ERRATUM

Erratum to: Characterizing interwell connectivity in waterflooded reservoirs using data-driven and reduced-physics models: a comparative study

Emre Artun¹

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Unfortunately, in the original published article, *Accuracy* subsection of Section 3.2, Table 4 and Table 5 were not correct. The correct text for the *Accuracy* subsection and Tables 4 and 5 are given below.

Accuracy Prediction capabilities of each method can be analyzed by comparing each method's ability to identify high-connectivity zones in the reservoir. As a qualitative comparison methodology, after ranking all of the 20 interwell connectivities between each of the five injectors and four producers, upper 10 values can be classified in the high-connectivity category and lower 10 values can be classified in the low-connectivity category. One can approximate the connectivity values for the numerical simulation model, by utilizing the average permeability between two wells and the distance between two wells (if two wells are close to each other and have a high-permeability streak between them, their connectivity would be the highest). The calculation is carried out using the following procedure: The logarithm of permeability between two wells is multiplied with the initial fractional-flow parameter which was calculated using the inverse-distance method (Eq. 9), and all connectivity values are normalized between 0 and 1 (1 represents the highest connectivity pair

in the field, and 0 represents the lowest connectivity pair in the field). These values are given in Table 5. After sorting the connectivity values obtained from the aforementioned procedure, as well as the predictions of data-driven and the reduced-physics models; it is seen that the data-driven and the reduced-physics models were able to correctly estimate 80 and 70 % of each connectivity category, respectively:

- Data-driven model was able to predict the following high-connectivity pairs that match with the numerical model-based connectivities: 1, 6, 9, 12, 15, 18, 19, 20
- Reduced-physics model was able to predict the following high-connectivity pairs that match with the numerical model-based connectivities: 1, 2, 9, 12, 18, 19, 20

The purpose of this approach was to perform a field-wide analysis that includes all injector–producer pairs and to distinguish higher-connectivity pairs from lower-connectivity pairs in the whole field. This process would help to understand which pairs would have greater impact on the field-wide production. An additional comparison methodology was to normalize the connectivity values for each injector such that the summation of connectivity values for a given injector adds up to 1. This is a natural consequence of the formulation of the capacitance–resistance model, but has to be manually defined as an additional constraint for the artificial neural network and numerical model-based connectivities. The connectivity values obtained after applying this constraint to all approaches are also shown in Table 5. When the quantities of connectivities are compared with the numerical model, both approaches are comparable with correlation coefficient values of 0.86 for the reduced-physics modeling approach and 0.84 for the data-driven modeling approach. These acceptable accuracy levels indicate that both methods have similar prediction capabilities. It should be noted that this comparison should

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✉ Emre Artun
artun@metu.edu

¹ Petroleum and Natural Gas Engineering Program, Middle East Technical University, Northern Cyprus Campus, Mersin 10, Kalkanlı, 99738 Güzelyurt, Turkey

Table 4 Characteristics of data-driven and reduced-physics modeling approaches in various aspects

	Data-driven modeling (ANN)	Reduced-physics modeling (CRM)
Accuracy (based on the specific example presented in this study and a qualitative field-wide comparison)	80 %	70 %
Accuracy (based on the specific example presented in this study and a quantitative injector-based comparison)	Correlation coefficient = 0.84	Correlation coefficient = 0.86
Data requirements	Flexible	Fixed
Modeling approach	Flexible data-driven model	Physics-based, include assumptions
Training algorithm	Flexible	Flexible
Training speed	Fast	Fast
Expertise requirements	Moderate	Moderate
To develop the tool	ANN background needed	Reservoir eng. background needed
To train	ANN background needed	Optimization knowledge (for fine-tuning)

Table 5 List of connectivity values from the numerical, data-driven and reduced-physics models

Well pair			Connectivity (based on qualitative, field-wide comparison)			Connectivity (based on quantitative, injector-based comparison)		
No.	Injector	Producer	Numerical	Data-driven	Reduced-physics	Numerical	Data-driven	Reduced-physics
1	I1	P1	1.000	1.000	1.000	0.694	0.572	0.990
2	I2	P1	0.233	0.117	0.548	0.345	0.119	0.553
3	I3	P1	0.169	0.206	0.057	0.146	0.178	0.053
4	I4	P1	0.104	0.239	0.117	0.155	0.122	0.122
5	I5	P1	0.104	0.213	0.126	0.155	0.169	0.126
6	I1	P2	0.233	0.250	0.002	0.162	0.143	0.002
7	I2	P2	0.104	0.177	0.003	0.155	0.181	0.003
8	I3	P2	0.169	0.205	0.010	0.146	0.177	0.009
9	I4	P2	0.233	0.903	0.178	0.345	0.462	0.186
10	I5	P2	0.104	0.239	0.001	0.155	0.190	0.001
11	I1	P3	0.104	0.293	0.003	0.072	0.168	0.003
12	I2	P3	0.233	0.521	0.137	0.345	0.532	0.138
13	I3	P3	0.169	0.184	0.033	0.146	0.159	0.031
14	I4	P3	0.104	0.373	0.001	0.155	0.191	0.001
15	I5	P3	0.233	0.402	0.106	0.345	0.319	0.106
16	I1	P4	0.104	0.204	0.005	0.072	0.117	0.005
17	I2	P4	0.104	0.165	0.303	0.155	0.168	0.306
18	I3	P4	0.651	0.561	0.974	0.563	0.485	0.907
19	I4	P4	0.233	0.438	0.662	0.345	0.224	0.691
20	I5	P4	0.233	0.405	0.766	0.345	0.322	0.767

not be generalized since it is only performed using the results from the synthetic case presented. For a fair comparison of accuracy and prediction abilities, different cases

(especially real cases in more complex reservoirs and operational changes) should be considered as well.