Title: **Deep learning applications for the pore-scale and beyond**

Abstract: This talk explores advanced deep learning applications across multiple scales in subsurface modelling, from pore-scale mineral dissolution to reservoir-scale CO_2 plume migration and beyond. At the pore scale, we demonstrate a recursive, multi-step prediction framework with model stacking to accelerate reactive dissolution simulations. Our approach achieves 94% accuracy in predicting porosity changes over 100 timesteps—delivering results 2–3 orders of magnitude faster than conventional numerical solvers. Extending these techniques to reservoir-scale problems, we introduce a U-shaped Fourier Neural Operator (UFNO) framework augmented with FiLM layers that disentangles scalar and spatial features. This methodology enhances prediction accuracy by 15%, reaching an overall accuracy of 97%, and performs 100× faster than traditional Eclipse simulations for CO_2 plume migration. Finally, we address the challenge of limited imaging resolution in rock characterization by employing patch-based Generative Adversarial Networks with a novel local padding technique. This innovation eliminates boundary artefacts inherent in tiled super resolution methods, enabling seamless, high-resolution representations of complex, heterogeneous rock samples. Overall, our results underscore the potential of deep learning to accelerate and extend subsurface simulations, offering promising avenues for enhanced accuracy and computational efficiency in geoscientific applications.

Bio: Hannah Menke is an Associate Professor of Integrated AI for GeoEnergy Applications and co-leads the DigiPorFlow group at the Institute of GeoEnergy at Heriot-Watt University. Her research focusses on upscaling flow and transport in porous media using a combination of multi-scale imaging, numerical modelling, and machine learning. She is also a co-founder of The GeoChemFoam Project, the world's most advanced open-source pore-scale numerical solver. She did her undergrad in Earth and Environmental Engineering at Columbia University in New York and a PhD and PostDoc at Imperial College London.