Geologically Consistent Prior Parameter Distributions for Uncertainty Quantification of Geothermal Reservoirs

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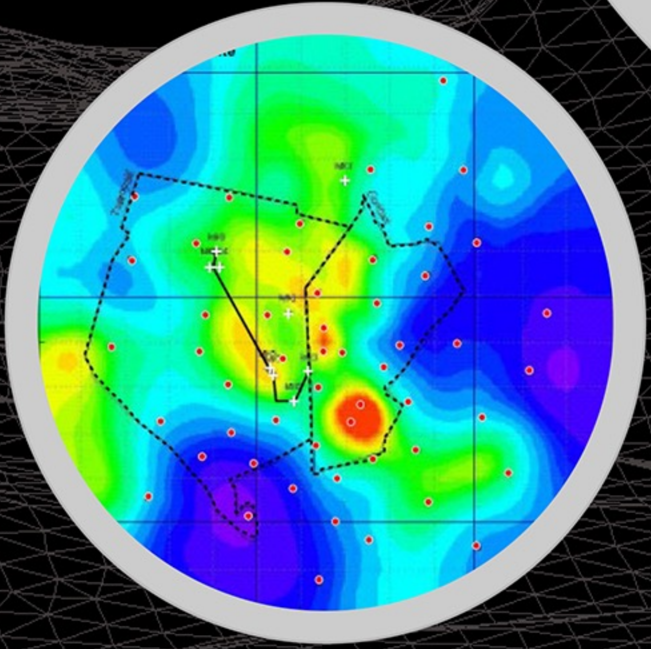

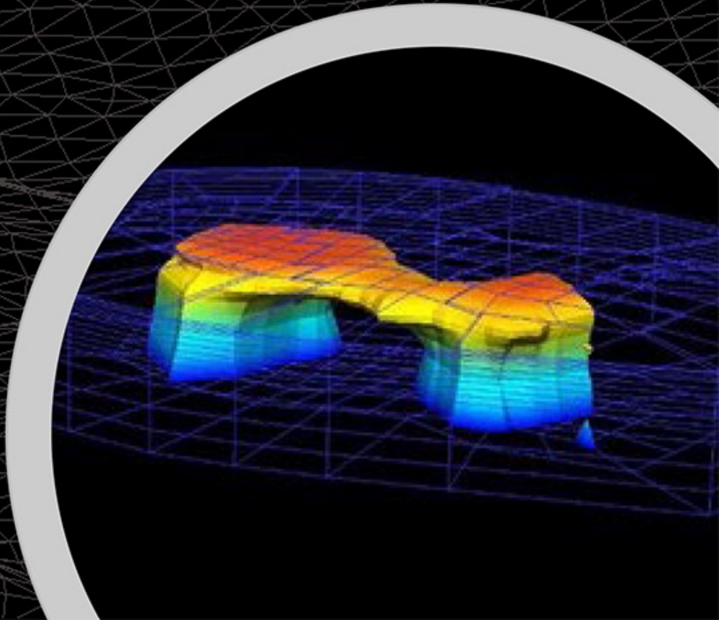

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Outline

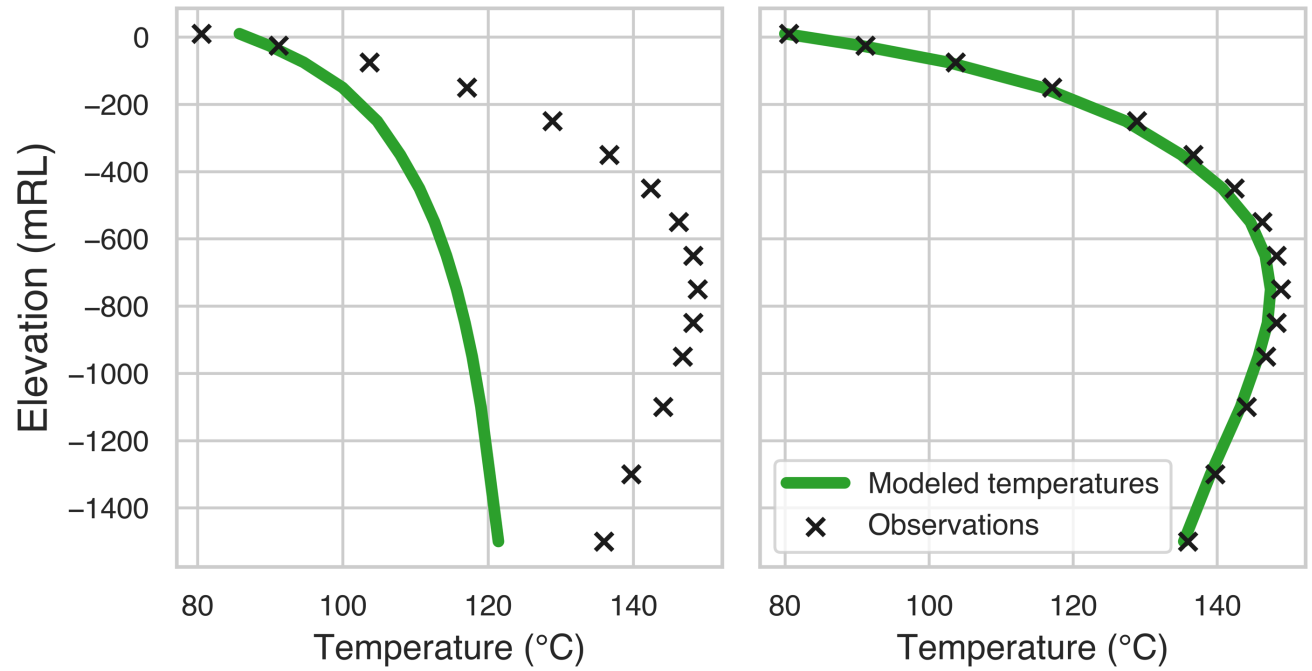
- Background
  - Model calibration and the Bayesian approach
  - Prior distributions
- Prior distribution characterisation
  - Reservoir model
  - Sampling methods
- Comparisons
- Conclusions and Future Work

Background

Reservoir Model Calibration

Adjust model parameters (permeabilities, upflows)

Evaluate match with measured data (temperatures, pressures)



Bayesian Model Calibration

- The solution to the calibration problem in the Bayesian framework is a probability distribution called the posterior.
- The modeler's prior beliefs are combined with measured data to form the posterior.

$$\underbrace{p(\theta|y)}_{\text{Posterior}} \propto \underbrace{p(y|\theta)}_{\text{Likelihood}}\underbrace{p(\theta)}_{\text{Prior}}$$

Prior Distributions

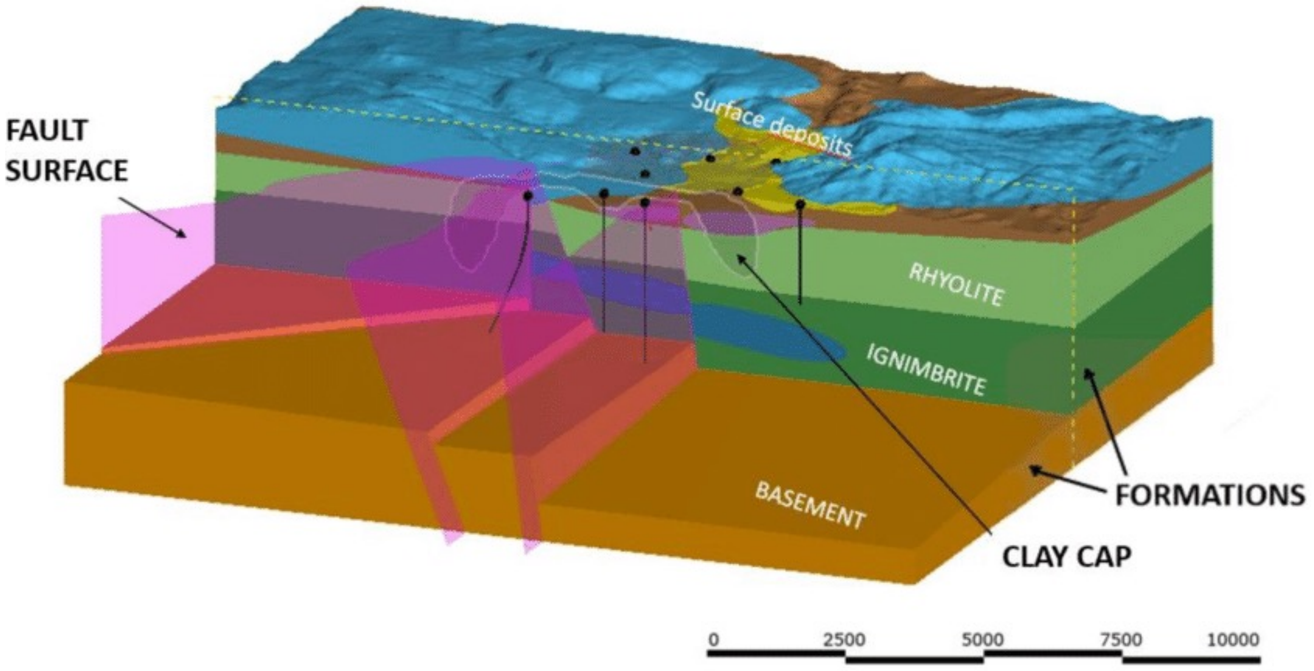
- Characterising the prior can be difficult!
- Common practice in reservoir modeling is to model permeabilities using a multivariate normal distribution
- However, this can have geologically inconsistent results

Aims

- Characterize a prior that follows simple geological principles
- Compare the model outputs produced by this prior and a prior constructed in the typical, naïve manner

Prior Characterisation

Reservoir Model



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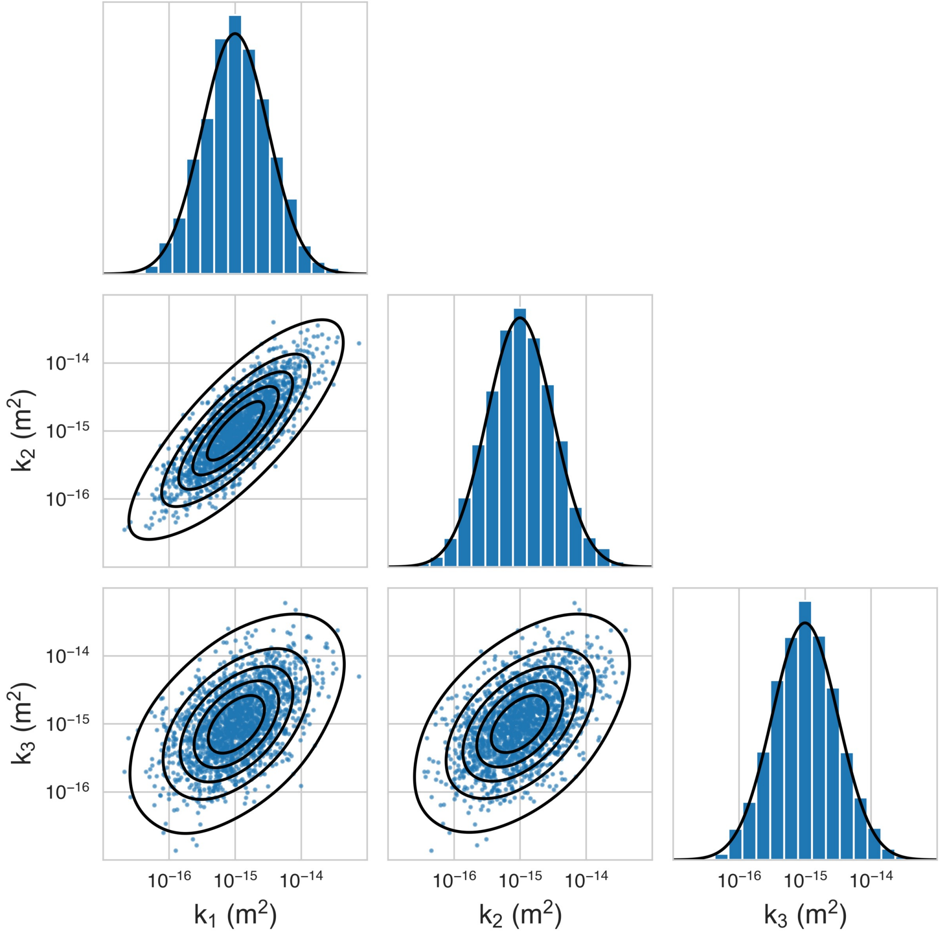
Prior Characterisation

- We aimed to characterise a prior that followed geological principles, and one that didn't, but was otherwise very similar
- Both priors incorporated
  - Subsurface permeabilities
  - Deep mass upflows

Base Rock Type Permeabilities



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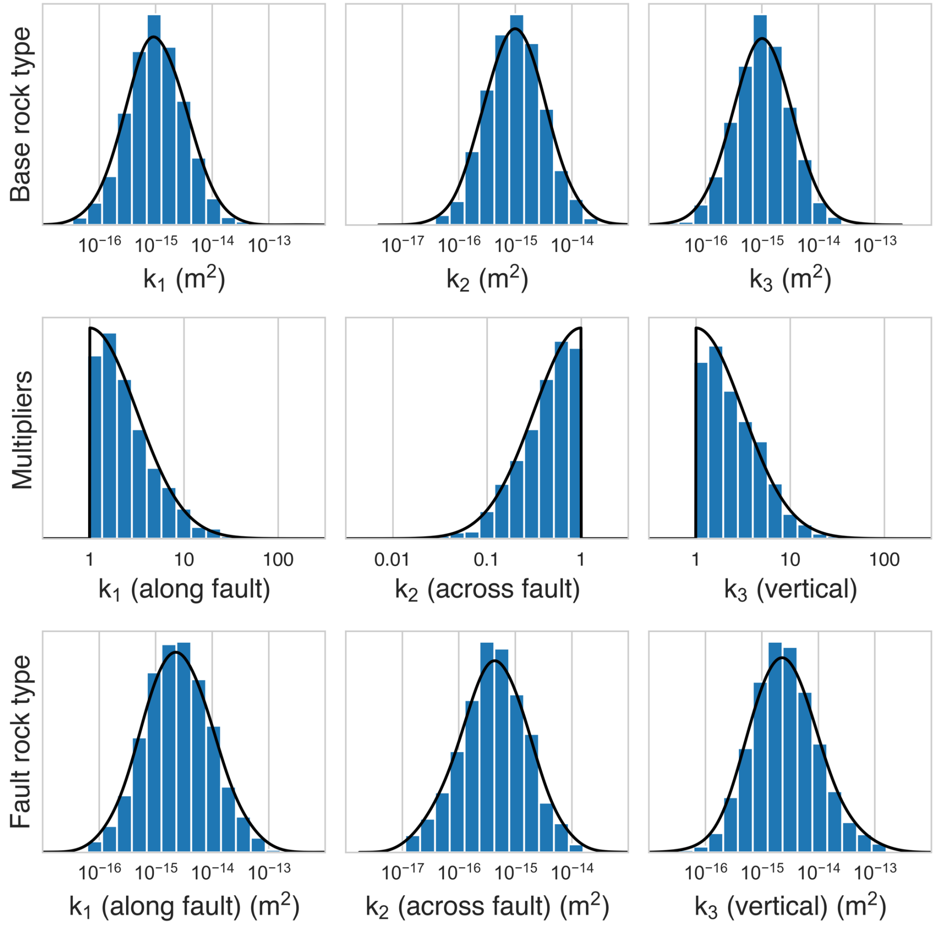
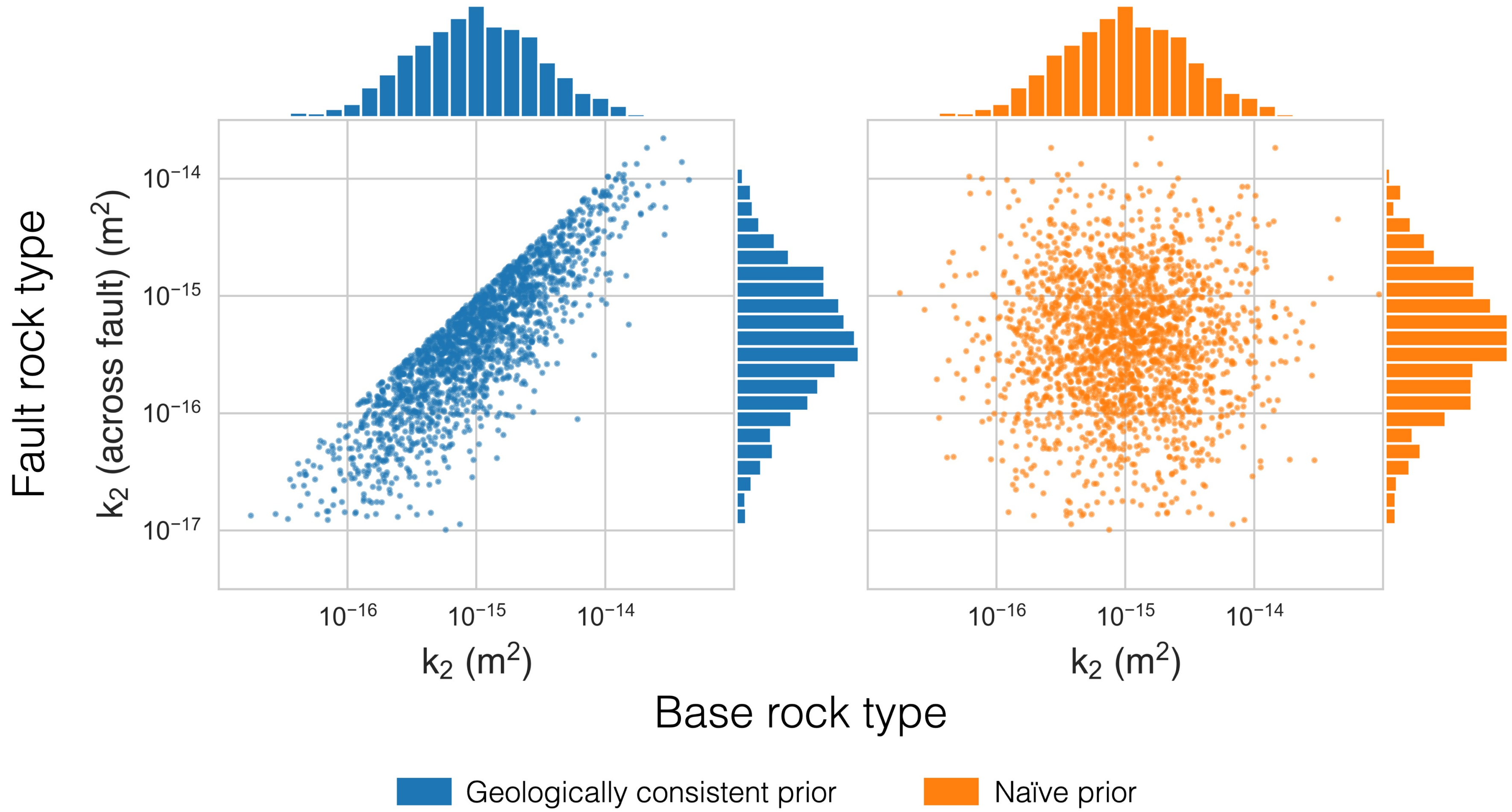
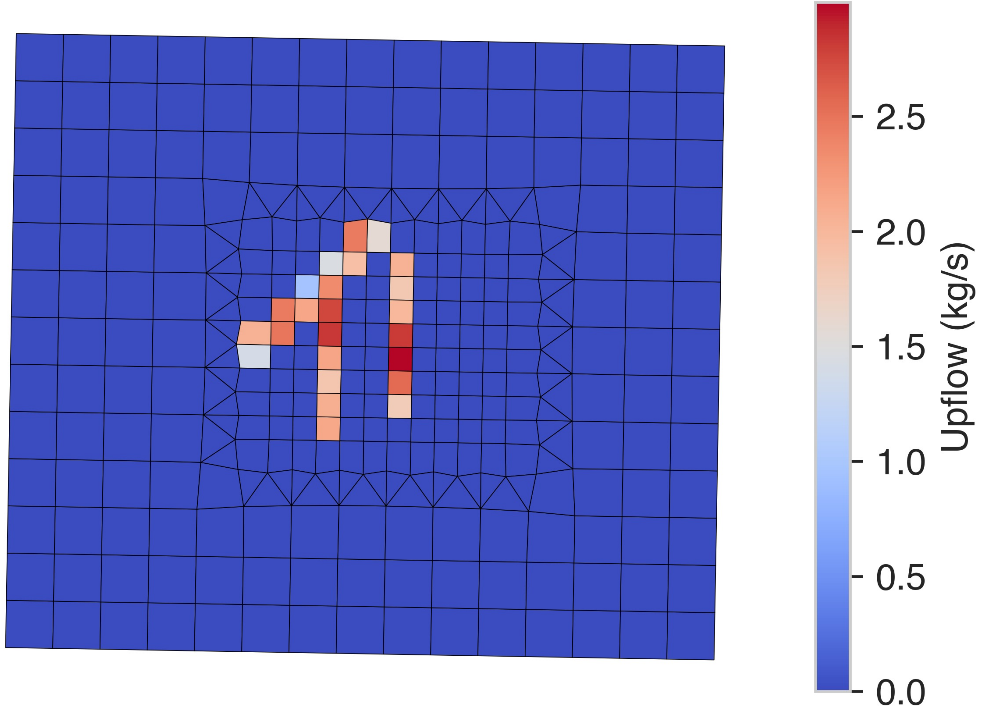
Other Rock Type Permeabilities

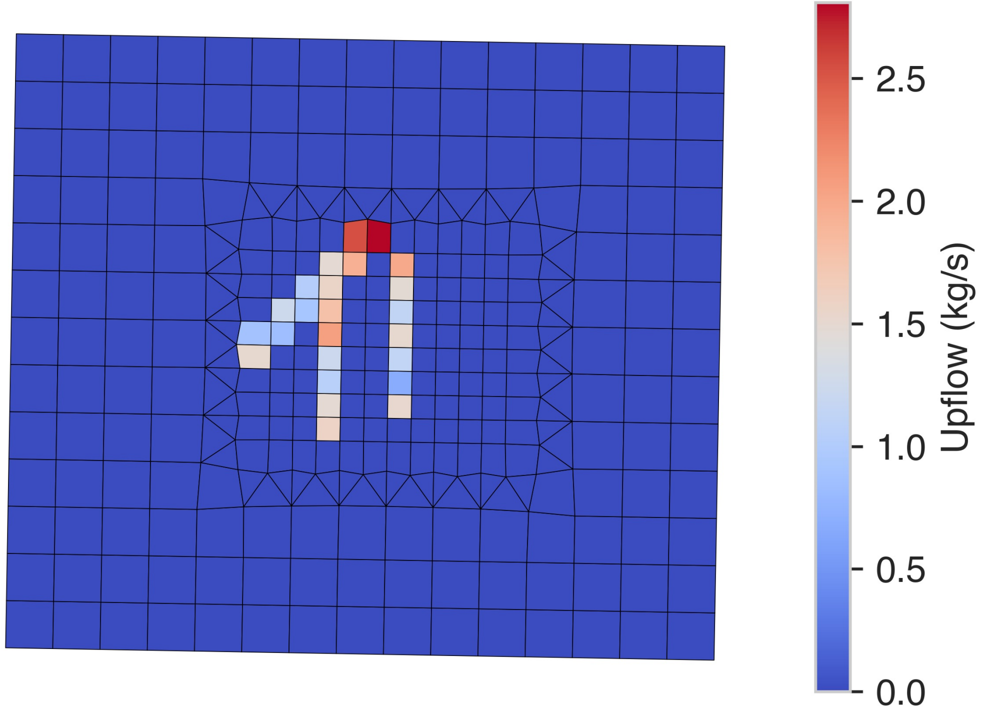


Naïve Prior Permeabilities



Deep Mass Upflows



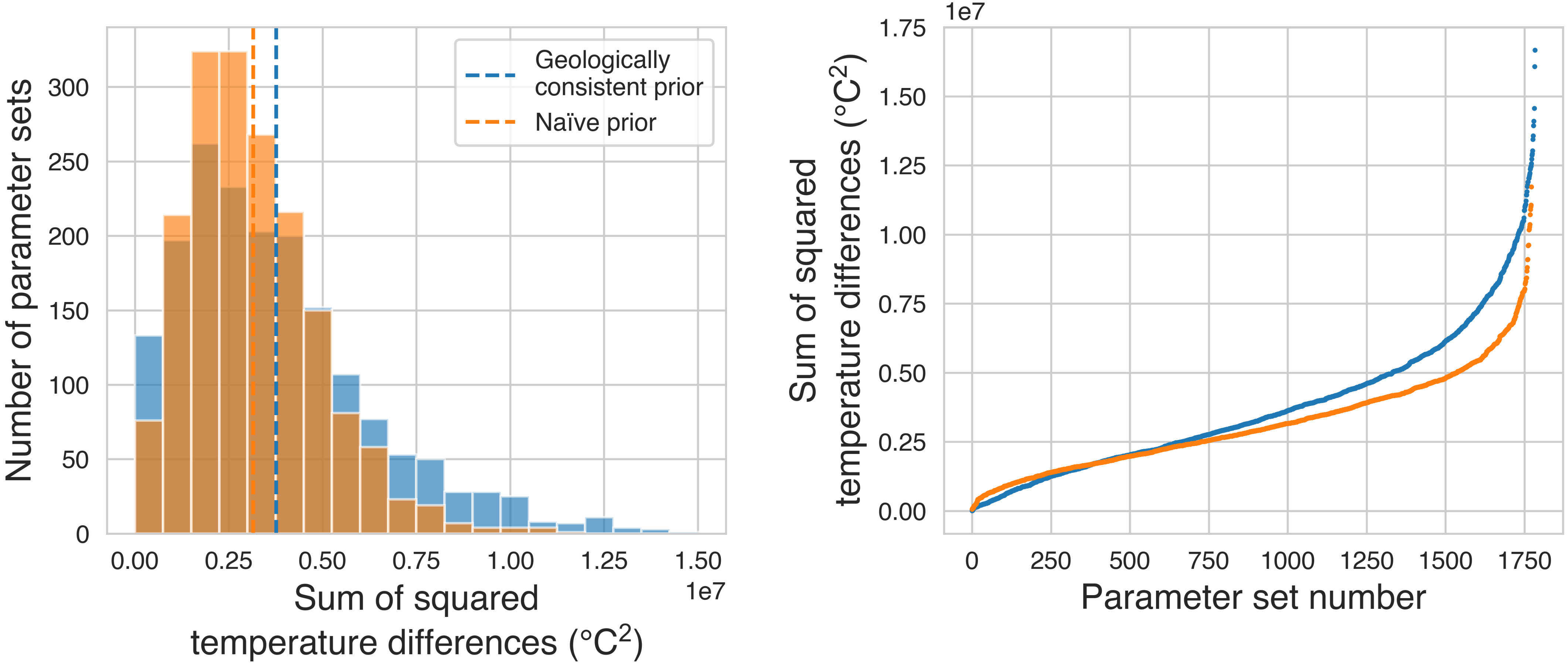


Comparisons

Comparisons

- Closeness of temperature profile outside reservoir to constant temperature gradient of 30°C/km
- Closeness of temperature beneath clay cap to 190°C
- Agreement between modeled temperatures and downhole temperature data
- Shapes of convective plumes produced

Temperatures Outside Reservoir



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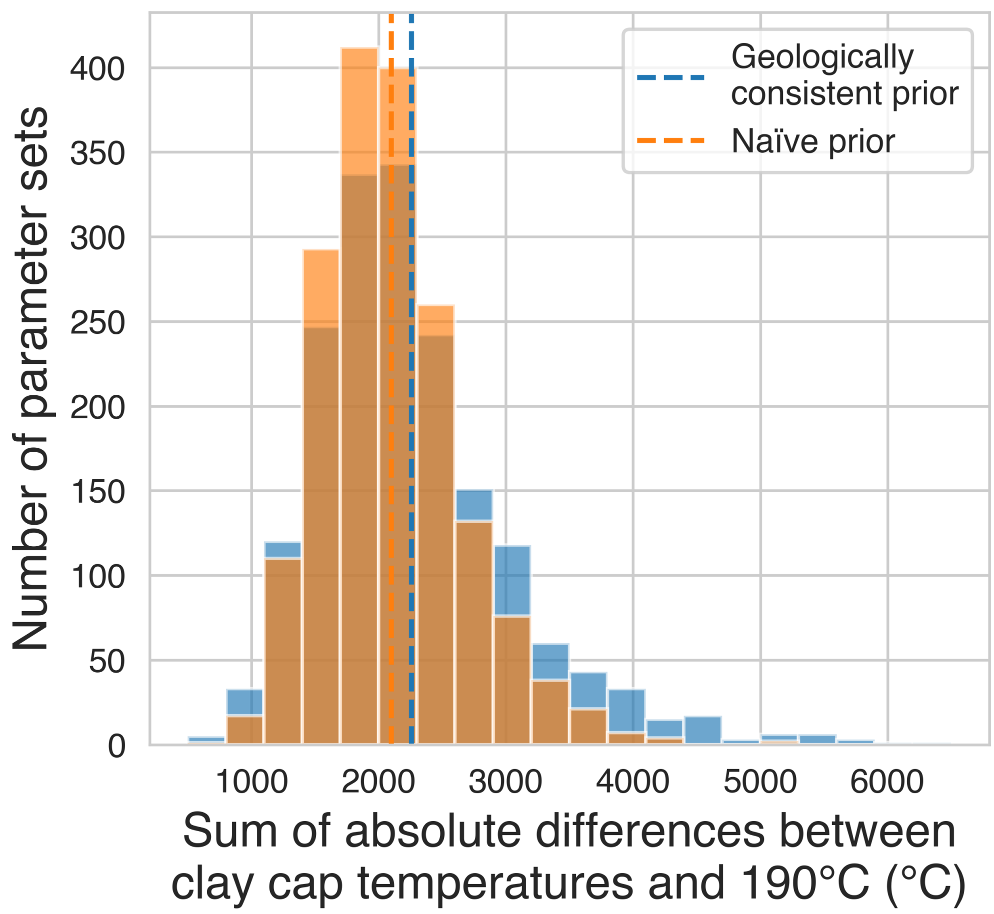
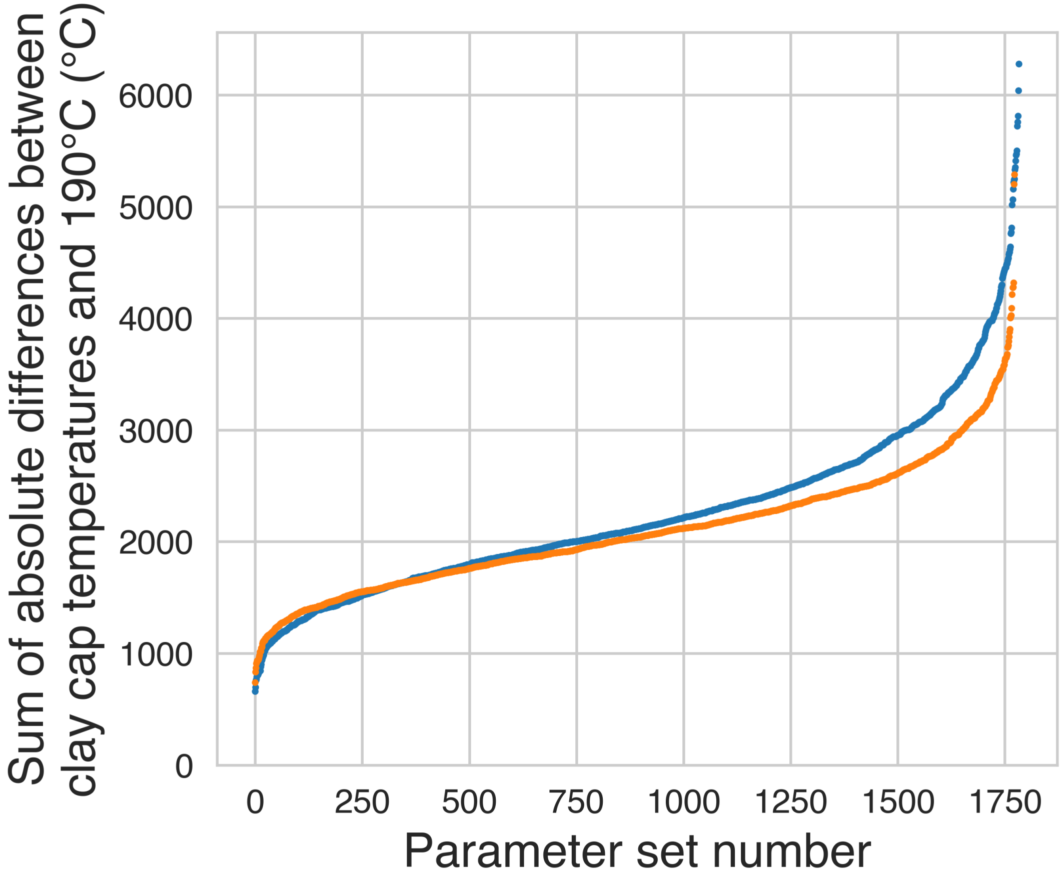
Temperatures Beneath Clay Cap





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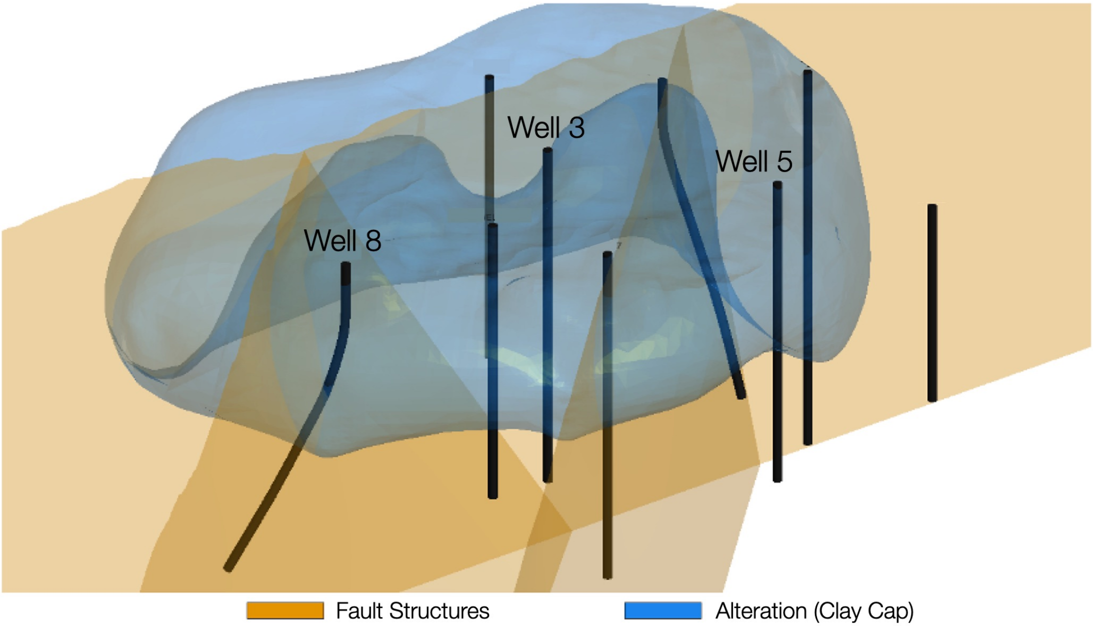
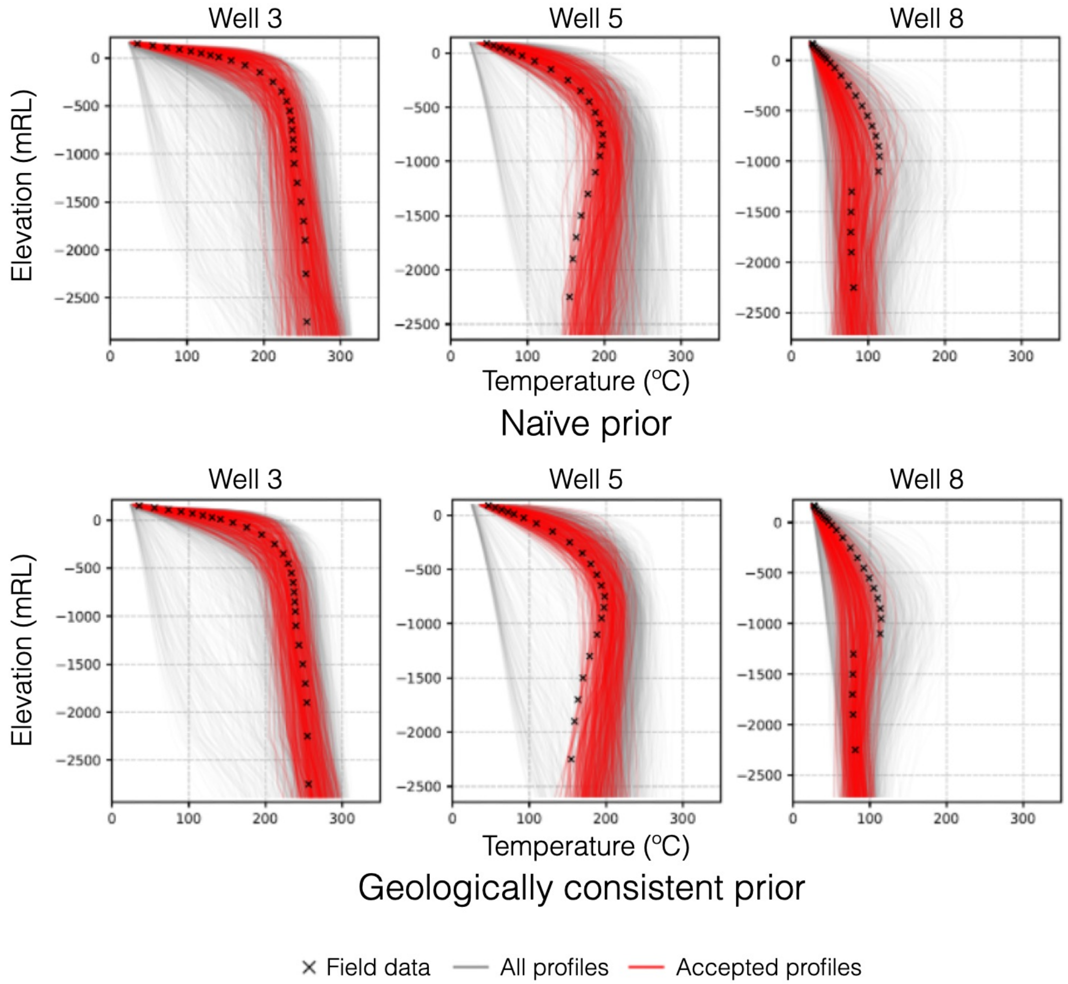
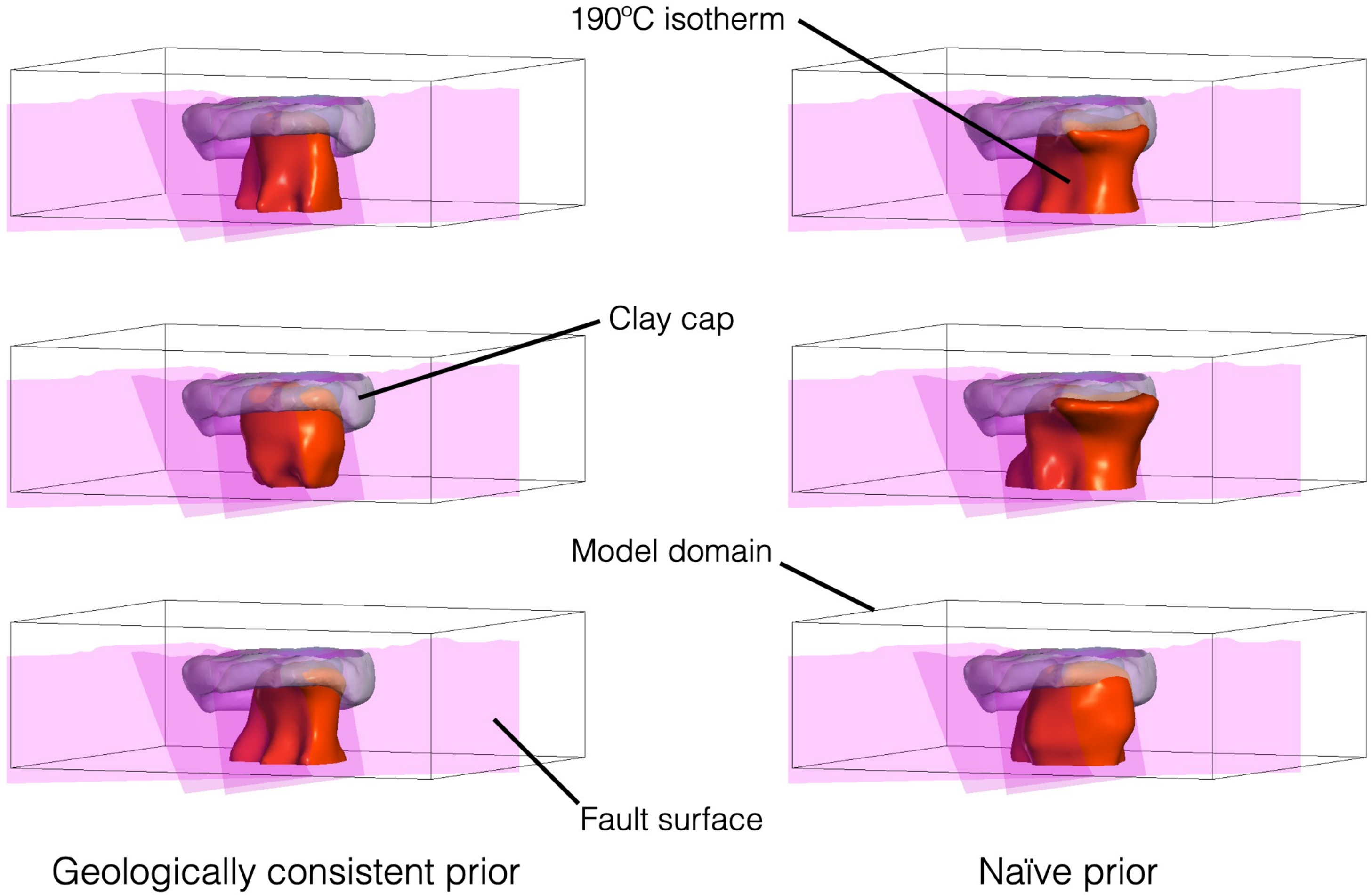
Downhole Temperature Profiles





Convective Plumes



Conclusions and Next Steps

Conclusions

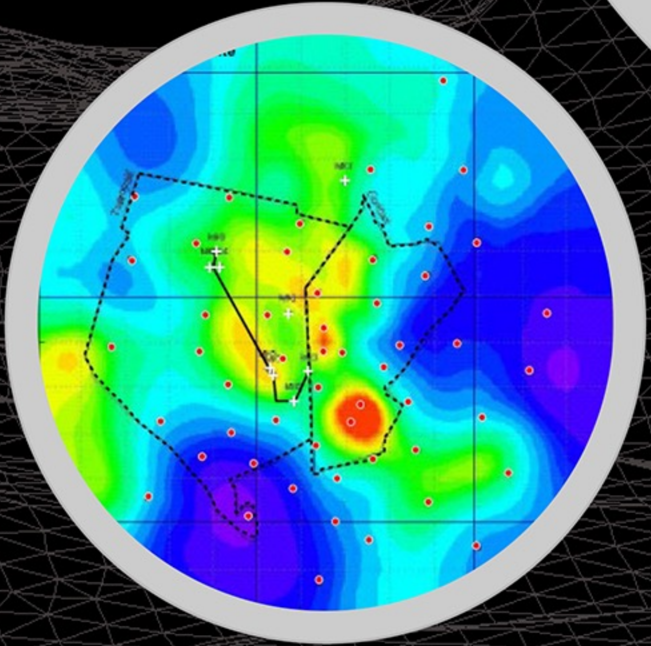
- We have demonstrated techniques to:
  - Characterize a geologically consistent prior distribution
  - Evaluate its quality relative to a prior constructed in a naïve way
- It is hard to identify which prior produces more realistic geothermal systems based on our quantitative analysis
  - However, there are some differences which should be investigated further
- The convective plumes produced using the geologically consistent prior appear to be more realistic

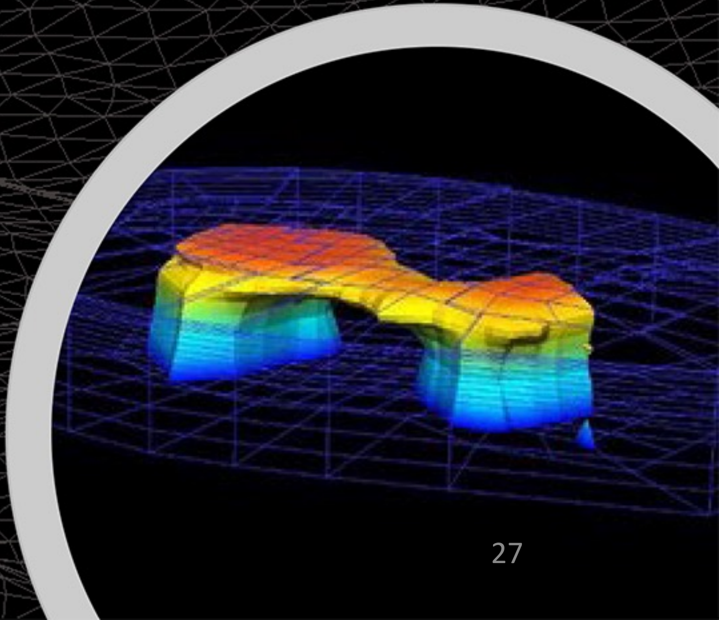
Next Steps

- Investigating how transient phenomena are modeled using parameters from each type of prior
- Carrying out a similar analysis on a more complex model

Tēnā koutou! | Thank you!

Pātaitai? | Questions?





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