Environmental Monitoring and Stakeholder Engagement in the GoM Region: Progress and Next Steps

Presented by
Katherine Romanak

Funding Acknowledgement

Partnership for carbon capture & offshore geologic storage

GoMCarb

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Accelerating CCS Technologies

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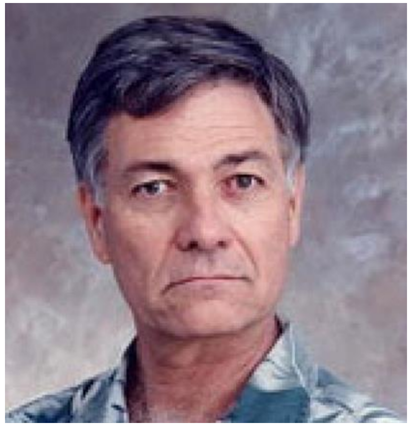

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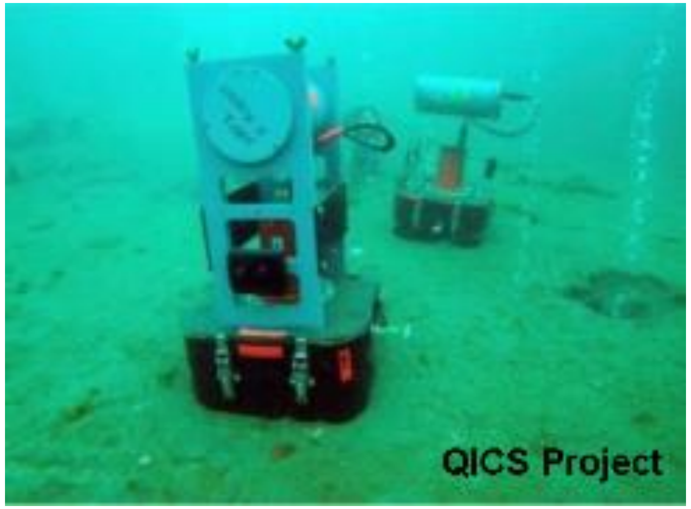
Approach to Offshore Environmental Monitoring

- Consider learnings from:
  - US Regional Carbon Sequestration Partnerships
  - Collaboration on international offshore projects (Tomakomai, STEMM-CCS)
  - Knowledge sharing at the International Workshop on Offshore Geologic CO_2 Storage Series
- Apply these strategies with regard to the specific marine processes in the GoM
- Identify knowledge gaps in the GoM
- Determine direction of future work

Components of Environmental Monitoring

1. Locate anomalies at the seabed
2. Attribute the source of anomalies (leakage or natural variability?)
3. Quantify any leakage that occurs
4. Public assurance of environmental protection



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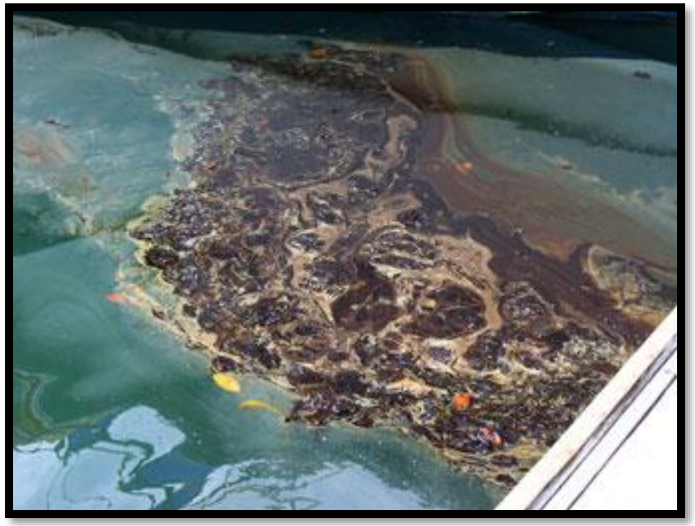
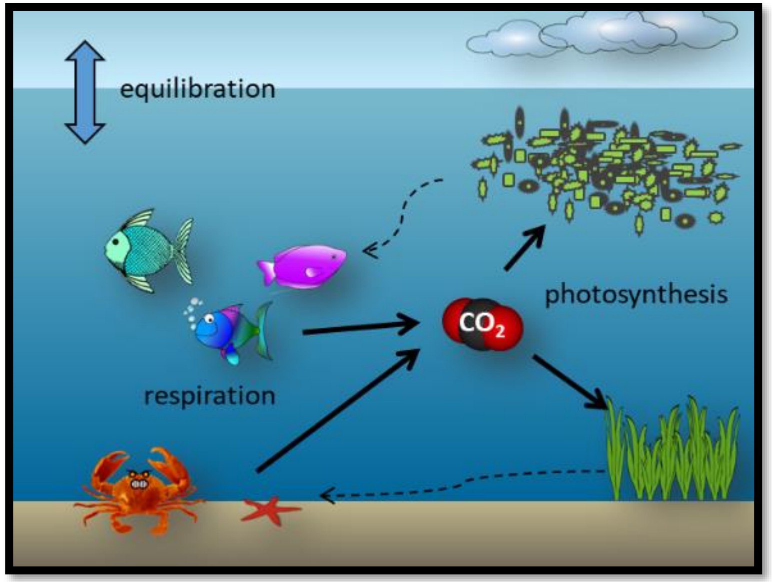
Monitoring Challenge

Common marine pollutants are foreign to the environment and easily attributed



CO_2 is a natural ecosystem Component. Source attribution is complex



Courtesy of Jerry Blackford

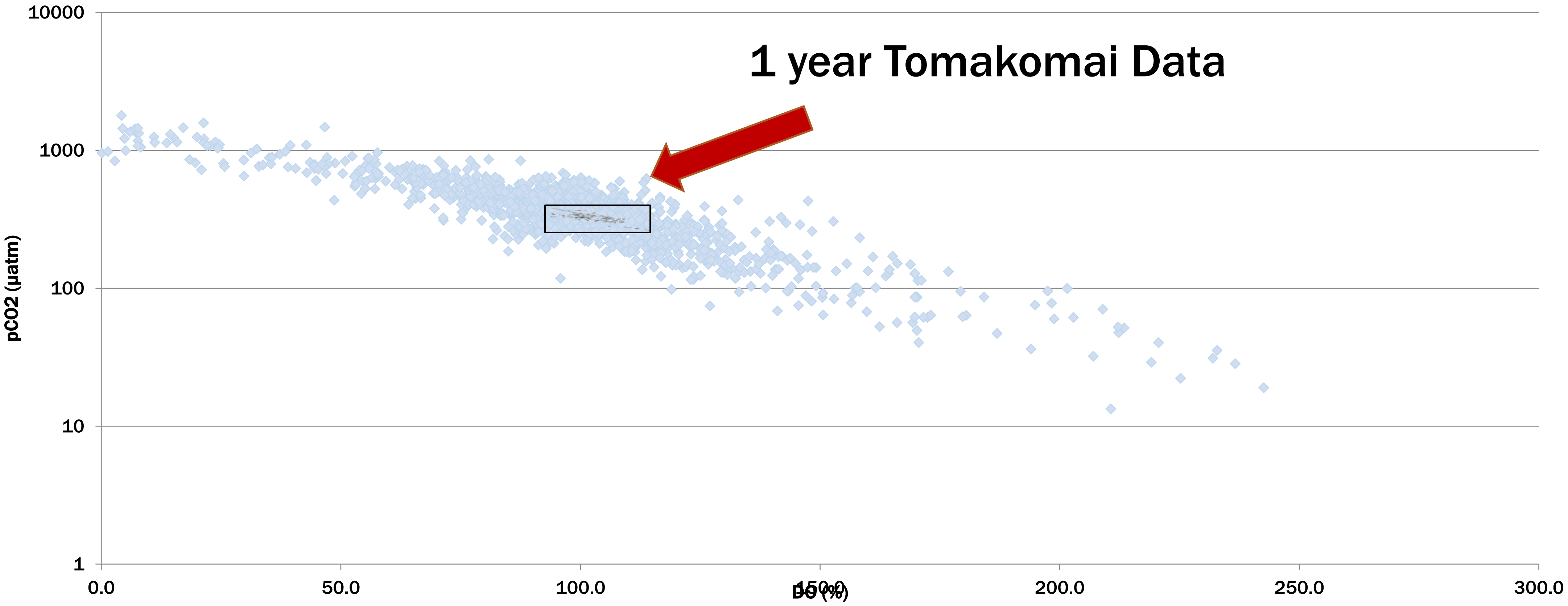
Tomakomai Project

- Tomakomai Offshore demonstration project Hokkaido Japan
- Derived leakage thresholds from 1 year of baseline data
- Injection began April 2016 with routine environmental monitoring plan
- May, 2016, operations were halted after 7,163 ton CO_2 was injected
- High CO_2 levels observed in the routine monitoring
- February 2017 operations resumed

False positives due to chemical variability are a potential risk to projects

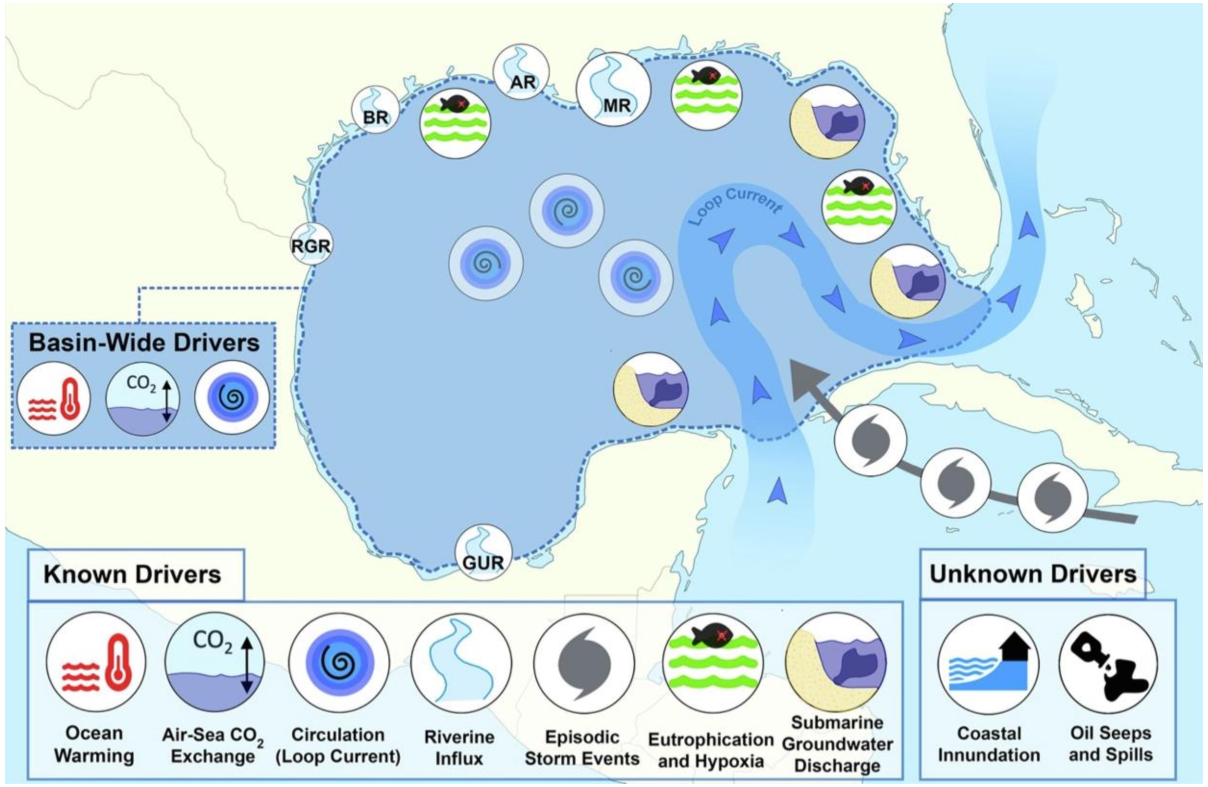
Slide courtesy of Jun Kita, MERI

10 Years of Osaka Bay Data vs 1 year Tomakomai Data Variability across time



Drivers of Variability in the GoM

- Ocean warming
- Anthropogenic atmospheric input
- Loop current and associated eddies
- Freshwater riverine inputs create hypoxic zones
  - Storms
    - Enhance mixing
    - Floodwater input
  - Submarine groundwater discharge
  - Hydrocarbon seeps



Osborne, E, et al., 2022, Progress in Oceanography, Volume 209, https://doi.org/10.1016/j.pocean.2022.102882.

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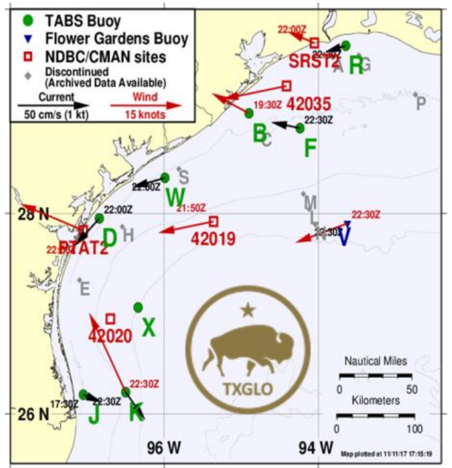
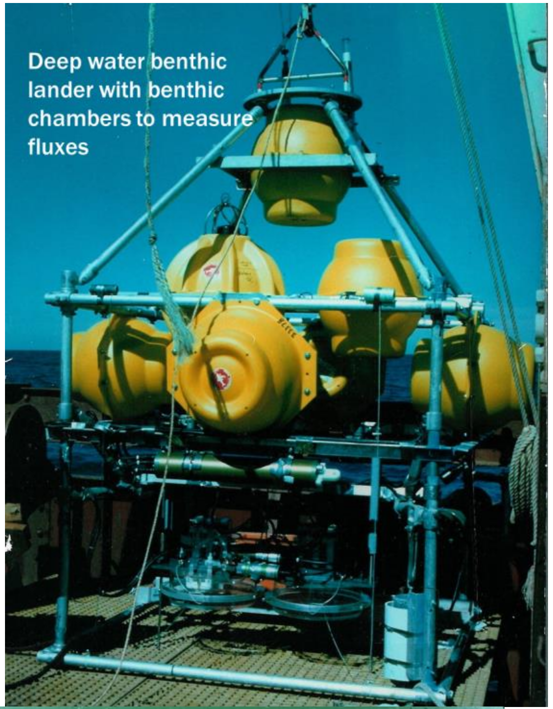
Monitoring Infrastructure

Texas Automated Buoy System

- Funded by the Texas General Land Office
- Continuous operations since 1995
- 8 Coastal Buoys
- 2 FGBNMS Buoys
- Surface currents, T, S
- Atmospheric Variables
- Primary mission is oil spill mitigation

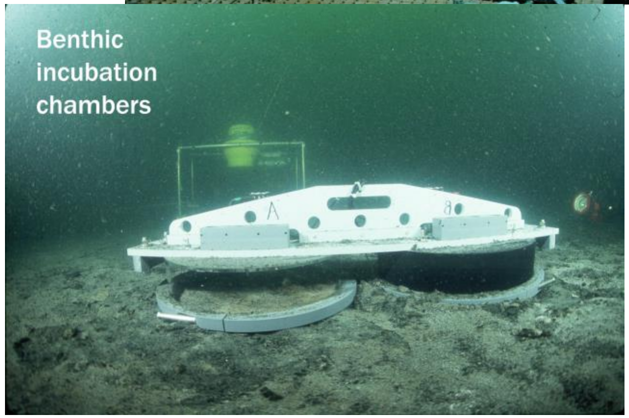


http://tabs.gerg.tamu.edu

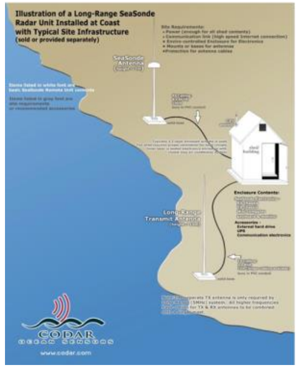


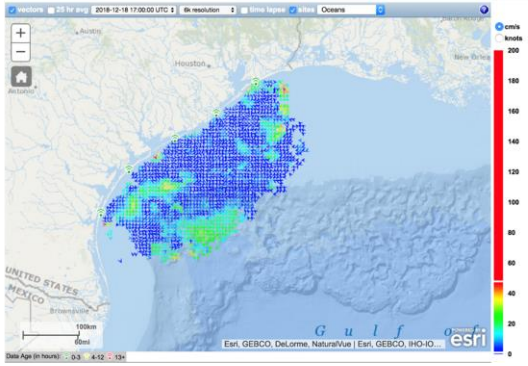
The TABS Family

- Advantages
  - Real time data
  - Solar Power
  - MET and Oceanographic data from a single platform
  - Very versatile sensor platform
  - Can collect data from remote subsurface moorings
  - Can be designed for any water depth
  - Can provide power to sensors for long deployments
- Disadvantages
  - Vandalism
  - Ship Collision
  - Fishing targets
  - Expensive



HF Radar in the GOM





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Tony Knap, Gil Rowe

The Process-based CSEEP Attribution Method: towards application in the shelf off south Texas

Abdirahman Omar, Senior Researcher

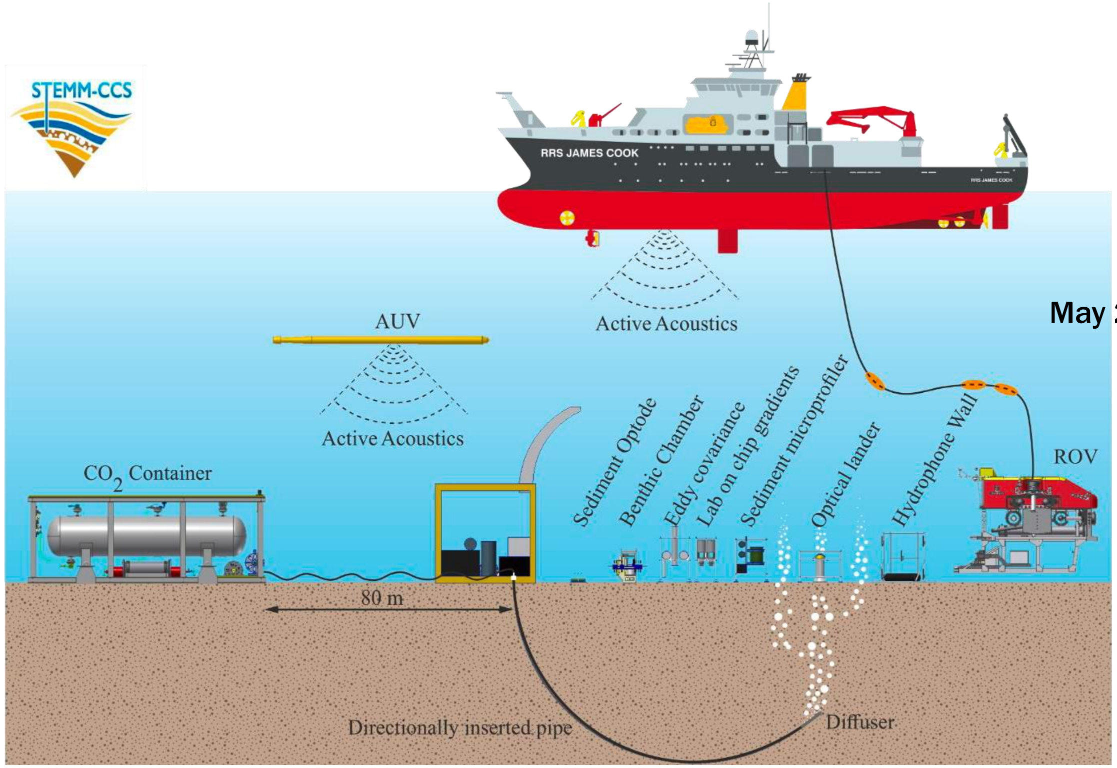
NORCE Norwegian Research Centre AS, Bergen, Norway

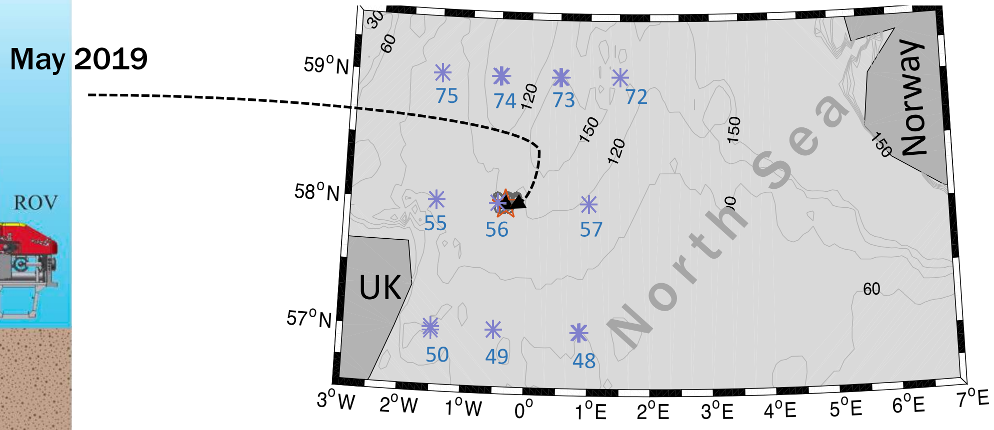
With input from:

Katherine Romanak, BEG, University of Texas

Katie Shamberger, Texas A&M University.

Data from the STEMM-CCS experiment and multi-year baseline cruises





Data from: 2001, 2002, 2005, 2008, 2011, 2017, 2018, 2019

Estimation of natural C-variability

Dissolved inorganic carbon: $C = C_b + C_{nat}$

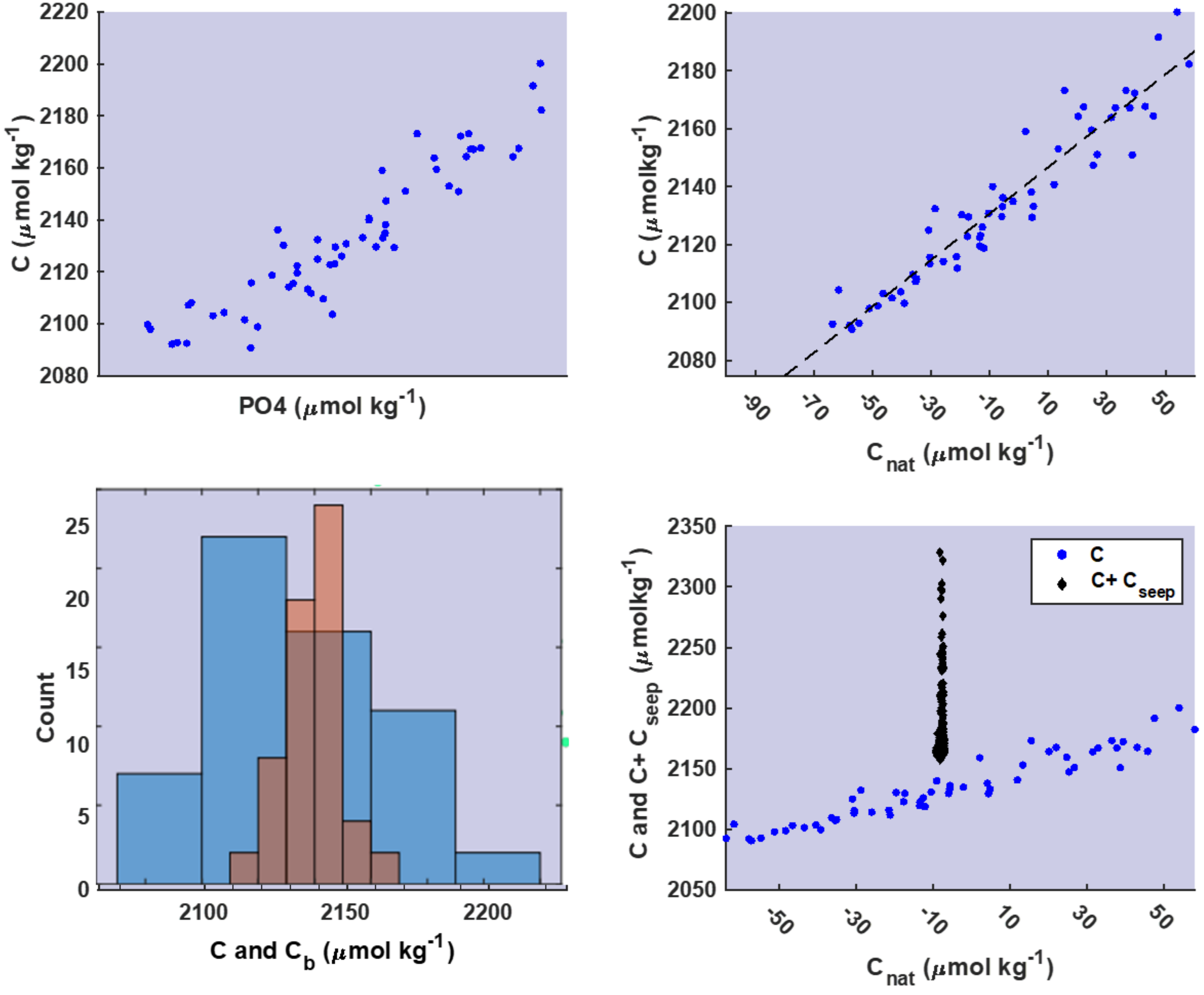
Approach: quantify natural variability and filter it out for easy identification of CO_2 seepage

Main processes governing C changes	**Parameterisation**
Organic matter cycling	$C_{omc} = R_{C:P} * \Delta PO_4$
Calcium carbonate cycling	$C_{ccc} = R_{C:PA} * \Delta PA$
Mixing between water masses	$C_{mix} = \mathrm{dPA/dS} * \Delta S$
Air sea CO_2 exchange	$C_{ant} = \mathrm{dC/dt} * \Delta time$

C_{nat} (computed natural variability)

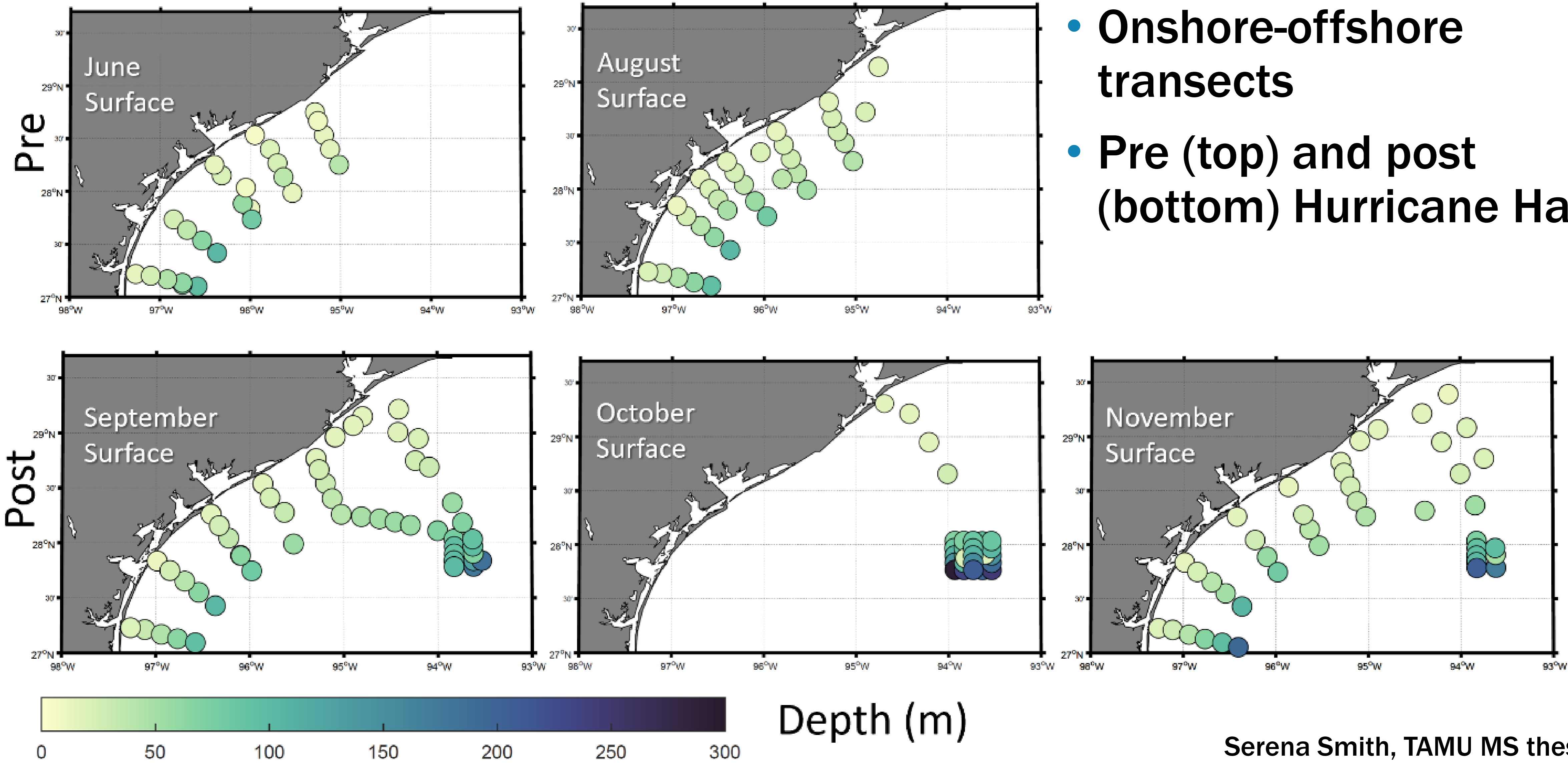
C-seep Development at STEMM-CCS

- Organic matter cycling is the primary driver of near seafloor C-variability (upper left graph)
- C-variability successfully computed, i.e., strong linear relationship between observed and computed (upper right)
- Substantial minimization of variability (lower left)
- Seepage C fall above of the C-C_{nat} line (lower right)
- Data from STEMM-CCS and historical cruises (2001, 2002, 2005, 2008, 2011).



2017 Texas Continental Shelf Data SHAMBERGER

- Onshore-offshore transects
- Pre (top) and post (bottom) Hurricane Harvey

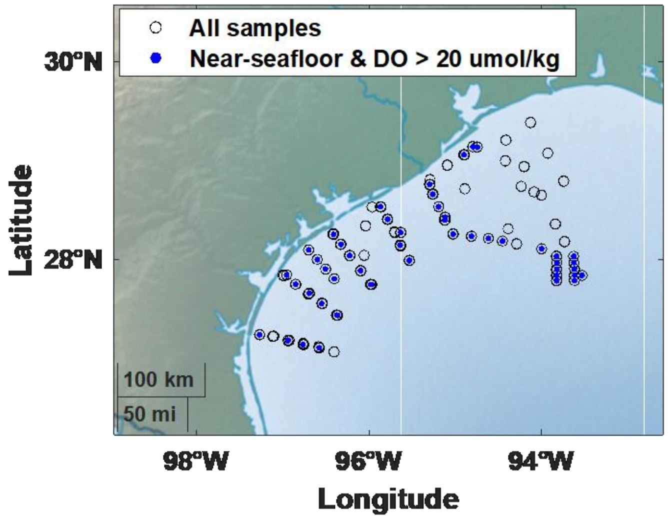


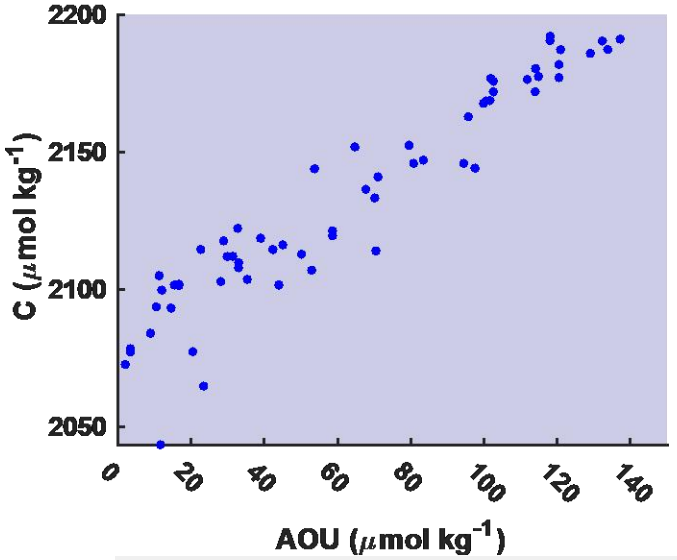
Serena Smith, TAMU MS thesis, 2020

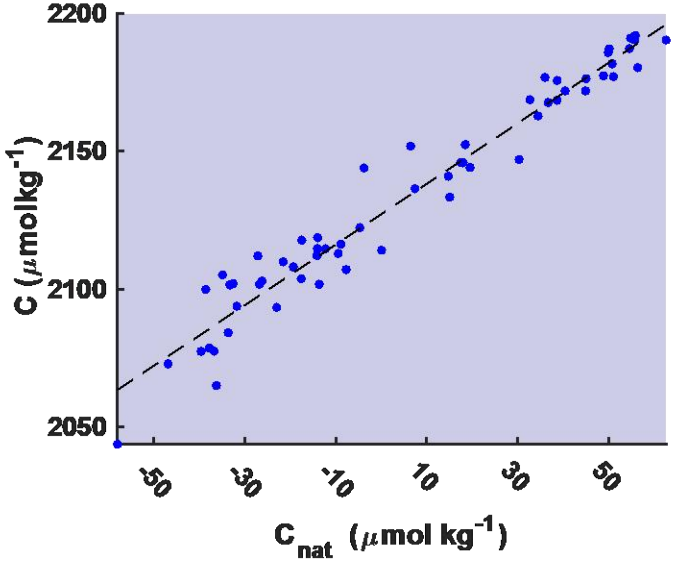
Continental Shelf off Texas: Preliminary Results

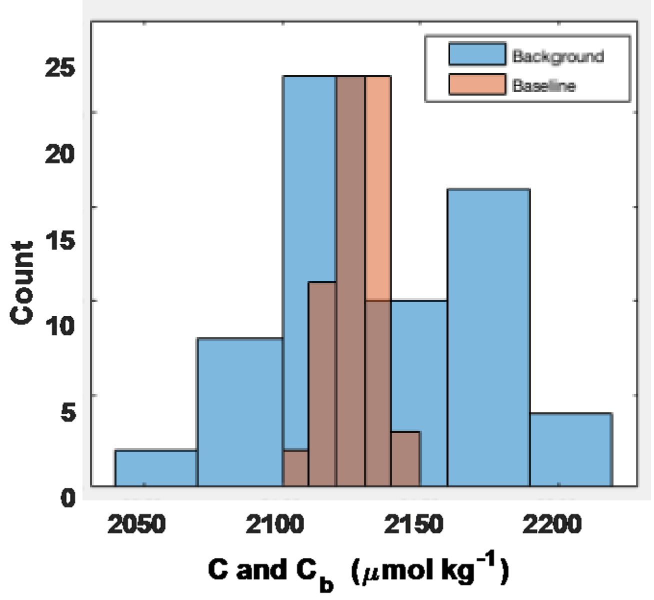
Data courtesy of Katie Shamberger

- Organic matter cycling is the primary driver of near seafloor variability (upper right)
- C-variability successfully computed, i.e., strong linear relationship between observec and computed (lower left)
- Substantial minimization of variability (lower right)



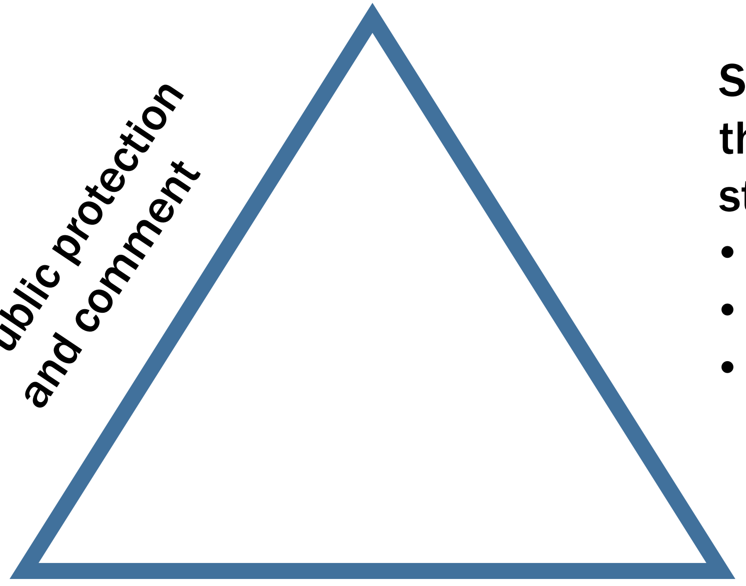






Stakeholder Engagement

Interplay Among CCS Stakeholder Components



Stakeholder interactions with the technical aspects of storage

- Assurance
- Understanding
- Acceptance

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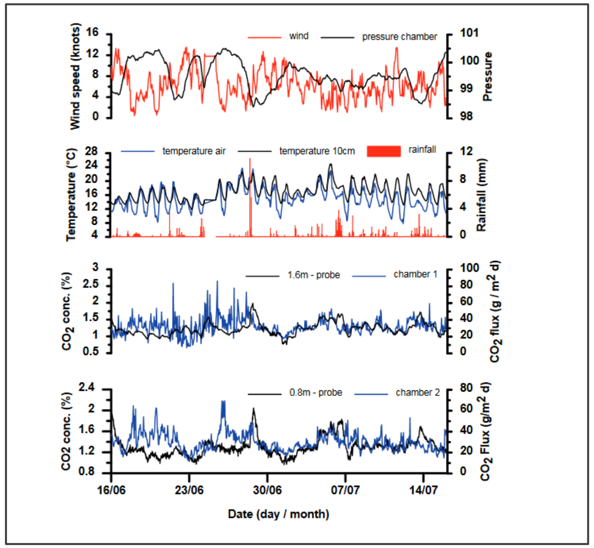
Baseline vs Stoichiometric Approaches

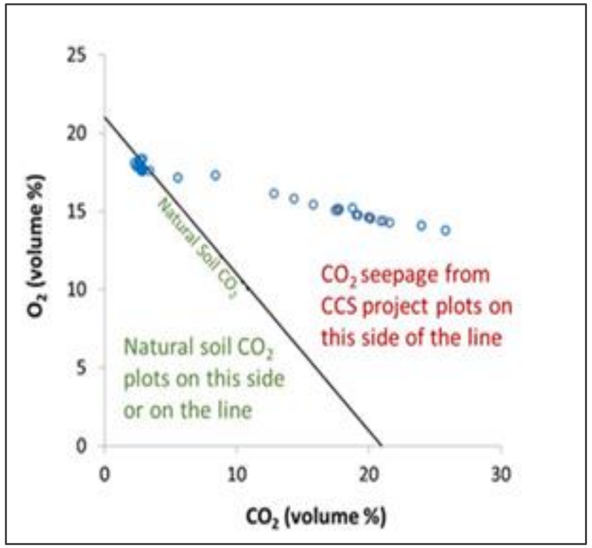
Complex



Jones et al., 2014, Energy Procedia, Volume 63, Pages 4155-4162

- 1-3 years of CO_2 soil gas and weather data
- Complex algorithms to determine thresholds
- Need time to determine leakage
- Methods inaccessible to lay stakeholders

Simple



- One-time characterization of soil gas
- Simple data reduction with clear graphical threshold
- Real time answer
- Methods easily understood by lay stakeholders

Survey Sample

- American adults aged 18 and older
- Data collection by global market research firm YouGov.
- Living in Texas and Louisiana (west GoM, O&G prevalent). Florida (east GoM, O&G not prevalent)
- States were chosen because they are close to existing or proposed CCS facilities- both onshore and offshore.
- An attention check was included to screen out inattentive subjects. Midway through the survey, one question asked them to select “somewhat agree” as their response.
- Only those who responded correctly were included in the final sample of 997 subjects (Texas = 328; Louisiana = 336; Florida = 333).
- Our sample was 44% male and 56% female.
- The average age was 47
- High school graduate (40.3%).
- 56.7% white, 18.6% Black or African American, 20.3% Hispanic, remainder were Asian, Native American or a combination of two or more races.

Novel Segmentation Approach

- We did not approach our public as uniform or singular.
- Used audience segmentation approaches to understand how different audiences process and respond to different messages.

T test Variable	Higher Science Orientation n=471 (47.2%)	Lower Science Orientation n=526 (52.8%)
Science Values (1.00)	M = 4.44	M = 3.29
Need for Cognition (0.37)	M = 3.63	M = 2.94
Science Media Consumption (0.81)	M = 3.17	M = 2.03
Climate Change Beliefs (0.46)	M = 4.53	M = 3.24

Note: all $p<0.001$
T-tests and chi-square tests confirmed the experimental groups did not differ according to age, gender, ethnicity, education, income or political ideology.

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Clustered Variables

- Attitudes toward science.
  - Sample items include “Science and research play an important role in my life”, “In general, I trust science”, and “Science should have no limits to what it is able to investigate.”
- Climate change Beliefs.
  - “Climate change is a serious problem” and “CO_2 that is emitted from power plants and industrial sources has been scientifically linked to climate change”
- Need for cognition.
  - Sample items include “I would prefer complex to simple problems” and “Learning new ways to think doesn’t excite me very much”
- Science media consumption.
  - Frequency with which subjects consumed science-oriented media content (science documentaries, science-themed entertainment shows, or science blogs)

Stakeholder Population Hypothesis

High Science Orientation

- Prefers complex messages and effortful cognition
- Consumes science media

- Trust more rigorous complex approaches?
- Feel safer with complex monitoring because it seems more rigorous?
- Trusts the scientist?
- Self assurance to participate in monitoring?

Low Science Orientation

- Trouble with complex messages
- Little science media consumption

- Prefers simple approaches?
- Feels safer with approaches they can understand?
- Trusts the scientist?
- No self assurance to participate?

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Preamble CCS Explainer

We'd like you to think about carbon dioxide gas (or CO_2). There are many sources for CO_2, but one source is industry such as generating power, making cement, iron and steel. Capturing and storing the CO_2 has been proposed as one way to reduce the impact on the earth's atmosphere from CO_2 that is emitted from power plants and industrial sources. This technology is called carbon capture and storage. Carbon capture and storage is a process where the carbon dioxide is trapped, transported and injected into rocks miles below the ground surface deep underground. The stored CO_2 is then unable to affect the atmosphere.

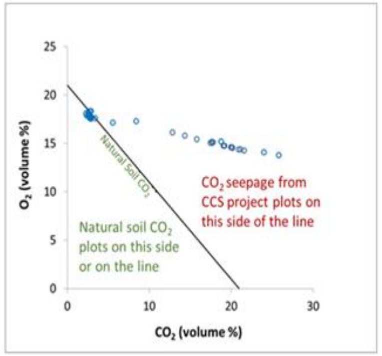
CO_2 occurs naturally in the soils and sediments of the earth. There are several ways to tell the difference between CO_2 that is natural and CO_2 that might seep or release slowly from a CCS project. We want to hear your opinion on these different methods for detecting seepage.

Key Variables

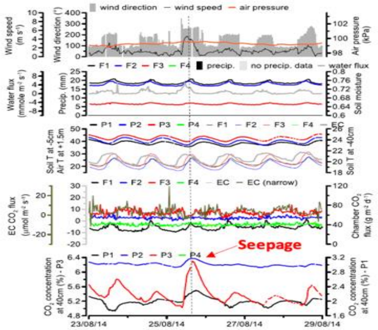
- ***Message elaboration***. Sample items: paid attention to message – did not pay attention to the message; was very involved – very uninvolved) to rate their engagement with the message about the monitoring system
- ***Attitude toward the monitoring approach.*** This scale used three items adapted from Taylor and Todd [18] and Chen, Fan and Farn [19]. Sample items include "Using this CO_2 monitoring approach would be a fun experience" and "Using this CO_2 monitoring approach is a smart idea"
- ***Perceived ease of use***. This scale used three items adapted from the literature [18, 19]. Sample items include "I think the CO_2 monitoring approach would be easy to use" and "Learning how to use the CO_2 monitoring approach would not be a problem" (M = 3.16, SD = .97; α = .88).
- ***Perceived usefulness***. Also adapted from previous literature [20, 19], sample items include "Using the CO_2 monitoring approach would improve my understanding of CCS" and "The CO_2 monitoring approach would make CCS less confusing" (M = 3.37, SD = .98; α = .89)
- ***Self-efficacy***. This was measured with three items drawn from Cheon, Lee, Crooks & Song [21]. Sample items include: "I would be confident about using this CO_2 monitoring approach" and "Using this CO_2 monitoring approach would not challenge me" (M = 3.21, SD = 1.04; α = .87).
- ***Behavioural control.*** We used three items adapted previous scales [18], [21]. Sample items include "I have sufficient knowledge to use this CO_2 monitoring approach" and "I am capable of using this CO_2 monitoring approach" (M = 2.87, SD = 1.13; α = .90).
- ***Intention to use***. This was measured with three items adapted from previous literature [18, 21, 22]. Sample items include "I would like to see the real-time data as it comes in" and "I would be interested in having the CO_2 monitor on my property" (M = 3.35, SD = 1.08; α = .82).
- ***Support for CCS.*** This was measured with a single item asking subjects how strongly they would support or oppose a carbon capture and storage project being constructed within 15 miles of their home with the CO_2 monitoring approach they read about (M = 2.76, SD = 1.17).

2x2 Experiment

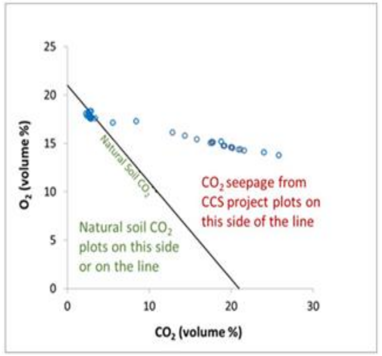
Simple Monitoring
Academic Social Norm



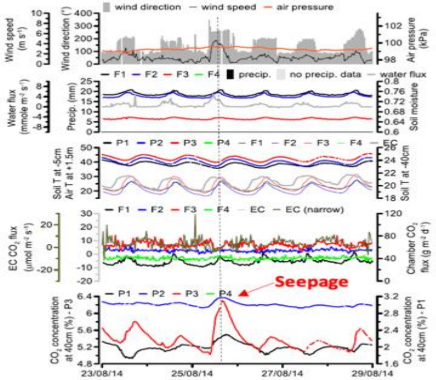
Complex Monitoring
Academic Social Norm



Simple Monitoring
Community Social Norm



Complex Monitoring
Community Social Norm



Results

High Science Orientation

- Simple monitoring influenced outcomes positively
- Social norms had no influence (academic vs community)

Low Science Orientation

- Simple monitoring was favoured over complex.
- Social norms were the primary influential factor

Simple monitoring approaches were preferred in both populations- the ability to understand an approach was favorable over a rigorous complex approach and lead to more acceptance of CCS overall.

Conclusions and Recommendations

- Building on our prior experience with terrestrial CO_2 storage projects and international collaborations with offshore projects – balanced approach with focus on processes.
- Hurricanes and hypoxia are characteristic of the northern GoM and add environmental complexity.
- Infrastructure is available for data collection (TABS, HF radar, AUVs) and can be enhanced as needed.
- Ratio based approaches to attribution are being successfully developed for the GoM.

Conclusions and Recommendations

- Beliefs about monitoring and CCS are statistically different among people with high science values and those with low science values within the sample population.
- Focus on simple approaches because it speaks to both groups
- Important to engage community leaders in stakeholder outreach.
- Find a community leader with HSO for initial communication and then let them communicate with the community.
- Can place messaging in science media to reach HSO

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