

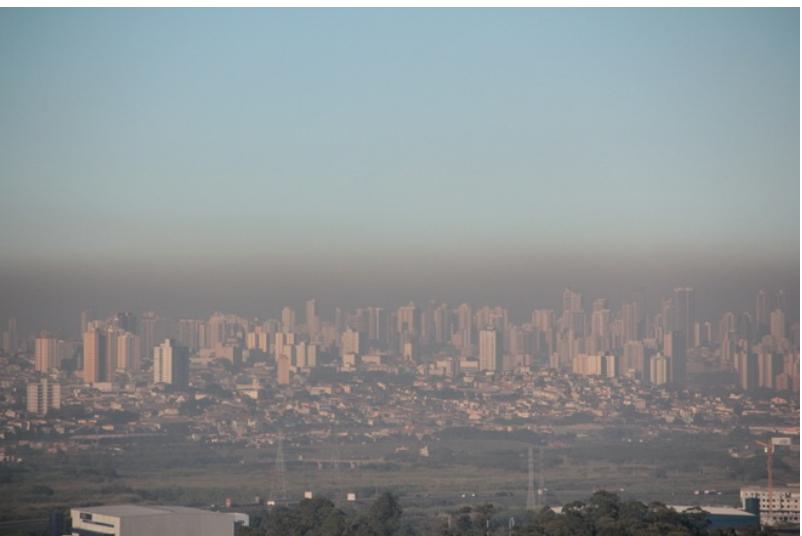


SPATIAL STATISTICS IN R

# Geostatistical data

Barry Rowlingson  
Geostatistician

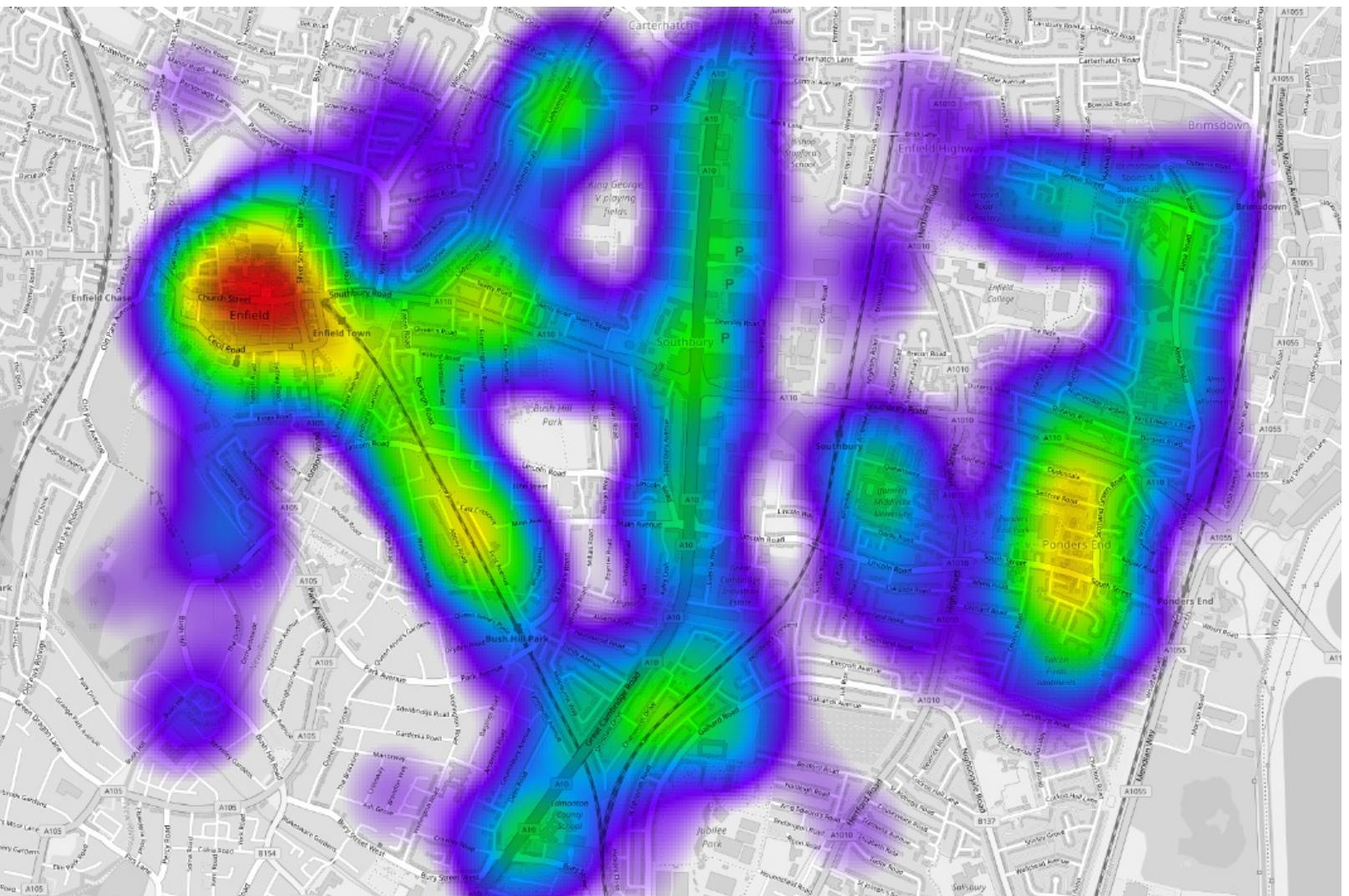
# Data



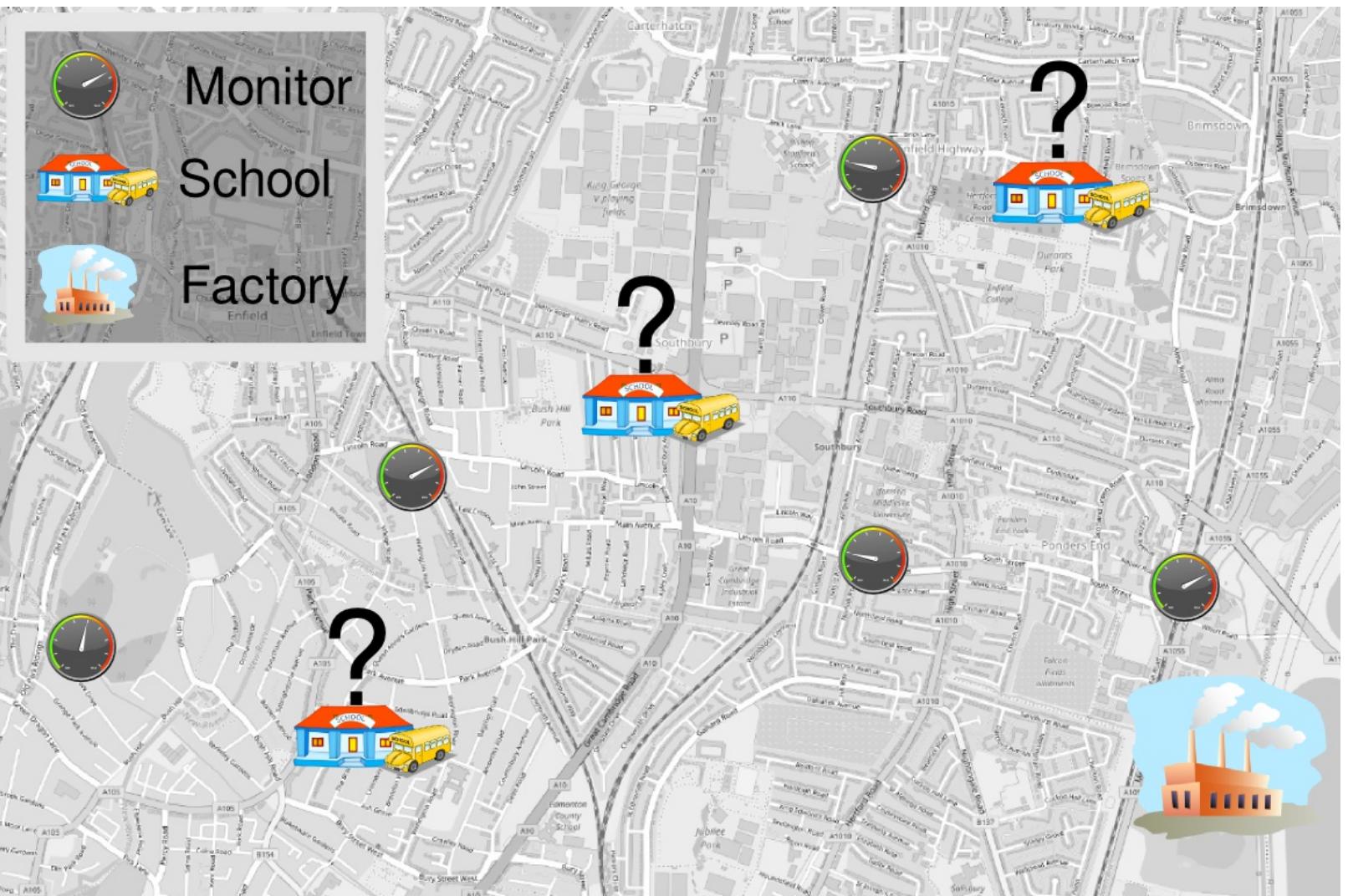
# Total



# Map



# Point Predictions



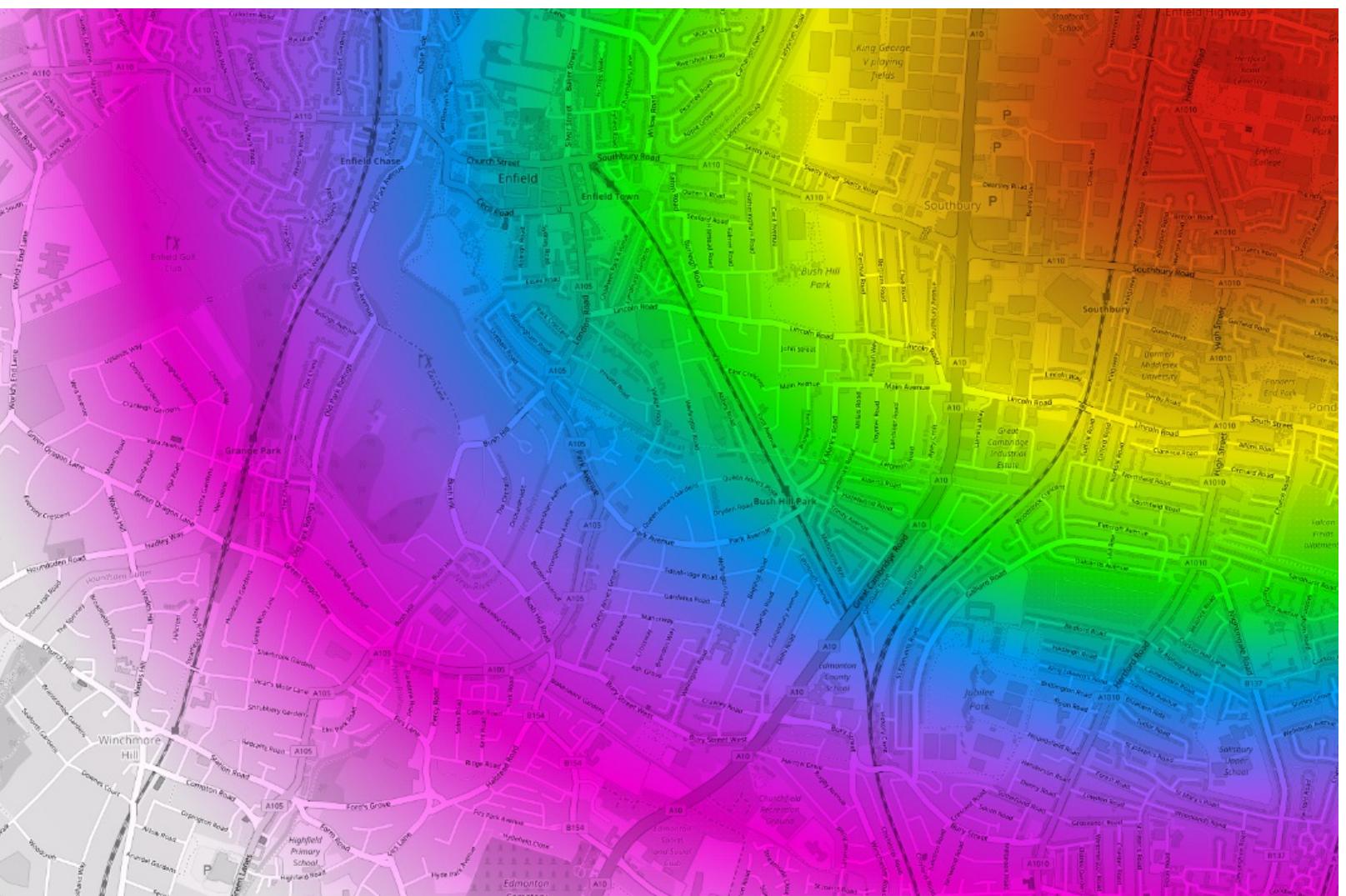
# Sampling Pattern



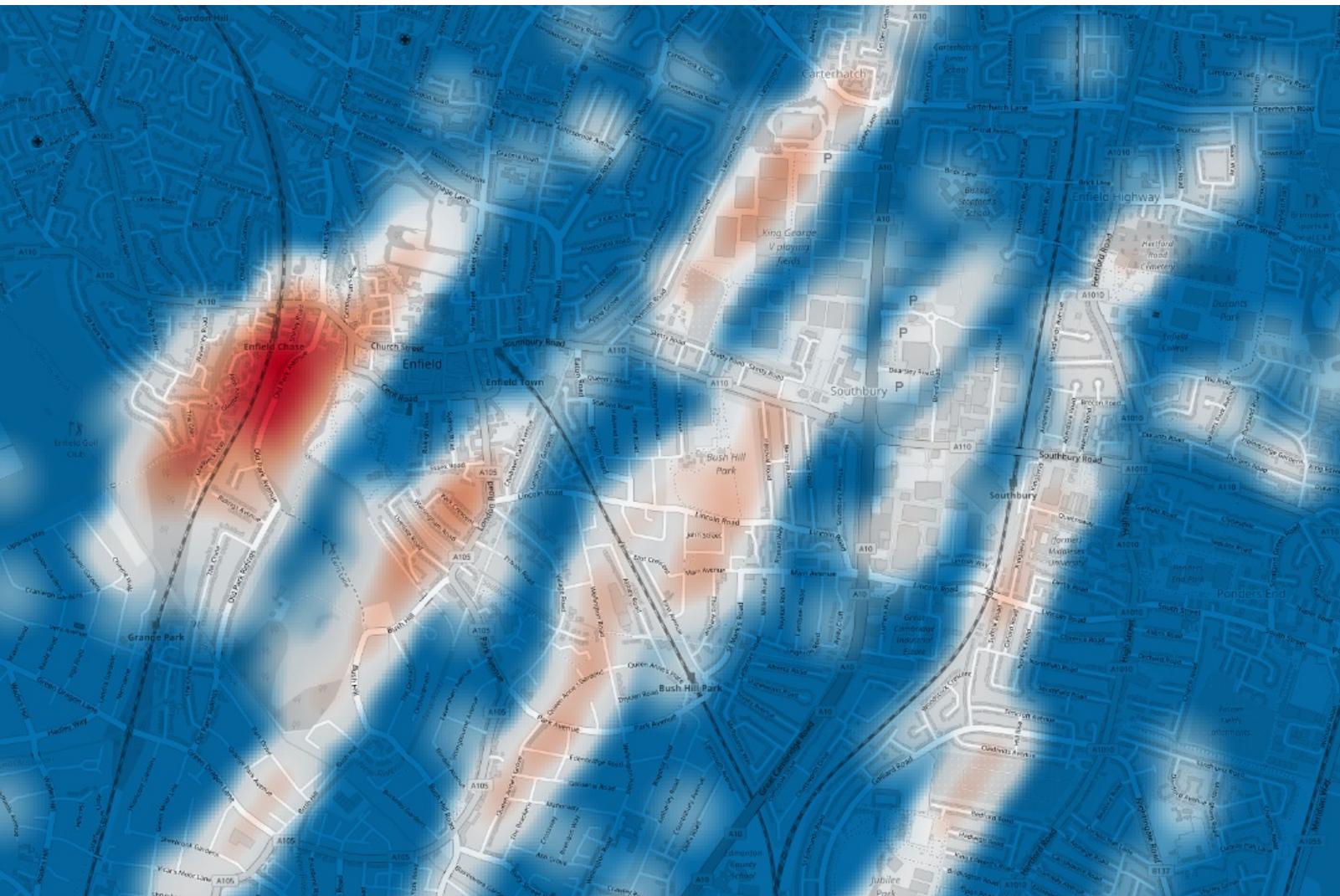
# Response

- Continuous?
- Fraction/Percentage?
- Count?
- Binary?
- Categorical?

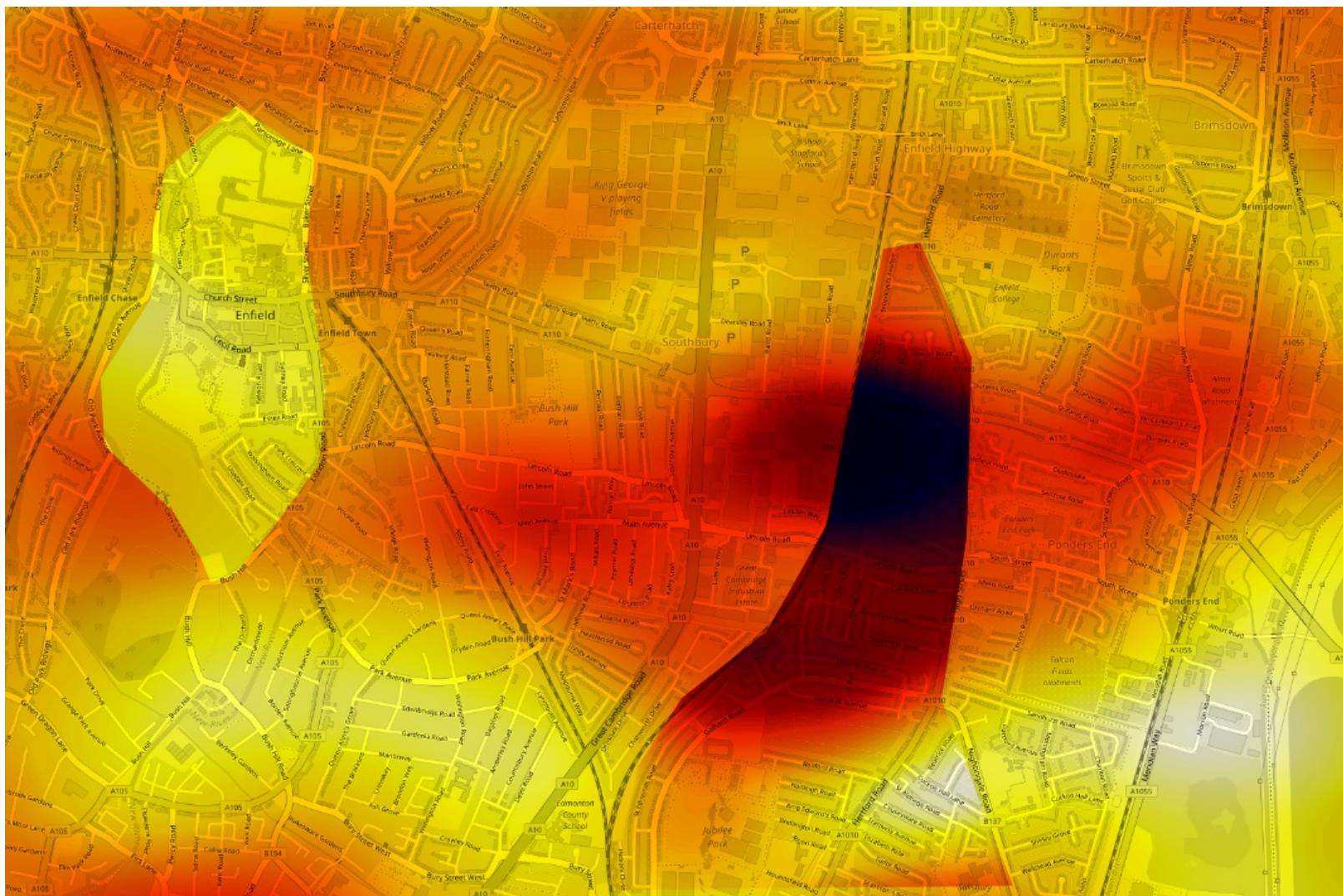
# Large-scale Trend



# Anisotropy - Directionality



# Discontinuities





SPATIAL STATISTICS IN R

**Let's practice!**



SPATIAL STATISTICS IN R

# The variogram

Barry Rowlingson  
Variographer

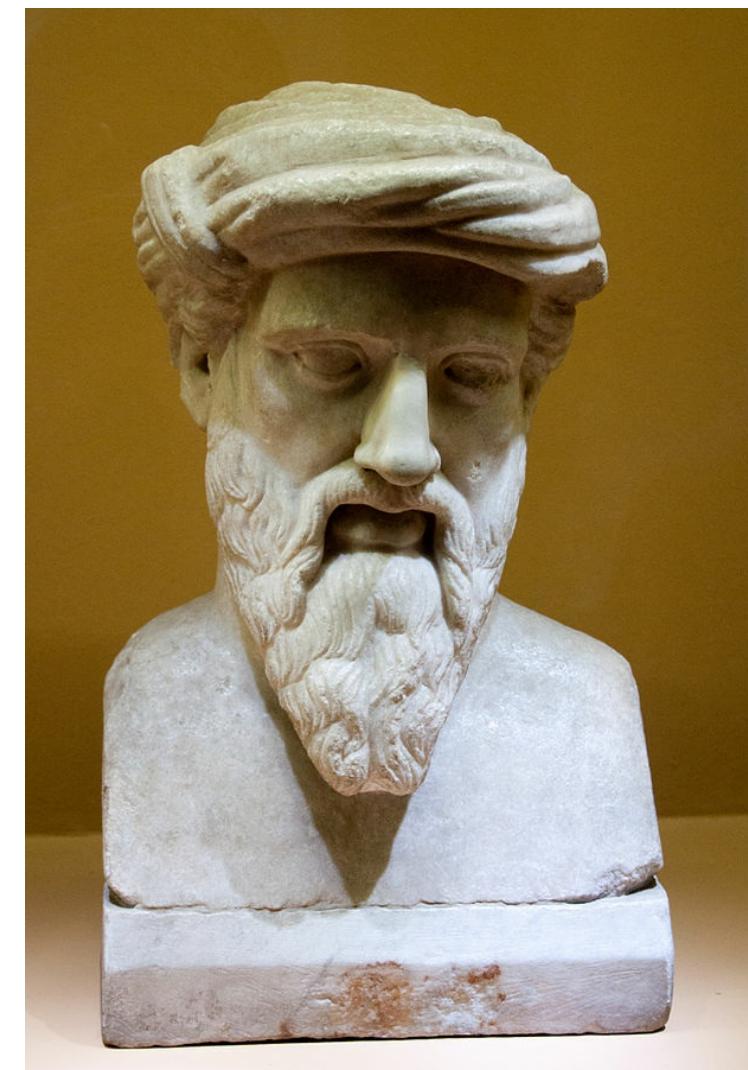
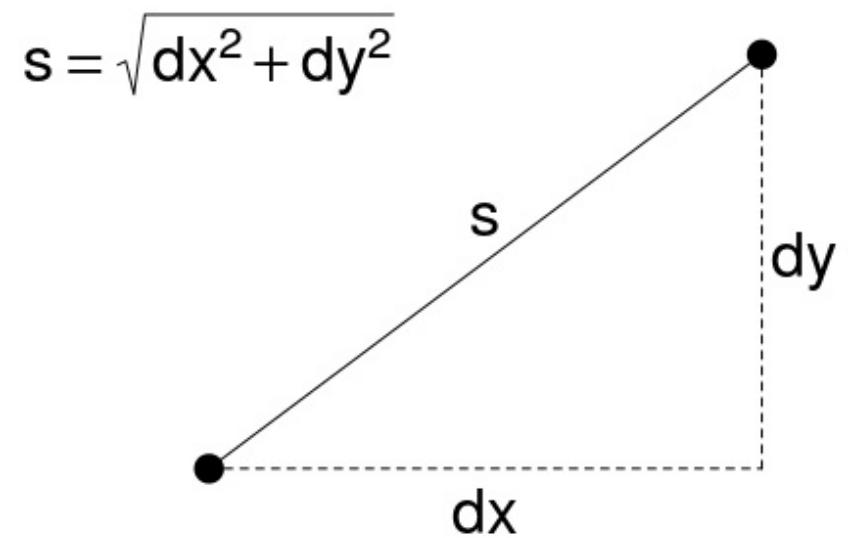
# Tobler



**"Everything is related to everything else, but near things are more related than distant things."**

Photo:  
User:Alvesgaspar/Wikimedia  
Commons/CC-BY-SA-3.0

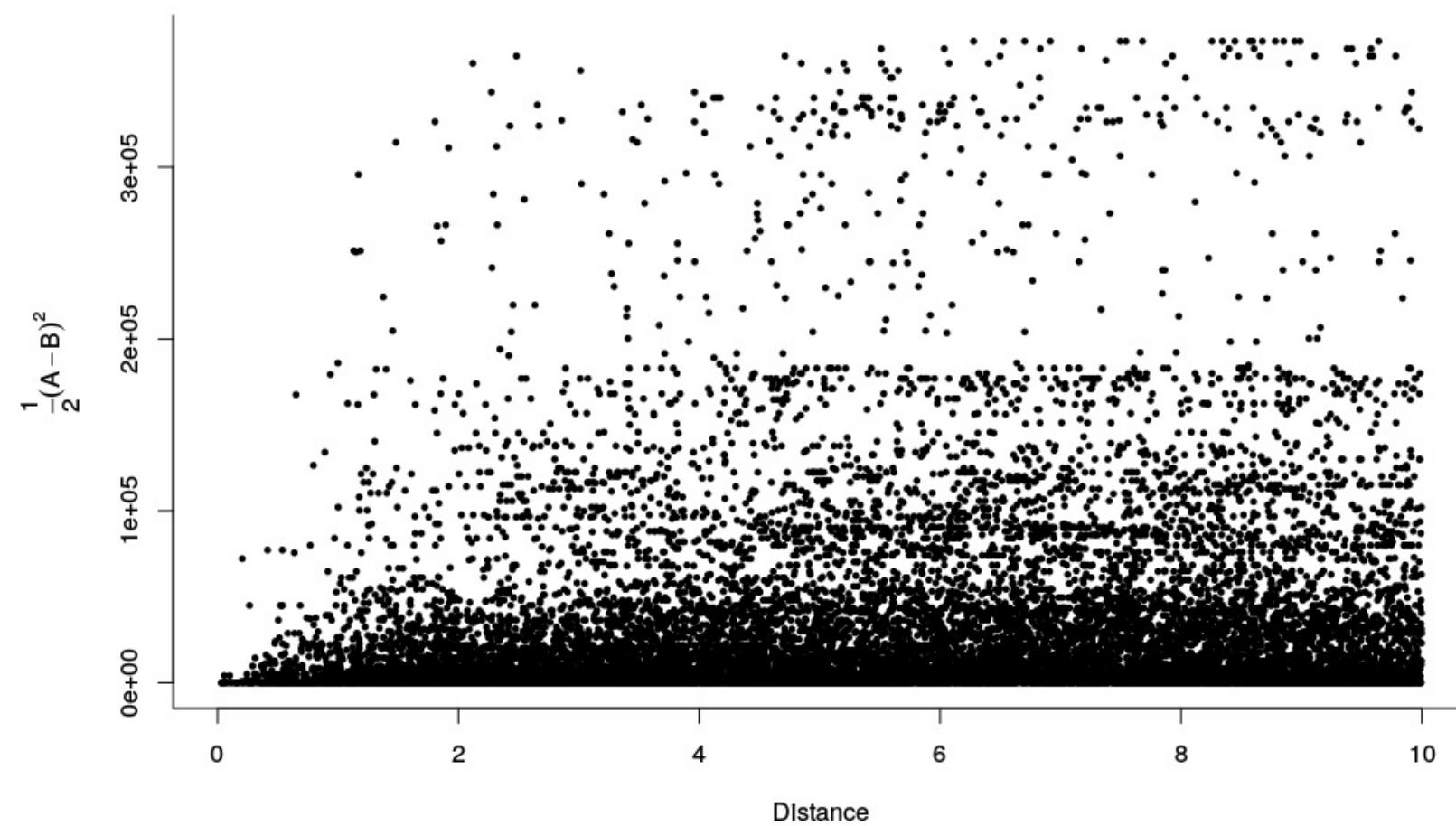
# Pythagoras



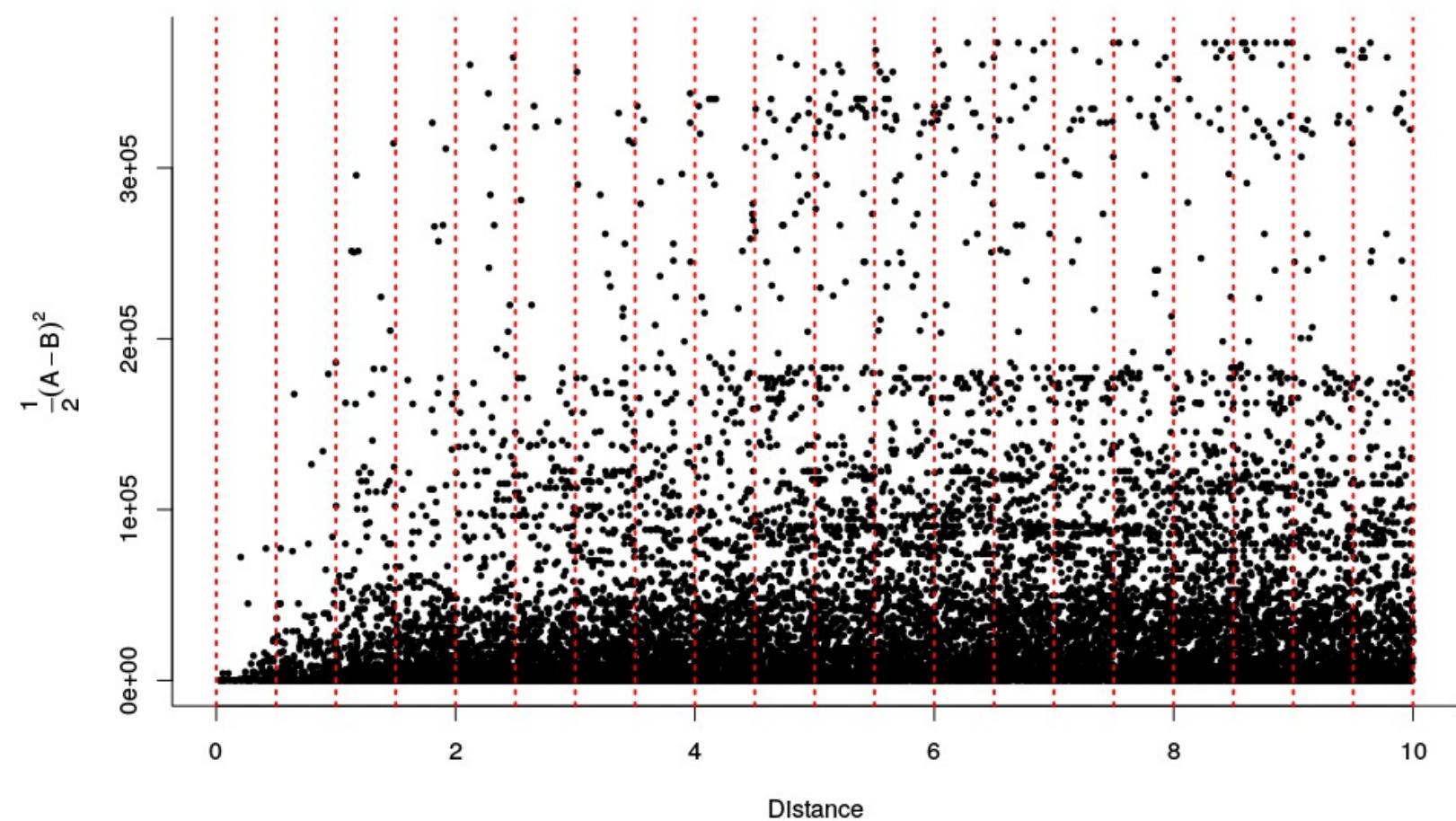
# Difference

$$\Delta = (A - B)^2$$

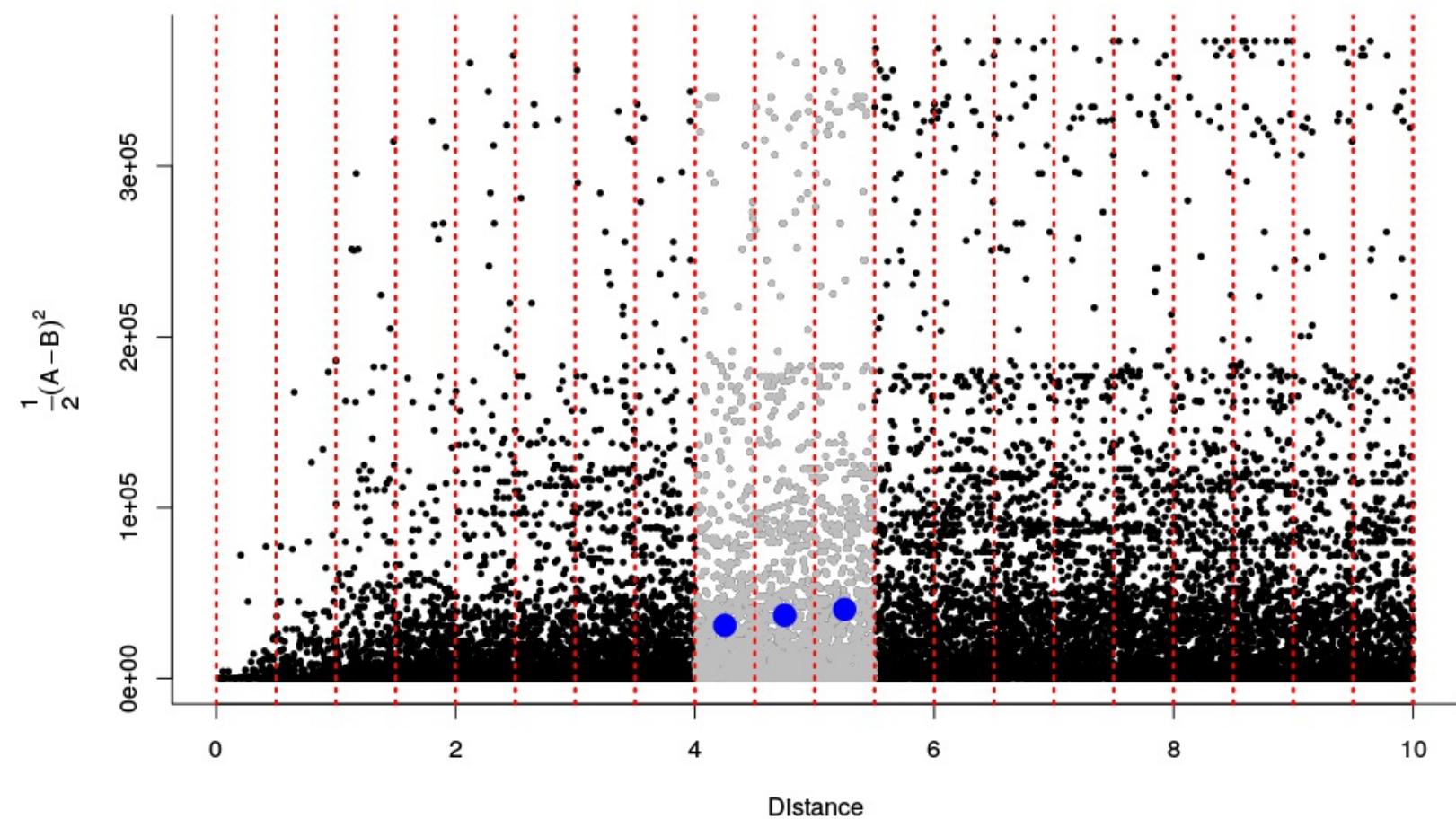
# Variogram Cloud



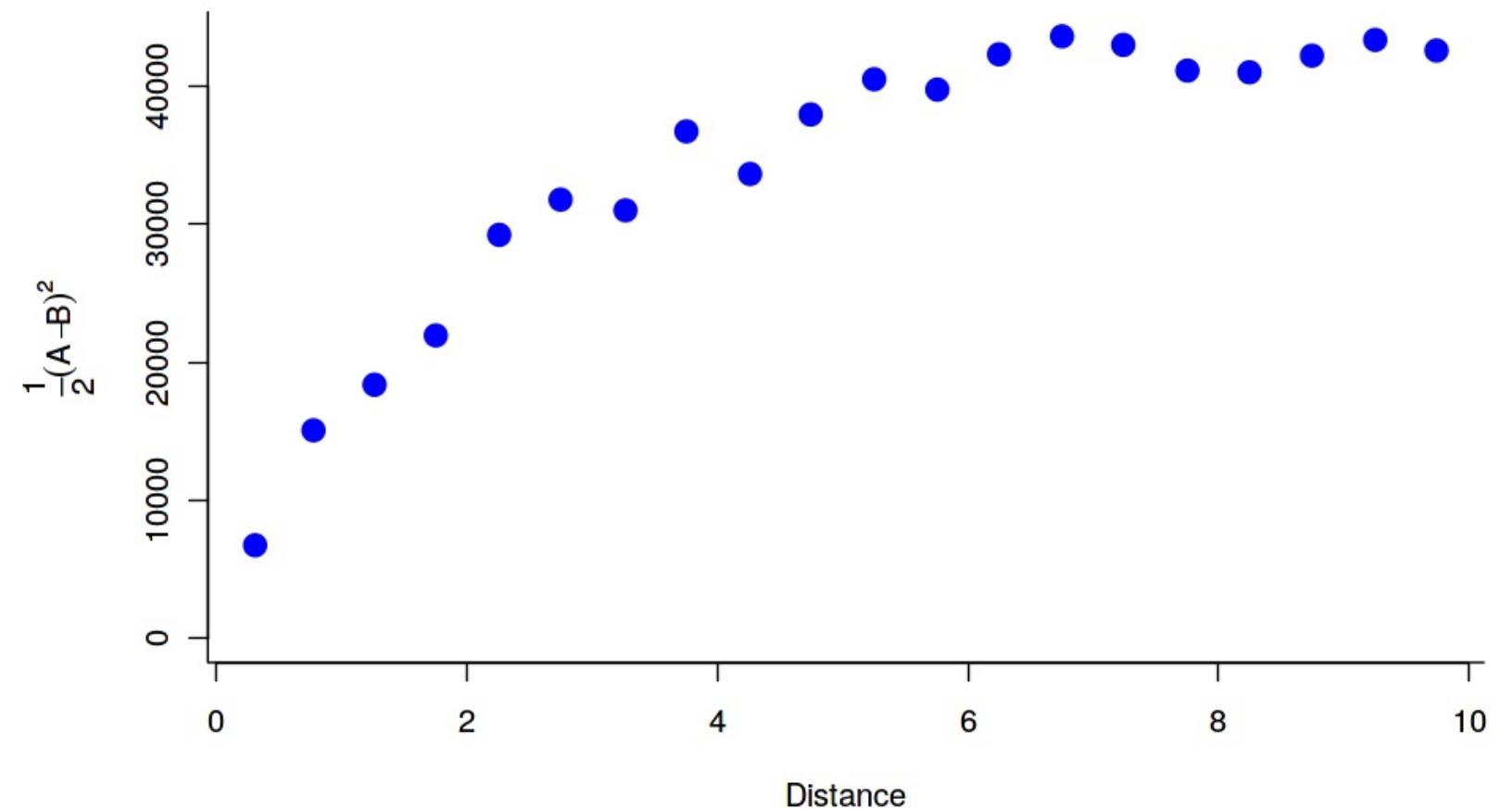
# Construct Bins



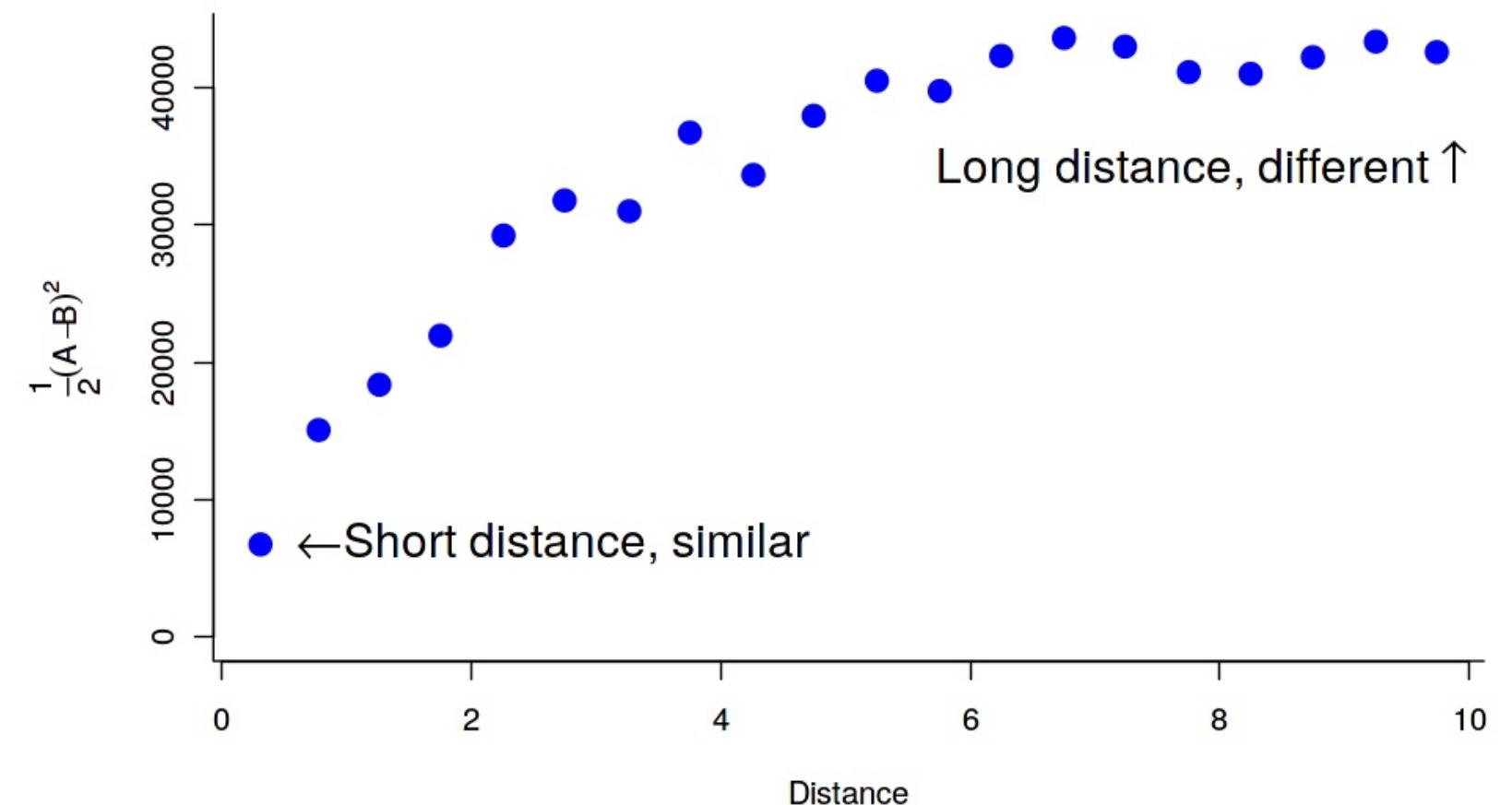
# Average In Bins



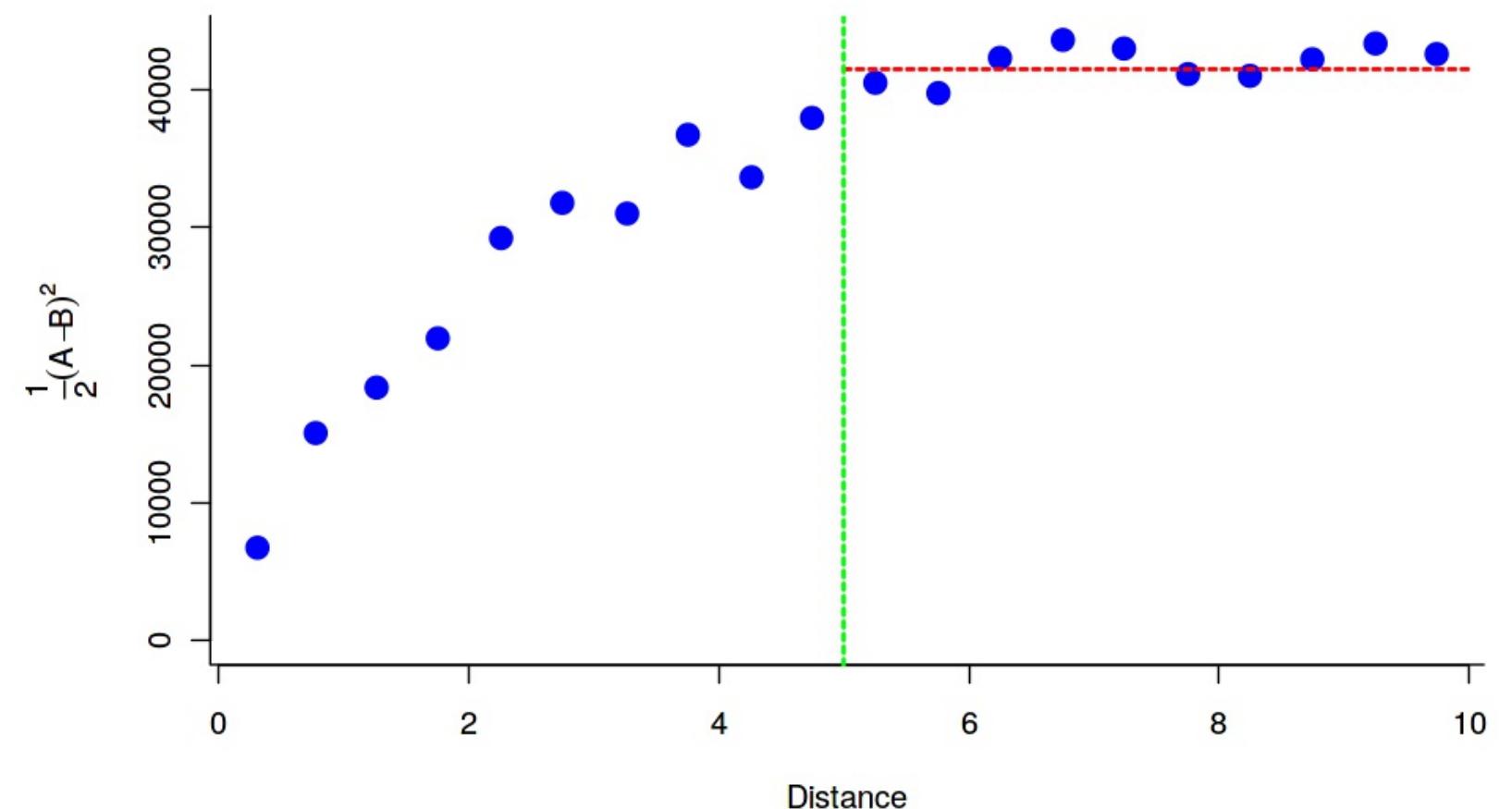
# Variogram



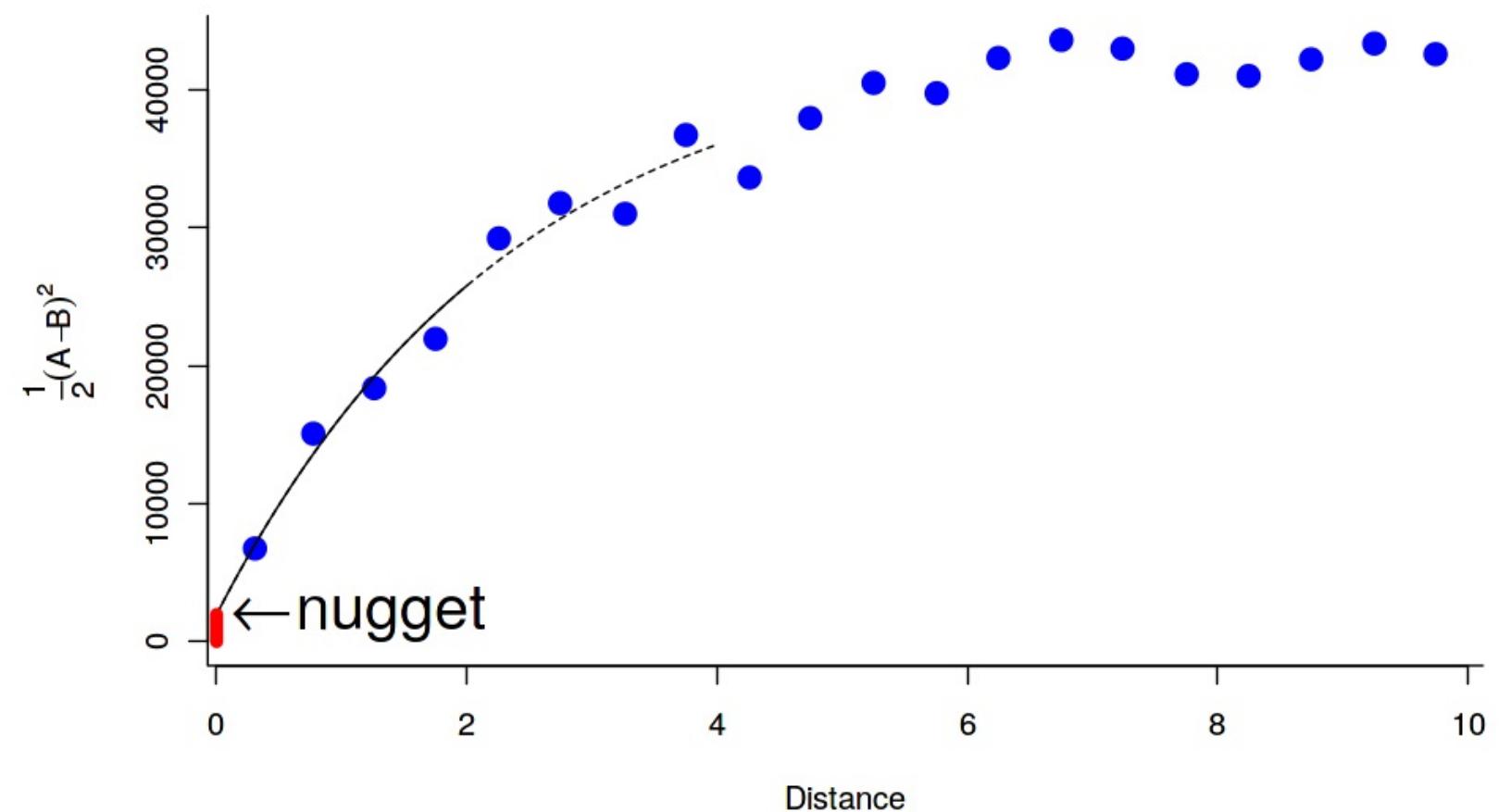
# Variogram



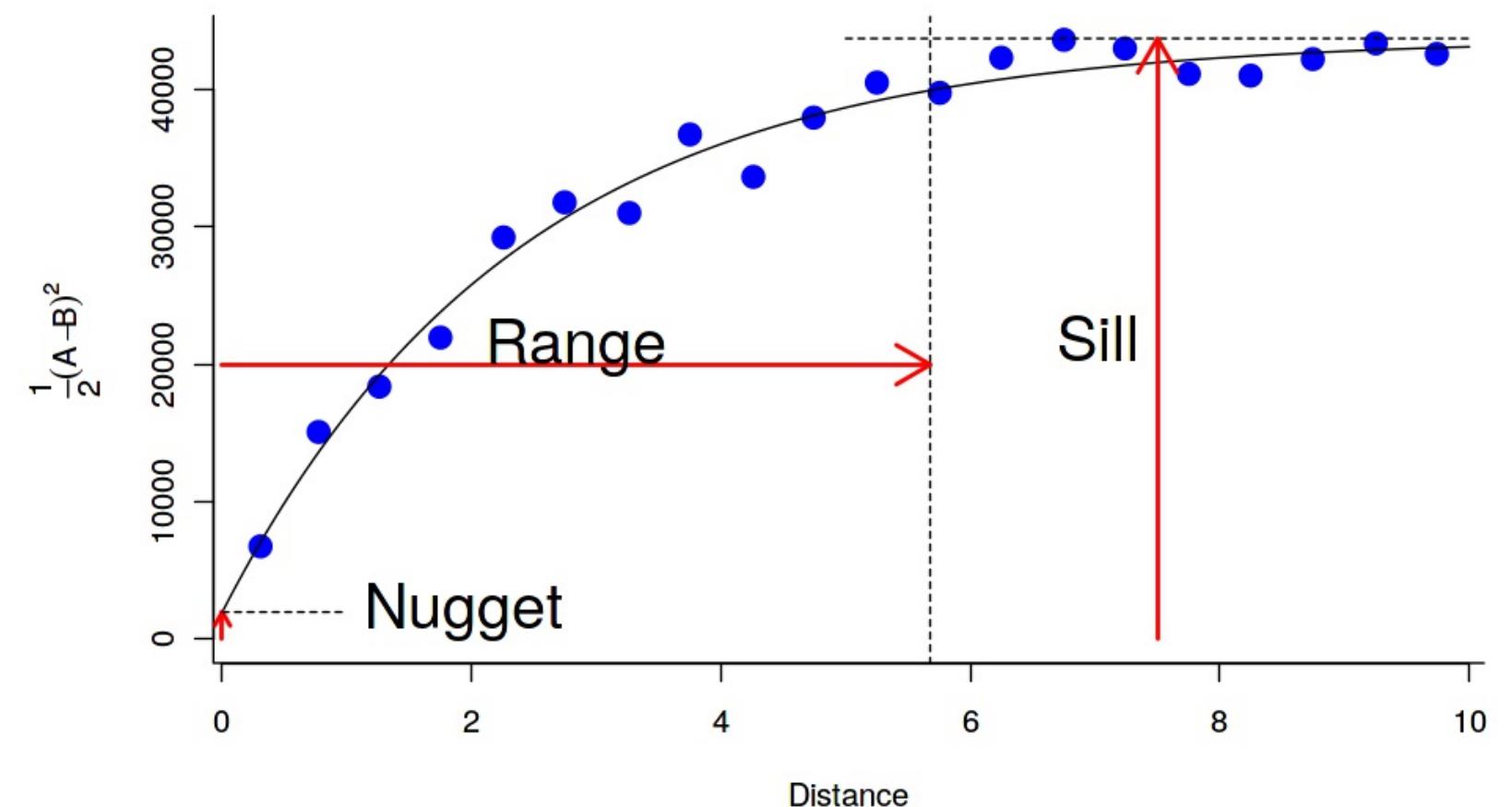
# Variogram



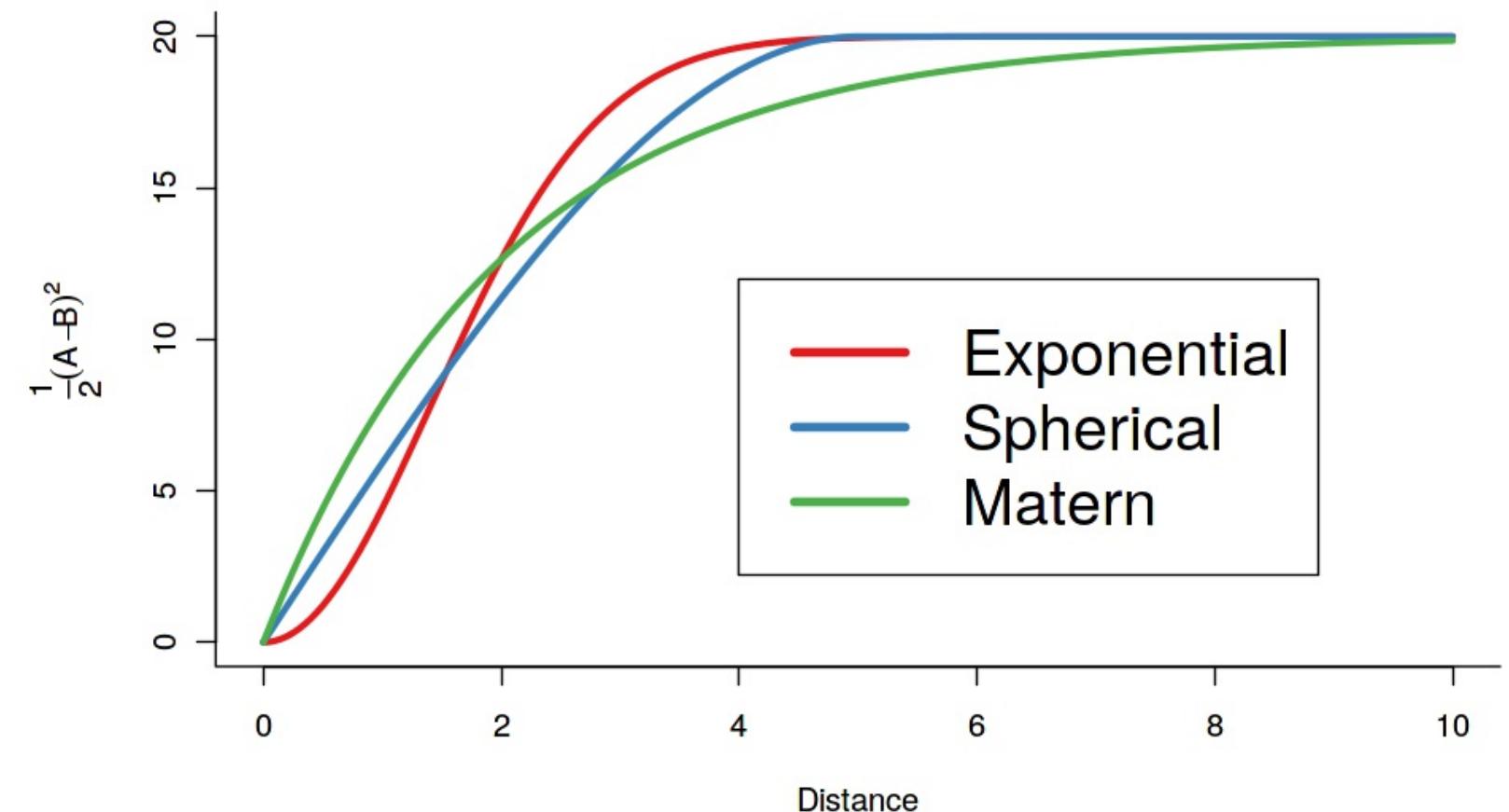
# Variogram



# Variogram



# Variogram Functions



# Matern

$$C(d) = \sigma^2 \frac{2^{1-\nu}}{\Gamma(\nu)} \left( \sqrt{2\nu} \frac{d}{\rho} \right)^\nu K_\nu \left( \sqrt{2\nu} \frac{d}{\rho} \right)$$



SPATIAL STATISTICS IN R

**Let's practice!**

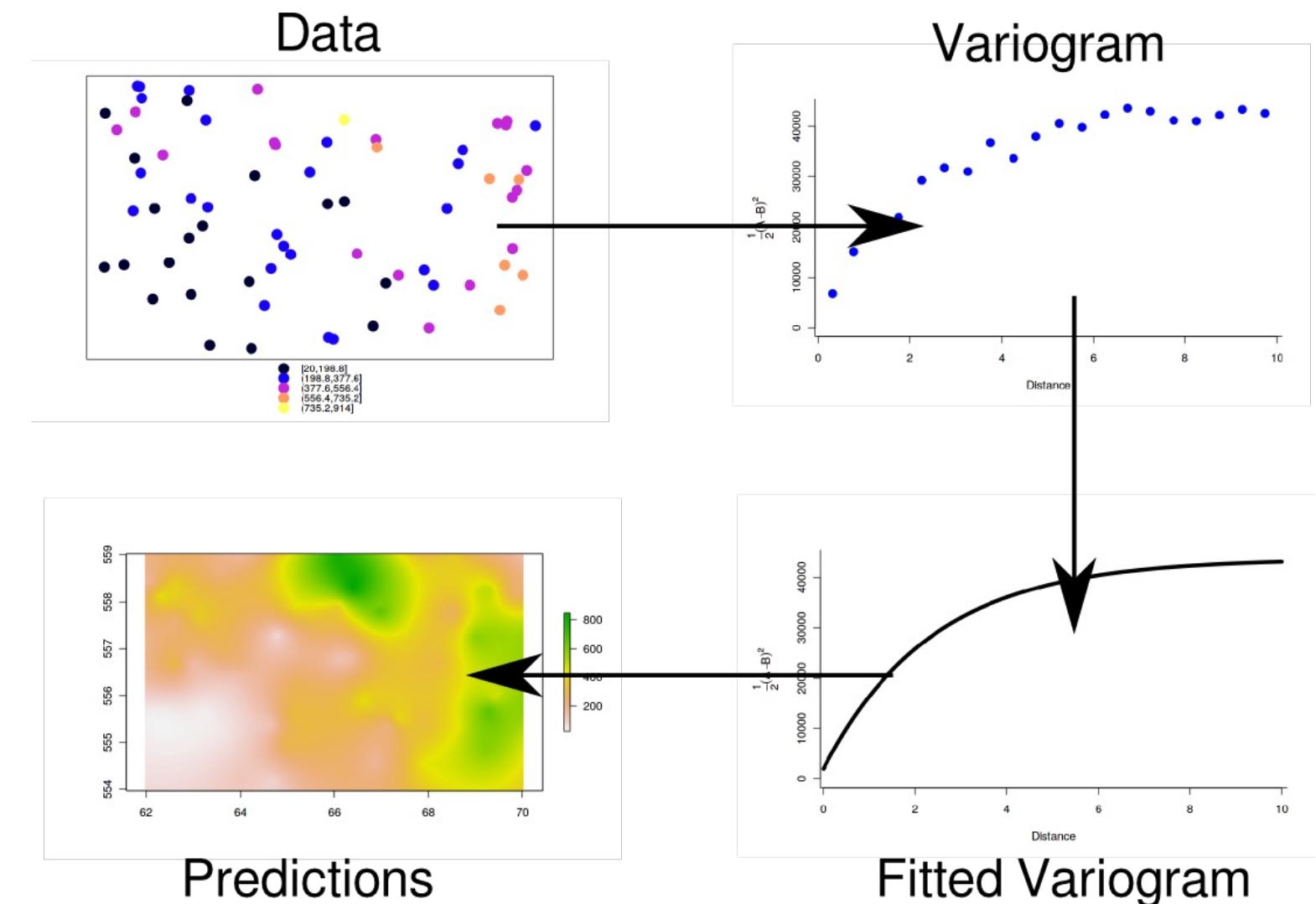


SPATIAL STATISTICS IN R

# Kriging predictions

Barry Rowlingson  
Kriger

# Kriging



# Flavours

The diagram illustrates the relationships between different types of kriging methods. At the top, "indicator kriging" is written in purple. Below it, "co-kriging" is written in pink. To the right, "universal kriging" is written in red. In the center, "ordinary kriging" is written in red. Below "ordinary kriging", "block kriging" is written in black. At the bottom, "simple kriging" is written in blue. The words are arranged in a circular pattern, suggesting a relationship or flow between them.

# Kriging Equations

$$\hat{Z}(x_0) = \begin{pmatrix} z_1 \\ \vdots \\ z_n \end{pmatrix}' \begin{pmatrix} c(x_1, x_1) & \cdots & c(x_1, x_n) \\ \vdots & \ddots & \vdots \\ c(x_n, x_1) & \cdots & c(x_n, x_n) \end{pmatrix}^{-1} \begin{pmatrix} c(x_1, x_0) \\ \vdots \\ c(x_n, x_0) \end{pmatrix}$$

$$\text{Var}(\hat{Z}(x_0) - Z(x_0)) = c(x_0, x_0) - \begin{pmatrix} c(x_1, x_0) \\ \vdots \\ c(x_n, x_0) \end{pmatrix}' \begin{pmatrix} c(x_1, x_1) & \cdots & c(x_1, x_n) \\ \vdots & \ddots & \vdots \\ c(x_n, x_1) & \cdots & c(x_n, x_n) \end{pmatrix}^{-1} \begin{pmatrix} c(x_1, x_0) \\ \vdots \\ c(x_n, x_0) \end{pmatrix}$$

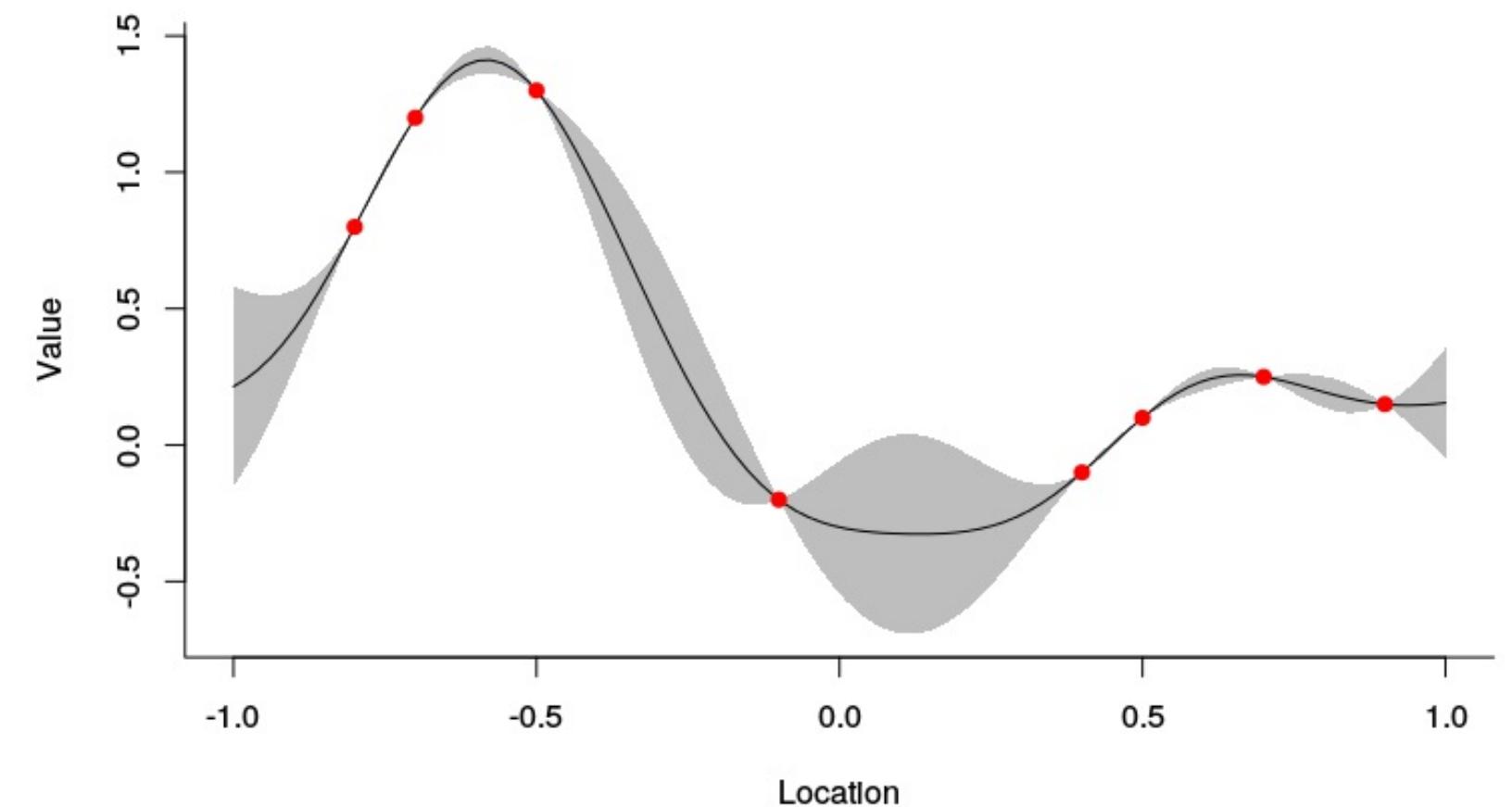
# Outputs

X	Y	Prediction	Variance
66.40	558.30	<b>849.49</b>	<b>3941.76</b>
66.40	558.35	<b>844.15</b>	<b>5159.70</b>
66.35	558.30	<b>829.24</b>	<b>4687.44</b>
66.35	558.35	<b>834.29</b>	<b>5423.28</b>
66.45	558.35	<b>834.01</b>	<b>5856.16</b>
66.45	558.30	<b>828.36</b>	<b>5294.68</b>
66.40	558.40	<b>835.68</b>	<b>6413.80</b>
...	...	...	...

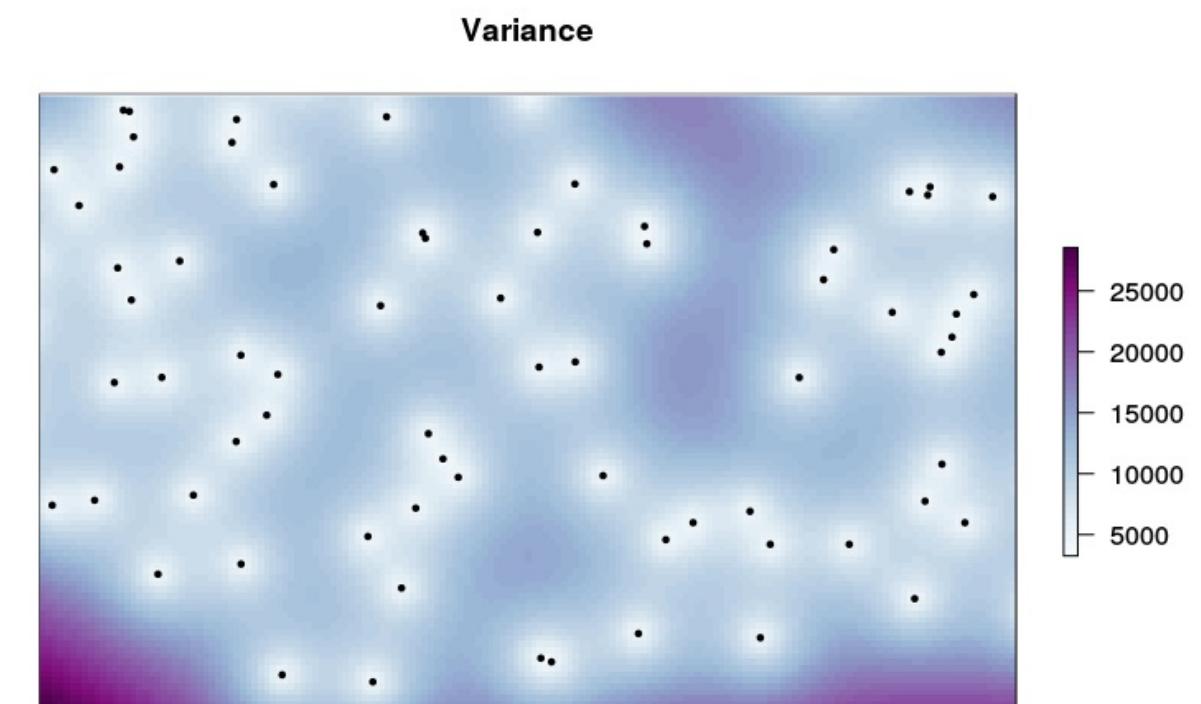
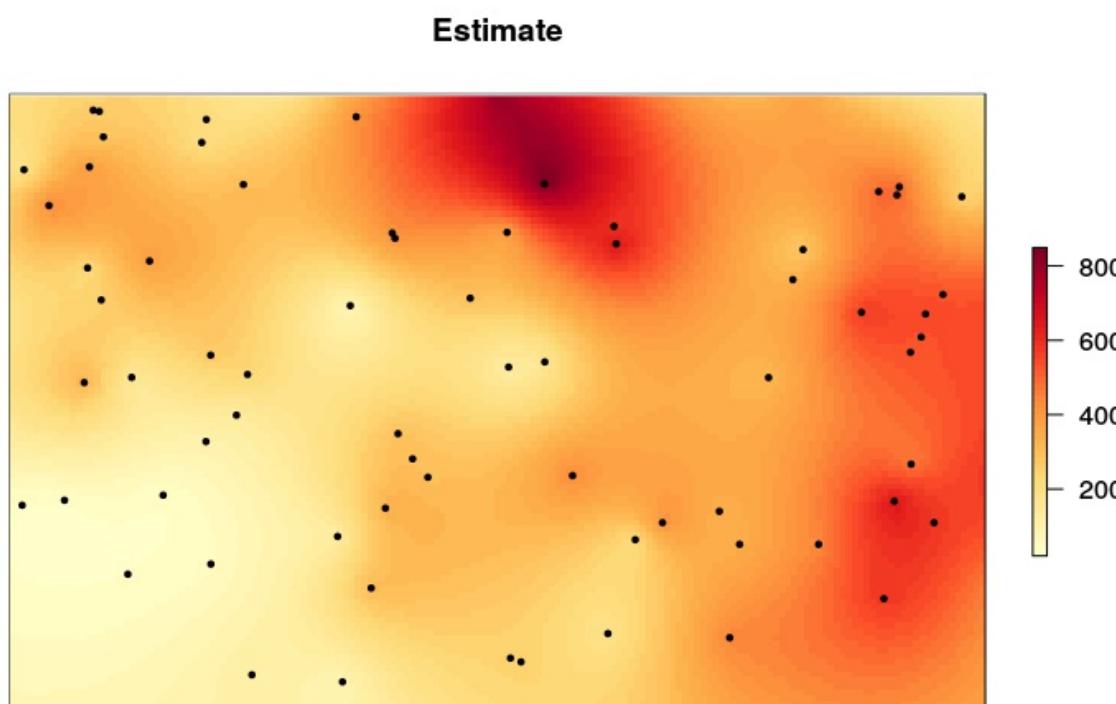
# Outputs

X	Y	Prediction	Variance	P > 750
66.40	558.30	<b>849.49</b>	<b>3941.76</b>	<b>0.94</b>
66.40	558.35	<b>844.15</b>	<b>5159.70</b>	<b>0.91</b>
66.35	558.30	<b>829.24</b>	<b>4687.44</b>	<b>0.88</b>
66.35	558.35	<b>834.29</b>	<b>5423.28</b>	<b>0.87</b>
66.45	558.35	<b>834.01</b>	<b>5856.16</b>	<b>0.86</b>
66.45	558.30	<b>828.36</b>	<b>5294.68</b>	<b>0.86</b>
66.40	558.40	<b>835.68</b>	<b>6413.80</b>	<b>0.86</b>
...	...	...	...	...

# Estimate and +/- 2SE



# Estimate and Variance





SPATIAL STATISTICS IN R

**Let's practice!**

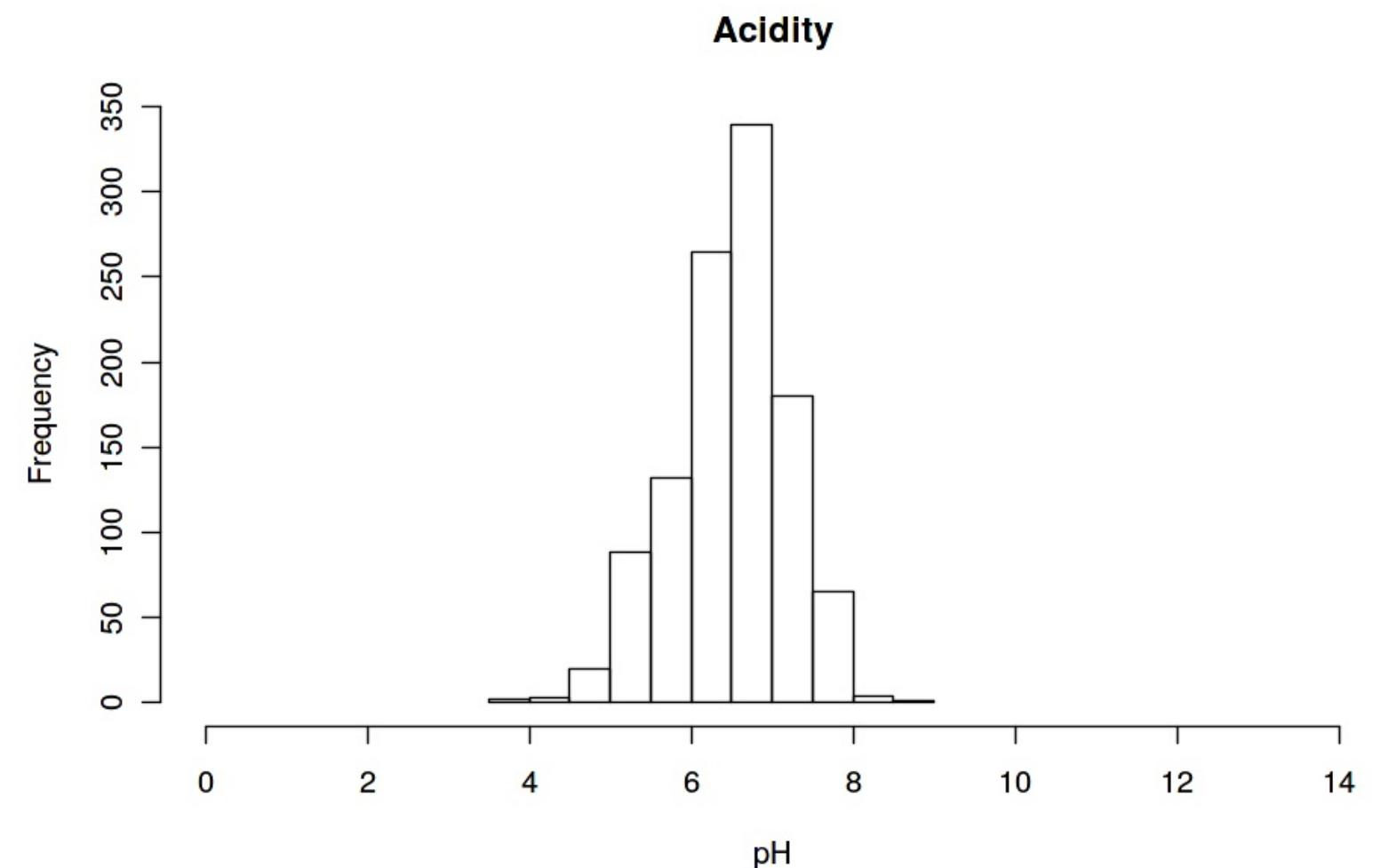


SPATIAL STATISTICS IN R

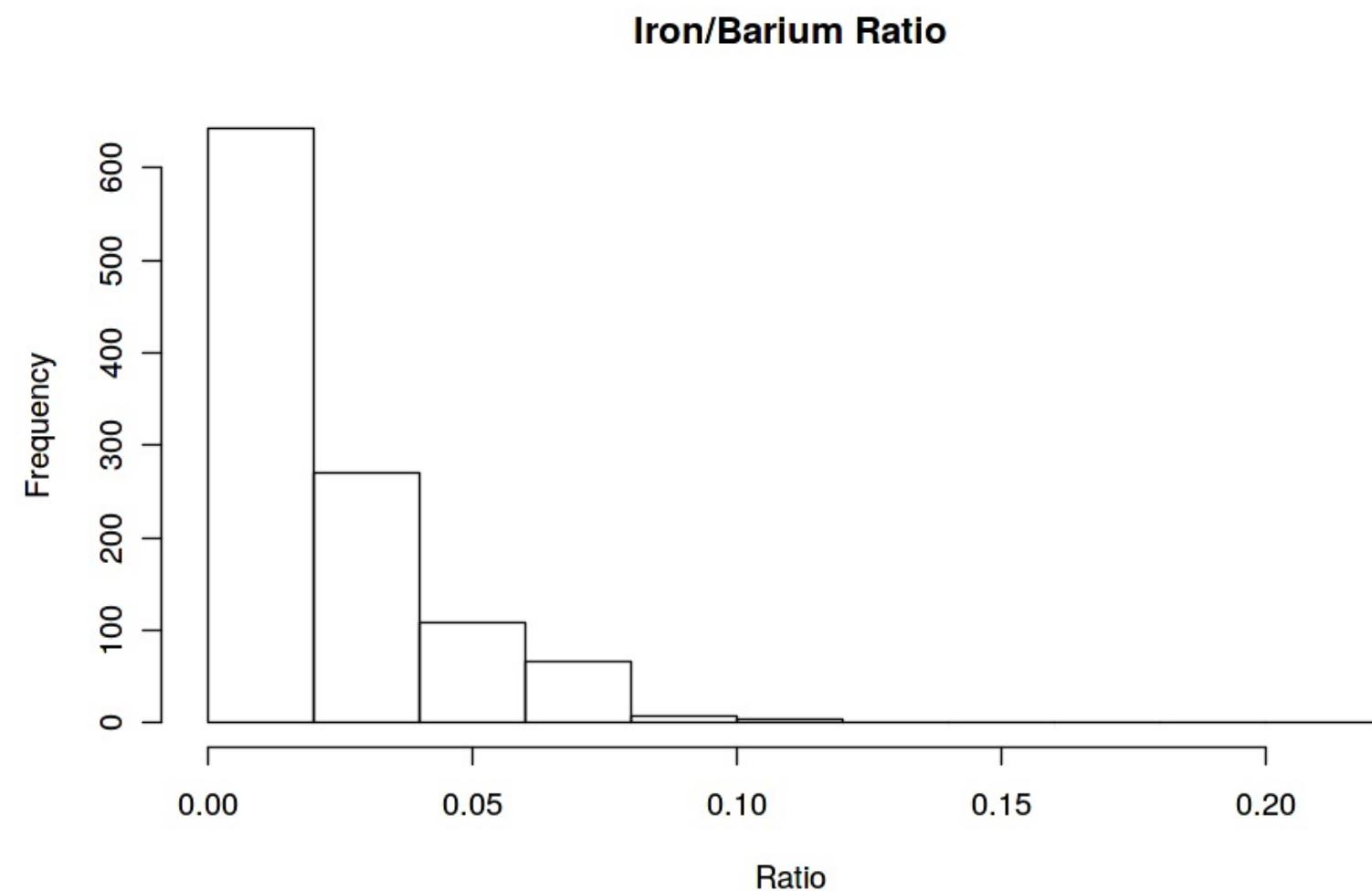
# Automatic kriging

Barry Rowlingson  
Krigomatic

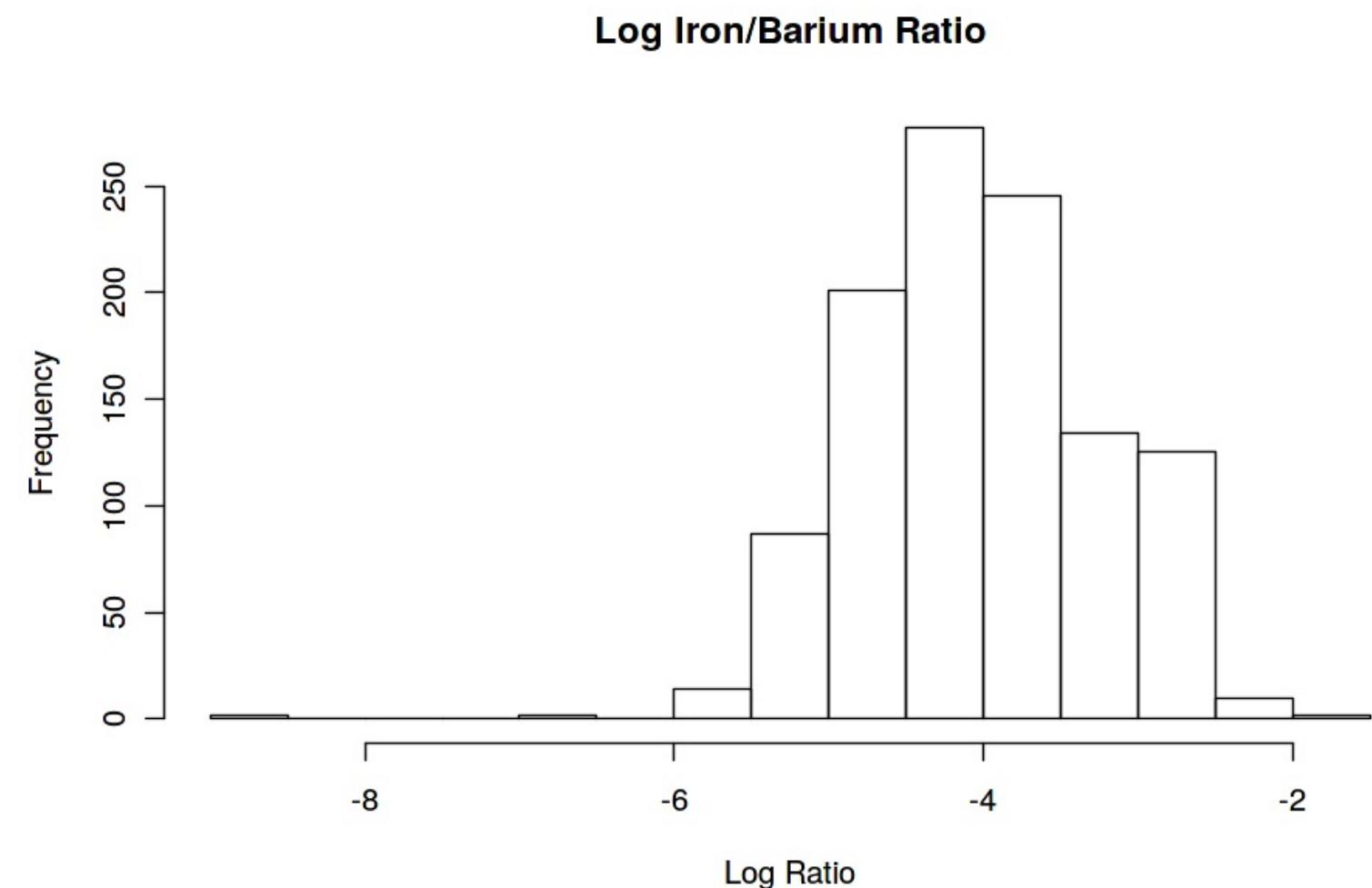
# Gaussian Data



# Ratio Data



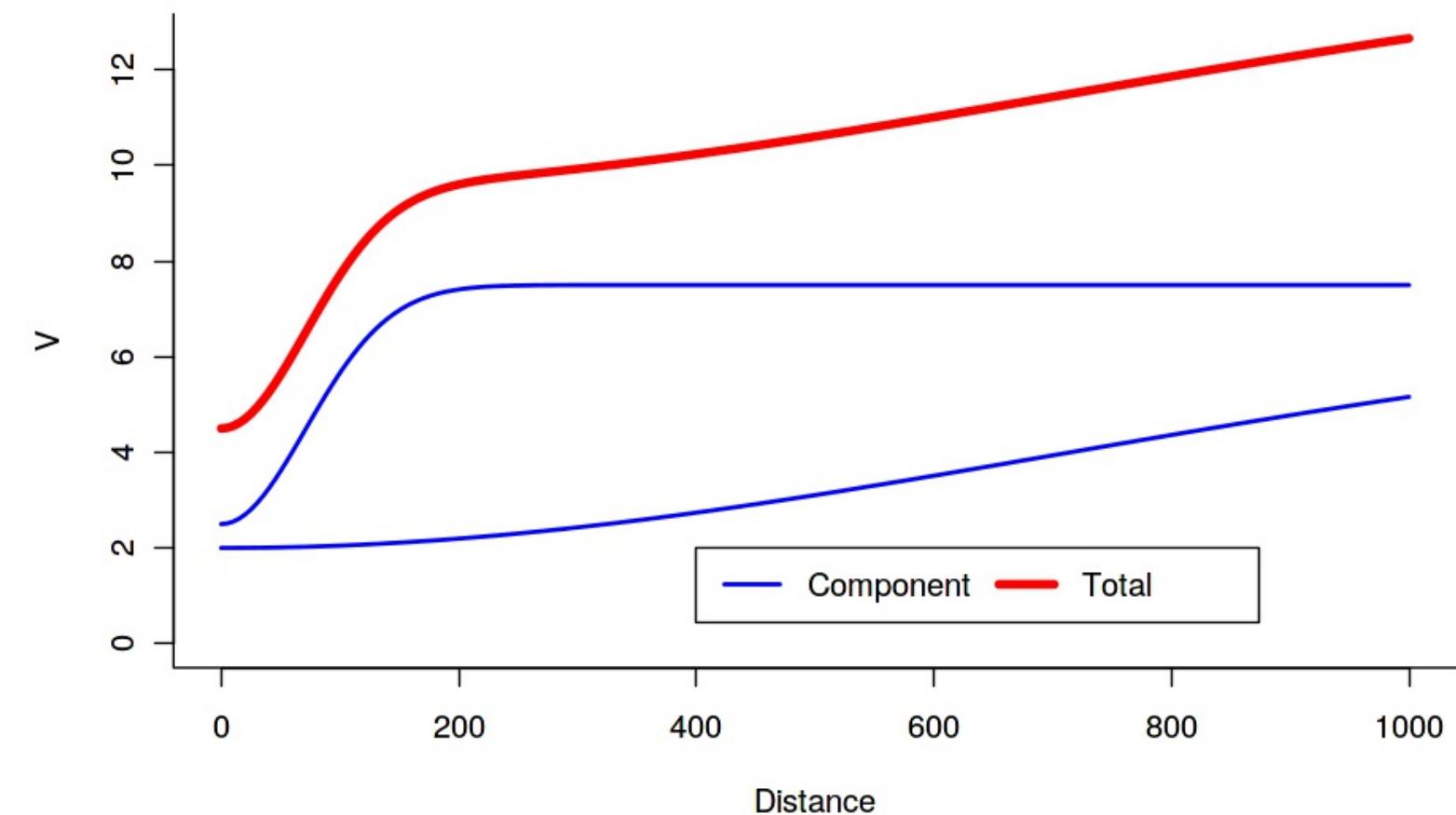
# Log-Transform



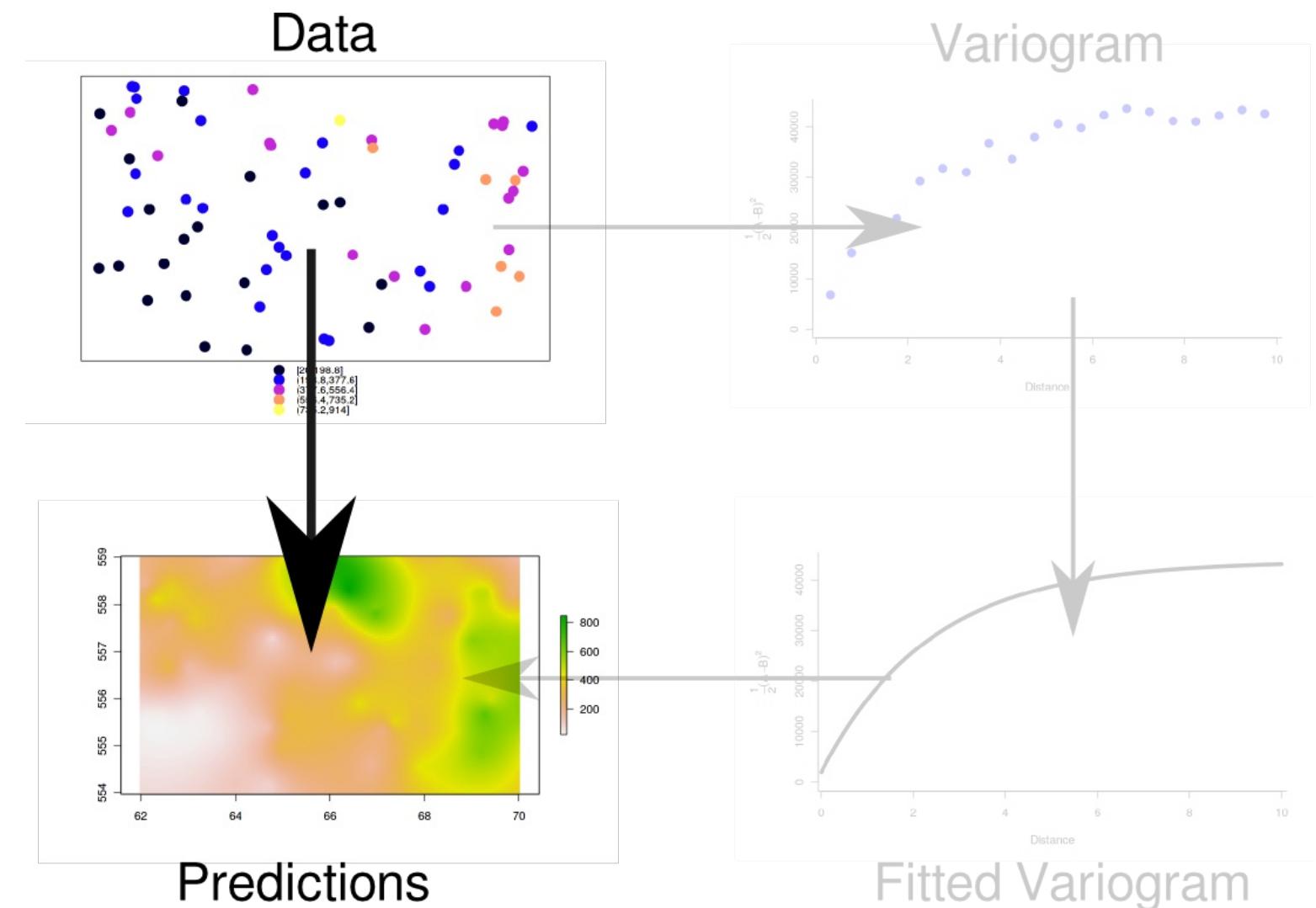
# Computer-intensive Methods



# Nested Variogam

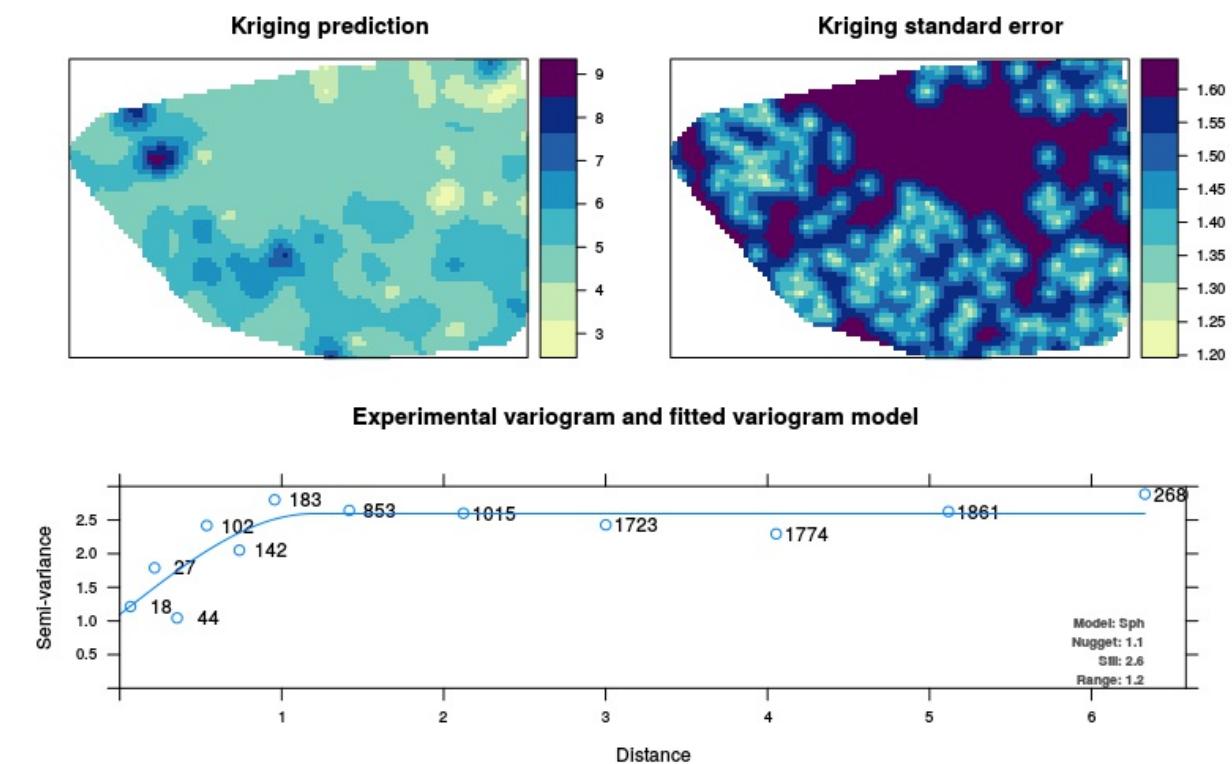


# Auto Kriging



# The automap Package

```
FeMap <- autoKrige(Fe ~ 1,  
                     data = geo)  
[using ordinary kriging]  
plot(FeMap)
```





SPATIAL STATISTICS IN R

**Let's practice!**

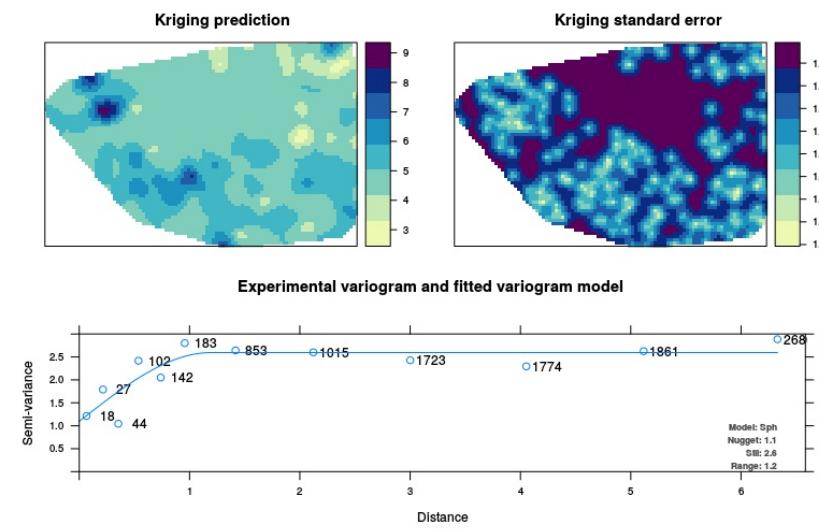
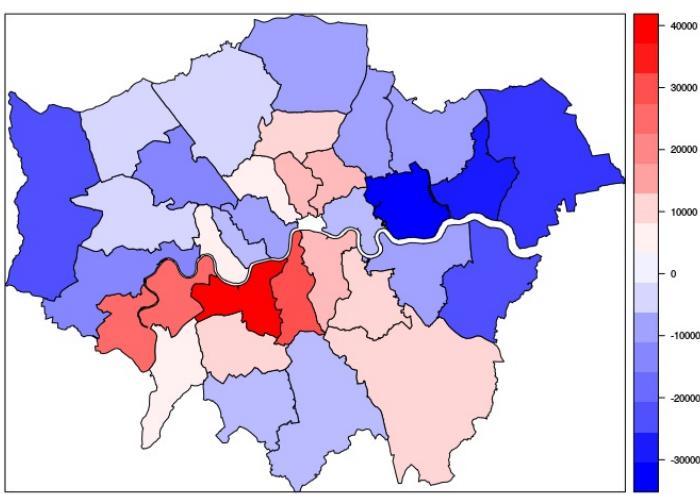
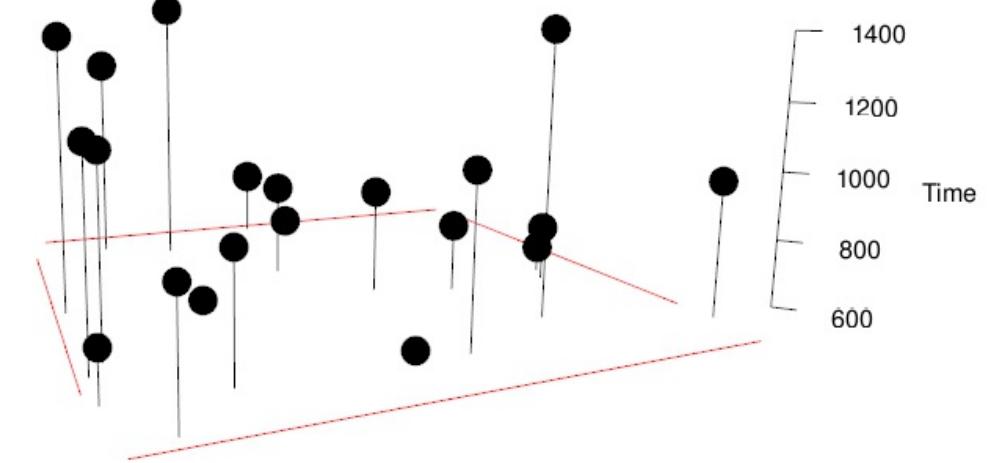


SPATIAL STATISTICS IN R

# Last Words

Barry Rowlingson  
Wrapper-Up

# Learnings





SPATIAL STATISTICS IN R

**The End!**