TEMPERATURE CALCULATION USING THERMAL BANDS OF (ETM+)SENSOR

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Abstract

In this research, the ground temperature was calculated within a part of the province of Sulaymaniyah - northern Iraq, using the thermal bands(low acquisition, and high acquisition thermal bands) of the ETM+ sensor mounted in the LANDSAT 7 satellite. Practically, a linear profile within Dukan Lake (province of Sulaymaniyah) , has been indicated, and the temperature degree for its pixel has been calculated from both low acquisition and high acquisition thermal bands, this process has been implemented utilizing ERDAS Imagine 9.2 software package; the obtained results indicate that there is a significant convergence between the values of temperature calculated from both thermal bands indicating the accuracy of the adopted Mathematical Model in the calculation . In the second part of the work, the distribution of temperature degree over the study region has been extracted as a raster map. By averaging both low gain and high gain thermal bands.

Keyword: Thermal Satellite, Satellite Images, Surface Temperature.

احتساب درجة الحرارة باستخدام القنوات الحرارية للمتحسس ETM +

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**مركز بحوث التحسس النائي، دائرة تكنولوجيا الفضاء والاتصالات، وزارة العلوم والتكنولوجيا. بغداد-العراق.

الخلاصة

يتألف الجزء العملي في هذا البحث من مرحلتين ، في المرحلة الأولى ، تم احتساب درجات الحرارة لجزء من محافظة السليمانية-شمال العراق باستخدام القناتين الحراريتين (واطئة الاكتساب، وعالية الاكتساب) ضمن المتحسس ETM+ المحمول على القمر الصناعي LANDSAT 7 ، إذ احتسبت درجة على امتداد مقطع طولي ضمن بحيرة دوكان في محافظة السليمانية (شمال العراق) ، وقد اعتمدت الحقيبة البرمجية ERDAS Imagine 9.2 في تنفيذ هذه الحسابات، ومن خلال النتائج المستحصلة لوحظ إن هنالك تقارب مابين قيم درجات الحرارة

المحسوبة من القناتين الحراريتين (الواطئة الأكتساب والعالية الأكتساب) مما يدل على صحة(او معقولية) الموديل الرياضي المستخدم في احتساب درجات الحرارة . إما في الجزء الثاني ، فقد تم احتساب خارطة التوزيع الحراري لمنطقة الدراسة المشار إليها أعلاه،وذلك من معدل الحسابي مابين خارطتي التوزيع الحراري لكل من القناتين الحراريتين ، واطئة الاكتساب وعالية الاكتساب.

الكلمات المفتاحية:-المتحسسات الحرارية الفضائية، صور فضائية، درجة الحرارة السطحية.

1- Introduction

A known fact from the radiological physics law, every object has a temperature higher than absolute zero (-273) emit electromagnetic rays, and most of these rays fall within the thermal infrared region. The simple question raised in this research, it is possible to calculate the temperature of various landmarks using radiance . The answer is yes; practically this process depends on conversion of intensity radiation to temperature.

In remote sensing, there are many satellites equipped with sensors operate within the range of infrared heat. The ETM+ sensor mounted on the satellite Landsat-7, which has been used in this research is one of the best used in this field. It has a high spatial resolution accuracy compared to other thermal sensors on other satellites, as well as the fact that the thermal imaging in this sensor is determined by two bands, one band is 6-1 where the acquisition the how gain ,while the second band is 6-2,the acquisition will be high gain (1,2)

The most important factor in accurately calculating the temperature of deferent natural landscape features is the emissivity of deferent landscape features, which have deferent value depending on physical and chemical properties of the materials that make up the feature ground, as an example (black body) has an emissivity coefficient equal one which is highest absorbency. Generally the true value of objects ranges between zero and one, as well as they depend on both the temperature and wavelength (3, 4).

2 –Mathematical formula to convert the images values to temperature using ETM+ sensor.

The thermal band within the ETM+ sensor imaging temperatures implied by storing them as numbers ranging from (0 to 255), and convert numeric values to Kelvin temperatures, and by carrying out a process that involves two steps .In the first step it convert numeric value of the image to the radiance using Bias and Gain coefficients, then radiance values converted to temperature, as explain in the following .

2.1- Conversion of the numeric pixel values to the radiance

Firstly, the values of bias and gain are obtained for both bands in the data file which belong to scene capture by ETM+ sensor, by converting the pixel values into the radiance values as follows (5):

$$CV_R = G(CV_{DN}) + B$$

Where:

CV_R is the cell value as radiance

CV_{DN} is the cell value digital number

G is the gain

B is the bias (or offset)

2.2- Conversions of radiance to Kelvin temperature

After obtaining the radiance values from the digital images elements, calculating temperature become easy by applying the inverse of the Plank function according to the following mathematical formula (6):

$$T = \frac{K_2}{\ln\left(\frac{K_1}{CV_R} + 1\right)}$$

where

T : is degrees Kelvin

K1 : watts/(meter squared * ster * µm)

K2: Kelvin

3- The study area, used satellite images

The study area is in Suleimania (the north of Iraq) , the red highlighted area on the map of Iraq seen in fig 1. The coordinates of the area borders are illustrated in (table 1). Satellite images used in our project are taken by ETM+ sensor which is mounted on Landsat 7. These images lie within the thermal infra-red region. (fig 3 and 2) ,(table

1) shows the details of these images.This project uses ERDAS IMAGINE (V9.2) in calculating radiant temperature and according to what is been mentioned in paragraph 2.

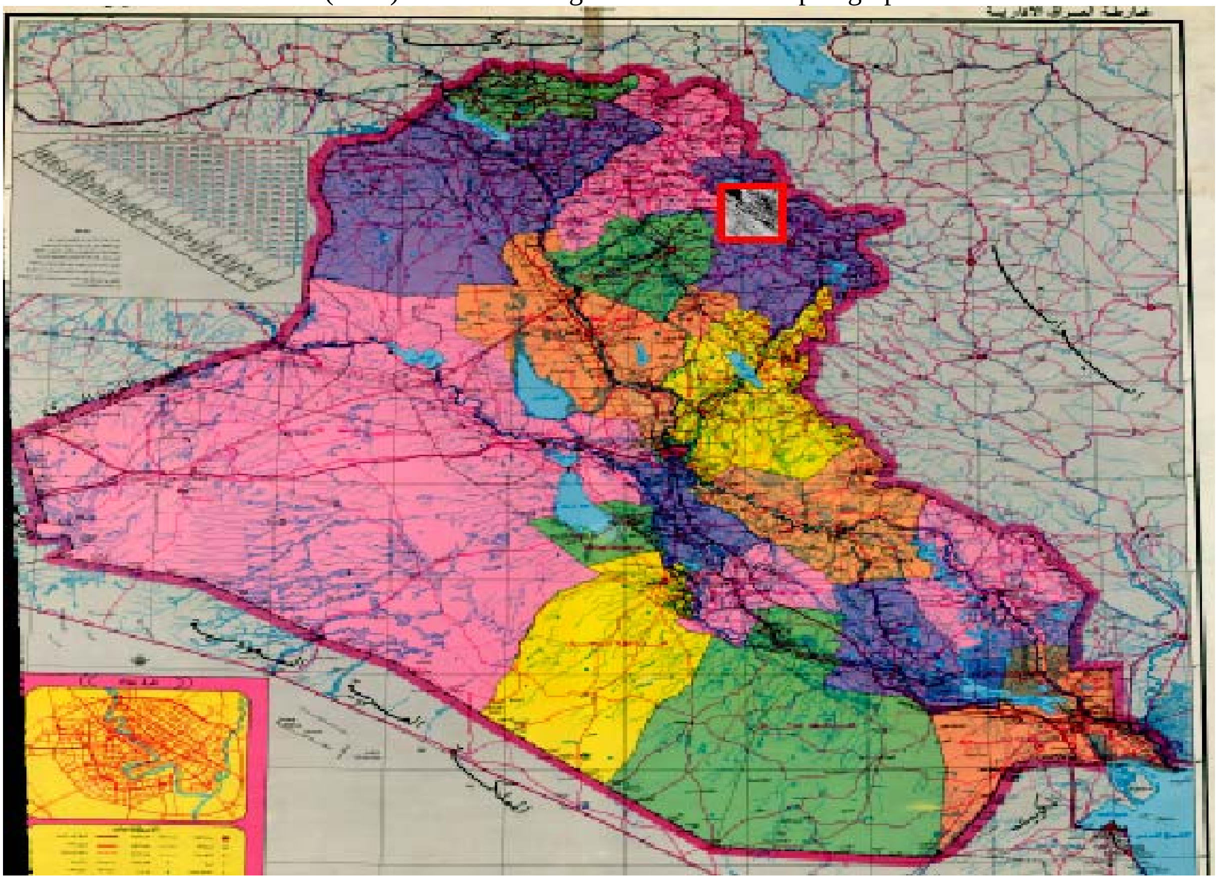

Figure 1: red rectangle represents the boundaries of the study area.

Table 1: Details of satellite images of the study area.

Satellite	Landsat 7	
Sensor	ETM+	
Used Thermal Bands (60 m)	6-1 and 6-2	
The image is part of a scene	path	168
	row	35
Acquisition Date	6-9-2002	
Image columns number	820	
Image Rows number	1039	
Upper left X	482475	
Upper left Y	4003665	
Lower Right X	531615	
Lower Right Y	3941385	
Pixel Size X (m)	60	
Pixel Size Y (m)	60	
Projection	UTM Zone 38 North	
Spheroid	WGS 84	
Datum	WGS 84	

Figure 2: Image of the study area within the thermal band 6-1 (low acquisition) with spatial resolution of 60 m.

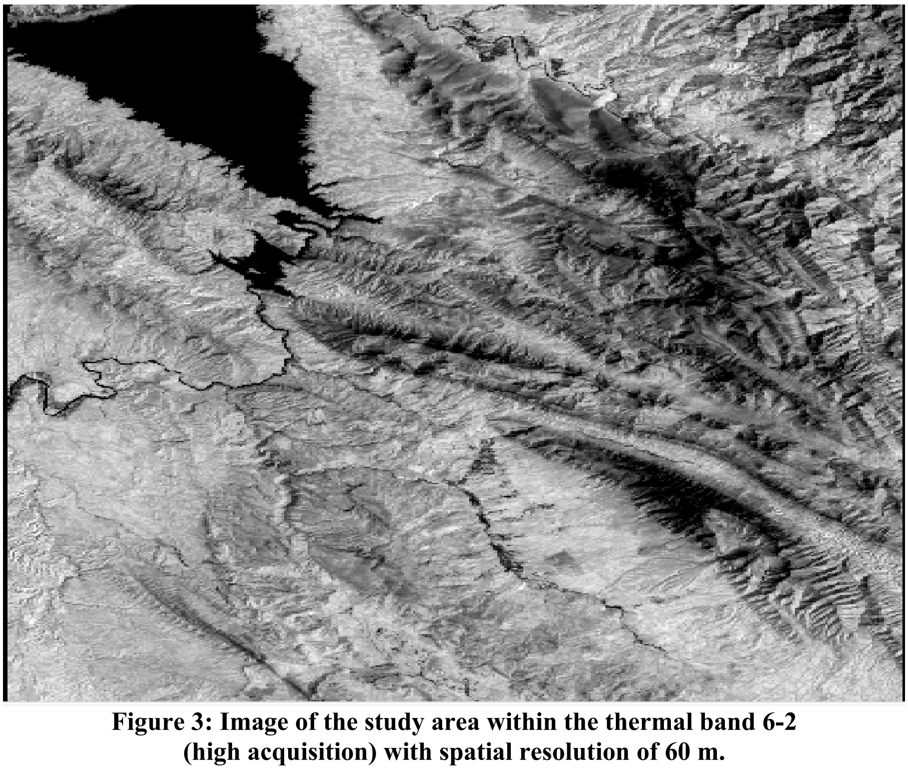

Figure 3: Image of the study area within the thermal band 6-2 (high acquisition) with spatial resolution of 60 m.

٤-Methodology and the results

The methodology of the work depends on calculating Land temperature for both low and high gain thermal bands. To check the accuracy of the above calculation, specified profiles has been indicated within the lake body for both thermal bands), then, visual comparison between the behavior of the profile for the both bands has been implemented, the comparison results show high rate of similarity. This indicates the accuracy of the used method in calculating radiant temperature as shown in figures (4,5,6,7 and 8) and(table 2). While in the second part, the temperature distribution map for the study area indicated above has been obtained from average of the temperature distribution maps for both Low and high gain thermal bands as shown in the (fig 8) and (table 2).

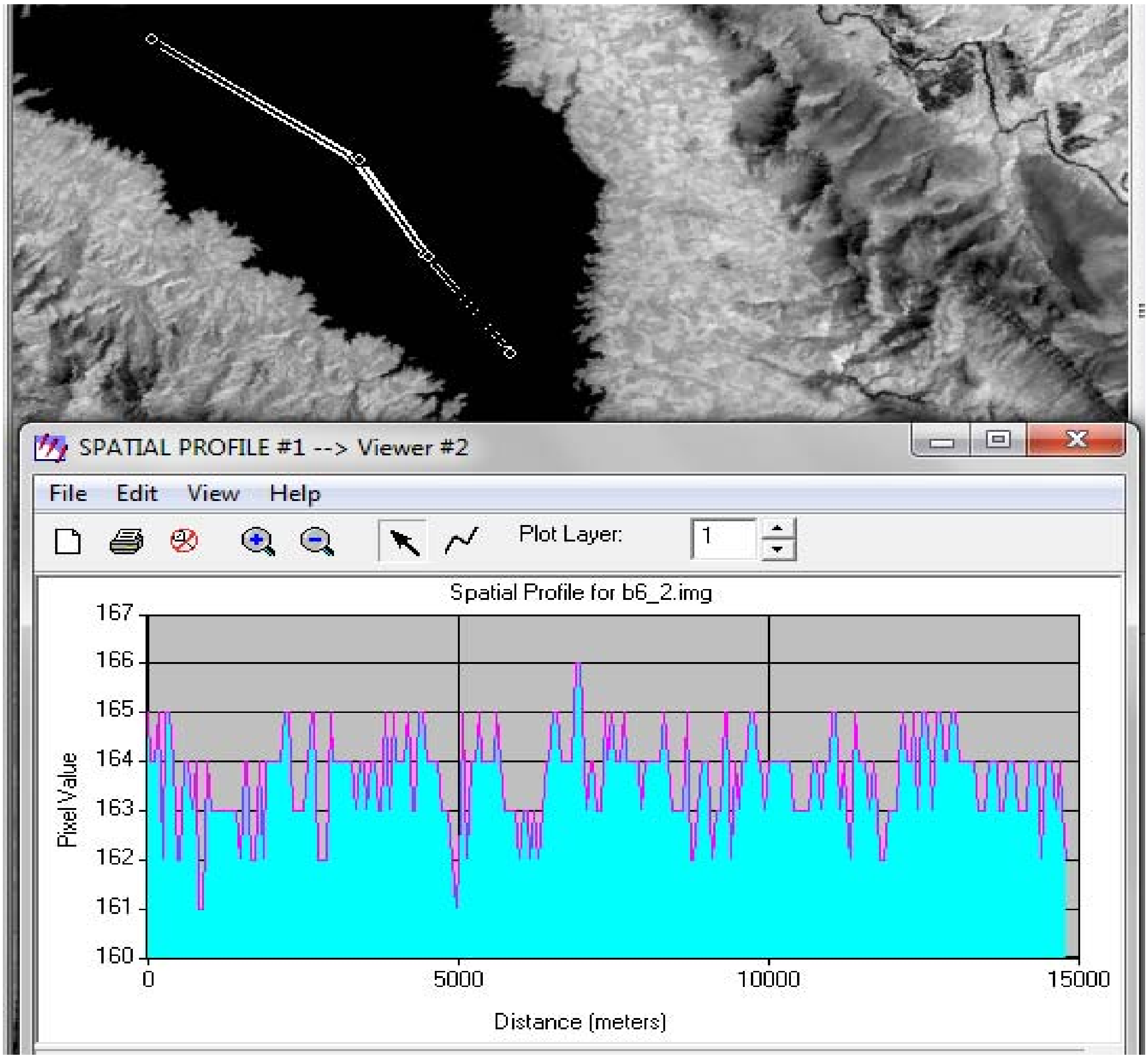

Figure 4: numeric values for image elements in the thermal band and low acquisition (Band 6-1).

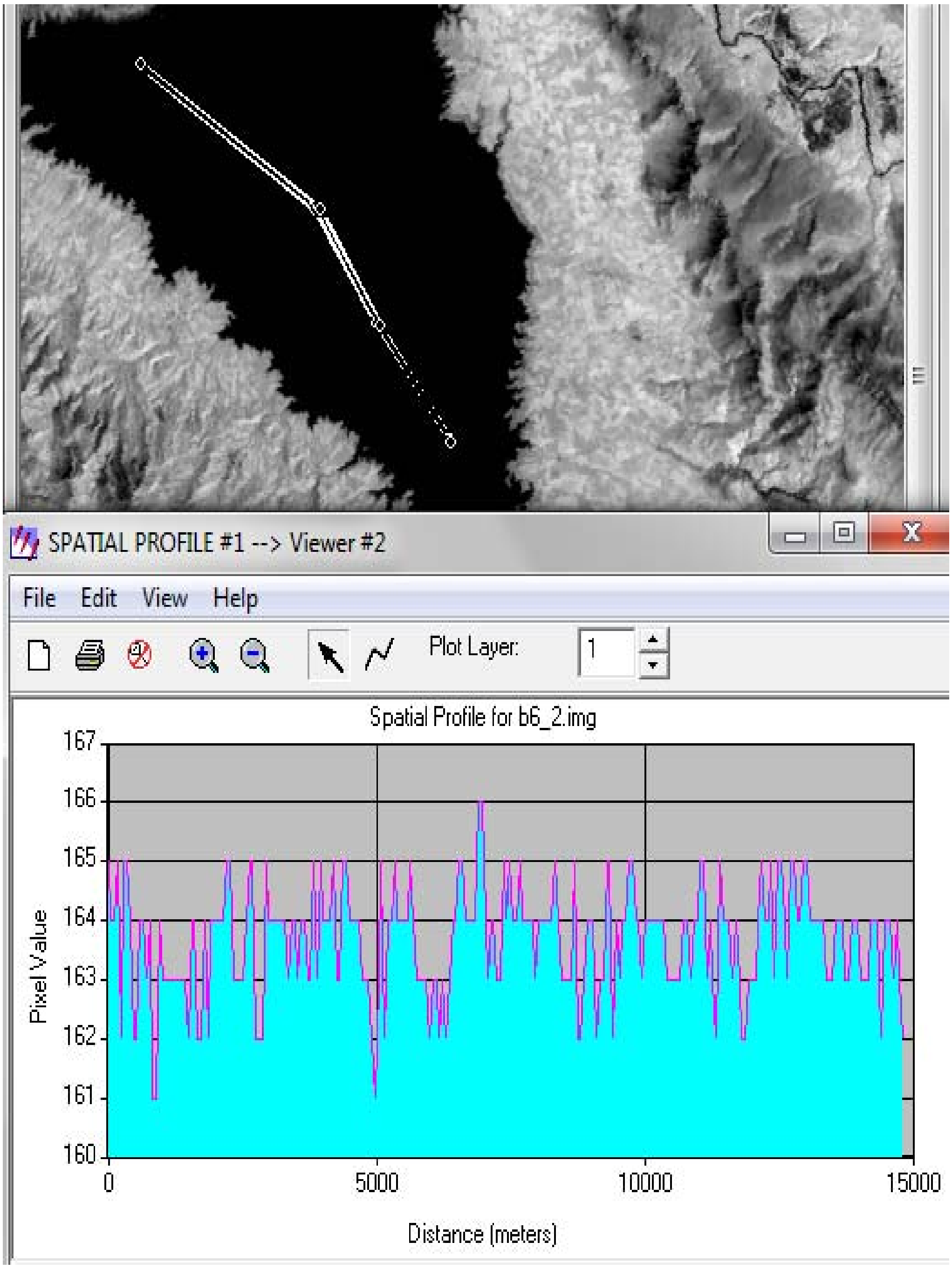

Figure 5: numerical values for image elements in the thermal band high acquisition (Band 6-2).

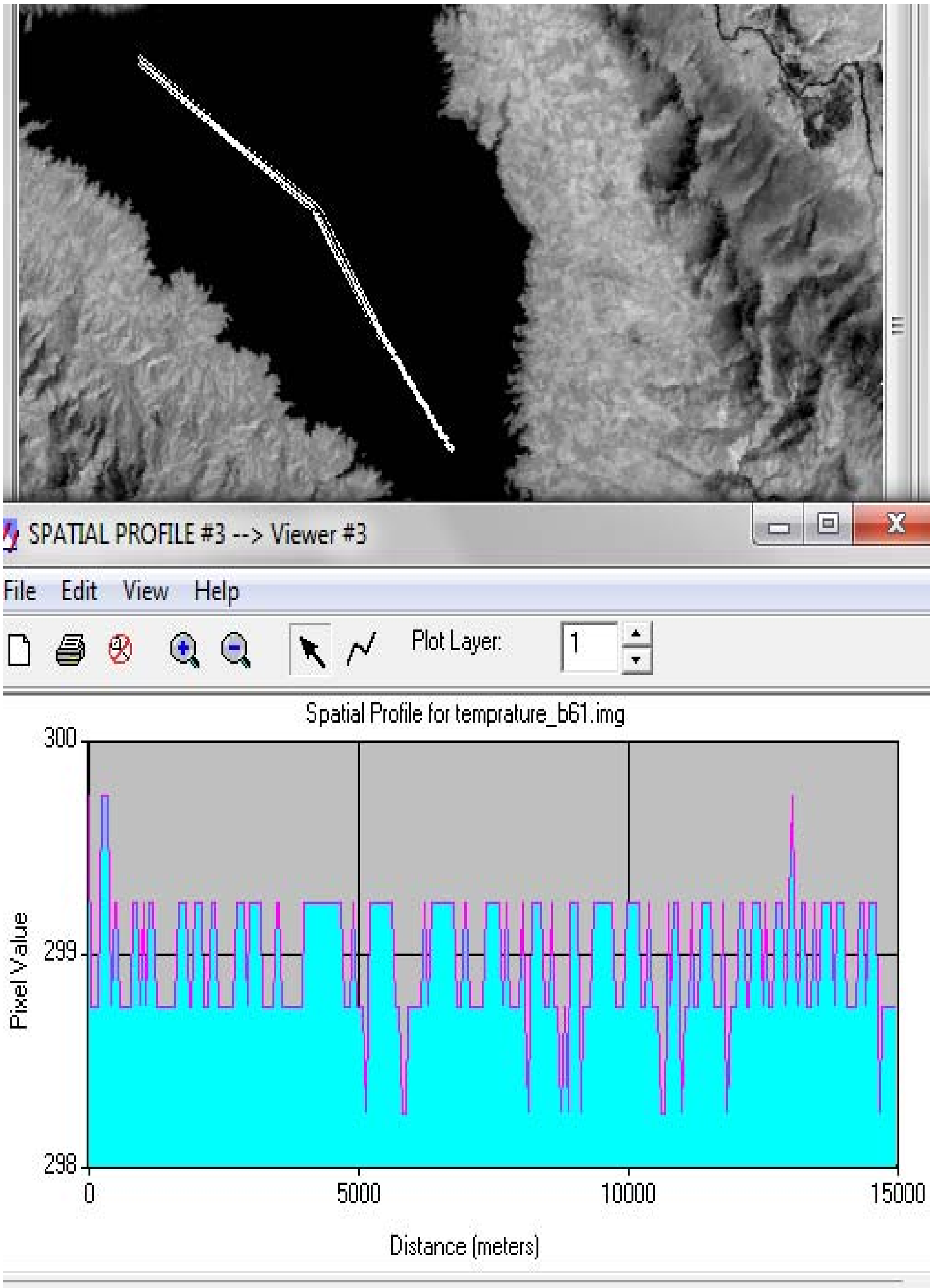

Figure 6: the temperature of the longitudinal section of the image of the band thermal and low acquisition.

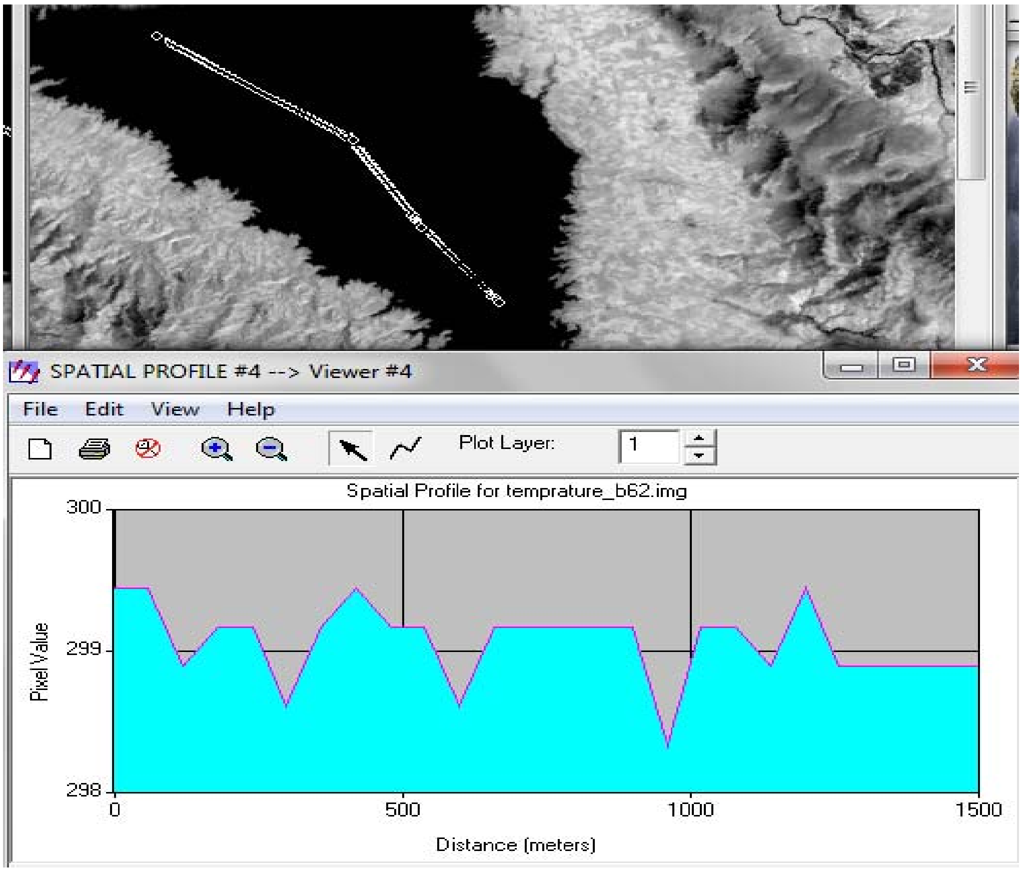

Figure 7: the temperature of the longitudinal section of the image of the thermal band high acquisition.

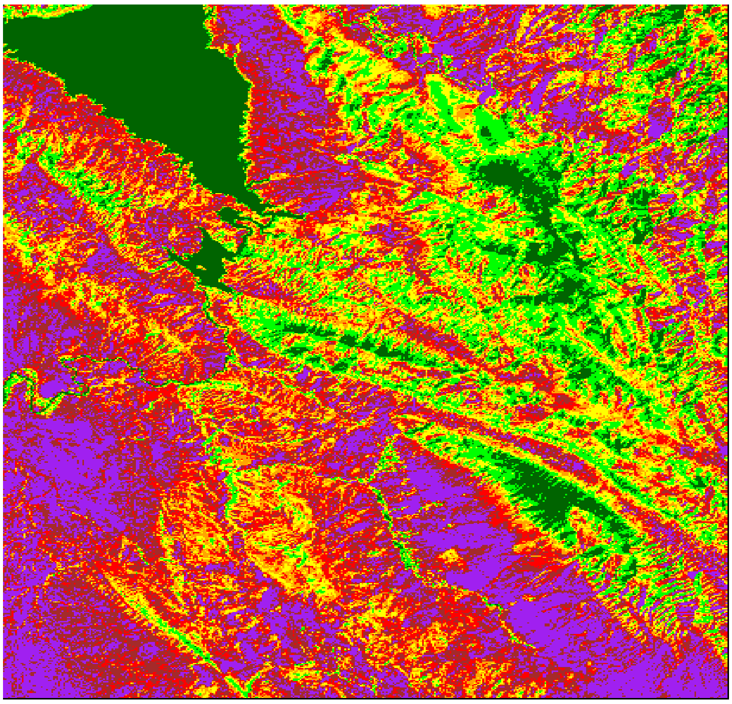

Figure 8: The temperature distribution map for study area.

Table 2: guide to temperature in figure (8).

Kelvin temperature	Color
٣٠٠	green
٣٠٧-٣٠٠١	Light green
٣٠١١-٣٠٨	yellow
٣١٣-٣١٢	orange
٣١٤	red
٣١٦-٣١٥	Brown
٣٢٠-٣١٧	Purple

6 -Conclusions

1-There is high similarity in results obtained using low or high bands which indicates the accuracy of the mathematical formula used in calculating temperature.

2-It is not possible to calculate temperature unless we have the data base of the conditions when thermal image were taken, which the digital numbers of the coefficient have used to get the values of the bias and gain of both bands.

3-There is some difference in the sensitivity of calculating the digital numbers of the picture elements between the two bands, which has an impact on the accuracy of the calculated results.

4-It is difficult to decide which band (low or high gain) is better at calculating temperature as there are other factors in the atmosphere which play role like clouds,humidity,air temperature or other physic-chemical properties of the land.

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