Ocean Wave Measurement using Synthetic Aperture Radar Cross-track Interferometry

Akitsugu Nadai, Toshihiko Umehara, Shoichiro Kojima, and Jyunpei Uemoto

Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology, 4-2-1 Nukuikitamachi, Koganei, Tokyo, Japan

Abstract – **The usefulness of synthetic aperture radar (SAR) cross-track Interferometry for ocean wave measurement is examined using airborne SAR. Though the 2-dimensional spectrum of intense image is influenced by the geometric relation between illuminating directions, the 2-dimensional spectra of ocean surface topography with different illuminating directions agree each other. The result indicates the usefulness of SAR cross-track interferometry for ocean wave measurement.**

Index Terms **— Ocean waves, Cross-track Interferometry, Synthetic Aperture Radar (SAR)**

1. Introduction

The synthetic aperture radar (SAR) cross-track interferometry is widely utilized to measure the topography of the earth's crust. This technique is, however, not utilized to the ocean surface measurements very much. In this paper, the SAR cross-track interferometry is used to measure ocean waves as the topography of ocean surface.

The conventional method of ocean wave measurement using SAR is based on the analysis of the 2-dimansional spatial pattern on the intensity image [1]. The intensity of each ocean wave component, however, differs with the geometric relation between the wavenumber vector of ocean waves and the illuminating (flight) direction of SAR. So, the 2-dimensional spectrum of intensity image does not directly related to the ocean wave spectrum.

Moreover, ocean waves are a kind of moving targets with not only its propagation but also the ocean currents. The movement of ocean waves within the synthetic aperture time influences the intensity and the sharpness of ocean wave patterns on intensity image. As a result, the estimation of true spectrum of ocean waves is difficult.

If the SAR cross-track interferometry can measure the topography of ocean surface with small spatial scales, the ocean wave spectrum is able to be analyzed, even as the influence of the motion still remains.

In this paper, the ocean wave spectrum is analyzed from the ocean topographies obtained by the airborne interferometric SAR: Pi-SAR [2] developed by National Institute of Information and Communications Technology (NICT) and Japan Aerospace Exploration Agency (JAXA).

2. Observation

The cross-track Interferometric observation of ocean surface using the Pi-SAR was done at the northwestern sea off Okinawa Island. In this observation, the Pi-SAR observed same ocean area with two flight directions in short time, to examine the influence of the geometric relation between the illuminating direction and ocean waves. The ocean wave spectrum is obtained as the 2-dimensional spectrum of topography of ocean surface. The 2-dimensional spectrum of the intensity image is also obtained for comparison. Moreover, the sea truth data were obtained on the surface buoy near the observation area.

The obtained intensity images and ocean surface topographies are shown in Fig. 1, with their 2-dimensional spectra. The strongest peaks in the spectra of the intensity images differ with the illuminating direction as mentioned before. This difference represents that the spectral intensity of the intensity image is determined not only by the intensity of wave components but also by the geometric relation between the direction of wavenumber vector of ocean waves and the illuminating direction. It is because the tilt modulation effect and the hydrodynamic modulation effect, which visualize the ocean wave pattern on intensity image, depend on the geometric relation between the ocean wave components and the illuminating direction of SAR.

On the other hand, the strongest peaks in the spectra of the topographies of ocean surface agree each other, regardless of the illuminating direction. This result represents that the spectra of topography of ocean surface are independent of the geometric relation between the illuminating direction and the wavenumber vector of ocean waves. Therefore, the topography of ocean surface obtained by the SAR cross-track Interferometry represents directly the surface elevation, and the SAR cross-track interferometry is a useful to measure ocean waves.

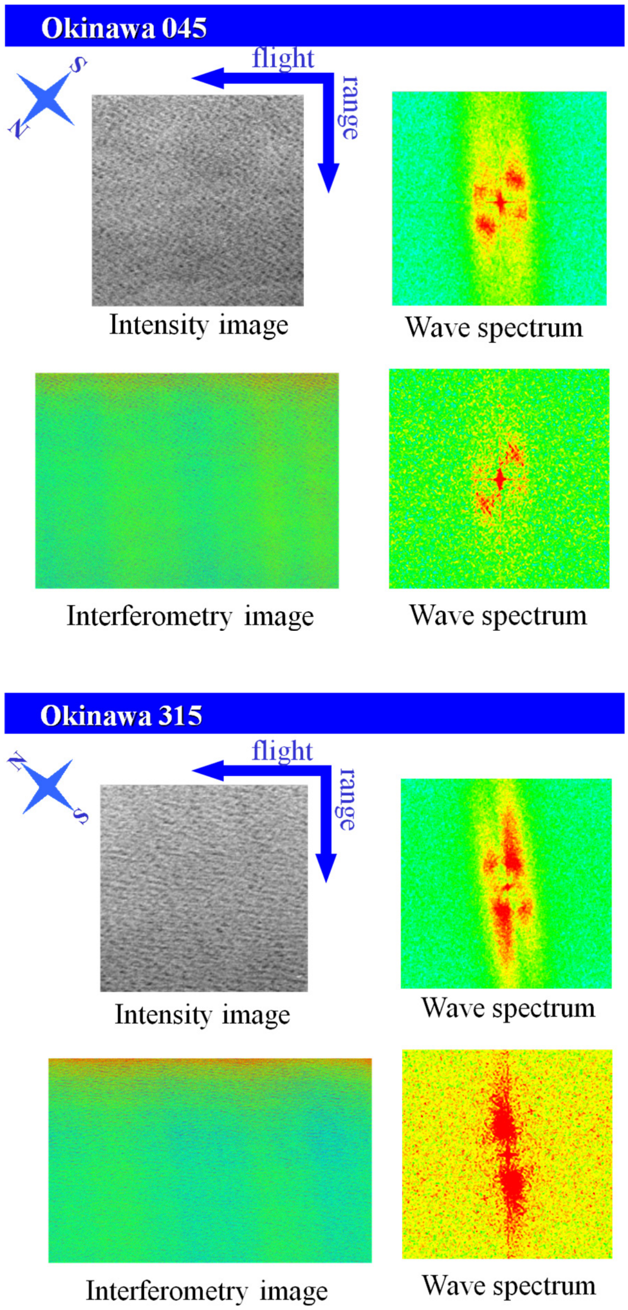

Fig. 1: Results of ocean wave measurement at the northwestern sea off Okinawa with two flight directions of 45 deg. and 315 deg. due the north.

3. Conclusion

The strongest peaks on 2-dimansional spectra of ocean surface topography agree between SAR observations with different illuminating directions. On the other hand, the conventional method to measure ocean waves using SAR, which is based on the 2-dimansional spectrum of intensity image, is influenced by the geometric relation between the illuminating direction and ocean waves. The results represent the usefulness of the SAR cross-track interferometry to measure the ocean waves.

The results also represent the usefulness of the SAR cross-track interferometry to measure the topography of ocean surface. In these days, there are some satellite plans as the ocean altimeter using the SAR cross-track interferometry. The result may become one of the feasibility studies of such a new type ocean altimeter.

References

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