GoMCarb Publication Highlights

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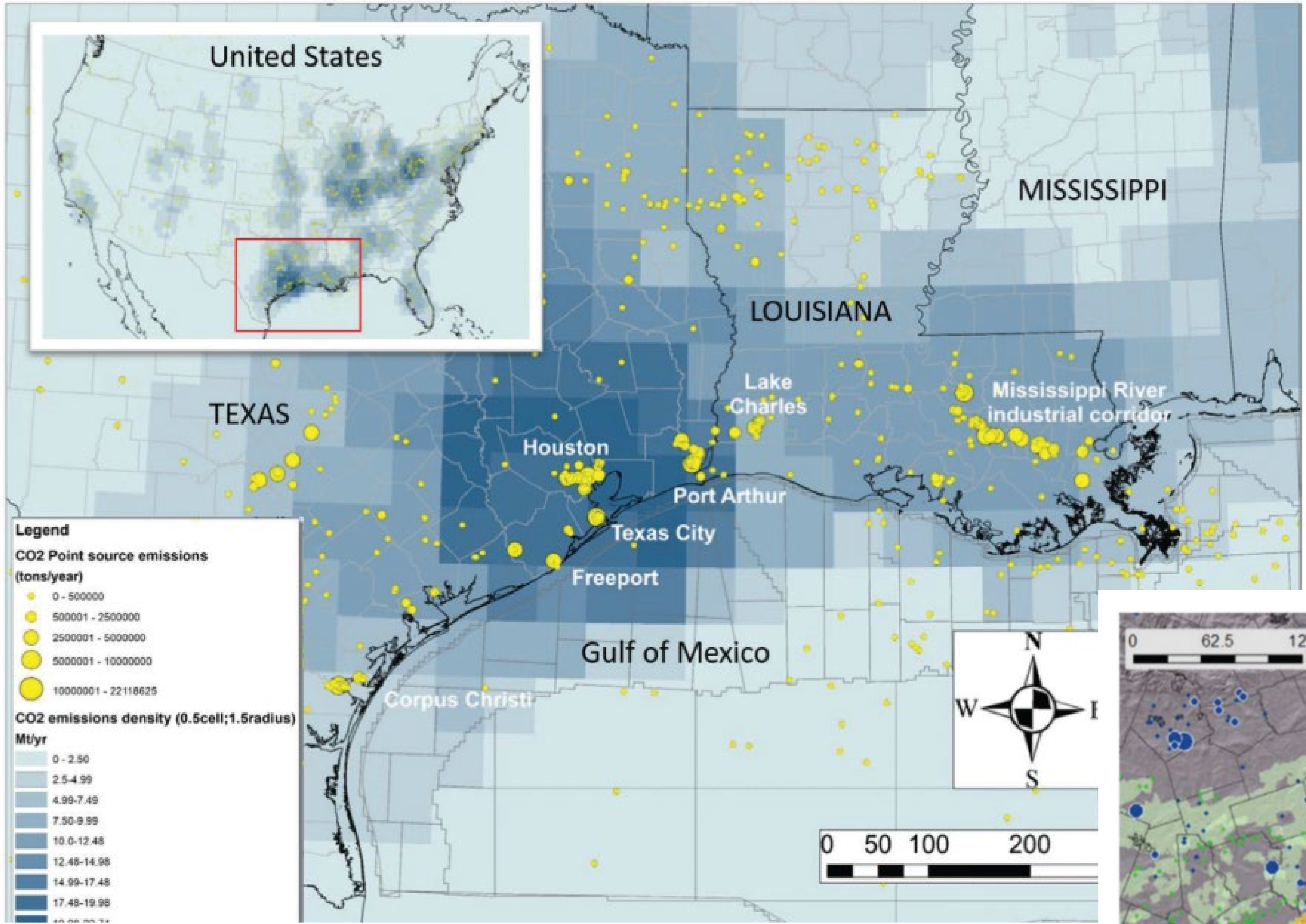


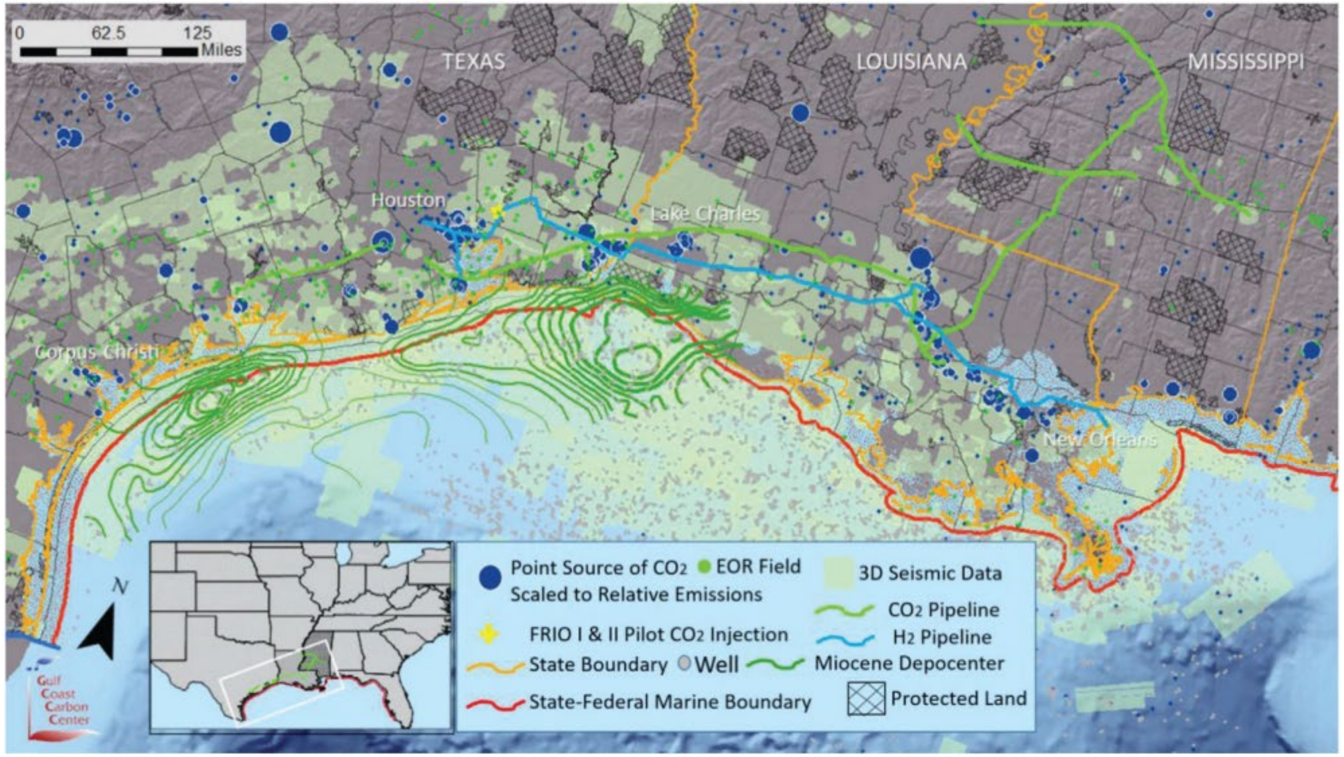
On the Map

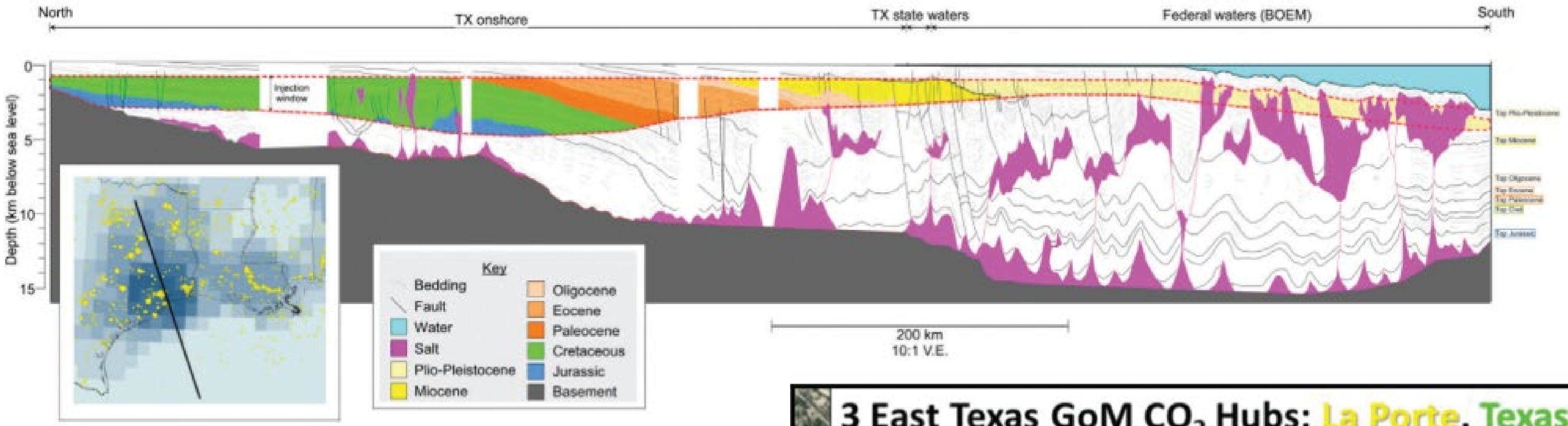
ghg GREENHOUSE GASES SCIENCE AND TECHNOLOGY

Carbon capture, utilization, and storage hub development on the Gulf Coast

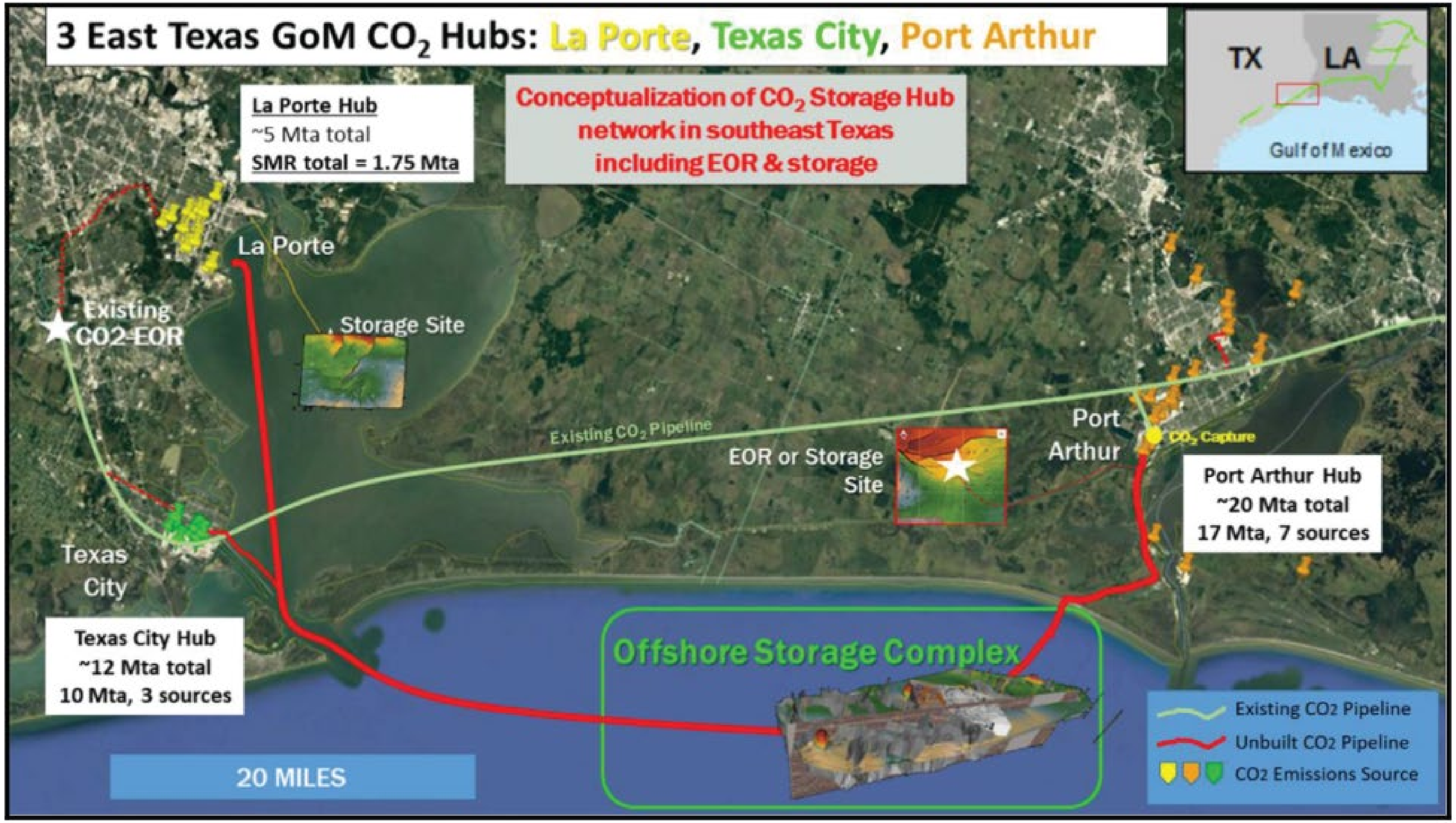
T.A. Meckel, A.P. Bump, S.D. Hovorka and R.H. Trevino, The University of Texas at Austin, Austin, TX, USA

- <u>The Gulf Coast</u> of the United States hosts diverse power generation, refining, and petrochemical processing facilities, resulting in the <u>nation's largest volumetric concentration of industrial CO_2 emissions</u>, rivaled only by the Ohio River Valley.
- These emissions sources are <u>concentrated in specific industrial clusters that allow combining emissions streams to achieve economies of scale</u>.





- The region is currently undergoing globally significant industrial expansion and investment as a result of abundant and inexpensive regional unconventional natural gas availability, and is a growing exporter of liquefied natural gas (LNG).



- <u>Offshore storage is particularly attractive, as it provides simplified land leasing models (single governmental land owner), proven reservoir quality, and presents fewer risks to both protected groundwater and populated areas.</u>
- The region continues to evolve as an active carbon-handling hub, and is uniquely suited to justify additional investment in carbon capture, utilization, and storage (CCUS) technologies via a large-scale integrated project development.

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International Journal of Greenhouse Gas Control 115 (2022) 103612

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International Journal of Greenhouse Gas Control

journal homepage: www.elsevier.com/locate/ijggc

Assessing Impacts on Pressure Stabilization and Leasing Acreage for CO_2 Storage Utilizing Oil Migration Concepts

Melianna Ulfah [a,*], Seyyed Hosseini [b], Susan Hovorka [b], Alex Bump [b], Sahar Bakhshian [b], Dallas Dunlap [b]

[a] Jackson School of Geosciences, The University of Texas Austin, Austin, TX 78712, United States
[b] Gulf Coast Carbon Center, Bureau of Economic Geology, 10611 Exploration Way, Austin, TX 78758, United States

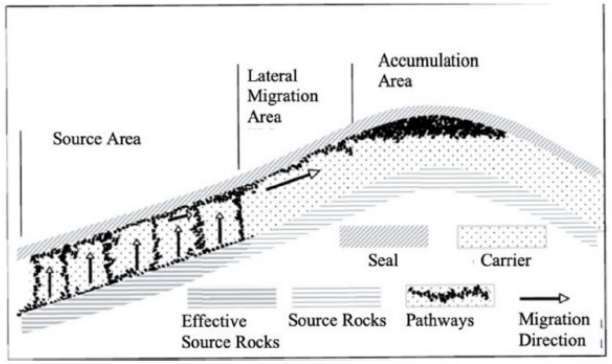
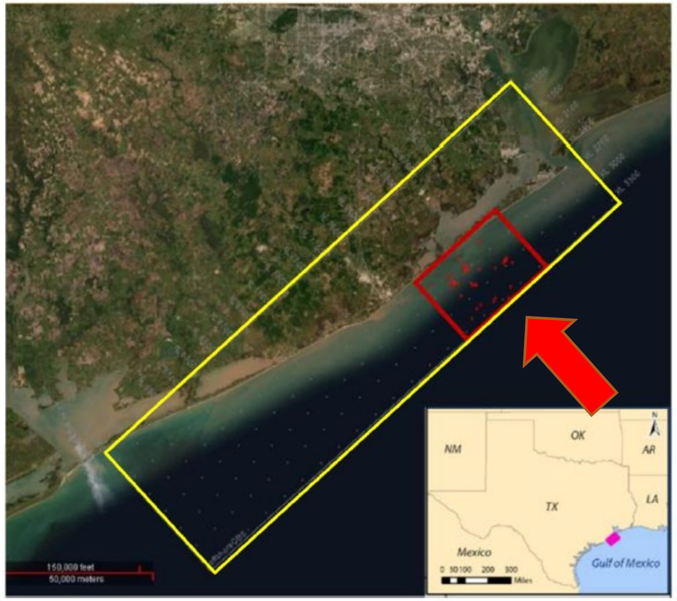


Fig. 1. Diagrammatic representation of migration pathways (modified from Zhang et al, 2006)



- If we inject CO_2 down to a syncline – analogous to the carrier bed in the petroleum system – how would this injection mechanism impact storage capacity and plume shape, migration, and stabilization?

- To address this question, we built a reservoir model, based on seismic interpretation of Middle Miocene strata, offshore Galveston, Texas.

- Modeling investigated how far the CO_2 plume would migrate under two scenarios:
  1. injecting CO_2 at the base of the salt withdrawal basin (syncline scenario) and
  2. injecting CO_2 at the base of the structural closure, similar to a common injection well location for EOR purposes (base scenario).

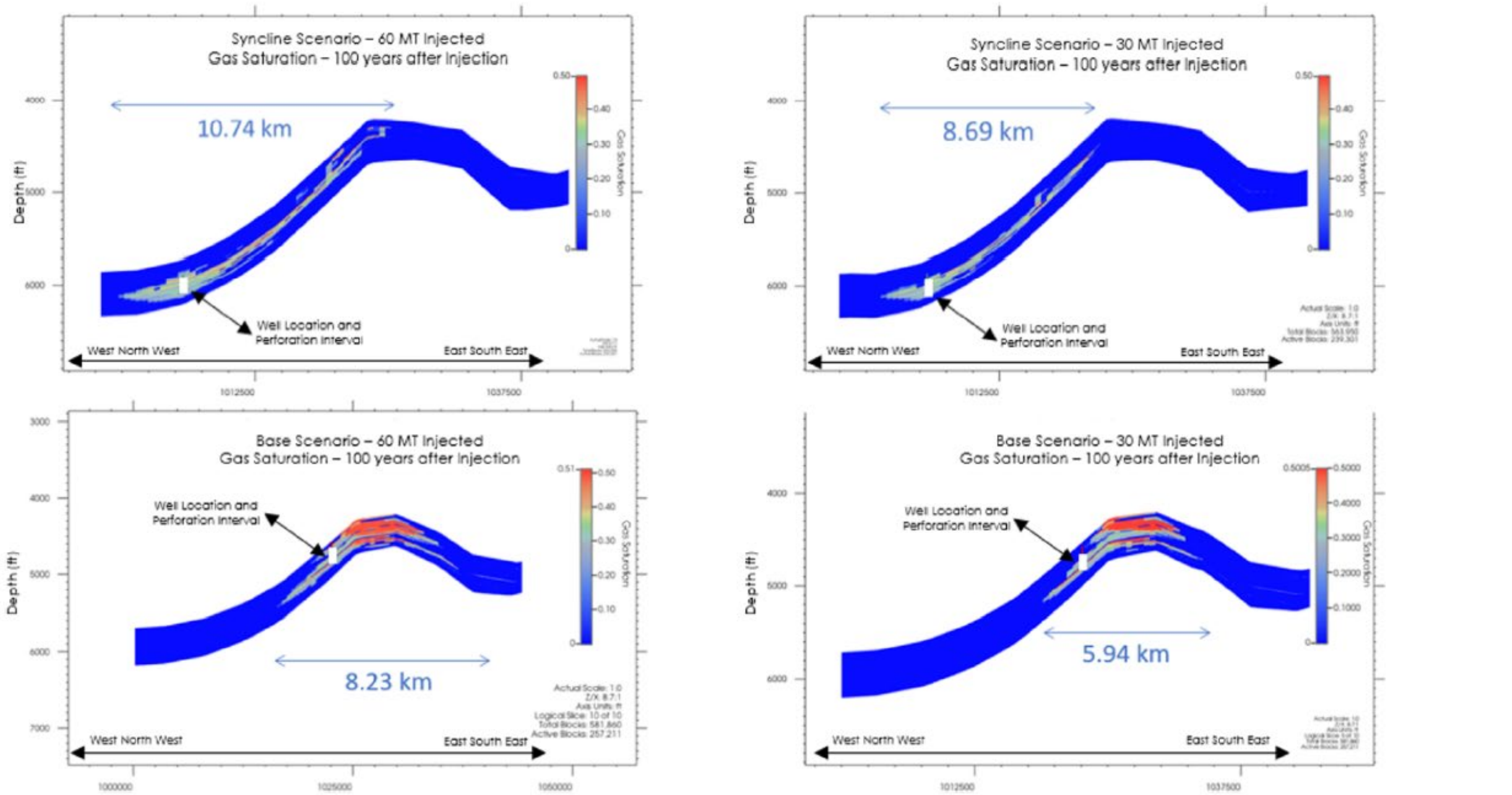


Fig. 14. Cross-section views of the plumes in all scenarios after 100 years after injection stops along with each of the lateral plume migration distances.

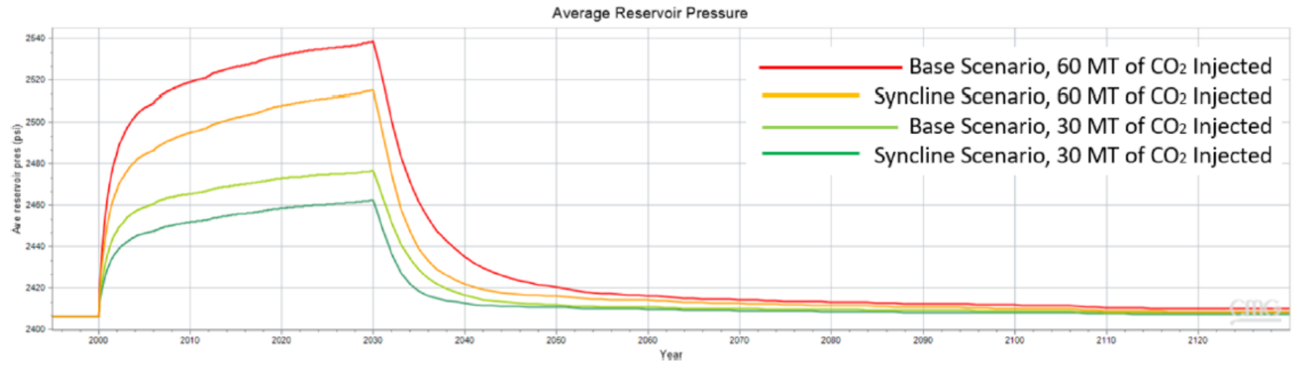
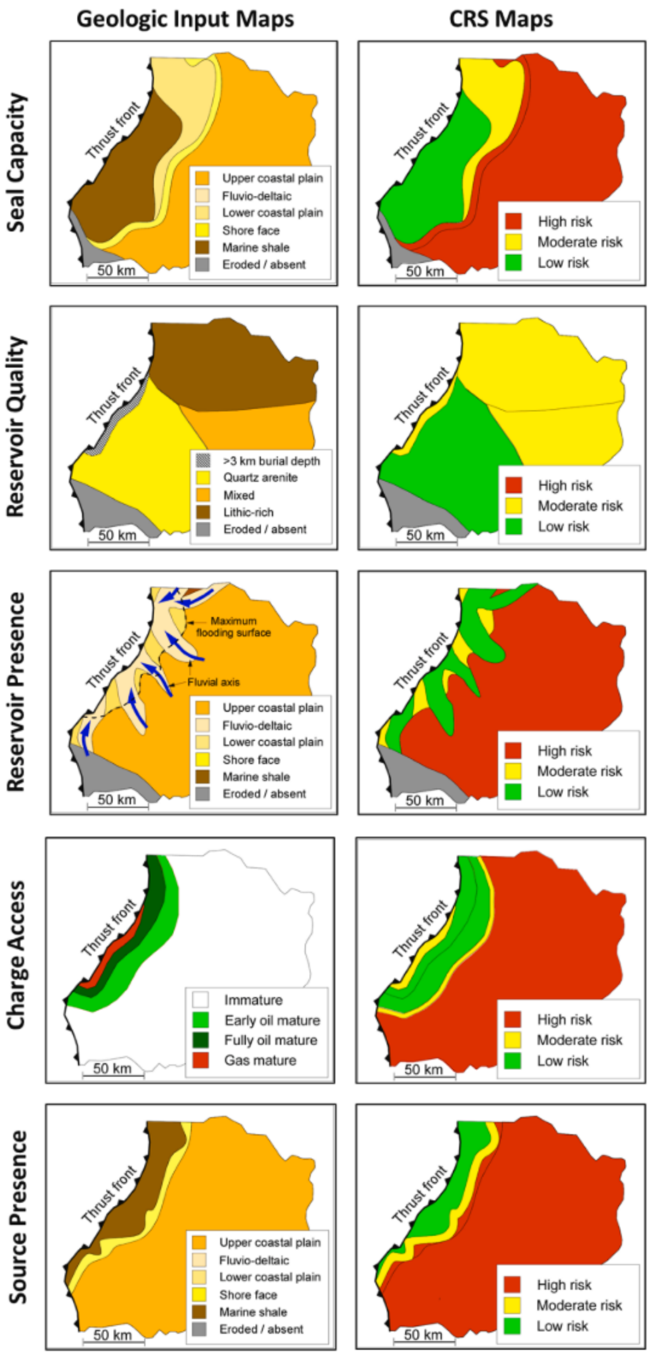
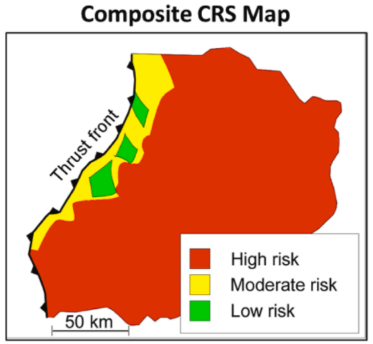


Fig. 18. Evolution of average reservoir pressure for all scenarios from the start of injection, 30 years of continuous injection, and 100 years after injection stops.

- **The simulation shows that injecting the CO_2 into a syncline limits the vertical migration of CO_2, thus making synclinal injection more secure.**
- **In the syncline scenario, the geological layer around the injection point is more heterogeneous than the layer in the base scenario; thus, the CO_2 tends to migrate laterally.**
- **Moreover, the simulation also shows that in the syncline scenario, the times needed for the reservoir to reach its stabilized pressure after the end of injections are faster.**
- **To summarize, CO_2 injection at the base of a syncline could provide additional storage, increase the safety of the project from the limited vertical plume migration, and expedite plume stabilization, which could result in the decrease of monitoring frequency as the project runs, thus lowering the operating cost of the project in the long run.**





Rules of Addition

Inputs	Output
All green	Green
Any yellow but no red	Yellow
Any red	Red

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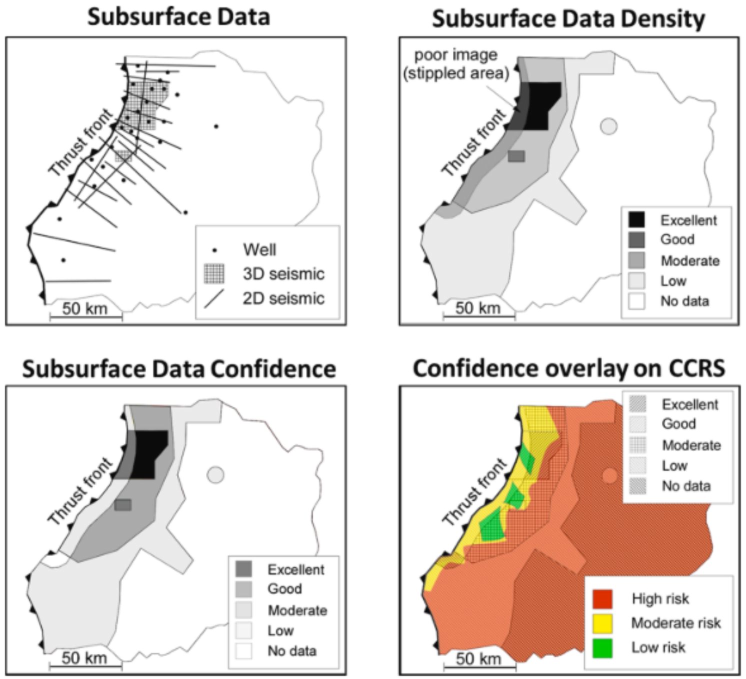
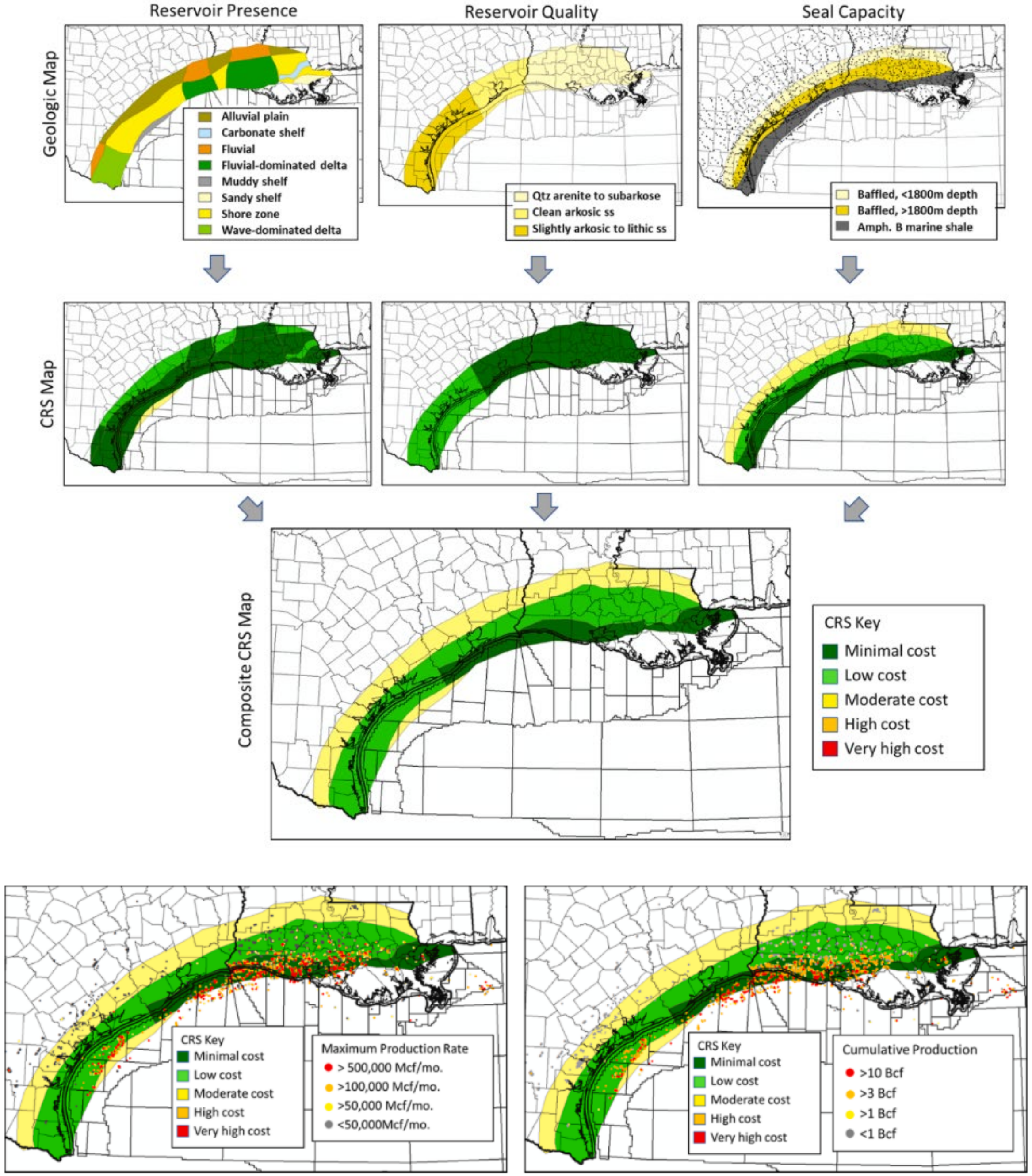
Common risk segment mapping: Streamlining exploration for carbon storage sites, with application to coastal Texas and Louisiana

Alexander P. Bump *, Susan D. Hovorka, Timothy A. Meckel

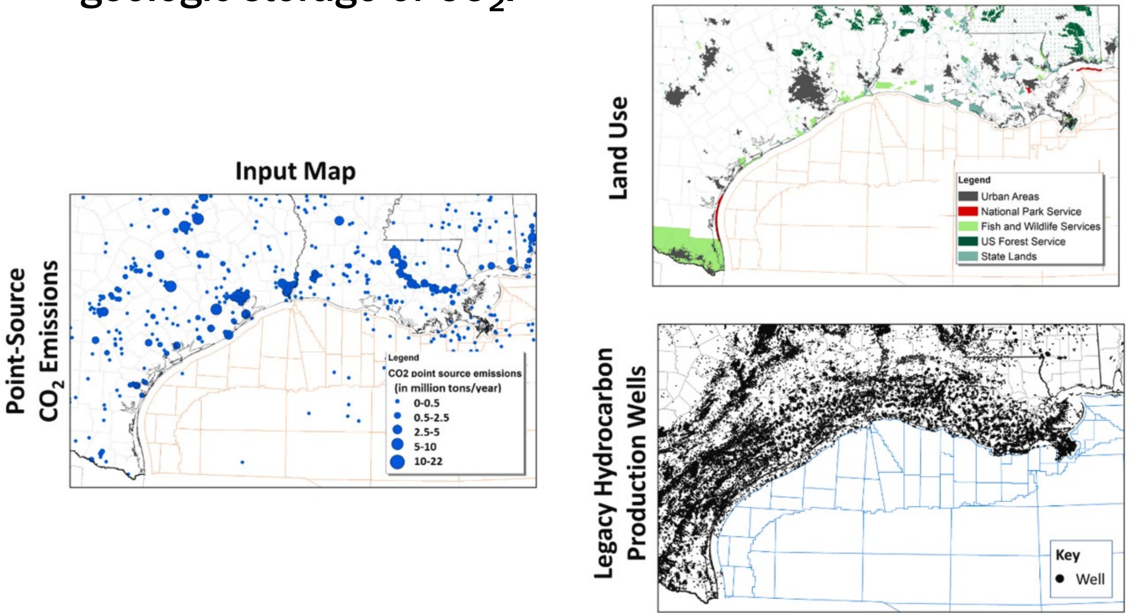
Gulf Coast Carbon Center, Bureau of Economic Geology, Jackson School of GeoSciences, The University of Texas at Austin

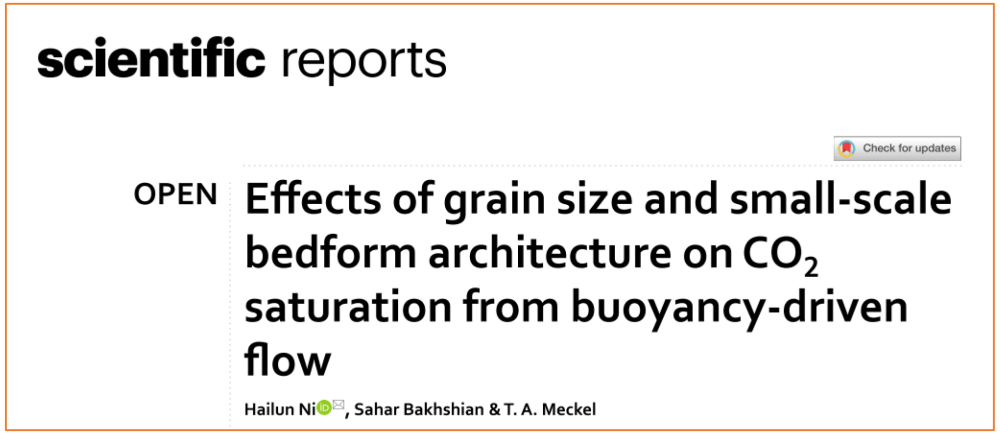
- Large-scale deployment of Carbon Capture and Storage (CCS) will require a commensurately large number of sites.
- Efficient screening methods are needed to create investment assurance and focus efforts on the most promising sites.
- The problem is similar to petroleum exploration, for which there are well-developed (though seldom published) workflows, including Common Risk Segment (CRS) mapping.





- In this paper, we adapt the CRS process to screening for CO_2 storage sites.
- Critically, we redefine the process in terms of cost of characterization and development, rather than chance of success.
- For illustration, we apply the process to the example of the Lower Miocene on the Texas and Louisiana Gulf Coast.
- We show that the predictions are consistent with historic hydrocarbon production volumes and rates.
- The result highlights sweet spots and identifies critical risks, suggesting a focus for further data collection and analysis.
- The method developed here can be applied to both surface and subsurface factors anywhere that there is interest in geologic storage of CO_2.




scientific reports

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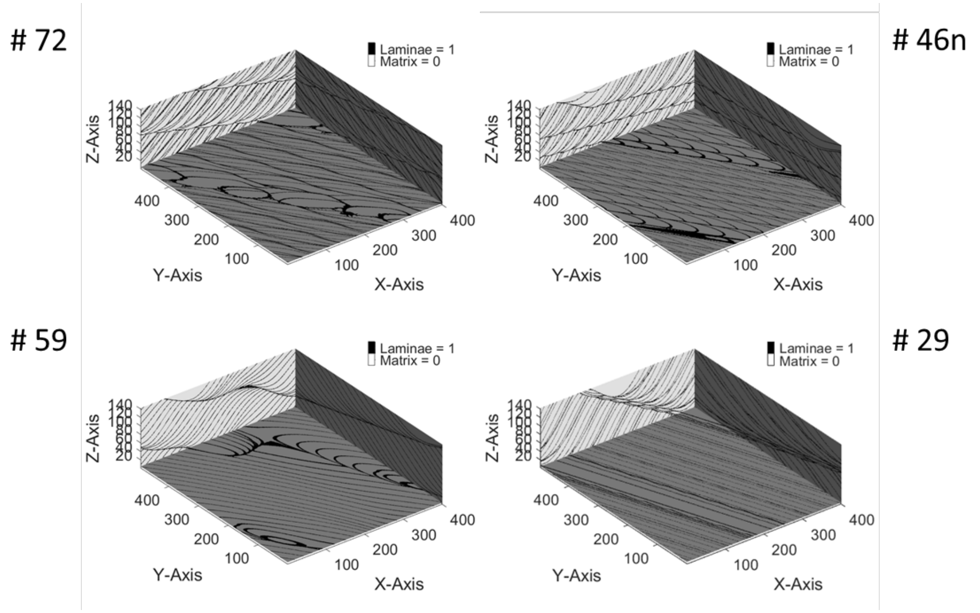
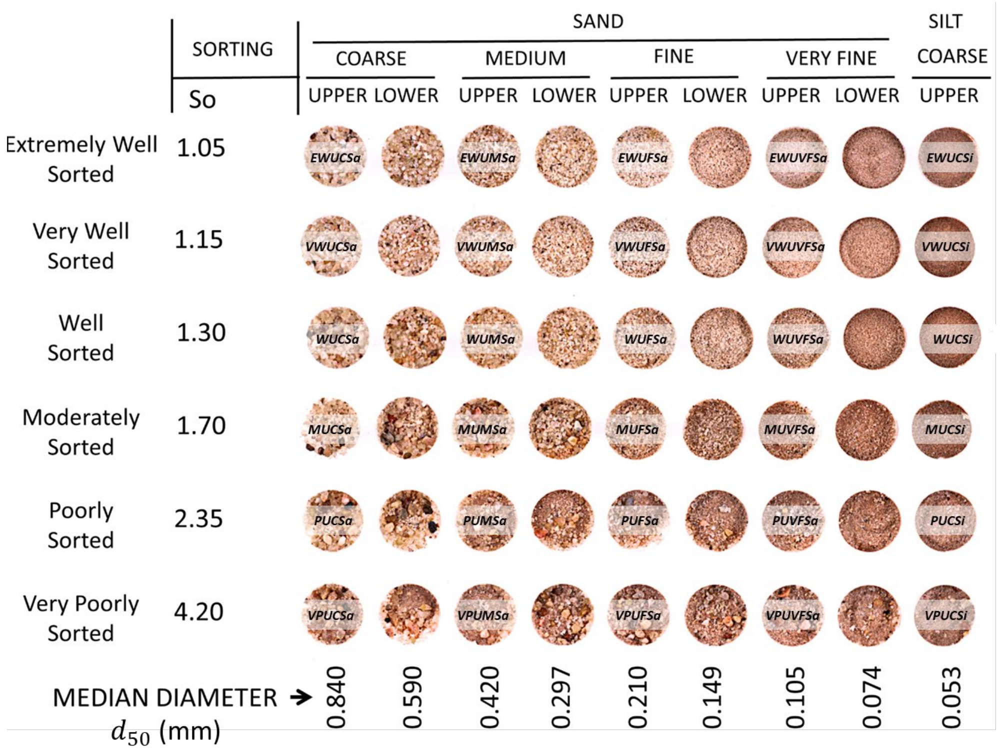
OPEN

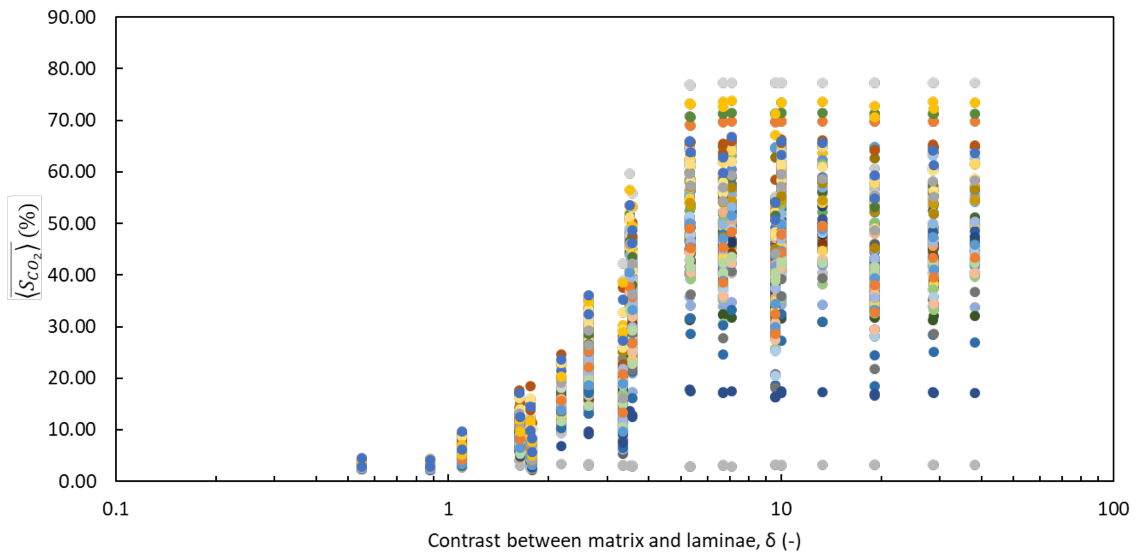
Effects of grain size and small-scale bedform architecture on CO_2 saturation from buoyancy-driven flow

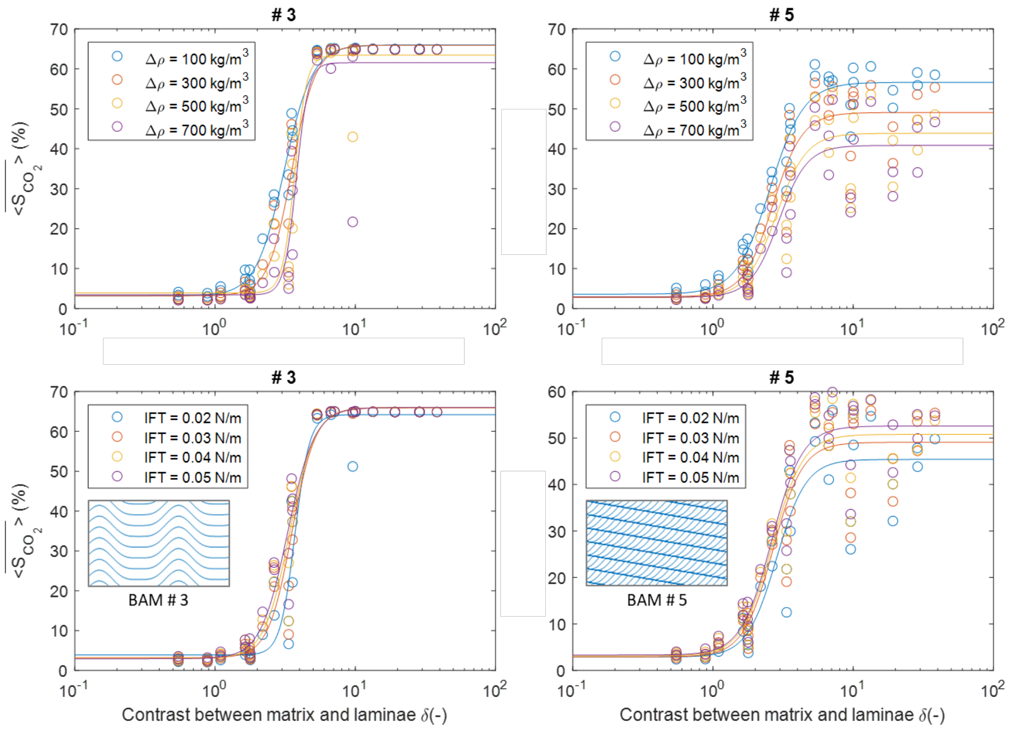
Hailun Ni, Sahar Bakhshian & T. A. Meckel





- **Small-scale (mm-dm scale) heterogeneity has been shown to significantly impact CO_2 migration and trapping.**
- **Realistic simulation domains are constructed by varying two important aspects of small-scale geologic heterogeneity: sedimentary bedform architecture and grain size contrast between the matrix and the laminae facies.**
- **Buoyancy- driven flow simulation runs cover 59 bedform architecture and 40 grain size contrast cases.**





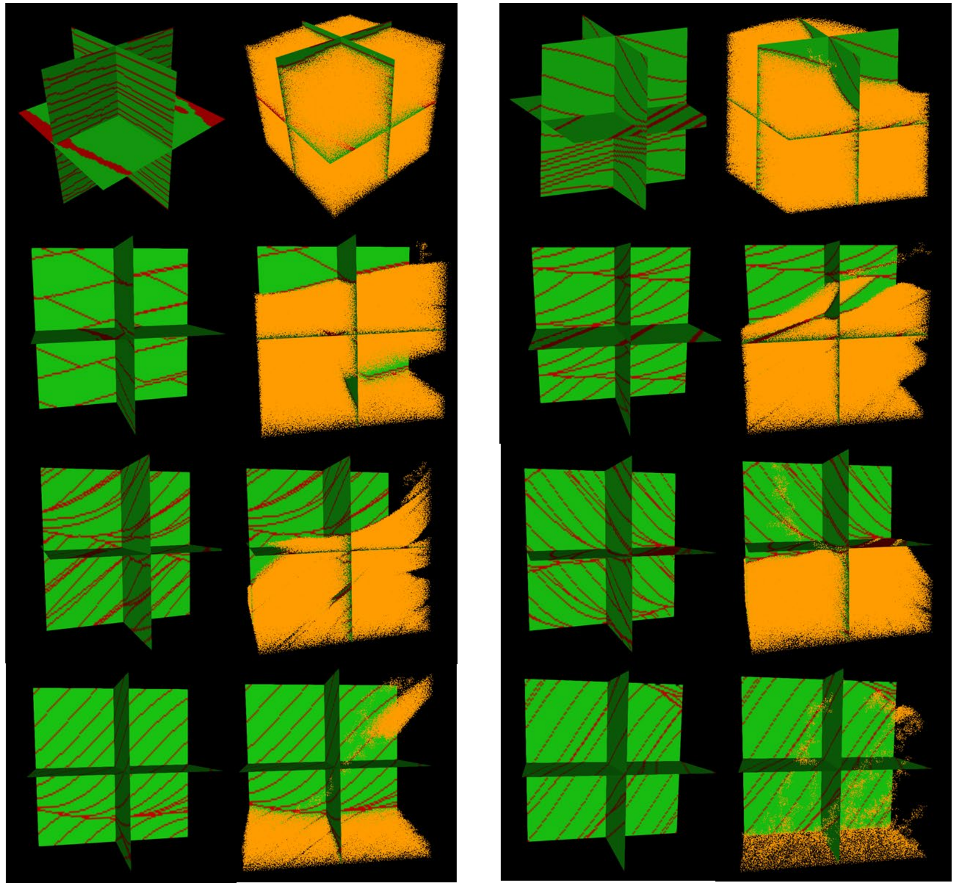
- Simulation results show that the <u>domain effective CO_2 saturation is strongly affected by both grain size and bedform architecture</u>.
- Differences in <u>bedform architecture</u> can impact how CO_2 saturation values respond to other variables such as <u>grain sorting</u> and <u>fluid properties</u>.
- The value of this study is to <u>provide a comprehensive simulation dataset</u>, upon which <u>prediction models</u> can be built for upscaling purposes in field-scale simulations.

67
C_4 = 78

43a
C_4 = 62

72
C_4 = 43

59
C_4 = 17

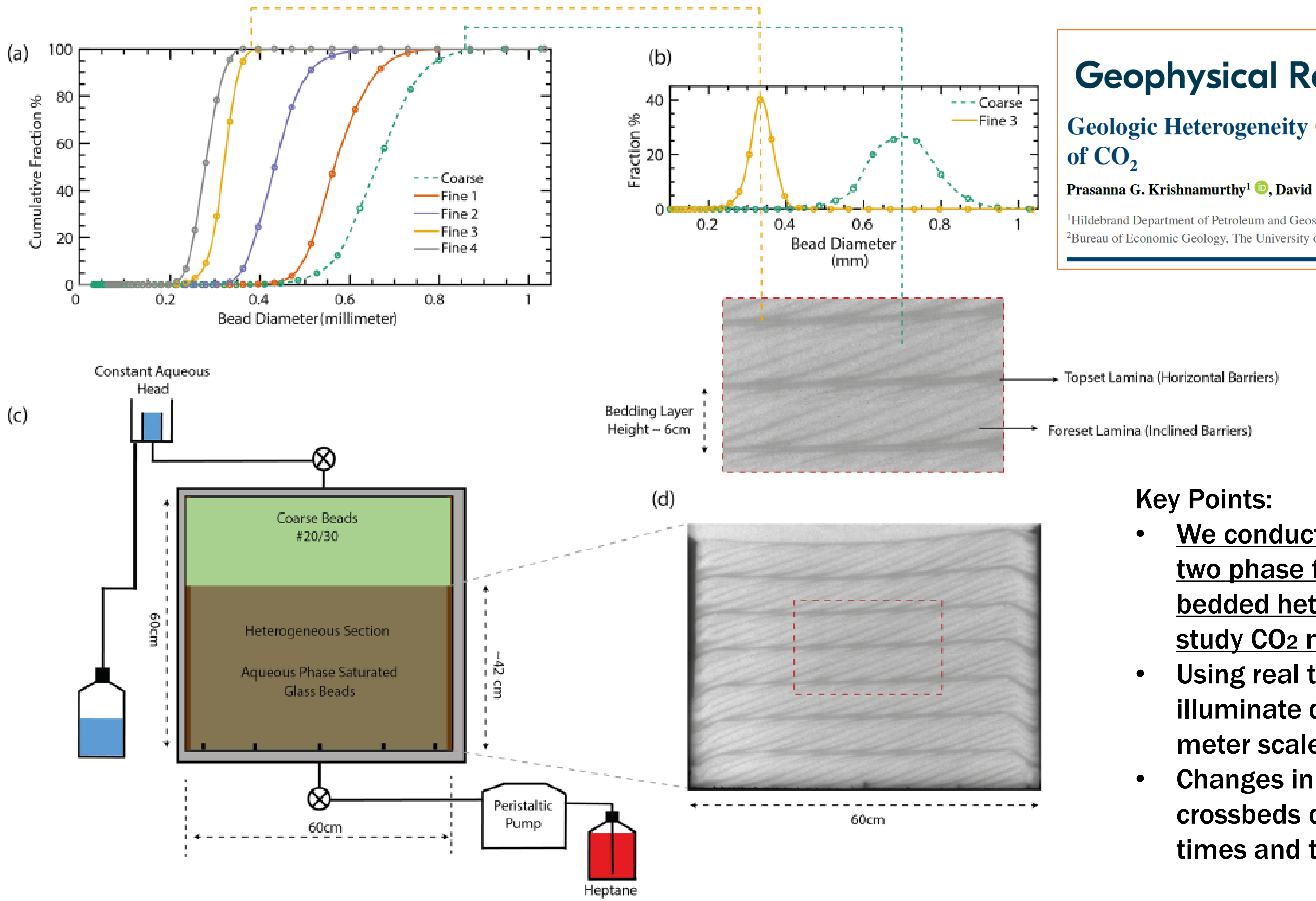


4
C_4 =71

22b
C_4 =47

46n
C_4 = 27

29
C_4 = 3



Geophysical Research Letters

Geologic Heterogeneity Controls on Trapping and Migration of CO_2

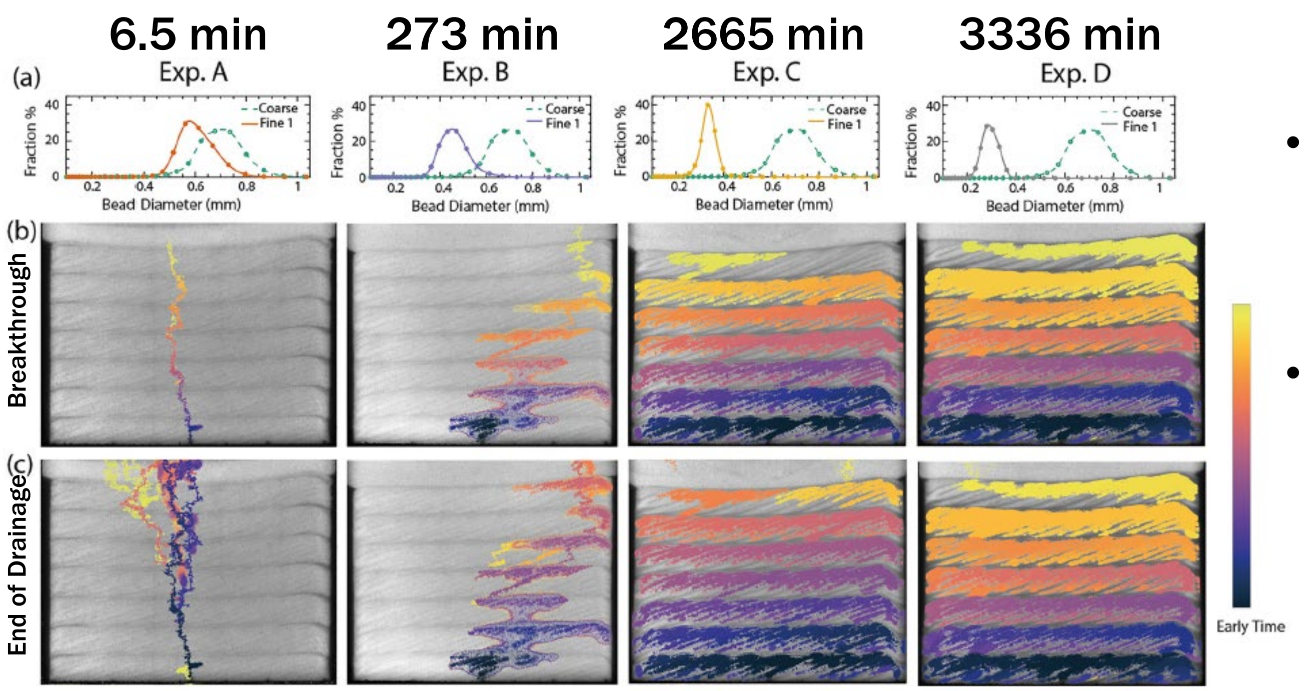
Prasanna G. Krishnamurthy[1], **David DiCarlo**[1], **and Tip Meckel**[2]

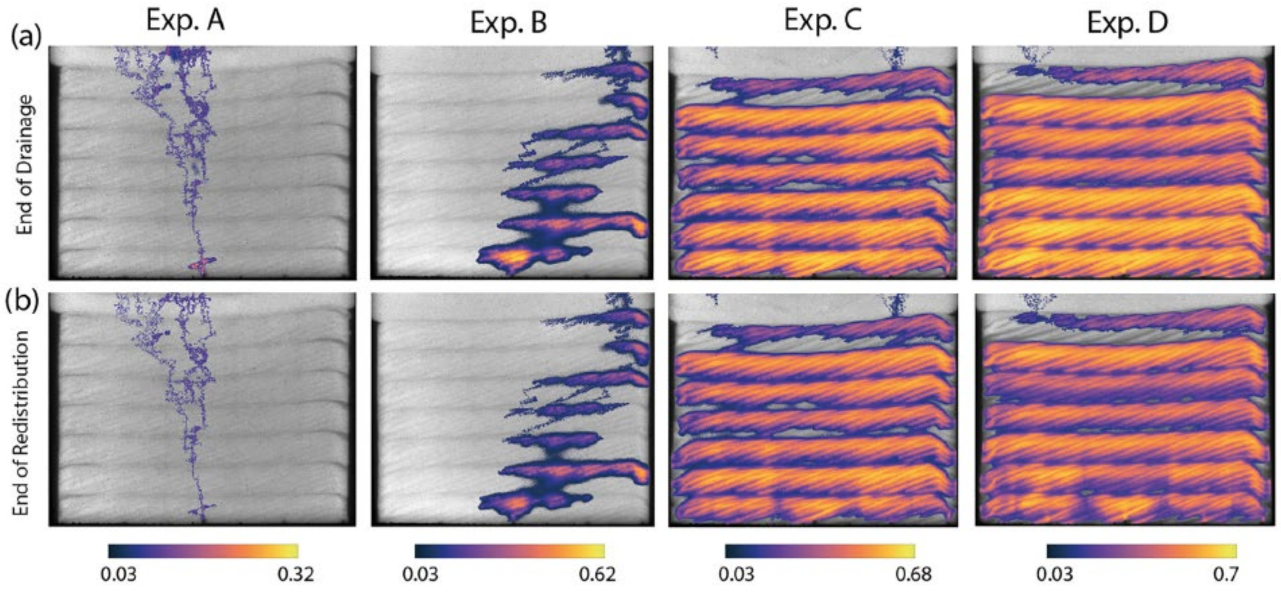
[1]Hildebrand Department of Petroleum and Geosystems Engineering, The University of Texas at Austin, Austin, TX, USA, [2]Bureau of Economic Geology, The University of Texas at Austin, Austin, TX, USA

Key Points:

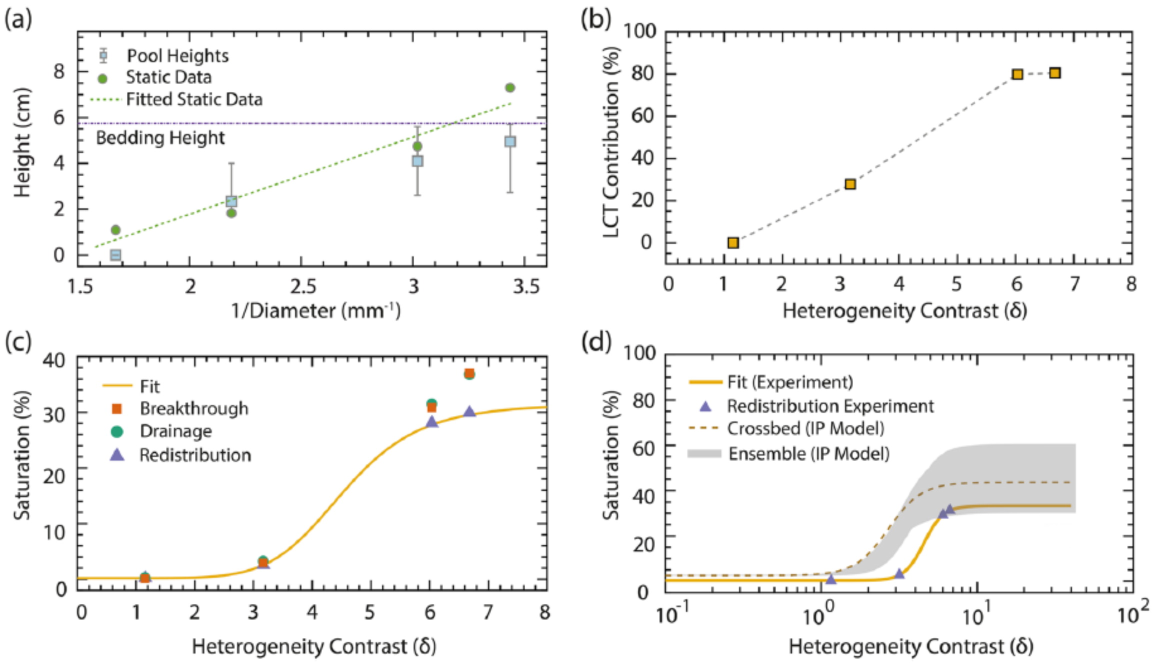
- <u>**We conduct unique intermediate-scale, two phase flow experiments in cross-bedded heterogeneous bead packs to study CO2 migration and trapping**</u>
- **Using real time visualization, we illuminate dynamic flow processes at the meter scale**
- **Changes in grain size contrast of crossbeds drastically affect migration times and trapped volumes of CO2**

Breakthrough time





- We show that subtle changes in rock properties, especially the grain size contrast, <u>can slow down migration speeds and increase trapped volumes by 10–100 times</u>.
- Our results also show that <u>heterogeneities can contribute up to 80% of the total storage capacity</u>.



Original Research Article

ghg GREENHOUSE GASES SCIENCE AND TECHNOLOGY

Major CO_2 blowouts from offshore wells are strongly attenuated in water deeper than 50 m

Curtis M. Oldenburg and **Lehua Pan**, Energy Geosciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

- Growing interest in offshore geologic carbon sequestration (GCS) motivates evaluation of the consequences of subsea CO_2 well blowouts.
- We have simulated a hypothetical major CO_2 well blowout in shallow water of the Texas Gulf Coast.
- We use a coupled reservoir-well model (T2Well) to simulate the subsea blowout flow rate for input to an integral model (TAMOC) for modeling CO_2 transport in the water column. Bubble sizes are estimated for the blowout scenario for input to TAMOC.

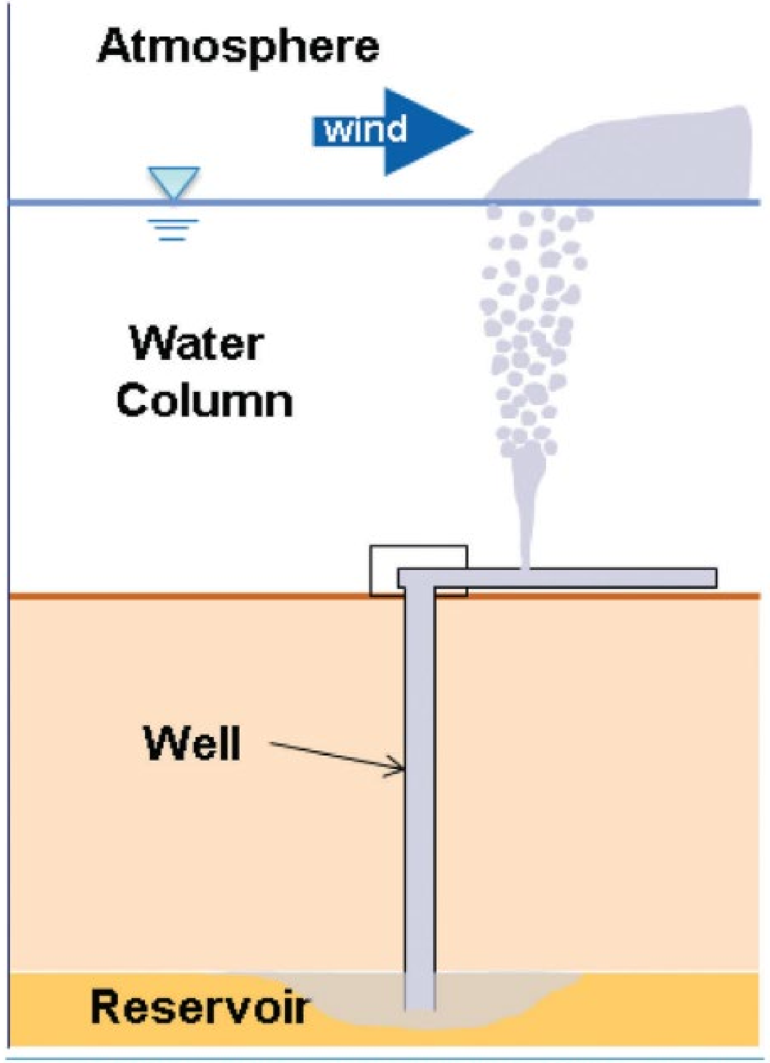


Figure 1. Conceptual model of an offshore CO_2 well with blowout near the wellhead showing the reservoir, well, short pipe segment, water column, and atmospheric regions.

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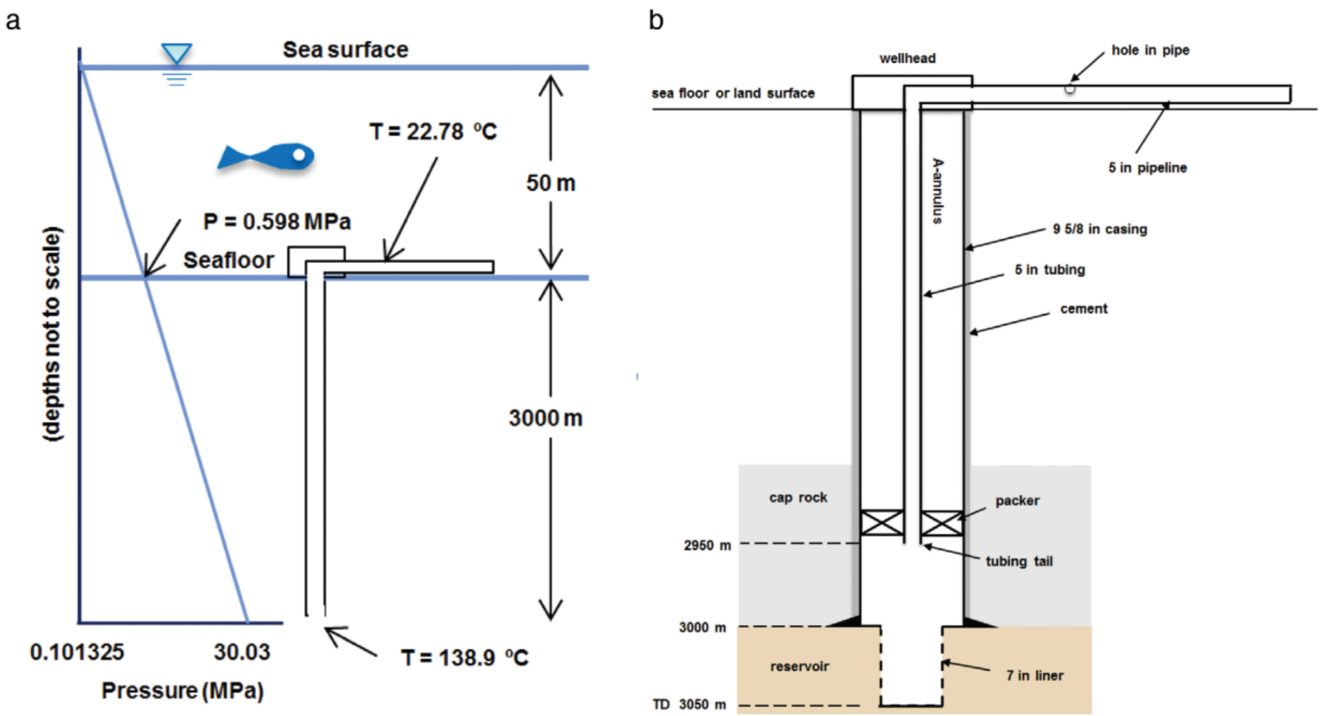
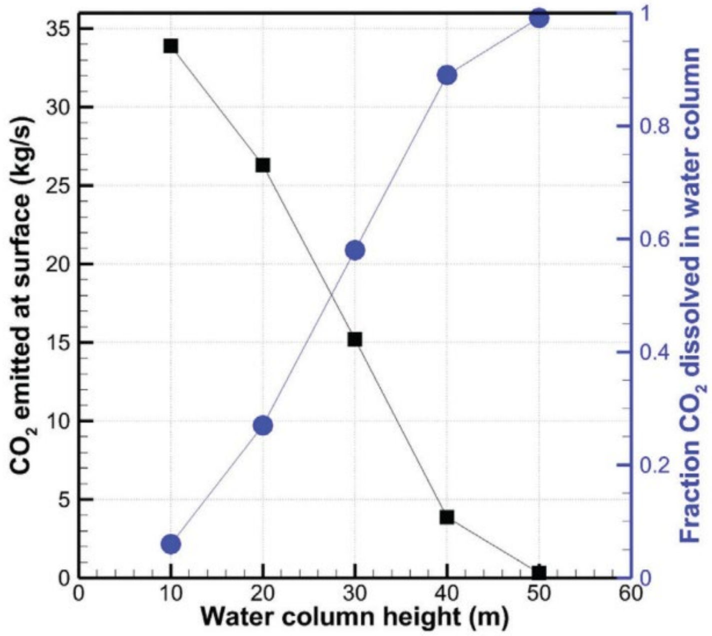
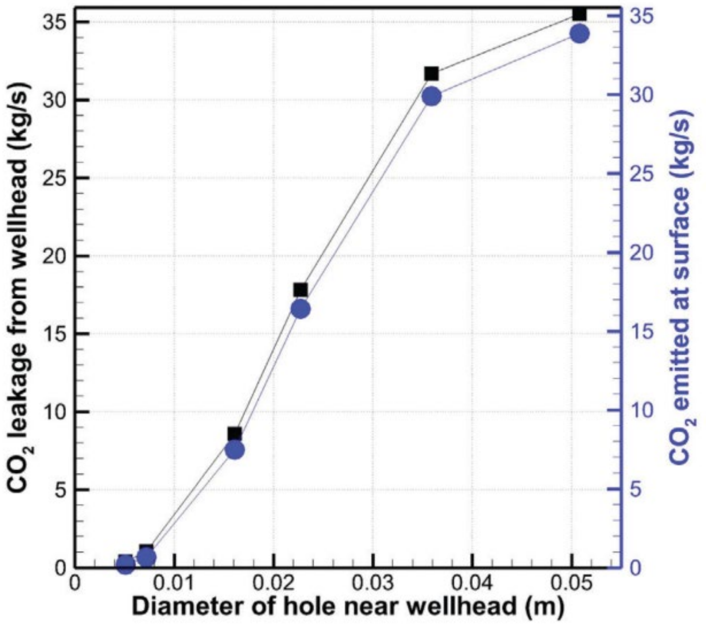


Figure 3. (a) Sketch of pressure, temperature, and depth conditions for the 50-m-deep offshore well, and (b) reservoir and well system domain used in the T2Well blowout simulation.





- Results suggest that a major CO_2 blowout in ≥50 m of water will be almost entirely attenuated by the water column due to CO_2 dissolution into seawater during upward rise.
- In contrast, the same blowout in 10 m of water will hardly be attenuated at all.
- Results also show that the size of the orifice of the leak strongly controls the CO_2 blowout rate.

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Modeling and Analysis

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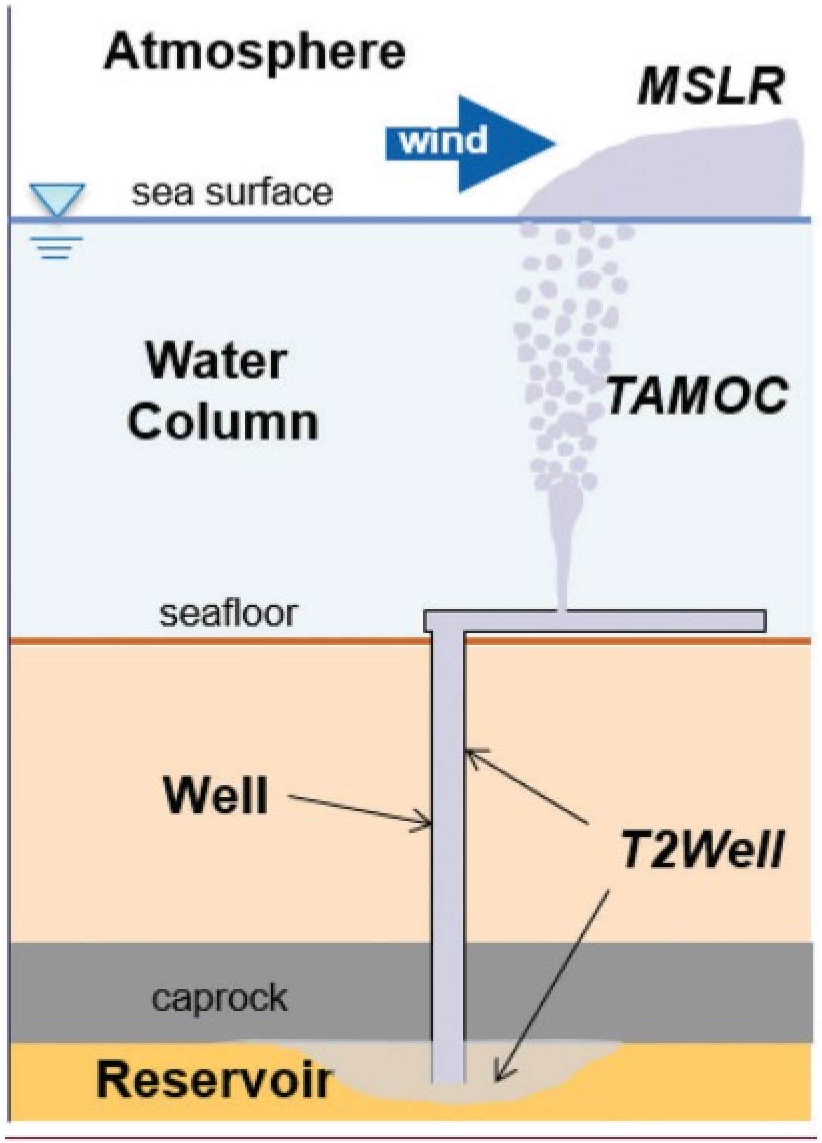
Downwind dispersion of CO_2 from a major subsea blowout in shallow offshore waters

Curtis M. Oldenburg and **Yingqi Zhang**, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

- In the context of risk assessment of human health and safety, we have used previously simulated coupled well-reservoir and water column model results <u>as a source term for dense gas dispersion of CO_2 above the sea surface.</u>
- <u>The models are linked together by one-way coupling</u>, that is, output of one model is used as input to the next model.
- <u>These first-of-their-kind coupled flow results are applicable to assessing the hazard of CO_2 to people at and downwind of the sea surface location of emission.</u>



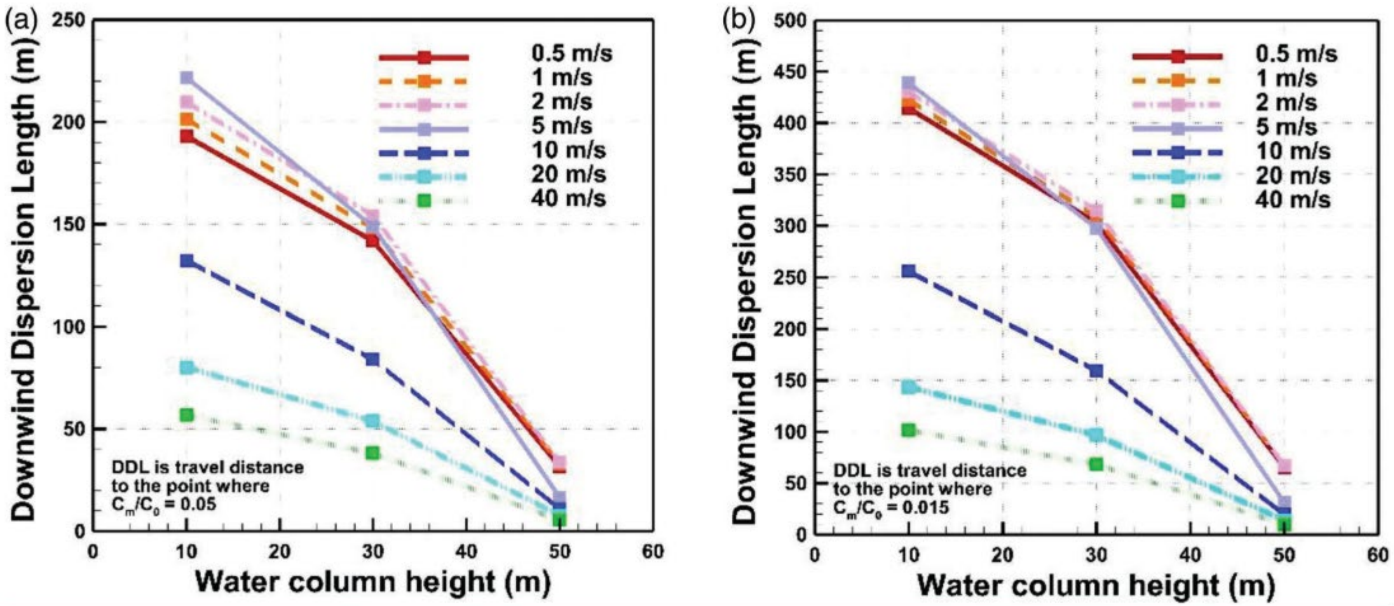


Figure 3. Downwind dispersion length (DDL) for the subsea CO_2 blowout scenarios for different water column heights (different surface leakage rates) and wind speeds for two different critical concentrations: (a) $C_m/C_0 = 0.05$; (b) $C_m/C_0 = 0.015$ (note the different y-axis scales)

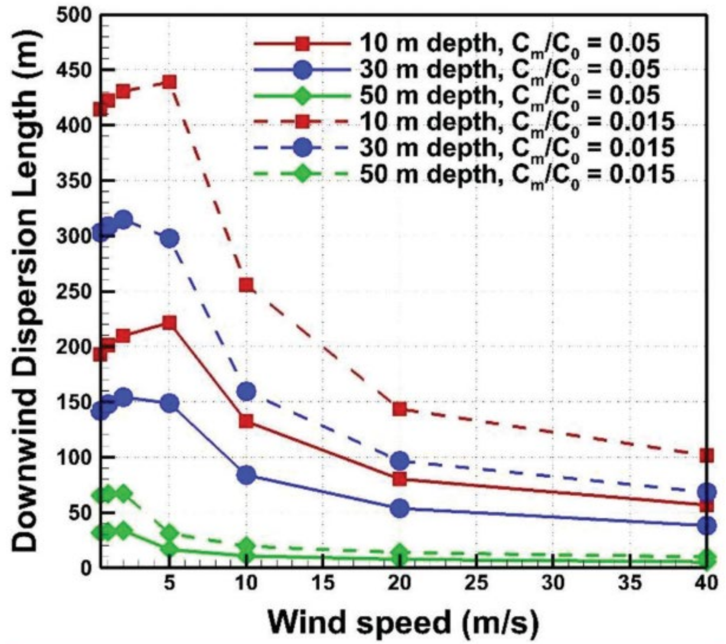


Figure 4. DDL as a function of windspeed for three different water column depths and two different critical concentrations. The plot shows that a maximum DDL occurs for windspeeds of 2–5 m/s depending on the case

- Hazard is quantified by plotting the downwind dispersion length (DDL), which we define in the study as the distances from the emission source to the point at which the emitted CO_2 has been diluted to 5% and 1.5% in air by volume.
- Results suggest that large-scale blowouts in shallow water (10 m) may cause hazardous CO_2 plumes extending on the order of several hundred meters downwind.
- Details of the modeling show DDL has a maximum for windspeed (at an elevation of 10 m) of approximately 5 m/s, with smaller DDL for both weaker and stronger winds.
- This is explained by the fact that wind favors transport but also causes dispersion; therefore there is a certain wind speed that maximizes DDL.

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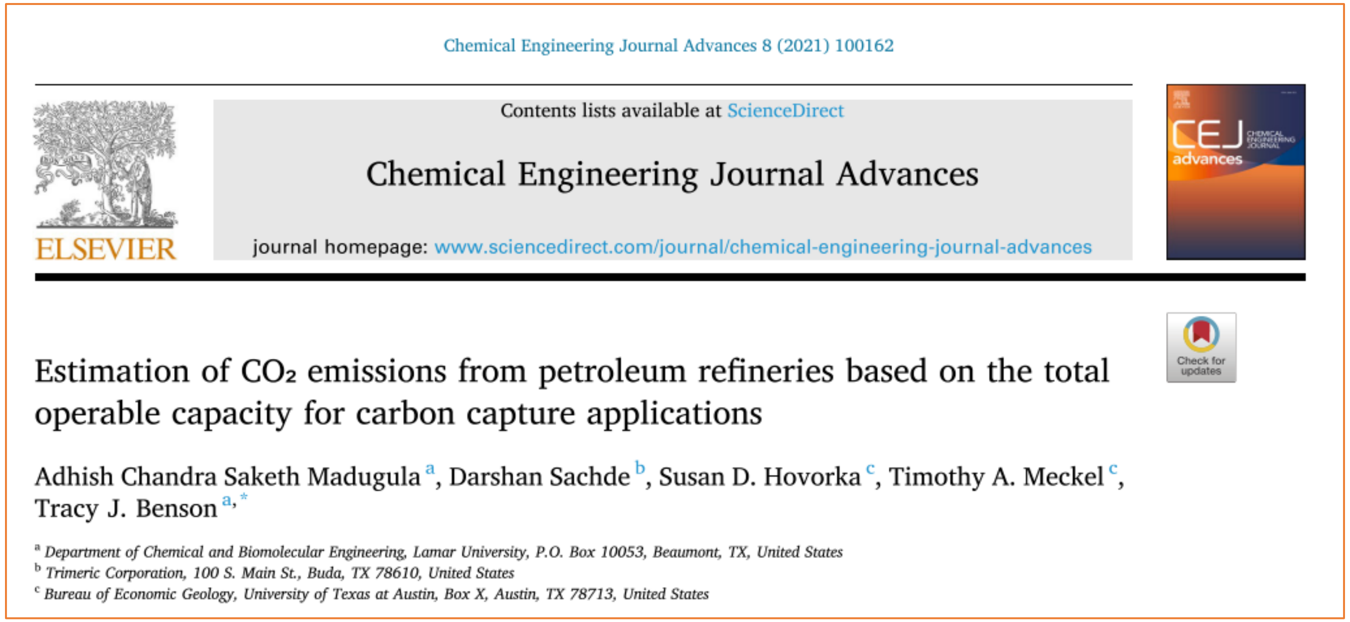
Chemical Engineering Journal Advances 8 (2021) 100162

Contents lists available at ScienceDirect

Chemical Engineering Journal Advances

journal homepage: www.sciencedirect.com/journal/chemical-engineering-journal-advances

Estimation of CO_2 emissions from petroleum refineries based on the total operable capacity for carbon capture applications

Adhish Chandra Saketh Madugula [a], Darshan Sachde [b], Susan D. Hovorka [c], Timothy A. Meckel [c], Tracy J. Benson [a,*]

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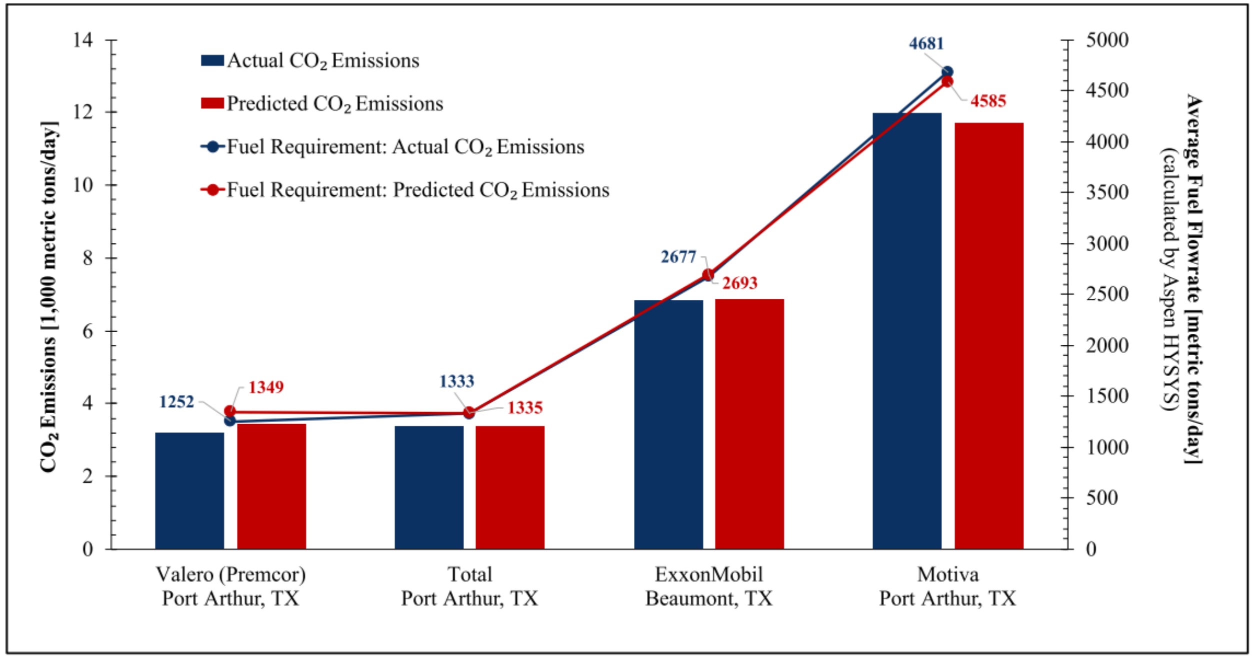
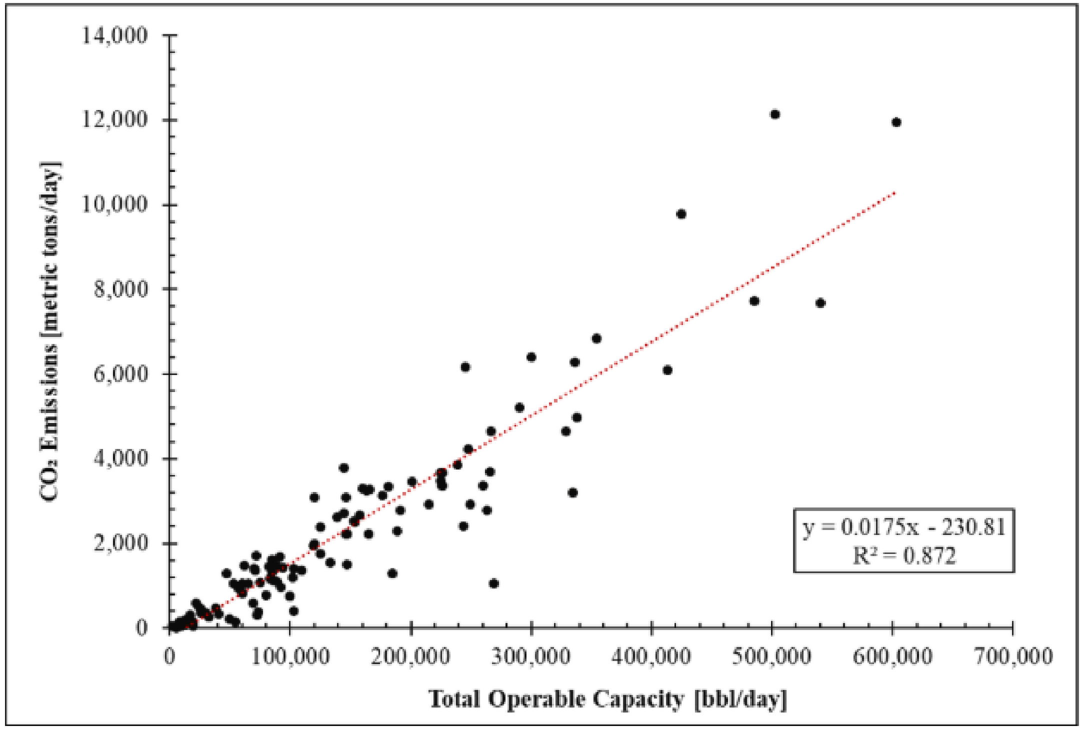
[c] Bureau of Economic Geology, University of Texas at Austin, Box X, Austin, TX 78713, United States





- Petroleum refineries, in particular, produce several streams that are CO_2-rich, including fluidized catalytic cracking, steam methane reforming, and natural gas combustion processes that generate heat for re- finery operations.
- Of these, stationary combustion processes account for nearly two-thirds of all CO_2 generated within a refinery.
- In this work, a regression analysis was performed to correlate the size and power requirements for the combined capture, compression, and dehydration process dependent upon a refinery's operating capacity.
- Refinery capacity and CO_2 generation data from 128 U.S. refineries were normalized, and a linear regression model was developed.

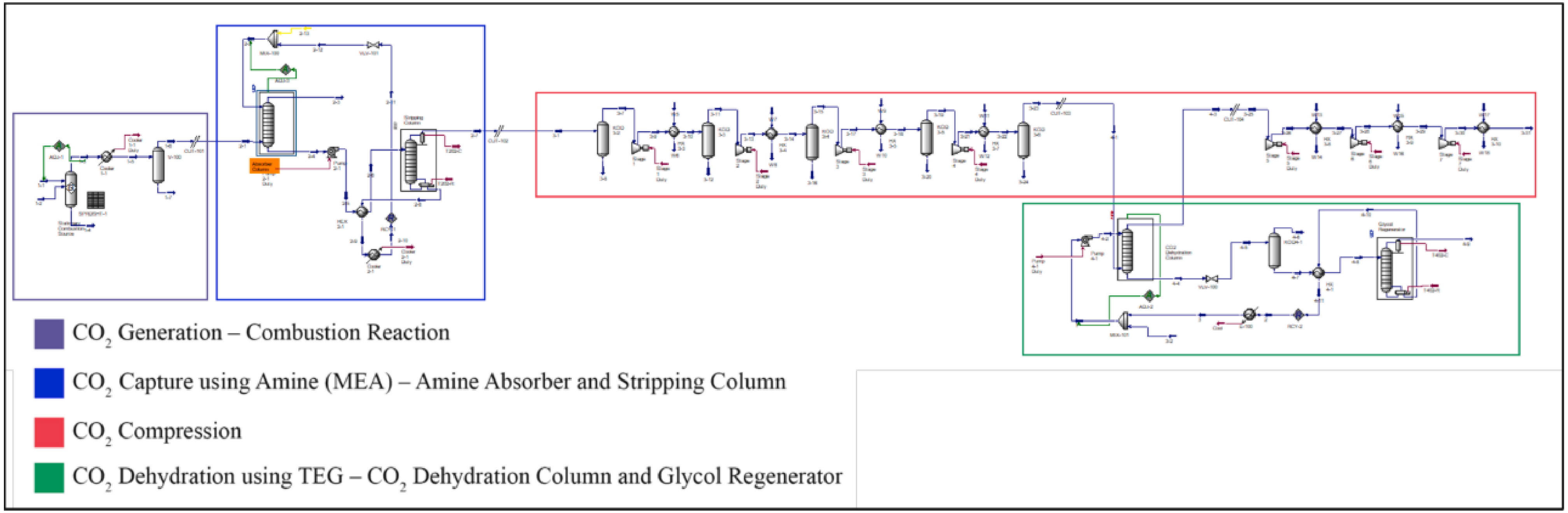
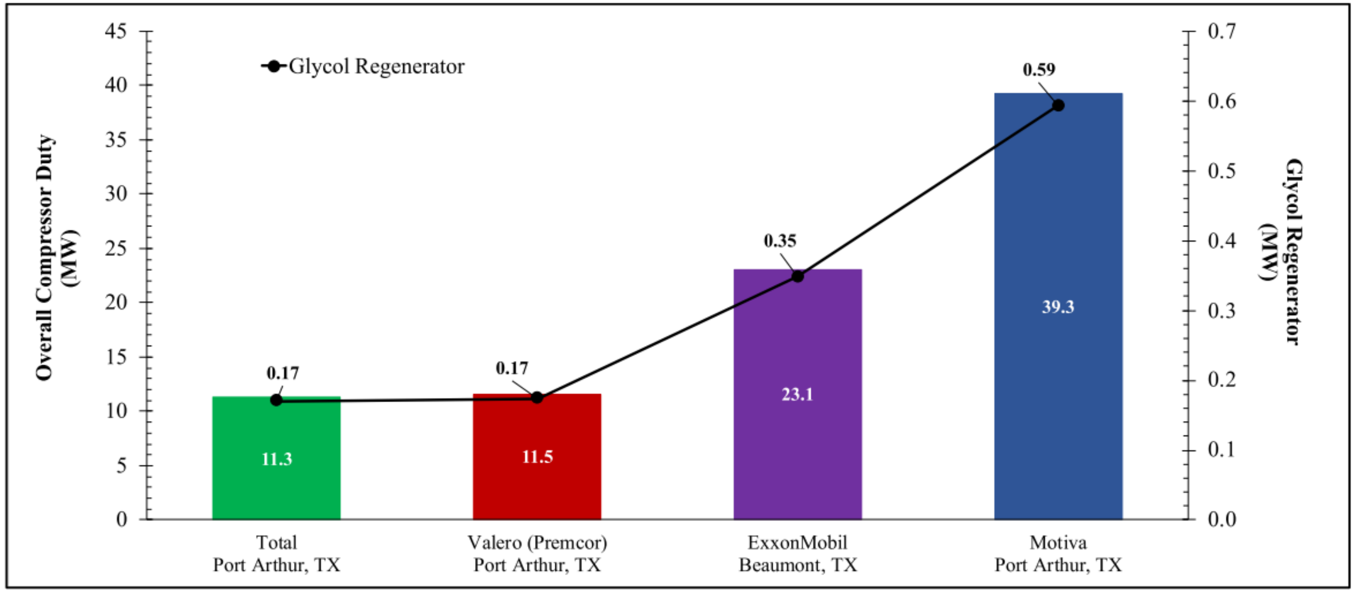


Fig. 2. Aspen HYSYS Simulation of the capture, compression, and dehydration of flue gas CO_2 from stationary combustion source



- A capture, compression, and dehydration process model was developed using Aspen HYSYS for delivery of CO_2 (10–15 wt. % in steam) to pipeline specifications (500 ppm H_2O, 15.2 MPa).
- Predicted CO_2 emissions were 0.1 to 7.7 % of actual emissions, depending on whether a refinery had a low, medium, or high carbon emission/capacity ratio.