AOGS 2005

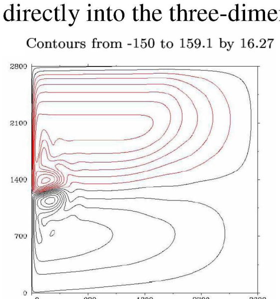
An Inverse Spectral Element Ocean Model

DALE HAIDVOGEL[1], JULIA LEVIN[1] and MOHAMED ISKANDARANI[2]
[1]*Institute of Marine and Coastal Sciences, Rutgers University, New Jersey, U.S.A.*
[2]*Rosenstiel School of Marine & Atmospheric Science, University of Miami, Florida, U.S.A.*

A new hierarchy of ocean circulation models based on unstructured grid, spectral finite element methods has been developed. The advantages offered by these methods include geometric flexibility, good scalability on parallel computers including Beowulf-class systems; and dual h-p paths to convergence. The hierarchy of models at present incorporates shallow water, multiply layered, and continuously stratified versions.

In preparation for data-assimilative applications, we have lately implemented a two-dimensional (shallow water) inverse spectral element ocean model (ISEOM). The solution to the nonlinear inverse problem is obtained by finding an optimal solution to the tangent linear problem and then iterating on nonlinearity. The optimal solution to the tangent linear problem is in turn obtained by an indirect representer method. The spectral element tangent-linear and adjoint models are incorporated within the framework of the Inverse Ocean Model developed by Bennett and Chua at Oregon State University. We describe the tangent-linear and adjoint systems and outline the indirect representer approach. We then present the results of a wind-driven double gyre twin experiment. Finally we mention ongoing applications of the ISEOM system.

Although the two-dimensional inverse model can be used in its own right to study barotropic processes and other single-layer phenomena (e.g., the oceanic tide, horizontal wave propagation, and the abyssal circulation); the shallow water model is also used as the barotropic engine in our three-dimensional spectral element ocean model. Its tangent linear and adjoint formulations may therefore be incorporated directly into the three-dimensional inverse model, currently under development.



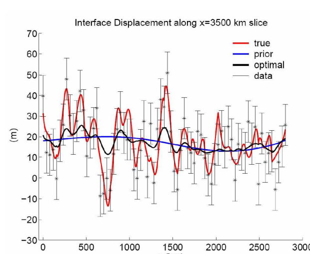


Figure 1: (left) Snapshot of the interface displacement (meters) in a wind-driven, double-gyre experiment before assimilation (prior run). Black contours show positive values of the interface displacement, and red contours, negative values.

Figure 2: (right) Comparison of interface displacements along a slice in the y direction: prior run (blue), true solution (obtained by the addition of small-scale noise to the initial conditions and forcing of the prior run; red), and the optimal approximation to the true solution (black) obtained by assimilation of data (true solution plus noise; grey dots).