Korean Journal of Remote Sensing, Vol.18, No.3, 2002, pp.127~139

Study on the Korean Waters using the CAL/VAL of the OSMI Level 2 Data

Young-Sang Suh*, Lee-Hyun Jang*, B. G. Mitchell, M. Kahru**,
Kota Prasad***, and H. Y. Shin***

Marine Remote Sensing Lab., National Fisheries Research and Development Institute*
Scripps Institution of Oceanography, UCSD**, SeaSpace Corporation***

Abstract : A comparison was made between the chlorophyll a and suspended solid (SS) retrievals from OSMI and SeaWiFS sensor to chlorophyll a and SS values determined with the standard method during the NFRDI's research cruises.

The percentage of organic and inorganic materials from the SS was calculated to study the contribution of turbid water in the northern part of the East China Sea.

The open sea waters in the Kuroshio regions of the East China Sea showed relatively higher concentration of volatile SS. However, towards the northwestern part of the East China Sea, the situation became much more optically different with the non-volatile SS from the Yangtze river and the sea bottom sources in the sea in winter and spring seasons.

Furthermore, in order to indirectly detect low salinity water with high turbidity, which related to the Yangtze river using remote sensed data from the satellites, a comparison between the results of the band ratio(nLw 490nm/nLw 555nm) of SeaWiFS (OSMI) and the distribution of low salinity around the Jeju Island was presented.

Key Words : OSMI, SeaWiFS, Calibration and Validation of Satellite data.

1. Introduction

The Korean Multi-Purpose Satellite (KOMPSAT-1) with the capability of monitoring ocean color was launched in December 21, 1999. The Ocean Scanning Multi-Spectral Imager (OSMI) is the first Korean ocean monitoring space-borne instrument on KOMPSAT-1 satellite developed by the Korean Aerospace Research Institute (Cho *et al.*, 1998). The visible bands of OSMI are very similar to the bands of SeaWiFS on Orbview-2 satellite.

Remote sensing studies typically involve the mapping of concentrations of a given variable in water bodies using radiance collected by a sensor placed above the water surface. Quantification of concentrations is usually achieved by the development of empirical or semi-empirical models correlating the radiance (or reflectance), as measured by remote sensor, with the 'ground truth' data (Yacobi *et al*, 1995).

The spectral area used for remote sensing in Case I

Received 30 April 2002; Accepted 3 June 2002.

waters is limited to the blue and green range (Gordon and Morel, 1983). Attempts to apply Case I-derived algorithms for Case II productive waters have demonstrated their limitation when applied to measurements of waters with high concentrations of Chl and/or suspended and dissolved organic matter (GKSS, 1986).

Suh *et al.* (2001) studied the relationship between *in situ* chlorophyll measurements onboard the Korean NFRDI's ship and the estimated chlorophyll from the SeaWiFS satellite data using the ocean color chlorophyll 2 algorithm (OC 2 ; O'Reilly *et al.*, 1998) in the region of the northern East China Sea.

Suh *et al.* (2001) determined the total suspended solid mass, and compared it with SeaWiFS (OSMI) spectral band ratio (nLw 490nm/ nLw 555nm). As one moves even closer to the northwestern part of the East China Sea, the situation becomes much more optically complicated, not only due to higher concentration of phytoplankton, but also due to suspended solid and dissolved materials from terrestrial and sea bottom sources. The color often approaches yellow-brown in the turbidity waters (case 2 waters).

The purposes of this study are 1: to understand ocean optical properties, 2: to develop simple calibration and validation methods using SeaWiFS (OSMI) level 2 data.

2. Chlorophyll Measuring in Field

We filtered appropriate amount of volume of seawater sample on GF/F filter. We filtered the sea water sample enough so that green color can be seen on the filter as possible as. Also we prepared a blank, which was a GF/F filter filtered with 0.45um filtered sea water. We placed the filter on a histoprep, wrapped in aluminum foil, and stored in LN2 Dewar/Dryshipper. The samples stored in LN2 Dewar, placed the filter in a 1ml test tube, filled with 10ml 90% acetone, seal top with parafilm, wrapped the entire test tube with aluminum foil, and stored in refrigerator for approximately 24 hours. Samples should be read between 24 - 36 hours for best results.

After extraction, brought samples out and let tubes equilibrate to room temperature. We turned on the Fluorometer and let it warm up for about 20 - 30 minutes. There should be a standard chlorophyll that should be measured on the Fluorometer at the beginning of every chlorophyll sample reading to test the integrity of the Fluorometer.

We took each sample and wiped the tube with kimwipes and inserted in the sample compartment. We read and recorded reading under Rb value. We placed ~3 drops of 10% HCl in the test tube, sealed top with parafilm, inverted several times gently, and placed test tube with sample back into the sample compartment (Strickland and Parsons, 1968).

3. Ocean Optical Properties

We were interested in the optical properties in the northern East China Sea.

Data from free fall castings of the PRR-800 spectral radiometer which has 6 bands (412, 443, 490, 510, 555, 665(670)nm) at SeaWiFS (OSMI) spectral bands were collected from the northern East China Sea in February, 2000 and in May, 2001 (Fig. 1).

The northern East China Sea waters were similar with the global waters (*e.g.* CalCOFI) in May, 2001 (Fig. 2). The waters were dramatically different from the many other global waters in February, 2000 (Fig. 3). In these waters, very high reflectance is associated with Case 2 waters with heavy suspended solid load (Suh *et al.*, 2001). However it was difficult to know which one of organic detritus or mineral sediments was the major contributor to the high reflectivity in the northern East China Sea.

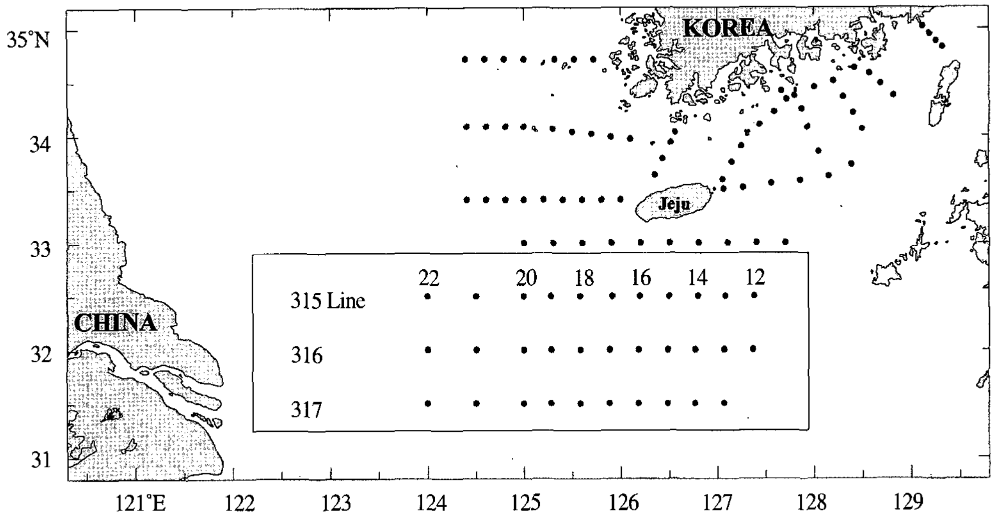


Fig. 1. Station map of the OSMI cruise 2000 and 2001.

Therefore, the measurement of the percentage of volatile and non-volatile SS in total SS was made to determine which one of the two contributed to high reflectivity in the northwestern part of the East China Sea in February and May, 2001 (Fig. 4). The open sea waters in the Kuroshio regions of the East China Sea show relatively higher concentrations of volatile SS. However, towards the northwestern part of the East China Sea, the situation becomes much more optically different with the non-volatile SS from the Yangtze river and the bottom sources of the sea in winter and spring seasons.

4. Simple Calibration and Validation Method (Simple CAL/VAL Method)

We studied the relationship between the measured ocean color in the fields of the East China Sea and the estimated ocean color data of level 2 from the satellite.

1) Chlorophyll α Algorithm

The relationship between the measured chlorophyll and the SeaWiFS (OSMI) chlorophyll can be expressed by the following equation (1) in the northern part of the East China Sea (Fig. 5a).

$$\mathrm{Chl} = 0.187\,\mathrm{Ln}(X) + 0.408,\ R2 = 0.73 \qquad (1)$$

where, X is the estimated chlorophyll α from the SeaWiFS data using the OC 2 algorithm.

2) Suspended Solid Algorithm

The relationship between the measured suspended solid and the SeaWiFS (OSMI) band ratio can be expressed by the following equation (2) in the northern part of the East China Sea (Fig. 5b).

$$\mathrm{SS} = -0.632\,\mathrm{Ln}(X) + 2.201,\ R2 = 0.56 \qquad (2)$$

where, X is the band ratio nLw(490)/nLw(555).

3) Regeneration of Chlorophyll α and SS Imageries using the Simple CAL/VAL Method for Level 2 of SeaWiFS (OSMI) Satellite Data

A chlorophyll plot using the OC 2 algorithm is shown in Fig. 6a. A plot using the simple CAL/VAL method (1) for chlorophyll from the OSMI data on 26th September, 2000 is shown in Fig. 6b. A comparison plot

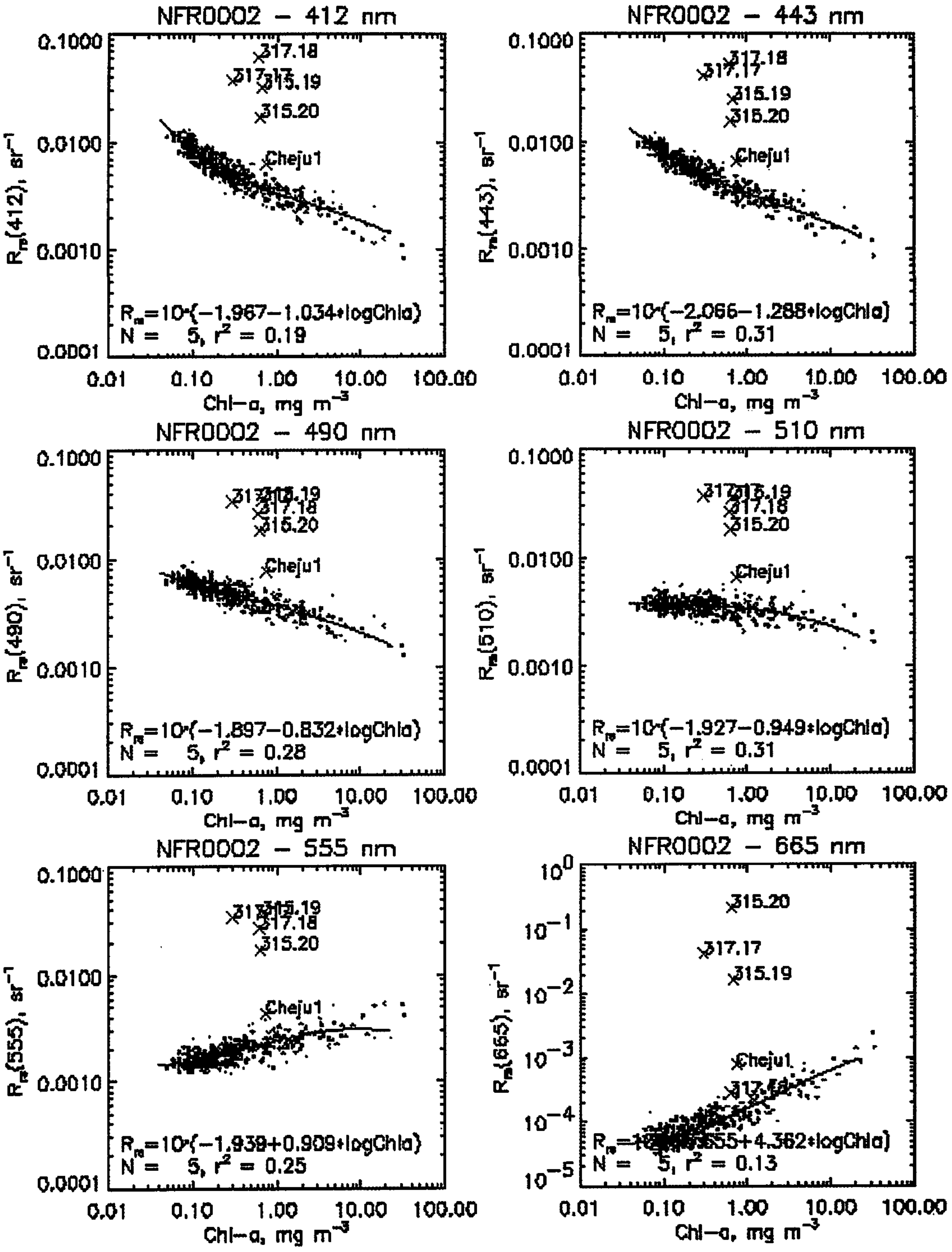


Fig. 2. Remote sensing reflectance(Rrs) at SeaWiFS spectral bands (412, 443, 490, 510, 555, 665nm) for the CalCOFI reference data set (●) and the NFRDI February data (×) in 2000 (Suh *et al.*, 2001).

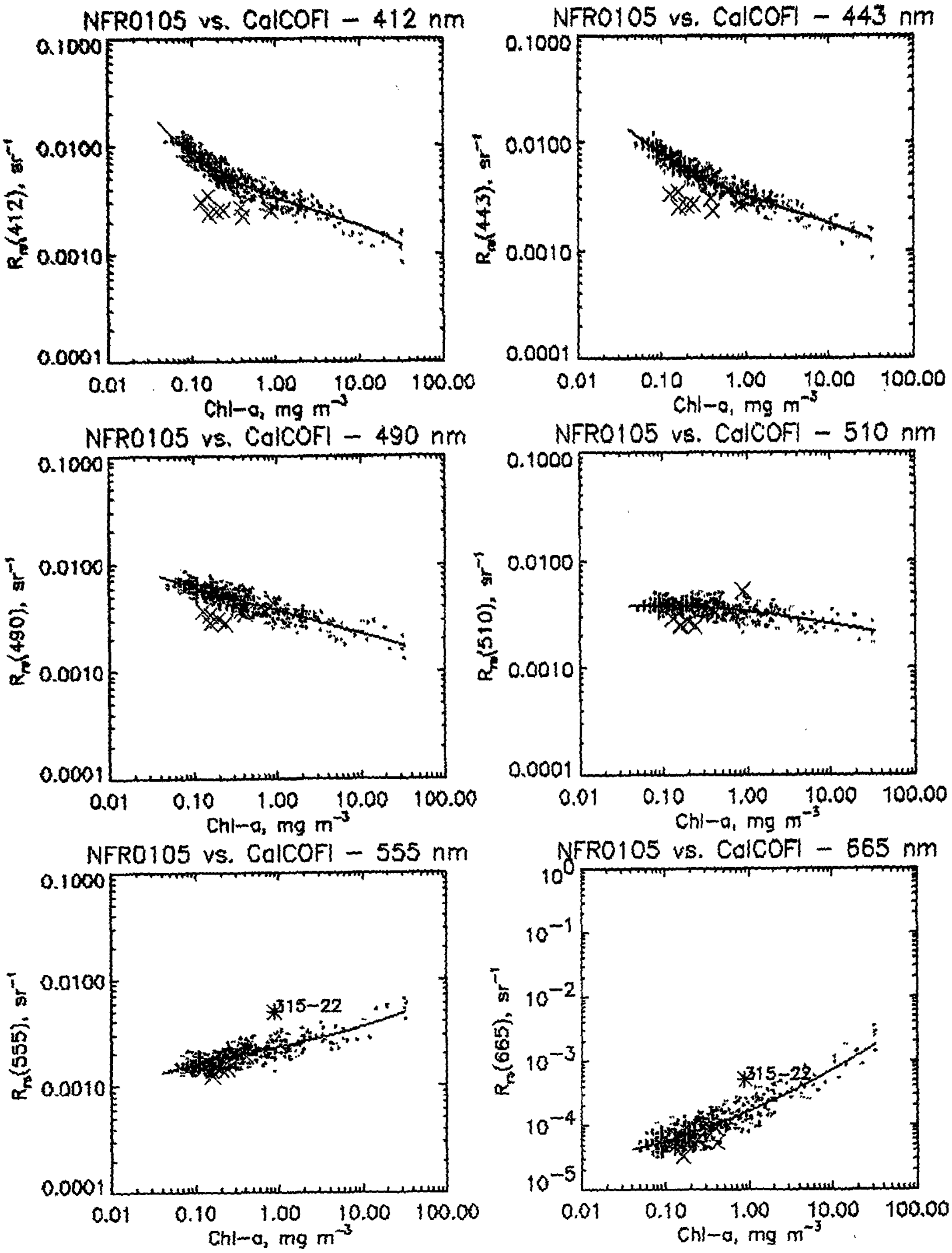


Fig. 3. Same as the Fig. 2, except for May, 2001.

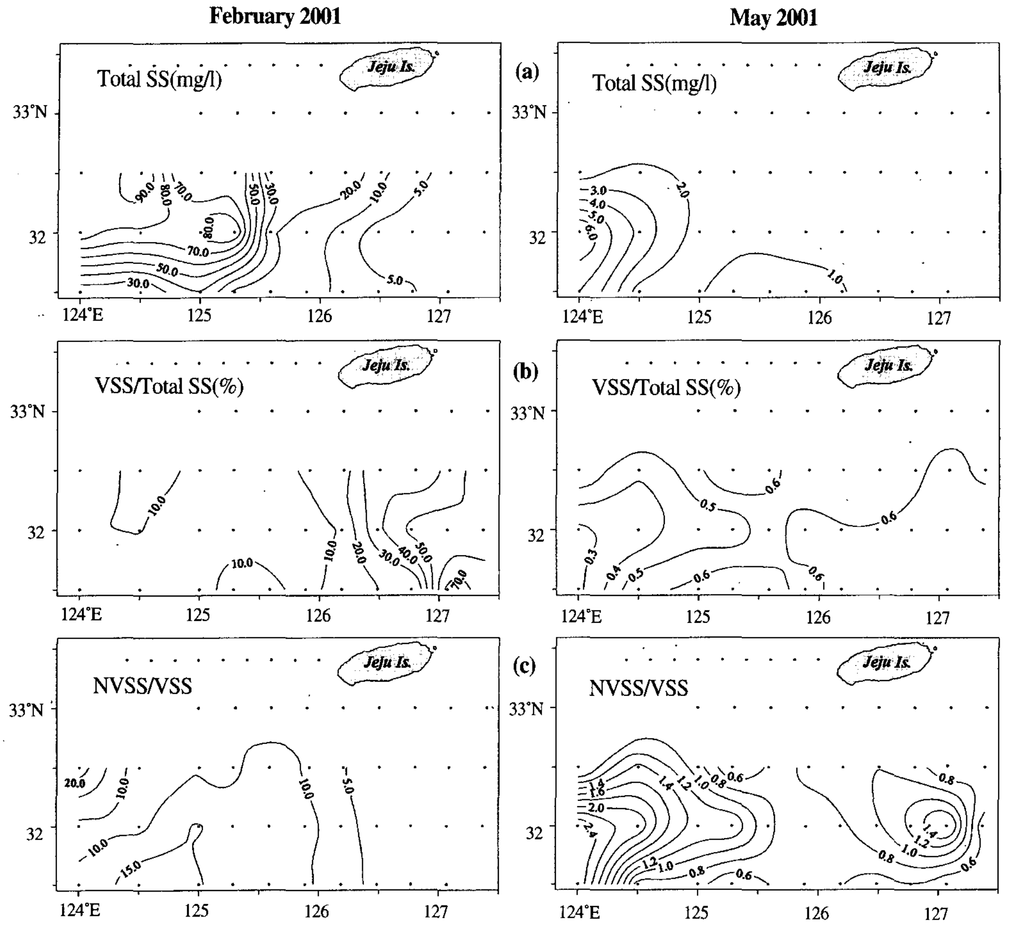


Fig. 4. Distributions of the (a) total suspended solid (SS), (b) volatile SS /total SS (%) and (c) nonvolatile SS /volatile SS in February and May, 2001.

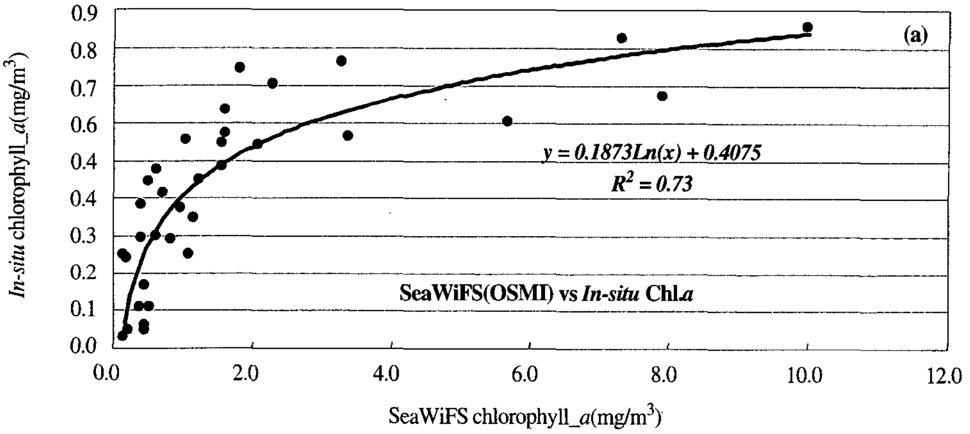


Fig. 5a. Relationship between the measured field chlorophyll a and the estimated chlorophyll a from the processed SeaWiFS (OSMI) imagery using the OC 2 algorithm in the northern East China Sea in Feb., May, Aug., and Nov., 2000.

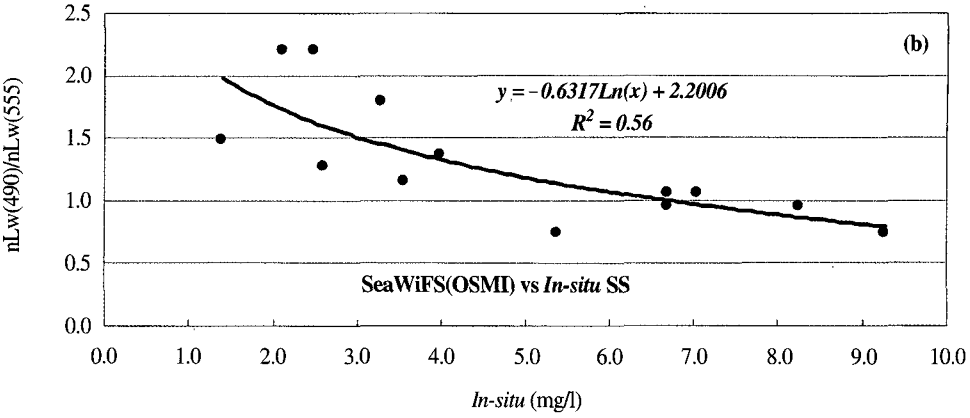
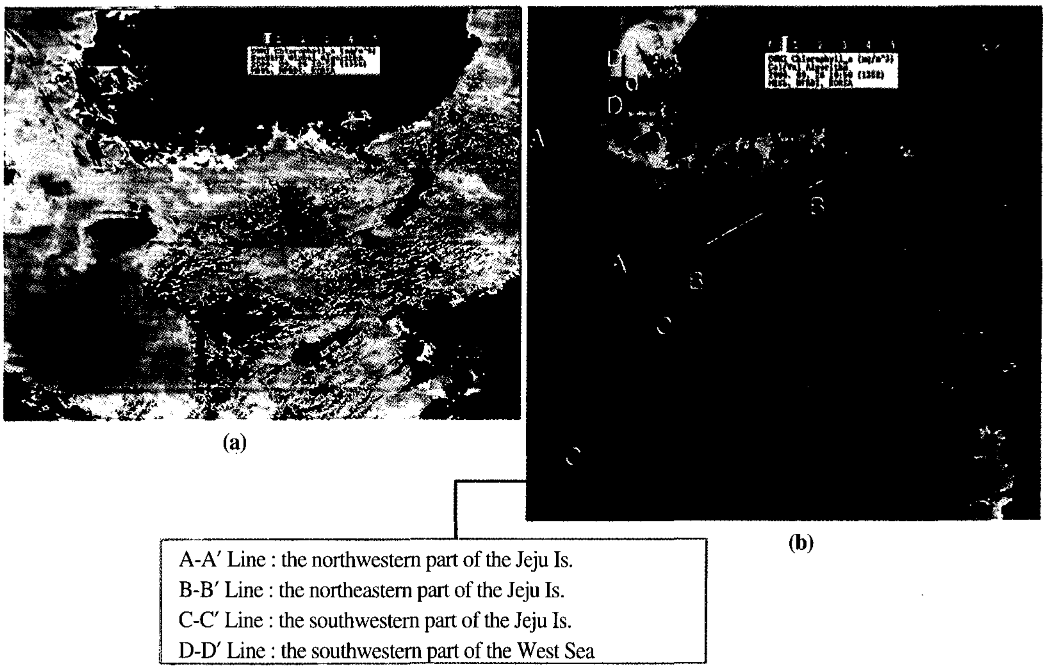


Fig. 5b. Relationship between the measured field suspended solid and the estimated SS from the SeaWiFS (OSMI) bands ratio in the northern East China Sea in Feb., May, Aug., and Nov., 2000.



A-A′ Line : the northwestern part of the Jeju Is.
B-B′ Line : the northeastern part of the Jeju Is.
C-C′ Line : the southwestern part of the Jeju Is.
D-D′ Line : the southwestern part of the West Sea

Fig. 6. (a) Estimated imagery for chlorophyll a from OSMI using the OC 2 algorithm on 26th Sept., 2000.
(b) CAL/VAL imagery for chlorophyll a from OSMI and the resample lines on the imagery data..

between the two chlorophyll values in the northern East China Sea is shown in Fig. 7.

Delta chlorophyll a values using between the OC 2 algorithm and simple CAL/VAL method were 0.1~0.2mg/m^3 in the a little clear waters (A-A', B-B', C-C') around the Jeju Is, and 0.3~0.6mg/m^3 in the turbid water and transitional waters (D-D') related to the switching 96 CCD on OSMI. After we did geometric correction for OSMI imagery on 26th September 2000, a comparison made between the

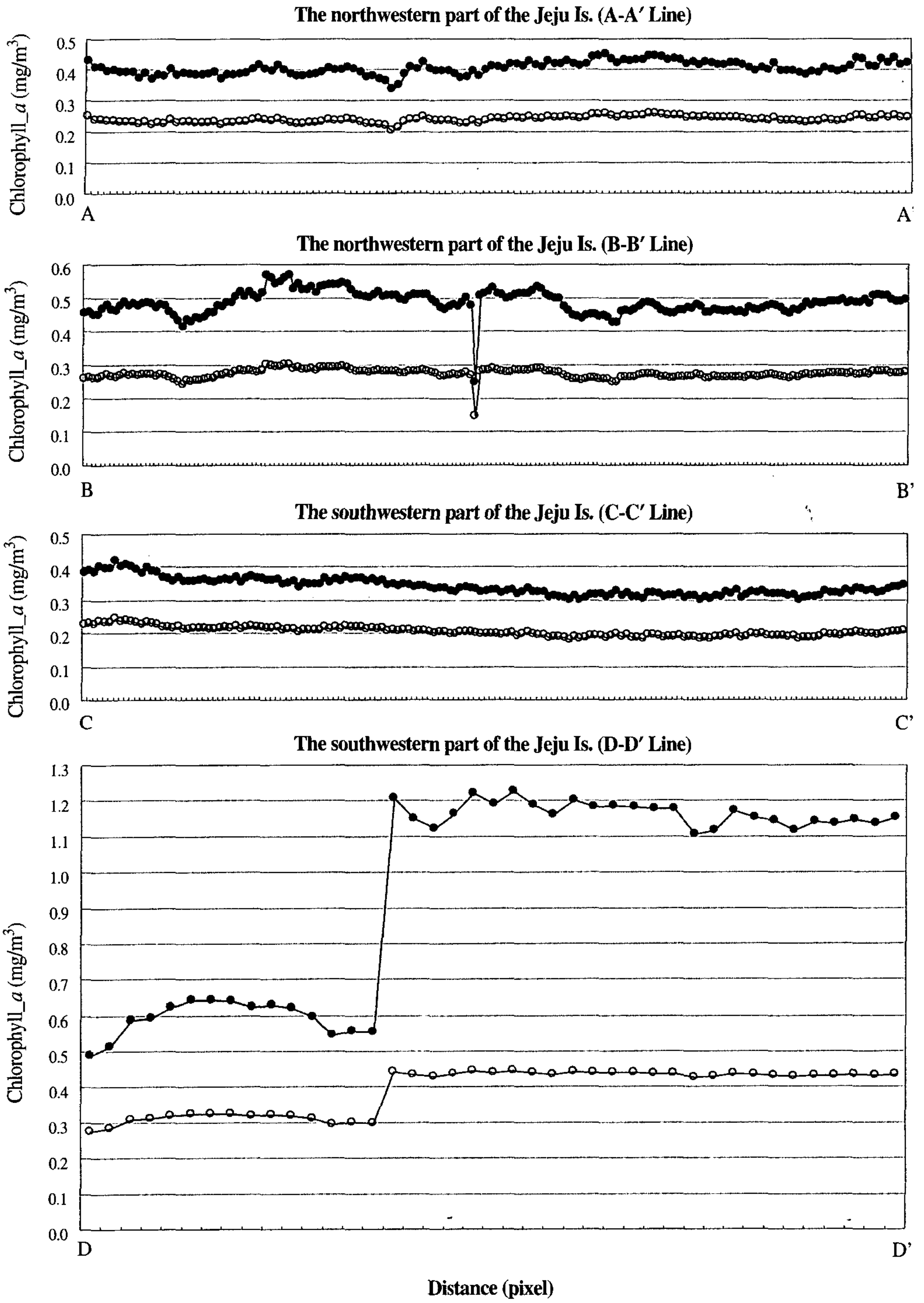


Fig. 7. Comparison between the chlorophyll *a* values derived from the OC 2 algorithm for SeaWiFS(-●-) and the ones from simple CAL/VAL method for OSMI (-○-) on 26th Sept., 2000. Data sampling lines are the same as the Fig. 6(b).

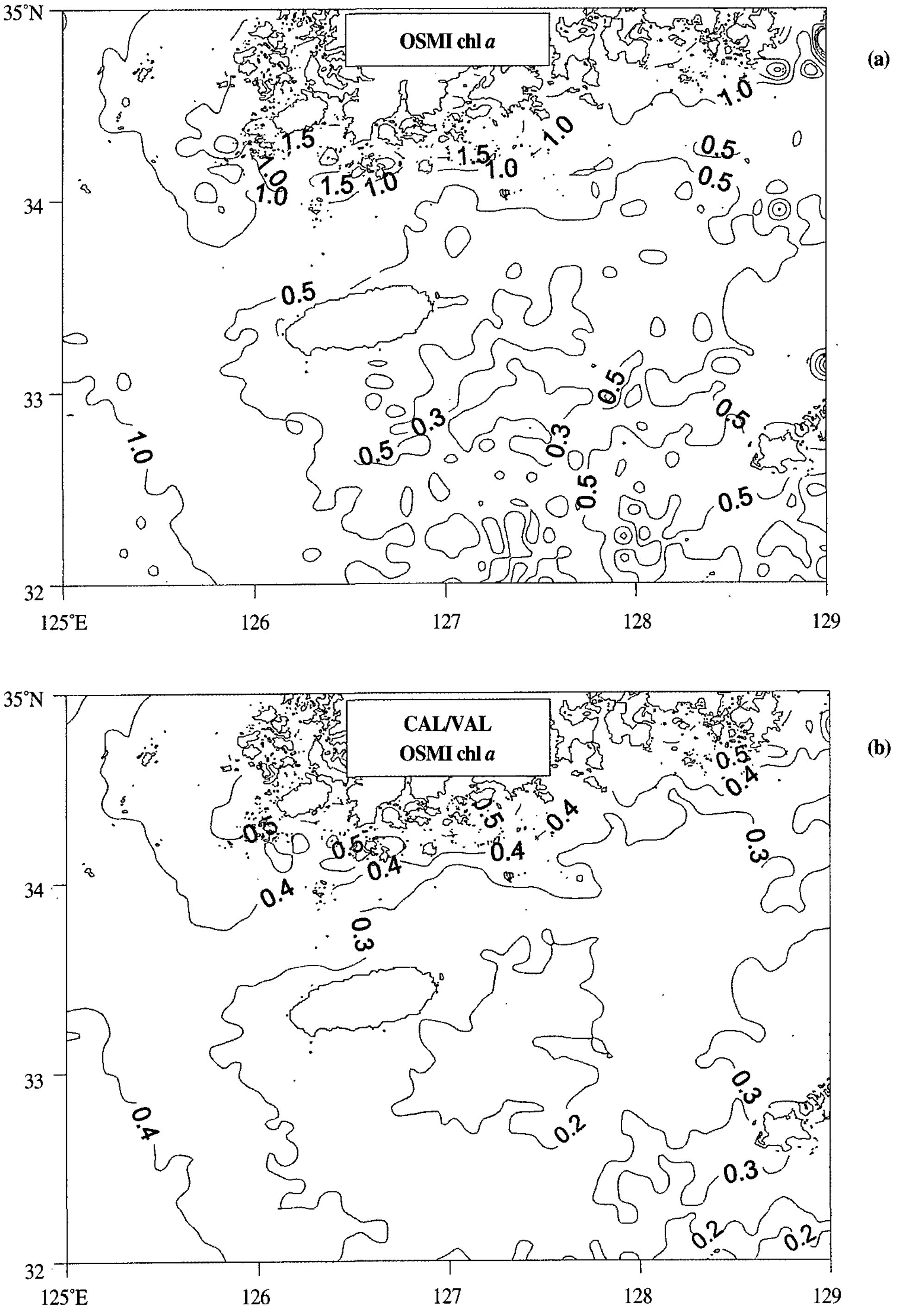


Fig. 8. Distributions of the chlorophyll *α* (mg/m^3) from geometric correction for OSMI imagery on 26th September, 2000.
(a) Chlorophyll *α* from OSMI level 2 data using OC 2.
(b) Chlorophyll *α* from OSMI data using the simple CAL/VAL method.

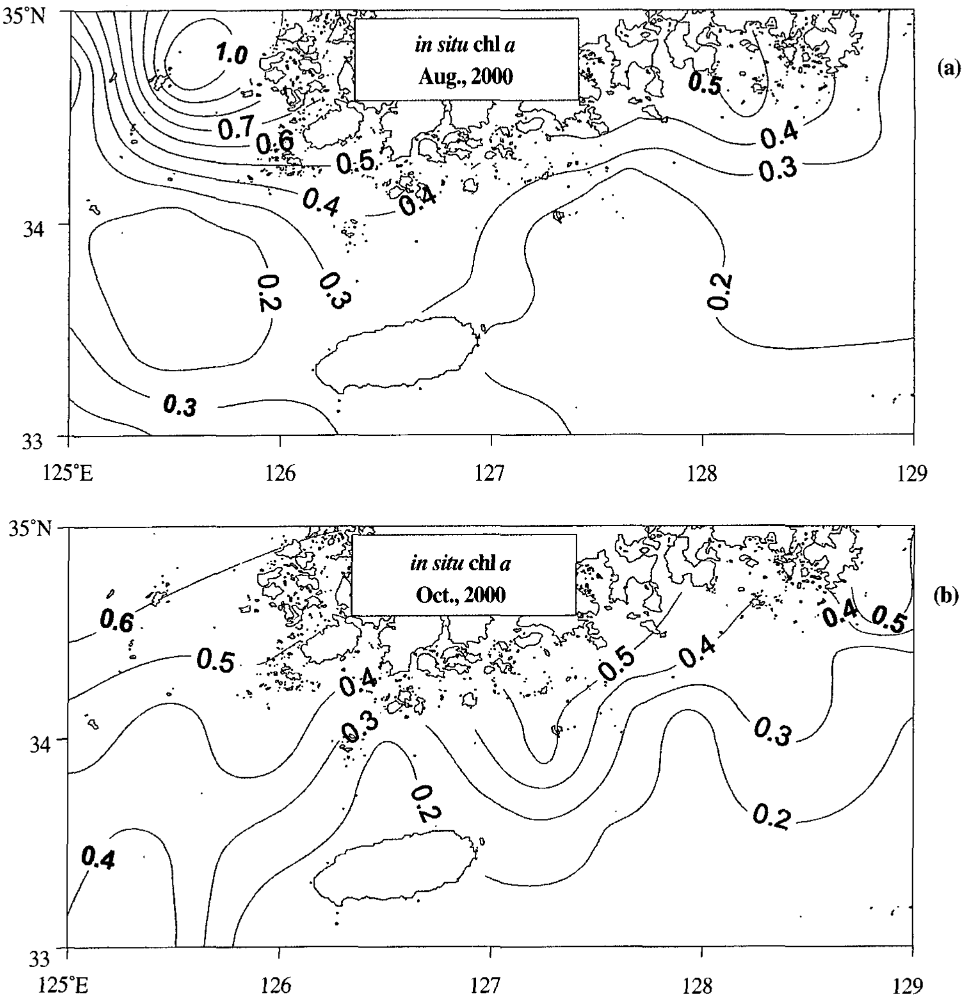


Fig. 9. Distribution of *in situ* chlorophyll a (mg/m^3) in August (a) and October (b), 2000.

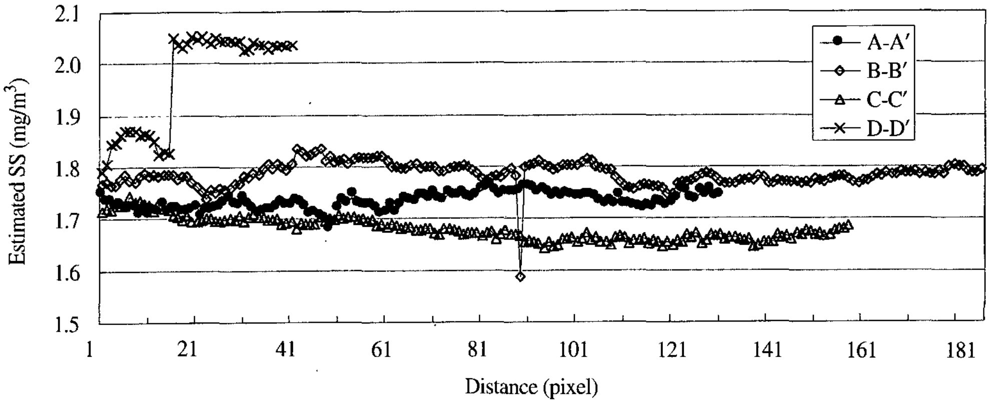


Fig. 10. Variations of suspended solid (SS) in the resample lines of the CAL/VAL SS on OSMI imagery.

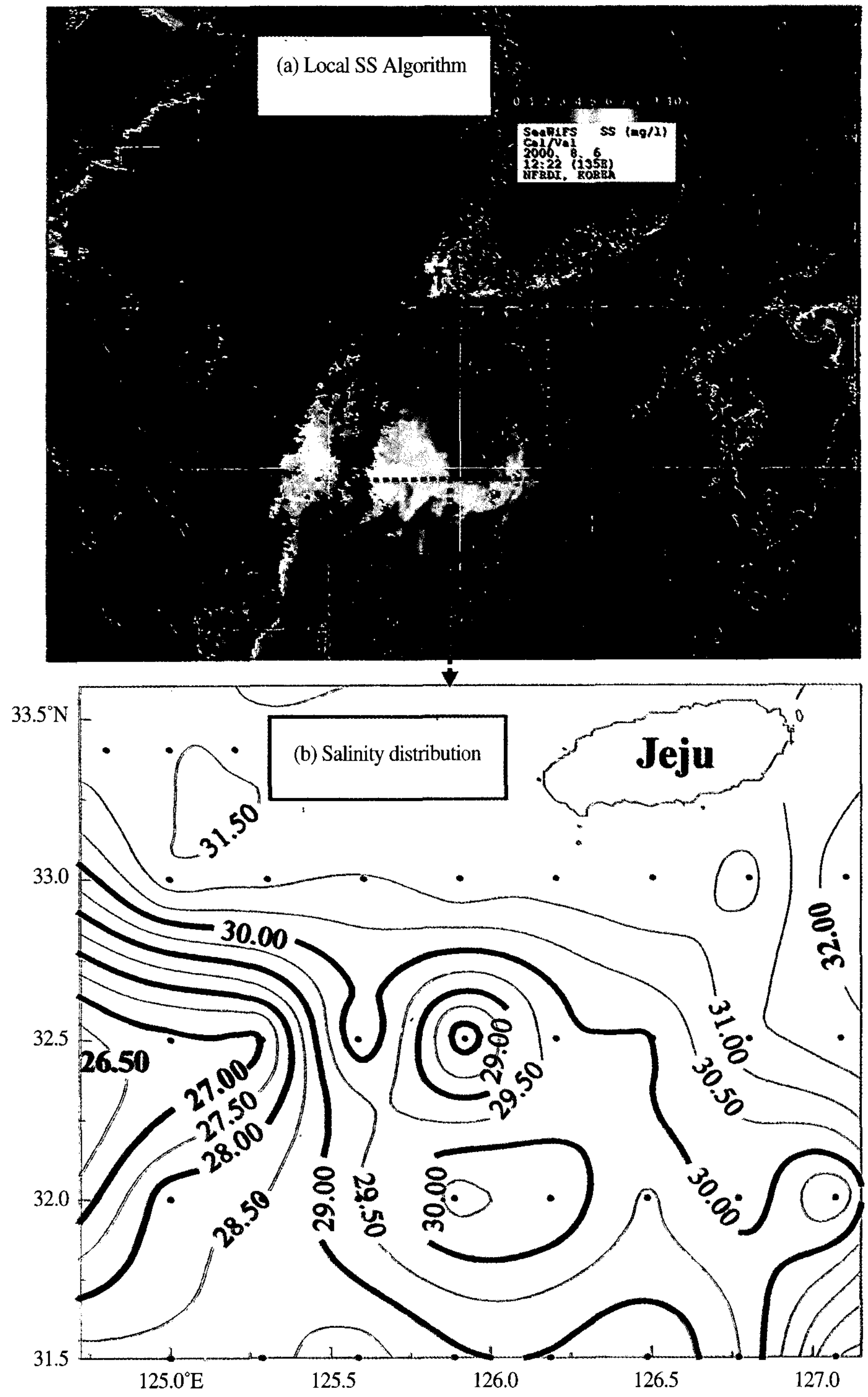


Fig. 11. Map showing (a) the distribution of SS from the SeaWiFS band ratio (nLw 490/ nLw 555) using the simple CAL/VAL method on August 6, 2000, and (b) the distribution of salinity (psu) from the measured field data in August, 2000.

chlorophyll α from OSMI using OC 2 and the chlorophyll α from OSMI data using the simple CAL/VAL method. The delta chlorophyll α values were 0.1~0.2mg/m^3 in a little clear water and 0.5~1.0mg/m^3 in turbid water.

To compare between the estimated chlorophyll a using the simple CAL/VAL method and the *in situ* chlorophyll α, the measured field chlorophyll α data are shown in Fig. 9. The chlorophyll α values derived from the simple CAL/VAL method (Fig. 8b) are very similar to the *in situ* ones in October, 2000 (Fig. 9b).

A comparison plot among the SS values at the 4 lines is shown in Fig. 6b and Fig. 10. In case of the differential SS values among a little clear water, turbid water, and the transitional waters related to the switching 96 CCD on OSMI, the SS values in the turbid water and transitional waters (D-D') are higher than others. Specially the SS values were suddenly increased in the region (D-d-D') between one scanning of 96 CCD on OSMI and another scanning of the CCDs.

An imagery using the above simple CAL/VAL method (2) for SS from the SeaWiFS data on 6th August, 2000 is shown in Fig. 11a. The distribution of SS using the simple CAL/VAL method is very similar to the distribution of salinity (iso-line 28psu) at that time (Fig. 11b).

5. Conclusions

The oceanographic stations in the northern East China Sea observed very strong absorption caused by suspended solids during the winter period. However, the ocean color properties of the stations in the spring were intermediate between case 1 and case 2 (Fig. 3).

The ocean color of the northern East China Sea is optically complicated due to the contributions not only from concentration of phytoplanktons, but also from suspended solids. In order to validate satellite ocean color retrievals and to develop simple CAL/VAL methods for complex case 2 regions require continuous routine ship-based studies. In case of the stripes on the OSMI imagery, the data errors introduced by the nature of whisk-broom scan related to the OSMI instrument (also known as bow-tie effect) should be corrected from raw data at channel access data unit(CADU) level.

The northern East China Sea is regarded as an important fisheries ground. However, the surface salinity is very low in summer seasons because of the run offs from the Yangtze river. A highly feasible method of detecting low salinity water in the East China Sea during the summer has been developed using the relationship between the turbid water from the Yangtze river and the bands ratio of SeaWiFS (OSMI) (Fig. 11b). Suh *et al.*(1993) had shown the relationship between the measured transparency in turbid water and the digital radiance values from channel 1 of NOAA/AVHRR. The relationship between the measured surface salinity and the estimated SS in turbid water will be interested in the monitoring low salinity water in the East China Sea in summer season using ocean color satellite.

Acknowledgements

This research has been supported by Ministry of Science and Technology of the Government of Korea through the sub project entitled Study on the CAL/VAL of the OSMI satellite data and the application for the Korean fisheries.

References

Cho Y. M. and *et al.*, 1998. Ocean scanning multi spectral imager (OSMI), Proceedings of the Fifth International Conference on Remote Sensing for Marine and Coastal Environments, San Diego, California, U.S.A, pp.1-459.

Cho Y. M. 2000. Prelaunch radiometric performance analysis of ocean scanning multi-spectral imager (OSMI). *J. Korean Society of Remote Sensing*, 16(2): 135-143.

GKSS. 1986. *The Use of Chlorophyll Fluorescence Measurements from Space for Separating Constituents of Sea Water.* ESA Contract No. RFQ3-5059/84/NL/MD, Vol. II, Appendices. GKSS Research Centre.

Gordon, H. and Morel, A. 1983. *Remote Assessment of Ocean Color for Interpretation of Satellite Visible Imagery.* A Review. Springer-Verlag, New York, 114 pp.

O'Reilly, J.E., S. Maritorena, B.G. Mitchell, D.A. Siegel, K.L. Carder, S.A. Garver, M. Kahru and C.R. McClain. 1998. Ocean color chlorophyll algorithms for SeaWiFS. *J. Geophys. Res.*, 103: 24, 937-24, 953.

Strickland J. D. H. and T. R. Parsons. 1968. *A Practical Handbook of Seawater Analysis.* 311 pp.

Suh, Y. S., B. G. Mitchell, L. H. Jang, S. G. Lee and S. J. Yoo, 2001. Calibration and validation of ocean color satellite imagery. *J. Korean Environmental Sciences Society*, 10(6): 431-436. (*in Korean*)

Suh, Y. S., S. D. Hahn and Y. Q. Kang, 1993. Estimation of transparency from the AVHRR channel 1 digital number of NOAA satellite in the southeastern Yellow Sea. *J. Korean Society of Remote Sensing*, 9(2): 1-5.

Yacobi Y. Z., Gitelson A. and Mayo M. 1995. Remote sensing of chlorophyll in Lake Kinneret using high spectral-resolution radiometer and Landsat TM: spectral features of reflectance and algorithm development. *J. Plankton Research*, 17(11): 2155-2173.