Getting value from simulation time: seeing decision trees rather than decision forests

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Any geomodel and simulation will be wrong in some detail. Therefore run multiple models.

However, needs are different compared to a conventional workflow:
- Search for models that are history matches yet different.
- More extensive computational power.
- More sophisticated search engines.
- Success is a portfolio of models, which is where the problem starts.

Still need clarity for decision makers:
- Who are normally used to being presented with a case, and maybe upside+downside.
Where we are going

Any individual model will fail
Surveillance needs to be practical

Generating 10 models with different geostatistics is a necessary step, but insufficient.

We need something to measure directly.
What we need are specifics (where/when/what) and outcomes:

Monitor well A01 in July 2019 for watercut, reference case expects 45%, optimistic case expects 35%.
There is one Reference Case \( \rightarrow \) 
\[ H = 2366 \]

Also, there are two additional reference cases considered:
\[ E = 2765 = \text{Reference Case 1} \]
\[ D = 2502 = \text{Reference Case 2} \]

The rest of the cases there are in the range between \( P05 \) and \( P95 \) for how much water will come with the oil.
Comparison of two assets

- Norway Yme
- Access to cloud computing
- Access to petrel workflows
  - 30kstb/d
  - 3000 simulations
- Access to decision tree tool
- Portfolio of 12 history matches.

- Non-operated
- Access to cloud computing
- Access to petrel workflows
  - 90kstb/d
  - 1000 simulations
- Conventional decision making
  - P90/P50/P10 simulations.
Cloud computing has advantages
  • We have the capacity to run multiple cases quickly
  • Norway was about 3000 simulations x 3 hours x 16 cores
Simulation cases are about 10x more intensive on cases/kbopd than a non-op compute intensive asset.

If the decision maker is just left with case 2406 vs case 2778 vs case 2376, then you’ve already lost them.

If the comparison is in an indirect variable (variogram, correlation length, Corey exponent, Pc) for case 2406 vs 2778 vs 2376, that doesn’t help

Key insight:
Get the decision maker to see value
Key insight:
Any history match tool can be used on predictions

History match compares a simulation with actual observations.

We can also compare a simulation with another simulation

So we can compare a prediction for case A with the prediction for case B, in things we can measure.
Building the 3D matrix

Conventional history match: compare to history
Simple 1D grid

New perspective: compare predictions
Extends to 2D symmetric grid

Compare at different times
Extends to 3D grid.
Plan around this branch, as this branch is 8 cases out of 12 that behave the same for the first 2 years.
Yme Beta North E1 well

Plan around this branch, as this branch is 5 cases out of 12 that behave the same for the first 2 years.
Simulation is cheap compared to a failed well, but is easily perceived as a cost.

Asset with the outcome tree tool has been allowed to use more power – about 145000 core hours. About a factor of 10 more intense per kstb/d of the asset.

Decision makers get clarity from a familiar language – decision trees.

- We don’t have to discuss underlying geological parameters
- We don’t have to refer to case names, just branches.
Three levels of sophistication

Run everything to the end of history, even if not a history match.

End models when they fail.

End models when they fail, and successes go directly into prediction.
The way Greg thinks
Recommend the optimizer can do multi objective function.

Check Giorgio’s talk

FOREACH 2 year increment {
    Check match quality.
    IF (UDQ History Match is acceptable)
    THEN
        continue
    ELSE
        the model triggers an ACTIONX END and ends cleanly
        don’t run more models that are similar to those that ended early.
    ENDIF
}

Some models reaches end of history

IF (UDQ History Match is acceptable)
    THEN
        continue into prediction
        calculate NPV for prediction
        compare with a synthetic .vol file containing NPV at the end of prediction
        tell the system to maximise the difference to a reference case
        set up an exclusion zone so we don’t get small variations.
    ELSE
        the model triggers an ACTIONX END and ends cleanly
        don’t run more models that are similar to those that ended early.
ENDIF
The way the simulator will think
Recommend the optimizer can do multi objective function.

Check Giorgio’s talk
Most runs fail to complete

For the ones that do complete

There is a .vol file to compare with.
The user has asked to match to one data type,
The .vol file has one data point at the end of time.

Find cases that have the best objective function.

Best matches are lower values
so the calculation is \(-\text{abs}(\text{NPV}_{\text{reference}} - \text{NPV}_{\text{case}})\) for cases that finish prediction
and a positive \text{RMS}_\text{error} for cases that finish history
and +1000 for cases that finish early.

and for cases that are within a short distance of existing predictions
terminate before they start
and +1000 match quality for cases that finish early.
ACTION
  IF (TIME > $daylimit1) AND (FOPT < $target1) END
ENDACTIO

Create a variable $daylimit as the number of days to check if the simulation is good compared to the target oil production.

Useful if you just want to run some initial tests on the first year of simulation

(set $daylimit to 365) and check the field is able to reach 99% of the historical oil production.)

Trims out runs that don’t match the initial history, to let the system move on to run other cases.

DEFINE FUTIME1  ABS(TIME-90) /
DEFINE FUTEST1  ABS(FGPT-400)/400 /
/
ACTIONX
  ENDO1 1/
  FUTIME1 < 0.5 AND /
  FUTEST1 > 0.1 /
/
END

ENDACTIO