.re.kr, youn@kari.re.kr

Abstract: The Communication Ocean, Meteorological Satellite (COMS) as the one of the national space program has been developed by Korea Aerospace Research Institute (KARI). The Geostationary Ocean Color Imager (GOCI) is one of the main payloads of COMS which will provide consistent monitoring of ocean-colour around the Korean Peninsula from geostationary platforms. The ocean color observation from geostationary platform is required to remedy the coverage constraints imposed by polar orbiting platforms. In this paper the main characteristics of GOCI are described and compared with the current ocean color sensors. The GOCI will provide the measurement data of 6 visible channels and 2 near-infrared channels (400nm ~ 900nm). The high radiometric sensitivity is essential of ocean color sensor because of the weak water leaving radiance.

Keywords: COMS, GOCI, Ocean Color Sensor.

1. Introduction

Space based observations of ocean color has been began with CZCS (Coastal Zone Color Scanner) which was flown aboard the NIMBUS-7 platform and which collected ocean color data from November 1978 to June 1986. Since then many missions have been launched by various countries with increasing sophistication for ocean color monitoring: SeaWiFS (Sea Viewing Wide Field Sensor), OCTS (Ocean Color and Thermal Scanner), OCM (Ocean Color Monitor), MODIS (Moderate Resolution Imaging Spectro-Radiometer), MERIS (Medium Resolution Imaging Spectro-Radiometer). These ocean color sensors on low Earth orbiting satellites are capable of supplying highly accurate water-leaving spectral radiance with high spectral and spatial resolution at a global revisit period of approximately two to three days. The relatively low frequency coverage of these sensors, further reduced in the presence of clouds, is inadequate to resolve processes operating at a shorter time scales. In addition, the current sun-synchronous polar orbiter observations along coasts are aliased with the tidal frequency [1]. High frequency observations are required in order to remove the effects of tidal aliasing and to validate tidal mixing terms in coastal ecosystem models. Ocean color observation from geostationary platform is required to remedy the coverage constraints imposed by polar orbiting platforms. Unfortunately, no current geostationary platform possesses the ability to measure ocean color. Korea Aerospace Research Institute (KARI) has a plan to launch the Communication Ocean, Meteorological Satellite (COMS) for consistent monitoring of the Korean Peninsula and studying processes which can vary rapidly in time on land, oceans, and atmospheres. There are three main payloads for COMS; Ka band payload, Geostationary Ocean Color Imager, Meteorological Imager. The GOCI will provide a monitoring of ocean-color around the Korean Peninsula from geostationary platforms.

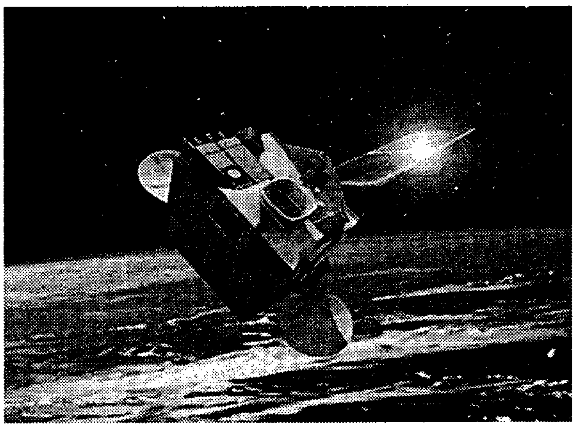

Fig. 1. Communication Ocean, Meteorological Satellite (COMS).

2. Geostationary Ocean Color Imager (GOCI)

The mission GOCI and the corresponding requirement specification have been defined according to the requirement from the oceanography user community in Korea. The GOCI mission is limited for the local-scale ocean color monitoring because the COMS is planned to be located in geostationary orbit. The development process of GOCI has been started from July 2005. It is on the design stage currently.

1) Missions

The current sun-synchronous polar orbit ocean color sensors are used for global ocean observation and coastal monitoring. Unfortunately these sensors do not satisfy the requirements of continuous, unbroken observations which have been arisen from the science society. The GOCI could be one of the solutions for this problem, especially for the local-scale ocean color monitoring. The primary mission for GOCI is to provide the remote sensing data of open sea and coastal water environment around the Korean Peninsular. The missions of GOCI are followed:

- Detecting, monitoring and predicting short term biophysical phenomena
- Studies on biogeochemical variables and cycle
- Detecting, monitoring and predicting noxious or toxic algal blooms of notable extension
- Monitoring the health of marine ecosystem
- Coastal zone and resource management
- Producing an improved marine fisheries information to the fisherman communities

The coastal monitoring mission of GOCI is established according to the requirements of GOCI user community. Increased concerns about the rapid and negative changes of coastal areas have high-lighted the necessity for the development of integrated systems for research and operational use in monitoring the resources and processes in coastal waters. More than 98% of the world's catch of marine species is taken within 300 km of the coastline, and more than half of the total biological production of the ocean takes place in that zone [2]. In many coastal areas, a considerable increase in the concentration of nutrients in coastal waters has been recorded. Nutrient enrichment of the waters stimulates the growth of phytoplankton, leading, in certain circumstances, to the phenomenon of algal blooms and to anoxia in the lower part of the water column with destruction of the benthic fauna and flora.

2) Technical Requirements

The GOCI will be designed to provide information multi-spectral data to detect, monitor, quantify, and predict short term changes of coastal ocean environment for marine science research and application purpose. Table 1 shows the summary of the major technical requirements of the GOCI. The spatial resolution (GSD) shall be less than 500m in both E/W and S/N directions at the center of the target area. It will be varied over the target area according to the imaging geometry including the projection on Earth and the orbital position of the satellite.

Table 1. Technical requirements of GOCI.9

Items	Technical requirements
Ground Sample Distance (GSD)	≤ 500m × 500m at the center of the target area
Target area	≥ 2500km × 2500km centered on 36N° latitude and 130 E°
Spectral coverage	412 nm ~ 865 nm (8 channels)
Spectral resolution (Bandwidth)	10 nm ~ 40 nm
SNR	750 ~ 1200
Dynamic range	NEdR ~ Maximum cloud radiance
Radiometric calibration accuracy	4 %
Digitization	12 bit

This high spatial resolution will enable to map and monitor small scale oceanic biophysical variables in the coastal water environments. The target area for the GOCI observation shown in Figure 2 covers the sea area around the Korean Peninsula.

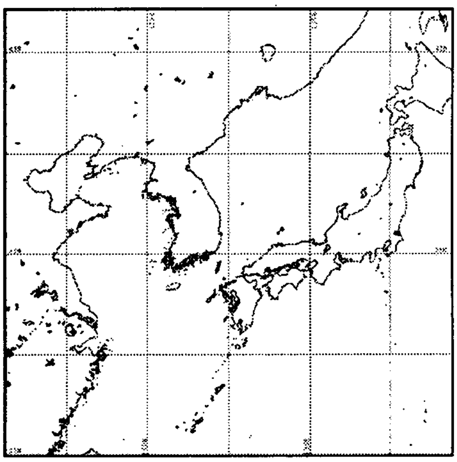

Fig. 2. Image target area for GOCI observation.

The physical interpretation of GOCI data needs an accurate sensor calibration. In general, an accuracy of few percents is required for the radiometric calibration of ocean color missions [3][4]. For GOCI, the absolute radiometric accuracy shall be less than 4% over the range of the saturation radiance. The ocean color sensor measurements would be contaminated by stray light from clouds in adjacent pixels on orbit. It is known that the stray light contamination to be roughly proportional to the brightness of the adjacent cloud [5]. The one of the GOCI major requirements is a very large dynamic range that extends from the noise equivalent differential radiance (NEdR) to the cloud radiance. The cloud radiance measurement will be used to take account of the stray light effect to the sea observation. The eight channels of GOCI cover spectral range from 412nm to 865 nm. Table 2 gives the spectral channels and their primary use in detail. The channel positions of spectral bands are optimized for monitoring of ocean color. In the visible, the majority of the light flux at the top of the atmosphere comes from the atmosphere itself. For real application, the removal of the atmospheric radiance from that measured at the top of the atmosphere is an essential part of ocean-color processing. In case of GOCI, the two channels are selected for atmospheric correction.

Table 2. Spectral channels of GOCI.

Band	Band Center	Primary use
B1	412 nm	Yellow substance and turbidity
B2	443 nm	Chlorophyll absorption maximum
B3	490 nm	Chlorophyll and other pigments
B4	555 nm	Turbidity, suspended sediment
B5	660 nm	Baseline of fluorescence signal, Chlorophyll, suspended sediment
B6	680 nm	Atmospheric correction and fluorescence signal,
B7	745 nm	Atmospheric correction and base line of fluorescence signal.
B8	865 nm	Aerosol optical thickness, vegetation, water vapor reference over the ocean

3. Comparison with LEO Sensors

The technical requirements of GOCI are compared with the characteristics of synchronous, polar orbiting satellite sensors. Table 3 shows the summary of the characteristics of several ocean color sensors in terms of the observation coverage and the temporal scale. Sensors on low Earth orbiting satellites are capable of supplying highly accurate water-leaving spectral radiance with high spectral and spatial resolution at a global observation. It is difficult to resolve processes operating at a shorter time scales because of the low temporal frequency using the low orbiting satellite sensors. In addition, the current sun-synchronous polar orbiter observations along coasts are aliased with the tidal frequency [1]. High frequency observations are required in order to remove the effects of tidal aliasing and to validate tidal mixing terms in coastal ecosystem models. The GOCI could provide high frequency observations of the environment and permit the resolution of dynamic processes with time scales of hours to days. However the observation coverage of GOCI is limited on the sea around the Korea peninsula. The "fixed view" of the COMS platforms offers a consistent viewing geometry to the target area, monitoring features that can only be detected by instruments capable of "staring", and increasing daily image coverage by compositing cloud-free areas of individual images collected during the same day. Furthermore, augmenting the continuous ocean-color observation of geostationary platforms with the high spectral and spatial resolution data from polar orbiters will allow the investigation of oceanic processes not possible with either platform separately.

Table 3. Observation coverage and temporal scale.

Sensor	Ground resolution (at nadir)	Recurrent period of satellite	Global coverage
CZCS	825 m	6 days	No global coverage
MOS	520 m	24 days	No global coverage
OCTS	700 m	41 days	3 days
SeaWiFS	1.13 km	16 days	2 days
POLDER	6×7 km	41 days	1 day quasi-global
MODIS	1.0 km	16 days	1-2 days global
MERIS	1.2 km /300 m	35 days	3 days global
GLI	1.0 km /250 m	4 days	3 days global
GOCI	< 500m	1 hour (for day time)	No global coverage

The radiometric performance of GOCI is compared with the low earth orbit satellite sensors in Figure 3. Except the CZCS, the radiometric performances are very high in comparison with the land image sensors. Since ocean color sensor measures very small water leaving radiance signal immersed in large atmospheric path radiance, one of the challenges of the ocean sensor is to carry out measurements with high precision. This demands a very high signal to noise ratio (SNR) performance. The GOCI will provide the observation data with a good radiometric performance. IFOV of GOCI is 25 ~ 125 times smaller than other sensors onboard at LEO platform due to the fact all other sensors operate from a LEO platforms which are about 40 ~ 50 times closer to earth. Since spectral bandwidth is determined by other considerations, the options to compensate for the reduced IFOV are to increase the integration time in the GOCI case.

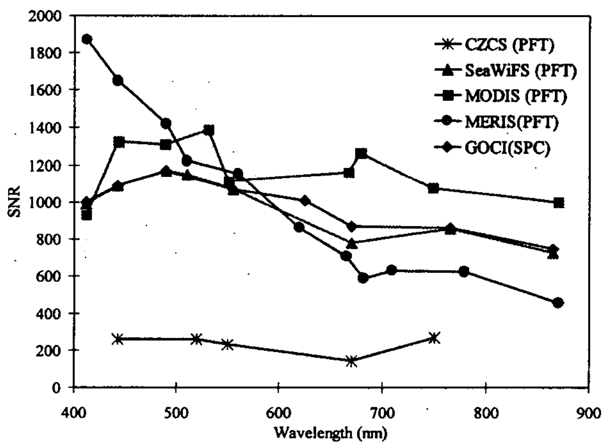

Fig. 3. SNR performance.

Table 4 shows the summary of spectral bands for several ocean color sensors [1]. The GOCI will provide the observation data for 8 spectral bands.

Table 4. Spectral coverage for ocean color observation.

Ocean Color Sensor	N. of Bands	Spectral bands/bandwidth [nm]
CZCS	5	443/20, 520/20, 550/20, 670/20, 750/100
OCTS	8	412/20, 443/20, 490/20, 520/20, 565/20, 670/20, 765/40, 865/40
SeaWiFS	8	412/20, 443/20, 490/20, 510/20, 555/20, 670/20, 765/40, 865/40
POLDER	7	443/20, 490/20, 565/20, 670/20, 763/10, 765/40, 865/40, 910/20
MODIS	9	412.5/15, 443/10, 488/10, 531/10, 551/10, 667/10, 678/10, 748/10, 869.5/15
MERIS	11	412.5/10, 442.5/10, 490/10, 510/10, 560/10, 620/10, 665/10, 681.25/7.5, 709/9, 779/14, 870/20
GOCI	8	412/20, 443/20, 490/20, 555/20, 660/20, 680/10, 745/20, 865/40

4. Conclusions

The primary mission of GOCI is to provide a monitoring of ocean-color around the Korean Peninsula from geostationary platforms. It is planned to be loaded on Communication, Ocean, and Meteorological Satellite (COMS) of Korea. The GOCI will provide the remote sensing data of 6 visible channels and 2 near-infrared channels (400nm ~ 900nm) for observation of ocean color. The high spatial and temporal resolution of GOCI will enable to map and monitor small scale oceanic biophysical variables in the coastal water environments.

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