Remote Sensing Monitoring of Vegetation Coverage of Hunshandake Sand Based on HJ-1A

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Abstract. Hunshandake Sand has sparse vegetation and serious desertification, which is one of the main reasons for the dust weather in the Beijing-Tianjin-Hebei region. Dynamic monitoring of vegetation coverage in this area is of great significance for predicting sand and dust weather in the Beijing-Tianjin-Hebei region. Remote sensing technology has the advantages of large area, multiple time phases, and high accuracy. This study is based on the CCD data of the HJ-1A, using NDVI parameters as the main input parameters, and using an improved pixel binary model to invert the vegetation coverage of the study area. On this basis, the land use type data is used to extract another vegetation coverage of the study area during the period. The vegetation coverage in different periods of the study area is calculated by band to achieve the purpose of dynamic monitoring. The results show that desertification is common in the northwest of the study area, and the vegetation coverage is becoming lower and lower, while the vegetation coverage in the northeast and south is increasing, and the overall vegetation coverage in the study area is increasing. The experimental results are more consistent with the actual situation, which confirms that the improved pixel binary model has higher accuracy and a certain degree of universality, and the overall desertification control effect of the Hunshandake Sand is better.

1. Introduction
Vegetation coverage is one of the parameters describing the quality of the ecosystem, which is of great significance for desertification control and forestry management. By monitoring the dynamic changes of vegetation coverage, information such as the vegetation change status and the degree of desertification in the target area can be obtained in time, providing a basis for establishing a more completed and targeted ecological environment management plan. The traditional vegetation coverage estimation method relies on the measured sample to make the estimation, which consumes manpower and material resources, and the measurement effect is poor. Remote sensing technology can dynamically monitor the target area on a large scale, providing a fast, effective, and low-cost monitoring method for monitoring the vegetation status [1].

The Hunshandake Sand is one of the top ten desert sandy lands in China, and one of the four sandy lands in the central and eastern parts of Inner Mongolia. It is an important part of the eastern marginal area of the desertification land of Asian grasslands. Many researchers have done a series of studies on
the degree of desertification of the Hunshandake Sand, the loss of water bodies, and the quality of the ecological environment. YUAN [2] integrated MODIS NDVI data, temperature, precipitation and other meteorological data from 2000 to 2014 to analyze the vegetation coverage changes and influencing factors of the Hunshandake Sand. Liu [3] studied the desertification of the Hunshandake Sand based on TM/ETM+ image data, gave the desertification rate and pointed out that the sandstorm source control project launched in 2000 effectively alleviated the deterioration of local desertification. Husitule [4] used TM images to study the land use type changes in the Hunshandake sandy area from 1990 to 2000 based on the GIS platform, and pointed out that the grassland degradation rate was rapid, which led to the continuous decline of sandy ecological environment management. It can be seen that there are many studies on the ecological conditions of the Hunshandake Sand, and certain effects have been achieved in the ecological management of the area.

This paper uses HJ-1A CCD data to inversion the vegetation coverage in the central area of the Hunshandake Sandy through the improved pixel binary model, and compare it with the vegetation coverage obtained by using land use classification maps, in the end, the study found changes in vegetation coverage from 2006 to 2009. The results are consistent with the desertification process and vegetation cover changes in the study area. Generally, the experimental results are more consistent with the actual situation, and provide a certain reference value for the formulation of ecological management decisions in this area.

2. Research area and data source

2.1 Study area

The Hunshandake Sand is located between 114°55′~116°38′ east longitude and 41°46′~43°07′ north latitude. It is located at the southern end of the Xilin Gol Grassland in central Inner Mongolia. In parts of the southeastern part of the Sundak Sandy Land (Figure 1b), the land types in this area are diverse, with sand and vegetation in the north and south respectively. The Hunshandake Sand is 180 km away from Beijing in a straight line. It is the nearest sand source to Beijing. The Hunshandake Sand has sparse vegetation and bare ground, and sand and dust weather were prone to be formed in windy weather. In recent years, the sand and dust weather that has occurred frequently in the Beijing-Tianjin-Hebei region in spring is related to the deterioration of the ecological environment in Hunshandake Sand. Since the beginning of the 20th century, people have gradually increased the research on the desertification of the Hunshandake Sand. The number of research papers during this period is shown in Figure 2.

Severe vegetation degradation and desertification in the Hunshandake Sand will pose a great threat of wind and sand in the Beijing-Tianjin-Hebei region. The distribution of sand and dust days in Beijing is shown in Figure 3. The sand and dust situation were relatively serious before the 20th century. After the 20th century, the situation has greatly improved. Among them, the number of blowing sand days in 2009 was one of the lowest years in Beijing in the past 60 years. Therefore, the HJ-1A data in 2009 and the land use classification data in 2006 were selected to monitor the vegetation coverage change of the Hunshandake Sand.
2.2 Remote sensing images
The Environment One satellite system is an earth observation system specially used for environmental and disaster monitoring. It is mainly composed of two optical satellites (HJ-1A, HJ-1B) and one radar satellite (HJ-1C), with optical, infrared, Hyperspectral multiple detection methods, with large-scale, all-weather, all-weather, dynamic environmental and disaster monitoring capabilities. The data used in this study is the CCD data of HJ-1A. This research selects the HJ-1A CCD2 data of August 11, 2009 with higher impression quality, and the band parameters are shown in the table 1.

Table 1 Introduction of HJ-1A remote sensing image data bands

| Satellite Data | Band | spectral region (μm) | Band selection principle |
|---------------|------|----------------------|--------------------------|
| HJ-1A CCD     | 1    | 0.43–0.52            | According to the spectral range of the HJ-1A CCD data band3 and Band,4 are selected as R and NIR in the NDVI formula. |
|               | 2    | 0.52–0.60            |                          |
|               | 3    | 0.63–0.69            |                          |
|               | 4    | 0.76–0.95            |                          |

3. Introduction to research methods and experimental flowchart

3.1 Experimental flowchart
According to the characteristics of environmental small satellite CCD data and the requirements of grassland vegetation change monitoring, the research process is as follows: first perform data preprocessing on the data, which mainly includes data reading, radiation calibration, geometric correction, atmospheric correction, and research area cutting. After preprocessing, an inversion model
was established to invert the NDVI and vegetation coverage in the Hunshandake area. Finally, according to the vegetation coverage data in different periods, remote sensing monitoring of grassland land degradation is realized.

### 3.2 Vegetation coverage inversion

Constructing different vegetation indices from different bands of remote sensing images and then inverting vegetation growth is the main way of remote sensing inversion of vegetation coverage. NDVI (Normalized Difference Vegetation Index) is the most commonly used Vegetation Index at home and abroad to represent the change of Vegetation coverage. Its expression is shown in Formula (1), specifically meaning the Difference between the reflection value of near-infrared band (NIR) and the reflection value of red band (R) than the sum of the two. Taking NDVI value as the main input parameter, Li et al. [5] improved the pixel dichotomy model. The improved model obtained has high accuracy and good universality, and has been widely used in China at present. The expression of this model is shown in Formula (2). In this study, the model was used to estimate the vegetation coverage in the study area.

\[
\text{NDVI} = \frac{(\text{NIR} \times R)}{(\text{NIR} + R)}
\]

\[
\text{FC} = \frac{(\text{NDVI} - \text{NDVI}_{\text{soil}})}{(\text{NDVI}_{\text{veg}} - \text{NDVI}_{\text{soil}})}
\]

In the formula, FC is the vegetation coverage, and \(\text{NDVI}_{\text{soil}}\) is the NDVI value of the area which is completely bare soil or without vegetation coverage. \(\text{NDVI}_{\text{veg}}\) is the NDVI value of the pixel which is completely covered by vegetation.

### 3.3 Monitoring of vegetation coverage changes

The change monitoring of vegetation coverage requires the comparison of two phases of data. This study uses HJ-1A remote sensing image data to retrieve the vegetation coverage in 2009, and the vegetation coverage in 2006 is based on land use classification data.

Select the land use classification map in August 2006, the DN values of various land types in the image are different. Vegetation coverage usually refers to the ratio of forest area to the total land area, but when calculating forest coverage, forest area generally also includes the area of shrubs, the area of farmland forest nets, and the area of surrounding trees. Therefore, the vegetation coverage area is defined as cultivated land, woodland, grassland, and the vegetation coverage are extracted according to the DN value of the image. Then, the vegetation coverage of the two periods will be monitored through the band calculation tool.

### 4. Analysis of research results

Based on ENVI5.3 remote sensing image processing software, according to the research process in the previous article, the vegetation coverage of the Hunshandake Sand was obtained in two phases, and the vegetation coverage changes during the period from 2009 to 2006 were extracted through the band calculation tool. Superimposed display, the obtained research thematic map is shown in Figure 4.

According to the thematic map, the desertification in the northwest of the study area is more serious, and the vegetation coverage change in the southwest is less, or the original land type is bare land. The overall vegetation coverage increased gradually from west to east, and the increase of vegetation coverage was more obvious in the southwest, which was consistent with the visual interpretation results and the actual situation. The southwest region serves as a barrier to reduce the sandstorm weather in the Beijing-Tianjin-Hebei region to some extent. It’s shows that the desertification control work in the study area has achieved results.
5. Conclusion

By comparing the two methods to obtain vegetation coverage, it can be seen that the method of using remote sensing image data to carry out model-based inversion has a higher accuracy, but the preprocessing is complicated, and there are certain requirements for the accuracy of the model.

Through this study, it can be seen that remote sensing technology can meet the demand of large-scale dynamic monitoring to some extent at present, but there are also some problems, such as missing part of time series image, complex comprehensive analysis process of long time series.

With the development of earth observation technology and the maturity of data storage technology, the remote sensing industry has stepped into the era of big data, and the remote sensing industry has accumulated a huge amount of high-quality remote sensing data[6]. In the future, the combination of remote sensing and artificial intelligence can be considered to detect the change of vegetation coverage in a longer time series and provide support for making decisions on desertification control and ecological protection.

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