

IMPERIAL

Department of Earth Science
and Engineering

PhD Project Description

A New Paradigm in Probabilistic Landscape Evolution Modelling (ProbLEM)

Supervisor

Gareth Roberts

Project Summary

Landscapes are the interface connecting the solid Earth to the chemical, physical and biological domains at its surface where the critical zone supports life. They transport natural resources and contaminants, deliver chemicals to the oceans and produce hazards including floods and landslides. Landscape evolution plays a key role in stabilizing climate, driving biodiversity and water security. Their form and evolution are used to understand geological processes from Earth's deep interior to its surface. The societal and scientific need to understand landscape evolution from micro- to macro-scales is emphasized by the recent Oroville Dam (California, USA) spillway collapse caused by unexpected structural erosion, which is expected to cost \$1billion USD to repair. It is also emphasized by the >\$100bn USD cost of storing nuclear waste in Geological Disposal Facilities, which must be secure from erosion for up to ca. 1 million years. Unfortunately, all existing theories of landscape evolution and state-of-the-art models struggle with scale, physical realism, data integration, and unknowable contingencies, which severely restricts reliable prediction of landscape change. A key issue is that unlike, say, meteorology or oceanography geomorphology lacks a universal equation or theory (e.g. Navier-Stokes) that can be applied to all regions and across scales. *ProbLEM* will address these shortcomings by building on our recent preliminary work in which we established that stochastic theory can be used to understand landform evolution from micro- to macro scales. We will build on this work to establish a new paradigm of landscape evolution founded on a mathematical, probabilistic and scale-bridging theory and modelling.

Select Reading from the Group:

- Roberts GG. Learning How Landscapes Evolve with Neural Operators, *Esurf*, (2025), <https://doi.org/10.5194/esurf-13-563-2025>.
- Morris, MJ, Roberts GG. Impact of Noise on Landscape Evolution and Metrics Derived from Stream Power Models, *Esurf*, (2025), <https://doi.org/10.5194/esurf-13-1003-2025>.
- Roberts GG, Wani O. A theory of stochastic fluvial landscape evolution, *Proceedings of the Royal Society A*, (2024), doi:10.1098/rspa.2023.0456.

Who are we looking for?

We are looking for motivated hard hard-working students with a background in the earth science, physics, mathematics, computing or engineering, and with the willingness to learn computational and mathematical methods as needed. Skills developed will include advanced experimental and numerical modelling methods, with extensive training provided.