A Robust Ensemble-Based Kalman Filter for Data Assimilation into a 3D Ecosystem Model of the Cretan Sea (Eastern Mediterranean)

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An application of the robust filtering approach with an ensemble square-root Kalman filter for data assimilation into an ecosystem model of the Cretan Sea (Eastern Mediterranean) is presented and discussed.

The ecosystem system comprises two on-line coupled sub-models: the three-dimensional Princeton Ocean Model and the European Regional Seas Ecosystem Model (ERSEM) [1]. The ecosystem model is under hydrodynamic control, in winter and spring when mixing events significantly influence the biology by transporting nutrients from below the thermocline into the euphotic zone and organic matter passes to the benthos. For the remainder of the year it is under ecological control. Accounting for model deficiencies remain a significant problem for any EnKF assimilation, as they limit the accuracy of the estimated background covariance crucial for proper weighting of the model prediction in the assimilation. Additionally, poor behavior of KFs during ecosystem bloom periods is now acknowledged as a common difficulty. A KF is indeed generally quite inefficient with highly intermittent and fast varying processes having probability distributions not well characterized by means and variances. This contribution addresses these difficulties through an assimilation scheme that is based on the Singular Evolutive Interpolated Kalman (SEIK) [2] filter implemented with a time-local H_infinity filtering strategy to enhance robustness and performances during periods of strong ecosystem variability [3]. It is shown that robustness can be achieved in the SEIK filter by introducing an adaptive inflation scheme of the modes of the filter error covariance matrix.

Twin-experiments are performed to evaluate the performance of the assimilation system and to study the benefits of using robust filtering in and ensemble-filtering framework. Pseudo-observations of surface chlorophyll extracted from a model reference run for the year 2003 were assimilated every two days to correct the ecosystem model predictions. Simulation results suggest that the adaptive inflation scheme significantly improves the behavior of the SEIK filter during periods of strong ecosystem variability.

References

[1] **Petihakis, G., et al., *Modelling the Spatial and Temporal Variability of the Cretan Sea Ecosystem.* Journal of Marine Systems, 36, pp. 173-196, 2002. (Journal Article)**

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[3] **Luo, X. and I. Hoteit, *Robust ensemble filtering and its relation to covariance inflation in the ensemble Kalman filter.* Mon. Weather Rev., 139, pp. 3938–3953, 2011. (Journal Article)**