# CoFI workshop

Sub22, 30th November 2022

A **Co**mmon **F**ramework for **I**nference




# On the menu

- Introduction: Why CoFI?
- Interactive session 1: CoFI toy examples (Malcolm)
- Espresso: Earth Science PRoblems for the Evaluation of Strategies, Solvers and Optimizers (Jiawen)

Lunch and coffee

- Interactive session 2: X-ray and seismic Tomography with CoFI (Malcolm)
- Interactive session 3: Electrical Resistivity Imaging with CoFI (Juerg)
- Wrap up and discussion.

InLab

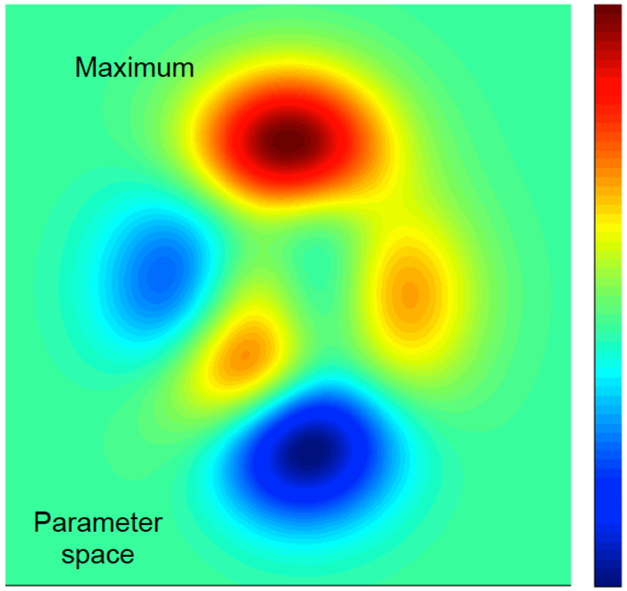
# What we hope you will take away today

- An understanding of what CoFI & Espresso are
- How to use CoFI and Espresso.
- How to get involved.


*A work in progress and example driven…*

# Two approaches to inversion

## Parameter estimation

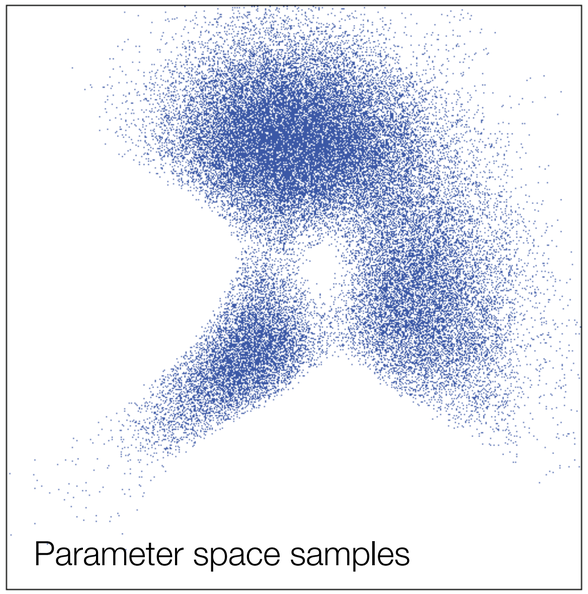



Log Likelihood or misfit function

Optimisation of a misfit function

$$\phi(\mathbf{m}) = ||\mathbf{d} - g(\mathbf{m})||_2^2 + \alpha^2 ||\mathbf{m}||_2^2$$

## Parameter sampling




Sample a target PDF

$$p(\mathbf{m}|\mathbf{d}) = k \times p(\mathbf{d}|\mathbf{m})\ p(\mathbf{m})$$

InLab

# The CoFI jigsaw concept

The **researcher** says:

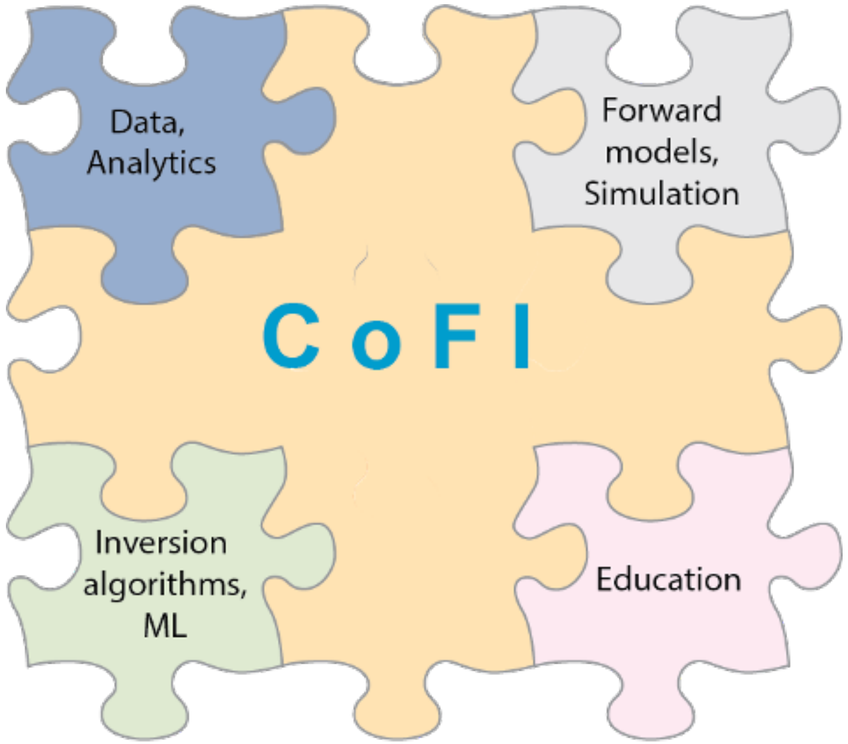
- What inference methods are suited to my data?
- Where can I get access to them?
- How much work is that for me?

The inference **specialist** says:

- I would like to test my algorithm on a different problem
- Where can I get access to them?
- How much work is that for me?

The research **manager** says:

- How can my staff learn about inference methods?
- How do we access the necessary expertise?
- Can we experiment which different approaches?
- How long will it take?

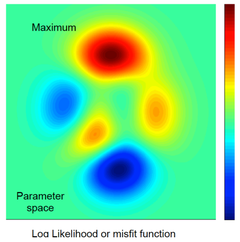


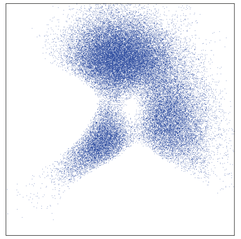

*CoFI connects the pieces*

InLab

Some context can be found here: inlab.edu.au/files/CoFI-club.pdf

# The CoFI methods tree



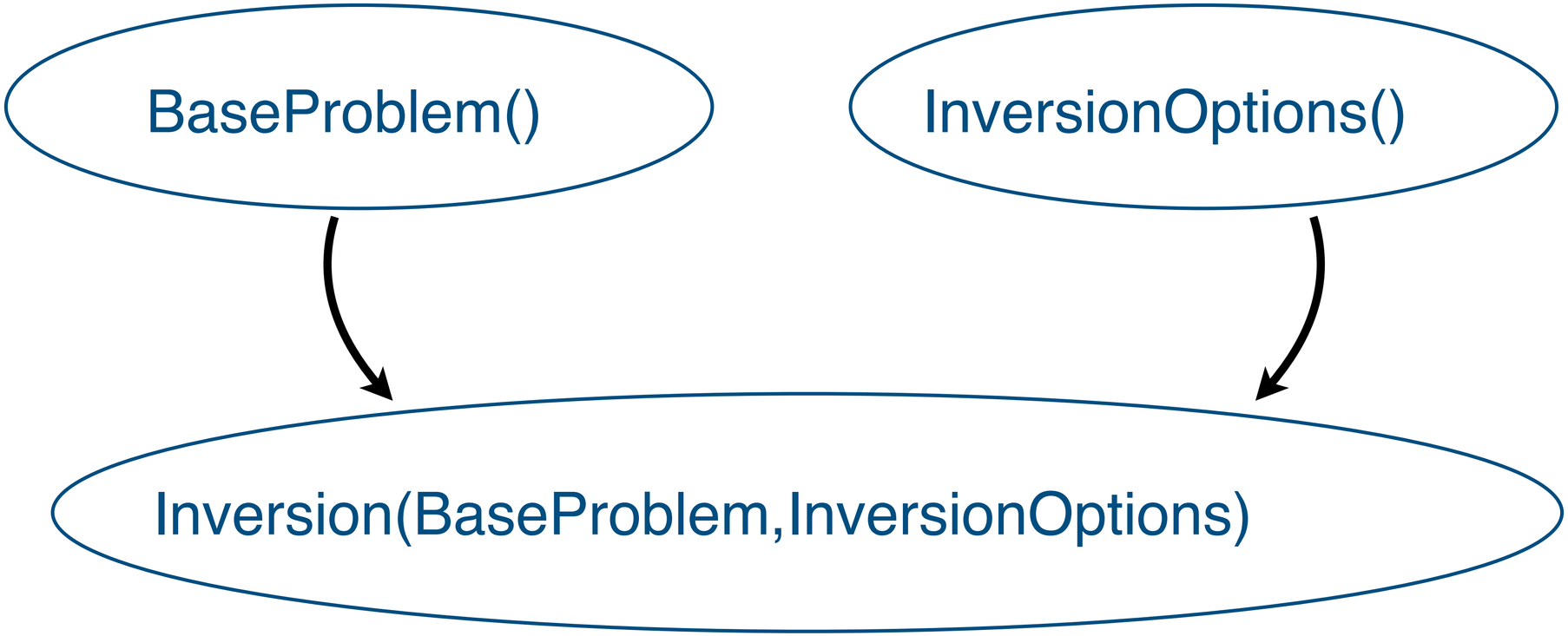
- CoFI - Common Framework for Inference
  - Parameter estimation
    - Matrix based solvers
      - Linear
        - scipy.linalg.lstsq
          PETSc
          ...
    - Optimization
      - Non linear
      - Linear
        - scipy.optimize.minimize
          torch.optim
          PETSc
          ...
  - Ensemble methods
    - Direct Search
      - Monte Carlo
        - Neighbourhood Algorithm
          Bayesian Optimization
          Slime mold algorithm
          ...
      - Deterministic
        - Nested grids
          Hilbert Curves
          ...
    - Bayesian Sampling
      - McMC samplers
        - Basic metropolis
          Affine Invariant sampler
          emcee
          pyMC
          ...
      - Trans-D McMC
        - Basic Trans-D
          RJ-mcmc

InLab

# The Common Framework

*Define the problem…*

*Choose the options…*




*Run the code…*