LIBERTY OILFIELD SERVICES

Paper Summary

A Method to the Madness

"Life is messy and relationships are complex. Multi-variate analysis can provide clarity", overheard in the hallways near the nerd corner at Liberty's office

Anyone can conduct multi-variate analysis (MVA) and come up with correlations between possible cause and effect. But the results can often be complete madness. It takes frac experts like Liberty to follow a proper analysis method to determine if trends are valid and make physical sense.

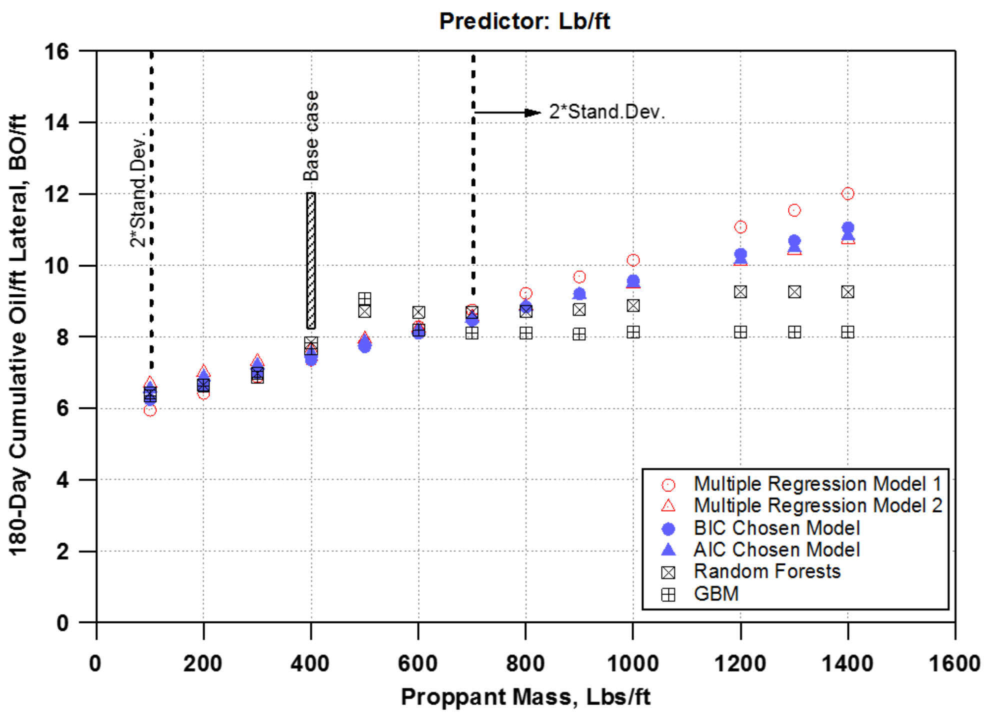
We are real-data guys and gals, and love to learn from the message contained in completion and production data. This paper presents a comparison of statistical and machine-learning methods to evaluate relationships between completion and petrophysical parameters and production. Our analysis provides insight on how to maximize oil production from horizontal wells drilled in unconventional reservoirs. While engineers can use other techniques such as analytical methods or numerical reservoir simulation to evaluate the well and reservoir parameters that impact production the most, we believe that these other techniques should be seen as complementary methods to what we present here. Who doesn't want to use what he finds out by looking over the neighbor's fence?

A new perspective presented in this paper is the importance of cross-validation with "hold-out" datasets in the workflow to develop reliable statistical models.

An ongoing dilemma for MVA that does not follow the proper methodology is that these models often result in poor predictions, even if they result in a high correlation between model and observations. To improve model prediction we therefore include a unique ten-fold cross-validation step to evaluate the predictive performance of our models based on test error. In this approach, the training dataset is randomly split into ten different groups. Next, each of the ten groups is removed and the model was trained on the remaining data. Then, the model is used to make predictions on the group that was held out. The statistical method that results in the highest correlation and smallest and most consistent error between training and hold-out datasets is generally the one that results in the most reliable model.

In addition to cross-validation, we evaluate a wide range of statistical models to determine which provides the best predictive model. We generally favor multi-regression models for their robustness and the simplicity of linear terms, but can also resort to Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC) chosen models that include more complex functions. These models are still simpler and more interpretable than Random Forests (RF) and Gradient Boosting Model (GBM), which we also have at our disposal for consideration as the best model to predict well production.

The figure below show the sensitivity results of one of the completion-related variables on predicted 180-day cumulative oil/ft using all the models used in this study. In general, the multiple regression, RF and GBM yield similar results when the values of the predictor of interest are within two standard deviations from their means. For the case of mass-of-proppant-pumped sensitivity, note that the RF and GBM show a diminishing increase in the 180-day cumulative oil/ft above 700 lbs/ft. This illustrates that different statistical models can lead to different results.



In the Rough Rider Middle Bakken, increasing frac fluid volume, proppant mass, maximum treatment rate, and reducing stage spacing improve oil production. Doubling frac fluid volume from 10 to 20 bbl/ft has the largest impact on production with about a 23% increase in the 180-day cumulative oil/ft. Increasing proppant mass from 400 to 600 lbs/ft adds about 9% production. In the Rough Rider Three Forks, increasing proppant mass from 400 to 600 lbs/ft has the largest impact on production with about a 21% increase in the 180-day cumulative oil/ft. Long-term stabilized water cut stands out as the most influential predictor of well performance for both formations, regardless of the models used.

Further financial evaluation shows that pumping more proppant provides the most effective completion lever to provide more “bang for your buck”, with a smaller than 2% increase in completion cost due to more proppant resulting in an expected 10% increase in production performance in most Williston areas.

That’s the method Liberty pursues in the Williston Basin to help operators achieve lower $/BOE. Spending your money on anything else is madness!

More information

SPE Paper 179171, “Evaluating the Relationship Between Well Parameters and Production Using Multivariate Statistical Models: A Middle Bakken and Three Forks Case History”, by E. Lolon et al.