Monitoring Sea Environment Change Using Remote Sensing in the Ariake Sea

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Abstract: Recently, the environment of the Ariake Sea, Japan has changed drastically. In this study, the result of sea survey, synchronizing the passage time of the Landsat in August 2002 was collated with the satellite data to develop the evaluating equation for transparency and sea surface temperature (SST). By Applying these equations to 5 satellite images of the same season, the transparency and SST in summer of 1985, 1991, 1996 and 2000 is estimated. Consequently, the transparency had increased until 2000 and then decreased in 2002. The SST, on the other hand, shows no remarkable trend.

Keywords: Landsat/TM, the Ariake Sea, transparency, sea surface temperature

1. Introduction

In the last decade, the environment of the Ariake Sea, Japan has changed drastically and the marine product in this sea was decreased to an unprofitable level. The relationship of the change and the sea dike construction in the Isahaya Bay has been the target of the disputes of the society for these years and thus, to view the environmental change of the Ariake Sea during this period has an important social value. Although there are observation networks founded by the surrounding prefectures since 1960s, the remote sensing technique is helpful to interpolate the point data to continuous surface data in case they can be estimated from the remotely sensed data.

The Ariake Sea is a half-closing sea area surrounded by the cities and towns as well as many development projects have been undertaken historically. Such a sea area is, generally, prone to eutrophication or contamination by the influence of the surrounding lands.

In these decades, abnormal phenomenon including increase of red tides and decrease of shellfish products such as Pen shell (*Atrina pectinata*) are observed in the Ariake Sea. These phenomenon are interpreted to be derived from various factors and the exact cause of these abnormal phenomenon has not been identified despite studies from various standpoints.

The research institutes located in the surrounding area of the Ariake Sea have collected the data on sea environment since 1960s.

However, these are point data and to evaluate continuous sea surface environment, the use of remote sensing provides very helpful data.

In this study, by combination of Landsat/TM, ETM+ data analysis and field survey at almost the same time of satellite passage, the evaluation model equation is developed and using this, the environmental change of the Ariake Sea is evaluated.

2. Methodology

The flowchart of the environment evaluation of the Ariake Sea used in this study is depicted in the Fig. 1. The analysis is divided into the following four steps.

1. Field survey on the sea.
2. Pre-processing of the satellite images (i.e. geometric and simple atmospheric corrections).
3. Developing model equation from the relationship between the field observation and satellite data.
4. Detecting environmental change by applying the equation to the past satellite images.

The satellite images used in the study is shown in the Table 1. All the images are observed in the almost the same season from July to August.

This study covered almost all the areas of the Ariake Sea, except the southernmost part.

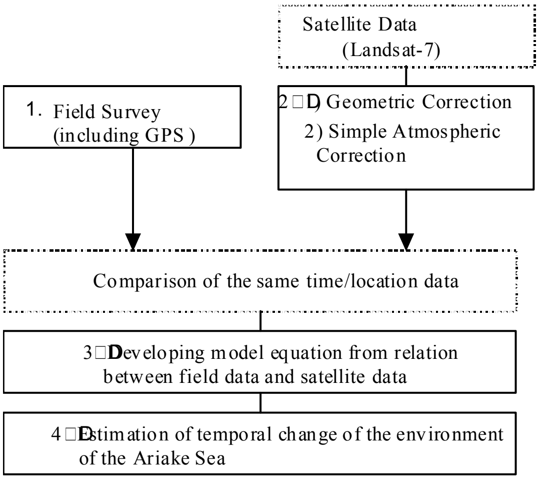

Fig. 1. The flowchart of this study

Table 1. The satellite images used in this study

Date(mm/ dd/ yyyy)	Time(hh:mm:ss)	Cloud coverage(%)
08/ 29/ 1985	AM 10:23:10	10
08/ 14/ 1991	AM 10:17:10	20
08/ 11/ 1996	AM 10:09:30	20
07/ 21/ 2000	AM 10:30:40	10
08/ 04/ 2002	AM 10:41:50	40

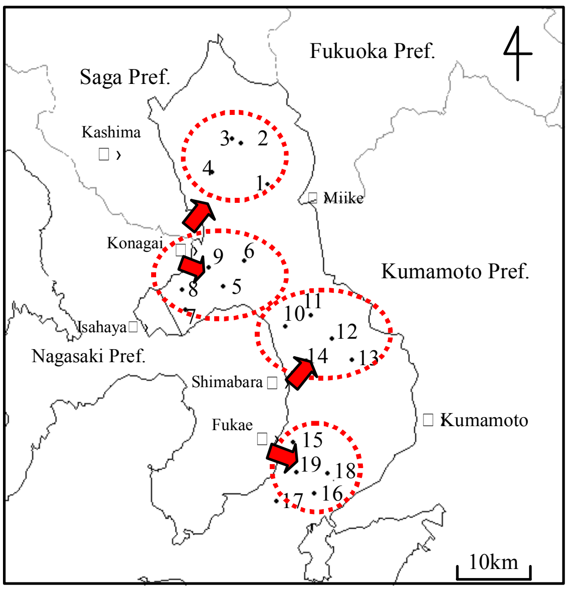

Fig. 2. The study area

3. Field Observation and Developing Model Equation

Synchronizing the passage of the Landsat-7, the field survey on the sea is conducted around AM 11:00 on the 4th, Aug, 2002. The observation points are distributed as shown in Fig. 2. The field observation is conducted on the fishing boats seen in the Photo 1. The field data is collected as seen in Photo 2.

From the field survey data, the transparency is relatively low, i.e. between 0.9 m and 3.0 m, in the inner part of the sea. In the middle to southern part, i.e. the off-shore of the Shimabara and Fukae, transparency is high marking between 5.0 m and 6.0 m. There was no remarkable temporal change in SST although slightly high temperature was seen in some southern observation points.

From the relationship between the field data and Landsat/ETM+ data, the conversion equation from reflectance to transparency (m) and from radiation temperature to sea surface temperature are developed.

The evaluating equations for summer season derived by linear approximation are (1) and (2) for transparency and SST, respectively.

$$\text{Trans(m)} = -2.6473 \times \text{ref.TM2} + 10.206 \qquad (1)$$

Photo 1. Fishing boat used for the field observation

Photo 2 Field observation

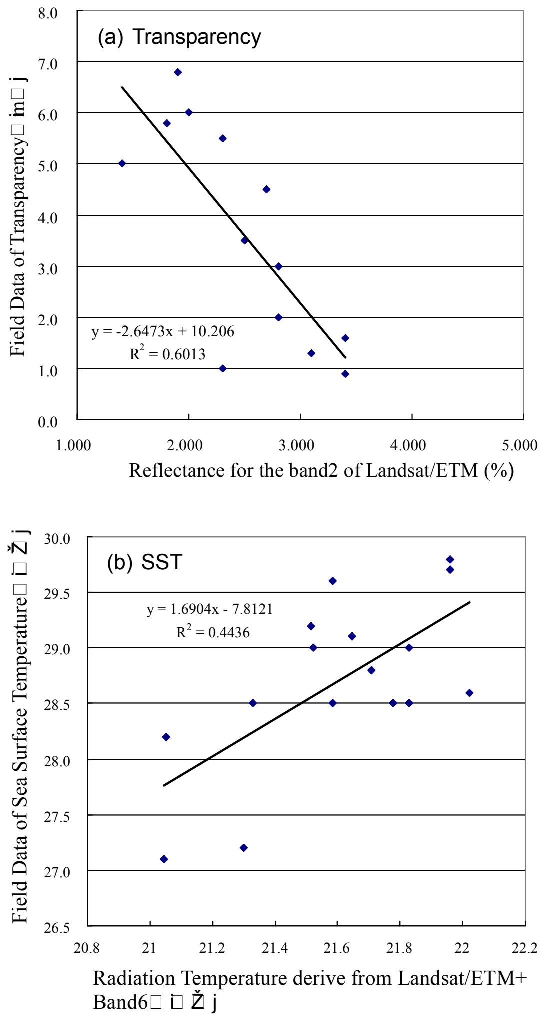

Fig. 3. The relationship between the field data and satellite data. (a): Transparency (b): SST

Where, Trans is transparency and ref.TM2 is the reflectance (%) of the band 2 (525-605nm)[1] of Landsat/TM or ETM+.

$$SST(℃)=1.6904 \times T6 - 7.8121 \quad (2)$$

Where, SST is the sea surface temperature and T6 is the radiation temperature derived from band 6 （10.40-12.50μm）[1] of Landsat/ TM or ETM+.

4. Result of Estimation

1) Transparency

On 29 August 1985 the transparency in the north to middle part of the Ariake Sea is only 2 to 4 m and 4 to 5 m even in the southern part. On 14 August 1991, although we can see low transparency around Shimabara Peninsula, the sea is more transparent than 1995 in the large part.

On 11 August 1996, some clouds are seen in the central part of the study area. We can see higher transparency than 1985/1991 especially, marking more than 7 m, in the southern part.

On 21 July 2000, the low transparency, 3 to 4 m, is observed in the inner area and the Isahaya Bay and on the other hand, around Shimabara Peninsula and in the southern part of the sea, the high value more than 7 m is observed.

Although the increasing trend can be seen in the transparency, that decreased in 2002 in the large area. However, the influences of clouds and the aerosol from Mt. Fugen-dake through the north-northwest wind [2] should be considered. Therefore, data accumulation in the future is important.

2) Sea Surface Temperature

In the Ariake Sea, SST is low in the southern area, which is influenced by the cold open sea, and high in the inner area.

On 29th August 1985 and 21 July 2000, the SST is as low as 26 – 28 °C. The SST in the inner part on the 14th Aug., 1991, was 30–31°C. On 11 August 1996, the SST is high, 30-31 °C , in the whole area. In that day, the air temperature is high and this may influence to the SST.

There are no markedly trend for the SST.

3. Conclusions

In this study, estimation of the transparency and the the sea surface temperature is attempted using Landsat/TM, ETM+. The strong relationship, 0.44 and 0.60 as coefficients of determination, was seen between the result of field survey and satellite data. Using this relationship, we could develop the estimation equation for the summer season The equation for the other season is future work. However, it is difficult to evaluate environmental condition only with Landsat, whose repeat period is 16 days. It is helpful to combine with the other satellite data, which has a short repeat period, making up for rough spatial resolution.

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References

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[2] Japan Meteorological Agency: http://www.data.kishou.go.jp/ marine/tide/suisan/suisan.php