An Algorithm for Land Surface Temperature Analysis of Remote Sensing Image Coverage Over AlQassim, Saudi Arabia

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SUMMARY

An algorithm approach to derive the land surface temperature (LST) of remote sensing image is presented. The algorithm was based on the brightness temperature from satellite sensor, surface emissivity and solar zenith angle of AlQassim, Saudi Arabia. Land Surface Temperature (LST) derived from Landsat TM 5 imagery using a simple regression calibration model was used in this study. The surface emissivity was derived from the NDVI values. The LST used in the algorithm calibration were derived from ATCOR2_T in the PCI Geomatica image processing software. The correlation between the land surface temperature and brightness temperature was increased significantly after the surface emissivity and solar zenith angle were added to the model. In this study, we are using two dates of satellite imagery for retrieval the LST values. The LST of the two different seasons were discussed in this study. The result of the experiment indicates the high spatial resolution satellite image can be used to derive the LST values.

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1. INTRODUCTION

Estimation of LST from remotely sensed data is nowadays usual. LST is a key parameter in the physics of land surface processes because it is involved in the energy balance as well as in the evapotranspiration and desertification processes (Peres and DaCamara, 2004). The extensive requirement of land surface temperature (LST) for environmental studies and management activities of the Earth's resources has made the remote sensing of LST an important academic topic during the last two decades (Sobrino, et al., 2004). One of the most important parameters in all surfaces–atmosphere interactions and energy fluxes between the ground and the atmosphere is land surface temperature (Sobrizo, et al., 2003). In the literature review, normally researchers using split window methods for retrieving the LST values. But Landsat TM only has one thermal band which it makes the use of split window impossible. The objective of this study was to propose a mono window technique for retrieving the LST from Landsat TM with combined surface emissivity and the solar angle, θ. The emissivity values used in this study were calculated based on the NDVI values. The correlation coefficient (R) values were increasing after surface emmisivity and solar angle were added to the algorithm model.

2. STUDY AREA

The study area in the Arabian Peninsula, located between latitude of 12ºN and 32ºN and between longitude of 20ºE and 35ºE (Figure 1). This particular geographical position gives the area of the great bioclimatic diversity. The desert of the Arabian Peninsular is located as a part of the hot desert, which extends from the Sahara in Africa in the west to the Thar Desert in Indo-Pakistan sub-continent in the east.

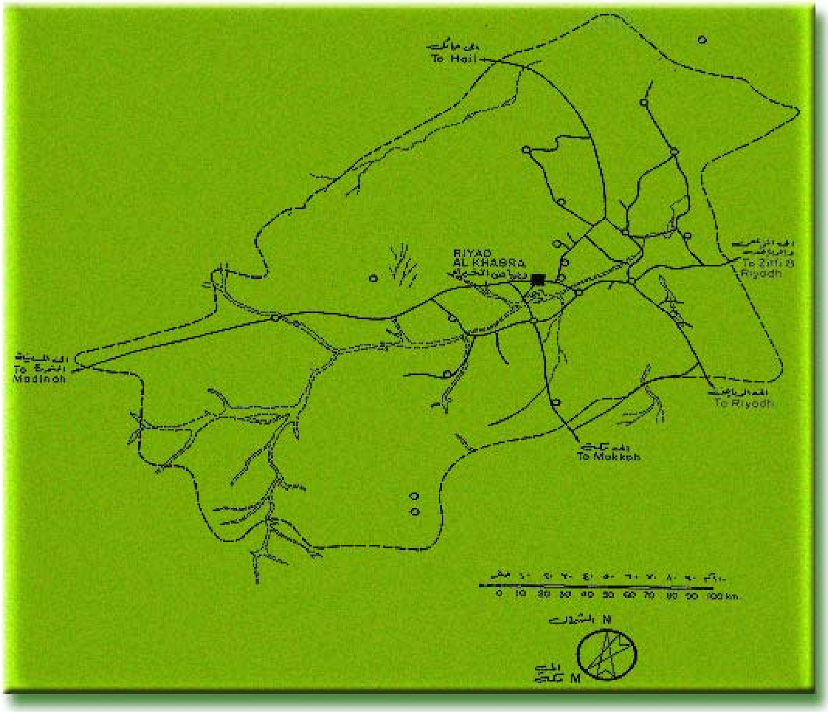

Figure 1: The study area in the central of Saudi Arabia

3. DATA ANALYSIS AND RESULTS

Satellite Landsat TM image on 18-08-1998 and 22-01-1998 were used for retrieval LST over AlQassim Saudi Arabia. Surface emissivity and incoming solar radiation was considered in the proposed algorithm. The solar zenith angle was used to replace the incoming solar radiation in analysis is because they are highly correlated but solar zenith angle can be calculated easily (Yang and Wang). The land surface emissivity (LSE) values were needed in this proposed model. An easy procedure to apply for retrieving the LSE was based on the NDVI. The method proposed obtains the emissivity values from the NDVI considering different cases:

(a) NDVI < 0.2
In this case, the pixel is considered as bare soil and the mean emissivity value used in this study was 0.97 (Sobrino, et al., 2004).

(b) NDVI>0.5
Pixels with NDVI values higher than 0.5 are considered as fully vegetated, and then a constant value for the emissivity is assumed, typically of 0.99. It should be noted that the samples considered in the paper are not included in cases (a) or (b).

(c) 0.2<NDVI<0.5

In this case, a mixture of the bare soil and vegetation composes the pixel, and the emissivity is calculated according to the following equation:

$$\varepsilon = \varepsilon_v P_v + \varepsilon_s (1 - P_v) + d\varepsilon \qquad (1)$$

where ε_v is the vegetation of the emissivity and ε_s is the soil emissivity, P_v is the vegetation proportion obtained according to (Sobrino, et al., 2004):

$$P_v = \left[\frac{NDVI - NDVI_{\min}}{NDVI_{\max} - NDVI_{\min}} \right]^2$$

$NDVI_{\max} = 0.5$

$NDVI_{\min} = 0.2$

The term in Equation (1) includes the effect of the geometrical distribution of the natural surfaces and also the internal reflections. For plain surfaces, this term is negligible, but for heterogeneous and rough surfaces, as forest, this term can reach a value of 2%. A good approximation for this term can be given by

$$d\varepsilon = (1 - \varepsilon_s)(1 - P_v) F \varepsilon_v$$

where F is a shape factor (Sobrino, et al., 1990) whose mean value, assuming different geometrical distributions, is 0.55. The proposed algorithm model was shown in the Equation (2).

$$T_G = a_0 + a_1 T_B^2 + a_2 T_B + a_3 \varepsilon + a_4 \theta \qquad (2)$$

The land surface temperatures used in the algorithm calibration were deriving using ATCOR2_T in the PCI Geomatica image processing software.

A set of 30 location over AlQassim, Saudi Arabia were selected randomly and then the surface emissivity and solar zenith angle was calculated for algorithm regression analysis. Comparison between the used of original satellite brightness temperature and the proposed algorithm with added surface emissivity and solar angle were shown in Table 1 and Table 2 for the two different date of satellite imagery. The produced results clearly had shown the increasing of correlation coefficient, R, value and decreasing the root-mean-square error, RMS, value when retrieval LST using the proposed algorithm with included the surface emissivity and solar angle values.

Table 1: Model to estimate LST using original satellite brightness temperature, quadratic algorithm and proposed algorithm with added surface emissivity and solar angle (18-08-1998)

Algorithm Models	R	RMS
Original satellite brightness temperature	0.1241	5.2154
Proposed algorithm with added surface emissivity and solar angle	0.7915	2.0159

Table 2: Model to estimate LST using original satellite brightness temperature, quadratic algorithm and proposed algorithm with added surface emissivity and solar angle (22-01-1998)

Algorithm Models	R	RMS
Original satellite brightness temperature	0.0512	8.2159
Proposed algorithm with added surface emissivity and solar angle	0.8102	1.9215

4. CONCLUSION

In this study, we present an algorithm to retrieve LST by using mono window from Landsat TM data. The algorithm accuracy has been found improved with considered the surface emissivity and incoming solar radiation. The RMS value was increased from 5.2154 K to 2.0159 K using the proposed mono algorithm.

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