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SAGEEP 2019

MPS Models Can Tell you Where to Drill

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Content of Presentation

- MPS – A quick overview
- The workflow of the Methodology
- Some Definitions – Gausian Kernel, Convolutions, Entropy
- The MPS workflow in GeoScene3D
- The Study Area and Data
- Results
- Conclusions

Motivation

- Developed a MPS tool in GeoScene3D
- Part of the GAP Project
- How to utilize MPS – realizations?

Workflow:

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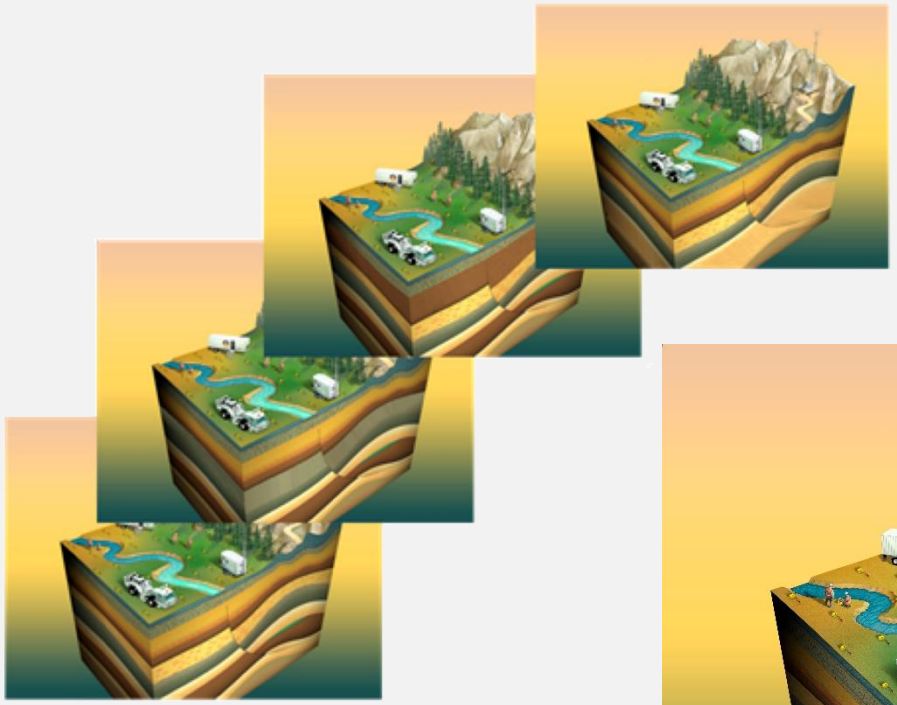
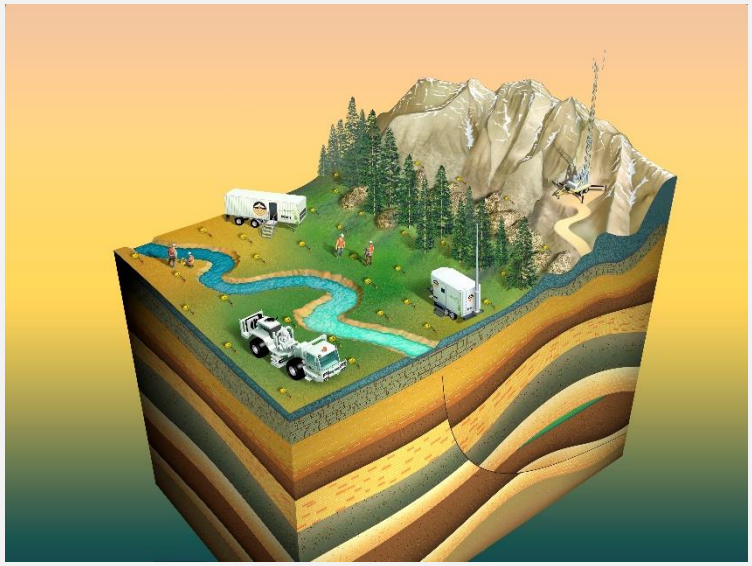
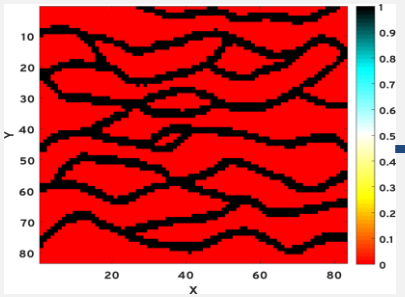
The Fundamental Problem



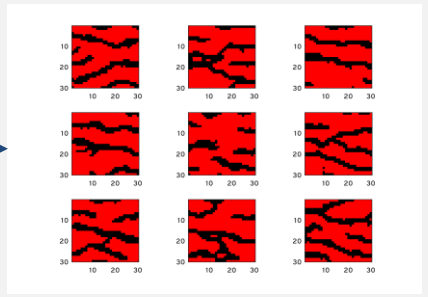


Multiple Point Statistics (MPS)

$$f_I(\overline{m}) \propto \prod_i f_{I_i}(\overline{m}) \quad \propto \quad f_{I_{TI}}(\overline{m}) f_{I_{hard}}(\overline{m})\, f_{I_{Soft}}(\overline{m})$$

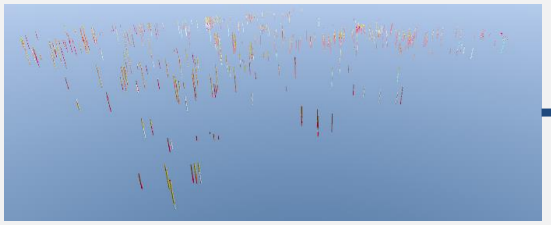


MPS Algorithm

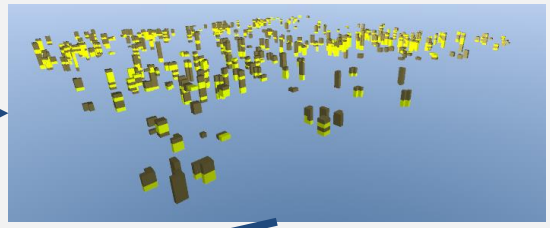


Realizations from $f_{I_{TI}}(\overline{m})$

Borehole Data

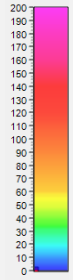


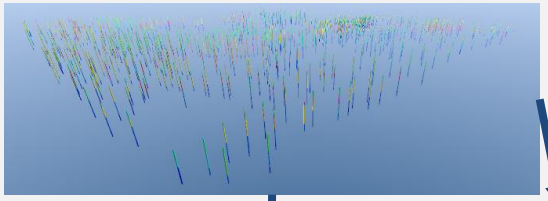
Cathegorize and make Hard data Grid



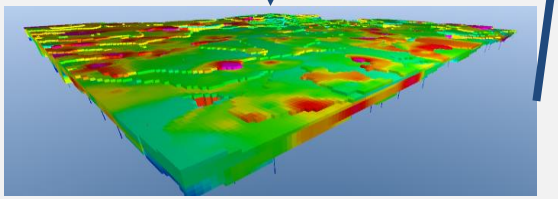
FP_C2 - Sand
FG_C1 - Clay

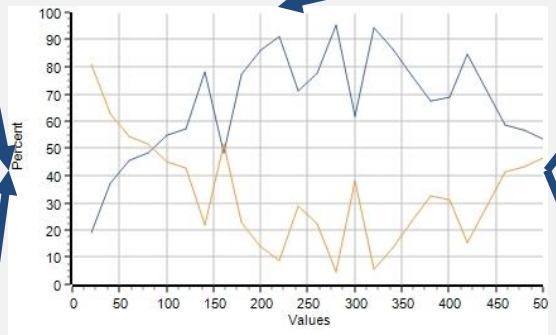
Resistivity data



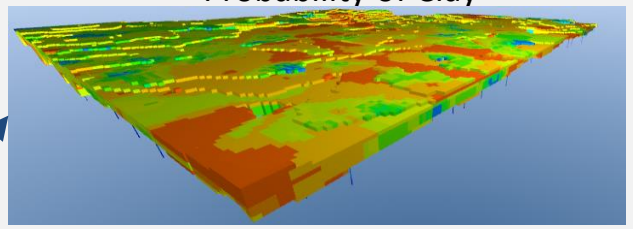


3D interpolation

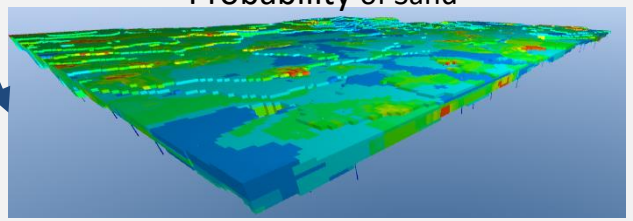




Probability of Clay



Probability of Sand



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Workflow of the Method

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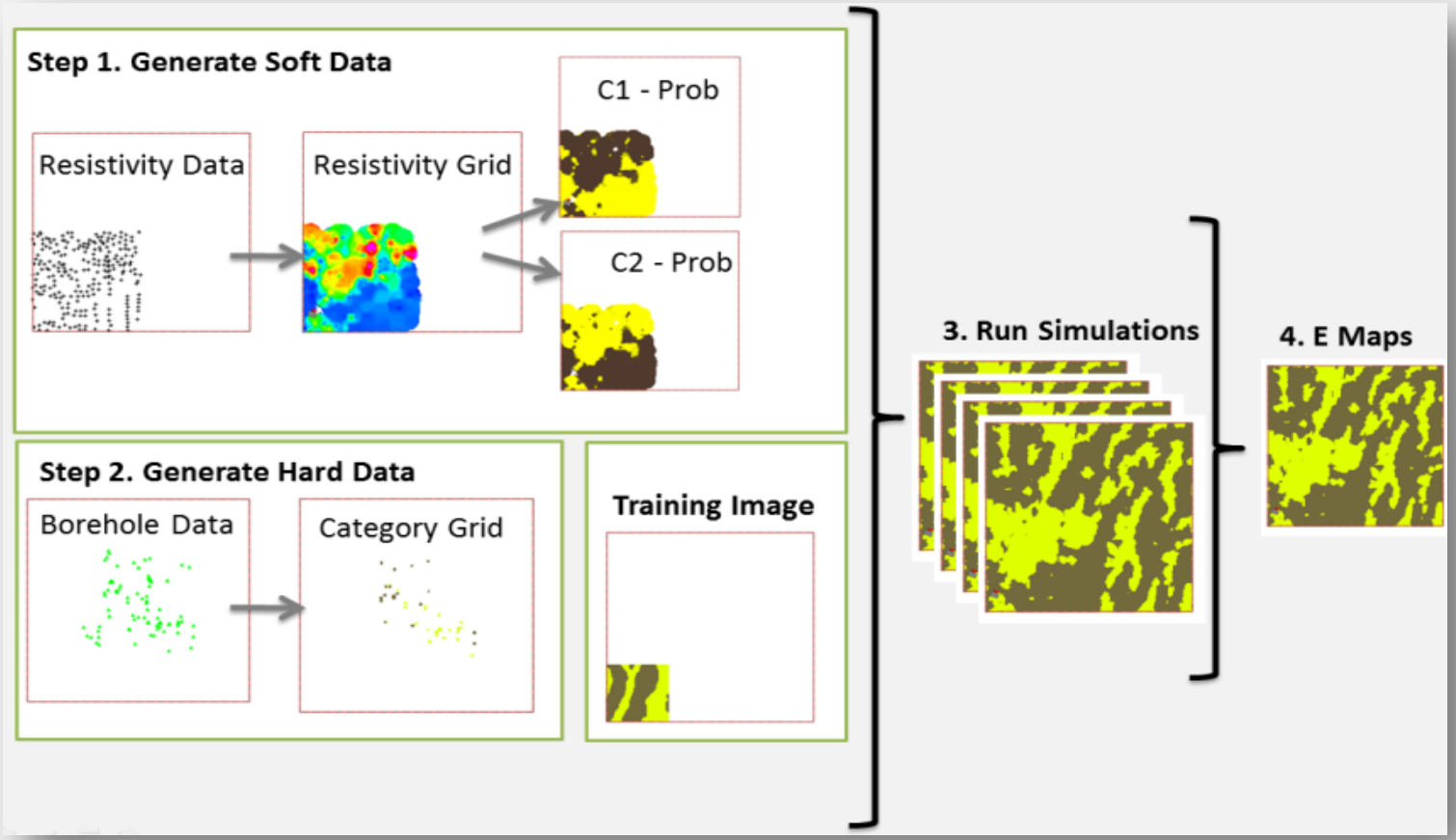
MPS Workflow in GeoScene3D

Make a Training Image → Define Hard/Soft Data → Run Simulations → Alternatively compute E-Maps



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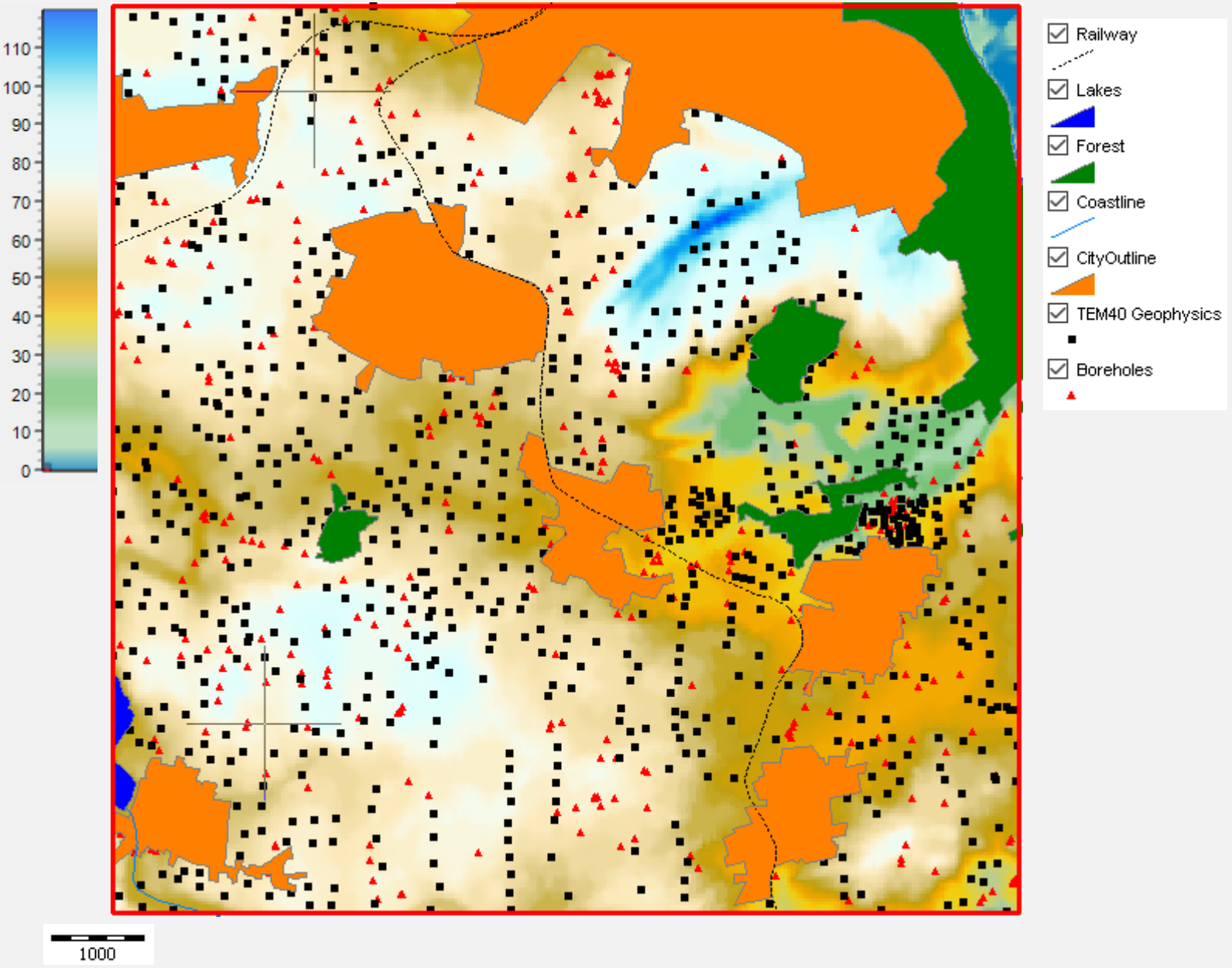
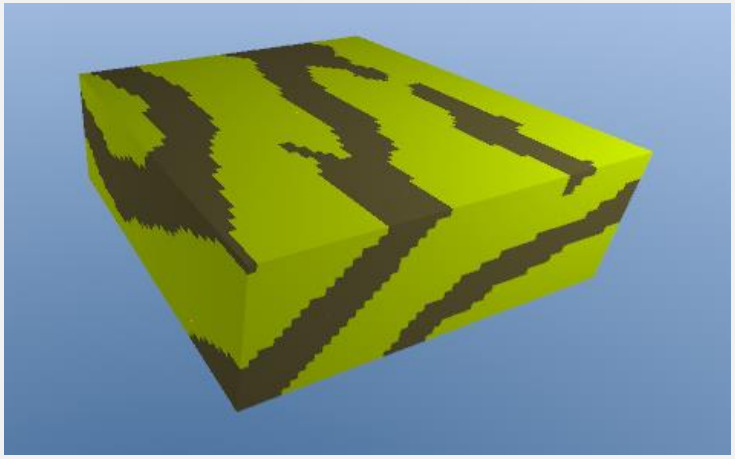
The Simulation Area



The Training Image (TI)

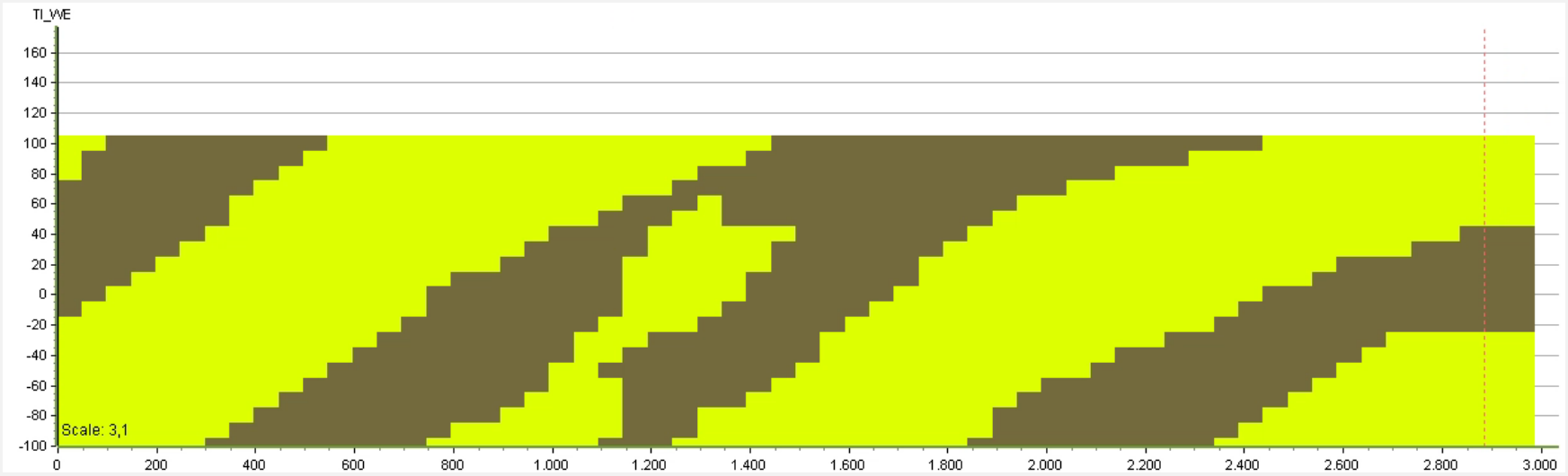
Horizontal slices

3D View



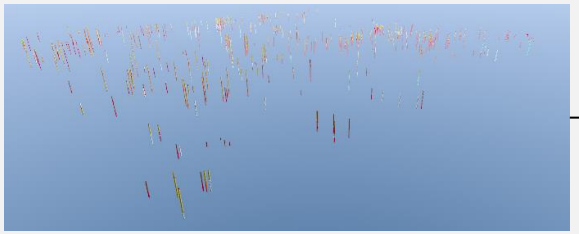
- 3D Grid: 61x61x21 Voxels
- Total # Voxels: 78141
- Voxel Size: 50x50x10 m

WE cross-section

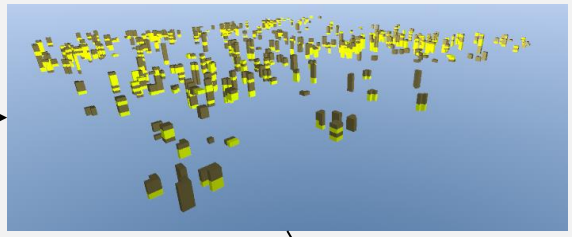


Hard and Soft data

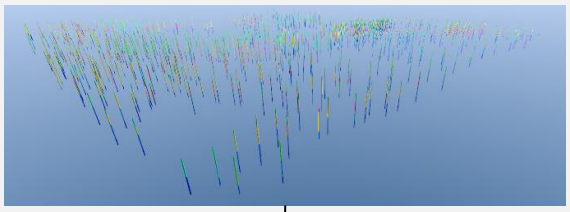
Borehole Data



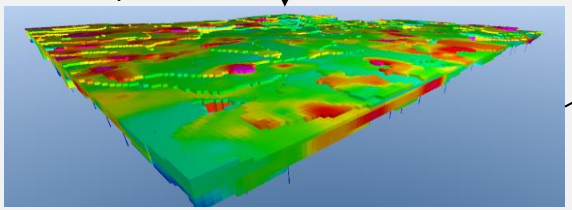
Cathegorize and make Hard data Grid

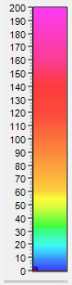


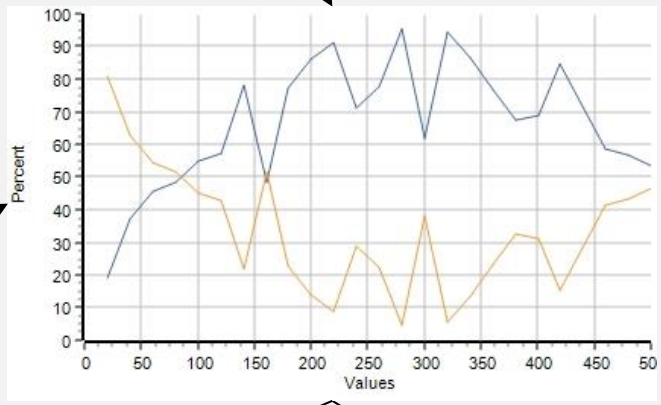
Resistivity data



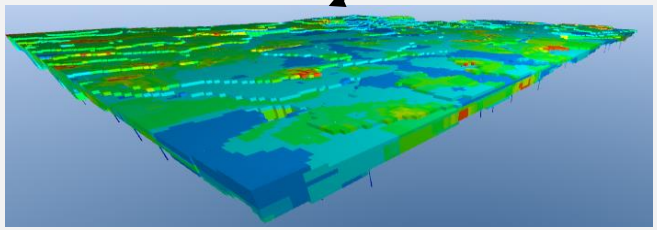
3D interpolation



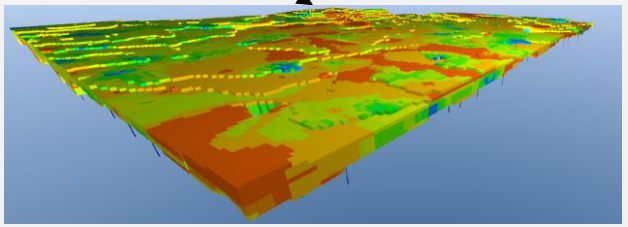




Probability of Sand



Probability of Clay



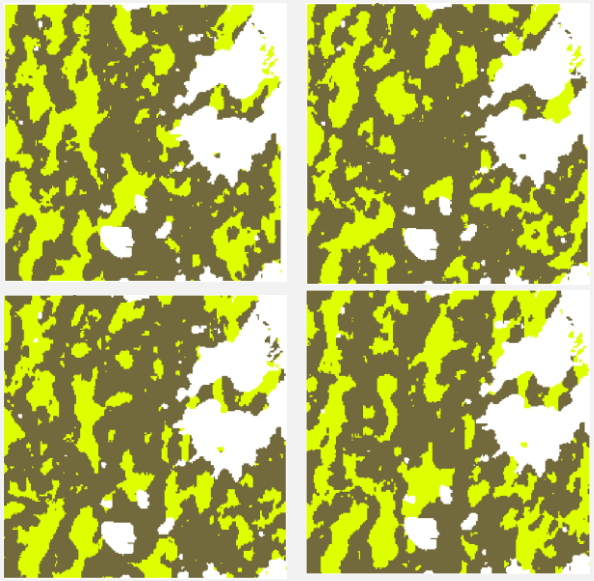
Simulation Results

Simulation Setup:

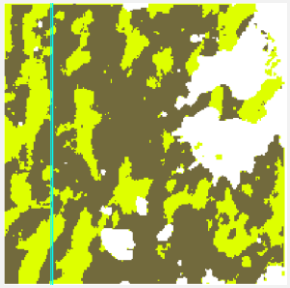
- The Snesim Algorithm
- Template Size: 5-5-3
- 5 Multiple Grids
- Random Simulation path

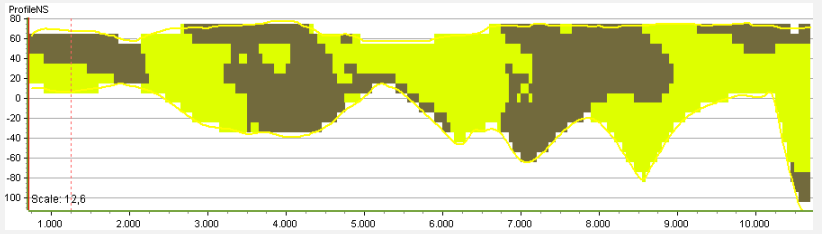
FP_C2 - Sand
FG_C1 - Clay

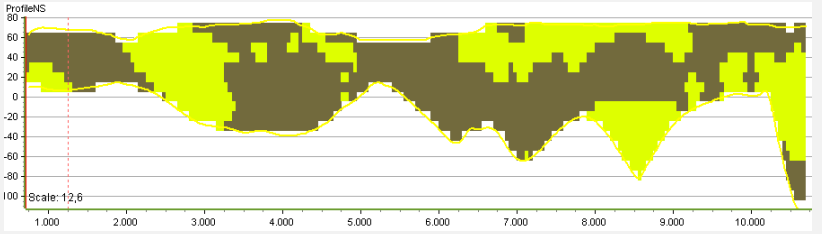
4 realizations

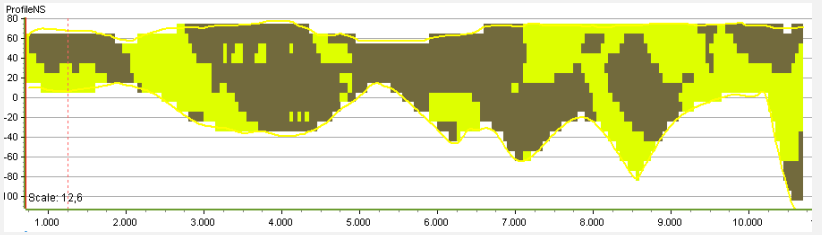


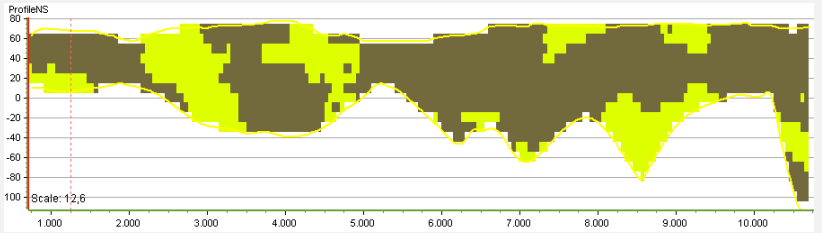
The Mode Model











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Entropy

The Shannon Entropy from Information Theory:

$$S = -\sum_{i} (\mathrm{P}_i \log_2 \mathrm{P}_i)$$

- S is proportional to uncertainty
- S = 1 indicates max uncertainty – No information
- S = 0 indicates no uncertainty – Fully informed.

- Equal number of outcomes for all chategories in a pixel/voxel from a simulation result in S=1
- All outcomes in pixes/voxel has the same category: S=0

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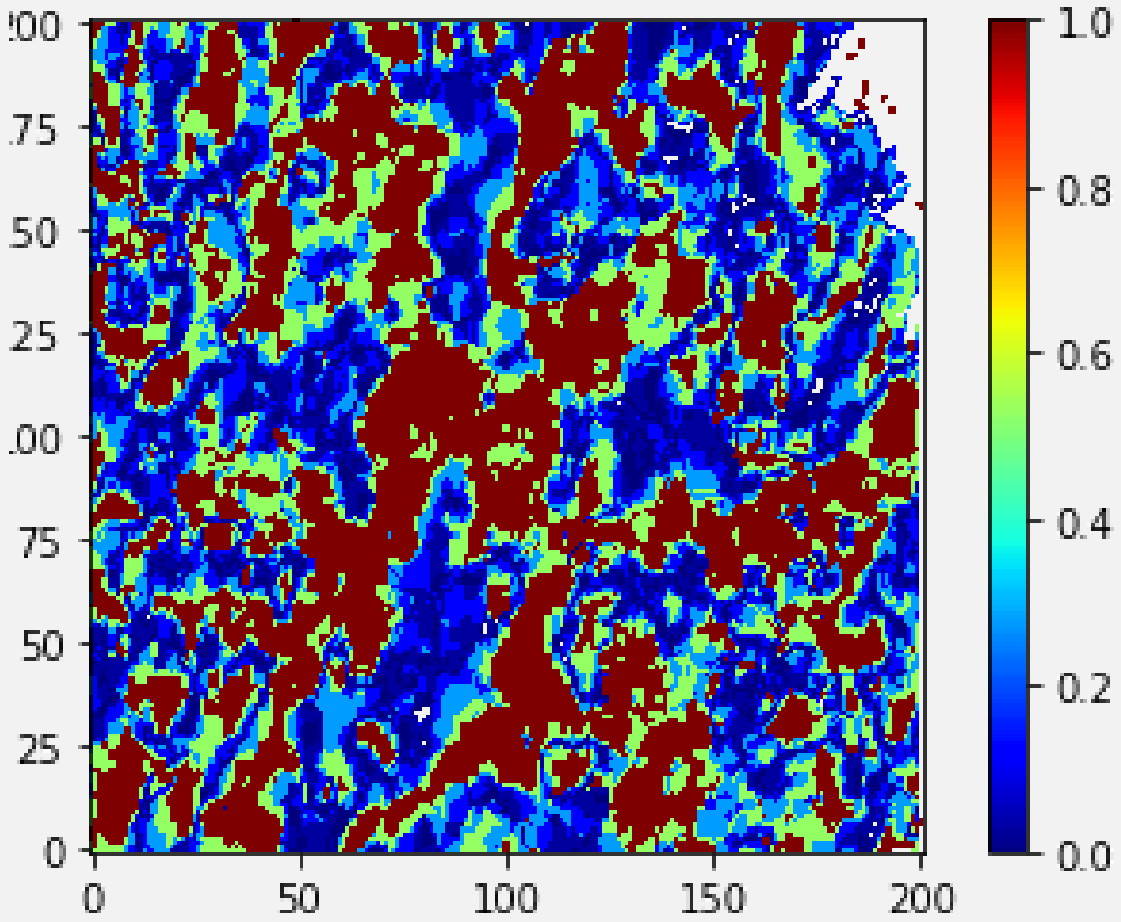
Entropy Grid with no convolution



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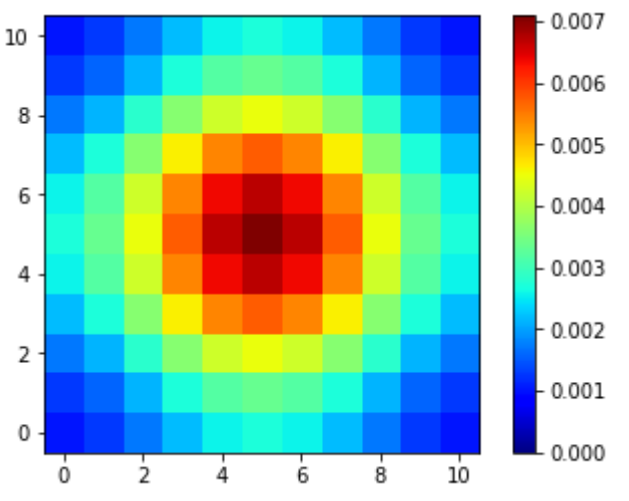
Gaussian Kernel

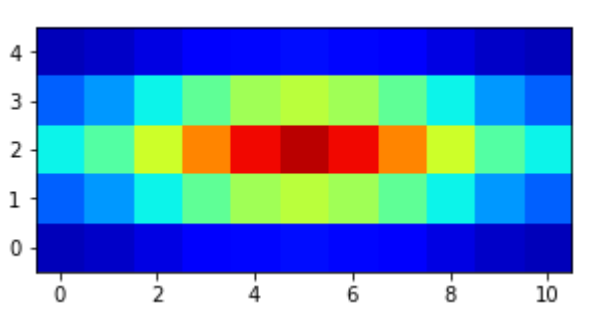
Smoothed Dirac Delta in 3D.

3D Gaussian Kernel with ellipsoidial shape of 11*11*5 cells. 500m x 500m x 50m
Std. of 3, 3 and 1

Horisontal slize



Verticle Slize



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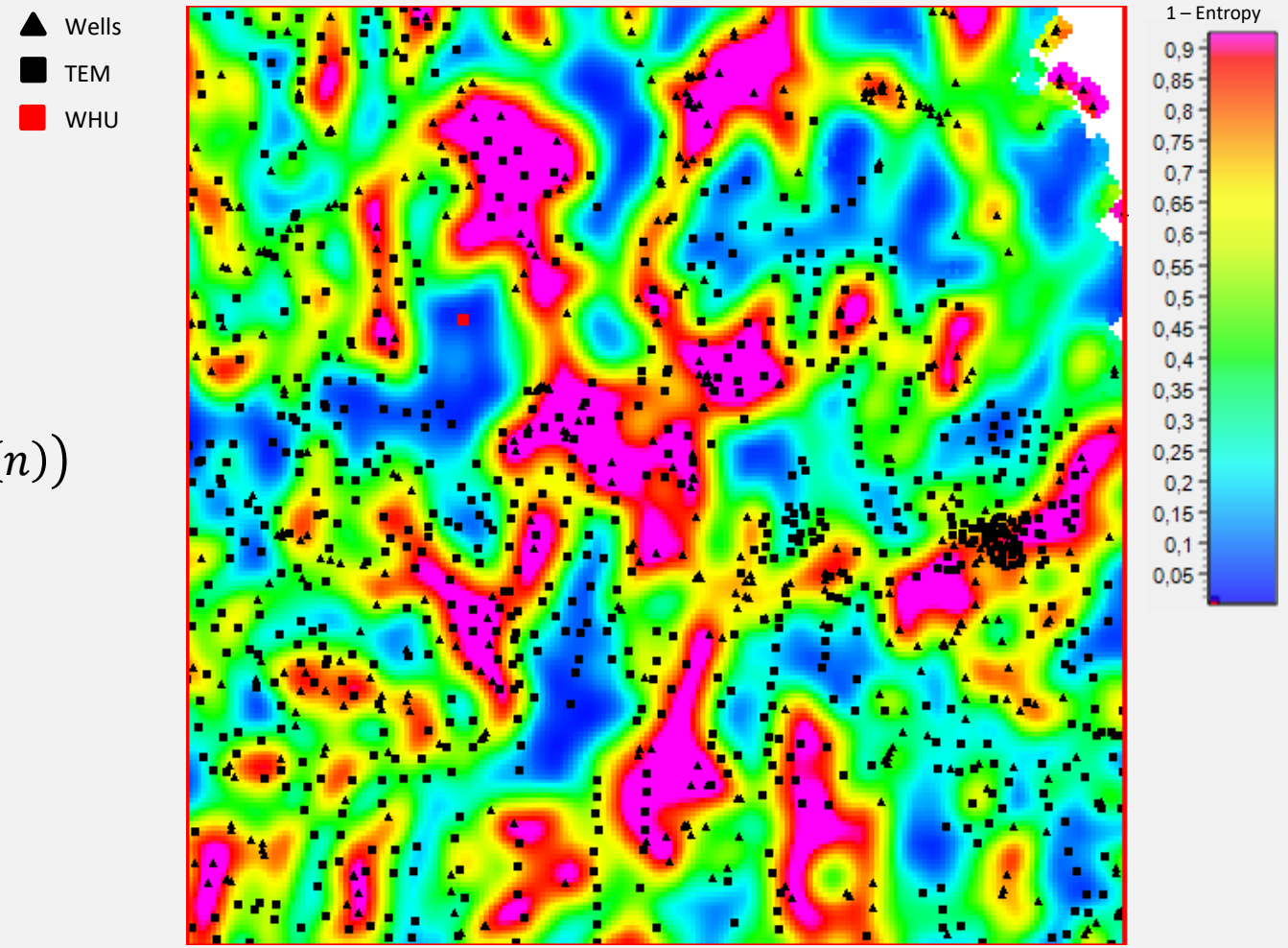
Results

1 – Entropy in the upper 10 meters.

$$WHU = \frac{1}{n}\sum_{n}\left(1 - S(n)\right)$$



Results

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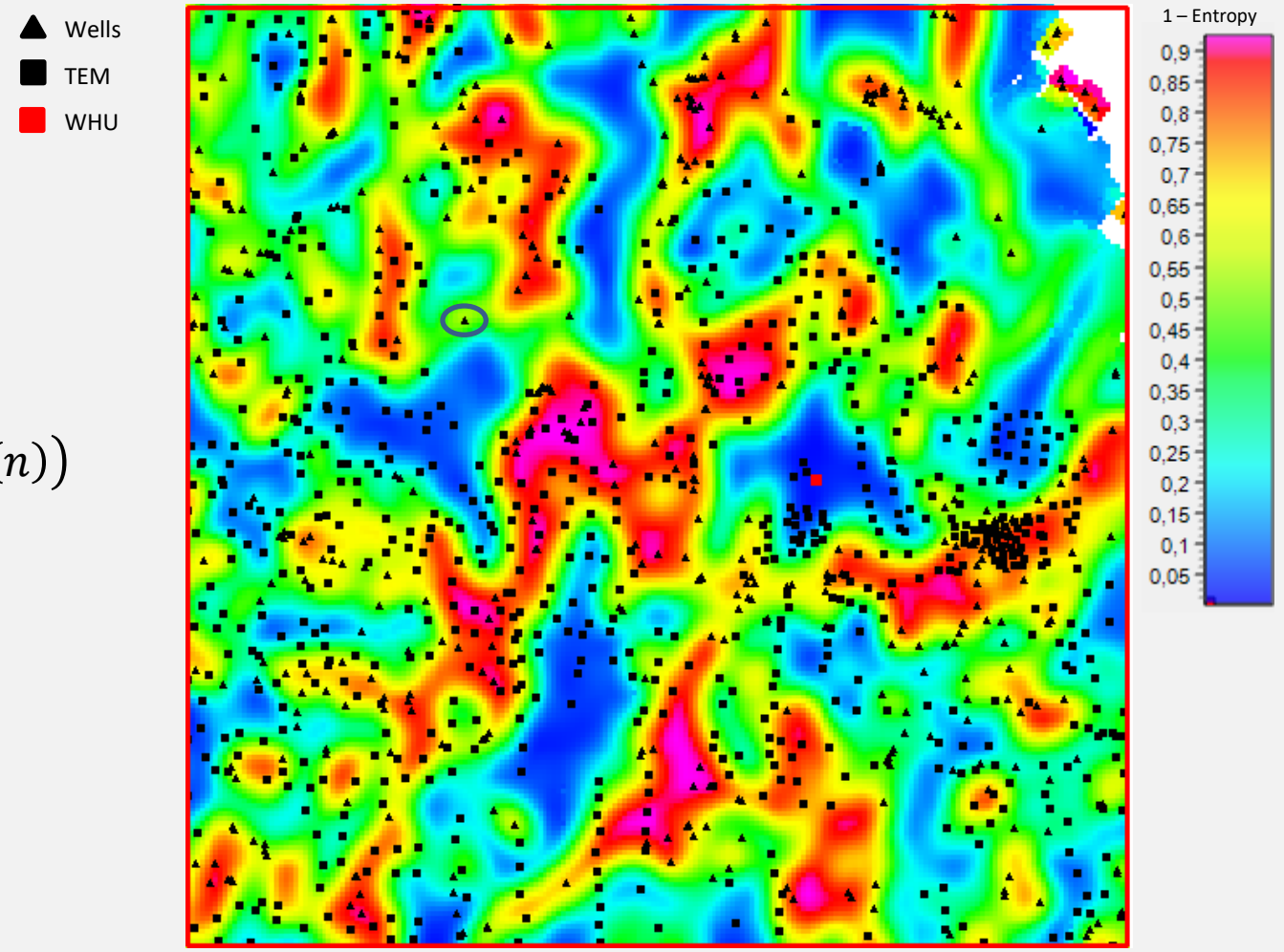

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Concluding remarks

- MPS Realizations represent different Geologic scenarios
- The Entropy provides information on the certainty/quality of our probabilistic model
- Convolving the Entropy model allows including the surrounding information content
- Obtaining information (e.g. by drilling) at the location with highest entropy will update the probabilistic model the most
- Necessary to apply a Gaussian Filter, or is the spatial information already represented in the MPS realizations?