

# STUDY ON THE REMOTE SENSING APPLICATION TECHNIQUES BASED ON CHINESE SATELLITES IN SIBERIAN AREA

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## ABSTRACT:

With the development of the Earth Observation System, many Chinese satellites are launched and used, such as China-Brazil Earth Resources Satellite (CBERS), FY series meteorological satellites, "Beijing-1" small satellite, and so on. The paper studied the application techniques of Chinese satellites in Russia Siberian area. The core research work is divided into 3 parts as below. (1) Chinese satellite land use/land cover monitoring techniques research. (2) Chinese satellite regional environmental background values extraction and parameter inversion techniques. (3) Chinese satellite regional ecological evaluation techniques. Through the 3 kinds of techniques study and experiments validation, the paper analyzed the Chinese satellites remotely images features and discovered some key techniques.

## 1. INTRODUCTION

With the development of the Earth Observation System, many Chinese satellites are launched and used, such as China-Brazil Earth Resources Satellite (CBERS), FY series meteorological satellites, "Beijing-1" small satellite, and so on. Although remotely sensed images collected from these Chinese satellites are widely used in more and more fields recent years, they have not been used outside China. With the development of GEOSS, we should pay more attention to the application techniques and capacities of Chinese satellite in other places outside China. Russia Siberian area is suitable for this research, because this area has not only plentiful natural resources, but also typical regional geographical features which are sensitive to the earth's environment change as below.

### 1.1 Scientific significance to the global change research

Siberian area is the hotspot area in the global change research and Earth System Science integrated research. "Globe change and regional response" has been taken as the basic research facing the nation significant strategic needs in the China National Guideline on Medium- and Long-Term Program for Science and Technology Development (2006-2020).

### 1.2 Regional ecosystem security

Siberian and its south neighboring area locate at the East Asian Monsoon area, where are sensitive to earth's environment change. At present, the area is facing to the problems like drying up of rivers, desertification, inadequate protection of soil and water resources, frequently disasters, etc. All of these compose a serious obstacle to the economic and social sustainable development of related countries in this intersection region.

### 1.3 The integrated research demand of multi-subjects

Research work in Siberian area has integrated and multidisciplinary crossed characteristics. Many environmental factors of global change grades have typical gradual change character in this area. For example, the annual mean temperature varies from -20°C to 20°C. The annual mean precipitation varies from 100mm to 2000mm. The number of population by per square kilometer varies less 10 to more than 1000. The level of land use varies from rare exploitation to high intensity using, and so on. If these dynamic changes information can be detected by remote sensing, this will help to reveal the rules of the resource & environment and ecological evolution and the Regional Response characteristics for multi-subjects need.

## 2. RELATED RESEARCH PROGRESSES

### 2.1 International remote sensing research and application progress in high latitude region

Many countries have launched amounts of survey and investigation projects or engineering on resources and environment by means of GIS and RS techniques, such as land use, land cover, crop yield assessment, vegetation monitoring, soil and water quality survey and so on. For instance, United States Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA) and U.S. Commerce Department launched a joint project for Large Area Crop Inventory Experiment (LACIE) from 1974 to 1977. This project monitored the wheat crop area and accessed its yields in North America with high accuracy (over 90%). Another project for agriculture and resources inventory surveys through aerospace (AGRISTARS) was implemented from 1980 to 1986 which has been developed to an integrated running system.

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1:100 scale land cover datasets also were produced based on remotely sensed data in USA in recent years.

European Economic Community executed the huge project named MARS to monitor the plantation, crop change in Europe since 1992. MARS had the running capacity and reported to the agriculture headquarters of Europe Economic Community every two weeks. Canada has realized macro resources survey, update and mapping mechanism based on RS and GIS recent years.

## 2.2 Resources and environment remote sensing development in China

After several Five-Year Plans, China has achieved huge progress in resources and environment remote sensing synthesized application. From 1985 to 1990, remote sensing technique development has been one of the national key scientific research projects. Large research projects and application engineering have been launched such as loess plateau remote sensing survey, "Three North" protection forest project, and so on. From 1990 to 1995, remote sensing techniques have been used in natural hazards monitoring and evaluation, crop yield assessment, etc (Wang Naibin,1996; Pan Xizhe,1998). From 1995 to 2000 years, resources and environment macro survey and investigation for land has been implemented in China (Liu Yuji, et al,2000). Through these work, many land resources databases (e.g., land use/land cover databases) have been established. In the latest decade, remote sensing techniques are used in many industries, such as city development, environment protection, disaster prevention and protection, regional analysis, global change, and so on. These widely application has brought obvious social and economical effects for the development of China.

## 2.3 Remote sensing research and application for Chinese satellites

China Brazil Earth Resources Satellite (CBERS-01) which was jointly developed by China and Brazil was successfully launched on October 14, 1999. It includes three sensors: 1) WFI (300 km swath; 260 m resolution; 4 bands); 2) IR-MSS (20 km swath; 80 m resolution; 4 bands including thermal); and 3) CCD (20 m resolution; 4 bands). These images are concentrated mainly over Brazil and China. It has been now switched to the stage of operation and application since it was relegated to China Centre for Resources Satellite Data and Application (CRESDA) on March 2, 2000. CBERS-02 was launched on September 1, 2000. And now, CBERS-02B was launched on September 19, 2007. Since 2000 to now, more than 230000 images are published to native and international users. These images almost cover the whole China region 170 times.

Several kinds of meteorological satellites have been launched by China. The famous one is FENG YUN series satellites. FENG YUN 1 and FENG YUN 3 satellite (the code name FY-1 and FY-3) (FENG YUN = "Wind and Cloud") are the first generation of sun synchronous meteorological satellite, FENG YUN 2 satellite (the code name FY-2) is the first generation of geostationary meteorological satellite. FY-1C and D was launched in 1999 and 2002. They have 10-channel (visible and IR) scanning radiators. It is competent for monitoring for ice, snow, vegetation, soil moisture, water and related land cover. FY-2C was launched in October, 2004. Its resolution is about 1.25km. Its images scope covers 1/3 of the world centred by China. FY-3 is a new generation polar orbit meteorological satellite of China launched in 2006. There are total of 11

different remote sensing sensors onboard it, which are designed to get the geophysical parameters of atmosphere, land, and ocean surfaces at the same time all day and night and in all weather conditions.

Beijing-1 satellite (DMC + 4 microsattellites) was launched on October 27th 2005, which covers a large area and has outstanding ability of continual observation. Beijing-1 carries the same 32 meter GSD multispectral sensor, but the addition of high-capacity hard drives and X band data link enable the satellite to acquire, store and transmit up to 4100 kilometres along track, a 16-fold increase on the first generation DMC satellites. The data can be stored on the satellite and down-linked at the satellite owner's facility or can be downloaded direct to a suitable local ground station. Beijing-1 also carries a 4 meter panchromatic imager, which has a 24 kilometre swath and can use on-board storage to acquire up to 4100 kilometres along track. The panchromatic data is useful for infrastructure mapping, change detection, field boundary delineation and many other tasks for which very high resolution data is required.

While, till to now the mainly use of Chinese satellites are focused on native area of China, and its application techniques are not professional. It is still need more research and study in native and international area.

## 3. MAINBODY

### 3.1 Target and research area

**3.1.1 Target:** According to the global application requirements of Chinese satellites, the paper studied the application techniques of domestic satellites in Russia Siberian area where is neighboring area of China. The core research target can be divided into 3 parts as below. (1) Chinese satellite land use/land cover monitoring techniques research. (2) Chinese satellite regional environmental background values extraction and parameter inversion techniques. (3) Chinese satellite regional ecological evaluation techniques.

**3.1.2 Research area:** The research area in Siberian and its neighboring region covers from 90E to 125E, and its length and width is respectively about 6000km and 200km. The core research and application technique research area is mainly focused on the surrounding area of Baikal Lake of Russia, where covers the area from east longitude 100 to 110, from north latitude 50 to 60. Research area is shown in figure 1.

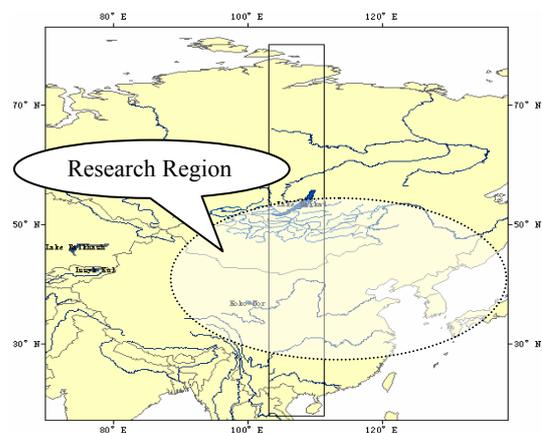


Figure 1. Research region

### 3.2 Research methods and technique flow

Technique flow of remote sensing application based on Chinese satellites in Siberian area can be seen in figure 2 as below. It includes 6 steps.

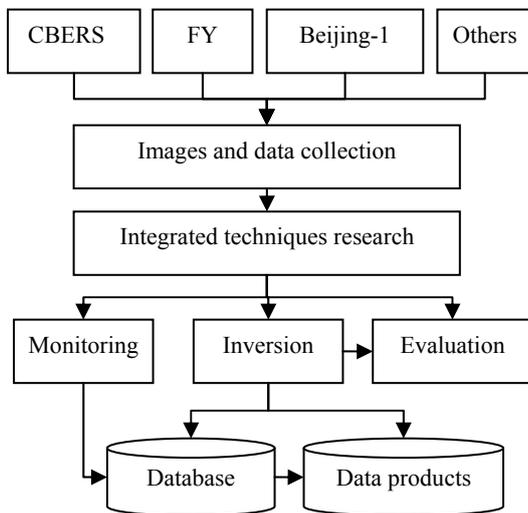


Figure 2. Technique flow of Chinese satellite research

**3.2.1 Collect the basic and related data resources in Siberian area:** Data collection is the basis of integrated, synthesis and quantificational remote sensing analysis. Related Chinese satellites are collected in this area, such as CBERS-02 images, Beijing-1 images, FY images, and so on. Besides remotely images, related multi-scale and sources data are also collected, such as terrain data, social economic data, historical investigation data, and related serial data in local field stations, etc.

**3.2.2 Regional land use/cover remote sensing monitoring research:** According to the land resources classification system based on remotely sensed data, land use/cover monitoring techniques are researched. This study is based on CBERS-1, CBERS-2 images. We used land use classification system developed by Chinese Academy of Sciences (Liu Jiyuan, et al, 2003), which is a hierarchical classification system of 25 land cover classes. The 25 classes of land cover were grouped further into 6 aggregated classes of land cover, i.e., croplands, woodlands, grasslands, water bodies, built-up areas and unused land.

#### Research Points

1. Geometric correction method for CBERS in Siberian area.

thermal spectrum bands. For example, FY-2 images are selected as the main data resources in this research. Their data features are listed as below.

1. Visible Spectrophotometer (VIS): Spatial resolution 1.25km, temporal resolution 1 hour, spectrum scope from 0.55 to 1.05 $\mu$ m.
2. Thermal Infrared (TIR): Spatial resolution 5 km, temporal resolution 1 hour, spectrum scope from 10.5 to 12.5 $\mu$ m.

2. GCP numbers and its error evaluation report.
3. Image processing techniques, including band combination, signature enhancement, image extraction techniques, etc.
4. Classification techniques based on CBERS-02, etc.

#### 3.2.3 Regional environmental background values extraction and parameter inversion techniques research:

Extraction of the regional ecological background information or products will provide parameter support for regional ecological environment evaluation. These information or products mainly focus on the index of regional ecological environment, such as land ecological classification products, vegetation condition products (e.g., vegetation Index, Leaf Area Index, etc.), ground energy balance products (temperature, radiation, etc.), water balance products (transpiration, soil moisture, etc.), and Net Primary Productivity, etc (Jiang Dong, et al,2002).

#### 3.2.4 Regional ecological environment evaluation techniques research:

Remote sensing monitoring and information extraction will provide data resources for ecological environment. Based on the land cover classification data and energy & water balance parameters extracted above, the paper used D-PSE-R (Driver-Pressure, State, and Exposure-Response) model to evaluate the Siberian area regional ecological security.

#### 3.2.5 Satellite spectrum features analysis:

Through the compare with Chinese satellite monitoring techniques, ecological background extraction and parameter inversion techniques, ecological environment evaluation techniques, analyze the image spectrum features, establish the image satellite spectrum database, and provide reference for Chinese satellites' global application.

#### 3.2.6 Data quality control and standardize processing:

Quality and accuracy is the basis of data product of Chinese satellite for its widely application. ISO standards and technique specifications are implemented in the research. These standards include "ISO 19113 geographical information quality basic element", "ISO 19114 geographical information quality evaluation procedure", "ISO 19115 geographical information metadata", "ISO 19138 geographical information data quality", "ISO 19139 geographical metadata execute specification", etc.

### 3.3 Regional ecological background parameter inversion techniques study

#### 3.3.1 Data resources

Meteorological satellites are good data resources for regional ecological background parameter inversion because they have

3. Water Vapour (WV): Spatial resolution 5 km, temporal resolution 1 hour, spectrum scope from 6.2 to 7.6 $\mu$ m.

**3.3.2 Parameter inversion techniques study:** Guided by theories on energy flow and materials exchange with in Soil, Atmosphere, Plant Continuant (SPAC), based on the thermal infrared and visible light information extracted from FY satellites, multiple kinds of energy and water balance parameters could be retrieved, such as land surface temperature, evaporation, vegetable transpiration, etc.,

Land surface energy allocation and water balance's formulas are listed as below (McAnaney K.J., et al.1995).

$$\begin{aligned} I_n &= H + LE + G \\ P &= E + I + R \end{aligned} \quad (1)$$

where  $I_n$  = land surface net radiation flux  
 $H$  = heat flux from land surface to atmosphere  
 $LE$  = real transpiration  
 $G$  = heat flux in soil layer from ground  
 $P$  = precipitation  
 $E$  = Transpiration including ground evaporate and vegetation leaf area transpiration  
 $I$  = ground water infiltration  
 $R$  = ground water run off

Water parameters of SPAC can be achieved through the remote sensing image reflection. SPAC includes 2 water parameters, i.e., precipitation and ground transpiration. Traditional method based on field survey restricts the large area soil moisture monitoring in real time because of limited in-situ observation sites. Remote sensing makes the precipitation and transpiration data available quickly complemented with ground survey data.

Transpiration includes two parts, i.e., ground evaporation and vegetation leaf transpiration. Its calculation based on the formula (1) and (2). We can get these data from FY-2 images through 5 steps as below.

1. Correspondents
2. Atmosphere correction
3. Net radiation calculate
4. Heat flux calculate
5. Real transpiration calculate

$$H = (\alpha_c + \alpha_r)(T_o - T_\alpha) \quad (2)$$

where  $\alpha_c, \alpha_r$  = surface and atmosphere impedance (4~6)  
 $T_o, T_\alpha$  = surface and atmosphere temperature

### 3.4 Conclusions

In general, Chinese satellite images have their unique features respectively. According to different research targets, these satellite images can be selected and mixed use. For example, Beijing-1 image is suitable for local area land use/cover classification and mapping because of its high spatial resolution. CBERS image is suitable for regional resources monitoring because of its multi spectrum and middle-high spatial resolution. FY image is suitable for land surface energy and water balance

parameter reflection because of its high temporal resolution and thermal channel. While, more and more practices should be experimented in the near future to discover the monitoring, information inversion and regional ecological evaluation techniques based on Chinese satellites.

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