Postprint: Extraction of Crop Planting Structure in Agricultural Areas of the Kaidu-Kongque River Basin, Xinjiang Based on Remote Sensing Data

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Abstract

Crop planting structure is a crucial component of the spatial pattern of crops and serves as the foundation for optimal allocation of regional land and water resources. Taking the agricultural area of the Xinjiang Kaikong River basin as the study region, this study integrated crop phenological information and 2016 MODIS NDVI time-series curves to identify critical periods with distinct growth differences among different crops, selected Landsat 8 OLI imagery from these critical periods, constructed knowledge rules for extracting major crops, and performed crop classification and identification based on the decision tree method. In 2016, the total planted area of major crops in the Kaikong River agricultural area was 5.07×105 hm2, with cotton having the largest planted area of 1.97×105 hm2, followed by corn and wheat. The Bosten Lake and Kaidu River agricultural areas primarily cultivated pepper, corn, and wheat, with a relatively fragmented planting structure; the Kongque River agricultural area had a relatively homogeneous planting structure, dominated by cotton and fragrant pear. Comparison with results from crop classification and identification using only time-series MODIS data demonstrated that the integrated use of MODIS and Landsat data significantly improved crop identification accuracy, with overall classification accuracy increasing from 62.58% to 88.37% and the kappa coefficient increasing from 0.53 to 0.86. This method comprehensively leverages the temporal characteristics of MODIS data and the high spatial resolution of Landsat data, effectively avoiding the poor classification accuracy resulting from insufficient spatial resolution of MODIS data while also circumventing the blind selection of temporal phases or data redundancy caused by insufficient temporal resolution of Landsat data, thereby demonstrating certain application value in extracting agricultural planting structures in arid regions.

Full Text

Extraction of Crop Planting Structure Based on Remote Sensing Data in the Kai-Kong River Basin, Xinjiang

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Abstract: Crop planting structure plays an important role in crop spatial patterns and serves as the foundation for optimal allocation of regional land and water resources. This paper proposes a method for crop classification that comprehensively utilizes high temporal resolution MODIS images and high spatial resolution Landsat images. Due to the large scope of the study area, it is difficult to obtain crop sample points uniformly throughout the whole research area under traffic and time constraints. MODIS and Landsat data for 2016, combined with crop phenology data, were used to construct experimental sample points, thereby providing a better solution for crop extraction in this area where sample access is difficult. NDVI time-series curves for different crops were constructed based on experimental sample points. The critical periods of crops during the growing season were obtained from these NDVI time-series curves. For these key periods, Landsat 8 OLI images were selected. Next, extraction knowledge rules for the main crops were constructed, and identification and classification of crops were performed based on decision tree. In 2016, the main crop planting area was 5.07×10 hm^2 of the Kai-Kong River Basin agricultural region, with the largest planting area found for cotton (1.97×10 hm^2), followed by those for corn and wheat. The Bosten Lake and Kaidu River agricultural area was dominated by pepper, corn, and wheat, and the planting structure was relatively scattered. The planting structure of the Peacock River agricultural area was relatively simple, with cotton and pear as main crops. A comparative experiment based on time-series MODIS images for crop recognition and classification was also conducted. Results were verified and compared with sample points of field survey. The accuracy of crop classification using MODIS and Landsat data was obviously improved as compared with the accuracy of crop classification using only time-series MODIS data. Overall classification accuracy increased from 62.58% to 88.37%, and kappa coefficient increased from 0.53 to 0.86. The use of high temporal resolution MODIS data and high spatial resolution Landsat data can improve the accuracy of crop extraction to a certain extent; this avoided (1) poor classification accuracy caused by the insufficient spatial resolution of MODIS data and (2) phase selection blindness or data redundancy caused by the insufficient temporal resolution of Landsat data. Therefore, this approach has high potential application value in the extraction of crop planting structure

in arid areas.

Keywords: crop; planting structure; MODIS; Landsat 8 OLI; multi-source data integration; Kai-Kong River Basin

1 Study Area and Data

1.1 Study Area

The Kai-Kong River Basin agricultural area is located in Xinjiang, with geographical coordinates of 82°56 -88°12 E, 40°48 -43°20 N (Fig. 1). The region has an arid climate with annual precipitation of 20–40 mm and average annual temperature of 3–10°C. The main crops include cotton, corn, wheat, pepper, and pear. Based on differences in planting structure and geographical location, the study area is divided into three sub-regions: the Bosten Lake and Kaidu River agricultural area, the Peacock River agricultural area, and the Kaidu River upstream agricultural area.

1.2 Data Sources

The primary data sources include Landsat 8 OLI imagery and MODIS products. Landsat 8 OLI data have a spatial resolution of 30 m and were obtained from the Geospatial Data Cloud (http://www.gscloud.cn/), covering seven scenes from April to September 2016. MODIS data include MOD13Q1 (250 m resolution, 16-day interval) and MOD09A1 (500 m resolution, 8-day interval) products, acquired from NASA's LAADS Web (https://ladsweb.nascom.nasa.gov/search). Google Earth high-resolution imagery was used for validation purposes.

Main crop phenological data for the Kai-Kong River Basin are shown in Table 2. Field survey data were collected in July 2018, including GPS coordinates of sample points and crop types, which were used for accuracy assessment.

Fig. 1 Location of study area and spatial distribution of sample points

Table 2 Main crop phenology of the Kai-Kong River Basin

2 Methods

2.2 NDVI Time Series Construction

NDVI time series were constructed from MODIS data using the Savitzky-Golay filter to remove noise. Sample points were selected through a stratified sampling approach based on crop phenology and spectral characteristics. A total of 394 candidate sample points were initially selected from Google Earth imagery, including 43 cotton points, 61 corn points, 52 wheat points, 68 pepper points, 71 pear points, and 99 other land cover points. These points were further refined using Landsat 8 imagery to ensure purity, resulting in 149 final sample points for classification.

Fig. 2 Candidate sample point selection method

Annual variation curves of NDVI for different crops show distinct phenological patterns (Fig. 3). Cotton exhibits a typical single-peak curve, while corn and wheat show different peak timings. Pepper and pear have unique NDVI signatures that distinguish them from other crops. These characteristic curves form the basis for constructing crop extraction rules.

Fig. 3 Annual variation curve of NDVI covered by different crops and confusing surface

2.3.1 MNDWI Water Index

The Modified Normalized Difference Water Index (MNDWI) was used to mask water bodies. The MNDWI is calculated as:

$$\text{MNDWI} = \frac{\text{Green} - \text{MIR}}{\text{Green} + \text{MIR}}$$

where Green is the green band and MIR is the mid-infrared band. Water bodies were identified using a threshold of MNDWI > 0, which effectively separated water from other land cover types.

3 Results

The classification results for 2016 show that the total crop planting area in the Kai-Kong River Basin agricultural region was 5.07×10 hm². Cotton was the dominant crop with 1.97×10 hm², accounting for 38.9% of the total crop area. Corn and wheat were the second and third most extensive crops, respectively. The Bosten Lake and Kaidu River agricultural area showed a diversified planting structure with pepper, corn, and wheat as major crops. In contrast, the Peacock River agricultural area had a simpler structure dominated by cotton and pear.

Classification accuracy assessment using field survey samples showed significant improvement when integrating MODIS and Landsat data compared to using MODIS data alone. The overall accuracy increased from 62.58% to 88.37%, and the kappa coefficient improved from 0.53 to 0.86. This demonstrates that the multi-source data integration approach effectively leverages the high temporal resolution of MODIS data for phenological characterization and the high spatial resolution of Landsat data for precise boundary delineation.

References

[1] Hu Qiong, Wu Wenbin, Song Xi, et al. Recent progresses in research of crop patterns mapping by using remote sensing[J]. Scientia Agricultura Sinica, 2015, 48(10): 1900–1914.

[2] Guo Yushan, Liu Qingsheng, Liu Gaohuan, et al. Extraction of main crops in Yellow River Delta based on MODIS NDVI time series[J]. Journal of Natural Resources, 2017, 32(10): 1808–1818.

[3] Liu Jikai, Zhong Shiquan, Liang Wenhai. Extraction of crop planting structure based on multi-temporal Landsat 8 OLI image[J]. Remote Sensing Technology and Application, 2015, 30(4): 775-783.

[4] Yang Xiongwei, Chen Chunhua. Paddy fields area extraction based on landsat data with integrating temporal features[J]. Geospatial Information, 2018, 16(6): 87-89.

[5] Hu Qiong. Research on Crop Remote Sensing Recognition Method Based on Time-series MODIS Image[D]. Beijing: Chinese Academy of Agricultural Sciences, 2018.

[6] Li Ainong, Song Mengqiang, Ma Liqun. Reconstruction of NDVI time-series datasets of MODIS based on Savitzky-Golay filter[J]. Journal of Remote Sensing, 2010, 14(4): 725-741.

[7] Xu Hanqiu. A study on information extracting of water body with the modified normalized difference water index (MNDWI)[J]. Journal of Remote Sensing, 2005, 9(5): 589-595.

[8] Fu Sitao, Zhou Yun. Research on normalized vegetation index algorithm based on remote sensing image[J]. Jiangxi Cehui, 2010(3): 17-33.

[9] McFeeters SK. The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features[J]. International Journal of Remote Sensing, 1996, 17(7): 1425-1432.

[10] Chen Jin, Zhu Xiaoliang. Research on water body extraction using remote sensing image[J]. Journal of Remote Sensing, 2010, 14(3): 547-559.

Note: Figure translations are in progress. See original paper for figures.