DIRECT: **DI**gital **RE**servoir **C**haracterization **T**echnology

Industrial Affiliates Proposal

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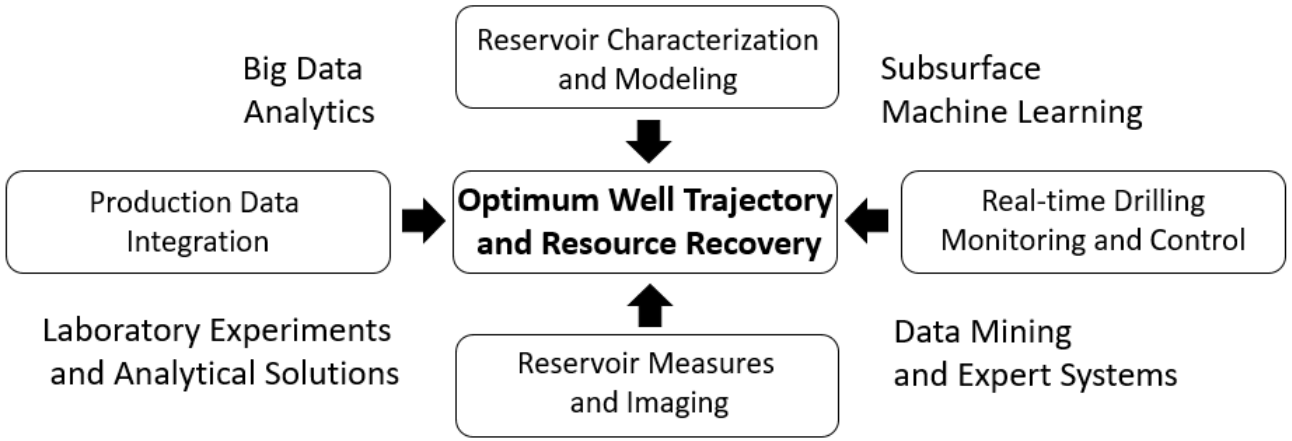
Optimum well trajectory and resource recovery through integration of engineering, data analytics, and machine learning.



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UT Petroleum and Geosystems Engineering
Geomechanics, Drilling Automation and Expert Systems

Prof. Carlos Torres-Verdin
Petroleum and Geosystems Engineering
Geophysics

Our Opportunity

Combine best-practice and cutting-edge technology in

reservoir spatiotemporal characterization and modeling

real-time drilling control

production data integration

reservoir geophysics

with emerging technology in

big data analytics and machine learning

to optimize well trajectory and resource recovery.

data analytics and machine learning with engineering and geoscience

Our Opportunity

Develop integrated modeling and decision support systems to solve the following outstanding problems:

Integration: Maximizing the integration of deterministic engineering, geological description, target-oriented drilling, geophysical measurements, borehole formation evaluation, production history and core data to construct high-resolution reservoir models for improved production forecast accuracy.

Characterization: Improving the spatial resolution of reservoir description and modeling based on enhanced data integration for improved development decision-making.

Grey Box Modeling: Development of big data analytics and machine learning methods that fully account for geospatial and engineering knowledge.

Our Opportunity

Develop integrated modeling and decision support systems to solve the following outstanding problems:

Robust Decision Making: Automated, expert systems to support consistent evaluation of subsurface and production data.

System Interpretability: Advanced system summarization and spatial visualization for model interrogation and learning from models for credible decision support.

Optimum Drilling: Development of modern, production-oriented drilling strategies by designing trajectories for optimum well placement to maximize reserves intersection and recovery factors by primary or secondary production means.

Our Opportunity

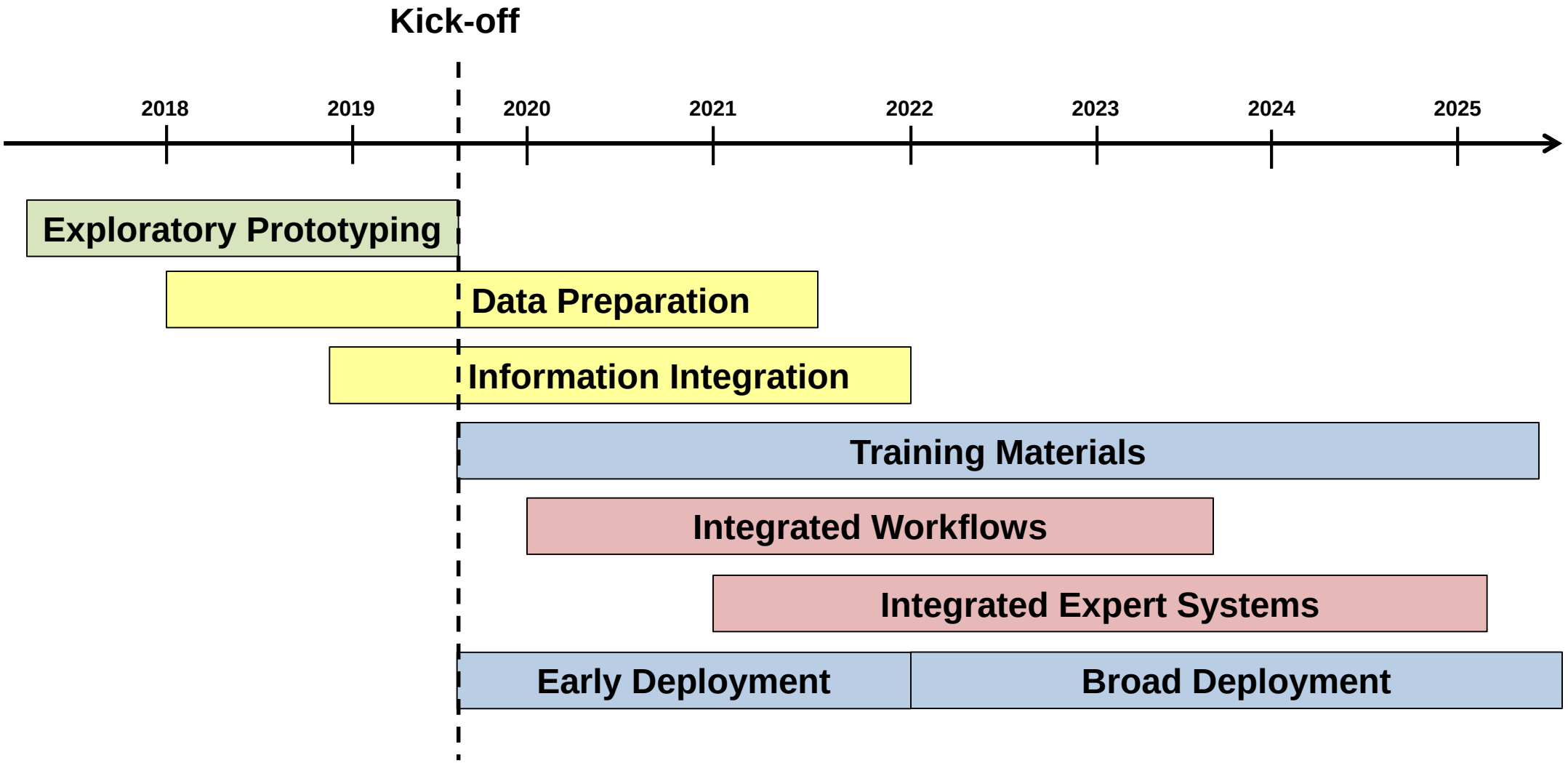
Develop integrated modeling and decision support systems to solve the following outstanding problems:

In-fill Drilling: Development of modern, efficient, and cost-effective strategies to evaluate in-fill drilling, primary or secondary production, and intelligent feedback control systems for reactive production under variable geological, fluid and financial constraints.

Uncertainty Quantification: Development of modern methods to ascertain the value of measurements and the uncertainty of descriptions and quantifications.

Modern Software Solutions for Reservoir Characterization: Development of modern computer and software solutions for rapid and efficient 3D collocated multi-physics description, visualization, modeling, well geosteering, and production forecasting.

Our Plan


Kick-off
2018
2019
2020
2021
2022
2023
2024
2025
Exploratory Prototyping
Data Preparation
Information Integration
Training Materials
Integrated Workflows
Integrated Expert Systems
Early Deployment
Broad Deployment

Our Short-term Plan

Q3 2019 – Q3 2021 our consortium will develop new methods and workflows in spatial, big data analytics for petrophysical, geophysical, reservoir engineering and geomechanical integration into subsurface models for optimum well trajectories and reservoir recovery, including:

Data Preparation: Novel big data analytics methods and workflows for data debiasing, imputation of missing data, feature and anomaly detection.

Information Integration: Novel reservoir-oriented methods for geophysical data processing and interpretation for high-resolution reservoir description and updating.

Operational Capability Development: Well-documented examples, best practice workflows and case studies, training and mentoring for development of member company operational capability.

Early Deployment: Provide source code and workflows with training materials to support early partner adoption of new technologies.

Our Mid-term Plan

Q3 2021 – Q3 2023 our consortium will develop novel machine learning-based geomodeling and forecasting methods and workflows.

Best Practice Modeling Workflows: Novel machine learning methods and workflows for spatiotemporal, multivariate modeling that account for data bias, spatial correlation and trends, multivariate physics-based constraints that are robust in the presence of sparse data and big data.

Operational Capability Development: Well-documented examples, best practice workflows and case studies, training and mentoring for development of member company operational capability.

Early Deployment: Provide source code and workflows with training materials to support early partner adoption of new technologies.

Our Long-term Plan

Q3 2023 – Q3 2025 our consortium will develop real-time updateable expert systems for optimum field development.

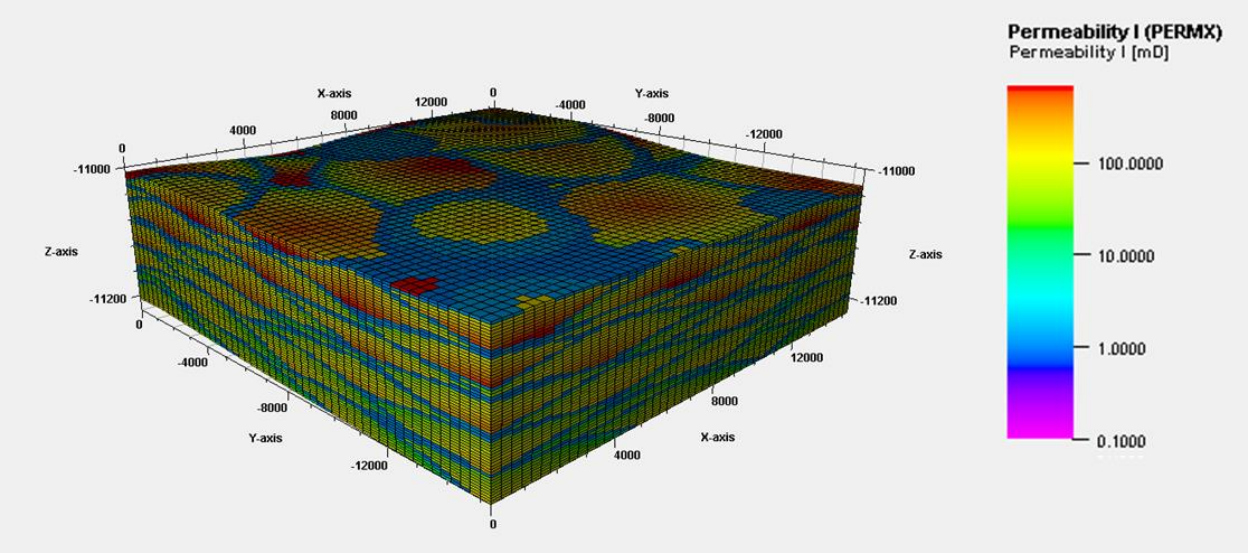
Integrated Expert Systems: Novel integrated systems for optimum production-oriented well geo-steering and completion.

Broad Deployment: Port algorithms and key findings into a modern computer and software architecture and protocols for user-friendly interactions, diagnostics, learning and decision support.

Initial Exploratory Prototypes

Q3 2018 – Q3 2019 our teams have conducted initial exploratory prototyping to assist with scoping the opportunity to develop student capabilities.

Reservoir Modeling: Methods for advanced, grid-free heterogeneity modeling for a *numerical testing laboratory* by Honggeun Jo (2nd Year PhD student)



Process-mimicking model for deep-water lobe depositional system: dimension of 5 km x 5 km x 60 m, perfect compensational stacking pattern.

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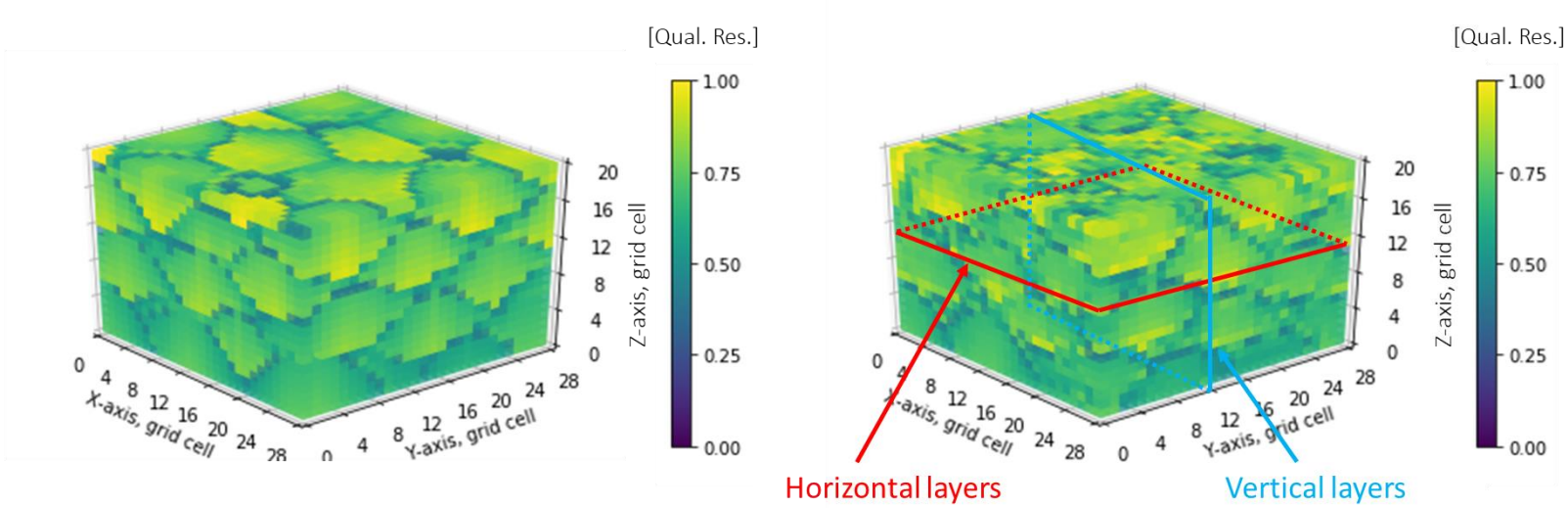
Reservoir Modeling: Machine learning based *subsusurface heterogeneity models* by Honggeun Jo (2nd Year PhD student).



Left - process-mimicking model, Right - result from deep convolutional generative adversarial networks (DCGANS).

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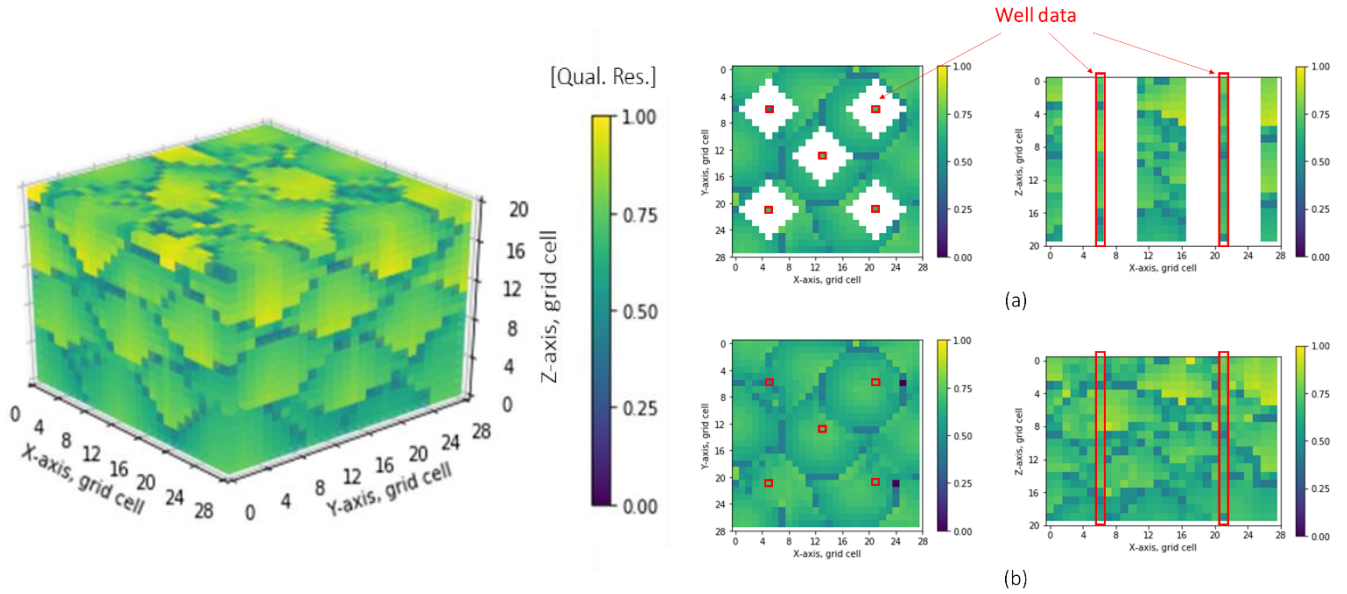
Reservoir Modeling: Subsurface *model conditioning* by semantic image inpainting by Honggeun Jo (2nd Year PhD student).



Left - process-mimicking model, Right – well conditioning with semantic image inpainting.

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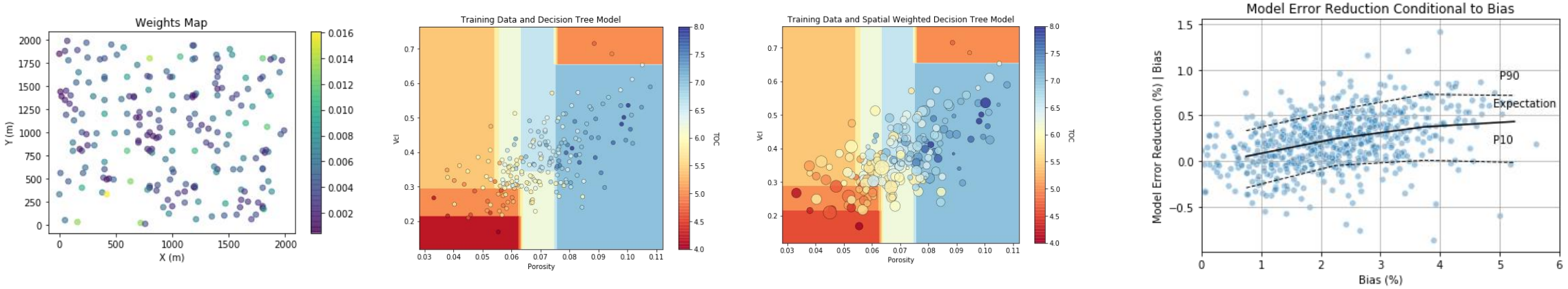
Spatial Bias in Machine Learning: Quantification and mitigation of *spatial bias in machine learning* by Wendi Liu (1st Year PhD student).



Left – spatial data, decision tree naïve and debiased, Right – error reduction vs. amount of bias.

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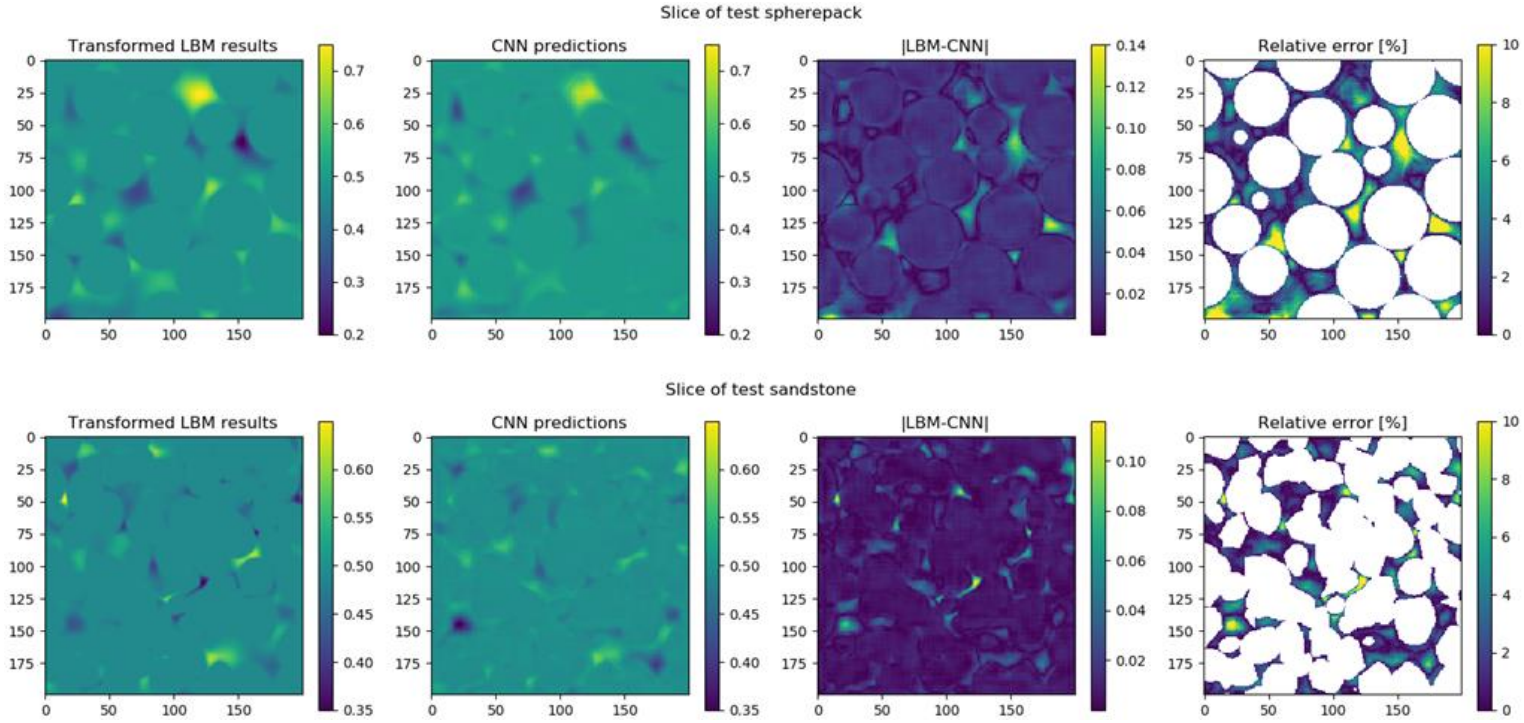
Flow Proxies, Scaling: Machine learning-based *flow proxy* for intragranular flow.
by Javier Santos (1st Year PhD student).



Latice Boltzmann vs. convolutional neural nets prediction of flow velocity.

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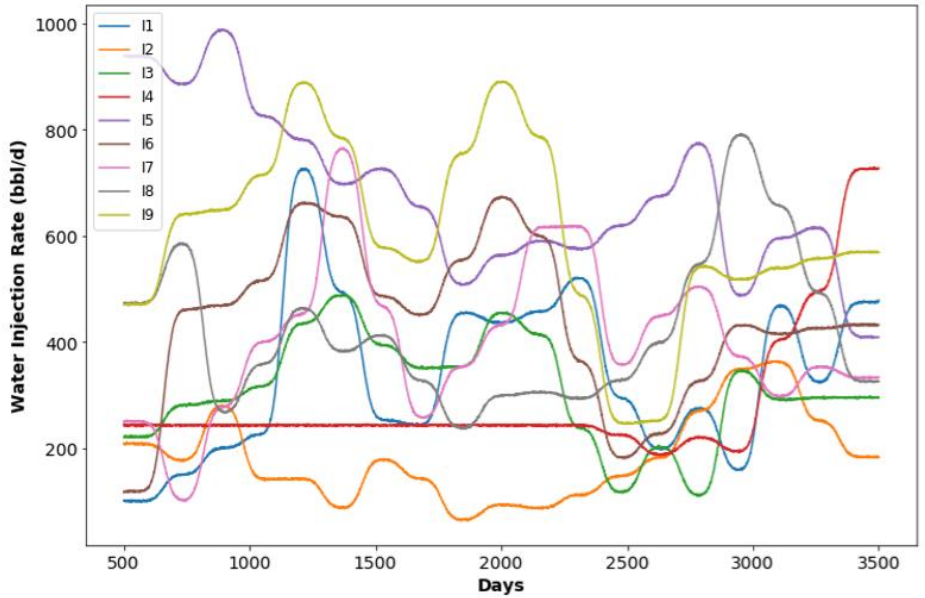
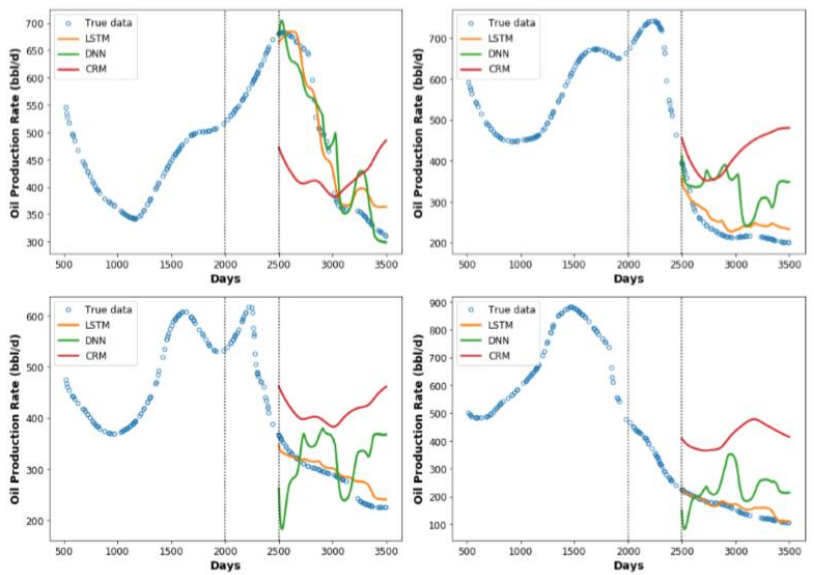
Flow Proxies, Scaling: Machine learning-based *flow forecasting* given multiple well injection and history. by Azor Nwachukwu (Completed PhD Dec., 2018).

Injection Rates Over Train and Test Intervals



Production Over Train and Modeled Over Test



Recurrent neural nets for multiple well injection to prediction model.

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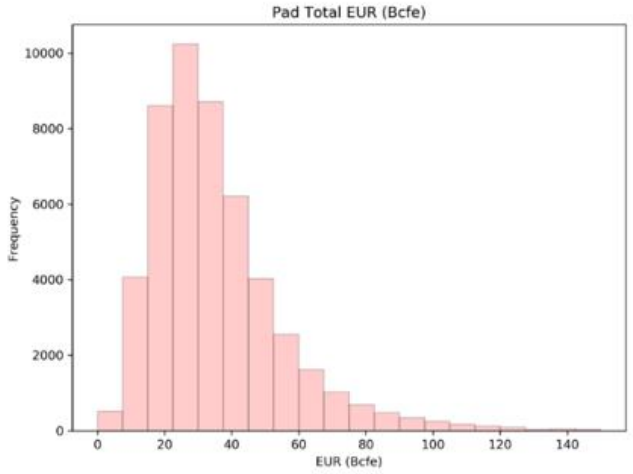
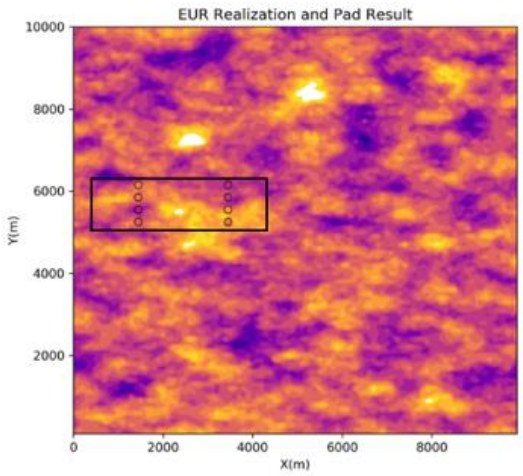
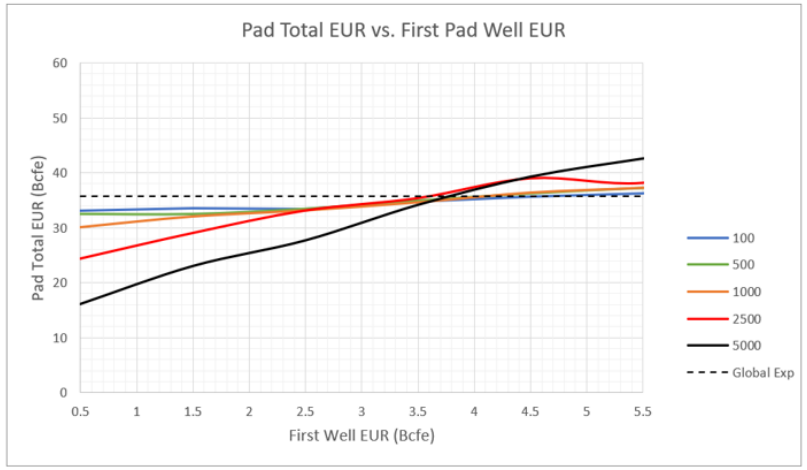
Data Analytics, Value of Information: Model resampling to evaluate the value of information for early pad production by Michael Pyrcz.

EUR Distributions





Early Indicator for Pad Aggregate Performance



Determination of the value of early production information relative to spatial continuity of production.

Initial Exploratory Prototypes

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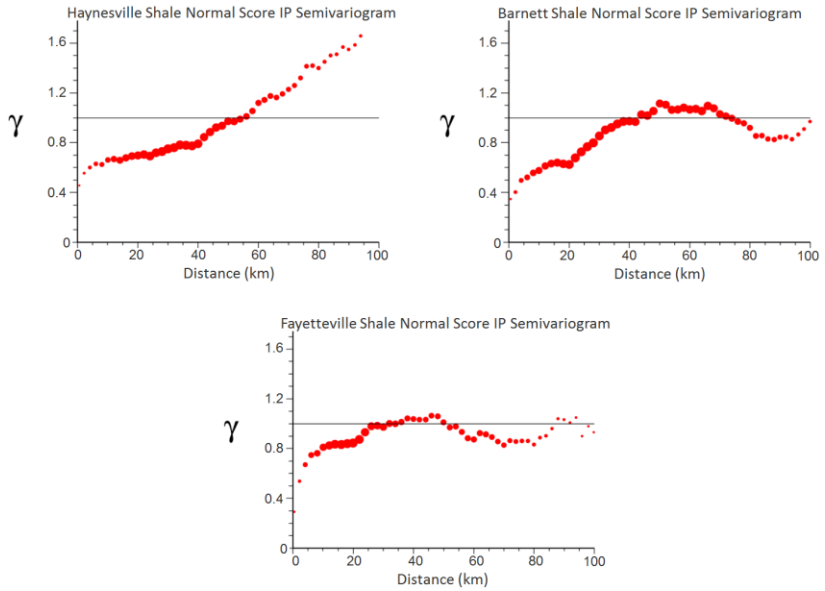
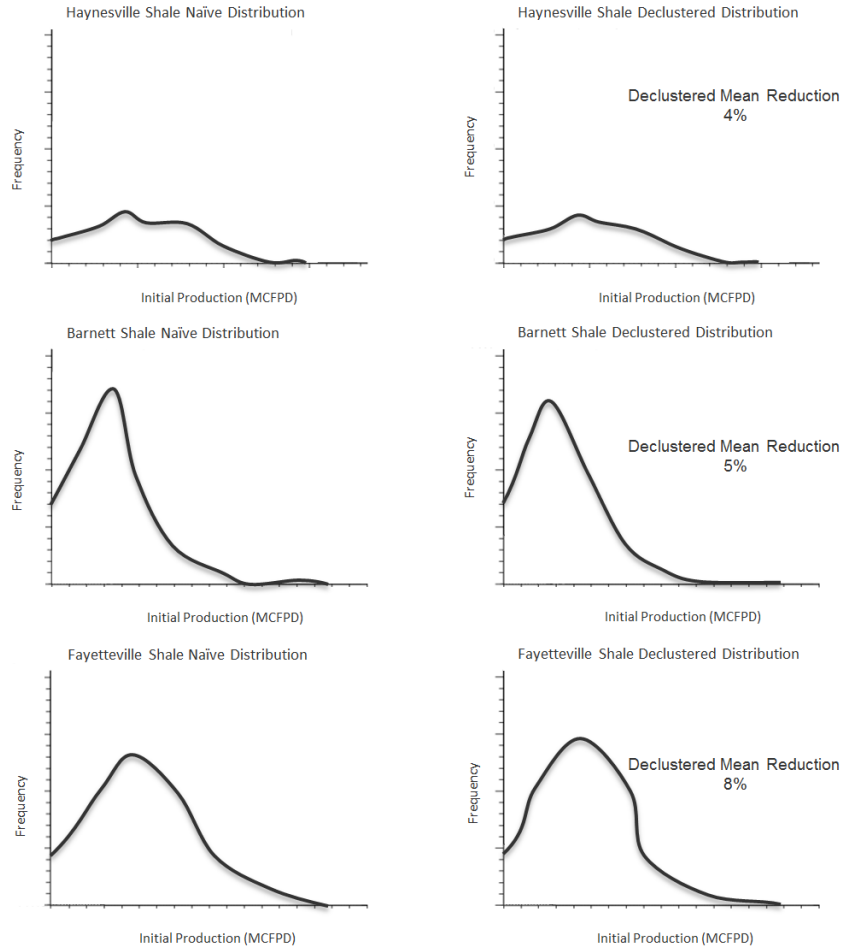
Data Analytics, Geostatistics: Spatiotemporal analysis, anomaly detection by Michael Pyrcz.

EUR Spatial Continuity for Unconventionals



Spatial Sample Declustering for Unconventionals



Spatial continuity analysis and formulation of representative distributions.

For More Information

Join early for the opportunity for early steering.

For further information concerning the consortium goals, plans and membership contact:

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