UNDERSTANDING SCATTERING OF SOUND AT BASIN-SCALES WITH NUMERICAL EXPERIMENTS AND THEORY

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LONG-TERM GOALS

There are two goals of this research. The first is to understand the role of internal waves and the mesoscale in scattering sound in the vertical dimension. The second is to develop computer algorithms to predict the extent of this scattering.

OBJECTIVES

Acoustic transmissions at 133 Hz, 60 ms resolution, were received at 3709 km from the Kaneohe source at a receiver mounted 1000 m beneath the axis of the sound channel. Ray traces and parabolic approximations indicate that the duration of the received energy should be about 2.5 s if the sound propagates through a climatological-average of the sound-speed profile in the northeast Pacific (Spiesberger and Tappert, 1996). But the duration of the acoustic energy is 3.5 s. In order to account for this additional second, we postulate that the meso and fine-scales scatter energy at least 1000 m downwards from the axis of the sound channel.

APPROACH

We utilized the U. Miami Parabolic Equation model to simulate the broadband transmission of sound from the source to the receiver (Tappert *et al.*, 1995). The effects of the mesoscale and internal wave fields on the propagation of sound are estimated separately and together by modelling the sound speed field with climatological, climatological+mesoscale, and climatological+mesoscale+internal wave fields. The research was conducted in collaboration with Dr. Michael Wolfson at Pennsylvania State University.

WORK COMPLETED

Numerical simulations are completed and have been compared with the data (Wolfson and Spiesberger, 1997).

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **Understanding Scattering of Sound at Basin-scales with Numerical Experiments and Theory**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Pennsylvania State University,Department of Meteorology,University Park,PA,16802**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

RESULTS

We found that both the mesoscale and internal wave fields are required to understand the multipath at the receiver. The mesoscale vertically scatters the sound by a few hundred meters and introduces a travel time bias of about 0.6 s for near-axial multipath. The bias delays the arrival times of these multipath. These delayed arrivals are further scattered an additional 800 m down to the depth of the receiver by the internal wave field. The travel time bias introduced by internal waves is relatively small, e.g. O(10) ms.

The observed multipath which are stable at the receiver are also stable in the numerical simulations (Spiesberger and Tappert, 1996; Wolfson and Spiesberger, 1997). The stability of these modelled paths in the precense of fluctuations adds to the body of evidence that these paths are useful for mapping temperature change (Spiesberger *et al.*, 1998).

IMPACT/APPLICATIONS

The fluctuations of eddies and internal waves limit the number of multipath that may be available for mapping the sound speed field with tomography. The near-axial multipath are very sensitive to these fluctuations, and it is not clear how to use them for tomographic inversions. Multipath which are sensitive to fluctuations may be useful for inferring statistical properties of the eddies and internal waves.

TRANSITIONS

No transitions have been identified.

RELATED PROJECTS

The vertical scattering of sound by internal waves has been investigated by Colosi *et al.* (1994). Wolfson (pers. comm.) is investigating the sensitivity of rays to the mesoscale in three-dimensions. M. Brown and F. Tappert (pers. comm.) are investigating ray and finite-wavelength chaos in the presence of ocean structures.

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