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Optimal Estimation of Surface Reflectance from Landsat TM Visible and Mid Infrared Data over Penang Island

H. S. Lim, M. Z. MatJafri, K. Abdullah and N. Mohd. Saleh

***Abstract*—**Retrieval of the surface reflectance is important in the remotely sensed data analysis to obtain the atmospheric reflectance or atmospheric correction. The relationship between visible and mid infrared reflectance over land was investigated and developed in this study. The surface reflectances of the two visible bands were measured using a handheld spectroradiometer collected around Penang Island. In this study, we use the assumption that the 2.1 μm band is not affected by aerosol and it is transparent to most aerosol types (except dust). Therefore the satellite observed signal is the same as the surface signal in 2.1 μm band. The correlation between the surface reflectance measured by the spectroradiometer in the blue and red region and the 2.1 μm observed by the satellite has been established. We investigate five dates of Landsat TM scenes in this study. The finding obtained by this study indicates that the surface reflectance can be retrieved from the 2.1 μm band.

***Keywords*—**Surface Reflectance, Landsat TM, Aerosol, Spectroradiometer.

I. Introduction

ATMOSPHERIC aerosol particles directly affect the Earth's radiation balance by backscattering and absorbing short wavelength solar radiation. However, there is considerable uncertainty over the ''direct effect'' of aerosols due to their spatial and temporal heterogeneity [1]. Atmospheric pollution in cities is receiving more and more attention [2]. Air pollution has long been a problem in the industrialized nations of the West. The accuracy of aerosol remote sensing techniques heavily depends on the information of the ground reflectance [3].

The objective of this study was to establish a correlation between the visible and mid infrared reflectance over land. The surface reflectances of the two visible bands were measured using a handheld spectroradiometer collected around Penang Island. The correlation between the surface reflectance measured by the spectroradiometer in the blue and red region and the 2.1 μm observed by the satellite has been established.

H. S. Lim is with the School of Physics, Universiti Sains Malaysia, 11800 Penang, Malaysia (corresponding author to provide phone: 604-6533663; fax: 604-6579150; e-mail: hslim@usm.my).

M. Z. MatJafri was the School of Physics, Universiti Sains Malaysia, 11800 Penang, Malaysia (e-mail: mjafri@usm.my).

K. Abdullah is with the School of Physics, Universiti Sains Malaysia, 11800 Penang, Malaysia (e-mail: kirudd@usm.my).

N. Mohd. Saleh is with the School of Physics, Universiti Sains Malaysia, 11800 Penang, Malaysia (e-mail: nasirun@usm.my).

II. Study Area

The study area is the Penang Island, Malaysia, located within latitudes 5o 12' N to 5o 30' N and longitudes 100o 09' E to 100o 26' E. The corresponding satellite track for the TM scenes is 128/56. The map of the region is shown in Figure 1. The satellite images were acquired on 5-2-2003, 6-3-02, 15-2-01, 19-3-04 and 17-1-02. The corresponding PM10 measurements were collected simultaneously during the satellite overpasses.



Fig. 1 Study area

III. Data Analysis and Results

The raw satellite image was used for the retrieval of surface reflectance. In this study, we assumed that the 2.2 μm wavelength is much larger than the size of most aerosol types (smoke, sulfates, etc.) so that these aerosols are transparent to solar radiation at 2.2 μm. The advantage of this long wavelength is that it is not affected by accumulation mode aerosol, e.g., sulfates and organic particles; though it is affected by dust [4]. Besides that, they are also less sensitive to aerosol scattering (since their wavelength is much longer

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than the size of most aerosol particles) but still sensitive enough to the surface characteristics. Firstly, we assume that the surface reflectance of the visible and the middle-infra bands are linearly relate [5] as

$$Rr = tR7 \quad (1)$$

where t is the ratio coefficient and R7 is the reflectance for band 7 of Landsat TM5. In this study, we assume that the wavelength of the band 7 is larger that the size of the aerosol particles. The surface reflectance values for visible bands (TM1 and TM3) were retrieved by using the established relationship with the mid-infrared band (TM7) [5]. We assumed that the surface reflectance of several selected targets did not change with time in this study. So, we measured the surface reflectance at 56 locations over Penang Island using a handheld spectroradiometer. The reflectance observed by satellite images were extracted corresponding to the in-situ spectroradiometer reflectance measurements. We obtained a linear relationship between the reflectance measured by spectroradiometer and observed by satellite images for the two visible bands and the correlations are given below

$$\rho(TM1) = \rho(TM7)/3.85 \quad (2)$$
$$\rho(TM3) = \rho(TM7)/1.92 \quad (3)$$

The remotely-sensed signals in the visible and near infrared channels at satellite or airborne platforms are combinations of surface and atmospheric contributions, with relative amounts varying across the two wavelength regions, depending on the condition of the atmosphere. We can retrieved the surface reflectance values for the visible band (TM1 and TM3) from the middle-infra band using the above relationship.

Over a simple black target, the atmospheric reflectance observed, is written here as the simple sum of reflectance of aerosols and Rayleigh contributions. This simplification, however, is not valid at short wavelengths (less than 0.45 pm) or large sun zenith angles [6].

We can obtain the atmospheric reflectance values by subtracted the measured surface reflectance from the satellite total reflectance [reflectance at the top of atmospheric, ρ(TOA)] (Equation 4).

$$Rs - TRr = Ratm \quad (4)$$

where:
Rs = reflectance recorded by satellite sensor
Rr = reflectance from surface references
Ratm = reflectance from atmospheric components (aerosols and molecules)
T = transmittance

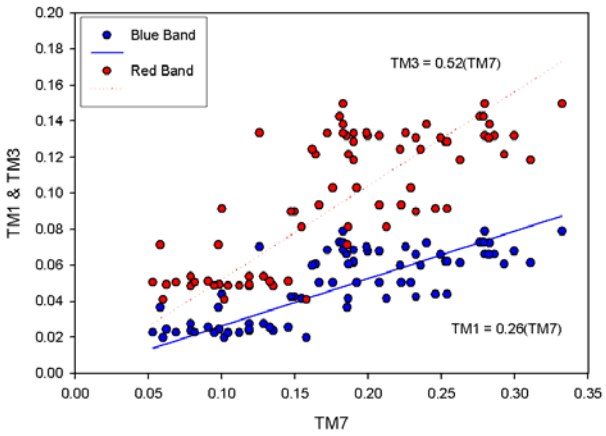


Fig. 2 Correlation between visible and mid infrared surface reflectances for Landsat TM

IV. CONCLUSION

The established correlation between the visible and mid infrared reflectance over land in this study for retrieval the surface reflectance can be used for air quality study. Atmospheric reflectance can be retrieval by subtracted the measured surface reflectance from the satellite total reflectance. The established relationships between the visible and mid-infrared have to be verified in future studies. This study indicates that the surface reflectance can be retrieved from the 2.1 μm band.

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Lim Hwee San is a lecturer at the school of physics, Universiti Sains Malaysia. He obtained his B.Sc. from USM in Geophysics in 2001 and M.Sc. from USM in remote sensing in 2003. He obtained his Ph.D in environmental remote sensing from USM in 2006. His research interests are remote sensing applications for water quality monitoring, air quality monitoring, land surface properties and digital images classification. He is a Member of the International Society for Optical Engineering, US.



Mohd. Zubir Mat Jafri is a lecturer at the school of physics, Universiti Sains Malaysia. He obtained his B.Sc. in Physics (1984) from Universiti Kebangsaan Malaysia, his M.Sc. in microprocessor technology and application (1991) from Brighton Polytechnic, UK, and his Ph.D. from University College of Swansea, Wales (1996) in research area of algorithm development for detecting curve from digital images. He has more than 20 years teaching experience in the area of physics, optical communication, digital and analogue electronic and also microprocessors. He is also active in research work on current-based system, automation visual inspection system, digital image processing, and remote sensing. He has published more than 100 articles in these area. He is a Life Member of Malaysian Institute of Physics and Member of the International Society for Optical Engineering, US.



Khiruddin Abdullah received his B.Sc. (Physics) in 1982 from Bedford College, University of London, and M.Sc. (Geophysics) from Imperial College, London, in 1984, and his Ph.D. in remote sensing from the University of Dundee, Scotland in 1994. he is currently a faculty member at the School of Physics, Universiti Sains Malaysia teaching courses in geophysics and remote sensing. His research interests include remote sensing applications in marine and coastal environments. Presently, he is working on remote sensing algorithm for retrievals of water quality parameters and sea surface temperature.



Nasirun Mohd. Saleh received his B.Sc. (Geophysics) in 1982 from (USM), M.Sc. (Meteorology) from Reading, UK, in 1985, and M.Phil. (Boundary Layer Meteorology) from East Anglia University, UK in 1997. He is currently a Director of USM's Islamic Centre and Coordinator of Astronomy and Atmospheric Science Research Unit, Universiti Sains Malaysia. He is currently a faculty member in the School of Physics, Universiti Sains Malaysia, teaching courses in geophysics, meteorology and remote sensing. His research interests include meteorology applications.

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