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Outstanding Student & PhD candidate Presentation contest

Towards structure-based joint geological-geophysical inversion for improved characterization of geothermal reservoirs

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Motivation

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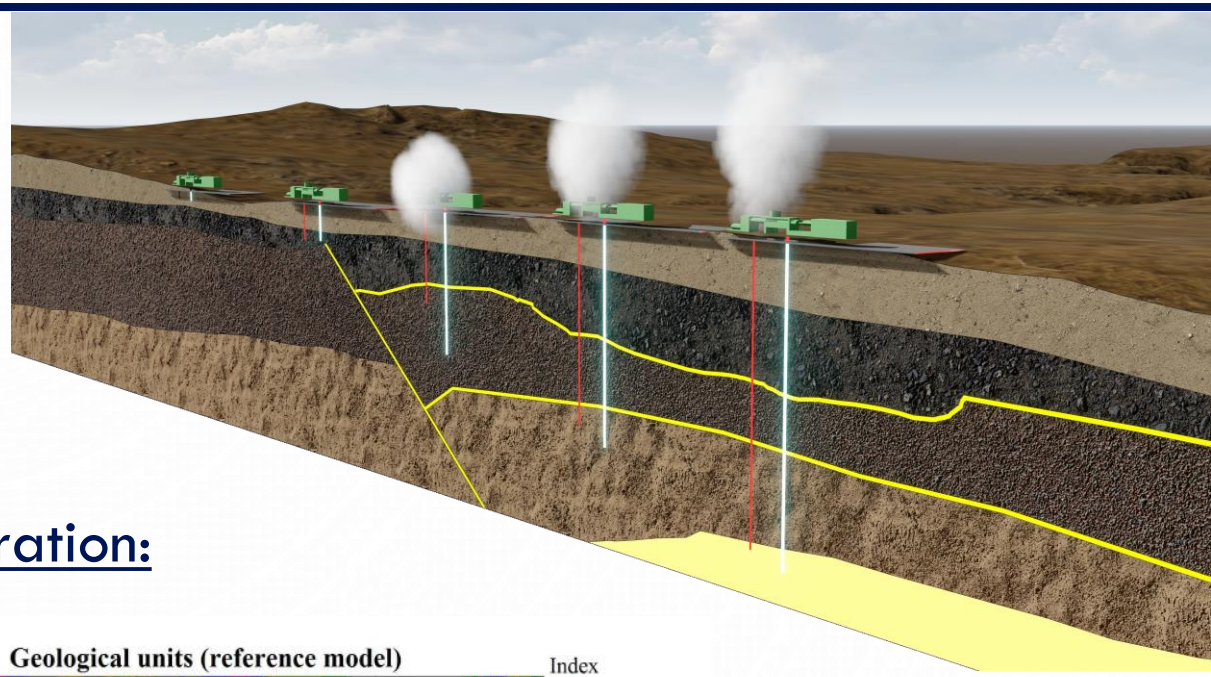
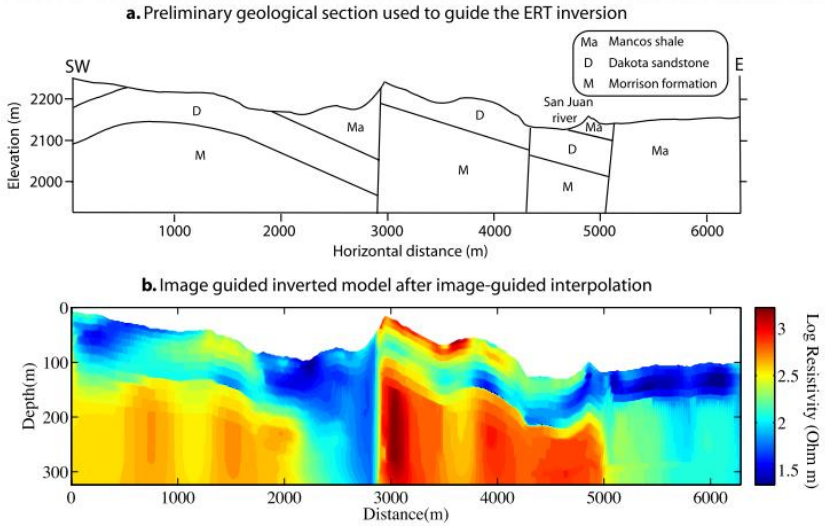
Why?

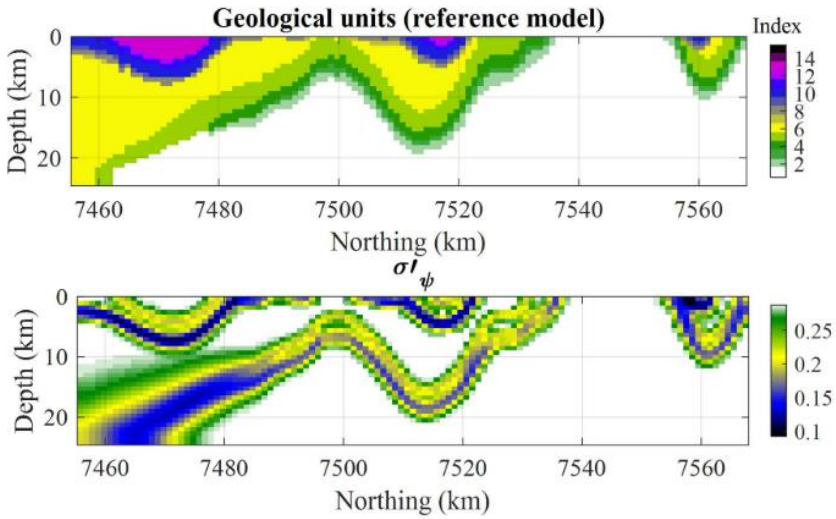
- Increase efficiency in geothermal systems
- Improve subsurface images by integrating geological models which can result in sharp subsurface interfaces



Current methods of geological-geophysical integration:



(Zhou et al. 2014)



(Giraud et al. 2021)

Motivation

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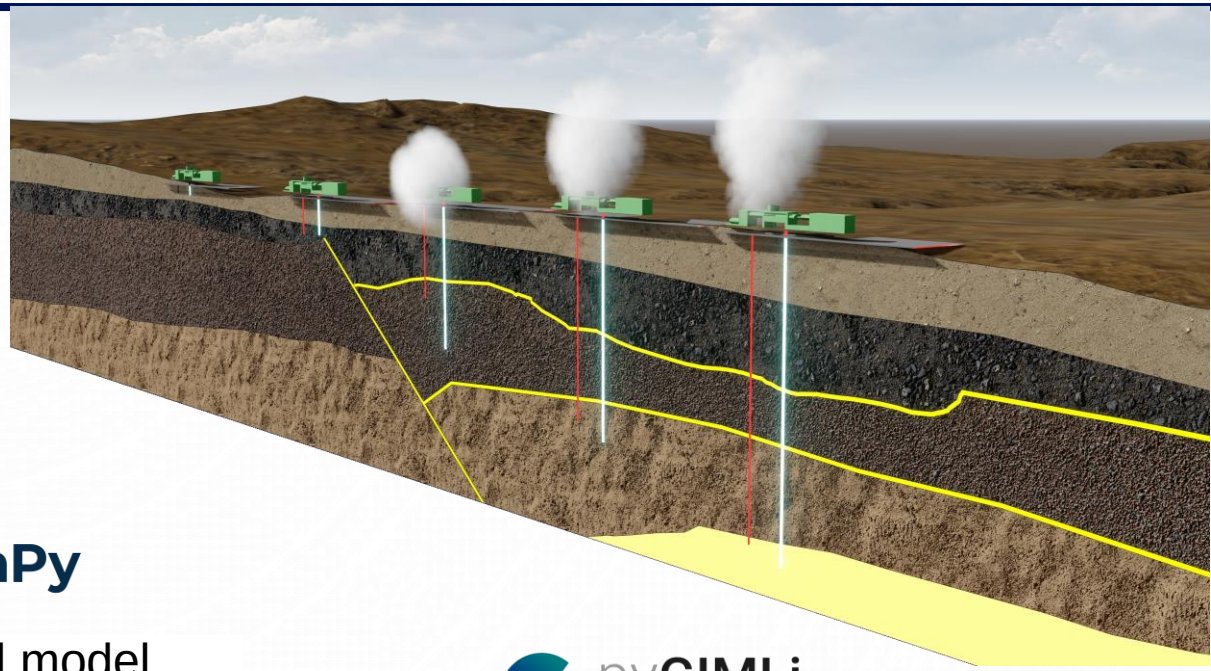
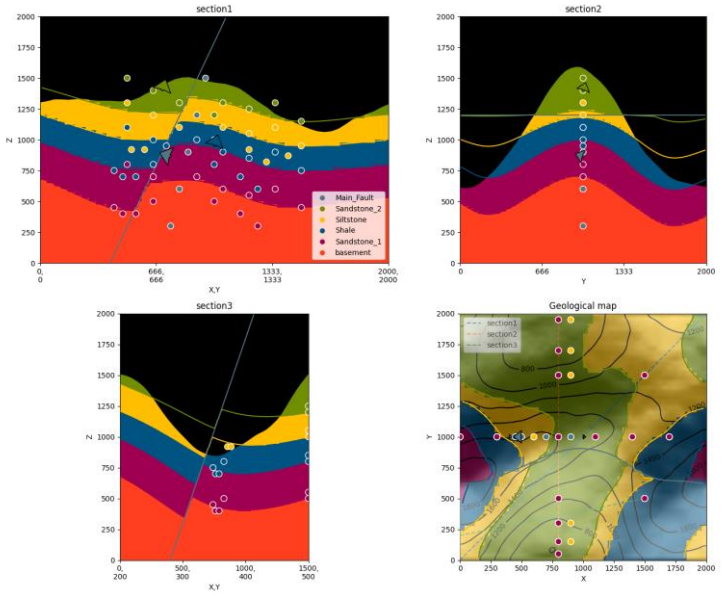
Proposed method of geological-geophysical integration:

- Geometric inversion using an initial geological model and geophysical parameter field

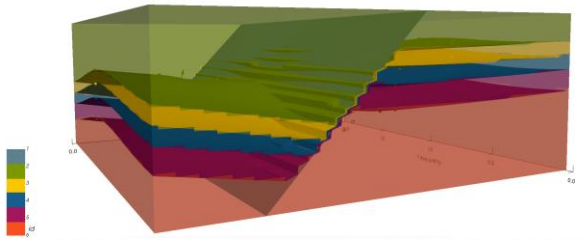




(de la Varga et al., 2019)

GemPy

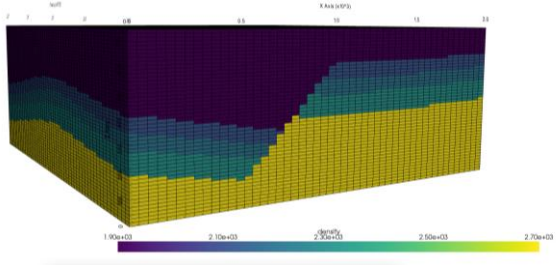
Geological model



pyGIMLi

Geophysical Inversion & Modelling Library

Geophysical parameters



Multiple geophysical methods

Methods

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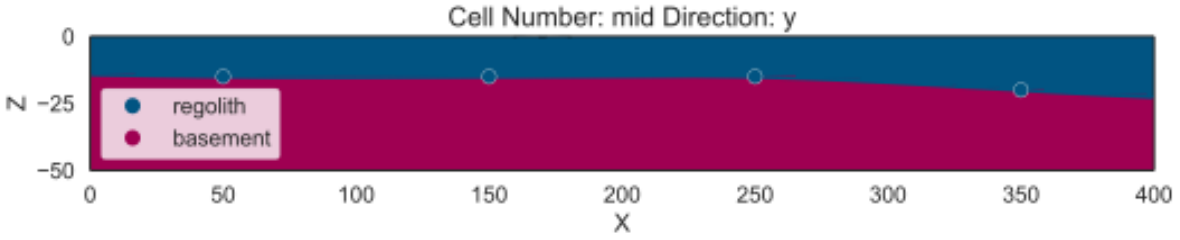
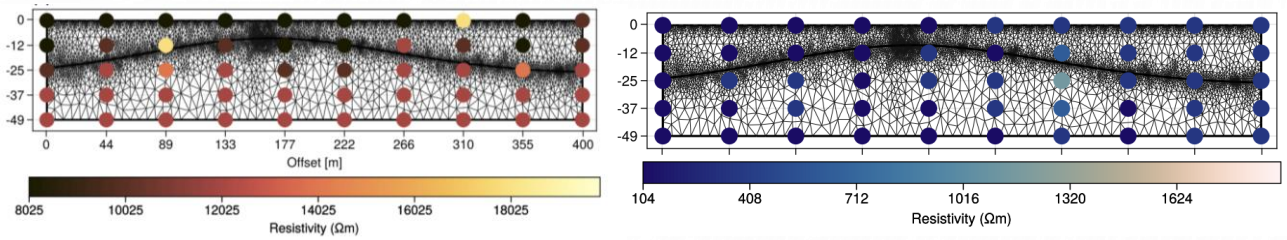
Geometric inversion : Constant or changing geophysical parameters with surfaces allowed to move within geometrical bounds.

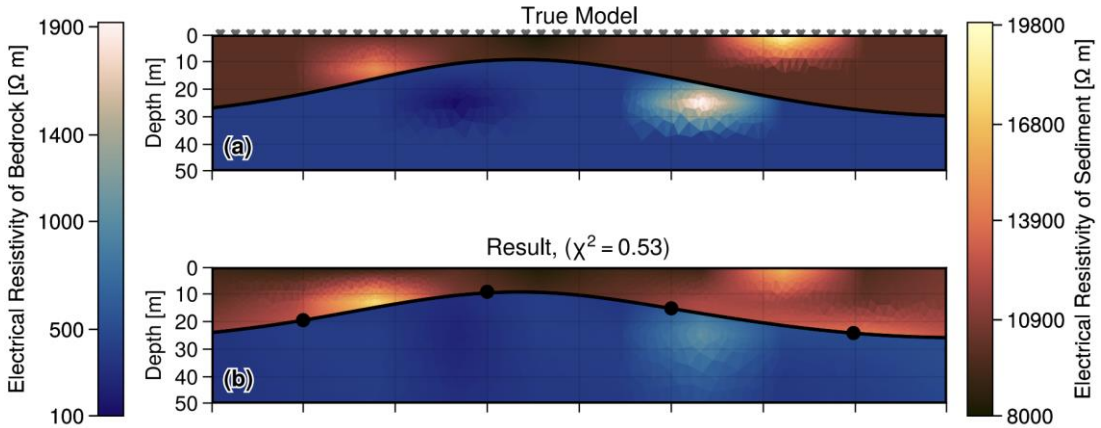
Interface points



Geophysical parameters



Förderer et al. (2021)



Förderer et al. (2021)

Synthetic Case – Constant Layer Parameters

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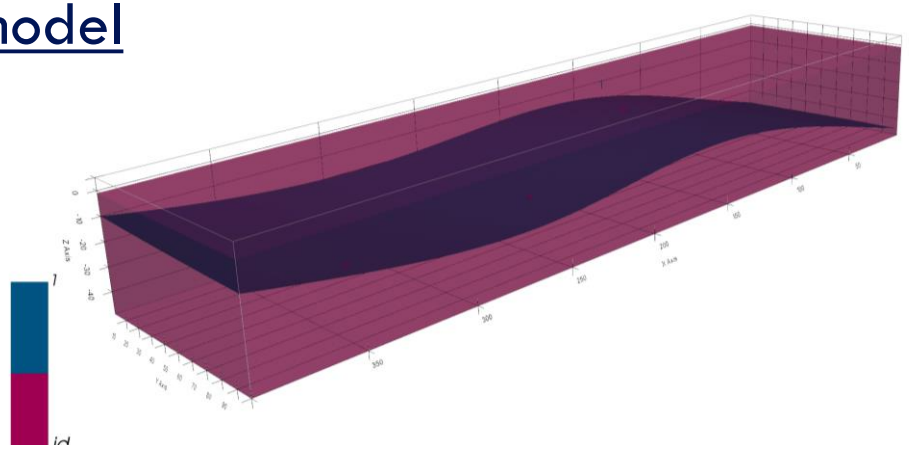
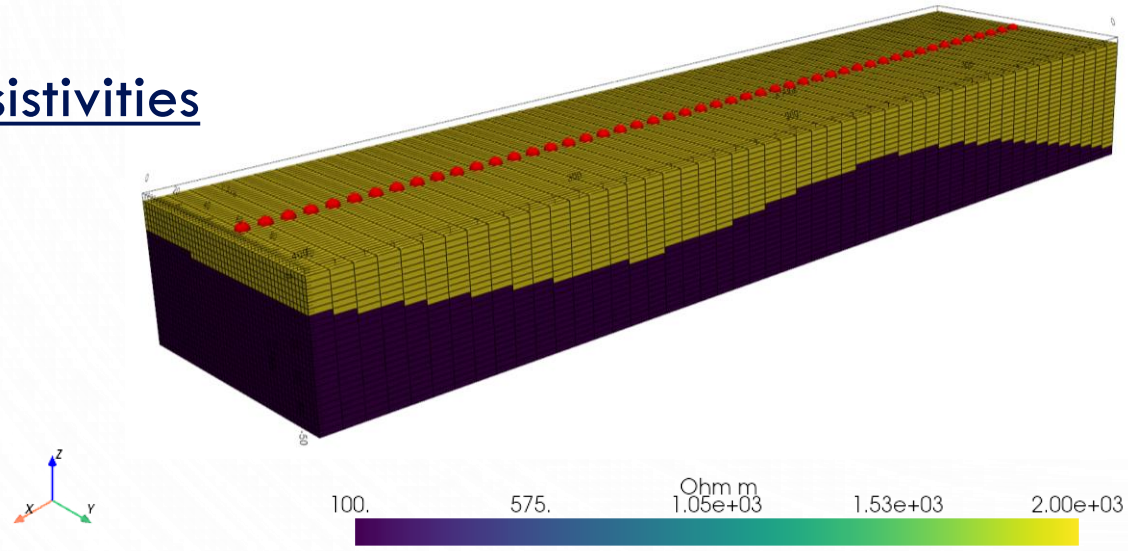
GemPy model



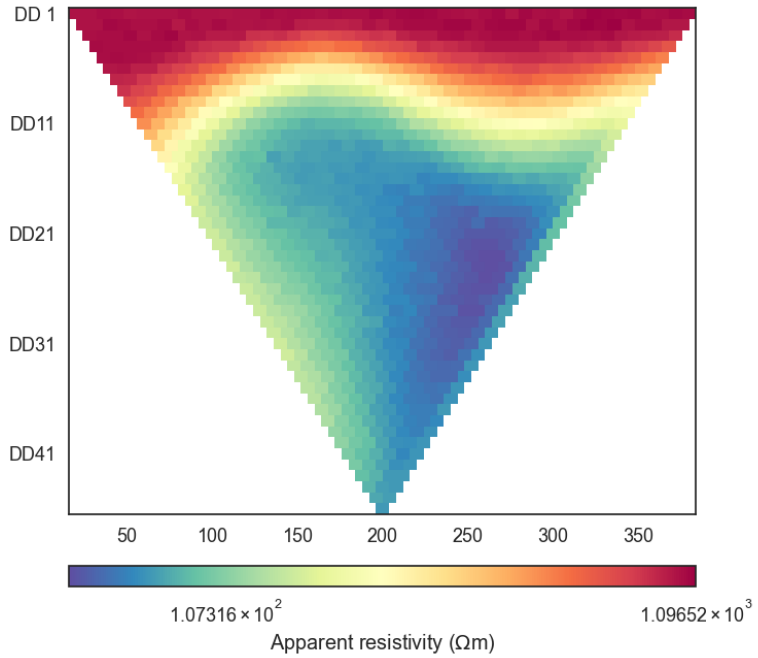
Resistivities



Model information:

- 2 layers
- 4 interface points
- Constant resistivity in each layer
- 49 electrodes (dipole-dipole array)

Synthetic pseudosection



Preliminary Inversion

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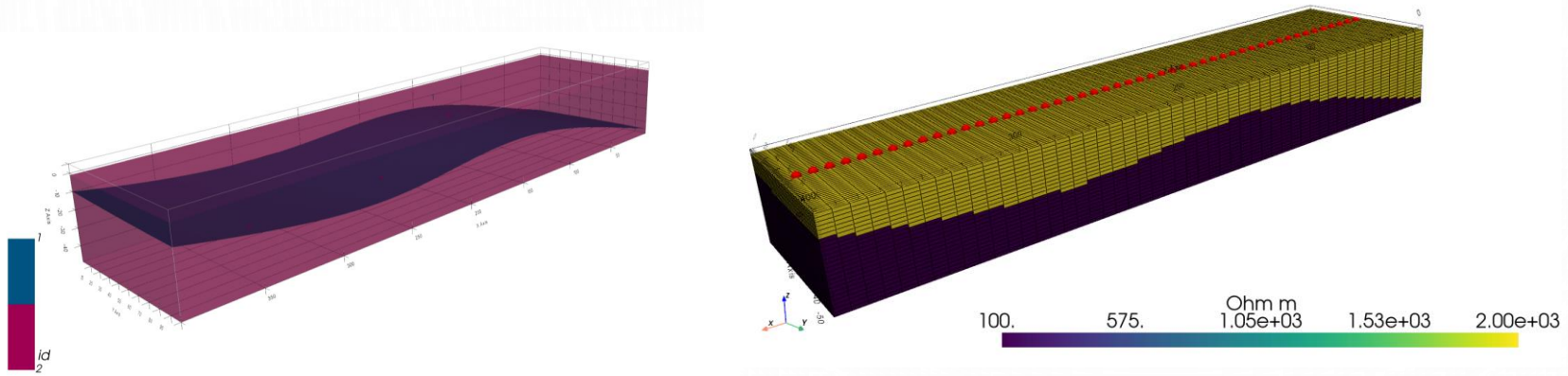
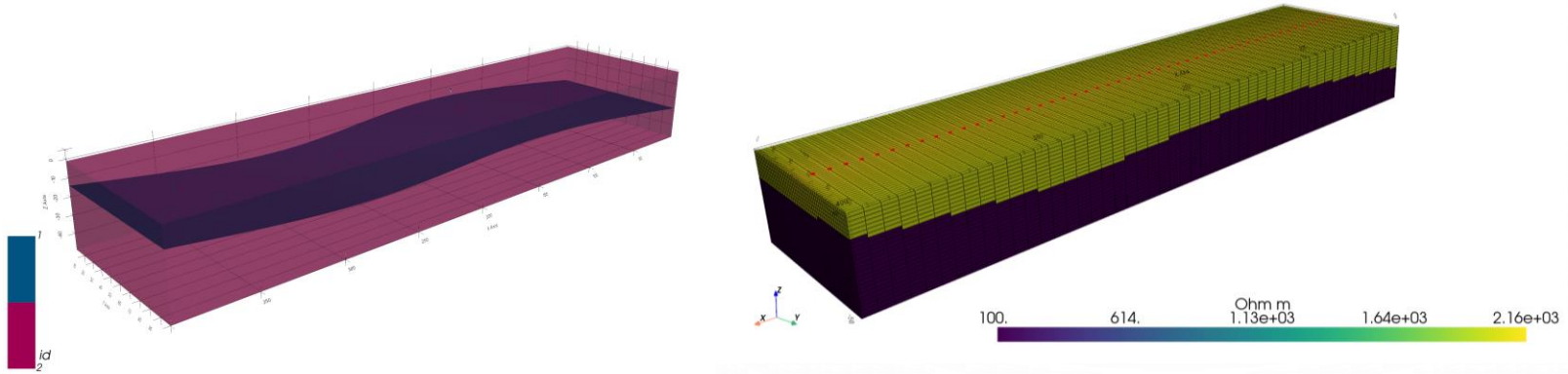
Synthetic base case



Inversion result



Regularization of model parameters

Smoothing and/or damping of all directions of interface points and parameter points.

- X = Damping
- Y = Damping
- Z = First-order smoothing

- Top layer = Damping
- Bottom layer = Damping

Preliminary Inversion – 2D View

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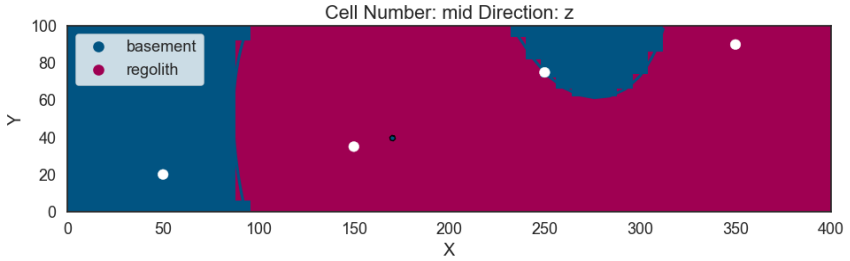
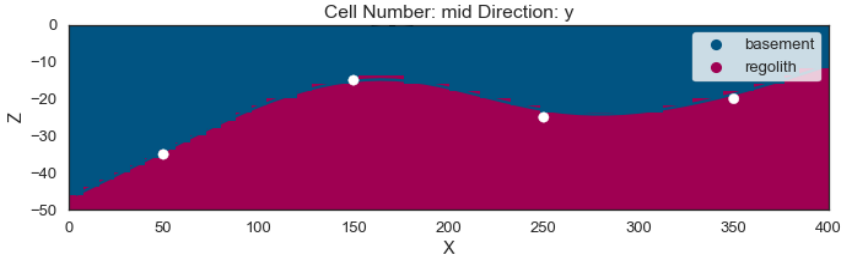
X – Y

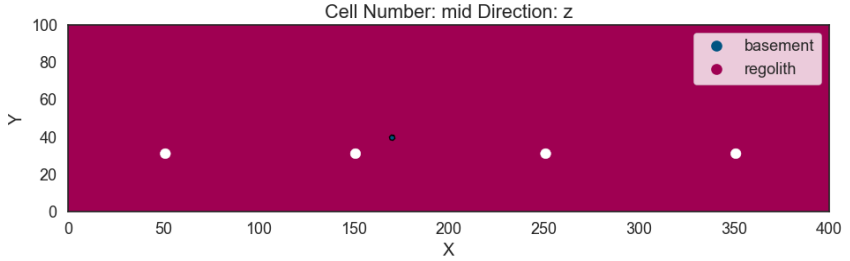
X – Z

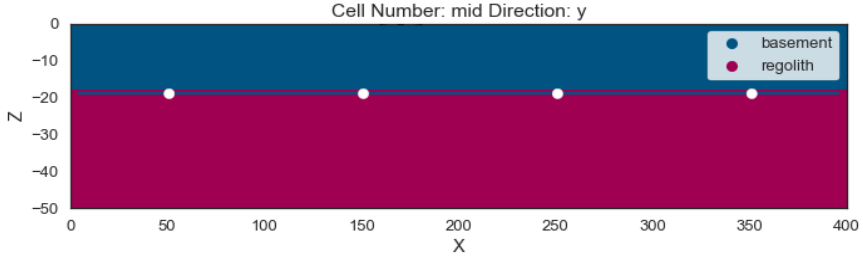
True model



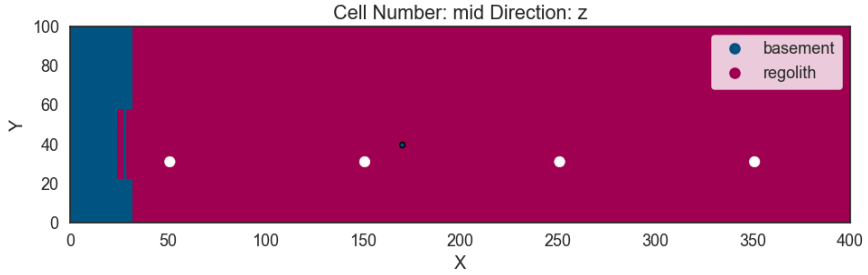


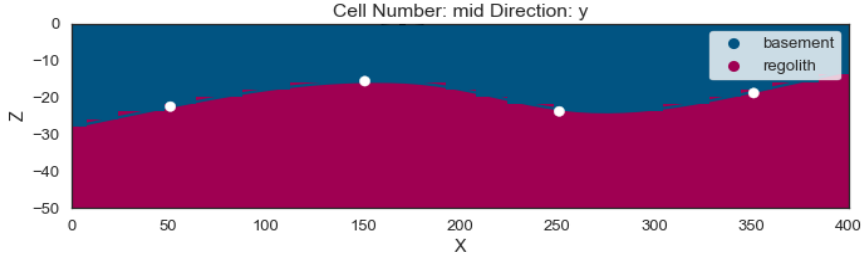
Starting model





Inversion result





Interface points are not moving in
X or Y direction with respect to the starting model.

Some interface points were recovered at the right depth but not all.

Sensitivity Analysis

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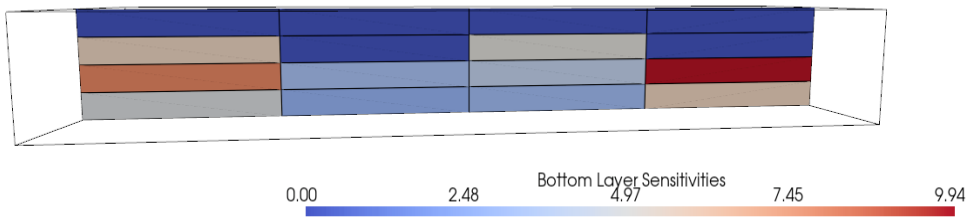
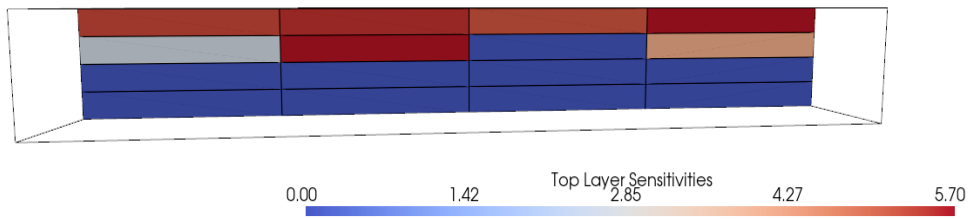
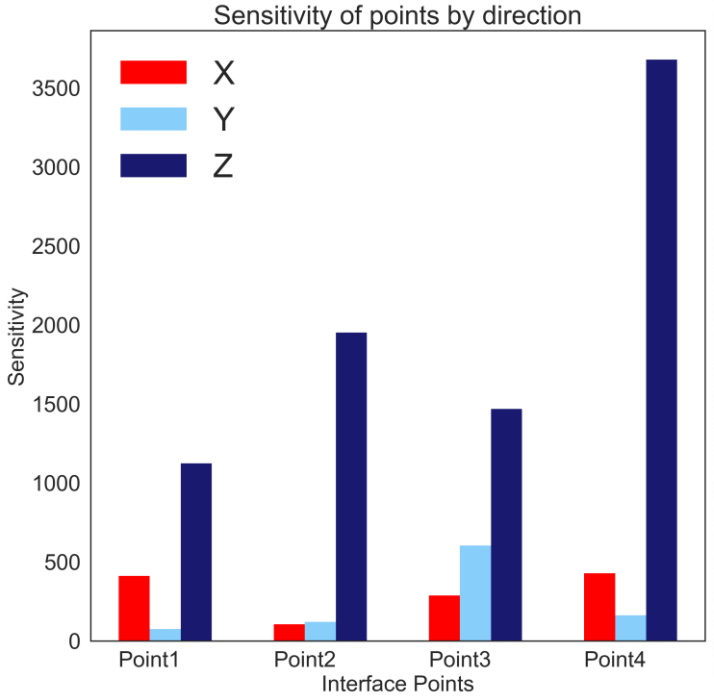
Geophysical parameters

The bottom layer shows higher sensitivity towards the right edge which correlates with the high sensitivity seen in interface point 4.

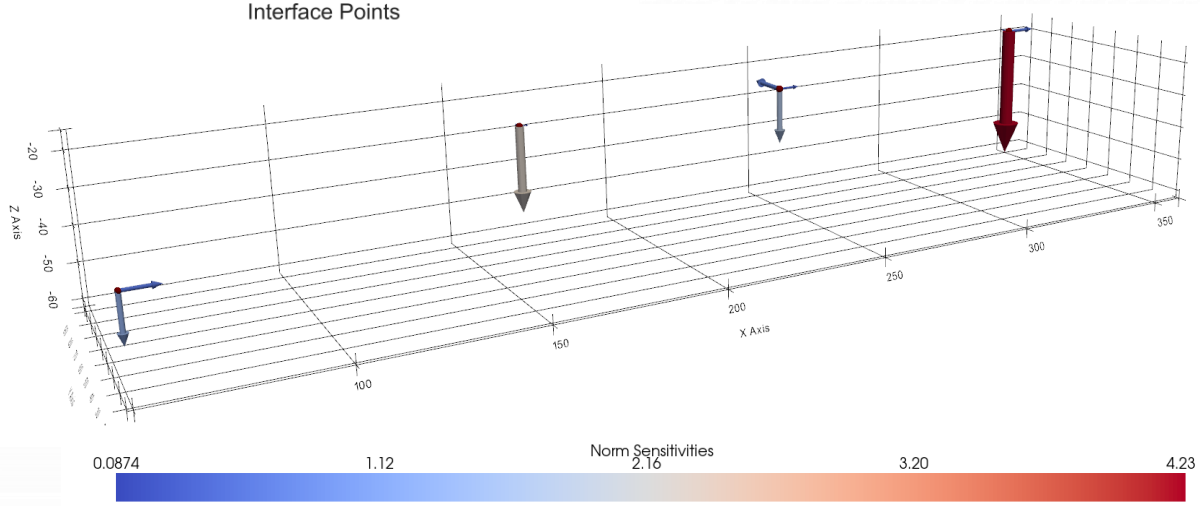






Interface points

This model presents much higher sensitivities in the Z direction. In this case, X and Y direction could be discarded as model parameters.



Conclusions and Future Work

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- The geometric inversion was adapted to a ERT 3D synthetic case study.
- A sensitivity analysis was done to analyze the sensitivity of geophysical properties and interface points.
- For this model geometry, the sensitivities of the interface points in X and Y direction are smaller than Z.
- Further analysis is needed to understand the sensitivities of the geophysical parameters and if/how they are dependent on the interface points.
- This analysis helps to discard model parameters with low sensitivities and allow for lower-parametrization for more complex models.
- Future work involves more complex models and adapting other geophysical methods that are common for deep geothermal exploration.

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Thank you for your attention!

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