SIMULATION AND OPTIMIZATION OF THE PERFORMANCE OF SPACE-BORNE RADAR OCEAN WAVE SPECTROMETER

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1. **Introduction**

Directional energy spectrum is one of the most important dynamic characteristic of ocean waves. Many methods have been adopted for researching the spectra of ocean waves. In the last decades, big progresses had been achieved on observing sea surface by means of remote sensing. Synthetic aperture radar (SAR) is by now the only effective sensor for estimating directional ocean wave properties, but it only works for some special kinds of sea states. It requires proper wind and SWH conditions. Especially, the relationship between SAR images and actual ocean wave field is nonlinear and it is hard to retrieve directional wave spectra from a SAR scene directly. In order to improve the measurement of ocean wave spectra, several techniques with real aperture radar (RAR) had been proposed to measure directional wave spectra. Some research results had been presented by F. C. Jackson *et al.* and D. Hauser *et al.*

In this paper, some important results about the performances of RAR ocean wave spectrometer are provided. In Section 3, details of the simulation process are presented, which is improved from the method developed by D. Hauser; in section 4, effects of system parameters (such as pulse bandwidth and antenna) and measurement conditions (such as wind speed and significant wave height (SWH)) on the ocean wave spectra measurement performances are discussed, especially, the impact of the angle between the direction of wave propagation and the direction of observation beam on the system performance is investigated; finally, impact of normalized radar cross section (NRCS) measurement precision on the ocean wave spectra is evaluated.

2. Theory

The observation geometry of SB-ROWS is presented in Fig.1. The coordinate origin represents the initial nadir of the sensor. *Ox* axis points to the along-track direction and *Oy* directs the across track. The radar beam's look direction is defined as *OX* axis, with which *OY* and *Oz* complete to be a right system.

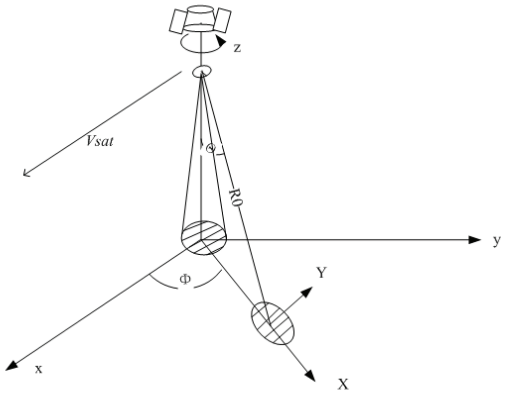

Fig.1 Observation geometry of SB-ROWS.

At low incidence ($\theta \leq 15^{o}$), the modulation mechanism mainly depends on quasi-specular reflection from wave facets oriented normal to the radar look direction. Hydrodynamic modulation, which is an effect of capillary-Bragg waves, is negligible. The NRCS is modulated by the local slope of sea surface, what is named as tilt modulation. The modulation spectrum is proportional to the wave slope spectrum, which can be retrieved from measurement of range-profile of the NRCS of the ocean surface.

3. Simulation Procedure

The simulator is designed for the end-to-end performance analysis of spectrum retrieval with the discussed system. The simulation starts with an initial sea state and a set of parameters defining the radar system. The output is a set of retrieved wave height spectra in discrete directions after averaging. Fig.2 presented the diagram of the simulation procedure.

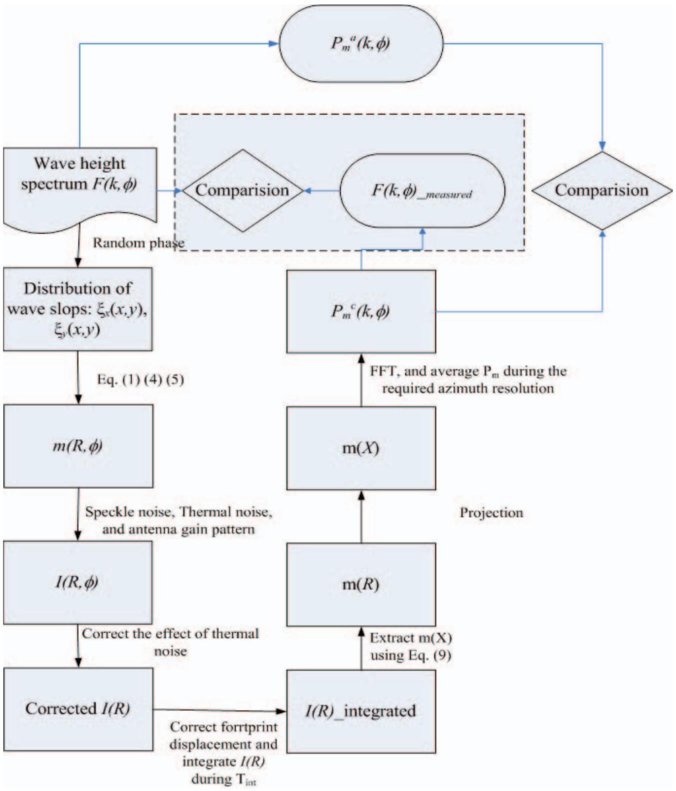

Fig. 2 Overall approaches for simulation methodology

4. Simulation Results

Results for different cases of system features are presented.

A. Effects of wind speed/SWH

B. Effect of pulse bandwidth

C. Effect of antenna gain pattern

D. Effects of amplitude of directional wave spectra

E. Effect of inaccuracies of the mean radar cross section.

5. Conclusion

In this paper, a simulation method is presented to analyze and optimize the performance of a real aperture radar system for oceanic directional wave spectra, taking into account of data processing parameters. The results show that spaceborne radar ocean wave spectrometer (SB-ROWS) can measure spectra of fully developed waves with significant wave heights (SWH) over approximately 2.0 meter and swell surface under low wind conditions. The minimum detectable wavelength in the study is about 40 m. The wavelength resolution for a wavelength of 200 m is better than 30 m, and the directional resolution after averaging is better than 20^o.