



The Funk Equation is a novel approach to predict low quantity methane using low cost sensors. Using the data collected from the matrix of low concentrations a resistance ratio is constructed taking the form  (assume this is defined and explained earlier).

The Funk equation takes in three variables: Resistance Ratio, Absolute Humidity, and temperature. To get absolute humidity, the inputs are Relative humidity as a value from 0 to 100. The temperature should be in Celsius.

The models were first trained on a single train-test split using all of the sensors at once too ensure viability. Instead of having hundreds of datapoints for each level in the matrix, an average was taken for each sensor from the last 225 data points at each PPM and that single point was used. All models were curve fit in Python using the scipy.optimize curve\_fit function. After ensuring the model was viable, a Monte Carlo simulation was performed where the train-test split was randomized using the iteration number as the seed to ensure repeatability could be maintained. The data was split 90% for use in the training of the model and 10% for use in the testing of the model. all the results are shown from the 10% of data that the model was not trained on. The number of iterations was 1,000 when fitting all sensors and when fitting each sensor individually, to ensure each model had the best chance to normalize the resulting RMSE (root mean squared error) and R-Squared. This was repeated for each iteration of the Funk equation, however only the most recent and best Funk equation will be shown and analyzed. As seen in the table after 1,000 iterations, the Funk equation performed approximately 60% better when comparing RMSE. The histograms of the RMSE also show a similar story. Both graphs show an approximately normal distribution which signifies no abnormality within the results of the Monte Carlo simulation.

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| Results using V0 calibration | RMSE | R-Squared |
| Funk Equation | 4.83 | 0.92 |
| Bastviken Equation | 6.78 | 0.84 |

It is recommended to use several baseline Vout conditions for each sensor which would be seen the most at a sensor site when there is no methane leak, however if that is impractical, the Vref from the sensor can be uses with a slight decrease in accuracy. The one testing area the equation struggles with when not using calibrations is low temperature low humidity. For creating separate curve-fits using the Funk equation, it is recommended to use a log transformation to fit the curve as this form is known to be unstable, sometimes due to its exponential nature.

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| Results using just VRef | RMSE | R-Squared |
| Funk Equation | 7.84 | 0.79 |
| Bastviken Equation | 14.8 | 0.26 |

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| **RMSE** | **Sensor 0** | **Sensor 3** | **Sensor 5** | **Sensor 7** | **Sensor 8** | **Sensor 10** | **Sensor 13** | **Sensor 15** |
| **Funk** | 5.42 | 4.34 | 4.41 | 5.12 | 4.43 | 5.54 | 4.88 | 5.19 |
| **Bastviken** | 6.93 | 6.25 | 6.45 | 7.09 | 6.82 | 7.11 | 6.71 | 7.08 |
| **R-Squared** | **Sensor 0** | **Sensor 3** | **Sensor 5** | **Sensor 7** | **Sensor 8** | **Sensor 10** | **Sensor 13** | **Sensor 15** |
| **Funk** | 0.89 | 0.93 | 0.93 | 0.90 | 0.92 | 0.89 | 0.91 | 0.90 |
| **Bastviken** | 0.82 | 0.85 | 0.84 | 0.81 | 0.82 | 0.81 | 0.83 | 0.81 |

The Funk equation shows an average improvement of approximately 27.86% over the Bastviken equation across all sensors for the RMSE and a 10.32% improvement over the Bastviken equation for the R-Squared.

A graph of a function

Description automatically generatedA diagram of a function with Ryugyong Hotel in the background

Description automatically generatedA graph of a diagram

Description automatically generatedA graph of a function with Ryugyong Hotel in the background

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