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Retrograde Estimation and Forecasting of Chaotic Systems. Part 1: Theoretical Foundations JOSEPH CESSNA, CHRISTOPHER COLBURN, THOMAS BEWLEY, University of California-San Diego — Chaotic systems are characterized by long-term unpredictability. Previous methods designed to estimate and forecast such systems, such as extended Kalman filtering [a matrix-based approach] and 4Dvar [aka Moving-Horizon Estimation (MHE), a vector-based approach], are essentially based on the assumption that Gaussian uncertainties in the initial state estimate and Gaussian disturbances to the state and measurements lead to uncertainty on the state estimate at later times that is well described by a Gaussian model. This assumption is not valid in chaotic nonlinear systems. A new method is thus proposed which revisits past measurements in order to reconcile them with more recent measurements of the system. This new approach, which we refer to as Model Predictive Estimation (MPE), is a straightforward extension of 4Dvar/MHE, an operational algorithm recently adopted by the weather forecasting community. Our new method leverages backwards-in-time (aka,"retrograde") time marches of the system, a receding-horizon optimization framework, and adaptive adjustment of the optimization horizon based on the quality of the estimate at each iteration.

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