Spatial Distribution of Rice Planting Based on Data Fusion Model in Southern China

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Abstract. Acquiring the real and accurate spatial distribution of rice planting in the agricultural area of the basin is the precondition of implementing precision agricultural management, and the basis of building the database of agricultural non-point source pollution risk control and management. In order to overcome the characteristics of scattered rice distribution in southern China, such as small planting area, and instantaneous and periodicity of satellite sensor imaging, ESTARFM model was used to fuse NDVI data of MODIS09A1 and Landsat 8. The NDVI image data with both high spatial resolution and high temporal resolution were obtained after fused. The conditions and thresholds of decision tree classification method were determined with the help of curve feature information of NDVI indices of various crops in the growing period. The main results as follows: The spatial distribution of paddy ecosystem was extracted by multi-source data fusion and decision tree classification to meet the accuracy verification requirements; three cropping patterns, early rice, middle-season rice and late rice were extracted.

1. Introduction

Acquiring the real and accurate spatial distribution of rice planting in the agricultural area of the basin was the basis for building the database of agricultural non-point source pollution risk control and management [1]. Agricultural remote sensing technology has gradually become one of the important means to obtain precise information. However, limited by the scattered distribution of rice and the small planting area, the instantaneous and periodic characteristics of satellite sensor imaging make it difficult to obtain low-cost and high-precision remote sensing image data [2]. Spatio-temporal fusion technology can solve the problem that single data source can’t meet the need of high spatial and temporal accuracy data [3], and provide remote sensing data with high temporal and spatial resolution at the same time [4]. After comparing and evaluating the main spatial-temporal fusion algorithms [5], ESTARFM model was used to fuse the NDVI data of MODIS09A1 and Landsat 8 with the weighted summation method of similar terrestrial spectrum [6]. The results showed that the rice growth cycle of the study area in 2017 had both high spatial resolution and high temporal resolution. Finally, the spatial distribution of rice planting types in the study area was extracted.

2. Research Area, Data Sources and Research Methods

2.1. Research Areas
Jinjiang river basin is locate in Quanzhou city, Fujian province, 117°44′-118°47′E, 24°31′-25°32′N. It
originates in the southern foot of the eastern Daiyun Mountains. Rice is the main food crop in the study area, and the area proportion of early rice, middle rice and late rice was 13:28:33 (figure 1).

![NDVI curves under different patterns.](image)

**Figure 1.** NDVI curves under different patterns.

2.2. Data Sources
In this paper the surface reflectance synthetic product data MOD09A1 of MODIS, a medium-resolution imaging spectrometer was selected. It covered a period of 8 days from January 1 to December 31, 2017. There were 46 remote sensing images covering row and column numbers of h28v06. The original image was pre-processed by cloud removal, mosaic, projection conversion and band extraction, and then the data were cut in batches by using MRT preprocessing toolkit. Considering the factors such as data quality and data expression richness, Landsat 8 images covering row numbers 119042, 119043, 120042 and 120043 were selected, which included 4 issues on June 26th, August 15th, September 13th and October 2nd. The original remote sensing images were pre-processed by cloud removal, radiation calibration, atmospheric correction, stitching and cutting.

2.3. Research Methods

2.3.1. ESTARFM Model. The data fusion of remote sensing image is based on the algorithm which combines the data with spatial resolution advantage and the data with temporal resolution advantage [7]. The remote sensing image data with both high spatial resolution and high temporal resolution can be obtained by using the space-time fusion technology of remote sensing image. The method of remote sensing image fusion selected in this paper was ESTARFM optimized by Zhu [8] et al. based on STARM model. This method is mainly based on spectral neighborhood similarity criterion. It combines MODIS data with Landsat 8 image reflectivity of high spatial resolution in the form of weighted summation, and generates image with high spatial and temporal resolution simultaneously. The method divides the pixels into pure pixels with single land use type and mixed pixels with multiple land use types.

2.3.2. Decision Tree Classification. Decision tree classification method has the characteristics of intuition and robustness. In this paper, the decision tree classification method was used to judge the nodes of the phenological curve information of rice growth. The key of decision tree application is to determine the conditions and thresholds. Firstly, referring to the relevant literature, the information of rice planting was obtained and converted into NDVI information. Secondly, using the difference of planting time between the three kinds of rice planting pattern, the decision tree judgment conditions were obtained, such as the peak period of NDVI in early rice planting was greater than other time. Finally, the spatial distribution of target terrain was obtained by using statistical data.
3. Research Results and Analysis

3.1. Remote Sensing Image Data Fusion
Considering the factors of data quality, data expression richness and rice growth cycle, Landsat 8 data covering research areas were obtained, and MODIS images from July 12th to November 1st, 2017 were selected. Considering the applicability of remote sensing indicators and the richness of information expression, NDVI was used as the only index for current land classification extraction. The NDVI index data of the above data were extracted and the ESTARFM model data fusion was carried out according to the principle of time proximity priority. A total of 15 images with high spatial and temporal resolution were generated.

Two pairs of time image data were selected for comparison (figure 2), and the fusion results basically retained the key information. However, there were some problems in fusion image, such as abrupt change of adjacent boundary pixels and low image continuity, which lead to poor fusion effect [9]. There are two reasons for the analysis: first, the systematic errors among different sensors, the differences between spectral settings and spectral response functions of sensors, which cannot be avoided by geometric registration, and second, the variability of pixel reflectance exists in both time and space scales. Second, the model algorithm is inadequate, and the algorithm defaults that the image of different types shows a linear relationship, but the phenomenon of non-linear spectral mixing in vegetation coverage areas such as crops and grasslands with high planting density is also widespread.

![Figure 2. Effect of data fusion.](image)

3.2. Target Classification Extraction and Accuracy Evaluation
Based on the acquired image data with high spatial and temporal resolution, the harmonic analysis of time series data was carried out [10]. The peak time of NDVI in early rice was in June, that in middle rice was in July, and that in late rice was in August. The determination of peak time meant that the value of NDVI in this period was higher than that in other periods. With the help of the above information, the most significant difference was found. Finally, the spatial distribution of rice planting were obtained (figure 3).

![Figure 3. Spatial distribution of various paddy patterns.](image)

In order to test the results of extracting spatial distribution of rice rotation planting, the area was validated by using statistical yearbook data. Compared with the statistical yearbook data (table 1), the relative accuracy of the extracted area of early rice was 82.55%, and the relative accuracy of the
extracted area of rice-rice rotation pattern distribution was 97.38%, which met the classification accuracy requirements.

| Area (km²)       | Classified extraction area (km²) | Relative precision /% |
|------------------|----------------------------------|-----------------------|
| Early rice       | 145.8                            | 120.3                 | 82.50                           |
| Middle-season rice| 79.3                             | 84.6                  | 91.07                           |
| Late rice        | 132.4                            | 150.9                 | 86.03                           |
| Overall accuracy |                                  |                       | 86.53                           |

4. Conclusion and Discussion
The following conclusions were obtained:
1) The classification results of remote sensing images were verified by using statistical yearbook data, field survey data and Google image data, and the verification results meet the accuracy requirements.
2) According to the relative size of NDVI index among different cropping patterns in paddy ecosystem, the spatial distribution of different cropping patterns was obtained. Among them, late rice model with an area of 150.9 km², which was widely distributed. Secondly, the middle-season rice model, with an area of 91.07 km², the early rice model, with an area of 120.3 km².

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