Research on Methods of Dynamically Monitoting Flooding by Space Technology

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ABSTRACT: The paper takes flooding monitoring in Nenjiang River in Jilin Province of China in August of 1998 as an example, according to characteristics of diverse satellites (NOAA, SAR, TM) data resources, we were conducting a comprehensive analysis on flood dynamic monitoring by the method of remote sensing techniques. By processing and overlapping SAR and TM images we can determine image features of inundated objects, compile a composite image map with land-use maps and dynamically monitor flooding submerged areas. In this way we may accurately, quickly and real-time provide the scientific basis for comprehensively appraising the disaster degrees of afflicted areas.
KEYWORDS: flooding monitoring, image processing, remote sensing (RS)

1.Introduction

With the rapid development of remote sensing technology, more and more methods of acquiring remote sensing data are booming, RS data are also more and more abundant. Accordingly RS application fields are wider and deeper. It is more and more important for RS application how to extract more abundant, effective and useful data from these abundant data resources. In the processing of dynamic monitoring by RS on flooding, during August of 1998 in Nenjiang River in Jilin Province, we can determine the afflicted area of flooding through image of NOAA meteorological satellite and SAR the image of Radar satellite. Firstly select SAR image as main data resource of extracting flooding data and TM image as background data resource of disaster analysis. Secondly composite them in order to highlight image characteristics of water body and inundated objects, then overlay the co-registration map and the land-use map made before the flooding, finally derive the statistics table of inundated area of the study region. By this method we can quickly and directly make qualitative and quantitative analysis on submerged procession of flooding.

2.Data Source Selection and Image Pre-Processing

2.1.Data Sources

In the project we adopted three data resources—NOAA meteorological satellite imagery, SAR Radar imagery and Landsat TM imagery. Meteorological satellite data has an advantage of even (well-distributed), continuous, high-temporal resolution, obvious regional outline feature, low cost, but a disadvantage of lower space resolution and being affected by some cloud. So we adopted NOAA satellite image on August 12, 1998 and August 13, 1998 to outline area of inundated field.

For TM image (Table 1) data, the spectrum resolution is higher, channels are more, band is narrower. So we can easily make up diverse bands and extract thematic data in accordance with different application aims (Xupeng Chen *et al*, 1990). Here we select June of 1998's image as the basic data source of study region's land resource.

Table 1 TM image feature

RS platform	band	Space resolution	time
Landsat	TM4,3,2	30m x 30m	June of 1996

As an active RS, radar RS has characteristics of full-climate, full-time, good-penetration, high-temporal resolution, Radarsat satellite, which can get the same image each 3 or 4 days, is ready to dynamically monitor and extract flooding data for a large area (Enpu Wan *et a*l, 1996).

2.2. Image Pre-Processing

RS data describes the nature. Every terrestrial object has its own spatial features, such as the position, the shape, size and spatial relationship, which are partly distorted in the course of acquiring these data by RS technology. So the spatial distribution of RS image objects must be corrected by selecting ground control points. Here we adopt ERDAS and ENVI software platform to do precise geometric correction for TM image and SAR image.

1) Precise geometric correction for TM image

Firstly, stretching image on ERDAS software platform, secondly selecting at least nine typical control points which distribute evenly and have obvious characters as GCP in the image and its vector database with a scale of 1:200000 terrain map (adopt ALBERT Dual Standard Latitude Equal Area projection). Lastly setting up transposed relationship between image coordinate and map coordinate according to known control points. Uncontrolled point shifts would be accomplished by Interpolation method. The transposed relationship is:

$$U_i=a_0+a_1x_i+a_2y_i+a_3x_i^2+a_4x_iy_i+a_5y_i^2+\ldots\ldots \text{Eg. 1}$$

$$V_i=b_0+b_1x_i+b_2y_i+b_3x_i^2+b_4x_iy_i+b_5y_i^2+\ldots\ldots \text{Eq. 2}$$

Where the elements U_i, V_i, x_i, y_i are image and ground coordinate of point i respectively, the parameters a_n, b_n is the coefficients, n is the number of control points.

2) SAR image geometric correction and TM and SAR image spatial registration

There are many methods of geometric correction for SAR image. Accordingly there are different rectification methods in accordance with situation of image areas such as the factor of terrain fluctuation areas of study region (Ronghong Jia *et al*, 1998). Monitoring field with small area and little terrain fluctuation is limited to Nenjiang River in the western part of Jilin Province. So polynomial approach method is adopted to rectify.

Selecting thirty even-distributed controlled points in two images based on precisely rectified TM image. Only outlines of water distinguish in SAR image, but the flood water area is large. It is difficult to select controlled point, so it is best to select controlled point on banks, intersection or corner of main road. Then rectify SAR image into TM image coordinate with Least Square Polynomial Fit Rectification Function after selecting controlled point.

$$U_i=a_0+a_1x+a_2y+a_3x^2+a_4xy+a_5y^2+\ldots\ldots \text{Eq. 3}$$

$$V_i=b_0+b_1x+b_2y+b_3x^2+b_4xy+b_5y^2+\ldots\ldots \text{Eq. 4}$$

In the same time, the Nearest Neighbor Resample Method is adopted for a brightness interpolation calculation. Selecting four points around the calculated point, comparing the distance among them. Which one is the shortest, we will select the brightness value of the point (x, y) as object's brightness value f (x, y). In this way re-sampling and rectifying SAR image by Nearest Neighbor Method would give the nearest spectrum intensity to a new grid point to accomplish SAR image geometric rectification and complete spatial registration between TM and SAR images.

SAR has many spot noises, which directly affect the analysis and the usefulness of the image. So we adopt Gamma Map filter whose size of window is 9 X 9 in ENVI environment (Baralidi. A. and Parmiggiani.,A, 1995) (see Fig 1). From the map we can see that spot noises were removed through filter and good water outline was getting clear. These data is a good of extracting flooding areas quickly.

3. Co-Registration Between Sar and Tm Images

In SAR image water body is black whose brightness is low. SAR image should be processed before SAR and TM images were overlain in order to make other data be seen.

3.1.Automatically Extracting Flood Data From Sar Image

As SAR image has different angles in the process of imaging every time, its gray characteristic and color vary differently. We scale gray values for five rectified and filtered SAR image (August 9, 16, 20, 23, 29, 1998) up to 255. Then under ENVI environment analyzing gray section of every image as to select suitable threshold value (Table 2), do two-value procession, give gray value which is greater than threshold value zero and less than threshold value one. Make modeling and produce two-value image that only reserves water information, that is, water is white, others are black. Set parameters of smooth samples and least spots and use automatic trace vectoring to extract the area of water body, produce DXF file In CorelDRAW software Trace function, transpose it into coverage by ARC/INFO. And edit and dispose them under Arcedit module. Finally make five-time flood state data map (Fig 2).

Table 2: SAR image extract flood data threshold value

time	August 9	August 16	August 20	August 23	August 29
Threshold value	80	45	90	45	92

3.2. Color Composition of Sar and Tm Images

RS image color composition of different bands is one of the most simple and useful RS image co-registration technology. Here we overlay both TM image taken before the flood and SAR image made during the flood. Because of TM image's abundant information and high resolution, choose two bands namely TM4 and TM3 through many experiment analyses. TM4 is the near-infrared band, which is benefit to recognize water. TM3 is the red band, which fully reflects the vegetation type and the coverage degree. By Combining TM4 with TM3, we can reserve and project data of arable land, vegetation, residential area and water to offer important background information for flooding monitoring. First give TM3, TM4, two-value SAR image red, green, blue colors respectively, do pseudo-color composition, which not only reserves image object feature before the flood, but also add and project flood inundated state information to improve image recognition precision.

SAR image before filtering SAR image after filtering

Fig. 1 Comparison Of The Two SAR Images

Fig. 2 Flooding Areas Extracted From SAR Image

4. Flood Dynamic Monitoeing Procession and Disaster Statitics

4.1. Flood Dynamic Monitoeing Procession

By using five-time (August 9, 16, 20, 23, 29) flood inundated maps which were extracted from SAR image, estimate flood inundated area in study region, which is reflected by Fig. 2, from which we can see that the inundated area on August 9 is 51.62 X $10^4 hm^2$. On August 23 is the largest, 139.54 X $10^4 hm^2$. Then flood gradually decreases, on August 29 inundated area decreases by 108.54 X $10^4 hm^2$. Overlay these five flood inundated state maps, then produce flood inundated procession map, in which represent different time flood inundated states by different colors, for example Fig 3, in which red is the water region in flutter seasons. Flood inundated procession is represented by blue

unit：square kilometer

Time type	August 9	August 16	August 20	August 23	August 29
Paddy field	35.5253	212.3310	242.8335	275.8153	273.5303
Dry land	176.3030	548.9629	916.7478	1313.2969	791.5644
forest	88.7708	150.6811	166.2747	207.5152	63.2640
Grass land	534.0340	1094.9290	2515.8999	3009.4512	2028.2640
resident land	18.3929	46.7308	85.5966	127.8890	54.2647
industry-mining land	0.6127	1.6360	0.4035	2.5105	1.1547
dene	653.5278	673.9266	703.1595	700.5545	689.3791
bottomland	23.8405	5.7884	20.3499	19.7620	1.0505
alkaline land	924.1537	2091.6362	3758.3372	3937.7633	2741.1028
Marsh	1154.9234	1827.3251	2027.9408	2136.3465	1946.6035
total	3591.8842	6654.9371	10767.5434	11733.9234	8590.1780

from light to dark. Then we can clearly see flood inundated procession.

4.2. Flood Disaster Statistics

GIS technology is used to overlay the acquired flood inundated present map and the resource map before flood to acquire different time inundated land-resource type area (Table 3). Fig6, which is drawn by Table4, is varied curve of different land-resource-type submerged area and represents varied situation of flood inundated area.

5. Conclusion

1) It is a quick, useful, capable method to monitor flooding disaster by way of RS co-registration image procession. In the procession of investigating flood-inundated state, multi-data-resource gives play to essential function.
2) Reflect flooding disaster is macroscopic and distinct by RS co-registration image. Flood gradually developed procession map. More directly represent flood dynamic varied procession.
3) GIS is essential method for real-time, quantitatively monitoring flood procession and estimating flood disaster.

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Xupeng Chen, Xingshi Zhao, 1990, Remote sensing geography analysis, Beijing: Editorial Department of Acta Geodaetica Et Cartographica Sinica Table 3: flood inundated area statistic table on monitoring time in middle and lower reaches of Nenjiang River

Fig. 3 Flooding Processing in the Middle & Lower Reaches of Nenjiang River (August, 1998)