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Representer-based variational data assimilation in a nonlinear model of nearshore circulation

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A representer-based variational data assimilation (DA) method is implemented with a shallow-water model of circulation in the nearshore surf zone and with synthetic data. The behavior of the DA system is evaluated in a strongly nonlinear (irregular flow) regime over time intervals that are large compared to time scales characteristic of instabilities and eddy interactions. True, reference solutions, from which the synthetic data are sampled, correspond to a fully-developed unsteady nonlinear flow supported by a steady forcing (representing the effect of breaking waves). Forcing and initial conditions are adjusted to fit the data. The convergence of the nonlinear optimization algorithm, proceeding as a series of linearized problems, and the accuracy of the forcing and state estimates depend on the choice of the forcing error covariance C defining the norm of the model residual term in the penalty functional. Although a choice of a steady C is consistent with the steady true forcing, convergence cannot be achieved with such a covariance. The model has a limited memory of the initial conditions and the DA system cannot find sufficient degrees of freedom in the steady forcing to control eddy variability over the entire assimilation interval. Implementing a bell-shaped temporal correlation function in C (with the decorrelation scale comparable or smaller than the characteristic eddy scale) yields a converging linearized inverse solution that describes correctly the spatio-temporal variability in the eddy field. However, a corresponding estimate of the forcing is not satisfactory, with the incorrect time-mean and with magnitudes of temporal deviations comparable to the mean. Better inversion can be achieved by implementing a composite C with a temporal correlation separated into an O(1) steady and small amplitude time-variable parts. Then, the inverse forcing estimate is improved. The time variable component of the forcing estimate helps to control eddy variability in the inverse solution without contributing to the average energy balance.