ISSN 2616-5872 Vol.4, Issue 1: 22-27, DOI: 10.25236/AJEE.2022.040105

Research on Retrieval of Surface Temperature Based on Landsat8 Data Atmospheric Correction Method

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Abstract: *With the development of remote sensing technology, various land surface temperature retrieval algorithms have been proposed one after another. How to use remote sensing data to retrieve the changing trend of land surface temperature and then plan the development of future cities has become a research hotspot. This paper takes Jinan City, China, as an example, selects 2017 and 2018 Landsat8 OLI and TIRS remote sensing images, uses ENVI software, uses atmospheric correction method to perform temperature inversion, and combines the measured data of 10 measurement sites in Jinan City and the inversion results of this research Comparing the data. Using linear regression analysis, the correlation coefficients between the inverted temperature and the measured land temperature are 0.8815 and 0.8756, respectively, which means that the correlation is relatively high. The atmospheric correction method is used to invert the surface temperature of Ji Nan City. The rationality of this policy provides a reference for effectively responding to regional or global climate change.*

Keywords: *Temperature inversion, landsat8, atmospheric correction method, regression analysis.*

1. Introduction

The surface temperature is the heat energy after the solar radiation reaches the ground after reflection and absorption, and then the temperature is measured. At present, some scholars have conducted related research and proposed a land surface temperature retrieval algorithm based on remote sensing thermal infrared band[1]; There are three main types: single-channel algorithm, split window algorithm and atmospheric correction method. Among them, the single-channel algorithm is mainly represented by Zhihao Qin's single-window algorithm inversion of land surface temperature using land satellite TM6 data[2]. The split window algorithm is maintly based on MODIS/NOAA/AVHRR and other image data with two thermal infrared bands. Among them, MODIS data is more effective in the inversion of surface temperature[3], but its resolution is low, and the inversion accuracy is not high enough. The atmospheric correction method eliminates the radiation error caused by the influence of the atmosphere and inverts the actual surface reflectivity of the ground object. This method mainly relies on the information of the image itself, which is convenient and practical.

In this paper, Jinan City, Shandong Province, China is used as the research area, based on the previous results, Landsat8 is used as the data source, the temperature in Jinan is retrieved by atmospheric correction method, and the normalization is calculated based on the reflection values of infrared and thermal infrared. Vegetation index, the coverage of vegetation is introduced, and Van’s empirical formula is used to realize the accurate calculation of vegetation coverage and surface emissivity in the study area; according to the real-time atmospheric water vapor content in Jinan, a suitable atmospheric transmittance model is selected for atmospheric Estimation of transmittance[4]; calculate the blackbody radiance at the same temperature based on the TIRS10 radiance image, and finally calculate the surface inversion temperature to compare the difference in specific emissivity and the relationship between surface temperature and vegetation coverage[5].

2. Data acquisition and data processing

2.1. General situation of the research area

Jinan is the capital of Shandong Province. It is located in the central and western part of Shandong Province, between 36°01′ to 37°32′ north latitude and 116°11′ to 117°44′ east longitude. Situated in the mid-latitude zone, the four seasons are distinct. Jinan is surrounded by mountains on three sides, Tai Mountain in the south, and the Yellow River in the north. The terrain is high in the south and low in the

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north, with a height difference of more than 500 meters. The average sea wave height is 118 meters. Pollution will be challenging to eliminate. It is known as the Northern Stove. Therefore, real-time surface temperature monitoring of Jinan City is necessary, and it is a reference for regional or global climate change monitoring.

2.2. Data collection

The remote sensing data in this paper uses the Landsat8 OLI and TIRS satellite images on May 16, 2017, and May 3, 2018. The OLI data is used to calculate the surface emissivity of the study area, the TIRS data is used to retrieve the LST, and the measured temperature data is obtained from Jinan Weather Station and 2345 Historical Weather Website.

2.3. Landsat 8 data preprocessing

Data processing includes LANDSAT 8 multi-spectral data radiation calibration and atmospheric correction, LANDSAT 8 thermal infrared data radiation calibration, and mosaic cutting processing. The atmospheric correction adopts the FLAASH model, the scale conversion factor of the model parameter is 1, the graphic center coordinate is set according to the image metadata, the sensor type is Landsat8 OLI, the atmospheric model is developed to mid-latitude summer according to the latitude and longitude of Jinan, and the aerosol model is set to nothing.

3. Land surface temperature inversion algorithm

In recent years, domestic and foreign scholars have successively proposed many algorithms for retrieving land surface temperatures, such as the single-window algorithm and atmospheric correction method in the single-channel algorithm, and the split-window algorithm in the multi-channel algorithm.

In view of the special geographical location of Jinan and its complex topography, the return of water vapor and hot air is not easy to diffuse, and the influence of the atmosphere on the absorption and radiation of sunlight and radiation from the target is more obvious, so it is particularly important to eliminate the influence of the atmosphere. It is important, so there are shortcomings in the simple single-window algorithm. This study uses the TIRS10 band of Landsat8 images and uses atmospheric correction to retrieve the surface temperature. Below we focus on the atmospheric correction method:

3.1. Atmospheric Correction Method

The basic principle of the atmospheric correction method is to subtract the influence of the atmosphere on the surface thermal radiation from the total thermal radiation observed by the satellite sensor to obtain the surface thermal radiation intensity, which is then converted into the corresponding surface temperature.

The thermal infrared radiance value received by the satellite sensor is composed of three parts: the upward radiance of the atmosphere $L\uparrow$, the true radiance of the ground reaching the satellite sensor after passing through the atmosphere; after reaching the ground the downward radiant energy of the atmosphere $L\downarrow$ reflected the energy. The expression of the thermal infrared radiance value received by the satellite sensor L_λ can be written as:

$$L_\lambda = [\varepsilon B(T_s) + (1-\varepsilon) L\downarrow]\tau + L\uparrow \tag{1}$$

ε is the surface specific emissivity; T_s is the true surface temperature (K); $B(T_s)$ isthe black body thermal radiance, τ and is the transmittance of the atmosphere in the thermal infrared band. Then the radiance of a black body with a temperature T of in the thermal infrared band $B(T_s)$ is:

$$B(T_s) = \frac{L_\lambda - L\uparrow - \tau(1-\varepsilon)L\downarrow}{\tau\varepsilon} \tag{2}$$

The true temperature of the ground T_s can be obtained as a function of Planck's formula.

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4. Surface temperature inversion and accuracy analysis

Based on the research process of the atmospheric correction method, the inversion temperature of the surface is finally required, and the Planck function is needed. The following describes how to calculate the various parameters required in the Planck function to obtain the result.

4.1. NDVI index calculation

In this experiment, Band Math is used to calculate the exponent. The calculation formula is:

$$NDVI = (NIR - R)/(NIR + R) \tag{3}$$

NDVI refers to the reflection value in the near-infrared band, and R refers to the reflection value in the red light band.

4.2. Calculate vegetation coverage

Vegetation coverage can be used to evaluate the extent of regional vegetation coverage. This experiment uses mixed pixel decomposition, and the formula is as follows:

$$F_v = (NDVI - NDVI_s)/(NDVI_v - NDVI_s) \tag{4}$$

Among them, F_v is the vegetation coverage, NDVI is the normalized vegetation index, $NDVI_v$ is the total vegetation coverage, and $NDVI_s$ is pure bare soil.

4.3. Calculate the surface emissivity

In view of the inoperability of accurately measuring the surface specific emissivity, the relative emissivity value can only be obtained through assumptions. This study is based on the visible light and near-infrared spectrum information to estimate the emissivity:

$$\varepsilon = 1.0094 + 0.047 \ln(NDVI) \tag{5}$$

Among them, ε is the surface emissivity and $NDVI$ is the normalized vegetation index.

4.4. Calculate atmospheric transmittance

Then the atmospheric transmittance model applied to the 31 band can be applied to the TIRS10 of the landsat8 data, and the mid-latitude atmospheric profile data is simulated to obtain 31 the general atmospheric transmittance calculation equation of the band:

$$\tau_{31} = 2.89798 - 1.88366 - (\omega / - 21.22704) \tag{6}$$

Through the transformation of formula (11), the calculation of TIRS10 of landsat8 data can be realized, and the atmospheric transmittance τ can be obtained.

4.5. Calculate the radiance value of a black body at the same temperature

According to the introduction of the atmospheric correction method in 3.1 above, the radiance value of a black body with a temperature of T in the thermal infrared band is $B(T_s)$, and the expression of the thermal infrared radiance value received by the satellite sensor L_λ is deformed to obtain the formula:

$$B(T_s) = \frac{L_\lambda - L\uparrow - \tau(1-\varepsilon)L\downarrow}{\tau\varepsilon} \tag{7}$$

Among them, L_λ can be obtained from the thermal infrared image radiation calibration. In the formula, L_λ, $L\uparrow$, τ, ε, $L\downarrow$ are all known values at this time, and the above formula $B(T_s)$ is

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used to obtain the radiance value of a black body with a temperature of T in the thermal infrared band.

4.6. Inversion result

According to the radiance value of the black body with a temperature of T, the true surface temperature T_s can be obtained through the inverse function of Planck's formula. The formula is as follows:

$$T_s = \frac{K_2}{\ln(K_1 / B(T_s) + 1)} \tag{8}$$

For TIRS Band10, $K_1 = 774.89W/(m2\mu msr), K_2 = 1321.08K$

After the above process is completed, the results can be output in the ENVI software, as shown in Figure 1 and Figure 2, which are the results of Jinan temperature inversion in 2017 and 2018, respectively.

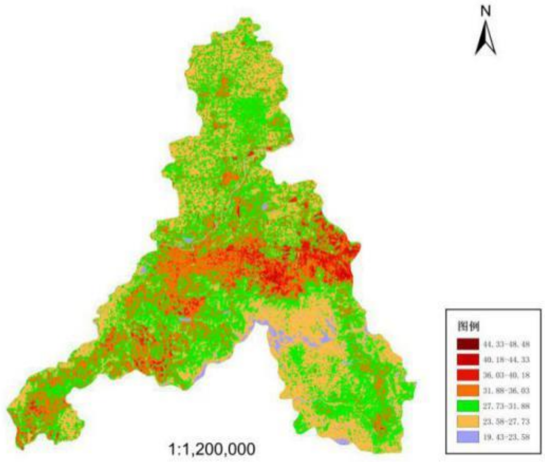

Figure 1: The results of temperature inversion in 2017

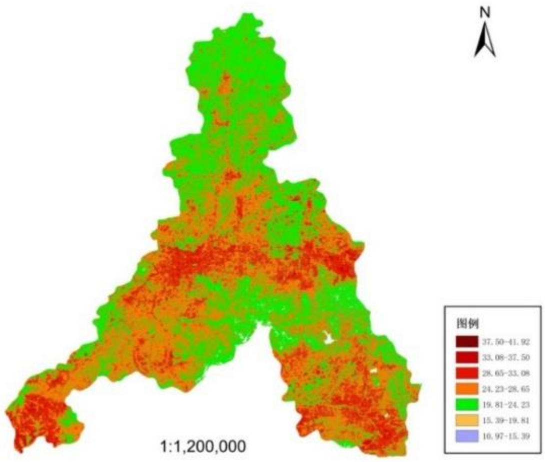

Figure 2: The results of temperature inversion in 2018

4.7. Accuracy verification

In order to accurately verify the accuracy of temperature inversion, this paper compares the measured land data with the inversion data. The imaging time of the landsat8 image is about 10:50 am every day, so the measured temperature of the land in the same time period is obtained by interpolation, and the two are compared, as shown in Table 1 and Table 2.

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Table 1: Comparison of inversion and measured data on May 16, 2017

Site	Surface temperature(℃)		
	Inverte temperature	actual data	Atmospheric correction error
Mashan Town	33.33	30.78	2.55
Huaiyin Plaza	33.70	31.24	2.46
Taiping Town Government	30.07	28.12	1.95
City Hall	34.47	32.15	2.32
Spring City Square	33.90	29.99	3.91
Pingyin Ancheng Pao Point	31.64	29.33	2.31
Thermal Power Company	30.99	30.01	0.98
Shanghe Jade Emperor Temple	31.00	29.98	1.02
Huanghe Town	29.55	28.64	0.91
Qixingtai	24.34	24.12	0.22
average value	31.30	29.45	1.86

Table 2: Comparison of inversion and measured data on May 3, 2018

Site	Surface temperature(℃)		
	Inverted temperature	actual data	Atmospheric correction error
Mashan Town	27.1	24.97	2.13
Huaiyin Plaza	28.66	25.16	3.5
Taiping Town Government	25.60	24.65	0.95
City Hall	29.49	27.65	1.84
Spring City Square	30.66	27.36	3.3
Pingyin Ancheng Pao Point	27.31	25.03	2.08
Thermal Power Company	27.01	26.12	0.89
Shanghe Jade Emperor Temple	25.70	23.79	1.91
Huanghe Town	23.69	23.11	0.58
Qixingtai	21.79	20.19	1.6
average value	26.70	24.80	1.9

Due to the limited number of measured data samples in this experiment, errors will occur during the interpolation process according to the temperature reported by the meteorological station and when the satellites collect data in the field. In order to improve the conviction of this experiment, the inversion results of two years Perform correlation analysis with the measured data, the average errors obtained in 2017 and 2018 are 1.86 and 1.90. The inversion and measured data of 2017 and 2018 are subjected to linear regression analysis, and the estimated constants for two years are 0.5677 and 0.5201 respectively. The average is 0.5439, and the correlation coefficients are 0.8815 and 0.8756 respectively. The correlation is relatively high, indicating that the inversion results of this study are reasonable.

According to the above statistics, the surface inversion temperature is generally higher than the measured data. The main reasons are as follows: (1) The time period studied in this paper is May, the temperature rises rapidly, and the temperature measured by the surface monitoring station .It's around 10:30, and the time to get the downloaded image is around 10:50 in the morning. (2) There are problems with the inversion accuracy. When building the algorithm model, it is necessary to input real-time pressure, wind speed, humidity and other parameters, but the information of other sites is missing in this experiment. (3) The radiation received by high-altitude remote sensing satellite sensors includes not only direct radiation from the surface, but also the second attenuation of the atmosphere before it can enter the sensor, followed by atmospheric scattering, reflection and radiation, and radiation from the ground itself. The satellite sensor makes the radiation value of the remote sensor higher than the radiation value

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of the earth's surface.

5. Conclusion and discussion

After realizing the accurate calculation of atmospheric transmittance and surface emissivity, the real surface temperature can be calculated by inversion of Jinan surface temperature using atmospheric correction method according to the approximate constants obtained by linear regression, which has good applicability and rationality. And provide reference for effective response to regional or global climate change. Combining with the exploration purpose of this experiment, the temperature change trend in Jinan area can be obtained through atmospheric correction based on continuous years of image data. For example, in agriculture, predict the crops suitable for planting in a certain plot in the next few years and increase the yield of crops; in cities In terms of planning, rationally arrange the density of buildings, green vegetation, etc., reduce the heat island effect, and improve the quality of the environment.

According to the error between the inversion result and the measured data, this experiment has the following shortcomings: (1) The number of image data periods is too small and the time interval between the two images is large. (2) The calibration of thermal infrared images only uses one band to participate in the algorithm analyze. (3) The parameters used by the algorithm are model-based parameters and will be different from the actual ones, which will affect the accuracy of the algorithm model constructed when processing images. It will be improved in future research.

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