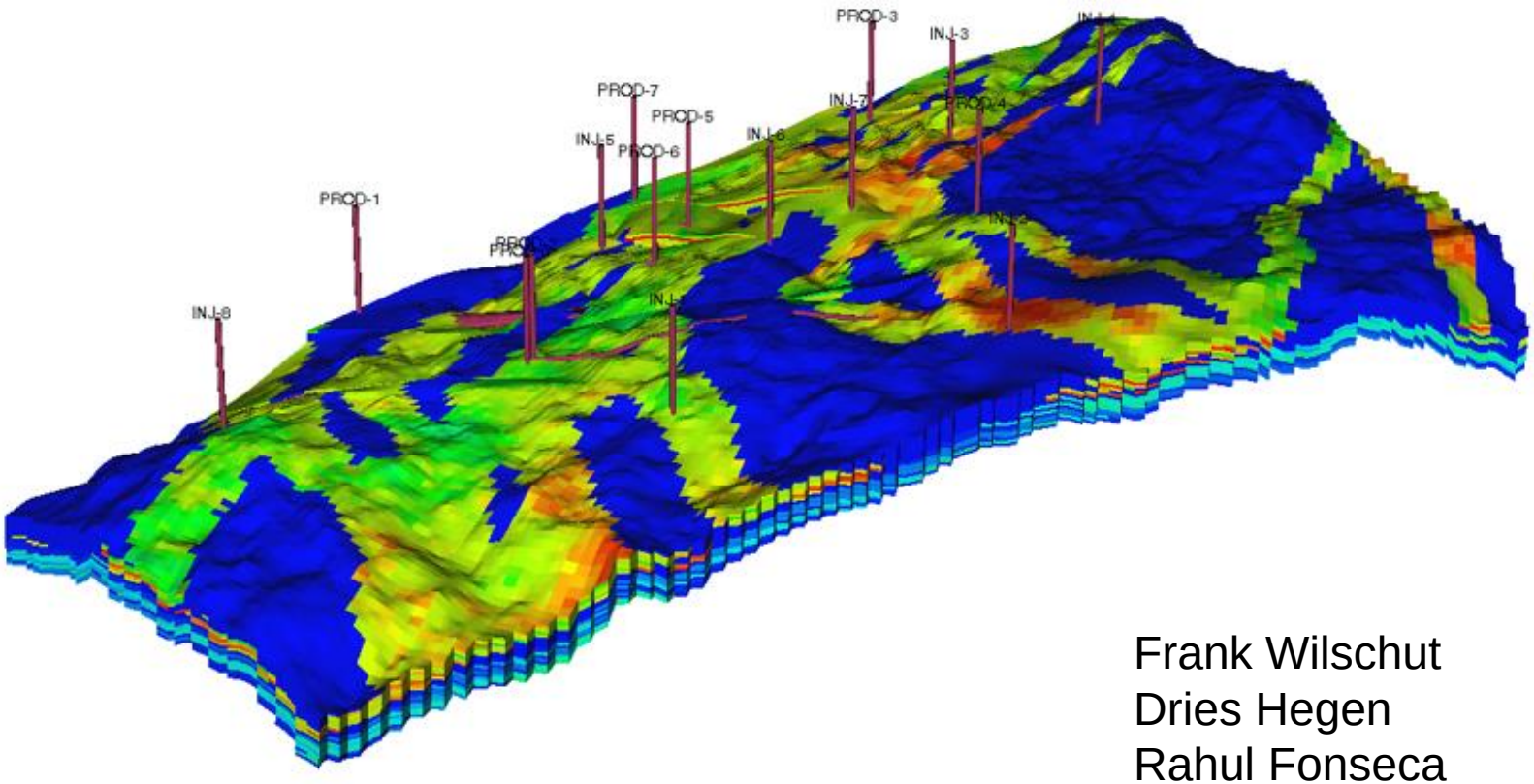
OLYMPUS FIELD DEVELOPMENT OPTIMIZATION CHALLENGE



Frank Wilschut
Dries Hegen
Rahul Fonseca

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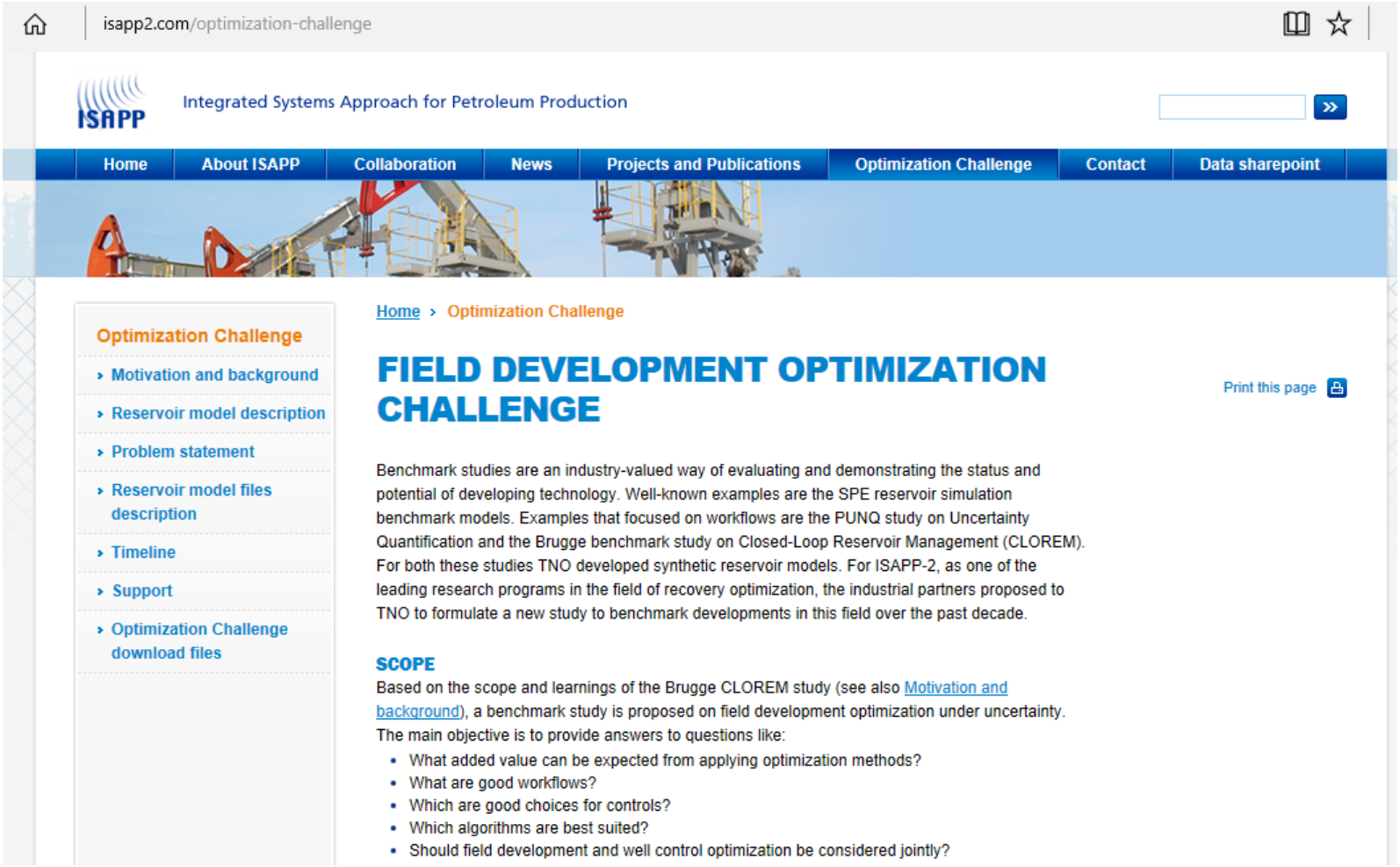
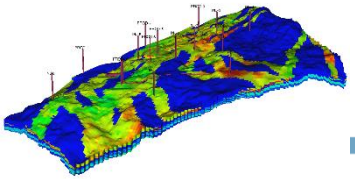


dries.hegen@tno.nl rahul.fonseca@tno.nl frank.wilschut@tno.nl

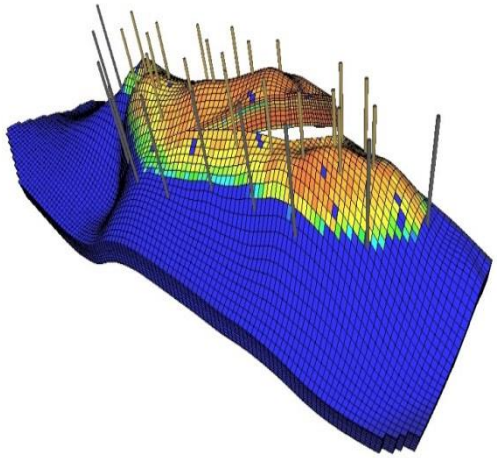


TIMELINE

- August/September 2017: Call for Abstracts for OLYMPUS workshop will be opened
- Q1 2018 (exact date to be announced): Abstract deadline workshop
- April 2018: OLYMPUS workshop committee selects workshop program and authors will be informed.
- June 2018: All accepted authors will now have to submit the results obtained for the OLYMPUS challenge
- August 2018: Deadline for paper submission to Computational Geosciences Special Issue
- September 7, 2018: OLYMPUS workshop after ECMOR, Barcelona.

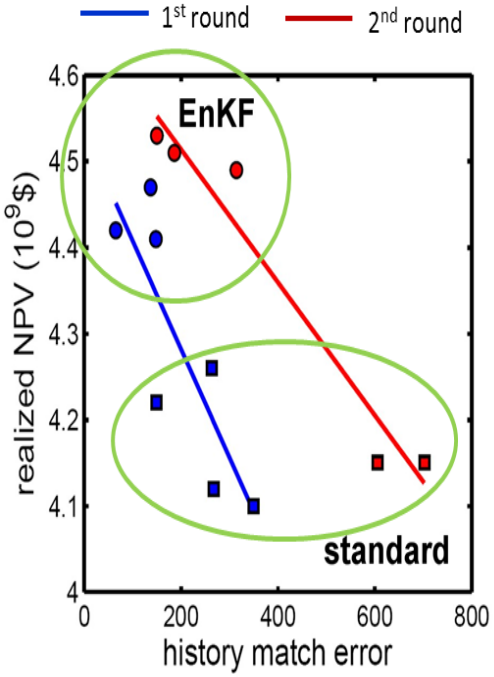
2008 SPE CLOSED-LOOP BENCHMARK

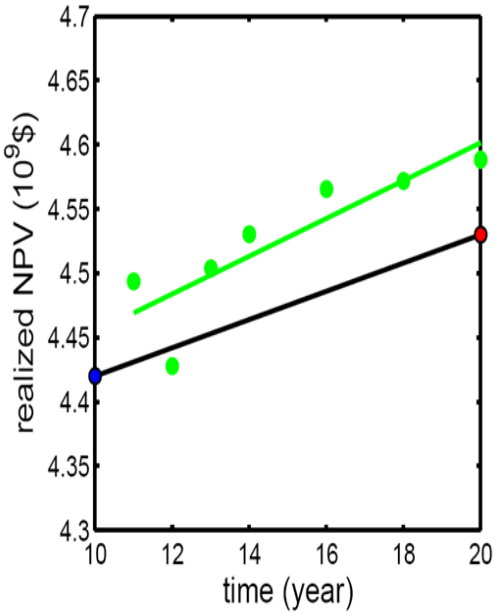
- Competitive SPE benchmark study (Brugge)
- Comparing different history matching and optimization workflows
- TNO built and managed the ‘true’ reservoir
- Steps taken by participants:
  - Do a history match based on 10 years of measurements
  - Provide a recovery strategy for the next 20 years
  - Repeat these steps at year 20.



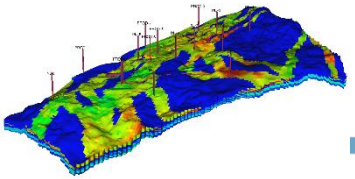
CLOSED LOOP BENCHMARK LEARNINGS

- A good history match increases the probability of increasing ultimate value from the field
- Fully accounting for uncertainty (through ensemble methods) increases value
- Increasing the frequency of updating models and strategies increases value





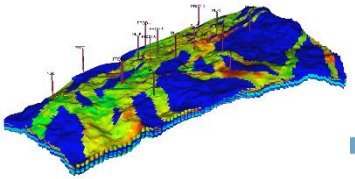
Participant with lowest HM Error and highest NPV : U. Oklahoma, using EnKF and EnOpt



OBJECTIVES FOR OLYMPUS CHALLENGE

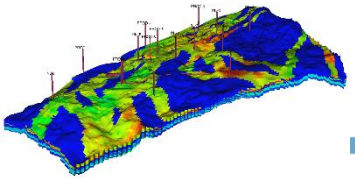
- Aimed at Field Development (FD) Optimization under uncertainty
  - So, no history matching involved

- Questions we aim to address in this challenge are:
  - What added value can be expected from applying optimization methods?
  - What are good workflows?
  - Which are good choices of controls?
  - Which algorithms are best suited?
  - Should FD and well control optimization be considered jointly?



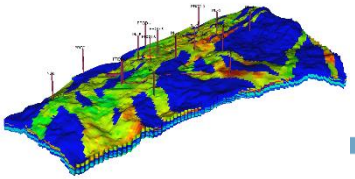
OPTIMIZATION CHALLENGES

- Some controls (wells, drilling order) may naturally appear as integer or binary variables
- Number of wells may not be constant throughout an optimization process
- Non-smoothness of objective function (e.g. due to drilling costs and drilling order)
- Evaluation of different well trajectories: frequent re-computation of well-reservoir connectivity.
- Joint well placement and control optimization is a mixed-control problem
- Time-dependent nonlinear input and/or output constraints
- High level of uncertainty involved during the early FD stage



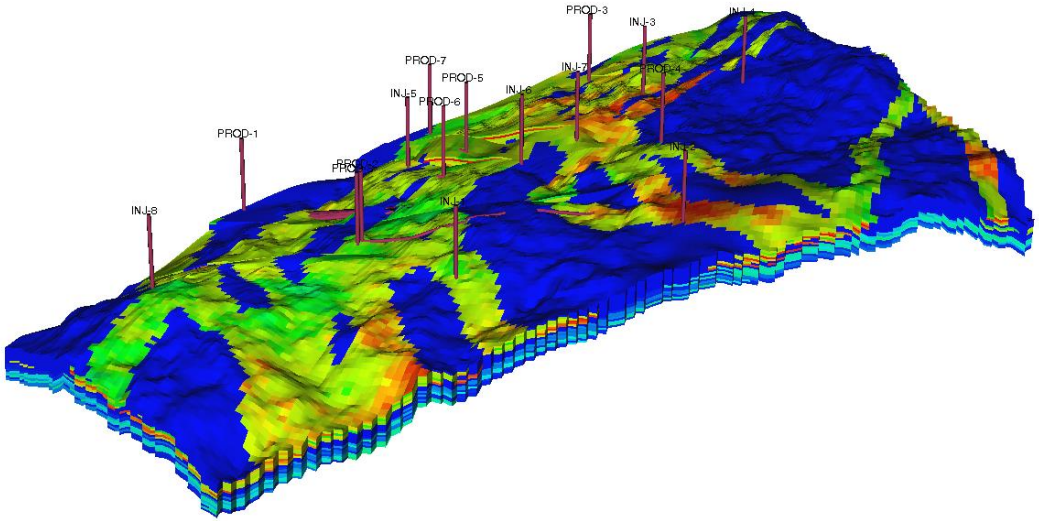
OLYMPUS MODEL CHARACTERISTICS

- Faulting
  - Makes regular well patterns suboptimal
  - Modest fault throws, allowing contact between different reservoir zones across the fault
- Vertical barrier
  - Different placement and operating strategies required for top and bottom reservoirs
- Channels
  - Risk of fast water breakthrough
  - Connect multiple sand with single well
  - Different channel densities
- Lateral coarsening
  - A lateral trend with a reverse trend in NTG (uniform STOIIP) -> requires different well density; modeled as a series of clinoforms

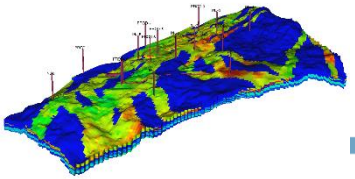


OLYMPUS MODEL CHARACTERISTICS

- An ensemble of 50 geological model realizations available to anyone considering participation
  - Many requests for input files received so far

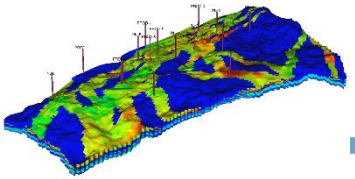


- Reference well placement strategy provided for the well control optimization exercise.
  - Uses 11 production wells and 7 injection wells to operate the reservoir model.
  - This strategy was developed using traditional reservoir engineering techniques based on a single model chosen from the ensemble of model realizations



OLYMPUS MODEL CHARACTERISTICS

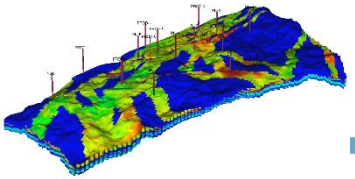
- 9 km x 3 km x 50 m (cells 50 m x 50 m x 3 m)
- ~200,000 active cells, grid is not regular
- Run time 10-15 minutes (ECLIPSE, 20 years)
- Only oil and water in the reservoir
- Decks available for ECLIPSE, IMEX, OPM-FLOW, AD-GPRS and INTERSECT



OLYMPUS CHALLENGE DEFINITION

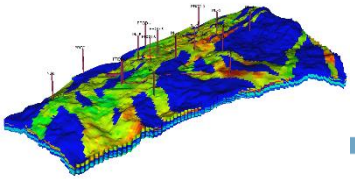
Three optimization exercises (a single economic model applies to all of them):

1. Well Control Optimization
   - Fixed inj-prod wells configuration, rates and BHP as controls
2. Field Development Optimization
   - Produce a field development plan including drilling/completion schedule, optimize well trajectory but use a reactive control strategy
3. Joint Optimization of Well Placement and Control
   - Combine challenge #1 and #2.



FINAL WORKSHOP

- September 7, 2018: Olympus workshop, very likely to take place in Barcelona, in conjunction with ECMOR 2018 (ECMOR finishes Sept 6).
  - Presentation and discussion on results obtained
  - Participants for this workshop will have the opportunity to report their results in Computational Geosciences Special Issue

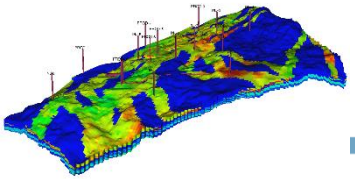


ACKNOWLEDGEMENTS

- Support from ISAPP-2 consortium partners ENI, Statoil, Petrobras along with support from Delft University of Technology

- All contributions and advice from Kees Geel (TNO) during the building of the ensemble of OLYMPUS models.

- Feedback from
  - all foreseen participants who registered for the OLYMPUS challenge
  - participants at the TNO Optimization Workshop held on 2nd September 2016 in Utrecht, The Netherlands



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SUPPORT

The ISAPP Field Development optimization benchmark challenge has been developed by TNO on request out of the ISAPP-2 program. TNO will provide support to participants where possible and facilitate follow-up such as:

- Provide clarifications on issues with the published benchmark challenge
- Potentially incorporate suggested improvements
- Publish any clarifications and changes via FAQ on this website (found below) and to all registered participants by e-mail
- Organization of a workshop
- Discuss option on publication in connection to the benchmark challenge in a special journal issue

It should be also clear that that support and facilitation of follow-up excludes several activities among which:

- Providing access to reservoir simulators for which compatible versions of the reservoir model are available
- Support on software tooling that is applied by participants.

For support from TNO staff please contact:

- Rahul Fonseca, +31-888664758,
- Dries Hegen, +31-888665410,

where E-mail addresses for both of them concern firstname.secondname (at) tno.nl.

FREQUENTLY ASKED QUESTIONS (LAST UPDATE JUNE 8, 2017)

1. Can I use any reservoir simulator for the OLYMPUS challenge? **Yes, Participants are allowed to use any simulator they would like to use for the Olympus Field Development Optimization**