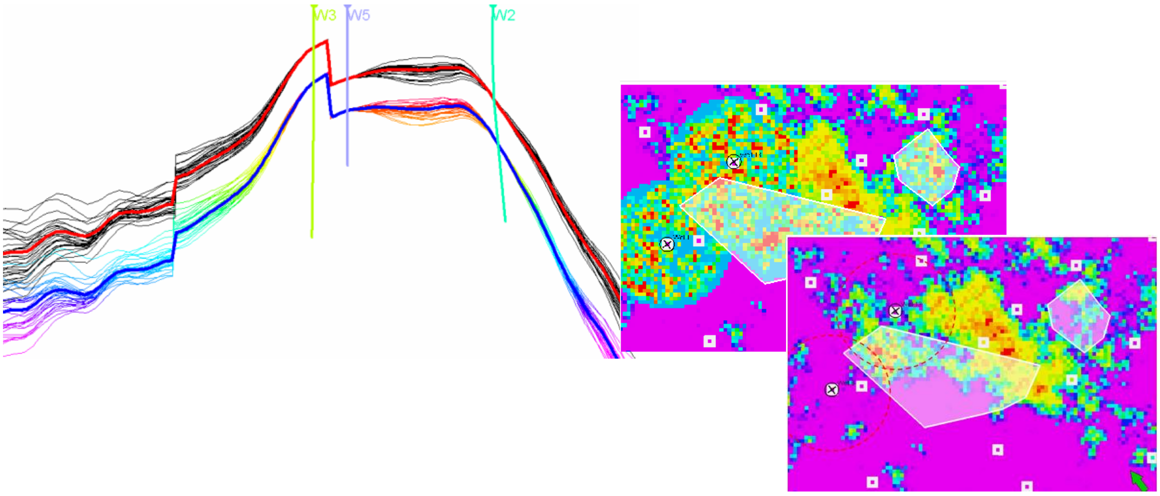


RESERVOIR MODEL VALIDATION

Clausthal University of Technology

Online Master Course SS 2020

Abstract

An increasing number of reservoir modeling projects consider subsurface uncertainties as a mandatory input to support decision processes and risk assessments in reservoir management.
The purpose of this course is to introduce subsurface uncertainty management from modelling to prediction in reservoir simulation workflows. Technologies and workflow designs are discussed with a focus on practical reservoir simulation projects.
Sessions will introduce the theoretical background of uncertainty modelling processes, data analytics, optimization techniques and practical implementations of workflow designs.
Session are supported by tutorials which introduce the practical implementation of uncertainty quantitation and optimization techniques.
An extra session is added to give participants the opportunity to get familiar with a public benchmark project for field development optimization under uncertainty.

Special Note

Due to the Corona pandemic 2020 this course will be held online following recommendations and guidelines from the Clausthal University of Technology. Major parts of the course content will be presented online during scheduled sessions which will allow a certain degree of interactions with attendees. Further details will be announced during the first lecture on Monday the 27th of April. An invitation to the first online session using the online platform BigBlueButton will be sent to all registered students via StudIP.

Lectures on Reservoir Model Validation

Introduction to Uncertainty Management, Data Analytics and Optimization Techniques

Lecturer

Dr Ralf. Schulze-Riegert

(Technology Expert Uncertainty&Optimization)

Date		
Location	**Institute of Petroleum Engineering,** **Clausthal University of Technology** **Agricolastr. 10**	
Dates	**Dates in 2020**	**Time**
	Monday 27th April	**13:00 – 17:00**
	Tuesday 28th April	**10:00 – 12:00** **13:00 – 15:00**
	Further lecture dates in May	
	Tuesdays 5th, 12th May	**13:00 – 15:00**
	Fridays 8th, 15th May	**10:00 – 12:00**
	Extra tutorial day	**date will be announced later**
Lecturer	**Dr. Ralf Schulze-Riegert, Schlumberger Norwegian Technology Center, Norway**	

Bibliographical note:

Ralf Schulze-Riegert works at the Schlumberger Norwegian Technology Center, with a focus on optimization and uncertainty quantification in reservoir simulation. He holds a PhD degree in theoretical physics from the University of Hanover, Germany and worked in consulting positions for the Oil & Gas and automotive industries for 25 years. Since 2005 he has been a part-time lecturer at the Clausthal University of Technology, Germany, delivering a course on “Reservoir model validation, uncertainty management and optimization under uncertainty”.

In Schlumberger, Ralf Schulze-Riegert works in a global consulting group and advices project and product development teams on implementing practical workflow designs in reservoir uncertainty management studies. With application to reservoir simulation, he regularly presents and authors research findings and case studies.

COURSE AGENDA

Introduction to uncertainty management in subsurface modelling and simulation workflows

While risk reduction defines a key value of uncertainty quantification projects, execution challenges exist on various levels for real reservoir simulation projects which need to be managed. Uncertainty quantification workflows deliver estimates on expected future outcomes. The verification process is based on a non-trivial relationship between belief and evidence. Transparency and reproducibility are therefore key prerequisites for creating trust and adding value in result presentation as an input to reservoir management decision processes. Sessions and tutorials develop the conceptual background and will support the understanding of these objectives.

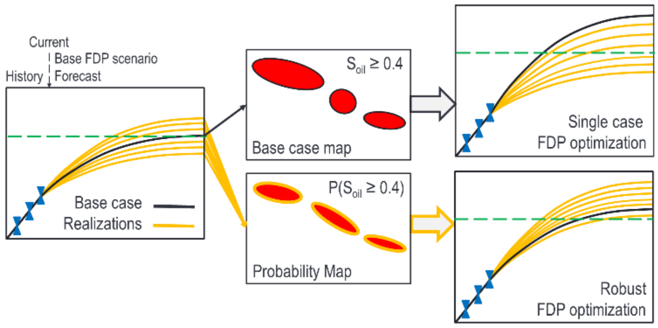
<table>
<tr><th colspan="2">Sessions</th><th>Session</th></tr>
<tr><td></td><td>Welcome and introduction / motivation</td><td></td></tr>
<tr><td>1</td><td>Introduction to technologies used in uncertainty quantification and risk management
A review on probabilistic principals: A Bayesian formulation
Data analytics, machine learning, experimental design, Monte Carlo simulation</td><td></td></tr>
<tr><td>2</td><td>Estimation of prediction uncertainty
Uncertainty Quantitation:
Overview subsurface uncertainties
Propagation of uncertainties
Workflow designs
Optimization techniques used in multiple-realization workflows
Optimization principles, parametrization concepts
Introduction to stochastic optimization techniques
Application and limitation</td><td></td></tr>
<tr><td>3</td><td>Reservoir Model Validation: History Matching
Introduction to History Matching
Implementation of optimization techniques – an overview
Systematic approach to history matching problems
Example: RFT/SFT History Matching
Estimation of prediction uncertainty incl. historical data
Introduction to Markov Chain Monte Carlo workflows in History matching
Analysis of multiple-realization data
Discussion</td><td></td></tr>
<tr><td>6</td><td>Field Development Optimization under Uncertainty
Basic concepts and application scenarios
Ensemble-based modelling for uncertainty assessment
Value of information
Efficient workflow design combining data analytics, machine learning, experimental design, sampling and optimization techniques</td><td></td></tr>
<tr><td>7</td><td>Tutorial and training
SCAL data analysis: Calibration of relative permeability curves
The Olympus Challenge: Field development optimization under uncertainty
Multiple-Realization workflows, objectives and design
Economical model coupled to simulation workflow
Discrete and continuous parameters in optimization workflows
Participation in this session requires the attendance in the full course</td><td>½ Day
To be announced later</td></tr>
</table>

FURTHER READING

Selected case examples which will be discussed during the lectures.

Uncertainty quantification of a brownfield oil-rim field development plan

The diagram shows a conceptual workflow design for FDP optimization under uncertainty. Results are compared to a single base case workflow scenario.

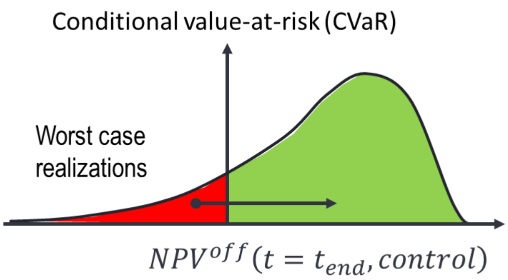


Multiple-realizations are history matched and meet historical production data (left). Multiple realizations (orange lines) are compared to a base case model (black line) for a field development scenario. At the beginning of the forecast period the area of remaining oil saturation higher than 40% is shown for the baseline FDP scenario (upper middle). A probability map visualizes areas with a probability finding oil saturation higher than 40% based on all available multiple realizations (lower middle). An optimized FDP based on a single case shows a broad distribution of outcomes (upper right). An optimized FDP based on multiple realizations (lower right) is more robust and is expected to show a narrow distribution of outcomes targeting an overall lower risk potential.

Reference:

Elharith M., Huey H.Y., Tewari R.D., Claire L., Fawzi N.S., Schulze Riegert R. (2019), Integrated modeling of a complex oil rim development scenario under subsurface uncertainty, Journal of Petroleum Exploration and Production Technology, doi.org/10.1007/s13202-019-0639-4

Field development optimization under uncertainty – Olympus challenge.



Abstract: This work describes a structured approach to the OLYMPUS field development optimization challenge. The focus of the exercise was to design practical, robust workflows that can be implemented by reservoir engineers using existing data analytics, experimental design and optimization techniques. Probability maps are applied to interpret reservoir characteristics across an ensemble of equiprobable realizations. A sequential schedule optimization approach is presented to handle a large number of control parameters with a decreasing impact on economic performance due to discounting effects over the production cycle of the reservoir. Data analytics methods and hierarchical clustering are used for interpretation of results. The structured approach provided a manageable solution for improvement of reservoir performance including optimization under uncertainty of well controls, field development plan and combined strategies.

References:

Schulze-Riegert, R., Nwakile, M., Skripkin, S., Whymark, M., Baffoe, J., Geissenhoener, D., Anton, A., Meulengracht, C.S., Ng, K.J., Standardized Workflow Design For Field Development Plan Optimization Under Uncertainty, Comput Geosci (2019). doi.org/10.1007/s10596-019-09905-9

Fonseca, R.M., Della Rossa, E., Emerick, A.A., Hanea, R.G., Jansen, J.D.: Overview of the OLYMPUS Field Development Optimization Challenge. ECMOR XVI - 16th European Conference on the Mathematics of Oil Recovery. EAGE. (2018). doi.org/10.3997/2214-4609.201802246