CS-183

NEARSHORE ZONE WATER DEPTH ESTIMATION USING SPOT-HRV DATA

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1. Introduction

Data collection is the main problem facing engineers and scientists conducting research in the coastal zone. Periodic bottom surveys are difficult to obtain either due to financial problems or lack of man power resources. Because of these problems our understanding of the nearshore hydraulics and sediment transport processes are based on theories and laboratory experiments, rather than extensive field information. In recent years the use of airborne and satellite remote sensing particularly, using the visible wavelengths which penetrate to greater water depth, (Smith and Baker, 1981) in bottom surveys in the nearshore zone has increased. Methods of deriving bottom topography from multispectral data are based on regresssion analysis and classification techniques. The authors successfully used the level slice method to estimate nearshore zone (Oyodo River mouth area) water depth of the same study site. By this level slice method the image of the nearshore zone was divided into discrete colours such that the resulting image appears to be divided into slices, each displayed into a specific colour. In this study the simple regression technique is used to evaluate scene parameters for eventual depth estimation.

2. Methodology

The study site is Oyodo River mouth which is located between Miyazaki Port and Airport. SPOT XS data of December 20,1988 and January 9, 1991 are used. Band 3 of SPOT XS was combined separately with bands 1 and 2 to output character map of the area. The function of band 3 was to separate land and water bodies and bands 1 and 2 were used to estimate water depth. From the character maps the pixel positions were located on bathymetric contour maps of the area and subsequently, co-register radiance counts or Computer Compatible Tape counts (CCTs) from the substrate and water depth. The natural logarithm of CCTs and the corresponding water depth of five section were then plotted as shown in Fig.1. The data used is SPOT XS December 20,

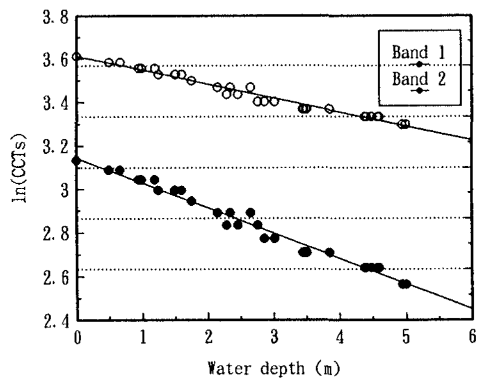

Fig.1 Relation between CCTs and water depth

1988. The upper and lower lines show the relations between water depths and CCTs from band 1 and band 2, respectively. The physical meaning of the slopes and intercepts are explained shortly.

2.1 Estimation of Scene Coefficients

The attenuation of light energy may described by equation (1).

$$T_r = e^{-\alpha z} \qquad (1)$$

Here T_r is the fraction of the radiant flux , and α is the volume attenuation constant assuming a homogeneous medium (Jerlov, 1976). To allow for substrate reflectance effects a generalized version (Jupp, 1988) of equation (1) was adopted as

$$L_e = e^{-2kz} L_b + (1 - e^{-2kz}) L_w \qquad (2)$$

Here L_e: radiance (CCTs) emerging from the water mass, L_b: radiance of wet substrate material for no water cover, L_w: radiance from deep water and k is the effective attenuation coefficient for the water body. Since reflectance is proportional to radiance equation (2) can be normalized to reflectance (Bierwirth et al, 1993)

$$R_{ei} = e^{-2k_i z} R_{bi} + (1 - e^{-2k_i z}) R_{wi} \qquad (3)$$

where, R_e: effective reflectance of water body, R_b: substrate reflectance, i: number of bands, R_w: water column molecules reflectance and z is water depth.

After the necessary corrections for instrument gain and deep water effect equation (3) becomes,

$$R_{ei} - R_{wi} = R_i = R_{bi} e^{-2k_i z} \qquad (4)$$

Here i=1,N where N is the number of bands. If R_i is assumed to be proportional to CCTs denoted by C_i, then

$$C_i G / I = R_i \qquad (5)$$

where G is the instrument gain and I is the average solar irradiance. Hence by substitution and rearrangment, equation (4) becomes,

$$\ln C_i = A_i - 2k_i z \qquad (6)$$

where $A_i = \ln R_{bi} - \ln G + \ln I$

From equation (6), a plot of $\ln C_i$ against z as shown in Fig.1 offers a means of estimating the scene parameters, k and A. The slope is a measure of k and A can be estimated from the intercept. Table 1 shows the values of k, A and threshold values for bands 1 and 2 of SPOT XS of December 20, 1988.

Table 1 Scene coefficients

Data	Band	k	e^A	Threshold value
SPOT 2XS:	1	0.06	37	38
20/12/88	2	0.12	23	24

From Table 1 it can be seen that the threshold values and A are related by e^A =Threshold value-1.

2.2 Verification

To evaluate the usefulness of the method, the scene coefficients listed in Table and threshold values of bands 1 and 2 of SPOT XS 09/01/91 were used to estimate water depth of the same area. The threshold values for bands 1 and 2 are 40 and 22, respectively. The results are shown in Figs. 2 and 3. From these two Figs. the usefulness of the method can seen. In particular as the depth increases, the estimated depths tend to deviate more from the true depth. This is due to penetration problem.

3. Conclusion

The main conclusions of this study can be summarized as follows:

1. Water depths up to 5m can be estimated from this method. In particular as the depth increases the accuracy of the method decreases due to penetration problem.
2. Estimated scene coefficients can be used for other SPOT scenes if the water column conditions are approximately the same.

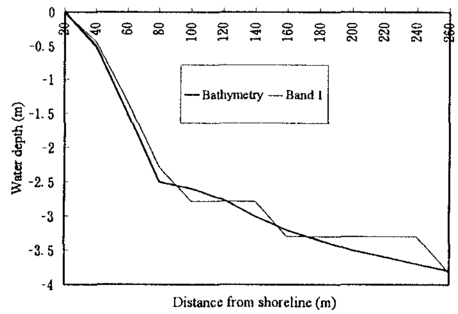

Fig.2 Comparison of estimated depth from band 1 and bathymetric data

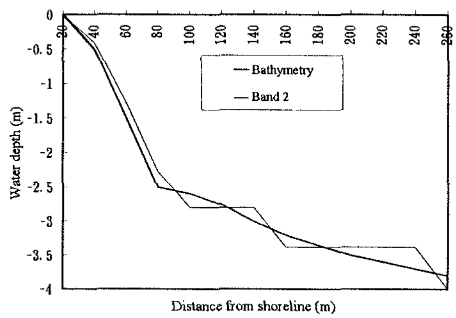

Fig.2 Comparison of estimated depth from band 2 and bathymetric data

4. Acknowledgement

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5. References.

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