ESTIMATION OF AEROSOL LOADING FROM DIFFERENT WAVELENGTHS IN KUALA LUMPUR USING DARK PIXEL SUBTRACTION TECHNIQUE

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Abstract- Atmospheric aerosol plays an important indicator of visibility distance range. The challenging part to study the effect of atmospheric aerosol on surface reflectance is its immeasurable assortment. High density of aerosol will scatter radiation in different wavelength range. Depending on the wavelength, the prevailing atmospheric conditions and the brightness of the observed surface, the recorded at-sensor reflectance may be either higher or lower than the surface reflectance. In this study, the estimation of aerosol loading will be derived not only on visible (blue) wavelength but also at near-infrared wavelength range. Using dark pixel subtraction technique to derive surface reflectance from imaging data, these values would be critical to be assigned. The result showed that the highest significance of correlation (r^2) was recorded at visible (blue) band with $r^2 = 0.9652$.

Keywords- Atmospheric aerosol, visibility, wavelength, reflectance

I. INTRODUCTION

In optical remote sensing, spectral signatures are analyzed to retrieve spatio-temporal information of the land surface. The uniqueness of satellite remote sensing lies in its ability to show large land areas and to detect features at electromagnetic wavelengths which are not visible to the human eye.

The atmosphere significantly modulates the signal received by the sensor. The reduced transmission is due to the fact that some reflected photons are either scattered out of the field-of-view (FOV) of the sensor or absorbed by the atmospheric constituents [1], [2], [3]. This multiplicative effects leads to a reduced image contrast and biases the data [4]. The second atmospheric effect is additive in nature and completely independent from the surface brightness. In fact, part of the incoming solar irradiance may be scattered into the FOV of the sensor without having interacted with the surface. This is so called atmospheric path radiance [5], [3]. Both effects increase with the amount of aerosol particles in the atmosphere and are strongly wavelength dependent [6].

Rayleigh and aerosol scattering effects are more significant than absorption effects in the visible light spectral range causing an increase in the at-sensor measured radiance values. This scattering is wavelength dependent with a greater effect at shorter wavelengths, such as the blue band. The atmospheric effects are also wavelength dependent. Therefore, visible (blue band) and near-infrared wavelengths have been applied from urban model to estimate aerosol loading in Kuala Lumpur.

II. DATA AND MATERIALS

2.1. Data Acquisition

Archived TM Landsat 5 is obtained from Malaysian Remote Sensing Agency (ARSM) for the Kuala Lumpur. Detailed description showed in Table I. The image was subsetted into the region of interest. The image was geocorrected from ARSM.

Table 1. Descriptions of Landsat 5 TM images for Kuala Lumpur

Image description	1999
Sensor type	Landsat 5 TM
Date	11-02-1999
Latitude/longitude	03°09'N 101°41'E
Resolution (meter)	30
Cloud cover (%)	3.4

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2.2. Study Site

Kuala Lumpur is chosen as a study area because due to its 100 percent level urbanization (1,556,200 people) and as development city in Malaysia [7]. Geographically, it lies between latitudes 03°09'N and longitudes 101°41'E and located at interior of country in Malaysia. Kuala Lumpur is surrounded within the Klang Valley region with an area about 244 km^2 [8]. The temperatures in Kuala Lumpur were ranging between 26.4°C to 29.0°C [9].

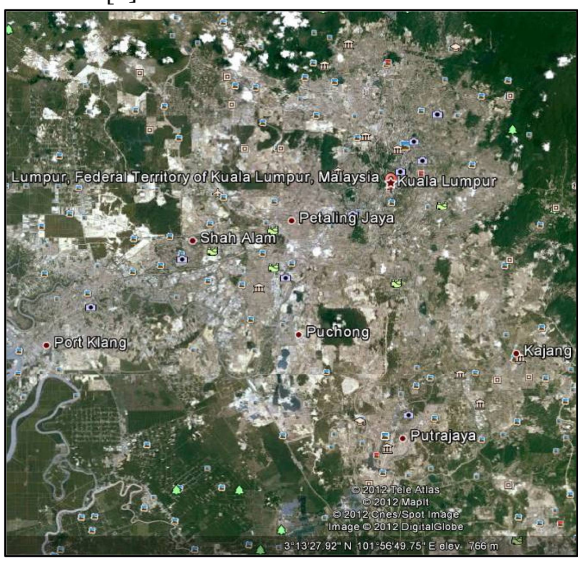


Figure 1. Location of study site

III. METHODOLOGY

Dark pixel subtraction technique is adopted [2], [10], [11], [12] to estimate the aerosol loading using urban aerosol algorithm in ATCOR 2. Water body has chosen as a dark target because of suitability in term of reflectance characteristic [2], [10], [11], [12]. Therefore, visible (blue) wavelength is used to take into account of scattering effects and NIR for absorption effects. The surface reflectance is computed for every non-discarded pixel (cloud, mixed, shadow) using radiative transfer equation. Values are providing in scaled surface reflectance and converted into percent (%) reflectance using scale 4. Then later, was converted to apparent reflectance for true reflectance value.

IV. RESULTS AND ANALYSIS

Table 2 shows the estimation of urban aerosol loading with different wavelengths in Kuala Lumpur. Overall pattern that can be shown from the result is decreasing of urban aerosol loading when the visibility was set to be higher for visible (blue) wavelength. Maximum value of aerosol loading was recorded 0.307 at 10 km of visibility range. The minimum value was recorded at 50 km visibility range with 0.193.

The results were found opposite with aerosol estimated at visible wavelength, where higher aerosol loading estimated at the minimum distance range 10 km for NIR wavelength. The highest value of aerosol loading was recorded 0.138 at 50 km of visibility range. The lowest value was recorded at 10 km visibility range with 0.096.

Table 2. Comparison of Apparent reflectance of urban aerosol loading between visible (blue) and NIR wavelength for year 1999

Visibility range (km)	Urban aerosol (apparent reflectance)	
	Visible (blue)	Near-infrared (NIR)
10	0.307	0.096
15	0.277	0.120
20	0.237	0.123
25	0.224	0.132
30	0.225	0.131
35	0.215	0.139
40	0.205	0.136
45	0.195	0.143
50	0.193	0.138

Figure 2 shows the dependency analysis of correlation (Pearson) of aerosol loading with visibility range in Kuala Lumpur for different wavelengths. Visible (blue) band exhibited inversely correlated between aerosol loads and visibility with r^2 = 0.9652 meanwhile linearly correlated was derived from NIR band with r^2 = 0.8122. The result showed that the highest significance of correlation (r^2) was recorded at visible (blue) band.

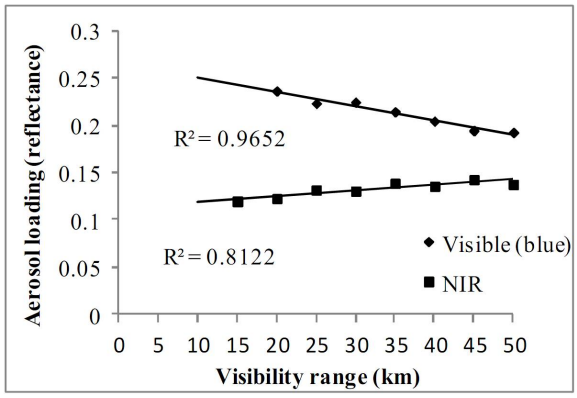


Figure 2. Aerosol Loading with Visibility Ranges for Different Wavelength

Particularly, the shorter wavelengths have stronger effect of aerosol and molecular scattering where the particle size is comparable to the radiation wavelength [13]. Surface reflectance would improved by the aerosol scattering while aerosol absorption would decreased the visible brightness of brighter surfaces. Consequently, the capability of object that can be seen would reduced when the reflectance increase by the influence of aerosol.

In visible band, the impact of short wavelength is mostly from Rayleigh scattering because the absorption by water vapour or other gases is very weak and thus can be ignored [14], [15]. A similar study done by [16] shows that aerosol decreased sharply with wavebands. Aerosols affect the visibility throughout

the absorption and scattering of solar radiation [17], [18] and thus modified the Earth's energy balance directly.

CONCLUSIONS

From this study, a general conclusion has been proposed in which the decreasing of aerosol loading when the visibility increase in visible band might be due to scattering effects. As atmospheric effects is mainly caused by scattering and absorption of atmospheric gaseous, aerosol and clouds, thus, the most important point in order to perform an atmospheric correction is to be aware of the optical characteristic of the atmosphere.

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