3P-59

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 573-574
6-8 December, 2010

Simulation of Sound Propagation in Shallow Water of Antarctic Ocean with Seamount
海丘を有する南極浅海での音波伝搬シミュレーション

Takenobu Tsuchiya†[1], Ryuta Niikawa[1], Nobuyuki Endoh[1] (Faculty of Engineering, Kanagawa Univ.)
土屋　健伸†[1]　新川　竜大[1]　遠藤　信行[1] (神奈川大・工)

1. Introduction

It is important to research the phenomenon of Ocean climate in polar region, such as Arctic and Antarctic Ocean, because polar region was large influenced to the energy circulation of the global climate in the earth. Therefore, measurement of oceanic environment carried out in the polar region by many country organizations. However, the observation of the oceans with ice layer on sea surface was very difficult. Recently, the climate research of Ocean using Autonomous Underwater Vehicle (AUV) is being planned in the Antarctic Ocean. In order to know the fundamental data of characteristics of sound propagation in Antarctic Ocean fot development of AUV, we reported the characteristics of sound propagation in this Ocean[1)]. We silulated the amplitude of pulse wave propagated in underwater of Lűtzow-Holm bay in observed OW used by observed data in JARE-31 near Showa base.

In this study, we simulated pulse waveform used by parabolic equation method. Parabolic Equation (PE) method [2)] is very useful method to calculate the sound propagation in underwater field. We investigated about the influence of amplitude of pulse wave by bathymetry in observed line L with seamount.

2. Simulation model for sound propagation

Figure 1 shows simulation model for sound propagation in Antarctic Ocean using parabolic equation method. We assumed that the one transmitter was placed four different depths at 50, 100, and 200 m and propagation range was constant at 36 km in observed line L. Depth of seamount is at 225 m from sea surface. We calculate propagation pulse in Antarctic Ocean with two bottom models to research the influence of amplitude of pulse wave by bathymetry. By confirming the fluctuation of amplitude of pulse to influence by depth of source and receivers, we estimate about the amplitude of pulse by parabolic equation method to change the depth of source and receivers.

kenshin@kanagawa-u.ac.jp

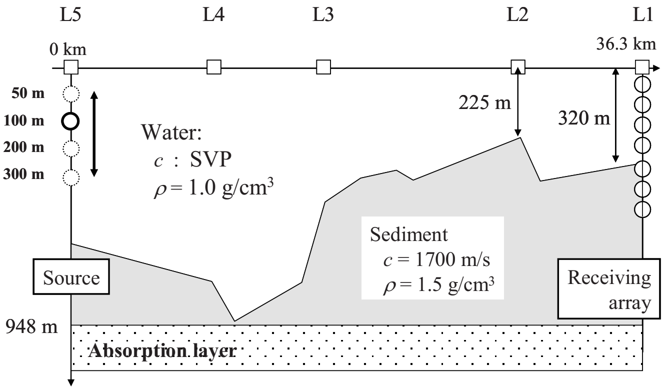

Fig. 1 Simulation model of sound propagation in Lutzow-Holm bay used by PE method.

In this simulation, in order to investigate about the characteristics of sound propagation in Lűtzow-Holm bay, we calculated sound pressure filed by PE method with two sea bottom models that were varied the depth of sea bottom and acoustical parameter. In the first case, the depth of sea bottom in this mode which was defined by Range-Dependent (RD) model was assumed by measurement bathymetry as shown in Fig. 1. In the second case, the model, which was defined by Absorption layer (AB) model, has a flat sea bottom with absorption layer to neglect reflected pulse wave from sea bottom. The bottom depth was constant value at 958 m. In RD model, acoustical parameter of bottom assumed 1700 m/s in sound velocity and 1.5 g/cm^3 in density. The sound source adapted Gaussian starter pulse to the horizontal direction calculated by Eq. (1)

$$s(t) = \sin\left[2\pi f_0 \left(t - t_0\right)\right] \exp\left\{-\left[w\left(t - t_0\right)\right]^2\right\} \qquad (1)$$

where, t is time, $s(t)$ indicates sound waveform in time domain. f_0 indicates the center frequency of sound source at 1 kHz. When t equals t_0, this equation takes the maximum value in the all time. w relates band width of frequency spectrum.

3. Calculation results

Figure 2 shows estimated waveform used by parabolic equation method to propagate in the

Antarctic Ocean in the case of line L. In this case, we calculated sound propagation assumed two bottom models. Figure 2 (a) and (b) shows estimated pulse waveform in the case of RD and AB model when sound source and receiver placed at 100 m in depth. As shown Fig. 2 (a), main pulse wave received at t = 1.08 [s]. Received pulse wave after 1.11 [s] was multiple reflected sea surface and bottom. Arrival time of received pulse wave reflected sea surface and bottom be later than main pulse because propagation length was larger than main pulse. If received pulse do not reflect sea surface and bottom multiple, arrival time of the pulse became fast, because the pulse wave propagated to the faster layer of sound velocity. The proof of these results was clearly shown as Fig. 2 (b). First pulse arrived at t = 1.00 [s]. The pulse wave propagated deeper layer in water columns over 900 m. As a result, amplitude of sound pulse was different to two cases, because main pulse interfered by reflective pulse at sea surface and bottom. However, the maximum difference value was about -4 dB between RD and AB model. The fluctuation value of amplitude of pulse is small when sound source placed at 100 m in depth. By describing the fluctuations in amplitude of pulse, we denote the relationship between the pulse amplitude and receiver depth as shown in **Fig. 3**. The pulse amplitude in vertical axis is normalized by the amplitude of the received pulse at 100 m. The pulse amplitude of receiver over 320m at depth is very smaller than for other receivers because the receivers are placed inside sediment. When the sound source placed at 50 m, the amplitude varied from 4 to -6 dB. Clearly, the fluctuation of pulse amplitude varied from +7 to -8 dB in water column on line L.

4. Summary

In order to know the characteristic of pulse wave propagation at observed line L in by Lützow-Holm bay of the Antarctic Ocean, we analyzed pulse propagation in Lützow-Holm bay using PE method. It is clearly shown that the fluctuation of the amplitude of sound pulse by bathymetry on observed line L with seamount.

Acknowledgment

This study was partly supported by a 2010 and 2011 Grand-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology (Grant No. 18700445), Japan.

References

1. T. Tsuchiya, S. Matsumoto, T. Anada and N. Endoh : Jpn. J. Appl. Phys. **49** (2010) 07HG14.
2. T. Tsuchiya, T. Okuyama, N. Endoh, T. Nakamura and I. Nakano : Jpn. J. Appl. Phys. **39** (2000) 3212

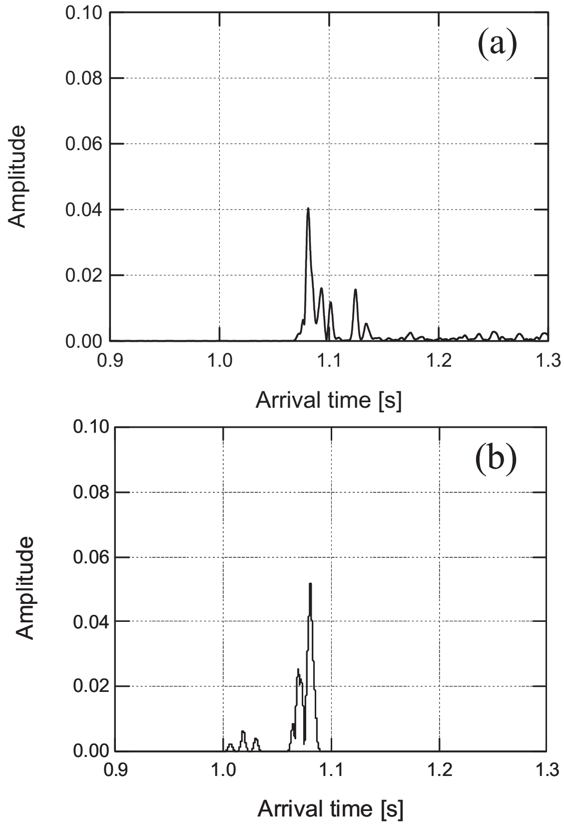

Fig. 2 Eestimated waveform calculated by parabolic equation method to propagate in the Antarctic Ocean using inverse Fourier transfer propagated in line L. (a) and (b) show the calculation results of RD and AB model when sound source and receiver placed at 100 m in depth

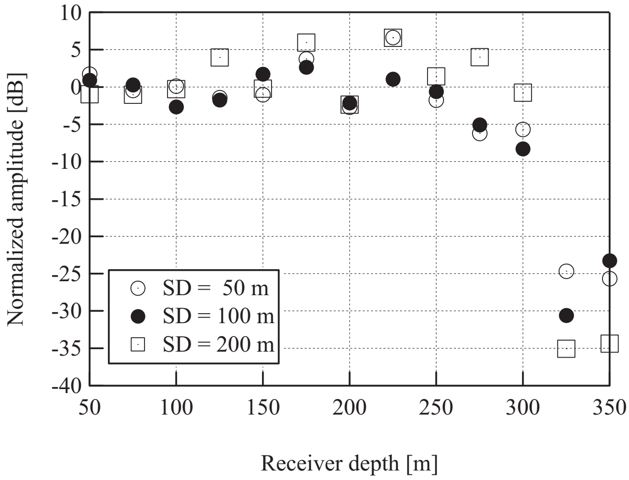

Fig. 3 Relationship between amplitude of receiving pulse and depth of receiver in RD model.