



Grane

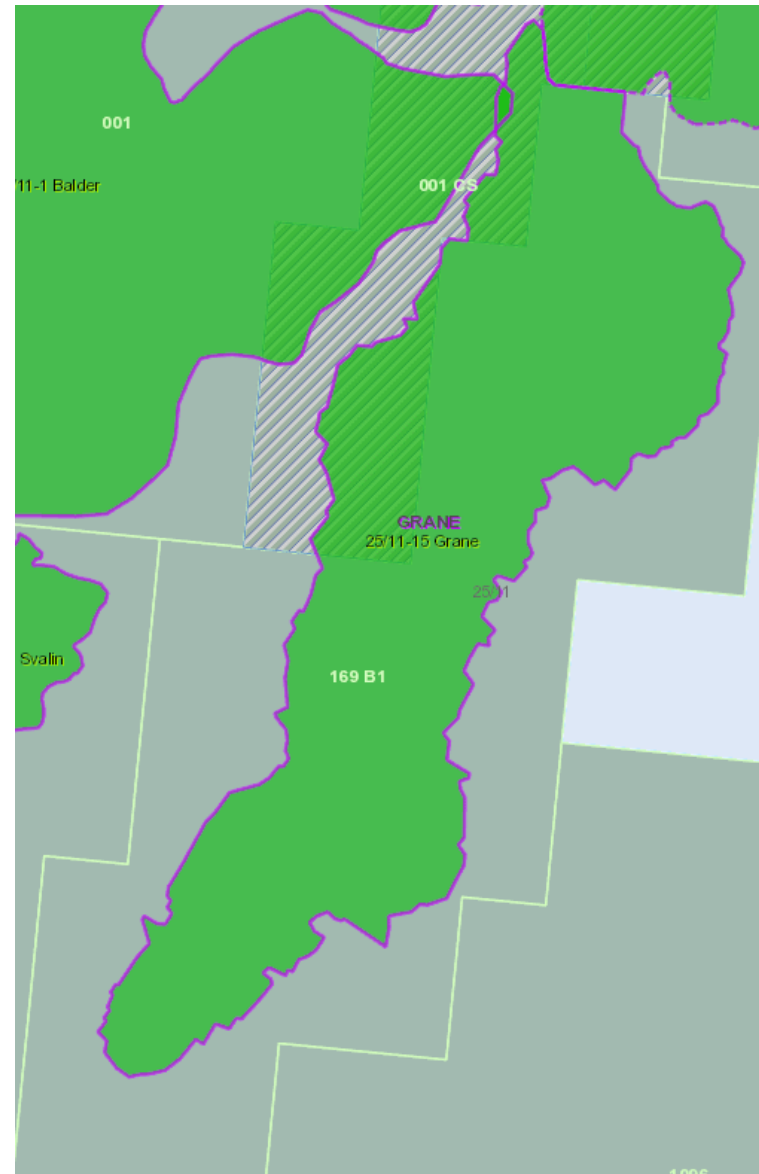
Ensemble based history matching on a mature field

Force seminar 7-8 December 2022

Brit Gunn Erslund & Anne Ullern

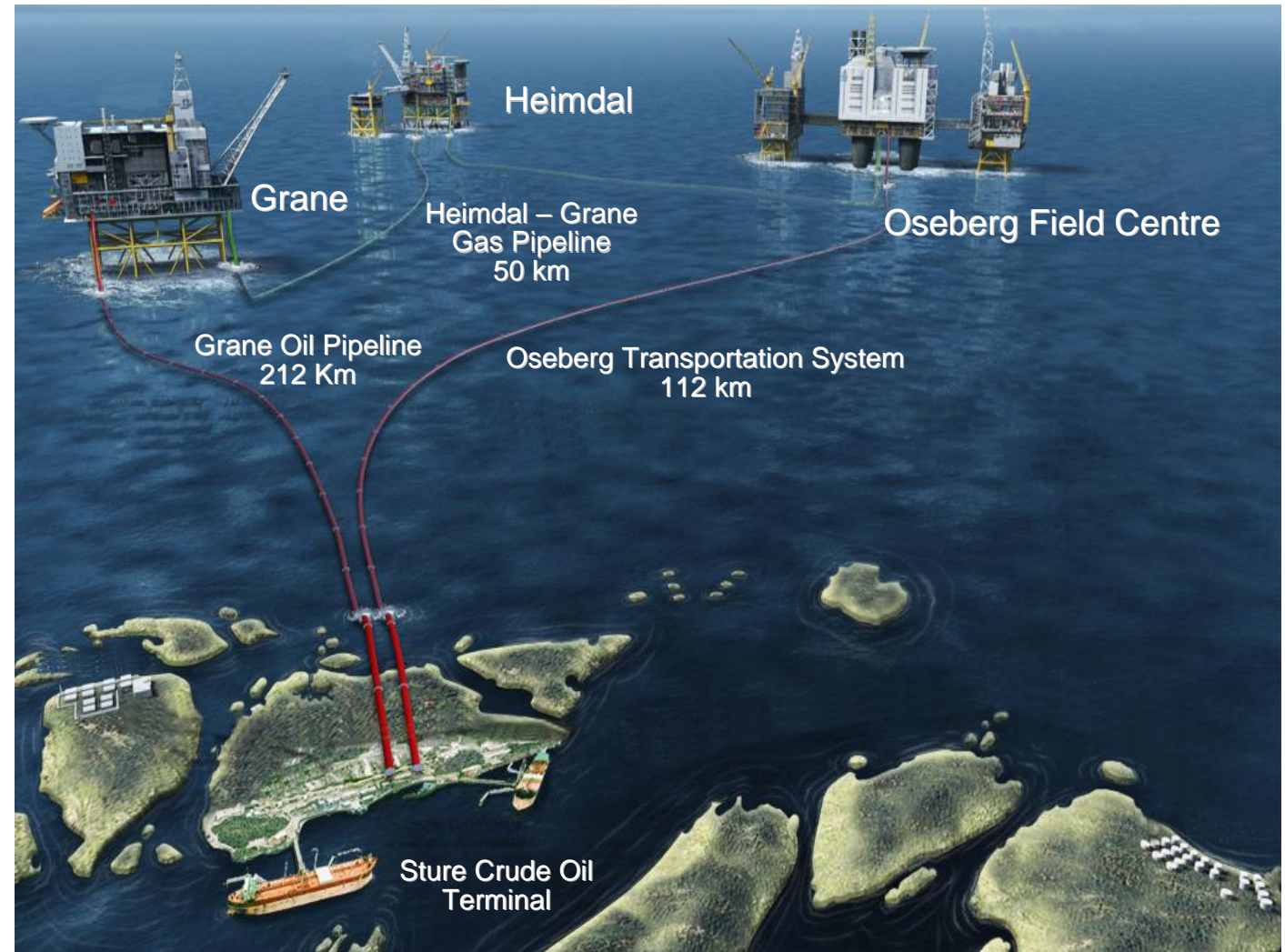
Outline

- Introduction
- Modeling strategy & sensitivity analysis
- History matching
- Prediction



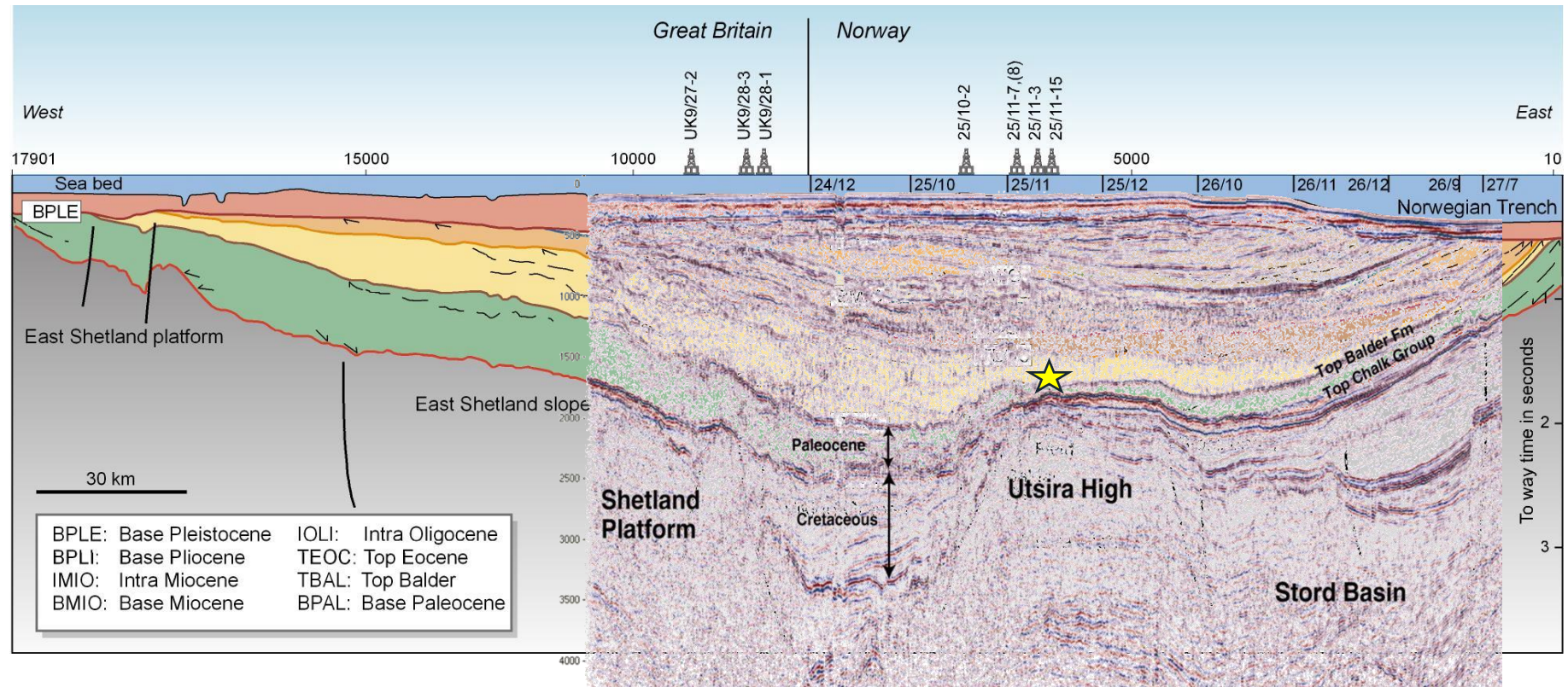
Introduction to Grane

- Discovered: 1991
- Production start up: Sept 2003
- Production and drilling facility:
 - Grane Platform
 - 40 slots
 - Gas lift and gas injection
- Heavy oil (19 API), no initial gas cap
- STOIIIP: ~ 220 MSm³
- Target recovery factor: 70%
- Daily production ~ 8000 Sm³/sd



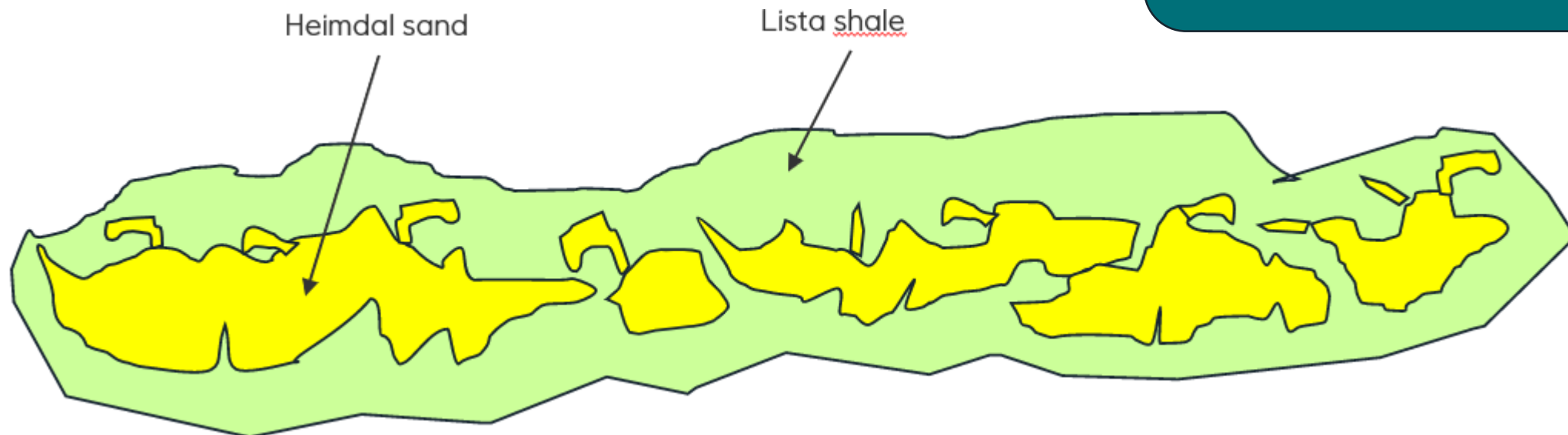
Geological setting

- Paleocene Heimdal sandstone member of the Lista Formation
- Located at the eastern margin of the Hordaplattform
- Origin as turbiditic sandstones; sourced from the East Shetland platform
- Later remobilized and injected into surrounding strata



Heimdal – sand properties

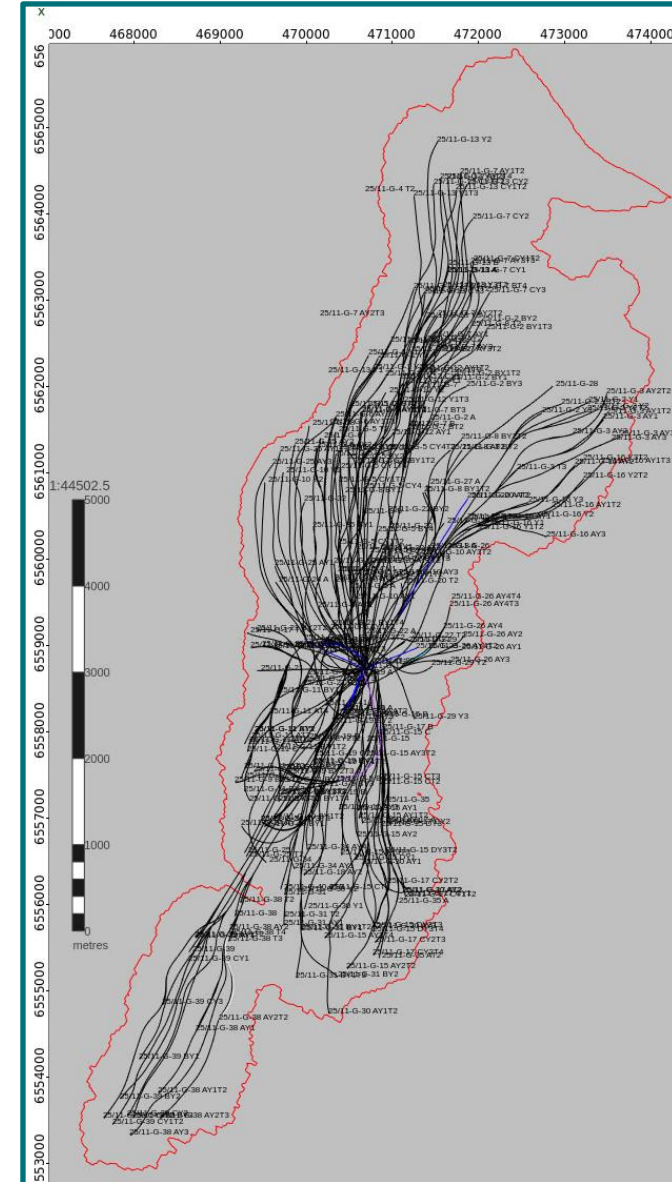
Neto gross in Lower Heimdal > 90 %:
 Permeability 4-12 Darcy
 Porosity: ~33%



The model input data

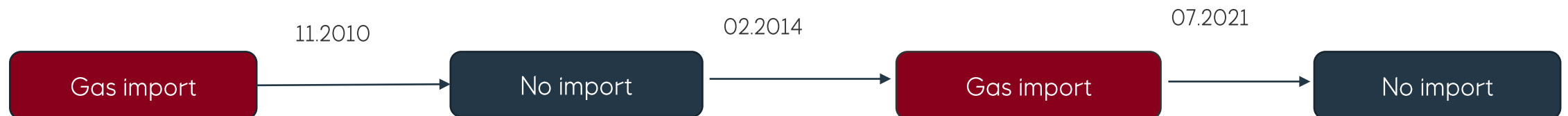
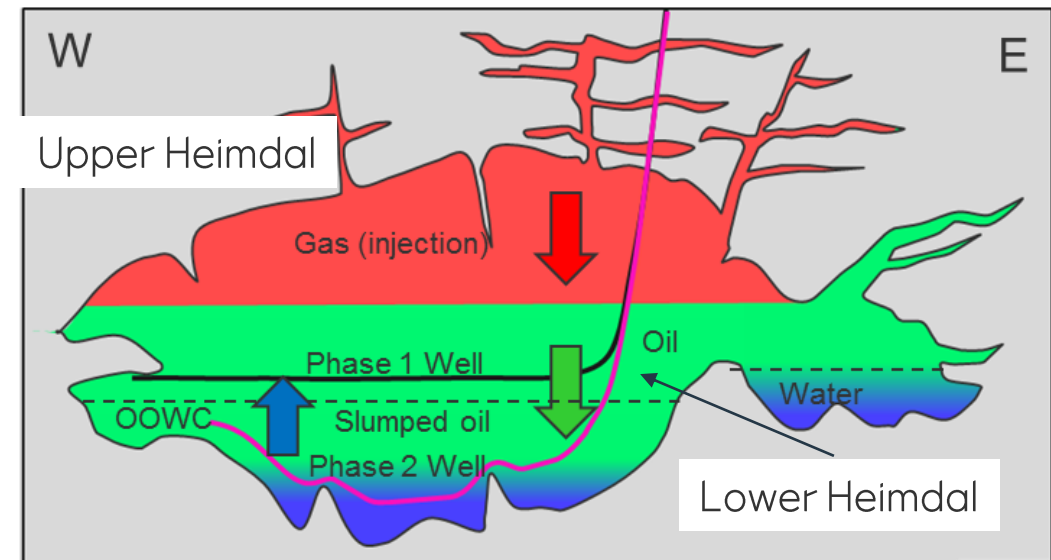
- Well data:
- Approx ~ 300 well tracks
 - Explorataion wells and pilots
 - Producers:
 - Single well bores
 - Multilaterals

Frequent and high-resolution seismic data of the dynamics → input for sand probability

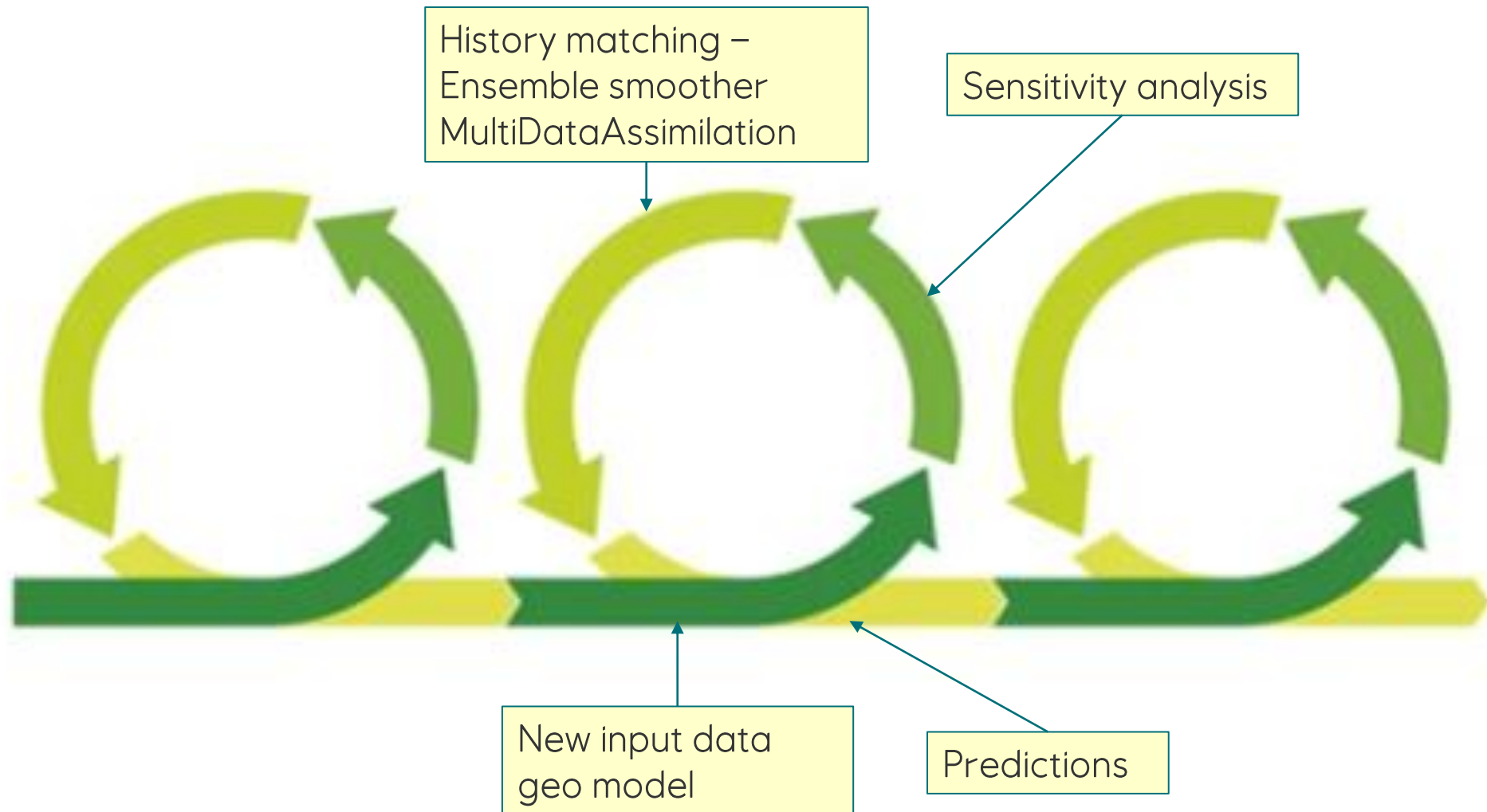


Grane drainage strategy

- Gas injection for pressure support.
 - Import gas
 - re-inject produced gas
- Limited water injection
- Initially draining level above OWC
- Currently draining level below initial OWC (slumped oil)



Modeling strategy on Grane



Average Grane prod with rms-seed ~133.5 MSm³

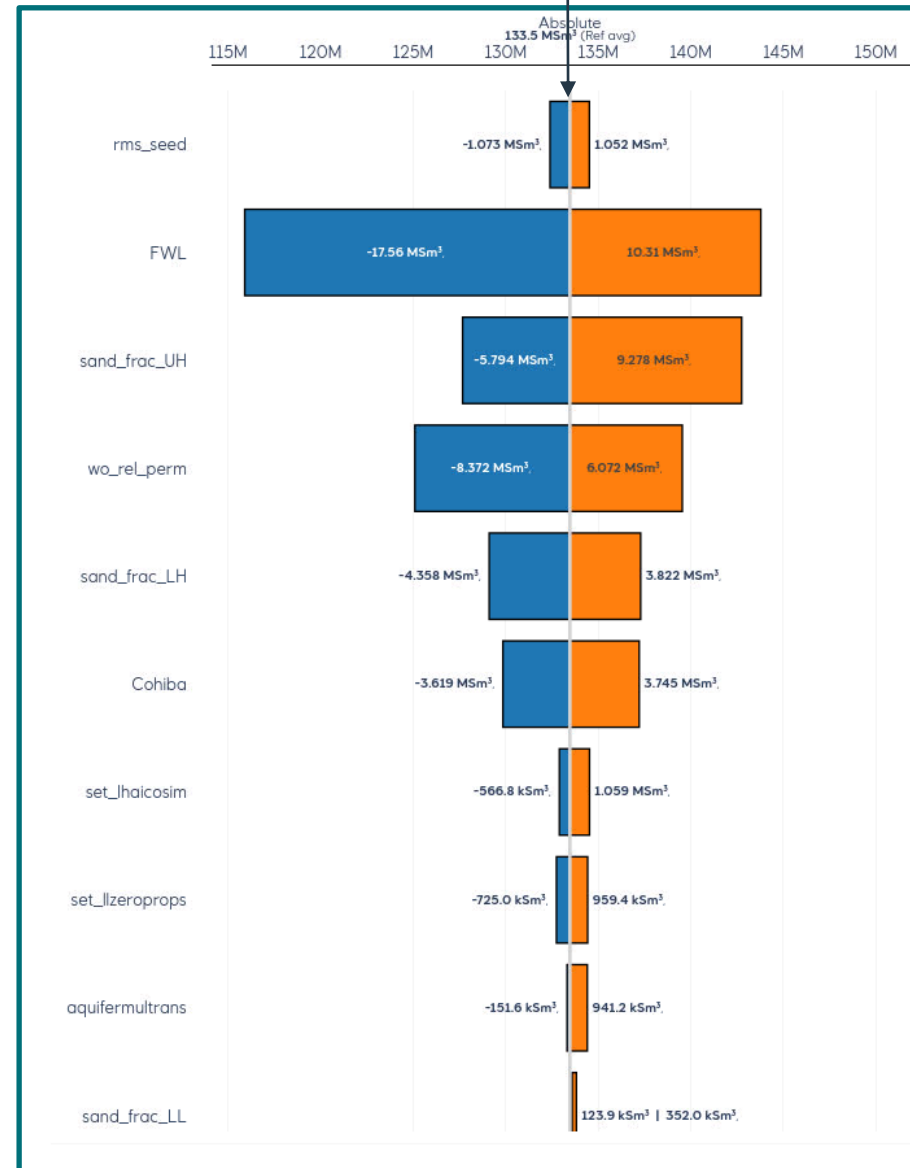
Sensitivity analysis

Sensitivities

- RMS-seed
- Structural uncertainty
- FWL
- Sand fraction
- Connection to aquifers
- Seismic conditioning
- Water and oil relative permeability

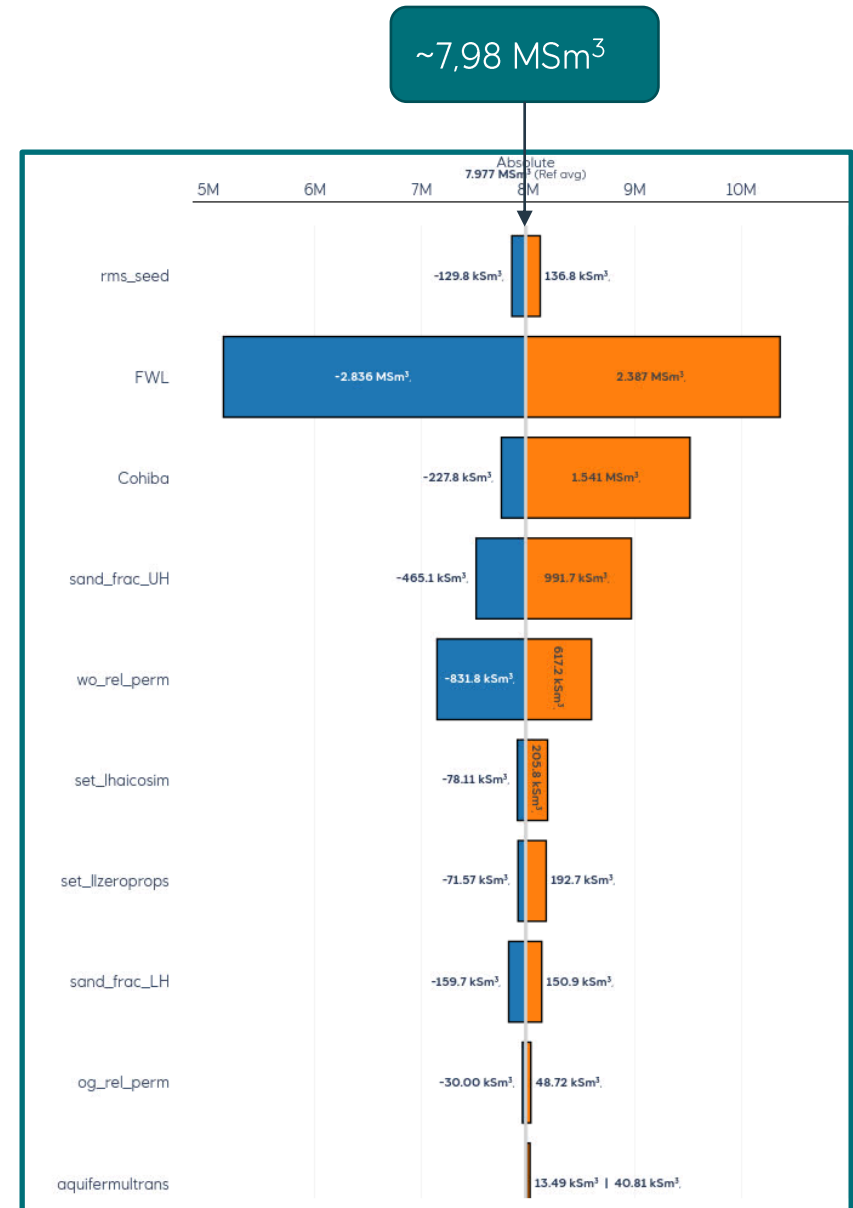
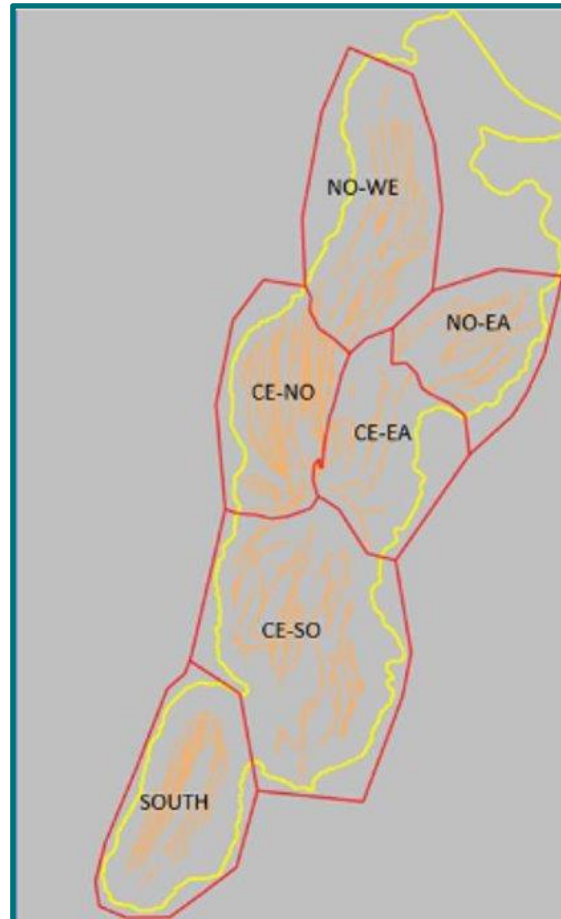
- Grane oil produced ~133 MSm³
- Good coverage on field level

Reference case = realization-0 from sensitivity study



Sensitivity analysis on group level area SOUTH

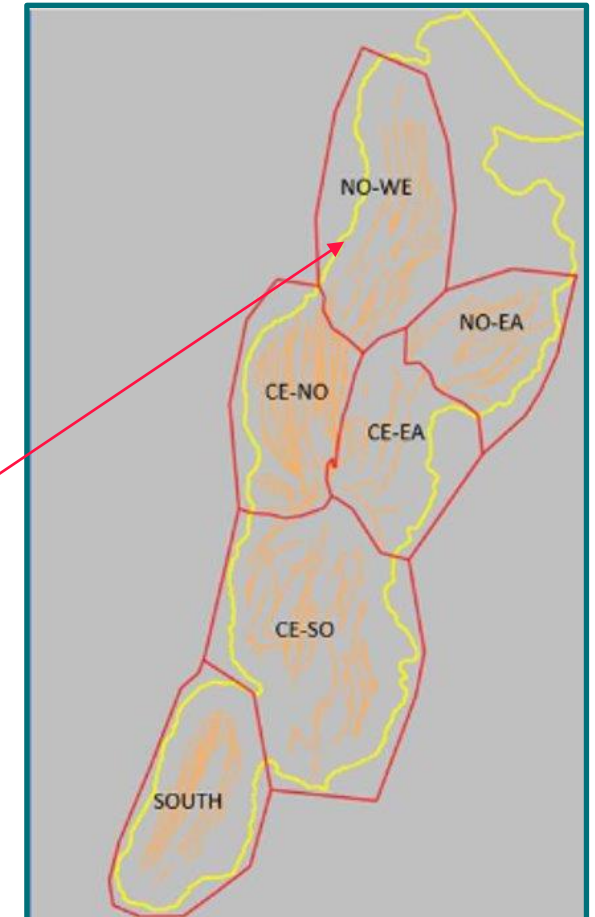
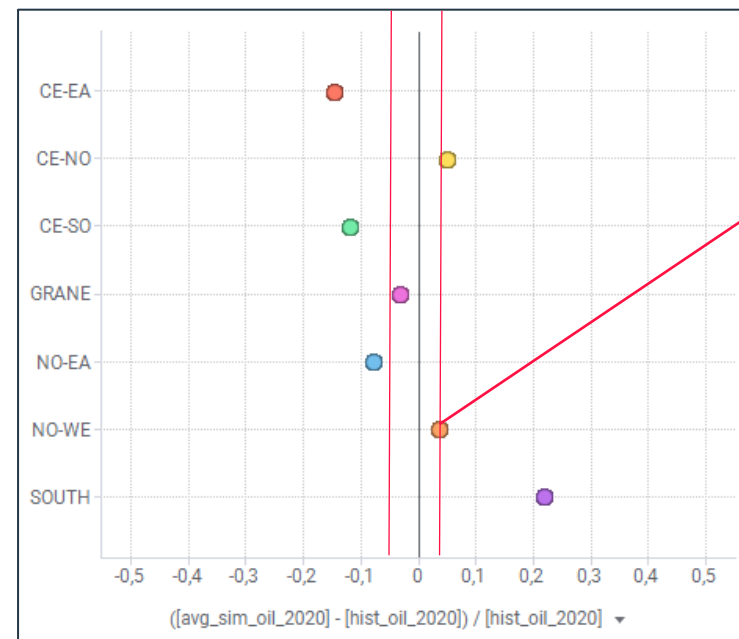
- Allocated production:
 - ~6.78 MSm³
- Simulated average rms-seed
 - ~7.98 MSm³
- Only covered by the uncertainty FWL



Initial status – prior models

- History match checked on group level
 - Total oil production
 - Total water production
 - Total gas production
- Acceptable match
 - Cum oil mismatch < 5%
 - Cum gas mismatch < 10%
 - Cum water mismatch < 10%
- Only NO-WE fulfills the criteria
- GRANE = total field production

Mismatch in oil production at end 2020



Matching criteria and parameters

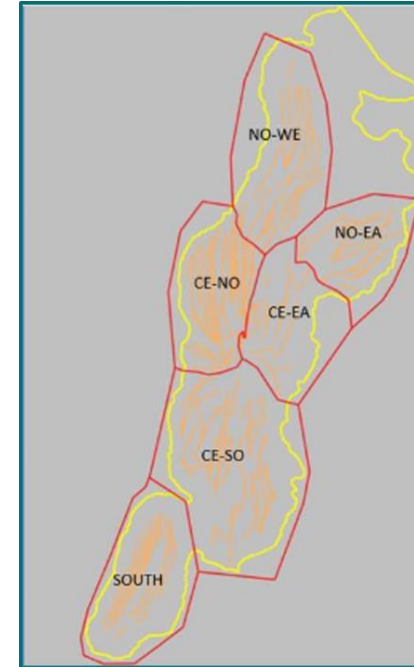
Matching cumulative production on group level

Observation (matching) data:

- Cumulative oil production +/- 5%
- Cumulative gas production +/- 10%

Limit the matching to 3 different points in times

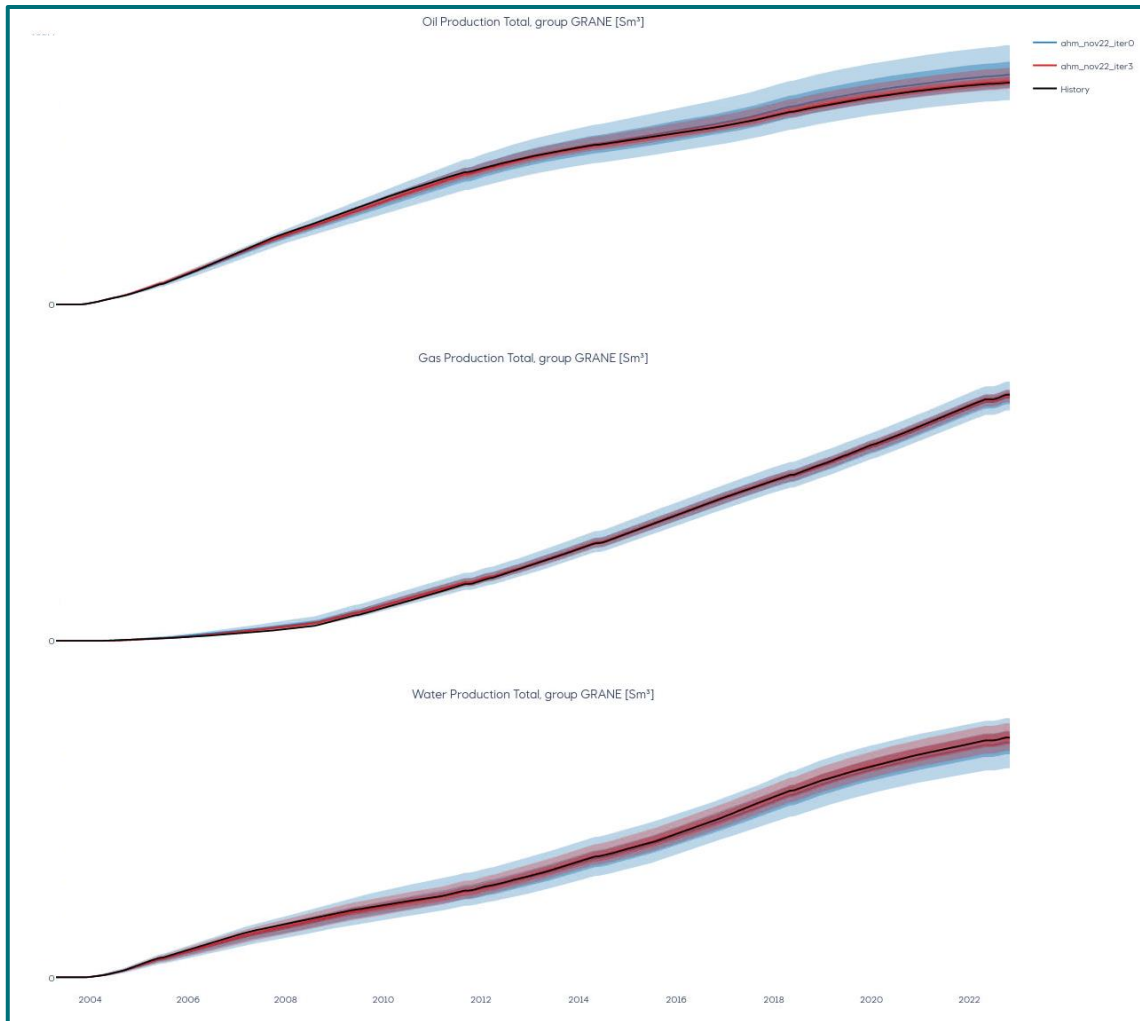
- 01.01.2010
- 01.01.2015
- 01.01.2020



Matching parameters:

- Structural uncertainty
- FWL
- Facies volume fraction
- Relative permeability
- Aquifer connection

History match – Grane production

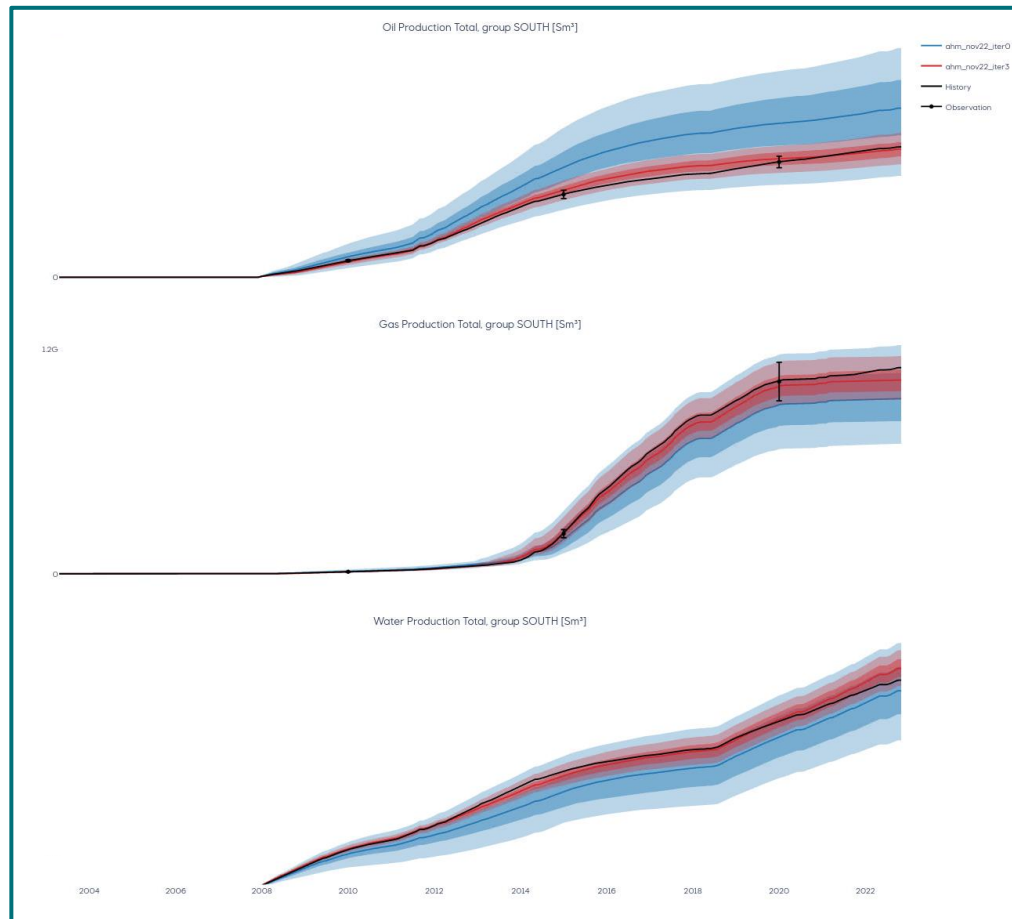
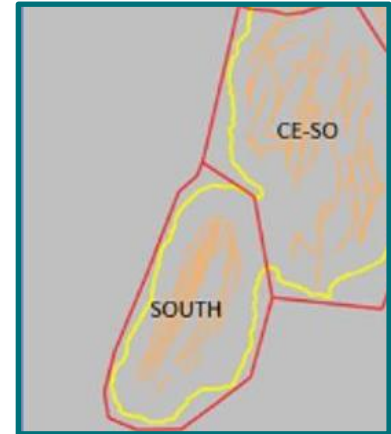


History matching narrow the span in all phases

The average field production is close to the history in 2022

Mismatch in 2022 ~ 0,9 M or less than 1%.

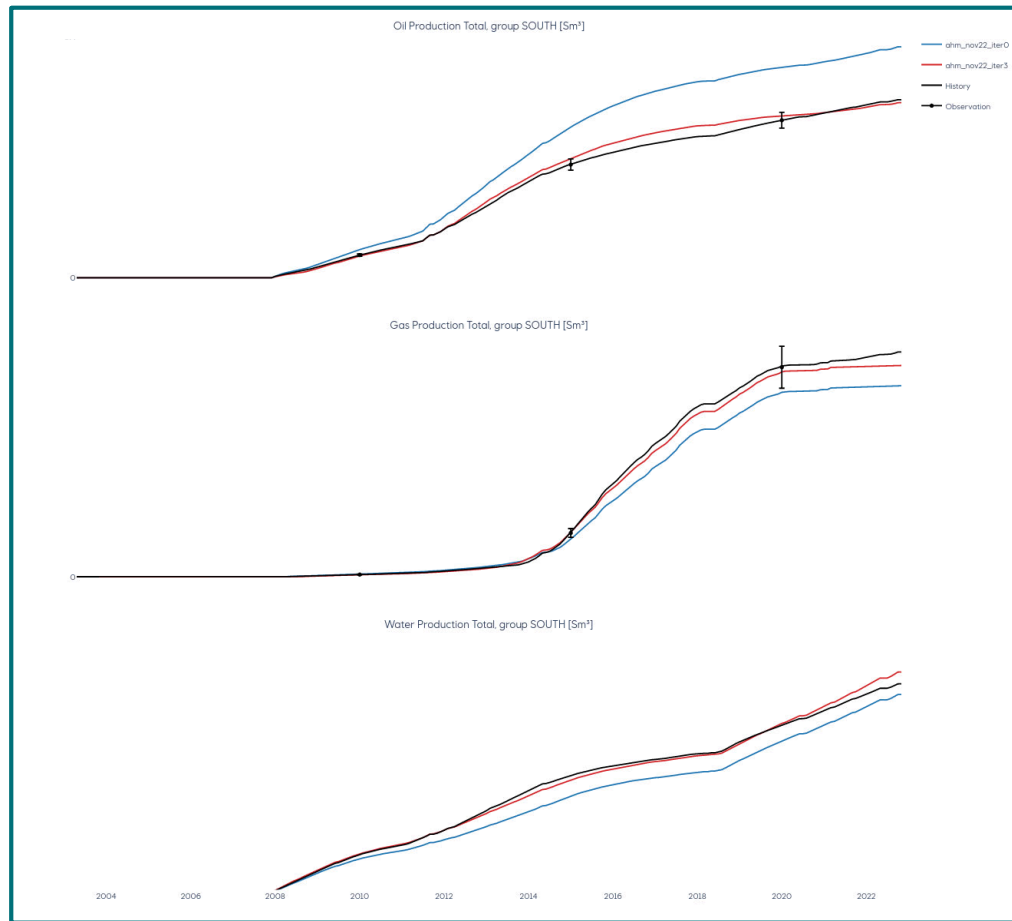
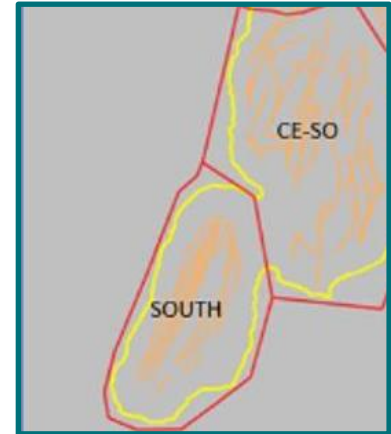
Initial and final history match in the southern part of Grane



- Initial ensemble (blue)
 - Large spread
 - Observation point were covered
 - Mean oil to high

- Final ensemble (red)
 - Narrow spread
 - Mean inside the observation uncertainties

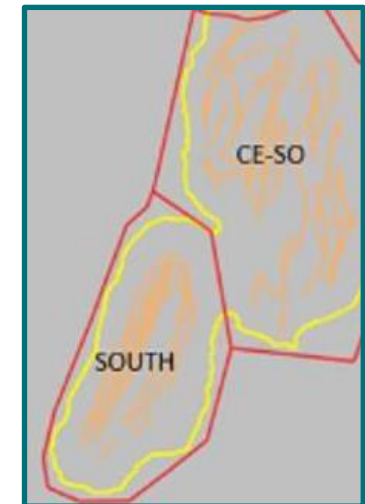
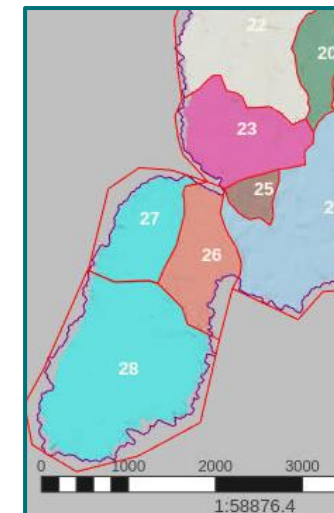
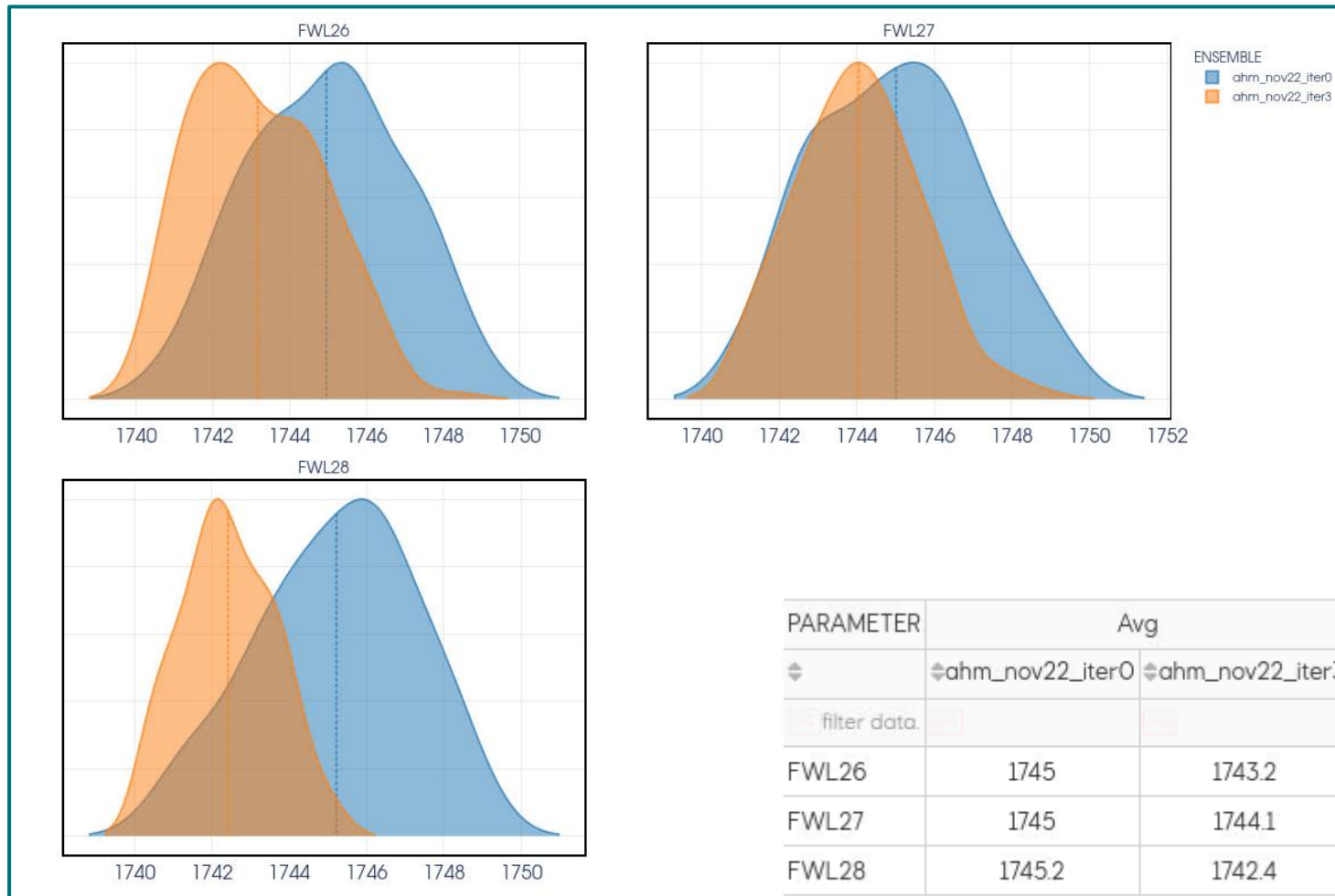
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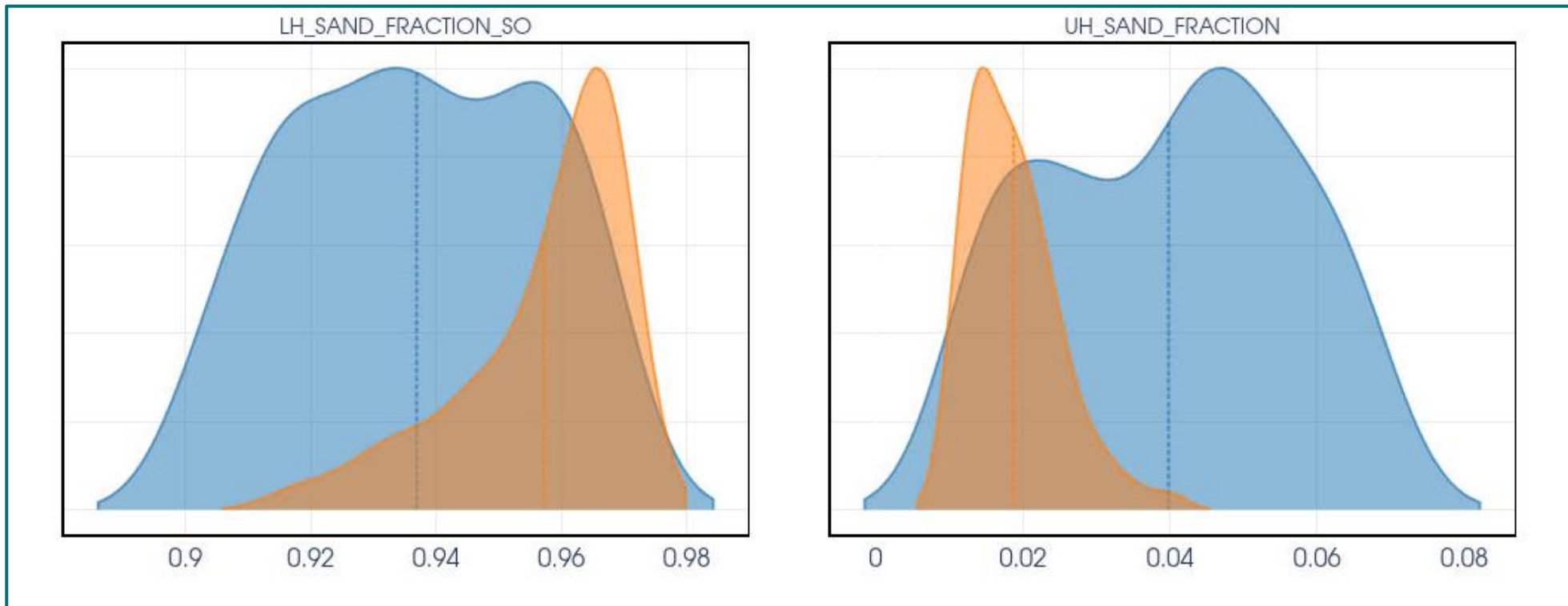
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Changes in oil water contact



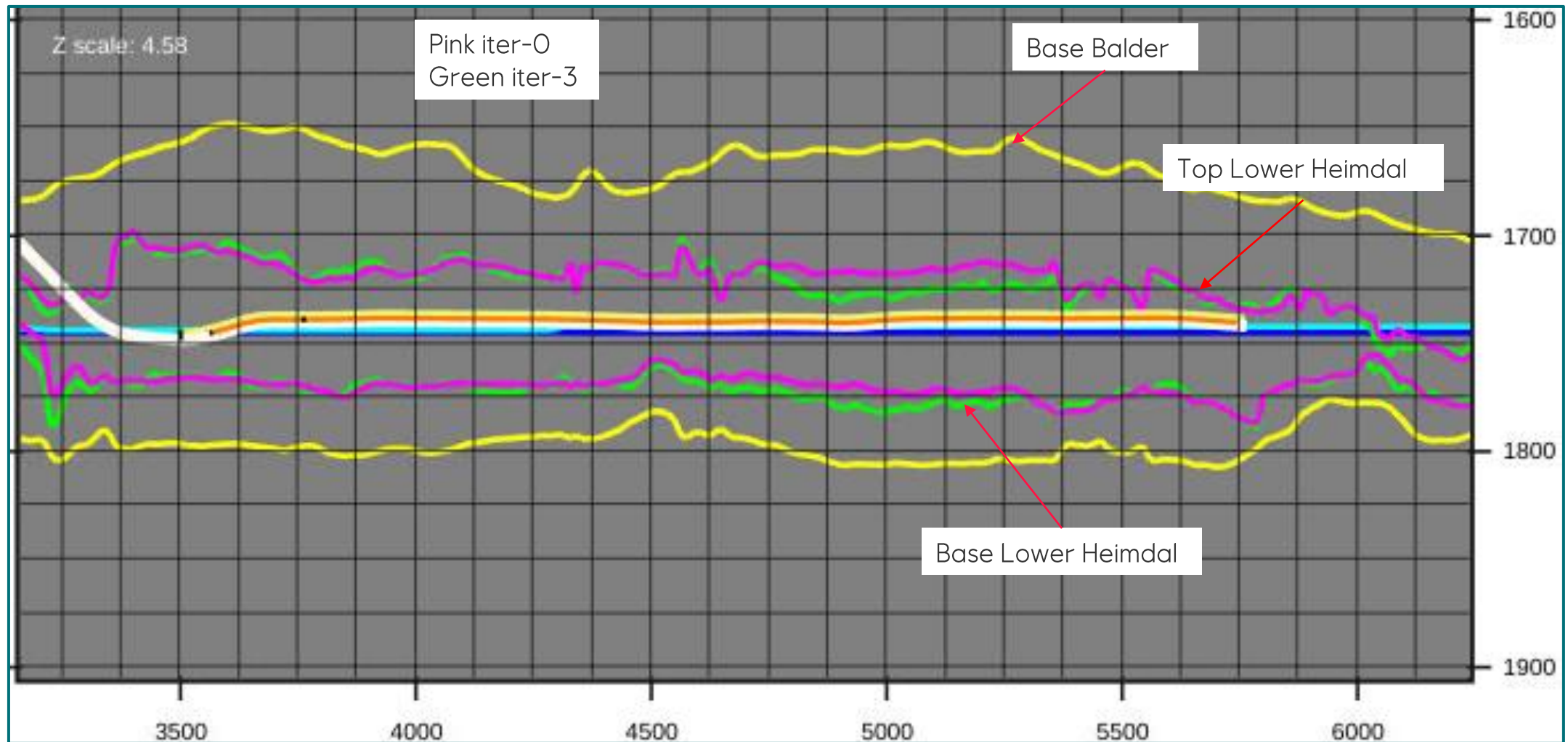
The oil water contact is moved shallower in the history matching algorithm

Sand fraction in upper and lower Heimdal

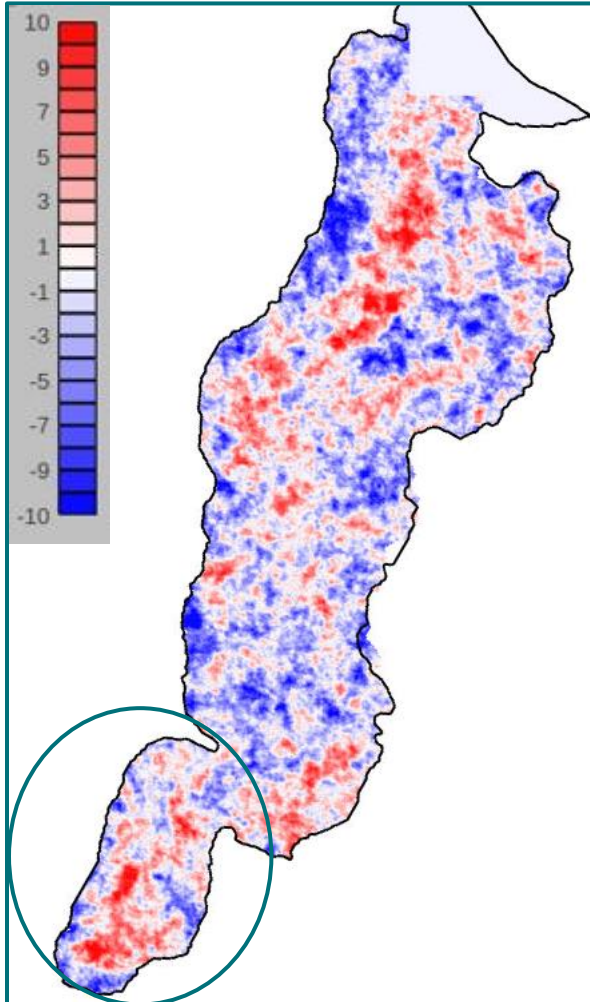


The sand fraction in lower Heimdal is increasing while it is decreasing in upper Heimdal

Cross section along 25/11-G-39 BY2 – mean surfaces



Average difference in at top Lower Heimdal iter-0 to iter-3



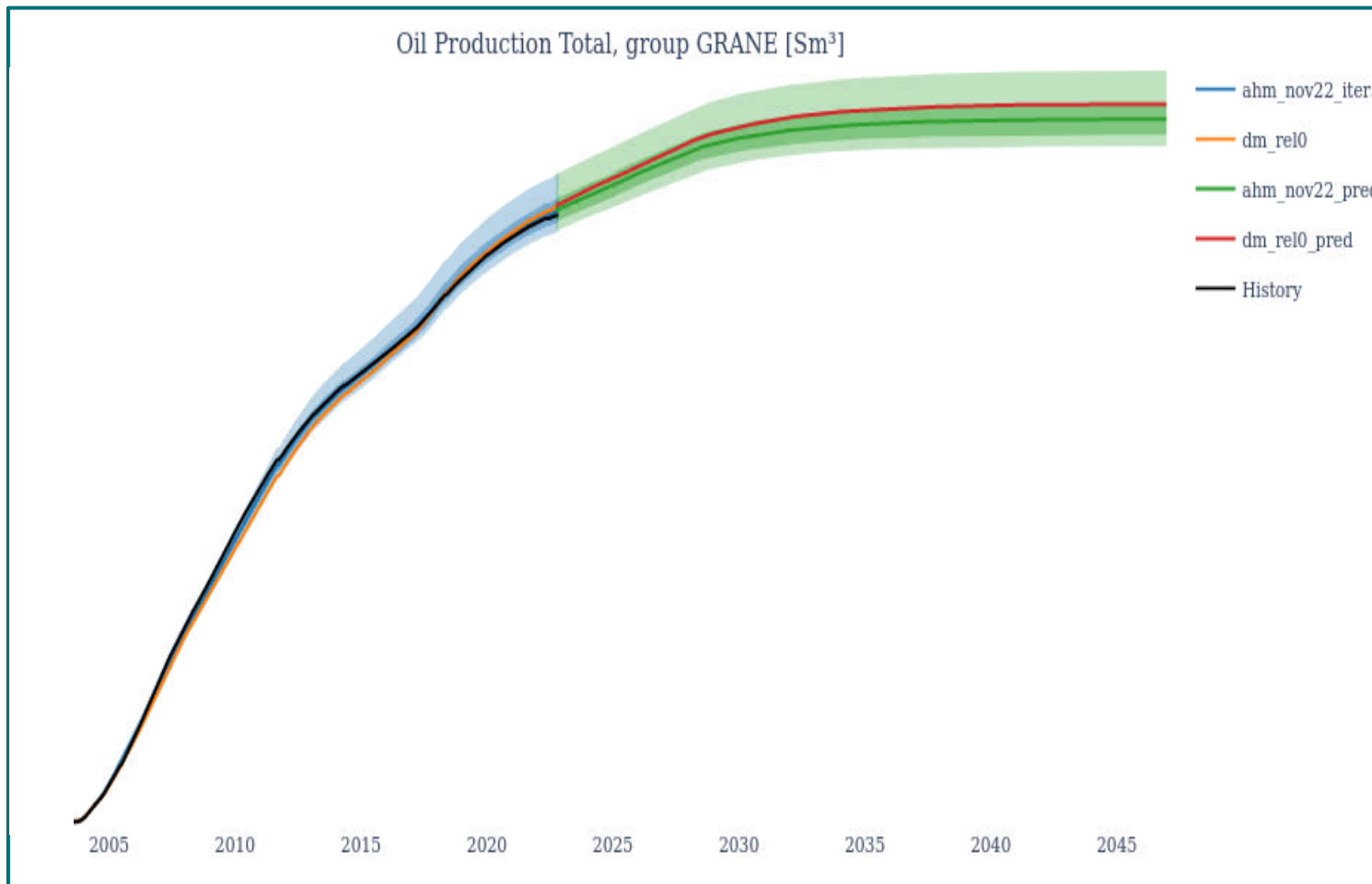
The top structure is pushed down in the south during the history matching:

Reduction in the initial volumes due to:

- Changes in oil water contact
- Sand fraction
- Structure

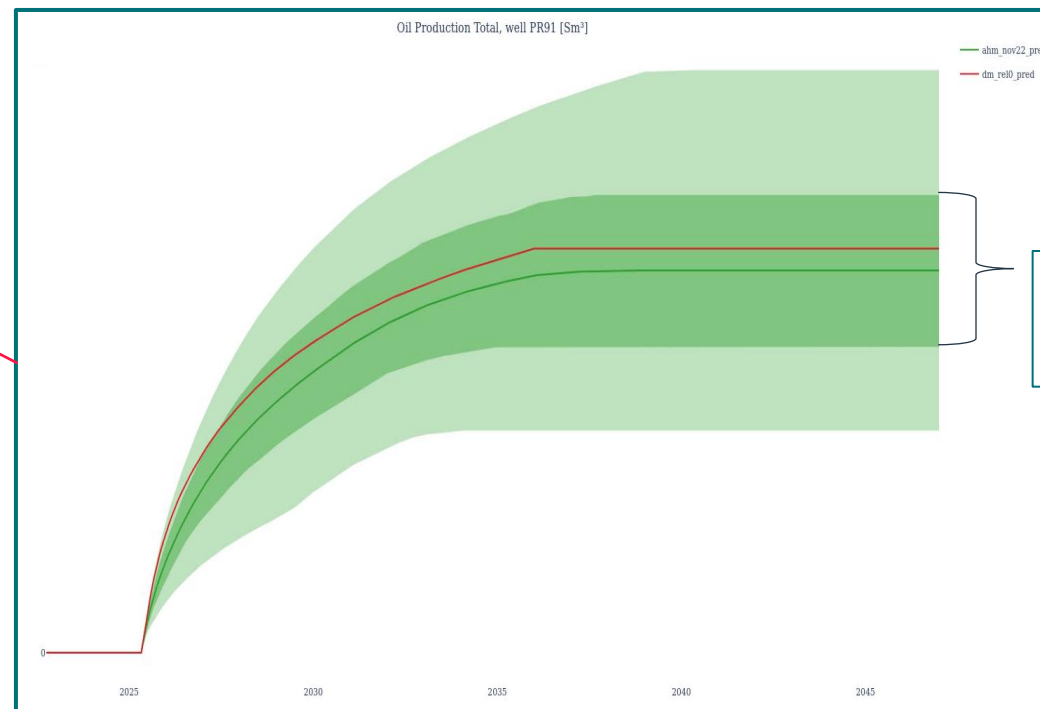
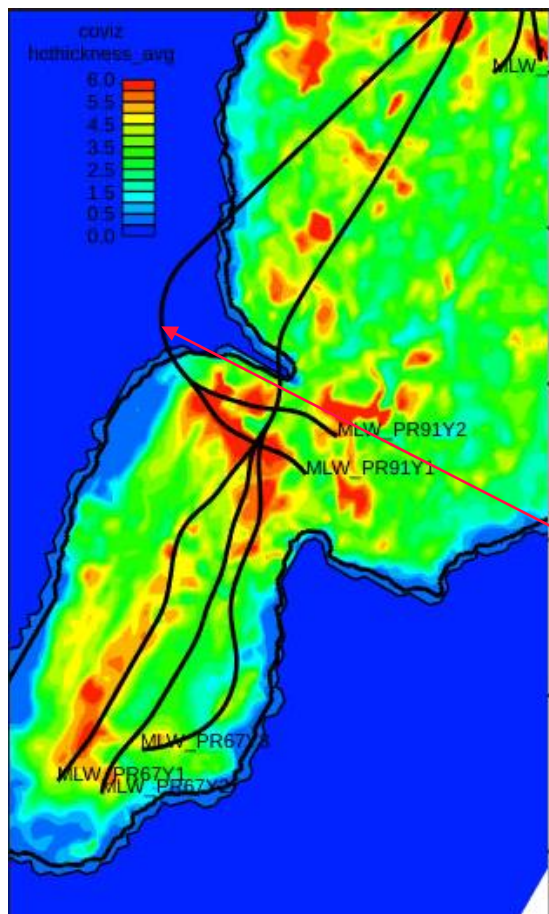
~ 2- 3 M Sm³

History matched ensemble versus reference model for prediction on field level



- Reference case model prediction – close to P10 from the ensemble
- Ensemble modeling gives a spread in the prediction
- The mean production tend to be less optimistic than the reference model

Example- future well target MLW_PR91 in south



P10-P90:
~ 370 kSm³

Closing remarks

- History matching → on group level
- Since HM started
 - One new well → impacts structure (base Heimdal)
- The models is used for the annual maturation of drilling targets and studies
- Modelling is a continuous process
- Thanks to the partners Vår Energi, ConocoPhillips Skandinavia and Petoro for letting me present





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