
Carbon Solutions
The Webinar Will Begin Shortly

CARBON SOLUTIONS

Location, Location, CO_2 Removal: A Data-Driven Approach to DAC Siting

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Carbon Solutions Webinar Series: NECTAR

April 24, 2024

By definition, a net-zero emission target includes carbon dioxide removal (CDR)

Otherwise, it would be a zero-emission target

Why is CDR Needed?

1. Accelerate the pace of reaching net-zero

between now and whenever we hit net-zero

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1. Accelerate the pace of reaching net-zero

between now and whenever we hit net-zero

2. Offset emissions from “hard to decarbonize” sectors/processes

after we hit net-zero, if we move fast enough

3. Remove past emissions so we can “hit” warming targets

after we hit net-zero, if we don’t move fast enough

IPCC 2022 Mitigation of Climate Change Report:

Global GHG emissions are projected to peak *before 2025* in pathways that limit warming to 1.5 C and 2 C

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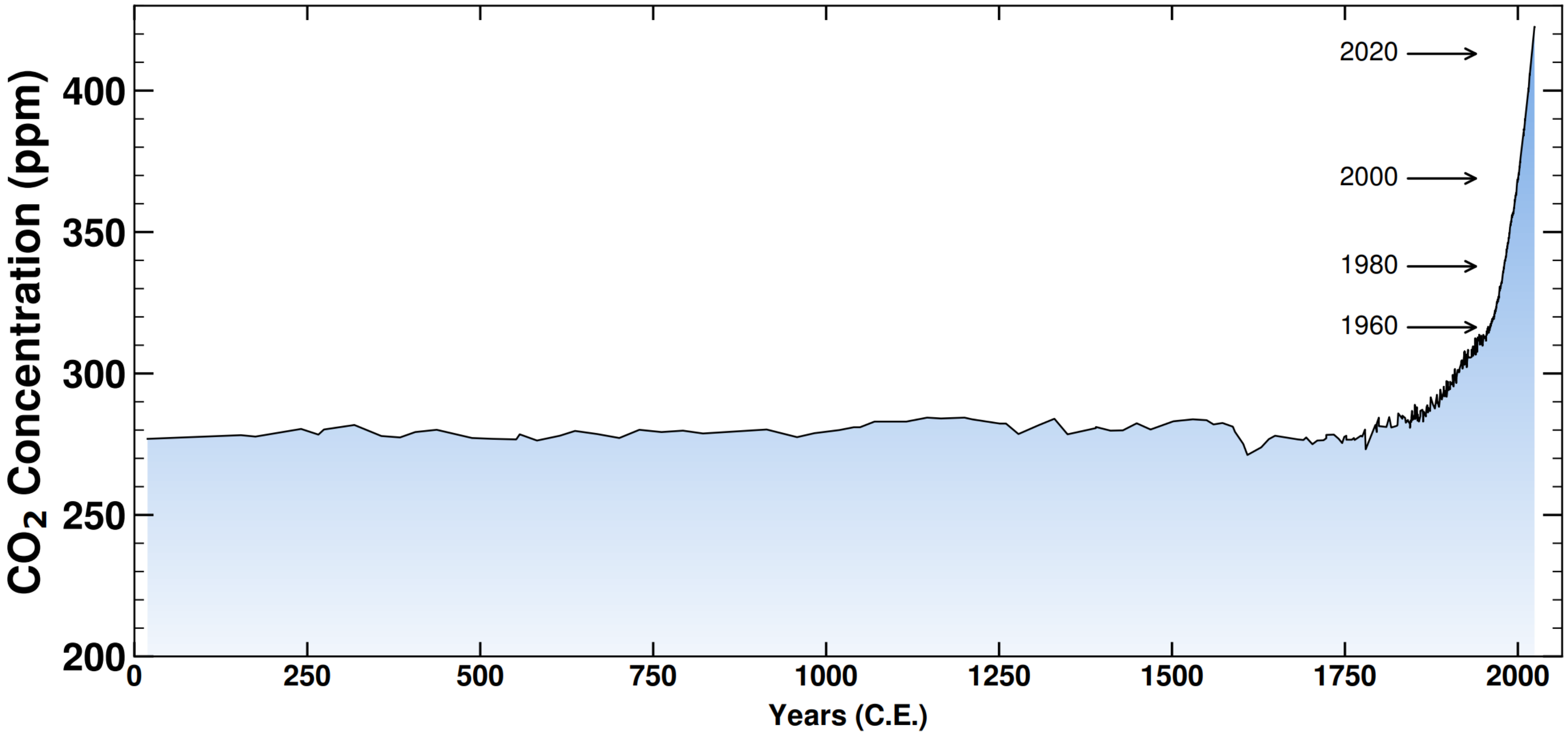

https://keelingcurve.ucsd.edu/

DAC is one approach to CDR

“Direct air capture (DAC) is removing CO_2 from the air using machines built for that purpose”

-LLNL 2020 Getting to Neutral Report

https://www.reuters.com/sustainability/climate-energy/climate-tech-company-heirloom-opens-us-commercial-carbon-capture-plant-2023-11-09/

https://climeworks.com/press-release/climeworks-launches-orca

How Much DAC is Needed in the USA in 2050?

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Short Answer: zero to hundreds of $MtCO_2$

For reference, DOE "DAC Hubs" funding will contribute funding towards 4 $MtCO_2$/yr

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Longer Answer

LCRI Net Zero America

- Maximum in "High Fuel Cost" scenario: 134 $MtCO_2$ in 2050
  - In this scenario, bioenergy feedstock is limited. In other scenarios, no DAC is deployed because traditional CCS is cheaper and ample bioenergy for renewable fuels and BECCS

IPCC Sixth Assessment Report (AR6)

- Maximum across all models and scenarios: 464 $MtCO_2$ in 2050

Princeton Net Zero America

- Maximum in "E-" scenario: 720 $MtCO_2$ in 2050
  - In this scenario, less electrification of transportation and no new land converted to biomass production.

Where Should DAC Be Deployed?

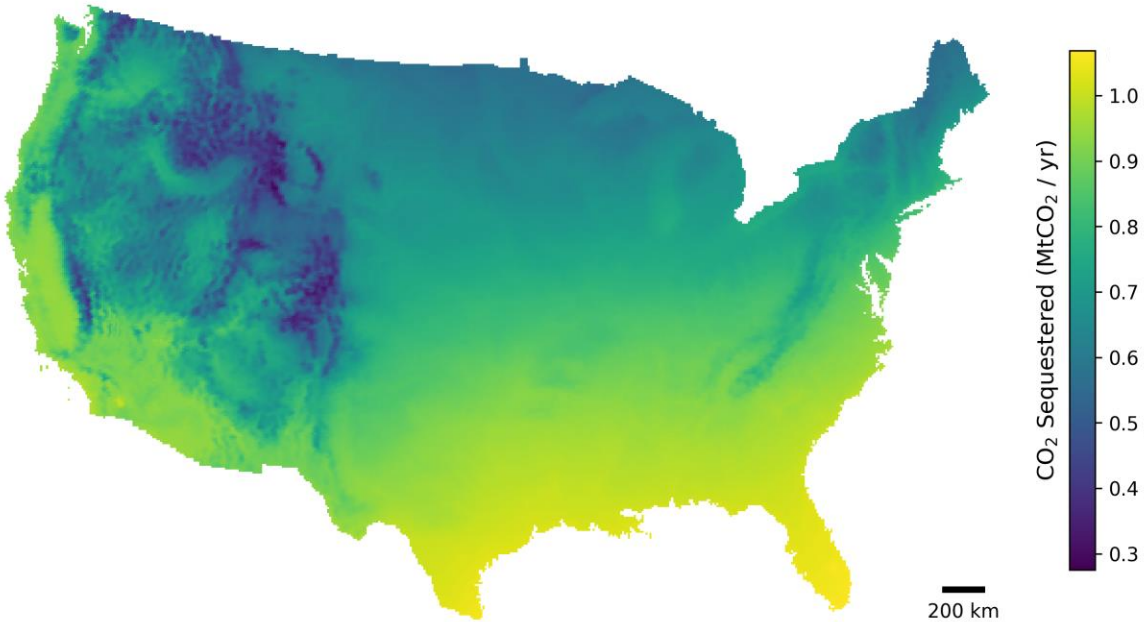
…it depends

1. How will the performance change due to weather?

Magnitude and variability

DAC Systems Can Be Much Different Than One Another

Liquid-Solvent ("High-Temperature") DAC



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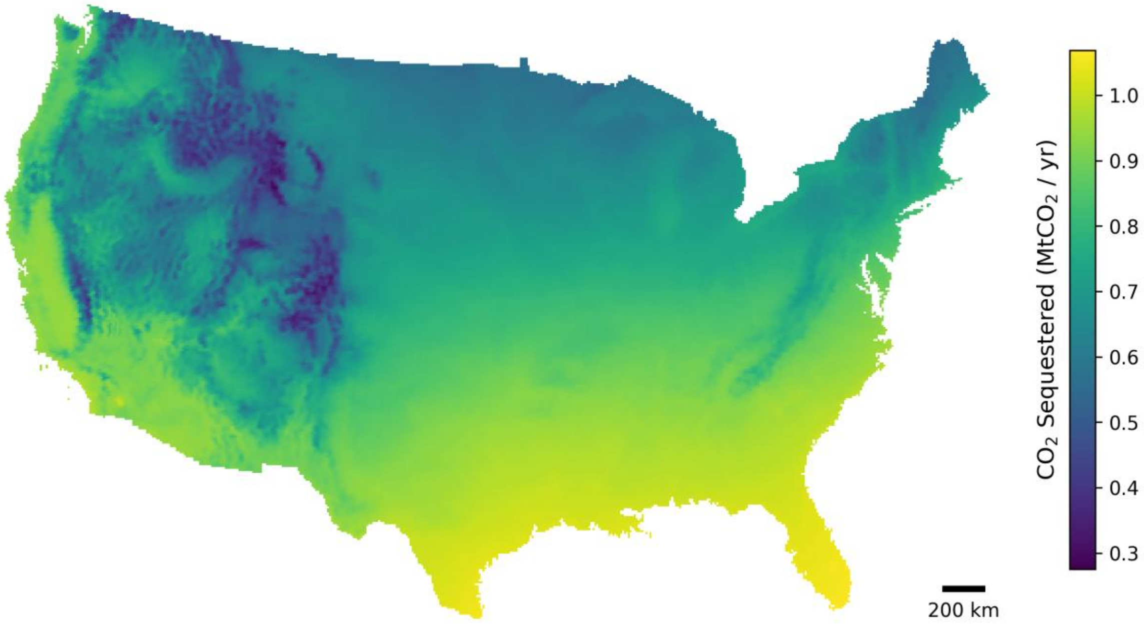

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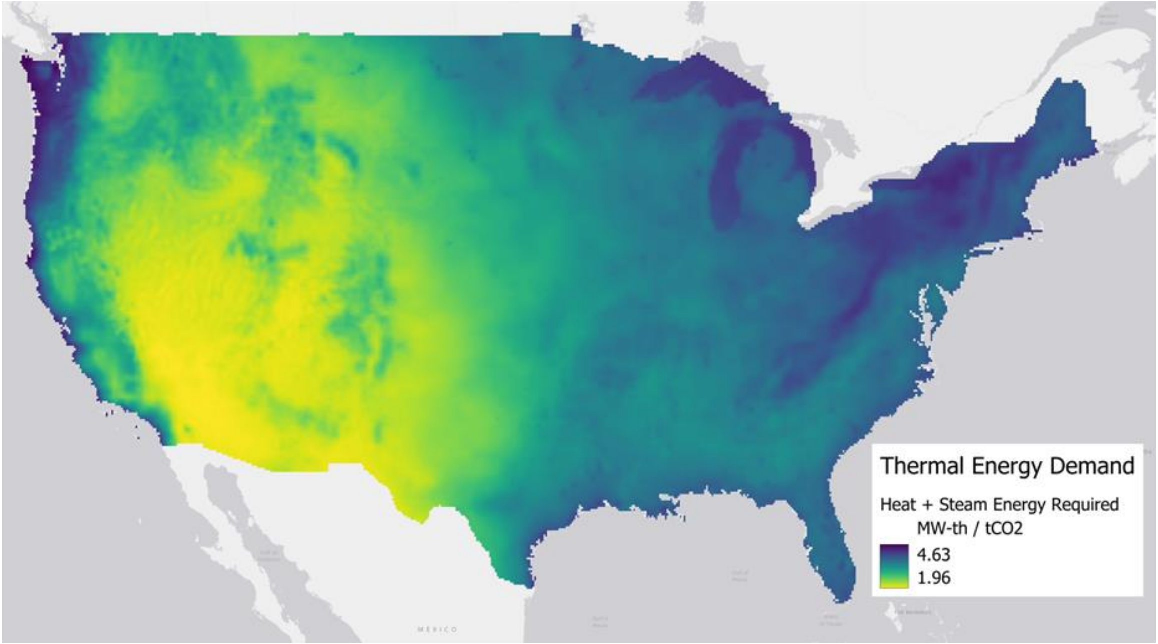
Solid-Sorbent ("Low-Temperature") DAC



Ogland-Hand et al (2024). *Meeting Net-Zero America Direct Air Capture Targets with Sedimentary Basin Geothermal Heat While Considering Environmental Justice*

…it depends

1. How will the performance change due to weather?

Magnitude and variability

2. How will DAC be powered?

Electrical *and* thermal energy

3. Where will the captured CO_2 be stored?

Should the CO_2 be transported?

4. Where will DAC provide the most community benefits?

Energy system disproportionally affects disadvantaged communities

5. Many other considerations

Water use, business model, land ownership, …

Deploying DAC is…

Negative CO_2 Emission Transition Roadmap (NECTAR)

"Taking it from rocket science to routine"

Negative CO_2 Emission Transition Roadmap (NECTAR)

Data-driven approach to DAC Siting

- Quantify geospatial tradeoffs

Development funded by DOE's SBIR program

- Phase I: Feb 2022 – Feb 2023
- Phase II: April 2023 – April 2025

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Three case studies

- NGO
- CO_2 storage developer
- DAC developer

"Taking it from rocket science to routine"

Case Study 1

Client/Customer: Non-governmental Organization (NGO)

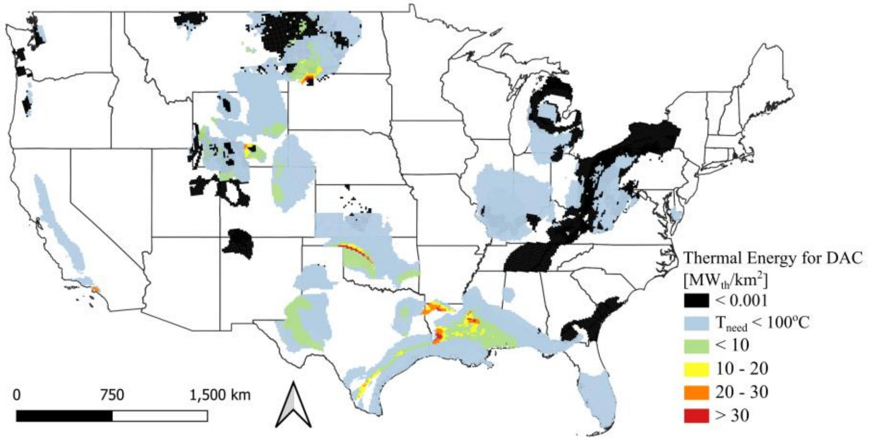
Carbon Solutions Engagement: Consultant

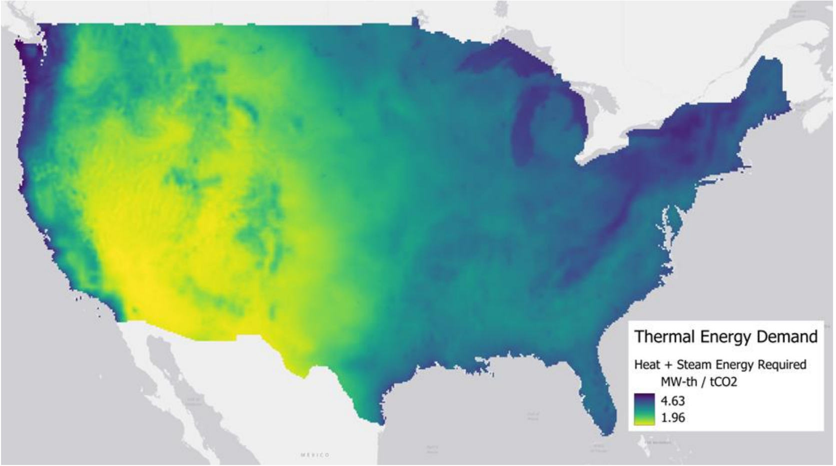
Task: Investigate if the United States can achieve energy transition targets using geothermal heat to deploy DAC in, or outside of, disadvantaged communities?

Case Study 1: NGO

Scientific Foundation

- Conference Paper (*Stanford Geothermal Workshop*)
- Process-level modeling of sedimentary basin geothermal heat across the United States
- Solid-sorbent (“Low-temperature”) DAC system with 20-year average of high-resolution weather data
- Energy category of Climate and Economic Justice Screening Tool used to define disadvantaged communities
  - Are at or above 90th percentile of energy cost OR or PM2.5 in the air
  - Are above 65th percentile for low income





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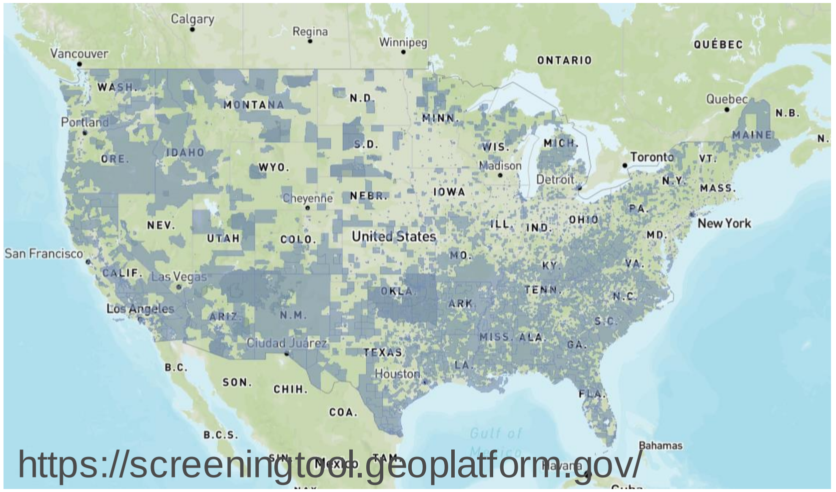


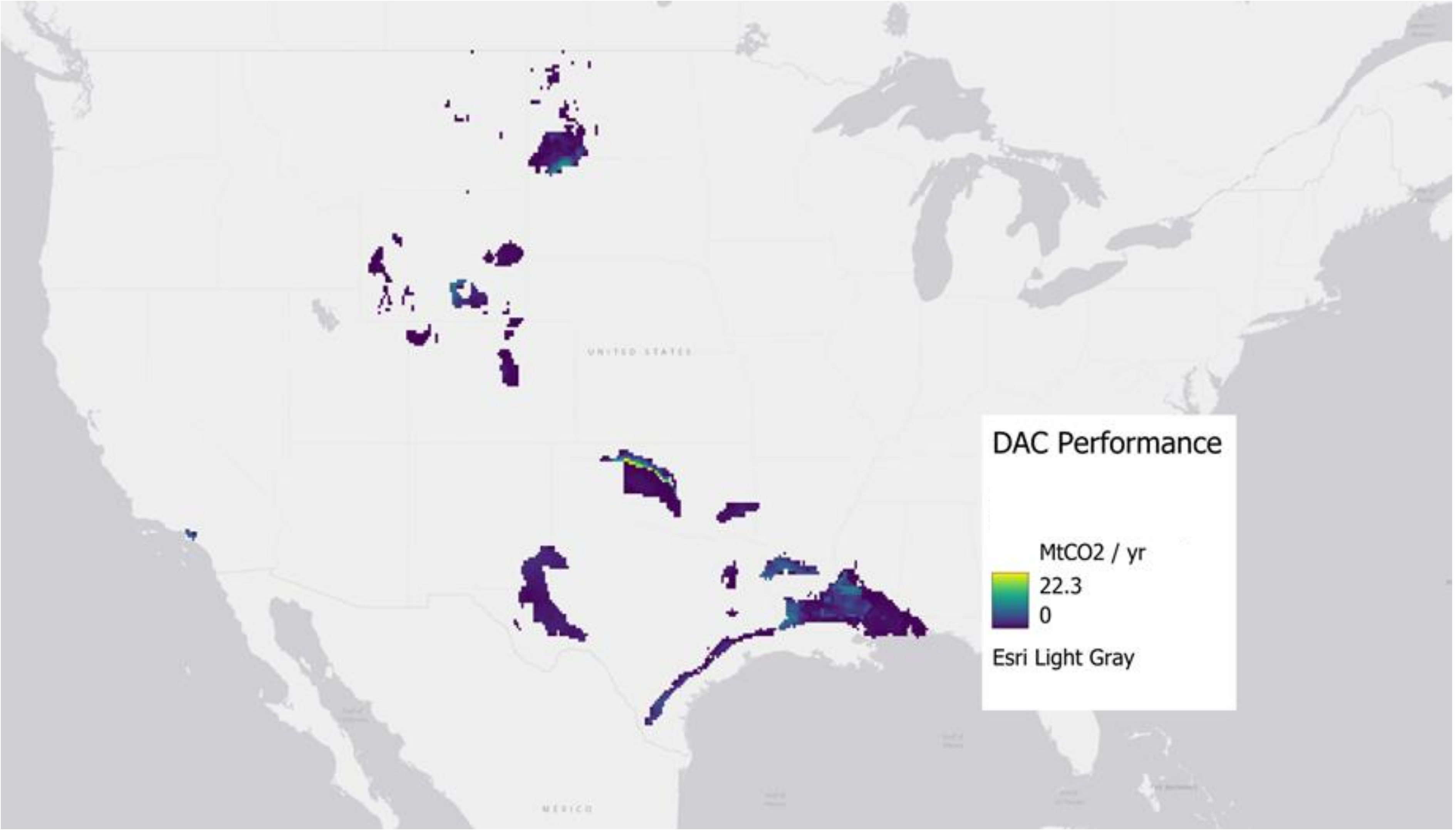
https://screeningtool.geoplatform.gov/

Best locations

- High quantity of geothermal heat
- Persistent weather favoring lower thermal energy demand
- Oklahoma and South Dakota better than Louisiana and Mississippi

Worst locations

- Near-zero potential due to near-zero heat



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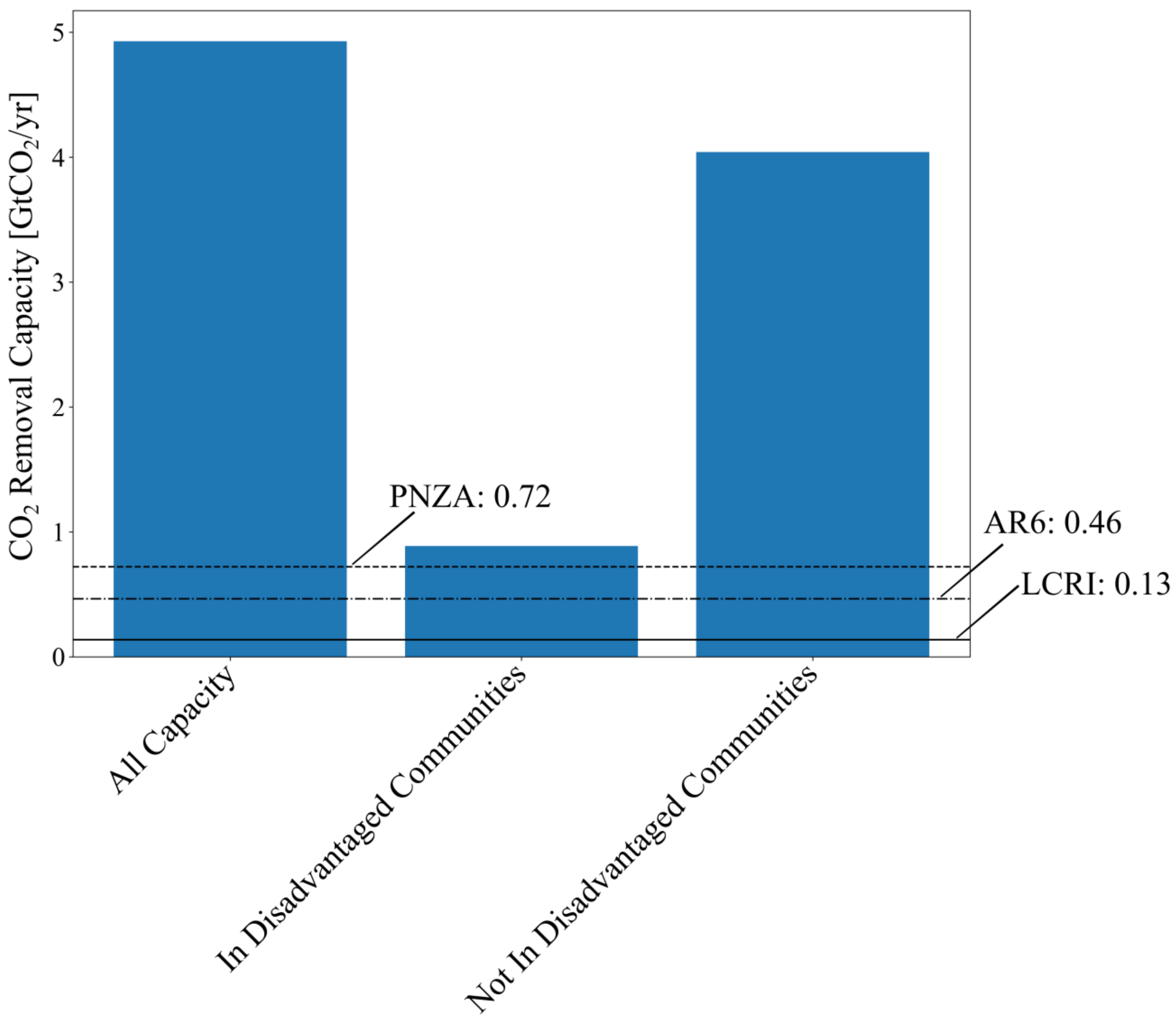
Case Study 1: NGO

Total: 4.9 $GtCO_2$/yr

- Order of magnitude more than needed to hit energy transition goals

Environmental Justice

- Sufficient capacity to hit goals, regardless of it occurs within or outside of disadvantaged communities



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Case Study 2

Client/Customer: CO_2 Storage Developer, down-selecting sites to develop

Carbon Solutions Engagement: Consultant

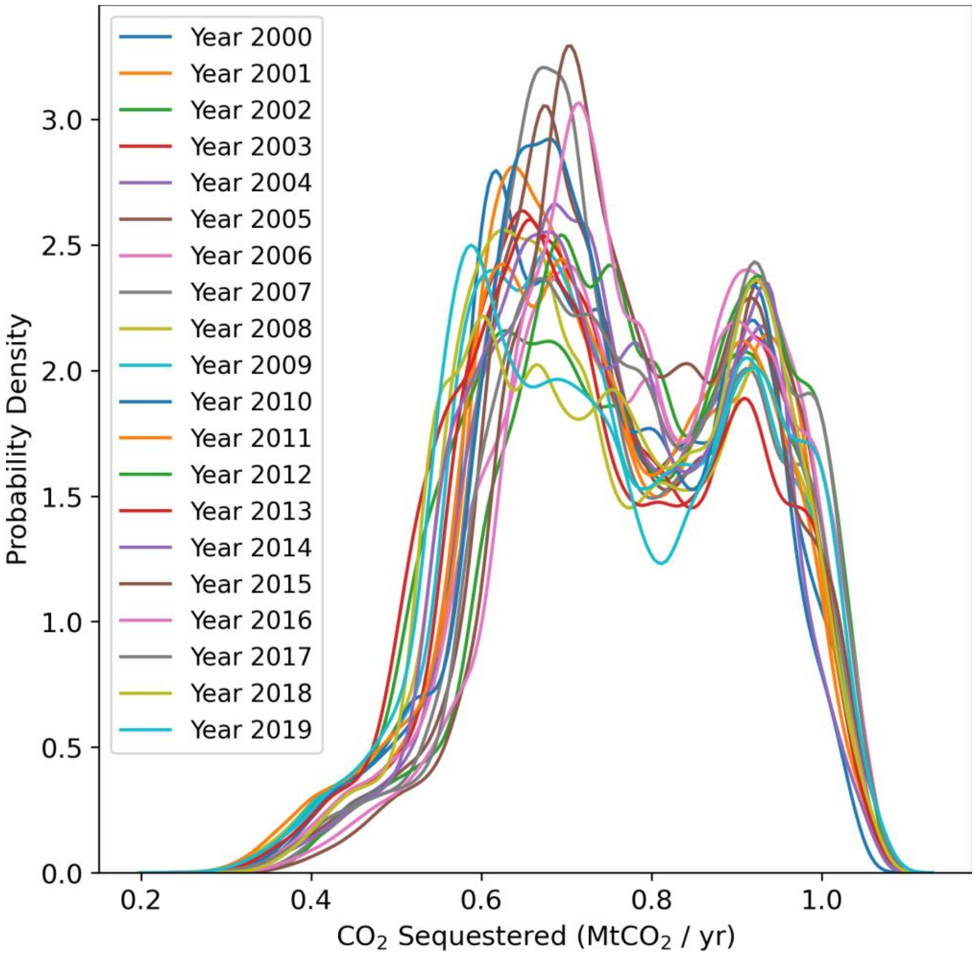
Tasks

- **High-temperature DAC:** Considering developing in LA vs Burbank, which location has better weather?
- **Low-temperature DAC:** Considering developing a CO_2 storage site in the Midwest: 1) What CO_2 emitters are in the area? 2) How do the energy requirements for low-temperature DAC change as a function of weather?

Case Study 2: CO_2 Storage Developer | High-Temperature DAC

Scientific Foundation

- Peer-reviewed paper (*Frontiers in Climate*)
- Process-level modeling of a 1 $MtCO_2$/yr liquid solvent DAC system
- Used 20 years of high-resolution reanalysis weather data



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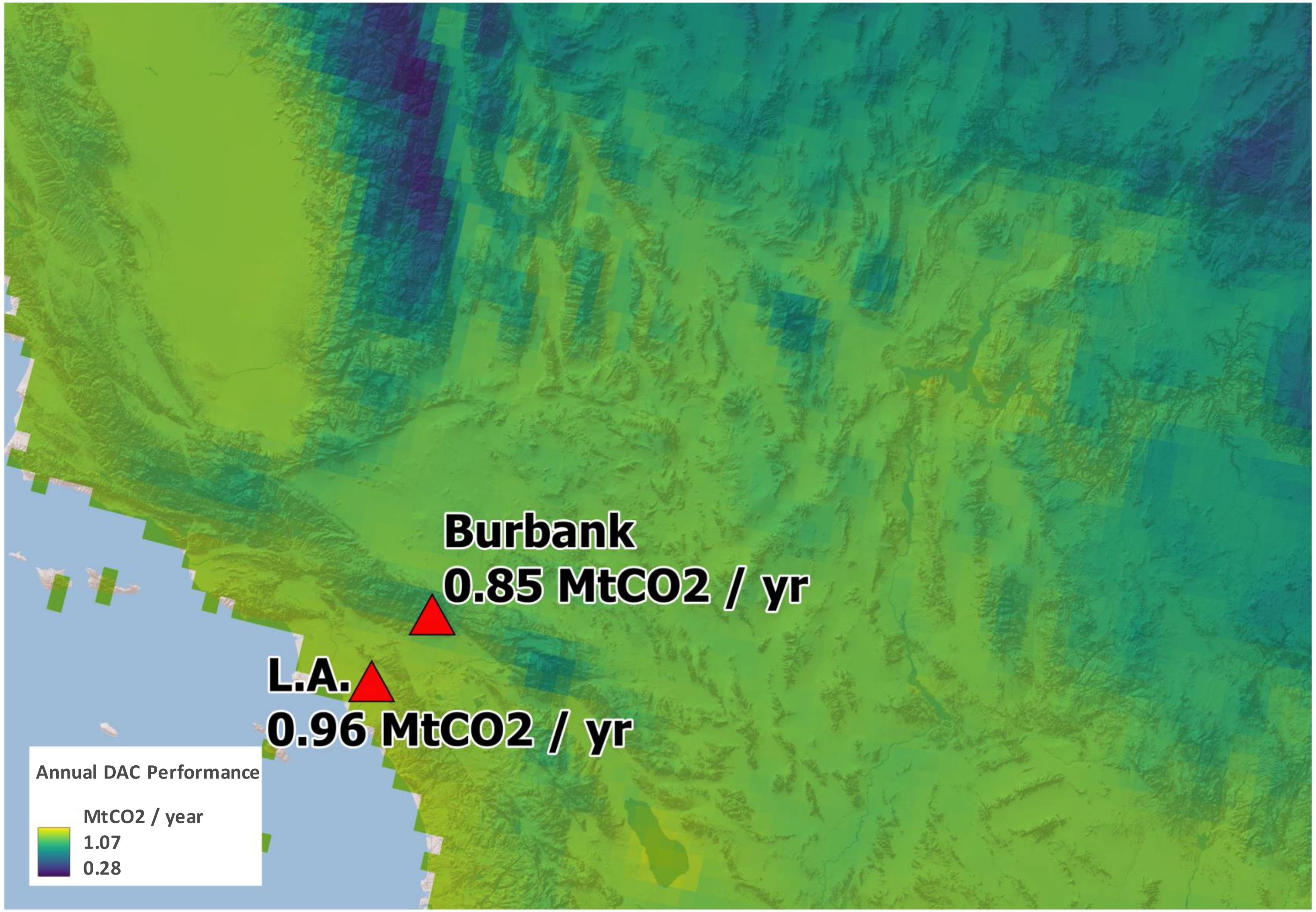
Case Study 2: CO_2 Storage Developer | High-Temperature DAC

Impact of weather

- Difference between Burbank and L.A. is on average 110,000 tCO_2/yr

Revenue

- Under 45Q, each tonne sequestered is worth $180
- 110,000 tCO_2/yr equates to ~$20M/yr difference



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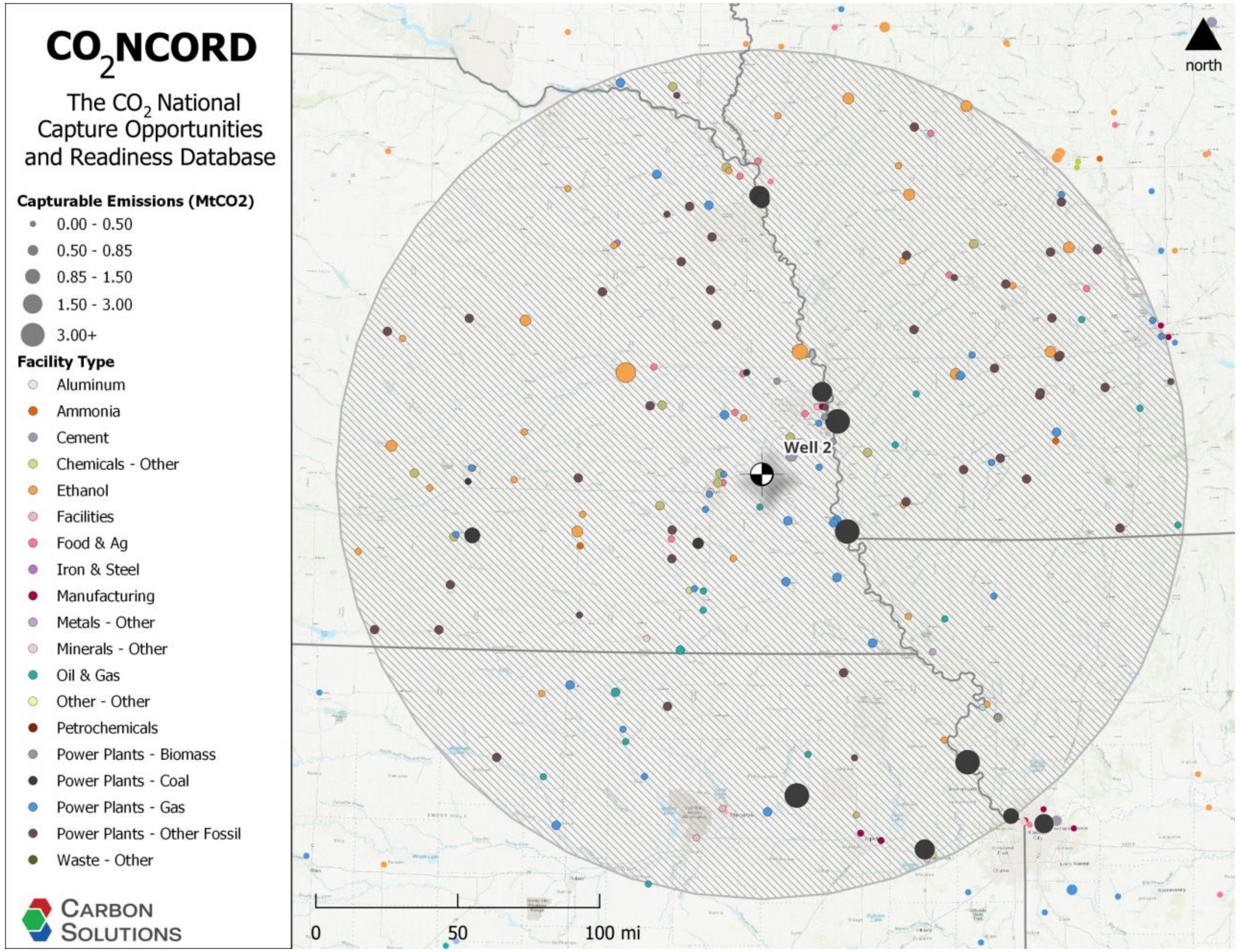
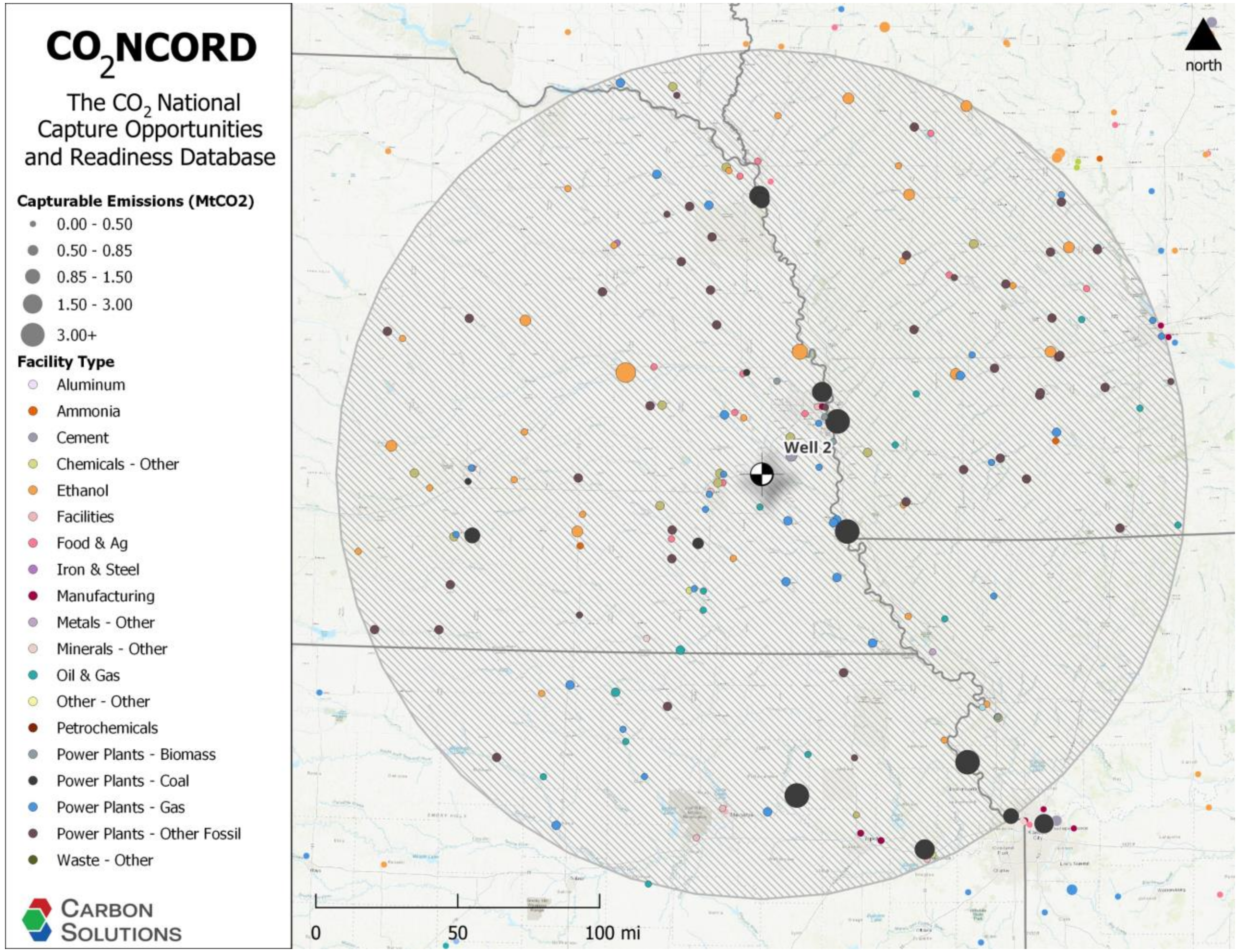
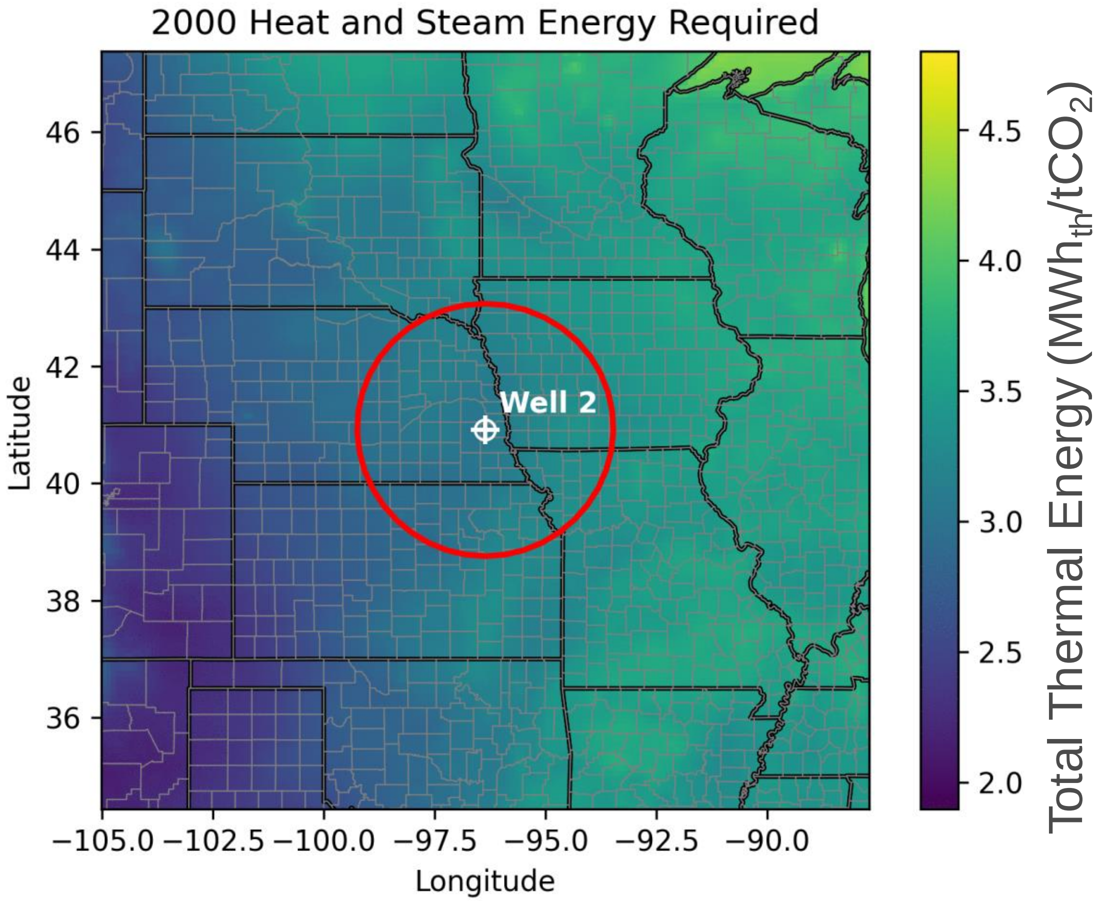
Case Study 2: CO_2 Storage Developer | Low-temperature DAC



Project SiMBa CarbonSAFE with Avalon

Case Study 2: CO_2 Storage Developer | Low-temperature DAC





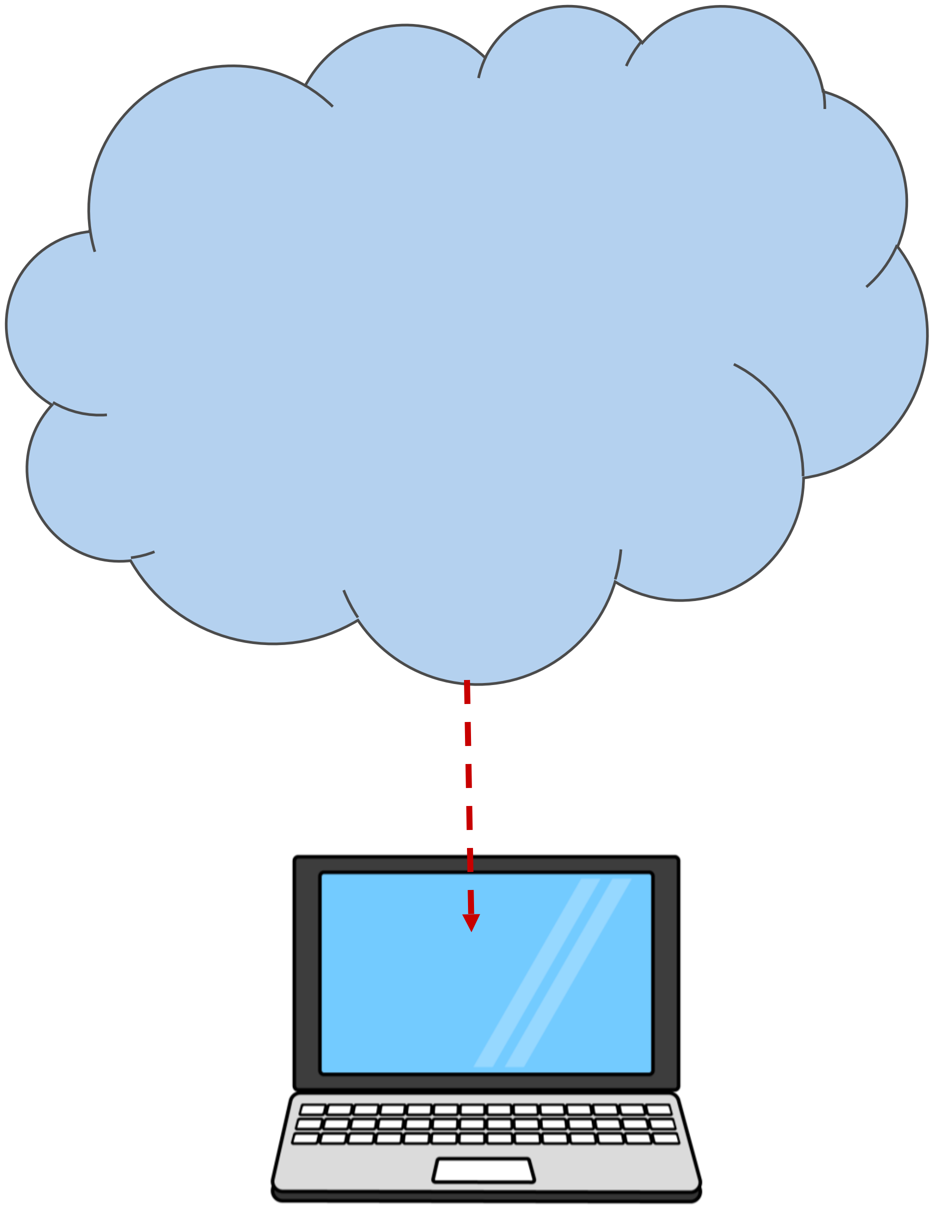
Project SiMBa CarbonSAFE with Avalon

Case Study 3

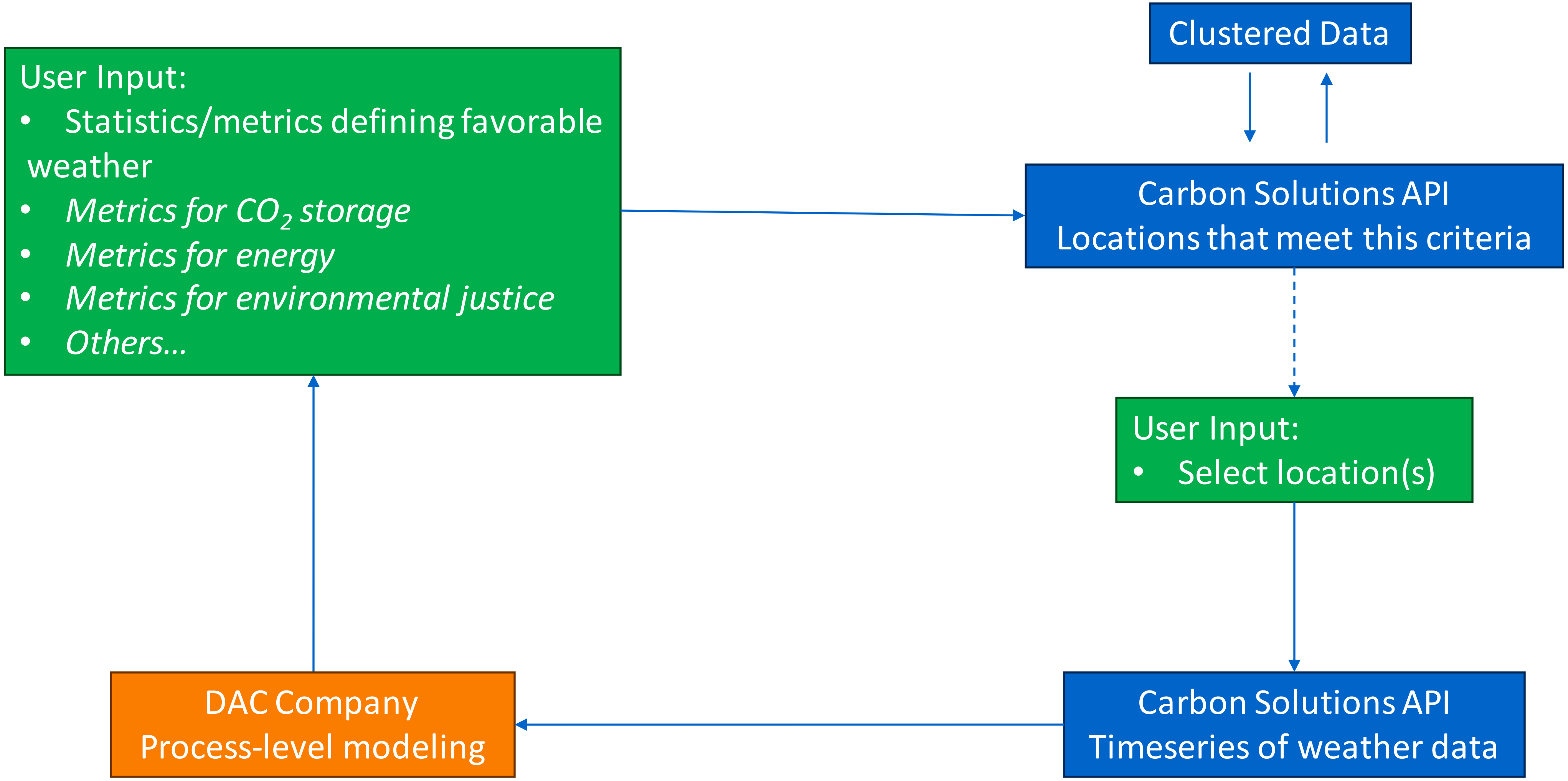
Client/Customer: DAC Developer, optimizing their proprietary design

Carbon Solutions Engagement: Software-as-a-Service (SaaS)

Tasks: What regions of the US are representative of the weather our DAC system needs?



Case Study 3: DAC Company



Case Study 3: DAC Company

Overall Framework

User input
Metrics for many weather variables

↓

Results
1) Groups that meet this criteria
2) Map of the groups

↓

Outputs
- Timeseries of hourly weather data

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Outputs
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Simple Example Demonstration For This Webinar

one weather variable (air temperature) and two metrics of that variable

User input
- Range in mean annual temperature [C]
- Annual temperature variability [C]

Results
1) Clusters that meet this criteria
2) Map of cluster locations

Outputs
- Timeseries of hourly weather data

Case Study 3: DAC Company

Take Aways

Deploying DAC is “harder than rocket science”

- Many inter-related geospatial factors

Our solution is NECTAR

- Data-driven approach for balancing geospatial tradeoffs
- Consulting (currently available)
- SaaS (coming soon!)

DOE Award DE-SC0022486

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Example Case Studies

- NGO doing policy analysis (consultants)
- CO_2 storage developers down-selecting sites (consultants)
- DAC developers optimizing their process designs (SaaS)

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We’re just getting started

- Geospatial considerations: energy, water requirements, CO_2 storage
- Analyses: risk assessments, hub prospecting, spatial representativeness
- Capabilities: user-friendly front end, APIs

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Thank you!

NECTAR:

The Negative CO_2 Emission Transition Roadmap

Innovative DAC siting platform that empowers users to make informed decisions and balance geospatial tradeoffs

Optimize DAC Siting: identify ideal locations with the best weather for CO_2 productivity, energy consumption, cost, etc.

Enhance Design & Modeling: integrate weather data into your DAC modeling processes for robust and climate-resilient designs.

Foundational Decision-Making: gain valuable insights into weather volatility and representativeness to maximize long-term project performance.

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Hourly Reanalysis Weather Data

Representative Seasonal Metrics

Advanced data reduction algorithms for fast response

Integrable with process-level DAC models

API service

Revolutionize your DAC siting decisions with comprehensive weather data and analysis

Data-driven Weather Intelligence

Hourly, 10 km reanalysis data: Access a comprehensive 70-year weather dataset (1950-present) with high spatial resolution.

59+ available weather parameters: Gain insights into crucial factors like temperature, humidity, wind speed, and more.

Advanced location matching: Identify multiple locations with weather conditions similar to your desired location.

Seasonality & volatility analysis: Understand annual weather patterns, potential weather fluctuations, and extreme events at different locations.

Flexible data access: Download specific data for targeted locations or utilize our API for seamless integration into your workflows.

Contact us: jonathan.ogland-hand@carbonsolutionsllc.com