RS & GIS Based Analysis of Snow distribution & Change in Emin River Basin, Xinjiang, China*

LIU Zhihui [1,2,3,4] PEI Huan [1] FANG Shifeng[1] JIANG Hong[1] ZHENG Jianghua[1]
ZHAO Qiudong[1] LU Zhi[1] LI Min

[1] College of Resources and Environment Science, Xinjiang University, Urumqi, P.R.China; [2] Oasis Ecology Key laboratory of Xinjiang Uygur Autonomous region, Xinjiang University, P. R. China; [3] International Center for Desert Affairs-Research on Sustainable Development in Arid and Semi-arid Lands; [4] Xinjiang Key Subject of Ecology; 14 Shengli Road, Urumqi, Xinjiang, 830046, P.R.China. Tel. +86+991+8582378,Fax: +86+991+8585504, Email: lzh@xju.edu.cn

1. Introduction

Detecting of snow coverage change plays an important role in both flood/drought forecast in spring and the research on the relation between snow coverage change and the global climate change. This paper took the Emin River Basin as our typical study area, based on MODIS image, used RS and GIS software, analyzed the change of snow coverage per half-day between March 4th and March 12th in Emin River Basin, with the last method, and then set up the relationship between snow cover and the influent factors, the result is that, the fast rise of temperature was the primary cause of the vast snow melt.

2. Approaches

2.1 The introduction of Research Area

Emin river basin located in the westernmost of Xinjiang, the geography coordinate is E 82° 29' - 84° 45', N 45° 32'- 47° 14'. The main stream originated from Kmier Mountain, the altitude of mountain is not high, mostly are from 1000 to 2000m mid-lower mountain. The area of Emin river basin is 17137km^2,because of the mountain in the basin is not high; the type of runoff is rain off and snowmelt mixture.

2.2 The pretreatment of MODIS data

* Sponsored by the Project of National Scientific Foundation of China (70361001) and Project of Oasis Ecology Key laboratory of Xinjiang, Project of the innovation group for Oasis Ecology.

The used data are March 4th to 12th MODIS data, in order to draw snow, we must do the marking computation at first, namely transform the detecting number to physics quantity, we need the reflectance, the correction of the solar altitude angle of the data, and geometry correction, in order to do the analysis integrating the basic geography data. There are two named Latitude and longitude data attribute, which can be used to correct the image.

2.3 Eliminating cloud

In this paper 0.66μm (red wave band) reflectance is used, for making a cloud mask, and eliminating cloud. After the examination, taking 0.18 as threshold can get good result, then applying no cloud region snow parameter to snow cover region, using ARCGIS to interpolate information below cloud (Wang Jian,1988).

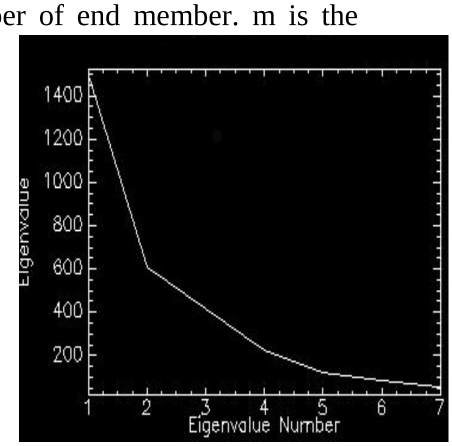
2.4 The extracting of snow information

2.4.1 unmixed pixel method

Linear spectrum mixed model is in common use in spectrum mix analysis because MODIS' s lower space resolution, mixed pixel proportion is high, it is defined as: the lightness of pixel is a linear combination, which is composed of the end member spectrum lightness of pixel and it's occupation of area proportion. It is expressed as formula

$$R_{i\lambda} = \sum_{k=1}^{N} f_{ki} C_{k\lambda} + \varepsilon_{i\lambda} \quad (1)$$

where $R_{i\lambda}$ is the spectrum reflectance of $\bar{i}$ pixel in λ band. $C_{k\lambda}$ is the spectrum reflectance of k end member in λ band. f_{ki} is area proportion of k end member in the pixel. $\varepsilon_{i\lambda}$ is the error of ī pixel in λ band. N is the number of end member. m is the number of band. N<m. Using the least twain multiplication to solve f_{ki} and making $\varepsilon_{i\lambda}$ the least, meanwhile, satisfying the two conditions below: the sum of area proportion f_{ki} up to 1 and every end member area proportion between [0, 1] (Cross M. 1991). The pivotal question of linear mixed model is to determine end member, the most successful method is pixel purity index (PPI).



2.4.2 Extracting of end member spectrum using PPI

Firstly lower data dimension using minimum noise fraction (MNF), MNF is similar to PC analysis, which is used to separate the noise of the data and determine the dimension, from the band energy change profile (figure1) we can descry: the energy change from band 1 to band 2 is the fastest, Fig1. The rotation of MNF

band 2 to band 3 taking the second place, the energy value of last several band is low and the noise is rather more. Then creating a great deal of stochastic testing vectors crossing through data aggregation inner in succession, then projecting spectrum spot to every testing vector separately, the result of projecting is choosing extreme in this direction by a certain limit, along with constant change of vector direction, recording the number of each pixel of extreme, finally considering the maximal frequency point is the purity point (Keshava N, Mustard J E. 2002). After the PPI operation of the image, analyzing the end member scatter point plot (figure 2), and comparing to ground cover type map, finding there are five end members in the research area. Extracting the spectral eigenvalue of end member (figure 3), the blue curve in figure 3 is the snow spectral eigenvalue.

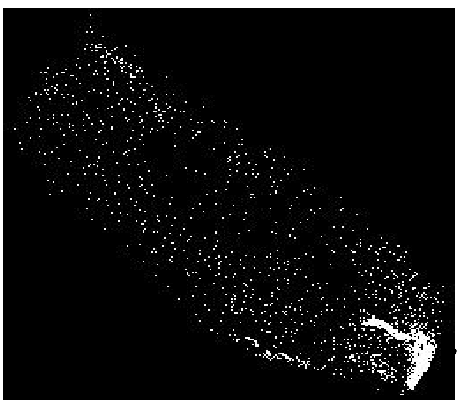


Fig. 2 the end member scatter plots from PPI

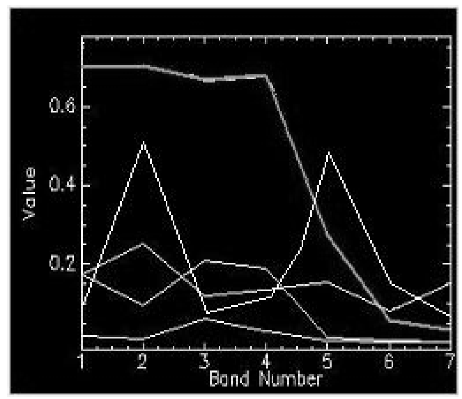


Fig.3 Spectral eigenvalue of land object in study area

2.4.3 Extracting and calculation of snow cover

The results of extracting snow information of MODIS data using linear spectrum mixed model is showed in figure 4, the digital number of each pixel shows the snow area proportion in this pixel. Using statistic function of ENVI can calculate the whole snow cover in research area. Compared the results of snow cover by way of linear spectrum mixed model with NDSI, the two methods demonstrate quite consistent results.

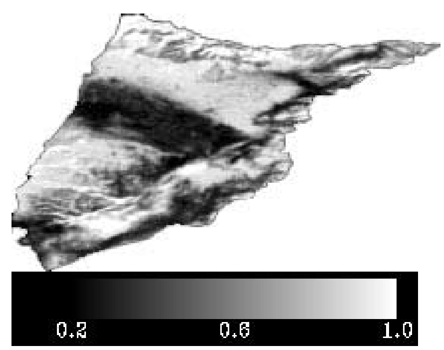


Fig.4 Snow cover of Emin River

2.5 Extracting snow cover according to elevation scope

Because of the difference of terrain and ground condition, the snow distribution in different elevation scope has the great discrepancy (Xu, H, Bailey, J, O, Barrett, E. C. et al, 1993). Extracting snow cover according to elevation scope by DEM of the catchment is the main purpose of snow cover mapping, and it is an important input parameter in simulation of snowmelt flow. In order to get the results, on the basis of remote sensing image analysis, making use of GIS space analysis, the area of snow cover in each elevation scope was extracted.

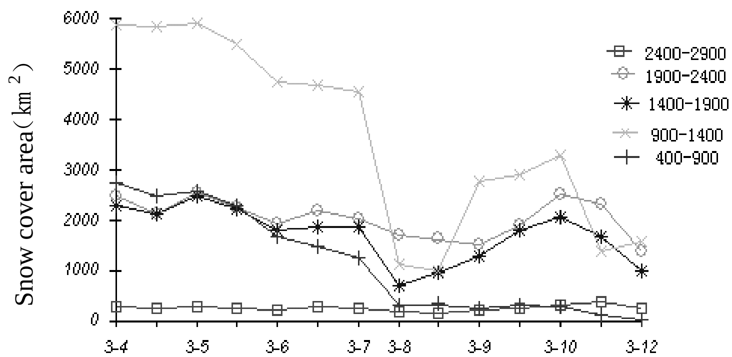


Fig .5 Snow cover depletion curve in Emin river basin

3. The Relation Between Snow cover Change And influcent Factors

In the practical research, many factors have influence on snow cover change as variable *Y*, and these factors include: average day temperature, precipitation, wind speed, dew point temperature, average sea level pressure and the fastest wind speed. Because of the limit of Emin river basin climate data, we use the stepwise regression method, only build the regression model of daily snow cover change and factors on elevation 400 - 900m. (Formula 2)

$$Y = -5111.93 + 122.47X_1 + 622.2X_2 + 30.29X_3 \quad (2)$$

Where Y is the quantity of snow area change, X_1 is the day average temperature, X_2 is the gross precipitation quantity and X_3 is the dew point temperature. $R=0.9$, $F=518.7$, pass the test of $p=0.0001$.

From Formula 2, we can see that the quantity of snow area change has the great relativity to the daily average temperature, the gross precipitation quantity and the dew point temperature, and present positive correlativity. This shows that the higher the temperature is, the faster the snow melting, this point cannot be doubly, and the precipitation fall on the snow will accelerate the snow melting.

4. Conclusion

1. This paper makes use of linear mixed spectral model and integrates MODIS data to extract snow information, resolving the problem of mixed pixel, improving the snow monitoring precision.
2. The results of extracting snow cover according to elevation scope show that the snow change in each elevation scope has the great difference, the change of snow cover in elevation scope of 900 - 1400m is the most drastic, this is determined by the character of ground condition, solar radiation, grade and slope.
3. The regression model of snow cover change and factors shows that snowmelt has the most relativity to temperature and precipitation; the hoist of temperature is the main reason of snow melting.

References

Wang Jian, 1988, *Snow cover distribution in the Heihe River in the Qilian Mt*. [A], Proceedings of Lanzhou Institute of Glaciology and Geoeryology, CAS[C], pp. 55-63.

Cross M. 1991, "Sub-pixel measurement of tropical cover using AVHRR data" [J], *International Journal of Remote Sensing,* 12(5), pp. 11-19.

Keshava N, Mustard J E. 2002, *Spectral Unmixing* (J). IEEE Signal Processing Magazine, 1, pp. 44 - 57.

Xu, H, Bailey, J, O, Barrett, E. C. et al, 1993, "Monitoring snow area and depth with integration of remote sensing and GIS" [J], *International Journal of Remote Sensing,* 14 (17), pp. 3259-3268.

Biography

First author: Professor LIU Zhihui, Male，born on July, 2, 1957, dean of College of Resources and Environment Science, Xinjiang University, Urumqi, P.R.China, vice-director of Oasis Ecology Key laboratory of Xinjiang Uygur Autonomous region, P. R. China. Interests: Hydrology, Water Resources, Environment Protection, Geographical Information System, Decision Support System, Sustainable Development.