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[redacted]S-GPS-Based Agricultural Condition Monitoring Systems at a National Scale

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Abstract: China has a large population and limited arable land. It is essential to monitor agricultural condition, mainly annual farmland variation, crop condition and forecast grain yield for government decision making. In recent years, information technology has made considerable progress and 3S technology, Remote Sensing, GIS and GPS, have been used for resources and crop monitoring at a national or global scale. 3S technology based on agricultural condition monitoring systems at a national scale is introduced in this paper.

Key words: RS; GIS; GPS; agricultural condition; agricultural resources; crop condition; yield estimation

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1 Introduction

Agricultural condition monitoring includes agricultural resources and crop monitoring. The objective of resources monitoring is to monitor the quality and quantity of arable land and their changes. Crop monitoring is to monitor main crops acreage and distribution, crop condition, disasters and yield estimation. China has a large population and limited arable land. It is essential to monitor annual agricultural conditions for government decision making.

In recent years, information technology has made considerable progress and 3S technology, RS (Remote Sensing), GIS, GPS and Internet, have been used for resources and crop monitoring at a national or global scale. RS and GPS are used for data collection, GIS is used as a data analyzing center and Internet provides a very fast, convenient and economic method for information exchange. The decision making technology has a revolutionary on collecting objective, timely and regular information at a national scale. Today, crop condition and grain yield information is sensitive to the world grain market.

Development of 3S technology based agricultural condition monitoring systems at a national scale in the Ministry of Agriculture was introduced in this paper mainly based on the authors' three projects: (1) 3*S-based resources and enviromental information system for the Ministry of Agriculture* is supported by the Department of Science and Technology (1997～2000); (2) *A pilot project of national agricultural condition monitoring system for the Ministry of Agriculture* is supported by the Ministry of Agriculture (1996～1999); (3) *Crop condition models based on characteristic papameters of NDVI(Normalized Different Vegetation Index)* is supported by National Natural Science Foundation of China (1999～2001).

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Biographies: Yang Bangjie (1948－), Ph. D., professor, vice president of Chinese Academy of Agricultural Engineering. Email: bjyang@agri.gov.cn; Pei Zhiyuan and Zhang Songling, senior engineer.

2 3S-based Agricultural Resources Information System

2.1 Resources and Environmental Information System for the Ministry of Agriculture (Agri-REIS)

The objective of this project is to develop an information system using RS and GIS, to collect arable land information and statistical data to provide the government with agricultural resources and environmental information for China's sustainable agricultural development.

2.2 The Technical Index of AgriREIS

The Information System with a scale of 1∶250 000 at a national scale and 1∶100 000 in some development areas such as Beijing-Tianjin Metropolitan Area, Yangtze River Delta and Zhujiang River Delta areas using Landsat TM data. The land use was identified as 28 categories[1].

2.3 The Information Demand of the Ministry of Agriculture

The Ministry of Agriculture needs resources and environmental information for:

1) Quantity of farmland, grassland and potential land for agriculture; 2) Variety of land use such as crop structure or changes to other use; 3) Quality of farmland such as pollution, salinity, desertification and fertility.

Some information cannot be obtained from satellite remote sensing, additional information comes from traditional statistic information collected by field investigation.

2.4 Information System Design[2]

The system was designed as a GIS based information system (Fig. 1).

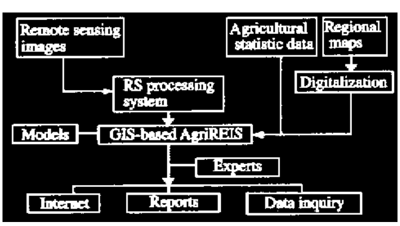

Fig. 1　The structure of the resources and environmental information system for the Ministry of Agriculture

1) Data resources: data come from remote sensing, agricultural statistic data and historical information.

2) GIS based information system: GIS was used for data storage, integration and analysis for decision making.

3) Information release: The information was summarized in thematic maps, reports for government and a part of information is released on the Internet for the public.

2.5 Decision Support System

The decision support system was organized by models, information and experts' experience[3]. Experts do the decision analysis with survey data and images from the GIS based AgriREIS. The reports are sent to related departments of the Ministry of Agriculture. The system can support reliable and timely information for government decision making.

3 3S-Based Crop Monitoring System

3.1 Ground Monitoring System

Traditionally, there is a ground monitoring system all over the country organized by the Ministry of Agriculture. Every county has an agricultural monitoring office in the local government. They collect crop information such as crops acreage, field management, crop condition, disasters and production, as arranged by the Ministry. The advantage is that complete data can be collected, but there are obvious shortcomings: 1) Subjectivity: the information is collected by many people all over the country with their own judgements, it is difficult to do this to the same standard; 2) Timeliness: collecting information from field and sending it to central government is a time consuming work; 3) Limited area coverage: collecting crop information is limited to a small number of points because of time and money restrictions. With information from limited points, it is impossible to draw a crop condition map of China.

3.2 Crop Monitoring Using RS

1) Objectives and advantages

Remote Sensing is used for crop monitoring including crop distribution, acreage, growth condition, disaster and yield estimation. The advantage of RS monitoring is to collect the whole country's information quickly, objectively and economically. Some information must be obtained from the ground such as disease, and in some areas it is difficult to get images because of clouds. Crop monitoring needs ground information support.

2) Advances and problems

In 1980s, RS was used for crop monitoring in United States and European countries. From the Sixth Five-Year Plan (1981～1995), yield estimation using RS was the key state research project supported by the government. However, there was no operational system at a national scale which could be used by the Ministry of Agriculture. The reasons were: 1) Technical problems: in China, because of small-scale family farms and mixed crop systems, it is difficult to analyze even clear images; 2) Financial problems: expensive images are needed for an operational system at a national scale, especially for monitoring paddy fields, expensive radar images are needed; 3) Organizations: researchers think more in terms of academic achievements, not operational systems for the Ministry of Agriculture.

So, integrated information from RS and ground monitoring are needed for the Ministry of Agriculture, not only RS. Operational systems are different from academic achievement, therefore government and research institutes need to cooperate.

3.3 3S-Based Crop Monitoring System

The objective of this project is to develop a national crop monitoring system integrated with remote sensing and ground monitoring.

1) Technical approaches

The guidelines of the system design are: 1) crop condition monitoring and yield estimation at a national scale; 2) economical and timely operational system; 3) integrated remote sensing and ground monitoring.

In European countries, yields have been estimated by modeling the unit of production and measuring the crop acreage with a high spatial resolution remote sensing. This approach has problems of high cumulative error and expense. Another approach is to use high time resolution image NOAA data to estimate yield, this method is suitable for national scale and low cost, the problem is that it is difficult to measure acreage.

The main ideas of this research are: 1) the priority is for crop acreage estimation, because sown area is the first step to guarantee grain production; 2) Crop condition monitoring is useful for government to guide agricultural management and early yield estimation, and also suitable for RS monitoring; 3) Yield at a national scale will be estimated by cumulative NDVI model and ground information. The technical approaches are to develop crop condition and yield estimation models using cheap and high time resolution NOAA data, to rely on support from the ground monitoring system, and to use a GIS as a data analysis center with a land use information system AgriREIS (Fig. 2).

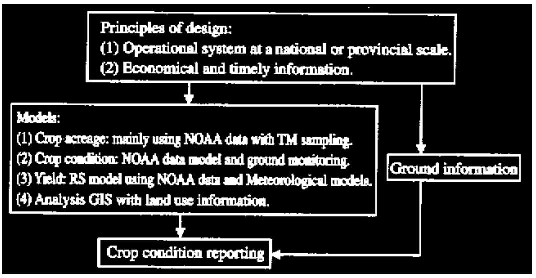

Fig. 2 Technical approaches for crop monitoring

2) Design of crop monitoring system

(1) Function of the system

The functions of the system include: crop identification and area measurement; crop condition monitoring; disaster monitoring; and yield estimation.

(2) System structure[4]

The structure of the system was designed as in Fig. 3 including three models: RS-GPS based data collecting subsystem; Internet based communication system; and GIS-based data processing, analyzing and reporting system.

3.4 Definition and Monitoring of Crop Condition

1) Definition of crop condition

In the late 1970s and early 1980s, considerable research efforts were focused on the use of multispectral images for crop inventory and crop production in USA. In 1990s, they were changed to pre-

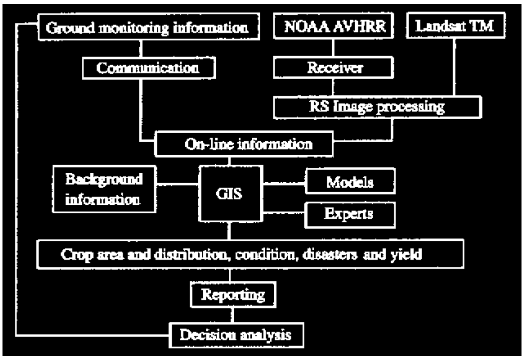

Fig. 3　3S-based crop monitoring system

cision crop management[5].

From the 1980s, yield estimation using remote sensing was researched for about twenty years. But actually, crop growth condition and tendency monitoring, namely crop condition monitoring, is the most important task for agricultural remote sensing applycation. The objectives of crop monitoring are (1) to support crop management; (2) for early yield estimation. There are no clear definition for crop condition and no standard calculation method for remote sensing monitoring. Crop condition models based on characteristic parameters of NDVI is a research project supported by National Natural Science Foundation of China (1999～2001). The objective of this research is to give a scientific definition, to develop RS models and standard measurement methods for crop condition.

Crop condition means crop growth condition and tendency, and can be described by individual and community characteristics. Good crop condition is considered as a crop community with a group of healthily developed individuals. The individual characteristics can be described with stem, leaf, root and ear's conditions. Crop community can be described by the community's density, distribution and development. Leaf Area Index (*LAI*) is a comprehensive parameter related to individual and community characteristics[6].

2) Approach of monitoring using RS

LAI can be measured by RS. *LAI* is a comprehensive parameter related to crop condition and can be measured by RS. All plants need sunlight for photosynthesis and try to get more energy from sunlight. That is why *LAI*s are very close each other in the same growth stage. *LAI* can be measured but the individual and community characteristics still need ground observation.

NDVI is a commonly used RS parameter related to *LAI*, growth stage and biomass. The approach for crop condition monitoring using RS is to measure *LAI* and estimate the crop condition by models integrated with *LAI* and information on the growth stage observed on ground (Fig. 4).

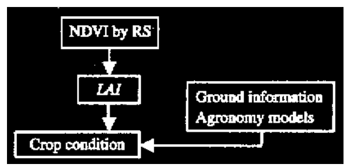

Fig. 4　Approach of crop condition monitoring

3) RS models of crop condition

There are two kinds of RS crop condition models. One is for crop condition evaluation and another for diagnosis.

Evaluation models include the following two kinds of models[6]: comparison year by year and grading models.

The evaluation models are used for early yield estimation and diagnosis models are used for field management. Diagnosis models include crop growth stage, fertilizer and water conditions, disease and insects, weeds identification ,etc.. Only NDVI is not enough for diagnosis models, a group of parameters, or a vector, is needed to model the situation[6].

4　Conclusions and Prospects

1) Operational monitoring methods development has been paid more attention to in this research. 3S-based resources and crop monitoring systems at a national scale are developed and used in the Ministry of Agriculture.

2) Development of crop diagnosis models is a

challenge for agricultural RS scientists as the same situation in precision agriculture.

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基于 3S 技术的国家级农情监测系统

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摘　要：中国人口多、耕地有限，农情信息主要是耕地与粮棉作物生产的信息，对生产管理与政府决策是至关重要的。农情监测的主要任务是监测耕地的变化，粮棉作物的面积、长势、灾害与产量。由于信息技术的发展，3S 技术，即遥感(RS)，GIS 与 GPS 技术，已用于国家与全球尺度的农情监测。该文介绍了作者近年来承担国家与农业部的科研项目而开发的农业部农情遥感监测系统与信息服务系统。

关键词：RS；GIS；GPS；农情；农业资源；作物长势；估产

基于3S技术的国家级农情监测系统

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相似文献(10条)

1. 期刊论文 何庆成 RS和GIS技术集成及其应用 -水文地质工程地质2000,27(2)

本文简要地介绍了RS（遥感图像处理系统）和GIS（地理信息系统）技术及其集成的基本概念和方法。讨论了RS和GIS技术及其集成的内在涵义、相互关系，认为RS是GIS重要的外部信息源，是其数据更新的重要手段，尤其对于全球性的环境变化研究和地理动力学分析，更必须有RS所提供的覆盖全球的动态数据与GIS的结合。反之，GIS则可以提供RS所需要的一些辅助数据，以提高RS图像的信息量和分辨率，同时，GIS可以将实地调查所获得的非遥感数据与遥感数据结合，从而提高RS图像处理和解释的精度。而RS和GIS技术的结合集遥感、地理信息系统技术的功能于一体，构成高度自动化、实时化和智能化的地理信息系统，是空间信息适时采集、处理、更新及动态地理过程的现势性分析与提供决策辅助信息的有力手段

2. 期刊论文 马荣华.毛端谦.胡孟春.黄杏元.MA Rong-hua.MAO Duan-qian.HU Meng-chun.HUANG Xing-yuan 综合RS与GIS方法的海南生态环境研究 -江西师范大学学报(自然科学版)2000,24(4)

以1987年海南植被类型图，1988年海南省土壤侵蚀图和1987年与1988年的TM遥感资料为信息源，综合应用ERDAS和ARC / INFO软件分析了海南建省前后生态环境的变化情况，并对生态环境现状进行了评价.结果表明，作为本区自然生态环境质量标志的季雨林、雨林面积变化不大，自然生态环境质量由中部山区向外依次降低.人类活动对自然生态环境的影响明显，人工植被大幅度增加，但天然植被面积呈现减少趋势.

3. 期刊论文 何华春 RS及GIS技术在风景区规划制图中的应用 -中南林业调查规划2002,21(4)

以湖南省攸县酒埠江风景区为例,探讨了RS和GIS集成技术在风景区规划制图中的实际应用,阐述了将RS和GIS技术应用于制作风景区旅游规划专题图的重要意义及主要途径.

4. 期刊论文 张宇.谷建才.曹立颜.陈平.杜剑 基于RS和GIS的径向基神经网络模型对森林蓄积量的估测 -浙江林业科技2009,29(5)

以塞罕坝机械林场的华北落叶松林为研究对象,利用SPOT5影像,基于RS和GIS确定蓄积量主要影响因子,即海拔、坡向、郁闭度、SP1、SP3、SP1/2、SP1-2/1+2、SP2~*3/1,选取径向基神经网络模型中的广义回归神经网络模型对其蓄积量进行估测.结果表明:对林分蓄积量估测的最高精度为98.70%,最低精度为68.56%,预估检验的所有样地的平均精度为87.24%.利用径向基GRNN模型建立森林蓄积量估测模型对蓄积量进行估测时,效率高,计算方法比较简洁,易于操作.

5. 期刊论文 乔家君.毛磊.QIAO Jia-jun.MAO Lei 基于RS、GIS村域农田数据库设计研究——以河南省吴沟村为例 -农业系统科学与综合研究2009,25(3)

以河南省巩义市吴沟村为例,以卫星遥感图像为建库数字化参照依据,采用目视解译方法,利用ERDAS Imangine 8.6和MapInfo Professional 7.0 SCP为数据库平台,依次提取出旱地梯田、旱坡地、菜地、退耕还林地等不同图层的田块,根据分析处理要求,针对农田系统的特征进行数据结构设计,建立相应的农田空间数据库;以2008年4月以及2002年4月两次对吴沟村全体农户的实地调查为基础,建立农田各种形式的投入、产出能量数据库.完成的数据库可以实现如下功能:①数据浏览与操作功能,如对农田系统信息的放大、缩小、漫游、全图等以及时全村现有482块农田地块的查看和修改:②数据管理和维护,如时吴沟村农田数据进行条件查询、SQL查询、Mapbagic程序查询等.③数据转入和转出,可以将Mapinfo下的农田数据转入或转出到其他GIS软件中,扩展该农田数据库的使用范围.图5,表1,参11.

6. 期刊论文 王晓红.刘耀林.彭恢铭.WANG Xiao-hong.LIU Yao-lin.PENG Hui-ming 应用RS和GIS技术监测石漠化

的研究 -中国水土保持2006(5)

在介绍石漠化及其危害的基础上,阐述了基于RS和GIS技术监测石漠化的意义、应用RS和GIS技术监测石漠化的研究现状和监测方法,提出目前存在的主要问题:①石漠化调查资料缺乏;②应用RS和GIS技术监测石漠化还没有形成较合理、完善的研究方法,也谈不上信息共享和实际应用;③还没有建立基于RS和GIS技术的石漠化预警预报模型和运行系统.建议加大采用RS和GIS技术对石漠化的研究工作力度,探索石漠化遥感调查监测的实用技术,建立石漠化预警预报模型和运行系统,同时采用新机制,增强石漠化调查与评价的服务意识.

7.期刊论文 穆斯塔克·达力伯·贾巴.冯健.孙冬英 基于RS和GIS技术对中国陕西省北部地区土壤水蚀风险评估 -水土保持通报2005,25(1)

运用遥感(RS)和地理信息系统(GIS)技术来进行中国陕西省北部地区的土壤水蚀风险评估.综合运用RS和GIS技术以及修订的通用土壤流失方程式(简称RUSLE)来定量化地评估土壤侵蚀.建立了一个关于土壤侵蚀、斜坡长度/坡度、降雨侵蚀和人类活动的评估系统.评估值输入修订的世界土壤亏损方程式中,用来计算土壤退化进程的风险,土壤退化又叫土壤侵蚀.利用榆林和靖边两地区的1987年和1999年的陆地卫星TM传感图像来制作研究区土地使用/覆盖情况的地图,然后用这些地图产生RUSLE方程中的人类活动因子.使用ER mapper/Info两个软件来管理和处理主要数据,及处理卫星图像和表格数据源.根据统计分析,3 985.9 km2(33.12%)的土地面积有轻微到中度的土壤侵蚀,2 941.4 km2(24.44%)的土地面积有高的土壤侵蚀,总土地面积中3 522.1 km2(29.27%)正面临着很高的土壤侵蚀风险,总体上来说,研究区处于高的土壤水蚀风险中.

8.期刊论文 徐彬 GIS与RS系统集成研究 -计算机与现代化2009(11)

RS信息具有周期动态性、信息丰富、获取效率高等优势,而GIS则具有高效的空间数据管理和灵活的空间数据综合分析能力,但两者均有一定的局限性.随着GIS技术和RS技术的发展,人们迫切希望能够将RS的强大的图像处理与GIS强大的空间分析等结合起来,解决日益复杂的环境问题,因此,GIS与RS的系统集成问题成为关注的热点.本文通过综合分析GIS与RS系统集成现状,探讨GIS与RS系统集成的技术方法、关键问题和方式.随着对地观测技术的发展,以RS为核心,融入GIS功能的系统集成已成为当前发展的主要趋势.

9.期刊论文 高龙华.张行南.GAO Long-hua.ZHAGN Xing-nan RS和GIS支持下农业非点源污染模型研究评述 -中国水土保持2005(11)

农业非点源污染主要由降雨径流、土壤侵蚀、地表溶质溶出和土壤溶质渗漏4个过程形成.从数据获取和数据处理两方面分析了农业非点源污染模型研究中引入RS和GIS技术的必要性和可行性,总结了模型与RS、GIS的集成主要表现为3个层次,在此基础上提出引入空间决策支持系统是集成研究的发展方向,将目前模型与RS、GIS集成方式概括为松散集成、紧密集成和完全集成3种,阐述了每种集成方式的实现方法和难易程度.综合叙述和展望了国内外农业非点源污染模型与RS、GIS集成研究取得的成果和最新研究进展,分析了集成研究面临的问题,对其中的主要问题如模型验证、运算效率以及模型与GIS匹配问题进行了深入探讨并且提出了解决的办法.

10.期刊论文 苏建云 GIS技术对RS图像信息提取的影响 -泉州师范学院学报2001,19(4)

现代技术的发展促使了GIS与RS的结合,由于是两个相对独立的系统,GIS技术的引入必将对RS产生影响,尤其在RS的图像信息提取方面.文中从GIS与RS结合的背景、GIS技术对RS图像信息提取的影响、存在问题、前景展望等方面进行论述,以期让人们对二者的结合有较深入的认识.

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