SUMMARY

History matching, which is an inverse problem, is traditionally performed by a trial and error approach to minimize the mismatch between observed and simulated data. Modification of parameters on sequential simulation usually leads to rock properties which are way far from geological interpretation. This renders the predictive power of the simulation model doubtful. In the presented approach, the adjoint method is used to capture the derivatives of the mismatch (sensitivities) with respect to each parameter at the grid level. Adjoint methods derive the analytical sensitivities based on prior knowledge of fluid flow equations implemented in a dynamic simulator. During the modification step, the sensitivity and rock property updates are iteratively calculated and implemented grid cell by grid cell until convergence is reached. The workflow is applied to history matching of an abandoned North German oilfield model with long production life. The outcome suggested that, with the use of this technique, improvements can be achieved beyond the scope of manual approach using a small number of simulation runs. Both the history match quality and the predictive capability of the dynamic simulation model are improved.
Assisted History Matching with Application of Adjoint Method Sensitivity Computation: Case Study North German Basin Oilfield

The role of computer assisted techniques in history matching (HM) and forecasting of the performance of petroleum reservoirs based on dynamic simulation models is continuously gaining importance. History matching, which is an inverse problem, is traditionally performed by a trial and error approach. The goal is usually to minimize the mismatch between observed and simulated data through modification of model parameters on sequential simulation runs. Expert knowledge is needed to intuitively address the complex nature of the non-linear relationship between the mismatch and the model parameters as well as the asymmetry of model parameters to measured data. Additionally, traditional HM approaches are highly controlled by practical constraints; model complexity, scalability, time, etc. For these reasons, it usually leads to modifications of rock property which are unrealistic and way far from geological interpretation. This renders the predictive power of the simulation model doubtful.

In the presented approach, the adjoint method is used to capture the derivatives of the mismatch (sensitivities) with respect to each parameter at the grid level. Adjoint methods derive the analytical sensitivities based on the knowledge of the constitutive fluid flow equations implemented within the reservoir dynamic simulator. During the modification step, the sensitivity and rock property updates are iteratively calculated and implemented grid cell by grid cell until convergence is reached. The workflow shown in the figure below involves:

1. Launching a simulation
2. Calculating the derivatives of mismatch for each grid block
3. Modifying rock properties based on computed sensitivities.

The goal is to assist the engineer to identify which parameters, and to what extent these parameters, affect the mismatch thence an intuitive parameter modification to improve the match quality.

The suggested approach is applied to history matching of an abandoned North German oilfield full-scale two-phase simulation model with more than 44 years of production history and 47 wells. The outcome suggested that, with the use of this technique, improvements can be achieved beyond the scope of manual approach using a small number of simulation runs. Both the history match quality and the predictive capability of the dynamic simulation model are improved.

![Workflow diagram](image-url)

Figure 1: Workflow coupling an Assisted History Matching process with the Adjoint gradient based optimization technique.
Figure 2: Reservoir model and field level match after 20 iteration loop.

Figure 3: Property array constrained modifications.