

# A Bayesian Optimisation Workflow for Field Development Planning Under Geological Uncertainty

R. Bordas<sup>1\*</sup>, J.R. Heritage<sup>1</sup>, M.A. Javed<sup>1</sup>, G. Peacock<sup>1</sup>, T. Taha<sup>1</sup>, P. Ward<sup>1</sup>, I. Vernon<sup>2</sup>, R.P. Hammersley<sup>1</sup>

<sup>1</sup> Emerson Exploration & Production Software; <sup>2</sup> Department of Mathematical Sciences, Durham University

## Summary

---

Field development planning using reservoir models is a key step in the field development process. Numerical optimisation of specific field development strategies is often used to aid planning. Bayesian Optimisation is a popular optimisation method that has previously been applied to this problem. However, reservoir models can have a high degree of geological uncertainty associated with them, even after history matching. It is important to be able to perform optimisation that accounts for this uncertainty. To date, limited attention has been given to Bayesian Optimisation of field development strategies under geological uncertainty.

Much of the recent work in this area has focused on Ensemble Optimisation methods. These naturally handle geological uncertainty using ensembles of geological realisations. This can result in a high computational cost, as large ensembles are required to capture the geological uncertainty. Bayesian Optimisation offers an alternative solution using probabilistic surrogate or proxy models that can capture the geological uncertainty. However, incorporating geological uncertainty into proxy models and using those models in a Bayesian Optimisation loop remains a challenging task. Further, the effect of the additional proxy model uncertainty on optimisation results has not been well studied.

We propose a Bayesian Optimisation workflow comprising a Stochastic Bayes Linear proxy model and a combination of experimental and sequential design techniques. The workflow is designed to include a combination of static and dynamic uncertainties, with a new geological realisation generated and used to simulate fluid flow during each run of the model. The workflow is demonstrated by optimising several field development strategies in a synthetic North Sea reservoir model. The ability of the workflow to locate optima and correctly account for the geological uncertainty is studied and the computational cost is quantified.

The performance and practical implications of the proposed approach are discussed. These are important in designing an accurate and computationally efficient optimisation workflow under geological uncertainty and, ultimately, are factors in developing decision support tools for field development.