Storm surge and seiche in Tokyo Bay observed by HF radar

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ABSTRACT

The sea surface currents induced by the storm surges and the seiches in Tokyo Bay were investigated using HF radar data. According to the tide data at Harumi, the number of storm surges larger than 50 cm was 15 from 2005 to 2014. Among these surges, the number of seiches larger than 10 cm was 8 (53%). The period of these seiches was 6-7 hrs. Using harmonic analysis, residual current was obtained from HF radar’s sea surface current data. The phase of residual current is 2 hrs earlier than that of the seiches. Therefore, it is possible to predict the occurrence of the seiches 2 hrs in advance from HF radar’s data.

KEY WORDS: Storm surge; Seiche; Typhoon; Tokyo Bay; HF radar; Residual current; Wind driven current

INTRODUCTION

Tokyo Bay, located in the central part of Japan, has a length of 50 km, a mean depth of 15 m, and an area of 960 km² (Fujiwara et al., 2002). It is connected to the Pacific Ocean through the mouth of the bay (Fig.1).

The seiche of Tokyo Bay is mainly caused by typhoon, extratropical storm and tsunami (Unoki, 1959). Kanari (2003) investigated Typhoon No.15 (Typhoon 0115) in 2001 which caused 155 mins and 6 hrs seiche. He mentioned that 155 mins seiche corresponds to the period of the closed basin type seiche whose antinodes locate at Chiba and Yokosuka. Six hrs seiche corresponds to the seiche in the narrow basin open at one end whose antinode locates at Chiba and node locates at the mouth of Tokyo Bay as shown in schematic Fig.2. Typhoon No. 22 in 2004 (Typhoon 0422) also caused 1.9 hrs and 5.3 hrs seiche (Konishi, 2007). Konishi (2007) mentioned 5.3 hrs seiche corresponds to Kanari’s 6 hrs seiche. On the other hand, there were two different oscillation modes with the period of 1.9 hrs. One was the longitudinal mode of Tokyo Bay corresponding to Kanari’s 155 mins seiche. Another was the confined mode to the northern part of Tokyo Bay.

Hiyajo et al. (2011) investigated the 72 storm surges observed since 1946 until 2009. About 80% (59 cases) of storm surges have the seiche whose periods are 6-7 hrs. The 6 hrs seiche of Tokyo Bay was discovered by Unoki and Yamaguchi (1987). They mentioned that the

Figure 1. Tokyo Bay and observation sites.

Figure 2. Schematic figures of the seiche mode of Tokyo Bay