A Module for Model Updating and Dynamic Risk Assessment by Assimilating Monitoring Data in the NRAP-RAMP Tool

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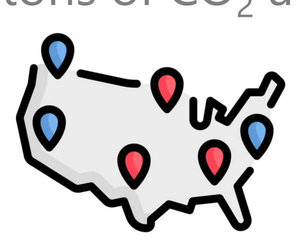
NRAP National Risk Assessment Partnership

Motivation

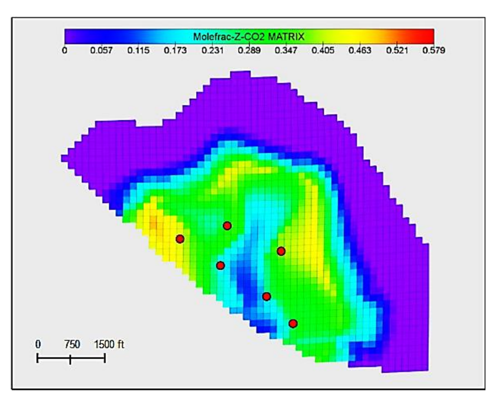
Introduction: Carbon capture and storage plays a key role in mitigating CO_2 emissions to reach the net-zero objectives. Thus, deploying large-scale geologic CO_2 sequestration projects requires dynamic risk assessments to ensure safe CO_2 containment in multicomponent storage sites.

US goal: store 400 -1800 million metric tons of CO_2 annually

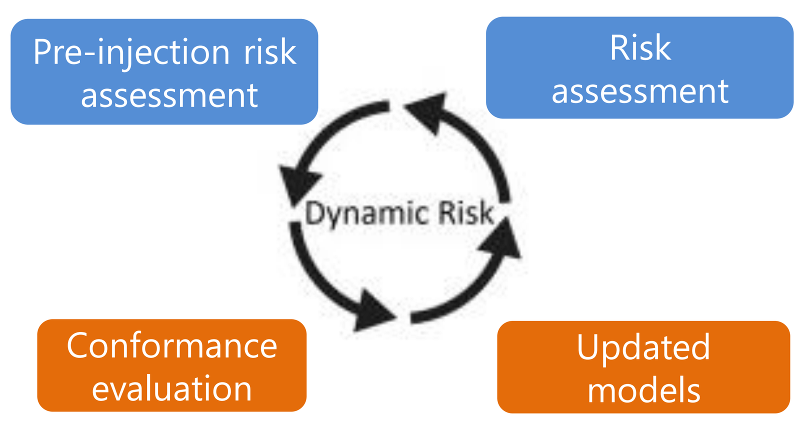


Challenges

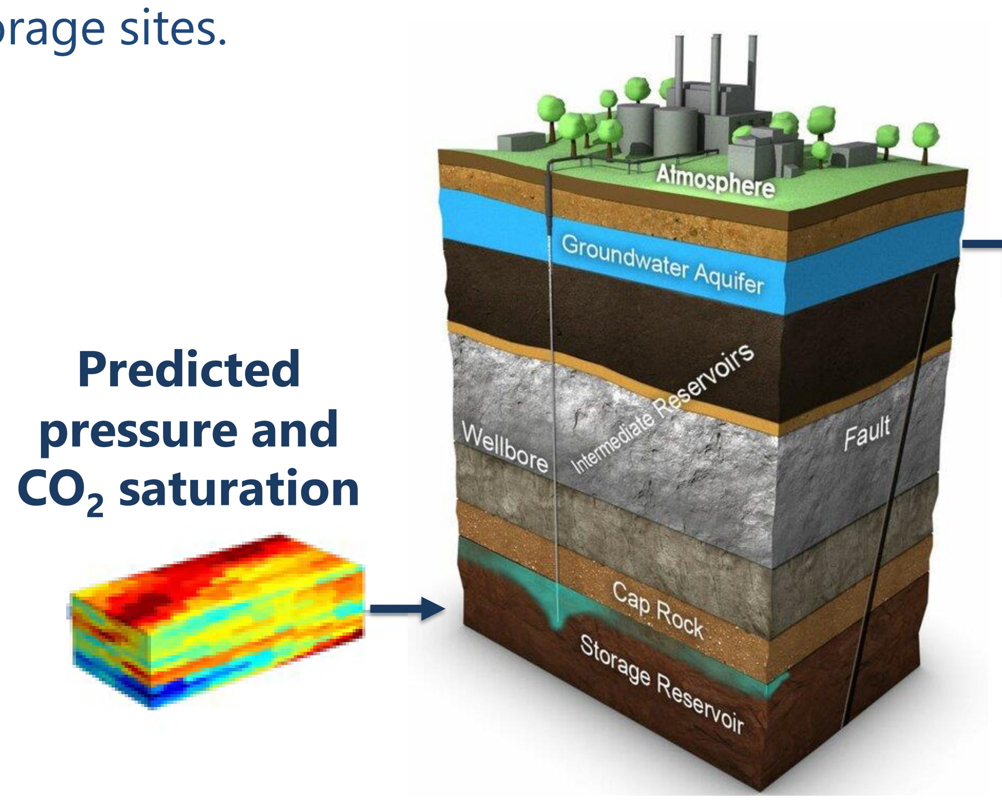
Time-consuming simulations



Dynamic risk assessment



Objective: Assimilate point/spatial monitoring measurements into reservoir models for parameter updating and integration into NRAP-Open-IAM to reduce the uncertainty in risk metrics of geologic CO_2 storage sites.



Analysis of risk metrics

CO_2 and brine leakage rates to the aquifer

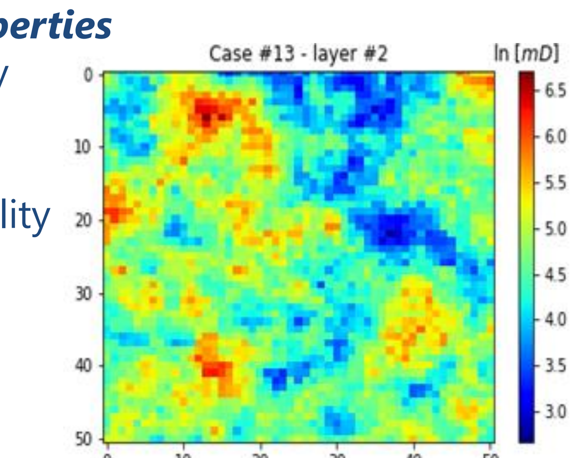
Predicted pressure and CO_2 saturation

Inputs

Operating conditions
- CO_2 injector locations
- Injection period and rates

Reservoir properties
- Permeability
- Porosity
- Fault transmissibility

Observed information
- Direct pressure and CO_2 measurements
- Pressure and CO_2 data interpreted from geophysical monitoring

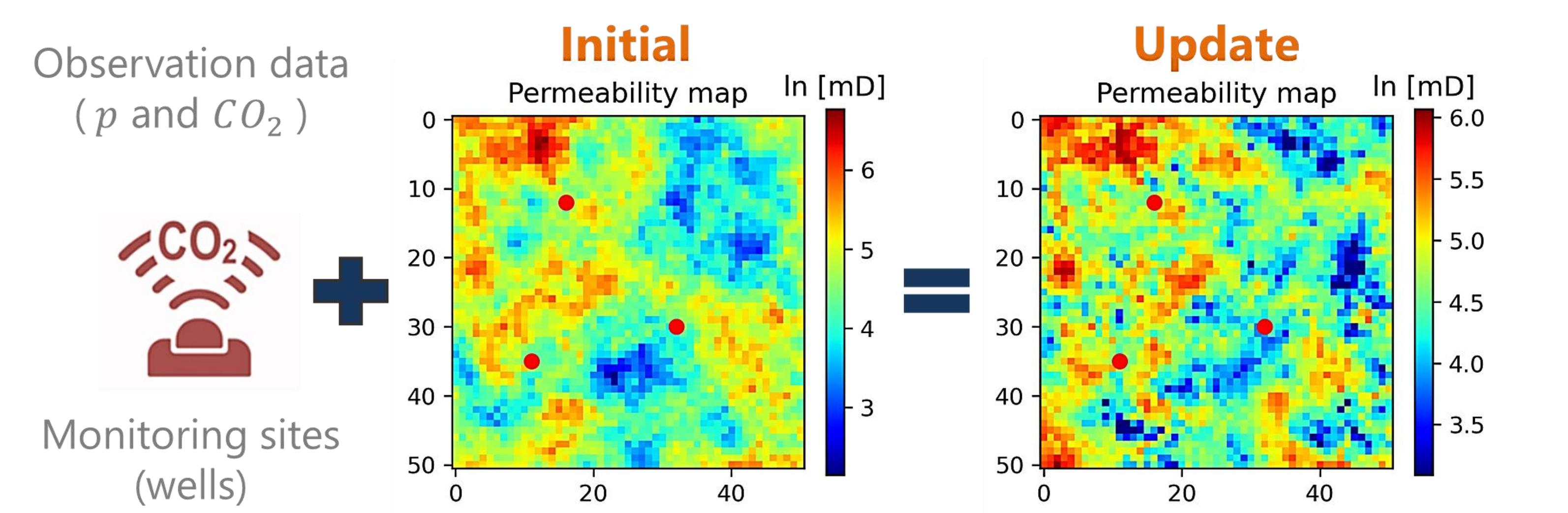


What?

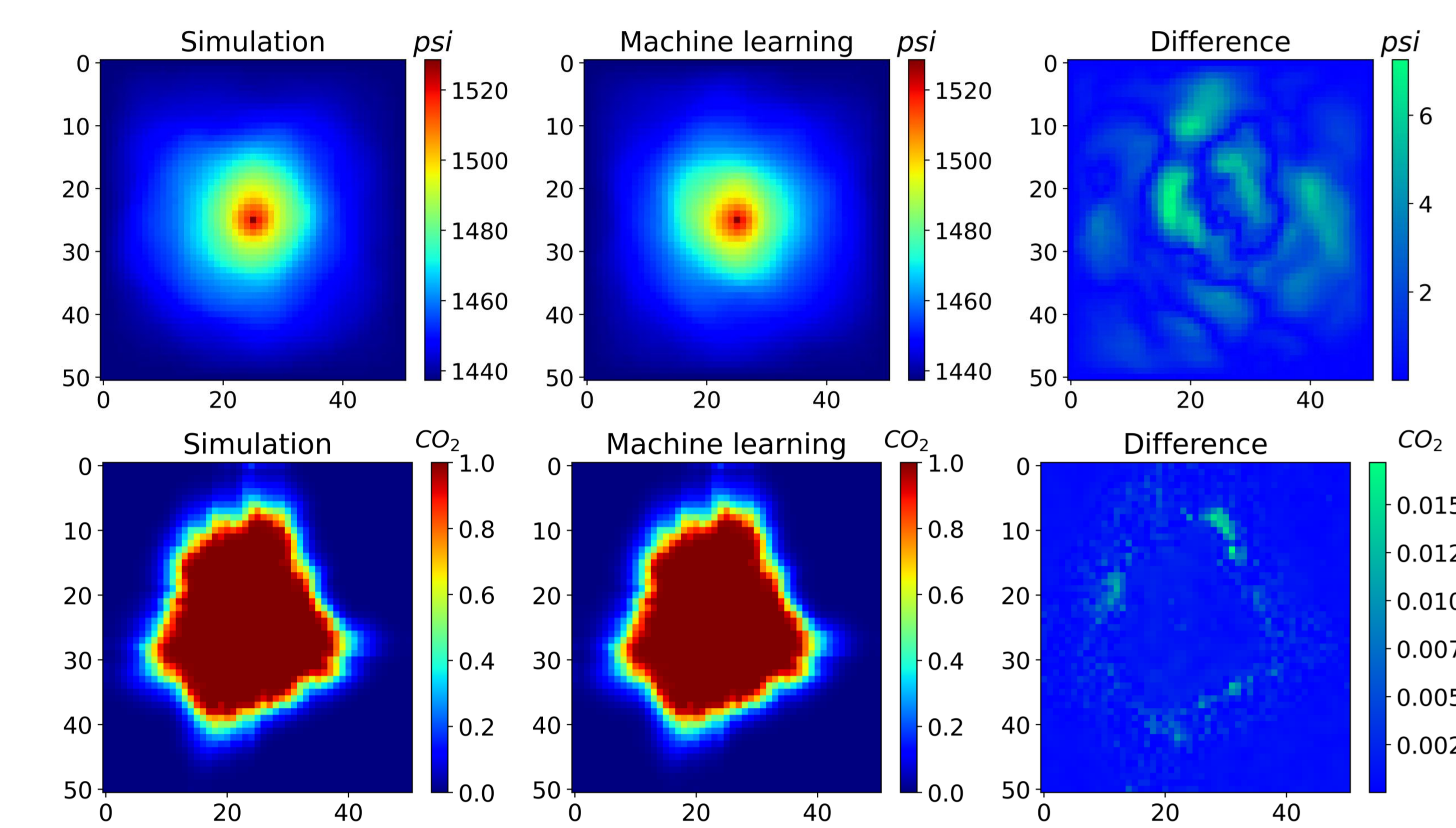
Development

Pressure and CO_2 saturation data in reservoir models are estimated with deep-learning proxies based on Fourier Neural Operators (FNOs) and the implementation of the Ensemble-Smoother with Multiple Data Assimilation (ES-MDA) as the inverse modeling engine.

1 Conformance evaluation

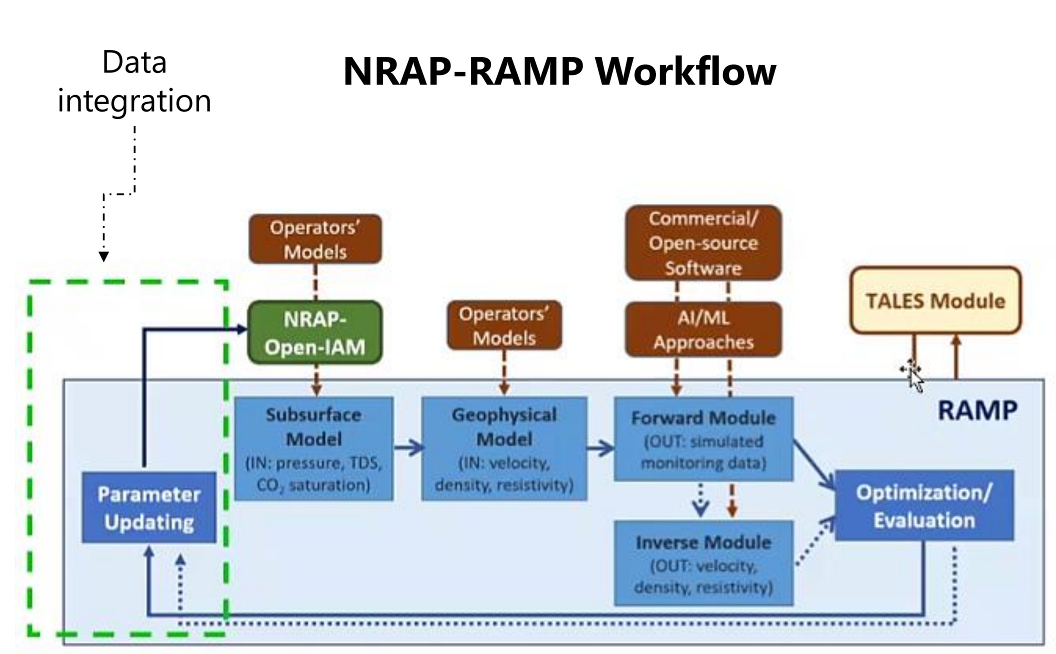


2 Prediction of pressure and CO_2 saturation with machine learning

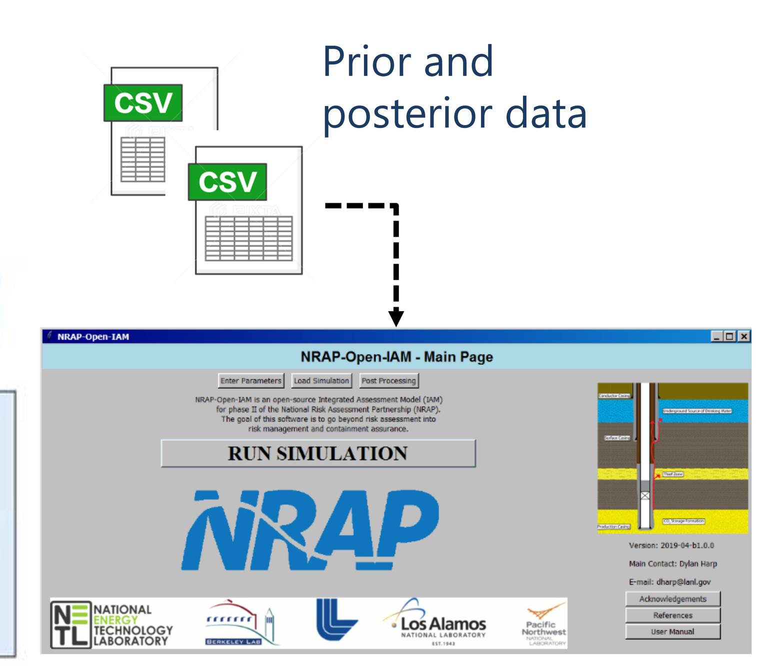


Rapid prediction of properties compared to time-consuming simulations: 12-month results.

3 Integration of pressure and CO_2 saturation data into NRAP-RAMP



Prior and posterior data

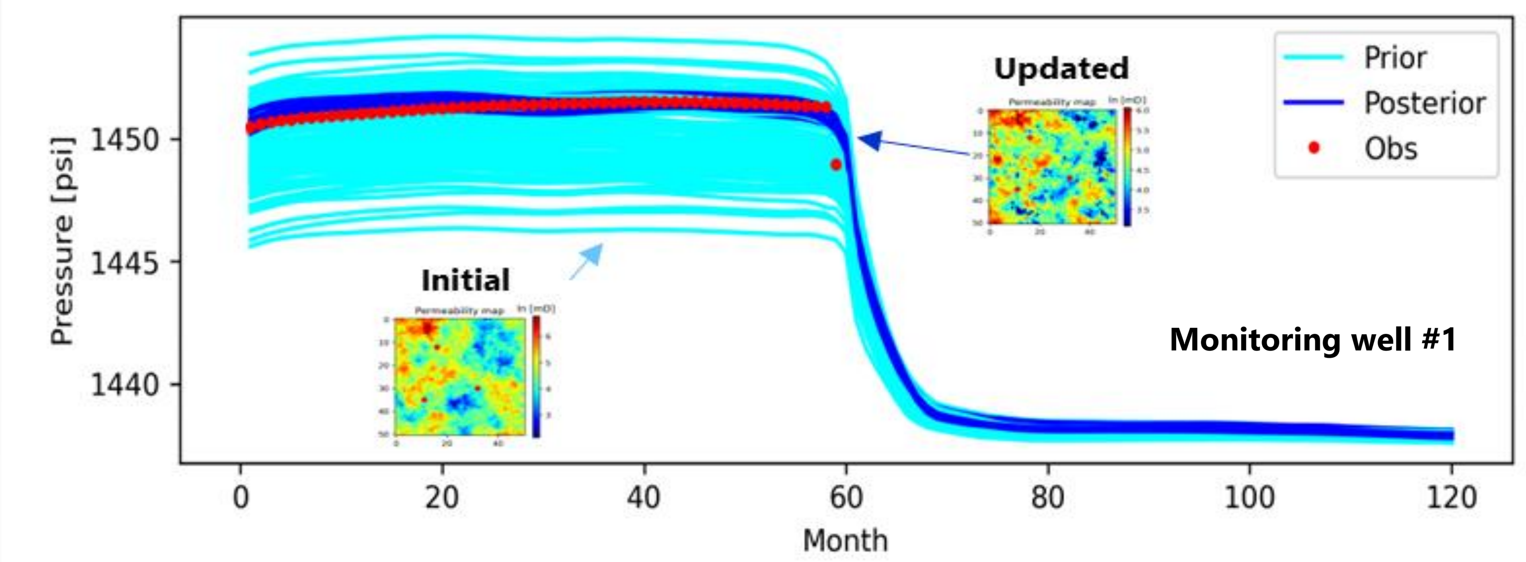


How?

Results

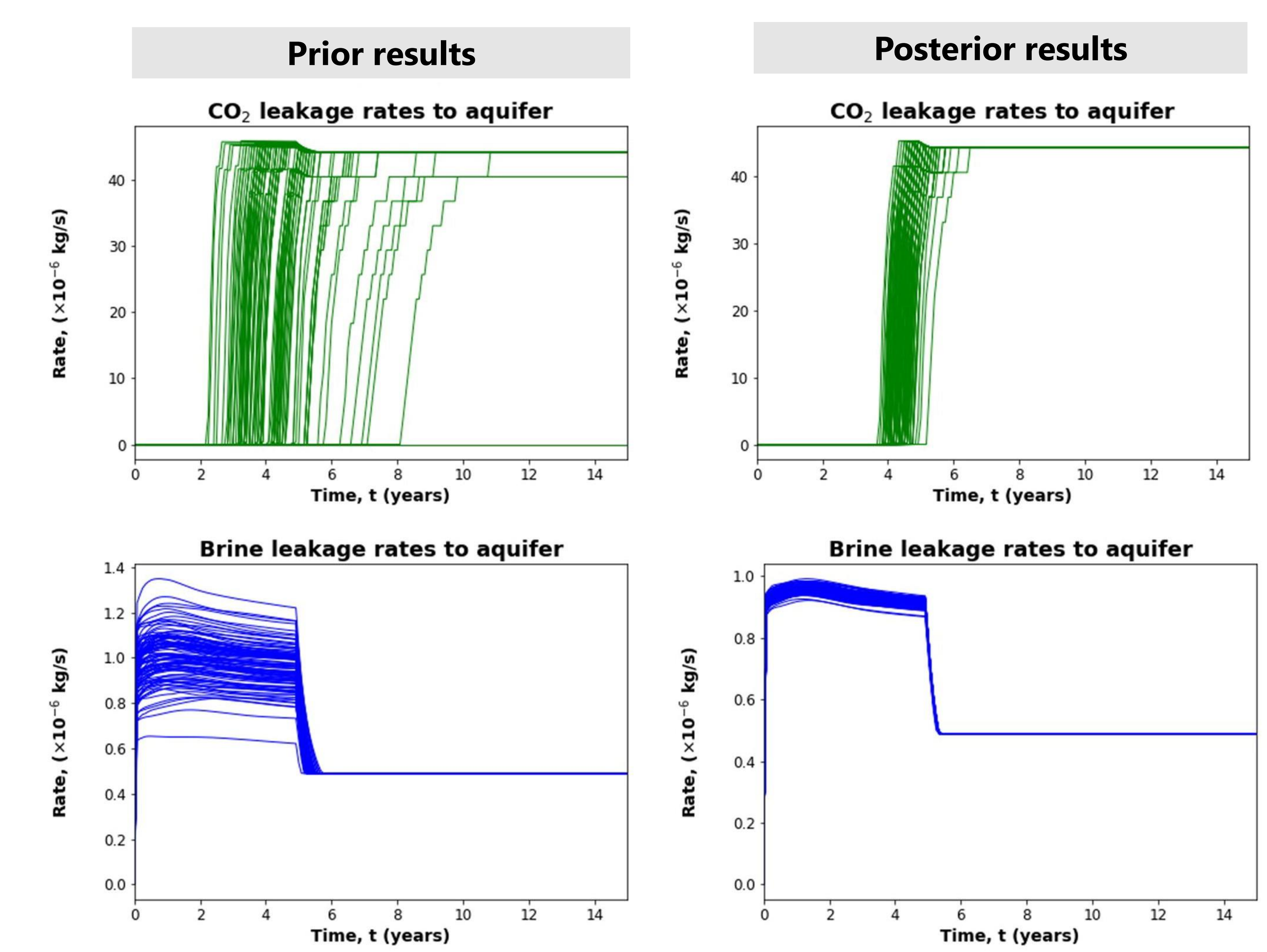
History matching

Comparison of pressure profiles obtained with initial and updated models for a monitoring well in the reservoir.



- Prior results exhibit large variability (uncertainty)
- Posterior responses show small differences against observed data

Leakage risk assessment



CO_2/brine leakage rates to the aquifer present a large uncertainty in the breakthrough time when relying only on prior models.

Conclusions: We developed a novel machine-learning workflow that enables the rapid and accurate prediction of pressure and CO_2 saturation evolution in geologic storage reservoirs. This approach serves as a novel generator of prior and posterior data that can be easily integrated into NRAP-Open-IAM for uncertainty analysis in risk-related geologic storage metrics. As a result, it is possible to investigate the leakage likelihood in key components to support risk-management decisions in carbon sequestration deployment.

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So what?

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