Acoustic Tomography With Navy Sonars

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Award #: N00014-97-1-0484

LONG-TERM GOAL

Utilize Navy sonars to map and understand temperature variability in ocean basins using acoustical tomography and hydrographic data. The data can be used to check and update ocean models for nowcasts and forecasts, and to check complimentary information from satellites.

Most of the data come from U.S. submarines which tow arrays and measure temperature at 1-s intervals. Additional data come from the U.S. Navy's Sound Surveillance System (SOSUS).

OBJECTIVES

A principal objective of this grant is to show it is possible to use U.S. submarines to collect temperature and acoustical tomography data over basin-scales. A secondary objective is to show it possible to read existing Navy data tapes at SOSUS stations to process tomography signals from ATOC sources and sources deployed by Naval Air.

APPROACH

Data are to be collected from submarines and SOSUS stations, and combined with hydrographic data to map ocean temperatures using a Kalman filter.

WORK COMPLETED

Acoustical data have been collected from a submarine. These data show high signal-to-noise ratios at 3000 km from electronically generated signals from the Kauaii ATOC source.
ATOC source signals have been successfully processed from the Navy's data tapes at SOSUS stations.
Acoustic signals generated from Naval Air exercises have been successfully interpreted from the SOSUS data tapes.

RESULTS

We have found that submarines provide excellent platforms for receiving acoustic tomography data over basin-scales. We have learned that existing hydrographic data sets show westward-propagating Rossby waves which emanate from the west coast of the U.S. following El Nino's and La Nina's. These Rossby waves are evident in these data sets since the 1970's, leading to temperature variations of a few degrees Celsius. The speeds of these waves are consistently faster than predicted using standard linear theory, as the work by Chelton and Schax have observed using the TOPEX/POSEIDON altimeter. The Naval Research Laboratory's Layered Ocean Model (Hurlburt et al., 1996) shows similar

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
1998		**00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Acoustic Tomography With Navy Sonars	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,Applied Research Laboratory,PO Box 30,State College,PA,16804**	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
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

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

westward-propagating Rossby waves following ENSO events. However, the speed of the modeled Rossby waves are significantly slower than observed, despite the fact that the ocean model incorporates physical mechanisms that have been proposed to explain why the Rossby waves travel faster than given by standard linear theory (Jacobson and Spiesberger, 1998).

We have found that it is usually the case that ray theory is adequate for interpreting multipath transmissions over basin scales in the northeast Pacific (Norris et al, 1998). We have found that Rossby waves linked to ENSO are a dominant parameter affecting climatic temperature variability in the northeast Pacific (Spiesberger et al. 1998). These waves lead to temperature variations of a few degrees Celsius at 300 m depth (Spiesberger et al., 1998; Jacobson and Spiesberger, 1998). We have found that acoustic thermometry data can measure changes in the sea surface height, due to thermal expansion, to an accuracy of about 0.3 cm. This is about ten times more accurate than is possible from the one billion dollar TOPEX/POSEIDON satellite altimeter (Spiesberger et al, 1998).

IMPACT/APPLICATIONS

Utilizing the U.S. submarine fleet to collect oceanographic data will greatly increase the quality of our images of the temperature field in the ocean's interior. These images will make it possible to better test theories, models, and other sensor's estimates of the ocean, such as satellites.

TRANSITIONS

This work is at a start, and it is too early for a transition to have occurred. Discussions with the Navy are underway.

RELATED PROJECTS

The ATOC project is utilizing SOSUS stations to map the ocean's temperature field from basin-scale transmissions.

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