INTRODUCTION OF CHINA CROPWATCH SYSTEM WITH REMOTE SENSING

Wu Bingfang*

Institute of Remote Sensing Applications, Chinese Academy of Sciences, Datun Road, Beijing, China-wubf@irsa.ac.cn

Commission VIII, WG VIII/10

KEY WORDS: Crop Monitoring, Remote Sensing, China, System

ABSTRACT:

This paper introduces the progress of China Crop Watch System with Remote Sensing (CCWS). Crop-relevant information is important for the national economy and the people's livelihood. It is also beneficial information for grain trade and agricultural production. With about 20-years' researching experiences, China CropWatch System was developed by Institute of remote sensing applications (IRSA), Chinese Academy of Sciences (CAS) in 1998 and operated since then. The CCWS covers the entire China and 46 main grain growing countries in the world. The monitoring contents are crop growing condition, crop production, drought, crop plantation structure and cropping index. In line with 9 years' operation and improvement, the CCWS publishes 7 month bulletins and 20 newsletters every year, which had become important information sources of government bodies.

1. INTRODUCTION

Crop-specific information is collected mainly through surveys of standing crops in agricultural research stations and agro-meteorological stations. The method mainly consists of on-the-spot visual assessment. However, the number of such stations is limited because of the high cost of maintaining them. Also, spatial variation in physi-chemical properties of soil and farming practices makes it difficult to extrapolate the data from one station to represent a larger area. Therefore, it is necessary to have a better method of collecting crop-specific information.

Remote sensing technology can obtain both the macro and the micro information about the monitoring target (Sun Jiulin, 1996). The large-scale crop information can be monitored by using remote sensing technology (Chen Shupeng, 1990). In past 30 years, it has seen commendable progress in the use of remote sensing to monitor crops and remote sensing has made it possible to obtain quantitative crop-specific information on a regional scale or global scale. The China CropWatch System (CCWS) has been a success application of remote sensing technology in crop monitoring. With about 20 years' of research experience behind it, the Institute of Remote Sensing Applications (IRSA) of the Chinese Academy of Sciences (CAS) developed the system in 1998 and has kept it into operation ever since. CCWS covers entire China and 46 major grain-growing countries of the world. The system served more than 20 departments in China.

The structure, monitoring contents, operation, progress and future activities of the system were described in detail in the paper.

2. SYSTEM CONTENTS

CCWS consists of seven models: crop growth monitoring, drought monitoring, grain production estimation, crop production prediction, crop planting structure inventory, cropping index monitoring, and grain supply–demand balance and early-warning (Figure 1). The monitoring can be carried out on different scales or levels ranging from a county through a province and the whole country to the main producing countries in the world.

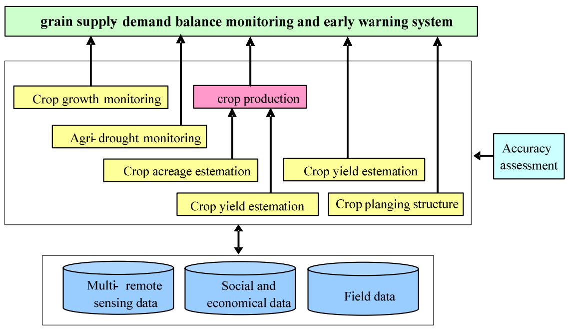

Figure 1. Contents of China crop watch system using remote sensing

2.1 Crop growth Monitoring

Crop growth reflects the growth of seedlings, an early stage in a crop's growth, as well as the metaphase and the anaphase of each crop as it matures and the changing trends in its yield. Monitoring crop condition with remote sensing can get the condition of cereal crops seedlings, as well as the status and trend of their growth. It also helps to acquire the crop production information (RAO M. V. K, Ayyangar R. S, 1982).

* Corresponding author

CCWS monitors crop growth with two methods: real-time monitoring and crop-growing process monitoring. In real-time monitoring, maps of the crop condition are generated from the difference between the vegetation index of the previous year and the current year (Wu B F, 2000). The map shows different grads of crop growth, each in a different colour. Spatial difference in crop growth can easily be seen from the map. AVHRR and MODIS data are used, large coverage makes it possible to monitor the crop continuously and dynamically. In crop growing process monitoring, growing profile of crops can be generate by collocate the remote sensed data along time; it can reflect the change of crop parameters from planting, seedling, tassel, to maturation and harvest (Zhang F, 2004; S. M. E. Groten, 1993). Normalized difference vegetation index (NDVI), Leaf area index (LAI) and net primary productivity (NPP) are used to monitor the crop growth in different period during the crop-growing season. Different regions has different indicator, NDVI, LAI or NPP.

2.2 Drought Monitoring

Agricultural drought is a natural disaster when water supply cannot meet the needs of the growing crop. China is one of the countries in the world that suffer from serious droughts, which reduce the country's grain production considerably. CCWS monitors the drought by computing indices from satellite data, which have strong relationship with drought, and then building drought model with these indices. Regular monitoring can not only predict droughts but also estimate their severity. The prediction and estimation of the drought development can be realized by monitoring the crop drought continuously.

2.3 Crop production Prediction

By monitoring the crop planting area and predicting the yield, CCWS can make a crop production prediction one month before the harvest. Eight crops, including winter wheat, spring wheat, early rice, semi-late rice, late rice, spring maize, summer maize and soybean are covered in the activity.

2.3.1 Yield prediction: CCWS adopts four models for yield prediction, namely the agro-meteorological model (Meng Q Y, 2004), the remote sensing index model (Cook, Paul W, 1995), a combination of both, and the biomass model. The biomass model combines inputs from three models, namely the photosynthetically active radiation (PAR) model, the light use efficiency model, and the land surface energy balance model, along with AVHRR/TM data from remote sensing to calculate regional total crop biomass; that value is then used in conjunction with the harvest index. CCWS generates the first crop yield prediction a month before the harvest and the second estimation one month after harvest.

2.3.2 Crop planting area monitoring: A method based on two independent sampling frames is proposed for estimating the area using remote sensing technology together with sampling on the ground. By stratifying the main crop-growing areas into regions and applying stratified cluster sampling frames to the data from remote sensing, crop planting ratio (that is, the proportion of the total area sown to the total arable land area) are monitored, and the transect sampling frames and GVG (integration of GPS, Video and GIS) sampling system are used to estimate each crop's planting ratio (that is, the proportion of area under a given crop to the total sown area). Using these two ratios, the total sown area under each crop can be estimated.

2.3.3 Production prediction: On the basis of the estimation of areas and yield per unit area), CCWS predicts the total yield of each of the eight crops in China. Besides, it makes it feasible to carry out the grain supply–demand analysis on different spatial scales. The model provides the results of such analyses, and an early warning when needed, to users. As with other models, this model too can provide information for any specific area or region specified by the user.

3. OPERATION AND APPLICATION

China CropWatch System has been put into operation since 1998. Every year, 7 monthly bulletins and 20 newsletters are released, covering crop condition, crop acreage and yield, drought, agro-meteorology, cropping index and crop planting structure, as well as grain production. The results of monitoring were also initially made available on the intranet of the government and later on the Internet as well.

In its 9 years' operation, the CCWS has published more than 60 monthly bulletins and over 160 newsletters, which had become a important information source for government bodies. A highlight of the part played by CCWS is its accurate prediction that domestic grain production in 2000 would decrease by 3% and that in 2001 would remain at the same level as that of the previous year, which proved immensely useful to decision-makers involved in macro control.

4. VALIDATION

CCWS has its own validation program. Each year, a few validation sites have been selected to do the field measurement for verifying specific results. The crop LAI every 10 days and crop type proportion have been measured to verify the crop condition and crop acreage. Validation shows that the accuracy is up to 97% for plant proportion and 95% for crop type proportion (He L H, 2004; Li Q Z, 2004).

After comprehensive validation work have been done in different area of China during the last 9 years, the accuracy of each monitoring item for all monitoring content in CCWS is proved to be higher than 95%, which can meet the users' requirement on accuracy for the system (Wu B F, 2004; Li Q Z, 2004).

5. PROGRESS

CCWS has been making great progress in terms of content, quality, range, and frequency each year since 1998.

5.1 Monitoring Area

The CCWS continuously expands its monitoring area. From 1998 to 2006, its monitoring area has expanded from east China to national wide, to north and South America, to Australia and Thailand. Now, almost all the main grain producing countries in the world are monitored by CCWS. Meanwhile, the CCWS continuously expands its monitoring contents, from crop condition monitoring, crop acreage estimation and crop yield prediction, to grain production, crop structure, cropping index, etc (Wu B F, 2004).

5.2 Data Source

NOAA/AVHRR, SPOT/VGT, Landsat TM used to be the main data source of the system. But now CCWS is converting its main data source to MODIS, IRS P6 and RadarSat. IRS data can cover a large area than TM at the same expense. Experiments and analyses were carried to evaluate the applicability of a new remote sensing data before it is used in the system. Corresponding data pre-processing systems were developed to process these data which can also guarantee the data quality.

5.3 Methodology

CCWS has been continually improving its methods on the following aspects in the last 9 years:

5.3.1 Crop yield prediction: There are four models for the prediction of yield per unit area within CCWS, including agro-meteorological model, remote sensing index model, a combination model of the above two and the biomass model. Each model has its own value. Four models are integrated into one value based on the ground observation data and for different regions. The zonal suitability of different models was also discussed (Xu Xingang, 2007).

5.3.2 Drought monitoring: Vegetation Condition Index and Temperature Condition Index from remote sensing data are used to calculate Vegetation Health Index, with different weight coefficients. Weight coefficients are based on the relation analysis of two indices and soil moisture from ground observation for each drought zone of China (Mu Lingli, 2006). Vegetation Health Index has been used to monitor drought since March 2005.

5.3.3 Crop growth monitoring: Taking the main food crops as monitoring target, CCWS studied the suitability and validity of six remote sensing indices in different zones, for different crops and at different growing periods both in real-time monitoring and crop growing process monitoring. The six remote sensing indices used in the study are NDVI, LAI, NPP, TCI, VCI and NDWI. It found that NDVI, LAI and NPP are good indices. The country scale index collection for crop growth monitoring with remote sensing were build after research (Meng jihua, 2006).

5.4 Systematization

While continuously researching and applying new methods and models to the system, CCWS also improve the systematization of the system. Systems and models are developed for different purposes of monitoring. Systematization helped the system to generate standard monitoring result, which can also help to increase the efficiency of the system by reducing its production time.

6. FUTURE ACTIVITIES

To improve its services, CCWS development are focusing on the following aspects: (1) Reduce the operational expense by reducing the ground survey and increase the use of remote sensing data in the system. (2) Develop a new serving method for delivering crop relevant information to clients. (3) Improve the quality of existing products. (4) Improve the systematization degree of the system.

References

Sun Jiulin, 1996. *Pandect on Dynamic Monitoring and Yield Estimation for Crop in China*. Beijing: China Sciences & Technology Press, pp. 11-13

Chen Shupeng, Zhao Yingshi, 1990. *Ceo-science Analysis of Remote Sensing*. Beijing: Publishing House of Surveying and Mapping, pp. 19-21

Wu B F, 2000a. Operational remote sensing methods for agricultural statistics. *Acta Geographica Sinica*, 55(1), pp. 23-35

RAO M. V. K, Ayyangar R. S, 1982a. Role of multispectral data in assessing crop management and crop yield. *Machine Processing of Remote Sensed Data Symposium*, pp. 1103-1112

Wu B F, Tian Y C, 2004. GVG crop process monitoring system. *Journal of Remote Sensing*, 8(6), pp. 570-580

Wu B F, Zhang F, 2004. The integrate method for crop growing monitor. *Journal of Remote Sensing*, 8(6), pp. 498-514

Meng Q Y, Li Q Z, Wu B F, 2004. Operational crop yield estimating method for agricultural statistics. *Journal of Remote Sensing*, 8(6), pp. 602-610

Cook, Paul W, Doraiswamy P C, 1995. Spring wheat yield assessment using NOAA AVHRR data. *Cananian Journal of Remote Sensing*, 21(1), pp.43-51

Wu B F, Li Q Z, 2004. Crop acreage estimation using two individual sampling frameworks with stratification. *Journal of Remote Sensing*, 8(6), pp.551-569

Li Q Z. Wu B F, 2004. Assessment of crop proportion monitoring using Landsat TM imagery. *Journal of Remote Sensing*, 8(6), pp. 581-587

S. M. E. Groten, 1993. NDVI crop monitoring and early yield assessment of Burkina Faso. *International Journal of Remote Sensing*, 14 (8), pp. 1495-1515

Zeng L, Zhang Y, Wu B F, 2004. A short-term model of grain supply and demand balance based on remote sensing monitoring and agriculture statistical data. *Journal of Remote Sensing*, 8(6), pp. 645-654

He L H. The relationship of VEGETATION-derived index and site-measured rice LAI. *Journal of Remote Sensing*, 2004, 8(6), pp. 672-676

Fan J L, Wu B F, 2004. Methodology of cropping index retrieval from NDVI profile. *Journal of Remote Sensing*, 8(6), 628-636

Mu Lingli, 2006. Agricultural drought monitoring with vegetation condition and temperature condition. *World Sci-tech R&D*, 28(3), pp. 26-31

Xu Xingang, 2007. *Research of Crop Yield Models*. PhD dissertation of IRSA, CAS, China, pp. 27-68

Meng Jihua, 2006. *Research on Crop Growth Monitoring Indicators with Remote Sensing*. PhD dissertation of IMHE (Institute of Mountain Hazards and Environment), CAS, China, pp. 78-89