# STUDY ON EVOLUTIONS OF JIANGSU RADIATING SANDBANKS BASED ON SAR IMAGES

**Yanwei SONG [(1)] Jie ZHANG [(2)]**

*[(1)] Ocean University of China, No.5 Yushan Road, 266003 Qingdao , China*
*[(2)] First Institute of Oceanography, SOA, No.6 Xianxialing Road, 266061 Qingdao, China*

## ABSTRACT

The main goal of this study is to obtain high-resolution data to describe the evolution trends of Jiangsu Radiating Sandbanks, which exhibit considerable quasi-regular variations. Because SAR images have the advantages of imaging underwater sandbanks and all weather, we collect different period images to analyses the temporal and spatial variability of Jiangsu Radiating Sandbanks. The result indicates that the evolutions of Jiangsu Radiating Sandbanks are both in two and three-dimension. The former is related to overall on/off shore sandbanks migration, whereas the latter is induced by the horizontal amplitude growth, migration, or length scale change of the quasi-regular topography. By using the methods of crisp enhancement, density slice, overlay analysis and supervised classification etc, we show the changes of primary sand ridges, and then conclude the evolution trends of the whole radiating sandbanks.

## 1. INTRODUCTION

The Yellow Sea is a shallow marginal sea of the western Pacific, lying north of, and adjacent to the East China Sea. The Yellow Sea receives large amounts of sediment from Chinese rivers. The great preponderance of sediment physiognomy in the Yellow Sea is Jiangsu Radiating Sandbanks (as Fig.1). There are a series of underwater radiating sand ridges along the coast of Jiangsu. The troughs alternate with ridges and distribute about 200km from south to north and 140km from east to west where the water deep is between 0m and 25m. The radiating sandbanks have complicated and special hydrodynamics, geology and geomorphology conditions. The tidal current is strong in this area. Average speeds of flooding and ebbing of tidal current in this area are over 1.4 m/s. Average tide range in this area is about 2.5~4.0 m, and the largest tide range of Huangsha tidal channel is up to 9.28 m. Here in this study, SAR images are chosen to analysis the distributing characteristics and evolution trends of Jiangsu Radiating Sandbanks.

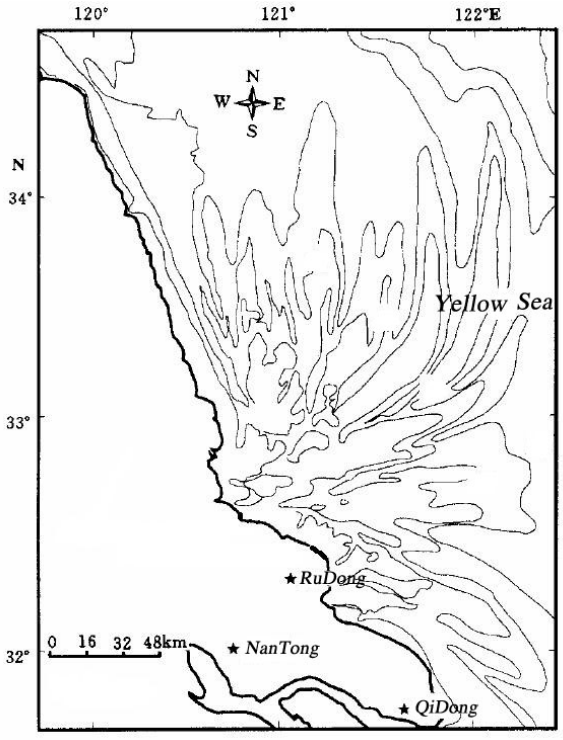


Fig.1 Sketch map of Jiangsu Radiating Sandbanks

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## 2. METHODS

The topography of Jiangsu Radiating Sandbanks is very complicated, and topography of sand ridges change ceaselessly by the action of tidal current. So monitoring of dynamic movement with routine investigation technology is very difficult. SAR is one advanced imaging sensor of remote sensing and is generally known to posses a number of advantages over visible/infrared systems. These include all weather, day and night image acquisition capability unhindered by cloud cover, the prominent expression of surface roughness. It has been proved by a lot of practice that SAR can be used in detecting shallow underwater bottom topography.

SAR maps the sea surface roughness through Bragg scattering from the capillary waves and short gravity waves. Sand ridges in shallow sea change sea currents of sea surface and sea currents modulate further distribution of micro-scale waves of sea surface, so sand ridges can be detected in SAR scenes. Because of tidal flow's converging and diverging over sand ridge, it shows bright-dark stripes in SAR images. Although tidal channels can also modulate SAR image intensity, it is much weaker than sand ridges. SAR images provide good ground resolution of 12.5m and are sensitive to variations in surface roughness, and differences in topographic relief. In this paper, ENVISAT ASAR image are used to interpret the features of sand ridges and tidal channels. Furthermore, we study evolution of sand ridges using ERS-2 SAR images and show the variation trends of Jiangsu Radiating Sandbanks.

### 2.1 Images disposing

In order to make the characteristics of objects in SAR images more obviously, the first step is to dispose the images. In this study, by using the methods of crisp enhancement, density slice, overlay analysis and supervised classification etc, we enhance the shape characteristics of Jiangsu Radiating Sandbanks. The comparison results of the original image and disposed images are shown in Fig.2.

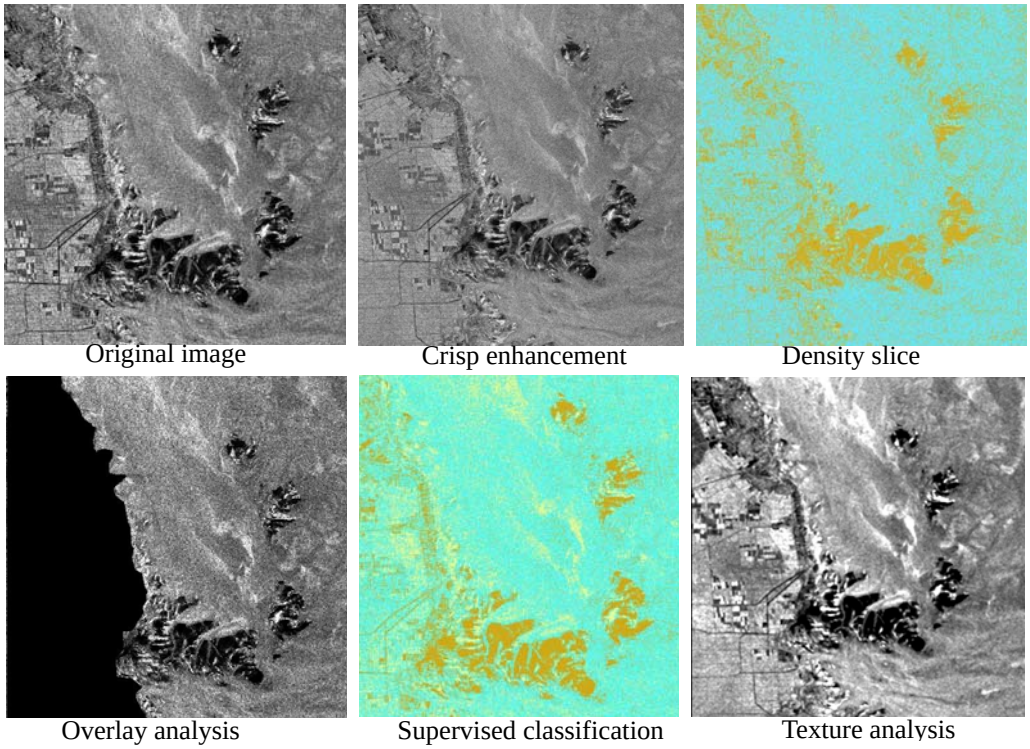



Fig.2 Comparison of original SAR image and disposed SAR images

### 2.2 Interpretation

In order to derive the information of sand ridges and tidal channels from SAR image, we analyses correlative charts and literatures. There are almost 70 sand ridges and tidal channels in the study area, but in the SAR images, there are only the large scale sand ridges and tidal channels can been identified. The interpretation results are shown in Fig. 3 and Table.1.

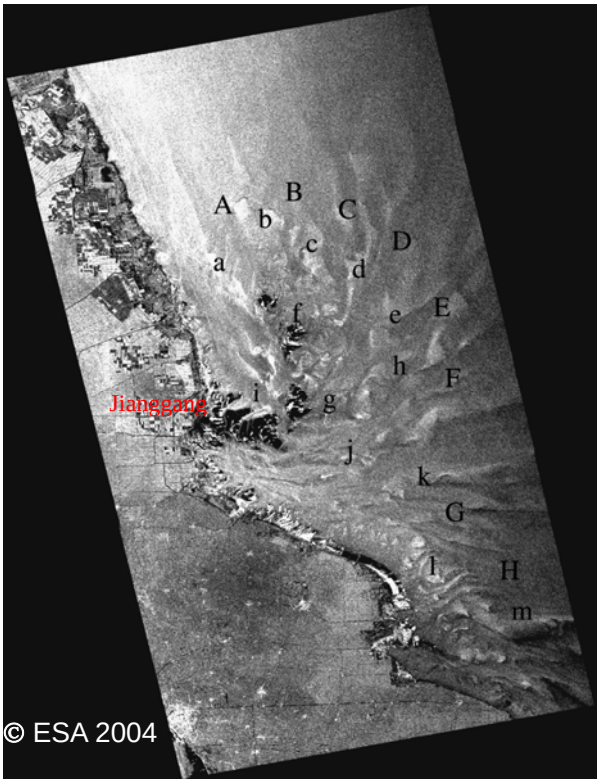



Fig.3 ENVISAT ASAR image (IS2, VV) acquired on Aug 30, 2004 of Jiangsu Radiating Sandbanks

Table.1 Interpretation Results

| Label | Ridge Name | Orientation | Label | Channel Name | Orientation |
|---|---|---|---|---|---|
| a | Xiaoyin sand ridge | N-S | A | Xi yang | N-S |
| b | Liangyue sand ridge | N-S | B | Xiao bei cao | N-S |
| c | Taiping sand ridge | N-S | C | Chen jia wu cao | N-S |
| d | Maozhu sand ridge | NW-SE | D | Cao mi shu yang | NW-SE |
| e | Wai mao zhu sand ridge | NW-SE | E | Ku shui yang | NW-SE |
| f | Dong sand ridge | N-S | F | Huang sha yang | W-E |
| g | Zhu gen sand ridge | W-E | G | Lan sha yang | NW-SE |
| h | Jiang jia sand ridge | W-E | H | Wang cang hong | NW-SE |
| i | Tiao zi ni sand ridg | W-E | | | |
| j | He tun sand ridge | W-E | | | |
| k | Tai yang sand ridge | W-E | | | |
| l | Yao sand ridge | NW-SE | | | |
| m | Wu long sand ridge | W-E | | | |

According to the SAR image and the interpretation results, we can analyses some distributing characteristics of Jiangsu Radiating Sandbanks:

(1) The center of Jiangsu radiating sandbanks is Jianggang.

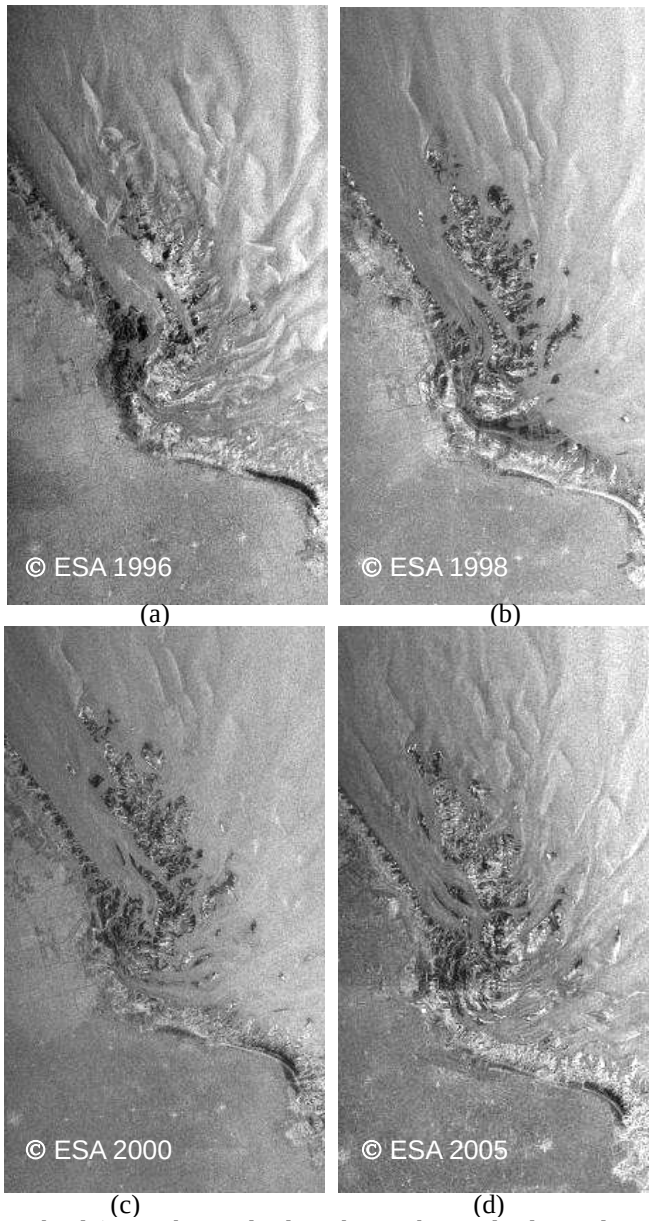
(2) The ridges alternate with the channels, the orientation of ridges and its sideward channels is consistent.

(3) Taking Jiang jia sand ridge as the borderline, Jiangsu Radiating Sandbanks can be divided into the north part and the south part. The orientation of north sand ridges is nearly N-S, while the orientation of south sand ridges is nearly W-E.

**2.3 Evolutions Study**

Aiming at analyzing the temporal and spatial variability of Jiangsu Radiating Sandbanks, we chose SAR images from 1996 to 2000(as Fig.4); with the help of professional soft we ascertain the positions of the main sandbanks of different periods. Before the study, we resolve two key problems when using SAR images in different time. The first is the matching of these

images accurately. We matched images and checked precision through using 22 field position datum. This field spots were usually the crossing points of the roads, the crossing points of the roads and the ditches, the corners of the manmade ditches, the crossing points of the roads and the banks, river gates and so on. When choosing these spots, we made a certain distance among them in order to improve precision. The second is the tidal height revision of the images in different time. We chose the SAR images on the time of low-tidal to reduce the errors of different tidal level.




(a) (b)

(c) (d)

Fig4 ERS-2 SAR image of Subei Shoal (Dongsha sand ridge Zhugensha sand ridge and Tiaozini sand ridge) a: acquired on Sep 1, 1996, b: acquired on Apr 19, 1998, c: acquired on Aug 6, 2000, d: acquired on Jun 26, 2005

In order to explain the evolution of all the primary sand ridges, we mainly study on the changes of two aspects: position and scale. The evolution analysis concentrates on the migration and area of sand ridge. According to the degree of evolution, we compartmentalize Jiangsu Radiating Sandbanks to three types: steady type, transitional type and dynamic type. Through analyzing the relationship of evolution, position and scale of sand ridges, we conclude the rules of evolution trends of Jiangsu Radiating Sandbanks.

Table.2 Evolution Analysis

| Ridge Name | Evolution Analysis | | Stability Types | Position | Scale |
|---|---|---|---|---|---|
| | migration | area | | | |
| Xiaoyin sand ridge | shoreward | decrease | dynamic | periphery | small |
| Liangyue sand ridge | southward | decrease | dynamic | periphery | small |
| Taiping sand ridge | southward | decrease | transitional | periphery | small |
| Maozhu sand ridge | -- | decrease | steady | periphery | large |
| Wai mao zhu sand ridge | -- | decrease | steady | periphery | large |
| Dong sand ridge | shoreward | -- | dynamic | center | large |
| Zhu gen sand ridge | southward | increase | transitional | middle | medium |
| Jiang jia sand ridge | southward | decrease | transitional | middle | medium |
| Tiao zi ni sand ridg | shoreward | increase | dynamic | center | large |
| He tun sand ridge | southward | decrease | transitional | middle | medium |
| Tai yang sand ridge | southward | decrease | dynamic | middle | small |
| Yao sand ridge | -- | -- | steady | periphery | large |
| Wu long sand ridge | -- | decrease | steady | periphery | large |

*Note: The symbol "--"in table.2 means no apparent evaluation.*

By comparison of interpretation results of different periods SAR images, it can be known that Jiangsu Radiating Sandbanks have a lot of evolutions in the past 9 years and the evolutions are both in two and three-dimension. The former is related to overall on/off shore sandbanks migration, whereas the latter is induced by the horizontal amplitude growth, migration, or length scale change.

Through the above table, we can draw the following conclusions:

(1) The stability of the sand ridge is correlative with its. In general the steady sand ridges lie in the periphery of this area and mostly are large-scale sand ridges, while the dynamic sand ridges lie in the center of this area and are small-scale sand ridges; and the position and scale of transitional sand ridges are in the middle.

(2) Generally the Jiangsu Radiating Sandbanks have the migration trends of southward, and the alongshore sand ridges have the trends of shoreward. The functions of hydrodynamics and geology in this area are the primary factors that lead to the migration trends.

(3) Total radial sand ridges are in a period of division and shrinking. All sand ridges are in erosion except those in the middle of the sand ridges and near beach.

## 3. CONCLUSION

This paper proposes to monitor the evolution trends of Jiangsu Radiating Sandbanks based on SAR data. At first we dispose the SAR images to enhance the information of objects, and then through interpretation we explain the distribution condition of primary sand ridges and tidal channels. Finally, through comparing the SAR images from 1996 to 2005, we analyses the evolutions of primary sand ridges and conclude the evolutions rule of whole sandbanks. The primary study results are as the following:

(1) Sand ridges and tidal channels can be identified clearly in SAR images. We identified 13 sand ridges and 8 tidal channels.

(2) The distribution characteristics of Jiangsu Radiating Sandbanks can be described that the sand ridges alternate with tidal channels and the center is Jianggang.

(3) The results of evaluation analysis indicate that the Jiangsu Radiating Sandbanks have changed very much in the past 9 years.

(4) According to the stability, we compartmentalize Jiangsu Radiating Sandbanks to three types: steady, transitional and dynamic. The stability of the sand ridge is correlative with its position and scale.

(5) Monitoring of sandbanks evolution has been mostly completed applying SAR techniques. It is worth emphasizing some advantages of SAR imagery in detecting underwater information.

## 4. ACKNOWLEDGE

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