A COMPARISON OF ATMOSPHERIC CORRECTION MODELS FOR WORLDVIEW-2 IMAGERY AND THE EFFECT ON BATHYMETRY PREDICTION

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1．Introduction

Remote sensing mapping in combine with simple field survey became a solution to map the shallow water bathymetry. The limitation of imagery quality became problems in evaluating shallow water areas, especially atmospheric noise. The objective of atmospheric correction is to retrieve the surface reflectance (that characterizes the surface properties) from remotely sensed imagery by removing the atmospheric effects. Atmospheric correction has been shown to significantly improve the accuracy of image analysis. Three atmospheric correction methods were compared in this study. Two of the methods (DOS-COST and Lyzenga) were image-based method and 6S is an absolute modeling method. The effects of corrections were studied in coastal shallow water areas, and then tested to predict the bathymetry.

2. Methodology

In this study we used Worldview-2 imagery with six visible bands and two near infrared bands of Gili mantra islands on January 2010. Digital numbers were converted to top-of-atmosphere reflectance using the absolute radiometric calibration factors and effective bandwidths for each band, according to the formulas and directions provided by the satellite data provider DigitalGlobe. Depth data was collected in 1370 sampling points. The Garmin Fishfinder 160C was used to record the position of sampling locations and depth.

The DOS model is based on the basic assumption that within the image some pixels are in complete shadow and their radiances received at the satellite are due to atmospheric scattering (path radiance). Moreover, the COST model (Chavez, 1996) is improved the DOS model by added the cosine function of solar zenith angle or satellite view angle to approximate atmospheric transmittance to account for the multiplicative effects of atmospheric scattering and absorption. The equation of DOS and COST method is written as

$$\boldsymbol{R_{DOS-COST}(\lambda)_i = R(\lambda)_i - R_{haze}(\lambda)_i - R_{1\%}(\lambda)_i} \tag{1}$$

where $R_{haze}(\lambda)$ is atmospheric path radiance that calculate from the average of several deep ocean pixels, and $R_{1\%}(\lambda)$ is one percent of the dark object assumption.

Lyzenga in 2006 proposed an improvement of atmospheric correction method using the NIR band. Where the sea surface scattering or atmospheric scattering are not assumed homogeneous over the target area; they are expected to vary from pixel to pixel. The correction method removes the pixel-wise variations using the NIR bands. Thus, we can expect a correlation between $R(\lambda)_\infty$ and R_{NIR} for an arbitrary visible wavelength. The new equation for the atmospheric corrected reflectance is written as:

$$\boldsymbol{R_{ly}(\lambda)_i = R(\lambda)_i - \alpha(\lambda)_{i0} - \alpha(\lambda)_{NIRn} \cdot R_{NIRn}} \tag{2}$$

where R_{NIR} is the measure of reflectance in the NIR band, and $\alpha(\lambda)$ represent coefficients between the visible reflectance and NIR reflectance of the deep-water pixels.

The 6S (Second Simulation of a Satellite Signal in the Solar Spectrum) model is a radiative transfer code that calculate the atmospheric corrected reflectance (Vermote et.al. 2006). The input information for model the atmospheric conditions are time, geographic location, viewing and illumination geometry, atmospheric conditions and ground height. There is no BRDF are considered apart from a Lambertian target assumption. The surface is always assumed homogeneous. Then the equation used to estimate the atmospherically corrected reflectance is:

$$R_{6S}(\lambda)_i = \frac{\left(\frac{1/Tg(\lambda)_i}{T(\theta_s.\theta_v)(\lambda)_i}.R(\lambda)_i - \frac{\rho a(\lambda)_i}{T(\theta_s.\theta_v)(\lambda)_i}\right)}{\left(1+\left(\frac{1/Tg(\lambda)_i}{T(\theta_s.\theta_v)(\lambda)_i}.R(\lambda)_i - \frac{\rho a(\lambda)_i}{T(\theta_s.\theta_v)(\lambda)_i}\right).\ s(\lambda)_i\right)} \quad (3)$$

where Tg(λ) is total gasses transmittance, T(θ_s)(λ) and T(θ_v θ_s)(λ) are downwelling and upwelling of rayleigh and aerosol scattering, $\rho_a(\lambda)$ is atmospheric path radiance, and s(λ) is spectral albedo total of atmosphere.

The multiple linear regression analysis is conducted with depth as the dependent variable and the linearized surface reflectance value as the independent variables. The input data is the 1370 depth measurement point that randomly partitioned into 10 subsets, defining a 10-fold cross-validation. Then predict the depth using the formula as follows:

$$\textbf{Predict Depth} = Y_{int} + (m_{coastal})(x_{coastal}) + (m_{blue})(x_{blue}) + (m_{green})(x_{green}) + (m_{yellow})(x_{yellow}) + (m_{red})(x_{red}) + (m_{rededge})(x_{rededge}) \quad (4)$$

where: $\mathbf{Y_{int}}$ = Y intercept; $\mathbf{m}$ = slope; $\mathbf{x}$ = linearized surface reflectance value

3. Result and Discussion

The expected reflectance pattern for sand in the visible bands is a low reflectance in the coastal band, a rise from the blue band until the yellow band then slightly lower in red until rededge band (e.g., Hochberg and Atkinson, 2003). The DOS-COST and 6S corrected data showed this pattern expect for yellow to rededge band, a not unexpected result (Figure 1). TOA reflectance (no atmospheric corrected) was high in the coastal band and gradually low from yellow band, this is cause by the water absorption for band yellow to rededge and the high atmospheric noise in coastal band. Moreover, the Lyzenga

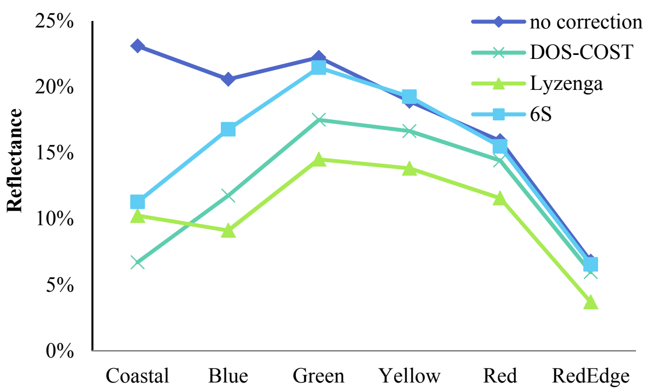

Fig. 1 Reflectance of submerge sand for the correction methods.

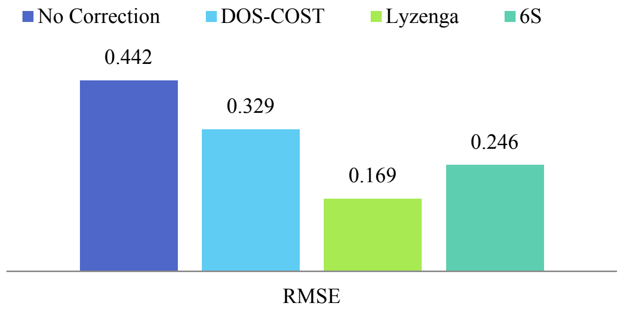

Fig. 2 Difference in bathymetry prediction as a result of correction methods

method gave the same pattern like TOA reflectance with lower value. The coastal and blue band has always been problematic, due to the varying atmospheric noise.

We next implemented the atmospheric correction model by performed a multiple regression analysis to estimated bathymetry for each method and no correction surface reflectance. Result of this analysis is represent in Table 1, specifying the error of each method. The DOS-COST result was improved the accuracy of bathymetry prediction follow with the 6S method (Figure 2). This result had shown the importance of atmospheric correction in bathymetry prediction. In the conclusion the Lyzenga method had shown the best accuracy because this method corrects not only the atmospheric but also surface noise, additionally the correction was done in pixels level.

References

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