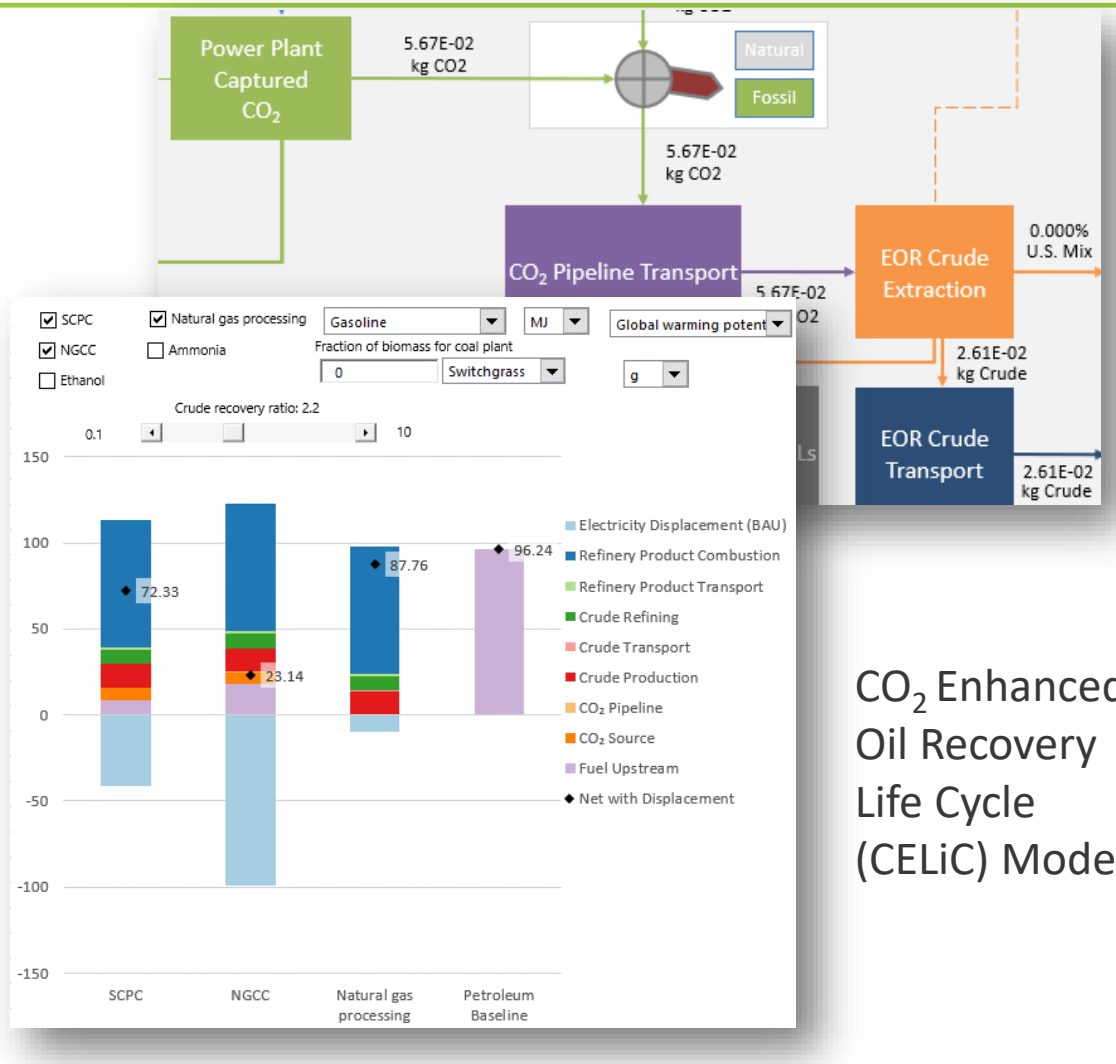
NETL Life Cycle Analysis of Energy Technology and Pathways

- Considers life cycle environmental burden and cost analysis
- Used as a tool and framework for evaluating energy technology and policy options on a common basis.
- Products include detailed reports and dynamic software tools

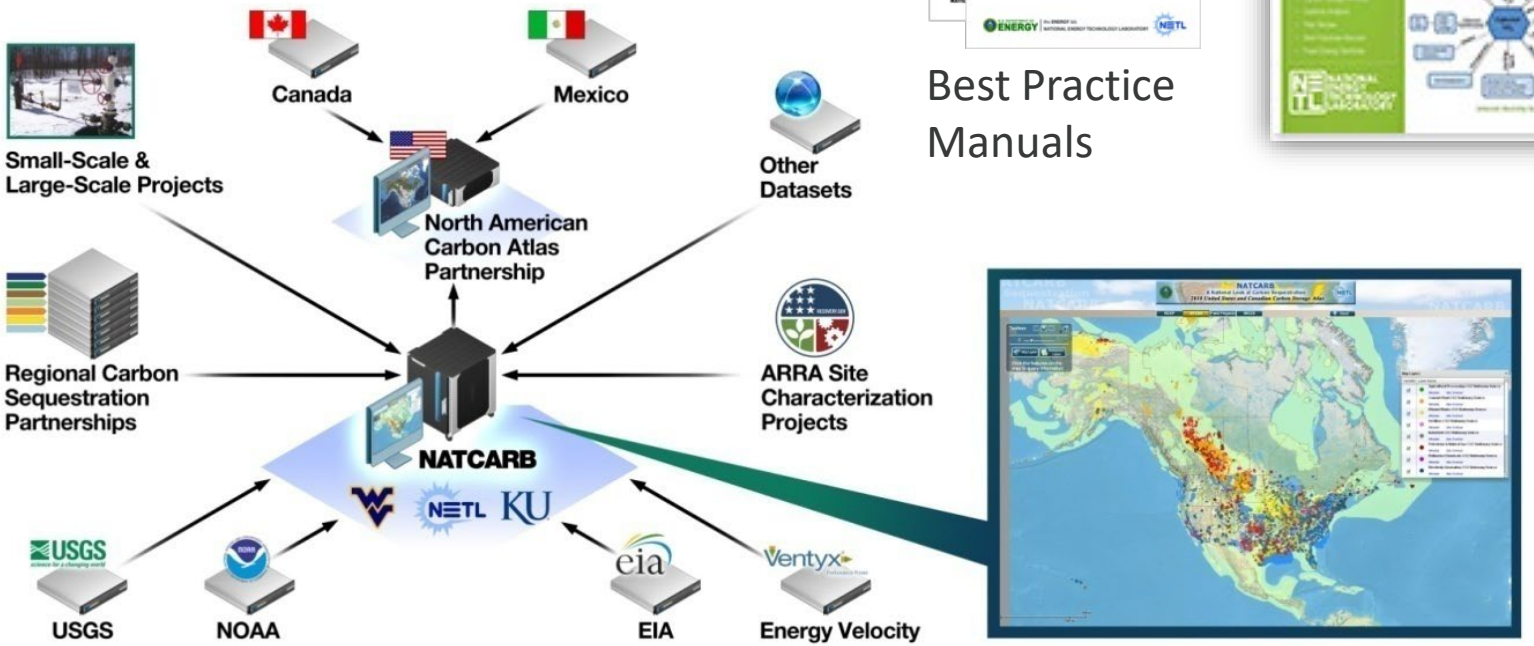


CO_2 Enhanced Oil Recovery Life Cycle (CELiC) Model

Knowledge-Sharing Products

EDX Energy Data eXchange

Best Practice Manuals



Thanks

Dilmore@netl.doe.gov

www.edx.netl.doe.gov/nrap
NRAP@netl.doe.gov

Carbon Storage Assurance Facility Enterprise

NATIONAL ENERGY TECHNOLOGY LABORATORY

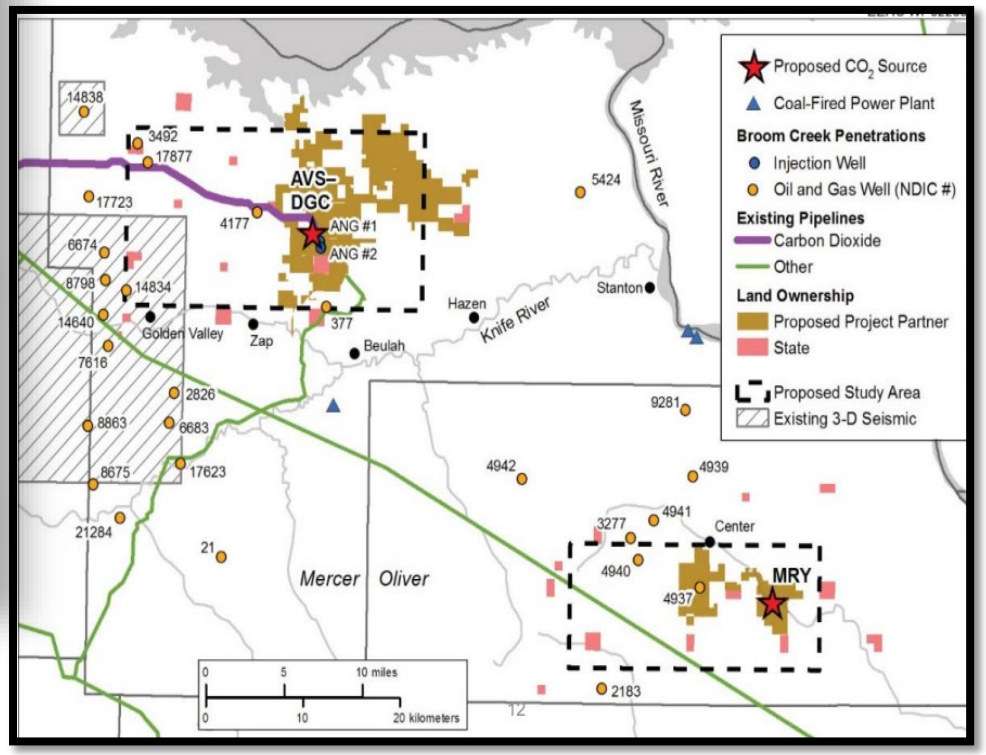
Address the knowledge gaps for 50-100 MMT CO_2 storage complexes

Objectives:

- Perform risk reduction scenarios for site and source selection and operations of an integrated project
- Perform field testing of risk, geologic storage, modeling and monitoring technologies, and injection strategies for storage (50-100 MMT) complex
- Determine how to address challenges (both technical and non-technical) associated with storage (50-100 MMT) characterization and monitoring

Phases:

- Integrated CCS Pre-Feasibility
- Storage Complex Feasibility
- Site Characterization
- Permitting and Construction

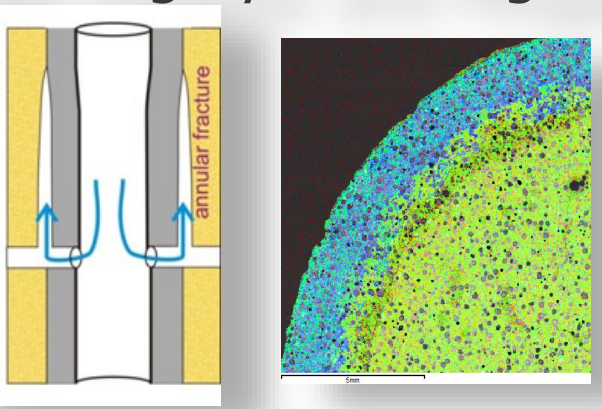


Map Depicting Two Study Areas of the North Dakota CarbonSAFE Feasibility Study

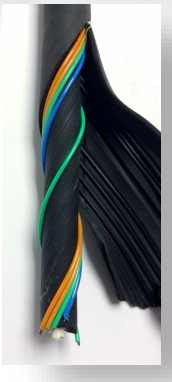
Carbon Storage Program
Addressing Subsurface Challenges and Risk

NATIONAL ENERGY TECHNOLOGY LABORATORY

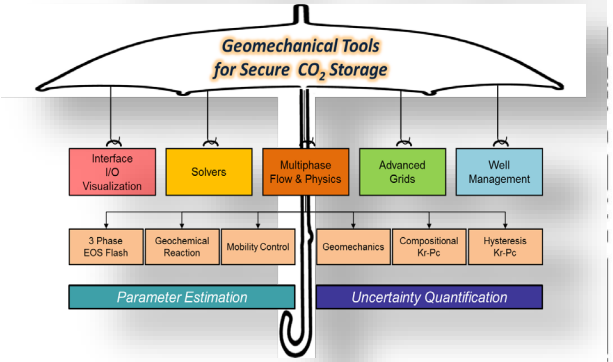
Well Integrity and Mitigation

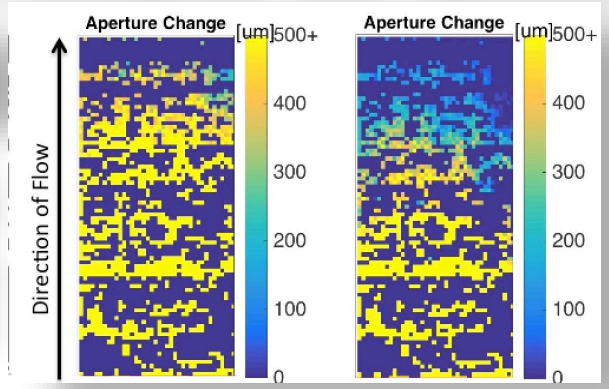


Monitoring Verification and Accounting (MVA)

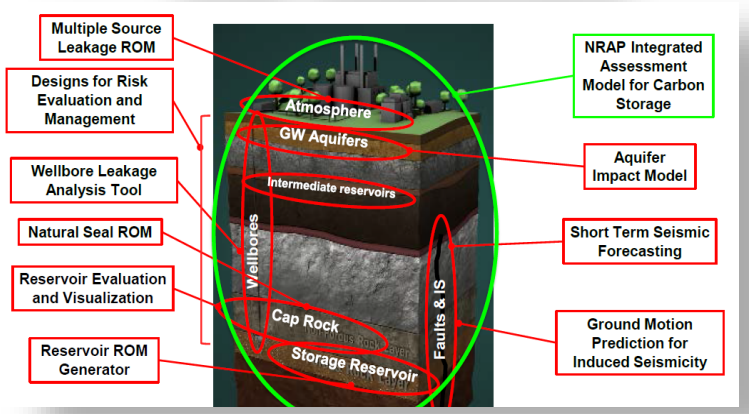


Storage Complex Efficiency and Security





Risk Assessment

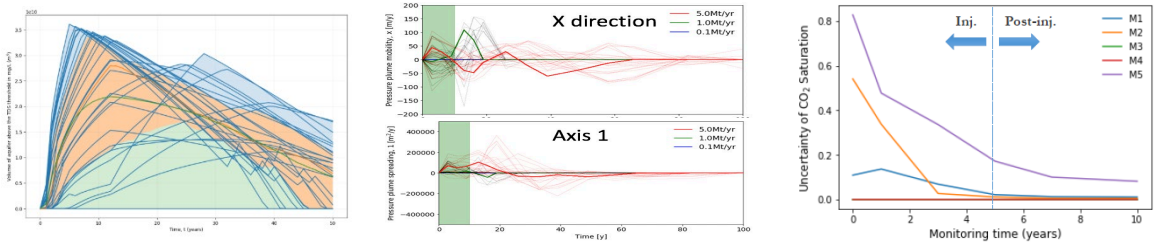


Containment Assurance

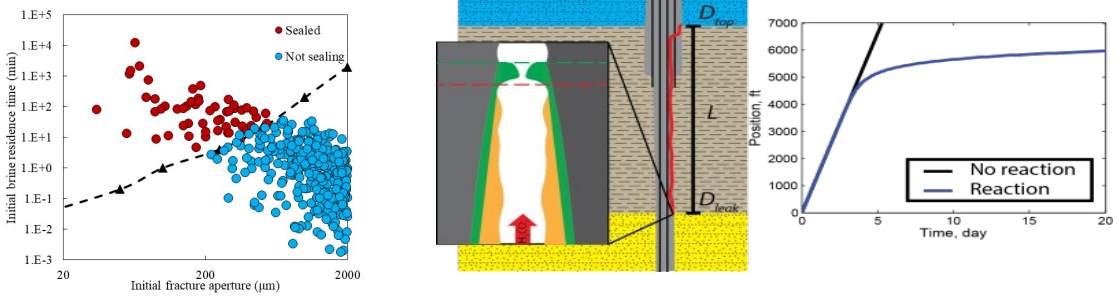
Objectives: Develop robust, science-based *methods* and *software tools* to:

- *predict* containment effectiveness and leakage risk
- *evaluate* the effectiveness of leakage risk monitoring, management, and mitigation.

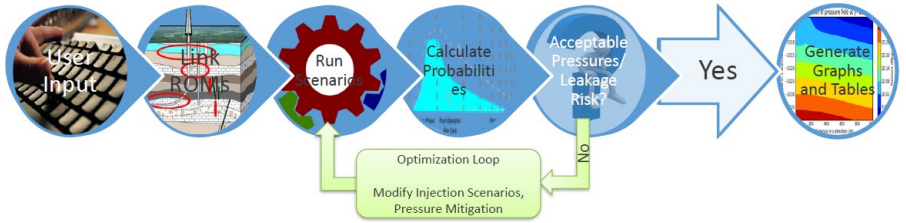
Developing integrated assessments of GCS site performance



Developing improved characterizations of leakage behavior

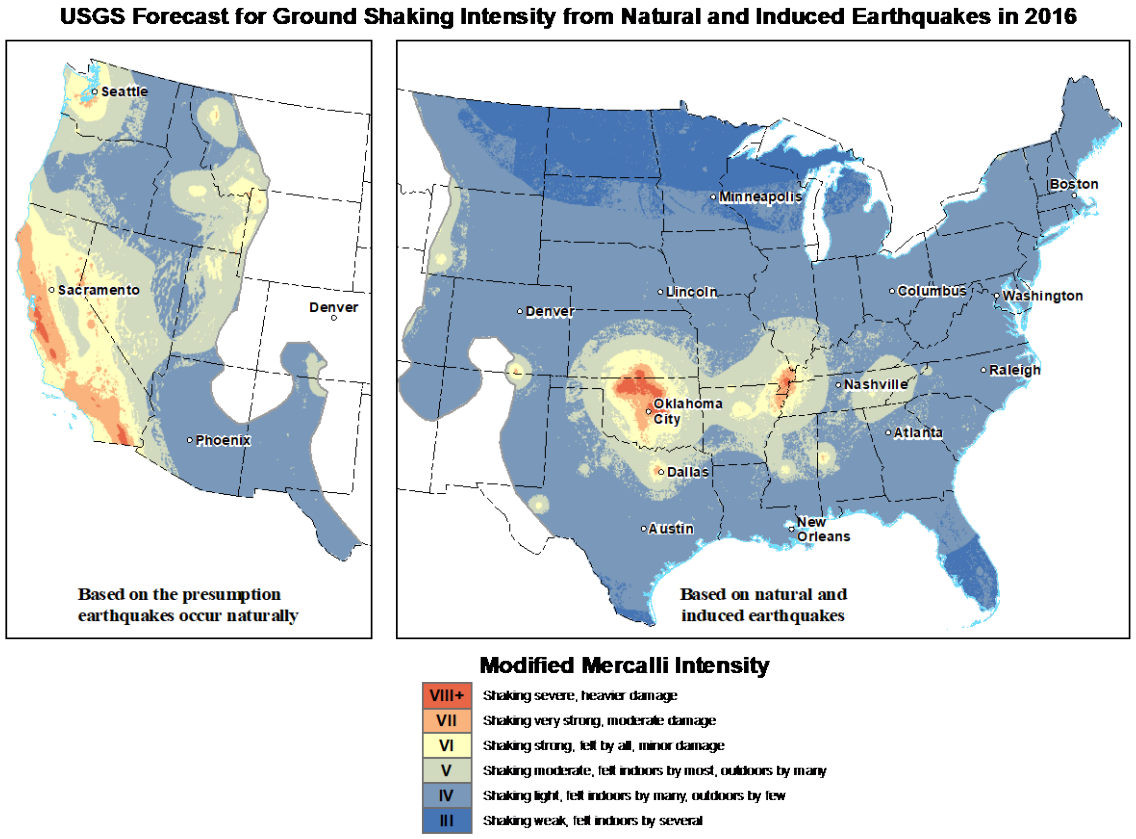


Mitigation and risk management performance



Induced Seismicity Risk

Objective: Develop practical tools to support the assessment and management of induced seismicity risk at carbon storage sites and identify site characteristics and operational approaches to lower seismic risk.

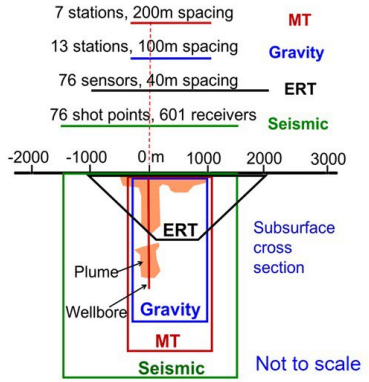


USGS map displaying intensity of potential ground shaking from natural and human-induced earthquakes. There is a small chance (one percent) that ground shaking intensity will occur at this level or higher. There is a greater chance (99 percent) that ground shaking will be lower than what is displayed in these maps.

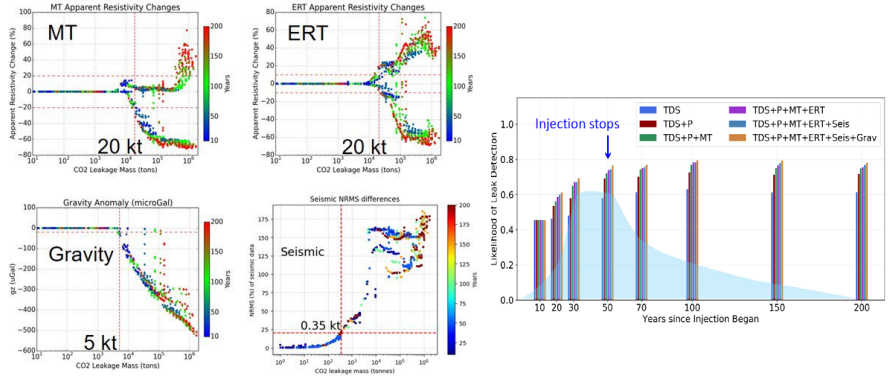
Strategic Monitoring for Uncertainty Reduction

Objective: Develop insights, methods, and computational tools to understand the ability of various monitoring technologies to detect system behavior, amidst uncertainties.

Modeling of Geophysical Monitoring

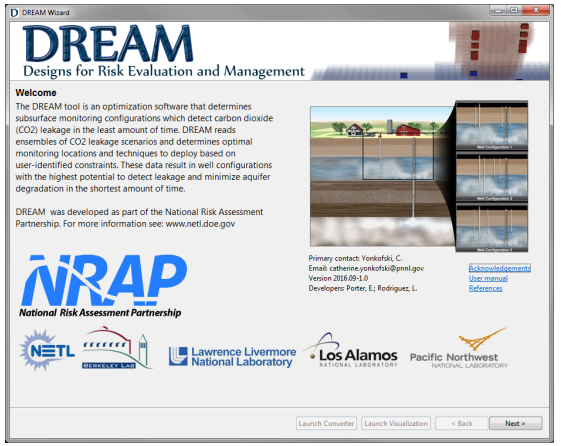


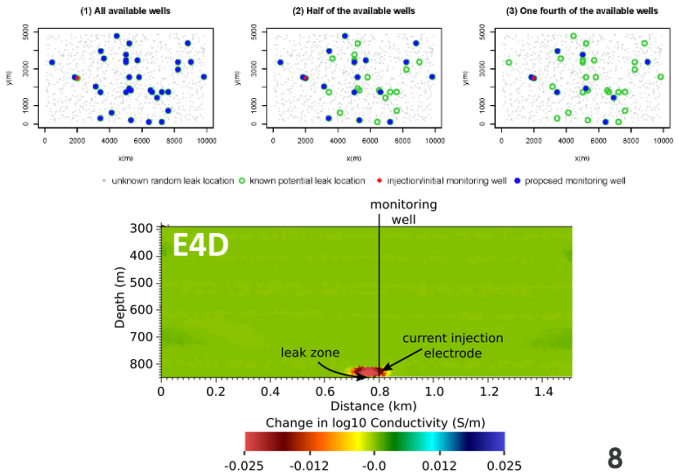
Layout of Surface Geophysical Methods



Geophysical signals versus CO_2 leakage mass

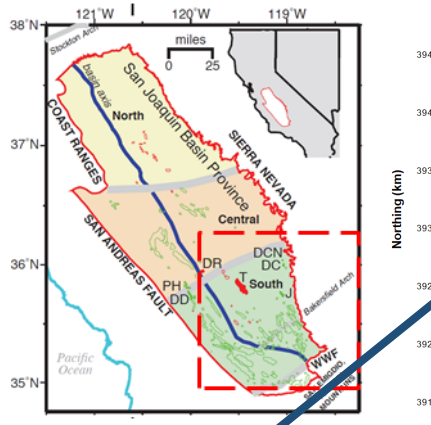
Risk-Based Monitoring Network Design

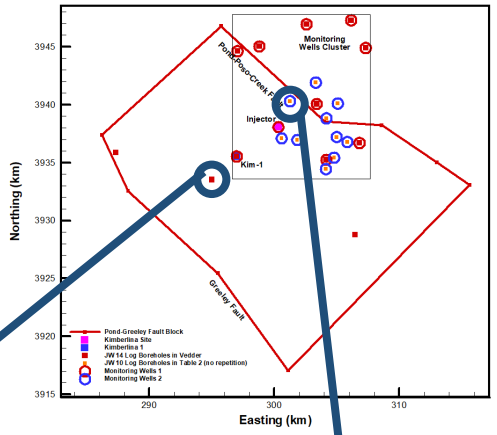




Validating tools and workflows with Field and Synthetic Datasets

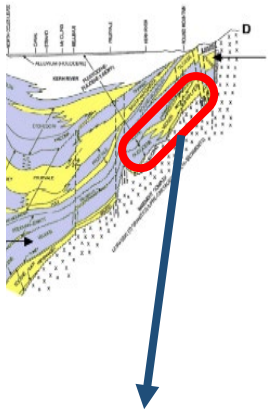
Kimberlina, San Joakin Basin, CA



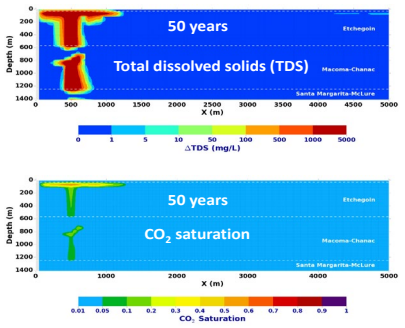


Secondary CO_2 zones:
Etchegoin
Santa Margarita
Olcese

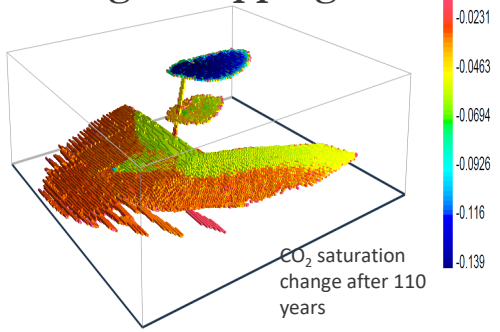
Injection Zone:
Vedder Sands



Hypothetical well leakage

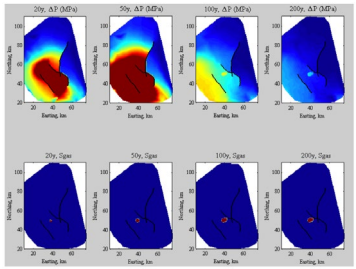


Hypothetical leakage through a dipping fault

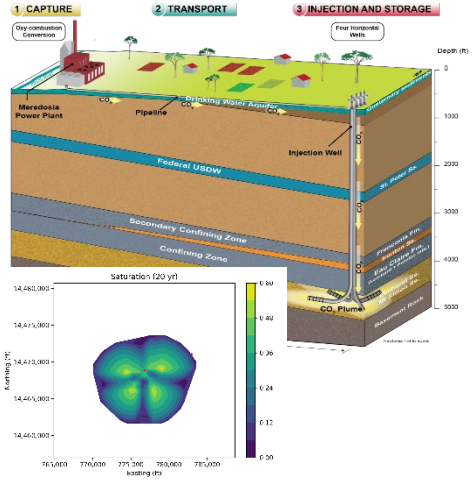


CO_2 saturation change after 110 years

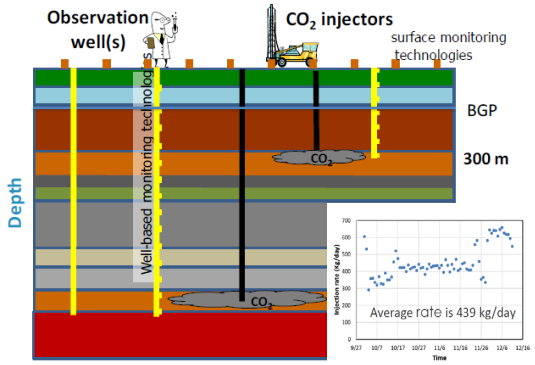
Stochastic plume, pressure response

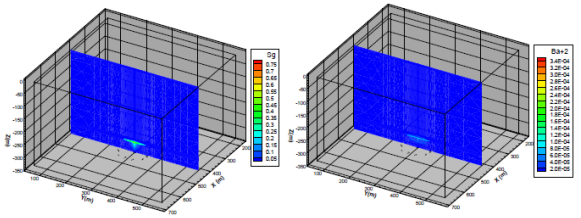


Retrospective risk assessment at FutureGen 2.0 site

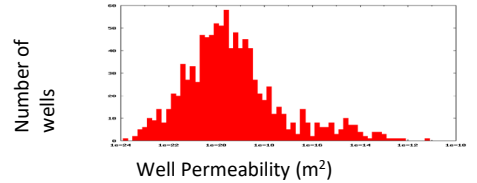


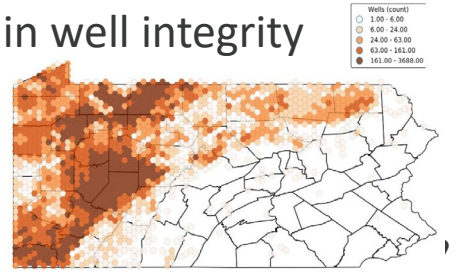
Application of NRAP tools at CaMI field test





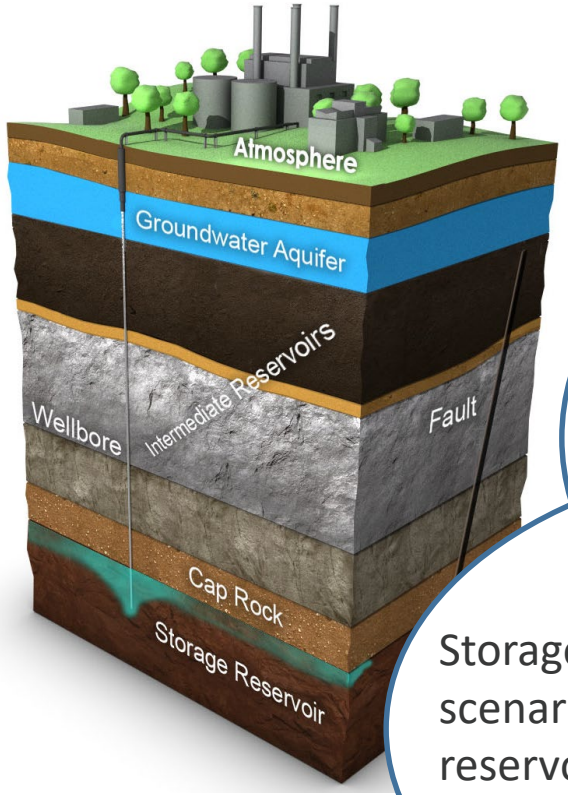
Constrain uncertainty in well integrity



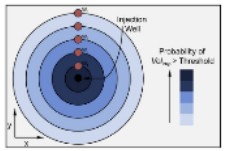


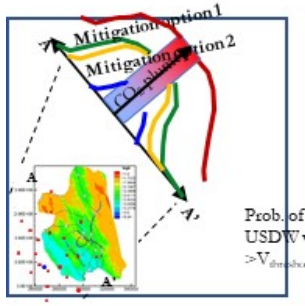
NRAP Open Source Integrated Assessment Model (NRAP-Open-IAM)

An ***open source*** ***(Python-based)*** platform to simulate long-term, full-system behavior (reservoir to aquifer/atmosphere) of GCS sites.

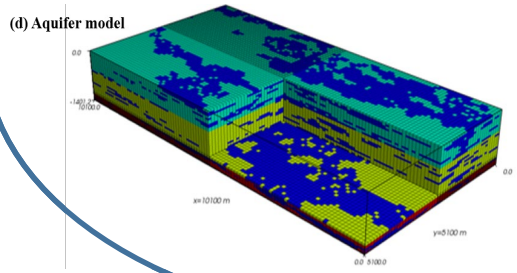


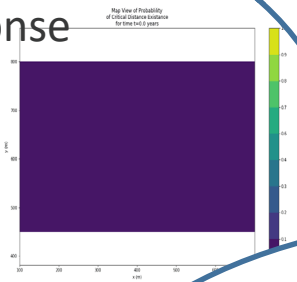
Risk Management and Site Closure Evaluation



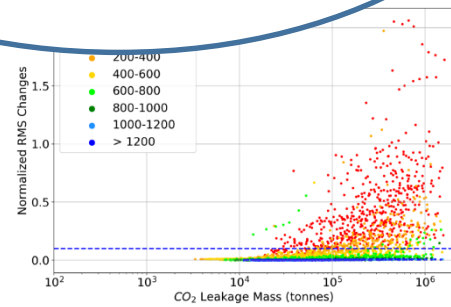


Groundwater aquifer and atmospheric response

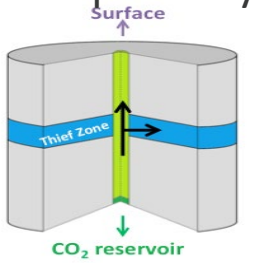


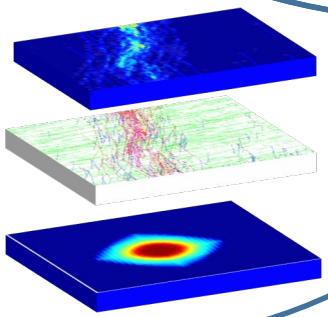


Leakage monitoring design

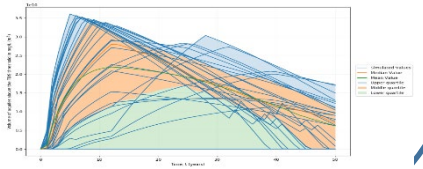


Leakage pathways

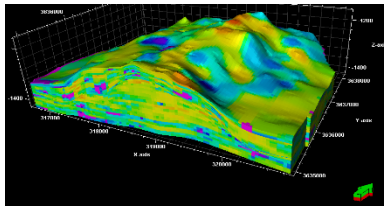




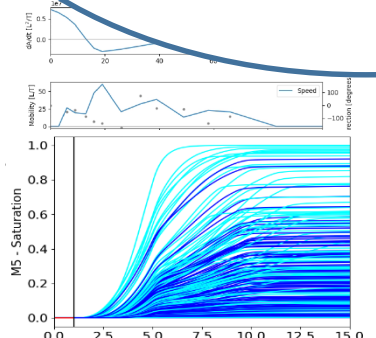
Probabilistic assessment of risk and uncentainty quantification



Storage scenario and reservoir response

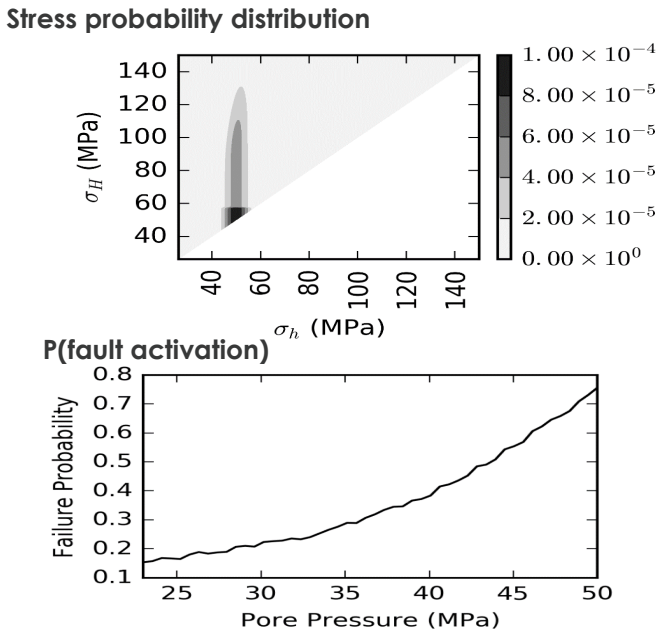


Plume stability and reservoir concordance evaluation



NRAP Induced Seismicity Risk Assessment and Management Tools

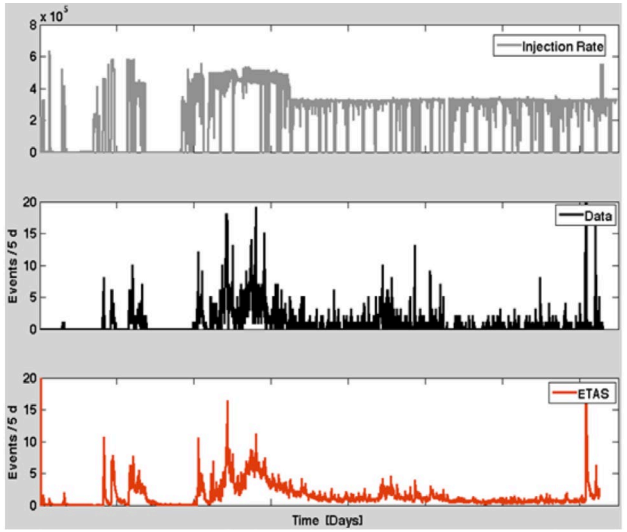
State of Stress Analysis Tool (SOSAT)



(Burghardt, 2018)

Beta tool available at: www.edx.netl.doe.gov/nrap

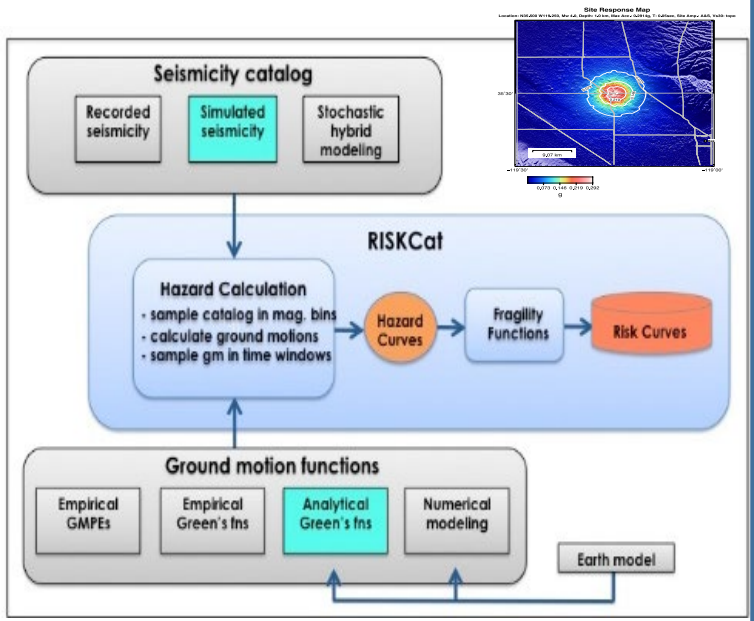
Short-term seismicity forecasting (STSF)



(Bachmann et al., 2014)

Beta tool available at: www.edx.netl.doe.gov/nrap

Probabilistic seismic risk analysis



(Savy and Foxall, 2018)

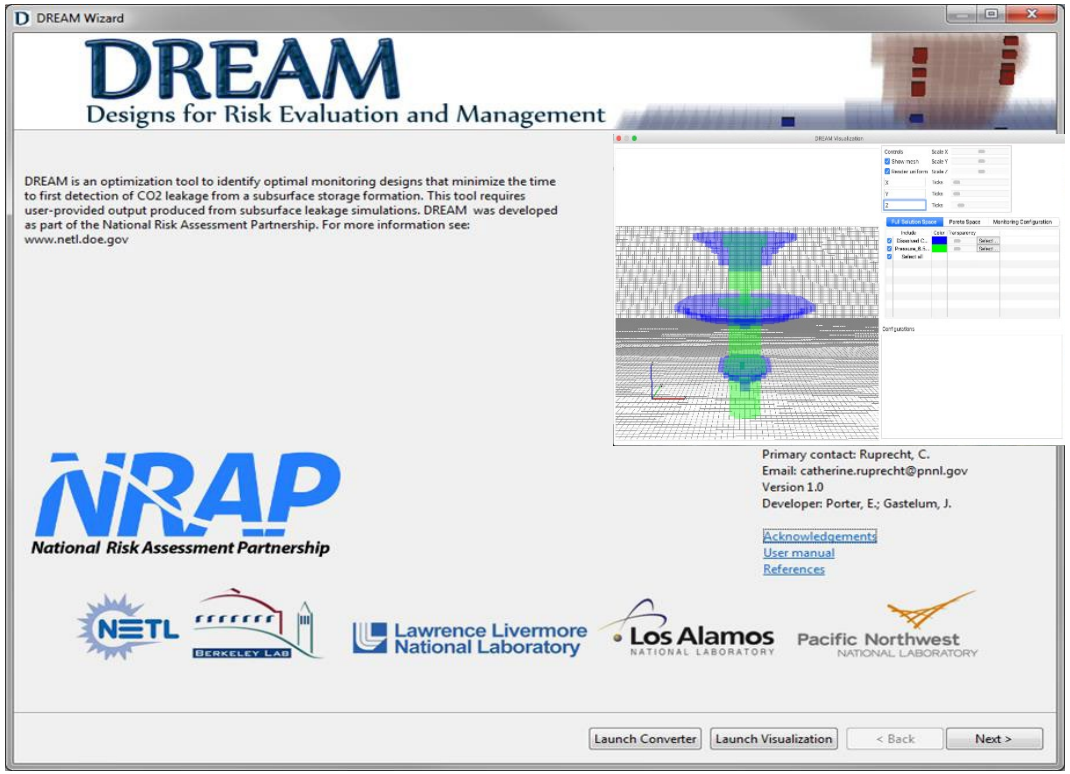
Beta tool forthcoming

Designs for Risk Evaluation and Management (DREAM 2.0)

- Estimates time to detection for a monitoring system
- Evaluates and select optimal monitoring designs

Tool available at:
www.edx.netl.doe.gov/nrap

- **Optimizes subsurface monitoring design for a specified GCS site**
- **Finds monitoring design (well location and depth, sensor type) that yields minimum expected time to first detection of CO_2 leakage (E[TFD])**
- **Can incorporate budget and operational constraints**
- **Uses ensembles of subsurface simulation**
- **Current release includes groundwater monitoring and ERT; gravity forthcoming**



(Yonkofski et al., 2017)