Bayesian inference for the spatial random effects model

Emily L. Kang
N. Cressie
The Ohio State University

Abstract

Spatial statistical analysis of massive amounts of spatial data can be challenging, because computation of optimal procedures can break down. The spatial random effects (SRE) model uses a fixed number of known but not necessarily orthogonal (multi-resolutional) spatial basis functions, which allows a flexible family of non-stationary covariance functions, results in dimension reduction, and yields optimal spatial predictors whose computations are scalable. By modeling spatial data in a hierarchical manner with a process model that includes the SRE model, one could either estimate the SRE model's parameters or take a Bayesian approach and put a prior distribution on them. In this article, we develop Bayesian inference for the SRE model when the spatial basis functions are multi-resolutional. Then the covariance matrix of the random effects decomposes naturally in terms of Givens angles and eigenvalues, for which a new class of prior distributions is chosen. Comparisons of this prior to other types of priors used in the random-effects literature are given for simulated data. Further, a large remote-sensing dataset of aerosol optical depth (AOD), from the Multi-angle Imaging SpectroRadiometer (MISR) instrument on the Terra satellite, is analyzed using the new prior in a fully Bayesian framework and compared to an empirical-Bayesian analysis.