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Nonlinear measurement function in the Ensemble-Kalman filter and a practical application of the Sigma-point Kalman filter

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In this study, we explored several computational schemes of the Kalman gain of Ensemble Kalman Filter (EnKF) for nonlinear measurement function. Emphasis is placed on a comprehensive interpretation of the current algorithm and an extension of it based on statistically rigorous derivations. It was mathematically proven that the modified Kalman gain formulas can remove the implicit assumption in the current algorithm. A simple Lorenz model was used as a test bed to compare these algorithms. Experiments showed that the modified Kalman gain could perform better than the current one for the Lorenz model parameter estimate, which involves a highly nonlinear measurement function.

Another issue addressed in this study was the computational cost of the Sigma-point Kalman filters (SPKFs). The truncated single value decomposition (TSVD) method was used to construct a reduced rank SPKF. A realistic ENSO (El Nino and Southern Oscillation) forecast model was used to test the reduced rank SPKF. The performance of the reduced rank SPKF was compared to the square root Ensemble Kalman filter (EnSRF) that was designed parallel to the SPKF. The reduced rank SPKF was found to be very computationally feasible and led to smaller errors compared to the EnSRF, in terms of ENSO simulation.