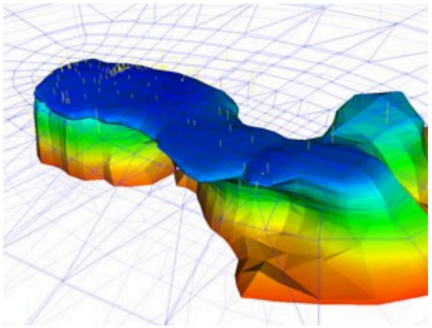
Uncertainty Quantification for Energy Models

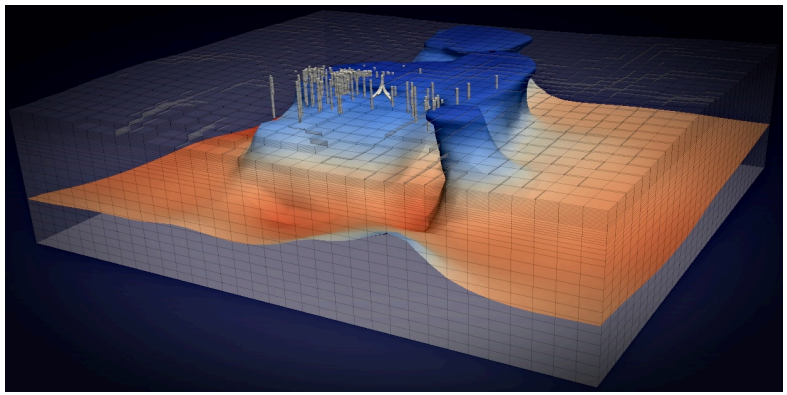
Oliver Maclaren
oliver.maclaren@auckland.ac.nz
The University of Auckland
Department of Engineering Science

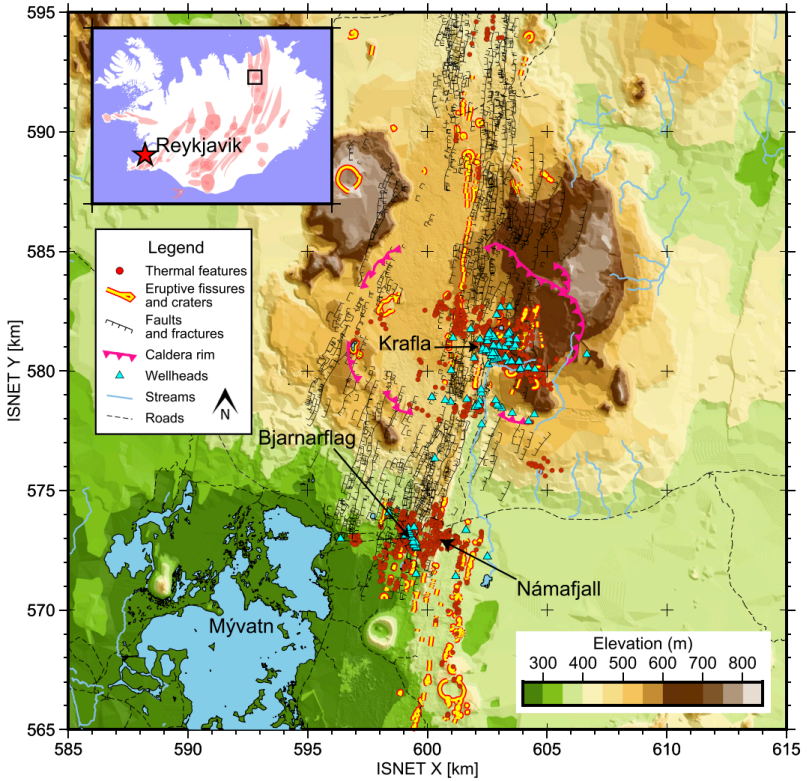
People (UoA Geothermal Institute)

- Mike O'Sullivan (Snr)
- John O'Sullivan
- Adrian Croucher
- Angus Yeh
- Ryan Tonkin
- Ken Dekkers
- Michael Gravatt
- Ruanui Nicholson
- **Oliver Maclaren**
- Etc

Uncertainty for large-scale geothermal reservoir models







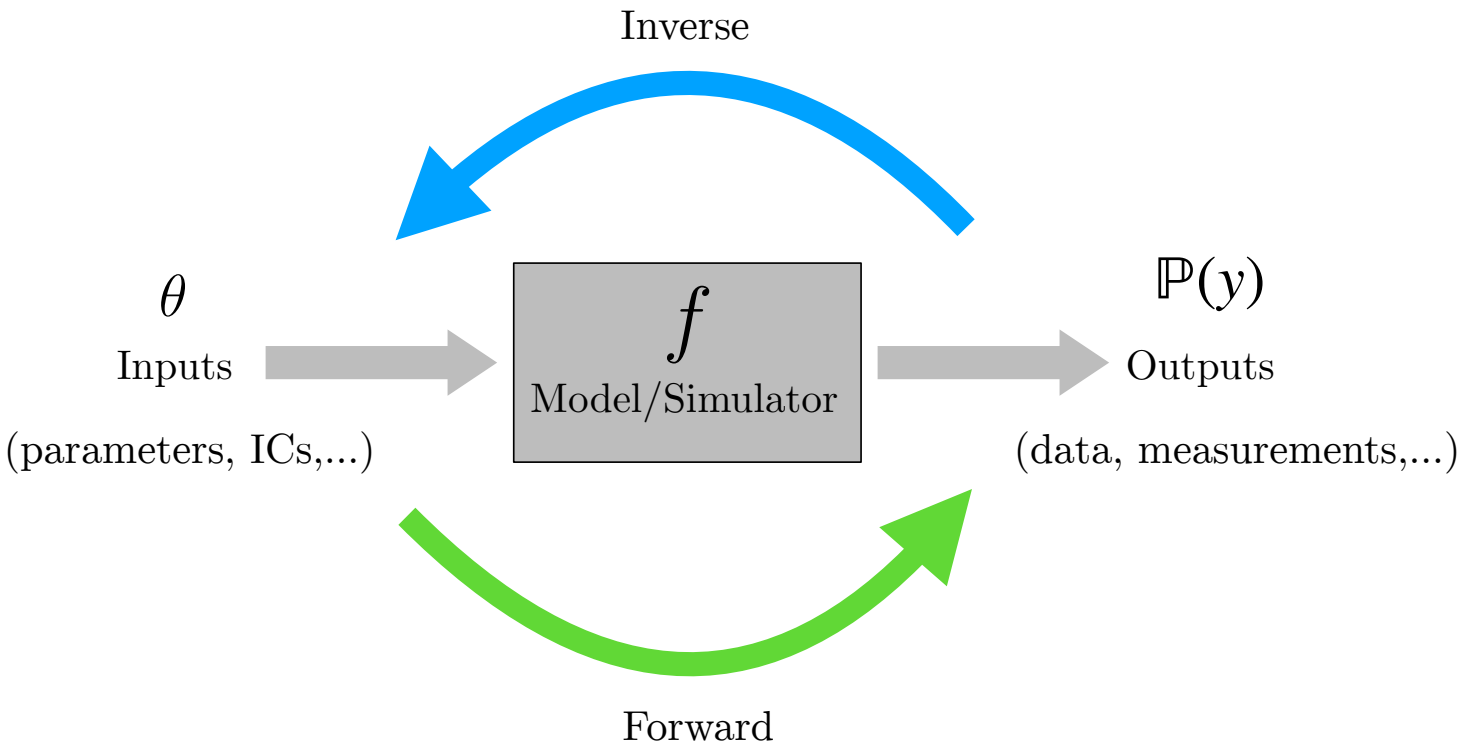
Geothermal questions

- What is the **resource potential** for a new well? E.g. where and how hot are the heat sources?
- What is the **permeability structure** under the ground?
- How well can I **predict** the future?
- **Where should I take measurements** (drill observation wells) to learn about my features of interest?
- How can I encode my **prior information**

Sources of uncertainty

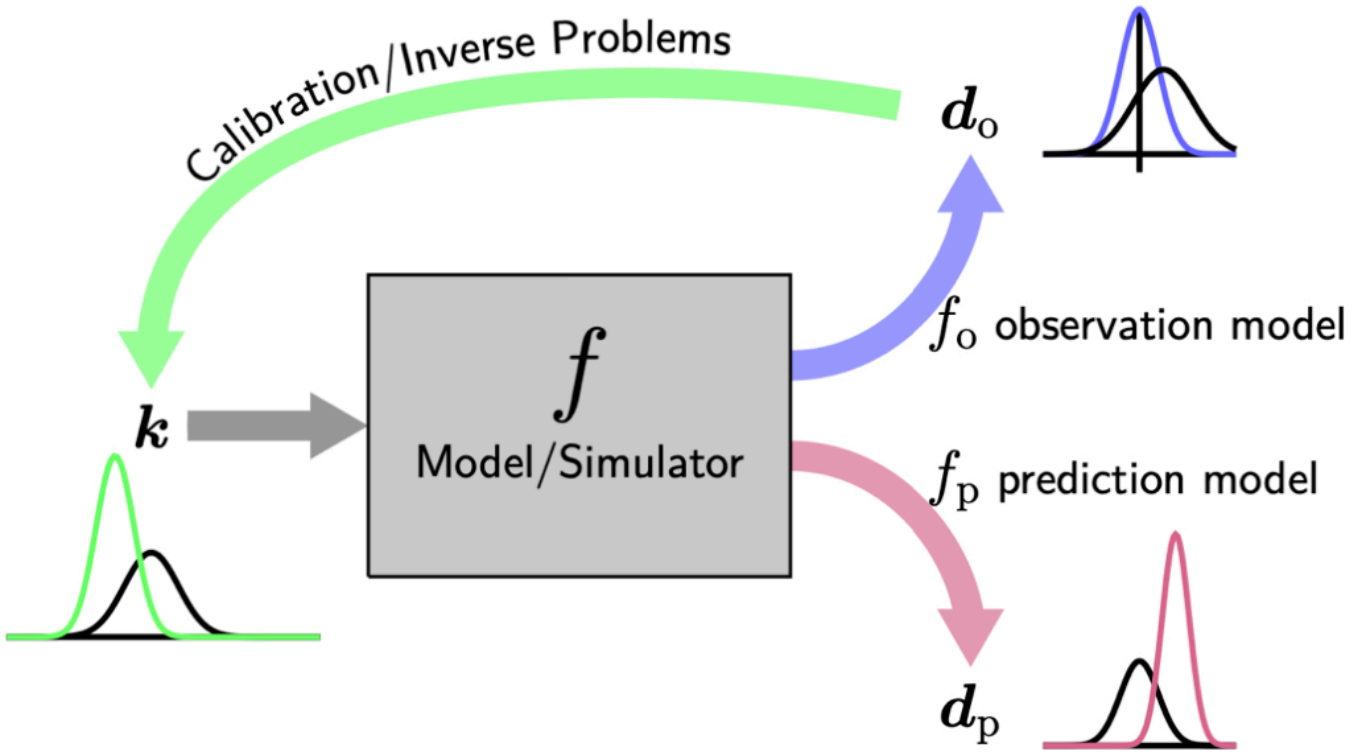
- Uncertainty in ***parameters*** (inverse or inferential uncertainty)
- Uncertainty in ***predictions*** (predictive uncertainty)
- Uncertainty in the ***model representation*** (misspecification)
- Uncertainty in the ***data*** compared to (noise, censoring, selection bias etc)

In a picture



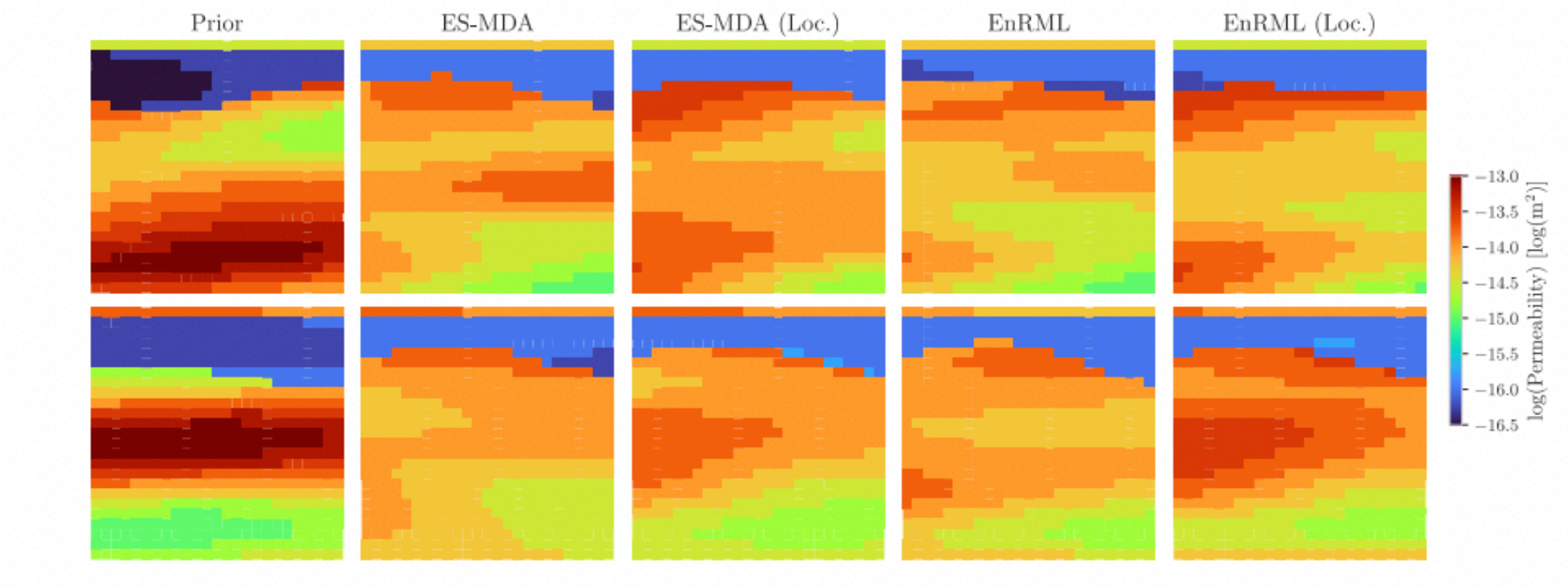
Statistical (Bayesian or Frequentist!) model
Output: explicit or implicit probability distribution

In a picture II



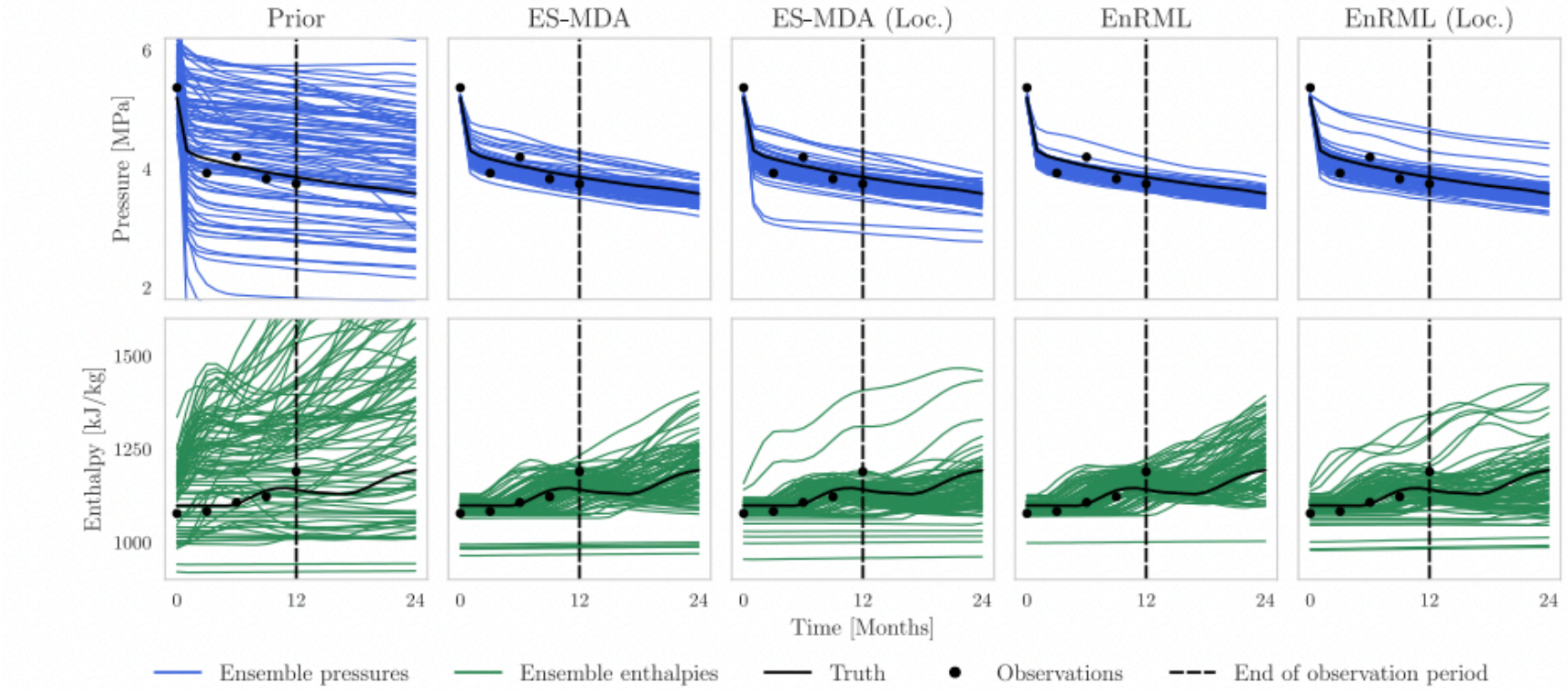
Goals

Infer permeability



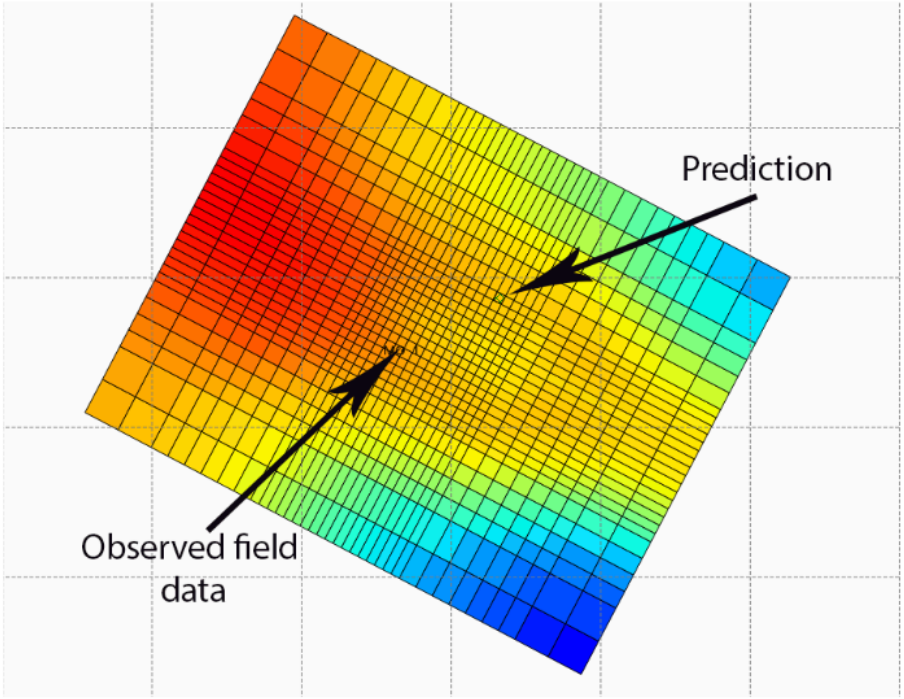
Goals

Predict future



Goals

Take measurements to reduce uncertainty at another location



Approaches

PDE-constrained optimisation

- Compute derivatives using direct and adjoint methods

Direct simulation-based inference

- Approximate Bayesian computation (ABC)
- Ensemble methods
- Data-space inversion
- Surrogate model/emulator/synthetic likelihood

Thanks!