Applications on Ocean Monitoring Based on Airborne SAR Data

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Abstract-In this paper, the ocean goals, including ships, coastline, using of sea area, islands, oil spell, sea ice and green tide ,are monitored based on Airborne SAR data. We analyze the principles and advantages of the use of airborne SAR data to monitor these seven targets. The experience has shown that the use of airborne SAR data on monitoring marine targets has irreplaceable advantages compare with other sensors.

Keywords: Airborne SAR, ocean monitor, ships and tail track, coastline, use of sea area, islands, oil spill, sea ice, green tide.

I. INTRODUCTION

The airborne SAR is an active sensors. The sensor can obtain high-resolution data. SAR can work all-day and all-weather. Airborne SAR is more mobile than other sensors. Airborne SAR can still provide data under the condition of intense airspace and atrocious weather.

II. MONITORING TARGETS

Different flight programs are designed based on different data needs and different monitoring targets. Airborne SAR images are made after processing the raw airborne SAR data. This paper expounded airborne SAR image characteristics and monitoring principle on ships and tail track, coastline, using of sea areas, islands, oil spill, sea ice and green tide etc.

A. ships and tail track

1) Ships

Ships are made of metal typically. Ships' superstructure can form corner reflectors which make ships to become a strong reflector. It is bright on SAR image where there are ships[1]. Physical factors will affect the ships detection include ships' factors , SAR factors and sea state factors. Ships' factors include the ships' structure, shape and tonnage, etc. SAR factors include polarization, the angle of incidence, the angle between the radar beam and ship. Sea state factors include sea condition and climate.

The resolution of airborne SAR images is high. It is submeter generally. Ships are hard targets on airborne SAR images. They also have fixed size and details. Ships on airborne SAR image are usually composed by two types of points. They are the high brightness point which caused by ships' superstructure and masts and the low brightness point which caused by decks. High brightness points can form strong peaks. Low brightness points can form weak peaks. The distribution of strong peaks and weak peaks is the most important characteristic to target recognition. To sum up, ships on airborne SAR images have the following characteristics: (1) asymmetrical brightness distribution; (2) hard target; (3) clear ship details.

Figure 1 is a airborne SAR image. The image resolution is 0.5m. The ship's length and width can be confirmed through the SAR image.
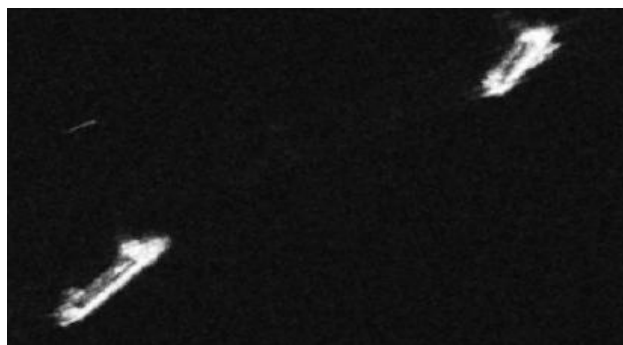

Fig1 ships on airborne SAR image

SAR image speckle filtering should be done first in order to filter out speckle noise and smooth the image. Image filtering is helpful to target extraction[2]. We can select the appropriate algorithm to detect ships based on the

characteristics of ships on the image. Currently, main ship detection algorithms based on SAR images include direct detection algorithms and indirect detection algorithms. Indirect detection algorithms are based on ship trail. CFAR algorithm is the most classic for ship detection. CFAR is widely used. It is a single-liminal image segmentation algorithm. It is mainly used on low-resolution SAR images(25m).

2) Tail track

Tail track detection is able to more accurate estimate of the actual position of ships. Four kinds of trail waves can be caused by ships sailing on sea surface. They are Kelvin waves, narrow V-shaped waves, turbulent waves and internal waves[3]. Different types of waves will influence SAR echo differently. SAR images can not show all types of waves. Figure 2 is SAR image which show ship trail waves.

Fig2 SAR image which show ship trail waves

Tail trace detection algorithms based on SAR image need to consider the problems include: (1) waves have a certain width; (2) grayscale can be darker than the sea background bright, also can be lighter than the sea background bright; (3) Tail trace can be necessarily straight; (4) SAR image has inherent speckle noise; (5) other linear waves can be concluded.

The current ship trail detection algorithm includes: Radon, Hough transform, Dempster-Shfer methods and morphological methods. Different tail trace detection algorithms have different emphases. By selecting appropriate detection algorithm, the ship's speed and tonnage can also be calculated.

B. Coastline

Coastline can be divided into island coastline and mainland coastline. Coastline means the position of average high tide for years. Coastline may change by four reasons mainly: (1)

crustal movement; (2) melting ice; (3) river sediment accumulation; (4) human activities[4].

Coastline in SAR images is the dividing line of the land and the sea. To concern the position of coastline is actually to concern the edge of sea. There are several variety of algorithms, such as the traditional edge detection operators. Level set algorithm is a more advanced algorithm.

Coastline edge can be concerned after selecting appropriate preprocessing methods. But the edge is only the instantaneous water line at the time of data acquisition. The position of instantaneous water line may be influenced by tide easily, particularly in the region of relatively flat terrain. The position of coastline should be corrected in view of tide.

C. Use of Sea Areas

There are two emphases on monitoring sea areas. The first one is range. The second is using purpose.

Airborne SAR data is more sensitive to the surface reflectance and roughness. of the surface features, We can easily and clearly monitor the coastal engineering. Figure 3 is Airborne SAR images near Dongjiakou port. The resolution is 0.5 meters. We can clearly see the progress of the coastal engineering from the SAR image. If the range of coastal engineering is out-law we will confirm the illegal area.
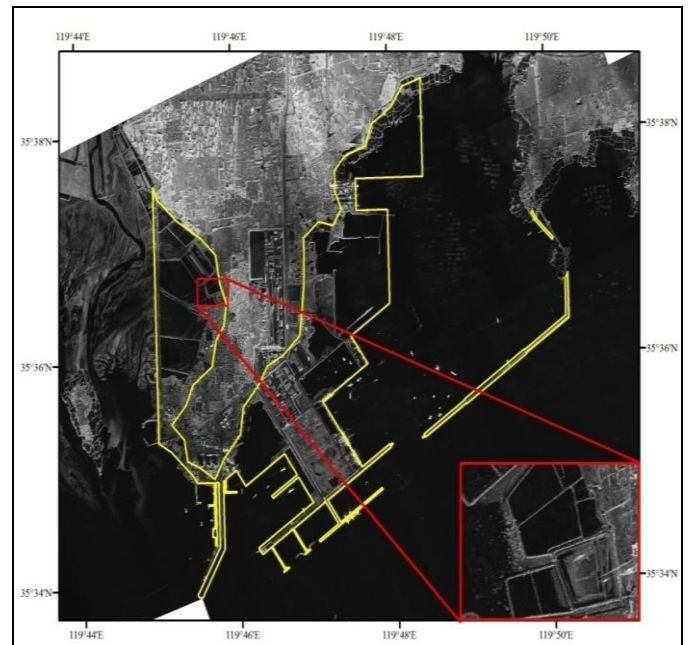

Fig3 Dongjiakou port(yellow solid line is the legal borderline, the resolution is 0.5m, data acquisition time is December 2012)

D. Islands

Protecting and managing islands is seamed more and more important. Airborne SAR can obtain high resolution data efficient. High-resolution airborne SAR images can be produced after being rectified recur to high-precision optical remote sensing data. Development and protection on island can be monitored by airborne SAR images.

E. Oil Spill

Marine oil pollution may be caused by a variety of ways. The most serious oil spills are from ships and blowout. In recent years, with the great development of the oil industry, oil spill occurred frequently. Our government and marine department are more and more attaching importance to monitor marine oil spills especially since "7-16" Dalian Xingang oil spill and Penglai 19-3 oil spill.

Airborne remote sensing is a kind of advanced technical means for monitoring marine oil spill. Oil spill always occurred in bad weather condition. Under the bad weather condition, satellite images are difficult to be obtained. It is also difficult to monitor the entire area by the use of ships. Airborne remote sensing can work under bad condition efficaciously.

Oil spill on the sea surface could weaken radar backscatter. The oil spill area is always darker than normal sea water area on the SAR image. X and C-band SAR can detect oil spill efficaciously[5].
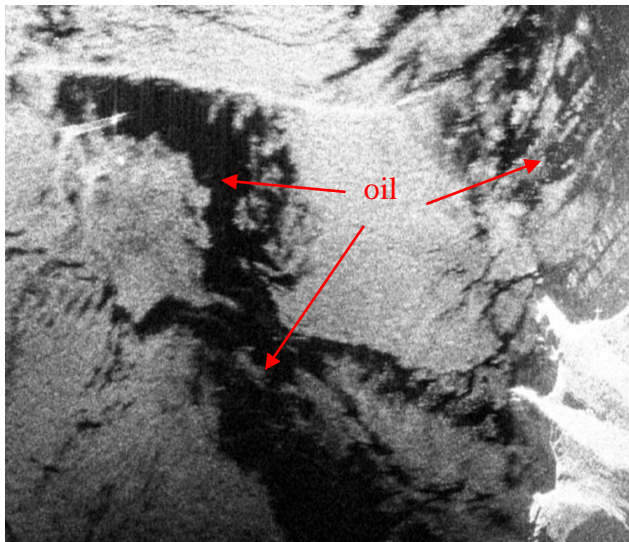

Fig4 Oil Spill detected by airborne SAR images(July 2010, near Dalian Sanshan island)

In order to determine the boundary of the oil spill area, image segmentation should be done first[6]. There are a variety of image segmentation algorithms. Figure 5 is the result of oil spill by using level-set algorithm.
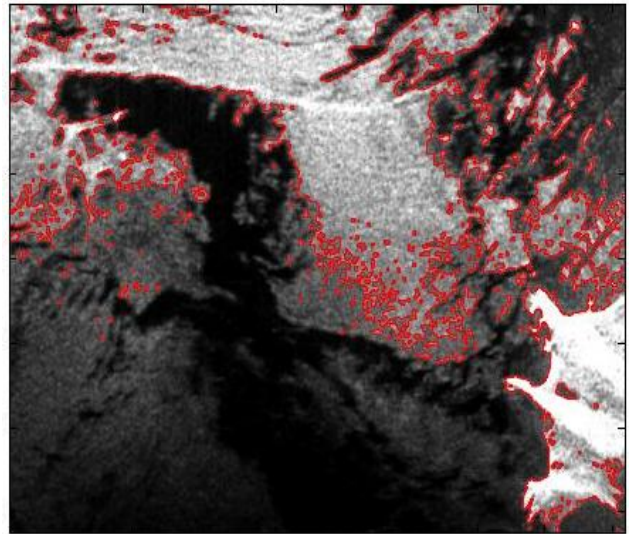

Fig5 The result of Oil spills by the use of level-set (red solid line is the oil spill area boundary).

F. Sea Ice

There will be sea ice in part of Bohai and North Yellow Sea in every winter. Sea ice is a serious kind of marine disasters. It will cause harm to the marine ecology, marine transportation and offshore oil platforms.

Characteristics of electromagnetic waves from sea water and sea ice are significant difference. Strong radar reflector layer will form in ice-water contact surface. Sea-ice component in the radar image show the rich phenomenon of echo. The factors influencing radar scattering include: sea ice surface roughness, the dielectric constant of sea ice, the direction of radar beam.

Figure 6 is airborne SAR images of sea ice near Liaodong Bay acquired on December 30, 2011. The distribution of the fixed ice and flowed ice can be clearly seen from the SAR image. The area of smooth fixed-ice is uniform dark. The area of rough fixed-ice is lighter than smooth fixed-ice. Sea ice can be concerned by use of the relationship between sea-ice surface roughness and radar backscatter.
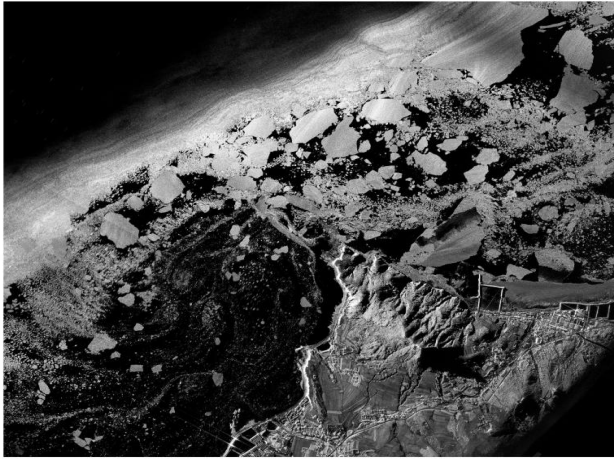
Fig6 Airborne SAR images of sea ice(acquired on December 2011)

G. Green Tide

Green tide is one of the serious marine disasters occurred in every June to October. It may damage the marine ecosystem seriously. It may threaten the marine food safety too. In the summer of 2008, serious green tide disaster impact not only on coastal water quality, and also a serious threat to Olympic Regatta in Qingdao.

Dispersing green tide could change the roughness of the sea surface. When electromagnetic wave detect sea surface, reflection characteristics are different between sea water and green tide. Based on above characteristics, we can distinguish green tide area and sea water.

III. CONCLUSION

This paper described the advantages and principles of using airborne SAR data to monitor seven marine targets. Experience has shown that airborne SAR can monitor marine targets effectively. Airborne SAR also has irreplaceable advantages compare with other optical remote sensing instrument.

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