Spatial Data Approaches to Improve Production and Reduce Risks of Impacts

Geospatial & Geostatistical Analyses to Improve Science-Based Decision Making

Kelly Rose, Geology & Geospatial Research Lead
Jennifer Bauer, MacKenzie Mark-Moser, Devin Justman, Aaron Barkhurst, Mark Dehlin, Chad Rowan, and Deborah Glosser
Office of Research and Development
U.S. DOE, National Energy Technology Laboratory

https://edx.netl.doe.gov/
Early government research led to private sector investment in coalbed methane and shale technologies.

Current DOE research goals are focused on:

- Understanding system behavior
- Improving efficiency
- Reducing risk & uncertainty
- Environmental sustainability
NETL’s Geology & Geospatial R&D Team

**MISSION:** Seeks to reduce uncertainty about, and provide data to characterize engineered-natural energy systems through development of data, information, approaches and numerical simulations spanning the micron to regional scale.

- **Subsurface interpretation & analysis**
  - (core, wellbore, reservoir scales)
- **Geostatistics & spatial analysis**
- **Geosystems modeling & code development**
- **Geo-samples characterization & analysis**
- **Webification & online analytics**
- **Geo-hydrology**

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Research conducted by the G&G Team spans...

- Conventional and unconventional hydrocarbons
  - Offshore hydrocarbon systems
  - Underground CO2 storage
  - Natural gas hydrates
  - Geothermal systems
- Cementitious and natural geomaterials

**Spatio-Temporal Seismicity Trends 1950-2015**

**Offshore hydrocarbon spill prevention & response readiness**

**EDX – R&D Data Resource & Collaboration Tool**

Can be used to address questions such as:
- Resources evaluation
- Impact assessments
- Understanding trends in the data
- Calculating Project Feasibility
- Identifying Knowledge Gaps

4D Geothermal Monitoring: to ensure EGS reservoir longevity

**CO2 Storage Assessment**

**Unconventional Resource Risk Assessments**

**New geospatial/statistical approaches**

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Challenges

- Finding & accessing pertinent, relevant datasets to support analyses
- Even seemingly “perfect” datasets come with risks
- Learning to acknowledge & use uncertainty to inform
- Think holistically about E&P systems and approaches
- What’s good for one end user is good for another
  - E.g. R&D approaches leveraged for regulatory or commercial needs

Safe, efficient, and successful E&P requires many of the same elements as energy R&D
1. Need access to key data/inputs
2. Need for advanced geospatial/statistical approaches for analysis
3. Need for big data & advanced computing capabilities to handle probabilistic and geospatial analyses
4. Need for a secure, coordinated system for inter-entity assessments and evaluations

[Image from: http://www.nature.com/news/scientists-losing-data-at-a-rapid-rate-1.14416]

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Assessing Spatial Trends & Potential Risks

Background

- Hydrocarbon development can align with other elements (e.g. leakage pathways, induced seismicity risks, etc.)

- These increase potential for inefficient and/or risky development.

Objectives

- Demonstrate how spatio-temporal geostatistical approaches can be used to inform decision making and reduce risks for all stakeholders.
Geostatistical & Spatial Analytical Tools and Approaches

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Spatially Integrated Multivariate Probability Assessment (SIMPA) approach

- A multi-scale integrated probability analysis tool
- Evaluates trends and knowledge gaps associated with engineered-natural systems in support of risk, resource and impact assessments
- Vector and raster data are used together through a gridding technique (A). Figures B and C depict how density (B) and distance (C) values are calculated.

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SIMPA bridges the gaps among Python, Arc, and R to utilize state-of-the-art spatial analyses.

SIMPA can be used to identify risks and calculate the probability of impact related to well injection and production activities at meso-scales.

SIMPA seeks to identify areas within a user specific area that have a higher probability of impact related to fluid and/or gas migration.


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Subsurface Trend Analysis (STA)—Reducing Geologic Uncertainty

- Provides a scientific base for predicting and quantifying potential risks associated with exploration and production in the subsurface
- Integrates basin analysis with geospatial and geostatistical methods to reduce uncertainty

Key basin analysis based on burial history, structural and tectonic influences, and diagenetic overprinting

Multi-variate approach that combines a priori geologic knowledge with spatial and geostatistical analyses to offer high resolution insights about subsurface properties to help reduce geologic uncertainty

Variable Grid Method (VGM) is an approach designed to address issues of data uncertainty by communicating the data (colors) and uncertainties (grid cell sizes) simultaneously in a single layer.

VGM is a flexible method that allows for the communication of different data and uncertainty types, while still preserving the overall spatial trends and patterns.

ArcGIS, Python based tool in beta testing for VGM approach

VGM In Use

VGM has been used for defining the spatial uncertainty and trends for CO2 Storage Estimates in the Oriskany Formation.

VGM has also been used to estimate the depth to the base of groundwater to evaluate risks of groundwater contamination.

VGM can be used for a variety of needs including:

- Resource evaluation
- Impact assessments
- Understanding trends in data
- Calculating project feasibility
- Identifying knowledge gaps

When utilized for subsurface analysis and exploration, VGM helps analyze the *relationship between uncertainty and data*...

- **Patent** #61/938,862 filed by DOE 2/2015
- Selected for a Special Issue in *Transactions in GIS* and corresponding presentation at the Esri International User Conference in July, 2015
- Python based ArcGIS compatible tool in beta testing


... to effectively guide research, management and policy decisions and drive advance computation analyses to reduce exploratory risk
Increasing collection and creation of data, tools, and models related to improve R&D efficiency

Numerous methods to access, interact with, and publish data, tools and models

Several limitations to current methods

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In 2011, the **Energy Data eXchange (EDX)**, was developed for NETL/DOE R&D as an *innovative* solution to these challenges by offering:

- A secure, online *coordination and collaboration ecosystem* that supports energy research & analysis
- Enduring and reliable *access* to historic and current R&D *data, data driven products, and tools*
- Both *public* and *secure, private* functionalities

**Built by researchers for research**

**Public Access**
Enable knowledge transfer, data reuse & discovery

**Secure/Private Access**
Support research development, collaboration, & online analytics

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Evaluating Induced Seismicity with Geoscience Computing & Big Data –

*Multi-variate examination of the cause(s) of increasing induced seismicity events*

- Geoscience computing advances for more efficient data management, fusion, and accessibility (data gathering, mining & fusion)
- Development of probabilistic approaches to analyze likelihood of induced seismicity (data analysis)

**Oklahoma Induced Seismicity Project**

- Precipitation
- Infrastructure
- Elevation
- Aquifer Data
- Geology
- Well Data
- Reservoir Data
- Seismic Events

**# of OK seismic events, 1975-2015**
Thank you

Kelly Rose
Geology & Geospatial Research Lead
Kelly.rose@netl.doe.gov

More information: https://edx.netl.doe.gov