CROP AREA ESTIMATION BASED ON MODIS-VI TIME SERIES BY PAN-CPI MODEL

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1. INTRODUCTION

Crop area estimation is one of the most important applications of quantitative remote sensing in agriculture. The periodic acquisition of remote sensing data at high quality with short temporal intervals is an extremely efficient way to monitor the seasonal development of crop, and it's also a prerequisite for large-scale crop area quantitative measurement. The majority of the conventional estimation of crop area were based on medium/high-resolution remote sensing data (10-30m scale) or coarse-resolution remote sensing data (250-1000m scale). Many researches have indicated that the approach combining coarse resolution and medium/high resolution data will be the main trend in future for crop area estimation [1-5].

According to the different application of coarse resolution remote sensing data, crop area estimation by combing coarse resolution and medium/high resolution data can be categorized into two classes. One way is selecting single or multi-temporal coarse resolution data during the crop growth period to do spectral unmixing with pure end-members provided by medium/high resolution remote sensing data or ground data [1, 6, 7]. This method ignores the time sequential characteristics in the crop growing season, which is a unique advantage presented by coarse resolution remote sensing data. So, the above method only performs well in the area with relative homogenous cultivation structure, and performs poorly in areas with complex, fragmental cultivation structure. Another method is to establish a semi-quantitative or regression model based on the whole MODIS-VI time series with the support of high resolution results as samples to get the crop area information [8-11].The advantage of the second method is obvious that it takes full advantage of the predominance of different resolution remote sensing data. However, different crops will be displayed distinctly during their own respective growing phenological periods [12, 13]. How to highlight the characteristics during critical phonological periods and inhabit other non-critical phenological characteristics is the linchpin of getting a more satisfied crop area estimation result in future studies. In addition, regard this method used, they all have ignored the impact on the recognition results caused by geometric registration in the past studies. In fact, in most cases, perfect geometric registration between different scale remote sensing data is so ambiguous that the influence caused by geometric registration error is even greater than that of model limitation [14, 15].Therefore, in depth analysis is required, in order to minimize the geometric registration error produced in combing coarse and medium/high resolution remote sensing data.

Compared to natural vegetation, various types of crops have their own representative phenological calendar features, which change dramatically with the seasons and make a vast difference to natural vegetation. The MODIS-VI time series has become the best indicator to identify the phenological feature of crop. In this paper, a new crop area index, called Pan-CPI, is proposed to reflect the quantitative functional relationship between the MODIS-VI time series and crop planted areas to solve the problems discussed above. The key parameters of Pan-CPI are calculated through the samples supporting by TM images and the MODIS-VI time series images to survey the winter wheat area in the experimental region, which is located in and around Tongzhou, Beijing, China. Meanwhile, the result will be analyzed and evaluated by different assessment criteria to search a new way for crop area estimation.

2. STUDY AREA

The experimental area is located at 39°35′N-39°59′N and 116°30′-117°1′E in Tongzhou, Beijing and its surrounding areas. The area contains the Tongzhou District and the eastern part of Hebei province, covering 45km*45km, 180*180 MODIS pixels. The varying distributions of winter wheat represent a complex and fragmentary cultivation structure (Fig.1)

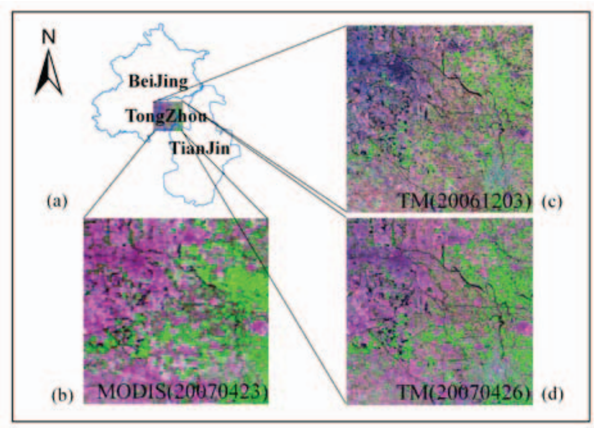

Fig.1 Maps of study area

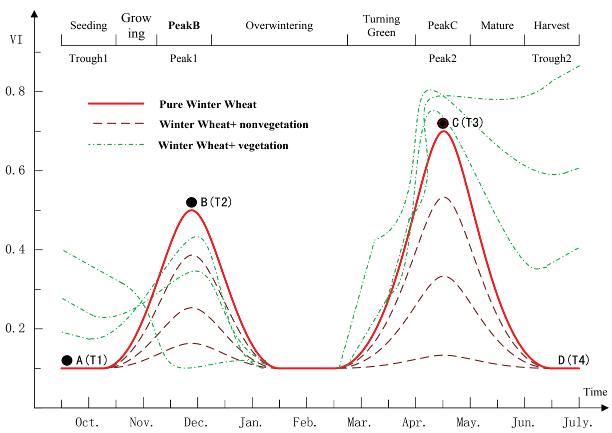

Fig.2 The scheme of Pan-CPI model concept

3. METHODOLOGY

Crop Proportion Index model shows the crop percentage in a unit area in a specific time, called Pan-CPI for short.

The scheme of Pan-CPI model concept is shown in Figure 2. Points A, B C, D show the four key phases in the winter wheat growth cycle in Figure 2. In particular, for the crop whose VI time series curve presents only one peak, the two peak values were considerate to be one in the Pan_CPI model. Another case is the field mixed with bare soil or other crops. In this situation, the four key phases used for the pure winter wheat area will changed due to the low VI value of the mixed field. In detail, two slopes (Point A to Point B and Point C to Point D in Figure 2) of the winter wheat standard curve will be lower than that in the pure area of winter wheat. Based on the above terms, we predict the proportion of crops in a unit area to be a significantly positive correlation with the two slopes. Taking the period of time T1 to T2 and time T3 to T4 as one time unit, Pan-CPI can presents as follows:

$$Pan - CPI = F((A * T_1 + B * T_2), (C * T_3 + D * T_4), E) \qquad (1\text{-}1)$$

Here, T1、T2、T3、T4 is the VI of the four key phases in pheonology. A、B、C、D are coefficients, and E is residual constant.

4. Result

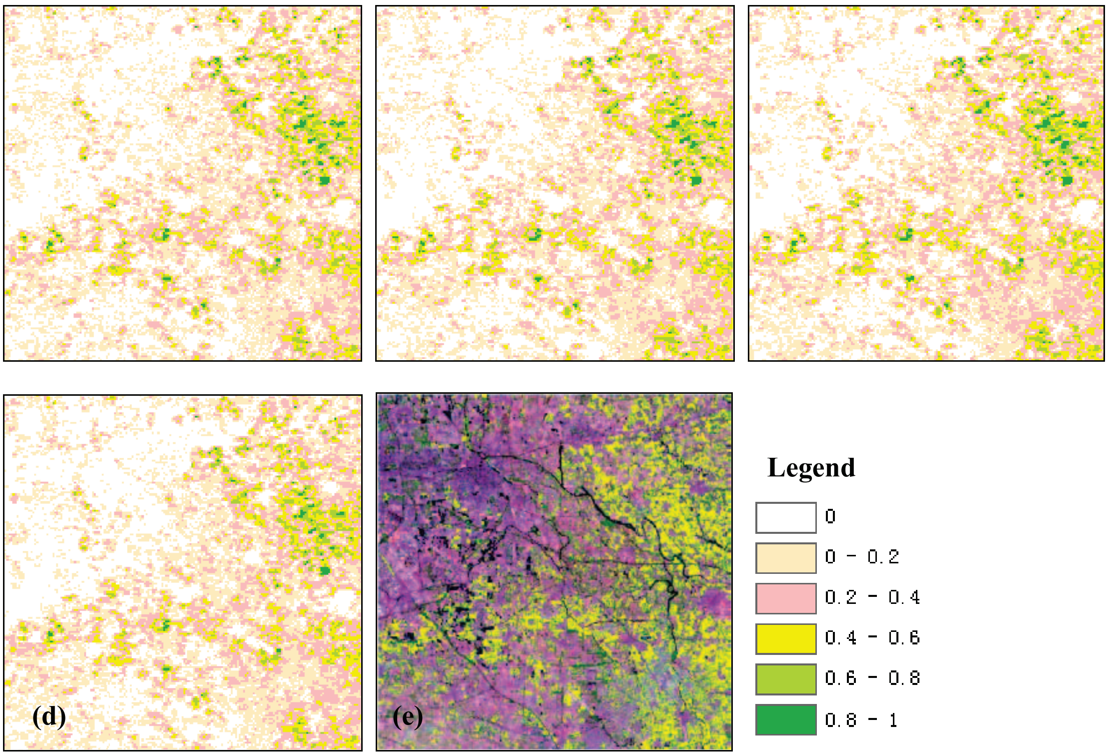

Figure 3 percentage maps of winter wheat by Pan_CPI model on MODIS with support of different population of samples and the classification map of TM images.
((a)percentage maps of winter wheat on MODIS with support of 5% samples;(b) percentage maps of winter wheat on MODIS with support of 10% samples;(c) percentage maps of winter wheat on MODIS with support of 15% samples;(d) percentage maps of winter wheat on MODIS with support of 20% samples;(e) the classification map of winter wheat on TM image)

Table 1 The evaluation results of PAN-CPI model

Evaluation criteria	population of samples %	Test										Max	Min	Mean	Variance
		1	2	3	4	5	6	7	8	9	10				
R^2	5	0.897	0.842	0.887	0.847	0.890	0.915	0.926	0.822	0.916	0.811	0.926	0.811	0.875	0.031
	10	0.857	0.847	0.843	0.802	0.882	0.900	0.816	0.870	0.853	0.834	0.900	0.802	0.850	0.021
	15	0.846	0.835	0.868	0.804	0.858	0.888	0.857	0.810	0.878	0.872	0.888	0.804	0.852	0.018
	20	0.869	0.859	0.852	0.895	0.867	0.873	0.963	0.932	0.849	0.879	0.963	0.849	0.884	0.013
A_R	5	0.927	0.938	0.974	0.903	0.887	0.994	0.975	0.931	0.992	0.979	0.994	0.887	0.950	0.026
	10	0.985	0.976	0.951	0.965	0.946	0.997	0.944	0.976	0.994	0.971	0.997	0.944	0.971	0.025
	15	0.989	0.959	0.974	0.986	0.983	0.907	0.965	0.924	0.975	0.985	0.989	0.907	0.965	0.022
	20	0.969	0.999	0.951	0.974	0.999	0.994	0.979	0.979	0.993	0.999	0.999	0.951	0.984	0.025

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