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What should an ideal objective function for 4D stratigraphic units look like ?

Griffiths, C.M. [1]

[1] *CSIRO Petroleum Resources, Kensington, WA*
Email: cedric.griffiths@csiro.au

Abstract: Stratigraphic units are the three-dimensional representation of the preserved history of deposition and erosion of sediment on the earths crust as it changes over geological time. They can thus arguably be considered four-dimensional. Each discrete unit is bounded by an unconformity or disconformity representing 'missing' time (hiatus) – or time for which we have no evidence of sedimentation at that location. Stratigraphic forward modelling aims, within a limited area of the earths crust, to reproduce the pattern of sediment erosion, transport, deposition, erosion and re-deposition. We do this in order to predict the preserved distribution of sediments of economic or societal value sometimes many kilometres below the surface.

The resolution of the modelling depends on the purpose of the study. Typical oil-field reservoir studies may require spatial predictions at 25 m or less and temporal resolutions of the order of 10000 years. Regional studies encompassing an entire basin may have spatial resolutions of the order of kilometres with the same temporal resolution.

Observations against which the predictions may be validated or compared vary from 3D seismic records at around 10 m horizontal and 2 m vertical resolution, well data at discrete locations with a vertical resolution of 15 cm for wireline data and 1 mm for sparse core data, to 2D seismic data at line separations of the order of hundreds of metres.

The ideal objective function for quantitatively comparing stratigraphic forward modelling results with this type of observation requires at least the following properties, enabling comparison of the:

- properties, thickness, and age(duration) of a preserved unit
- distribution and (lateral change in) duration of the hiatus' separating each unit
- shape of a preserved unit
- shape of a hiatus

Many objective functions currently used in, for example, ensemble Kalman filtering approaches, are based on some relatively simple statistical measure. As Reynolds (2008) states: 'critical assumptions are that: Predictions of state vectors are Gaussian; Covariances can be represented by ensemble members; Gaussian noise in data; Predicted data are a linear function of the state vector'.

Although property, thickness, and duration values for each individual 3D unit or hiatus may be considered Gaussian, the temporal assemblage of units and spatial distribution is not. Objective functions that do not have such underlying assumptions may be preferable in the case of stratigraphioc forward modelling. Some alternatives are discussed.

Keywords: *Stratigraphic units, Objective functions.*

Abstract only