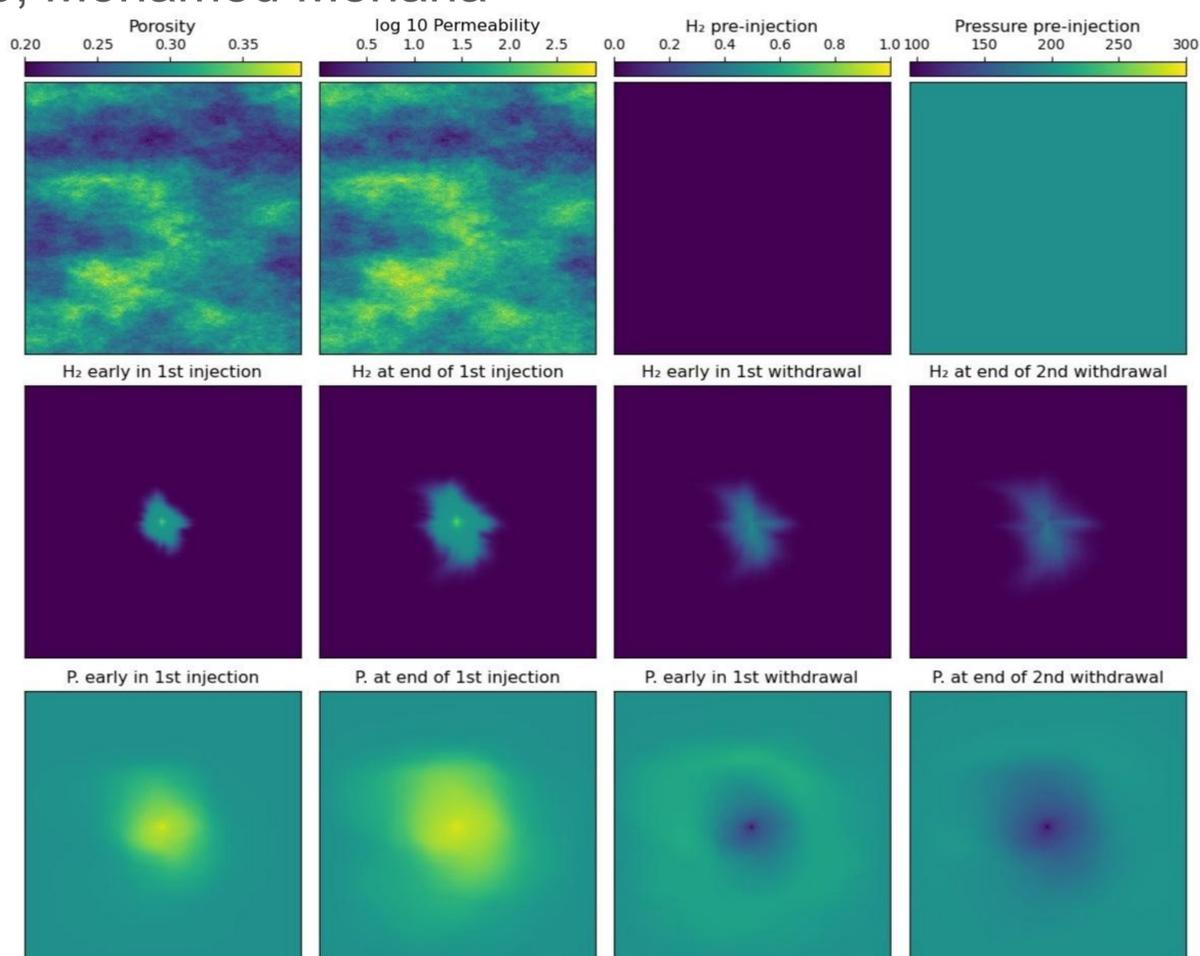


Enabling Clean Energy Resilience with Machine Learning-Empowered Underground Hydrogen Storage

Alvaro Carbonero, Shaowen Mao, Mohamed Mehana

Introduction

- Hydrogen has the potential to enable large scale clean energy integration by solving the problem of unpredictable power generation.
- The large scale deployment of Underground Hydrogen Storage (UHS) operations is hindered by expensive computational simulations.
- Machine learning can develop fast and accurate proxies to these computational simulations, but first it needs to overcome the unique challenges of UHS simulations.



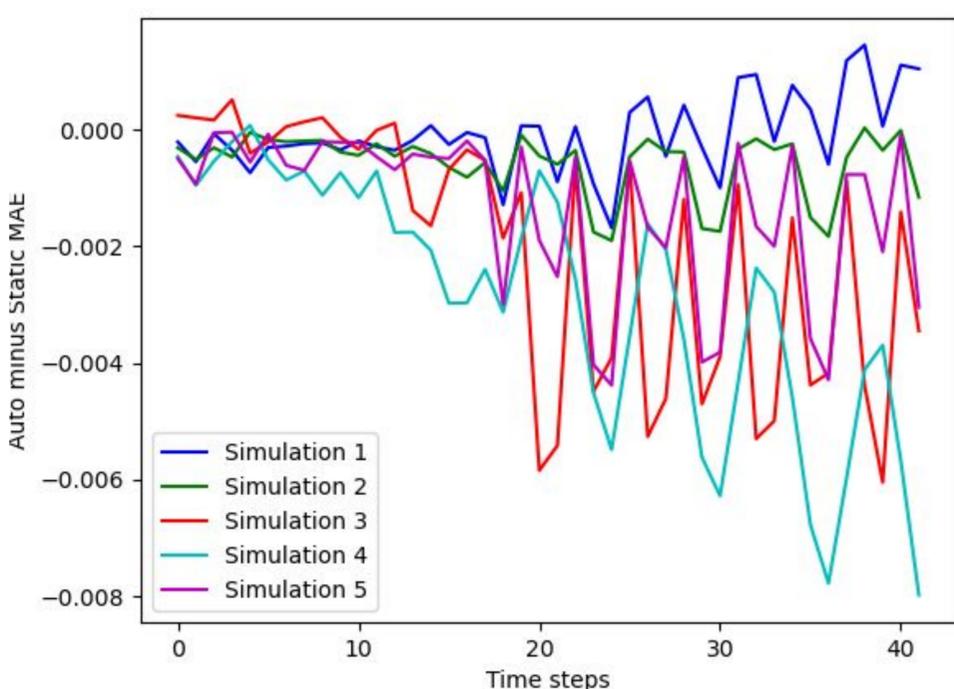
Problem and methods

- A UHS ML model needs to handle:
 - Input parameters: permeability, porosity, reservoir depth, thickness, injection-withdrawal scheme, injection pressure, production pressure, etc.
 - Output parameters: H₂ saturation, pressure, surface deformation, H₂ recovery factor, production purity, gas-water ratio, and well injectivity.
- Possible methods are similar to carbon sequestration, such as nested Fourier Neural Operators [1]. Nonetheless, there are key differences that set UHS apart.

Key Challenges

- ❑ **Developing auto-regressive models:** due to the cyclic nature of hydrogen injection and withdrawal, auto-regressive models provide big advantages not offered by static models.
- ❑ **Receiving and predicting scalar values:** although there are methods that handle inputs and outputs with combined scalar and spatial values, more intricate methods might outperform them.
- ❑ **Real-time high-resolution UHS predictions:** such methods exist for carbon sequestration, but UHS plumes have further intricacies from cushion gas interactions and injection-withdrawal schemes.

Preliminary: auto-reg. vs static



- Two U-net models trained on 800 simulations, 7 years each split into 42 time steps, to predict H₂.
- Plotted is the difference between the models in 5 test simulations. Auto does better!

Ask us questions! Read the paper!



QR Code to arxiv paper!

Questions? Email {alvaro.carbonero, shaowen.mao, mzm}@lanl.gov