Property Modelling, how much of it do you really need?

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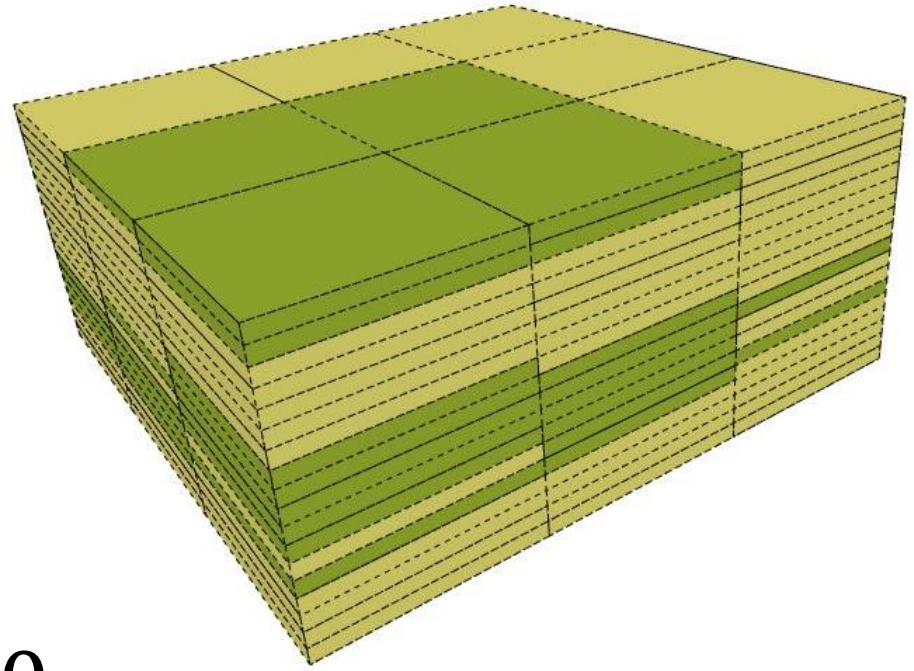
Force Seminar 6-7. February 2024

Property modelling – The basics

- Based on Geostatistics
- The regionalized variable theory



$$E[Z_V{}^* - Z_V] = 0$$

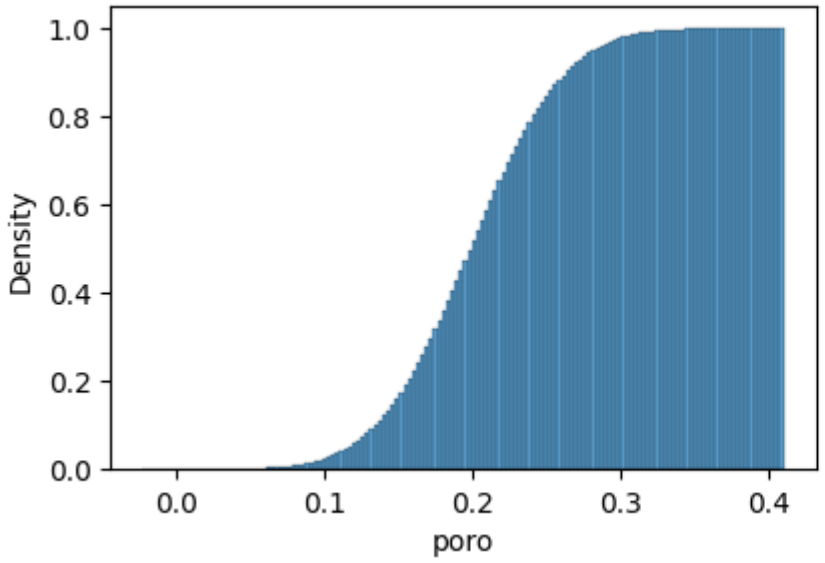
Questions to be asked

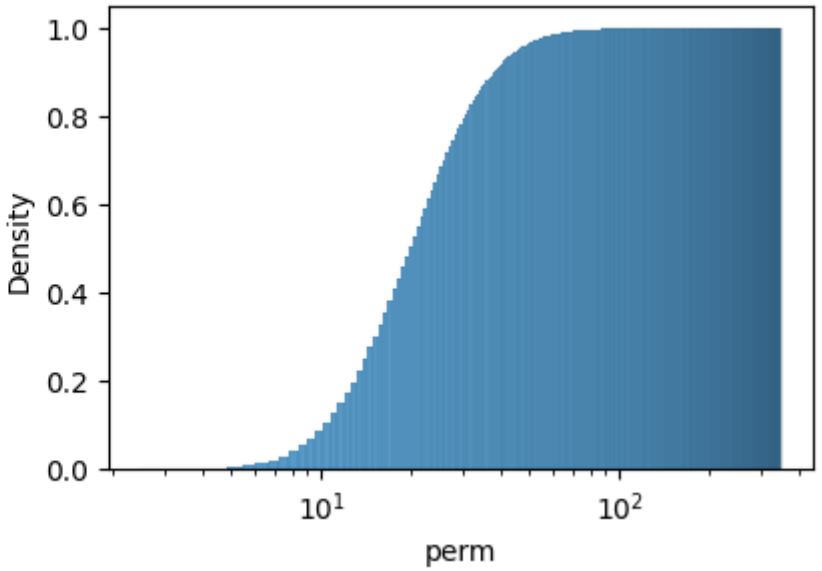
- How to quantify the trend(s) to incorporate
- How to quantify the variability to model over the grid cells?

Well Data

The classical rules of thumb

- Porosity has a normal distribution
- Permeability is log normally distributed
- Relations
  - $\log(Perm$
  - $Perm_x =$
  - $Perm_z =$
- And you have t





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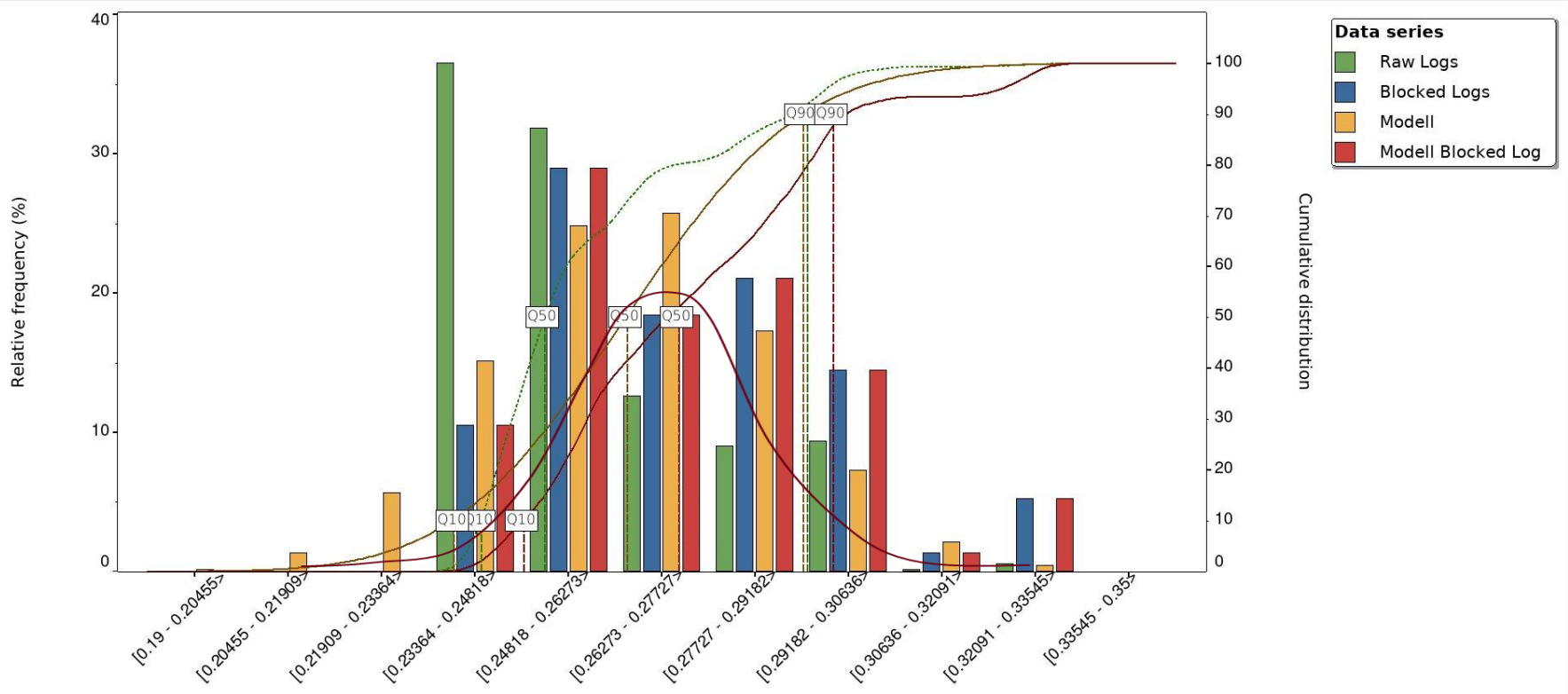
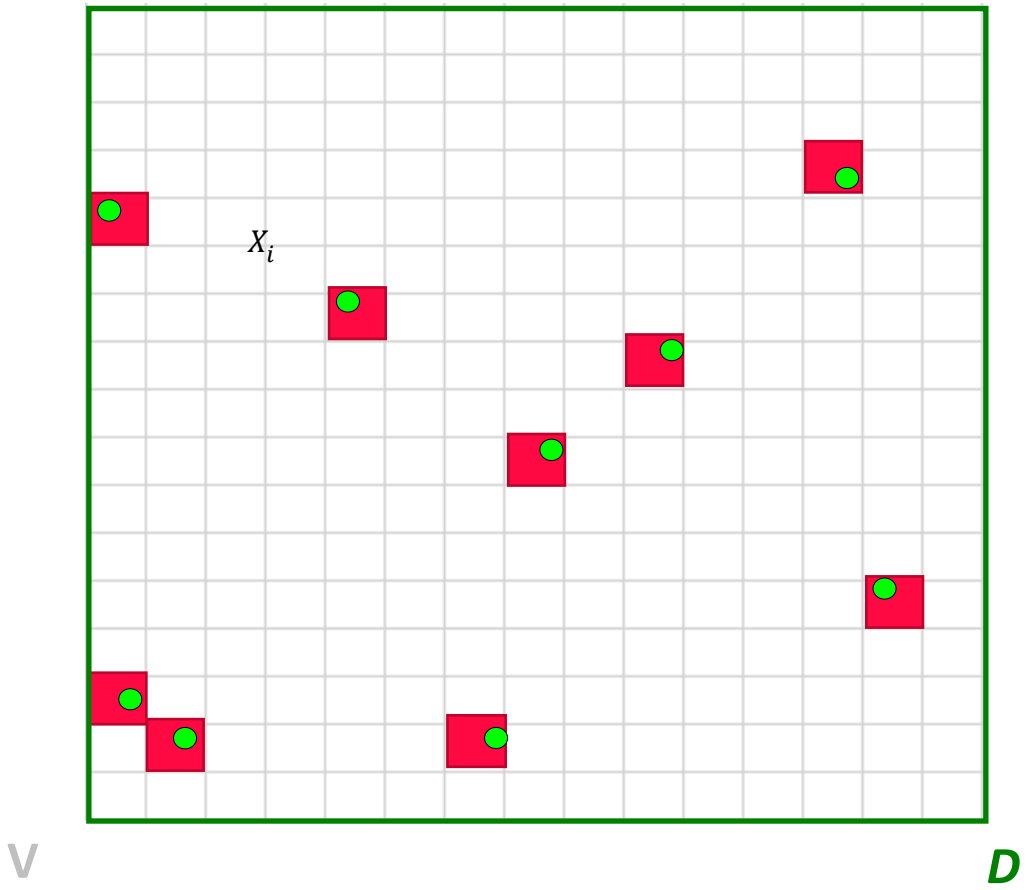


Statistical information										
Series	Min	Max	Mean	Median	Mode	Std	Skewness	Q10	Q50	Q90
Raw Logs	0.24	0.33	0.26	0.25		0.02	1.26	0.24	0.25	0.29
Blocked Logs	0.24	0.33	0.27	0.27		0.02	0.63	0.25	0.27	0.30
Modell	0.16	0.34	0.26	0.26		0.02	0.06	0.24	0.26	0.29
Modell Blocked Log	0.24	0.33	0.27	0.27		0.02	0.63	0.25	0.27	0.30

Filling the grid cells with well information, the basics



Scale reduction of variability

Variance at the scale of the 3d grid

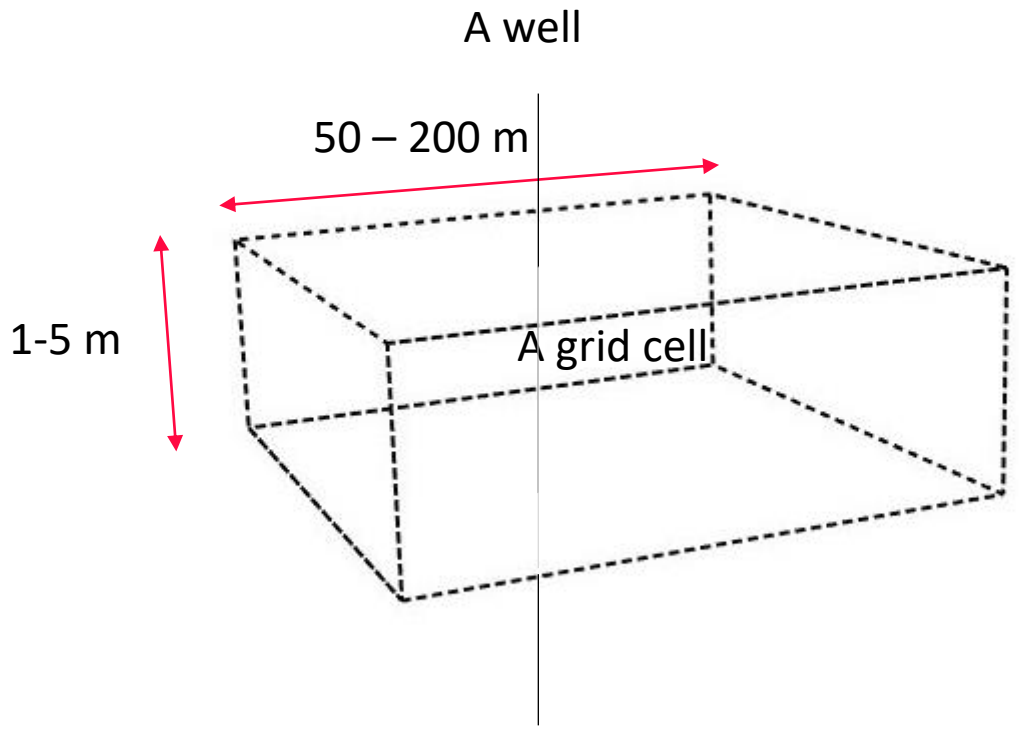
Variance of the measured property

Variance absorbed by the scale change

$$\sigma^2(v, D) = \sigma^2(x_o, D) - \sigma^2(x_o, v)$$

Conditioning to logs

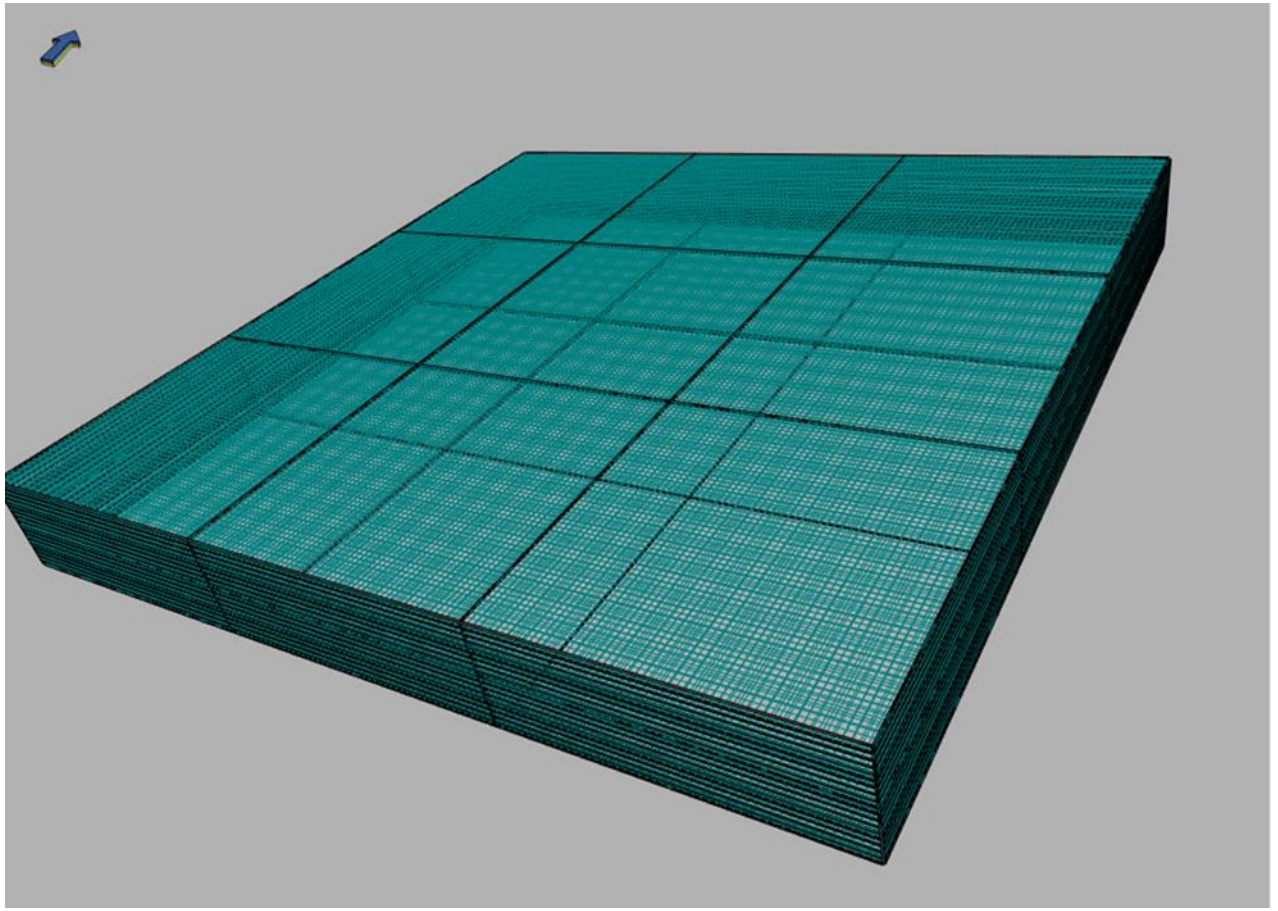
- Petrophysical logs represented as cells in the modelling
  - For each grid cell we use the mean,
    and commonly the arithmetic mean ($\frac{\sum_1^n x}{n}$)
- Between 0.1 and 20 % is covered by the well



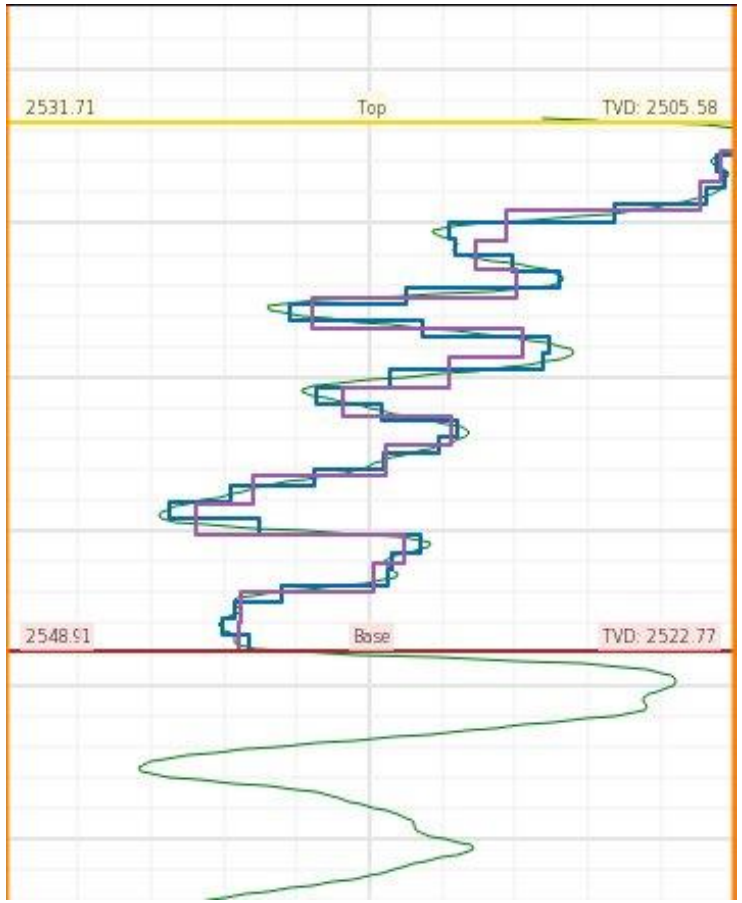
The well log is strongly under-sampling what is represented by the cell

Synthetic example: The Grid Setup

- Two grids:
    1. A coarse grid, with typical grid resolution
    2. A finer grid, representing the “true” geology
- The fine grid is a refinement of the coarse grid
- Modelling in the fine grid to represent the “true” variability, and then upscaling to the coarse grid to quantify the variability at the coarse scale



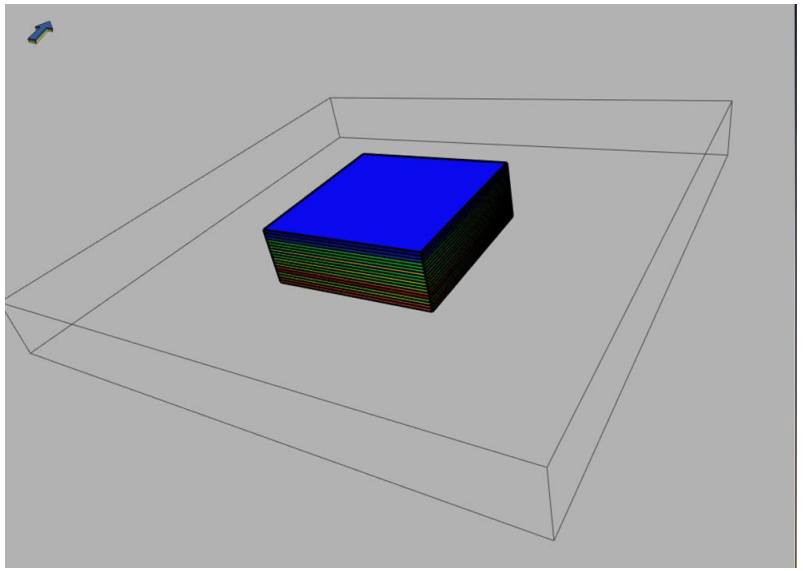
Synthetic example: Conventional Upscaling



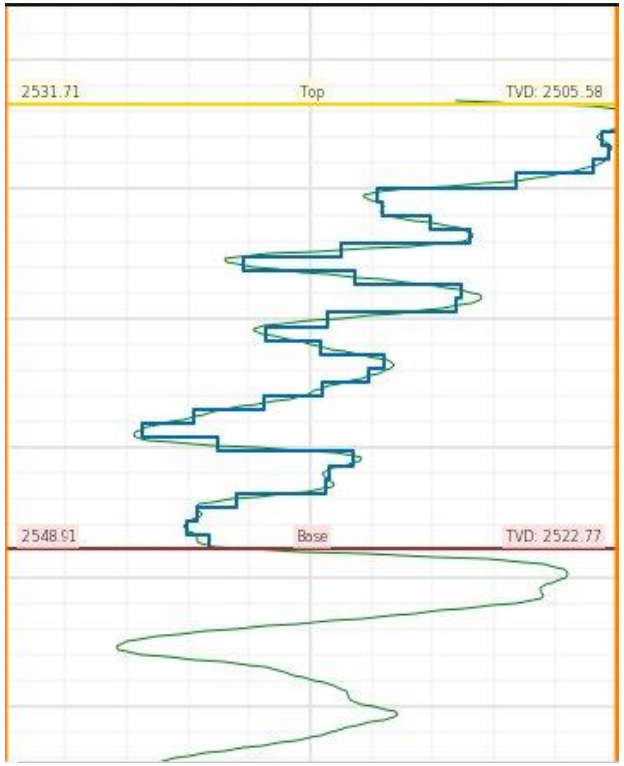
Raw Curve

Blocked Curve (Fine grid)

Blocked Curve (Coarse grid)

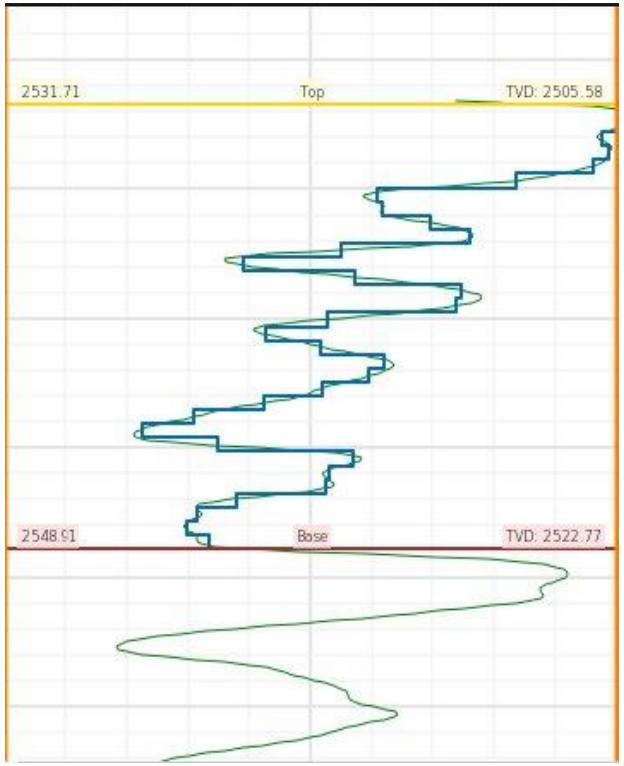


Synthetic example: Property modelling setup



- Model assumptions for the fine grid:
  - Stationary porosity field, i.e. the background trend is a simple arithmetic mean of the well data
  - Uncorrelated static noise. This is modelled with the standard deviation used directly from the upscaled well log
  - Two variogram scenarios made
    - 1x1 x 0.5 m
    - 10x10 x 0.5 m

Synthetic example: Extracting results



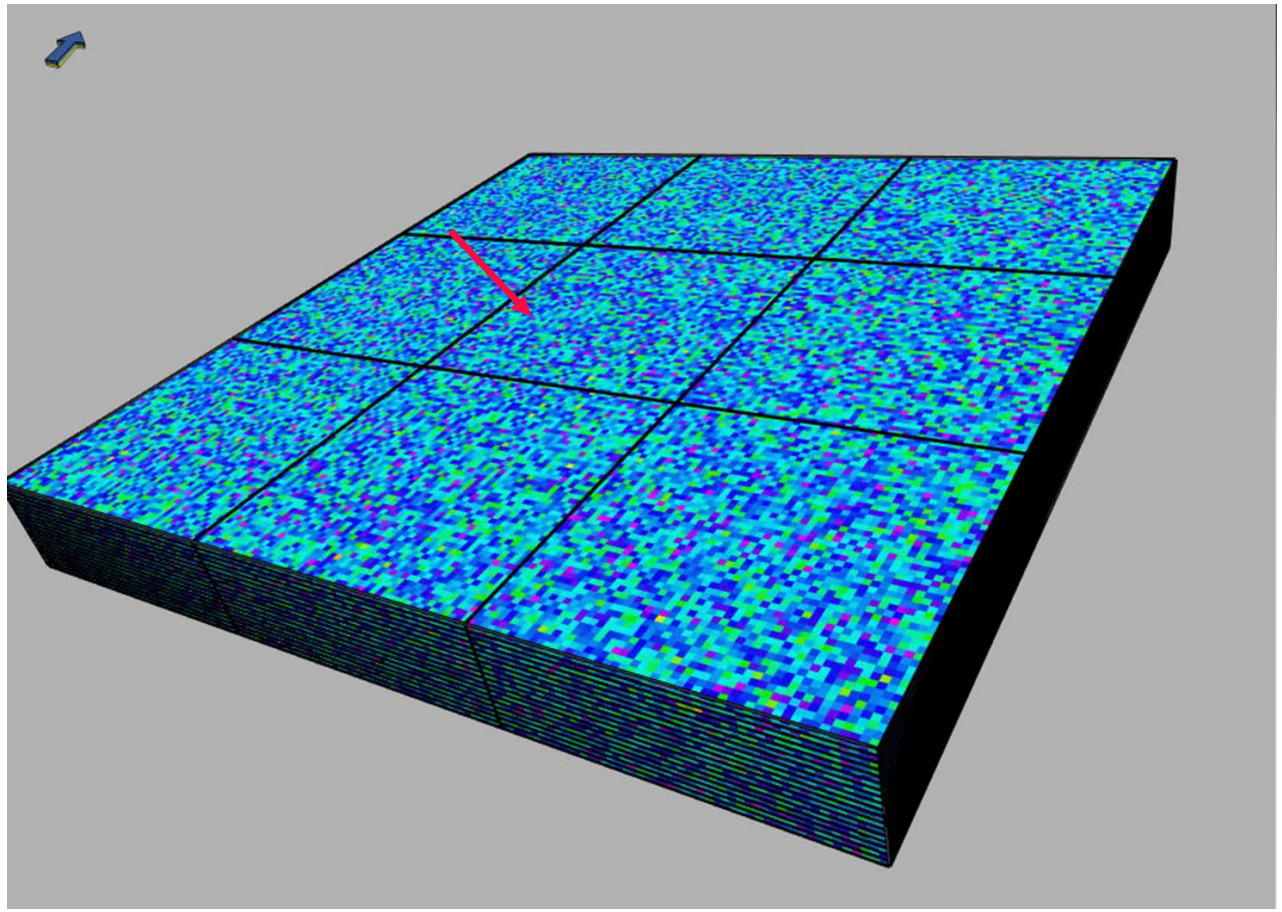
- Results are generated with a two-step process:

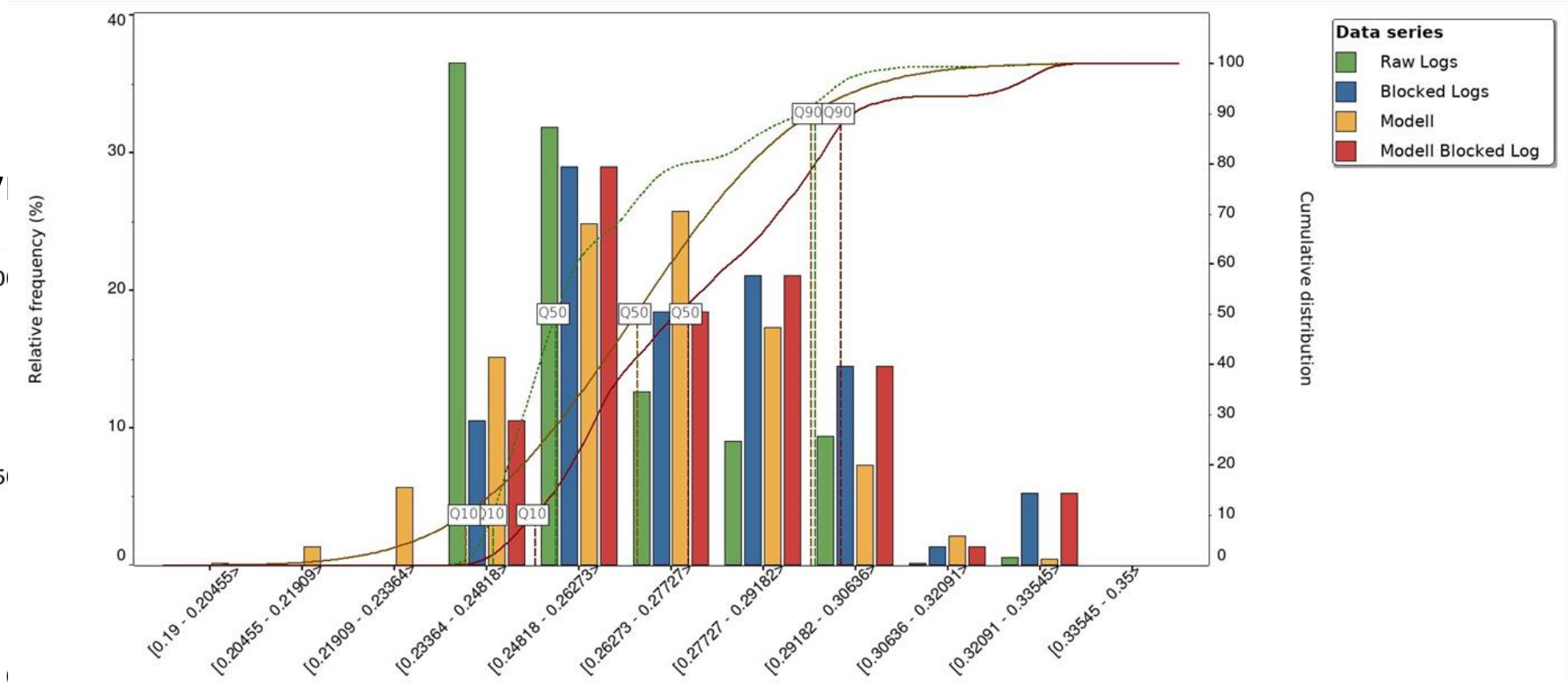
1. Upscaling the modelled fine scale results back to the coarse grid
2. Sampling back to the cells penetrated by wells in the coarse grid

Synthetic example: results 1x1 log

Raw Curve

Upscaled curve





Relative frequency (%)

Series
Log
Blocked_gr
Blocked_re
PHID_thro

Statistical information

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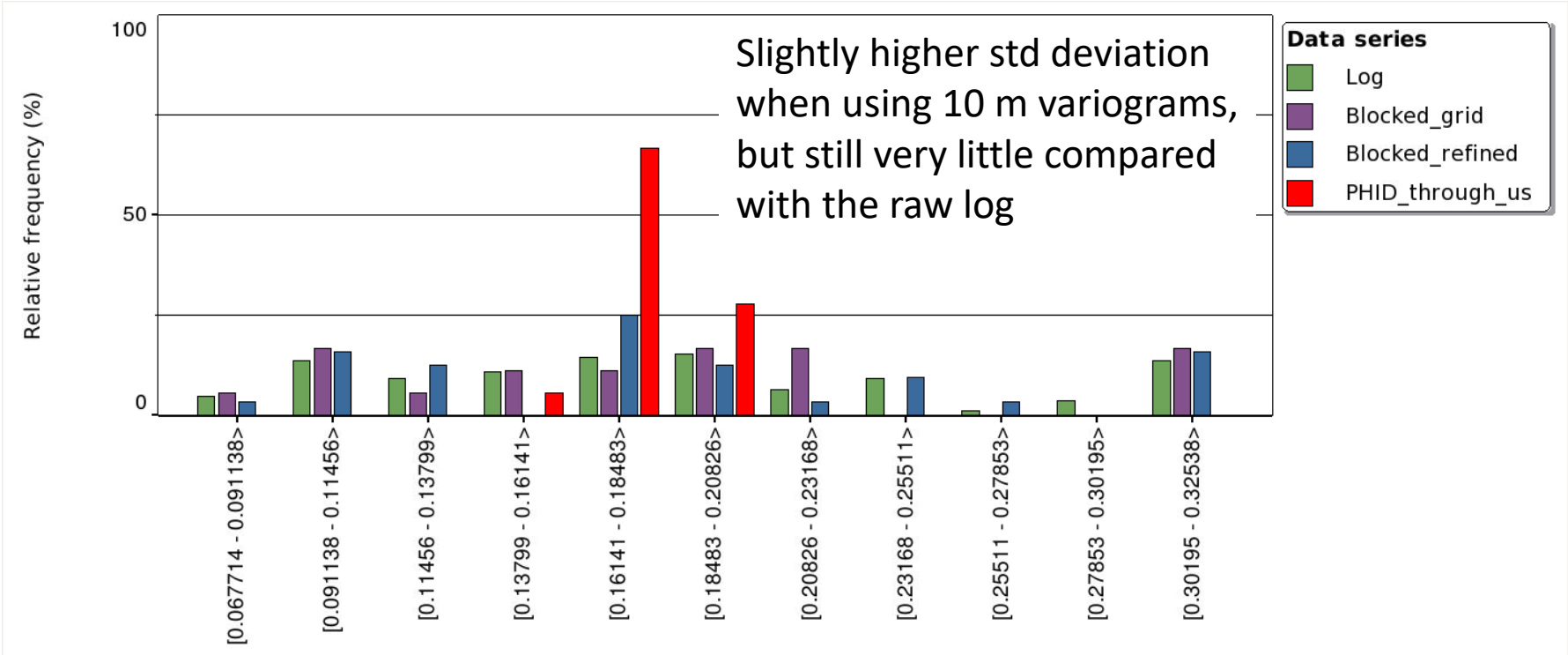
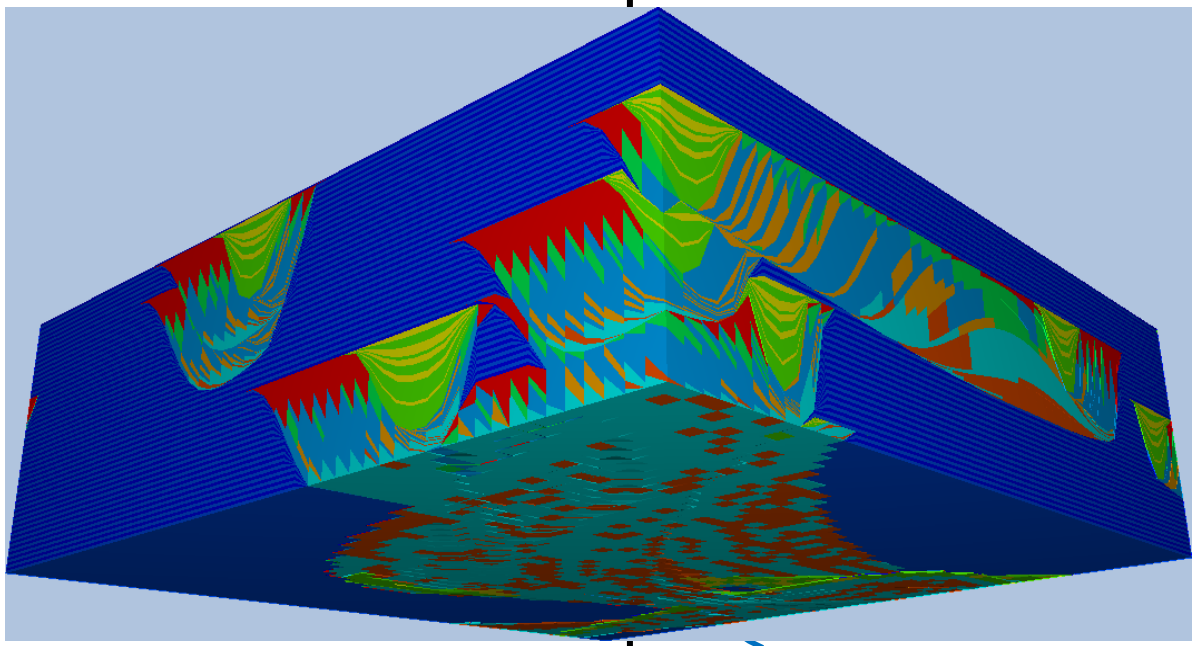
Synthetic example: Results 10x10 Log and Statistics



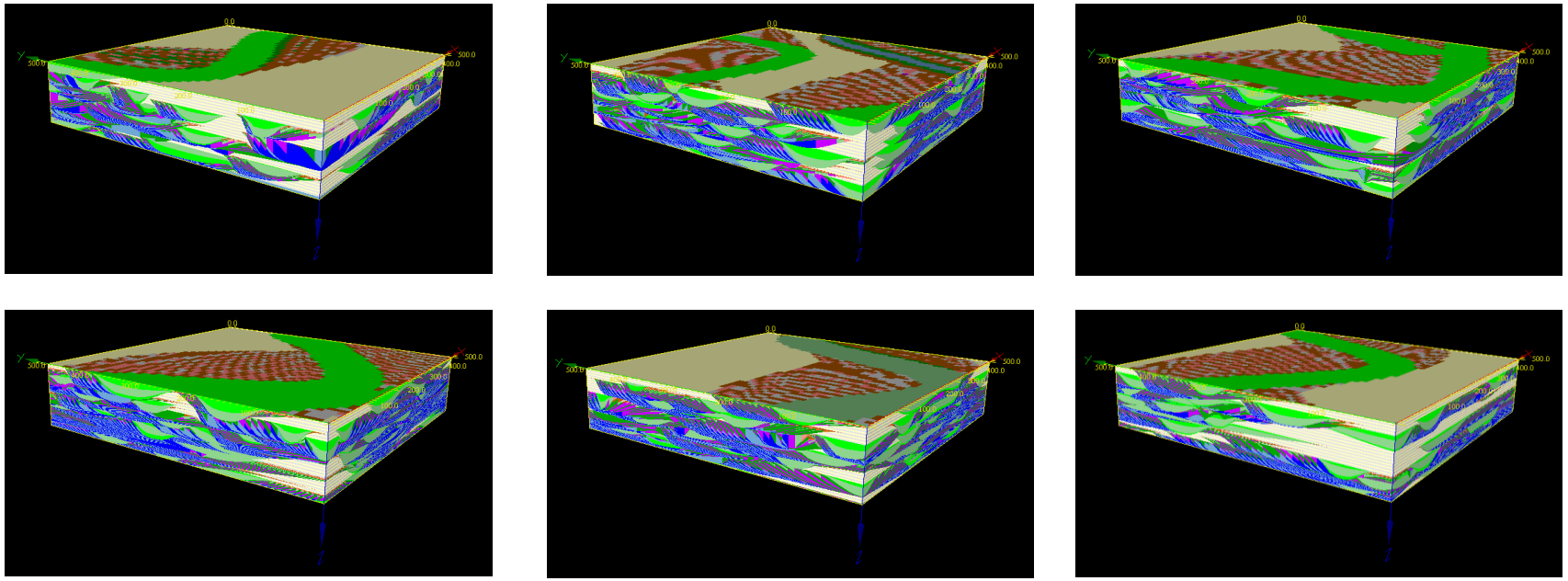
But, what about permeability?

- The presented example is modelling an additive property:
    - meaning aggregating over a bigger volume is just averaging over the smaller parts

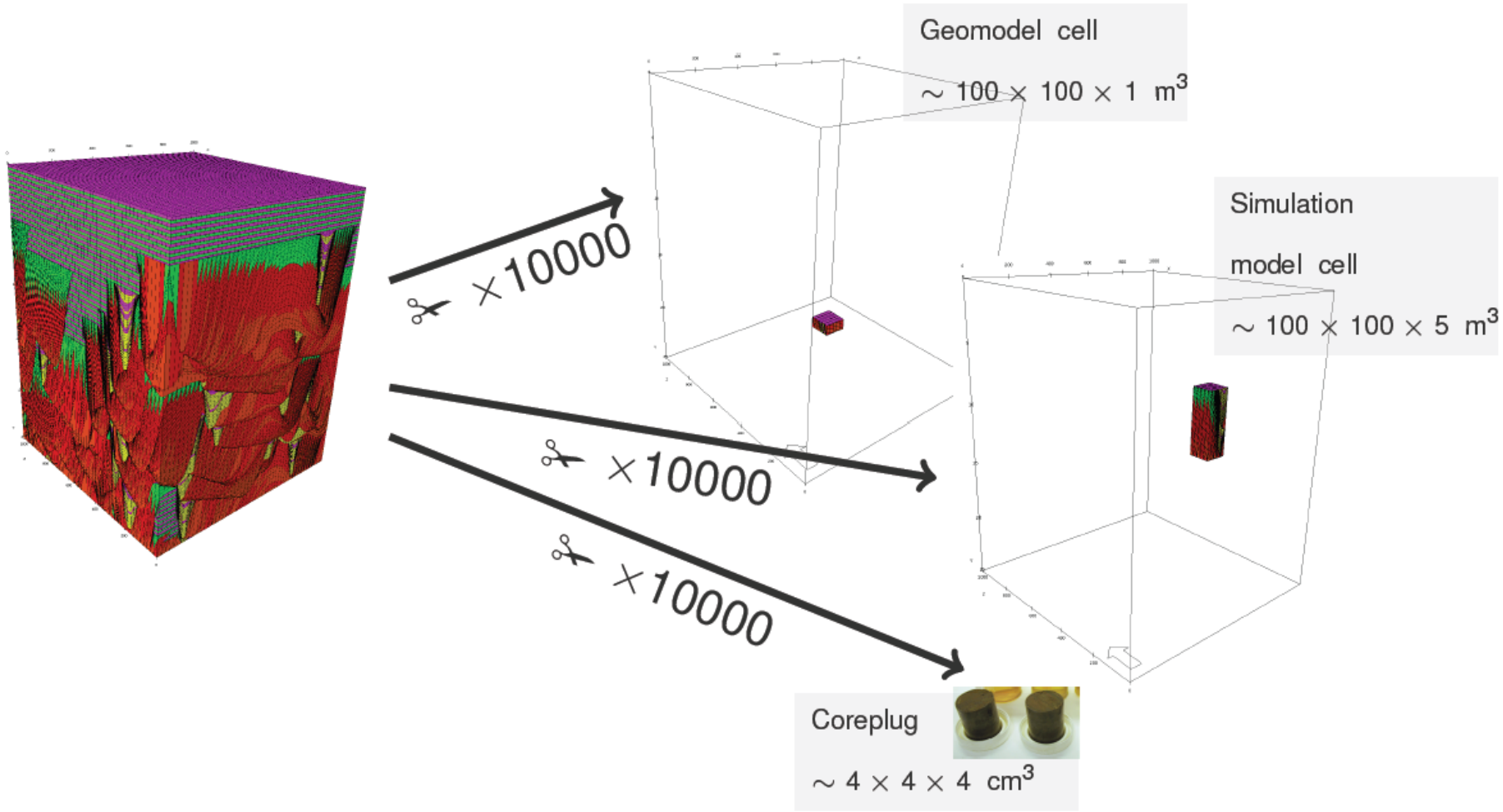
- Permeability is an example of a property that is non additive



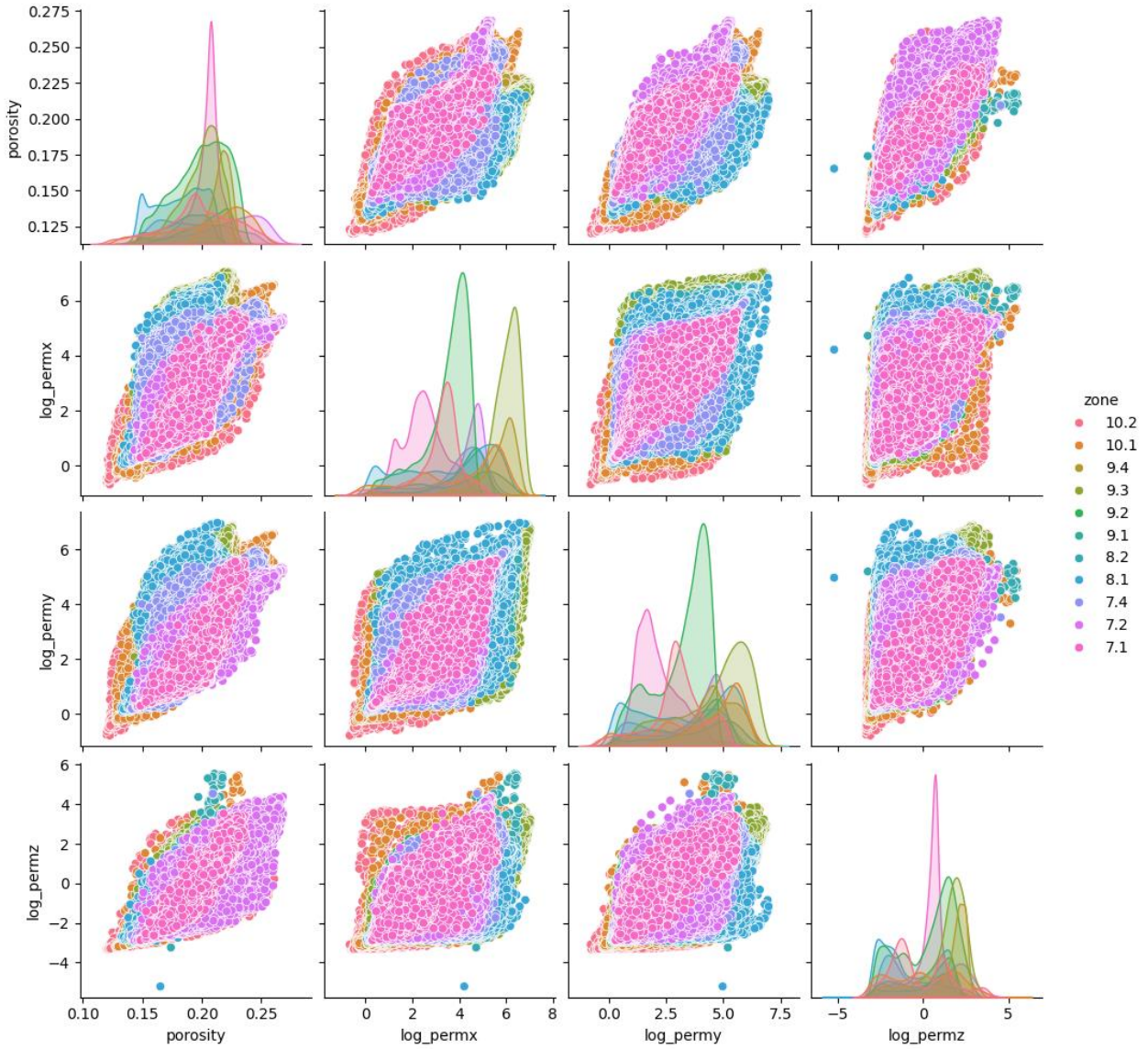
A slightly more complex methodology



Subsampling



Results from the study



Do the rules of thumb make sense?

- Is there really any point in conditioning to wells?
- Is there any need for modelling variability for porosity?
- Permeability: Can we model this sensibly with geostatistical methods?