The University of Chicago
Department of Statistics
Ph.D. Seminar

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"Space-time models and their application to air pollution"

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ABSTRACT

New statistical procedures to evaluate the Models-3/Community Multiscale Air Quality (CMAQ) using observed data are introduced. Certain space-time correlations are used to assess dynamic aspects of CMAQ and to compare the space-time structure of CMAQ to that of observations. Our analyses show that, overall, CMAQ matches the space-time correlation structure of observed sulfate concentrations well. Analyses on the space-time correlation of the difference of observations and CMAQ output show that CMAQ partially captures time lagged spatial variation of sulfate concentrations. Separable covariance functions are shown to provide a poor description of the observations. This part of the thesis has been published at Jun, M., Stein, M. L. (2004), Statistical Comparison of Observed and CMAQ Modeled Daily Sulfate Levels., Atmospheric Environment, Volume 38, Issue 27, pp. 4427-4436.

For space-time processes on global or large scales, it is critical to use models that respect the Earth's spherical shape. The covariance functions of such processes should not only be positive definite on sphere$\times$time, but also be capable of capturing the dynamics of the processes well. We develop space-time covariance functions on sphere$\times$time that are flexible in producing space-time interactions, especially space-time asymmetries. Our idea is to consider a sum of independent processes, where each process is obtained by applying a first-order differential operator to a fully symmetric process on sphere$\times$time. The resulting covariance functions can produce various types of space-time interactions and give different covariance structures along different latitudes. Our approach yields explicit expressions for the covariance functions, which has great advantages in computation. Moreover, it applies equally well to generating asymmetric space-time covariance functions on flat or other spatial domains. We study various characteristics of our new covariance functions, focusing on their space-time interactions.

We model global total column ozone levels using our new class of space-time covariance functions for spherical domain. The fitted results through restricted maximum likelihood estimation method are given along with various diagnostic results of the fit. The results of the best linear unbiased prediction at new sites are given and asymptotic distribution of the parameter estimates are presented.