


复旦大学数学科学学院
数学综合报告会

报告题目：Combining Stochastic Parameterized Reduced-Order Models with Machine Learning for Data Assimilation and Uncertainty Quantification with Partial Observations

报告人：Prof. Nan Chen (University of Wisconsin-Madison

时间：2022-11-30 星期三 9:30-10:30

地点：ZOOM： https://uwmadison.zoom.us/j/2960984741

报告摘要：

A hybrid data assimilation algorithm is developed for complex dynamical systems with partial observations. The method starts with applying a spectral decomposition to the entire spatiotemporal fields, followed by creating a machine learning model that builds a nonlinear map between the coefficients of observed and unobserved state variables for each spectral mode. A cheap low-order nonlinear stochastic parameterized extended Kalman filter (SPEKF) model is employed as the forecast model in the ensemble Kalman filter to deal with each mode associated with the observed variables. The resulting ensemble members are then fed into the machine learning model to create an ensemble of the corresponding unobserved variables. In addition to the ensemble spread, the training residual in the machine learning-induced nonlinear map is further incorporated into the state estimation that advances the quantification of the posterior uncertainty. The hybrid data assimilation algorithm is applied to a precipitation quasi-geostrophic (PQG) model, which includes the effects of water vapor, clouds, and rainfall beyond the classical two-layer QG model. The complicated nonlinearities in the PQG equations prevent traditional methods from building simple and accurate reduced-order forecast models. In contrast, the SPEKF model is skillful in recovering the intermittently observed states, and the machine learning model effectively estimates the chaotic unobserved signals. Utilizing the calibrated SPEKF and machine learning models under the situation of a moderate cloud fraction, the resulting hybrid data assimilation remains reasonably accurate when applied to other geophysical scenarios with nearly clear skies or relatively heavy rainfall, implying the robustness of the algorithm.

非线性数学模型与方法教育部重点实验室
中法应用数学国际联合实验室
上海市现代应用数学重点实验室
复旦大学数学研究所