PROPAGATION OF SUBINERTIAL VARIATIONS IN THE SOYA WARM CURRENT REVEALED BY HF OCEAN RADARS

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1. INTRODUCTION

The Sea of Okhotsk (Fig. 1), a marginal sea adjacent to the North Pacific, is one of the southernmost seasonal sea ice zones in the Northern Hemisphere. The Sea of Okhotsk is connected with the Sea of Japan through the Soya/La Perouse Strait, which is located between Hokkaido, Japan, and Sakhalin, Russia. The Soya Warm Current (SWC) enters the Sea of Okhotsk from the Sea of Japan through the Soya Strait and flows along the coast of Hokkaido as a coastal boundary current. It supplies warm, saline water in the Sea of Japan to the Sea of Okhotsk, and greatly affects local climate and marine environment. However, the SWC has never been continuously monitored due to the difficulties involved in field observations related to various reasons, such as severe weather conditions in winter, political issues at the border strait, and conflicts with high fishing activities. Detailed features of the SWC and its variations have not been clarified. In 2003, we installed three HF ocean radars in the Soya Strait to monitor the surface current fields [1]. The HF radars clearly captured the seasonal and subinertial variations in the SWC [2], [3]. In this paper, propagation of the subinertial variations in the SWC along the coast is investigated by using data from the HF radars, coastal tide gauge and a bottom-mounted ADCP.

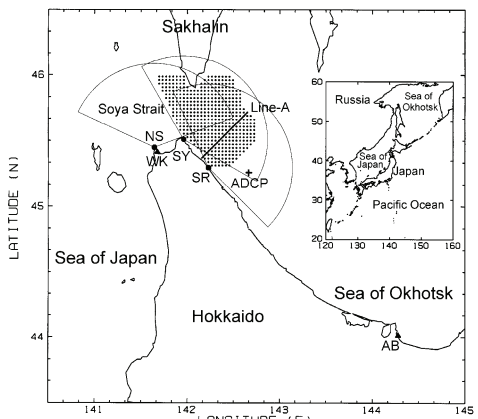

Fig. 1. A map of the Soya/La Perouse Strait showing locations and coverage of the HF radar stations (NS: Noshappu, SY: Soya, SR: Sarufutsu), locations of the tide gauge stations (WK: Wakkanai, AB: Abashiri), and bottom-mounted ADCP (+).

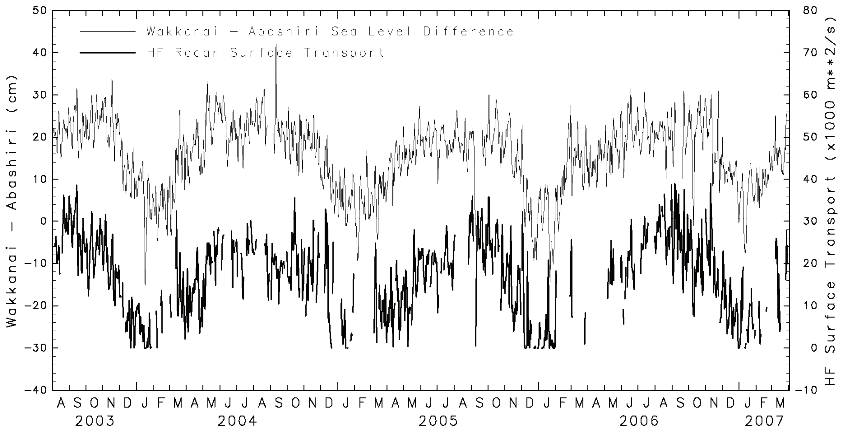

Fig. 2. Daily surface transport of the SWC (thick line) across Line-A and sea level difference between Wakkanai and Abashiri (thin line).

2. SUBINERTIAL VARIATIONS IN THE SWC

All Daily surface transport across Line-A (Fig. 1) was defined by the integration of the daily southeastward current component along the line from the coast to a point at which the component becomes negative. Figure 2 shows the time series of the surface transport (thick line). The driving force of the SWC is ascribed to the sea level difference between the Sea of Japan and the Sea of Okhotsk. For comparison with the surface transport as observed by the HF radars, we calculated the sea level difference between two tide gauge stations, Wakkanai (labeled as WK in Fig. 1) and Abashiri (AB in Fig. 1), which represents sea level difference between the Sea of Japan and the Sea of Okhotsk. A 48-hour tide-killer filter was applied to the hourly tide gauge records at these stations. The daily-mean sea levels were then calculated, and atmospheric pressure correction was performed using the daily-mean sea level pressure observed at weather stations in the cities of Wakkanai and Abashiri. The time series is shown by a thin line in Fig. 2. The surface transport of the SWC and the sea level difference along the current show a good correlation with a correlation coefficient of 0.787. Both time series exhibit not only clear seasonal variations but also subinertial variations with time scales of approximately 10 to 15 days. The surface transport and sea level difference oscillated coherently in annual and subinertial time scales.

Results of spectral analyses of the sea level difference between Wakkanai and Abashiri, surface transport observed by the HF radars, and ECMWF 10-m height wind speed near the strait (not shown here) revealed that the coherence between the sea level difference and surface transport was generally high in the frequency band of the subinertial variations around the peak period of 10-15 days. The cross spectrum between the ECMWF meridional wind and surface transport exhibits significant coherence in the subinertial frequency range of 5- to 20-day periods, with a phase lag of one to two days. These results suggest that sea level difference through the

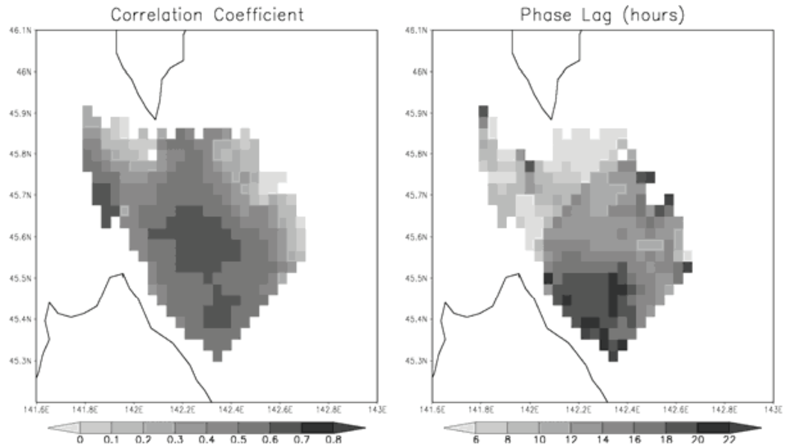

Fig. 3. Maximum value of the lag correlation coefficient (right) and lag time (right) between the filtered sea level difference and alongshore velocity component.

strait caused by wind-generated coastally trapped waves on the east coast of Sakhalin and west coast of Hokkaido are considered to be a possible mechanism causing the subinertial variations in the SWC.

3. PROPAGATION OF THE SUNINERTIAL VARIATIONS ALONG THE COAST

Propagation of the subinertial variations in the SWC along the coast is also investigated by using the surface current fields derived from the HF radars. A 24-hour tide-killer filter was applied to the hourly along-shore velocity components, and then a band-pass filter with cut-off periods of 3.7 and 44 days was applied to extract velocity variations associated with the subinertial variations. The same tide-killer and band-pass filters were also applied to the hourly sea level difference between Wakkanai and Abashiri.

At each observation grid point of the HF radar, lag correlation between the filtered sea level difference and along-shore velocity component was calculated. The maximum of the correlation coefficient and lag time at each point are shown in Fig. 3. Within a distance of approximately 50 km from the coast of Hokkaido, where the SWC flows, the correlation coefficient is high (~ 0.6) and the lag time increases with the distance from the Soya Strait along the coast. The relationship between the distance from the strait along the coast and phase lag is plotted in Fig. 4. Only the data from grid points within a distance of 10-50 km from the coast of Hokkaido were used. The regression line indicates the subinertial variations propagate downstream along the coast with a phase speed of 4 km/h (~ 95 km/day or 1.1 m/s). Similar phase speed was also obtained from analyses of data from bottom-mounted ADCPs in this region (not shown here). This value of the phase speed is very close to the phase speed of the 3rd-mode barotropic continental shelf waves, which is estimated from the bottom topography in this region.

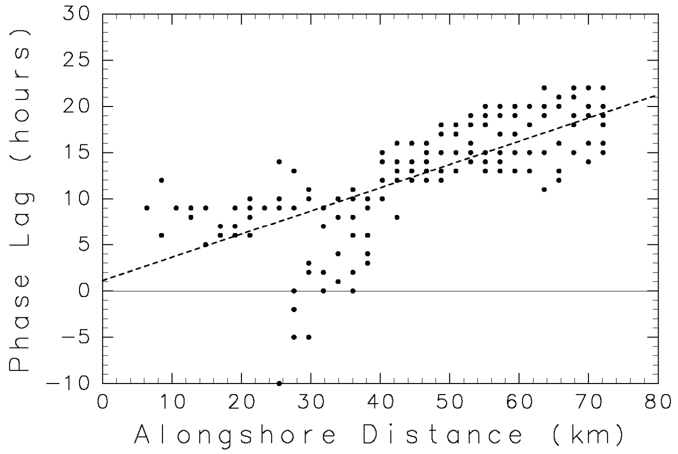

Fig. 4. Relationship between the alongshore distance and lag time.

The velocity anomaly profiles associated with the subinertial variations (not shown here) also suggests that the variations propagate as the 3rd-mode barotropic continental shelf waves.

4. REFERENCES

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