A modern approach to identify remaining opportunities through integrated modelling practices in a mature field

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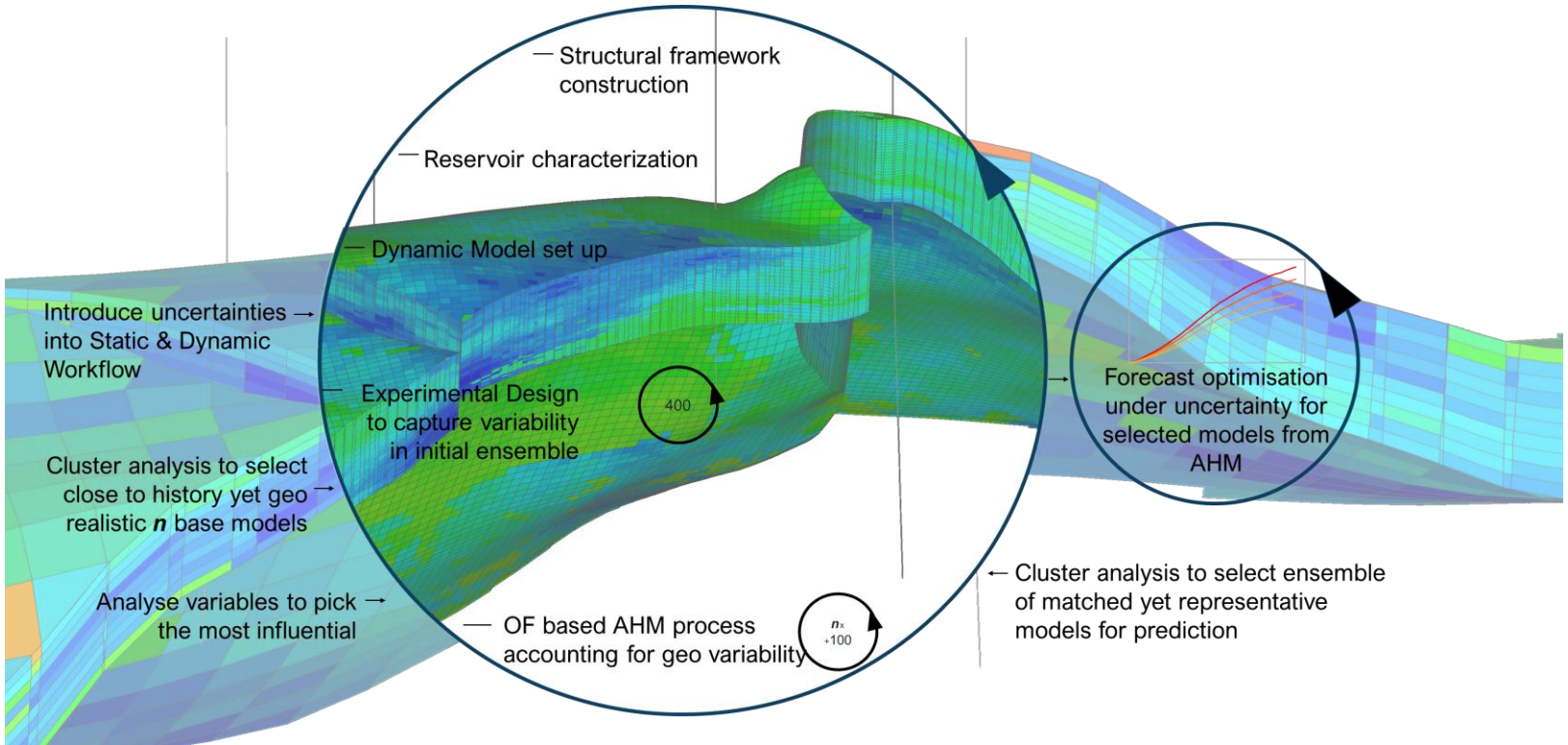
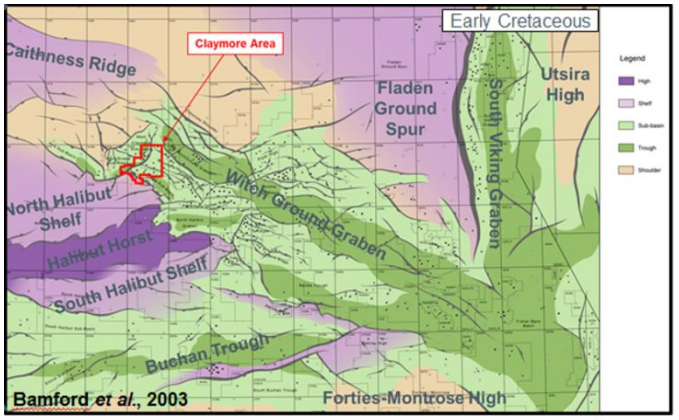
The Challenges and Objectives

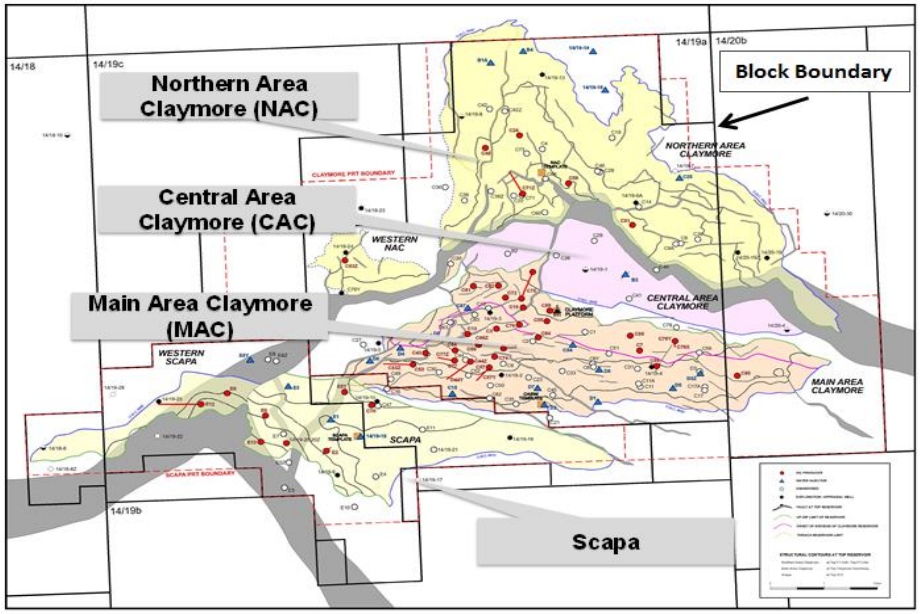
- Capturing multiple potential geological & development scenarios
  - Create an integrated workflow to generate multiple scenarios based on static and dynamic uncertainties
- Extrapolation of existing data on new areas is associated with significant uncertainties
  - Identify key uncertain properties and propagate into the AOI which contains spare data
- Running fine-scale model is time-consuming
  - Find a trade-off of model resolution and simulation run time to capture heterogeneities for an ensemble of models



Northern Area Claymore - Overview

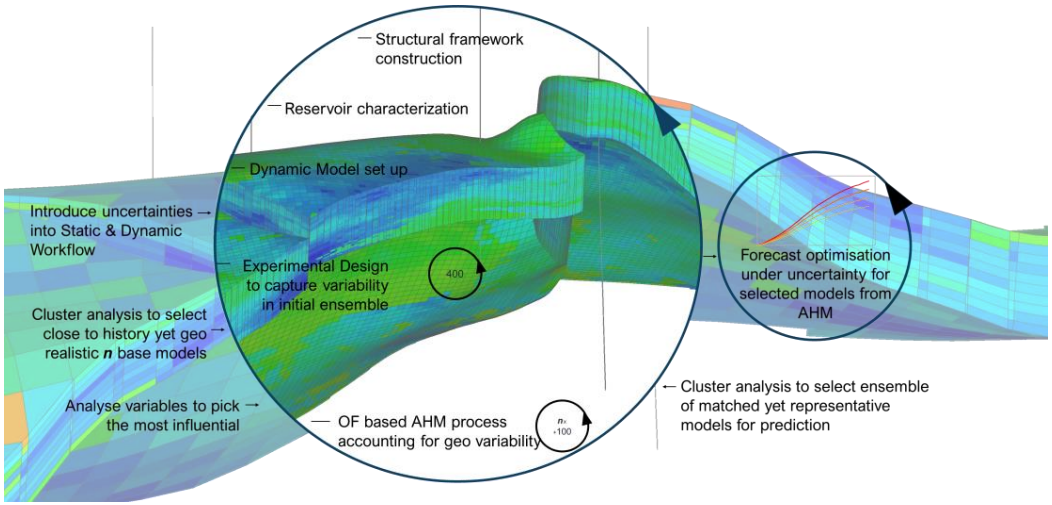
- 160 km north east of Aberdeen in the CNS
- First production from the Claymore field commencing in November 1977
- Claymore Platform
  - 36 slots
  - 2 sub-sea injection templates
- NAC field on production since 1978.
- Historically 17 producers and 7 injectors.





Ensemble Workflow Approach

1. A single structural static model was selected as a seed model.
2. 400 HM runs conducted on the seed model with varying parameters.
3. 1st Stage AHM: 4 clusters recognised from the 400 HM runs and 1 model from each cluster selected.
4. Each of the 4 selected models adhered to geological principles.
5. 2nd Stage AHM: Optimization experiments were conducted on each of the 4 models with objective function to minimise the RFT mismatch.
6. 3 models selected from each of the 4 optimization experiments.
7. Ensemble contains 12 history matched models.



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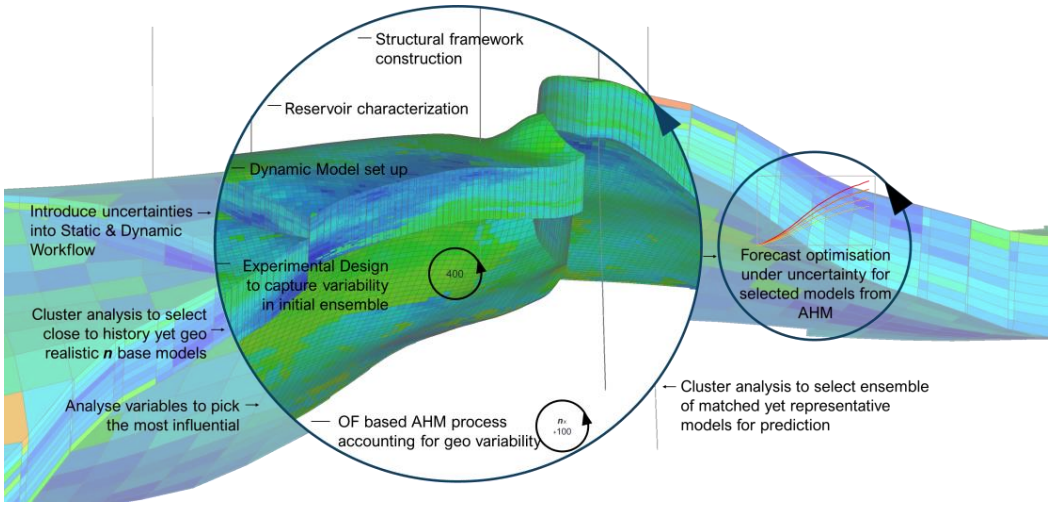
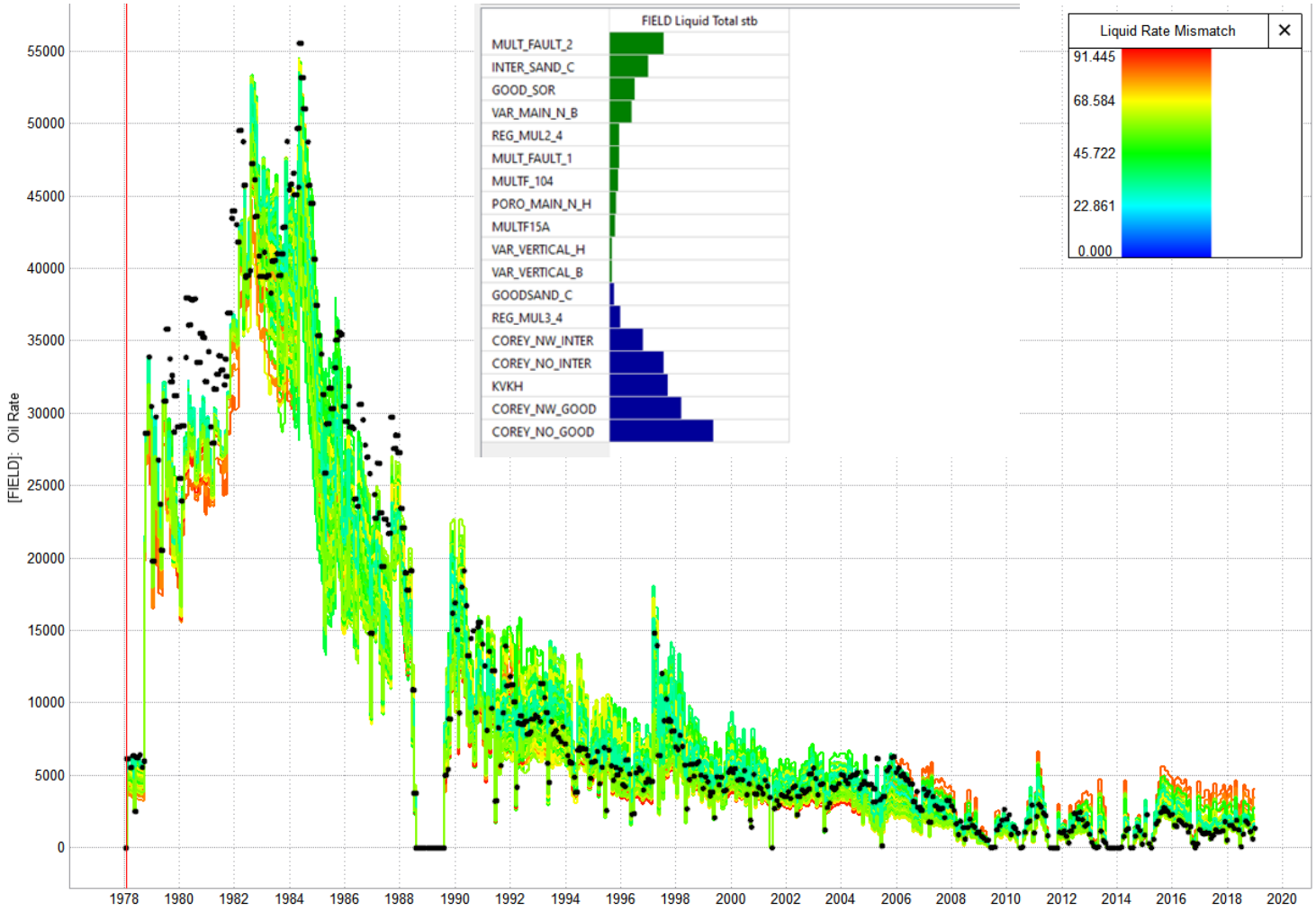


Sensitivity Analysis for Variables



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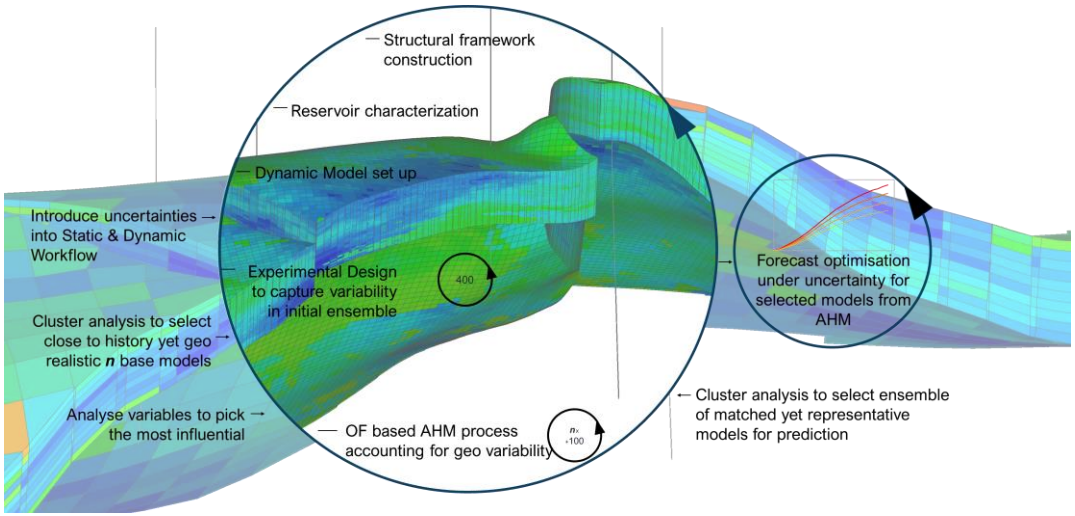
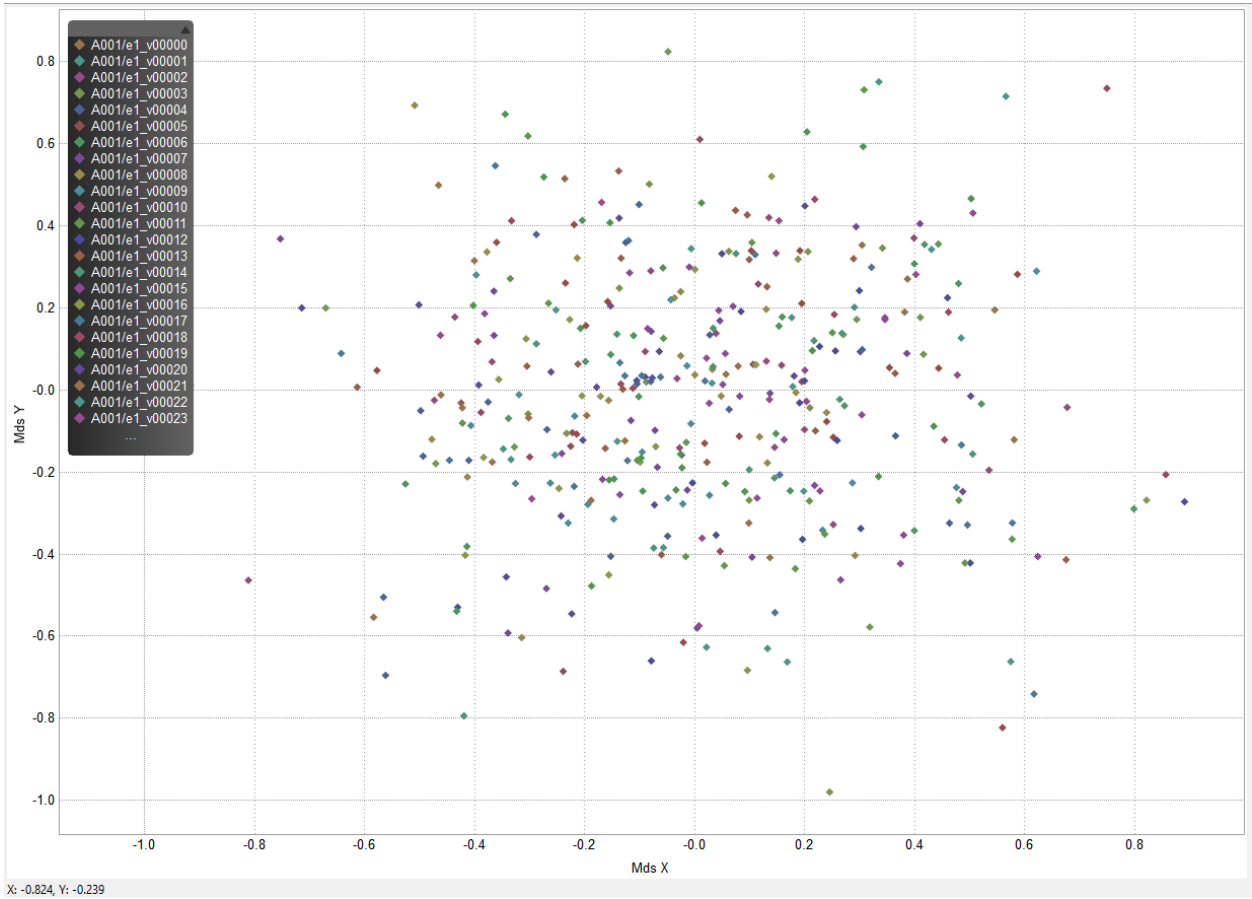
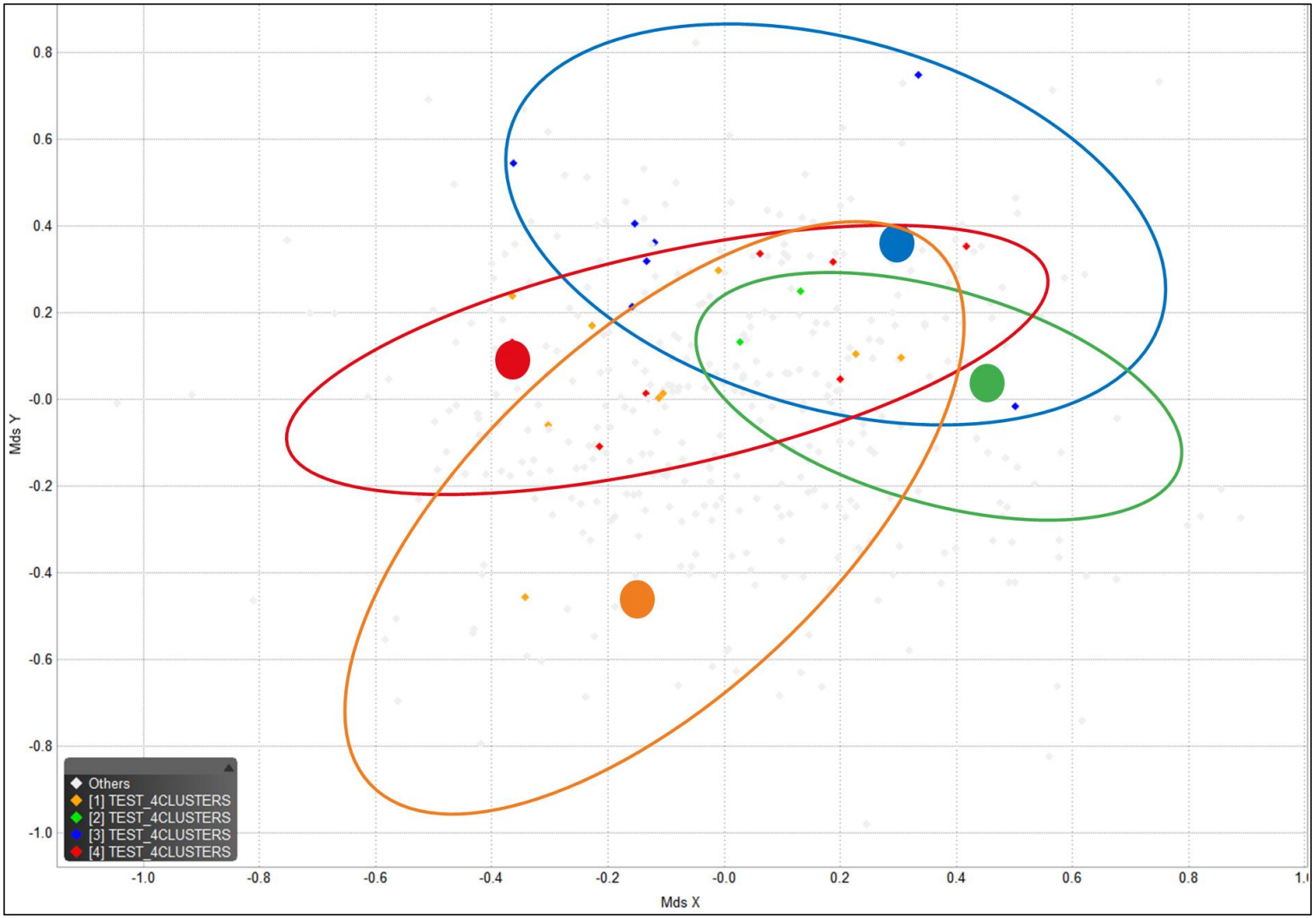


2D Multidimensional Scaling Plot: 400 HM runs

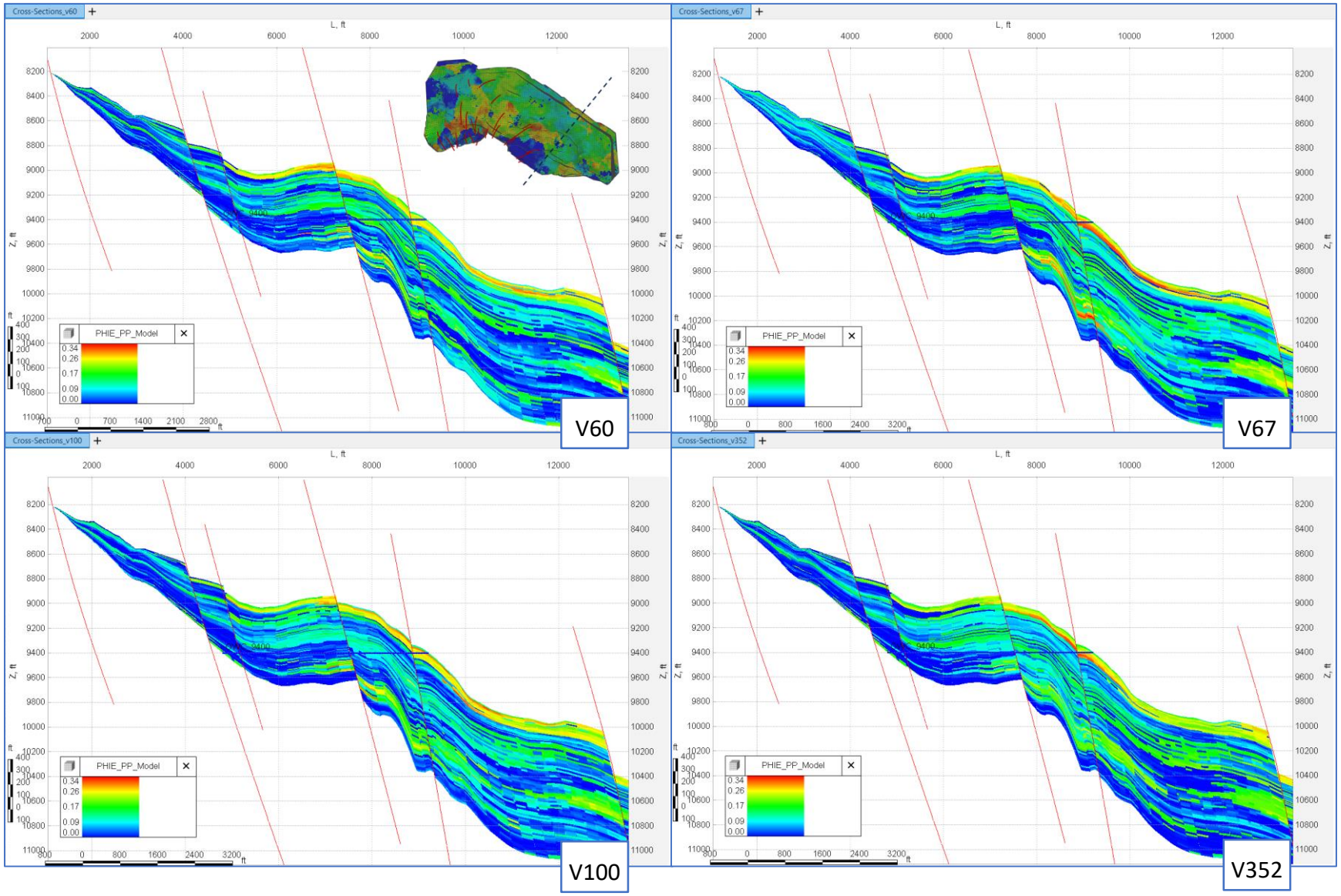
- Multidimensional Scaling was used to select models for ensemble from different clusters.
- This technique allows to represent a spread of possible unique solutions



Identification Process - Centre of Clusters



Selected models adhered to geological principles



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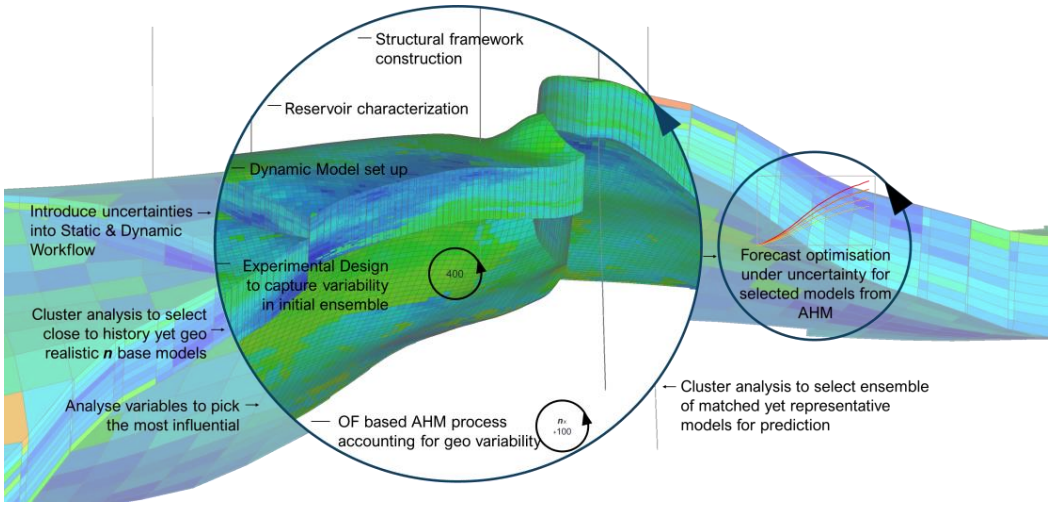

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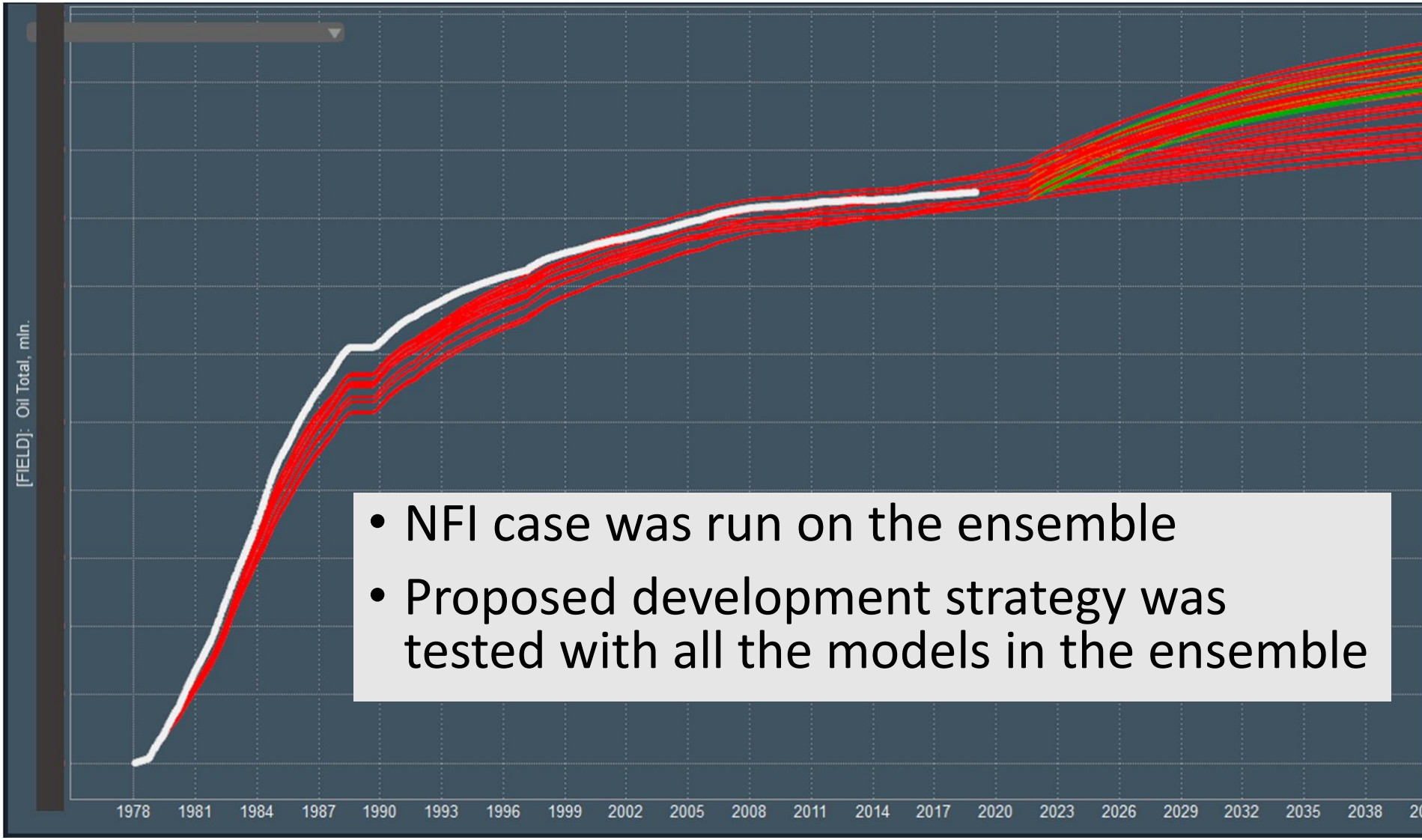
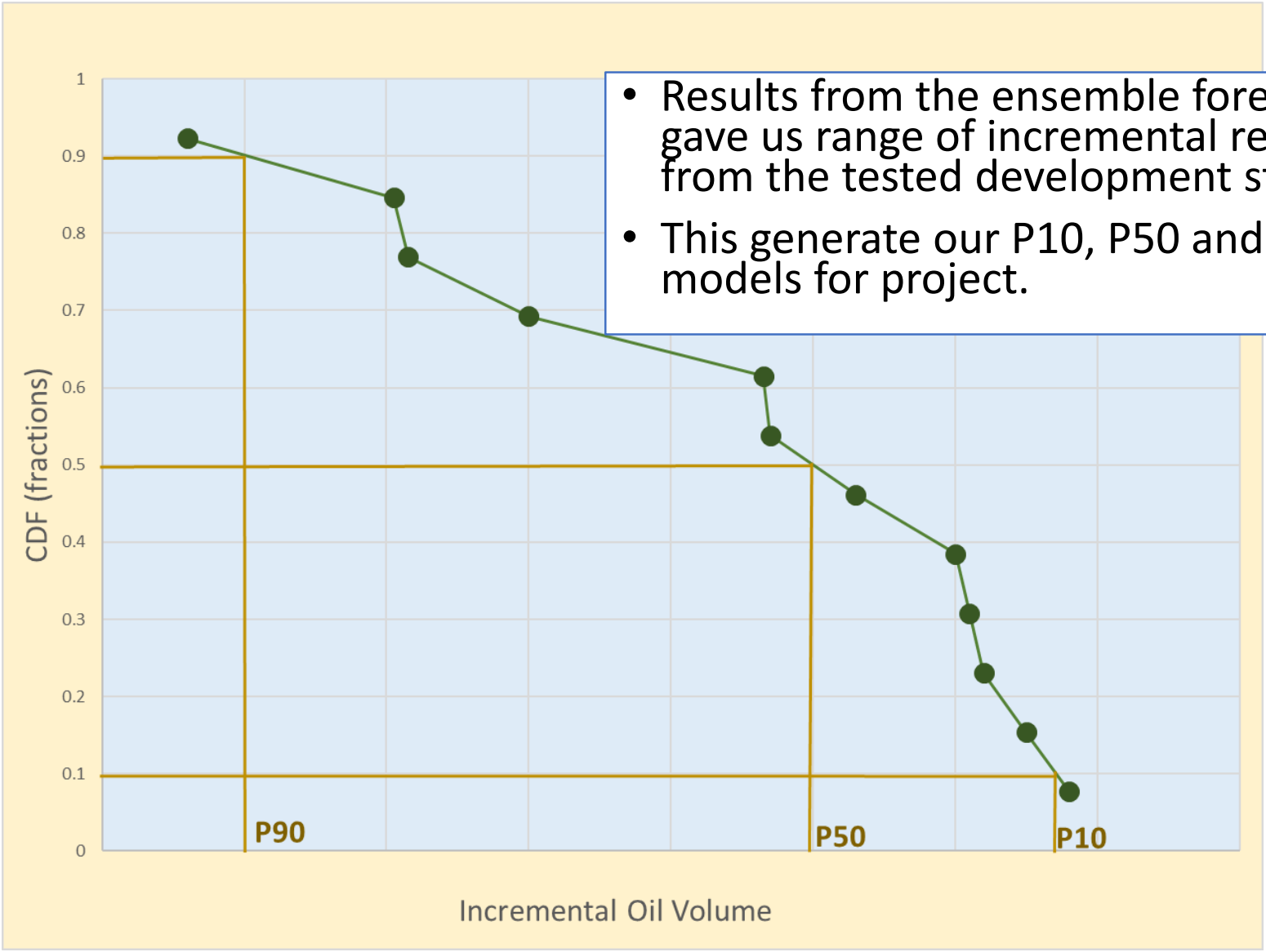


- NFI case was run on the ensemble
- Proposed development strategy was tested with all the models in the ensemble

Ensemble Models



- Results from the ensemble forecast runs gave us range of incremental recovery from the tested development strategy
- This generate our P10, P50 and P90 models for project.

Conclusions and Lessons Learned

- Generated an Ensemble consisting of history matched models, each with unique combinations of uncertain variables
- Choose objective function wisely.
- Model run-time is critical – fit for purpose design.
- Don’t underestimate the number of runs required to generate an ensemble.

Acknowledgements

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- Dana Petroleum for permission to present this study.

- Valuable contribution by RFD team in providing support to our project. Their energy and innovation helped us overcome many challenges during the course of the project.