Updating NATCARB and Carbon Storage Geospatial Resources via EDX Cloud
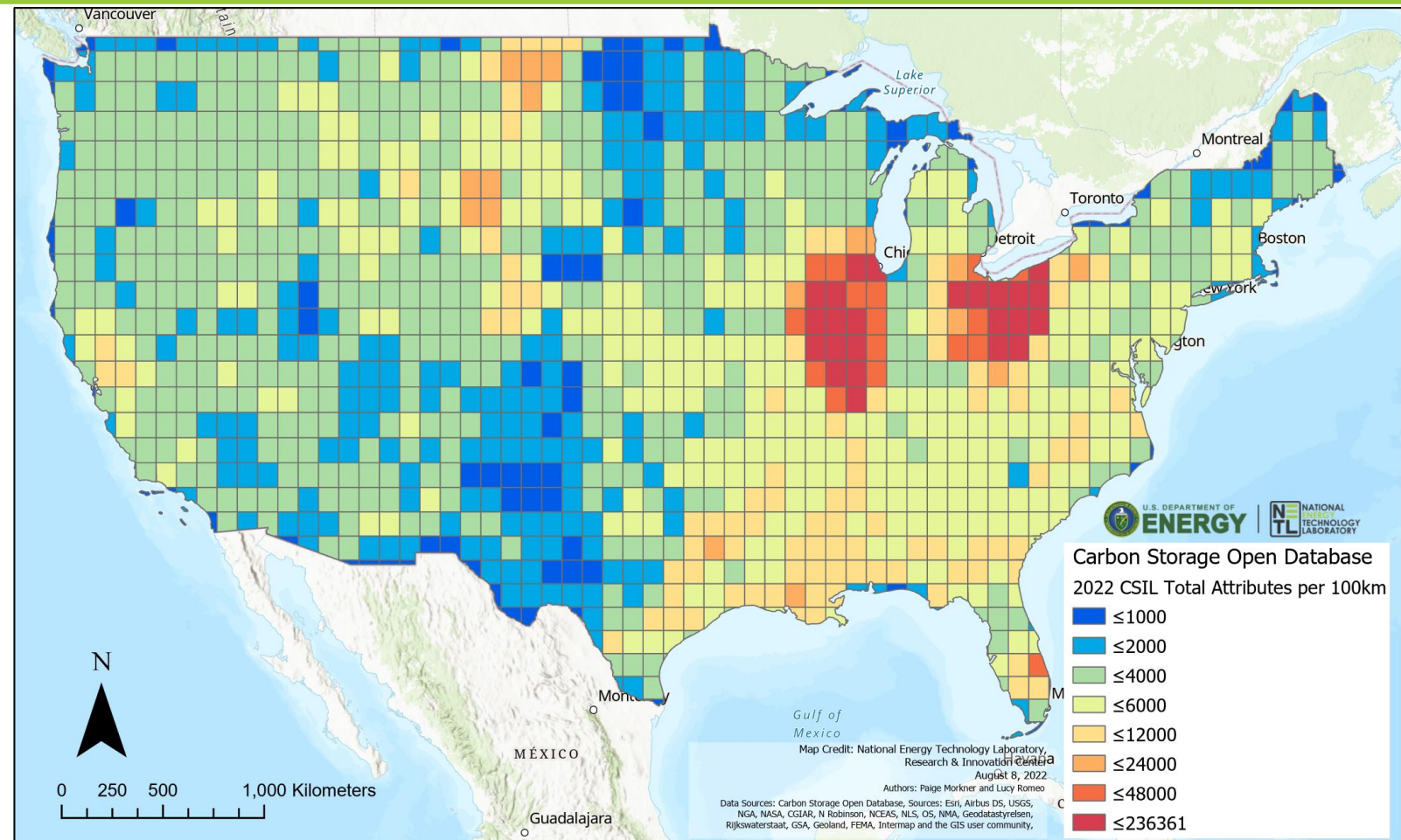
Paige Morkner
NETL Support Contract
Research Innovation Center

Carbon Storage Open Database
2022 CSIL Total Attributes per 100km

- ≤1000
- ≤2000
- ≤4000
- ≤6000
- ≤12000
- ≤24000
- ≤48000
- ≤236361

Map Credit: National Energy Technology Laboratory, Research & Innovation Center
August 8, 2022
Authors: Paige Morkner and Lucy Romeo
Data Sources: Carbon Storage Open Database, Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community,

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management Project Review Meeting
August 16th, 2022, Pittsburgh, PA

Disclaimer

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Authors and Contact Information

Paige Morkner[1,2], Jennifer Bauer[1], Scott Pantaleone[1,2], Jacob Shay[1,2], Chad Rowan[1,3], Vic Baker[1,3], Joseph Obradovich[1,3], and Kelly Rose[1]

[1] National Energy Technology Laboratory, 1450 Queen Avenue SW, Albany, OR 97321, USA

[2] NETL Support Contractor, 1450 Queen Avenue SW, Albany, OR 97321, USA

[3] NETL Support Contractor, 3610 Collins Ferry Road, Morgantown, WV 26507, USA

A history of DOE Program Product Curation
DOE Carbon Storage

EDX Energy Data eXchange ®

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

| 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |

- 2015 DOE Program managers **initiated requirement** to contribute & curate CS data products from CS program in EDX
- Included requirements in FOAs and data management plans for individual projects implemented across the US
- Funded NETL RIC EDX team to provide customized support to the CS-affiliated performers, as well as development of data science-informed optimizations in EDX for the CS Program
- EDX team also hosted in-person and web-based training and informational webinars for extramural partners
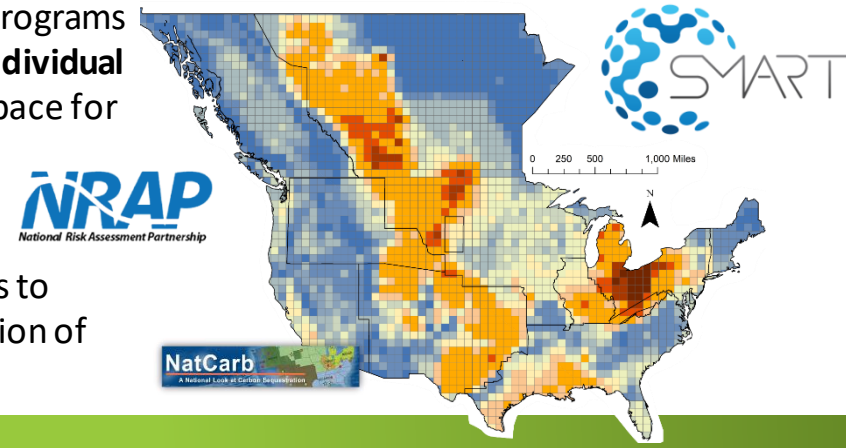
NETL SmartSearch automates data discovery using AI/ML by …
1) **Analyzing** content you like
2) **Finding** new, targeted content

http://www
Databases

- 2020 CS Program had a **foundation** of data resources from both DOE-funded projects and extramural AI-discovered assets
- NETL deployed **Open-carbon storage data collection** via EDX as a refined, integrated database (included Program & AI-discovered assets), with **hundreds of thousands of attributes, from thousands of data resources**
- In use accelerating **DOE's SMART-CS initiative, regulatory, and commercial (SBIR)** efforts too
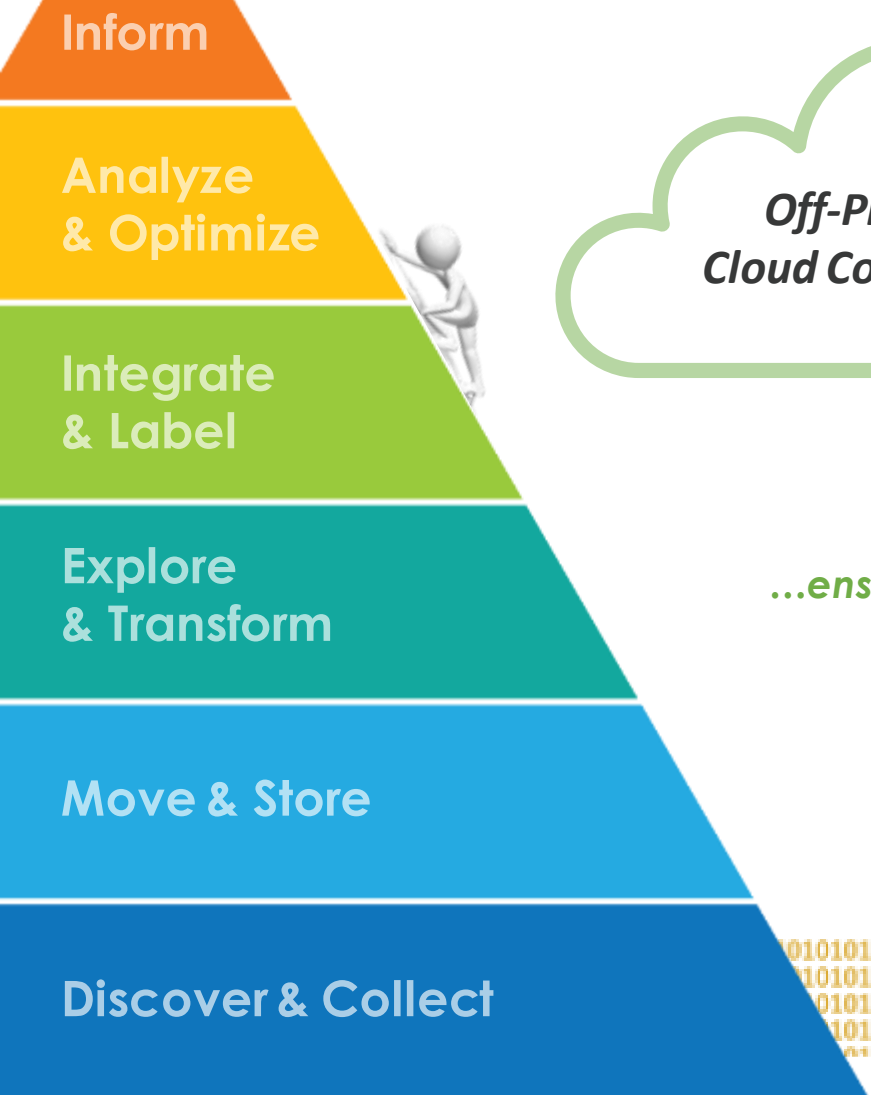
- Expanded to CarbonSafe and additional extramural programs
- EDX used by each CS Program extramural team (**51 individual Private Workspaces**) in their ongoing work, staging space for products. New awardees initiate their workspace at beginning of each project
- NETL geo-data science and EDX teams launched development of AI and data-science enhanced efforts to acquire, tag, organize, refine, and improve virtualization of CS-program products as they were accumulating

BSCSP
PCOR
WESTCARB
MRCSP
MGSC
SWP
SECARB

NRAP National Risk Assessment Partnership

SMART

NatCarb
A National Look at Carbon Sequestration

0 250 500 1,000 Miles

EDX ++

Connecting data <u>to</u> resources for analysis & computing
Driving next-gen AI R&D…scaling the pyramid

NETL — NATIONAL ENERGY TECHNOLOGY LABORATORY

Pyramid levels (top to bottom):
- Inform
- Analyze & Optimize
- Integrate & Label
- Explore & Transform
- Move & Store
- Discover & Collect

OSTI.GOV
OpenEI — Open Energy Information

Off-Prem Cloud Compute

Other systems & resources

NATIONAL ENERGY TECHNOLOGY LABORATORY — WSE
JOULE NETL SUPERCOMPUTER — WATT The Power of Ai
On-Prem Compute

ESnet

EDX++ FRAMEWORK

…ensuring compliance with Federal/DOE regulations

EDX® Energy Data eXchange

…ensuring preservation and access to DOE FECM knowledge and data resources

Big Data

Carbon Storage Data on the Energy Data eXchange (EDX)

Carbon Storage Data on EDX
- Over 2500 submissions on EDX
  - *1.569TB of Published EDX resources*
  - *3,185 open data resources*
- **100+ TB of seismic data and counting on NETL's WATT**
- *Groups specific to: RCSPs, CarbonSAFE, FutureGen, Illinois Basin Decatur Project, NRAP, and more*

Carbon Storage Open Database:
- **Group on EDX for targeted data resources from FECM research related to Carbon Storage**
- **Data collection scraped from public websites and ArcREST servers**
- **896 Shapefiles and rasters available on EDX's GeoCube**
- **1846 text-based documents on EDX**

NATCARB Database 2015
- Reservoir data for deep saline, unminable coal, and depleted oil and gas reservoirs
- Brine produced waters data
- Geochemical data
- Major sedimentary basins for USA

- Gap analysis of NATCARB database conducted in 2019 showed gaps in carbon storage property values reported by the RCSPs including salinity, permeability, basin name, temperature, pressure, thickness, porosity, and depth

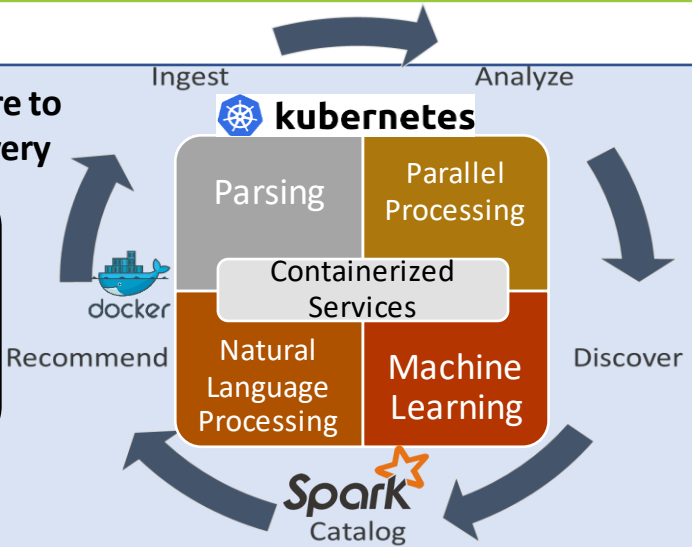- Goal in EY22 was to mitigate gaps leveraging AI/ML tools developed through CS Program

NATCARB Saline 10km 2015

Percent Completeness

Category	Value
Resource Name	100
Rsc Area per Cell	97
Volume	91
Depth	74
Thickness	74
Porosity	45
Pressure	35
Temperature	35
Basin Name	24
Permeability	9
Salinity	9
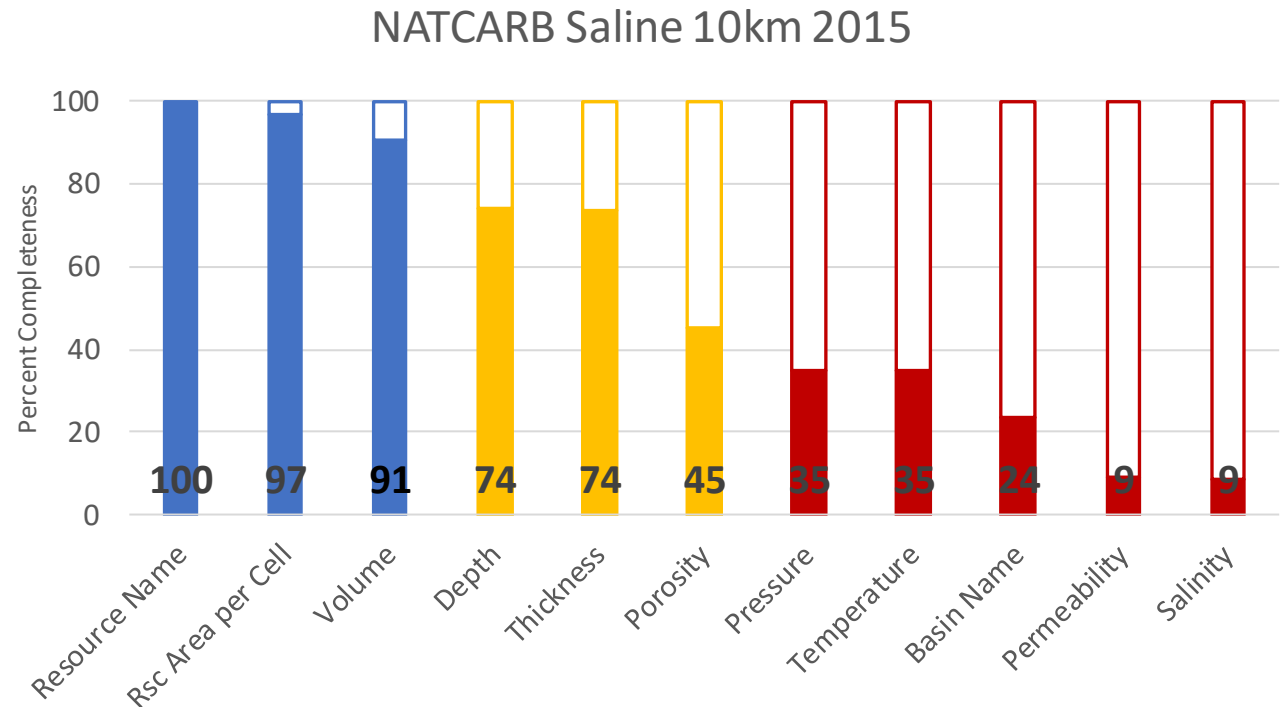
Discovering and Transforming Information with AI/ML Tools at NETL

AI informed approach

Challenge: data infrastructure to AI/ML enhanced data discovery

Employing AI/ML tools to find open resources

NETL SmartSearch

Ingest — Analyze

kubernetes

Parsing	Parallel Processing
Containerized Services	
Natural Language Processing	Machine Learning

docker

Recommend — Discover

Spark Catalog

SmartSearch leverages ML+NLP to:
1) **Analyzing** content you like
2) **Finding** new content via www, local, enterprise data stores
3) Telling you **how relevant** the new data is to what you like

Opportunity:

Infinitely scalable to return text, graphical, tabular, image, html, spatial, etc. result

Example applications to date

Global Open Oil & Gas Infrastructure Database

Rose, K. et al. Development of an Open Global Oil and Gas Infrastructure Inventory and Geodatabase; NETL-TRS-6-2018. DOI: 10.18141/1427573.

Carbon Storage data resources

Morkner, P., et al. 2022. Distilling Data to Drive Carbon Storage Insights. *Computers & Geosciences*.

PCA AMO Topics

Alloy property data

Wenzlick, M., et al. 2021. Data science techniques, assumptions, and challenges in alloy clustering and property prediction. *Journal of Materials Engineering and Performance*.
Wenzlick M., et al (2021) Incorporating Historical Data and Past Analyses for Improved Tensile Property Prediction of 9% Cr.

eXtremeMAT

Leveraging SmartSearch to update NATCARB

- Leveraging information from gap analysis, we used SmartSearch to look for data that would help fill gaps

- Used NATCARB database as seed data

- Seed parsed terms are then used to search the WWW for other relevant results

- Results are returned of webpages that likely contain relevant results
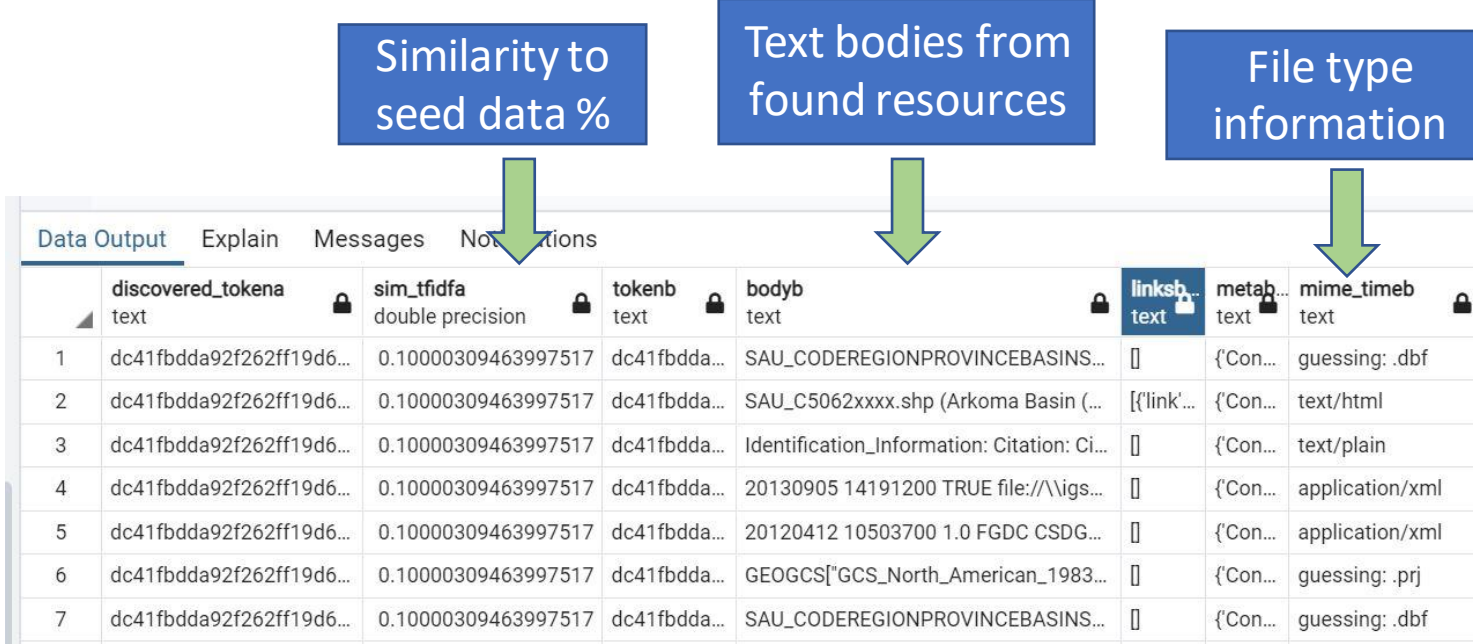
Output data from SmartSearch and processing into PostgreSQL

- 10,000+ results of text-based documents, shapefiles, and other data were collected using SmartSearch
- The data text bodies were inputted into a PostgreSQL database to make them easily quarriable and searchable via keywords
- Data was integrated from SmartSearch results, manual research for information, and from the USGS Saline Resource Assessment data

Similarity to seed data %

Text bodies from found resources

File type information

Results – what attributes were contributed to NATCARB?

New data was added to new columns within Saline 10km layer within NATCARB

Added additional data to:
- Basin Names
- Porosity, Permeability, Depth (top and bottom), Thickness

New columns of data added:
- Formation Name (more granular level than Resource in NATCARB v5)
- Lithology
- Depositional Environment
- Minor Lithology and Depositional Environment
- Citations for all new data

Example of lithologies identified for NATCARB Saline 10km reservoir units

NATCARB Saline 10K 2015

Resource Name	Rsc Area per Cell	Volume	Depth	Thickness	Porosity	Pressure	Temperature	Basin Name	Permeability	Salinity
100	97	91	74	74	45	35	35	24	9	9
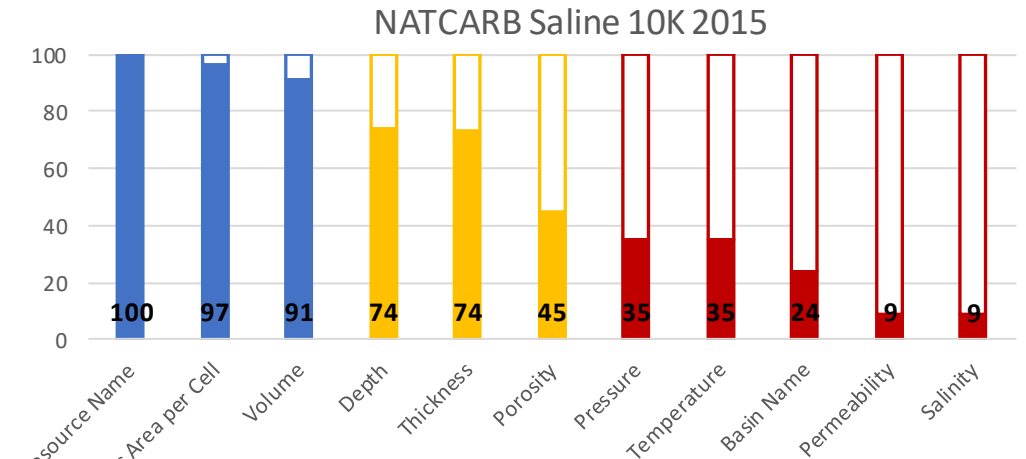
With additional data added →

NATCARB Saline 10K 2022

Resource Name	Rsc Area per Cell	Volume	Depth	Thickness	Porosity	Pressure	Temperature	Basin Name	Permeability	Salinity
100	97	91	79	79	49	35	35	90	10	9
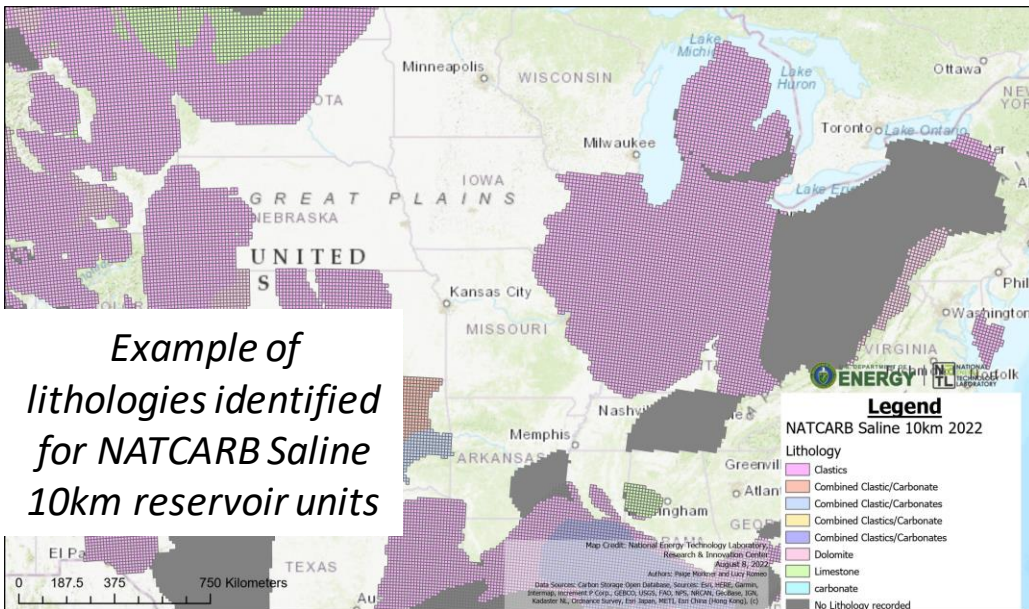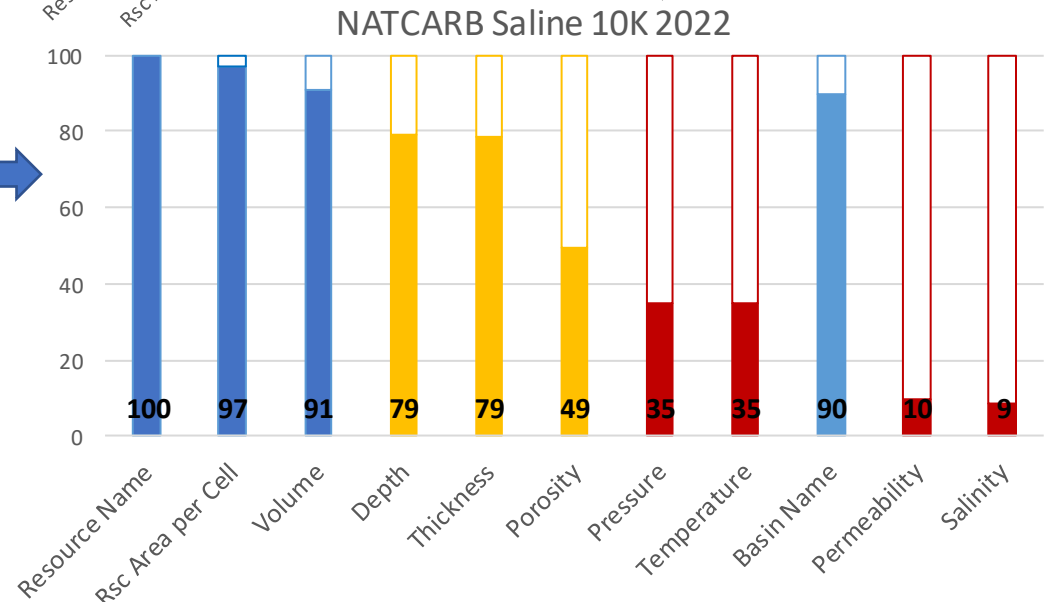
GeoCube and EDX Geospatial

- Data added to the NATCARB Viewer on GeoCube:
  - EPA 2020 Large CO_2 emitter point sources
  - Basalt Basins
  - Updated Saline 10km Grid Shapefile
    - Also can be downloaded directly with documentation from EDX:
    - https://edx.netl.doe.gov/dataset/natcarb-atlas-saline-basin-10km-grid
- Additional 586 Shapefiles added to the Carbon Storage Open Database – see talk tomorrow for more details
- New GeoCube release leveraging EDX++
  - See demo during Tools demo Tuesday evening!

What's next: EDX4CCS

NETL Research Carbon Storage Program

NETL SmartSearch

NETL SmartParse

NatCarb
A National Look at Carbon Sequestration

CarbonSAFE Projects

Pre-Feasibility
Feasibility
Site Characterization and CO₂ Capture Assessment

Carbon Storage Open Database

GEO CUBE

EDX®
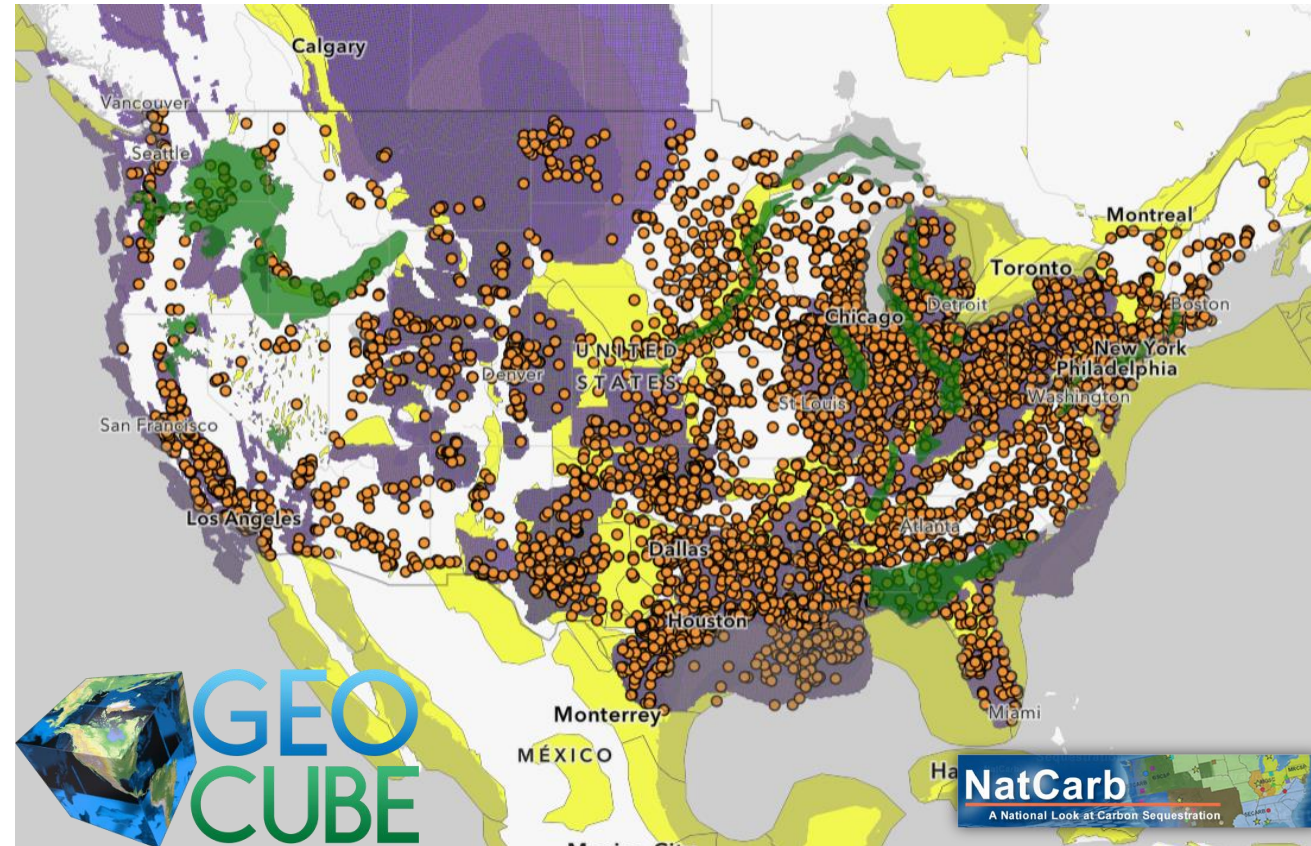
EDX4CCS

Data, Integration, generation, and deployment to feed SMART, NRAP, and regulatory models

Tools, Develop and/or integrate deployment of tools for data interaction and visualization, decision-support such as for pipelines, regulatory permitting, resource characterization, data visualization, and more

Core CCS EDX DisCO2ver platform, Broader community virtualized data computing platform and central EDX CCS data and tool hub

SMART

NRAP
National Risk Assessment Partnership

EDX.4CCS
Energy Data eXchange

U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

Resources

NETL — NATIONAL ENERGY TECHNOLOGY LABORATORY
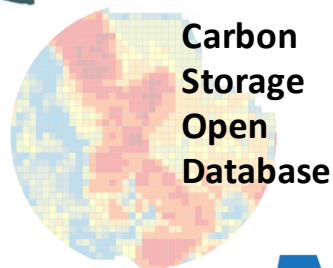
Contact:

Paige Morkner, Paige.Morkner@netl.doe.gov

Data resources and important URLs:

https://edx.netl.doe.gov/dataset/natcarb-atlas-saline-basin-10km-grid

https://edx.netl.doe.gov/dataset/natcarb

https://edx.netl.doe.gov/dataset/carbon-storage-open-database

https://edx.netl.doe.gov/dataset/geocube

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

> **Talks and Demos this week:**
> - **Carbon Storage Open Database and GeoCube** - Demo, Tuesday 8/16, 5:45-7:45pm
> - **SmartSearch, scalable data search and aggregation in the Cloud for CCS and beyond** – Talk, Vic Baker, presented by Paige Morkner, 10:35am, Wednesday 8/17
> - **An Updated Carbon Storage Open Database - Geospatial Data Aggregation to Support Scaling up CCS** – Talk, Paige Morkner, 5:05pm, Wednesday 8/17

Citations:
Baker, D.V., Rose, K., Bauer, J., and Rager, D., 2016, Computational Advances and Data Analytics to Reduce Subsurface Uncertainty https://www.onepetro.org/conference-paper/ARMA-2016-493, ARMA 16-493, June 26-29, 2016, 16 pgs.
Morkner, P., Bauer, J., Creason, C., Sabbatino, M., Wingo, P., Greenburg, R., Walker, S., Yeates, D., Rose, K. 2022. Distilling Data to Drive Carbon Storage Insights. Computers & Geosciences. https://doi.org/10.1016/j.cageo.2021.104945
Rose, K.; Bauer, J.; Baker, V.; Bean, A.; DiGiulio, J.; Jones, K.; Justman, D.; Miller, R. M.; Romeo, L.; Sabbatino, M.; Tong, A.   Development of an Open Global Oil and Gas Infrastructure Inventory and Geodatabase; NETL-TRS-6-2018; NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2018; p 594; DOI: 10.18141/1427573.
Wenzlick, M.,et al. 2021. Data science techniques, assumptions, and challenges in alloy clustering and property prediction. *Journal of Materials Engineering and Performance.*
Wenzlick M., et al (2021) Incorporating Historical Data and Past Analyses for Improved Tensile Property Prediction of 9% Cr.

Organization Chart

Project Partners
DOE
NETL
RCSPs – Big Sky Carbon Sequestration Partnership, Southwest Partnership, Southeast Regional Carbon Sequestration Partnership, Midwest Regional Carbon Sequestration Partnership, Midwest Geological Sequestration Consortium, Plains CO_2 Reduction Partnership
CarbonSAFE projects
SMART
National Risk Assessment Partnership

Lead Organization
NETL

Principal Investigators
Kelly Rose, Jennifer Bauer

Task 28
Curation of Carbon Storage R&D Products Through Advanced Data Computing Solutions

Lead: Jennifer Bauer
Team: Kelly Rose, Chad Rowan, Michael Sabbatino, Paige Morkner, Lucy Romeo, TJ Jones, Aaron Barkhurst, Vic Baker, and other Matric Software Engineers and Developers
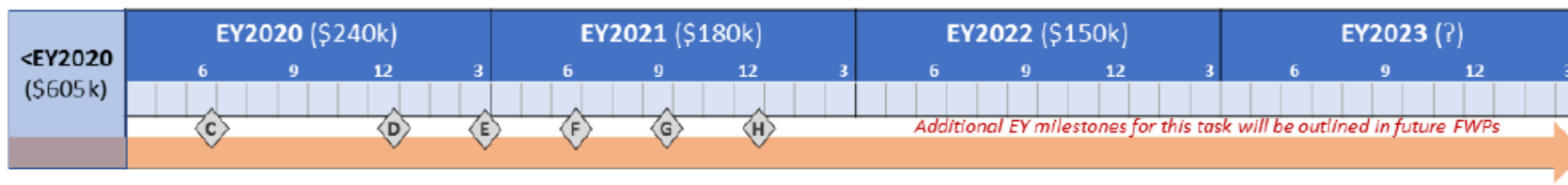
Task 27.0
Next Generation Development, Deployment, and Modernization of Database, Tools, Online Viewer, and Atlas

Lead: Jennifer Bauer
Team: Kelly Rose, Paige Morkner, Michael Sabbatino, Patrick Wingo, Andrew Bean, Aaron Barkhurst, and other Matric Software Engineers and Developers

Gantt Chart

Task 27.0: Project Timeline Overview

Natcarb - Next Generation Development, Deployment, and Modernization of Database, Tools, Online Viewer, and Atlas (PIs: Paige Morkner, Jennifer Bauer)

<EY2020 ($605k)	EY2020 ($240k)				EY2021 ($180k)				EY2022 ($150k)				EY2023 (?)			
	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3

Milestones: C, D, E, F, G, H

Additional EY milestones for this task will be outlined in future FWPs

Milestones

Number	Expected Completion Date	Milestone Description
EY20.27.C	06/30/2020	Identify tools and models that will be targeted for integration and inclusion within the Natcarb Viewer.
EY20.27.D	12/31/2020	Outline report/manuscript on updated technical capabilities of Natcarb Viewer.
EY20.27.E	03/31/2021	Release update of Natcarb Viewer and Natcarb Database to EDX.
EY21.27.F	06/30/2021	Catalog additional datasets, models, and text-based resources on EDX for future integration into the Natcarb Viewer and GeoCube.
EY21.27.G	09/30/2021	Catalog datasets returned from SmartSearch results targeting known data gaps in existing Natcarb and Open Carbon Storage Databases.
EY21.27.H	12/31/2021	Document capabilities to be incorporated in advanced spatial search capability for discovering spatial data from EDX and GeoCube.

Chart Key

- ◇ Milestone
- ▮ Project Completion
- ▮ Go/No-Go Timeframe

Impact

Key Accomplishments/Deliverables	Value Delivered
• 2018, Enhanced interface and updates to Natcarb Viewer and release through EDX (Barkhurst et al., 2018; Bauer et al., 2018) • 2019, Integration of advanced data use tools in Natcarb Viewer & GeoCube to improve data access and use • 2020, Integration of open-source data to develop Open Carbon Storage Database (Morkner et al., 2020) • 2021, Manuscript detailing innovative data integration strategies used to aggregate Natcarb, RCSP, and open CS data sources (Morkner et al., in review) • 2022, Support updates to Natcarb database and CS estimates	• Produce a robust subsurface data framework that provides **improved data access, data discoverability, and ease of use within the CS community.** • Integrate **online, advanced analytics and models to help facilitate research** across the CS community. • Support development of content and materials for Carbon Storage Atlas updates.

U.S. DEPARTMENT OF ENERGY

Task 27.0 is updating content into an existing tool with no development of a technology. Therefore, no TRL is assigned.