Integration of a CO_2 Sequestration System Model and Diverse Geospatial Data Using GIS Applications

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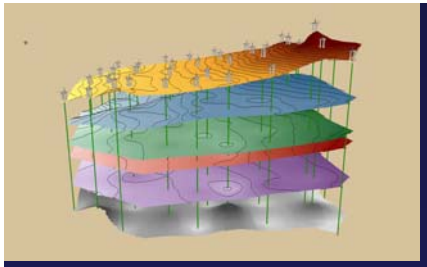


The Challenge: Data – Model Coupling

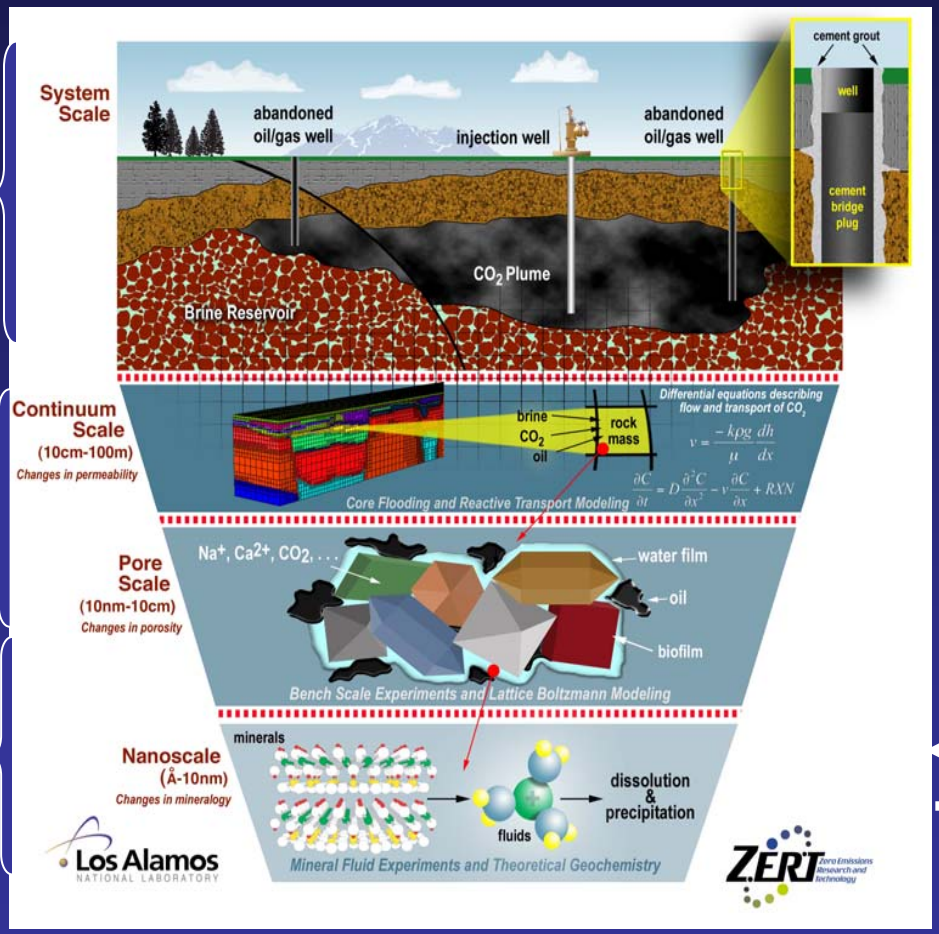
- Developing probabilistic risk assessment model of CO2 sequestration and potential release – *CO2PENS*
- Model data elements require stochastic input values
- Connect the model with diverse geospatial data on regional or national scale – Carbon Knowledge Base
- Abstract geospatial data to inform non-spatial, stochastic data elements

Science based decisions must consider dynamic evolution of fundamental processes to determine system behavior

CO_2 release

fluid flow

geochemical reactions

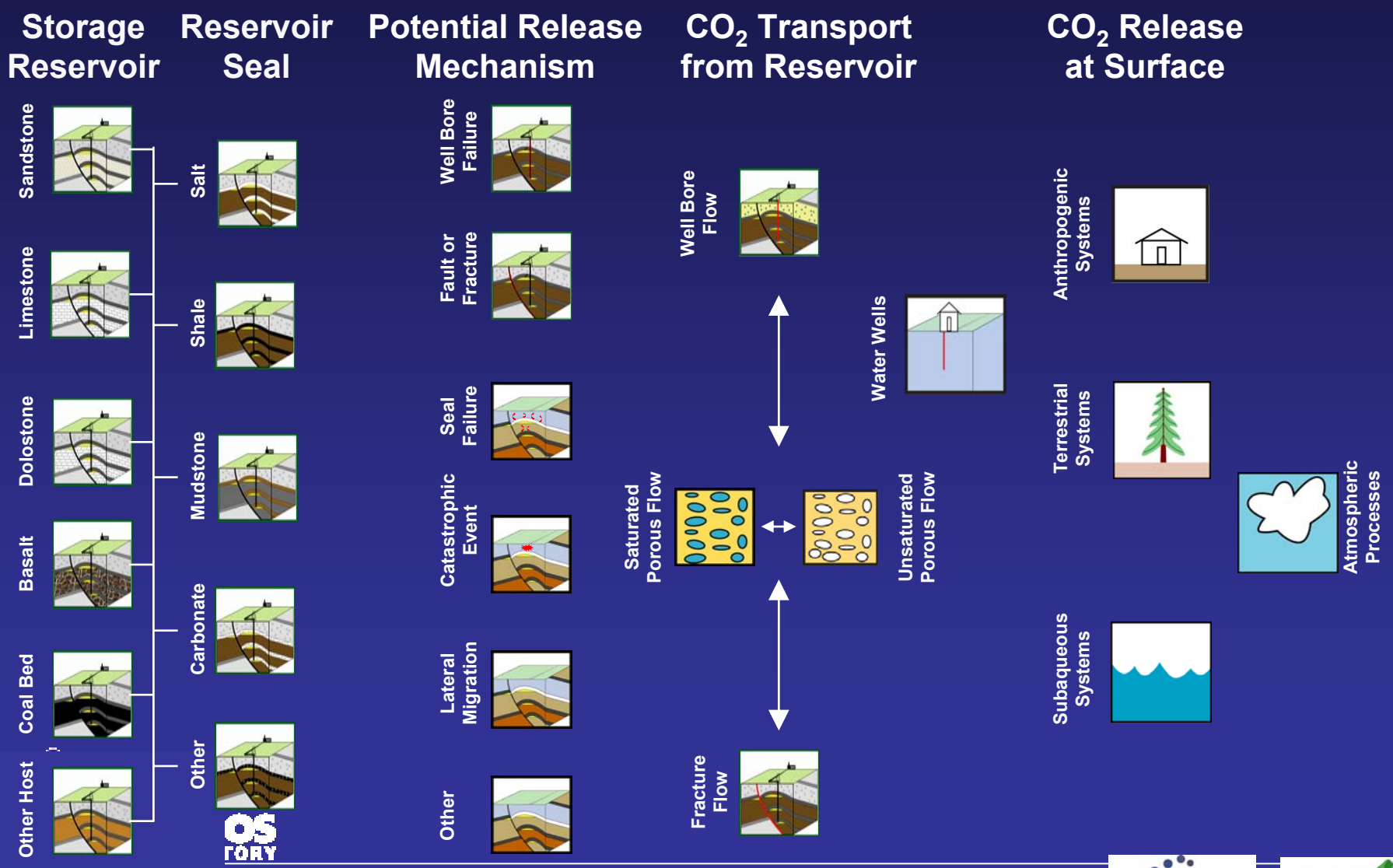


system model (probabilistic)

process-level models

Challenge spans wide ranges in length and time scales

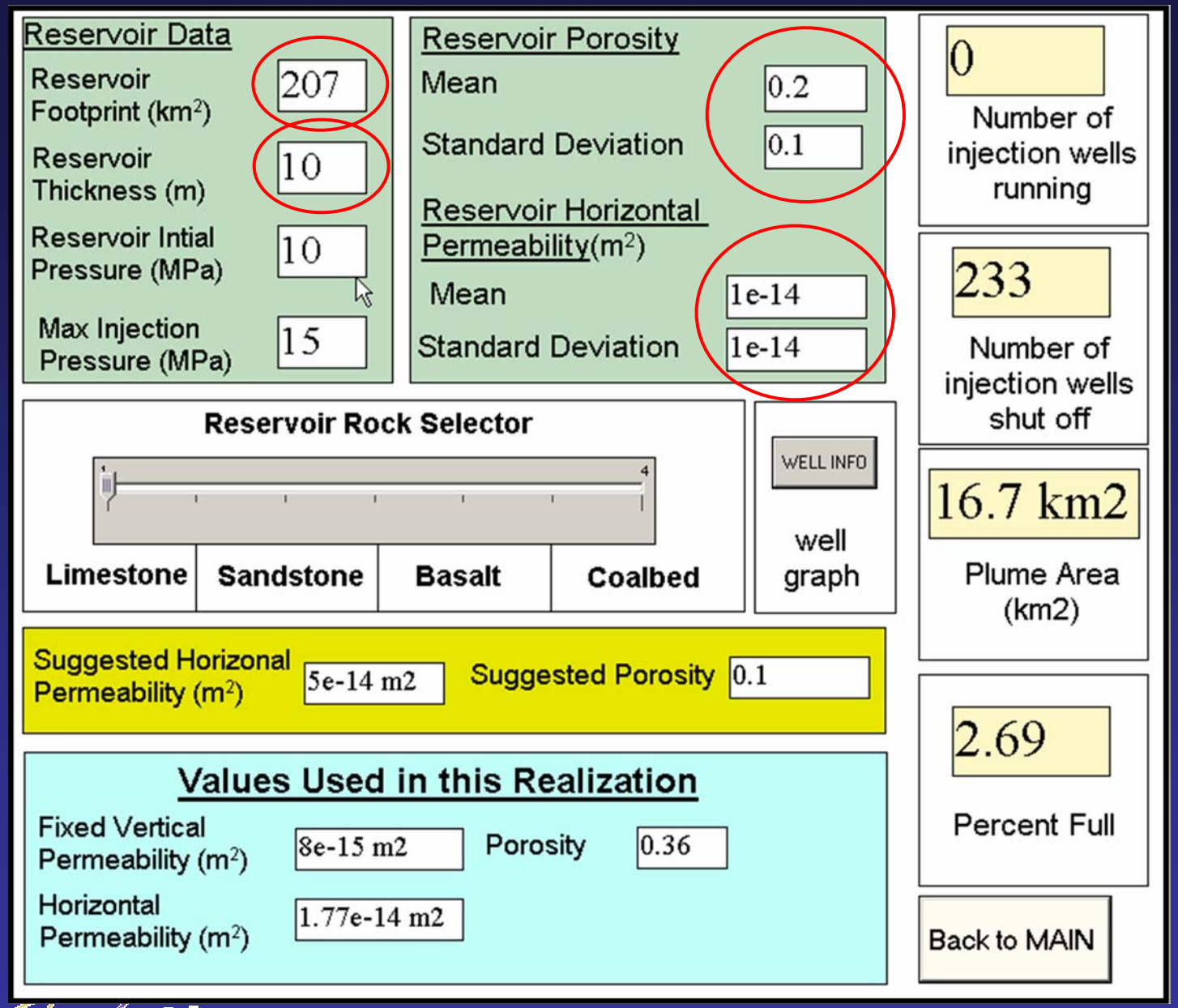
CO2-PENS framework can be used to determine probability distributions necessary for risk calculations.



CO_2-PENS: Systems-Level Framework for Analysis of CO_2 management/sequestration

- CO2-PENS is based on the conceptual framework
- Each box contains process models of varying complexity

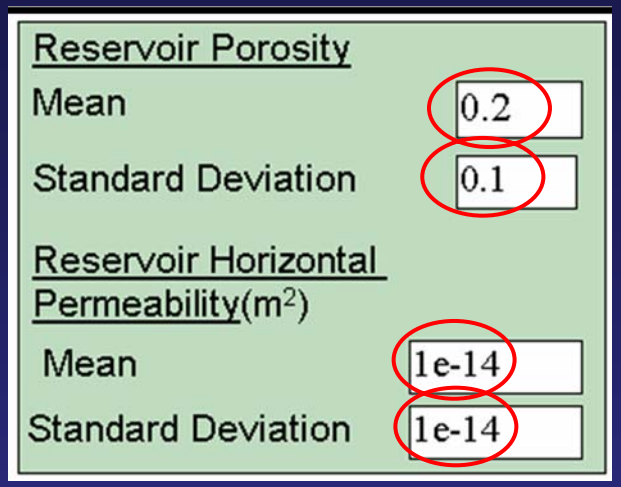
CO2-PENS: Predicting Engineered Natural Systems for Geologic CO2 Sequestration



CO2-PENS Model requires realistic input values,

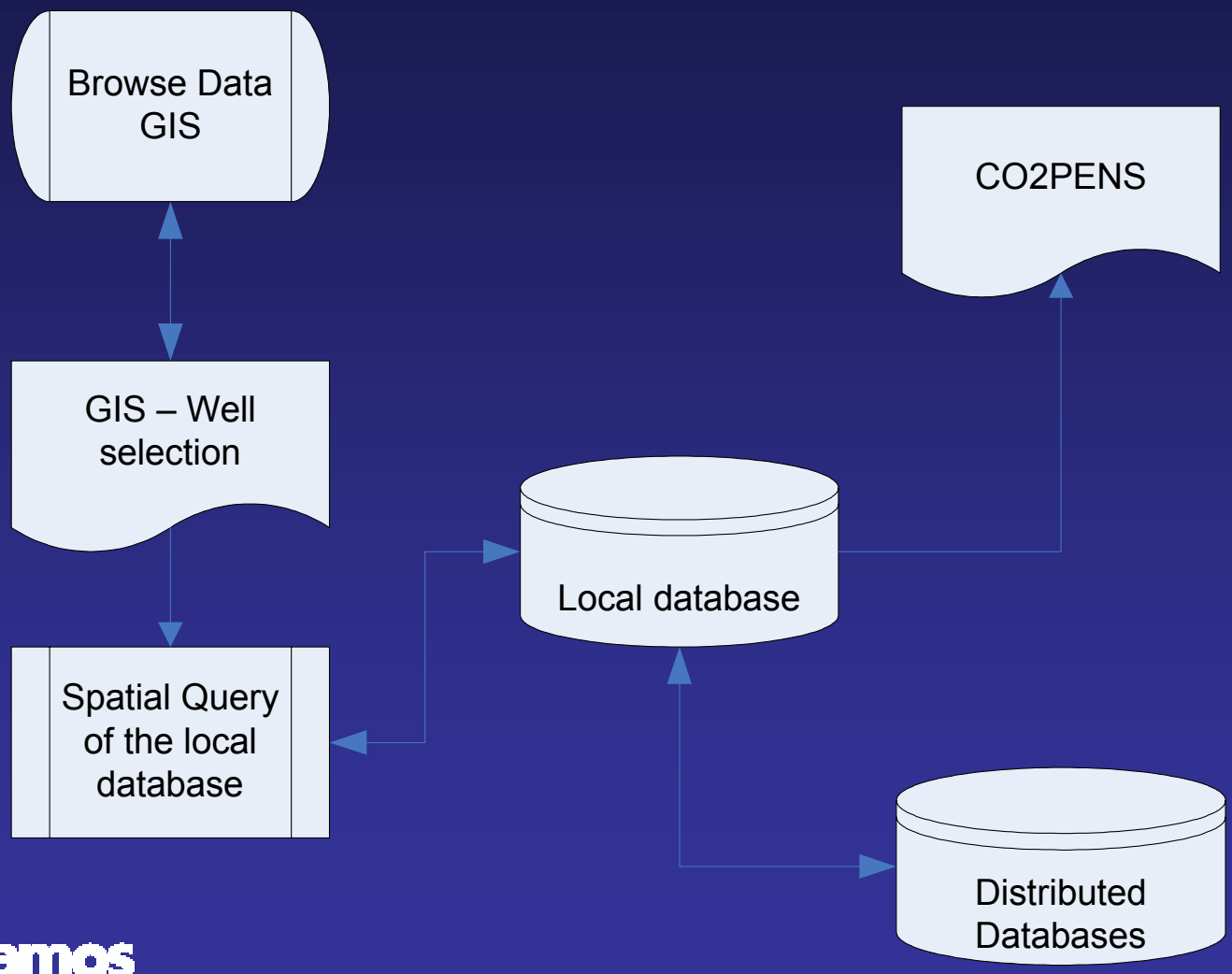
ideally provided by queries to external data sources

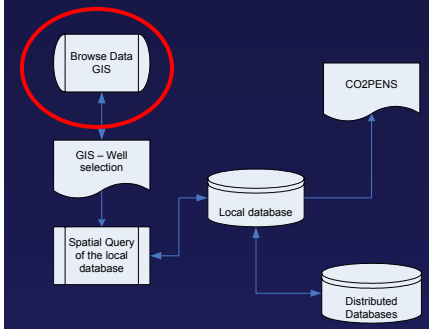
Evolution of data-model coupling



1. Manual input of values for model data elements (ad hoc data discovery, multiple steps)
2. Preprocess geospatial data into database, queried by model (2 steps)
3. Automated abstraction of geospatial data via GIS tools (select area, perform spatial analysis, query Knowledge Base, inform model – *integrated*)

CO2-PENS Data Flow



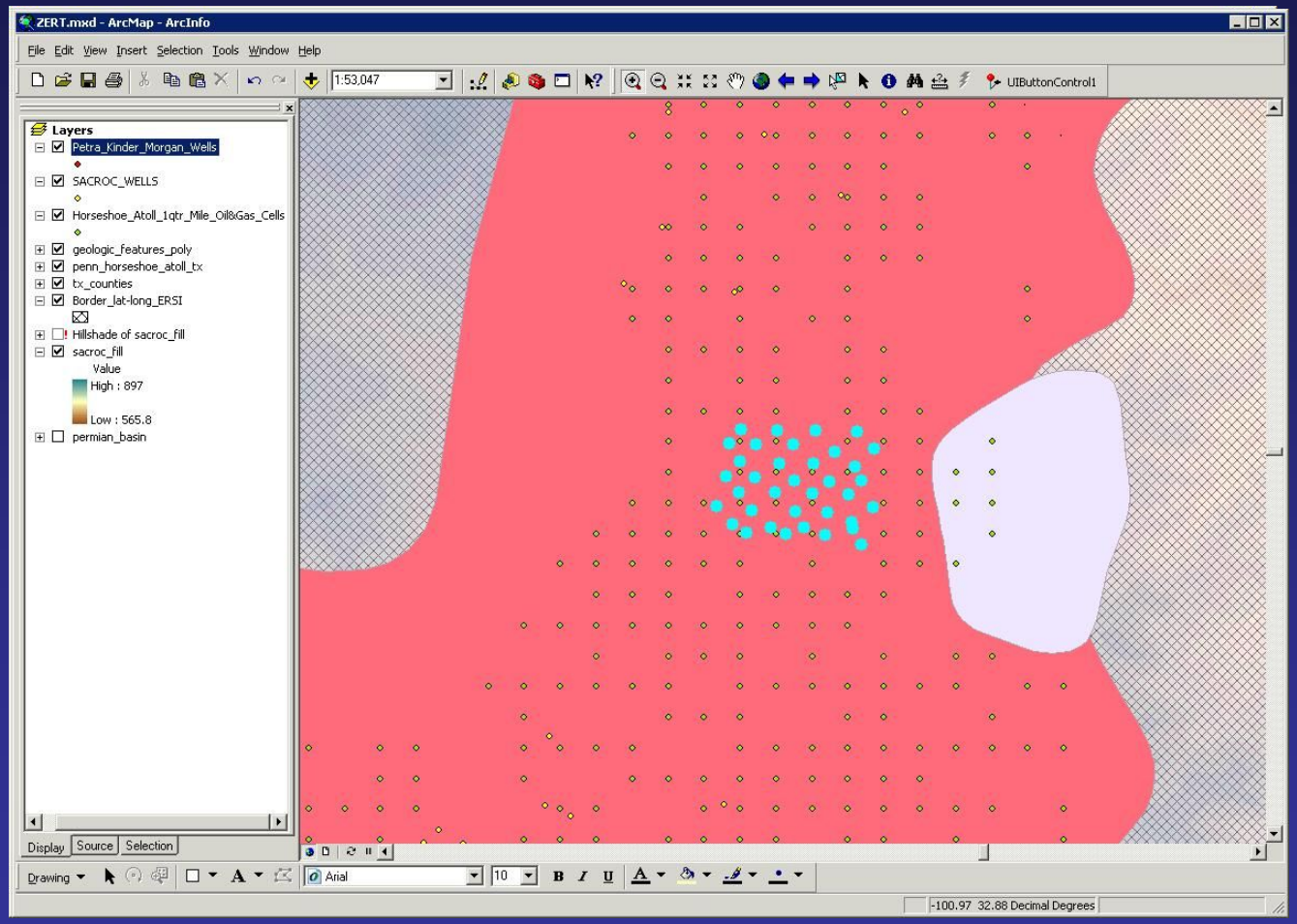


CO2-PENS Data Flow

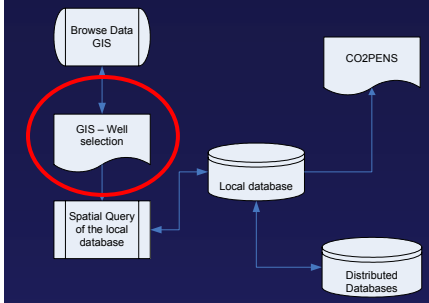
Data Overview

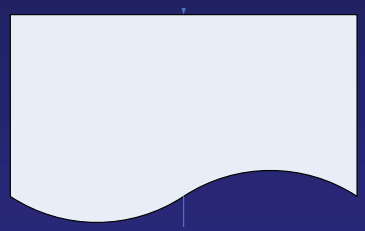
Zoom

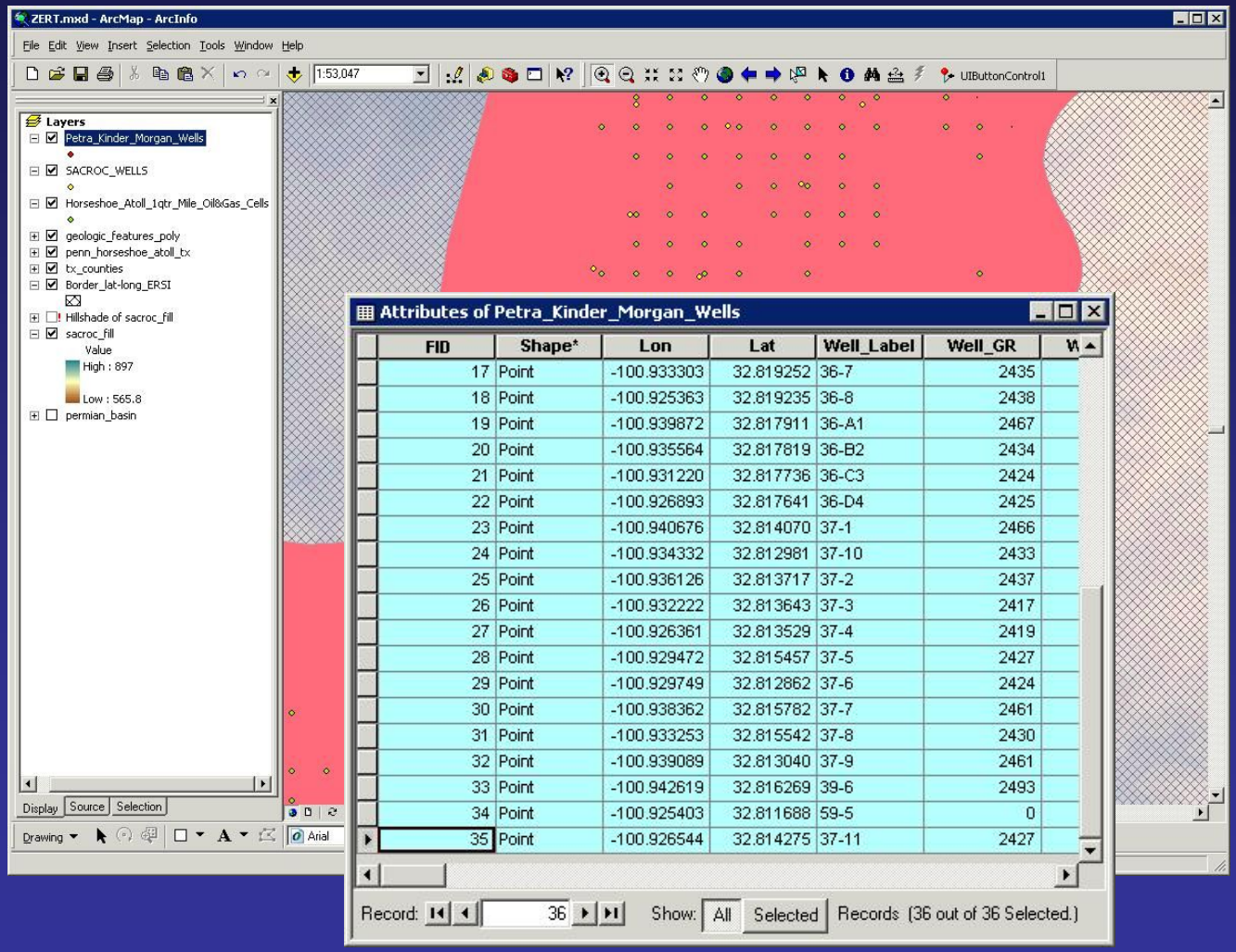
Select Area of Interest



CO2-PENS Data Flow







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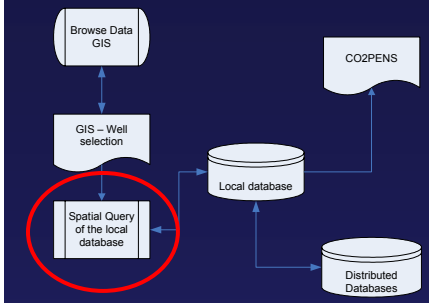
18	Point	-100.925363	32.819235	36-8	2438
19	Point	-100.939872	32.817911	36-A1	2467
20	Point	-100.935564	32.817819	36-B2	2434
21	Point	-100.931220	32.817736	36-C3	2424
22	Point	-100.926893	32.817641	36-D4	2425
23	Point	-100.940676	32.814070	37-1	2466
24	Point	-100.934332	32.812981	37-10	2433
25	Point	-100.936126	32.813717	37-2	2437
26	Point	-100.932222	32.813643	37-3	2417
27	Point	-100.926361	32.813529	37-4	2419
28	Point	-100.929472	32.815457	37-5	2427
29	Point	-100.929749	32.812862	37-6	2424
30	Point	-100.938362	32.815782	37-7	2461
31	Point	-100.933253	32.815542	37-8	2430
32	Point	-100.939089	32.813040	37-9	2461
33	Point	-100.942619	32.816269	39-6	2493
34	Point	-100.925403	32.811688	59-5	0
35	Point	-100.926544	32.814275	37-11	2427

Data Inspection

Evaluation of completeness, quality

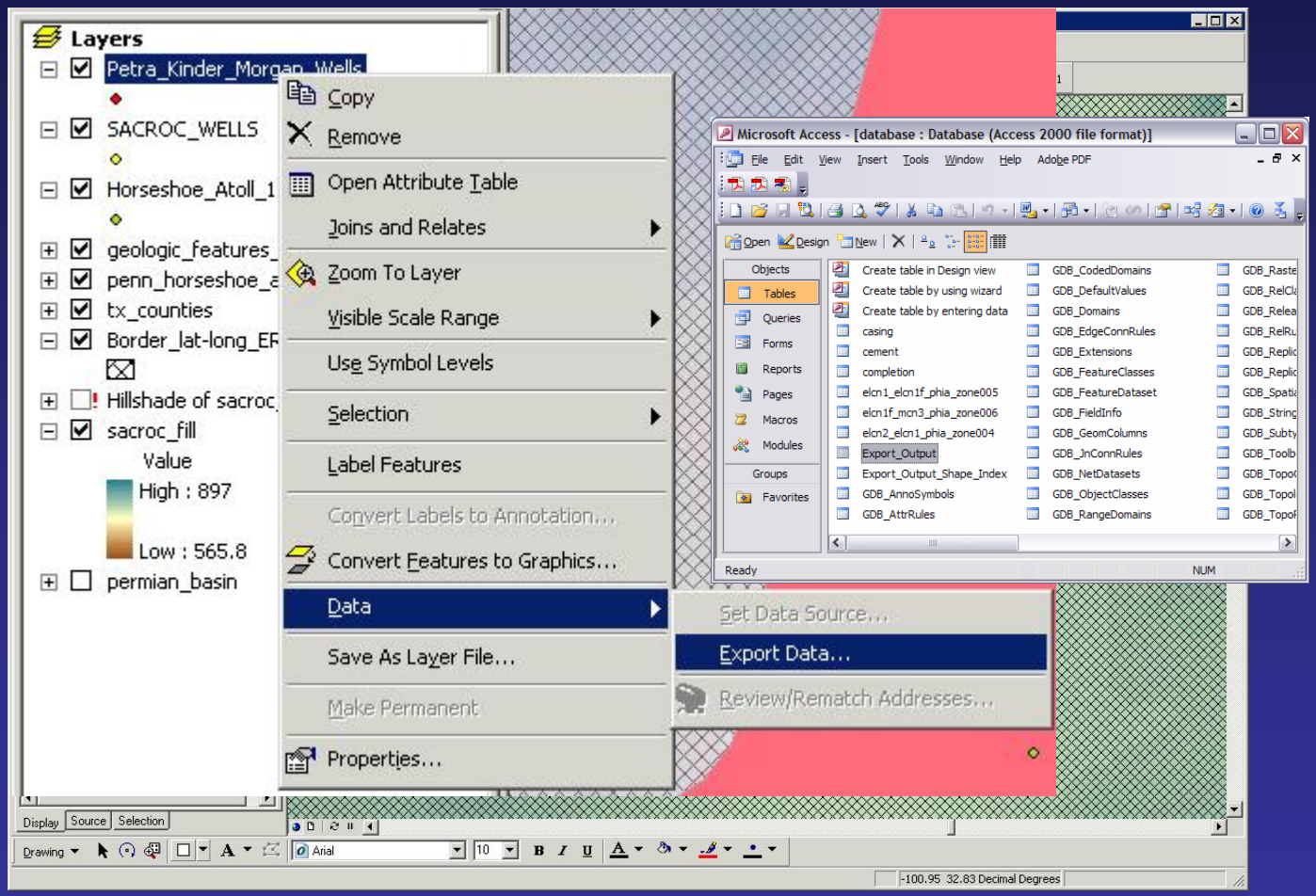
CO2-PENS Data Flow



Build Geodatabase

Data Selection

Export to Geodatabase



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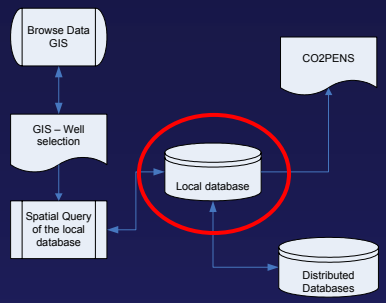
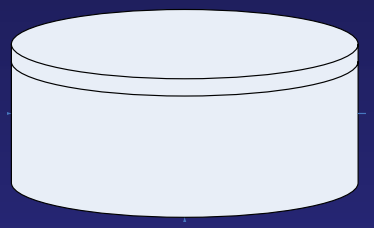
ZERT Zero Emissions Research and Technology

GISLab Los Alamos National Laboratory

CO2-PENS Data Flow





Microsoft Access - [Export_Output : Table]

File Edit View Insert Format Records Tools Window Help Adobe PDF

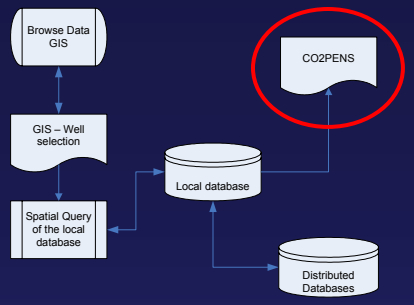
ID	UWI_API	LABEL	DATUM	SURFLAT	SURFLON
1	4.241531965E+11	34-11	2474	47.11332	-110.94109
2	4.241503371E+11	34-5	2481	32.825298	-100.93967
3	4.241503372E+11	34-6	2471	32.825194	-100.935392
4	4.241531588E+11	34-9	2467	32.823494	-100.937836
5	4.241503273E+11	35-1	2464	32.82149	-100.939798
6	4.241503274E+11	35-2	2455	32.821218	-100.935115
7	4.241532034E+11	35-6	2487	32.819818	-100.941451
8	4.241531655E+11	36-6	2469	32.819619	-100.937957
(AutoNumber)					

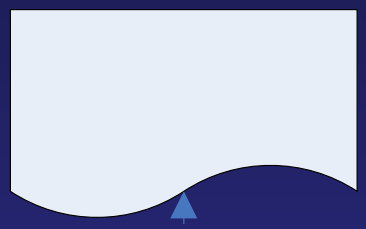
Record: 1 of 8

Datasheet View NUM

Custom geodatabase generated prior to each model run

CO2-PENS Data Flow

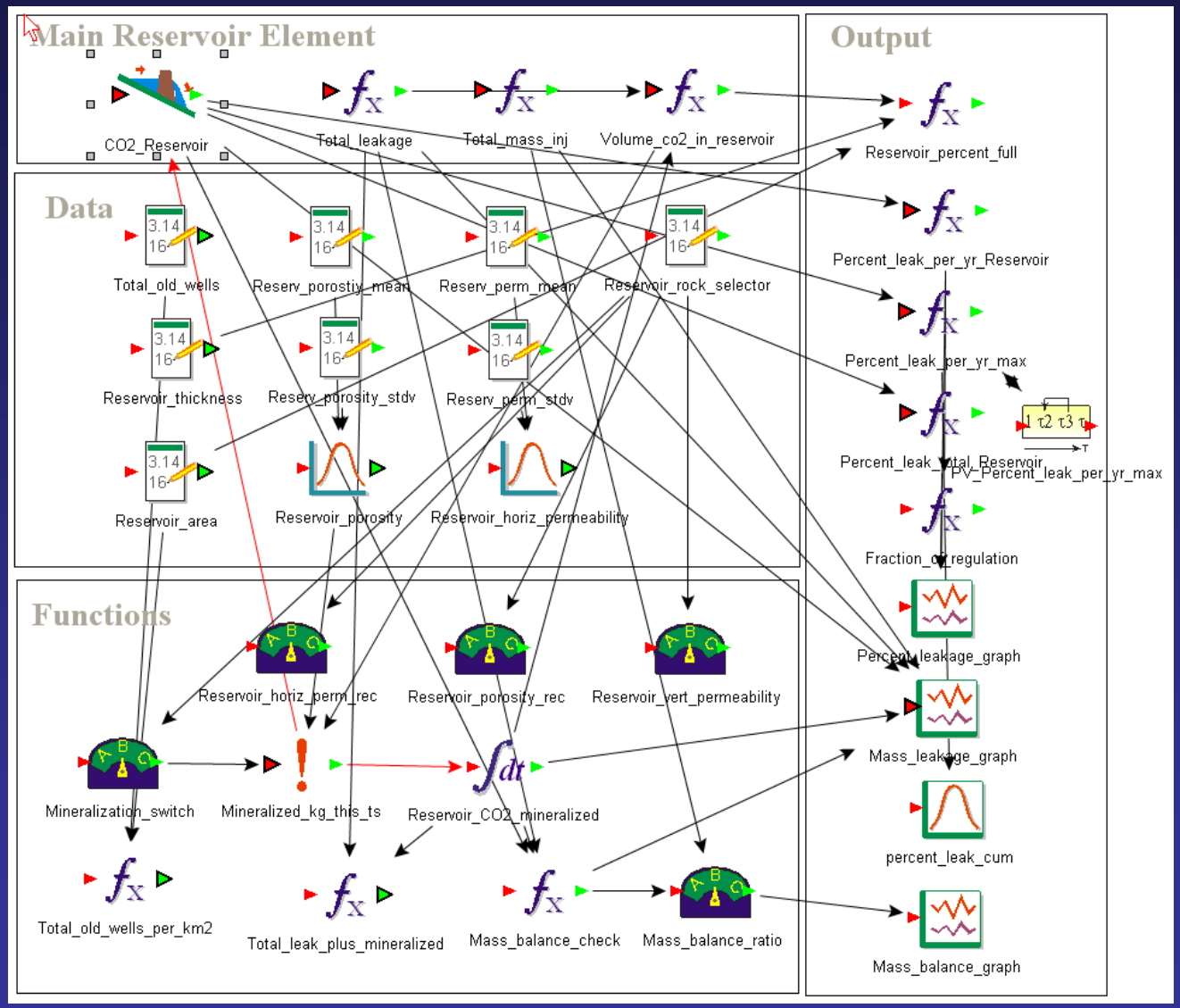




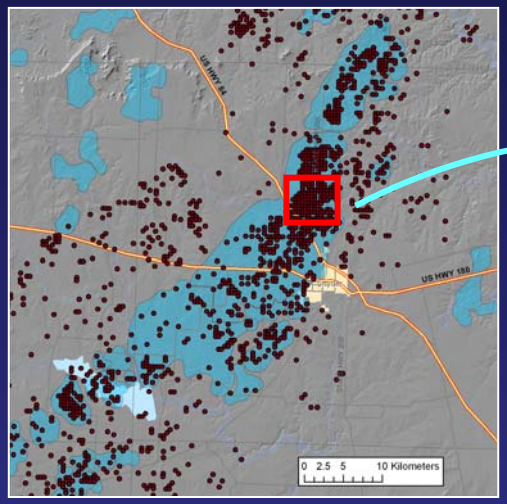
Data Elements by category

Dynamic control of model flow

Connect to database via ODBC

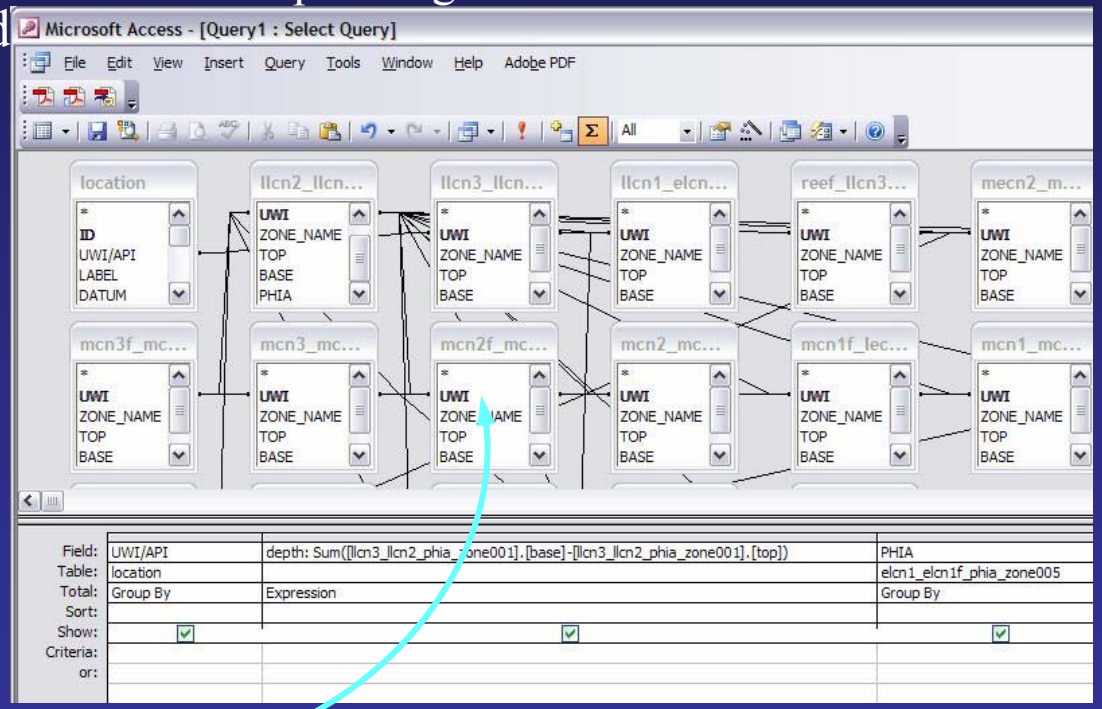


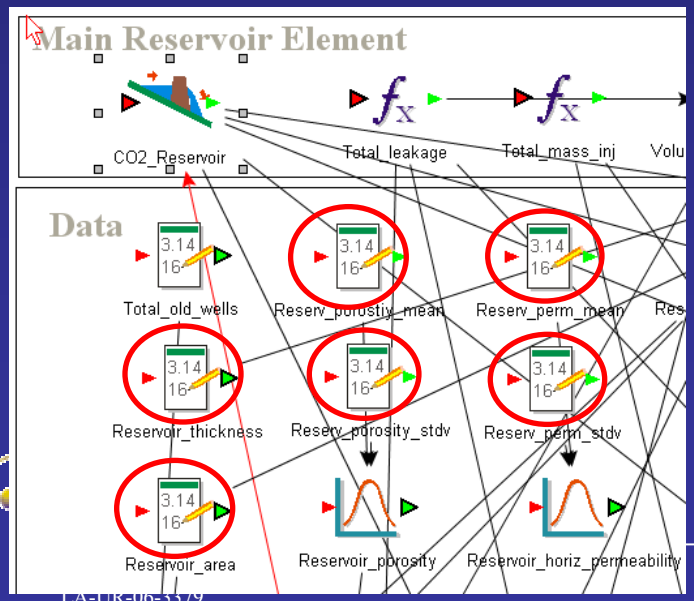
Data Connection: Porosity, Permeability, Area, Thickness…



Export and Generate Statistics

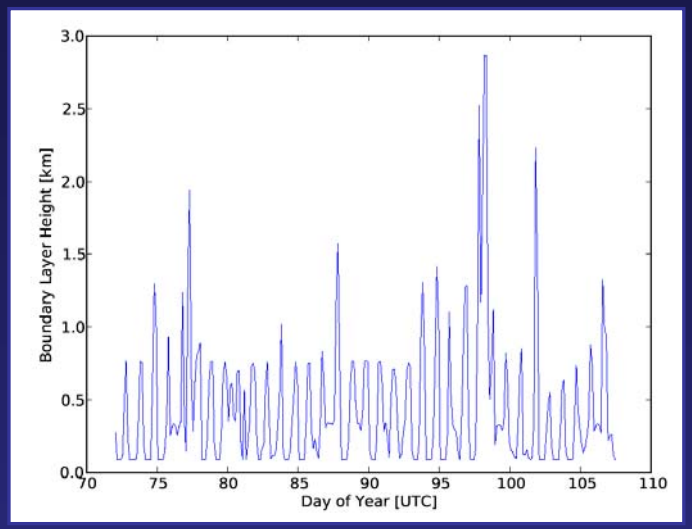
PETRA database, 20 reservoir formations
Export to geodatabase and statistics

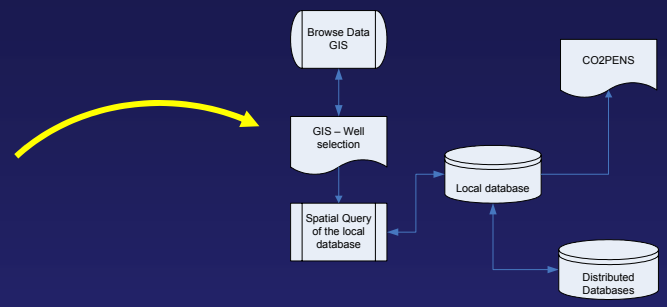




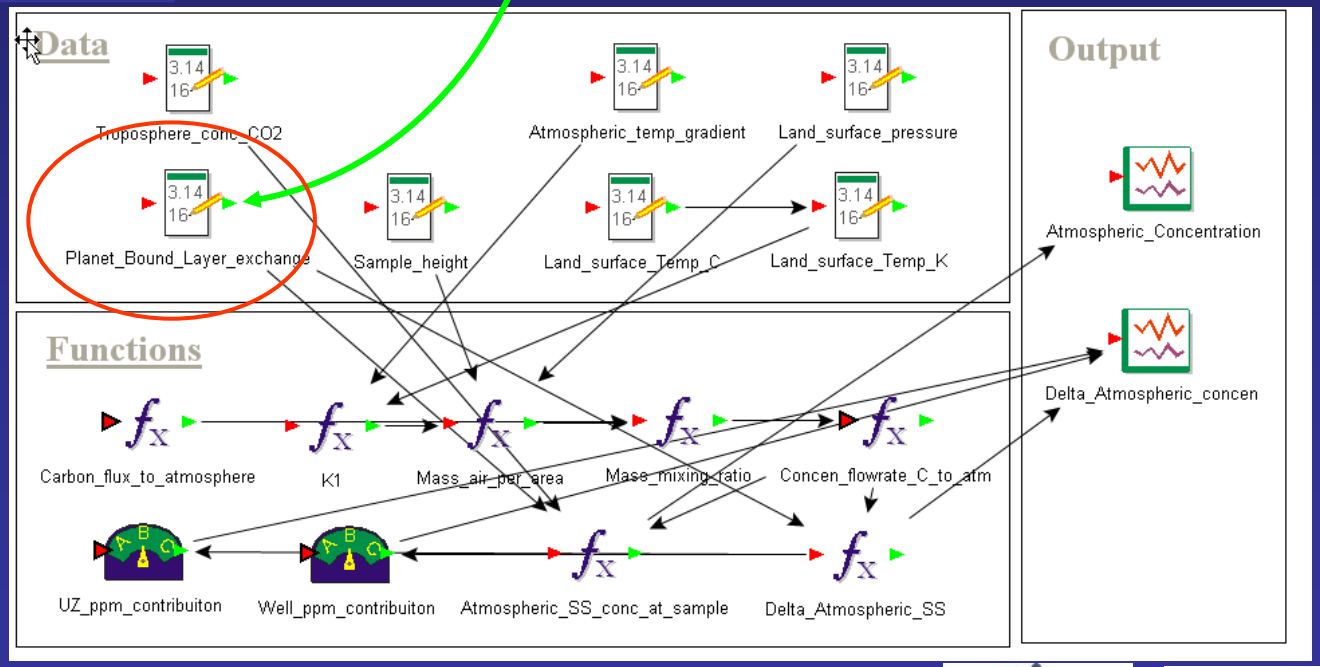
Connect to GoldSim Data Elements (ODBC)

Data Connection: Planetary Boundary Layer Thickness





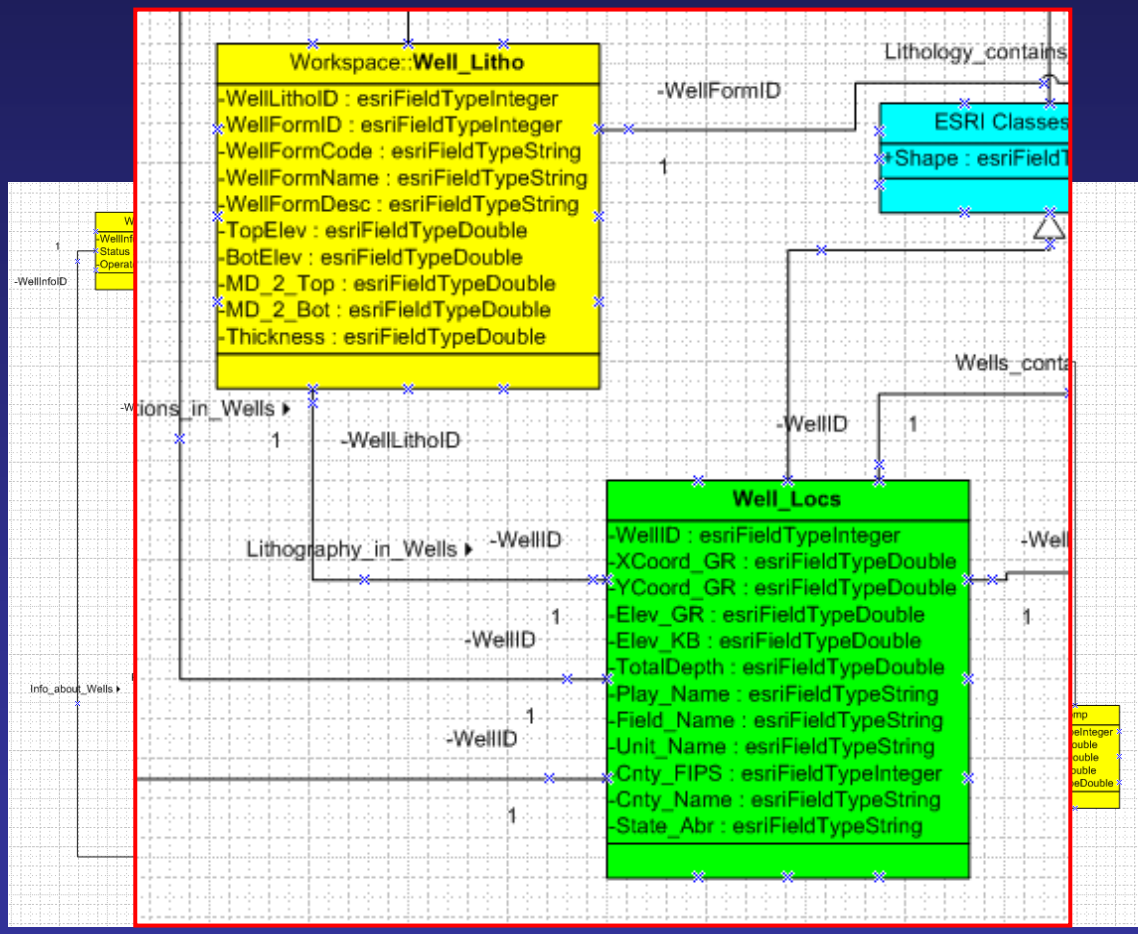
- Global grid with 3000 samples in time
- NetCDF format
- Need custom data conversion tool



Data Connection: Wellbore Integrity

Quantifying Qualitative Data

1. Geodatabase schema for well information, built by feature class geometries and relationships
2. Attributes:
   - Location
   - Construction details
   - Formations
   - Lithologies



Data Connection: Wellbore Integrity

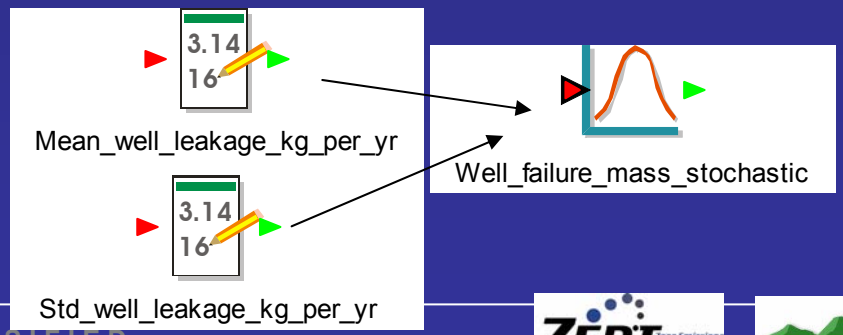
2. Abstract qualitative information into stochastic wellbore failure parameter, for example

Age (completion date):	30 yr
Casing type:	st, 9-5/8 in
depth:	1646 ft
Cement Seals:	300 ft
Cement type:	xxx
Perforations	50 ft
Integrity Score (1-5):	?

- OR -

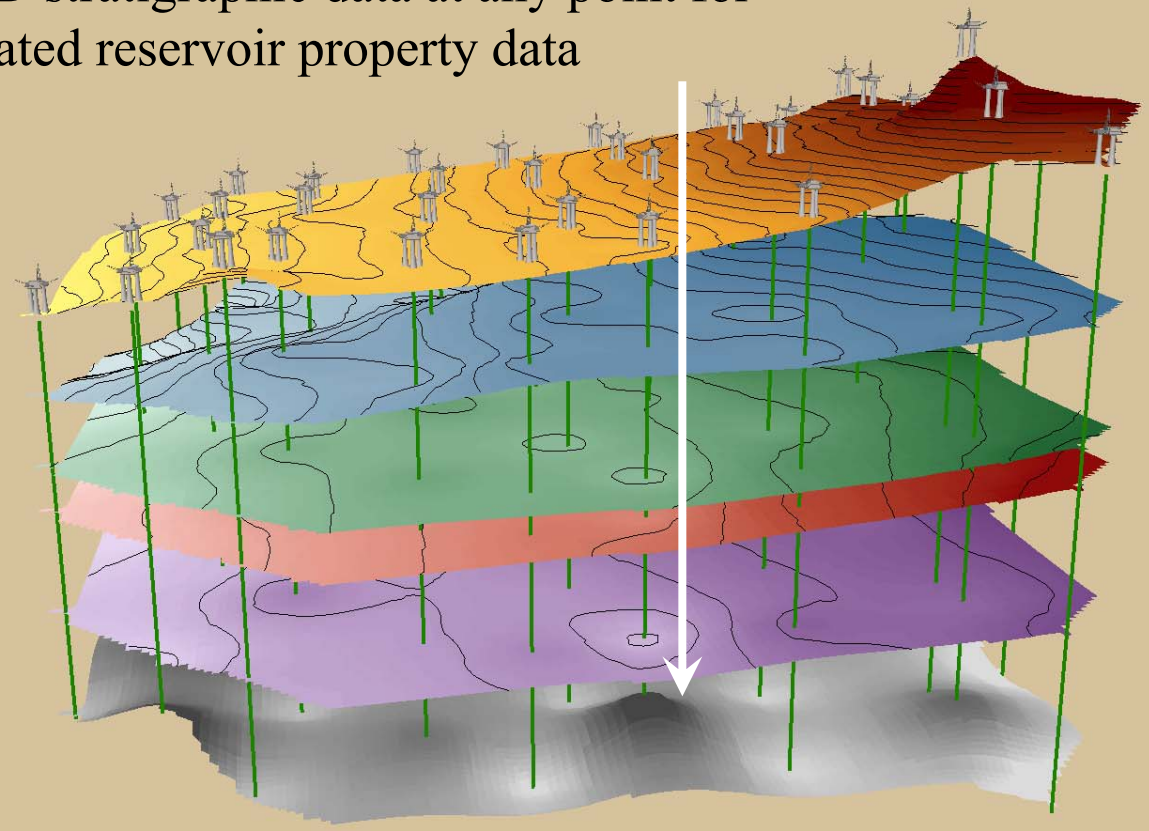
Use Age as proxy for well completion data not readily available (i.e. electronic)

Assume default industry std well completion techniques by decade, assign well integrity score



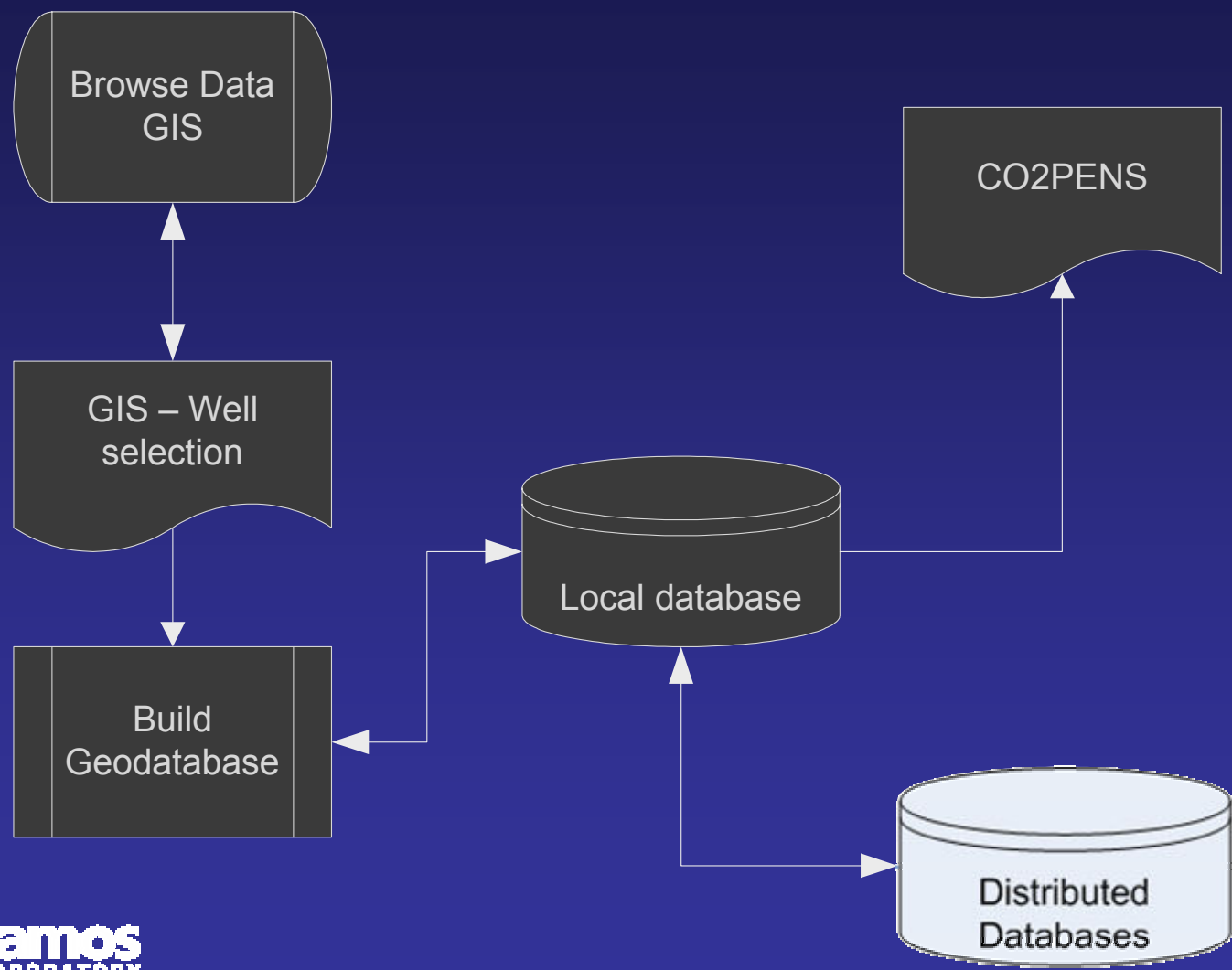
Moving Beyond Well-Based Data: Interpolation

Probe 3D stratigraphic data at any point for interpolated reservoir property data

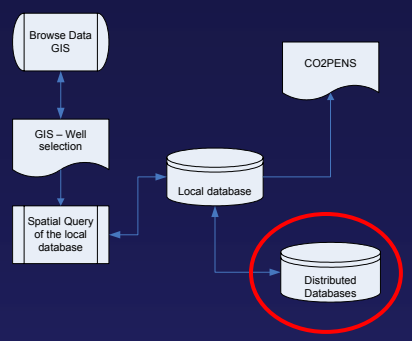


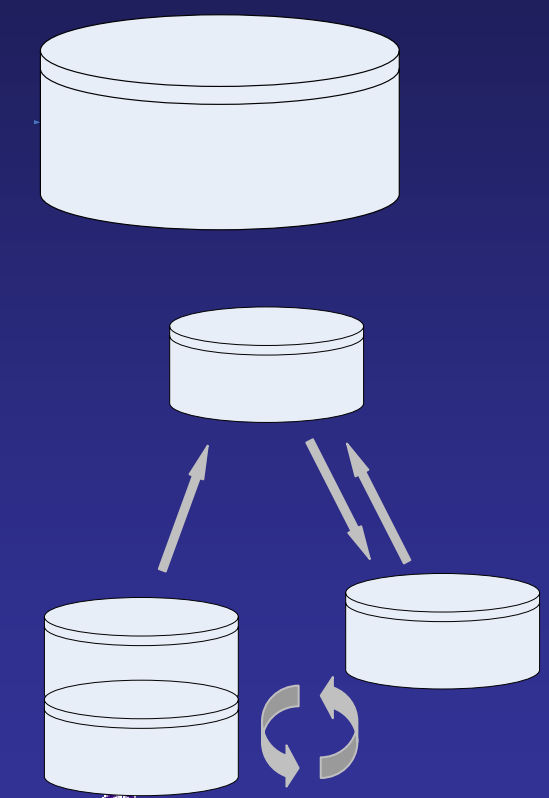
GIS rendering of formation top grids and well locations

Future Enhancements to CO2PENS Will Include Links to Distributed Databases



Distributed Database Connectivity





Open Database Connectivity (ODBC) enables the incorporation of data from different sources (Regional Partnerships, NatCarb, etc.), likely supporting different database software and operating system platforms

ODBC, the MS Access Geodatabase and GoldSim will allow connections to:

- Oracle
- SQL Server
- MySQL
- *.CSV
- *.TXT
- *.ASC
- *.DBF

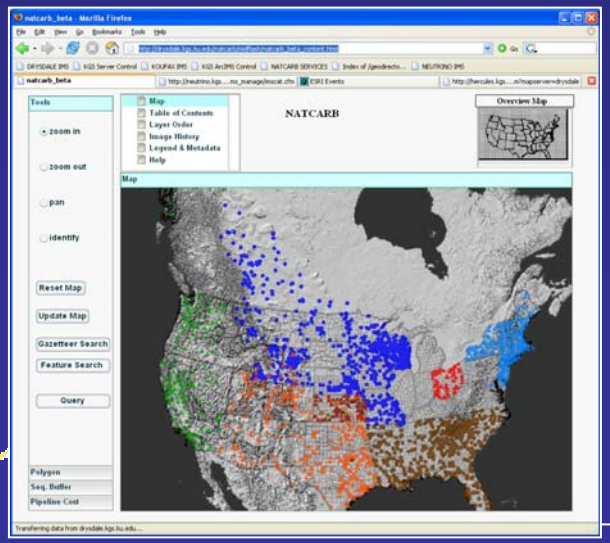
The Future: Model Connections to NatCarb Data Portal

Now:

- Distributed data sources, served by NatCarb portal
- Metadata library provides catalog for model interface

Next Steps:

- Build links to online data services for automated model query
- Simulation repository



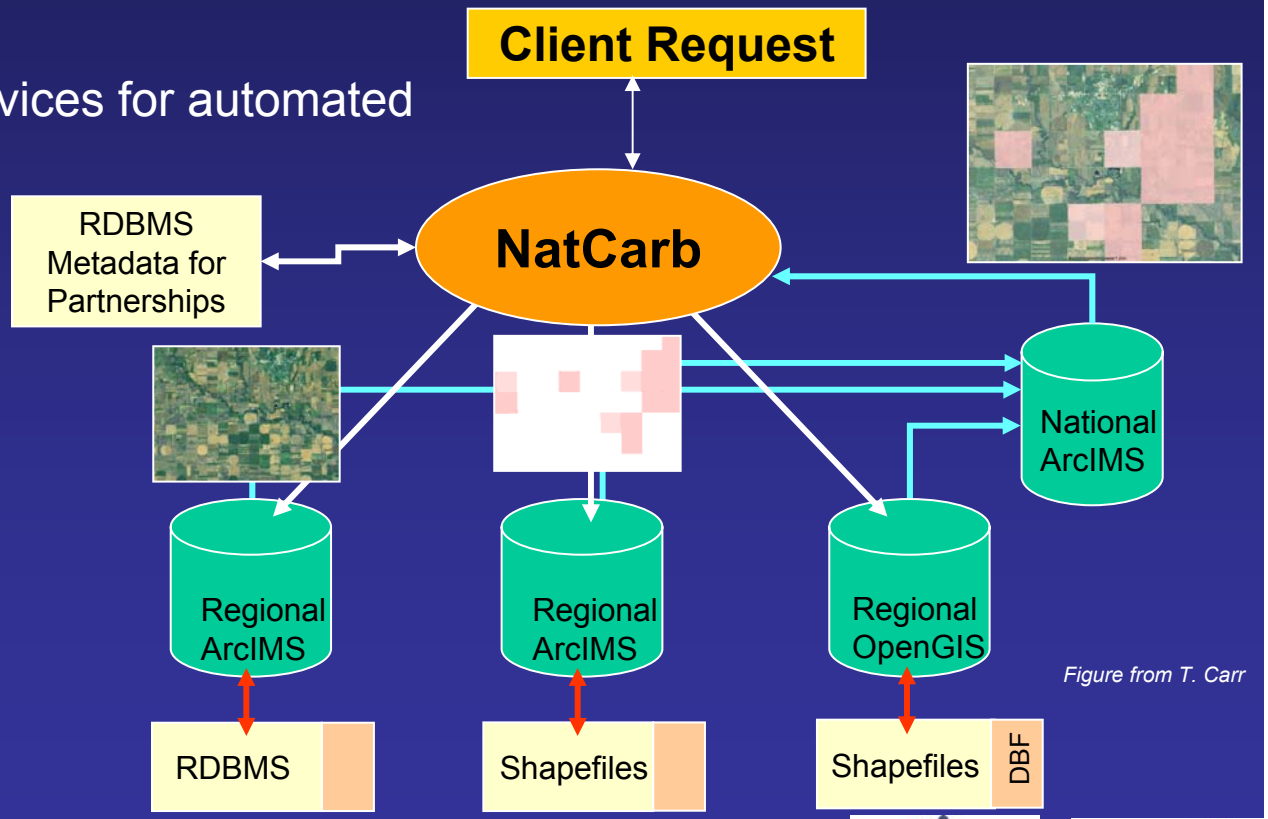
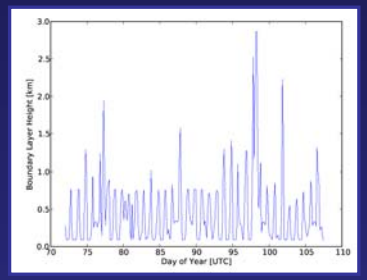
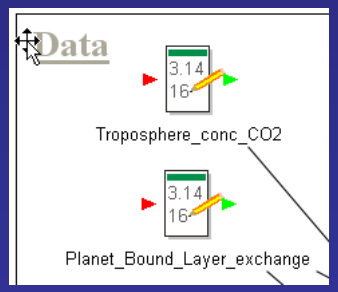
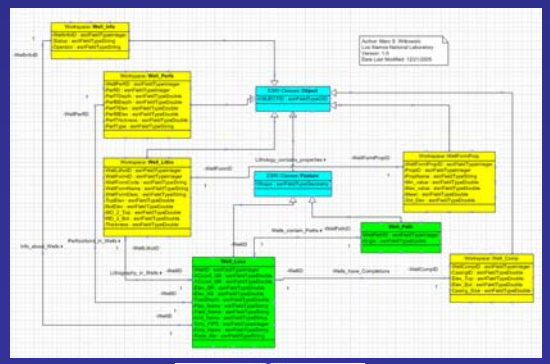


Figure from T. Carr

Challenges for Data-Model Coupling



- Missing data
- Data in non-electronic format (e.g. hardcopy well logs!)
- Quantifying uncertainty
- Quantifying qualitative information
- Spatial, temporal interpolations
- Diverse data types, structures
- Establishing connections to data sources
- Construction of Integrated modeling / data abstraction interface (GIS)