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CO2 Geological Storage Modeling with Machine Learning

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CO2 geological storage plays an essential role in global decarbonization and the energy transition. Predicting the transport of CO2 in subsurface formations requires numerical simulations of multiphase flow through porous media. However, such simulations are challenging at scale due to the high computational costs of existing numerical methods. As a result, the lack of efficient modeling approaches can lead to significant uncertainties in evaluating storage capacities and optimizing for safe and effective injection sites.

Machine learning (ML) provides a powerful alternative to numerical simulation with several orders of magnitude speedups while maintaining comparable accuracy. We demonstrate the viability of a general-purpose ML-based framework that can serve as an alternative to numerical simulation for modeling CO2 geological storage through a series of progressively more powerful ML model architectures, including convolutional neural networks, enhanced-Fourier Neural Operators (U-FNO), Nested Fourier Neural Operator (FNO), and graph neural operators (MGN). The ML modeling series provides predicting capabilities across reservoir and basin scales, speeding up flow prediction up to 700,000 times compared to numerical methods.

The fast inference of machine learning models enables many critical tasks for CO2 geological storage decision-making that were prohibitively expensive. This framework allows for unprecedented real-time modeling and probabilistic simulations that can support the scale-up of global CO2 geological storage deployment. The trained machine learning models are hosted in the public web application https://CCSNet.ai to demonstrate the predictability to the community.

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References

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