CONSTRUCTION AND VALIDATION OF A GEOSTATISTICAL MODEL OF PCDD AND PCDF DEPOSITION FROM INCINERATION

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AIMS

1. Present a geostatistical simulation-based methodology to:
   - combine the detailed process-based modeling of atmospheric deposition from an incinerator with the probabilistic modeling of residual field variability,
   - estimate soil TEQ_{DF}-WHO_{98} (Toxic Equivalents) at the geography level that is the most relevant for decision making (i.e. census block)
2. Apply and validate the methodology to the incinerator in Midland, Michigan.

MATERIAL AND METHODS

- Data available (Figure 1):
  1. 53 soil TEQ concentrations measured during sampling campaigns in 1980-1990s
  2. total deposition flux values (both dry and wet) predicted at the nodes of a 261×261 receptor grid (spacing = 50 m) using EPA Industrial Source Complex (ISC3) dispersion model
- Methodology:
  1. Normal score transform of 53 TEQ data
  2. Regression of 53 normal scores versus wet and dry deposition ⇒ TEQ spatial trend estimate over receptor grid
  3. Computation and modeling of variogram of regression residuals
  4. Sequential Gaussian simulation using trend model (step 2) in kriging ⇒ 100 realizations of TEQ value maps (Figure 2)
  5. Average point simulated values within each census block ⇒ distribution of 100 simulated block values ⇒ Model of uncertainty at census block level (Figure 3)
- Validation:
  1. Collection of 51 new samples in census blocks with largest expected dioxin level and population at risk
  2. Comparison of new observations with simulated distributions ⇒ assess accuracy and precision of model of uncertainty

RESULTS: Model creation

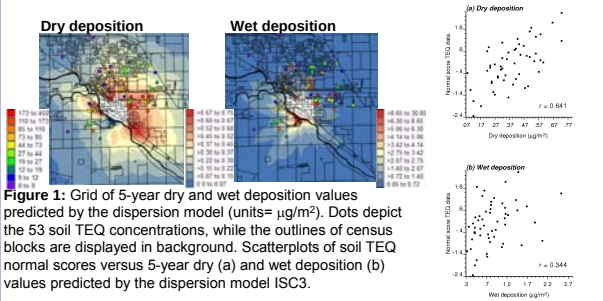

Figure 1: Grid of 5-year dry and wet deposition values predicted by the dispersion model (units= μg/m²). Dots depict the 53 soil TEQ concentrations, while the outlines of census blocks are displayed in background. Scatterplots of soil TEQ normal scores versus 5-year dry (a) and wet deposition (b) values predicted by the dispersion model ISC3.

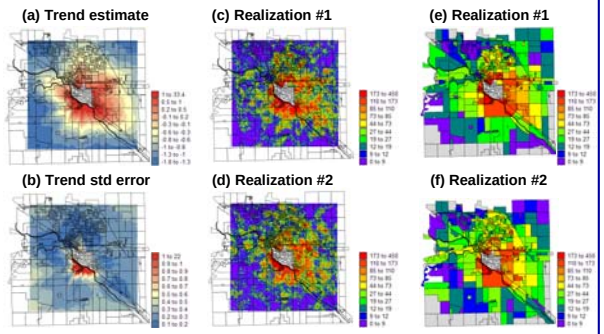

Figure 2: TEQ normal score estimate (a) and associated standard error (b) computed at the nodes of the simulation grid using linear regression. Two realizations of the spatial distribution of TEQ values (c,d) generated by sequential Gaussian simulation, and the results of the averaging to the census block level (e,f). The central hatched area denotes the plant property.

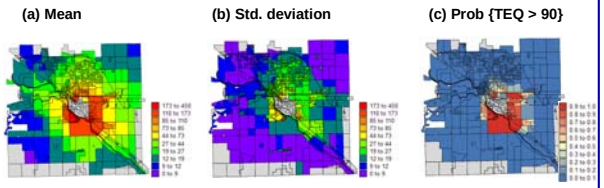

Figure 3: Summary statistics for the distribution of 100 TEQ values simulated at the level of census blocks: mean (a), standard deviation (b) and probability that the TEQ concentration exceeds 90 ng/g (c). Hatched polygons denote census blocks outside the simulation area.

RESULTS: Model validation

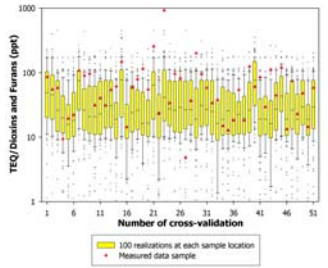

Figure 4: Box plots of the distributions of 100 simulated TEQ values corresponding to the grid nodes the closest to the location of the 51 UMDES samples (values denoted by ▲).

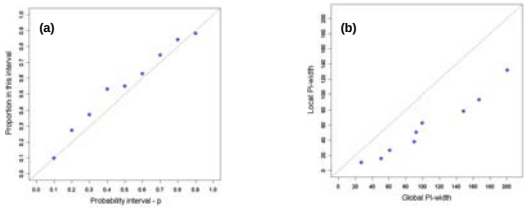

Figure 5: Plot of the proportion of observed TEQ values falling into probability intervals (PI) of increasing size (accuracy plot, a). The width of these local PIs is plotted against the width of the global PIs that are derived from the sample histogram (b).

CONCLUSIONS

Benefits of stochastic simulation over interpolation:

1. maps of simulated point TEQ values can easily be aggregated to the geography that is the most relevant for decision making (i.e. census block)
2. uncertainty at the larger scale is simply modeled by the empirical distribution of aggregated simulated values

Geostatistical model:

1. provides a a realistic assessment of the range of possible TEQ values that could be observed at unsampled locations
2. is more precise than the aspatial approach whereby the uncertainty model is based on the global histogram of the data

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