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Improving Adaptive Stochastic Modelling for Kalman Filter and Its Applications

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Abstract: The Kalman filter relies on functional and stochastic models. The reliable stochastic models mean that the model errors and their covariance matrix should accurately describe the reliability of dynamic models and observational information. Classical Adaptive stochastic modelling can be classified into two groups, namely, innovation-based adaptive modelling and residual-based adaptive modeling. They use an average quadratic form of the residuals of observations and predicted states within a window to evaluate the covariance matrices of observations and dynamic model errors at the present epoch. This implies that all the historical residuals within the window provide the same contribution to the covariance evaluation without considering their differences in precision and correlation in time and space. To overcome the problem, an improving adaptive stochastic modelling is developed in this paper by using a weighted average quadratic form of the historical residuals of observations and predicted states to evaluate the covariance matrices of observations and dynamic model errors at the present epoch. The weight function is constructed based on the variances of observational residuals or predicted state residuals, and space distance between the previous and the present epoch. A process noise scaling method by using L-curve is proposed. Two numerical examples, Kalman filter-based orbit determination of GEO satellite and GPS kinematic position, were conducted to verify the performance of the proposed method.