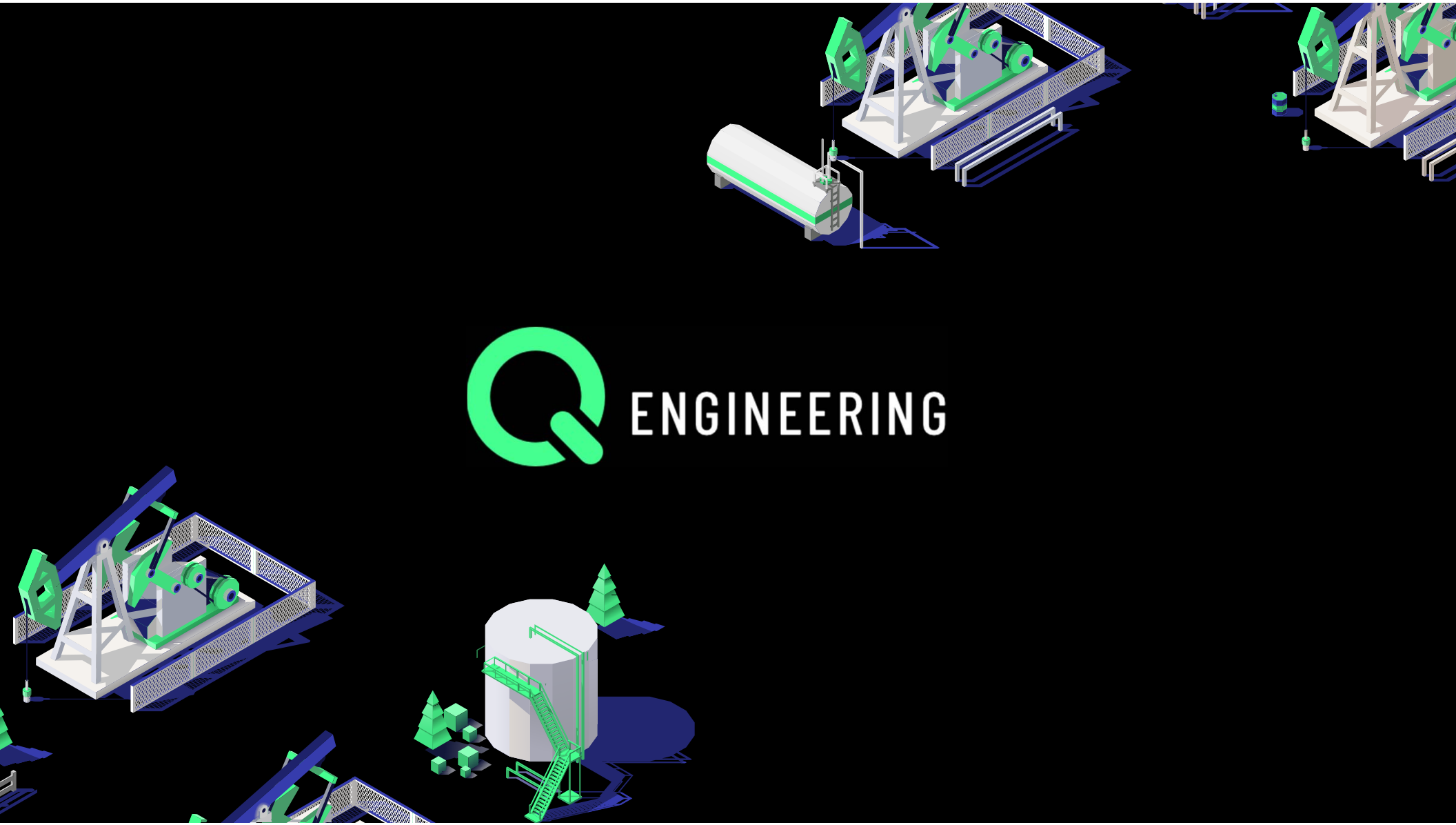
ENGINEERING

USING CLOUD TECHNOLOGY TO IMPROVE PREDICTIONS

Presented By: James Ruiz

14th Annual Ryder Scott Conference

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INTRODUCTION

- background -> james ruiz
- Q's mission -> to 10x transaction speed, by partnering with the top oil and gas operators
- how -> use the cloud to simulate forecasts, type wells, and profitability
- why cloud -> the fastest possible way to easily prototype and scale powerful innovations

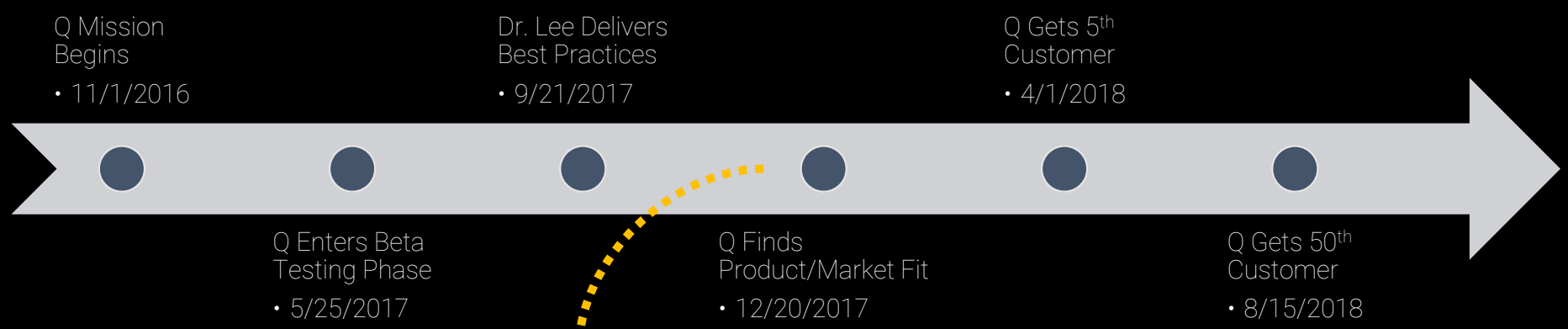
ABOUT

the metrics

- ~ 1 billion simulations per month
- ~ 15 million well predictions created
- initiative began < 2 years ago
- growth began < 5 months ago
- > 50 E&P customers in last five months
- ~ 5 thousand type well predictions for actionable investments
- Tibco (Spotfire) Partner
- Amazon Web Services (AWS) Partner

INTRODUCTION

a startup's journey



- Q brands TypecurveStudio
  - because Dr. John Lee & Randy Freeborn Automated Type Well Generator was too long
  - when TypecurveStudio was named, we didn't know that Type Well was the new rave

LAST YEAR AT THIS CONFERENCE

Dr. John Lee delivered his best practices for type well generation

BEST PRACTICES

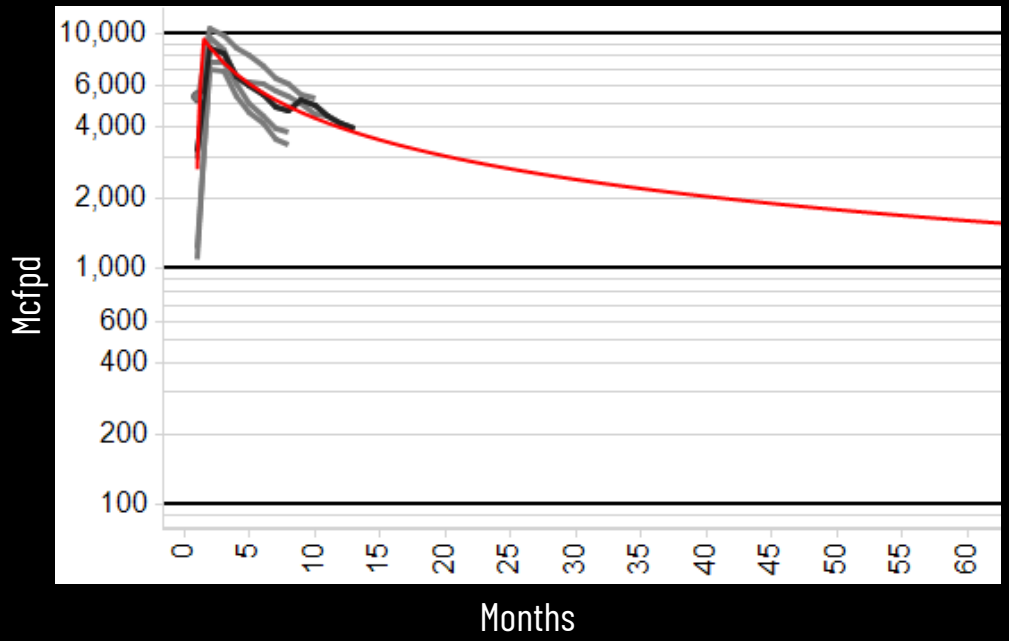
a refresher

- Dr. John Lee, RSC 2017
  - Identify objective of type well
  - Select wells to use in type well construction, consistent with objective
  - Place wells into bins with ≥50 wells
  - Scale as needed to normalize well production
  - Forecast each well separately, rather than group and then forecast
  - Avoid survivorship bias
    - Include abandoned wells (with zero rate) in well count
    - Forecast future production for wells with short histories
  - Avoid “time slice” method
  - Validate results

THE CLASSIC STORY

type well prediction leads to a menacing investment

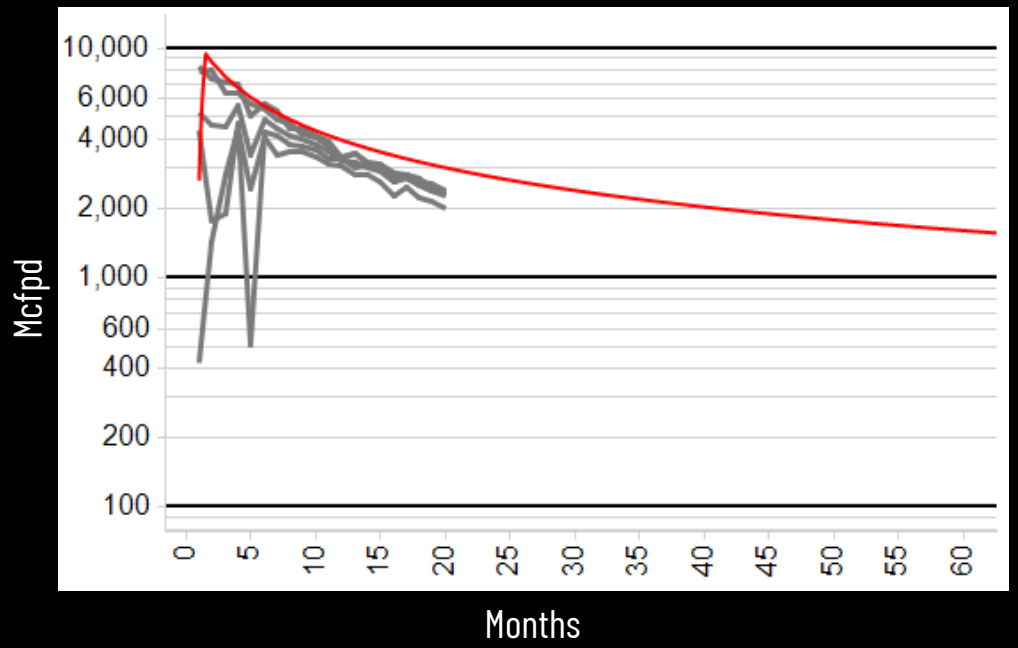
- Recent vintage wells are frequently picked to construct type wells
- Leads to small bin sizes
- Wells were normalized using treated/completed lateral length
- Time-slice method was used to create a forecast
- Average time-slice was honored, resulting in a 14 Bcf type well



THE CLASSIC STORY

new wells are drilled

- Investment is approved, and a drilling campaign begins
- BUT… to the company's dismay, every well underperforms the type well
- Management is less than pleased!



THE CLASSIC STORY

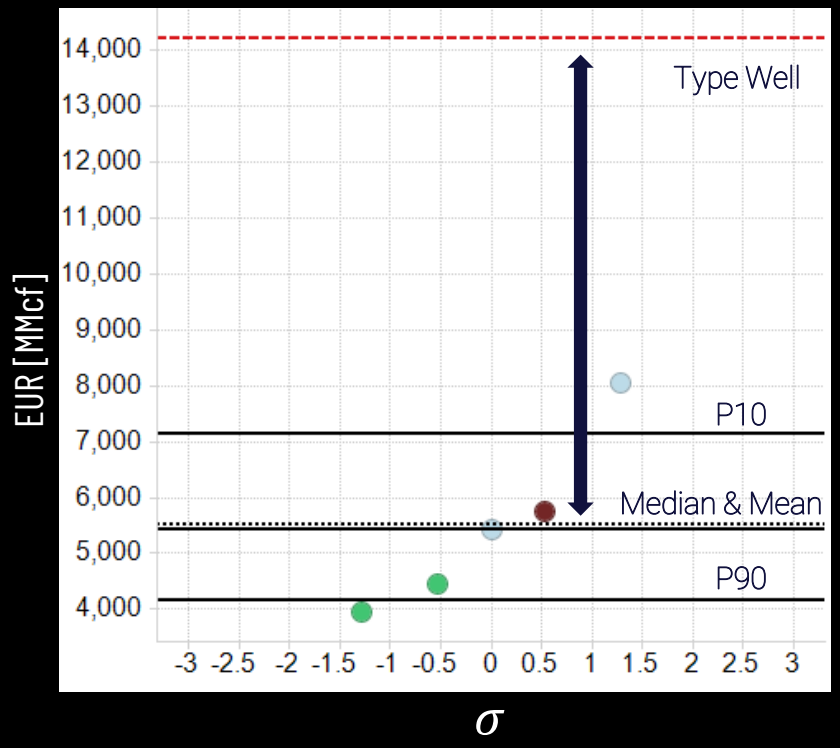
reconciliation takes place

- The reservoir engineers are asked to reconcile the gap between prediction and actuals
- Decide to re-forecast each of the constituent wells in their type well population
- A probit plot is created to identify how their prediction relates to the distribution of results

THE CLASSIC STORY

reconciliation reveals that the prediction is outside of best-practices

- After investigation, the reservoir engineering team realized that the P10 EUR was actually 7 Bcf, half of the 14 Bcf prediction



BEST PRACTICES

are people using them?

- Met with the brightest engineers across 100 operators
- Most are aware of the problem, but don't have the time to employ best practices
- To implement, engineers generally have to forecast 100-200 wells before creating a type well, this evaluation friction is enough to justify deferring the use of best practices for the sake of economy
    - Focus to reduce this friction

BEST PRACTICES

how can we improve deal flow & evaluation speeds, without compromising best practices?

- Dr. John Lee, RSC 2017
  - Identify objective of type well
  - Select wells to use in type well construction, consistent with objective
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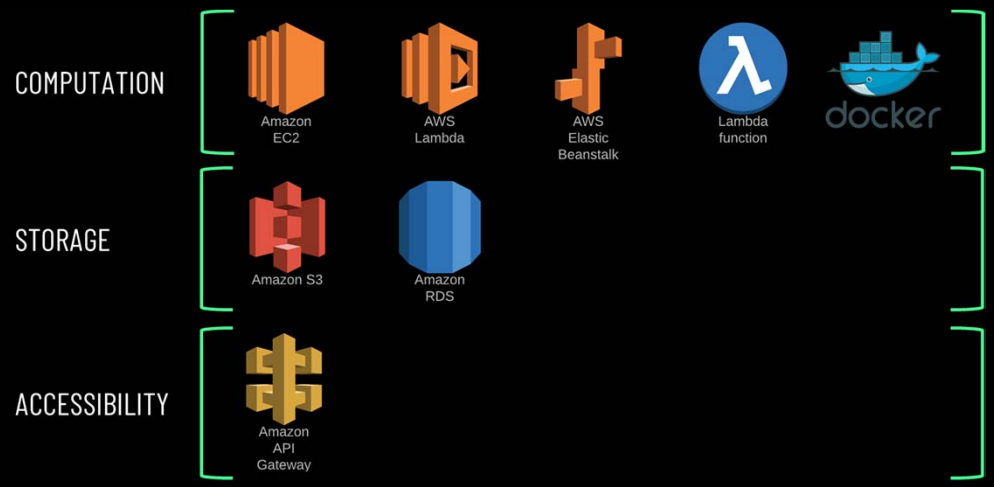
HOW Q IMPROVED PREDICTIONS

using the Amazon Cloud (AWS)

THE PROPOSED BEST PRACTICES REQUIRE COMPUTE

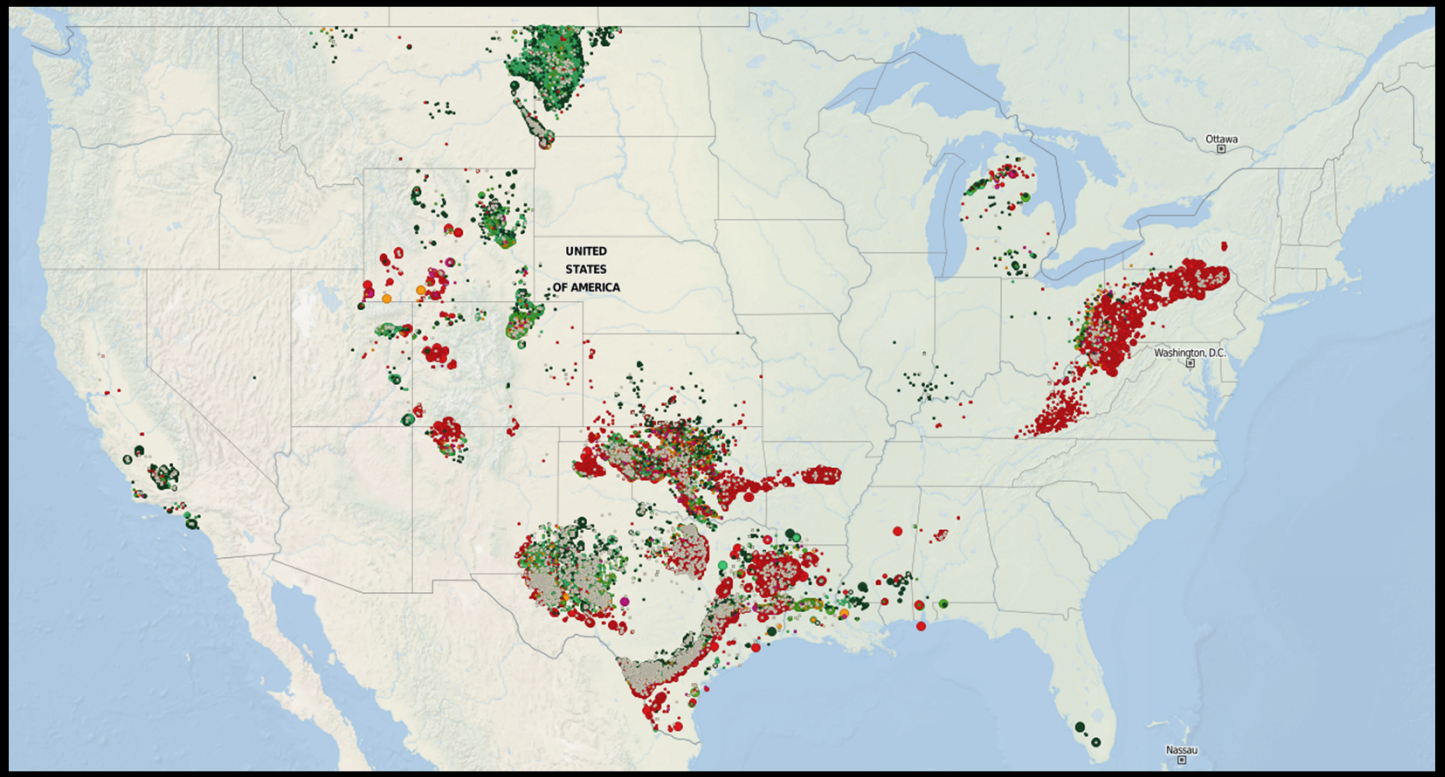
a lot of it, so we built a cloud computer with AWS components

- Can deliver forecasts & type well predictions in near real time
- Can scale to over 100 billion simulations per month
- Encrypts data stored in system
- Can hold every well in the United States, millions of times over



ENGINEERS WERE LIMITED BY SCALE

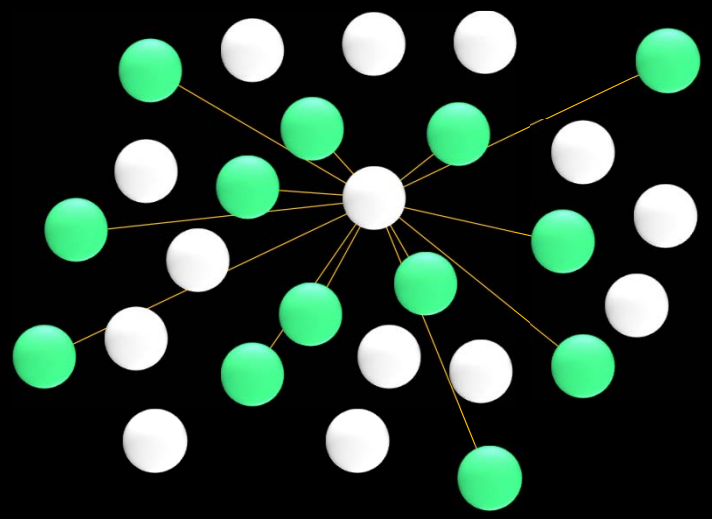
AWS has over 2 million servers, one can load every well in the united states many times over



EFFECTIVE AUTO-FORECASTING IS NOW A NECESSITY

best practices require an engineer to forecast 100-200 wells, per type well

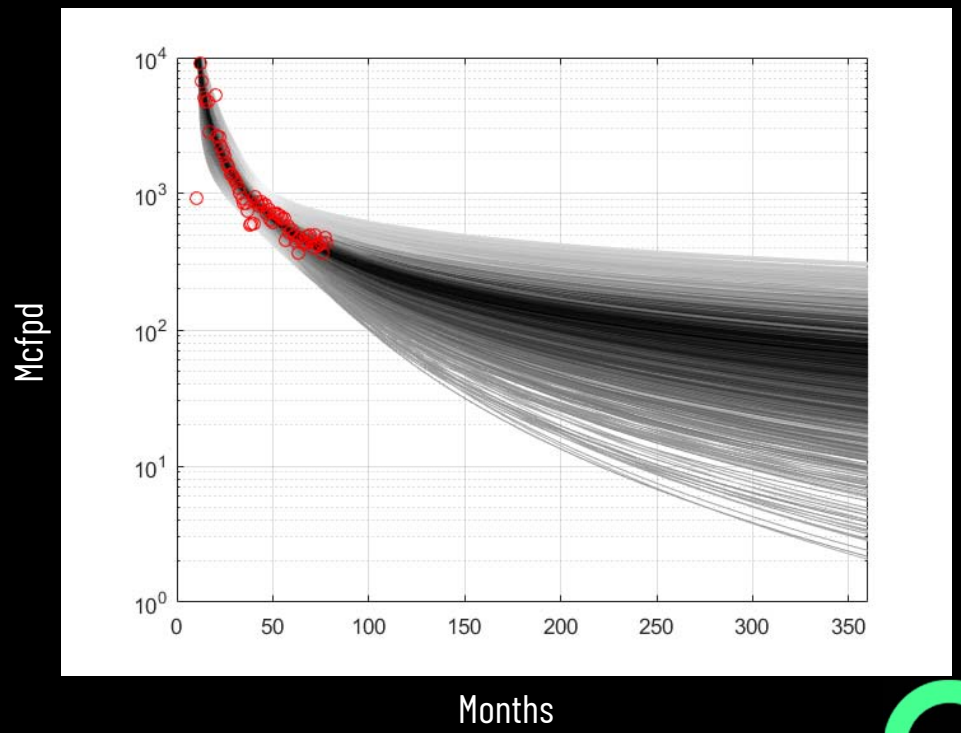
- Automated forecasting has traditionally been limited in effectiveness – algorithms were not designed to learn, as engineers do
- Engineers learn as they forecast more and more wells
- An effective automated forecasting system should learn as well
- By making the database size unlimited, we were able to load every learning candidate possible
- These computational requirements to build this type of model are tremendous, requiring an elastic configuration in the cloud



WHY ADOPT A PROBABILISTIC FRAMEWORK?

regressing on least error does not lead to the best fit

- There are many possible forecast realities, a probabilistic system seeks to explore the entire domain
- The probabilistic framework provides an engineer with the ability to have more control over the risk that they choose to model into their predictions



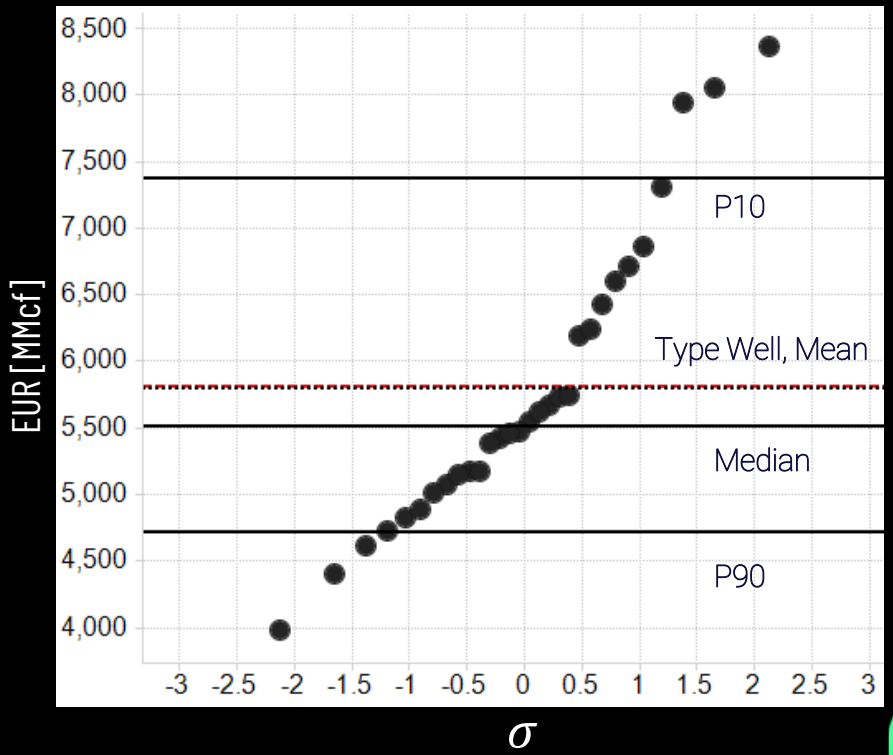
AWS Elastic Beanstalk

By using AWS Elastic Beanstalk, we were able to run 25 thousand simulations in less than 100 milliseconds

BEST PRACTICE: FORCAST EACH WELL & VALIDATE

type wells need to be evaluated within the context of the wells around it

- Engineers like instantaneous feedback
- Every time a type well is updated, ensure alignment with your objective (mean, P50, etc.)



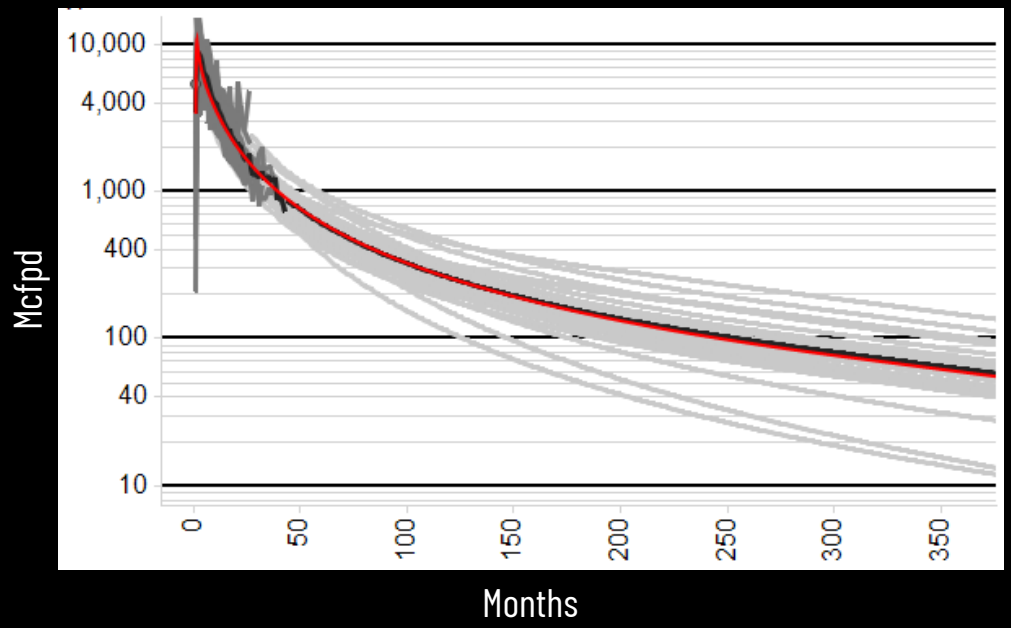
AWS Lambda

Using AWS Lambda, we were able to create this feedback loop nearly in real-time

BEST PRACTICE: GROUP THE FORCASTS

don't forecast the groups

- This practice identifies inconsistencies in individual well forecasts
- Grouping the forecasts prevents bias from wells with a short producing history



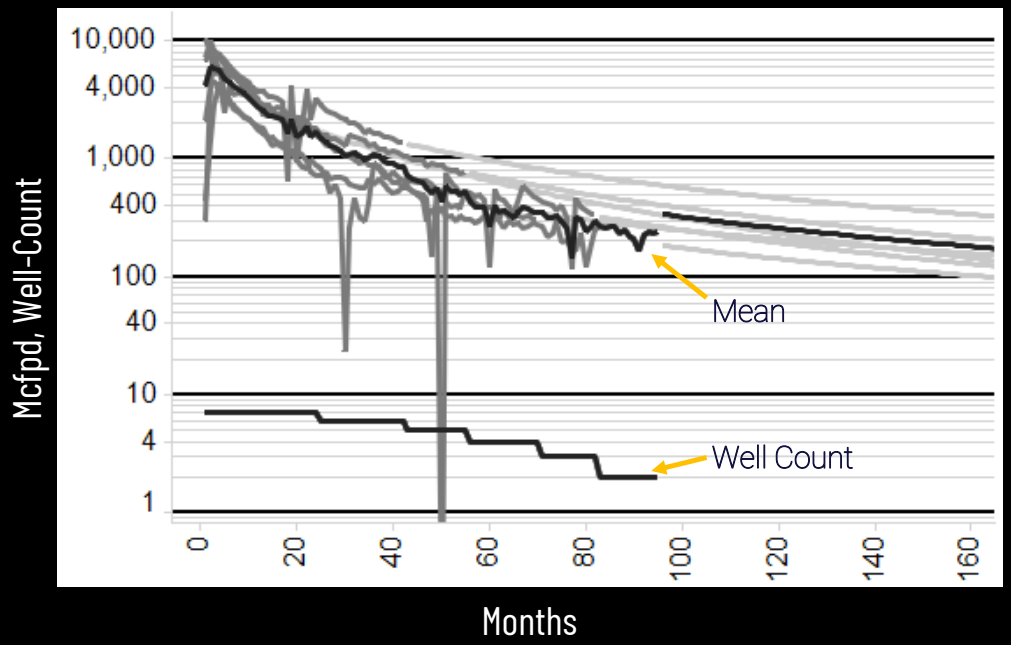
AWS Lambda

Using AWS Lambda, we implemented this feature to compute as the well selection changes

BEST PRACTICE: AVOID SURVIVORSHIP BIAS

sample size cutoffs lead to inconsistent results

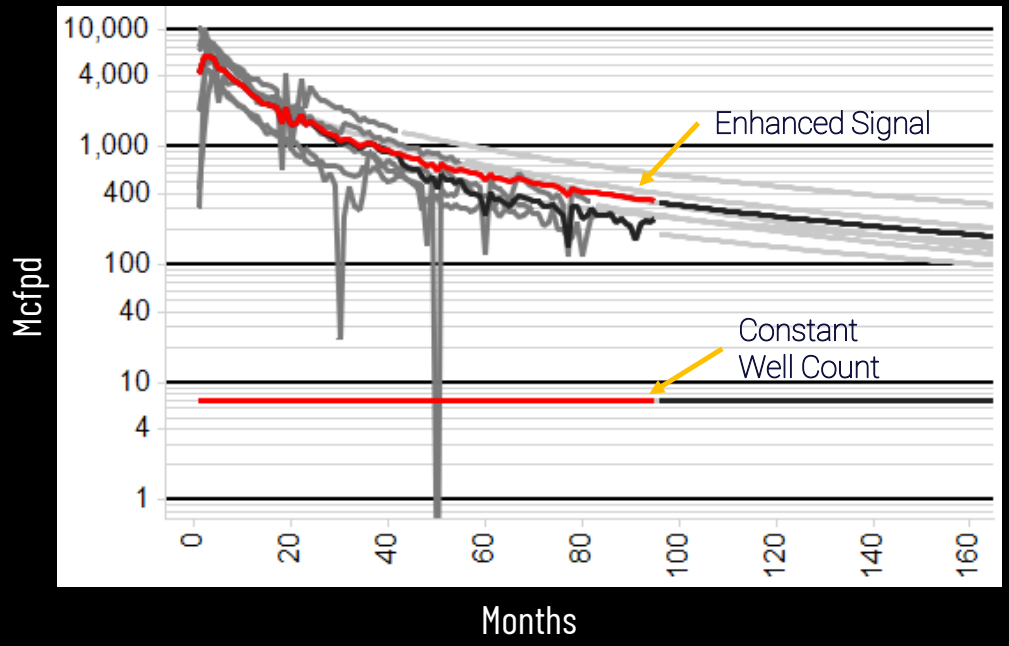
- Traditionally, sample size cutoffs are used to identify when to stop “trusting” the average production stream
- With collections of mixed vintages, this can lead to erroneously low, or high, type well predictions
- This averaging technique does not provide enough signal from individual well collections



BEST PRACTICE: AVOID SURVIVORSHIP BIAS

by using a constant sample size

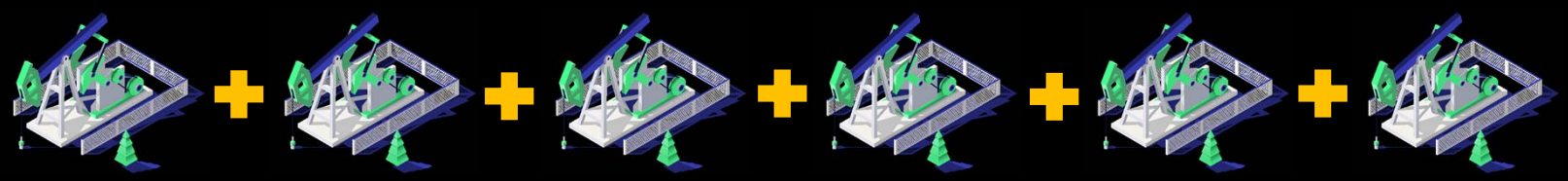
- A proposed method from FourPoint, and Marathon, enhances the signal in the average line by holding the sample size constant
- The constant sample size method, replaces the truncated well history with the forecast from the individual wells
- This enhances the signal by honoring operational events, while bridging the gap between grouped production, and grouped forecasts
- Grouping the forecasts alone washes out the buildup period and subtle production characteristics that engineers use to inform their predictions



VALIDATE THE TYPE WELL

how well does one type well actually model performance?

- Compare the actual production wedge, to a production wedge of type wells

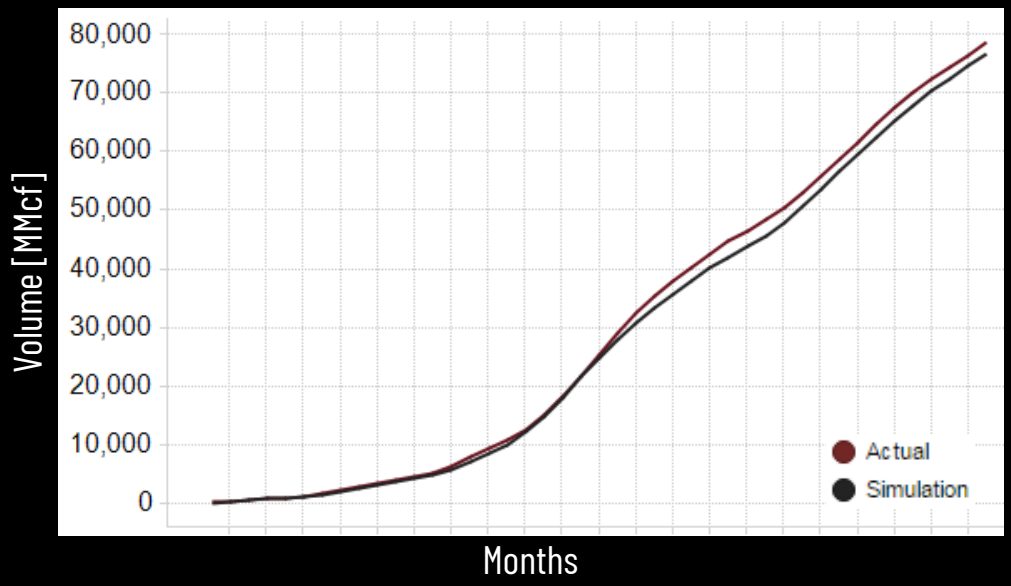


Re-drill Well 1	Re-drill Well 2	Re-drill Well 3	Re-drill Well 4	Re-drill Well 5	Re-drill Well 6
Drill Type Well	Drill Type Well	Drill Type Well	Drill Type Well	Drill Type Well	Drill Type Well

VALIDATE THE TYPE WELL

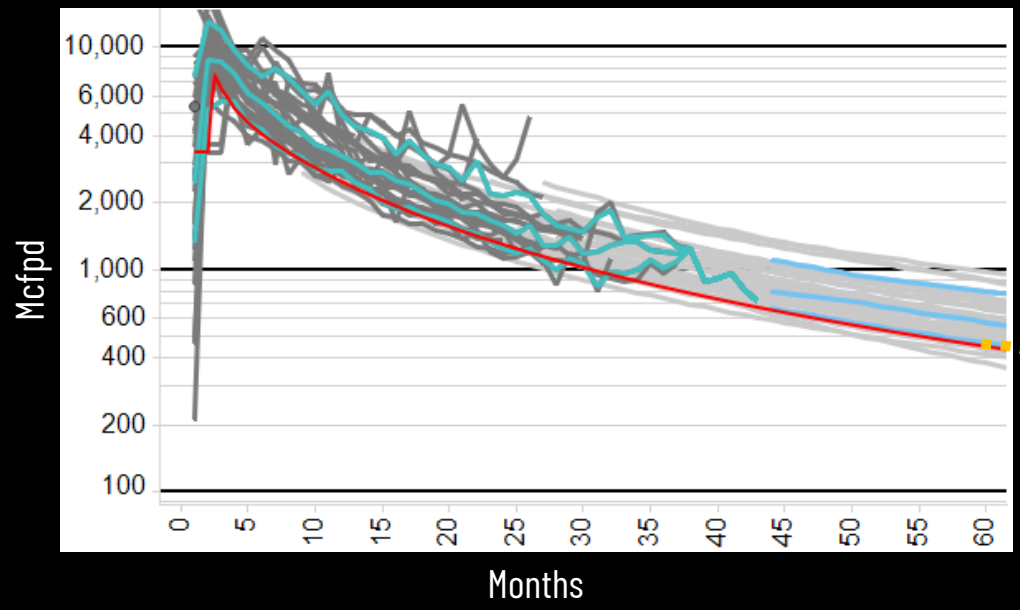
how well does one type well actually model performance?

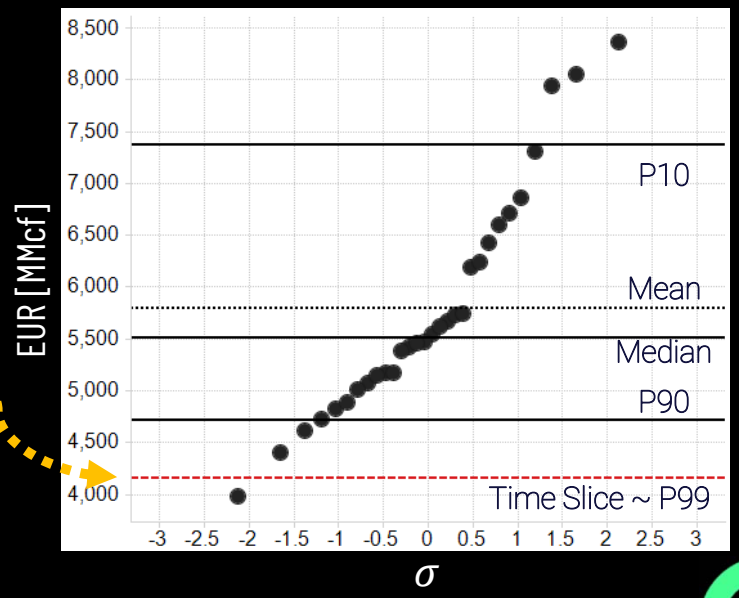
- Although history matching has normally been reserved for highly technical models, one can also apply it to simple drilling models
- One can create a drilling program of actual wells, rollup the production wedge, and compare it to the wedge composed only of type wells
- By matching the two wedges, one can gain confidence that the modelled type well can predict their next drilling campaign



BEST PRACTICE: AVOID THE TIME SLICE METHOD

using P90 “time-slice” generates a P99 prediction in this scenario

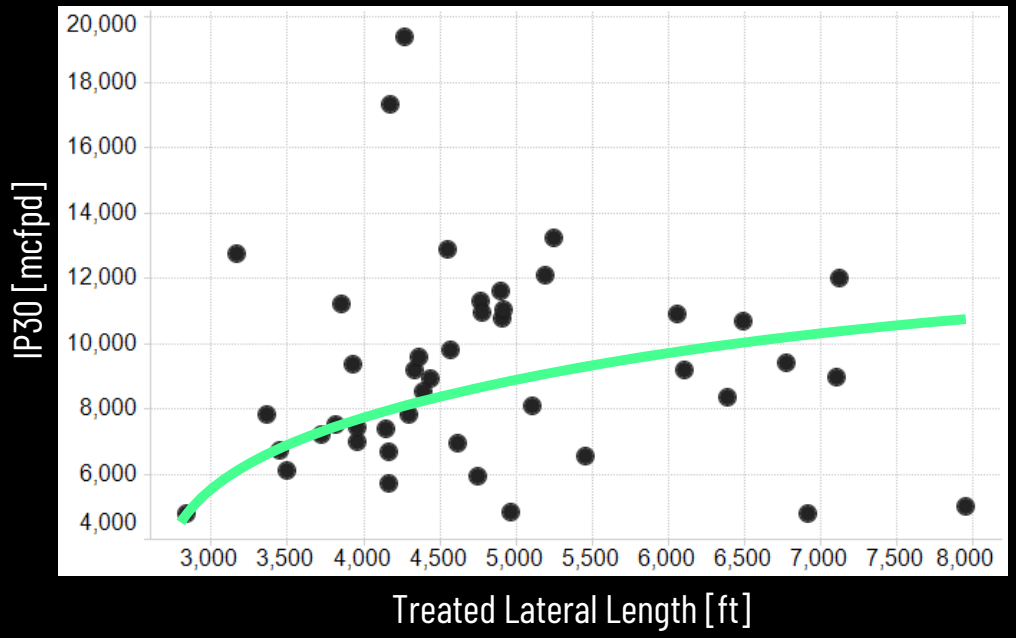




BEST PRACTICE: UNDERSTAND WHAT YOU NORMALIZE

avoid using the shortest wells in the field to predict the longest wells

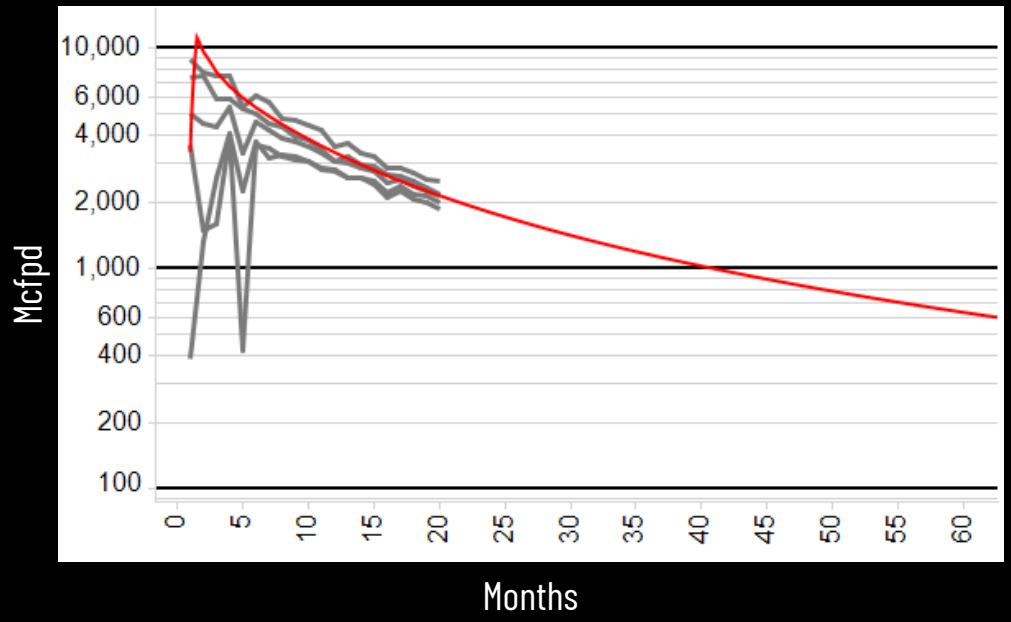
- It is generally understood that IP does not scale well with treated lateral length, as the graphic illustrates
- When using an automated system, one must account for this carefully selecting the wells in a type-well group



ALTHOUGH IP NORMALIZATION ISN'T PERFECT

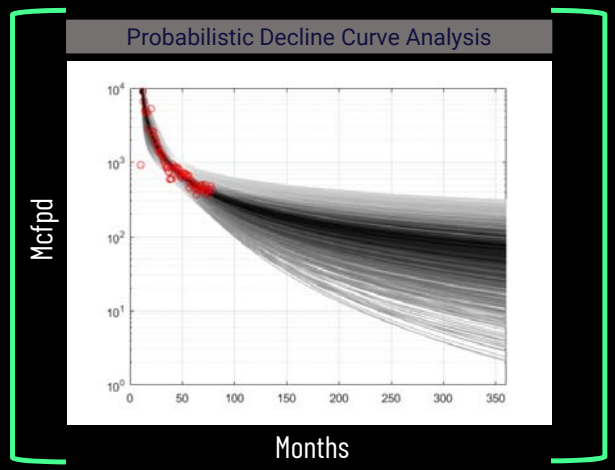
sometimes it's the only tool that you have

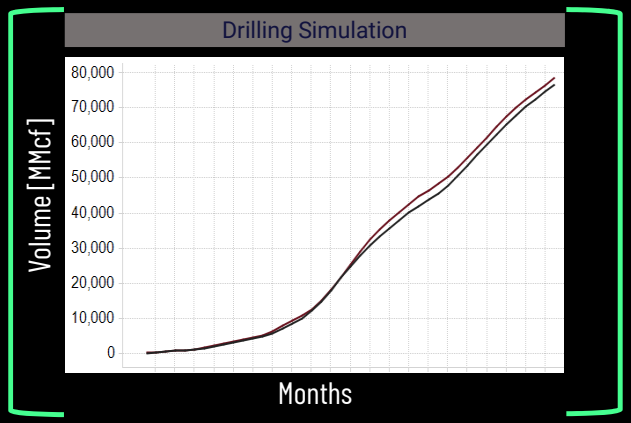
- The new wells that were drilled align more closely with the prediction, however, new PDM techniques were applied to the new generation of wells that were drilled
- We have observed that EUR's appear to have stronger correlations than IP when measured against lateral length
- We recommend that engineers develop an understanding of how the shape of the production profiles change with lateral length, and build sensitivities into their decision

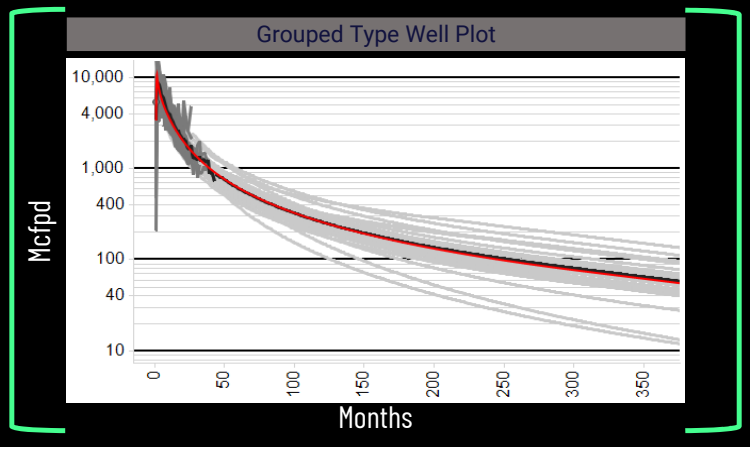


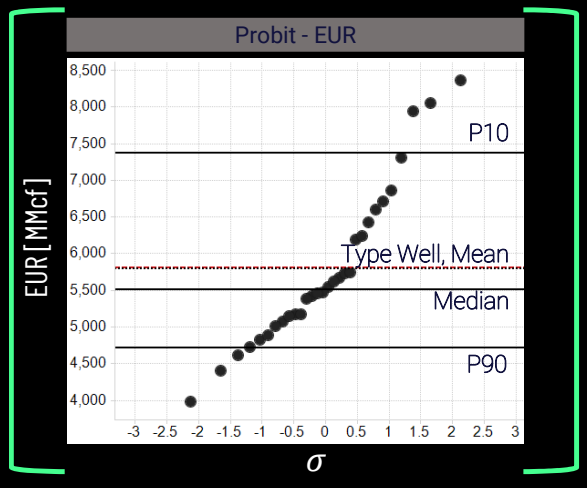
CALIBRATED TYPE WELLS CAN BE CREATED IN REAL TIME

by combining a probabilistic framework, grouped forecasts, history matching, and probit analysis









IN SUMMARY

- Cloud implementation is in practice by over 50 E&P companies
- The best practices delivered by Dr. John Lee have been validated by more than 300 engineers
- By creating a fit-for-purpose cloud computer, we have been able to implement the industry's best practices in a nearly real time process, achieving more than a 10x improvement in valuation speed
- The cloud was chosen as the framework of this analysis because methods can be created, tested, and scaled in minutes – this is simply not possible with desktop solutions
- Grouping forecasts, history matching, and probabilistic forecasting are the new norm, and we are working diligently on removing errors due to time-slicing & survivorship bias

FUTURE

my hopes

PYTHON WILL BECOME AS USEFUL AS EXCEL

PyQTools

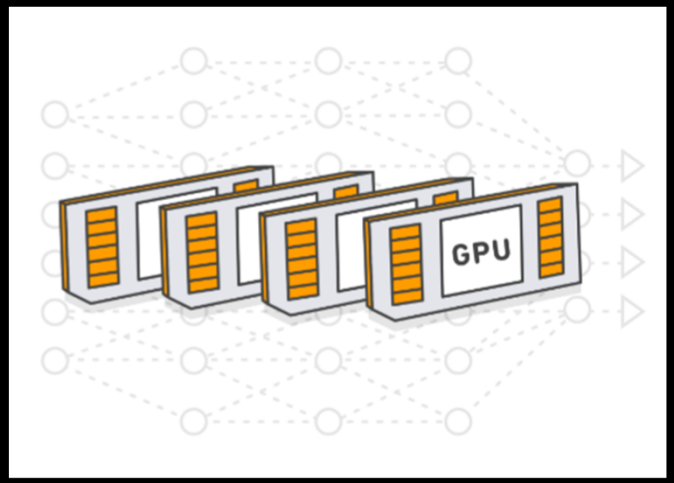
- More and more engineers know Python
- Custom workflows will be created by leveraging best practices as a service
- Engineers can focus on creating novel workflows, without having to rebuild the fundamental building blocks

```
from PyQTools import cloud_forecaster, cloud_typewell_generator

forecast_results = cloud_forecaster(wells = [well1, well2, well3], inputs)

typewell_results = cloud_typewell_generator(wells = forecast_results)

plot(typewell_results)
```

MASSIVE SIMULATIONS WILL BECOME COMMONPLACE

just as common as forecasting

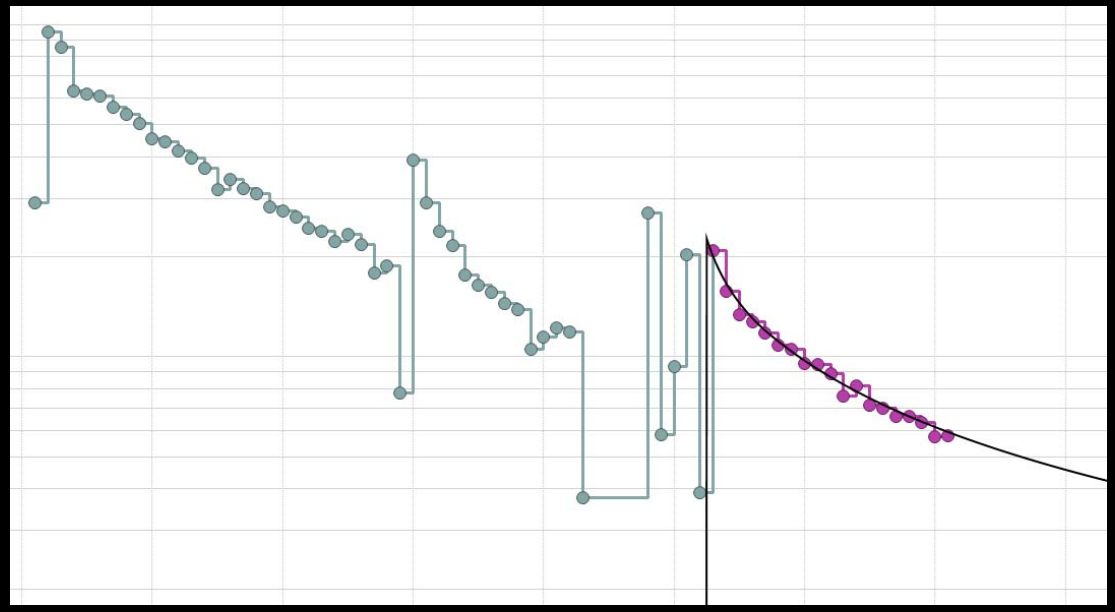
- With massive improvements in automated forecast quality, there is a need for ways to easily access fast, robust forecasts very quickly
- An appropriate forecasting system must allow engineers to alter forecasts, save forecast versions, and tune the way the forecasting model runs
- We are testing arrays of elastic GPU's to achieve this task, it is one of our most ambitious effort to date



TO MAXIMIZE ACCURACY

segmentation will be improved to isolate operational events

- In order to improve forecasts, engineers will need to create reliable algorithms to segment operational periods within a wells history



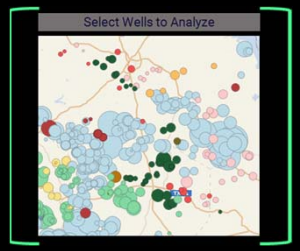
THANK YOU

standing on the shoulders of giants

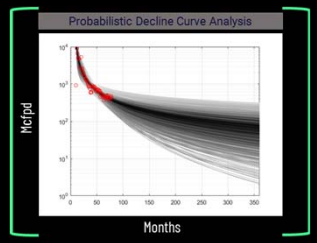
by james@q.engineering

GENERAL WORKFLOW

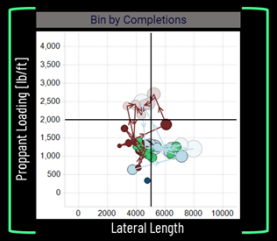
SELECT WELLS

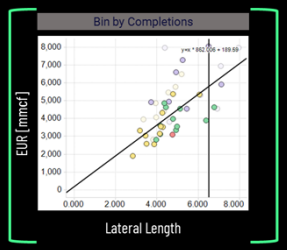


FORECAST ALL WELLS PROBIBILISTICALLY



BIN & NORMALIZE





GROUP, TYPE WELL, & VALIDATE