Using GIS to Analyze People's Behaviors in Hurricane Evacuation

Lixin Huang, GISP, E.I.
Advanced Transportation Engineering Consultants
Miami, FL

April 28, 2009

Using GIS to Analyze People's Behaviors in Hurricane Evacuation

- Introduction
- Data Preparation
- Model Development
- Model Results
- Conclusion

Introduction

- Hurricane Threat in Coastal Areas
- Evacuation - One of the solutions
- Analysis of People's Behaviors – Evacuation Distance
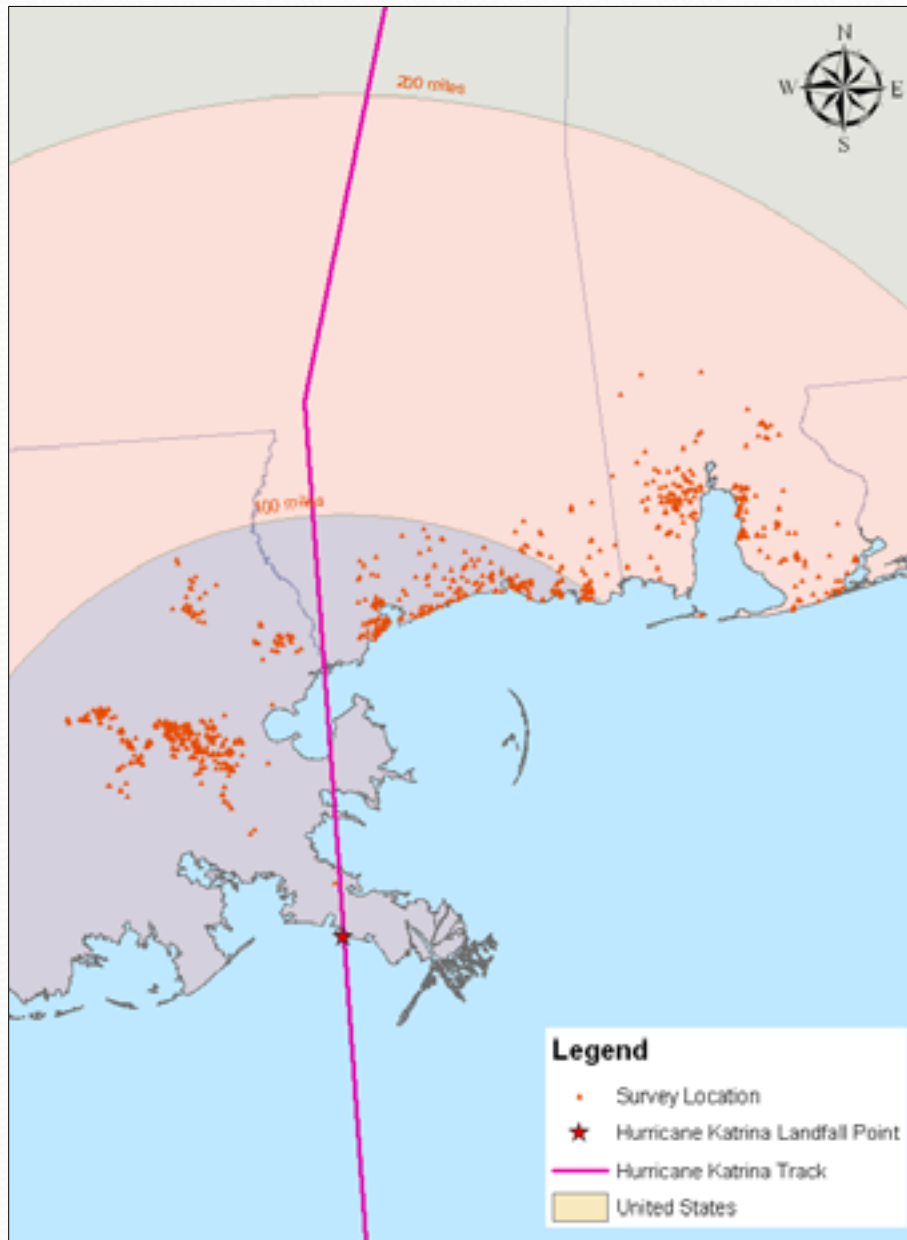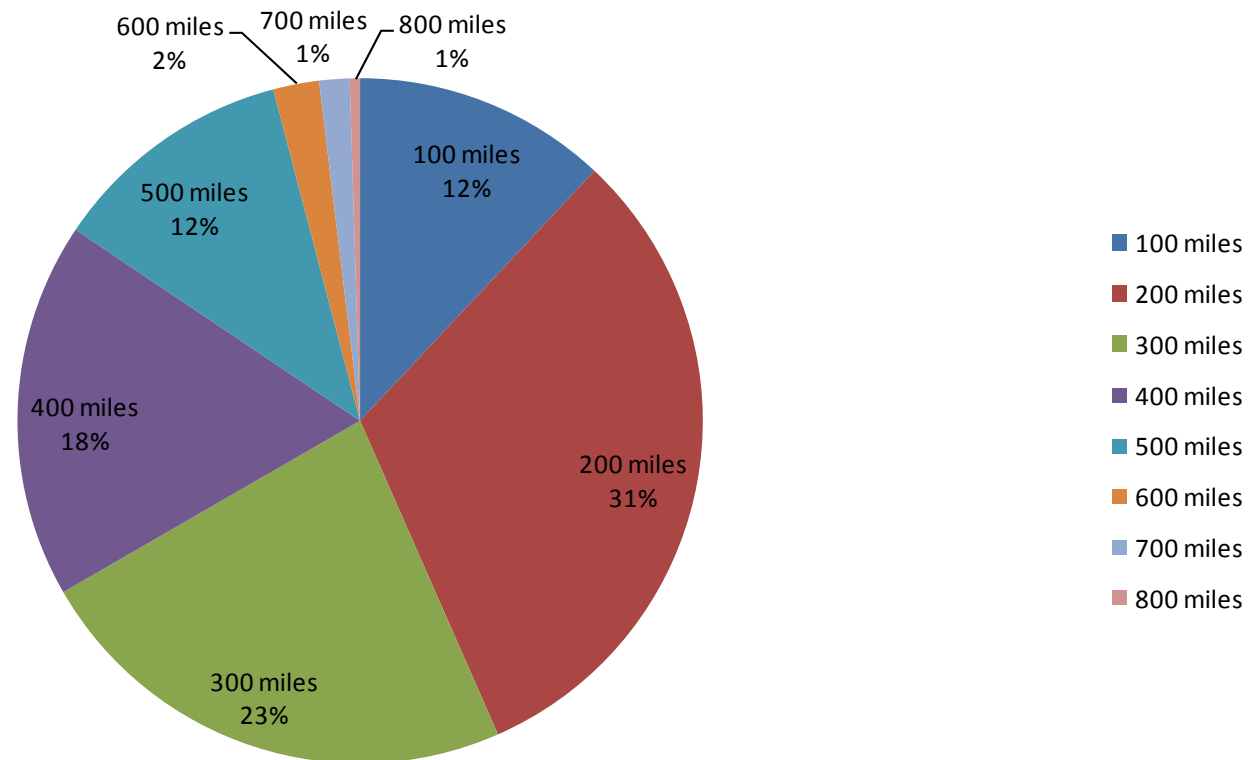- Socio-economic and Demographic Data

Data Preparation

- Data Source: Hurricane Katrina Survey from NSF
- Variables Selection

	Variable Name	**Variable Type**
Response Variable	Evacuation Distance	Quantitative
Explanatory Variables	Age	Quantitative
	Education Level	Categorical
	Gender	Categorical
	Household Size	Quantitative
	Income	Categorical
	Marital Status	Categorical
	Own or Rent	Categorical
	Race	Categorical

Legend
- · Survey Location
- ★ Hurricane Katrina Landfall Point
- — Hurricane Katrina Track
- United States

Distribution of Evacuation Destination Distance from Hurricane Landfall Point

- Three Types of Evacuation Destination

Evacuation Destination	Data Available	Assumption
Within Household's Neighborhood	N/A	Centroid of the Zip Code the Household is Located in
Out of Household's Neighborhood but Within Household's County	N/A	Centroid of the County the Household is Located in
Out of Household's County	Names of Destination City and State	Centroid of the City the Household evacuated to
	Names of Destination State	Centroid of the State the Household evacuated to

Legend

■ Evacuation Destination
★ Hurricane Katrina Landfall Point
— Hurricane Katrina Track
▢ United States
▢ Other Countries

Categorical Variables: Recode to dummy variables

Explanatory Variable: Income

Value	Description	Dummy Variables					
		Dum2	Dum3	Dum4	Dum5	Dum6	Dum7
1	UNDER $10,000	0	0	0	0	0	0
2	$10,000 - $20,000	1	0	0	0	0	0
3	$20,000 - $30,000	0	1	0	0	0	0
4	$30,000 - $50,000	0	0	1	0	0	0
5	$50,000 - $80,000	0	0	0	1	0	0
6	OVER$80,000	0	0	0	0	1	0
7	DON'T KNOW/NO RESPONSE	0	0	0	0	0	1

Model Development

- Ordinary Least Squares (OLS) Regression
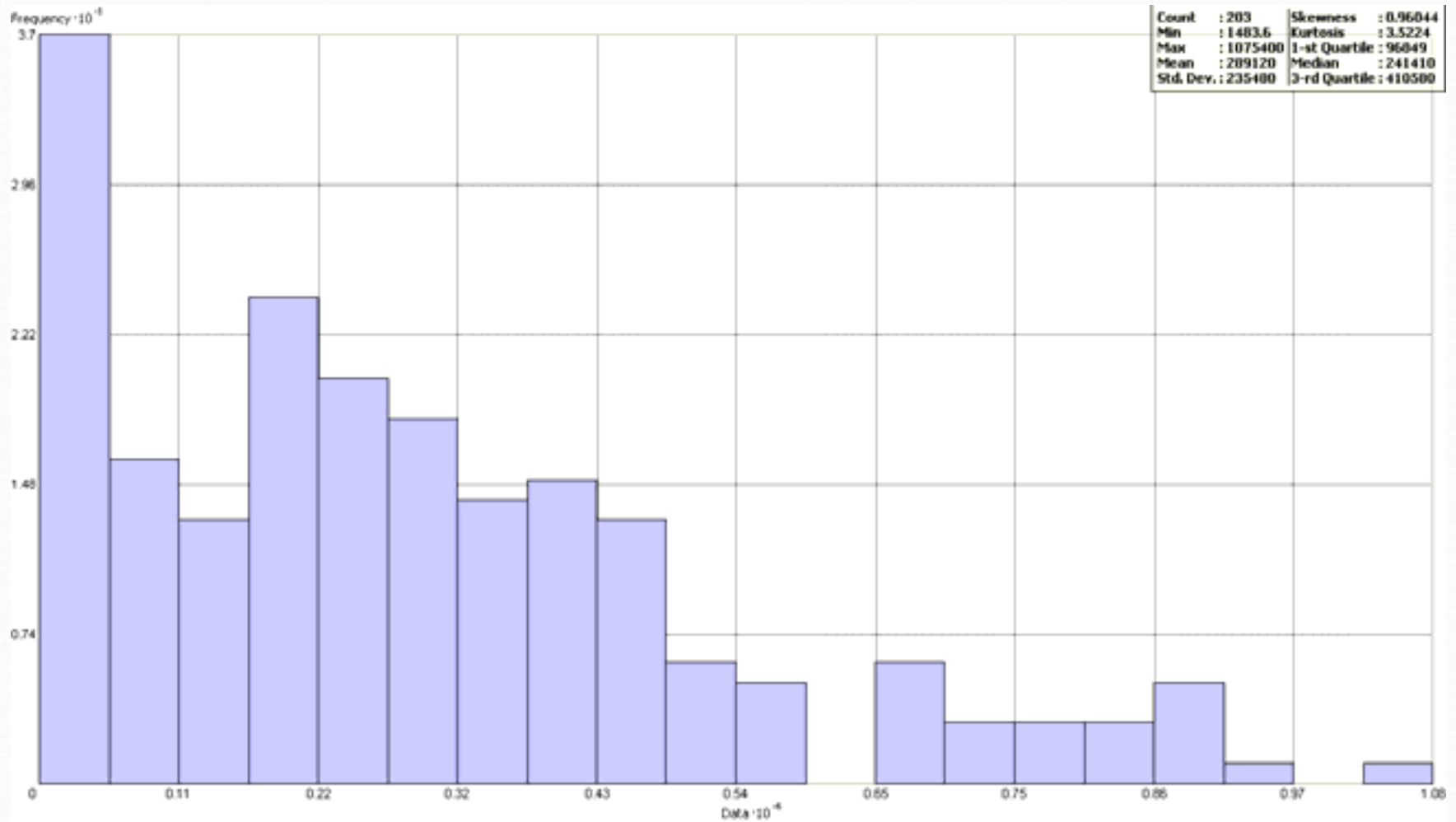- Geographically Weighted Regression (GWR)

- Ordinary Least Squares (OLS) Regression
  - Include Quantitative and Categorical Variables
  - Response Variable Transformation (Natural Logarithm)

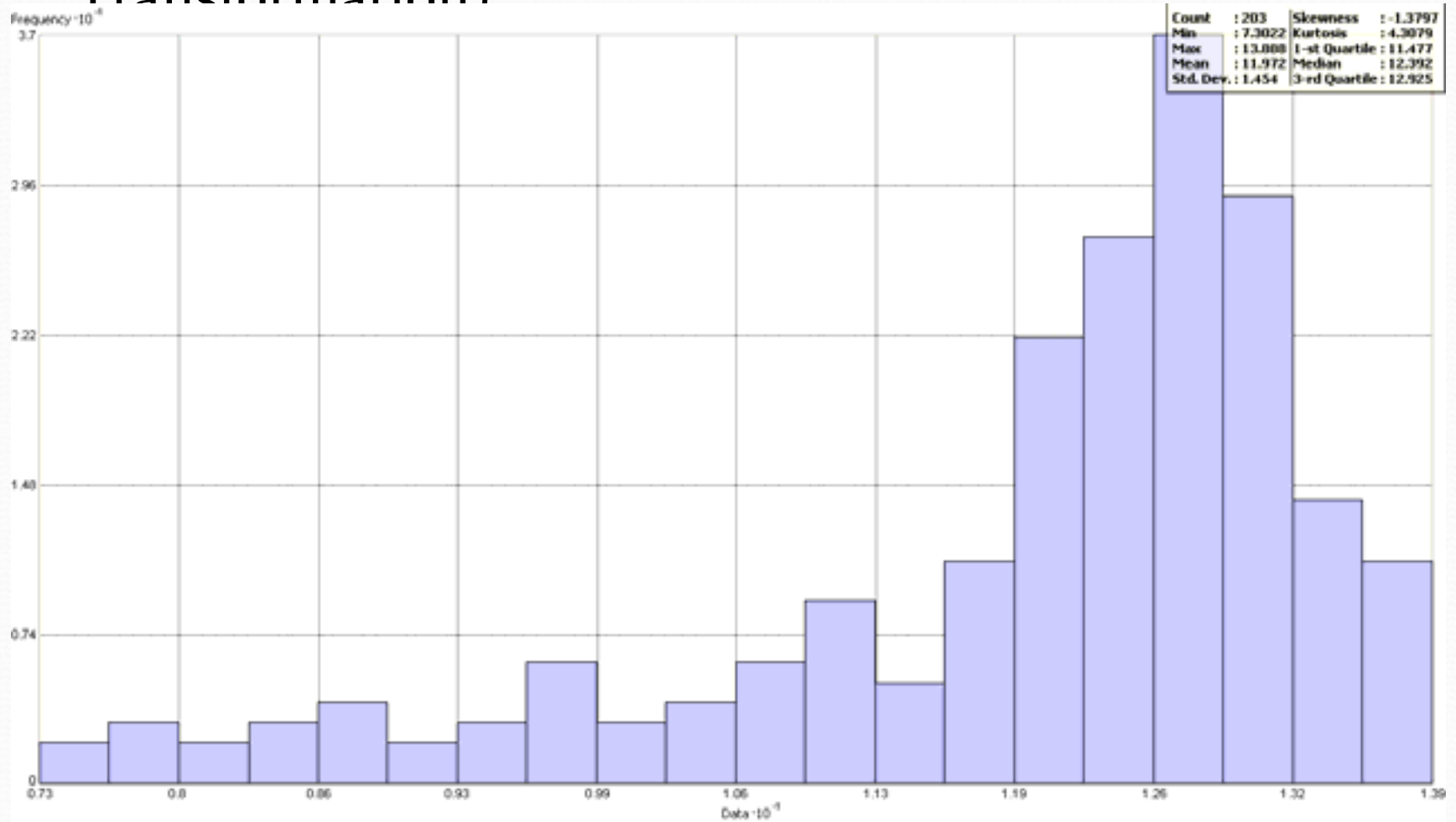$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \cdots + \beta_\eta x_\eta + \varepsilon$$

Where:

y:	Response Variable,
η:	Number of Explanatory Variables,
β_η:	Regression Coefficients,
x_η:	Explanatory Variables, and
ε:	Random Error Term / Residual.

- Response Variable Distribution (Before Transformation)

- Response Variable Distribution (After Transformation)

- Geographically Weighted Regression (GWR)
  - Include Quantitative Variables: Age and Household Size
  - Exclude Categorical Variables to avoid local colinearity
 - Response Variable Transformation (Natural Logarithm)

Model Results

- Ordinary Least Squares (OLS) Regression

Statistical Diagnostics	Value	Remarks
R-Squared	0.07	Very low global model performance
Adjusted R-Squared	0.01	Very low global model performance
Variance Inflation Factor (VIF)	1.02 ~ 4.04	< 7. No indication of variables redundancy
Joint Wald Statistic	0 (Probability)	Statistically significant model
Koenker (BP) Statistic	0.032 (Probability)	Statistically significant non-stationarity
The Jarque-Bera Statistic	0 (Probability)	Model misspecification
Moran's I Index for Standard Residual	0.06	No indication of spatial autocorrelation

- Ordinary Least Squares (OLS) Regression
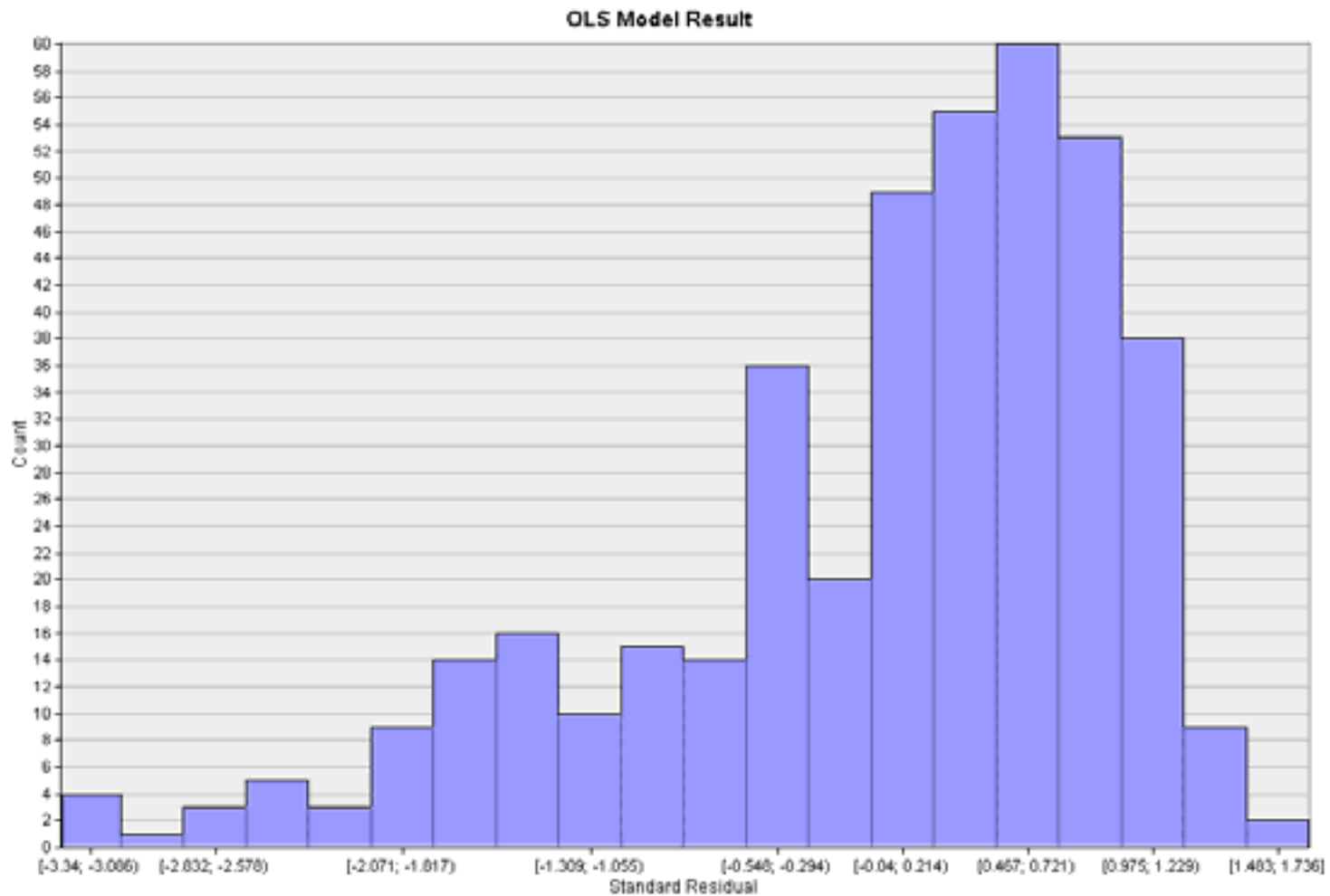
Ordinary Least Squares (OLS) Regression
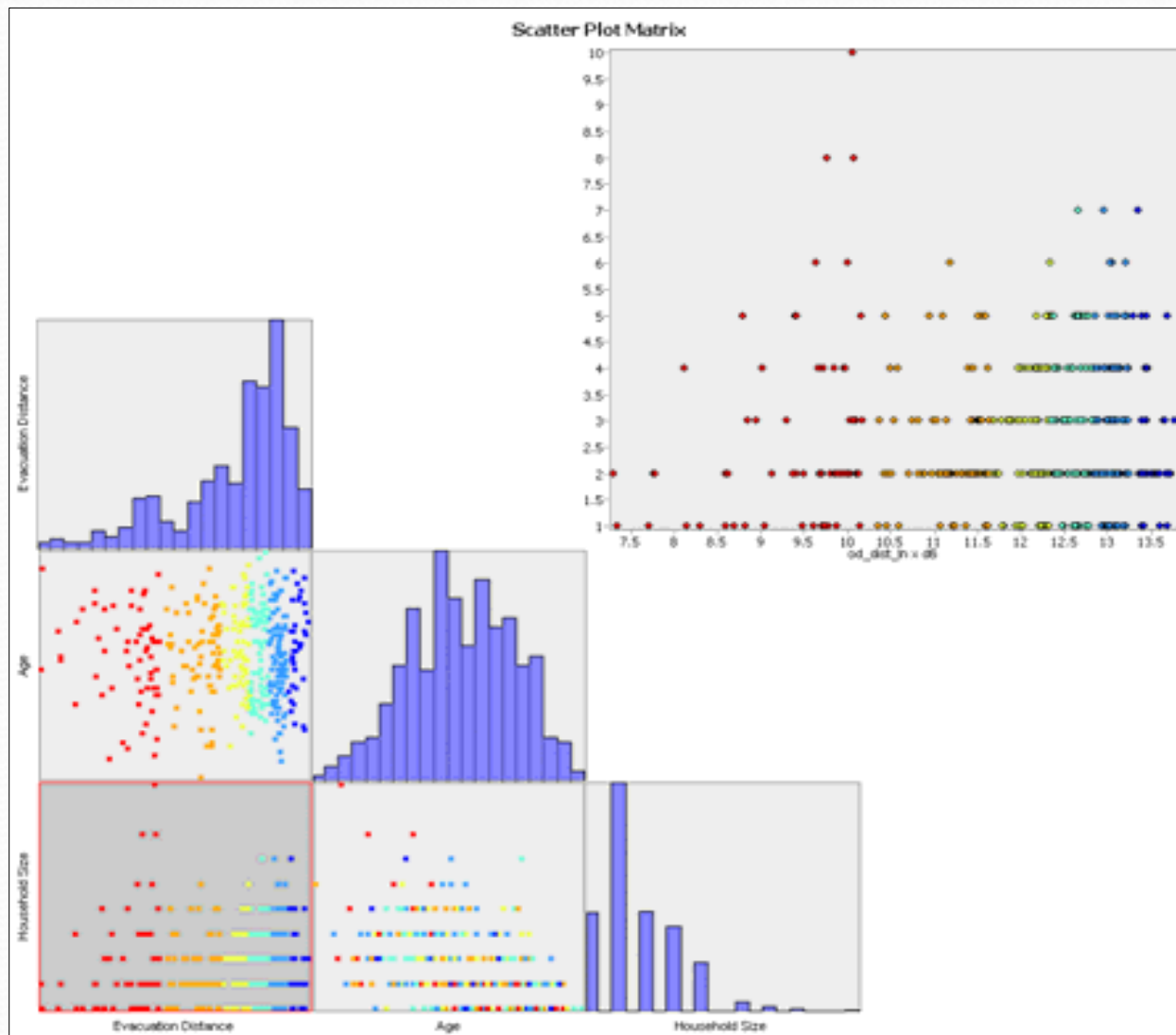
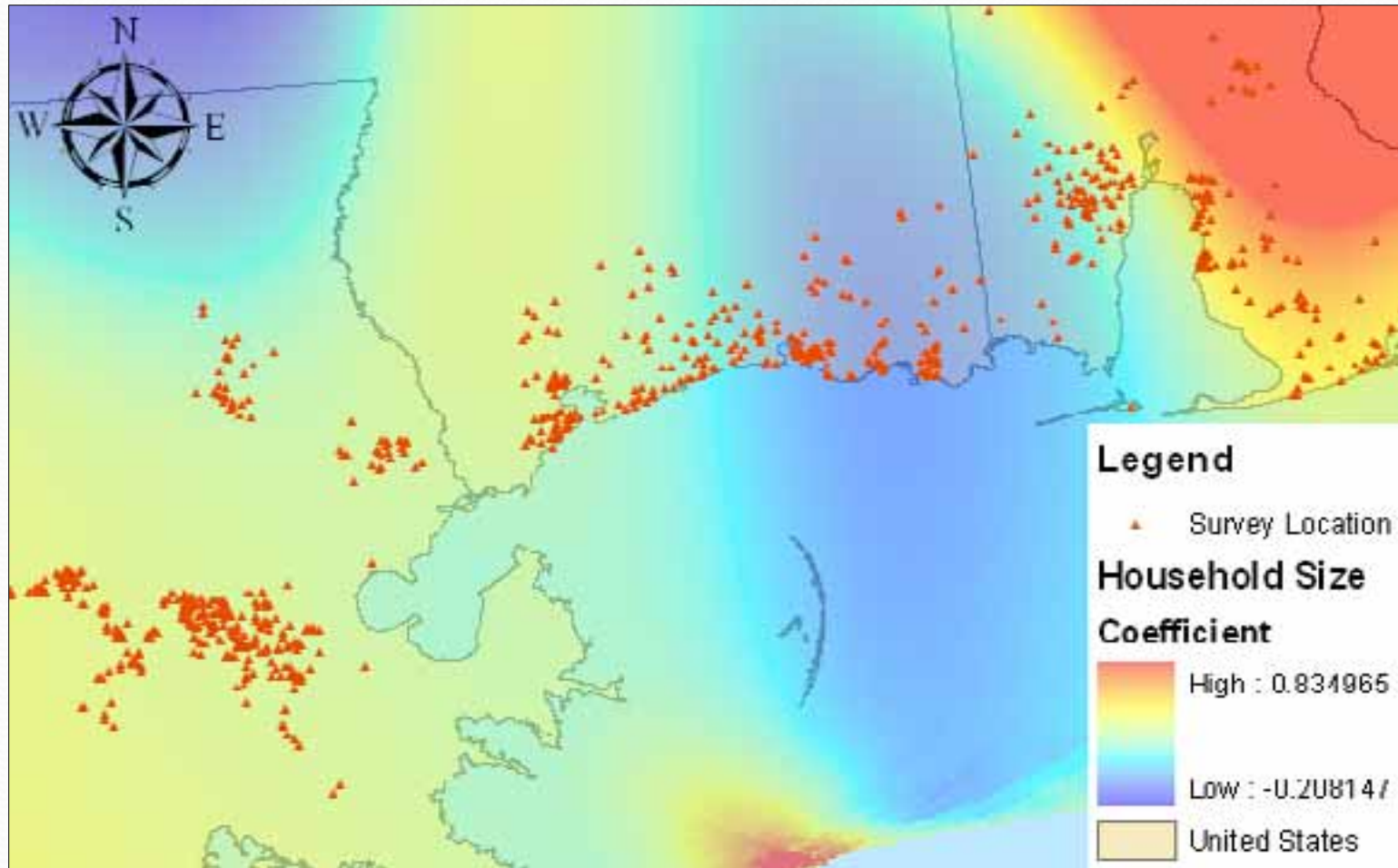- # Geographically Weighted Regression (GWR)

| Statistical Diagnostics	Value	Remarks
R-Squared	0.20	Low global model performance
Adjusted R-Squared	0.16	Low global model performance
Condition Number	12.02 ~ 19.75	< 30. Not indication of local colinearity
Local R-Squared	0.00 ~ 0.24	Low local model performance
Moran's I Index for Standard Residual	0.02	No indication of spatial autocorrelation

- Geographically Weighted Regression (GWR)
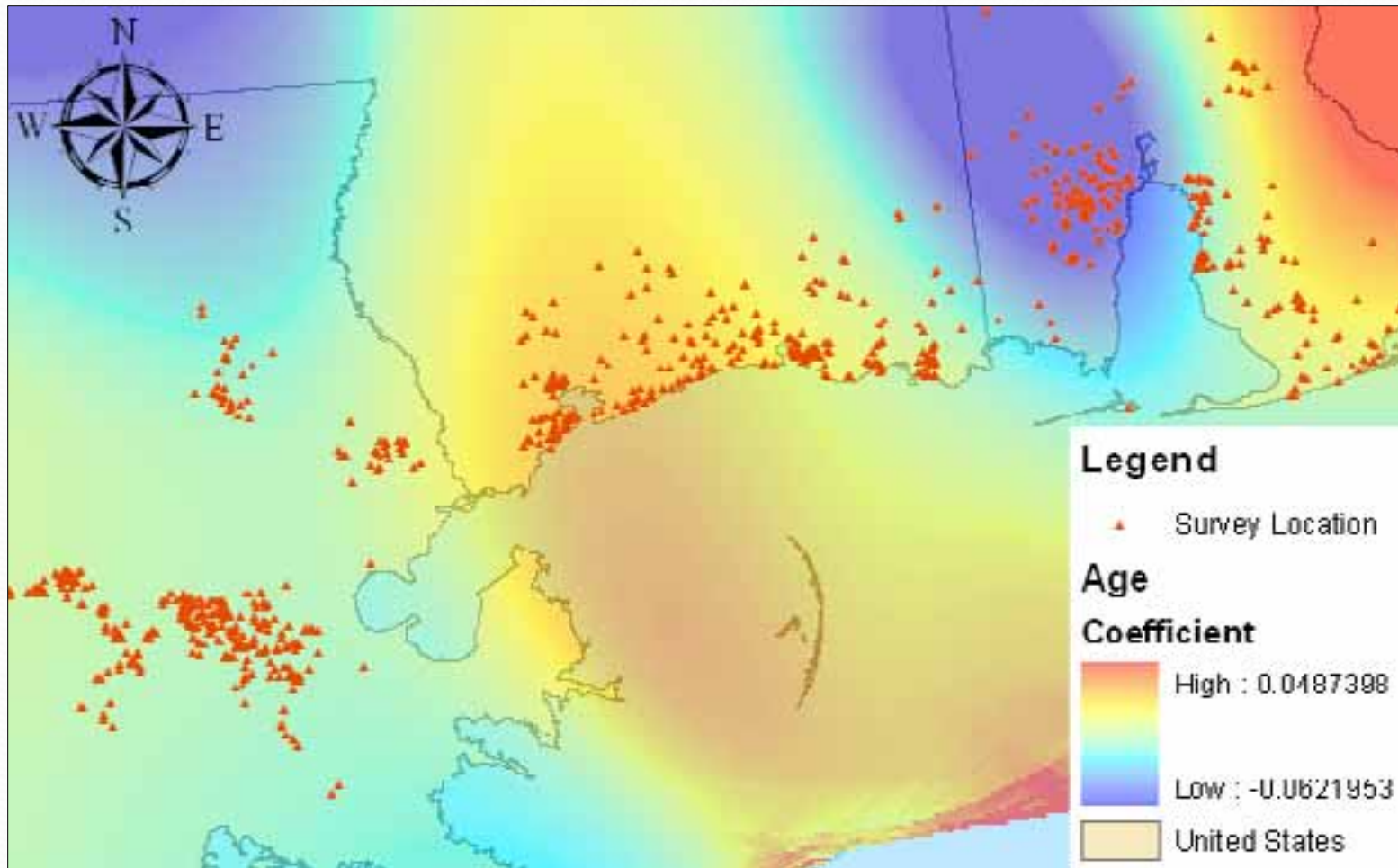
Geographically Weighted Regression (GWR)

Geographically Weighted Regression (GWR)
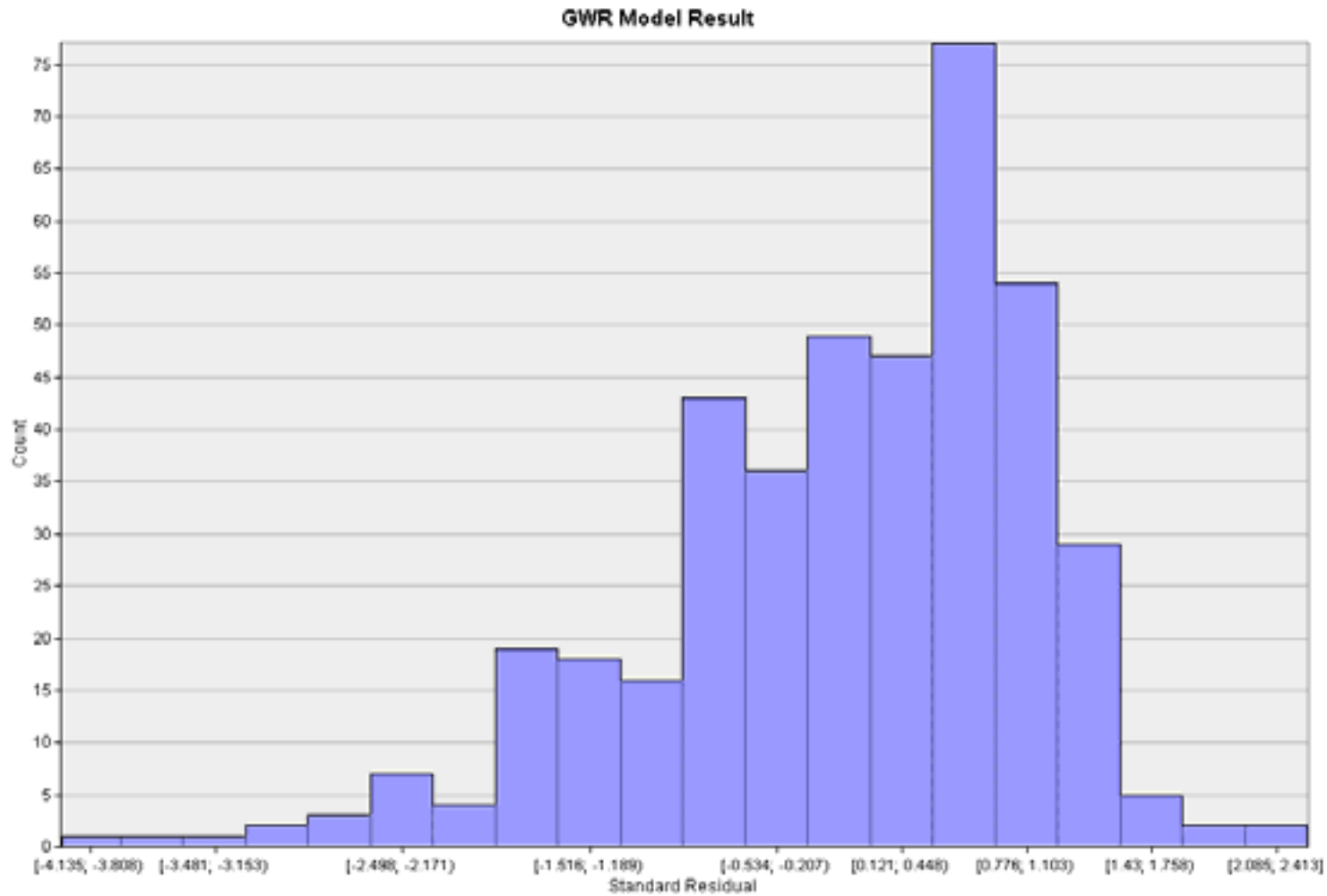
GWR Model Result

Geographically Weighted Regression (GWR)
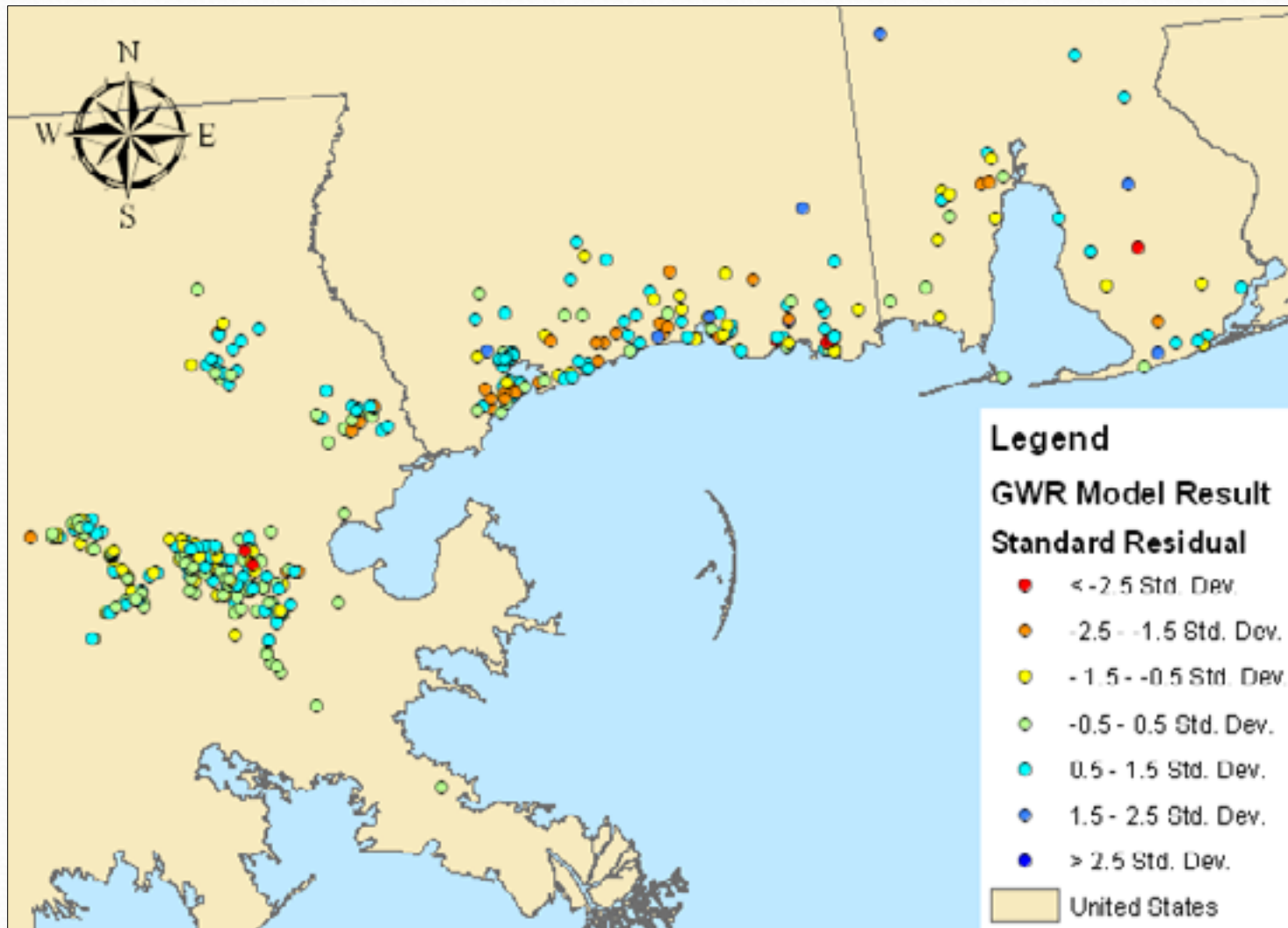
Conclusion

- OLS Regression Model:
  - Model Misspecification
- GWR Model:
  - Regional Variation
  - Low Performance

Questions?