Nonstationary spatial covariance estimation using penalized likelihood

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Abstract

This thesis considers nonstationary spatial covariance estimation using empirical orthogonal functions (EOFs) under the consideration that data may be observed only at some sparse, irregularly spaced locations with repeated measurements. Instead of obtaining EOFs by principal component analysis based on a class of pre-specified basis functions or a pre-smoothing step with data imputed on a regular grid, two semiparametric approaches are advocated for EOF estimation, which are based on smoothing splines and regression splines using penalized likelihood. An expectation-conditional-maximization algorithm is proposed to obtain the penalized maximum likelihood estimates of the mean and the covariance parameters simultaneously. Some simulation results show that the proposed methods perform well in both spatial prediction and covariance function estimation, regardless of whether the underlying spatial process is stationary or nonstationary. In addition, the methods are applied to analyze a precipitation dataset in Colorado. Some further extension to spatio-temporal models is also provided.

Keywords: ECM algorithm, empirical orthogonal function, nonstationary spatial covariance model, penalized likelihood, penalized regression splines, smoothing splines, spatial prediction, spatio-temporal modeling