

# Use of Functional Geostatistics for the diaigraphies analysis

N. Desassis



Geovariances  
Where no one has gone before

# Introduction

- It is currently more difficult for the coal companies
- They try to optimize the use of the available information
- How to use the diagraphies (logs) to estimate quality variables ?



- Part I : Gregory Crinum study

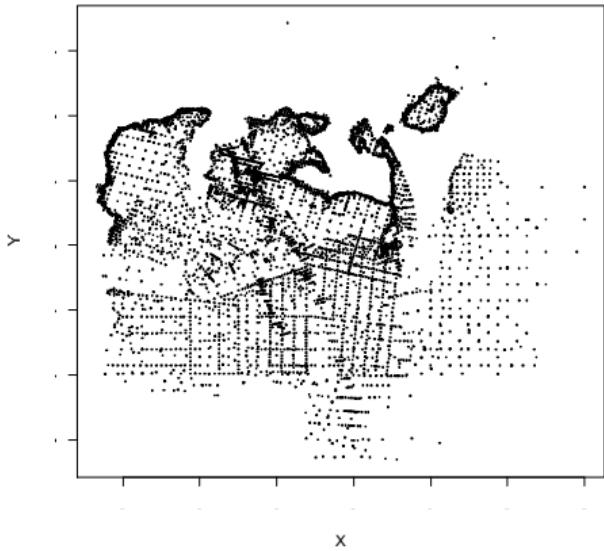
- ✓ The data
- ✓ k-mean classification
- ✓ Results

- Part II : Functional geostatistics

- ✓ Method
- ✓ A toy example



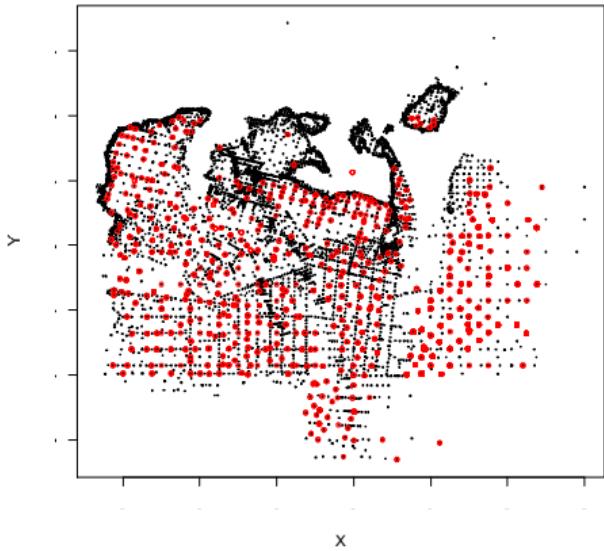
# Gregory Crinum data set



- BMA data set : 6857 points



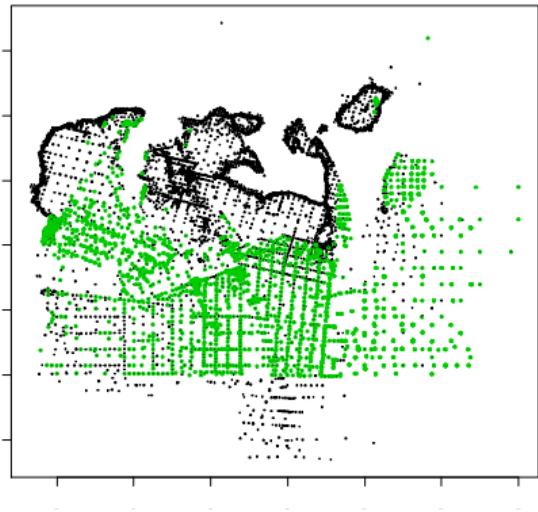
# Gregory Crinum data set



- BMA data set : 6857 points
- 558 points with coal quality



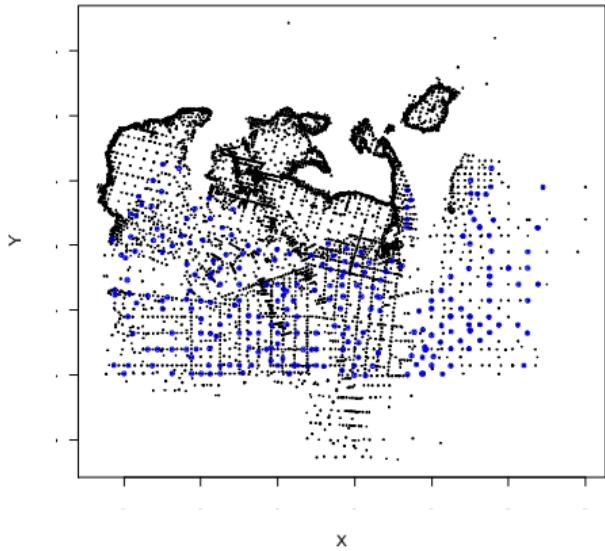
# Gregory Crinum data set



- BMA data set : 6857 points
- 558 points with coal quality
- 1848 points with diagraphies



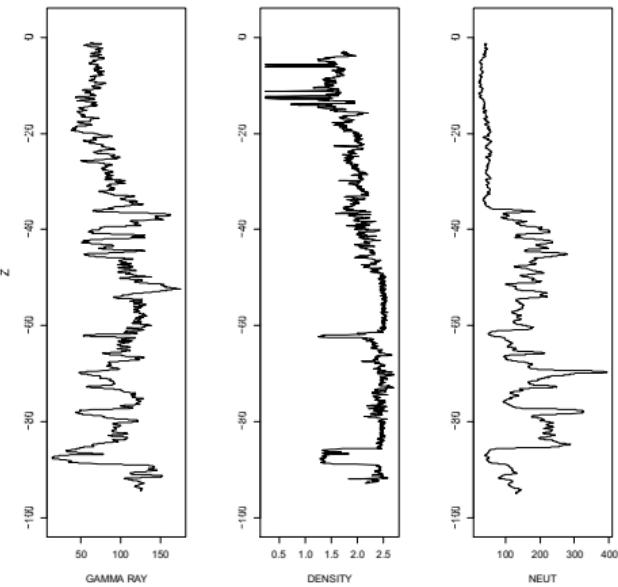
# Gregory Crinum data set



- BMA data set : 6857 points
- 558 points with coal quality
- 2640 points with diagraphies
- 256 points with both



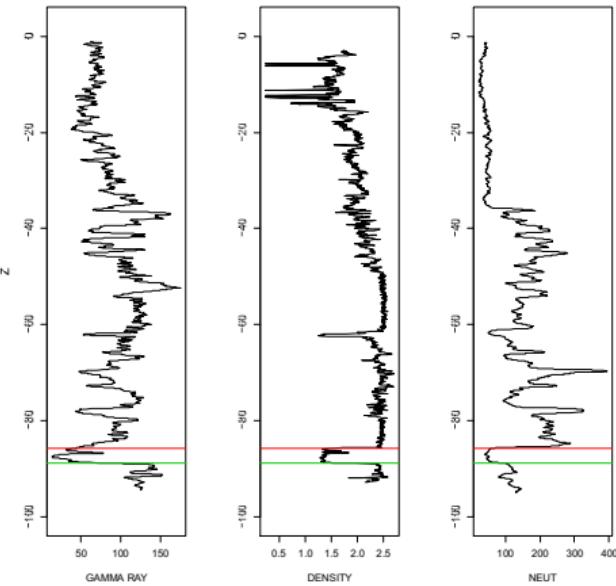
# Diagraphies



- 11 variables



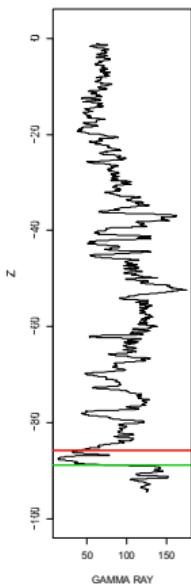
# Diagraphies



- 11 variables
- focus on one coal seam



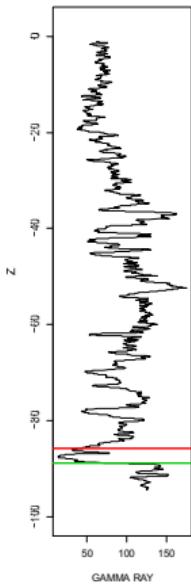
# Diagraphies



- 11 variables
- focus on one coal seam
- Gamma Ray



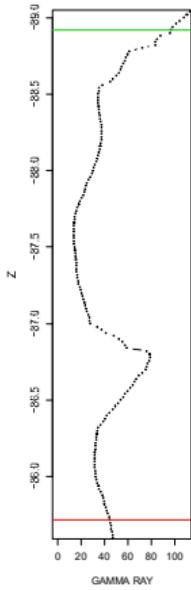
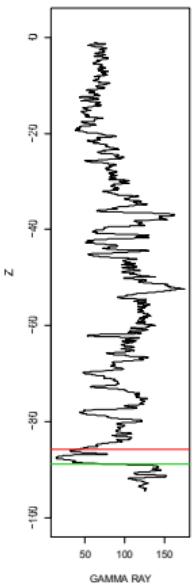
# 256 Gamma Ray curves



- Restriction to the interesting coal seam



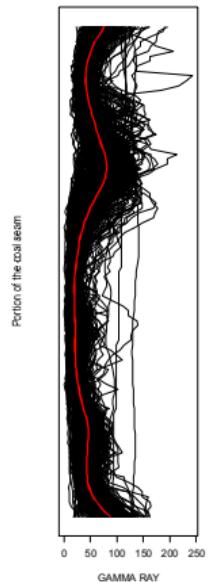
# 256 Gamma Ray curves



- Restriction to the interesting coal seam



# 256 Gamma Ray curves



- Restriction to the interesting coal seam
- Classification with k-means algorithm on the curve values



# k-means

- Input :  $k$  the number of clusters
- Initialisation : create randomly  $k$  groups of curves

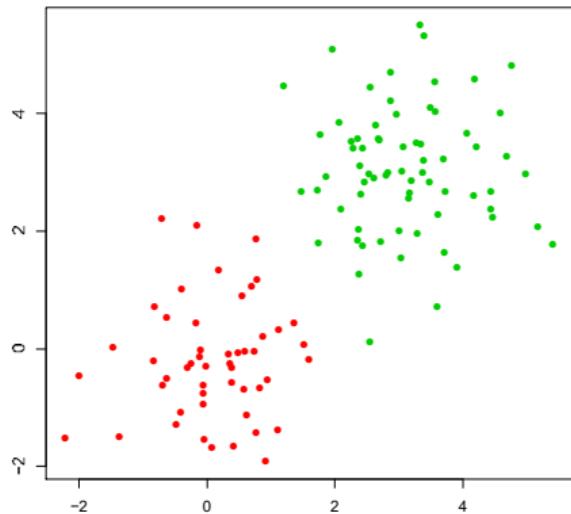


# k-means

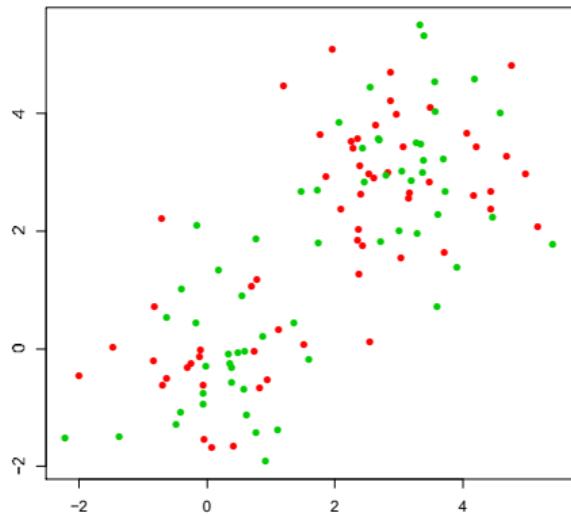
- Input :  $k$  the number of clusters
- Initialisation : create randomly  $k$  groups of curves
- Iterate :
  - ✓ Compute the  $k$  means of the curves (by group)
  - ✓ Reassign each curve to the group with the closest average curve



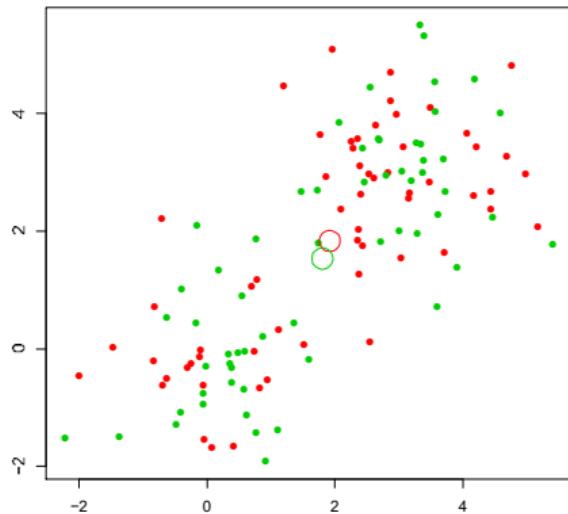
# Illustration



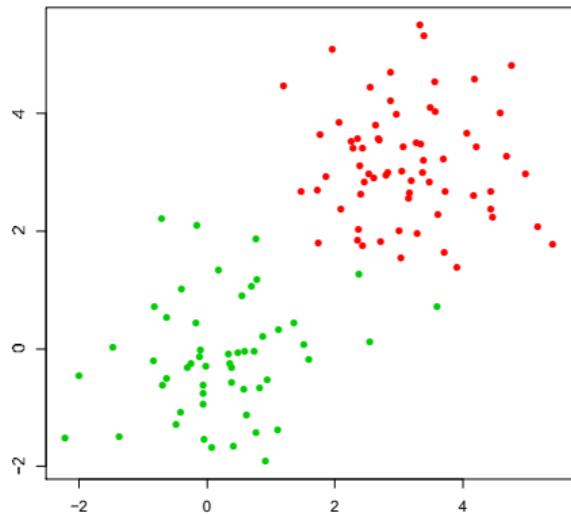
# Initialisation



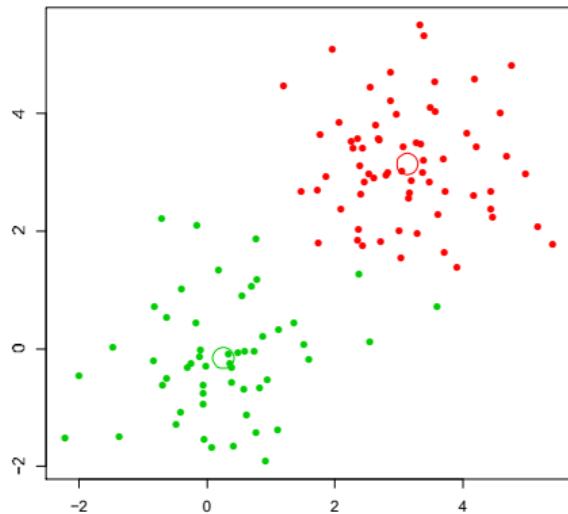
# Center of each cluster



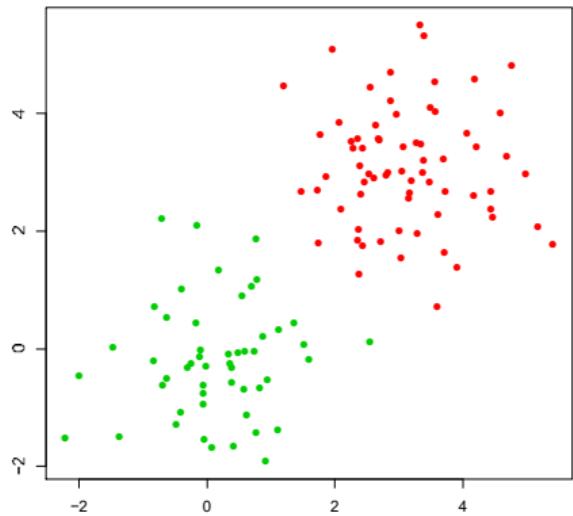
# Reassignment



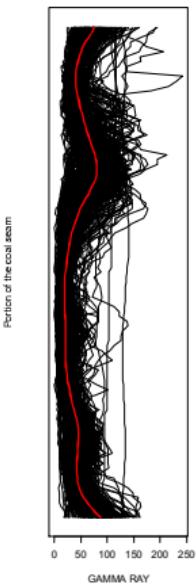
# Center of each cluster



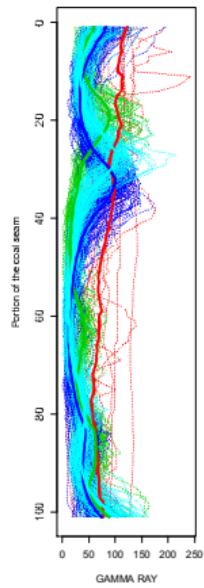
# Reassignment



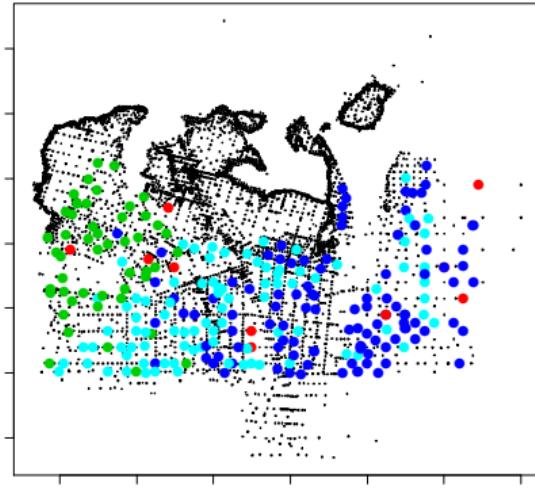
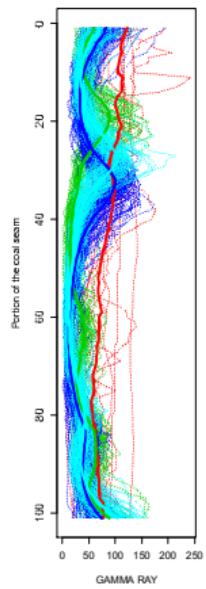
# Results with 4 clusters



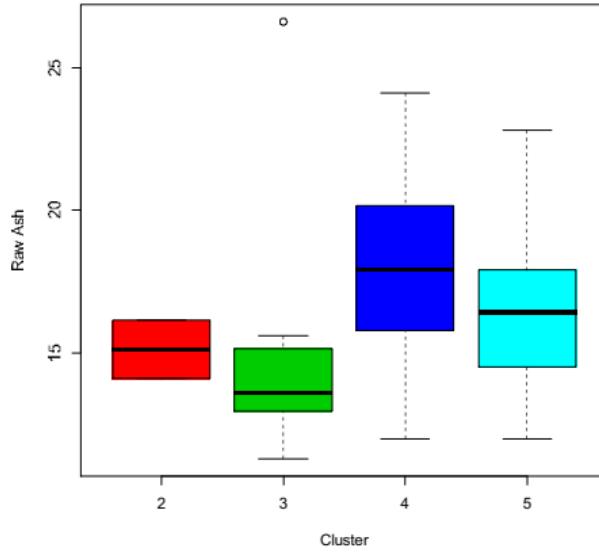
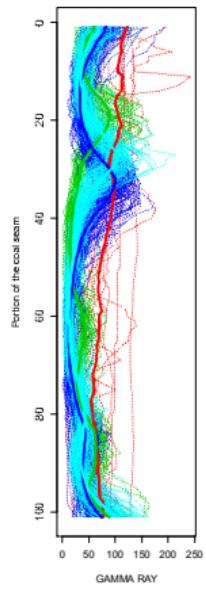
# Results with 4 clusters



# Spatialisation of the result



# Link with the raw ash



# Functional geostatistics



Geovariances  
Where no one has gone before

# Why and how ?

- Why do we need to develop specific methods
  - ✓ Non-stationarities
  - ✓ Strong anisotropies



# Why and how ?

- Why do we need to develop specific methods
  - ✓ Non-stationarities
  - ✓ Strong anisotropies
- Steps of the functional geostatistics (Nerini et al., 2009)



# Why and how ?

- Why do we need to develop specific methods
  - ✓ Non-stationarities
  - ✓ Strong anisotropies
- Steps of the functional geostatistics (Nerini et al., 2009)
  - ✓ Interpolation (Linear, B-Splines, ...)



# Why and how ?

- Why do we need to develop specific methods
  - ✓ Non-stationarities
  - ✓ Strong anisotropies
- Steps of the functional geostatistics (Nerini et al., 2009)
  - ✓ Interpolation (Linear, B-Splines, ...)
  - ✓ Polynomial interpolation (Chebychev, Legendre, ...)



# Why and how ?

- Why do we need to develop specific methods
  - ✓ Non-stationarities
  - ✓ Strong anisotropies
- Steps of the functional geostatistics (Nerini et al., 2009)
  - ✓ Interpolation (Linear, B-Splines, ...)
  - ✓ Polynomial interpolation (Chebychev, Legendre, ...)
  - ✓ Variography of the coefficients (Coregionalisation)



# Why and how ?

- Why do we need to develop specific methods
  - ✓ Non-stationarities
  - ✓ Strong anisotropies
- Steps of the functional geostatistics (Nerini et al., 2009)
  - ✓ Interpolation (Linear, B-Splines, ...)
  - ✓ Polynomial interpolation (Chebychev, Legendre, ...)
  - ✓ Variography of the coefficients (Coregionalisation)
  - ✓ Cokriging of the coefficients

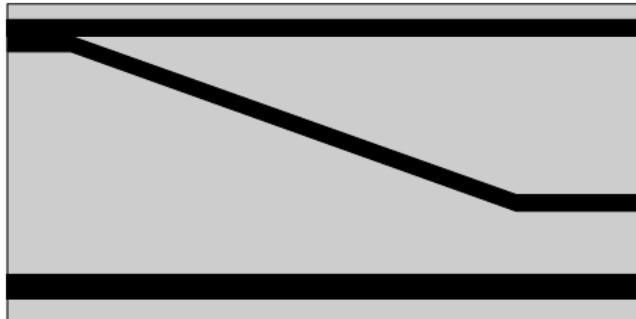


# Why and how ?

- Why do we need to develop specific methods
  - ✓ Non-stationarities
  - ✓ Strong anisotropies
- Steps of the functional geostatistics (Nerini et al., 2009)
  - ✓ Interpolation (Linear, B-Splines, ...)
  - ✓ Polynomial interpolation (Chebychev, Legendre, ...)
  - ✓ Variography of the coefficients (Coregionalisation)
  - ✓ Cokriging of the coefficients
  - ✓ Evaluation of the curves



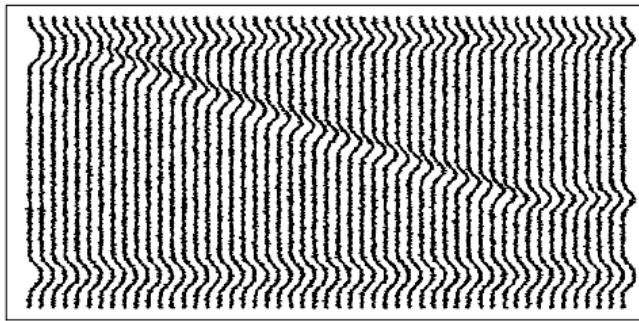
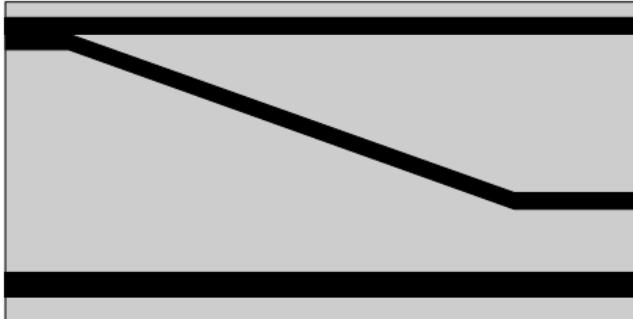
# A toy example



- A fictive deposit with 2 layers



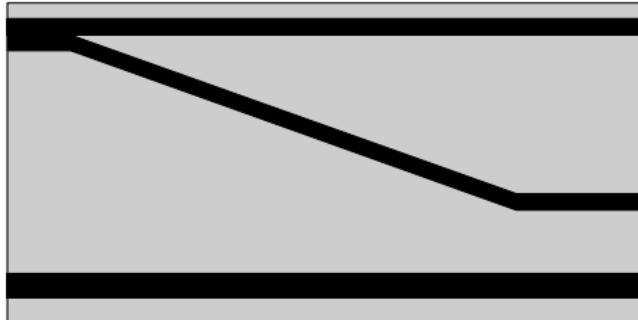
# A toy example



- A fictive deposit with 2 layers
- Simulated diagraphies

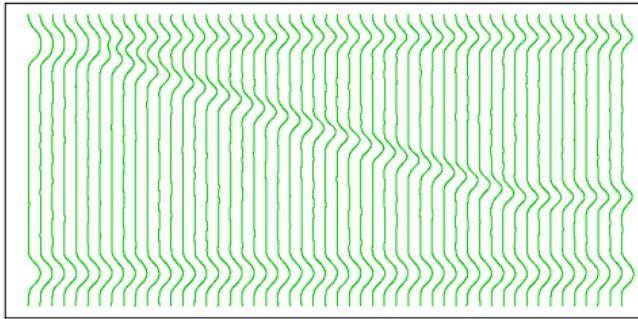


# Use of B-splines

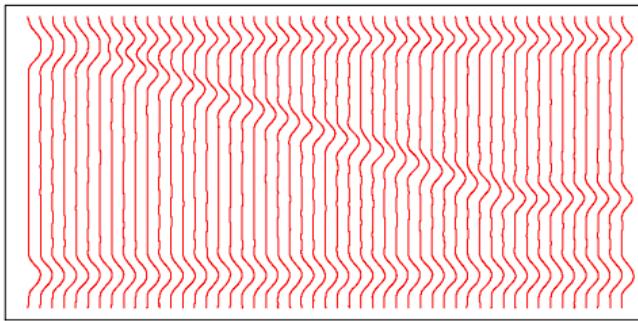
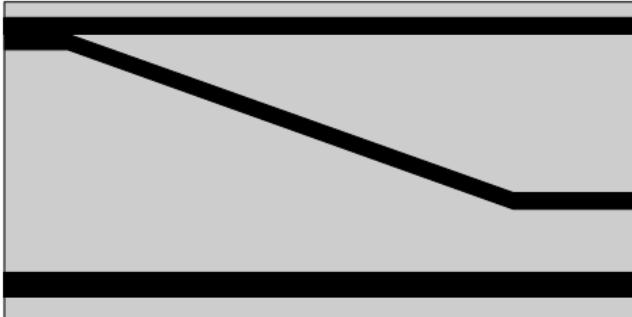


Two aims :

- Regularisation
- Interpolation



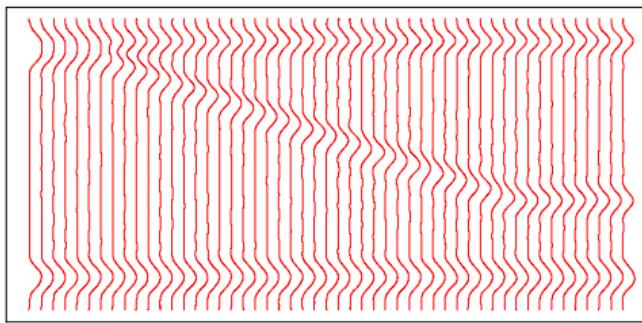
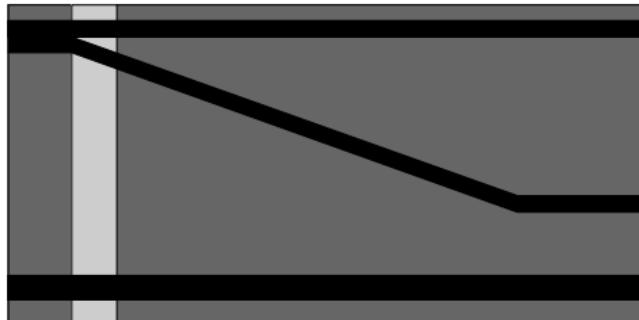
# Polynom interpolation



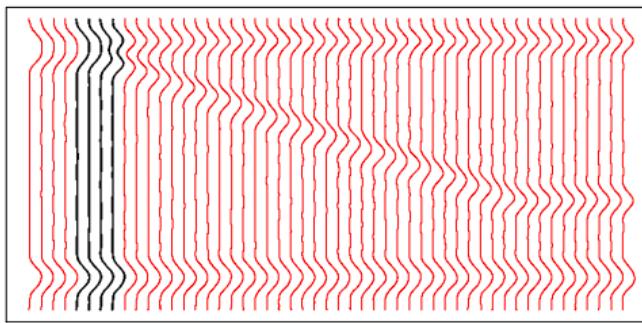
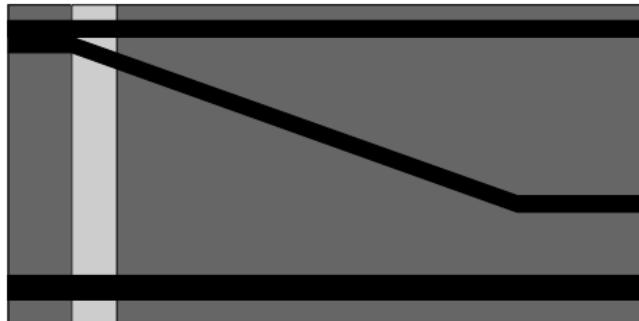
- Chebyshev polynomials
- Evaluation of the coefficients by Gauss quadrature
- Need to know the values of the function at the roots of the polynomials



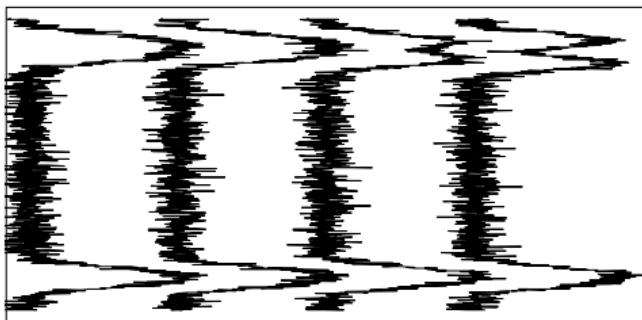
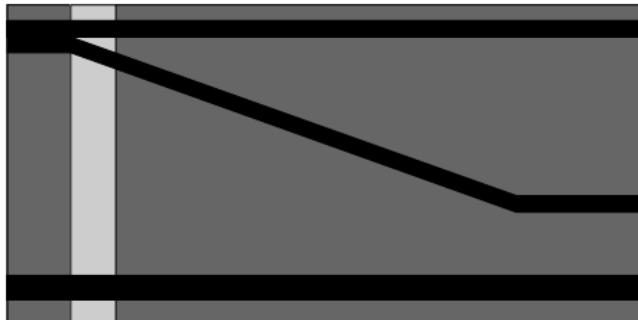
# Zoom



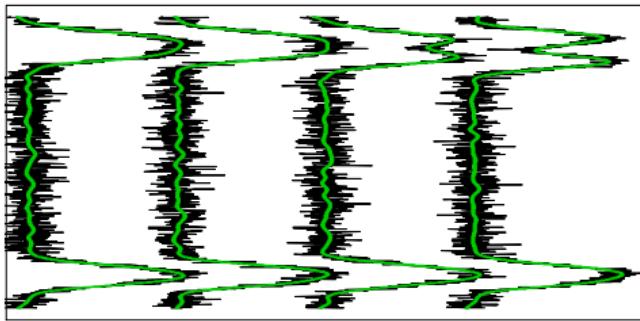
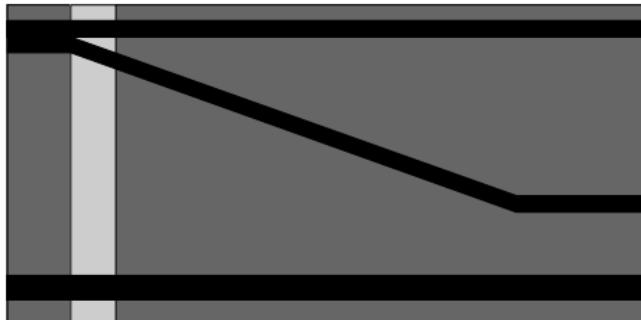
# Zoom



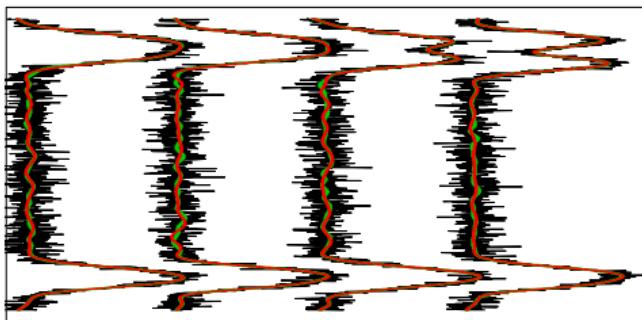
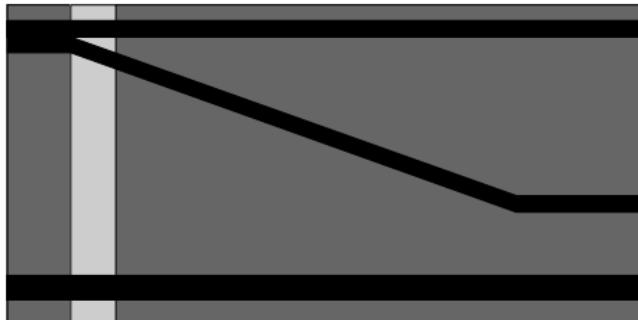
# Zoom



# Zoom : B-Splines



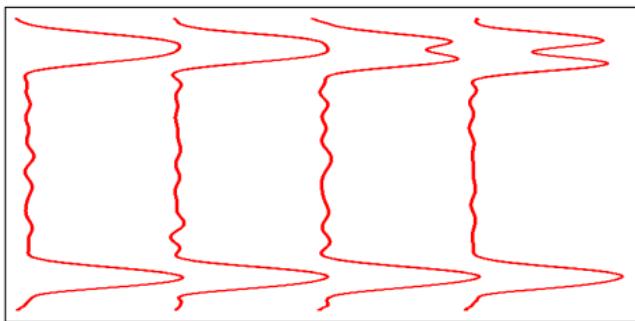
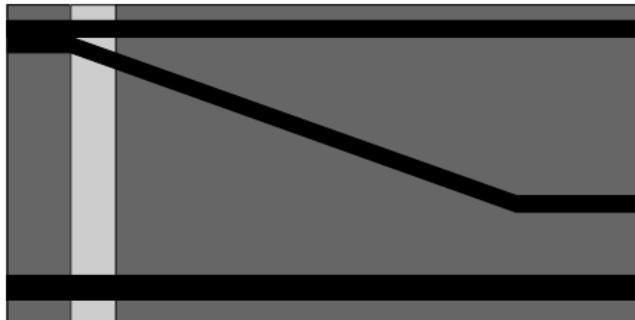
# Zoom : Polynom interpolation



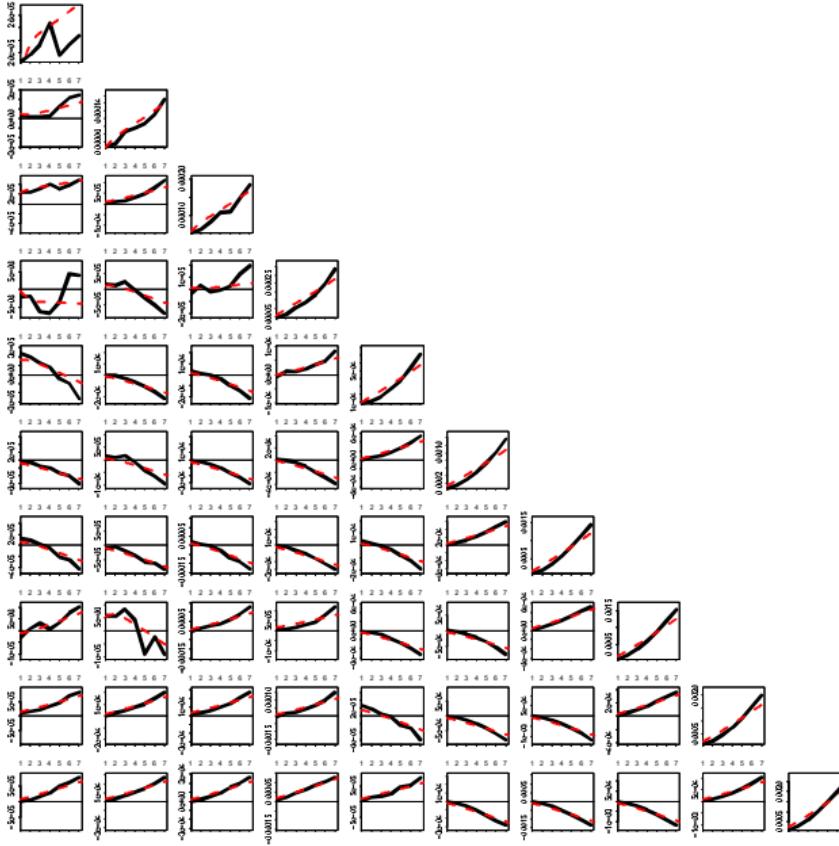
- 40 polynoms
- Runge effect



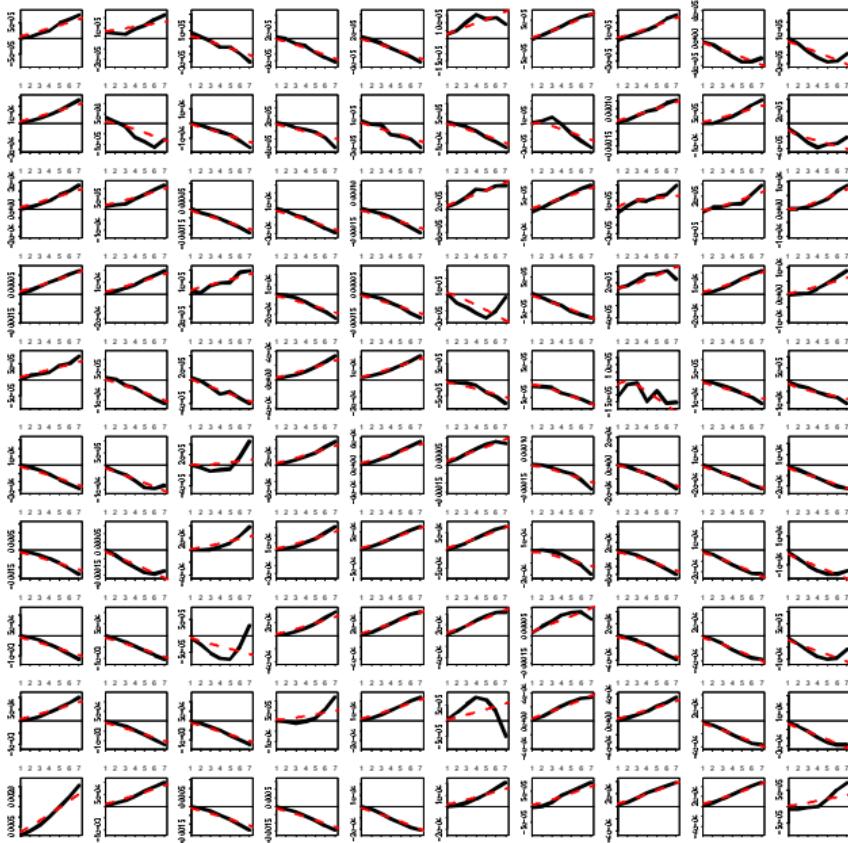
# A toy example



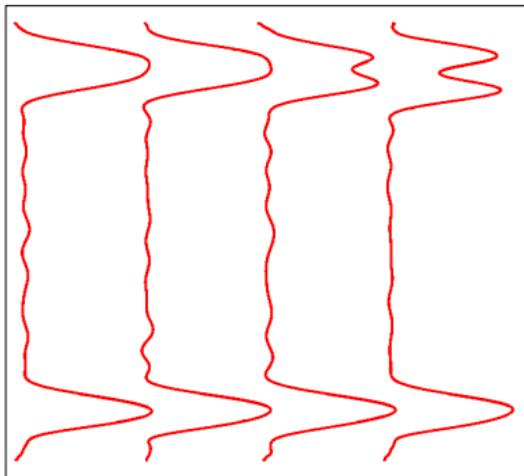
# Variography



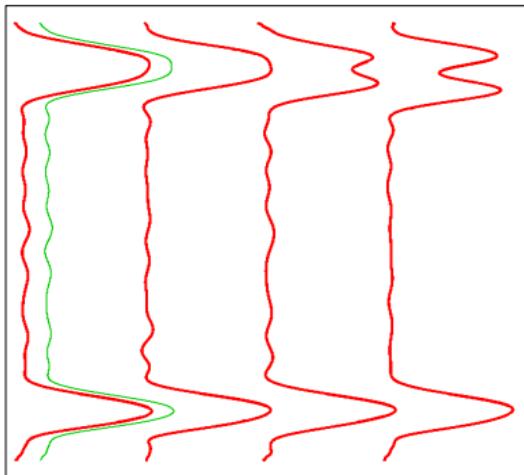
# Variography



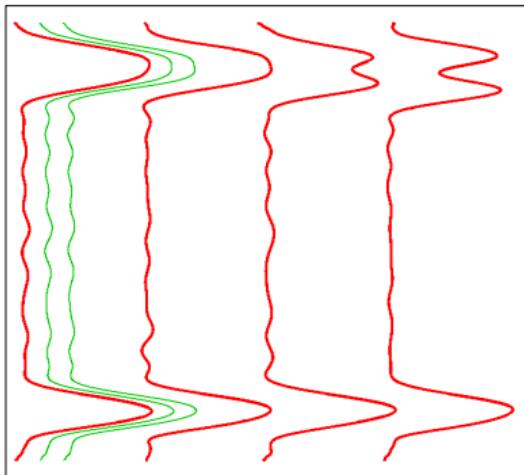
# Cokriging



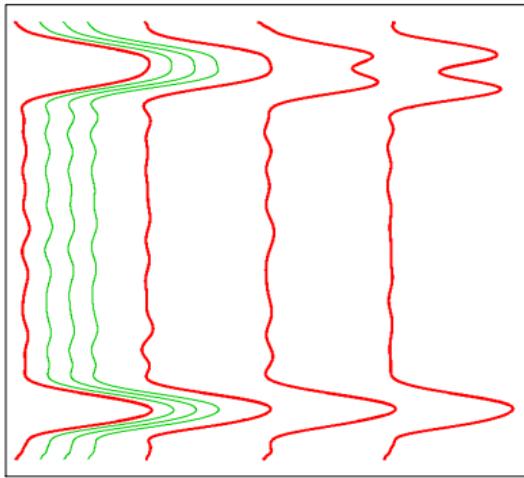
# Cokriging



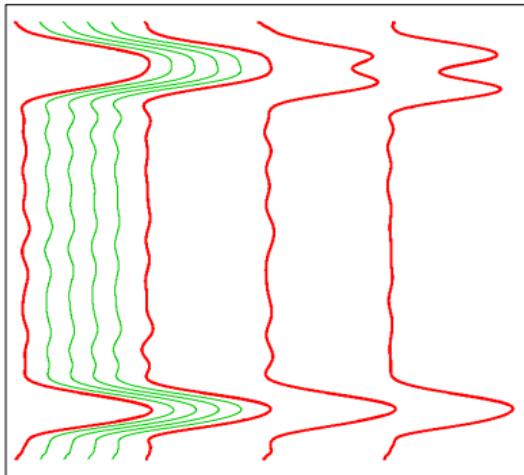
# Cokriging



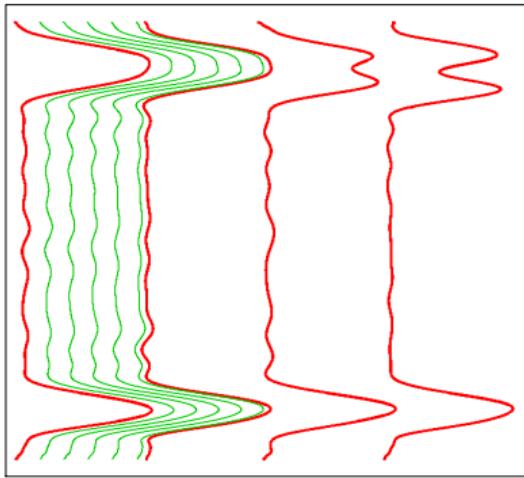
# Cokriging



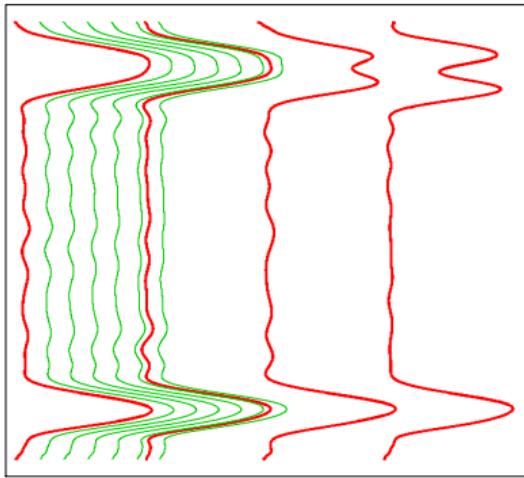
# Cokriging



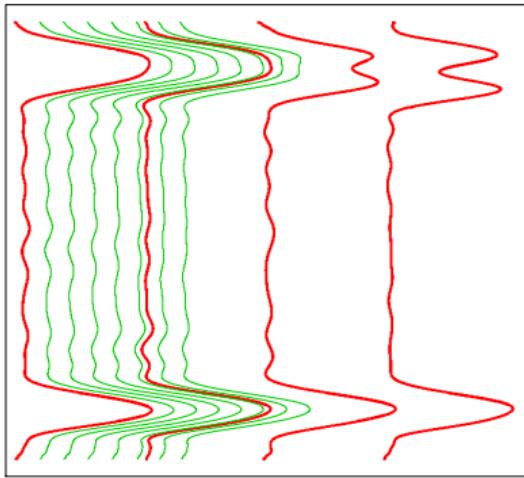
# Cokriging



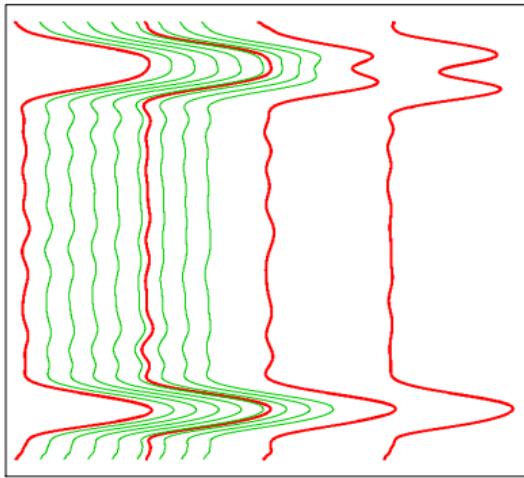
# Cokriging



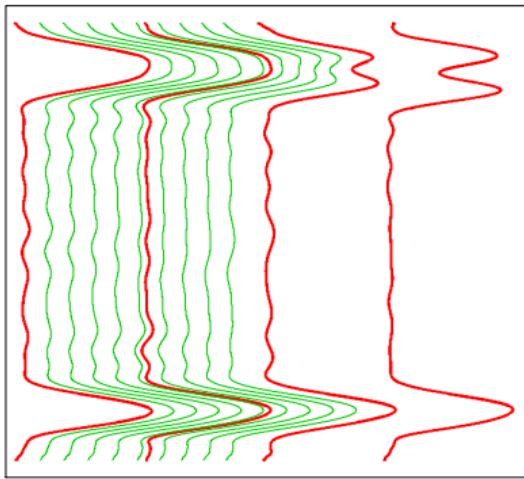
# Cokriging



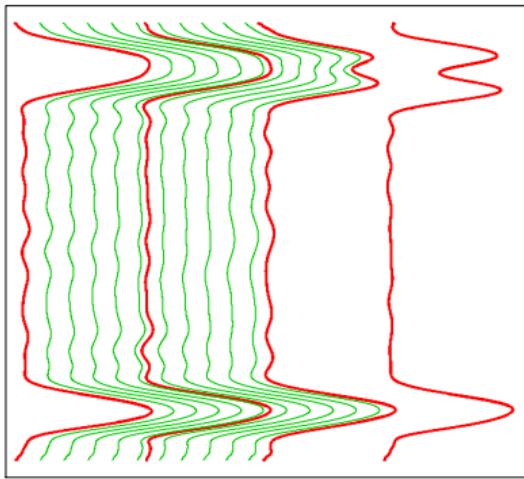
# Cokriging



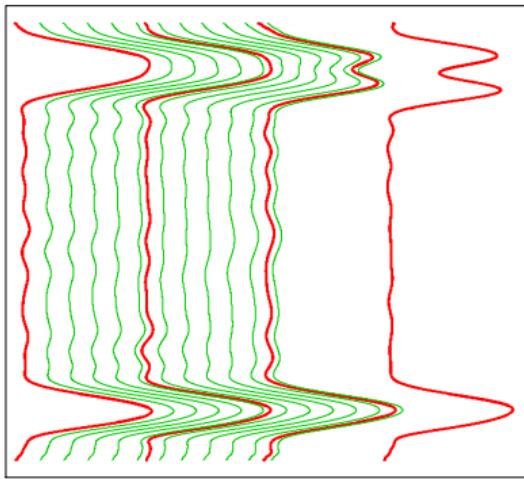
# Cokriging



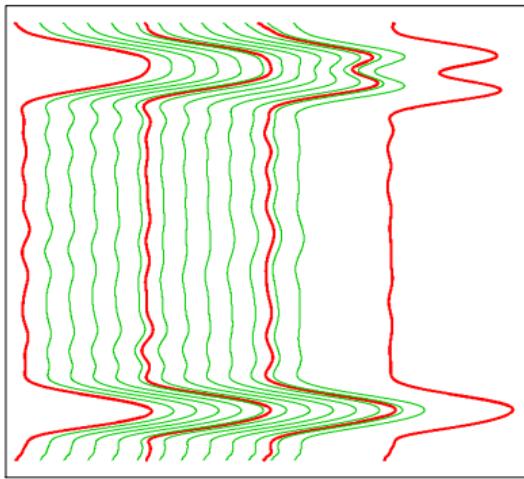
# Cokriging



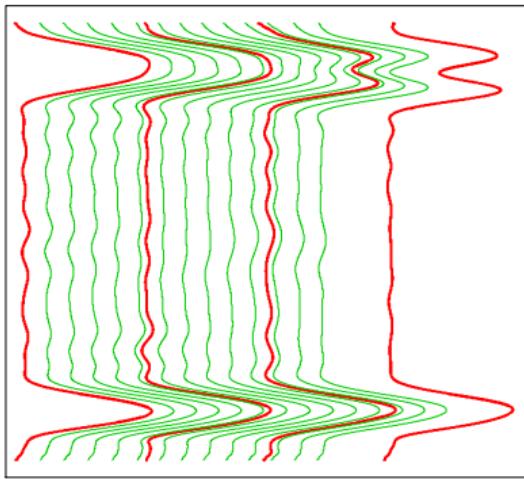
# Cokriging



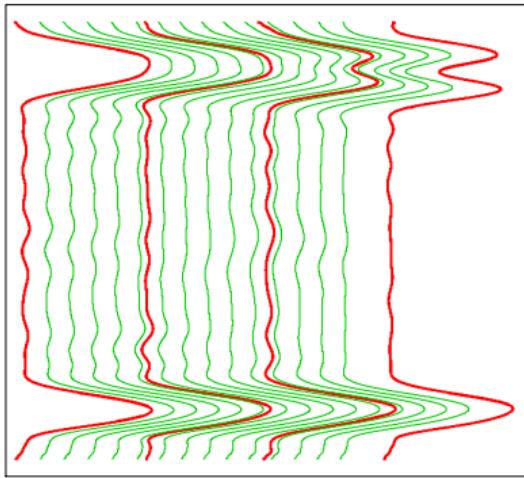
# Cokriging



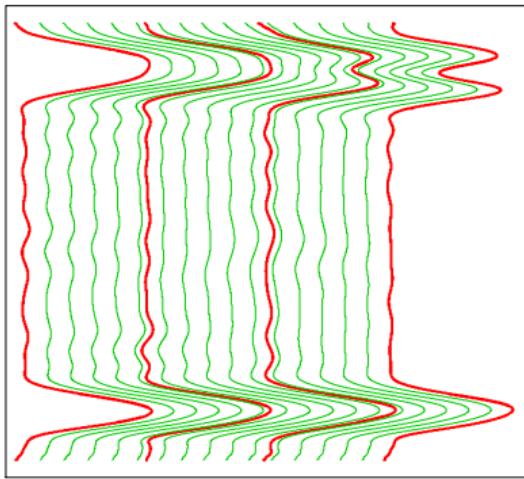
# Cokriging



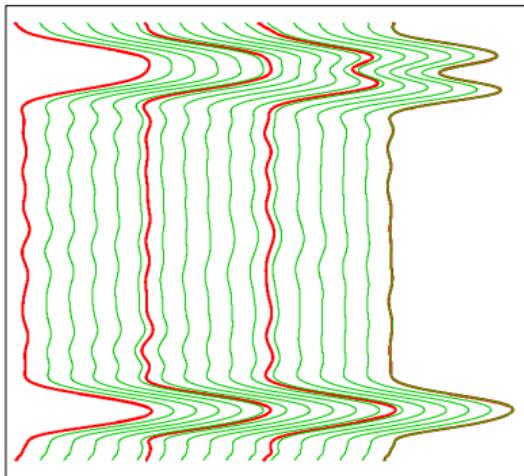
# Cokriging



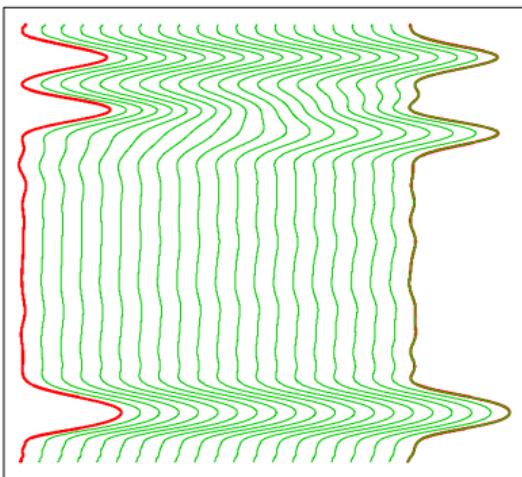
# Cokriging



# Cokriging



# With 2 data



# Conclusions

- A promising methodology
- Next step : apply to the coal data
- Extension to the simulations (facies simulations ?)
- Several issues :
  - ✓ Number and types of polynomials
  - ✓ Multivariate model and high dimension



# Thank for your attention.

Nerini, Monestiez and Manté (2009) **Journal of Multivariate Analysis** *Cokriging for spatial functional data*

