

NEXT

A Schlumberger Company

Petrel 2017 Property Modeling Module 17: Petrophysical modeling using secondary data



Schlumberger-Private

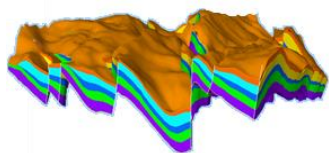
Petrel 2017 Property modeling

Intro

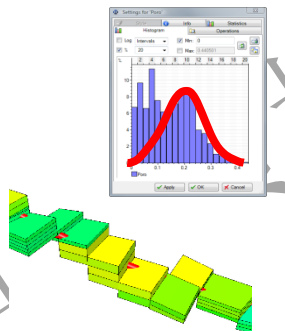
Property modeling
data preparation

Scale up well logs

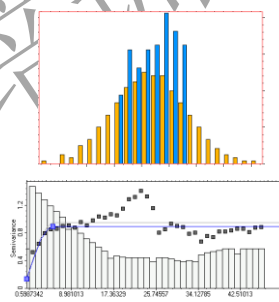
Univariate and bivariate geostatistics



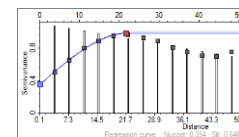
Petrel Property Modeling
objective and workflow



Basic statistics



Variogram
modeling

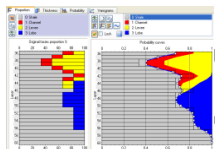


Facies modeling

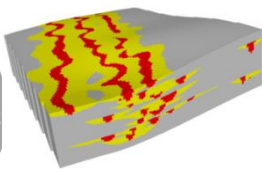
Petrophysical modeling

Volume calculation and
Uncertainty analysis

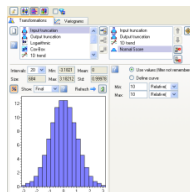
Discrete
data analysis



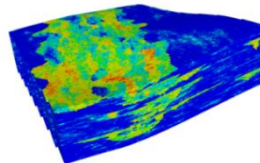
Stochastic facies
modeling



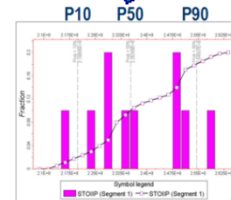
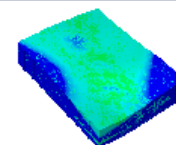
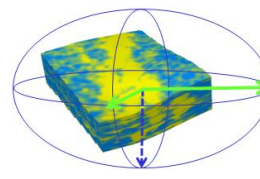
Continuous
data analysis



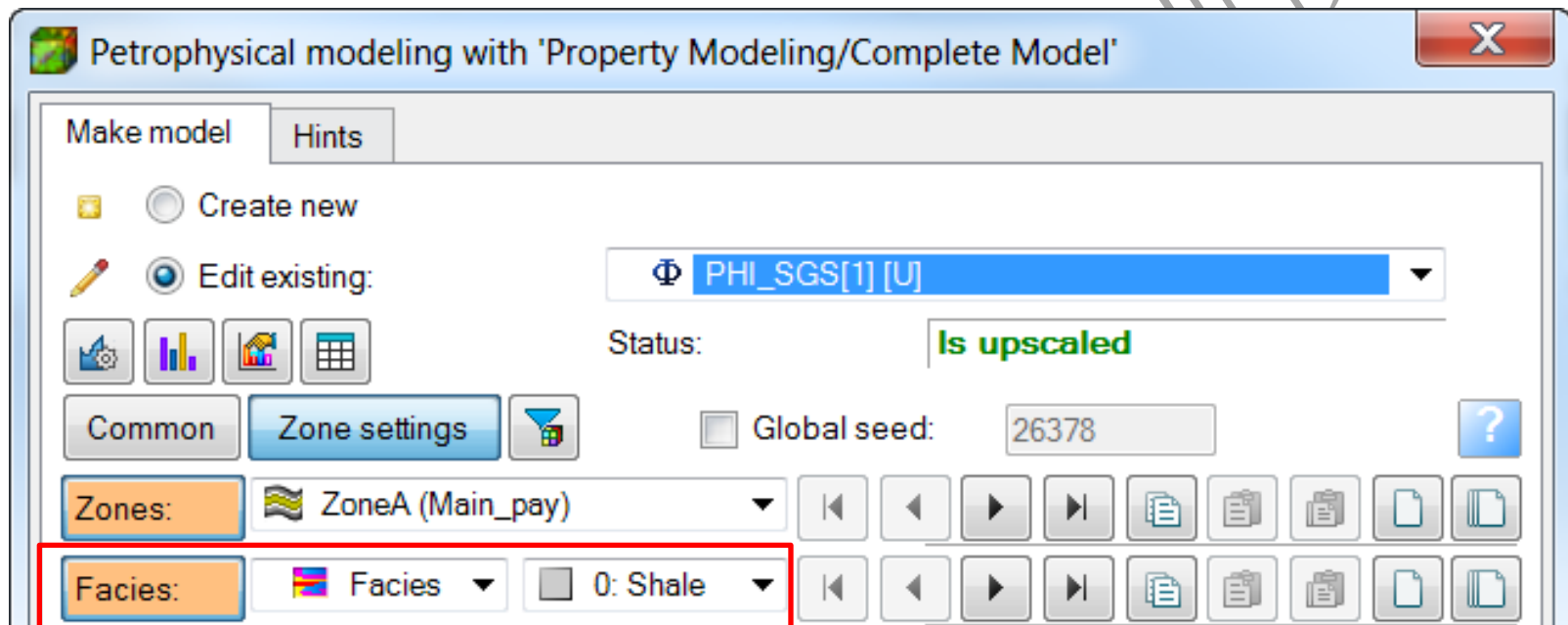
Stochastic and
deterministic
petrophysical modeling:
Gaussian simulation



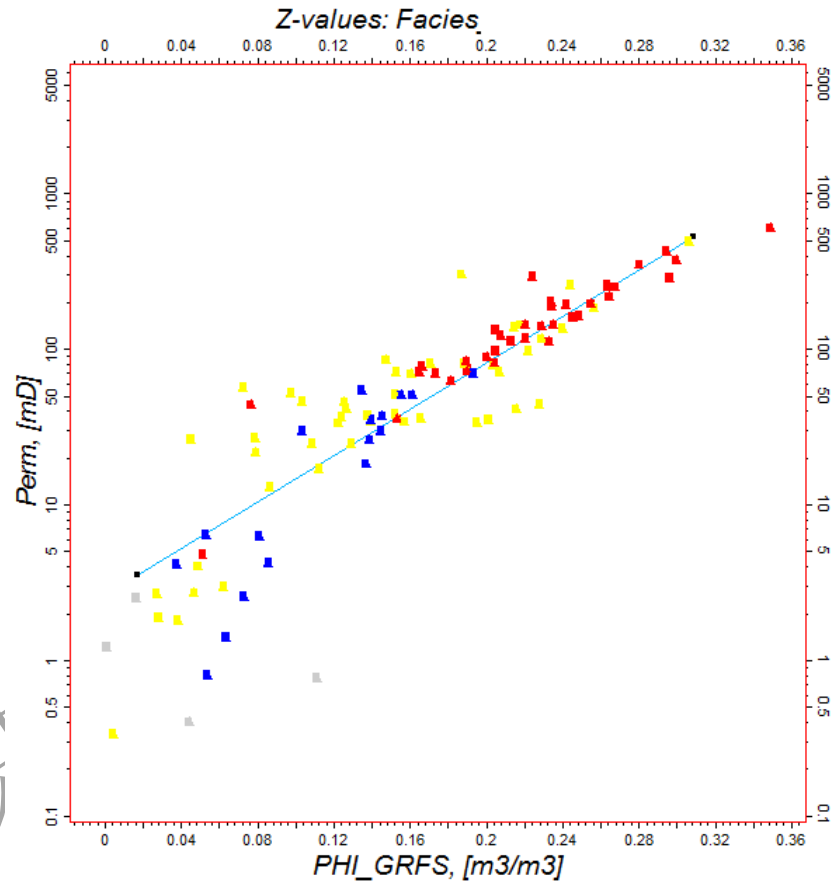
Use of secondary
information for
property modeling



Conditioning to a facies realization



Correlation with secondary data



Local varying mean (LVM): Theory

$$z(x_0) = \sum_i^n \lambda_i z(x_i) + [1 - \sum_i^n \lambda_i] m(x_0)$$

- $Z(x_i)$: Data points (for example, porosity).
- $m(x_0)$: Secondary input such as a 2D map (porosity) or a property with a strongly correlated positive value.
- The sum of the weights λ_i can be less than one.
- The smaller the weights the bigger the influence of the Local varying mean $m(x_0)$ on the calculated value $Z(x_0)$.
- Local varying mean gains influence with increasing distance of location x_0 from data points (decreasing weights λ_i).

IMPORTANT: Secondary input should be smooth and available for all locations x_0 and Positively correlated to the primary data.

Local varying mean

Collocated Co-kriging

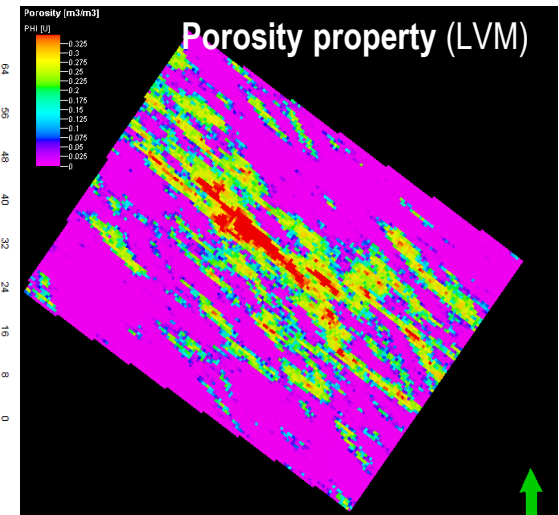
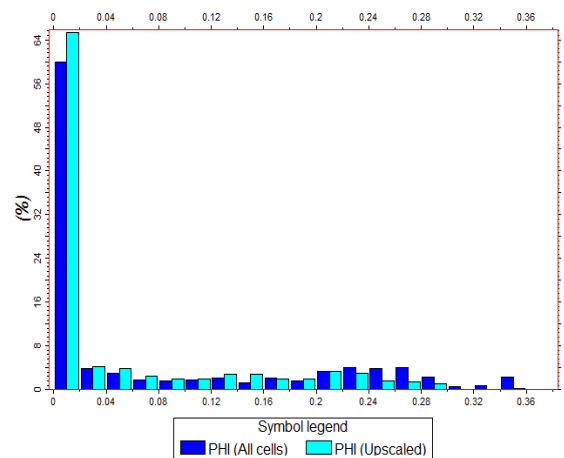
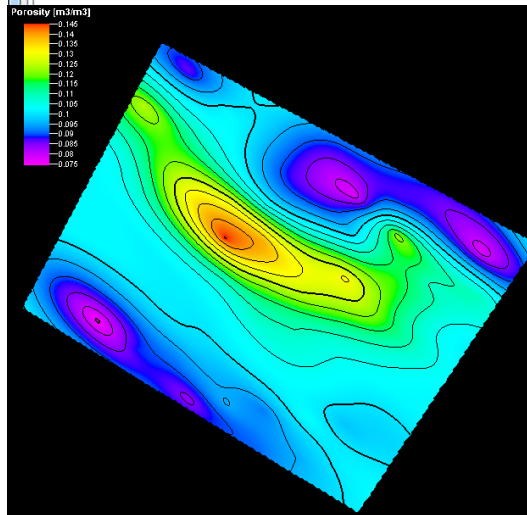
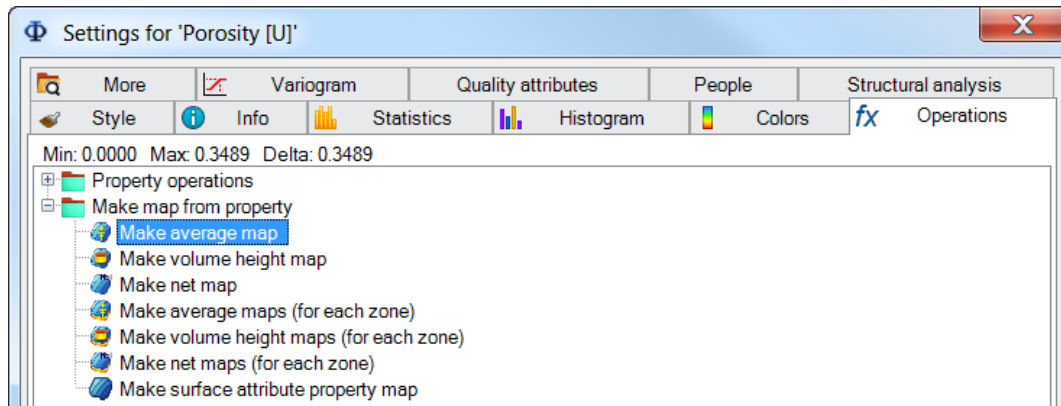
Bivariate distribution

Local varying mean

The screenshot shows the 'Co-kriging' tab of a software interface. The 'Secondary variable' section includes a 'Vertical function' checkbox, a 'Depth options' dropdown set to 'Based on layer index', and an 'Inverse X axis' checkbox. The 'Bivariate distribution' section has a 'Horizontal' checkbox checked, with a value of 'average map for PHI_GRFS_Arithmetic mea' entered in the adjacent field. The 'Local varying mean' section has a 'Method' dropdown with 'Local varying mean' selected. Red boxes highlight the 'Co-kriging' tab, the 'Horizontal' field, and the 'Method' dropdown. A line points from the 'Collocated Co-kriging' text to the 'Co-kriging' tab.

Section	Option	Value
Secondary variable	Vertical function	<input type="checkbox"/>
	Depth options	Based on layer index
	Inverse X axis	<input type="checkbox"/>
Bivariate distribution	Horizontal	<input checked="" type="checkbox"/> average map for PHI_GRFS_Arithmetic mea
	Volume	<input type="checkbox"/>
Local varying mean	Method	Local varying mean
		Collocated co-kriging

Average porosity map



Co-kriging: Theory

Traditional Co-kriging equation: $Z_{COK}(x_0) = \sum_i \lambda_i Z(x_i) + \sum_j \mu_j Y(x_j)$

- Requires variograms of primary and secondary property and a cross variogram.
- Consequently, a larger equation system is constructed with more constraints.

Collocated Co-kriging equation: $Z_{CCOK}(x_0) = \sum_i \lambda_i Z(x_i) + \mu Y(x_0)$

- A simplified equation system → faster than traditional Co-kriging.
- Possible solution if there is a more densely sampled secondary variable.
- Requires a variogram only for the primary property, using a correlation coefficient for the secondary property.

Collocated Co-kriging

Bivariate distribution

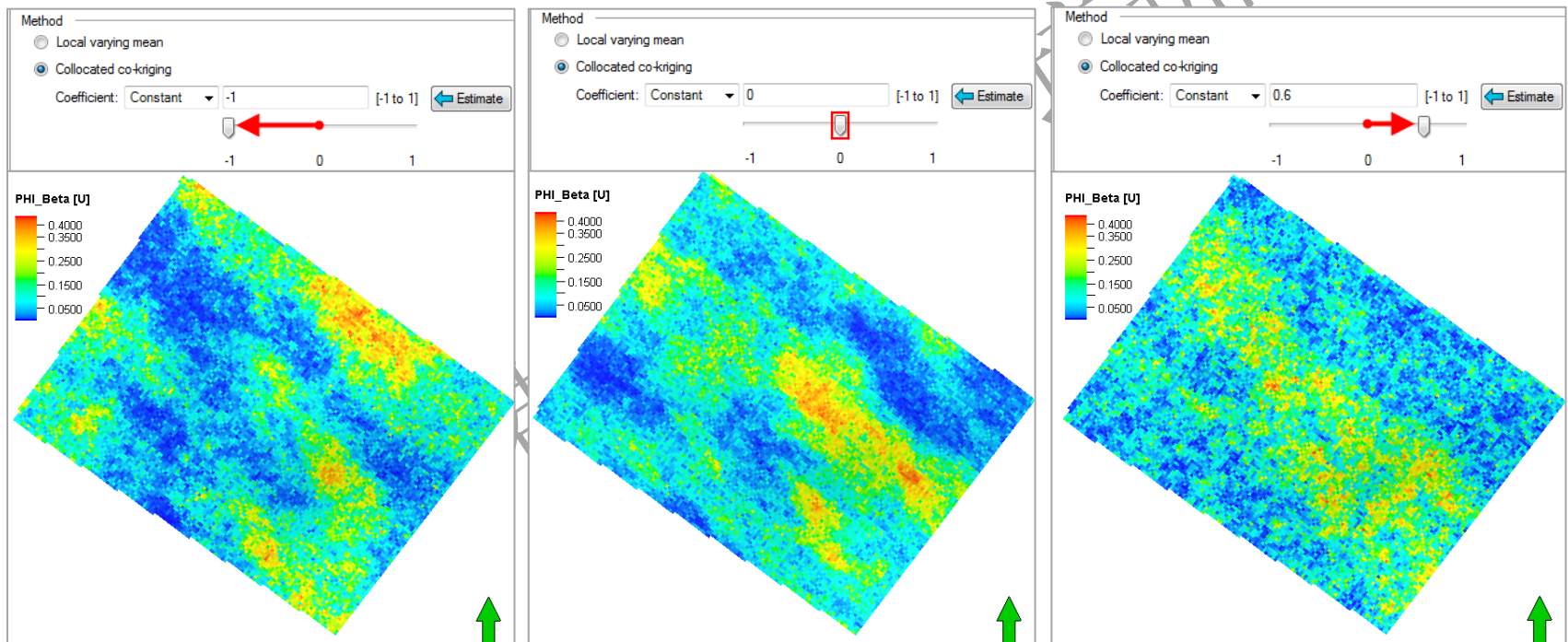
Local varying mean

Collocated co-kriging

Coefficient choice and estimate function

The screenshot shows the 'Co-kriging' tab selected in a software interface. The 'Secondary variable' section includes a 'Volume' checkbox checked and set to 'AI_rescaled'. The 'Method' section has 'Collocated co-kriging' selected. The 'Coefficient' is set to 'Constant' with a value of '0.55' and an 'Estimate' button. A red box highlights the 'Co-kriging' tab, the 'Volume' checkbox and its value, the 'Collocated co-kriging' radio button, and the 'Coefficient' section. Annotations with arrows point to these specific elements from the left. A 'Bivariate distribution' label with an arrow points to the 'Co-kriging' tab. A large, faint watermark '仅供内部使用' is visible across the interface.

Correlation coefficient slider bar



Bivariate distribution

Variogram Distribution Co-kriging Expert Hints

Seed number

Seed: 22496

Output data range

Min: 0 Relative(%)

Max: 0 Relative(%)

Estimate

Distribution method

Standard Bivariate

Secondary property: Φ PHI_Seismic(AI) [U]

Status: Is upscaled

Distribution

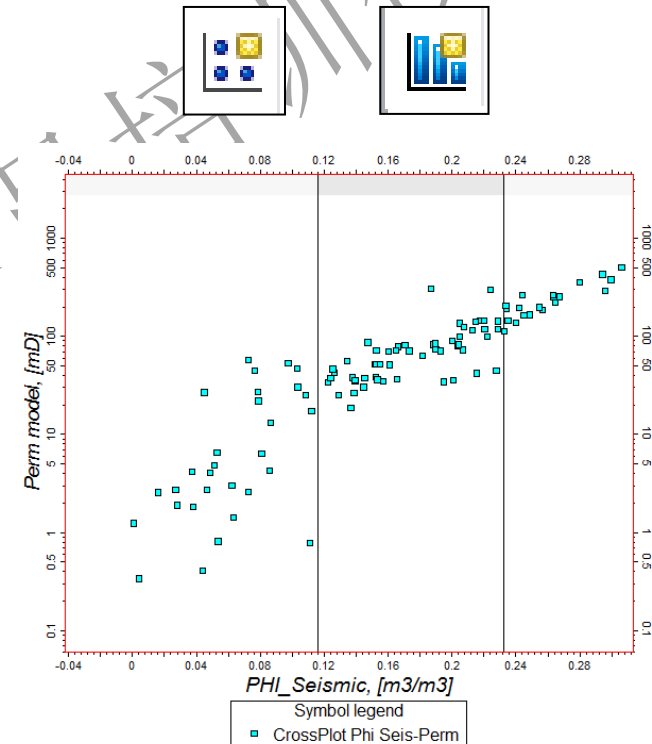
From upscaled logs

From crossplot PHI-Perm_Xplot

Primary: k Permeability

Secondary: Φ Porosity

(Intervals are from this:)



Variogram Distribution Co-kriging Expert Hints

Seed number

☐ Seed: 22496

Output data range

Min: 0 Relative(%)

Max: 0 Relative(%)

Distribution method

☐ Standard ☒ Bivariate

Secondary property: Φ PHI_Seismic(AI) [U]

Status: Is upscaled

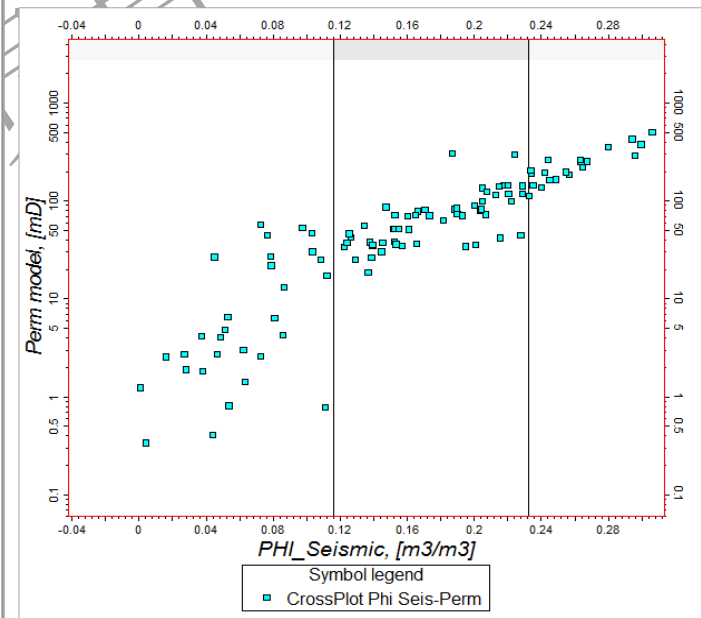
Distribution

☐ From upscaled logs ☒ From crossplot

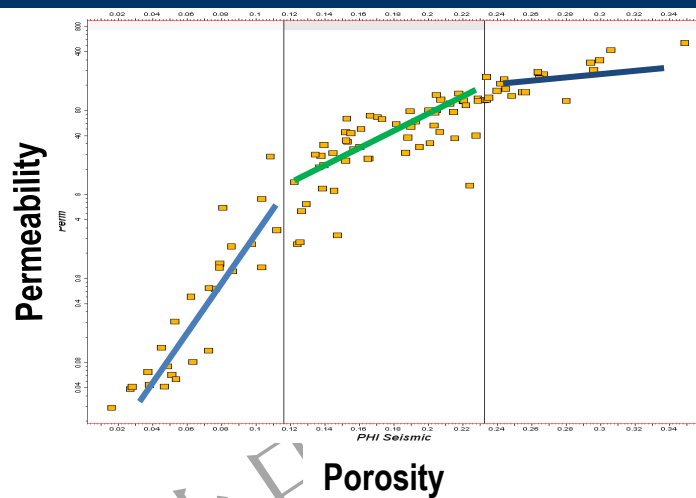
PHI-Perm_Xplot

Primary: k Permeability

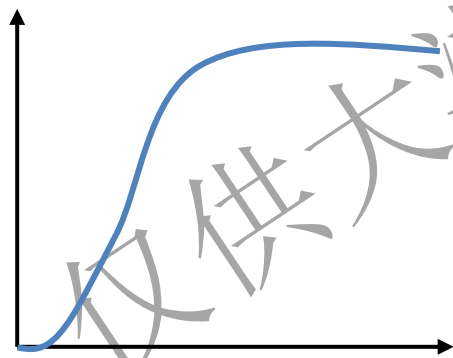
(Intervals are from this:) Secondary: Φ Porosity



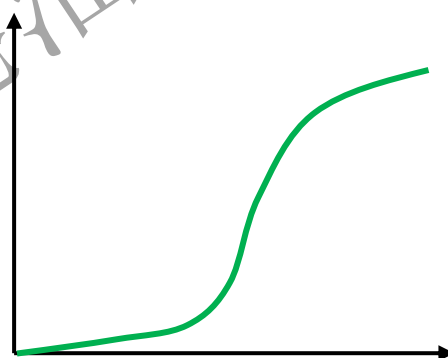
Raw crossplot with bins



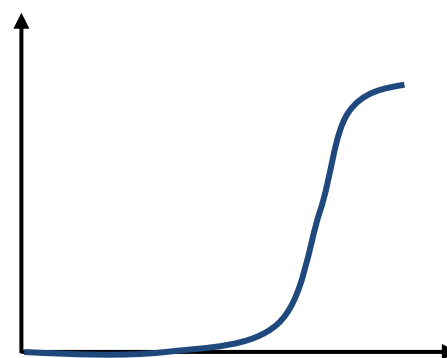
CDF for low porosity



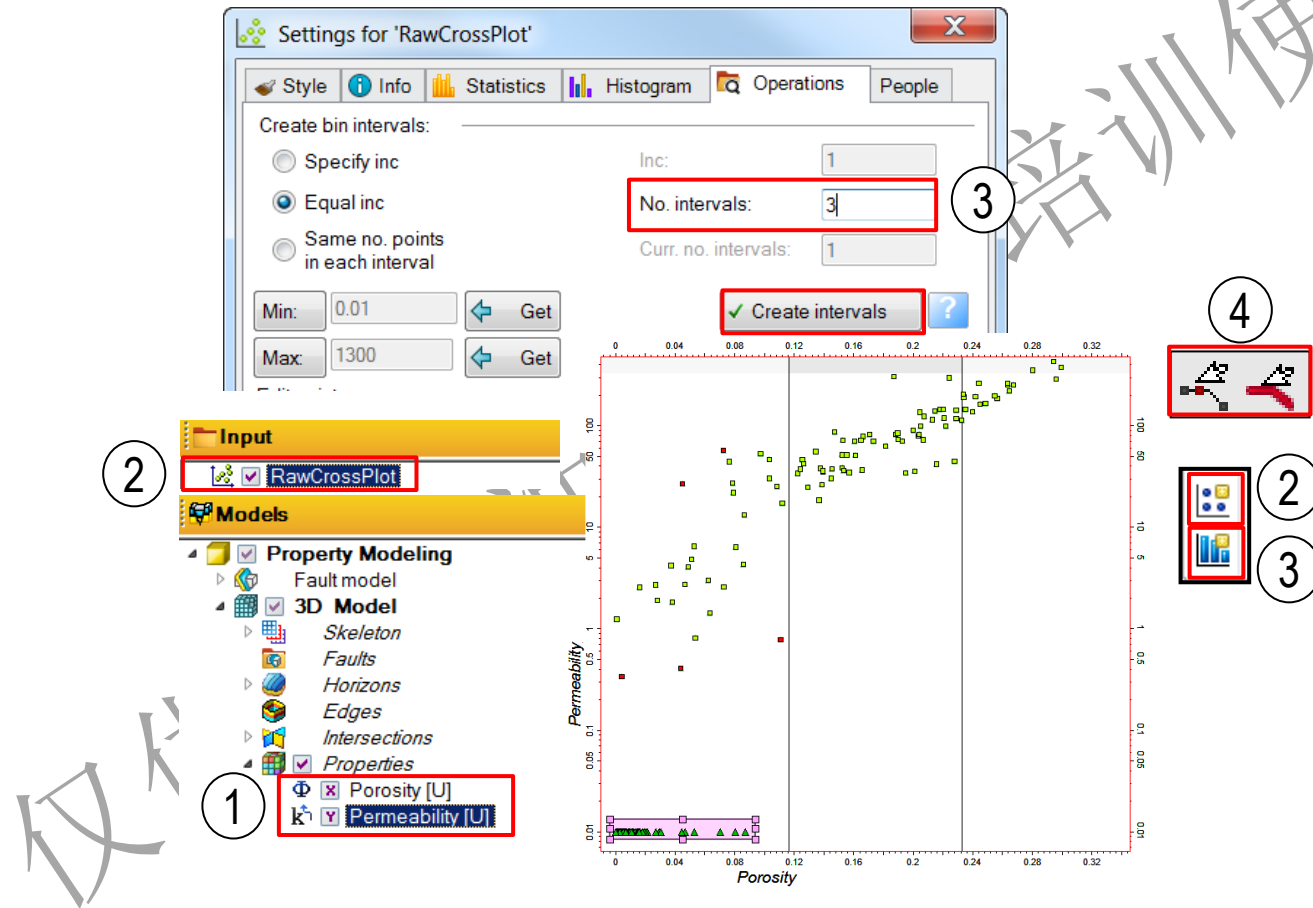
CDF for medium porosity



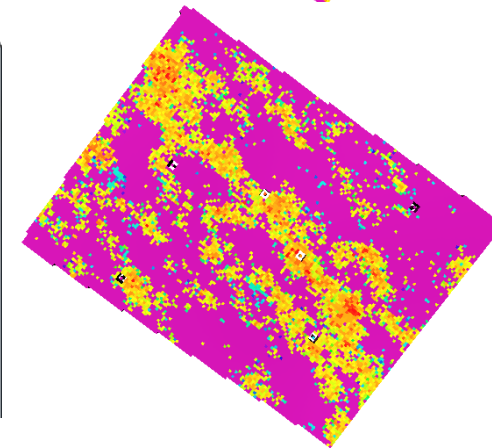
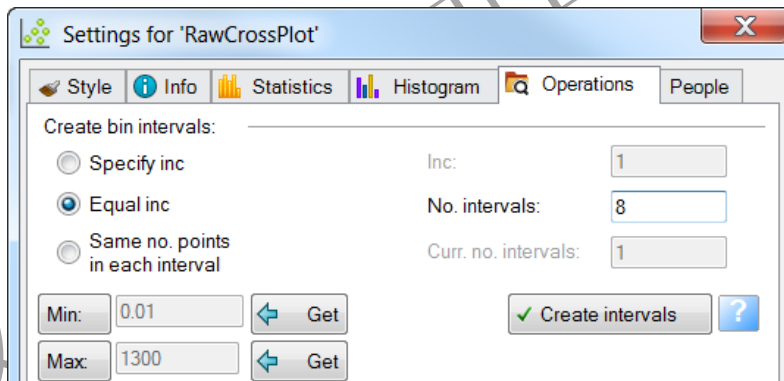
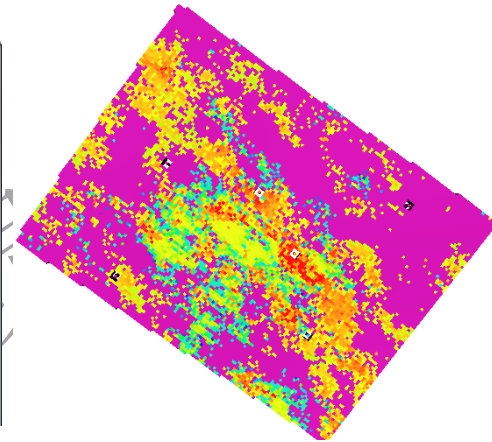
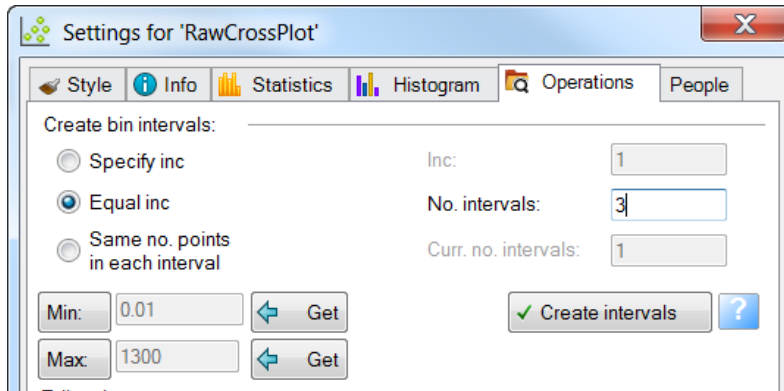
CDF for high porosity



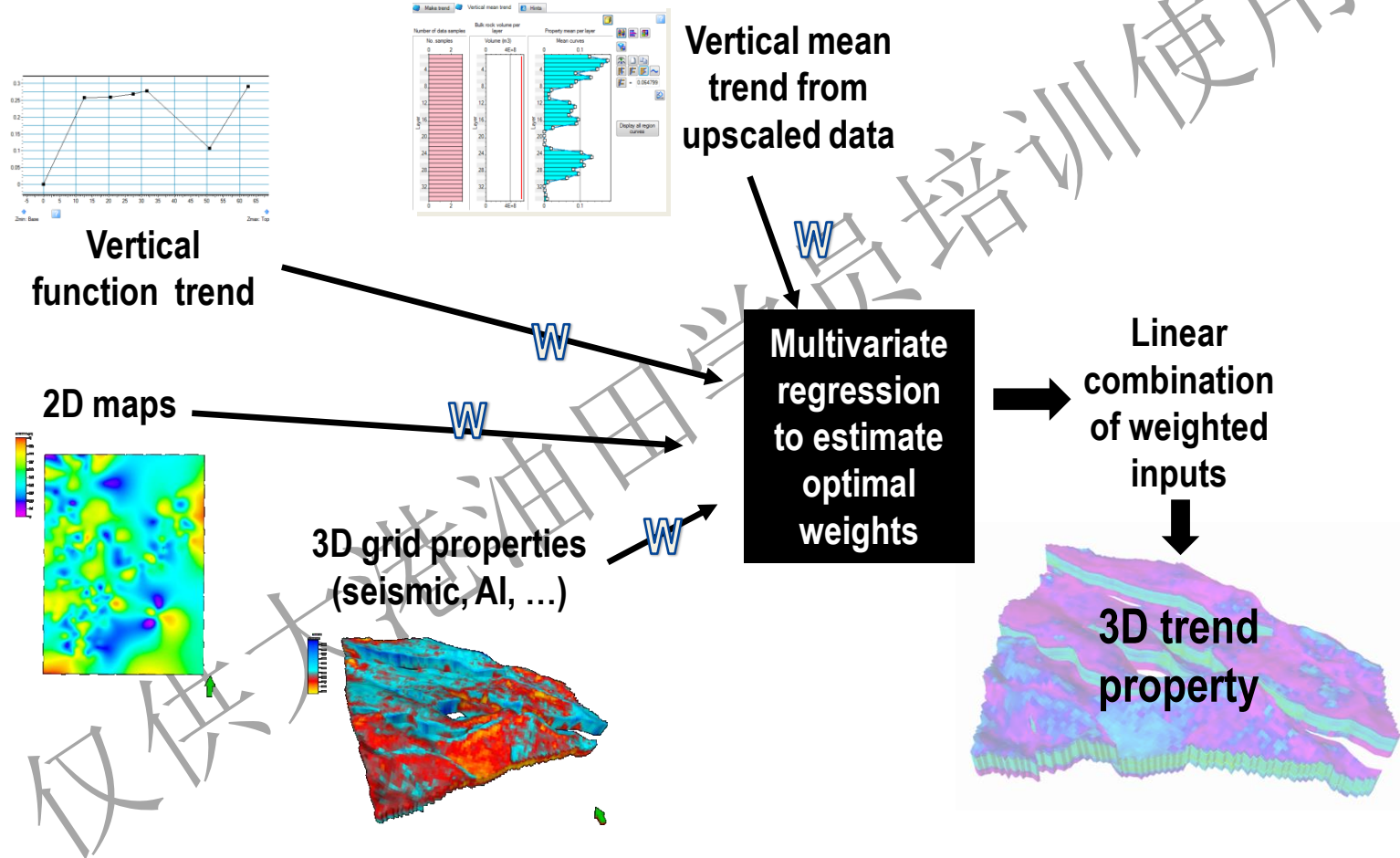
Create crossplot bins

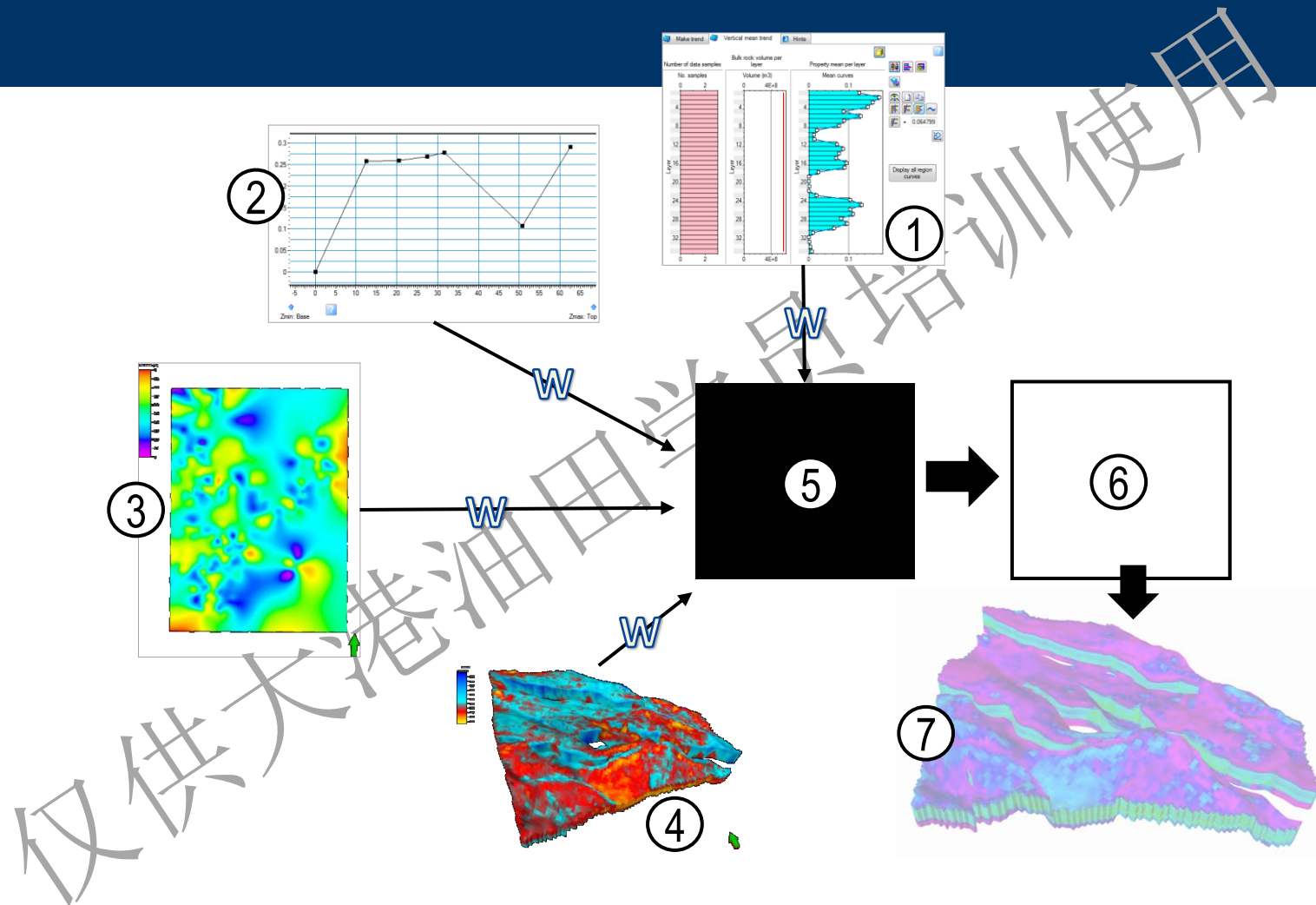


Use different bins

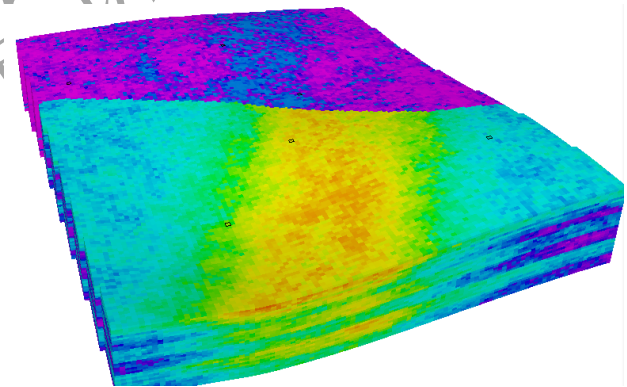
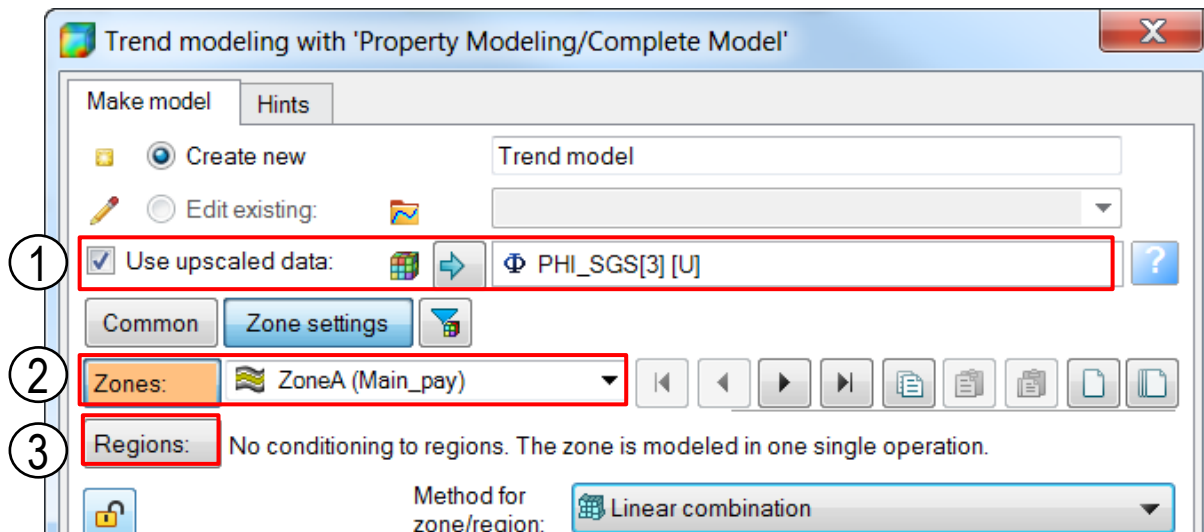


Continuous trend modeling (1)





Continuous trend modeling (2)



Make trend

Assign constant value section

Trend transformation section

Input trends section

Output trend transformation section

Make trend Vertical mean trend Hints

Trends

☐ Assign constant value: 0 Estimate

Trend transformation

☒ Gaussian transform ☐ Normalize to [0,1]

Input trends

Estimate trend weights

☒ Vertical: ☐ Phi normal distrib Weight: 0.0164 -1 0 1

Depth options: Based on absolu ?

☒ Inverse X axis ☐ Scale depth axis

Horizontal/Volume trend:

☒ AI_rescaled Weight: 0.51629 -1 0 1

☐ Weight: 1 -1 0 1

☐ Weight: 1 -1 0 1

☐ Weight: 1 -1 0 1

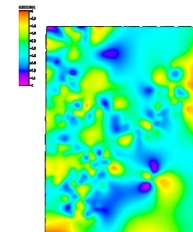
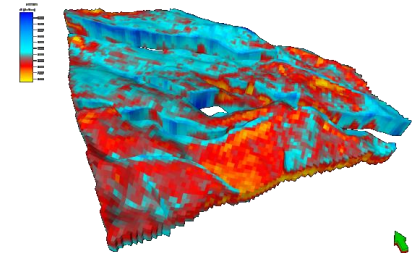
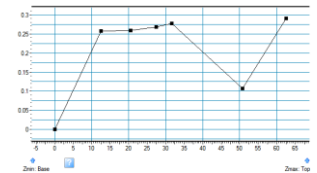
Output trend transformation

☒ Back-transform by upscaled Min: 0 Relative(%)

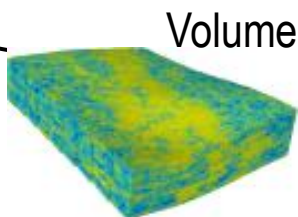
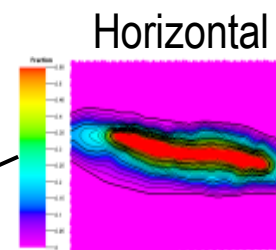
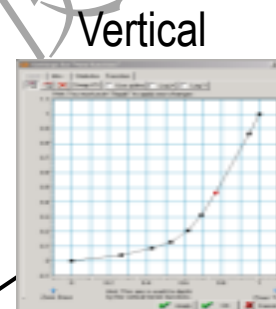
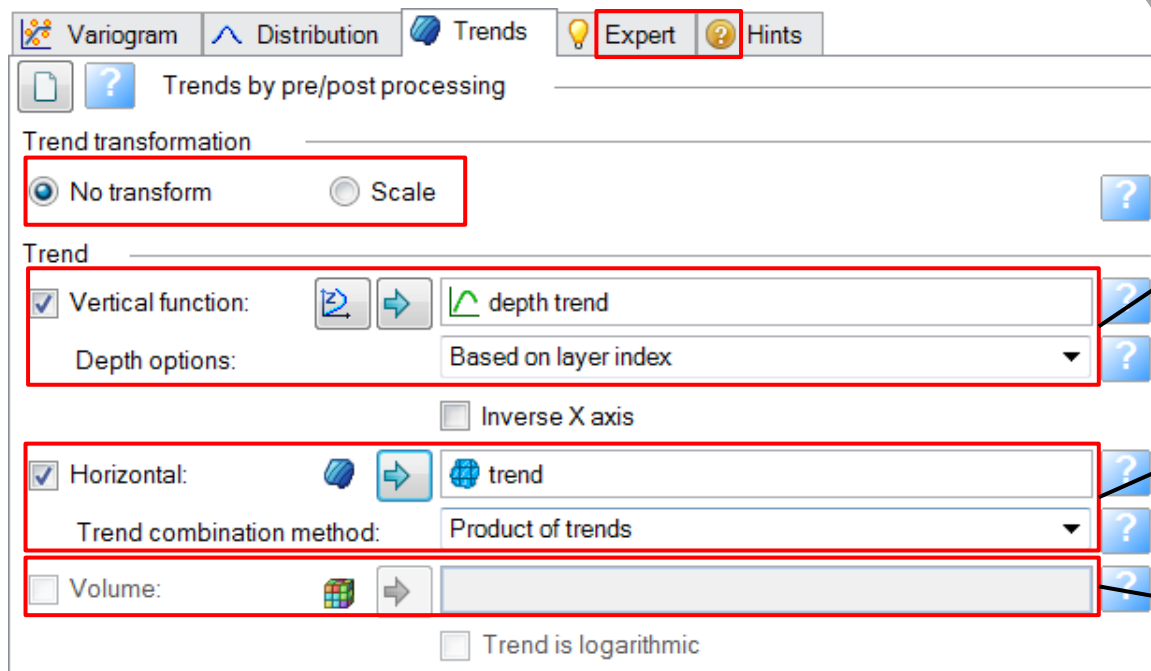
☐ User-defined transformation Max: 0 Relative(%) Estimate

☐ No transform

Trend weight



Application of trends



Exercises

- Create a porosity model with Co-kriging
- Create a permeability model with Co-kriging
- Create a permeability model with trend data
- Create a permeability model with Bivariate distribution