

**Project 5: Spatial Interpolation and Depth Analysis of Gulf of Mexico Oil and Gas
Platforms**

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a. Introduction

The purpose of this project was to analyze spatial patterns in water depth across the Gulf of Mexico oil and gas platforms and to evaluate the performance of different spatial interpolation techniques in predicting depth values. The study area encompassed the central and northern Gulf of Mexico, including offshore regions near Louisiana, Texas, and Mississippi, as shown in *Figure 1. Study Area – Gulf of Mexico Oil and Gas Platforms*. The primary objective was to process the available platform depth data, apply statistical transformations to improve distributional characteristics, and compare two interpolation methods, Inverse Distance Weighting (IDW) and Simple Kriging, against each other and against the NOAA U.S. Coastal Relief Model bathymetric dataset. A combination of GIS-based geoprocessing and geostatistical modeling was employed, culminating in the creation of detailed predictive depth maps and comparative error analyses.

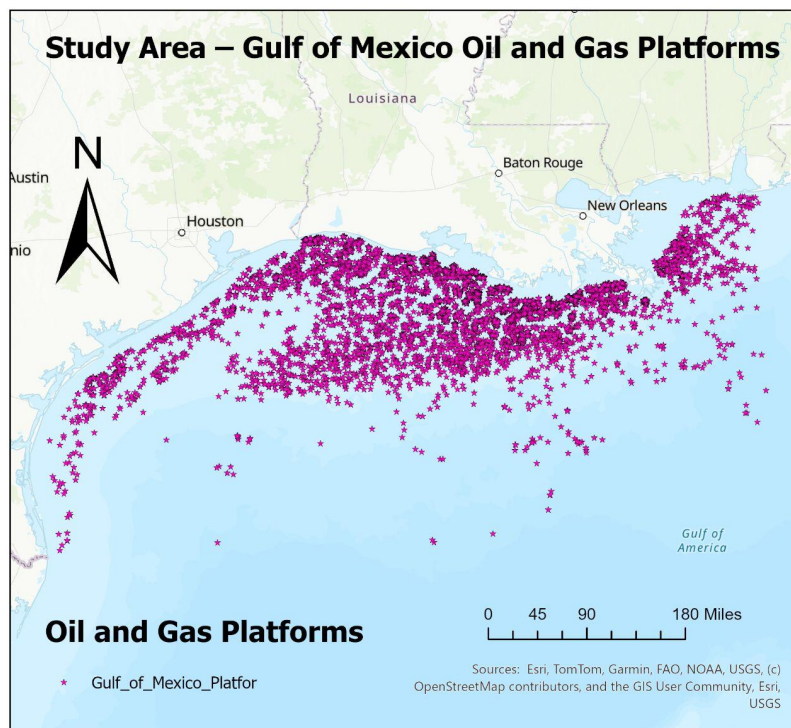


Figure 1. Study Area – Gulf of Mexico Oil and Gas Platforms

b. Data and Data Processing

The original dataset consisted of platform locations and water depth measurements in feet, projected in WGS 1984 (ITRF00). For spatial analysis accuracy, the data were reprojected to NAD 1983 UTM Zone 15N to align with the NOAA bathymetric raster and facilitate precise distance-based interpolation.

Dataset	Description	Data Source
Oil_and_Natural_Gas_Platform	A dataset comprising point features representing the locations of oil and natural gas drilling platforms situated along the coastal regions of the United States.	United States Department of Homeland Security (DHS)
Remotely Sensed Bathymetric Data for the Gulf of Mexico	Bathymetric data for the Gulf of Mexico obtained through remote sensing, sourced from the Gulf of Mexico Coastal Ocean Observing System (GCOOS).	Gulf of Mexico Coastal Ocean Observing System (GCOOS)
U.S. Coastal Relief Model Vol. 4 - Central Gulf of Mexico (NetCDF)	Comprehensive offshore bathymetry and topography dataset covering the central Gulf of Mexico, integrating multibeam bathymetry, hydrographic surveys, and trackline bathymetry. Downloaded as NetCDF format from NOAA NCEI.	Download NetCDF File (NOAA National Centers for Environmental Information)

Table 1. Dataset Description

Erroneous and null depth entries, including values of -999 and 0, were removed to ensure data integrity. Depth values were converted from feet to meters by multiplying by 0.3048, and a new field, Water Depth (m), was added to the attribute table. Initial exploration of the water depth distribution revealed a strong right skew, with a mean of approximately 35.88 m and a median of 17.37 m, as well as a large standard deviation of 115.91 m, indicating the presence of extreme deep-water outliers. To address the skewness, a log base-10 transformation was applied, producing the LOG_WDEPTH variable. The resulting distribution, illustrated in *Figure 2*.

Distribution of LOG_WDEPTH, was more symmetric, with a mean of 1.28, median of 1.24, and standard deviation of 0.40, thereby improving suitability for geostatistical modeling.

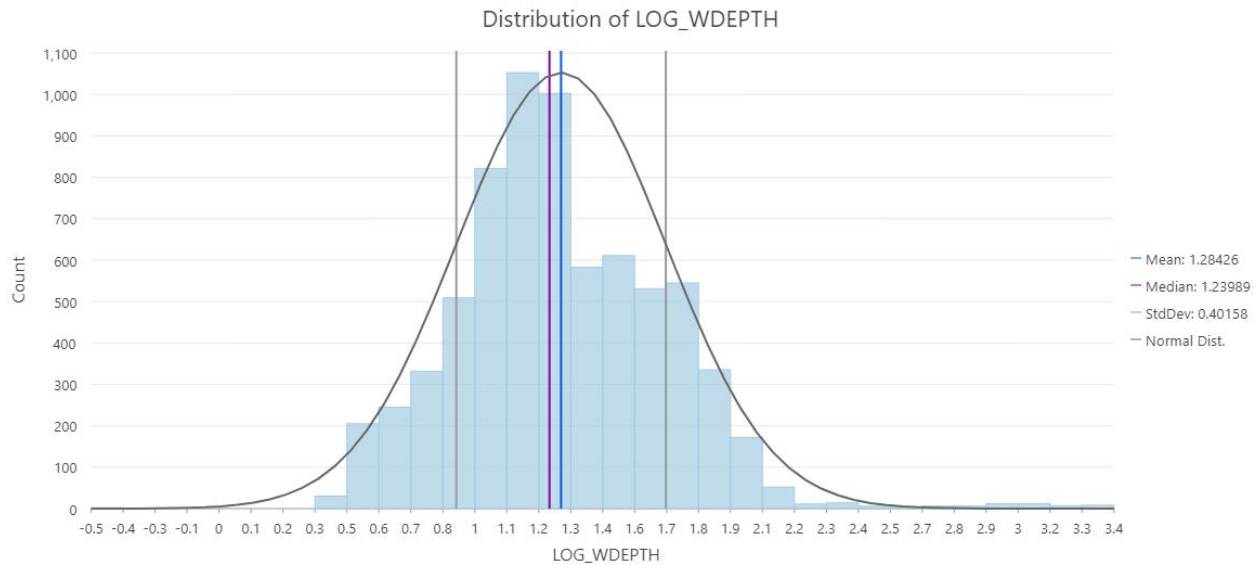


Figure 2. Distribution of LOG_WDEPTH

c. Methods

Two interpolation techniques were selected for analysis. Simple Kriging was chosen for its ability to incorporate spatial autocorrelation and provide estimates of prediction uncertainty, making it valuable for evaluating confidence in spatial predictions. A first-order polynomial trend analysis was also performed to model large-scale depth gradients before interpolation, and residual maps were generated to highlight local deviations from the trend surface (*Figure 3. Residual Map of Log Water Depth*). IDW was selected as a deterministic method that is computationally efficient and capable of producing smooth predictions while heavily weighting nearby observations. This made it suitable for comparison against Kriging in terms of precision and bias. Both methods were applied to the log-transformed depth values, and results were back-transformed to meters for comparison with NOAA's DEM. Cross-validation was used to quantify prediction accuracy, with mean error and root mean square error (RMSE) calculated for

each technique. For NOAA data integration, the U.S. Coastal Relief Model Vol. 4 for the central Gulf of Mexico was obtained as a NetCDF file, projected into NAD 1983 UTM Zone 15N, resampled to match the interpolation raster resolution, and converted to meters for direct comparison.

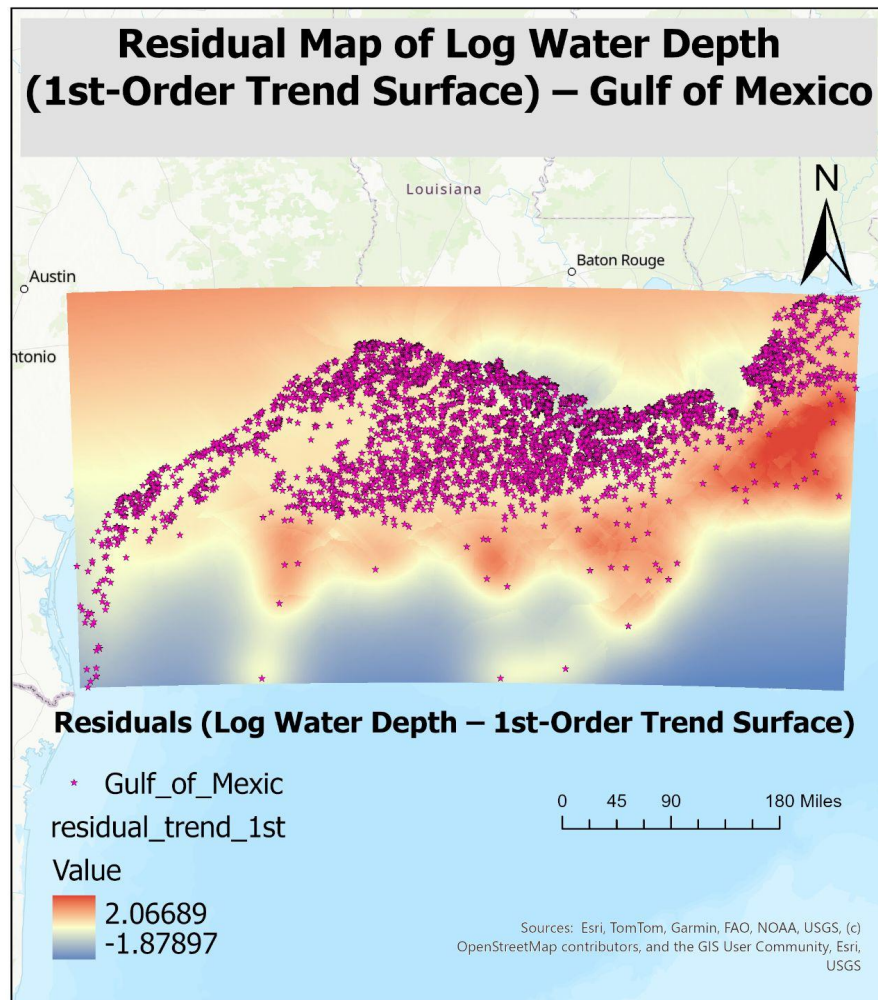


Figure 3. Residual Map of Log Water Depth

Prior to conducting the interpolation analyses, a first-order trend surface model of the log-transformed water depth was generated to examine large-scale spatial patterns across the Gulf of Mexico. This preliminary step allowed for the identification of broad depth gradients and provided insights into the regional bathymetric structure before applying localized interpolation

methods. The trend surface map (*Figure 4. First-Order Trend Surface of Log Water Depth in the Gulf of Mexico*) revealed a clear north-south gradient in water depth, with shallower areas concentrated along the continental shelf and deeper zones extending toward the central and southern Gulf. This understanding informed the interpretation of residuals and improved the assessment of model performance in later stages of the analysis.

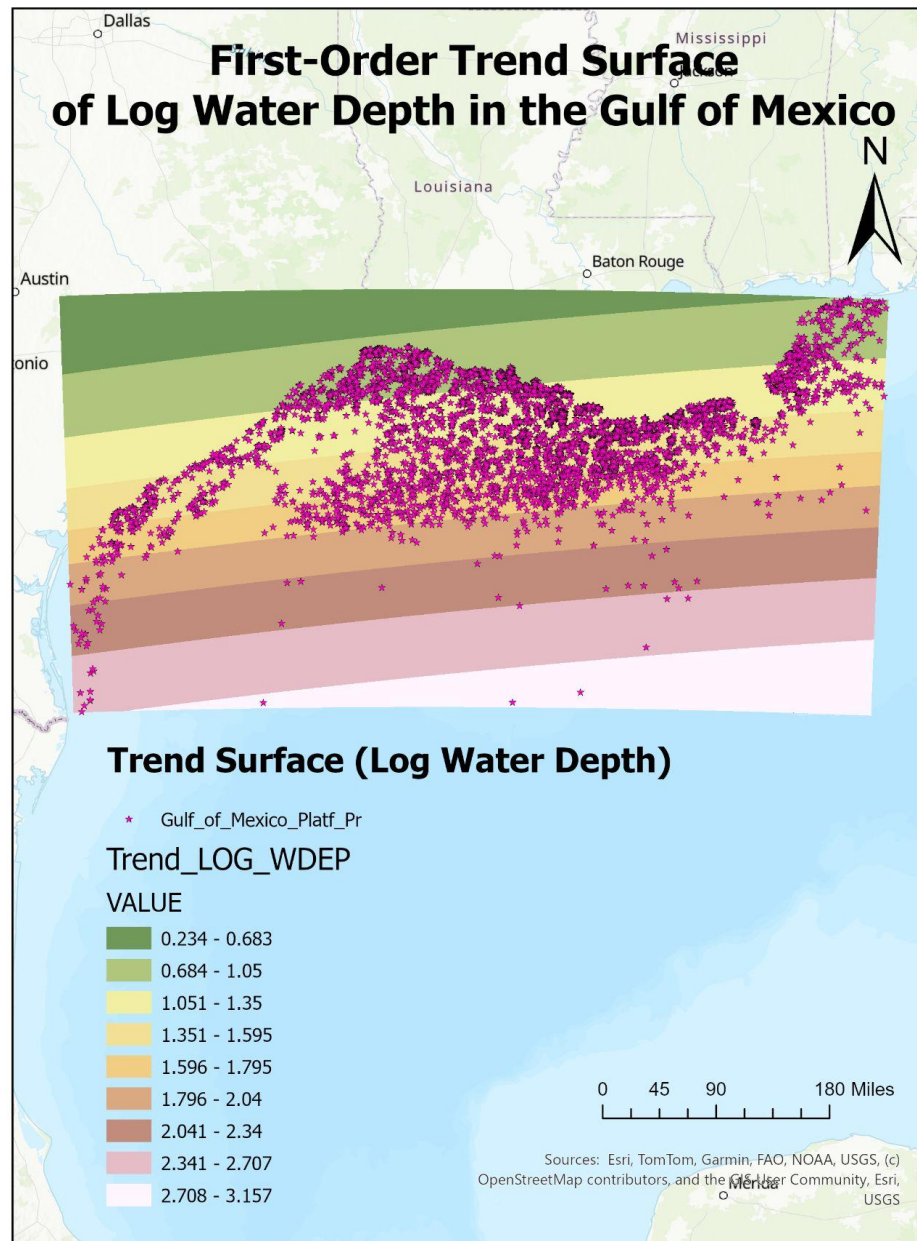


Figure 4. First-Order Trend Surface of Log Water Depth in the Gulf of Mexico

d. Results

The IDW interpolation produced predictions that closely matched observed values, with a mean prediction error of -0.0045 and an RMSE of 0.0697, as shown in *Figure 5*.

LOG_WDEPTH_IDW_CV_Predicted_vs_Measured and *Figure 6*.

LOG_WDEPTH_IDW_CV_Distribution. The predicted and measured distributions were nearly identical, and errors were centered near zero with no systematic bias across the depth range (*Figure 7. LOG_WDEPTH_IDW_CV_Error*). Simple Kriging predictions are also closely aligned with measured values, with a mean prediction error of 0.0061 and an RMSE of 0.0880, as seen in *Figure 8. LOG_WDEPTH_Simple_Kriging_CV_Prediction_Predicted_vs_Measured*.

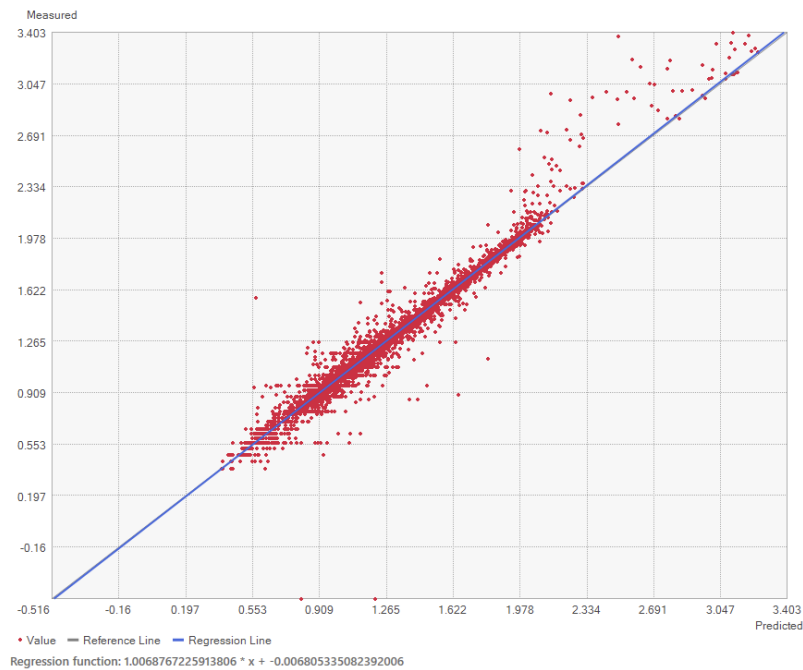


Figure 5. LOG_WDEPTH_IDW_CV_Predicted_vs_Measured

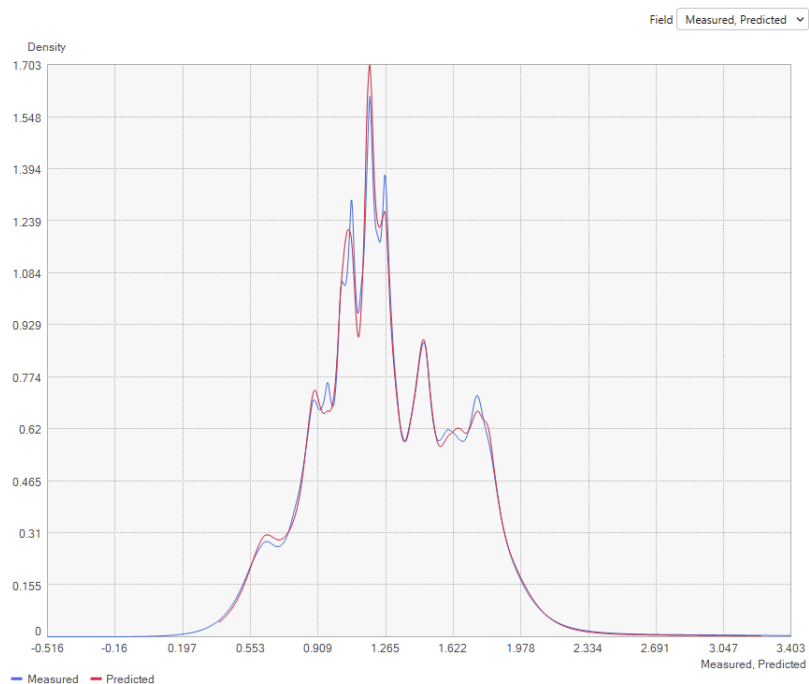


Figure 6. LOG_WDEPTH_IDW_CV_Distribution

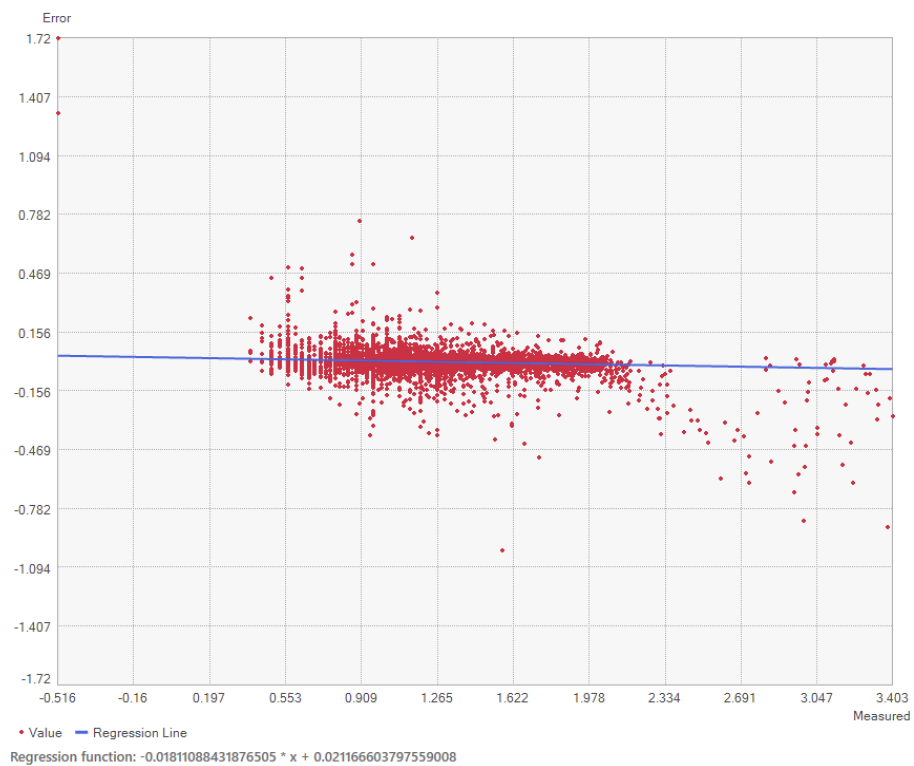


Figure 7. LOG_WDEPTH_IDW_CV_Error

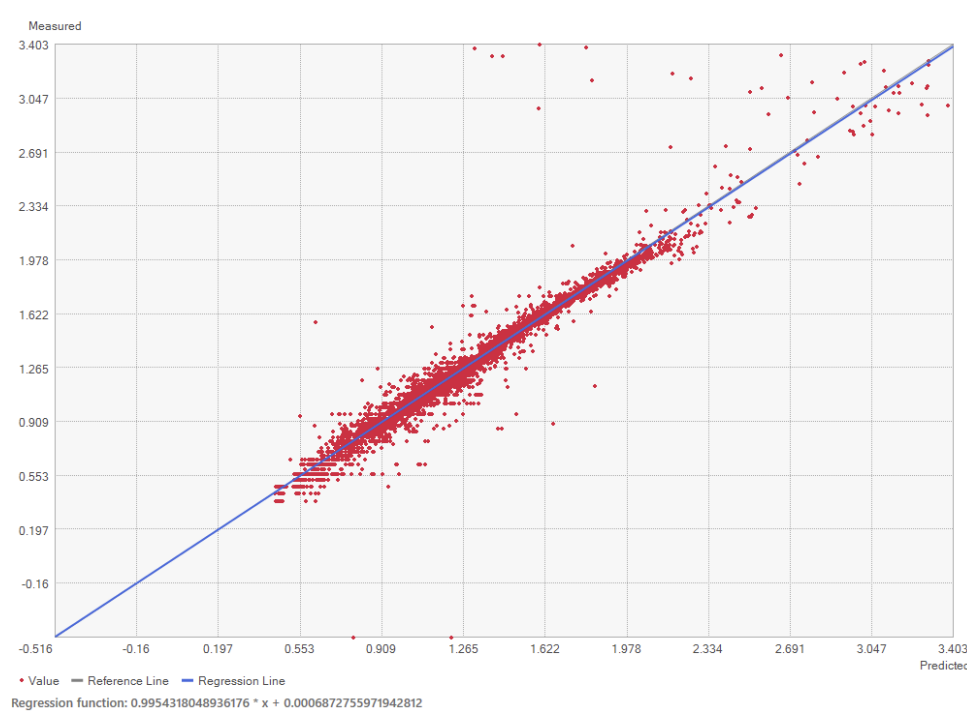


Figure 8. LOG_WDEPTH_Simple_Kriging_CV_Prediction_Predicted_vs_Measured

The Kriging-predicted distribution (*Figure 9.*

LOG_WDEPTH_Simple_Kriging_CV_Prediction_Distribution) matched the observed distribution well, though slight deviations appeared near secondary peaks. The normal Q-Q plot (*Figure 10. LOG_WDEPTH_Simple_Kriging_CV_Prediction_Normal QQ Plot*) confirmed that Kriging residuals largely met the normality assumption, except at the extreme tails.

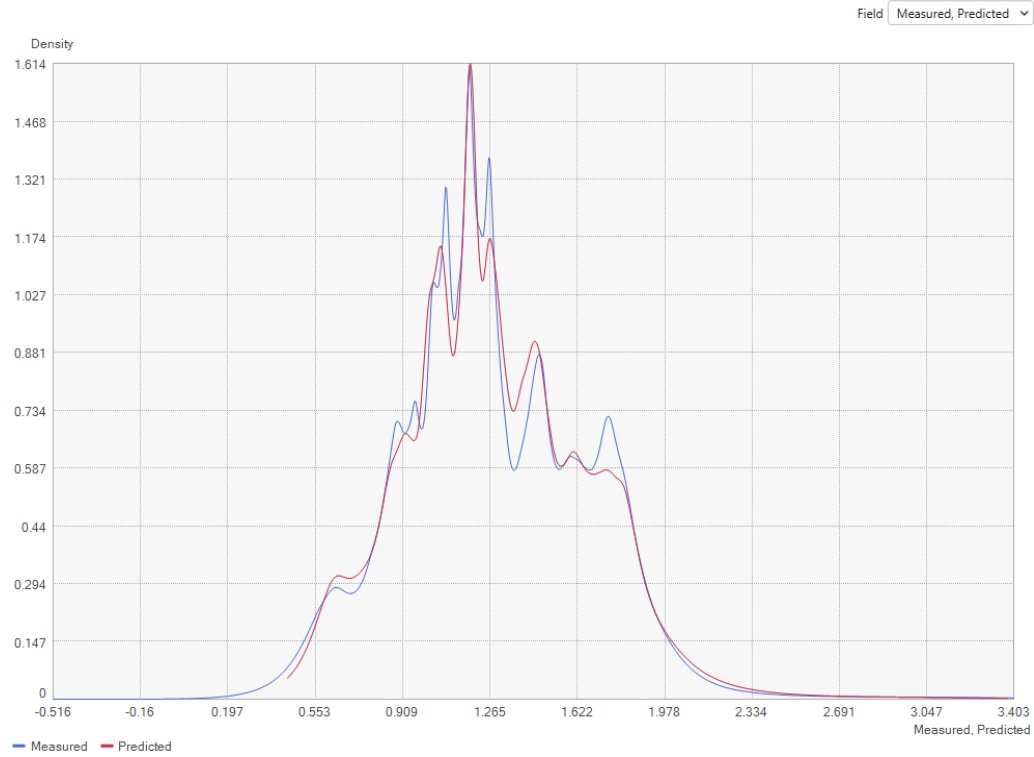


Figure 9. LOG_WDEPTH_Simple_Kriging_CV_Prediction_Distribution

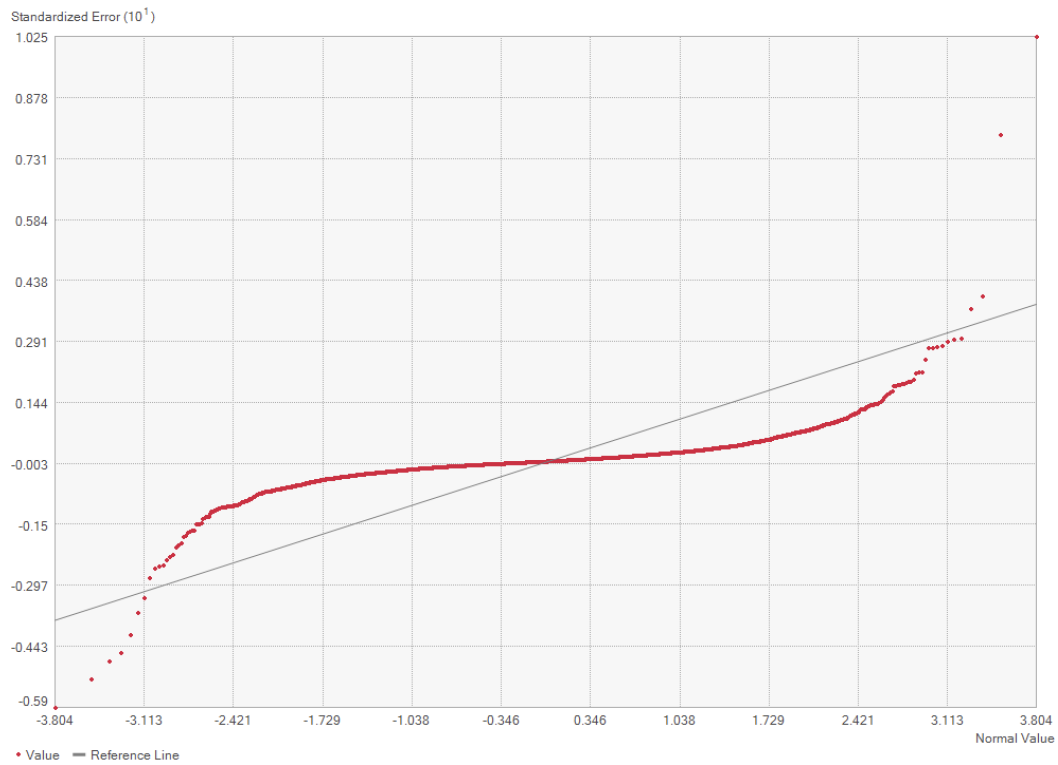


Figure 10. LOG_WDEPTH_Simple_Kriging_CV_Prediction_Normal_QQ Plot

Both techniques produced maps showing spatial depth variation across the Gulf (Figures 11 and 12, IDW Prediction of LOG_WDEPTH and Simple Kriging Prediction of LOG_WDEPTH), with Kriging additionally providing a standard error map for uncertainty visualization (Figure 13. Simple Kriging Standard Error of LOG_WDEPTH).

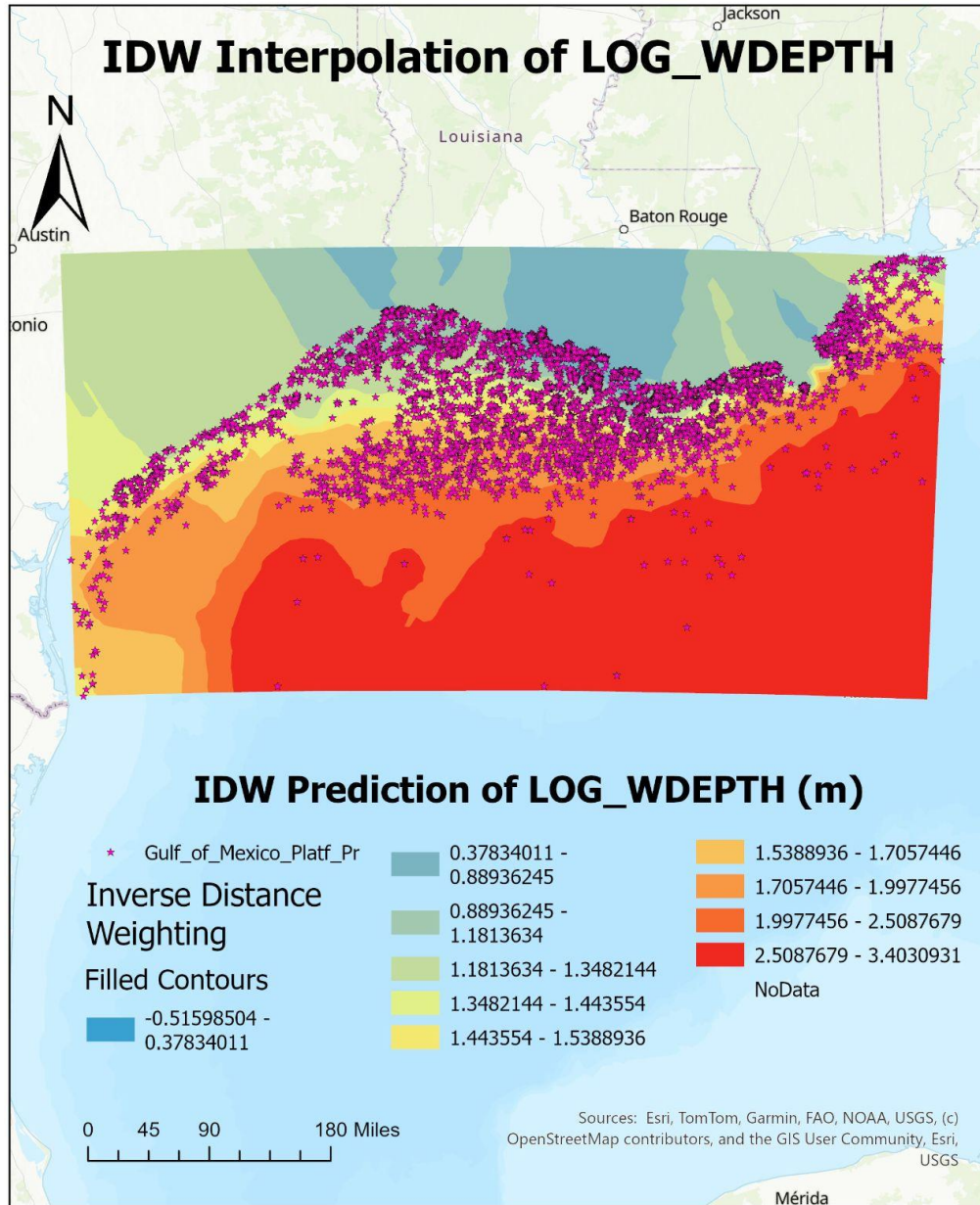


Figure 11. IDW Prediction of LOG_WDEPTH

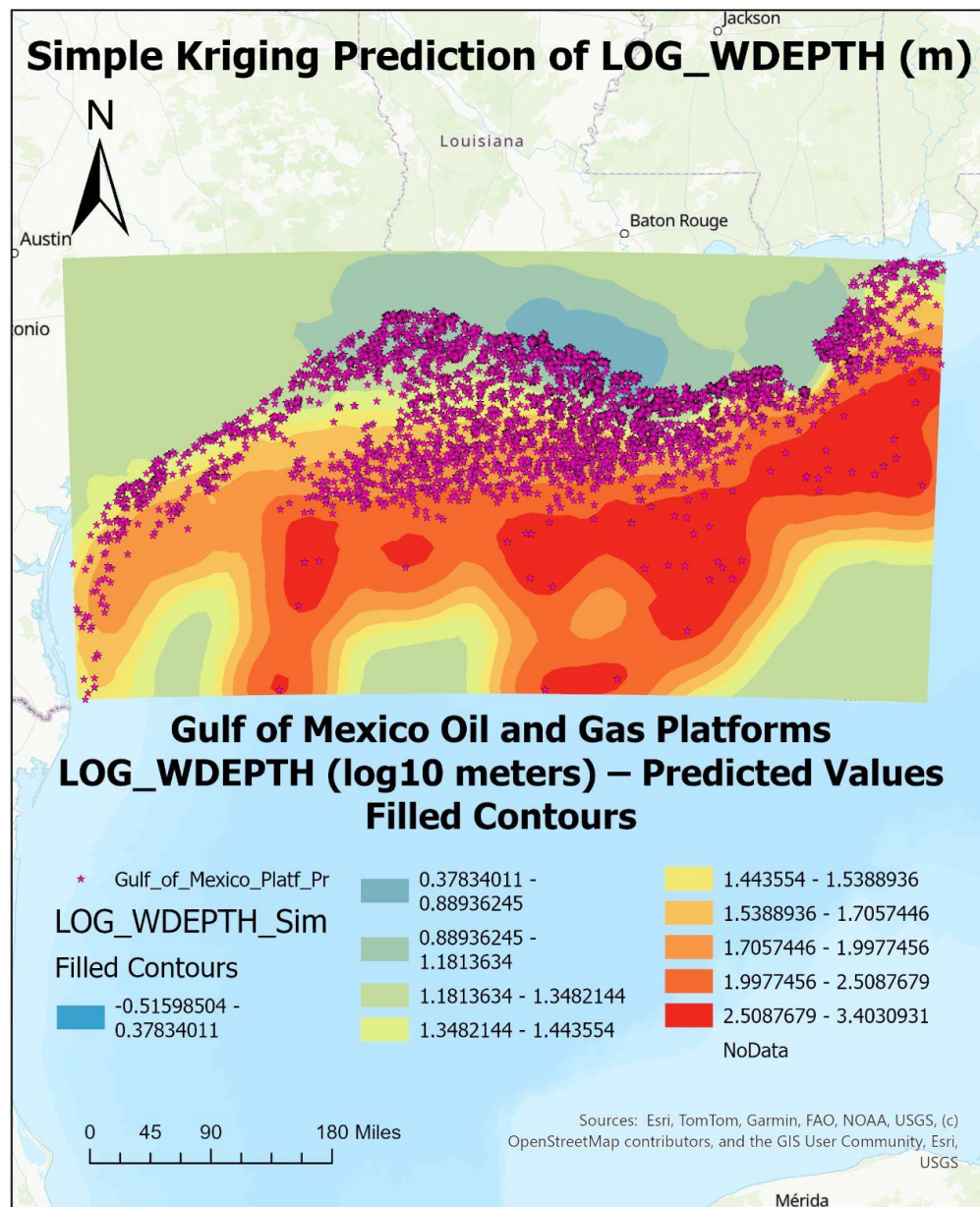


Figure 12. Simple Kriging Prediction of LOG_WDEPTH

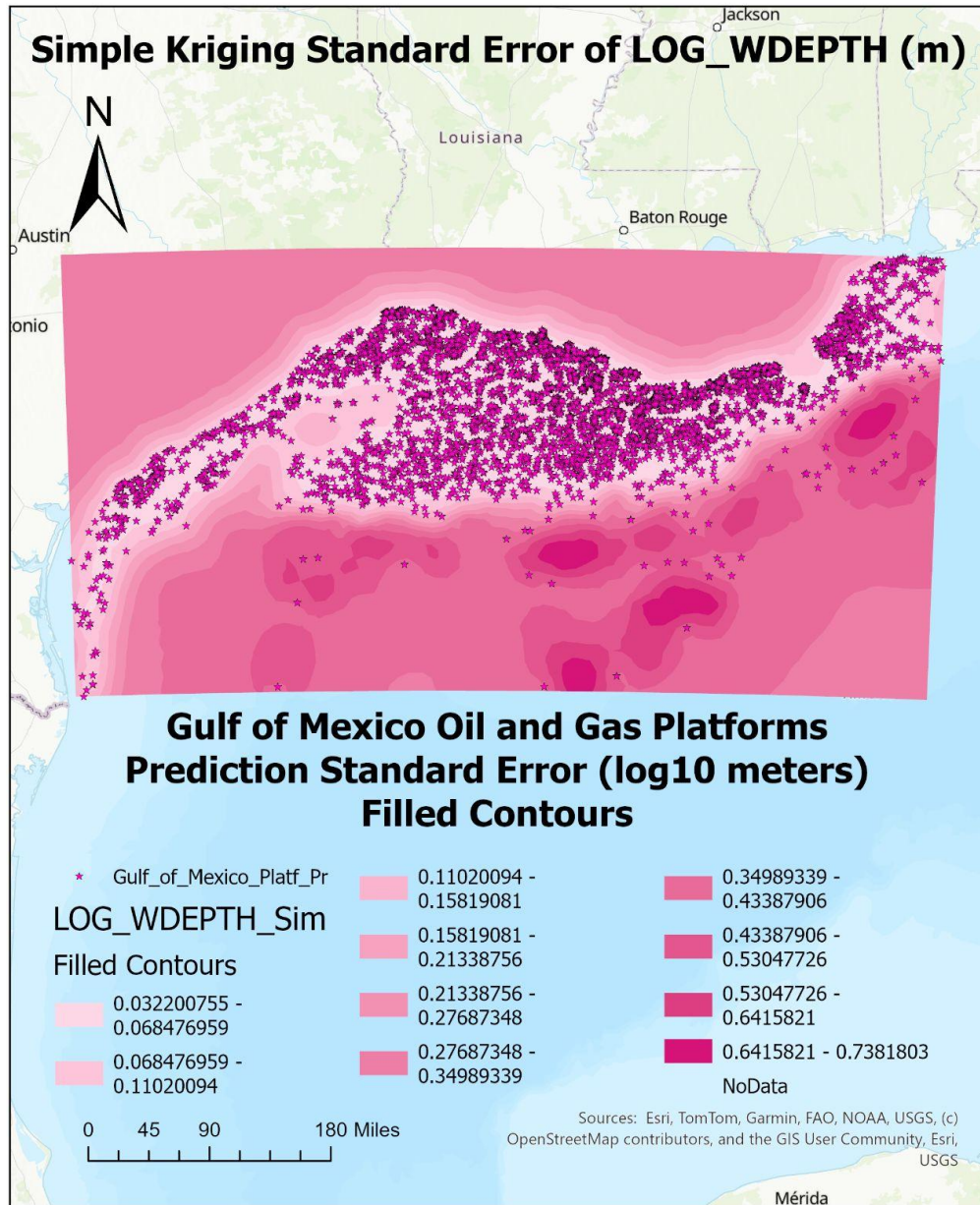


Figure 13. Simple Kriging Standard Error of LOG_WDEPTH

Comparisons against NOAA's DEM revealed distinct spatial patterns in depth differences. The IDW–NOAA difference map (*Figure 14. Difference in Depth: IDW – NOAA*) showed relatively small deviations, with most of the study area falling within ± 50 m of NOAA values. The Kriging–NOAA difference map (*Figure 15. Difference in Depth: Kriging – NOAA*) indicated larger discrepancies in certain deep-water regions, with differences exceeding 500 m in

isolated areas. Summary statistics (*Table 2. Error Statistics for Bathymetric Depth Estimation Methods*) showed that IDW achieved the smallest bias (-0.17 m) and lowest standard deviation (1.69 m) compared to observations, outperforming both Kriging (-2.57 m bias, 63.08 m std. dev.) and NOAA (-0.55 m bias, 5.85 m std. dev.).

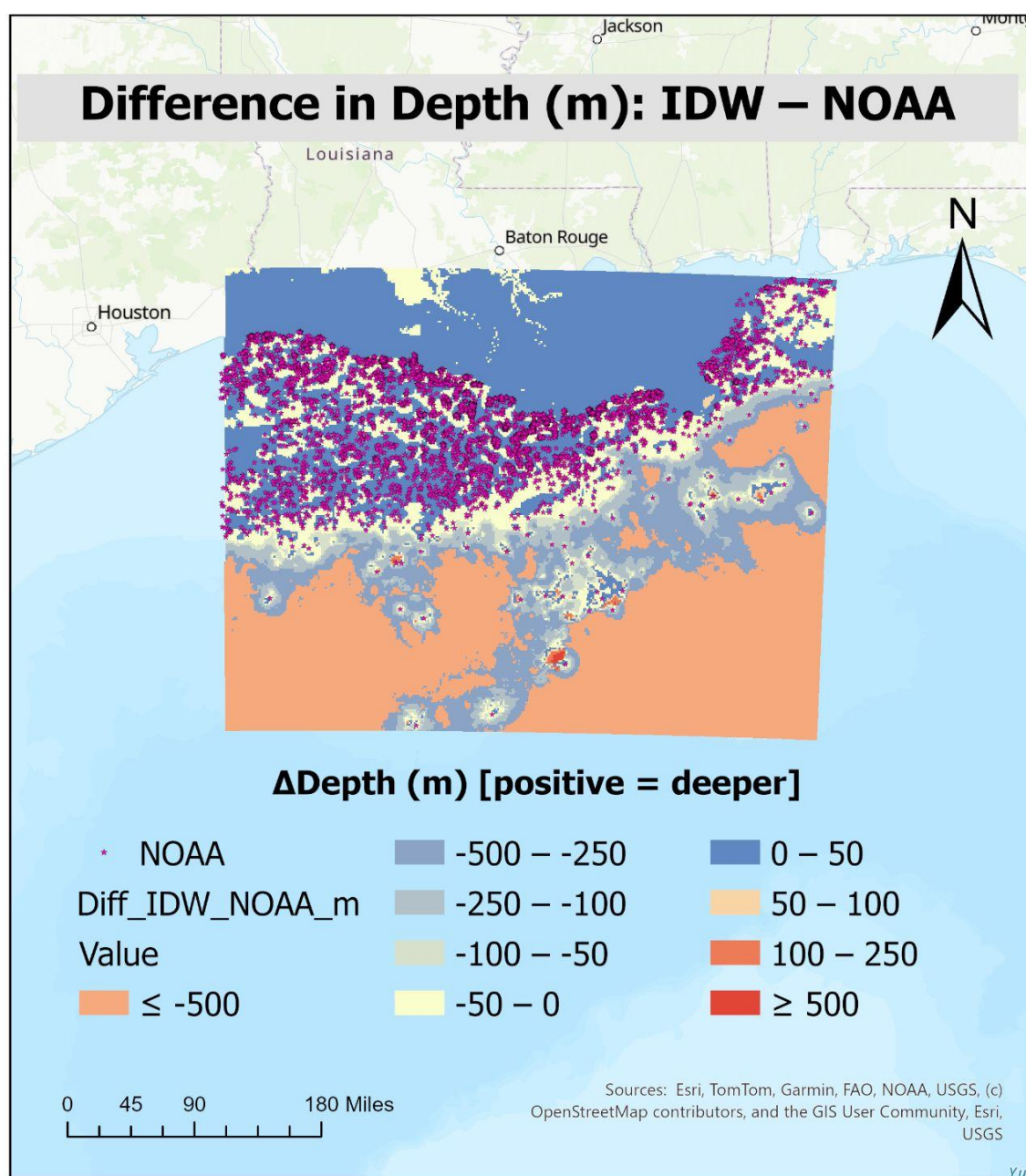


Figure 14. Difference in Depth: IDW – NOAA

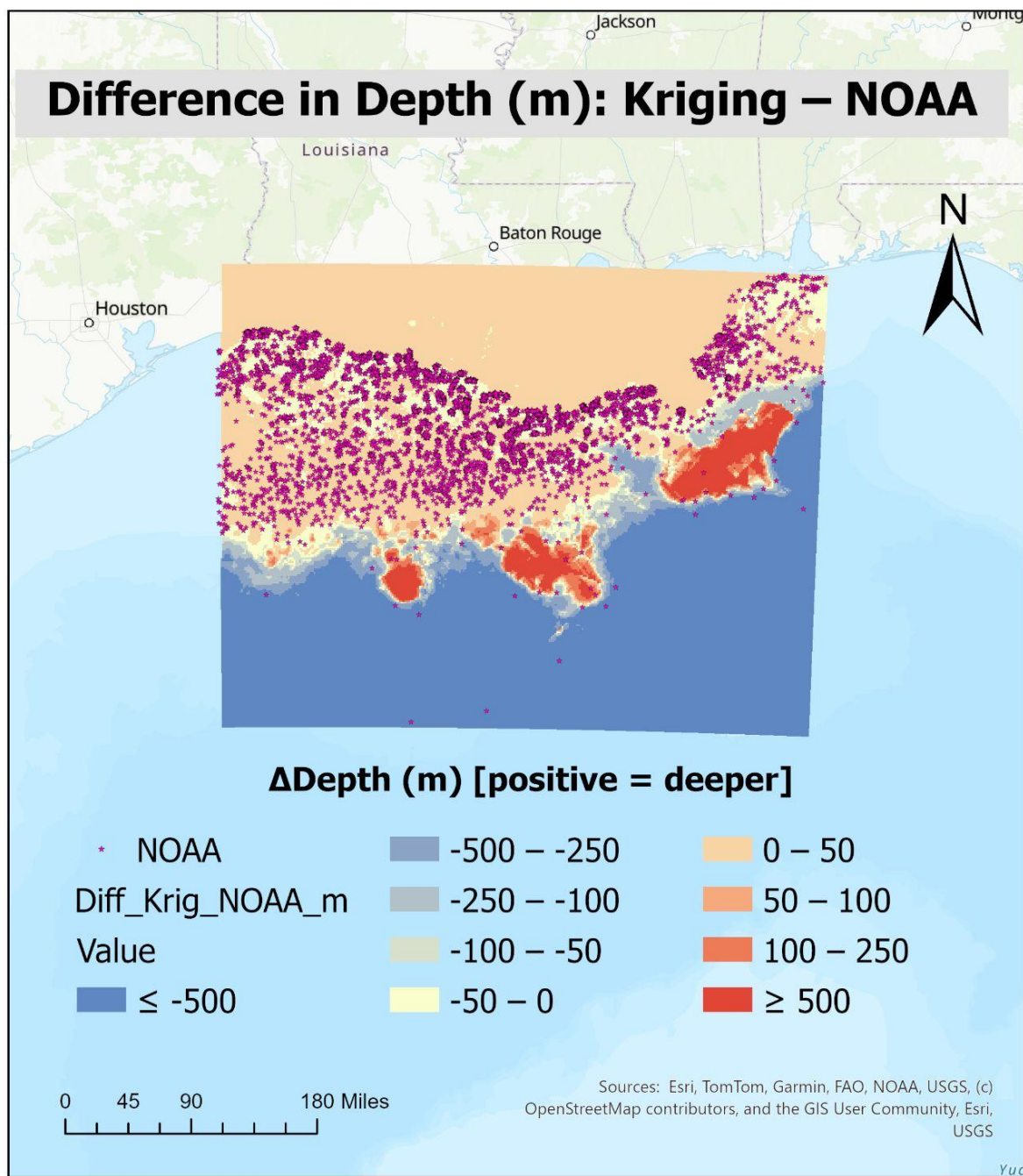


Figure 15. Difference in Depth: Kriging – NOAA

Method	Mean Error (m)	Std. Deviation (m)	Min Error (m)	Max Error (m)
NOAA	-0.55	5.85	-256.06	186.67
Kriging	-2.57	63.08	-2044.61	511.16
IDW	-0.17	1.69	-43.78	19.29

Table 2. Error Statistics for Bathymetric Depth Estimation Methods

e. Discussion

The results indicate that IDW was the most precise method for this dataset, producing low bias and consistent predictions across the Gulf of Mexico platforms. Kriging's inclusion of spatial autocorrelation and ability to provide standard error maps is advantageous for understanding prediction uncertainty, but its performance was hindered by larger deviations in certain deep-water areas. NOAA's DEM aligned well with observations in general but showed less agreement than IDW. One limitation of the analysis is the inherent spatial bias in platform distribution, with denser sampling in shallower waters near shore and sparser coverage offshore. This spatial clustering may have influenced interpolation accuracy, particularly for Kriging, which depends heavily on the spatial structure of the input data. Additionally, while the log transformation improved model performance, it assumes a consistent multiplicative error structure, which may not fully capture depth variability in heterogeneous bathymetric environments. Future work could integrate additional bathymetric datasets, explore anisotropic variogram models for Kriging, and assess hybrid approaches that combine deterministic and geostatistical methods.

f. Appendix

Chenyi Weng took the lead in data preprocessing, projection transformations, log transformation of depth values, and executing the IDW interpolation analysis, as well as preparing the majority of the visualizations, including distribution maps and NOAA DEM difference outputs. Monica Delgado contributed by performing the Simple Kriging interpolation, generating the trend surface and residual maps, and assisting with the statistical cross-validation. Both authors collaborated closely on interpreting the results, composing the discussion, and refining the final report.

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