Demonstration of GLOBAL

Aditya Vyas

November 10th, 2015

Outline

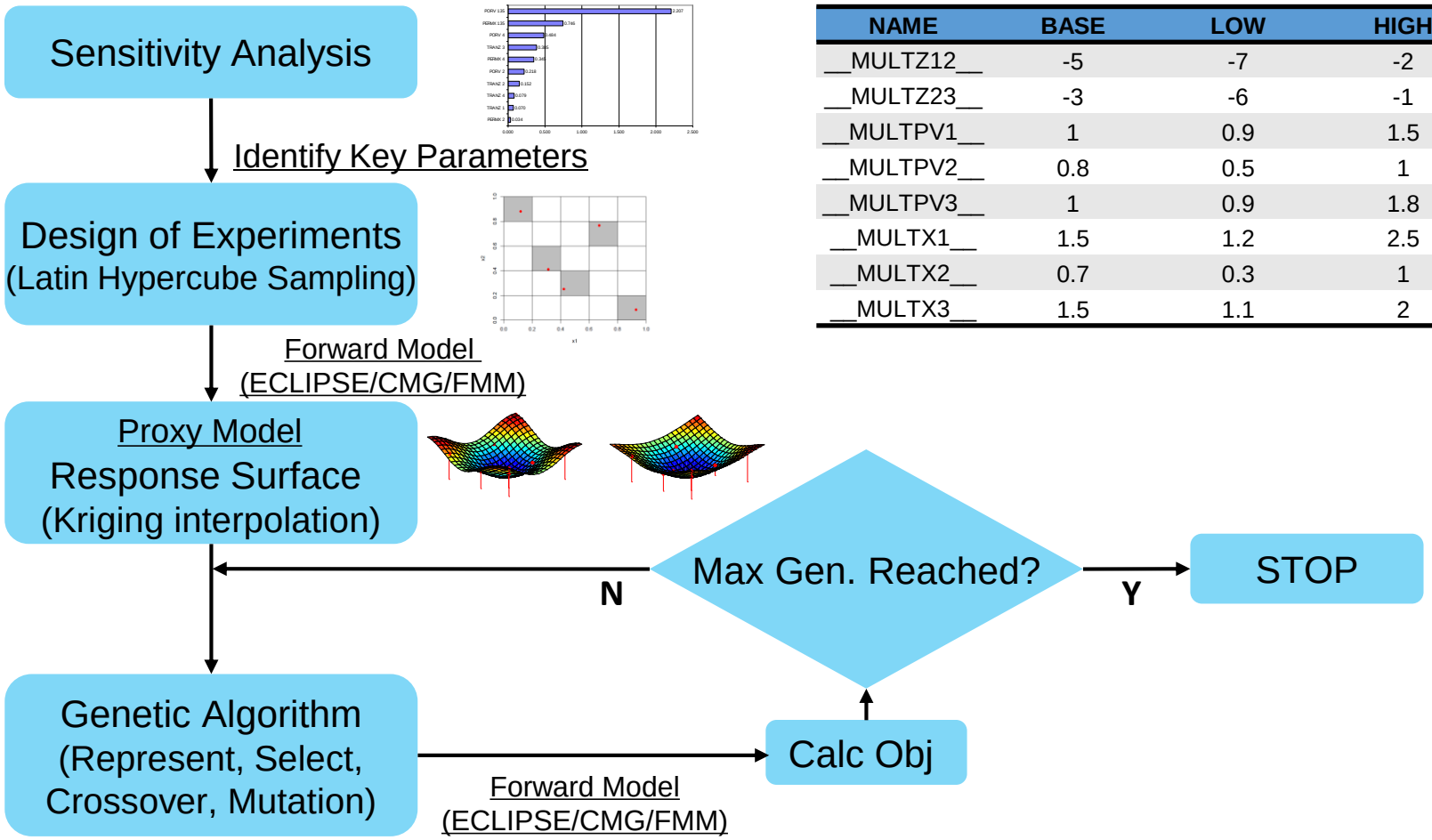
- Introduction
- Global Algorithm
- Eclipse Model Description
- Global Workflow
- View Global Results
- Global GUI

Introduction

- GLOBAL is a History Matching software based on a derivative-free method
- Options for Forward Models – FMM, ECLIPSE and CMG
- It uses algorithms of Latin Hypercube Sampling, Genetic algorithm, Kriging, etc
- Developed in C++ and C# (for GUI)
- Can be implemented in both Windows and Linux

Global Algorithm

✓ GA based Optimization Software



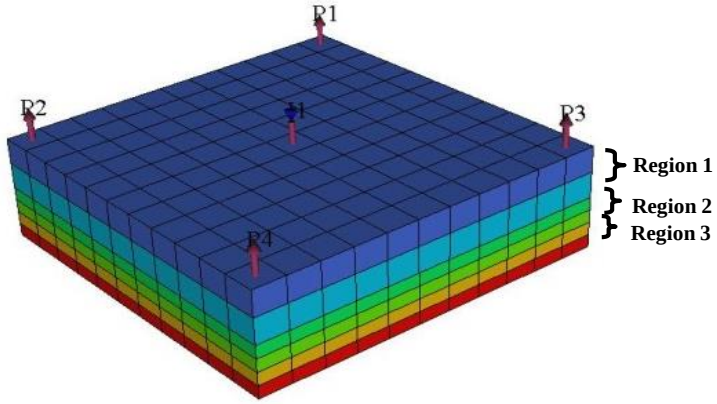
NAME	BASE	LOW	HIGH
__MULTZ12__	-5	-7	-2
__MULTZ23__	-3	-6	-1
__MULTPV1__	1	0.9	1.5
__MULTPV2__	0.8	0.5	1
__MULTPV3__	1	0.9	1.8
__MULTX1__	1.5	1.2	2.5
__MULTX2__	0.7	0.3	1
__MULTX3__	1.5	1.1	2

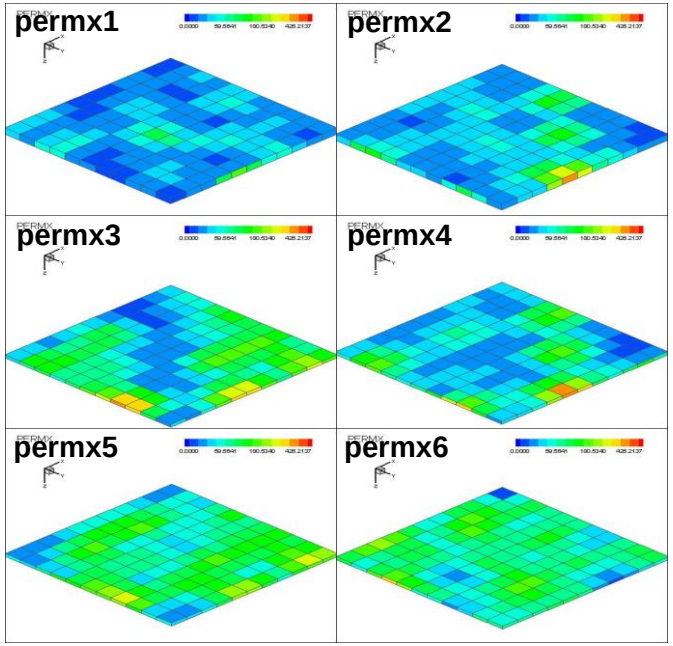
MCERI
Model Calibration and Efficient Reservoir Imaging

ECLIPSE Synthetic Case

Model for synthetic case

- 3D three-phase reservoir
- Grid blocks: 11×11×6
- One injector and four producers
- Three global regions defined by model layers (1-2, 3-4, 5-6)
- **Uncertain Parameters:**
  pore volumes (regions 1-3)
  horizontal permeability (regions 1-3)
  vertical transmissibility (x2)



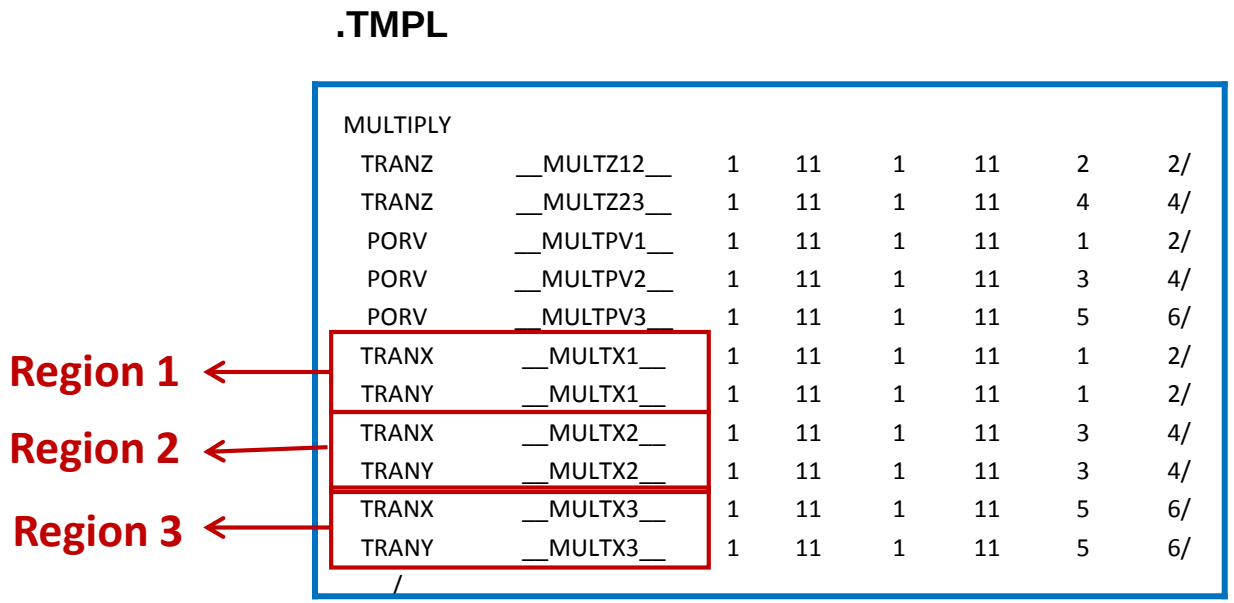


MCERI
Model Calibration and Efficient Reservoir Imaging

Workflow Steps

- Identify global unknowns
- Construct Template Files (.TMPL)
- Construct Distribution File (.DISTR)
- Prepare GLOBAL Input file (.INP)
- Run GLOBAL in command prompt window
- View Objective file (*.OBJ)

STEP 1: Construct Template Files (.TMPL)



- Variables __NAME__ are tokens which are replaced by values to create a valid Eclipse include file
- Templates can be created for any simulator or for any text based application

MCERI
Model Calibration and Efficient Reservoir Imaging

*.TMPL to *.INC file conversion by GLOBAL

.TMPL

```
MULTIPLY
  TRANZ     __MULTZ12__   1   11   1   11   2   2/
  TRANZ     __MULTZ23__   1   11   1   11   4   4/
  PORV      __MULTPV1__   1   11   1   11   1   2/
  PORV      __MULTPV2__   1   11   1   11   3   4/
  PORV      __MULTPV3__   1   11   1   11   5   6/
  TRANX     __MULTX1__    1   11   1   11   1   2/
  TRANY     __MULTX1__    1   11   1   11   1   2/
  TRANX     __MULTX2__    1   11   1   11   3   4/
  TRANY     __MULTX2__    1   11   1   11   3   4/
  TRANX     __MULTX3__    1   11   1   11   5   6/
  TRANY     __MULTX3__    1   11   1   11   5   6/
    /
```

.INC

```
MULTIPLY
  TRANZ   9.14E-05   1   11   1   11   2   2/
  TRANZ   4.86E-05   1   11   1   11   4   4/
  PORV    1.18706    1   11   1   11   1   2/
  PORV    0.754902   1   11   1   11   3   4/
  PORV    1.44706    1   11   1   11   5   6/
  TRANX   1.86784    1   11   1   11   1   2/
  TRANY   1.86784    1   11   1   11   1   2/
  TRANX   0.516863   1   11   1   11   3   4/
  TRANY   0.516863   1   11   1   11   3   4/
  TRANX   1.69294    1   11   1   11   5   6/
  TRANY   1.69294    1   11   1   11   5   6/
    /
```

- GLOBAL substitutes variable names GA evolved values
- If there are mathematical expressions, GLOBAL calculates resultant values
- GLOBAL saves resultant file as .INC file for inclusion to ECLIPSE *.DATA

MCERI
Model Calibration and Efficient Reservoir Imaging

STEP 2: Construct DISTRIBUTION File (.DISTR)

--NAME?	BASE	LOW	HIGH	NBIT	LOG10?	CONT?
__MULTZ12__	-5	-7	-2	4	1	1
__MULTZ23__	-3	-6	-1	4	1	1
__MULTPV1__	1	0.9	1.5	4	0	1
__MULTPV2__	0.8	0.5	1	4	0	1
__MULTPV3__	1	0.9	1.8	4	0	1
__MULTX1__	1.5	1.2	2.5	4	0	1
__MULTX2__	0.7	0.3	1	4	0	1
__MULTX3__	1.5	1.1	2	4	0	1

- **BASE** – sensitivity analysis as baseline in the Tornado diagram
- **LOW/HIGH** – lower and higher bounds of variables
- **NBIT** – number of bits used to represent current variable in a genome binary string
- **LOG10** – whether base/low/high values in current row are after log10
- **CONT** – whether this variable is continuous (1) or discrete (0)

MCERI
Model Calibration and Efficient Reservoir Imaging

STEP 3: Prepare input file (.INP)

DIP_STUDYNAME ECLRFT	**Simulator settings** ECLIPSE
DIP_OBJECTIVE LPT|MDT	**Objective settings**
DIP_SMRY_OBS1 SCHEDULE	Observed data from WCONHIST (Observed production data prepared in WCONHIST and WCONINJH; Observed MDT data prepared in ECL Office format)
DIP_MDT_OBS1 obs_mdt_office.txt	
-- use first 19 .S* file for HM, rest for prediction DIP_KEY_TSTEP 19 1-19	TSTEPS in OBJ.
DIP_INC_TMPL 1 MULTIPLY.TMPL	**Variable settings** Templates for variable substitution
DIP_INC_DISTR COARSE.DISTR	Distribution of variables
DIP_PROXY_NED 50 DIP_PROXY_TOL 0.5	**Proxy settings** NO. of experiment designs Tolerance for proxy check
DIP_GA_REPLACE 0.7 DIP_GA_POPSIZE 50 DIP_GA_NGEN 20	**GA settings** Elitism algorithm (Bottom 70% replaced) Population size (Even NO.) Max. NO. of generation

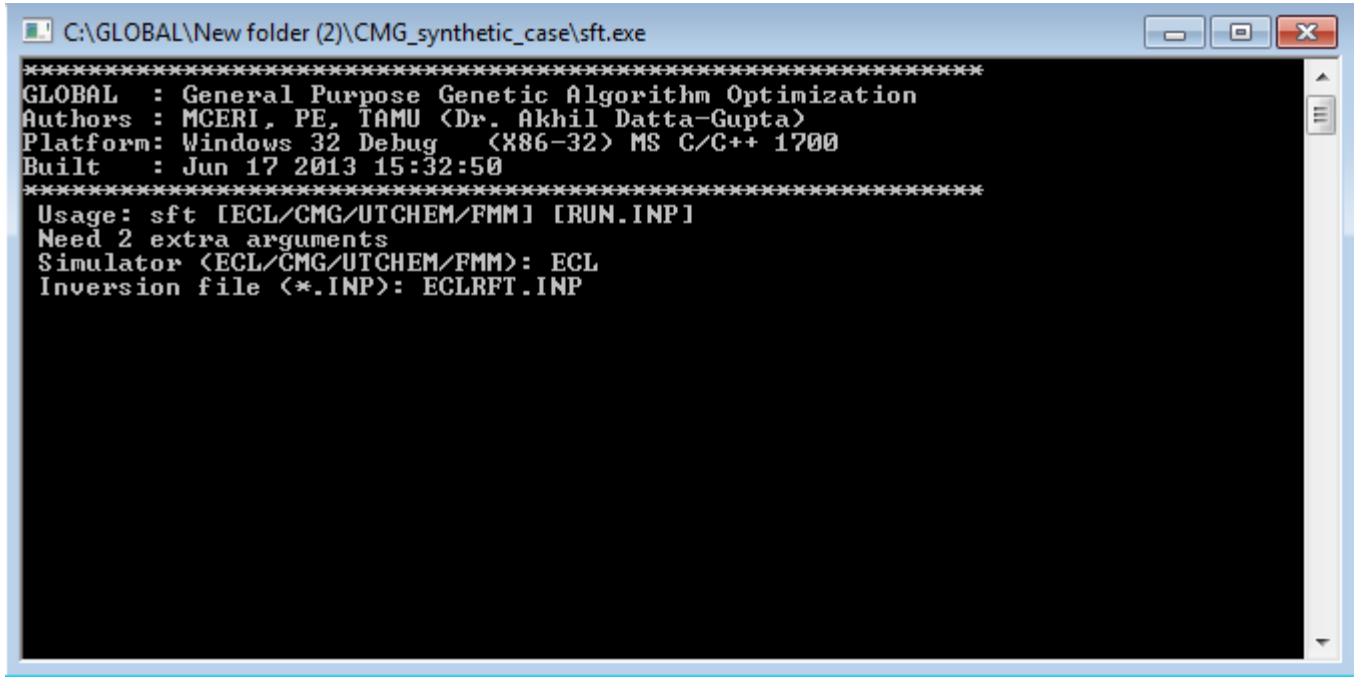
MCERI
Model Calibration and Efficient Reservoir Imaging

STEP 4: Run global

- Add ECLIPSE into the system path

  PATH=%PATH%;c:/ecl/macros

- Double-click on the executable file
- Input "ECL" and "ECLRFT.INP" interactively



MCERI
Model Calibration and Efficient Reservoir Imaging

VIEW OPTIMIZATION RESULTS

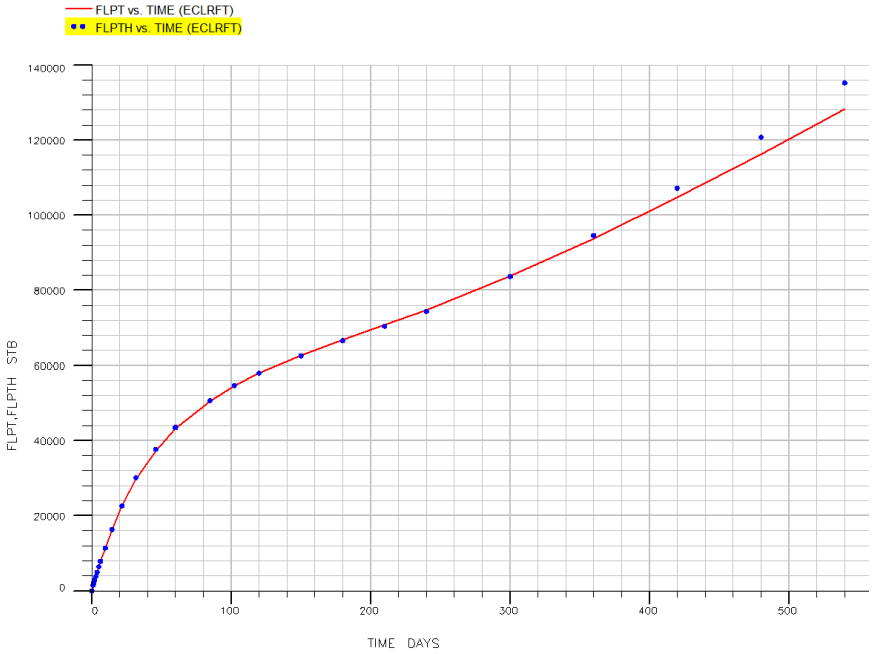
- Check results from .OBJ file
- Open .OBJ file by EXCEL and sort by objectives from smallest to largest
- Choose models with smaller objectives.
- Each chosen model is labeled by Run#. You can find the corresponding zip file backed up by the name *_####_Run#.zip

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	__MULTZ12_	__MULTZ23	__MULTPV1	__MULTPV2_	__MULTPV3_	__MULTX1_	__MULTX2_	__MULTX3	ObjOver	ObjProx	ProxyEr	DataExact	objLP	objMD	Run#	Generation
2	-3.22E+00	-2.12E+00	1.19E+00	8.88E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.77E+00	3.77E+00	0.00E+00	0.00E+00	9.23E+01	2.05E+01	444	20
3	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.88E-01	1.73E+00	3.81E+00	3.81E+00	0.00E+00	0.00E+00	9.79E+01	2.08E+01	401	18
4	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.88E-01	1.73E+00	3.82E+00	3.82E+00	0.00E+00	0.00E+00	9.86E+01	2.09E+01	388	18
5	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.88E-01	1.73E+00	3.82E+00	3.82E+00	0.00E+00	0.00E+00	9.84E+01	2.10E+01	413	19
6	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.88E-01	1.73E+00	3.82E+00	3.82E+00	0.00E+00	0.00E+00	9.88E+01	2.10E+01	389	18
7	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.82E+00	3.82E+00	0.00E+00	0.00E+00	1.01E+02	2.06E+01	323	14
8	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.82E+00	3.82E+00	0.00E+00	0.00E+00	1.01E+02	2.06E+01	370	17
9	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.82E+00	3.82E+00	0.00E+00	0.00E+00	1.01E+02	2.07E+01	397	18
10	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.83E+00	3.83E+00	0.00E+00	0.00E+00	1.02E+02	2.07E+01	315	13
11	-2.90E+00	-2.10E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.83E+00	3.83E+00	0.00E+00	0.00E+00	1.03E+02	2.06E+01	432	20
12	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.88E-01	1.73E+00	3.83E+00	3.83E+00	0.00E+00	0.00E+00	1.01E+02	2.10E+01	422	19
13	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.66E-01	1.73E+00	3.83E+00	3.83E+00	0.00E+00	0.00E+00	1.03E+02	2.07E+01	349	15
14	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.88E-01	1.73E+00	3.83E+00	3.83E+00	0.00E+00	0.00E+00	1.00E+02	2.12E+01	404	18
15	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.83E+00	3.83E+00	0.00E+00	0.00E+00	1.04E+02	2.06E+01	415	19
16	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.59E+00	5.88E-01	1.73E+00	3.83E+00	3.83E+00	0.00E+00	0.00E+00	9.91E+01	2.16E+01	403	18
17	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.66E-01	1.73E+00	3.84E+00	3.84E+00	0.00E+00	0.00E+00	1.03E+02	2.08E+01	427	19
18	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.66E-01	1.73E+00	3.84E+00	3.84E+00	0.00E+00	0.00E+00	1.04E+02	2.07E+01	406	18
19	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.88E-01	1.73E+00	3.84E+00	3.84E+00	0.00E+00	0.00E+00	1.02E+02	2.11E+01	433	20
20	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.66E-01	1.73E+00	3.84E+00	3.84E+00	0.00E+00	0.00E+00	1.04E+02	2.09E+01	390	18
21	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.84E+00	3.84E+00	0.00E+00	0.00E+00	1.05E+02	2.07E+01	393	18
22	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.88E-01	1.73E+00	3.84E+00	3.84E+00	0.00E+00	0.00E+00	1.02E+02	2.13E+01	398	18
23	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.88E-01	1.73E+00	3.84E+00	3.84E+00	0.00E+00	0.00E+00	1.02E+02	2.12E+01	375	17
24	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.88E-01	1.73E+00	3.85E+00	3.85E+00	0.00E+00	0.00E+00	1.03E+02	2.12E+01	435	20
25	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.66E-01	1.73E+00	3.85E+00	3.85E+00	0.00E+00	0.00E+00	1.06E+02	2.09E+01	428	19
26	-3.22E+00	-2.10E+00	1.19E+00	9.04E-01	1.46E+00	1.60E+00	5.66E-01	1.73E+00	3.85E+00	3.85E+00	0.00E+00	0.00E+00	1.06E+02	2.09E+01	425	19
27	-3.22E+00	-2.12E+00	1.19E+00	9.04E-01	1.46E+00	1.58E+00	5.88E-01	1.73E+00	3.87E+00	3.87E+00	0.00E+00	0.00E+00	1.02E+02	2.26E+01	442	20
28	-3.22E+00	-2.10E+00	1.20E+00	9.04E-01	1.45E+00	1.60E+00	5.88E-01	1.73E+00	3.88E+00	3.88E+00	0.00E+00	0.00E+00	1.10E+02	2.13E+01	436	20
29	-3.22E+00	-2.12E+00	1.20E+00	9.04E-01	1.45E+00	1.60E+00	5.66E-01	1.73E+00	3.89E+00	3.89E+00	0.00E+00	0.00E+00	1.15E+02	2.07E+01	429	20

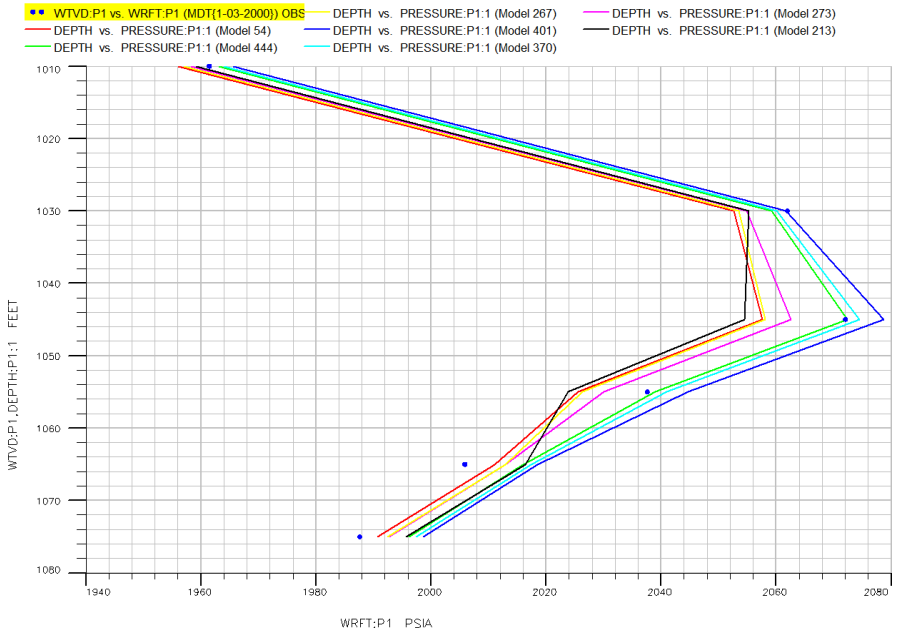
MCERI
Model Calibration and Efficient Reservoir Imaging

Global Results in ECLIPSE Office

RESULTING MATCHES



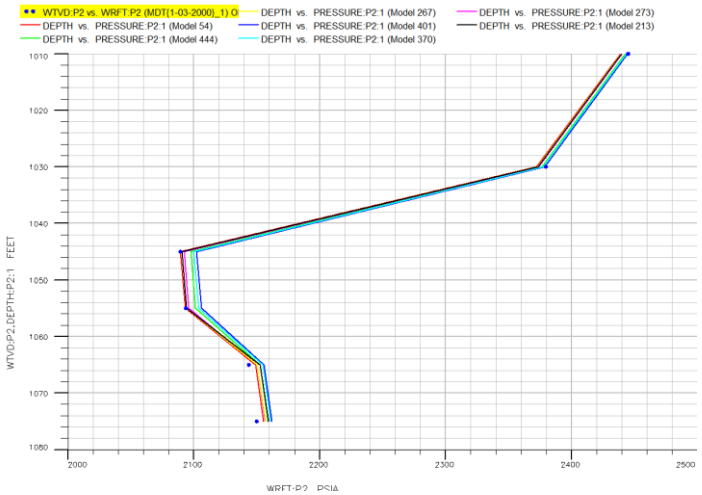
Liquid production from global updates



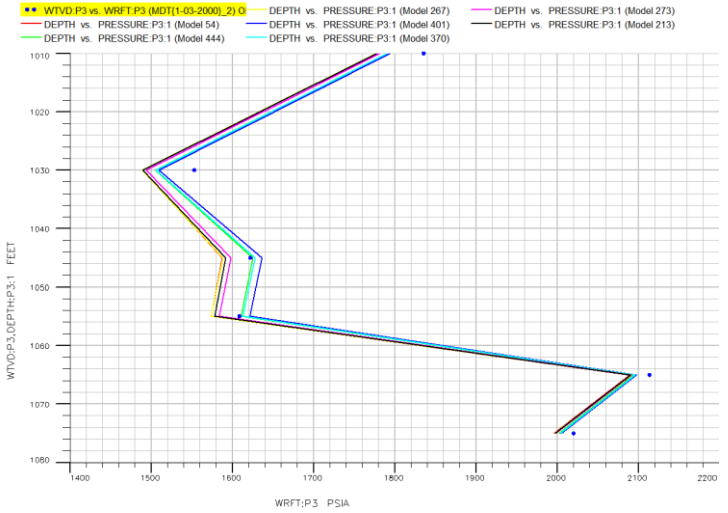
MDT pressure matches: P1

MCERI
Model Calibration and Efficient Reservoir Imaging

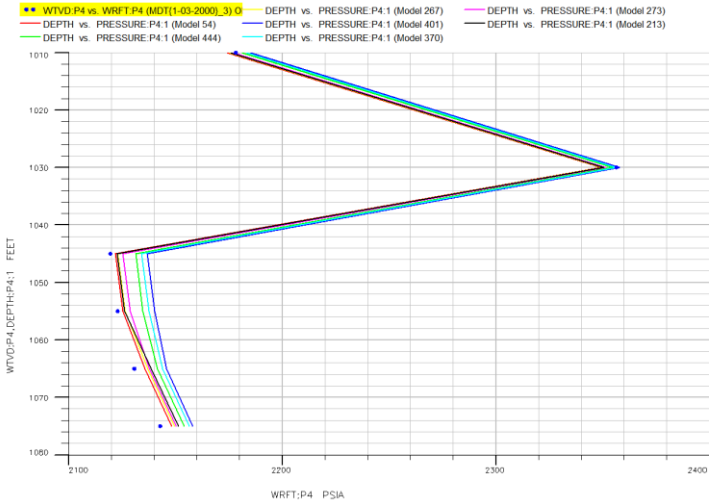
RESULTING MATCHES (Cont.)



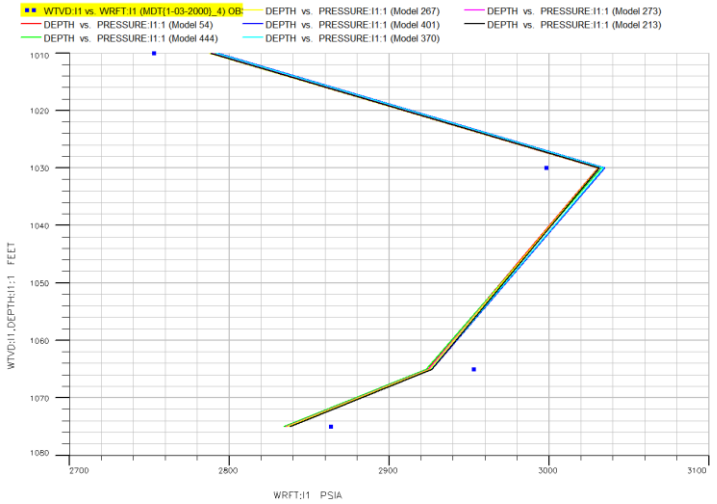
MDT pressure matches: P2



MDT pressure matches: P3



MDT pressure matches: P4

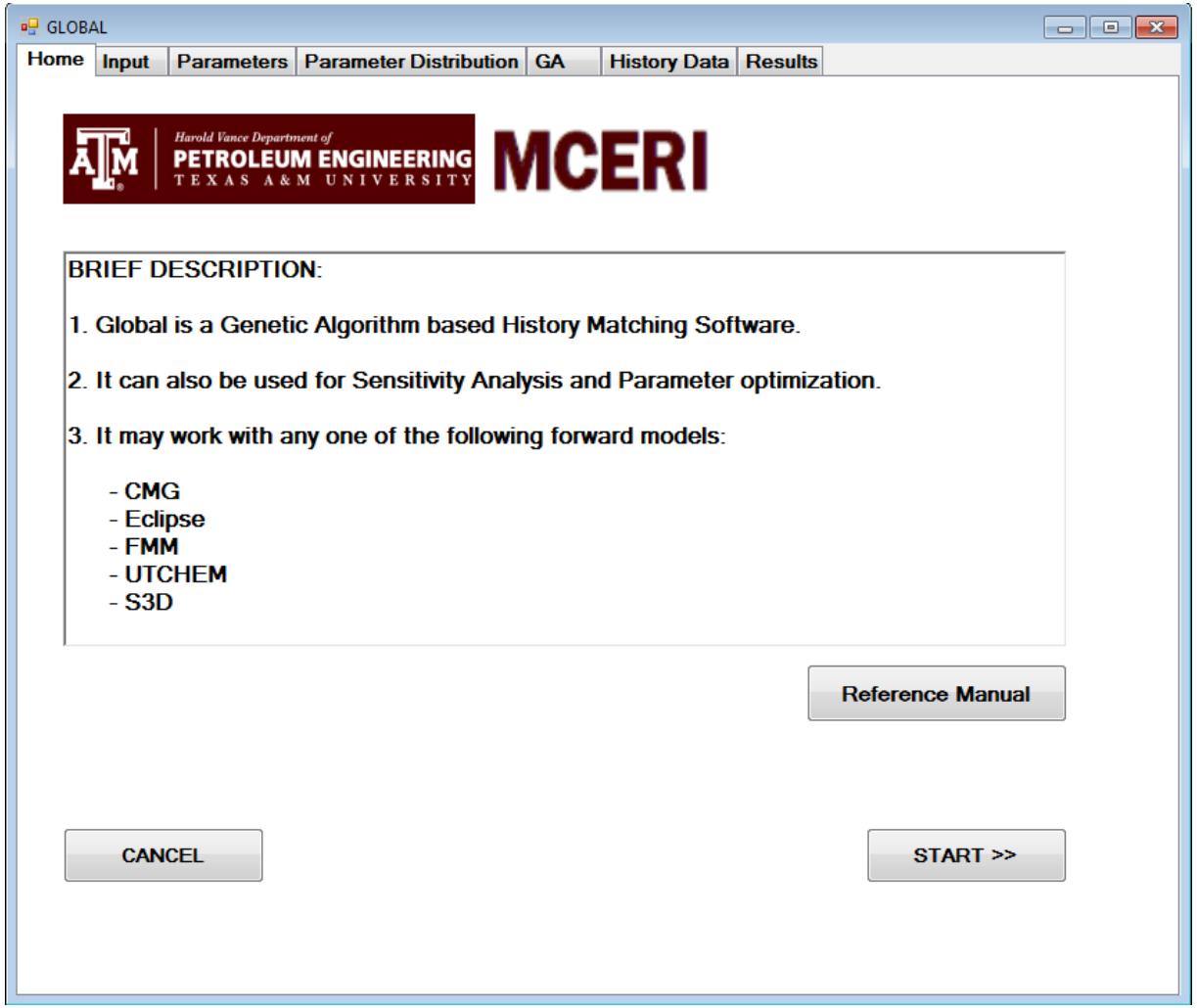


MDT pressure matches: I1

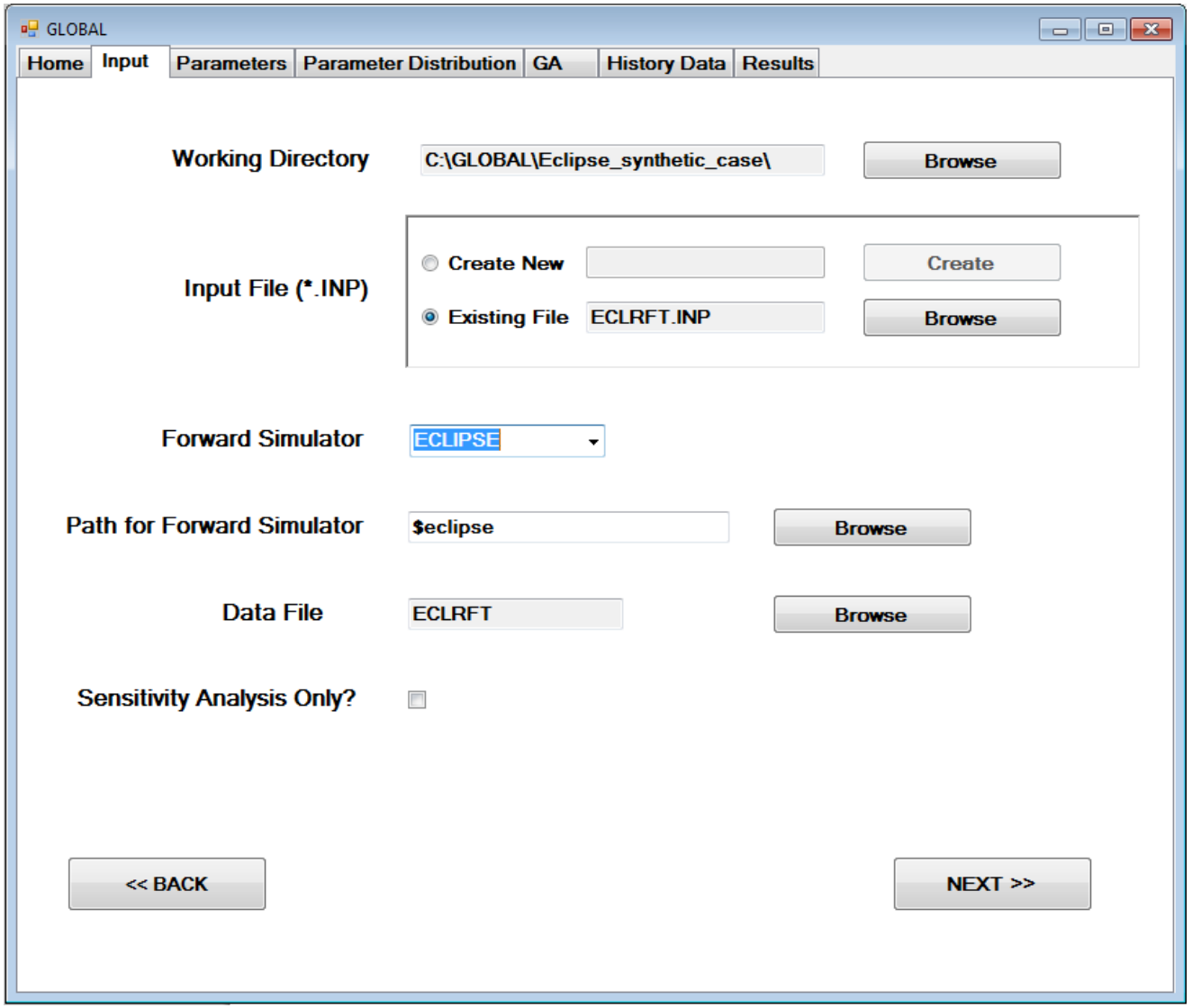
MCERI
Model Calibration and Efficient Reservoir Imaging

Global GUI
(Standalone Application in C#)

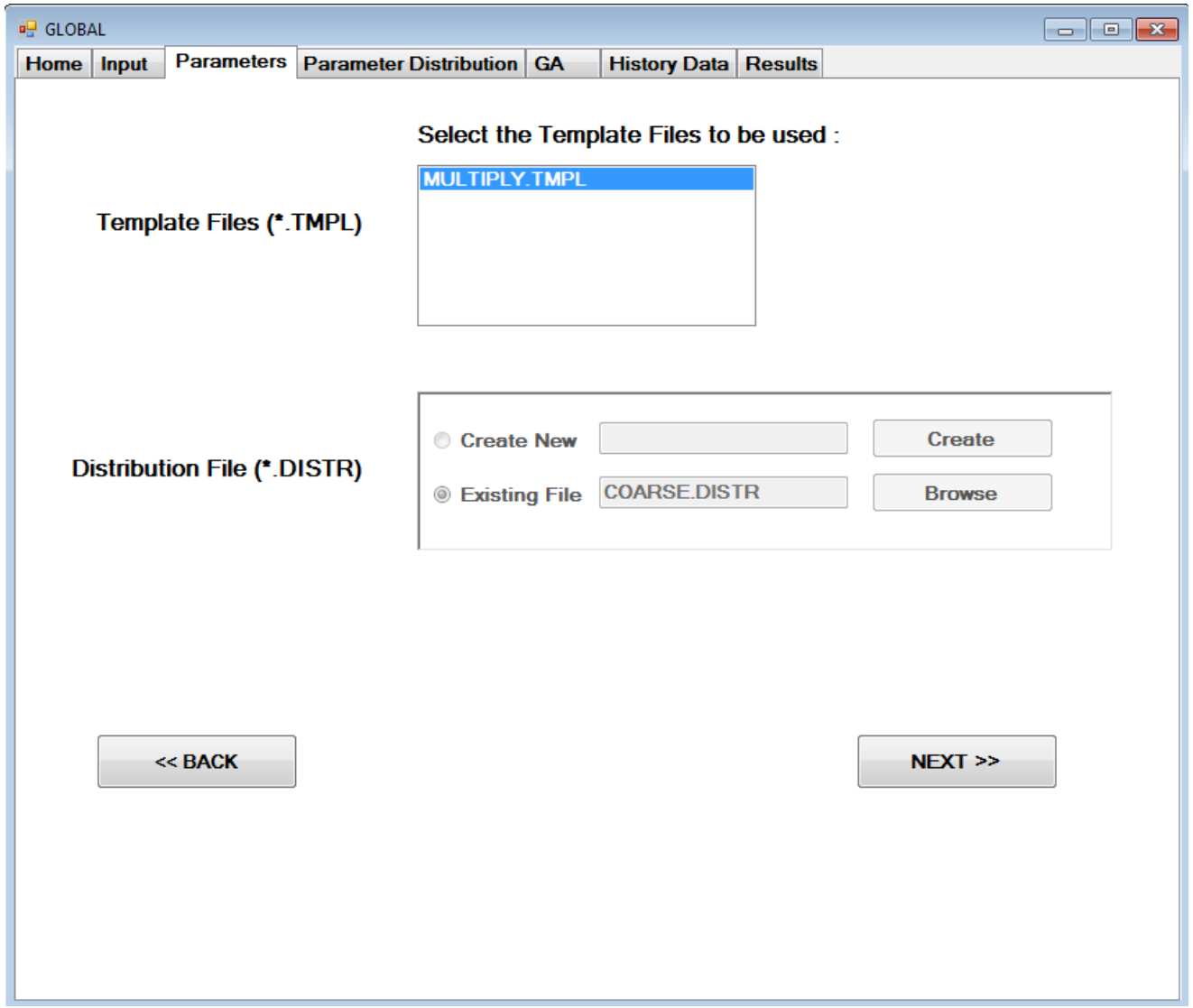
Home Page


GLOBAL
Home
Input
Parameters
Parameter Distribution
GA
History Data
Results
Harold Vance Department of
PETROLEUM ENGINEERING
TEXAS A&M UNIVERSITY
MCERI
BRIEF DESCRIPTION:
1. Global is a Genetic Algorithm based History Matching Software.
2. It can also be used for Sensitivity Analysis and Parameter optimization.
3. It may work with any one of the following forward models:
- CMG
- Eclipse
- FMM
- UTCHEM
- S3D
Reference Manual
CANCEL
START >>

Global Inputs

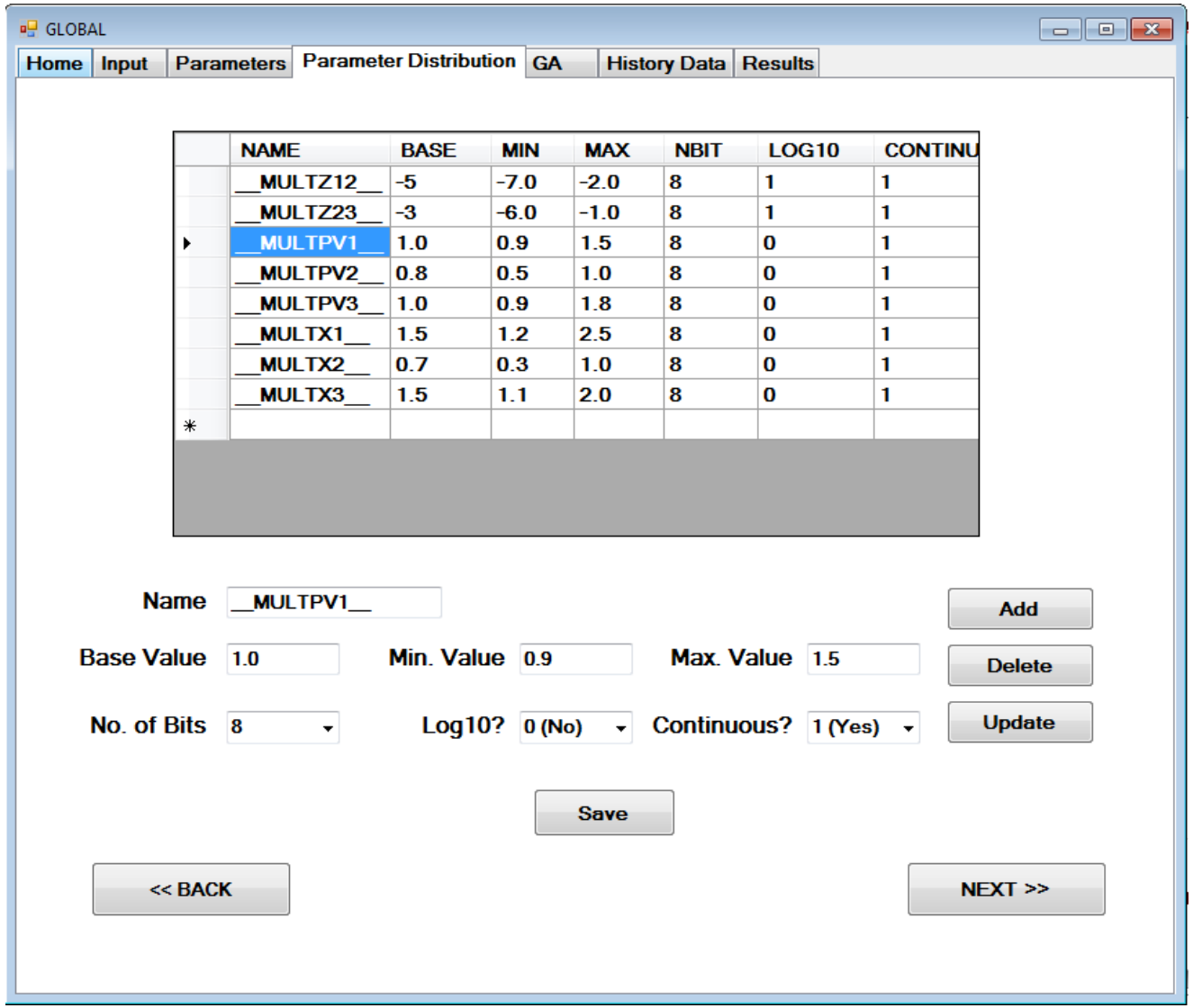


Global Parameters

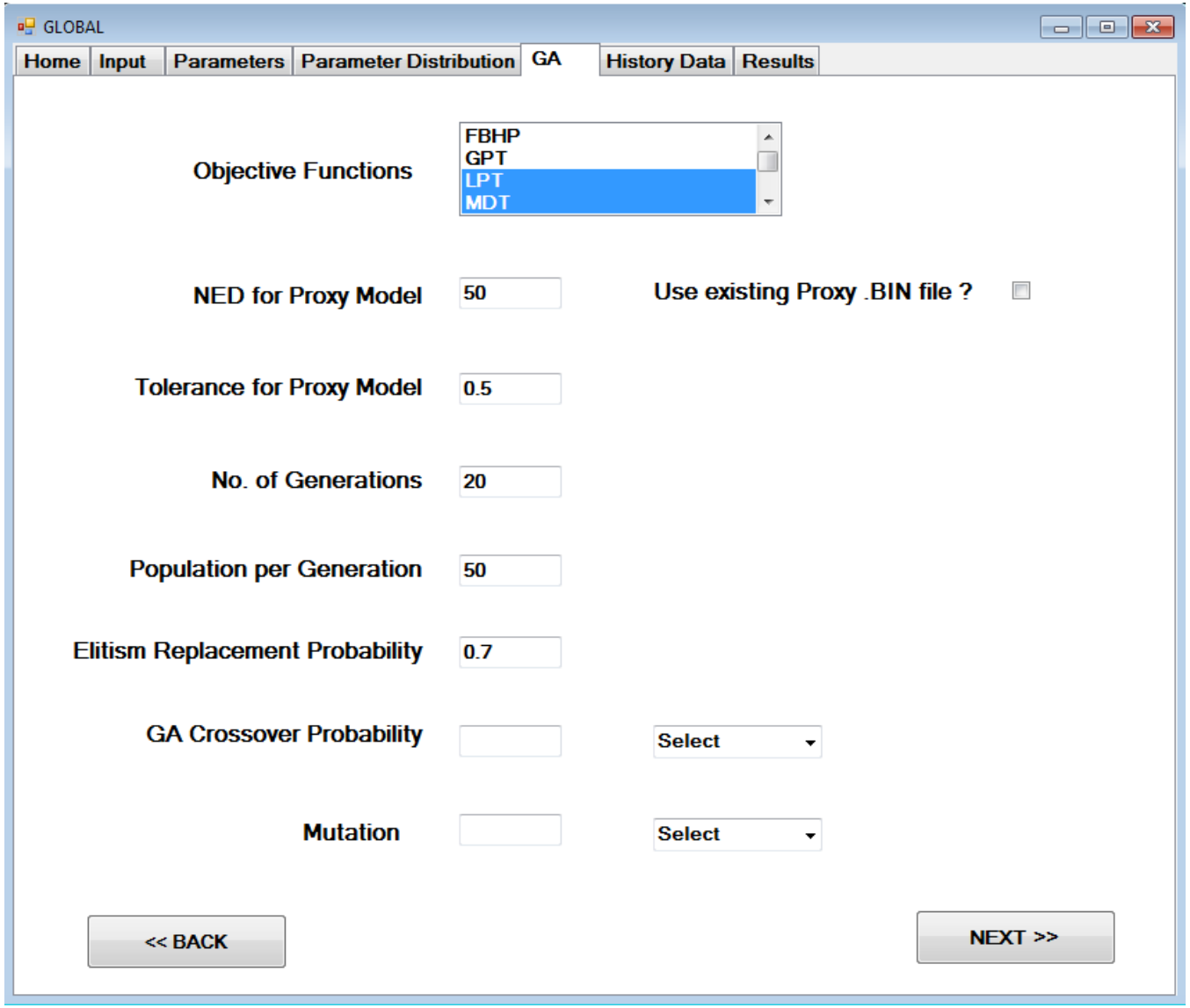


MCERI
Model Calibration and Efficient Reservoir Imaging

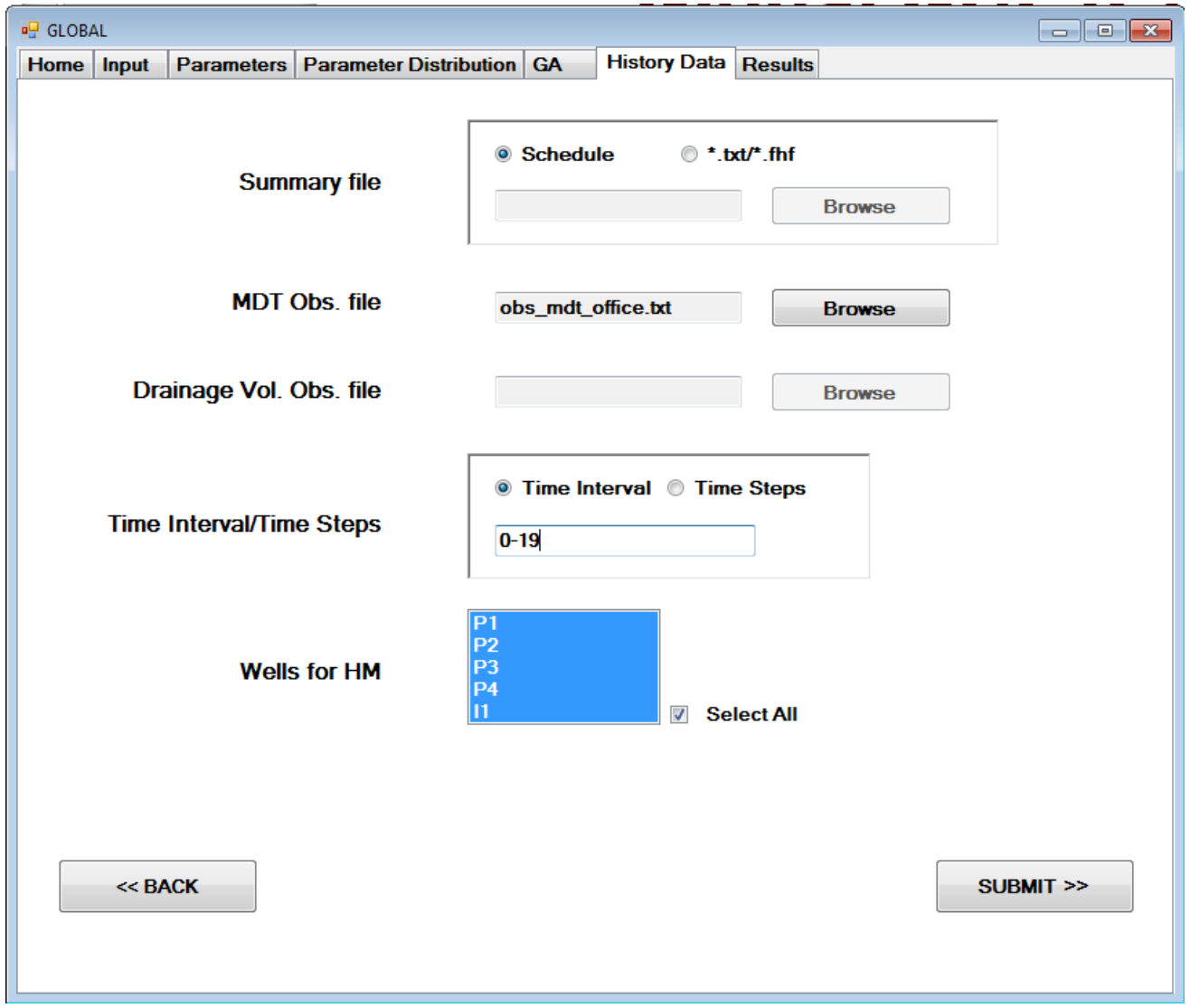
Parameter Distribution



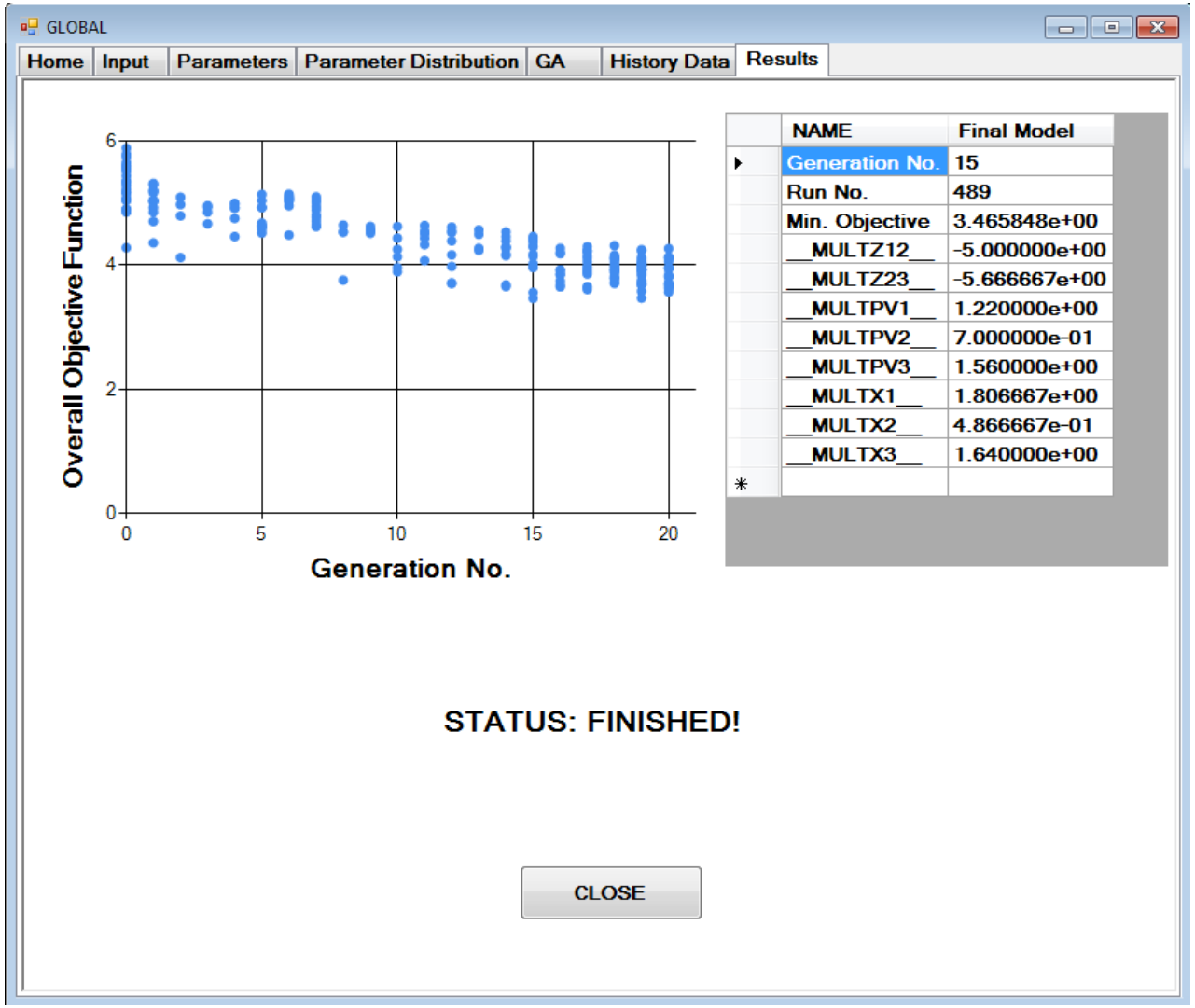
Global GA


GLOBAL
Home
Input
Parameters
Parameter Distribution
GA
History Data
Results
Objective Functions
FBHP
GPT
LPT
MDT
NED for Proxy Model
50
Use existing Proxy .BIN file ?
Tolerance for Proxy Model
0.5
No. of Generations
20
Population per Generation
50
Elitism Replacement Probability
0.7
GA Crossover Probability
Select
Mutation
Select
<< BACK
NEXT >>

History Data



Results



MCERI
Model Calibration and Efficient Reservoir Imaging