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Multi-Dimensional Data Assimilation for Physical-biological Models

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LONG-TERM GOAL

The long-term goal of our research is to develop mathematical models that can be used to obtain better understanding of the interactions between physical and biological processes in marine ecosystems and their role in structuring marine food webs.

OBJECTIVES

To accomplish our long-term goal we are pursuing the following research objectives: 1) develop approaches for assimilating multidisciplinary measurements into marine ecosystem models; 2) use data assimilation techniques with physical-biological models to investigate the types of data and frequency at which data need to be assimilated; and 3) use the data assimilation techniques to investigate the structure of marine ecosystem models. These research objectives are directed at developing techniques and approaches that are needed for the full capability of multidisciplinary measurement programs to be realized.

APPROACH

The amount and type of data needed for input to data-assimilative multi-component marine ecosystem models are currently determined empirically for each model. This approach lacks rigor and generality and results in data-assimilative approaches that are model specific. We are developing methods for using Empirical Orthogonal Function (EOF) techniques to determine the data needs for data- assimilative marine ecosystem models. Using EOF analysis, data can be decomposed into orthogonal functions and their corresponding temporal coefficients. These EOF structures allow determination of the primary interconnections of the ecosystem, which in turn, allows insight into the processes that need to be well represented in the data assimilation. The EOF structures then provide the basis for the data assimilative ecosystem model.

WORK COMPLETED

In the first year of this project, we have developed a 4-6 component model of the lower trophic levels of a marine ecosystem. This model was used to generate simulated data sets which were then subsampled at different frequencies and the EOF structures of these data sets were computed. Numerical experiments with the model and data sets showed that using only the first several of the independent modes, it was possible to not only reconstruct the time-development all of the original ecosystem components, but to extend the time series of the original components beyond the scope of the initial data set. Subsequent analysis of the variance of each eigenvector allowed ranking of the importance of each ecosystem component in determining the overall ecosystem structure. We are now undertaking additional simulations with actual data sets to further test this approach. We have acquired the Langley Tow Tank data set from Dr. Percy Donaghay, as well as the time series from the JGOFS HOT and BATS sites and these will be used to test the model in a variety of applications.

RESULTS

The primary result from our research is that the EOF method works with biological data sets. It is possible to obtain basic structures from these data that can then be used as a basis for reconstructing the primary linkages and interactions in a marine ecosystem through a data assimilative ecosystem model. A poster describing our results will be presented at the 1998 Fall Meeting of the American Geophysical Union, as part of the special session on Interdisciplinary Data Assimilation.

IMPACT/APPLICATION

Our results show that the combined EOF-data assimilation model is a promising approach for efficiently combining data and models. This will further the development and use of data assimilation for combined optical-ecosystem-circulation models.

TRANSITIONS

We anticipate that the models and data assimilation methods developed in this study will be used in the analysis of data sets obtained from the ONR-sponsored Thin Layers program.

RELATED PROJECTS

1 - This project is joint with Dr. Percy Donaghay at the University of Rhode Island.

REFERENCES

None

PUBLICATIONS

None