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
Developing 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