Accounting for spatially varying directional effects in spatial covariance structures

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Wind direction plays an important role in the spread of pollutant levels over a geographical region. We discuss how to include wind directional information in the covariance function of spatial models. We follow the spatial convolution approach initially proposed by Higdon and co-authors, wherein a spatial process is described by a convolution between a smoothing kernel and a white noise process. We propose two different ways of accounting for wind direction in the kernel function. For comparison purposes, we also consider a more flexible kernel parametrization, that makes use of latent processes which vary smoothly across the region. Inference procedure follows the Bayesian paradigm, and uncertainty about parameter estimation is naturally accounted for when performing spatial interpolation. We analyze ozone levels observed at a monitoring network in the Northeast of the USA. Sam- ples from the posterior distribution under our proposed models are obtained much faster when compared to the kernel based on latent processes. Our models provide better results, in terms of model fitting and spatial interpolation, when compared to simple isotropic and geometrical anisotropic models. Despite the small number of parameters, our proposed models provide fits which are comparable to those obtained under the kernel based on latent processes.

Key Words: Gaussian processes; nonstationarity; process convolution; projection.