

DESTINY: A Software for Flow Diagnostics and History Matching Using Streamlines

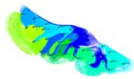
Hongquan Chen



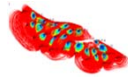
Outline

- Software Introduction
 - Flow diagnostics & History matching

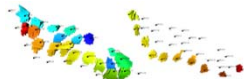
- Flow diagnostics



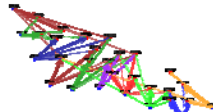
Streamline



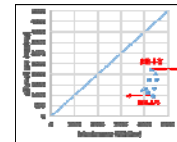
Time of Flight



Drainage(Swept) Volume

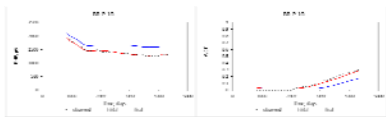


Rate Allocation

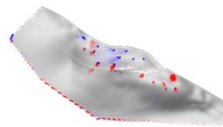


Injection Efficiency

- History matching



Well Responses Before and After Calibration



Permeability Calibration



BHP, WCT Sensitivity



Software Introduction

ECLIPSE

Finite
difference
simulation

DESTINY

Not streamline simulator but
Post-simulation processing

Flow diagnostics:

- Streamlines
- Well partitioning
- Drainage/swept volume

- Rate allocation
- Injection efficiency

History matching:

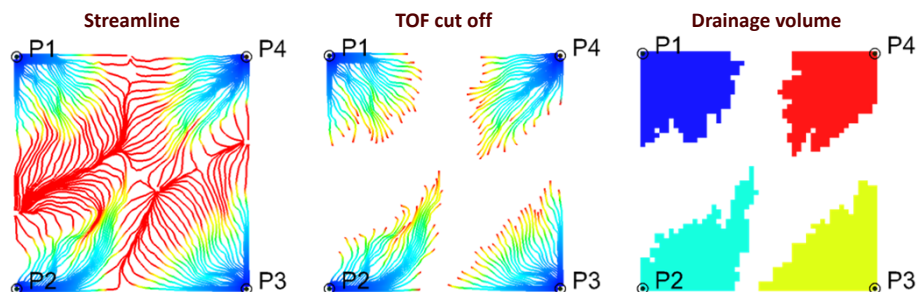
- Permeability calibration
- Sensitivity calculation



Visualization

Flow Diagnostics

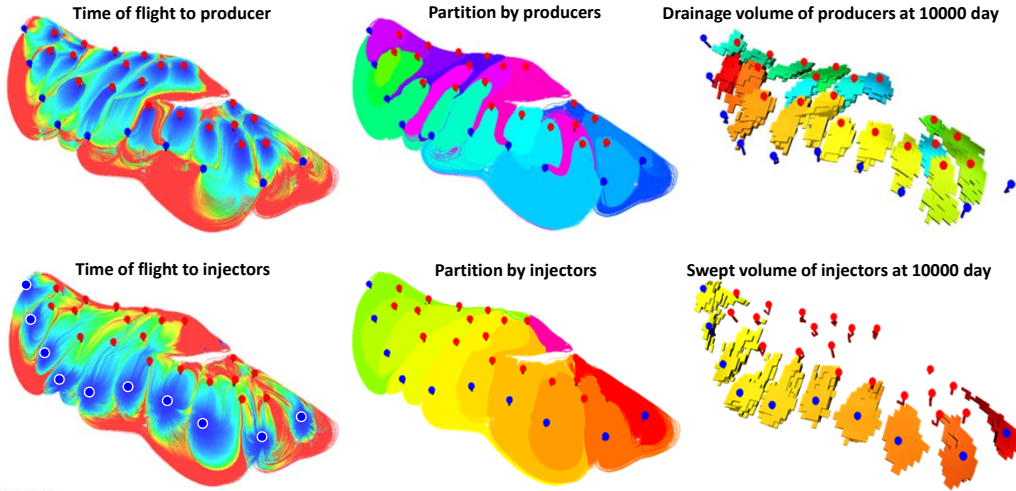
- Streamline: show flow path according to the velocity field.
- Time of flight (TOF): particle travel time along streamline.
- Drainage volume of producer at time t : the reservoir volume covered by streamlines within time t .



Flow Diagnostics

- producer
- injector

Brugge Case

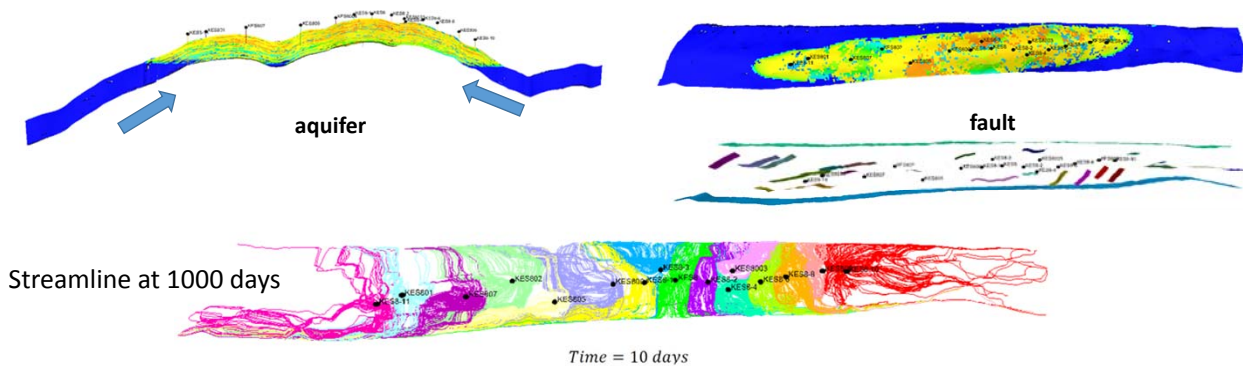


MCERI

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Flow Diagnostics

A tight gas reservoir case with producers only



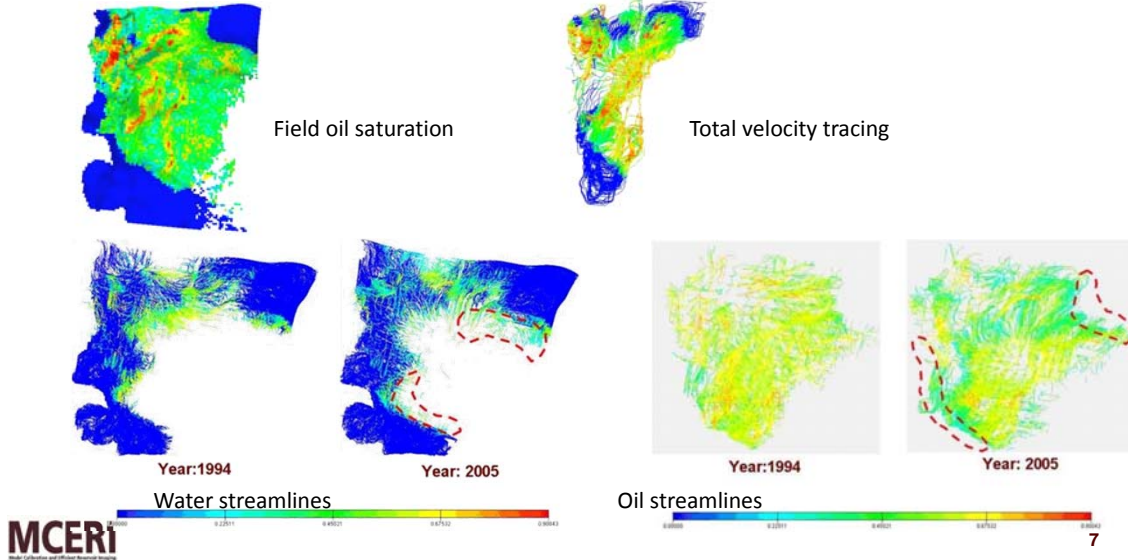
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Flow Diagnostics

- Phase tracing captures the movement of every phase

Phase streamlines



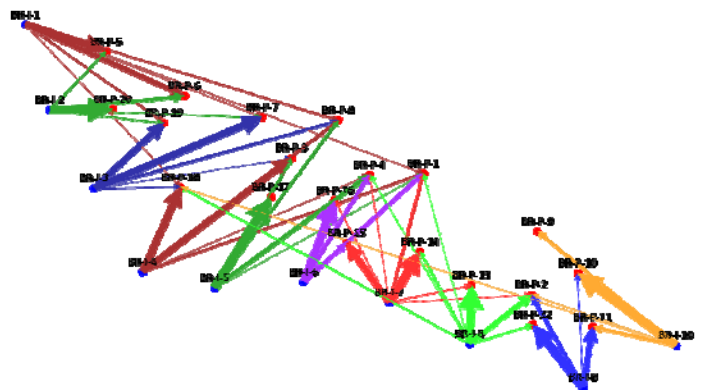
Flow Diagnostics

Rate Allocation Map

	injectors									
wellname	BR-I-1	BR-I-2	BR-I-3	BR-I-4	BR-I-5	BR-I-6	BR-I-7	BR-I-8	BR-I-9	BR-I-10
BR-P-1	176.632	0	0	476.908	35.3265	830.172	512.234	17.6632	0	0
BR-P-2	0	0	0	0	0	0	52.9897	1059.79	847.836	194.296
BR-P-3	0	0	17.6632	1678.01	370.928	0	0	0	0	0
BR-P-4	0	0	0	70.653	971.478	759.519	141.306	88.3162	0	0
BR-P-5	1907.63	353.265	0	0	0	0	0	0	0	0
BR-P-6	1165.77	989.141	0	0	0	0	0	0	0	0
BR-P-7	105.979	229.622	1713.33	0	0	0	0	0	0	0
BR-P-8	370.928	0	688.866	529.897	494.571	0	0	0	0	0
BR-P-9	0	0	0	0	0	0	0	0	671.203	0
BR-P-10	0	0	0	0	0	0	0	0	141.306	2190.24
BR-P-11	0	0	0	0	0	0	0	0	1342.41	847.836
BR-P-12	0	0	0	0	0	0	0	406.255	2048.94	0
BR-P-13	0	0	0	0	0	0	211.959	2101.93	0	0
BR-P-14	0	0	0	0	0	0	2013.61	247.285	0	0
BR-P-15	0	0	0	0	0	847.836	1430.72	0	0	0
BR-P-16	0	0	0	0	88.3162	2031.27	70.653	0	0	0
BR-P-17	0	0	0	0	2243.23	0	0	0	0	0
BR-P-18	105.979	0	406.255	1748.66	0	0	0	247.285	0	35.3265
BR-P-19	229.622	441.581	1483.71	0	0	0	0	0	0	0
BR-P-20	0	2119.59	0	0	0	0	0	0	0	0

producers

Rate allocation

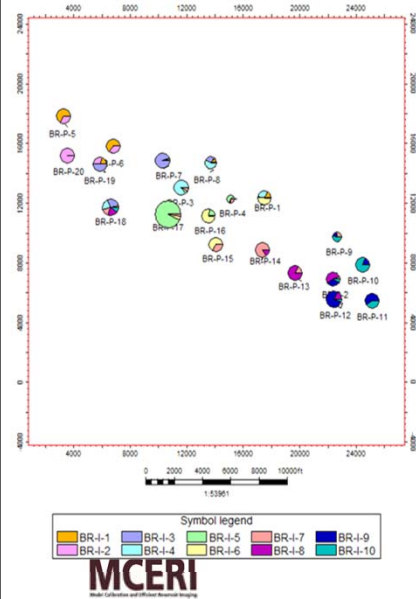


- Connector thickness stands for liquid rate allocation (streamline number)

Flow Diagnostics

Production Allocation Map

- Bubble size stands for liquid production rate
- Portion size stands for rate allocation from different injectors



	injectors										
	BR-I-1	BR-I-2	BR-I-3	BR-I-4	BR-I-5	BR-I-6	BR-I-7	BR-I-8	BR-I-9	BR-I-10	sum
BR-P-1	10	0	0	27	2	47	29	1	0	0	116
BR-P-2	0	0	0	0	0	0	3	60	48	11	122
BR-P-3	0	0	1	95	21	0	0	0	0	0	117
BR-P-4	0	0	0	4	55	43	8	5	0	0	115
BR-P-5	108	20	0	0	0	0	0	0	0	0	128
BR-P-6	66	56	0	0	0	0	0	0	0	0	122
BR-P-7	6	13	97	0	0	0	0	0	0	0	116
BR-P-8	21	0	39	30	28	0	0	0	0	0	118
BR-P-9	0	0	0	0	0	0	0	0	0	38	38
BR-P-10	0	0	0	0	0	0	0	8	124	132	132
BR-P-11	0	0	0	0	0	0	0	76	48	124	124
BR-P-12	0	0	0	0	0	0	0	23	116	0	139
BR-P-13	0	0	0	0	0	0	12	119	0	0	131
BR-P-14	0	0	0	0	0	0	114	14	0	0	128
BR-P-15	0	0	0	0	0	48	81	0	0	0	129
BR-P-16	0	0	0	5	115	4	0	0	0	0	124
BR-P-17	0	0	0	127	0	0	0	0	0	0	127
BR-P-18	6	0	23	99	0	0	14	0	2	144	144
BR-P-19	13	25	84	0	0	0	0	0	0	0	122
BR-P-20	0	120	0	0	0	0	0	0	0	0	120
sum	230	234	244	255	238	253	251	236	248	223	

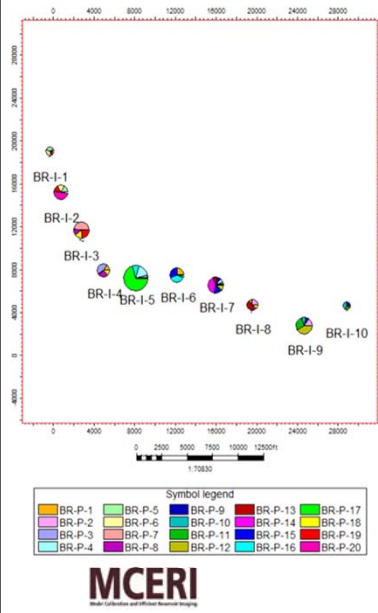
producers

Rate allocation

Flow Diagnostics

Injection Allocation Map

- Bubble size stands for injection rate
- Portion size stands for injection allocation to different producers



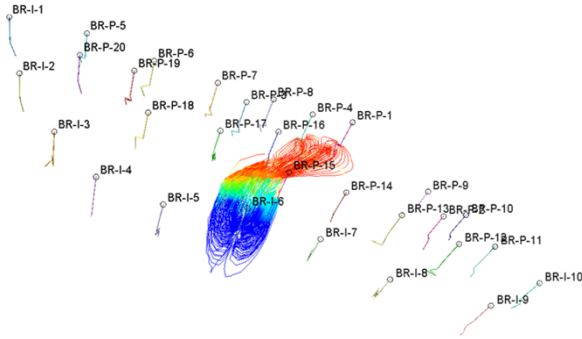
	injectors										
	BR-I-1	BR-I-2	BR-I-3	BR-I-4	BR-I-5	BR-I-6	BR-I-7	BR-I-8	BR-I-9	BR-I-10	sum
BR-P-1	10	0	0	27	2	47	29	1	0	0	116
BR-P-2	0	0	0	0	0	0	3	60	48	11	122
BR-P-3	0	0	1	95	21	0	0	0	0	0	117
BR-P-4	0	0	0	4	55	43	8	5	0	0	115
BR-P-5	108	20	0	0	0	0	0	0	0	0	128
BR-P-6	66	56	0	0	0	0	0	0	0	0	122
BR-P-7	6	13	97	0	0	0	0	0	0	0	116
BR-P-8	21	0	39	30	28	0	0	0	0	0	118
BR-P-9	0	0	0	0	0	0	0	0	0	38	38
BR-P-10	0	0	0	0	0	0	0	8	124	132	132
BR-P-11	0	0	0	0	0	0	0	76	48	124	124
BR-P-12	0	0	0	0	0	0	0	23	116	0	139
BR-P-13	0	0	0	0	0	0	12	119	0	0	131
BR-P-14	0	0	0	0	0	0	114	14	0	0	128
BR-P-15	0	0	0	0	0	48	81	0	0	0	129
BR-P-16	0	0	0	5	115	4	0	0	0	0	124
BR-P-17	0	0	0	127	0	0	0	0	0	0	127
BR-P-18	6	0	23	99	0	0	14	0	2	144	144
BR-P-19	13	25	84	0	0	0	0	0	0	0	122
BR-P-20	0	120	0	0	0	0	0	0	0	0	120
sum	230	234	244	255	238	253	251	236	248	223	

producers

Rate allocation

Flow Diagnostics

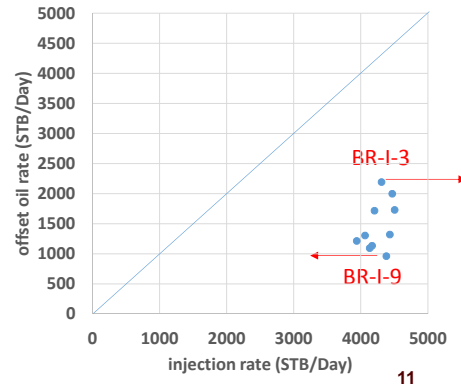
$$Injection_Efficiency = \frac{offset_oil_rate(STB / Day)}{injection_rate(STB / Day)}$$



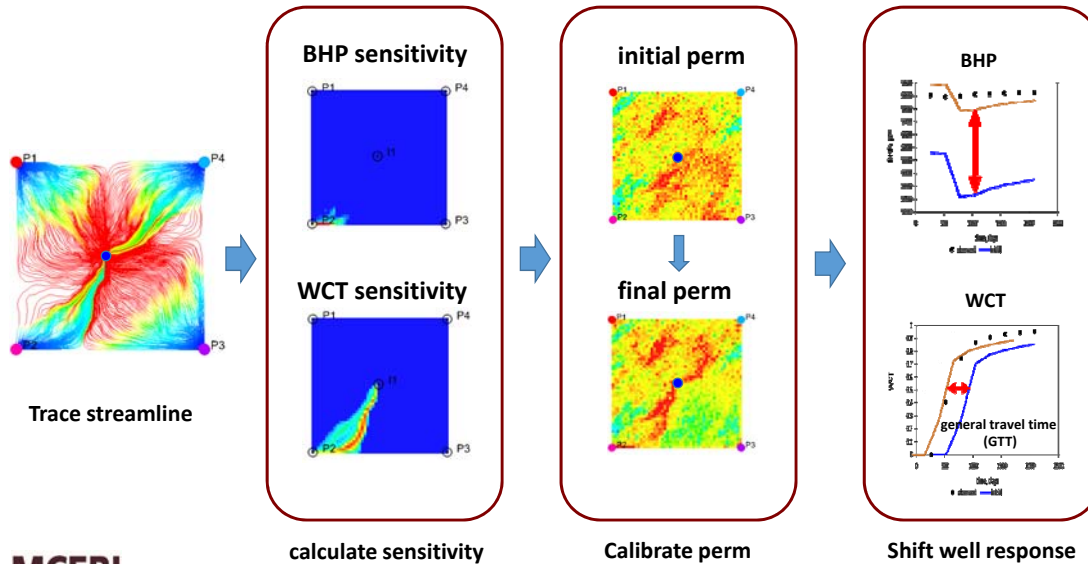
For rate optimization:
 Increase injection rate of high efficiency
 Decrease injection rate of low efficiency



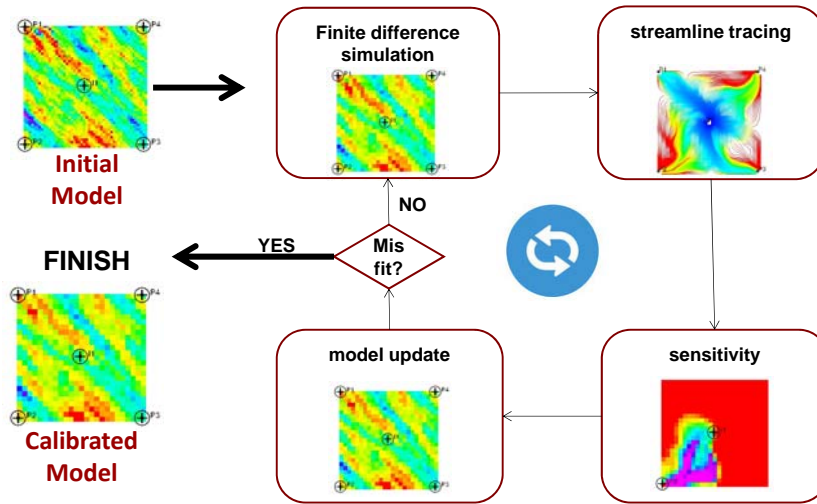
BEGIN	HEADER				
X					
Y					
Z					
STRING,WellName					
FLOAT,InjRate					
FLOAT,OffsetOilRate					
END	HEADER				
15116.3	7035.19	5660.69	BR-I-1	4063.55	1305.78
16217.2	10860.4	5785.64	BR-I-2	4133.2	1095.86
18198.2	14374.2	5738.69	BR-I-3	4309.83	2194.2
20375	18131.5	5712.17	BR-I-4	4504.13	1730.36
23587.8	18842.4	5711.87	BR-I-5	4203.85	1718.01
27586.2	18574.9	5649.83	BR-I-6	4468.8	1999.38
31429.9	19491.6	5638.81	BR-I-7	4433.47	1321.75
35021.2	21346	5656.59	BR-I-8	4168.52	1137.18
40119.3	23284.4	5686.68	BR-I-9	4380.48	962.567
44291.1	21422.7	5658.79	BR-I-10	3938.9	1215.4



History Matching

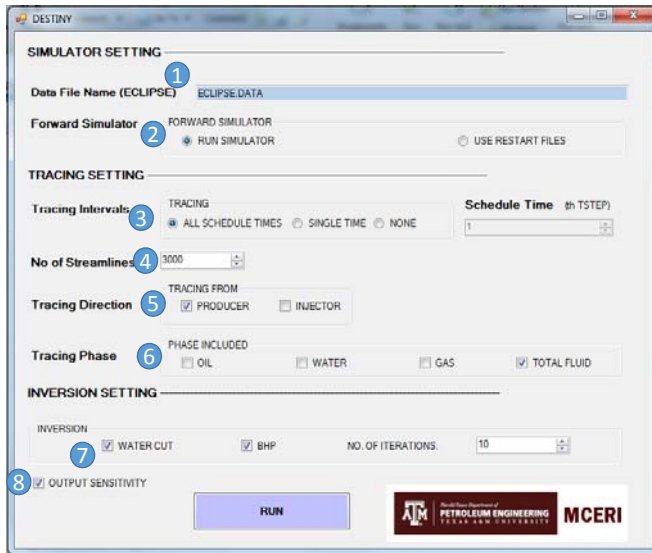


History Matching: Basic Workflow



Training

Software interface

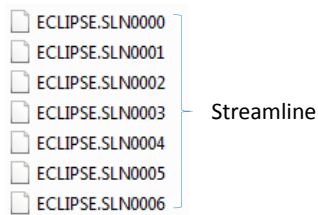


Setting

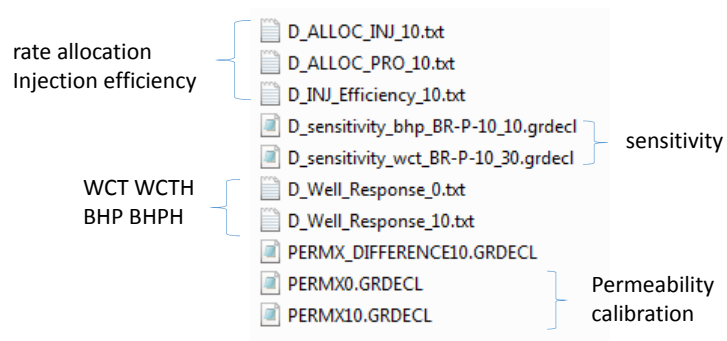
1. name of simulation deck file
2. Run simulation or not
3. All: trace streamlines for all steps; Single: need to specify which step to trace streamline in Schedule time box.
4. Total number of streamlines for the whole reservoir.
5. Trace streamline from producers or injectors
6. Can trace phase streamlines or streamlines of total flux.
7. History matching water cut and flowing bottom hole pressure for each producer.
8. Output inversion sensitivity

Generated Files

Under working directory



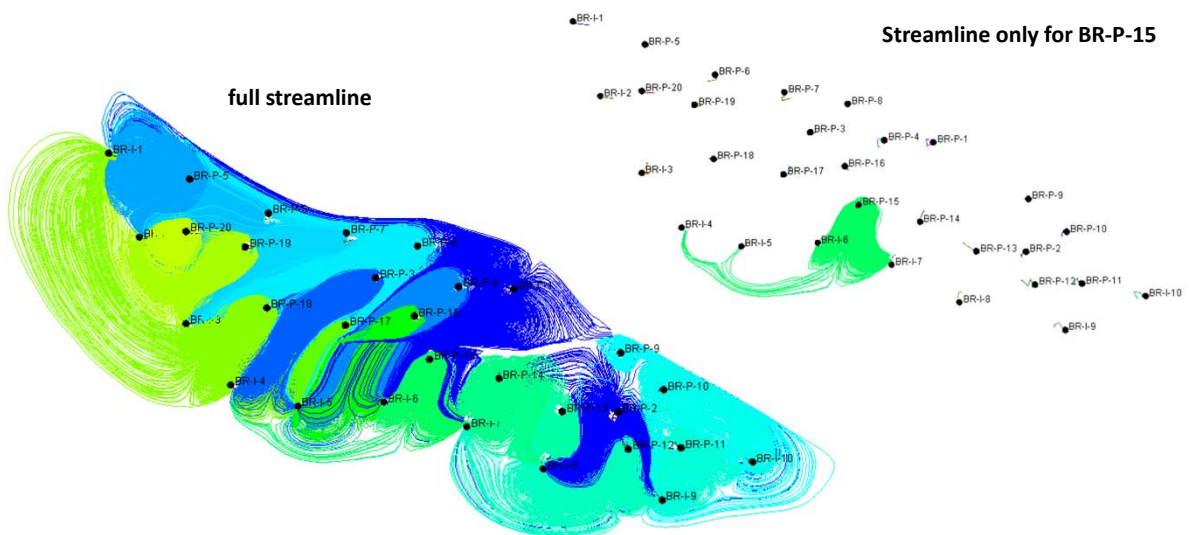
Inside Destiny folder



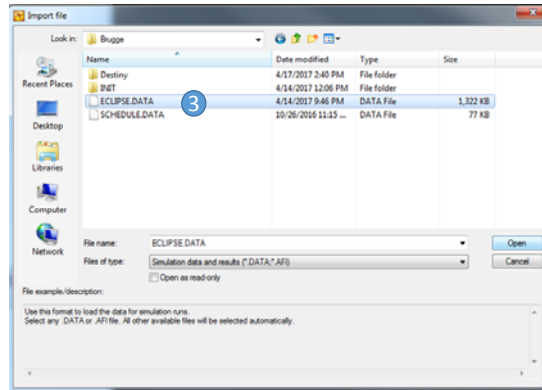
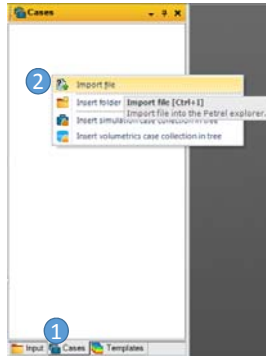
The following slides shows how to visualize these files in Petrel and Excel.

Flow Diagnostics

Streamline

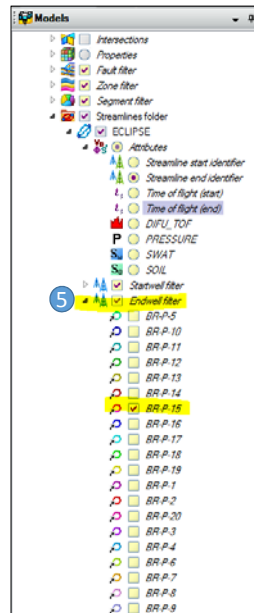
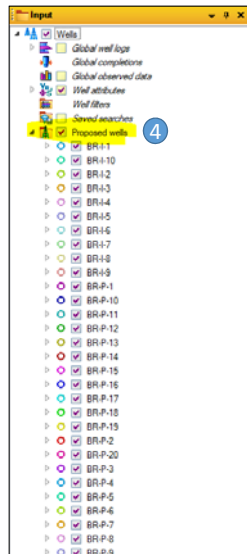
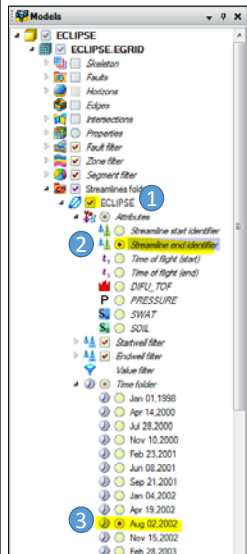


Streamline

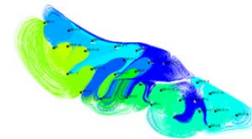


1. Open petrel and go to cases tab.
2. Right click to import file.
3. Choose ECLIPSE.DATA to import the Brugge case simulation result.

Streamline

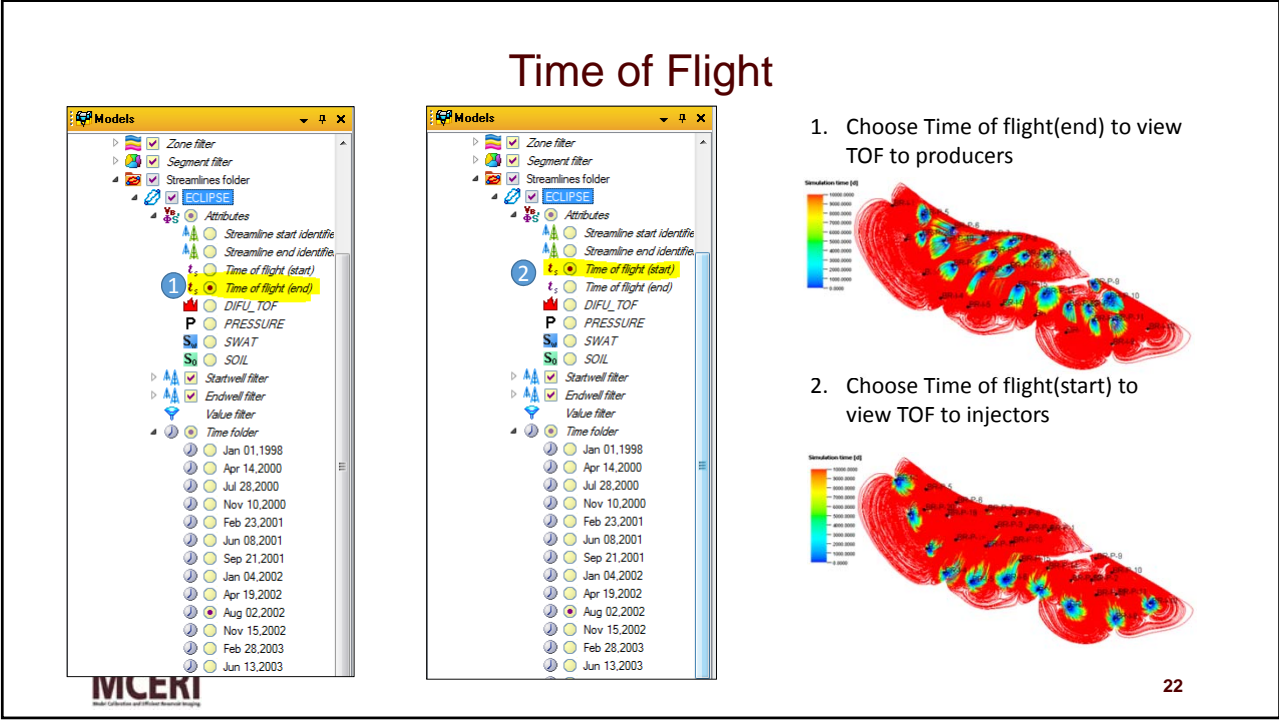
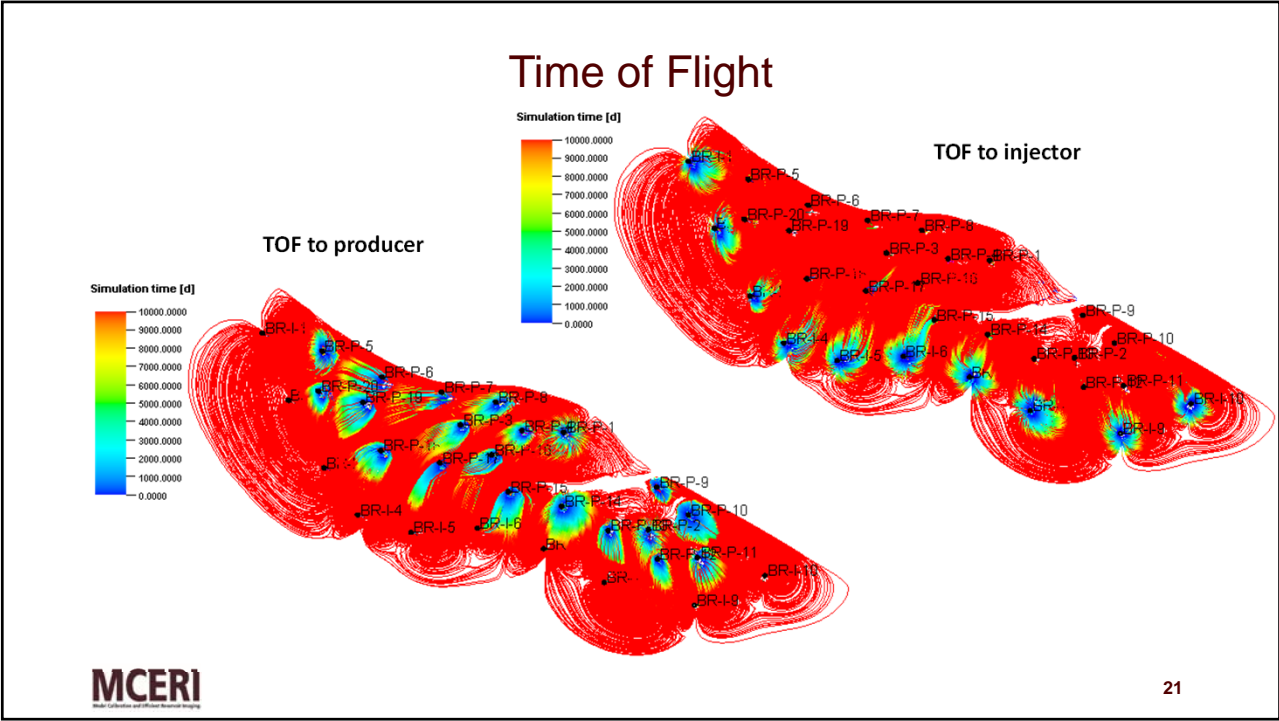


1. Go to Models tab and check streamline box to show streamline.
2. Choose the property which is to be shown on streamline.
3. Choose the time step to show streamline.
4. Turn on all wells for visualizing the well positions.

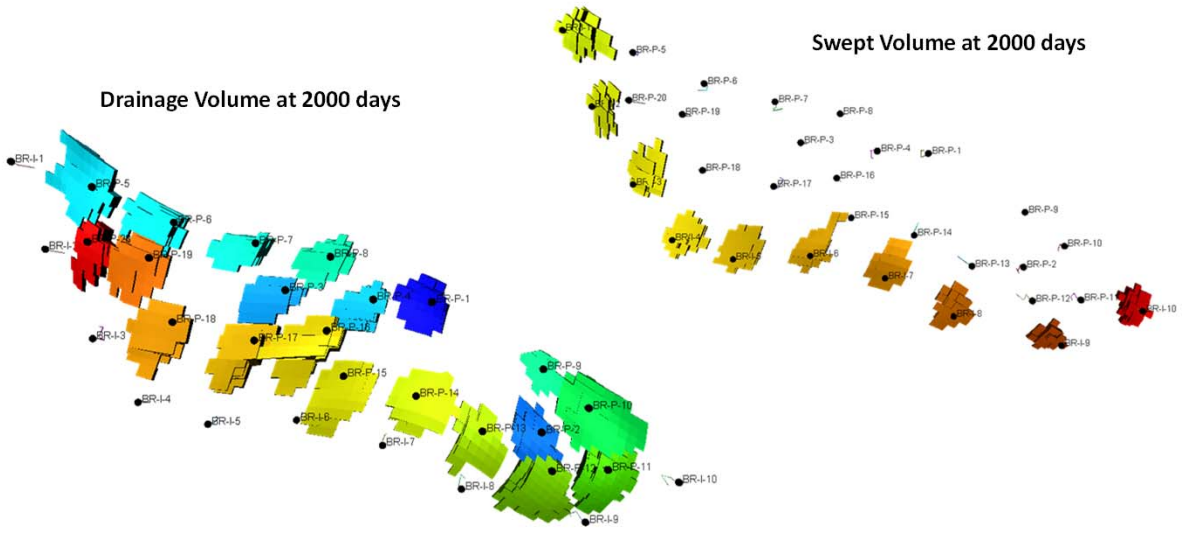


5. Pick streamlines only for specific well.





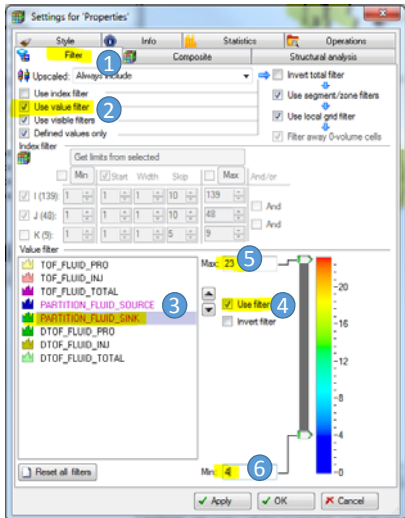
Drainage(Swept) Volume



Drainage(Swept) Volume

1. Import diagnostic results from D_grid_diagnose_10.grdecl.
2. Double click Properties and go to filter tab.

Drainage(Swept) Volume



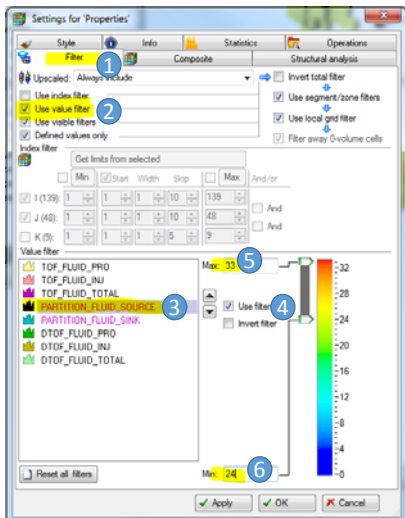
D_terminator.log		
1	ACT	
2	INACT	
3	STAG	
4	BR-P-1	1164.83
5	BR-P-2	1164.83
6	BR-P-3	1269.3
7	BR-P-4	1269.3
8	BR-P-5	0
9	BR-P-6	1269.3
10	BR-P-7	1269.3
11	BR-P-8	1373.77
12	BR-P-9	1373.77
13	BR-P-10	0
14	BR-P-11	0
15	BR-P-12	0
16	BR-P-13	955.884
17	BR-P-14	955.884
18	BR-P-15	955.884
19	BR-P-16	1060.36
20	BR-P-17	1060.36
21	BR-P-18	1060.36
22	BR-P-19	1060.36
23	BR-P-20	1164.83
24	BR-I-1	1373.77
25	BR-I-2	1478.25
26	BR-I-3	1478.25
27	BR-I-4	1478.25
28	BR-I-5	1478.25
29	BR-I-6	1582.72
30	BR-I-7	1582.72
31	BR-I-8	1582.72
32	BR-I-9	1687.19
33	BR-I-10	1687.19

The use of filter

1. Choose filter tab.
2. Check use value filter box.
3. Highlight PARTITION_FLUID_SINK term.
4. Check use filter box.
5. Set Max as 23.
6. Set Min as 4. .

(the partition numbers of corresponding wells are listed in **D_terminator.log** file, which is in Destiny folder under current case directory).

Drainage(Swept) Volume



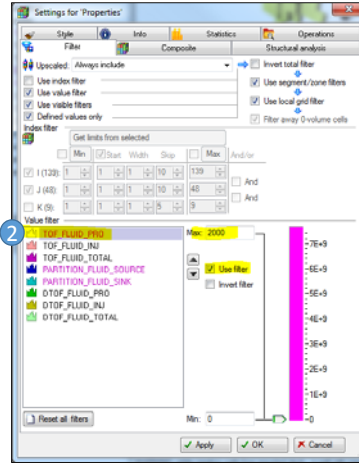
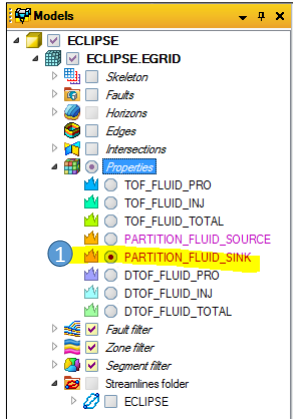
D_terminator.log		
1	ACT	
2	INACT	
3	STAG	
4	BR-P-1	1164.83
5	BR-P-2	1164.83
6	BR-P-3	1269.3
7	BR-P-4	1269.3
8	BR-P-5	0
9	BR-P-6	1269.3
10	BR-P-7	1269.3
11	BR-P-8	1373.77
12	BR-P-9	1373.77
13	BR-P-10	0
14	BR-P-11	0
15	BR-P-12	0
16	BR-P-13	955.884
17	BR-P-14	955.884
18	BR-P-15	955.884
19	BR-P-16	1060.36
20	BR-P-17	1060.36
21	BR-P-18	1060.36
22	BR-P-19	1060.36
23	BR-P-20	1164.83
24	BR-I-1	1373.77
25	BR-I-2	1478.25
26	BR-I-3	1478.25
27	BR-I-4	1478.25
28	BR-I-5	1478.25
29	BR-I-6	1582.72
30	BR-I-7	1582.72
31	BR-I-8	1582.72
32	BR-I-9	1687.19
33	BR-I-10	1687.19

The use of filter

1. Choose filter tab.
2. Check use value filter box.
3. Highlight PARTITION_FLUID_SOURCE term.
4. Check use filter box.
5. Set Max as 33.
6. Set Min as 24. .

(the partition numbers of corresponding wells are listed in **D_terminator.log** file, which is in Destiny folder under current case directory).

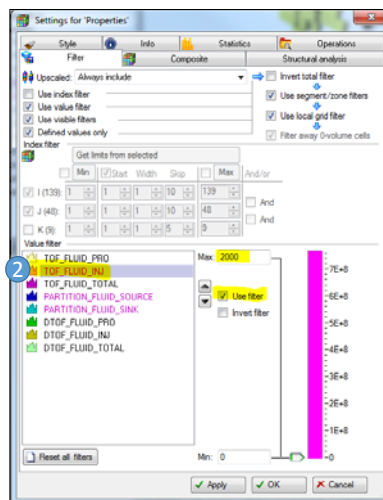
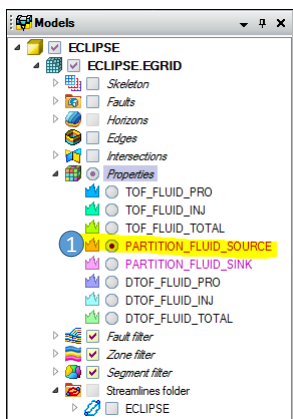
Drainage(Swept) Volume



1. Choose PARTITION_FLUID_SINK term to view reservoir partition according to **producers**.
2. Use TOF_FLUID_PRO as filter to cut out drainage volume at time 2000 day.



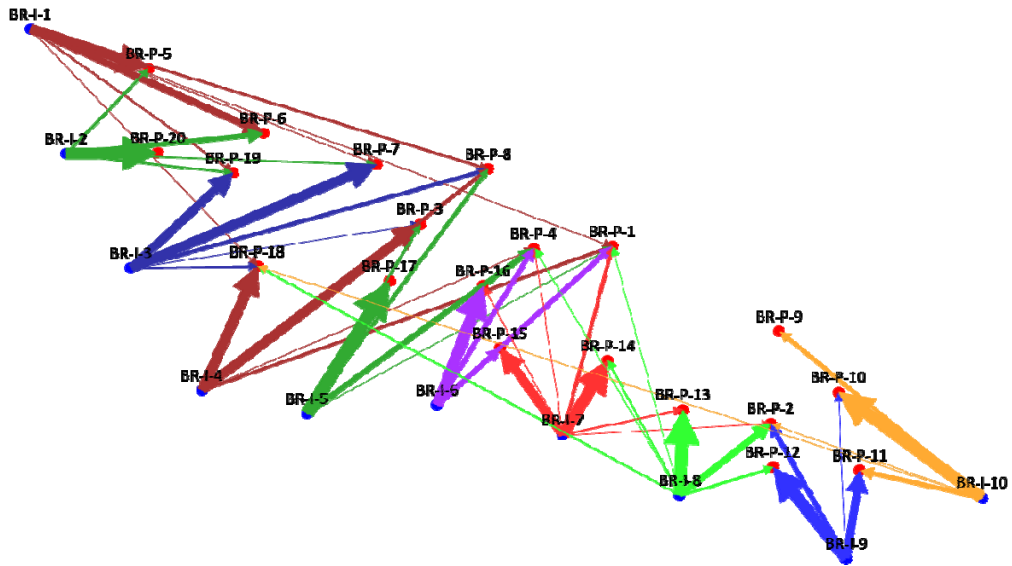
Drainage(Swept) Volume



1. Choose PARTITION_FLUID_SOURCE term to view reservoir partition according to **injectors**.
2. Use TOF_FLUID_INJ as filter to cut out swept volume at time 2000 day.



Rate Allocation

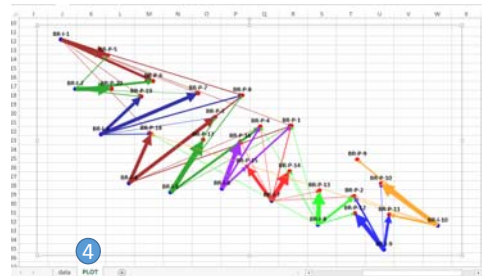


Rate Allocation

1. D_RateAlloc_Plot.xlsm
2. D_PRO_ALLOC_10.txt
3. D_INJ_ALLOC_10.txt

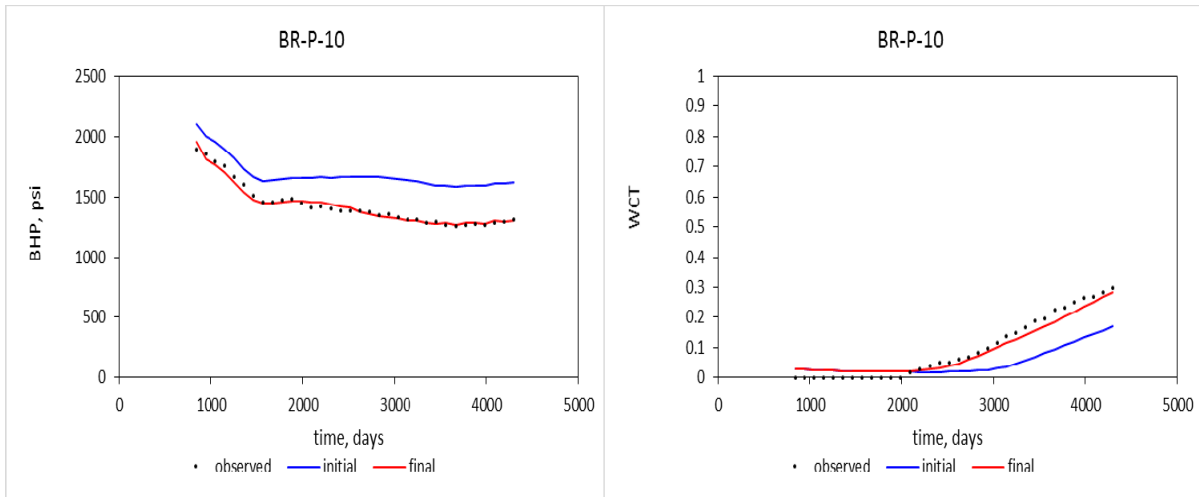
1. Open D_RateAlloc_Plot.xlsm
2. Import data to data sheet from D_PRO_ALLOC_10.txt and D_INJ_ALLOC_10.txt.
3. Click PLOT in data sheet.
4. Check result in PLOT sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O					
1						15116.3	16217.2	18198.2	20375	21587.8	27586.2	31429.9	35021.2	40119.3	44291.1					
2						7095.19	10900.4	14374.2	18113.5	18842.4	18374.9	19491.4	21346	23204.4	21422.7					
3						404.6014	478.2417	520.781	507.5247	636.5151	723.3752	804.9112	882.0314	991.506	1061.09					
4						171.0709	253.2119	328.6659	409.3487	424.6142	418.8701	438.5549	478.3756	520	480.0226					
5																				
6						32956.4	13709.4	817.6927	314.3902	BR-P-1	10	0	0	27	2	47	29	1	0	0
7						17811.8	19142.7	943.9556	431.6028	BR-P-2	0	0	0	0	0	3	60	48	11	0
8						27099.4	13022.3	711.0629	299.64	BR-P-3	0	0	1	95	21	0	0	0	0	0
9						30549.4	13784.6	786.0057	115.5756	BR-P-4	0	0	0	4	55	43	8	5	0	0
10						18742.9	8242.25	532.4776	196.9908	BR-P-5	508	20	0	0	0	0	0	0	0	0
11						22284	30239.9	607.8736	339.6876	BR-P-6	66	36	0	0	0	0	0	0	0	0
12						25725.4	11189.6	682.4171	260.281	BR-P-7	6	13	97	0	0	0	0	0	0	0
13						29150.3	11339	755.962	263.4892	BR-P-8	21	0	39	30	28	0	0	0	0	0
14						38068.5	18311.3	947.4679	370.2624	BR-P-9	0	0	0	0	0	0	0	0	0	38
15						19051.9	18181.7	984.4229	410.4366	BR-P-10	0	0	0	0	0	0	0	0	8	124
16						40542.4	20589.3	1000.591	462.1285	BR-P-11	0	0	0	0	0	0	0	0	79	48
17						37878.7	20477.6	943.3922	459.7279	BR-P-12	0	0	0	0	0	0	0	23	116	0
18						35117	18718.5	884.0886	421.9537	BR-P-13	0	0	0	0	0	0	12	119	0	0
19						32811	17207.5	834.3704	389.9071	BR-P-14	0	0	0	0	0	0	14	14	0	0
20						29514.9	16833.9	761.7913	381.4845	BR-P-15	0	0	0	0	0	48	81	0	0	0
21						28990.1	14906.9	752.5219	340.1049	BR-P-16	0	0	0	0	3	115	4	0	0	0
22						26114.6	14780.1	690.7746	337.3883	BR-P-17	0	0	0	0	127	0	0	0	0	0
23						22051.2	14322.4	604.0126	327.6378	BR-P-18	6	0	23	99	0	0	14	0	0	2
24						21236.8	11438.9	587.9633	265.4344	BR-P-19	13	25	84	0	0	0	0	0	0	0
25						19023.7	10844.5	538.5074	252.4705	BR-P-20	0	120	0	0	0	0	0	0	0	0
26																				



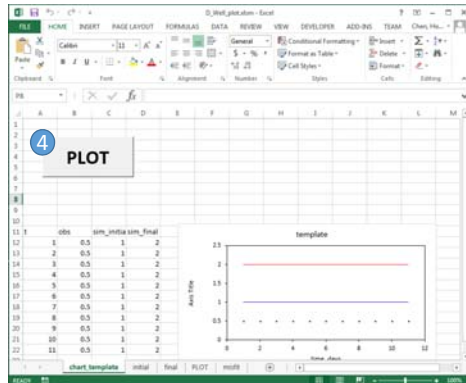
History Matching

Well Responses Before and After Calibration

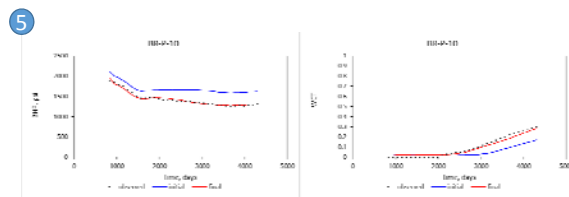


Well Responses Before and After Calibration

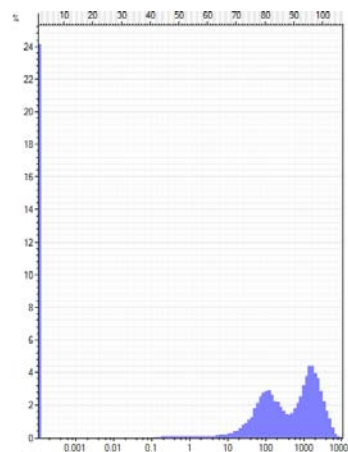
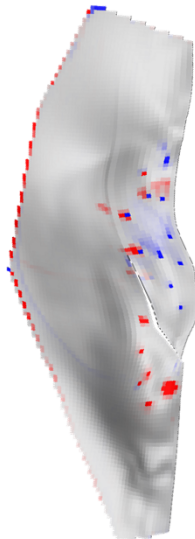
- 1 D_Well_plot.xlsm
- 2 D_Well_Response_0.txt
- 3 D_Well_Response_10.txt



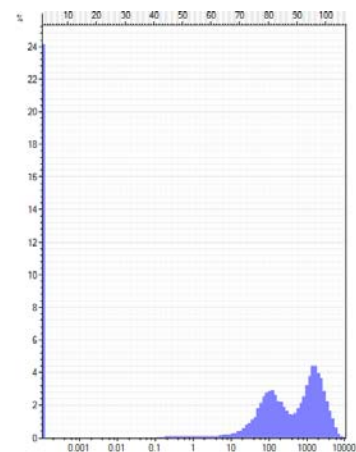
1. Open D_Well_plot.xlsm in the package
2. Import initial simulation result D_Well_Response_0.txt to initial sheet
3. Import final simulation result D_Well_Response_10.txt to final sheet
4. Go to chart_template sheet and click PLOT
5. Check the plots in PLOT sheet



Permeability Calibration

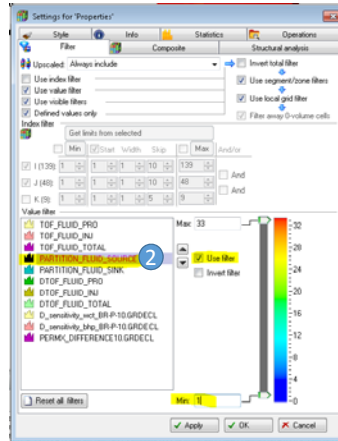
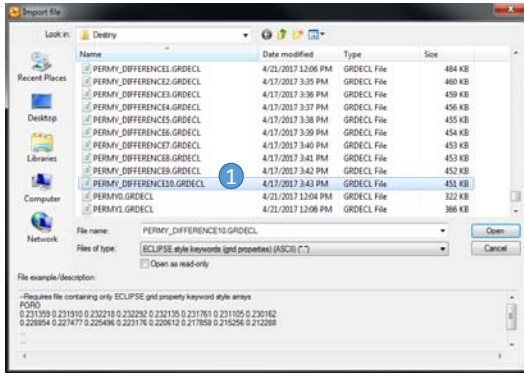


Initial permx histogram



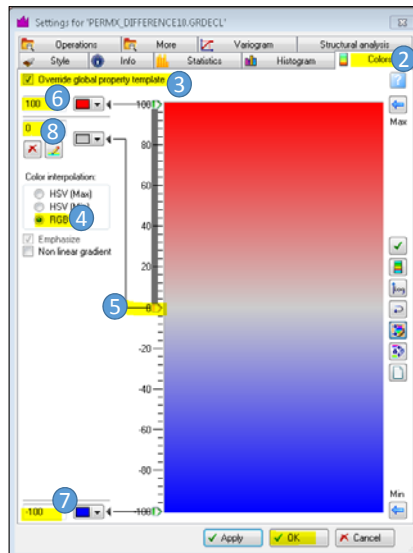
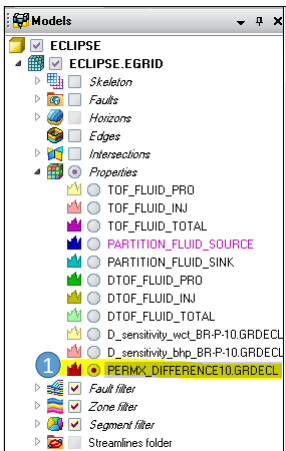
updated permx histogram

Permeability Calibration

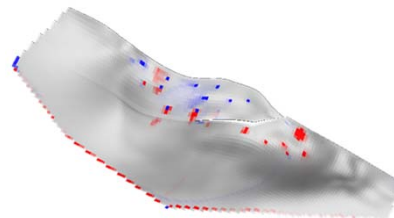


1. Import PERMX_DIFFERENCE10
2. In Filter tab, uncheck all value filters but only use PARTITION_FLUID_SOURCE, set the Min as 1 to filter out all the inactive cells

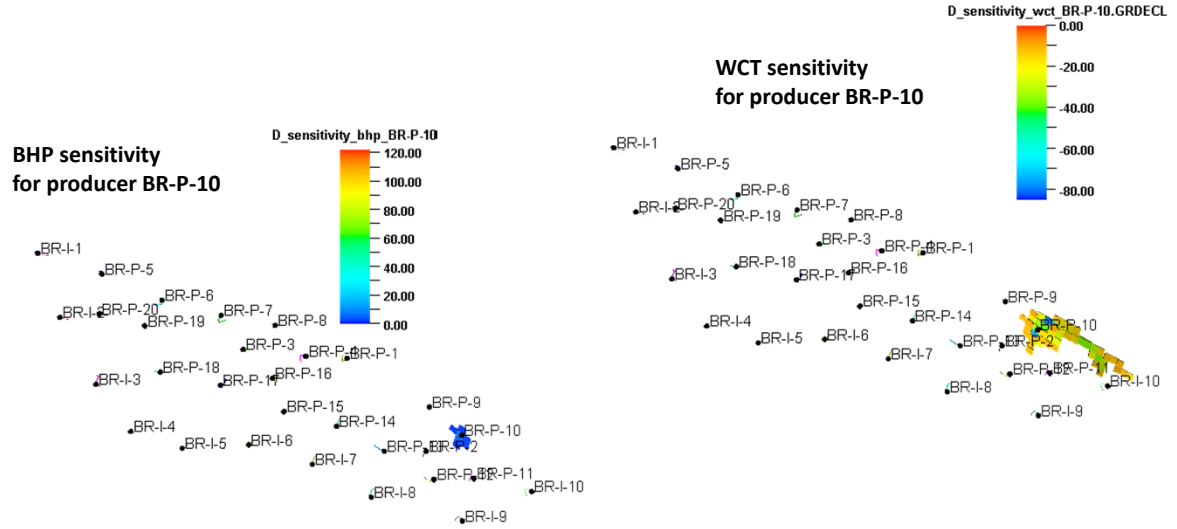
Permeability Calibration



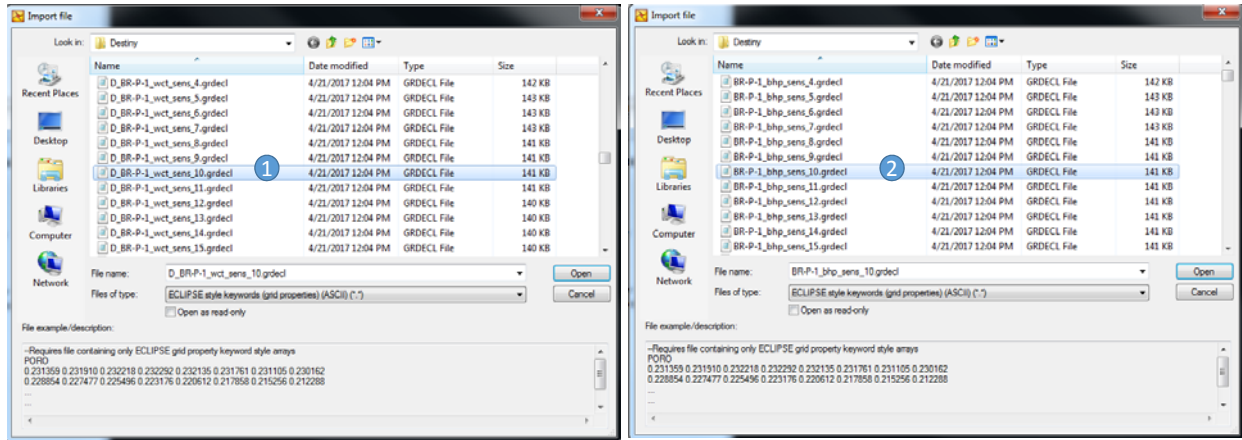
1. Choose PERMX_DIFFERENCE10 to view and double click it to set colors
2. Choose Colors tab
3. Check Override global property templates
4. Choose RGB
5. Insert new color tab in the middle of color scale
6. Set max as 500
7. Set min as -500 and make the color blue
8. Set middle value as 0 and make the color gray



BHP, WCT Sensitivity



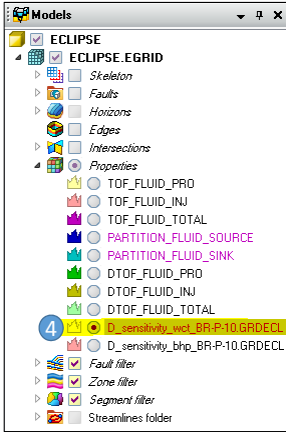
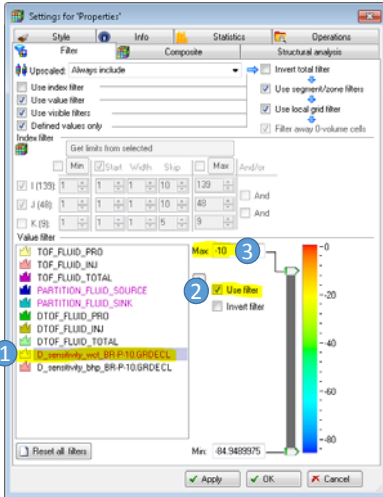
BHP, WCT Sensitivity



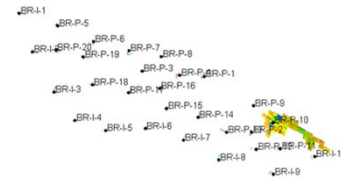
Use DESTINY to import sensitivity

1. Choose D_sensitivity_wct_BR-P-10 to import sensitivity of cells towards BR-P-10's WCT curve.
2. Choose D_sensitivity_bhp_BR-P-10 to import sensitivity of cells towards BR-P-10's BHP curve.

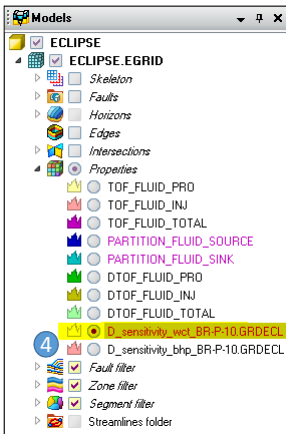
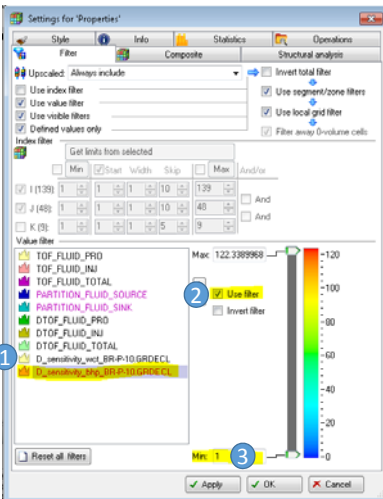
BHP, WCT Sensitivity



1. highlight D_sensitivity_wct_BR-P-10 in filter tab
2. Check use filter
3. Set Max as -10 to filter out insensitive cells
4. In Models section, Choose D_sensitivity_wct_BR-P-10 to view the cells that are sensitive for well BR-P-10's water cut



BHP, WCT Sensitivity



1. highlight D_sensitivity_bhp_BR-P-10 in filter tab
2. Check use filter
3. Set Min as 1 to filter out insensitive cells
4. In Models section, Choose D_sensitivity_bhp_BR-P-10 to view the cells that are sensitive for well BR-P-10's bottom hole pressure.

