Big Data, ROMs, Machine Learning

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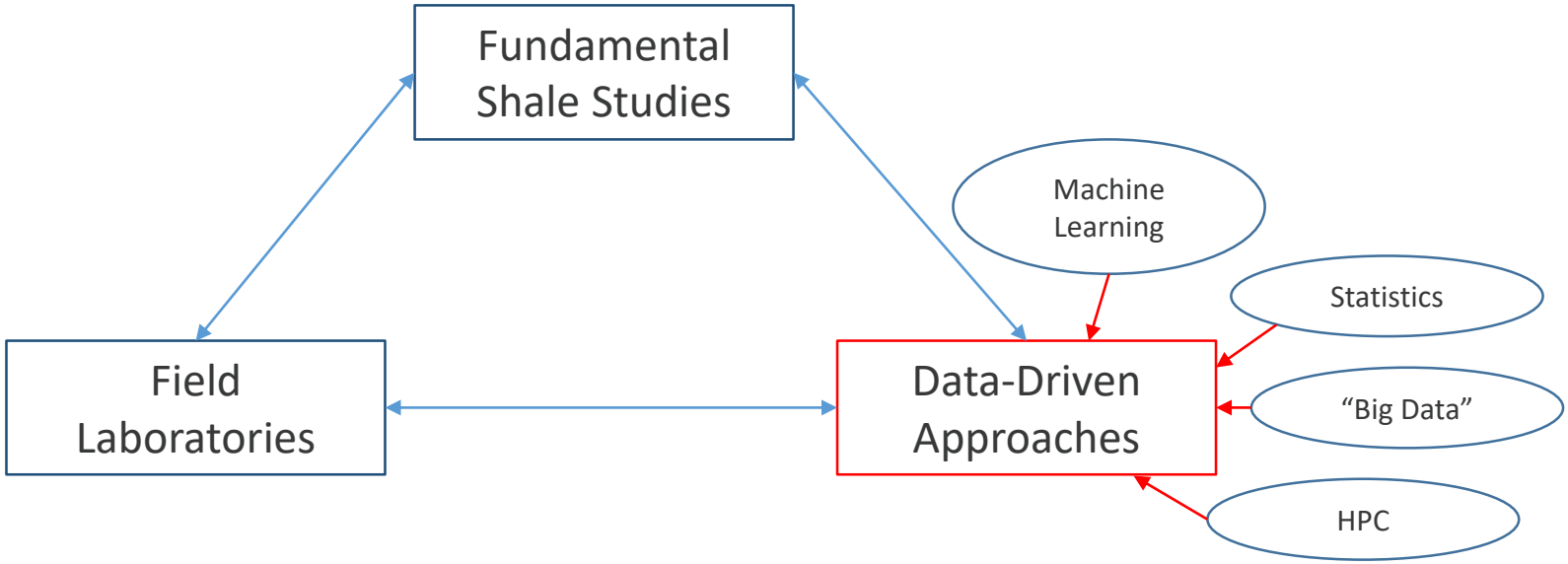
Some DOE R&D in Machine Learning

- DOE's Office of Science recently held a workshop on Machine Learning
- USEA hosted workshop on July 12 on big data for clean coal applications
- CMU workshop July 17-18 on "Real-time Decision Making in the Subsurface"
- High performance computing systems and applications are key DOE lab capabilities for big data analytics and machine learning
- Core R&D ongoing in multiscale modeling and image processing
  - Identifying correlations in data
  - Reducing dimensionality
  - Improving sampling techniques
  - Automating characterization methods
- Improving robustness and interpretability of ML approaches
- Uncertainty quantification
- Quantum computing

Data-driven approaches for improving unconventional resource recovery

- Individual unconventional basins behave differently from each other and so require different approaches/methods.
- Fundamental physical phenomena are the same regardless of basins.
- Data driven approaches coupled with understanding of basic physics and chemistry will improve recovery efficiency.

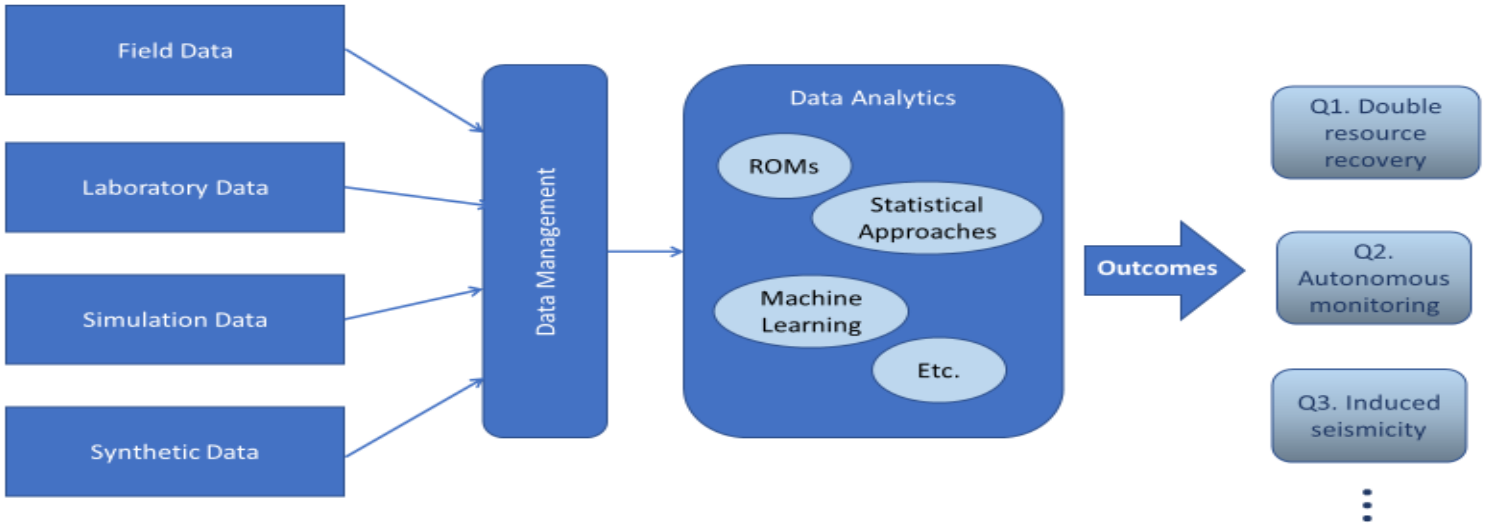


Intelligent Subsurface Engineering

- **Robust tools to rapidly predict shale production**

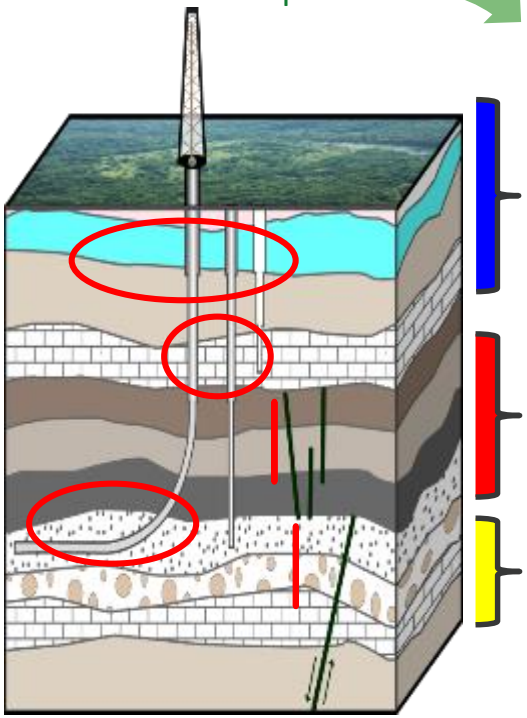
  Near-term: Identify opportunities in hydraulic fracturing design, well placement, and operations to incrementally improve recovery and reduce costs

  Long-term: Automation of subsurface operations in real time to substantially improve recovery, reduce cost, and reduce failures

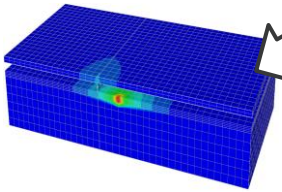


Reduced-order models (ROMs) developed to assess risk in storage applications.

A. Divide system into discrete components



B. Develop detailed component models that are validated against lab/field data

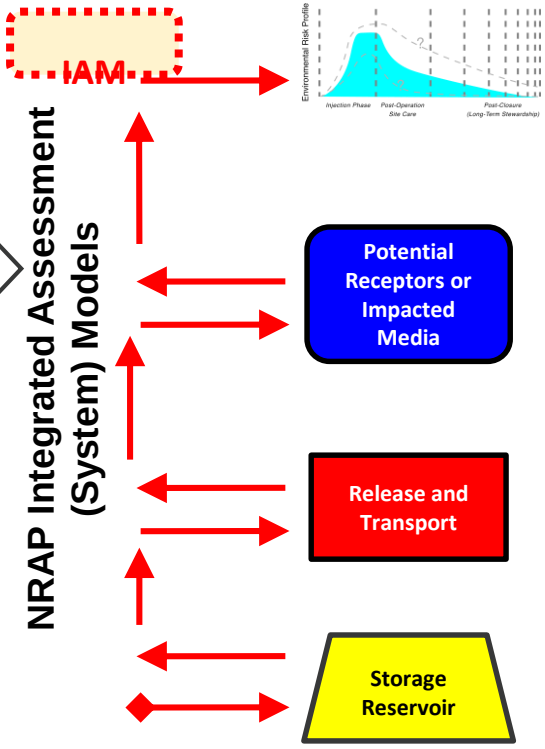


Energy Data Exchange (EDX)

Data

C. Develop reduced-order models (ROMs) that rapidly reproduce component model predictions

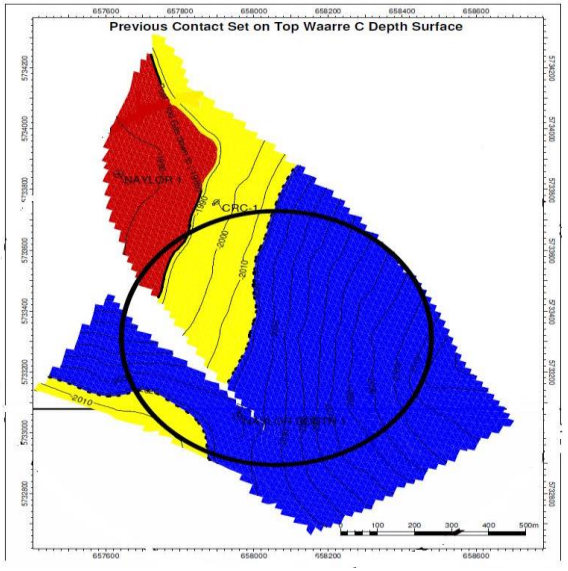
D. Link ROMs via integrated assessment models (IAMs) to predict system performance

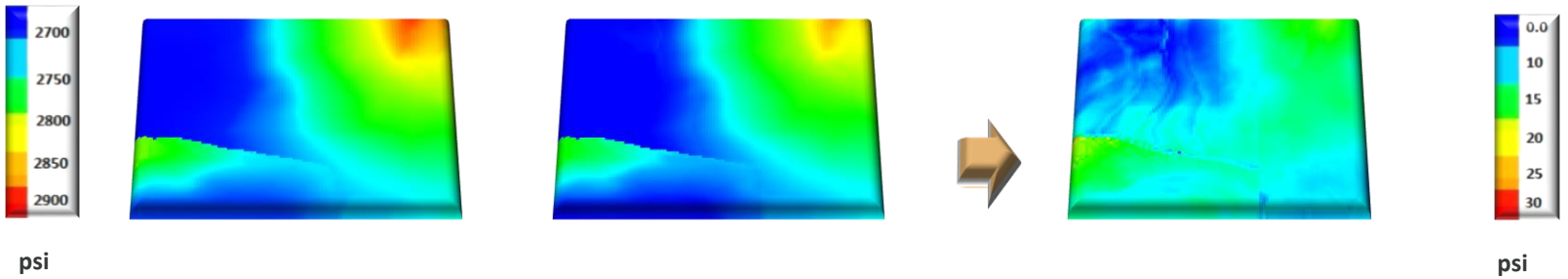


E. Exercise whole system model to explore risk performance

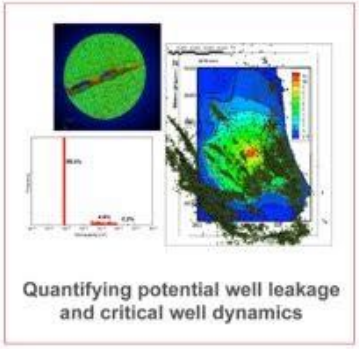
Surrogate reservoir modeling

- **Utilizes data mining and neural networks to predict reservoir behavior**
  - Pressures
  - Saturations
- **Can be trained with a relatively small number of reservoir simulations**
- **Allows for spatial heterogeneity and operational variability**
- **Shrinks time for reservoir simulation from days and hours to minutes and seconds**

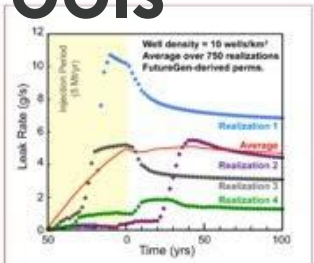




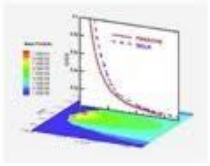
NRAP Phase I Tools



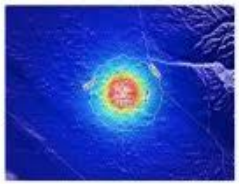
Quantifying potential well leakage and critical well dynamics



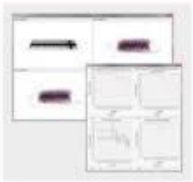
Probabilistic assessment of whole-system containment and leakage risk



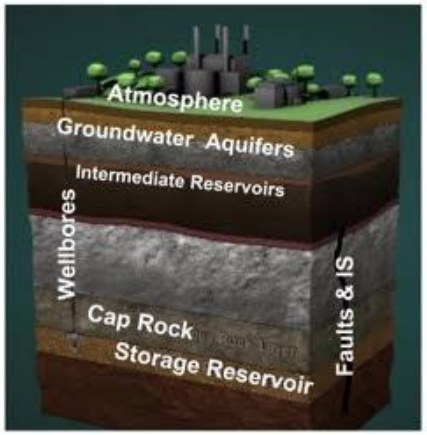
Rapid estimation of atmospheric dispersion

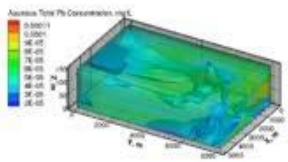


Estimating ground motion response from potential induced seismicity



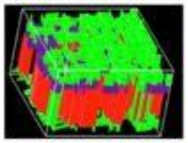
Prototype design approaches for strategic monitoring

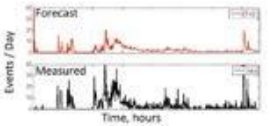




Predicting groundwater impacts from potential leakage

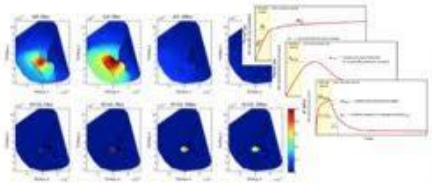
Estimating containment effectiveness of fractured seals





Forecasting short-term, injection-related induced seismicity

Identify critical reservoir storage/risk relationships



Reducing uncertainty in fault/fracture slip-induced permeability changes

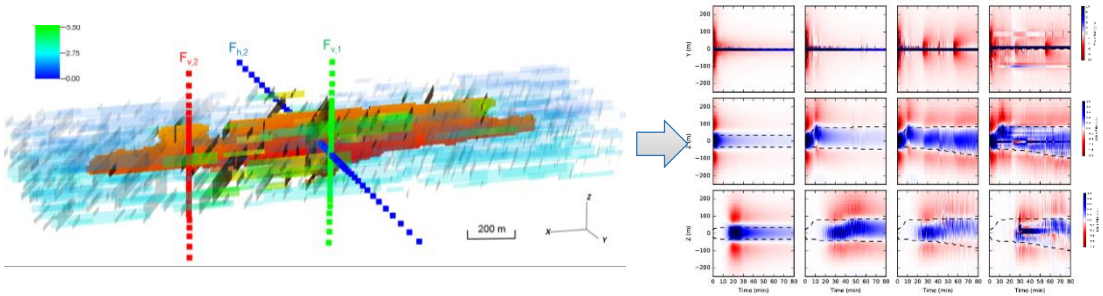
edx.netl.doe.gov/nrap

Machine learning and distributed sensing

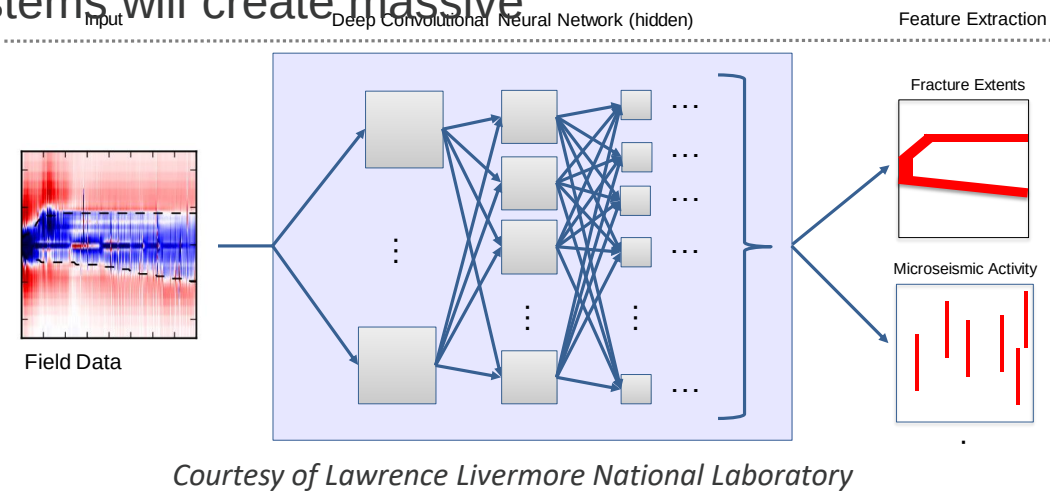
Fiber-optic systems will create massive data streams

- Simulate subsurface processes using the GEOS code and record synthetic DAS measurements
- Design and train a deep convolutional neural network (DCNN) to identify features
- Optimize the DCNN and test it on field data

Capability could be used to make pumping schedule changes in real time during stimulation to target pay zone more effectively



Fiber-optic systems will create massive data streams

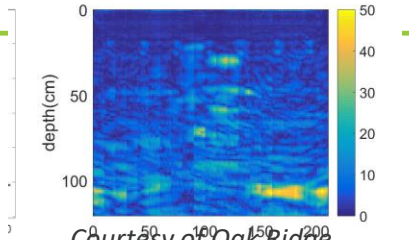


Courtesy of Lawrence Livermore National Laboratory

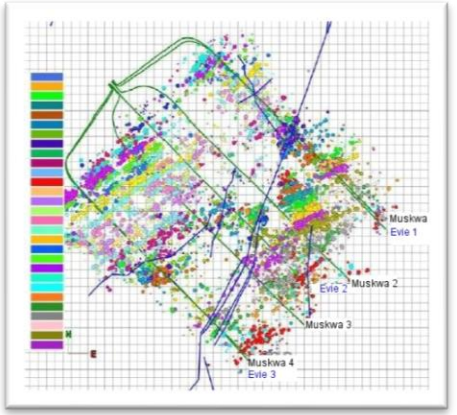
Dark fiber also contains a potential wealth of data that is being mined (LBNL)

Other EXAMPLES OF O&G USE

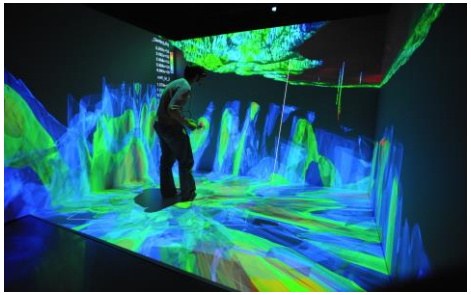
- Improved ultrasound reconstruction algorithm development for Oil, Gas, and Geothermal wells using model based iterative methods (ORNL)
- Advance novel deep and machine learning techniques to develop methods for predicting unconventional oil and gas production characteristics (SNL)
- Detecting anomalies in petabytes of geophysical and geochemical data (SNL)
- Data-driven approaches to addressing induced seismicity (INL, LANL, LBNL, LLNL, NETL, PNNL, SNL)
- Advanced approaches to understand shale reservoir performance by analyzing production data (INL, NETL, LANL)
- Fusing pore and reservoir scale information in models (LBNL)
- Toolset Development for Massive Datasets in Immersive Environments (INL, PNNL)
- Real-time subsurface imaging, combining forward coupled simulation with process feedback and control (PNNL)
- Deriving empirical models for complex fractured flow systems (LANL)



Courtesy of Oak Ridge National Lab



Courtesy of Sandia National Lab



Computer Assisted Virtual Environment (CAVE) system displaying and earth model

Courtesy of Idaho National Lab

Thank You!

- Questions?
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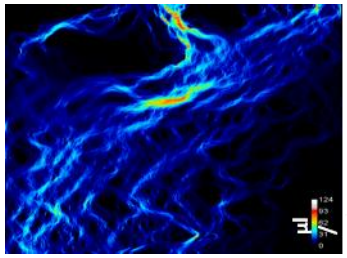
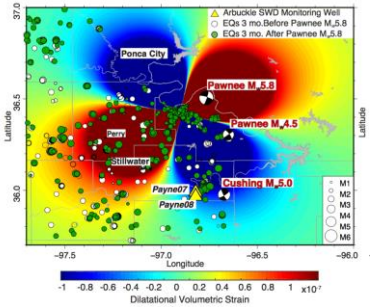
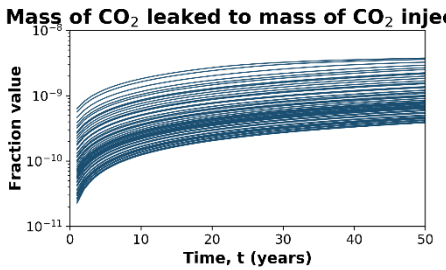
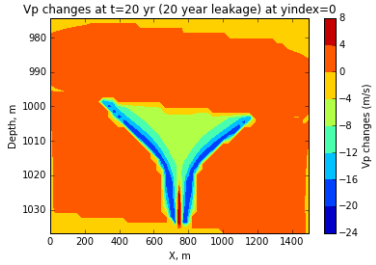
National Risk Assessment Partnership

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









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