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PSDM Uncertainty Characterization And Calibration Using A Fast Marching Algorithm

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Summary

PSDM provides very good imaging results but is often not optimal for time to depth conversion. PSDM model uncertainties quantification and calibration to well data may benefit from geostatistics. Complexity in the geological structures (presence of a salt dome for example) can be very challenging for spatializing data and requires therefore the use of innovative geostatistical techniques such as kriging with a fast marching algorithm.

Introduction

PSDM provides good imaging results but is very often not optimal for time to depth conversion. PSDM model uncertainties quantification and calibration to the wells may benefit from geostatistics. Complexity in the geological structures (presence of a salt dome for example) can be very challenging for spatializing data and requires therefore the need of innovative geostatistical techniques such as kriging with a fast marching algorithm.

A case study over the Oda field is used to present the methodology and the results. The Oda field is located in the Norwegian North Sea (licence PL405).

Oda Case Study

The data available consists of a smoothed PSDM velocity field, eight horizons and seven wells with sonic logs and well tops. The purpose of the study is to characterize the PSDM model uncertainty and then to calibrate it to the well data. The main challenge comes from the presence of a salt dome (see Figure 1). Conventional kriging techniques are inappropriate to handle such non-stationary geometries.

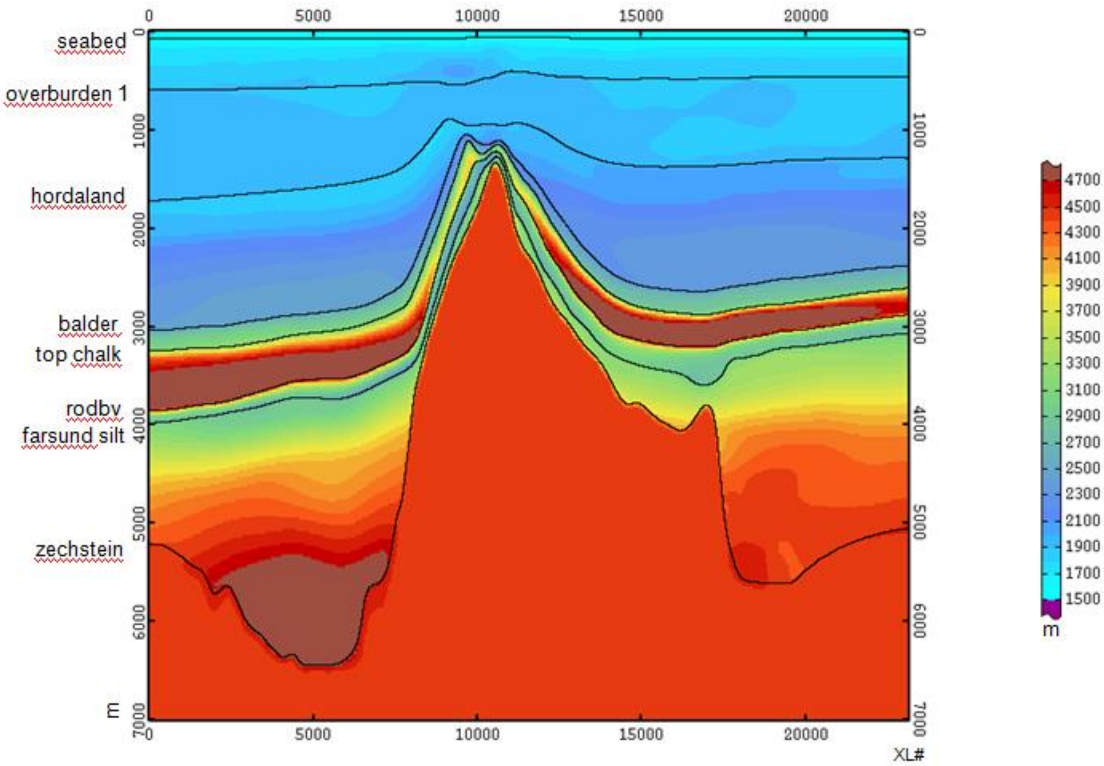

Figure 1 *PSDM instantaneous velocities, IL1600.*

In a first step, depth misties are obtained for each horizon by computing the differences between the horizon and the well tops.

The spatialization of the depth misties on a particular horizon has to follow the geological configuration (salt dome). Euclidian distances are no longer valid in such a structural context and should be replaced. A fast marching algorithm (Kimmel and Sethian 1998) is used to approximate the shortest path distance to follow the salt dome configuration. This shortest path distance replaces the usual Euclidean distance to compute covariance function values for kriging (Montouchet 2017). Depth misties are then spatialized on each horizon (see Figure 2). The low number of wells makes the interpretation of a spatial range difficult.

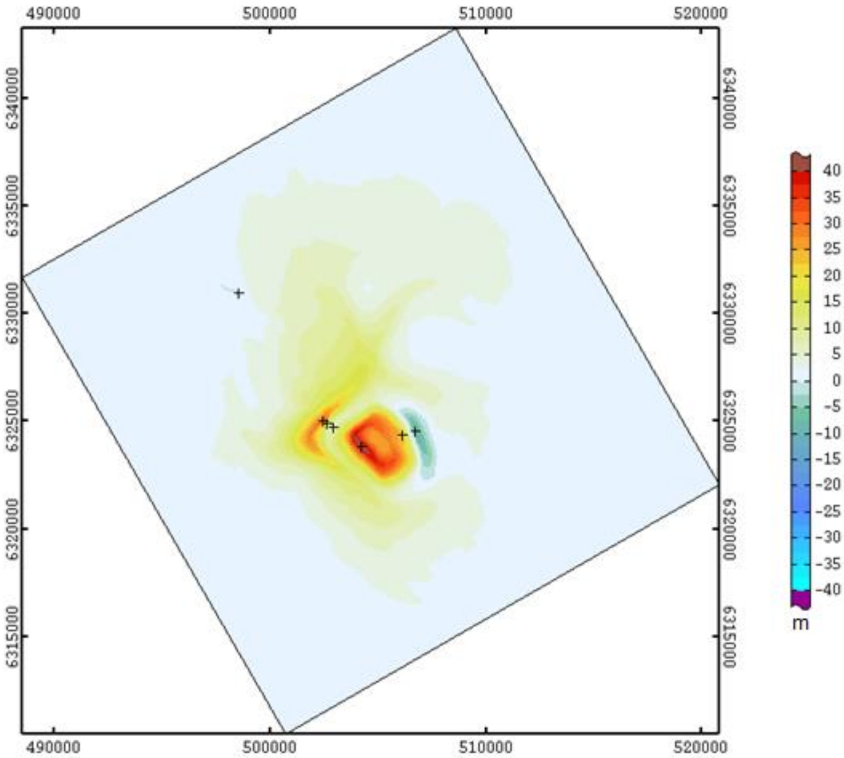

Figure 2 *Estimated depth misties for the Farsund Silt horizon.*

A variability analysis of the estimated depth misties is performed. Geostatistical kriging is then used to spatialize the uncertainty estimated at each horizon and obtain a 3D volume corresponding to the PSDM model uncertainty.

Finally, the PSDM model is calibrated to the wells. The key parameters derived from the spatial analysis of the depth misties are used to build the geostatistical calibration model. The PSDM velocity volume is calibrated to the wells by 3D Kriging with External Drift technique leading to a calibrated velocity volume.

Conclusion

The resulting calibrated PSDM velocity model and depth surfaces now incorporate 3D spatially understandable residual depth errors at the well locations. This enables the calibrated seismic data and velocities to be directly used by all disciplines involved in the Oda field technical studies.

Acknowledgements

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