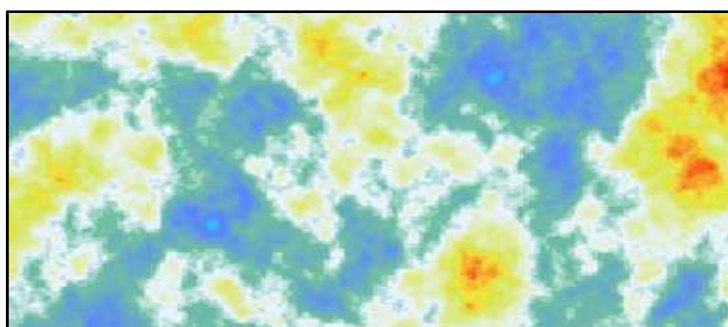
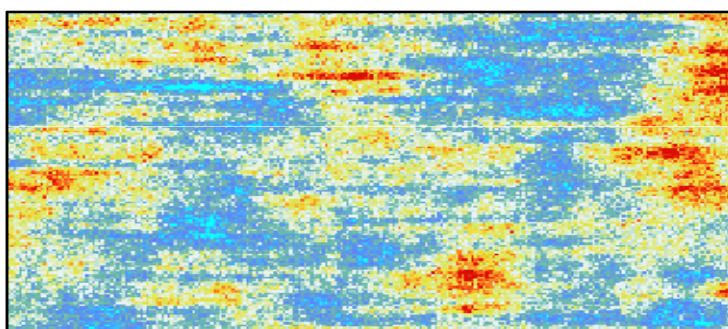


OIL & GAS / HOW TO...

REMOVE QUICKLY STRUCTURATED NOISE FROM A SEISMIC MAP OR CUBE

Last update : 13/03/2009

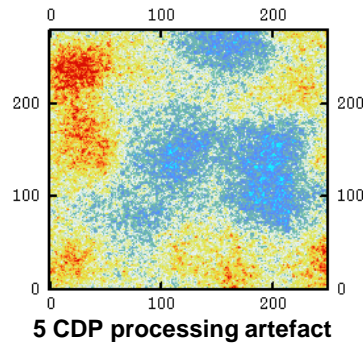
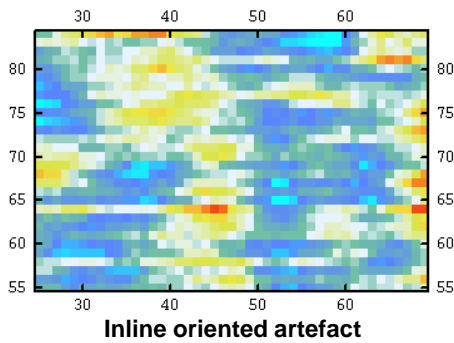


Keywords

Seismic data, footprint, nugget effect, noise removal, experimental variogram, nested variogram model, factorial kriging, image filtering.

Introduction

Seismic data are often polluted by acquisition or processing artefacts which should be removed as they may have a negative impact on subsequent seismic processing or interpretation processes.



Here is described an **ISATIS solution for removing quickly and efficiently artefacts** – structured (acquisition footprint, patterns due to oriented processing windows, etc.) or not (white noise) – from a seismic map or cube while preserving fully the signal resolution.

The solution is based on factorial kriging technique and benefits from the **fast « image filtering » algorithm** implemented in ISATIS.

Moreover, this solution should profit to anyone who is interested in applying factorial kriging techniques to images.

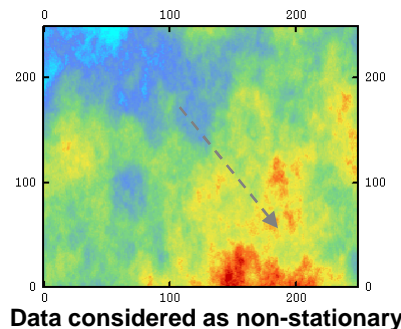
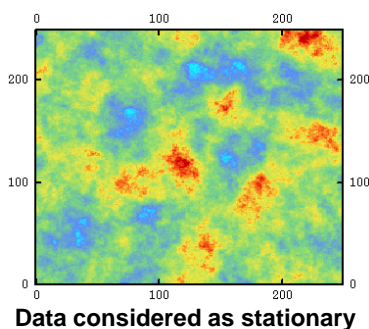
Description

Flowchart

1. Trend estimation (if necessary)
2. Structural analysis
3. Noise removal by factorial kriging technique
4. Validation

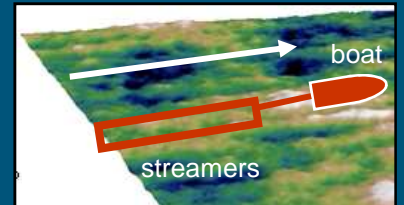
1. Trend estimation (in case of non-stationary data)

Very large scale and non-stationary variations must be estimated and removed from the raw data. In [How to compute quickly a reliable trend](#) is described a **fast trend estimation solution**.



Footprint

The **footprint** is an acquisition artefact, which is related to seismic acquisition geometry. In marine seismics, the footprint corresponds to a distortion of the amplitude and phase of reflections, leading to a higher continuity of seismic data along the direction defined by the streamers.



Acquisition pattern

Factorial kriging

Factorial kriging technique is a powerful geostatistical technique, which enables to partition spatially sampled data from their structural content.

Some references:

Pour une analyse krigéante des données régionalisées - G. Matheron - 1982 - Report N-732, Centre de Géostatistique, ENSMP, Fontainebleau, France.

<http://www.geovariances.com/software/factorial-kriging-ar0137.html>

ISATIS +

Non-stationary geostatistical models are implemented in ISATIS.

Why removing a trend ?

The factorial kriging approach makes interpretation of the data in terms of several structures (nested model).

A multi-structure interpretation is difficult to realize with non-stationary data.

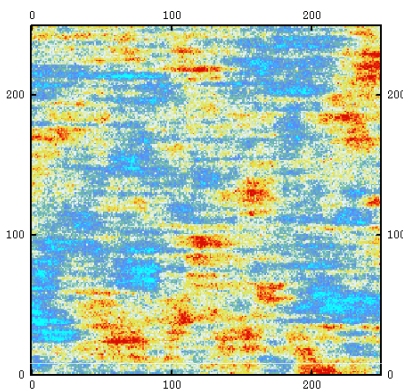
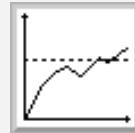
2. Structural analysis

2.1. Experimental variogram

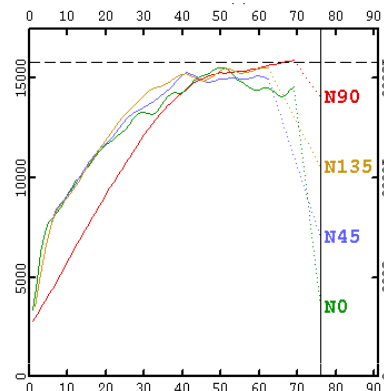
As images or cubes correspond to data sampled on a regular grid, the computation of the experimental variogram is fast. In 2D, at least 4 variogram directions must be computed.

Experimental variogram computing (2D)

- Open Statistics / Exploratory Data Analysis
- Load the data
- Variogram calculation parameters
- List of options: Irregular Directions
- Define directions and OK
- Save the experimental variogram



Data



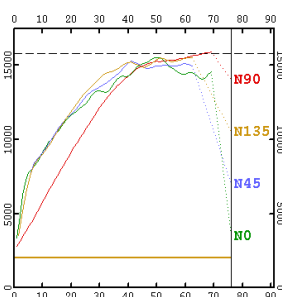
Experimental variogram computed in 4 directions

2.2. Variogram modeling

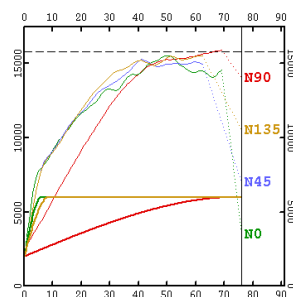
The experimental variogram is interpreted in terms of consistent (geological) and noise structures. More details about variogram modeling are in [How to modelize a 3D experimental variogram](#).

Variogram modeling

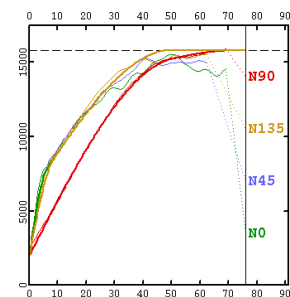
- Open Statistics / Variogram Fitting
- Add structures corresponding to the structural interpretation
- Save the variogram model



Nugget



Nugget + Inline structure



Nugget + Inline structure + geological structure

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The **Variogram Map application** is meant to analyze the spatial continuity of variables in all directions of the space in a 2D view. It is very useful to pick the possible anisotropies.



Experimental variogram

The experimental variogram is a statistical function characterizing the spatial dependence between samples of a spatial data set.

In the stationary case, the experimental variogram corresponds to the opposite of the (non-normalized) auto-correlation function.

One reference:

ARMSTRONG M. (1998)
Basic linear geostatistics. Ed. Springer

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The **Variogram Fitting panel** allows to fit a wide range of variogram models by offering various modeling options : more than 12 variogram function types available, nested model handling, possibility of internal drift definition, 3D anisotropy definition, etc.

Inline effect

The **Inline effect** corresponds to artificial continuity in the Inline direction. Inline effect is often related to acquisition footprint effect. Sometimes it may be caused by Inline oriented seismic processing.

Inline effect has a variogram signature and thus can be modeled (by an anisotropic structure).

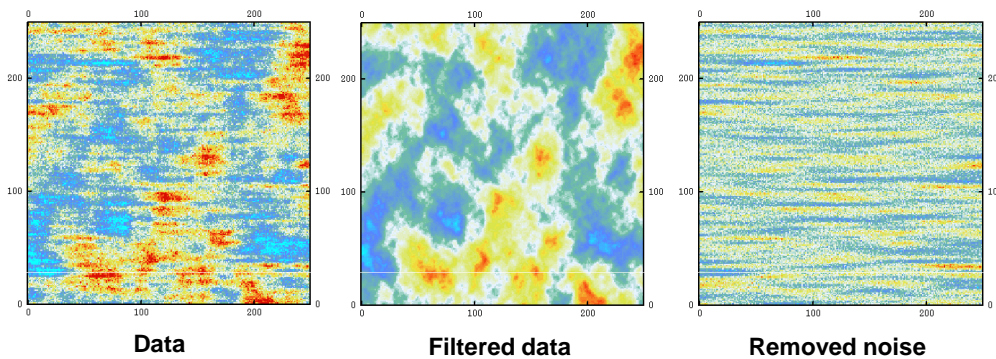
3. Noise removal by factorial kriging technique

Factorial kriging technique allows to estimate any component (or combination of components) of a nested variogram model. In such way, noise structures can be filtered out from the data.

ISATIS implements the fast "image filtering" algorithm which is dedicated to factorial kriging of images or cubes (grid data).

Factorial kriging

- Open Interpolate / Estimation / Image Filtering
- Input Grid File: data
- Output Grid File: filtered data
- Model: load the variogram model
- Special Model Options / Filtering Model Components
- Select the components to be filtered out (noise structures)
- Define the Image Neighborhood (expressed in grid nodes)
- Run

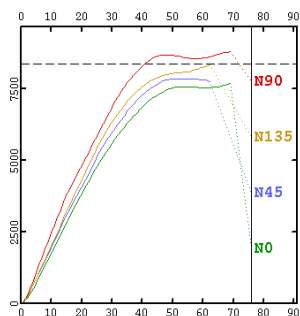


4. Validation

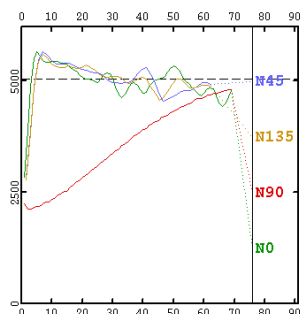
Visual inspection of the data, of the filtered data and of the removed noise, is the first and the more intuitive step for validating the filtering process.

As a complement, it is recommended to compute the experimental variograms related respectively to the filtered data and to the removed noise. They should be consistent with the variogram model.

Finally, the correlation coefficient between the filtered data and the removed noise must be closed to 0. In the example presented here, it is equal to 0.16.



Experimental variogram of the filtered data



Experimental variogram of the removed noise

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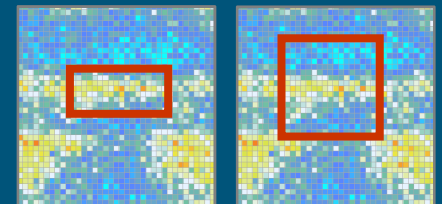
The « **image filtering** » algorithm implemented in ISATIS takes advantage of the regular sampling of the data by minimizing the number of kriging systems to solve. Kriging computation performance is highly improved.

Kriging Neighborhood

For large data sets, the **kriging neighborhood dimensions** are often the result of a compromise between the required quality of the filtering process and the available running time. It is recommended to test several neighborhood parameter settings on a small area before filtering the entire data set.

For filtering an Inline effect, the neighborhood must be large enough in the direction perpendicular to the Inline direction:

Inline direction
→



Neighborhood not OK

Neighborhood OK

Additive model

The **factorial kriging model is an additive model** where the variable A is decomposed into independent components B and C.

Thus, the correlation coefficient between B and C should be null.

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