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Kriging in High Dimensional Attribute Space using Principal Component Analysis

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Contents

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The Idea

Overall objective is to produce accurate and reliable **estimations of the porosity levels** in the subsurface of a reservoir.

Well-known fact that **seismic attributes** can be used to guide **interpolation and extrapolation** of porosity based on **well log observations**.

Current idea: to **free the estimation of physical restrictions**. Let the **estimation be guided by geological similarity** instead of the conventional distance measure in XYZ space.

Our choice of interpolation method is the **Kriging technique**.

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Test Case: The South Arne Field

The South Arne Field is a chalk reservoir situated in the Danish Sector of the Central North Sea some 220 km off the Danish coast.

We have access to 8 attributes in a dense geographical 2D grid with more than 75,000 points.

The porosity is sparsely sampled within the grid. We have 213 observed values.

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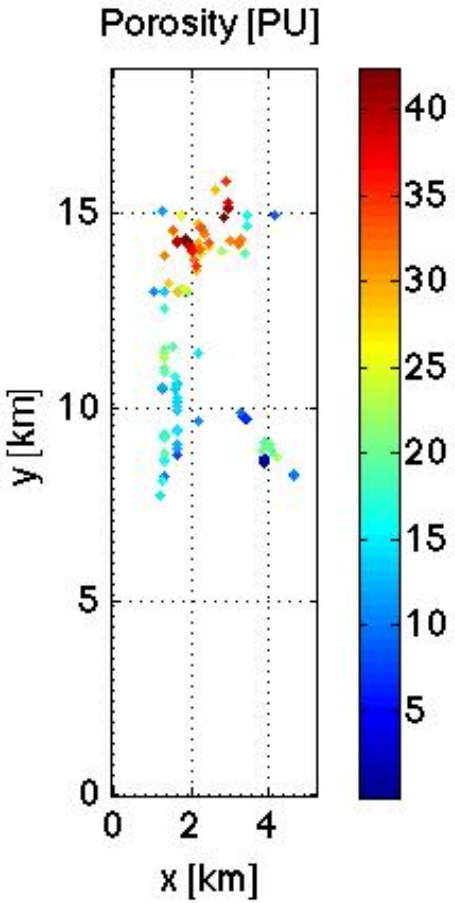
To evaluate the quality of our estimation we compute the differences between **observed porosity values** of the blind data set and the corresponding **estimated porosity values**.

We then compare the following:

- Mean value of the differences
- Estimated standard deviation of the differences



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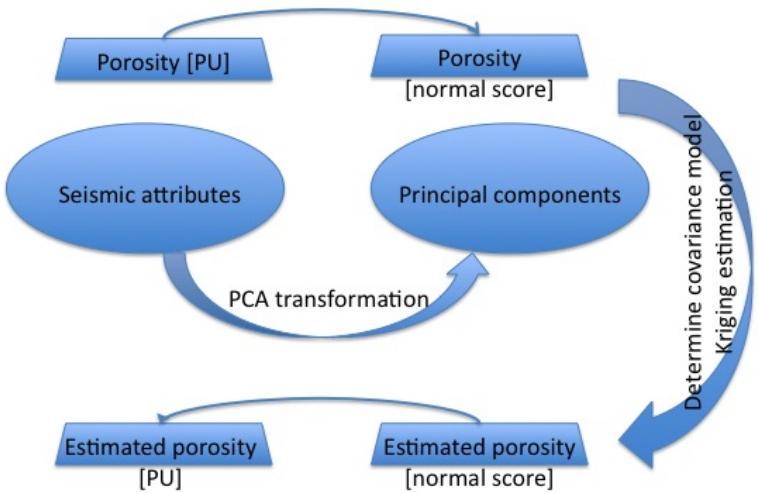
Outline of the method

1. Normal score transformation of the porosity data.
2. PCA transformation of the attributes.
3. Definition of a distance measure in the principal component space.
4. Computation of optimal covariance parameters.
5. Formulation and solution of the kriging system
6. Back transformation of the porosity values estimated in normal score space.



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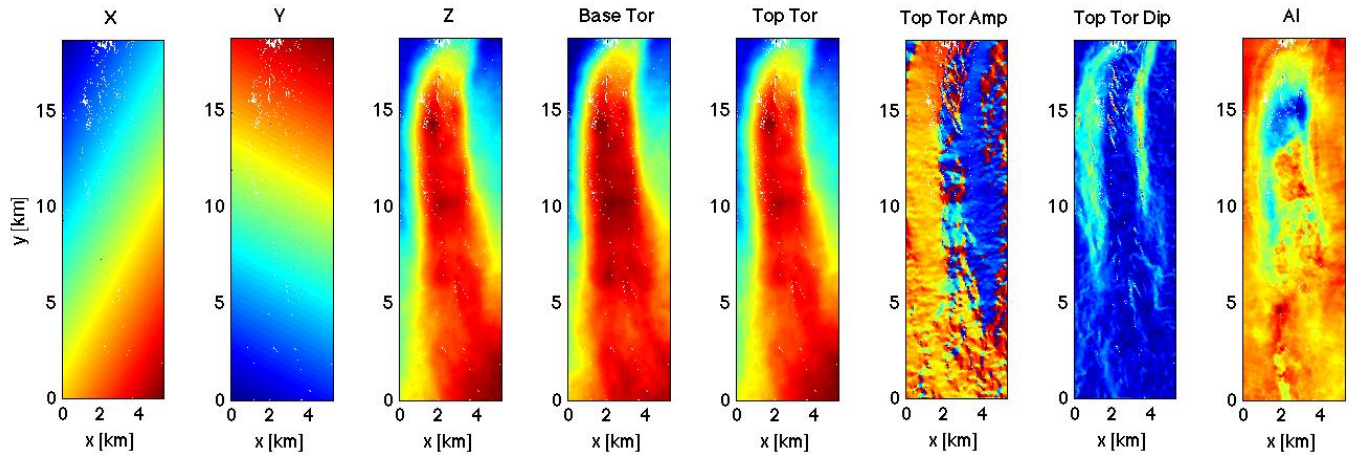
Seismic Attributes



- Physical coordinates, x, y and z.
- Two way travel times to the top and the base of the reservoir
- The amplitude and the dip at the top
- The acoustic impedance.

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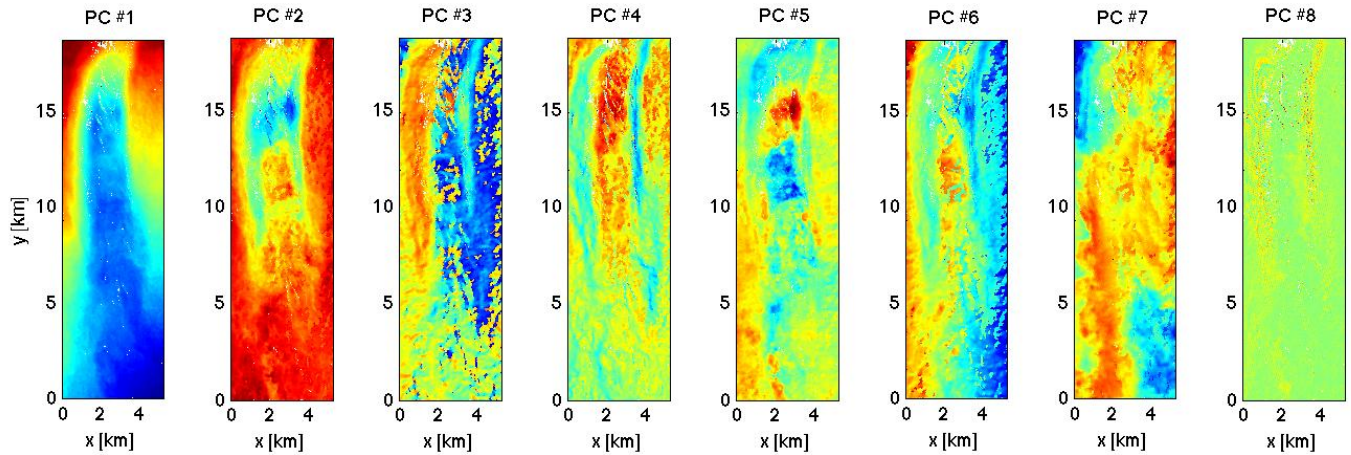
Principal Components



Different color scale used for each sub figure - red/blue indicates high/low values.

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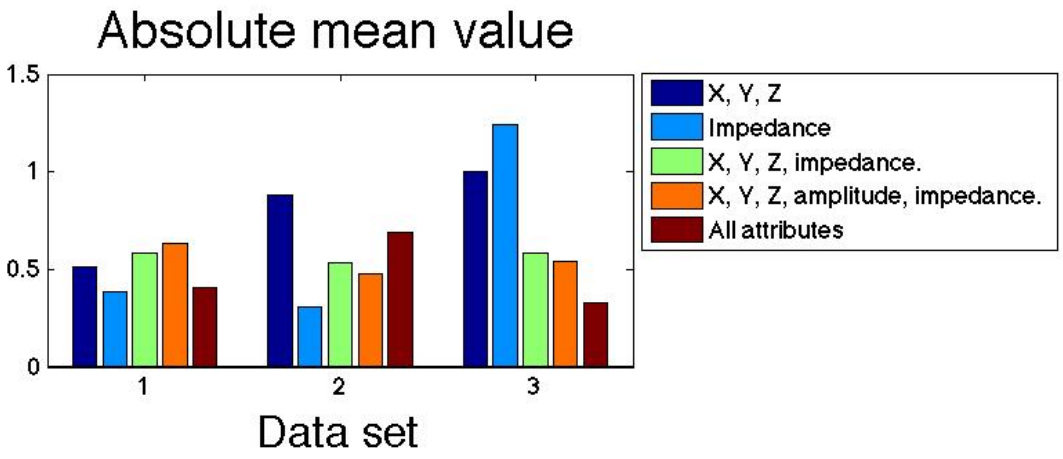
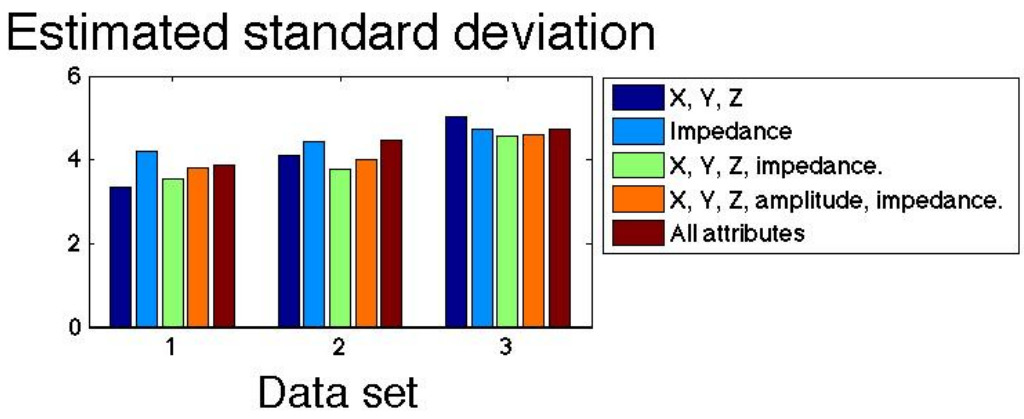
Results for the Test Case

Varying the set of attributes yields:





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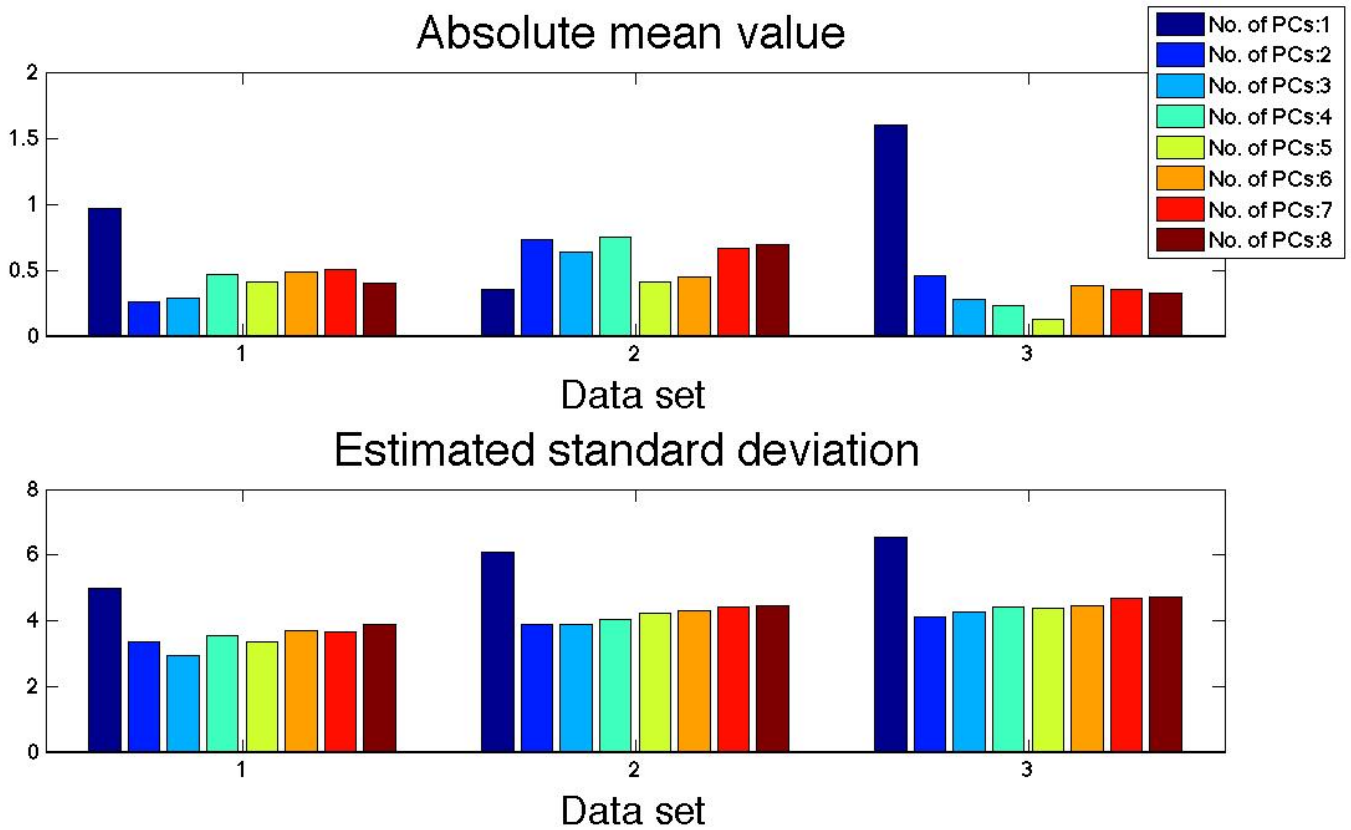
Using all attributes but varying the number of principal components:



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Conclusion and Future Work

What have we seen?

- Choice of attributes matters.
- The dimensions of the interpolation domain can be successfully reduced. Selecting few principal components does not necessarily decrease the accuracy.

Not covered in this presentation:

- Type of covariance model.
- Type of Kriging method (and trend functions).
- Evaluation of the estimation in the entire domain by for instance confidence intervals.