Los Alamos NATIONAL LABORATORY

National Risk Assessment Partnership: Delivering Tools to Support Risk-Based Decision Making for Geologic Carbon Storage Deployment

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CUSP Annual Meeting

September 11th, 2024

LA-UR-24-29698

Disclaimer

NRAP leverages DOE's capabilities to quantitatively assess and manage long-term environmental risks amidst geologic uncertainty and variability.

NRAP
National Risk Assessment Partnership

Technical Team

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Pacific Northwest
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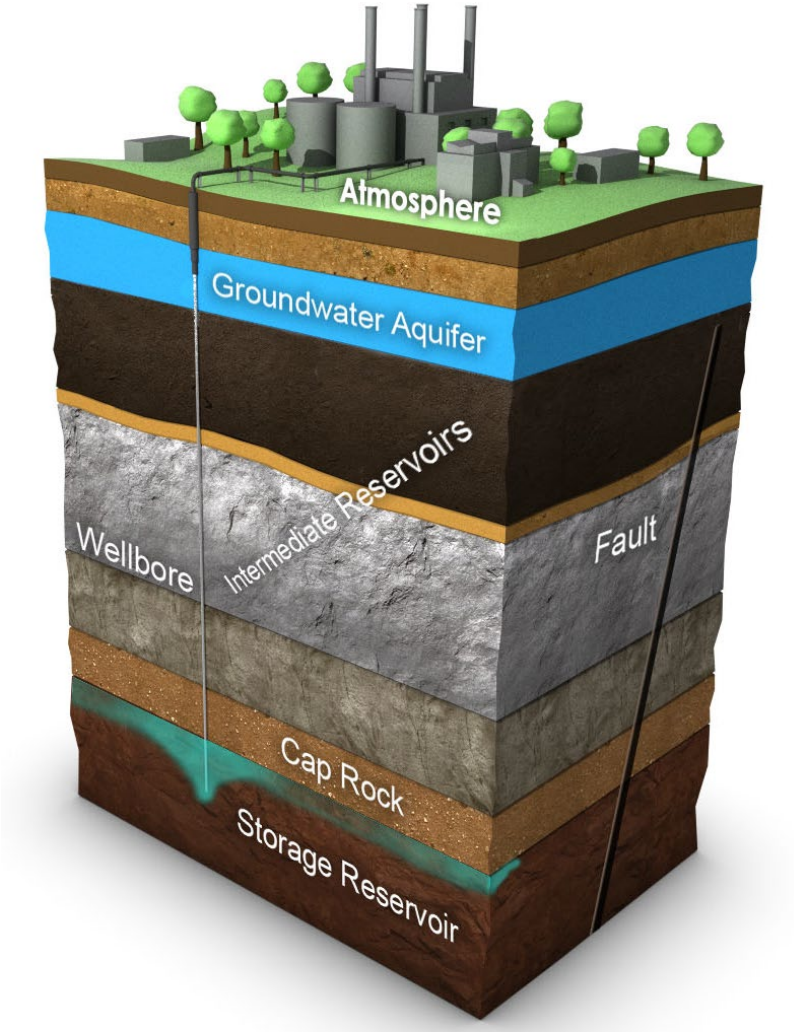
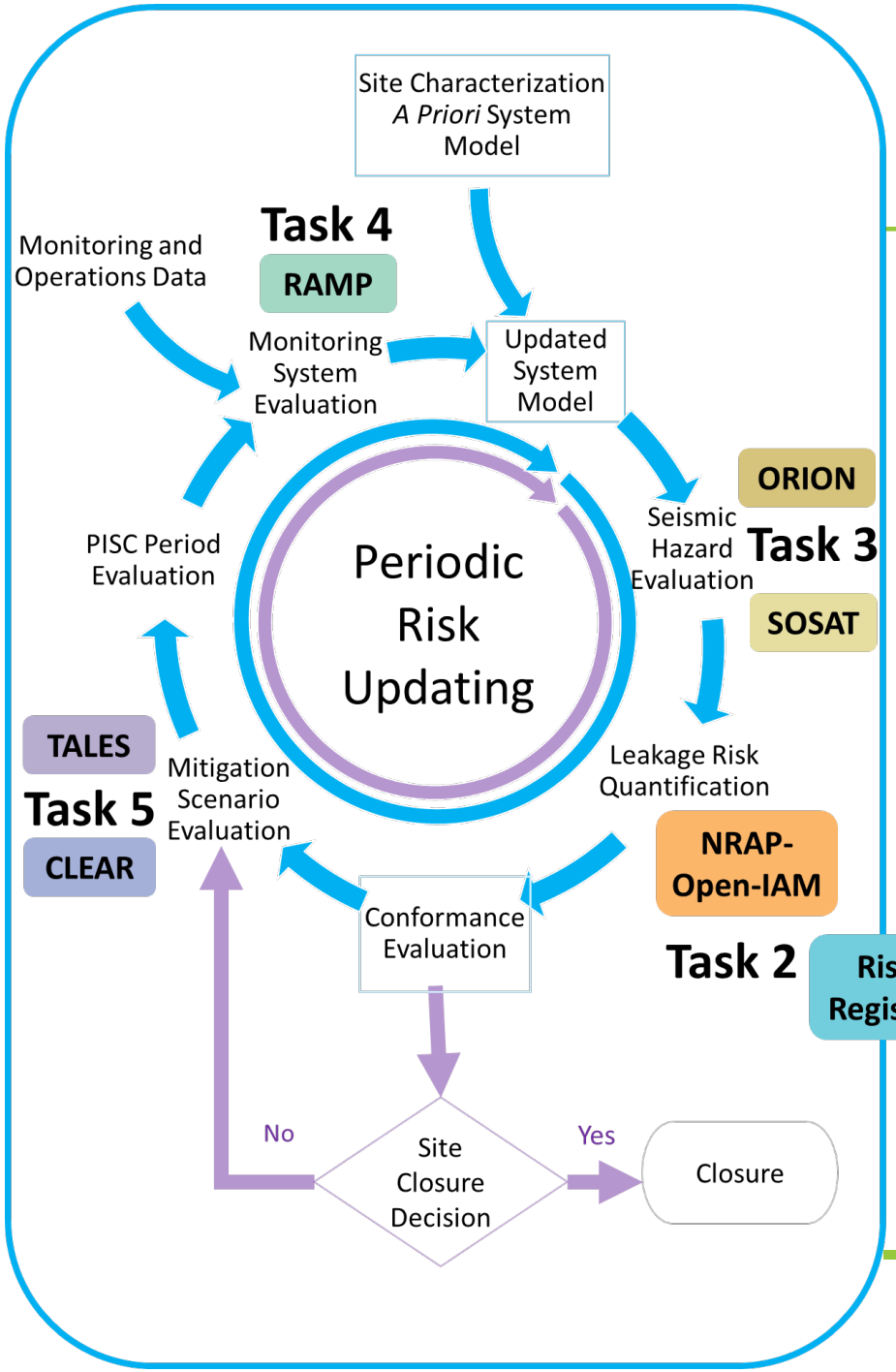
NRAP Website: https://edx.netl.doe.gov/nrap/





NRAP
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Developing numerical tools to facilitate permitting and support decision making related to multiple aspect of risk management.

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Evolving Focus of NRAP

- Phase I (2010–2016) - Risk Assessment and Uncertainty Quantification
- Phase II (2017–2022) - Risk Management and Uncertainty Reduction
- Phase III (2022 – 2027) – Supporting CCS deployment.

NRAP Phase III Objective:

Maturing practical, useable tools and methods to quantitatively assess and manage risks and liability for geologic carbon storage at site and basin scales, and promoting their application for permitting and risk-related decision support to enable geologic carbon storage commercial deployment.

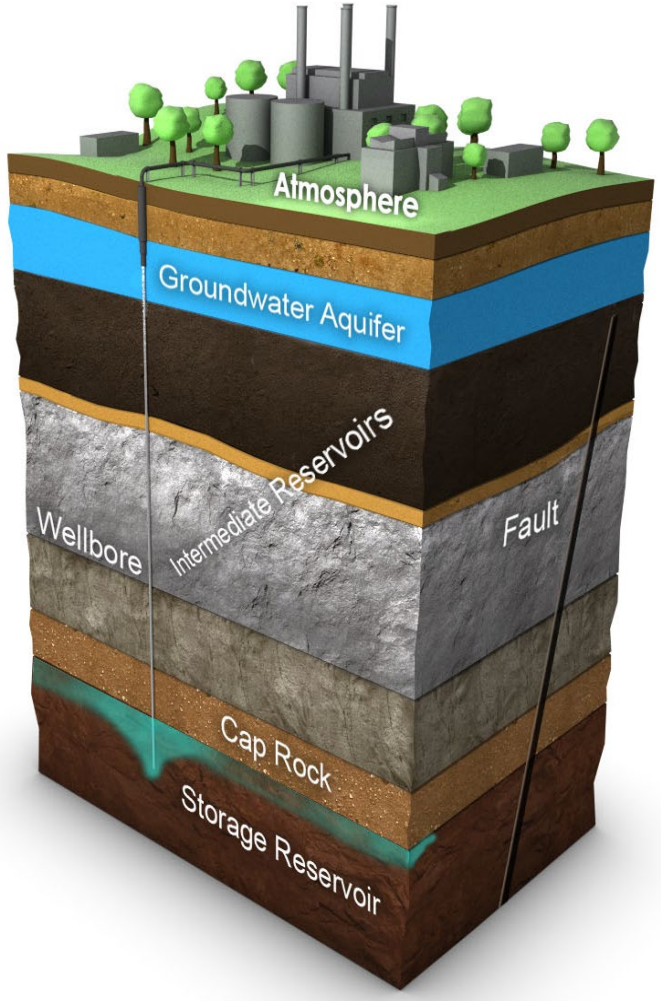
NRAP Phase III Toolset

- NRAP Open-Source Integrated Assessment Model (NRAP-Open-IAM β v1.1.0; 7/2024)
- Operational Forecasting of Induced Seismicity Toolkit (ORION v1.0.0; 3/2024)
- State of Stress Analysis Tool (wSOSAT v1.0.0; 3/2024)
- Risk-Based Adaptive Monitoring Planning (RAMP) Tool (Prototype 8/2024; α version Coming Soon!)
- Techno-economic and Liability Evaluation (TALES) Model (α v0.5)
  - Carbon Capture, Utilization, and Storage Leakage Evaluation and Remediation (CLEAR) model (Prototype 8/2024)
  - Reservoir Remediation Module (Remed-Res; Prototype 8/2024)

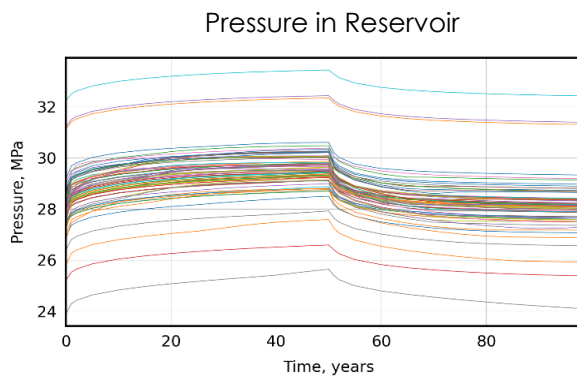
Access the NRAP Toolset here:

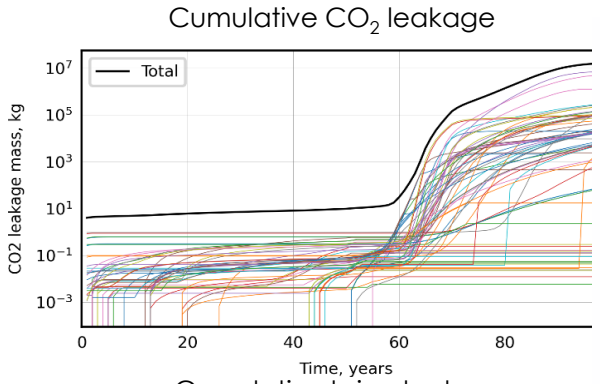
Tool for Containment Assurance and Leakage Risk Management

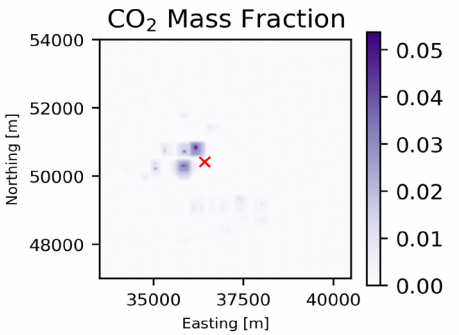
NRAP-Open-IAM Application

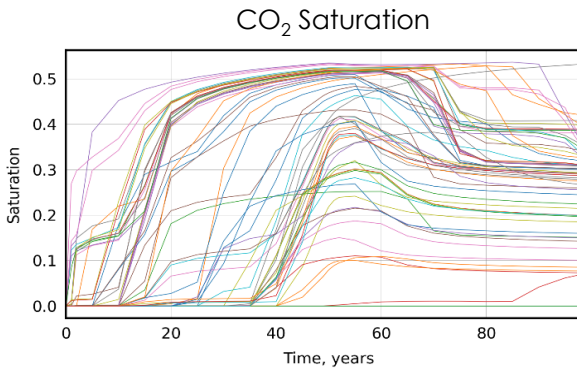


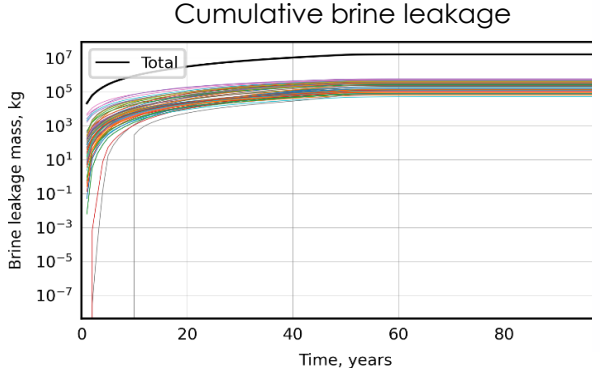
Reservoir LUT (Kimberlina Site) → **Multisegmented Wellbore ROM** → **Aquifer Impact ROM**

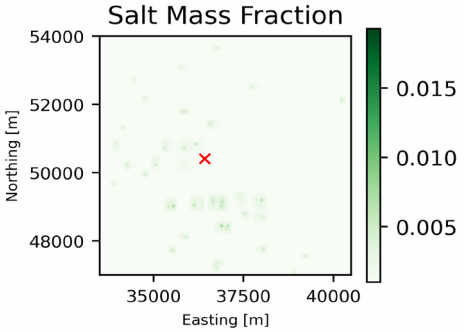






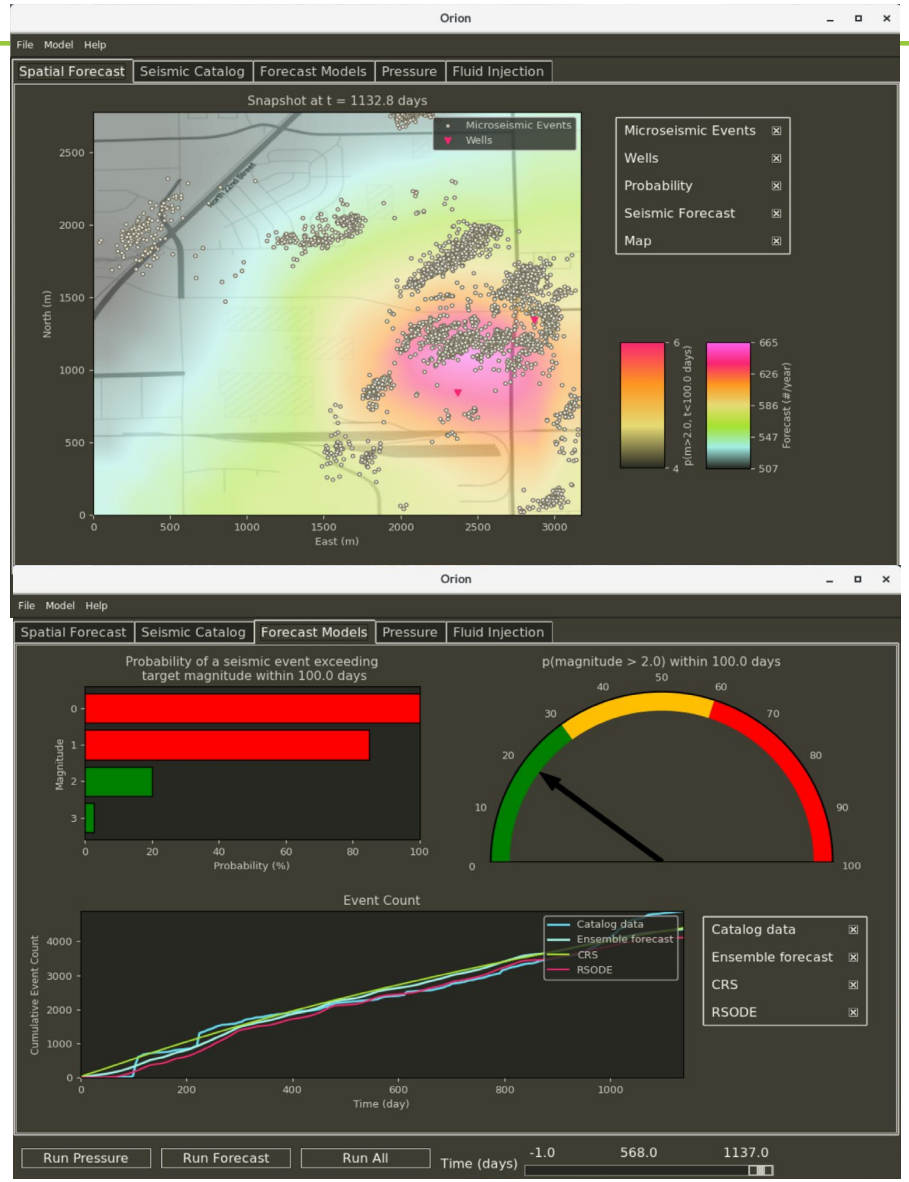


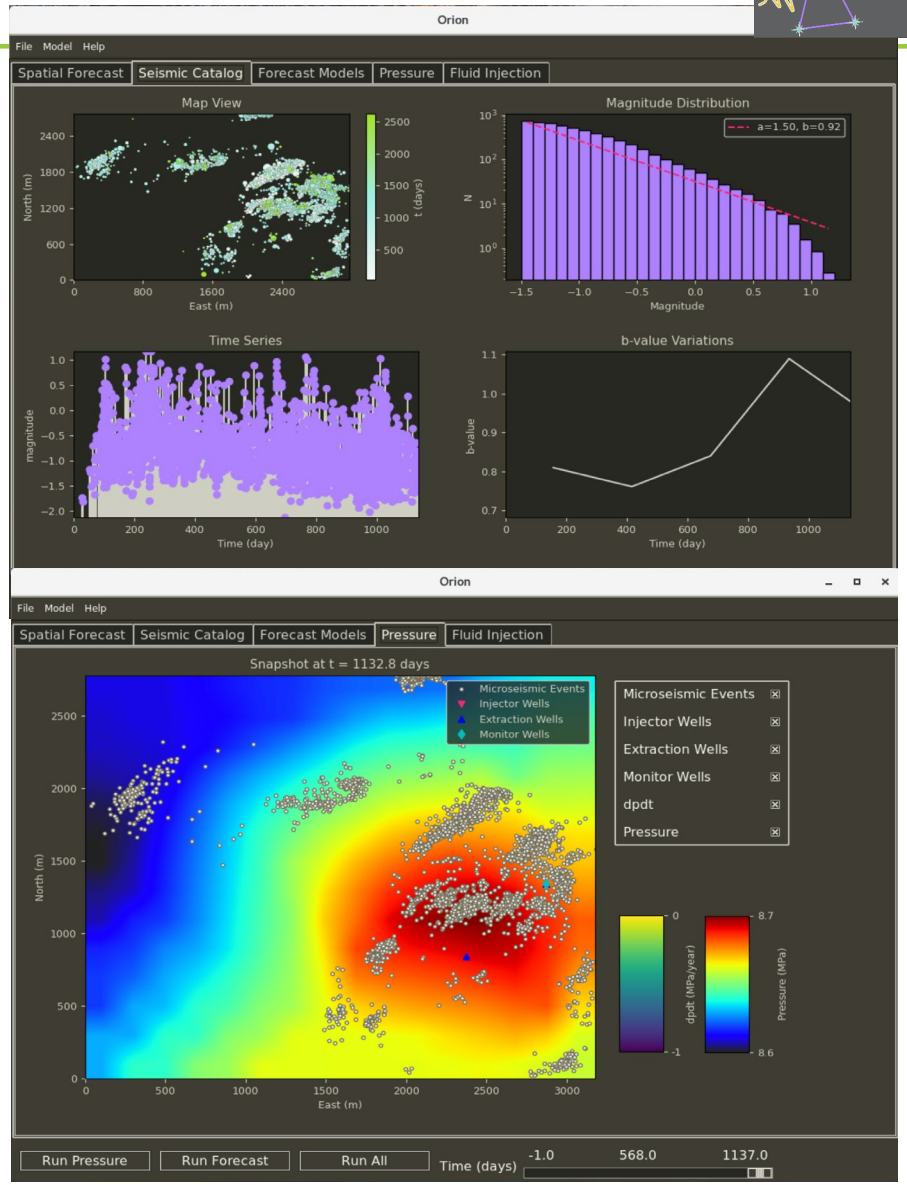




Tool to forecast and manage induced seismicity risk

- Import:
  - Well locations
  - Injection rates
  - Reservoir properties
  - Seismicity catalog
- Compute reservoir pressure and Coulomb stress changes
- Compute spatial and temporal seismicity forecast (via physics and statistical models)

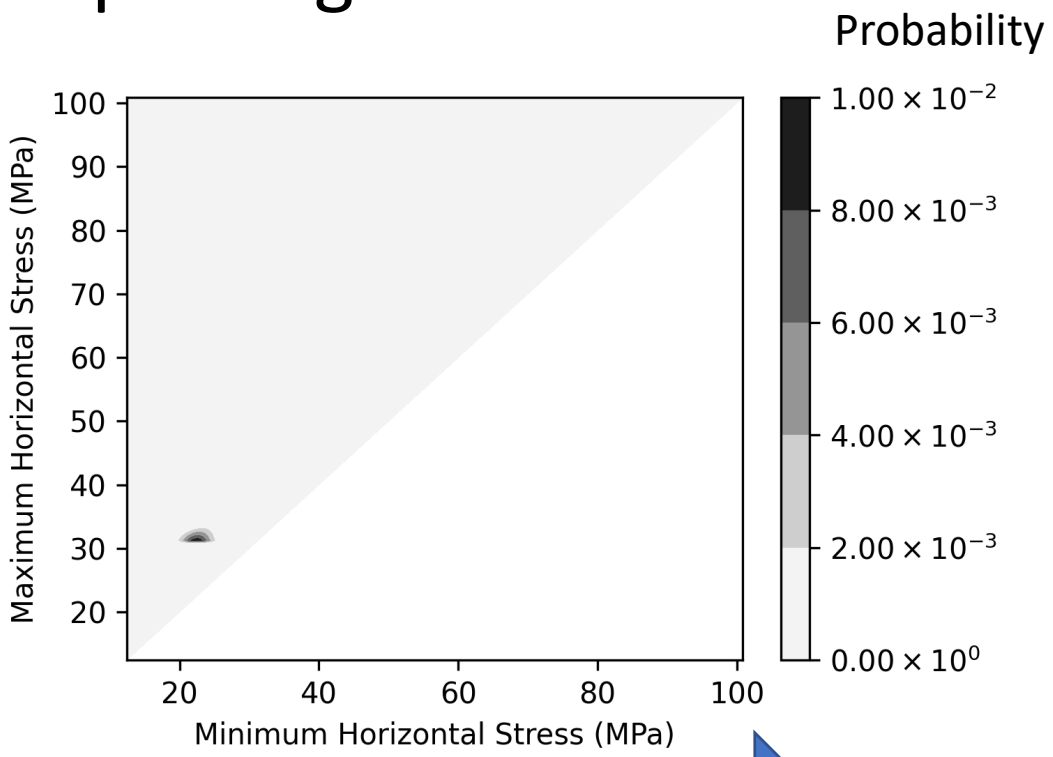




Kroll, Kayla, and Sherman, Christopher. *ORION: Operational FoRecastIng Of INduced Seismicity*. United States: N. p., 2023. Web. doi:10.18141/1958726.

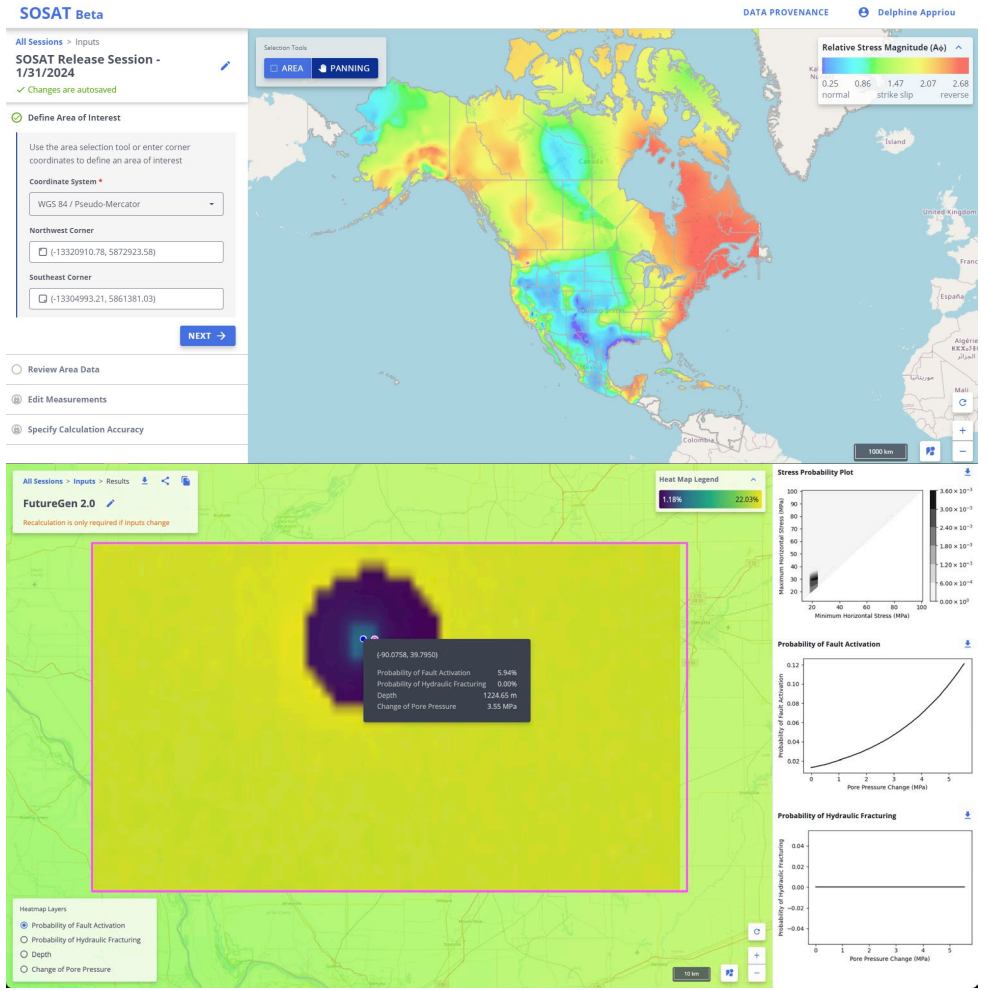
Tool to estimate probability distribution of the stress state

Updating state-of-stress



More Information w/ Time

Modified from: Burghardt & Appriou (2021)



Burghardt et al., 2024

U.S. DEPARTMENT OF ENERGY

https://sosat.pnnl.gov/

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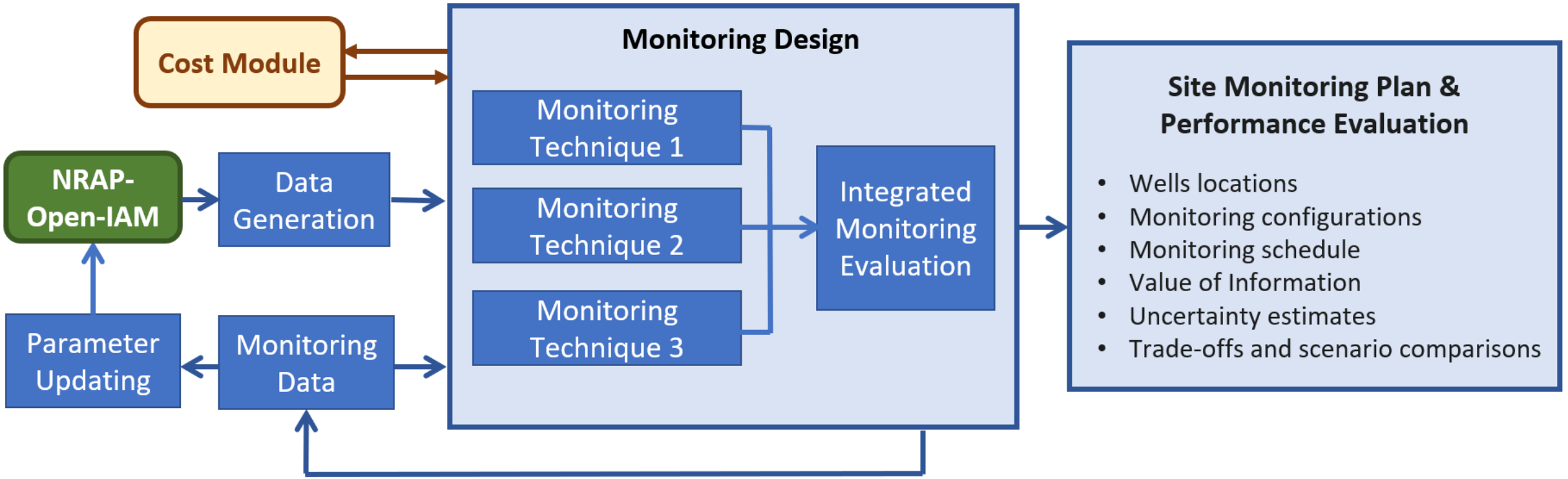
Tool to design adaptive, risk-based monitoring plans

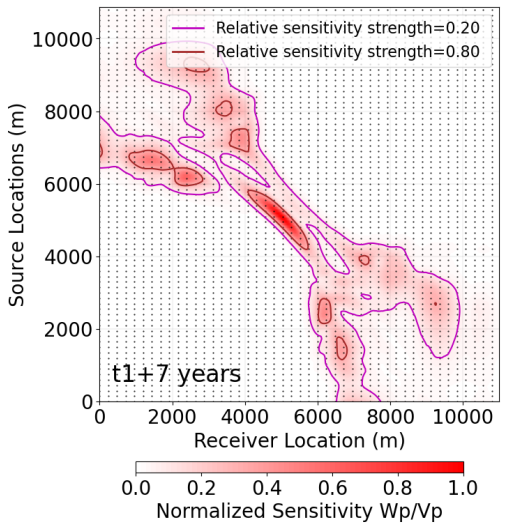


RAMP allows the user **to assess multiple monitoring technologies** (downhole pressure, fluid geochemical sampling, indirect methods – seismic, gravity, electrical/electromagnetic) and their **combination**, **sensor configurations, monitoring intervals**, and select an **optimal site monitoring plan** based on the **main project objectives**.

Elements of the Risk Adaptive Monitoring Planning (RAMP) Tool

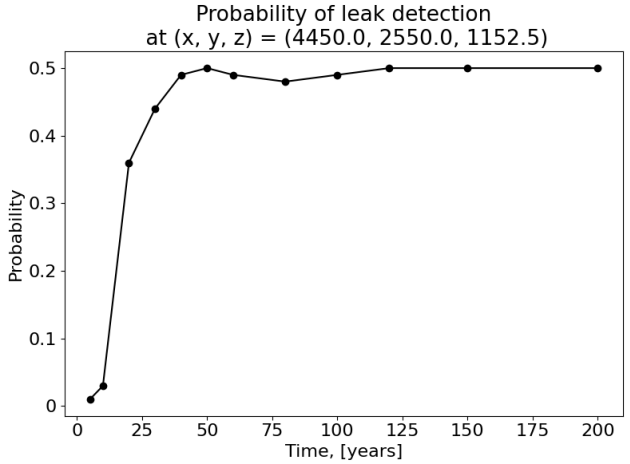
Monitoring Design/Optimization

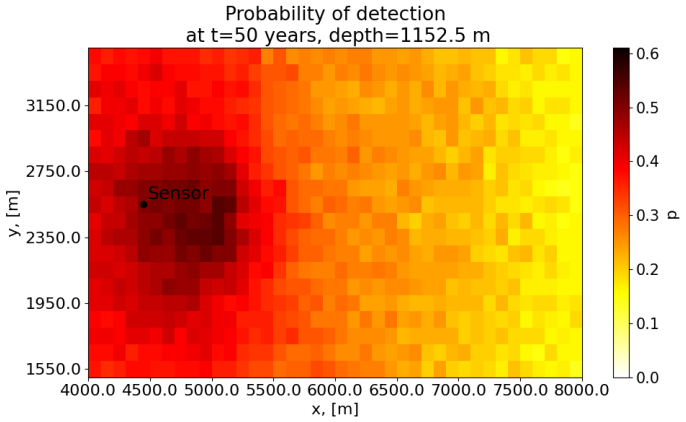
$$\text{Sensitivity Strength} = \frac{\sum \text{sens above a threshold}}{\sum \text{all sensitivity values}}$$



Outputs

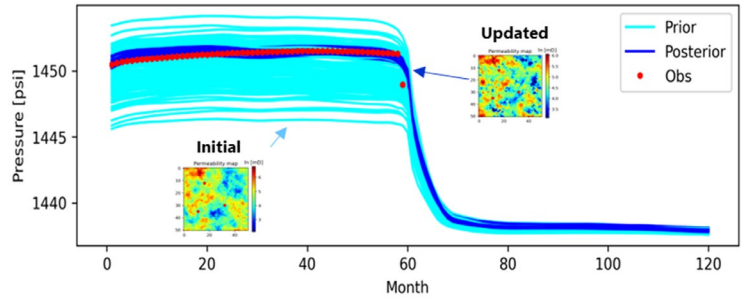
Evaluating Probability of Leak Detection



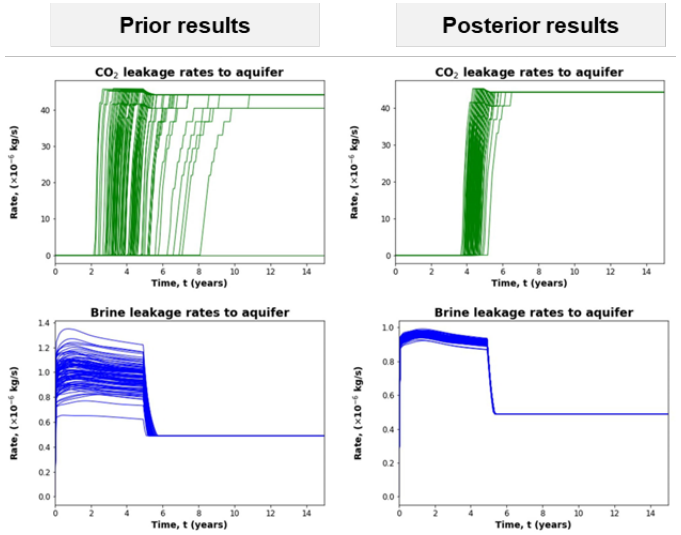


Model Updating and Dynamic Risk Assessment Using Monitoring Data

History matching reservoir pressure (initial and updated models



Assessing risk of CO_2 and brine leakage to aquifer

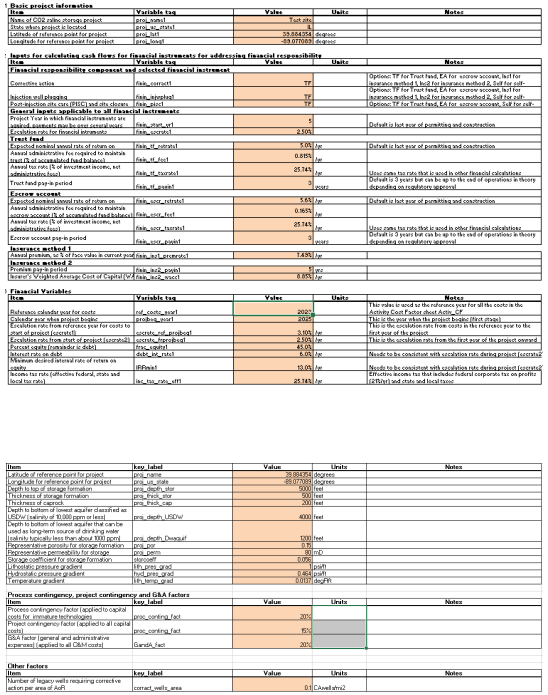


Technoeconomic and Liability Evaluation (TALES) Model

Linking project technical risk to cost and liability

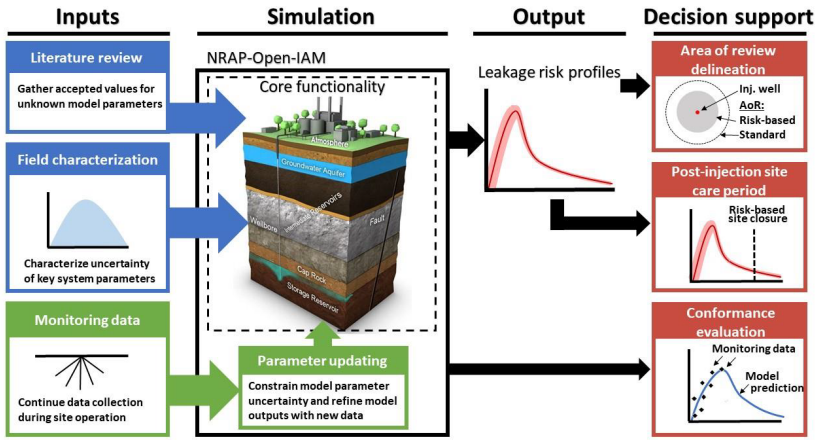
Scenario Definition

- Inputs for scenario definition, injection schedule, activity costs, etc.



Risk & Cost Model

Site performance and risk quantification

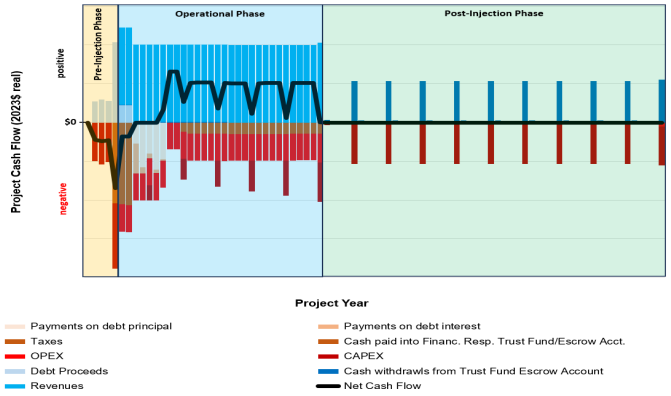


Risk mitigation/remedial response activity and cost estimation

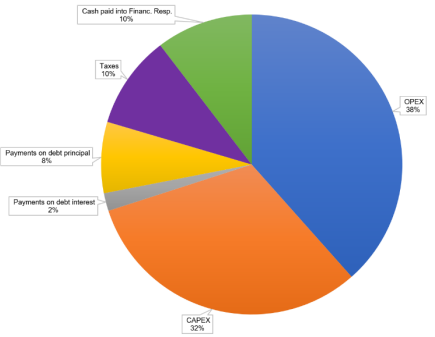
(Under Development)

Scenario Evaluation

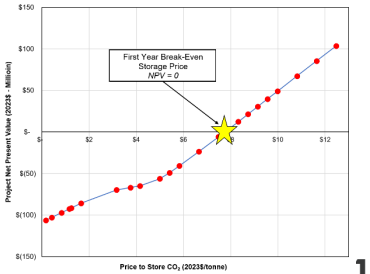
Cash Flow



Total Expense



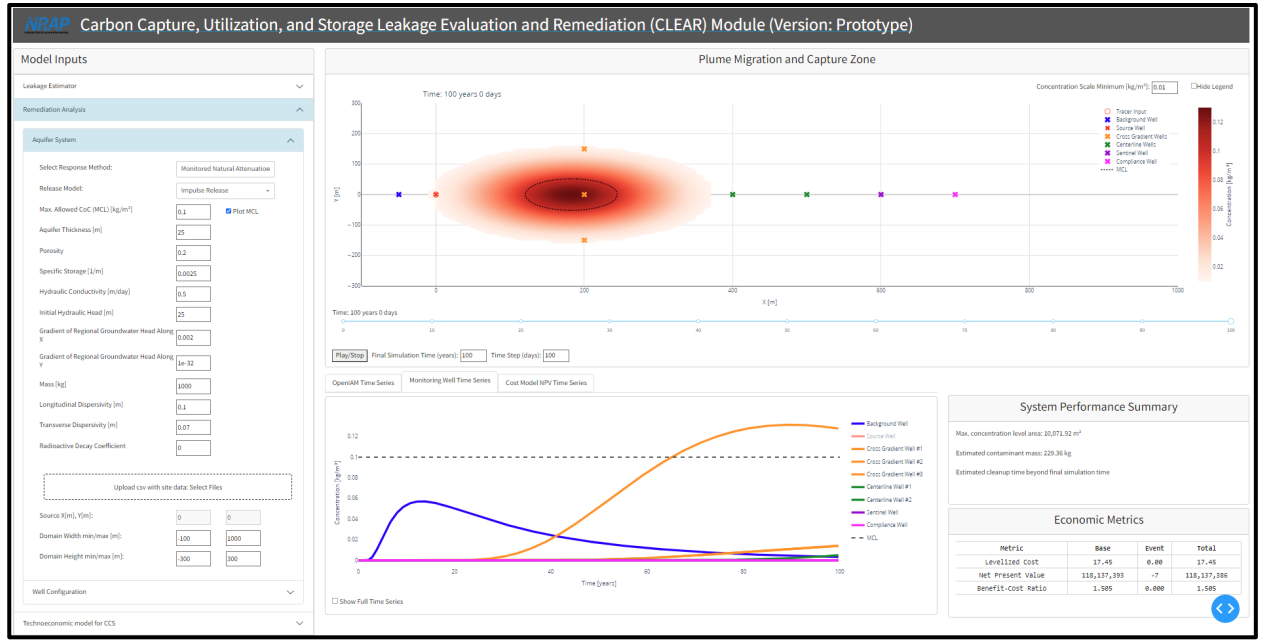
Net Present Value / Break Even



Modules to estimate remedial response.

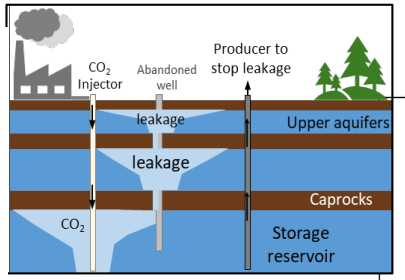
CLEAR module (USDW remedial action) (Prototype demo 8/6/2024)

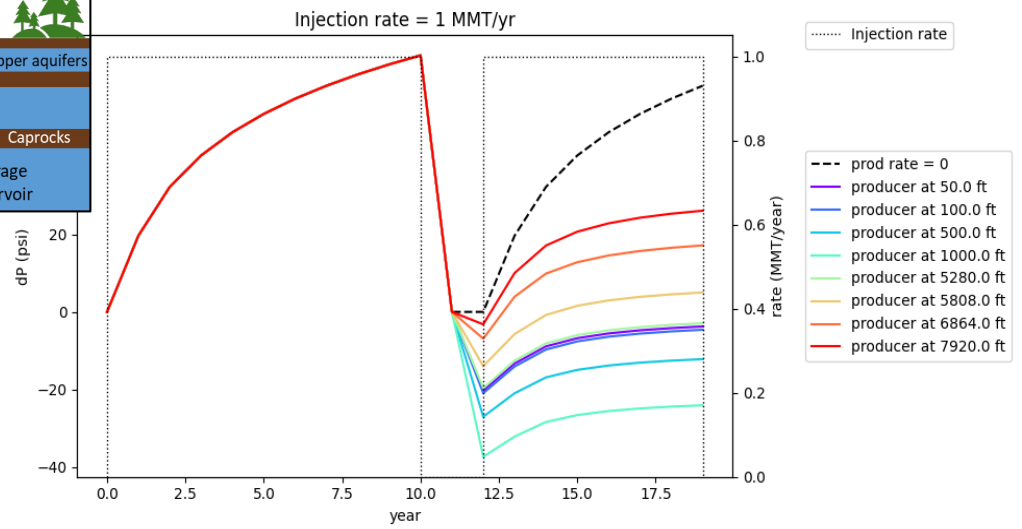
- CO_2 or brine plume distribution over time in the impacted aquifer.
- Pump and Treat RR Approach
- Monitored Natural Attenuation (MNA)



Reservoir Remediation Module (Remed-Res; Prototype 8/2024)

- Estimate pressure mitigation effect of brine production scenarios

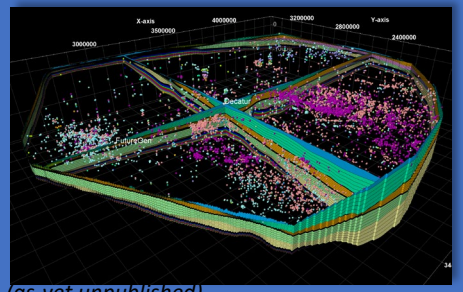




Estimating basin-scale risks of broad GCS deployment

Approach: Case stud(ies) leveraging the NRAP tools to forecast basin-scale response and assess risks for credible deployment scenarios.

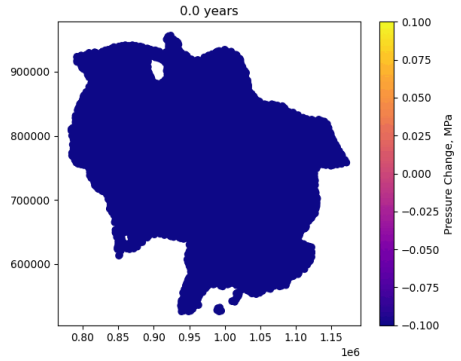
Basin-Scale Geologic Modeling and Characterization



Creason (as-yet unpublished)

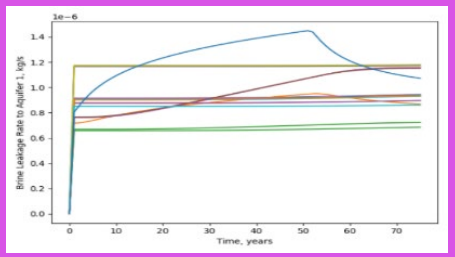
GCS Deployment Scenarios

Basin-Scale Reservoir Simulation

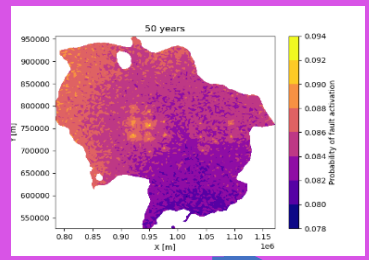


Forecasts of Basin-Wide Risks

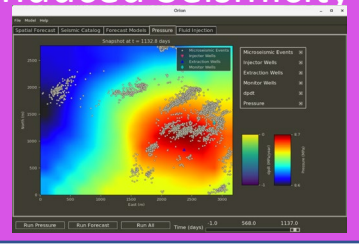
Leakage Risk



State-of-stress



Induced Seismicity



Develop Insights on Basin-Scale Risks and Risk Management

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Thank you!

Access the NRAP Toolset here:

Contact us at:

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NRAP Website: https://edx.netl.doe.gov/nrap/

NRAP Tools: https://edx.netl.doe.gov/group/nrap-toolset