NOAA/AVHRR DATA AND VEGETATION ZONALITY OF THE LOESS PLATEAU

Zhou Yingchun, Wang Naibin
Commission for Integrated Survey of Natural Resources,
Chinese Academy of Sciences, Beijing 100101, P.R.China
ISPRS Commission VII

Abstract: The Main Sediment-Producing Area of the Loess Plateau in the north of China has serious soil erosion problem. Vegetative cover plays an important role in controlling environmental deterioration of this area. This paper takes NOAA/AVHRR digital images as a main information source, completes geometrical registration and solor elevation correction, then calculates vegetation index of the study area in order to find zonal differentiation of vegetation in this area. Normalized vegetation index (NVI) suitable for vegetative biomass research in areas with sparse vegetation is employed to describe the vegetation status of the study area. According to calculated NVI, a color vegetation level map is generated. On this map, vegetation coverage is increased from northwest to southeast. The curved zonal pattern of vegetal cover distribution is clearly showed. This rule conforms to the results come from normal survey. The results come from two different methods verify their reliability. Comparing NVI map with several maps of natural factors, we find that NVI distribution and distribution of precipitation from July to September of this area have strong correlation which is more obvious than correlation of the NVI distribution pattern to that of other natural factors such as temperature factors and other rainfall factors. It could be concluded that precipitation from July to September is the most important factor influencing vegetation development in the study area.

Key Words: Remote Sensing, Vegetation, Zonality, NOAA/AVHRR, Vegetation Index

INTRODUCTION

Spatial remote sensing information sources such as Landsats, meteorological satellites improve the accuracy, objectivity and speed in natural resource survey and environment monitoring. Due to the short coverage cycle, wide coverage area and strong synchronous character of meteorological satellites, they have remarkable advantages in dynamic monitoring and research on macroscopic rules. This paper takes NOAA/AVHRR digital data as main information sources, completes geometrical correction and solar elevation correction, then calculates the vegetation index of the study area in order to find the vegetation zonality of the Main Sediment-Producing Area of the Loess Plateau, a narrow area along the canyon of the Yellow River.

This area has the most serious soil erosion problem. It's an area with deep loess layer, densly scattered gullies and sparse vegetation coverage. Rainfall is few but most fall in the summer in the form of rainstorms. Vegetation is an important factor in controlling soil erosion and improving the environment.

NOAA/AVHRR AND VEGETATION INDEX

The meteorological satellite ground station in Beijing receives information sent out by NOAA-9 and NOAA-10 satellites every day and provides AVHRR digital data or imagery to users. NOAA series are the third generation of meteorological satellites. They travel on near polar orbits and their scanning angle is about 55.4 degree covering a ground area of 2700 KM wide. Users can select data in suitable scanning angle according their special requirements. Scan lines of Advanced Very High Resolution Radiometers (AVHRR) on NOAA consist of 2048 pixels. An image of 512 by 512 pixels covers an area of 563Km by 563Km. Using AVHRR data in the circumstance not requiring high accuracy will reduce the amount of data greatly. Although meteorological satellite are mainly designed to serve the field of meteorological research, the channel 1 and channel 2 of NOAA/AVHRR have similar wave length with Landsat at channel 5 and channel 7. These channels are frequently used for ground object research. Comparison between the synchronous and near synchronous information acquired by AVHRR and Landsat MSS in three different areas shows that the two systems have good data correlation. Correlation coefficient of AVHRR CH1 to MSS5 and AVHRR CH2 to MSS7 are about 70%. Large pixels in AVHRR image do not smooth the most important change of the earth's surface. This conclusion shows that it is suitable to substitute MSS data by AVHRR data in macroscopic analysis of large area.

Vegetation biomass calculated from AVHRR data has been widely used in the field of agriculture and forestry such as vegetation growing status monitoring and crop yield forcasting.

There are several methods to calculate vegetation indices which have different usages. The ratio vegetation index is the ratio of data in near infrared band and visible light band. RVI is sensitive to dense vegetal cover and is suitable for research in areas with rich vegetation. When vegetation coverage is less than 50%, RVI cannot recognize the difference in vegetation density. Environmental vegetation index (EVI) rises greatly when vegetation biomass increases in areas which have vegetation coverage of 15%-25%. Normalization vegetation index (NVI) is defined as (IR-R)/(IR+R). NVI in areas with vegetation coverage of 15% or less is higher than NVI of exposed soil. When the vegetation coverage increases from 25%-80%, NVI rises linearly. When vegetation coverage is higher than 80%, NVI is not sensitive to vegetation density change. Therefore NVI is suitable for vegetation biomass research in the early period of vegetation development and in areas with sparse vegetation. It's feasible to use NVI to do vegetation coverage research in the Loess Plateau.

CALCULATION OF VEGETATION INDEX

Geometric Correction

Digital image received on July 11,1988 was employed in this study. As a small part of this image is covered by fog, another image which is acquired in July and is perfect in this small part is selected to replace the foggy area after mosaicing. In order to correct image distortion and complete geometrical registration, geometric correction of the original image in necessary. Polynomial correction of both images is completed in VAX-11/785 computer system.

Solar Elevation Correction

An AVHRR image of 512 by 512 pixels represents a large ground area. The different solar elevations of pixels have different influences on their luminance. This influence would hinder accurate visual interpretation and digital analysis. The purpose to correct solar elevation is to regulate pixels' luminance in order that every pixel's luminance is related to the same intensity of solar illumination. This process will eliminate the error produced by the difference in intensity of illumination. We use the normal correction method here.

To reduce amount of calculation, grids of 15' by 15' in latitude and longitude are divided and pixels in each grid use the same solar elevation angle when solar elevation correction is processed. After this process, pixels in each image gain their luminance when the sun lights irradiate perpendicularly.

NVI Calculation

The model calculating NVI is:

$$NVI = \frac{CH2-CH1}{CH2+CH1}$$

After calculating, each image becomes a single band image of normalization vegetation index. Each pixel in this image represents the level of vegetation coverage of the ground area it corresponding.

According to the statistics of NVI, most pixels have indices between 36 and 52 except the foggy area. If one pixel is covered by fog, its NVI is less than 36. After mosaicing it will be replaced NVI in the auxiliary image. The pixel's NVI is divided into ten levels.

SPATIAL DISTRIBUTION OF VEGETATION COVERAGE

In order to analyse correlation of NVI to other natural environmental factors in this area,the NVI image is inputted into ARC/INFO system to generate a color map and each level is given a shade pattern. A background coverage overlays this map to make it easy to be explained.

On the color map of NVI level, different shade patterns represent different vegetation zones. though each level does not represent absolute biomass, their relative difference is enough to show the zonal distribution rule of vegetation. From northwest to southeast, vegetation coverage is increased. The curved zonal distribution pattern of vegetation coverage is clearly showed on the map. This rule conforms to the natural rule of the study area acquired by normal survey. The results come from two different methods verify their reliablity each other.

We can delineate the vegetation status according to NVI color map and reference materials. Northwest of a line connected by Zhungeer, Shenmu, Yulin, and Jingbian counties is semi-desert and steppe vegetation. Only few sand-born herbs grow in this zone. The next zone in the southeast of this line is the grassland zone which is dominated by herbs and shrubs. It is the zone that has the most serious erosion activity in the Loess Plateau. The third zone is the forest steppe. Secondary forests remain in few gully areas. Deciduous broad-leaved forests distribute in loess gully and shrubs distribute in hilly slope. The southest zone lies in the southeast of Hancheng and Hejin county, is deciduous broad-leaved forest zone. Natural vegetations remain well in this zone.

Comparing the NVI map with several maps of natural factors, we find that NVI distribution and the distribution of precipitation from July to September of this area have strong correlation which is more obvious than correlations of the NVI distribution pattern to other natural factors such as temperature factors and other rainfall factors.

We create a regionalization model based on the NVI map and maps of other geographical factors which are climatic component, loess thickness, gully density and erosive modulus and divide the study area into six subareas with different natural conditions. In this process, NVI is used to quantify vegetation.

CONCLUSIONS

NOAA/AVHRR images have coarser resolution than Landsat images, but they have advantages in macroscopic physical geographic environment research.

Introducing remote sensing technology to the field analysing physical geographical rule will bring in quantitative, timely, accurate, and objective results quickly and conveniently.

In quantitative geography, it is difficult to quantify vegetation factors. Using vegetation index is a way to solve this problem.

+References from Journals:
Differences in Vegetation Indices for Simulated Landsat-5 MSS and TM, NOAA-9 AVHRR and Spot-1 Sensor Systems. Remote Sensing of Environment. 1987.

+References from books:
He Jianbang,1990. Research on Loess Plateau Information System, National Lab. of Resources and Environment Information System, Beijing.

Guo Defang, 1984. Computer Processing and Pattern Recognition of remote sensing image.

Huang Qian, 1985. Dynamic Information of vegetation seasonal pattern on NOAA/AVNRR Images.