

Objective and Background

Results: Validation and Prediction

Objective: We propose a method to detect fluid leakage by using only the well injection and production rates. Unlike pressure-based methods, the proposed method does not require detailed geologic and reservoir flow models to simulate the behavior that often carry significant sources of uncertainty. In addition to detecting the time and the amount of fluid leakage, this method provides an insight about the leak location, reservoir properties, and the fluid compressibility.

Novelties: We use our method to detect fluid leakage for two different scenarios, i.e. leakage to an above zone monitoring interval, and intra-reservoir leakage between two compartments. The two novelties of the proposed method are:

1. Requires only readily-available data (injection and production rates).
2. In addition to detecting the time, location, and the amount of fluid leakage, this method provides an insight about the reservoir geology and the fluid compressibility.

Method

Model Equation:

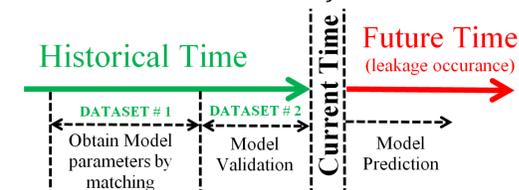
$$\tau_j \frac{dq_j}{dt} + q_j(t_k) = \sum_{i=1}^{n_{inj}} f_{ij} q_i(t_k) - c_t V_p \frac{dp_{wf}^{(j)}}{dt}$$

$$\begin{cases} \sum_{j=1}^{n_{prod}} f_{ij} \leq 1 \text{ for all } i \\ f_{ij}, \tau_j \geq 0 \text{ for all } j \end{cases}$$

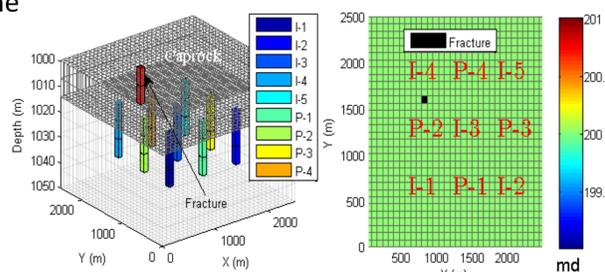
$$q_j(t_k) = \underbrace{q_j(t_{k-1}) e^{-\frac{\Delta t}{\tau_j}}}_{\text{initial rate decay}} + \underbrace{\left(1 - e^{-\frac{\Delta t}{\tau_j}}\right) \sum_{i=1}^{n_{inj}} f_{ij} q_i(t_k)}_{\text{injection contribution}} - \underbrace{\left(c_t V_p\right) \left\{ \frac{p_{wf}^{(j)}(t_k) - p_{wf}^{(j)}(t_{k-1})}{\Delta t} \right\} \left(1 - e^{-\frac{\Delta t}{\tau_j}}\right)}_{\text{BHP changes and well productivity}}$$

Validation and Prediction:

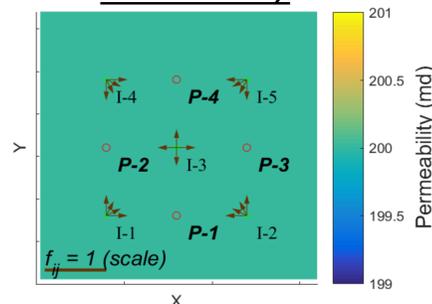
$$\min z = \sum_{k=1}^{n_t} \sum_{j=1}^{n_{prod}} [q_j^{obs}(t_k) - q_j^{model}(t_k)]^2$$



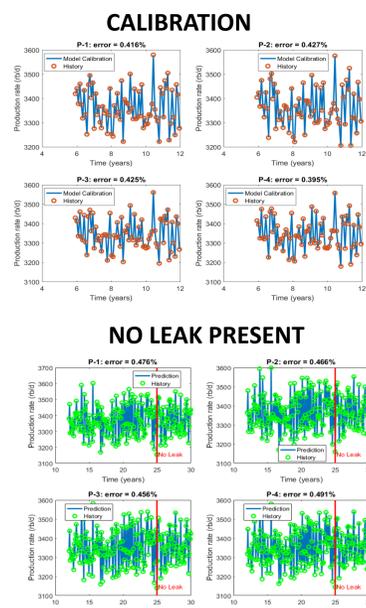
Five Spot Pattern



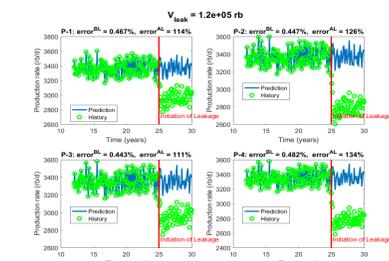
Connectivity



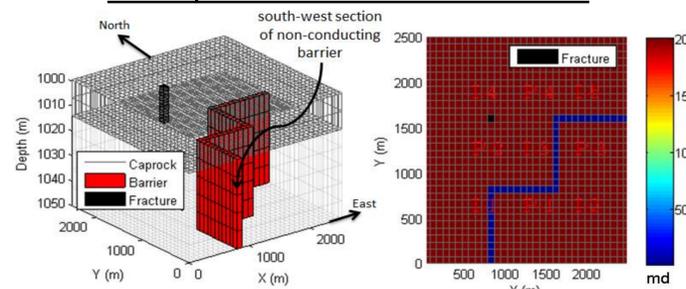
Detection of Leakage



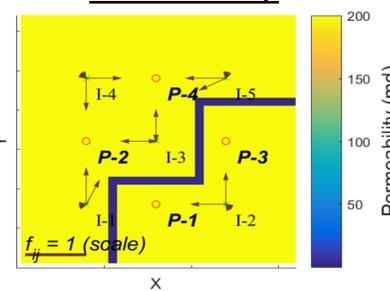
LEAK THROUGH CAPROCK



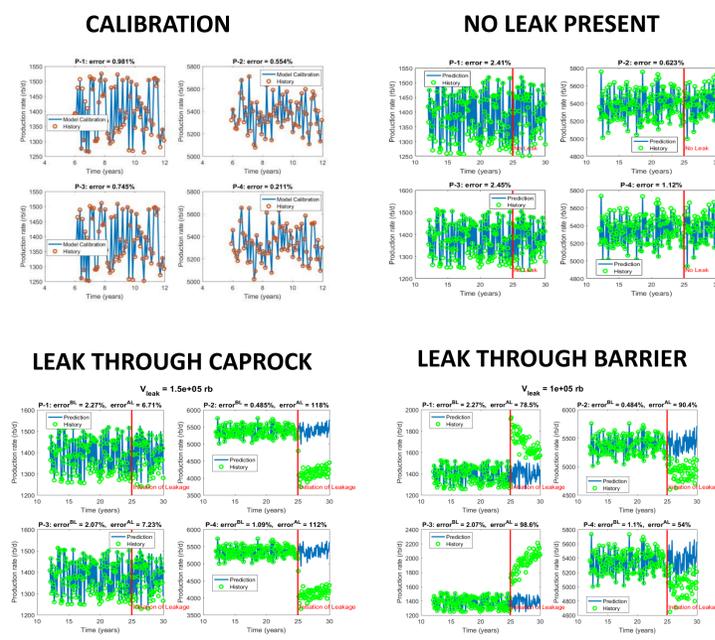
Five Spot Pattern with a Barrier



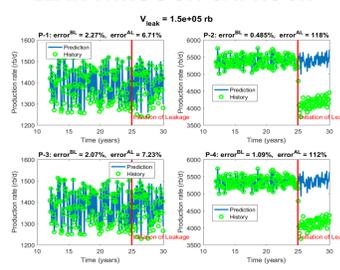
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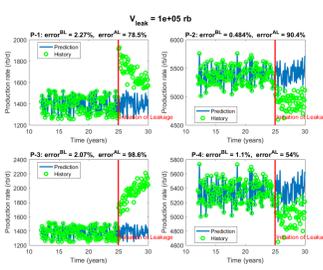
Detection of Leakage



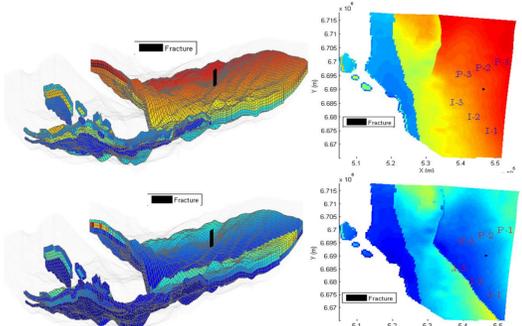
LEAK THROUGH CAPROCK



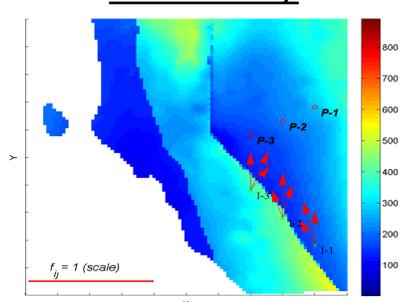
LEAK THROUGH BARRIER



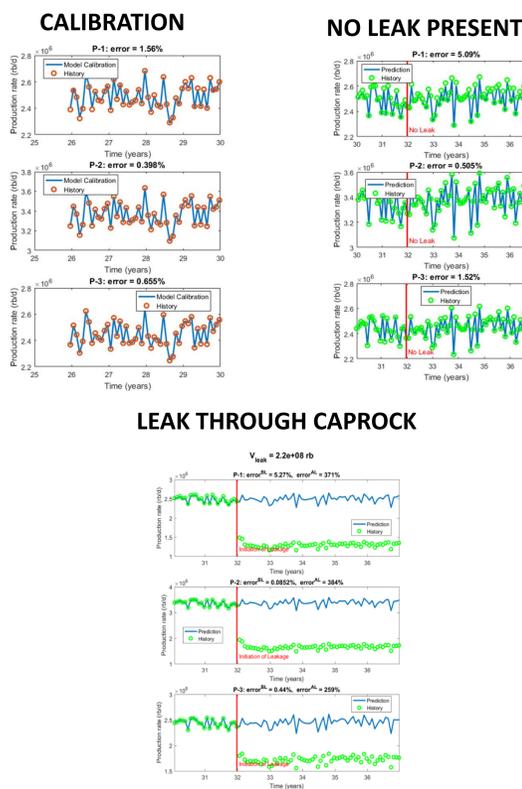
A Large and Complex Field



Connectivity



Detection of Leakage



LEAK THROUGH CAPROCK

