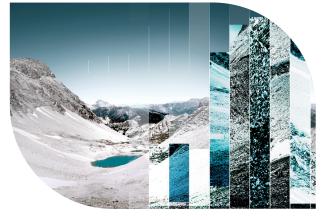# TECHNICAL SPECIFICATIONS

CougarFlow®
Uncertainty Analysis
for Basin Modeling & Forward Stratigraphic Modeling

Software Presentation

Through a multiple realizations approach based on experimental design and state of the art optimization algorithms, CougarFlow® aims at reducing the number of simulation runs to properly explore the possible solutions of a model. CougarFlow® is seamlessly linked to DionisosFlow® and TemisFlow™ on the OpenFlow Suite platform to allow:

- **A thorough screening of uncertainties** on a given range of input parameters and their influence on key simulation outputs;
- **Uncertainty analysis** for quantifying parameters impact and associated optimization.
- **Assisted calibration** through a gradient-based optimization algorithm.

Functionalities and Algorithms

UNCERTAIN PARAMETERS

- Scalars such as diffusion coefficients, thermal conductivities...
- Curves such as sea level curve, permeability/porosity curve...
- Continuous maps such as bathymetry maps, initial TOC maps...
- Discrete maps such as facies maps and kerogen maps
- Possibility to group parameters with metaparameter option

EXPERIMENTAL DESIGN

- From the simplest to the more complex: Classical, Full, User defined, Latin Hypercube, and D-Optimal designs for uncertain domain sampling
- Addition of confirmation runs

TYPES OF RESPONSES

- Scalars: value within one cell or for a group of cells
- Pseudo-well: along tentative well path or vertical sedimentary column
- Maps: for a given unit or as an upscaling a several units
- Objective functions: error between observed data and simulated data

RESPONSE SURFACE APPROACH

- Algorithms to compute Parametric (Least Angle Regression Square) and Non-Parametric Response Surface Models (Kriging)
- QC tools to analyze and validate the Predictivity of Response Surface Model: Spider and Tornado plots, Cross plot and Quality Indicators such as Predictivity Q2 and Predictivity with confirmation runs Q2 conf (blind tests)

GLOBAL SENSITIVITY ANALYSIS

- Qualitative and quantitative sensitivity analysis to determine the most influential parameters
- Automatic calculation of interactions between parameters

RISK QUANTIFICATION

- Uncertainty propagation to determine the range of potential values for a response (P10, P50, P90)
- Controllable uncertainty optimization to find a minimum on the surface response for an aid to calibration

MULTI GEOLOGICAL SCENARIO ANALYSIS

- Possibility to combine multiple independent scenarios within a single CougarFlow analysis
- Possibility to give weights to each scenario
- Combined percentile maps and probability of success maps as results

ASSISTED CALIBRATION

- Objective-function based optimizations:
  - User defined weight definition
  - Global analysis or separated analysis (by well or property)
- Gradient-based methods: Optim (Cougar's historical method) and SQPAL (to avoid non-physical fluid flow models)

EXTRAS

- Seamless link with DionisosFlow® and TemisFlow™
- Link with third-party geo-modelers: Petrel

Results Analysis

- Many viewers are available: histograms, cross-plots, graphs, logs, maps, cross-sections, 3D inherited histograms OpenFlow™ platform
- Filters and graphic settings
- Specific plots for uncertainty analysis: cross-plots, tornado plot, spider plot, Pareto plot
- Dedicated and guided editor for map analysis

Data Management

DATA IMPORT/EXPORT

The following formats are available:

- Templates, preferences and color scales from OpenFlow™
- Groovy scripts & packages
- Data exchange between OpenFlow Suite projects

DATABASE

- MySQL or Oracle database
- Improved data security and integrity, reduced data storage
- User and project administration

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OTHER FACILITIES

- Unit system management
- Workflow manager: create, delete, configure, start, stop, load, restart, monitor a workflow...; manual and automatic launch/stop/restart/load
- Help through an online reference manual and contextual information
- Search tool
- Perspectives for display
- Workflow tree
- Host & Activity settings

Extensions and Customization

- Direct link to transfer data between Petrel and OpenFlow™ using an Ocean plugin
- Scripting facility based upon Groovy language

System Requirements

- **Operating Systems**:
    - Supported on Windows 10, Compatible with Windows 11
    - Linux Red Hat 7 and Red Hat 8 for calculators only (unavailable GUI)
- **RAM**: 48 Gb or more recommended, 32Gb minimum
- **Minimum free disk space**: 5 Gb (for installation files)
- **CPU**: x86-64 processors (Opteron, CoreDuo, Core2Duo, Xeon & EMT64, Nehalem, Westmere, Sandy Bridge, Core i3, i5, i7)
- **Dualcore or Quadcore**: 2 GHz or more recommended
- **Graphics board**: NVIDIA (except Quadro FX 1000, Quadro FX 3500, Quadro NVS 110 M, Quadro NVS 280 SD, and NVS 300) with recent driver (at least OpenGL 3.3 -driver 330 or later)
- Openmotif rpm package must be installed on Linux
- **Database**: MySQL 5.5, 5.6.X (with X superior to 22), 5.7 or 8.0 and Oracle 12c, 18c or 19c
- FlexLM 11.16.2 server for licensing

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