SPE LARGE SCALE COMPUTING AND BIG DATA CHALLENGES IN RESERVOIR SIMULATION CONFERENCE AND EXHIBITION

15–17 September 2014
ISTANBUL, TURKEY
The Grand Tarabya

Application Of Gradual Deformation Method For History Matching Brugge Field Study

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SPE International
Society of Petroleum Engineers

Presentation Outline

- Overview
- Gradual Deformation Method – Previous Applications
- Methodology
- Brugge Field – History Details
- Results and Discussion
- Acknowledgment

Overview

- History matching methods
  - Gradient based minimization
    - Local or Global search
  - Ensemble based minimization
    - Uncertainty represented as geostatistical realizations
- Real Field Challenges
  - Require many reservoir simulation runs – Fast solver
    - proxy model approximations
  - Identify all possible history matches – non uniqueness
  - Address practical reservoir engineering constraints – New methodologies

Gradual Deformation Method

- General method description
  - Generate geostatistical realizations representing uncertainty
  - Combine two realizations to generate new realizations

$$Z_i = X_i \cos \alpha_i + Y_i \sin \alpha_i$$

  - Where
  - Z_i - new realization
  - X_i, Y_i - independent Gaussian random noise
  - α_i - deformation parameter

Gradual Deformation Method

Previous Applications

SPE-63064
- Regional GDM / Patchwork

SPE- 107173
- Local GDM based on streamlines
- Gradient based optimization

SPE- 121274
- Continuous parameters with deformation variables used to build response surfaces

Conclusions

- Could be efficient for regions with independent dynamic behavior
- High convergence rate observed for regionalized GDM
- Probabilistic inversion approach reduces prior mismatch function but sensitive to measurement errors

Our Methodology

- Observations
  - GDM needs other techniques to apply to real fields
  - Solution is constrained by statistical assumptions (Gaussian distribution)
- Propose a new trajectory search GDM methodology
  - Generate input Geostatistical Realization (i =1,2…. n)
  - Select a number of combinations of two

$$\binom{n}{2} = \frac{n*(n-1)}{2}$$

  - For each selected pairs, trajectory search GDM is carried out

$$\varphi_{new} = \varphi_i(1-\lambda) + \varphi_j\lambda$$

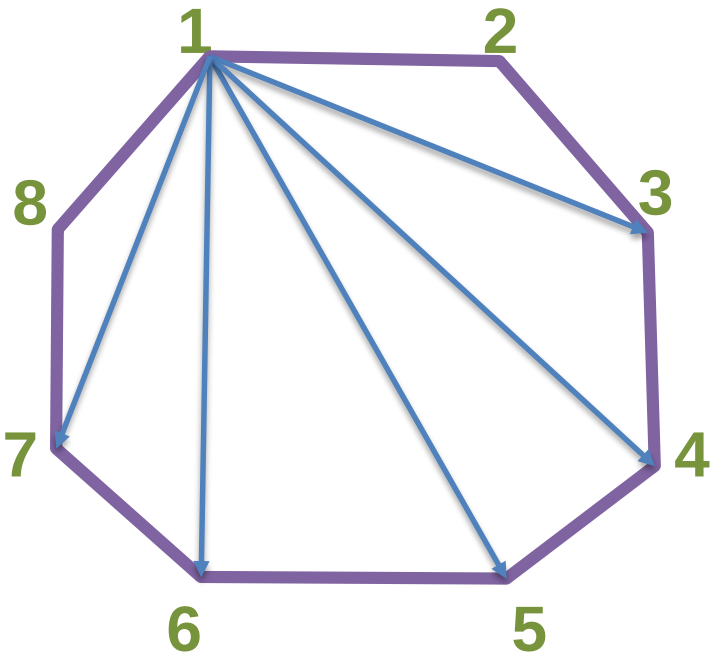
Where

φ – geostatistical realizations

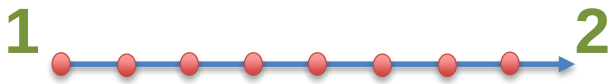
i,j – realization indices

λ - deformation parameter

Our Methodology



New realizations generated by combining pair of existing ones.



N – level trajectory search between each pair of realizations

Realization 1 combinations
1-2,1-3,1-4,1-5,1-6,1-7,1-8

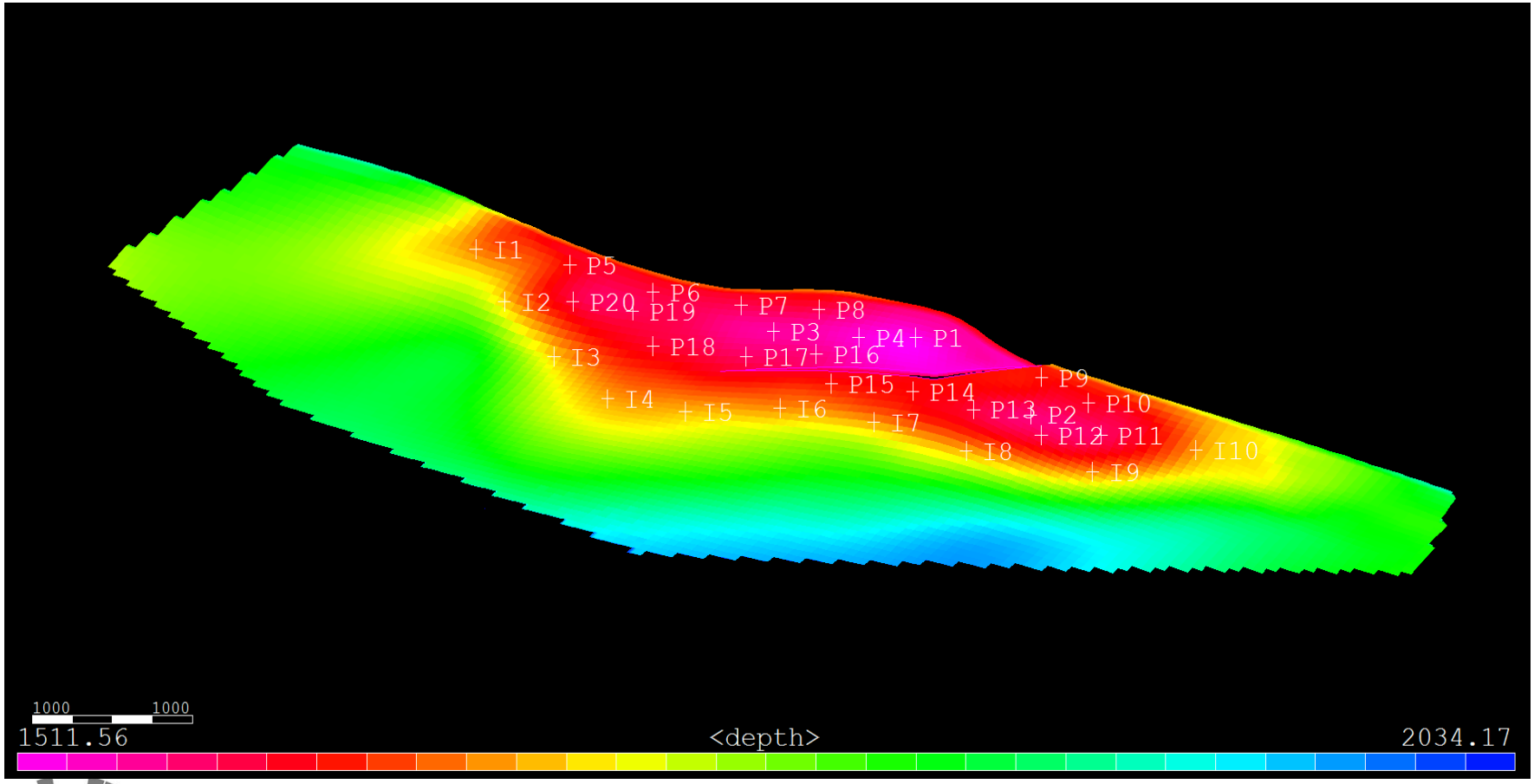
Trajectory discretization for 1-2: 8

Global mismatch function computed for all the combinations

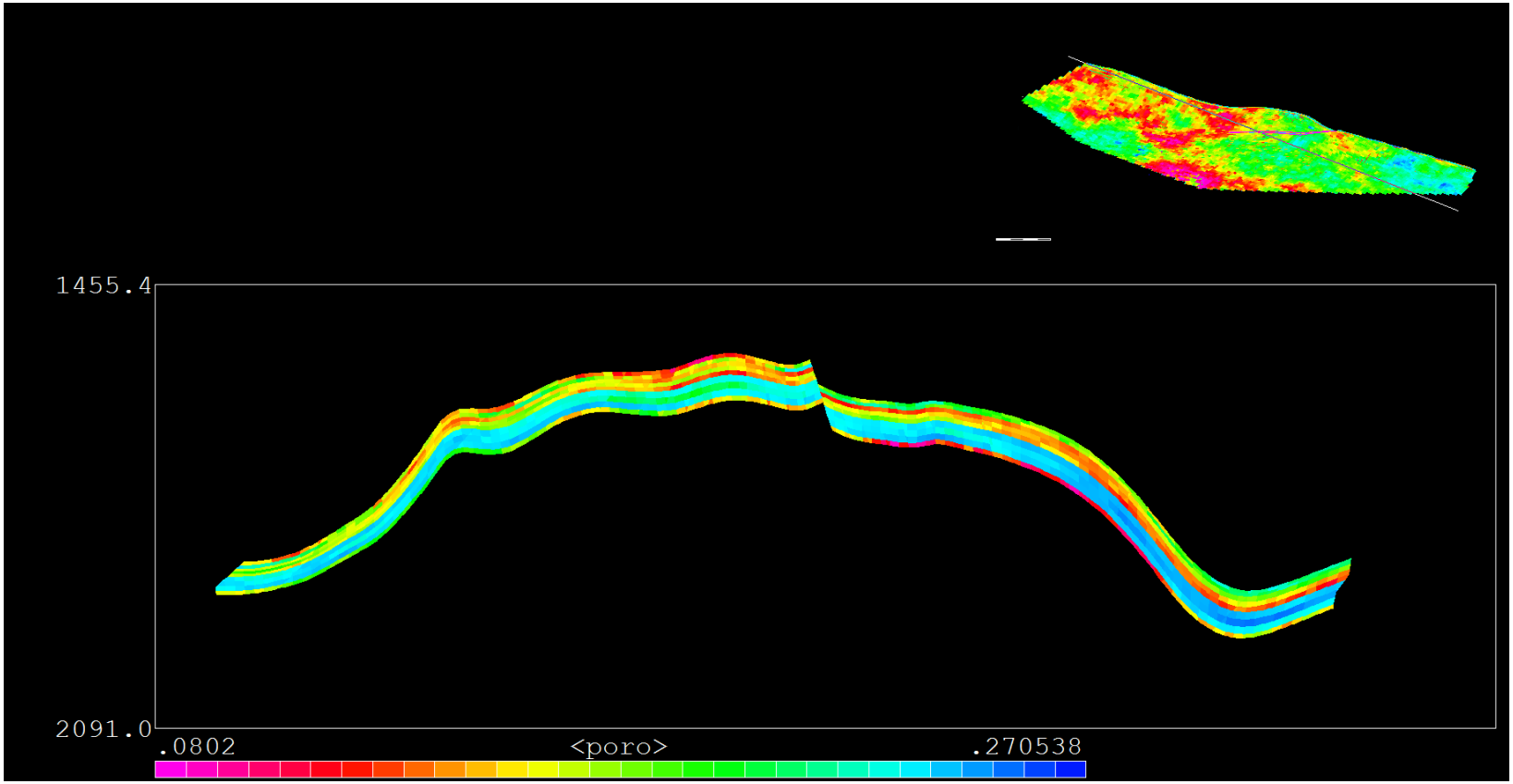
Brugge Field Study

- Details
  - 20 Producers, 10 Injectors with edge water drive
  - No Aquifer support
  - Two phase flow, 10 years History
    - Only Injection and Production rates used
    - producers shut when water-cut above 0.9
  - History match parameters
    - PERMX, PORO, PERMZ, NTG
  - 104 geological realizations

Brugge Field Study



Brugge Field Study



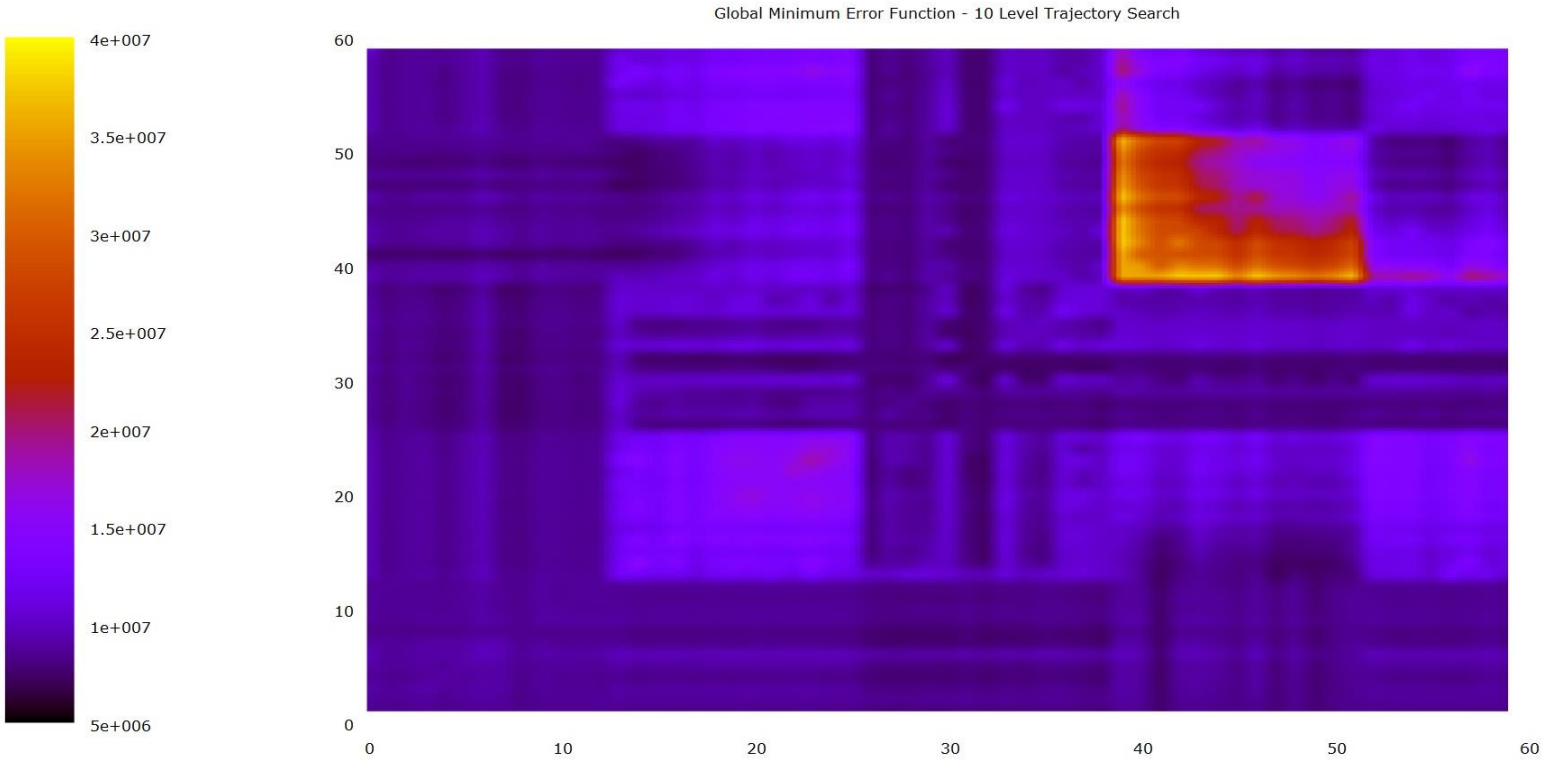
Brugge Field – Reservoir Simulation Details

- 104 geostatistical realizations were available but only 60 samples were taken for our study
- Total combinations $\binom{n}{2}$– 1770
- Trajectory Discretization Level – 10 and $\lambda = 0.1$
- Number of simulations conducted – 15990

- Reservoir Simulation tool used
  - ResAssure, a reservoir simulator combined with MCMC technology to aid trajectory sampling

- Total simulation time ~ 9 hrs
- Cloud computing used for carrying out simulations

Brugge Field - Results



Results - continued

- Average RMSE is calculated for 15990 realizations
- Best resulted realization has average RMSE= 414
- Realization groups are identified for wells for best history match
- Further clustering based on best well mismatch functions are to be generated

Conclusion

- Gradual Deformation Method is studied with Brugge Field with 10 year history
- Proposed new method based on trajectory sampling GDM
- Results on 60 realization run shows this technique reduces global objective function but found to be ineffective for tuning large number of variables.
- The results obtained show realization clusters with very good well level match
- This technique is useful for screening of lithofacies for local GDM in a real field study

Future Work

- Identify realization groups for regional deformation with patchwork
- Include 4D seismic information to constrain reservoir models
- Perform 20 years history match for Brugge
- Apply trajectory GDM for higher number of paired combinations i.e., 3,4 or higher realization combinations

References

- L.C. Reis et al. Production Data Integration Using a Gradual Deformation Approach: Application to an Oil Field (Offshore Brazil), Paper SPE 63064 presented at ATCE, Dallas, Texas,1-4 Oct 2000

- V.Gervais et al. History Matching Using Local Gradual Deformation, Paper SPE 107173 presented at SPE Europec/EAGE in London, 11-14 June 2007

- Daniel Busby et al. Uncertainty Reduction by Production Data Assimilation Combining Gradual Deformation with Adaptive Response Surface Methodology, Paper SPE 121274 presented at SPE Europec/EAGE in Amsterdam, 8-11 June 2009

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Questions?

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