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

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Context

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%.
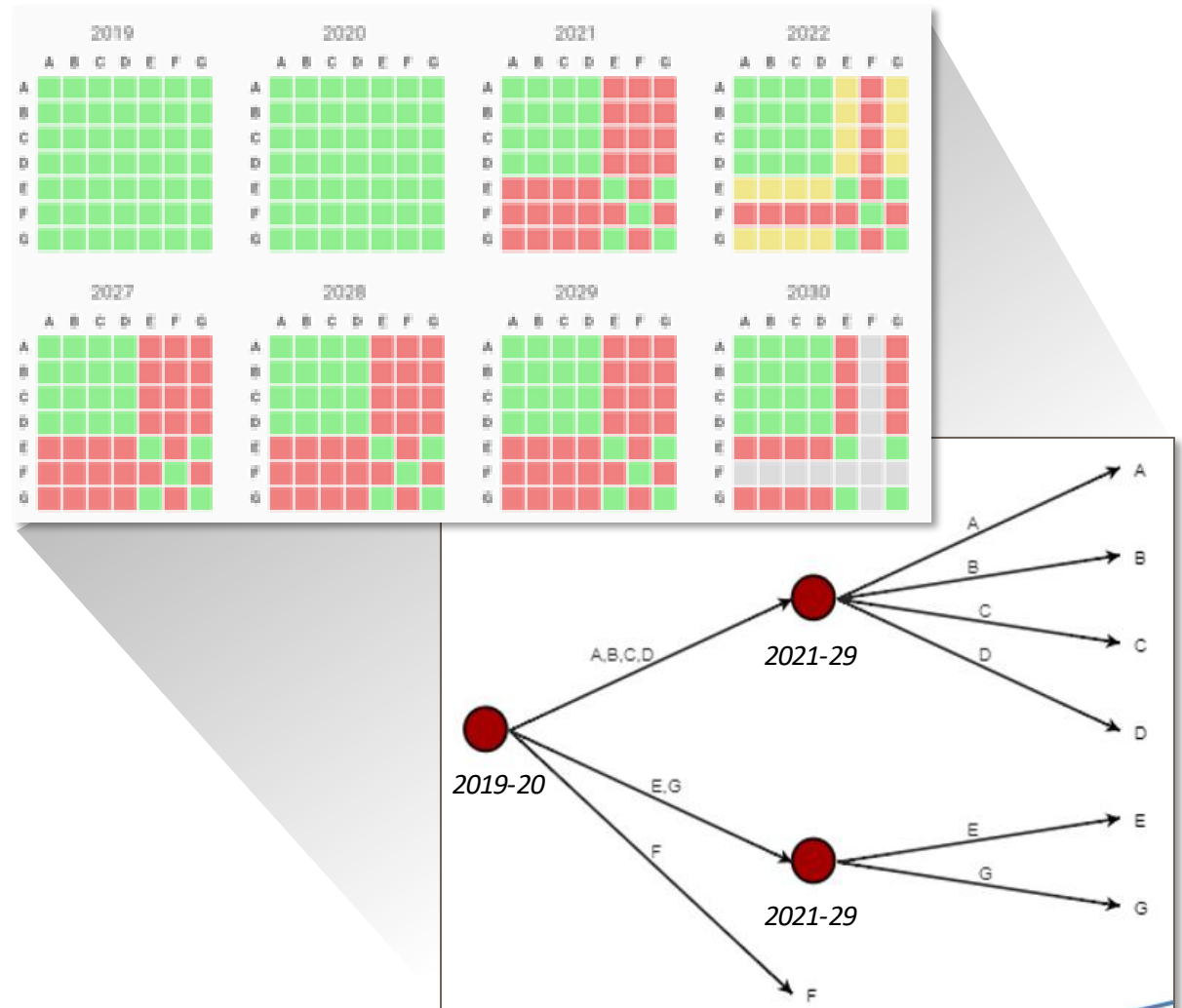
What a "successful" workflow may deliver

12 alternative history match cases were loaded:

A - 2778_P74

B - 2490_P05

C - 2780_P76

D - 2502_REF CASE_1

E - 2765_REF CASE_2

F - 2620_P90

G - 2764_P75

H - 2366_REF CASE

I - 2376_P10

J - 2455_P25

K - 2622_P95

L - 2406_P50

There is one **Reference Case →**
H = 2366

Also, there are two additional reference cases considered:
E = 2765 = Reference Case 1
D = 2502 = Reference Case 2

The rest of the cases there are in the range between P05 and P95 for how much wáter 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.

Key insight:
Get the decision maker to see value

Cloud computing has advantages
- We have the capacity to run multiple cases quickly
- Norway was about 3000 simulations x 3 hours x 16cores

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:
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.
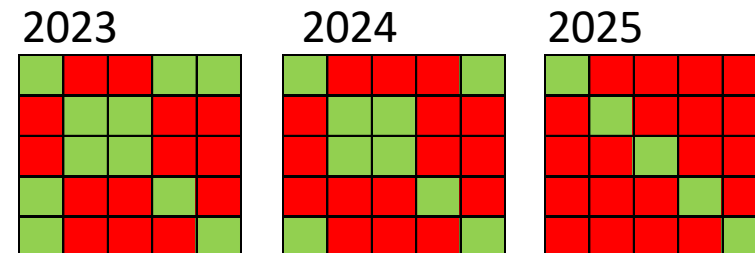
Building the 3D matrix

Conventional history match: compare to history
Simple 1D grid
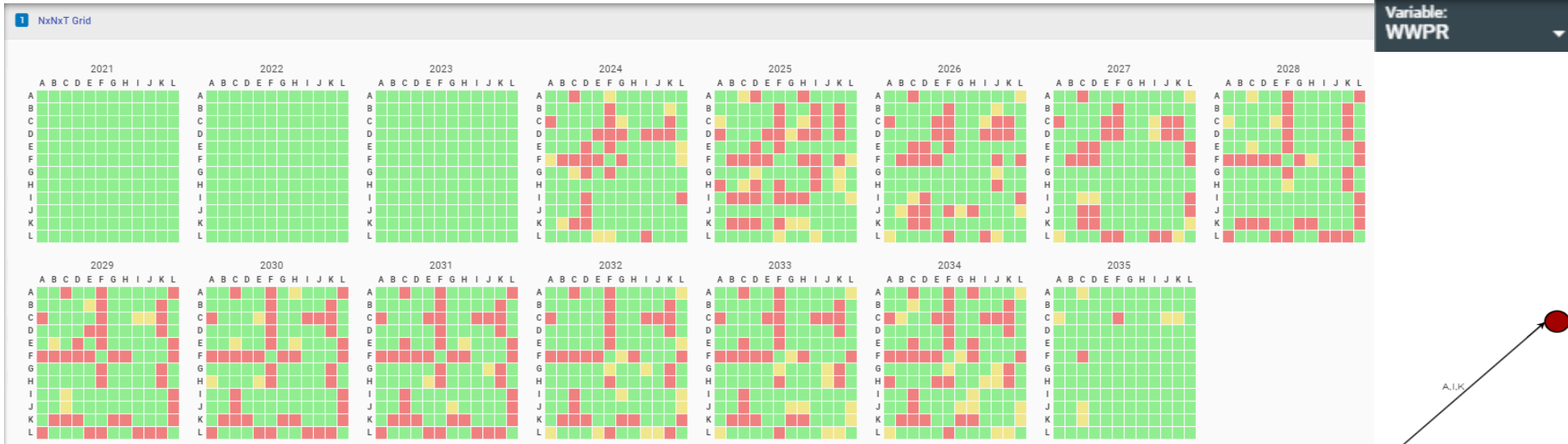
History		Case A	Case B	Case C	Case D	Case E

New perspective : compare predictions
Extends to 2D symmetric grid

Prediction for 2023		Case A	Case B	Case C	Case D	Case E
Case A						
Case B						
Case C						
Case D						
Case E						

Compare at different times
Extends to 3D grid.

2023   2024   2025

Yme Gamma SW 9 well

Plan around this branch, as this branch is 8 cases out of 12 that behave the same for the first 2 years.
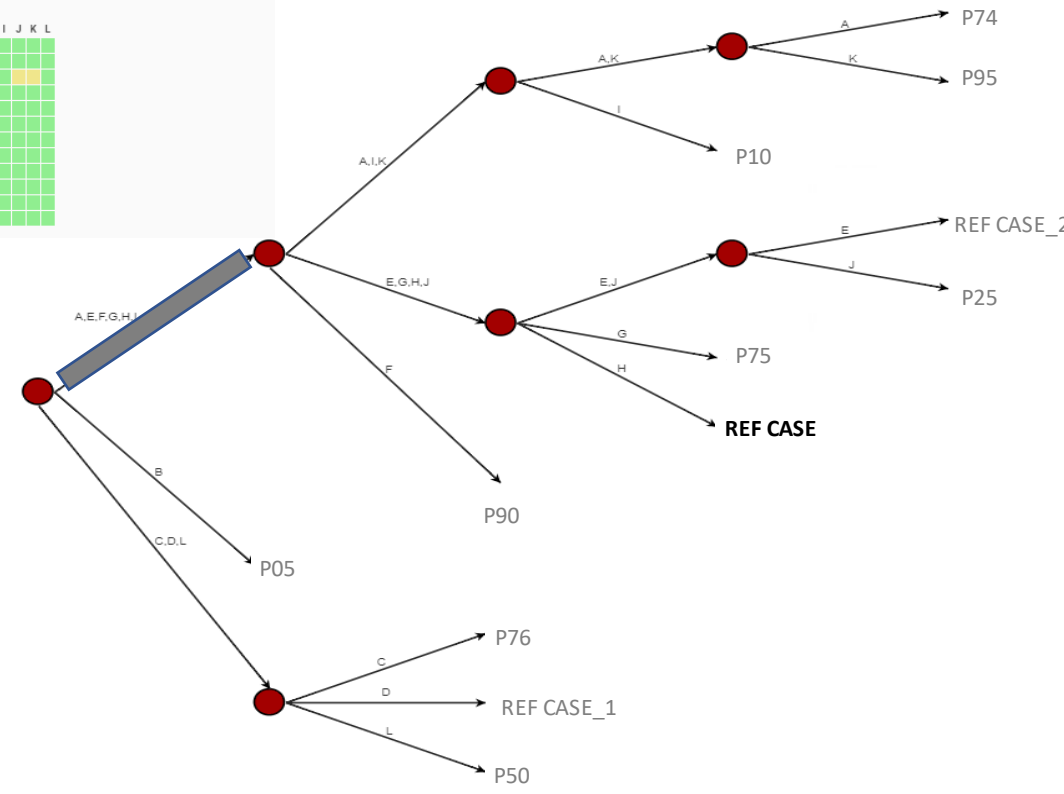
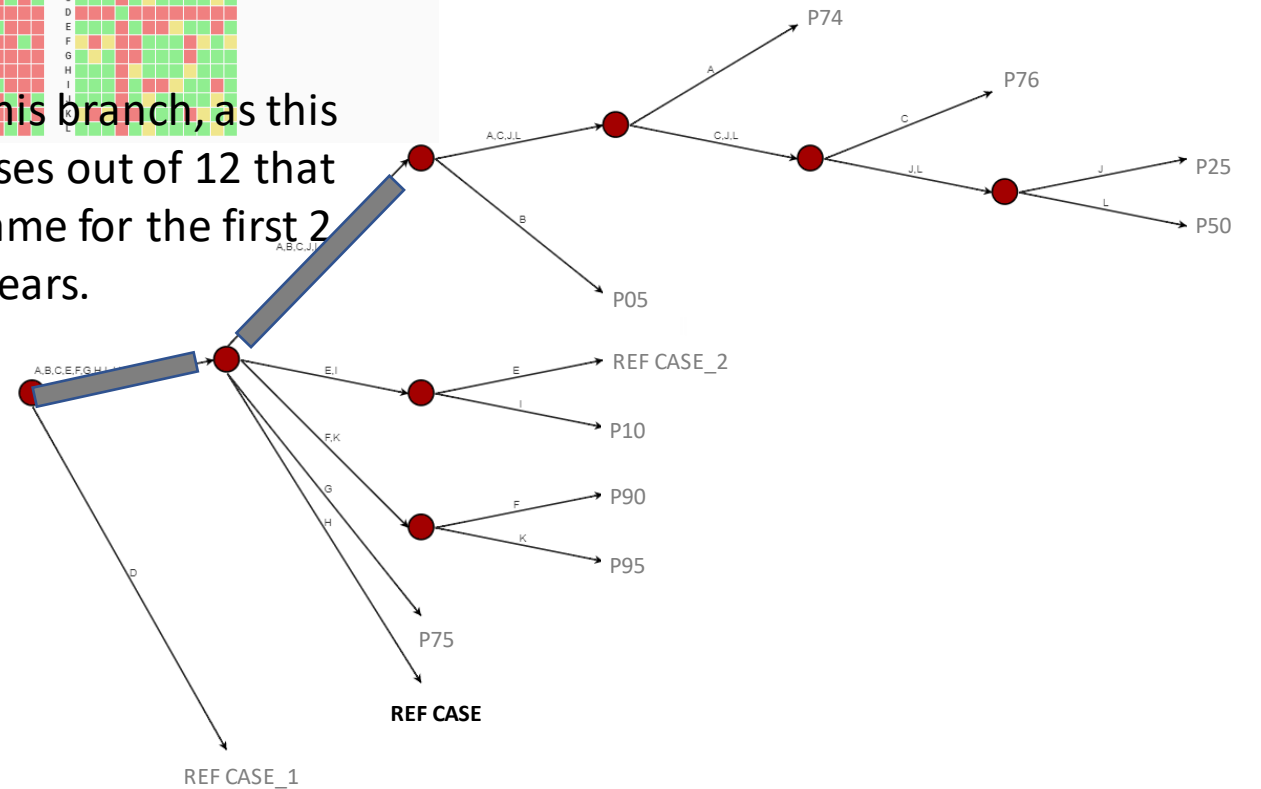# Yme Beta North E1 well
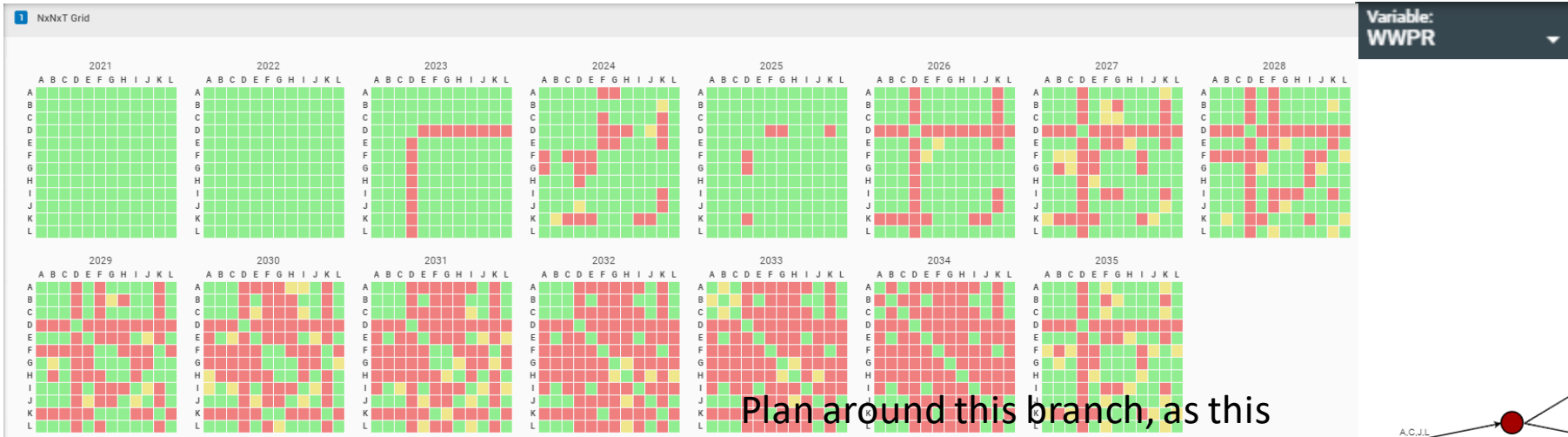
Plan around this branch, as this branch is 5 cases out of 12 that behave the same for the first 2 years.

Comparison

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
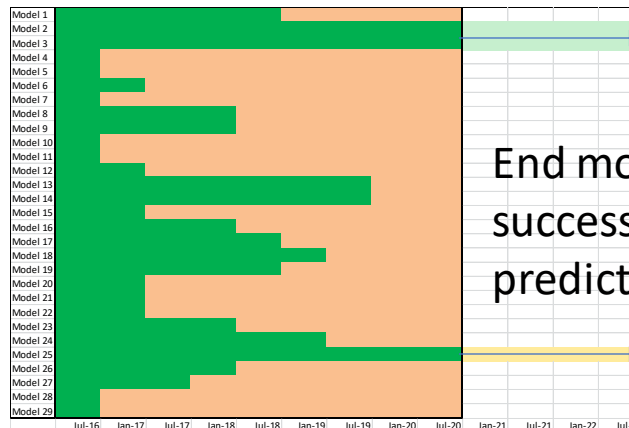- We don't have to refer to case names, just branches.

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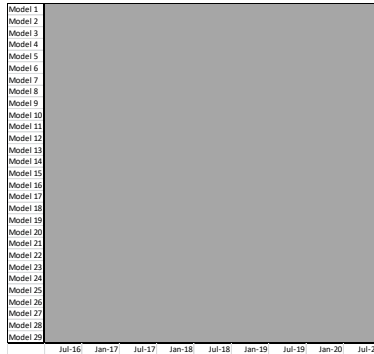
Run everything to the end of history, even if not a history match.

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 exclusión 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 $-abs(NPV\_reference - NPV\_case)$ for cases that finish prediction
       and a positive RMS_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.

Setting a history match test within a workflow

```
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
 ENDQ1 1/
 FUTIME1 < 0.5 AND /
 FUTEST1 > 0.1    /
 /
 END

 ENDACTIO
```