

Statistical Analysis of Surface Water Data

Building and Analyzing River Network



Outline

- 1 Motivation
- 2 River Network
- 3 Contour Visualization
- 4 Non-parametric Model
 - Application over Sulphate local-Network
- 5 Discussion

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Surface Water Data

- It includes *irregularly* spaced time series of Barium and Sulphate concentrations at approx. 80 PA counties from 1921-2015
- Deciphering spatial and temporal correlations may provide important insights about water quality deterioration due to energy extraction processes
- **Challenges:** spatial and temporal “sparsity”
 - Our current work:
 - Building weighted river tributary network
 - Contour visualization
 - Non-parametric model

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River Network

- Geological river tributary system from USGS.
- Directed network: corresponds to river flow
- Challenge: Large scale network; ~124K nodes
 - Localization to consider small regions

Building River Network

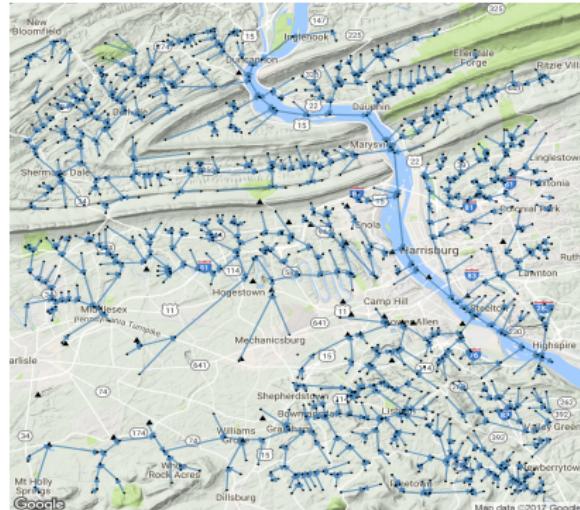


Figure: River local-Network example

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Concentration Contour Visualization

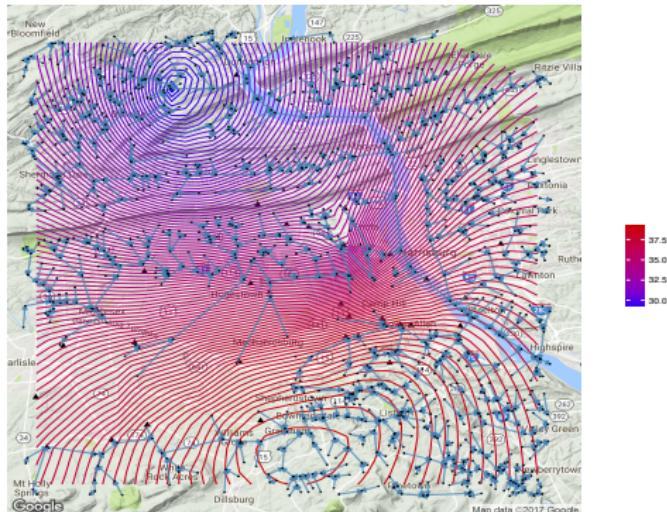


Figure: Contour plot for Concentration

Coal Density Contour Visualization

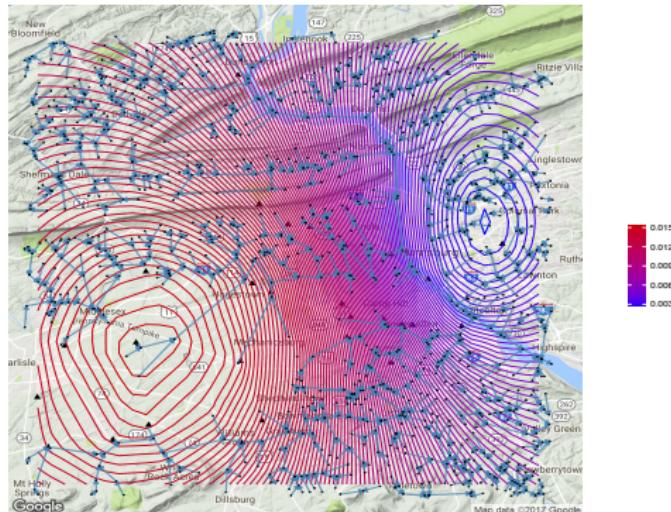


Figure: Contour plot for Coal Density

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Non-parametric Model

- **Why non-parametric?** Linear Model is insufficient to capture relationships between concentrations and Coal & Well densities.
- Model:
 - Concentration = $\beta_0 + \beta_1 \times \mathcal{I}(\text{degree from} > 1) + \mathcal{F}_1(\text{Coal Density}) + \mathcal{F}_2(\text{Well Density}) + \epsilon$
 - \mathcal{I} denotes the indicator function
 - \mathcal{F}_1 and \mathcal{F}_2 are non-parametric smoothers
 - β_0 and β_1 are intercept and slope respectively
 - ϵ denotes the error distributed normally ($\epsilon \sim \mathcal{N}(0, \sigma^2)$)

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Model Comparison

- Comparing with linear model

Residual Df	Residual Deviance	df	Deviance	F-value	p-value
1152.0	9152.9				
1145.7	7955.4	6.3	1197.5	27.403	$< 2.2 \times 10^{-16*}$

Table: Analysis of deviance to compare with linear model

- Non-parametric model is a better choice!

Estimated non-parametric smoothers

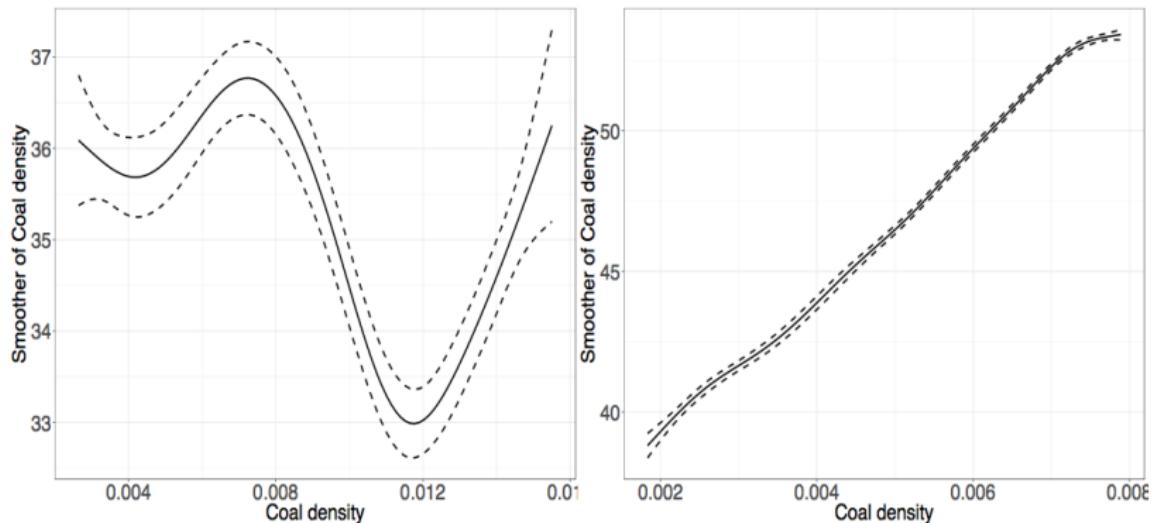


Figure: Estimated non-parametric smoothers of **Coal Density** for two regions

Interpretation of estimated smoothers

- Concentration monotonically increases with coal density in the range 0.0045 to 0.0075 for both regions. Similar patterns can be observed for many other regions.
- For densities greater than 0.012, concentration increases with coal density following similar rate as before.
- There is a dip in the range 0.0075 to 0.0012 suggesting some abnormal and perhaps interesting phenomenon.

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Discussion

Summary of current works:

- River Network and Non-parametric model
- Interactive [Shiny app](#) to explore many local regions