On the impacts of reservoir heterogeneity for CO_2 storage in an offshore saline reservoir

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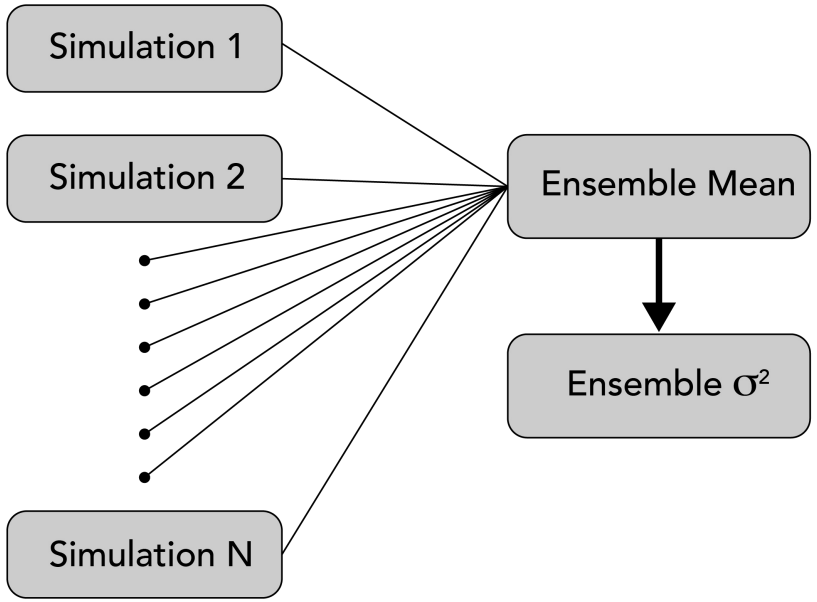
April 6, 2023

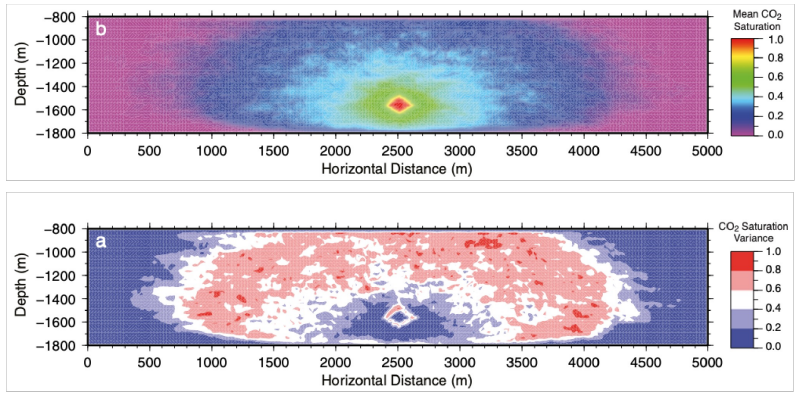
TASK 4.2.5: …develop and/or adapt Monte Carlo ensemble simulation methods to bound model uncertainty with respect to poorly constrained reservoir properties in an offshore geologic setting.

Simulation ensemble with equally probable & spatially variable permeability

Compute mean and variance for each grid cell in the ensemble, e.g., S_{CO2}, ΔP_f



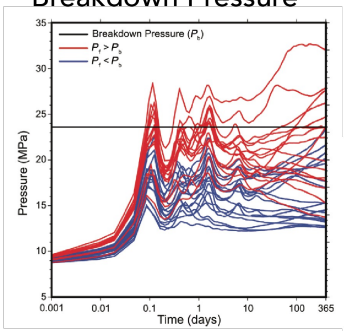
Ensemble Results



Pollyea & Fairley (2012)

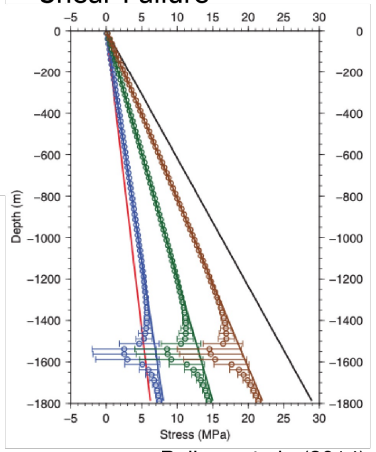
Ensemble Analysis

Breakdown Pressure



Jayne et al. (2019)

Shear Failure



Pollyea et al., (2014)

Research Objectives

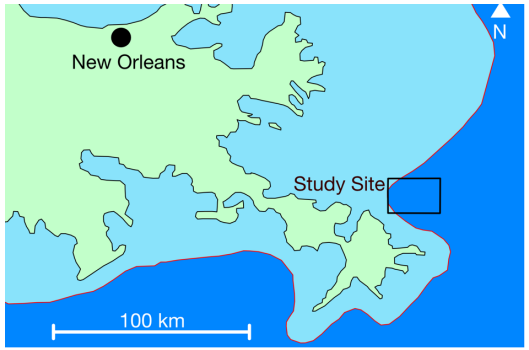
- Develop “representative” geologic model of central GOM
  - Faulting, salt structures, over/under pressure
- Quantify effects of spatial permeability uncertainty on CO_2 injections with ensemble simulation
  - CO_2 plume geometry, fluid pressure propagation
- Test different injection scenarios.

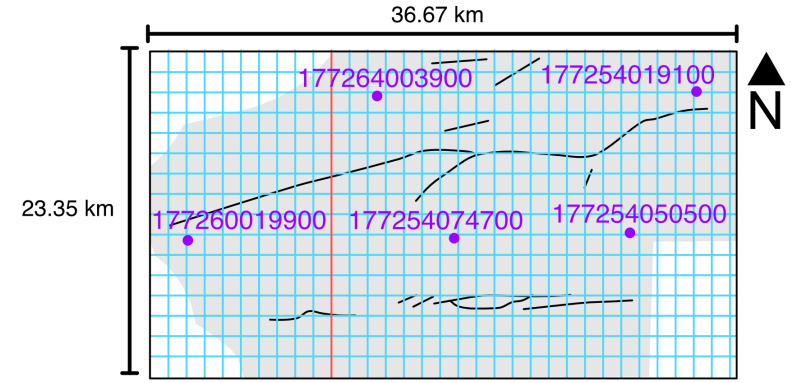
SECARB Offshore

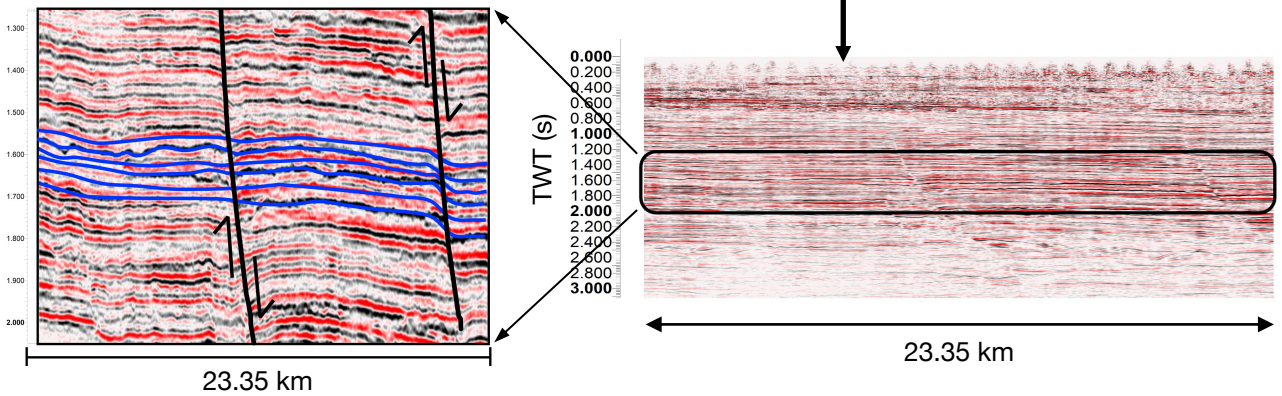
GEOLOGIC MODEL

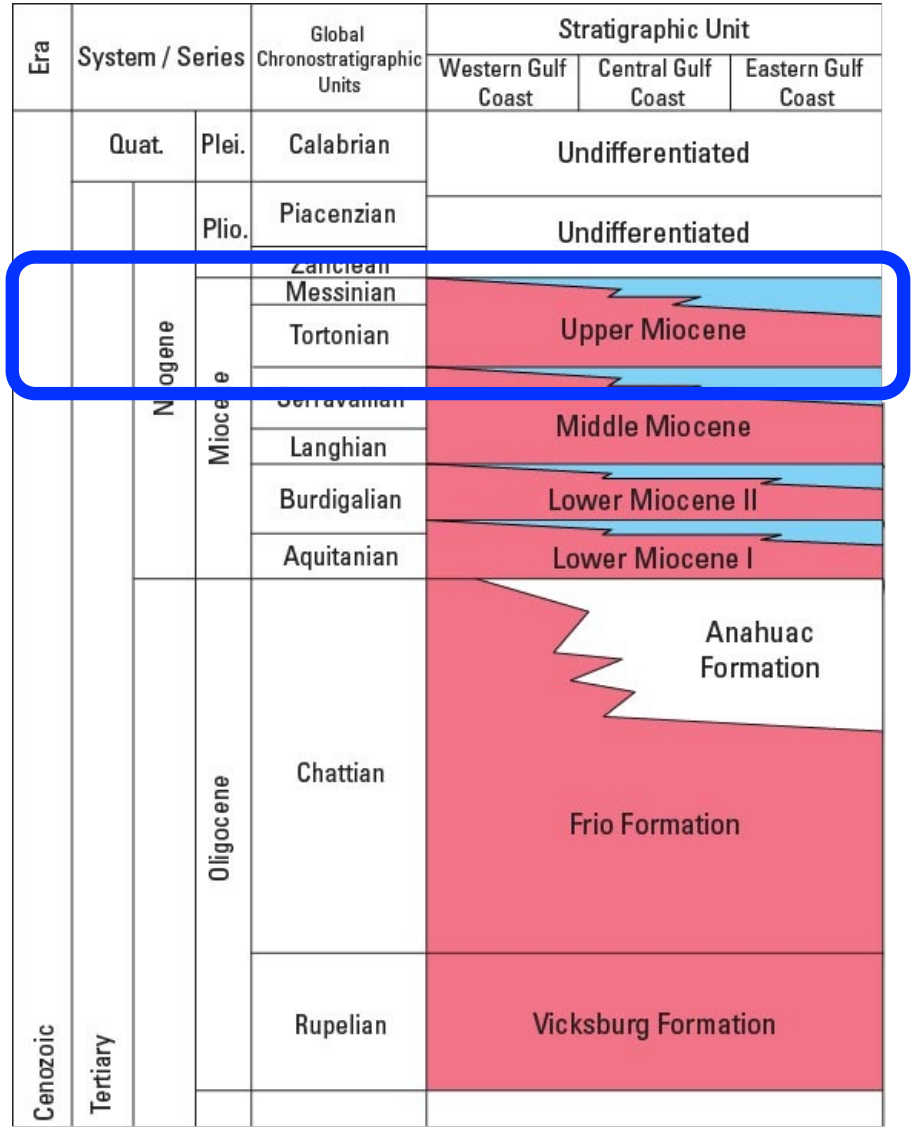
Upper Miocene Sands

- 3D Seismic from USGS Marine Seismic Survey Archive
- Interval of interest ~1400 – 1700 m depth
- Interpret two sand reservoirs & three shale formations
- Interpret fault network
- Tie geology to seismic with five wells

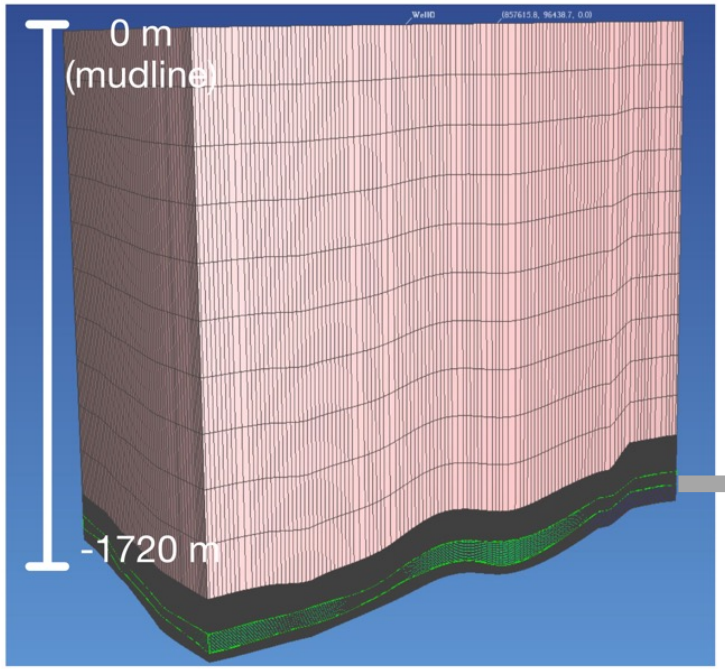








Model Domain



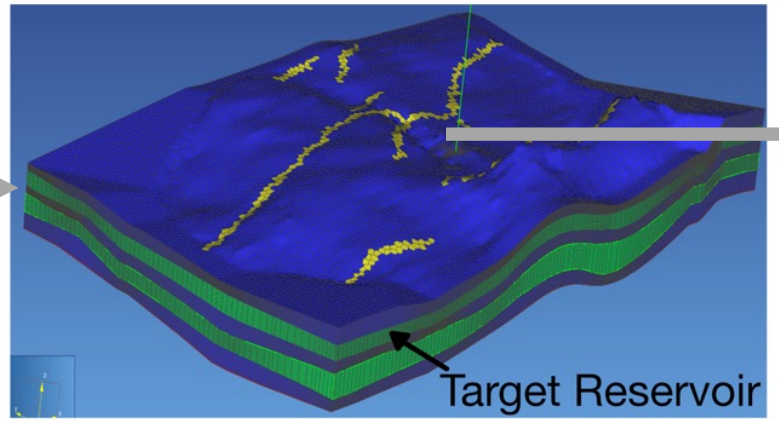
Polygonal lateral grid discretization

Regular vertical discretization

37 km × 23 km lateral extent

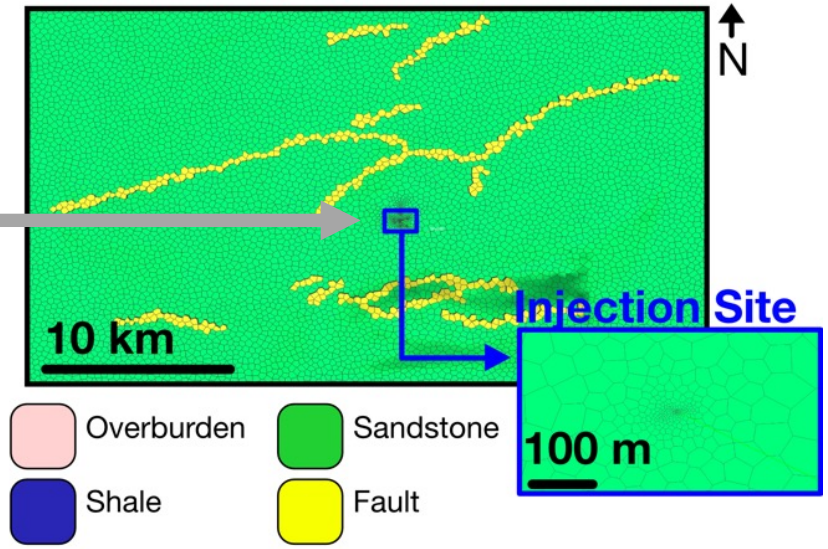
1720 m below mudline

Mudline is ~20 m below sea level



Avg reservoir thickness ~40 m

Avg cap thickness ~30 m



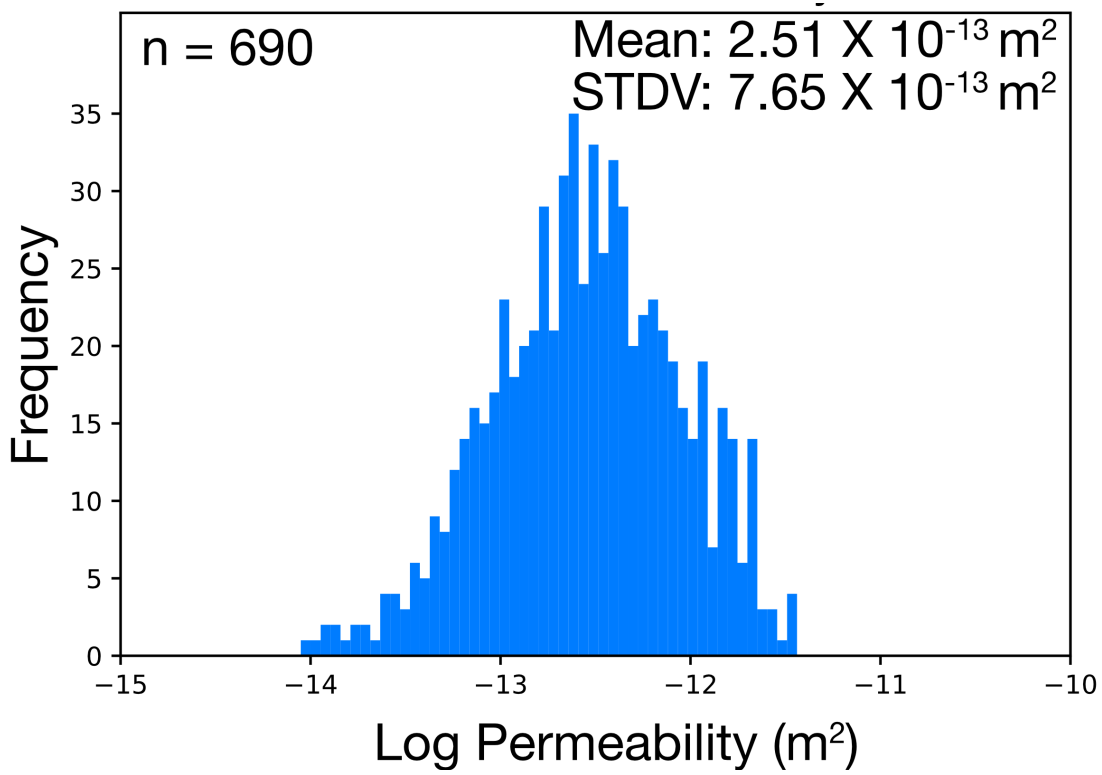
Well location bounded by faults ~5 km to north and south

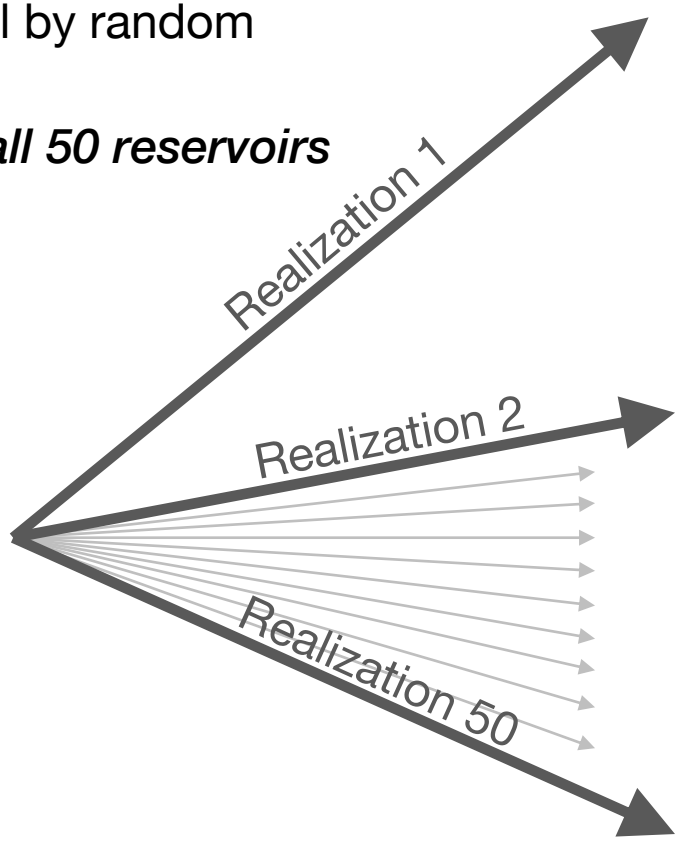
Grid refinement near injection well

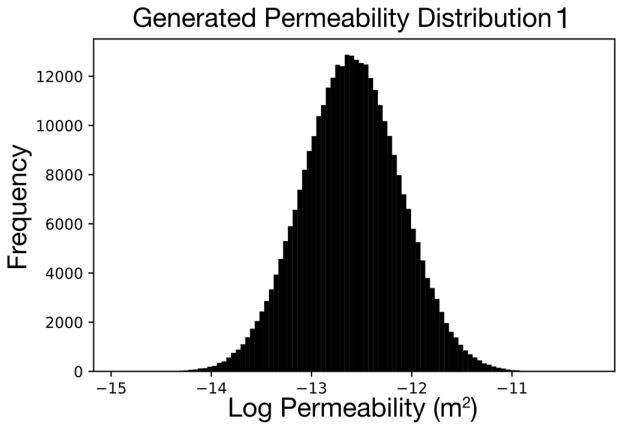
RESERVOIR PERMEABILITY DISTRIBUTION

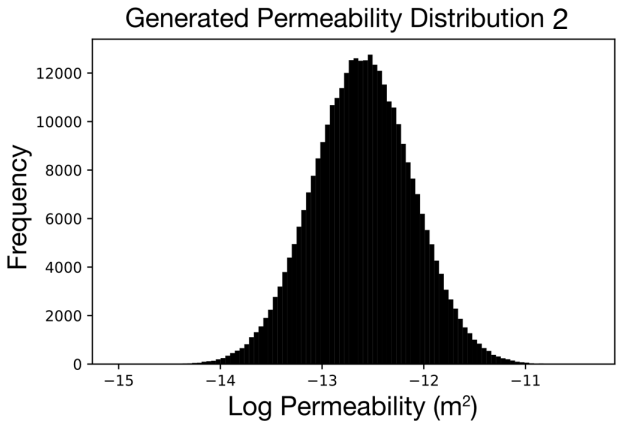
Permeability distribution from the ***BOEM Gulf of Mexico Gas & Oil Sands Data***

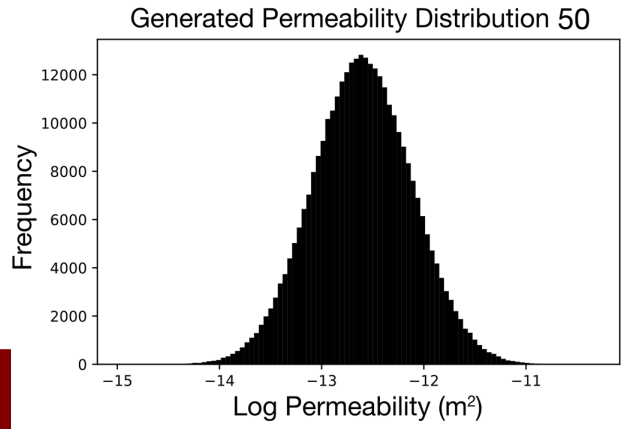
- Filter only permeability with Miocene chronozone
- Populate each grid cell in the target reservoir model by random draw from the Miocene permeability distribution
- ***Simulate 1M metric tons per year for 10 years in all 50 reservoirs***





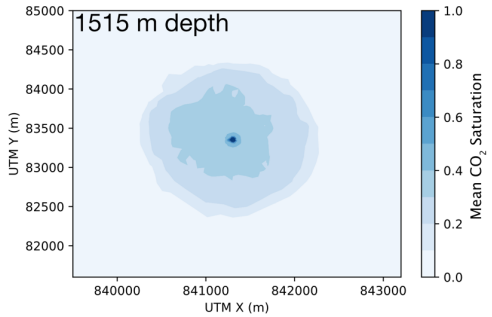


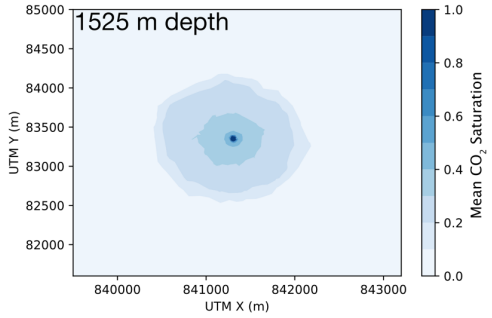


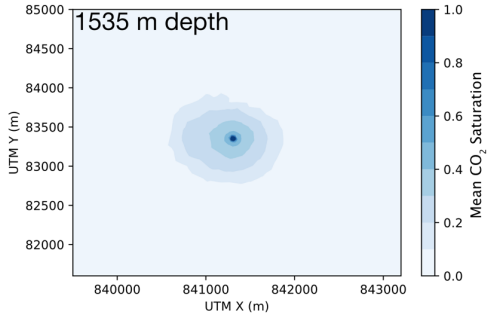


Results: CO_2 Saturation and Flow

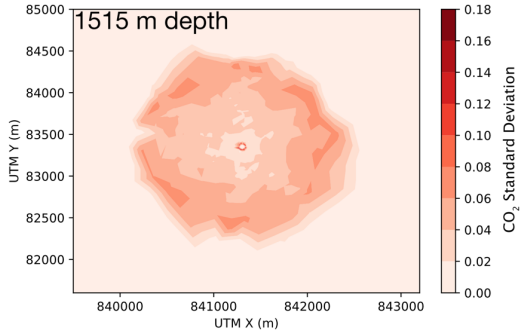
Mean CO_2 Saturation

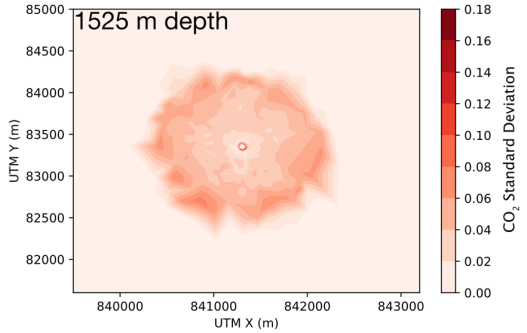


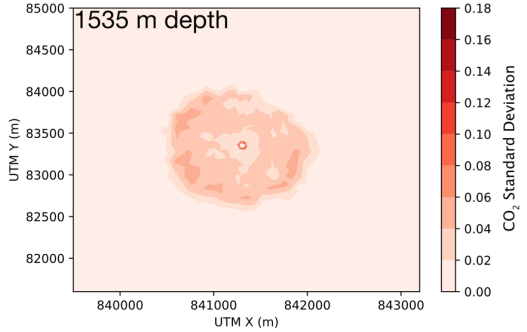


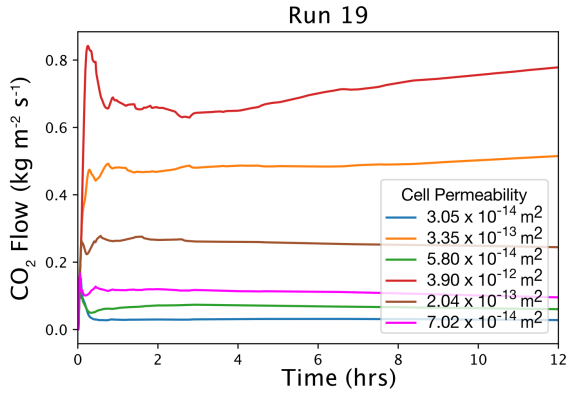


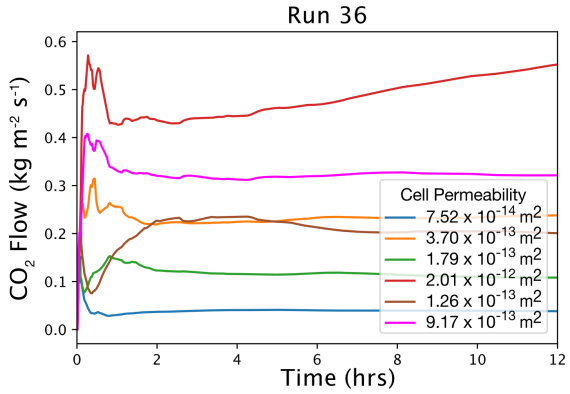
Std. Dev CO_2 Saturation

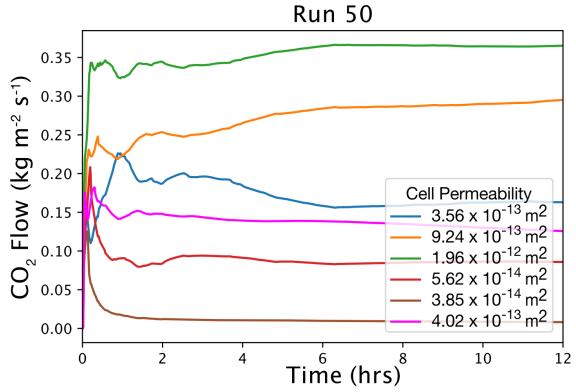






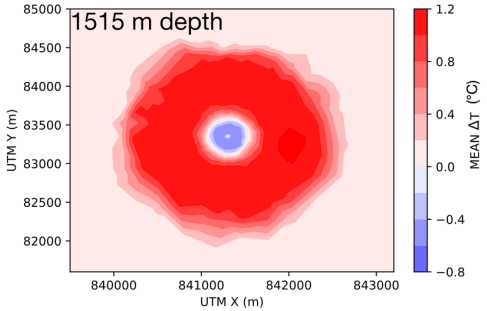


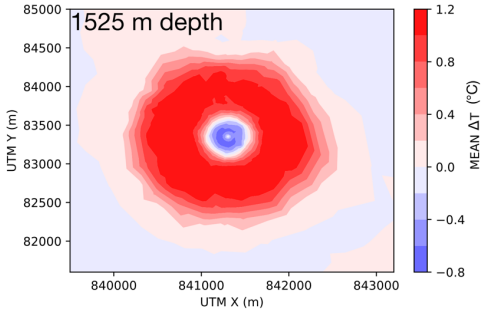


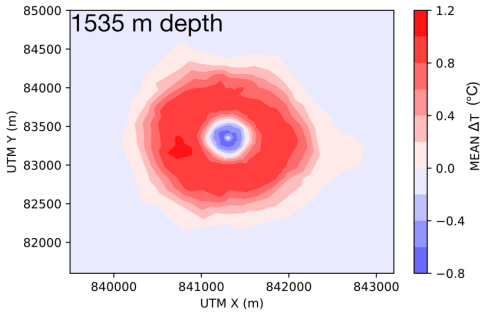


RESULTS: TEMPERATURE

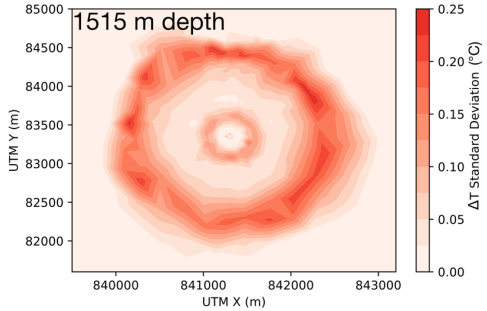
Mean Temperature

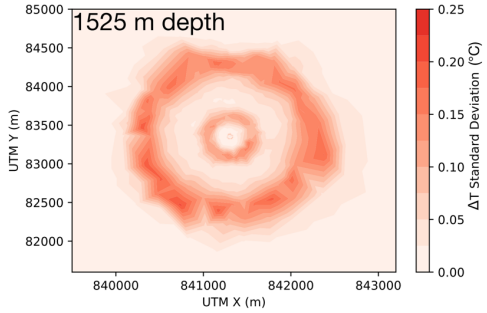


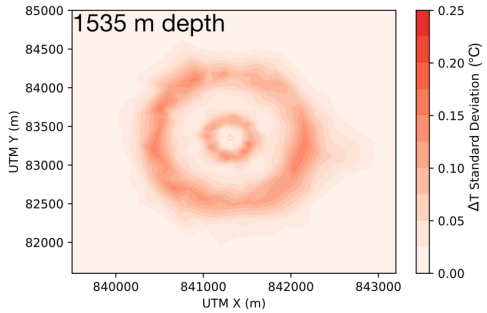


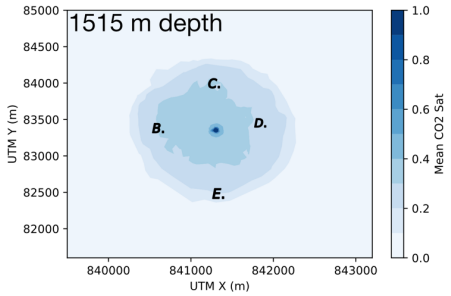


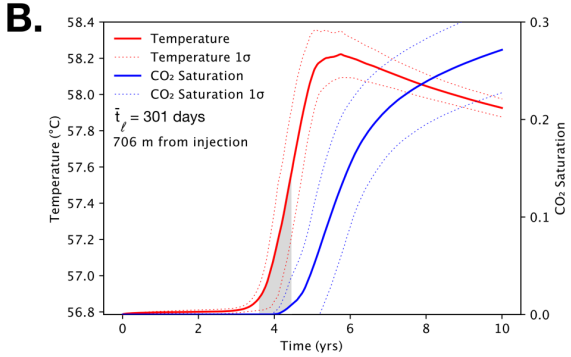
Std. Dev Temperature

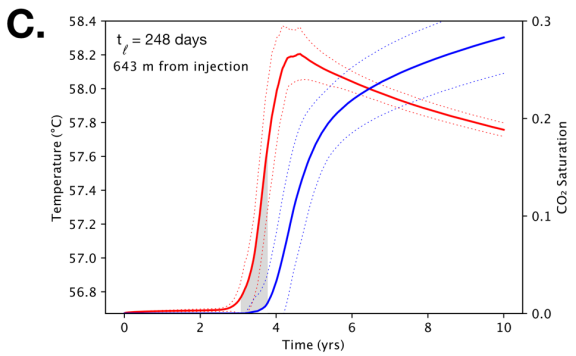


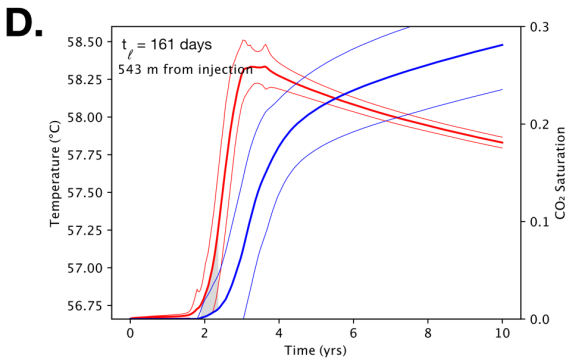


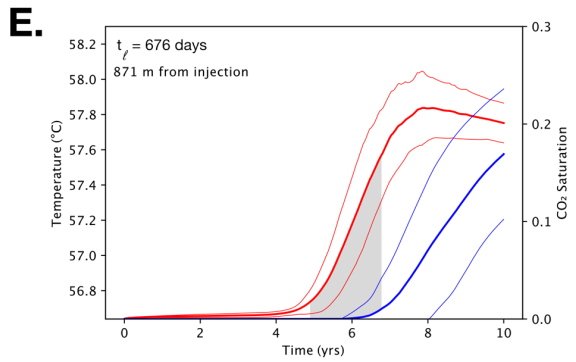




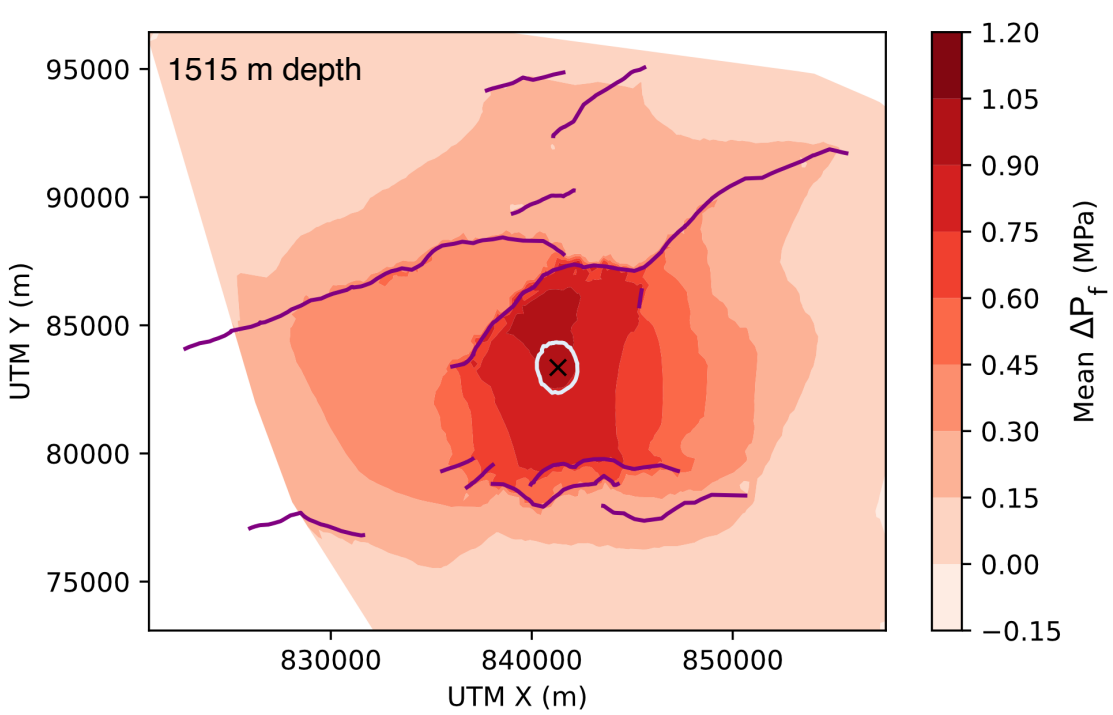


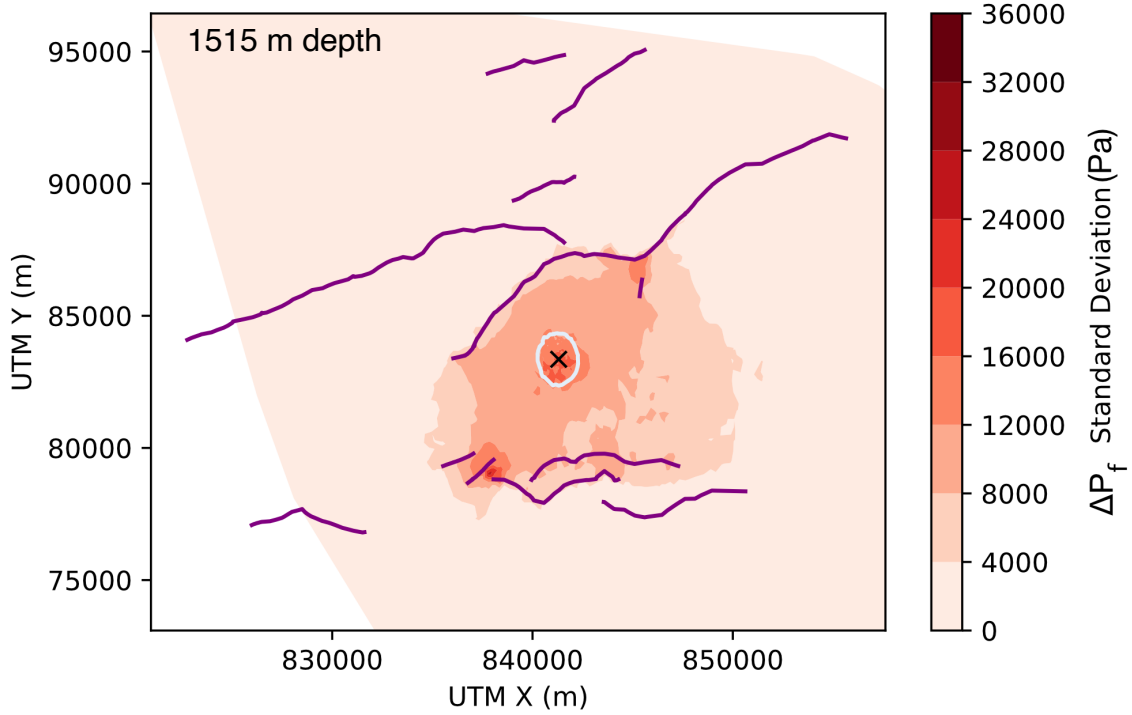






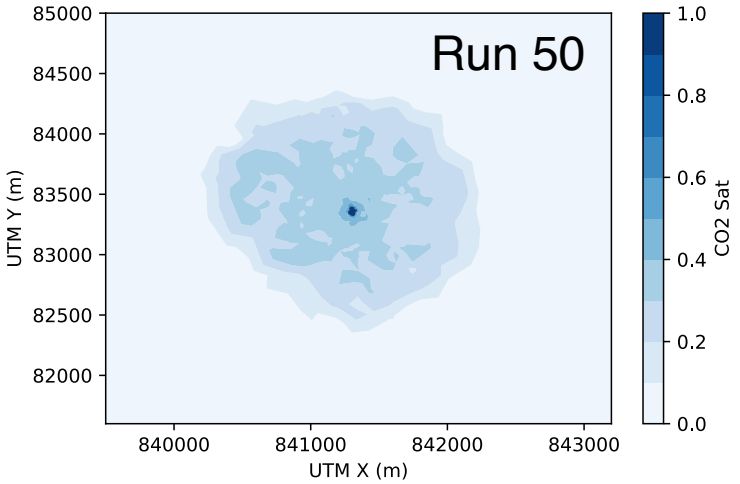
RESULTS: PRESSURE

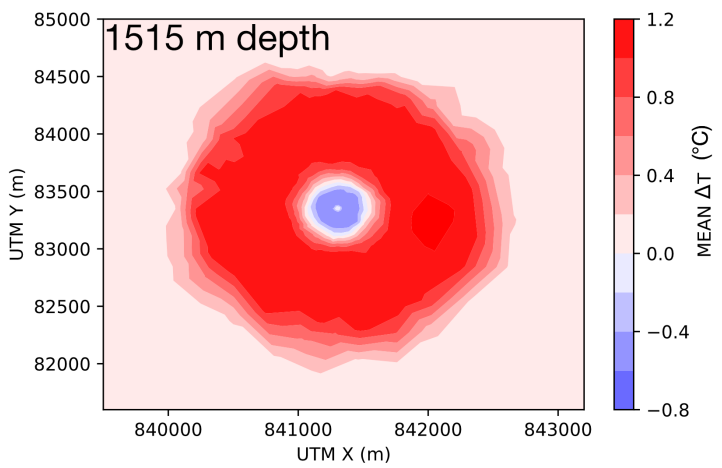


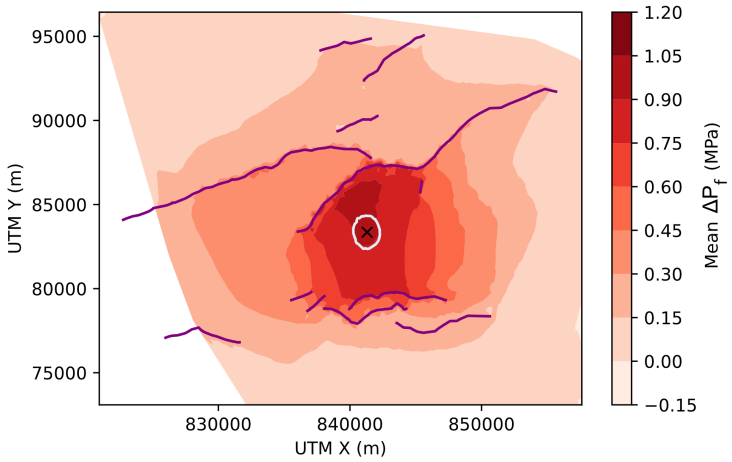


CONCLUSIONS

- Both near and far field permeability affect CO_2 flow
  - +/- 20% CO_2 saturation
- Warm front is precursor to CO_2 flow; potential for monitoring
- Additional research is needed to understand implications of far-field pressurization







- Thank you to our funding partners & collaborators with the SECARB Offshore team.
- Questions?

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