

# Honoring Uncertainty in Mapping & Interpreting Large Volumes of Digital Spatial Data

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*Mapping Uncertainty*



# Technology's Two-Edged Sword

- Massive electronic data bases offer access & analytic capability
- Computerized mapping leverages the data & extracts information
- Automated mapping can produce “results” with no information on their usefulness
- Understanding variance of mapped variables is critical to sensible use

# Example: Mapping Depth to “Ang-B” in the Gulf of Mexico

- Estimate depth to top of “Ang-B” by ordinary kriging
- Explicitly recognizes direction & degree of spatial continuity
- Provides unbiased estimator of depth to top of “Ang-B”
- Also provides estimator standard error reflecting uncertainty in estimated depth

# Variance of Estimated Depth

- Objective: find optimal weights,  $\lambda$ , for data to estimate mean value of distribution at target locations

$$\hat{z}(\vec{u}_0) = \sum_{i=1}^N \lambda_i z(\vec{u}_i) \quad SSE = \sum_{i=1}^N \left( z(\vec{u}_0) - \sum_{i=1}^N \lambda_i z(\vec{u}_i) \right)^2$$

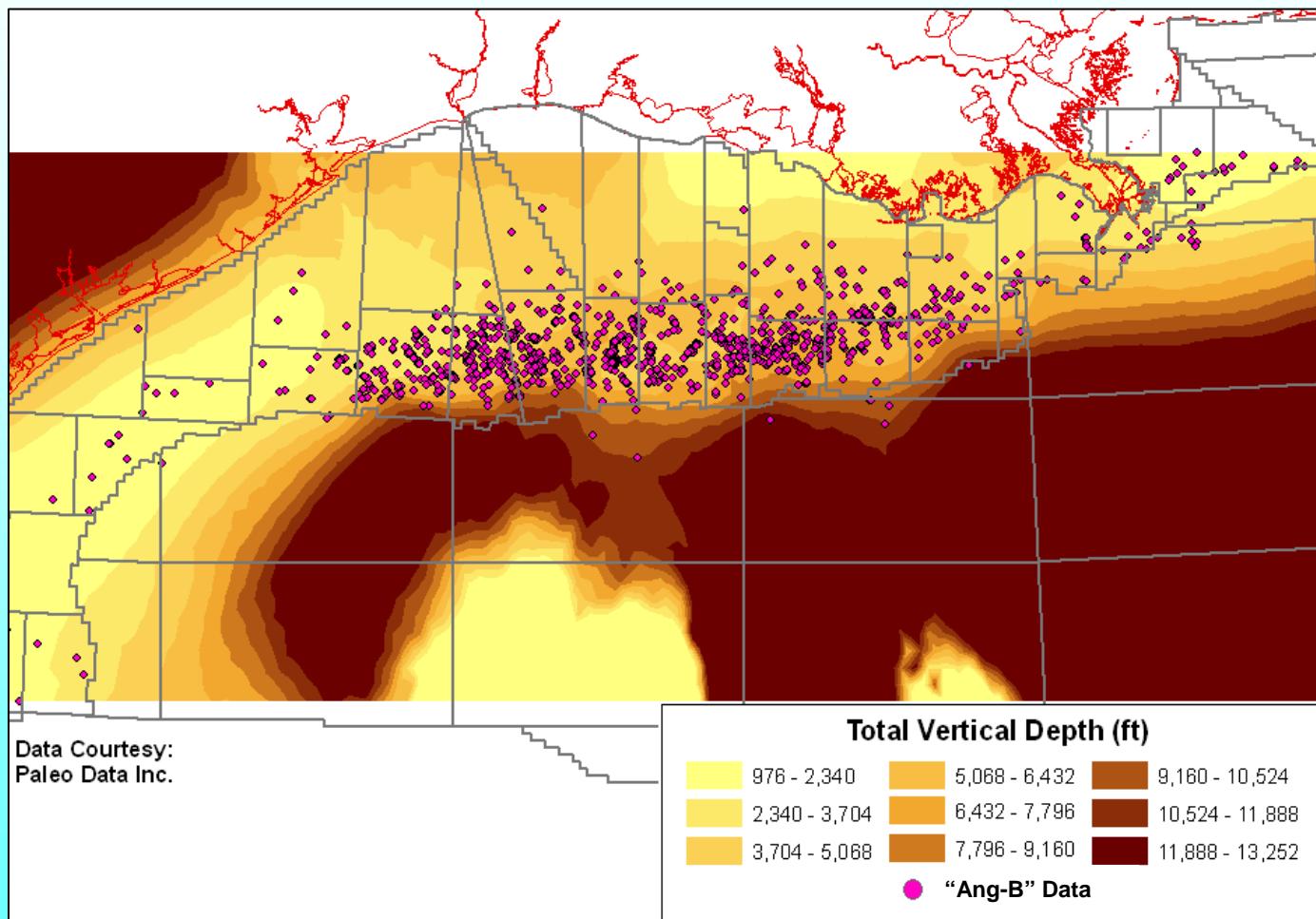
- Generalized least squares estimators of  $\lambda$

$$\hat{\lambda}_{(n+1 \times 1)} = \hat{\Gamma}_{(n+1 \times n+1)}^{-1} \hat{g}_{(n+1 \times 1)} \quad \hat{\Gamma} = \text{Covariance between data points} \quad \hat{g} = \text{Covariance between data and target location}$$

- Estimate of kriging variance & standard error

$$Var(\hat{z}(\vec{u}_0)) = \hat{\lambda}_{(1 \times 1)} \hat{g}'_{(1 \times n+1)} \quad SE(\hat{z}(\vec{u}_0)) = \sqrt{Var(\hat{z}(\vec{u}_0))}$$

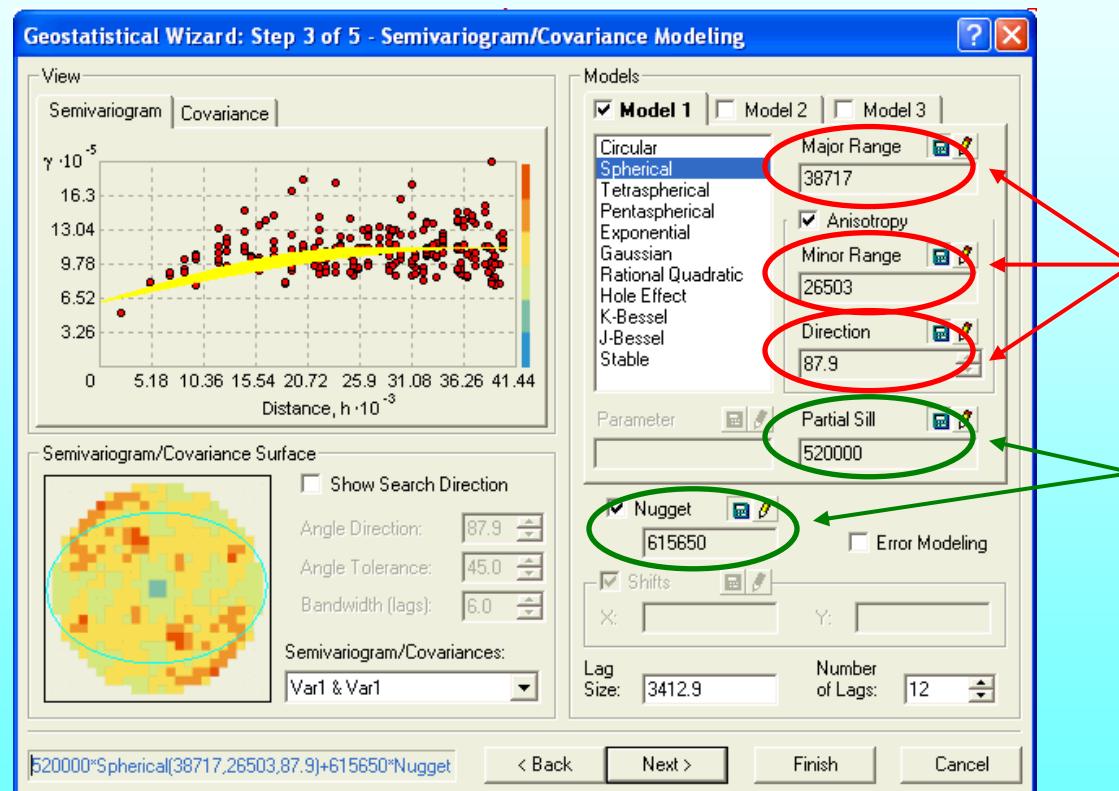
# Top “Ang-B” in Gulf of Mexico



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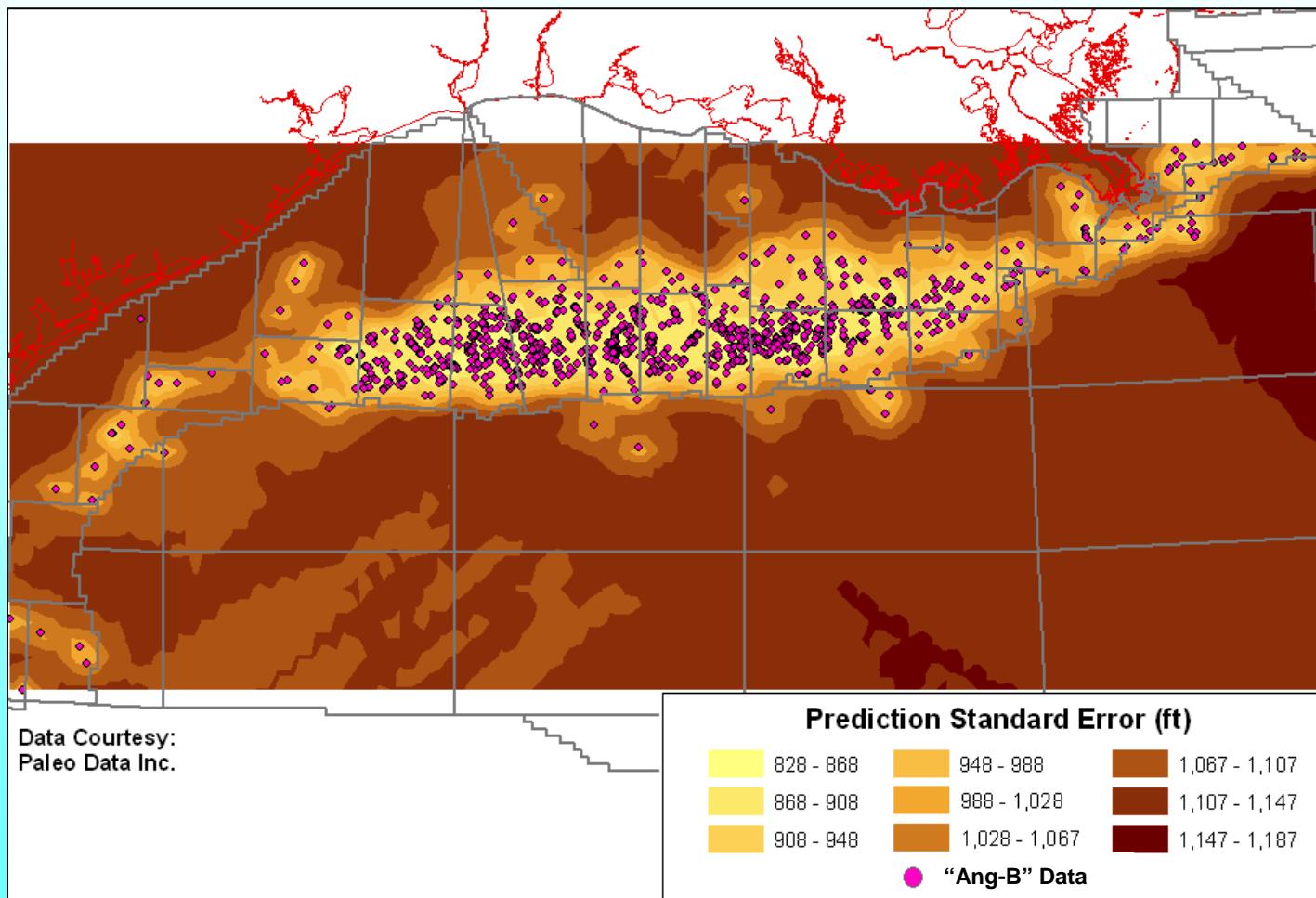
# Statistics on Spatial Continuity



Statistics on directional  
extent of spatial continuity

Statistics on overall  
extent of spatial continuity

# Mapping Prediction Standard Error



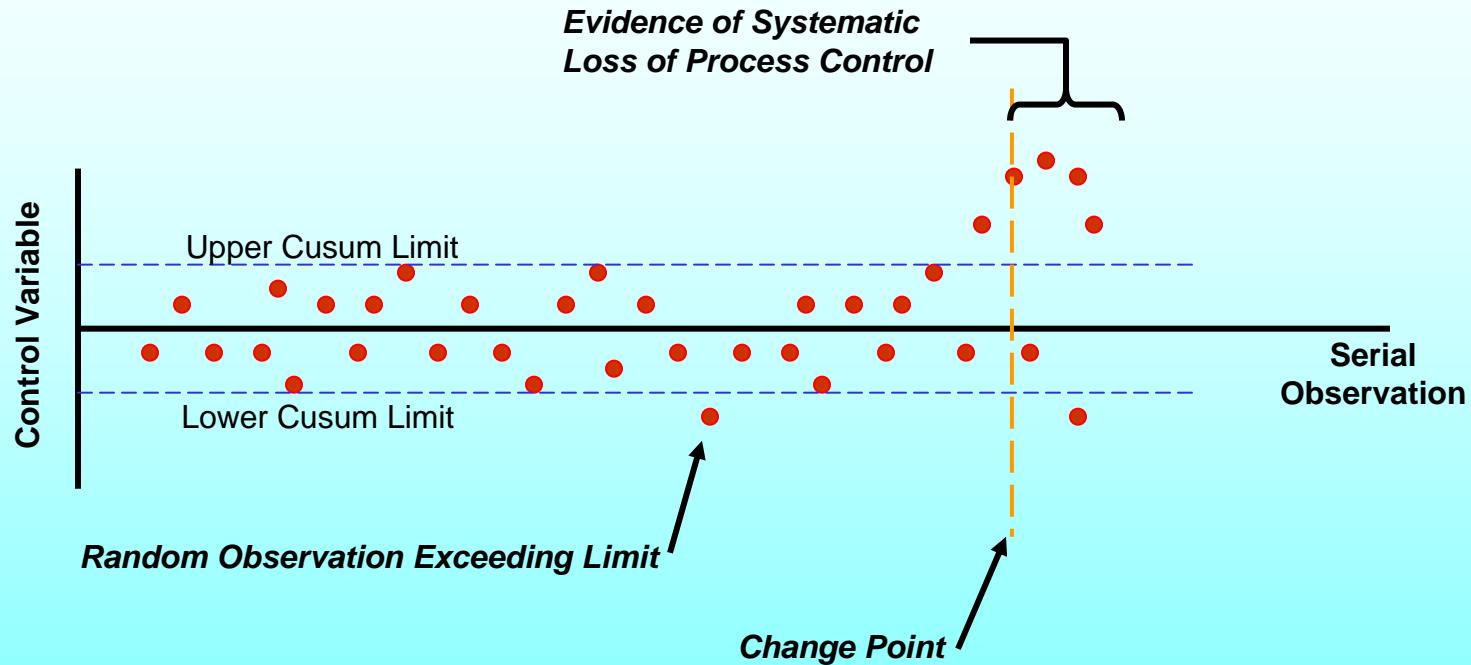
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# Determining “Optimal” Error Limit

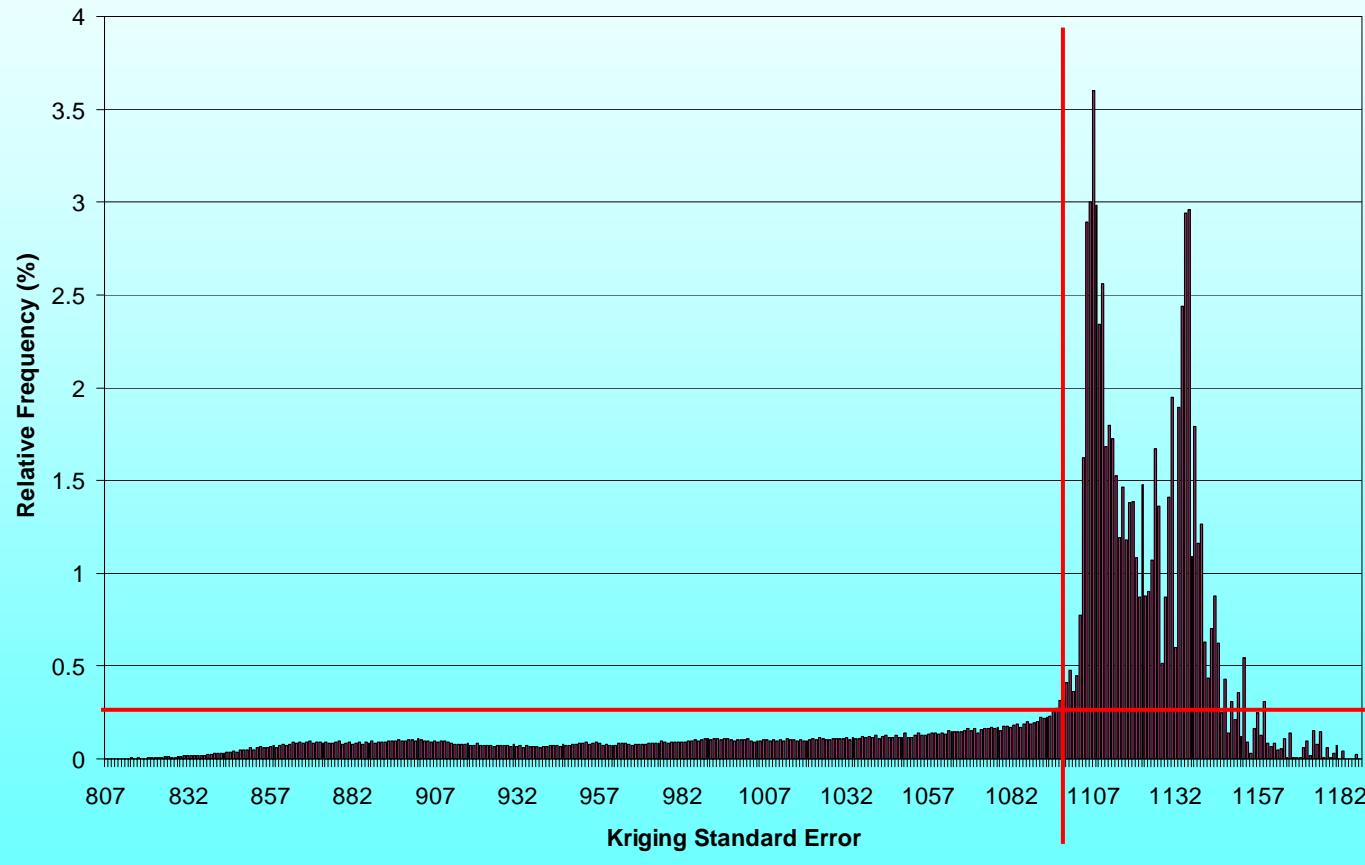
- Is there significant overall spatial continuity in data set?
- If so -
  - Join all points of SE grid to nearest data points – recording distance
  - Plot estimate SE vs. distance to data
- Statistical process control theory offers tools to determine change point (distance from data) where map estimation moves “out of control”

# Applying Statistical Control Theory



Cumsum involves the successive recalculation at each point of the probability that the new point belongs to the same statistical regime as all preceding points in the series

# Cusum to Determine Change Point in Mapping “Ang-B” Depth

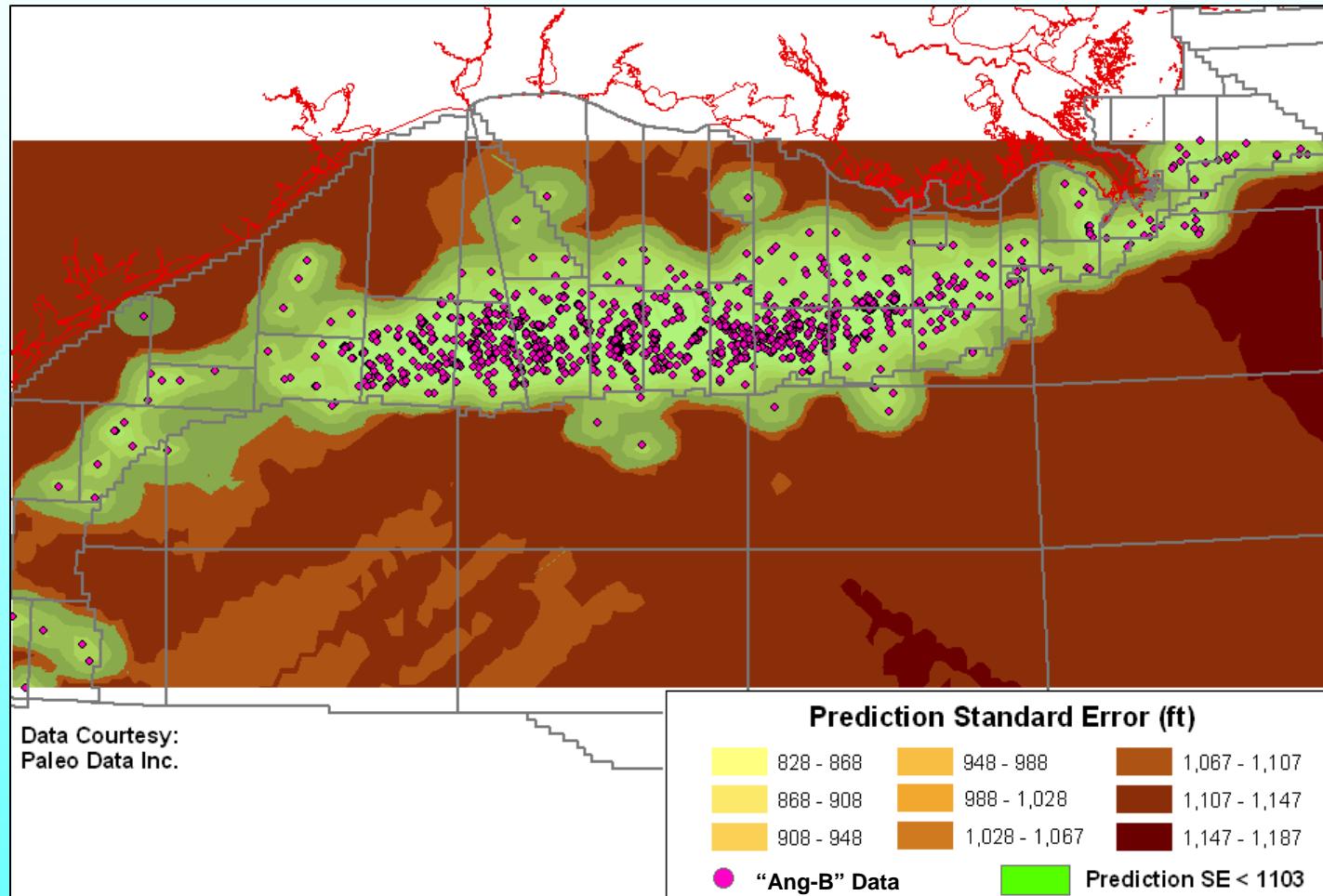


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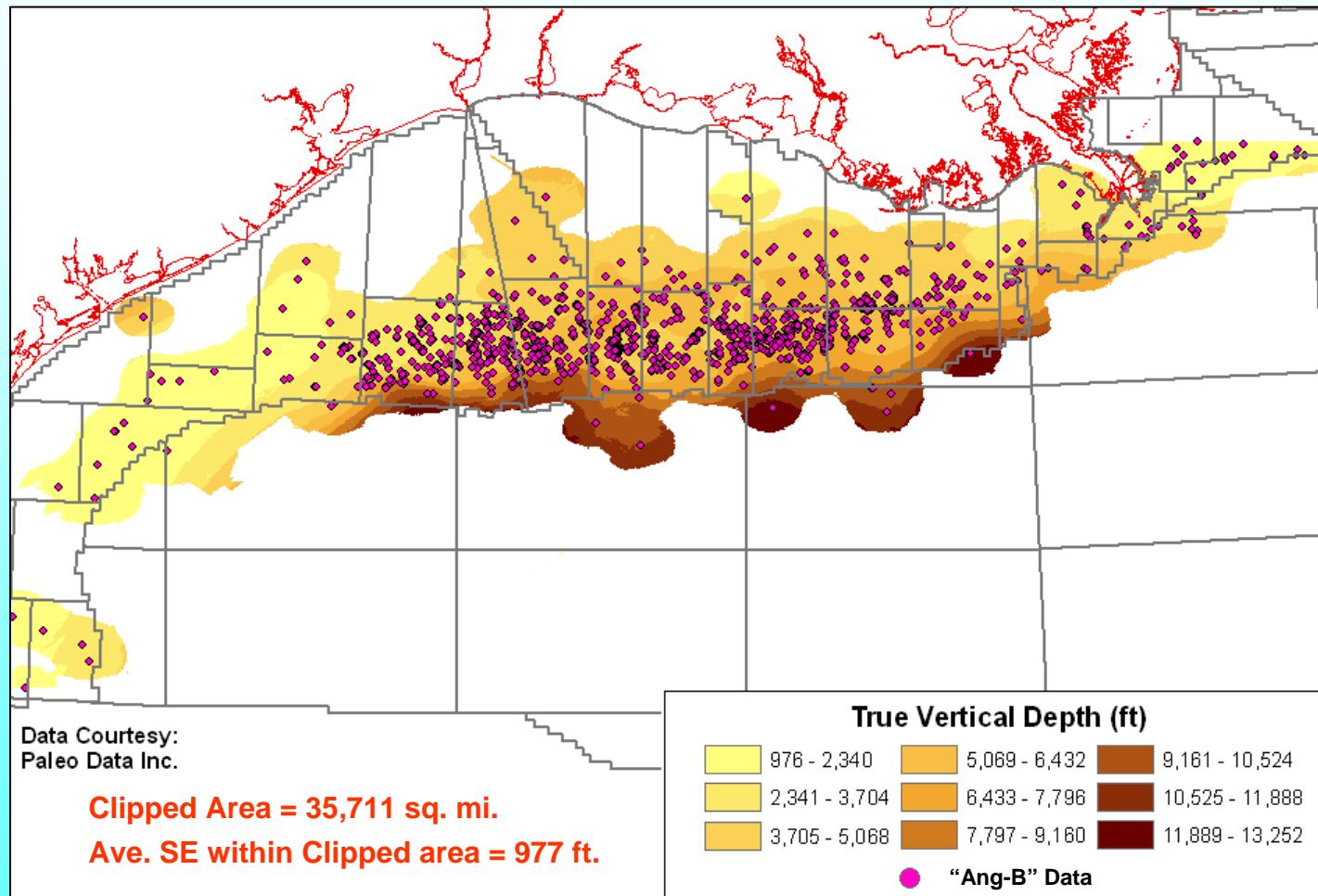
1103



# Mask Map Where Error $\geq 1103$



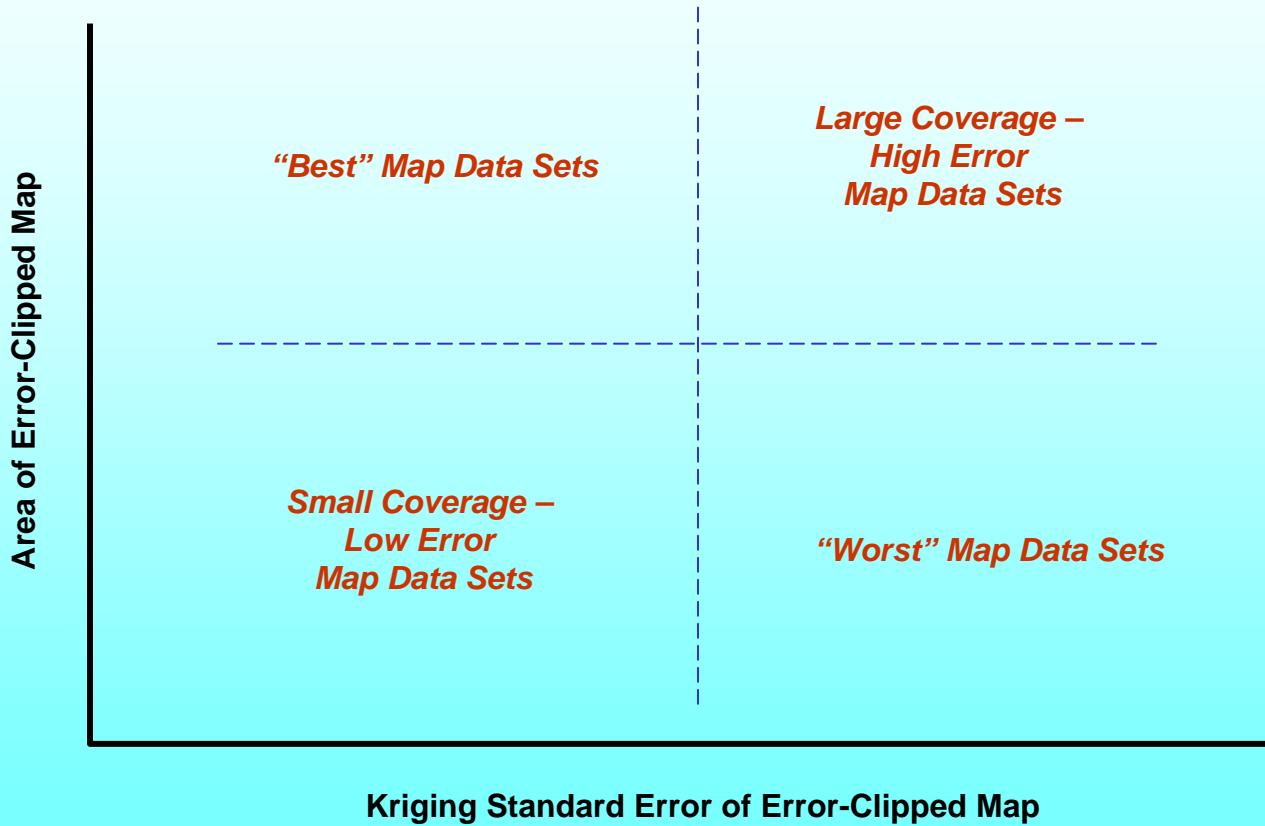
# Error-Clipped “Ang-B” Depth Map



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# Compare Map Data Sets



# Conclusions

- Geostatistics allows assessment of “quality” of large spatial data sets
- Statistical control theory provides tools for clipping map to areas “in control”
- Protocol can be applied to individual maps to limit extent to areas of useful results
- Clipped map area & average error allows comparison of alternative data sets
- Application can be automated