

# A new method for significant wave height retrieval from ScanSAR mode imagery

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**Abstract**—We usually make use of the wave stripes of the synthetic aperture radar(SAR) imagery to retrieve the ocean wave properties based on the SAR-ocean mapping model. Due to the lower resolution, the ScanSAR mode imagery has no apparent ocean wave stripes but possesses the great advantage of large area of observation. To exert the advantage of ScanSAR imagery, this paper develops the new model to retrieve the significant wave height(SWH) in case of no wave stripes. Firstly, we collect the isochronous wind speed and SWH from buoy according to the ScanSAR imagery. Then we propose the mode expression and debug out the coefficient by the fitting based on the isochronous data. Finally, we use other isochronous data to validate the model. Retrieved SWH have a correlation coefficient of 0.83 and root mean square error(rmse) of 0.33 m with the SWH of buoy. It shows the ScanSAR imagery has the ability of retrieving SWH.

**Index Terms**—ScanSAR imagery, retrieval, significant wave height.

## I. INTRODUCTION

For high resolution synthetic aperture radar(SAR) imagery, it can show the wave stripes and retrieve the ocean wave spectra based on the nonlinear SAR-ocean mapping model. Then any wave parameters like significant wave height(SWH) can be extracted from the spectra [1-6]. The above method is complex and only aims at the imagery having wave stripes. Due to the lower resolution(approximately 80 m), the ScanSAR mode imagery has no apparent ocean wave stripes

so that it can't retrieve SWH from the method. But ScanSAR imagery possesses the great advantage of large area of observation. As we known, SAR can retrieve the wind speed with empirical geophysical model function(GMF) between the backscatter coefficient( $\sigma_0$ ) and wind speed [7]. This paper will try similar method to develop the direct empirical model between the  $\sigma_0$  and SWH. From the mode, we can extract the SWH of SAR imagery in case of no wave stripes and prove the status of ocean environment monitoring.

## II. DATA

The isochronous data collected in this paper include: (1) ScanSAR imagery. We select ENVISAT ASAR WSS mode data as the ScanSAR imagery, which has the swath of 400 km  $\times$  400 km and the resolution of 80 m  $\times$  7.8 m(Azimuth direction  $\times$  Range direction). (2) Buoy data. It can provide the accurate SWH and wind speed data. Part of collected data are used to develop the mode of SWH retrieval from ScanSAR imagery, and the other part are used to validate the model performance.

The time of data is from January 1, 2009 to December 31, 2012. The location of data focus on the South China Sea(SCS). Figure 1 shows the coverage area of ScanSAR imagery. Based on the location of ScanSAR imagery, we collect the isochronous wind speed and SWH data from the buoy. The isochronous temporal window is 3 hour and spatial window is 25 km.

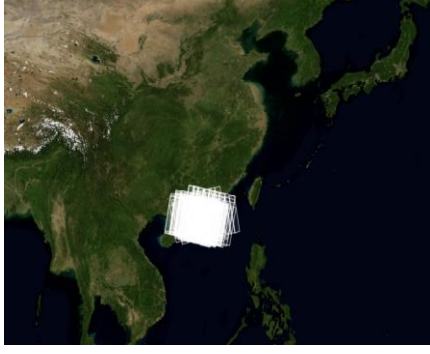


Fig. 1. The coverage area of all ScanSAR imagery, the white pane are the edges of imagery

### III. DATA PROCESSING

#### A. SAR imagery preprocessing

Figure 2 describes the preprocessing flow of ENVISAT ASAR WSS imagery. The main step is as follow:

##### (1) Image segmentation

ASAR WSS imagery has the wide swath, which is acquired from the combination of five antenna beams(SS1 to SS5) and is delivered as a single data file containing the subswath data records arranged sequentially. The five WSS beams acquire data with a substantial overlap (typically several hundred range samples, ~ 9 Km). So we must spilt it into five imagery and eliminate the overlapping portion.

##### (2) Deburst

As the ScanSAR imagery, WSS imagery work at burst mode. The imagery has many overlapping ‘bursts’ along the flight direction associated with a zero Doppler time for each range line. Figure 3 shows the discontinuous signal due to overlapping ‘bursts’. This paper will eliminate the discontinuity with the average method.

##### (3) Calibration

The pixel intensity of image can be converted into sigma0 with the following equation [8].

$$\sigma_{i,j}^o = \frac{DN_{i,j}^2}{K} \cdot \frac{q}{G(\theta_{i,j})^2} \left( \frac{R_{i,j}}{R_{ref}} \right)^3 \sin(\alpha_{i,j}) \quad (1)$$

Where  $\sigma_{i,j}^o$  is sigma0 at image,  $K$  is absolute calibration

constant,  $DN_{i,j}$  is the pixel intensity at image line and column “i,j”,  $G(\theta_{i,j})$  is the two-way antenna gain at the look angle corresponding to pixel “i,j”,  $R_{i,j}$  is the slant range distance to pixel line and column “i,j”,  $R_{ref}$  is the reference slant range distance,  $\alpha_{i,j}$  is the incidence angle at pixel line and column “i,j”.

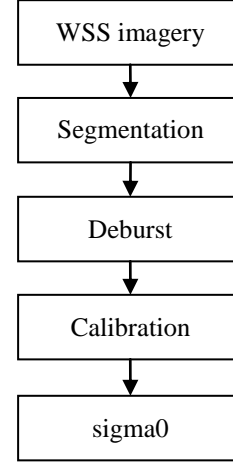


Fig. 2. The preprocessing flow of ENVISAT ASAR WSS imagery

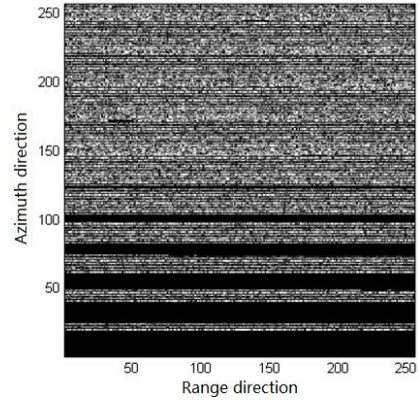


Fig. 3. The original ENVISAT ASAR WSS imagery

#### B. Wind speed height correction

Because the wind speed data from buoy are measured on different height above the sea surface. Therefore, we convert them into same height of 10 m by the following equation [9].

$$U_{10} = [\ln(10/z) / \ln(H_{buoy}/z)] \times U(H_{buoy}) \quad (2)$$

Where  $U_{10}$  is the wind speed for 10 m,  $z$  is roughness length and set to be  $1.52 \times 10^{-4}$ ,  $H_{buoy}$  is the measurement height of buoy.

#### IV. MODEL

In this paper, we develop a model to retrieve the SWH from ScanSAR imagery. Equation 3 is the proposed model expression, which has 9 coefficients. Figure 4 is the chart flow of establishing the model among the SWH, wind speed and sigma0. The model coefficients are debugged out by multi-parameters fitting and listed in Table 1.

$$\begin{aligned}
 SWH = & x_0 + x_1 \cdot \sigma_0 + x_2 \cdot \sigma_0^2 + \\
 & x_3 \cdot U_{10} + x_4 \cdot U_{10}^2 + x_5 \cdot \sigma_0 \cdot U_{10} + \\
 & x_6 \cdot \sigma_0^2 \cdot U_{10} + x_7 \cdot \sigma_0 \cdot U_{10}^2 + x_8 \cdot \sigma_0^2 \cdot U_{10}^2
 \end{aligned} \quad (3)$$

Where  $\sigma_0$  is the mean sigma0 for the area of 540 m x 540 m,  $x_0$ - $x_8$  is the constant coefficient.

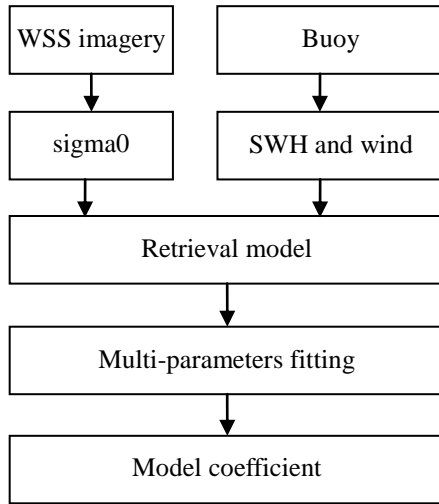


Fig. 4. The chart flow of establishing the retrieved model

TABLE I. MODEL COEFFICIENT

Coefficient	Value	Coefficient	Value
<b>x0</b>	1.5975	<b>x5</b>	0.7698
<b>x1</b>	-1.8179	<b>x6</b>	-0.3943
<b>x2</b>	1.0161	<b>x7</b>	-0.0679
<b>x3</b>	-0.3101	<b>x8</b>	0.0342
<b>x4</b>	0.0394	/	/

#### V. VALIDATION

In this section, the other isochronous WSS imagery and buoy data are used to validate the model performance. Firstly, we convert the imagery into sigma0 by the preprocessing. Then the wind speed are retrieved from the CMOD\_IFR2 model. Finally, the sigma0 and wind speed are imported into the developed model to retrieve the SWH. Figure 5 is the scatter of SWH from the WSS imagery and the buoy. It shows the correlation coefficient of 0.83. Figure 6 is the comparing of SWH from the WSS imagery and the buoy. They have the rmse of 0.33 m and relative error of 17.2%.

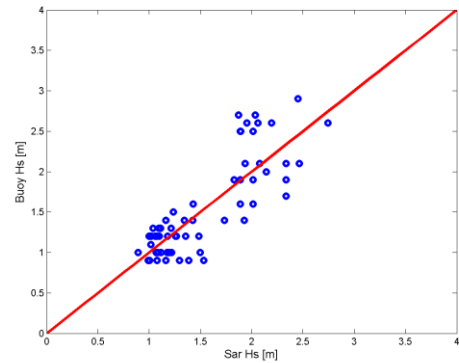


Fig. 5. The scatter of SWH from the WSS imagery and the buoy

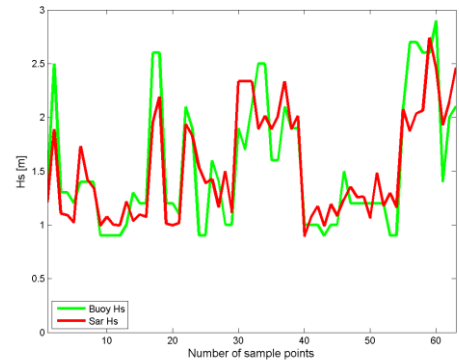


Fig. 6. The comparing of SWH from the WSS imagery and the buoy

#### VI. CONCLUSION

This paper aims to develop the SWH retrieval model from the ScanSAR mode imagery. Firstly, we collect the isochronous WSS imagery and buoy data. Buoy provide the wind speed and SWH data. Then we propose the model expression and debug out the 9 model coefficients. Finally, we use the developed model to retrieve the SWH from the imagery. The retrieved SWH are compared with the ones of buoy.

Comparative results show it has the correlation coefficient of 0.83, rmse of 0.33 m and relative error of 17.2% on SWH from the WSS imagery and the buoy. It demonstrates ScanSAR imagery has the ability of retrieving the SWH.

#### ACKNOWLEDGMENT

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