

Developing a National Structural Complexity Database for U.S. Saline Basins

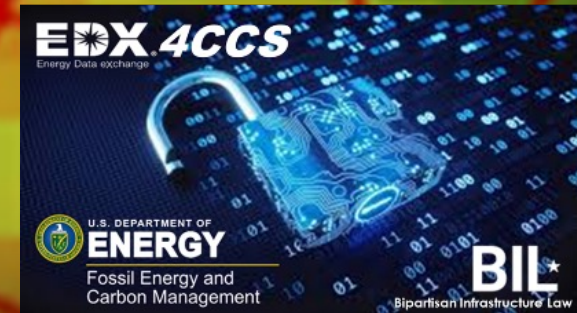


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2023 FECM/NETL Carbon Management Research Project Review Meeting

Aug. 28, 2023



Disclaimer



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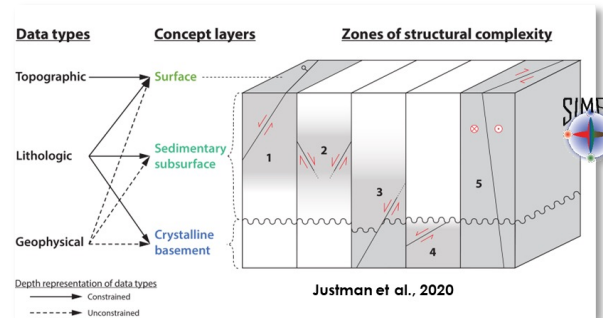
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Developing a National Structural Complexity (SC) Database for U.S. Saline Basins

Problem: Lack of information to better understand the influence structural complexity (SC) will have on long-term carbon storage security.

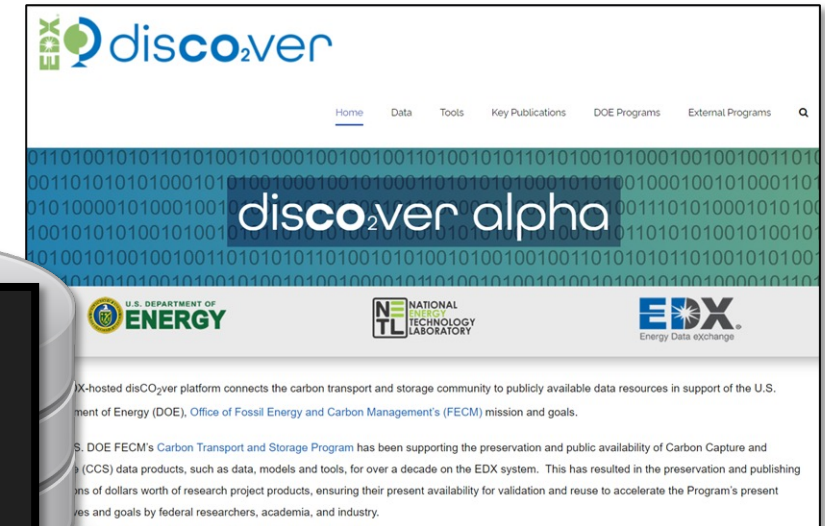
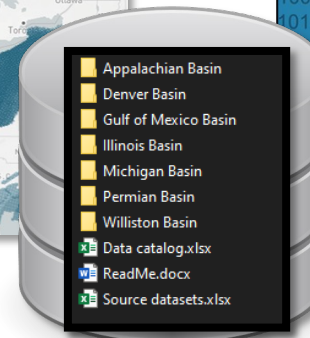
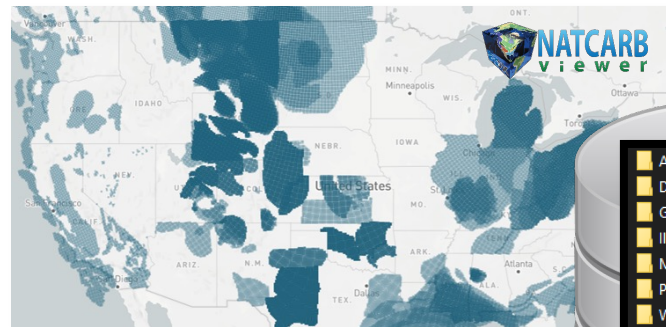
Solution:

- Produce spatial datasets for **selected saline basins** representing:
 - Existing, known SC
 - Predicted potential unknown SC
- Leverage SC method outlined in Justman et al. (2020)
- Assemble and integrate **basin-scale** results into a unified database for use in carbon storage-based assessments
- Publish database on the **EDX DisCO₂ver platform**



Ultimate Value Delivered:

- Provide information about **areas with limited or poor-quality structural complexity information**
- Assists with the identification of data gaps that may require additional, future field work

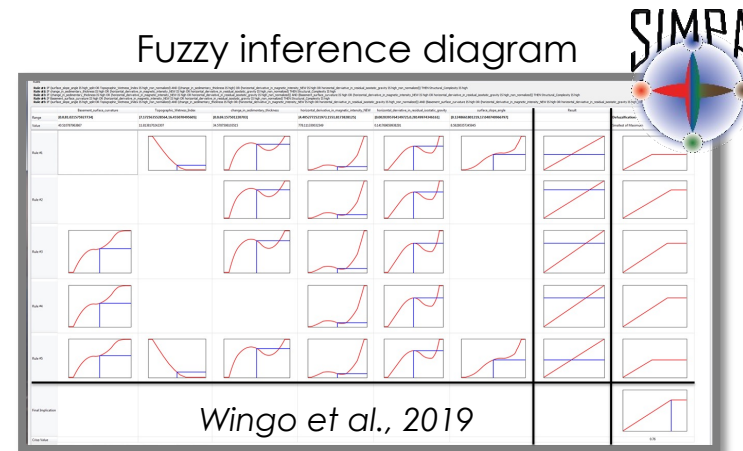
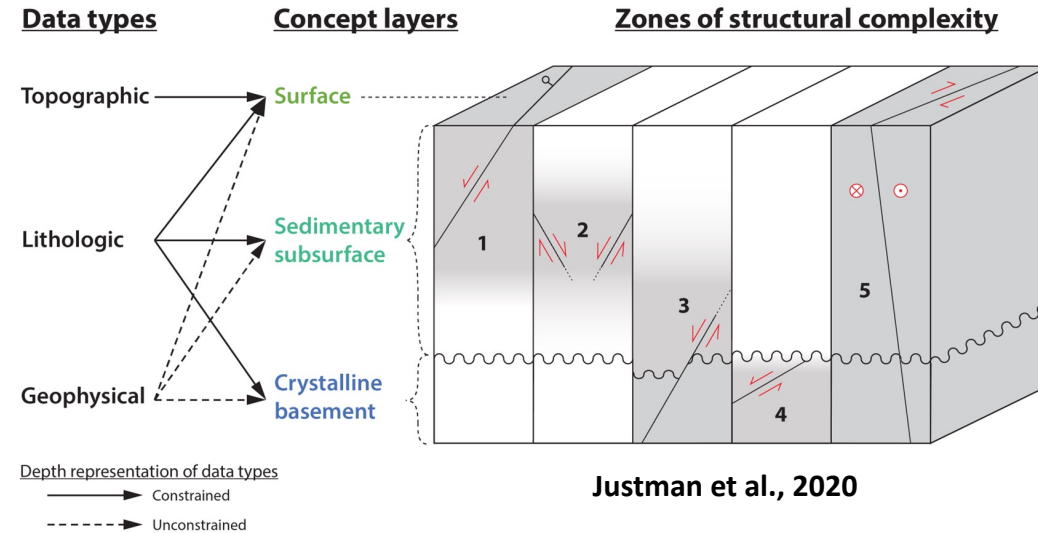


EDX DisCO₂ver (Alpha) Website

Developing a National Structural Complexity (SC) Database for U.S. Saline Basins

Method Overview

- Screening method and approach to predict the potential for complex structural features to exist
 - To better understand geo-hazards linked with faults and fractures
 - Mitigate risks associated with human-subsurface interactions
- Developed a geospatial data framework associated with two fuzzy logic rule-based inference models to
 - Characterize known structure
 - Predict known and unknown structure
- Tested and validated method in Oklahoma
 - SIMPA tool- Spatially Integrated Multivariate Probabilistic Assessment (Wingo et al., 2019)



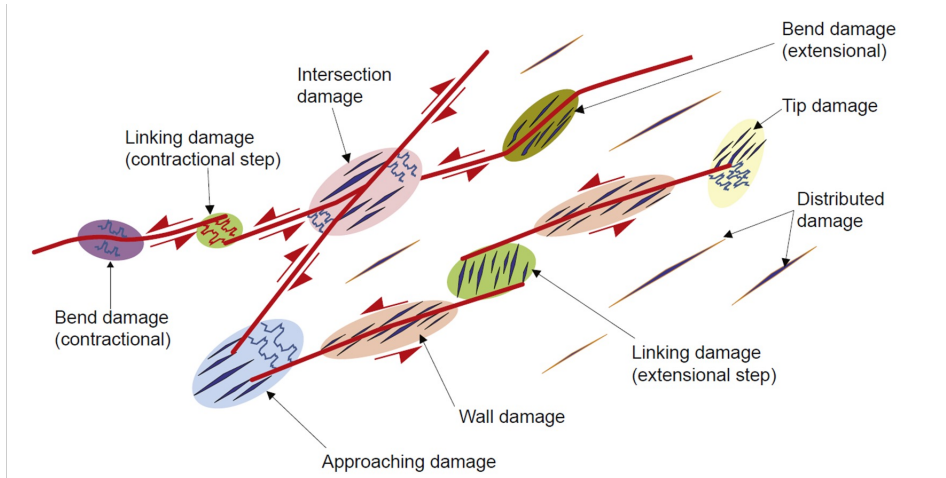
Justman, D., Creason, C. G., Rose, K., & Bauer, J. (2020). A knowledge-data framework and geospatial fuzzy logic-based approach to model and predict structural complexity. *Journal of Structural Geology*, 141, 104153.

Developing a National Structural Complexity (SC) Database for U.S. Saline Basins

Conceptual Framework

Known structural complexity

- Geospatial analytics to represent the concept of damage zones
 - Incorporates associated uncertainties with explicit structural datasets

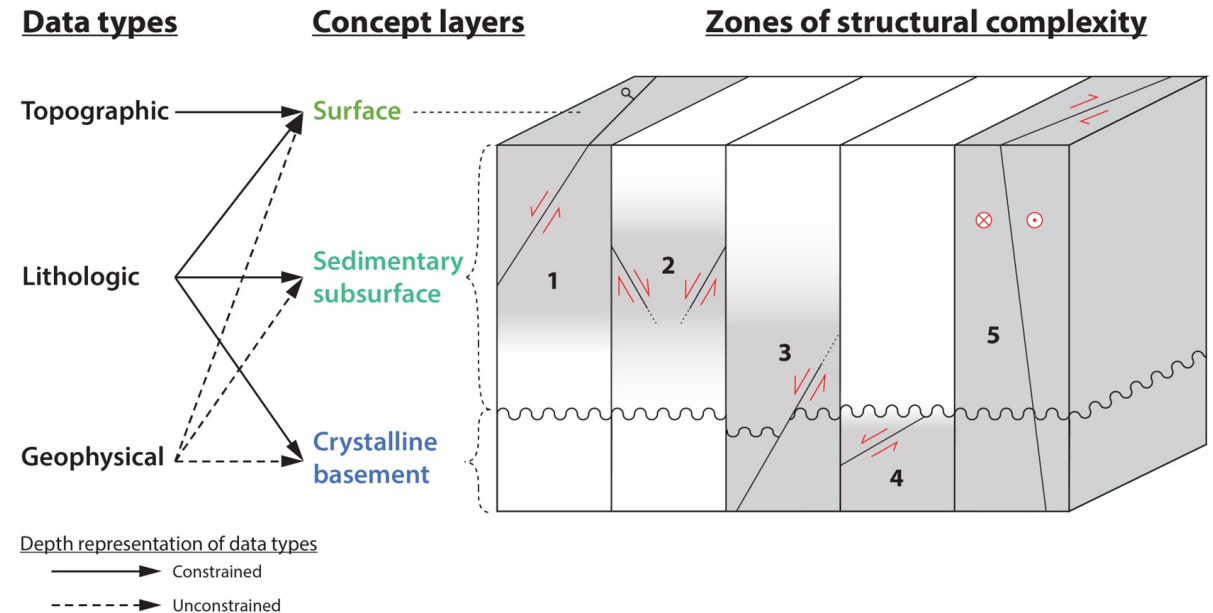


“Complex zones” or “damage zones” are areas with high fracture intensity/linkage and high variation in fracture orientations in contrast with surrounding areas and occur across a variety of tectonic setting, lithologies and scales.

Peacock et al. (2017)

Predicting structural complexity

- Zones of SC
 - Where can we test for SC to potentially exist?

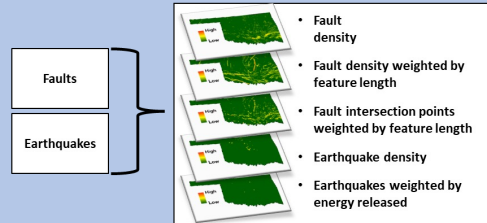


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Applied Framework

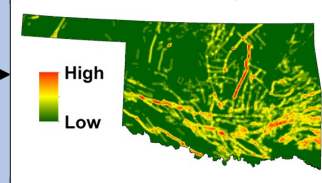
Characterizing
known structural
complexity

Identify and modify explicit
structural data to represent SC



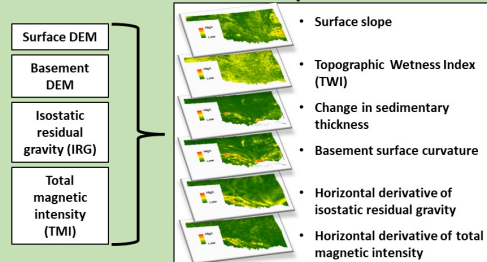
Apply fuzzy
inference model

Maximum known SC potential

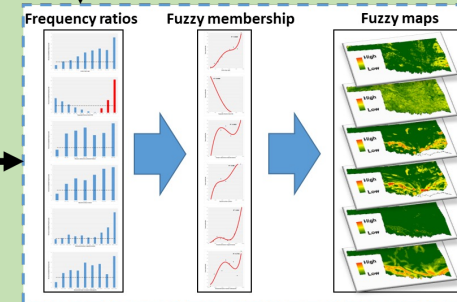


Predicting structural
complexity

Identify and modify proxy
structural data to represent SC



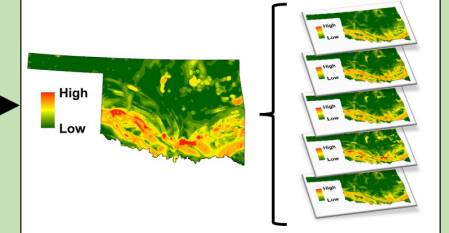
Training Process



Apply fuzzy
inference model

Evaluation

Predict SC for all zones



Justman et al., 2020

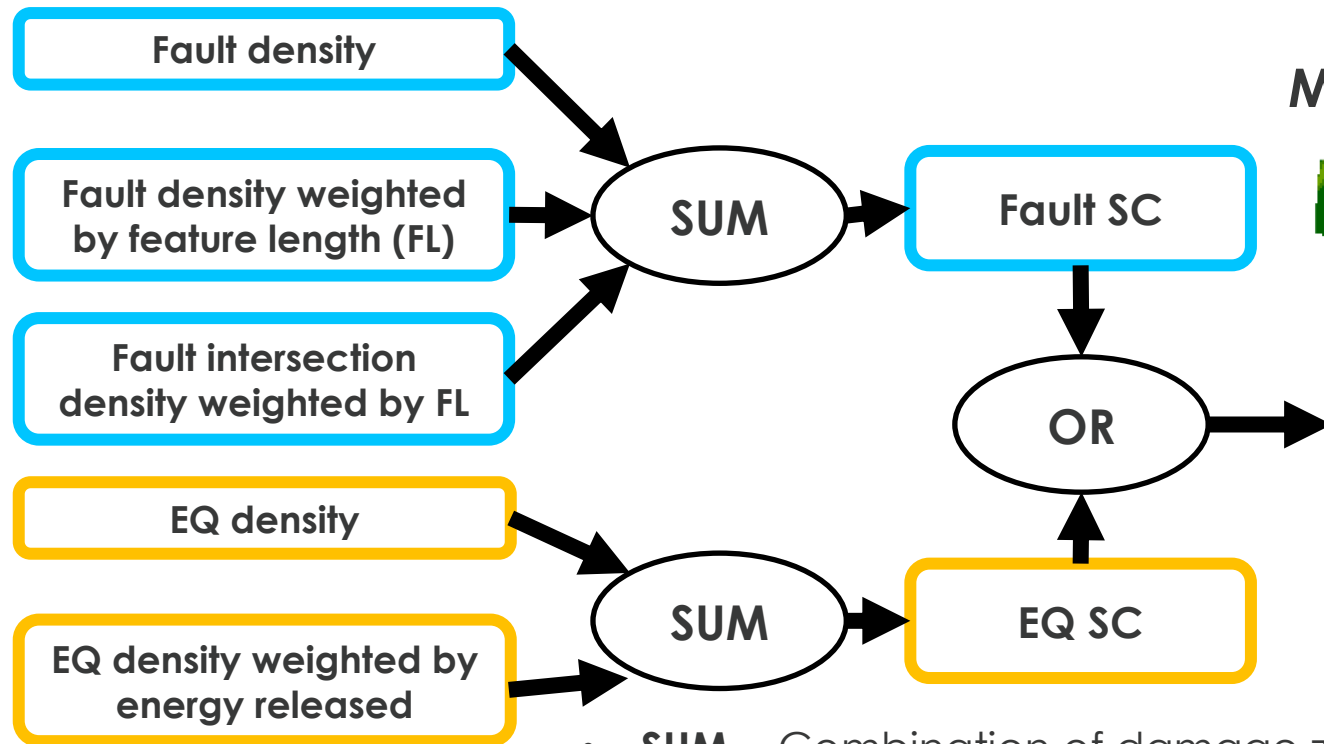
Defining Structurally Complex Areas

Identify **explicit**
structural datasets

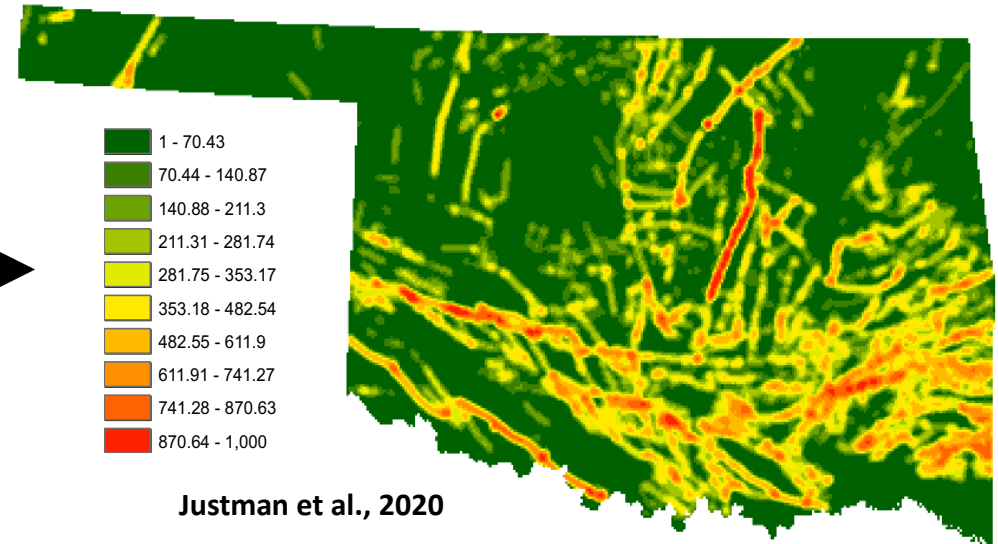
Modify **explicit** data
to represent **known**
structural complexity

Apply fuzzy inference
model

Create training and
test datasets



Maximum potential of known SC

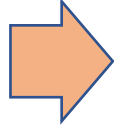


Justman et al., 2020

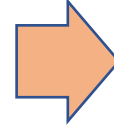
- **SUM** - Combination of damage zone representation > any one individual zone
- **OR** - Uncertainty in importance between explicit source datasets

Predicting Structural Complexity

Identify **proxy**
structural datasets



Modify **proxy** data to
represent **potential**
structural complexity



Train **proxy** datasets

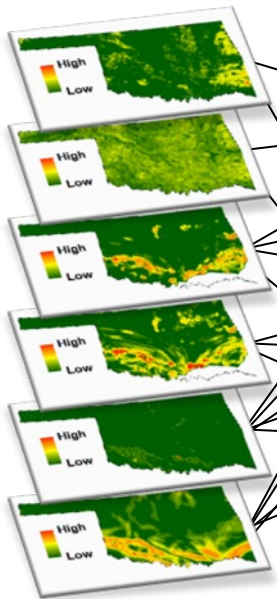


Apply fuzzy inference
model

Fuzzy maps

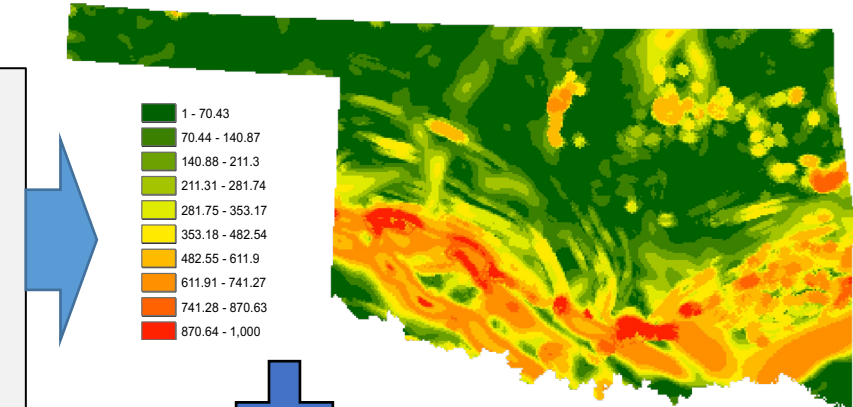
Zones of structural complexity

Predicted maximum
SC potential



- 1) Surface **AND** Subsurface
- 2) Subsurface
- 3) Subsurface **AND** Basement
- 4) Basement
- 5) Surface **AND** Subsurface **AND** Basement

- **AND** - Potential between cross cutting zones
- **OR** - Uncertainty in importance between datasets within layer



+ Map outputs for
each zone

Justman et al., 2020

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Evaluating Oklahoma results- Error classification

Did the model accurately predict structurally complex areas?

Yes!

Structurally
complex

Yes!

Not structurally
complex

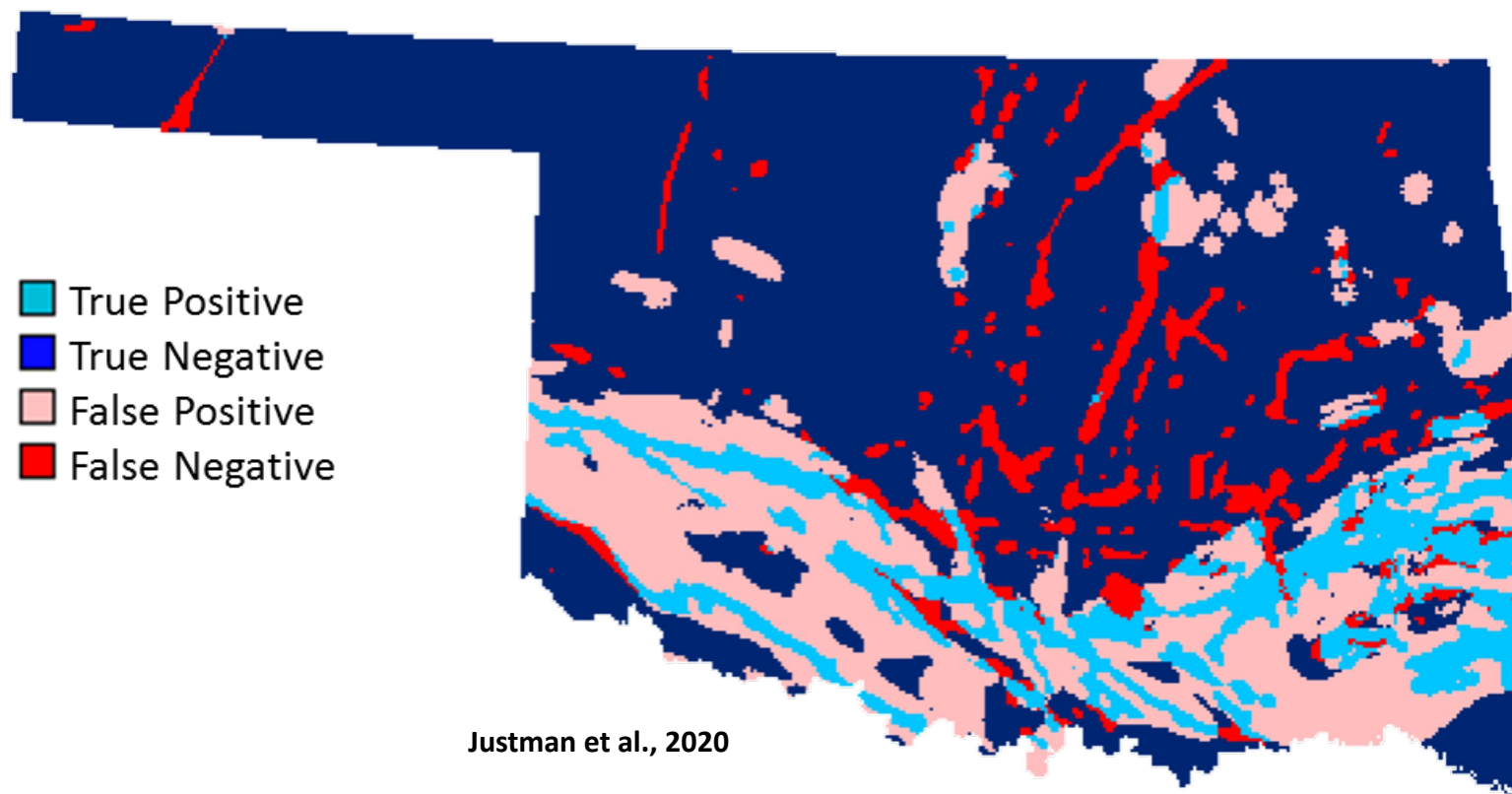
Potentially

Unknown or
unmapped
structure

No, but..

We know significant
structure exists here

Error classification map

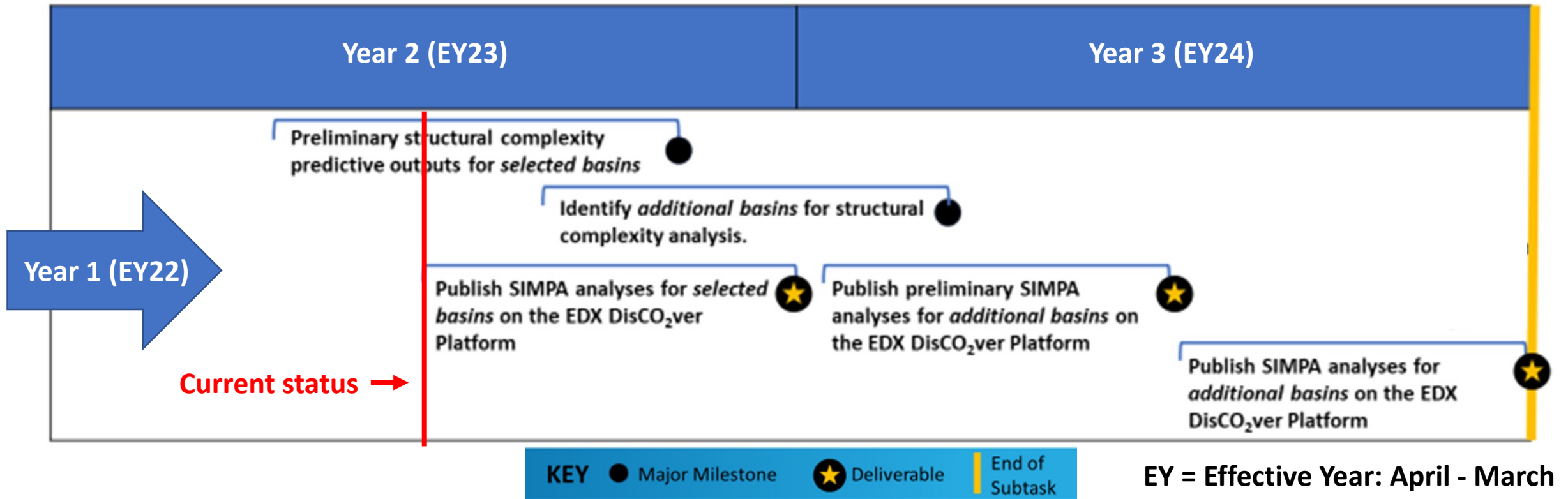


Justman et al., 2020

Project Timeline

Goal ⇒ Publish a database of structural complexity estimates for deep saline basins targeted by Carbon Capture and Storage (CCS) activities.

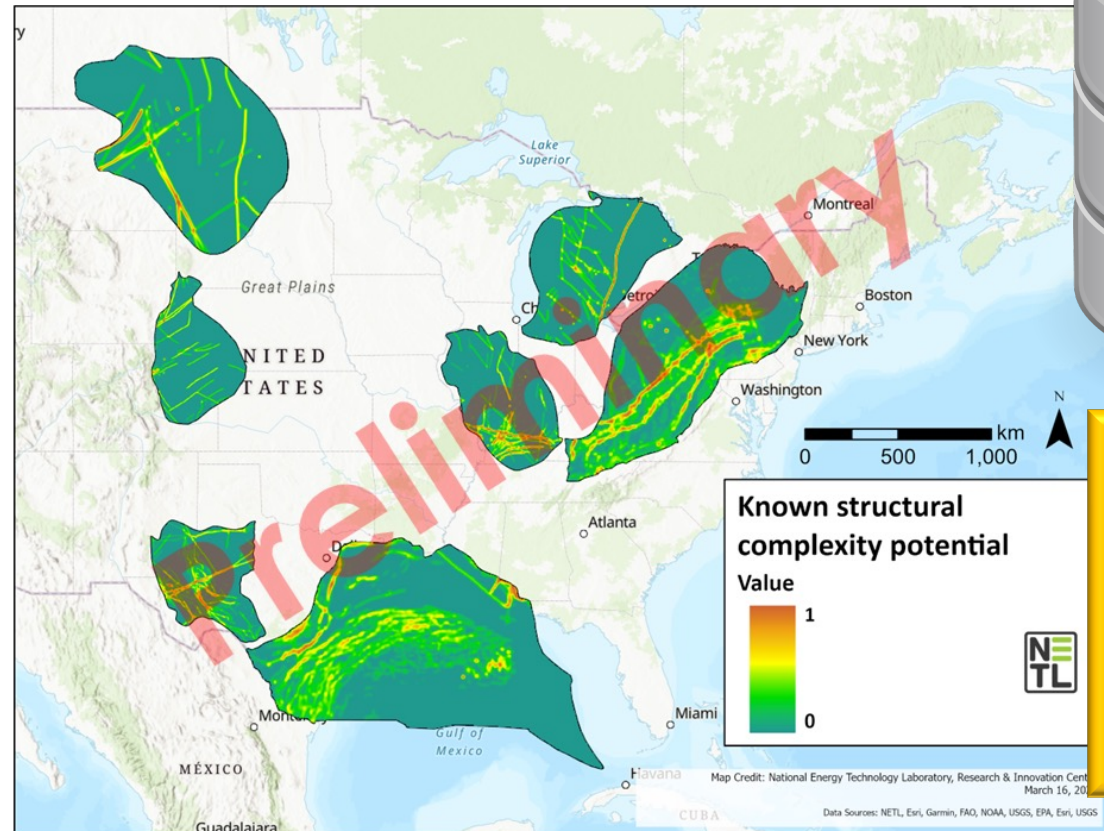
- No comprehensive database exists to assess potential subsurface CO₂ storage and migration pathway hazards.
- Provides critical information on potential CCS hazards not currently available to CCS program and stakeholders.



Developing a National Structural Complexity (SC) Database for U.S. Saline Basins

Year 1 accomplishments

- Selected **7 candidate saline basins** for SC analysis
 - Appalachian, Denver, GOM, Illinois, Michigan, Permian, and Williston
- Developed **151 datasets** representing **known structural complexity potential**
 - Public release (end of Year 2)
 - Developed processing tools to streamline and rapidly iterate outputs as needed
 - Resolution is scaled by basin size (~2-5km grid cells)

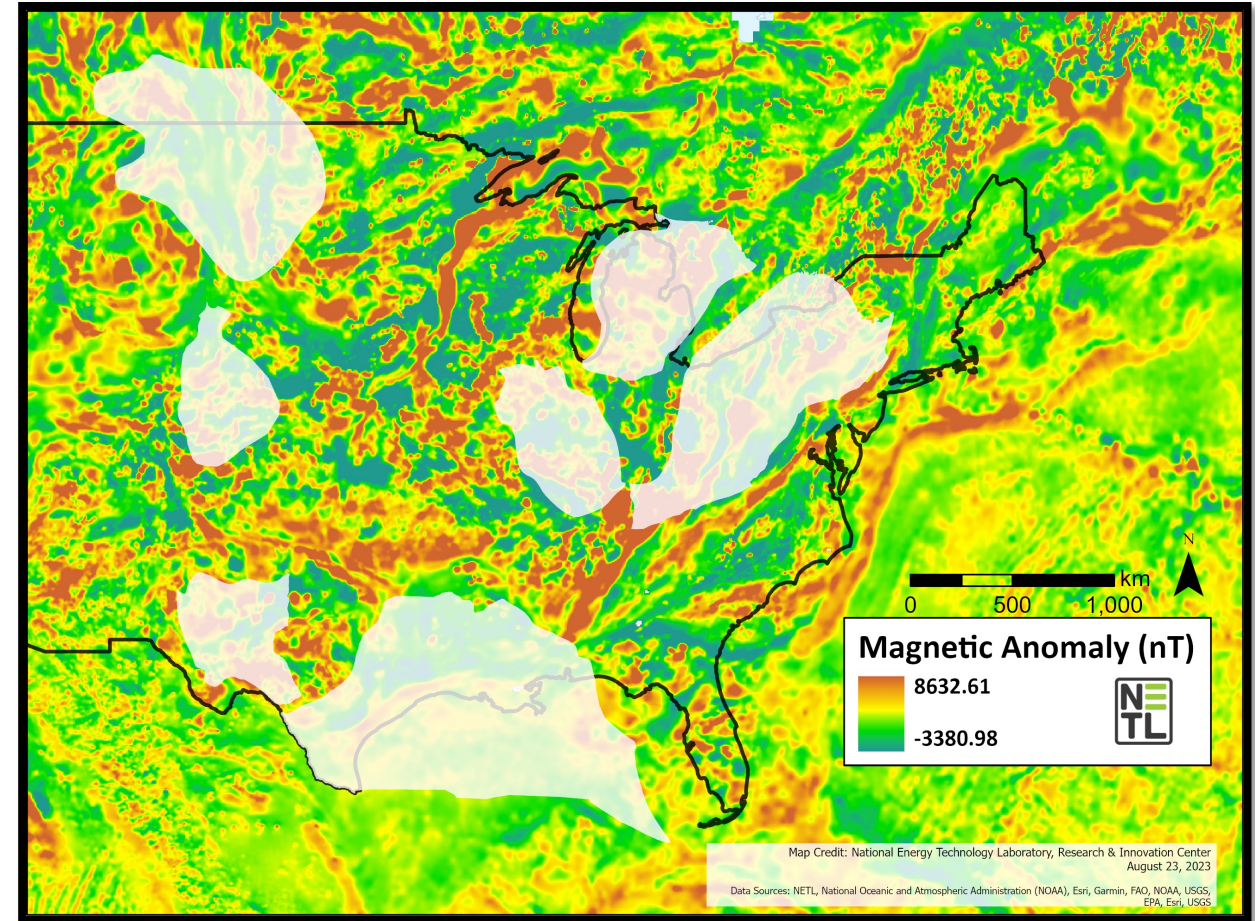
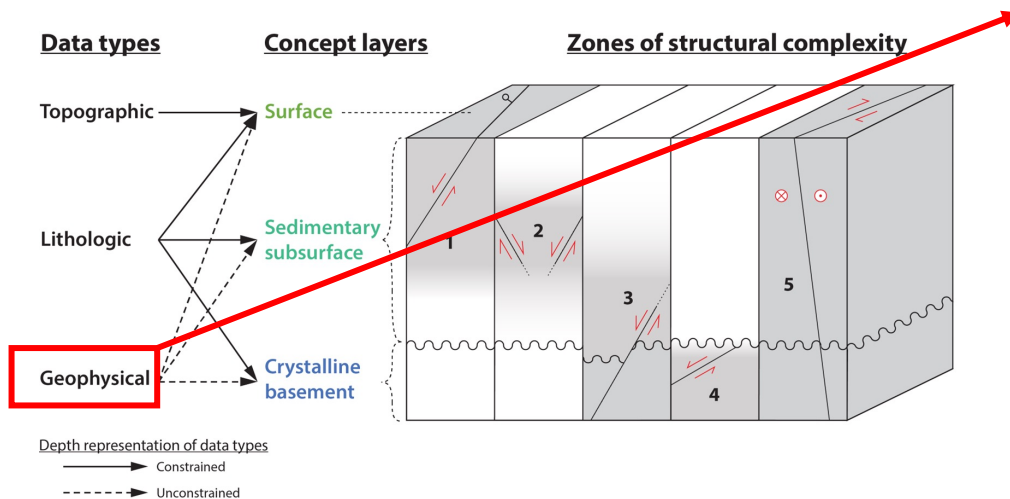


- 151 spatial (raster) datasets**
- 1.2 GB of data**
- Includes key metadata documentation**

Developing a National Structural Complexity Database for U.S. Saline Basins

Year 2 accomplishments & tasks

- **Completed** collection of proxy data for predicting SC for selected basins
 - Identified and cataloged ~90 topographic, lithologic, and geophysical data resources

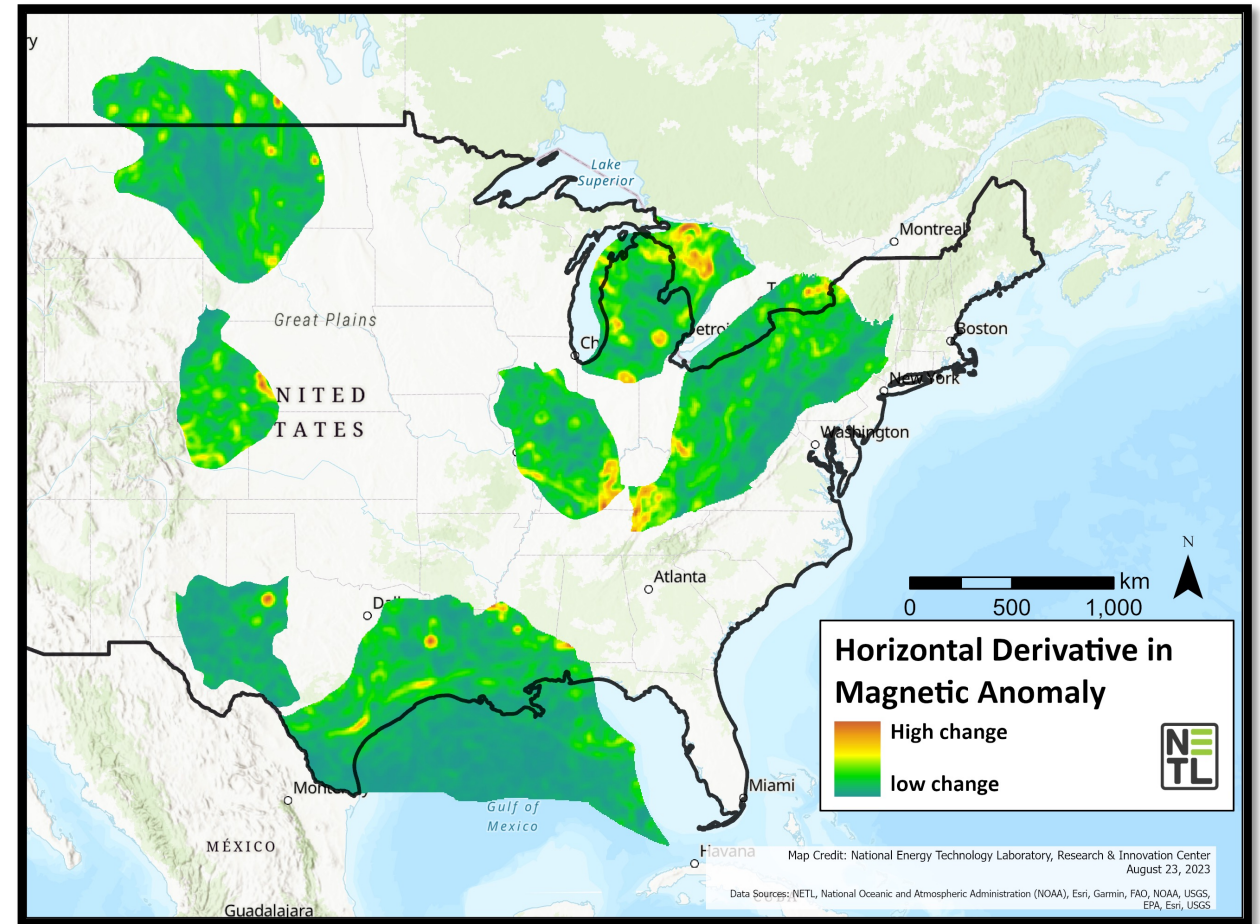
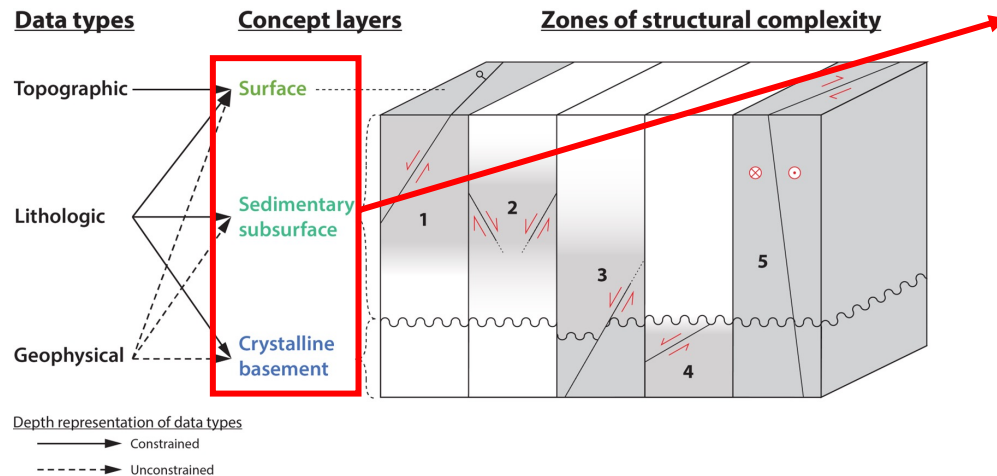


Example raw geophysical dataset- Magnetic anomalies (NOAA)

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Year 2 accomplishments & tasks

- **Currently** processing raw proxy data resources for input into database and predictive analyses
 - >60 processed proxy datasets
 - Developed tools to streamline processing



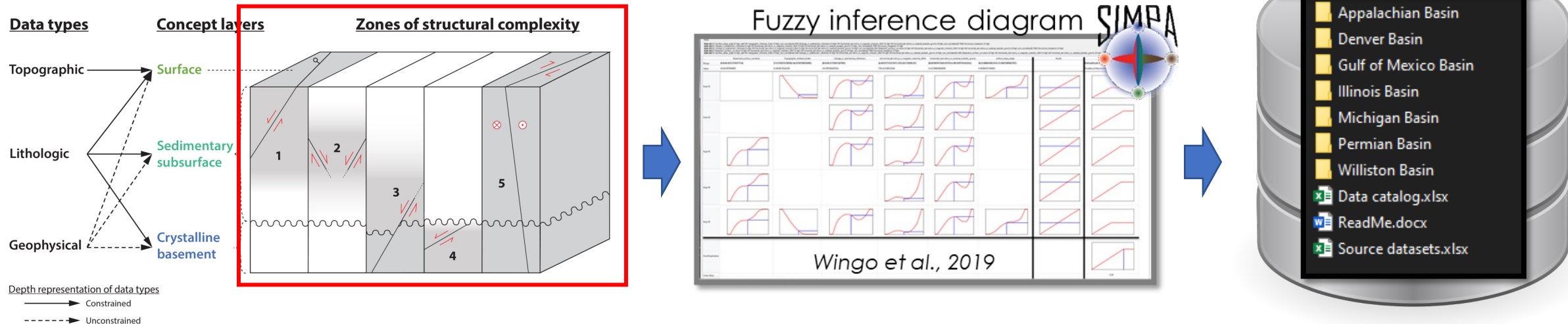
Example processed geophysical data for selected basins

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Year 2 accomplishments & tasks

- **Next steps**

- Leverage SIMPA tool and fuzzy logic method for zones of SC to obtain predicted SC outputs (**12/2023**)
- QAQC results, error maps
- Incorporate into database structure
- **Publicly release v1 of database (3/2024)**



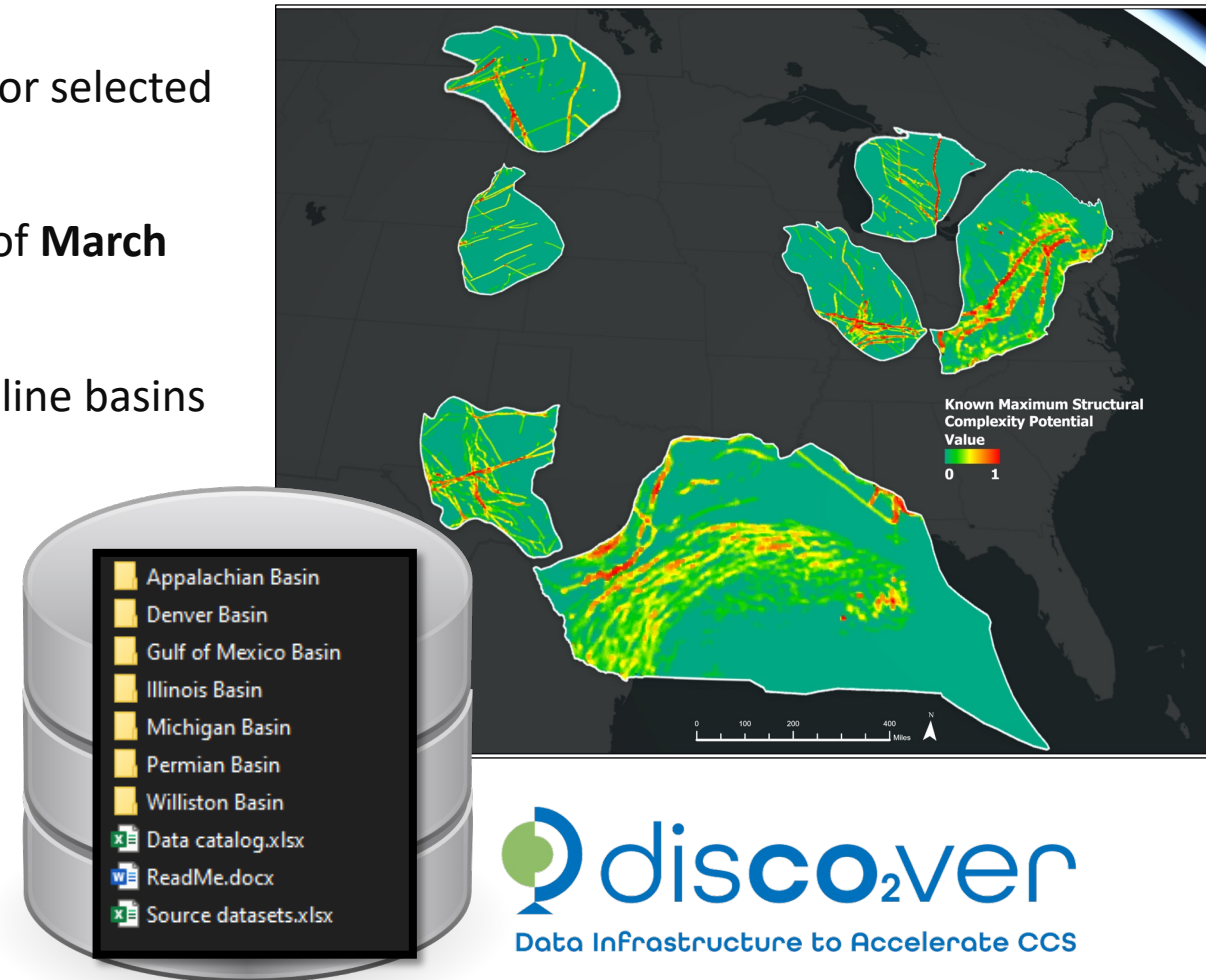
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Ultimate Outcomes

- A database of *basin-scale* structural complexity estimates for selected deep saline basins
- Published on **EDX DisCO₂ver Platform** for user access end of **March 2024**
- Year 3 (starting March 2025) - Expand database to other saline basins

Stakeholder Benefit

- Provide information about areas with limited or poor-quality structural complexity information
- Assists with the identification of data gaps that may require additional, future field work
- Results can be leveraged to inform carbon storage resource and feasibility assessment



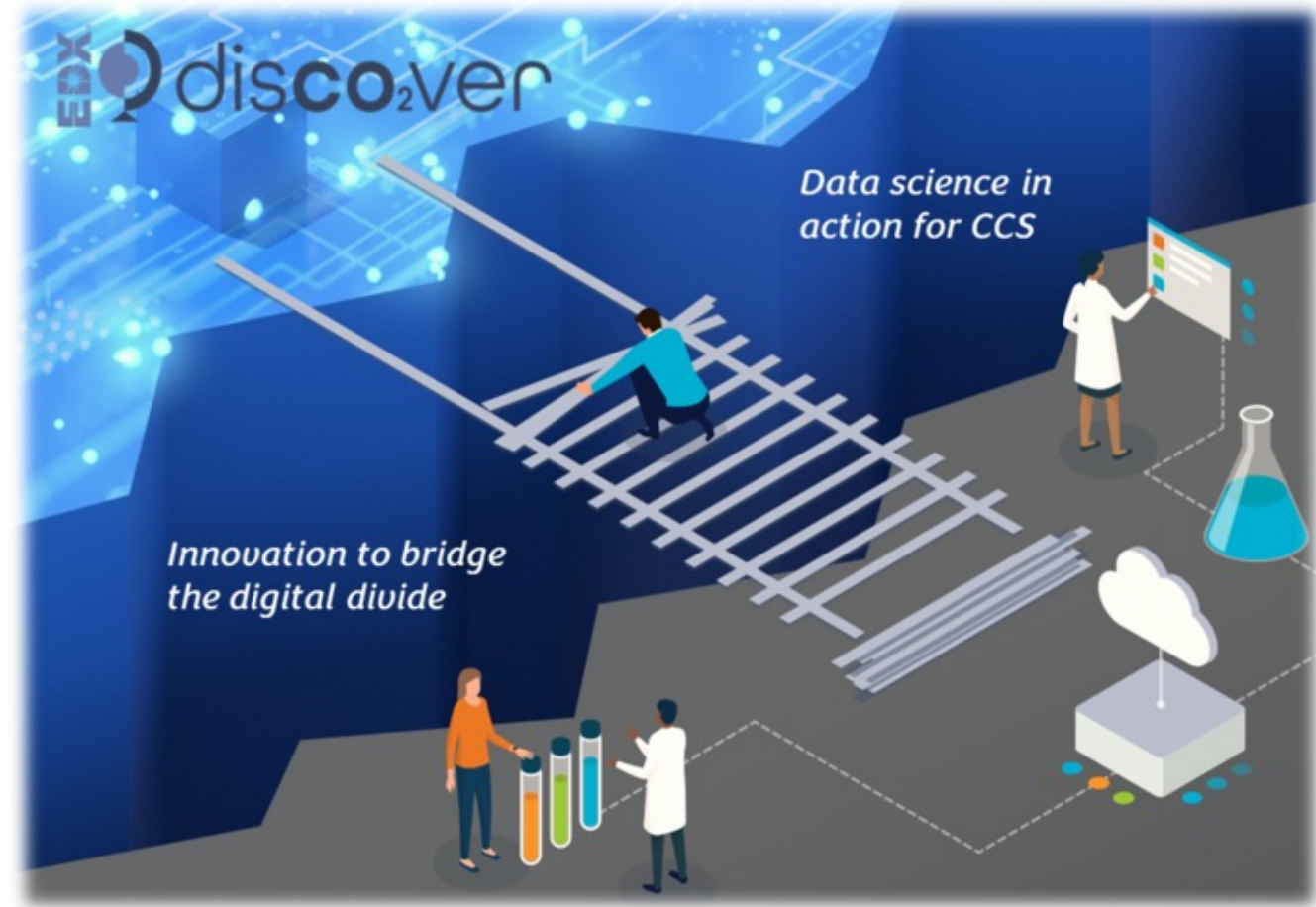
Tuesday Evening – Live Tool Demos!

When: 5:45 - 7:45 p.m.

Where: The Ballroom Foyer and
East/West Atriums

What:

- **Developing a National Structural Complexity Database** for US Saline Basins (Poster)-Dan Amrine
- **Environmental Justice and Social Justice** for CS Systems
- The **international offshore CS** and web-database and tool
- RokBase, Virtualizing **CS Rock Property Data** platform
- **Class VI Data Support Tool** for regulatory requirements
- **CO2 Pipeline Routing Smart Tool**
- Co2Locate - **Class II Well Reuse and Regional Evaluation Tool**
- **Carbon Storage Planning Framework Dashboard**
- **3D Data Viewer** and Preview Capability
- AllM Model, **Assessing Infrastructure Reuse Potential** for CS
- **EDX disCO2ver**, a one-stop tool for CO₂ digital resources



In demo "theater room" **EDX** support team will
offer in person demos & Q&A



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ENERGY

BIL*

SC method publication and data products

- Justman, D., Creason, C. G., Rose, K., & Bauer, J. (2020). A knowledge-data framework and geospatial fuzzy logic-based approach to model and predict structural complexity. *Journal of Structural Geology*, 141, 104153.
<https://doi.org/10.1016/j.jsg.2020.104153>
- Justman, D., Oklahoma structural complexity data, 2020-01-23,
<https://edx.netl.doe.gov/dataset/oklahoma-structural-complexity-data>, DOI:
10.18141/1503707

SIMPA tool

- Wingo, P., Justman, D., Creason, G., Jones, K., Bauer, J., and Rose, K., *SIMPA*, 2019-03-29, <https://edx.netl.doe.gov/dataset/simpa-tool>, DOI: 10.18141/1503876

Acknowledgments



This work was performed in support of the U.S. Department of Energy's Fossil Energy and Carbon Management's Geo-Analysis and Monitoring Team and was developed jointly through the U.S. DOE Office of Fossil Energy and Carbon Management's EDX4CCS Project (DE-FE 1025007), in part, from the Bipartisan Infrastructure Law.

This research was supported in part by an appointment to the U.S. Department of Energy (DOE) Postgraduate Research Program at the National Energy Technology Laboratory (NETL) administered by the Oak Ridge Institute for Science and Education (ORISE).

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Thank you!



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