A study on the oil spill information extraction method based on MODIS remote sensing images

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Abstract

By MODIS remote sensing images, this paper analyzes the oil spill of the Dalian New Port on July 16, 2010. After the pre-processing of destriping noises, "bowtie" elimination, geometric correction, atmospheric correction and so on, explore the effective method of extracting oil spill information. This article studies a new oil spill information extraction method which is texture filtering, grey value processing, and removing cloud area and band calculation by sequence. The extracted oil spill area which is calculated by the ArcGIS software is according with the report of the China Ocean Monitoring Ship, which shows the feasibility of this method.

Keyword: *MODIS; Oil Spill; Remote Sensing*

1.Introduction

With the development of ocean transportation, ocean environment pollution is more and more serious, especially the oil spill at sea. At present, SAR (Synthetic Aperture Radar) is mainly used for monitoring oil spill at home and abroad, whose extract oil spill by texture feature of the sea surface. It is limited to normal application because the high cost and the long scan cycle. MODIS(Moderate Resolution Imaging Spectroradiometer) is developed by NASA and some related scientific research institution, which was launched aboard the Terra satellite and the Aqua satellite, It can provide 4 scene images at the same area one day, so that the efficiency of the data greatly enhance. Combined with day and night MODIS images, it can better study the position, diffusion and so on about oil spill.

The method of extracting oil spill information by MODIS remote sensing images is still on exploration stage. Zhao Dongzhi and Cong Pifu (2000) analyzed spectral features for the Liao river crude oil, the 0# light diesel oil and the lubricating oil of different thickness [1], in the same year Zhang Yongning and Dingqian measured and analyzed the spectral features and reflectivity of the kerosene, the lubricating oil, the light diesel oil and the heavy diesel fuel [2], we can choose oil spill channel according to the lab result. Chen Weiwei, an Juba (2003) detected the oil spill edge in remote sensing image by the BP fusion model [3]. Han Kun, Li Ying (2008) determined oil spill according to the remoting sensing image tone [4]. Chen Hui, Zhao Chaofang (2008) analyzed oil spill feature in every band and get the spectral range with obvious oil slick feature, then extracted oil spill information [5]. Shen Liang et al. (2010) enhanced the pseudocolor information of the remote sensing image which made the oil spill information more obvious [6].

2.Principle of extracting oil spill

MODIS is the main information data acquisition instrument in earth observing system (EOS) series of satellites. MODIS instrument includes 36 spectral bands at three different spatial resolutions with nominal ground

fields of view of 250m (band 1~2), 500m (band 3~7) and 1km (band 8~36). The band 1, 3, 4, 8~14 (405~683nm) belong to visible light spectrum, the band 2, 15~19(743~965nm) belong to near-infrared spectrum, the band 5~7, 23(1.23~2.155μm) belong to SWIR. The two parts combined the near-infrared spectrum and SWIR are named as reflection infrared light spectrum in which the reflection of sun is greater than the radiation of oil spill, so that we can extract oil spill information by the temperature difference between the oil spill and sea water. The band 20~36 (except band 26) belong to thermal infrared spectrum.

The radiance and reflectance of oil spill are obviously different from sea water, so the grey value of the oil spill and sea water in MODIS image has obvious difference. If the radiation and reflection of oil spill are greatly different from sea water, the extracting oil spill information will be more explicit. In order to evaluate the oil spill information in every band, we calculated the contrast for the image of every band by Eq. (1) and Eq. (2).

$$c_L = \frac{|L_{oil}(\lambda) - L_{seawater}(\lambda)|}{L_{seawater}(\lambda)} \quad (1)$$

$$c_E = \frac{|E_{oil}(\lambda) - E_{seawater}(\lambda)|}{Eseawater(\lambda)} \quad (2)$$

Where $L_{oil}(\lambda)$ is the average of the radiance in pollution sea area, $E_{oil}(\lambda)$ is the average of the emissivity in pollution sea area, $L_{seawater}(\lambda)$ is the average of the radiance in background sea area, $E_{seawater}(\lambda)$ is the average of the emissivity in background sea area. The above data based on the same oil spill area and background sea area. The result show, there are obvious oil spill information in emission band 20(3.66~3.84μm), 22(3.929~3.989μm), 23 (4.02~4.08μm); Among 19 of 20 reflection bands, oil spill information can be extracted, what's more, the most obvious oil spill information is between 800nm and 2130nm. The oil spill on Jul. 16, 2010 is mainly made up of Daqing crude oil, the maximum value of oil slick reflectivity in visible light bands is 0.464μm (in band 9), the maximum value of oil slick reflectivity in near-infrared bands is 1.003μm (in band 5) [1], we chose the removing image with 250m spatial resolution for improving the resolution of the image, so that we chose band 1, 5, 9 for extracting oil spill information whose contrast have great difference.

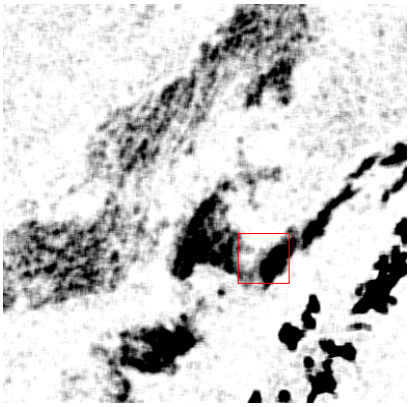


Figure1 The result via texture filtering process

3.Methodology

3.1Material

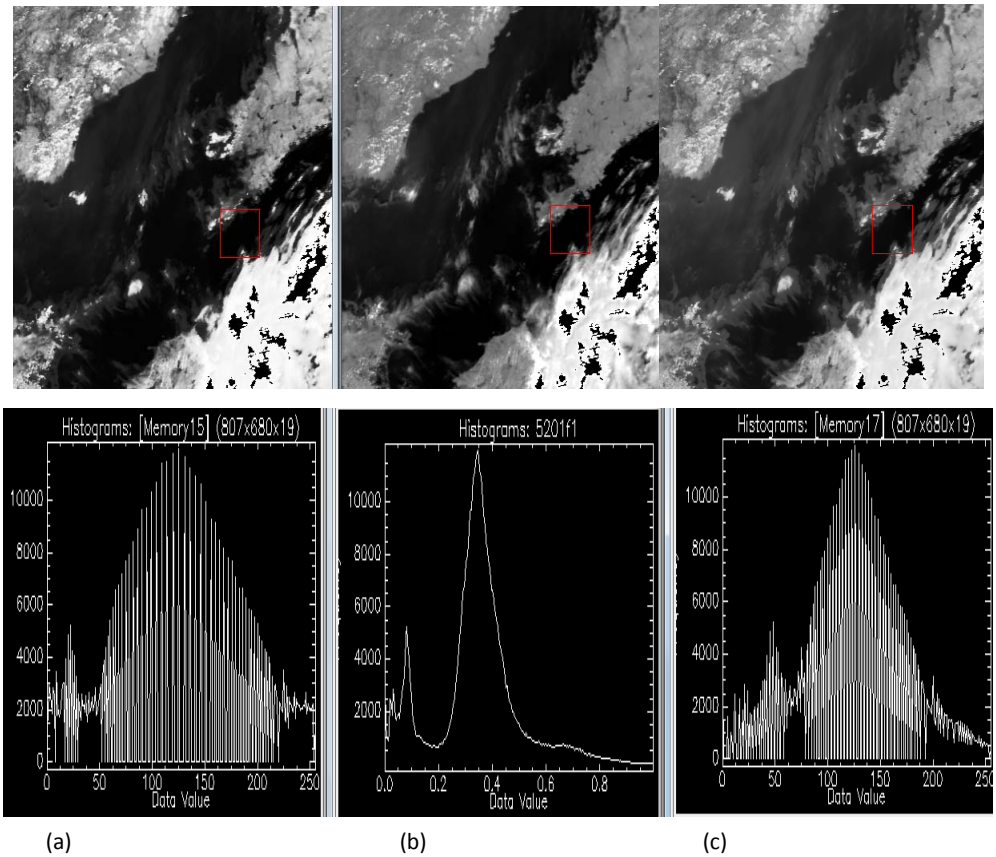
The MODIS L1B data of this paper come from Shanghai Ocean University remote sensing laboratory. After destriping noises, "bowtie" elimination, geometric correction and atmospheric correction, it can extract oil spill information. After the crude oil pipeline explosion in Dalian New Port areas on July 16, 2010, through analyzing the MODIS data for some days, the result show that the data at 05:20, in July 18, 2010 can obviously reveal oil spill information about target sea area, what's more, the sea area was covered by less cloud, so that this data is used for diagnosing and analyzing oil spill in this

paper. According to the accident report, the research sea area was located in Dayao Bay and Golden Pebble Beach Bay (38°59′39.19"N ～ 39°5′9.06"N, 121°53′31.88"E ～ 122°0′22.99"E).

3.2Results and discussion

Because of the difference of spectrum property between oil spill and sea water, the reflectance exist difference. It is the key point to enhance the contrast between oil spill and sea water for extracting oil spill information. After the pretreatment on MODIS remote sensing images, make use of extracting oil spill information method which is combined texture filtering and grey value processing. Texture filtering is the process of texture calculation for gray level frequency of occurrence in processing window by probability statistics, calculate texture image in four different directions (0°, 45°, 90°, 135°) based on GLCM (Gray Level Cooccurrence Matrix), the window size is 7×7，the textural features is entropy, then gain the mean of image in four different directions, last acquire the entropy image with image texture as the same as original image size. Realize image filtering by "ENVI/Filter/Texture/Occurrence Measures" (the process effect in Figure1).

The remote sensing image via texture filtering was attached such as histogram equalization and Gaussian contrast tensile processing by "ENVI/Basic Tools/stretch data", the gray value were stretched in 0-255 gray level (the process effect and histogram in Figure2). The stretch image reflect the characteristics of object, especially the process image by Gaussian contrast stretch, the oil spill information is more clear, the sea water around oil slick is more and more dark as the gray level difference is enhanced. From the gray histogram, show that image pixel is evenly and dynamically distributed in large gray area.



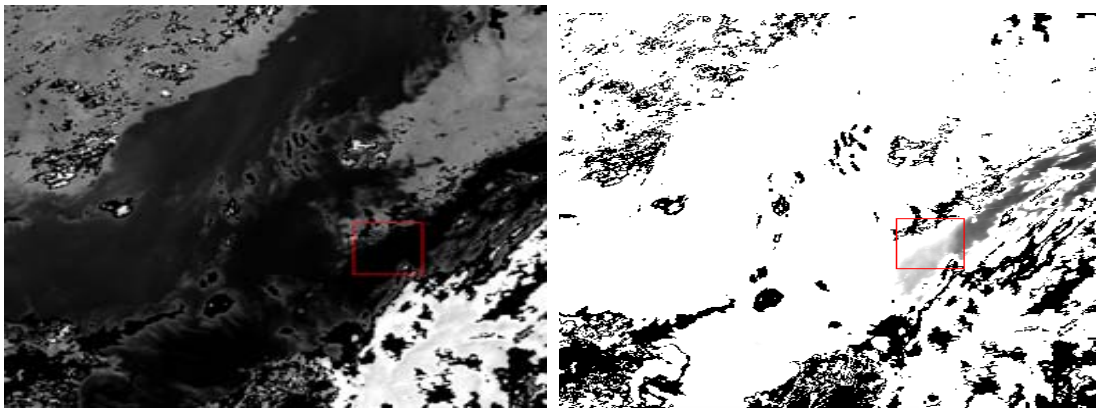
(a) (b) (c)

Figure2 (a) the image and the histogram after histogram equalization (b)the original image and the histogram on band 5 (c) the image and the histogram after Gaussian contrast stretch

Suspected oil spill area is still influenced by a few clouds according to the above picture, it can remove the clouds by band calculation. The cloud has high reflectivity in visible light and near-infrared wavelengths; its corresponding grey value is round 250. We can choose the gray value of trough of wave as threshold which is among peak area in high value according to histogram, set 0 where gray value is equal or greater than threshold, that's shielding off cloud area information, set 1 where gray value is less than threshold that can gain binary image. In this paper the image of band 5 is used for removing the clouds, set 231.01 as cloud threshold, then gain removing clouds image by band calculation (Eq. (3)).

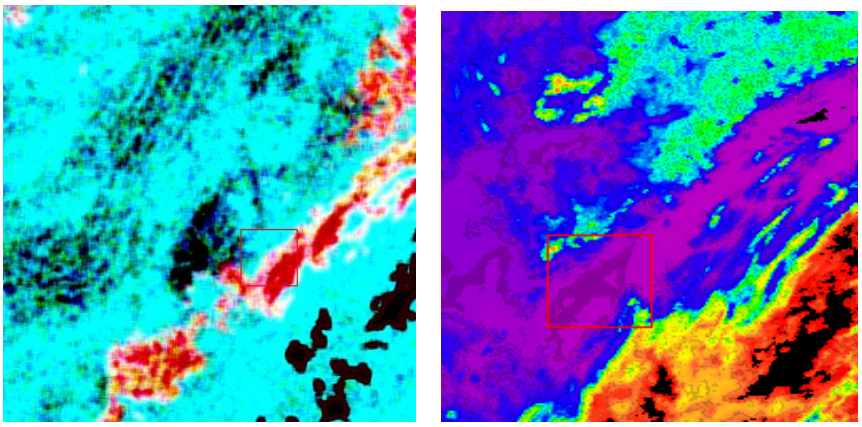
((b1 ge 231.01)*0+(b1 lt 231.01)*1)*b2 （3）

Where b1 is remote sensing images after the above process, b2 is remote sensing images of band 5.



(a) (b)

Figure3 (a) the image of removing clouds (b) the extracting oil spill area



(a) (b)

Figure4 (a) RGB synthesis color images by band 1,5,9 (b)Putple-Red+Stripes synthesis color images

The maximum reflectivity of the Daqing crude oil is 0.019[1], so that the value is the threshold as extracting oil spill information, set 1 where gray value is less threshold on the removing cloud image of band 5, that remain their original value, set 0 where gray value is greater than the threshold, that shield off all other information (Eq. (4)).

(b1<0.019)*1+ (b1>0.019)*0 （4）

Here b1 is the removing cloud image of band 5 (the result of band calculation in Figure3 (b)). The image show the

gray black oil spill area with obvious gradient, for enhanceing gray levels, the color image is made of band 1, band 5 and band 9, the oil spill information in that color image is more clear(in Figure4).

4.Conclusions

This paper chose the remote sensing image on July 18, 2010 as analyzing material by screening the MODIS images for some days about the Dalian New Port sea area after on July 16, 2010 and eliminating the influence of the clouds. After the pre-processing of destriping noises, "bowtie" elimination, geometric correction, atmospheric correction and so on for MODIS images, we applied the processing method which is combined texture filtering and linear stretch, then via removing the clouds and band calculation we extracted oil spill information. The result showed that the oil spill area was located in Dayao Bay, there was a floating oil belt with 10m width and nearly 20km length, this is according with the report of the China Ocean Monitoring Ship, which shows the feasibility of this method.

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