MODIS-NDVI-Based crop growth monitoring in China Agriculture Remote Sensing Monitoring System

HUANG Qing
Key Laboratory of Resource Remote Sensing and Digital Agriculture, Ministry of Agriculture, China / Hulunber Grassland Ecosystem Observation and Research Station
Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences
Beijing, China
e-mail: queengold@126.com

ZHANG Li
Key Laboratory of Resource Remote Sensing and Digital Agriculture, Ministry of Agriculture, China
Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences
Beijing, China
e-mail: zhangli@caas.net.cn

WU Wenbin
Key Laboratory of Resource Remote Sensing and Digital Agriculture, Ministry of Agriculture, China
Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences
Beijing, China
e-mail: wwb@mail.caas.net.cn

LI Dandan
Key Laboratory of Resource Remote Sensing and Digital Agriculture, Ministry of Agriculture, China
Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences
Beijing, China
e-mail: lidd@caas.net.cn

***Abstract*—Crop growth monitoring timely and accurately during the growing season is of great importance for accurate yield estimation, which can provide information support for making and adjusting agricultural policies. In this paper, a MODIS-NDVI-based method for operational crop growth monitoring in China Agriculture Remote Sensing Monitoring System (CHARMS) was presented. Some meteorological data such as temperature, precipitation and sunshine, as well as the field observation data were used to modify the models parameters. The crop growth conditions were categorized into three classes, better than usual, usual and worse than usual. Finally, the application of this method to spring wheat, winter wheat, spring maize, summer maize, cotton, soybean and paddy rice and its results were introduced.**

Keywords: Remote Sensing; Crop Growth Monitoring; China Agriculture Remote Sensing Monitoring System (CHARMS);NDVI;MODIS data

I. INTRODUCTION

China is a large agricultural country. Agricultural production is related to all levels of government, department of agricultural production management and ordinary people. Farmers can know crop growth condition through field observations and can have a preliminary forecasting to crop yield. Local government can have a comprehensive analysis and judgment to crop growth condition through field investigations or reports from lower department. The above-mentioned method is easier in small-scale for farmers to access crop growing information, but in large-scale, it is difficult to applications because of time, people and the accuracy of information cannot be assured. With an objective, timely feature, remote sensing can get a wide range of ground-based information in a short time and it has a unique advantage in monitoring the agricultural situation [1-3].

The early and successful example of using remote sensing technique to monitor agriculture is the United States. Since the mid-70s of 20th century, the United States began to carried the projects of "Large Area Crop Inventory and Experiment" (1974-1977), the project divided into three phases, the first phase was to monitor the changes of wheat acreage, estimate the yield and total production to nine wheat production states of the U.S. Great Plains; The second phase is to monitor the crops growth condition and food production not only their own country, but also Canada and parts of the former Soviet Union; The third phase is to monitor the changes of wheat acreage, estimate the yield and total production to the world's major grain-producing countries, such as Canada, Mexico, Argentina, Brazil, the former Soviet Union, China, India, the Middle East, Australia and etc., which established an agricultural monitor system of global level. The successful operation of the system make the United States occupy a dominant position in the global food trade, and also make the United States obtain economic benefits of hundreds of millions of dollars every year. From 1980 to 1986, the United States began to carried the project of "Agriculture and Resources Inventory Survey through Aerospace Remote Sensing", the main content of this project was for the inventory of agricultural resources

978-1-4244-8515-4/10/$26.00 ©2010 IEEE GRS2010

through the space remote sensing, to obtain crop information by remote sensing techniques, including a wide range of crop growth condition and yield forecasting all over the world [4-6].

In 1988, The European Union's "Monitoring Agriculture with Remote Sensing (MARS)" Project was lunched to develop operational remote sensing technology for information on the crops and their production, The target of it is to improve the agricultural statistics system within the European Community by using remote sensing technology, and to provide scientific and technical support on EU agriculture and food security policies. It is a ten year research project of applying remote sensing technology to agriculture. Its basic strategy consists of developing operational products using existing research results and knowledge available in the various member states. The MARS Project is coordinated and administered by the Space Applications Unit of the Joint Research Centre. It is funded and supervised by the Agriculture Directorate General and Euro stat. The MARS Project is organized into three major fields. The provision and improvement of crop yield and acreage statistics and timely forecasting of the agricultural production is given at the level of EU. The second field consists of providing scientific support for the implementation of the Common Agriculture Policy. Support is also made available for the transfer and adaptation of MARS results to users outside the European Commission [7-9].

The application of remote sensing technique in China began in aerial photography in the 50s of 20th century, and a rapid development was followed since then, After the 80's of 20th century, the application of remote sensing in agriculture becomes more extensive. In the monitoring of crop acreage and yield estimation by remote sensing, China has carried out wheat yield estimation in the Huang-Huai-Hai Plain, Beijing-Tianjin-Hebei region, North China, South China etc. and crops of being monitored include wheat, paddy rice, soybean, cotton etc.[10]. The Chinese Academy of Sciences and China Meteorological Bureau have also established some agriculture remote sensing monitoring systems, but they monitor mainly cultivated land crops growth, production etc, different crops growth condition within cultivated land have not been monitored separately yet and have not achieved regularly operation running. China Agriculture Remote Sensing Monitoring System (CHARMS) was established in 2001 by the Key Laboratory of Resource Remote Sensing and Digital Agriculture, Ministry of Agriculture, China. The main purpose of CHARMS is to monitor agricultural condition using remote sensing techniques and to provide basis information for government decision-making and agricultural production management. It has currently realized operational monitoring of crop acreage change, crop growth, agriculture disasters (drought, floods, frost damage, pest etc..) and crop yield estimation. The monitoring and predicting results have played a great role in keeping abreast of the latest agriculture condition. In this paper, a MODIS-NDVI-based method for operational crop growth monitoring in China Agriculture Remote Sensing Monitoring System was presented.

II. DATA AND METHODOLOGY

A. Data preparation

1) Remote sensing data preparation and preprocessing: Vegetation indexes are important parameters which carry abundant information of earth surface vegetation properties. NDVI (Normalized Difference Vegetation Index) which can be generated from the red and near-infrared bands of the MODIS data enhance the identify capacity to soil background and weaken the impact of atmosphere and terrain shadow, and NDVI values increase with the growth of the crops, and gradually decrease after reaching the maximum at a certain growth stage of the crops. NDVI has more advantages in monitoring crop growth condition than other index [23].

In order to effectively eliminate the cloud cover, atmospheric affects and other unfavorable factors, NDVI maximum values of monitoring period were composite (sixteen days mostly).The process of remote sensing data preparation and preprocessing is as follows: Firstly, every day MODIS data covering the whole China are received by MODIS satellite receiving station, then these data are transferred to the processing unit where processing is performed using the remote sensing image processing system. After the preprocessing, including radiometric correction, geometric correction, projection changes, clouds marks etc, the red and near-infrared bands of the MODIS data were used to composite NDVI. Daily images are used to produce a sixteen-day, cloud free composite image for NDVI with maximum value composite (MVC) method[3-4]. In this study, as we aims to compare the NDVI with last five-year average, NDVI data for the last five years in the same period were produced.

2) Other data preparation: Some other data related to crop growth condition were collected to a have some basic information about the study area and crops. These data include: regional topographic map; regional administrative division map; land use and land cover maps; crop distribution maps; historical MODIS data of monitoring period; meteorological data of temperature, precipitation and sunshine, as well as the field investigation data from 200 local counties.

B. Methodology

In this study, an improved NDVI difference model in CHARMS was used to assess different crops growth situation. Based on crop growth condition of current monitoring period, the maximum average NDVI data of the last five years was subtracted by the maximum NDVI of study period by using the Equation 1, resulting in a NDVI difference data, which shows can indicate the spatial difference of crop growth condition at a certain period. Since NDVI value for individual pixel can be affected by atmospheric condition, a 3 by 3 filter approach was applied to each pixel, namely, the value of each pixel is generated from the average NDVI values of itself and its adjacent 8-pixels.

$$R = NDVI_{09} - NDVI_{average} \tag{1}$$

Where, R is the crop growth index, NDVI09 is NDVI data for a particular period in 2009, NDVIaverage is the averaged NDVI of the past five years.

Moreover, meteorological data of temperature, precipitation and sunshine, as well as the field investigation data of 200 network counties were used to modify the model's parameters.

Based on the calculated R values, the crop growth condition were categorized into three classes, better than usual, usual and worse than usual, or well, general and bad. If there is cloud cover over the area, this area was processed as a non-monitored area, crop growth was not evaluated. Last, crop growth condition was assessment at four different scales, i.e., county, provincial, regional and national; and the spatial distribution maps of crop growth condition were also created. This method was then used to monitor the growth condition of spring wheat, winter wheat, spring maize, summer maize, cotton, soybean and paddy rice. The monitoring results can supply real time crop growth information for relevant department and relevant provinces or regions.

III. Results and Analysis

Figure 1 shows the crop growth condition of winter wheat, maize, rice and soybean during their growth periods in 2009. It can be seen that winter wheat growth condition was not good at the beginning of the year mainly due to the severe drought. However, it was getting better later. Soybean growth condition in northeast China was affected by low temperature, few sunshine and chilling injury in June and July months, crop growth was not worse than normal, but it also restored after that. In addition to the differences in time, crops growth conditions also differ in space.

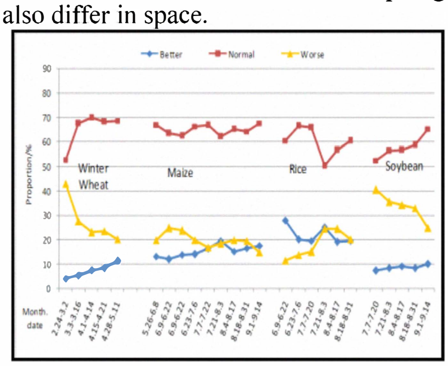

Fig. 1 Proportions of crops growth level - compared with five years average

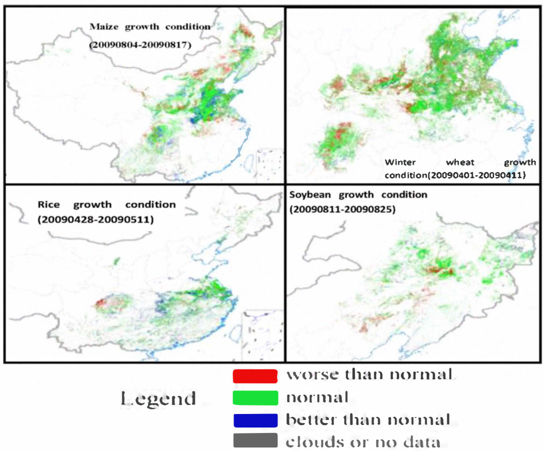

Fig.2 Examples of crops growth monitoring results in CHARMS

IV. Conclusion and Discussion

Crop growth dynamic monitoring is of significance in guarantying national food security and promoting agriculture sustainable development. To understand the agricultural production condition timely and accurately is related to government decision-making, agricultural production management and the general public concerns. Remote sensing can get a wide range of ground-based information in a short time and it has a unique advantage in monitoring the agricultural situation. The early crop growing condition monitoring in CHARMS are invaluable to decision makers and analysts within government agencies for better management of agriculture. It is recommended that further research are needed:

(1) To establish different remote sensing monitoring indicators system (NDVI/EVI/LAI/RVI/VCI/etc.) according different crop and different agricultural zoning.

(2) To develop integrated multi-model approach to monitor crop growth, such as the integration of meteorological model, statistical model and remote sensing model etc.

(3) To study how apply crop evaluating indicators to crop yields forecast in a better way.

Acknowledgments

This project was supported by the National Natural Science Foundation of China (40930101); by the National High Technology R&D Program(No. 2006AA120101, 2006AA15Z121 and No 2007AA10Z230), by the National Basic Research Program (No.2007CB106806), by the Foundation for National Non-Profit Scientific Institution, Ministry of Finance of China (2010-IARRP-02)and by the Open Project of Key Laboratory of Resource Remote Sensing and Digital Agriculture, Ministry of Agriculture(RDA1004).

REFERENCES

[1] B. F.Wu, "Operational Remote Sensing Methods for Agricultural Statistics," Journal, Acta geographica sinica, vol. 55(1), pp. 23-35,2000.

[2] Y.S. Zhao,Principle and Methods for Remote Sensing Applications, Science Press, Beijing, 2003, pp.399-409.

[3] Q. Huang, D.Wang, J.Liu,"State and development trend of spatial sampling in remote sensing monitoring of agriculture situation," Journal of China Agricultural Resources and Regional Planning, pp. 22-26,2009.

[4] J. D.Hill, The LACIE crop years - an assessment of the crop conditions experienced in the three years of LACIE. NASA Technical reports. http://ntrs.nasa.gov/search.jsp?N=4294888900+4294964632&Ntk=Abstract&Ntx=mode%20 matchall&Ntt=LACIE, available 2008, October 11.

[5] H.Q.liu, M.Y.Jin, W.P.Gong, "applications of remote sensing in agriculture in the united states," Journal, Journal of China Agricultural Resources and Regional Planning, vol. 20(2),pp.56-60,1999.

[6] B. F.Wu, C. L.Liu, "Crop growth monitor system with coupling of NOAA and VGT data," Vegetation 2000 Proceedings, pp. 355-359,2000.

[7] Monitoring Agriculture with Remote Sensing Project (1988-1998) and related Hungarian Activities. http://lazarus.elte.hu/gb/fm-ftf/73.htm,available January 1,2009.

[8] H.Q.liu,"The introduction of mars plan of European commission and Chinese agriculture remote sensing application, " Journal, Journal of China Agricultural Resources and Regional Planning, vol. 20(3), pp. 55-57,1999.

[9] JRC. "The Monitoring Agriculture Resources (MARS) Unit Mission." http://mars.jrc.ec.europa.eu/mars/About-us/GeoCAP. available 2008, October 10.

[10] H.J.Tang, H.Q.Liu, "The Application status, needs and prospects of spatial information technology in agricultural," http://219.239.34.169/was40/detail?record=96&channelid=40723,available 2007, March 20.

[11] http://en.wikipedia.org/wiki/Normalized_Difference_Vegetation_Index., available 2009-04-01.

[12] J.H.Meng, B.F.Wu, Q.Z. Li, L.Zhang,"Design and Implementation of a Global Crop Growth Monitoring System by Remote Sensing," World sci-tech R&D, vol. 28(3), pp. 41-44,2006.

[13] J.H. Wang, C.J. Zhao, W.J. Huang, et al. Basis and Application of Agricultural Quantitative Remote Sensing. Beijing: Science Press, 2008,pp. 259-276.

[14] D. Jiang, N.B. Wang, X.H. Yang, et al. "Principles of the Interaction between NDVI Profile and the Growing Situation of Crops ,"Journal, Acta ecologica sinica, vol. 22(2), pp. 247-252,2002.