KORTLÆGNING AF MARKERS HYDROGEOLOGI OG REDOX-REGIME

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OUTLINE

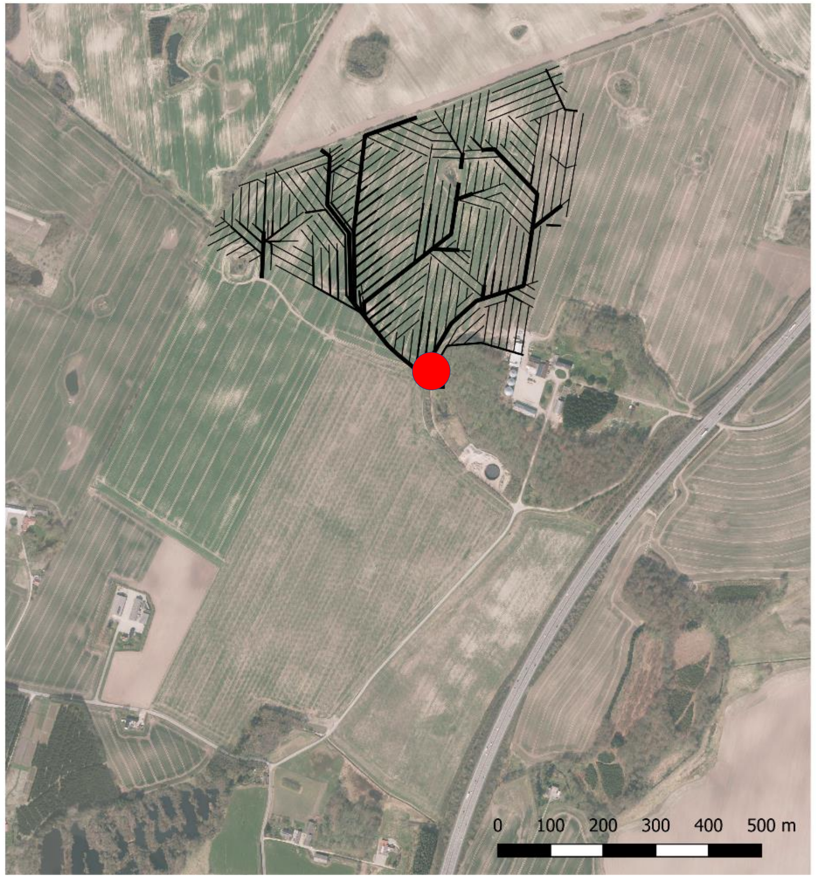
Variationer I hydrologiske responser over korte afstande

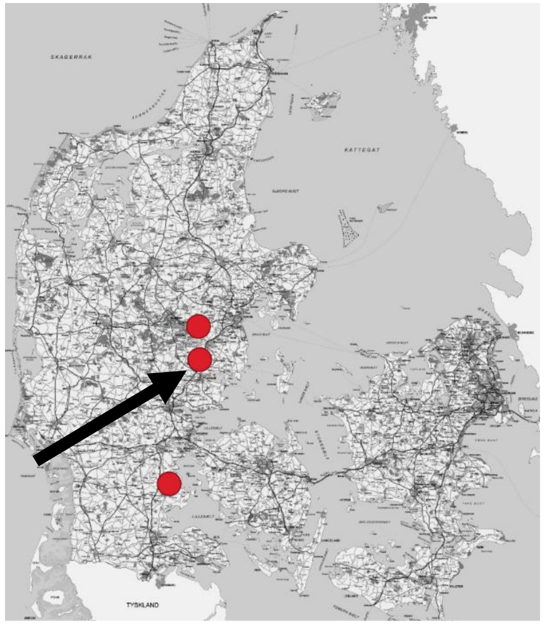
Modellering strømninger/vandspejl omkring dræn

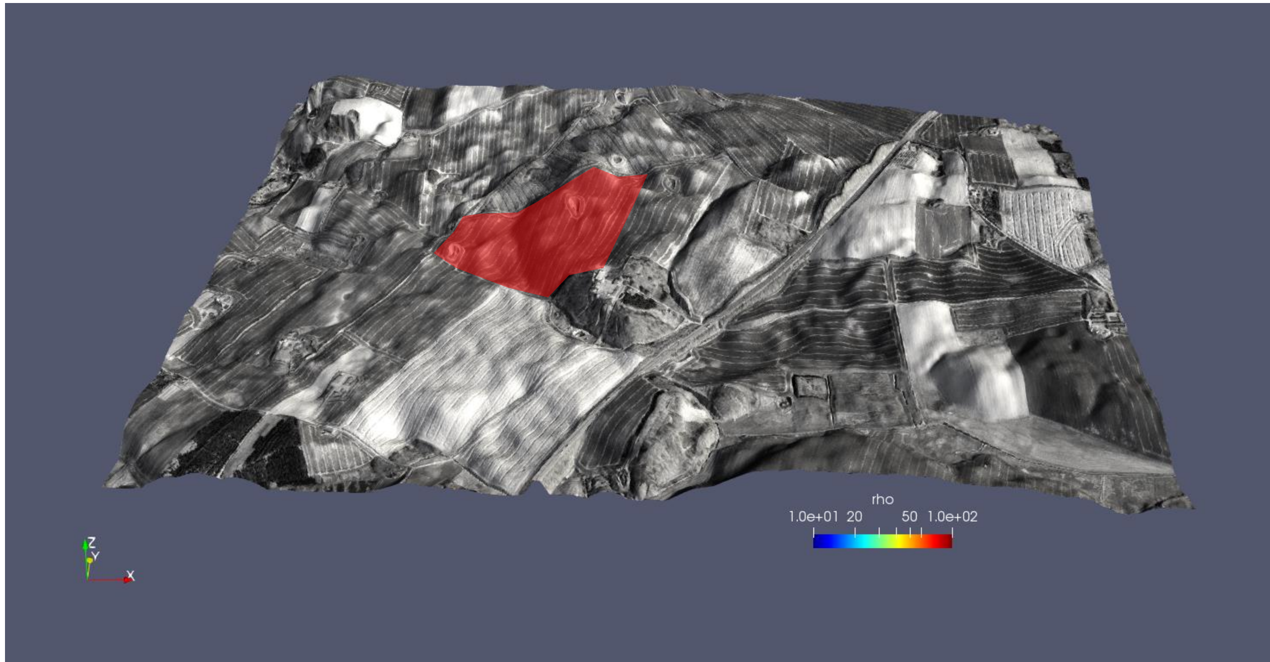
Eksempler på redox modellering på oplandsskala fra rOpen

Geofysiske metoder til strukturel kortlægning

UNDERGRUNDENS STRUKTURER OG HYDROGEOLOGIEN – GEDVED







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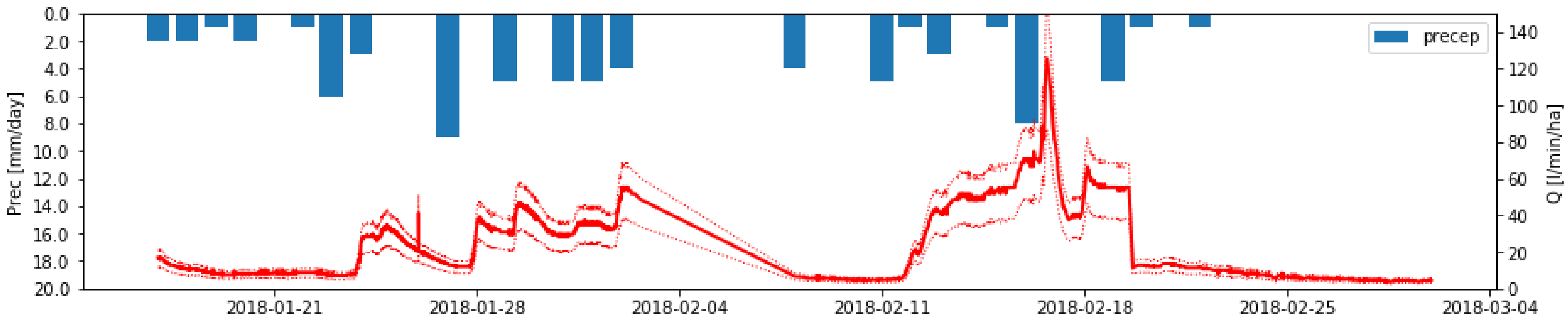

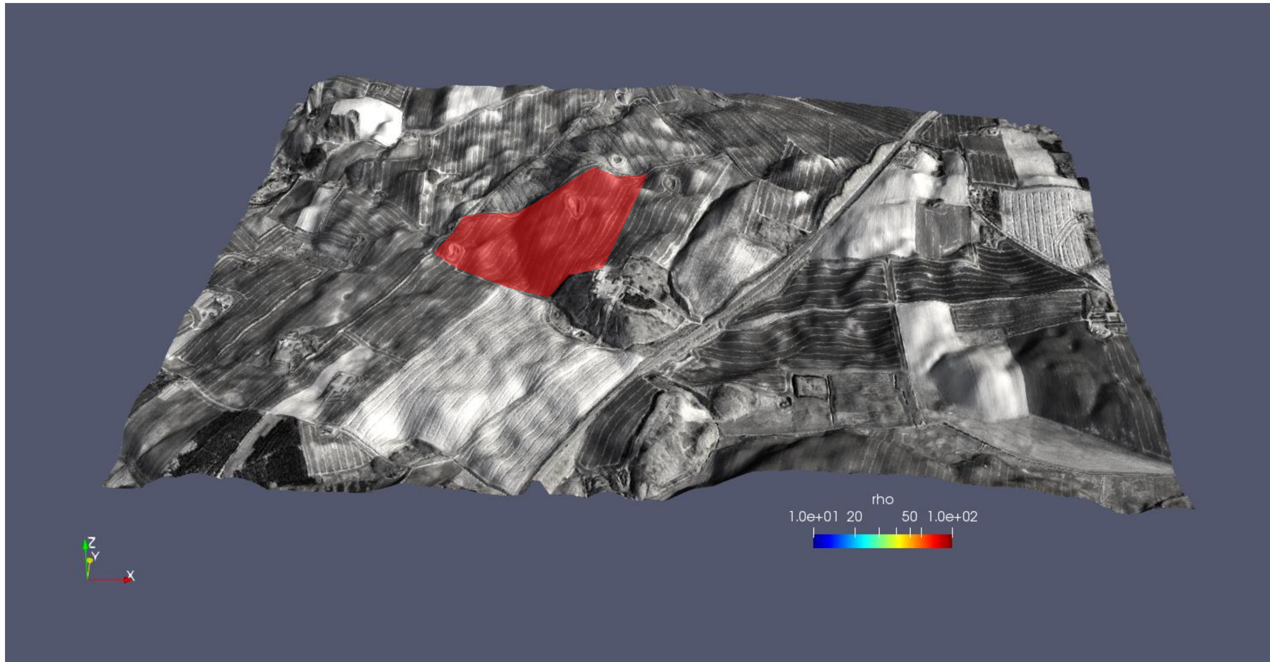

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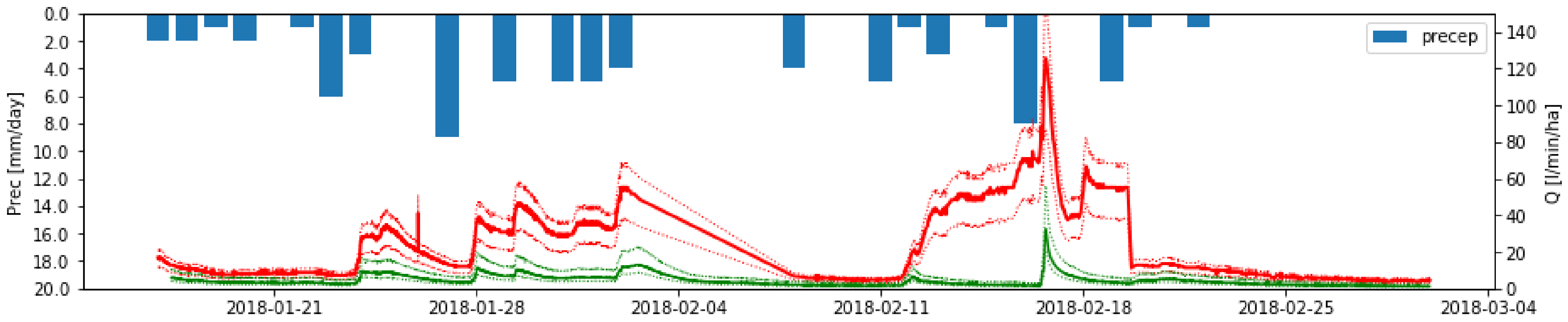

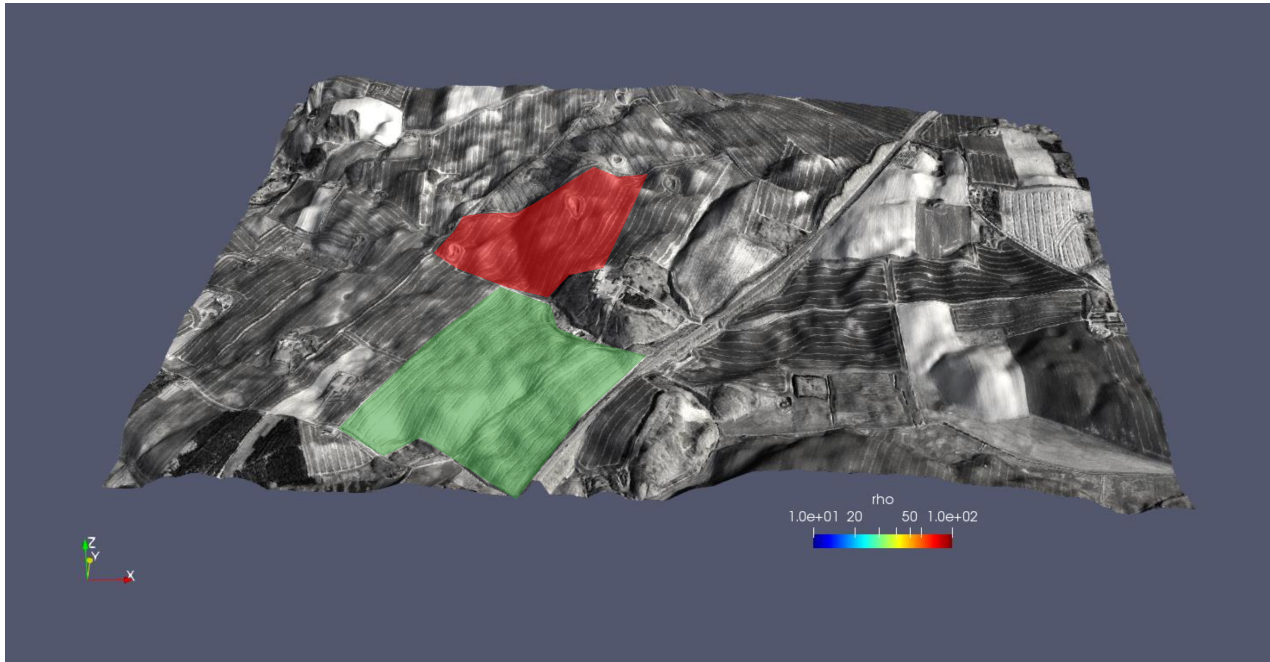

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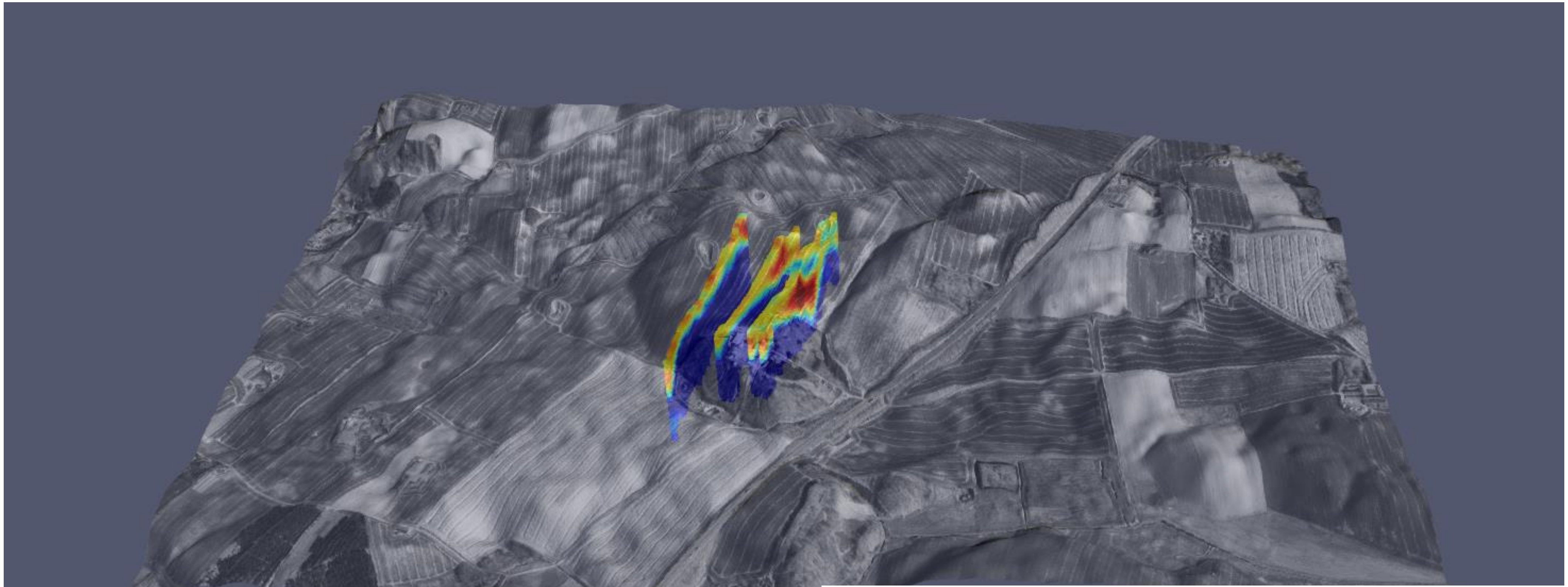

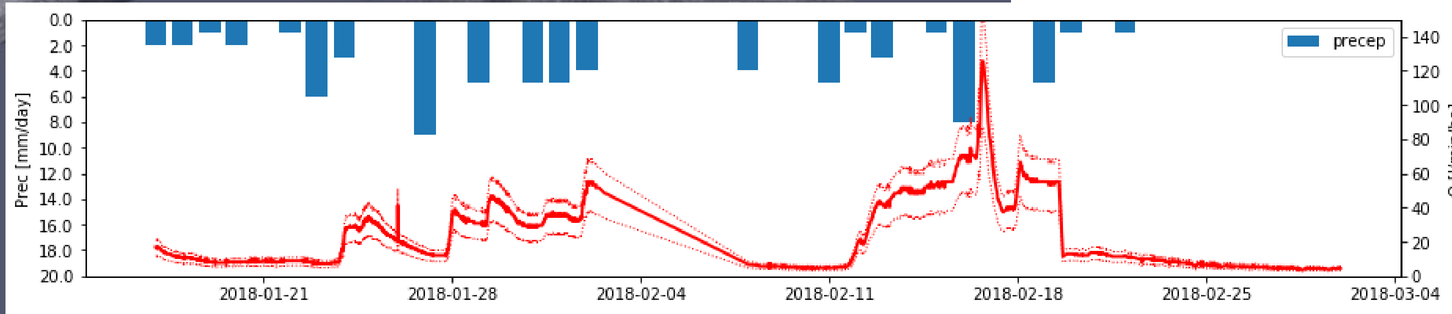

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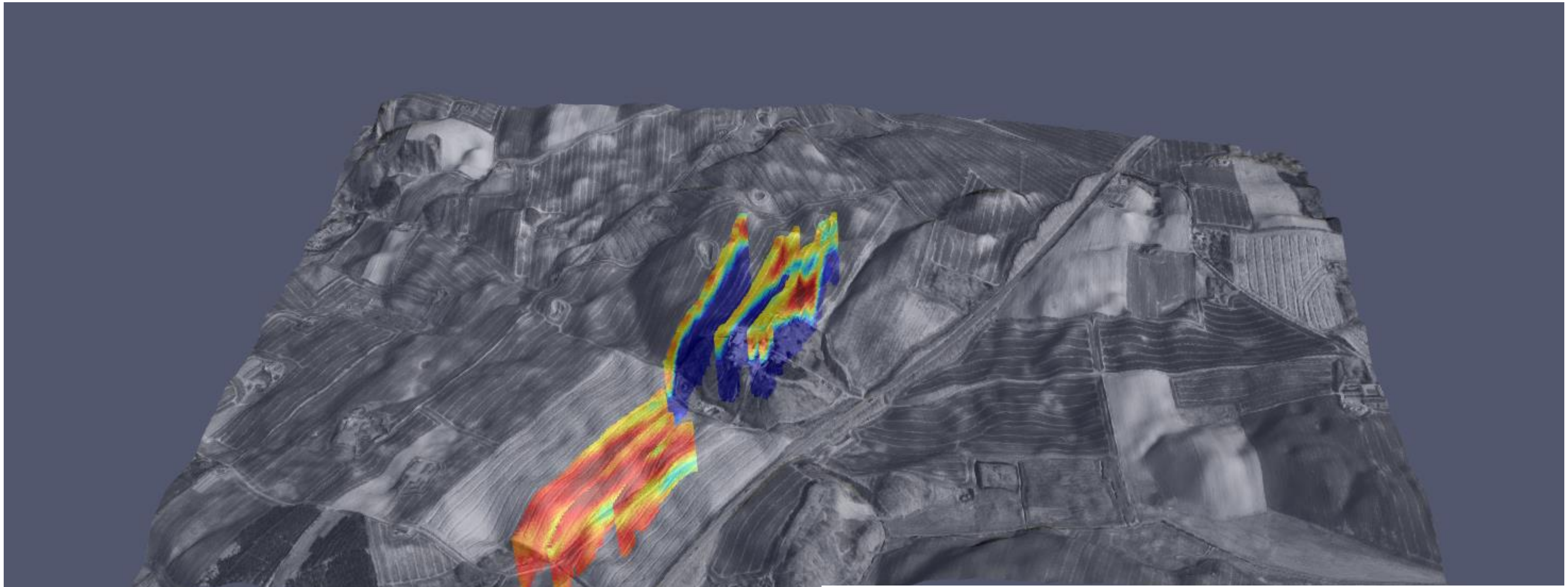

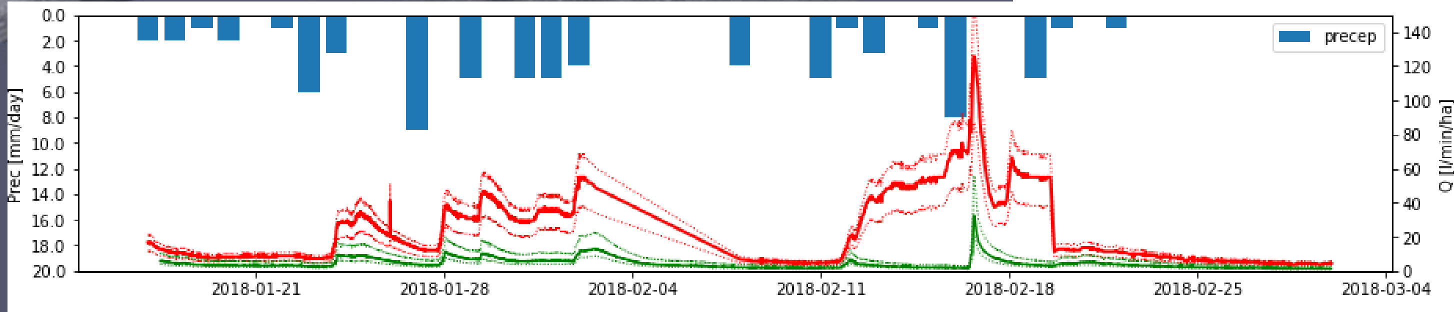

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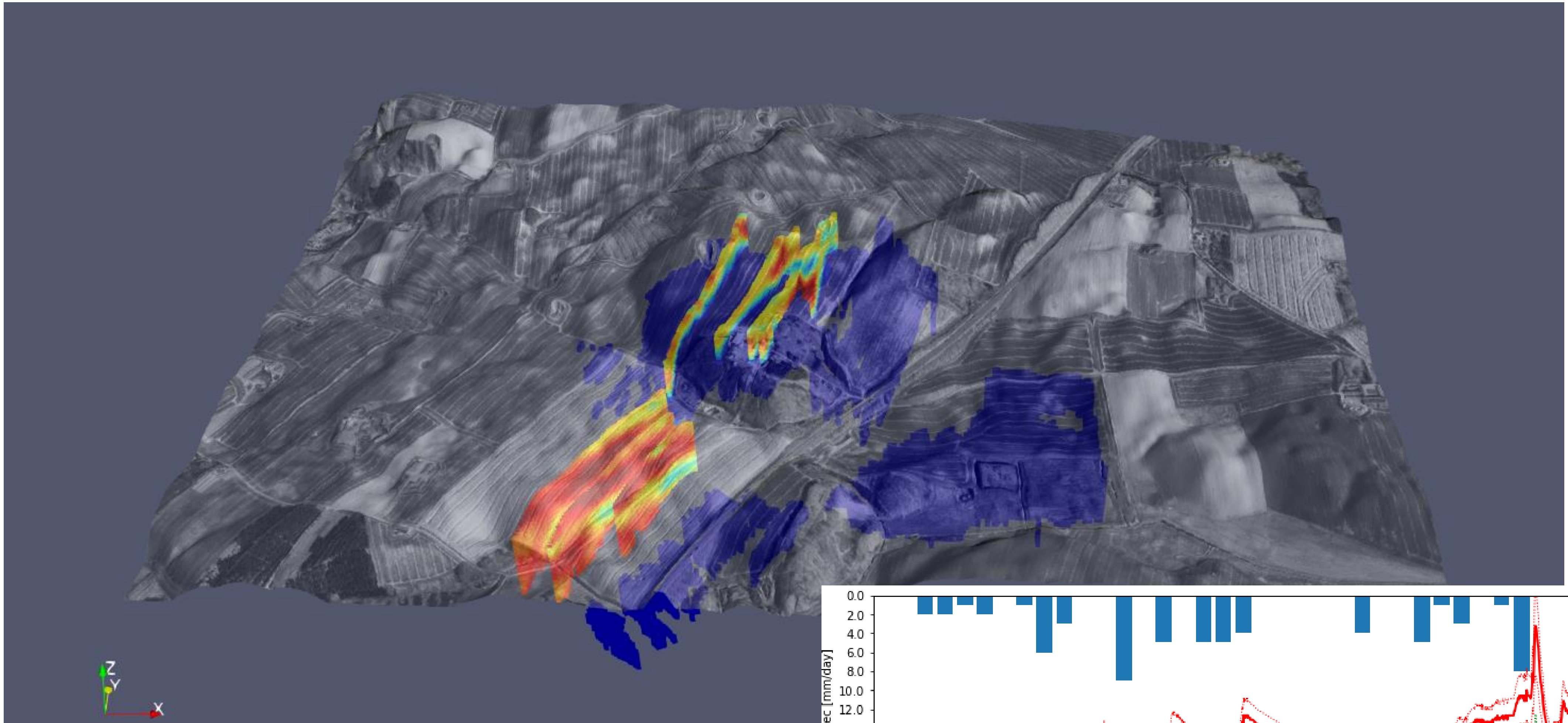
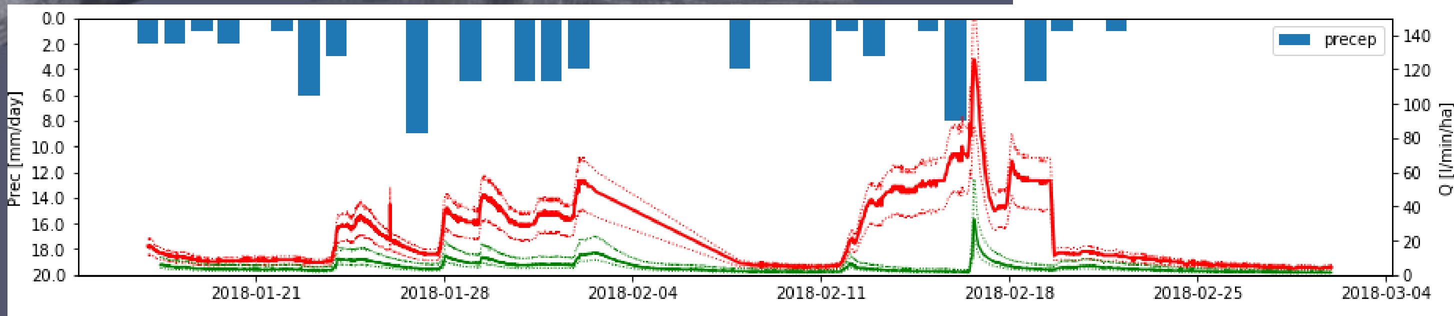
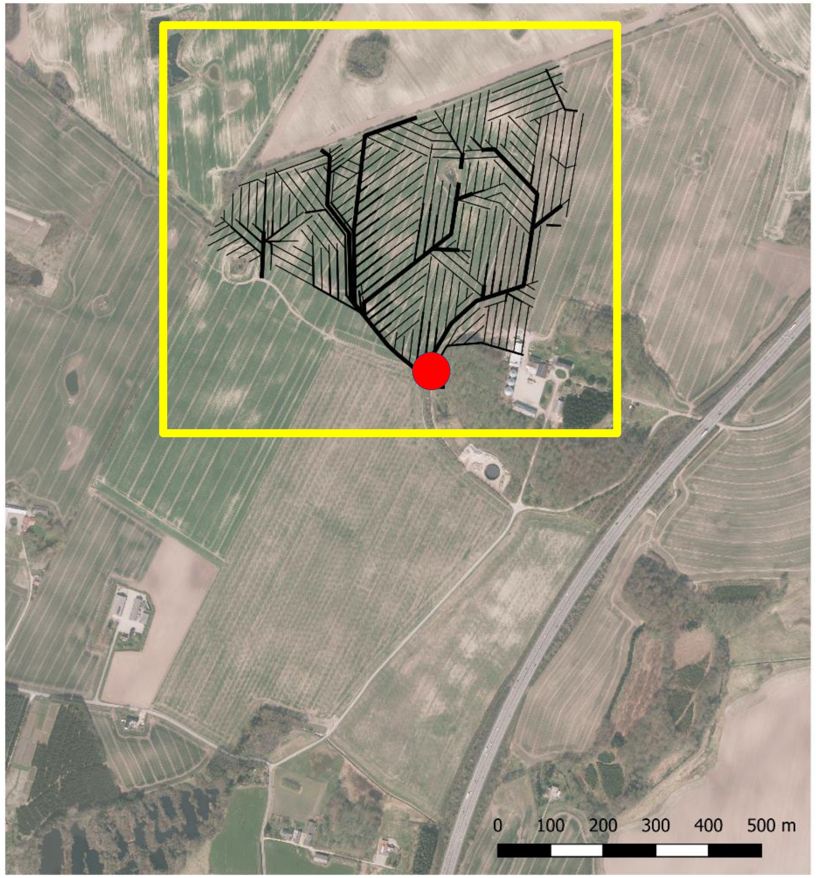
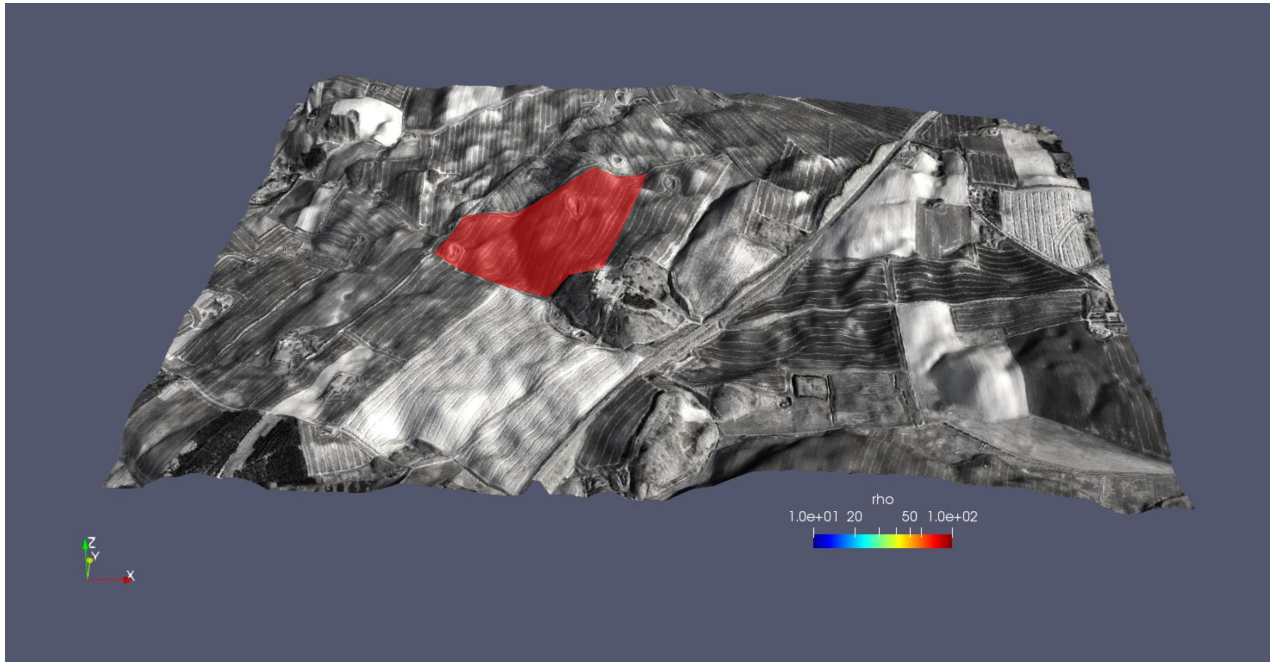




SIMULATING DRAIN FLOW IN FIELDS





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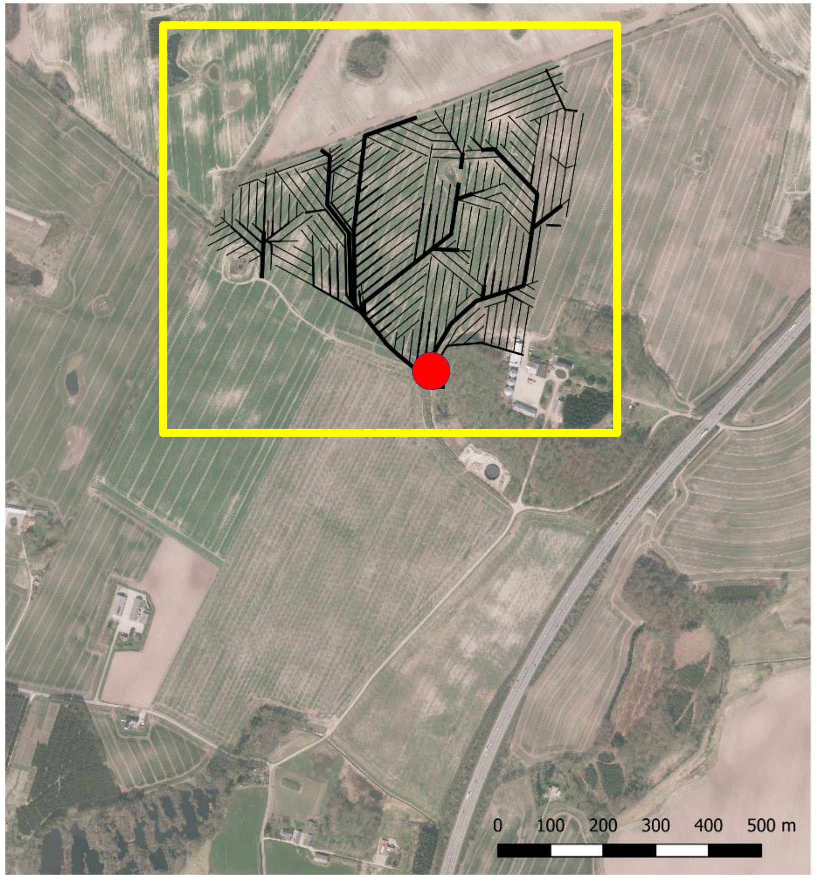

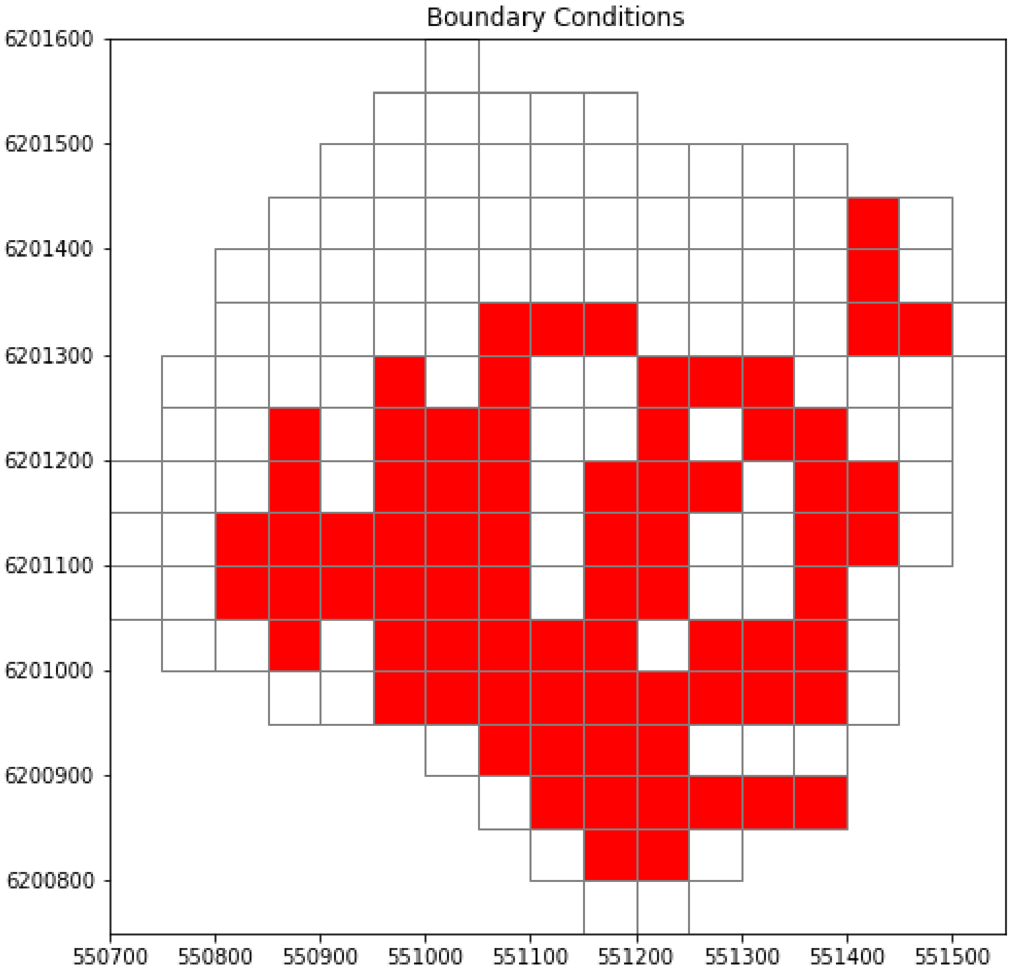

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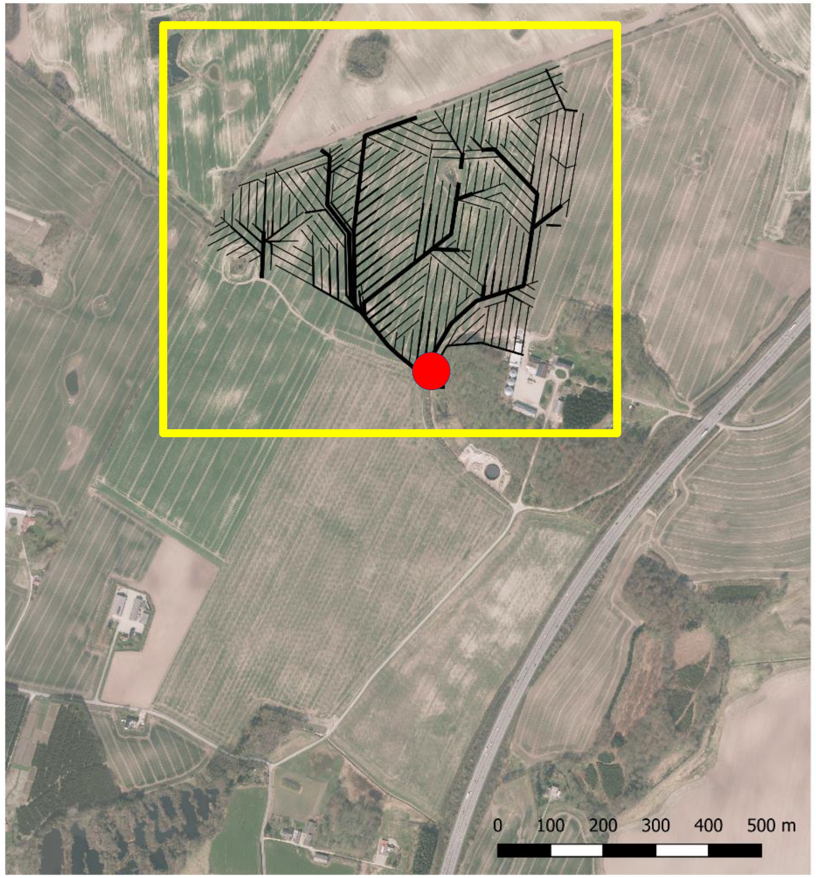

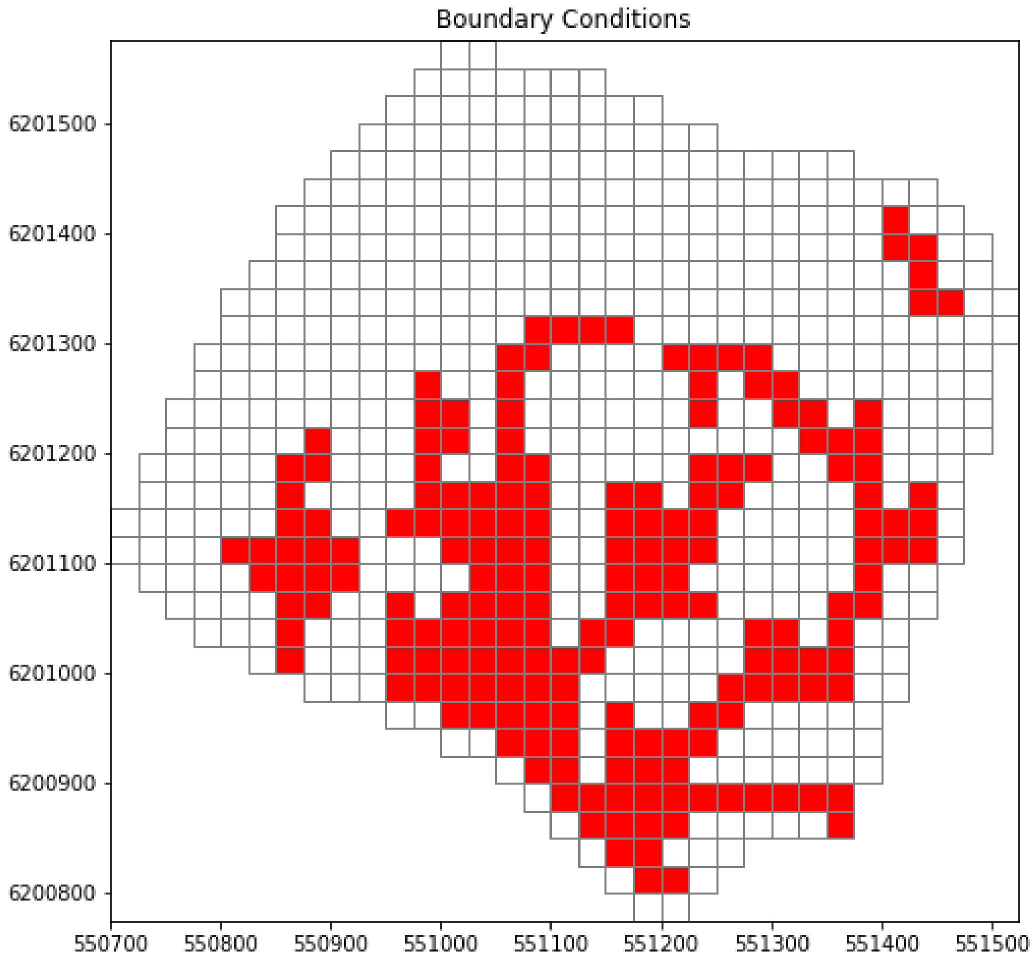

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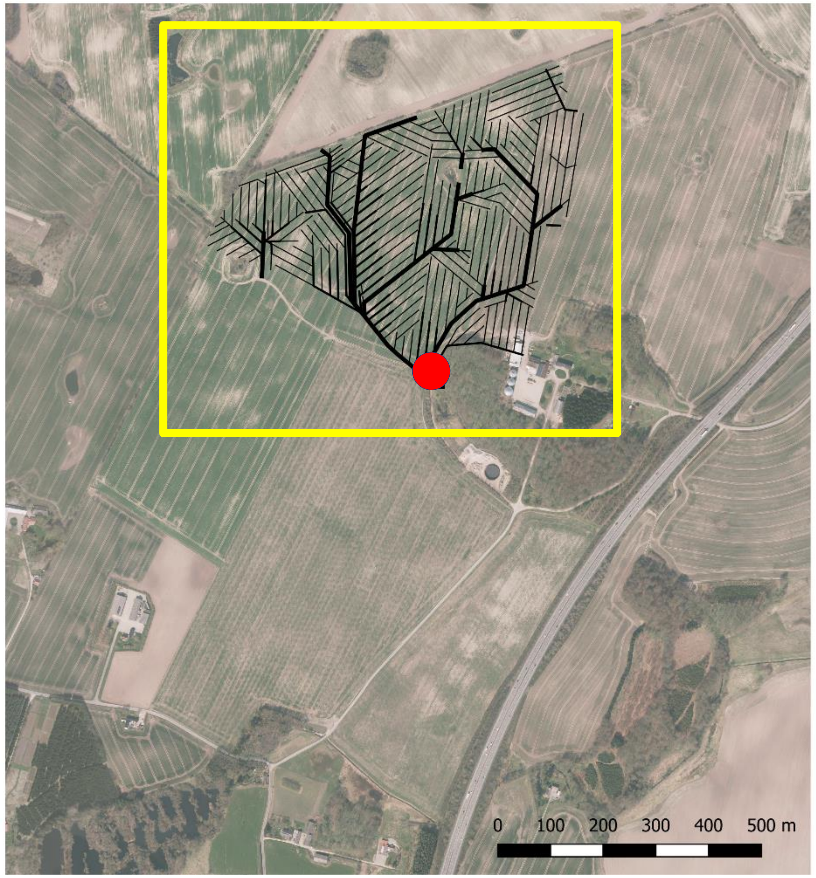

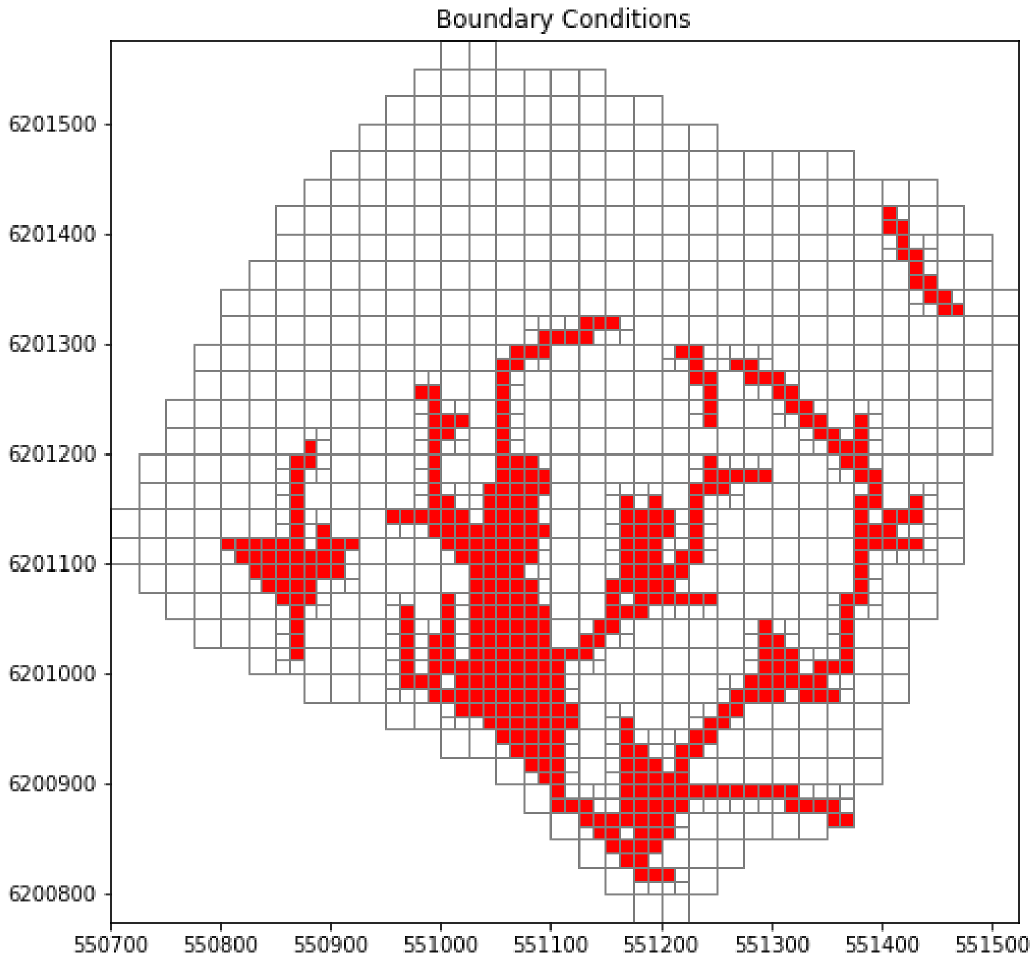

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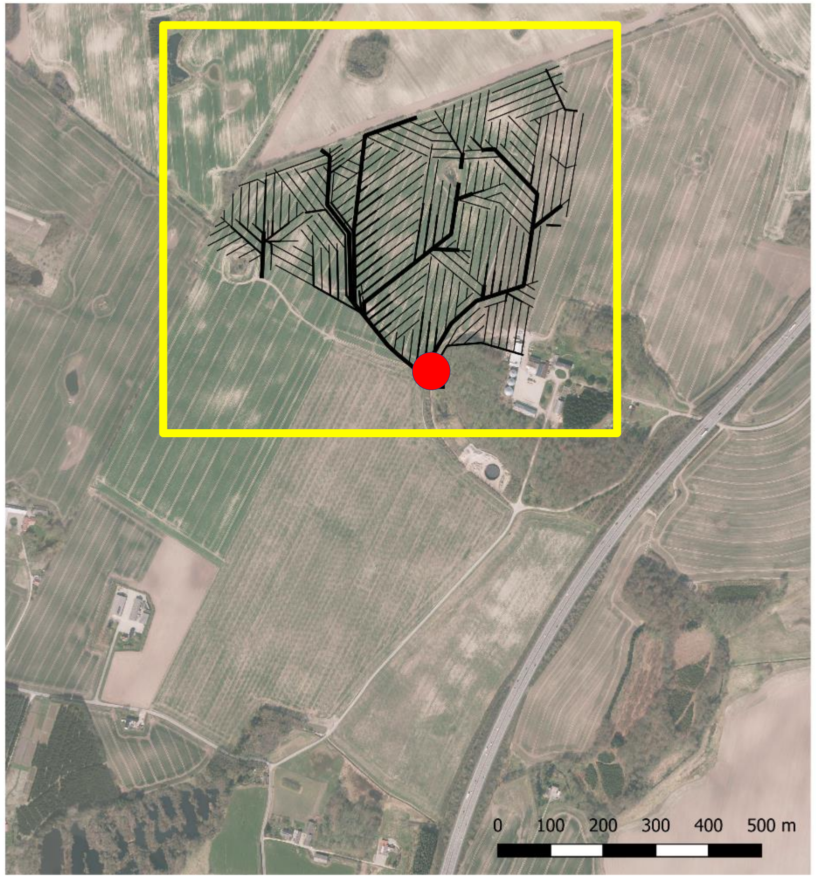

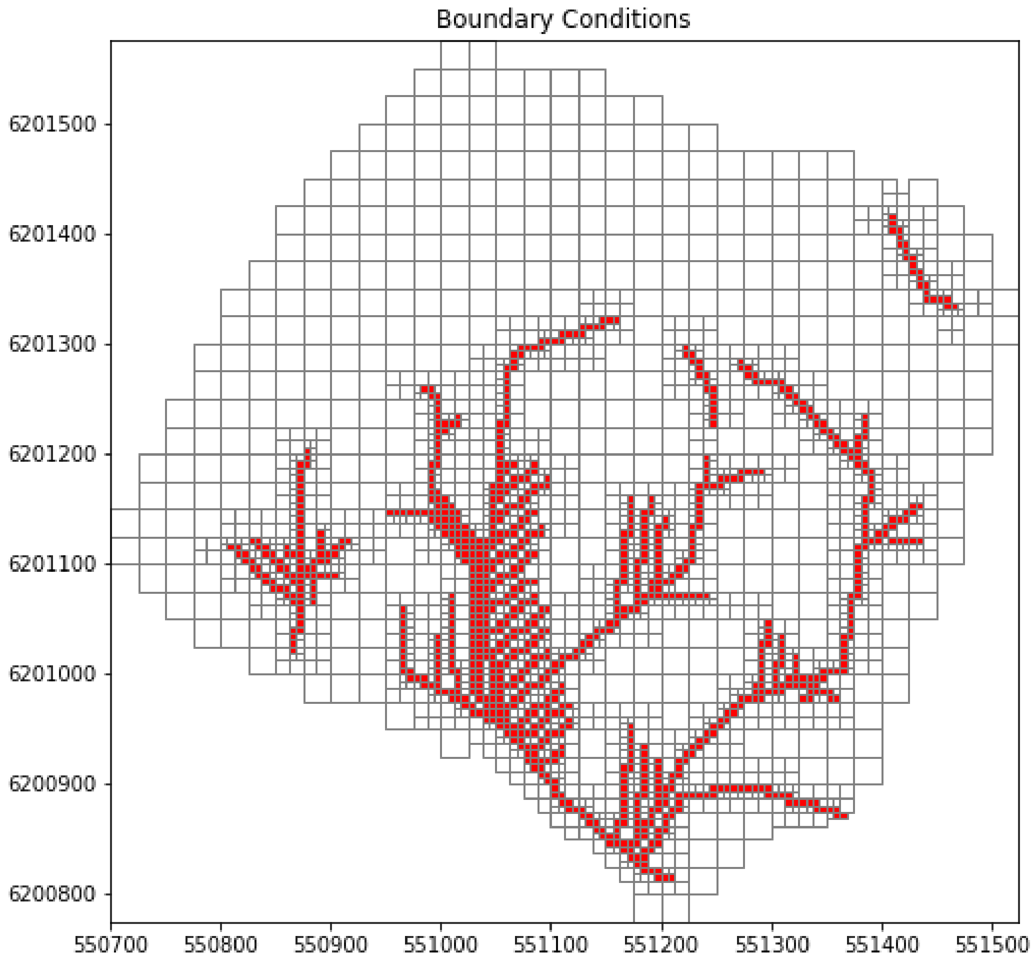

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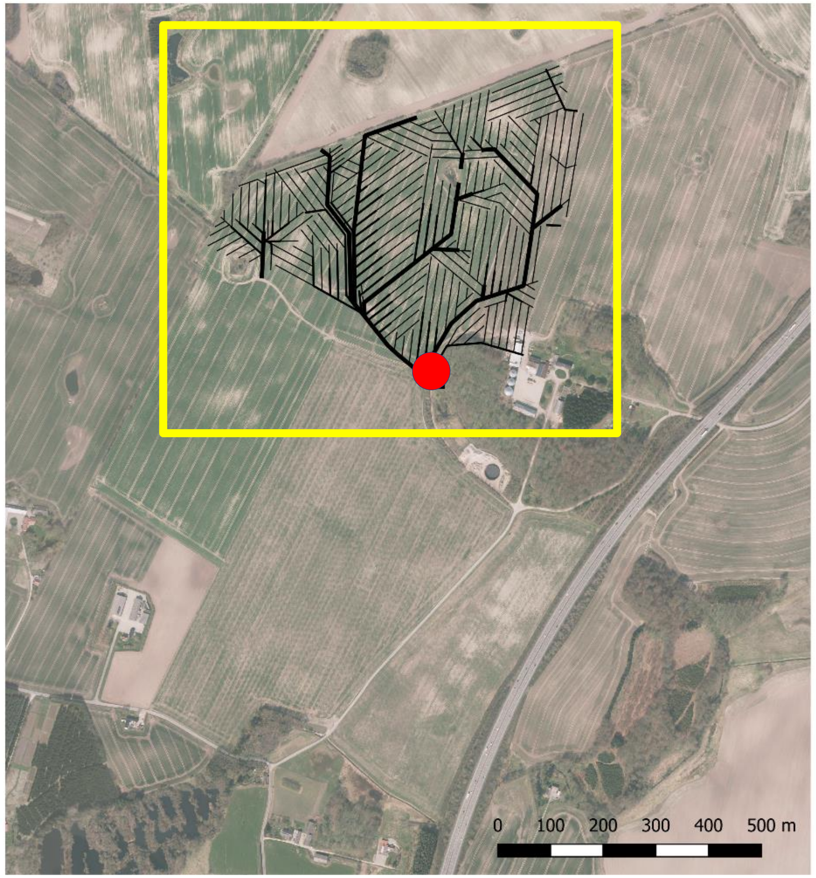

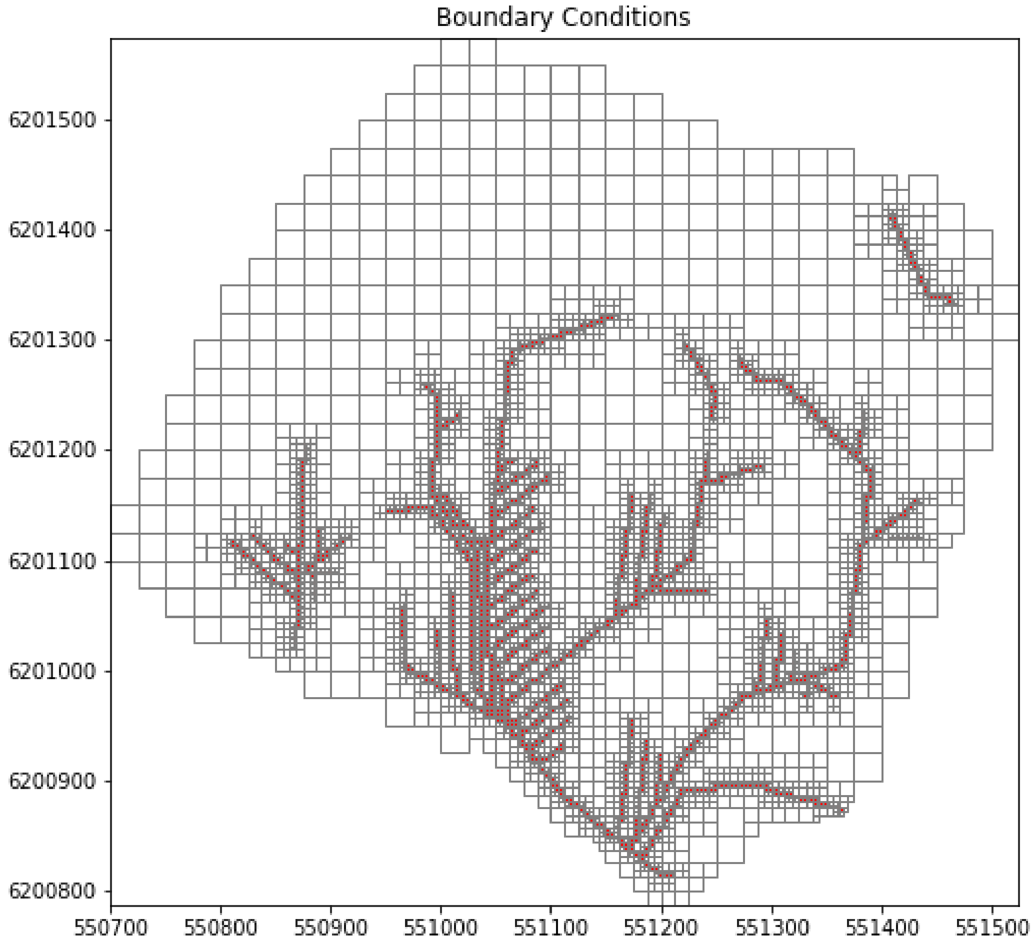

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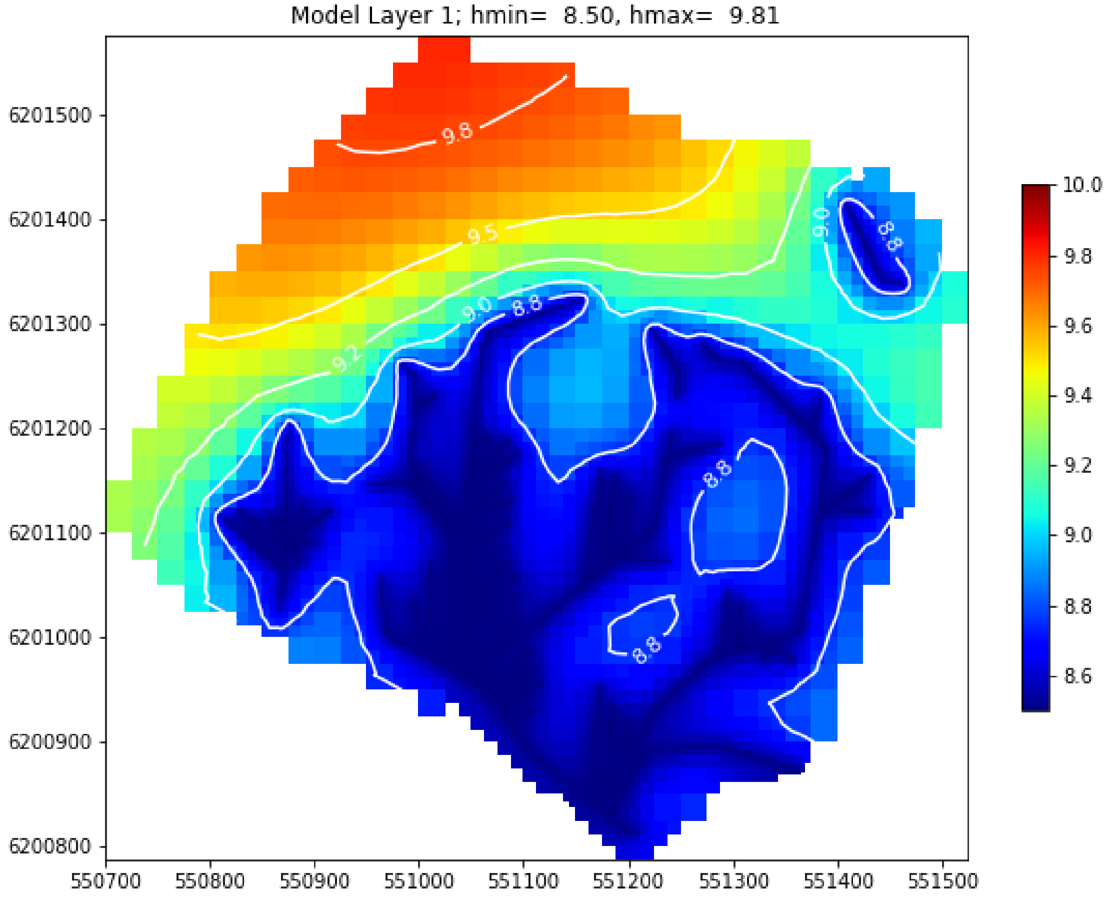

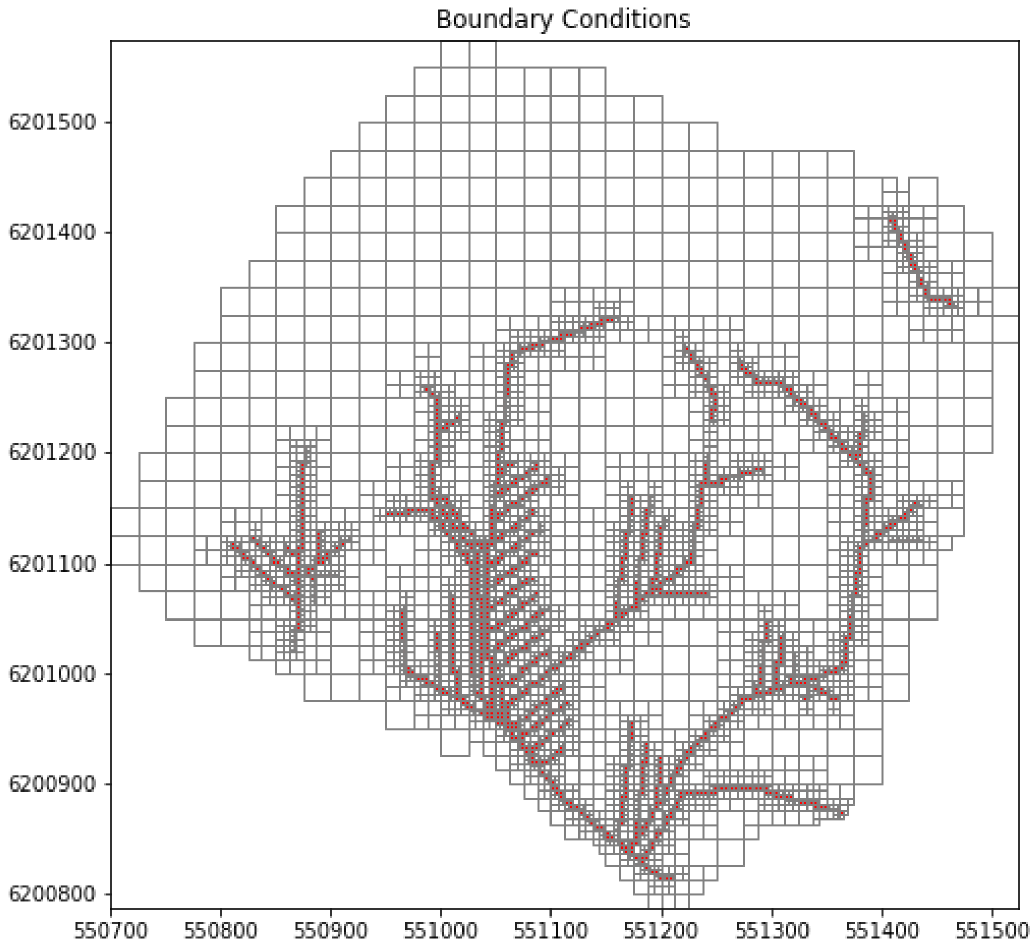

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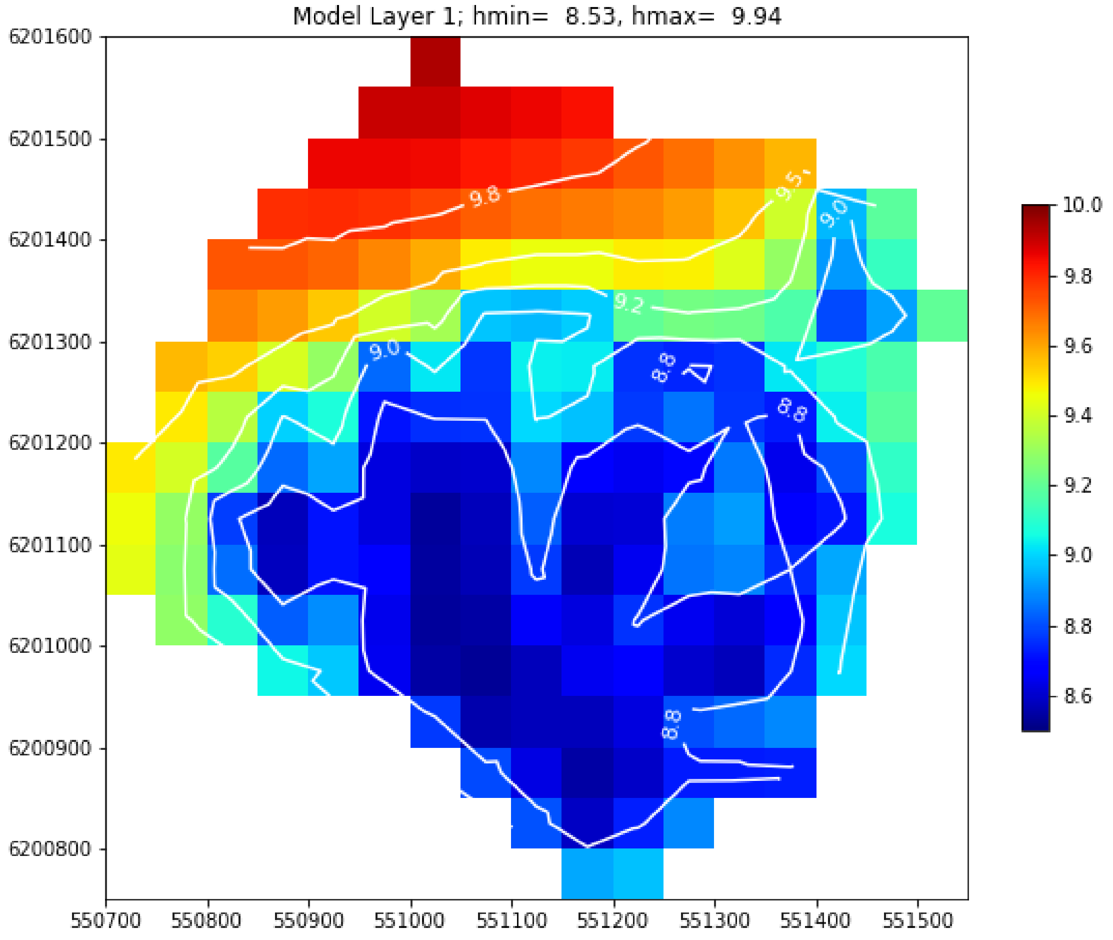

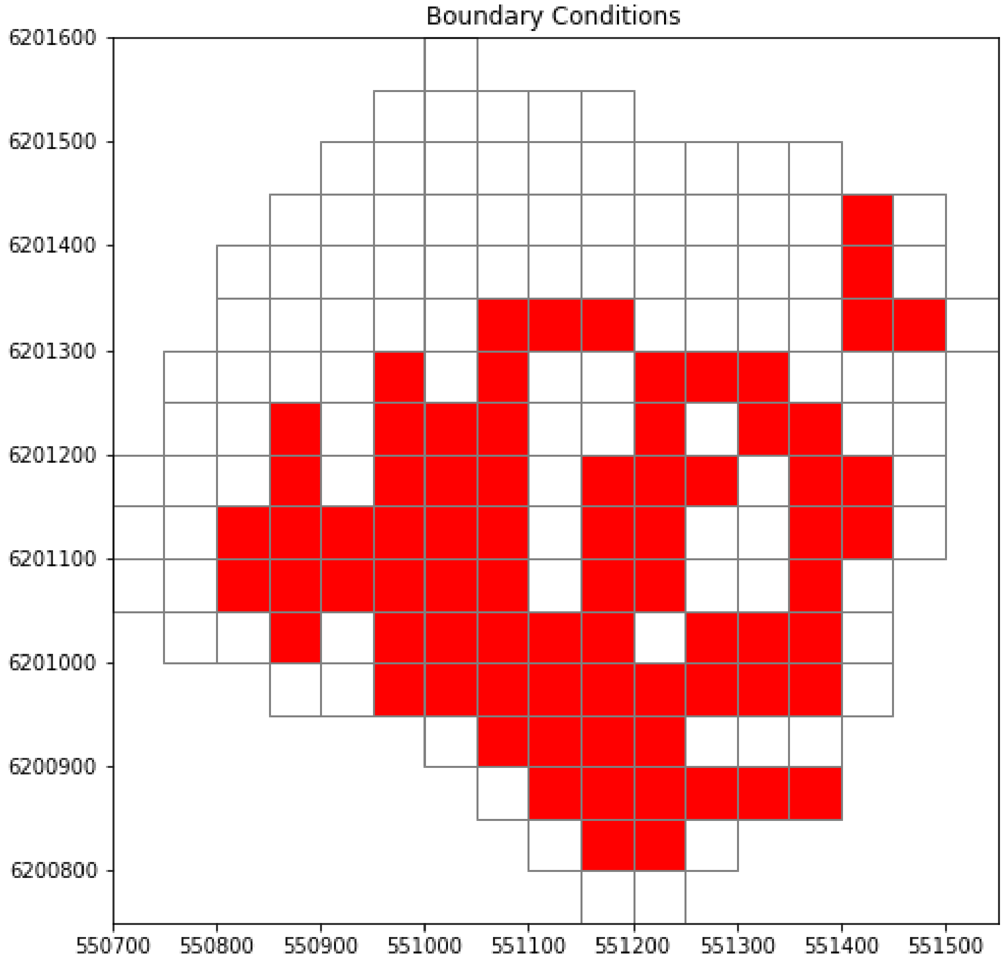

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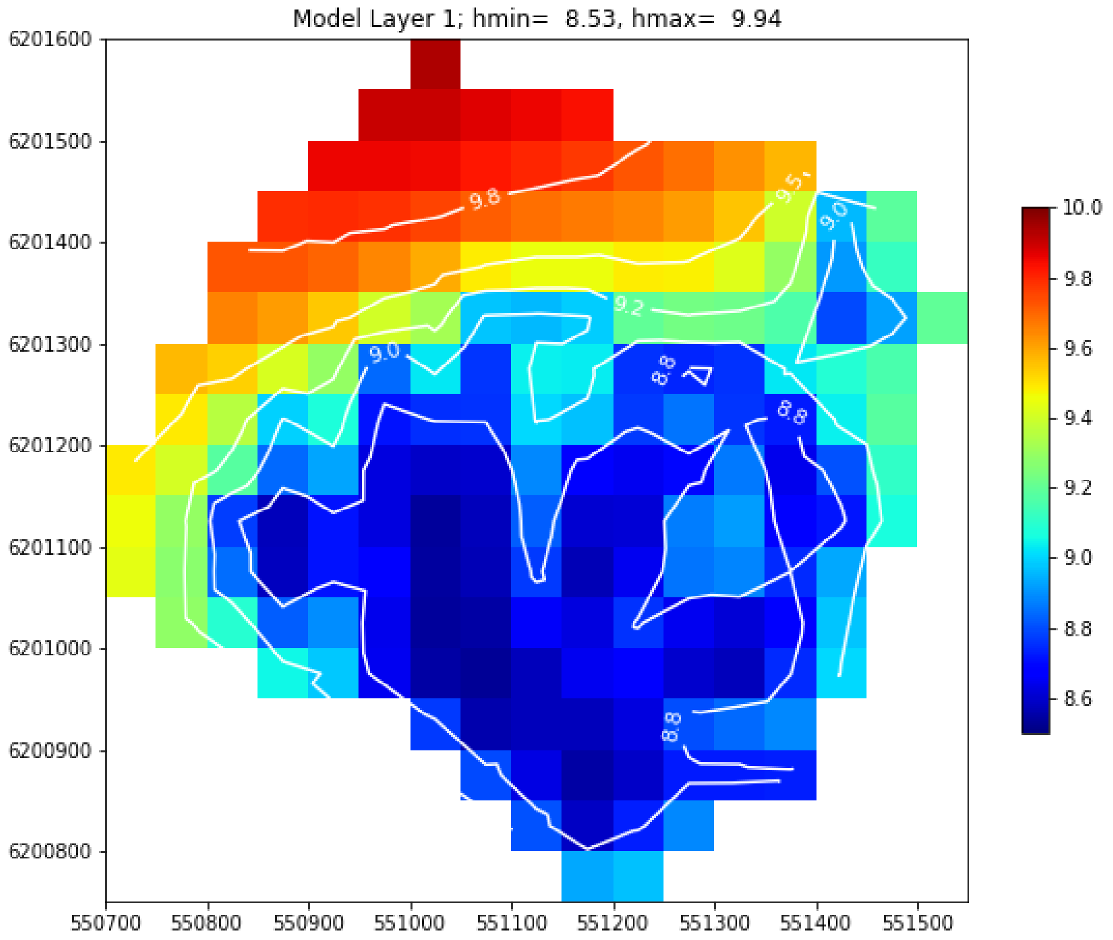

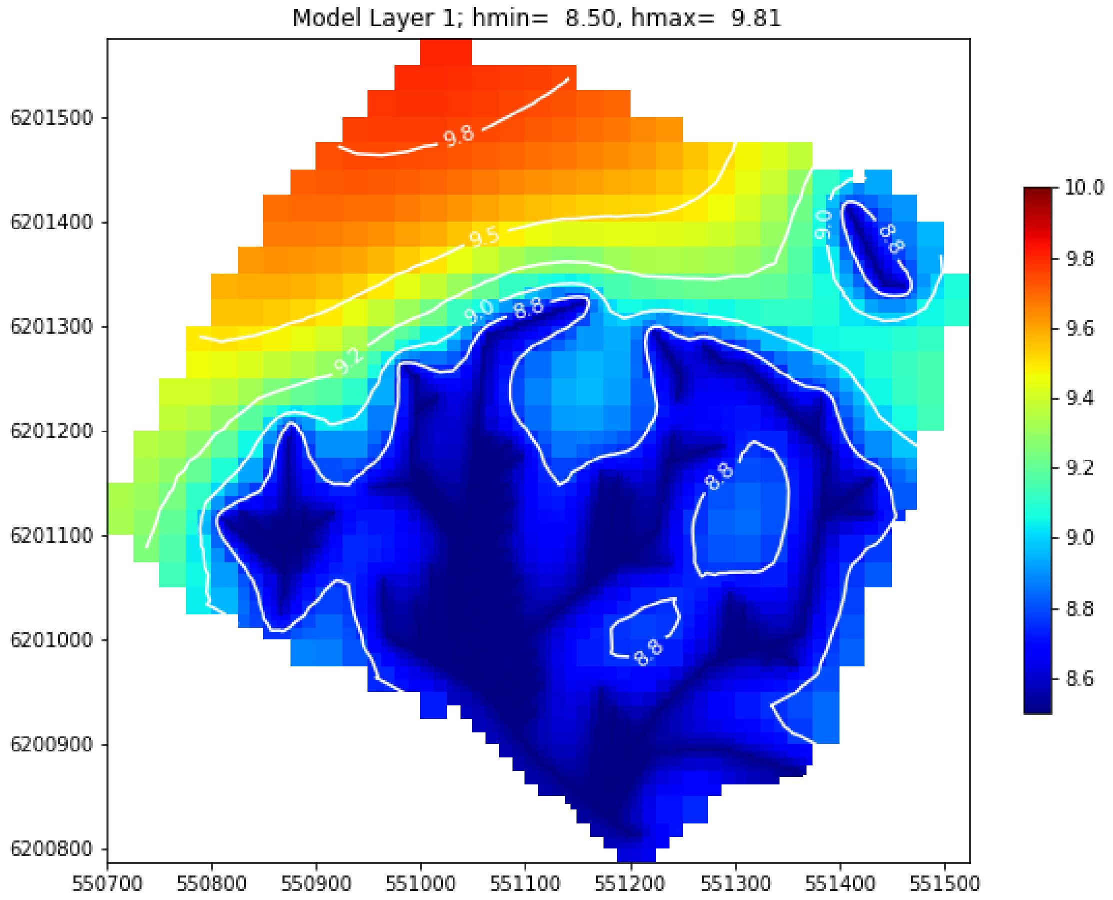

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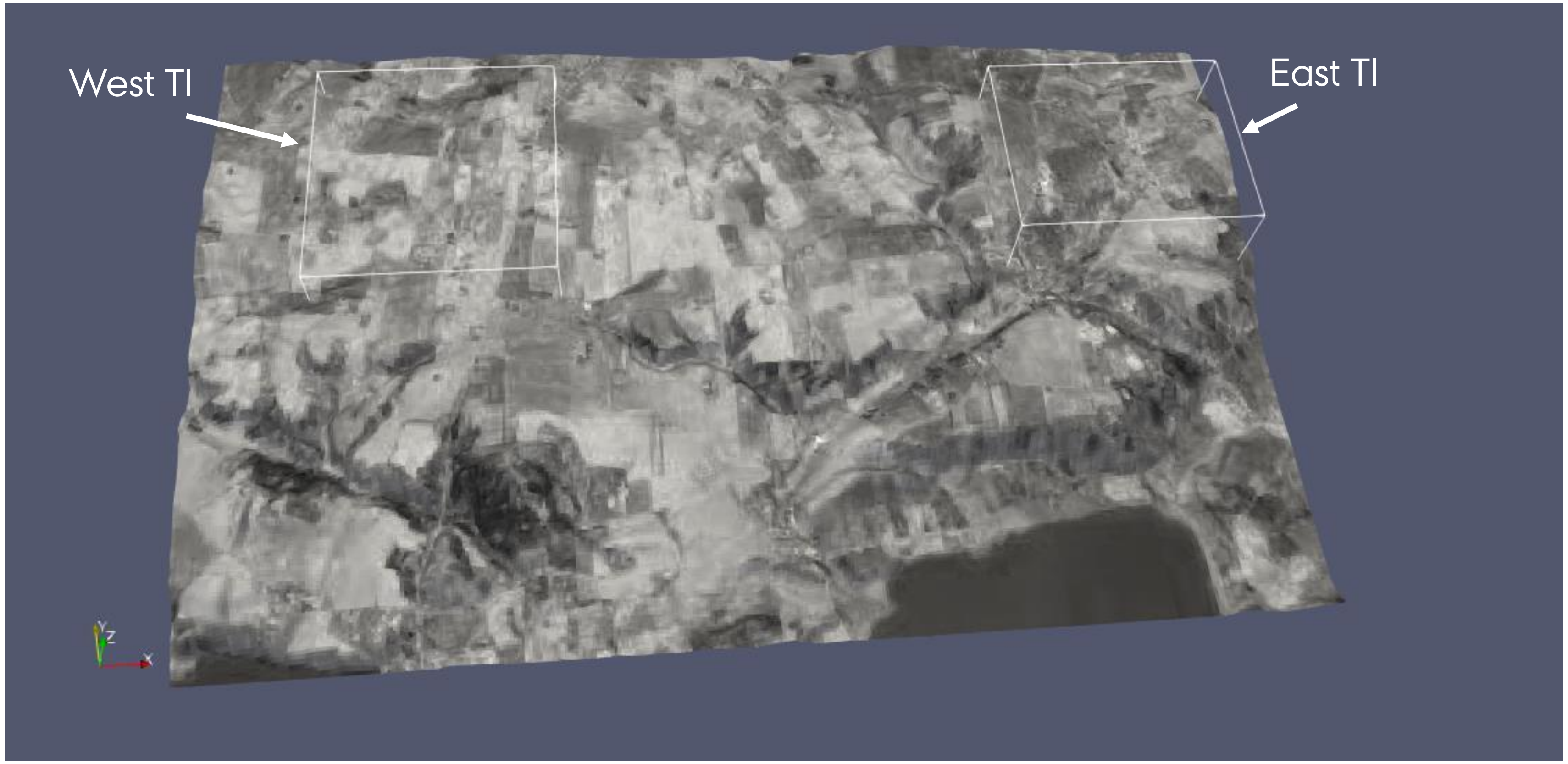
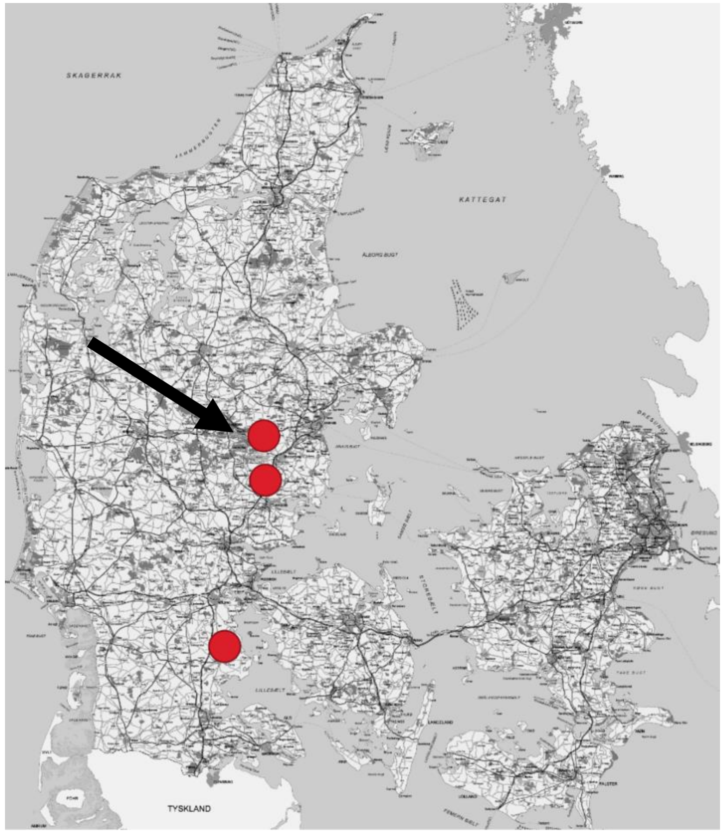
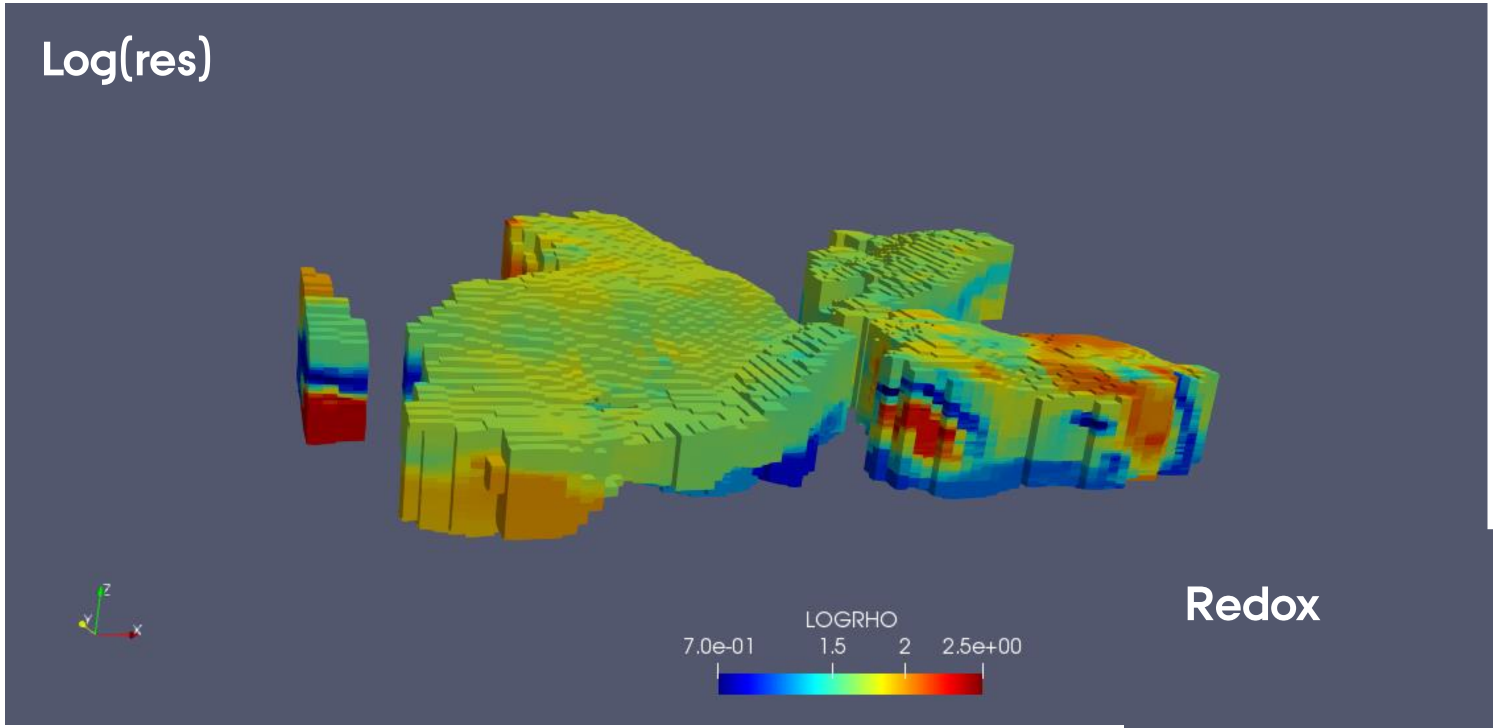
EXAMPEL OF CATCHMENT SCALE REDOX MODELS

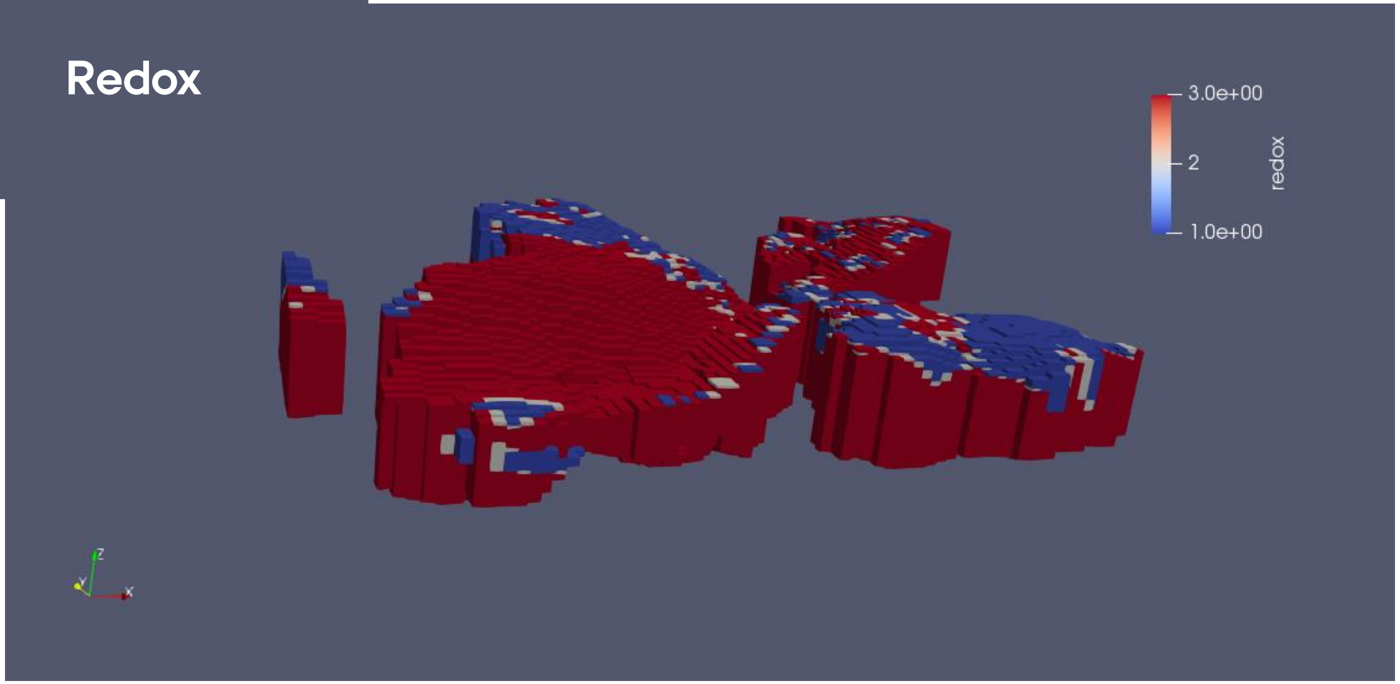




TRAINING IMAGE WITH 2 VARIABLES

East





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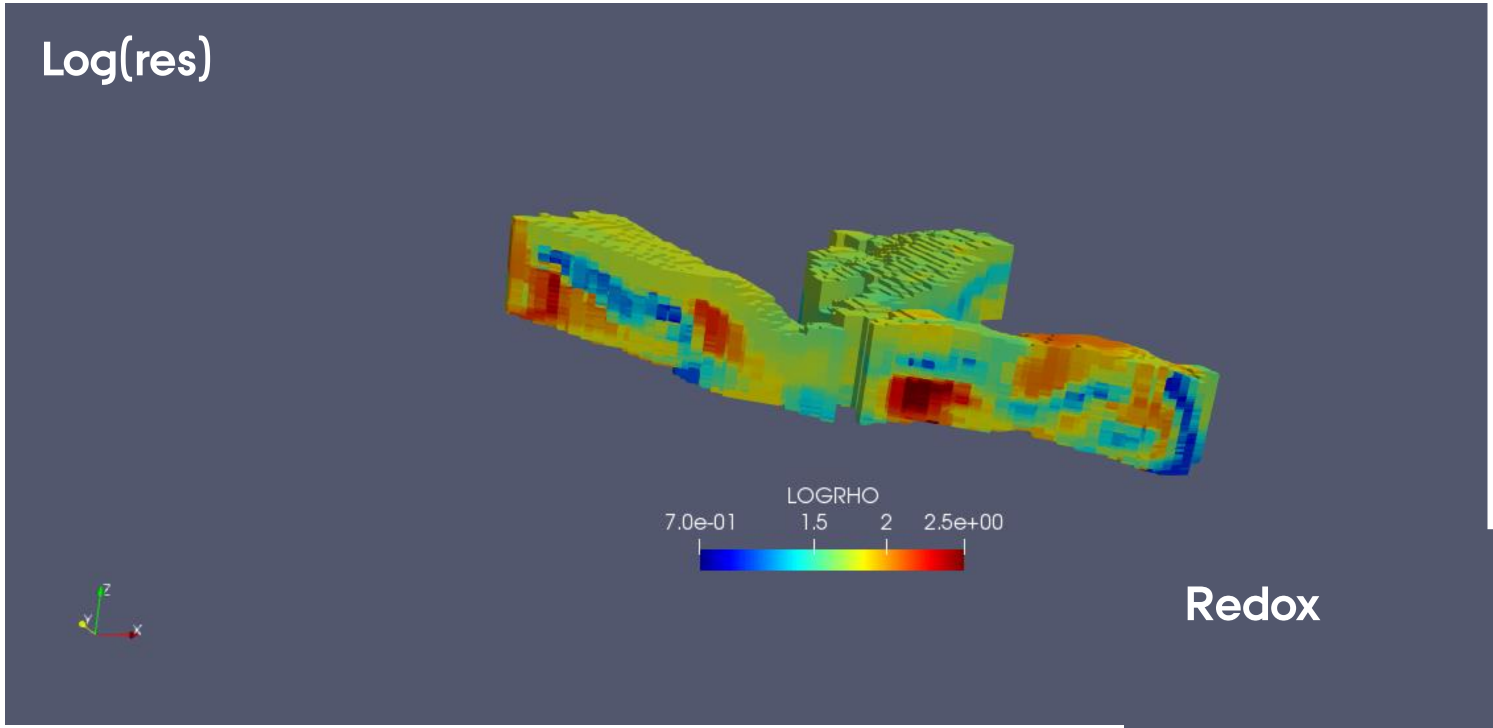

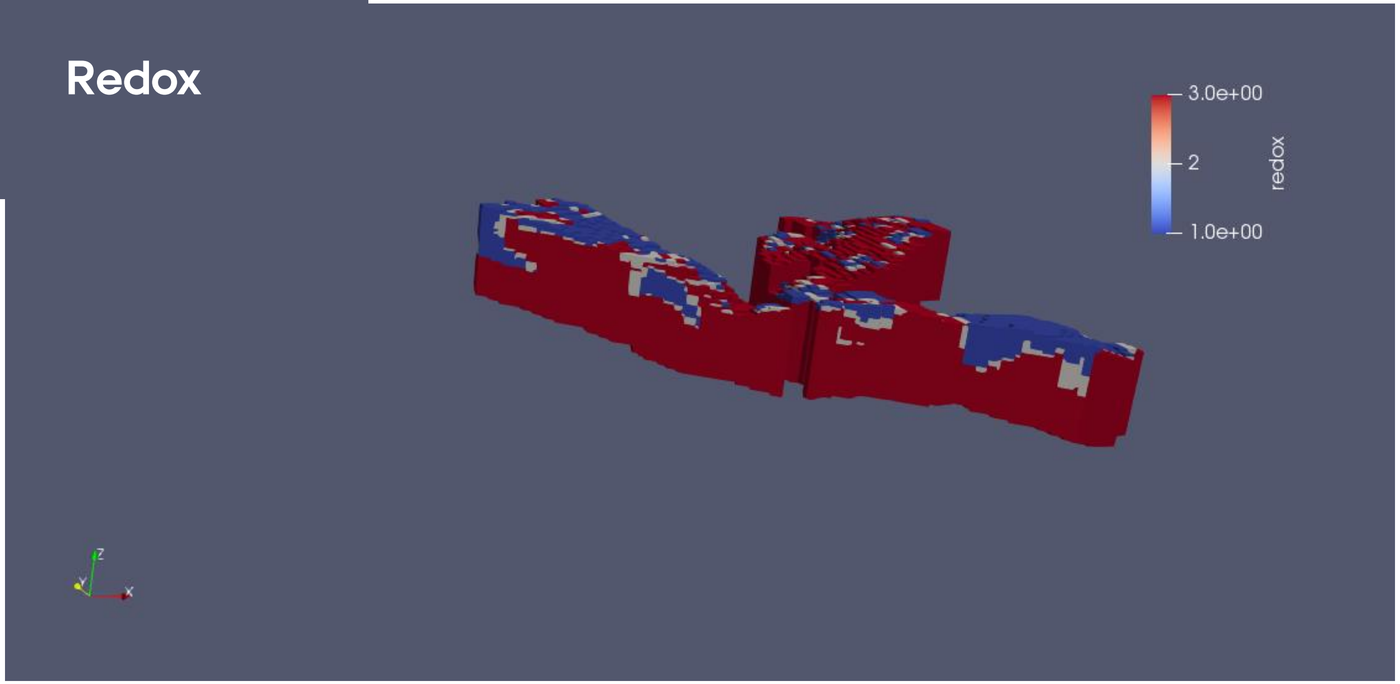

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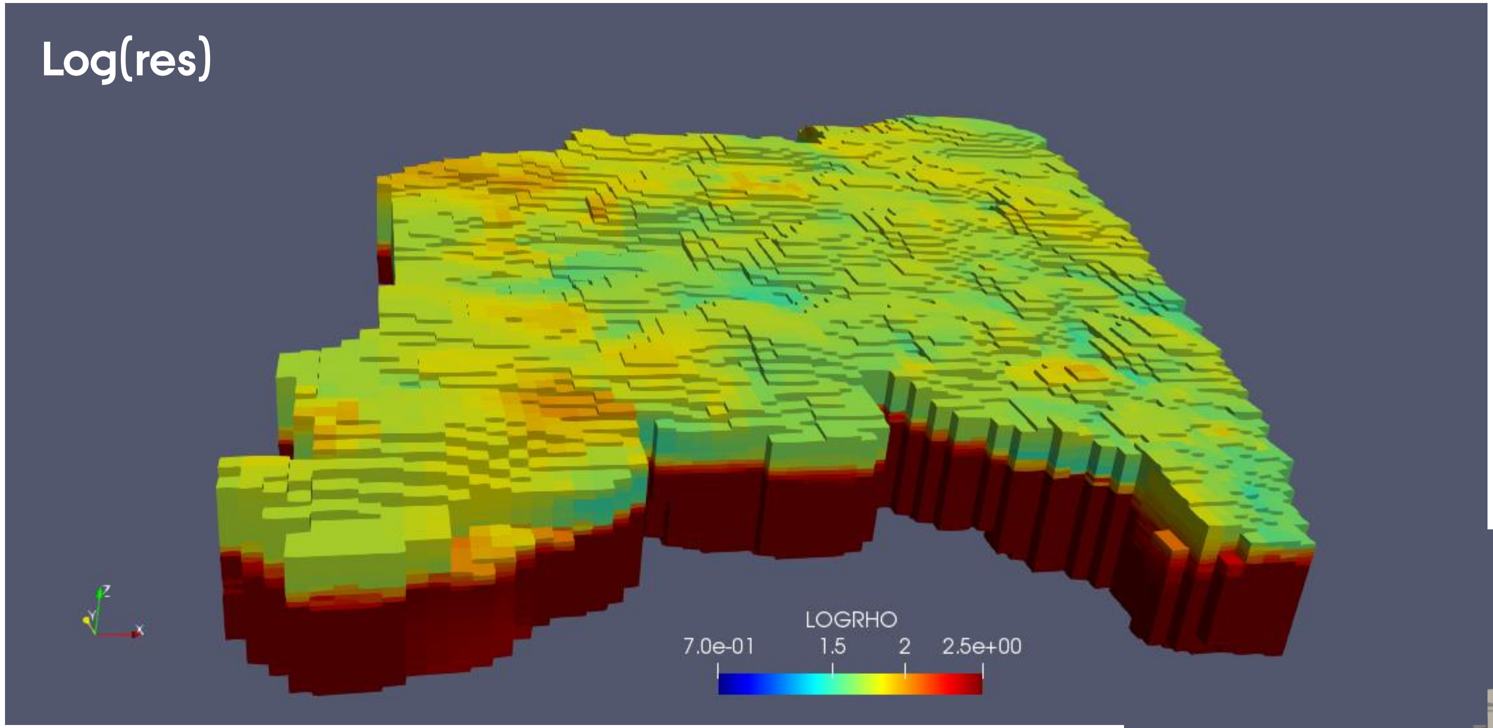

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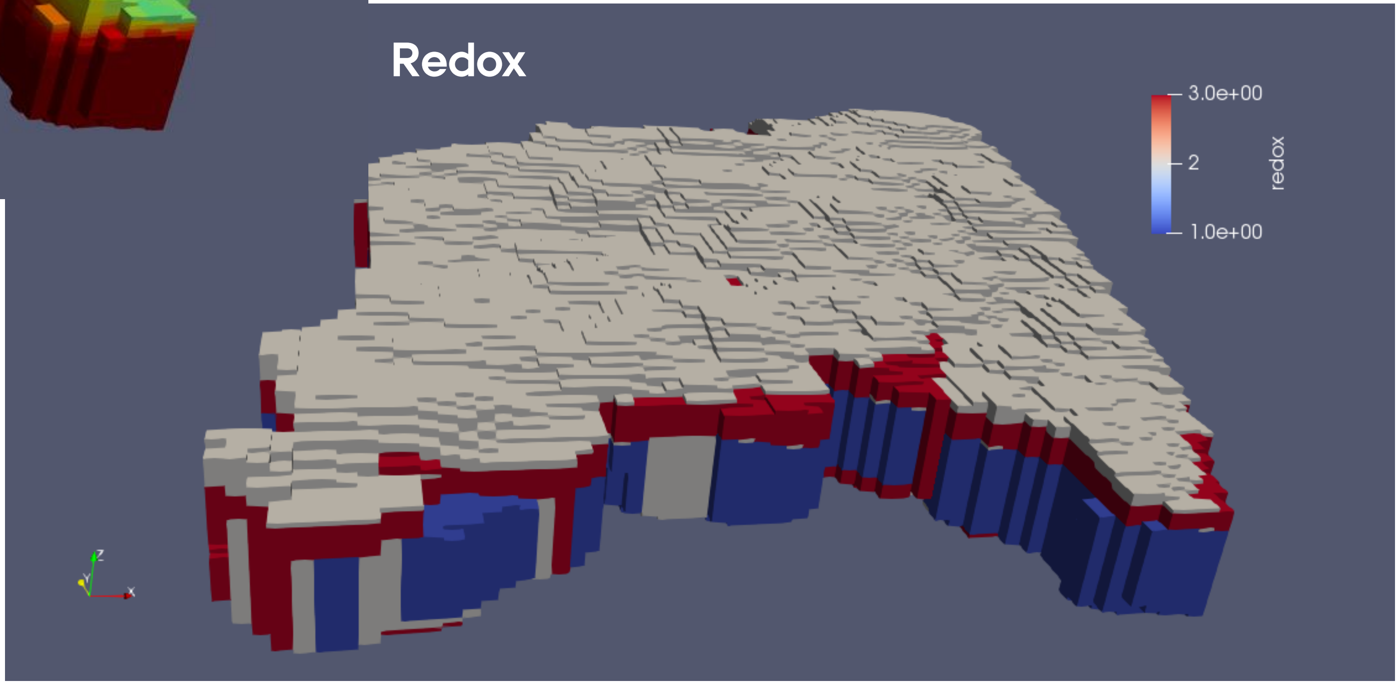

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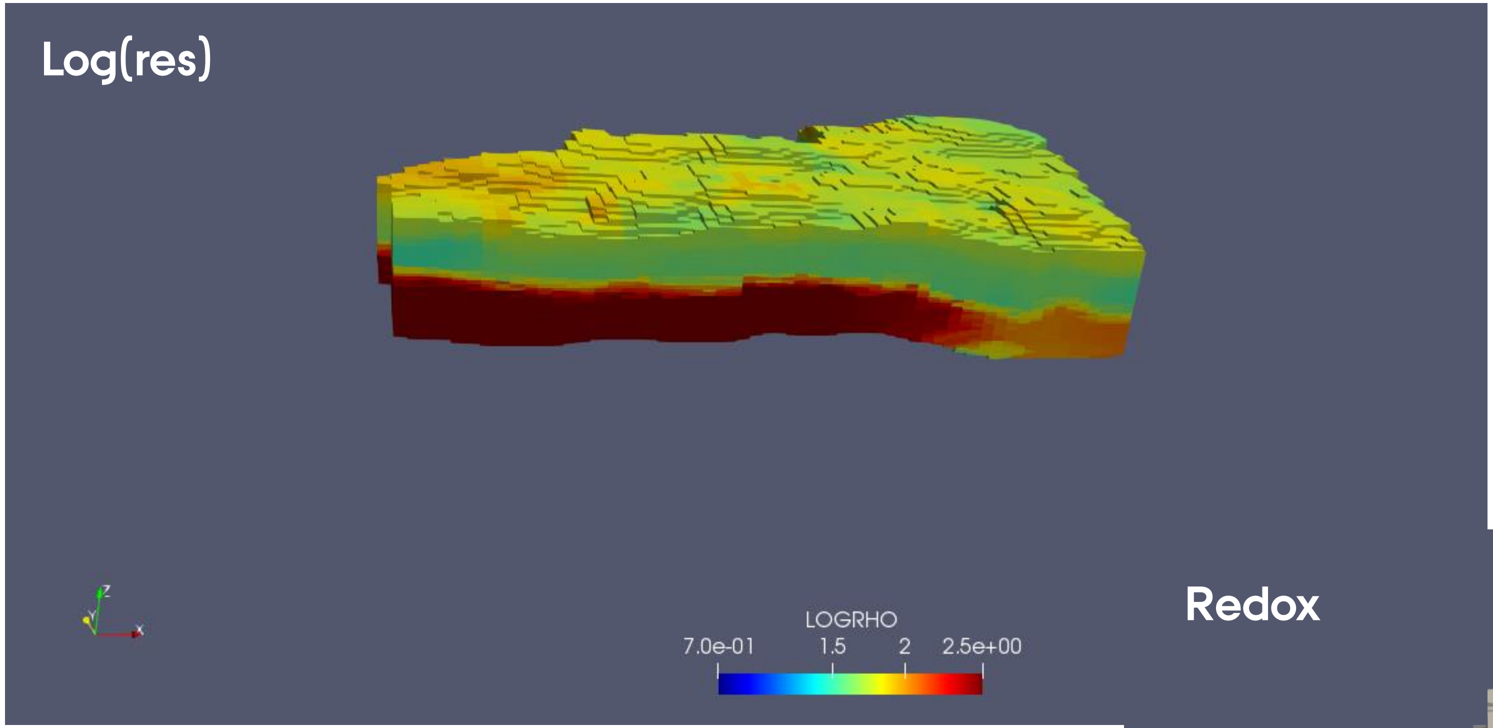

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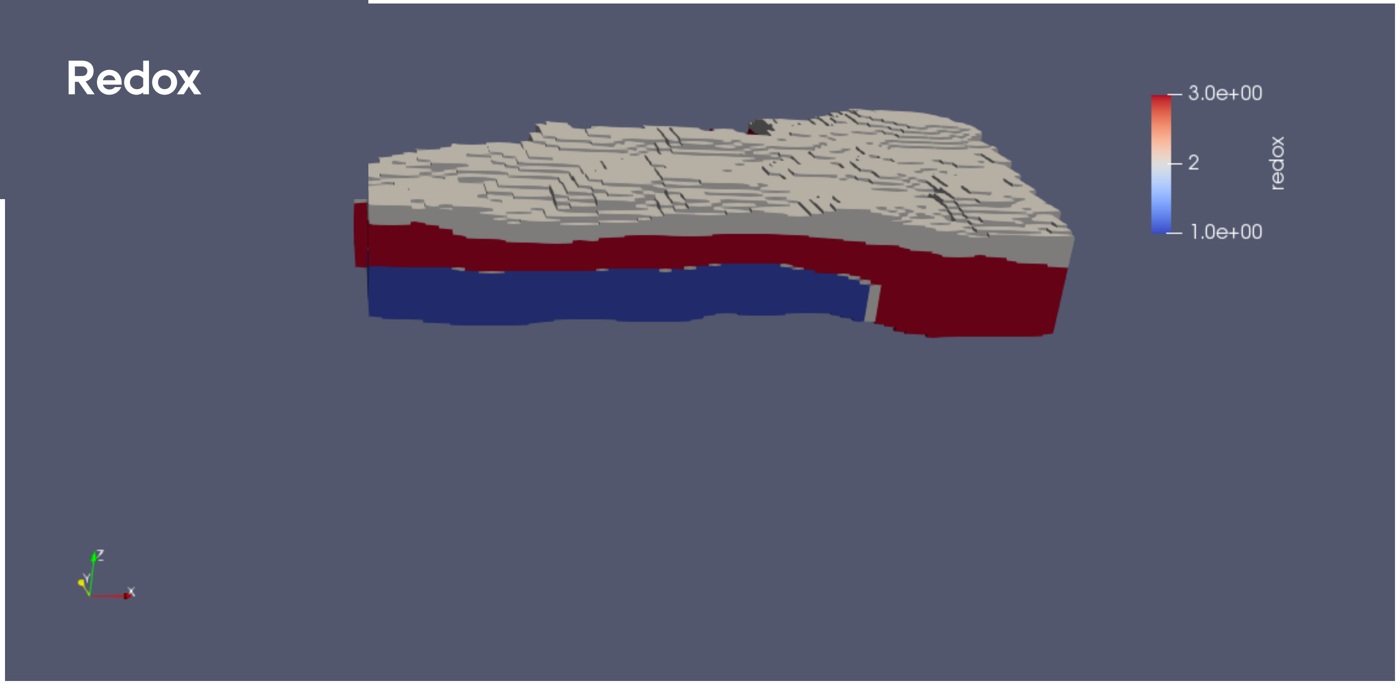

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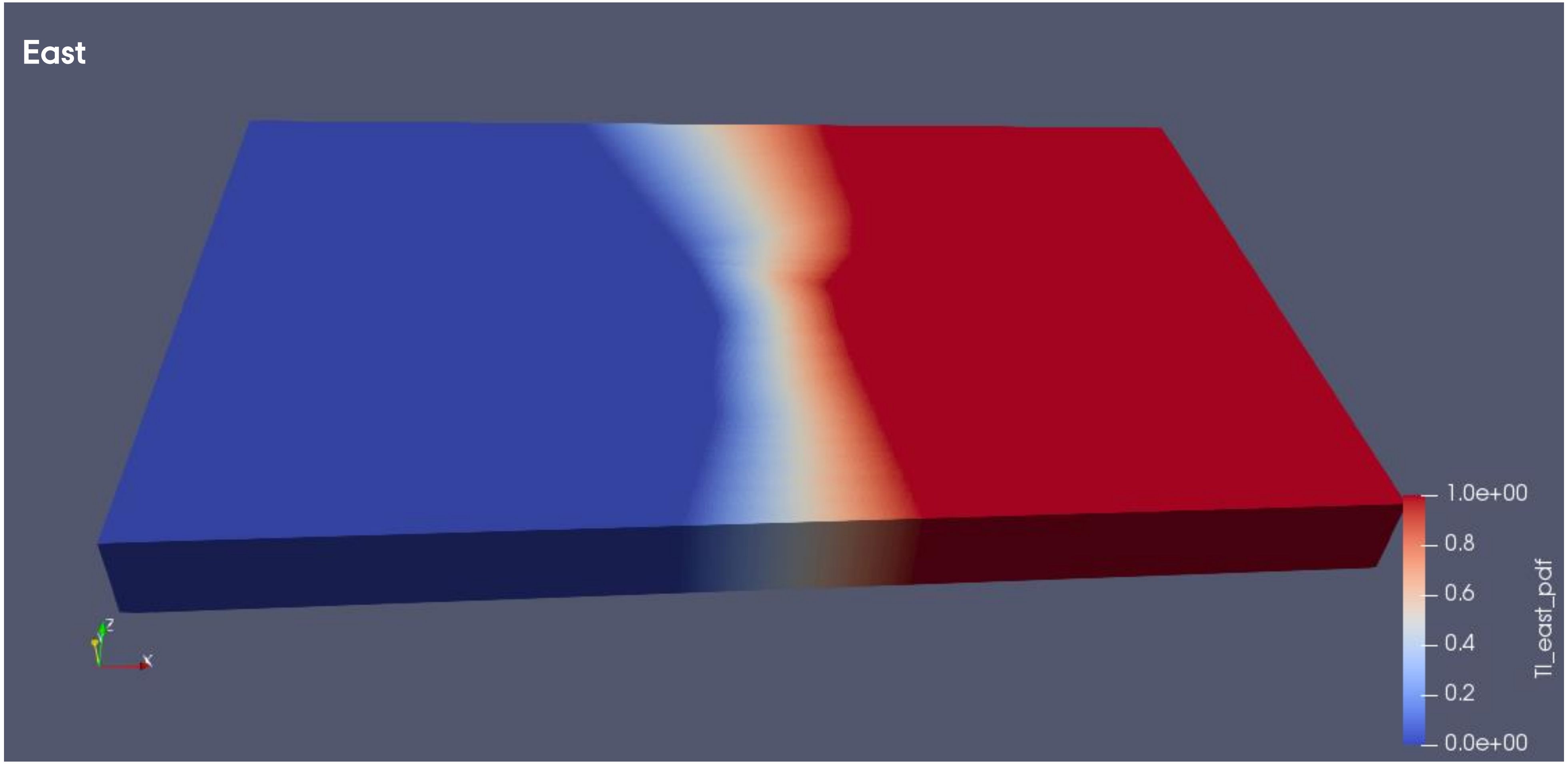

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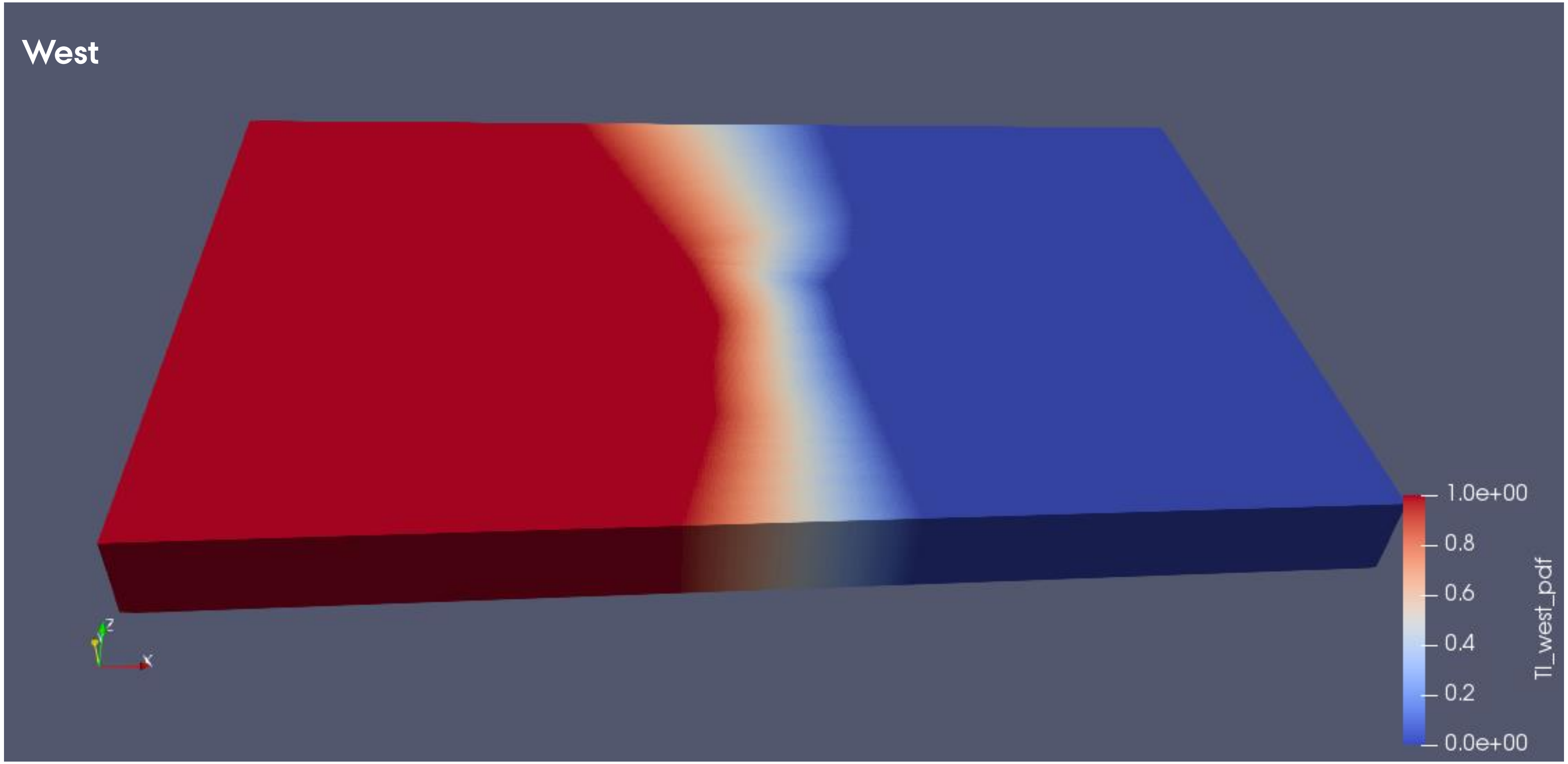
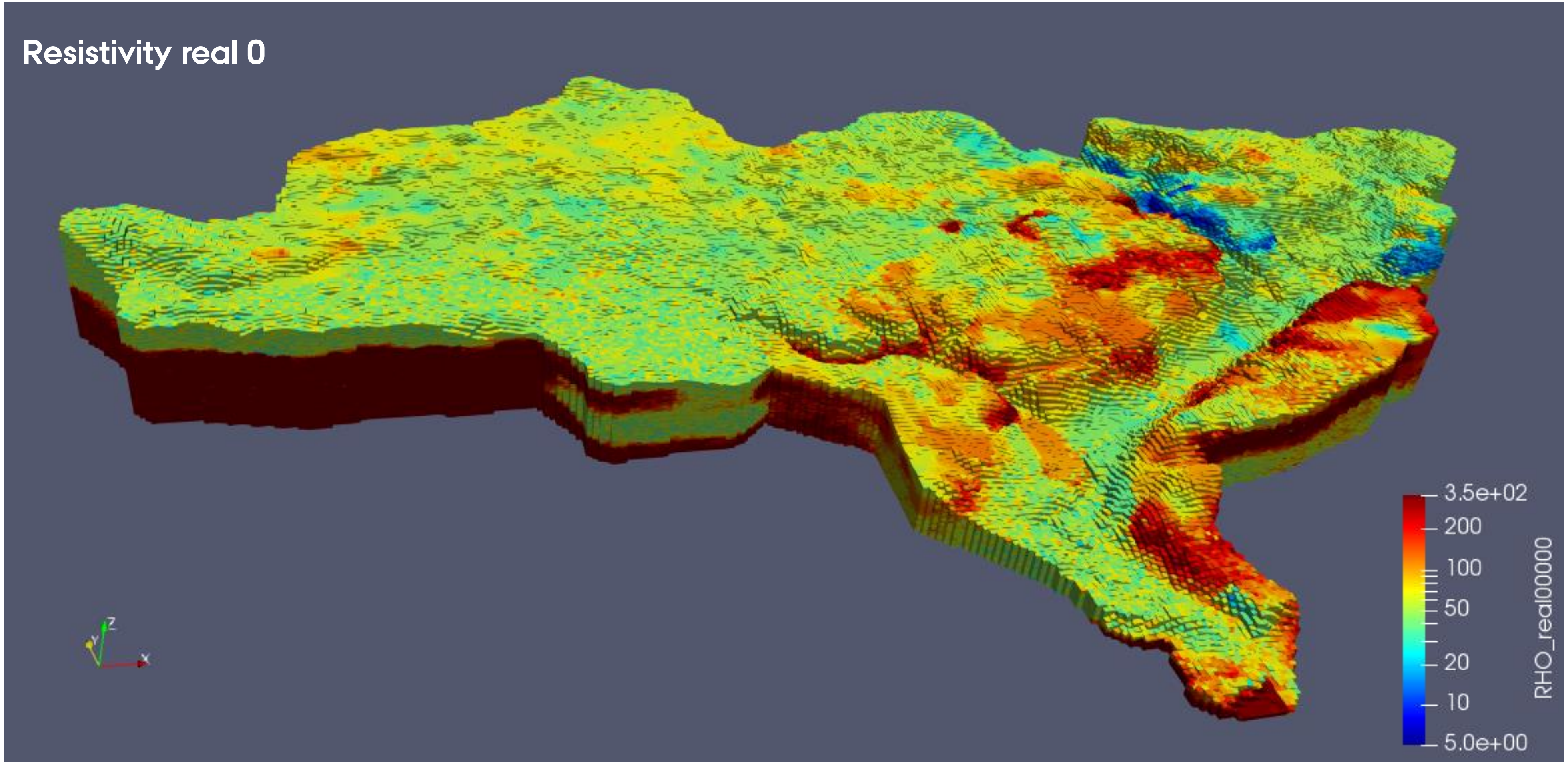


RESISTIVITY REALIZATIONS



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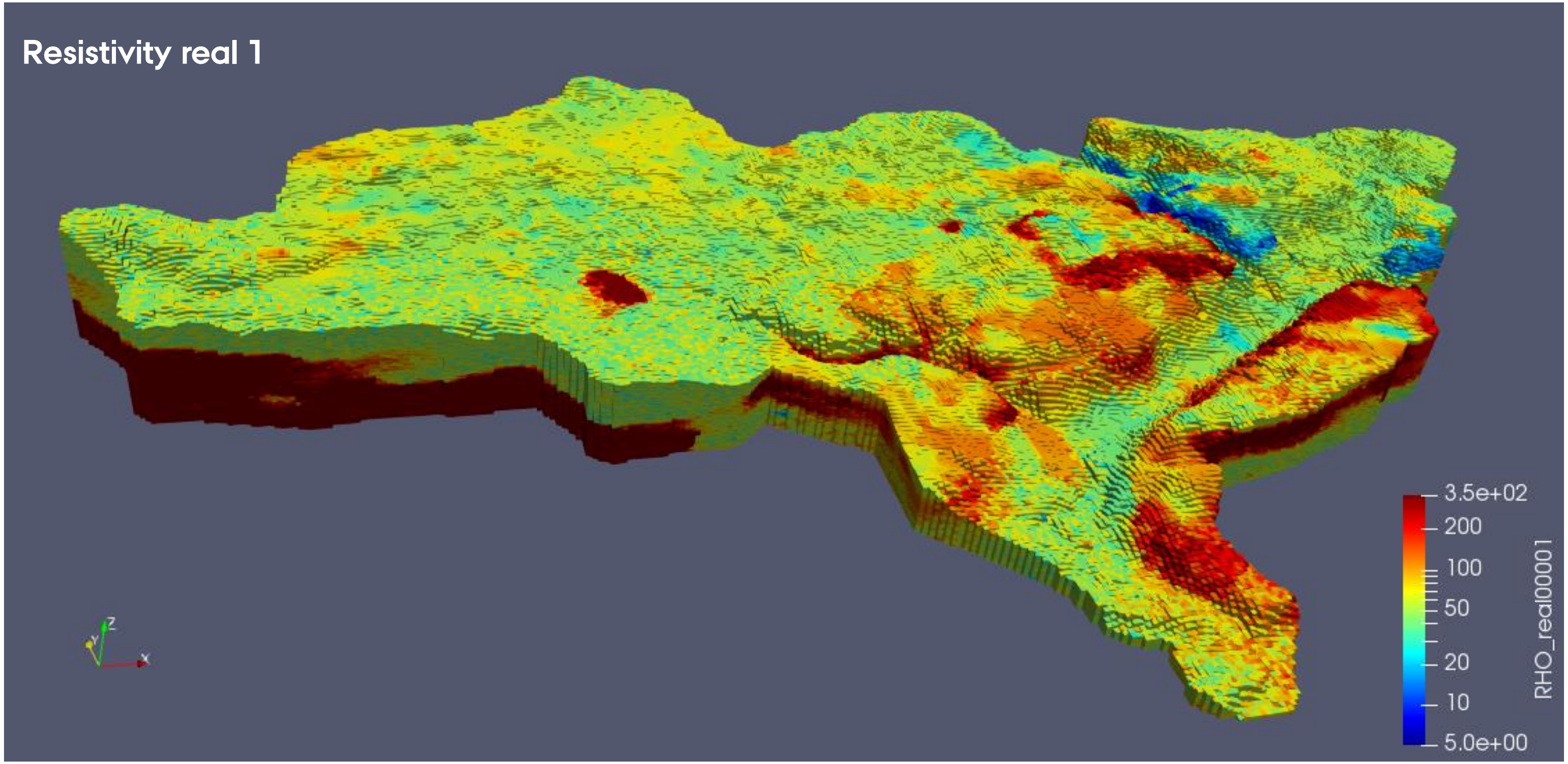

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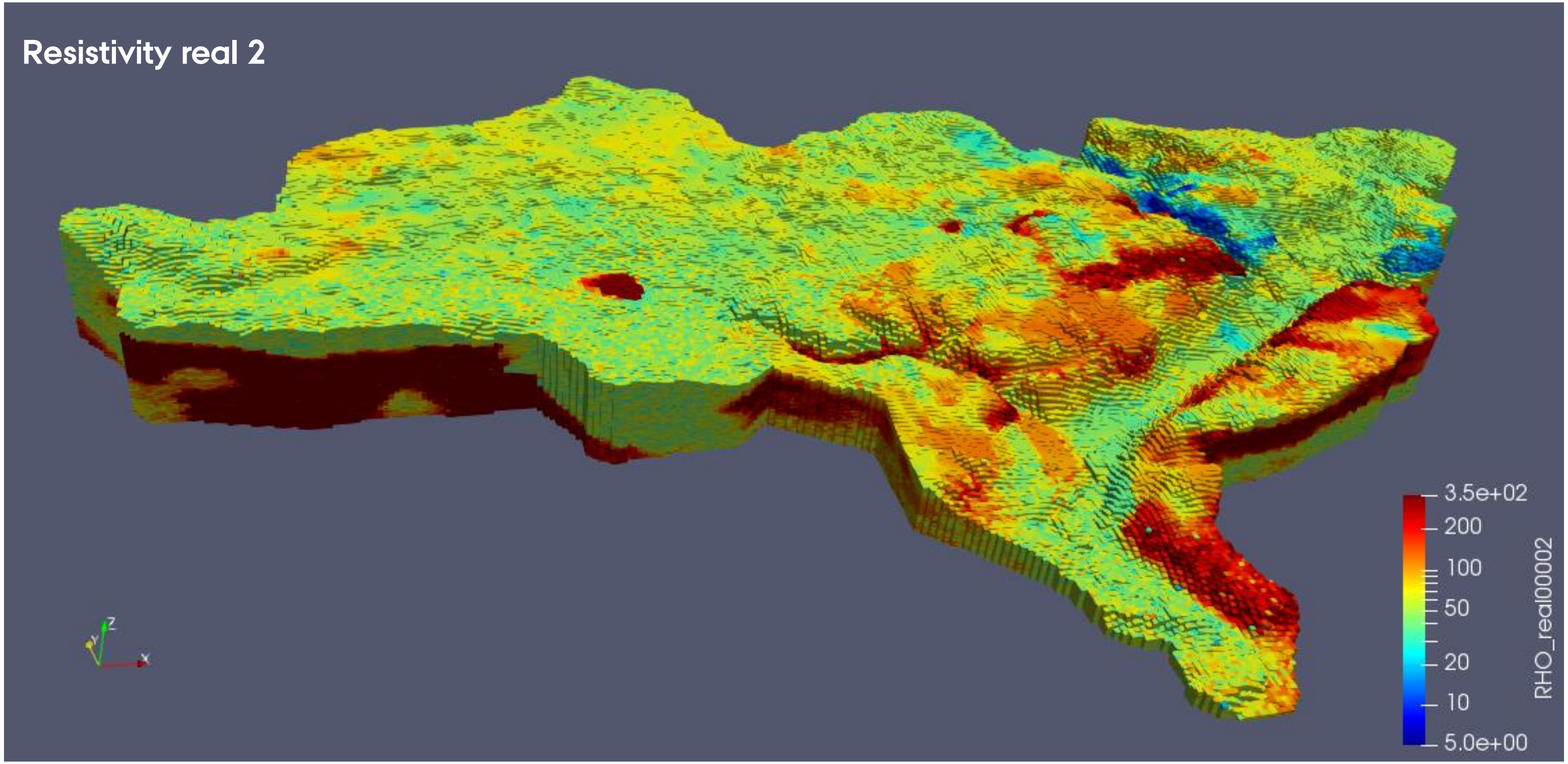

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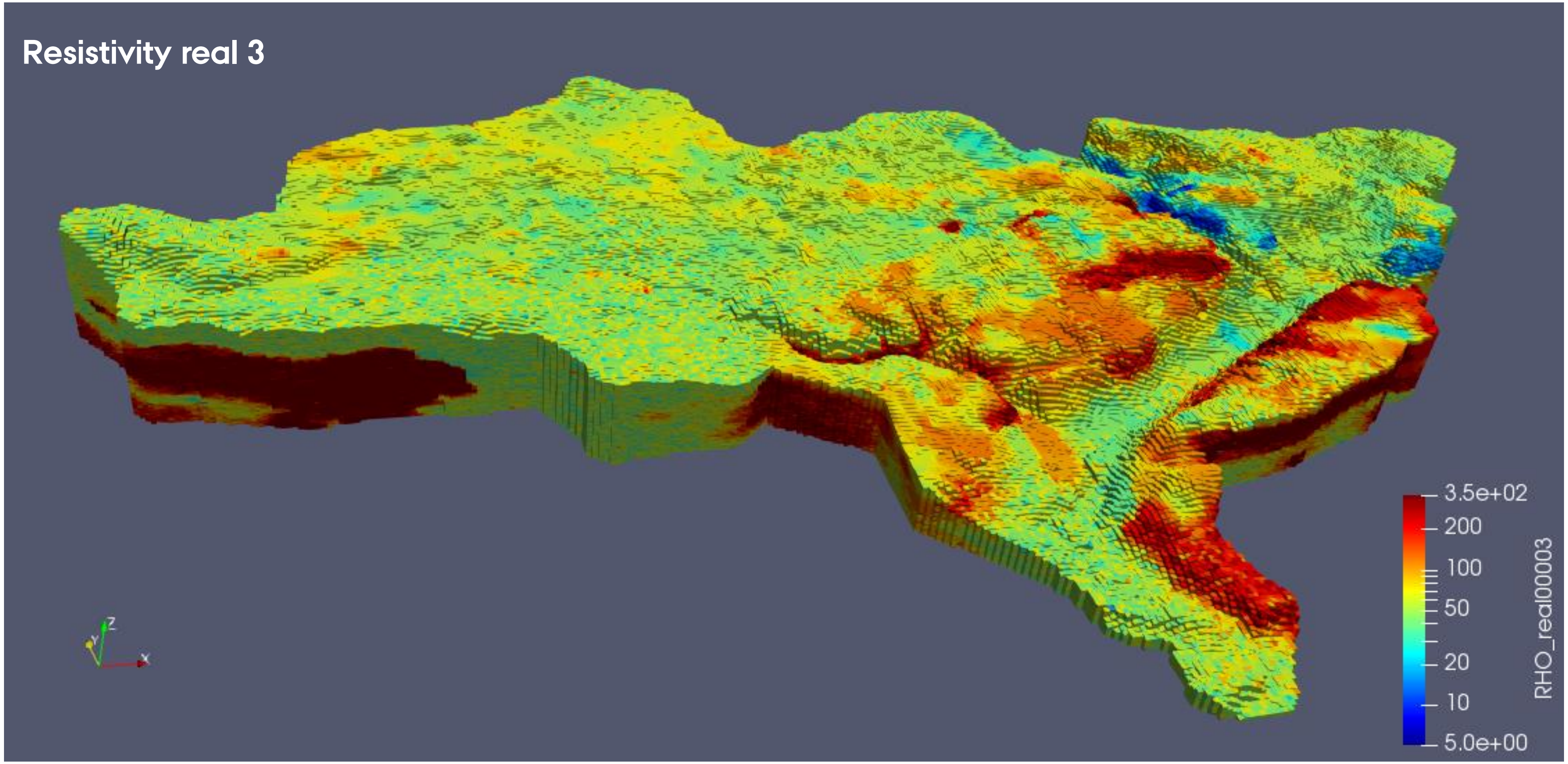

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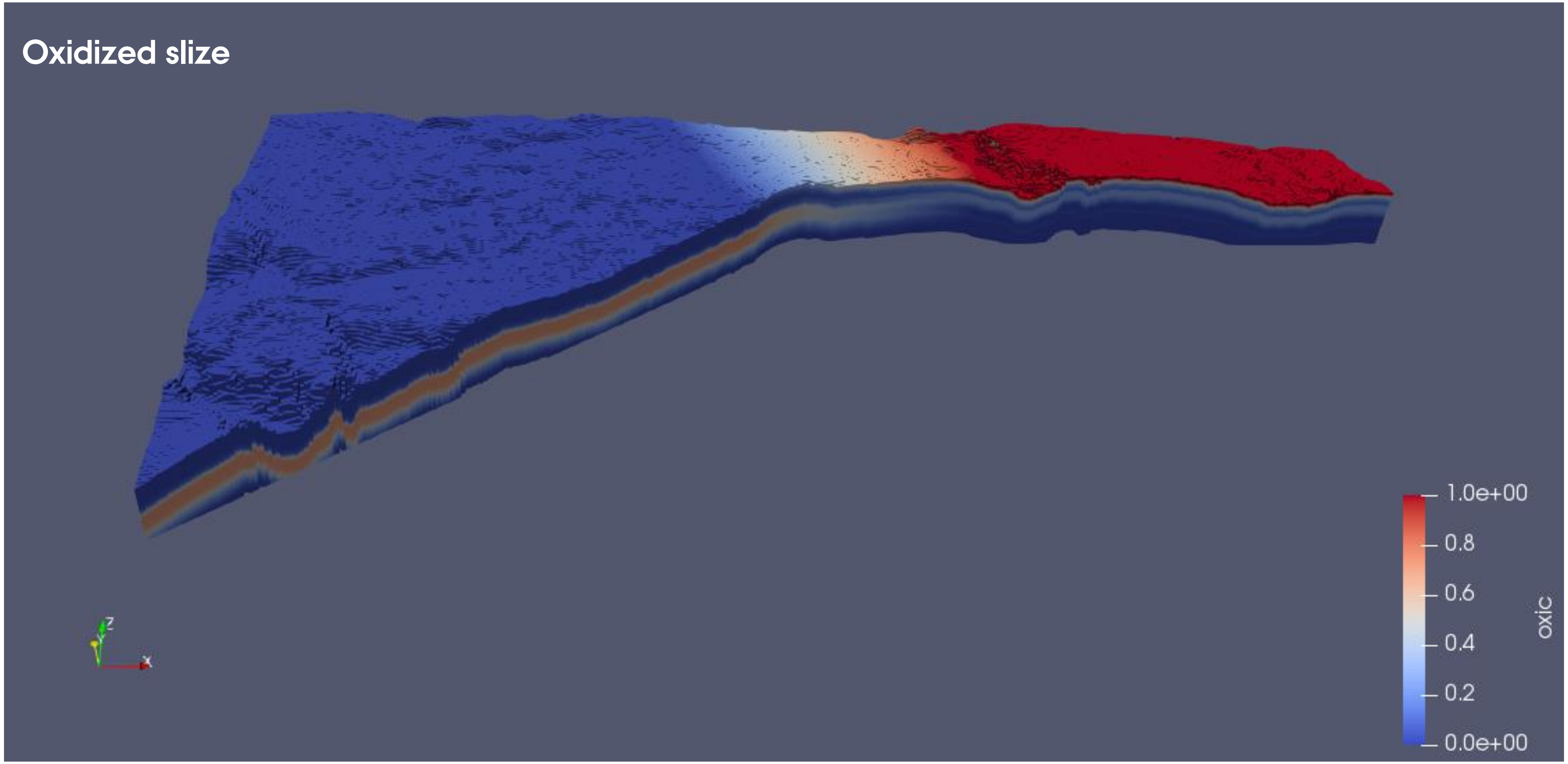

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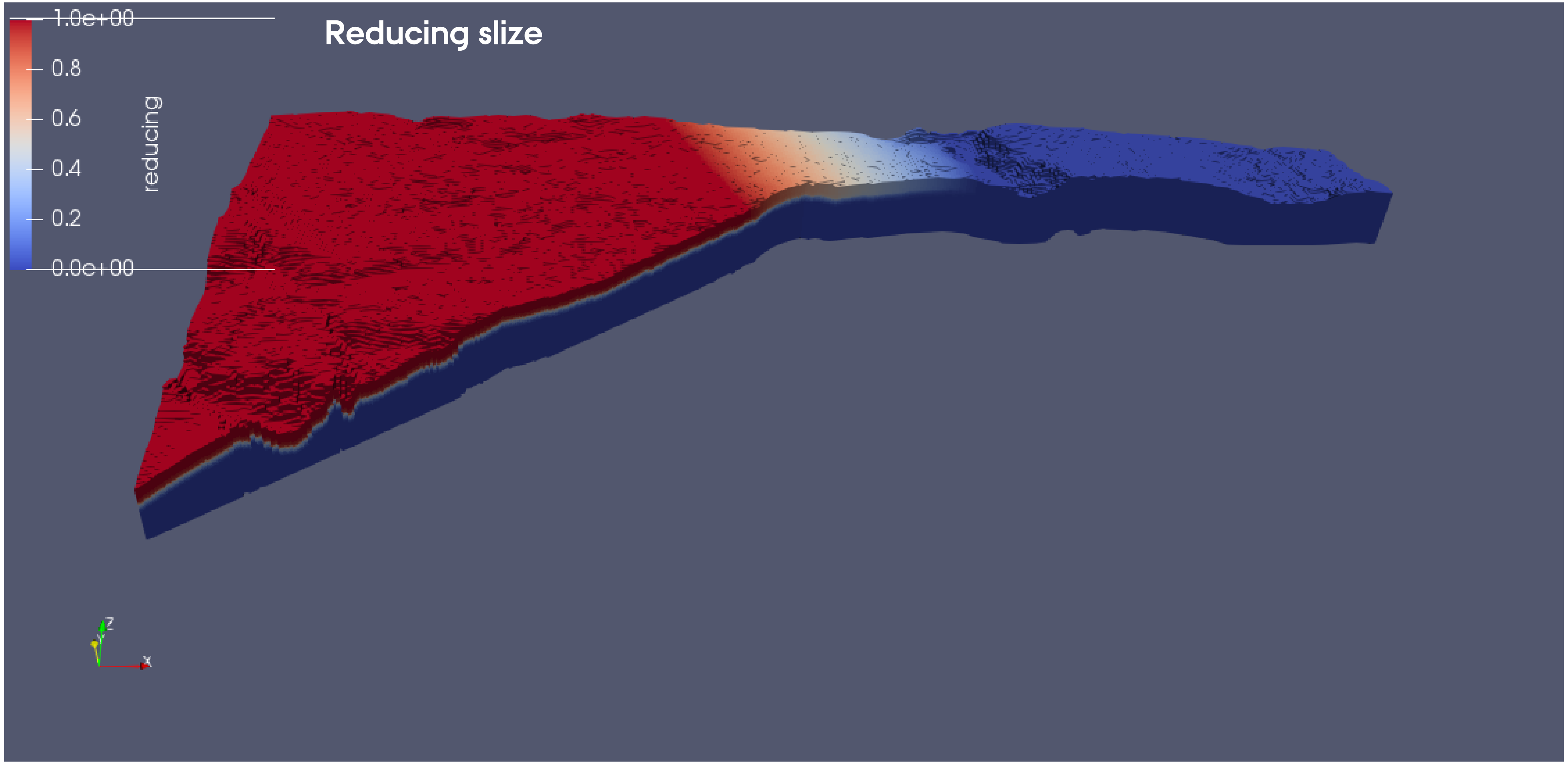

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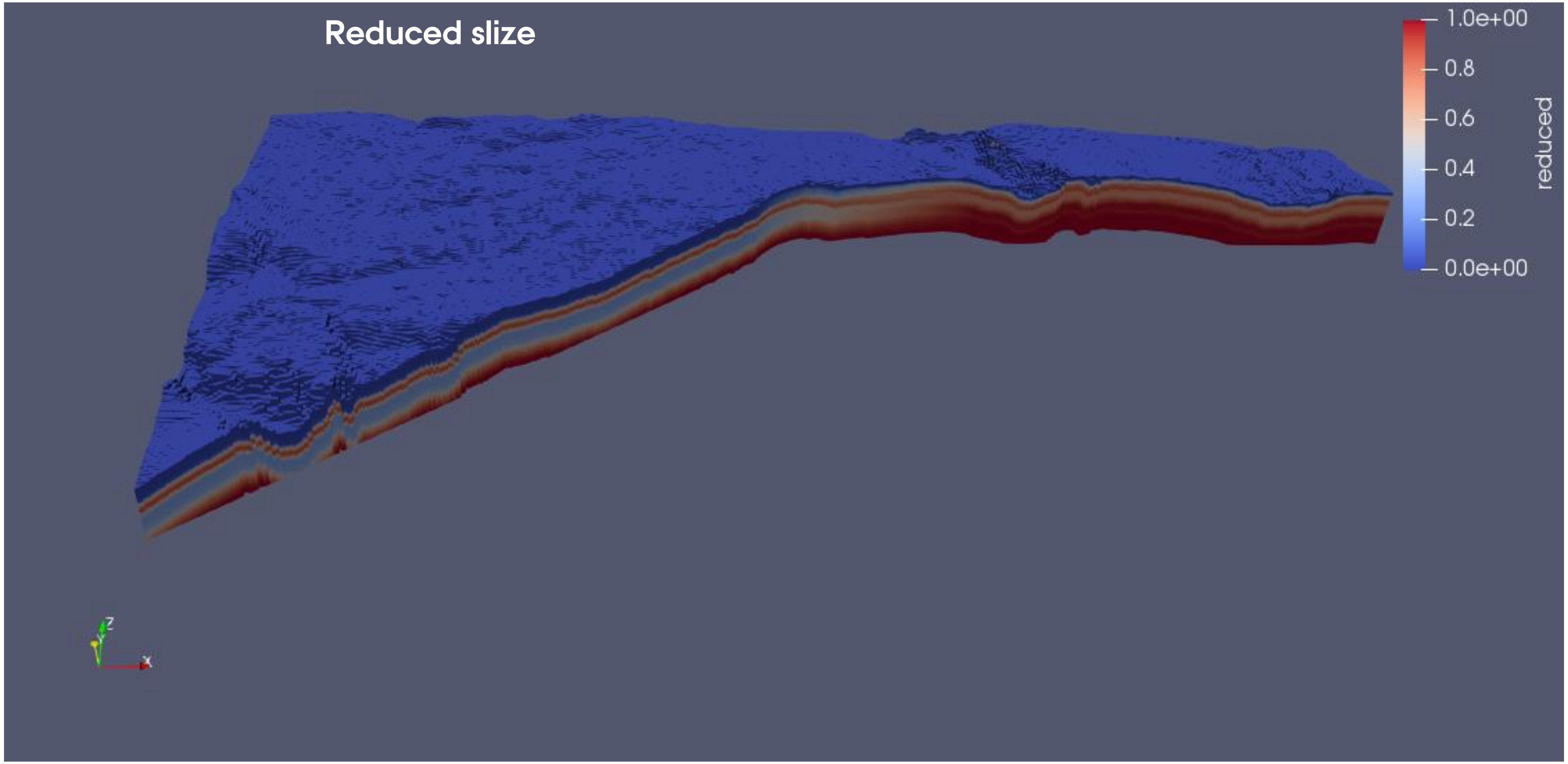
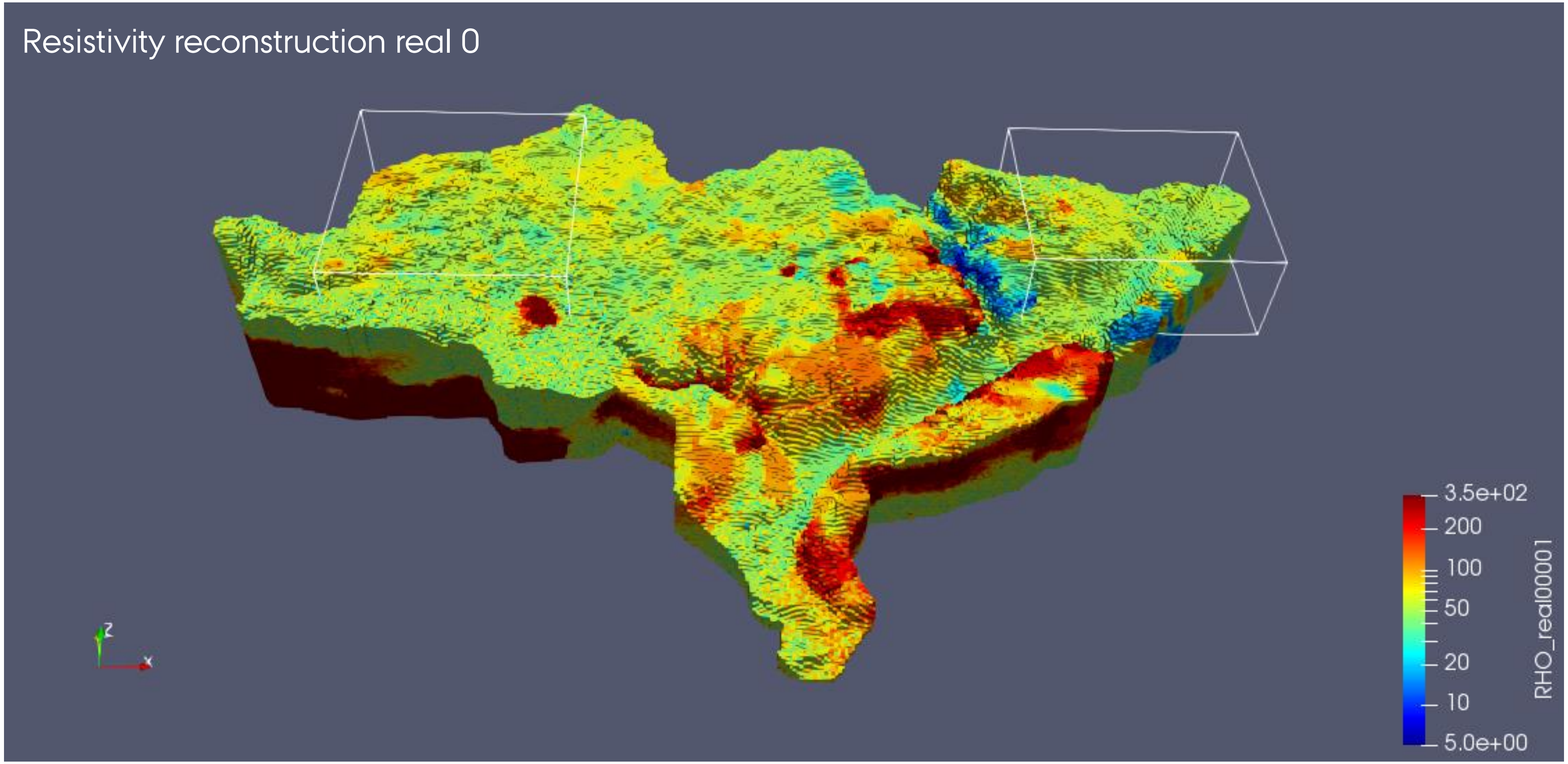
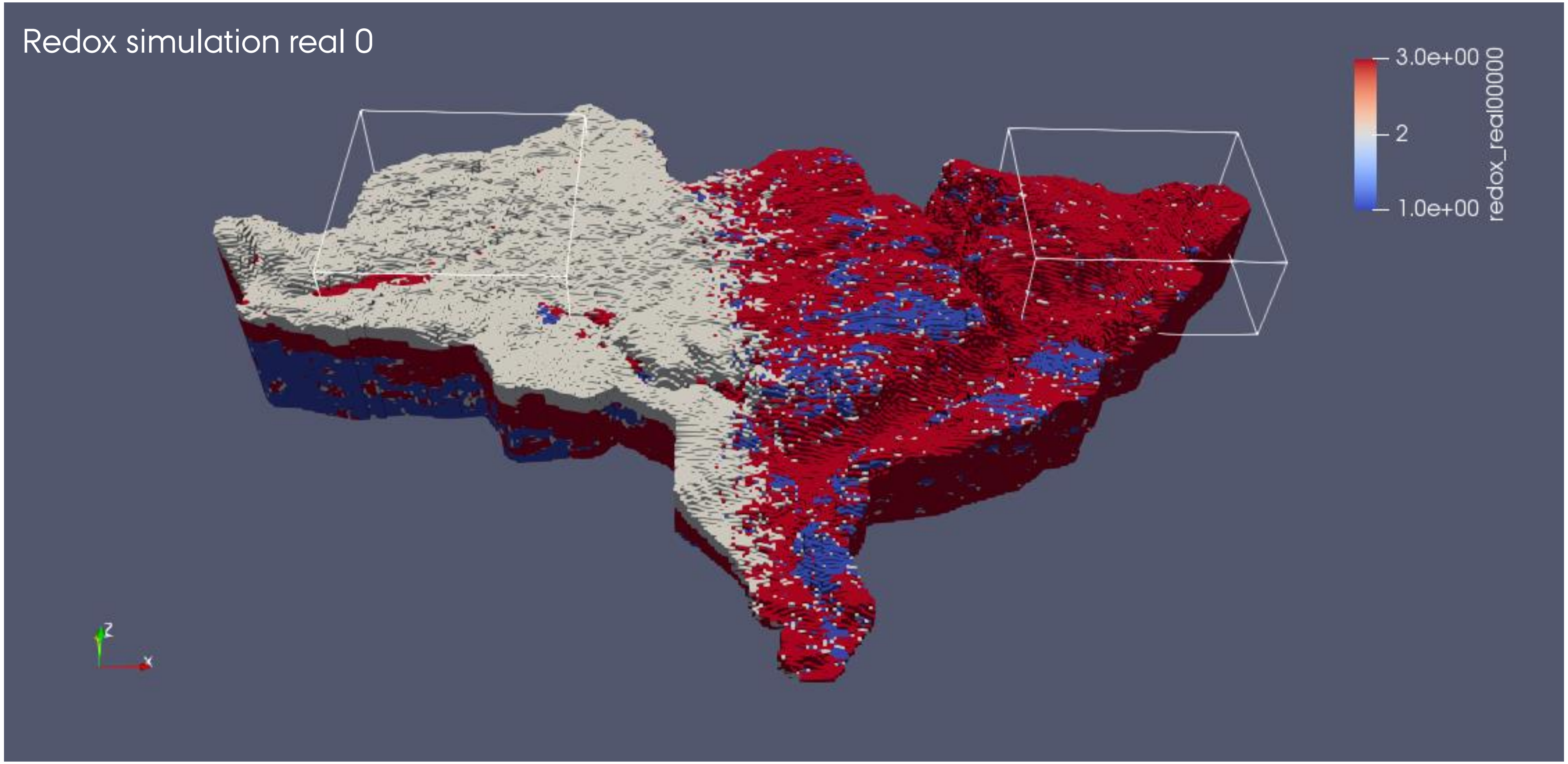


SIMULATIONS



SIMULATIONS



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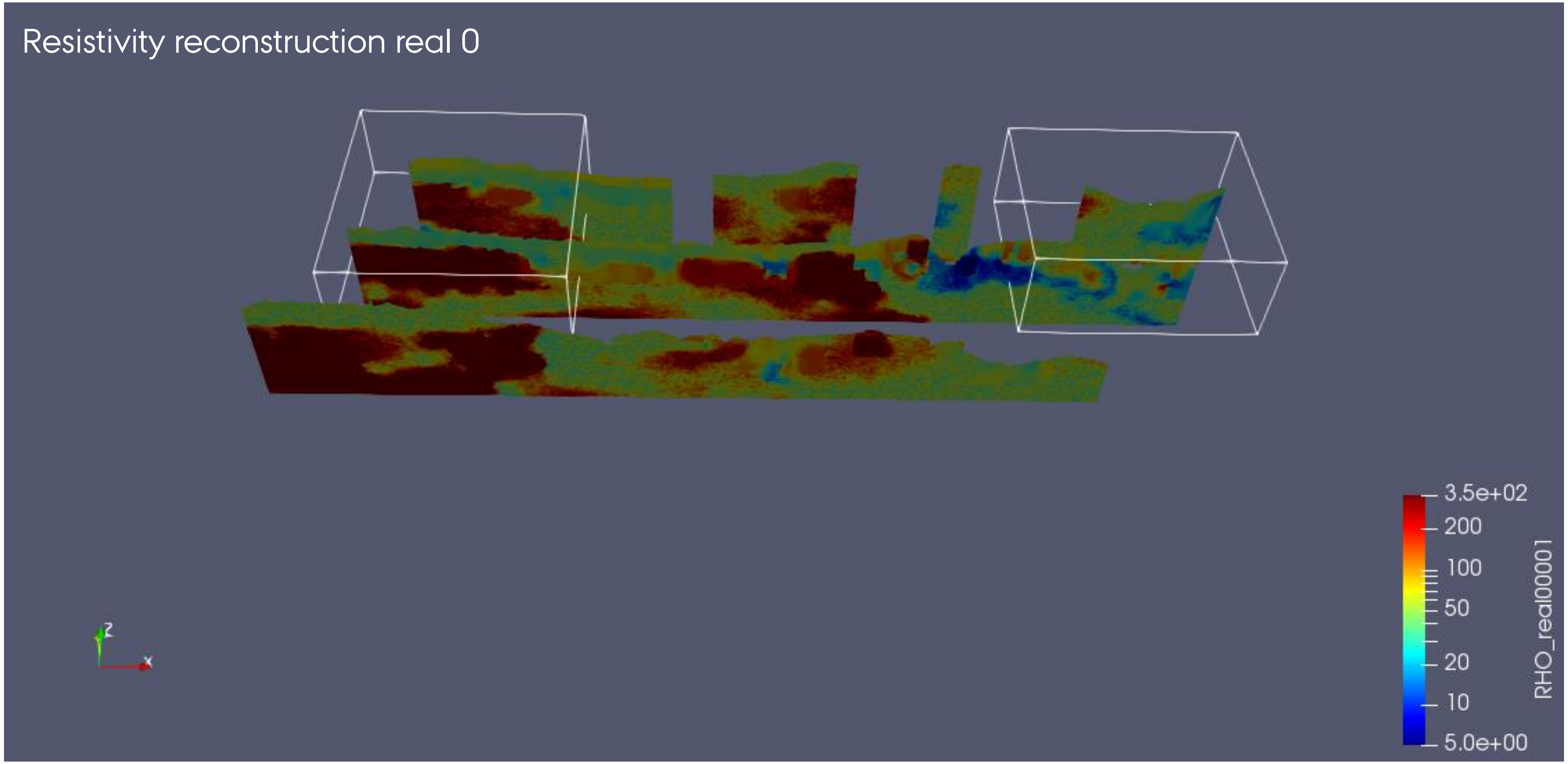

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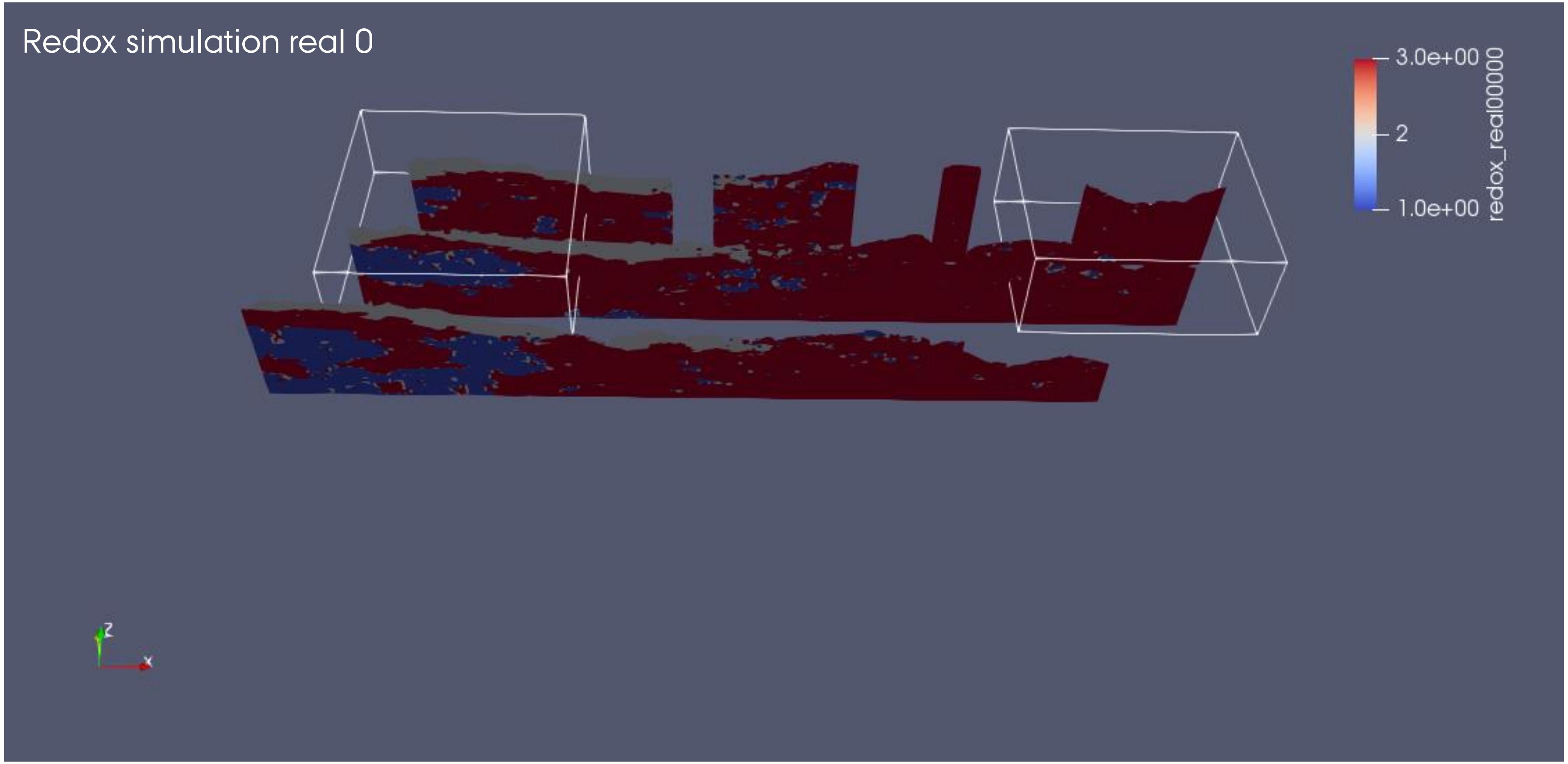
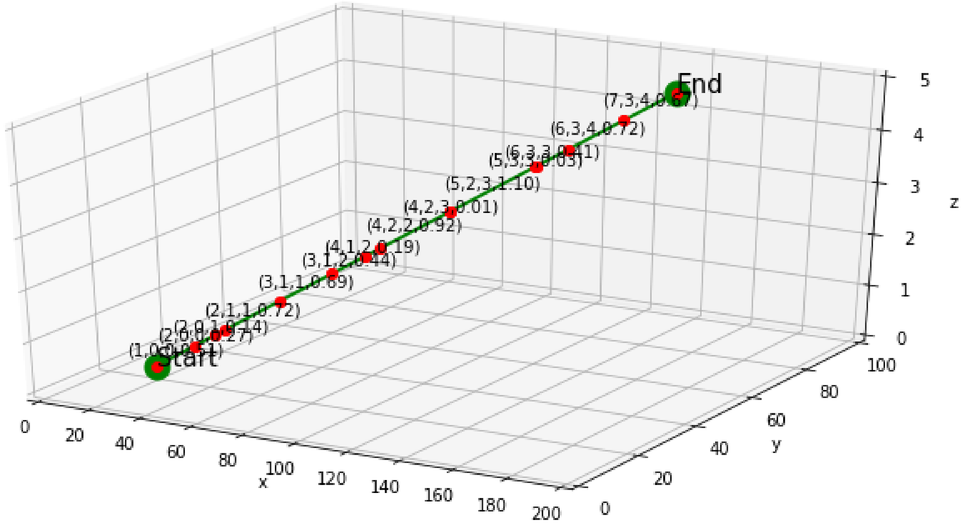
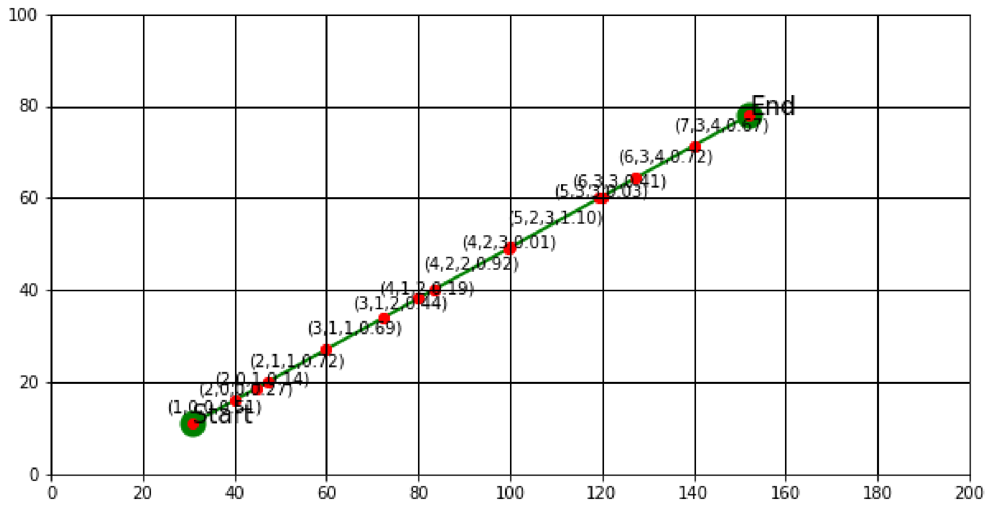


THE NSIM REDOX MODEL

- Using MODPATH we can track the flow path of a water particle through the subsurface
- Subsequently, this particle must be tracked through the redox grid in 3D



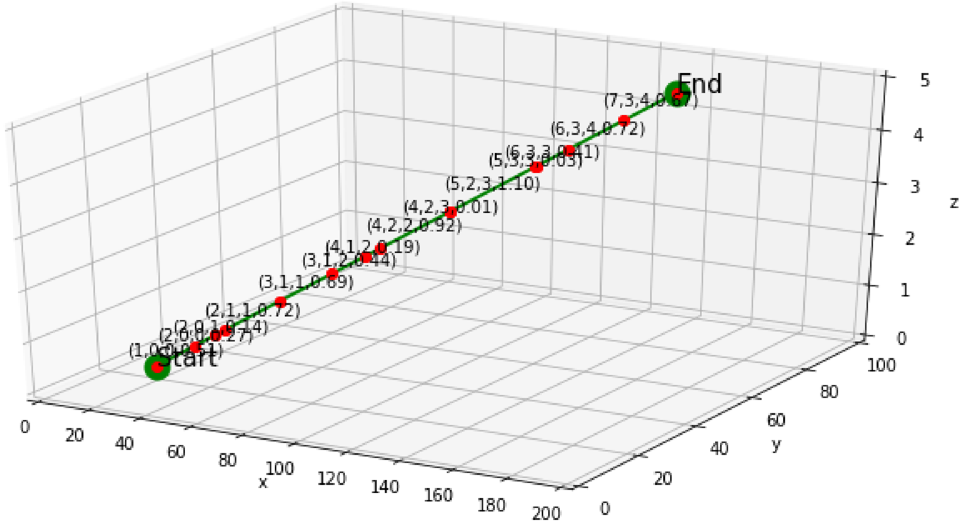


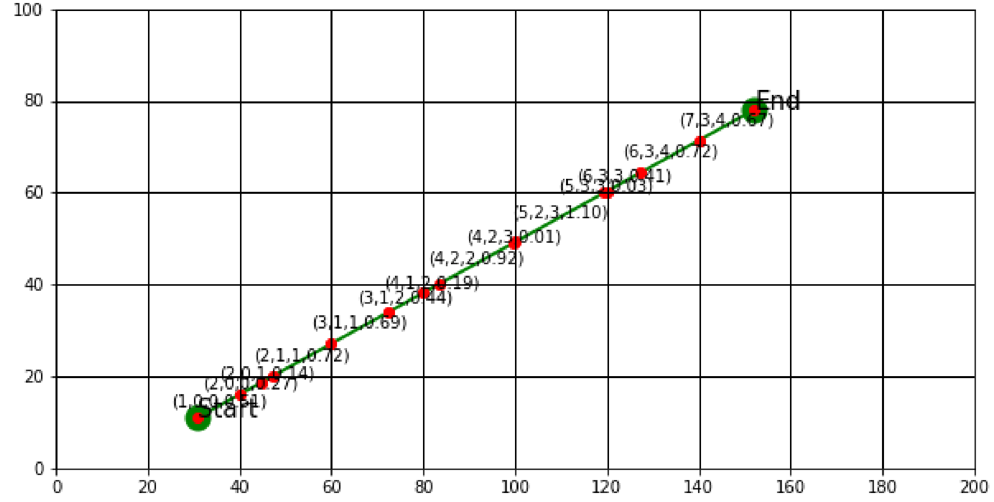
Start and End are the starting point and the endpoint of a particle track. The flow part of a particle will consist of several segments.
Red marks indicate where the particle track crosses a grid interface (in 3D)

3D representation of the same image as the right one

THE NSIM REDOX MODEL

- Based on the time stamps of the two points on the particle flow path, and the distance between them we can estimate the velocity, and the residence time in each cell in the redox model.





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3D representation of the same image as the right one

THE NSIM REDOX MODEL

Redox kinetics incorporated in the model:

0-order:

$$\frac{dC}{dt} = -k$$

1-order:

$$\frac{dC}{dt} = -k * C$$

With the 0'order kinetics, we can make the reduction maps simply based on relative numbers, without needing to now the input concentrations

With the first order kinetics, the reduction will be dependent on the input concentration, and we cannot make a single reduction map. This map will namely be dependent on the input of nutrients from the root-zone.

THE TEST MODEL

Number of rows: 50

Number of columns: 50

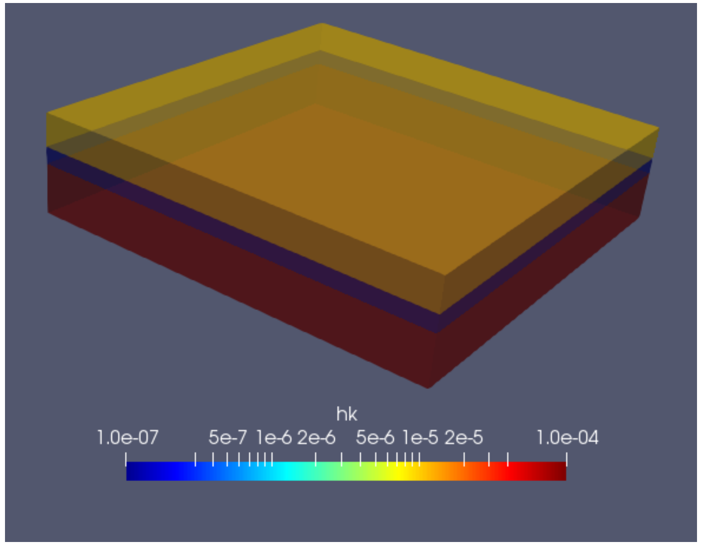
Number of layers: 6

Cell size = 50m x 50m

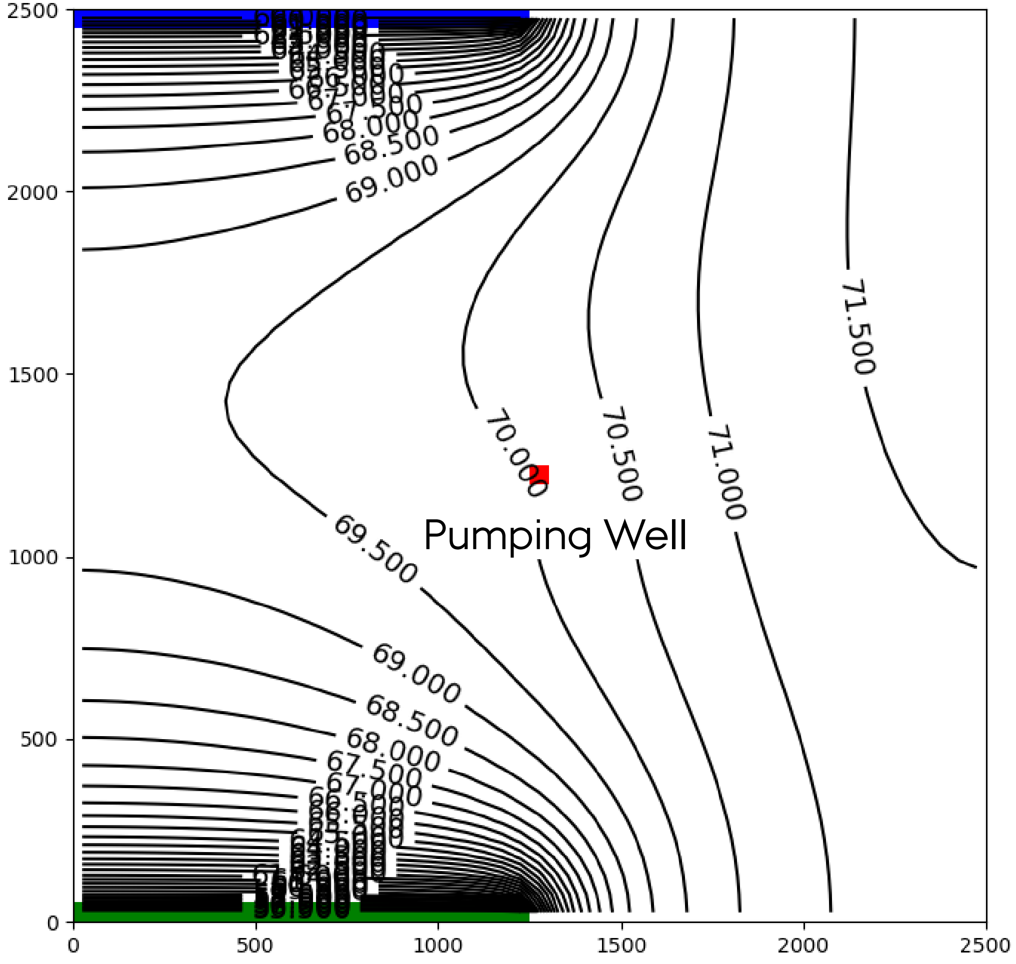
Layer thickness = 10m

Uniform Recharge

Hydraulic conductivity

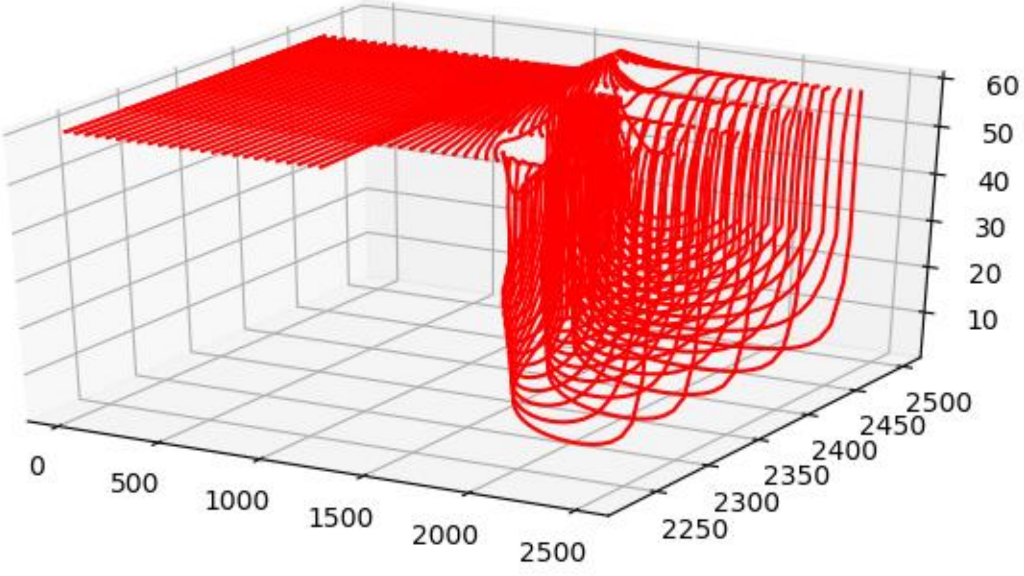


Constant head BC

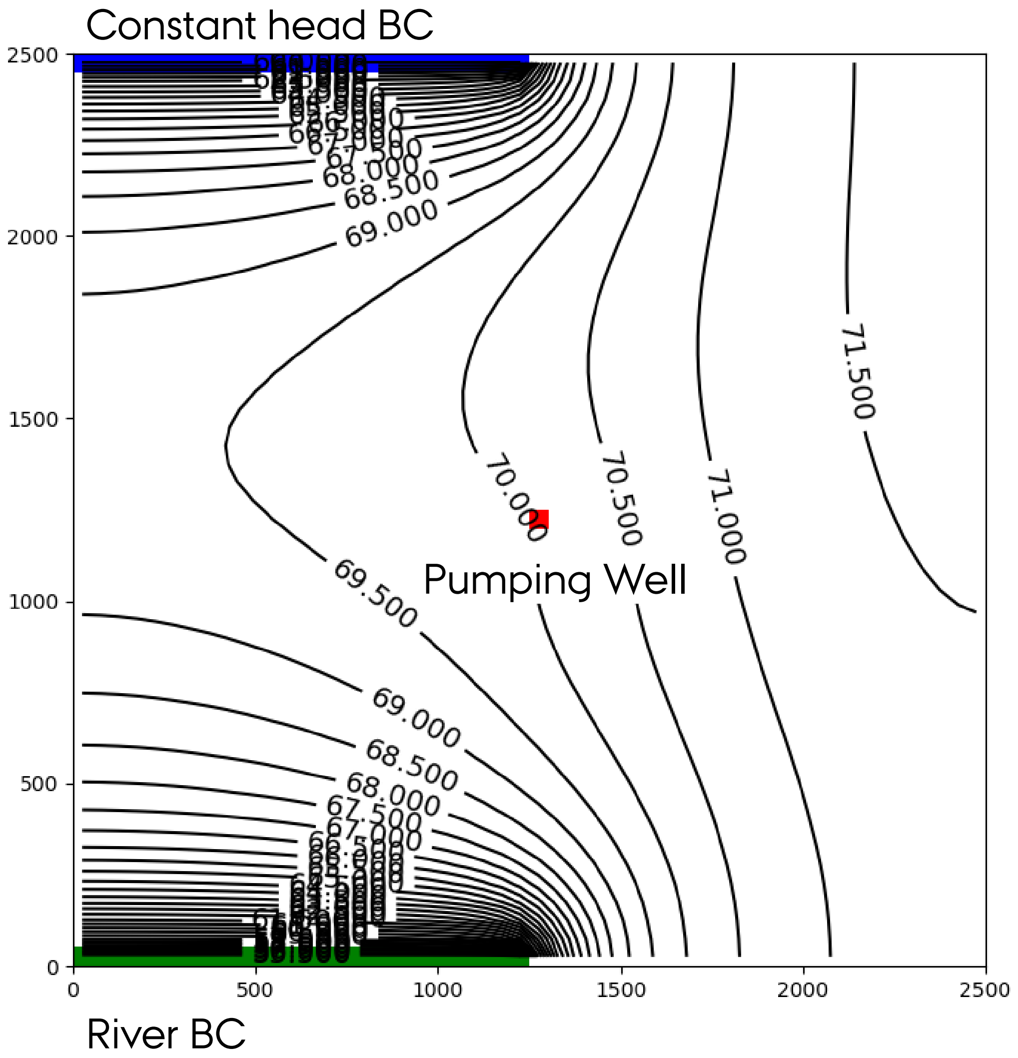


River BC

THE TEST MODEL



Examples of particle tracks. Particles towards west will flow directly to the BC. Particles to the east will go deep before reaching the BC



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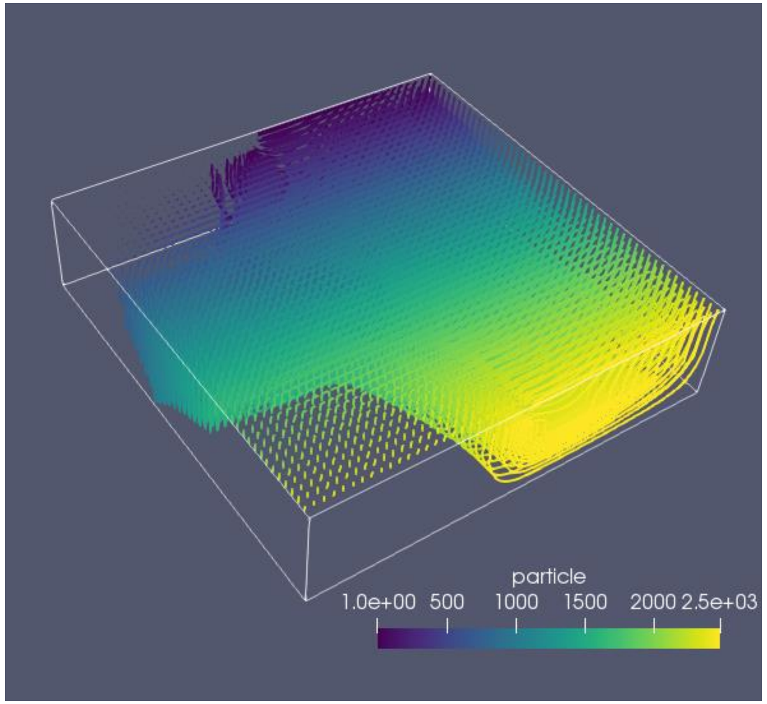

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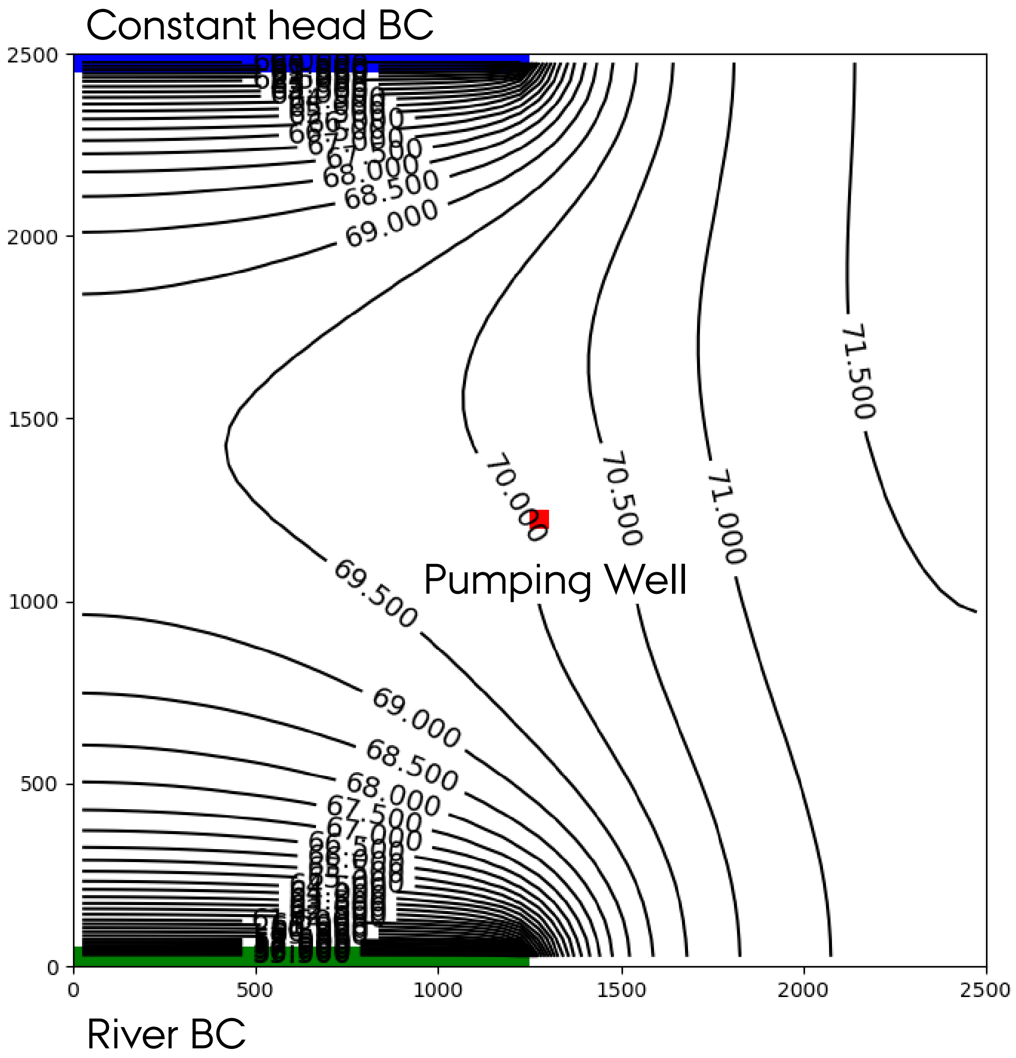


THE REDOX MODEL

Number of rows: 50

Number of columns: 50

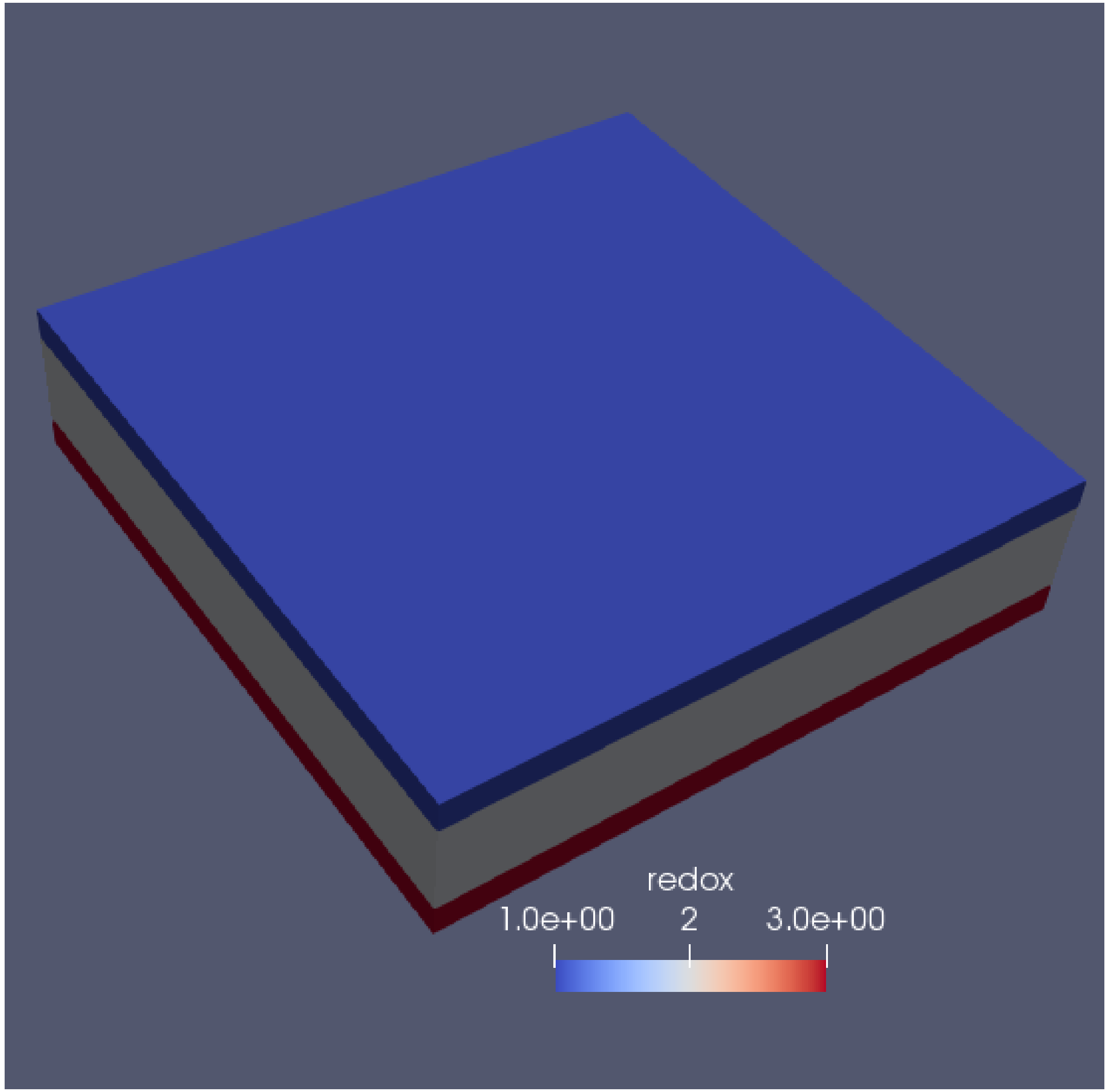
Number of layers: 10

Cell size = 50m x 50m

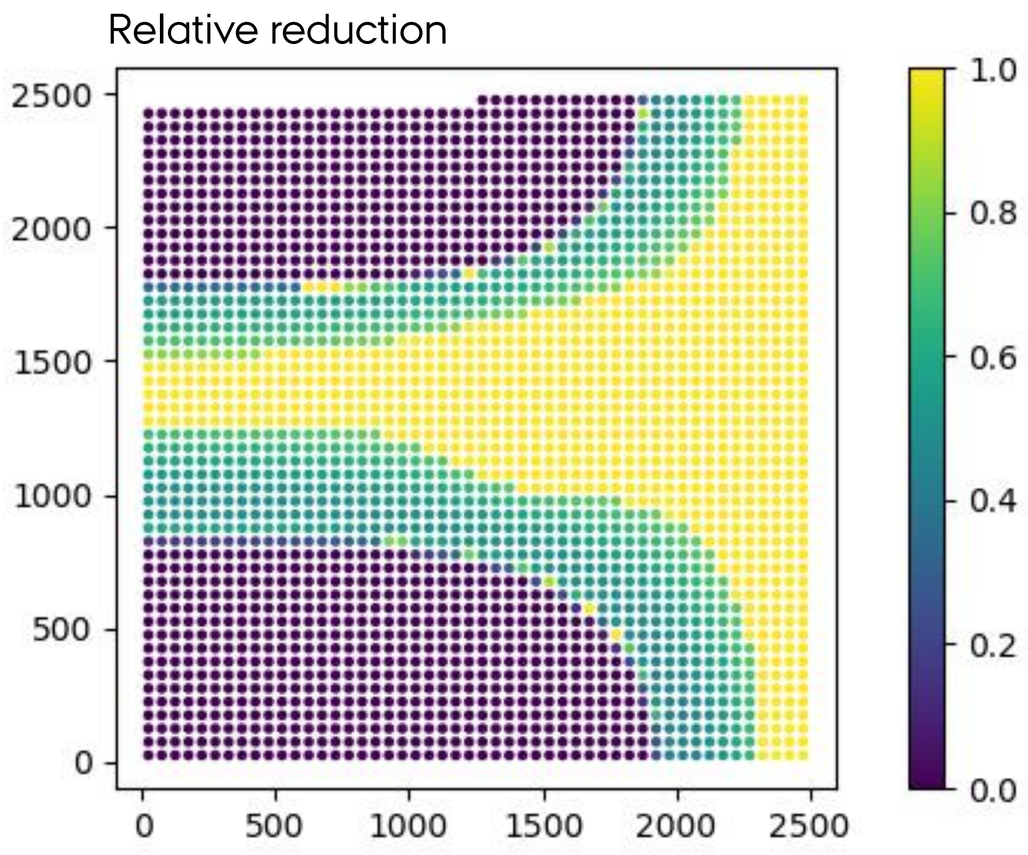
Layer thickness = 6m

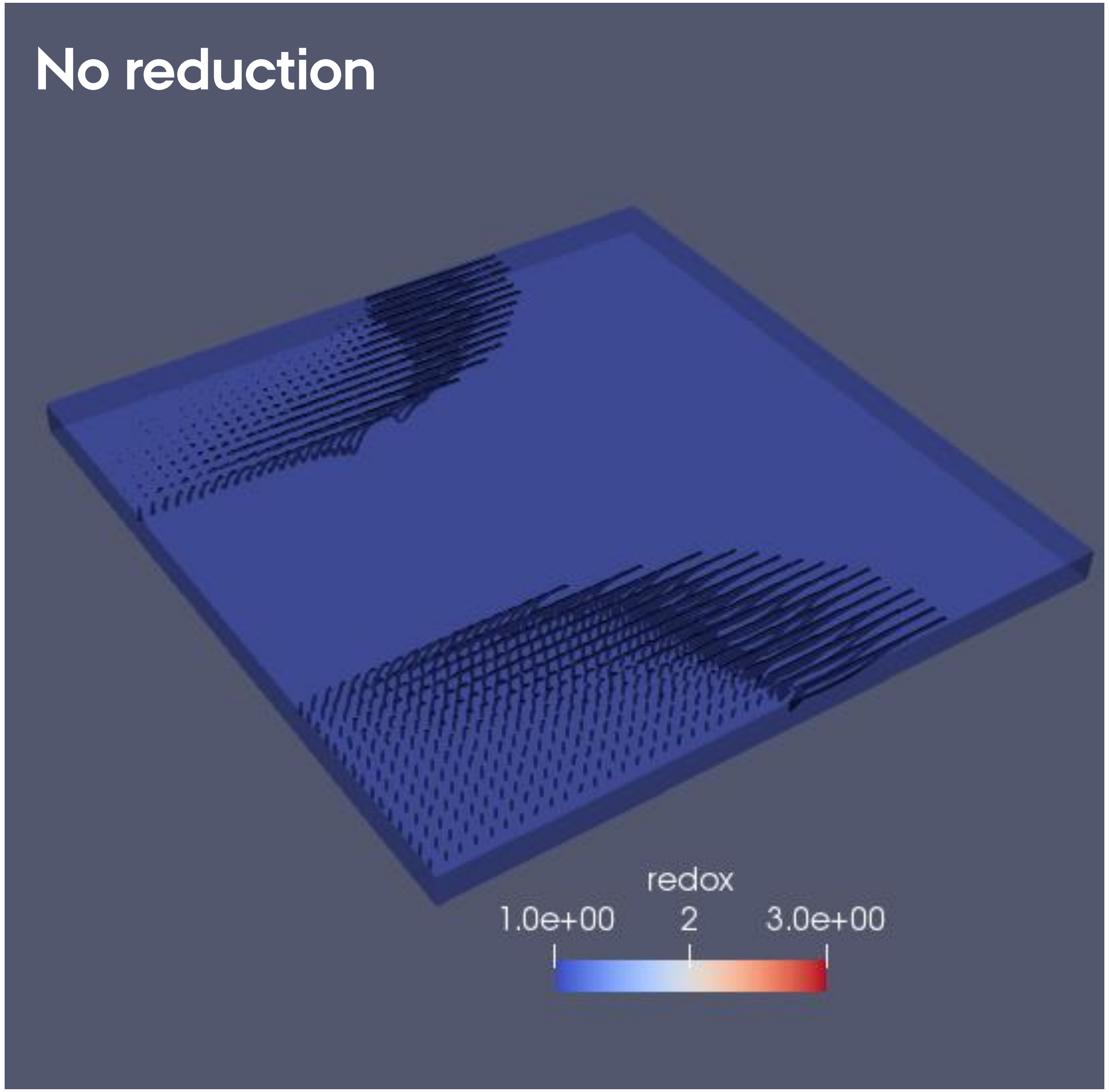
3 redox zones.

- 1: oxic
- 2: reducing
- 3: reduced

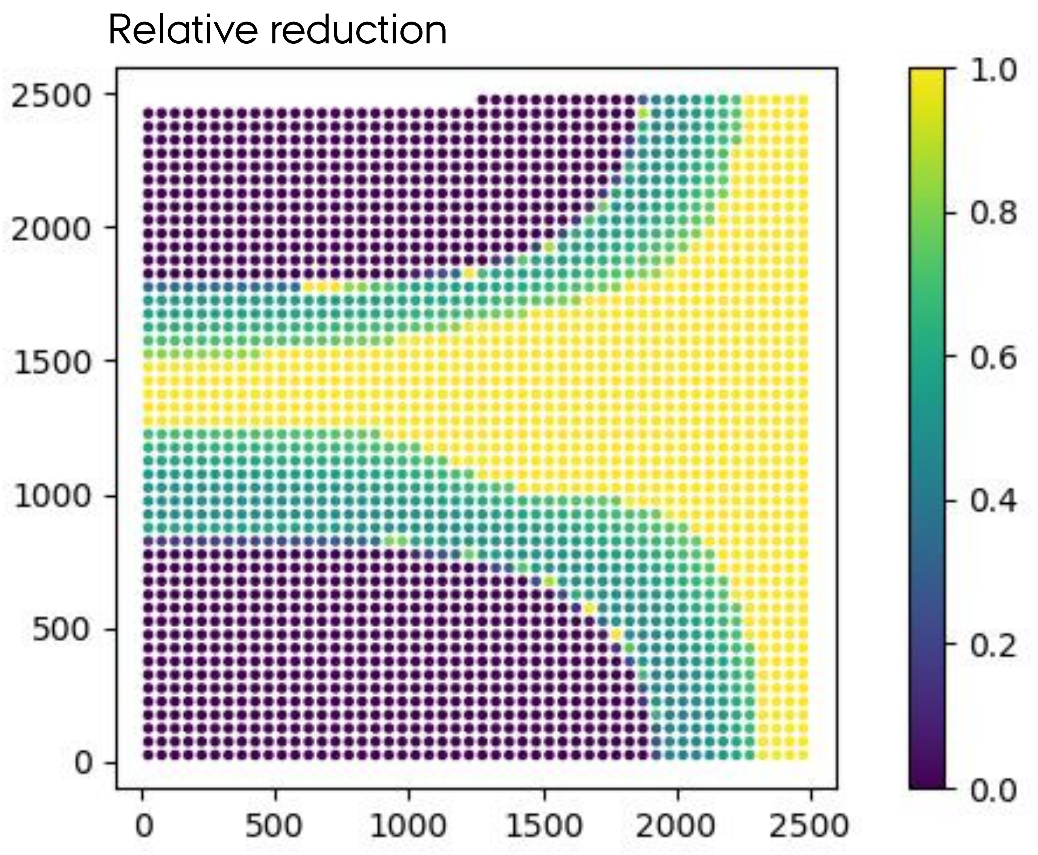


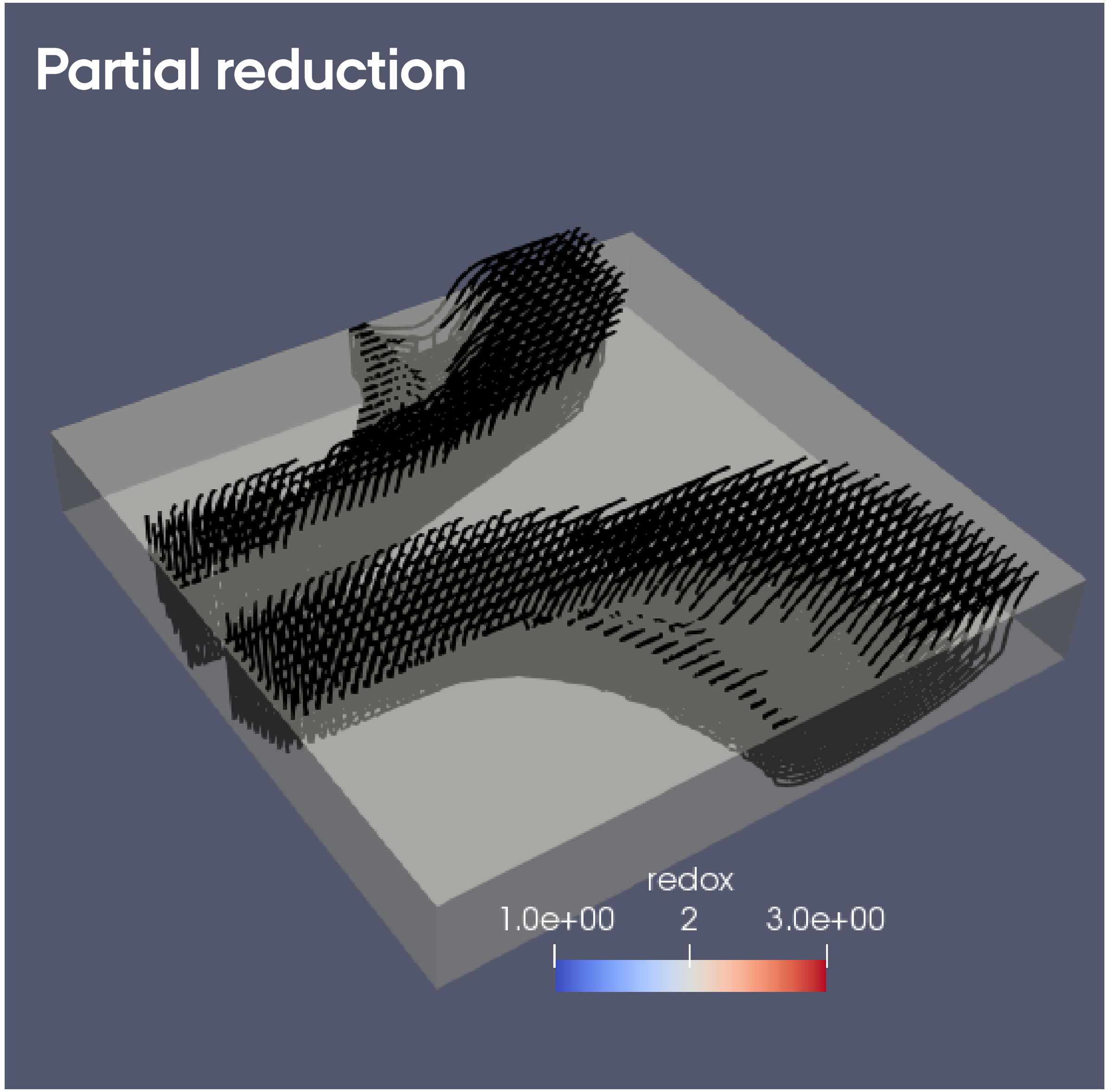
RESULTS: 0-ORDER



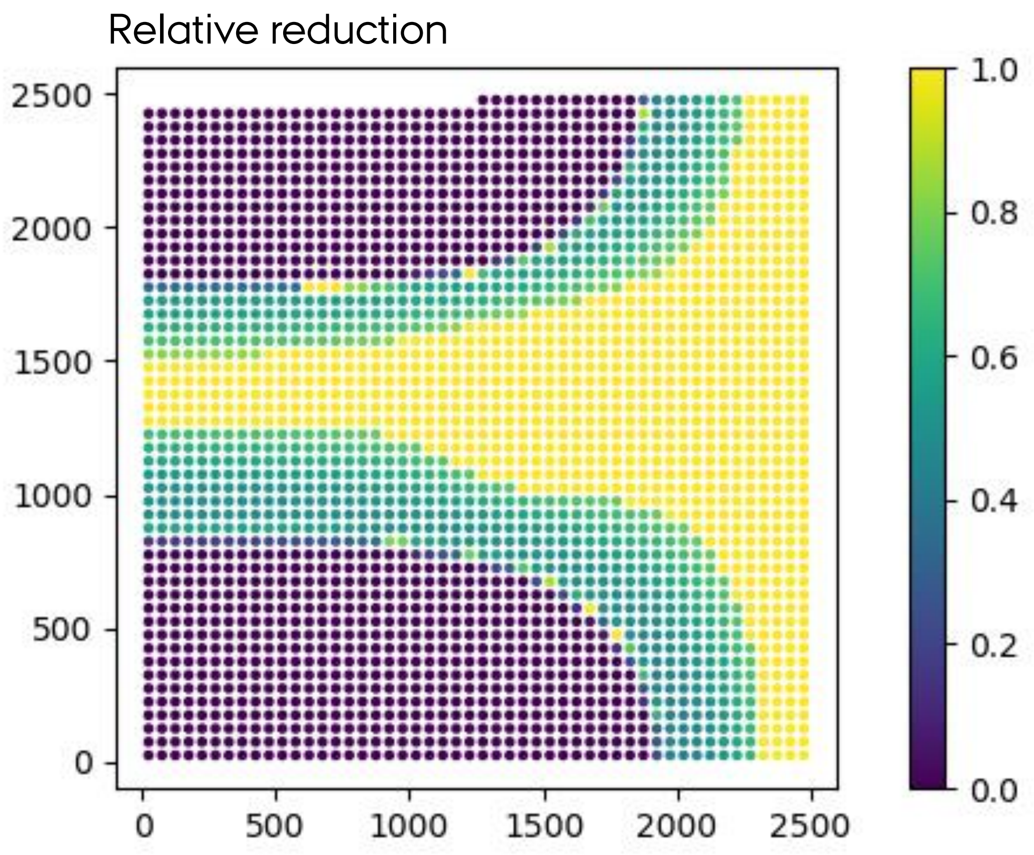


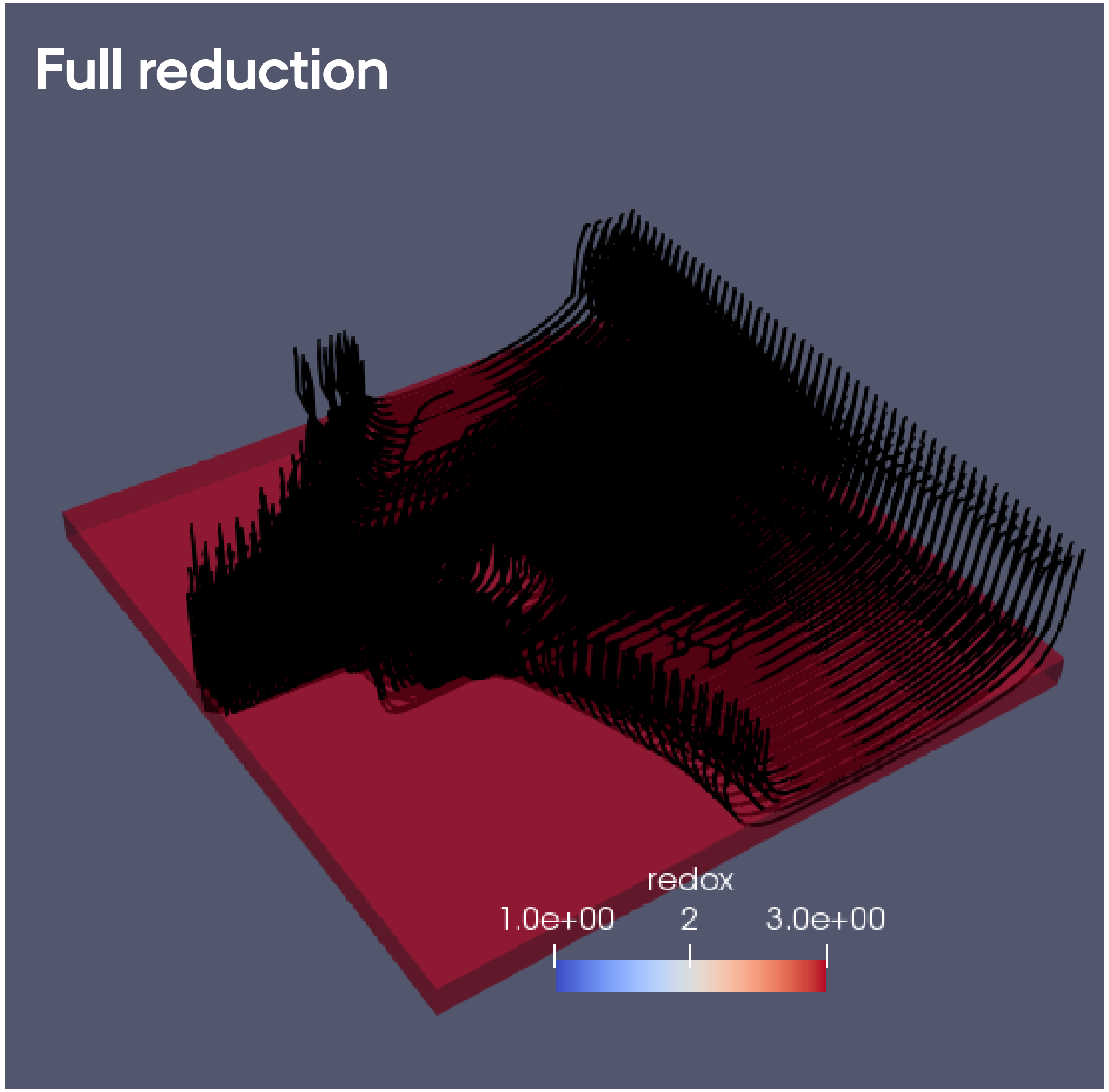
RESULTS: 0-ORDER



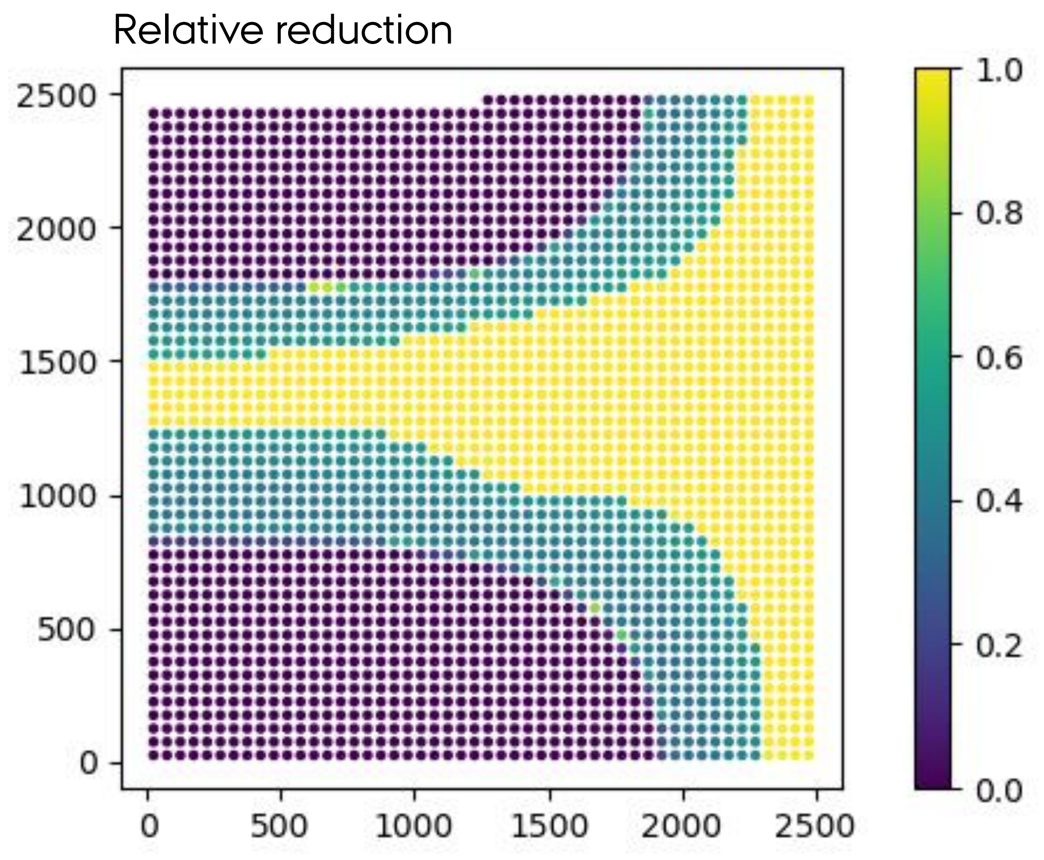


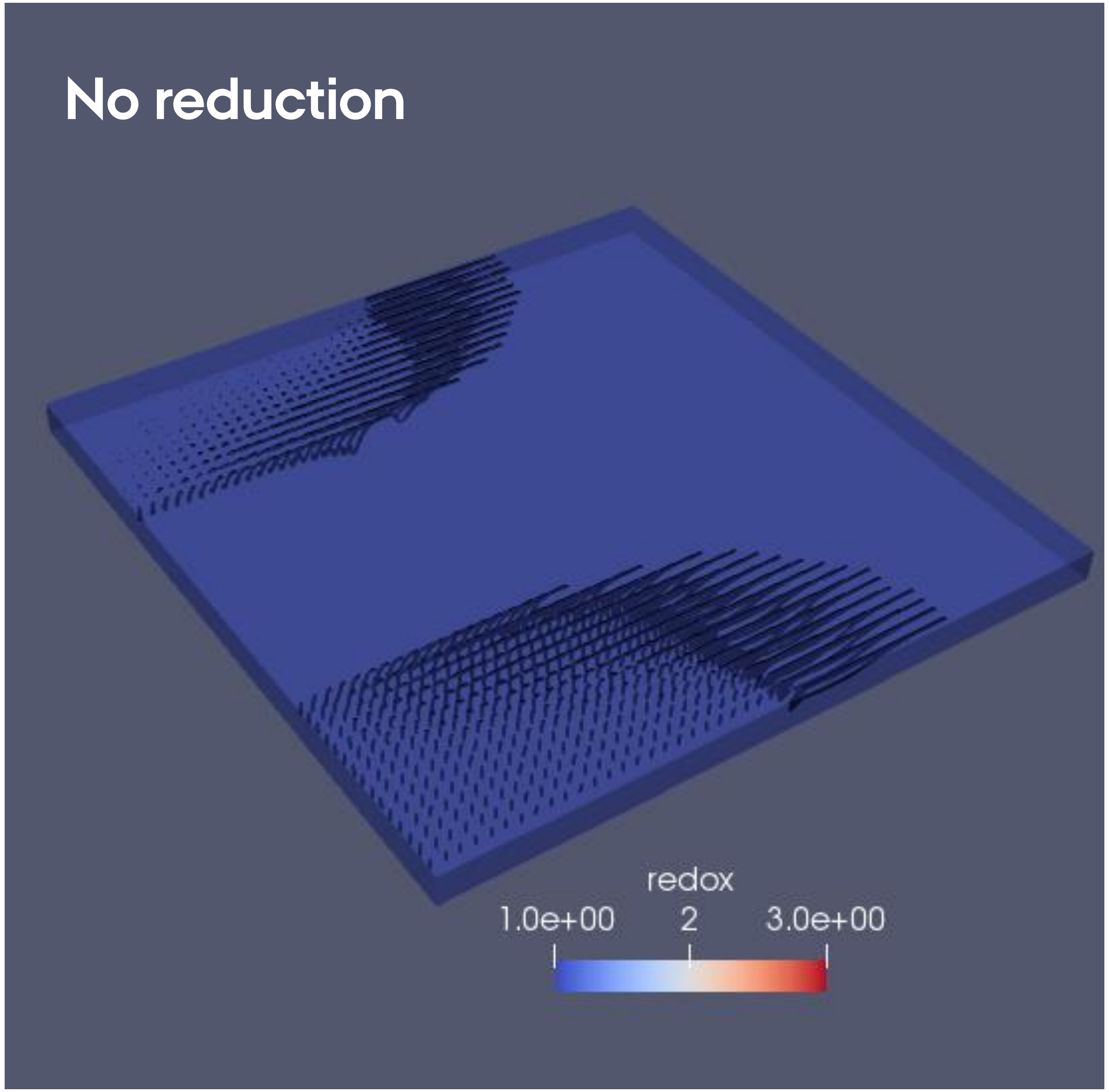
RESULTS: 0-ORDER



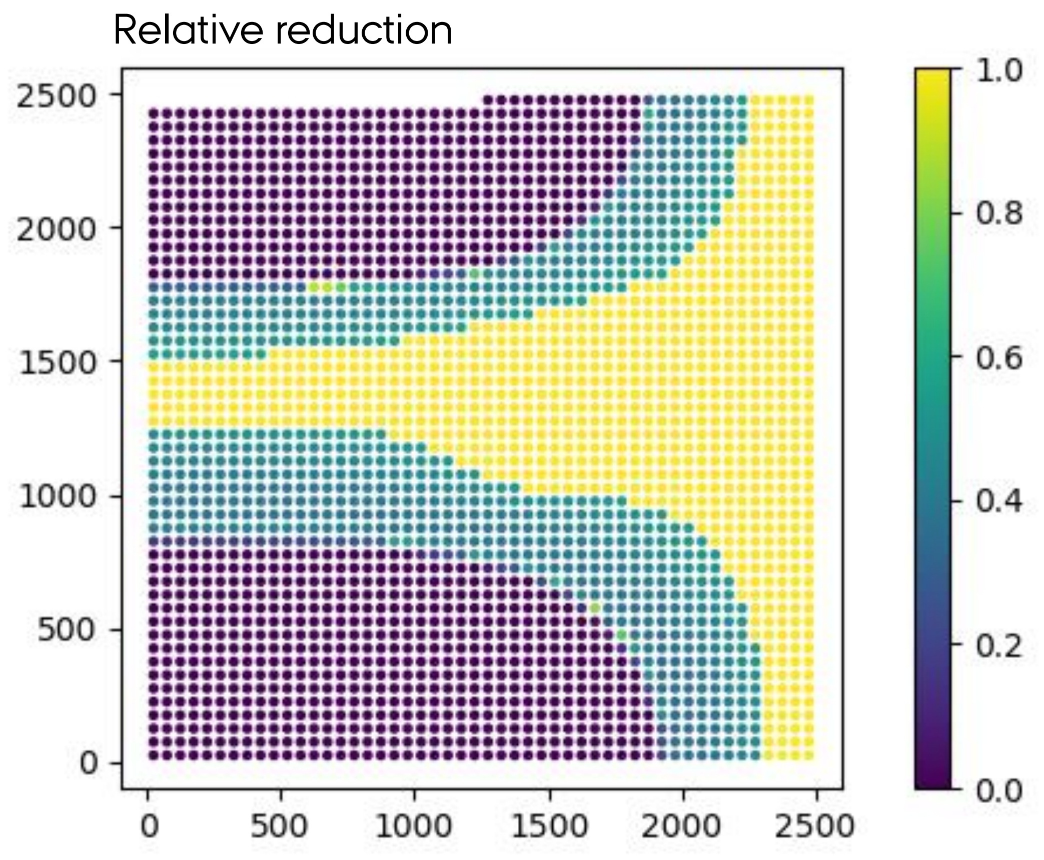


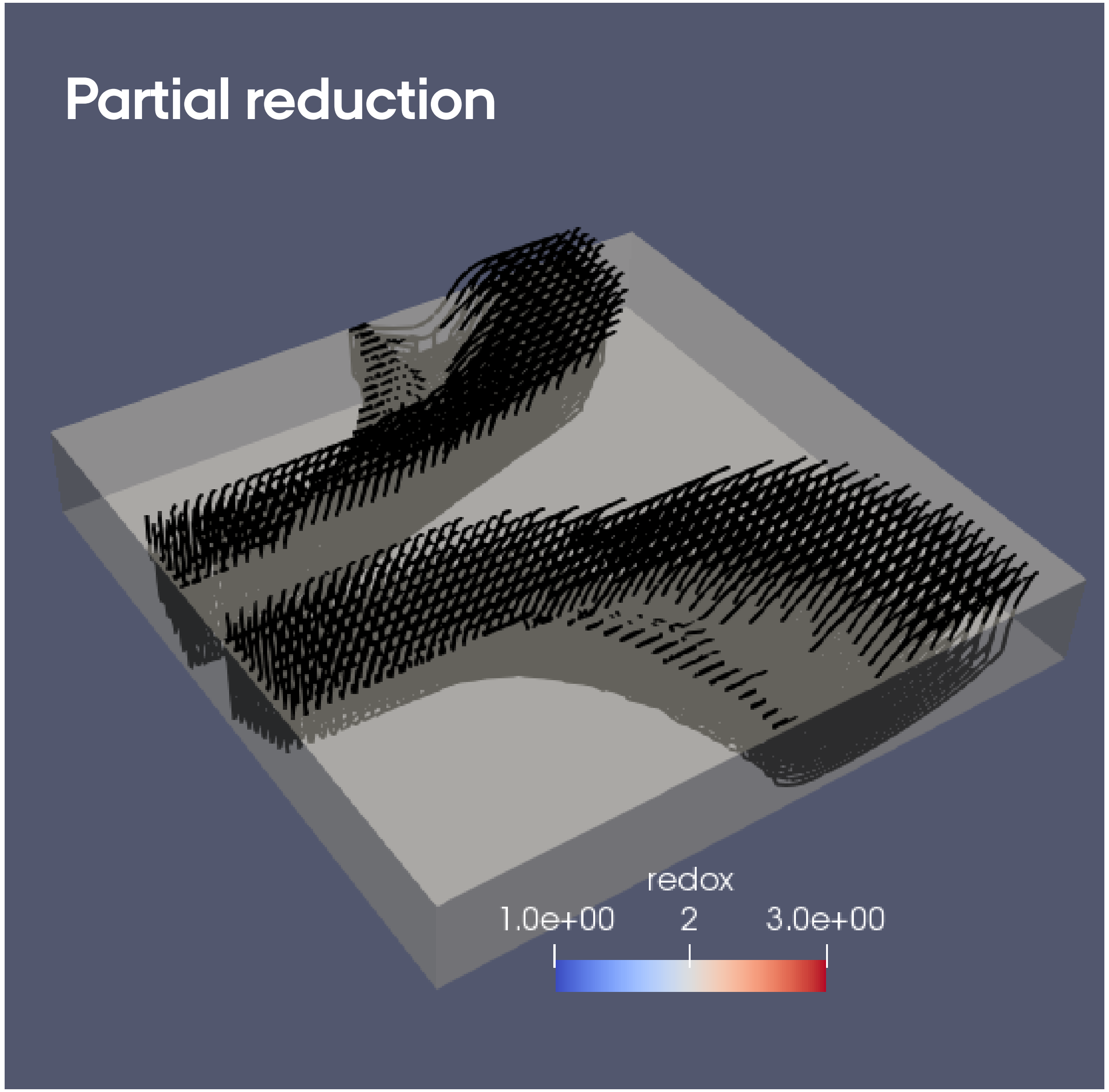
RESULTS: 1-ORDER



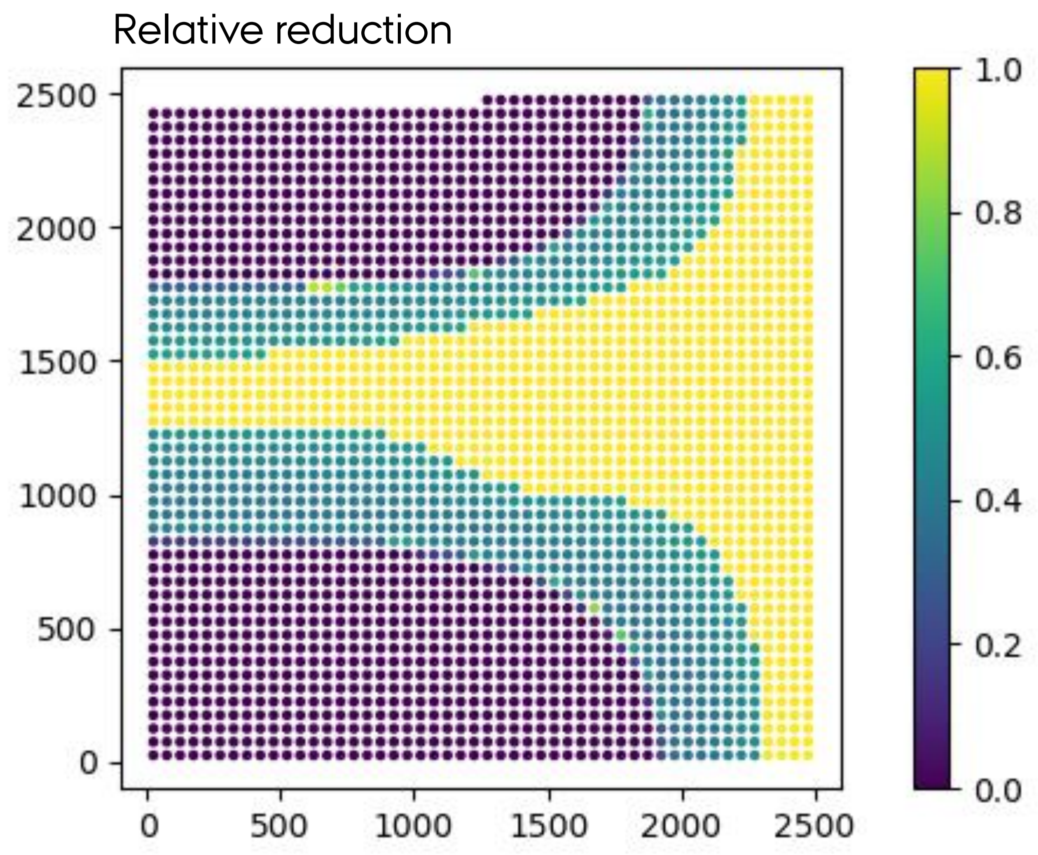


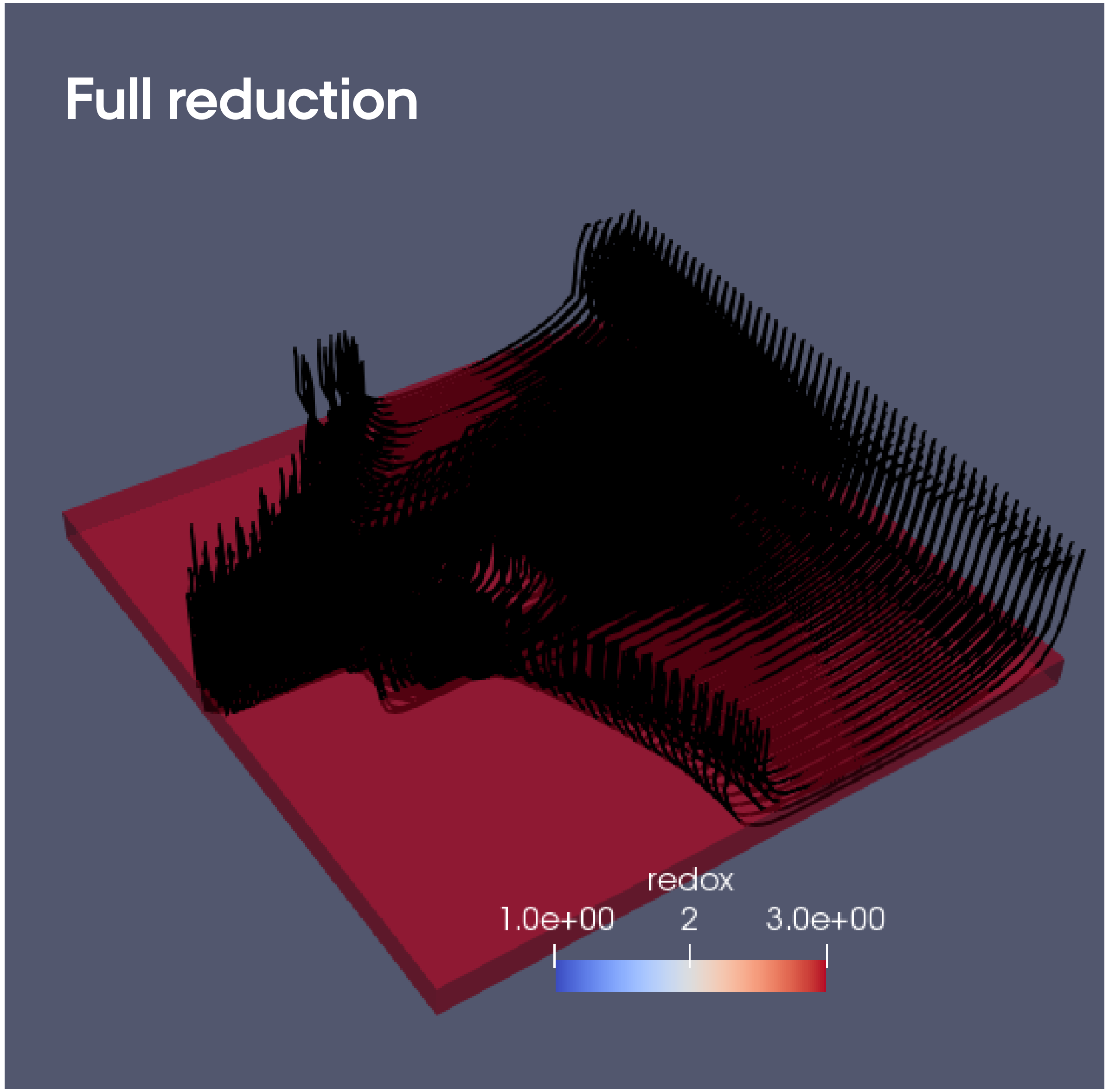
RESULTS: 1-ORDER



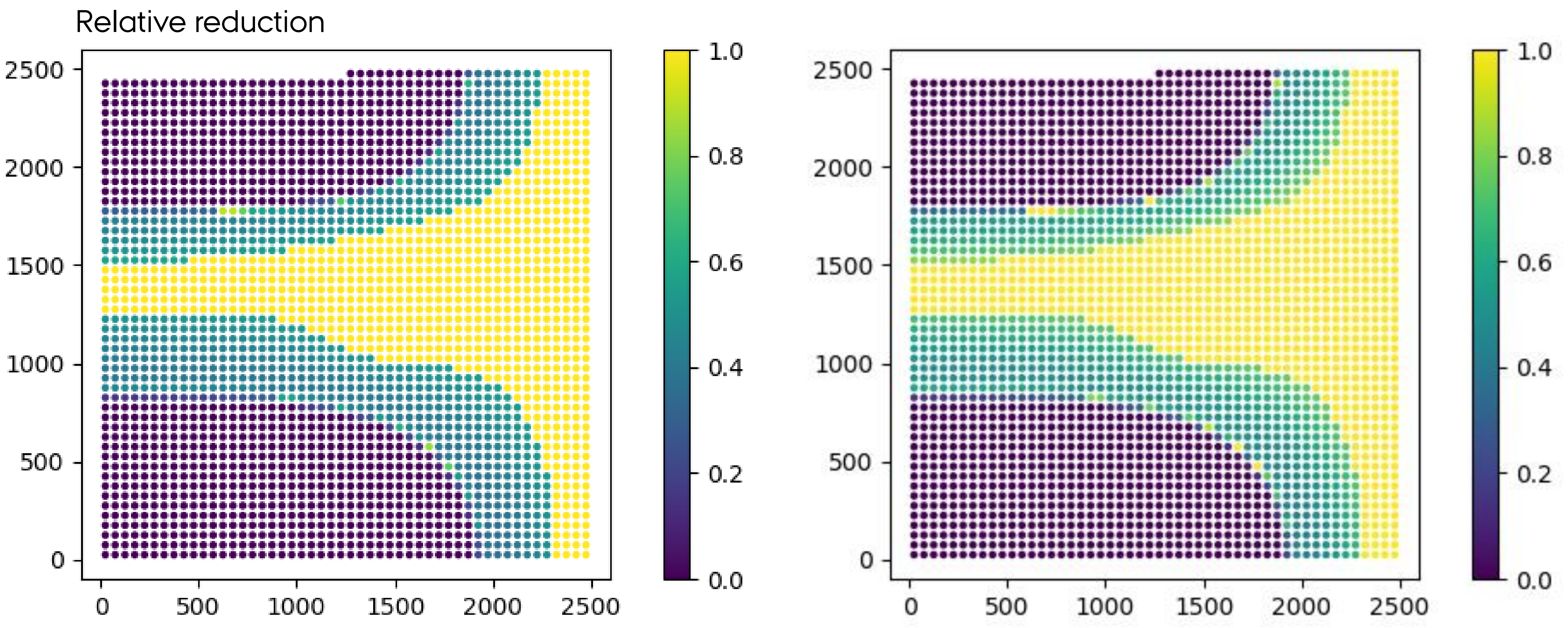


RESULTS: 1-ORDER





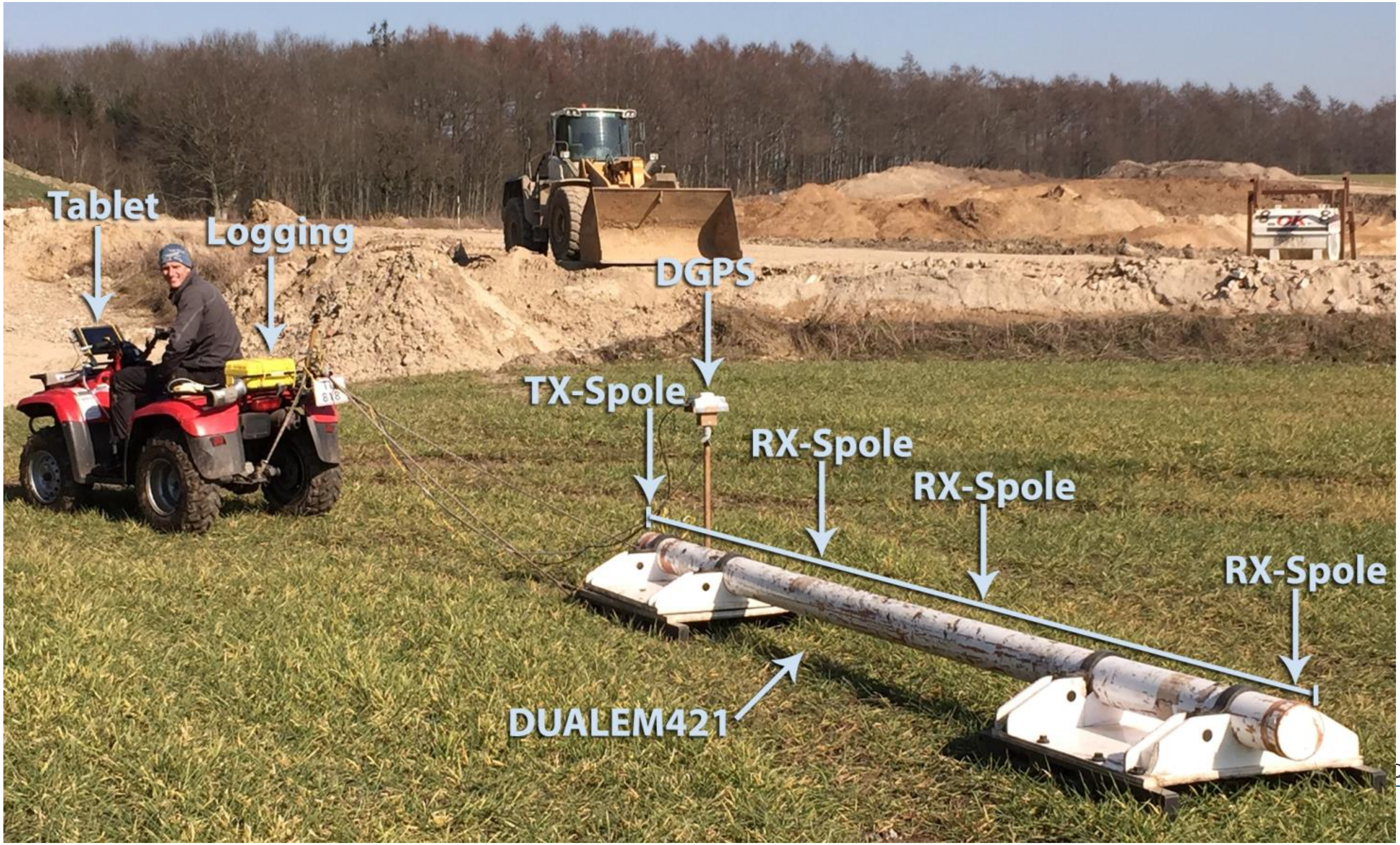
RESULTS: 1-ORDER VS. 0-ORDER



GEOFYSISKE METODER TIL STRUKTUREL KORTLÆGNING

TROELS NORVIN VILHELMSEN
RESEARCH HYDROLOGIST

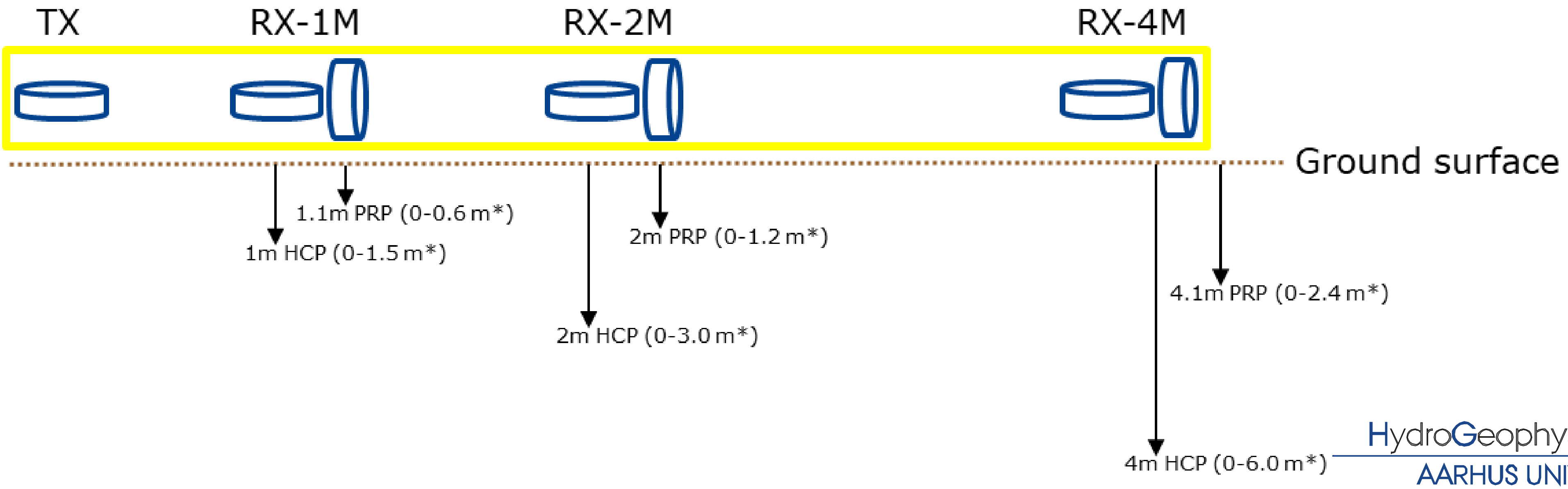
INSTRUMENTATION – DUALEM-421S



oup

ELECTROMAGNETIC INDUCTION

dualem.com



RESISTIVITY OF GEOLOGICAL FORMATIONS

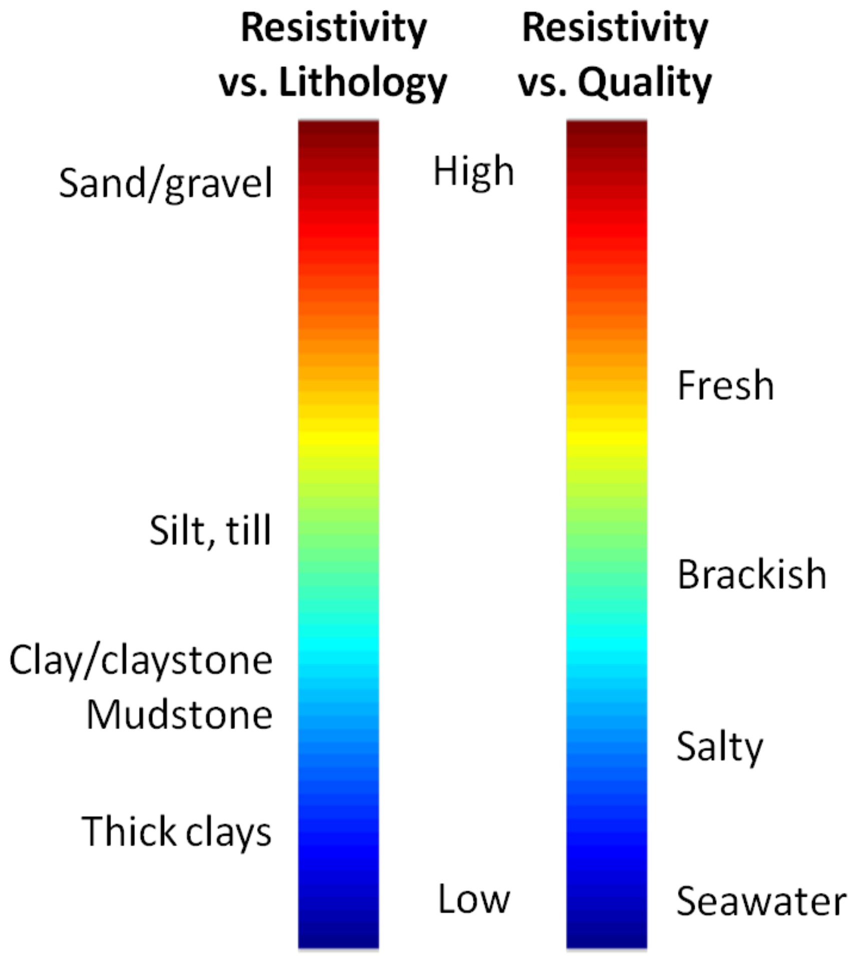
Sediment type – sand or clay (or a mixture)

Ion content of the pore water

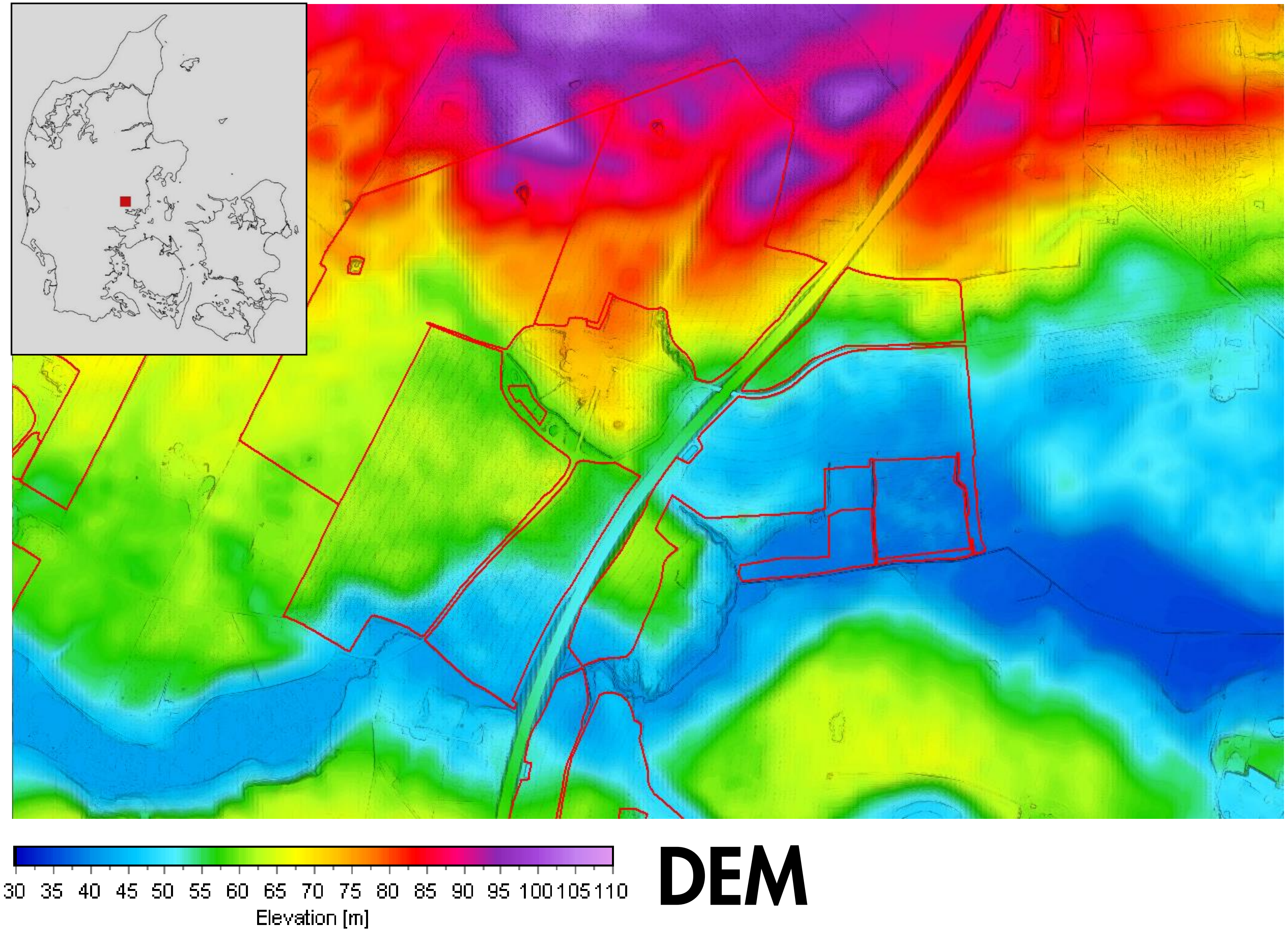
Clay type

Porosity and Saturation

Temperature



GCM-KORTLÆGNING



DEM

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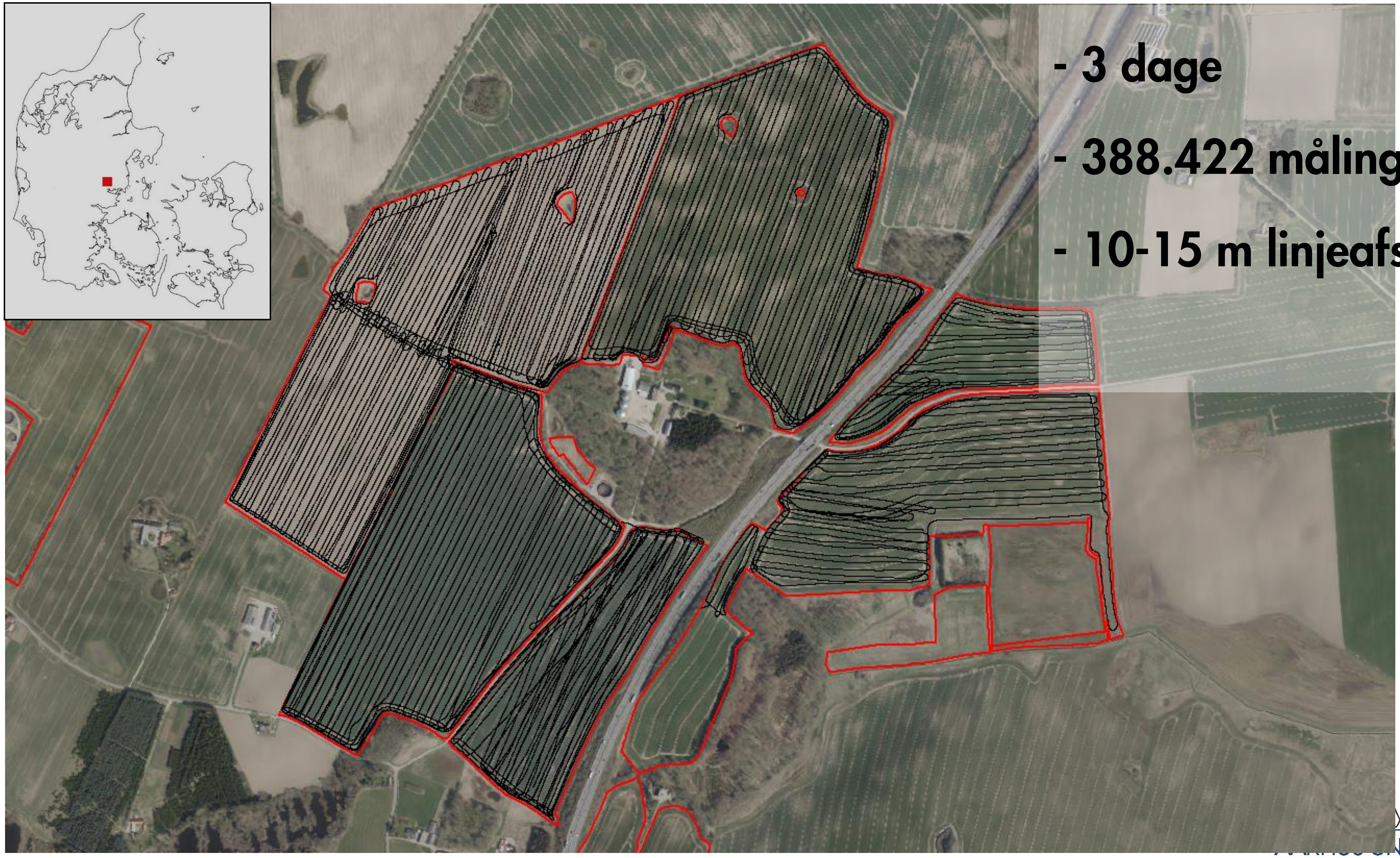
GCM-KORTLÆGNING



- 3 dage
- 388.422 målinger
- 10-15 m linjeafstand

GCM-KORTLÆGNING

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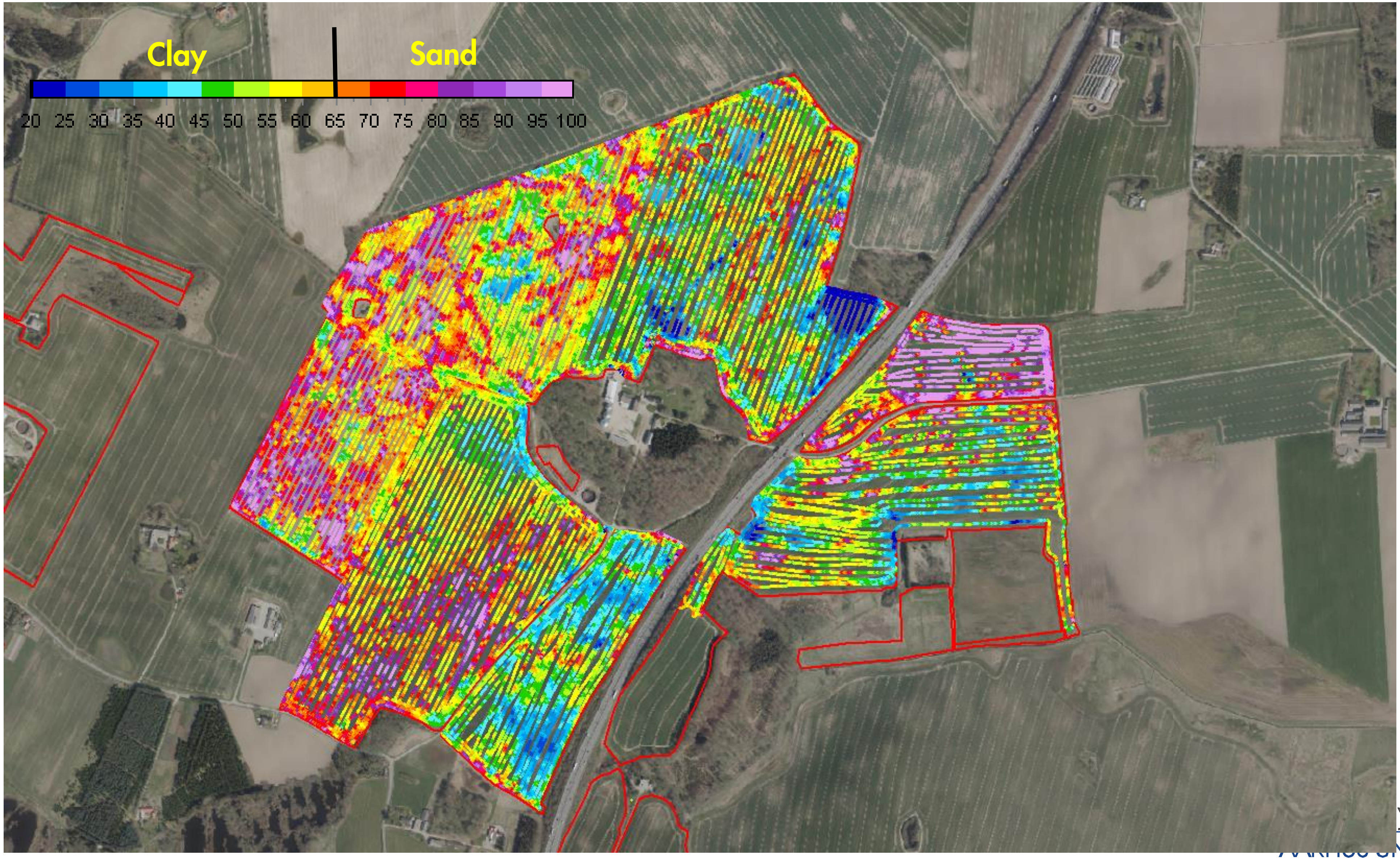
RESULTS – GCM (1.5 M)



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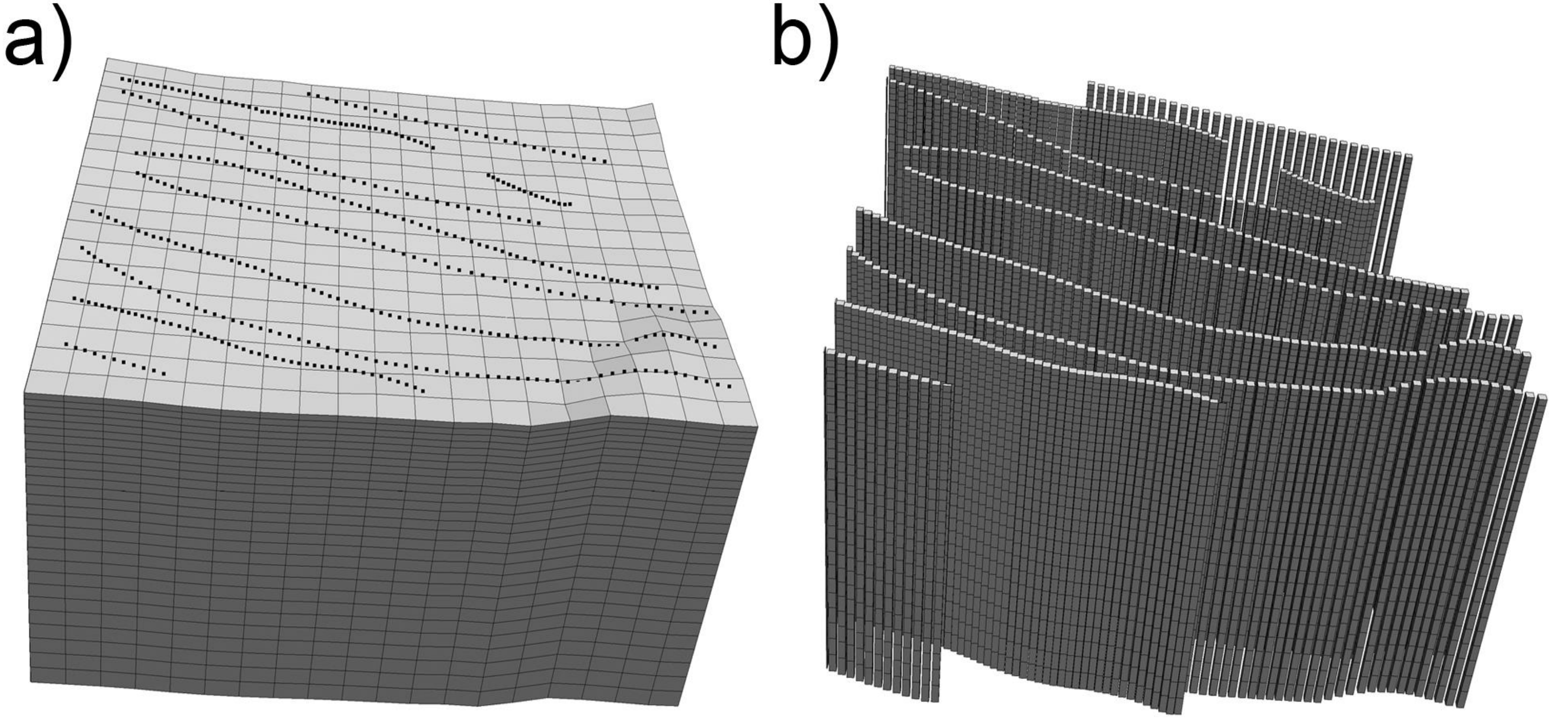
UDFORDRINGER

Konstant kalibrering af instrument

Temperatur-variationer → Resistivitetsvariationer

Inversion

- Gentagne målinger vil ikke ramme samme observationspunkt
- Voxel-formulering af model-rummet
- Time-lapse inversion



PERSPECTIVES

- With detailed measurements of root zone hydraulics with geophysical and hydraulic measurements, we want to describe/model the fluctuations in the water table between drains.

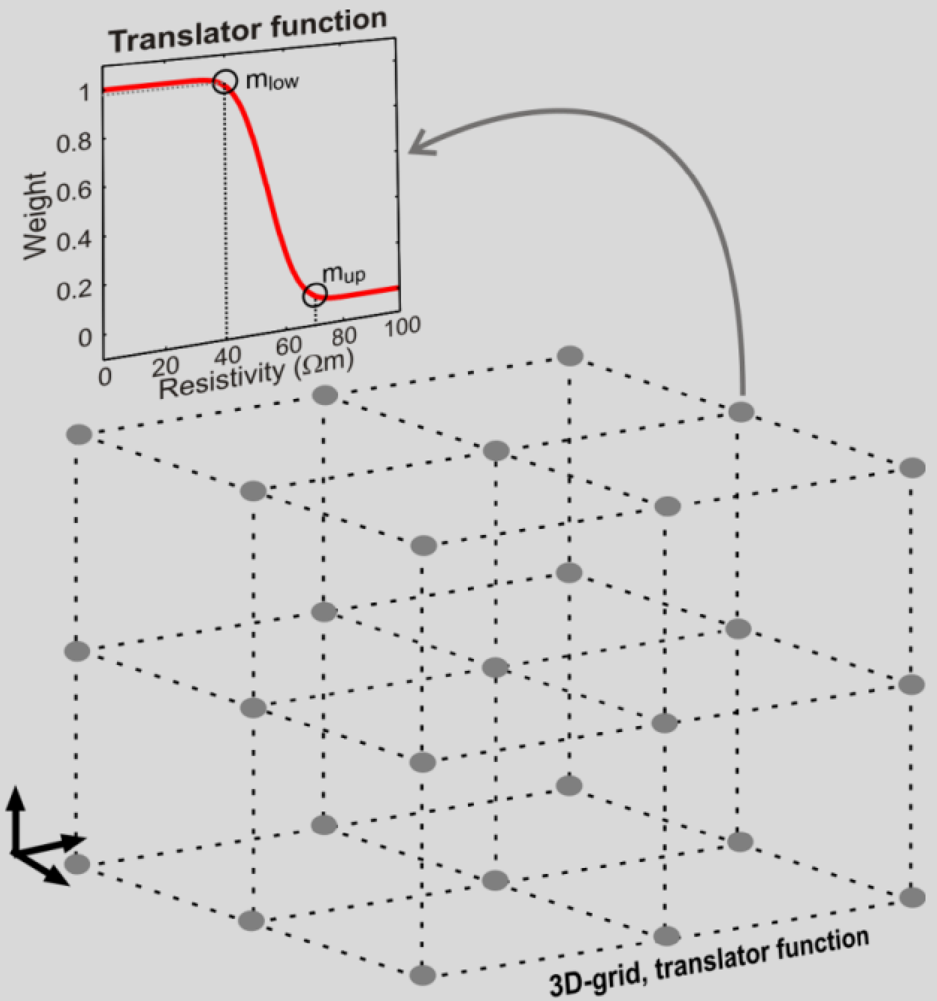
- Combined with the knowledge from redox measurements we hope to be able improve the understanding of near surface redox processes

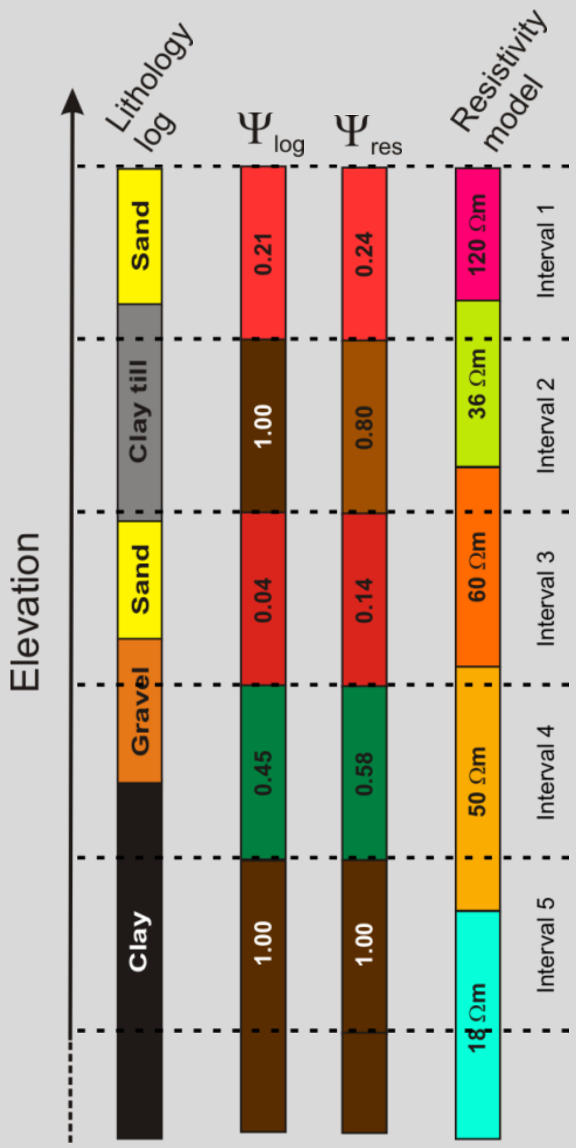
PLANLÆGNING OG MILESTONES

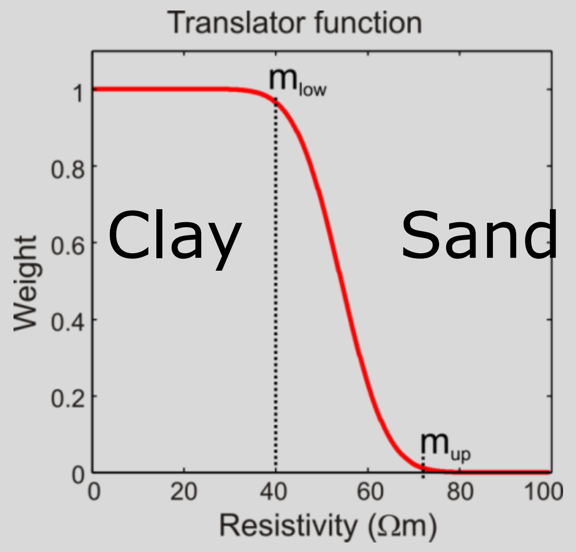
	Involverede projektdeltagere	2019 (Jan, Apr, Jul, Okt) / 2020 (Jan, Apr, Jul, Okt) / 2021 (Jan, Apr, Jul, Okt)
AP 2: Kortlægning af markers hydrogeologi og redox-regime	**AU_GEO (AP leder)**	
2.1. Kortlægning af arealers terrænnære hydrogeologi		
M2.11: Kortlægning af rumlig hydrogeologi (0-3 m)	AU_GEO	M2.11
M2.12: Måling af timelaps GCM (0-3 m)	AU_GEO	M2.12
2.2. Kortlægning af terrænær hydrologi		
M2.21: Udvikling af model til terrænnær hydrologi	GEUS, AU_GEO	M2.21
M2.22: Verifikation af drænmodel	GEUS, AU_GEO	M2.22
2.3. Kortlægning af terrænær redox dynamik		
M2.3: Udvikling af algoritmer for arealers redox-regime som input til Ejlskov softw	AU_GEO, GEUS	Ejlskov? M2.3

Workflow

1. **Calculate clay fraction from boreholes and resistivity models**



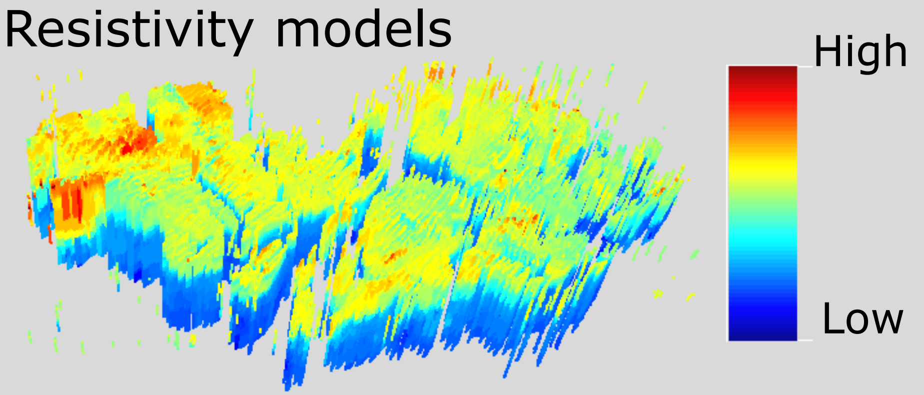


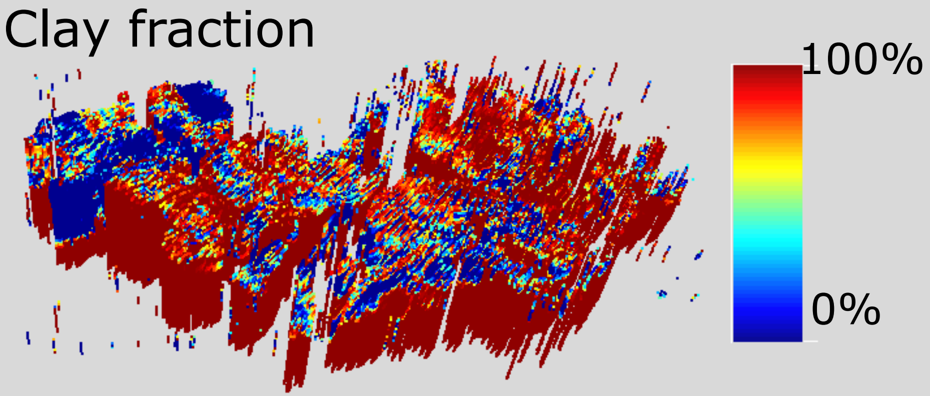


Foged et al., Hydrol. Earth Syst. Sci., 18, 4349–4362, 2014

Workflow

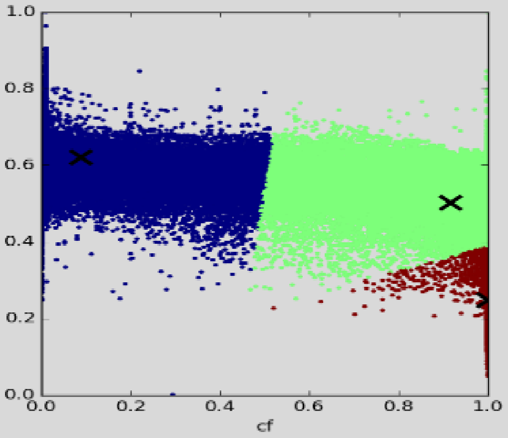
1. **Calculate clay fraction from boreholes and resistivity models**

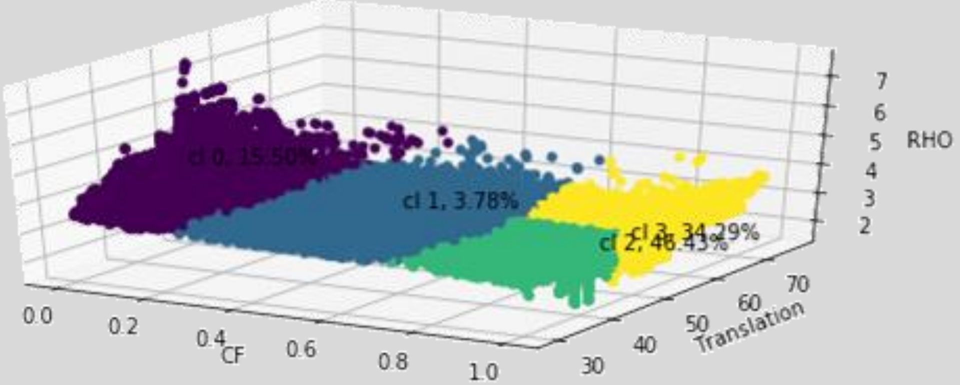




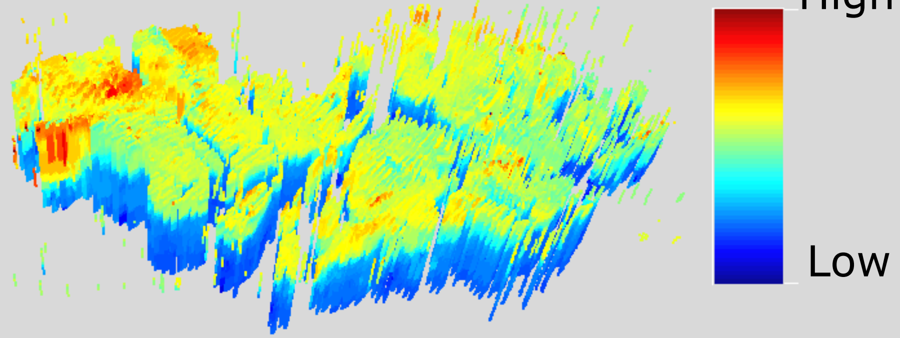
Workflow

1. **Calculate clay fraction from boreholes and resistivity models**
2. **Perform k-means clustering on principal components of clay fraction and resistivity**

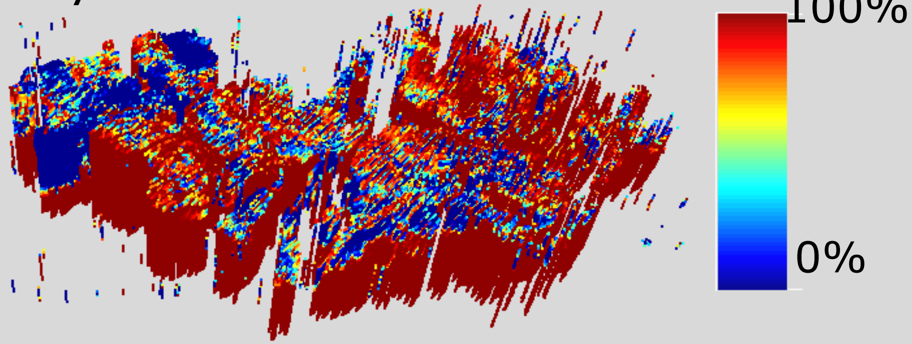


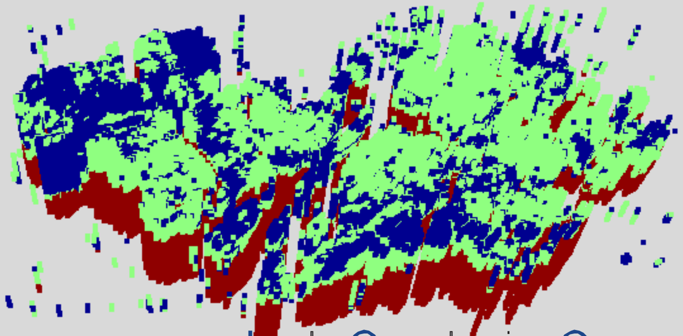


Resistivity models



Clay fraction





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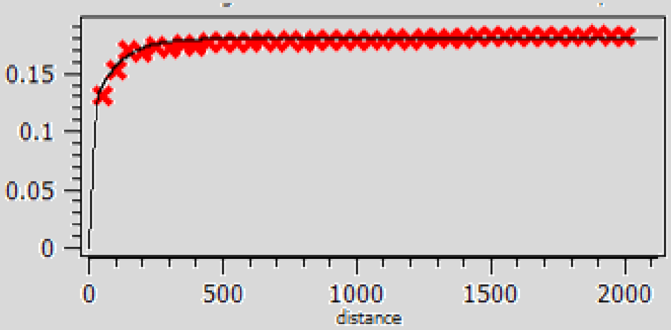
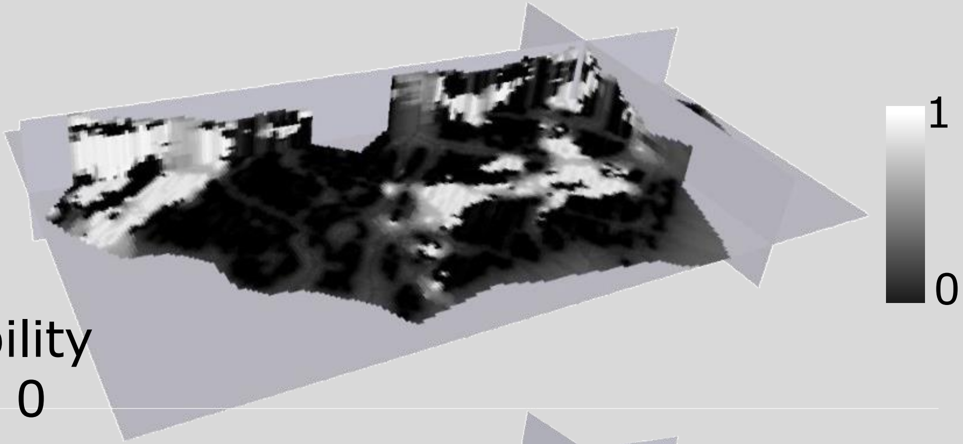
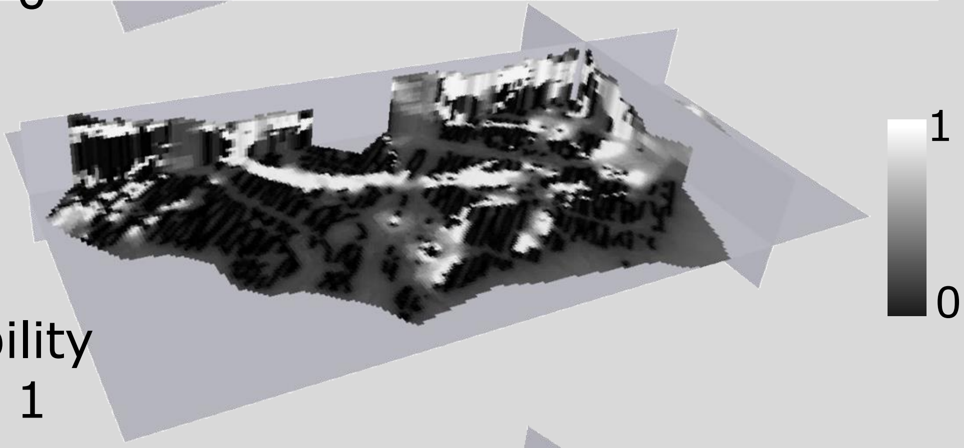
Workflow

1. **Calculate clay fraction from boreholes and resistivity models**
2. **Perform k-means clustering on principal components of clay fraction and resistivity**
3. **Calculate probability for the clusters using Indicator Kriging (IK)**

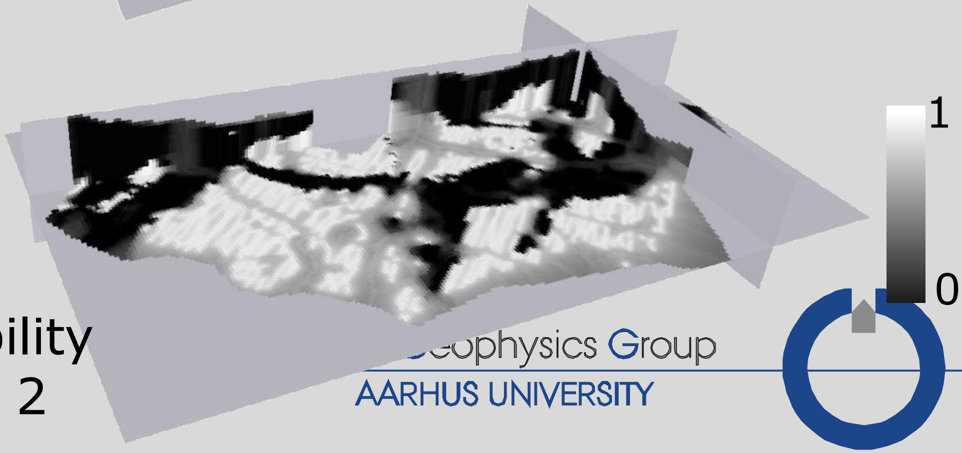




Probability cluster 0



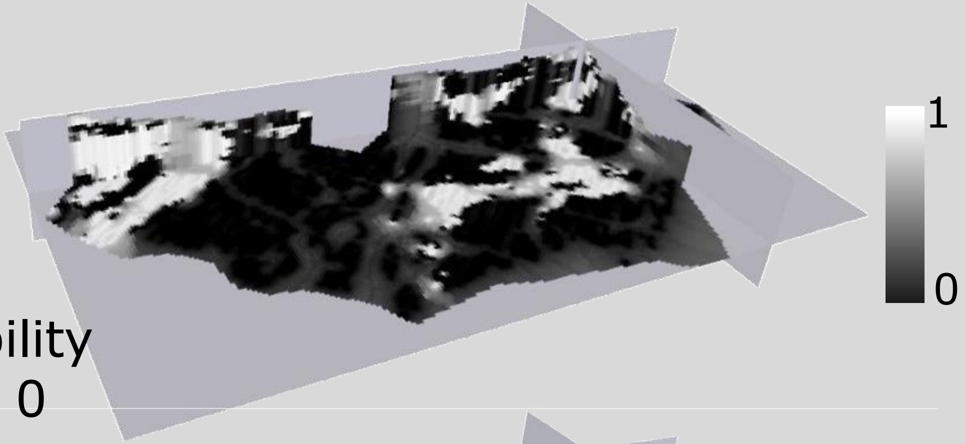
Probability cluster 1



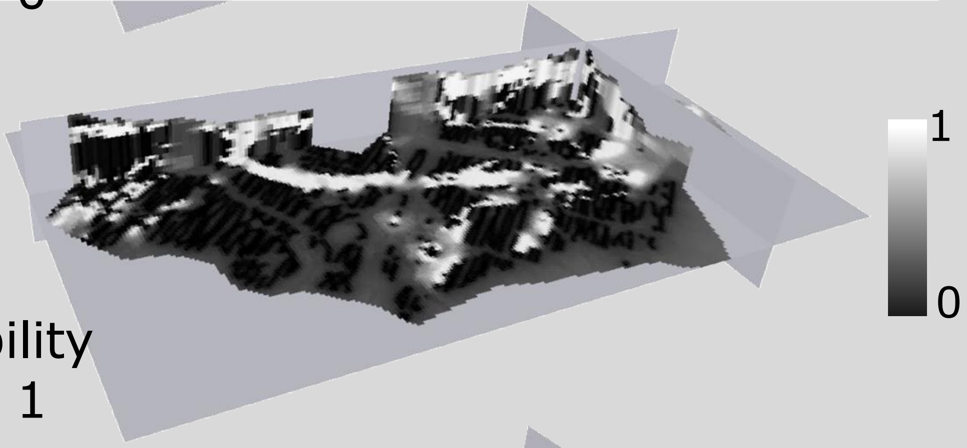
Probability cluster 2

Workflow

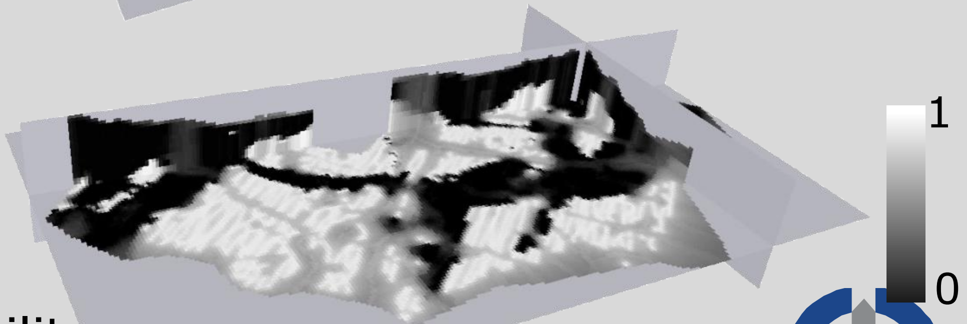
1. **Calculate clay fraction from boreholes and resistivity models**
2. **Perform k-means clustering on principal components of clay fraction and resistivity**
3. **Calculate probability for the clusters using Indicator Kriging (IK)**
4. **Based on (3) Calculate maximum probability to visualize the uncertainty in the model.**



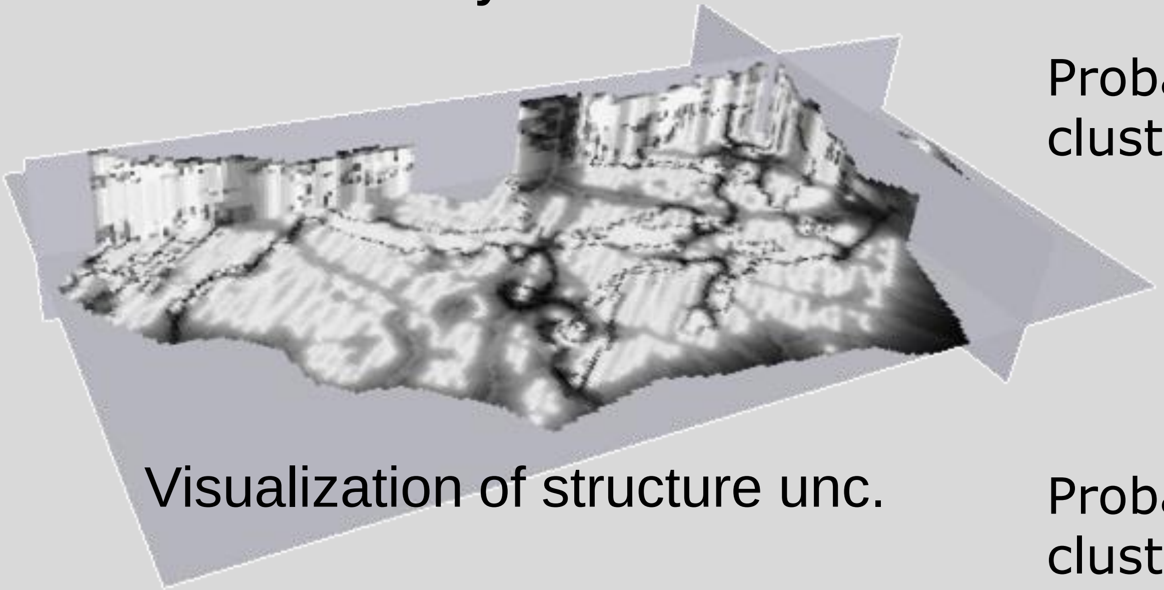
Probability cluster 0



Probability cluster 1



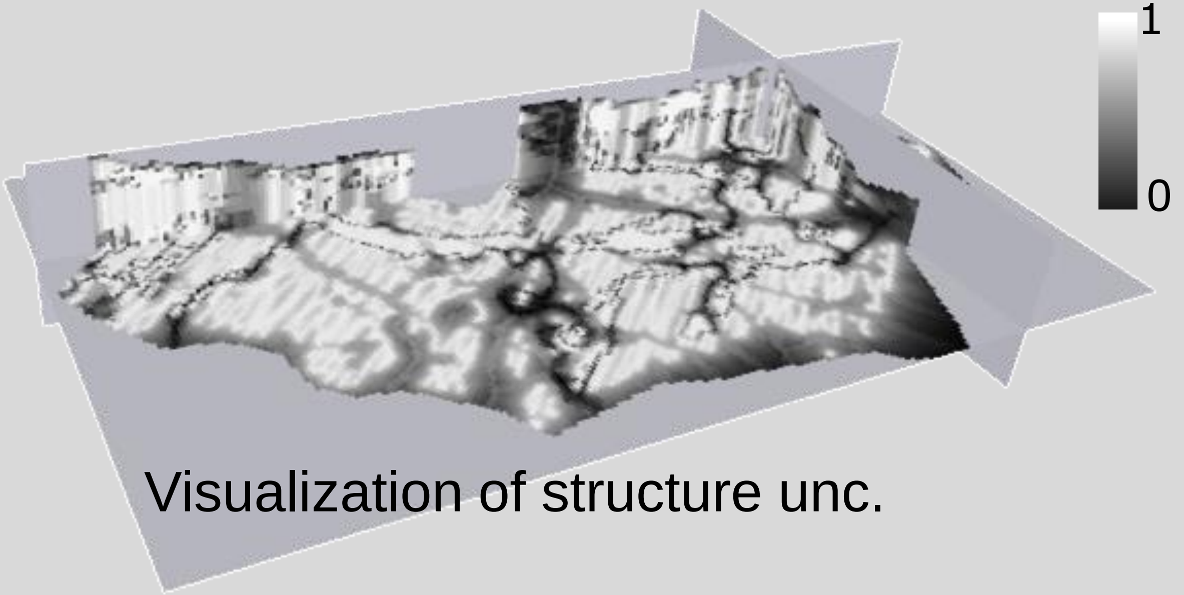
Probability cluster 2



Visualization of structure unc.

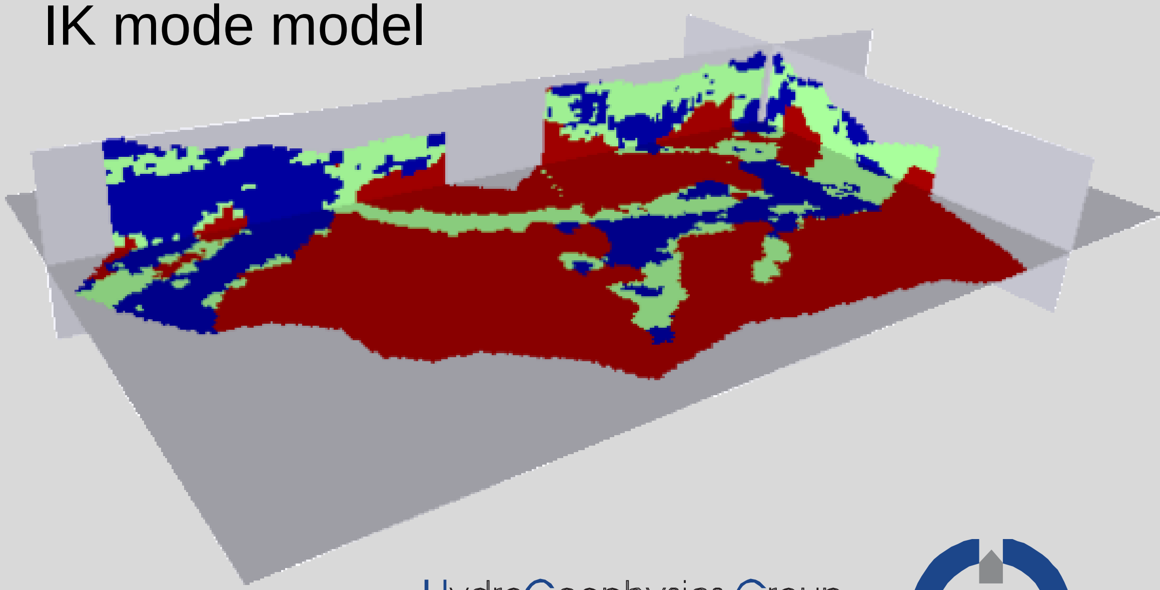
Workflow

1. **Calculate clay fraction from boreholes and resistivity models**
2. **Perform k-means clustering on principal components of clay fraction and resistivity**
3. **Calculate probability for the clusters using Indicator Kriging (IK)**
4. **Based on (3) Calculate maximum probability to visualize the uncertainty in the model.**
5. **Calculate cluster model with highest probability from (3) – the IK mode model**



Visualization of structure unc.

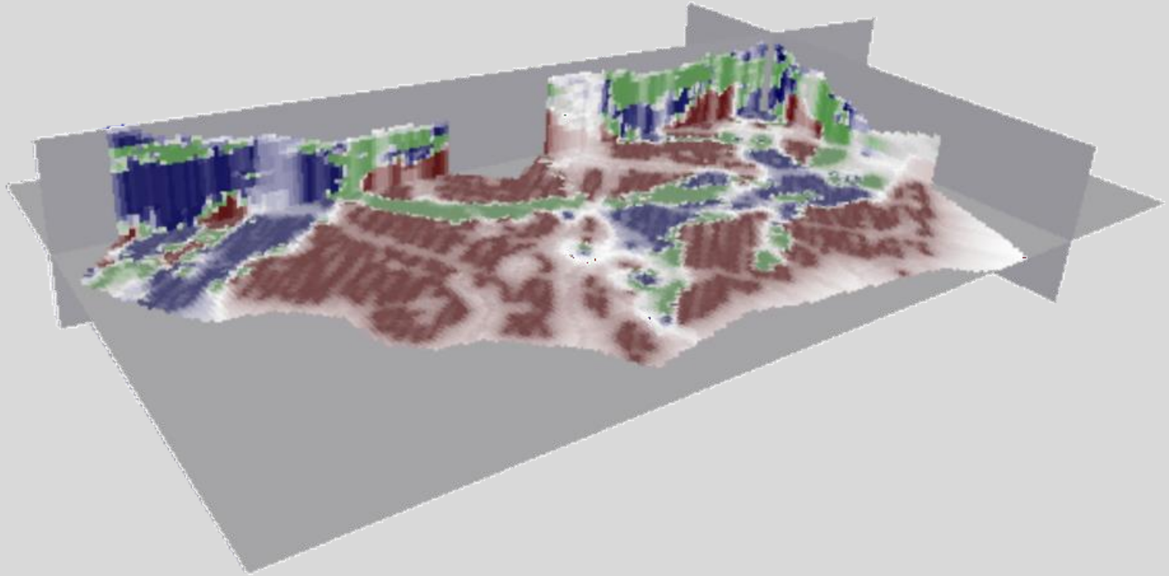
IK mode model



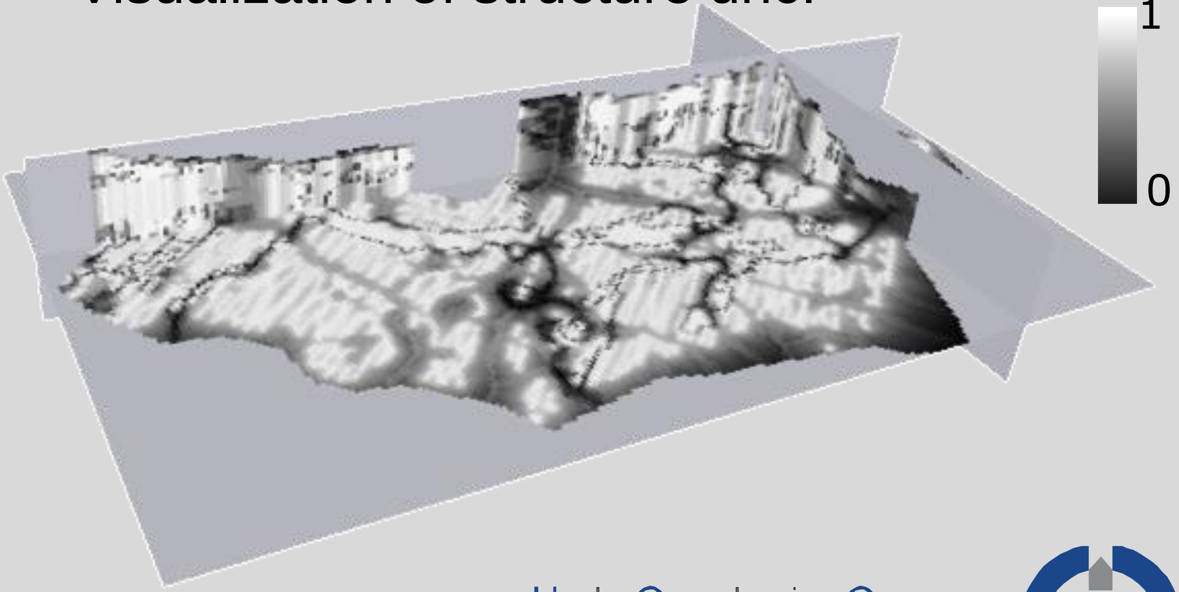
Workflow

5. **Calculate cluster model with highest probability from (3) – the IK mode model**

IK mode model



Visualization of structure unc.



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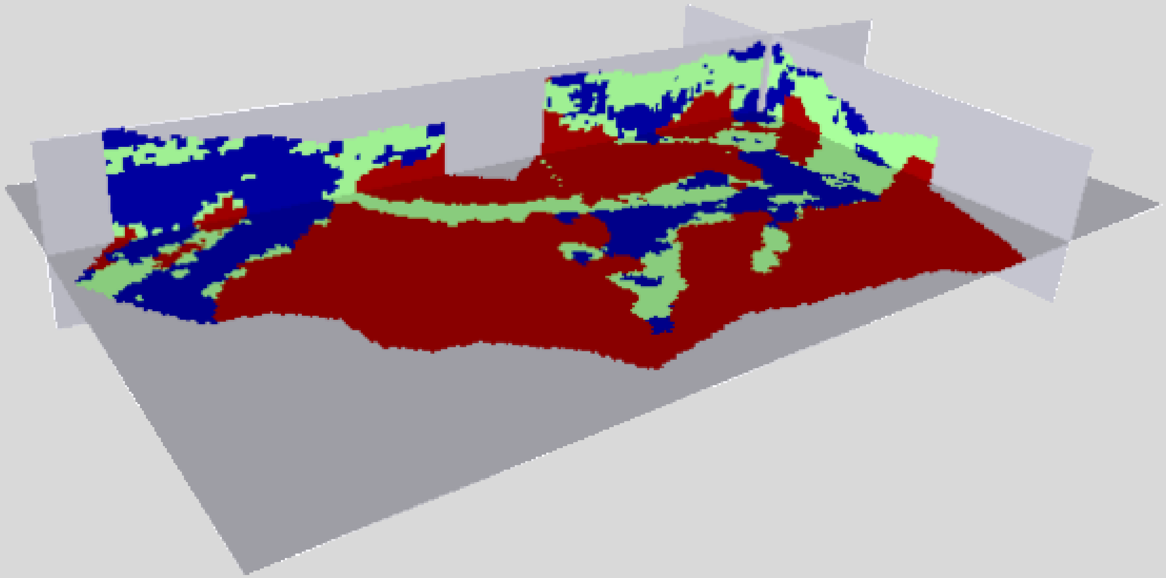
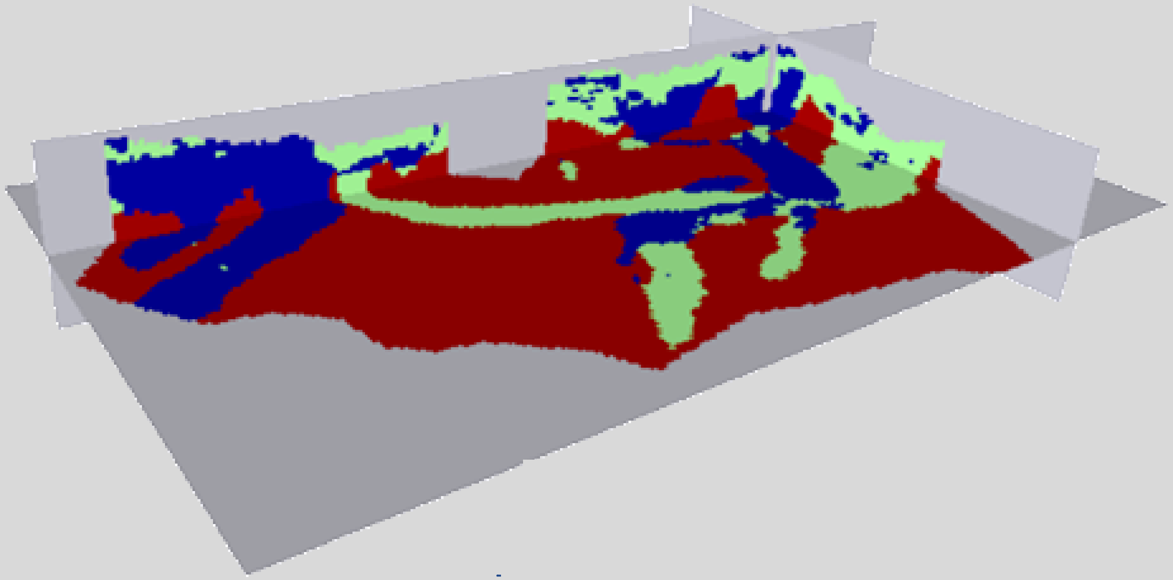
Workflow - intermezzo

IK mode model

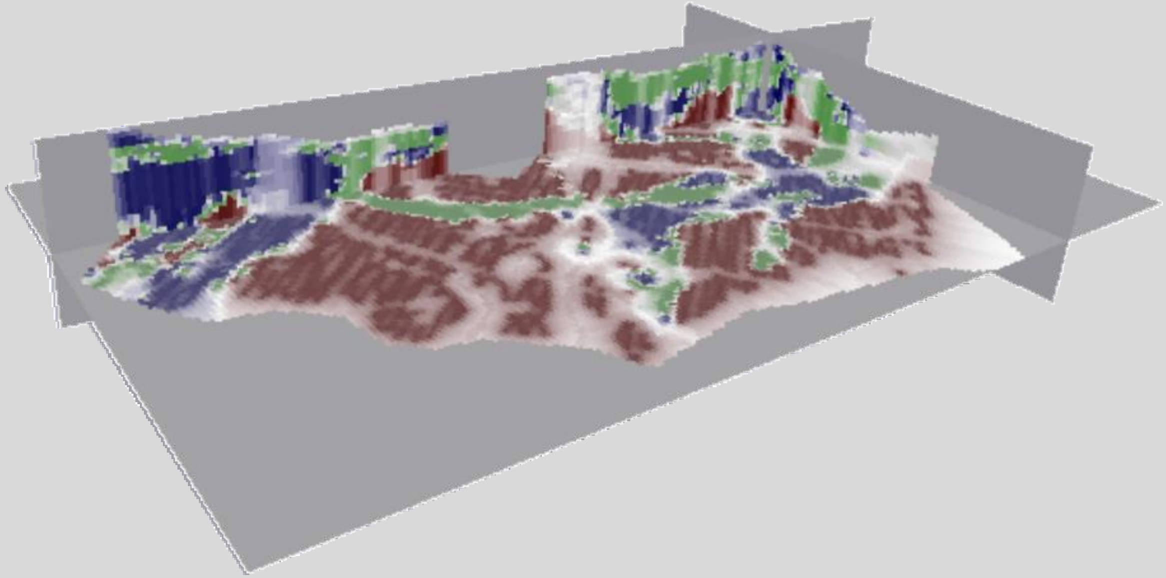


Manual model (simplified)

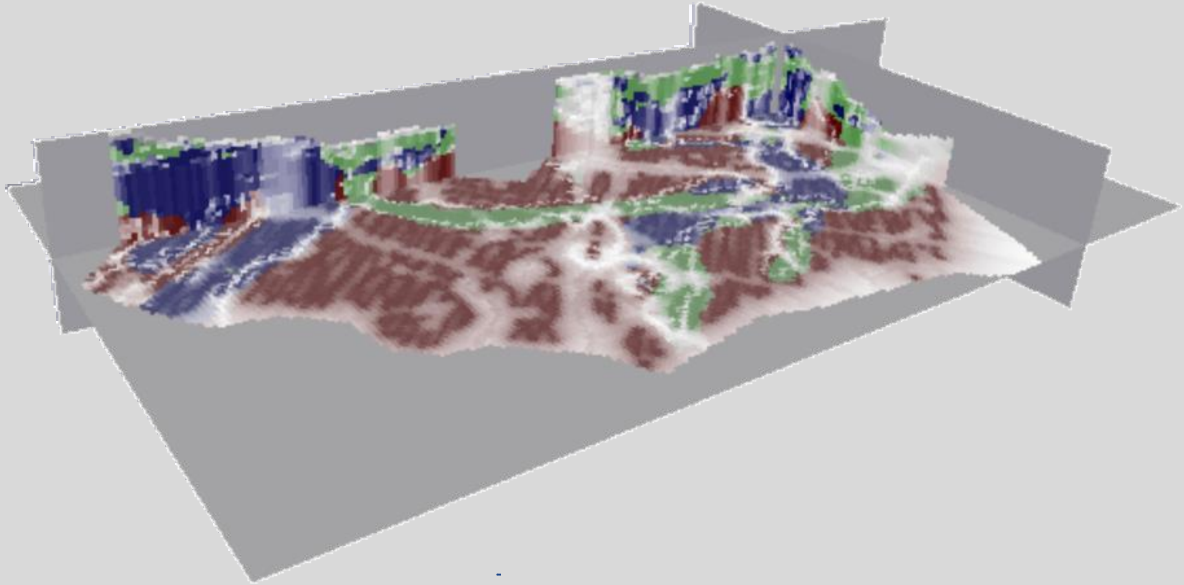


Workflow - intermezzo

IK mode model



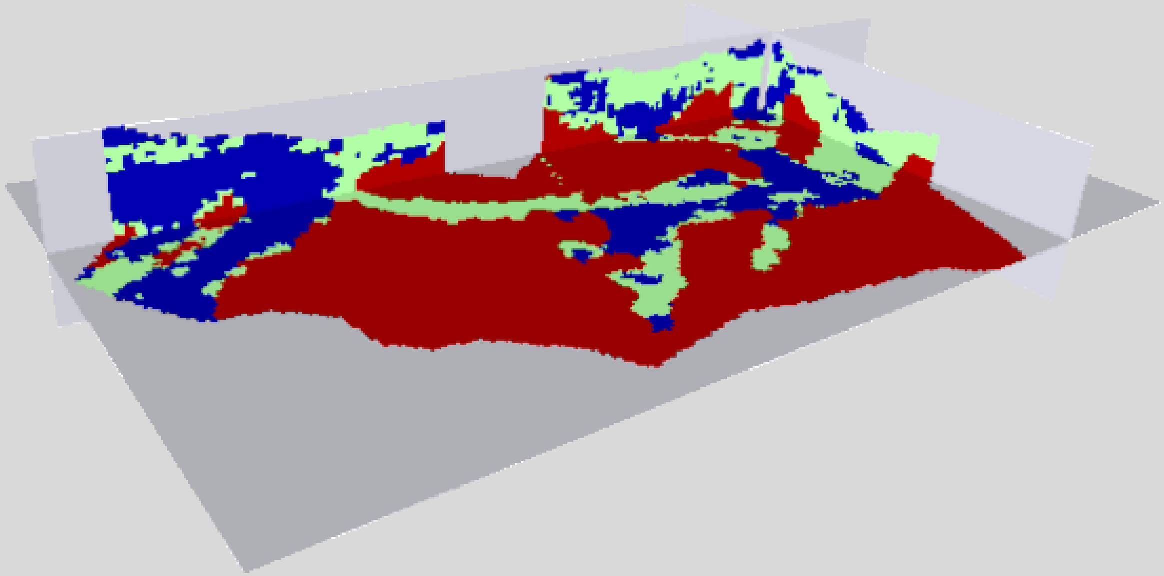
Manual model (simplified)

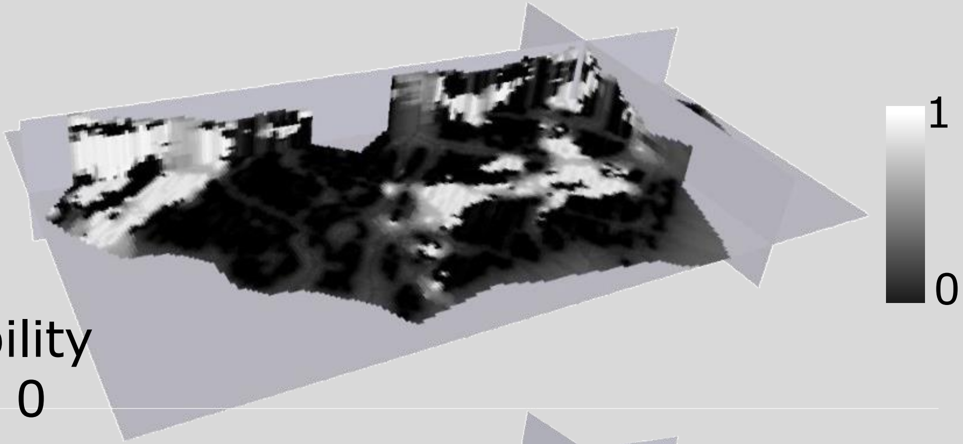


Workflow - continued

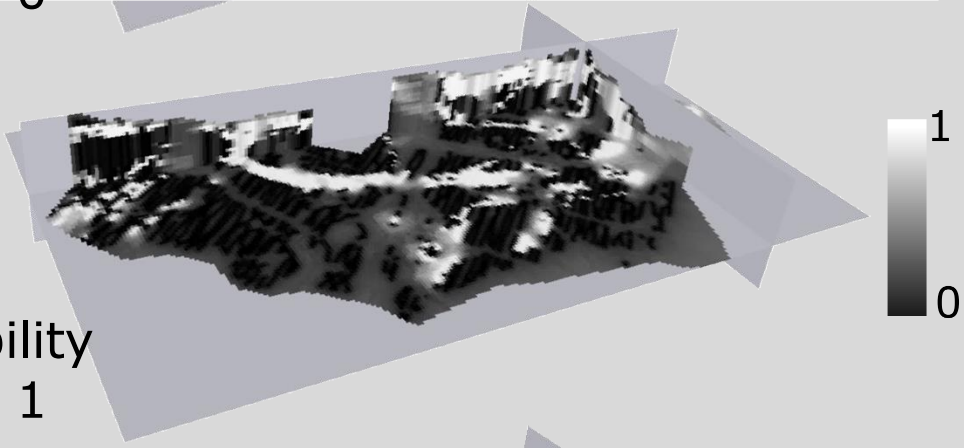
5. Calculate cluster model with highest probability from (3) – the IK mode model
6. Use mode model as TI together with probability distributions to calculate SNESIM model realizations

IK mode model

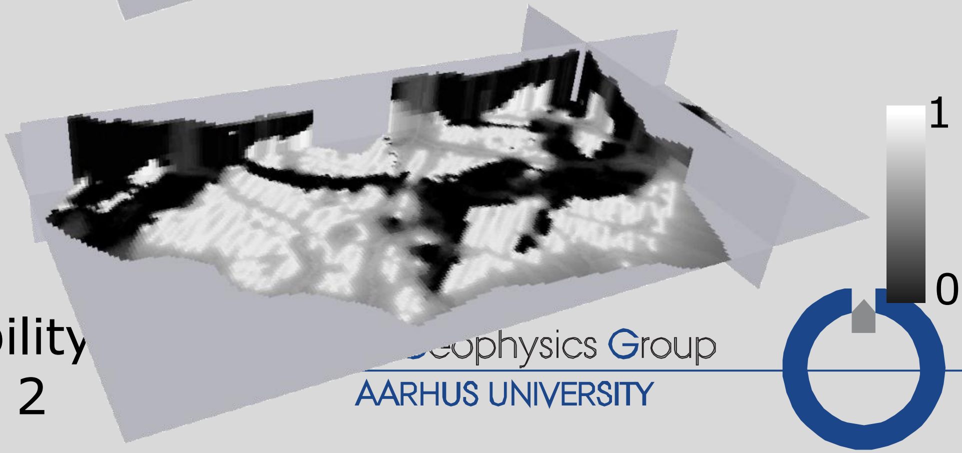




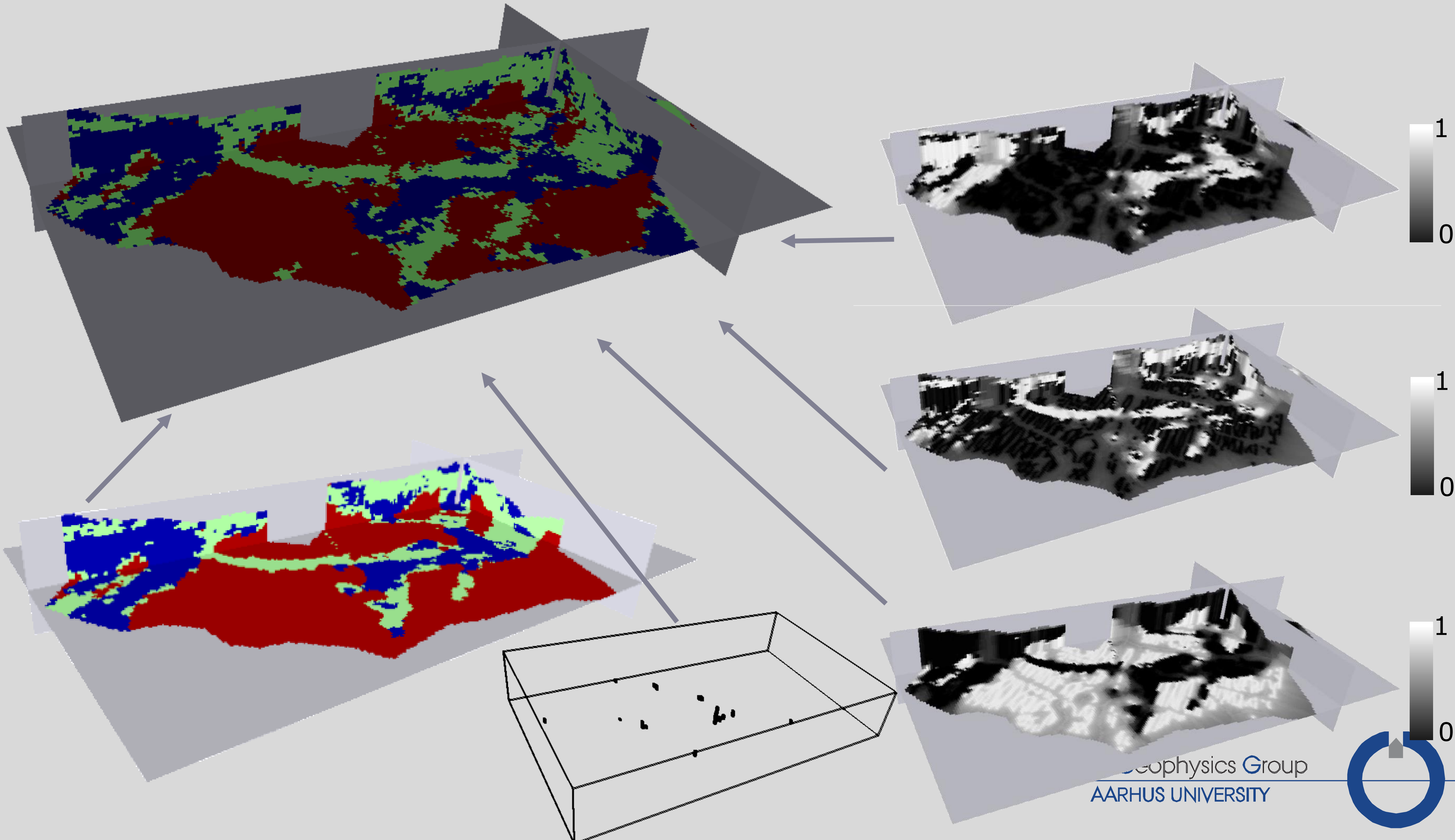
Probability cluster 0



Probability cluster 1



Probability cluster 2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