The numerical simulation of the month to month variability of the Western Mediterranean's Circulation

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The GHER 3D primitive equation model uses as state variables the velocity vector u, temperature T, salinity S, turbulent kinetic energy k and a generalized "pressure" q. By means of the usual Boussinesq approximation and the assumption of hydrostatic equilibrium, the primitive equations are then transformed by an original twofold vertical coordinate change (BECKERS 1988). The resulting equations in the transformed space are then (buoyancy $b(T,S)$ is used for this presentation)

$$\frac{\partial H\hat{\mathbf{u}}}{\partial \hat{t}} + \hat{\nabla}\cdot(H\hat{\mathbf{u}}\hat{\mathbf{u}}) + \frac{\partial}{\partial \hat{x}_3}(H\hat{u}_3\hat{\mathbf{u}}) + f\mathbf{e}_3 \wedge H\hat{\mathbf{u}} = -H\nabla q + \frac{\partial}{\partial \hat{x}_3}\left(\tilde{\nu}\frac{L^2}{H^2}\frac{\partial H\hat{\mathbf{u}}}{\partial \hat{x}_3}\right) + \hat{\nabla}\cdot\{\tilde{\kappa}\hat{\nabla}(H\hat{\mathbf{u}})\} \qquad (1)$$

$$\frac{\partial H b}{\partial \hat{t}} + \hat{\nabla}\cdot(H\hat{\mathbf{u}}b) + \frac{\partial}{\partial \hat{x}_3}(H\hat{u}_3 b) = \frac{\partial}{\partial \hat{x}_3}\left(\tilde{\lambda}^b\frac{L^2}{H^2}\frac{\partial H b}{\partial \hat{x}_3}\right) + \hat{\nabla}\cdot(\tilde{\kappa}^b H\hat{\nabla} b) \qquad (2)$$

$$\frac{\partial H k}{\partial \hat{t}} + \hat{\nabla}\cdot(H\hat{\mathbf{u}}k) + \frac{\partial}{\partial \hat{x}_3}(H\hat{u}_3 k) = H\left(\tilde{\nu}\left\|\frac{\partial u}{\partial x_3}\right\|^2 - \tilde{\lambda}^b\frac{\partial b}{\partial x_3}\right) + H(\pi^\circ - \epsilon) + \frac{\partial}{\partial \hat{x}_3}\left(\tilde{\lambda}^k\frac{L^2}{H^2}\frac{\partial H k}{\partial \hat{x}_3}\right) + \hat{\nabla}\cdot(\tilde{\kappa}^k H\hat{\nabla} k) \qquad (3)$$

The numerical scheme used is a finite volume scheme designed for an efficient time stepping (based on the mode splitting technique) on a vector computer. The model has already been tested under rather crude boundary conditions but has simulated successfully the deep water formation in the northern basin of the Western Mediterranean Sea (J.M. BECKERS and J.C.J. NIHOUL 1990). Indeed, the non-linear model indeed is based on a turbulent parameterization allowing strong vertical mixing when hydrostatic instabilities occur. The $k - l$ turbulence closure scheme is also adapted to simulate mesoscale turbulence not resolved by the general circulation model and special care is taken of the mixing associated with the mesoscale wind field. The need of appropriate boundary conditions is readily seen and the simulation of the month to month variability is only possible under the condition that these atmospheric data are available, especially for turbulent quantities like turbulent kinetic energy k on Fig.1.

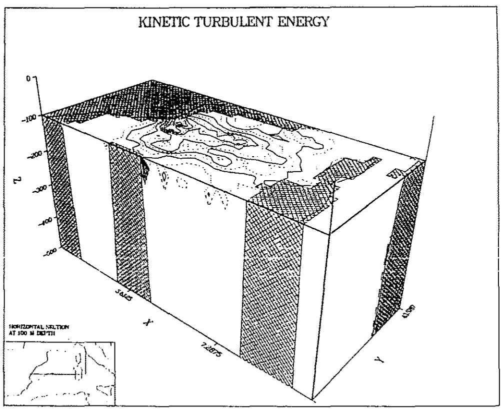

Fig.1.

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Data assimilation of the Eastern Mediterranean climatology using the adjoint method applied to the GFDL circulation model

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The objective of model fitting is to find the model state minimizing the misfit between the data and their model counterparts. The best fit is determined by the values of the independent variables that minimize the cost function. This technique was applied to assimilate the Eastern Mediterranean climatology in terms of wind stress field, termperature and salinity distributions.

The GFDL general circulation model was adapted to the Eastern Mediterranean with 0.25 degree of resolution and 17 vertical levels, and coupled with the adjoint version of the same model in order to fit the model to data to have a steady state solution.

The output fields of velocity, temperature, salinity and streamfunction are compared with the ISDGM multilevel model spinup.