PhD Dissertation Final Oral Defense

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Modern Space/Time Geostatistical Approaches to Mapping Point Sources of Pollution and Infectious Disease

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Point sources are defined in the context of environmental science as single identifiable locations that emit pollution into the environment. From a modeling perspective, they are "ground zero" - where a contaminant originates or is at a distance of 0 from the source - and they are desirable from the standpoint of mitigation strategies because the pollutant being produced must only be brought under control at the location of release. A set of studies were conducted to investigate whether modern geostatistical techniques, such as Bayesian Maximum Entropy which has the ability to incorporate non-Gaussian space/time data, can improve the estimates of a variable produced by point sources over that of the traditional kriging method. In Study 1, a single point source at the most famous Ground Zero is the focus in order to estimate atmospheric polycyclic aromatic hydrocarbons (PAHs) produced during the collapse and cleanup of the World Trade Center in New York City by modeling the mass fraction of PAH contained in $PM_{2.5}$. This PAH to $PM_{2.5}$ model is then applied to existing $PM_{2.5}$ monitors in the area to expand the number of estimated PAH measurements. Study 2 examines a situation where many point sources across space contribute to pollution in modeling hydrogen sulfide (H_2S) concentrations produced by industrial hog operations in an eastern North Carolina county with a high density of these facilities. Passive samplers that recorded H_2S were used to create a land use regression model to estimate individual source contribution to the community and then to produce geostatistical estimates after applying a non-Gaussian measurement error model to the data. Finally, Study 3 researches an unorthodox "point source" by attempting to identify core areas – locations with elevated rates that perpetuate an infection – of syphilis and gonorrhea in North Carolina. To locate these "sources," which have the ability to move in space and time, a Bayesian-derived non-Gaussian model for the error is used to improve estimation of incidence rates on a fine space/time scale. These estimates are then utilized in an outbreak detection algorithm so that a source of infection can be controlled before it increases and/or moves.

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