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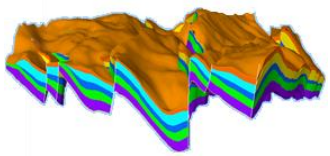
Petrel 2017 Property Modeling Module 13: Petrophysical modeling data analysis

Petrel 2017 Property modeling

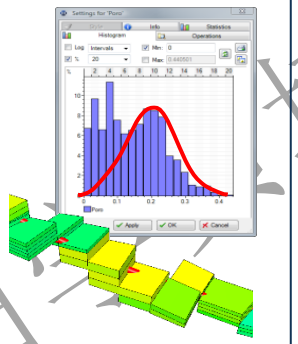


Intro

Petrel Property Modeling objective and workflow

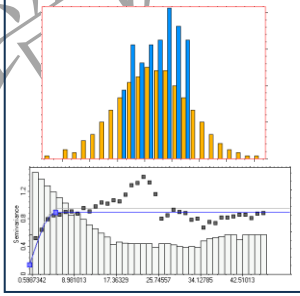
Property modeling data preparation

Scale up well logs

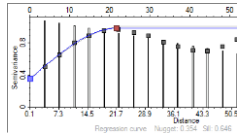


Univariate and bivariate geostatistics

Basic statistics

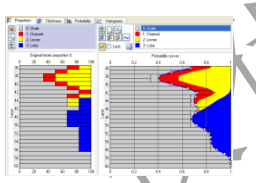


Variogram modeling

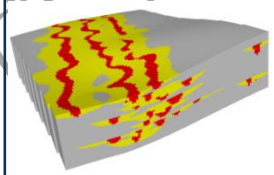


Facies modeling

Discrete data analysis

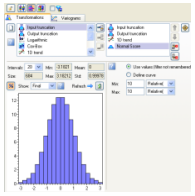


Stochastic facies modeling

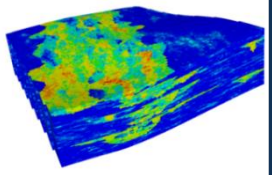


Petrophysical modeling

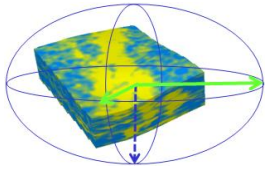
Continuous data analysis



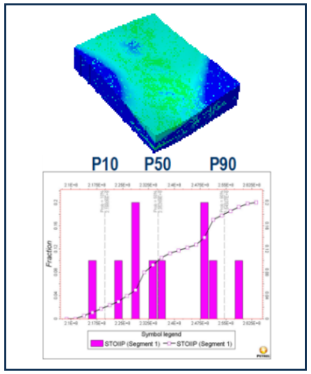
Stochastic and deterministic petrophysical modeling



Use of secondary information for property modeling



Volume calculation and Uncertainty analysis



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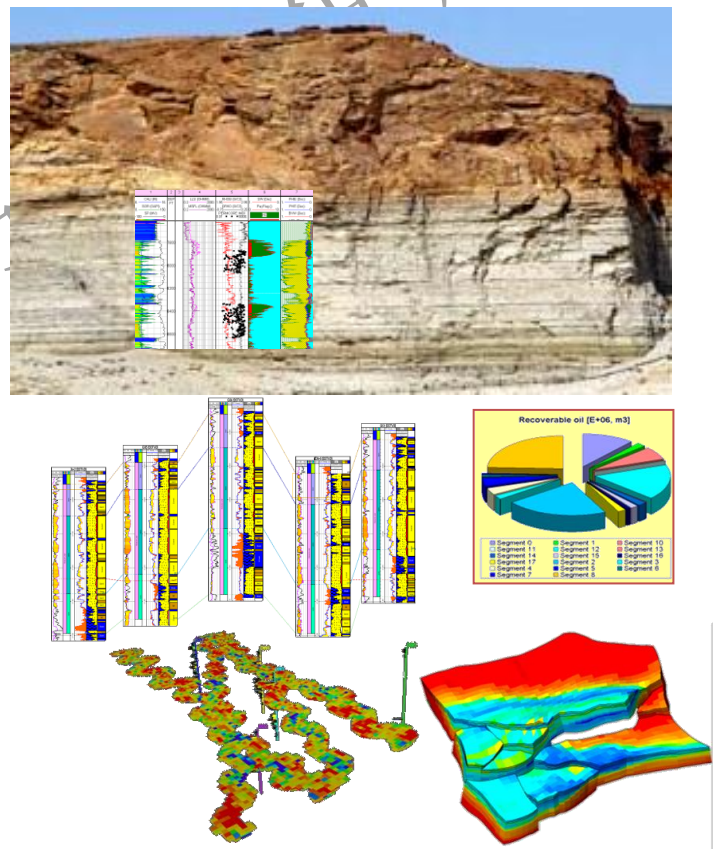
Overview

Key issues:

- Different petrophysical property distributions in each facies
- Various trends
- Spatial variation for each petrophysical parameter
- Correlation between parameters
- **Identify petrophysical features critical to production**



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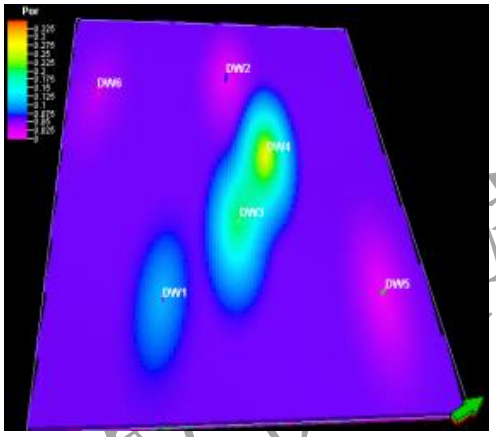
Petrel modeling techniques for continuous properties

Main course objective: Use Stochastic methods

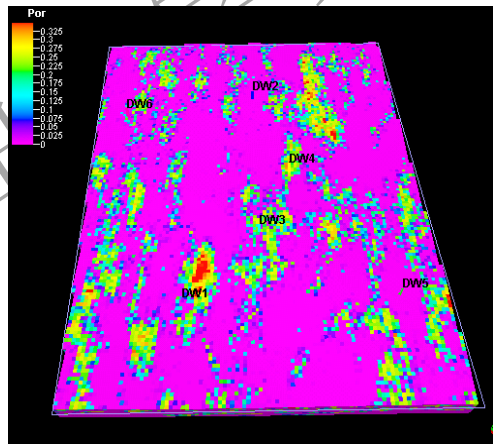
Deterministic: One single output

Kriging

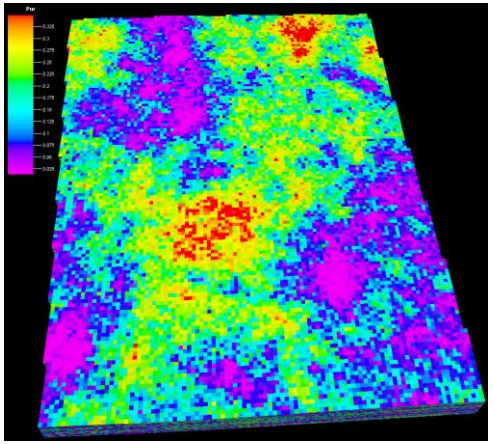


Stochastic: Multiple equally probable outputs

SGS



GRFS



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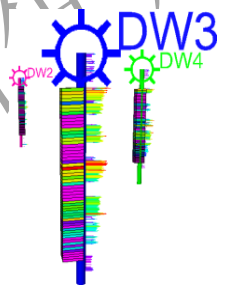
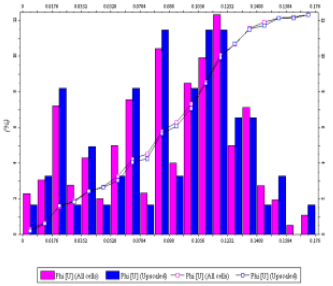
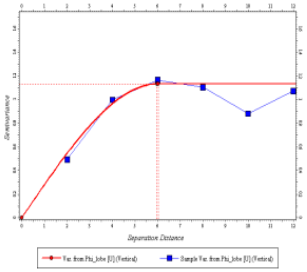
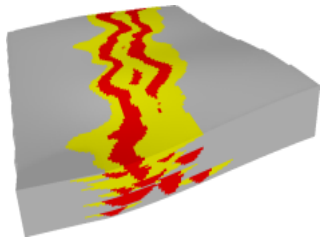
Property modeling inputs

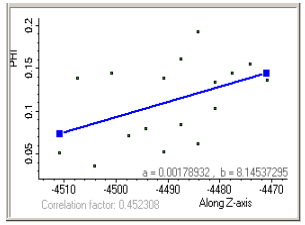
- Well data: Upscaled/blocked well logs
- Distribution: Histogram
- Variogram (spatial model):
  - Direction, model type, nugget, and sill
  - Correlation lengths in three directions (range).
- Facies model: Conditioning
- Spatial trends: Seismic/analogs
- Secondary parameters: Correlated











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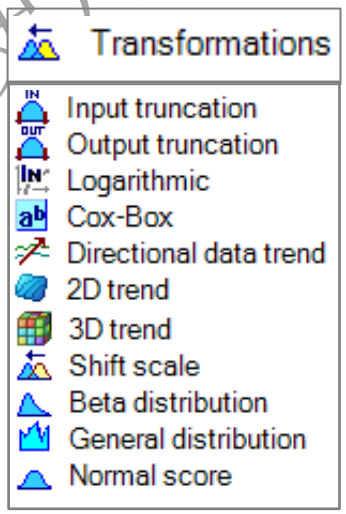
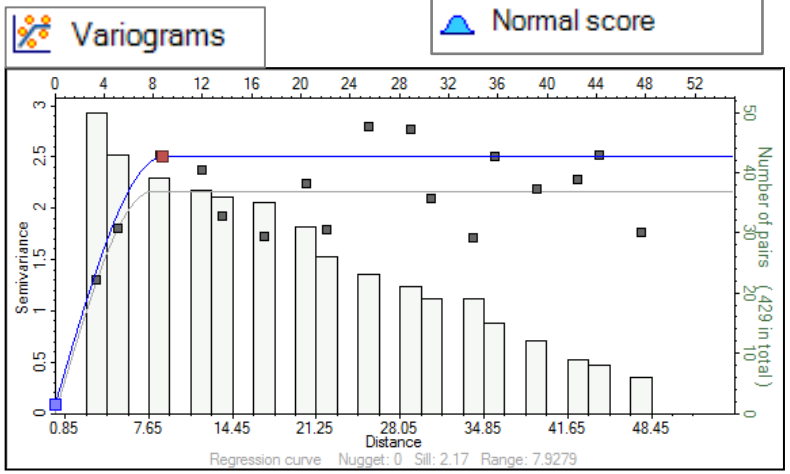
Statistical continuous data analysis

Data analysis is a process of quality control, understanding the data, and preparing inputs for petrophysical modeling.

Data analysis for continuous properties includes these functionalities:

- Data transformation: Data distribution and spatial trends
- Variogram analysis: Spatial variation
- Correlation: Relationship between parameters
- By interval (zone) and by facies: Maintain heterogeneity and difference





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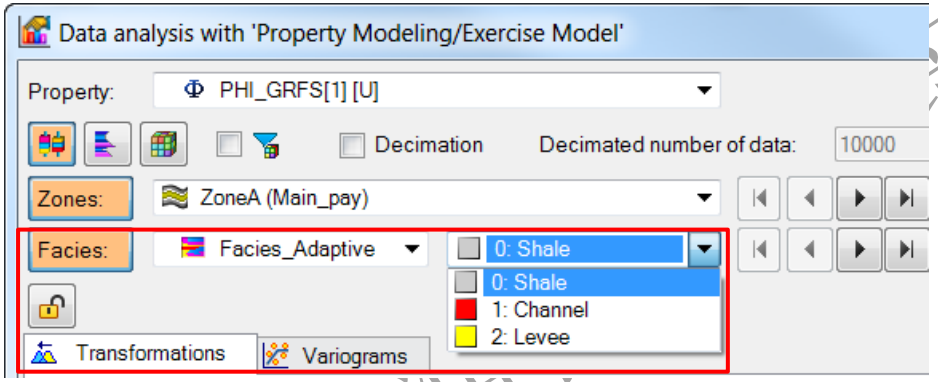
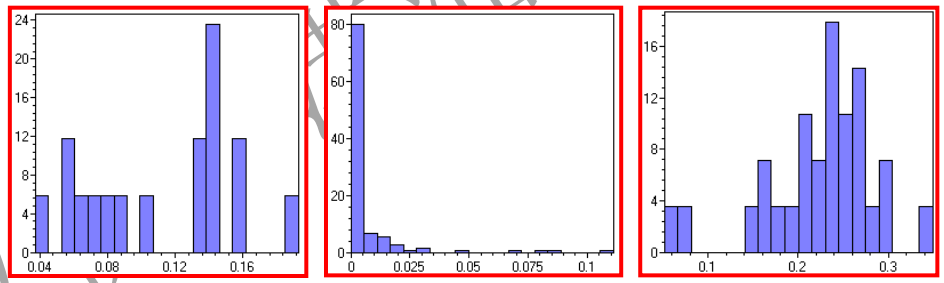
Distribution by individual facies

The distribution of a property can be different for each facies.

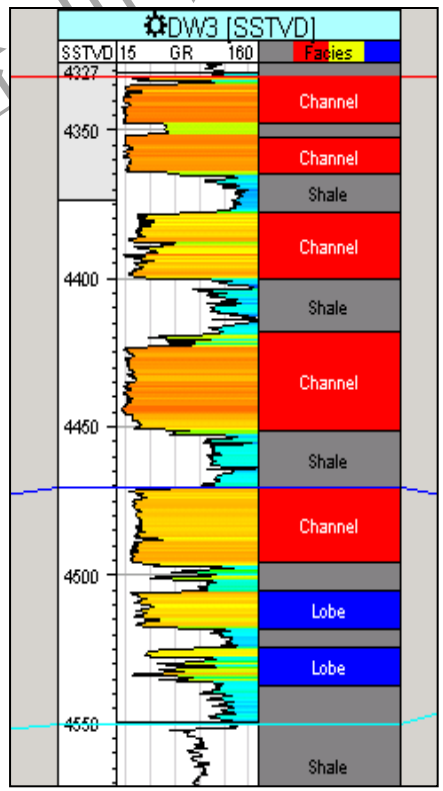




Lobe
Phi = 0.10

Shale
Phi = 0.02

Channel
Phi =0.22



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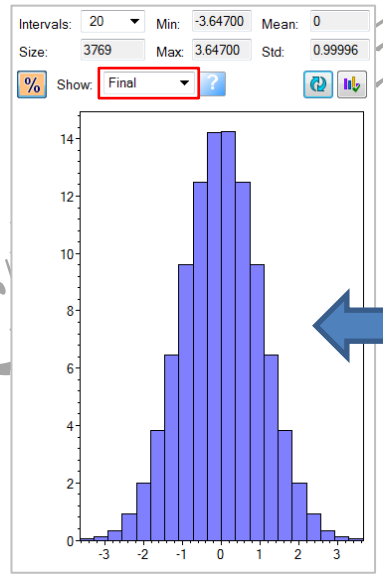
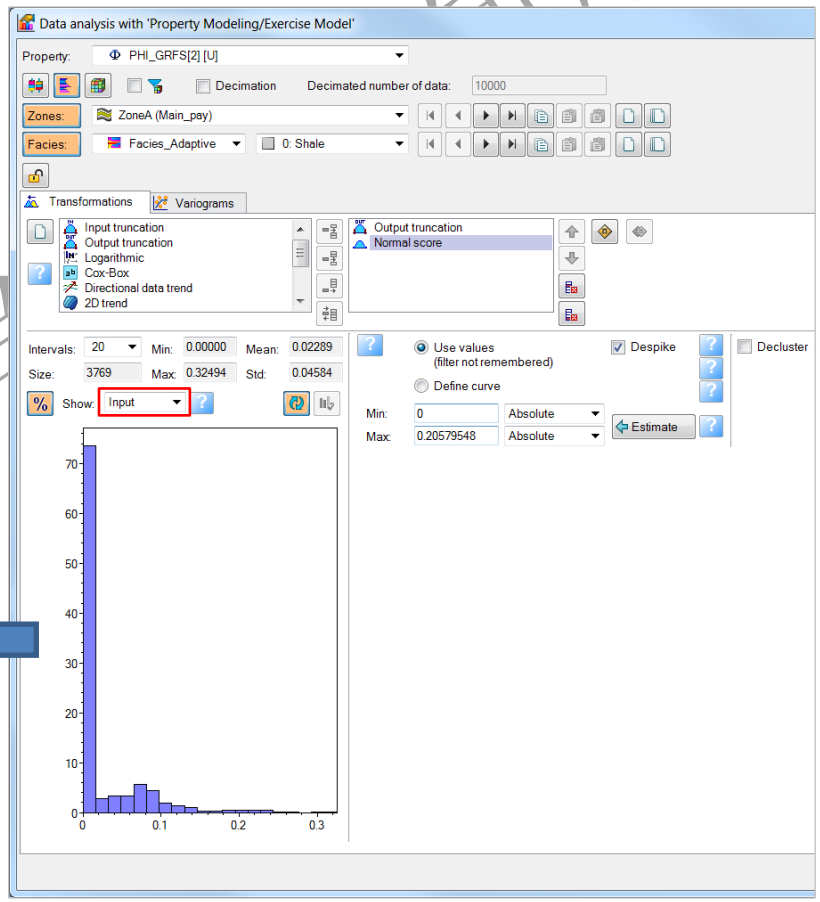
What is a transformation?

Transformations prepare real data to meet statistical requirements: stationary and normally distributed.





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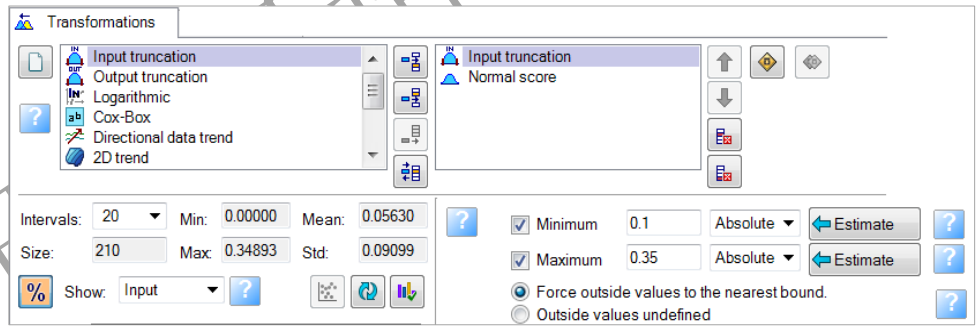
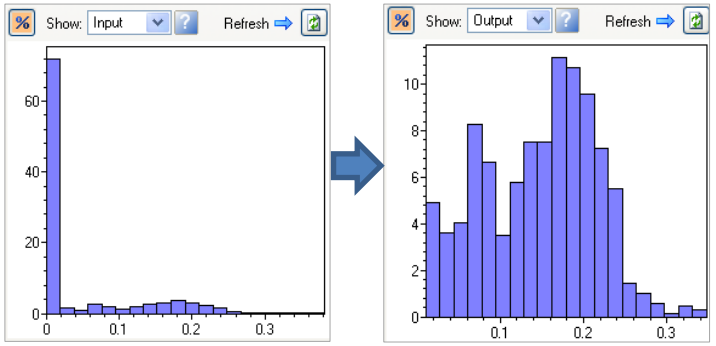
Input/Output truncation (distribution range)

Input truncation truncates the input distribution to remove unrepresentative data or push it to the next bin.



Output truncation truncates the output of a realization on back-transformation of data to include only those values in a desired range.



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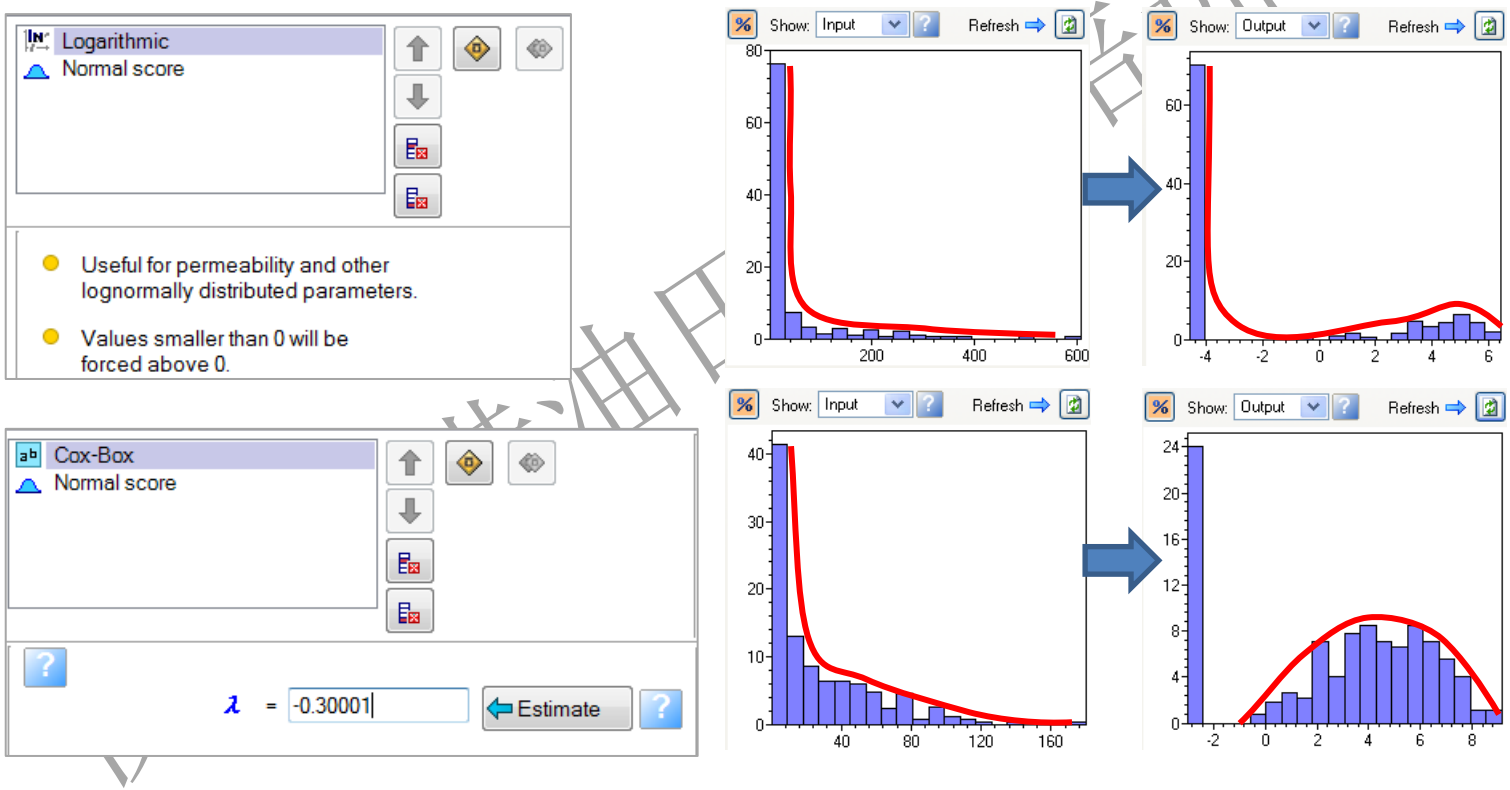
Logarithmic and Cox-Box transformations (shape and scale)

Applied on highly skewed distribution to approximate a normal distribution



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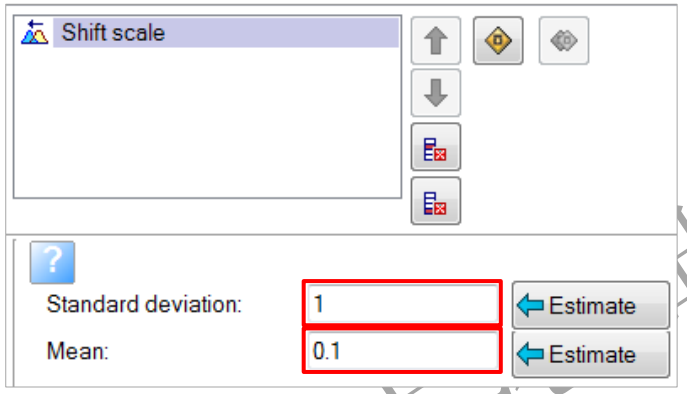
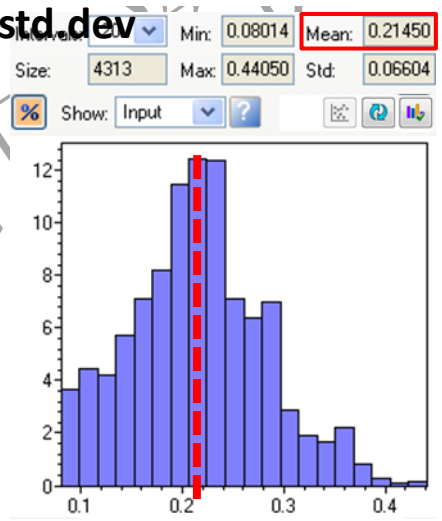
Distribution shift

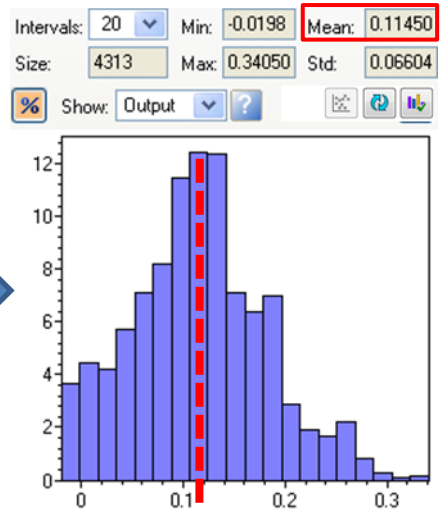
Shift scale shifts the data to a target or expected mean and scales the curve using the standard deviation.



New target mean = Input mean shift - real mean / std.dev



Mean por = 0.21



Mean por = 0.11

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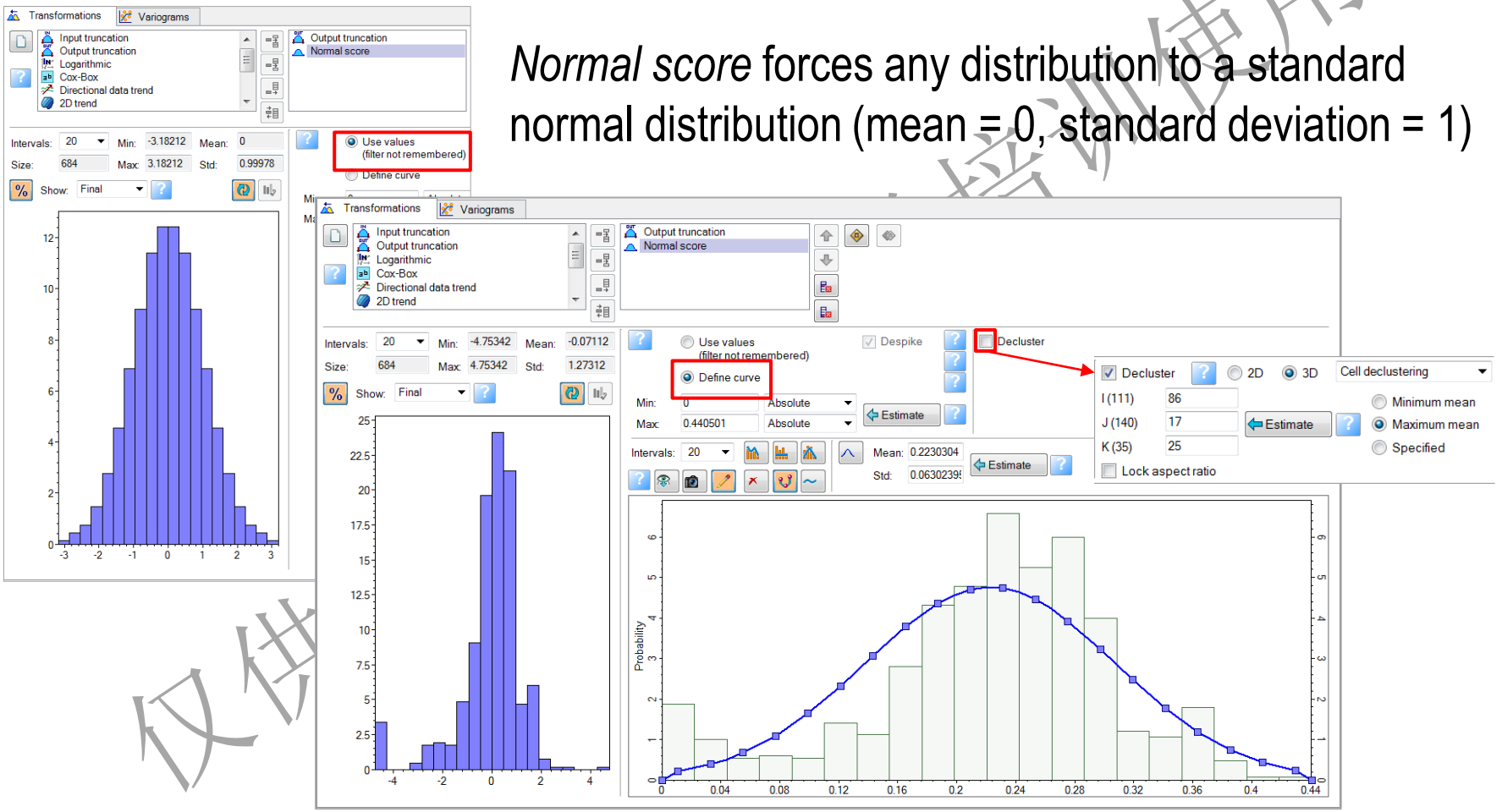
Normal score (scale/shape)



Normal score forces any distribution to a standard normal distribution (mean = 0, standard deviation = 1)

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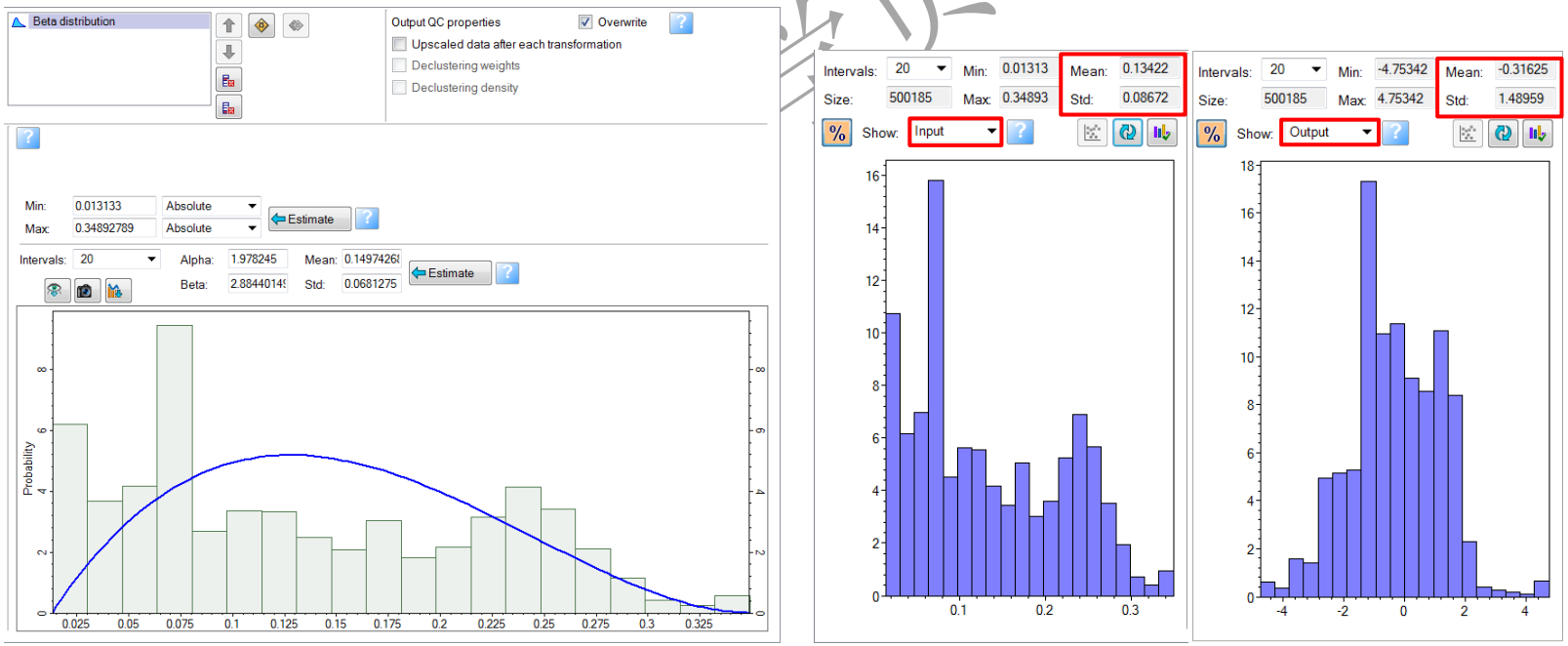
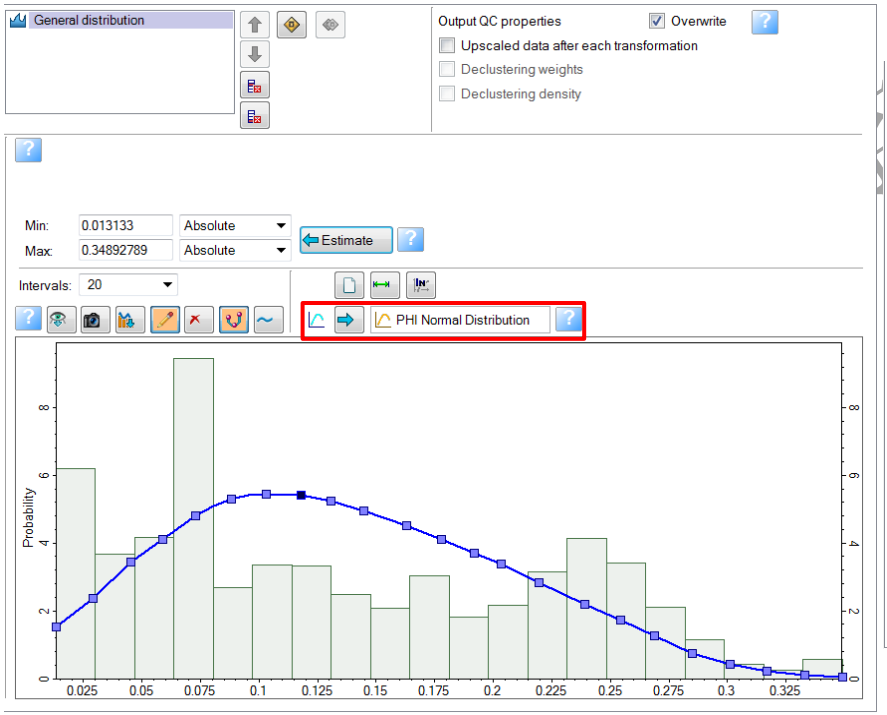
Beta distribution (scale/shape) (1)

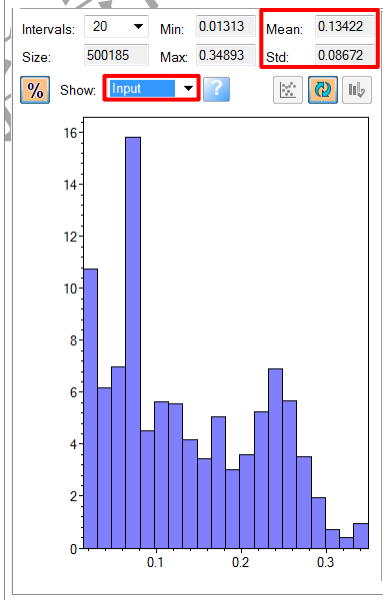
An alternative to Normal score transformation, it follows the given Beta distribution function and transforms it to a distribution close to a standard Gaussian normal.

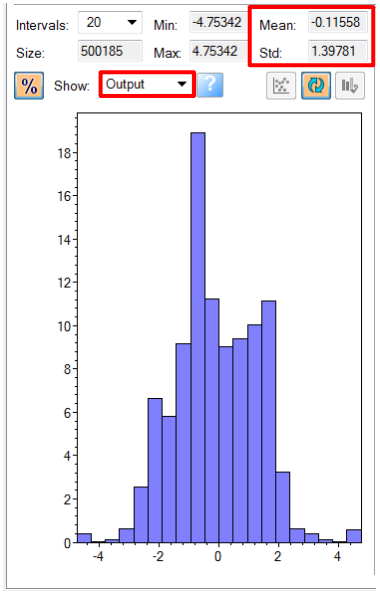


General distribution (scale/shape) (2)

General Distribution specifies the target distribution based on a user-defined function.







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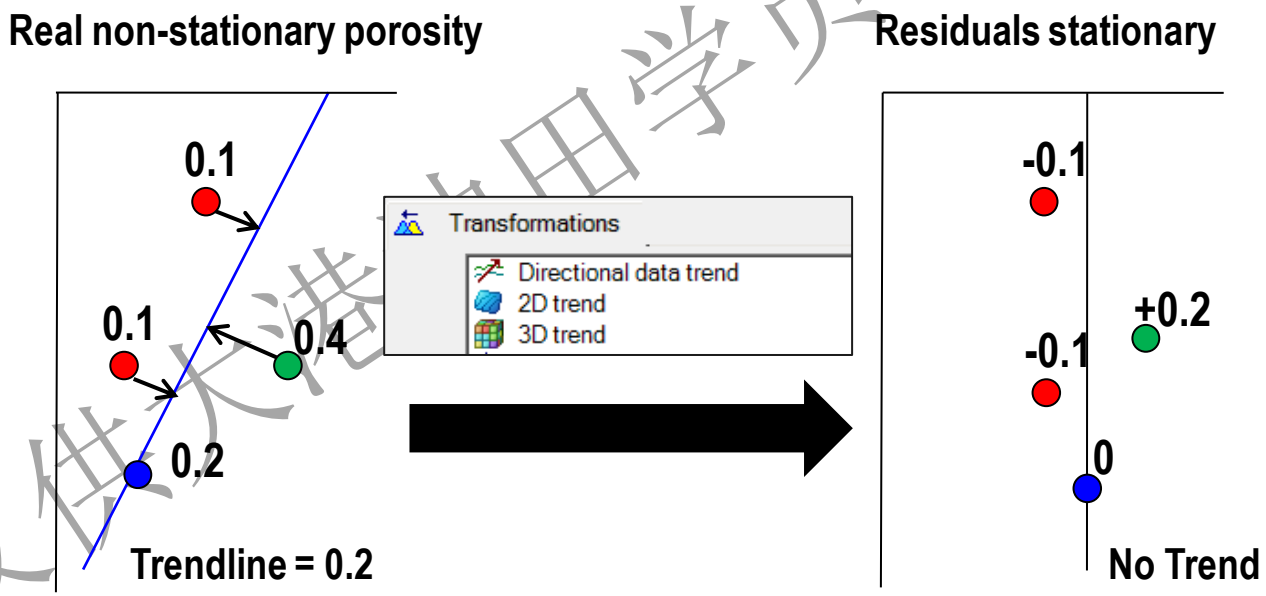
De-trending

By removing the residual values there is a higher likelihood of exhibiting a normal distribution. De-trending allows the spatial structure of the variogram to be seen easier.



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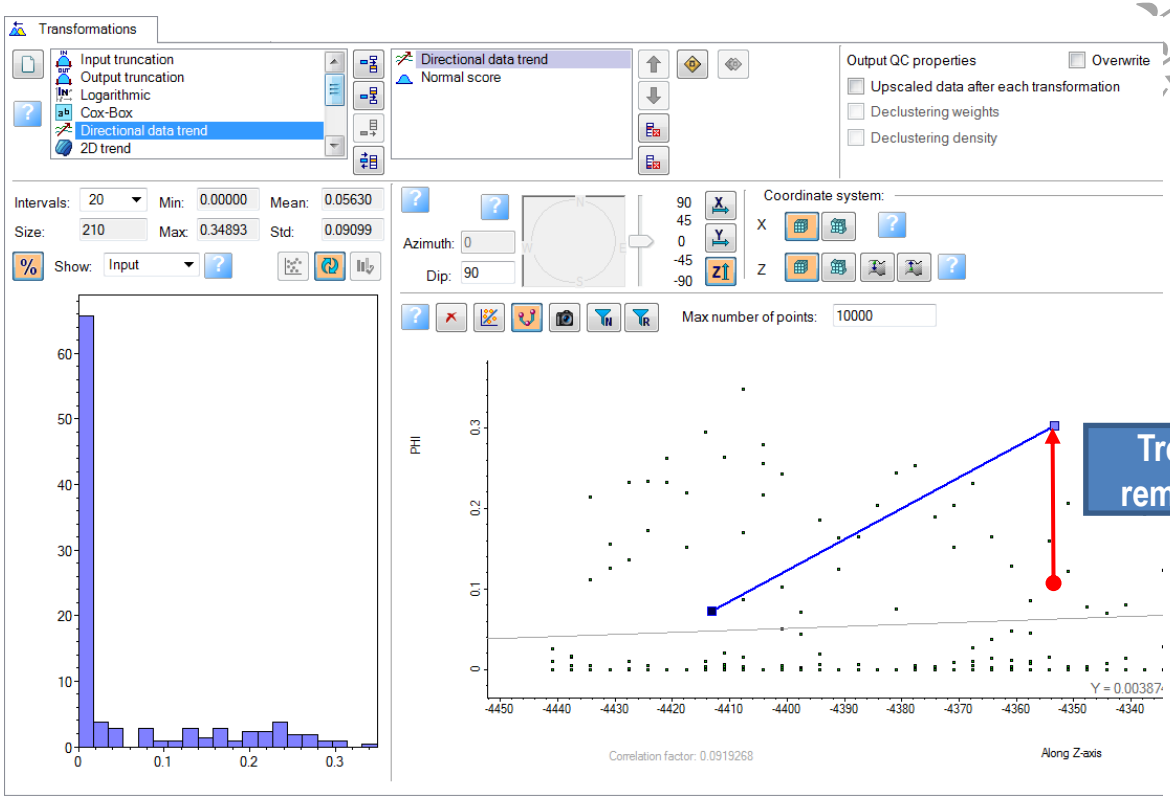
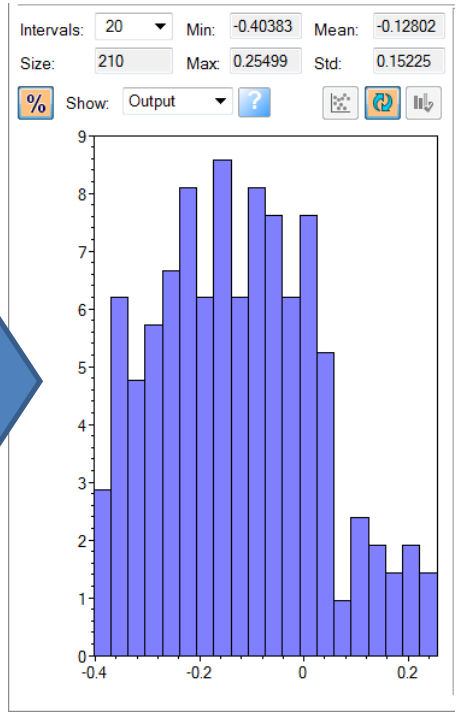
Directional data trend transformation

Vertical or horizontal trends can be investigated.

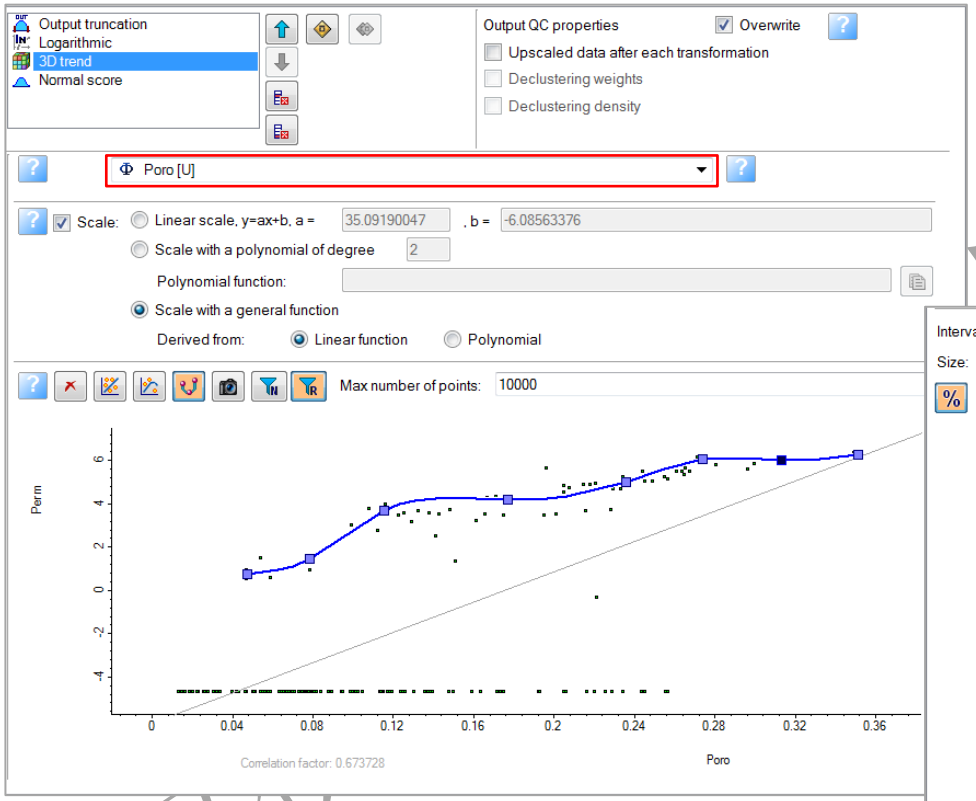


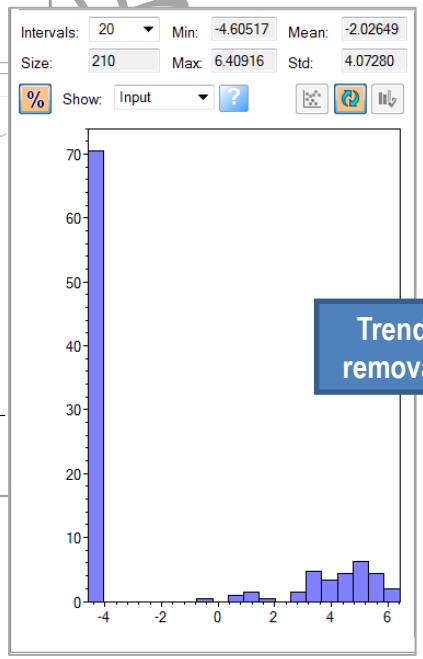
Trend removal

Distribution after trend removal

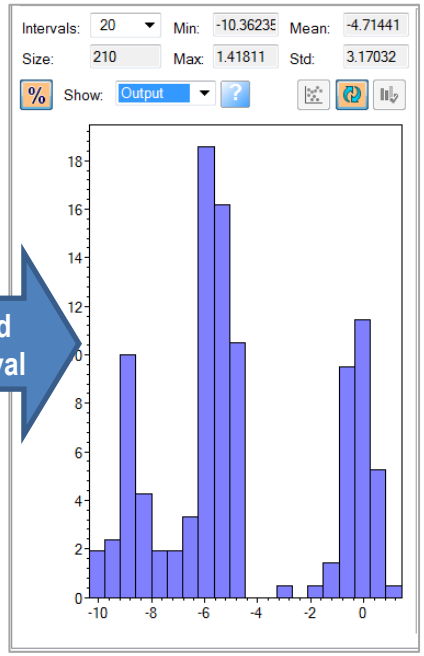


3D trend transformation





Trend removal



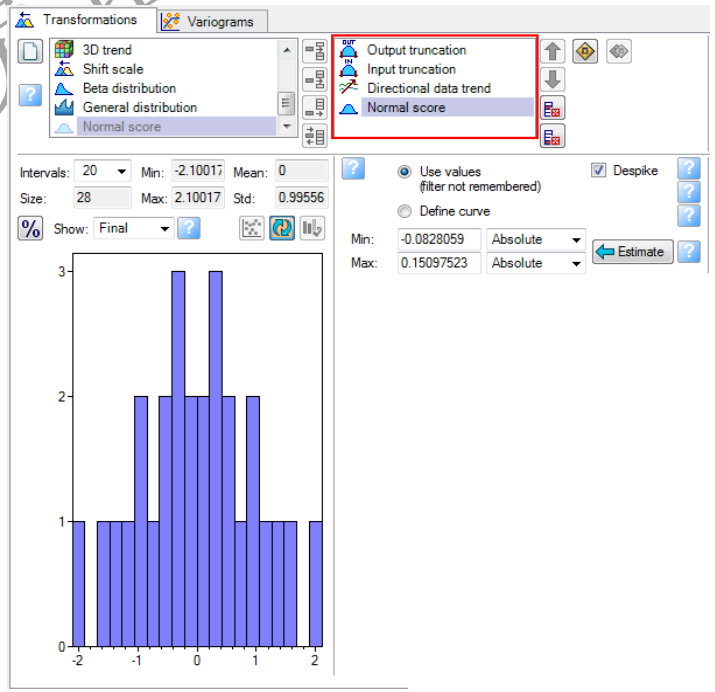
Transformation sequences

Before modeling, **Petrel** performs these transformations:

1. Truncate the input distribution (such as eliminating outliers).
2. Remove the Directional data trend (vertical compaction).
3. Normal score the data (mean = 0, standard deviation = 1).

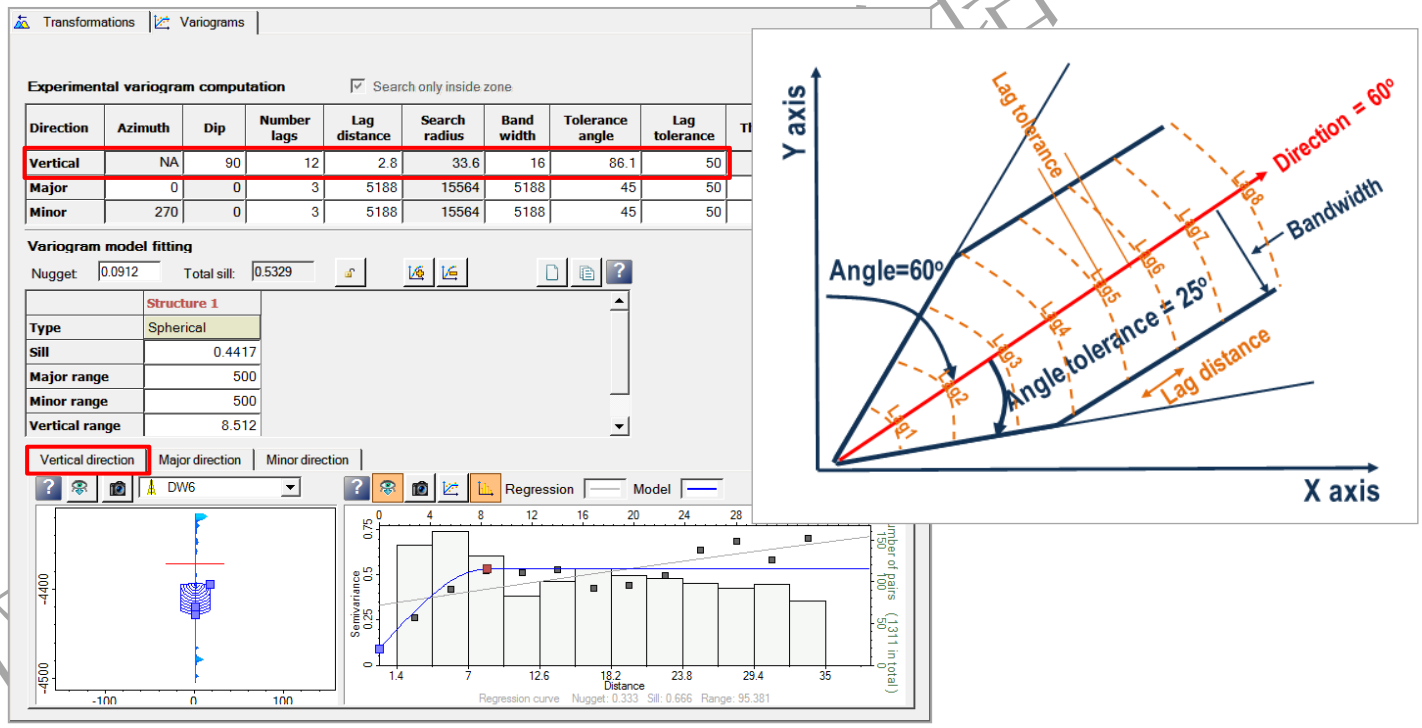
Perform modeling based on the transformed dataset, then back-transform the data.

1. Remove the Normal score transform.
2. Add the Directional data trend that was removed.
3. Truncate the output distribution (using set Max. and Min. values).



Variogram analysis

The variogram is a model of spatial continuity that identifies and quantifies the directions and scales of continuity.



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Transformations | Variograms

Experimental variogram computation — Search only inside zone

Direction	Azimuth	Dip	Number lags	Lag distance	Search radius	Band width	Tolerance angle	Lag tolerance	Thickness
Vertical	NA	90	12	2.8	33.6	16	86.1	50	NA
Major	0	0	3	5188	15564	5188	45	50	2.9
Minor	270	0	3	5188	15564	5188	45	50	2.9

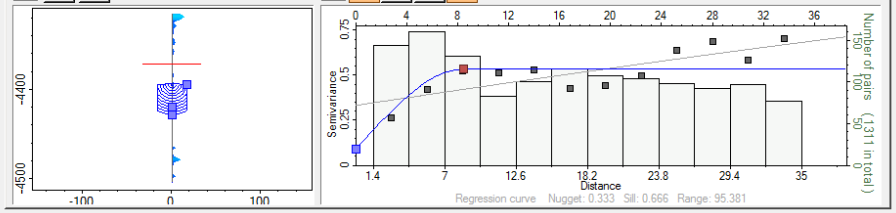
Variogram model fitting

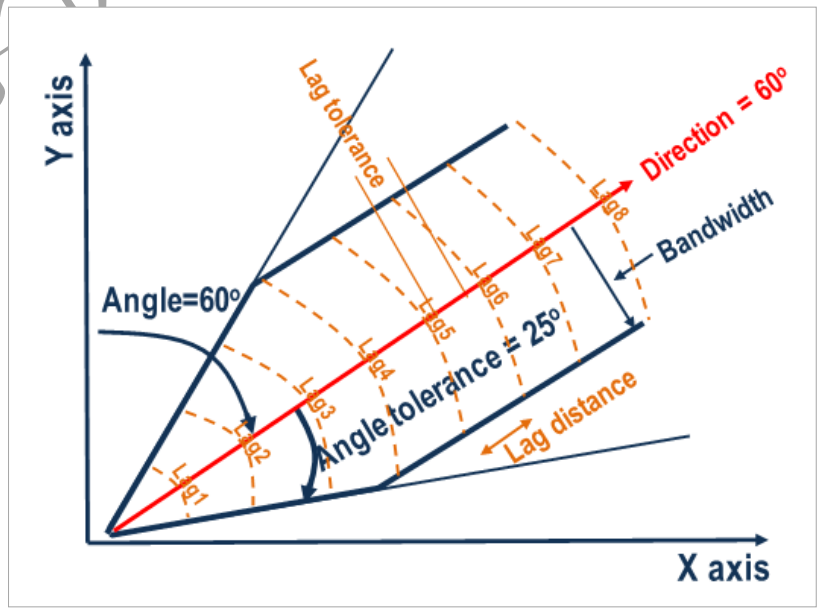
Nugget: 0.0912 Total sill: 0.5329

	Structure 1
Type	Spherical
Sill	0.4417
Major range	500
Minor range	500
Vertical range	8.512

Vertical direction | Major direction | Minor direction

DW6 — Regression — Model





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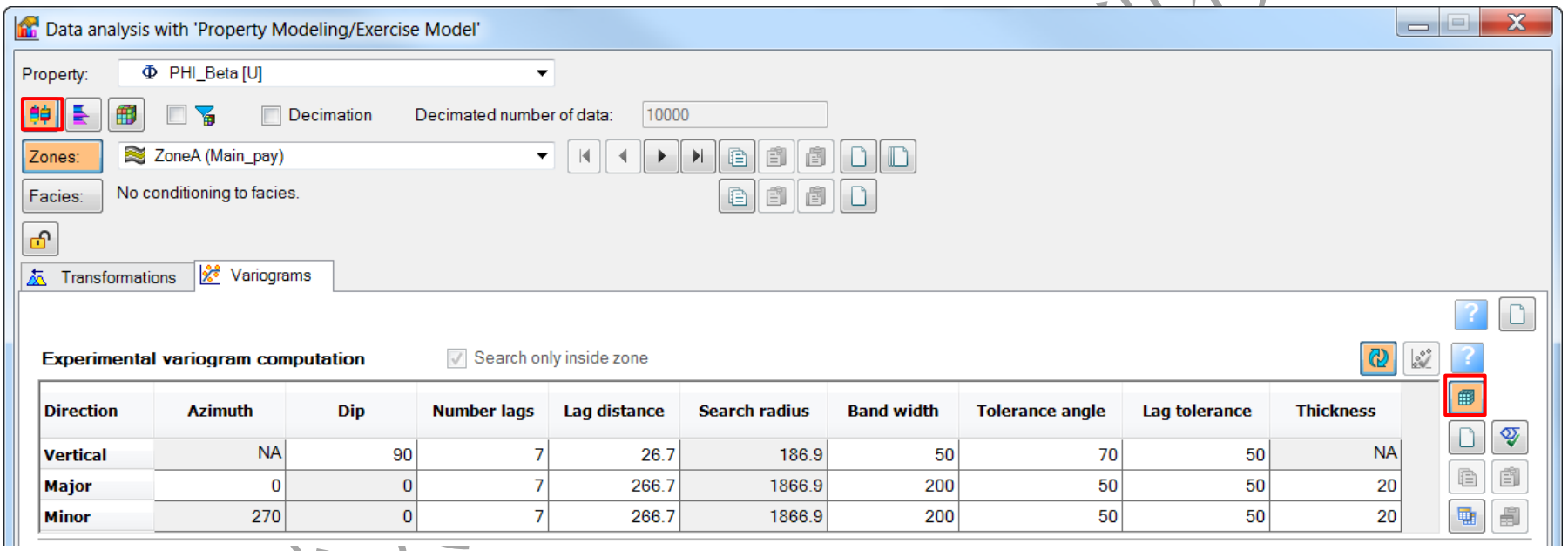
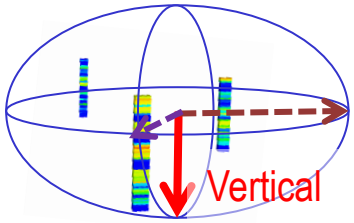
Upscaled logs and Simbox mode ON

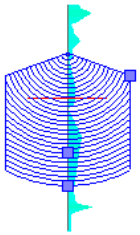


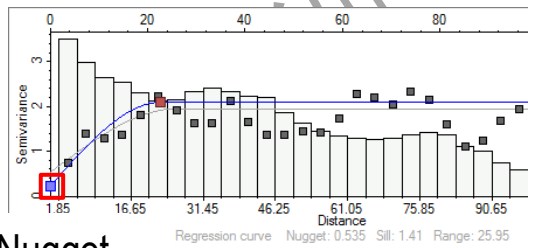
Direction	Azimuth	Dip	Number lags	Lag distance	Search radius	Band width	Tolerance angle	Lag tolerance	Thickness
Vertical	NA	90	7	26.7	186.9	50	70	50	NA
Major	0	0	7	266.7	1866.9	200	50	50	20
Minor	270	0	7	266.7	1866.9	200	50	50	20

Experimental variogram modeling

The search cone parameters help compute the experimental variogram.



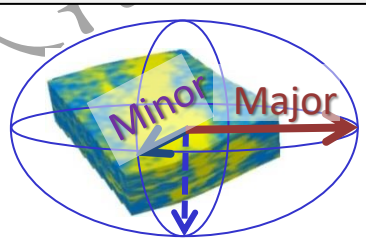


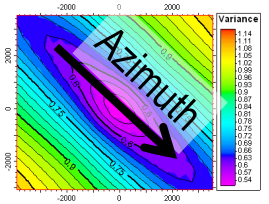


Nugget

Experimental variogram computation Search only inside zone

Direction	Azimuth	Dip	Number lags	Lag distance	Search radius	Band width	Tolerance angle	Lag tolerance	Thickness
Vertical	NA	90	12	2.8	33.6	16	86.1	50	NA
Major	315	0	3	4500	13500	5188	45	50	2.9
Minor	225	0	3	2000	6000	5188	45	50	2.9





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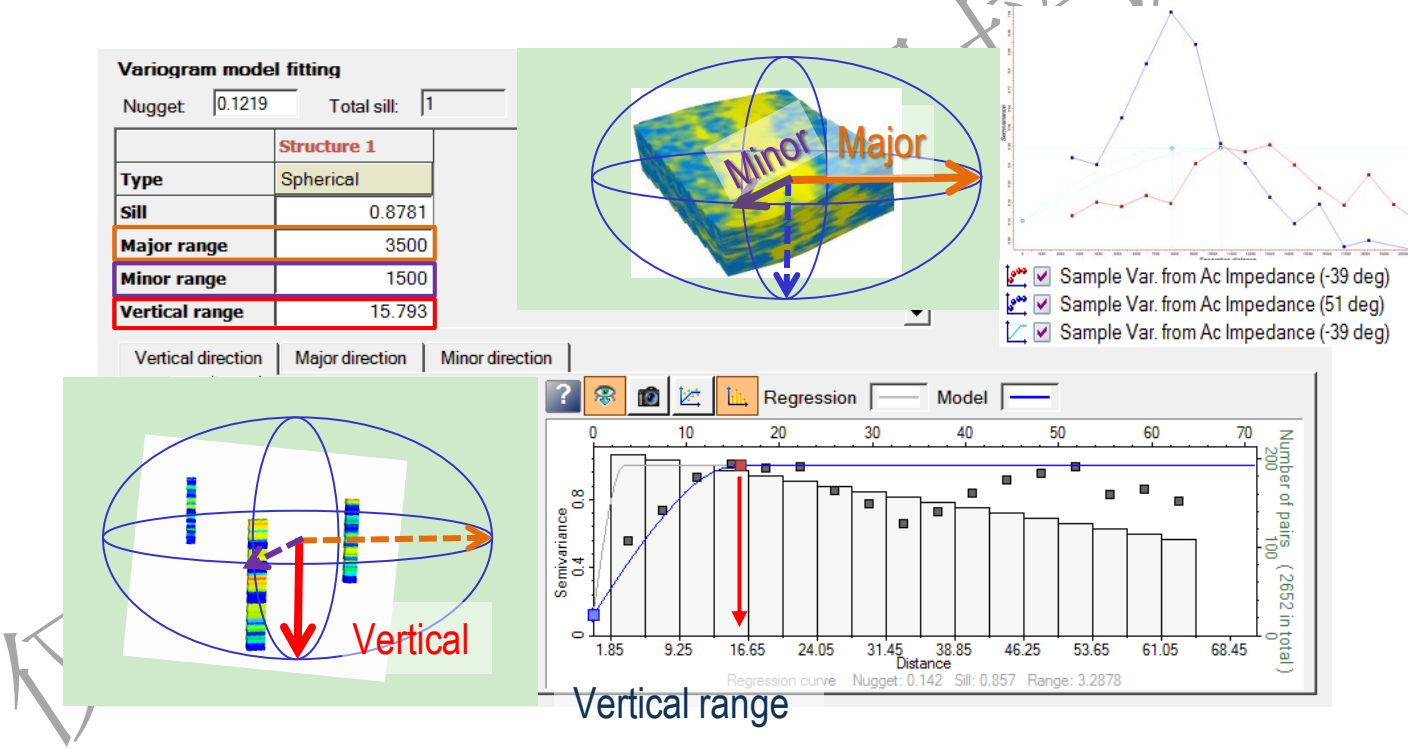
Variogram model fitting

Fit the model variogram to the experimental variogram in all three directions: vertical and two in the horizontal - major and minor.



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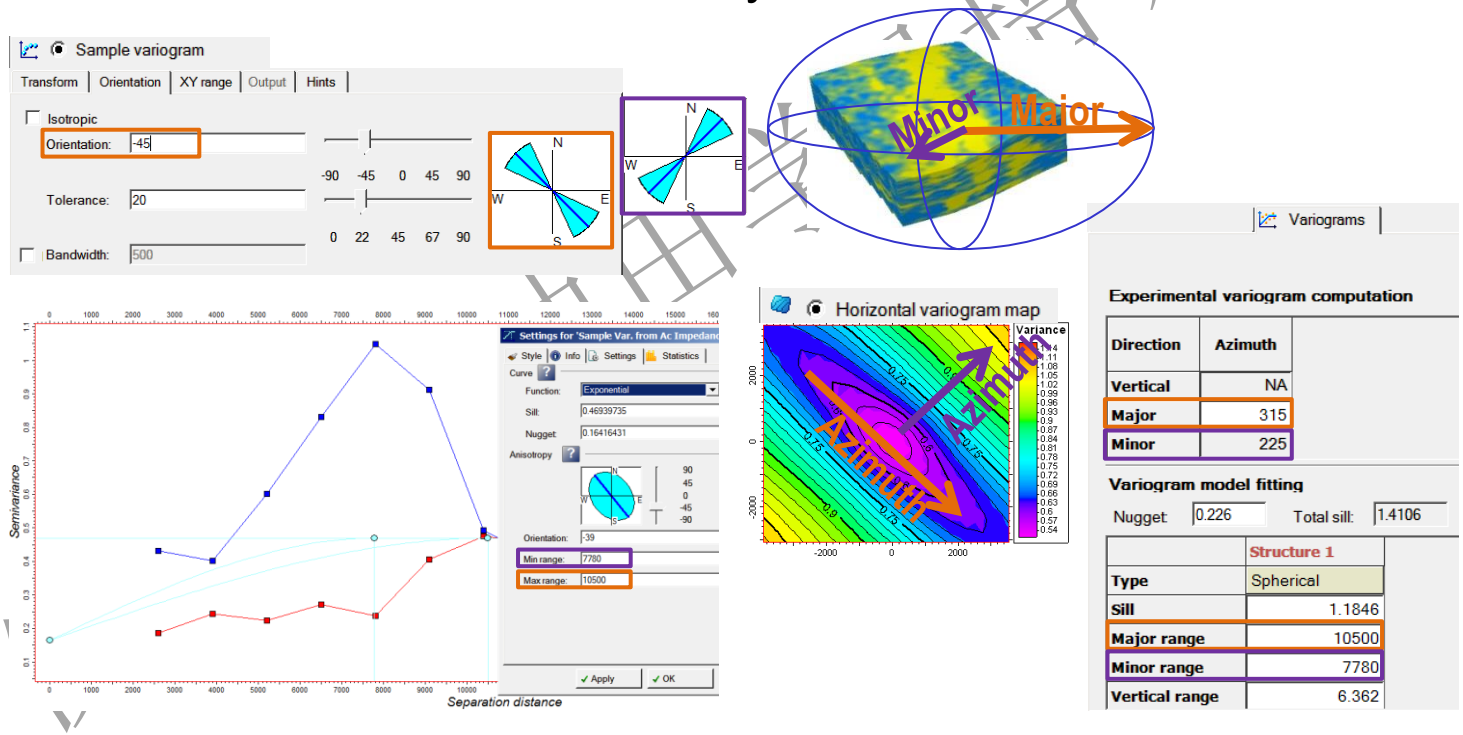
Secondary data

Often, well data is too sparse to enable variogram modeling in the horizontal direction. Find secondary well correlated data to analyze.



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Exercises

- Transform data
- Perform variogram analysis