

Cranfield Phase III Modeling

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Bureau of Economic Geology

Jackson School of Geosciences

The University of Texas at Austin

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Partnership Stakeholders' Briefing

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Questions to answer by modeling

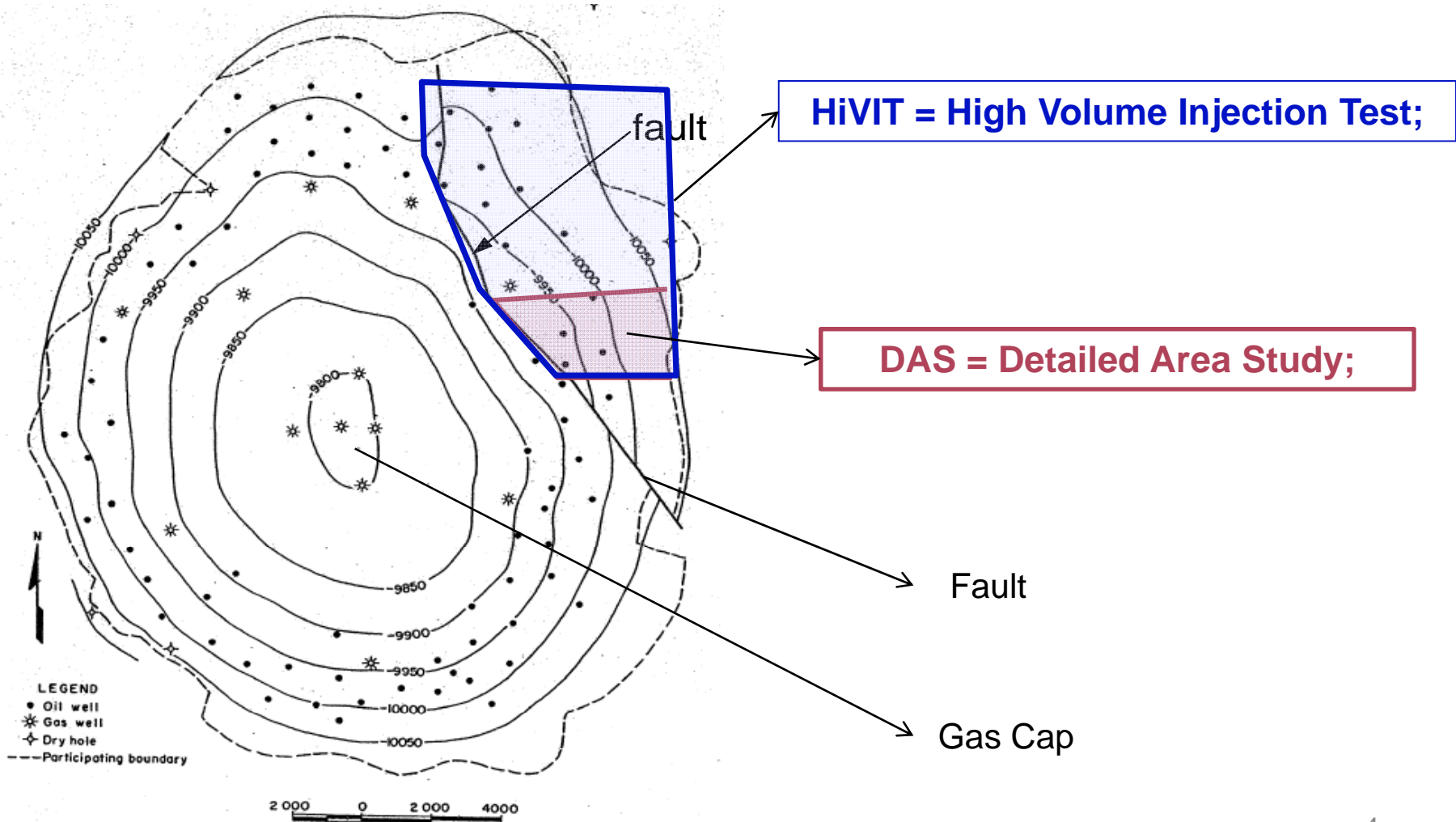
- What is maximum down dip extent of plume?
- How dissolution of CO₂ and exsolution of methane occurs and at what rate?
- How response of the system changes given changes in:
 - Relative permeability
 - Bed continuity of sand or barriers
 - Injection rate
 - Multiple flow path

Questions to answer by modeling – Big picture

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- What are the key facts that constrain the model for short and long term fate of CO₂?
- What uncertainties make a big difference at large volume injection, and what do not?
- How different is an EOR setting than a non-producing setting?
- How is four-way closure different than open dip reservoir?

Model Description

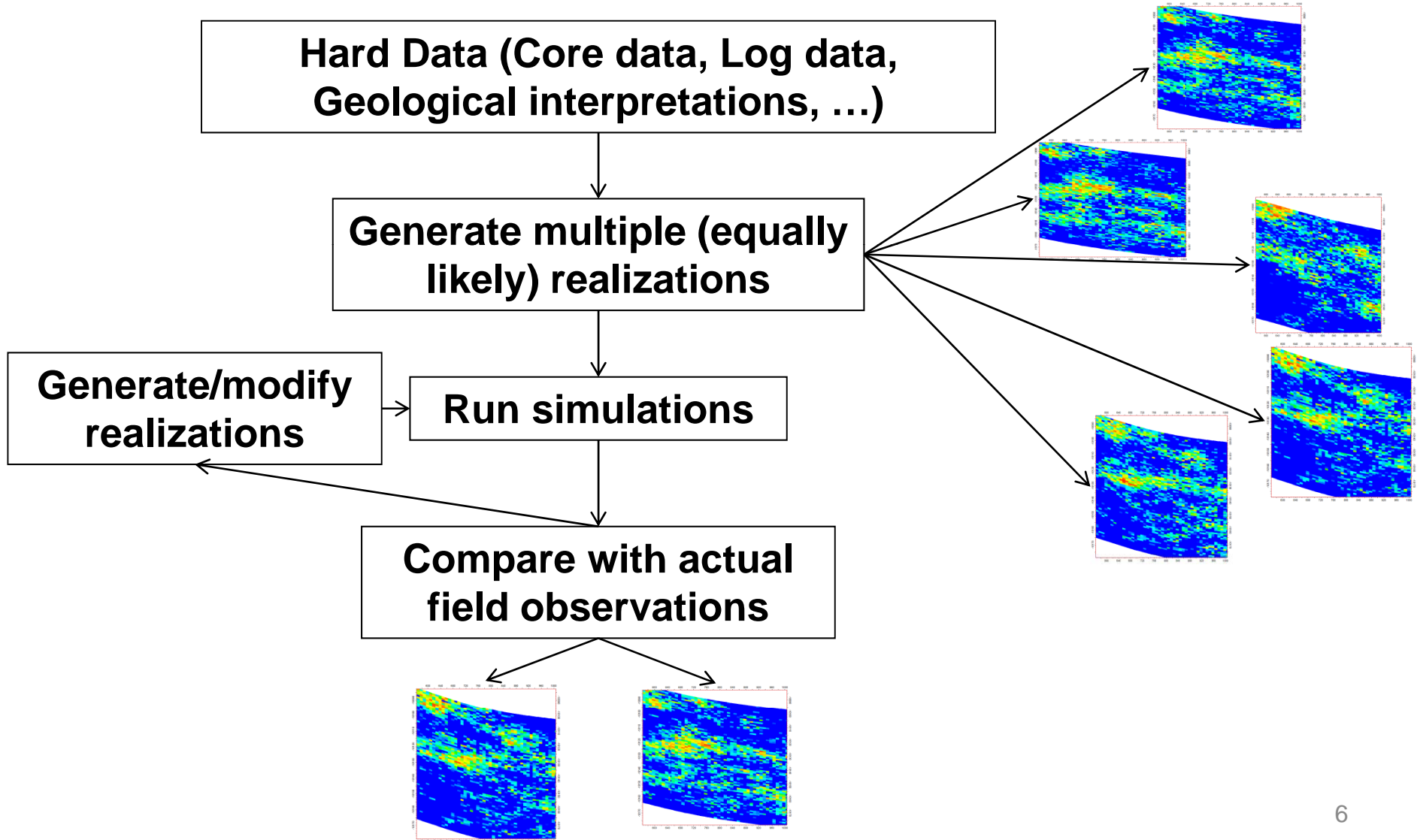


Modeling Approach

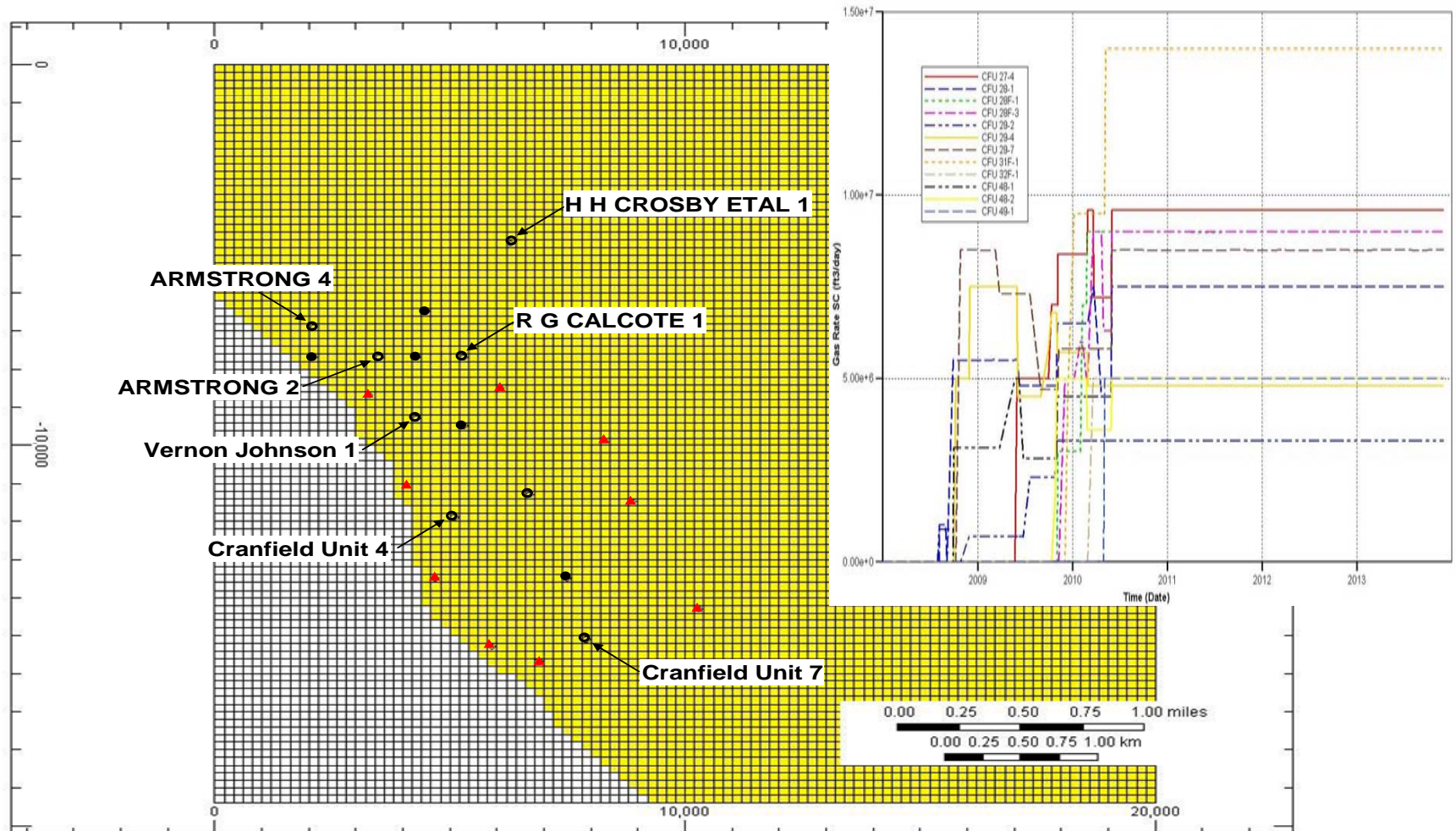
Generate multiple permeability and porosity realizations based on core and log data

- Upscaling methods
- Geostatistical parameters to change
 - Mean of permeability
 - Range of continuity
 - Direction of continuity

Modeling Approach

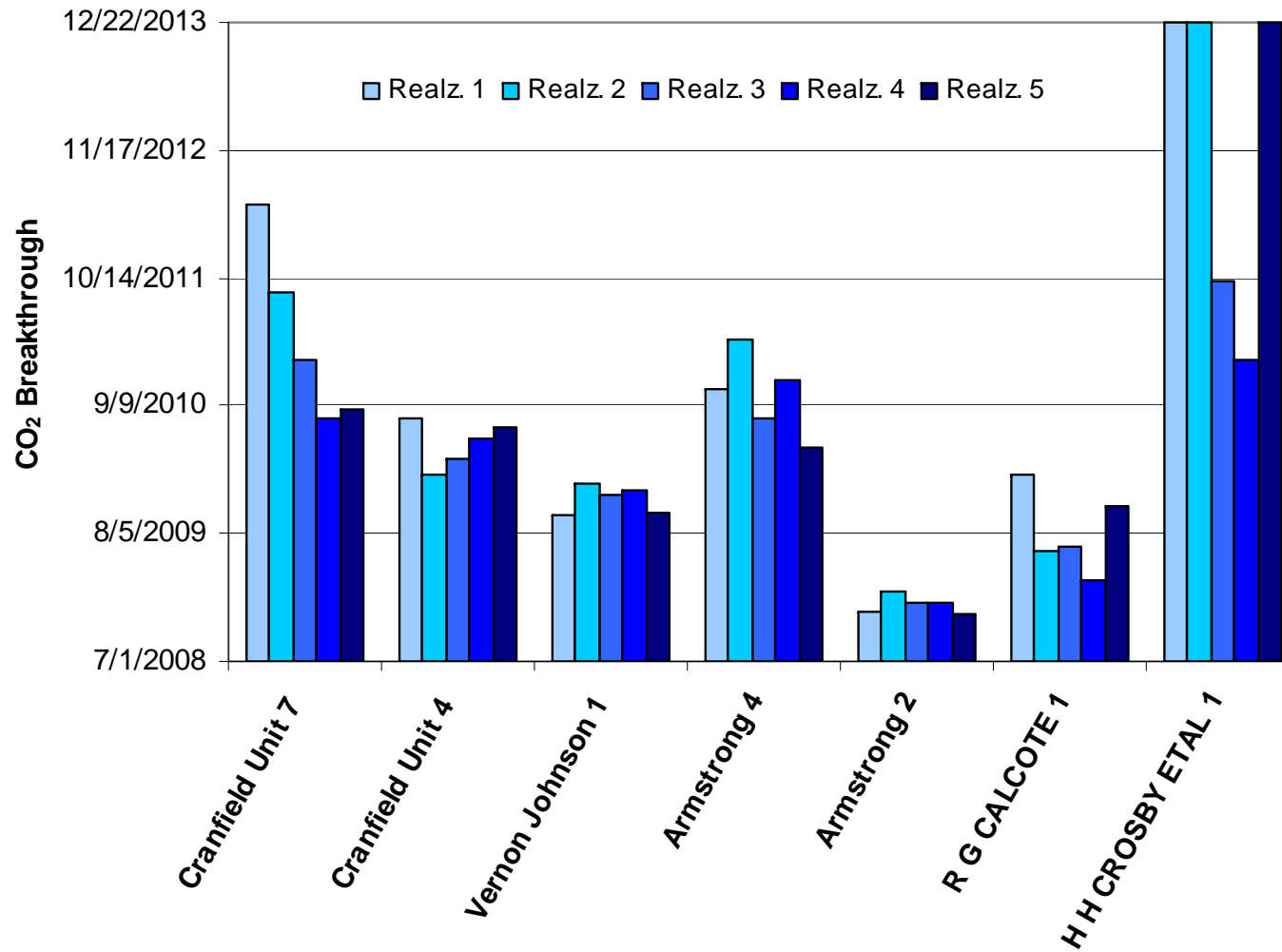


HiVIT Model - Analysis of P&A wells

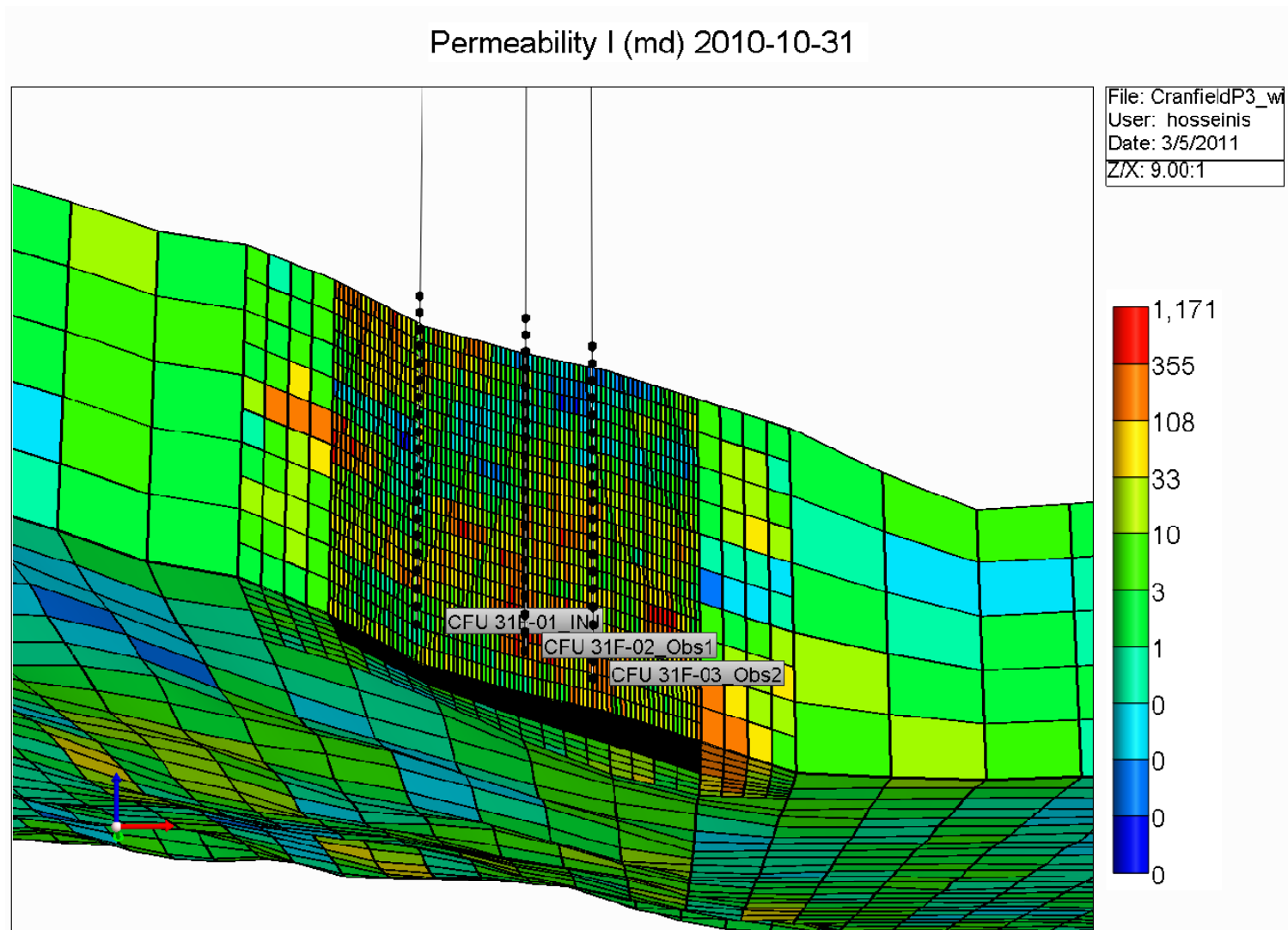


Note: only P&A wells are named, others are either injectors or producers.

Breakthrough in P&A Wells



DAS Model - Permeability

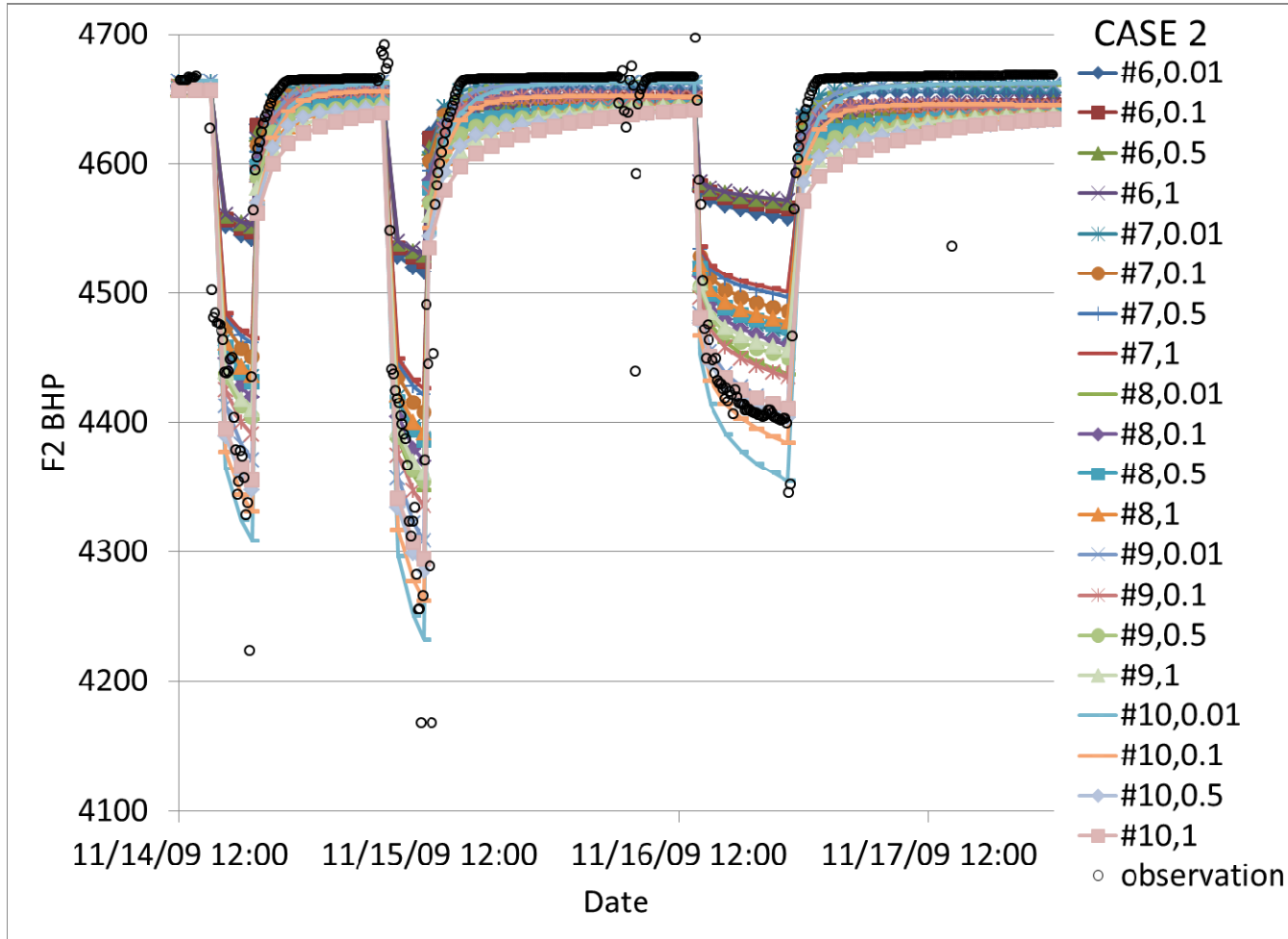


DAS Model

Compare model results against actual measurements

- Bottomhole pressure data before and after F1 injection
- Hydrotest pressure data
- Breakthrough time of CO₂ in observation wells
- Crosswell saturation distribution

Hydrotest

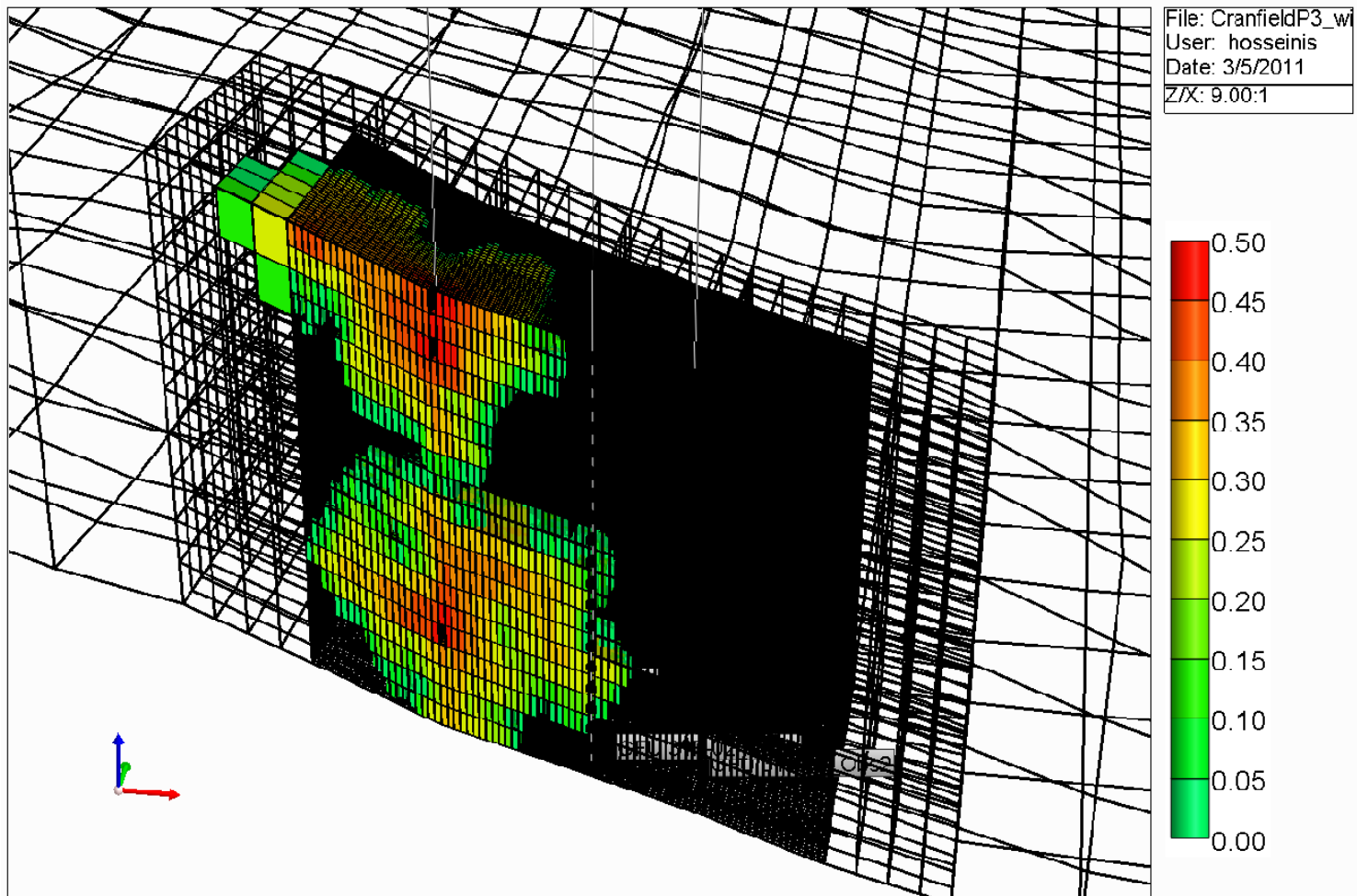


Saturation History Match

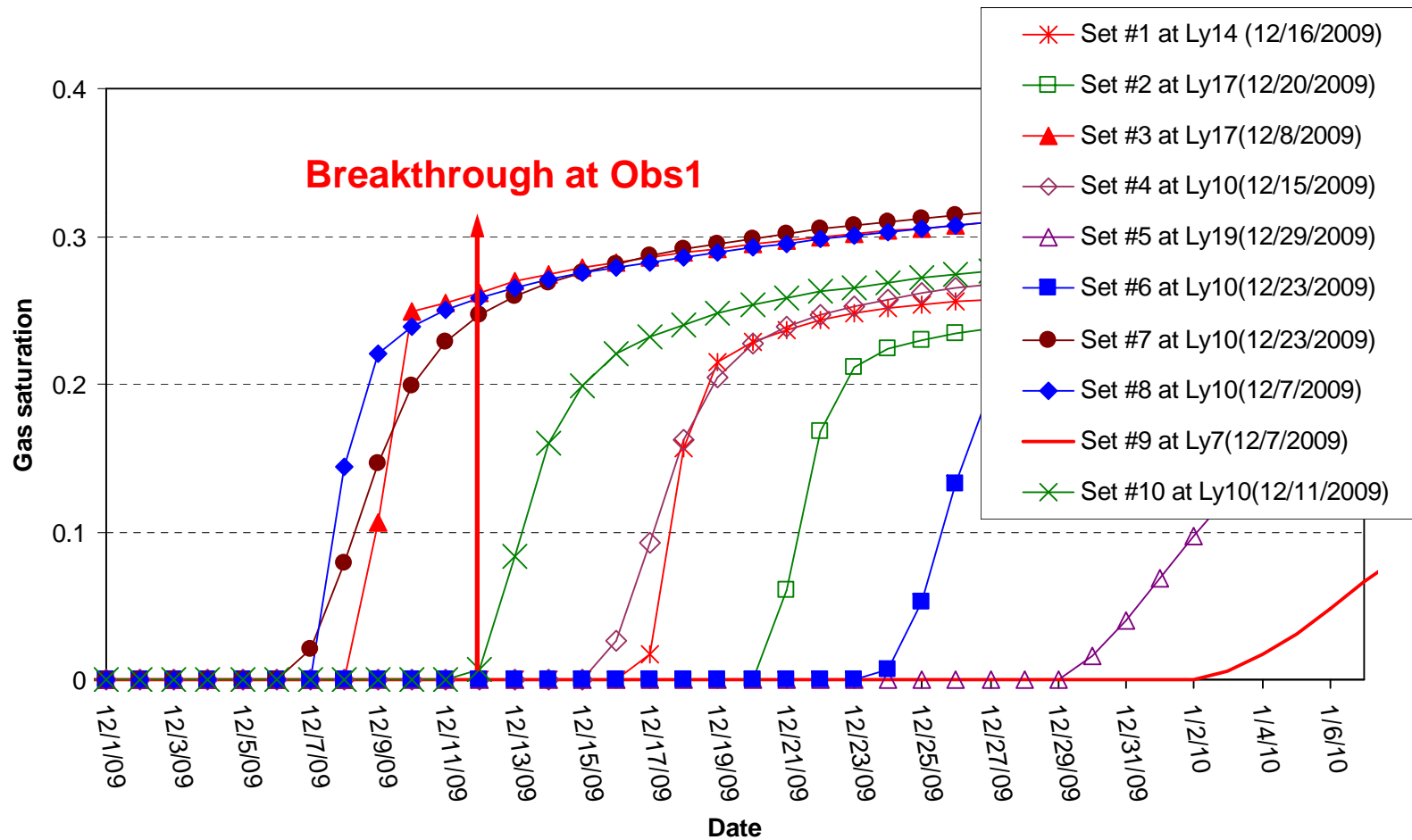
- Different measurements of saturation exist
 - RST
 - VSP
- Flow modeling will constrain our models based on:
 - Magnitude of saturation
 - Multiple zone evolve over time
 - Arrival time of saturations

Crosswell saturation after 1 month injection

Gas Saturation 2009-12-29



Breakthrough in Observation Wells



SIMSEQ – Blind collaboration

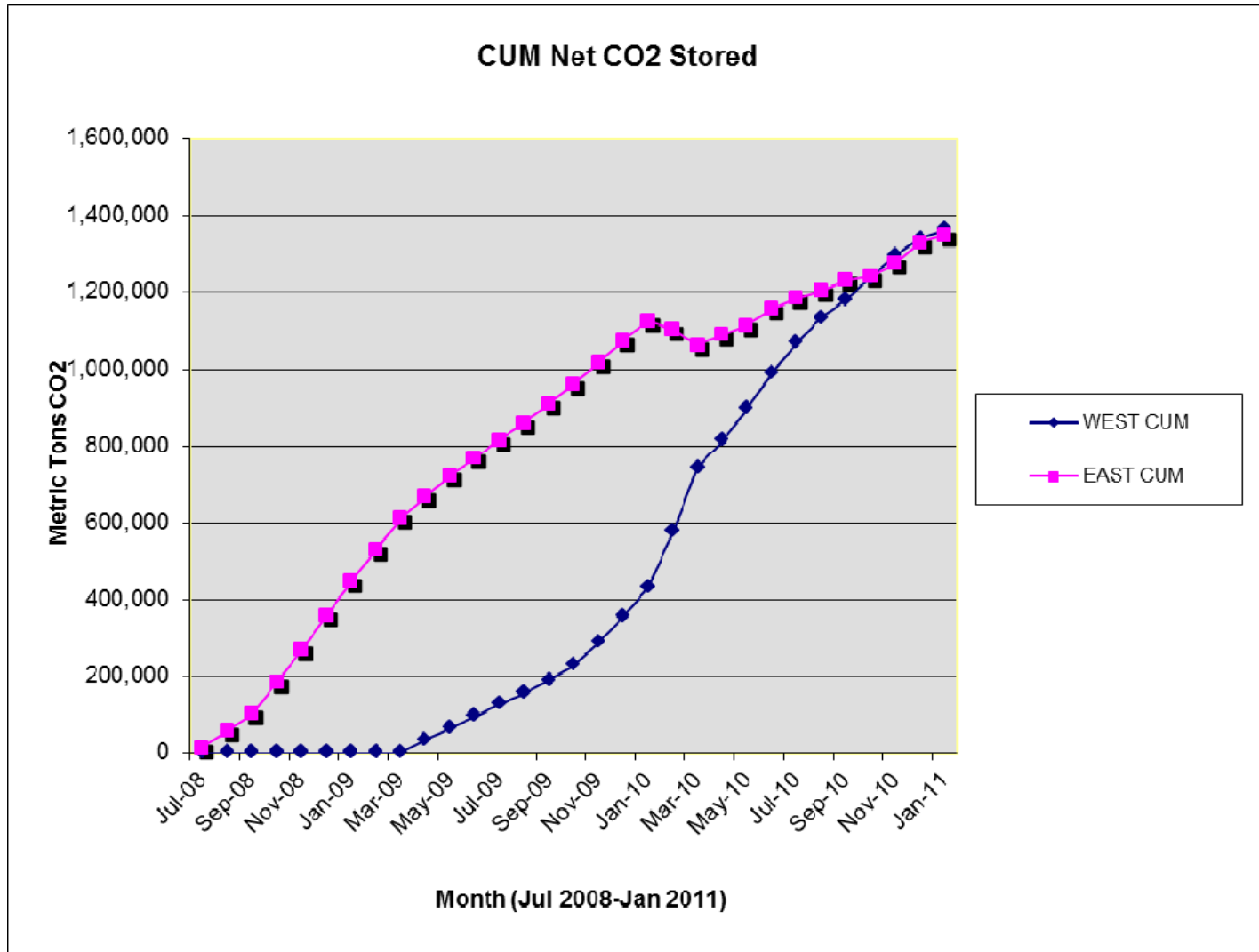
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- Blind collaboration between independent modeling groups to compare outputs
- This work is important because:
 - Investigates the uncertainty imposed by the modelers
 - Regulators will know consistency of the model predictions

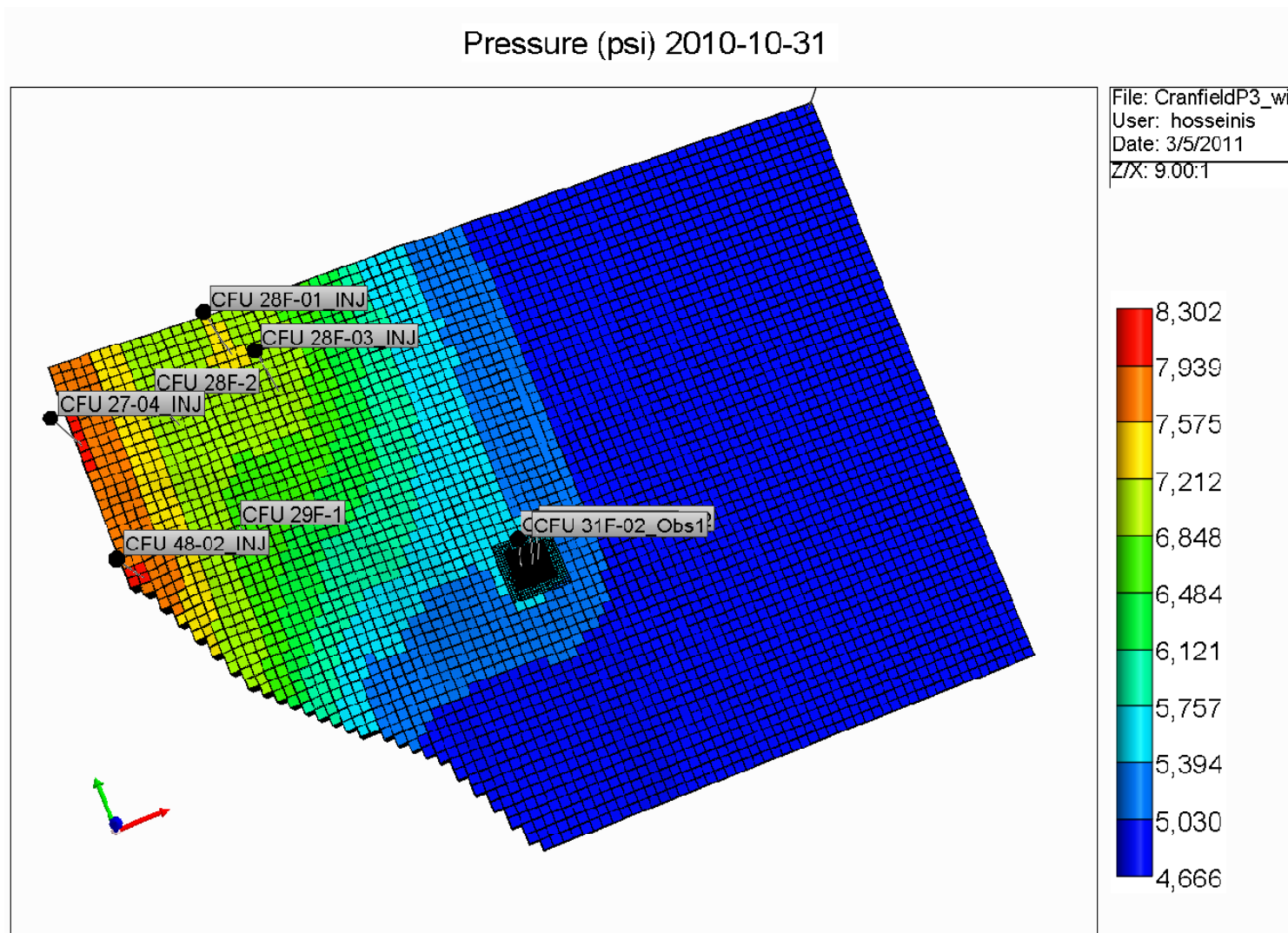
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Thank you

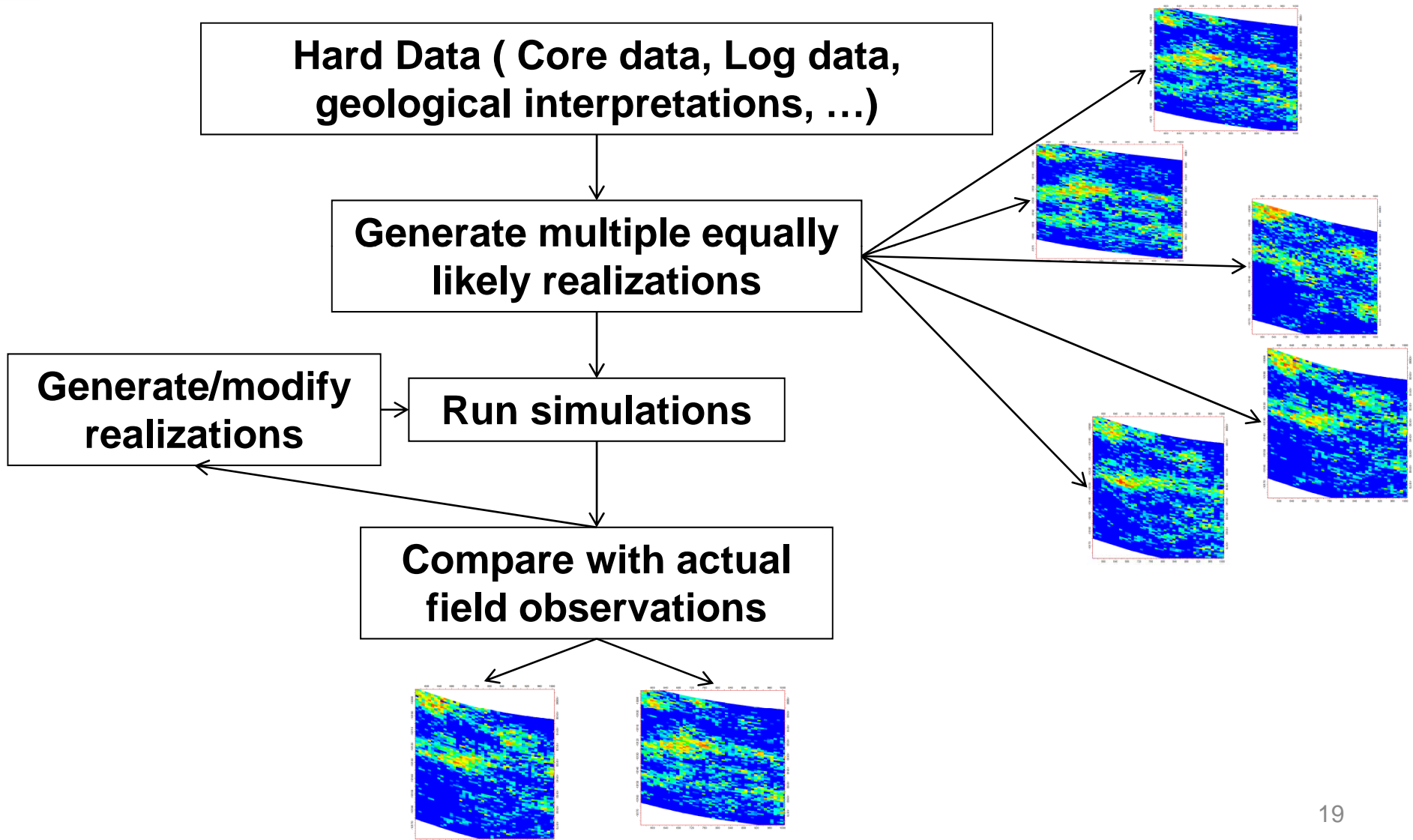
Net CO2 Stored



DAS Model - Pressure

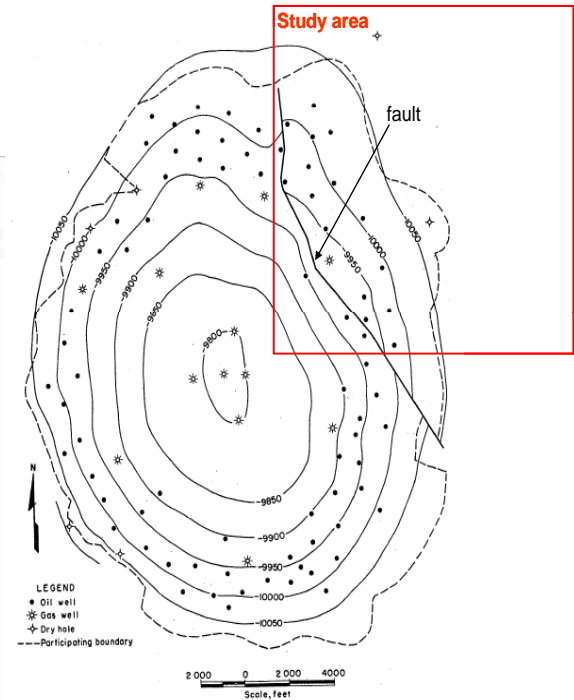
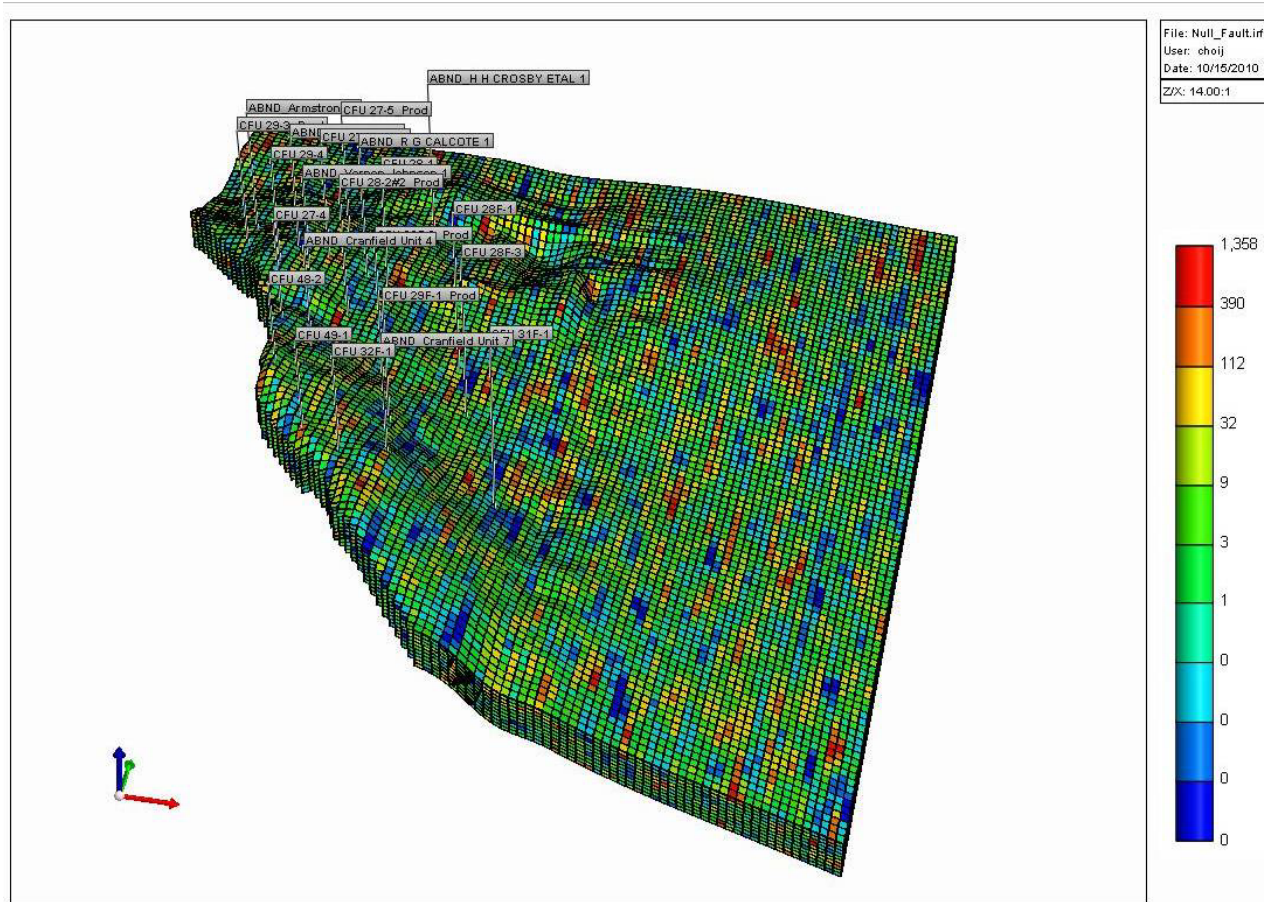


Multiple Realization Generation



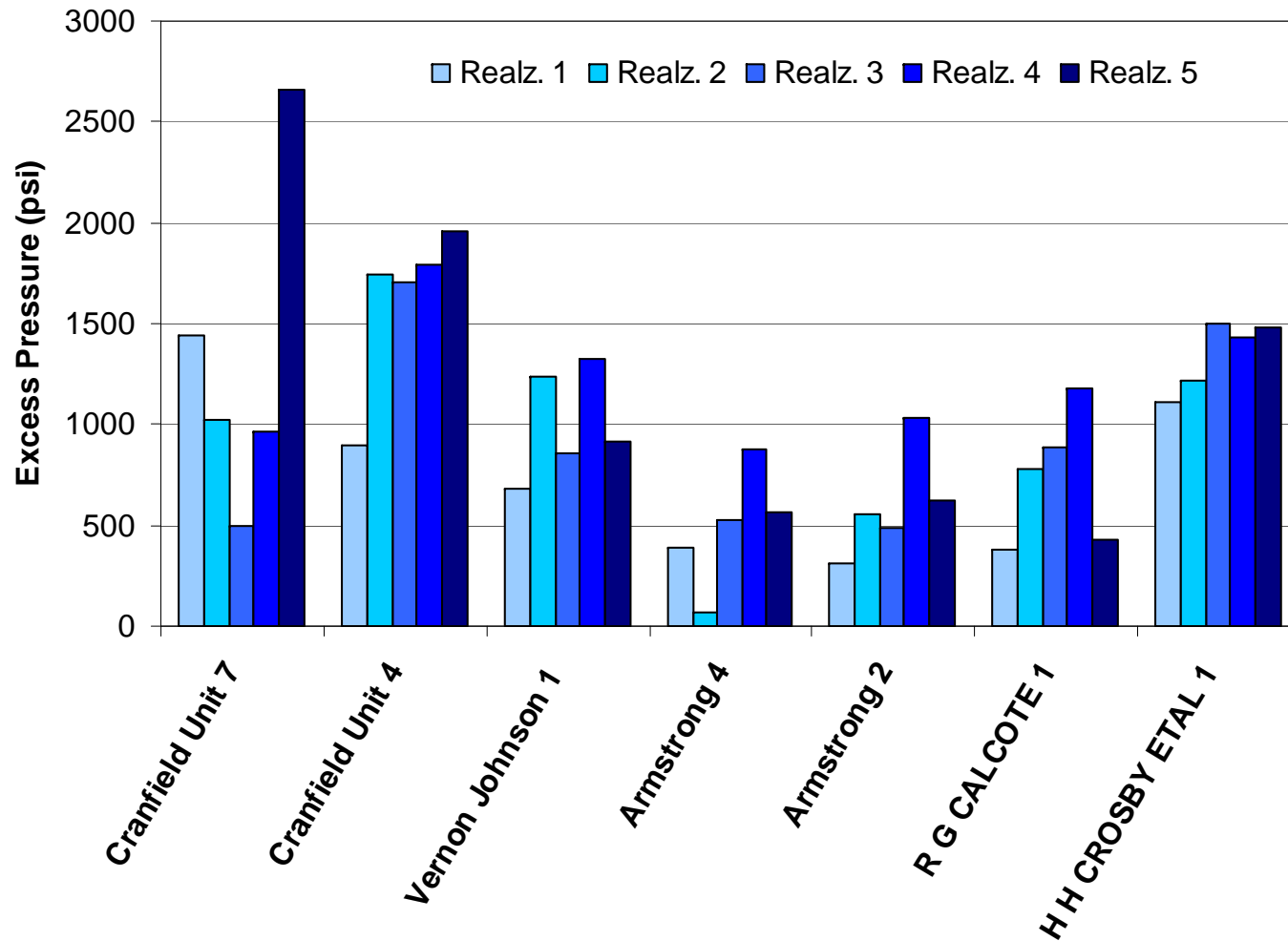
HiVIT Model - Analysis of P&A wells

What is pressure rise and CO₂ breakthrough time at P&A wells?

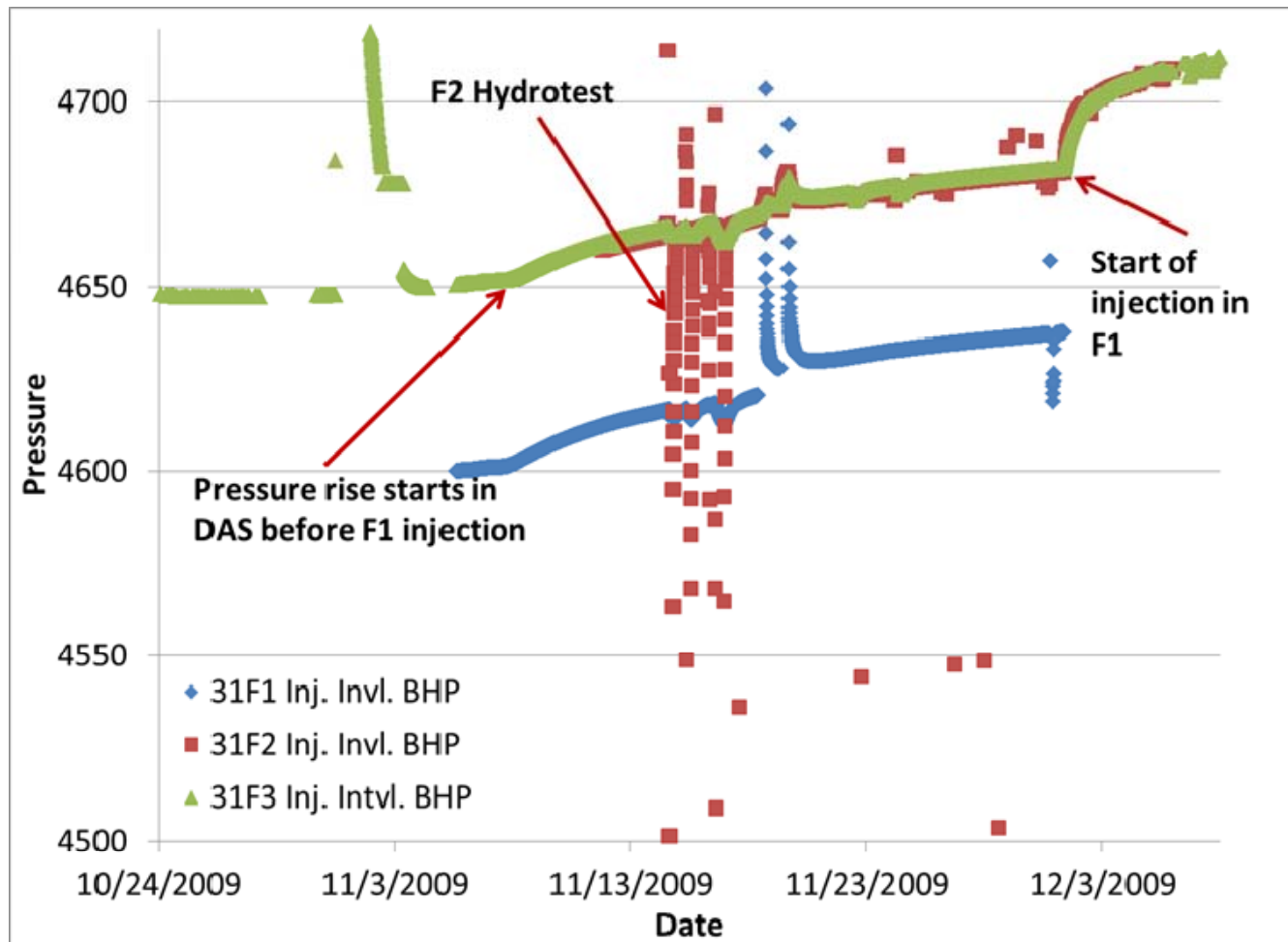


**Multiple Realizations
generated to
investigate the
uncertainty of the
results.**

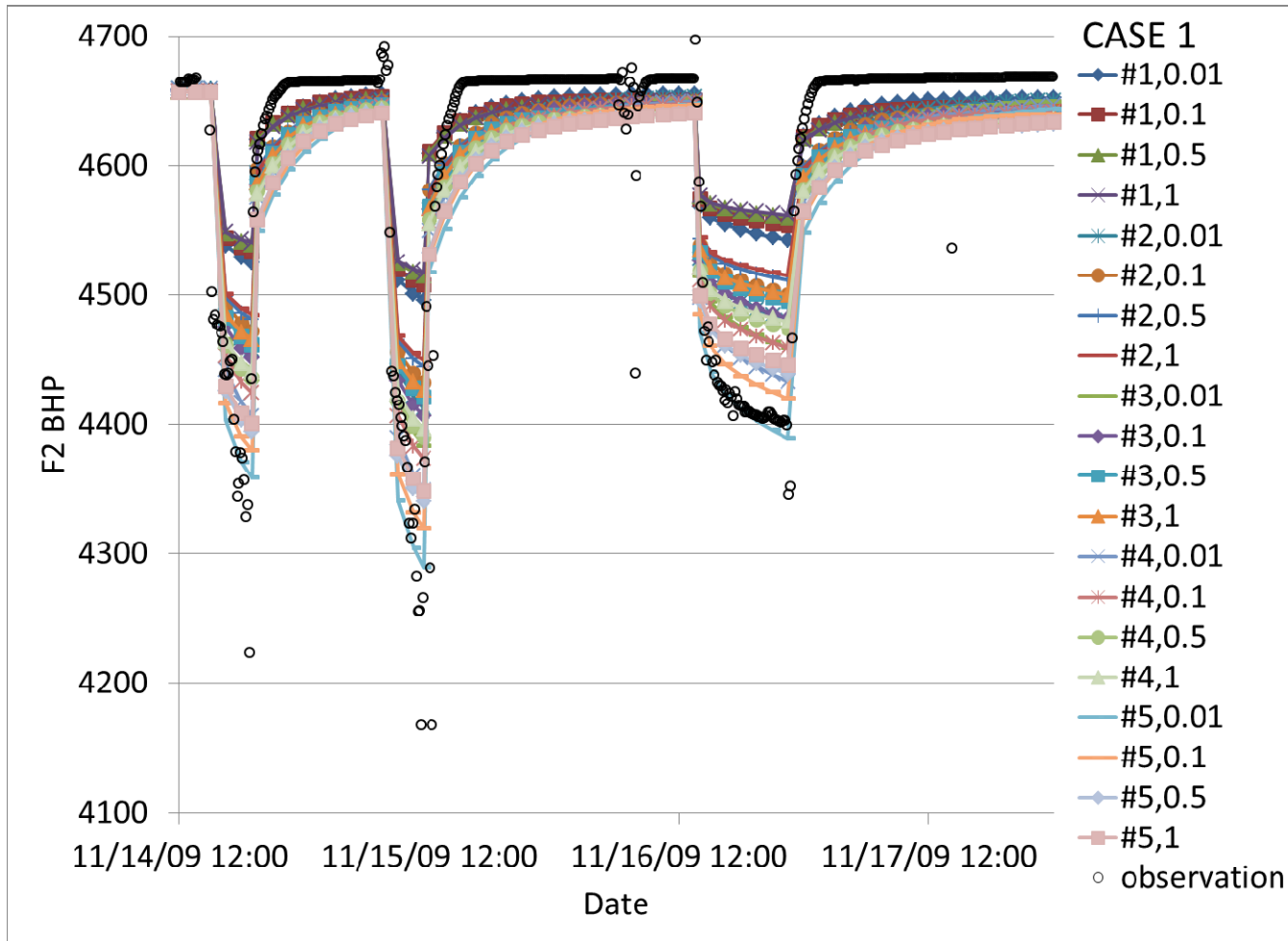
Excess Pressure in P&A Wells



Pressure Data - BHP



Hydrotest



SIMSEQ – Blind collaboration

Denbury data	
	Construction details (KB datum, perforated interval, casing volume, packer depth, pressure gage elevation)
	Open hole well logs
	Permeability, porosity from core plugs with depth and distance from DAS but without providing well locations or names.
	Relative permeability, with depth and distance from DAS but without providing well locations or names.
	Bottom hole locations of injectors
	Monthly injection rates of above injectors
	Bottom hole locations of producers
	Monthly production rates producers.
BEG inter. from Den. data	
	BEG structure contours on top and bottom of Tuscaloosa D-E in a ~1 mile radius around CFU-31 wells from seismic and log interpretation
	BEG mapped fault location
	BEG mapped oil/water contact

SIMSEQ – Blind collaboration

BEG data	
	Bottom hole location (X, Y Z) of the wells
	As built construction SS 31F2 and SS 31F3
	Open hole logs from SS 31F2 and SS 31F3
	Formation top picks
	Core permeability and porosity SS 31F2 and SS 31F3
	Petrographic analyses of injection formation (done by BEG)
	Pre-injection bottom hole pressure and temperature measurements in injection and observation wells
	USGS - brine geochemical analyses
	Single phase permeability from DAS pressure recovery and step injection tests
	Daily injection rate in tones, BHP and BHT at SS 31F1
	Any other operational information from DAS relevant to model match (e.g. flow rate during sampling)
Model Calibration	
	BEG Sub sampled dated bottom hole pressure data at 31-F2 and 31 F3
	BEG Interpreted CO2 breakthrough dates at SS 31F2 and SS 31 F3
	BEG/ Schlumberger dated and interpreted CO2 saturation at intervals from RST SS 31F2 and SS 31F3
	BEG/LBNL dated interpreted plume extent from seismic program
Public information	
	Draft papers from Phase 2
	Published modern and historic papers