A C-Band multi-polarimetric SAR flight experiment on Ocean application

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Abstract

The C-band polarimetric Synthetic Aperture Radar (SAR) data has wide application in the earth observation field, especially in ocean application. National Satellite Application Service （NSOAS）and Institute of Electronic of Chinese Academy of Science（IECAS） conduct airborne SAR flight experiment on ocean near Hainan province coastal in 2009. A large number of C-band polarimetric SAR data of ocean objects are recorded in the experiment. The situation of the experiment is induced, and inversion results of data are presented in this paper.

Keywords: C-Band multi-polarimetric SAR, fight experiment, Ocean applcation

1. Introduction

In order to obtain multi-polarimetric SAR data of ocean object and test its application in ocean observation, NSOAS and IECAS executed airborn SAR flight experiment near Hainan province coastal from February to March in 2009. A multi-polarimetric SAR system developed by IECAS is used in the experiment. And a great number SAR data of wave, wind, coastal zone, ship and its wake are recorded

In this paper, experiment plan and inversion results of data are present.

2. Airborne SAR system of IECAS

According to task demand C band is chosen from P, L, C, X and Ku as work band for its wider applications in ocean than others. The characteristics of sensor are listed in Table 1.

Table 1. Characteristics of SAR System

Property	Airborne SAR
Frequency Band	C
Flight height (m)	7200 ～ 8400
Flight velocity(m/s)	150～210
Polarization	VV/HH/HV/VH
sweep range of range beam(°)	±20
sweep range of azimuth beam(°)	±15
Highest resolution(m)	1

Figure 1(a) is antenna and Figure 1(b) is quick look processor of IECAS SAR system.

Fig.1.(a) Antenna of IECAS SAR System.

Fig.1. (b) Quick look processor of IECAS SAR System

3. The situation of flight experiment

3.1. Region of flight experiment

We choose South sea of china which near Hainan province as experiment region.

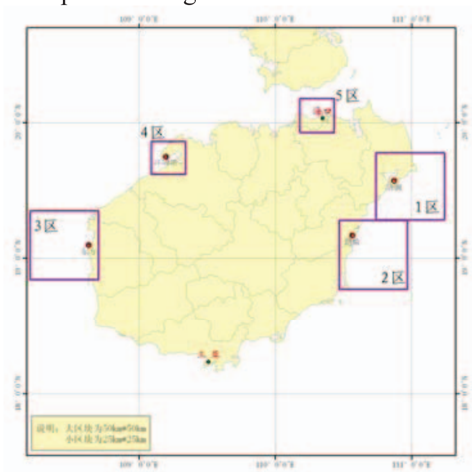


Fig.2. Sketch Map of Experiment Region

Figure.2 is sketch map of experiment region. In the figure, region 1 and 2 are wave, wind and ship wake observation region, region 5 is ship observation region. Region 3, 4 are candidate region.

3.2. The situation of the experiment

Add up to 16 flights are executed during experiment. In each flight, more than one ocean object are observed. The situation of flight is listed in Table 2.

Table 2. Statistics of Flight Experiment

Property	Region	Number of Observation
Castle zone	2	5
Ship	1,2,3,4,5	7
Wave andWind	1,2	9
Ship wake	1,2	2

Figure.3 (a), (b) illustrated buoy location during wave and wind observation. Figure.3 (c), (d) illustrated course of test ship during wake observation.

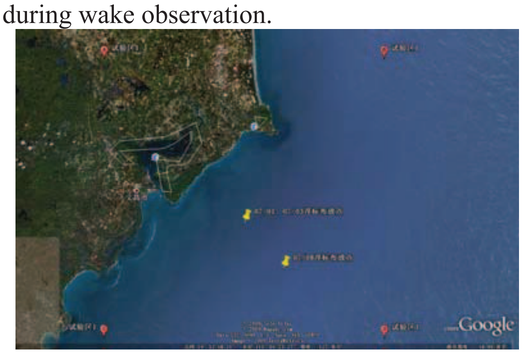


Fig.3. (a) Buoy location in Region 1

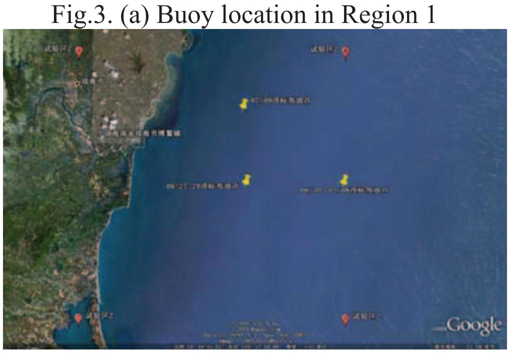


Fig.3. (b) Buoy location in Region 2

Fig.3. (c) Course of test ship in Region 1

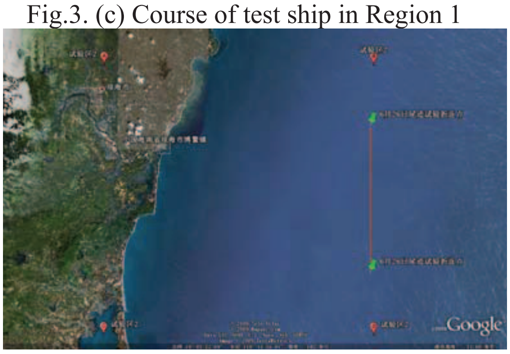


Fig.3. (d) Course of test ship in Region 2

3.3. Obtained SAR image and processing result

3.3.1 Wave

Airborne SAR is inversed to wave spectre. And the result is compared with buoy data which recorded at same time.

Firstly we compute the calibrated normalized radar cross section (NRCS) of airborne-SAR images. The SAR sub-images (usually 128*128 pixels) are filtered by a Gaussian high pass filter to remove the low wave number signal which has no relation to surface waves. The coarse SAR spectra are computed by performing 2-dimensional Fast Fourier Transform (2-D FFT) to corrected sub-images. Then the smoothed SAR image spectrum is derived by performing low pass filter to coarse spectra.

The directional wave spectra can be derived by the inversion of linear form of wave-SAR formula if the cases are considered to be swell cases [1].

Figure 4 (a), (b) is respectively airborne sub-image and its SAR spectre. Figure 4 (c) is wave rider buoy wave number spectrum and its (d) directional frequency spectrum

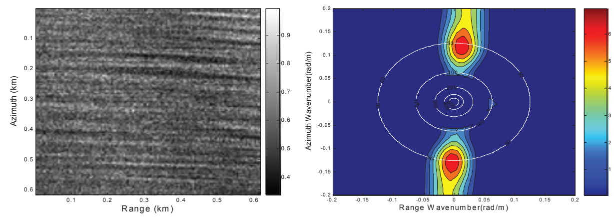


Figure 4(a) (b)

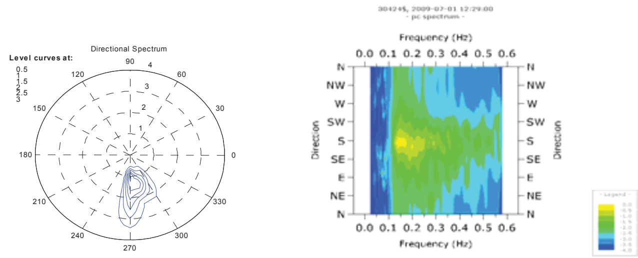


Figure 4 (c) (d)

Table 3 is result compared between inverse result and buoy data. We can find that inverse result fit the buoy data well.

Table3. Statistics of Flight Experiment

	Wave direction	Wave length	Wave height	Period
Airborne-SAR	182.1	50.7	1.2	6.9
Buoy	182.5	49.2	0.96	5.6

In observation experiment, spaceborne image which recorded at quasi same time with airborne image is also obtained in order to study inverse result difference between them. The most important difference between these two image sources is the platform range-to-velocity ratio R/V. More study about it will be presented in full paper submission.

3.3.2 Ship

First, we choose the amplitude ration of ship sample to sea sample as standard to evaluate ship detect performance of different polarity channel. Figure 5(a) is merged multi-polarization ship SAR image which recorded in region

5. Figure 5(b)-(c) is part different polarity ship sample images.

Figure 5 (a)(red:HH, green:VV, blue: HV)

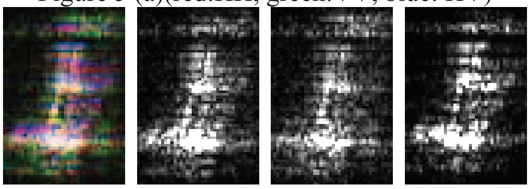


Figure 5 (b)(left: merged, left center: HH, right center:VV, right:HV)

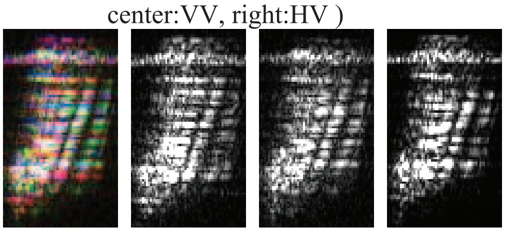


Figure 5 (c)

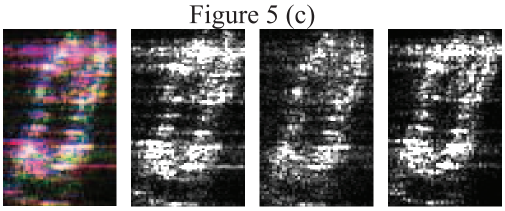


Figure 5 (d)

Table 4 is part statistic result about ratio of ship to sea in different polarity channel. Ratio of ship to sea in cross polarity image is larger than others in most situations. It shows that multi-polarization SAR which has cross polarity channel has advantage in ship detection than single polarity SAR.

Table 4 Statistic of ration of ship to sea in different channel

	Polarity channel	Ratio of Ship/sea
Ship1	HH	20.7469
	VV	19.9737
	HV	571.0221
Ship2	HH	17.6840
	VV	18.3698
	HV	516.2695
Ship3	HH	16.2098
	VV	15.6746
	HV	342.1922
Ship4	HH	30.8496
	VV	24.5797
	HV	839.3938
Ship5	HH	24.9217
	VV	20.7255
	HV	752.6428

Second, we merged different polarity channel image by Polarity Whiten Filter (PWF).We find the ratio of ship to sea in merged image is larger than that in cross polarity channel which mean multi channel data ship detection has more advantage. More detail will be presented in full paper submission.

3.3.3 Ship wake

Ship wake image is also obtained in this experiment. Figure 6 (a)-(d) are ship wake images recorded in same flight.

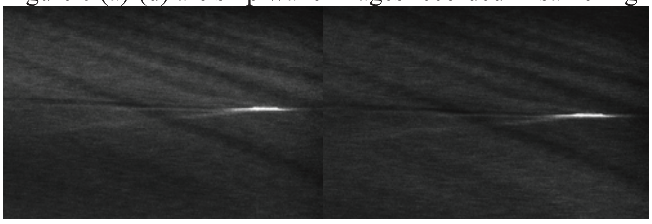


Figure 6 (a) VV (b)HH

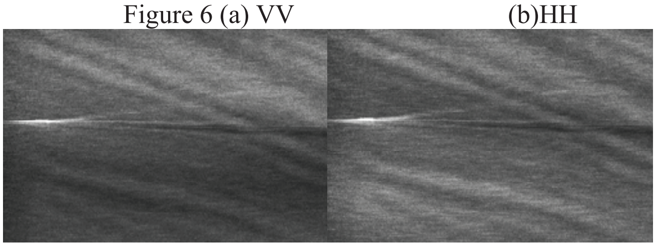


Figure 6 (c) VV (d)HH

The flight direction of (a),(b) is opposite to that of (c),(d).The effect of flight direction is very clear in those image.

A nomalized grey scale algorithm which based on Hough transform is used to detect wake. Figure 7(a)-(d) is wake detection result of figure 6(a). More detail about inverse ship location and ship direction will be presented in full paper submission.

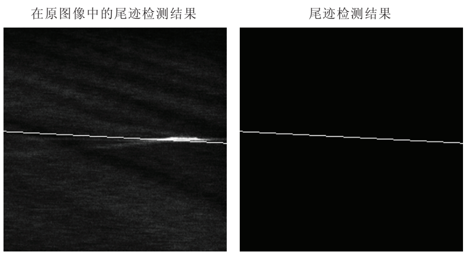
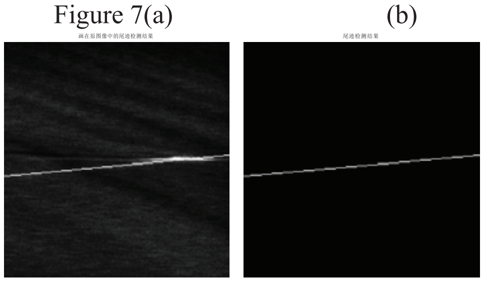


Figure 7(a) (b)



7(c) (d)

3.3.4 Costal zone

Figure 8, 9 is different polarity channel image on the same scene in region 2. The difference between those images is very clear.

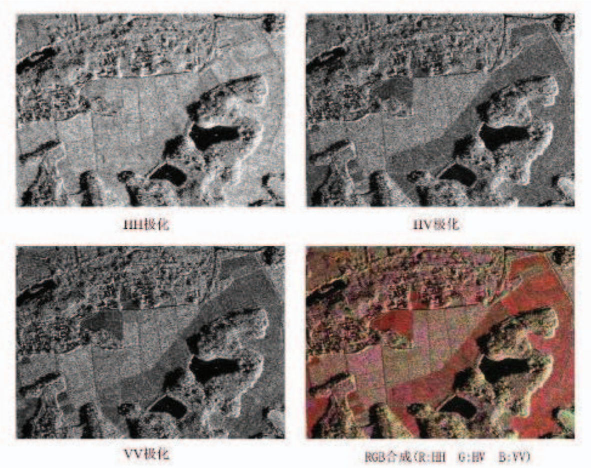


Figure 8

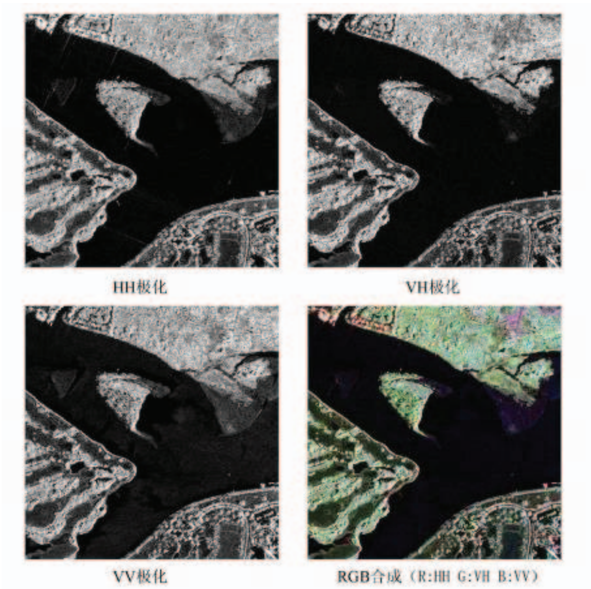


Figure 9

Figure 10 is merged SAR image in region 2, and Figure 11 is classification map of single polarity channel data and quad-polarity channel data in figure 10.

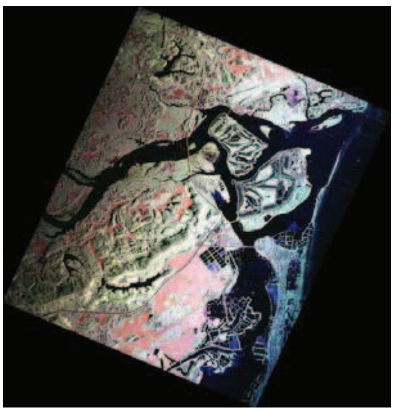


Figure 10

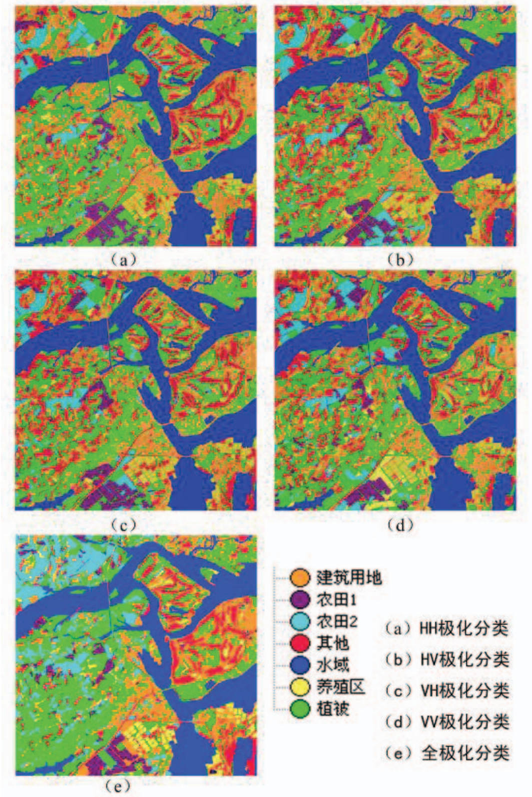


Figure 11

The classify accuracy of those image are evaluated through compare results of them with field observation data. It seems that specific polarity channel data has good classify accuracy in a given task. Besides that, quad-polarity channel data classify accuracy is also analyzed. More detail about it will be presented in full paper submission.