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How to find what you don't know: Visualising variability in 3D geological models

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Uncertainties in input data can have compounding effects on the predictive reliability of three-dimensional (3D) geological models. Resource exploration, tectonic studies and environmental modelling can be compromised by using 3D models that misrepresent the target geology, and drilling campaigns that attempt to intersect particular geological units guided by 3D models are at risk of failure if the exploration geologist is unaware of inherent uncertainties. In addition, the visual inspection of 3D models is often the first contact decision makers have with the geology, thus visually communicating the presence and magnitude of uncertainties contained within geological 3D models is critical. Unless uncertainties are presented early in the relationship between decision maker and model, the model will be considered more truthful than the uncertainties allow with each subsequent viewing.

We present a selection of visualisation techniques that provide the viewer with an insight to the location and amount of uncertainty contained within a model, and the geological characteristics which are most affected. A model of the Gippsland Basin, southeastern Australia is used as a case study to demonstrate the concepts of information entropy, stratigraphic variability and geodiversity. Central to the techniques shown here is the creation of a model suite, performed by creating similar (but not the same) version of the original model through perturbation of the input data. Specifically, structural data in the form of strike and dip measurements is perturbed in the creation of the model suite.

The visualisation techniques presented are: (i) information entropy; (ii) stratigraphic variability and (iii) geodiversity. Information entropy is used to analyse uncertainty in a spatial context, combining the empirical probability distributions of multiple outcomes with a single quantitative measure. Stratigraphic variability displays the number of possible lithologies that may exist at a given point within the model volume. Geodiversity analyses various model characteristics (or 'geodiveristy metrics'), including the depth, volume of unit, the curvature of an interface, the geological complexity of a contact and the contact relationships units have with each other. Principal component analysis, a multivariate statistical technique, is used to simultaneously examine each of the geodiveristy metrics to determine the boundaries of model space, and identify which metrics contribute most to model uncertainty. The combination of information entropy, stratigraphic variability and geodiversity analysis provides a descriptive and thorough representation of uncertainty with effective visualisation techniques that clearly communicate the geological uncertainty contained within the geological model.