Sandbar Analysis of Polarimetric SAR Images using Four-Component Scattering Decomposition

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1. Introduction

Sandbar is a foot print of river into the sea. Sandbar can shield the current flow of ocean to reduce the coast erosion by ocean. Because of the shielding, the area between sandbar and coast always provide an excellent place for sea-farming. Monitoring the change of sandbar is a very important thing for the ecosystem and fishery economic of Taiwan. [1] Traditional remote sensing can't analyze the boundary of sandbar very well. Fully polarimetric SAR system has the capability to classify different structures based on their own scattering mechanism.[2] General propose four-component scattering decomposition (G4U), a model based decomposition method[3][4][5], provide a very good costal classification and analysis results. In this paper, 6 Radarsat-2 data sets were collected to analysis the changes of sandbar, oyster farm and the wave front of ocean along the sandbank with different ocean conditions using four decomposition scattering decomposition model.[6]

2. Radarsat-2 Data Sets

These data sets which is listed in Table 1 are based on the research results of a RADARSAT-2 (RS2) Science and Operational Applications Research (SOAR) project (#: 3595) jointly proposed by U.S. Naval Research Laboratory and National Central University, Taiwan. The high-resolution (about 8 m) fully polarimetric RADARSAT-2 data should provide sufficient scattering information even with the limited C band foliage penetration at.[1] In this paper, the largest sandbar of Taiwan-Waisanting sandbar, outside a piece of reclaimed coastal land in Taiwan, was selected as the test site.

3. Scene Description

The Acq #1 data is shown in Figure 1 with Yamaguchi four-component decomposition with rotation (Y4R) vector color coding. The test area which includes sandbar and oyster farm shows with the red rectangle. The ground truth photo shows as Figure 2. Enlarged portion of test area using 3 different decomposition models are shown in Figure 3. According to the ground measurement data shown in Table 2, there are 4 different tide levels, 2 kind of wind direction and 5 different wind speeds in these 6 days. Figure 4 is the bathymetric data of sandbank and oyster farm, the location and direction of oyster farm can be found. Figure 5 shows the simulation of tide level based on the bathymetric data. According to Figure 5, The test area of Waisanting sandbar will be totally under water when the tide level over +0.9m. When the tide level is lower than -1.1m the test area will fully explore. Same situation can be observed by four-component decomposition models. Acq#4 and Acq#6 with +0.9m tide level show the same bright scattering mechanism in Figure 3, and the explored oyster farm area is very similar when the tide level below -1.1m.

4. Scattering mechanism of test area

4.1 Sandbar

There are two kinds of scattering mechanisms in these days. When the tide level is lower than sandbar, the water line with current wave front causes the boundary of sandbar. In Acq#1,2,3,5 of Figure 3, decomposition images show very dark in sandbar area. It's because Waisanting sandbar is flat surface, only few surface and manmade structure response can be detective and the west boundary of sandbar have clear surface (blue) and volume (green) response. The volume effect is cause by breaker wave and the amplitude of volume scattering and wind speed are in direct proportion. It's When the tide level higher than sandbar like Acq#4,6, the scattering mechanism is totally different with the other days. The shallows of the sandbar area will generate very serious rough and small wave. It explained that the response signal of Acq#4,6 is stronger than the others. The comparison between decomposition models shows that the G4U provide more correct description of sandbar underwater than the others.

4.2 Oyster farm

In these 6 days data, the scattering mechanism of oyster farm will also be changed because of the tide level. When the tide level is +0.9m like Acq#4 and Acq#6, there are almost no oyster farm explore in the air, only very few double bounce response (red) is shown. Then, the oyster coverage will increase follow the decreasing of tide level. The colourful result in oyster area means there are more complicate scattering mechanism [6] in this area. Because Acq#1 and Acq#5 have similar tide level, wind direction, and wind speed, a comparison of Acq#1 and Acq#5 shows in Figure 7. In Figure 7, the Pd between 2 images is almost the same. It means extra response of volume scattering is observed. Because of the oyster growth period, lots of oysters are grown up in summer. It will cause very serious volume scattering in C band. In this case, S4R and G4U keep more detail of the oyster farm.

5. Summary

This paper shows the time series scattering mechanism analysis of C band in sandbar area. Sandbar area is very complicate and variation by time, season, and tide. About the decomposition results of sandbar area, surface and volume scattering will be changed from weak to stronger when the tide level over the sandbar. Double bounce response of oyster farm should be the same if the environment conditions are same in any 2 images. When oyster farms are full of oysters, a strong volume scattering caused by lots of oyster shells will dominate the decomposition results in oyster area.

Figure 1: RadarSAT-2 Quad-Pol image (Acq#1), Y4R, Test area shows in red rectangle.

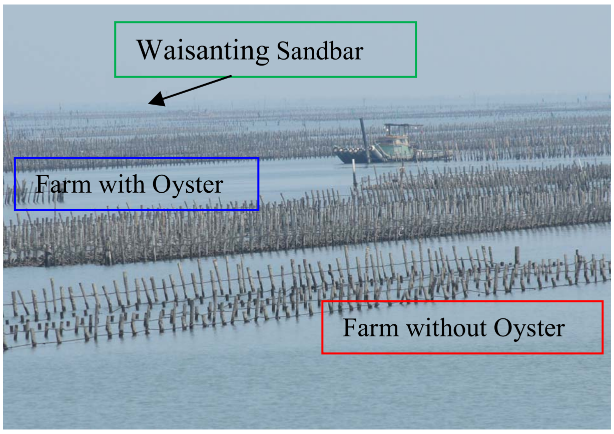

Figure 2: Photo of Oyster farm with and without oyster

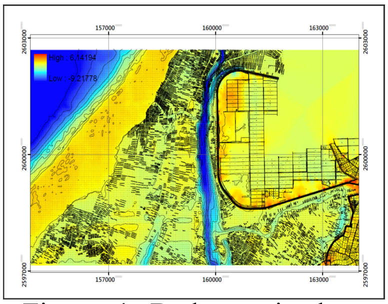

Figure 4: Bathymetric data of sandbank and oyster farm

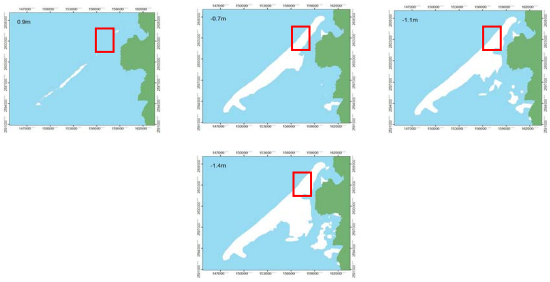

Figure 5: Sandbar area variation on 4 different tide level (-1.5m,-0.7m,-1.1m,+0.9m)

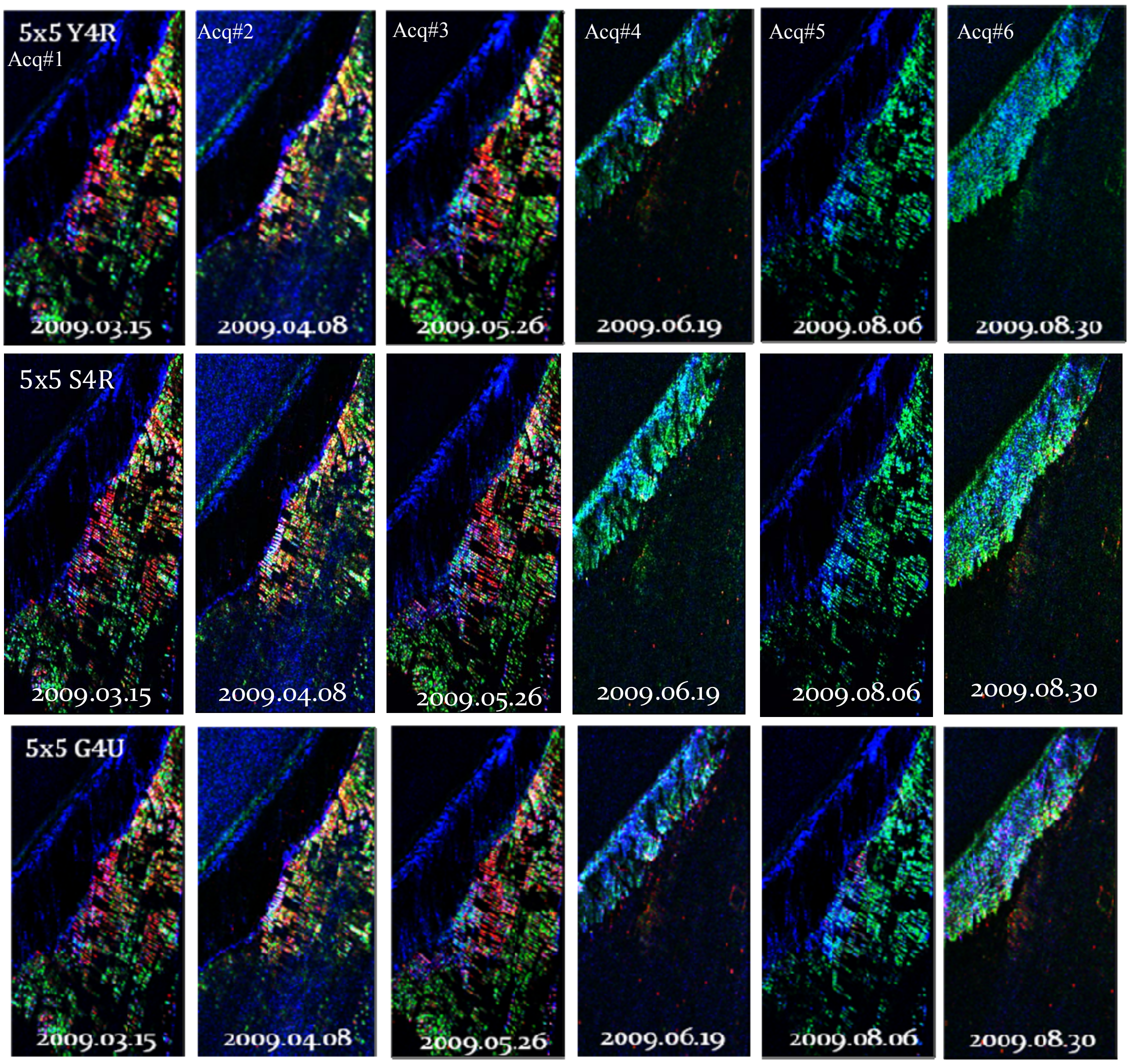

Figure 3: Sequence decomposition results of test area using Y4R, S4R and G4U

Figure 6: Manmade structure on Waisanting Sandbar

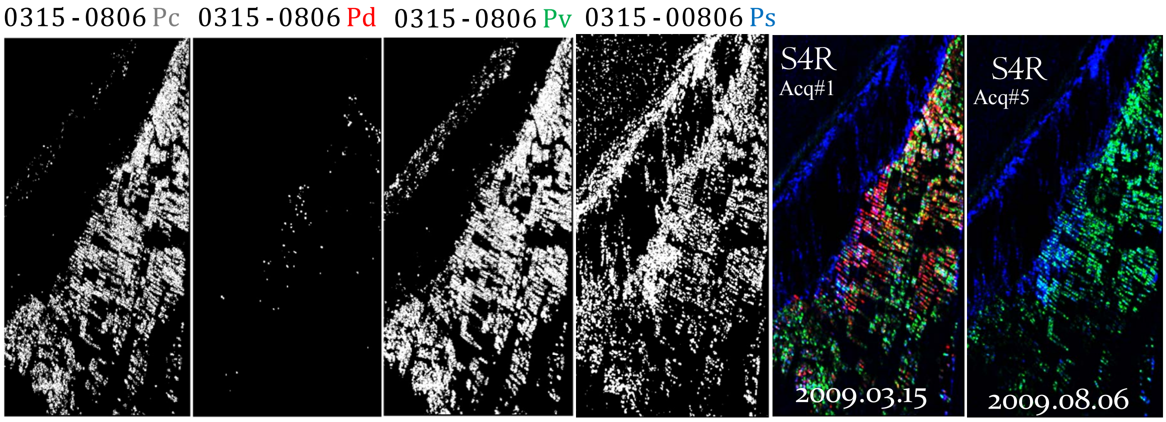

Figure 7: Change Detection between Acq#1 and Acq#5 using S4R decomposition, similar tide level, wind direction and wind speed.

Table 1: Data acquisitions of Radarsat-2 Fine Quad-Pol Mode

Acq#	Date	Time(LCT)	Orbit	Beam
1	2009/3/15	18:00	18-76A	FQ15
2	2009/4/8	18:00	19-119A	FQ15
3	2009/5/26	18:00	21-119A	FQ15
4	2009/6/19	18:00	22-119A	FQ15
5	2009/8/6	18:00	24-119A	FQ15
6	2009/8/30	18:00	25-119A	FQ15

Table 2: Tide and wind data at data acquisition time

Acq#	Date	Time(LCT)	Tide (m)	Wind direction	Wind speed (m/s)
1	2009/3/15	18:00	-1.14	NNE	8.3
2	2009/4/8	18:00	-0.72	NNE	12.6
3	2009/5/26	18:00	-1.71	NNE	7.9
4	2009/6/19	18:00	0.90	WSW	3.3
5	2009/8/6	18:00	-1.12	NNE	6.7
6	2009/8/30	18:00	0.91	NNE	8.3

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