EXTRACTION OF INFORMATION ON GEOLOGY HAZARD FROM MULTI-POLARIZATION SAR IMAGES

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Theme Sessions(ThS) ThS-11

KEY WORDS: Remote Sensing, SAR, Geology Hazard, Multi-Polarization

ABSTRACT:

Geology hazards are one of the main nature hazards in China, especially in southwest China. Now the remote sensing technology is considered the most powerful method for forecasting, monitoring, analyzing and assessment these geology hazards. In this paper, geology hazard information including lineament features and landslide body are extracted from multipolarization SAR data around Kunming city, Yunnan province, China. To reduce the influence of SAR speckle and enhance the linear character, a new filter method based on edge detection result is used in this work. The Normalized Difference Polarization Index (NDPI) is also used to analyse the surface characters include vegetation cover, soil (rock) type and roughness. Synthesizing NDPI, digital elevation data and in site monitoring results, the possible distributing map of landslide are created for the study area. The information from this map is basic accordant with that from historic records.

1. INTRODUCTION

Geology hazards are one of the main nature hazards in China, especially in southwest China. The loss of these geology hazards is enormous every year. So it is significant to forecast the time and location of these hazards. The approaches for forecasting and monitoring geology hazards include in situ monitoring, geology construct map analyzing and remote sensing technology monitoring. Now the remote sensing technology is considered the most powerful method for forecasting, monitoring, analyzing and assessment these geology hazards (SONG et al, 2006; YANG et al, 2003; YAO et al, 2006).

Currently, the information of geology hazards are collecting from remote sensing images based on the form and structure of the geology elements such as slide body, matter source area, circulating area, depositing area, etc. The method for this information extraction is manual vision interpretation supplied with computer analysis and in situ validation (ZHANG, 2005). Images used for geologic application include optical and microwave remote sensing images. Optical remote sensing such as visible and infrared are high quality and wieldy but it is restricted by weather condition. Microwave remote sensing especially SAR remote sensing instruments have the capabilities of all weather and all day/ night imaging, penetration, and terrain detection. So it is quite different from and complementary to passive systems such as visible, infrared and passive microwave radiometers. Especially the development of new imaging radar technologies, such as polarimetric SAR and interferometric SAR, provide unique geological environmental information. SAR data provide unique information about geology, such as lineament features, fault zone, stratum outcrop, and volcanic formation, as well as critical data for geological hazards and mineral resource assessments (CAO et al, 2004; TAN et al, 2004). Table 1 lists the foundation of SAR data source selection for extracting geology information.

Type	Application	X			C		
		hh	vv	x	hh	vv	x
Geology	Rock type mapping			●			●
	Geological structure	●	△	●		△	●
	Topography	△	△	●	△	△	●
	Underground exploration			—			●

(x: cross polarization. ●: Important. △: Helpful. —: Not necessarily. Blank: unknown.)

Table 1. The optimization combination of SAR data in geology application (GUO et al, 2000)

In this study, ENVISAT Advanced Synthetic Aperture Radar (ASAR) Alternating Polarization Mode (APMode) Precision Image is selected for data source. Since the launch of the European ENVISAT satellite, geology application has become one of the most important subjects of application of ENVISAT ASAR data. ASAR works at C-band (wavelength of 5.6 cm) for which the canopy volume scattering dominates and operates on five working modes. The alternative polarization mode (APMode) product contains two coregistered multipolarization images. It has been successfully used for assessment geological hazard, flood detection, and soil surface parameters inversion. In this paper, we assessed the efficiency of a single-date APMode product containing VV and VH polarizations for lineament features identification and landslide hazard assessment. As for landslide hazard assessment, a decision tree

method was constructed based on the surface dual-polarization backscatter differences and gradient.

2. STUDY AREA AND DATA

2.1 Study area

The study area is located in the Kunming city, Yunnan Province, China. The area of this region is almost 150 square km. The elevation is from 1780 to 2500 meter. Landform ups and downs are bigger. This area is one of the high-incidence geology hazard areas in Yunnan province (JIANG et al, 2003).

2.2 ASAR data

In this study, the multipolarization SAR data of date July 10, 2005 was selected for geology hazard information extracting including lineament features and landslide body. The data is operating at C-band, frequency (5.331 GHz), the cross-V polarization sub mode (one image VV and one image VH), IS4, descending, swath width 88 km, incidence angle from 31.0 to 36.3 degree. The subset covered most area of Kunming city was cut from original image. Image preprocessing including radiance calibration, geocorrection, and backscattering image generation was carried out in BEST software. Output of the preprocessing was converted to GeoTIF image type for further analysis.

2.3 Digital elevation data

The digital elevation data used in this study is supplied by the Shuttle Radar Topography Mission (SRTM), which is spearheaded by the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA). The resolution of this data is almost 90 meter.

3. METHODOLOGY

3.1 Radiance Calibration and Geometric Correction

Radiance calibration, geocorrection were carried out in BEST software in this study. Then backscattering image was generated following the equation below:

$$\sigma^0 = \frac{DN^2}{K} \sin\alpha \qquad (1)$$

where σ^0 = backscatter coefficient
  DN = digital number
  α = incidence angle
  K = absolute calibration coefficient

SAR image is distorted in the mountainous area for the hypsography. The distortion includes scale distortion, foreshortening, layover and shadow. To reduce these effects, Ortho SAR image is established by integrating original image and DEM data in Erdas software.
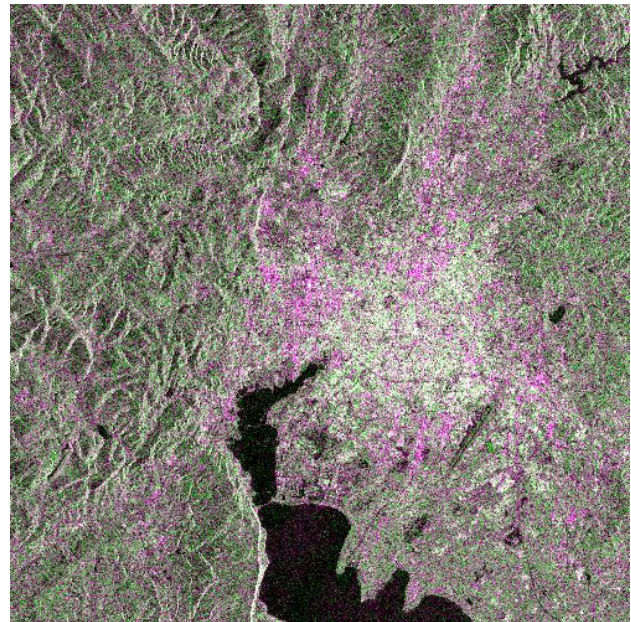

Figure 1. Pseudo colour composed map of study area (VV: VH: VV)

3.2 SAR Speckle Filter

Speckle in synthetic aperture radar (SAR) images disturbs SAR images calibration, interpretation and application, thus speckle reducing is an important step in SAR images processing. Ordinary methods destroy edges information while reducing speckle. In fact, the experiments indicate that there is always a kind of tradeoffs between smoothing out speckle and preserving the useful information. In this research, edges information must be preserved during speckle smooth for lineament features identification. So, A SAR filter method based on edge detection result is used in this paper. In this method, modified ratios of average (MROA) algorithm (BOVIK, 1988) is used for edge detection and mean filter is used for smoothing out speckle in non-edge area. Each pixel's value is calculated using the formula below.

$$P(i, j) = \frac{\sum_{k=-n}^{k=n} \sum_{l=-n}^{l=n} (P_o(i+k, j+k) \times S(i+k, j+k))}{\sum_{k=-n}^{k=n} \sum_{l=-n}^{l=n} (S(i+k, j+k))} \qquad (2)$$

where P_o = original image digital number
  P = filter image digital number
  n = the size of filter window
  S = the result of MROA algorithm.

3.3 Normalized Difference Polarization Index (NDPI)

As Table 1 shown, the cross-V polarization (one image VV and one image VH) SAR data are more useful than other formats in geologic structure identification. At the same time, the return signal from vegetation cover is different between each polarization. So several landslide can be observed from these images. To enhance the difference between lineament features, landslide and other earth surface, pseudo-colour composed

image and Normalized Difference Polarization Index (NDPI) image are used in the research. The expression of NDPI is listed below.

$$NDPI = \frac{\sigma_{vv} - \sigma_{vh}}{\sigma_{vv} + \sigma_{vh}} \qquad (3)$$

where σ_{vv} = VV polarization SAR data backscatter coefficient

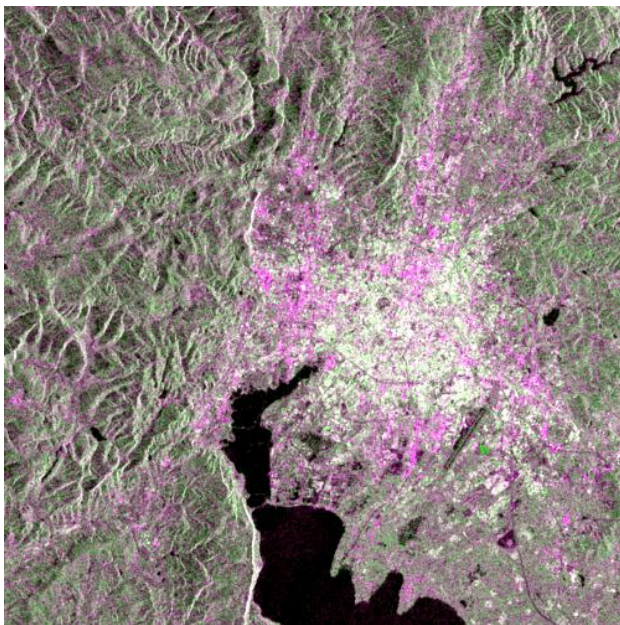σ_{vh} = VH polarization SAR data backscatter coefficient

Figure 2. Pseudo colour composed map of study area with data conducted through speckle filter (VV: VH: VV)

4. RESULTS AND DISCUSSIONS

4.1 Lineament features identification

Geologic structure such as drape and faultage can be classified from SAR image especially imaging with large incidence angle through vision interpretation. These features are much legible if their directions are perpendicular to range direction.

To enhance the characteristic of linear features, the technology with pseudo-colour composed and image enhanced was applied (Figure 4). In this image, Primary faultage in study area is relative clear. The faultage on the left is the most scale one over the region which direction is north to south along the west edge of Kunming basin. The other one on the right is vague which has been covered up by the city zone. The results from this image are basic accordant with that from historic records.
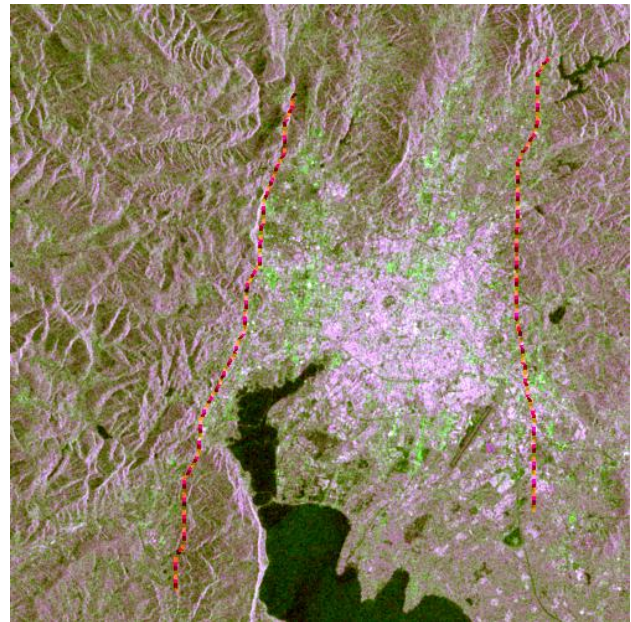

Figure 4. Primary faultage in study area (red line)

4.2 Assessment landslide hazard

Earth surface appearance can be changed during landslide occurred. So the rough degree of landslide area is differing from other terrain because vegetation cover and soil layer of this area were destroyed. On the other hand, SAR signal is sensitive with the change of vegetation cover and soil humidity. Based on the recorders of occurred landslide (CHEN, 2006), we made sure that there are some relationships between landslide hazard and surface roughness. There are also some relationships between surface roughness and NDPI. The higher the roughness is, the higher the NDPI value is. The roughness of city zone is bigger than water body. So City zone has the higher NDPI value (Figure 3). Water region has the lower NDPI value (Figure 3).
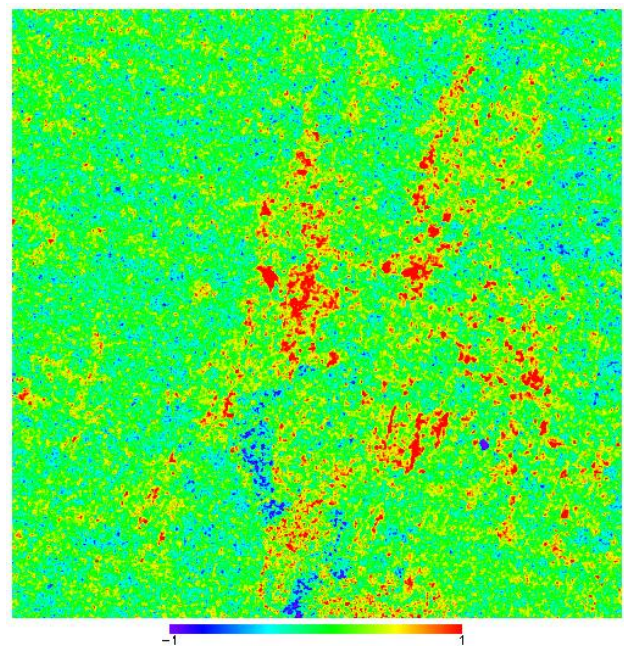

Figure 3. NDPI map of study area

Although the NDPI value of city zone is higher, the amount of landslide hazard occurred in city is less. Generally, landslide hazard occurred in the region with big hypsography. So we established the index system to assess the landslide hazard according to the NDPI value and gradient (Table 2). The risk grade map for landslide is created under this index system (Figure 5). From the result, there are two high risk zones in this study area. The one is located in northwest of the basin, the other is located in the west edge of Dian lake.

Risk level	Specification	
	NDPI	gradient
High	>0.2	>25
Middle	0.1<NDPI≤0.2	25<NDPI
	0.2<NDPI	15<NDPI≤25
Low	≤0.1	≤15

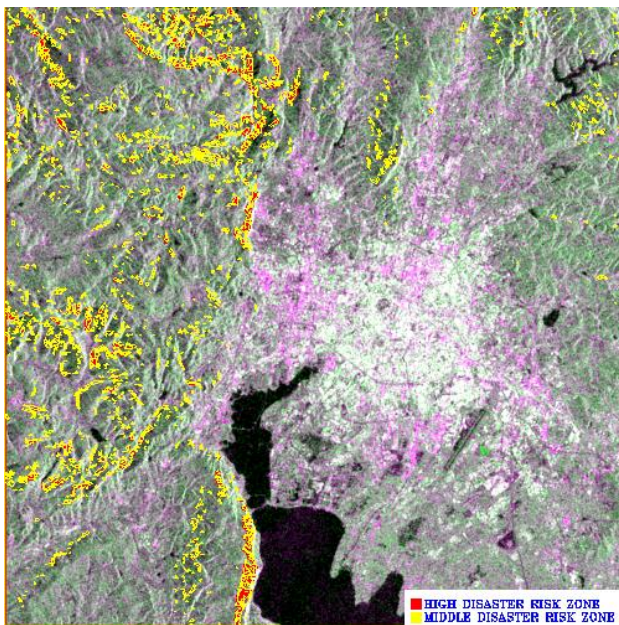Table 2. The conditions for landslide hazard assessment

Figure 5. The risk rating map of landslide for study area

5. CONCLUSION

In this paper, geologic hazard information is extracted from multipolarization SAR data based on vision interpretation and NDPI threshold method. Lineament features can be identified from the image with pseudo-colour composed and image enhanced technology. Furthermore, landslide can be observed based on difference of NDPI and surface gradient. Therefore, multipolarization SAR data is a useful source for geologic applications.

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