Weak Constraint 4D-Var Data Assimilation in the Regional Ocean Modeling System (ROMS) using a Saddle-Point Algorithm

The saddle-point formulation of weak constraint 4-dimensional variational (4D-Var) data assimilation has been developed for the Regional Ocean Modeling System (ROMS) and is applied here to the California Current System (CCS). Unlike the conventional forcing formulation of weak constraint 4D-Var, the saddle-point formulation can be efficiently parallelized in time which can lead to a substantial increase in efficiency. The performance of the ROMS saddle-point algorithm is described here and compared to that of the dual forcing formulation which is the current standard in ROMS. While the rate of convergence of the saddle-point formulation is slower than the dual forcing formulation, the increase in computational speed due to time-parallelization more than compensates for the additional inner-loop iterations required by the saddle-point algorithm in the CCS configuration considered here. Additional increases in performance can be achieved by running the 4D-Var inner-loop iterations at reduced resolution and/or reduced arithmetic precision. The results presented here indicate that in high performance computing environments, the saddle-point formulation of 4D-Var could be a game changer and significantly out-perform the forcing formulation for large data assimilation problems.

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