Carbon Storage Technical Viability Approach

EDX4CCS FWP, Task 21

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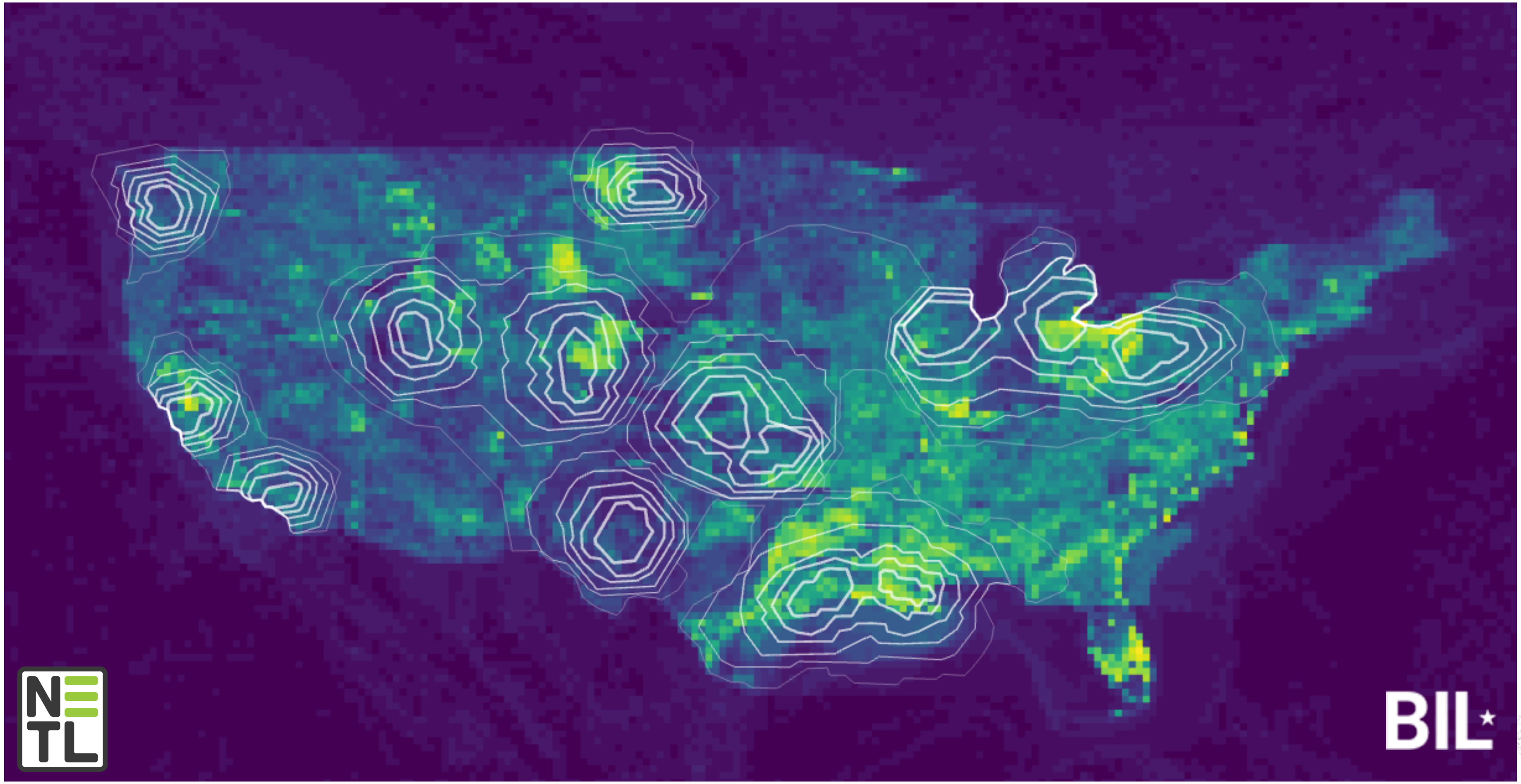

NETL Carbon Management Review Meeting

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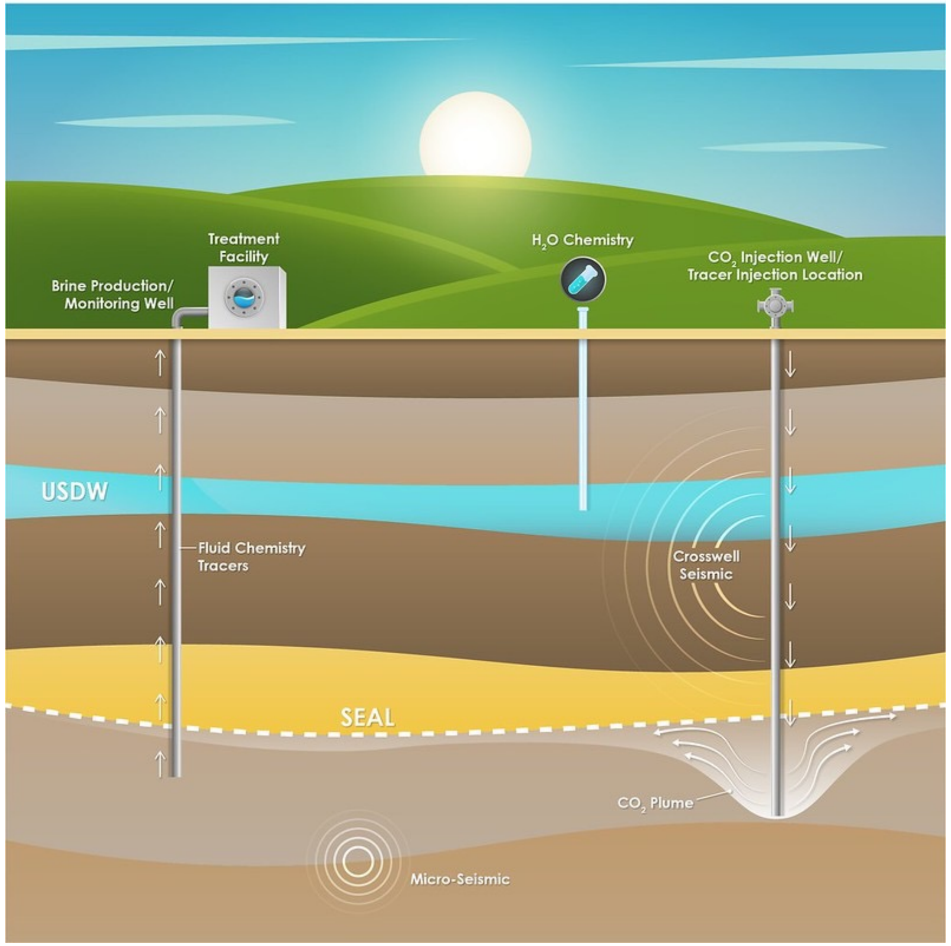
Carbon Storage Technical Viability Approach (CS TVA)

EDX4CCS 21



Problem: Poor understanding of data available and a lack of workflow that incorporates CO_2 storage resources and environmental and socio-economic factors that underlie technically viable, feasible carbon storage

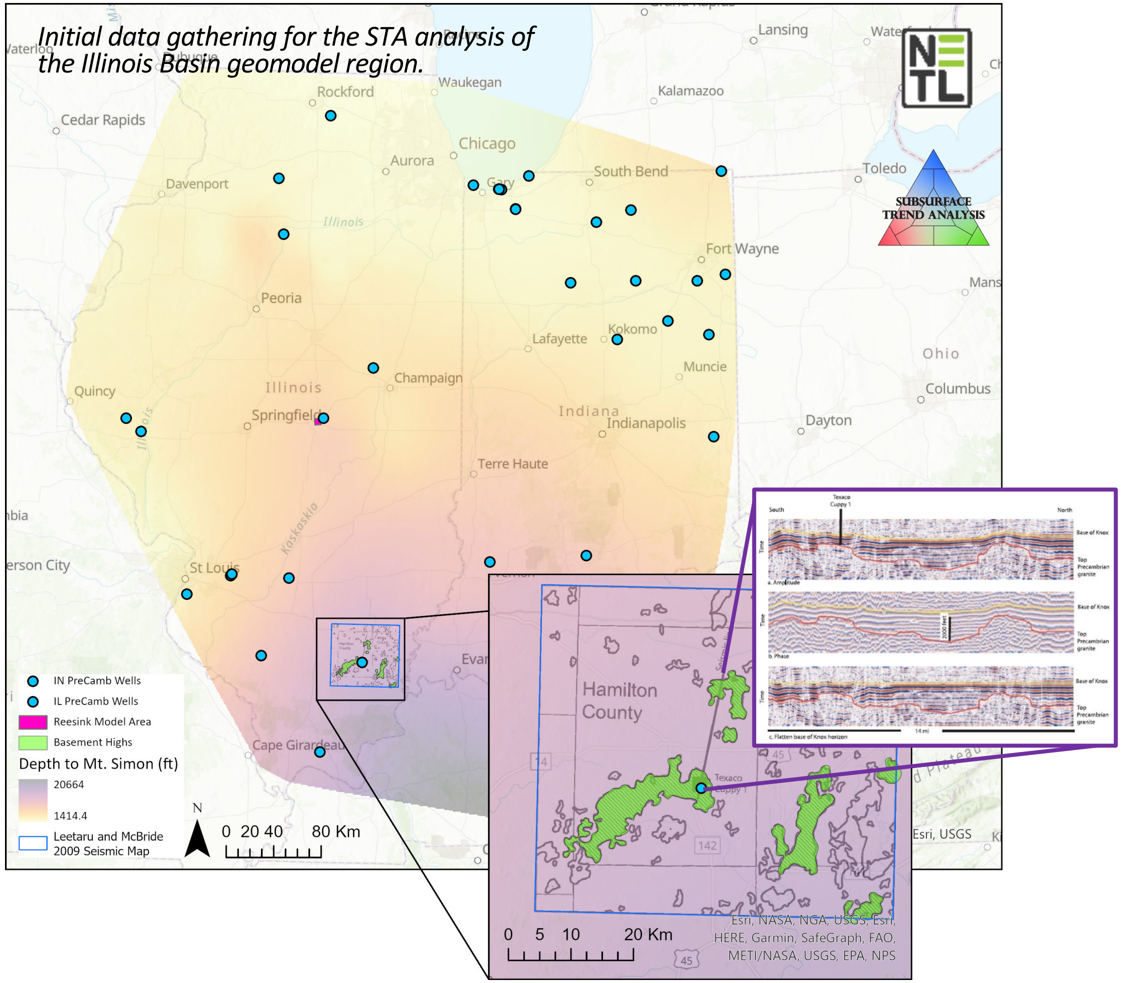
Key question: Where are the data?? Are they useful?

Solution: A database, evaluation criteria, and workflow that integrates these additional factors beyond technically recoverable storage resources to inform and accelerate **technically viable CS assessments** in the USA

Carbon Storage Technical Viability Approach

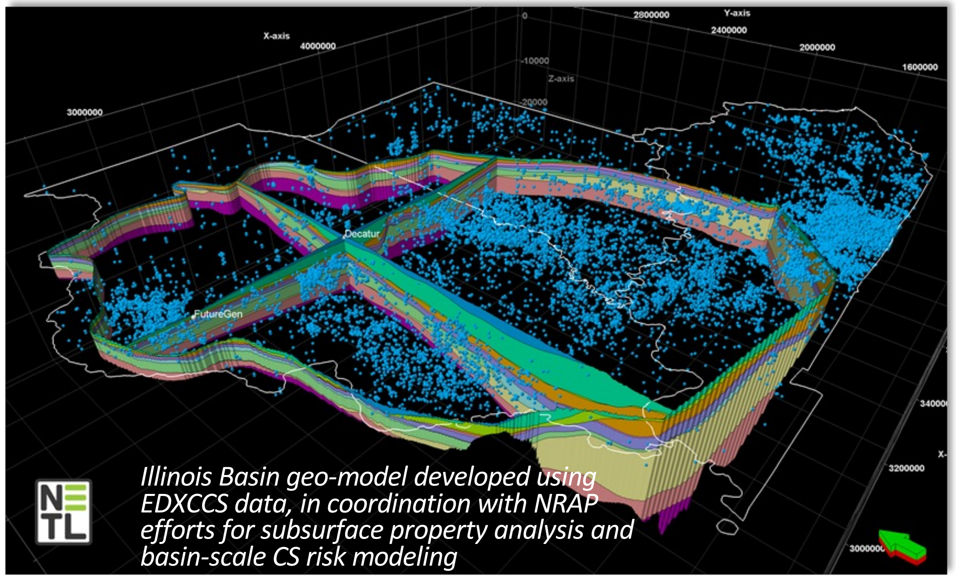
Three key research products:

- **Carbon Storage Technical Viability Approach Matrix**
    - *Categorizes components of technical viability per subject domain*
    - *Utilized to link data types for CS TVA assessment*
- **Database supporting technically viable carbon storage evaluations**
    - *Will build from initial EY22 release*
    - *Interoperation with other EDX4CCS database products*
- **Data availability workflow for technically viable carbon storage resource assessments**
    - *Utilizes data analytics, models and tools to communicate the availability of data for CS TVA assessments*

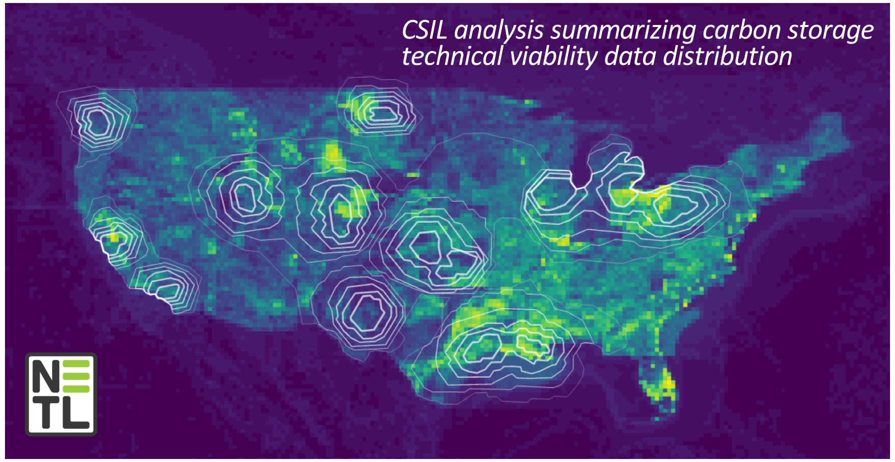


EDX4CCS 21 EY22 Achievements

- Design of initial version of EDX4CCS Carbon Storage Technical Viability Database
- Illinois Basin Geomodel
- Cumulative Spatial Impact Layers (CSIL) data analysis
- Release of the CS TVA Database Version 0.1
  - https://edx.netl.doe.gov/dataset/edx4ccs-carbon-storage-technical-viability-database-version-0-1
- Initiation of CS TVA Matrix
- Identification of key data types for CS TVA assessments



Illinois Basin geo-model developed using EDXCCS data, in coordination with NRAP efforts for subsurface property analysis and basin-scale CS risk modeling



CSIL analysis summarizing carbon storage technical viability data distribution

EDX4CCS 21 EY22 Challenges

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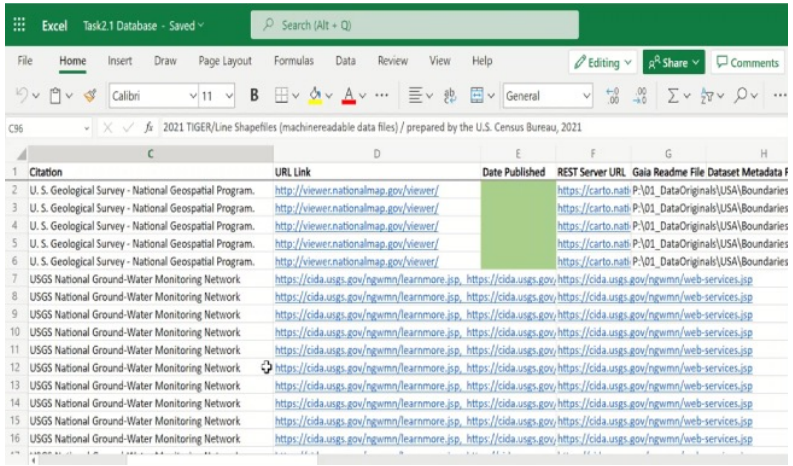
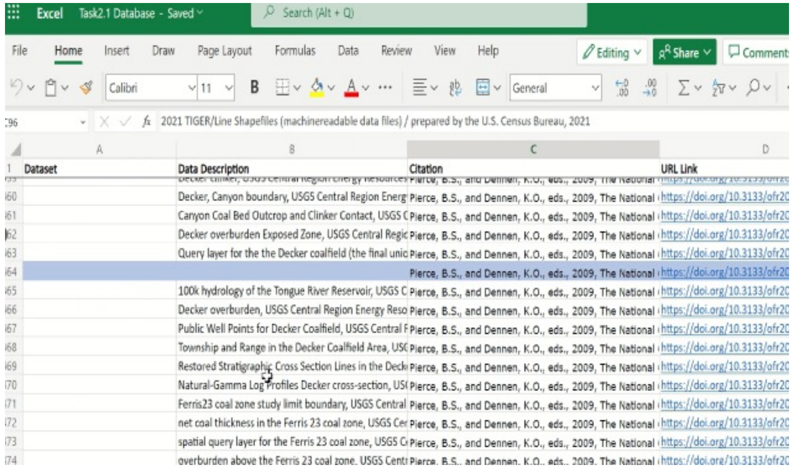
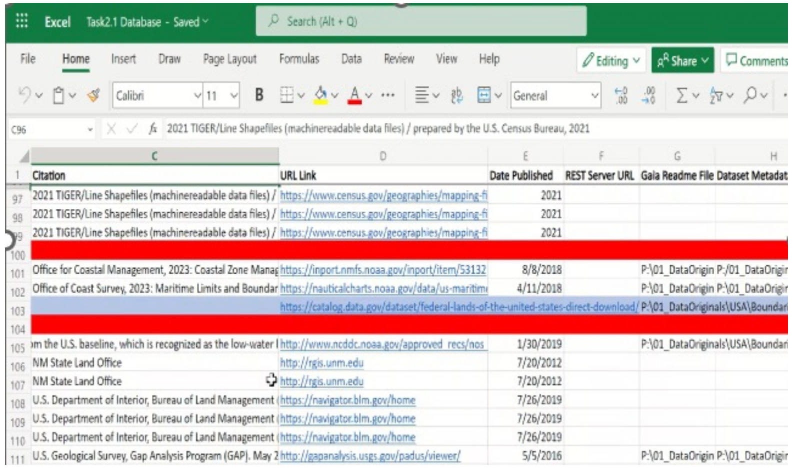
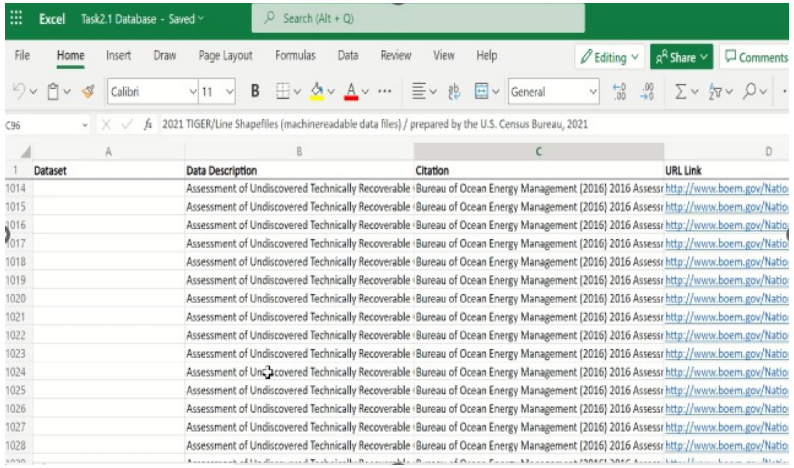
- Need for singular, comprehensive criteria to inform CS technical viability assessments
- **Tremendous amount of data** required for complete CS TVA assessment
- Data analysis and collection efforts spread across EDX4CCS tasks
- Data are disparate, inconsistently available/updated, and variably formatted leading to **analysis gaps and greater uncertainty**





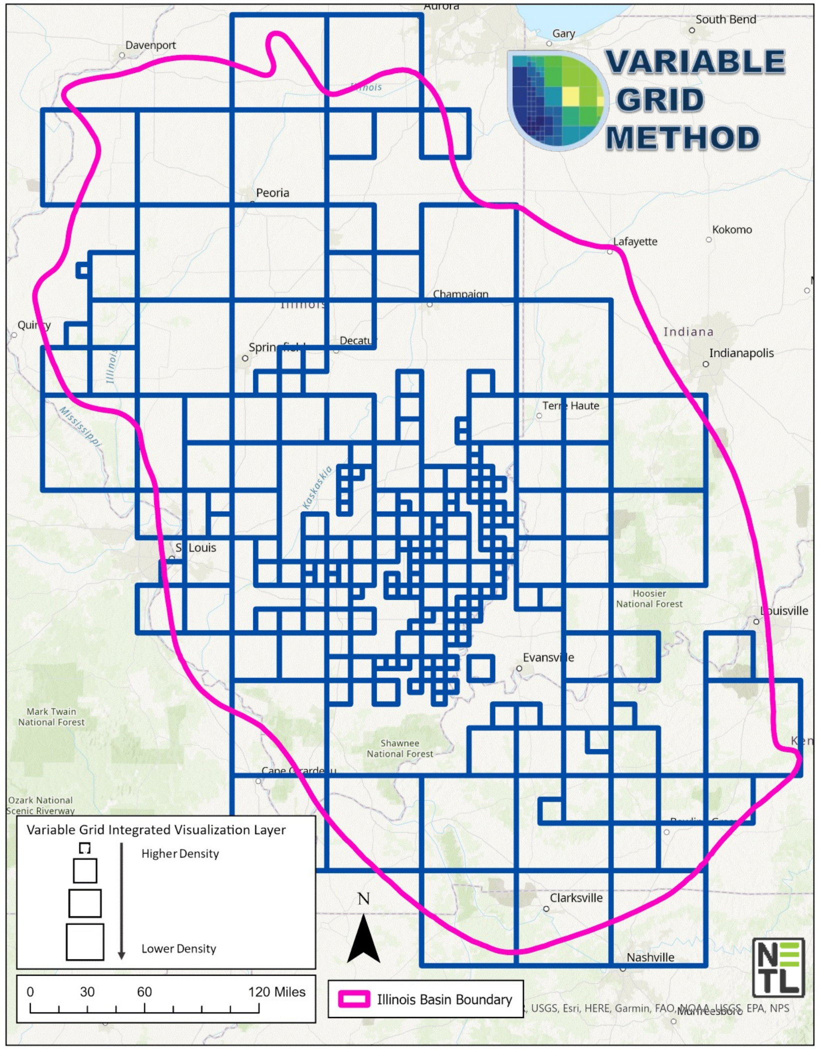




EDX4CCS 21 EY23 Progress to Date

- **Completed Illinois Basin geomodel**
- **Refined CS TVA Matrix** and **associated data types** to define criteria for CS TVA
- Continued development of CS TVA data strategy integrating EDX4CCS-generated data, databases via **cross-cutting coordination**
- Initiated evaluations of data science tools for incorporation into the **data availability workflow**

	Specific Component	Designation / Determination	Non - Viable	Possibly Non-Viable	Viable with Hurdles	Viable but Non Ideal	Fair / Decent Viability	Good Viability	Excellent Viability	Unknown Viability
			This component that would prevent the project from moving forward or cause it to terminate early.	This component has issues that would make the project non-economic, reduce its lifespan, or reduce total injection capacity.	This component has issues that will be detrimental to the project but can be overcome with time and /or money.	This component is not well suited for sequestration but likely not prohibitive to the project moving forward.	This component is not optimized but should be sufficient.	This component is well-suited for this project.	The component is ideal, optimized, and / or desirable for this project.	There are insufficient data available to assess this component therefore viability is unknown.
Reservoir Quality	Porosity	Porosity	Limited porosity.	Low porosity.		Low to moderate porosity.	Moderate porosity.	Good porosity.	Excellent porosity.	Unknown porosity.
	Permeability	Impact of permeability on injectivity.	Limited permeability will prevent injectivity.	Limited permeability will hinder injectivity.	Low permeability decreases injectivity.		Moderate permeability.	Good permeability.	Excellent and extensive permeability.	Unknown permeability.



EDX4CCS 21 EY23, Year 2 Goals

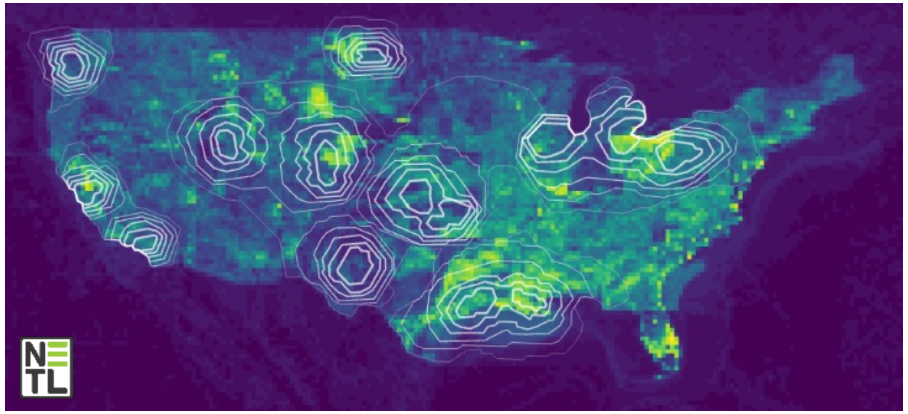
- *Illinois Basin Geomodel* ***(6/2023, complete)***
- *CS TVA Matrix* ***(11/2023)***
- *CS TVA Database Version 1.0* ***(11/2023)***
- *Data availability workflow* ***(03/2024)***
- *Fuzzified national assessment of CS TVA data availability* ***(03/2024)***

Benefits:

- **Integrates products** from EDX4CCS portfolio
- **Informs availability** of key data resources for carbon storage technical viability analysis
- **Provides a foundation** for assessing carbon storage technical viability

Carbon Storage Technical Viability Approach Workflow

- **Challenges: abundant, yet disparate and variably formatted data leads to gaps in understanding of CS system**
- **Proposed approach:**
  - Assess data resources for CS **technically viability** to highlight ideal basins and data/knowledge gaps



Goals:

- **Leverage FECM NETL tools and methods** for use in multi-scale analytical workflow
- **Demonstrate workflow at national scale** with existing data resources
- **Integrate data from crosscutting EDX4CCS tasks**

VARIABLE GRID METHOD

SUBSURFACE TREND ANALYSIS

CSIL

URC Method

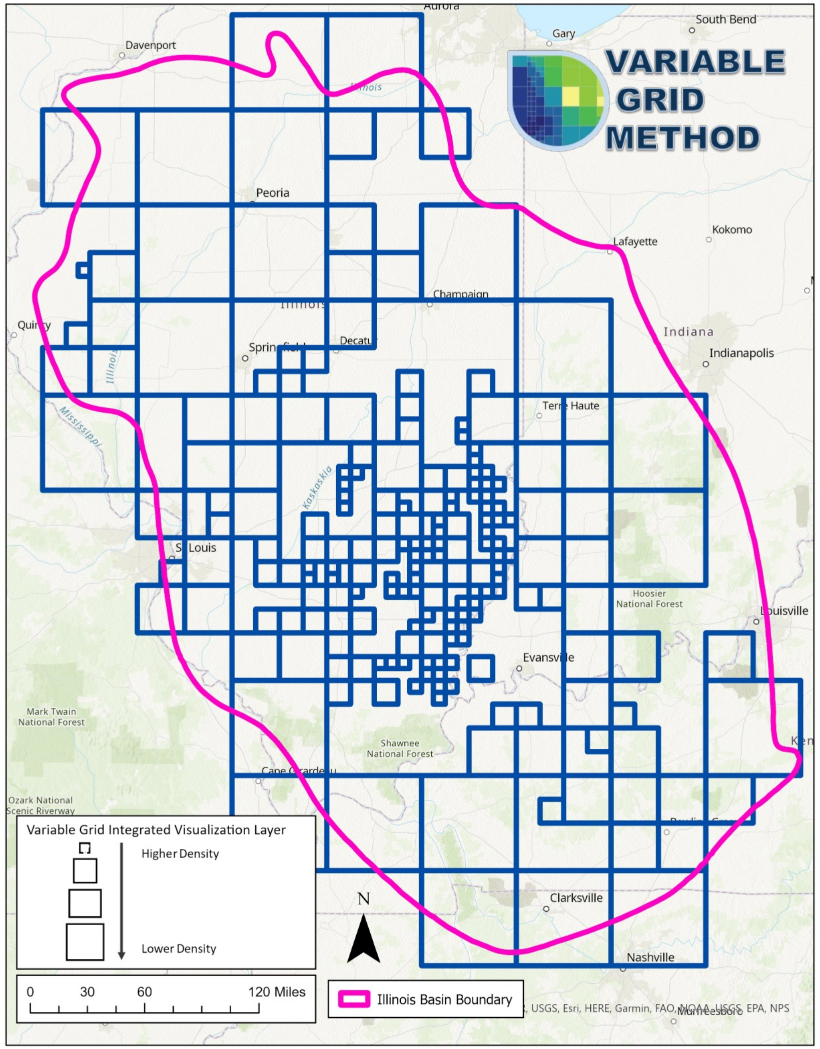
EDX Energy Data eXchange

disco2ver

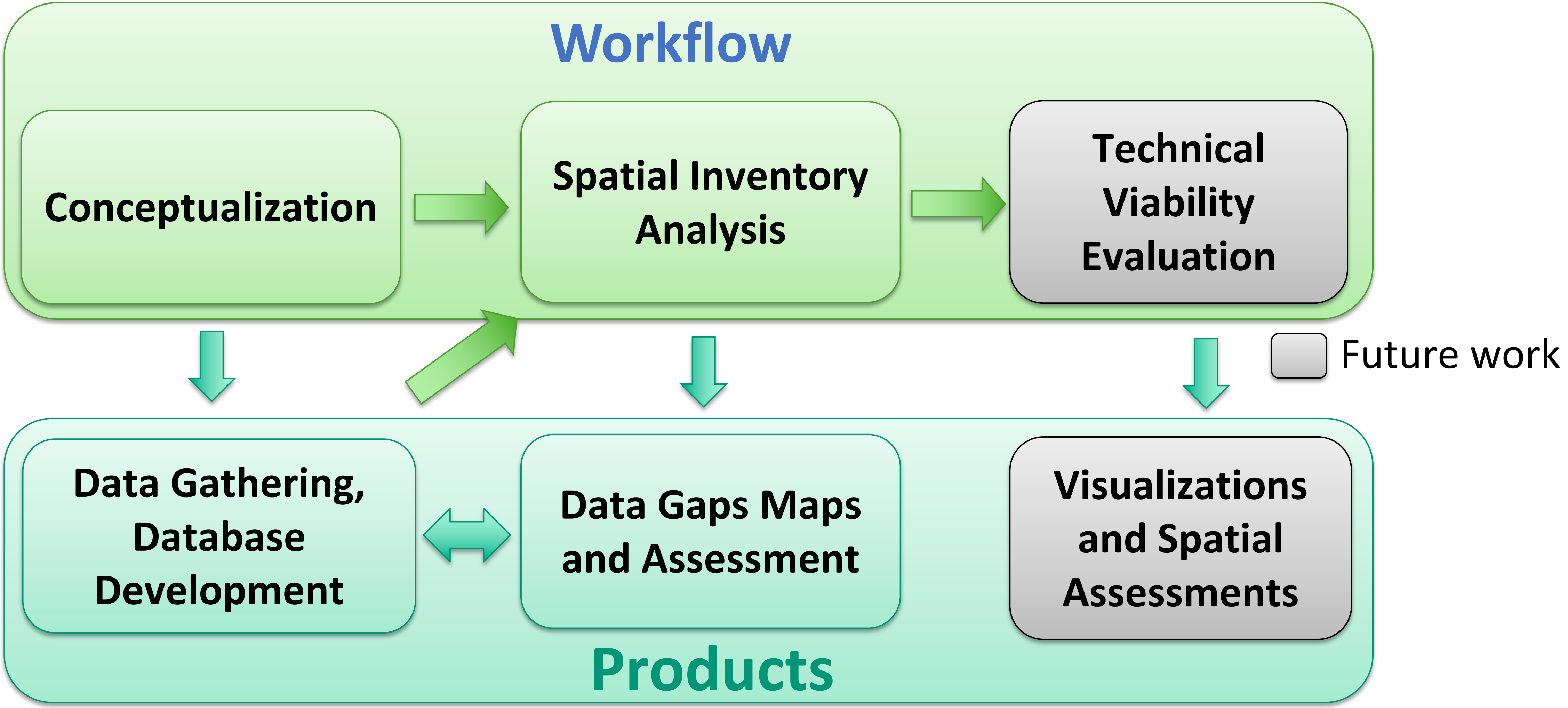
Carbon Storage Technical Viability Approach Workflow

Conveys CS viability in a region of interest *based on the data available* and informs storage resource estimates

- *CS TVA workflow in conceptualization stage*
- *Iterative approach between CS TVA matrix – database – workflow*
- *Data availability analyses and technical viability assessment are two key components of the Carbon Storage Technical Viability Approach (CS TVA)*



Carbon Storage Technical Viability Approach Workflow

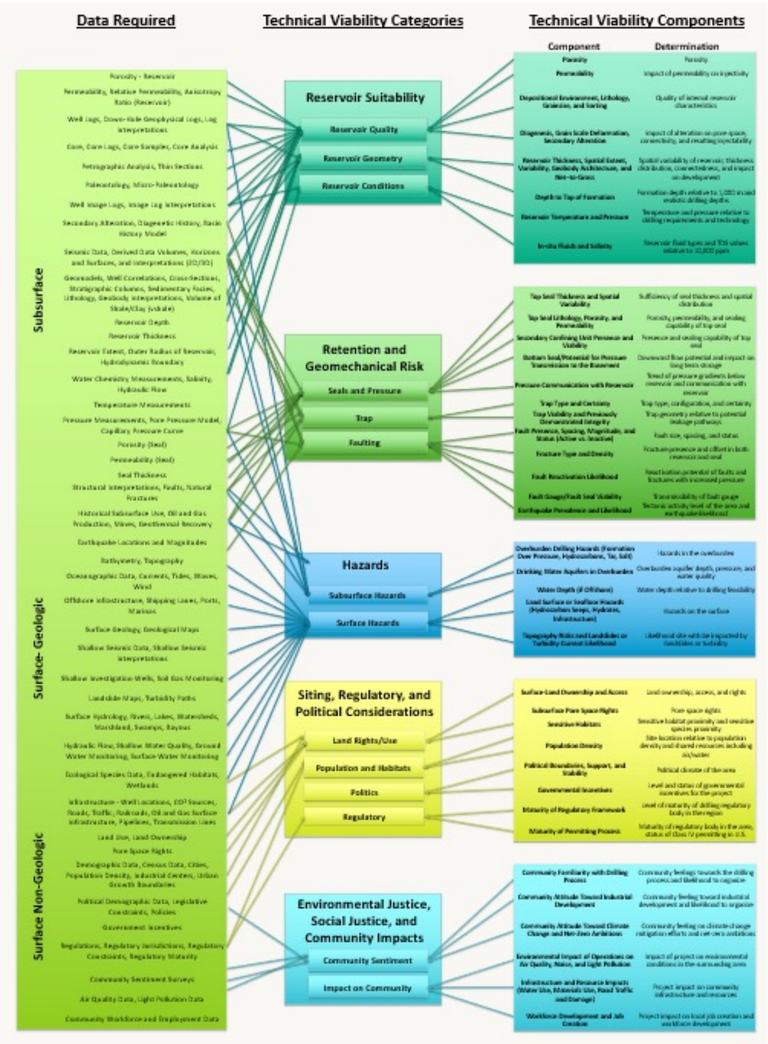


Carbon Storage Technical Viability Approach Matrix

Carbon Storage Technical Viability Approach Matrix is a criteria for systematic evaluation of the availability of data for the CS TVA

- *Criteria include* ***reservoir suitability, retention and geomechanical risk, hazards, siting/regulatory/political considerations, and environmental/social justice, community impacts***
- *Criteria are divided into categories, then subdivided into components and their determination*
- ***Data required for each determination are mapped to the CS TVA categories***

See poster by Mulhern et al. in the Carbon Transport and Storage section



Carbon Storage Technical Viability Approach Matrix

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Technical Viability Categories

Reservoir Suitability

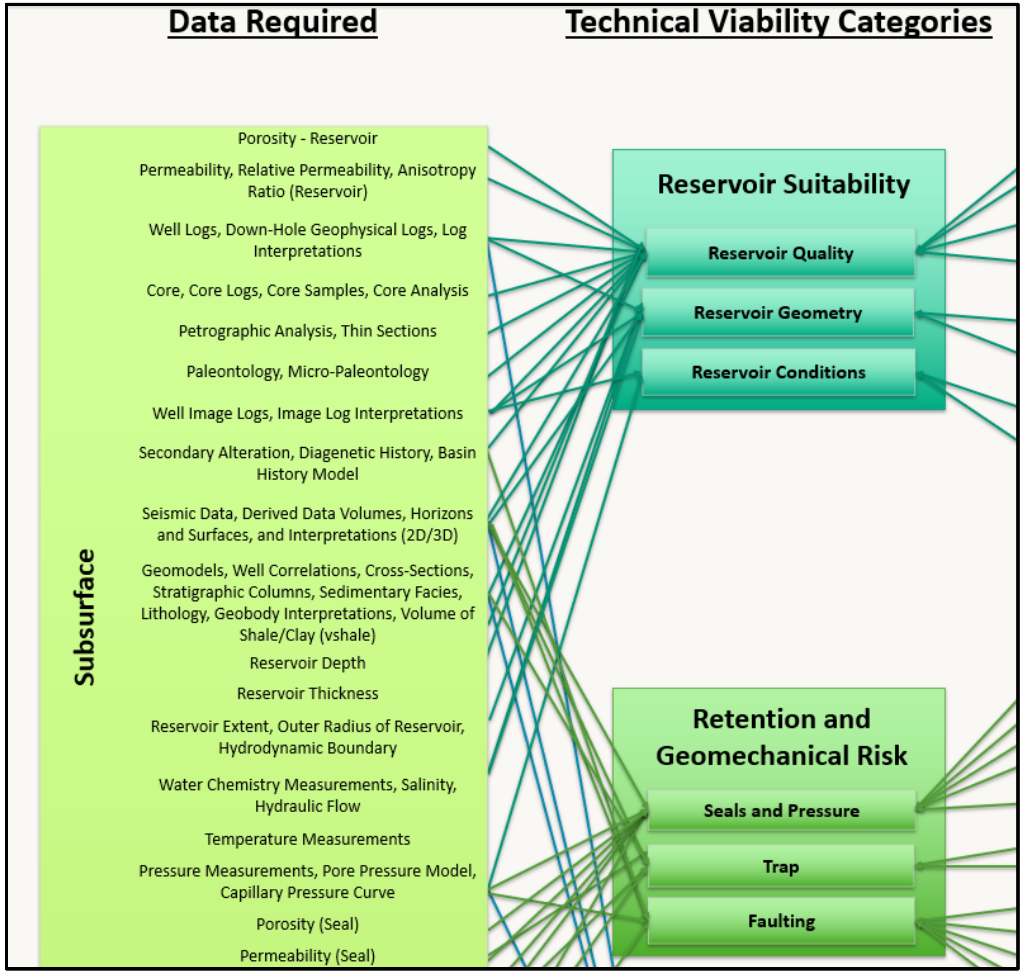
- **Reservoir Quality**
- **Reservoir Geometry**
- **Reservoir Conditions**

Technical Viability Components

Porosity	Porosity
Permeability	Impact of permeability on injectivity
Depositional Environment, Lithology, Grainsize, and Sorting	Quality of internal reservoir characteristics
Diagenesis, Grain Scale Deformation, Secondary Alteration	Impact of alteration on pore space, connectivity, and resulting injectability
Reservoir Thickness, Spatial Extent, Variability, Geobody Architecture, and Net–to-Gross	Spatial variability of reservoir, thickness distribution, connectedness, and impact on development
Depth to Top of Formation	Formation depth relative to 1,000 m and realistic drilling depths
Reservoir Temperature and Pressure	Temperature and pressure relative to drilling requirements and technology
In-situ Fluids and Salinity	Reservoir fluid types and TDS values relative to 10,000 ppm

See poster by Mulhern et al. in the Carbon Transport and Storage section

Carbon Storage Technical Viability Approach Matrix



Data required are mapped to each category and subcategory

- **Reflects multidisciplinary requirements of geologic carbon storage projects**

Technical Viability Assessment Method

Non-Viable	Possibly Non-Viable	Viable with Hurdles	Viable but Non-Ideal	Fair/Decent Viability	Good Viability	Excellent Viability	Unknown Viability
This component would prevent the project from moving forward or cause it to terminate early.	This component has issues that would make the project non-economic, reduce its lifespan, or reduce total injection capacity.	This component has issues that will be detrimental to the project but can be overcome with time and/or money.	This component is not well suited for sequestration but likely not prohibitive to the project moving forward.	This component is not optimized but should be sufficient.	This component is well-suited for this project.	The component is ideal, optimized, and/or desirable for this project.	There are insufficient data available to assess this component therefore viability is unknown.

Emphasizes need for data availability workflow to indicate gaps, support future database releases, and eventual CS TVA assessment

See poster in the Carbon Transport and Storage section

Carbon Storage Technical Viability Database

***Database** to support carbon storage technical viability analytics (released 6/2023)*

- ***Subsurface/physiographic** and **socioeconomic** spatial feature datasets*
  - *Currently >**1,200 shapefiles**, >**40 GB of data combined***
  - *>**51,000,000 features in the socioeconomic database***
- *v0.1 contains initial pass of available data; v1.0 will contain updates, additional file types, and newly released subsurface analysis data based on CS TVA Matrix*

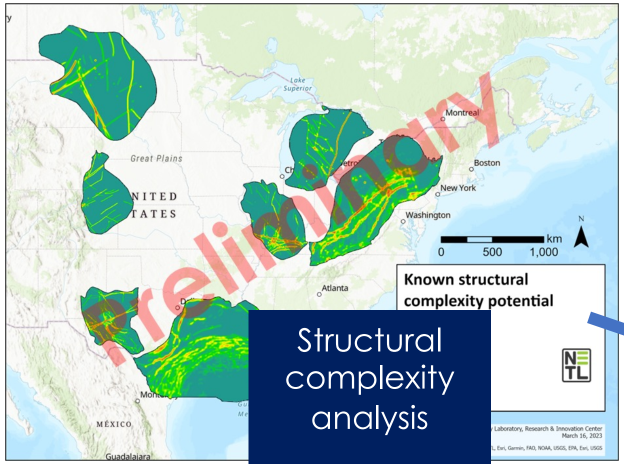
Carbon Storage Technical Viability Database

- Use of the **CS TVA Matrix to inform future database collections**
- **Data required for each component** of the CS TVA is identified
- Publicly available data that is not available in other EDX4CCS databases will be gathered into **Carbon Storage Technical Viability Database Version 1.0**
- Exploring options for **coordinated, interoperable databases** to be released via DisCO2ver

EDX Energy Data eXchange

disco2ver

Carbon Storage Technical Viability Database



Structural complexity analysis

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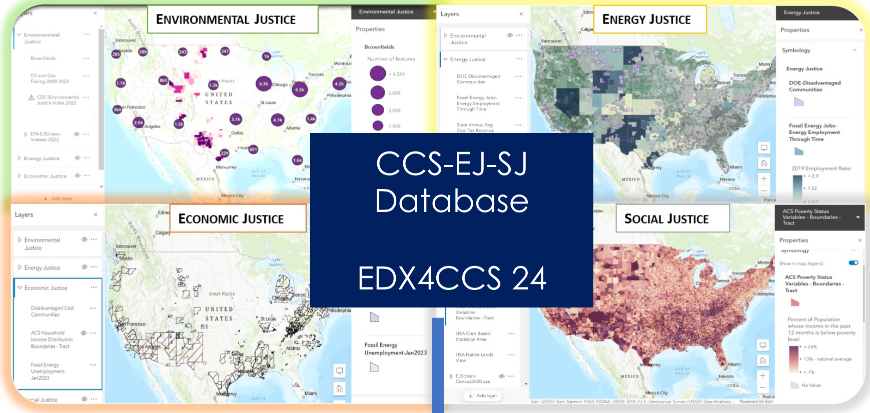
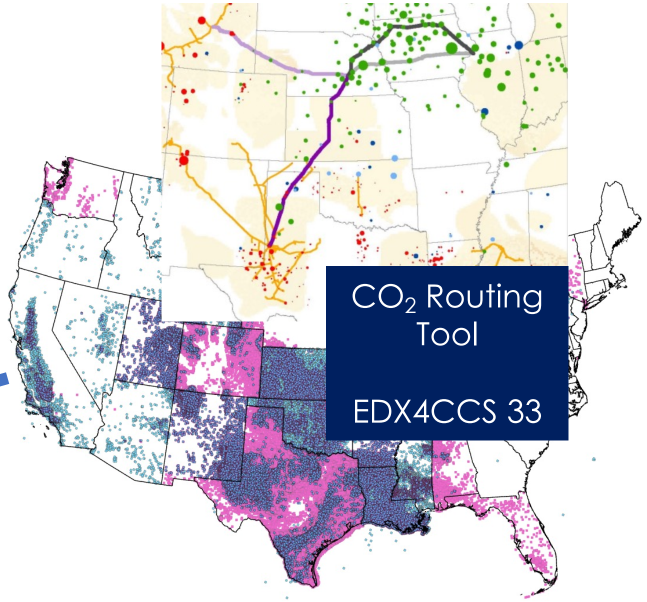


CCS-EJ-SJ Database

EDX4CCS 24



CO$_2$ Routing Tool

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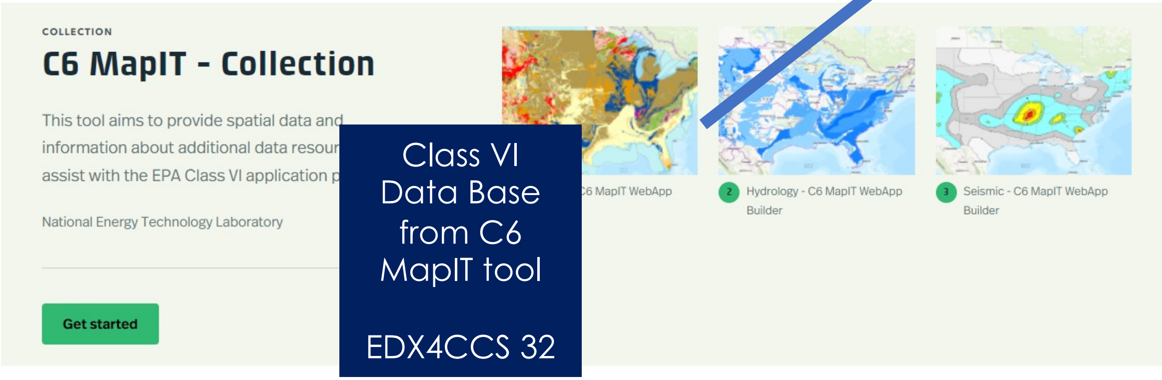
CS TVA

discover

EDX
Energy Data eXchange



Class VI Data Base from C6 MapIT tool

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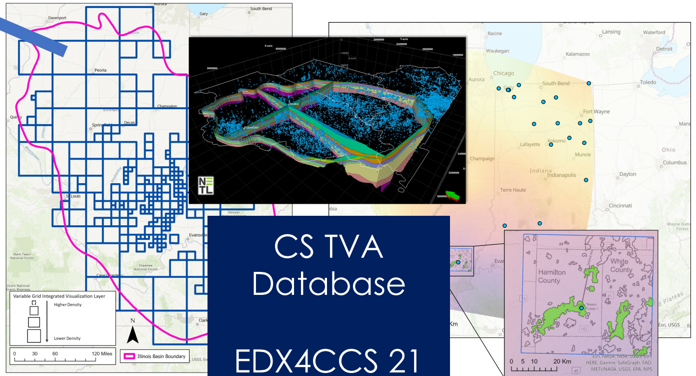

CS TVA Database

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Carbon Storage Technical Viability Approach Data Analytics

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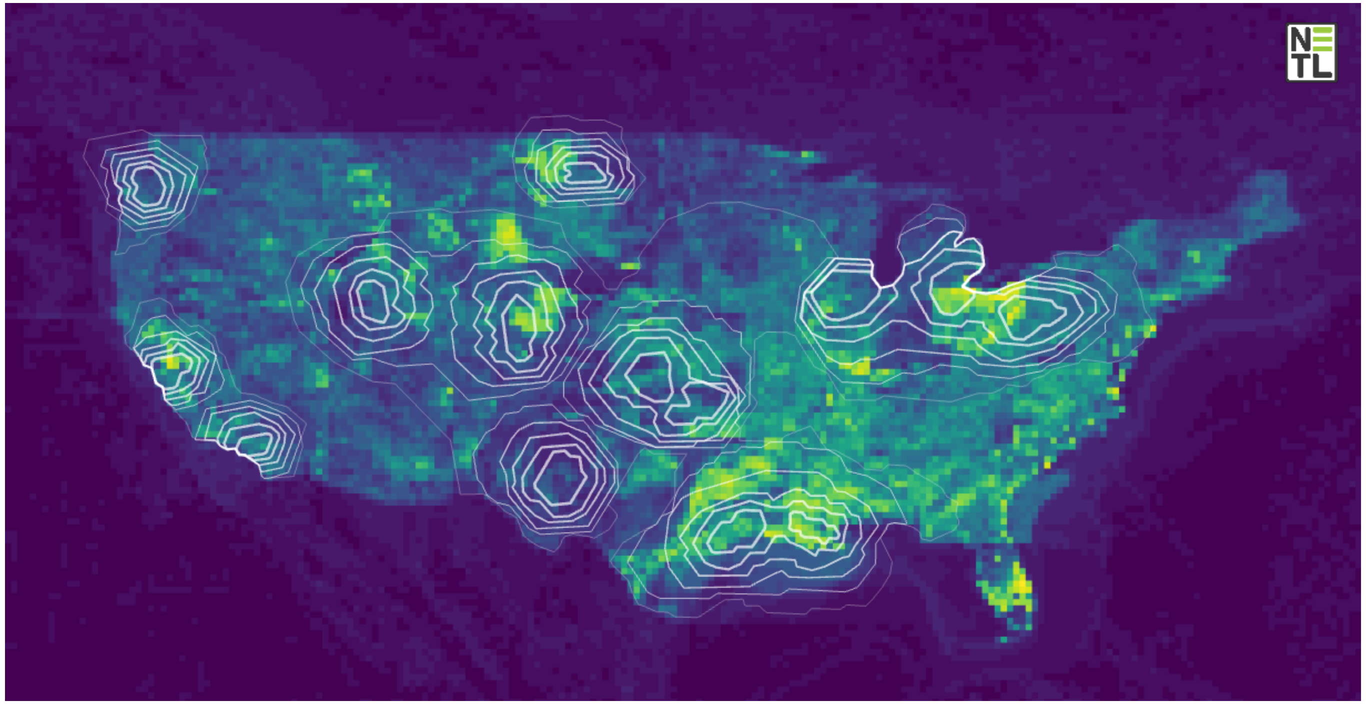
Cumulative Spatial Impact Layers

- **Visualize a summary of data availability**
- United States subsurface data supporting carbon storage technical viability analyses summarized using Cumulative Spatial Impact Layers (Romeo et al., 2019)
- **Future applications:** incorporate cross-cutting databases from EDX4CCS tasks



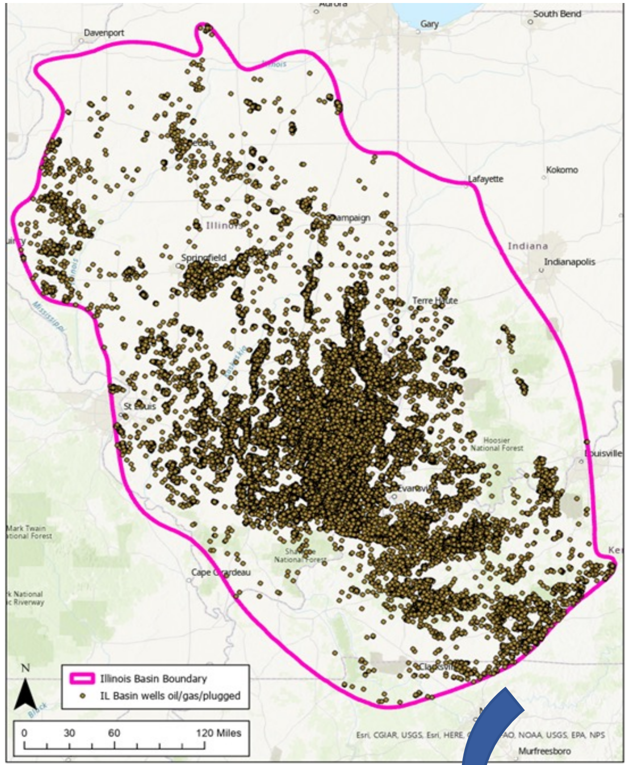
CSIL

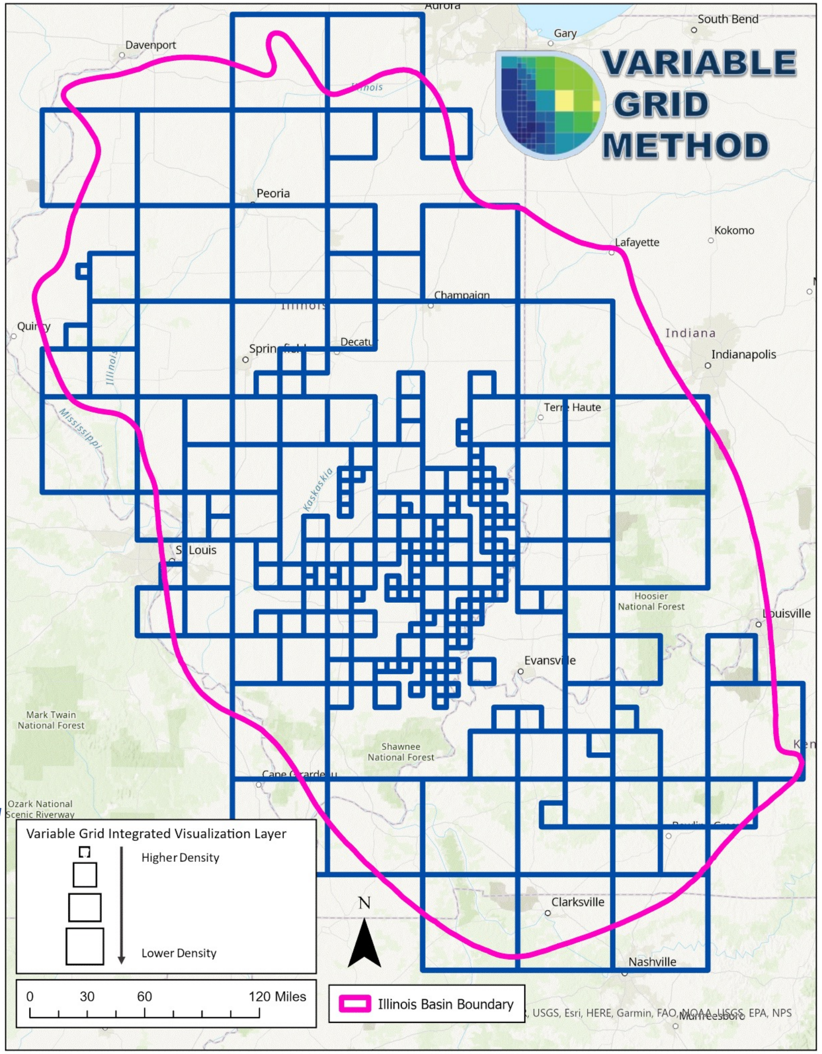
Romeo, L., Nelson, J., Wingo, P., Bauer, J. (2019) Cumulative Spatial Impact Layers: A novel multivariate spatio-temporal analytical summarization tool. Transactions in GIS, 23 (5)

Carbon Storage Technical Viability Approach Data Analytics

Variable Grid Method data density analysis

- Oil and gas well data density analyzed using Variable Grid Method (Bauer et al., 2015)
- **Future applications:** Integrate additional data types for multivariate uncertainty analysis
- **Visualize data uncertainty and density**



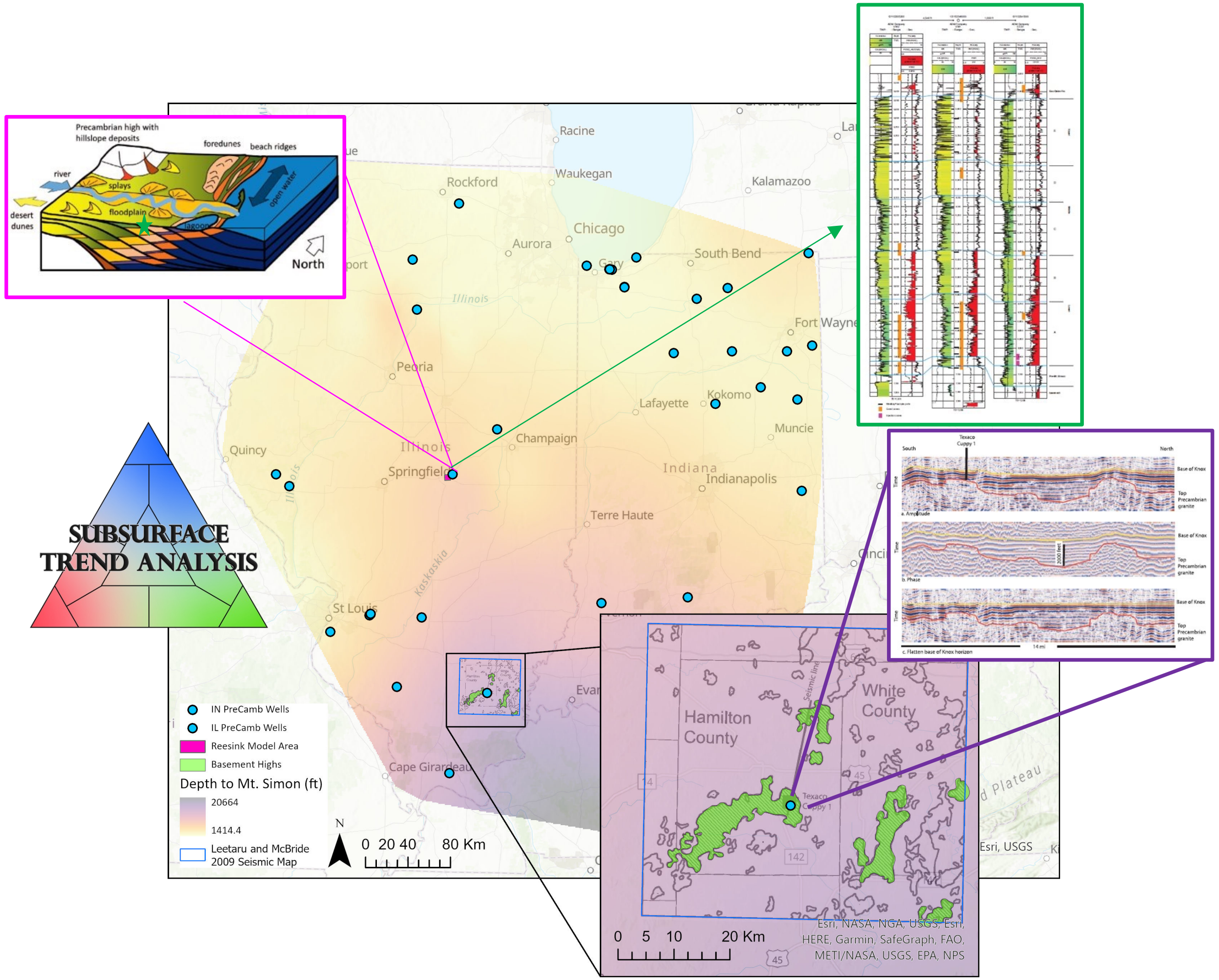


Bauer, J. and Rose, K. (2015) Variable grid method: An intuitive approach for simultaneously quantifying and visualizing spatial data and uncertainty. Transactions in GIS.

Carbon Storage Technical Viability Approach Data Analytics

Subsurface Trend Analysis

- Incorporates geologic knowledge and quantitative data when available to define geologic domains (Rose et al., 2020)
- **Multiple uses of the STA:**
  - **Constrain predictive analytics, fuzzy logic**
  - **Produce interpolations for data gaps**
- Structural and lithologic domains drafted for the Illinois Basin geomodel region, next step is finalizing geologic domains
- **Future applications:** potential inputs for fuzzified national assessment, data gaps interpolations

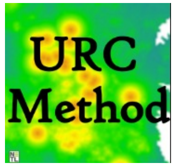


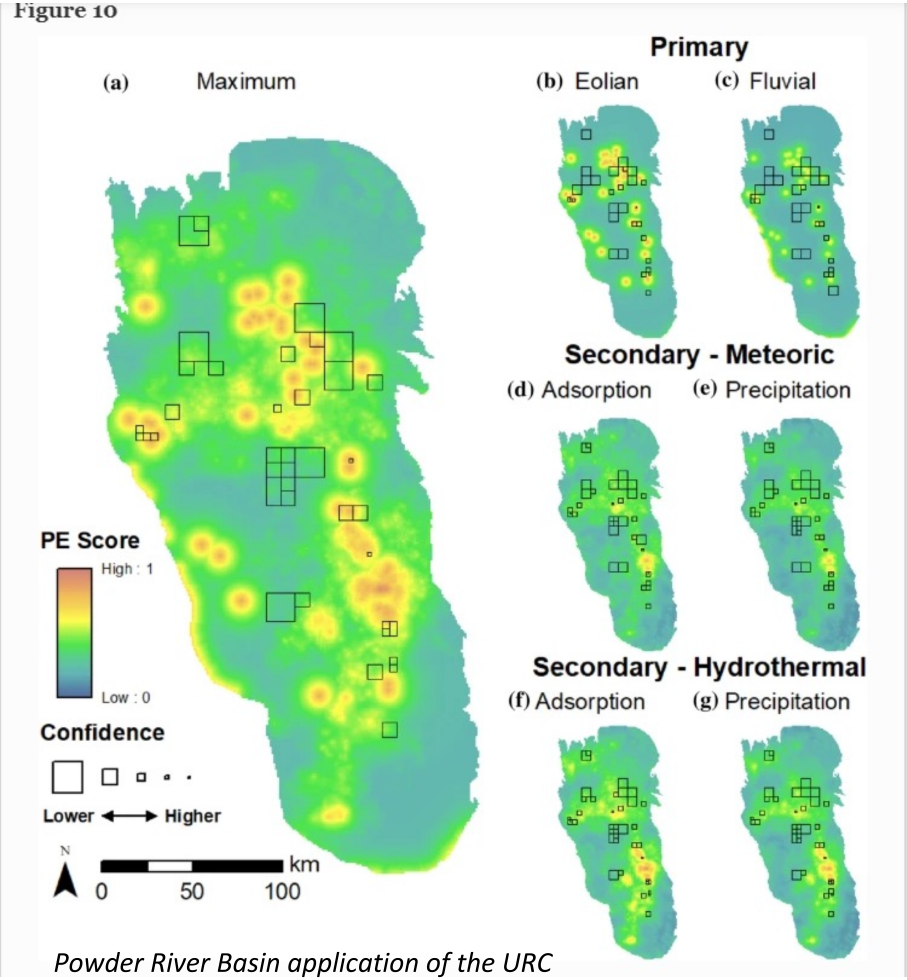
Rose, K., Bauer, J., Mark-Moser, M. (2020) A systematic, science-driven approach for predicting subsurface properties. AAPG Interpretation, 8, (1), T167-T181

Carbon Storage Technical Viability Approach Data Analytics

Data availability analysis using fuzzy logic via component of the Unconventional Rare earth and Critical minerals (URC) Tool (Creason et al., 2023)

- Indicates the data available to analyze carbon storage technical viability
- Utilizes fuzzy logic, a decision-making process that incorporates uncertainty and ambiguity in the data and qualitative processes
- **Future applications: fuzzified national CS data availability assessment; analyze data uncertainty and availability**





Powder River Basin application of the URC method (Creason et al., 2023)

Creason, C.G., Justman, D., Rose, K., Montross, S., Bean, A., Mark-Moser, M., Wingo, P., Sabbatino, M., Thomas, R.B. 2023. A Geo-Data Science Method for Assessing Unconventional Rare-Earth Element Resources in Sedimentary Systems. Natural Resources Research.

Summary

Challenges

- Defining carbon storage technical viability
- TREMENDOUS amount of data required for comprehensive CS technical viability assessment
- Data are disparate, inconsistently available, and variably formatted leading to **analysis gaps and greater uncertainty**

Proposed Approach

- Carbon Storage Technical Viability Matrix
- Database supporting technically viable carbon storage evaluations
- Data availability workflow for technically viable carbon storage assessments

Upcoming products

- *Finalized CS TVA Matrix **(11/2023)***
- *CS TVA Database Version 1.0 **(11/2023)***
- *Detailed data availability workflow **(03/2024)***
- *Fuzzified national assessment of CS TVA data availability **(03/2024)***

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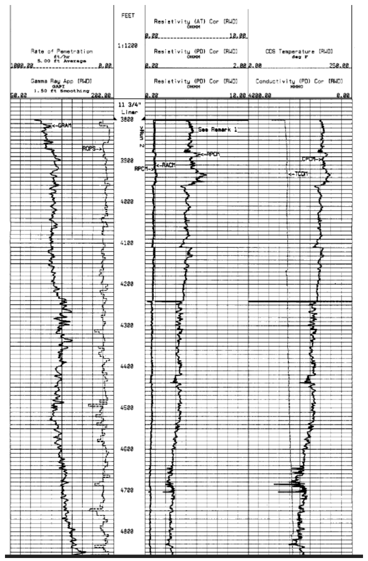
Automated well log reader for subsurface properties



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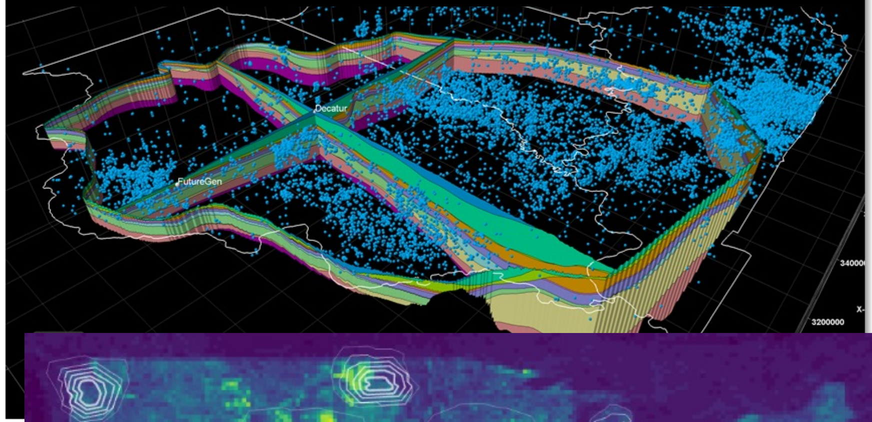
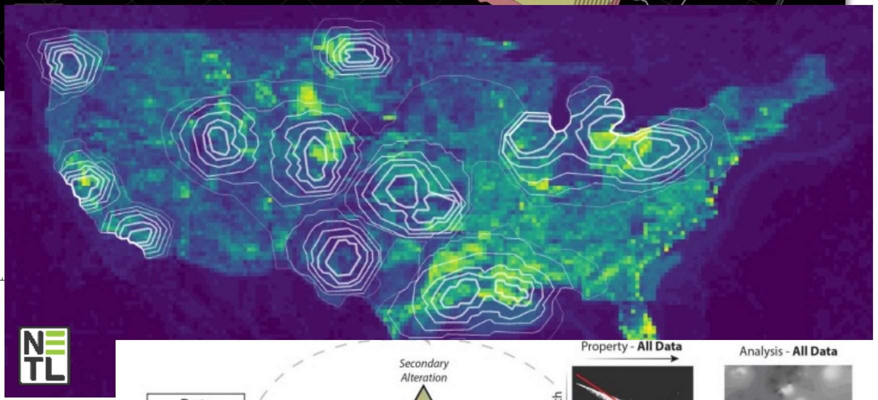
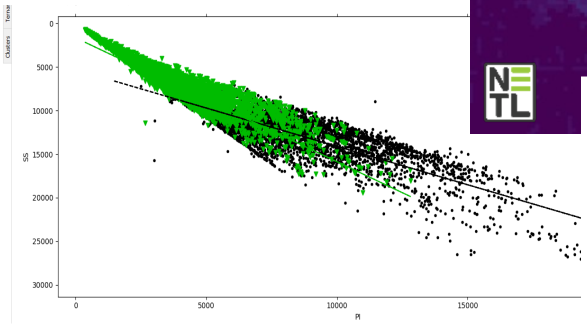
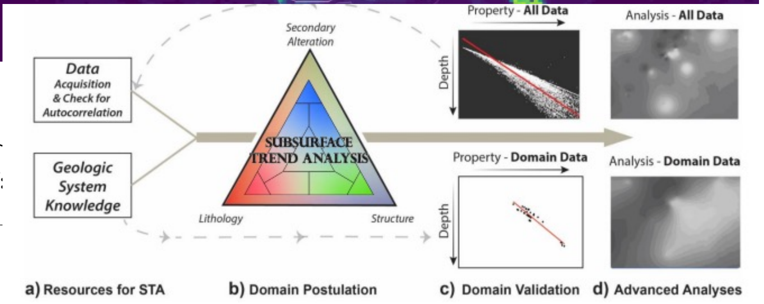






K-means machine learning technique for subsurface property analysis



Acknowledgments

EDX4CCS 2.1

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