Some features of Korean Seas observed by ADEOS/OCTS

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ABSTRACT

The chlorophyll-a concentration measured by OCTS could be used for observing the physical phenomena such as eddies, fronts, and upwelling in the oceans as well as for studying the ecology of phytoplankton.

In this study, biological and physical features in the East Sea/Japan Sea (the East Sea) and the Yellow Sea observed by OCTS are analyzed in comparison with other satellite data. And in situ chlorophyll data were compared with OCTS Level 2 chlorophyll data.

There was a striking correspondence between the satellite chlorophyll structure and other satellite data in the East Sea in the spring.

Very complicated ring structures in the SST are reflected in chlorophyll structure. In the Yellow Sea, the surface structure was rather simple.

While the discrepancies between in situ and OCTS algorithm version 3 chlorophyll were small in the East Sea, those for the Yellow Sea were rather big. Comparison with CZCS data for similar time of the year (May-June) shows that OCTS chlorophyll is higher in general.

Although the error is partly due to the fact that NASDA chlorophyll algorithm is an empirical algorithm for case 1 water, how much of this error is also due to the errors in sensor calibration or in atmospheric correction is not clear.

1. INTRODUCTION

The OCTS (Ocean Color & Temperature Sensor) on board ADEOS launched by NASDA in August 1996 was an ocean color sensor which produced chlorophyll data during eight months for the first time since CZCS (Coastal Zone Color Scanner). Chlorophyll-a data measured by OCTS can be used for studying physical and biological phenomena in the ocean.

Circulation systems of Korean Seas have been studied by many physical oceanographers using satellite data. A few examples include NOAA SST (Isoda and Saitoh, 1993) and Satellite tracked drifter data (Lee et al., 1997; Lie and Cho, 1997). Although the studies of phytoplankton in the East Sea were limited temporally and spatially, CZCS provided valuable information on the phytoplankton annual cycles of the region (Son, 1998: Yoo and Son, 1998). And ecology of phytoplankton in the presence of complicated circulation features such as the eddies and the Polar Fronts can be studied by ocean color sensors.

OCTS version 3 algorithm for chlorophyll-a was completed in October 1997, but validation with in situ data may not be enough. Also regional features have to be considered, especially, in case of Case

2 water such as the Yellow Sea.

In this study, the features of the East Sea circulation were observed by OCTS Level 2 chlorophyll data and other satellite data. Also, OCTS chlorophyll-a data were compared with in situ chlorophyll-a data.

2. DATA

OCTS Level 2 chlorophyll data in spring 1997 (March to June) were provided by NASDA. The chlorophyll data was processed using version 3 algorithm. Atmospheric algorithm used 670 and 765 bands, and ten aerosol models including the Yellow Sand model (Fukushima and Toratani, 1997). The chlorophyll-a concentration was calculated as followings:

$$Chl = 0.2818 * \left(\frac{L_4 + L_5}{L_3}\right)^{3.497}$$

where,

Chl : Chlorophyll-a concentration (g/l)

L_n : Atmospheric corrected normalized water-leaving radiance

$[mW \cdot sr^{-1} \cdot cm^{-2} \cdot \mu m^{-1}]$ L_3 = 490, L_4 = 520, L_5 = 565 (nm)

NOAA MCSST from Ocean Remote Sensing Lab in KORDI and TOPEX altimetry from NASA JPL were also used. OCTS chlorophyll was compared with in situ chlorophyll concentration measured by the Yellow Sea LME cruise in May 1997 and the cruise for the Polar Fronts in the East Sea in April 1997.

3. RESULTS

A distinct spatial heterogeneity of chlorophyll-a concentration was shown near the Polar frontal zone. Spring bloom occurred in the spring and moved from the southern area to the northern area of the Polar front as repeatedly seen by CZCS (Son, 1998). There was a striking correspondence between the satellite chlorophyll structure and SST in the East Sea/Japan Sea in the spring (Figure 1, 2).

A branch of the Tsushima Warm Current inflowing through the Korean Strait intrudes northward along the east coast of Korea. The Warm Current forms warm eddies encompassing cold water near the Dong-Han bay. chlorophyll concentration was higher inside cold water than in outer warm water. This can be easily seen when chlorophyll and SST structures are compared (Figure 4).

Spring bloom occurred along the east coast of Russia in mid March and increased in extent and concentration. It is known that in early spring, as ice is melted near the Tatar strait, low salinity water inflows along the east coast of Russia. And wind direction offered by NCAR is changed in March. The bloom could be induced by stability change from low salinity water or by change of wind direction.

OCTS chlorophyll concentration was compared with in situ data from the Polar front Cruise in the East Sea in April 1997 and from the Yellow Sea Large Marine Ecosystem (LME) cruise in May 1997 (Figure 5, Table 1). Although matching data are not enough, the discrepancies between in situ and OCTS algorithm version 3 chlorophyll concentration were big (rms error=4.8247) in the Yellow Sea while those for the East Sea were small (rms error=0.3542) and the deviations were relatively unbiased. In the Yellow Sea, OCTS chlorophyll concentrations were overestimated in general and especially, the value was very high near the Yangtz river. This result show that it is difficult to apply OCTS chlorophyll algorithm to Case 2 water such as the Yellow Sea which is strongly affected by shallow depth, tidal force, and suspended sediments.

OCTS chlorophyll in the Yellow Sea is higher in general than chlorophyll from CZCS for similar time of the year (May-June) even though observation timing and algorithm used for estimating chlorophyll are different.

4. DISCUSSION

Complicated patterns of phytoplankton distribution and circulation structures in the East Sea which were difficult to be observed by ship surveys could be seen by ocean color sensors. We could find that OCTS algorithm error is small in the East Sea but is big in the Yellow Sea from the comparison between in situ and OCTS chlorophyll data.

High chlorophyll concentration in cold water within warm eddy near the Dong-Han bay appeared in spring. This might be caused by upwelling within clockwise warm eddy or other ecological conditions such as change of stability as cold water meets warm water. In order to understand phytoplankton ecology in eddies, further studies on the water structure and phytoplankton physiology in the region should be made.

The comparison with CZCS data for similar time of the year in the Yellow Sea shows that OCTS chlorophyll is higher in general. Some causes could be considered. The first is sensor calibration error but OCTS chlorophyll concentration is similar to that from in situ and CZCS in the East Sea. So it is inferred that the effect by sensor calibration error is small. Errors in atmospheric correction have to be considered secondly. If the difference is real in the sea, then whether there has been a change in chlorophyll concentration, suspended sediment, or other optical matters in the Yellow Sea during the last decadal periods would be an interesting problem.

5. REFERENCES

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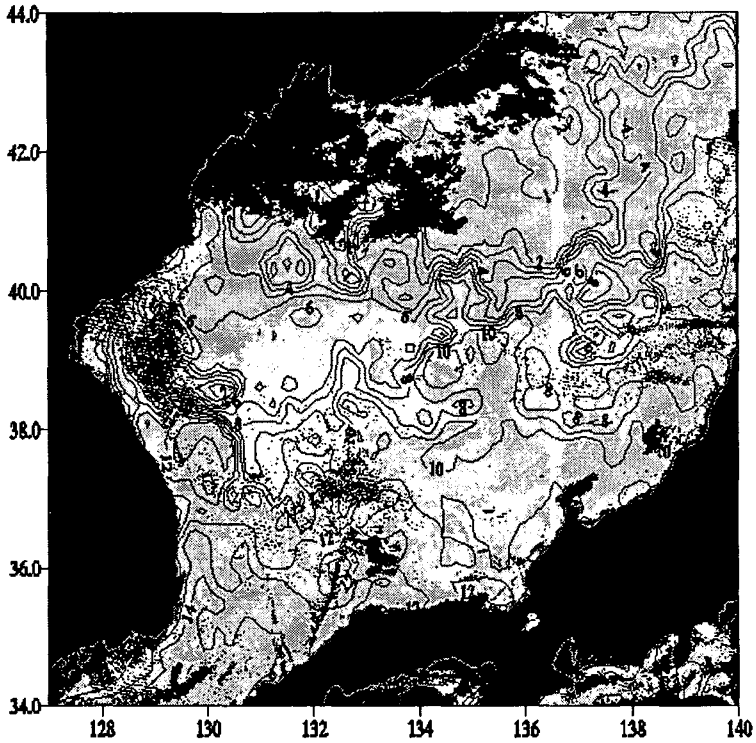

Figure 1. OCTS chlorohyll-a (image) on 97/04/10 and NOAA SST (contour) on 97/04/12

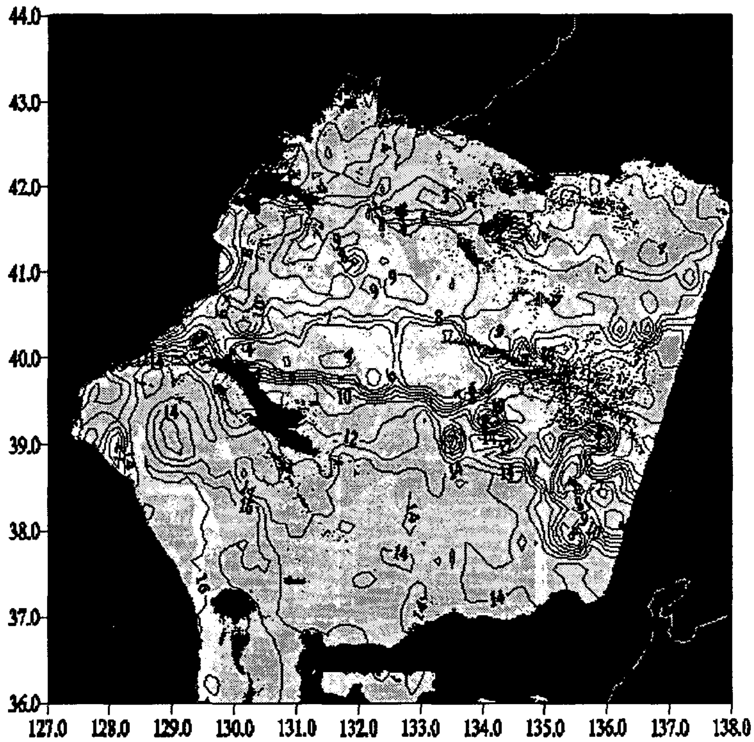

Figure 2. OCTS chlorohyll-a (image) and NOAA SST (contour) on 97/05/05.

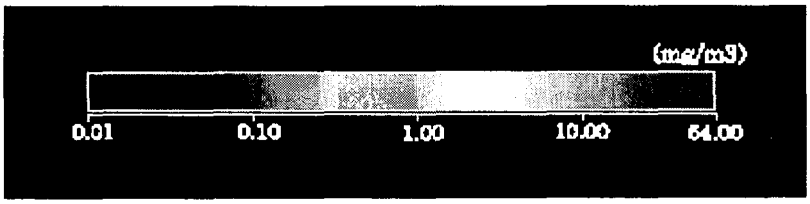

Figure 3. Color bar of chlorophyll concentration (mg/m3)

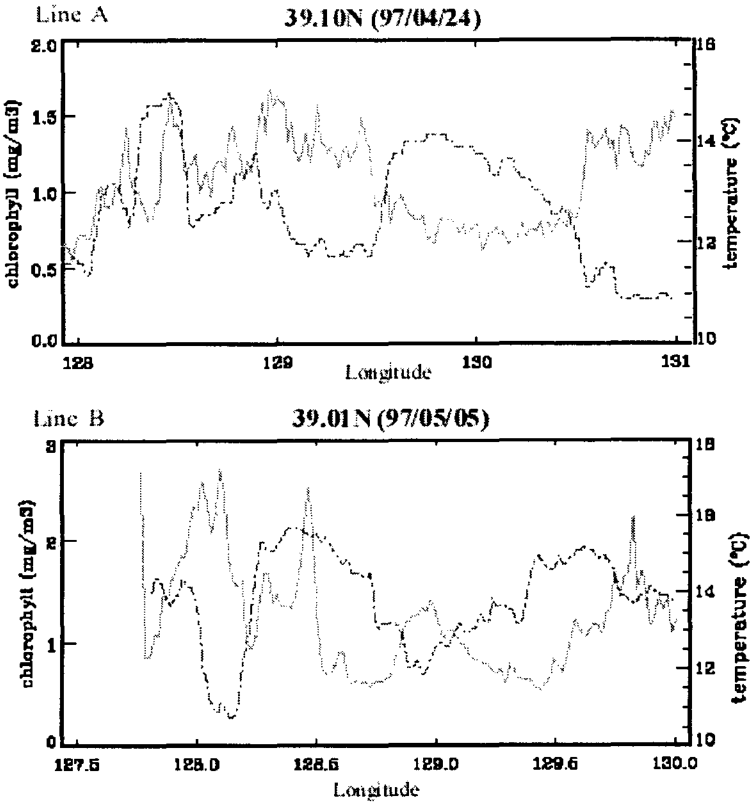

Figure 4. Comparison between the OCTS chlorophyll-a (solid line) and NOAA SST (dot line)

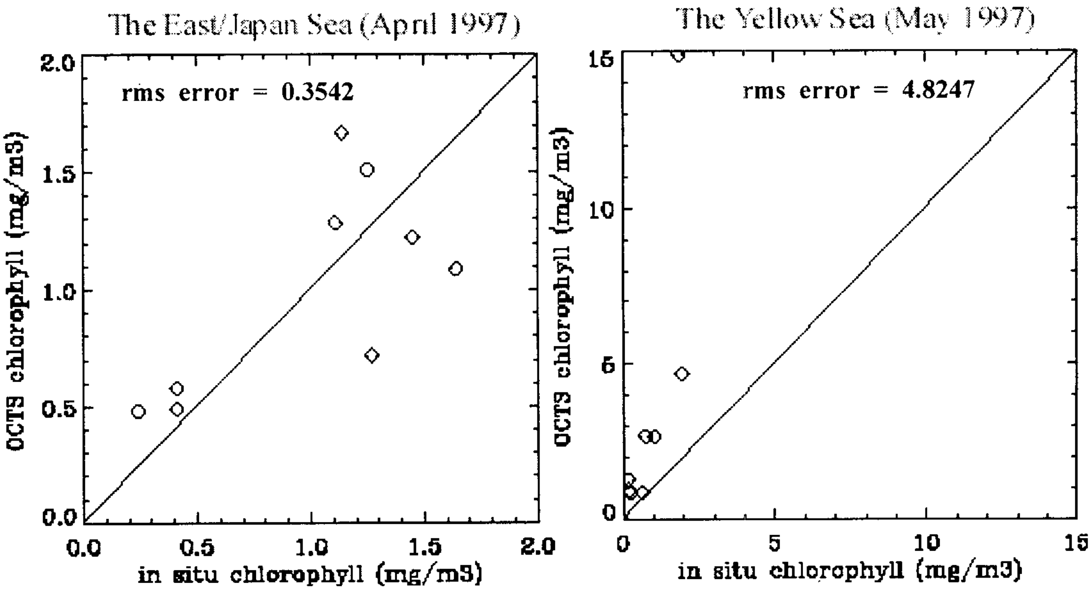

Figure 5. Comparison between the OCTS and in situ chlorophyll-a.

The East Sea/Japan Sea					
Lon	Lat.	In situ	Time	OCTS	Time
134.00	38.84	**1.27**	4/8, 19:34	**0.717**	4/9, 02:33
134.00	38.50	**1.64**	4/8, 23:10	**1.088**	4/9, 02:33
134.00	39.50	**1.45**	4/9, 10:00	**1.225**	4/9, 02:33
134.00	39.84	**0.24**	4/9, 14:25	**0.481**	4/9, 02:33
134.00	40.17	**0.41**	4/9, 17:30	**0.579**	4/9, 02:33
134.00	40.50	**0.41**	4/9, 21:30	**0.489**	4/9, 02:33
135.00	39.00	**1.14**	4/11, 11:45	**1.666**	4/12, 02:23
135.00	39.33	**1.25**	4/11, 03:30	**1.510**	4/12, 02:23
135.00	39.67	**1.11**	4/11, 05:05	**1.285**	4/12, 02:23

The Yellow Sea					
Lon.	Lat.	In situ	Time	OCTS	Time
126.00	32.00	**0.205**	5/20, 13:00	**0.950**	5/20, 02:33
125.00	32.01	**0.737**	5/20, 20:00	**2.678**	5/20, 02:33
124.00	32.02	**1.946**	5/21, 01:40	**4.671**	5/20, 02:33
124.00	33.00	**1.024**	5/21, 16:30	**2.666**	5/20, 02:33
123.00	32.99	**1.843**	5/21, 10:40	**14.888**	5/20, 02:33
124.00	36.00	**0.236**	5/29, 23:50	**0.844**	5/30, 03:04
125.00	37.00	**0.645**	5/30, 21:30	**0.855**	5/30, 03:04
124.00	37.00	**0.154**	5/30, 15:50	**1.270**	5/30, 03:04

Table 1. Comparison between in situ and OCTS chlorophyll-a.