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Numerical analysis of propagated pulse waveform in Luzow-Holm Bay of Antarctic Ocean

南極リュツォ・ホルム湾におけるパルス波形の数値解析

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1. Introduction

It is important to research the phenomenon of Ocean climate in the Antarctic Ocean, because polar region was large influenced to the energy circulation of the global climate. For example, the Japanese Antarctic Research Expedition (JARE-31) conducted a two-year program of atmosphere /sea-ice/ocean study in Antarctic Ocean from 1991 to 1992[1)]. However, the observation of boundless ocean with ice layer on sea surface was very difficult. Ocean Acoustic Tomography (OAT) using sound propagation times in ocean is useful observation system to know the actual temperature, salinity concentration of water and oceanic current[1)]. On the other hand, the climate research of Ocean using Autonomous Underwater Vogel (AUV) being planned in the Antarctic Ocean. In order to know the characteristics of sound propagation n Antarctic Ocean for development of underwater communication, we estimated the amplitude of pulse wave propagated in underwater of Lűtzow-Holm bay. In this paper, we calculated pulse waveform used by parabolic equation (PE) method.[3)]

2. Simulation model in Lűtzow -Holm bay on line OW

2.1 Environment data of Ocean model

We have investigated about the influence of amplitude of pulse wave by bathymetry in transverse line OW of the bay in Antarctic Ocean model that was covered ice surface for 39 km in range. By comparing with the amplitude of the pulse wave with or without reflected pulse from bottom, we ware assumed three kind bottom media model in this area. **Figure 1** shows simulation model and bathymetric chart of transverse line OW. As shown in this figure, bathymetry of transverse line OW has gradual upslope model, which is common bottom model in shallow water. Sound velocity profile was calculated by Del Grosso's

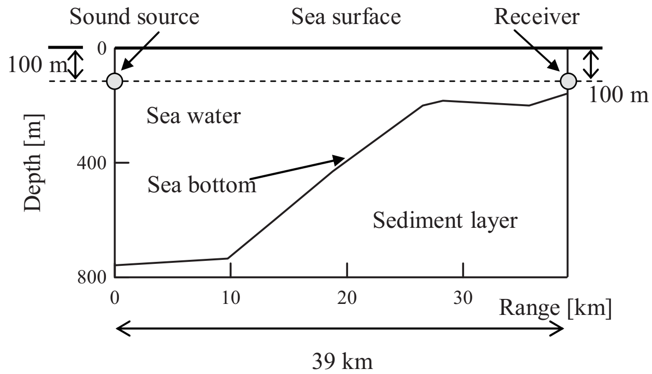

Fig. 1 Simulation model with bathymetric chart of transverse line OW for analysis of sound propagation in this Ocean.

equation[4)] using measurement data at each observation point. Any point of sound velocity to the horizontal direction was calculated by cubic-spline interpolation. We assume density of water is 1.0 g/cm^3. The depth of the sound source was assumed to be 100 m from sea surface. The sound source was radiated Gaussian pulse to the horizontal direction.

2.2 Acoustic parameters of three kinds bottom model

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 three sea bottom models that were varied the depth of sea bottom and acoustical parameter. In the first case, we defined Range-Independent (RI) model that model has a flat sea bottom. The depth of this model was 758 m. In the second 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 last case, the model, which was defined by Absorption layer (AB) model[5)], has a flat sea bottom with absorption layer to neglect reflected pulse wave from sea bottom. In these cases of RD and RI model, acoustical parameter of bottom assumed 1700 m/s in sound velocity and 1.5 g/cm^3 in density.

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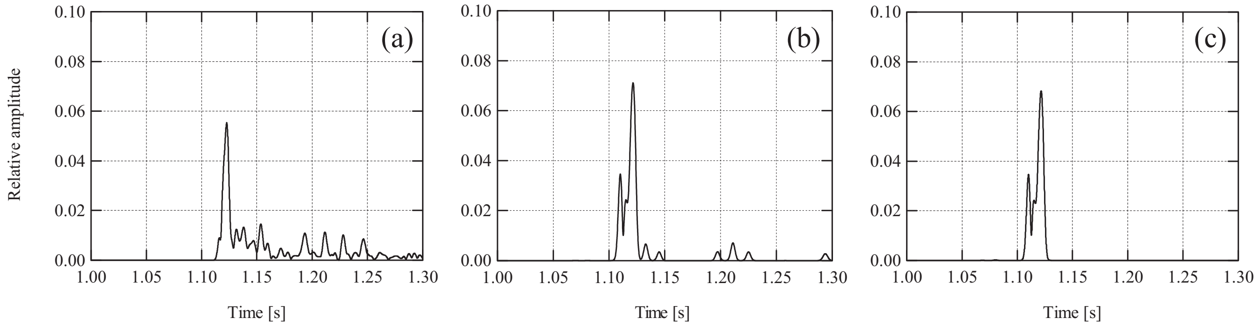

Fig. 2 Estimated waveform using parabolic equation method to propagate in Lűtzow-Holm bay. In this case, we calculated sound propagation assumed bottom shape and acoustical parameter (a) RD model: It is assumed that bottom depth data was used by measurement data (b) RI model : bottom depth was assumed the constant value (c) AB model : bottom depth was constant value and bottom layer was equivalent to absorption layer.

3. Calculation results

Figure 2 shows estimated waveform calculated by parabolic equation method to propagate in the Antarctic Ocean using inversion Fourier transfer. In this case, we calculated sound propagation assumed three bottom models. Figure 2 (a) shows estimated pulse waveform in the case of RD model. It is assumed that bottom depth data was used by measurement data. Figure 2 (b) shows estimated pulse waveform in the case of RI model. This model was assumed the float bottom shape which bottom depth equal to the depth of source point. In Fig. 2 (c), bottom layer equivalent to absorption layer. The bottom depth was constant value. As shown Fig. 2 (a), main pulse wave are received at t = 1.12 [s]. Received pulse wave after 1.13 [s], which has large radiation angle, was reflected sea bottom because propagation length was larger than main pulse. If received pulse has large radiation angle do not reflected sea bottom, arrival time of the pulse became a fast, because the pulse wave propagated to the fast area of sound velocity. As shown Fig. 2 (b), first arrival pulse at t = 1.11 [s] propagated to the deeper area in sea water. Three set pulse waves was arrived at t = 1.12 [s] and t = 1.19 [s]. These pulse waves were reflected from sea bottom and surface. The proof of these results was clearly shown as Fig. 2 (c). As a result, amplitude of sound pulse was different to three cases. However, the maximum difference value was about -3 dB between RD model and RI model. The value of changing amplitude is very small, because amplitude of reflected wave is small.

4. Conclusions

In this paper, in order to know the characteristics of sound propagation in Antarctic Ocean, we will know the characteristics of sound propagation in this Ocean. We used numerical analysis method to obtain the characteristics of sound propagation. In calculation results used by ray theory, it is shown that propagation pass was large influenced by bathymetry, because transverse line OW has upslope sea bottom and this area was near the Antarctica. On the other hand, it is clearly shown that continuous sound pressure field calculated by PE method was small influenced by bathymetry. In order to obtain the accuracy heavier of sound propagation in Antarctic Ocean, we calculate pulse waveform calculated by PE method to propagate in the Ocean using inversion Fourier transfer in three bottom model.

As a result, amplitude of sound pulse was different to three cases. The maximum difference value was about -3 dB between Range-Dependent model and Range-Independent model. It is clearly shown that the influence of the amplitude of sound pulse by bathymetry was small on transverse line OW in Antarctic Ocean. In future work, we calculated the sound propagation on transverse line L. In addition, we will be clearly shown that influence of data rate on underwater communication by multiple reflection pulse in Lűtzow-Holm Bay of Antarctic Ocean.

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