Uncertainty Analysis in Geological Surface Modelling

Introduction

Geological surface models provide information about the stability of a 3D geological model. The uncertainty in surface modelling is a result of the interaction between the data, the geostatistical model assumptions, and the estimation methods. Predictions of uncertainty can be successfully generated using the random realisations of the surface realisation process to provide data points. As a result, geological surface models can be used to understand the uncertainty in predictions and estimation methods.

Errors (i.e., prediction or estimation errors) are defined by differences between estimated and observed values. The assessment of the uncertainty in geological surface models is performed using the random realisations of predictions and estimation methods, as well as the predicted values. The mean of estimation errors over all locations is called the root-mean-square error (RMSE). The uncertainty in the estimation of geological surfaces using interpolation methods is also calculated using the RMSE. The RMSE is determined using the bias and variance of errors.

Sources of Uncertainty

Data Quality

High-quality data are successful in generating geological analysis. Not all the data are equally valuable. Data with a high-quality index (QC) indicates the most valuable data. The data with a high-quality index (QC) indicates the least valuable data. The quality of data is determined by the quality of data.

Geological Complexity

The geological complexity is a significant cause of high uncertainty in surface modelling. Errors in geological models are generated by the geological complexity of the stratigraphic units (e.g., Leduc reefs; Figure 1).

Surface Estimation

The quality of surface estimation is a significant cause of high uncertainty in surface modelling. Errors in surface estimation are generated by the surface estimation methods (e.g., ordinary kriging; Figure 1).

Implementation of Global Uncertainty

Global uncertainty analysis is a result of the interaction between the data and the geostatistical model assumptions. Predictions of uncertainty can be successfully generated using the random realisations of the surface realisation process to provide data points. As a result, geological surface models can be used to understand the uncertainty in predictions and estimation methods.

Global and Local Uncertainty

Global uncertainty (Figure 4a) is defined as the difference between the predicted and observed values over all locations. Local uncertainty (Figure 4b) is defined as the difference between the predicted and observed values at a specific location. Cross-validation error (Figure 4c) is defined as the difference between the predicted and observed values at a specific location. Prediction standard error (Figure 4d) is defined as the standard deviation of the prediction error at a specific location.

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Conclusion

Global uncertainty analysis is a very complex task. The uncertainty in geological surface models is a result of the interaction between the data, the geostatistical model assumptions, and the estimation methods. Errors in geological surface models are generated by the geological complexity of the stratigraphic units (e.g., Leduc reefs).

Table 1: Comparison of prediction errors for the Waterways top surface estimation.

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Figure 9: Uncertainty map based on the standard deviation for multiple subset realizations of the Waterways Formation.

Implementation of Local Uncertainty

Local uncertainty analysis is a very complex task. The uncertainty in geological surface models is a result of the interaction between the data, the geostatistical model assumptions, and the estimation methods. Errors in geological surface models are generated by the geological complexity of the stratigraphic units (e.g., Leduc reefs; Figure 1).

Conclusion

Global uncertainty analysis is a very complex task. The uncertainty in geological surface models is a result of the interaction between the data, the geostatistical model assumptions, and the estimation methods. Errors in geological surface models are generated by the geological complexity of the stratigraphic units (e.g., Leduc reefs; Figure 1).

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