D-4.3.2 Monitoring by Satellite Picture

Contact Person Kawasaki Kiyosi
Section Director
Marine Biotic Production Division
National Research Institute of Fisheries Science
Fisheries Agency
2-12-4 Fukuura, Kanazawa, Yokohama 236, Japan
Tel: 045-788-7647 Fax: 045-788-5001
E-mail: kkawasaki@ss.nrifs.affrc.go.jp

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In order to monitor natural and antholopogenic variations of coral reefs widely by satellites, algorism to detect the variations from satellite data taken at diffent dates was investigated. It was found that the LANDSAT-TM data were available for the purpose because of its high resolution, frequent picture taking and variety of picture bands. The pictures without cloud coverage over Okinawa Island were analyzed. Difference between the data taken at different dates does not represent the real difference of underwater targets because the data vary not only with reflection by underwater targets but also with solar latitude, transparency of sea water and depth of the targets. Therefore, the influence of solar latitude was eliminated and the influence of light dissipation in the water was made decrease by introducing the ratio of data on the two appropriate bands at the same date and by drawing pictures with the difference between the ratios at different dates. Underwater coverages by the red soil sediment taking place between June 5, 1989 and November 4, 1992 were confirmed on the picture drawn with the difference of the ratio. Further, the influence of geographic depth change was eliminated by drawing the picture with the ratio of the ratios at different dates. Only the influence of sea level remains without being eliminated but the tide calendar makes it possible to estimate the influence. Transparency or light dissipation coefficient of seawater can vary with seasonal change of primary production, progress of eutrophication and resuspension by storms. These influences should be estimated from *in situ* observations.

1. Introduction

Peoples are now afraide of worldwide declination of coral reefs with antholopogenic disturbances such as developments and global warming. In Japan also, destruction of coral

reefs with harbor construction, feeding of corals by crown-of-thorn starfish, decline and alternation of corals to zostella with soil sedimentation and to sargassum with eutropication caused by developments have been taking place. It is necessary to find out these variations and take countermeasure as soon as possible. However, it is not so easy to monitor coral reefs widely in a short time because of danger in navigation. It is important to investigate on available methods of monitaring.

2. Research Objectives

Satellite data usage may be available as a method to monitor coral reefs because many satellites have been raised and continue to be raised also in future. Therefore, this investigation forcuses on developing algorism of satellite data analysis making possible to extract variations taking place widely in coral reefs.

3. Mehtod

Availability of each satellite data was examined. Some available pictures taken at different dates containing same reefs without cloud coverage over Okinawa Island were bought and analyzed using personal computer.

4. Results

(1) Availability of data

It was found out that satellites data taken with resolving power high enough to make clear image of coral reef in detail were LANDSAT-TM image data and SPOT-HRV image data. However, SPOT-HRV image data were judged not to be adoptable because of few available bands and few available images. Only LANDSAT-TM image data taken with three available bands over a long period were judged to be adoptable. LANDSAT-MM image data also taken over a long period were omitted from the first becuse of low resolving power and lack of the blue band corresponding to the chlorophyll-a absorption.

(2) Principle and Data processing

The light intensity at satellite, Lu, reflected by underwater target is expressed as

$$Lu = a \cdot Ls \cdot R \exp\{-2K(h+D)\},$$

where a denote the atenuation factor related to atmospheric dissipation and sea surface albedo, Ls the sun light intensity at the sea surface mainly determined by solar altitute, R the albedo of underwater target the variation of which is now concerned, K the dissipation coefficient of seawater, h the tidal level, D the depth of underwater target. The purpose in this work is to extract the variation related to R as that related to Lu.

Fig. 1 shows the image drawn with the difference in Lu on a same band of LANDSAT-TM image data between different dates, ΔLu, where images of roads and shore lines instead of underwater target are exaggerated probably because correction of Lu related to a, Ls and others is not sufficient yet.

Fig. 2 shows the image drawn with the difference in the ratio of *Lu* on two appropriate bands of the data between different dates, $\Delta(Lu1/Lu2)$, where

$$Lu1/Lu2=R1/R2 \cdot \exp\{-2(K1-K2)(h+D)\}$$

because the difference in *a* between bands is generally small. When the differece in K between the two bands are small,

$$Lu1/Lu2=R1/R2$$

and, therefore, the variaton of underwater target, $\Delta(R1/R2)$, can be represented by that of the ratio, $\Delta(Lu1/Lu2)$. Thus, four underwater coverages by red soil sediment are clear and visible as four light bands in Fig. 2. The larger the differences in *a* and *K* between bands and dates, the larger the errors. Even when *K* does not vary with dates, errors from geographic difference in D and difference in h must be corrected.

Fig. 3 is the image drawn with the ratio of the ratios of the data on the two bands at different dates, $(Lu1/Lu2)/(Lu1'/Lu2')$, where

$$(Lu1/Lu2)/(Lu1'/Lu2')=(R1/R2)/(R1'/R2') \cdot \exp\{-2(K1-K2)h\}$$

when *K* does not vary with dates. The effect of geographic difference in D is eliminated. Thus, the four underwater coverages by red soil sediment are also clear and visible as four dark lines in Fig. 3.

Further examination and correction of errors related to *a*, *K* and *h* should be carried out in further *in situ* investigations.

5. Conclusion

(1) LANDSAT-TM image data are available for coral reef monitoring.

(2) It is possible to extract coral reef variation such as red soil sedimentation by drawing images not with the difference in data on a same band but with the difference in the ratio of data on two approprite bands or with the ratio of the ratios of data on the two bands, whole between different dates.

(3) Further examination and correction of errors related to the dissipation by atmosphare, the sea surface albedo, the dissipation by seawater and tidal level should be carried out in further *in situ* investigations.

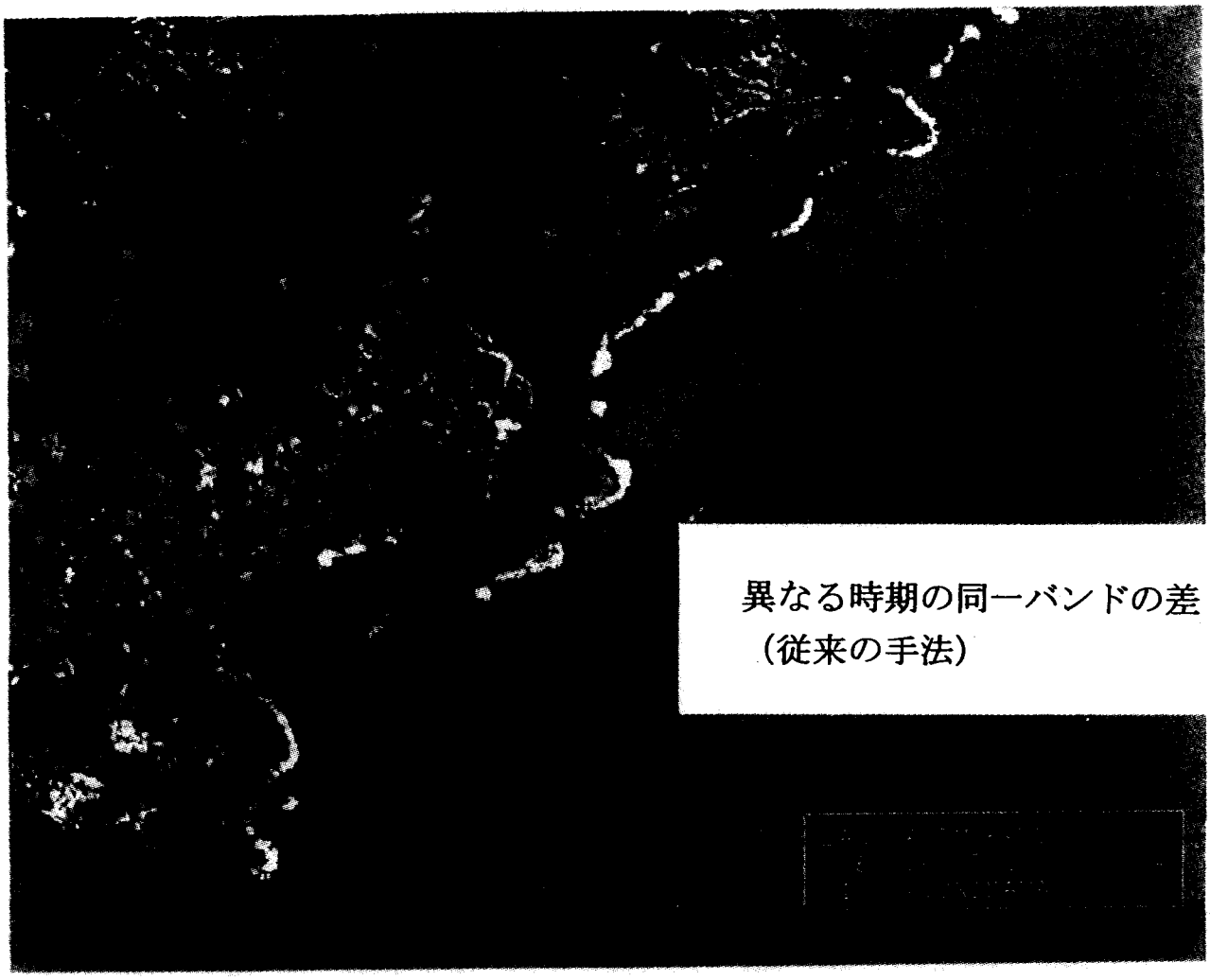

Fig. 1. Image drawn with the difference in data on a same band between different dates.

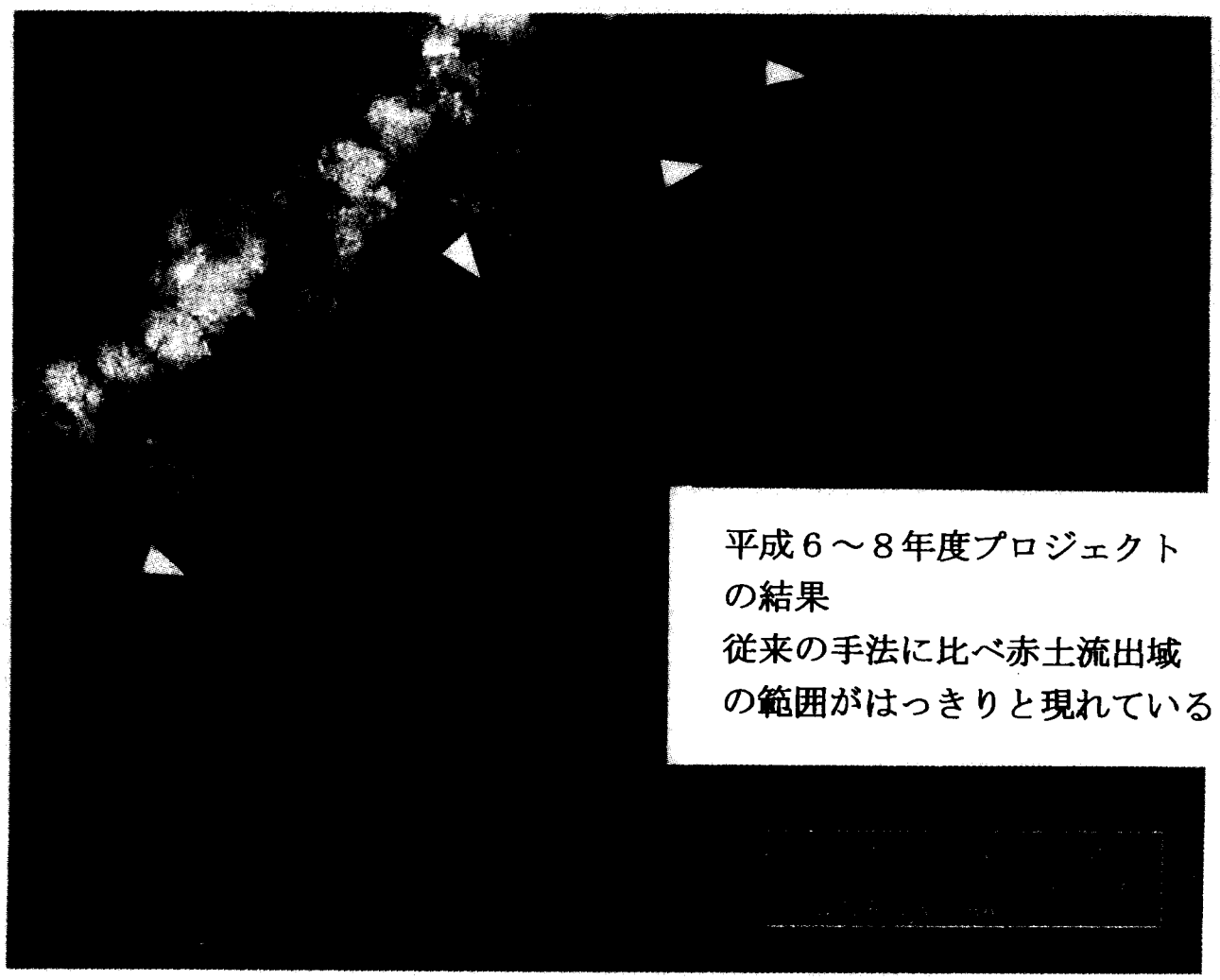

Fig. 2. Image drawn with the difference in the ratio of data on two appropriate bands between different dates.

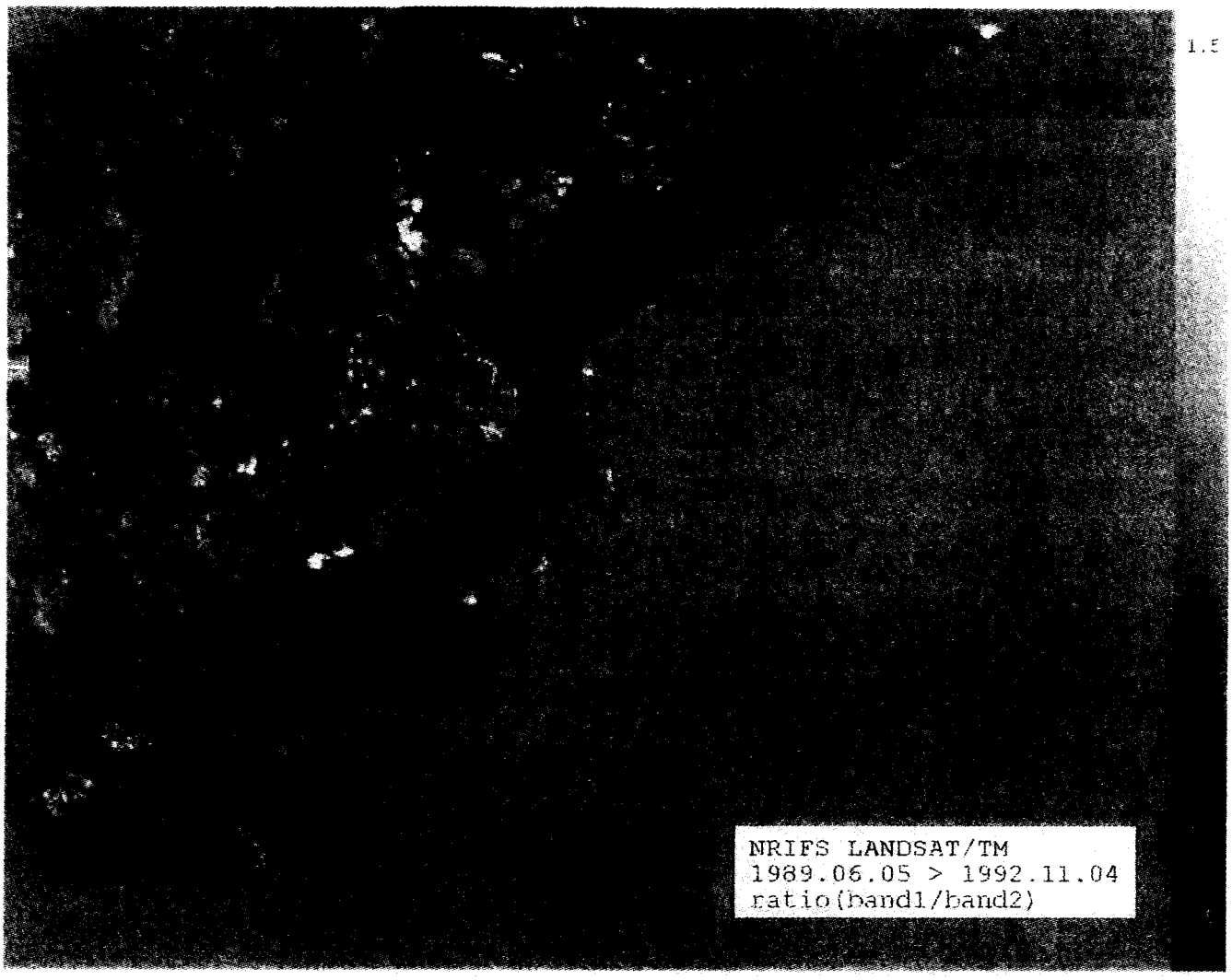

Fig. 3. Image drawn with the ratio of the ratios of data on the two bands at different dates.