Modeling and Managing Uncertainty & Risk in the Subsurface

Instructor: Jef Caers, Stanford University

Overview: In this 3-day short course, we cover a modern approach to managing and modeling uncertainty in subsurface formations within a decision making framework. The course uses a practical case study of a real field off the West Africa Coast to guide participants through the modeling workflow from geological interpretation to history matching and forecasting. We outline an uncertainty quantification workflow that focuses on several elements: 1) decision-driven sensitivity analysis to determine key reservoir variables, 2) geological scenario development to avoid reducing uncertainty artificially a-priori and during history matching, 3) integration of geological scenarios and geostatistical modeling with production data 4) avoiding over-constraining to seismic data. Issues of computational challenges are addressed through model validation and model selection.

What you will learn

Practical workflows and software for modeling uncertainty, integration geological, geophysical and production data to produce reservoir performance forecasts.

Summary Outline

- What is uncertainty?
- Managing uncertainty in the Oil & Gas industry
- What are sources of uncertainty?
- Ways of reasoning about uncertainty
- Decision making under uncertainty
- Representing uncertainty in metric space
- Decision-focused sensitivity analysis for reservoir forecasting
- Validating uncertainty models with reservoir log, seismic and production data
- Model selection and model complexity: addressing the computational challenge
- Uncertainty reduction with seismic and production data

Who should attend?

Reservoir geologist, geophysicist and engineers who are involved in a multi-disciplinary asset team building uncertainty models for reservoir appraisal and production planning.

Outline of Lectures

01. Introduction and overview

    Course attendees' introduction

    Course overview, motivation

    Introduction to case studies done WCA, WH, Danish

    Formulation of risk & uncertainty management problems at Petrobras

02. Making a first decision

    Decision game

03. Reasoning about uncertainty

    Philosophical overview

    Probabilistic reasoning (includes review on probability & Bayes' rule)

04. Decision making under uncertainty

    What is decision making?

    How to make formal decision?

    Decision trees

    Efficient frontier

05. Sources of uncertainty in the subsurface

    Nature of subsurface uncertainty

    Geological: structural and depositional

    Geophysical: data uncertainty, inversion uncertainty, calibration uncertainty

    Reservoir Engineering: fluid flow uncertainty, driving mechanism

    Reservoir modeling: multiple realizations

    Various stages in reservoir life: various ways of addressing uncertainty (from simple Monte Carlo, to complex modeling)

06. Visualizing uncertainty

    Concept of distance

Dimension reduction methods, PCA, FDA, MDS

07. Sensitivity analysis

Overview of methods: global/local, one-way/multi-way

Distance based generalized sensitivity

08. Modeling response uncertainty: ED/RSM

Application areas of Experimental Design

Sensitivity analysis with ED

Case study

09. Modeling response uncertainty: Distance Kernel Method

Methodology

Application areas of DKM

10. Structural uncertainty

Sources of structural uncertainty

Depositional vs physical domain

Handling uncertainty on fault transmissibility

11. Petroleum Geostatistics, Part I

Modeling geological continuity: variogram, Boolean, TI

SGEMS exercises

12. Petroleum Geostatistics, Part II

Estimation and stochastic simulation

Modeling with seismic data, various approaches

Pitfalls of uncertainty reduction with seismic data

13. Uncertainty in history matching (150 min)

History matching: how much is it needed?

Examples where a better match leads to a worse forecast

Dveloping an uncertainty focused HM strategy

Field-scale vs well-scale HM

Pitfalls of uncertainty reduction in HM

Scenario-screening with history data

Stochastic search by NA

14. Value of information

What is VOI?

Decision making and VOI

Fast calculation of VOI and sensitivity analysis

15. Summary: workflows for modeling & managing uncertainty

Discussion on various workflows & uncertainty management problems at Petrobras