2012 International Conference on Environment, Chemistry and Biology
IPCBEE vol.49 (2012) © (2012) IACSIT Press, Singapore
DOI: 10.7763/IPCBEE. 2012. V49. 36

Analyzing Climate Influence on Vegetation Based on HJ Images: A Case Study of Suizhou

Zhou Lyu+ and Peixuan Jiang

School of Remote Sensing and Information Engineering Wuhan University, Wuhan, 430079, China

Abstract. Using remote sensing for environmental monitoring provides scientific foundation for regional ecological and sustainable development, hazard assessment and reduction. This paper utilizes NDVI and Density Slice algorithm to process remote sensing image obtained from HJ-1-A to monitor vegetation growth change during the recent four years in the region of Suizhou, Hubei. By cross-referencing it with meteorological data of the same time period, we further discuss the influence of meteorological factors on vegetation growth. The result indicates that, with the drought during the first six months and the continual high temperature in summer in year 2012, the growth of green plants in the region has been severely impeded with clearly lower over-all NDVI compared with historical data.

Keywords: HJ-1-A, vegetation extraction, NDVI, meteorological data, remote sensing change detection

1. Introduction

Green plants have unique spectral reflectance characteristics largely determined by various pigments, among which chlorophyll plays the most important role. Chlorophyll can considerably reflect near-infrared energy and absorb visible bands' energy. However, when under threats, the content of the pigments in the leaf changes with the most noticeably reduction in the content of chlorophyll, which will lead to reduction in absorptance and significant increase in reflection on the red band [1]. Therefore, we can acquire fairly good result by linearly or non-linearly combining red and near-infrared bands to detect green plants, and the characteristic exponent obtained this way is defined as Vegetation Index.

Vegetation Index can emphasize vegetation and be utilized to estimate a variety of physiological and biochemical parameters of green plant to reflect its growth condition [2-5]. Among many Vegetation Indexes, Normalized Difference Vegetation Index (NDVI) is widely applied due to its simpleness as well as its advantages of eliminating most of the external influence. In this experiment, we conduct vegetation extraction to satellite images to analyze the vegetation growth condition in the region of Suizhou during summer time each year from 2009 to 2012. By cross-referencing the analytical result and the meteorological data of the same time periods, we can understand the threat experienced by the green plants in the region and provide support for disaster assessment and warning.

2. Data and Pre-processing

2.1. Overview of the Survey Area

The survey area of this paper is Suizhou, Hubei, with a geographic range from 112°43′ to 114°07′east, 31°19′ to 32°26′north. According to the land resource data published by the Land and Resource Bureau of Suizhou in April, 2012: among a total area of 961493.95 hectares of Suizhou, agricultural land(including farmland, forest and garden plot) takes up 789206.81 hectares, which accounts for 82.09% of the total land

+ Corresponding author. Tel.: + 86-15271917327;
E-mail address: lvzhou@whu.edu.cn.

area[6], which indicates relatively high vegetation coverage in the region. The administrative map of Suizhou is shown as Fig. 1.

Fig. 1 Maps of Suizhou

2.2. Data Preparation

2.2.1 Satellite Image Source

In our experiment, we select four CCD images of Suizhou in summer taken respectively at 06/22/2009, 08/13/2010, 07/08/2011, 07/23/2012(mm/dd/yyyy). The images are obtained by China Small Satellite Constellation for Environmental and Disaster Monitoring (Environmental Mitigation Satellite, HJ-1-A). HJ-1-A carries a multi-spectral(three visible bands and one near-infrared band) CCD camera of 30m resolution, and a hyperspectral HSI camera of 100m resolution[10]. The main parameters of HJ-1-A/B can be found on the website of China Center for Resources Satellite Data and Application(CRESDA)[7].

2.2.2 Meteorological data source

This paper adopts combined meteorological data of Model Re-analysis data and statistical yearbook from Bureau of Meteorology. The monthly average nocturnal temperature of Suizhou from June to August, from year 2009 to 2012 are acquired from NCAR/NCEP re-analysis outcome at the grid point of 32.5 °N, 112.5 °E within Suizhou; the monthly average precipitation from June to August, from year 2009 to 2010 are acquired via the same method, while the monthly average precipitation in the summer time from year 2011 to 2012 are provided by free statistical data on AccuWeather.com's website. Finally, related High Temperature Warning Signal released by the Bureau of Meteorology of Suizhou in July, 2012 is provided by the website of the Bureau.

2.3. Workflow

The workflow adopted in this paper is shown as follows:

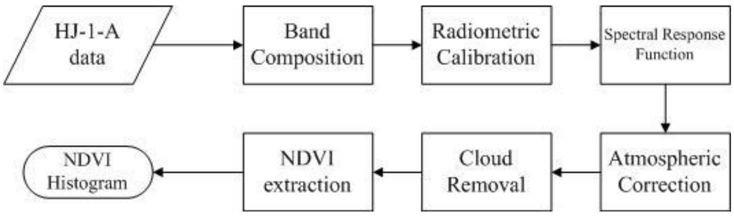


Fig. 2 Experiment workflow

2.3.1 Band Composition

CCD camera provides abundant information, of which the standard false color composition of band 432 is the optimal composition when studying vegetation in the image. We can acquire free HJ-1-A CCD image from CRESDA. Each downloaded data package includes four Geotiff files for each four different bands, a metadata description (.XML) and a coordinate file (.txt). The four Geotiff images of the CCD camera can be composed and opened directly in ENVI.

2.3.2 Sensor Calibration

The purpose of radiometric calibration is to transform the output DN (Digital Number) of the sensor to the radiometric brightness at the sensor's entrance. Therefore we can obtain the ground's real reflectance after atmospheric correction. CRESDA provides the formula and calibration coefficients for transforming DN value to radiometric brightness. We can finish the calibration automatically by using the patch tool of

HJ-1-A/1B in ENVI, calibration formula, units and coefficients of the sensor provided by .XML file in the HJ-1-A's data package.

2.3.3 Atmospheric Correction

In this paper, we choose FLAASH(Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes) method to correct distortions caused by atmosphere. FLAASH model's formula is as follows:

$$L = A \cdot \rho / (1 - \rho_e \cdot S) + B \cdot \rho_e / (1 - \rho_e \cdot S) + L_a \tag{1}$$

Where L represents spectral radiance that a single pixel receives, ρ represents the surface reflectance of this pixel, ρ_e represents the average reflectance of pixels which locates in the perimeter zone of the single pixels mentioned above. S represents the atmospheric spherical reflectivity and A, B are the coefficient based on geometry and atmosphere. These parameters are greatly determined by sun zenith, ground elevation, aerosol category, sun azimuth, latitude longitude and so on [8-10], which can be obtained from the metadata (.XML) in the package.

The results of atmospheric correction are as follows. We find that not only the image appearance changed a lot, but the spectrum curve also turned to the original conditions that are free from the influence of atmosphere.

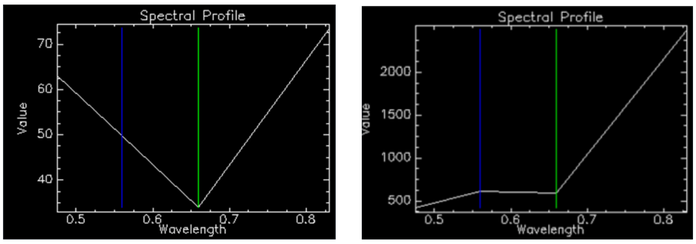


Fig. 3 Comparison of 2009 image's spectrum curves before and after FLAASH (left: before; right: after)

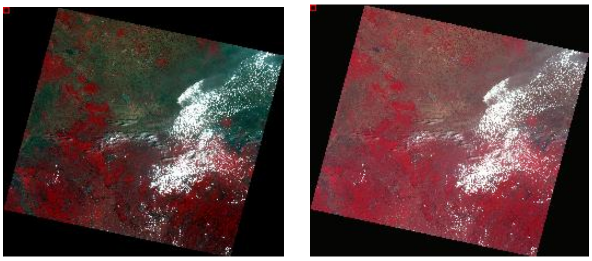


Fig. 4 Comparison of 2009 image before and after FLAASH (left: before; right: after)

2.3.4 Cloud Removal

Because of weather effects, it is rather difficult to obtain cloud-free images. So cloud removal becomes essential. This paper employs the Cloudy Point algorithm based on Haze Optimized Transformation (HOT) which is patched as the Haze Tool in ENVI to remove the cloud. The algorithm is an improvement on Dark Subtract algorithm whose basic idea is to hierarchically remove the cloud from the image in accordance with the thickness of the cloud, mainly to hierarchically segment the HOT image[11-15]. The degree of ground rehabilitation varies depending on the thickness of cloud, and the regions that are completely sheltered from the cloud are beyond consideration in this paper.

In general, results are fairly satisfactory with thin cloud though it may lead to loss of some information. However, the results are barely good with spissatus, sometimes serious ground distortion or blank regions may occur.

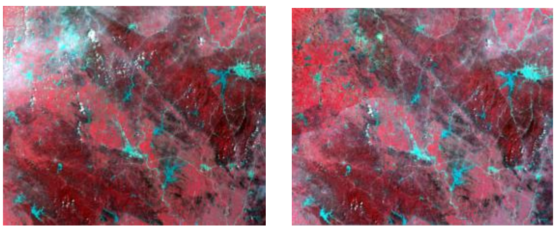


Fig. 5 Comparison of 2010 image before and after cloud removal (left: before; right: after)

3. Vegetation Extraction

3.1. General Workflow

The establishment of the vegetation index is based on the major spectral difference between red band and near-infrared band. The spectral reflectance on the red band is low, resulting from the green plants' strong absorption of red spectrum during photosynthesis; while the reflectance on near-infrared band is relatively high due to leaf cells' scattering the solar radiation in the near-infrared spectral region[16]. Among the various kinds of Vegetation Index, NDVI is widely used. NDVI is calculated from individual measurements as follows:

$$NDVI = \frac{\mathrm{NIR} - \mathrm{Red}}{\mathrm{NIR} + \mathrm{Red}} \tag{2}$$

Where Red and NIR stand for the spectral reflectance measurements acquired in the visible (red) and near-infrared regions, respectively. In practical application, we use the third band (red) and the forth band(near-infrared) of HJ-1-A satellite to calculate NDVI.

3.2. Process and Result Analysis

In order to observe the result of vegetation variation within this region more clearly, after extracting the vegetation using NDVI, we make density slice to the images by attaching the same color to the pixels with the same NDVI values. The results are as follows: we can see the ratio of different levels of growth conditions, which can be the indicator of plants' growth conditions.

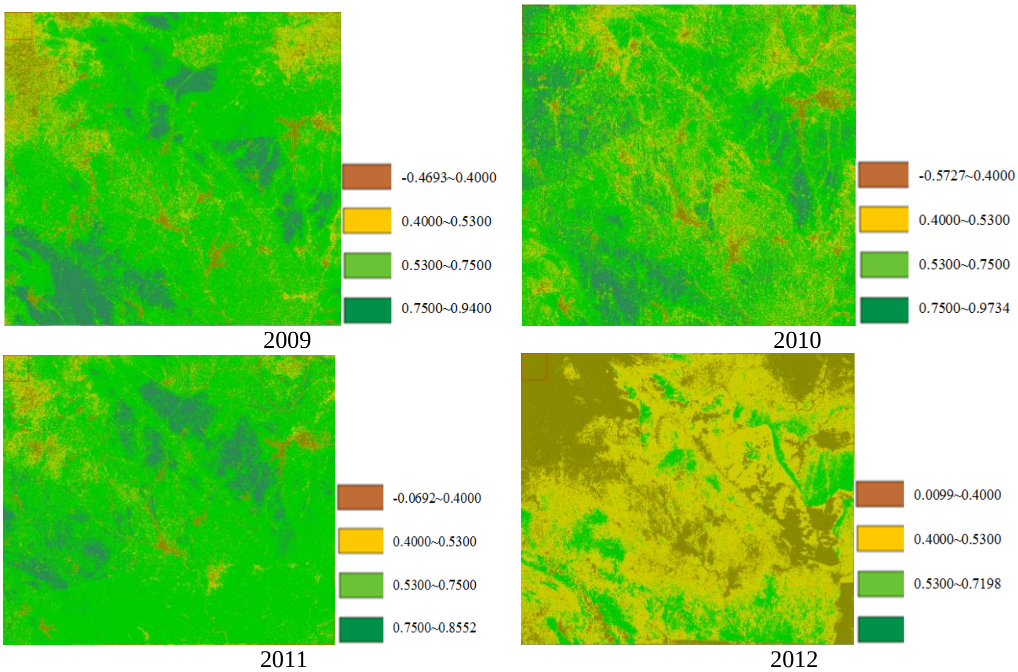
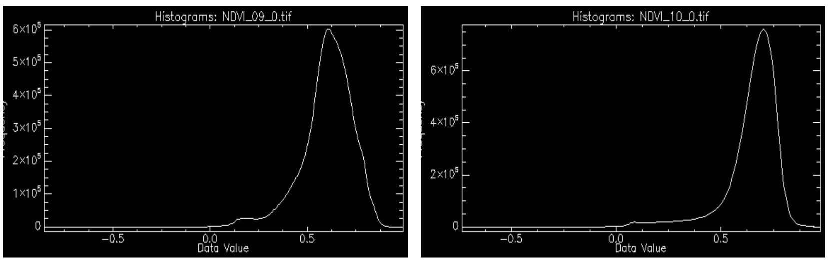
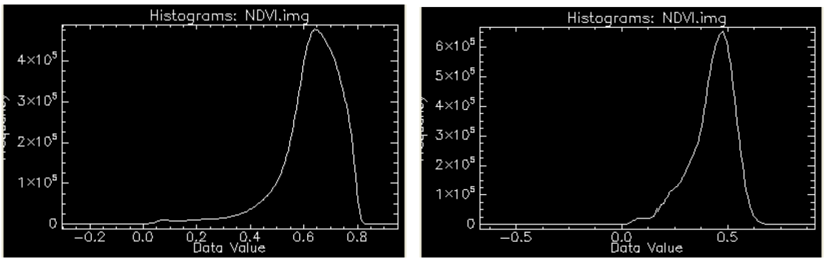


Fig. 6 NDVI density slice comparison from 2009 to 2012

Finally, we use ENVI's Quick Stats function to examine histograms of the single band NDVI images. The peak values of NDVI should mirror conditions of the majority of plants since the regions are mostly filled with vegetation. In the diagram 5, we see the histograms of NDVI from the year 2009 to 2012. By making further analysis, we find that the peak values are all greater than 0.6(in 2012 is even approximately 0.69) except the year of 2012, whose value is clearly less than 0.5.



2009 2010



2011 2012

Fig. 7 NDVI histogram of summer time vegetation in Suizhou, 2009-2012

We can understand the causes of this change by analyzing local meteorological data. The amount of precipitation from January to April in year 2012 is just one third as much as the same period in history, following which, the Meteorological Bureau continually reported high temperature warnings in July (See Table 1-2). Because of the high temperature and drought, the content of Chlorophyll is greatly reduced, which leads to decrease in absorption and increase in reflectance of red spectrum and opposite results of near-infrared spectrum, despite that the near-infrared spectrum is not the region mostly influenced by the lack of water (In fact, the near-infrared spectral reflectance will also be reduced at the wavelength of 0.9 μm)[1]. In one word, compared with healthy plants, the plants that are affected by high temperature and drought have lower NDVI values [17]. So, the histogram's peak value of the NDVI image in July, 2012 is much less than the ones from 2009 to 2011.

One thing that worth mentioning is that in August 2012, the amount of precipitation increased greatly (192 *mm* ,see Table 1) compared with the past following months. However, it has little effect on our result since our remote sensing image is obtained before August and the drought condition does not relieve by then.

Table 1 Monthly average precipitations and monthly average temperatures from June to August, 2009-2012 Suizhou (Grid Point: 32.5° N, 112.5 °E) (unit: mm; unit: ℃)

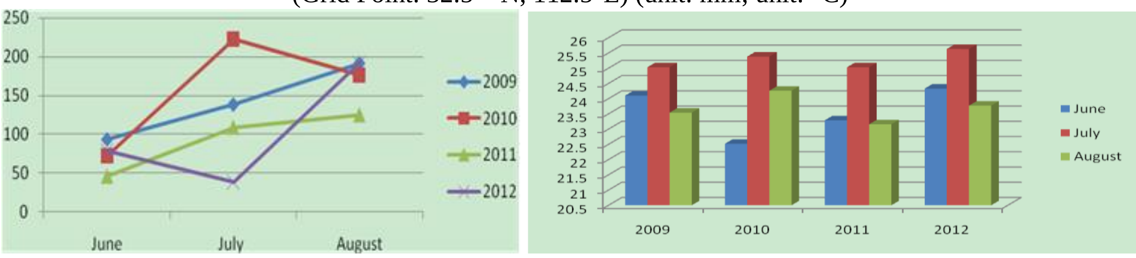


Table 2 High temperature warning signals published by Suizhou Meteorological Bureau, July, 2012

15:20, July 23rd, 2012	high temperature yellow warning signal
09:20, July 26th, 2012	high temperature yellow warning signal
09:50, July 29th, 2012	high temperature yellow warning signal
11:48, July 30th, 2012	high temperature Orange warning signal

4. Conclusion

We further verify the results by referencing ground's real condition material collected after the period of time. The announcements on the websites of the local government and news media reported the following statistics: Up to Aug. 11th, the city's total damaged forest area is 283,568 *mu* , which consists of 1560 *mu* damaged forestry seedlings with a lower than 50% survival rate for some species and 198,000 *mu* damaged matured forest[18]. The agricultural data collected after August's harvest suggested that the city's total affected agricultural land area is 924500 *mu* with 127,200 *mu* land produced basically nothing, accounting for 36.7% of the total agricultural land[19]. The situation clearly matches the experiment's result.

By extracting vegetation with the method of NDVI and analyzing the histogram of NDVI image, we can obtain the general growth condition of vegetation and their tendency of variability. In our experiment, the result proves that our method is capable of detecting the growth condition of the vegetation on the large scale, providing necessary support for the reduction of loss and influence of drought weather.

5. Summary and Prospect

Remote sensing technology can provide support for decision making in the field of monitoring growth condition of vegetation by using NDVI. However, how to increase the precision of remote sensing retrieval and to process the mass image data timely still need further research.

6. References

[1] X. L. Chen, H. M. Zhao, L. Q. Tian. Remote sensing of environment: Models and applications. Wuhan University Press, 2008

[2] Y. P. Li, G. T. Ge, R. S. Na, P. T. Liu, Z. X. Zhao. The applied research on estimating the yield of forage in Inner Mongolia grasslands using MERSI Data. Journal of Arid Resources and Environment, Vol. 26, No. 9, 2012

[3] G. S. Huang, C. Z. Xia. MODIS-based estimation of forest biomass in northeast China. Forest Resources Management, No. 4 2005

[4] Elgene O. Box, Brent N. Holben, V Kalb. Accuracy of the AVHRR vegetation index as a predictor of biomass, Primary Productivity and Net CO_2 Flux. Vegetatio, Vol. 80, No. 2, 1989

[5] D. A. Walker, N. A. Auerbach, M. M. Shippert. NDVI, Biomass, and Landscape Evolution of Glaciated Terrain in Northern Alaska. Polar Record, Vol. 31, 1995

[6] Land resources notification. Land Resources Bureau of Suizhou, April, 2012

[7] China Center for Resources Satellite Data and Application(http://www.cresda.com/n16/n1130/n1582/8384.html), May 8^{th}, 2009

[8] Atmospheric correction of hyper-spectral imagery: Evaluation of the FLAASH algorithm with AVRIS data. X. Y. Song, J.H. Wang, L. Y. Liu, W. J. Hunag, C. J. Zhao. Remote Sensing Technology and Application, 2005, 20(4)：393-398

[9] Research System Inc. FLAASH user’s guide. ENVI FLAASH Version 1.0, 2001:8-40

[10] Atmospheric correction of MODIS and its application in cyanobacteria bloom monitoring in Lake Taihu. G. Y. Li, Z. Y. Zhang, Y. F. Zheng, X. M. Liu. Journal of Lake Sciences, 2008 20(2)

[11] Haze removal for high-resolution satellite data: A case study. Dal Moro, L Halounova. International Journal of Remote Sensing, 2007, 28: 2187-2205

[12] Atmospheric correction of Landsat ETM+ land surface imagery—PartⅠ: Method. S.L Liang, H. L. Fang, M. Z. Chen. Ieee Transactions on Geoscience and Remote Sensing, 2001, 39: 2490-2498

[13] Atmospheric correction of Landsat ETM+ land surface imagery—PartⅡ: Validation and applications. S.L Liang, H. L. Fang, M. Z. Chen. Ieee Transactions on Geoscience and Remote Sensing, 2002, 40: 2736-2746

[14] A fast, simple and versatile algorithm to fill the depressions of digital elevation models. O. Planchon, F. Darboux. Catena, 2002, 46:159-176

[15] An image transform to characterize and compensate for spatial variations in thin cloud contamination of Landsat images. Y. Zhang, B. Guindon, J. Cihlar. (2002). Remote Sensing of Environment, 82,173-187

[16] Analysis for monitoring vegetation coverage change of Wuhan based on remote sensing data of MODIS. J. Huang, Z. H. Xia. Meteorological and Environmental Sciences. May, 2009. Vol. 32, No. 2

[17] Spatial-temporal variation of growing-season NDVI and its responses to climate change over the source region of the Yellow River. H. J. Xu, T. B. Yang, B. Zeng. Ecology and Environmental Sciences, 2012, 21(7)

[18] Forestry drought self-help work conference memo. Forestry Bureau of Suizhou, August, 2012

[19] News report from http://news.cnhubei.com/xw/hb/sz/201209/t2211441.shtml. August, 2012