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PROBABILITY OF MONITORING AND ANALYZING SEA SHORE ENVIRONMENT IN YAP USING SATELLITE DATA

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Abstract

Remote sensing technique is the effective technology for monitoring and analyzing environmental changes on the Earth surface. We focused to clarify the environmental changes in the Yap islands and Ulithi atoll using satellite data, especially the distribution of water depth around the Yap islands and in the Ulithi atoll. One of these results was compared with the environment of near shore of Japan. To serve our purpose, the sea-truth data were collected using portable spectrometer.

Keywords: remote sensing, estimation of sea depth, turbidity, sea-shore

Introduction

Remote sensing is the effective procedure to analyze and to monitor the environmental changes because of its potentials of monitoring the large area at the same time and of the time series analyzing. Many researchers and we have been clarifying several studies using satellite data[2-6, 9-11, 13)]. Especially, it was clarified that the water depth, shallower than 20 m, can be estimated by satellite data[1, 7, 8, 12)]. We reported that water depth shallower than 30 meters could be estimated by the satellite data[7)]. If the distribution of water depth is determined, it will help native people to easily find the waterway, and will help in evaluating the rising sea level in relation to the greenhouse effect.

This study was carried out as a project of the Research Center for the Pacific Islands in Kagoshima University. This project concerned clarify the self-reliance of islands, based on the Yap Islands in Micronesia.

Principle of the Evaluating of Water Depth

It is assumed that the extinction coefficient of the sea water, α_λ, is homogeneous vertically at each point. At the sea surface, radiance intensity, I_0, decreases in the sea water and becomes I_1 at the bottom. I_1 is expressed as $I_1=I_0\exp(-\alpha_\lambda h)$, where h is the depth. As the radiance I_1 is reflected by the sea-bed, I_1 becomes I_2, $I_{21}=\gamma_\lambda I_1$, where γ_λ denotes bottom reflection coefficient. When the radiance reaches the sea surfaces, the intensity becomes I_3, $I_3=I_2\exp(-\alpha_\lambda h)$. Then I_3 is expressed as $I_3=\gamma_\lambda I_0\exp(-2\alpha_\lambda h)$. I_3/I_0 is the reflectance at the sea surface. If the extinction coef-

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ficient of the water collected at the Yap and reflectance is measured, the depth can be evaluated.

Methodology

Sea Truth

Actual sea depths were measured by throwing the rope from the boat at several points. Spectral reflectances were measured by the handheld spectroradiometer (Model: 2703, Abe-sekkei Co. Japan), ranging from 400 nm to 1050 nm with 25 nm intervals. Sea sediments were collected on the same points and spectral reflectances were measured by the handheld spectrometer. Seawater, in the middle depth of each sampling point, was collected at the same time, and extinction coefficients of water, from 400 nm to 1100 nm, were measured by the spectrometer (Model: 121-0001, Hitachi Co.). These points were recognized and recorded by the handheld GPS instruments (Model: GPS-315, Magellan Co.). These points were shown in Figs.1 and 2 respectively.

Fig. 1. Sea truth point at Yap islands

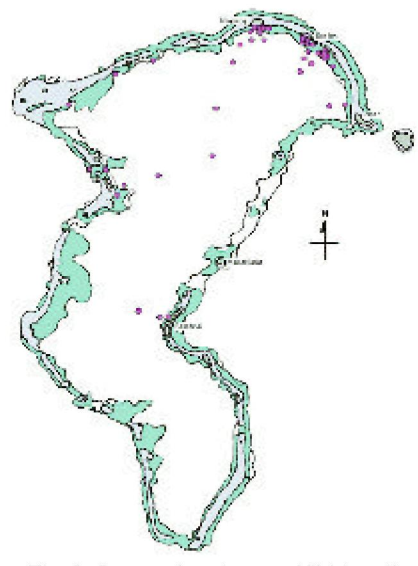

Fig. 2. Sea truth points at Ulithi atoll

Image Analysis

To date, many satellites have been observing the Earth surface. These satellite data have been received only bases, Hatoyama, Japan, Beijing, China etc. These data, observing Yap islands, have been limited in use. Moreover, reflected and emitted radiation from ground objects cannot penetrate the clouds. From these reasons, we determined to use the satellite data of Landsat-2/Multi Spectral Scanner (MSS), Landsat-5/Thematic Mapper (TM) and MOS-1/MESSR.

Landsat-2/MSS data consists of 4 bands, i.e., Band-4 (0.5 to 0.6 μm), Band-5 (0.6 to 0.7 μm), Band-6 (0.7 to 0.8 μm), and Band-7 (0.8 to 1.1 μm). Landsat-5/TM data consists of 7 bands, Band-1 (0.45 to 0.52 μm), Band-2 (0.52 to 0.60 μm), Band-3 (0.63 to 0.69 μm), Band-4 (0.76 to 0.90 μm), Band-5 (1.55 to 1.75 μm), Band-6 (10.40 to 12.50 μm), and Band-7 (2.08 to 2.35 μm). On the other hand, MESSR is consists of 4 bands, Band-1 (0.51 to 0.59 μm), Band-2 (0.61 to 0.69 μm), Band-3 (0.72 to 0.80 μm), and Band-4 (0.8 to 1.1 μm). It has to be noted that these observing regions slightly differed from satellite. These resolutions are 80 m, 30 m (except Band-6; Band-6 is 120 m) and 50 m for L-2/MSS L-5/TM and MESSR, respectively.

Results and Discussion

Characteristic of spectral reflectance of sea-sediment

The spectral reflectance of several sea-sediments, collected at many positions, is demonstrated in Fig. 3. As the collected sands differed in diameter according to sampling places, the spectral reflectance differed from collected place to places in the visible region. However, in the infrared region, these differences were observed to be decreasing. The tendency, that is increasing the wavelength increasing the reflectance, is the same tendency of the soils on the earth ground. The characteristics of spectral reflectance of coral differed according collection point. That is, the coral collected at point-1 was active with green color and the coral collected at point-43 was a white skeleton. The active coral had a small peak at 575 nm and showed high reflectance on the infrared region as is the same tendency with plants grown on the earth. On the other hand, skeletoned coral showed low reflectance among observed regions and was decreasing with increasing wavelength. The distribution of the sea sediments divided into five parts and these spectral reflectances were determined with these measuring results.

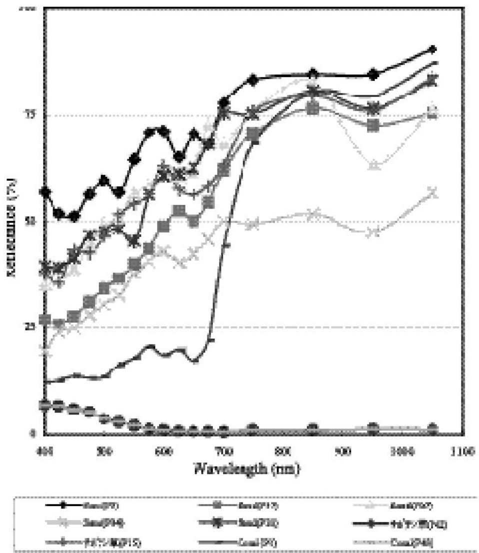

Fig. 3. Spectral characteristic of sea sediments

Changes of spectral reflectance by the sea depth

Spectral reflectance was measured at each point. One of these examples is demonstrated in Fig 4. In this point, sea depth was 35.3 m and *Halimeda* spp. were grown. Three measurements were done and the variations were not large. The spectral reflectances increased with increasing wavelength.

The relationships between the depth and mean reflectance corresponding with Landsat/MSS band was shown in Fig. 5. These relations are shown with the following equations.

Y4= -0.2066x+13.215, R^2=0.4074

Y5= -0.2018x+ 9.057, R^2=0.4476

Y6= -0.0456x+ 2.970, R^2=0.0726

Y7= -0.0318x+ 3.501, R^2=0.0297

Where Y is the mean reflectance of each MSS band and x is depth. In these cases on Ulithi atoll, as the sea sediments were not divided, the correlation coefficients were very low. On the other hand, our previous work at Yap islands could be represented with the following equations.

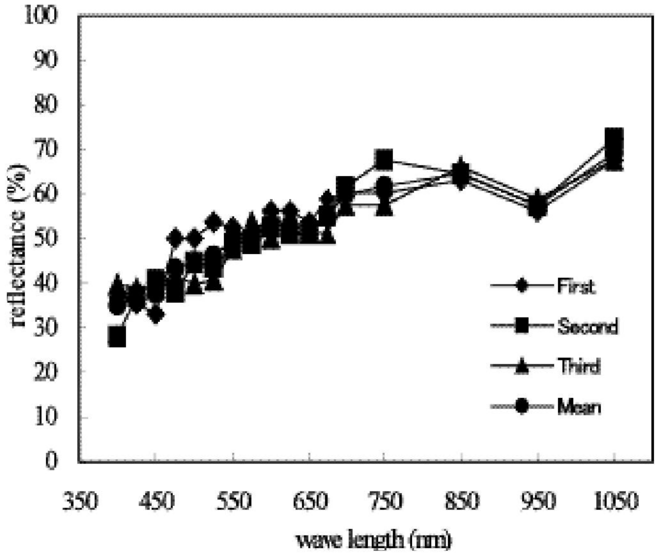

Fig. 4. Changes of Spectral Reflectance at Poin (35.3 m depth, Halimeda spp.)

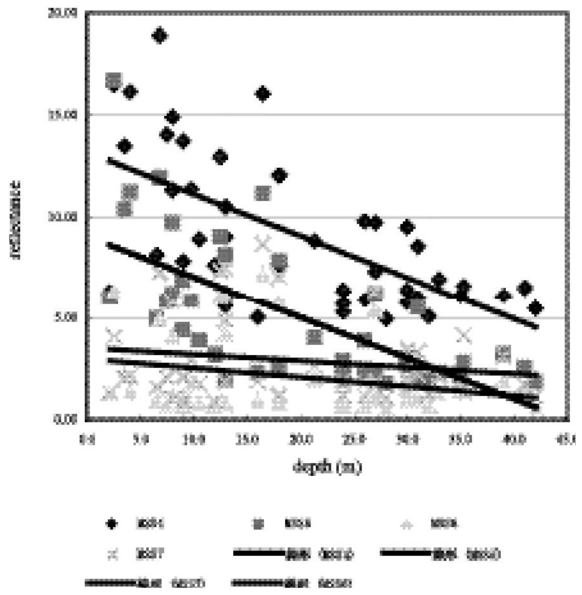

Fig. 5. Relationships between sea depth and mean reflectance corresponded with Landsat/MSS band

On sand

$Y4= -0.3718x+16.444,\ R^2=0.9743$

$Y5= -0.5308x+20.270,\ R^2=0.9643$

$Y6= -0.2804x+10.863,\ R^2=0.9480$

$Y7= -0.1358x+ 7.8323,\ R^2=0.6736$

On mud

$Y4= -0.0715x+6.4792,\ R^2=0.5901$

$Y5= -0.0993x+6.8819,\ R^2=0.7596$

$Y6= -0.0672x+4.7687,\ R^2=0.8609$

$Y7= -0.0095x+5.6078,\ R^2=0.0306$

The decreasing rate in the case of sand is larger than the case of mud. These results corresponded to the principle of evaluating the water depth.

To compare the results of Yap and Ulithi, Ulithi's data were not divided by type of sea sediment. To analyze the satellite data observed on Ulithi atoll, we would have to correlate these data with sea sediments.

Extinction coefficient of the seawater

The relationships of the extinction coefficient of sea water collected at several points in Ulithi atoll and wavelength were shown in Fig. 6. The extinction coefficients of sea water were compared with distinguished water. As these data were very changeable values at each wavelength, the extinction coefficient was observed decreasing with increasing wavelength.

These coefficients were calculated with corresponding satellite bands in Table 2. In Yap (1999) data, mean distinction coefficients differed from satellite bands as the observing region differed from satellite. These mean extinction coefficients decreased with increasing region. This tendency agreed with the theory of Rayleigh scattering. Comparing Ulithi (2001) and Yap (1999) in Landsat/MSS, the values of Ulithi were slightly smaller than the values of Yap. This shows that the sea water in Ulithi atoll is more transparent than the Yap near shore. Izumi has the worst transparency among the sites studied.

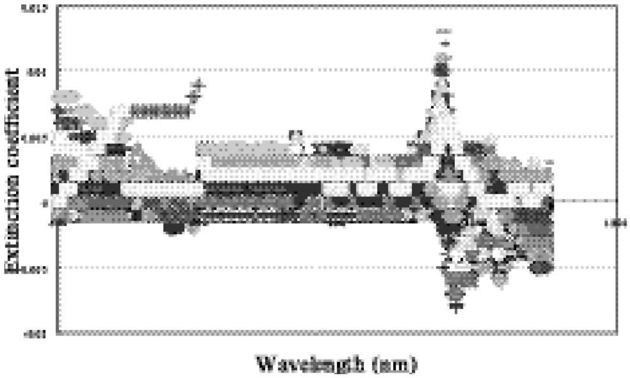

Fig. 6. Changes of extinction coefficient on several sea depth

Table 1. Spectral reflectance corresponded with Landsat/MSS on ea ach sediment

Band	region (nm)	Sand	Cactus (P42)	Cactus (P15)	Coral (P1)	Coral (P43)
MSS4	400-500	39.78	5.70	41.15	13.00	5.70
MSS5	500-600	46.21	2.14	54.33	17.39	2.19
MSS6	600-700	55.51	0.68	59.73	24.42	0.68
MSS7	800-1100	70.33	1.06	79.83	82.27	1.06

Table 2. Comparing the mean extinction coefficients at each studying area

Band	Region (nm)	Ulithi (2001)	Yap (1999)
MSS4	400～500	0.0010	0.0022
MSS5	500～600	0.0014	0.0016
MSS6	600～700	0.0013	0.0014
MSS7	800～1100	0.0006	0.0009
		Izumi (1997)	Yap (1999)
TM1	450～520	0.0080	0.0027
TM2	520～600	0.0082	0.0020
TM3	630～690	0.0070	0.0015
TM4	760～900	0.0064	0.0014

Conclusion

We focused on clarifying the environmental changes in Yap islands and Ulithi atoll using satellite data, especially about the distribution of water depth around the Yap islands and in the Ulithi atoll. One of these results was compared with the environment of near shore of Japan. This study showed the following results.

1. The distribution of the sea sediments in Ulithi atoll divided into five parts and these spectral reflectancse were determined with these measuring results.
2. Relationships between the depth and mean reflectance correspondent with Landsat/MSS band were determined. This shows the possibility of estimating the sea depth using satellite data.
3. The extinction coefficients were measured and compared with Yap, Ulithi and Izumi. It was clarified that Izumi has the worst environmental conditions among them.

We are now in the process of collecting satellite data from NASA in USA and NASDA in Japan. We hope to have success in making visual maps. And these visual maps will provide the environmental changes during 30 years.

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