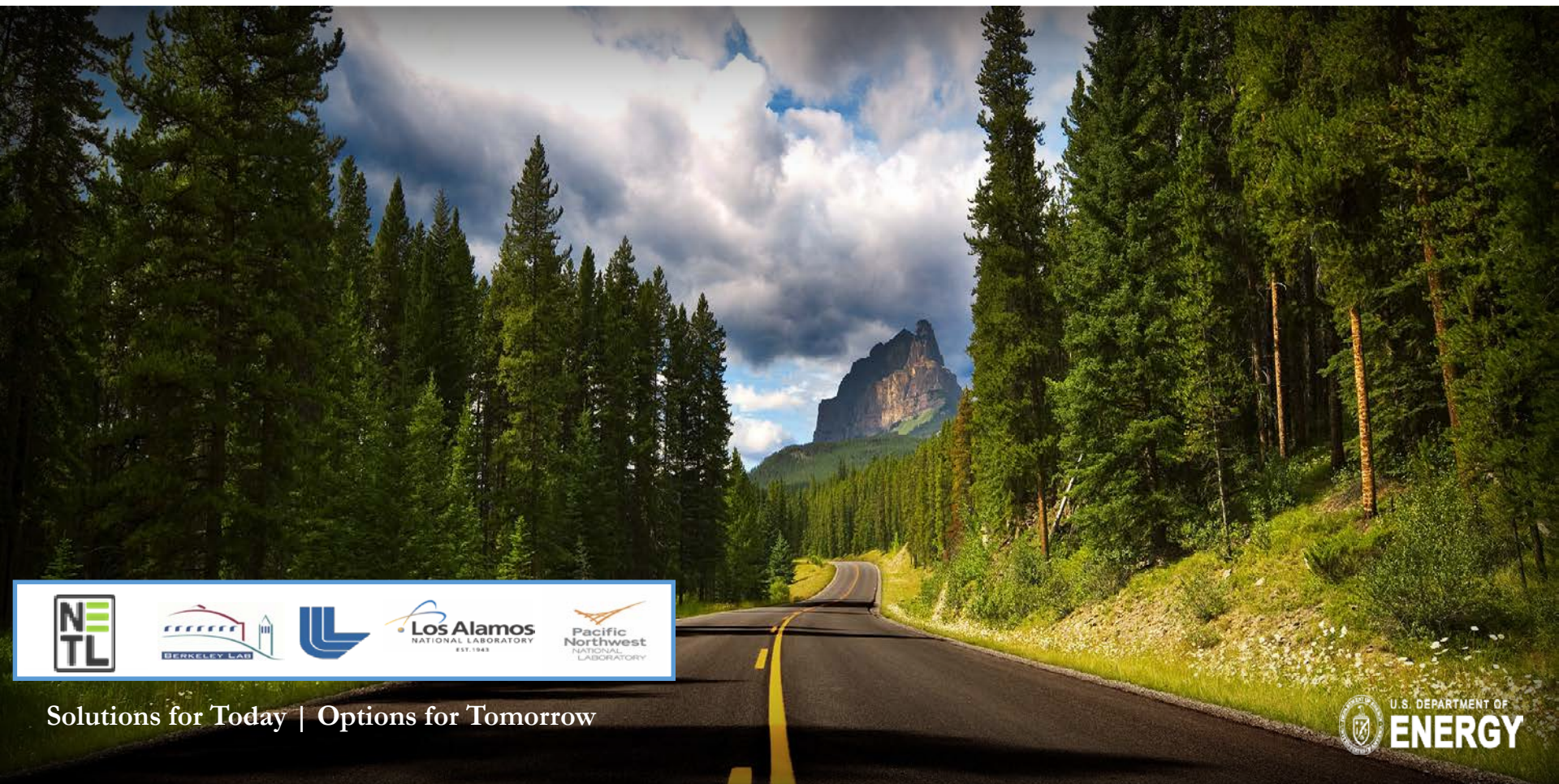


# U.S. DOE's National Risk Assessment Partnership:



## *Assessing Carbon Storage Risk to Support Decision Making Amidst Uncertainty*

Grant S. Bromhal  
Robert Dilmore  
August 1, 2017

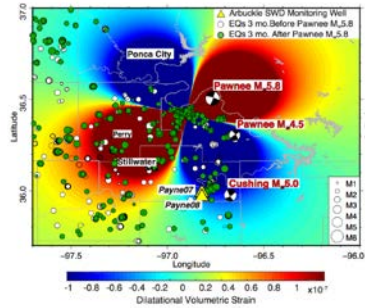
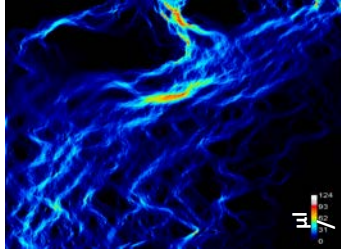


Solutions for Today | Options for Tomorrow

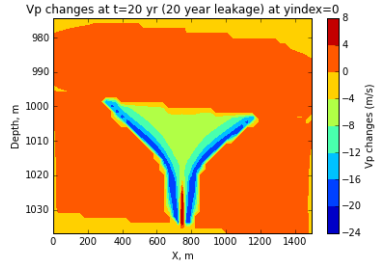
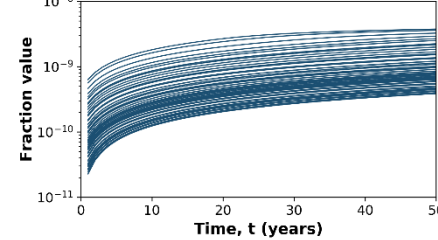


# National Risk Assessment Partnership

Dynamically addressing risks of fluid migration and ground motion amidst geologic uncertainty



Mass of CO<sub>2</sub> leaked to mass of CO<sub>2</sub> injected



## Technical Team

## Stakeholder Group



Wade, LLC



# Managing Leakage Risk

- Aliso Canyon Incident
- Leak began at Aliso Canyon October 23, 2015
- On February 17, 2016, leak was permanently plugged using relief well after failed top kills
- ~90,000 tonnes of gas leaked in four months
  
- ~4 TCF (~1.1 Gtonnes) of gas storage in US
- Number of UGS well is ~17,500
- Well ages range from 1 to more than 125 years
  - ~80% completed before 1980
  
- Significant differences in regulatory regimes between UGS and GCS

## Ensuring Safe and Reliable Underground Natural Gas Storage

Final Report of the Interagency Task Force  
on Natural Gas Storage Safety

October 2016



# Comparison between CCS and UGS

## Geologic Carbon Storage

- Storage in oil and gas fields, saline formations
- Requires new wells (Class VI) for injection
- Full well cemented (Class VI)
- Comprehensive well integrity and site monitoring requirements
- Non-flammable, denser than air
- No odorant used, maybe tracer

*From Bromhal and Freifeld, 2017*

## Underground Gas Storage

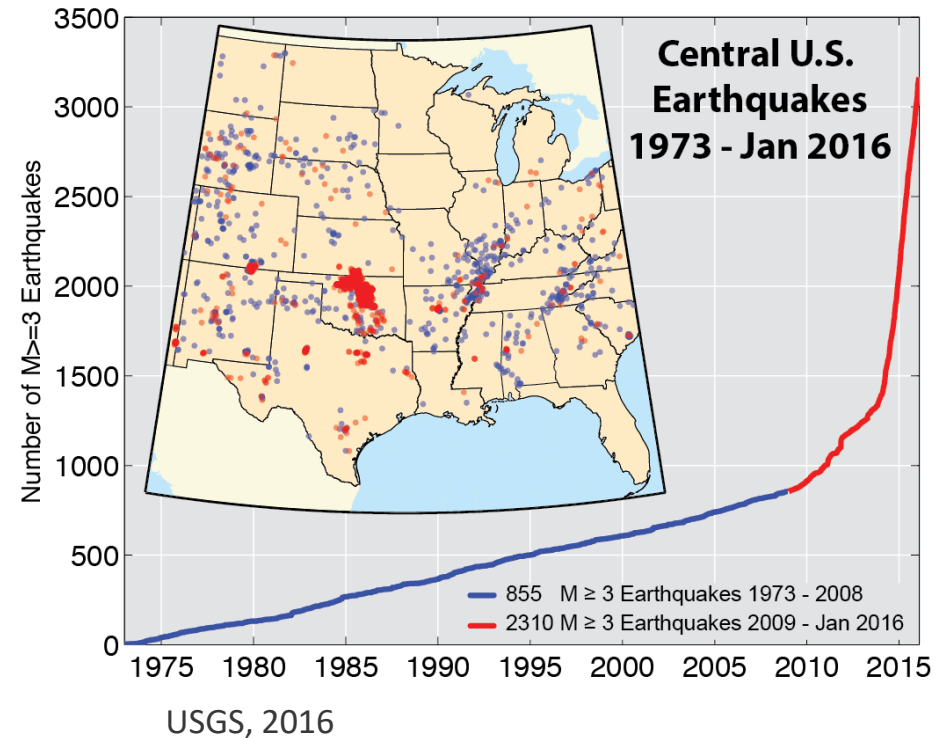
- Storage in oil and gas fields, saline formations, and salt domes
- Repurposes old oil and gas wells for injection and production
- Long well intervals without cement
- Flammable, lighter than air
- Use of odorant
- Some production through tubing and casing
- >15,000 wells at >400 facilities (US)
- ~4 TCF stored in U.S., much produced annually

May have active oil production in same fields (area) as GCS and UGS

4

# Managing Induced Seismicity Risk

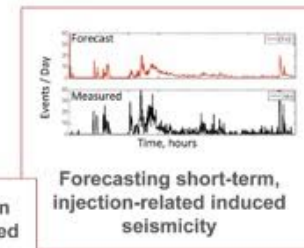
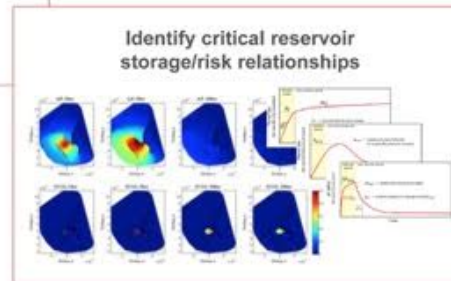
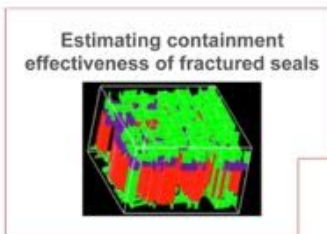
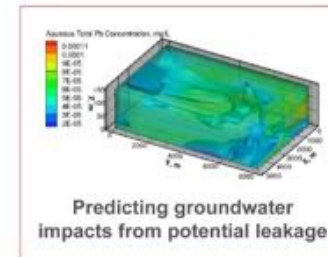
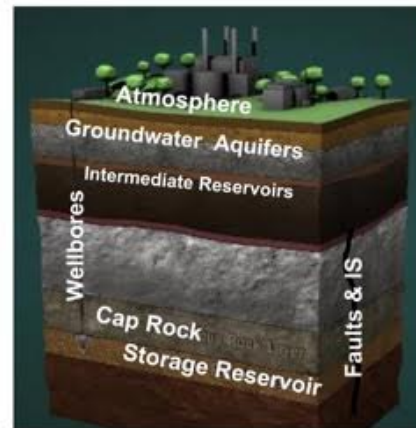
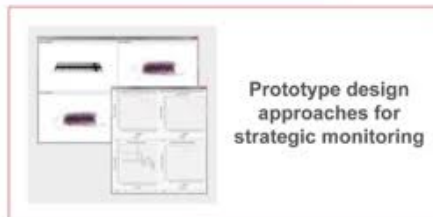
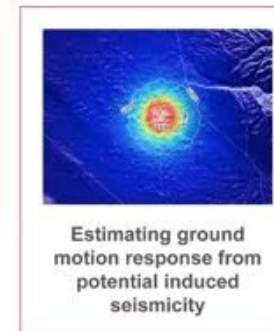
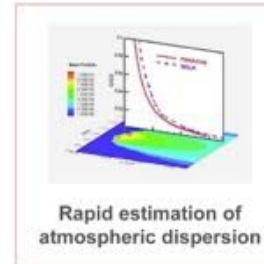
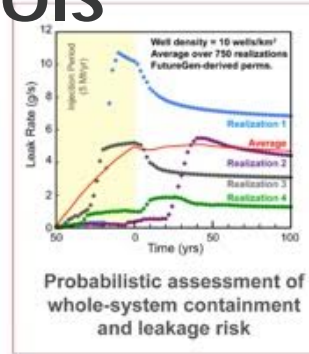
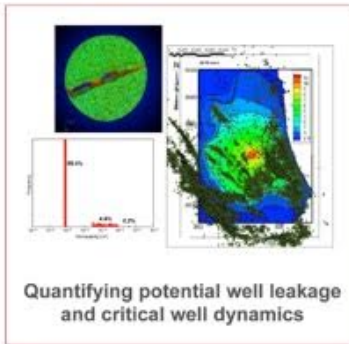
- In Oklahoma, 2015:
- 835 million bbl brine/yr
- Equivalent to  $\sim 90$  Mtonnes  $\text{CO}_2$
- 1 “wedge” of CCS:
  - 25 Gtonnes over 25 years
- Only a very small percentage of wells induce felt seismic activity, implying the risks can be managed



# NRAP Technical Team

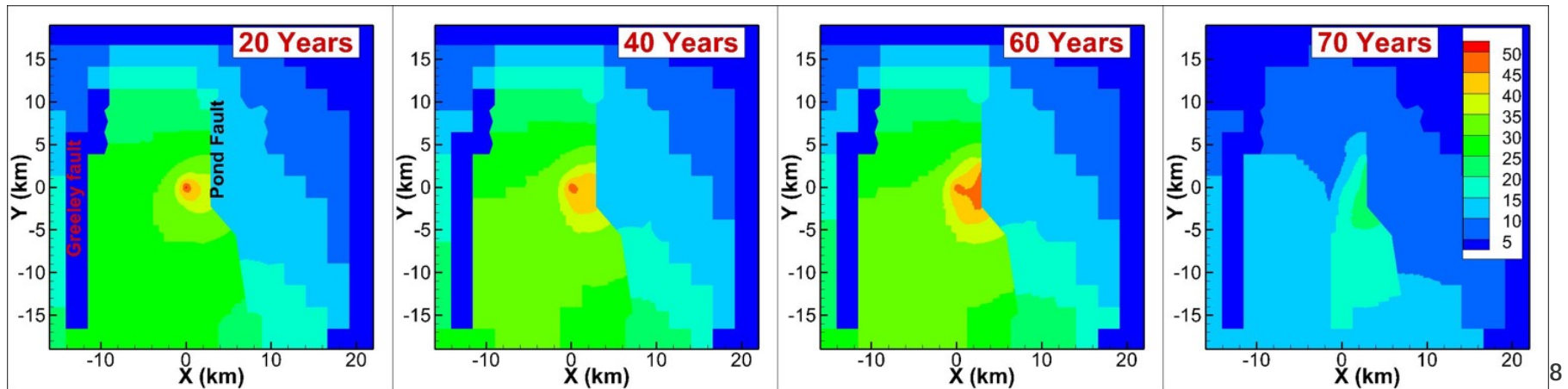


# NRAP Phase I Tools



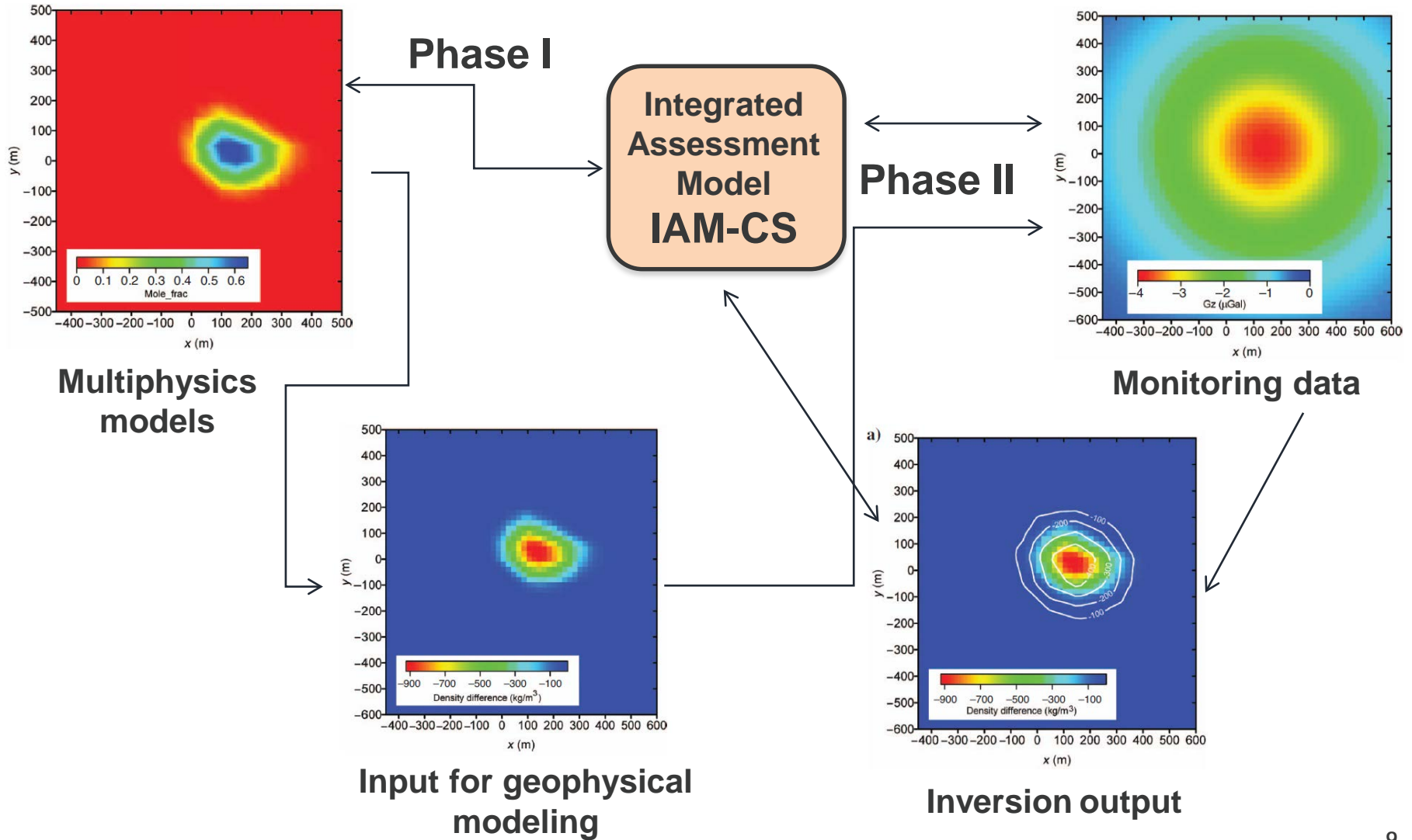
# Application and Validation of Tools (Diana Bacon)

- Demonstrated protocol for applying the Aquifer Impact Model to the Illinois Basin – Decatur Site
- Developed model to help plan the Containment and Monitoring Institute (CaMI) controlled leakage experiment
- Used field and laboratory data to better understand the relationship between rock elastic properties and induced seismicity
- Battelle's well integrity database is being used with the Wellbore Leakage Analysis Tool (WLAT) and DREAM tools to demonstrate design of practical monitoring strategies
- Developed risk-based AOR method using the NRAP-IAM-CS integrated assessment model
- Developed Kimberlina Site Data set for Testing of Monitoring Tools/Approaches





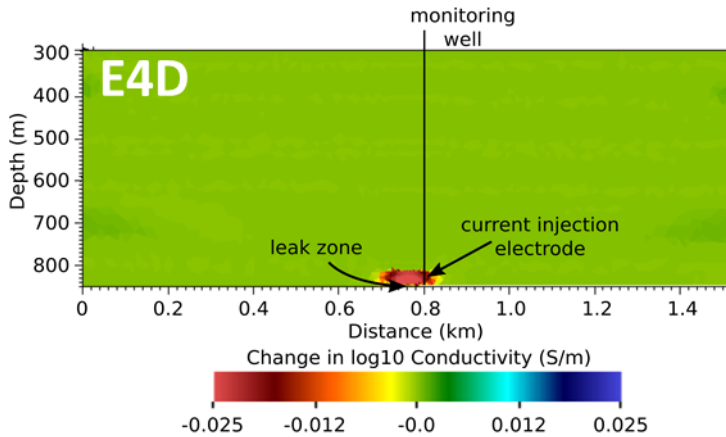
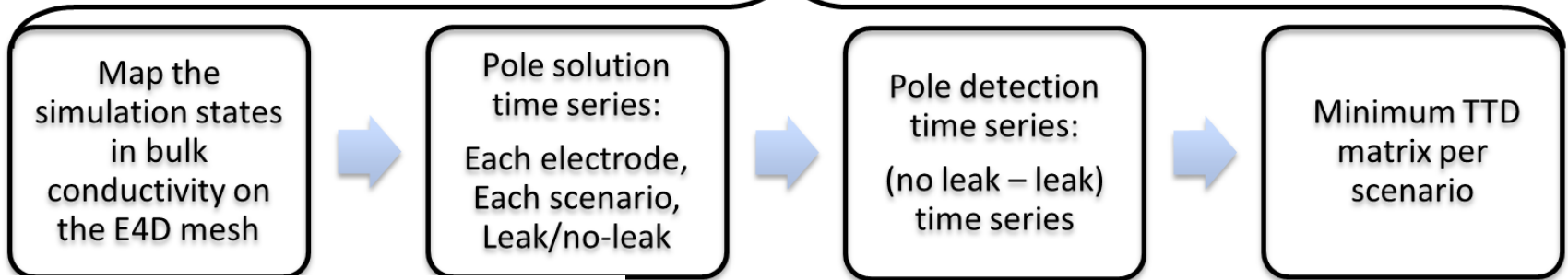
# Modeling of monitoring capabilities (Erika Gasperikova)



# Designing better monitoring networks



+ERT module



## Timeline:

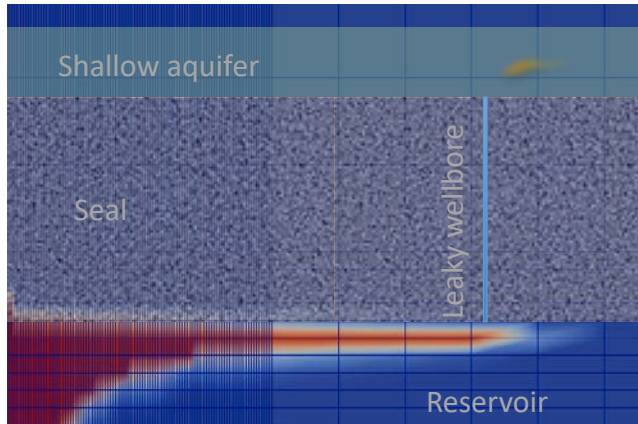
DREAM extension beta tool 12/31/2017

## Cross-cutting opportunities:

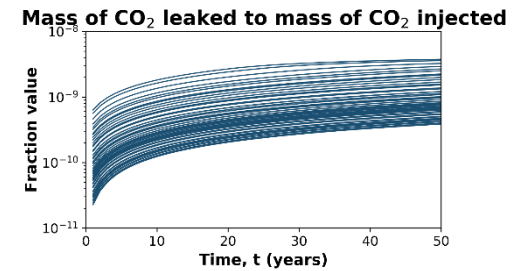
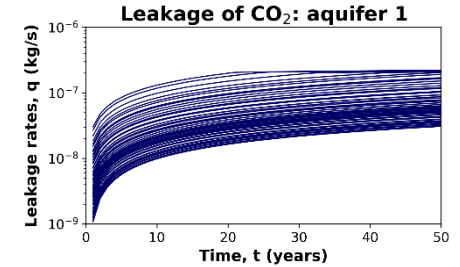
- Inclusion of additional methods (i.e., Gravity monitoring)
- Demo. of the DREAM/ERT module with leakage simulations

# New IAM capabilities (Elizabeth Keating)

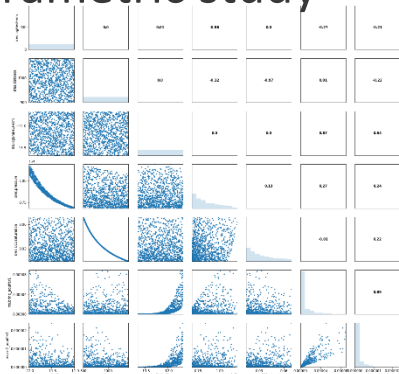
Leakage scenario



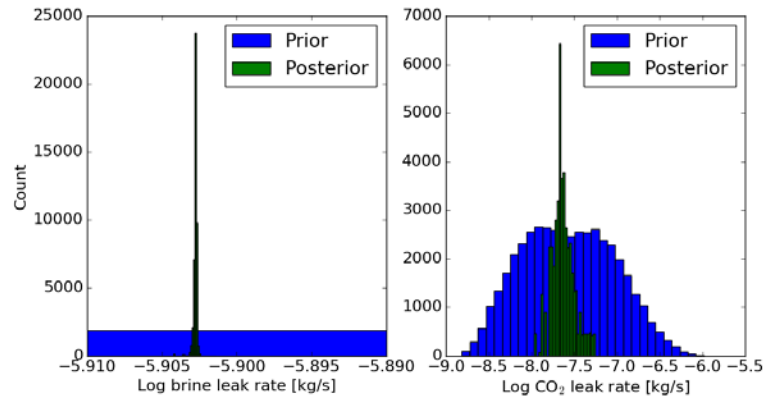
Probabilistic leakage risk calculations



Parametric study



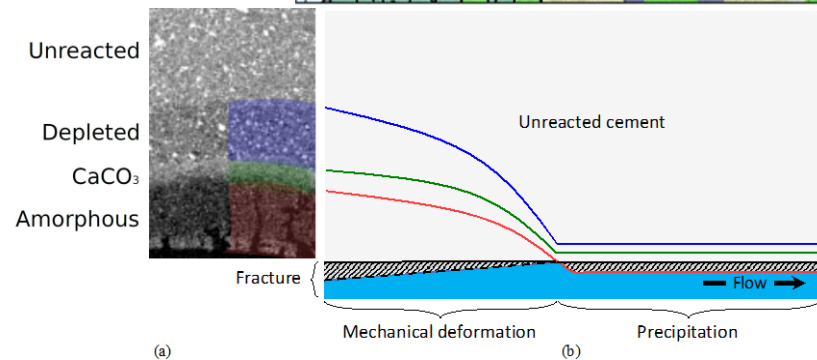
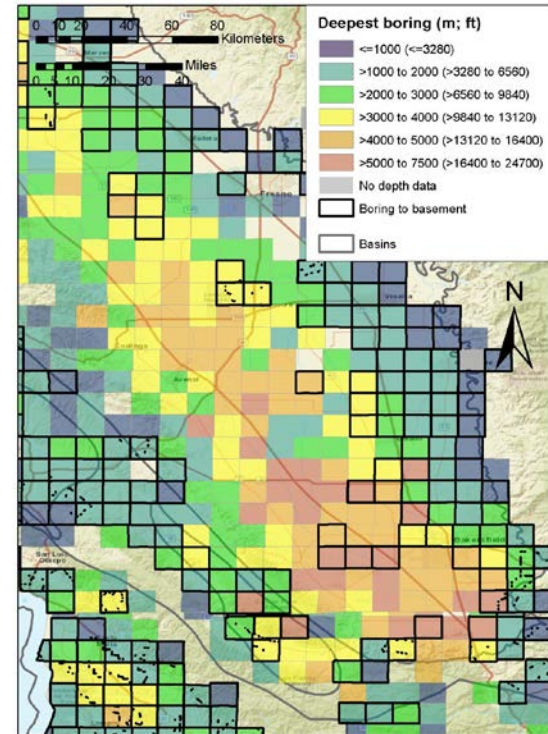
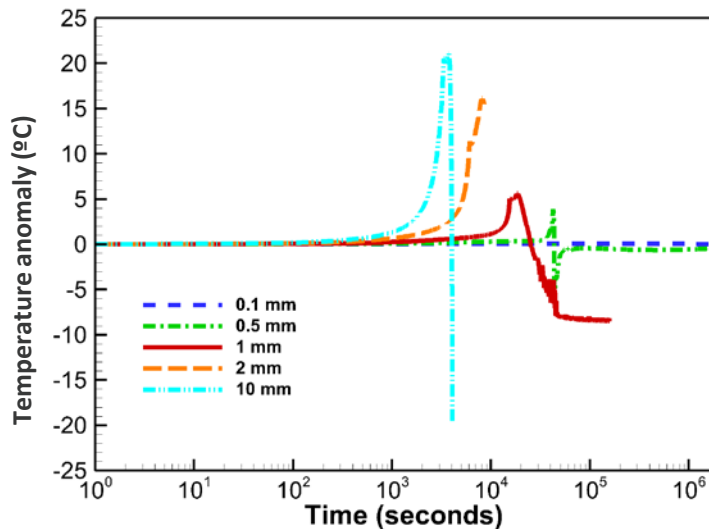
Risk assessment update using monitoring data



New ROMs focus on predicting above zone monitoring interval (AZMI) behavior

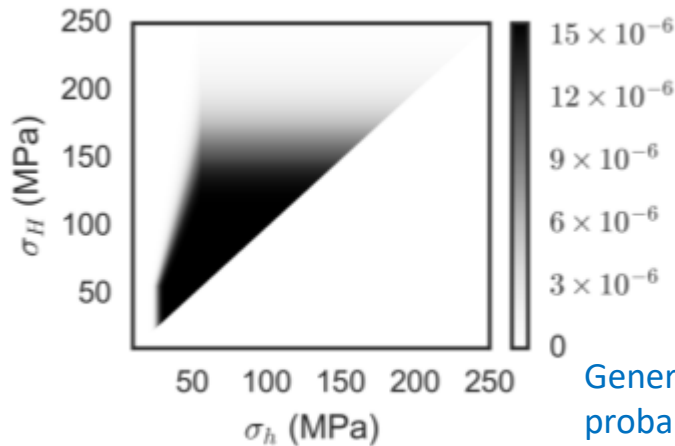
# IAM developed for risk management

- Seal integrity
- Wellbore integrity
- Leak mitigation
- Integrated risk assessment and risk management

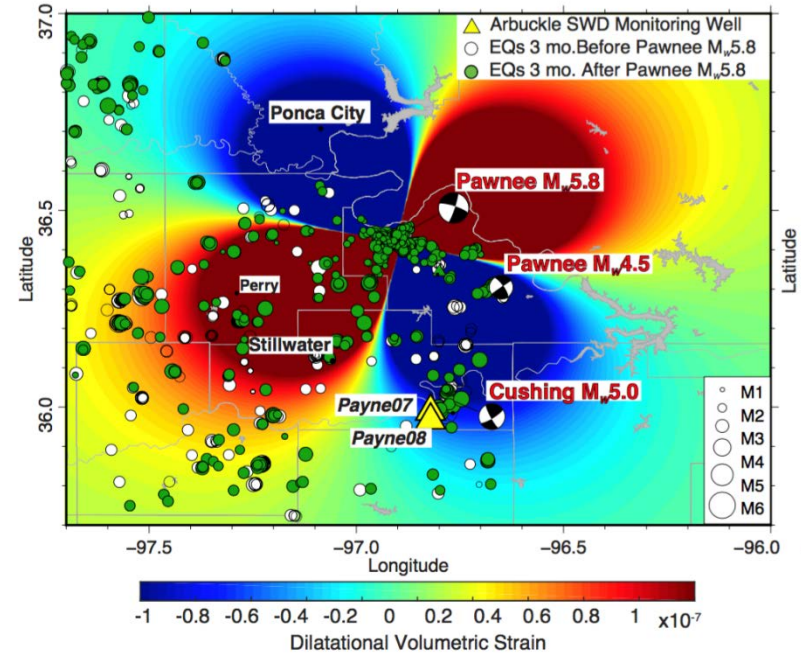


# Advances in Induced Seismicity (Josh White)

- Real-time hazard forecasting
- Active seismicity management
- Probabilistic seismic risk assessment
- Fault leakage
- Seismicity management protocols



Generating stress polygon to use for probabilistic assessment of fault reactivation potential



Use data and simulations to characterize formation mechanical and hydraulic properties

# Thank You!

## NRAP Talks and Tool User Workshop

- **Tuesday, Aug. 1, 1:40pm**
  - Induced Seismicity Risk; Josh White, LLNL
- **Wednesday, Aug. 2, 5:20pm**
  - Application of Risk Assessment Tools and Methodologies to Synthetic and Field Data; Diana Bacon, PNNL
- **Thursday, Aug. 3, 2:05pm**
  - Strategic Monitoring for Uncertainty Reduction; Erika Gasperikova, LBNL
- **Thursday, Aug. 3, 2:25pm**
  - Containment Assurance; Elizabeth Keating, LANL
- **Thursday, Aug. 3, 2:45pm**
  - Wellbore Integrity; Nicolas Huerta, NETL
- **Thursday, Aug. 3, 3:30-6:00pm**
  - NRAP Tool User Workshop

[www.edx.netl.doe.gov/nrap](http://www.edx.netl.doe.gov/nrap)  
t: [NRAP@netl.doe.gov](mailto:NRAP@netl.doe.gov)

Thank You!  
Questions and Comments?

