Oceanographic Observation in Hyuga-Nada by the High-Frequency Ocean Radar

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***Abstract* – High-Frequency (HF) ocean radar obtains hydrographic information as current velocities by analyzing backscattered Bragg resonance from sea surface and is suitable to observe the coast area. Hyuga-Nada is the eastern area off Miyazaki prefecture in Kyusyu island. The Kuroshio current approaches this area and it affects the sea condition and fishery, so it is improved to monitor the coast area. We observed this area by HF ocean radar and got the first-order peaks corresponding to Doppler frequency of the phase velocity satisfied Bragg resonance conditions. Also there are the two spectral peaks within a radar footprint area. This implies that there are two different flows in this area and it seems to be appeared a shear front or an eddy in a radar footprint. In the observation period, these two-peak spectra appear but don't always in the specific distance. It may be related to the distance from the Kuroshio current or the direction of sea wind.**

***Index Terms* — HF ocean radar, Hyuga-Nada, Doppler spectrum.**

1. Introduction

Ocean radar can obtain hydrographic information as current velocity or wave height by analyzing backscattered Bragg resonance from sea surface. It is mainly operated HF band (3-30 MHz). For the velocity, the effective observation distance is about 50 km and the observation depth is about 50 cm [1] when we use 24.5 MHz.

Hyuga-Nada is the eastern area off Miyazaki prefecture of Kyusyu Is. Japan. The Kuroshio current approaches this area and it affects the sea condition, which influences on fishery in this area. The sea condition of Hyuga-Nada has been researched with Sea Surface Temperature (SST) observation by satellite or floating buoys, but there are some problems such as SST can't be always observed due to clouds and the floating buoys observe only fixed points. HF ocean radar can obtain the sea condition even if a heavy storm and observe with a wide coverage.

The objective of this study is to observe the coast current by HF radar and to contribute to fishing industry. The first part of this paper presents about HF ocean radar. The next part shows oceanographic observations in Hyuga-Nada and discuss two-peak spectrum within a radar footprint area.

2. HF Ocean Radar

The antenna type of the radar in this study is chosen an array phased system. The antenna is used both transmission and reception and has an advantage to achieve greater sensitivity [2]. A beam width depends on length of antenna aperture. The antenna is consisted of 10 element antennas with an aperture length of 54 m. Then, a beam width is about 15 degrees but the effective beam width become narrower because of using both transmission and reception. The range resolution depends on a bandwidth. The bandwidth of this HF radar is 100 kHz, so the specific range resolution is 1.5 km. Also, the resolution of Doppler frequency f_{res} depends on observation time T_S as shown by

$$f_{res} = 1 / T_S . \qquad (1)$$

The observation time is 128 seconds in this study, it obtains the resolution of Doppler frequency is 1/128 Hz from (1). Also, velocity resolution v_{res} is given by

$$v_{res} = c\, f_{res} / 2f , \qquad (2)$$

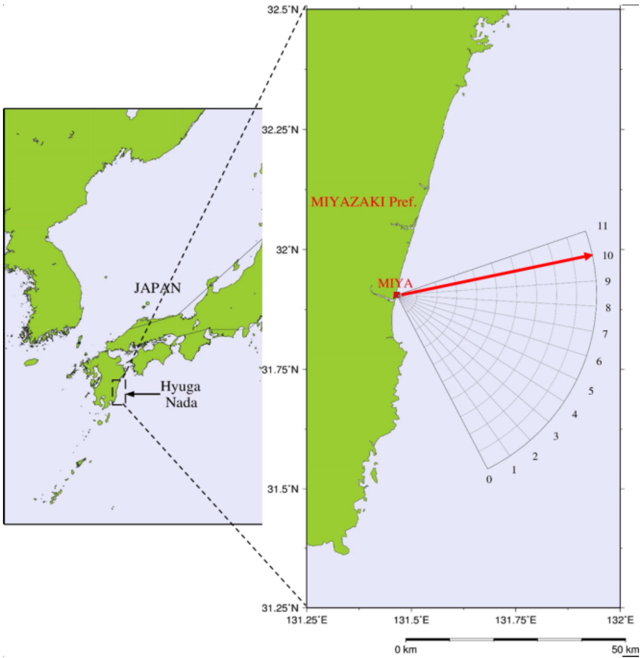

Fig. 1 The location of the radar site (MIYA) and the beam directions at Hyuga-Nada

where c is the speed of light and f is the operating frequency, which is 24.5 MHz. Then, velocity resolution v_{res} is 4.78 cm/s from (1) and (2). In practical observation, integration of several data is used for improving SNR.

3. Oceanographic observation

Fig. 1 shows the radar site and the beam directions in this oceanographic observation. In this observation, we steer beam from 153° to 70.5° shifted 7.5° steps, which direction is measured by clockwise from the North. It takes 10 minutes each one direction for the integration, then it takes 120 minutes for all 12 directions.

Fig. 2 shows range-Doppler spectrum at 1:40 JST on January 1, 2016 along the beam 10, which a red vector indicates in Fig. 1. The horizontal axis is Doppler frequency, the vertical axis is distance from the radar. There are spectral peaks at around ±0.505 Hz frequency. These frequencies are corresponding to the Doppler shift by the phase velocity of ocean waves with a half wavelength of the transmitting radio wave, which satisfied Bragg resonance conditions. In Fig. 2, there interestingly are seen the two spectral peaks with nearly same power each negative and positive area beyond 18 km. This implies that there are two different flows within a footprint. It seems to be appeared a shear front or an eddy in a footprint. Fig. 3 shows how often spectral peak branches in the period from December 19, 2015 to January 12, 2016. From Fig. 3, the two-peak spectra frequently appeared in this period but don't always appear at the area and in the specific distance.

4. Conclusion

We report the oceanographic observation at Hyuga-Nada by HF ocean radar. We got the first-order peaks corresponding to Doppler shift by the phase velocity of sea waves with Bragg resonance conditions and the two peaks at the observation area. These phenomena indicate there are different currents within a footprint. It seems to be appeared a shear front or an eddy in a radar footprint. Also, the two-peak spectra frequently appeared but don't always appear at the area and in the specific distance, so these spectra may not be caused the characteristic of the area, such as the sea-bottom topology, but may be related to the Kuroshio current effect and/or sea surface wind and others.

For future works, we will investigate the occurrence frequency for two peaks branching with a long term data and compare this two-peak spectrum with the distance or the velocity of the Kuroshio current and the direction or the velocity of sea surface wind.

References

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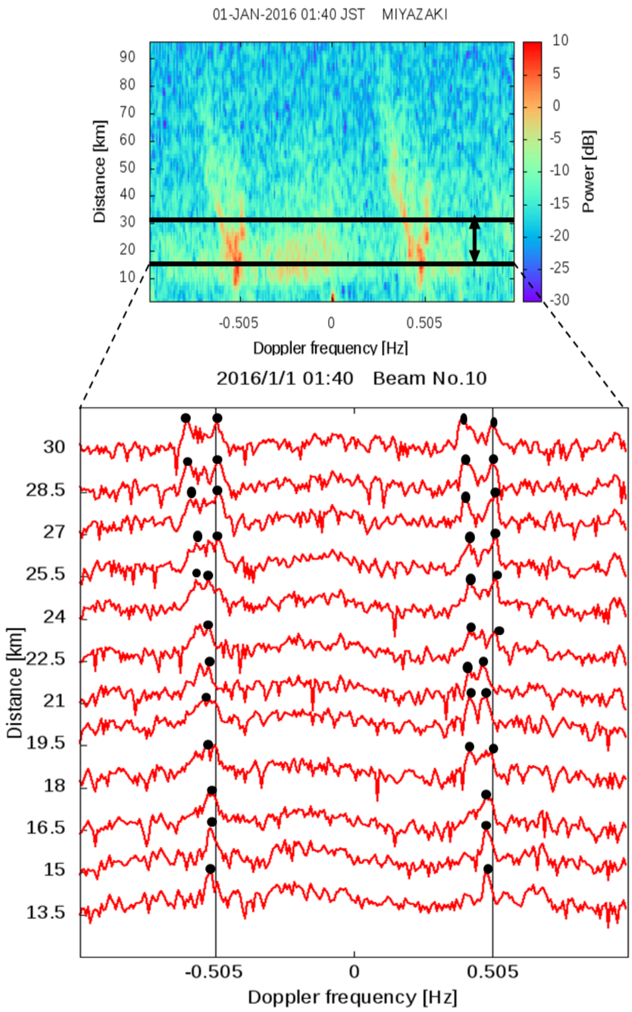

Fig. 2 Range-Doppler plots along the beam 10 at 1:40 JST on January 1, 2016. Dots show spectral peaks seems to be made by sea-surface current velocities.

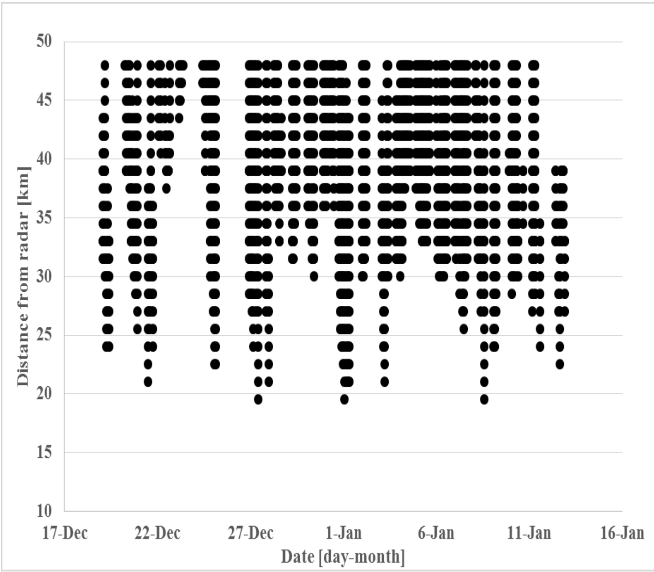

Fig. 3 The occurrence frequency for two peaks branching in the period from December 19, 2015 to January 12, 2016. Dot shows the occurrence of these spectra at the specified distance.