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Application of China–Brazil Earth resources satellite in China

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Abstract

The launch and successful operation of Chinese–Brazil Earth resources satellite (CBERS-1) in China has accelerated the application of space technology in China. These applications include agriculture, forestry, water conservation, land resources, city planning, environment protection and natural hazards monitoring and so on. The result of these applications provides a scientific basis for government decision making and has created great economic and social benefits in Chinese national economy construction. In this paper we present examples and provide auxiliary documentation of additional applications of the data from Earth resource monitoring.

Keywords: Resource satellite; Geological hazards monitoring; Environment monitoring

1. Introduction

The successful launch and operation of CBERS-1 has brought great convenience to the geological hazards monitoring in China and the concerning data has been applied to spheres like agriculture, forestry, water conservancy, land resources, minerals, city planning, environment protection and marine resources. Moreover, there have been great achievements, such as agricultural crops' yield estimation, monitoring survey of ecosystem and environment, investigation of mineral and underground water resources, investigation of natural hazards, coal bed spontaneous combustion, monitoring, city expansion and transportation networks, study on urban environment pollution and heat-island effect, and engineering route selection (Baugh et al., 1998). Remarkable economical and social benefits have been achieved in the application and several examples are discussed in this paper.

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2. Application to crop classification and monitoring of the growing condition

The application of CBERS-1 to agriculture primarily concentrated in crop classification and growth condition monitoring, and survey of crop cultivation area, land use and agricultural natural resource situation, crop's ecological environment and distribution of farming crops.

2.1. Crop remote sensing yield estimation in Nanjing

In this mission, CCD data of CBERS-1 that was served as main information source and other remote sensing and geographical information was taken as reference to integrate crop remote sensing yield estimation system to provide data basis for agriculture restructuring by local government.

2.2. Establishment of remote sensing monitoring system for cotton cultivation area in Xinjiang province

After computer image processing of CBERS-1 CCD data, it could be used to collect the distribution of cultivated

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land and to calculate cotton cultivation area in Xinjiang. The establishment of this system is a task aided by the foundational background database of GIS to plan cotton cultivation in Xinjiang province. At first, design and calculation of sampling frame and outer frame model were made with CBERS-1 data from optimum temporal to collect data of land area under cotton cultivation. Then, these data were assembled at the remote sensing monitoring system in Xinjiang and put into a national wide system. This professional operation has done very well as the system has filled a gap in the cotton monitoring in Xinjiang and made a contribution to direct farming production and supply data for macroscopic decision making.

2.3. Establishment of Chinese land use/vegetation time/space database

It is a program conducted by Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science. In this program, 1300-view CCD data of CBERS-1 data has been collected to establish the "Time/Space Database of Chinese Land Use/Vegetation" (Phinn, 1998). The construction of the database brings great convenience to classification of agricultural crops. A map of wheat and rape distribution in 2000 Nanjing has been completed, in which a high precise classification has been done for those concurrently growing crops of wheat and rape. Later to meet the needs of the Western Opening in China, the database was used in zoning of high quality farming crops in Guixi of Jiangxi province and used in pasture monitoring and land use survey in desert area (Friedl and Brodley, 1997).

3. Application to land resource survey

3.1. Application to water and mineral resources

CBERS-1 has been widely used in water conservation. In Tianjing where surface water resource is increasingly shrinking, the shortage degree of surface water resource has been identified and the scientific data and maps have been provided for decision making in harness of water shortage by divisions of water resource.

CBERS-1 data has also been used in geological surveys, selection of target mineralization area and land use planning. In project of "Survey and Appraisal of Mineral and Underground Water Resource in Northern Border of Talimu Basin", CCD data of 40-view CBERS-1 was used to make remote sensing mosaic images in the scale of 1–0.25 millionth for southwest Tianshan Mountain in northern border of Talimu Basin; appraisal of mineral resources, forecast of the favorable rich section for minerals and selection of the area of shallow underground water storage have been fulfilled (Saraf and Choudnury, 1998).

An analysis of its geological environment and evolution, an interpretation remote sensing map of shallow underground water distribution in Talimu River reaches on the scale of 1–0.25 millionth; A remote sensing ecology map in the scale of 1–0.5 millionth and a forecast map of mineral prospecting and a map of ecological geology have been completed. And the present situation and future tendency of ecological environment factors' distribution area has been measured and its prospect has been analyzed. In this project, the encircled shallow underground water sections, four target areas of gold/copper mineralization and five gold/copper ore body in Jigen areas are all valuable practical achievement for the Western Opening movement, and showed a direct impact to ecological management of Talimu region. Besides, some practical achievements have been made in engineering ecology, mineral thematic maps, uranium mine prospecting, oil field environment monitoring and assessments.

CBERS-1 data have also been employed in zoning research in the Jingyu volcano mineral water protection area in Changbaishan Mountain. The research result has played an important role in attracting investment and establishing a joint venture between Wahaha Group and Nongfushanquan Group.

3.2. Survey and monitoring of forestry resources

Tibet is a region of rich forestry resources with a top reservoir in China. As Linzhi forest is situated in southeast Tibet and the borders on south piedmont of Himalaya Indian, it is hard to carry out survey in the traditional manner. With the successful launch and operation of CBERS-1, the local satellite remote sensing system has got enough information to do all-round survey for forest resources. In the survey, 31-view CBERS-1 CCD data was applied to carry out standard forest classification by computer supervised classification method with consideration of local features. And a 2-grade classification of local forest reservoir has been completed in which the accuracy degree is 86.14%. The lowest and the highest grades of the forest reservoir are 0.50 and 1509 m^3/hectare, respectively. In results of the double-layer sampling interpretation the accuracy of the reservoir of the live standing timber is as high as 92.9%. The total forest reservoir in Linzhi district is two billion m^3 and the interpretation accuracy is 91.4% which is 6% higher than the accuracy of 86.9% obtained in 1997 and 1991. The method and experience will be an important foundation for future extension of CBERS-1 data in the forestry survey in China (Chen, 1996).

In addition, in application of digital Guizhou, CBERS-1 has been used in survey of Guiyang city forest resource and in survey and monitoring of the Red Forest.

3.3. Integrated land resources survey and city planning

The territory of Xinjing Autonomy accounts for more than one sixth of China, so it is not easy to conduct conventional land resource survey in so vast land. In 2000 combined with other remote sensing information, CBERS-1 data was applied to carry out overall survey mainly including national land resource environment, in which Xinjiang, Tibet autonomy, and Taiwan island and its surrounding region were included in order to understand natural conditions in Diaoyu island and the like. The whole national land resource was known clearly through the above survey.

CBERS-1 has been used in remote sensing application of city group expansion of Changsha-Zhuzhou-Xiangtan city in Hunan province. The main content of the city group expansion remote sensing survey is to study the group's process of revolution, to interpret remote sensing images from various times, to collect relevant information, to analysis expansion of space structure of the city group, to analysis changes of its communication network, and to forecast the city expansion tendency (Gong et al., 1995).

4. Application of CBERS-1 to monitoring of geological hazards

4.1. Earthquake hazards evaluation

On November 8th, 1997 an earthquake happened in Mani district, Tibet. It was the greatest one in a long term of 20 years. Mani is in a region with no habitation and no conveniences of transportation thus limiting the study on seismic faults. A linear trace of 220 km long could be read in CBERS-1 image by which an earthquake expert interpreted that the fault acts actively up to nowadays. The image demonstrates that in a range from Madangaichaka Lake to Chaoyang Lake, the leftward twist happened simultaneously by a serial of rivers that pass near the fault. It suggested the fault had a remarkable parallel movement and a leftwards movement about 3600 m had occurred. Mani earthquake fault has resulted in an Earth surface broken belt more than 110 km long and a maximum 6–7 m leftwards movement. The information from CBERS-1 supplied a scientific basis for collecting information of earthquake condition, for identification of Mani earthquake source and hazards evaluation.

4.2. Monitoring of landslide in yigong, Tibet

An exceptionally serious landslide happened on April 9th, 2000 in the tributary of Brahmaputra and Yigong River of Tibet and the sliding accumulation of rock and stone which was about 100 m high locked Yigong River and formed a barrier lake. It happened in the raining season and the water melted from snow poured into the lake constantly, so the height of the lake increased at a high speed. Monitoring the remote sensing images of May 6th, we saw that the landslide body slid from the elevation of 4550 m directly to 2200 m, the vertical height of the slide was 2350 m and increased to 2750 m on May 9th, and the heights of the landslide body rose to the elevation of 5100 m (Wang, 2003).

The relief and environment surrounding the Yigong Lake can also be manifested in the remote sensing images before the landslide. The total area of the Yigong Lake was 26 km^2 and the seeper of the lake surface was 9 km^2 before the landslide; the seeper increased to 20 km^2 on 13th April; the Lake was fully filled with water and the color of the water changed from clear blue to dirty white on 4th May; it became even bigger and the surface Lake area reached 37 km^2, and the bank was nearly crushed on 9th May. On 20th May (the 41st day of the landslide), the lake water remained rose rapidly, the area reached 43.6 km^2 and the bank was nearly crumbled (shown in Fig. 1, the surface lake water was blue before landslide and red after the landslide). On June 10, the bank was completely collapsed and there was evident deluge in the lower reaches of Yigong River and the big curve area of Brahmaputra. Two months after that, what can be shown on the remote sensing image of August 16 was that the river water along the two banks of Yigong River and the big curve area of Brahmaputra had dropped back to the original channel. During the two months, the height of the Yigong Lake increased about 100 m and the area of the seeper enlarged about 3.8 times, it was calculated that the gross of the flood reached 3.52 billion km^3, and the super mud-rock flow about 4.1 billion km^3 was formed. Moreover, Application Center of Chinese Earth Resource Satellite has timely carried out the observation of CCD camera side sway and by the data it was calculated that 37.1 km^2 cultivated land, resident land and high way area was involved in the landslide in 30 days of the hazards. The remote sensing information we got provided the real conditions of the hazards and a scientific basis for the decision making of hazards control and relief. This kind of application to hazards survey and monitoring showed remarkable impact and demonstrated the great importance to keep the initiative of satellite remote sensing in our own hand. The Application Center of Chinese Earth Resource Satellite made a timely observation of CCD camera side sway, which not only supply CCD data to monitoring, but also evaluated effect

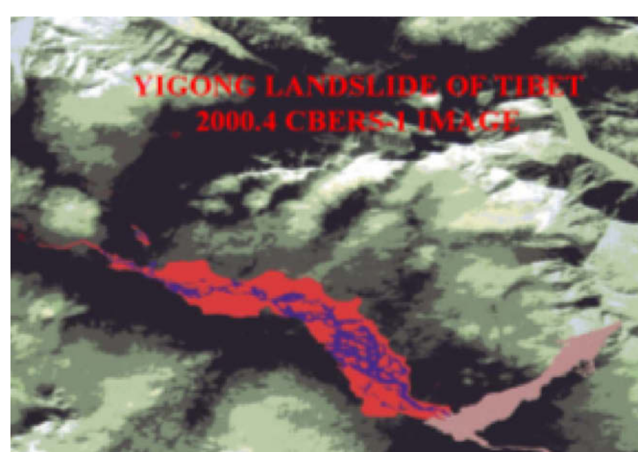

Fig. 1. Image of the Yigong Lake on 20th May (the 41st day of the landslide).

of Yigong landslide. The technology of the remote sensing followed the complete course of hazards, which played a big role in the resist and relief of the Yigong landslide and the flood disaster (Tassan, 1997).

4.3. Survey and monitoring of coal bed spontaneous combustion

It is effective to use CBERS-1 infra data and CCD data to do a survey of the spontaneous combustion of underground coal beds. In Ruqi valley of Ningxia Province from a colorful composite image of IRMSS B978 and B967, information about hazards area of coal bed spontaneous combustion has been collected to understand relatively accurate hazards extension. It provided useful basis for effective controlling underground coal fire. The coal bed spontaneous combustion will not only bring loss to mineral resource but also bring environment pollution, natural ecology damage and desertification.

5. Application to investigation and monitoring of ecosystem

Problems of damaged ecological balance and aggravation are limiting factors to sustainable growth of Chinese national economy. CBERS-1's application to survey and monitoring of the original and the changing situation of ecological factor is an important task. To control the aggravation and to recover and rebuild ecosystem's harmony is policy of Chinese government and is a good field for scientists to give full play to their abilities.

5.1. Survey and monitoring of desertification

Desertification is very serious in the West of China where there is drought, water shortage, sparse vegetation and margin ecological balance. The inferior ecological system is a limiting factor to economy growth and social development. In 2000, research on monitoring of desertification in the West has been conducted by Chinese Institute of Forestry Design and Planning. In six monitoring districts, zoning graded by desertification degree was done through comparison of CBERS-1 data in 2000 and information from the Land sat TM in 1987, and relevant ecosystem management and protection measurements were put forward. All these six districts covers a total area of 3.95 million hectares and the total cartography area is about 40,000 km^2; All groups have thematic map made about land use and desertification and so on. Through a comparison of land areas of various desertification conditions, the desertification degree, resulted desertification rate and amount for 13 years have been obtained and at the same time the possibility to control desertification is proved through remote sensing survey of the key monitoring districts. It is concluded that human conducted control is capable of slowing desertification course and improving regional ecological environment.

5.2. Case analysis of remote sensing survey for regional sustainable development

In study on sustainable development of the delta of the Yellow River, some self-generating environmental factors like ecological course, evolution of the delta, water contamination and soil salinization have been investigated. Using CBERS-1 data and other remote sensing information, we obtained six maps of seaboard evolution about different periods from 1976 to 2000 to demonstrate the evolution course of the Yellow River estuary, the moving course of land cover center and 25 years' history of the delta's change. In addition, zoning of seaboard functions has been done and its database has been established. And the evaluation of Yellow River water quality has been fulfilled with classification method and qualitative analysis. In this study the indicating system of sustainable development in the delta region consists of six units of economy, population, natural resources, society, ecological environment and science and technology capability in 23 indexes. Eight indexes of these 23 could be obtained from satellite remote sensing data, which suggests the great importance of CBERS-1 to study on sustainable development in China.

5.3. Survey and monitoring of city area environment

Monitoring of the environmental change of nine cities in northeastern Liaoning province has been carried out by Liaoning Center Station of Environment Monitoring. In this study, remote sensing interpretation has been done based on the CBERS-1 data and other background information of the area, and thematic maps of desertification, water resource, environmental geology and geological hazards have been made. Later on based on remote sensing analysis of typical environmental structure of basin cell view in northeastern China, the survey of regenerative resources distribution, bio-mass and present situation of its utilization and synchronous measurement of ground environment spectrum and remote sensing have been done and a relevant spectral database has been established. Besides monitoring and appraisal of some sharp environmental hazards like landslide, mudrock flow, earthquake and unexpected blowout and degenerate environment have been done. A satellite dynamic monitoring/control system of changing urban environmental conditions has been established. The achievements will supply basic data for reasonable utilization and protection of the environment. During the course of the work, a set of standard procedures has been established for spectrum measure, water quality sampling technology and water environment analysis...etc. All these achievements demonstrate that the spadework of satellite remote sensing will be helpful to urban environment management and improvement (Lo et al., 1997).

5.4. Pilot work of environment monitoring in typical area

The pilot program of environment monitoring in Chinese typical area was conducted by a group of scientists organized by the Chinese Academy of Environmental Sciences. In the program on basis of spectrum features of landscape ecological cell from CBERS-1, a classification system of 4 groups and 27 subgroups for remote sensing monitoring for landscape ecological cell view in Dianchi valley in Yunnan province has been set up. In the program a dynamic analysis for the ecological environment has been done with remote sensing technology to establish non-spot contamination pressure at various times and to find out the cause of the pressure change. It was concluded that the ecosystem's recovery in Dianchi was the only way out for water quality improvement. In remote sensing monitoring of water environment in Taihu and Chaohu lakes, a relational model of water quality data with remote sensing has been developed, in which the coefficiency of aquatic chlorophyll and CCD data of CBERS-1 is 0.8318 and the coefficiency of the total nitrogen and CCD data of CBERS-1 is 0.9237, which gives a demonstration for water quality monitoring with CBERS-1 data. Another application is calculation of aerosol turbidity of air contamination in Zhujiang and Beijing. The results show that the whole calculation values have reached a considerable high accuracy compared with the actual measurements. The fact suggests that the remote sensing technology employed in aerosol monitoring is fairly effective.

5.5. Survey and monitoring of pollution and seaboard environment

CBERS-1 data has been used in survey of classification state of red forest in Shankou area of Guangxi province by Chinese Center of Satellite Application to Sea/Ocean. Information of red forest's distribution has been obtained which supplied scientific basis for protection of red forest and seaboard environment protection planning and management. The results obtained in the land use survey of environmental landscape at Yangtze River estuary show that not only the land use situation becomes clear, but also the CBERS-1 data was also effective in monitoring of land use change of sea beach and evolution of seaboard.

The application of CBERS-1 data in pollution monitoring of sea beach zones is capable of showing pollution situation of aquatic body. In case of remote sensing analysis in Shuang-Tai-Zi estuary, the real measured pollution distribution curve showed a fairly good overlap with that from remote sensing data;Through the monitoring of sea area pollution, the spreading tendency of that pollution was distinguished, the relationship between contaminated water and its transparency, the relationship between nitrogen contents and phosphorus contents in water and remote sensing data could be analyzed (Shi, 2002).

5.6. Survey and monitoring of ecosystem engineering

Recently CBERS-1 data has been applied in more and more programs to national wide ecosystem management. For example, in a program conducted by Shanxi Center of Agro.-remote Sensing to planning of establishment of an animal farming focused area in Yanmenguan district, remote sensing survey and assessment has been done for all cultivated land in the district, especially the land on slope over 25°. In the survey, analysis of posting, directional and quantitative on purpose of land use reversion from crop cultivation to forestry or livestock farming has been done and the result supplied information for decision making by provincial government. In addition, like surveys, with the same purpose of land reverse to forest, to pasture and to lake, have been done in other areas of water shortage or soil/water erosion. The results obtained from the survey will be further used as reference in ecosystem management engineering. In the movement of the Chinese West Opening, surveys to utilize satellites are increasing.

6. Conclusions

The achievements from those applications to varieties of purposes of Chinese natural resources, environment and hazards relief and CBERS-1 data are effective to solve those relevant problems. Those achievements were obtained on the precondition of over 20 years' satellite remote sensing practice and on foundation to own an Earth resources satellite with the initiative in our own hands. The fact demonstrates that CBERS-1 data have played a great important role in national economy construction and social progress in China.

As far as the application of CBERS-1 is concerned, it has attracted great attention from local governments, administration departments and usage institution. On technology development, it has been combined with GIS and formed an application system, and in some cases it has been involved in professional system. Though the application of CBERS-1 is limited by some objective factors like the 26-day revisiting cycle, it has showed its great importance to growth of Chinese National economy. With the successful launch of CBERS-2 and the development and launch of the following ones, resource satellite application is destined to continue.

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