SIMPA- Clarifying probability of subsurface fluid/gas migration using fuzzy logic

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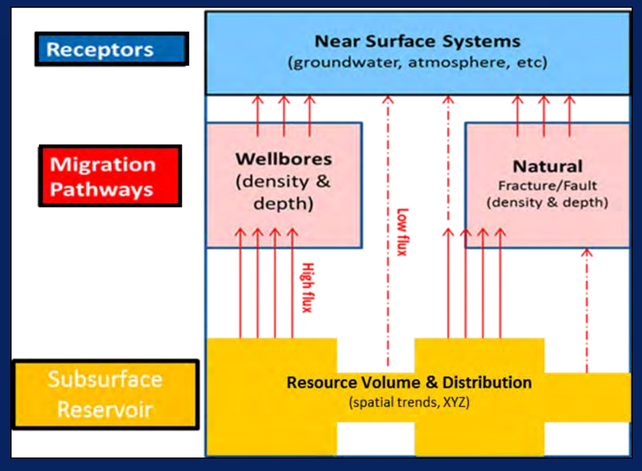
Abstract

Efforts to improve resource assessments and reduce potential risks coinciding with carbon storage, oil and gas, and other energy systems requires an understanding of the physical characteristics, dynamics, and interactions of natural and engineered subsurface systems. However, the heterogeneity and ambiguity of these data make it difficult to assess the likelihood of potential natural and anthropogenic fluid and/or gas migration pathways at various scales. But, successful applications of big data and machine learning in other scientific disciplines (e.g., medicine, atmospheric, security, etc.) suggests these approaches are well suited to coping with data and uncertainty challenges encountered in subsurface systems. Utilizing these methods, NETL has been developing the Spatially Integrated Multi-variate Probabilistic Assessment (SIMPA) tool to assess the likelihood of fluid and/or gas migration through the subsurface in support of high grade carbon storage assessments and to inform industry decisions related to the use of various carbon capture and storage methods and technologies. Here, we will provide details on the SIMPA fuzzy logic tool and some preliminary outputs.

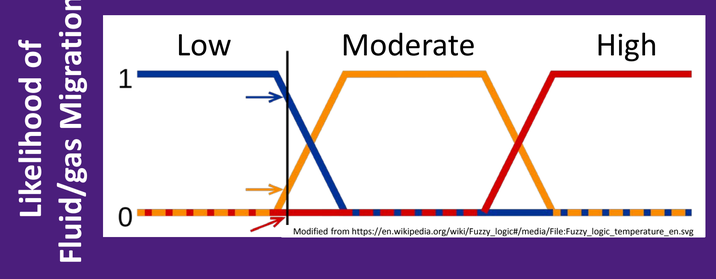
What is the Spatially Integrated Multivariate Probability Assessment (SIMPA)?

- A **data-driven framework** to identify the **probability of subsurface fluid and/or gas migration** at **multiple scales**
- A **decision support tool** that uses **fuzzy logic** to provide **insights** about key trends, patterns, and knowledge gaps related to subsurface complexity and probability of fluid and/or gas migration



What is fuzzy logic?

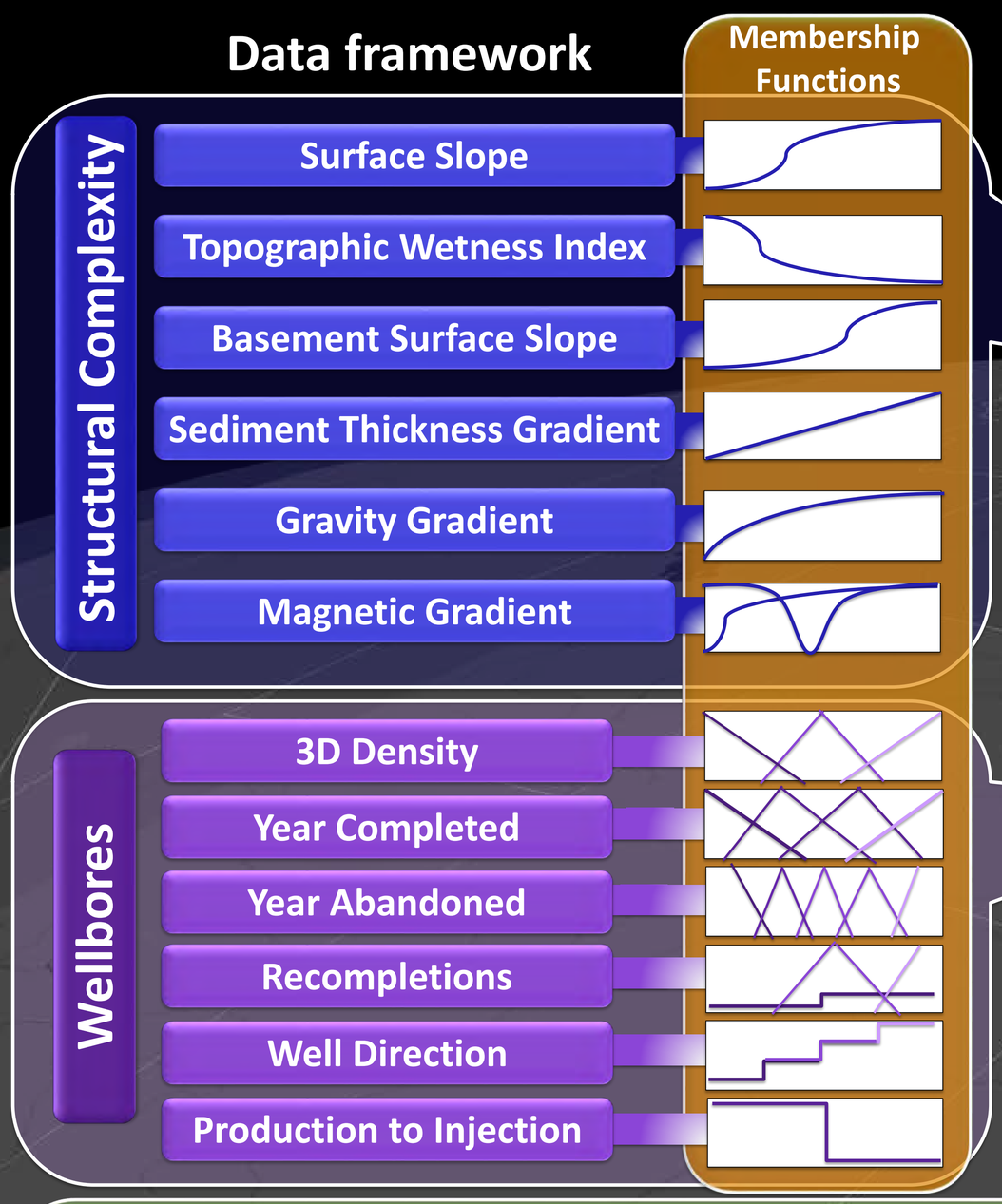
- Method of decision making to model highly complex systems, predict real world phenomena, and deal with uncertainty
- Computing based on "degrees of truth" through expert knowledge
- Based on fuzzy set theory- Data may not be binary 1 or 0 (crisp), but somewhere in between (fuzzy)

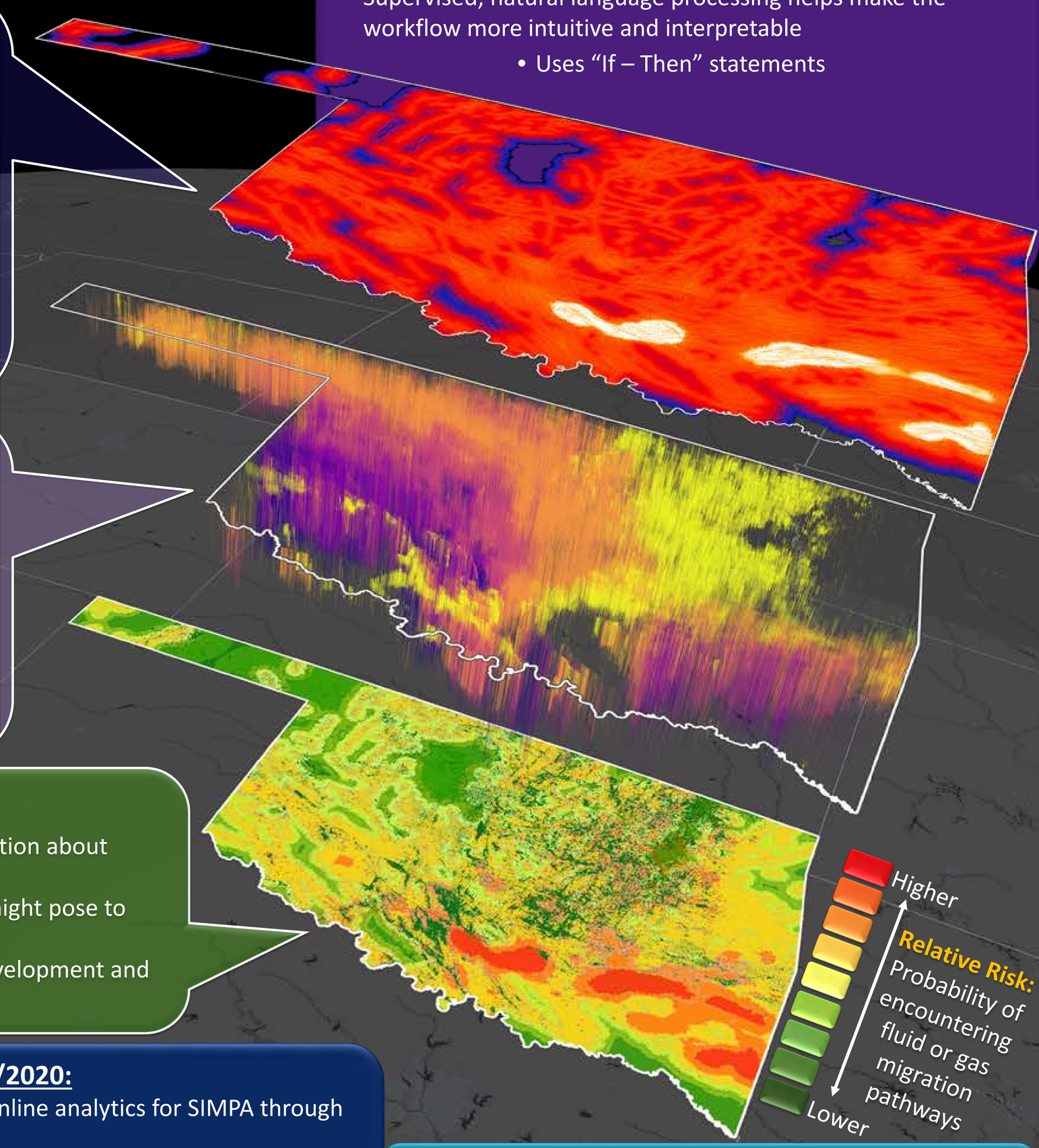


Why use fuzzy logic?

- Handles highly complex, real world data and uncertainty
- Works with numerical and categorical data inputs
- Can readily couple with other analytical approaches and spatial data
- Supervised, natural language processing helps make the workflow more intuitive and interpretable
  - Uses "If – Then" statements

Data framework





SIMPA tool will provide…

- **Robust storage assessments** by providing additional information about subsurface hazards
- **Evaluation of potential risks and impacts** that CO_2 storage might pose to various human health and environmental factors
- **Decision making and risk management** pertaining to the development and use of various carbon capture and storage methods

Next steps

4/2018 – 3/2019:

- Testing & Validation for SIMPA model
- Evaluate other regions, different scales
- Publicly release SIMPA model, version 1 through EDX
- Including supporting documents (user manuals, tutorials, data, etc.)

3/2019 – 4/2020:

- Support online analytics for SIMPA through EDX
- Enhance execution using big data techniques and advanced 3D/4D analytics to improve data discovery, integration, and analysis within the SIMPA model

Ultimate Outcome

- An open source, python based fuzzy logic tool
- Used for spatial analyses to assess leakage likelihood

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U.S. DEPARTMENT OF ENERGY

For more information on NETL's Carbon Storage portfolio, data, and tools visit:
https://edx.netl.doe.gov/carbonstorage

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