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동해안 해변의 자외선 반사량의 원격탐사

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Remote Sensing of the Ultraviolet Reflectance on the East Coast Beach

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요 약

최근에는 연안 지역의 개발이 진행됨에 따라 해변 근처에서 레저 활동을 하고 있는 사람들이 증가 하고 있다. 하지만, 오존층의 파괴로 지표면에 도달하는 자외선의 양은 증가하였다. 인체는 자외선에 의한 피부암과 눈 손상 등으로 유해한 영양을 받는다. 특히, 해변에서 자외선의 영향은 모래 표면으로 부터의 반사로 인해 내륙 지역보다 높다. 본 연구는 원격탐사를 이용한 동해안 해변의 자외선 반사 측정 방법의 기초자료로 활용할 수 있을 것으로 기대된다.

ABSTRACT

In the recent years, the development of coastal zone has been advancing, and the chance of leisure activity has increased near the sea. However, the destruction of ozone layer has resulted in an increase in the amount of ultraviolet radiation reaching the earth surface. The human body is harmfully influenced as skin cancer and eye damage by ultraviolet radiation. Especially, the effect of ultraviolet radiation on beach is higher than that inland area due to the reflection from the sand. This study is expected to use basic data on the method of measuring ultraviolet reflections on east coast beaches using remote sensing.

키워드

East Coast Beach, Ultraviolet, Radiation, Reflection, Remote Sensing
동해안 해변, 자외선, 방사선, 반사, 원격 탐사

Ⅰ. Introduction

Recently, following changes in the ways of life and lifestyles, those who enjoy various leisure activities such as sunbathing and swimming in coastal areas and beaches have been increasing.

The destruction of the ozone layer due to global environmental problems leads to damage to human skin by excessive ultraviolet radiation, and ultraviolet radiation are particularly strong in the beach. The reason is that there is direct ultraviolet(UV) radiation as well as ultraviolet radiation on the beach. The UV reflection on the beach is important for calculation of human exposure to UV radiation. UV reflection is determined by the reflectance of beach sand[1-2].

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Table 1 shows the reflectivity by wavelength range of beach sand in different countries published in previous studies.

Since the beach is wide, the method of measuring UV reflectance on the beach by point is quite time consuming. Therefore, the author has previously measured UV reflectance based on the area of the beach sand using an ultraviolet radiation camera in a helicopter or observatory[3-6].

However, there were difficulties in grasping the UV reflectance on coastlines because the shooting locations were limited, and coastlines were extensive. Although remote sensing[7-10] using ultraviolet radiation was also proposed, it is difficult to measure the UV reflectance accurately because atmospheric scattering is large and complex atmospheric correction can not be accurately measured. Therefore, this study aimed to measure the UV reflectance on the beach over a wide range using the short-wavelength visible light image data obtained from a satellite taking advantage of the fact that the reflectance of visible lights is highly correlated with the reflectance of ultraviolet radiations.

Table 1. Reflectivity of each beach sand in different countries

Item / Material(Beach)	Reflectance(%)		
	Visible ρ v	UV-A ρ v	UV-B ρ v
	450-510	315-400	280-315
Aus Melbourne(Apllobay)	28.8	10.8	8.42
Aus Tasmania(Bichen)	58.7	32.6	17.6
Aus Tasmania(White)	41.1	20.0	12.5
Jpn Okinawa(Manza)	53.2	23.7	18.5
Jpn Okinawa(Tinen)	39.3	16.1	12.3
Jpn Chiba(Kujyukuri)	15.2	5.87	3.86
Jpn Kagoshima(Oshima)	3.49	2.97	2.48
Kor Busan(Gwangalli)	28.8	12.5	10.0
Kor Busan(Haeundae)	31.8	10.8	5.47
Kor Goseong(Cheonjin)	28.3	12.1	9.05
Kor Sokcho(Sokcho)	30.4	13.9	10.9

II. Measurement area and data analysis

2.1 Measurement area

The satellite data used in this study are LANDSAT8 data obtained on May 7, 2020 at Cheonjin and Bongpo beaches in Goseong-gun, Gangwon-do, and Sokcho beach(bathing beach). Band 2 (450-510nm) image photographed in the wavelength range was used. Figure 1 shows the images provided by the Global Visualization Viewer of the United States Geological Survey.

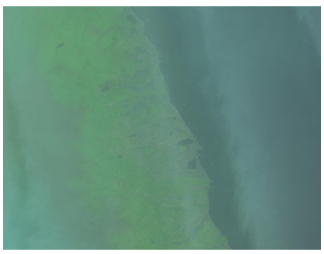


Fig. 1 Map showing measurement area Goseong Cheonjin, Bongpo Beach and Sokcho Beach

One pixel is equivalent to 30 × 30m and the image consists of 7761 × 7891 pixels. Image smoothing was performed using the image processing software (Image-pro Plus), and the gradation of each pixel was analyzed.

Each gradation of band 2 image was corresponded to the average value of ultraviolet spectral reflectance (hereinafter referred to as ultraviolet reflectance) of 280 to 400nm measured using a spectrophotometer (Shimadzu UV-1650).

Beach sand, asphalt, and concrete were used for real data. The real data were obtained from Cheonjin beach in Goseong, Gangwon-do (east longitude 128° 33' 37", north latitude 37° 15' 35") and Sokcho bathing beach (east longitude 128° 36' 13", north latitude 38° 11' 27"). Figures 2 shows the beach sand collection point on Cheonjin Beach and is a sampling point of real data. Figures 3 shows the beach sand collection point on Sokcho Beach and is a sampling point of real data.

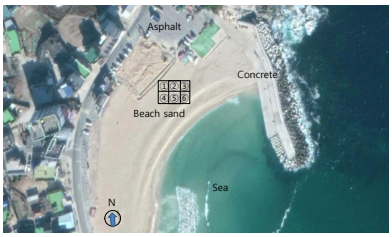


Fig. 2 Beach sand collection point for real data (Cheonjin Beach)

Fig. 3 Beach sand collection point for real data (Sokcho Beach)

Table 2 shows a total of 12points of two locations selected for real data, where beach sand was collected, that is, 6points at Cheonjin beach and 6points at Sokcho Beach, where ρ b represents UV-B (280~315nm) UV reflectance, ρ a represents UV-A (315~400nm) UV reflectance, and ρ v represents the analysis data of band 2 visible reflectance (450~510nm).

Table 2. Reflectivity of each beach sand in the wavelength range

Item / Material Point	Reflectance(%)		
	Visible ρ v	UV-A ρ v	UV-B ρ v
	450-520	315-400	280-315
①	27.1	12.50	9.39
②	28.3	11.12	8.41
③	28.8	12.90	9.52
④	28.2	12.10	8.32
⑤	28.4	11.89	9.21
⑥	28.8	12.30	9.44
⑦	29.2	13.80	10.50
⑧	30.1	14.20	11.60
⑨	31.2	13.90	10.90
⑩	28.7	12.80	9.65
⑪	30.8	13.90	11.10
⑫	32.8	15.30	12.20

III. Results and discussion

3.1 Gradation and band 2 visible reflectance

Figure 4 shows the relationship between the real visible reflectance ρ v and the gradation (G) and the following regression equation was obtained from the figure; where, r is a correlation coefficient.

$$\rho v = -0.0028G^2 + 1.0268G - 51.705 \quad (1)$$

$$(r = 0.967) (65 \leqq G \leqq 122)$$

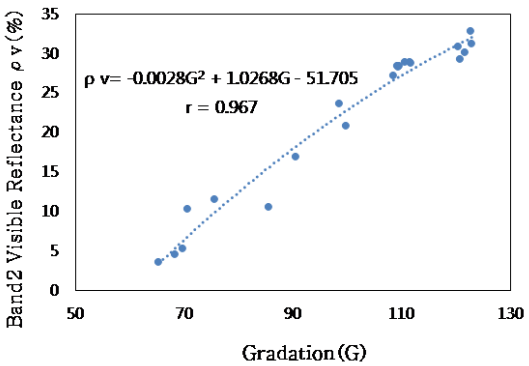


Fig. 4 Relationship between gradation and band 2 visible reflectance

3.2 band 2 visible reflectance and ultraviolet reflectance

Figure 5 show the relationships between band 2 visible reflectance and UV-A ultraviolet reflectance, and UV-B ultraviolet reflectance obtained from previous studies.

The regression equation of visible reflectance ρ v and UV-A ultraviolet reflectance ρ a becomes (2), where, r is a correlation coefficient.

$$\rho a = 0.3875 \rho v - 1.6718 (r = 0,947) \quad (2)$$

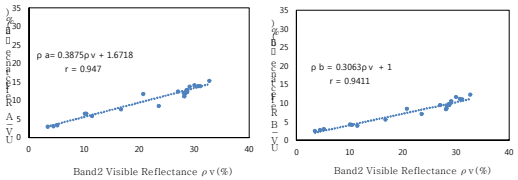
The regression equation of visible reflectance ρ v and UV-B ultraviolet reflectance ρ b becomes (3).

$$\rho b = 0.3063 \rho v + 1 (r = 0.9411) \quad (3)$$

The correlations between band 2 visible reflectance and UV-A and B ultraviolet reflectance

were shown to be high.

The correlation coefficient of the visible reflectance and UV-A ultraviolet reflectance was shown to be 0.947, and that of the visible reflectance and UV-B ultraviolet reflectance was shown to be 0.9411.



UV-A reflectance UV-B reflectance

Fig. 5 Relationship between band 2 visible reflectance and reflectance

For verification, the reflectance of sand collected from points distant from the actual measuring points were measured and the results were compared with the refletances calculated from the regression equation with the band 2 image as shown in Table 3.

It can be seen from Table 3 that the values compared and analyzed are almost identical.

Table 3. Comparison of UV reflectance between field samples and image samples

Item / Material	Reflectance(%)			
	UV-A ρ v		UV-B ρ v	
	Field Measurements	Image Calculated	Field Measurements	Image Calculated
Sample A	13.4	13.9	10.6	11.2
Sample B	14.1	14.3	11.3	11.1
Sample C	15.5	15.2	12.4	12.9

3.3 UV-A and B ultraviolet reflectance on the beach

Conceptual diagrams and images of the measuring points at Cheonjin and Bongpo beaches in Goseong and Sokcho beach are shown in Figures 6-8.

a. Cheonjin a. Bonpo

Fig. 6 Outline map of Beach measuring point

Fig. 7 Outline map of Sokcho Beach measuring point

Cheonjin, bonpo Sokcho

Fig. 8 Beach measuring points image

For processing of the images of the measuring points, A-A′, B-B′, and C-C′ were determined in the direction parallel to the dotted line, and the UV-A and B UV reflectance on these lines were calculated using equations (1), (2), and (3).

Figure 9 to 11 show the results of measurement of A-A ′to C-C′, and Table 4 shows changes in UV reflectance between A-A′ and C-C′. Minute variations of reflectance can be seen across Figures 9-11.

The variations are due to not only the beach sand mixed with shells, but also the grass, plants, and garbage left unattended on the beach that affect the UV reflectance.

As can be seen in Table 4, the UV-A UV reflectance of Cheonjin beach (A-A′) varied from 10.1 to 15.9%, and the UV-B UV reflectance varied from 7.16 to 13.5%.

In addition, UV-A UV reflectance of Bongpo beach (B-B′) varied from 9.01 to 17.8%, and the UV-B UV reflectance varied from 6.50 to 14.4%.

The place with high UV-A and B UV reflectance was Sokcho beach (C-C′), where the UV-A UV reflectance showed changes in the value in a range of 12.9~20.5%, and the UV-B UV reflectance showed changes in the value in a range of 10.0~17.7%. As for the average values, the UV-A UV reflectance in the case of Cheonjin beach (A-A ′) and Bongpo beach (B-B′) were similar at 13.1% and 13.6%, respectively, and the UV-B UV reflectance were similar at 10.2% and 10.6%, respectively.

However, in case of Sokcho beach (C-C ′), the UV-A and B UV reflectance were 16.9% and 18.5%, respectively, which were about 3% higher than Cheonjin beach (A-A ′) and Bongpo beach (B-B′). The characteristics of the beach sand at this point mixed with shells is considered to have been reflected on the reflectance.

Table 4. Change in UV reflectance at the measurement point

Item / Material	Reflectance(%)			
	UV-A ρ v		UV-B ρ v	
	Field Measurements	Image Calculated	Field Measurements	Image Calculated
A-A'	10.1-15.9	13.1	7.16-13.5	10.2
B-B'	9.01-17.3	13.6	6.50-14.4	10.6
C-C'	12.9-20.5	16.9	10.0-17.7	13.5

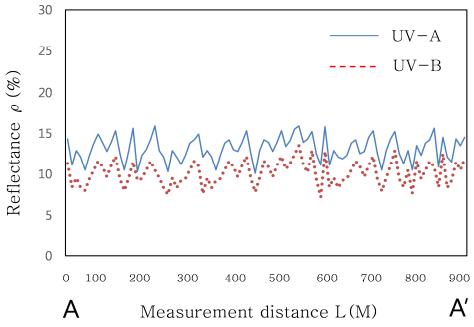


Fig. 9 UV-A,B reflectance of the A-A′section

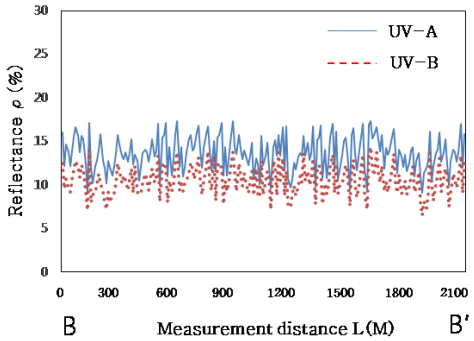


Fig. 10 UV-A,B reflectance of the B-B′section

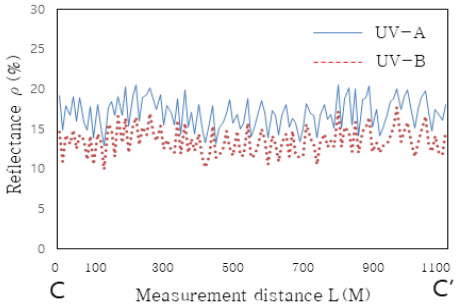


Fig. 11 UV-A,B reflectance of the C-C′section

Ⅳ.Conclusion

In this study, the UV reflectance of beach sand in a wide range could be measured using image data, taking advantage of the fact that the reflectance of visible lights is highly correlated with the reflectance of ultraviolet radiations. In addition,

the average UV reflectance at Cheonjin beach, Bongpo beach, and Sokcho beach on the East Coast could be expected to vary in a range of 13.1-16.9% in the case UV-A and in a range of 10.2-13.5% in the case of UV-B. The results of this study can predict UV exposure on the East Coast beach. Also, by measuring UV exposure in other coastal areas (west coast, south coast), We are trying to complete the UV exposure road map across the country.

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