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Sigma-point Kalman filter data assimilation methods for strongly nonlinear systems

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Performance of advanced derivativeless, sigma-point Kalman filter (SPKF) data assimilation schemes in a strongly nonlinear dynamical model is investigated. The SPKF data assimilation scheme is compared against traditional Kalman filters such as extended Kalman filter (EKF) and ensemble Kalman filter (EnKF) schemes. Three particular cases, namely the state, parameter and joint estimation of states and parameters simultaneously, from a set of discontinuous noisy observations are studied. The problems associated with the use of tangent linear model (TLM) or Jacobian when using traditional Kalman filters, are eliminated when using SPKF data assimilation algorithms.

The celebrated Lorenz model with highly nonlinear condition is used as the test-bed for data assimilation experiments. The results of SPKF data assimilation schemes are compared with those of traditional EKF and EnKF where a highly nonlinear chaotic case is studied. It is shown that the SPKF is capable of estimating the model state and parameters with better accuracy than EKF and EnKF. Numerical experiments showed that in all cases, the SPKF can give consistent results with better assimilation skills than EnKF and EKF, and can overcome the drawbacks associated with the use of EKF and EnKF.