PhD Open Days

Uncertainty quantification in geostatistical seismic inversion

PHD PROGRAMME IN PETROLEUM ENGINEERING

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Abstract

Geostatistical seismic inversion methodologies are one of the most powerful tools to model subsurface Earth's petro-elastic properties (e.g. P-and S-wave velocities, density and porosity), using well-log data and seismic reflection data. One of the main drawbacks of these type of methodologies is when at earlier stages of the iterative procedure it achieves very high local correlation coefficients that may cause the iterative procedure to be trapped in local minima and therefore compromising the exploration of the model parameter space. This effect is translated in similar elastic models during the entire iterative procedure. This work proposes the extension of traditional iterative geostatistical seismic inversion methodology in order to incorporate stochastic sequential simulation techniques that avoid the use of local correlation coefficients and consequently of being trapped in local minima far from the global one at early stages of the iterative procedure.

Methodology

The proposed iterative geostatistical seismic inversion procedure uses DSS with local probability distributions (Soares et al., 2017) as the model perturbation technique, that assume the uncertain soft data as a lack of accuracy and precision of the measurement. That uncertain data can be modelled by a set of possible values z which can occur according to a probability distribution function.
The proposed methodology has three direct advantages:

- speeds-up the inversion procedure;
- does not need the use of local correlation coefficients that may cause an overfitting of the inversion procedure after the 1st iteration.
- allows assessing local probability distribution function of the inverted elastic property at each seismic sample.

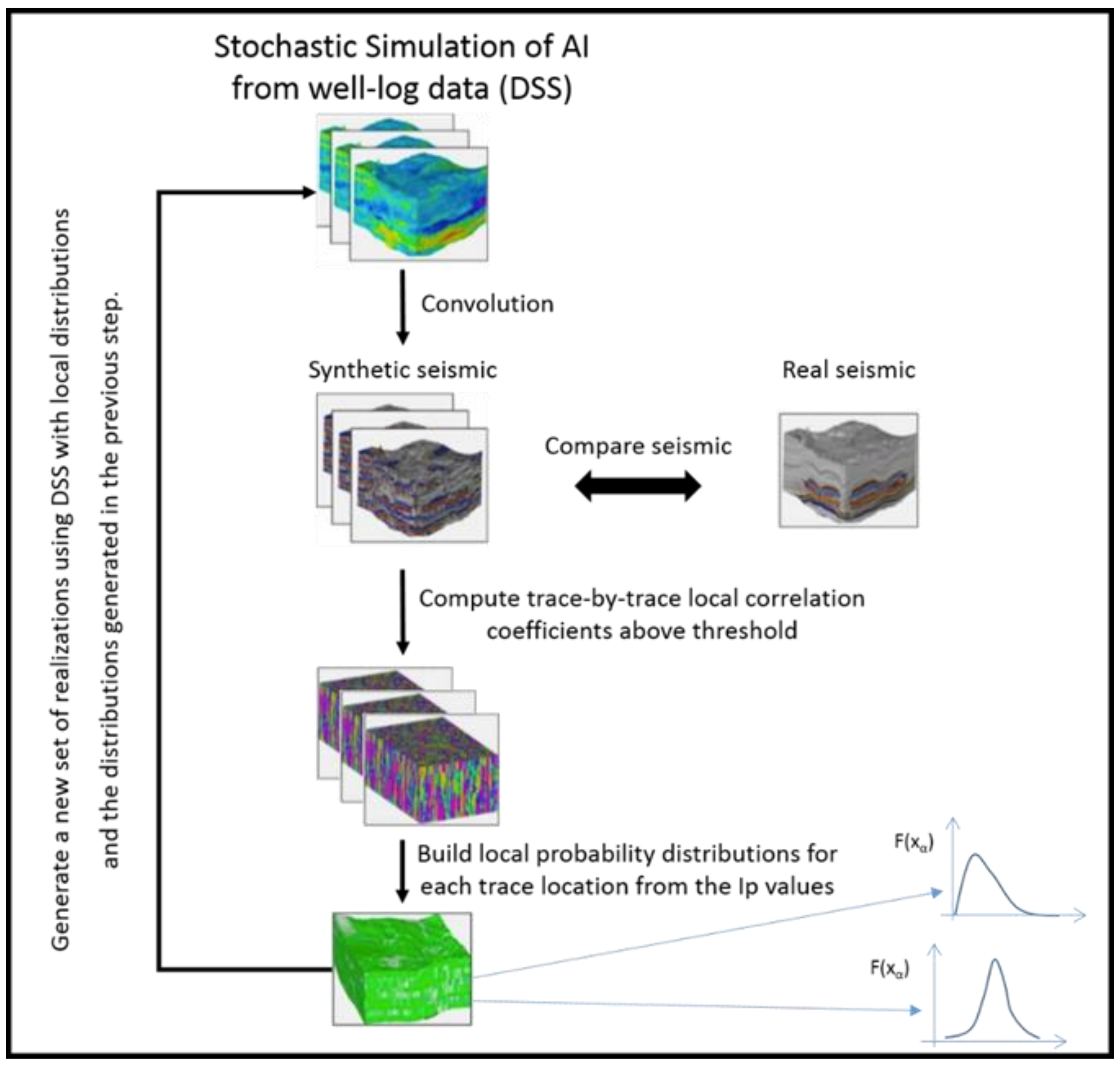
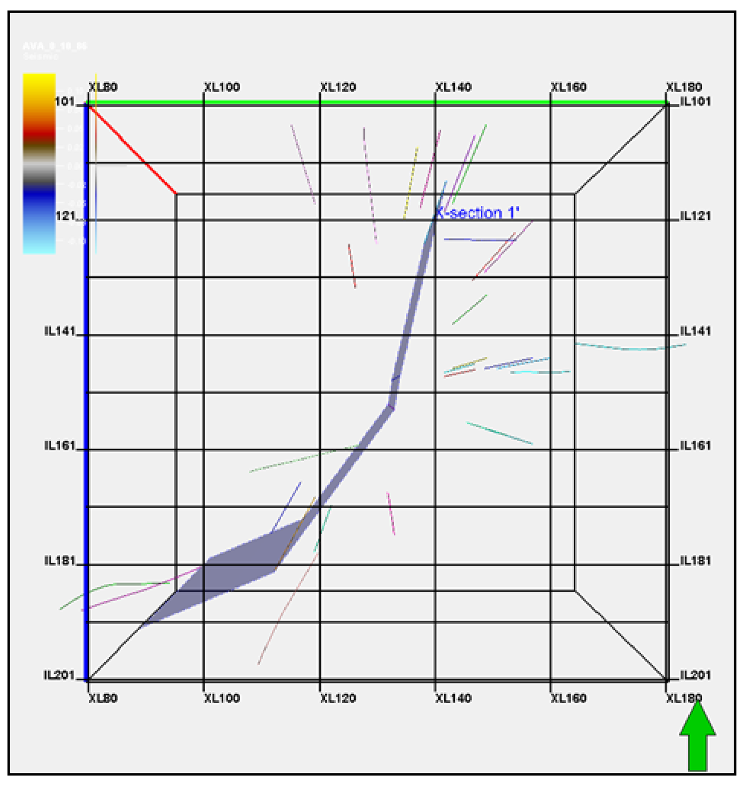


Figure 1: Schematic representation of the proposed geostatistical seismic inversion methodology based on the use of DSS with local probability.

Application

The proposed methodology was applied to a synthetic dataset (Figure 2) and a real dataset (Figure 3), with six iteration, each one with 32 models of Ip simulated.



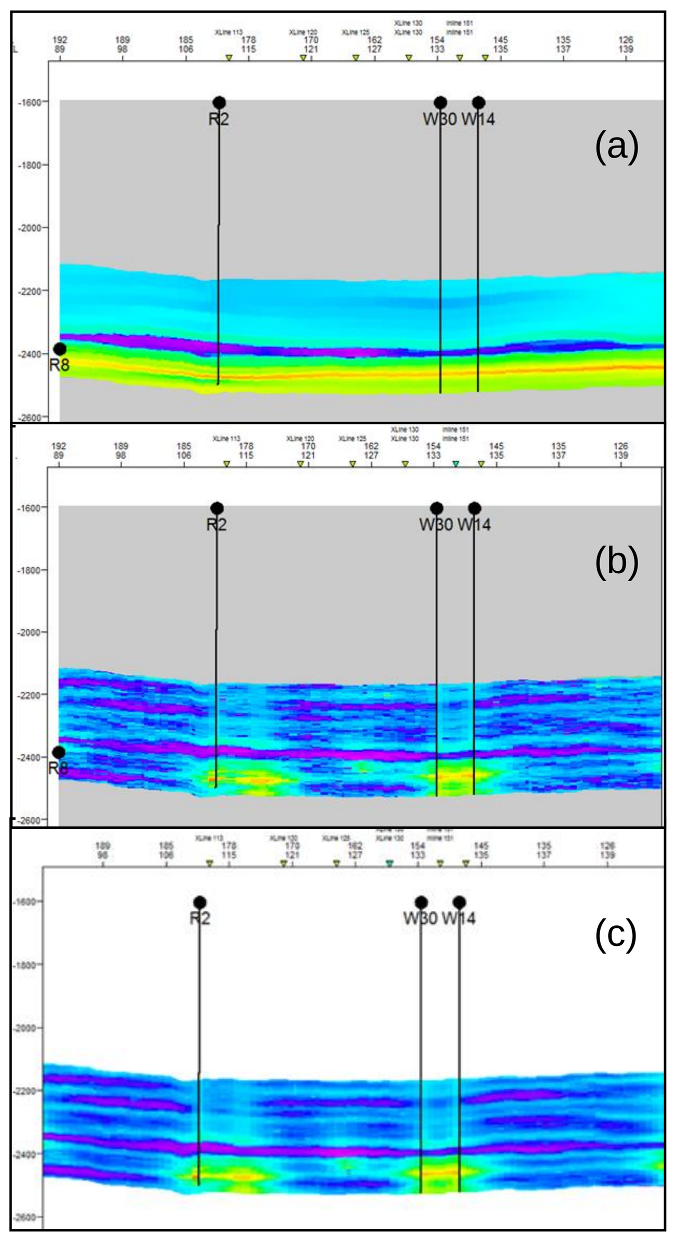
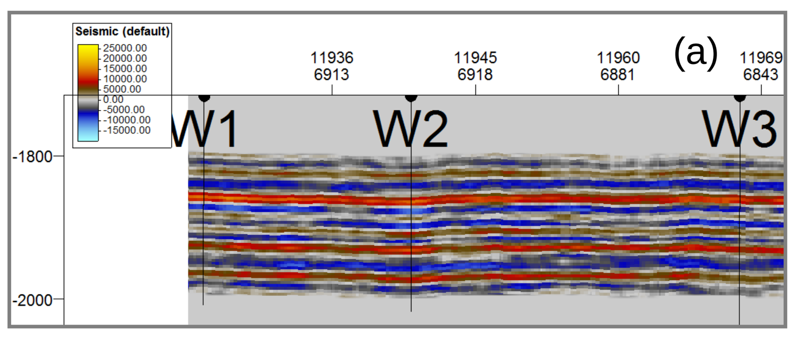


Figure 2: Synthetic dataset available (101x101x90 grid with 32 wells). (a) Real Ip model; (b and c) Realization of Ip from the 6th iteration and Mean Ip model from that iteration using the proposed geostatistical seismic inversion methodology.

The final synthetic seismic volume reached a global correlation coefficient when compared to the observed fullstack volume of about 80%. The inverted Ip models are able to reproduce properly the location and the value of the main features as interpreted from the true Ip model.



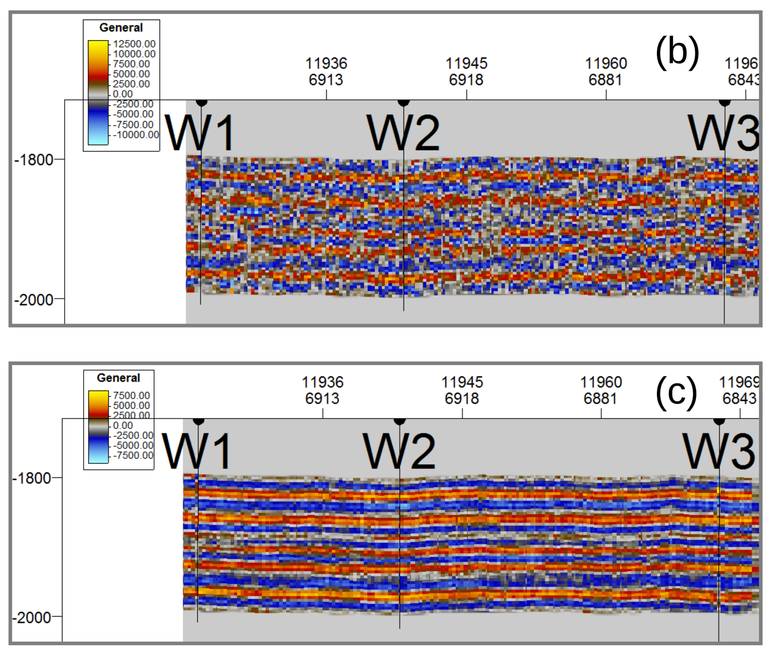


Figure 3: Real dataset available. (a) Real Seismic; (b and c) Seismic model from the 6th iteration and Mean seismic model from that iteration using the proposed GSI methodology.

Final remarks

- the inverted models from this methodology are more robust and match better the true Ip model than the traditional GSI;
- the ability to calculate statistical measurements at each cell of the grid;
- we are able to assess local uncertainties;
- avoid the iterative procedure to be trapped in local minima at early stages;
- a more comprehensive exploration of the model parameter space.

References

Soares, A., Nunes, R. and Azevedo, L. (2017) Integration of Uncertain Data in Geostatistical Modelling. Mathematical Geosciences.