Uses of Spatial Modelling in Environmental/Public Health

- Cluster detection/investigation
  - surveillance: space-time detection increases power relative to time detection (bioterrorism, water/food contamination)
  - hotspot discovery: hypothesizing possible environmental risk factors
  - hotspot assessment
- disease/risk mapping - hypothesis generation
  - continuous in space: geostatistics/Gaussian process models/kriging/nonparametric regression
  - discrete spatial regions: Markov random field models
- spatial prediction of covariates for nonspatial modelling
- spatial methods as general methods for nonparametric regression in 2-D

Challenges in Model Development

- models for data with disparate spatial scales
  - ❖ e.g., individual, census block, zip code, county
  - ❖ Bayesian hierarchical models with an unknown/random spatial risk function (e.g., Wolpert et al.)
- models for nonstationary surfaces (e.g. boundaries)
- sensitive and specific models for cluster detection/surveillance (e.g., Pagano et al.)
- models for observations with multiple/blurred locations
- incorporating measurement error (uncertain locations/risk factors) into spatial models
- combining deterministic (e.g., differential eqn.) and stochastic models to estimate environmental risk surfaces (O'Hagan, Fuentes)
- spatial models for matched case-control data

Challenges in Estimation, Model Assessment, Presentation

- fitting methods for continuous spatial surfaces (also, nonstationarity)
  - ❖ Bayesian hierarchical models easy to construct, hard to fit
- fast algorithms, user-friendly software for use by non-experts
- model selection and testing (e.g., Zhao & Wand)
- graphical issues
  - ❖ heterogeneous population density can obscure reality
  - ❖ standardized and rigorous mapping conventions (e.g., color schemes, uncertainty)
  - ❖ interfacing between statistical and GIS software