Observational System Simulation Experiments and Simulations In the South China Sea for Sampling Strategies, Sound Speed Analyses and Dynamical Studies

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LONG-TERM GOALS

This research will produce realistic four-dimensional field estimates in the coastal ocean for interdisciplinary physical-acoustical dynamical studies and comparisons for regions of steep topography and across the shelf-break with accuracies suitable for forward and inverse sound propagation use and the design of sampling schemes. The research includes comparisons of the similarities and differences of processes inherent to the South China Sea ASIAEX Shelfbreak and New England Shelfbreak PRIMER regions. Observational System Simulation Experiments (OSSEs) are utilized to optimize sampling schemes and, as appropriate and feasible, real-time forecasting for smart adaptive sampling.

OBJECTIVES

Our primary objectives are to: 1) prepare Observational System Simulation Experiments (OSSEs) for optimizing sampling schemes and, as appropriate and feasible, real-time forecasting for smart adaptive sampling; 2) perform hindcast simulations with data assimilation to provide the best possible four-dimensional physical fields with mesoscale and sub-mesoscale resolution for acoustic studies; and, 3) complete additional dynamical studies of selected important physical events as identified.

APPROACH

The Harvard Ocean Prediction System (HOPS) provides dynamically consistent and unified four-dimensional framework in which to integrate the *in situ* and remotely sensed synoptic observations collected during the field experiments, along with historical synoptic and climatological data, and generate physical fields. The use of HOPS, combining dynamics and data via data assimilation, provides for the optimal use of the collected data through four-dimensional field estimation. From the physical fields, sound-speed fields which are continuous in space and time can be produced. These fields are used to support the following acoustic studies:

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14. ABSTRACT
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15. SUBJECT TERMS

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1. Interpretation of the observed acoustic variability. Fluctuations in the acoustic observables (amplitude, phase and time) are related to the 4D sound speed variability and provide insight into the dynamics and variability of the propagation. Of particular interest is the sensitivity of each acoustic observable to each of the prominent mesoscale and sub-mesoscale ocean features and the establishment of efficient measurement models, linking the physical features to the acoustic observables.

2. Sonar performance prediction. Using the 4D fields in sound propagation models, the spatial and temporal distribution of sound energy as a function of source depth and frequency are quantifiable. From this, optimal sonar frequencies and depths in relation to specific frontal conditions are expected to be determined.

The uncertainty research and knowledge gained from PRIMER will be transferred and applied to ASIAEX. Our approach is based on dynamical studies, which involves modeling and simulating physical fields and high order uncertainties. The ASIAEX data will be assimilated in HOPS using Optimal Interpolation (OI) and Error Subspace Statistical Estimation (ESSE). Monte-Carlo-based simulations of 4D physical fields and dominant uncertainties will be carried out. The results will be analyzed and the dynamics occurring in the PRIMER and ASIAEX regions will be compared. Physical estimates will be transferred to acoustics models to be used by other ASIEX members. Stochastic error models for unresolved processes, forcing errors and boundary condition errors relevant to the ASIAEX dynamics and data sets will be further developed and improved.

WORK COMPLETED

Initial discussions have been carried out with WHOI (Gawarkiewicz, Lynch and Duda) so as to learn about and study the details of the ASIAEX observations. We have also started a first assessment of the main dynamical processes and features present in the South China Sea. The transfer of environmental uncertainties to acoustic fields was carried out via ESSE for the PRIMER region [2].

An initial modeling domain (Figure 1) has been designed and implemented which encompasses the general areas covered by both the 2000 and 2001 South China Sea CTD and SEASOAR surveys. The domain is centered at 21.25N, 117.5E. It has a resolution of 0.027 degrees, approximately 3km. The grid size is 113x96 points, indicating an approximate coverage of the region 20N - 22.5N, 116E - 119E. The bottom topography of the area is shown in Figure 2. A larger domain covering a larger portion of the South China Sea, into which this domain can be nested, is under devleopment.

RESULTS

The uncertainties in the PRIMER predicted acoustic wavefield associated with the transmission of low-frequency sound from the continental slope, through the shelfbreak front, onto the continental shelf have been examined in [1]. The combined ocean and acoustic results from the simulation study provides insights into the relations between the uncertainties in the ocean and acoustic estimates.

IMPACT/APPLICATIONS

The data set will provide a primary focus for our Uncertainty research as well as allowing the characterization of the physical/acoustical dynamics of the region and an inter-comparison with PRIMER for the identification of both generic and regionally specific processes.

TRANSITIONS

The software that have been developed for the uncertainty and 6.1-6.2 programs (e.g. advanced nesting schemes, stochastic models of internal tides, visualization algorithms, analysis of error PDF's, transfer to acoustic models, etc) will be directly useful for the ASIAEX studies. Similar feedbacks in the other direction are anticipated.

RELATED PROJECTS

This project is closely related to other Harvard projects, including: the new ONR project "Uncertainties and Interdisciplinary Transfers Through the End-to-End System (UNITES): Capturing Uncertainty in the Common Tactical Environmental Picture", and other Harvard research. Important collaborations are ongoing with: Dr. Glen Gawarkiewicz (WHOI) in OSSEs and adaptive sampling and in the area of dynamical studies of important events of shelfbreak front meandering and instability, and Prof. Ching-Sang Chiu (Naval Postgraduate School) in the utilization of high-resolution four-dimensional physical fields to support experimental design and the interpretation of acoustic data.

PUBLICATIONS

None to date.

REFERENCES

[1] Lermusiaux P.F.J., C.-S. Chiu and A.R. Robinson, 2001. Modeling Uncertainties in the Prediction of the Acoustic Wavefield in a Shelfbreak Environment. *Proceedings of the 5th International conference on theoretical and computational acoustics,* May 21-25, 2001. Beijing, China. In press.

[2] Robinson, A.R. and P.F.J. Lermusiaux, 2001. Data Assimilation for Modeling and Predicting Coupled Physical-Biological Interactions in the Sea. *THE SEA: Volume 12: Biological-Physical Interactions in the Sea*. Robinson, A.R., J.J. McCarthy and B.J. Rothschild (editors), in press.

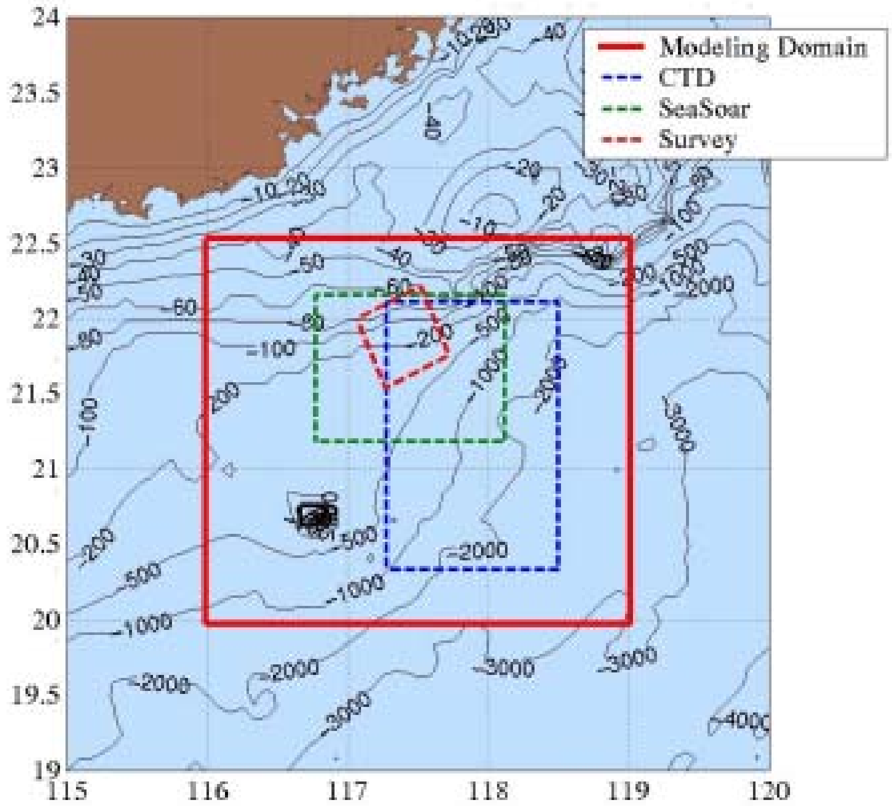

Figure 1 - location of initial modeling domain and relationship to general areas of 2000 and 2001 surveys. Contour intervals are in meters.

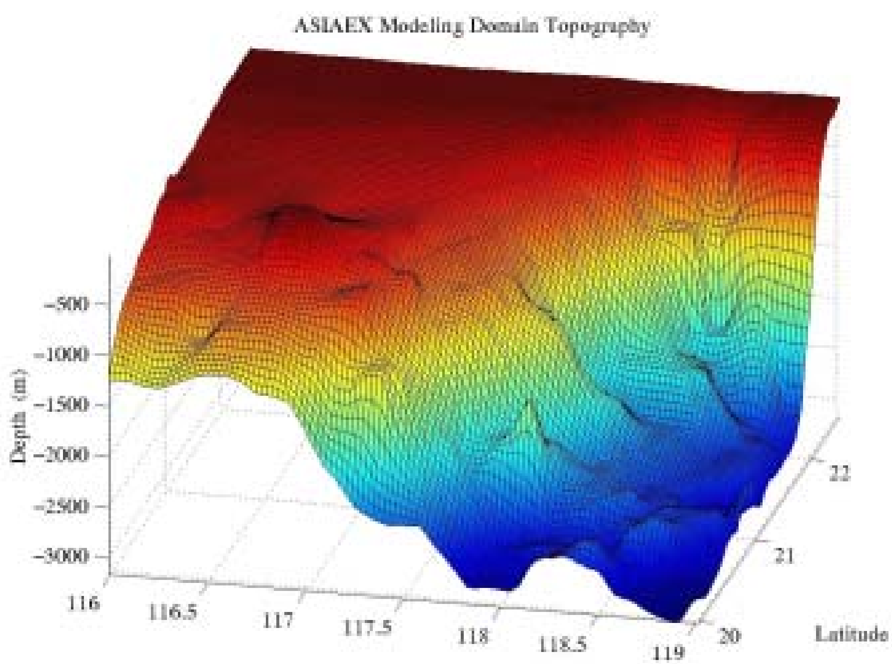

Figure 2 - bottom topography of initial modeling domain