Influence of Scale Variation on Regional precision of Rape acreage Remote Sensing Monitoring

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***Abstract*—The remote sensing techniques have been in good operation in the application study on crop acreage monitoring from the initial small regions up to now. The crop acreage monitoring is one of element tasks in the remote-sensing yield estimation, and its precise results can affect the reliability and applicability of the data directly. With development of data sets of multispectral and multi-spatial resolutions, the comprehensive application for multi-scale remote sensing data sources is the evitable trend in the operation of the remote sensing monitoring of the large crop acreage. Thus, it is imperative to study influence of the scale variation on remote sensing monitoring precision of the crop acreage. In the paper, Anhui Province as the research area, with rapeseed for target crops, using high spatial resolution spectrum of remote sensing image (SPOT5) cultivated area is extracted, then the extracted results in different spatial resolutions are available with the scale conversion of the results based on the principle of a simple majority. In this paper, the scale effect in crop acreage remote sensing monitoring is analyzed systematically in different spatial resolution, different monitoring methods and different remote sensing times by making use of the high spatial resolution satellite data and many precision evaluation indexes. The results lays the foundation in theory and experiment for data selection and precision guarantee in the crop acreage remote sensing monitoring based on multi-scale remote sensing data.**

Keywords-component; Scale Variation; Remote Sensing Monitoring; Regional Precision; Rape Acreage

I. INTRODUCTION

With the rapid development of remote sensing technology, various remote sensing classification methods are applied to the research on the extraction of crop area [1-3]. The supervision of crop areas is one of the element work of the remote sensing yield estimation, and the precision of the supervision result directly affects the reliability and practicability of data. With the increasing popularity of multi-spectral and multi-spatial resolution data sets, the comprehensive application of multi-scale sensing data sources is an essential trend of the remote sensing supervision business operation of a large scale of crop areas. Hence, the research on the influence of the scale change on the remote sensing supervision precision of cultivated area of is imperative [4].

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Rape ranks first in the five major oil crops, an important edible oil source and protein feed, and also an important industrial raw material. Its cultivation area occupies above 40% of the gross area of oil plants in China, and its yield accounts for above 30% of the gross yield of oil crops in China while takes the first place in the world.

Rape is deemed as the target crop in this research which is made on the image of remote sensing supervision precision of the area of the target crop through the scale change, so as to choose suitable remote sensing data to supervise the crop area, improve the supervision precision as expected, reduce the data cost, and provide scientific and reliable basis and introductions to the remote sensing supervision business of a large scale of crop areas on the basis of multi-scale remote sensing data.

II. Study Area and Data Acquisition

A. Study Area

Anhui Province is located in Southeast of China, between the east longitude from 114°54′ to 119°37′ and the north longitude from 29°41′ to 34°38′. The cultivation area of the whole province is 4080 thousand hectares, the land is fertile and suitable for growing various crops. Rape areas and yield of Anhui Province are both in the front rank in China, and the crop area of the whole province is basically kept around 933,300 hectares over the years. Among yields of crop and plant cultivation, rape ranks only second to grain and vegetables. Thus, rape cultivation has already become a principal way for the increase of incomes of farmers and is also plays a significant role in the agricultural structure adjustment of Anhui Province.

B. Data Acquisition

This research is made on remote sensing data sources of high spatial resolution, e.g. Landsat-TM and SPO5, which are commonly used in the remote sensing supervision business of crop areas, in accordance with the growth period of the target crop in the research area and the actual data collection. Original remote sensing data often cannot meet requirements of the research, e.g. serious geometric deformation of images. In order to utilize originally observed remote sensing data better and fully, the pretreatment of images shall be performed. The geometric precision correction of remote sensing images used in this research is done respectively, the correction error is in one pixel, the projection type is Albers homolographic projection, the central meridian is 105°, and the spheroid is Krasovsky.

III. Research Method

Remote sensing information about the rape area is retrieved through multi-spectral remote sensing images of high spatial resolution. By means of dimension conversion of extraction result on the basis of the plurality rule [5], the extraction result of different spatial resolutions is gained, the error matrix is established for the precision analysis on the basis of the actually measured sample data with the floor, so as to analyze the influence of different spatial resolutions on the supervision precision of the rape area.

Various automatic information extraction methods, e.g. Isodate classification method and Mahalanobis distance method, are used for the test, including different classification units and different classification algorithms, so as to compare the precision, efficiency and stability of the rape area by comparing different combinations. The combined way between random arrangement and outdoor actually measured sample site is adopted to make a precision evaluation on extraction result and to analyze the influence of different image classification methods on the remote sensing supervision precision of rape area.

The spectrum separability distance is calculated according to multiple remote sensing images covering the main growth period of rapes, so as to analyze the influence of different image time phases on the remote sensing supervision precision of the crop area.

By analyzing the influence of the above three aspects of scale changes on the remote sensing supervision precision of rape area, the optimal dimension selection of the rape area remote sensing supervision is analyzed, so as to lay a theoretical and experimental foundation for data selection and precision guarantee in the operation of the remote sensing supervision business of crop area based on the comprehensive application of multi-scale remote data.

IV. Result and Analysis

A. Research on Remote Sensing Supervision Precision Images of Rape Areas at Different Spatial Resolutions

The rape area 60km × 60km in the boarder of Anhui Province in 2009 is selected to be the typical research object, and the rape area extracted from SPOT5 multi-spectral image with the resolution of 10m is taken as the basic value, so as to perform the scale conversion on the basis of the plurality rule, get extraction results at different spatial resolution rates, make the precision analysis by establishing the error matrix with the sample site data actually measured on the ground, and analyze the influence of different spatial resolutions on the supervision precision of the rape area.

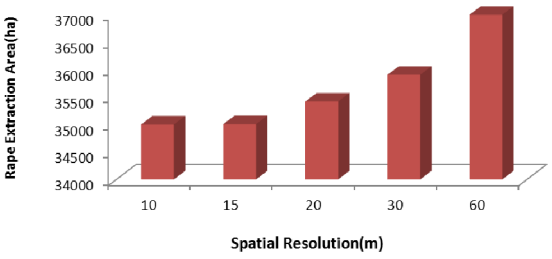

Figure1. Different spatial resolution of the rape extraction changes

The result shows that the interpreted rape figure spots are more and more precise, and the interpreted rape area is smaller and smaller, when the remote sensing image spatial resolution goes up (Figure.1). Due to the change of the spatial resolution scale, if the resolution ratio of the image is lower, more non-

targeted crop areas will be involved in the interpreted figure spots and the classification precision will become lower.

With multiple ground the kind of square in total area for rape benchmark values(A), compare A and A_i (A_i is by the scale of the changes extraction of rape, i is the spatial resolution) get area overall area of extraction accuracy, namely to regional precision(K).

$$K(i) = \left[1 - \frac{|A_i - A|}{A}\right] \times 100\ \% \quad (1)$$

The precision evaluation refers to the comparison between the actual data and the remote sensing classification result, so as to confirm the accuracy of the remote classification process. At present, there are two methods to evaluate the precision of the remote sensing extraction of crop areas: one is to compare investigation materials of ground samples and structure the classification error matrix, so as to calculate various indexes, e.g. overall accuracy rate; the second is to compare with statistics of the last year. In this paper, measured data for the extraction of the results are regional accuracy evaluation. With the reduction of the spatial resolution, and rape of planting area of remote sensing monitoring regional accuracy decreases (Figure.2).

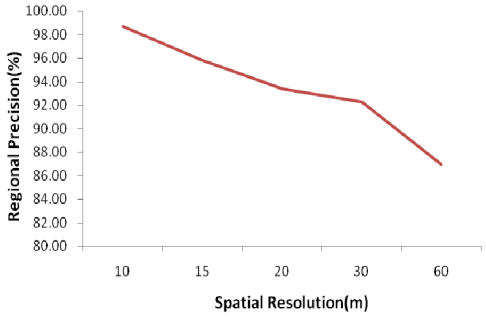

Figure2. Different spatial resolution rape area extraction regional precision changes

In the field investigation, GPS is used for 40 interpretation and verification spots of rape and other crop areas respective in the filed parcel and high resolution images QUICKBIRD (0.61m). In total, 200 outdoor verification spots are used for the precision verification (Table.1).

Table1. PRECISION OF RAPE AREA EXTRACTED FROM REMOTE SENSING IMAGES AT DIFFERENT SPATIAL RESOLUTION RATIOS ON VERIFICATION SPOTS

Spatial Resolution	Missing point	Correct extraction	Multiple points	Relative precision rate
30m	2	162	36	81.0%
15m	16	166	18	83.0%
10m	10	186	4	93.0%

The calculation result and image data show that the multi-section phenomenon becomes more obvious in the rape area extracted from the images with the reduction of spatial resolution ratio, and the multi-section phenomenon becomes less obvious with the increase of the spatial resolution ratio. Hence, the remote sensing supervision precision of the rape area can be increased with the increase of the spatial resolution ratio. Missing points can be reduced by means of visual interpretation.

B. Research on the Influence of Different Classification Methods on the Remote Sensing Supervision Precision of Rape Areas

In order to compare the influence of different classification methods on the remote sensing supervision precision of rape area, the remote sensing classification of SPOT5 remote images were made on March 25, 2009, by Mahalanobis distance, maximum likelihood, minimum distance, Isodate classification methods. The results after the classification were compared and analyzed by calculating the confusion matrix and sample sites actually measured on the ground(Table.2).

Table2. CONFUSION MATRIX COMPARISON BY VARIOUS AUTOMATIC CLASSIFICATION METHODS

Classification Theory and Method	Missing Point	Rape	Multiple points	Multiple point ratio	Missing point ratio
Mahalanobis Distance	6	128	3	2.29%	4.58%
Maximum Likelihood	15	113	9	7.56%	12.61%
Minimum Distance	32	95	10	8.55%	27.35%
Isodate classification	7	125	5	1.68%	4.20%

According to the table above, serious missing points pheromone exists by the minimum distance method. Among 137 pixels of rape, only 95 pixels are classified to be rapes, and the missing point percentage is 27.35%. Classification results by Mahalanobis distance method and maximum likelihood method are more ideal. The initial category number directly affects the precision of the rape area extracted by Isodate classification method. By means of research, if the setting of initial classification number is too low, and the confusion phenomenon will be relatively clear. If the setting is too higher, a large amount of small figure spots will appear, so as to bring certain interference to the classification judgment. In the plain area where rapes are widely distributed, the initial classification number shall be from 30 to 40 in order to meet the extract requirement. In the low hill area where a small quantity of rapes is distributed, the initial classification number shall be from 50 to 60.

When the classification is supervised, it takes too much time to select a training sample area, a training sample area shall be separately selected for each classification unit. Therefore, in the same time, the Isodate classification effect

is better. Meanwhile, by means of test comparison, in the area where the ground condition is complicated and figure spots are broken, Isodate classification result is better and more effective than the supervision classification result, and it is much easier to master the standard of Isodate classification result. During the extraction of special information, although the special information can be automatically classified by the computer, the manual visual interpretation is also necessary. It is discovered by statistic comparison, the precision of the extraction result after the visual rectification of people is improved clearly.

C. *Influences of Different Remote Sensing Image Time Phase on the Remote Sensing Supervision Precision of Rape Areas*

The growth period of Anhui rapes is from Sep. of each year to May of the next year, including seeding period, seedling period, bud period, blossoming period and silique growth and maturity period. In accordance with the growth period of rapes in Anhui Province and the remote sensing image collection condition, multiple Landsat5 TM images after 12 months are mainly selected for the analysis (Table.3).

Table3. REMOTE SENSING IMAGE LIST

Landsat5 TM Image Time	Dec. 10, 2008	Jan. 11, 2009	Feb. 12, 2009	April 1, 2009	May 3, 2009
Rape Growth season	Seedling Period	Seedling Period	Bud Period	Initial blossoming period	Final blossoming - mature period

Spectral differences between rapes and other crops planted in the same period are the foundation for the extraction of remote sensing information of rapes. If the spectral difference is more obvious, it is easier to identify rapes and the precision is higher. By the outdoor field investigation, rape planting, wheat planting and construction, forest land, areas of other crops are selected as the comparison samples, andenvi4.6 software is used for the spectrum separability calculation of 5 Landsat5 TM images in this paper (Table.4).

Table4. MAIN LAND UTILIZATION TYPES AND RAPE J-M DISTANCE

Landsat5 TM Time Phase	Dec. 10, 2008	Sept. 11, 2009	Feb. 12, 2009	April 1, 2009	May 3, 2009
Winter wheat	1.8229	0.9625	1.8901	2.0000	1.9451
Building	1.9999	1.9999	2.0000	2.0000	2.0000
Water body	1.9997	1.9998	2.0000	2.0000	2.0000
Forest land	1.9995	1.9394	1.9999	2.0000	1.9664
Other crops	1.9990	1.9790	2.0000	2.0000	1.8955

Table.4 shows that winter wheat, building and water body, etc. are closer to the rape separability and can be separated from the spectrum of rape. According to the calculation result of the single time phase TM remote sensing image J-M distance, the rape remote identification time phase of rapes of Anhui Province in the first ten days of April is the best. In the first ten days of April, rapes come into the blossoming period, winter wheat comes into the jointing stage, and the coverage rate of vegetations on the plough surface goes up rapidly. At the same time, the forest land comes into the sprouting period and has good spectrum separability. Based on these Landsat-TM remote sensing data of the rape of the planting area extraction and field measurement data comparison, found that based on the optimal phase extraction results area highest accuracy.

D. *Analysis on the Optimal Dimension for the Remote Sensing Supervision of Rape Areas*

Images of different scales have different application fields [6]. In, this paper, scales are changed on the basis of the extraction result of high spatial resolution, and the spatial resolution in the extraction result is changed to 15m and 30m, which is consistent with spatial resolutions of common data, e.g. ASTER and Landsat-TM, for the remote sensing supervision of crop areas. The analysis is made on the optimal dimension of the remote sensing supervision of rape areas according to the research result.

In view of the time phase, spectrums of rapes and non-rape plants are greatly different and colors/tones are obviously different on the 30m spatial resolution image formed in the blossoming period of rapes. In view of the precision evaluation result based on the data actually measured on the ground, the remotely measured value of the rape area from the remote sensing image of high resolution is more accurate. In terms of data procurement and cost disposal, if the area in a working area equals to the scale ($185\times185km^2$) covered by one Landsat5 TM image, at least 9.5 SPO-5 images and 9.5 ASTER images can meet the requirement for the overall coverage. Accordingly, the total costs for the three images (market prices) are about 3800 CNY (Landsat5-TM), 6650 CNY (ASTER) and 42000 CNY (SPOT-5) respectively. Hence, it is obvious that data procurement cost and manual disposal work amount can be increased gradually with the increase of the spatial resolution.

In conclusion, different remote sensing images shall be selected in different research areas for the remote sensing supervision of rape areas, and high resolution images shall be applied to the supervision of small scales. If the extraction scale is too large, the middle spatial resolution remote sensing images can be considered for the comprehensive cost and the extraction precision.

I. RESULT AND DISCUSSION

If the spatial resolution ratio is lower, more non-targeted crop areas will be involved in the interpreted figure spots and the classification precision will become lower. The precision evaluation of the extraction result through the verification points shows that the clear multi-section phenomenon exists in the rape area extracted from the remote sensing image of 30m spatial resolution. With the increase of the spatial resolution, the multi-section phenomenon will be reduced obviously. Hence, the remote supervision precision of rape areas can be increased with the increase of spatial resolution. Due to the difference between the cost and the image coverage, the author thinks different remote sensing images shall be selected

according to different research areas so as to extract the remote sensing information about the rape area, and the information of a small scale shall be extracted from high resolution images. If the extraction range is too large, the remote sensing image of the middle spatial resolution shall be considered for the comprehensive cost and the extraction precision.

Different classification methods affect the precision of the remote sensing supervision of rape areas. Mahalanobis Distance and Isodate classification methods can be used for extracting the remote sensing information about the rape area more precisely. In the same period of time, the unsupervised classification effect is better. By the test comparison, the unsupervised classification result in the area where the ground condition is complicated and figure spots are broken is better and more effective than the supervision classification result, and it is much easier to master the unsupervised classification result.

The selection of the remote sensing image in the best time phase is one of important cycle in the guarantee of the remote sensing supervision of high-precision crop areas. The spectrum difference of rape and other ropes growing in the same period is the foundation for the extraction of remote sensing information of rapes. If the spectrum difference is more obvious, it is much easier to identify rapes and the precision is higher.

In this paper, high spatial resolution satellite data are used, various precision evaluation indexes are applied, and the scale effect issue in the remote sensing measurement of crop areas is analyzed at different spatial resolutions, by different supervision methods and in terms of different remote sensing supervision time phases, etc. In the future, a further research will be made on multi-source remote sensing data and multiple targeted crops, so as to lay the theoretical and experimental foundation for the precision guarantee and data selection in the remote sensing supervision business operation of crop areas based on the comprehensive application of multi-scale remote sensing data.

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