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Petrel 2017 Property Modeling Module 16: Gaussian simulation in petrophysical modeling

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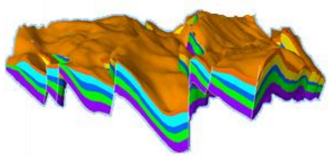
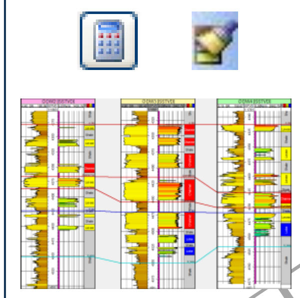
Petrel 2017 Property modeling



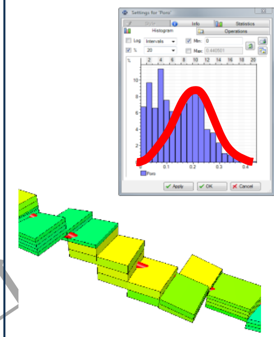
Intro

Petrel Property Modeling objective and workflow

Property modeling data preparation

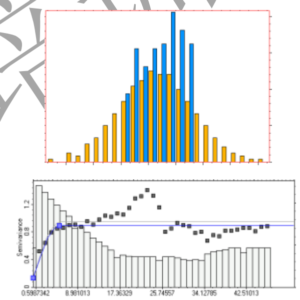


Scale up well logs

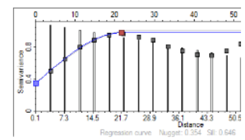


Univariate and bivariate geostatistics

Basic statistics

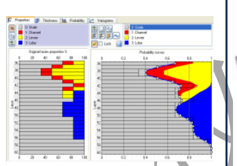


Variogram modeling

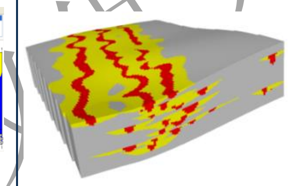


Facies modeling

Discrete data analysis

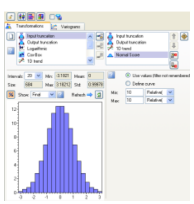


Stochastic facies modeling

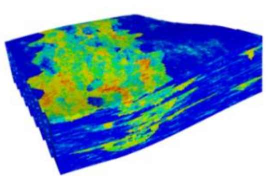


Petrophysical modeling

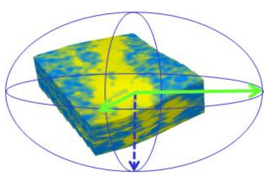
Continuous data analysis



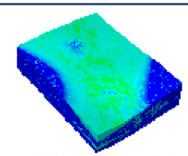
Stochastic and deterministic petrophysical modeling: Gaussian simulation

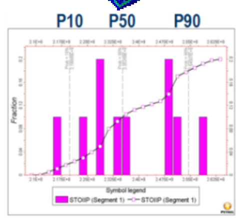


Use of secondary information for property modeling



Volume calculation and Uncertainty analysis





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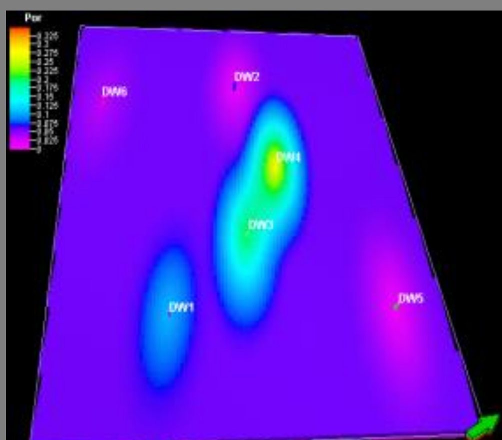
Petrel modeling techniques for continuous properties

Methods used in this course:

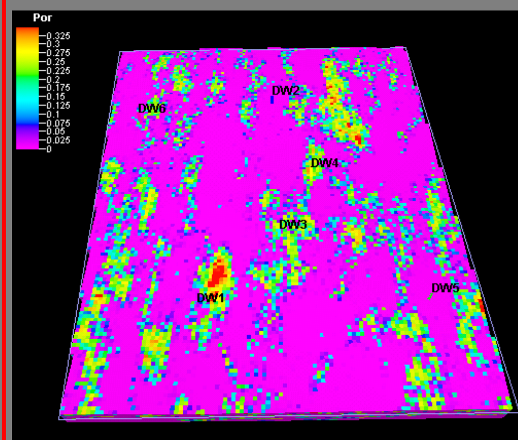
Deterministic: One output

Kriging

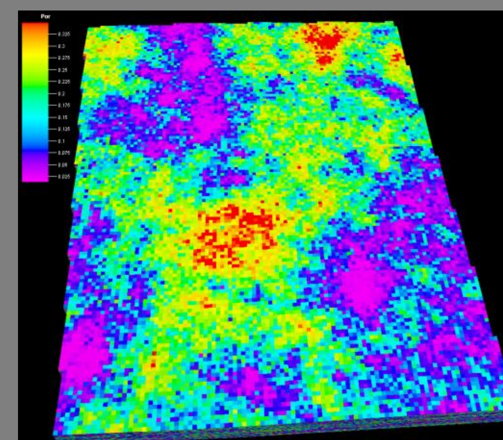


Stochastic: Multiple equally probable outputs

SGS



GRFS



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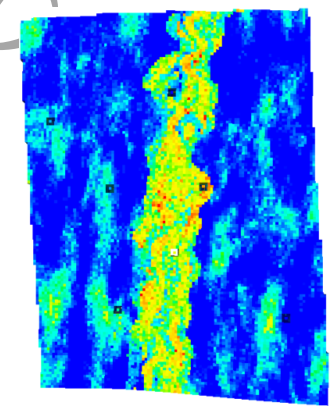
Overview

Gaussian Random Function simulation

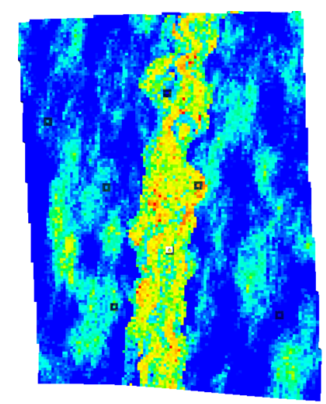
Preferred method. Faster than SGS with better reproduction of input statistics. Not sequential, allows the algorithm to be parallelized using a decomposition:

- Conditional simulation = Kriging + Unconditional Simulation
- Unconditional simulation. A Fast Fourier Transform algorithm that generates good variogram reproduction.



Sequential Gaussian simulation

Widely used stochastic GSLIB method based on Kriging. It can honor input data distributions, variograms, and trends.



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When can you use Gaussian simulation?

Typically, you use a Gaussian simulation method when sparse data is present, or no input data (wells) is available.

Inputs:

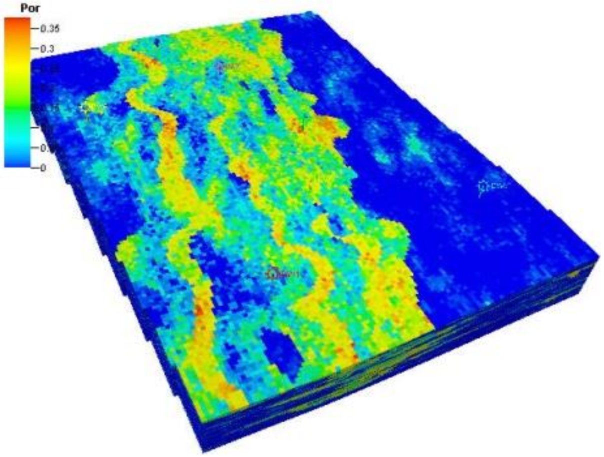
- Well data, facies model, trends, and secondary data
- Variogram (for different facies)

Underlying methods:

- Simple Kriging (Global means: stable)
- Ordinary Kriging (Re-estimates mean: more data)

Output:

- Pixel-based property honoring input data
- Can run multiple equiprobable realizations for uncertainty



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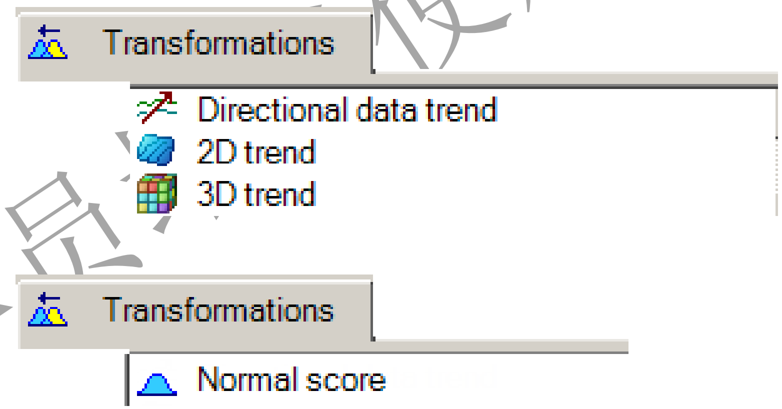
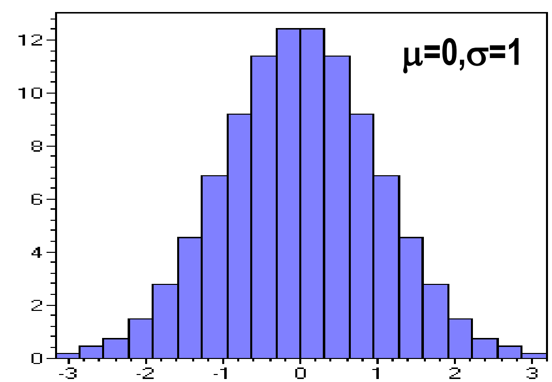
Data transformation

GRFS and SGS requirements:

- **Stationarity** (de-trending, not dependent on location)
- **Standard normal distribution** (mean = 0, standard deviation = 1)

Simulation result is back-transformed automatically. Spatial trend and original data distribution are honored.





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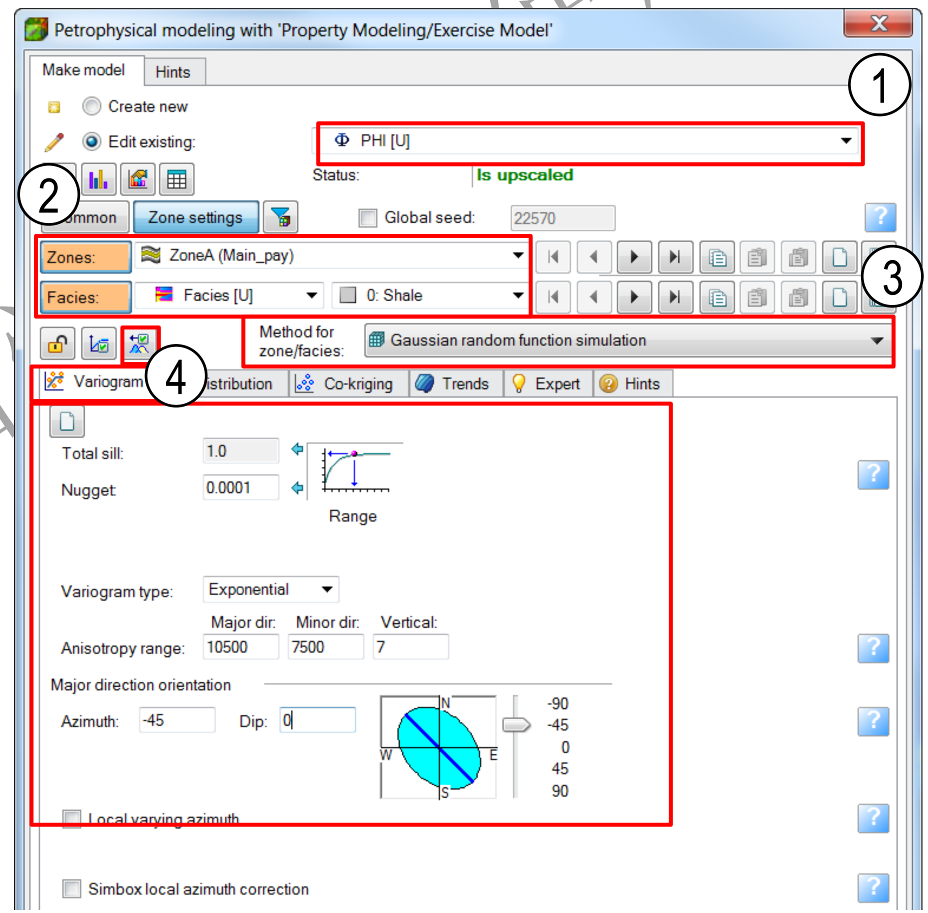
Variogram conditioned to a facies model

1. Select an existing upscaled property ([U] as suffix) to model.
2. Select the zone and facies.
3. Select Gaussian random function simulation or Sequential Gaussian simulation as the Method for zone/facies.
4. Specify the Nugget, Variogram type, Anisotropy range, and Major direction orientation on the **Variogram** tab or use a variogram from *Data analysis*.



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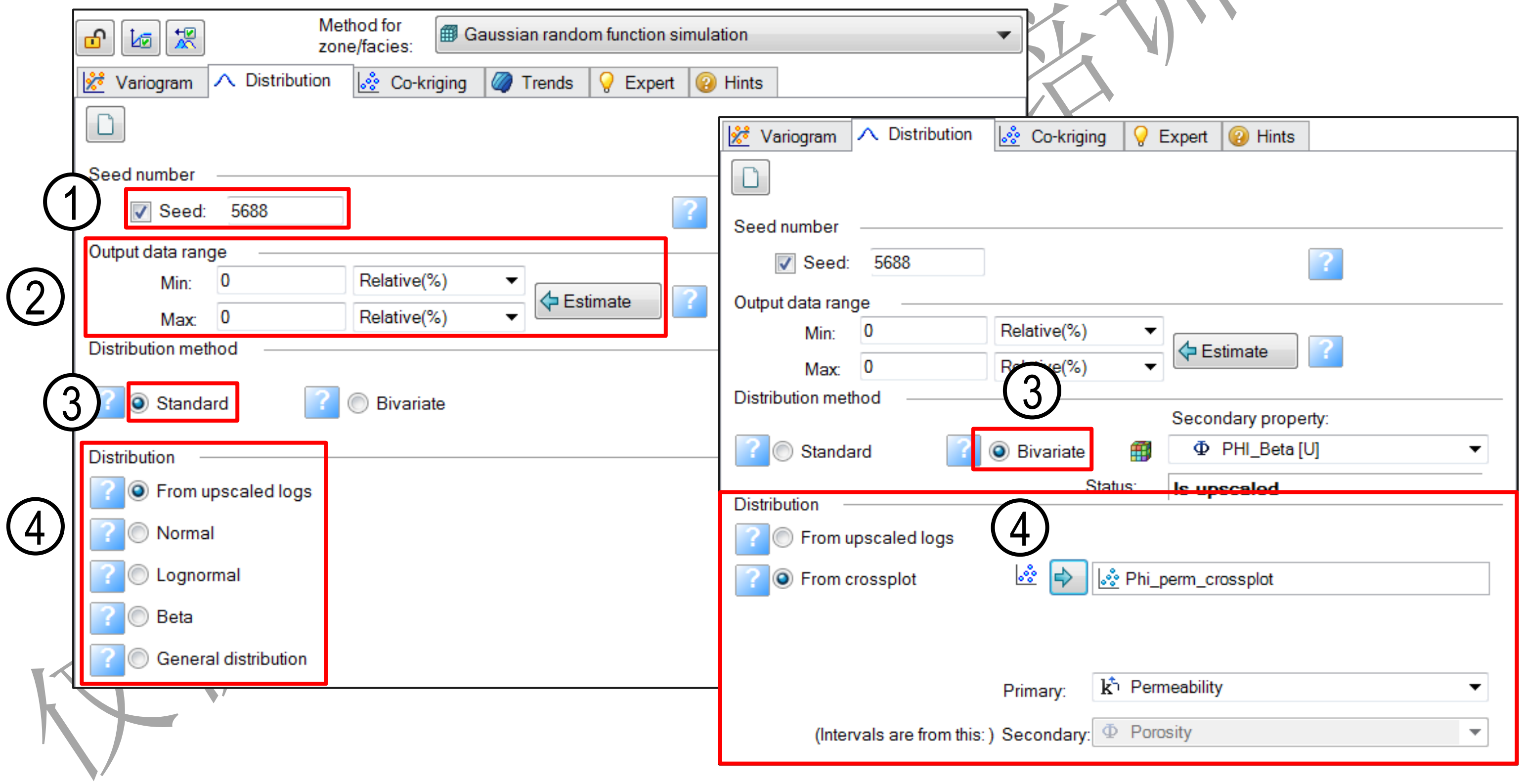
Distribution

Choose the type of distribution you would like your data to have.



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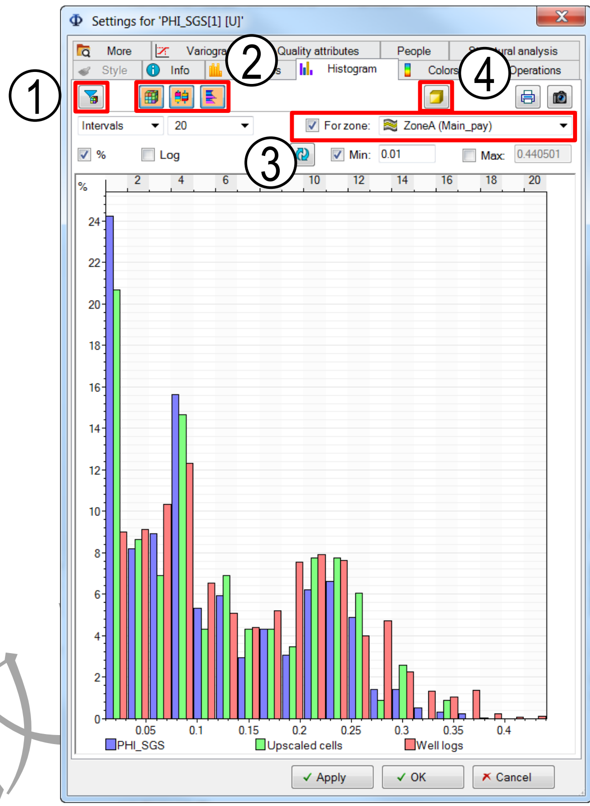
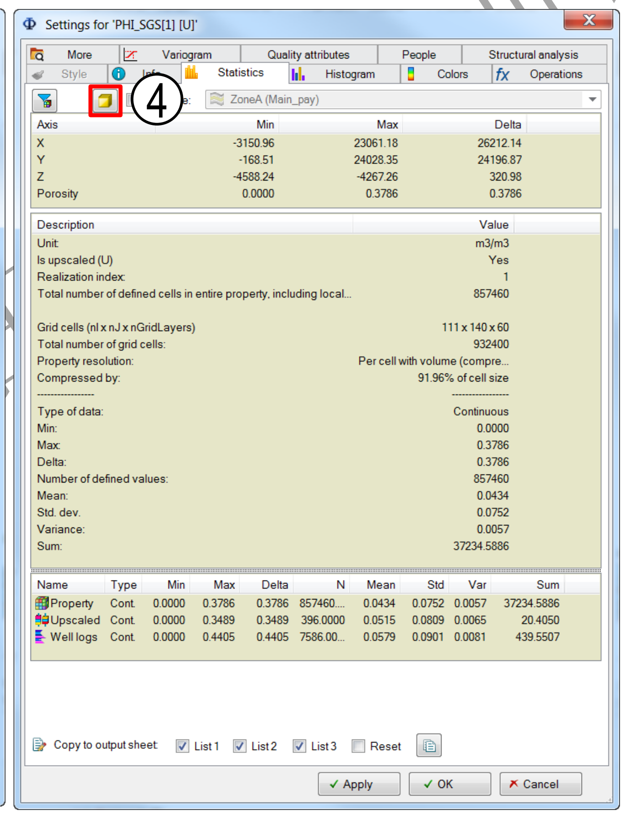
Results

Use the **Statistics** tab and the **Histogram** tab to QC your results.





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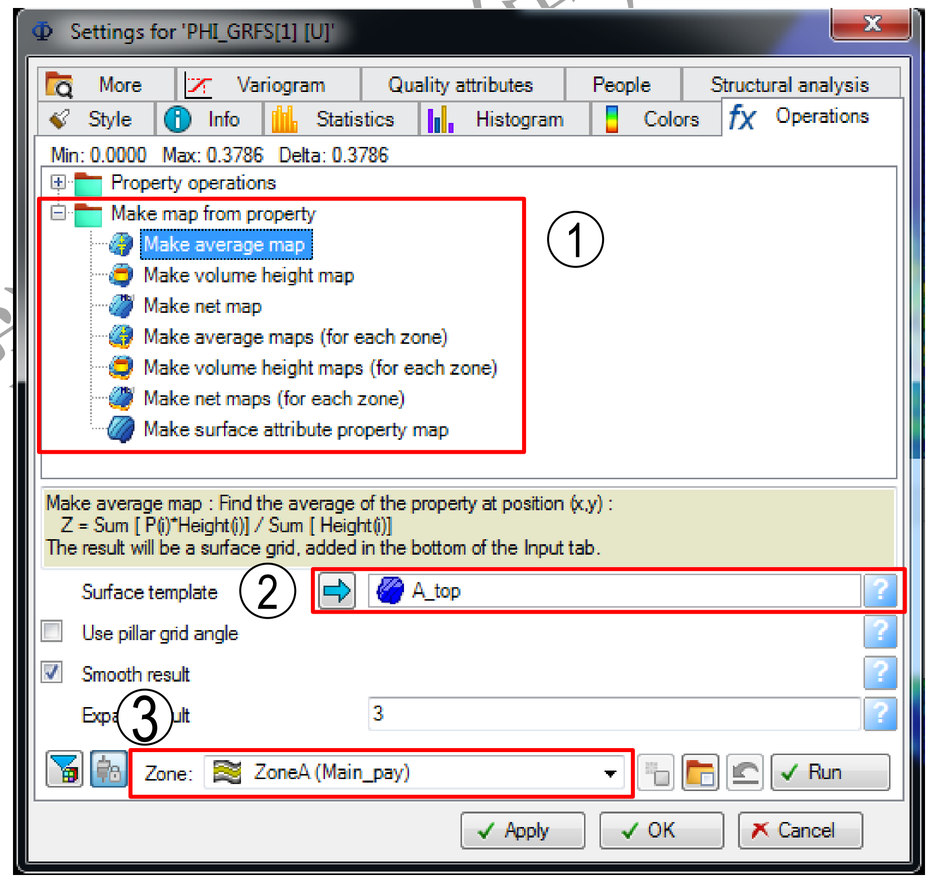
Property map

Build maps for a 3D property as part of the Operations available for properties.

1. Select a map.
2. Specify the resolution and extents of the surface.
3. Filter by zone or apply any other filter.



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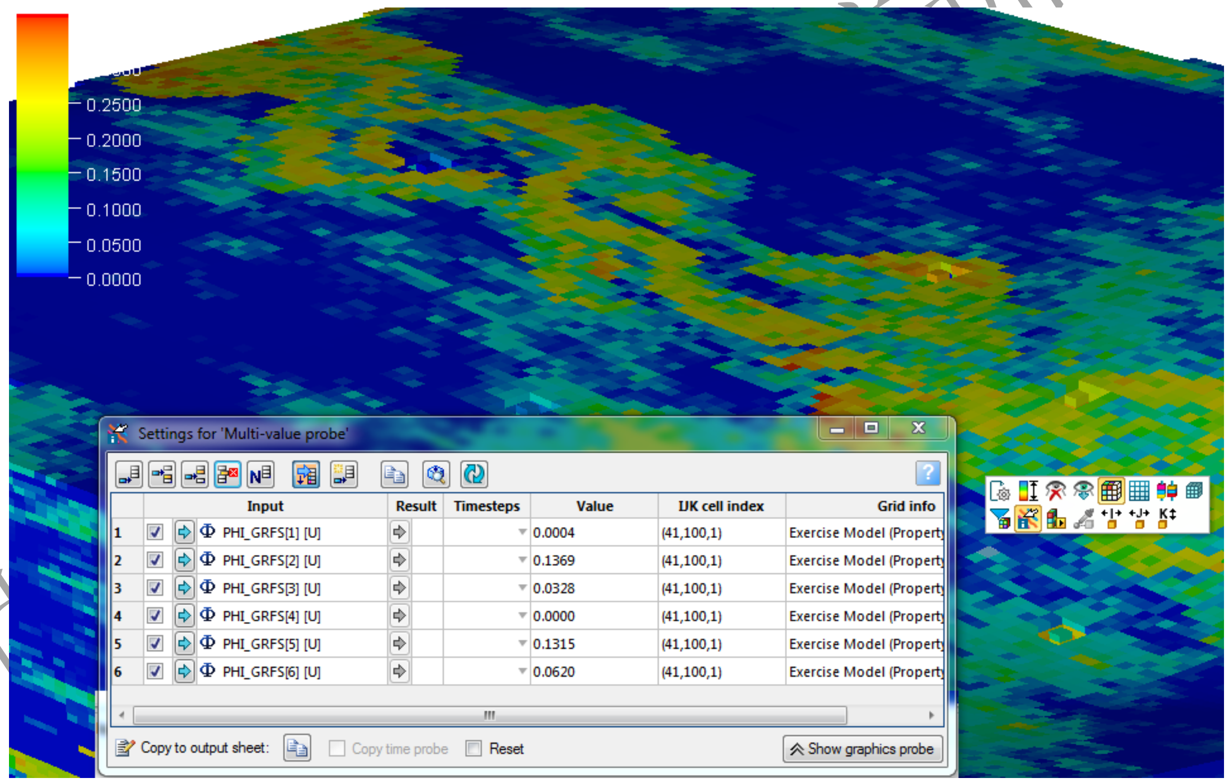
Multi-value probe

Multi-value probe inspects various grid properties and 3D simulation results.



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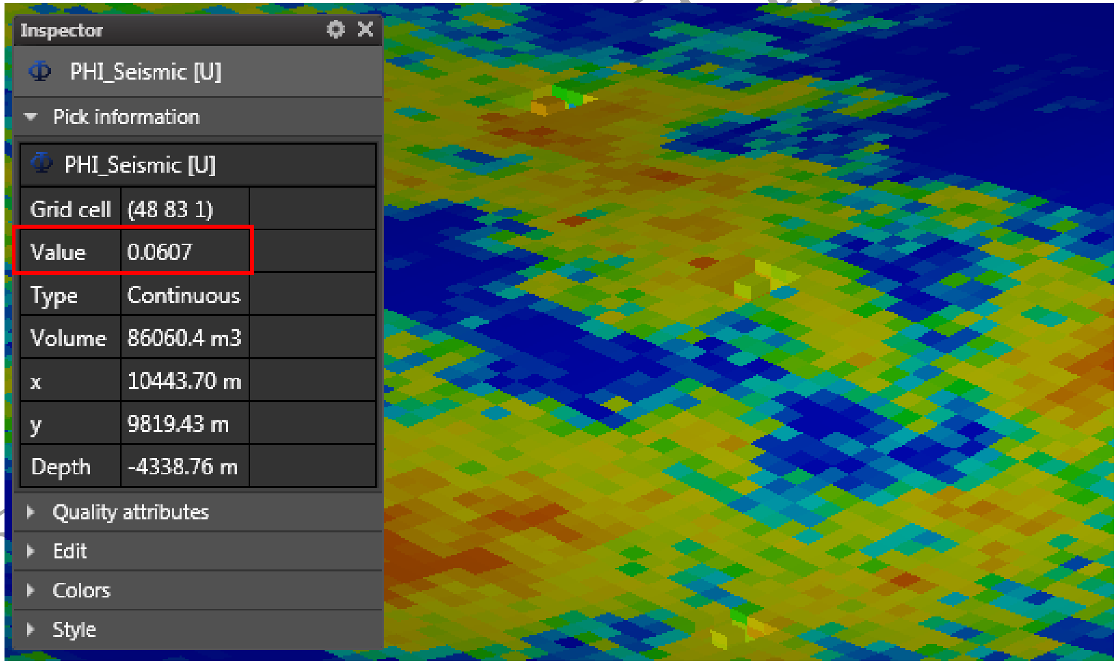
Edit cell property value

Properties can be edited in the display window on a cell-by-cell basis.



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Kriging/averaged simulation: Change of support effect

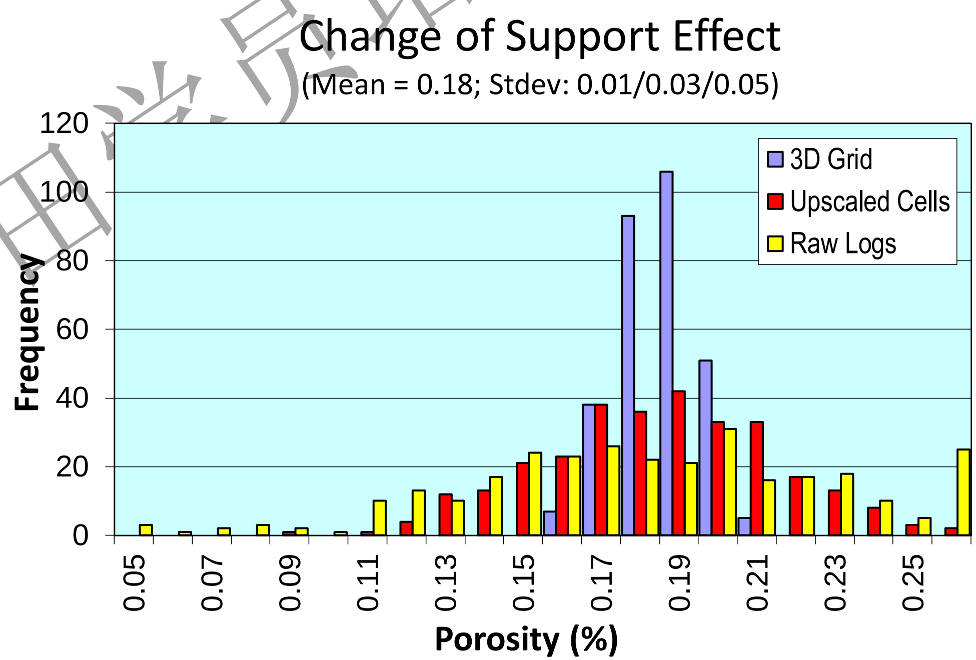
Change of Support Effect is a result of different volume support and the smoothing character of the (Kriging) algorithm. It affects the variance but not the mean.

Affine Correction:

$$z(V_1)corr = \frac{\sigma^2(V_2)}{\sigma^2(V_1)} * (z(V_1) - \bar{x}) + \bar{x}$$

V_1 = Variable 1 (3D model)

V_2 = Variable 2 (upscaled cells)



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Exercises

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