

Gulf Coast Carbon Center 2011-2014 Research Plan Update

The Gulf Coast Carbon Center (GCCC, www.gulfcoastcarbon.org) at the Bureau of Economic Geology seeks to reduce global emissions of atmospheric carbon dioxide (CO₂) by providing technical expertise in carbon sequestration technologies. The GCCC leads key research, development and monitoring programs to: strengthen confidence of industries moving to large-scale deployment of carbon capture, utilization and storage; provide rigorous, technical information to diverse stakeholders; and train future geoscientists and engineers in carbon mitigation and management.

Through a combination of industry, government and academic funding, GCCC focuses on areas where large-scale reduction of atmospheric release is needed and short-term action is possible. Investment in GCCC from our industry sponsors is key to the program's success because it allows flexibility, quick response, and innovation.

GCCC traditionally prepares an ambitious multi-year research plan in collaboration with our industry sponsors. We are entering the final year of the 2011-2014 plan. Two approaches to using sponsor funds have proven effective during this period (1) synthesizing results of ongoing, major studies and (2) leveraging pilot studies, requested by our sponsors, to obtain additional outside funding.

This update on the 2011-2014 plan presents our five thematic goals, reviews past progress and previews 2014 work. Much of this will be presented at our upcoming meeting (UTCCS-2, www.storeco2now.com/utccs-2) in January 2014. We will begin developing the next multi-year plan at our 2014 midyear sponsors meeting in Houston.

Theme #1: Reliable Capacity Estimation

Statement of GCCC 2011-2014 goal: Improve storage capacity estimation techniques to account for the major impact of interaction of multiphase flow, boundary conditions, maximum pressure, and geomechanics.

Progress: Past studies estimating local and regional storage capacity have been strongly focused on the interaction of multiphase fluids with reservoir heterogeneity, related to the classic problems in sweep inefficiency. The uncertainties in multiphase flow are unquestionably large; however, in many injection scenarios, the limit on the amount to be injected depends less on the extent of the plume than on the geomechanical limits on pressure change. Change in pressure is linked to boundary conditions as well as to geomechanics, with reservoir depth shown to be an important variable. During 2011-2013, GCCC researchers have made a number of breakthroughs in understanding these relationships.

In previous meetings, we discussed the outcome of gas field analog studies (master's thesis of Erin Miller) and model scenarios comparing different assumptions about boundary conditions (master's thesis of Kerstan Wallace). Both studies were elements of the Gulf of Mexico offshore capacity study led by Tip Meckel. This year, we have made substantive progress on the Gulf of Mexico-state lands Atlas; results will be presented by Dave Carr at the meeting in January 2014.

We have made progress on two new elements of capacity estimation. Seunghee Kim, a new GCCC postdoctoral researcher who is working with Seyyed Hosseini, is conducting novel work to validate geomechanical models using above zone monitoring interval (AZMI) data from Cranfield. In addition, Seyyed Hosseini received a three-year grant from US Department of Energy (US DOE) to construct a code that incorporates multiphase flow, boundary conditions, and geomechanics. This project follows our previous trend of leveraging GCCC funds and will continue for two more years. The current status of both these projects will be given at the January sponsors meeting.

Sponsors have received information about a GCCC initiative on global subsea CO₂ storage (iCCSc). More information about this will be presented at the special joint session between Massachusetts Institute of Technology and GCCC at the January 2014 sponsors meeting. GCCC has applied for a seed grant from the UT Austin Jackson School of Geosciences to help launch this initiative, and we look forward to feedback and input from sponsors.

Upcoming Work: Major 2014 activities will include (1) completion of the Gulf of Mexico offshore characterization study, including a focus on fault performance, (2) year two of Hosseini's EASiTool (US DOE) grant, and (3) continued work toward starting a global subsea storage initiative by engaging US DOE, US Department of Interior's Bureau of Ocean Energy Management (US BOEM), and international collaborators who have extensive experience with subsea CO₂ injection and/or have statutory requirements to participate in CO₂ injection demonstrations. Input from these potential collaborators and GCCC sponsors will shape our response.

Theme #2: Unconventional Enhanced Oil Recovery (EOR)

Statement of GCCC 2011-2014 goal: Explore impact of increased CO₂ supply on EOR.

Progress: Conventional EOR is currently conducted under conditions in which high CO₂ cost and restricted supply are rate-limiting to oil recovery. GCCC is moving forward to analyze ways in which potentially larger supplies of CO₂ (anthropogenic) might change the EOR business, and how this change will provide impetus for capturing larger volumes of CO₂.

In past sponsor meetings we have presented research related to (1) intermittency of CO₂ supply (as presented in the thesis of Stuart Coleman) and (2) the economic viability of capturing large quantities of CO₂ from coal-fired power generation and using it for CO₂-EOR at the regional level (Carey King et al., 2013). GCCC has also published a study showing how monitoring needs and possibilities are different for EOR versus injection into a saline formation (Wolaver et al., 2013).

This year's sponsor meeting will feature an assessment of the residual oil zones (ROZ) of the Permian basin as an unconventional EOR target (master's thesis of Logan West), and an update by Vanessa Nuñez on progress to make publicly available the GCCC database of EOR targets.

Upcoming Work: Major 2014 tasks will include (1) posting the EOR database online, (2) publishing results from ROZ study, and (3) continued progress and education on the intersection of CCS with EOR. GCCC researchers will continue data collection at EOR fields to provide the experience and input needed by policy makers, CO₂ injection operators, and CCS markets.

Theme #3: Monitoring methods optimization

Statement of GCCC 2011-2014 goal: Determine which information gained through various monitoring techniques comprises an effective strategy for CCS surveillance.

Progress: Most geologic storage studies have been conducted as research-oriented activities to test tools, validate models, and demonstrate feasibility. The objectives for monitoring a commercial project, however, are quite different. Monitoring in a commercial setting needs to meet stakeholder needs, and be durable, sustainable, reportable, and fit-to-purpose. Assessing large areas over long time frames drives commercial monitoring toward careful investment. During 2011-2013 GCCC conducted many evaluations to improve the understanding of monitoring optimization.

Studies presented in previous meetings include data collection and analysis at major research field projects, in particular Cranfield, Mississippi. We have also shared knowledge gained from monitoring planning and deployment at several large commercial projects in Texas. In addition, we completed a study funded by the US Environmental Protection Agency that (1) assessed monitoring tool sensitivity (presentation by Susan Hovorka at 2013 midyear meeting and upcoming paper), (2) tested a number of tools in field settings, and (3) conducted a formal value-of-information analysis on characterization for geologic storage (Puerta and Bickel, 2013).

At the January sponsors meeting, four new studies will be presented:

- First semester master's student Mike Patson will discuss experiments for understanding processes of fluid evolution during vertical transport and its significance to leakage detection.
- First semester Ph.D. student Jacob Anderson will discuss methane as a highly detectable proxy for CO₂ leakage assessment.
- Alex Sun will outline a new funded study that uses modeling and field experiments to explore the utility of pulsed pressure on leakage detection.
- Mehdi Zeidouni will present a novel method to assess plume stabilization using gas soluble tracers emplaced in an injection well at the end of injection. He plans to test this method at Citronelle CO₂ injection in Alabama.

Upcoming Work: Major 2014 tasks will include continuation of Mike Patson and Jacob Anderson's research, and conducting field experiments for the tools proposed by Alex Sun and Mehdi Zeidouni. We also expect to advance knowledge as one of our monitored commercial sites begins injection of anthropogenic CO₂. We will collaborate as possible with two other commercial site operators in Texas as they reach financial investment decisions and, we hope, begin preparation to receive CO₂.

Theme #4: Applying natural and industrial analogues to storage and leakage detection research.

Statement of GCCC 2011-2014 goal: Improve understanding of long-term fate of CO₂ through examination of analogs.

Progress: A goal set for geologic storage is long-term retention of CO₂ in the injection horizon. One method of assessing long-term results is to study places where similar processes are already underway. GCCC has undertaken several targeted studies that use this method, as well as collaborating with other global research.

In past meetings, we have discussed the "process-based" soil gas method developed by Katherine Romanak to compare natural CO₂ sources in playa lakes with observations at oilfield and controlled release sites. This method provides substantive improvements in response to concerns or leakage allegations because it differentiates between variations in in-situ gases controlled by biologic processes versus allochthonous introduced gas. This method is gaining interest among the international subsea storage community, but remains unexplored. GCCC researchers are seeking opportunities to apply this methodology to an international collaborative demonstration.

Three GCCC researchers will share results related to this theme at the January meeting. Toti Larson will present a study leveraging DOE funding to the Center for Frontiers of Subsurface Energy Security (CFSES) at Bravo Dome, a natural analog

reservoir. Katherine Romanak will give an update on the needs and challenges of smart data collection as part of environmental monitoring. Changbing Yang will give a synthesis of new results from the controlled release experiments at the Breckenridge field lab in Austin.

Upcoming Work: GCCC plans for 2014 include additional controlled release experiments and completion of near surface field work at Cranfield. We will also apply lessons learned to other EOR sites, including identification of transport mechanisms in the overburden, assessment of surface gas flux, and collaborative work related to applying a process-based approach to offshore monitoring.

Theme #5: Intersecting GCCC work with policy and regulation; Outreach and training

Statement of GCCC 2011-2014 goal: Increase accessibility of GCCC results.

Progress: The sponsors have asked GCCC researchers to ensure that the research we conduct is applicable to the real problems of CCS deployment and that current and future field operators have access to results as quickly as possible. This activity has taken several forms: (1) recruitment and support of students (undergraduate, master's, Ph.D., and postdoctoral programs in geology, earth and environmental resources, and petroleum and geosystems engineering), (2) funded workforce training, (3) networking and attendance at professional meetings, (4) technical publication in peer-reviewed literature, (5) service to sponsors, (6) web-based information including an active and up-to-date website, (7) our outreach FAQ website (www.co2facts.org), (8) e-mail News Flashes, and (9) quarterly sponsor newsletters.

2013 represents the final—and successful—year for the US DOE funded Alliance for Sequestration Training, Outreach, Research and Education (STORE, www.storeco2now.com) program. However, the program continues with joint support from the GCCC and the Center for Petroleum and Geosystems Engineering at UT Austin. GCCC researchers have also published a 16-paper volume in the *International Journal of Greenhouse Gas Control*. Juli Berwald and Ramón Treviño will provide updates on these efforts in the January 2014 meeting.

In addition, GCCC has interacted with stakeholders and provided information from past projects to improve and strengthen future projects. In 2013, a number of such “knowledge sharing” efforts were conducted. At the January 2014 meeting, Becky Smyth will present examples of sharing information through current (US BOEM) and future funded (Texas Clean Energy Project led by Summit Power) projects.

Upcoming Work: In 2014, our major goals will include (1) co-hosting (with two other UT CCS groups) the 12th International Conference on Greenhouse Gas Technology (<http://www.ghgt.info/index.php/Content-GHGT12/ghgt-12-overview.html>) and attending other major technical meetings, (2) continuing STORE outreach activities and seeking additional educational funding, (3) co-hosting the IEAGHG CCS Summer School at UT Austin with STORE in July of 2014, and (4) updating and maintaining web-based outreach, including a new blog to push research results to targeted users. Much of the development for the sub-sea storage initiative introduced in Theme 1 above will also fall under this theme. GCCC researchers will continue to synthesize results in multiple publications, which is a task viewed as critical by several parties.