Assessing Offshore CO_2 Saline Storage Potential with the NETL Calculator

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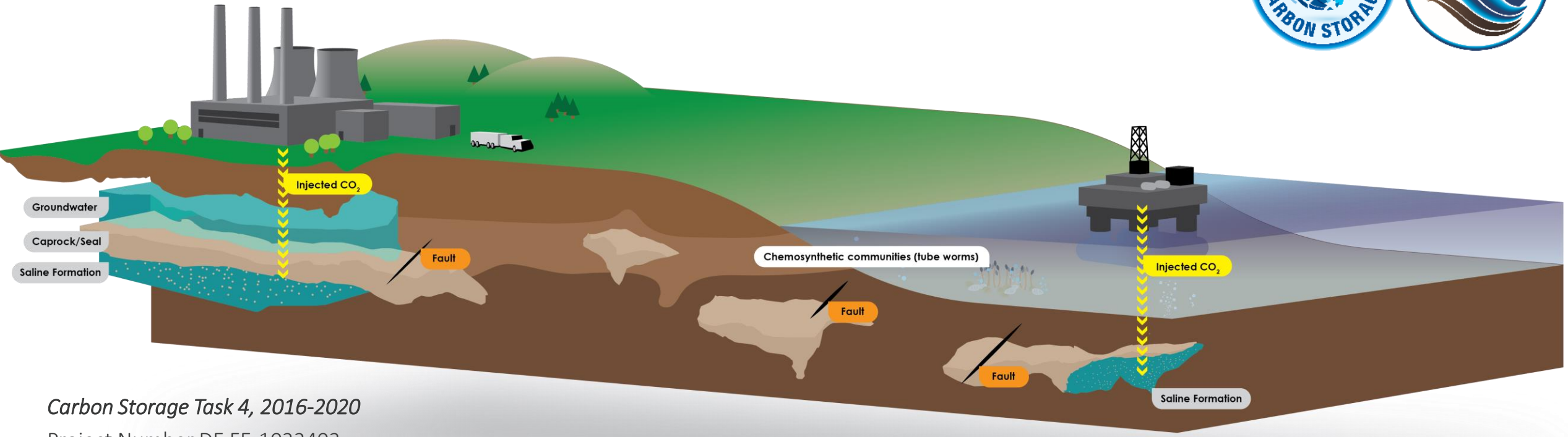


Carbon Storage Task 4, 2016-2020

Project Number DE FE-1022403
Carbon Capture Front End Engineering Design Studies and CarbonSafe
2020 Integrated Review Webinar
September 2020

Overview

I. Calculating **storage resource potential**

II. Tailoring methods to the **offshore**

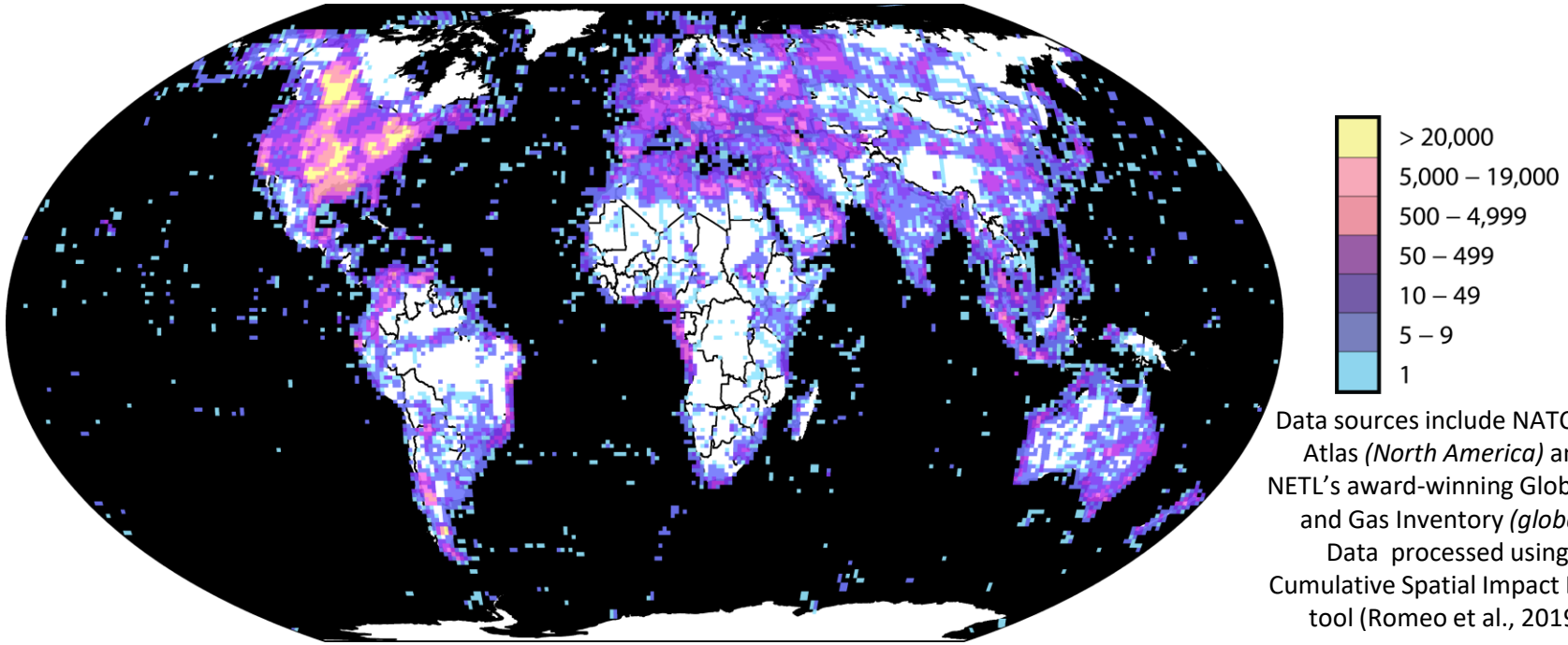
III. Development of the **Offshore CO_2 Storage Calculator** *for data-driven, spatial, long-term efficiency and storage estimations*

IV. Tool application in Gulf of Mexico

Values Delivered

- **Improve accuracy** of offshore saline resource estimations
- Tailor geologic efficiency terms from DOE CS method to **improve characterization of offshore CS reservoirs**
- **Deliver a data-driven technical assessment** of offshore CS resources through integration of **spatial, analytical tools** (first developed in FE32 projects)
- Improve stakeholder access and utility by releasing data and tools through **Energy Data eXchange (EDX)**

Density of Potential Sources of CO_2



Data sources include NATCARB Atlas *(North America)* and NETL's award-winning Global Oil and Gas Inventory *(global)* Data processed using Cumulative Spatial Impact Layer tool (Romeo et al., 2019)

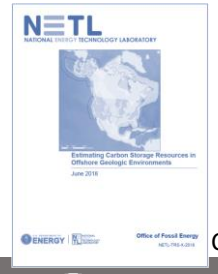
DOE CO_2 Storage Methodology

Goodman et al., 2016

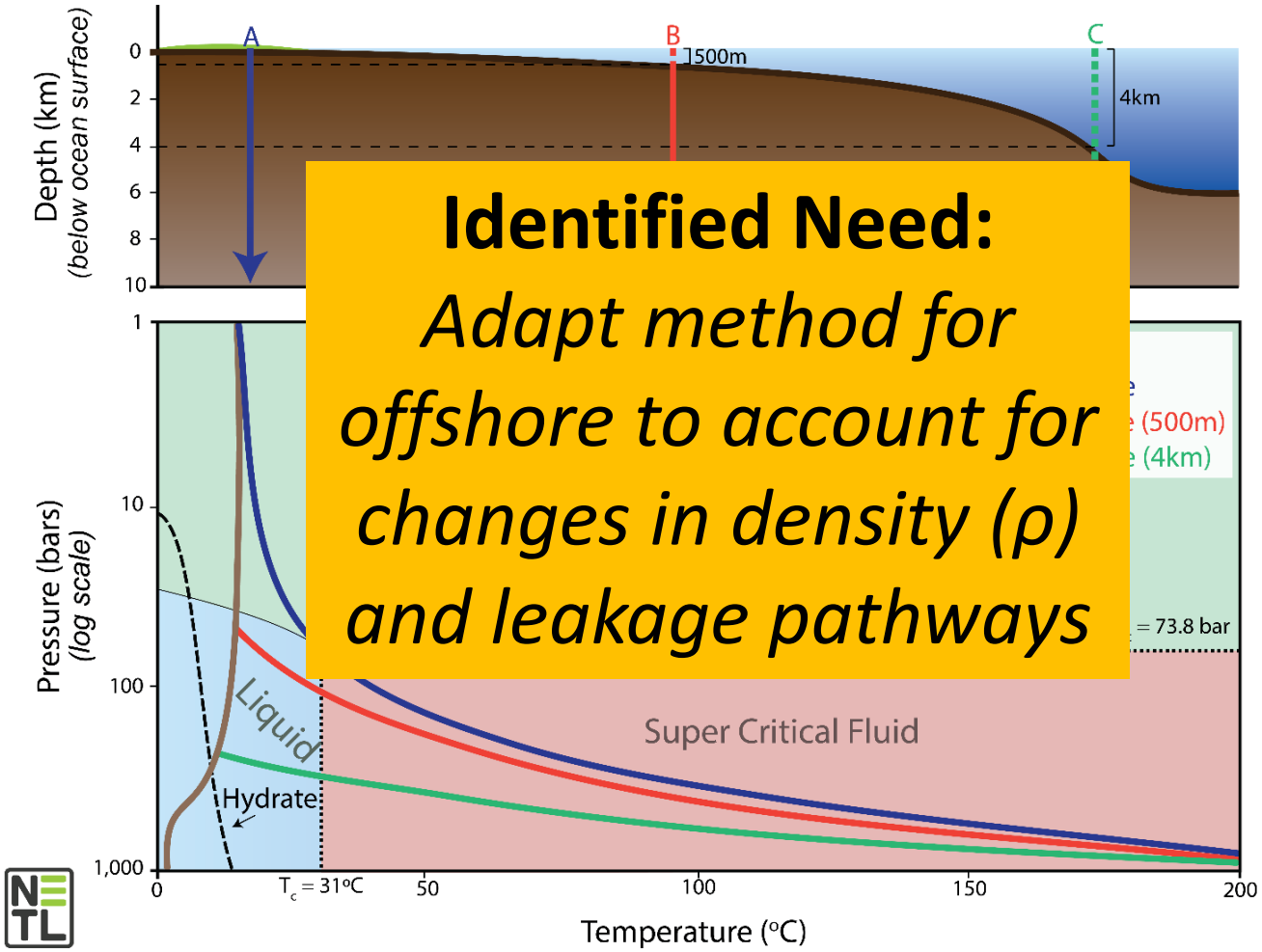
$$G_{CO_2} = A_t h_g \phi_t \rho E_{saline}$$

Research Problem:
Volumetric-based method is identical for both onshore & offshore systems

- **Long-term** volumetric estimation in **saline formations**
- Gigatons of CO_2 based on:
  - Area
  - Height
  - Porosity
  - Density
  - Efficiency
- **Key differences** in the offshore:
  - CO_2 behaves differently
    - Pressure, temperature, **density**
  - Sediments also behave differently
    - More **porous & permeable**
    - **Unlithified**



Cameron et al., 2018



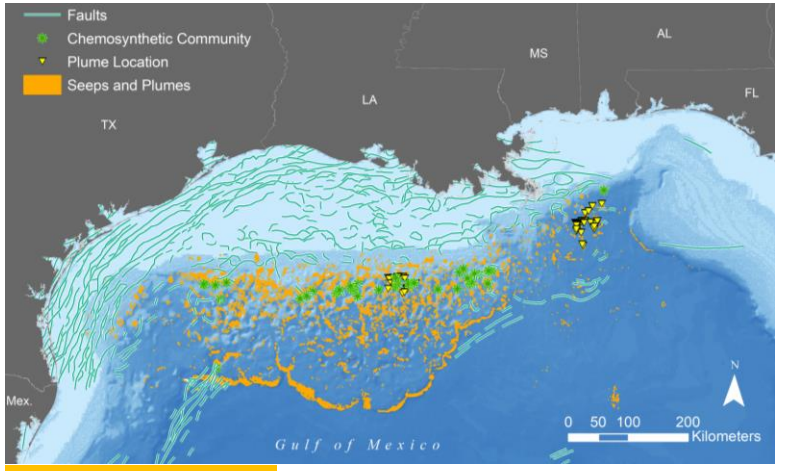
Identified Need:
Adapt method for offshore to account for changes in density (ρ) and leakage pathways

Meeting the need:

Offshore CO_2 Storage Calculator

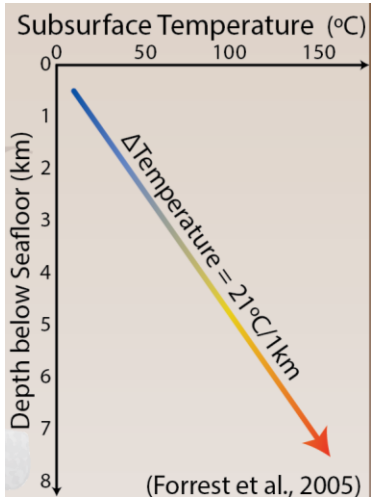
- **Accounts for changes in CO_2 density given the overlying water column** (Lemmon et al.)
- Enables the integration of **setback distances** from **potential leakage pathways** when spatially calculating area

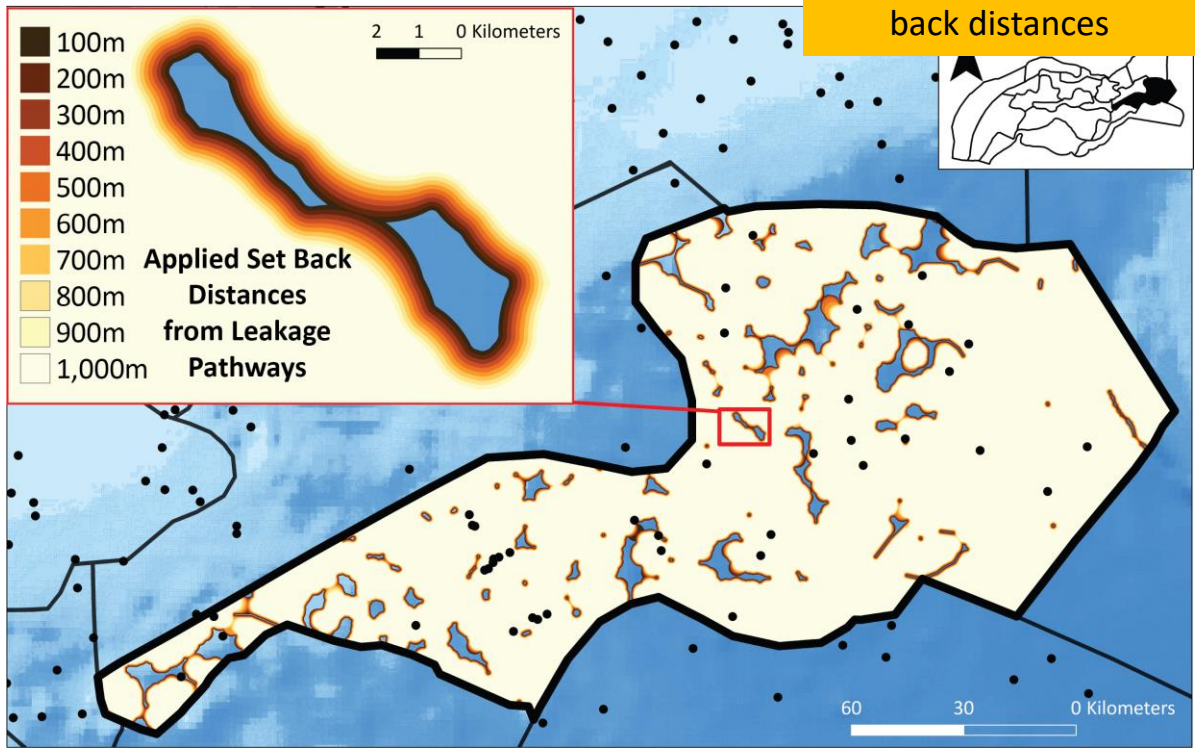
Romeo, et al., 2020



^ Leakage pathways

ˇ Application of spatial data to account for set back distances

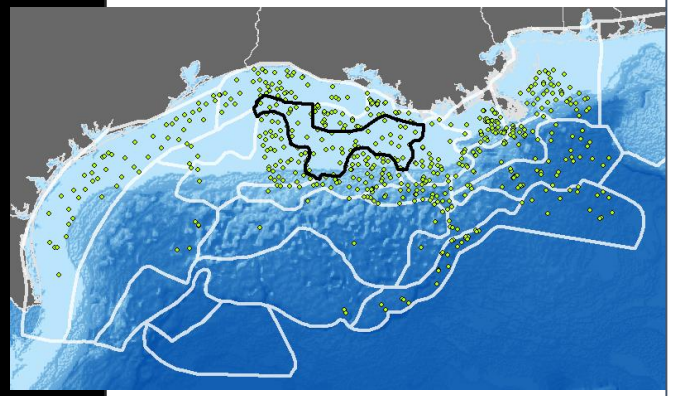




Figures on this page will be featured in upcoming publication, *Data-Driven Spatially Informed Offshore Carbon Storage Efficiency and Storage Resource Methodology* (Romeo et al., in prep.)

- **Open-source** and **standalone** tool, logic of which was built in Python (3.7)
- Enables **multi-scale assessments**
- Leverages **power of spatial data**
- **Flexible tool enables customization**, with 10-20 parameters depending on data available
- Applicable to multiple **lithologies** and **depositional environments** in saline formations (Gorecki et al., 2009)

EXAMPLE
Shelf Minibasin

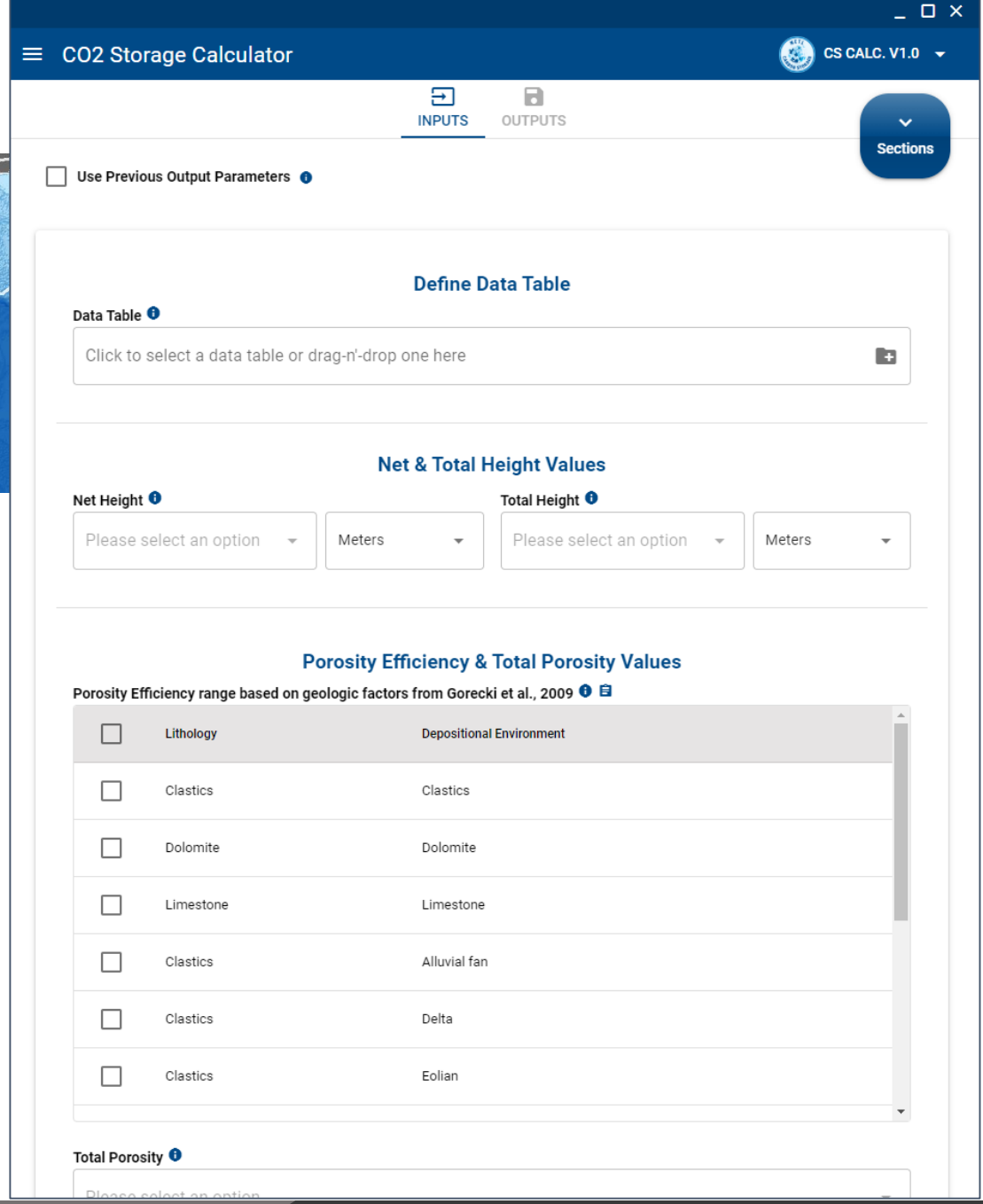


Slope basin and delta
***n = 50** well logs*

Average Efficiency Values (net/total)
Height efficiency: 0.11
Area efficiency: 0.92
Porosity efficiency: 0.69
Volumetric disp.: 0.36
Microscopic disp.: 0.59

CO_2 Density
Avg. density: 694.1 kg/m³
Avg. water depth: 35.3 m
Seafloor temp.: 23.4 °C
Avg. reservoir mid-depth: 2,232 m

disp. = displacement




Navigation
Calculator
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Results
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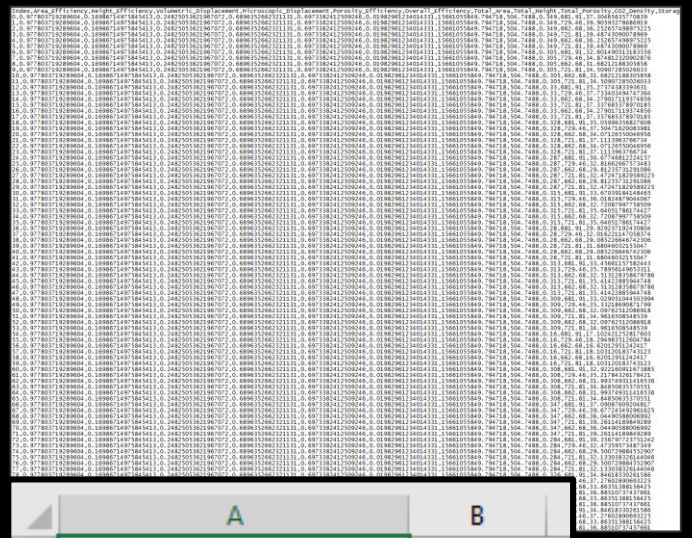
CO_2 Storage Calculator
CS CALC. V1.0
NETL
CARBON STORAGE
Offshore CO_2
Storage Calculator
START CALCULATING!!!
Type here to search
3:07 PM
6/15/2020

Results

A. Data table
B. Summary table
C. Variable distributions*
D. Phase distributions*
E. Spatial data*

* Optional outputs

A.

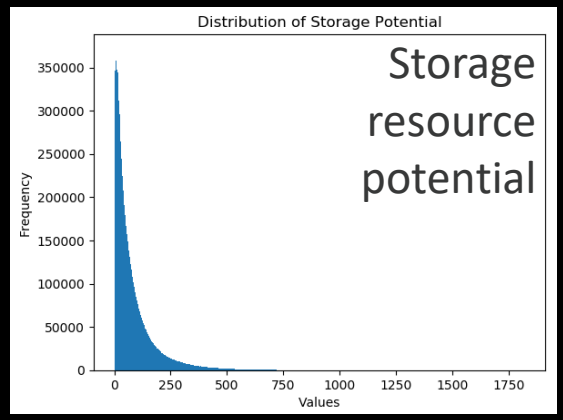


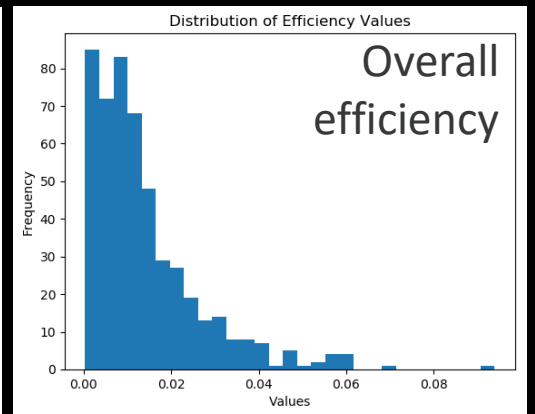
B.

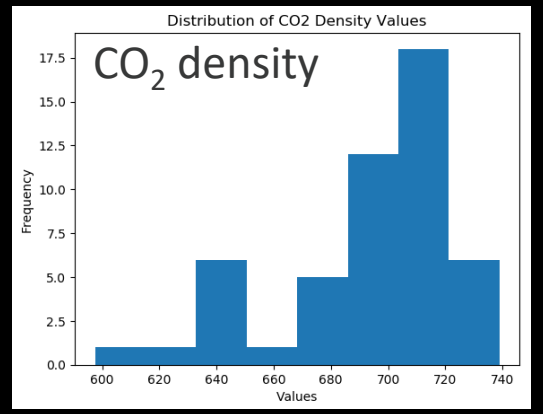
	A	B
1	Efficiency Values	N=500
2	Percentile	P-Value
3	10%	0.002217
4	50%	0.010381
5	90%	0.030359
6	Storage Potential Values	N=62500000
7	Percentile	P-Value
8	10%	8.798893
9	50%	48.93849
10	90%	197.8562

Results spanning all domains in the Northern GoM will be featured in upcoming publication (Romeo et al., in prep.)

C.







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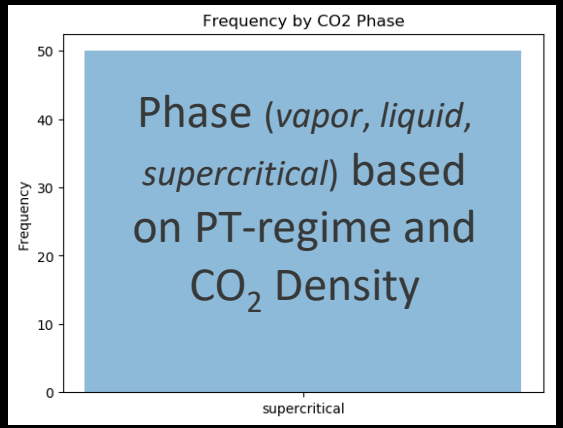

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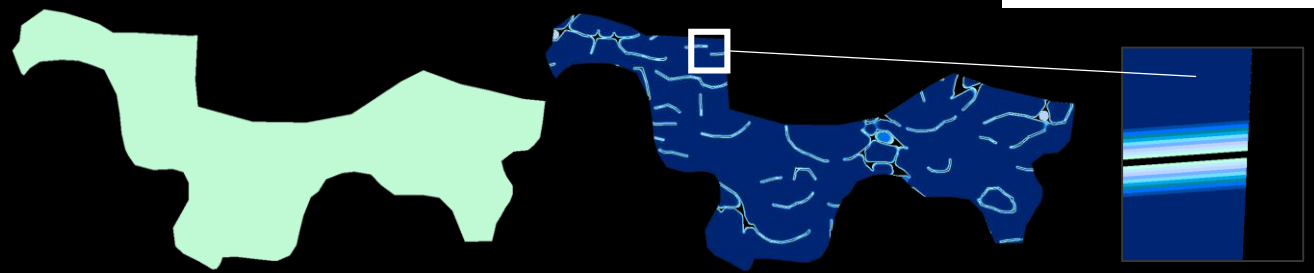
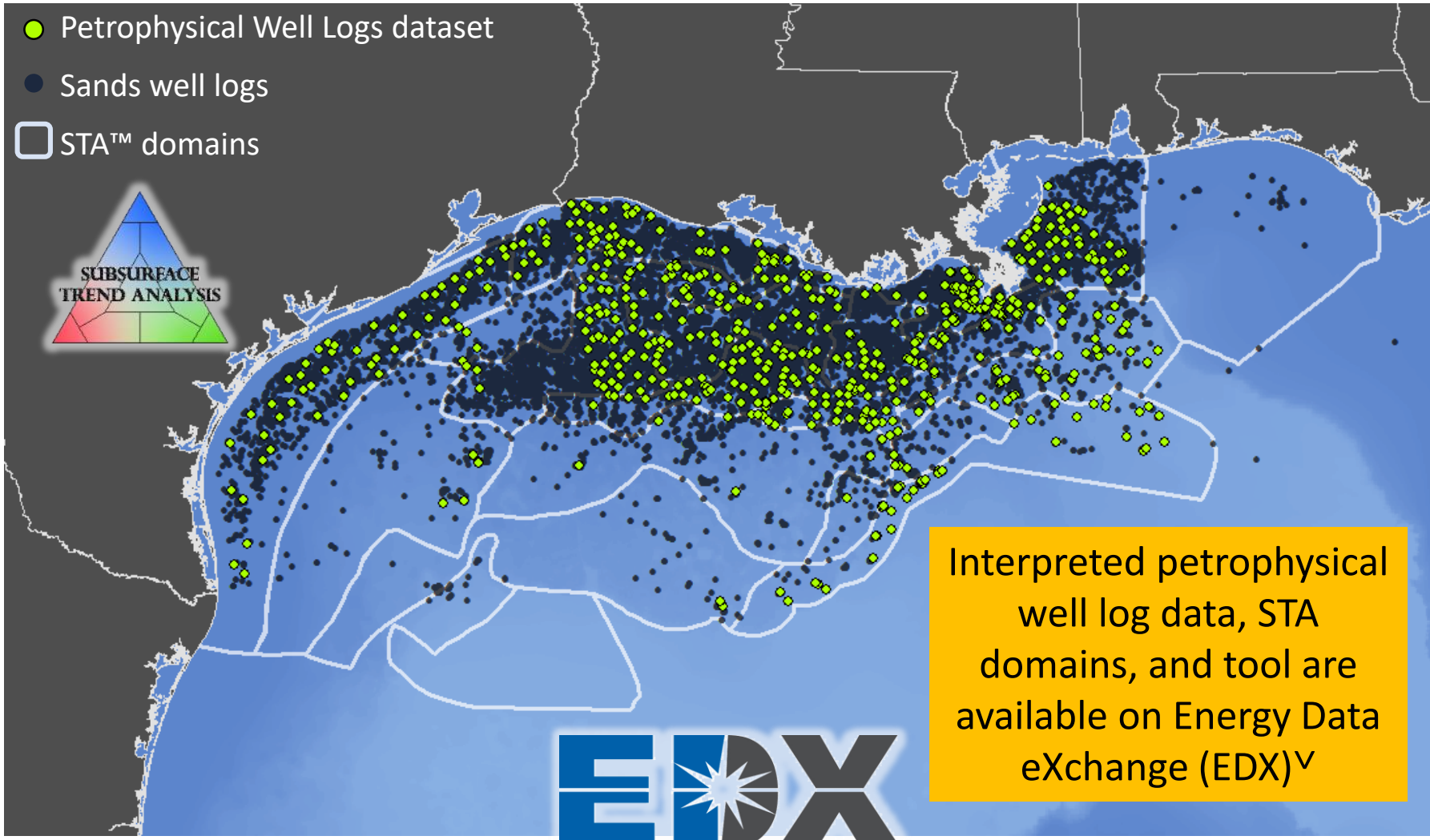


https://edx.netl.doe.gov/dataset/offshore-co2-storage-calculator

Key Accomplishments & Findings

- **Offshore ≠ onshore**
- Interpreted, released, and applied **Petrophysical Well Logs dataset** (Bean et al., 2020)
- Analyzed resource potential per geologic domain as defined by **NETL's Subsurface Trend Analysis™** (Mark-Moser et al., 2020)
- Storage potential ranged from **0.5 to >10k Gt of CO_2**, with all reservoir pressure-temperature regimes resulting in **liquid or supercritical CO_2** (Romeo et al., in prep)
- **Offshore CO_2 Storage Calculator** builds distribution of CO_2 storage, provides stats, graphs, and spatial outputs (Romeo et al., 2020)
- Data-driven **Calculator** capable of multi-scale evaluation and has been assessed for **non-GOM regions**



Thank you!

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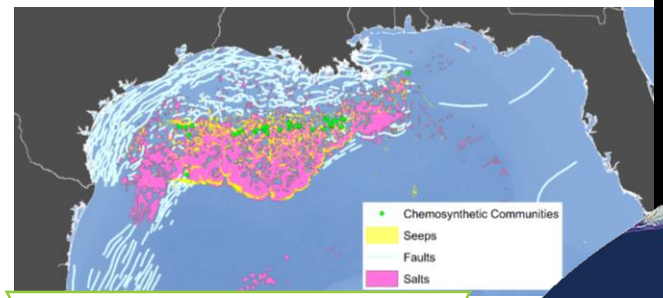
Co-PI: Lucy Romeo, Lucy.Romeo@netl.doe.gov

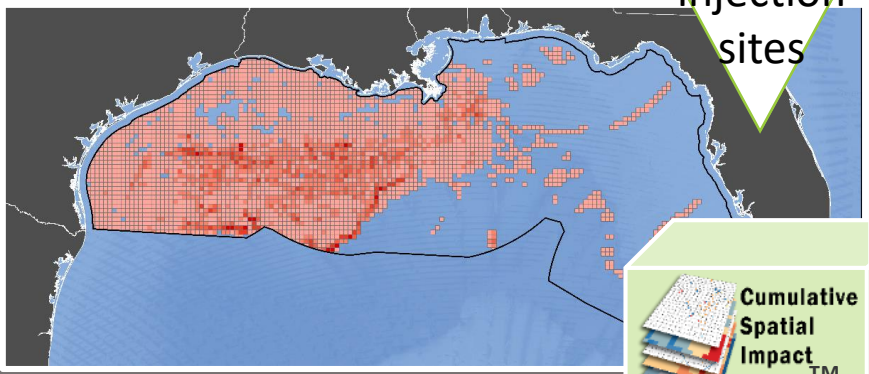
Synergistic/future potential:

- Expand to additional regions
- Leverage **Offshore Risk Modeling** suite
  - Evaluate uncertainty
  - Down-select injection sites



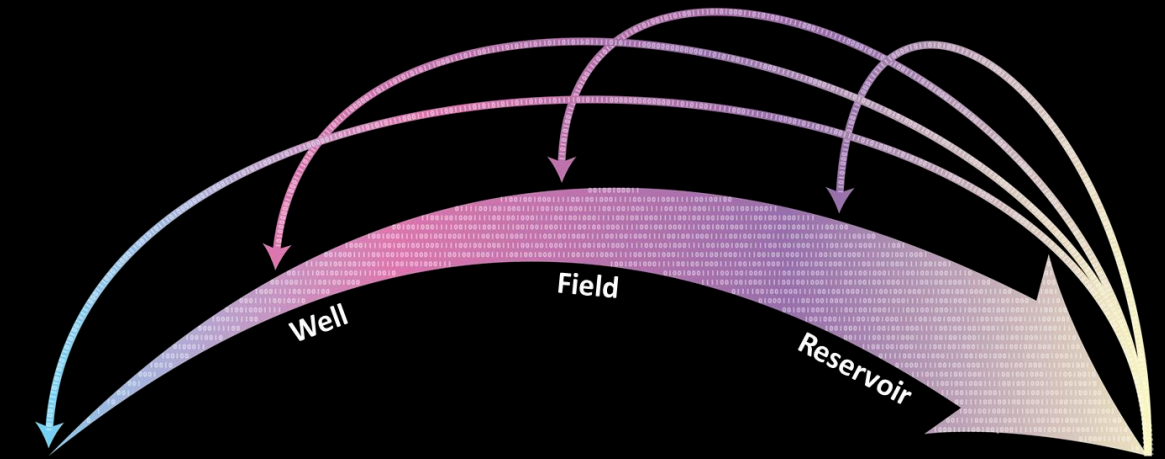
Storage efficiency & resource potential

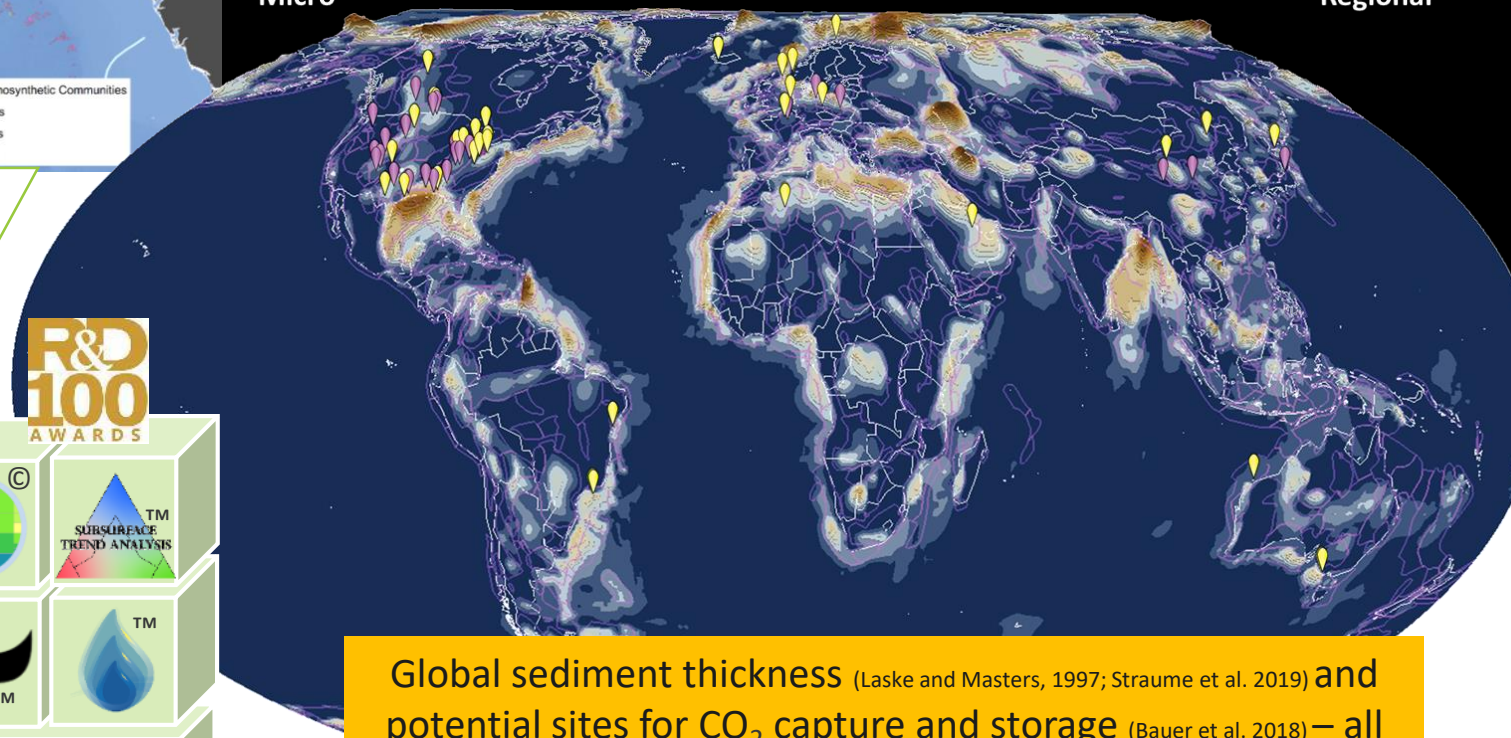
Select injection sites



Cumulative Spatial Impact Layers™

EDX Energy Data eXchange™





Global sediment thickness (Laske and Masters, 1997; Straume et al. 2019) and potential sites for CO_2 capture and storage (Bauer et al. 2018) – all featured in ESRI's GIS for Science, Vol. 2

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Pocket Slides

Assessing Offshore CO_2 Saline Storage Potential with the NETL Calculator

Project Number DE FE-1022403

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[3]MATRIC, Morgantown, WV

U.S. Department of Energy

National Energy Technology Laboratory

Carbon Capture Front End Engineering Design Studies and CarbonSafe
2020 Integrated Review Webinar

August-17-19 2020

Program Overview

- **Funding:** DOE (DE FE-1022403)
  - Carbon Storage/Storage Infrastructure, Task 4
  - Est. Total Budget: $86k
- **Overall Project Performance Dates**
  - EY17-EY20
- **Project Participants:** NETL, LRST, MATRIC
  - Task PI: Kelly Rose
  - Other Key Personnel: Lucy Romeo, Randal Thomas, MacKenzie Mark-Moser, Andrew Bean, Patrick Wingo, Aaron Barkhurst, and Jennifer Bauer

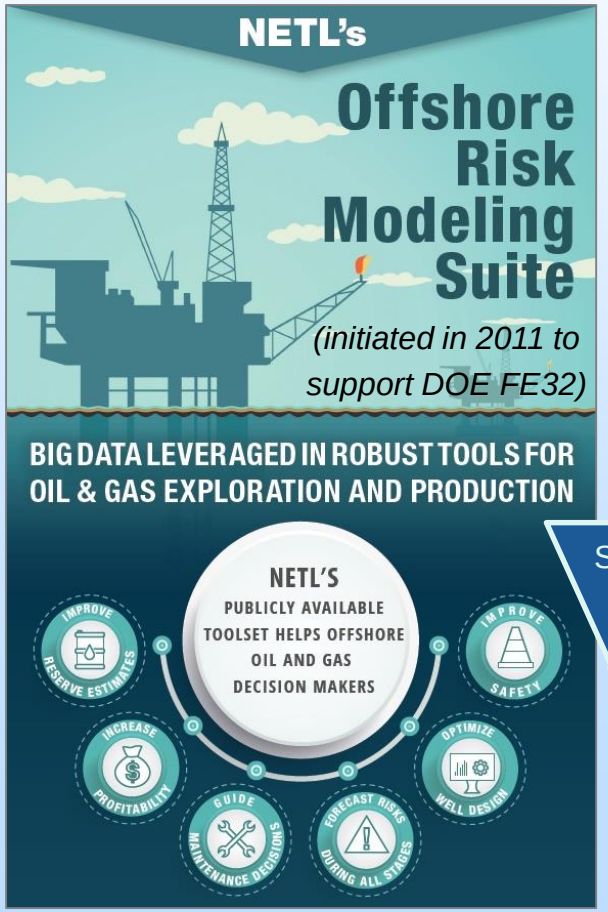
Project Objectives

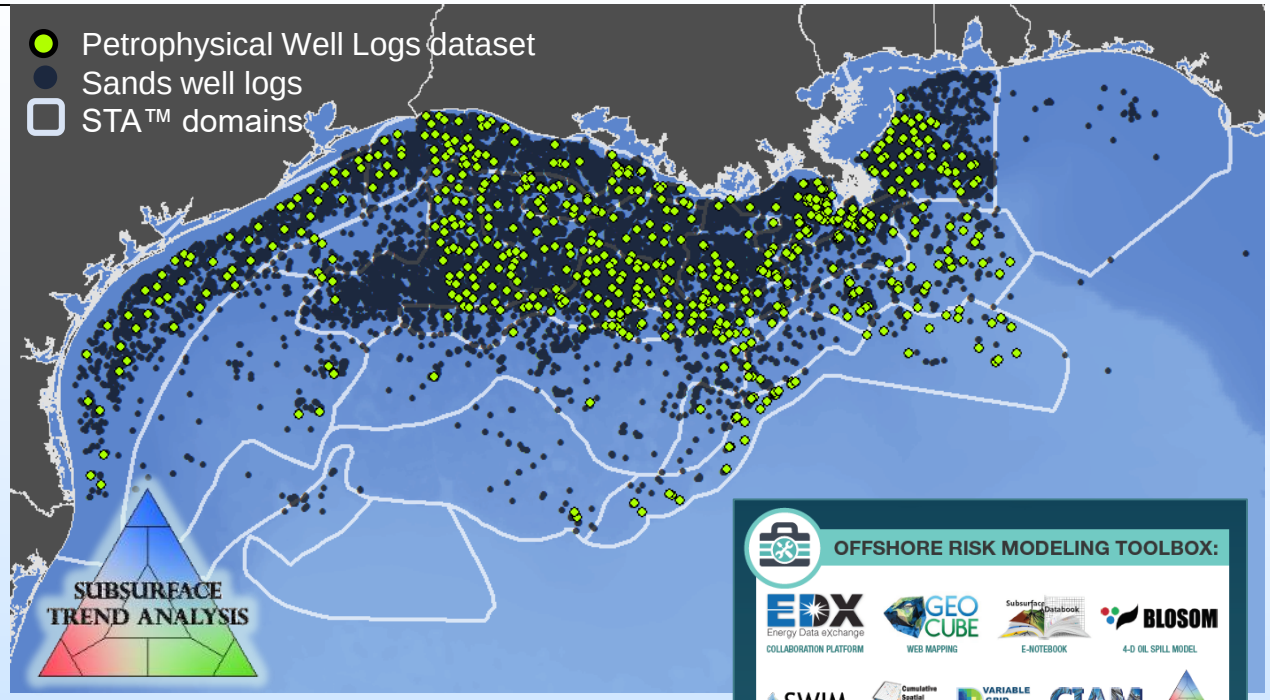
Resource Assessments: *Develop Defensible DOE Methods and Tools for Carbon Storage Atlas*

- Improve accuracy of offshore saline resource estimations
- Tailor geologic efficiency terms from DOE CS method to improve characterization of offshore CS reservoirs
- Build data-driven technical assessment of offshore CS resources through integration of spatial, analytical tools (first developed in FE32 projects)
- Improve external stakeholder access and utility by releasing data and tools via EDX

Technology Section

- Offshore saline formations
- Applied to geologically distinct domains (STA™) in northern Gulf of Mexico

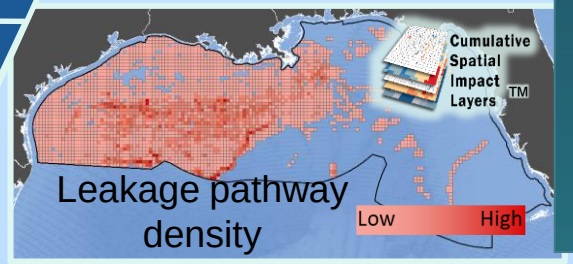




Storage efficiency & resource potential

Select injection sites

Leverage tools from **ORM** to **mitigate injection risk** to better understand favorable vs. unfavorable areas

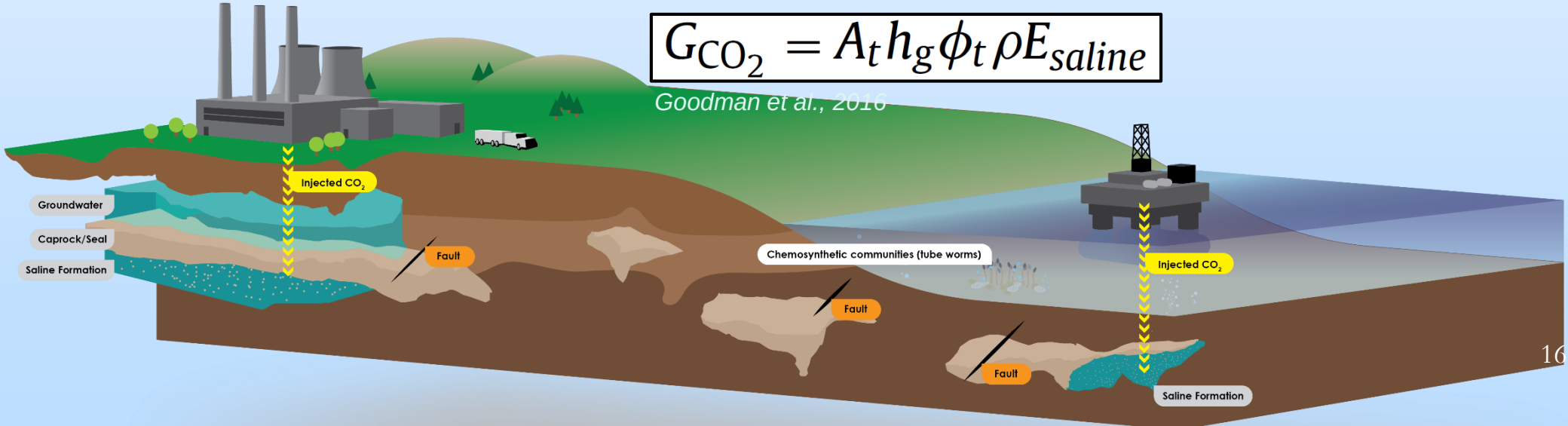


Technology Section

- **Potential economic benefits**
  - Mitigate risk-induced costs by accounting for leakage pathways
  - Quantifies potential long-term volumetric storage potential in saline formations for planning and preparedness
- Tailored DOE CS methodology for offshore saline storage
  - CO_2 pressure, temperature, density
  - Unlithified sediments

$$G_{CO_2} = A_t h_g \phi_t \rho E_{saline}$$

Goodman et al., 2016



Technical Approach/Project Scope

Completed Milestones:

Completion Date	Description
06/29/2018	Submit the final TRS report describing the Offshore Carbon Storage Methodology for Saline Reservoirs to the Carbon Storage Portfolio page on EDX for release.
08/31/2018	Develop carbon storage prediction surfaces based on well log attributes for multiple domains in the GOM.
11/30/2018	Begin peer-reviewed journal manuscript of the NETL offshore carbon storage methodology.
03/29/2019	Document how integration of NETL's Cumulative Spatial Impact Layer tool can work with CS Offshore Methodology and Screen Tool to improve CS assessment outcomes
09/30/2019	Evaluate robustness of offshore efficiency factors for saline reservoir assessment of offshore reservoirs in non-GOM, offshore regions.
10/31/2019	Evaluate potential of adapting Saline Offshore Methodology for use with Offshore CO2 EOR storage approach.
3/31/2020	Release updated versions of advanced spatial data computing tool, offshore CS efficiency factors, via EDX

Technical Approach/Project Scope

Project success criteria

- Meeting objectives
- Completion of milestones

Significant project risks and mitigation strategies

- Social & environmental risks of transporting and storing CO2 in coastal and offshore areas
- Inherently less data in offshore
- Recorded uncertainty
- Updated logic to work with data available

Project Status

Key accomplishments

- Developed CS prediction surfaces based on interpreted petrophysical well log attributes for multiple domains in GOM
- Tailored DOE CS methodology for offshore, applied data-driven logic to GOM domains
  - Released **Offshore CO2 Storage Calculator** to assess saline storage potential – an open-source and standalone tool on EDX
- Applied calculator to 18 domains in GOM
- Documented how integration of ORM tools can work with CS storage methodology to improve assessment outcomes with injection site selection and uncertainty quantification analyses
- Evaluated application of tool in non-GOM offshore regions

https://edx.netl.doe.gov/dataset/offshore-co2-storage-calculator

Project Status

Technology

- 2019, EDX release of petrophysical well log dataset
  - Bean, A., Romeo, L., Justman, D., DiGiulio, J., Miller, R., Cameron, E., and Rose, K, Petrophysical Well Log Interpretation Dataset, 2020-03-05, https://edx.netl.doe.gov/dataset/petrophysical-well-log-interpretation-dataset, DOI: 10.18141/1560053
- 2020, EDX release of Offshore CO2 Storage Calculator
  - Romeo, L., Wingo, P., Barkhurst, A., Thomas, R., and K. Rose. 2020. Offshore CO2 Storage Calculator, https://edx.netl.doe.gov/dataset/offshore-co2-storage-calculator, DOI: 10.18141/1607787

Publications

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- 2020, Journal manuscript on assessment application
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- 2020, Featured in ESRI's GIS for Science, Volume 2
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https://edx.netl.doe.gov/dataset/offshore-co2-storage-calculator

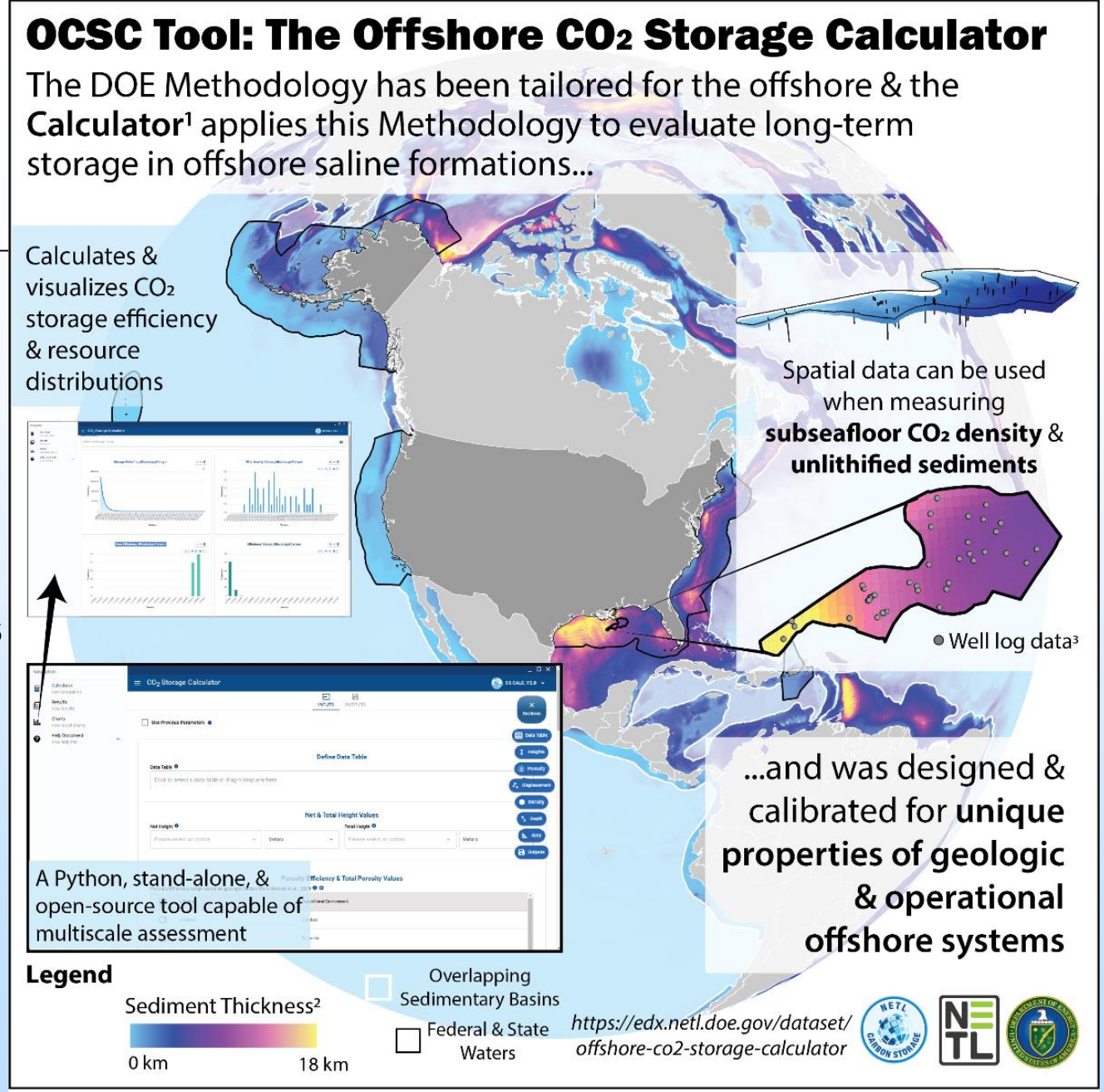
Project Status

Challenges

- Data availability & usability
- Pressure assumed hydrostatic

Synergy opportunities

- Expand application of data and tool to additional regions
- Refine open-source logic with additional data and knowledge
- Apply ORM suite for full-scale system assessment



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Summary Slide

Key findings

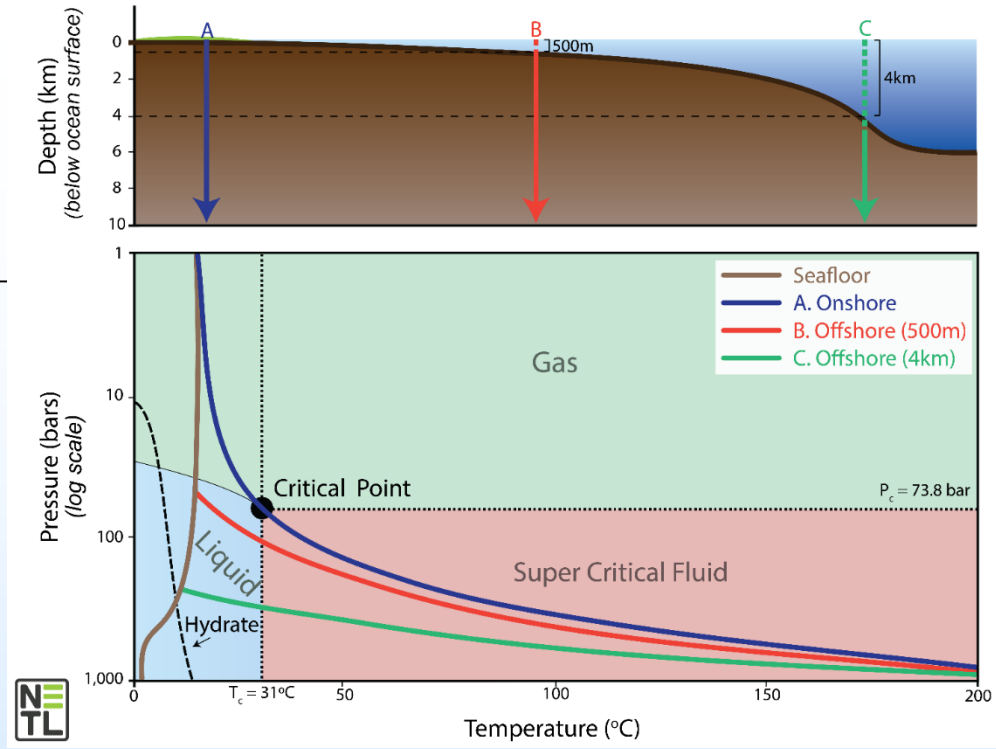
- Offshore subsurface is different from the onshore
- Potential storage results from GOM analyses ranged from 0.5Gt to >10kGt
- GOM analyses found pressure-temperature environments to store CO_2 in supercritical or liquid phases

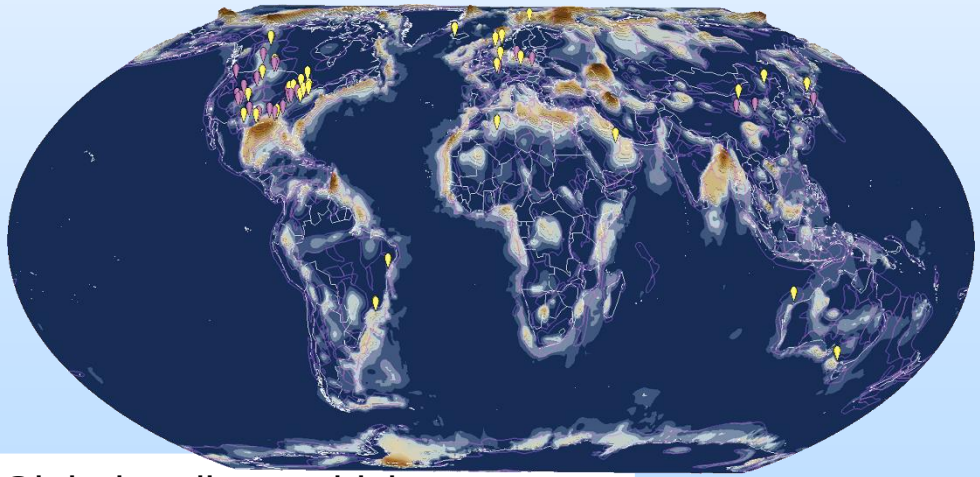
Lessons learned

- Tool should be capable of multi-scale
- Import to account for leakage pathways when assessing area

Future Potential

- Expand to other regions
- Leverage data and tool for additional tasks





Global sediment thickness
(Laske and Masters, 1997; Straume et al. 2019)
Potential CO2 capture & storage sites
(Bauer et al. 2018)

Organization Chart

Team member	Title	Affiliation	Project-related efforts
Kelly Rose, PhD	PI, Geo-data Scientist	NETL	Project management, geologic SME
Lucy Romeo	Co-PI, Research Scientist, Geo-data Researcher	LRST, NETL	Method and tool development, spatial data sciences
Randal Thomas, PhD	Research Scientist, Geochemist	LRST, NETL	Method development and geochemistry/physics SME
MacKenzie Mark-Moser	Research Scientist, Geologist	LRST, NETL	Offshore geologic SME
Andrew Bean	Research Scientist, Geologist	LRST, NETL	Geologic SME, petrophysical well log interpretations
Patrick Wingo	Research Scientist	LRST, NETL	Tool development
Aaron Barkhurst	Developer	MATRIC	Tool development

Gantt Chart

September 2016 – March 2020