

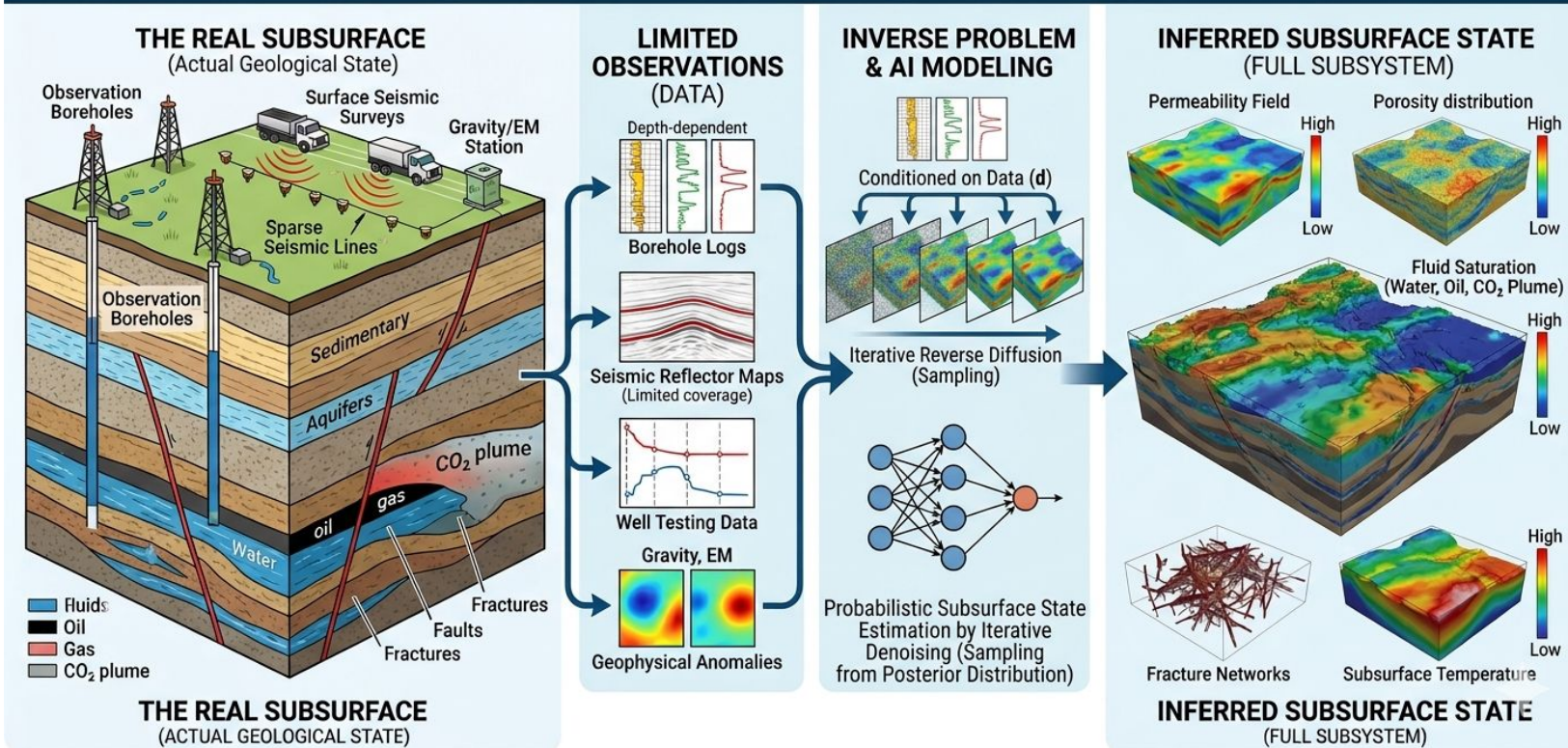
Solving Probabilistic Inverse Problems with Generative AI

EnviTrace AI for Earth Sciences
Workshop 2026

Adam Rupe
EnviTrace
NERSC, Berkeley Lab

OVERVIEW OF SUBSURFACE INVERSE PROBLEMS

Limited Observations to Full State Inference



Denoising Diffusion Probabilistic Models

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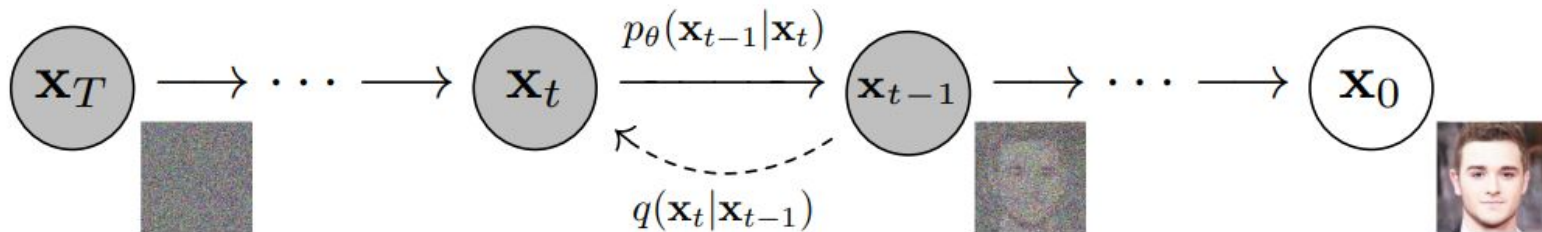
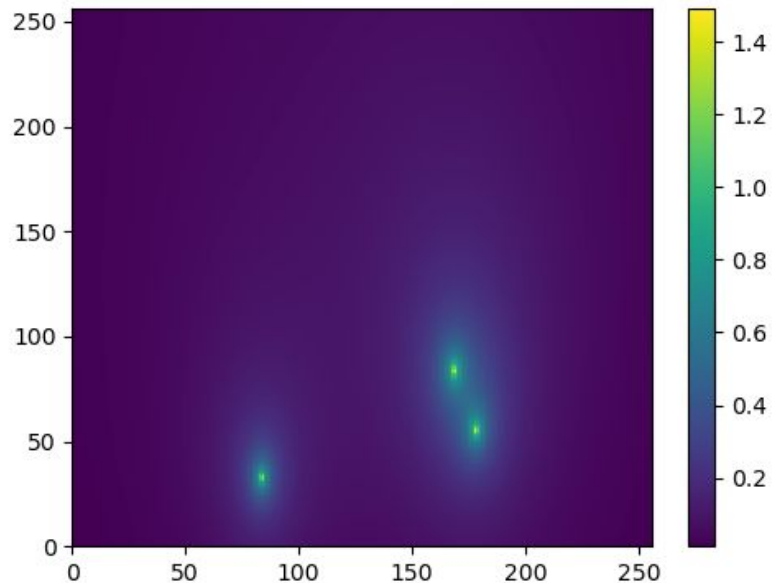


Figure 2: The directed graphical model considered in this work.

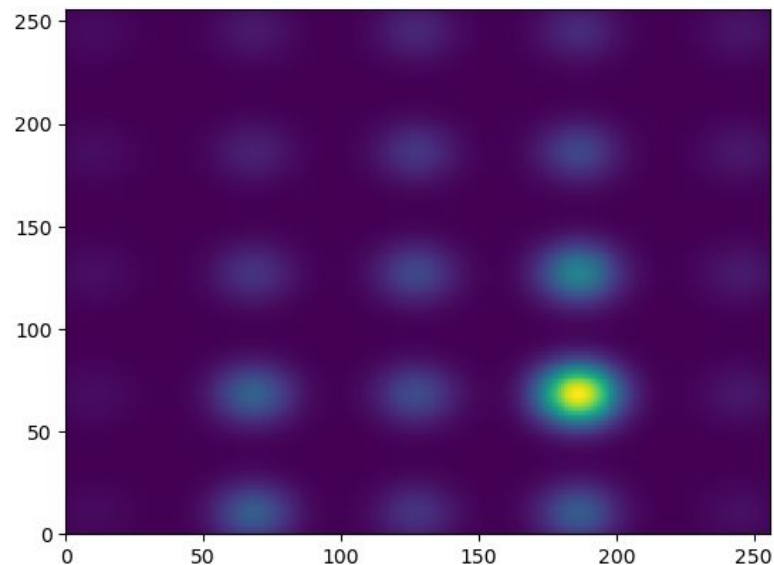
$$L_{\text{simple}}(\theta) := \mathbb{E}_{t, \mathbf{x}_0, \epsilon} \left[\left\| \epsilon - \epsilon_\theta(\sqrt{\bar{\alpha}_t} \mathbf{x}_0 + \sqrt{1 - \bar{\alpha}_t} \epsilon, t) \right\|^2 \right] \quad (14)$$

Contamination: 3 sources, 5x5 grid observables

Target (contamination field)

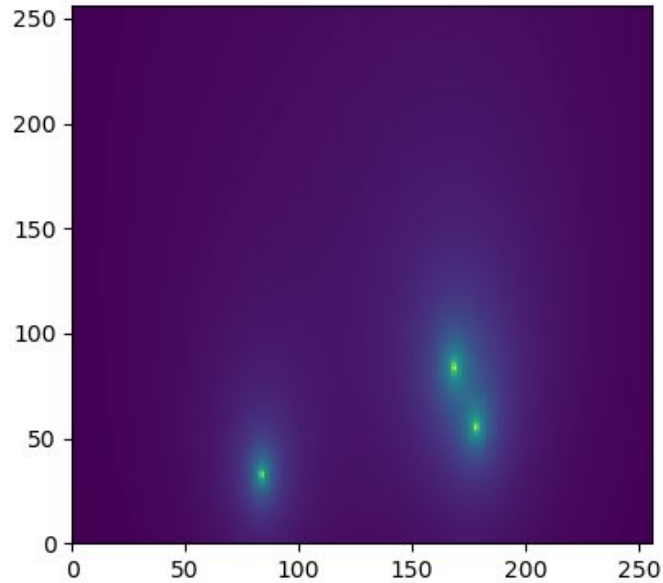


Input ("splatted" observations)

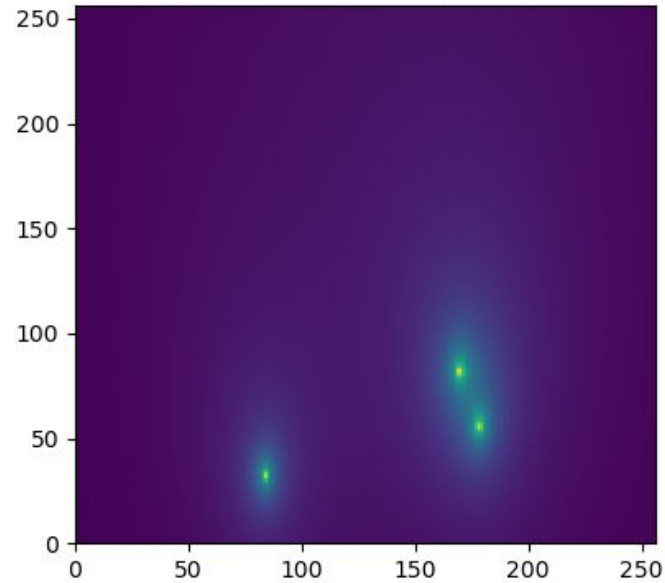


Contamination: 3 sources, 5x5 grid observables

Target (contamination field)

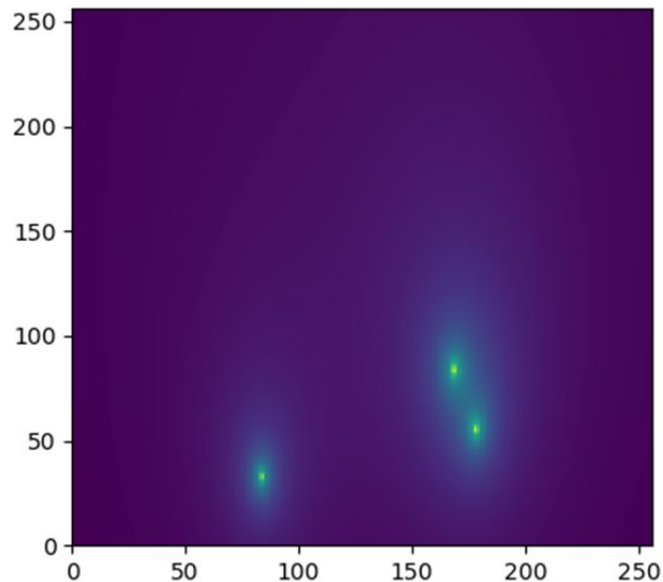


Single diffusion inverse sample

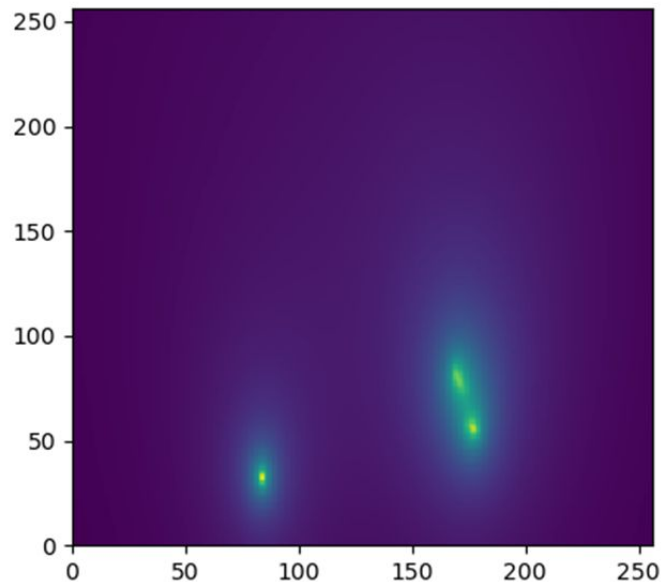


Contamination: 3 sources, 5x5 grid observables

Target (contamination field)

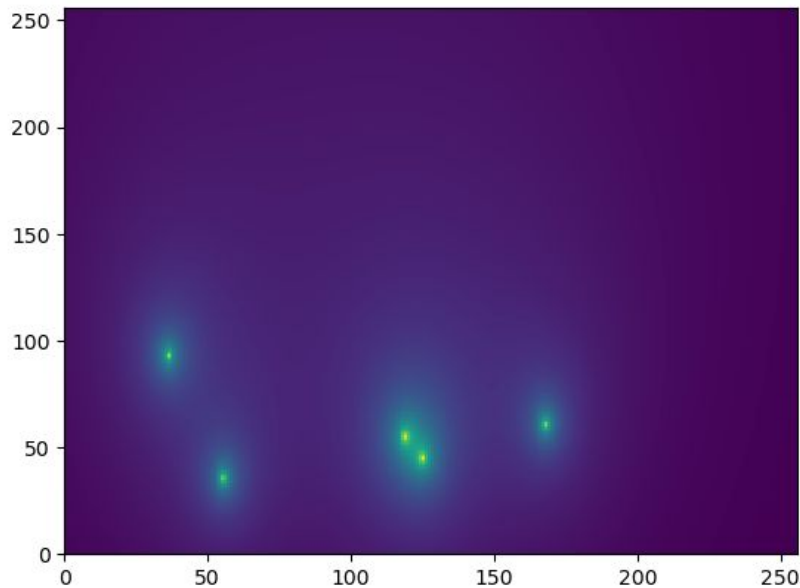


256 diffusion inverse samples

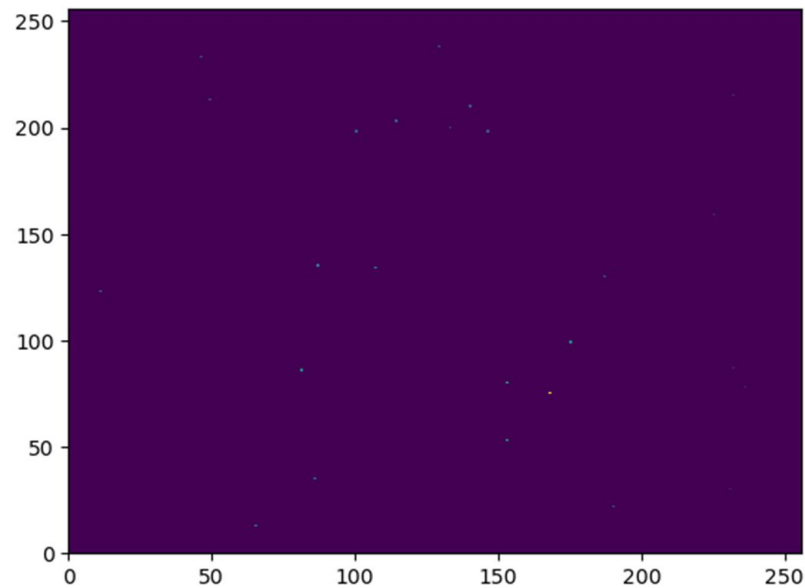


Contamination: 5 sources, 25 random observations

Target (contamination field)

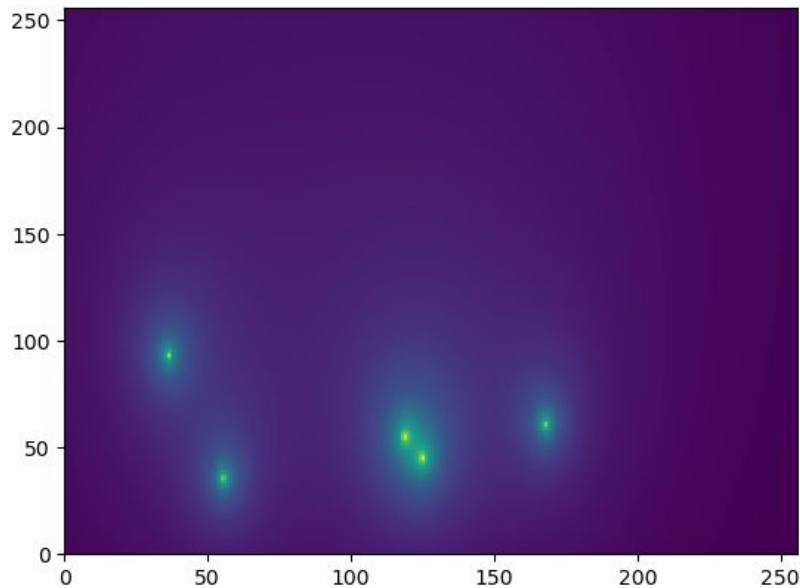


Original observations

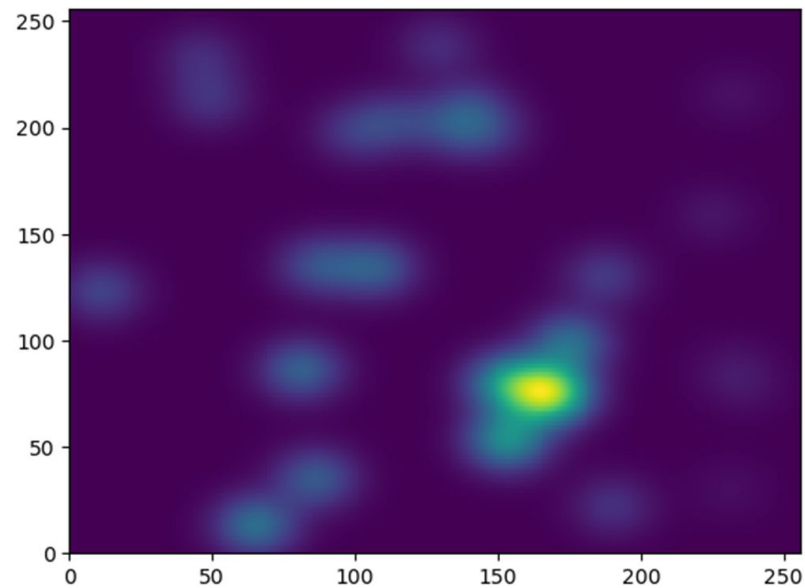


Contamination: 5 sources, 25 random observations

Target (contamination field)

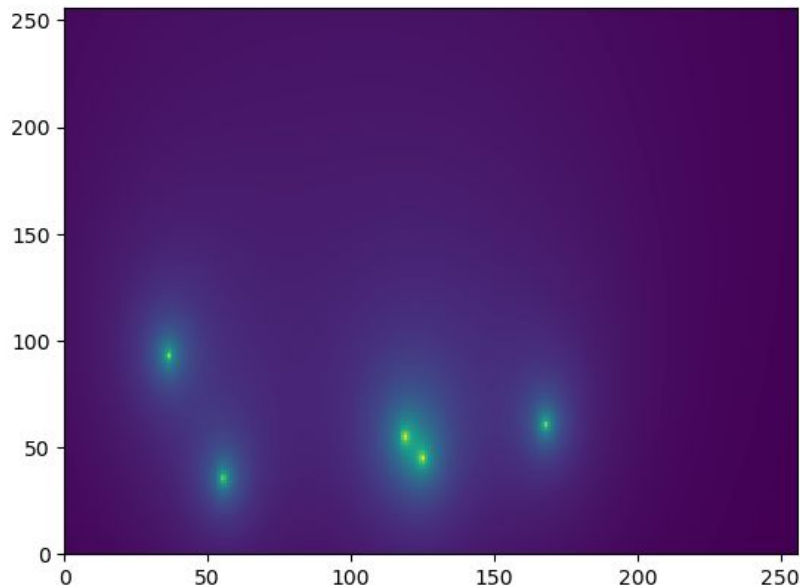


Splatted observations

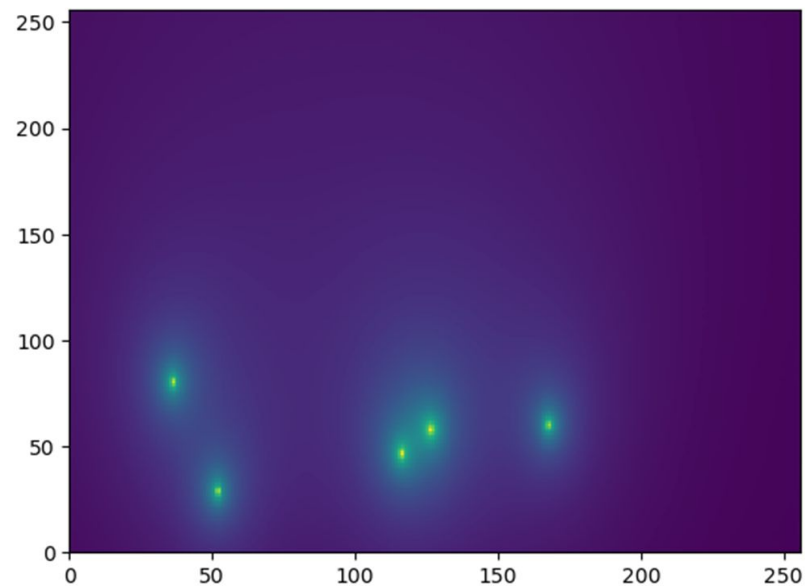


Contamination: 5 sources, 25 random observations

Target (contamination field)

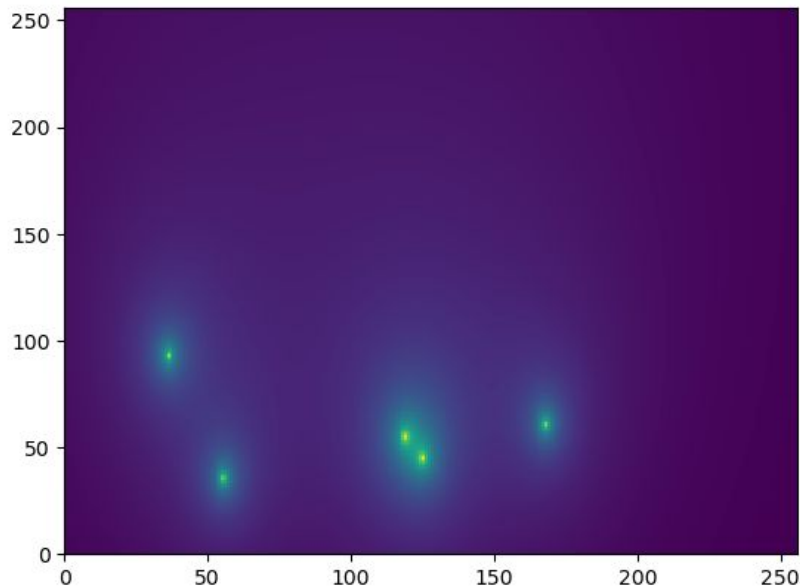


Single diffusion inverse sample

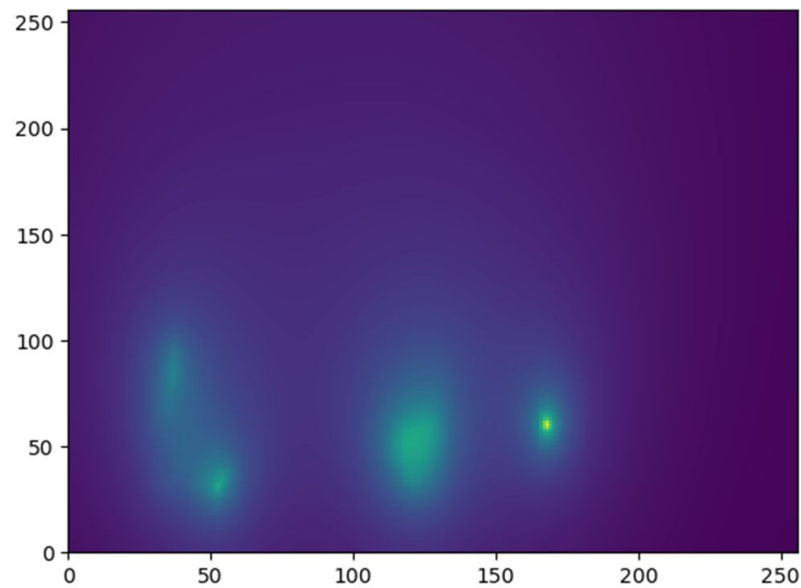


Contamination: 5 sources, 25 random observations

Target (contamination field)

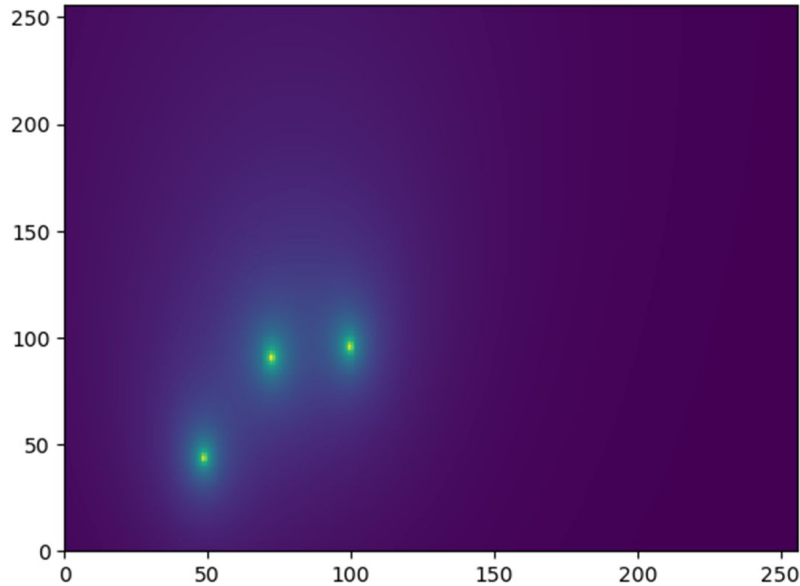


256 diffusion inverse samples

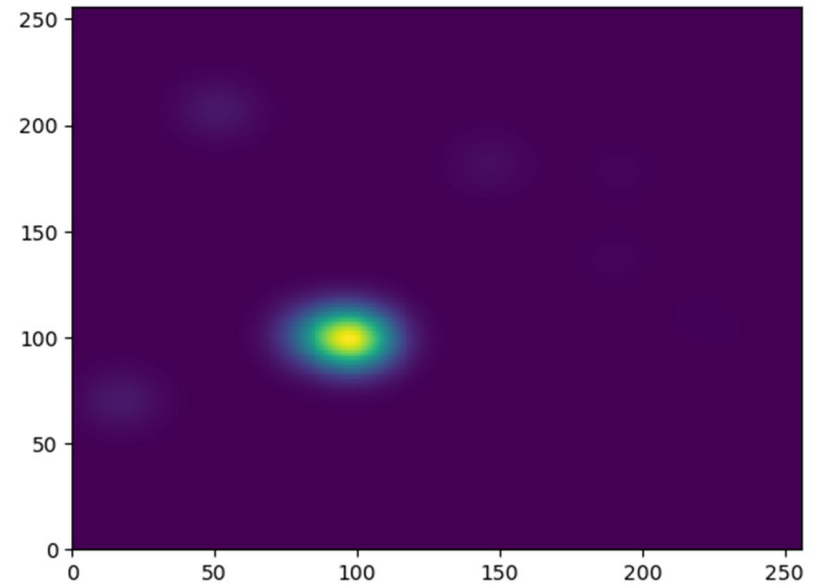


Contamination: 3 sources, 10 random observations

Target (contamination field)

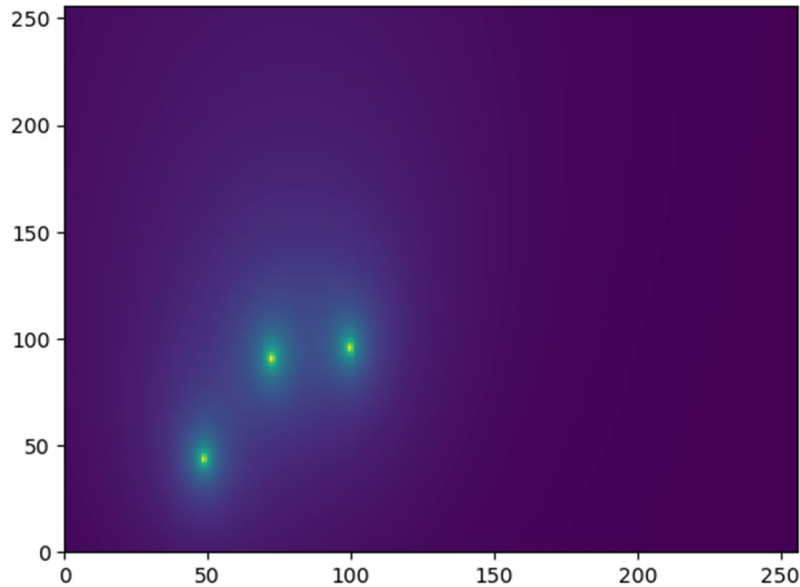


Splatted observations

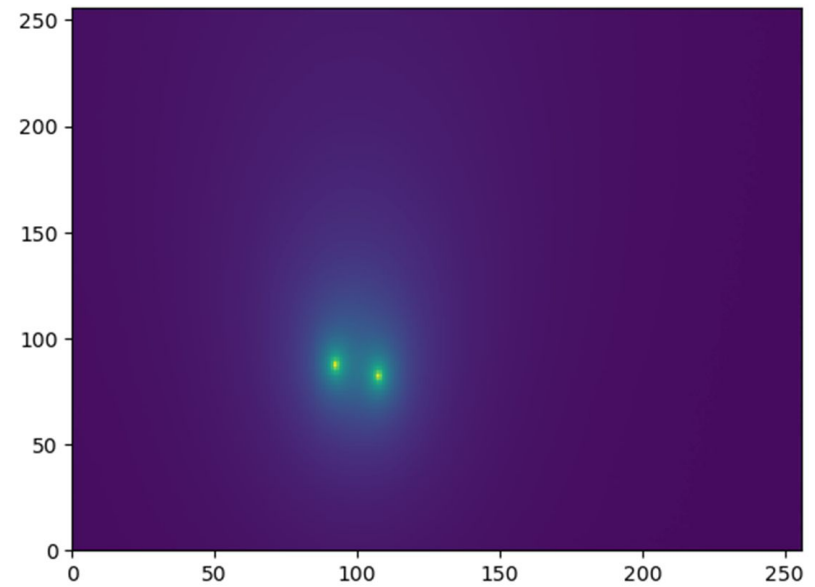


Contamination: 3 sources, 10 random observations

Target (contamination field)

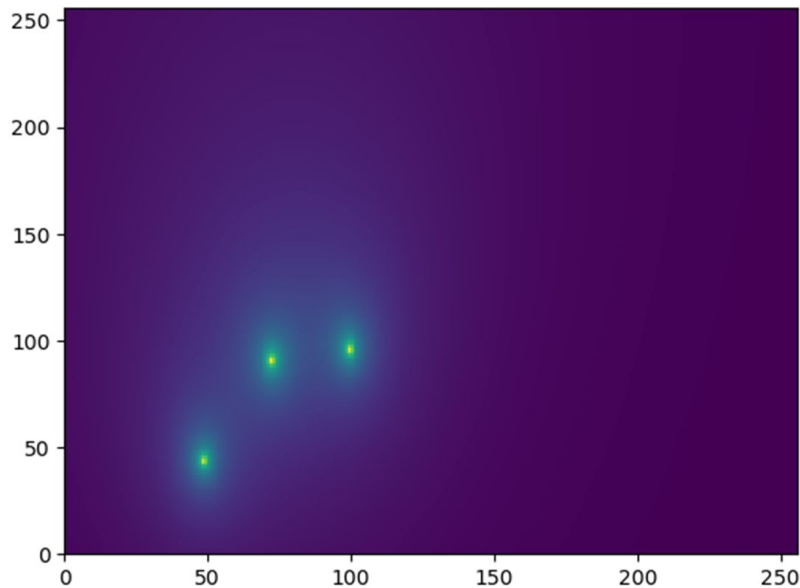


Single diffusion inverse sample

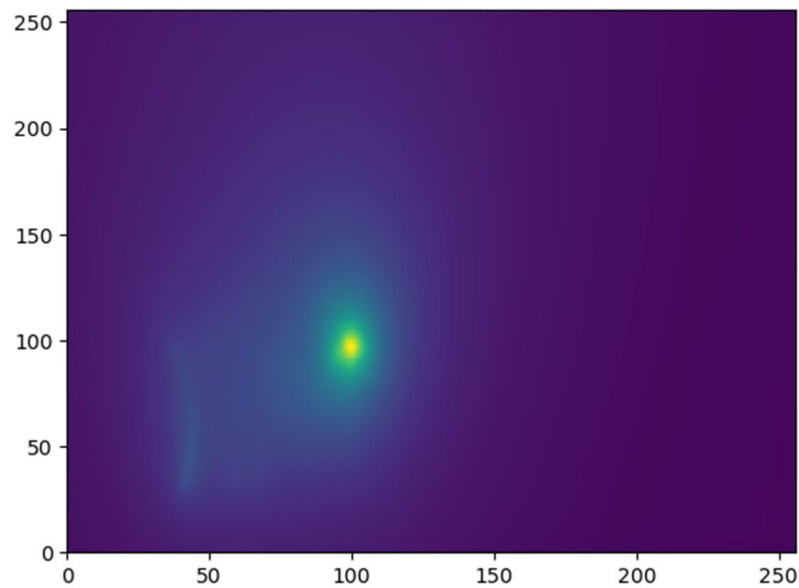


Contamination: 3 sources, 10 random observations

Target (contamination field)

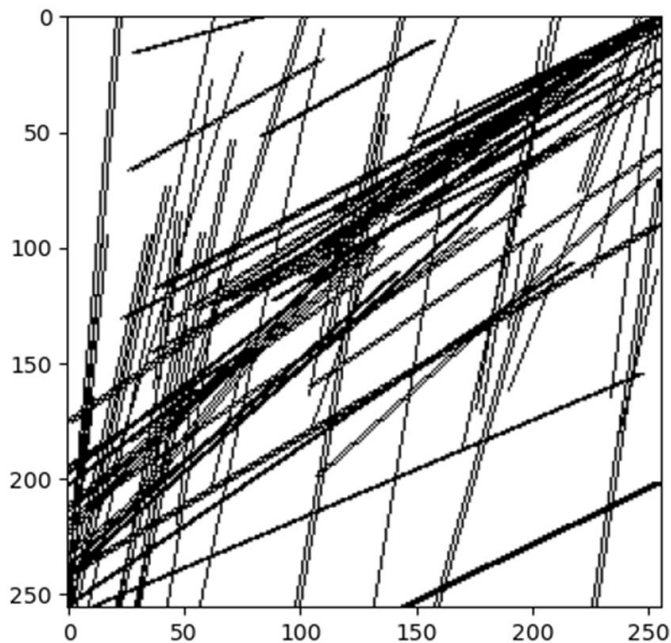


256 diffusion inverse samples

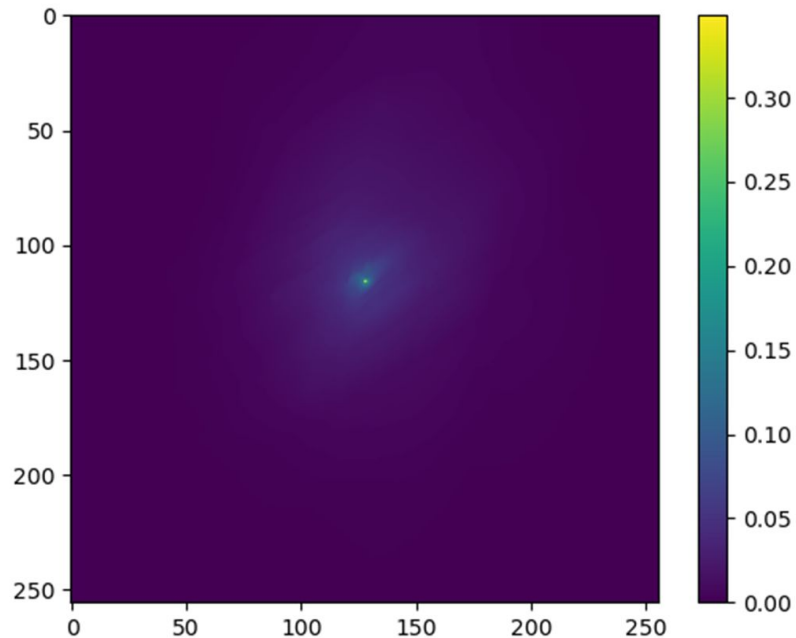


Equilibrium pressure fracture network inversion

Target fracture network

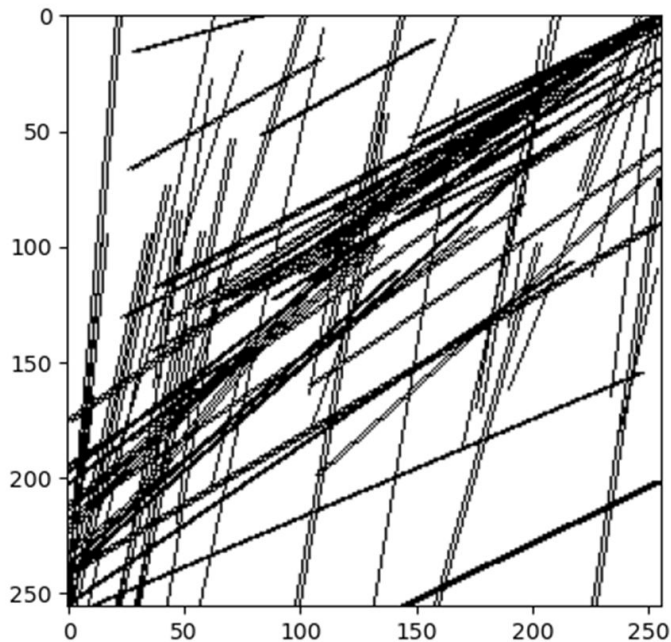


Equilibrium pressure (input)

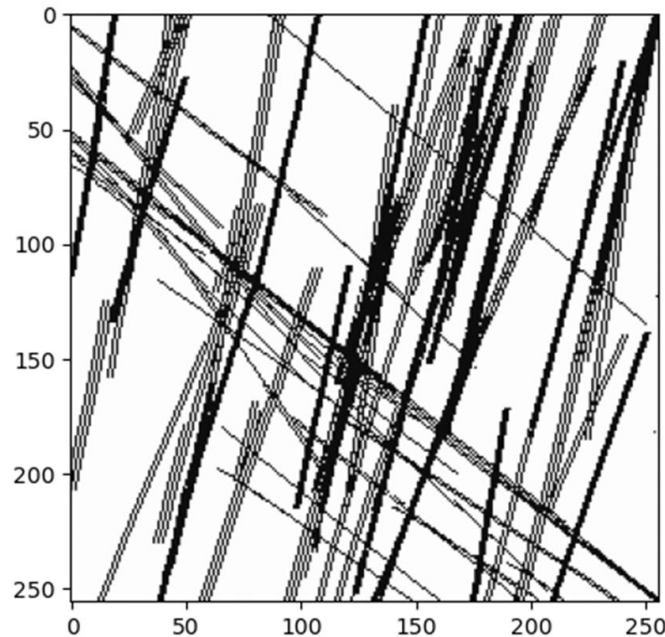


Equilibrium pressure fracture network inversion

Target fracture network

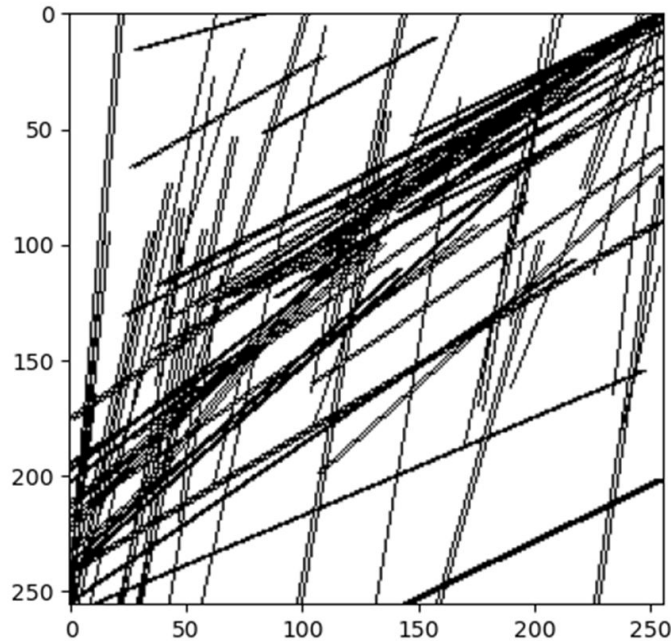


Single diffusion inverse sample

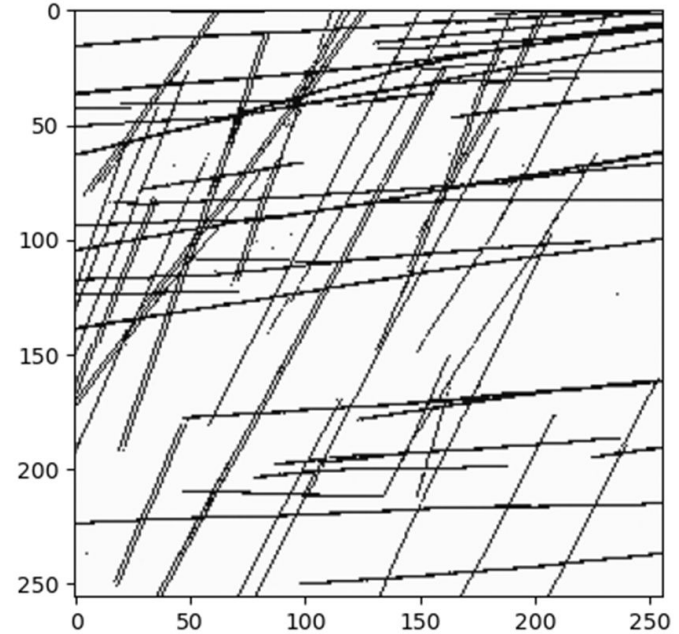


Equilibrium pressure fracture network inversion

Target fracture network

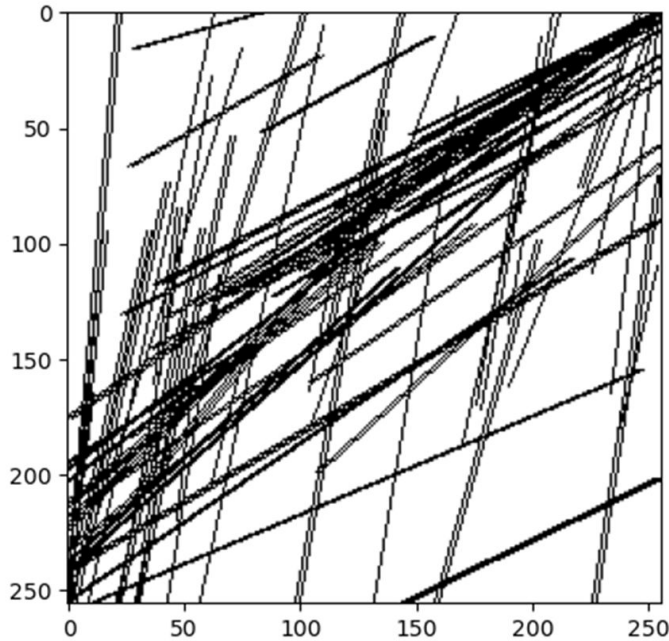


Single diffusion inverse sample

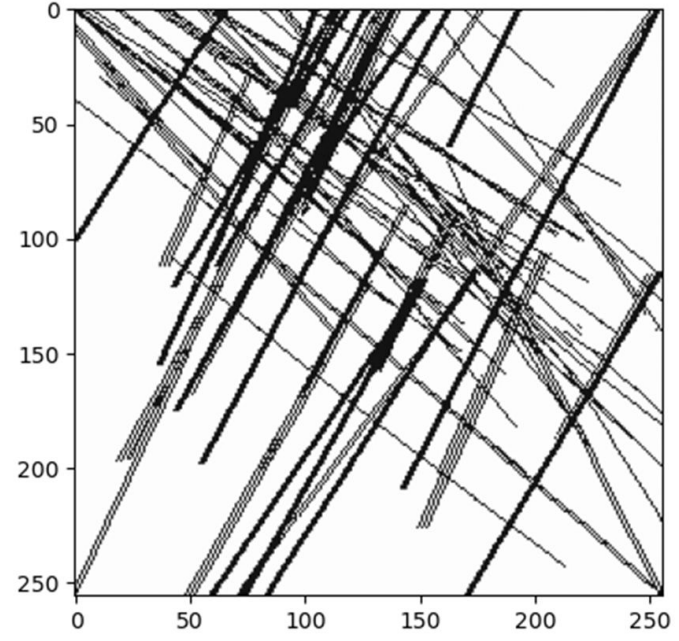


Equilibrium pressure fracture network inversion

Target fracture network

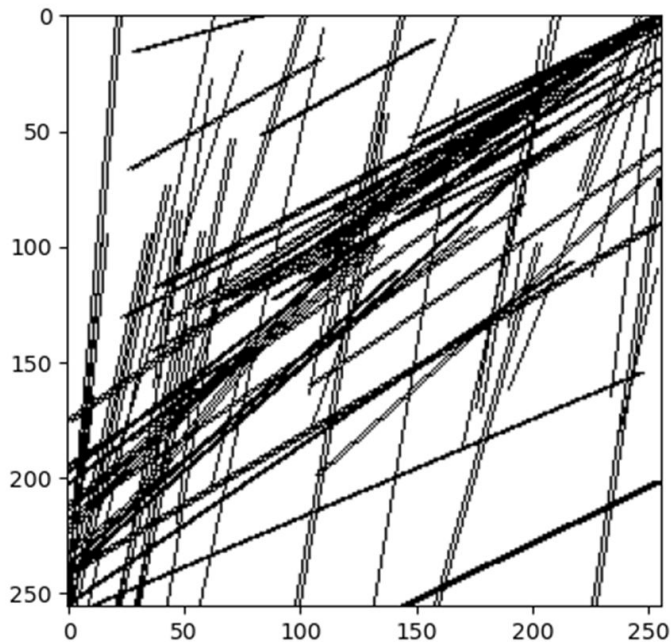


Single diffusion inverse sample

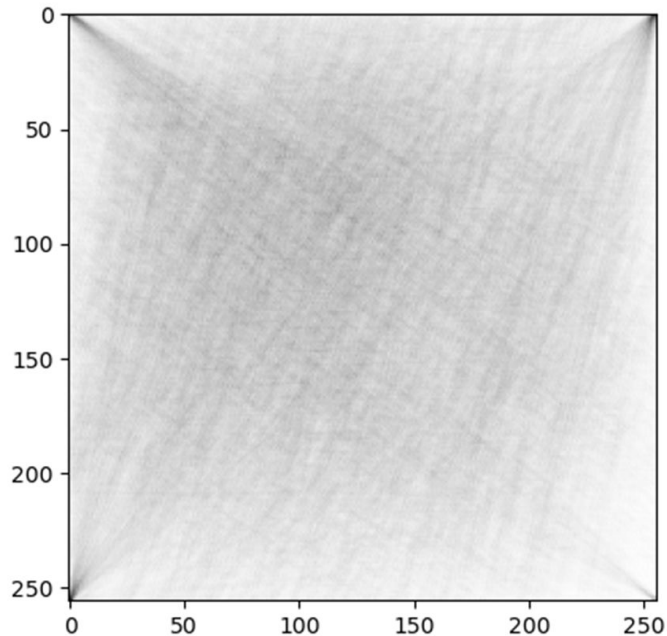


Equilibrium pressure fracture network inversion

Target fracture network



256 diffusion inverse samples



Thank you!

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