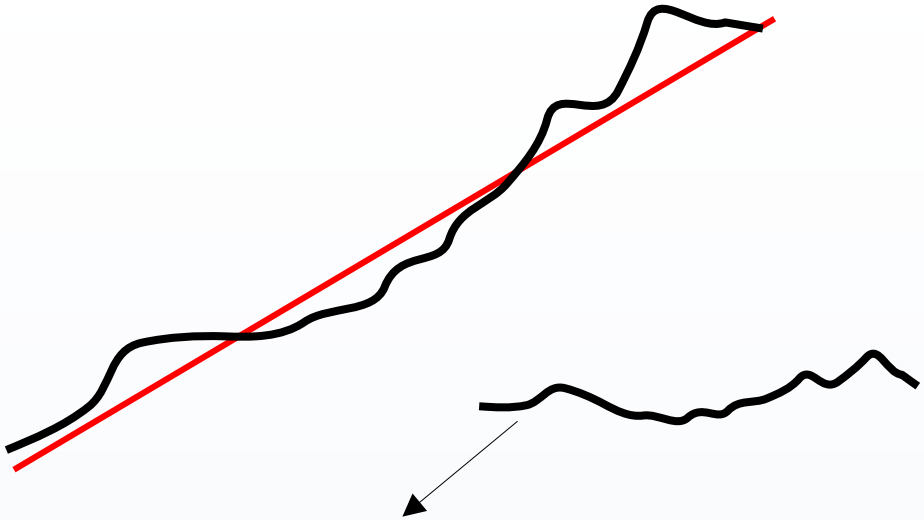
EGM702 – Photogrammetry and Advanced Image Analysis

Week 2, Part 3: Spatial Statistics

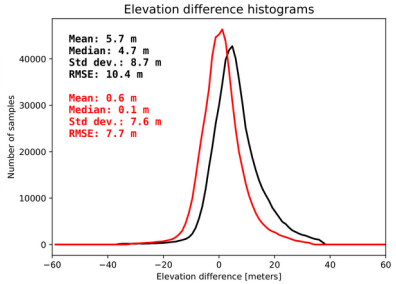
Spatial variables

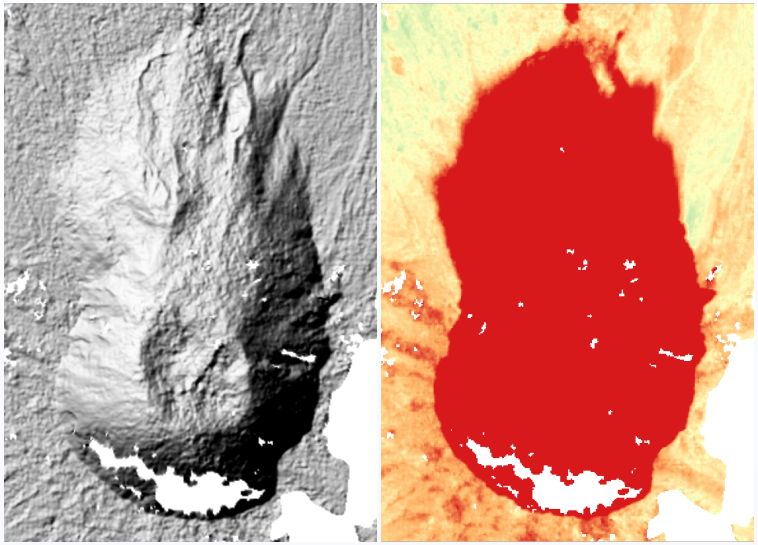
- Deterministic
- Stochastic (probabilistic)
  - Often assume observations are independent
  - In geostatistics, observations have spatial dependence
- Example: elevation



Uncertainty and spatial correlation

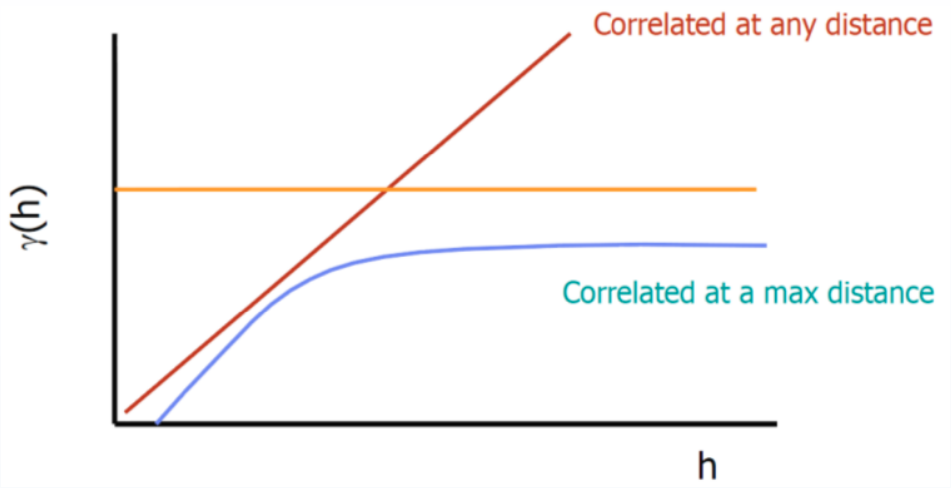
- Uncertainty: determining variance (σ^2) of some quantity
- e.g., NMAD/standard deviation for Δz
- What about for ΔV?
- Spatial correlation leads to underestimation of uncertainty





Semivariogram

- Trying to model variance as a function of separation
- Most frequently use semi-variance, γ (semivariogram)
- If data have stationarity, tells us about spatial autocorrelation



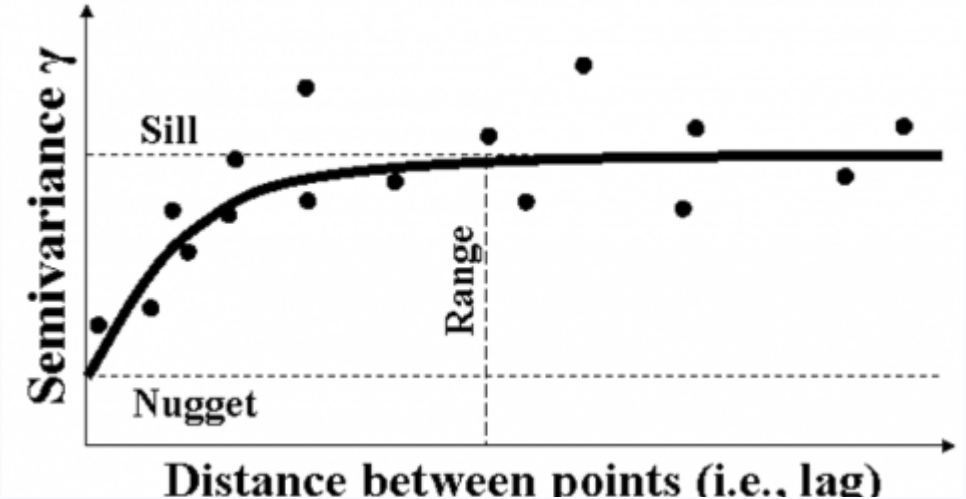
$$\gamma(h)=\frac{1}{2N}\sum_{i,j}(z_i-z_j)^2$$

Stationarity

- Assume that data are stationary:
  - Probability distribution doesn't change when shifted in space (or time)
  - i.e., μ, σ^2 are (mostly) constant in space (or time)
  - Same stimulus provokes the same process everywhere
- Often requires us to detrend data

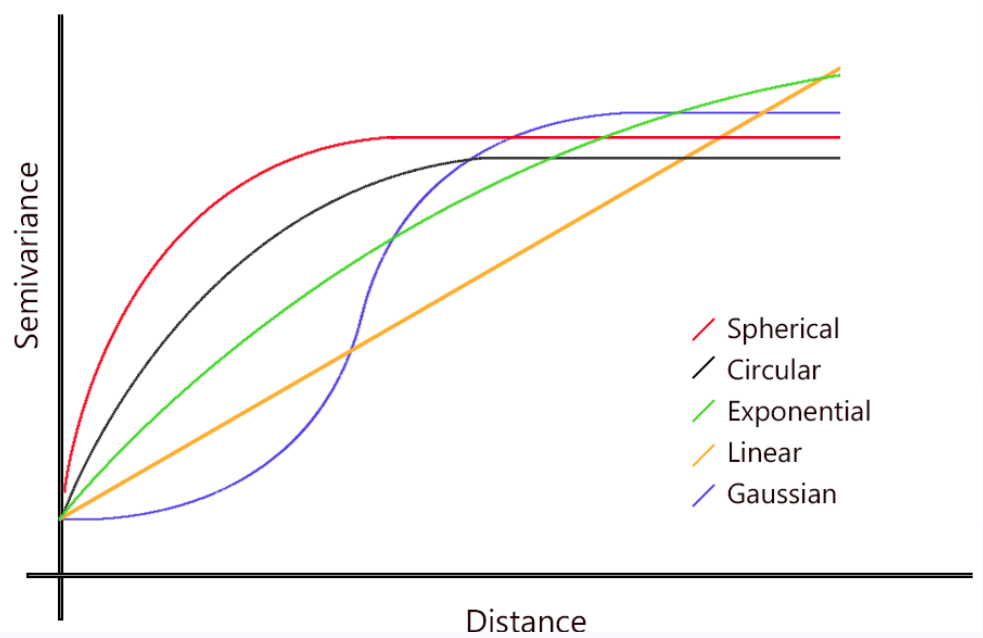
Semivariogram

- Lag: distance between data pairs
- Nugget: related to measurement error
- Sill: maximum value
- Range: lag distance at which autocorrelation diminishes



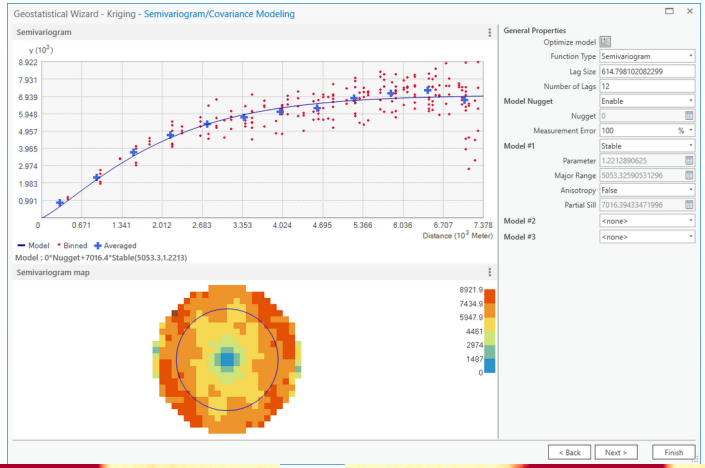
Semivariogram models

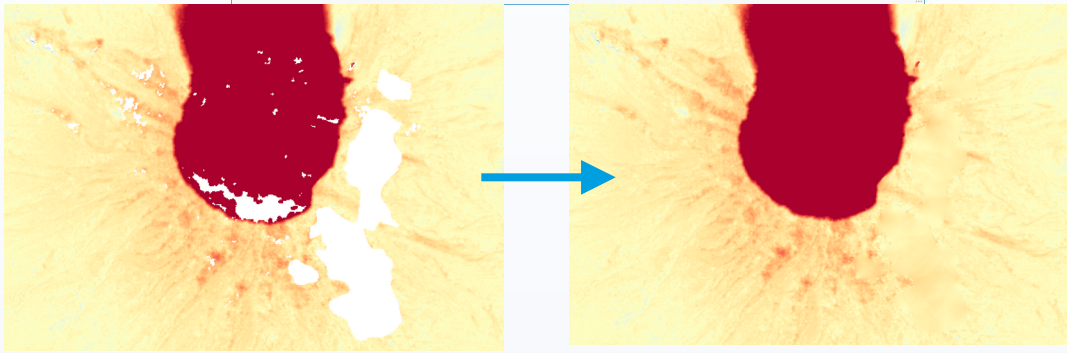
- Normally bin values by lag distance, take average
- Can model using different forms:
  - Can integrate analytically
  - Allows us to use for interpolation



Application: Kriging

- Can use variance to interpolate (predict) values at unsampled points
- Trying to model local (small-scale) variation
- Ordinary kriging:
  - Stationary
  - De-trended
  - Normally-distributed





Summary

- We often work with variables that have spatial dependence
- Have to account for spatially-correlated measurements
- Most common way to model this is the semivariogram
- Can be used to improve uncertainty estimation, interpolate/predict values

Additional resources

- Rolstad et al. 2009 [J. Glaciology]
- Spatial Statistics toolbox [ESRI]
- Handbook of Spatial Analysis [EFGS]