AN ALGORITHM FOR RETRIEVING LAND-SURFACE TEMPERATURE FROM MODIS DATA

——A CASE STUDY OF NORTHERN HEBEI, CHINA

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1. INTRODUCTION

The requirement for land surface temperature (LST) in environmental studies and resource management makes the remote sensing of LST an important topic. As a result, a number of studies about the development of methodologies for retrieving LST have been carried out. In order to solve the problems in land surface temperature retrieval, many scholars at home and abroad have put forth a wide range of surface temperature retrieval algorithm.

The accuracy of most algorithms is very high but they still need to make some assumptions regarding prior knowledge of atmosphere (especially water content). Owing to different considerations of the atmospheric effect on the radiation transfer through the air, the prior knowledge required is different. This paper attempts to use both the split-window algorithm and the Linear Spectral Mixed Model for computing vegetation fraction, in order to improve the algorithm proposed by Qin(2001), and then evaluate the feasibility of the method.

2. STUDY AREA AND DATA SOURCE

2.1. Study Area

The study area is located in northern Hebei Province, a mountainous district with high vegetation coverage in China, including four regions, they are Zhangjiakou, Chengde, Tangshan and Qinhuangdao.

2.2. Data Source

MODIS (Moderate-resolution Imaging Spectral Radiometer) is an EOS instrument that has 36 bands. It is particularly useful because of its global coverage, radiometric resolution and time resolution, dynamic ranges, and accurate calibration in multiple thermal infrared bands designed for retrievals of SST, LST and atmospheric properties, so an AQUA MODIS 1B image dated on Aug 7, 2009 was selected, and in this image our ground observation data has a relatively clear atmospheric condition.The MODIS/AQUA data is available free of charge at http://wist.echo.nasa.gov/.

3. METHODOLOGY

In this paper we select an algorithm proposed by Qin (2001) as the base of an algorithm improved by us which involves two essential parameters (transmittance and emissivity).

Before the retrieval of LST, image pre-processing was needed. Corrected the geometric and atmospheric distortions for the images, and got rid of the bowtie effect. The MODIS image was further rectified to a common Universal Transverse Mercator coordinate system. All available bands include bands 1-7, 19 and 31, 32.

Emissivity is an essential parameter for the retrieval of LST, which influences the accuracy of LST using split-window algorithm. In this section, vegetation fraction is one important parameter. We can estimate its emissivity according to the relationship between emission and vegetation fraction, using the following formula:

$$\varepsilon_{\mathrm{i}} = P_v R_v \varepsilon_{\mathrm{iv}} + \left(1 - P_v\right) R_s \varepsilon_{\mathrm{is}} + d\varepsilon \quad (1)$$

where ε_{i} is the average emissivity of the mixed pixel. P_v represents the vegetation fraction. $\varepsilon_{\mathrm{iv}}$ and $\varepsilon_{\mathrm{is}}$ denote the emissivity of vegetation and soil, R_v and R_s are the radiance ratio respectively.

After the calculation of Planck function, R_v and R_s are also simplified to be linear correlation with P_v as follows:

$$R_v = 0.92762 + 0.07033 P_v \quad (2)$$

$$R_s = 0.99782 + 0.08362 P_v \quad (3)$$

In this section, the vegetation fraction was quantitatively extracted from AQUA MODIS 1B data by using LSMM (Linear Spectral Mixed Model), instead of NDVI reflected vegetation fraction. Selecting suitable endmembers is the most critical point in the development of high quality fraction images. Prior to derivation of fraction images, the minimum noise fraction (MNF) transformation was performed to reduce data redundancy and correlations between spectral bands (bands 1-7). And then calculate the pixel purity index (PPI) which can show the number of this pixel is marked as the number of extreme values. All of these are helpful for us to choose the right endmembers. From the vegetation component map of LSMM calculation we can drew the vegetation fraction (Weng, 2004).

Another essential parameter transmittance was still based on the algorithm proposed by Qin (2001).

4. RESULTS AND DISCUSSION

The LST retrieved by our algorithm ranges from 298K to 308K, which is consistent with the LST products. Compared with the other three regions, the land surface temperature of Chengde especially in its northern area had a relatively lower temperature, and this area turns out to be a large coverage of well-distributed forest in the north according to the land use classification. While in Qinhuangdao and Tangshan, some pixels had a relatively higher temperatures, these pixels turn out to be residential buildings sites according to the land use classification.

MODIS LST products and field data obtained by IR FlexCam Thermal Imagers are used to validate the algorithm:.

Compared results of surface temperature of the profile, our result and the LST product had very consistent trend of temperature distribution. They have very good correlation, the correlation is significant at the 0.01 level. But our result has a relatively higher temperature than the LST products on average which were 303.4355K and302.3303K. To some extent the reason for this is the Atmospheric Correction factors which were not obtained by field survey, cloud influence was also one important reason.

Then we compared the computed data with field data obtained by IR FlexCam Thermal Imagers. Though the data we surveyed is not the average value of MODIS pixel data (1km*1km), but it can reflect the temperatures of different components covered by one pixel. Our field survey data can be used to validate the result of the temperature distribution, where there was covered by forest and water had a relatively lower temperature than that residential building sites.

LSMM applied in the algorithm for retrieving land surface temperature is helpful for widening the range of research. It also provides the chance of land surface temperature study in different kinds of land cover.

Key words: MODIS, land surface temperature, LSMM, northern Heibei China

Table1 Field survey data of different land cover types

Field survey data of different land cover(K)		
Vegetation	Soil	Water
305.33	315.78	300.78
302.32	312.56	300.28
304.86		304.35
303.45	303.56	302.50
301.78	305.67	301.89
304.44		303.11
300.86		301.56

5. REFERENCE

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