<table>
<thead>
<tr>
<th>論文・著書情報</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>論題 (和文)</strong></td>
</tr>
<tr>
<td>水中伝播時間帯の逆交差伝播データの相互伝播時間解析</td>
</tr>
<tr>
<td><strong>著者 (和文)</strong></td>
</tr>
<tr>
<td>王 勇, 蜂屋 弘之</td>
</tr>
<tr>
<td><strong>出典 (和文)</strong></td>
</tr>
<tr>
<td><strong>発行日</strong></td>
</tr>
<tr>
<td>2005, 1</td>
</tr>
</tbody>
</table>

Powered by T2R2 (Tokyo Institute Research Repository)
Differential travel time series of the reciprocal transmission in 1999 ocean acoustic tomography data

Yong Wang¹ and Hiroyuki Hachiya²,*

¹Graduate School of Science and Technology, Chiba University,
1–33 Yayoi-cho, Inage-ku, Chiba, 263–8522 Japan
²Faculty of Engineering, Chiba University,
1–33 Yayoi-cho, Inage-ku, Chiba, 263–8522 Japan

(Received 6 September 2004, Accepted for publication 14 October 2004)

Keywords: ocean acoustic tomography, underwater sound, reciprocal transmission, differential travel time

PACS number: 43.30.Qd, 43.30.Re [DOI: 10.1250/ast.26.76]

1. Introduction

Ocean acoustic tomography (OAT) [1] is widely recognized as a powerful technique for studying the thermal and current structure of the ocean. A number of sea trials have been conducted since the late 1970’s to determine the feasibility of OAT (see [2] for summary).

Sound travels faster in warm water than in cold water. By measuring the travel time of sound over a known path, the sound speed and thus temperature can be determined. Sound also travels faster with a current than against. By measuring the reciprocal travel times in each direction along a path, the absolute water velocity can be determined.

Travel time perturbations due to ocean currents are correspondingly one to two orders of magnitude smaller than travel time signals due to sound speed perturbations. The chief difficulty encountered in performing long-range reciprocal transmissions is the small size of the expected differential travel times, typically only a few milliseconds at 300-km range.

In the conventional method, the differential travel time by the ocean current is measured using amplitude information of the received signal. We presented the phase information of the signal is effective for realizing the high-precision measurement of travel time [3,4]. To measure the small order and short time current fluctuations, we proposed a new measurement technique, referred to complex vector method (CV method), using both the amplitude information and the phase information. In pervious paper we demonstrated preliminary results for several differential travel times using CV method. The preliminary result was promising [5]. In this paper, we present estimation results of the differential travel time series in about 1 month with the distance of 500 km, using the CV method.

2. Experiment

The Central Equatorial Pacific OAT experiment was conducted by the Japan Marine Science and Technology Center (JAMSTEC:the present Japan Agency for Marine-Earth Science and Technology) in December 1998 for two years to study El Niño and the Southern Oscillation (ENSO). Five acoustic transceivers were deployed over the flat beds

*e-mail: office@hachiya.net

(1–33 Yayoi-cho, Inage-ku, Chiba, 263–8522 Japan)

(Received 6 September 2004, Accepted for publication 14 October 2004)

Keywords: ocean acoustic tomography, underwater sound, reciprocal transmission, differential travel time

PACS number: 43.30.Qd, 43.30.Re [DOI: 10.1250/ast.26.76]
complex plane. And secondly, the travel time of the received signal is obtained by introducing the phase analyses of the complex received signals. From the theoretical analysis, we can estimate the travel time with error of 0.1 ms in SNR = 13 dB of the correlated signal.

We estimate differential travel time series of the ray path \( t_{C0} \) in reciprocal transmission along T3–T4 path in 1999 data. Figure 3 shows the correlated signals (a, b), amplitudes (c, d) and phases (e, f) of 13 shots in ray path \( t_{C0} \).

\[
\Delta t = t_{43} - t_{34},
\]

where \( t_{43} \) is the time in the direction from T4 to T3, \( t_{34} \) is the time in the reverse direction. The fluctuation in travel times of \( t_{C0} \) in the reciprocal transmission is very similar (Fig. 4 a and b), which was caused by transceivers position drift and temperature perturbation. The time series of travel time differences is computed using the CV method. The high-frequency variation as shown Fig. 4 c is probably due to tides and internal-wave-related fluctuations. The long-term variation with a low-frequency trend is also evident in Fig. 4 c, which is most likely a result of the passage of a mesoscale feature. The passage of a mesoscale feature seems to be reversed after April 30.
4. Conclusion

We presented the estimation results of the differential travel time series in reciprocal transmission data collected during the tomography experiment performed by JAMSTEC in 1999 at the Central Equatorial Pacific. The CV method was used for the estimation of differential travel times using reciprocal transmissions. The differential travel time series of -15 path have reasonable magnitudes, and we concluded presumably that the overall trend of low-frequency is caused by mesoscale fluctuations in this ocean region.

Acknowledgments

This research is partly supported by the Grant-in-Aid for the Creation of Innovations through Business-Academic-Public Sector Cooperation of the Japan Ministry of Education, Culture, Sports, Science and Technology.

References


![Fig. 4 Two-dimensional plot of the amplitude of the correlated signals between T3 and T4 (a, b) and differential travel time series (c) from 10 April 1999 to 20 May 1999.](image)