Flood Monitoring and Assessment by Remote Sensing and GIS in China

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Abstract

The paper introduces the application of flood monitoring and assessment by remote sensing and GIS in china and describes the frame of operational system for practical performance of flood disaster mitigation. In addition, The operational system for flood monitoring and assessment in RSTAC/ MWR and its application in the floods of 1998,1999 in china are introduced.

Keywords: Flood monitoring and assessment, Remote sensing and GIS

1. Introduction

China is a large country with very complicated natural conditions and often suffered from various disasters, such as flood and waterlogging, drought, earthquake, forest and grassland fire, snow, muddy-flow and so on. With the rapid development of society and economy, the losses resulting from natural disasters increase significantly. For example, the loss caused by floods and waterlogging was 50 billion RMB in 1991 for the whole country, 170 billion RMB in 1994, 150 billion RMB in 1995, 220 billion RMB in 1996, while 270 billion RMB in 1998. Natural disaster becomes one of main constrained factors limiting everlasting development of national economy.

Remote sensing (RS) technology has its special superiority and potentiality for disaster monitoring and assessment, so it has been applied for this purpose for a long time in China, especially for the disaster resulting from floods and waterlogging. A lot of scientific and practical achievements have been obtained in this field. Early in 1983, the Remote Sensing Technology Application Center of the Ministry of Water Resources of China (RSTAC/MWR) investigated the flood occurred in the Raoli River Basin located in the Sanjiang Plain by means of TM image of Landsat. The information on inundated area and the variation of river channel was successfully obtained. In 1984 and 1985, by using the polar-orbit meteorological satellites, the floods occurred in the Huaihe and Liaohe River Basins were investigated separately.

During this period, the airborne SAR image was used for monitoring the flood in the Panjing District of the Liaohe River Basin. After scanning, image processing was done by computer. At the same time,

airborne infrared remote sensing was applied for the investigation of distribution of obstacles in the channel of New Yongding River and the location of breaching dike in Sanjiangkou of the East Liao River. Especially from 1987 to 1989, through the cooperation among RSTAC/MWR, Chinese Academy of Science, National Bureau of Surveying & Mapping and Chinese Airforce, the application experiment of RS on flood protection was early or later carried out in the Yongding River, the Yellow River, the Jingjiang District, the Dongting Lake and the Huaihe River. A system for quasi-real-time and all-weather monitoring flood and waterlogging was established. It played an important role to the monitor of the heavy floods in the Huaihe River Basin as well as the middle and downstream basins of the Changjiang River in the year of 1991.

After 1991, a lot of experts recognized the importance of real time transmission of image data for reducing the loss to the minimum and suggested to set up the real-time transmission system of airborne remote sensing for disaster monitoring. Through five years' efforts, this system has been established and applied in 1994, 1995, 1996 , 1998 and 1999 respectively.

2. System for flood monitoring and assessment in China

2.1 Flood Monitoring

Flood and waterlogging monitoring in China is carried out in four levels of platform: meteorological satellite and space-borne SAR, airborne SAR, helicopter and ground observation stations for measurement of discharge and water elevation.

The National Satellite Meteorology Center is in charge of the macro and dynamic monitoring by meteorological satellites. It has three stations located in Beijing, Guangzhou and Ulumuqi, digital image data are transmitted to Beijing by communication satellite and mosaic image product for the whole country is made in Beijing after correction.

The Satellite Ground Receiving Station of the Chinese Academy of Science can receive the digital image data of Landsat, Radarsat, ERS, SPOT. The reservation of acquisition should be separately made at least one day, two days or three days before and the user can obtain the data after initial correction in 6 six hours.

The airborne SAR system is equipped on Learjet 36 with the flight altitude of 10,000 to 13,000 m. It is used for investigation of important water and other projects, such as dam, embankment, railway and so on, in urgent cases. The resolution of transmitted image is 6 m. The real-time image digital data is transmitted to RSTAC/MWR.

The flood monitoring by helicopter is mainly performed in case of fine weather condition, with the altitude of 900 m.

RSTAC/MWR can access the real-time database of the Ministry of Water Resources. The real-time discharge and water level are useful for the

option of alternatives for flood monitoring and also important for estimating loss resulting from flood.

All of these data are sent by network or other measures to RSTAC/MWR.

2.2 All-weather and Real-time Transmission System of Airborne SAR

This engineering system is the integration of RS, global positioning system (GPS), data transmission and image processing. The image data acquired by radar in aircraft is sent to communication satellite first, the transmitting station on the ground enhances the signal and sends it back to communication satellite, then the user stations can receive it in seconds. The system consists of three subsystems: information acquisition, data transmission and image processing.

The maximum effective distance of the synthetic aperture radar is 55 km, the real-time imager can deal with SAR signals with the resolution of 3 m into the data of SAR image of ground according to the semi survey band (resolution of 3 m) and full survey band (resolution of 6 m). At present, in order to realize the real-time transmission, the transmitted data are selected one from two, so the resolution of transmitted image data is 6 m.

GPS is linked with the navigation system. Apart from the allocation of radar image, it can provide the location of aircraft for the antenna servo system to ensure the trace to communication satellite.

He airborne station cryptographs, modulates and compresses the data of SAR image from the real-time imager and then sends them to the communication satellite. The transmitting station is mainly for solving the limitation of up link, increasing gain and avoiding the superposition of noises. After demodulation, decompression and decryption, the user station can perform data processing.

The subsystem of information processing mainly realizes real-time display of image, real-time record of data and real-time hard copy of image.

The functions and characteristics of the system can be summarized as: all weather, real-time data transmission, flexibility in time and space and high resolution. It made a great contribution for flood monitoring in 1998.

The study on improvement of this system has been finished and is being tested now. The resolution of transmitted image is improved from 6 m to 3 m, GPS data is transmitted together with image data, so the geometric correction and mosaic of bands would be carried out on the full use of increased GPS data.

2.3 Flood Assessment

On the basis of the monitoring data sources mentioned above, an integrated system for flood monitoring and assessment is established in RSTAC/MWR. It is a professional and operational center. Test operation will start from this year and official operation from 2001. The integration of software, hardware, data base and network is the key

issue of its successful establishment. It is a distributed operational system, including the sub-centers of meteorological satellite observation and ground hydrological observation. The meteorological satellite monitoring is mainly used for macro and dynamic monitoring on warning level, space-borne SAR for disaster condition assessment, and airborne SAR for important water and other projects investigation under urgent case. For space-borne SAR, ERS is used for the disaster condition investigation of local flood and for the rivers in north-south direction, while Radarsat for the floods covering a large area due to its wide scope of 500 km*500 km.

As for disaster condition investigation, main contents are the inundated area of each county and its mapping, including its landuse classification, especially the inundated area of cultivated land and that of residence area. For project investigation, it includes reservoir, embankment, sluice gate, flood basin, retarding basin, bridge, railway, highway, harbor, airport, oil field and so on.

The disaster assessment is performed on the basis of following data sources:

1) GIS for some of areas flooded frequently

2) Landuse classification from TM images before or after flood season

3)Topographic maps mainly used to find geographic control points

for geometric correction and extraction of administrative boundary.

4) Other thematic maps

3. Floods in 1998, 1999 as well as monitoring & assessment by remote sensing and GIS

In China, the heaviest flood since 1954 occurred in 1998, especially in the Changjiang River Basin and Nenjiang-Songhuajiang River Basin. While the highest water level in history and the second highest water level since 1954 occurred in the Taihu Lake and the Changjiang River separately in 1999.

RSTAC/MWR performed flood monitoring and assessment 9 times in 1998, five times for the Changjiang River Basin on 7th and 30th of July, 8th and 3rd of August respectively, four times for Northeast China on 4th, 17th, 21st and 30th of August respectively, four times by airborne SAR and five times by space-borne SAR, including Radarsat and ERS-2. The otal covering area of investigation is 480,000 km2. Besides, more than 50 meteorological satellite image products showing the inundated area of different river basins were made during the flood season. Up to 7th of August, RSTAC/MWR has done 6 times of flood monitoring and assessment in 1999, One time for the Taihu Lake Basin on 3rd July, three times for the Changjiang River Basin on 24th and 26th of July, one time for the Yellow River Basin and one time for North-east China on the same day of 7th August, five times by space-borne SAR of Radarsat and one time by airborne SAR. The total

monitoring area is 950,000 km2. Besides, 46 times of monitoring by meteorological satellite have been done.

The assessment consists of inundated area of each county and mapping,

Including cultivated area, resident area and other main landuse classification, as well as the situation of reservoir, breaching embankment, number of inundated oil well, length of inundated highway, the effect of water diversion and so on. All of these were finished within 48 hours. All information was sent to the State Flood and Drought Prevention Headquarter and the Office of State Council as early as possible, providing important data for decision-making on disaster relief and evaluation.

At present, the most important thing is to establish GIS for all areas where floods occur frequently. As the first step, the GIS with the scale of 1:100,000 is useful for loss evaluation, then that with the scale of 1:10,000 is necessary for flood routing in order to estimate economic losses resulting from different operational alternatives before the occurrence of flood, so as to provide information for decision-making on water projects operation and withdraw of resident. Besides, on the basis of long-term historical data including rainfall, runoff, water projects, population, economy, landuse and other factors, the flood hazard zoning with 8 classes and flood disaster risk zoning also with 8 classes in China have been finished. They are also very useful for flood prevention planing and decision-making before occurrence of flood disaster.

The most important information needed for flood prevention is rainfall, hydrological regime (water level and discharge), water project situation and disaster condition. What we are doing by RS and GIS is limited in the latter two aspects. The rainfall measurement by meteorological satellite and Doppler radar and conversion from inundated area to water level with the support of GIS would extend the application of RS and GIS to the first two aspects and become a tool which must be used in flood control.

4. The establishment of professional and operational system for flood monitoring and assessment

As mention above, a professional and operational system for flood monitoring and assessment has been established in RSTAC/ MWR. It is entirely different with scientific research. Through one year's test operation, some experiences have been obtained and sum up as follows.

The basic conditions for professional and operational system are:

1) ufficient and reliable remote sensing data source from different sensors
2) ufficient background data
3) ffective and quick technology for image processing, information extraction and analysis
4) ell-organized command system
5) uick communication

6) uality control system

In any case, RSTAC/MWR must send the information on inundated area, including the inundated area of each county and corresponding thematic map to the State Council and State Flood Control Headquarter 24 hours after acquisition of satellite image, and finish the assessment, including the inundated cultivated land and resistant area of each county as well as corresponding thematic map, within next 24 hours. The basic conditions mentioned above are fundamental for the success of flood monitoring and assessment.

5. CONCLUSIONC

1) Remote sensing and GIS can play important roles on flood monitoring and assessment, it is proved again by the performance for floods of China in 1998.
2) The establishment of operational system is essential for practical performance of flood disaster mitigation.
3) The extension of application of RS and GIS to decision-making before the occurrence of flood is a significant challenge in the near future.

Proposal for cooperative project: Operation of Flood Monitoring & Assessment by Remote Sensing & GIS

General target of project

Disaster caused by flood and waterlogging is a popular problem in China and Southeast Asia, flood disaster mitigation is an issue to which more attention are paid by not only the Chinese government but also other countries in this region.

Remote sensing technology has its special superiority and potentiality for disaster monitoring and assessment. This fact is continuously proved by the practice against flood hazard in different countries, including China. Operation is different from pure scientific research, although it has many special technologies which should be studied. It is performed by mature technology based on a lot of scientific research. The cooperation in this field is very practical and will be beneficial to China and the countries in Southeast Asia.

Content of project

The cooperative project may be performed in following three ways with different levels.

1.Establishment of operational system for flood monitoring and assessment by remote sensing and GIS

1) Macro and dynamic monitoring by meteorological satellite

2) Monitoring by space-borne SAR (side-looking synthetic aperture radar)

3) Assessment with aid of GIS-based database

4) Integration of hardware, software, database and model

5) Training of operators

2.Technology research and exchange on operation of flood monitoring and assessment.

1) Extraction of background data from remote sensing.

The data includes baseline of water body, landuse, water project.

2) Establishment of background database against flood hazard

The data covers baseline of water body, landuse, water project, administrative boundary, social and economic data, topography (DEM).

3) Flood disaster risk zoning and Flood hazard zoning

4) Quick extraction of water body from SAR

5) Models for assessment of economic loss due to flood and waterlogging

6) Integration of operation system

3.Training course

1) Application of remote sensing to flood monitoring and assessment.

2) Establishment of background database for flood monitoring and evaluation.

Organization and performance of project

After the initial approval of the project, a team

composed by the experts from China and Southeast Asia will be organized. The first task of this group is to draft a official document on the project. It will be led by two chief experts from both sides separately.

The detail of project will be described in the document, especially the content and selection of experimental area. This document will be submitted for examination and approval.

After official approval, the project will be carried out by the team according to the document.