



EVEREST optimization framework and link to OPM Flow

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Typical decisions in subsurface management

Geological uncertainties:
is the reservoir how we think it is?

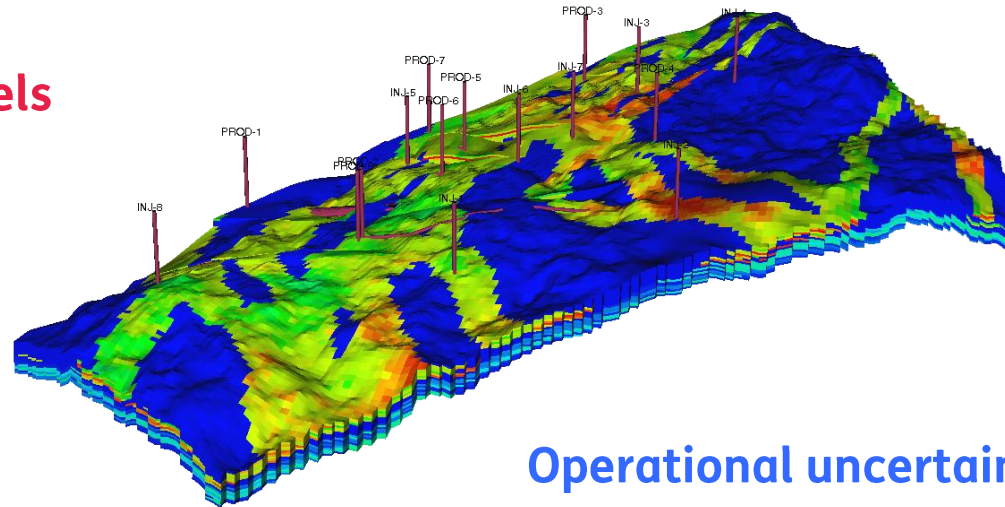
Constraints

Economic uncertainties:

what will be the oil / CO₂ / heat price in the next 30 years?

Slow models

Too many options



Safety

CO₂ footprint

Sparse information

Measurement uncertainties:
how reliable is the acquired data?

Operational uncertainties:

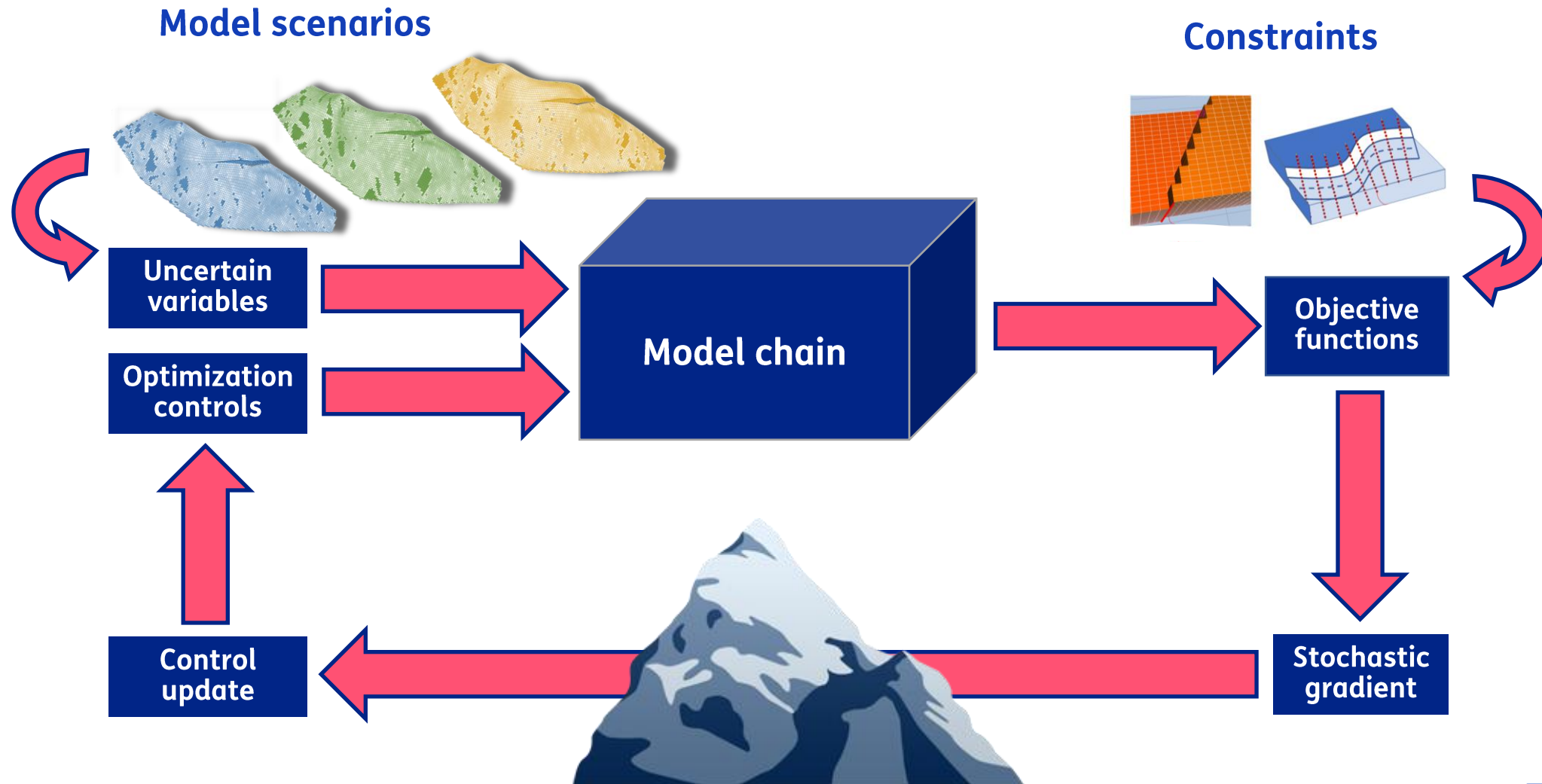
can the development strategy be executed as planned?

Multi-objective

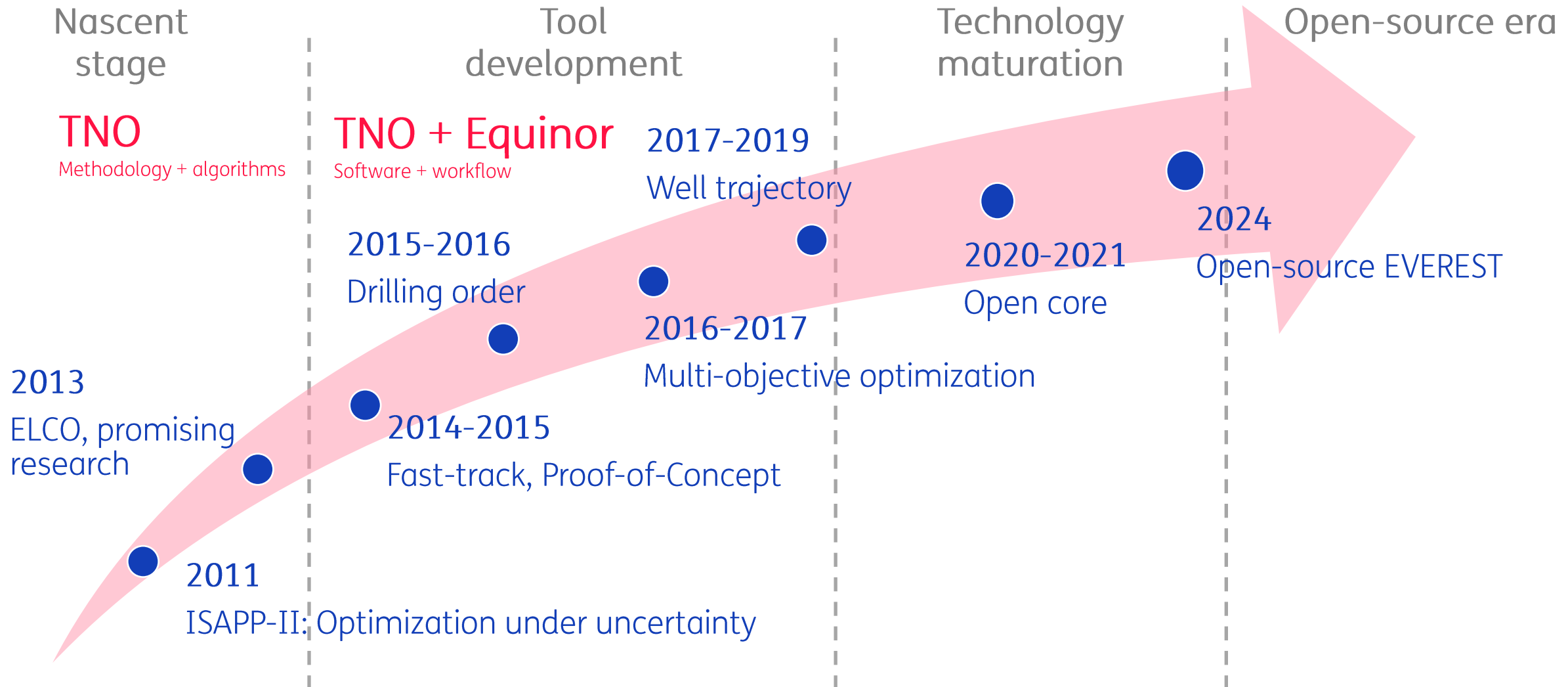
- How many wells?
- Well trajectory: where to drill wells?
- Well type: production or injection

- In which order to drill the wells?
- How to control the flow in the wells?
- Which additional data to acquire?

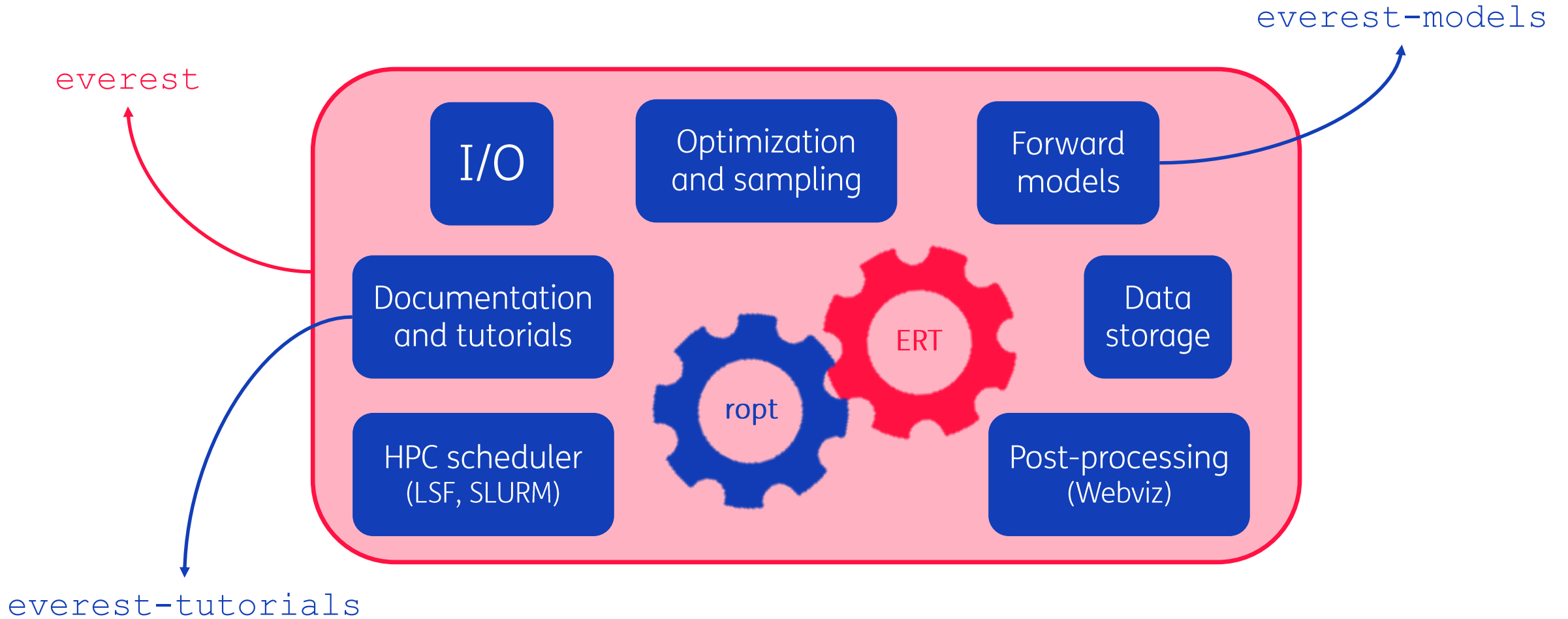
EVEREST™: optimization framework



Over a decade of R&D collaboration



EVEREST software components



Forward models for reservoir problems

everest-models

- Well selection optimization

- Drilling order optimization

- Well swapping optimization

- Well rate optimization



- Well trajectory optimization

+ commercial simulators



- Running reservoir simulators

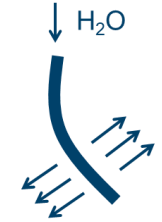
- Post-processing simulation results

EVEREST: recent applications



- Multi-objective optimization of **development strategy** in the large offshore Mariner field (Equinor)

- Optimization of **injection strategy** of offshore field in Brazil under geological uncertainties (Petrobras)



- Optimization of **design of hydraulic fracture stimulation** in offshore tight gas reservoir (Wintershall DEA)

- Optimization of infill **well target location** in multi-reservoir carbonate field (ADNOC)

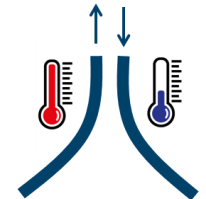


- **Well swapping** optimization in offshore oil field in Brazil (Equinor)

- Optimization of **CO₂ injection strategy** to maximize safe CO₂ storage capacity accounting for fault stability constraints



- Optimization of **geothermal field development strategy** under geomechanical constraints



- Optimization of **offshore wind farm layout** (Equinor)


- Optimization of **solar park design** for dual land use (power generation vs. agriculture)

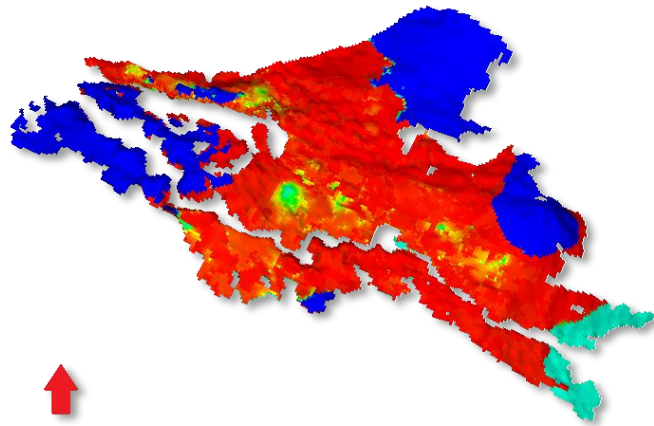


- **Well concept selection for geothermal** sites through optimization of sub-vertical, sub-horizontal and multi-lateral wells

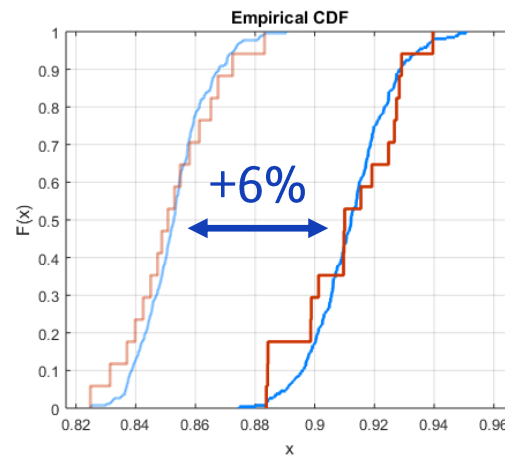


EVEREST: optimization of water injection rate

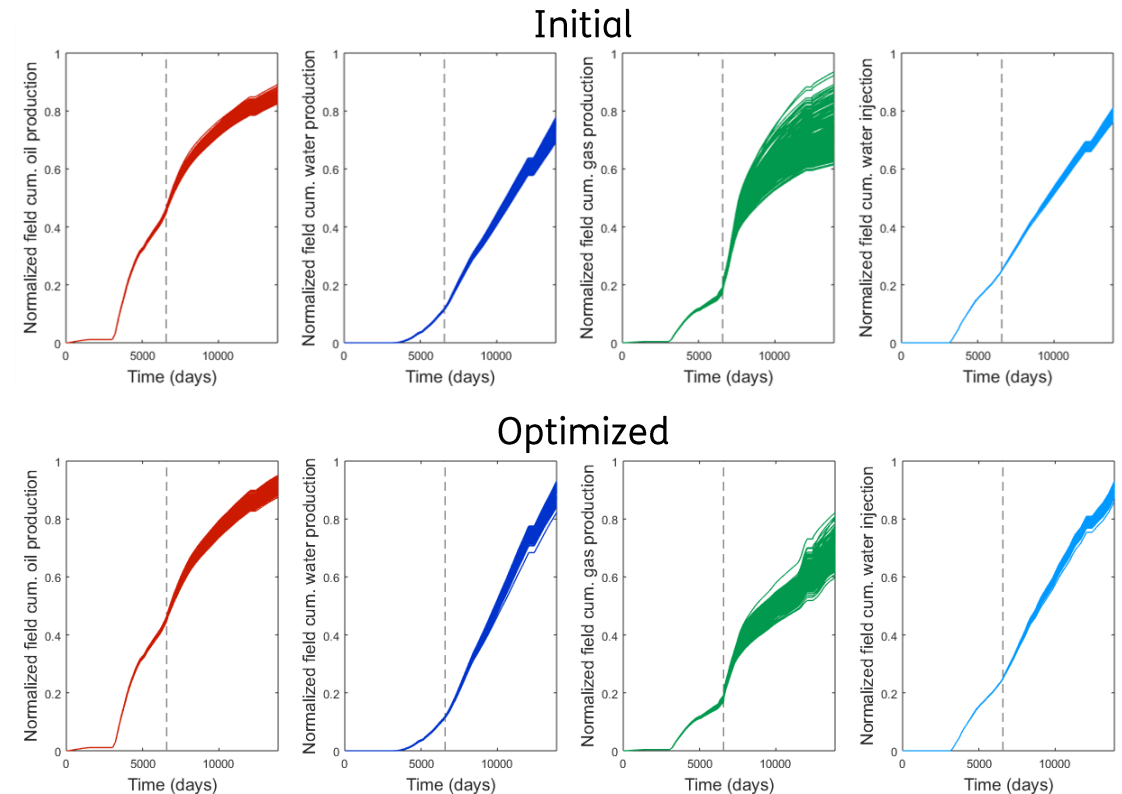
- Brown-field: optimize yearly water injection target rates over 20 years of production lifetime
- 19 production wells and 13 water injection wells, an ensemble of $N = 278$ models conditioned to the 20-year production history data
- Select a representative subset of 17 model realizations to be used throughout the optimization
- Black-oil model simulated with  OPM OPEN POROUS MEDIA



PETROBRAS

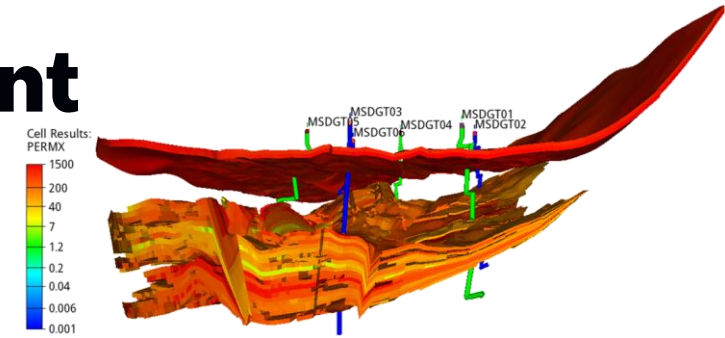


+6% oil production



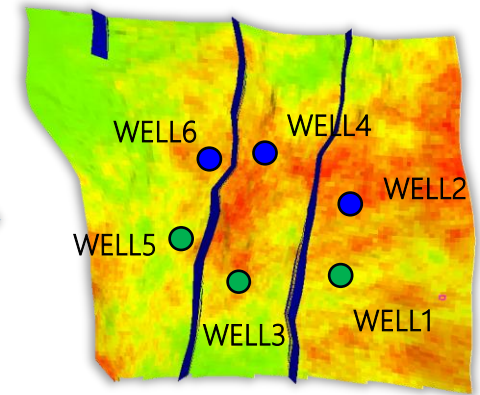
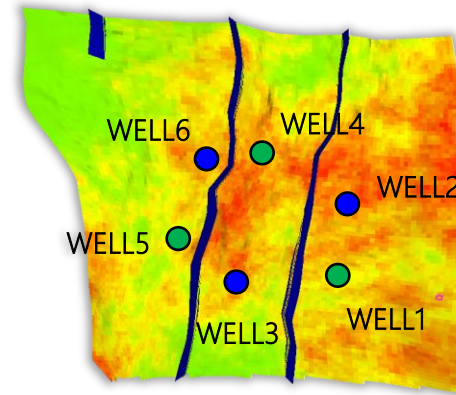
EVEREST: geothermal field development

- Case study in the Netherlands:
 - Stacked reservoir formations: optimize well type (injector or producer) and split of well production influx between formations
 - Ensemble of 40 geological realizations (uncertainty on permeability field and faults)
 - Constrained optimization: maximize NPV while honoring pressure / stress constraints at fault locations

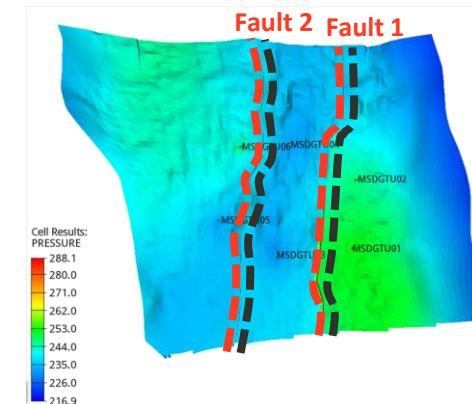
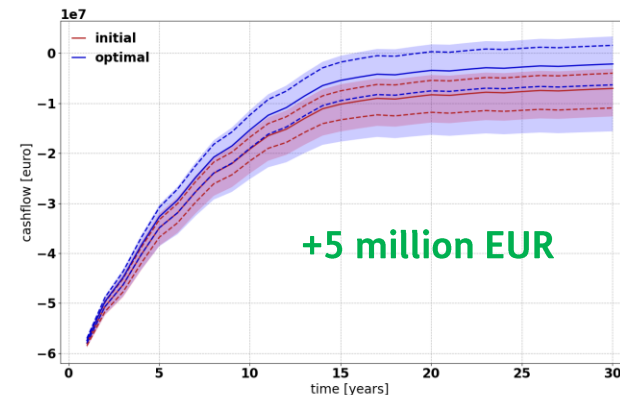
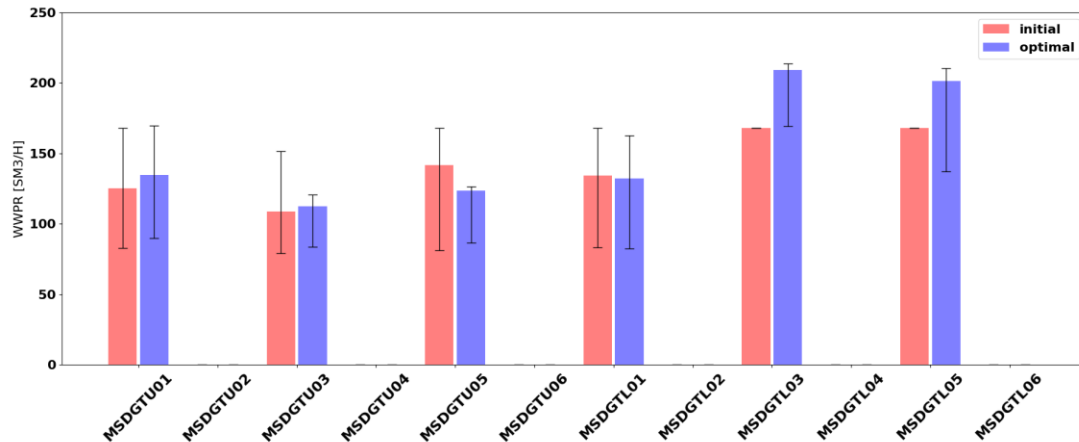


Initial well types

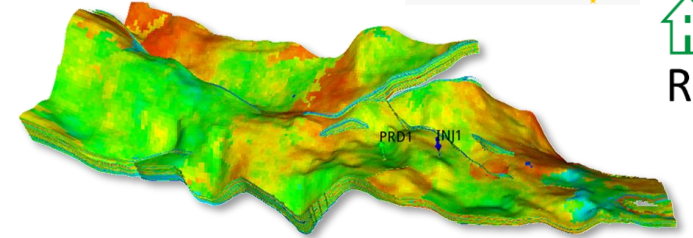
Optimal well types



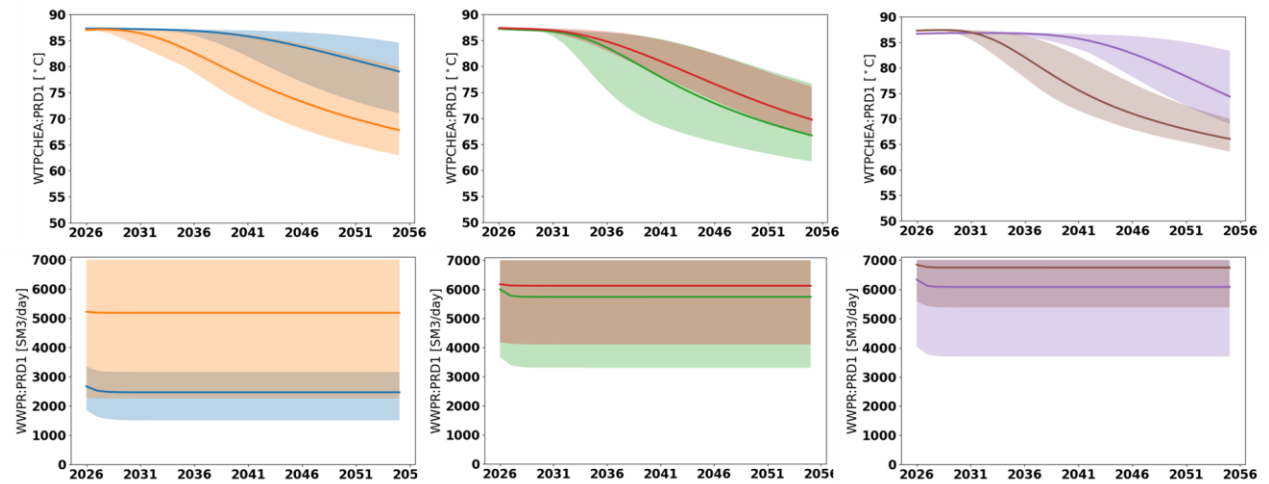
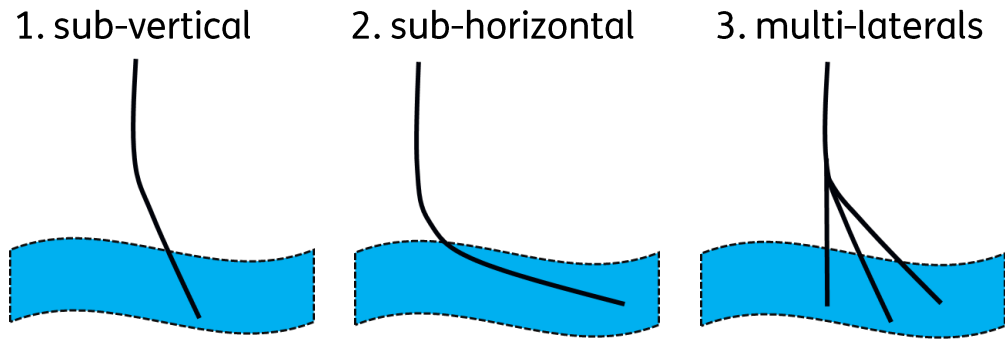
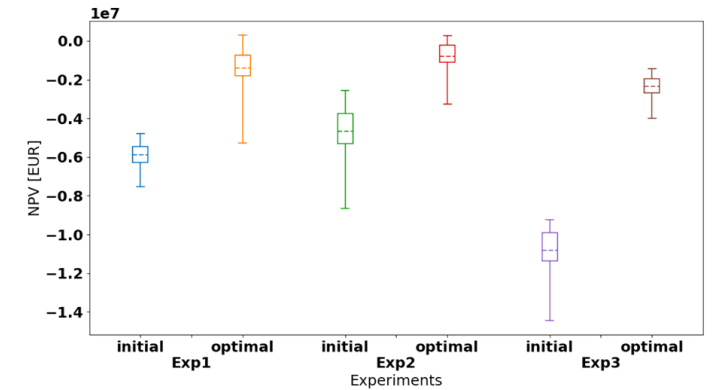
Optimal rates: higher production rate targets in lower formation



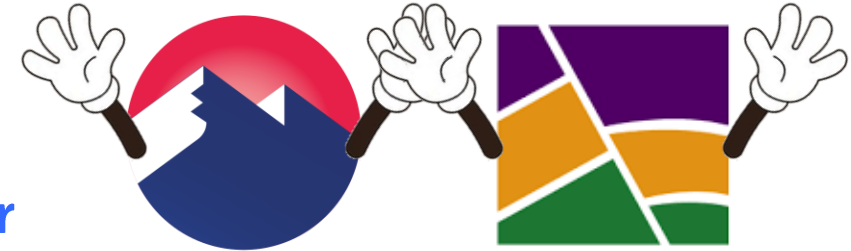
EVEREST: well concept selection



- Zwolle case study in the Netherlands:
 - Ensemble of 100 spatially heterogeneous realizations of target reservoir at Rotliegend formation (~2,400 m deep)
 - ~950,000 active cells (219 × 101 × 169 grid cells) covering ~45 km² with thickness ranging from 50-80 m
- Well trajectory optimization allows for simultaneous optimization of well locations and shapes
- 3 optimization experiments with different initial assumptions regarding shape of wells, namely:



EVEREST and OPM Flow



- **EVEREST is already fully compatible with OPM Flow simulator**
 - Handles OPM Flow input / output formats
 - Tutorial examples and several real-life case studies performed with OPM Flow
- **OPM Flow is an enabler for EVEREST**
 - Ensemble-based optimization requires running several batches of multiple reservoir simulations
 - No commercial licenses required → As many simulations in parallel as hardware resources (HPC cluster)
 - EVEREST and OPM Flow is a winning combination: cheaper and faster optimization studies
- **Cross-fertilization for further development**
 - Optimization needs lead to modern features in OPM Flow (e.g., grid-independent wells)
 - New options in OPM allow for new engineering optimization challenges to be tackled (e.g., network control)
 - Optimization under uncertainty helps stress-test OPM Flow: many / extreme input configurations are run

- **And of course...**

- OPM inspires EVEREST. Hopefully, one day:
 - A broad and vibrant EVEREST open-source community!
 - An annual EVEREST summit!



Thank you! Questions?



transforming uncertainty into opportunity

<https://www.everest.tools/>

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