GEOACOUSTIC BENCHMARK WORKSHOP

N.Ross Chapman
School of Earth and Ocean Sciences
University of Victoria
PO Box 3055
Victoria, B.C. V8W 3P6
phone: (250) 472-4340; fax: (250) 721-6200
email: chapman@uvic.ca
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Shallow-water acoustics

LONG TERM GOALS

Currently there is much research activity in inversion for geoacoustic properties, both in the development of new methods, and in the application of existing methods to data from shallow water environments. Various techniques such as matched field inversion, matched field tomography, acoustic noise inversion, reflection coefficient inversion, acoustic travel time inversion, and horizontal wavenumber inversion have been investigated. The long term goal of this project is to contribute to the understanding of existing methods, and to the development of new methods for geoacoustic inversion.

OBJECTIVES

The objective of this project is to organize and hold a Benchmark Workshop for testing existing methods for estimating geoacoustic properties of the ocean bottom by inversion of acoustic field data. The workshop will:

- identify specific difficulties associated with each inversion method;
- determine which methods are most sensitive to specific geoacoustic properties;
- determine a measure of the accuracy of each method for inverting geoacoustic properties.

The intent is to publish the workshop papers in a special issue of the Journal of Computational Acoustics in 1998.

APPROACH

The format of the workshop was to test various inversion methods against data sets that represented typical shallow water environments. The test cases were generated using random (but reasonable) values for the parameters of layered geoacoustic models, and the acoustic field data for each bottom model were provided on an ftp site for a selected band of frequencies. Model parameters included sediment layer thicknesses, sound speeds, densities and attenuations. The parameter values were unknown to the participants, except for one data set which was given with known input parameters so that participants could calibrate their methods. The workshop was organized in collaboration with Alex Tolstoy, IPD.

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The data sets for the test cases were generated by Gary Brooke (IPD) using SAFARI, and verified using the ORCA normal mode model. The verified data were stored on an ftp site at the University of Victoria in January 97, and participants were able to access the test cases in preparation for the workshop. The workshop was held in Vancouver, B.C. in June 97 at the McDonald-Detwiller facillities. A total of 21 papers were presented on the analysis of test case data, and also on applications to real data. Most of the inversion methods were based on matched field processing, but results using other methods were also presented. Following the workshop, 15 papers were submitted for the workshop special issue. The review process is currently underway for these papers.

RESULTS

The central issues for geoacoustic inversion that were identified in the workshop were:

1. Coherent (in frequency) vs. incoherent broadband processing;
2. Sensitivity of the model parameters and the effect on the accuracy of the estimates;
3. Associated with parameter sensitivity were three related issues:
   - design of experiment;
   - correlation of model parameters;
   - reparameterization;
4. Estimation of errors for the estimate: confidence limits.

Most inversion methods were successful in estimating the most sensitive model parameters to within 10 per cent; some methods, generally those based on broadband processing, were more successful than others in estimating values for the less sensitive parameters. Most of the participants used well-established normal mode codes for calculating replica fields in MF inversions: Kraken, ORCA (Westwood et al, 1996); Parabolic equation and Safari were used by two groups. Kraken was shown to have problems regarding its accuracy at some of the frequencies within the band 25-500 Hz for some of the environments. For the same conditions, ORCA did not experience any problems. Several new and innovative inversion schemes were devised to improve global search efficiency and overall inversion performance; these methods exploited either experimental design and/or frequency band to invert specific model parameters.

IMPACT/APPLICATIONS

The workshop concluded with a list of recommendations for continued investigation:

- investigation of coherent processors for broadband data (e.g. Westwood processor, waveform matching), and comparison with incoherent processors;
- reparameterization of the model parameter space for efficient global searches;
- comparison between genetic algorithm and other global search methods, in particular, simulated annealing;
- effect of noise in the data. Future work should proceed to investigate inversion performance in more realistic conditions;
- inversion in range dependent environments, including 3-dimensional effects.

The test case data will remain on the ftp site, and are available for use by other researchers.

TRANSITIONS

The workshop was attended by 38 researchers and students from North America (USA and Canada), Europe (UK, Netherlands, Greece, France) and Asia (Singapore, PRC). Information on various aspects of geoacoustic inversion was exchanged, and innovative new methods were presented. The proceedings will be published in a special issue of the Journal of COmputational Acoustics that will contain a summary paper by R. Chapman and A. Tolstoy to describe the findings of the Workshop.

RELATED PROJECTS

The results of the workshop are relevant to other projects in geoacoustic inversion.

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