

Ammonia-Diesel experimental data and modeling results

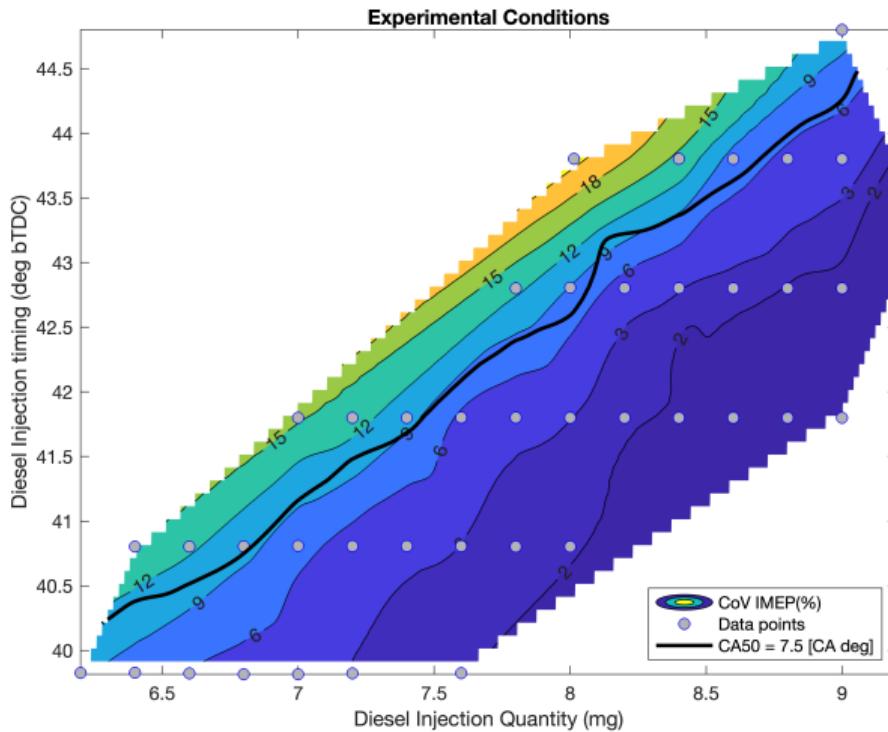
Bryan Maldonado
ORNL
September 29, 2024

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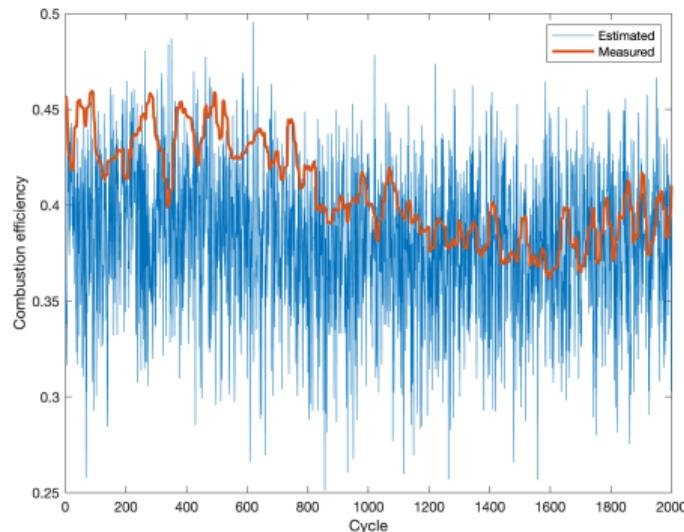
Ammonia-Diesel dual fuel operating conditions

Baseline operating condition: 1200 rpm, 6 bar IMEPn target, 42 g/min ammonia fuel flow



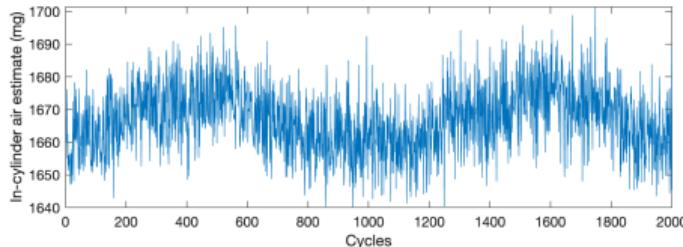
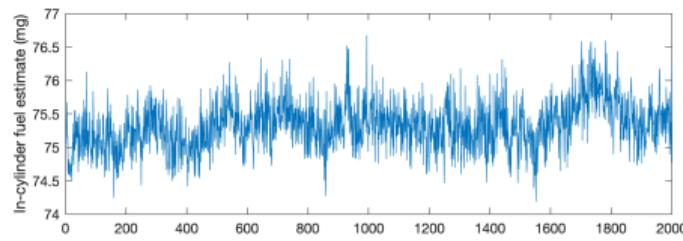
DI6.2 SOI40: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



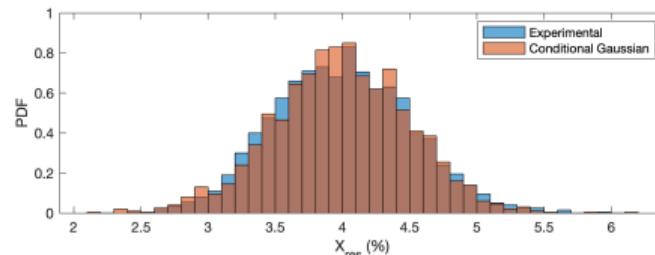
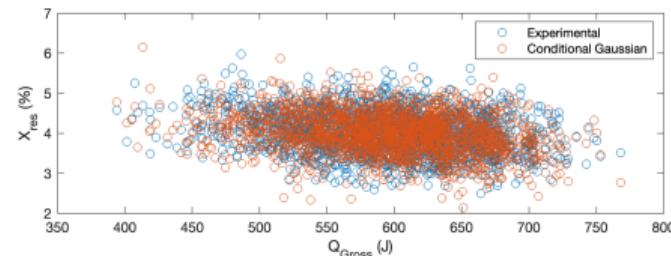
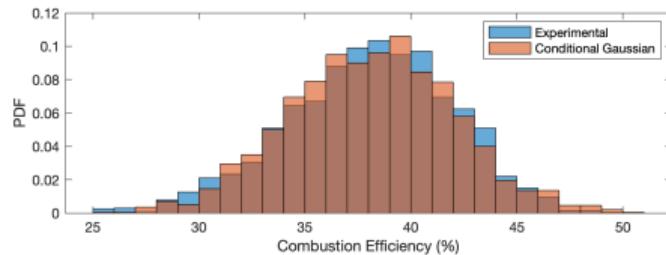
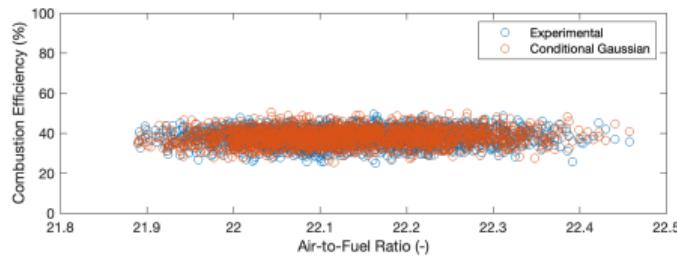
DI6.2 SOI40: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

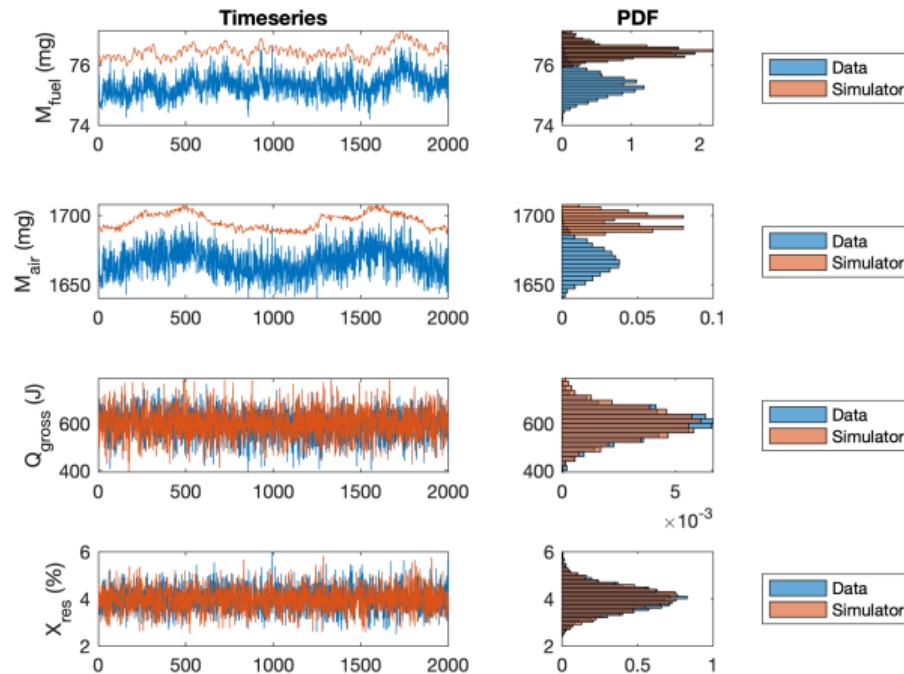
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

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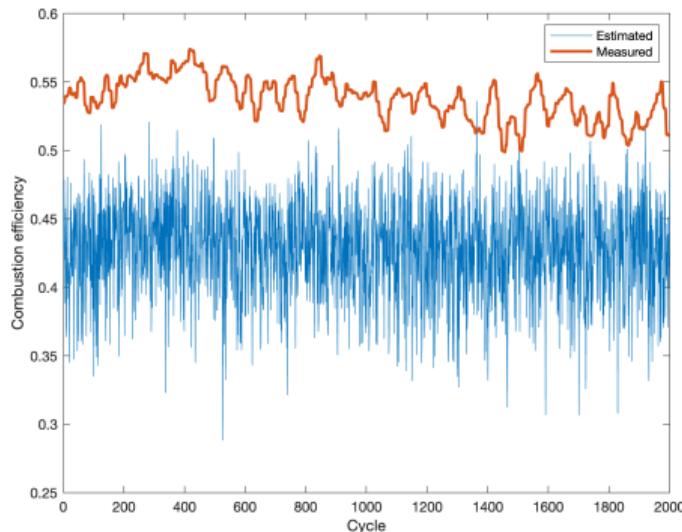
DI6.2 SOI40: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$

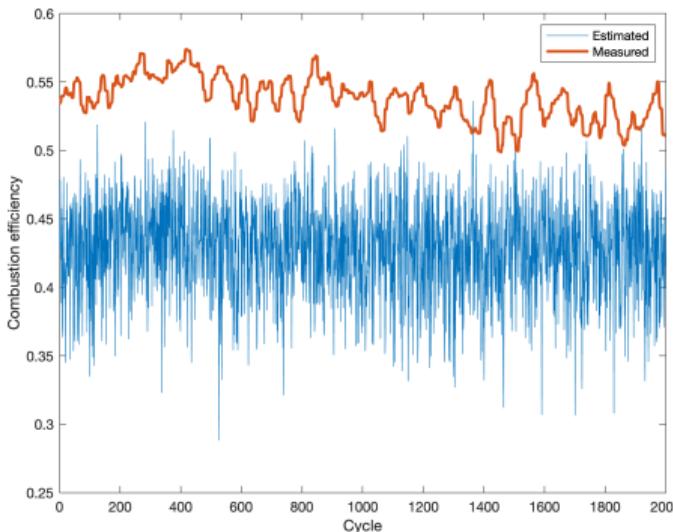


DI6.4 SOI40: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



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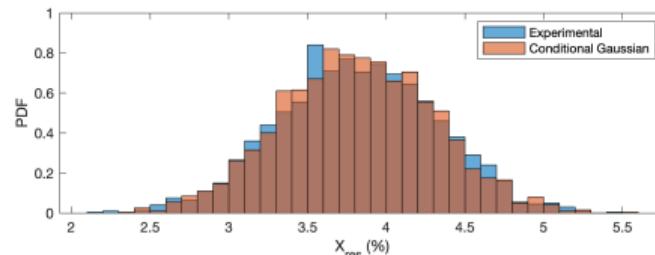
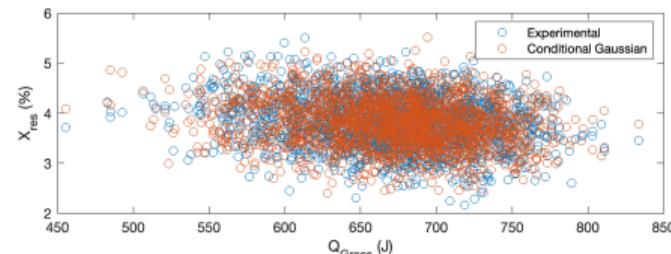
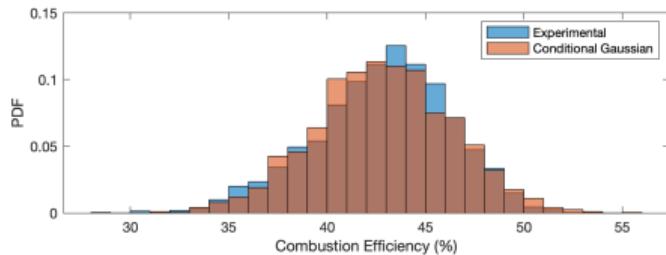
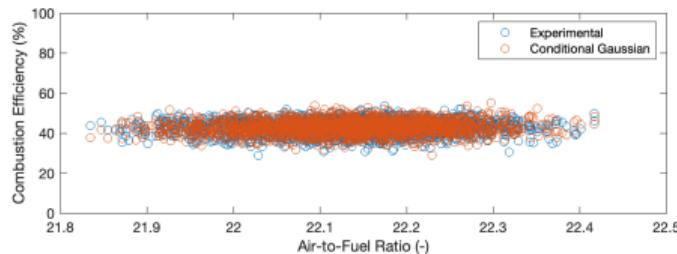
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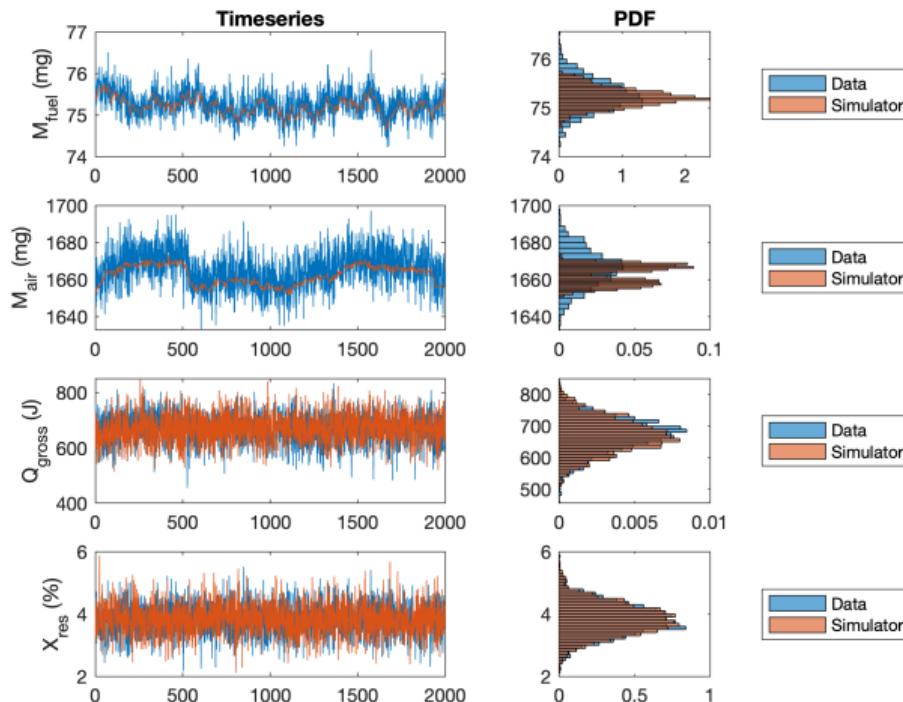
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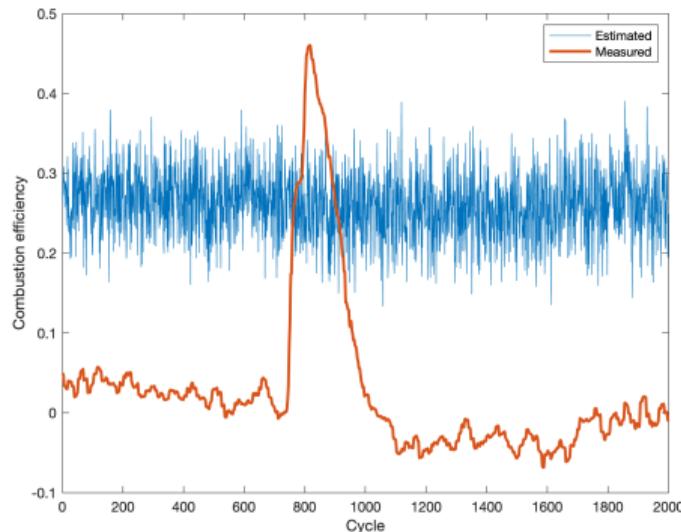
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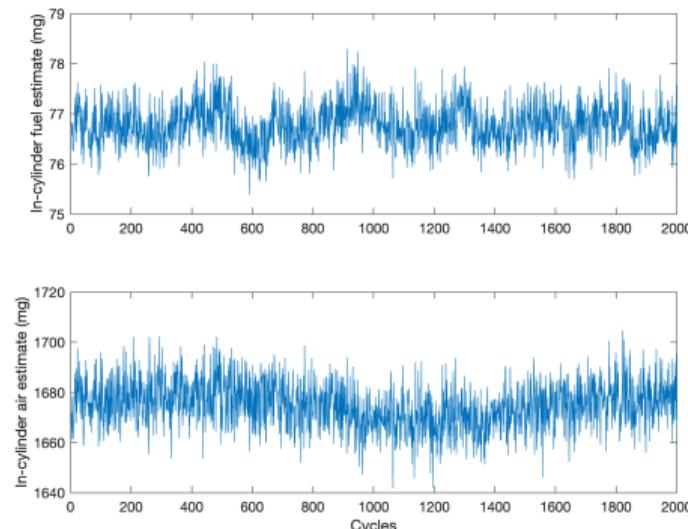
DI6.4 SOI41: Estimation of combustion efficiency and in-cylinder mass

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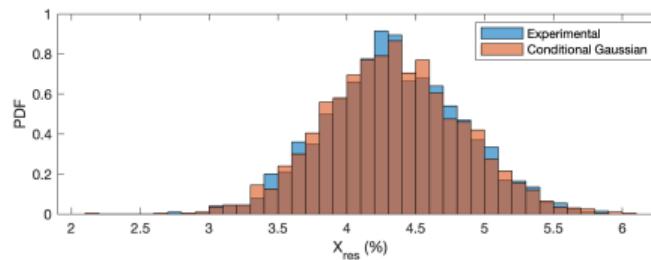
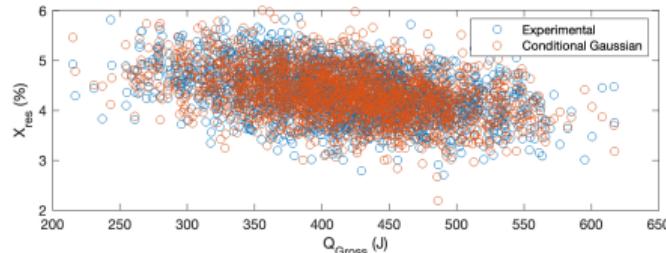
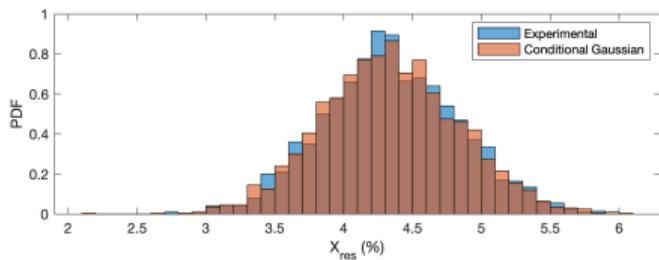
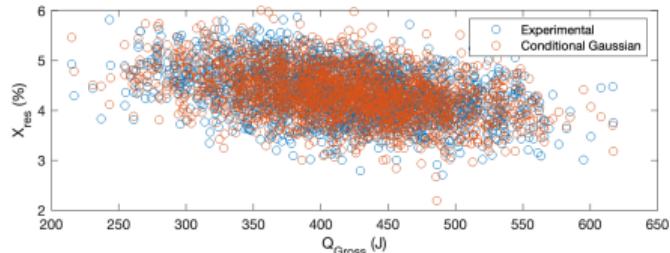
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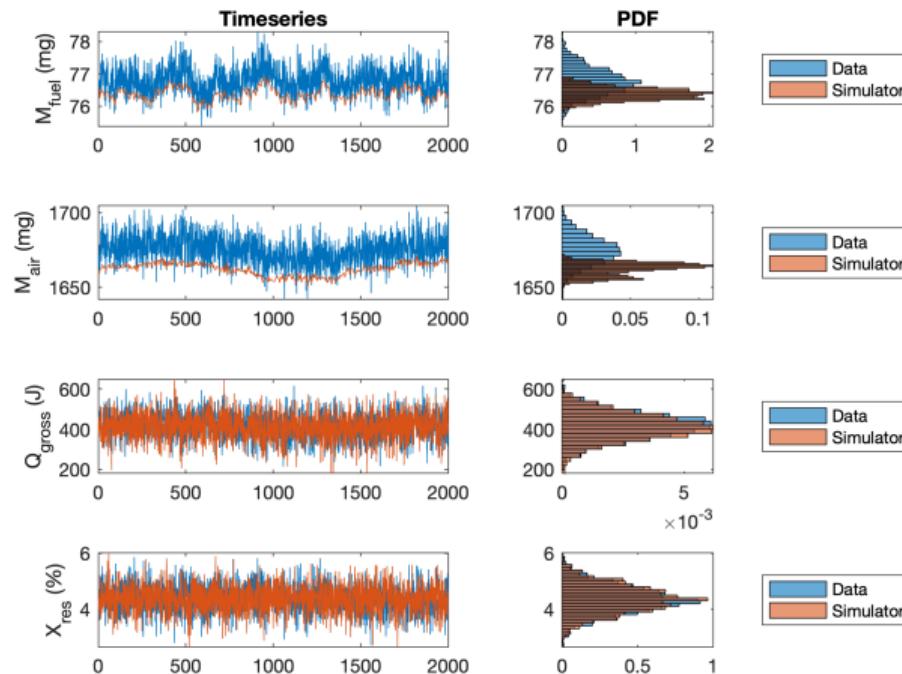
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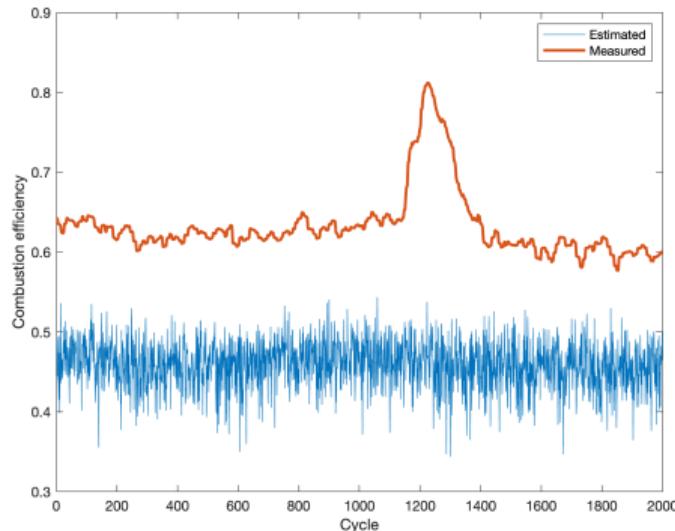
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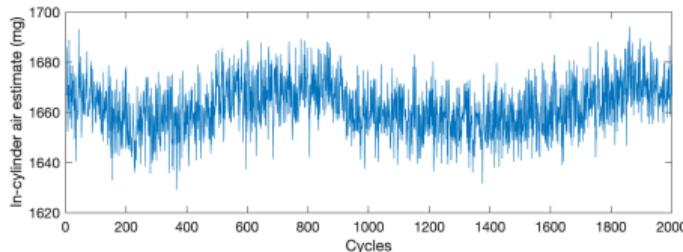
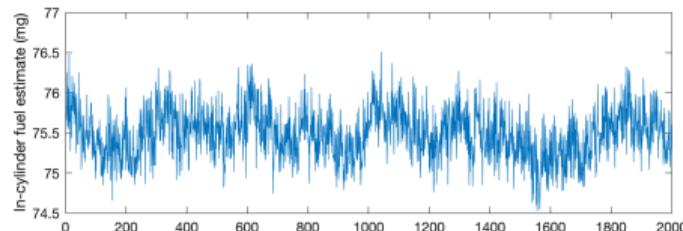
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$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



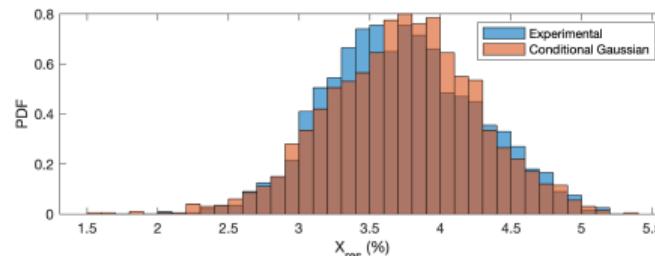
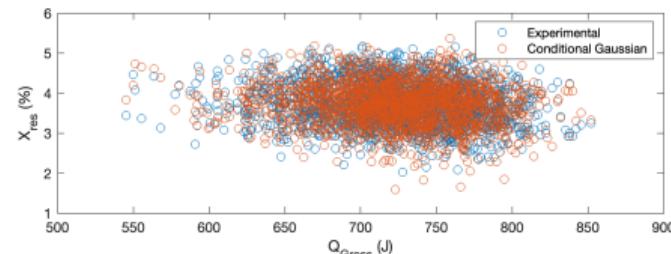
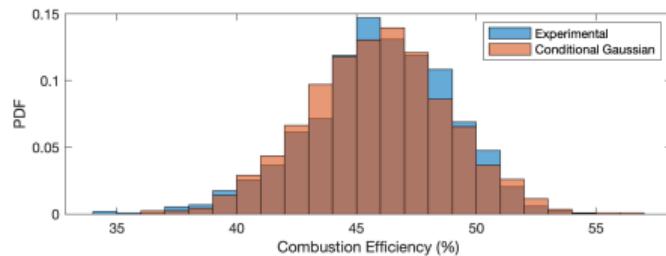
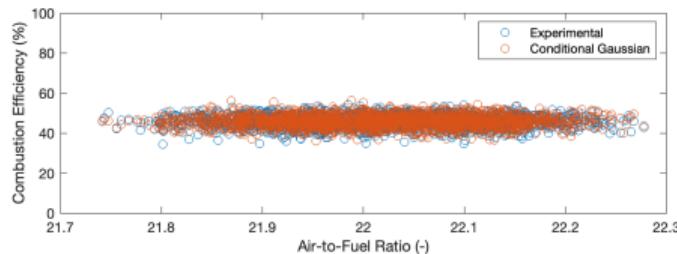
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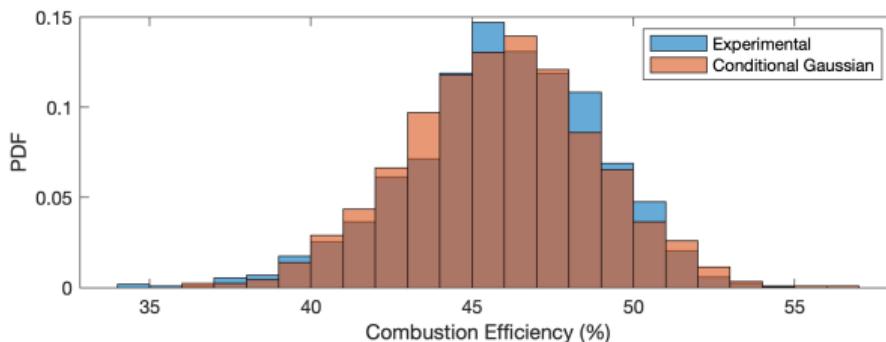
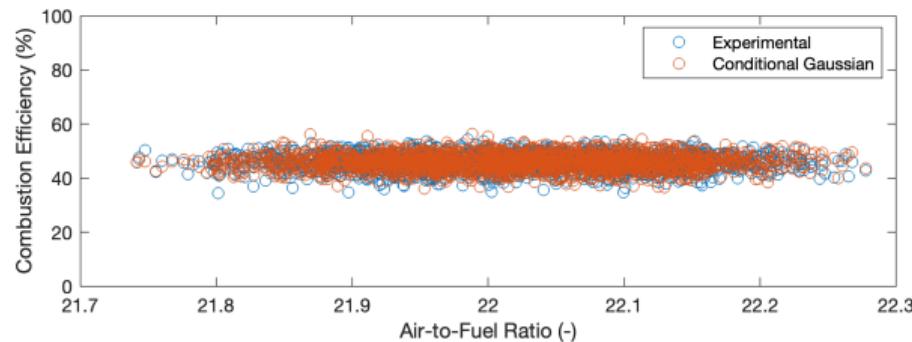
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

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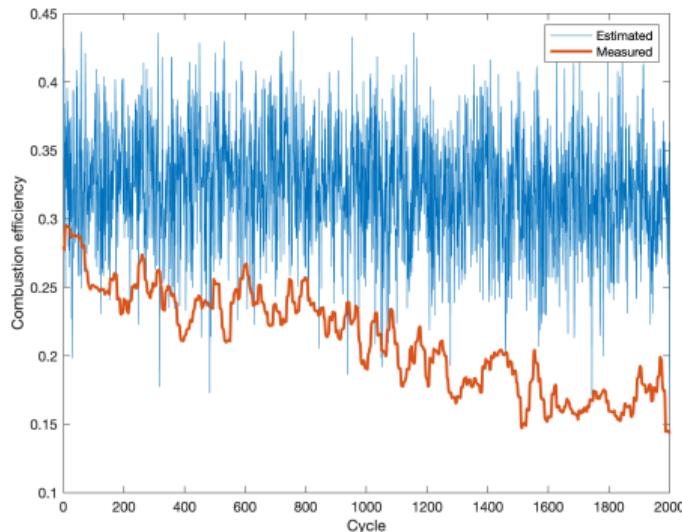
DI6.6 SOI40: Simulator Results

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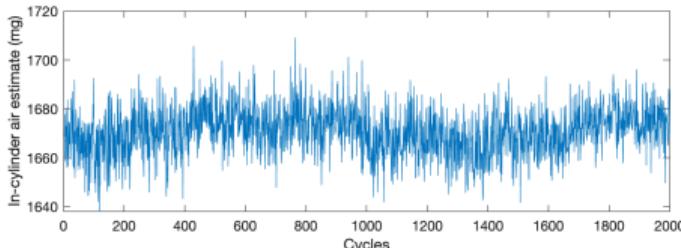
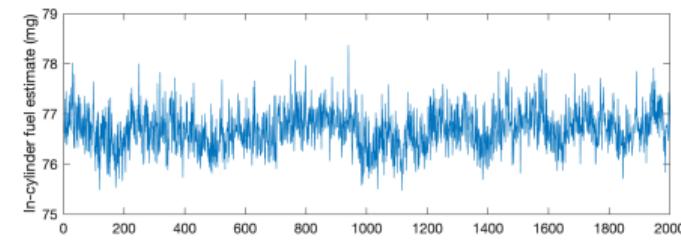
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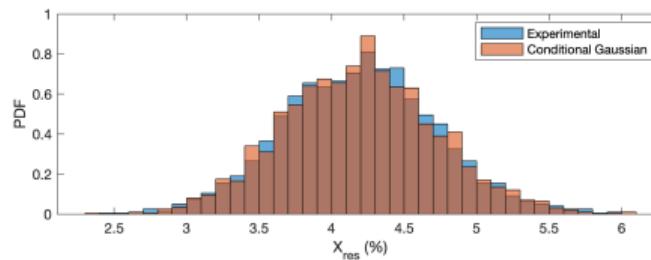
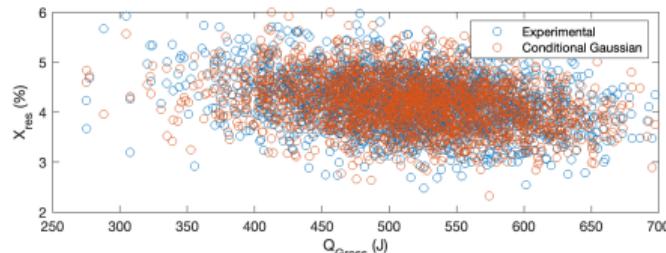
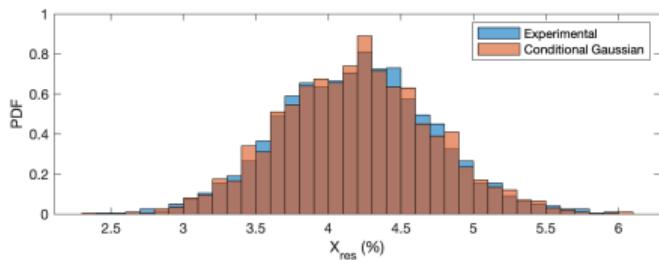
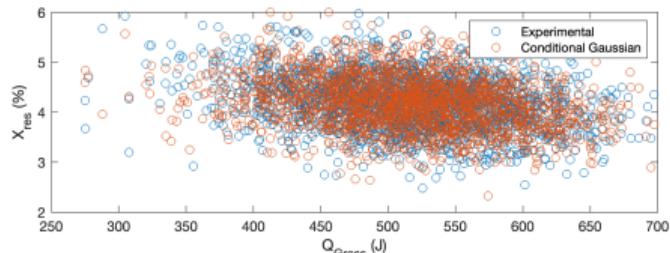
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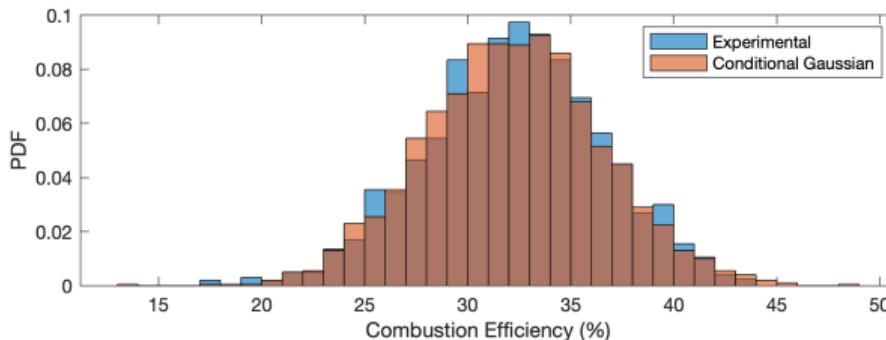
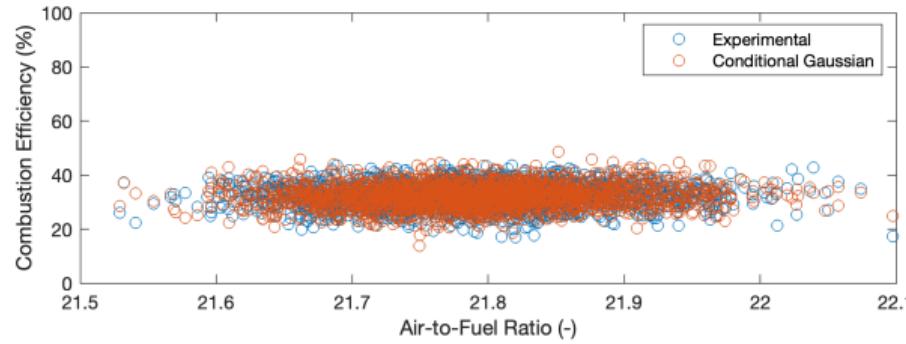
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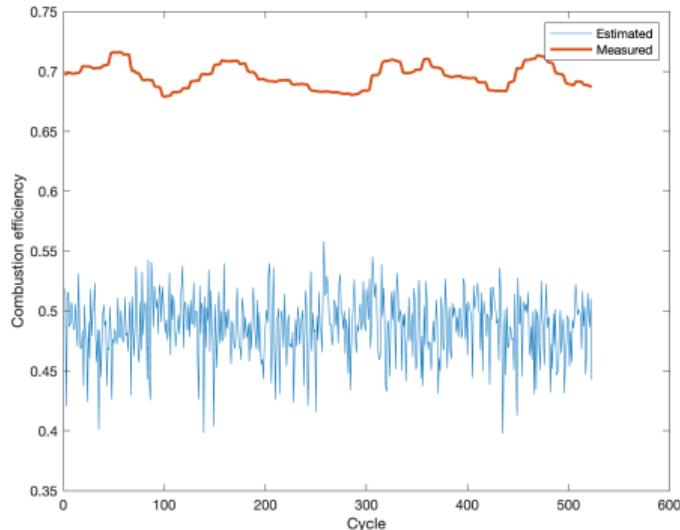
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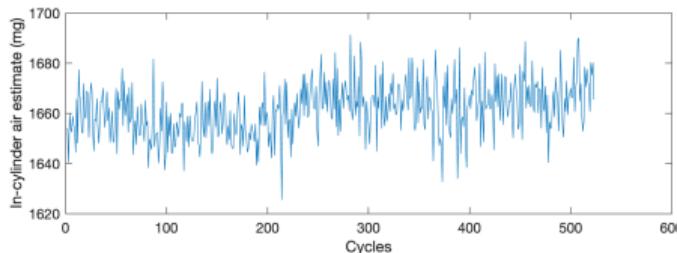
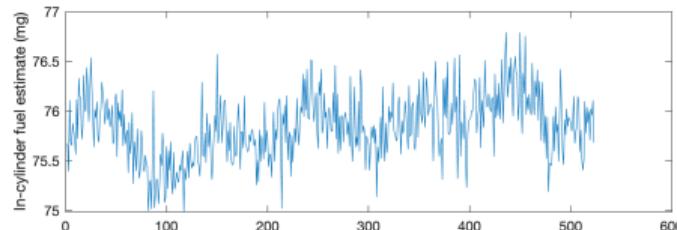
DI6.8 SOI40: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



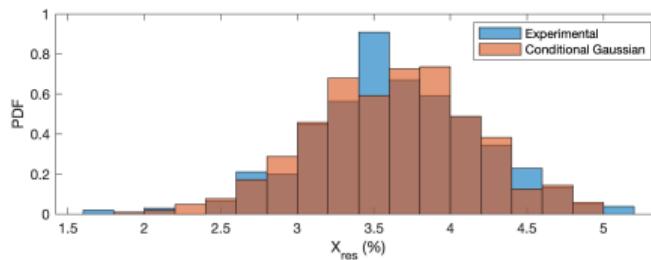
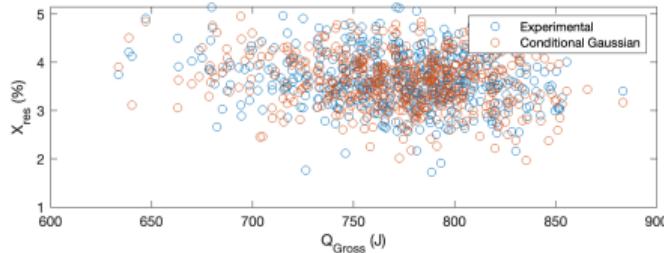
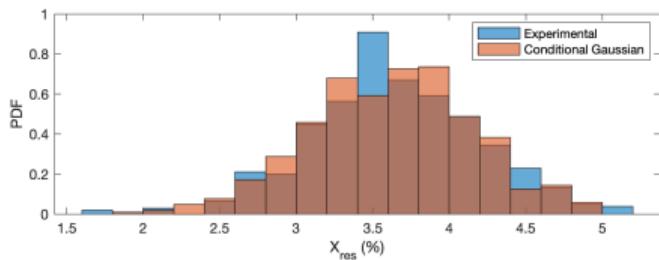
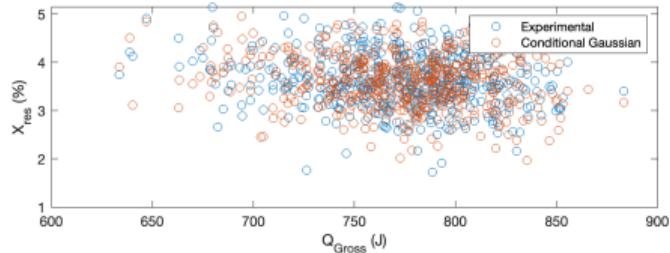
DI6.8 SOI40: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

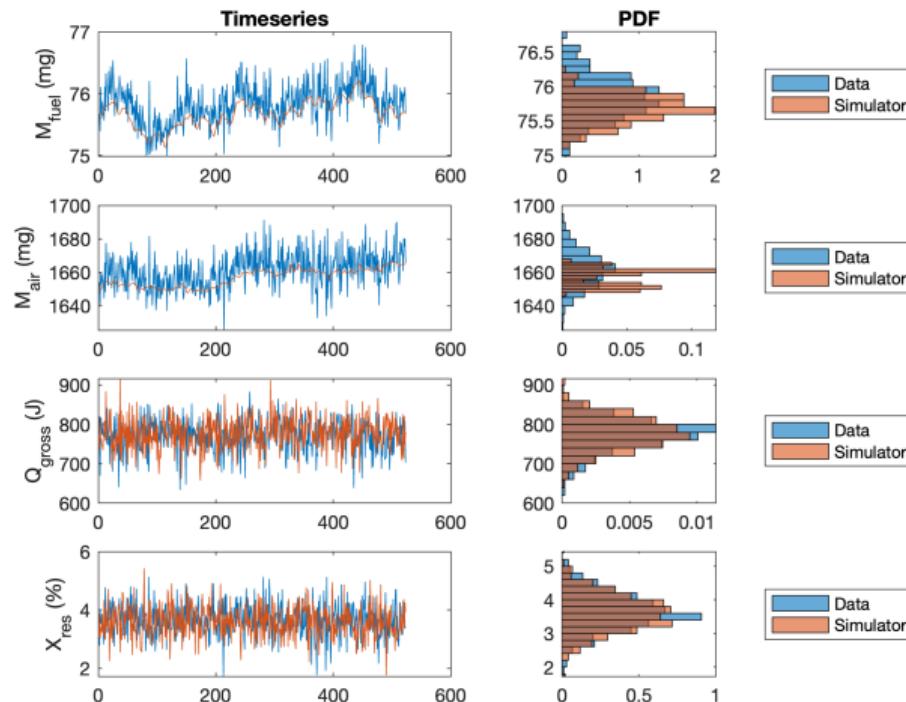
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



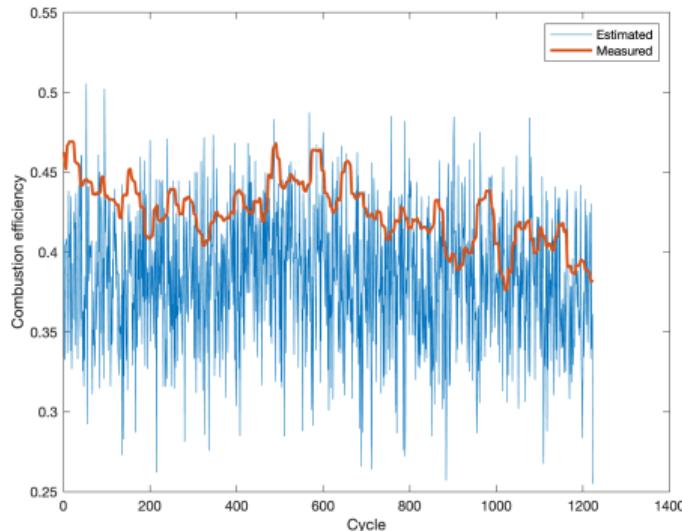
DI6.8 SOI40: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



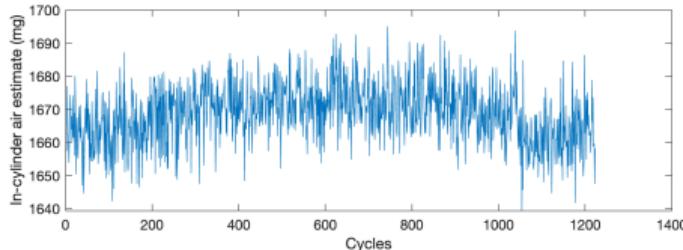
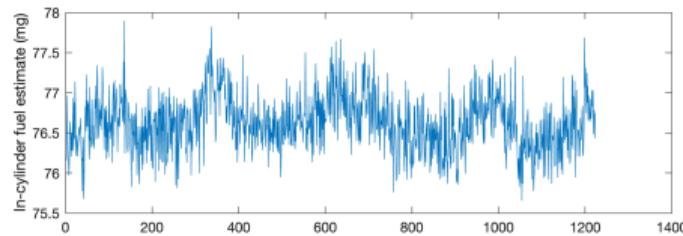
DI6.8 SOI41: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



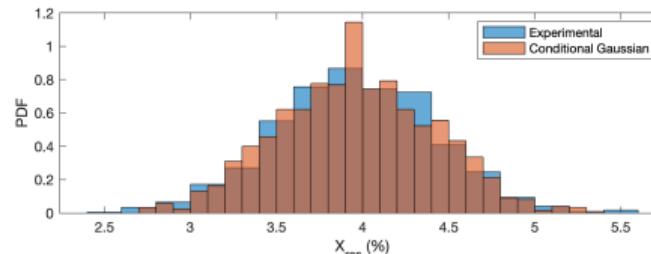
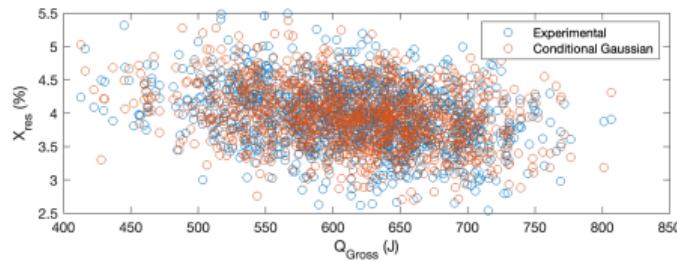
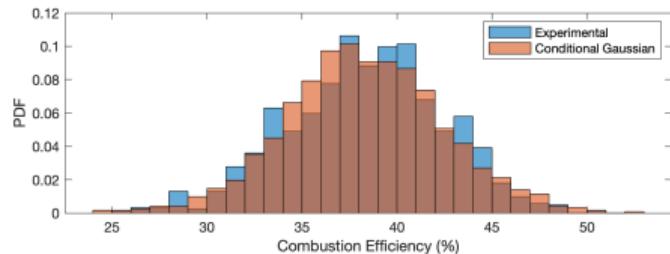
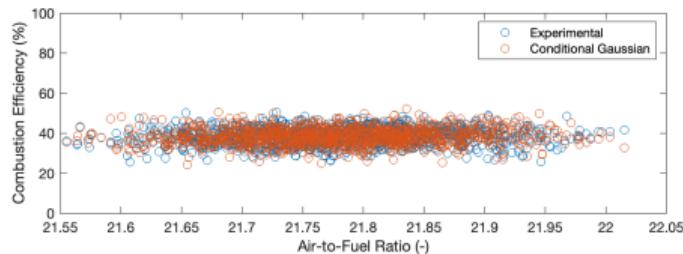
DI6.8 SOI41: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

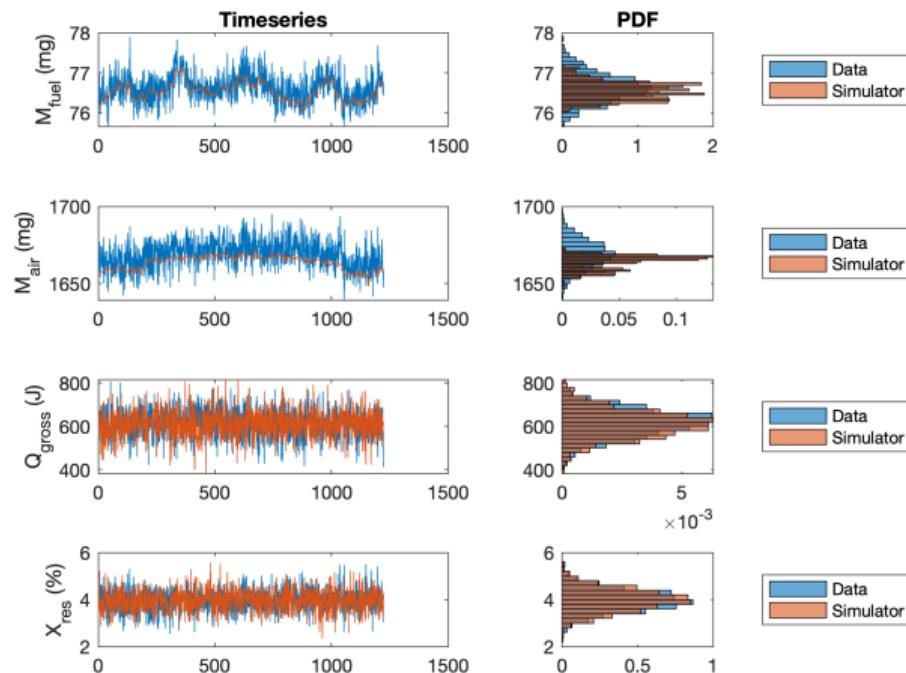
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



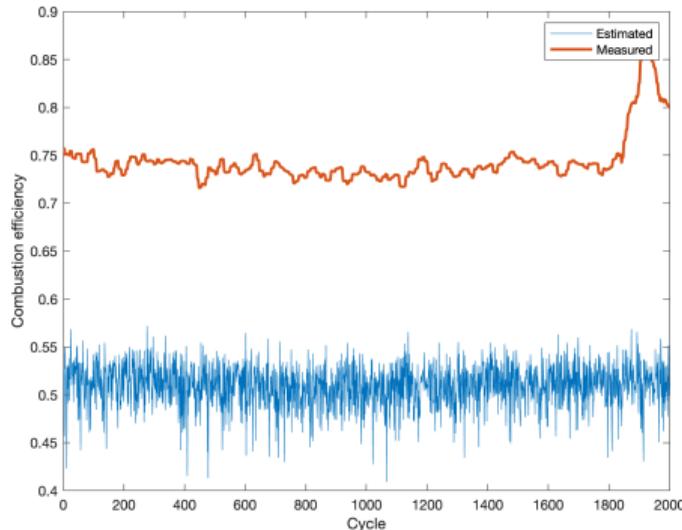
DI6.8 SOI41: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



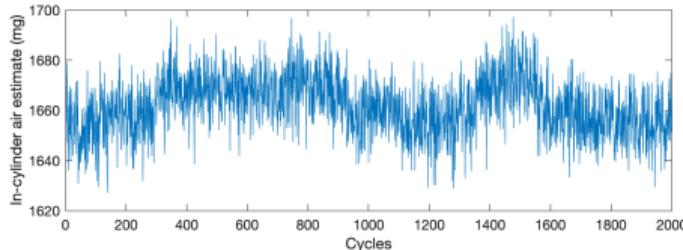
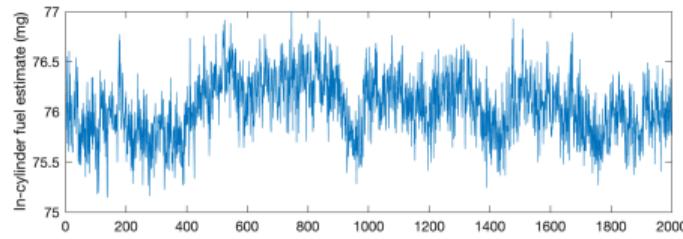
DI7.0 SOI40: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



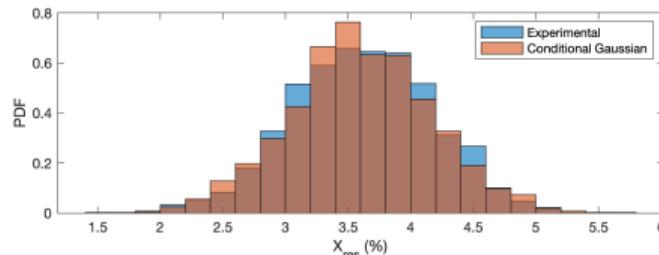
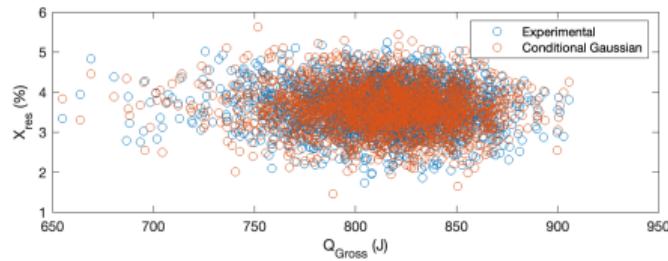
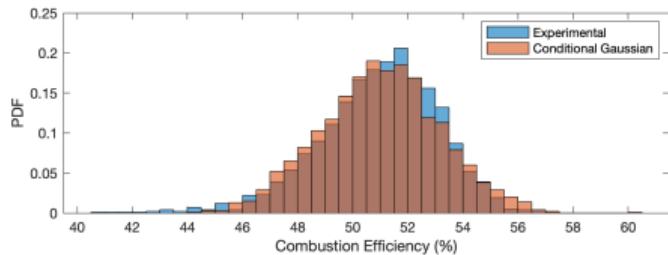
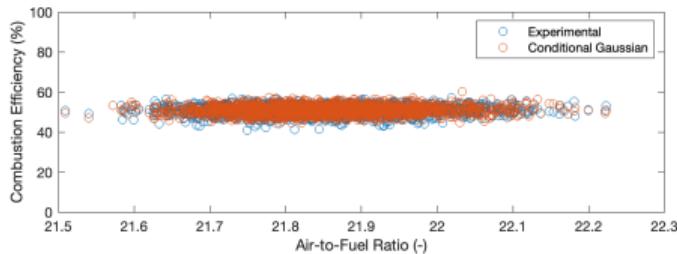
DI7.0 SOI40: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

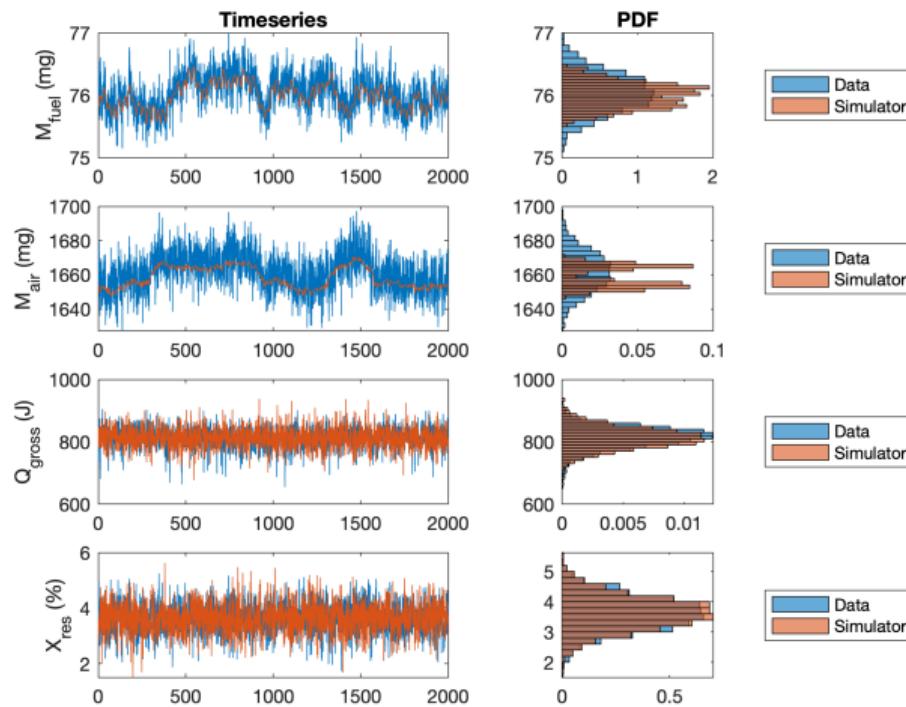
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



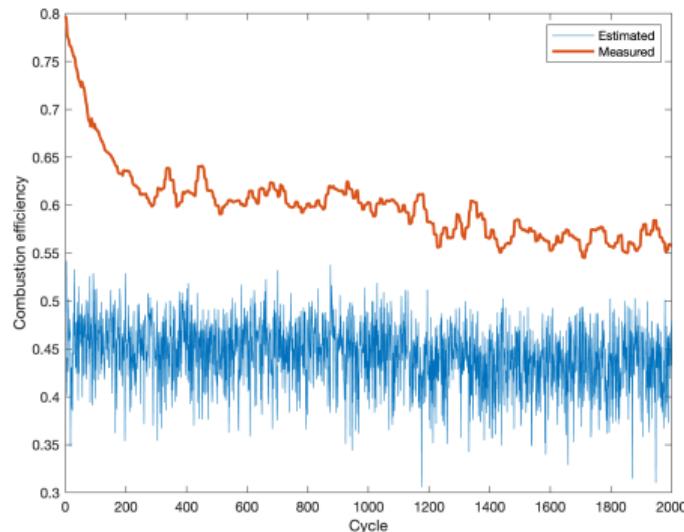
DI7.0 SOI40: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



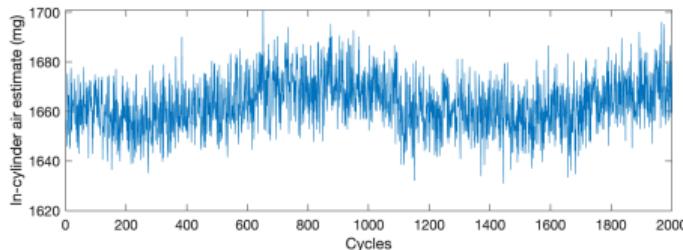
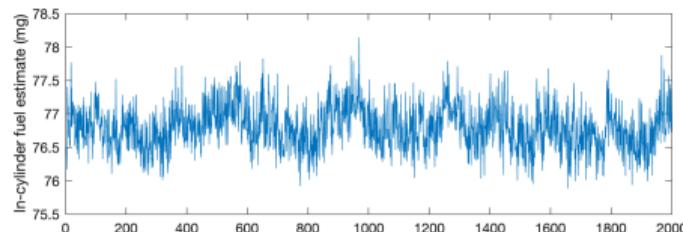
DI7.0 SOI41: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



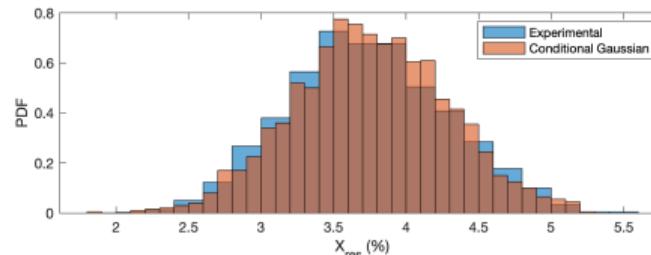
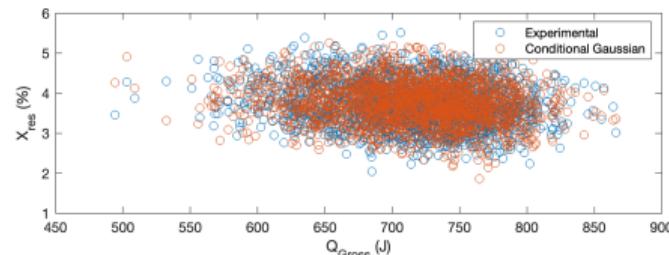
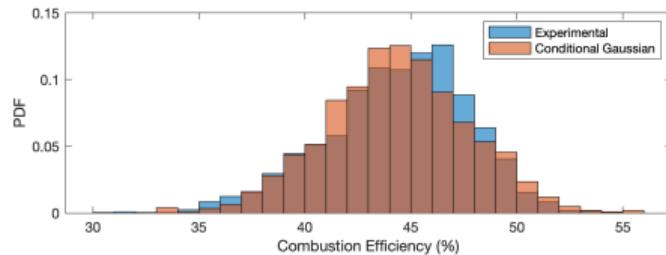
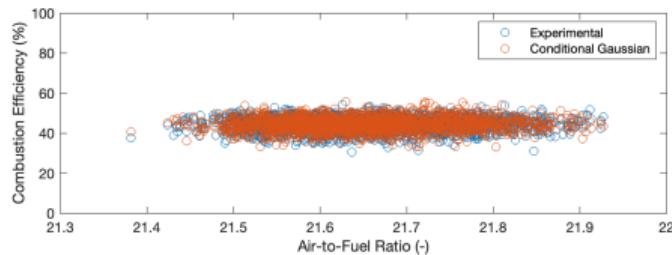
DI7.0 SOI41: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

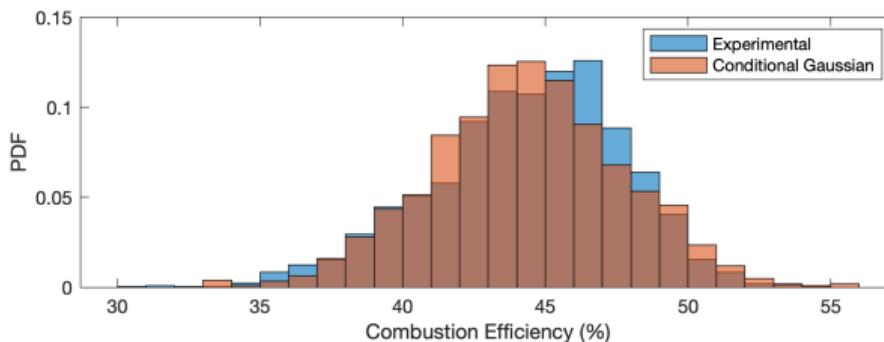
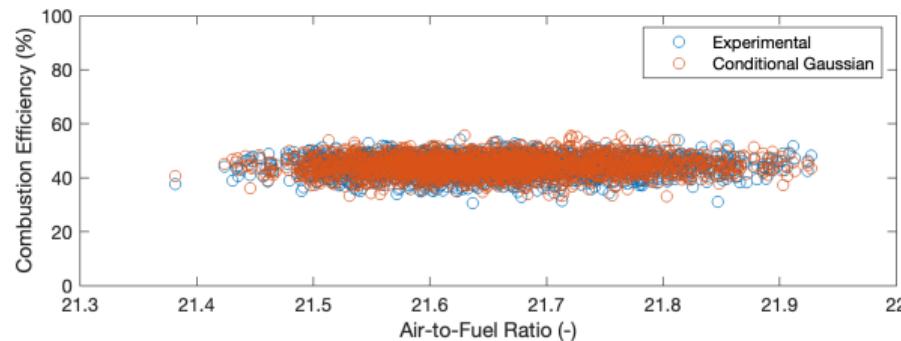
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



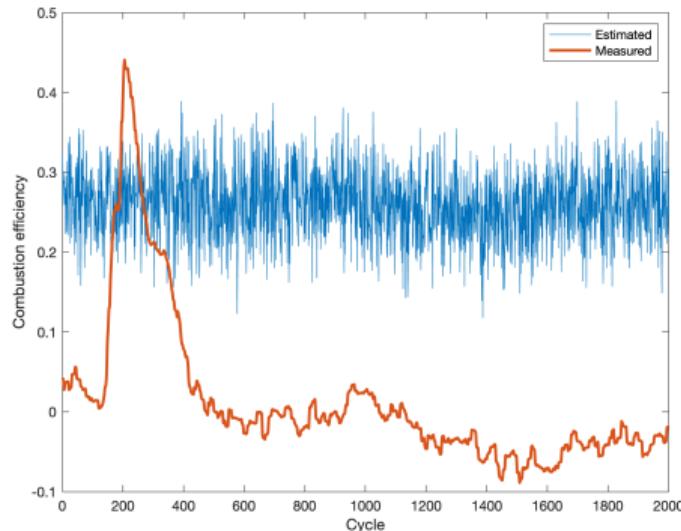
DI7.0 SOI41: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



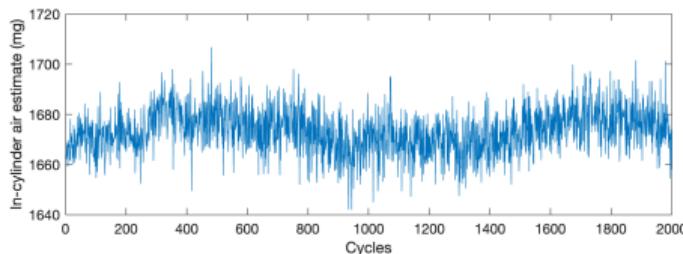
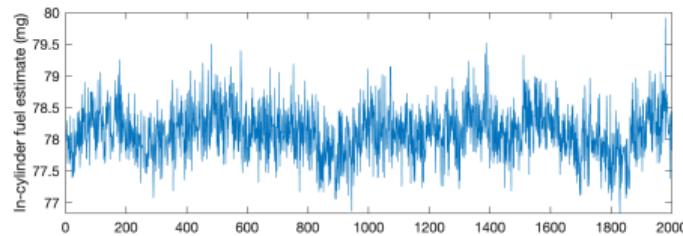
DI7.0 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



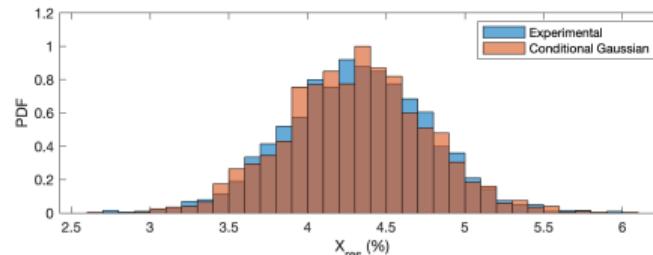
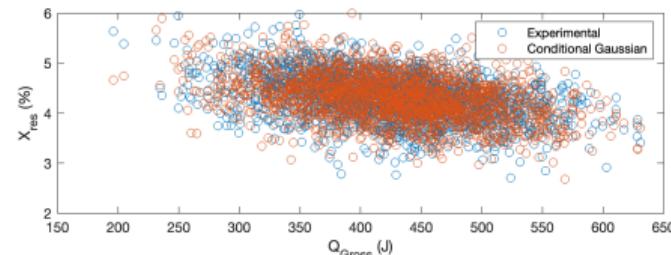
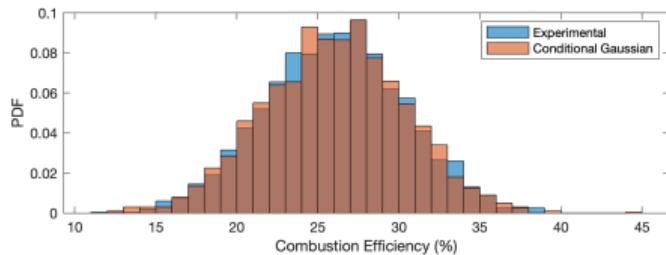
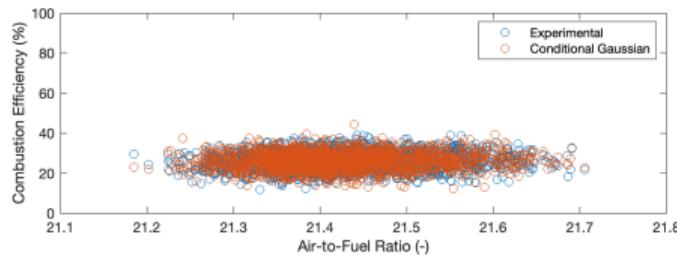
DI7.0 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

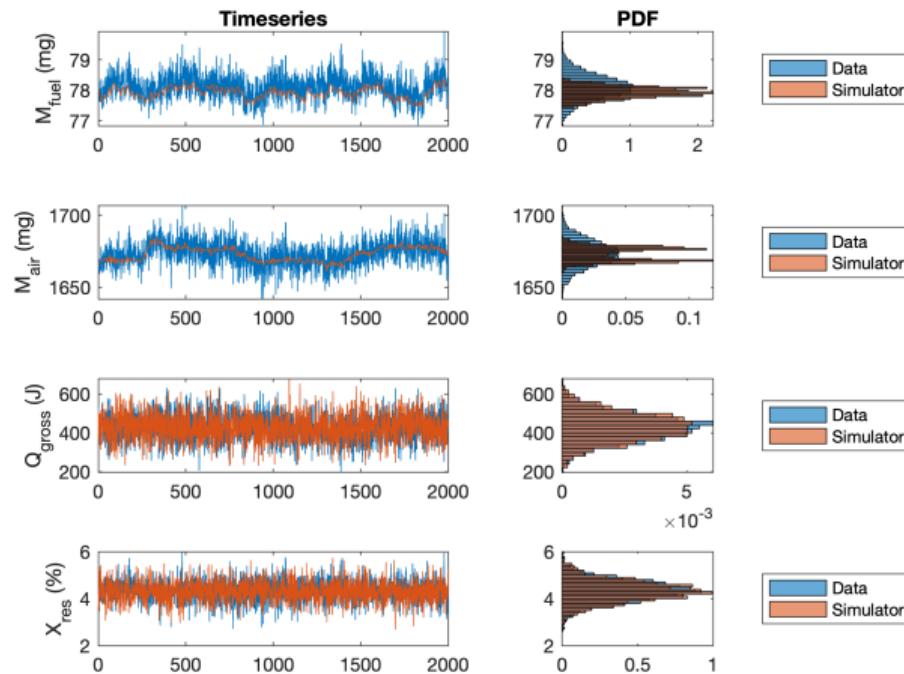
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



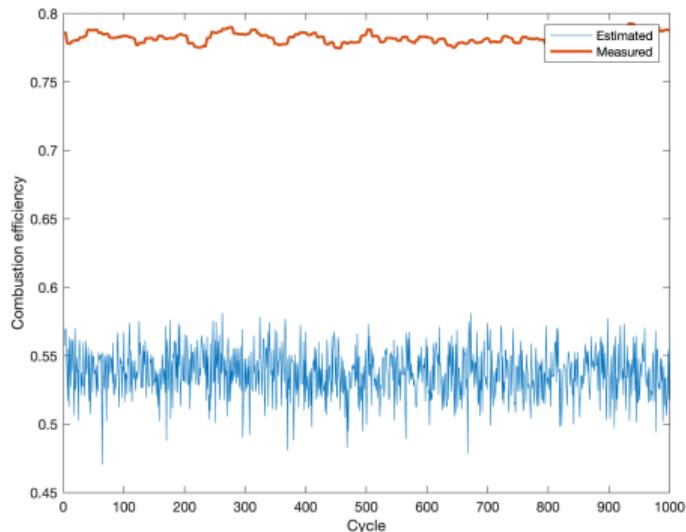
DI7.0 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



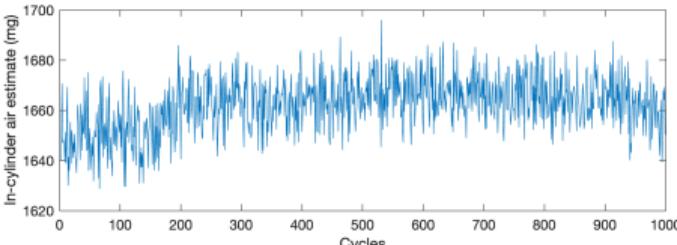
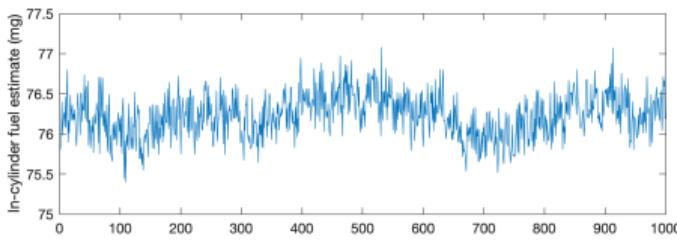
DI7.2 SOI40: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



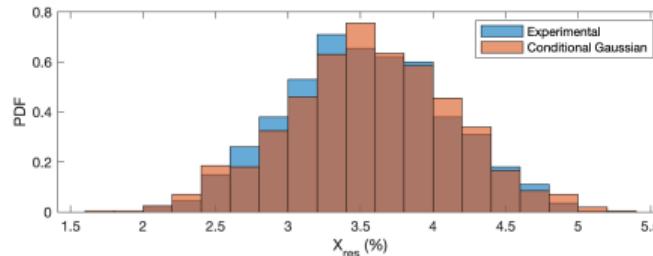
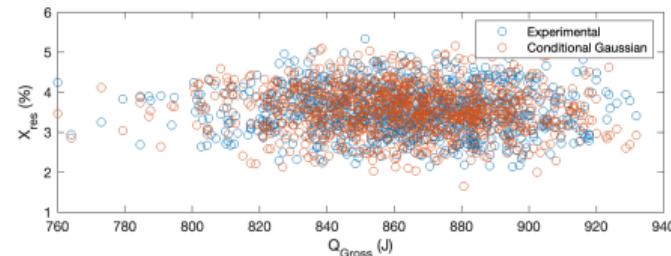
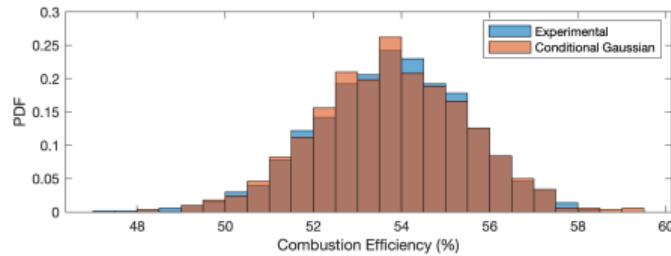
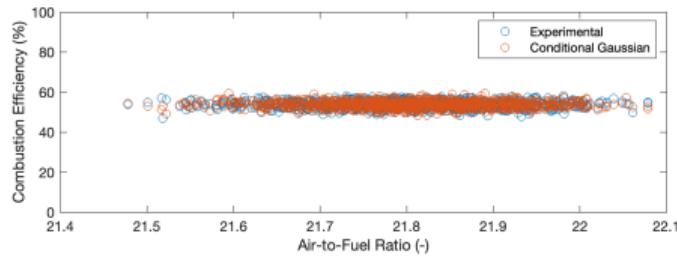
DI7.2 SOI40: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

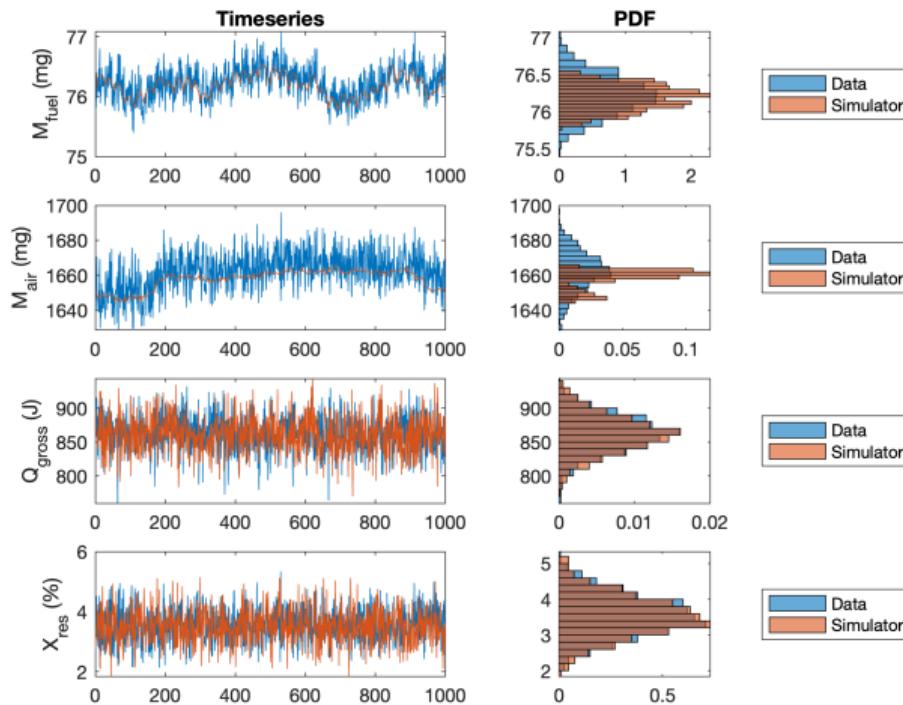
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



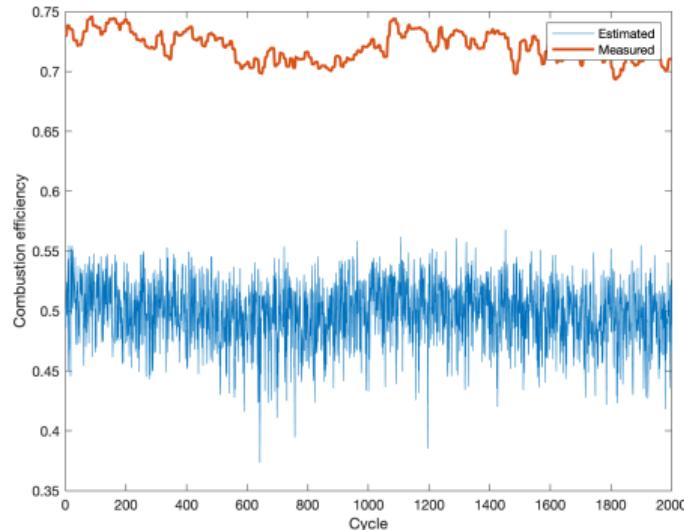
DI7.2 SOI40: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



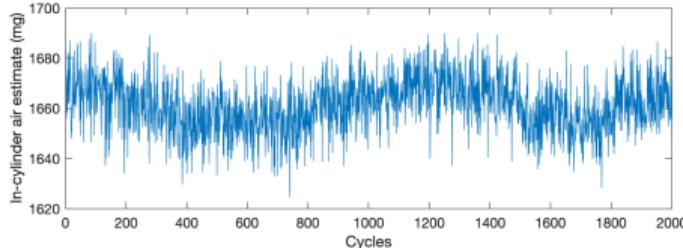
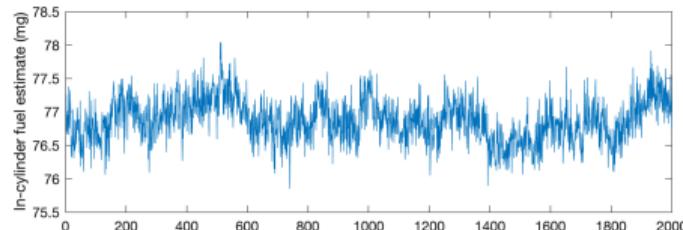
DI7.2 SOI41: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



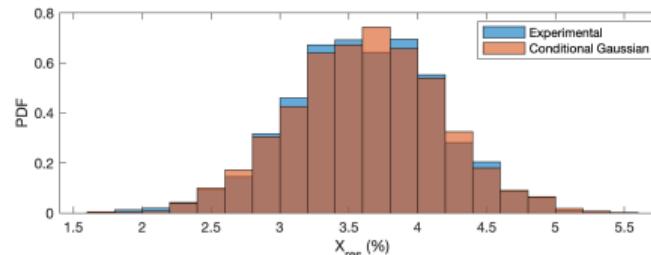
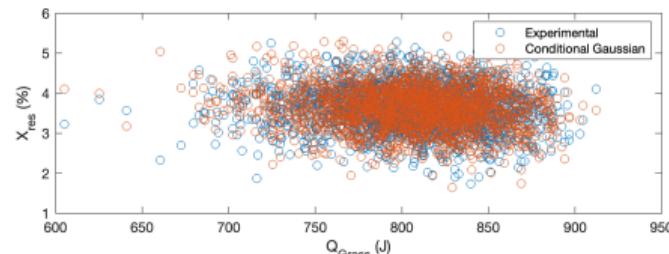
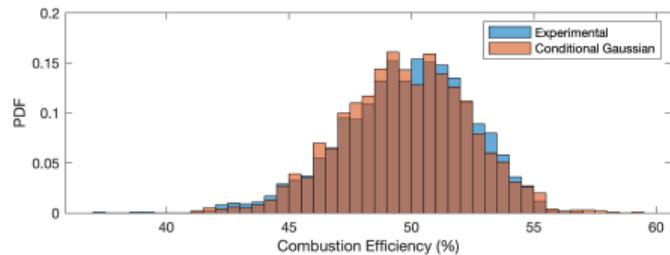
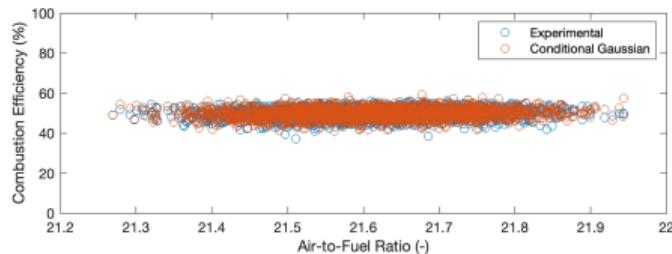
DI7.2 SOI41: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

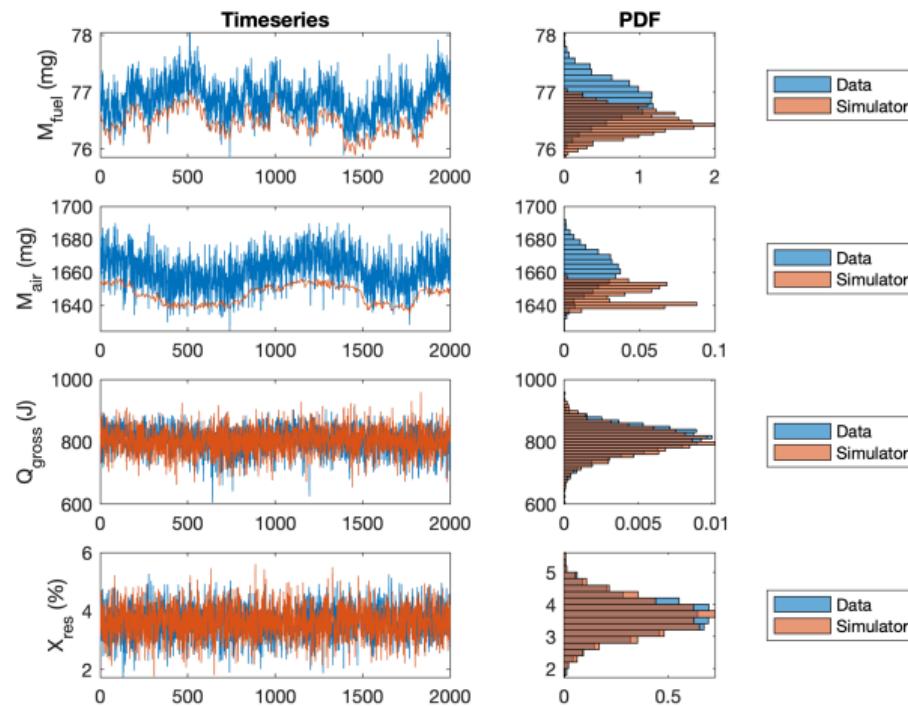
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



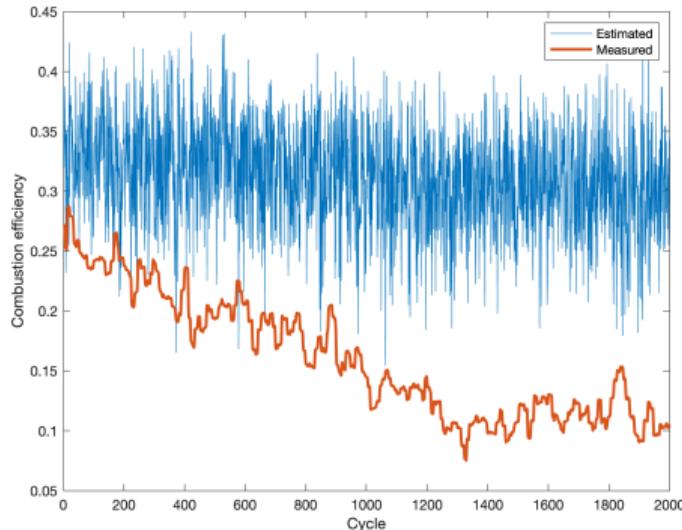
DI7.2 SOI41: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



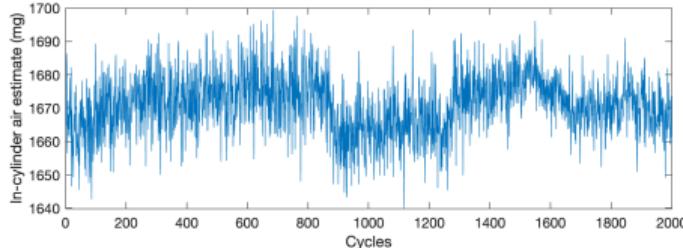
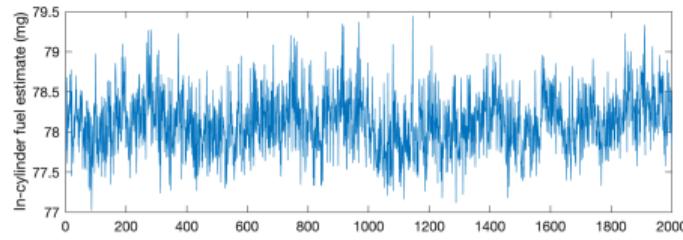
DI7.2 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



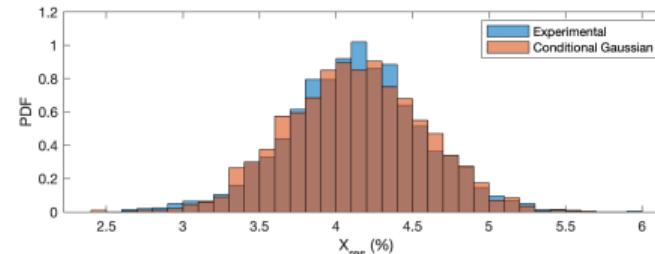
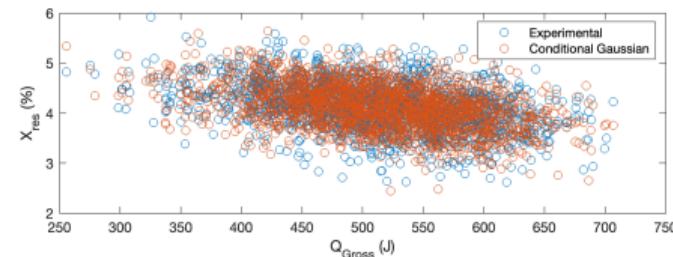
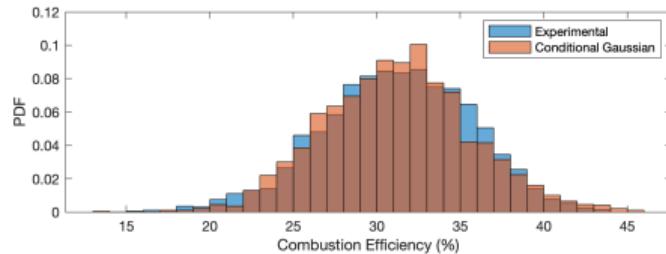
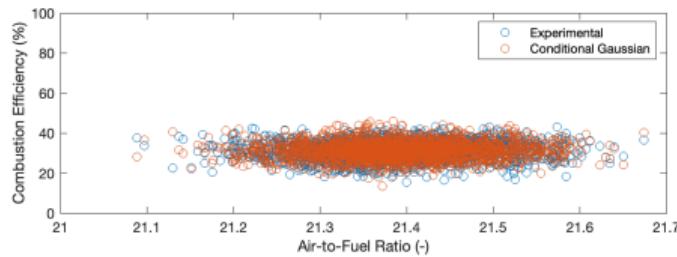
DI7.2 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

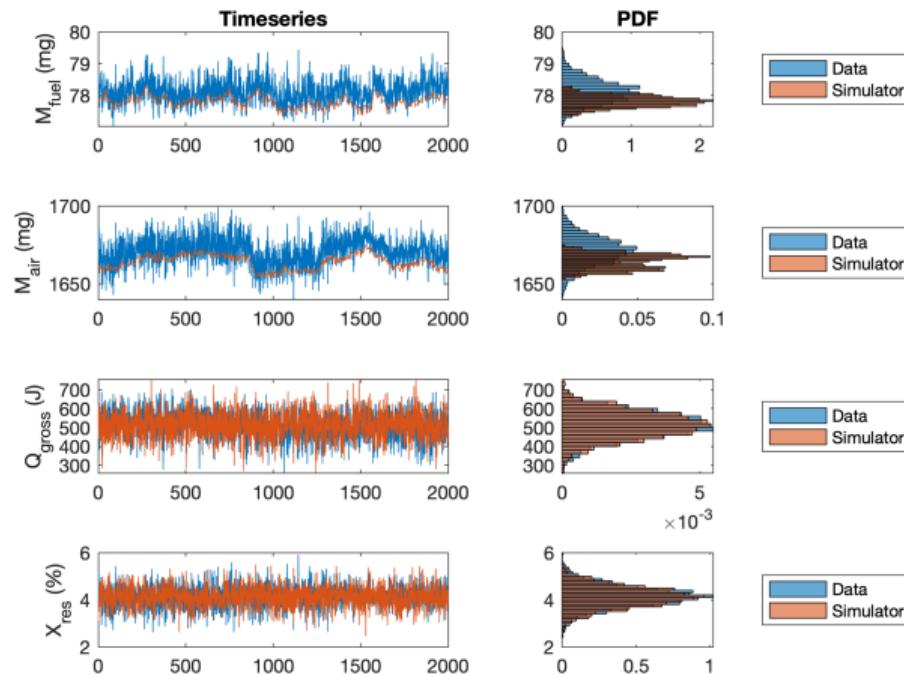
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



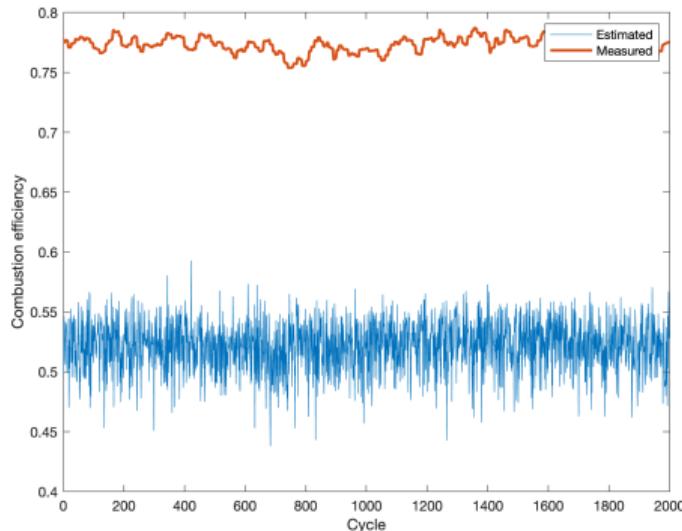
DI7.2 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$

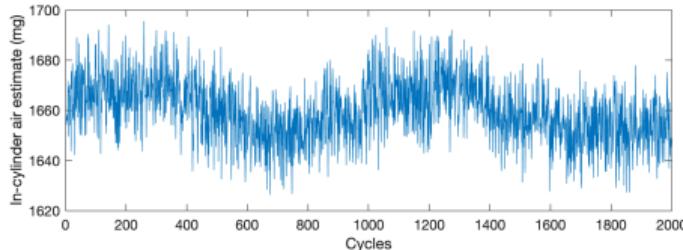
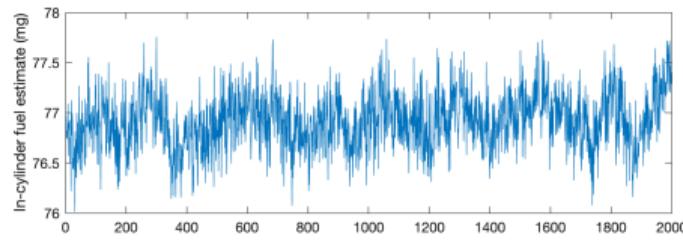


DI7.4 SOI41: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$
$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



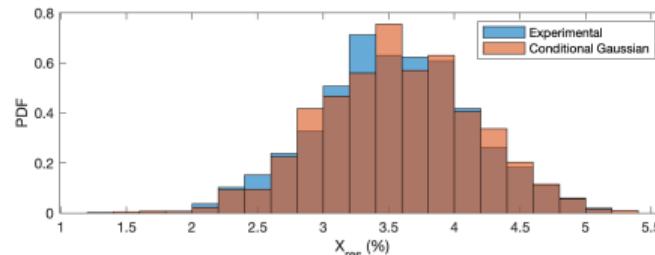
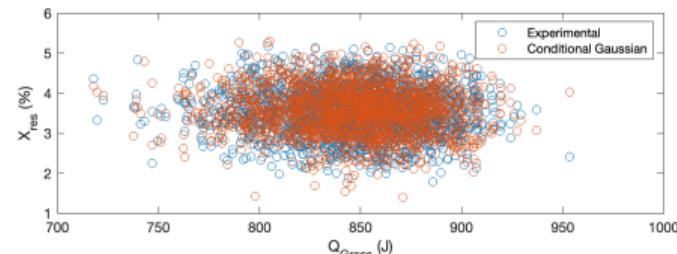
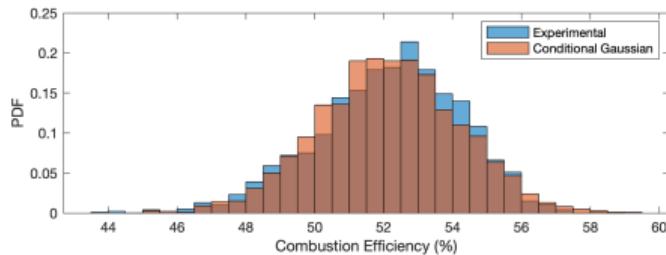
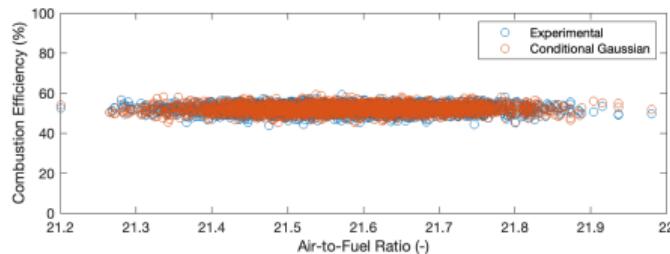
DI7.4 SOI41: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

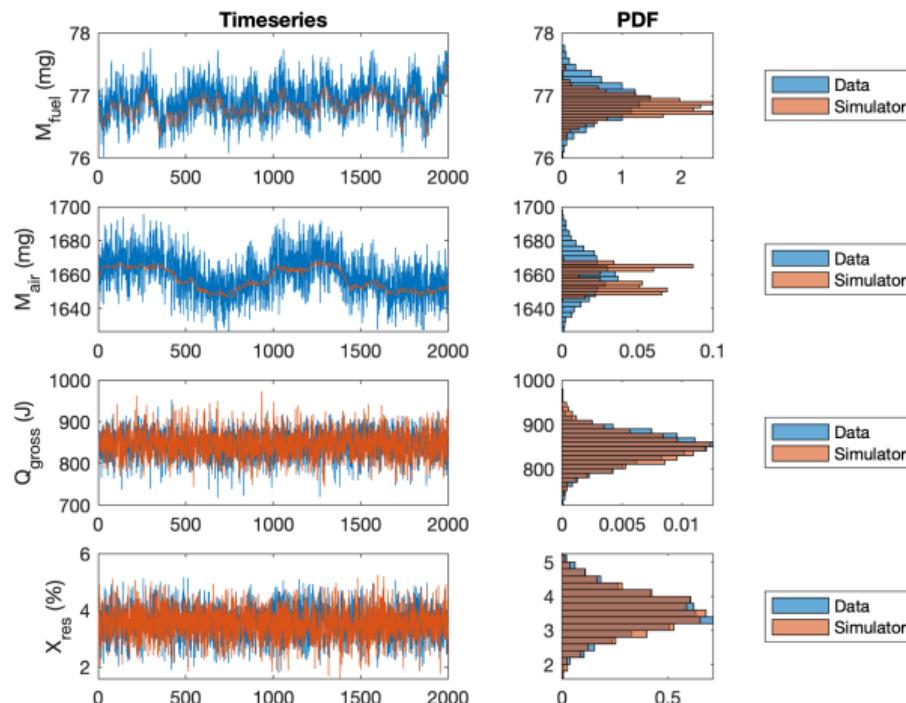
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



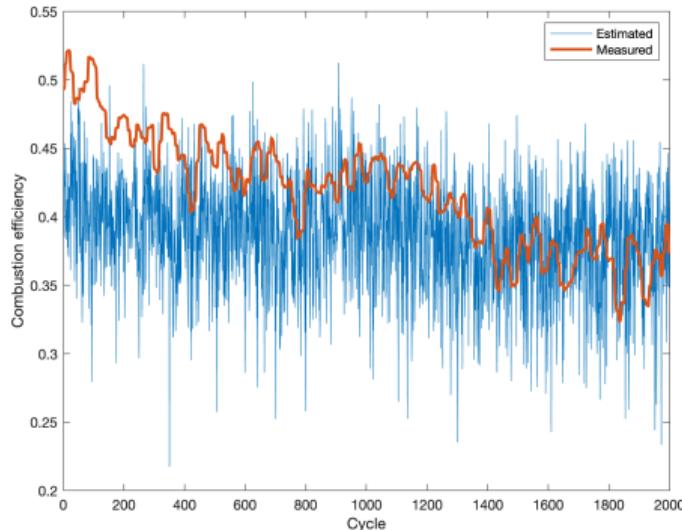
DI7.4 SOI41: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



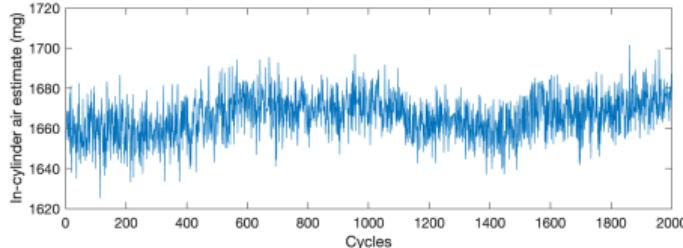
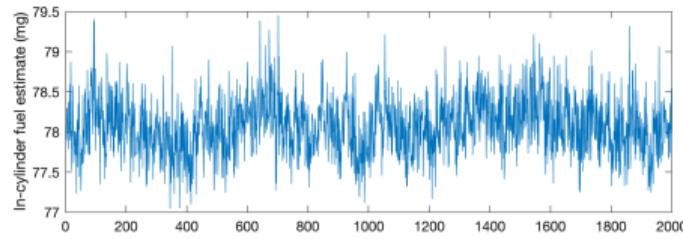
DI7.4 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



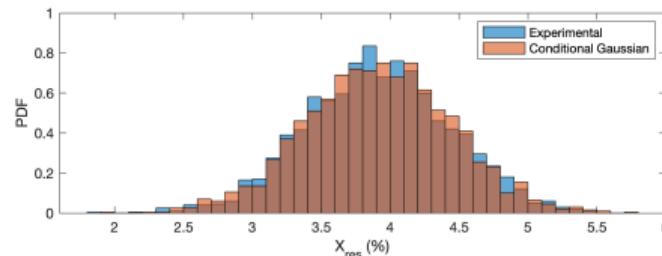
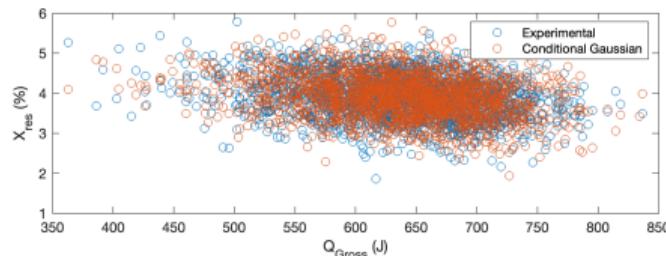
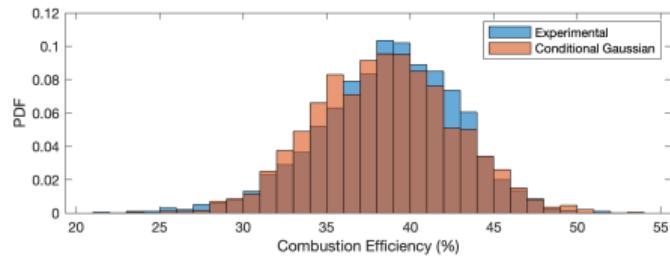
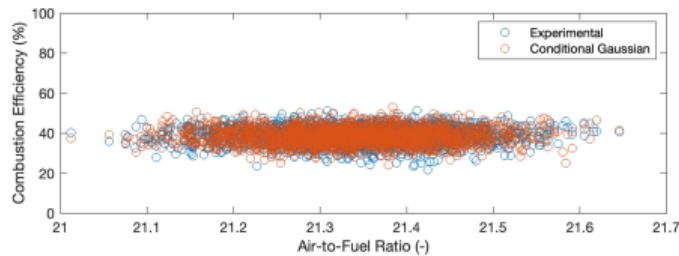
DI7.4 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

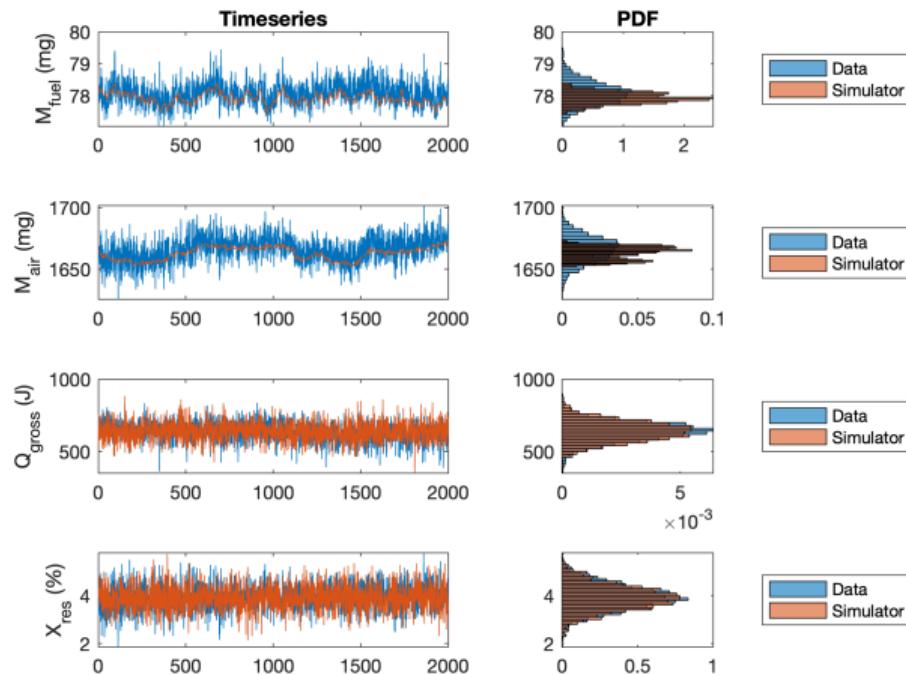
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



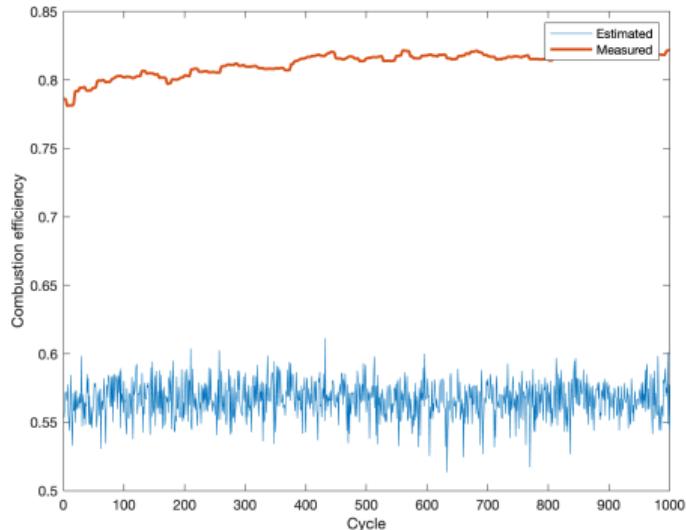
DI7.4 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



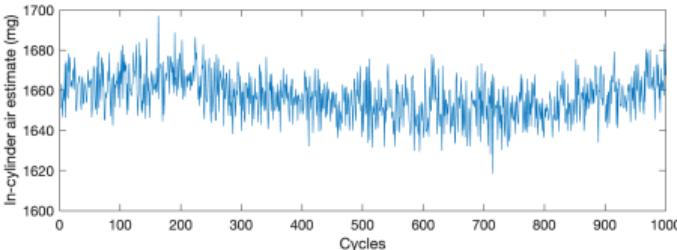
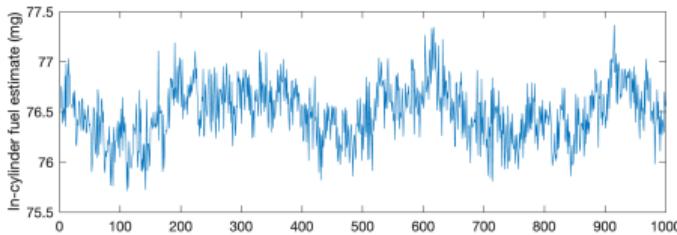
DI7.6 SOI40: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



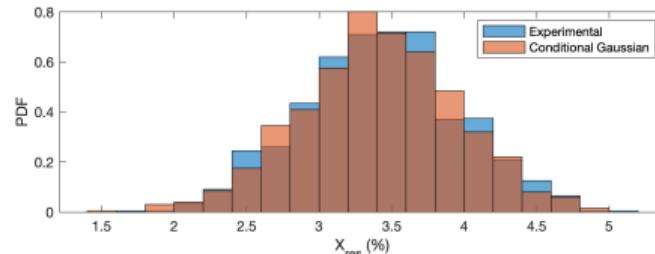
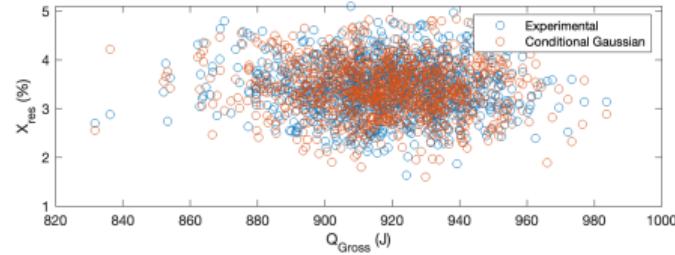
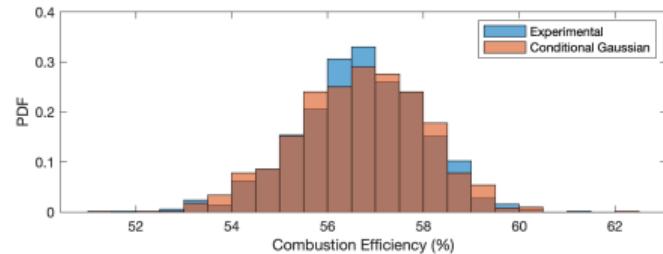
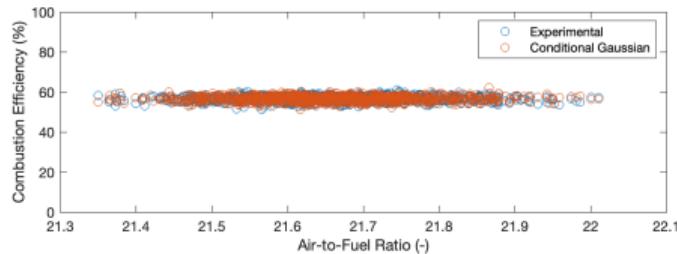
DI7.6 SOI40: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

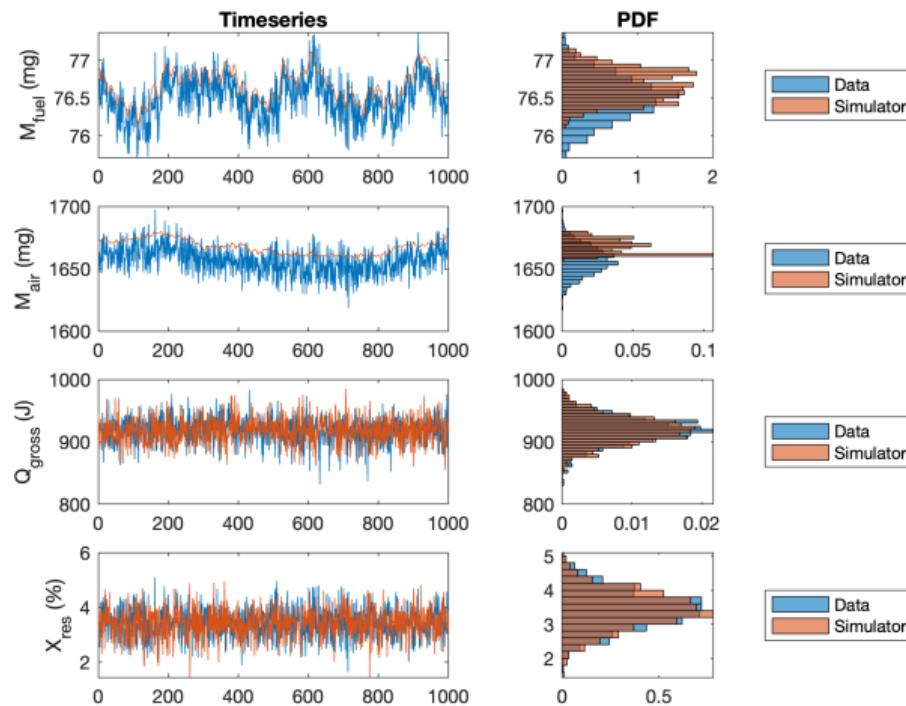
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



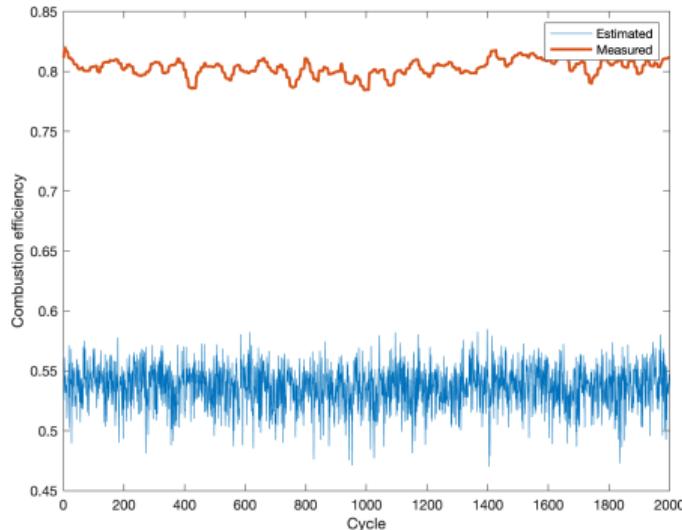
DI7.6 SOI40: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



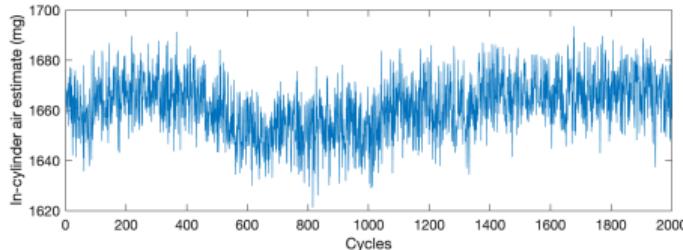
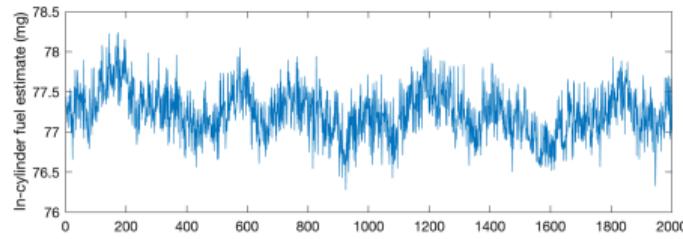
DI7.6 SOI41: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



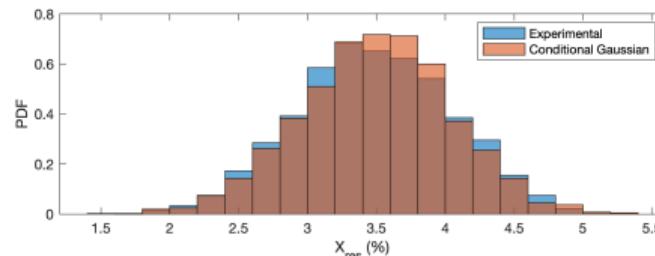
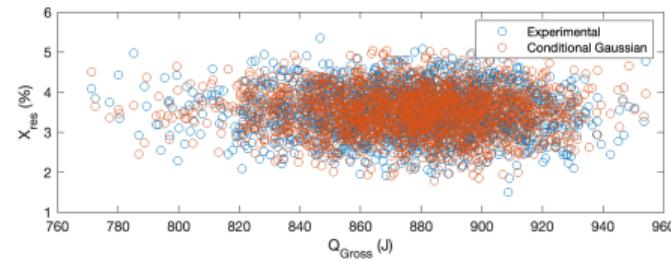
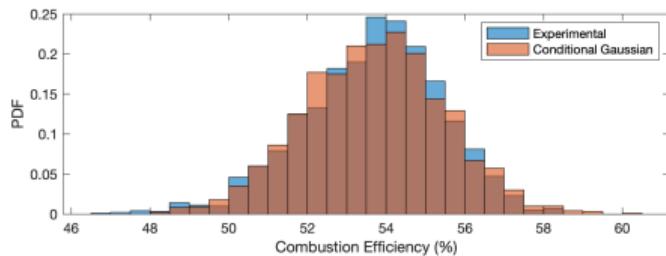
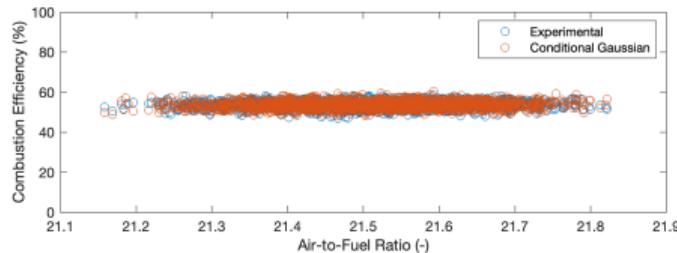
DI7.6 SOI41: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

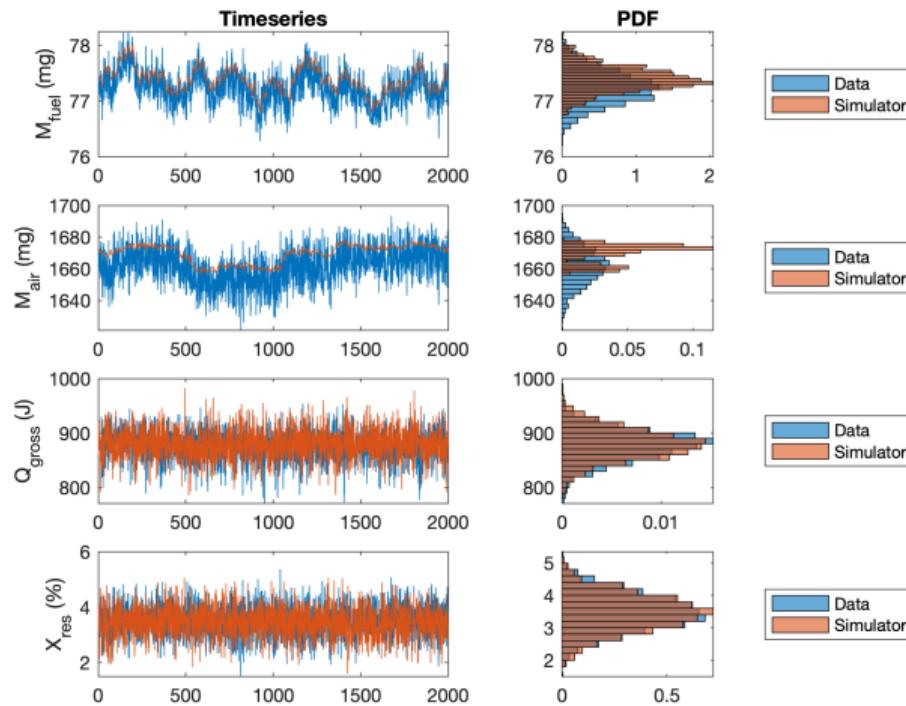
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



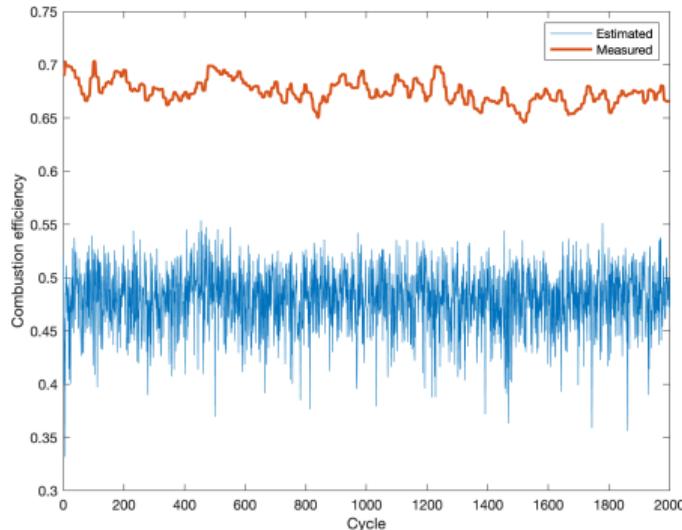
DI7.6 SOI41: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



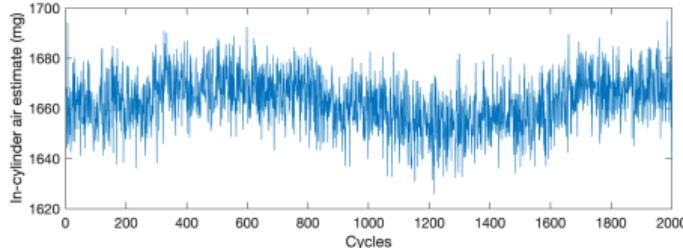
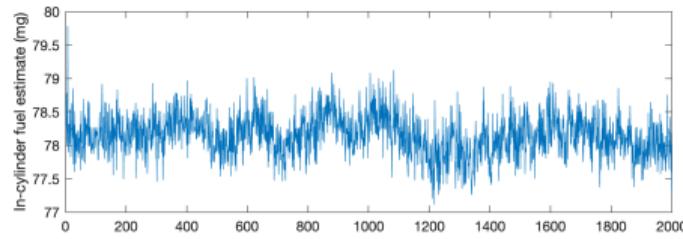
DI7.6 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



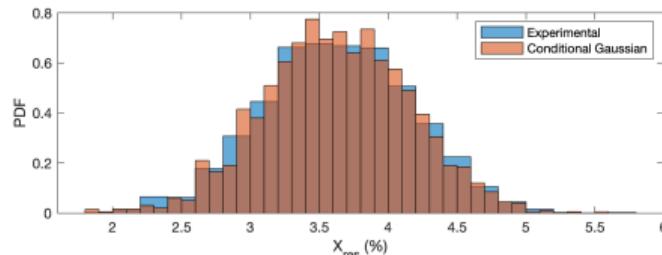
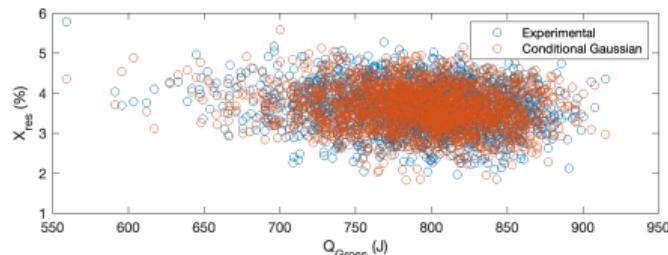
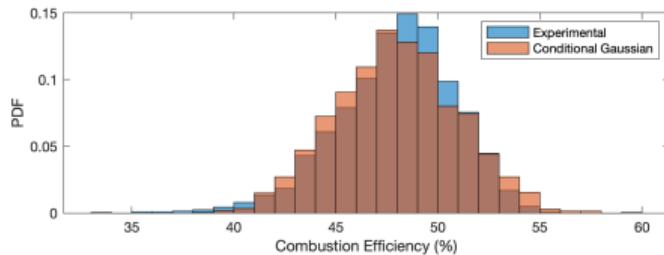
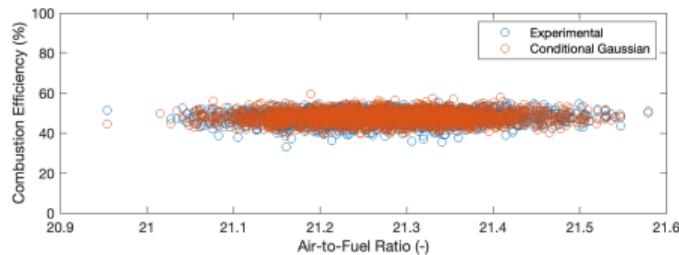
DI7.6 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

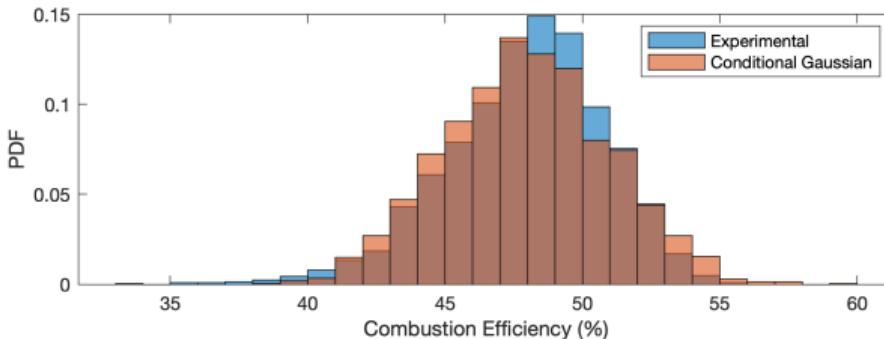
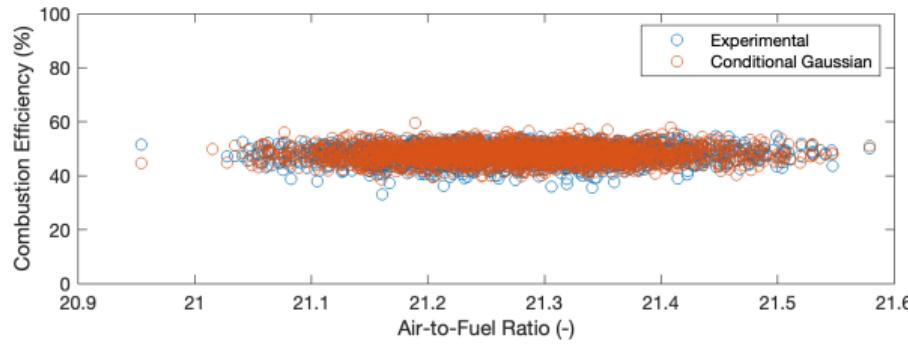
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



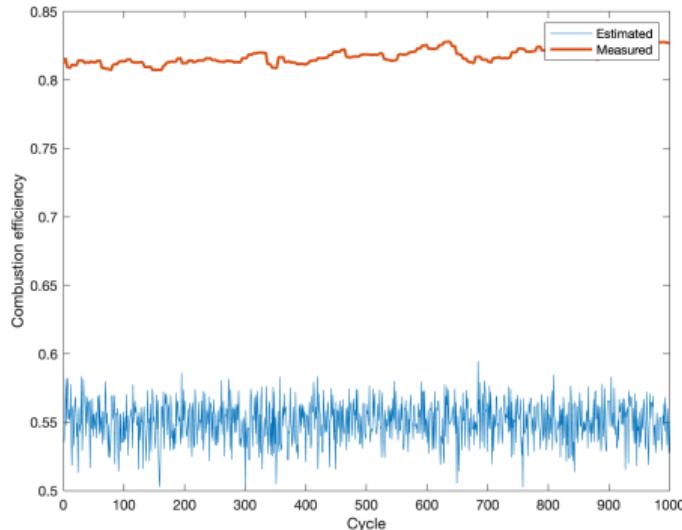
DI7.6 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



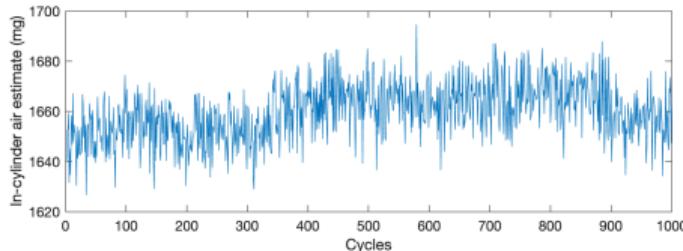
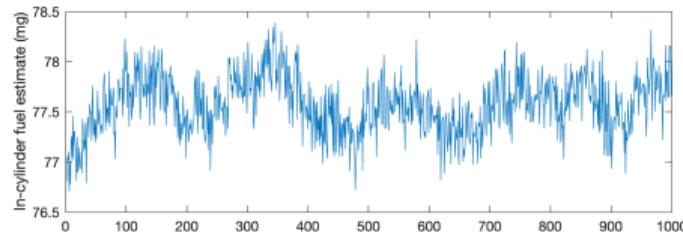
DI7.8 SOI41: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



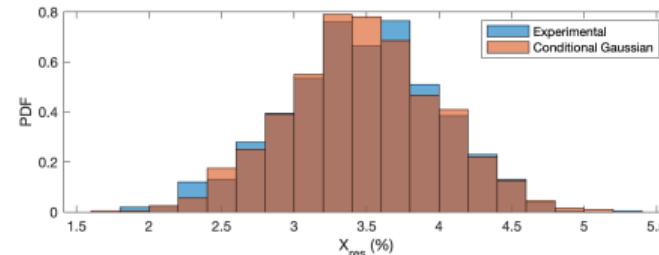
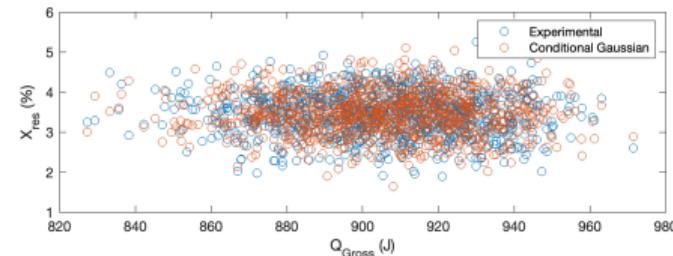
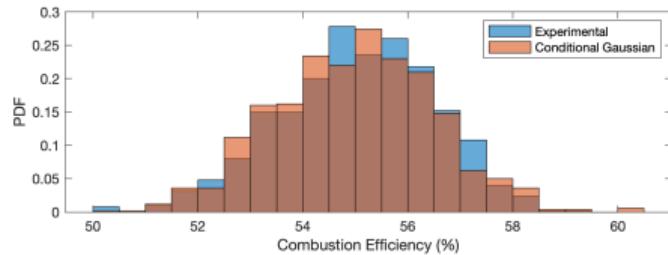
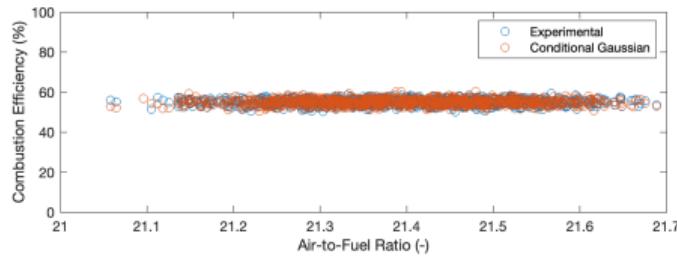
DI7.8 SOI41: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

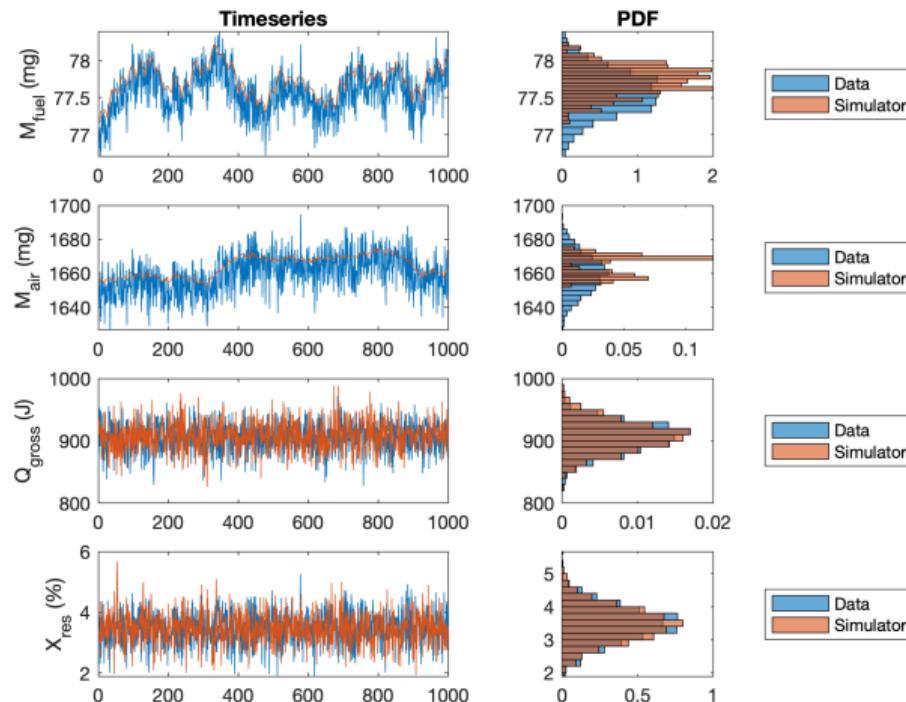
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



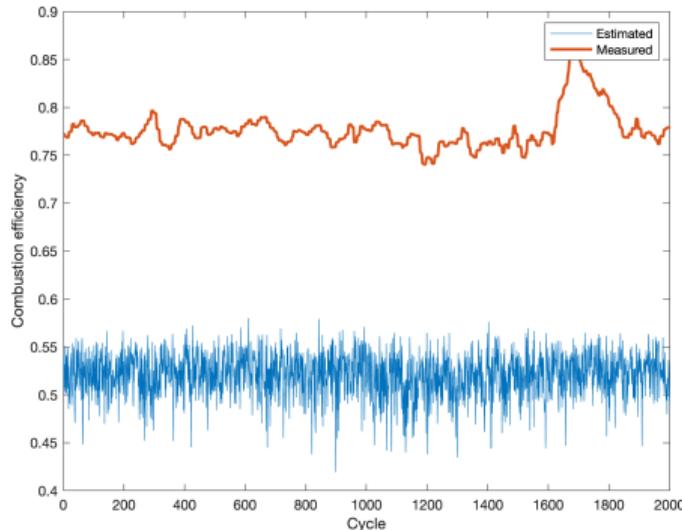
DI7.8 SOI41: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



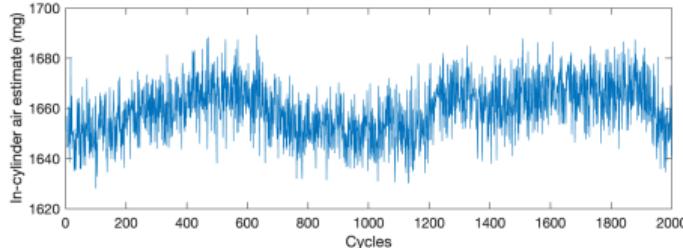
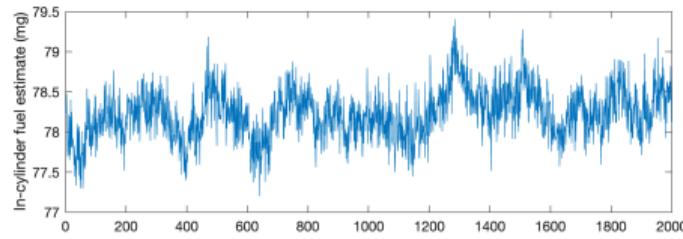
DI7.8 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



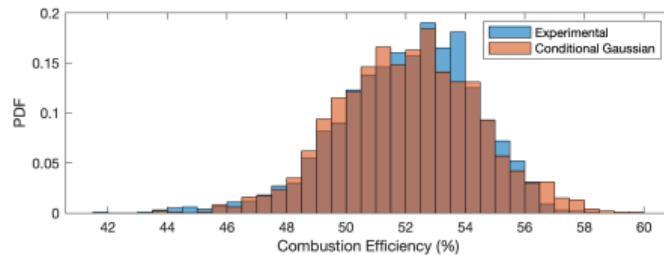
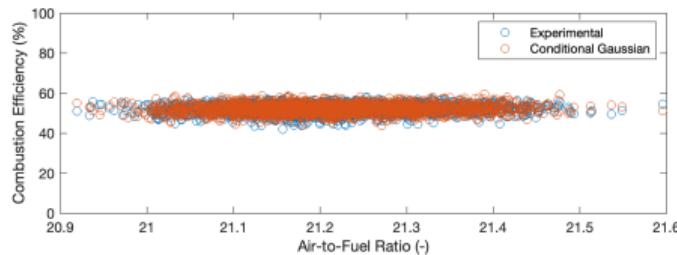
$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

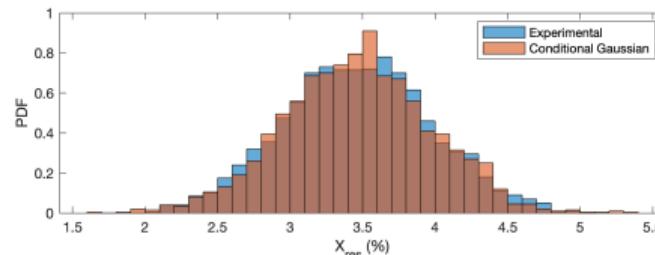
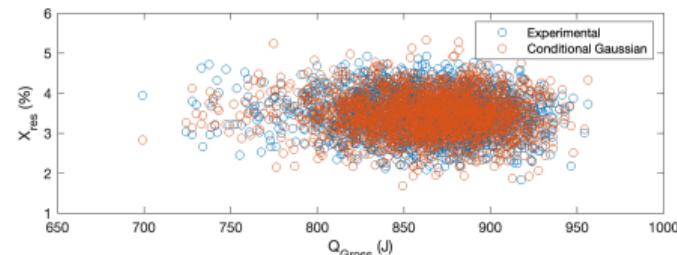


DI7.8 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{aligned} \begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} &\sim \mathcal{N}(\mu_\eta, \Sigma_\eta) \\ \therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} &\sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad , \end{aligned}$$

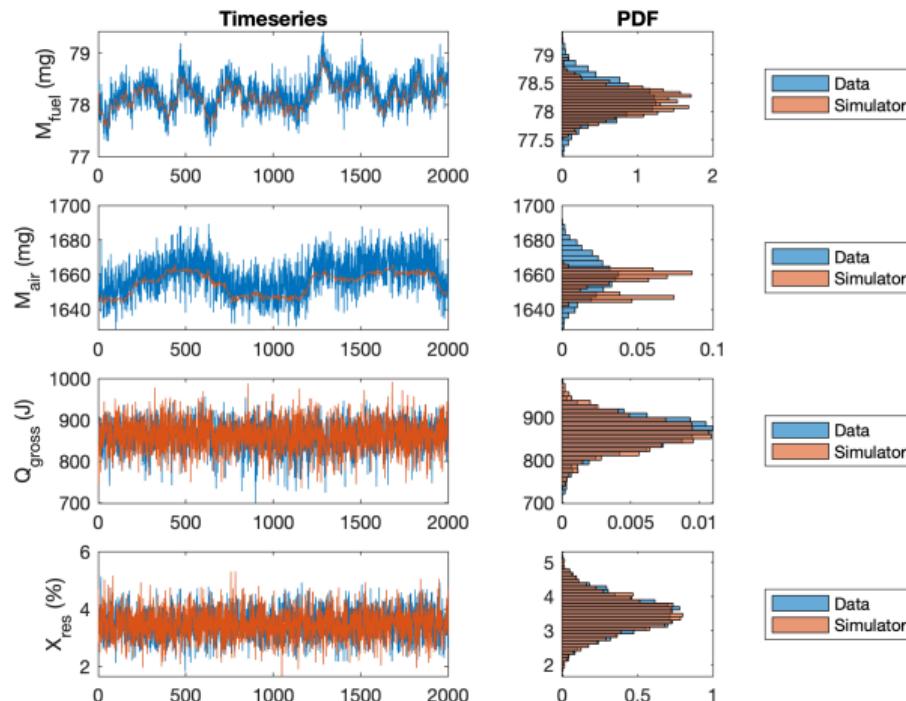


$$\begin{aligned} \begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} &\sim \mathcal{N}(\mu_X, \Sigma_X) \\ \therefore X_{\text{res}} \mid Q_{\text{gross}} &\sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \end{aligned}$$



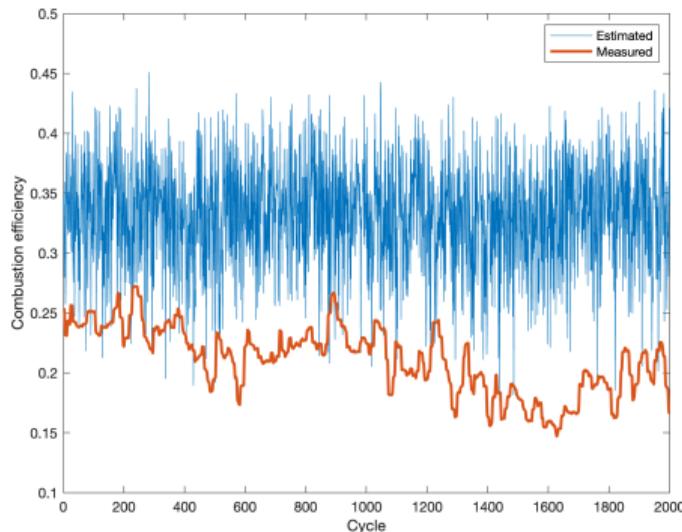
DI7.8 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



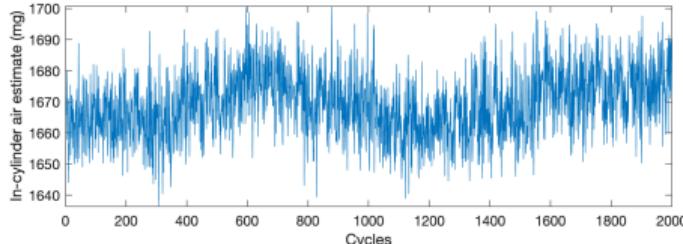
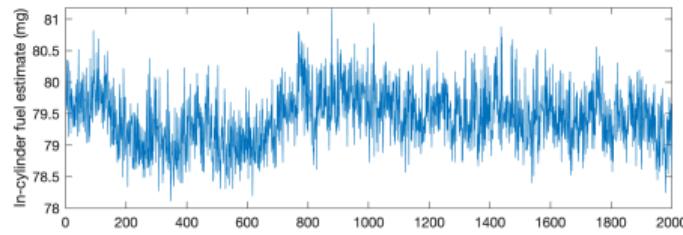
DI7.8 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



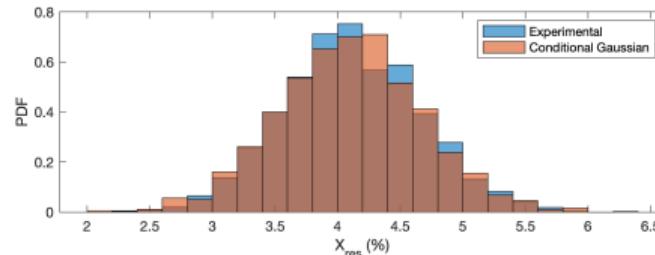
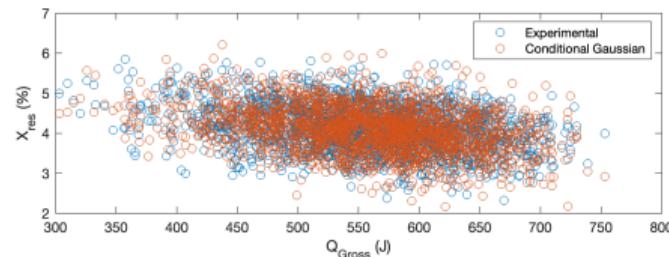
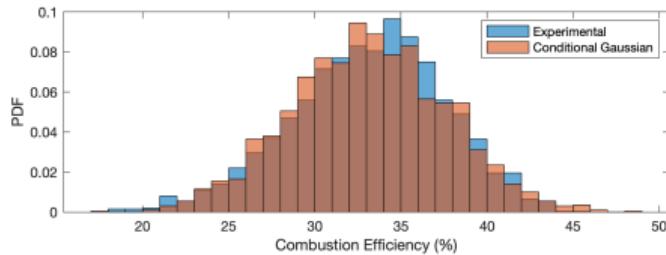
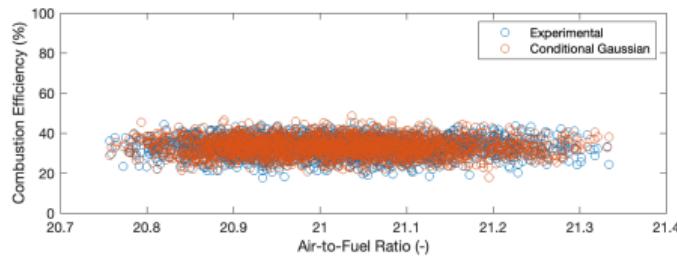
DI7.8 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

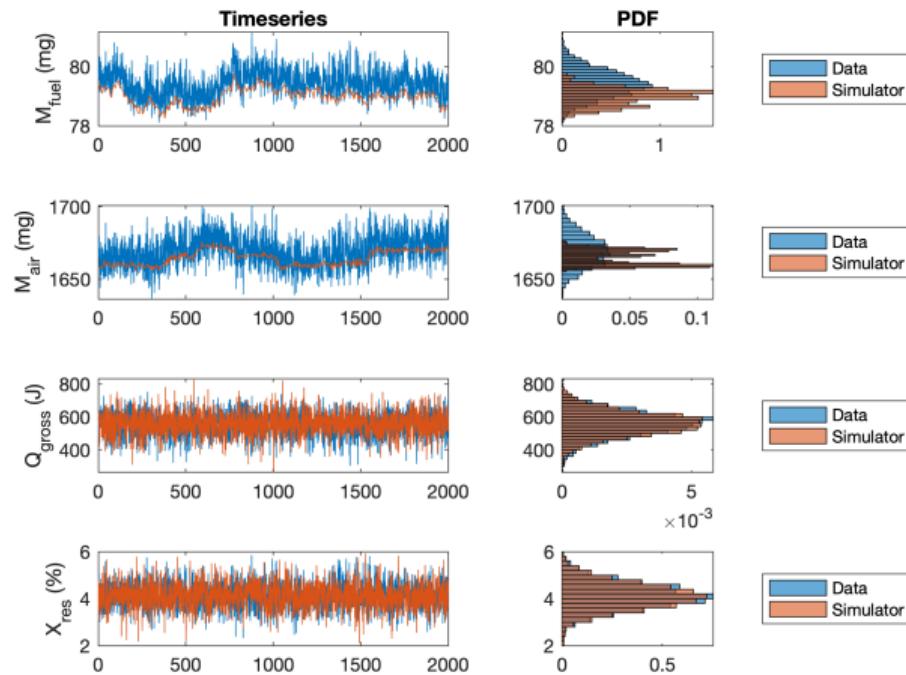
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



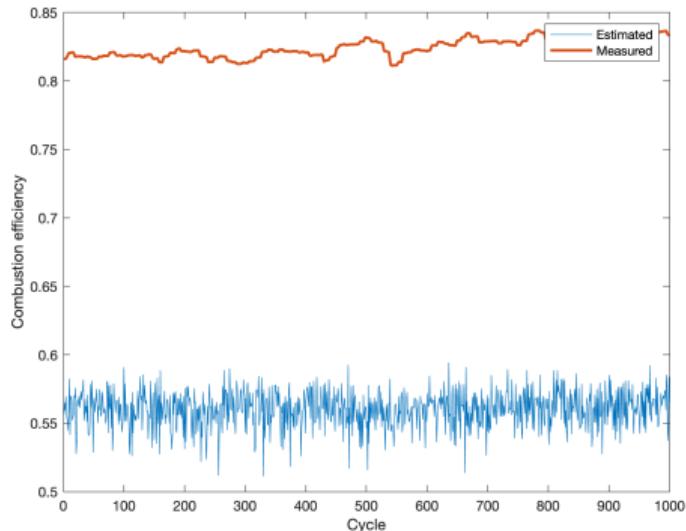
DI7.8 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$

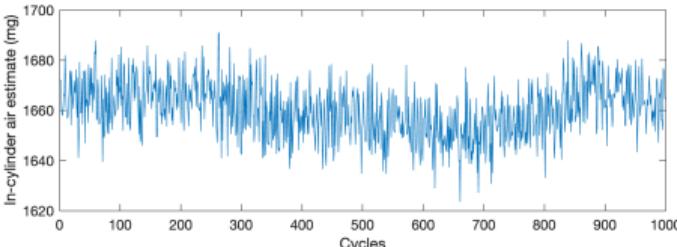
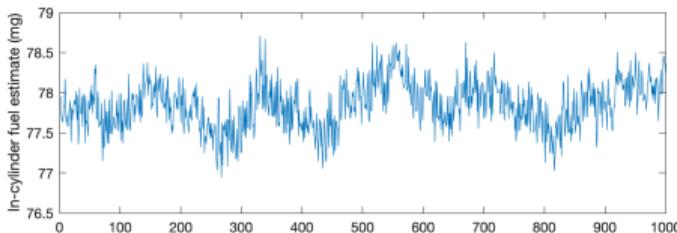


DI8.0 SOI41: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{1 - X_{\text{res}}}{\frac{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{Q_{\text{gross}}} - X_{\text{res}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$
$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



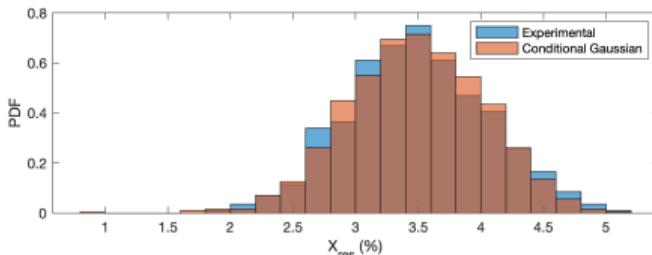
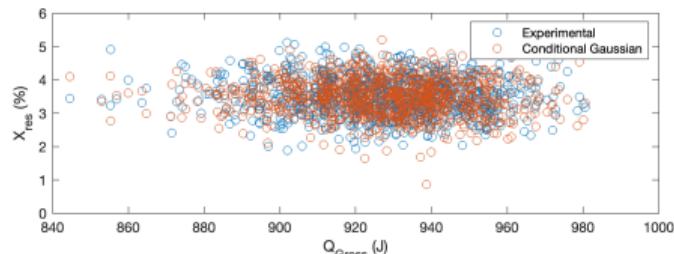
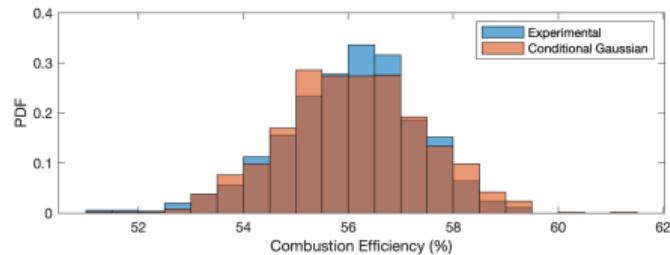
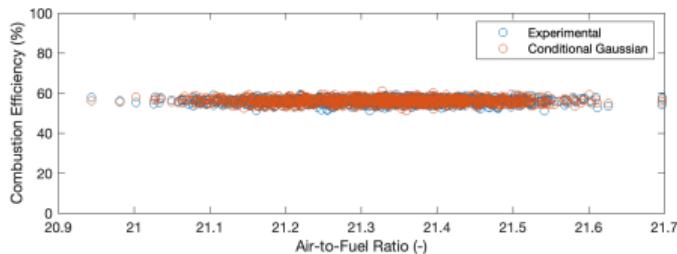
DI8.0 SOI41: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

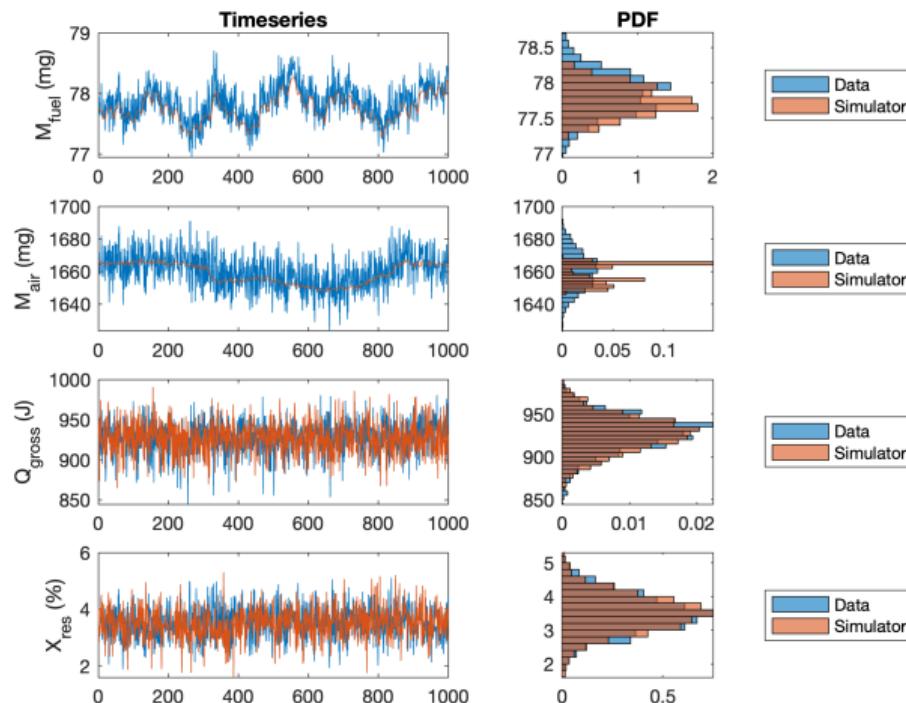
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



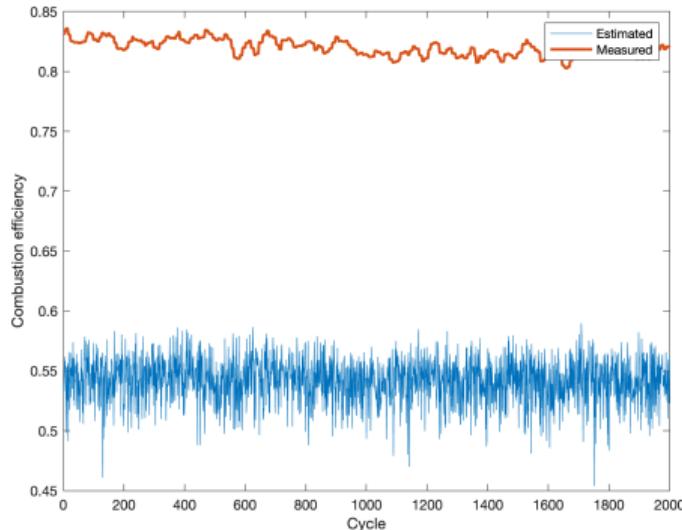
DI8.0 SOI41: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



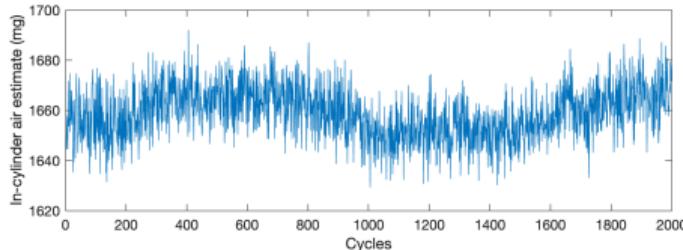
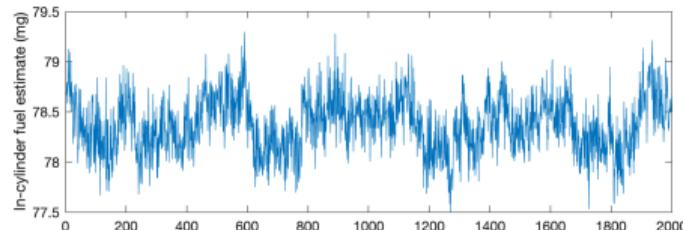
DI8.0 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



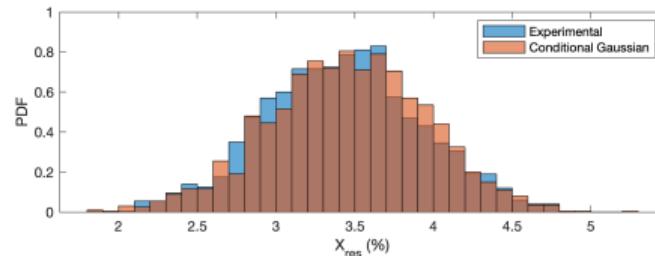
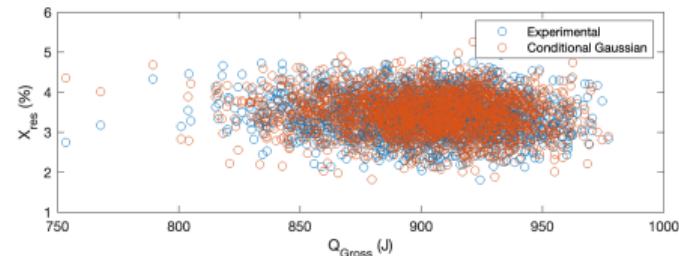
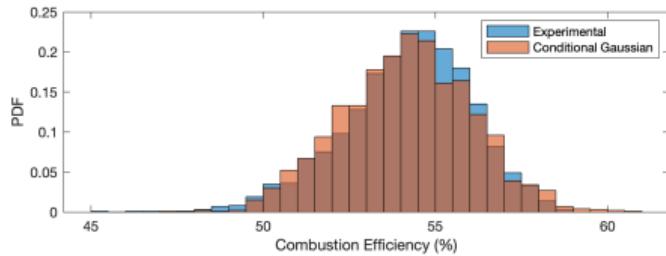
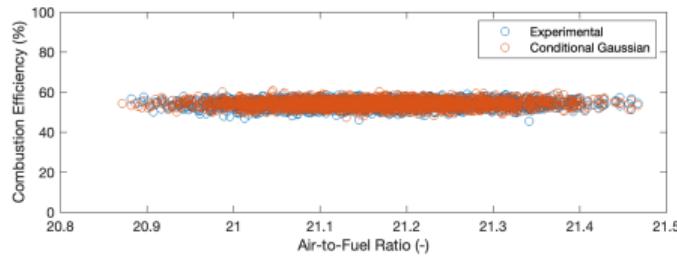
DI8.0 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

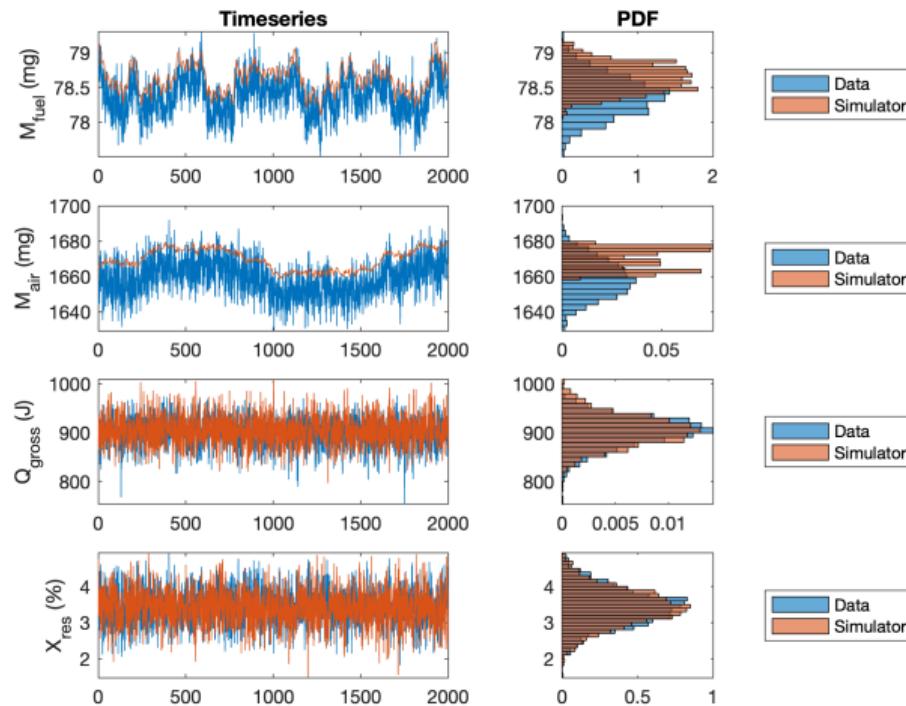
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



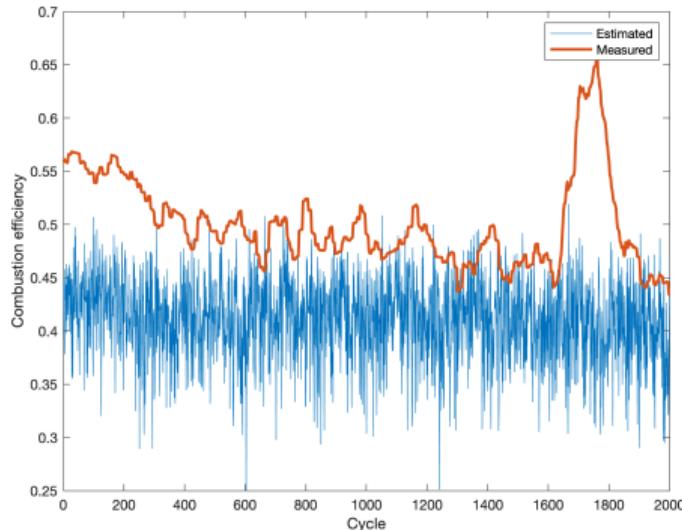
DI8.0 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



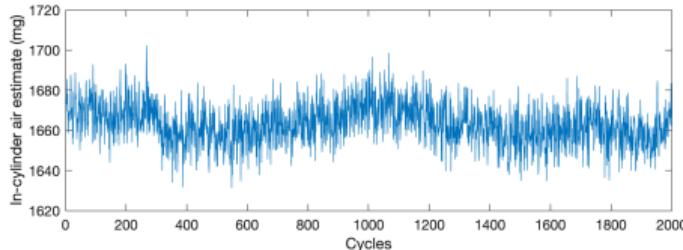
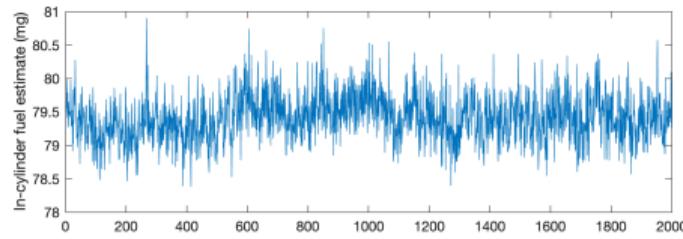
DI8.0 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

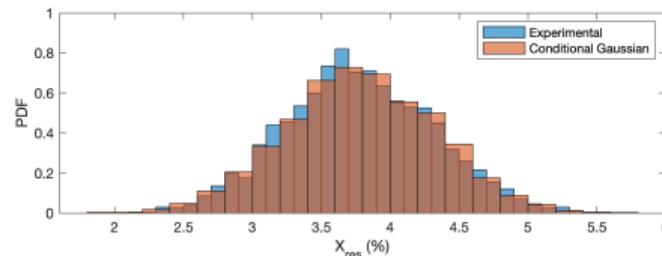
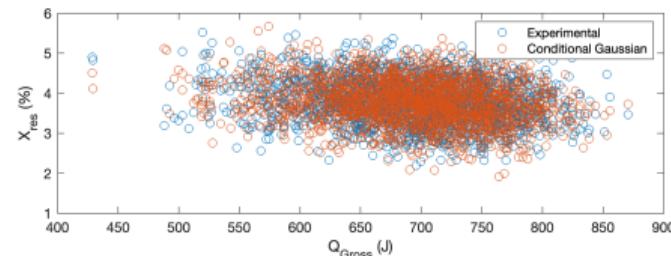
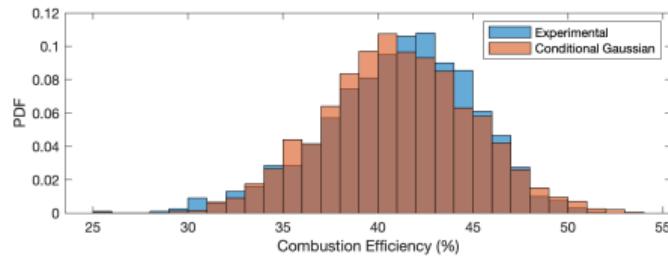
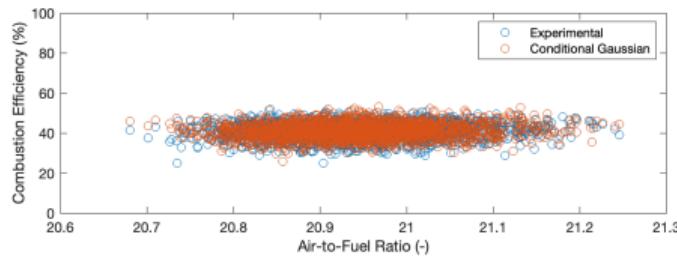
$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



DI8.0 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

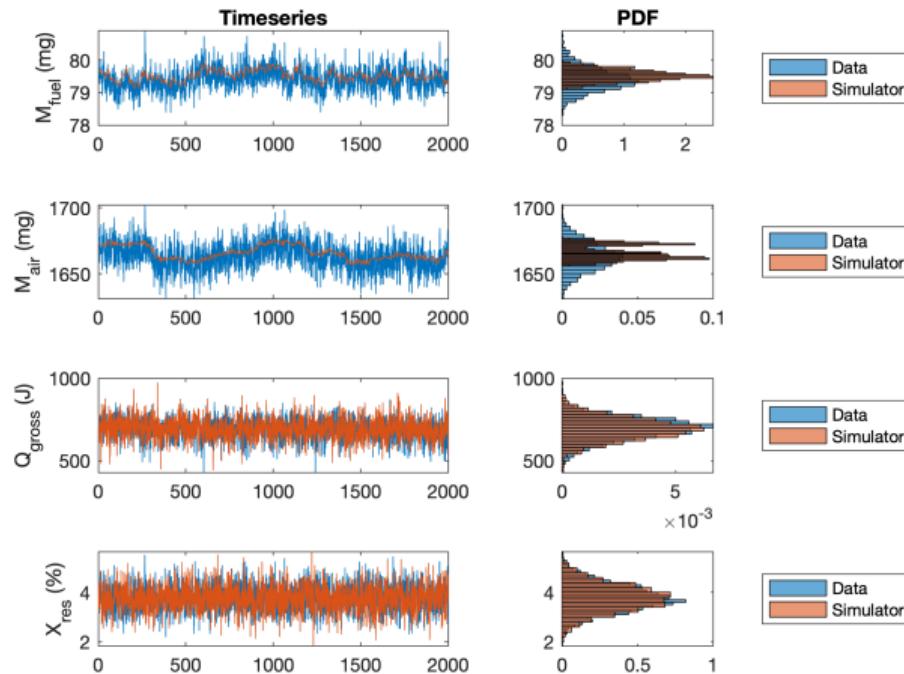
$$\begin{aligned} \begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} &\sim \mathcal{N}(\mu_\eta, \Sigma_\eta) \\ \therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} &\sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad , \end{aligned}$$

$$\begin{aligned} \begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} &\sim \mathcal{N}(\mu_X, \Sigma_X) \\ \therefore X_{\text{res}} \mid Q_{\text{gross}} &\sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \end{aligned}$$



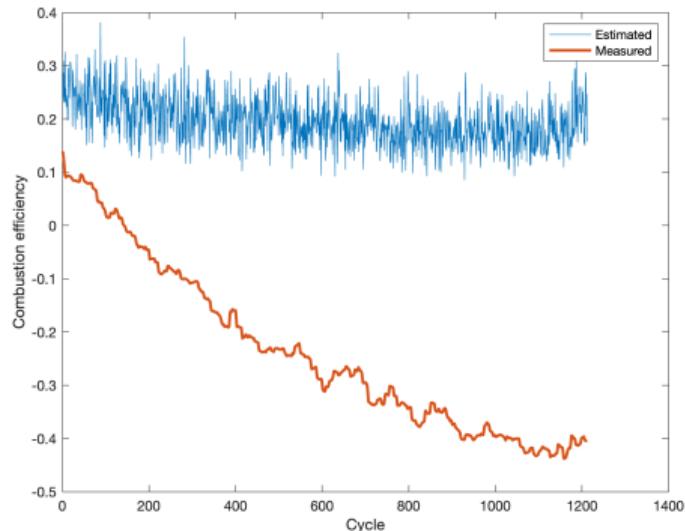
DI8.0 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$

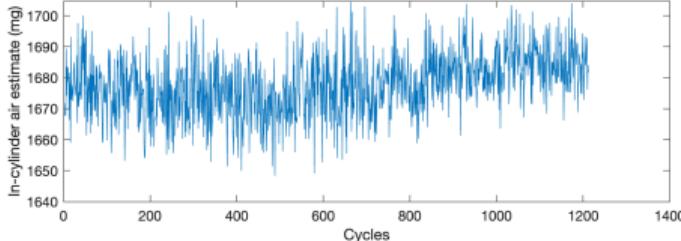
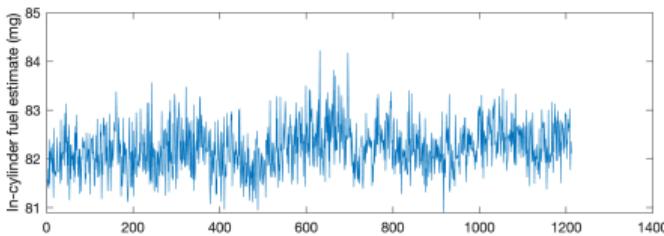


DI8.0 SOI44: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$
$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



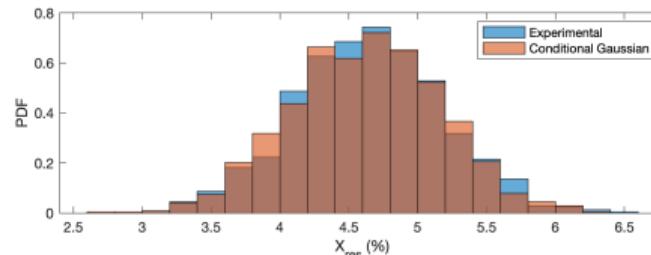
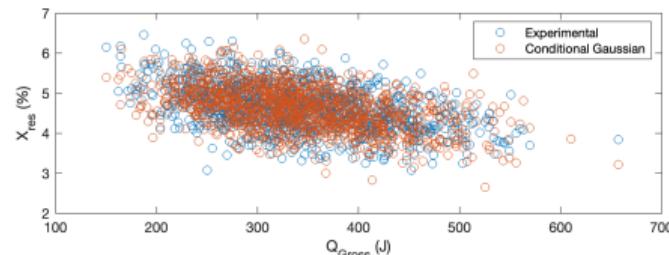
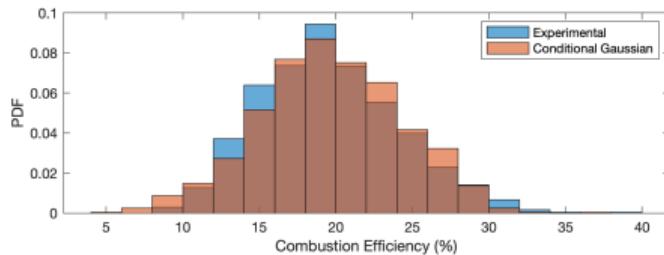
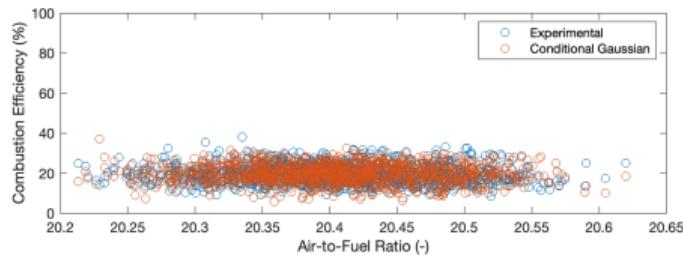
DI8.0 SOI44: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

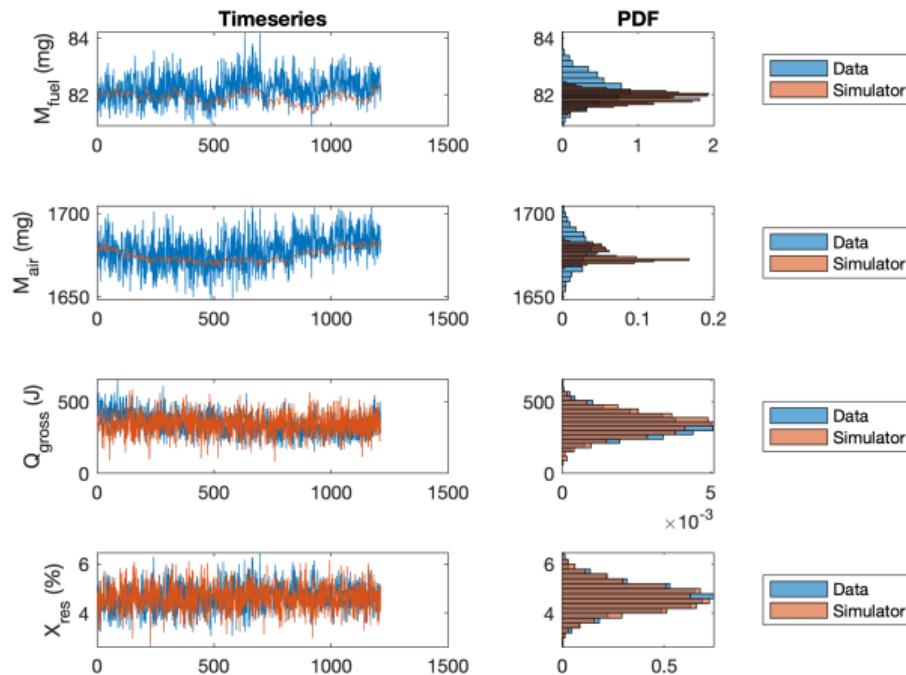
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



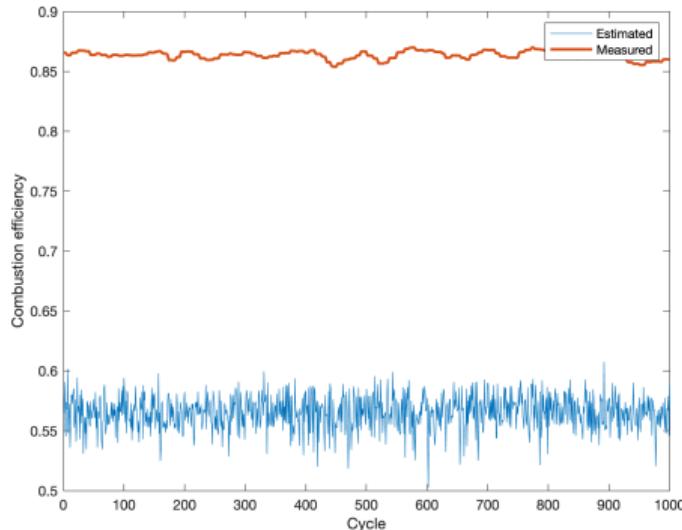
DI8.0 SOI44: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



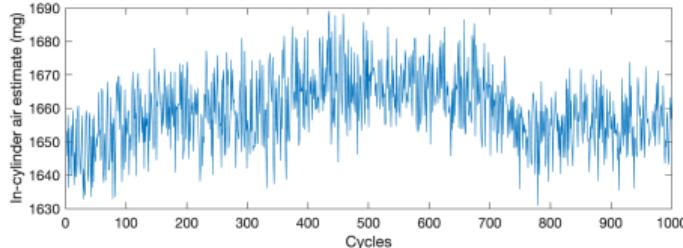
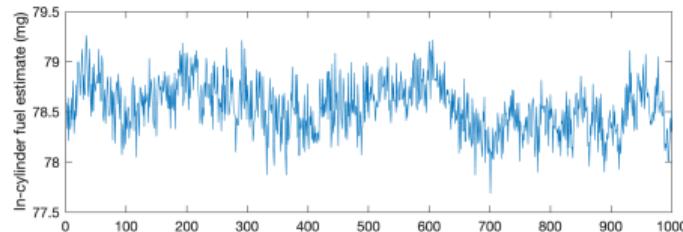
DI8.2 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



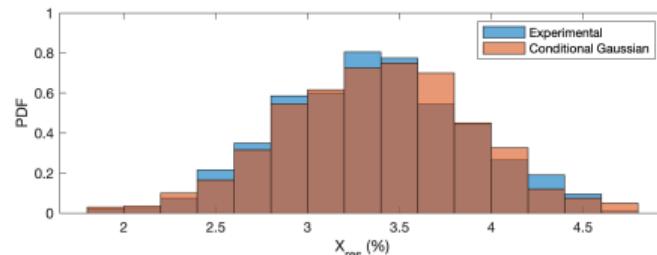
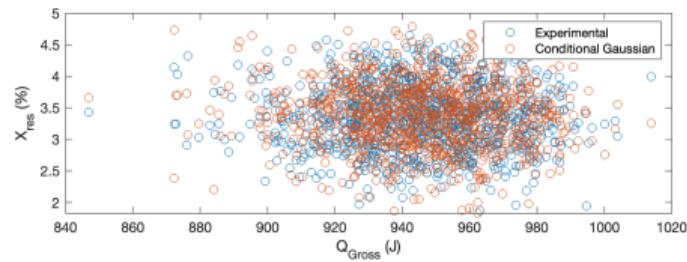
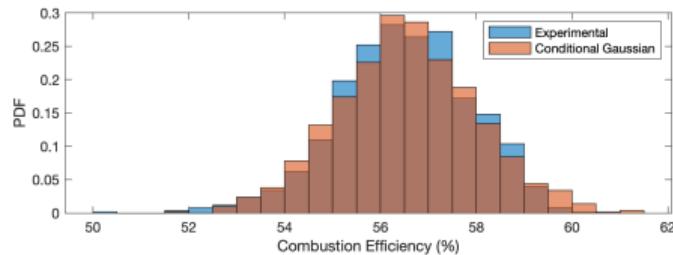
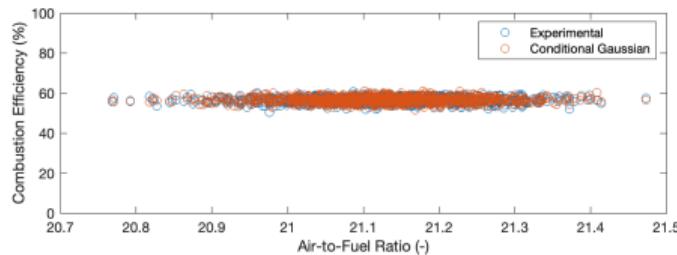
DI8.2 SOI42: Parametric model $(\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X)$

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

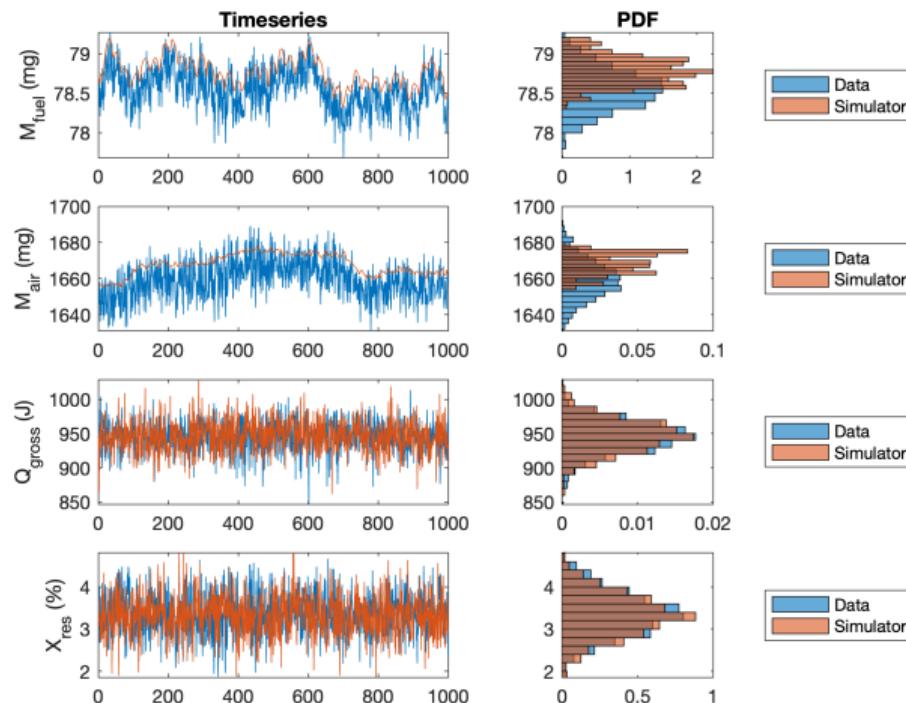
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



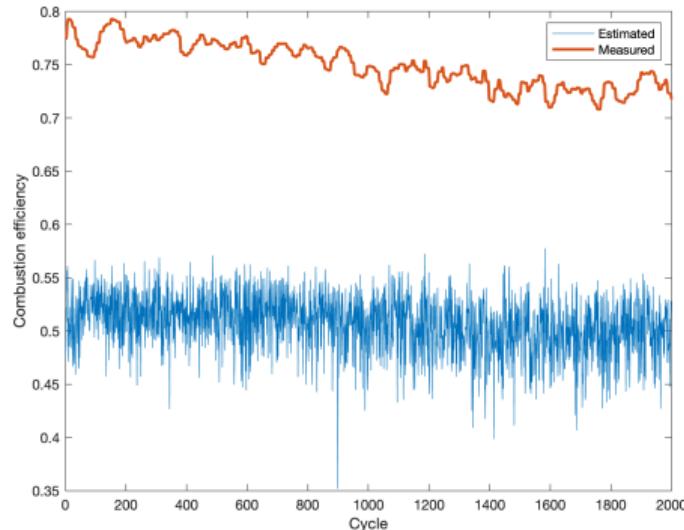
DI8.2 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



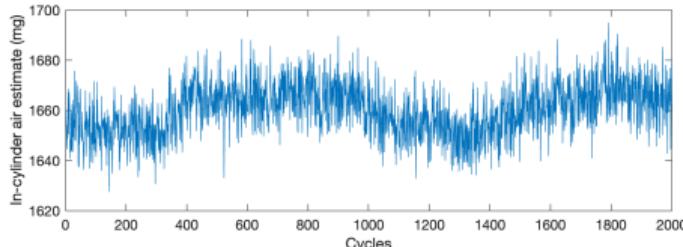
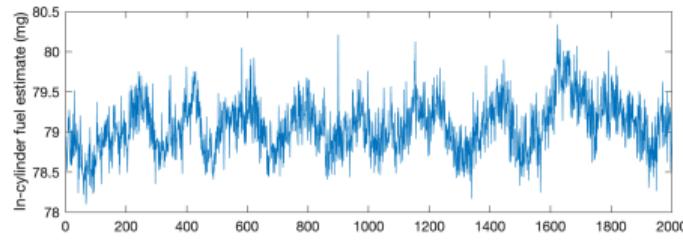
DI8.2 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



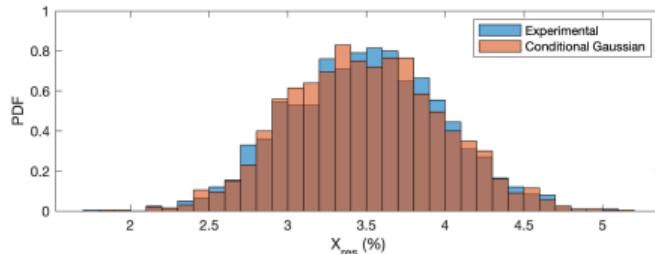
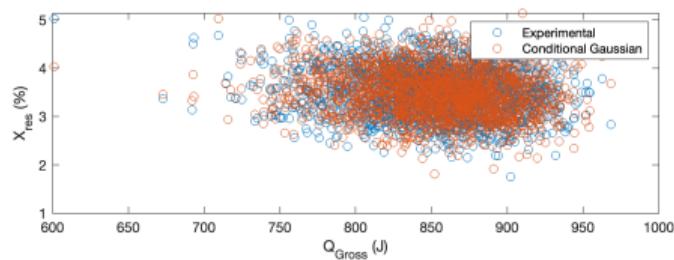
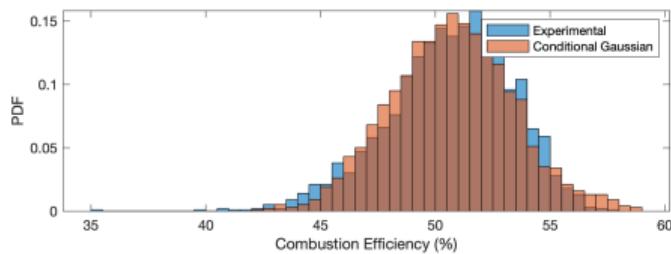
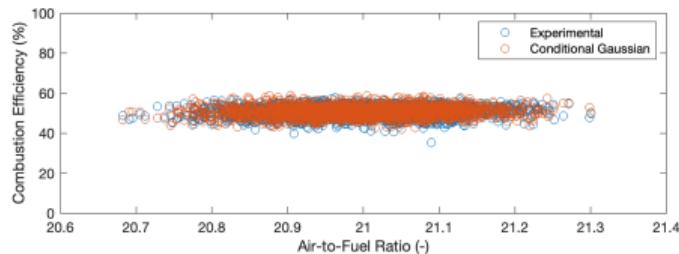
DI8.2 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

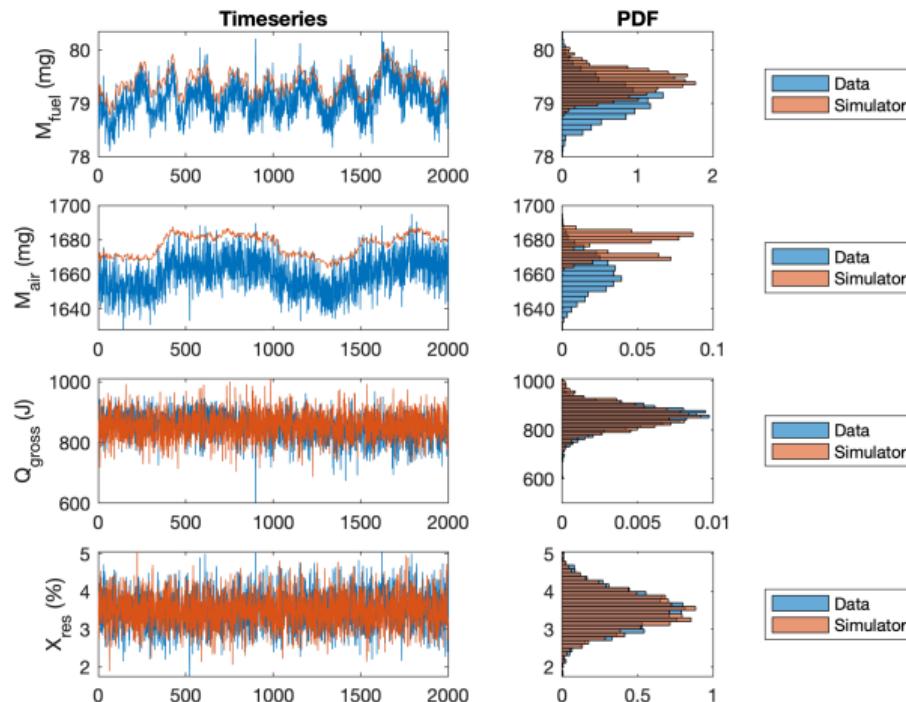
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



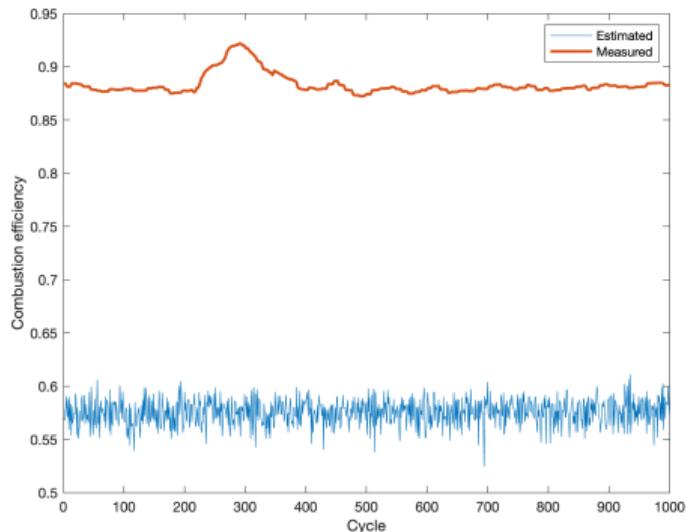
DI8.2 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



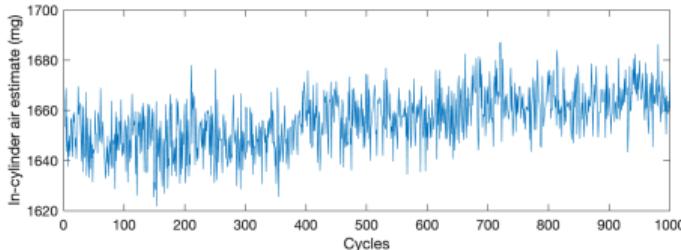
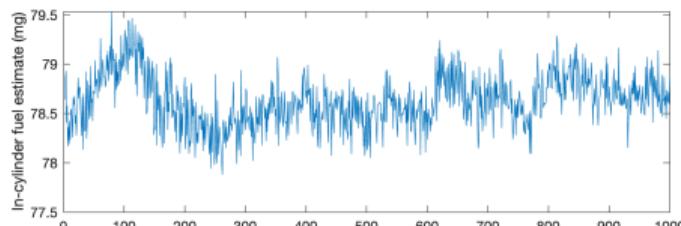
DI8.4 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



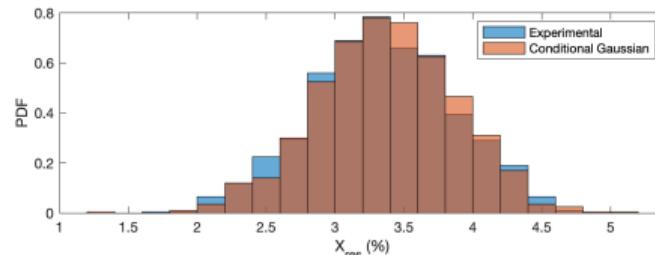
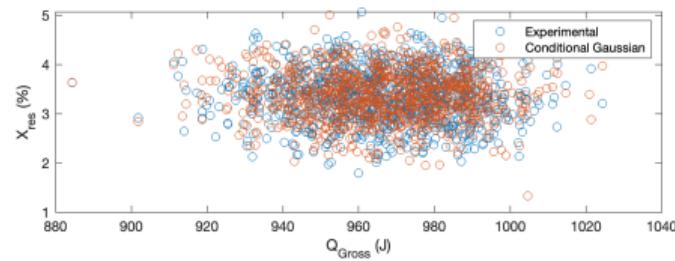
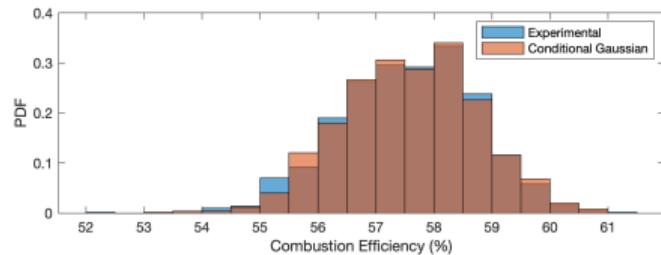
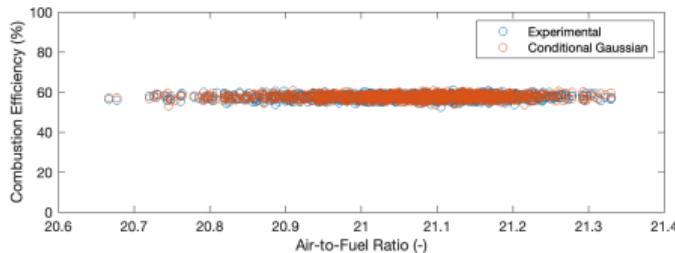
DI8.4 SOI42: Parametric model $(\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X)$

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

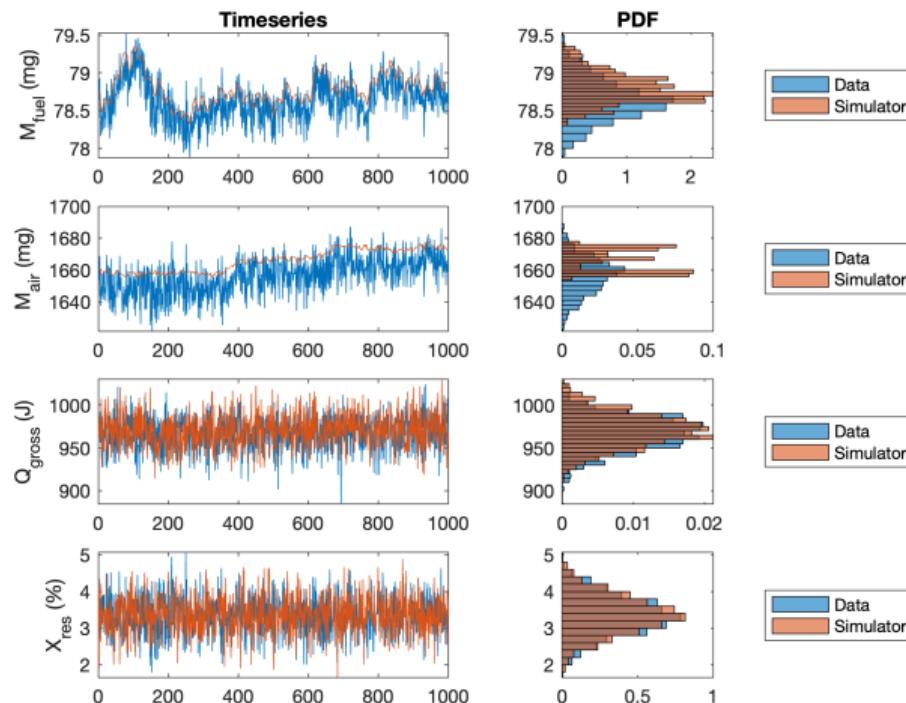
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



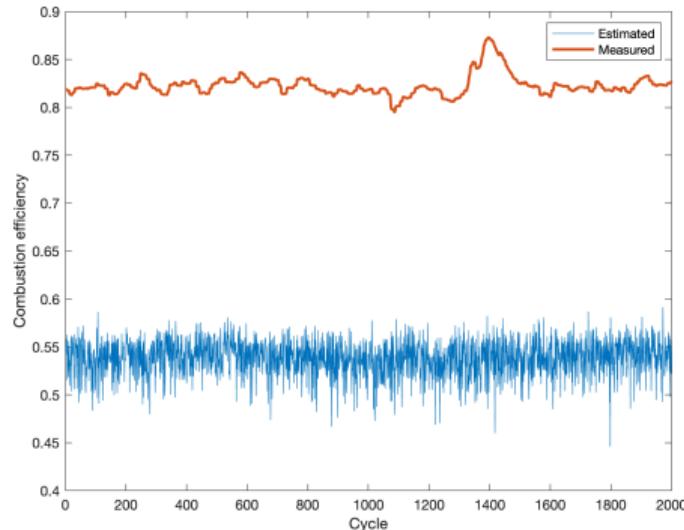
DI8.4 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



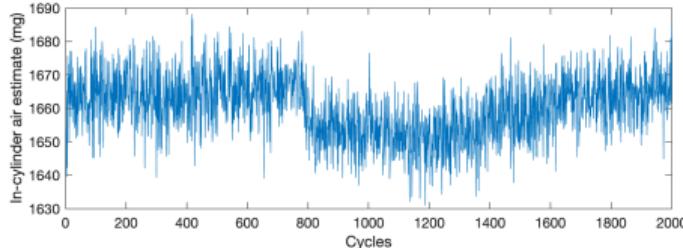
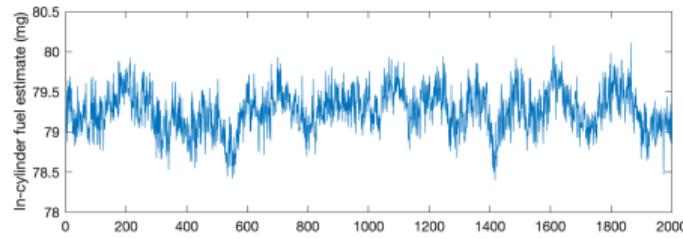
DI8.4 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



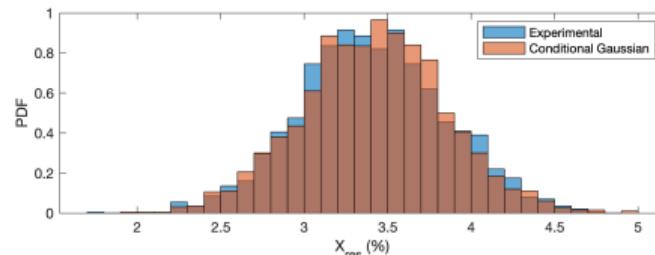
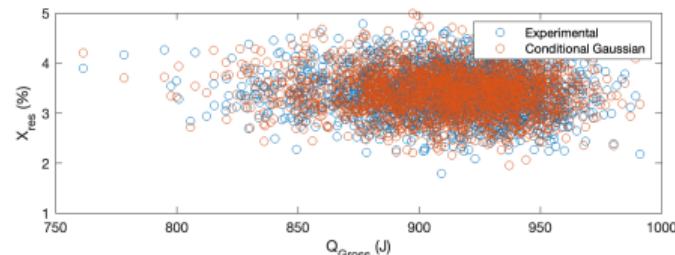
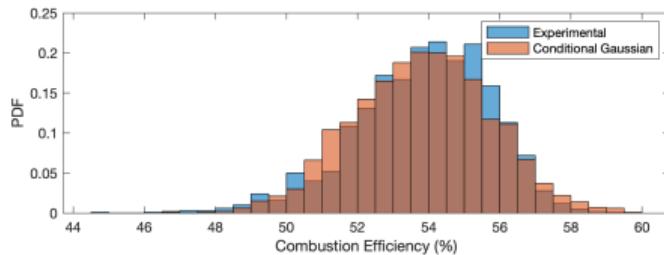
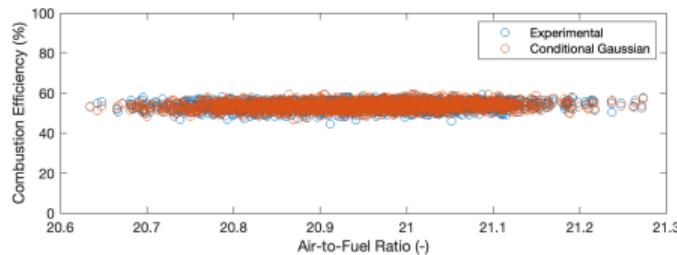
DI8.4 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

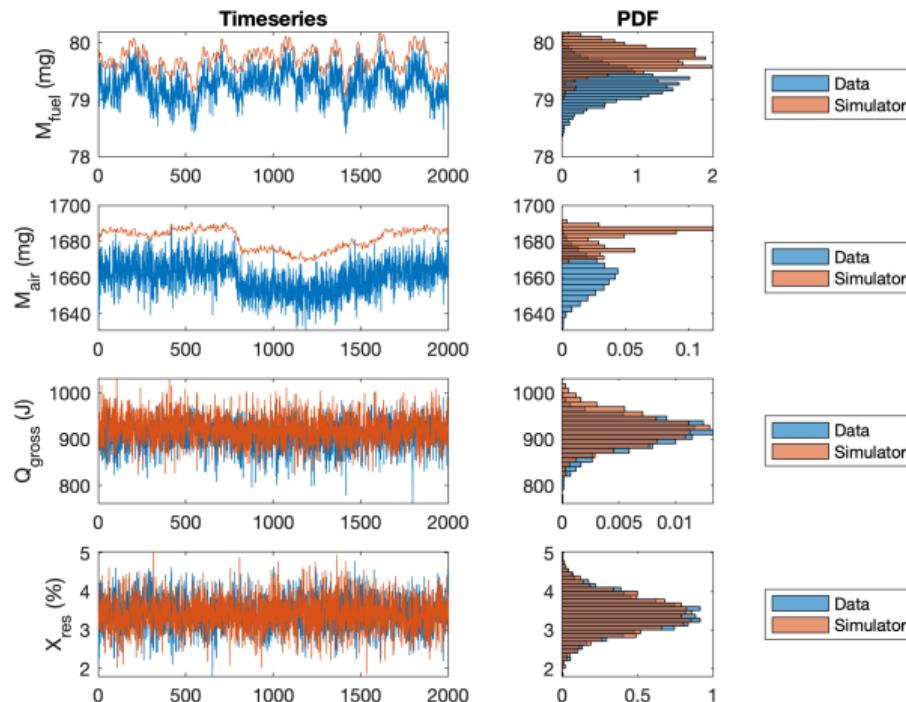
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



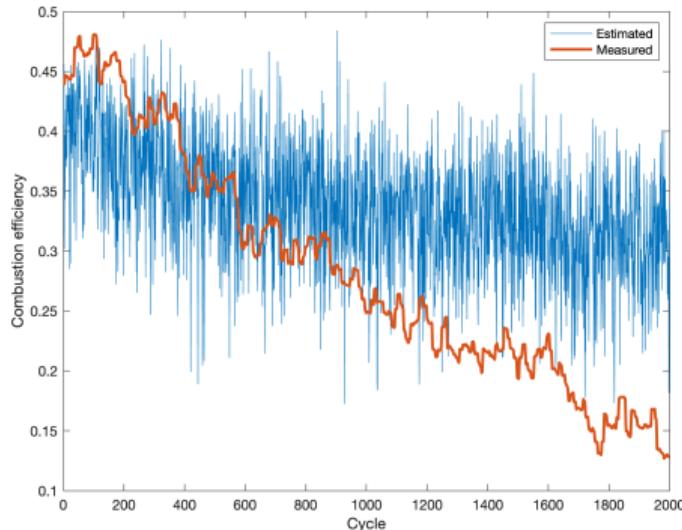
DI8.4 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



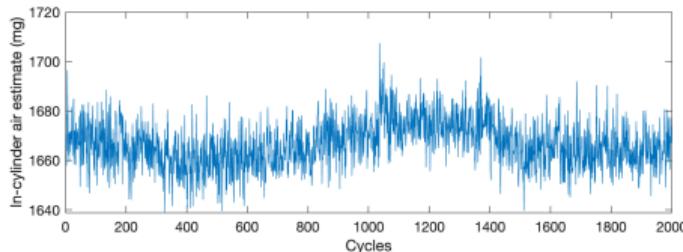
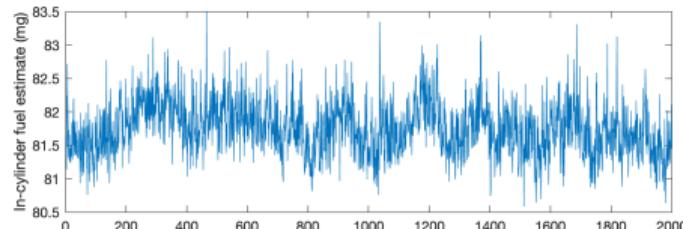
DI8.4 SOI44: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



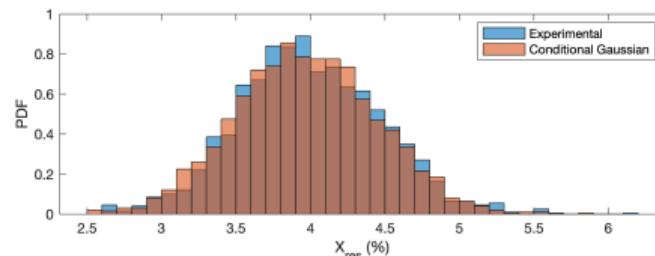
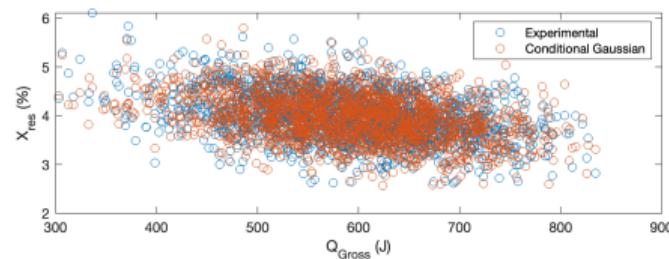
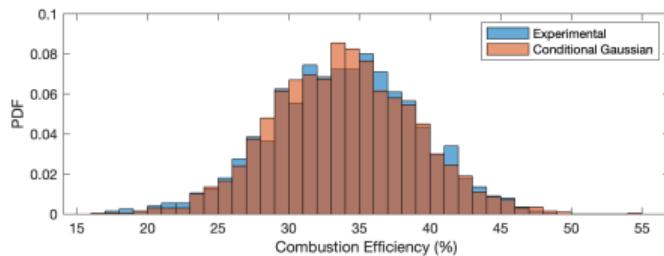
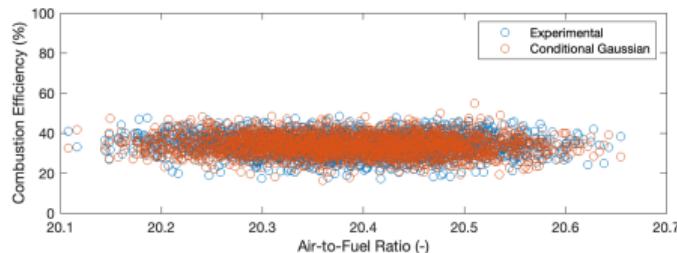
DI8.4 SOI44: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

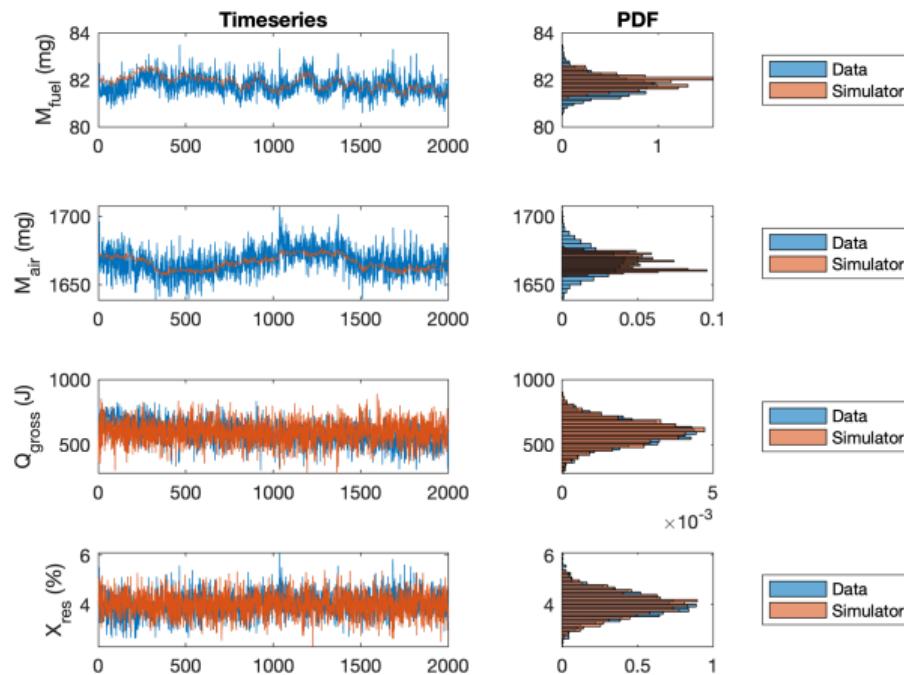
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



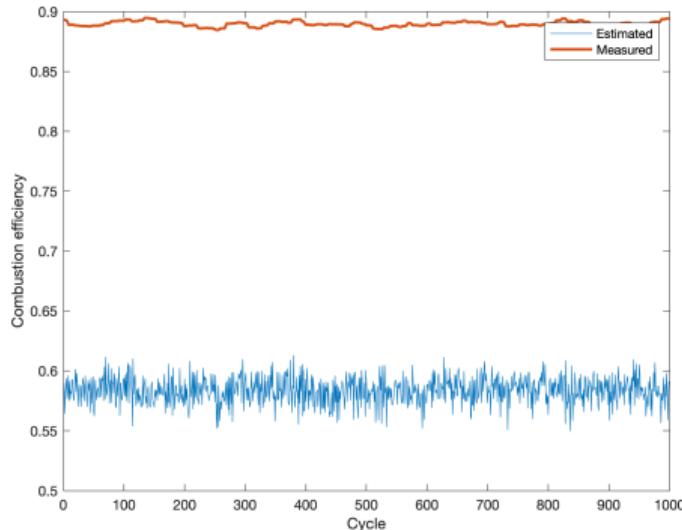
DI8.4 SOI44: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



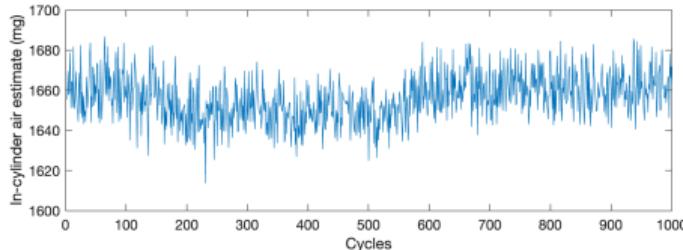
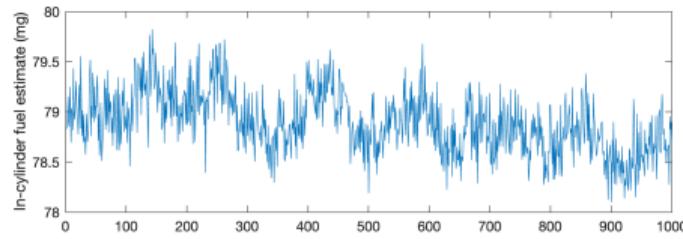
DI8.6 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



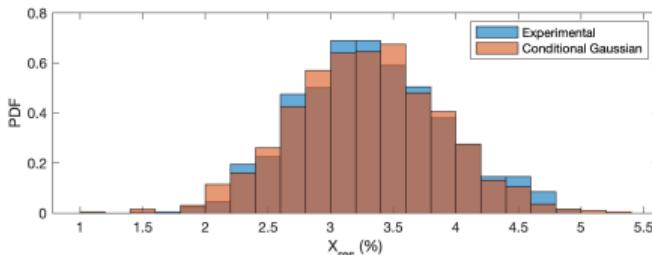
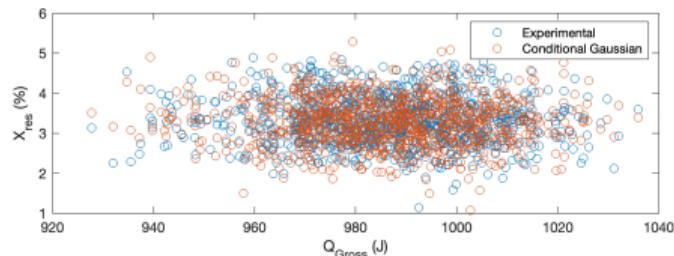
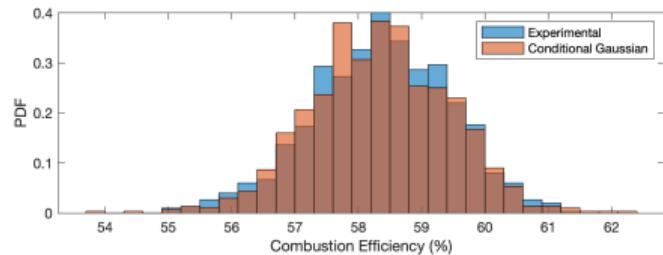
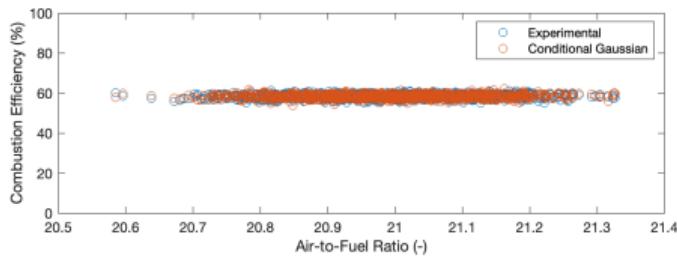
DI8.6 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

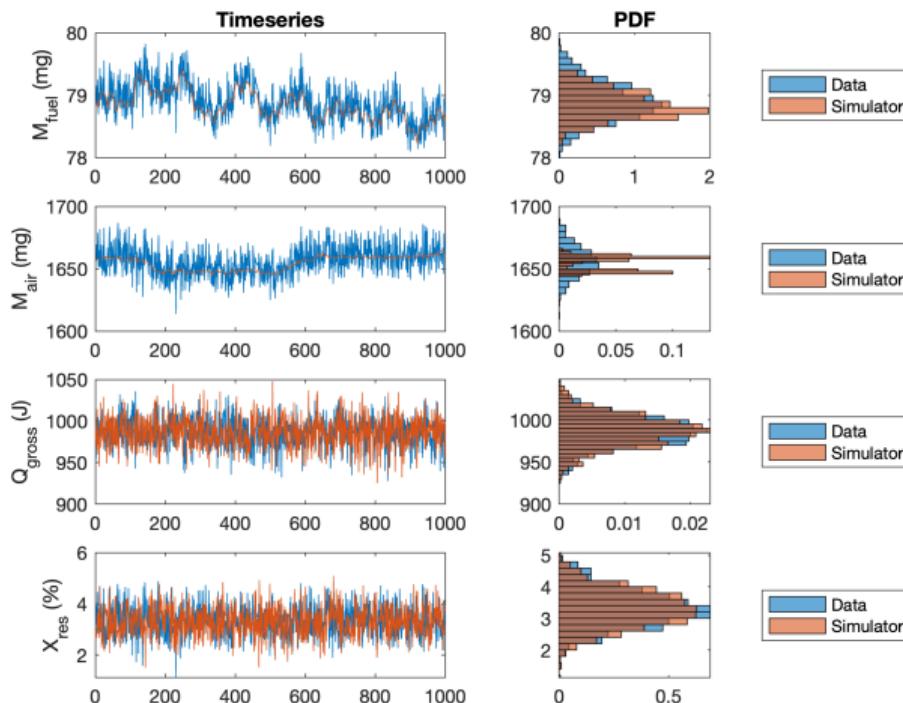
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



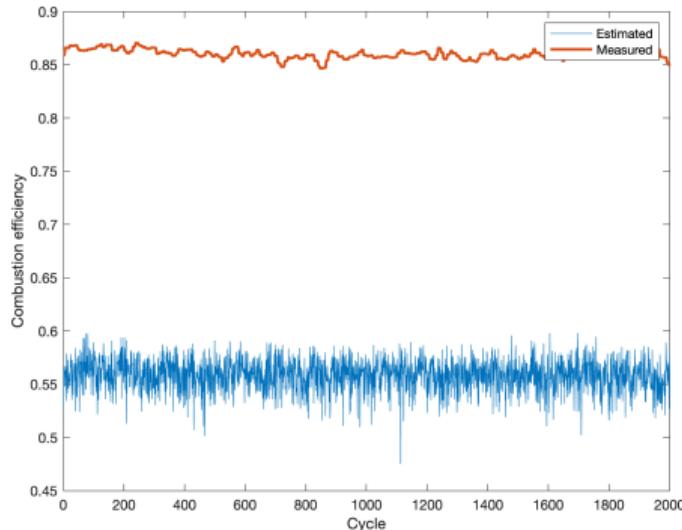
DI8.6 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



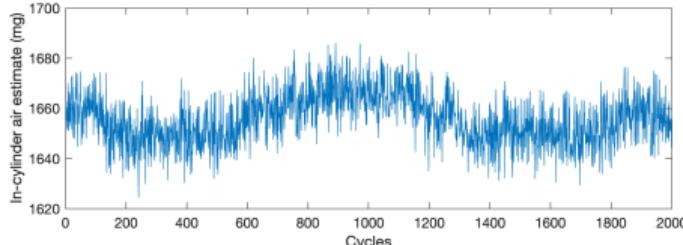
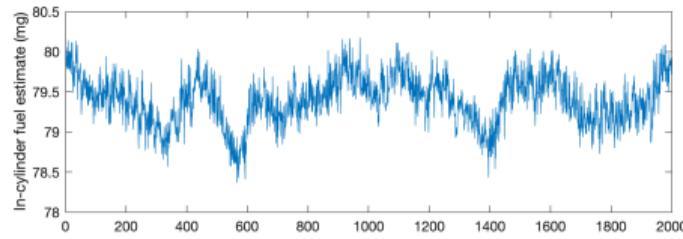
DI8.6 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



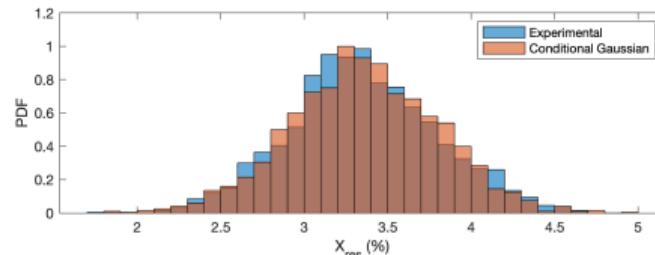
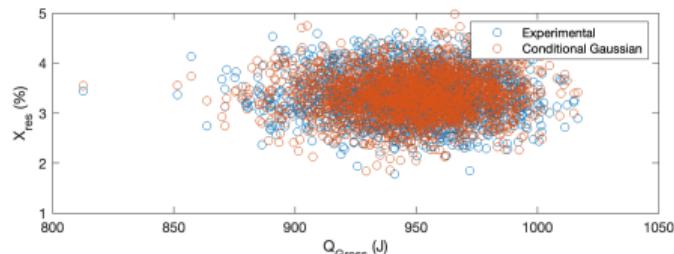
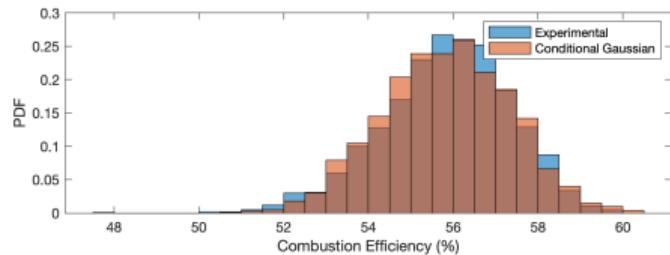
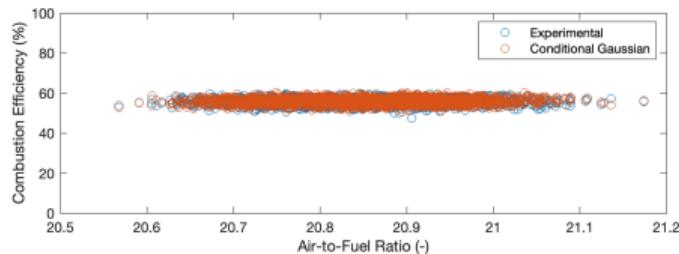
DI8.6 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

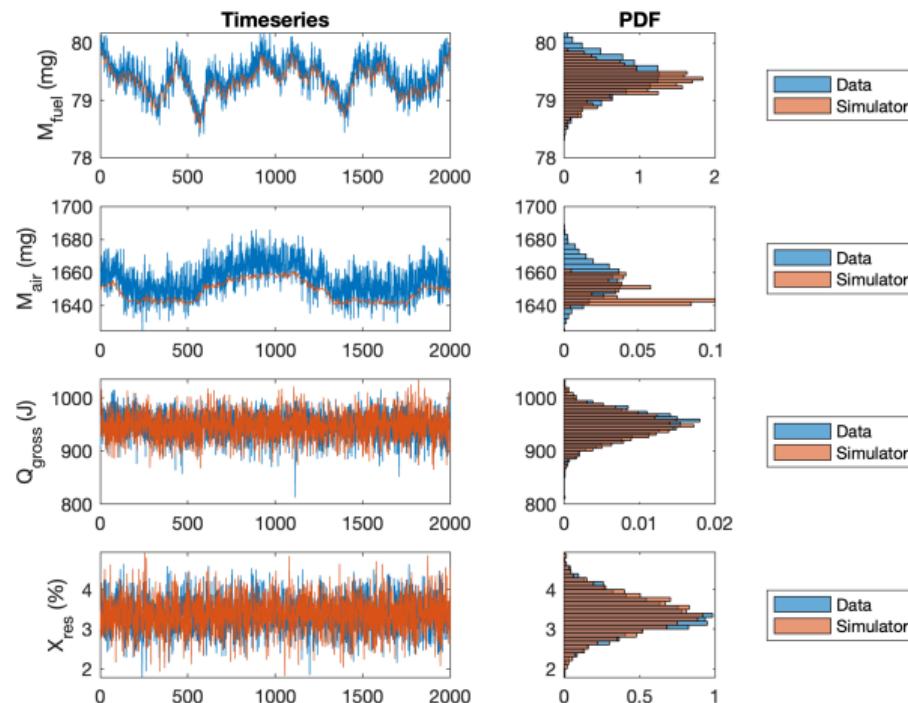
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



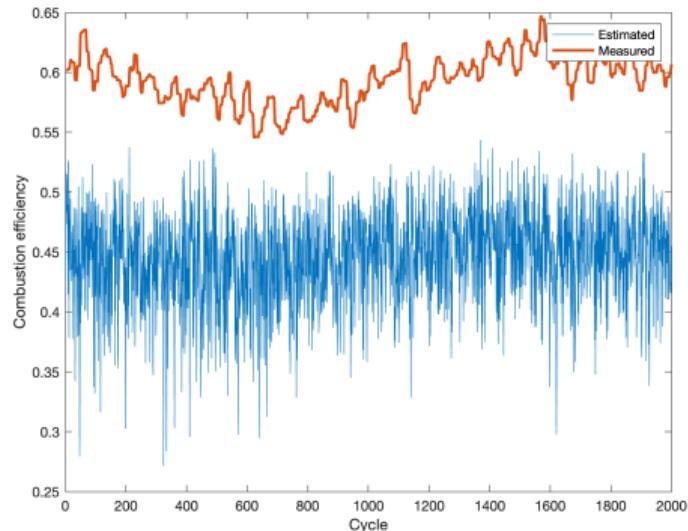
DI8.6 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



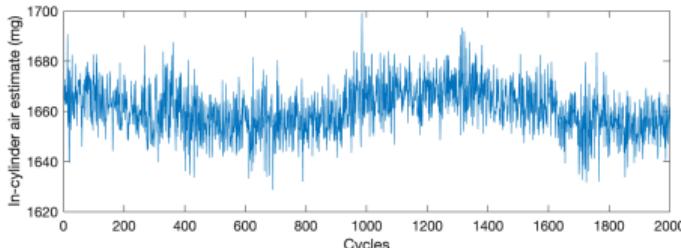
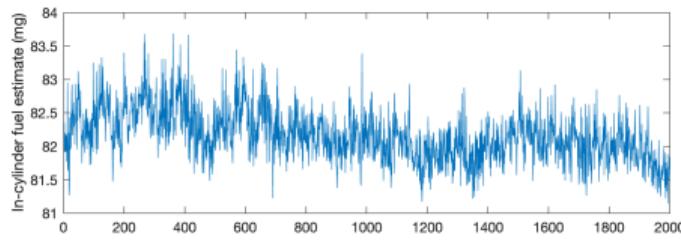
DI8.6 SOI44: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



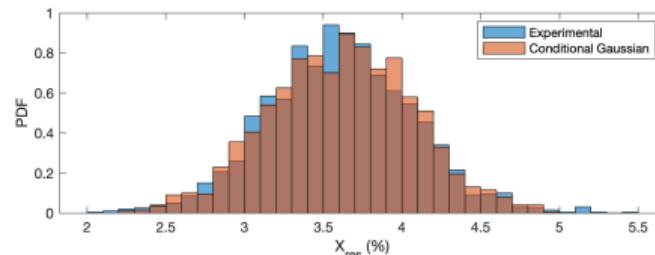
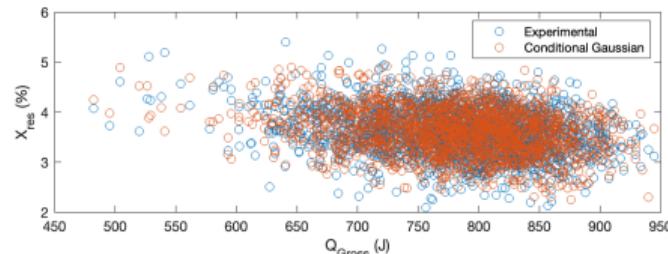
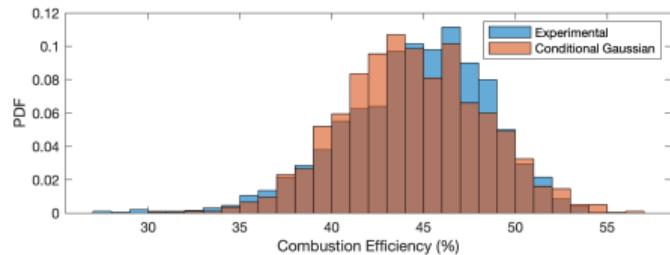
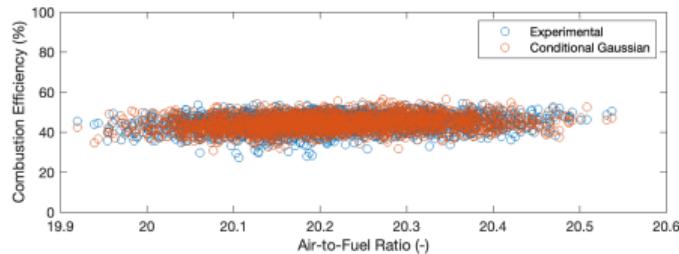
DI8.6 SOI44: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

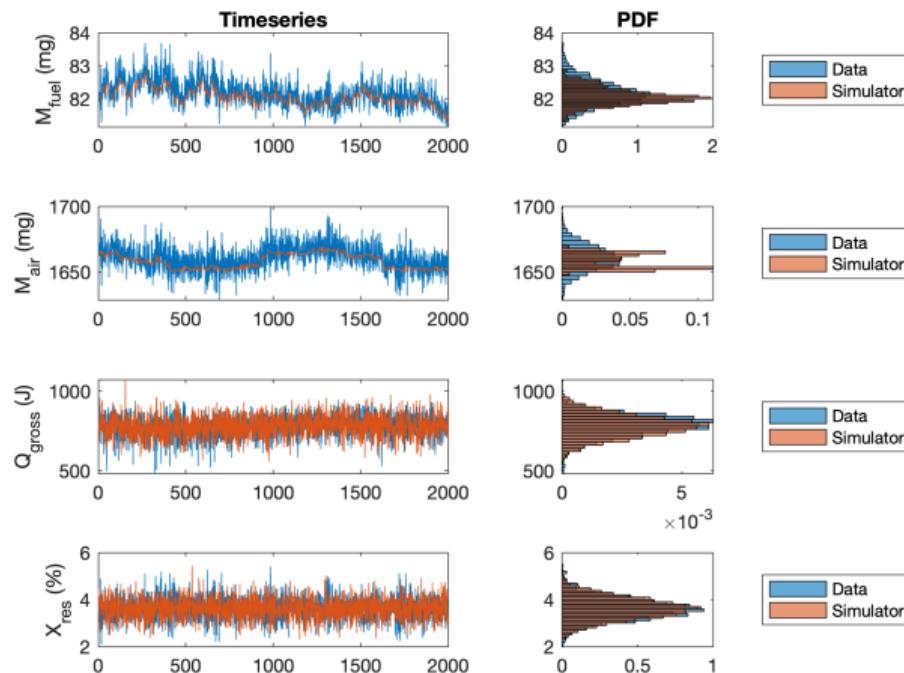
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



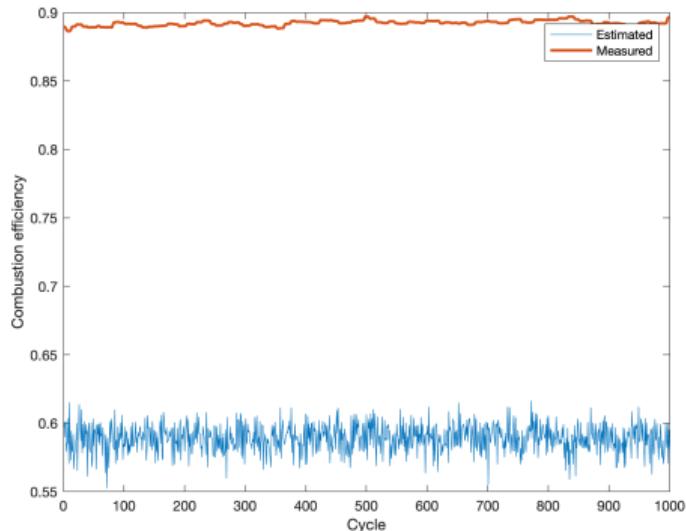
DI8.6 SOI44: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



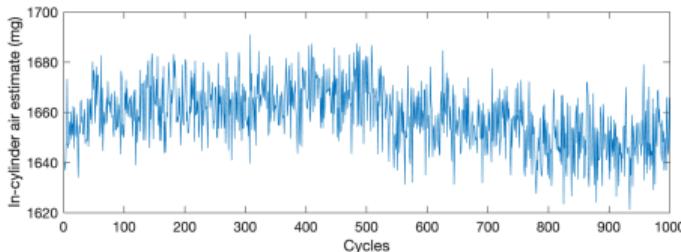
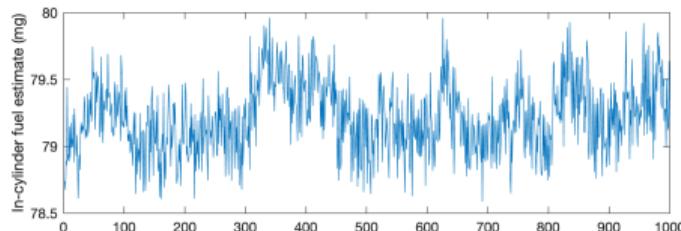
DI8.8 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



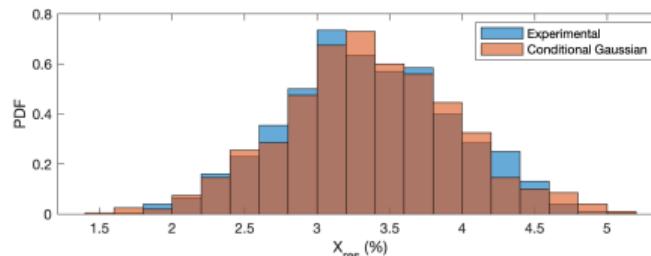
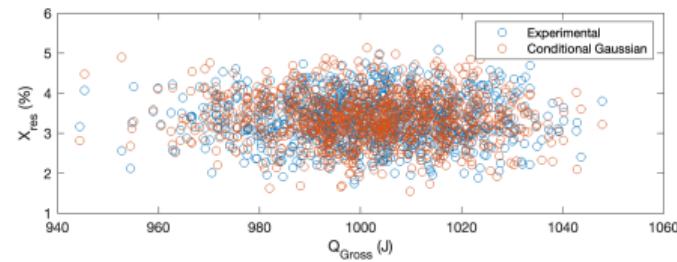
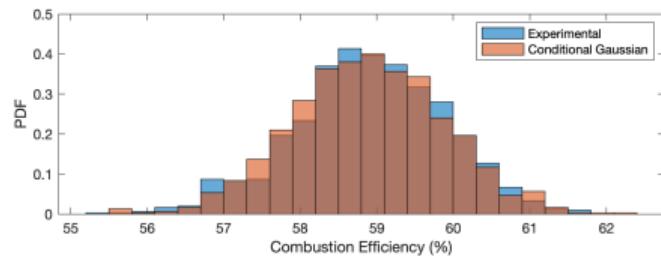
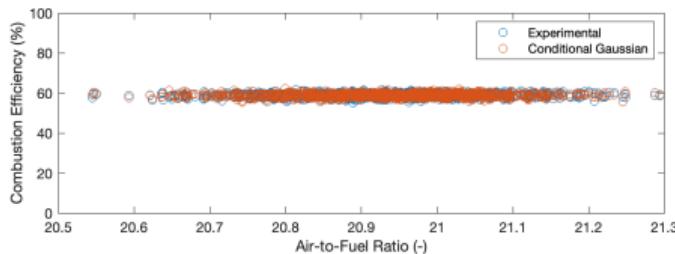
DI8.8 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

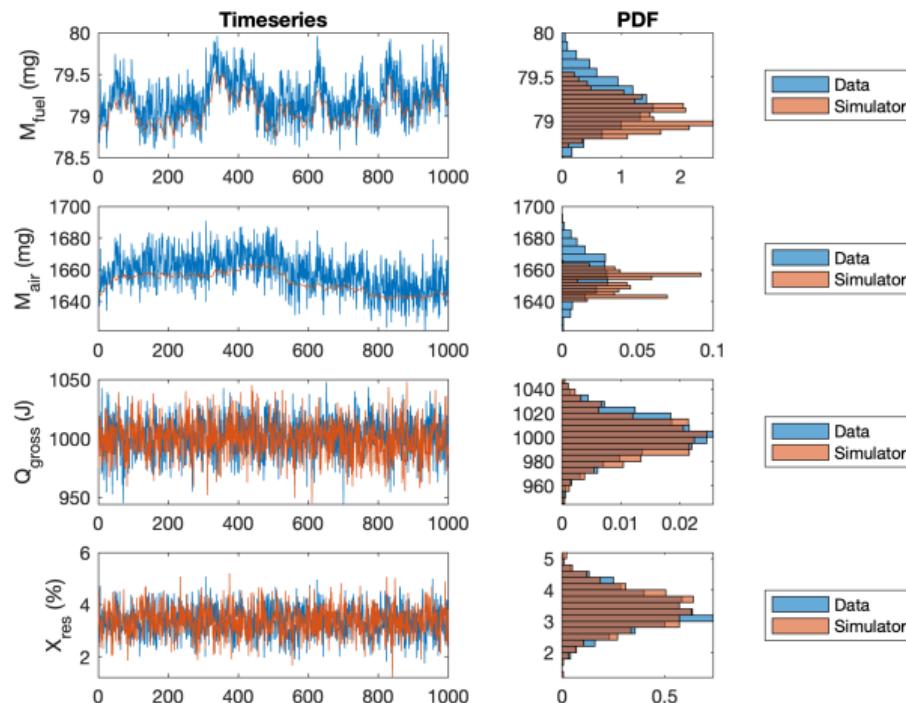
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



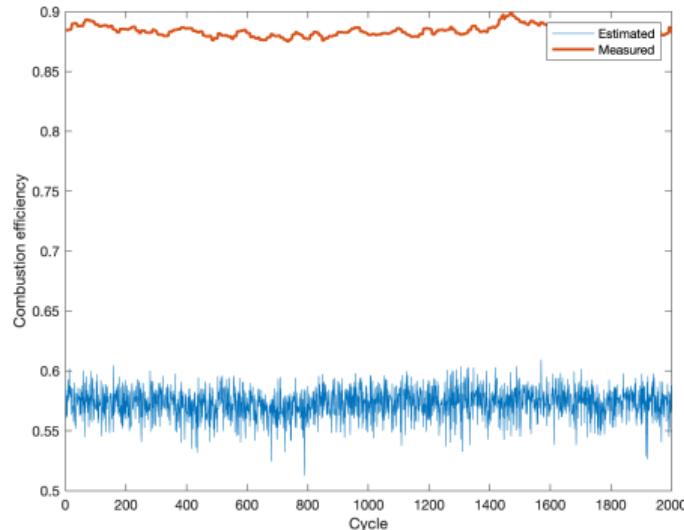
DI8.8 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



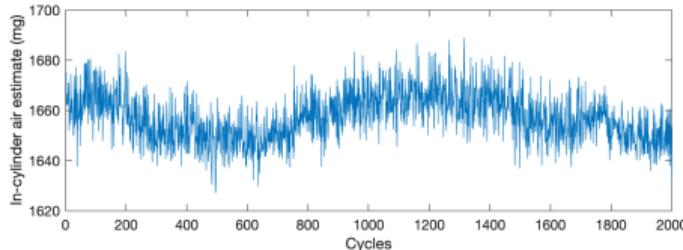
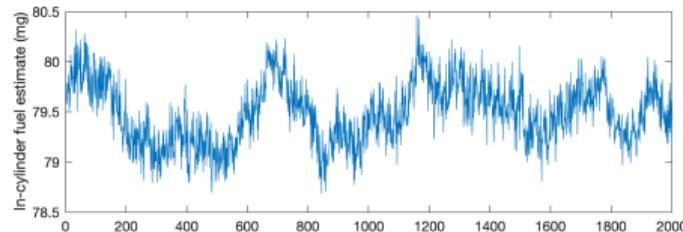
DI8.8 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



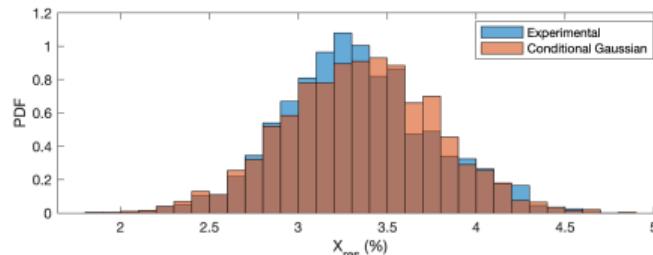
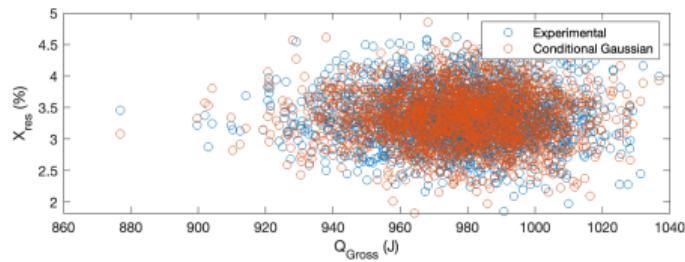
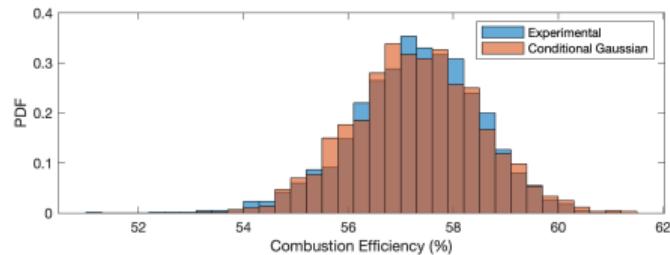
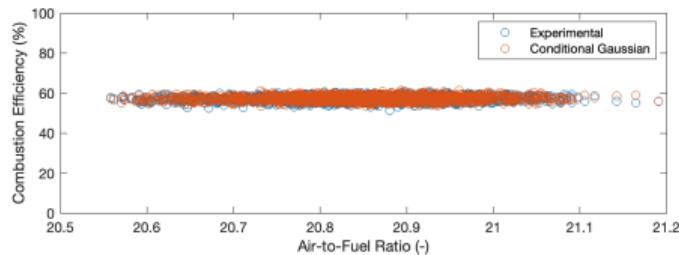
DI8.8 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

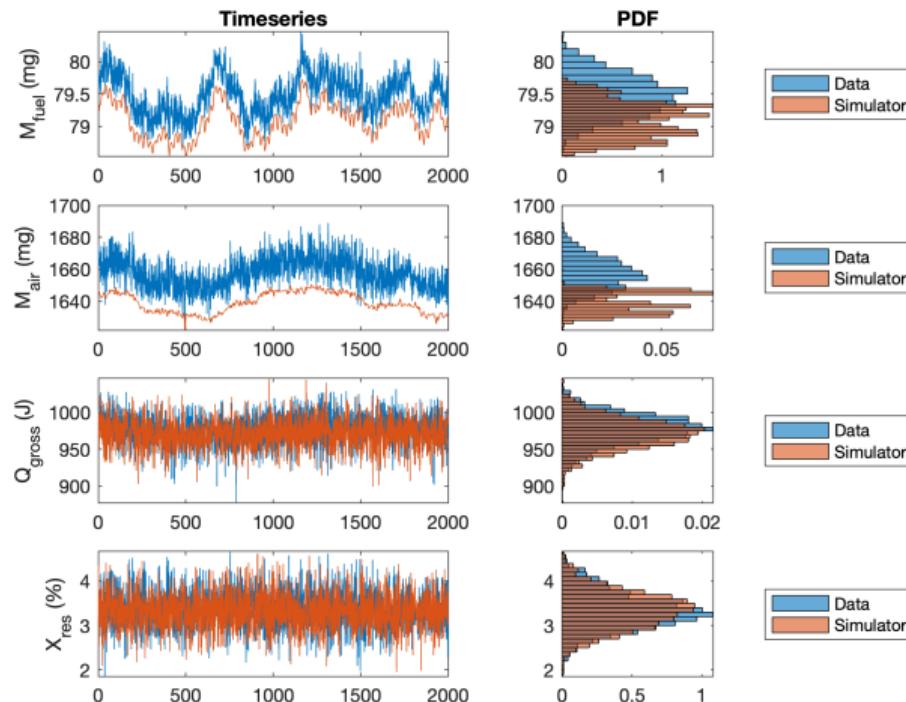
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



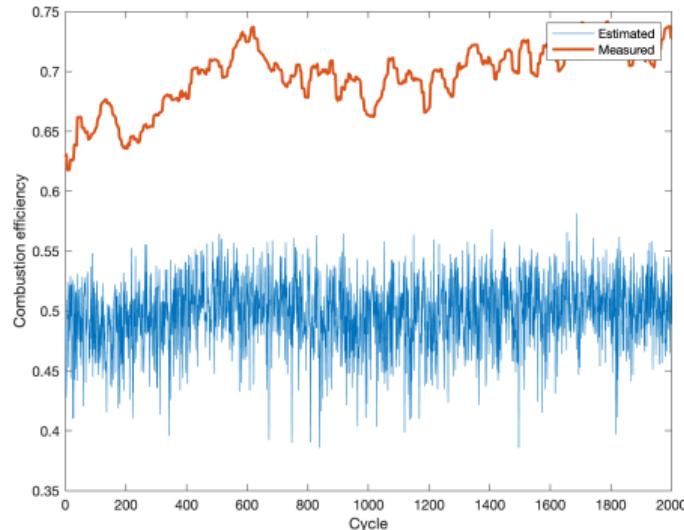
DI8.8 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



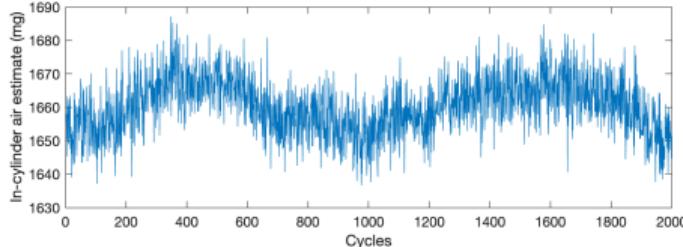
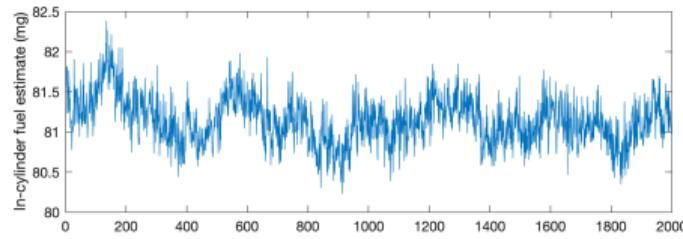
DI8.8 SOI44: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



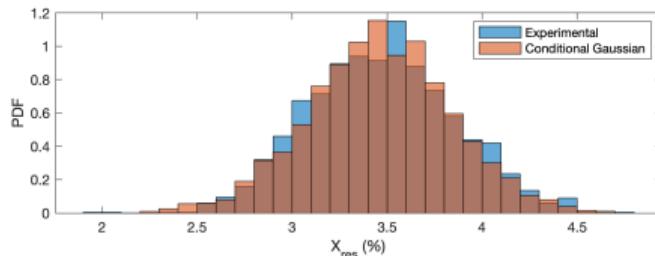
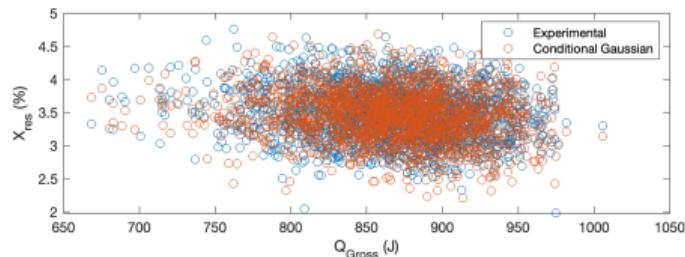
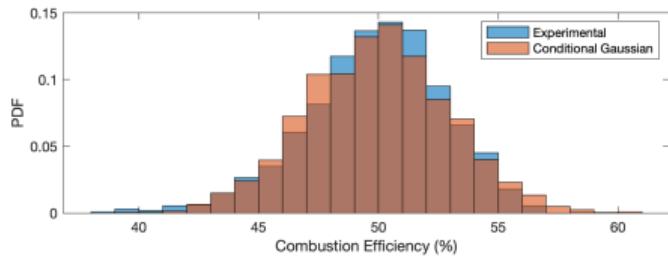
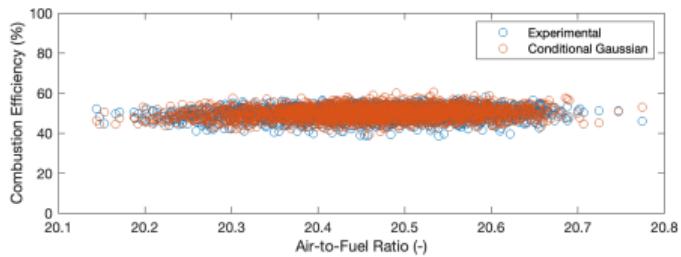
DI8.8 SOI44: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

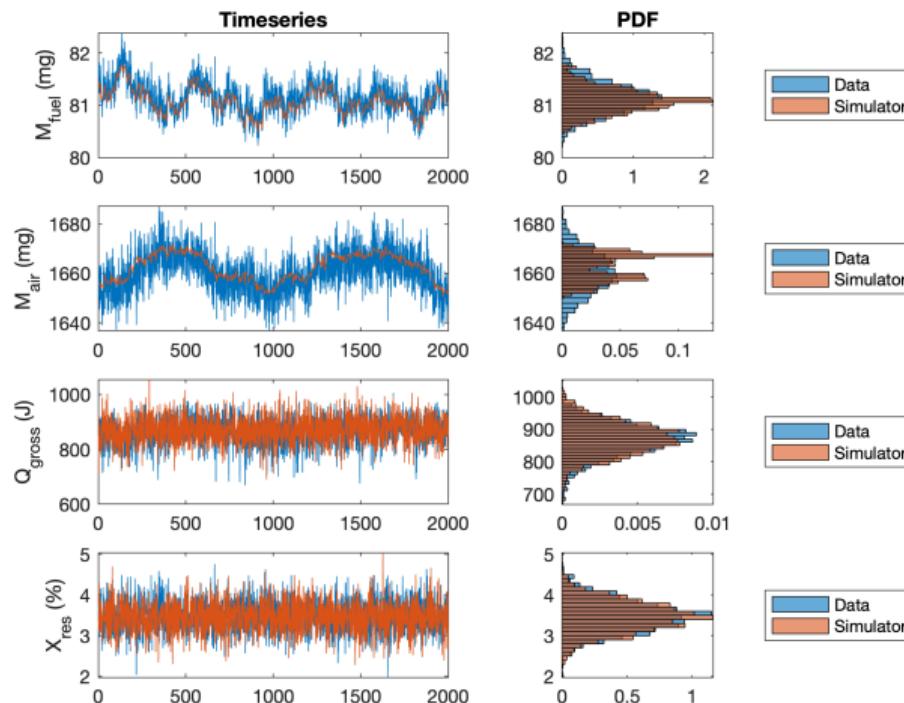
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



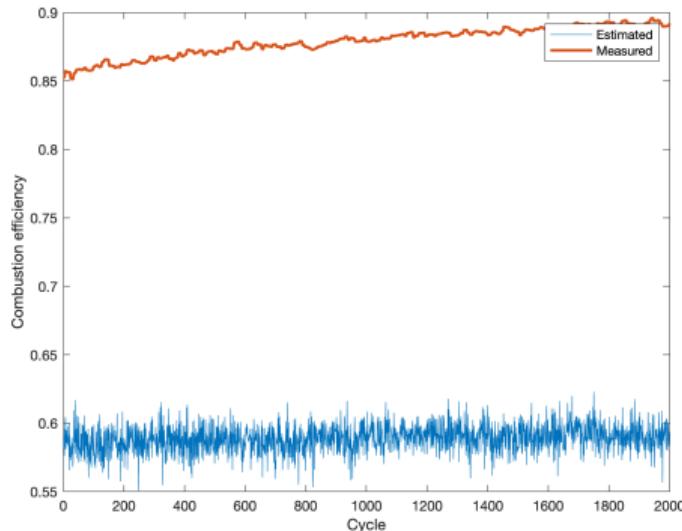
DI8.8 SOI44: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



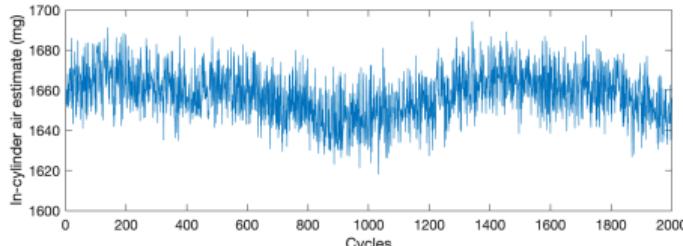
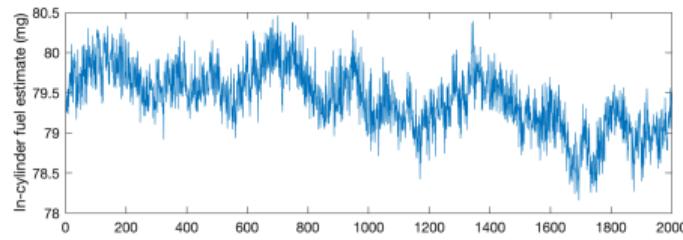
DI9.0 SOI42: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



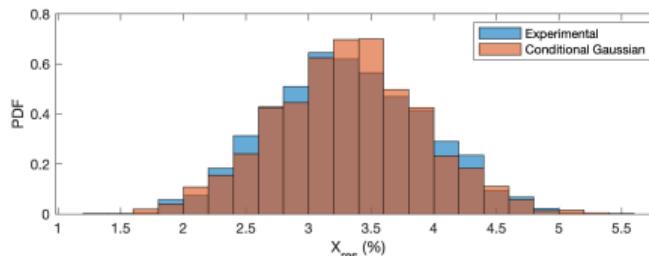
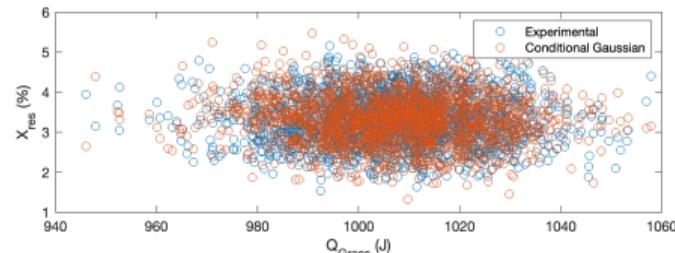
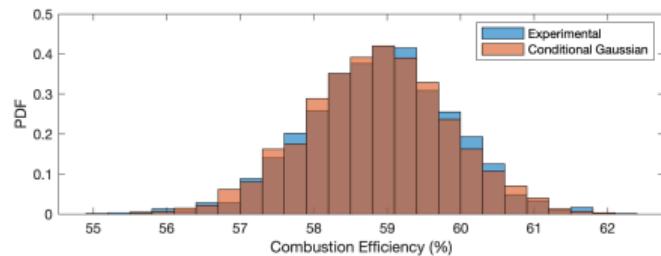
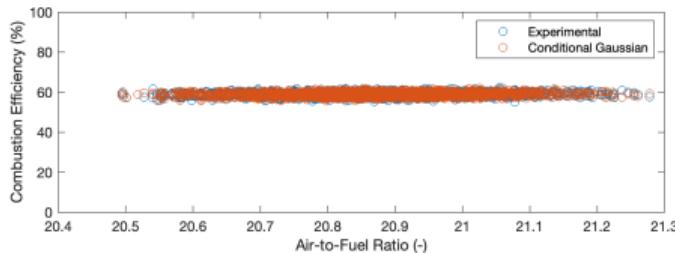
DI9.0 SOI42: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

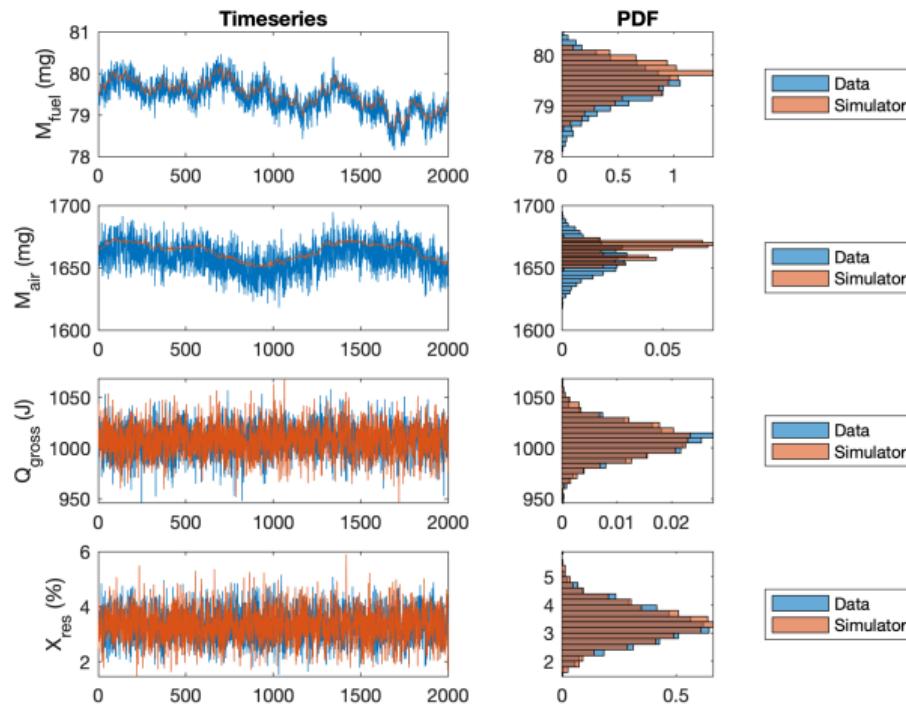
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



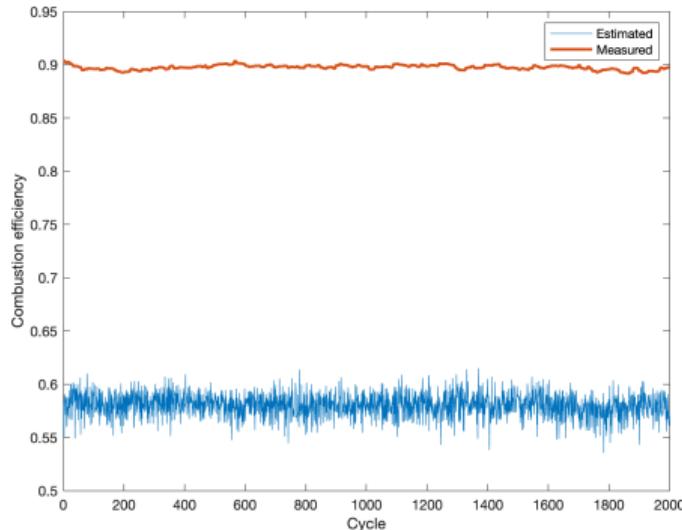
DI9.0 SOI42: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



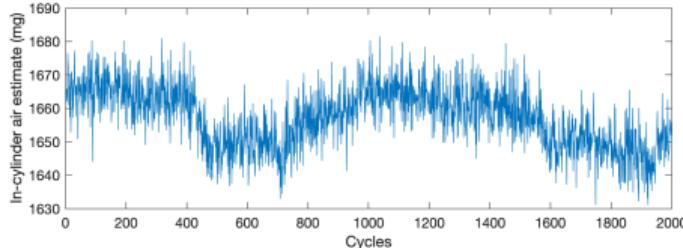
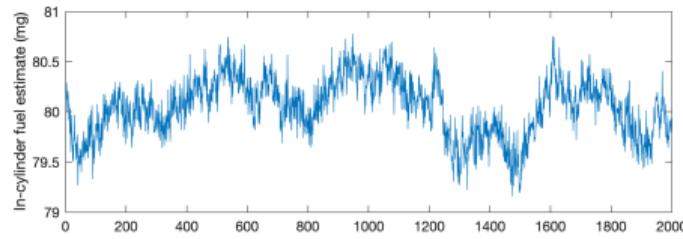
DI9.0 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



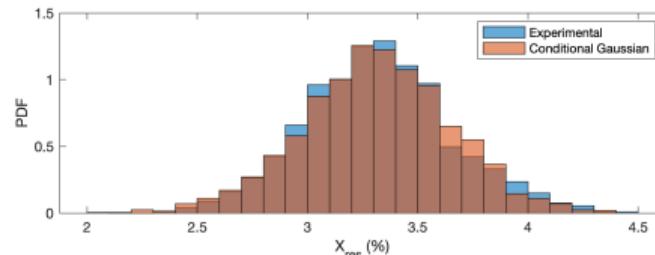
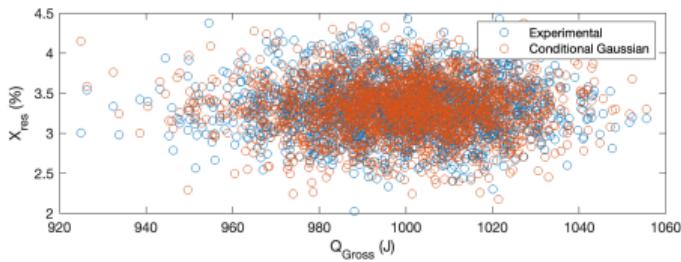
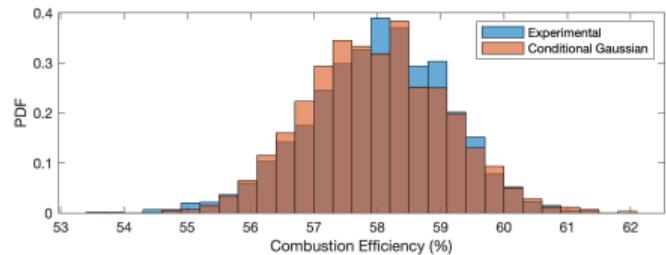
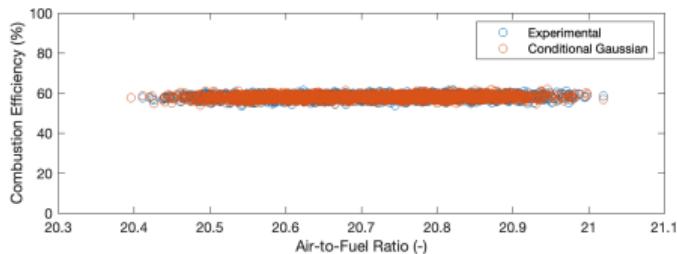
DI9.0 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

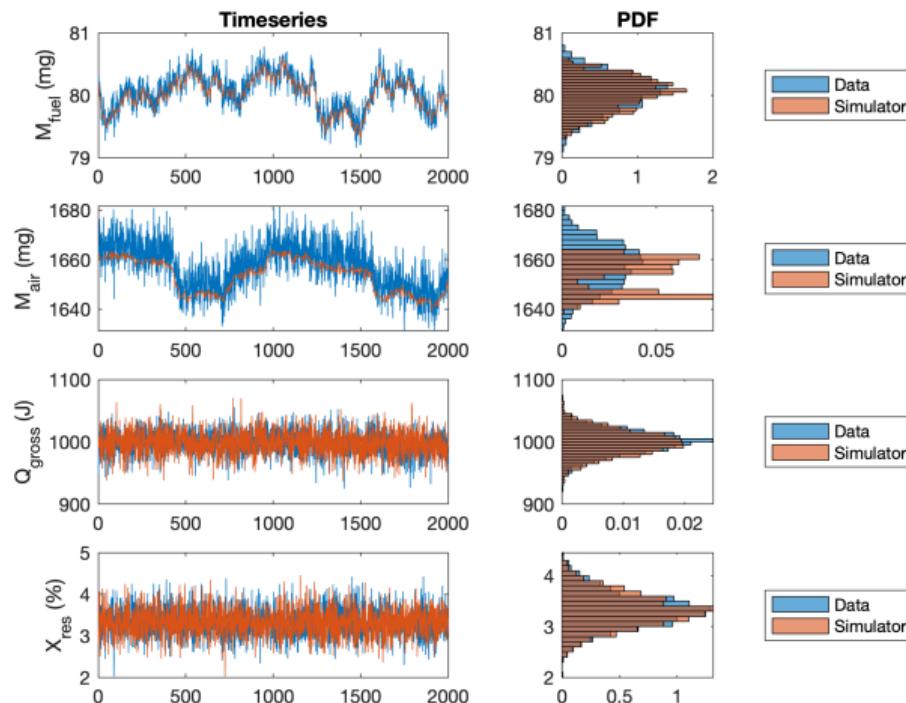
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



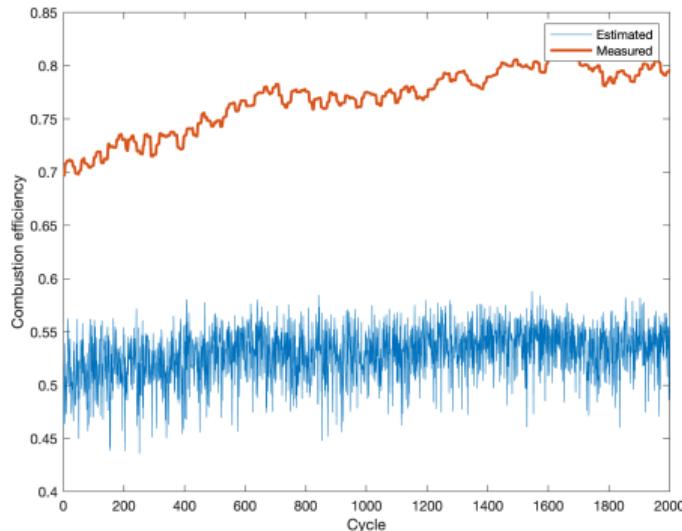
DI9.0 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



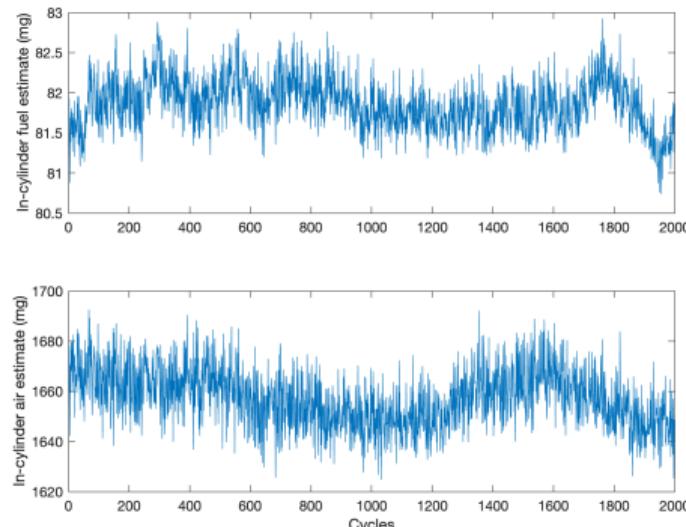
DI9.0 SOI44: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



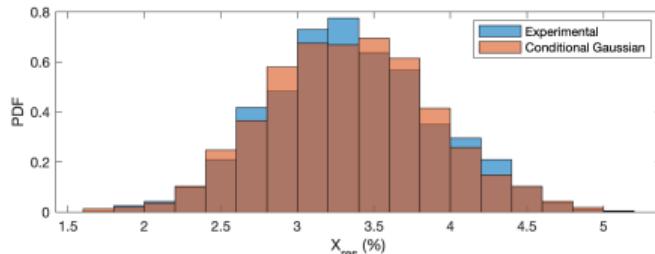
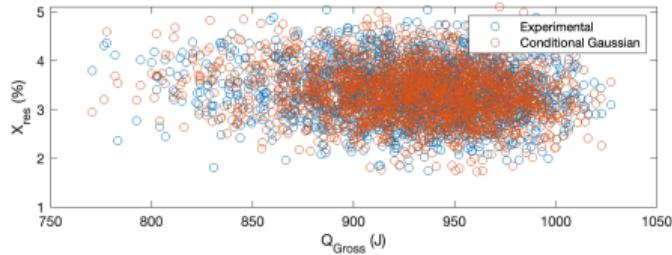
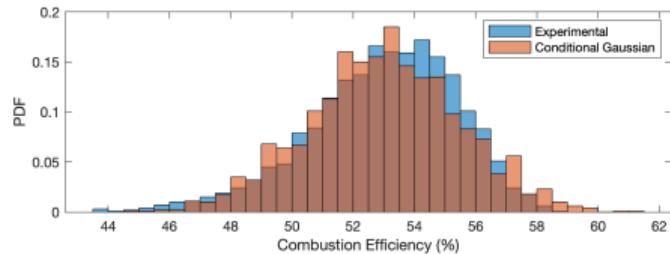
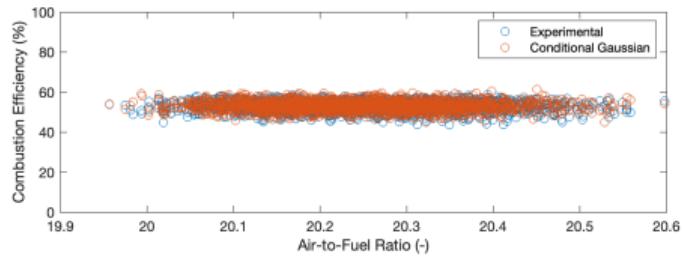
DI9.0 SOI44: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

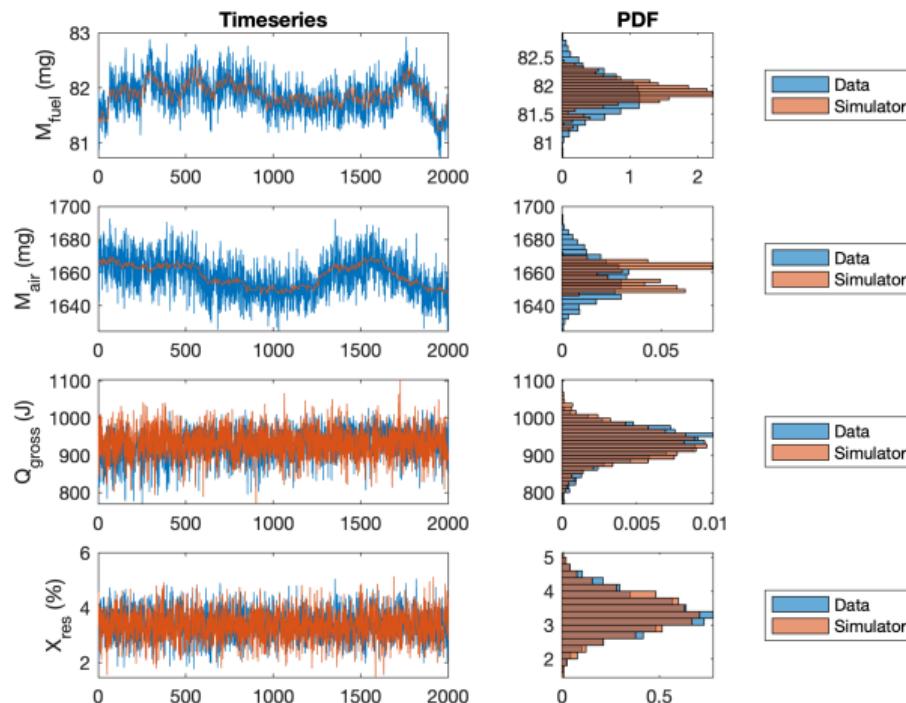
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



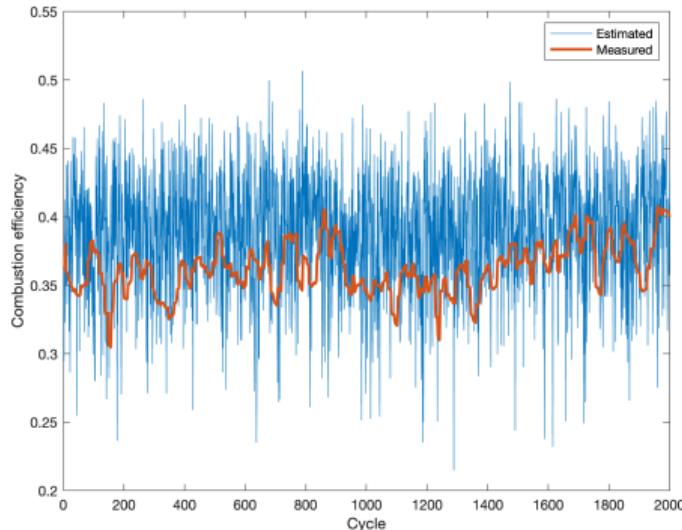
DI9.0 SOI44: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



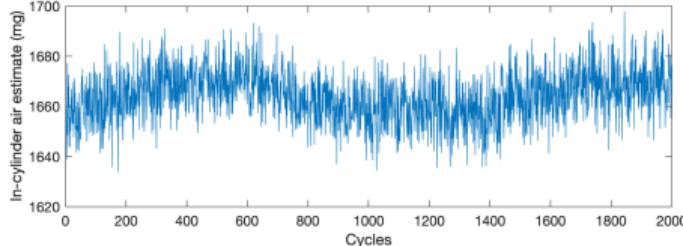
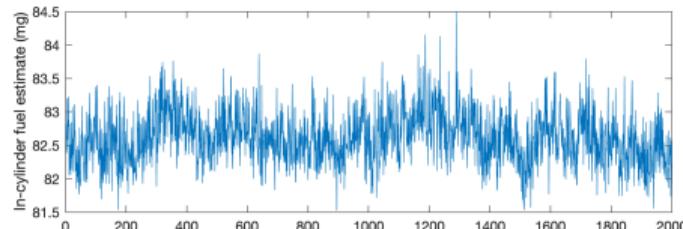
DI9.0 SOI45: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



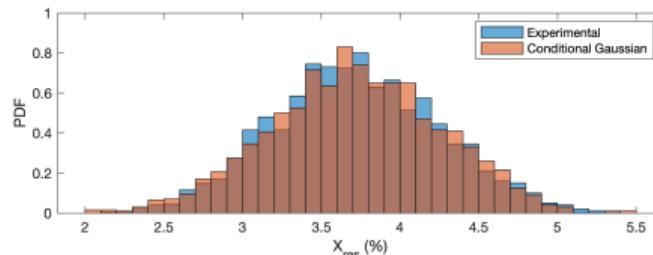
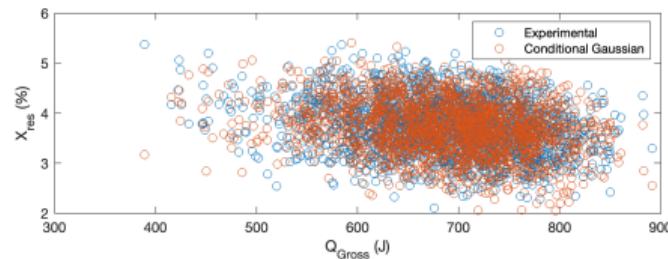
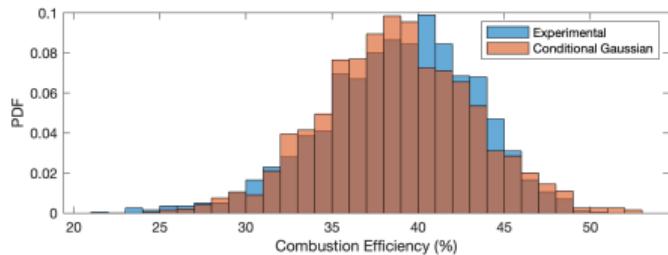
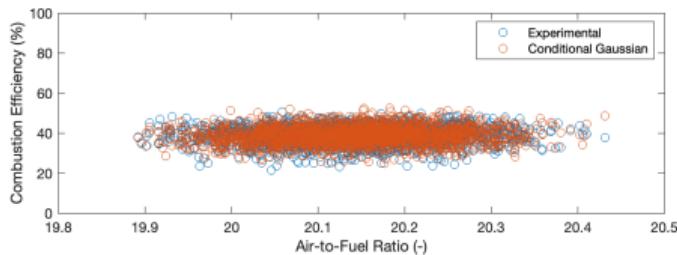
DI9.0 SOI45: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \quad ,$$

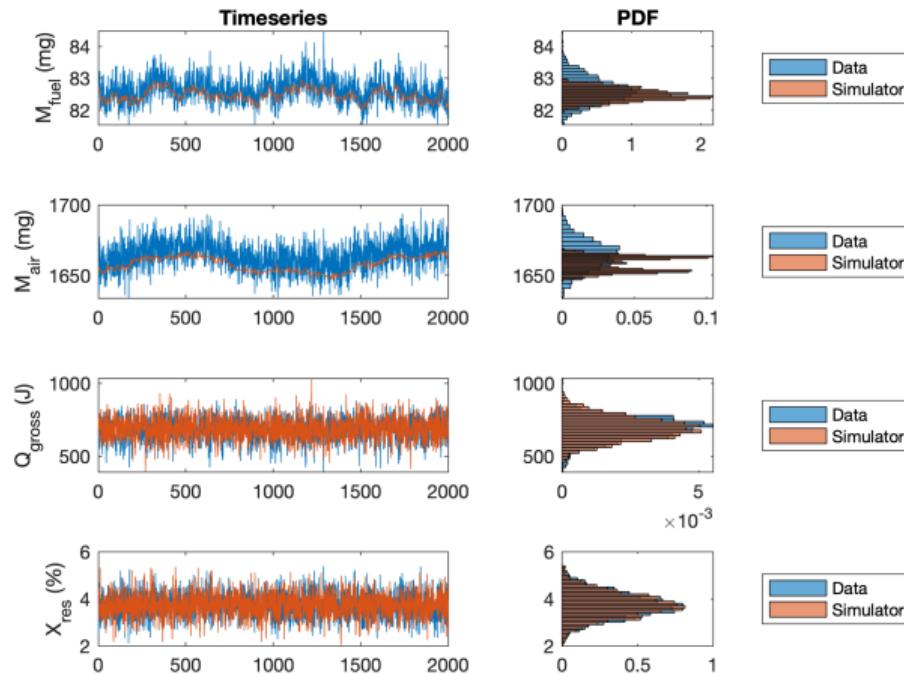
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$



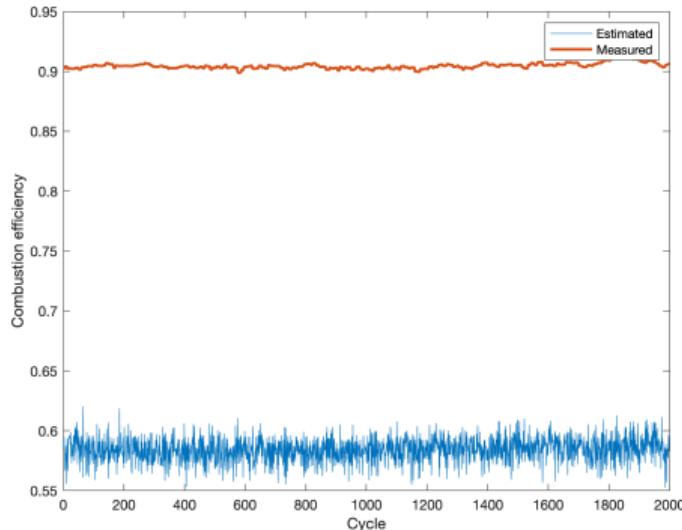
DI9.0 SOI45: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



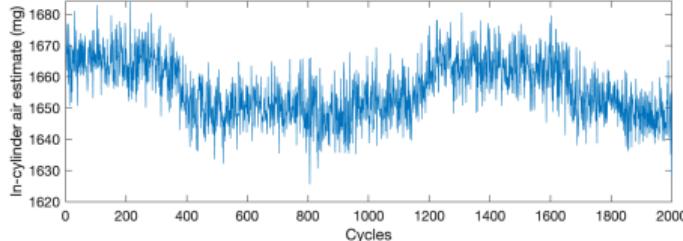
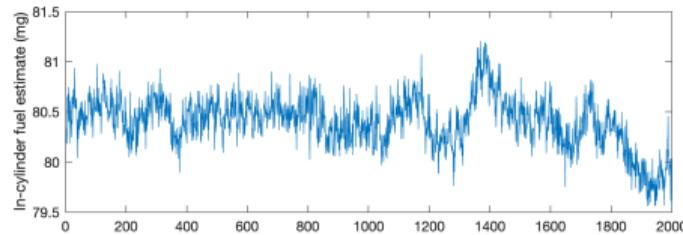
DI9.2 SOI43: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{1 - X_{\text{res}}}{\frac{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{Q_{\text{gross}}} - X_{\text{res}}},$$



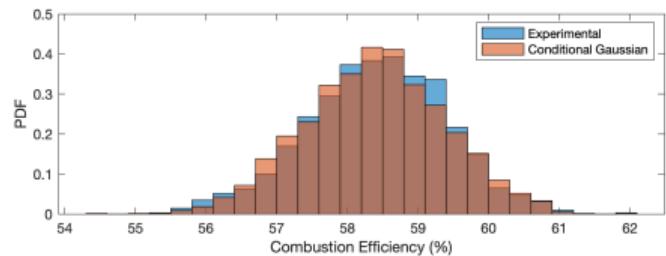
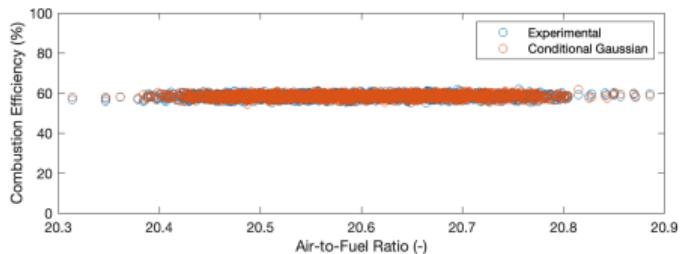
$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

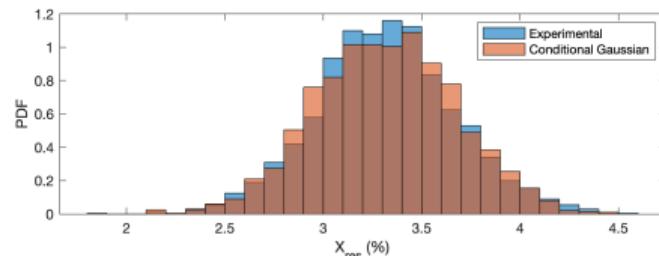
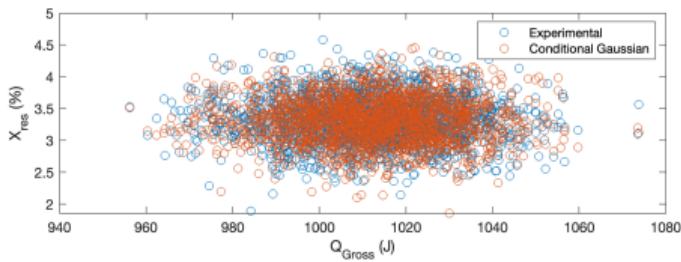


DI9.2 SOI43: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{aligned} \begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} &\sim \mathcal{N}(\mu_\eta, \Sigma_\eta) \\ \therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} &\sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \end{aligned},$$

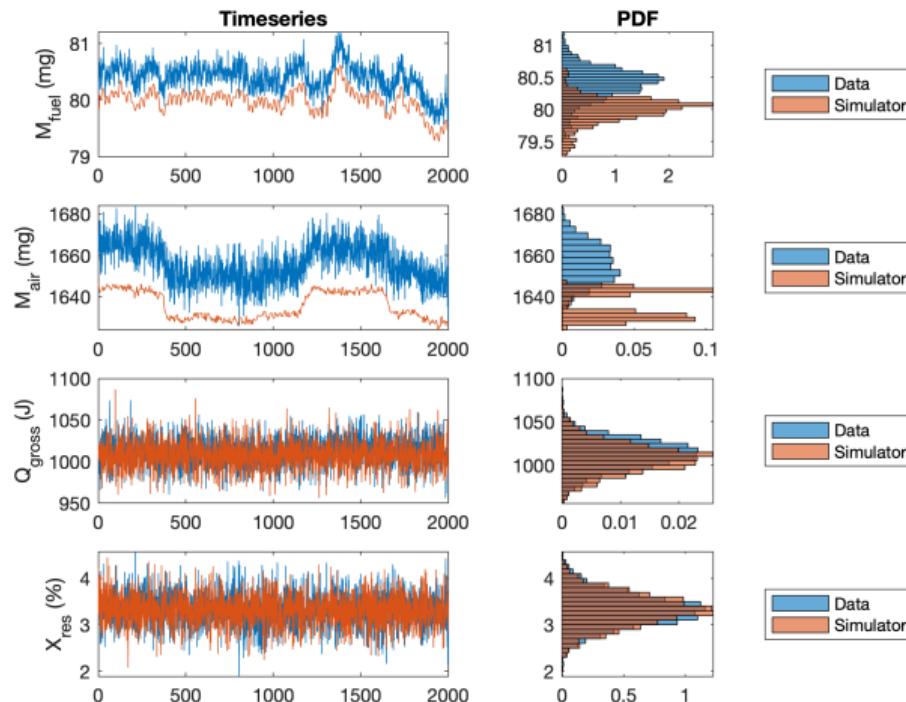


$$\begin{aligned} \begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} &\sim \mathcal{N}(\mu_X, \Sigma_X) \\ \therefore X_{\text{res}} \mid Q_{\text{gross}} &\sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) \end{aligned}$$



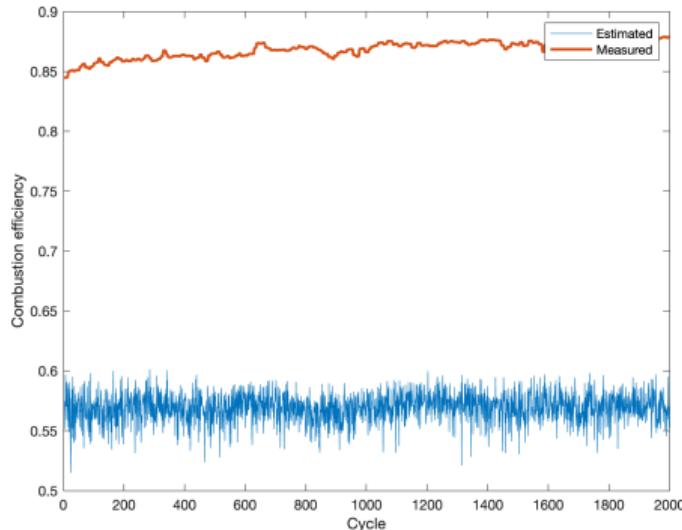
DI9.2 SOI43: Simulator Results

$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



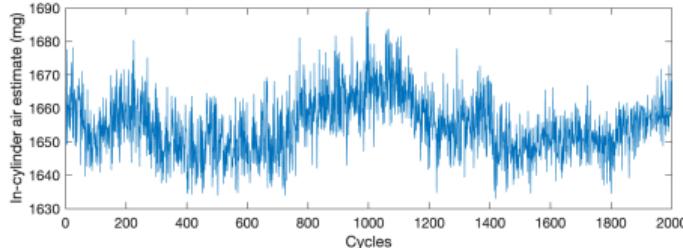
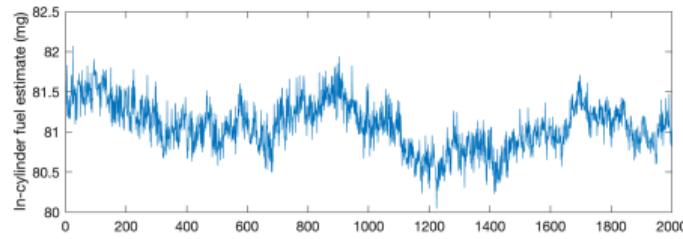
DI9.2 SOI44: Estimation of combustion efficiency and in-cylinder mass

$$\eta_c = \frac{\frac{1 - X_{\text{res}}}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}} - X_{\text{res}}}{Q_{\text{gross}}},$$



$$M_{\text{fuel}} = \frac{m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} - X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$

$$M_{\text{air}} = \frac{m_{\text{in}}^{\text{air}} + X_{\text{res}} \frac{Q_{\text{gross}}(m_{\text{in}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}})}{m_{\text{in}}^{\text{dsl}} Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}}{1 - X_{\text{res}}}$$



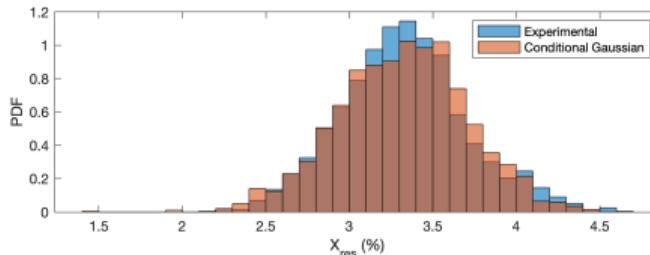
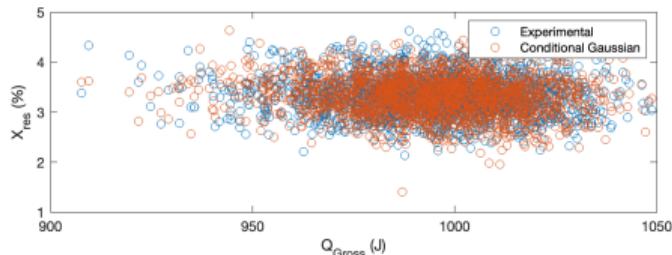
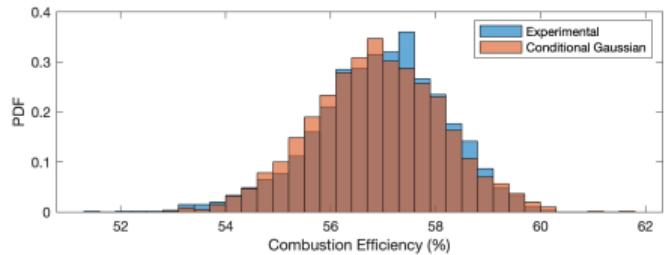
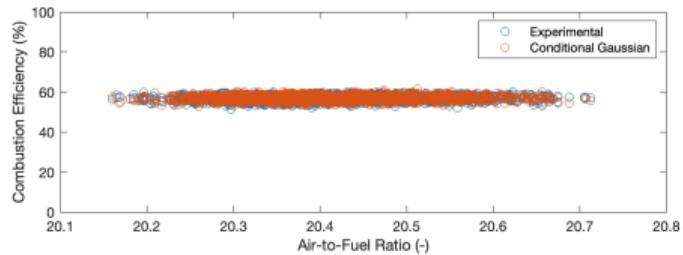
DI9.2 SOI44: Parametric model ($\mu_\eta, \Sigma_\eta, \mu_X, \Sigma_X$)

$$\begin{bmatrix} \eta_c & M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

$$\therefore \eta_c \mid \begin{bmatrix} M_{\text{fuel}} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma}) ,$$

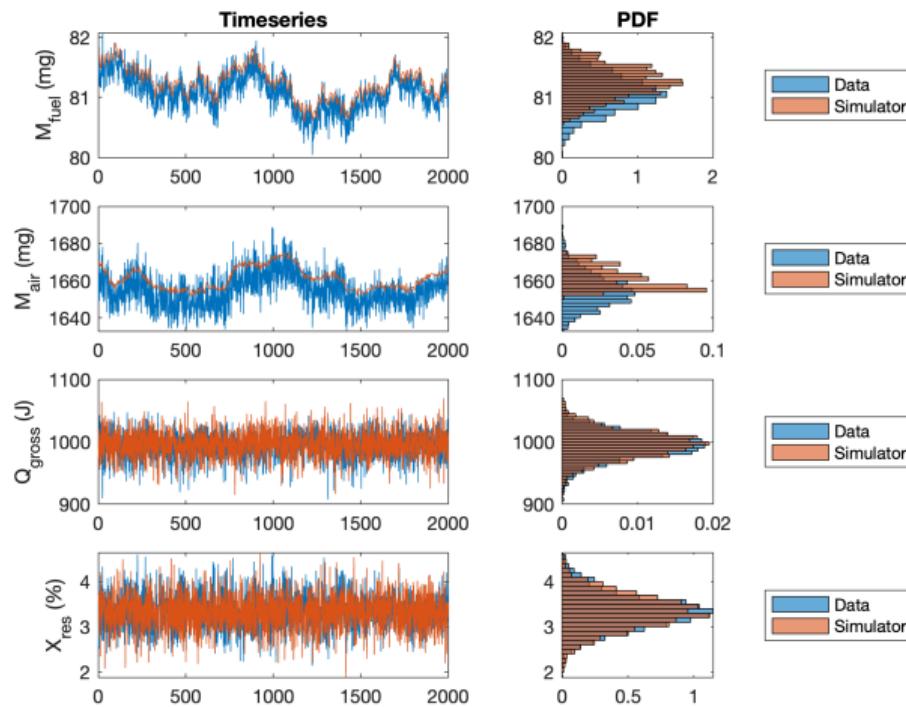
$$\begin{bmatrix} X_{\text{res}} & Q_{\text{gross}} \end{bmatrix} \sim \mathcal{N}(\mu_X, \Sigma_X)$$

$$\therefore X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\bar{\mu}, \bar{\Sigma})$$

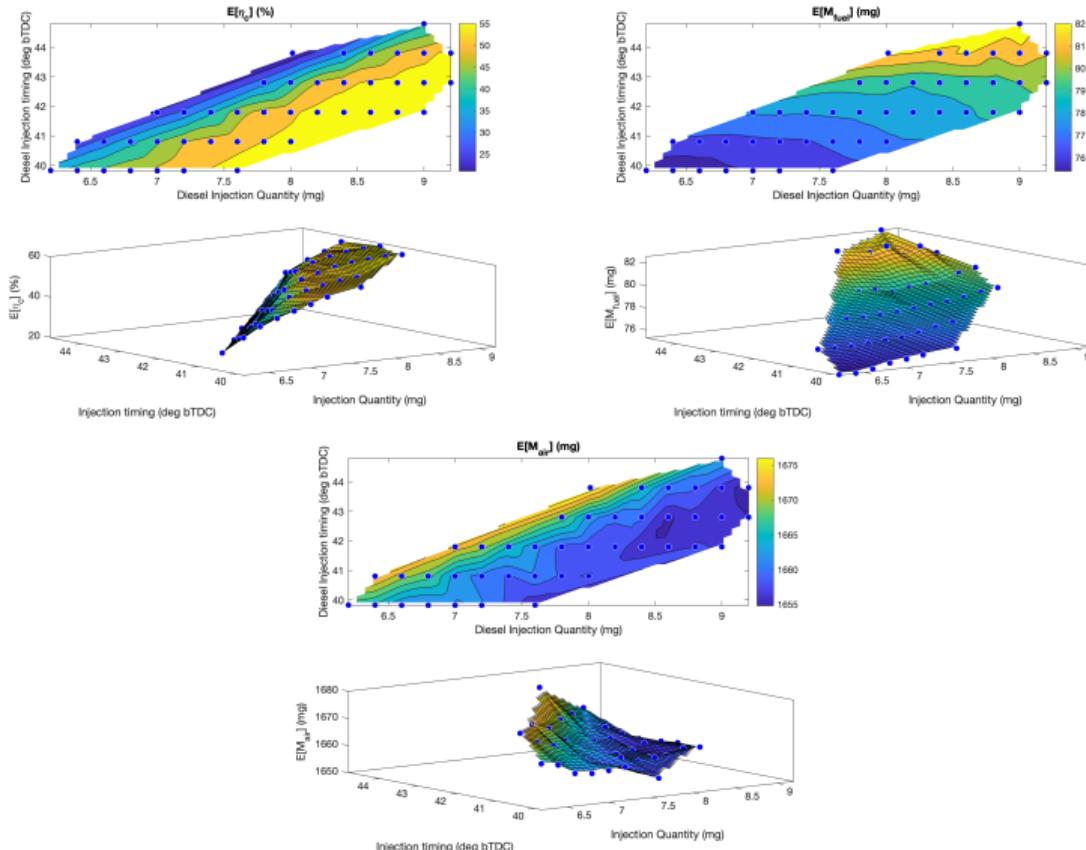


DI9.2 SOI44: Simulator Results

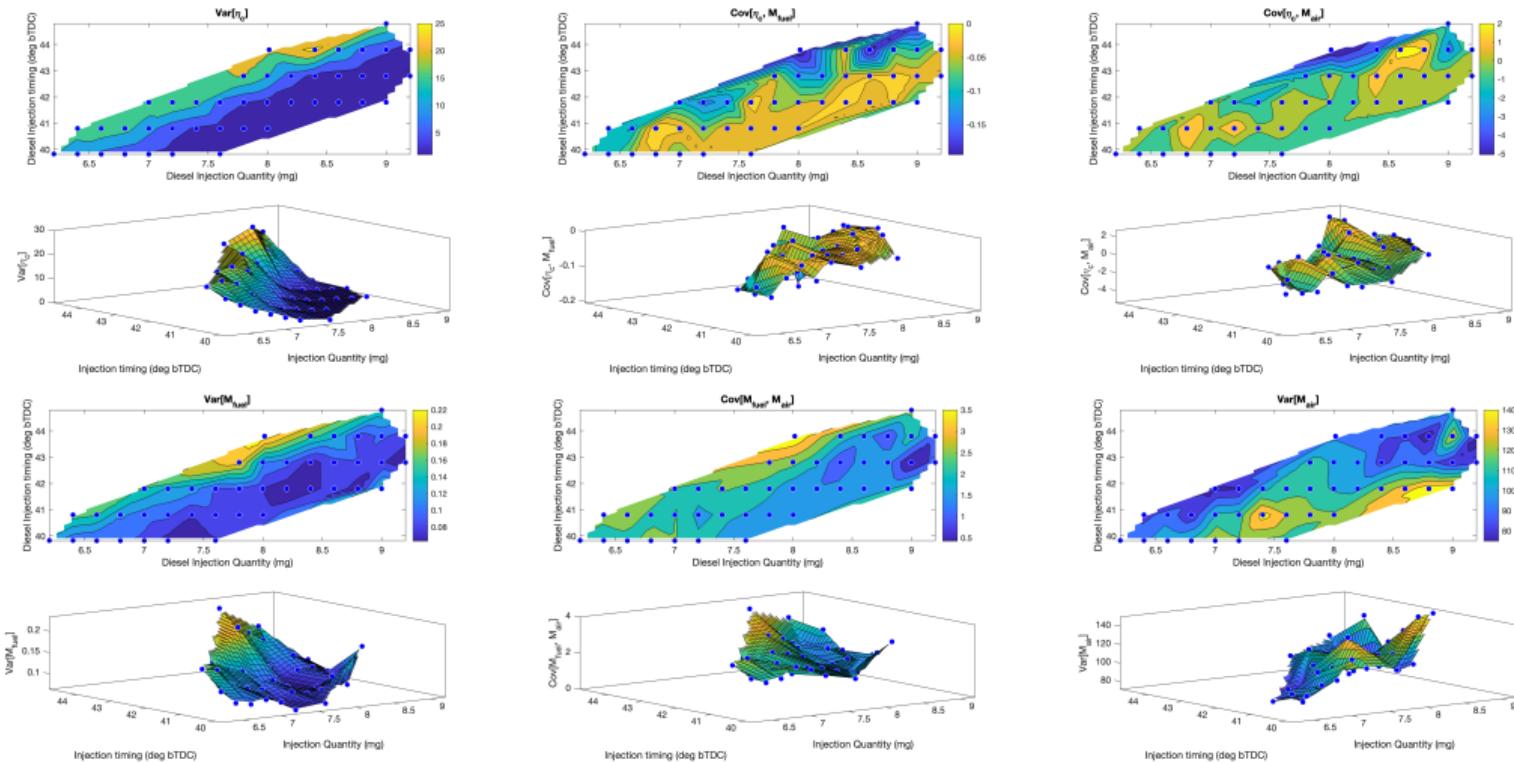
$$\begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 \\ \eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{NH3}} + m_{\text{in}}^{\text{dsl}}[k] \\ m_{\text{in}}^{\text{air}} \end{bmatrix}, Q_{\text{gross}}[k] = \eta_c[k] M_{\text{fuel}}[k] \frac{m_{\text{in}}^{\text{dsl}}[k] Q_{\text{LHV}}^{\text{dsl}} + m_{\text{in}}^{\text{NH3}} Q_{\text{LHV}}^{\text{NH3}}}{m_{\text{in}}^{\text{dsl}}[k] + m_{\text{in}}^{\text{NH3}}}$$



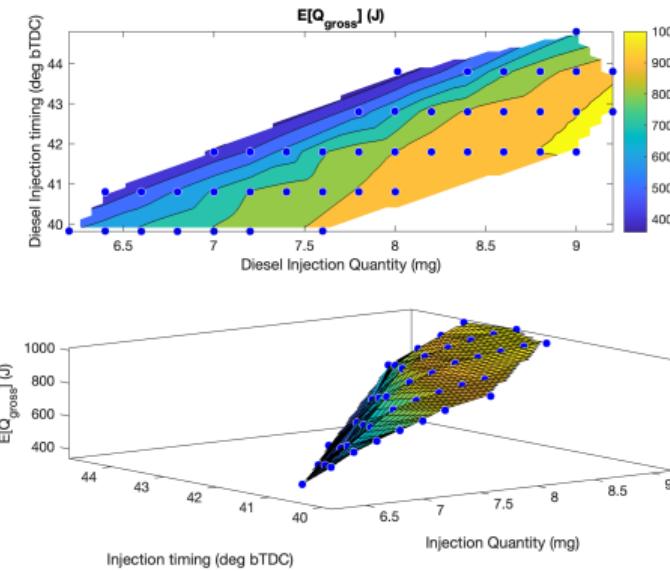
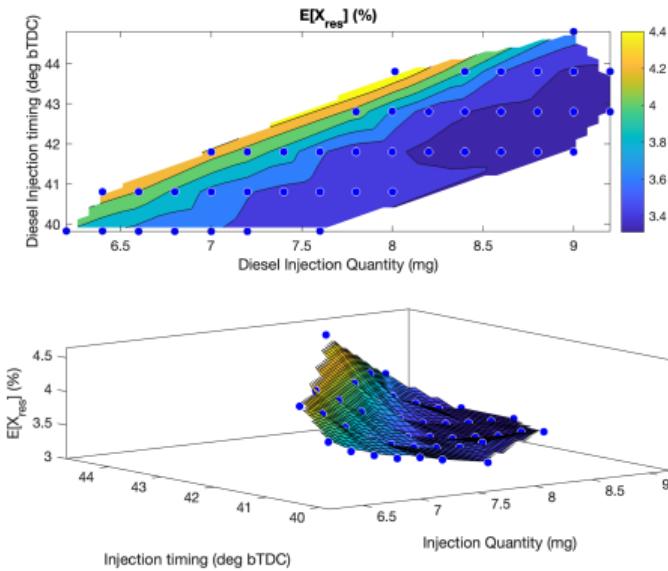
Model parameter μ_η as function of DI strategy



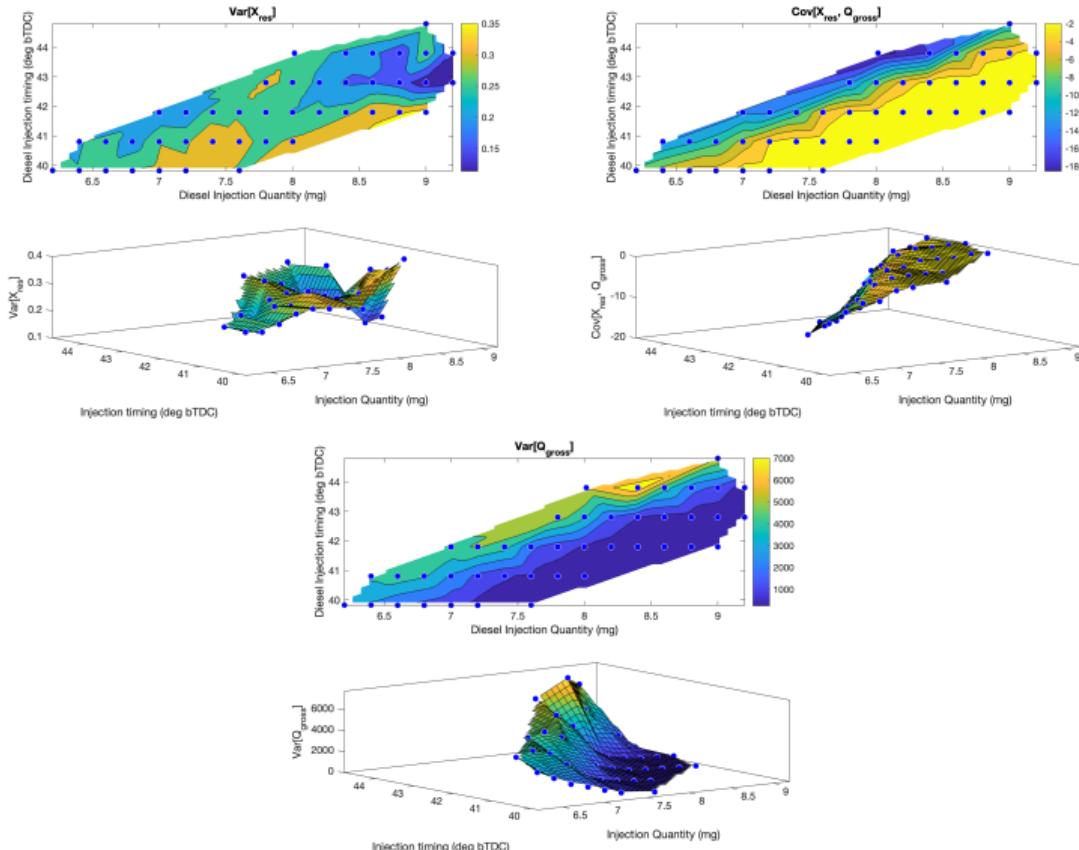
Model parameter Σ_η as function of DI strategy



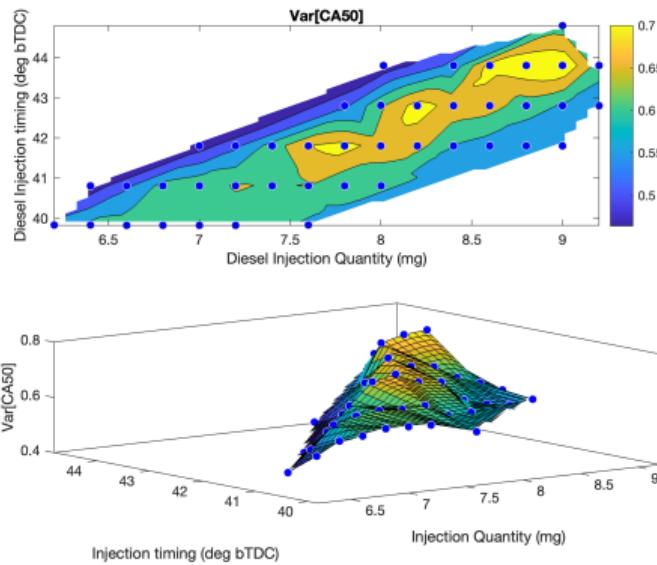
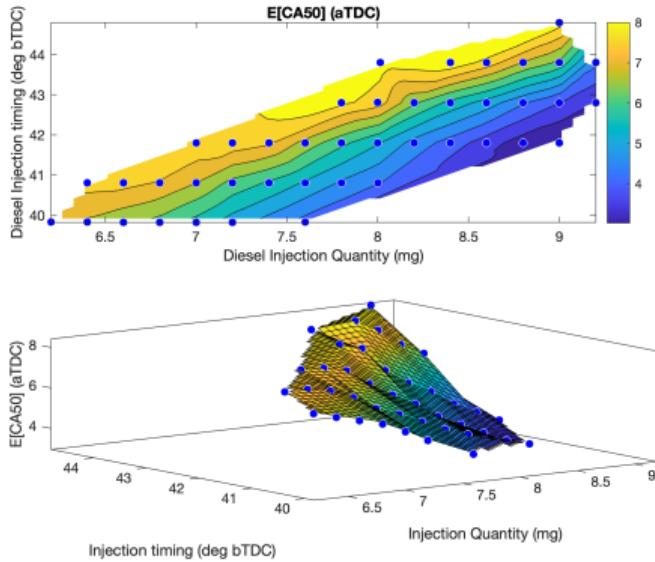
Model parameter μ_X as function of DI strategy



Model parameter Σ_X as function of DI strategy



Model parameters μ_{CA50} and Σ_{CA50} as function of DI strategy



Model performance

