

Supplementary Material

The main manuscript describes the results from the Random Forest model implementation using the field injection and field production data as inputs, and simulated oil saturation data as the output. The same model was also applied to the production, injection and oil saturation data all obtained from the simulation, and similar results were obtained because the simulation model was history matched with the field data. The model performance results with all simulation data are summarized in Table S1 and Figures S1 and S2, which shows very similar performance as with field injection and production, summarized in Table 8 and Figures 13 and 15 in the main manuscript. In Figures S1 and S2, the blue curve represents the actual saturation values (from the reservoir simulation), while the red curves represent the predicted saturation values from the Random Forest model.

Table S1. Random Forest model performance with production, injection and saturation data from the simulation.

	PF-1C	PF-14	PF-12	PF-11
RMSE	0.0500	0.0294	0.0446	0.0545
R ²	0.9332	0.9558	0.9031	0.9338

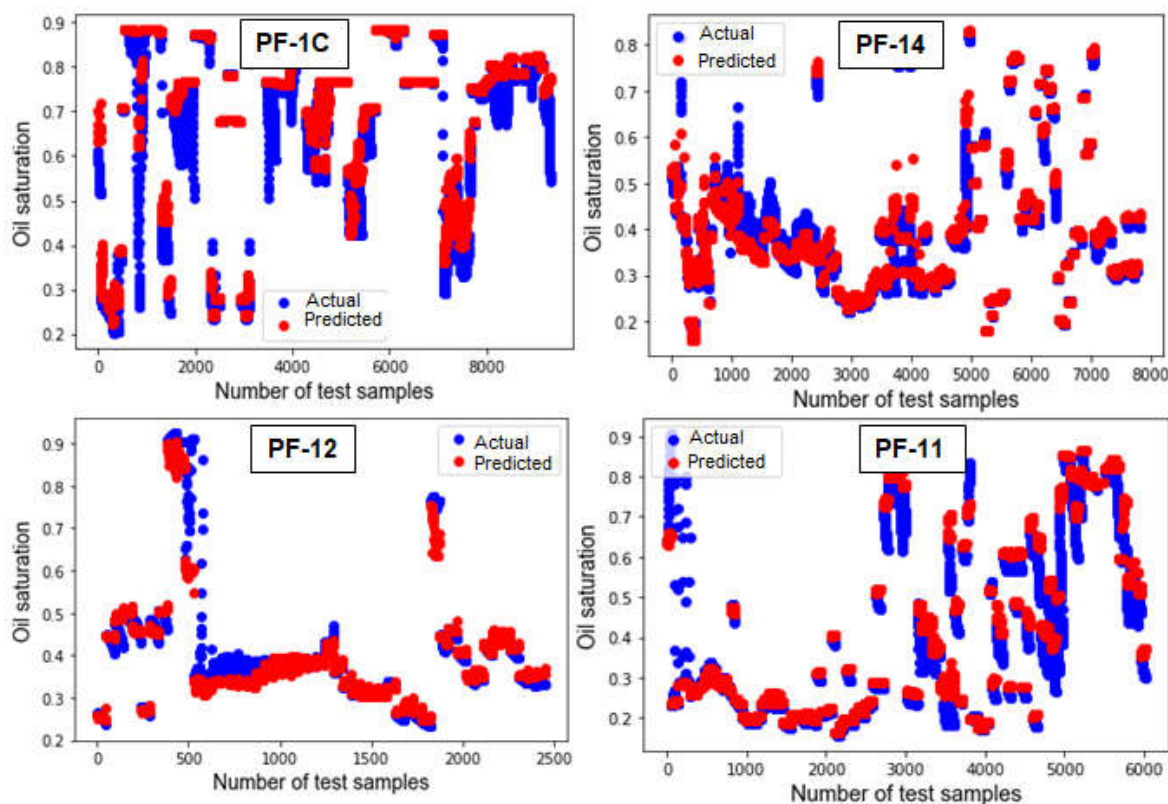


Figure S1. Performance of Random Forest model with the production, injection and saturation data from the simulation model.

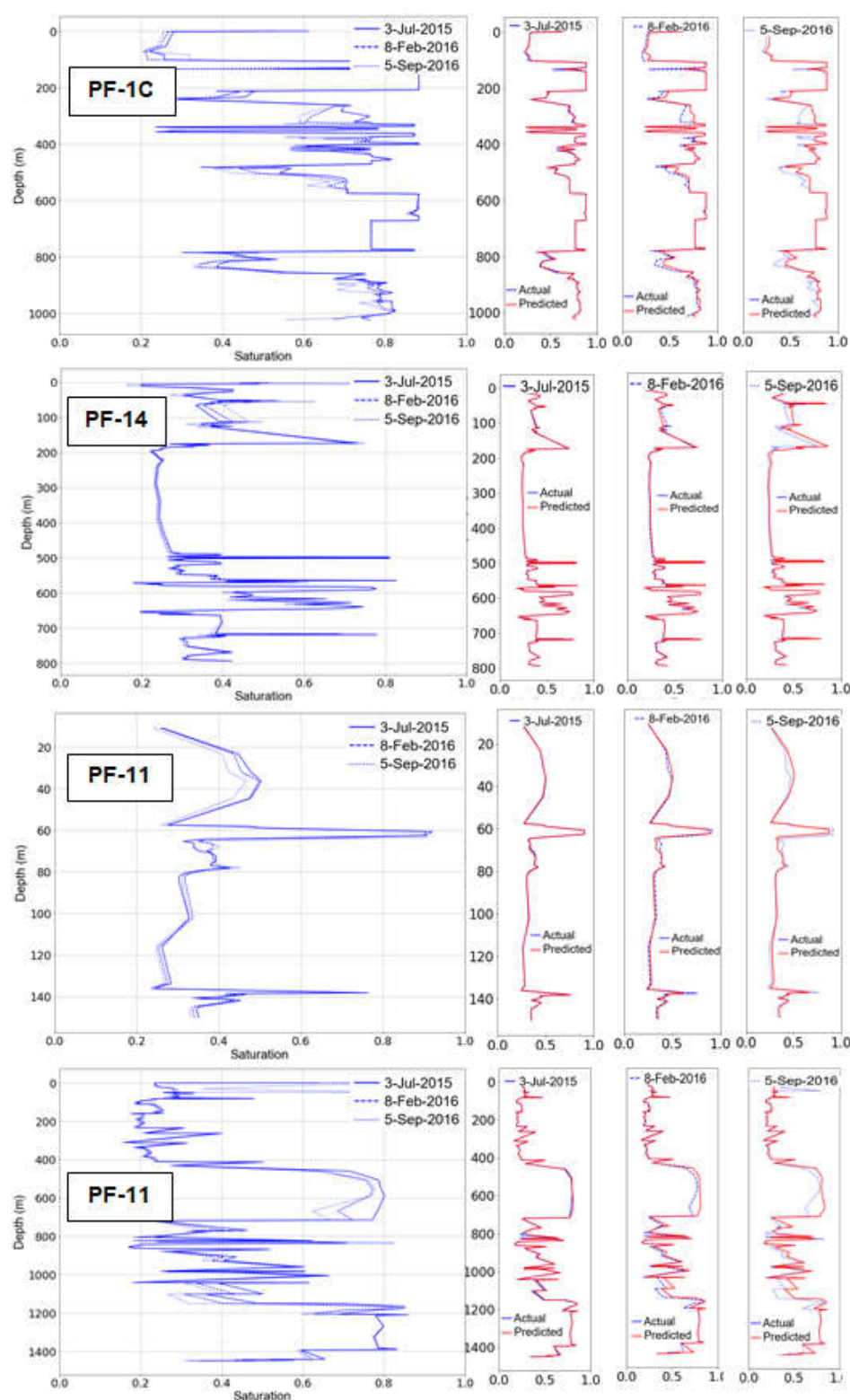


Figure S2. Predicted versus the actual time-lapsed oil saturation profiles with production, injection and saturation from the simulation model shown at the four test-well locations for three time-steps from the testing dataset.

Figure S3 shows an example of input and output features for the machine learning model for one of the four tests wells, PF-14. Here the input features are based the result of feature selection (refer to Sec. 4.1 and Table 7 in main manuscript)

and the output is the oil saturation at PF-14. The oil and water rates are in MSTB/month and gas rate is in MMSCF/month. Corresponding to each time-step (for instance 6/13/2015 and 6/23/2015 shown in Figure S1) there will be different saturation values along the measured depth of the well. In this example for PF-14, there are 184 saturation values along the 793 m completion interval for this well, corresponding to each time-step. This explains the number of datapoints summarized in Table 4.

INPUTS																			OUTPUT
Date	Production															Injection		Measured Depth, m (PF-14)	Oil Saturation (PF-14)
	PF-1C			PF-11			PF-12			PF-14			PF-15D			IF-4	IF-5		
	oil	gas	water	oil	gas	water	oil	gas	water	oil	gas	water	oil	gas	water	water	water		
6/13/2015	256.0	36917.3	1013.1	1597.6	230357.1	710.1	693.3	99960.3	1119.0	203.4	29321.7	3151.8	119.9	17293.9	8.9	3656.1	3673.6	1.90	0.52
6/13/2015	256.0	36917.3	1013.1	1597.6	230357.1	710.1	693.3	99960.3	1119.0	203.4	29321.7	3151.8	119.9	17293.9	8.9	3656.1	3673.6	3.06	0.44
...
6/13/2015	256.0	36917.3	1013.1	1597.6	230357.1	710.1	693.3	99960.3	1119.0	203.4	29321.7	3151.8	119.9	17293.9	8.9	3656.1	3673.6	793.11	0.42
6/23/2015	337.6	49947.5	745.7	1606.6	237672.4	785.3	680.6	100673.3	1207.9	199.6	29530.8	3402.3	119.8	17717.4	9.8	7217.0	7014.0	1.90	0.51
6/23/2015	337.6	49947.5	745.7	1606.6	237672.4	785.3	680.6	100673.3	1207.9	199.6	29530.8	3402.3	119.8	17717.4	9.8	7217.0	7014.0	3.06	0.44
...
6/23/2015	337.6	49947.5	745.7	1606.6	237672.4	785.3	680.6	100673.3	1207.9	199.6	29530.8	3402.3	119.8	17717.4	9.8	7217.0	7014.0	793.11	0.42

Figure S3. Input and output features for well PF-14 to illustrate the number of datapoints.

Tables S1–S4 summarize the optimal hyperparameters used for the Linear Regression, K-Neighbors, AdaBoost, and Gradient Boosting algorithms, respectively. An ANOVA test was performed on the MAPE achieved from 35 simulation runs using the different models to ensure that there is statistically significant difference. The results presented in Figure S4 show that F value is greater than F-critical and the p-value is very small, indicative of statistically significant difference.

Table S1. Optimal hyperparameters for the Linear Regression model.

copy_X	fit_intercept	normalize
True	True	True

Table S2. Optimal hyperparameters for the K-Neighbors Regression model.

n_neighbors	leaf_size	p	weights
5	30	2	uniform

Table S3. Optimal hyperparameters for the AdaBoost Regression model.

n_estimators	loss	Learning_rate
50	square	0.5

Table S4. Optimal hyperparameters for the Gradient Boosting Regression model.

n_estimators	Learning_rate	min_samples_split
100	0.3	2

	linear	RF	ada	gradient	k neigh
MAPE	0.1917	0.0533	0.1629	0.0745	0.1944
	0.1923	0.0532	0.1649	0.0798	0.1948
	0.1893	0.0498	0.1599	0.0756	0.1994
	0.1933	0.0521	0.1666	0.0766	0.2021
	0.1942	0.0514	0.1624	0.0676	0.2011
	0.1932	0.0523	0.1653	0.0723	0.2023
	0.1942	0.0532	0.1612	0.0743	0.2014
	0.1952	0.0557	0.1599	0.0721	0.2043
	0.192	0.0518	0.1563	0.0723	0.2019
	0.1942	0.0521	0.1664	0.0698	0.2018
	0.152	0.0534	0.1673	0.0743	0.2021
	0.1942	0.0583	0.1673	0.0683	0.1993
	0.1944	0.0594	0.1632	0.0746	0.1938
	0.1942	0.0517	0.1663	0.0722	0.2048
	0.1962	0.0549	0.1663	0.0759	0.2051
	0.1972	0.0539	0.1683	0.0756	0.2041
	0.195	0.0524	0.1624	0.0749	0.2048
	0.1972	0.0543	0.1639	0.0729	0.2095
	0.1942	0.0546	0.1623	0.0746	0.2083
	0.1915	0.0562	0.1663	0.0696	0.2073
	0.1952	0.0526	0.1643	0.0696	0.2037
	0.1949	0.0524	0.1623	0.0694	0.2042
	0.1962	0.0568	0.1664	0.0697	0.2048
	0.1963	0.0589	0.1673	0.0743	0.2056
	0.1922	0.0574	0.1635	0.0763	0.2029
	0.1942	0.0573	0.1664	0.0734	0.1994
	0.1944	0.0582	0.1673	0.0724	0.1984
	0.1934	0.0565	0.1623	0.0724	0.1986
	0.1954	0.0542	0.1612	0.0746	0.2049
	0.1976	0.0554	0.1596	0.0734	0.2055
	0.1975	0.0563	0.1566	0.0716	0.199
	0.1996	0.0563	0.1583	0.0714	0.2021
	0.1954	0.0569	0.1592	0.0737	0.2061
	0.1945	0.0531	0.1656	0.0746	0.2049
	0.1943	0.0561	0.1665	0.0752	0.2043

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
linear	35	6.7668	0.19333714	5.5748E-05		
RF	35	1.9124	0.05464	5.8989E-06		
ada	35	5.7262	0.16360571	1.0649E-05		
gradient	35	2.5598	0.07313714	6.8918E-06		
k neigh	35	7.087	0.20248571	1.3641E-05		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.66607721	4	0.1665193	8969.19029	1.538E-196	2.42481526
Within Groups	0.00315617	170	1.8566E-05			
Total	0.66923338	174				

Figure S4. Results from single-factor ANOVA analysis on the MAPE results from the machine learning models.