Empirical assessment of the uncertainty in a 3-D geological framework model

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Summary

Three-dimensional framework models are the state of the art to present geologists' understanding of a region in a form that can be used to support planning and decision making. However, there is little information on the uncertainty of such framework models. This poster reports an experiment in which five geologists each produced a framework model of a single region in the east of England which was then compared with independent validation observations.

Methods

The area used in this study was the TM24 Ordnance Survey map sheet around Ipswich and Woodbridge, Suffolk in Eastern England which covers an area of 10-km×10-km. Figure 1 to the right shows a 2-D map of the modelled units and an example cross-section.

A total of 347 boreholes were available for the map sheet. Five random and non-overlapping subsets of these boreholes were selected as validation subsets, one for each modeller. Each modeller was provided with a unique subset of boreholes after their particular validation subset was withheld. The modellers then proceeded independently to model selected units in the study area within the GSI3D environment (Kessler et al., 2009).

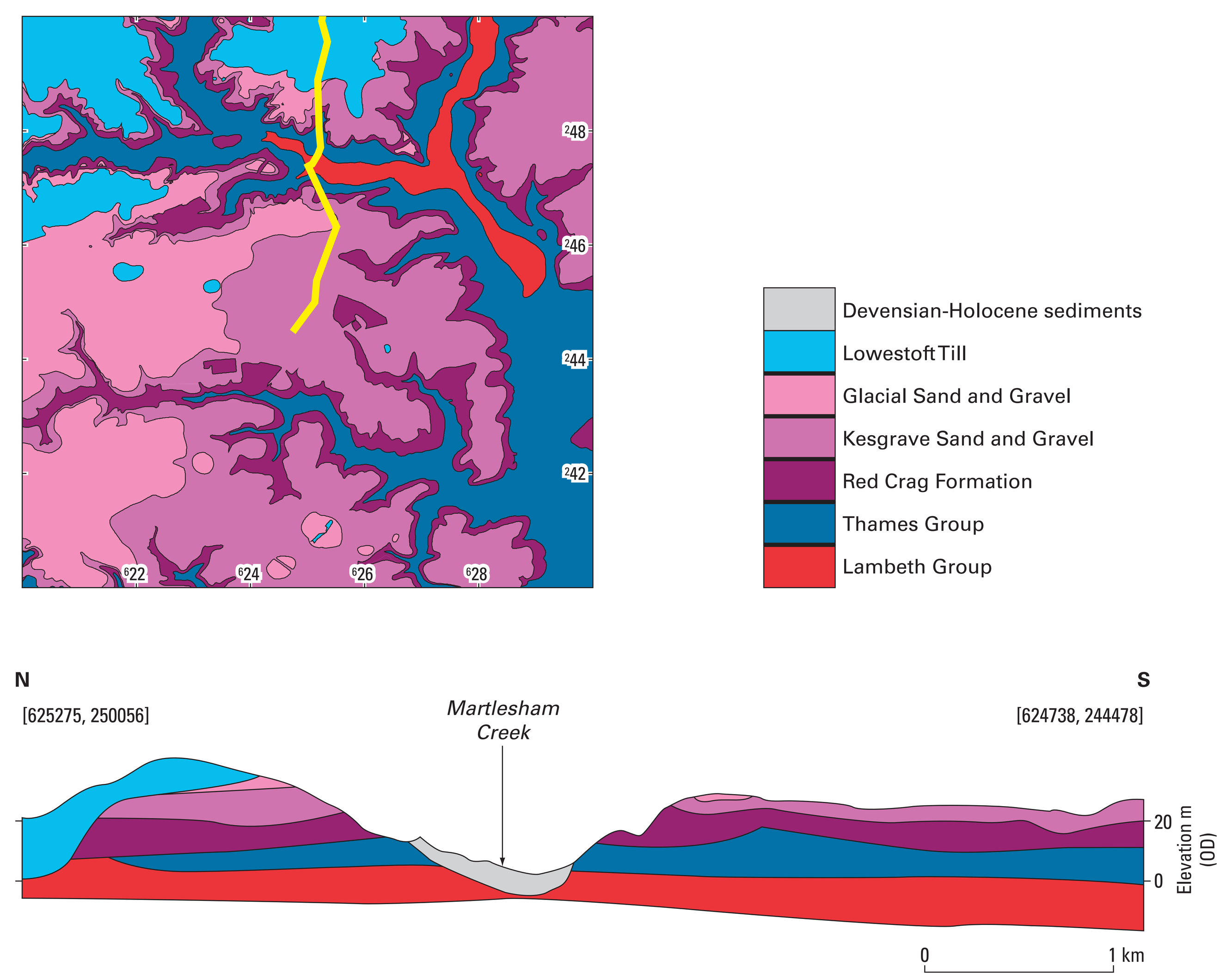

Figure 1: A 2-D map of the modelled units in the study area with an example cross-section.

Analysis

For each unit in the model the observed and modelled heights of surfaces were extracted for the validation boreholes. The model error was computed as the difference between the two. Figure 2 shows the plot of observed versus modelled height for all bases combined.

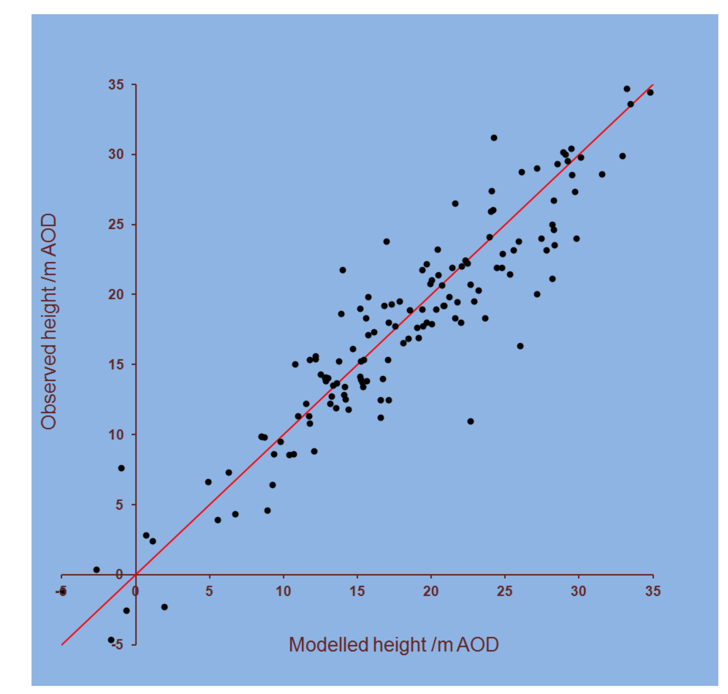

Figure 2: Observed height of surface above Ordnance Datum plotted against the modelled height.

Analysis

Model error was analysed using linear mixed models to evaluate evidence for:

- Random effects due to differences between modellers and their data subsets
- Systematic bias in the model
- Dependence of the variance of model error on factors such as distance to nearest borehole

Analyses were completed for separate units and for the combined set of bases.

Results

The statistical analysis showed:

- There was no evidence for an effect of modeller, and error variance attributable to this effect is generally small
- The mean error is not significantly different from zero (the model is unbiased)
- The uncertainty of the model appears to increase with depth, but there was no evidence that it depends on distance from the neighbouring borehole or the crop line
- The confidence interval about the model surface which contains the true surface with 95% probability varies from ±5.6 m to ±6.4 m

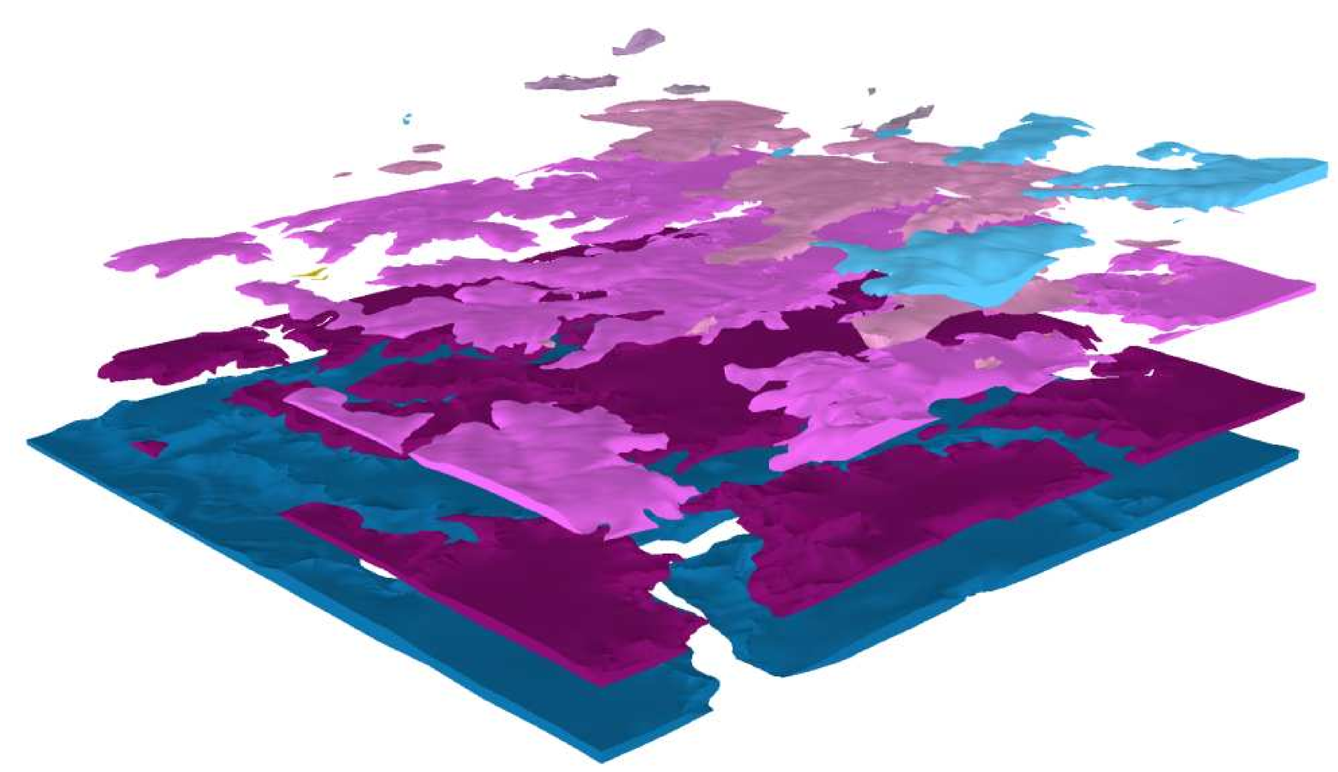

Figure 3: An exploded view of a model viewed from the North-East. Unit colours as in Figure 1.

Conclusions

- Designed modelling experiments can be used to quantify model uncertainty
- Such experiments should be used to benchmark uncertainty in models for different geological terrains
- Further work is needed to understand how errors emerge and propagate in the GSI3D workflow.

Reference and further information

Kessler, H., Mathers, S.J., Sobisch, H.-G. 2009. The capture and dissemination of integrated 3D geospatial knowledge at the British Geological Survey using GSI3D software and methodology. Computers & Geosciences, 35, 1311–1321.

This work is described in more detail in a paper in press:

Lark, R.M., Mathers, S.J., Thorpe, S., Arkley, S.L.B., Morgan, D.J., Lawrence, D.J.D. A statistical assessment of the uncertainty in a 3-D geological framework model. *Proceedings of the Geologists Association*

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