

LEARNING THE PHYSICS OF THE SUBSURFACE

Physics-informed ML, deep learning, and surrogate modelling for geological energy and environmental systems

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Format Two independent projects

Can AI make subsurface simulations faster without compromising physics?

Predicting how fluids, gases, and chemical species move through the Earth's subsurface is essential for safe energy storage, carbon sequestration, and environmental protection. Yet, exploring complex geological systems across many scenarios can demand substantial computational resources.

Scientific machine learning brings together artificial intelligence, physical laws, and numerical modelling to develop faster predictive tools while preserving the physical constraints that make simulations scientifically meaningful. These projects investigate two complementary approaches to accelerating subsurface modelling, and rigorously testing their accuracy, reliability, and computational efficiency.

PROJECT 01

Physics-Informed Neural Networks

Combine data-driven learning with the laws of physics.

PINNs embed governing equations and conservation laws into neural network training, aiming to produce predictions that are both accurate and physically consistent.

Research directions

- How accurately can PINNs capture subsurface physics?
- Do hard constraints enforce physics better than penalty-based methods?
- Can PINNs recover unknown properties from sparse data?

Explore: physics, PDEs, constraints, inverse modelling, uncertainty.

PROJECT 02

Neural Operators

Learn the patterns. Predict new scenarios.

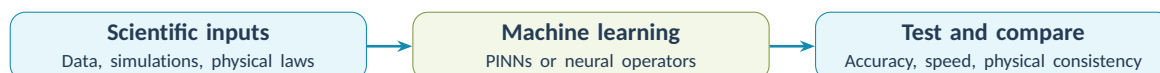
Neural operators learn mappings from inputs to solutions, enabling rapid predictions across different initial conditions, boundary conditions, and geological settings.

Research directions

- How accurately can they predict subsurface flow?
- How well do they generalise to unseen scenarios?
- How much computational time can they save compared with conventional numerical simulations?

Explore: surrogate modelling, generalisation, and benchmarking.

From scientific knowledge to useful predictions



Where can these methods make a difference?

- Underground hydrogen and CO₂ storage
- Groundwater flow and contaminant migration
- Reactive transport and water-rock interactions
- Faster simulation, optimisation, and uncertainty quantification

What will you gain?

- Practical Python and scientific ML skills
- Experience developing and validating models
- A reproducible case study and research report

Ready to explore machine learning for subsurface science?

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Projects can be tailored to your background and experience, with an emphasis on developing, testing, and critically evaluating scientific ML methods.