Integrating prior knowledge and locally varying model parameters with M-GeoStatistics: methodology and application to bathymetry mapping

Cédric MAGNERON[1], Nicolas JEANNEE[2], Olivier LE MOINE[3], Jean-François BOURILLET[4]

1 **ESTIMAGES** - 10 avenue du Québec, 91140 Villebon-sur-Yvette, France - cedric.magneron@estimages.com
2 **GEOVARIANCES** - 49bis Avenue Franklin Roosevelt, BP91, 77212 Avon, France - jeannee@geovariances.com
3 **IFREMER** - Laboratoire Environnement-Ressource des Pertuis Charentais, Avenue de Mus de Loup, 17390 La Tremblade, France - olemoine@ifremer.fr
4 **IFREMER** - Dép. Géosciences Marines, Laboratoire Environnements Sédimentaires, BP70, 29280 Plouzané, France - jean.francois.bourillet@ifremer.fr

Introduction

Most geostatistical methods rely on a global variogram model, assuming stationarity for the underlying random function. Applying stationary approaches in the case of large/complex areas, even locally with a moving neighbourhood, can lead to unsuitable estimates. Though preferable to some extent, non stationary approaches hardly handle prior knowledge nor reproduce precisely complex structures, such as local anisotropies, spatially varying small-scale structures or heterogeneity.

The Moving-GeoStatistics (M-GS) methodology is fully dedicated to the local optimization of parameters involved in variogram-based models. This methodology ensures a better adequacy between the geostatistical model and the data.

The methodology is applied for bathymetry mapping. The adequacy of the M-GS methodology is illustrated and compared with classical estimates for the Marenne-Oléron coast (West of France).

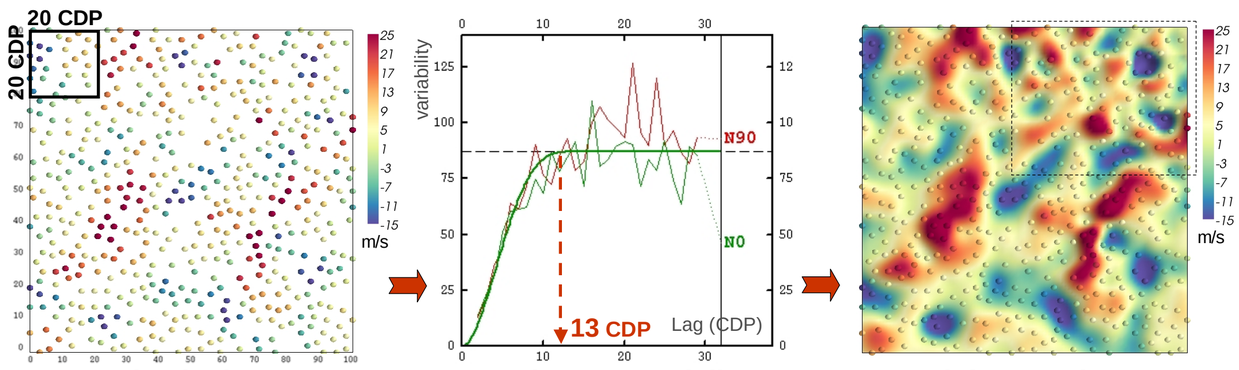
Conventional variogram-based models

The majority of geostatistical models that are daily implemented in the industry are variogram-based models.

Two types of parameters are involved in these models :

- **structural parameters**, related to a variogram model (range, sill, anisotropy coefficients, etc.)
- **computational parameters**, mainly tied to moving neighbourhood.

When facing with complex structural environment, global variogram-based models (i.e. with constant parameters) may not fit to local data characteristics and can lead to unexpected poor results.



2D seismic data set | **Variogram modeling** | **Kriging results**

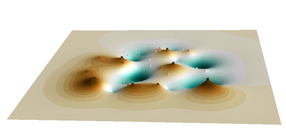
Global variogram - constant range of ~13 CDP over the field, **but** short range structures are observed in the N-E part of the field for example.

Moving-GeoStatistics (M-GS) models

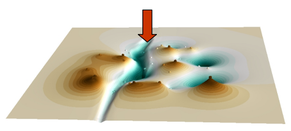
M-GS methodology is fully dedicated to the **local optimization of parameters** involved in variogram-based models.

The optimization process, which may be guided by objective or subjective criteria, is carried out during a M-structural analysis phase that leads to a set of **spatially variable structural and computational parameters**.

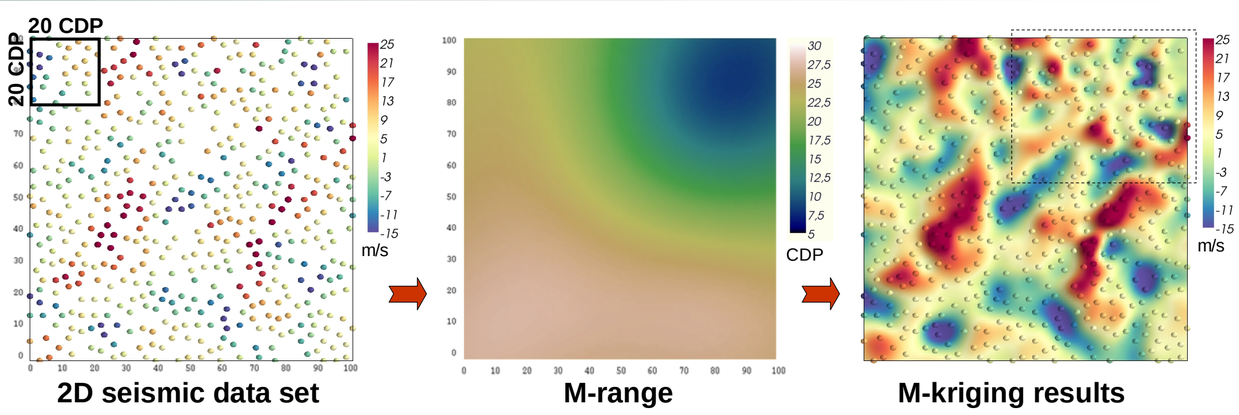
M-GS ensures a better adequacy between the geostatistical model and the data. Spatial estimation and simulation results are **more precise.** Moreover M-GS models allow to image **complex patterns** such as channel cutting a plain for example.



Mapping by conventional kriging



Channel mapping by M-Kriging



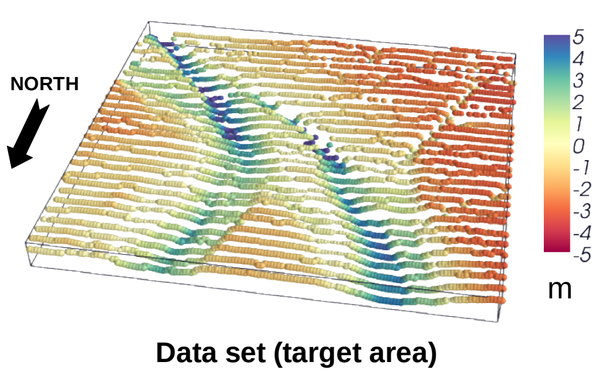
2D seismic data set | **M-range** | **M-kriging results**

M-structural analysis – the M-range presents strong variations, ranging from 6 to 27 CDP over the data field. Kriging results improved by 20% in the N-E area, as the standard deviation of (cross-validation) errors goes from 10.3 m/s to 8.2 m/s.

M-GS application to bathymetric mapping

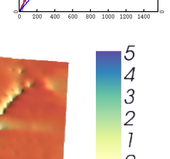
M-GS methodology in a complex structural environment and for a specific oriented-acquisition design is compared with classical estimates for bathymetry along the Marenne-Oleron coast (West of France).

Data set description : two thousand sample points organized along lines from West to East. Samples are separated by few meters within lines. The N-S gap between two lines is about 100m. Data were acquired with a single beam echoes sounder for the monitoring of the evolution of the muddy layer.

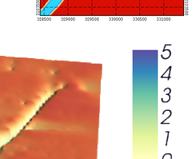


Data set (target area)

Artefacts on the walls of the channels due to the line organization of the data within strongly anisotropic areas.



Artefacts are no more visible. Channels are better imaged.



Mapping by conventional kriging
(global spherical model – 800m x 1200m)

Mapping by M-kriging
(M-GS model)

Conclusion

M-GS methodology, which is dedicated to the optimization of variogram-based models parameters, is proved to be promising when applied to bathymetric or seismic interpretation data in a complex structural environment.

The adequacy of the M-GS methodology in the framework of bathymetric mapping for Marenne-Oléron coast (West of France) is obvious. Moreover such methodology could be used to input different local structures into a general model in the aim of a regional synthesis…

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