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Parameter Estimation in Ocean Models using a Implicit 4D-Var Method

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A new version of the variational data-assimilation method 4D-Var is presented. It is shown that the, usually problematic, construction of the adjoint model can be circumvented by utilizing implicit time-stepping. The implicit time integration provides the tangent-linear model without any additional cost and relatively large time steps can be used. The gradient of the cost function is evaluated by the same iterative scheme as used for traditional 4D-Var, but the backward iteration is is replaced by a few additional solution of certain linear systems of equations. This new method is extended to include estimation of parameters. Instead of optimization over both the initial condition and parameters, sequential optimization is used. The success of the methodology is demostrated for specific test problems using a barotropic quasi-geostrophic model of the wind-driven circulation. The results indicate that the implicit 4D-Var method is capable of finding a good analysis and good parameter estimates for a large range of problems and that the method has great application potential to more complex ocean models.