OBSERVATION ON THE SUSPENDED SEDIMENT CONCENTRATIONS IN THE COASTAL AREA USING GEOSTATIONARY OCEAN COLOR IMAGER (GOCI)

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ABSTRACT

In this study, we tested the applicability of the geostationary ocean color imager (GOCI) to the detection of hourly variations in suspended sediment concentrations (SSC) on the coastal water in the west coast of Korea. GOCI is the world's first ocean color observation satellite positioned at the geostationary orbit. It has been launched in June, 2010 and is planned for use in real-time monitoring of the ocean environment around Korean Peninsula by daily analysis of ocean environment measurements of chlorophyll concentration, dissolved organic matter (DOM), and SS for seven years. Differently from the existing polar-orbit satellite, GOCI can get the data every one hour from 9 AM to 4 PM Local Time (eight times per day) around the Korean sea areas. This temporal resolution of the GOCI is very efficient to an ocean environmental analysis. A more detailed time-series monitoring will be possible for the spread and movement of the red-tide, SS, DOM and the other polluted materials. Here we investigate the change in optical reflectance presented in the time-series GOCI images. They are compared with the estimated SS from the water samples collected at the time correspondent to the image acquisition. Through this, it can be expected that the qualitative monitoring of temporal and daily variation in SSC in the Korean coastal waters would be possible.

INTRODUCTION

Satellite image combined with in situ measurements is an effective instrument to monitor the distribution and dynamic changes of seawater properties within wide area (i). In the early stage of observing the sea, ocean color satellite images such as coastal zone color scanner (CZCS) and sea-viewing wide field-of-view sensor (SeaWiFS) with relatively low spatial resolution were mainly used (ii,iii). Landsat or satellite pour l'Observation de la Terre (SPOT) images with high spatial resolution and poor temporal resolution have been also employed (iv,v). Recently, moderate-resolution imaging spectroradiometer (MODIS) image have been widely used because it has a relatively high spatial resolution (250 m) than other ocean color satellite images and can acquire data twice a day (vi). However, MODIS satellite image has still limitations to monitor the dynamic variations, for example daily or hourly variations in the sea surface, especially in the coastal region.

In June 2010, the world's first ocean color observation satellite which was located in the geostationary orbit, geostationary ocean color imager (GOCI) was launched successfully. It has been planned for use in real-time monitoring of the ocean environment around Korean Peninsula by daily analysis of ocean environment measurements because it can acquire the data eight times a day during the daytime (from 10 AM to 5 PM Local Time). The purpose of this work is to introduce the GOCI data, its processing systems and its products along with its potential fields of application. We also investigate its applicability to the monitoring of temporal variations in the seawater properties, in particular, the turbidity of Korean coastal water. The case study is carried out in Mokpo coastal area which is located on the southwest coast of Korean Peninsula.
Figure 1: (a) GOCI/COMS was successfully launched from the space center in Kourou, French Guiana on June 27, 2010. (b) GOCI coverage consists of sixteen slots of which size is equivalent to the GOCI IFOV.

**GOCI**

GOCI is the world's first ocean color observation satellite on geostationary orbit. It was successfully launched at Kourou Space Center in French Guiana by Ariane 5 Launch Vehicle in 27 June 2010 (Korea Standard Time) as one of the three main payloads in communication, ocean and meteorological satellite (COMS) (Fig. 1a). For the ocean observation, GOCI was developed by Korea Aerospace Research Institute (KARI) and EADS Astrium according to the user requirements assigned by Korea Ocean Research & Development Institute (KORDI). GOCI covers the 2,500 x 2,500 km square around Korean peninsula centered at 36°N and 130°E with about 500 m of ground sampling distance (GSD) and is comprised of sixteen (4x4) slot images (Fig. 1b). The mission of GOCI is detecting, monitoring and predicting short term biophysical phenomena and noxious or toxic algal blooms of notable extension. It also includes monitoring the health of marine ecosystem, coastal zone and resource management and producing improved marine fisheries information to the fisherman communities (vii). Moreover, some land applications for the vegetation management, forest fire, heavy snowfall and inland flood detection and monitoring are also possible. The mission life time of the GOCI is about seven years.

**Table 1: GOCI Band characteristics.** Because of geostationary observation and high special resolution, it required high optical performance (SNR). Each band is organized for special use.

<table>
<thead>
<tr>
<th>Band</th>
<th>Central wavelength</th>
<th>Band Width</th>
<th>SNR</th>
<th>Primary application</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>412 nm</td>
<td>20 nm</td>
<td>1,000</td>
<td>Yellow substance and turbidity</td>
</tr>
<tr>
<td>B2</td>
<td>443 nm</td>
<td>20 nm</td>
<td>1,090</td>
<td>Chlorophyll absorption maximum</td>
</tr>
<tr>
<td>B3</td>
<td>490 nm</td>
<td>20 nm</td>
<td>1,170</td>
<td>Chlorophyll and other pigments</td>
</tr>
<tr>
<td>B4</td>
<td>555 nm</td>
<td>20 nm</td>
<td>1,070</td>
<td>Turbidity, suspended sediment</td>
</tr>
<tr>
<td>B5</td>
<td>660 nm</td>
<td>20 nm</td>
<td>1,010</td>
<td>Baseline of fluorescence signal, chlorophyll, suspended sediment</td>
</tr>
<tr>
<td>B6</td>
<td>680 nm</td>
<td>10 nm</td>
<td>870</td>
<td>Atmospheric correction and fluorescence signal</td>
</tr>
<tr>
<td>B7</td>
<td>745 nm</td>
<td>20 nm</td>
<td>860</td>
<td>Atmospheric correction and baseline of fluorescence signal</td>
</tr>
<tr>
<td>B8</td>
<td>865 nm</td>
<td>40 nm</td>
<td>750</td>
<td>Aerosol optical thickness, vegetation, water vapor reference over the ocean</td>
</tr>
</tbody>
</table>
GOCI has six visible bands with band center 412 nm, 443 nm, 490 nm, 555 nm, 660 nm and 680 nm, and two near-infrared bands with band center 745 nm and 865 nm (Table 1). GOCI can observe ocean color change every hour in daytime and it must have comprised high optical performance like over 1 thousand SNR due to very low level ocean radiance signal.

The main operation of GOCI is carried out by Korea Ocean Satellite Center (KOSC) which had been established by KORDI. Main operational functions of KOSC are the acquisition, processing, and storage of the GOCI data and distribution service of ocean satellite standard products generated from the GOCI data.

KOSC has developed the GOCI data processing software which produces ocean environment analysis data such as chlorophyll concentration, SSC, CDOM, Red-Tide, etc. The system is composed of the image preprocessing system (IMPS) and the GOCI data processing system (GDPS). IMPS generate GOCI level 1B from raw satellite data and GDPS is the post-processing system to generate GOCI level 2 data. IMPS have a radiometric correction module named IRCM and a geometric correction module named INRSM. The former is focused on equipment’s mechanical noise reduction and radiometric accuracy. Whereas, the latter is focused on image navigation and image registration accuracy by landmark matching method and image mosaic method. GDPS have the atmospheric correction algorithms, as the spectral shape matching method (SSMM) and the sunglint correction algorithm (SGCA), and BRDF algorithm to solve bi-directional problem (viii). Several Case-II water analytical algorithms, like chlorophyll concentration, suspended sediment and dissolved organic matter, are contained in GDPS. GDPS will also generate the value added product like water quality, fishery ground information, water current vector, etc. Figure 2 shows the examples of IMPS and GDPS along with the GOCI distribution homepage (http://kosc.kordi.re.kr).

The basic concept for the distribution policy of the GOCI data is that accessing and acquiring the data should be quick and easy in order to instigate users to make full use of the GOCI data. KOSC will distribute the data which is generated after L1B; GOCI L1B that is geometrically corrected whole image data including header information, GOCI L1B region that is L1B subdivided into pre-defined regions, GOCI L2 that is bio/physical data induced by ocean analysis algorithms, GOCI L2 region, GOCI L2 LRIT that is small image for LRIT distribution such as CHL, SS and DOM, GOCI L1B/L2 browsing image that is very small insight image data for searching and browsing L1B/L2.

Figure 2: Examples of KOSC data processing systems (IMPS/GDPS) and GOCI distribution homepage (after Ahn et al., 2009).
CASE STUDY – MONITORING TURBIDITY IN KOREAN COASTAL WATER

In this case study, we investigated the hourly variations in turbidity in coastal waters on the west coast of Korea using GOCI images. The timely variation of the turbidity is an important key to understand the sediment dynamics in coastal region which is influenced by the tide like the west coast of Korean peninsula. Hence, the temporal variations of the SSC on the sea-surface can provide knowledge of the erosion/sedimentation pattern in the coastal zone (ix). Mokpo coastal area (Fig. 3) has a semidiurnal environment which is located in the western tip of the southwest coast of Korean Peninsula and is characterized by shallow water depths and strong tidal currents (x).

Map of SSC induced by the GOCI band 4 are shown in Figure 3. The area in red has the highest SSC value, which indicates the highest turbidity. On the contrary, the area in sky blue has relatively low turbidity on the sea surface. In Mokpo coastal area, near the land, the five images in Figure 3 show a time-series variation in turbidity. The high tide in the study area was at about 12:30 p.m. when the tide was at 4.16 m (Mokpo station) (www.khoa.go.kr). Thus, the acquisition time of the image on the top center in Figure 3 corresponds to the time of the flood tide. The pattern of decrease in the SSC value can be clearly seen near the land from the images from 10:16 to 13:16. A relatively low SSC in the image acquired on 14:16 was considered due to low intensity of illumination according to the low sun angle at the image acquisition time. Hourly variations in turbidity in the coastal water could be identified from the GOCI image, although the atmospheric corrections are still under improvement and the bidirectional reflectance distribution function (BRDF) correction is required for the GOCI images.

Figure 3: SSC images around the Mokpo coastal area generated from the GOCI band 4 acquired at an hour interval from 10:16 AM to 02:16 PM Local Time on March 17, 2011. SSC images were produced by empirical algorithm based upon the in-situ measurement. The tidal status at each time of image acquisition was also illustrated.
CONCLUSIONS

GOCI acquires remotely sensed images eight times a day for the real-time monitoring of the ocean environment around Korea with 500 m of spatial resolution. Its eight bands enable the observation of hourly variation in chlorophyll, DOM, SS and red tides along with providing marine fisheries information and some land applications. From a case study, hourly variations in SS in the coastal water could be identified from the GOCI images. However, the atmospheric corrections still need improvement and the bidirectional reflectance distribution function (BRDF) correction is required for the GOCI images.

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