

Ammonia-Diesel experimental data and modeling results

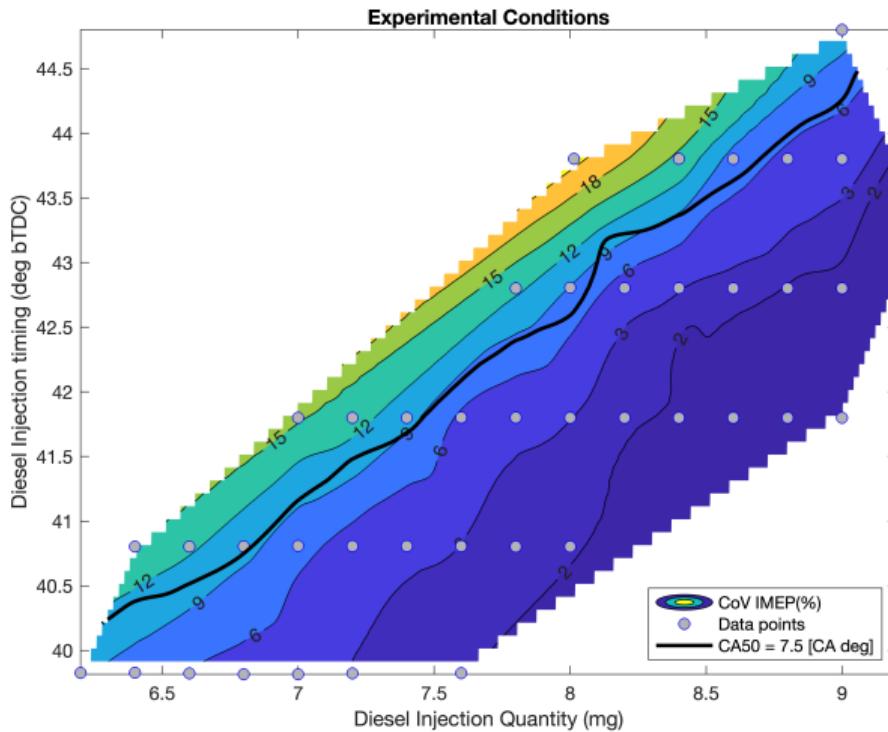
Bryan Maldonado
ORNL
February 21, 2025

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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



Physics-based model: Definitions

Symbol	Definition	Value
m_{in}^{dsl}	diesel fuel mass injected	cycle-to-cycle
$m_{in}^{NH_3}$	ammonia fuel mass injected	cycle-to-cycle
m_{in}^{air}	fresh air mass	cycle-to-cycle
M_{fuel}^{dsl}	in-cylinder diesel fuel mass	cycle-to-cycle
$M_{fuel}^{NH_3}$	in-cylinder ammonia fuel mass	cycle-to-cycle
M_{air}	in-cylinder air mass	cycle-to-cycle
AFR_s^{dsl}	diesel stoichiometric air-to-fuel ratio	14.5
$AFR_s^{NH_3}$	ammonia stoichiometric air-to-fuel ratio	6.04
Q_{LHV}^{dsl}	diesel lower heating values	44.1e6 (J)
$Q_{LHV}^{NH_3}$	ammonia lower heating values	18.6e6 (J)
η_c	combustion efficiency	cycle-to-cycle
X_{res}	residual gas fraction	cycle-to-cycle
Q_{gross}	gross heat release	cycle-to-cycle

Physics-based model: Formulation

Cycle-to-cycle dynamics

$$\begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} \\ M_{\text{fuel}}^{\text{NH}_3} \\ M_{\text{air}} \end{bmatrix}_{k+1} = X_{\text{res}}[k] \begin{bmatrix} 1 - \eta_c[k] & 0 & 0 \\ 0 & 1 - \eta_c[k] & 0 \\ -\text{AFR}_s^{\text{dsl}}\eta_c[k] & -\text{AFR}_s^{\text{NH}_3}\eta_c[k] & 1 \end{bmatrix} \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} \\ M_{\text{fuel}}^{\text{NH}_3} \\ M_{\text{air}} \end{bmatrix}_k + \begin{bmatrix} m_{\text{in}}^{\text{dsl}} \\ m_{\text{in}}^{\text{NH}_3} \\ m_{\text{in}}^{\text{air}} \end{bmatrix}_k$$

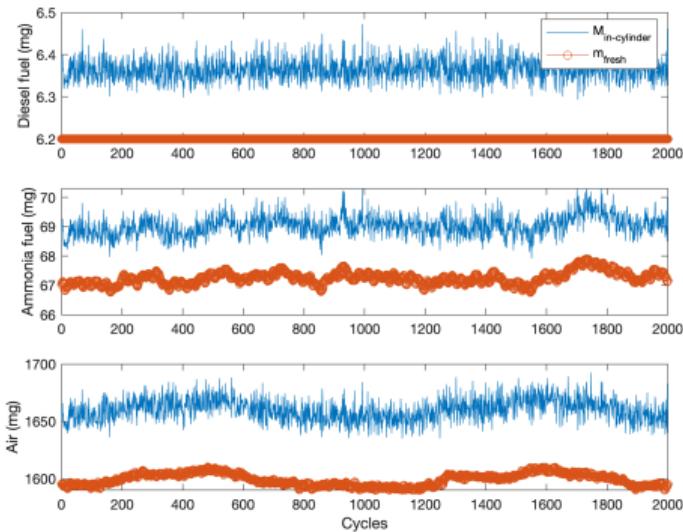
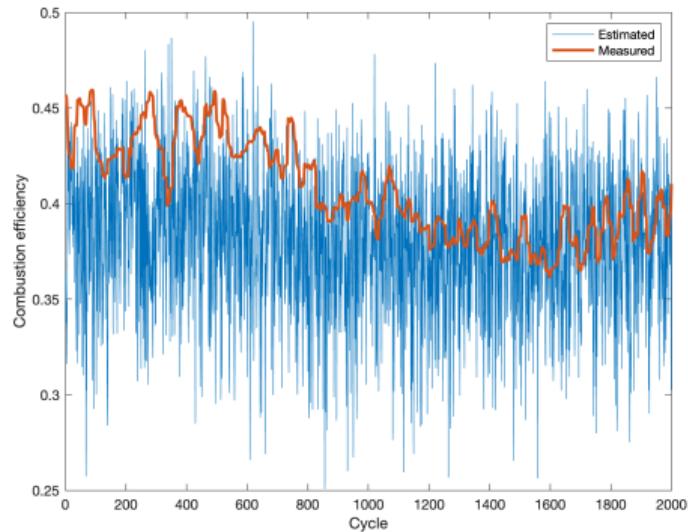
Gross heat release:

$$Q_{\text{gross}}[k] = \eta_c[k](Q_{\text{LHV}}^{\text{dsl}}M_{\text{fuel}}^{\text{dsl}}[k] + Q_{\text{LHV}}^{\text{NH}_3}M_{\text{fuel}}^{\text{NH}_3}[k])$$

CA50:

$$\text{CA50}[k] \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}}[k] & M_{\text{fuel}}^{\text{NH}_3}[k] & M_{\text{air}}[k] & \text{SOI}^{\text{dsl}}[k] \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

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

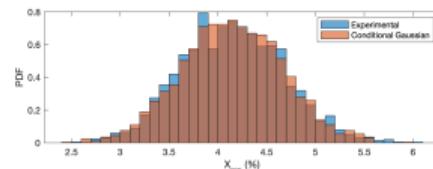
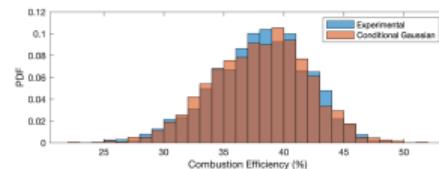
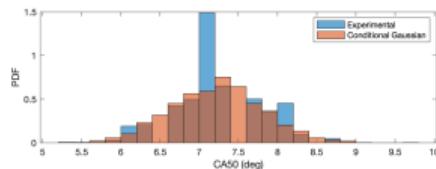
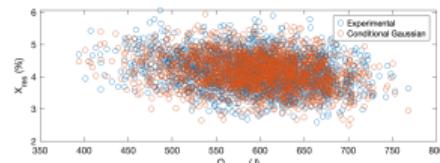
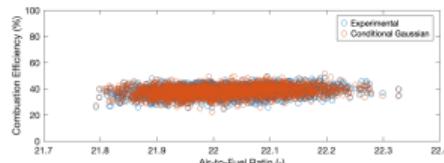
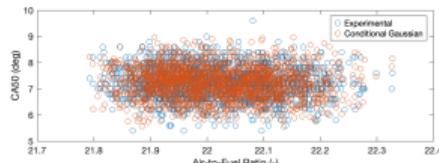


DI6.2 SOI40: Parametric models

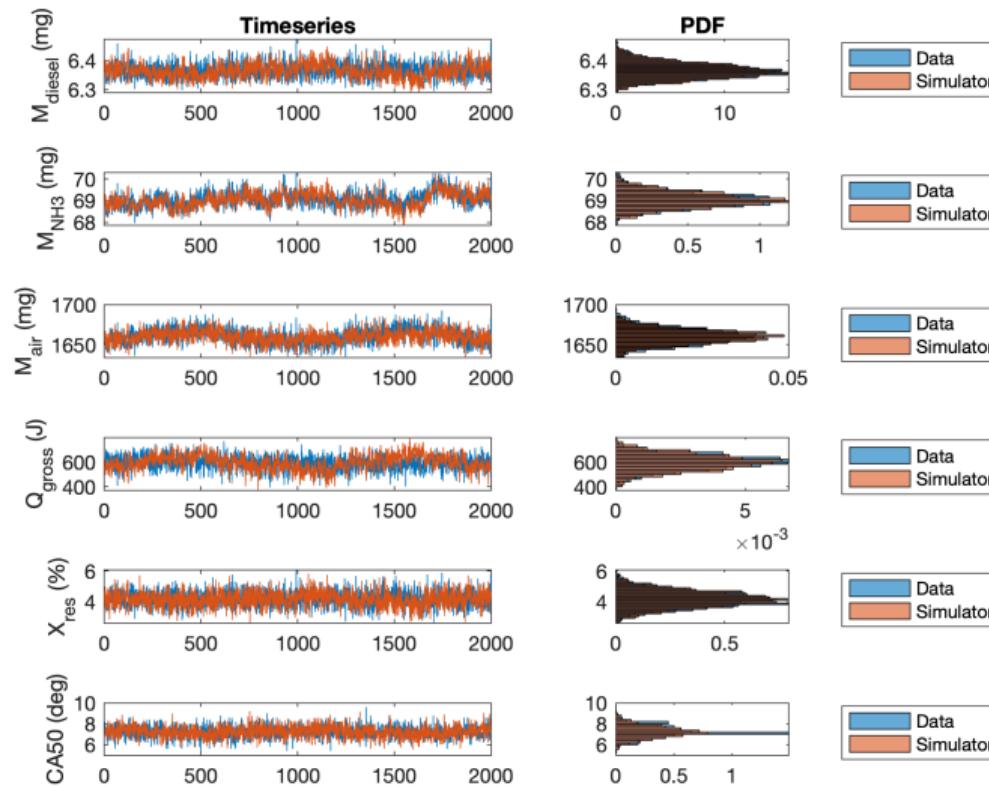
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

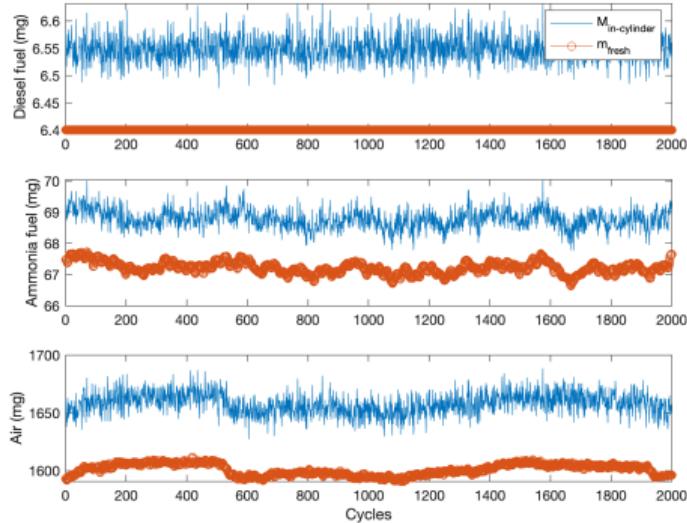
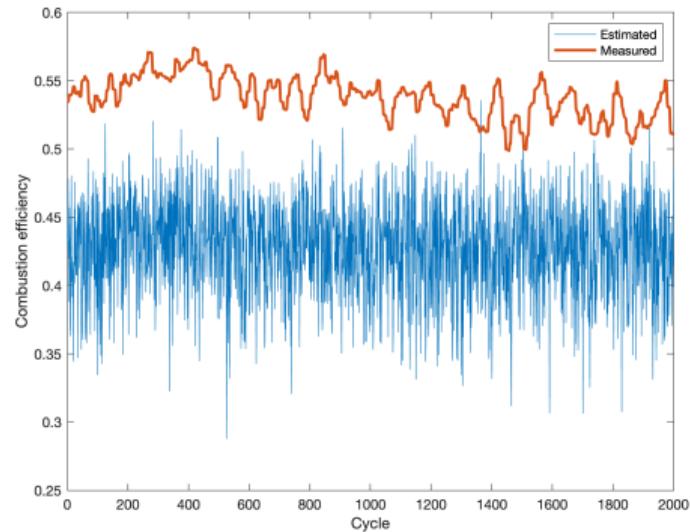
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI6.2 SOI40: Simulator Results



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

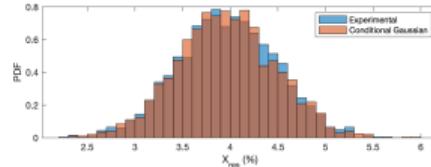
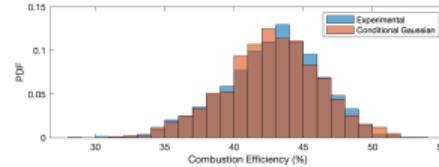
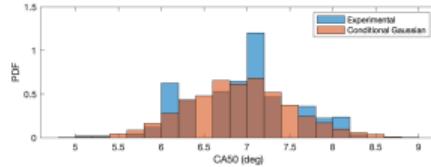
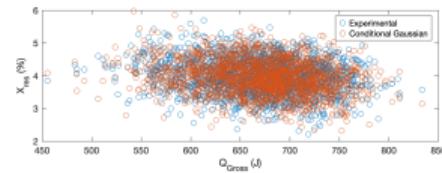
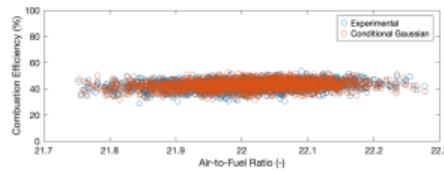
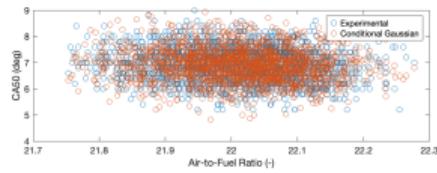


DI6.4 SOI40: Parametric models

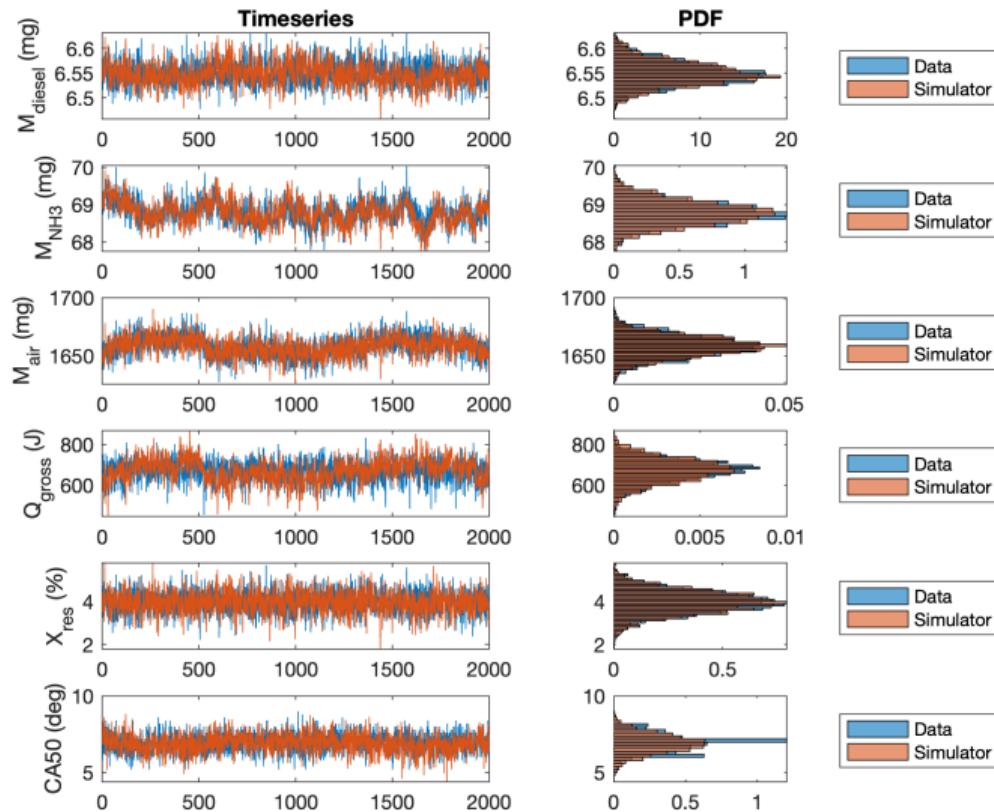
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

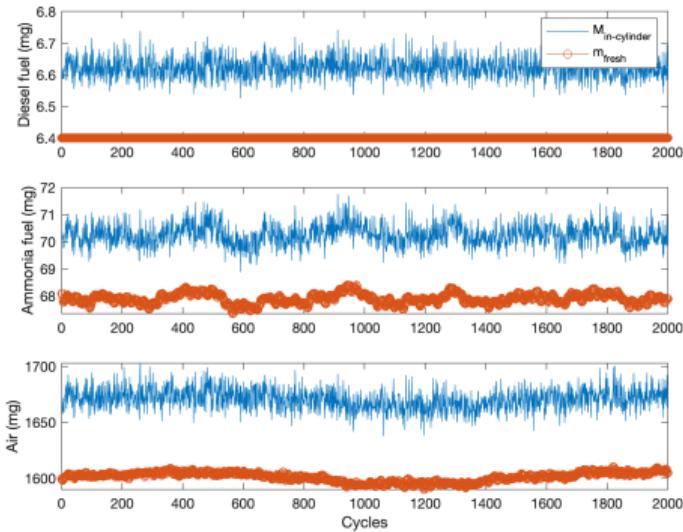
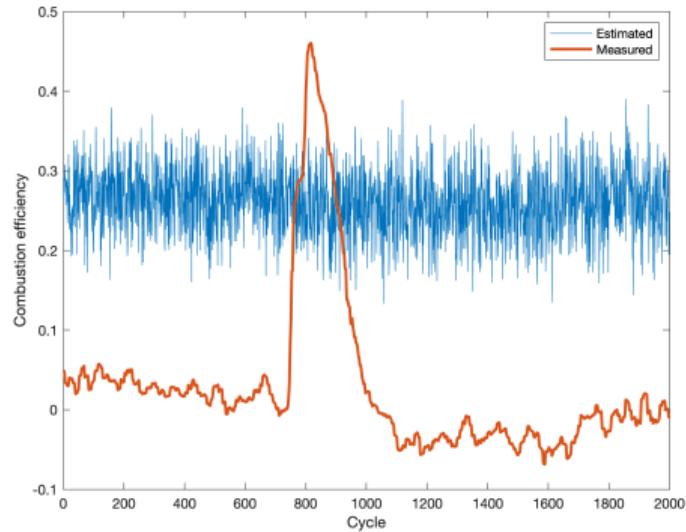
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI6.4 SOI40: Simulator Results



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

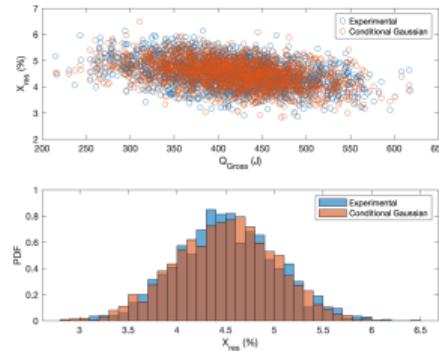
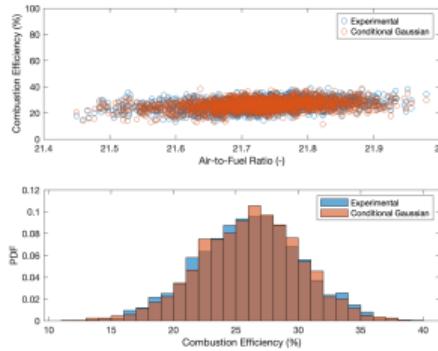
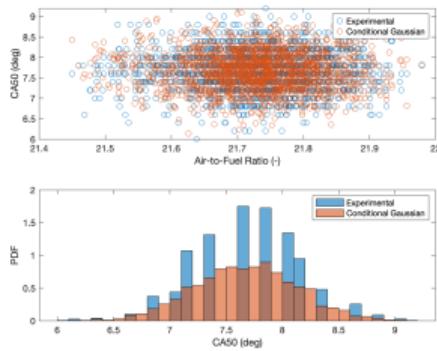


DI6.4 SOI41: Parametric models

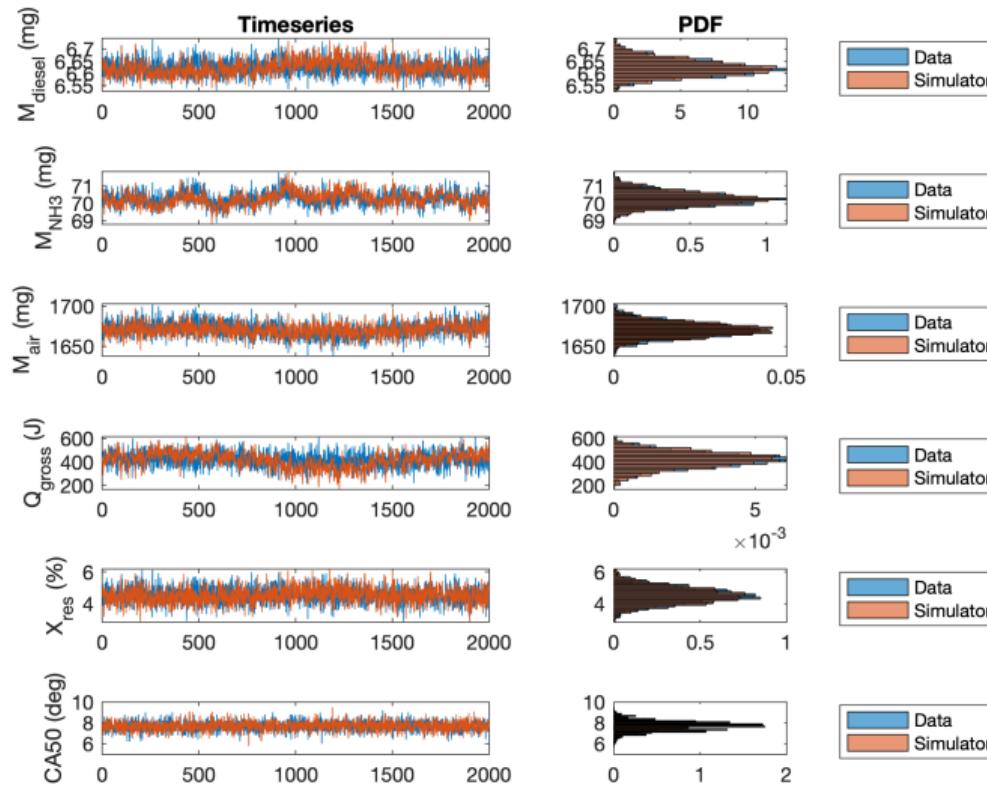
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

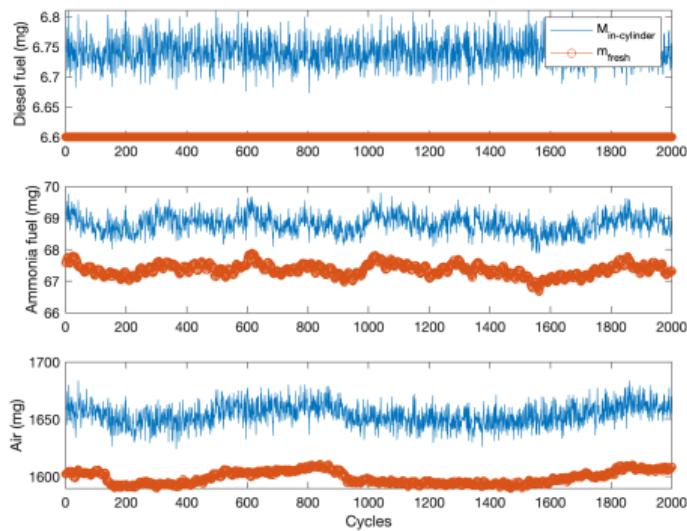
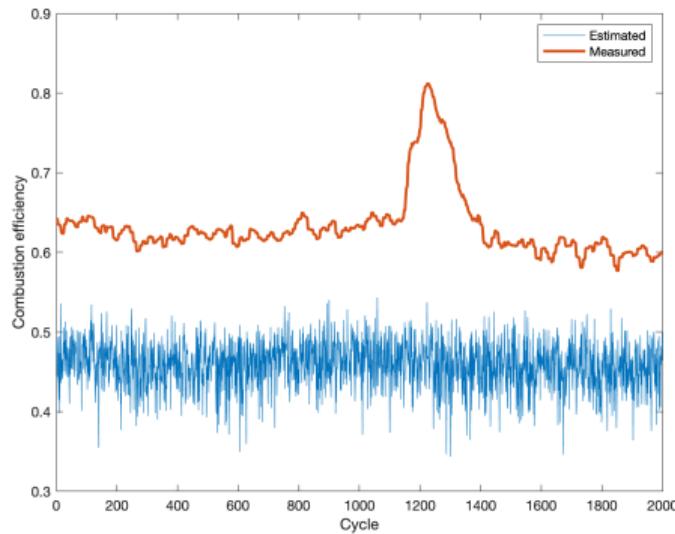
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI6.4 SOI41: Simulator Results



DI6.6 SOI40: Estimation of combustion efficiency and in-cylinder mass

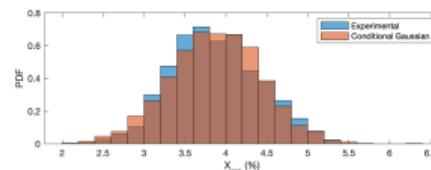
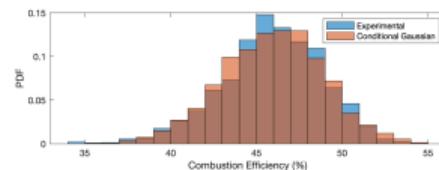
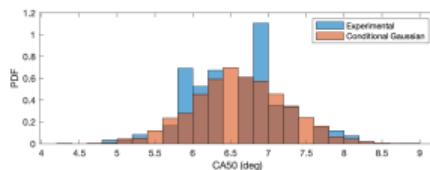
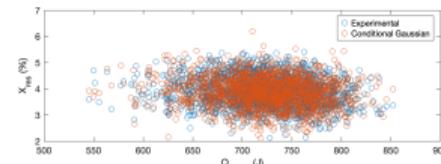
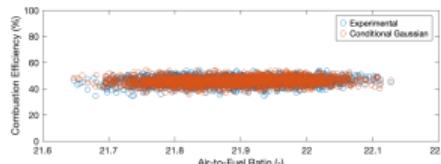
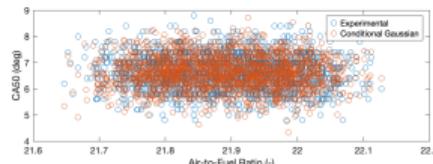


DI6.6 SOI40: Parametric models

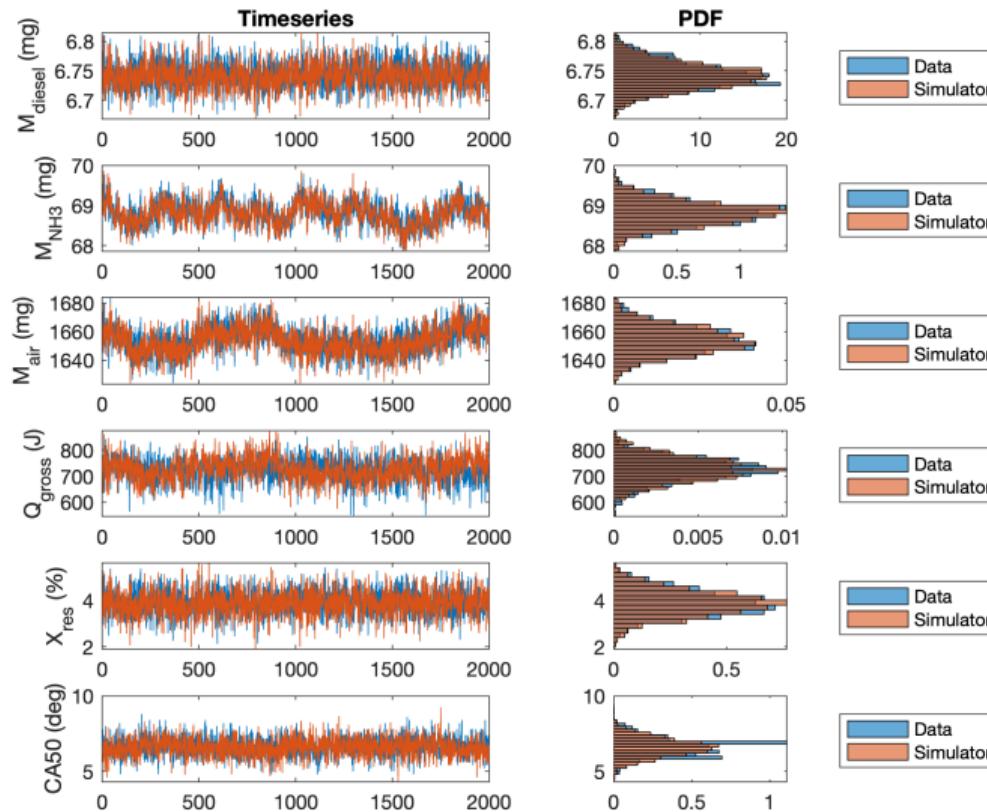
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

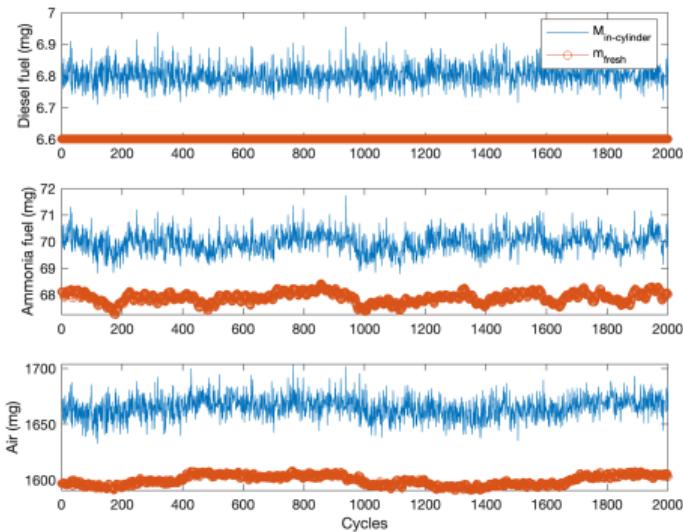
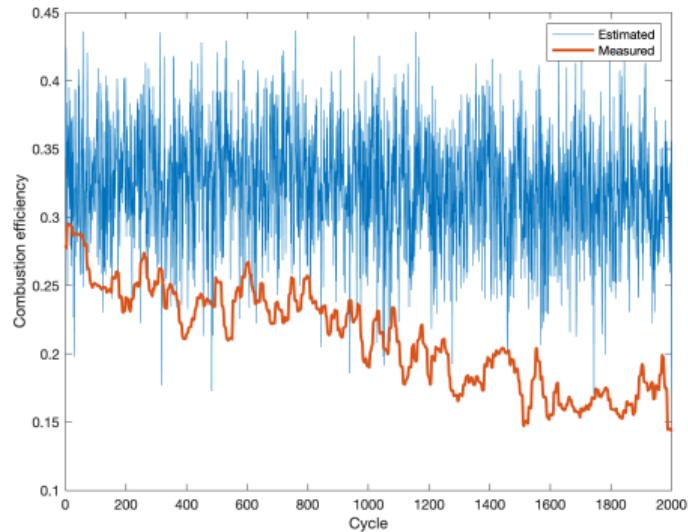
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI6.6 SOI40: Simulator Results



DI6.6 SOI41: Estimation of combustion efficiency and in-cylinder mass

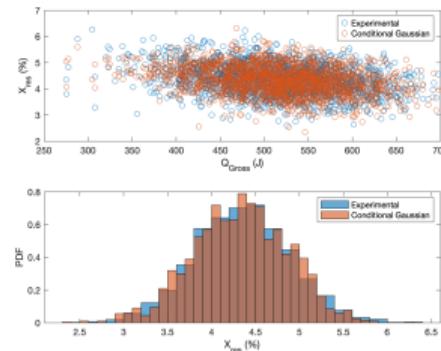
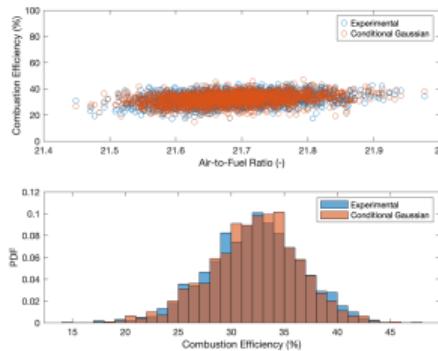
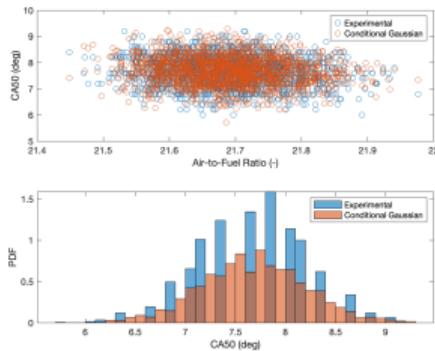


DI6.6 SOI41: Parametric models

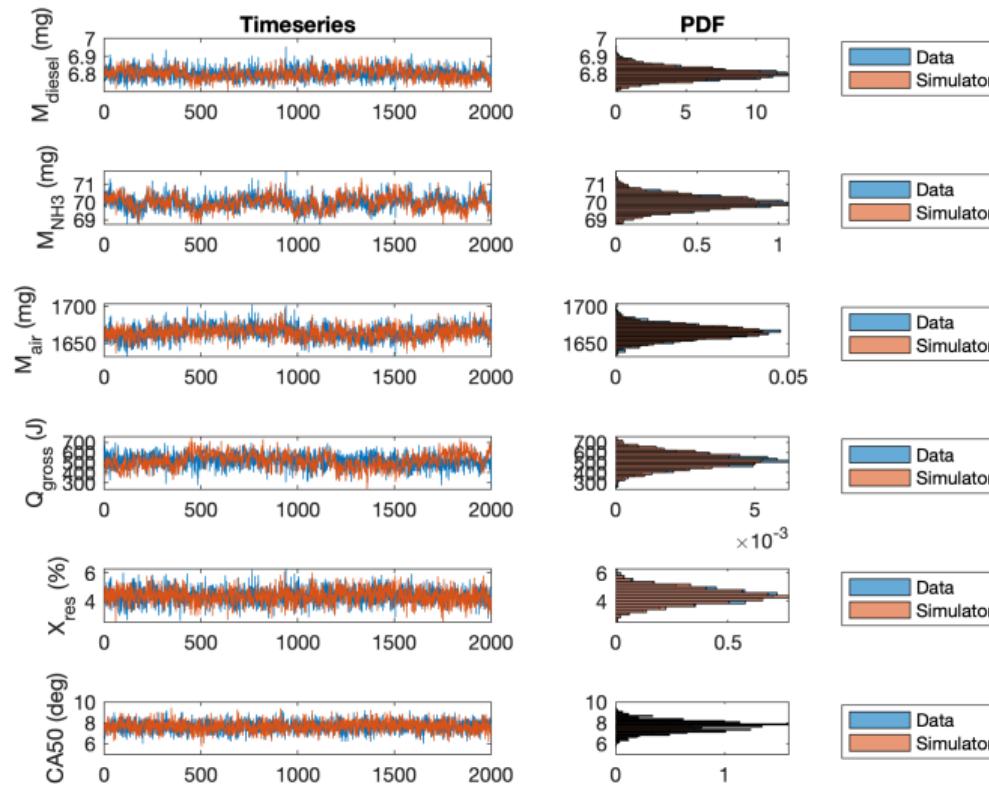
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

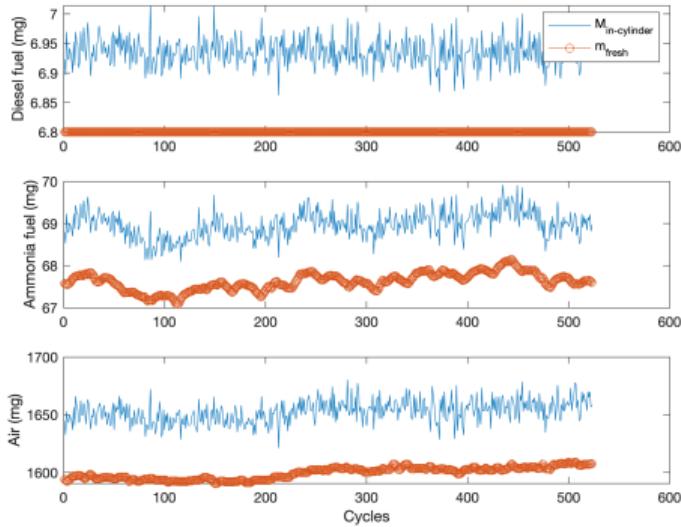
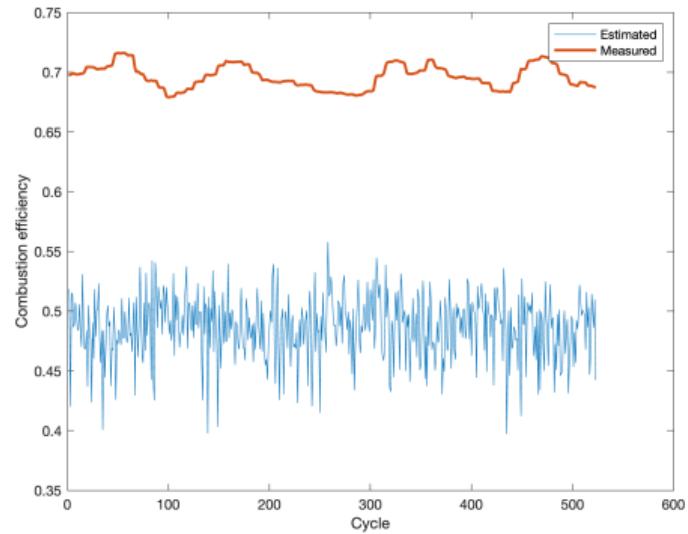
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI6.6 SOI41: Simulator Results



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

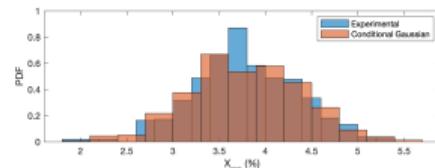
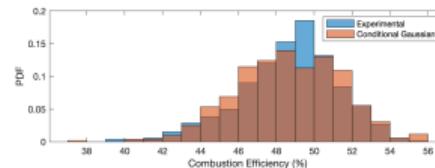
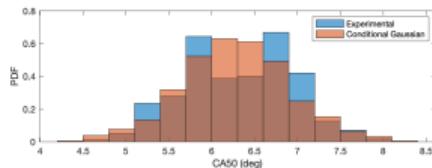
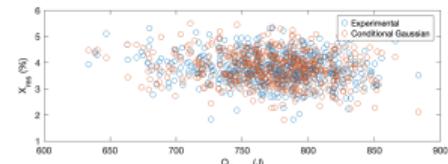
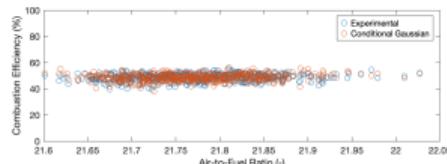
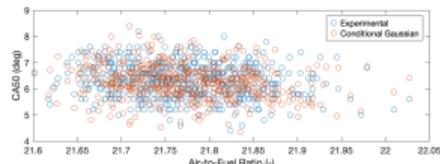


DI6.8 SOI40: Parametric models

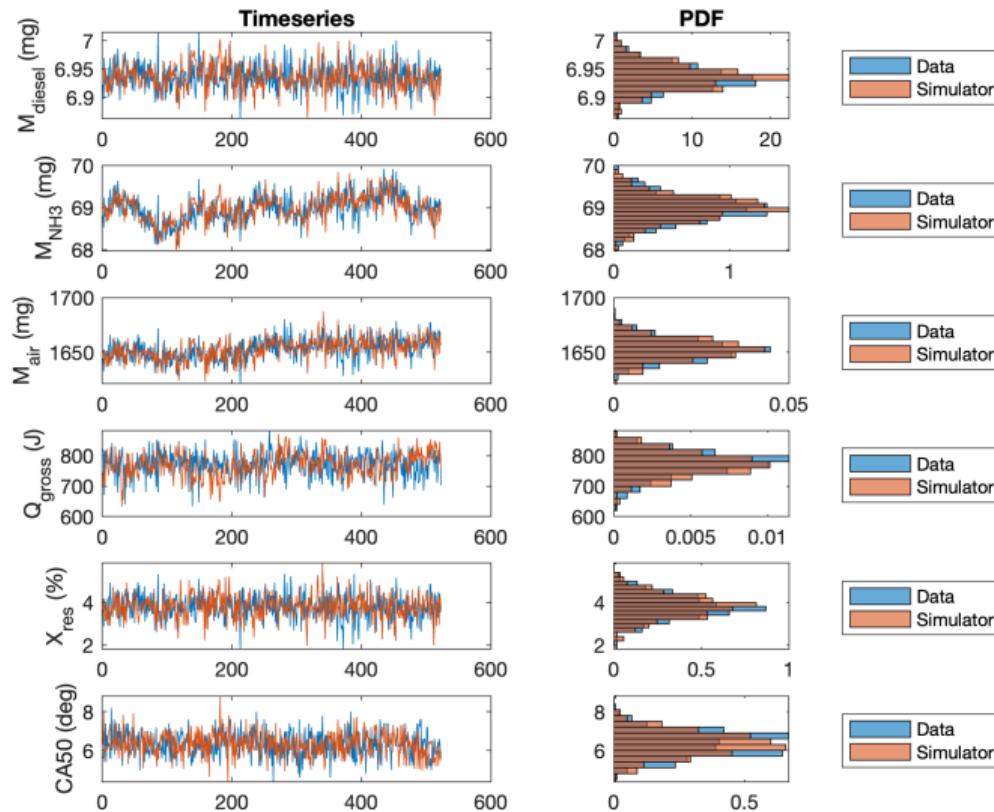
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$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

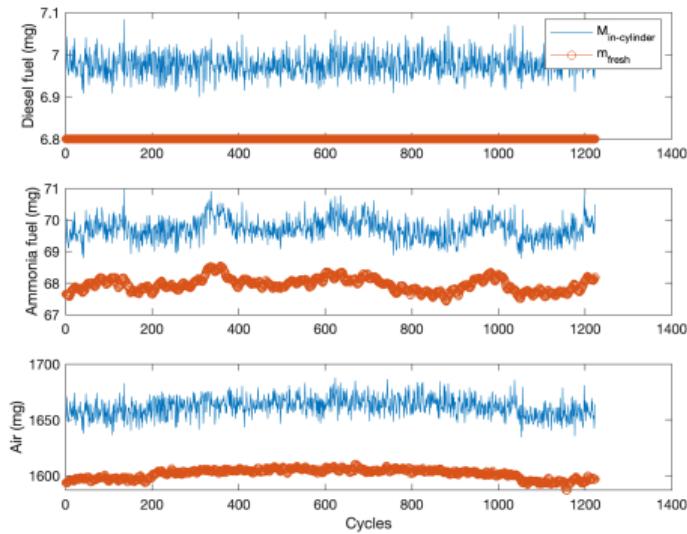
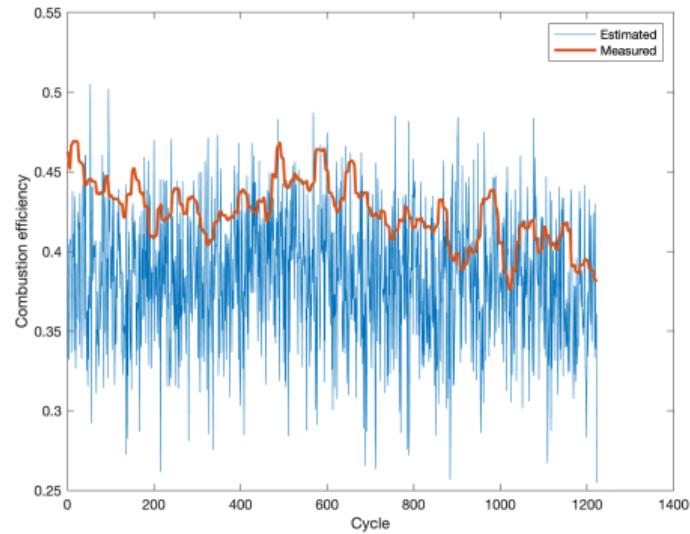
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI6.8 SOI40: Simulator Results



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

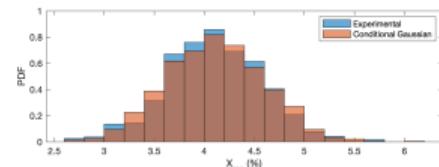
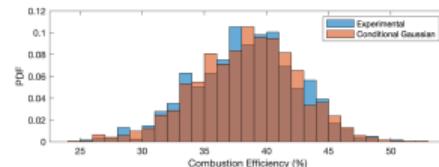
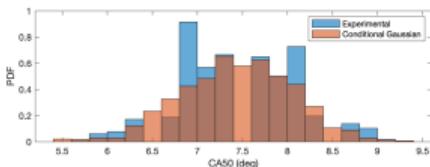
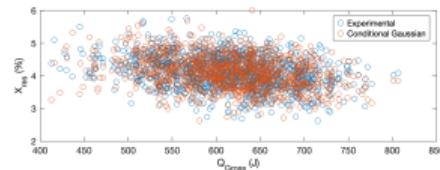
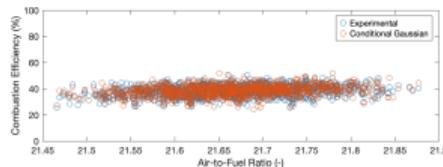
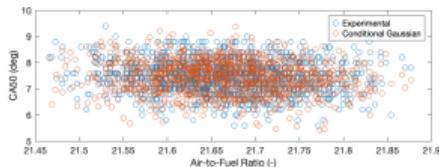


DI6.8 SOI41: Parametric models

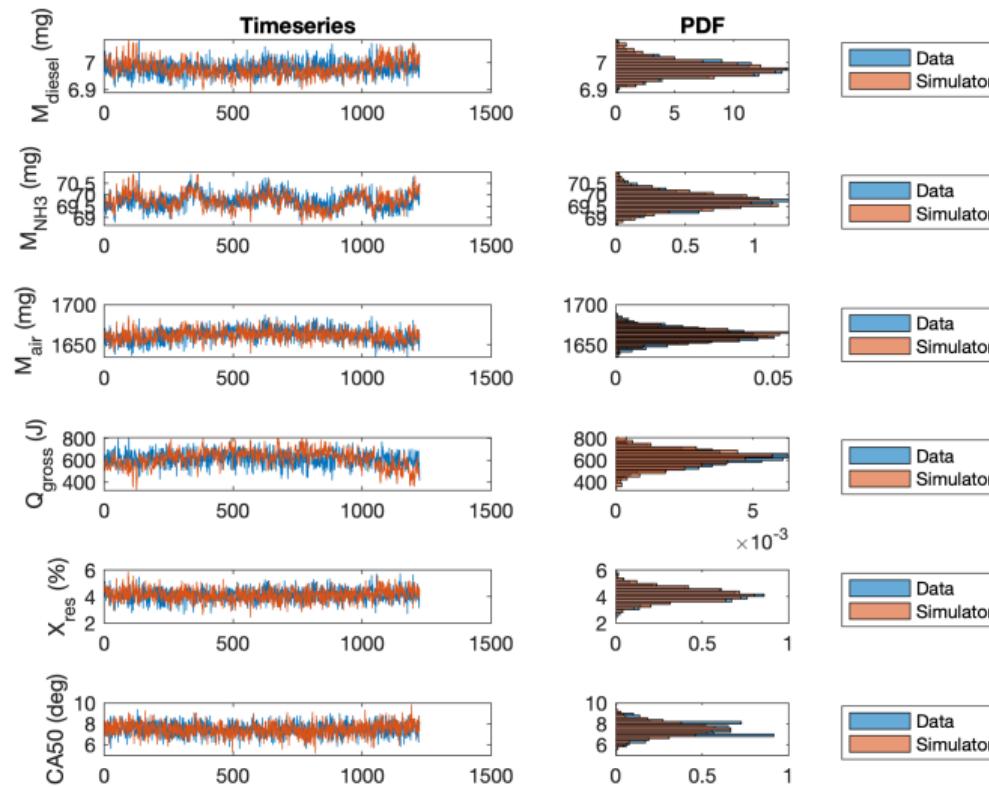
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

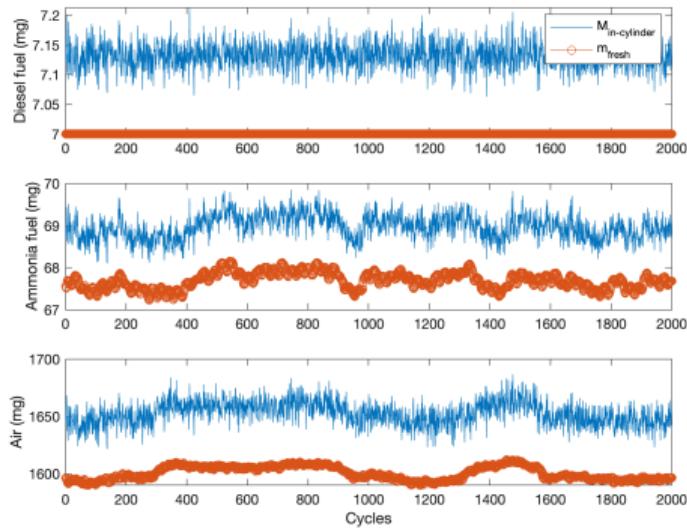
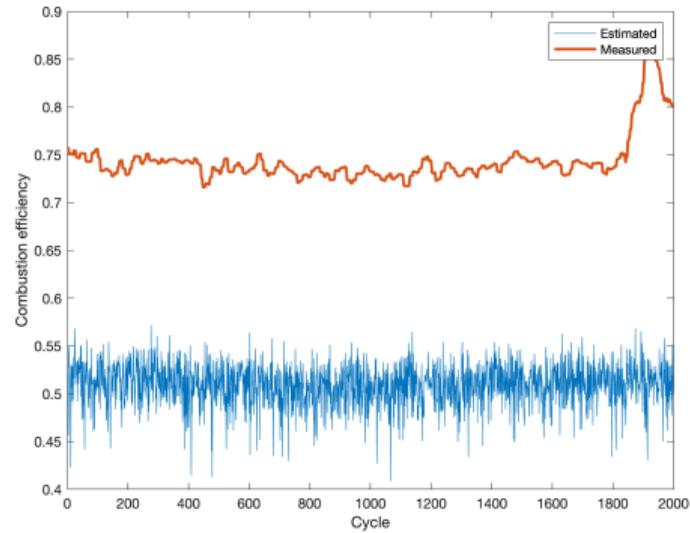
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI6.8 SOI41: Simulator Results



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

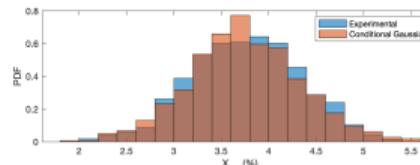
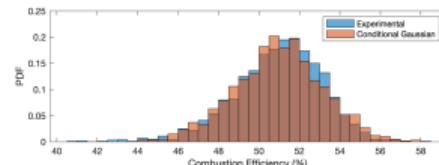
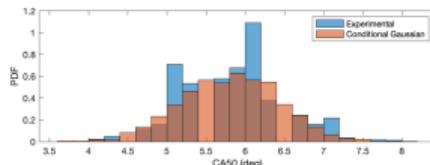
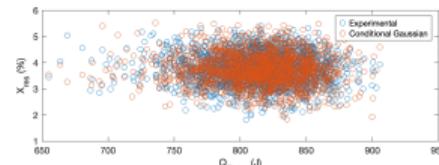
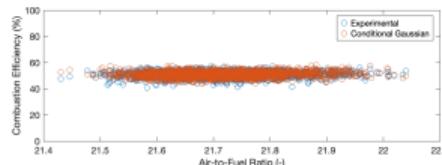
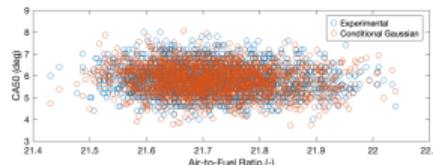


DI7.0 SOI40: Parametric models

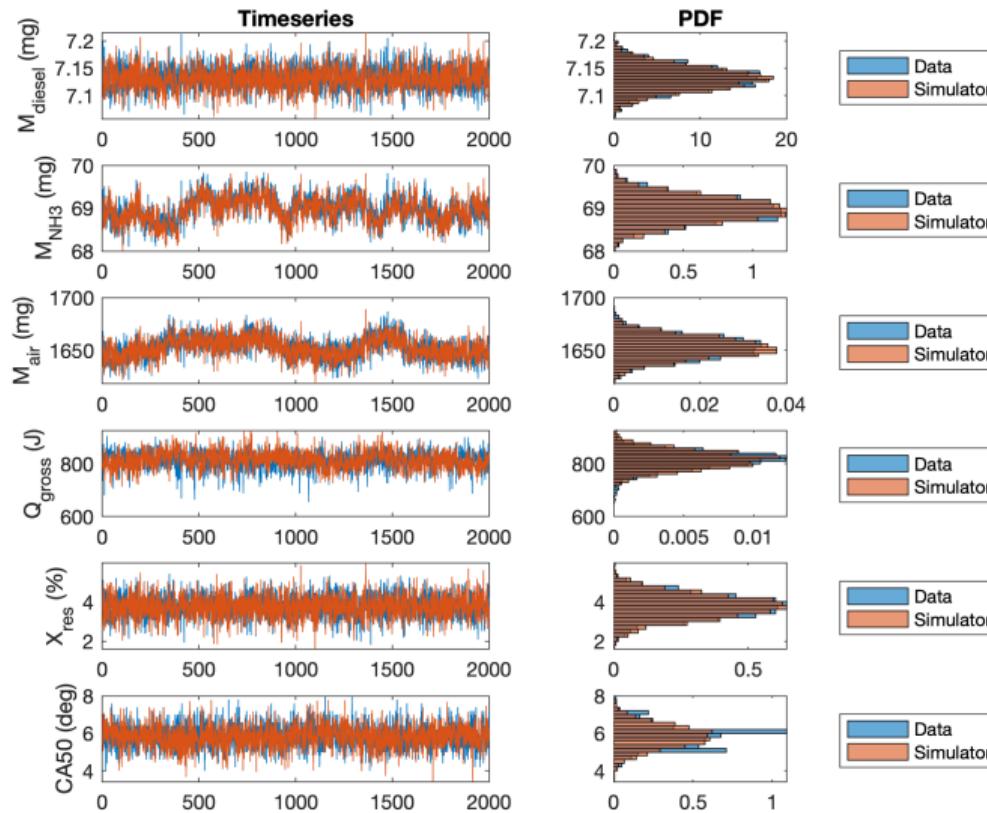
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

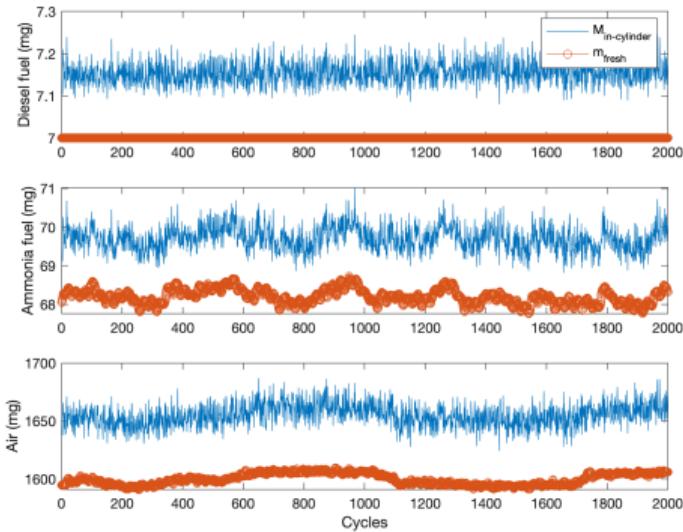
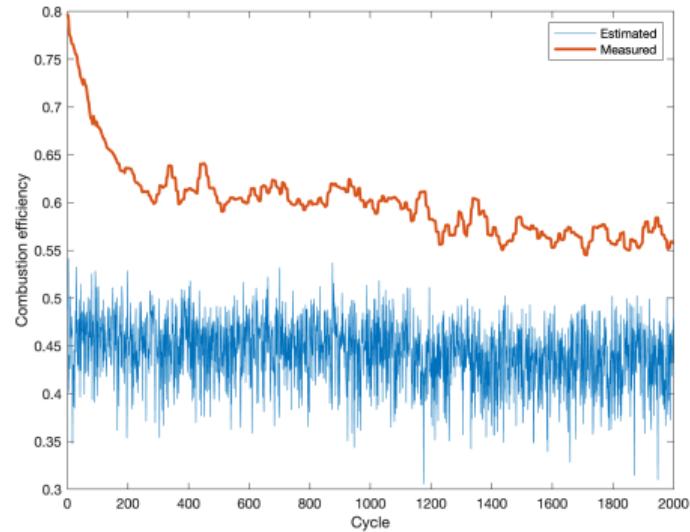
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.0 SOI40: Simulator Results



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

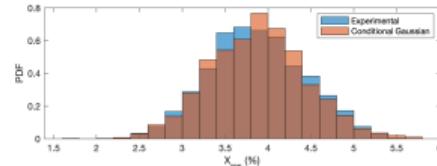
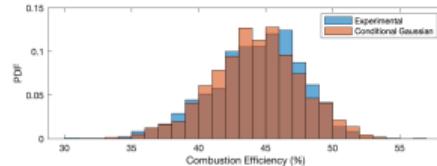
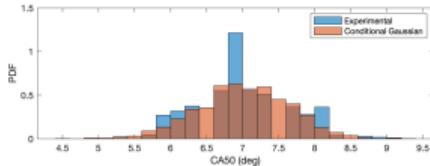
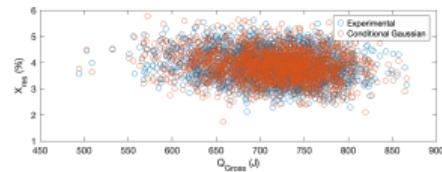
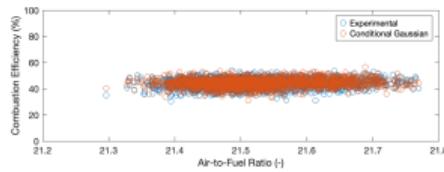
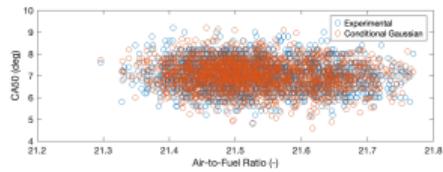


DI7.0 SOI41: Parametric models

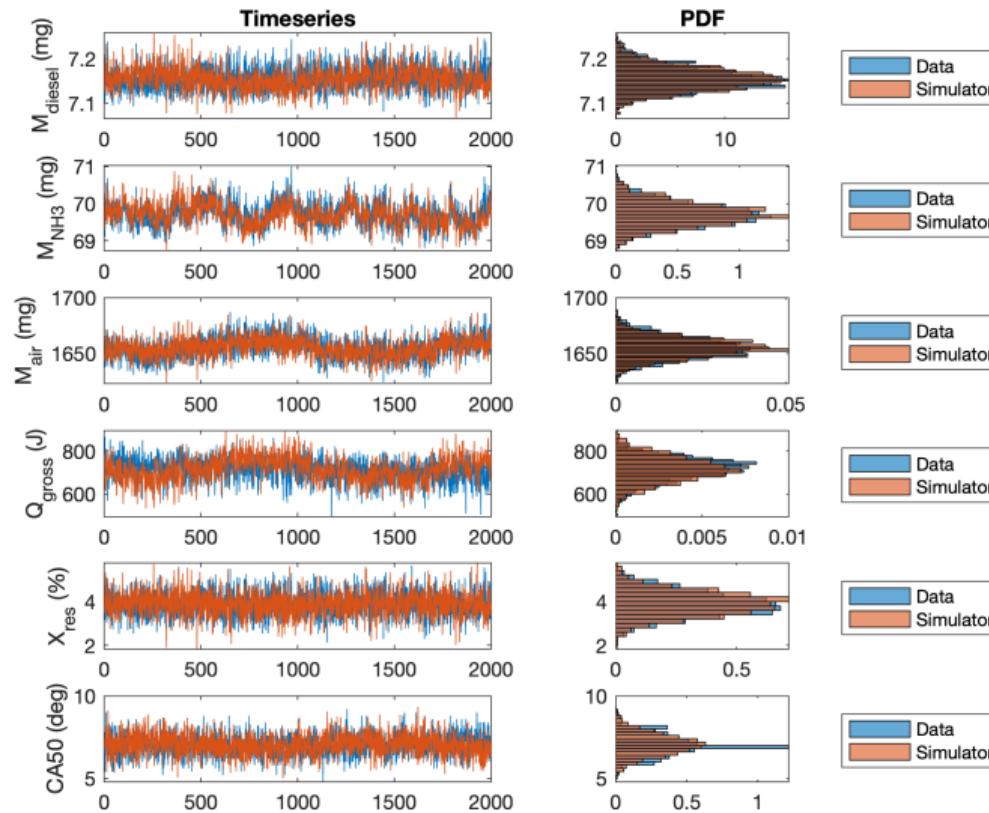
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

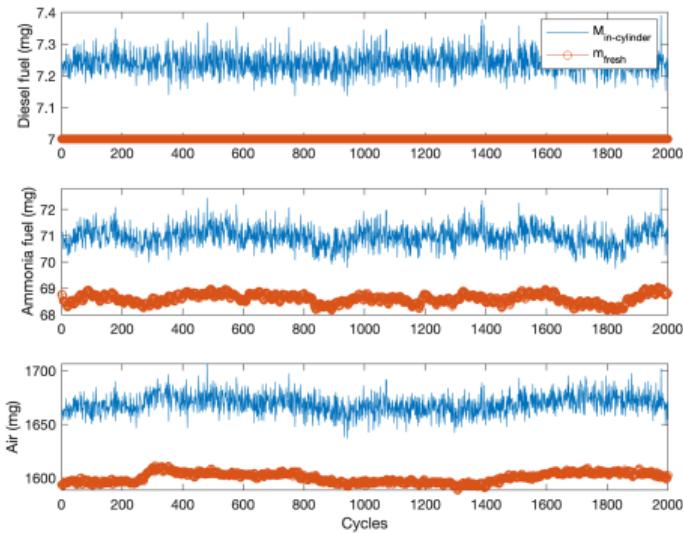
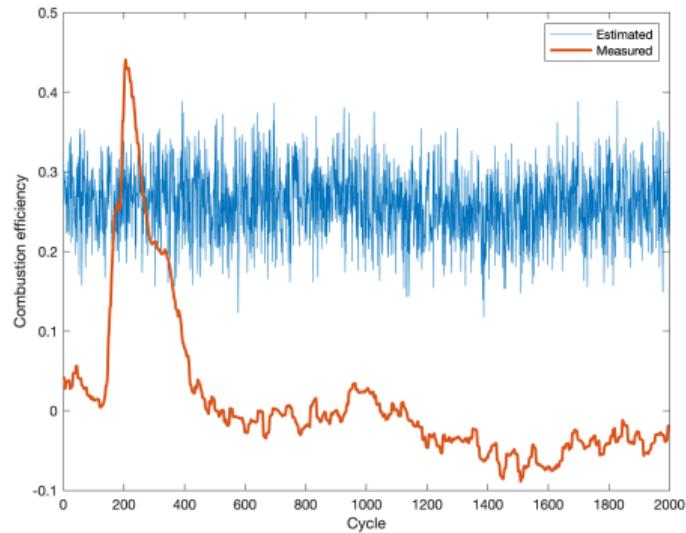
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.0 SOI41: Simulator Results



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

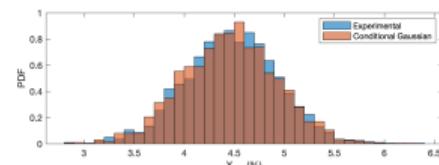
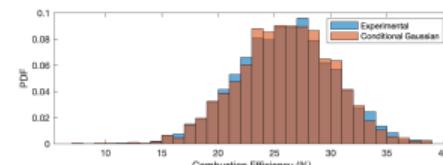
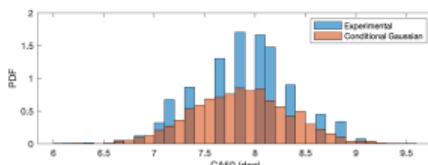
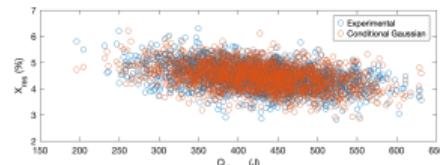
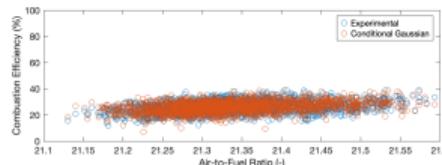
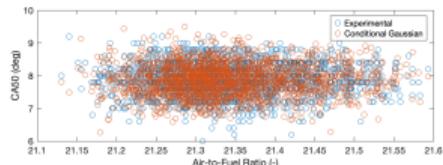


DI7.0 SOI42: Parametric models

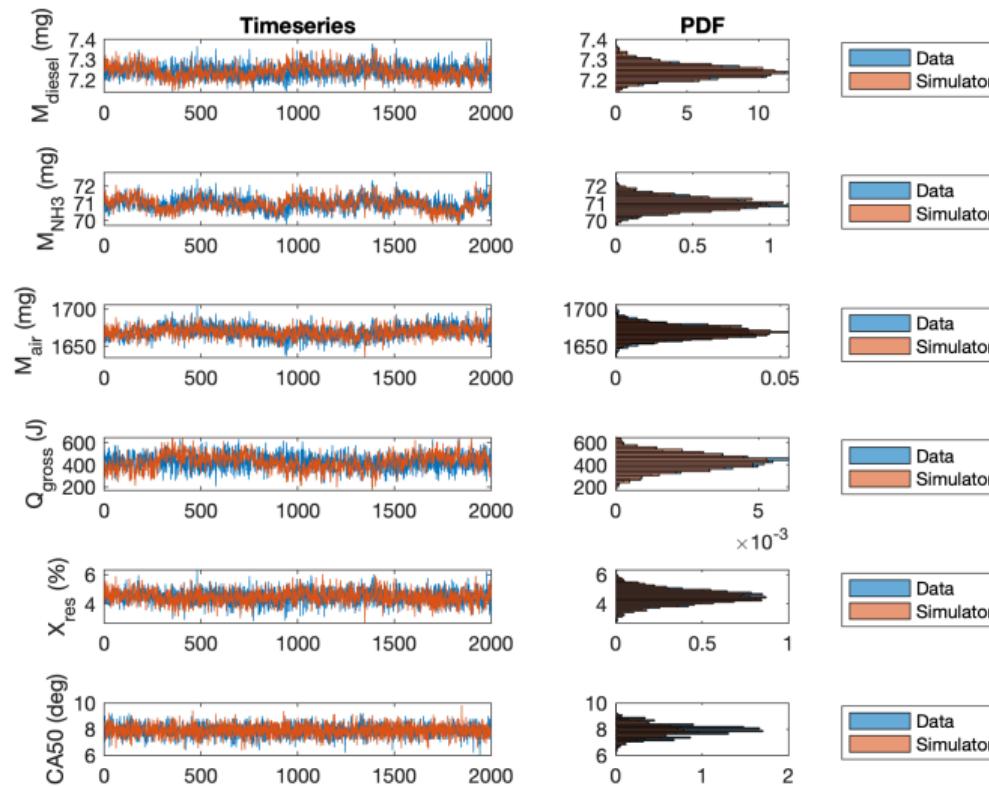
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

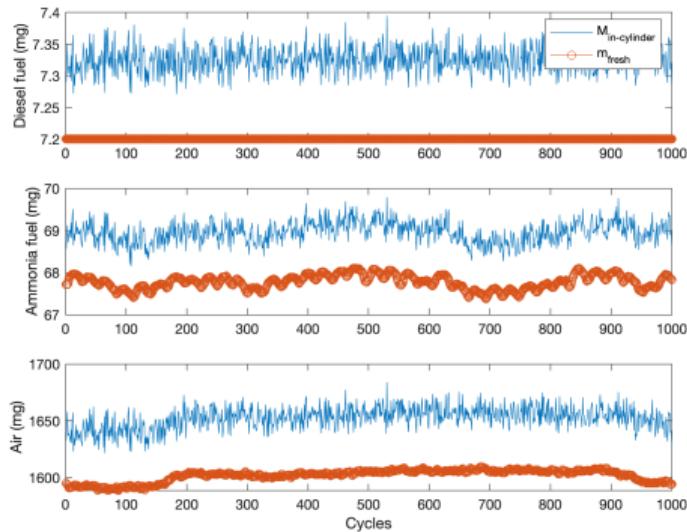
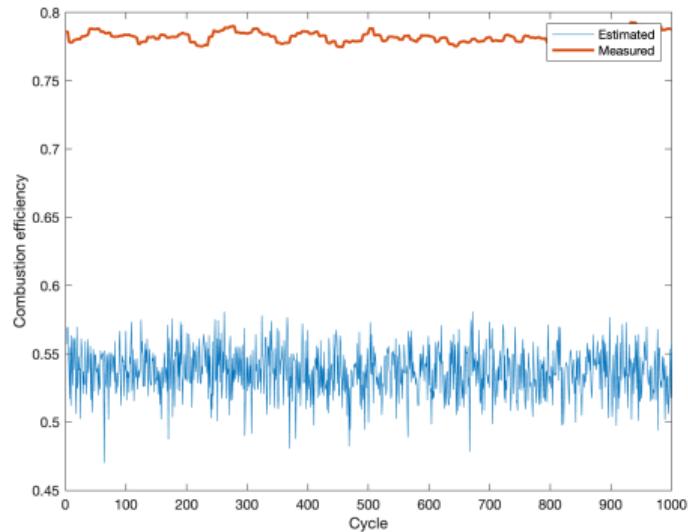
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.0 SOI42: Simulator Results



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

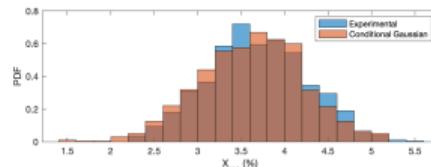
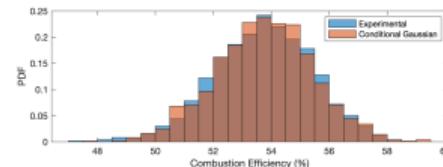
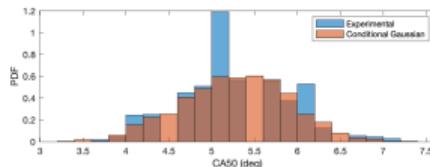
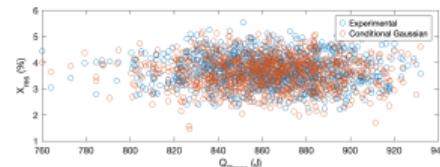
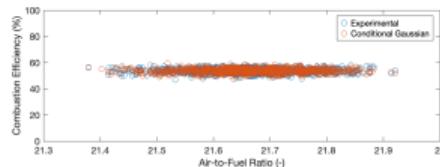
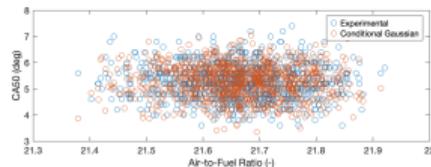


DI7.2 SOI40: Parametric models

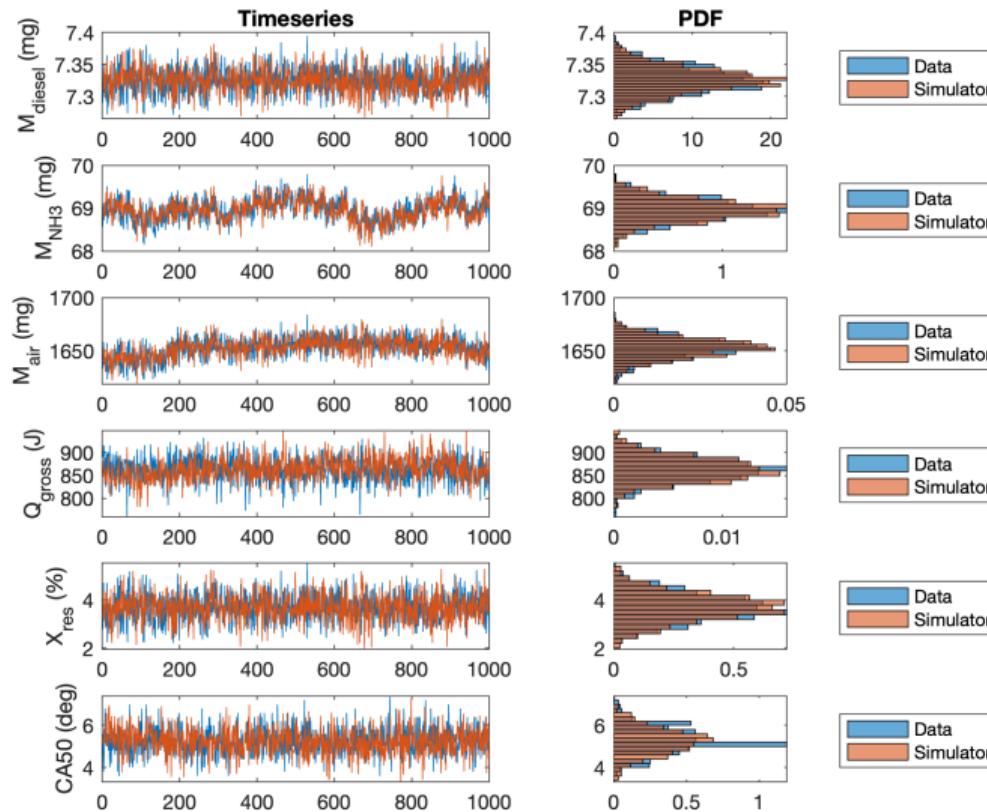
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

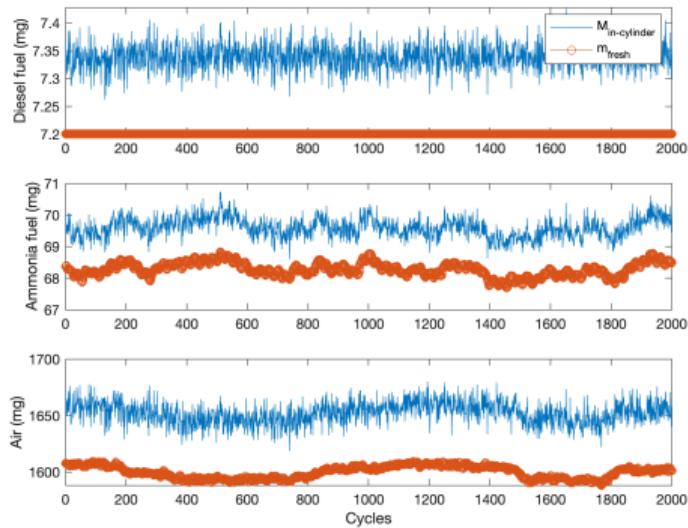
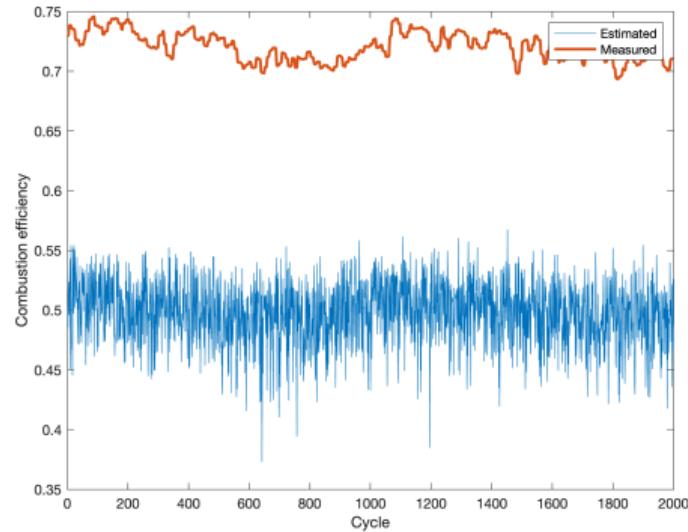
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.2 SOI40: Simulator Results



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

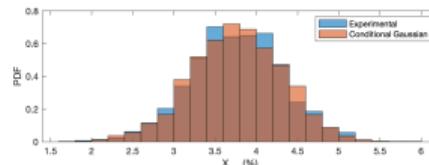
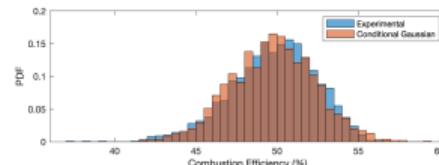
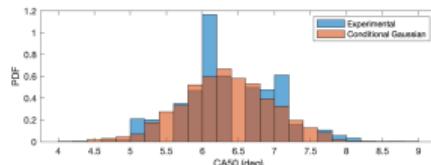
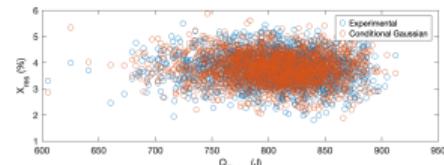
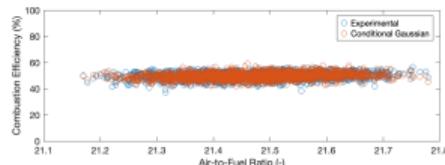
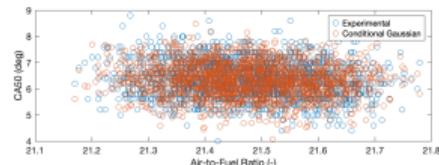


DI7.2 SOI41: Parametric models

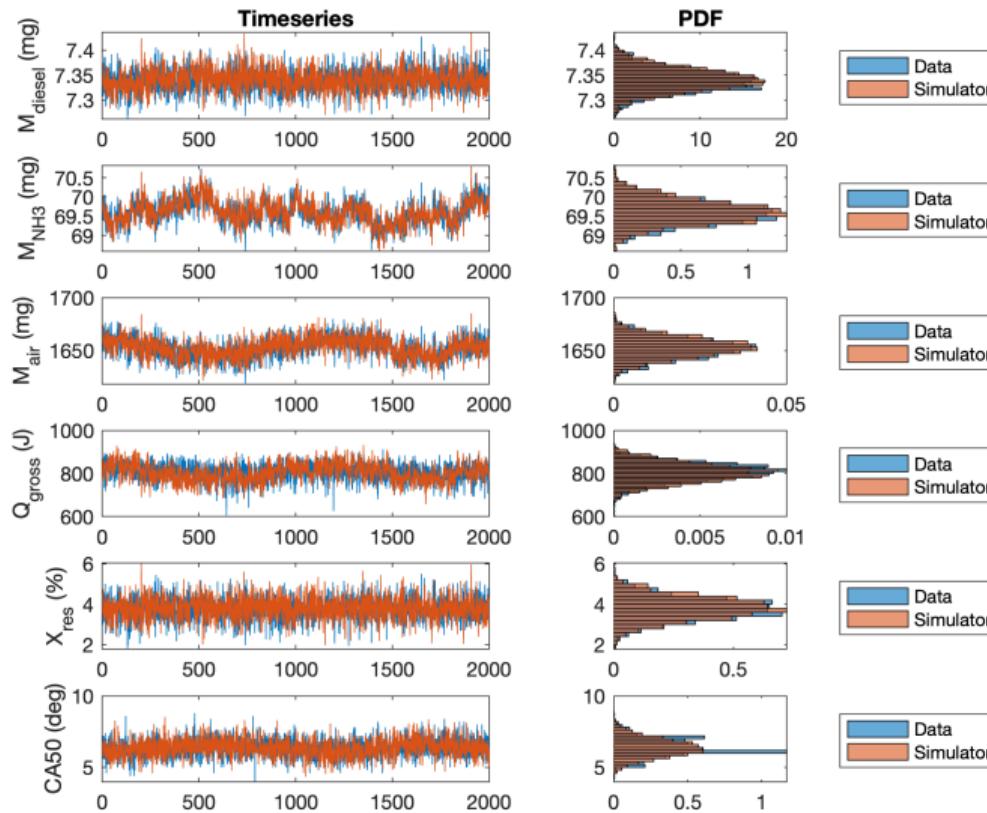
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

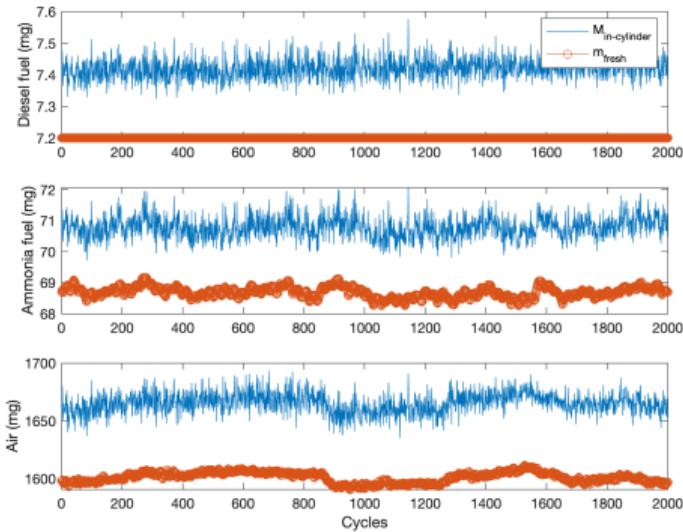
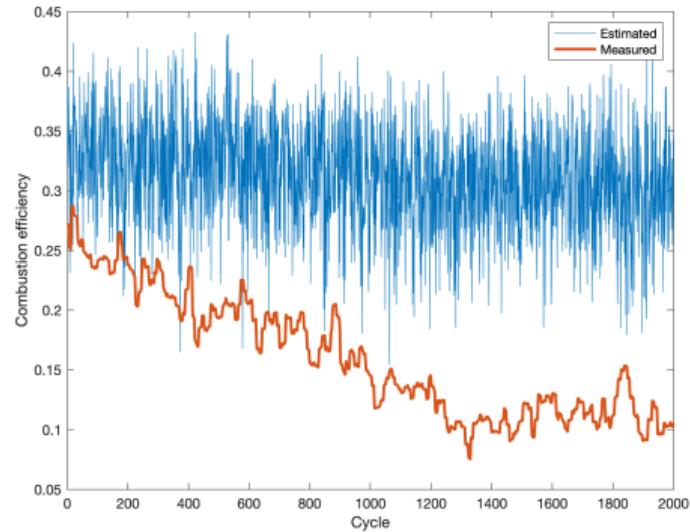
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.2 SOI41: Simulator Results



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

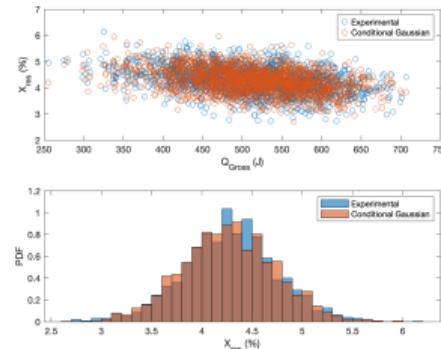
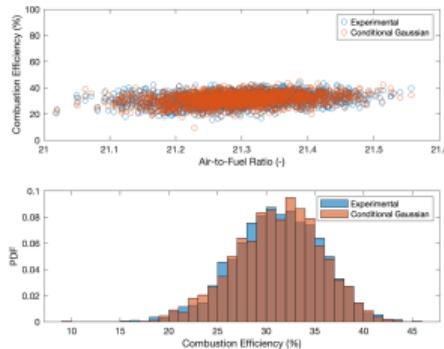
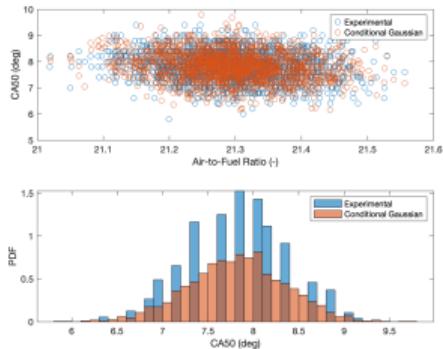


DI7.2 SOI42: Parametric models

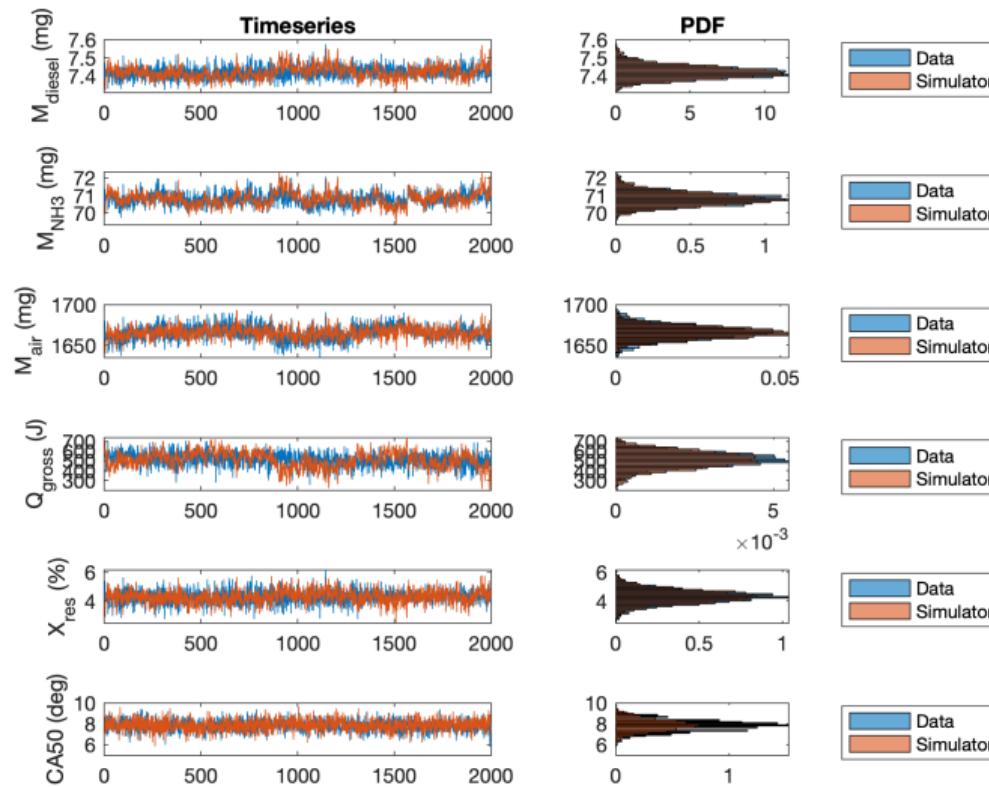
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

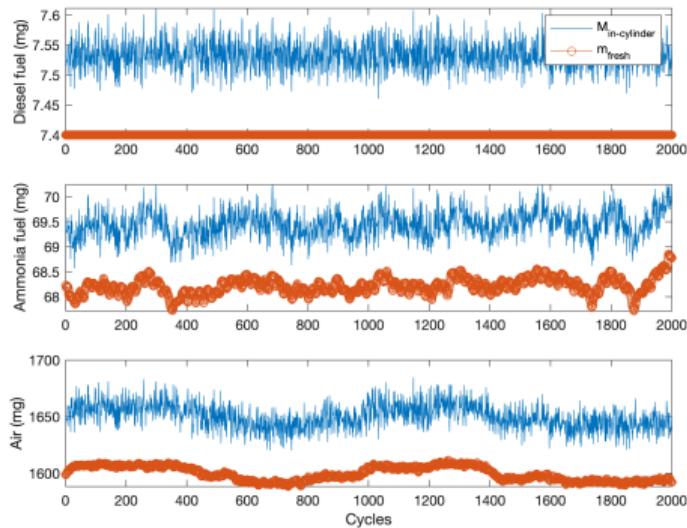
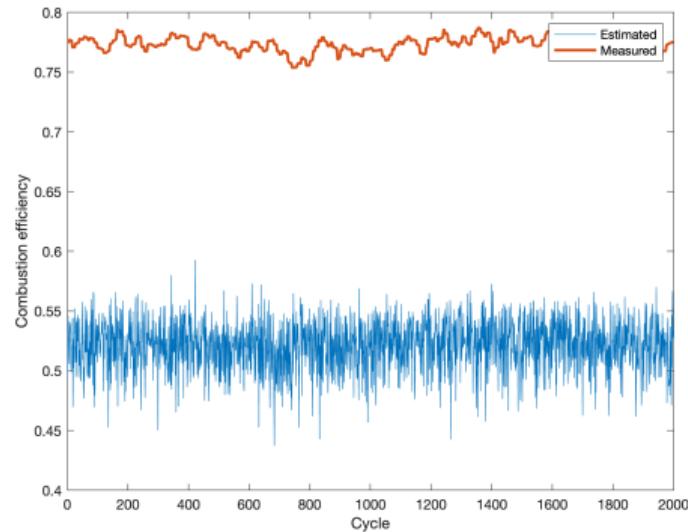
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.2 SOI42: Simulator Results



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

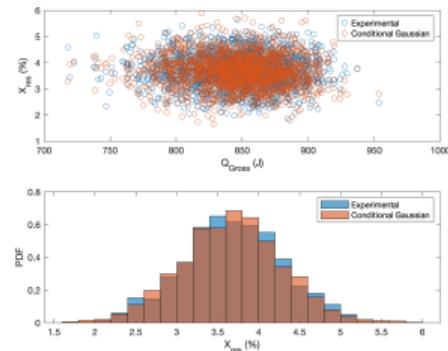
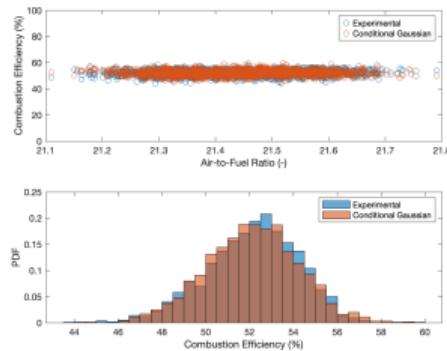
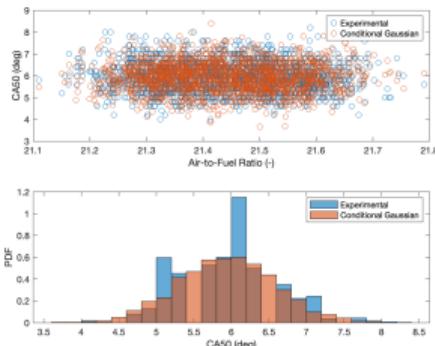


DI7.4 SOI41: Parametric models

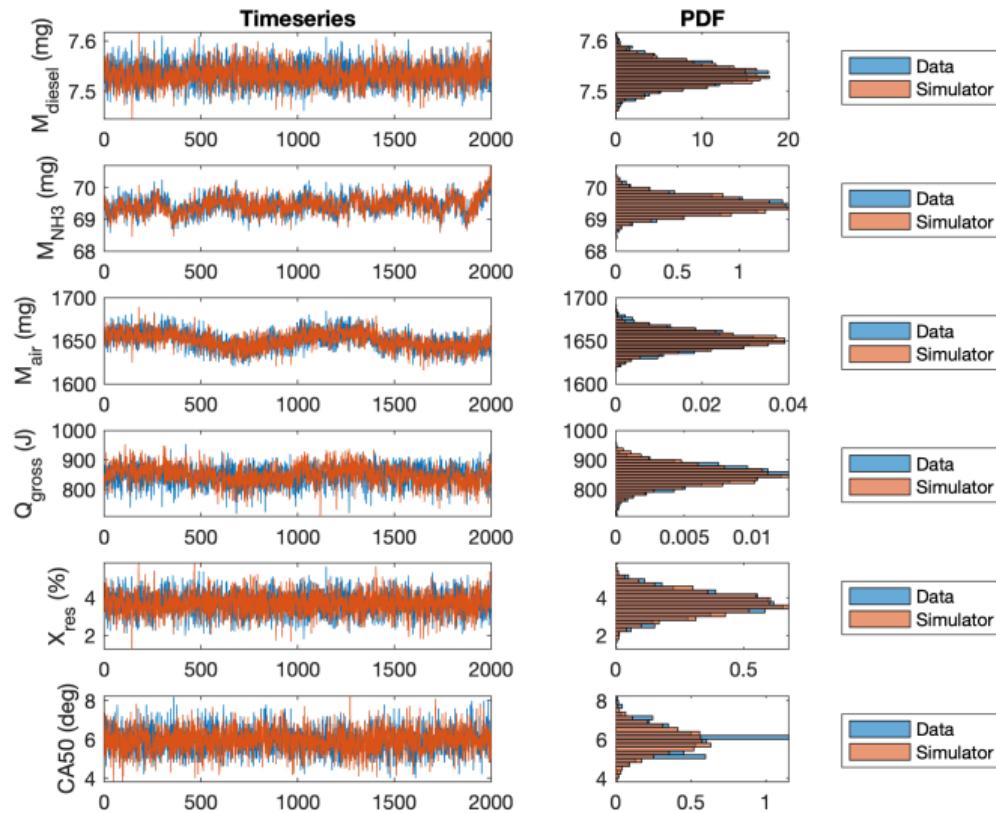
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

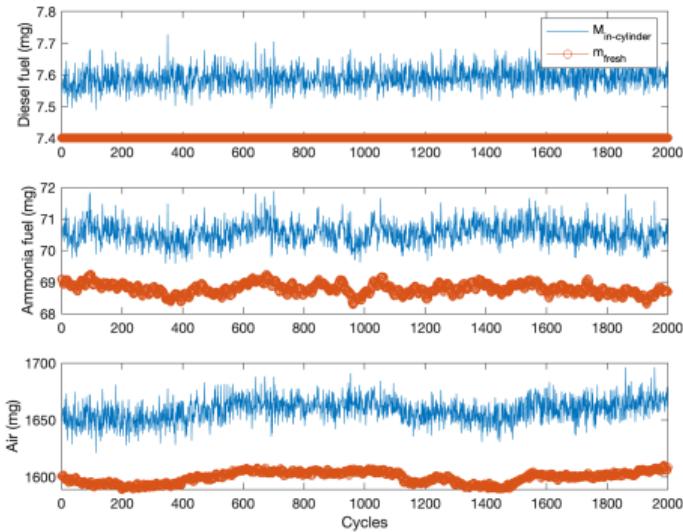
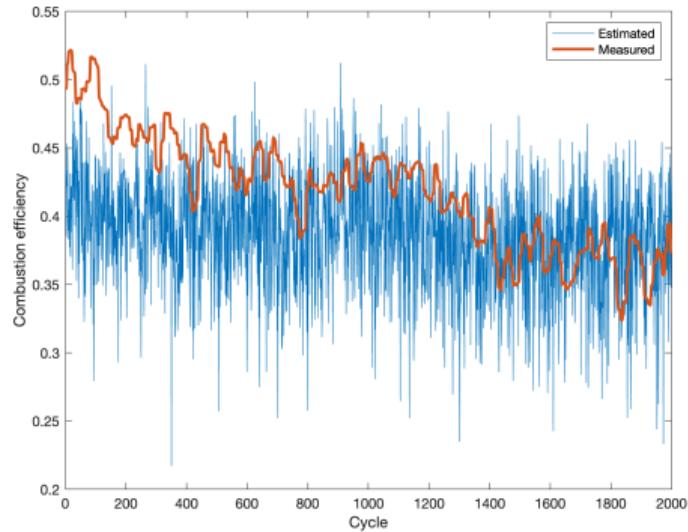
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.4 SOI41: Simulator Results



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

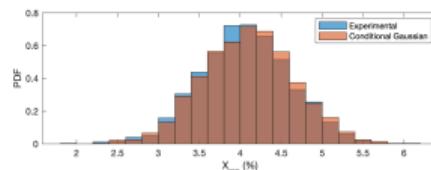
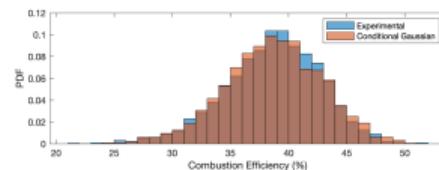
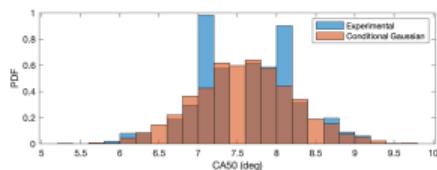
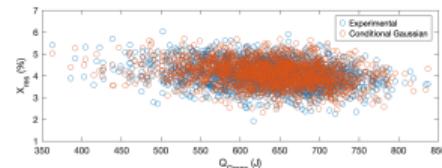
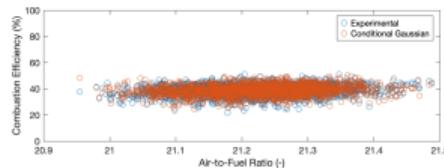
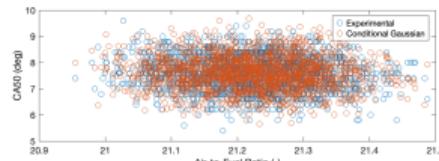


DI7.4 SOI42: Parametric models

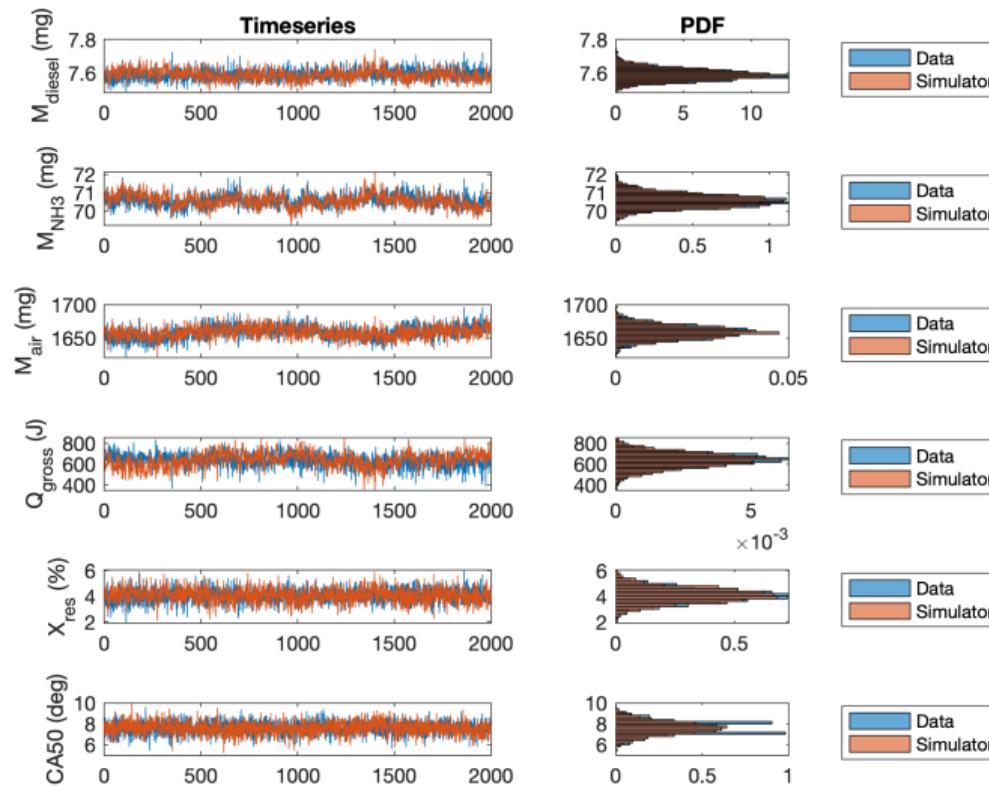
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

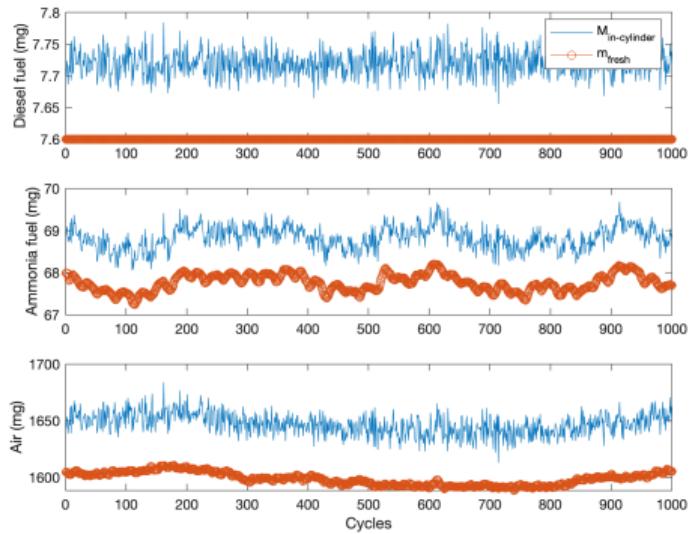
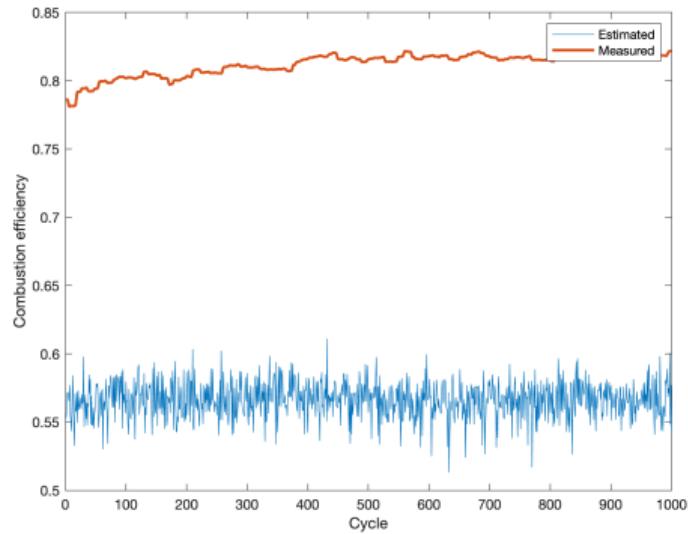
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.4 SOI42: Simulator Results



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

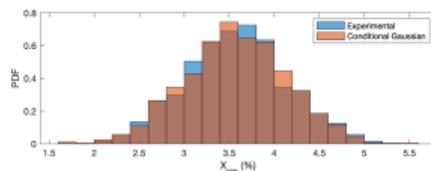
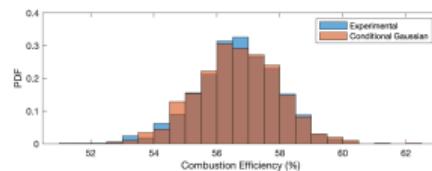
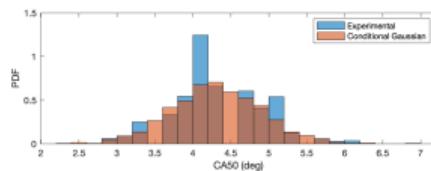
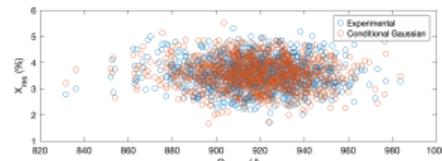
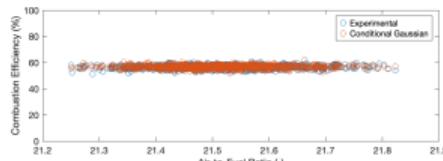
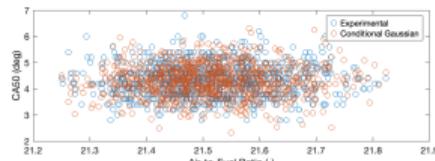


DI7.6 SOI40: Parametric models

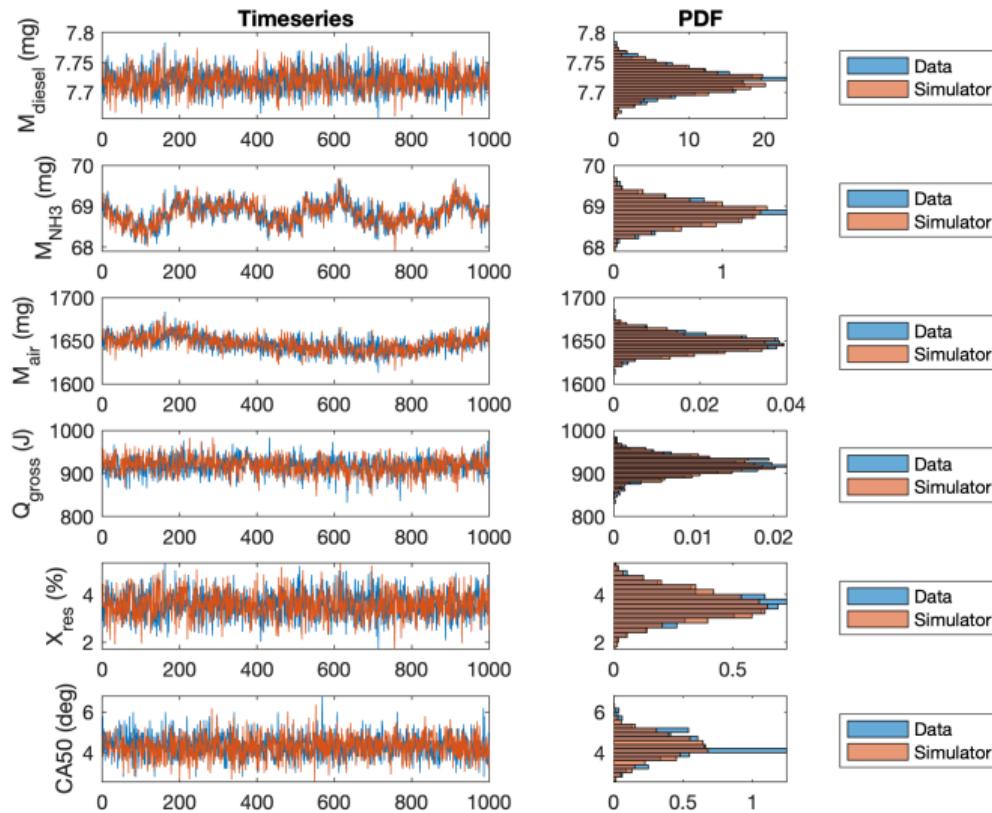
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

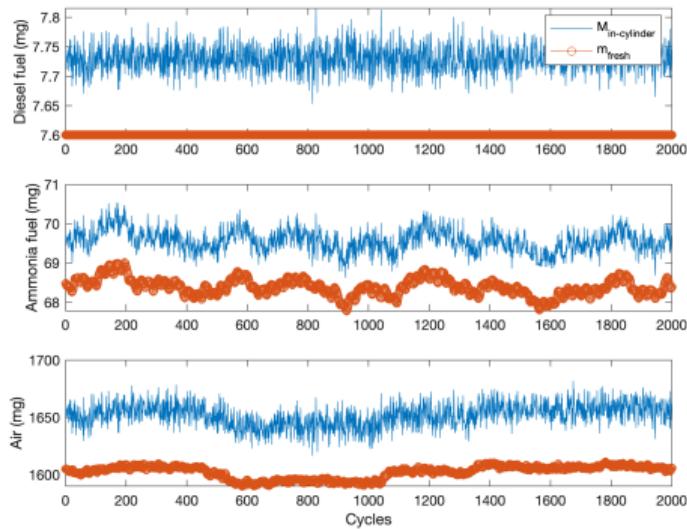
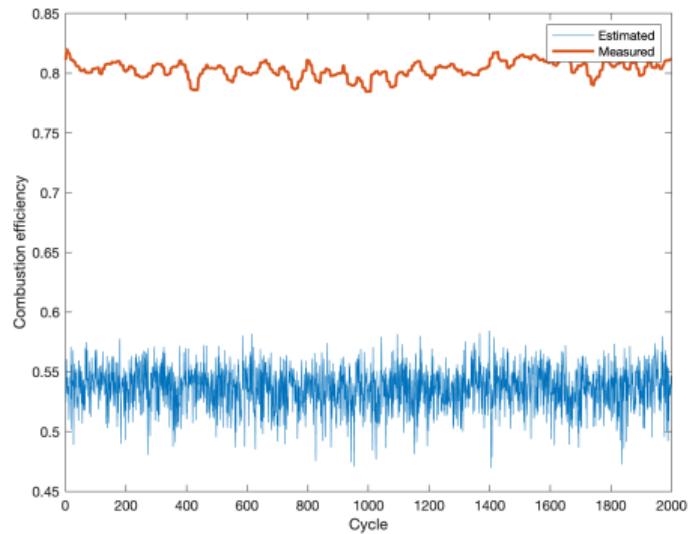
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.6 SOI40: Simulator Results



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

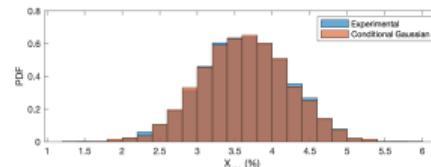
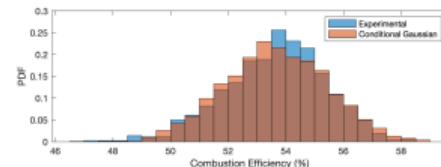
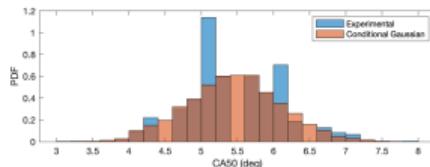
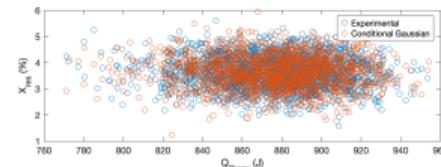
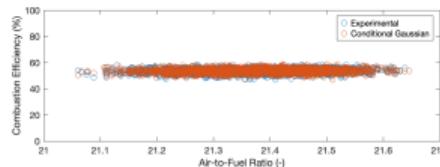
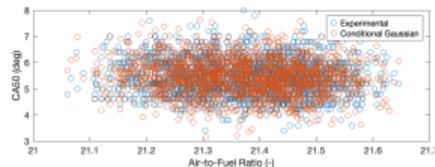


DI7.6 SOI41: Parametric models

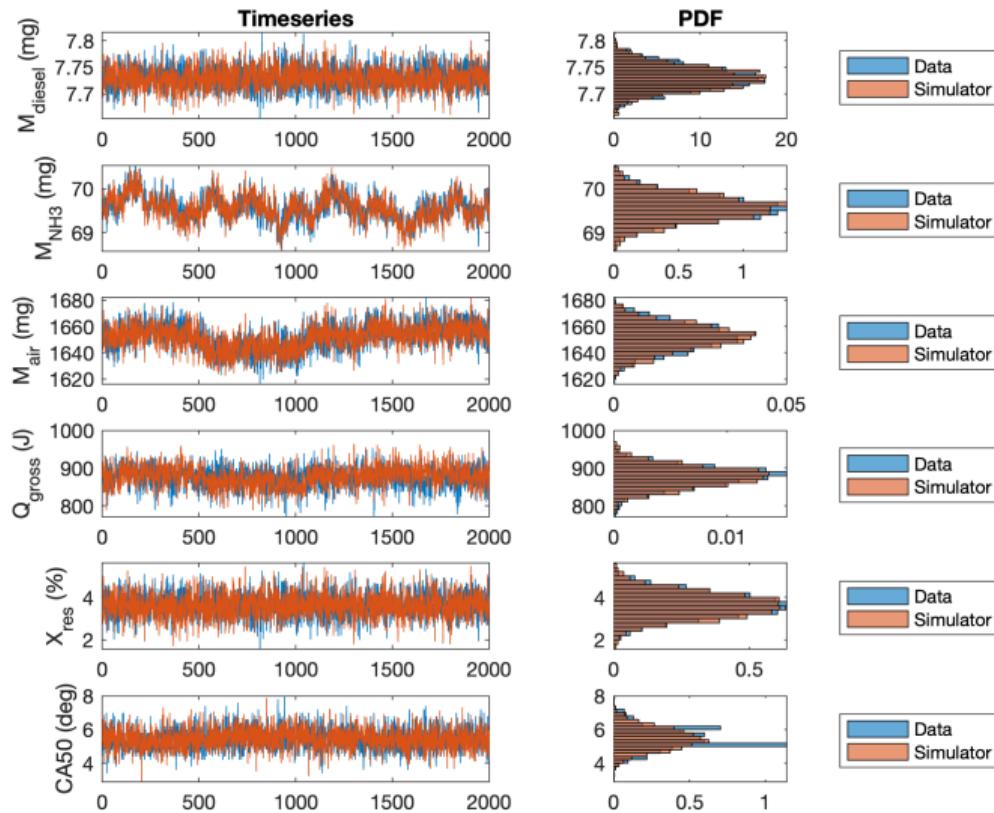
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

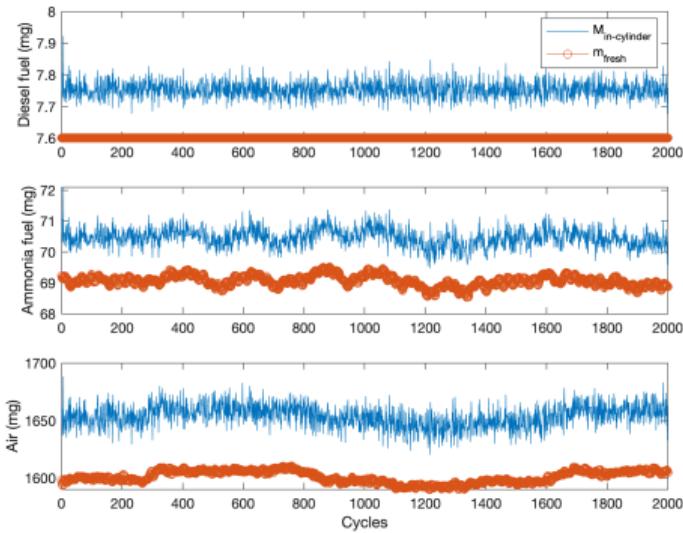
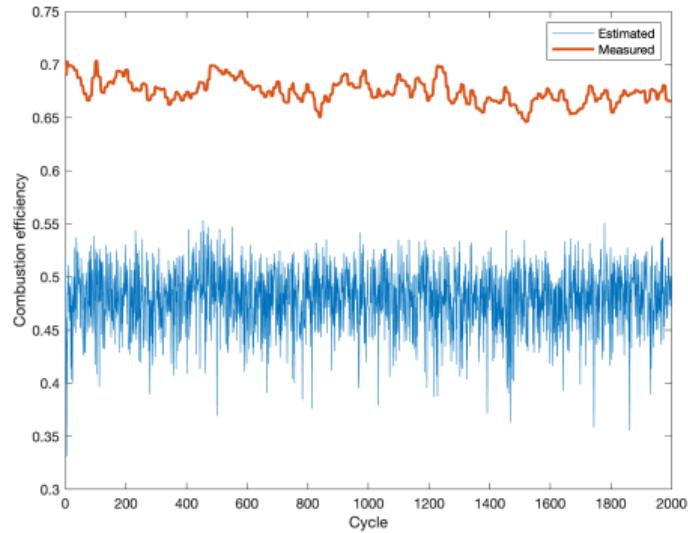
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.6 SOI41: Simulator Results



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

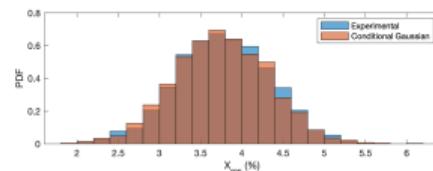
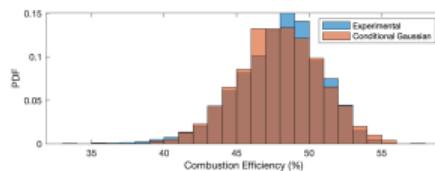
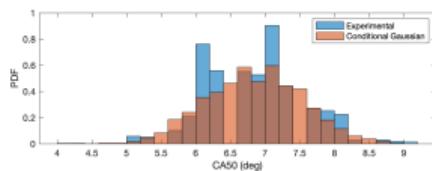
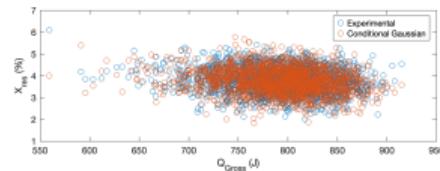
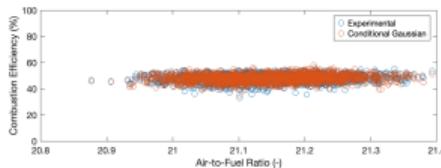
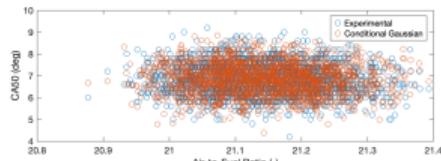


DI7.6 SOI42: Parametric models

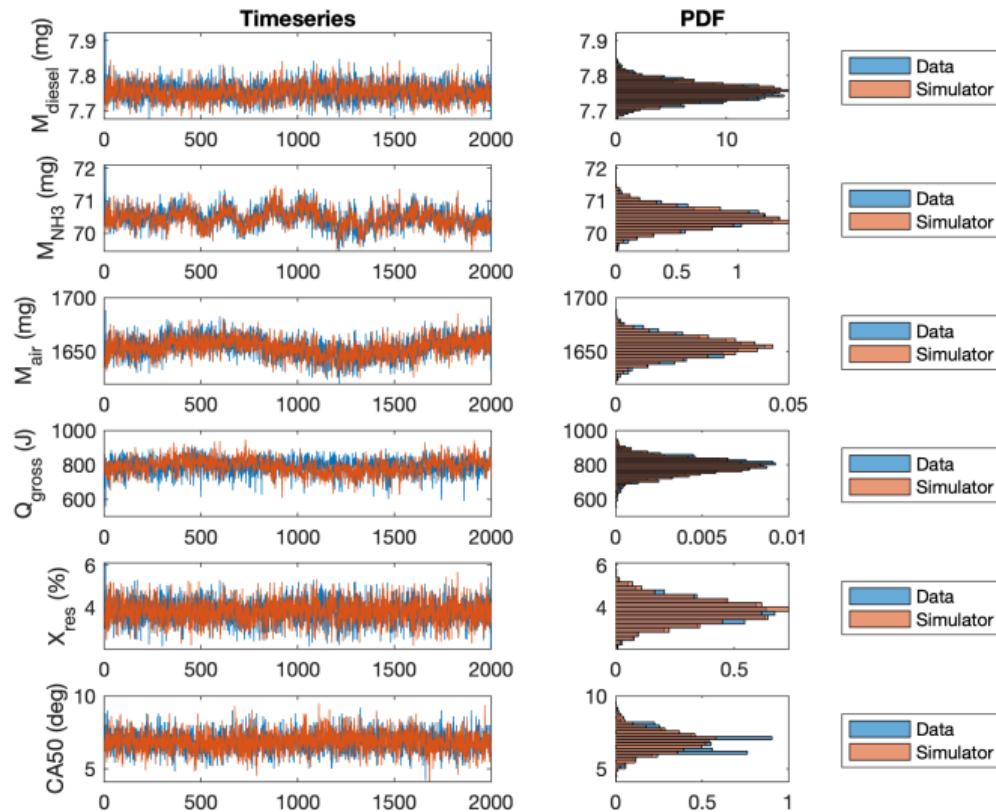
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

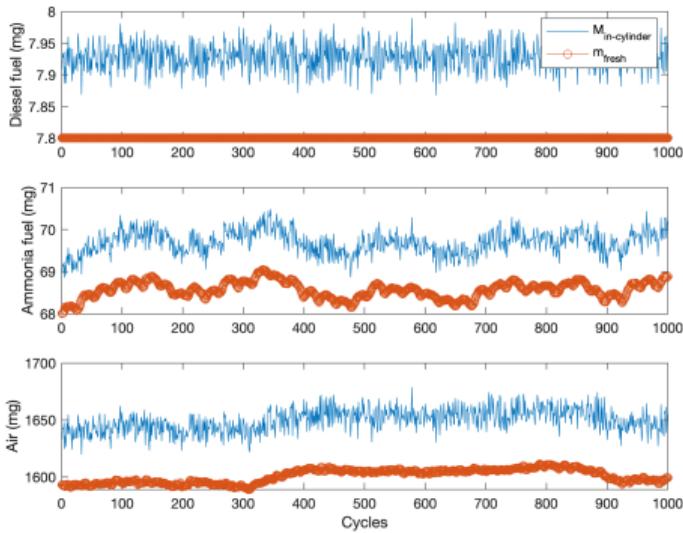
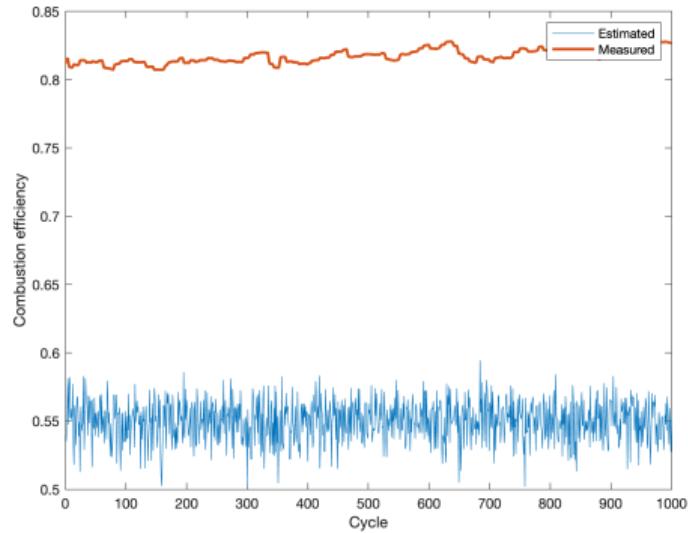
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.6 SOI42: Simulator Results



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

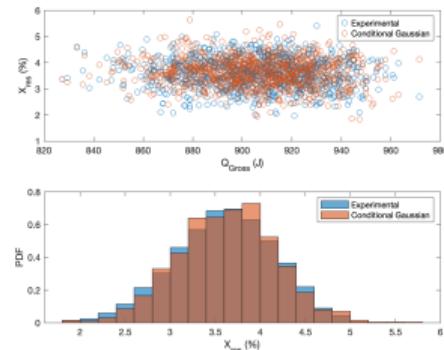
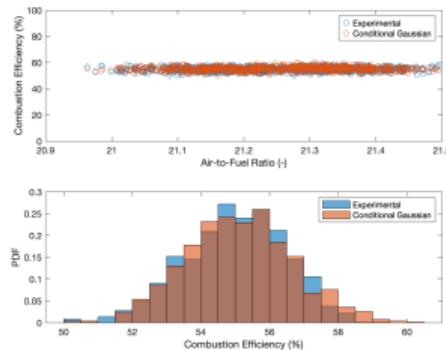
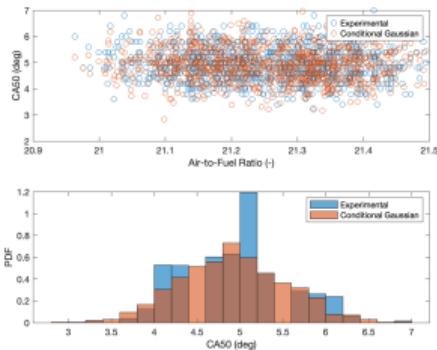


DI7.8 SOI41: Parametric models

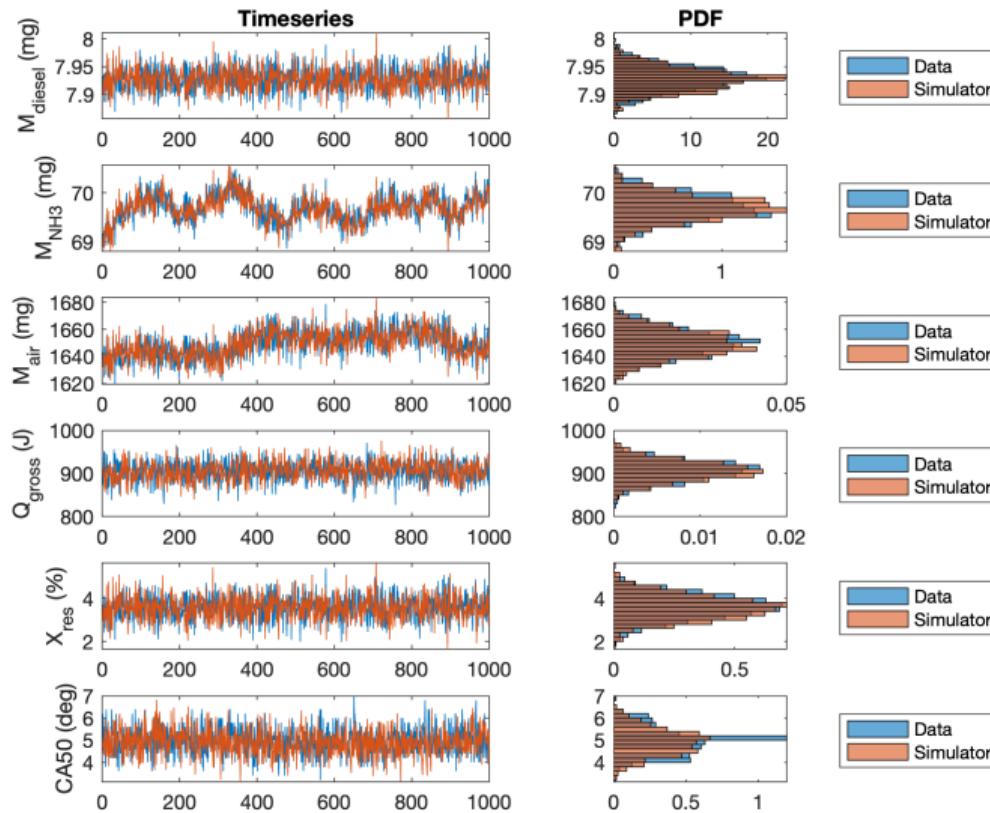
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

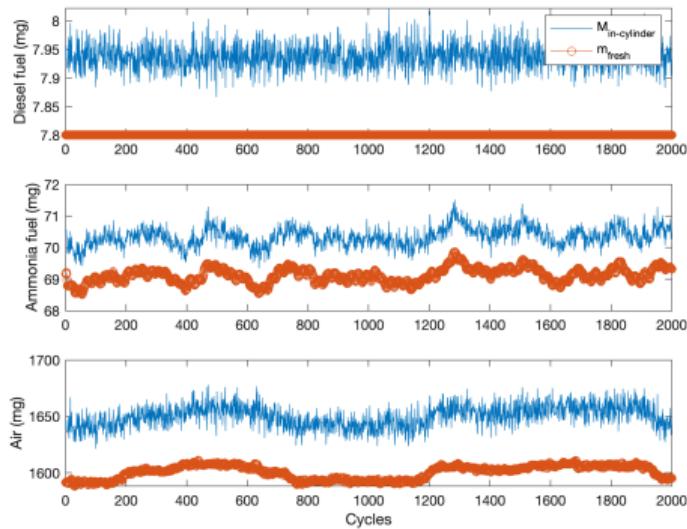
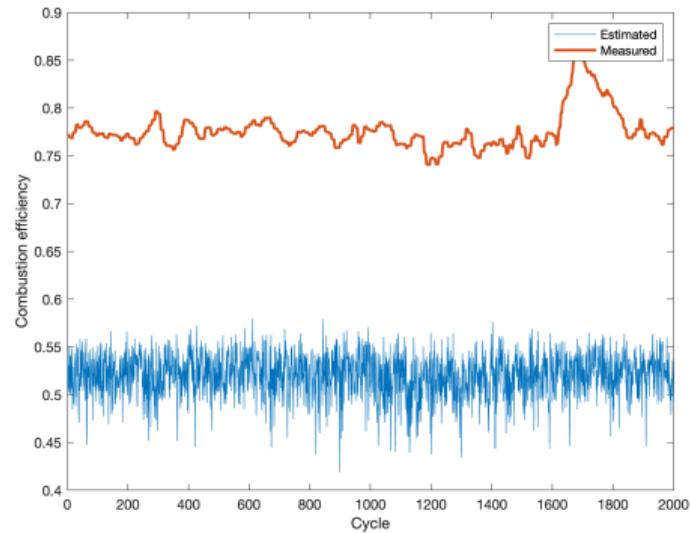
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.8 SOI41: Simulator Results



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

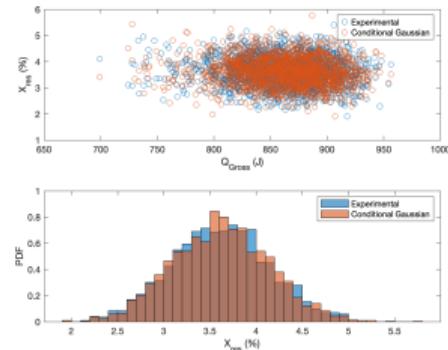
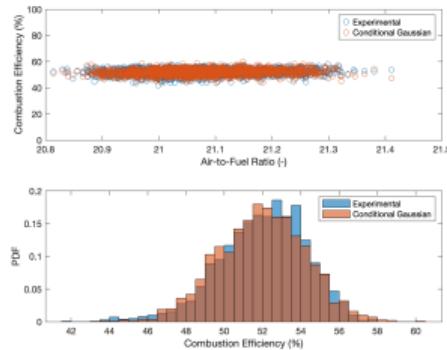
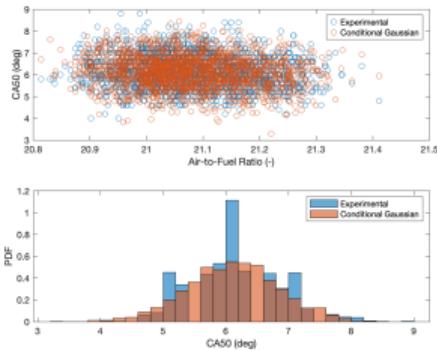


DI7.8 SOI42: Parametric models

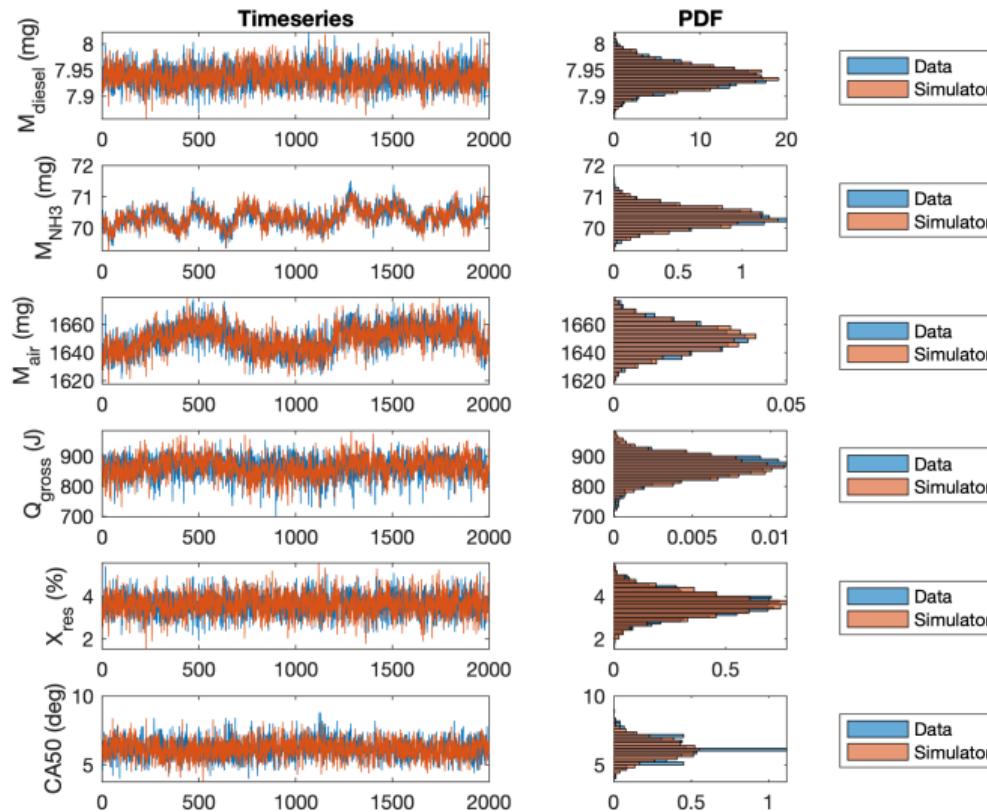
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

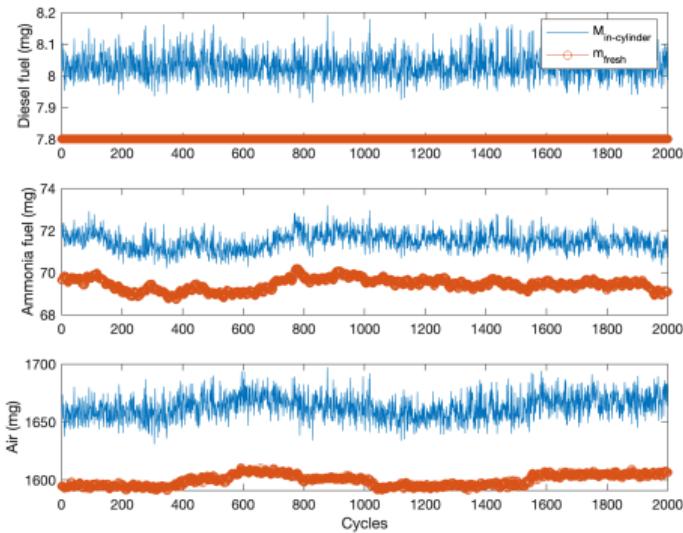
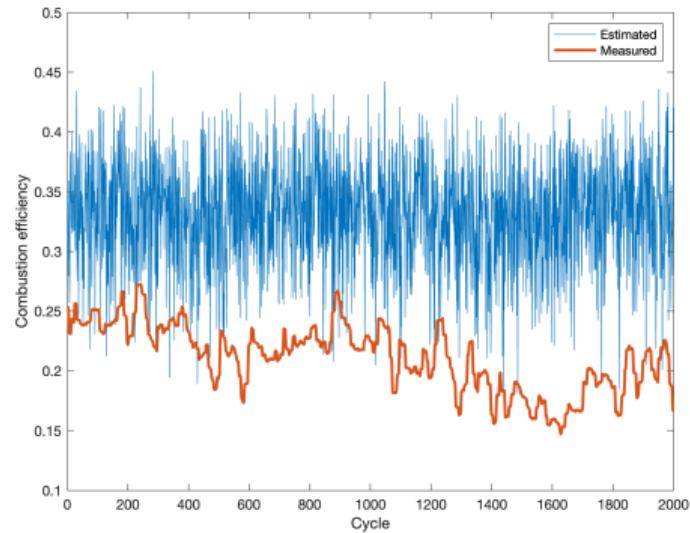
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.8 SOI42: Simulator Results



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

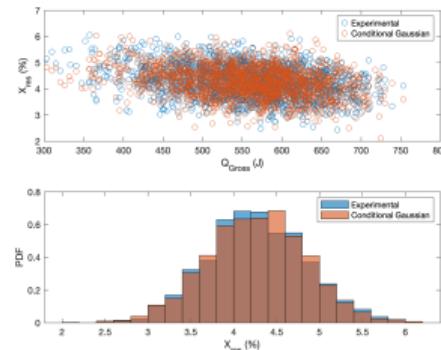
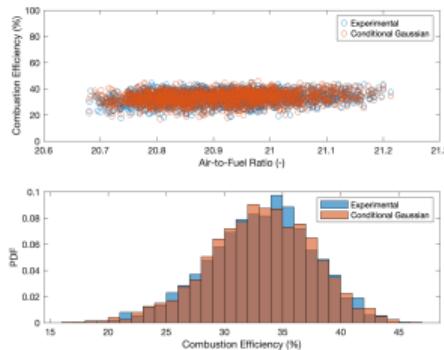
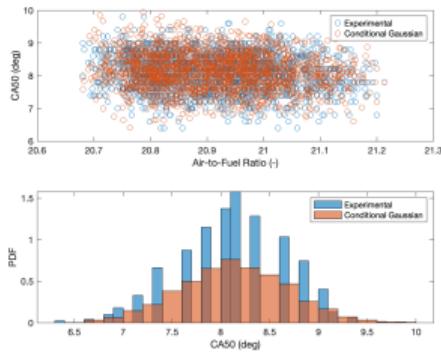


DI7.8 SOI43: Parametric models

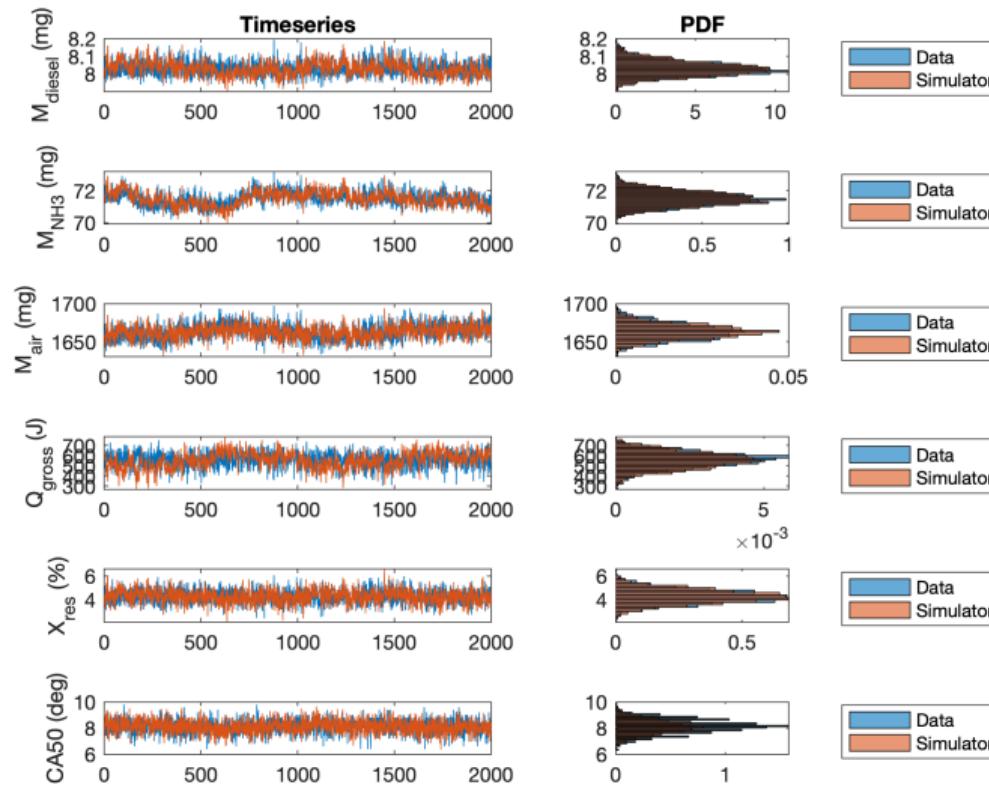
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

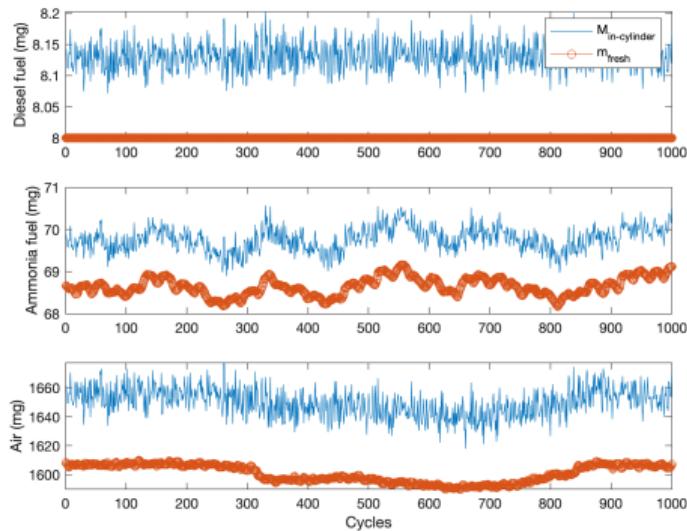
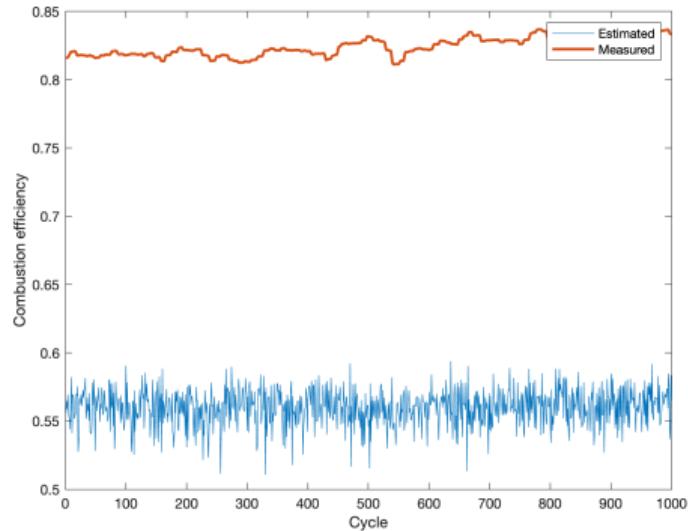
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI7.8 SOI43: Simulator Results



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

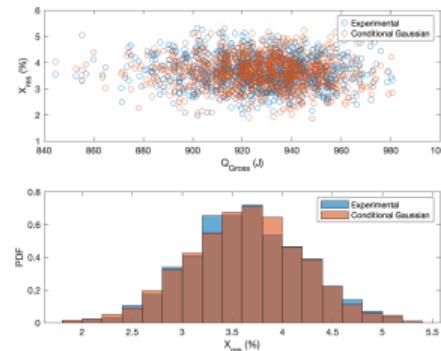
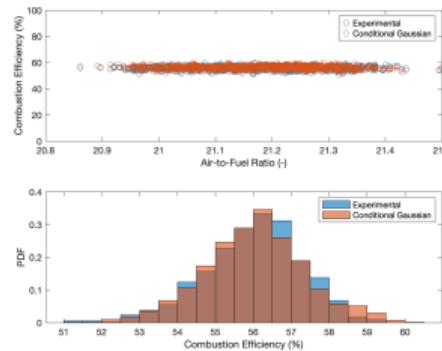
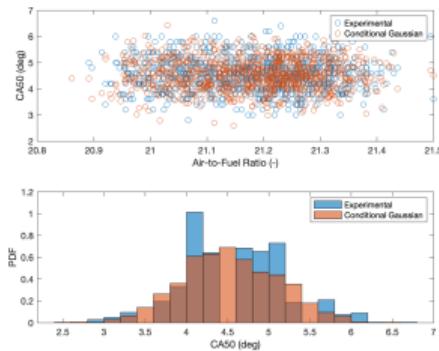


DI8.0 SOI41: Parametric models

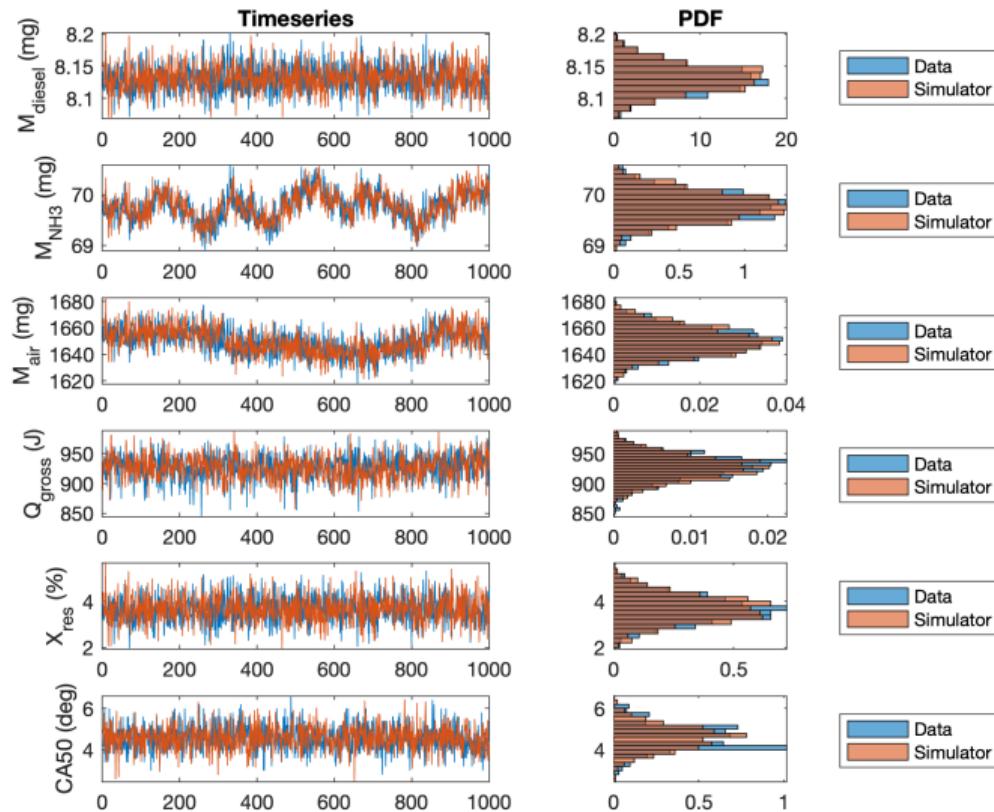
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

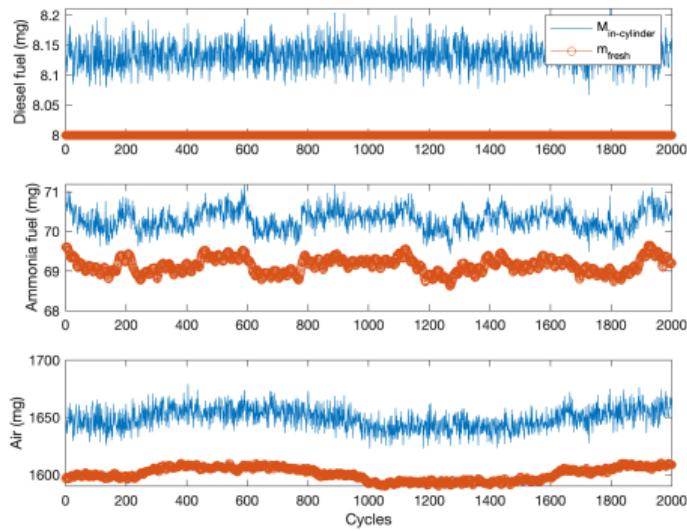
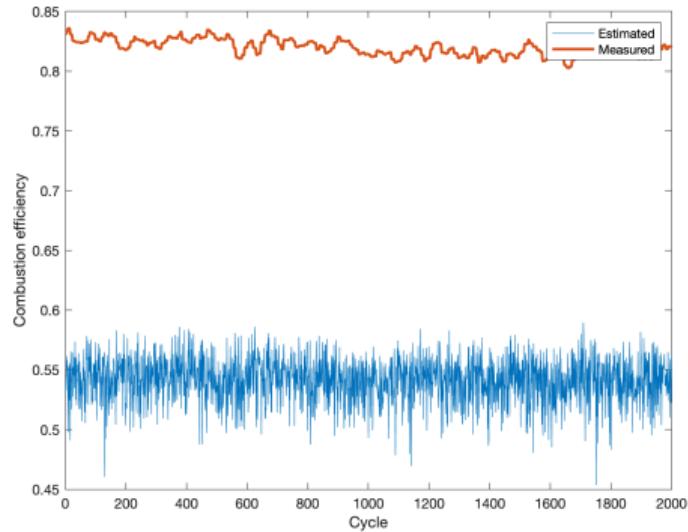
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.0 SOI41: Simulator Results



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

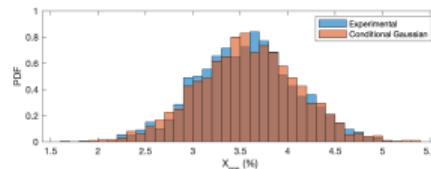
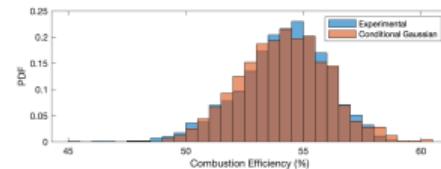
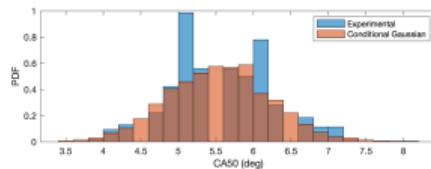
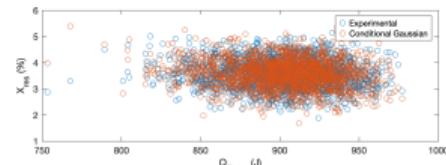
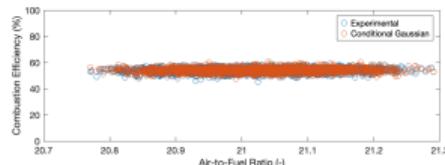
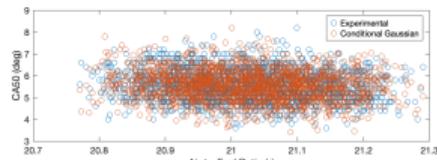


DI8.0 SOI42: Parametric models

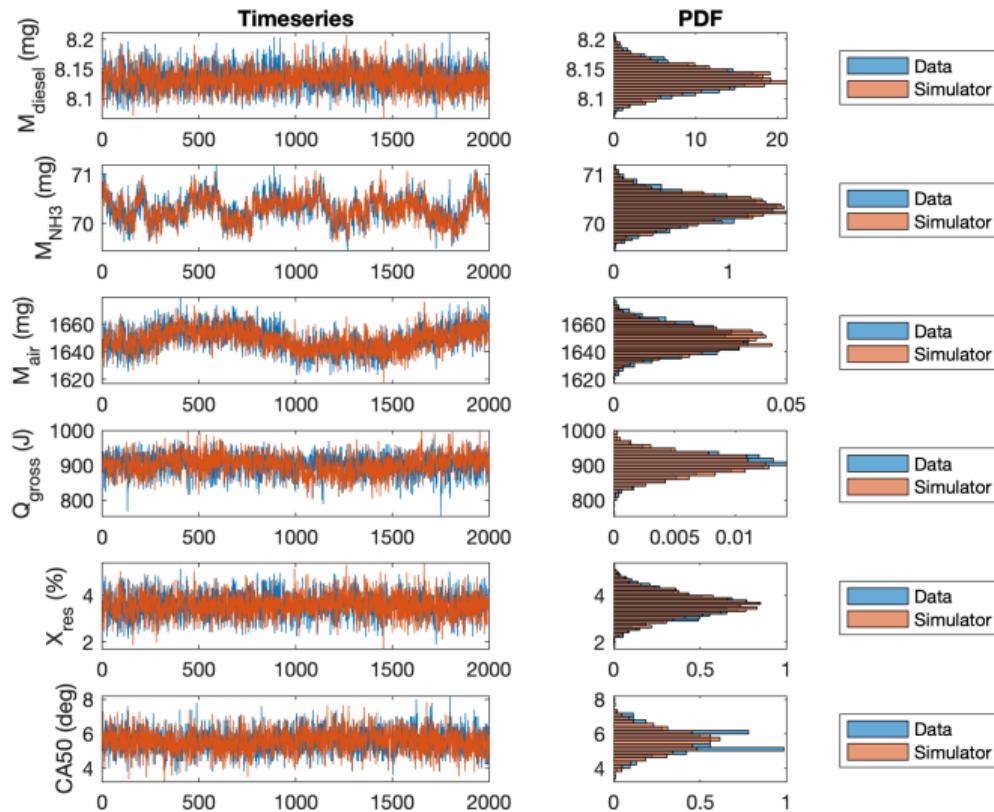
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

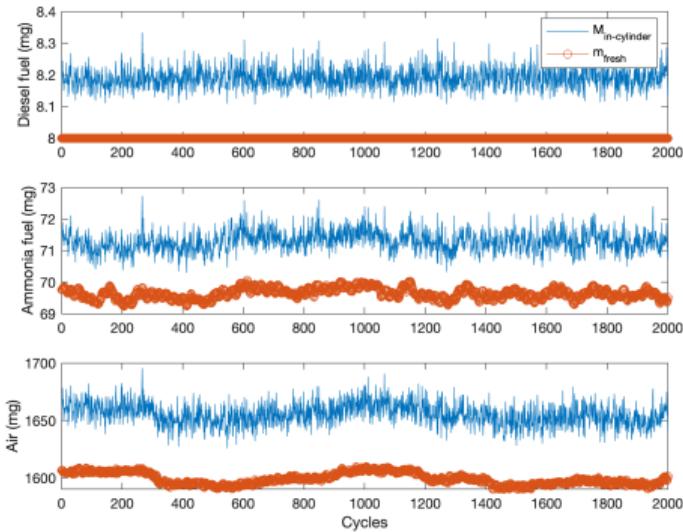
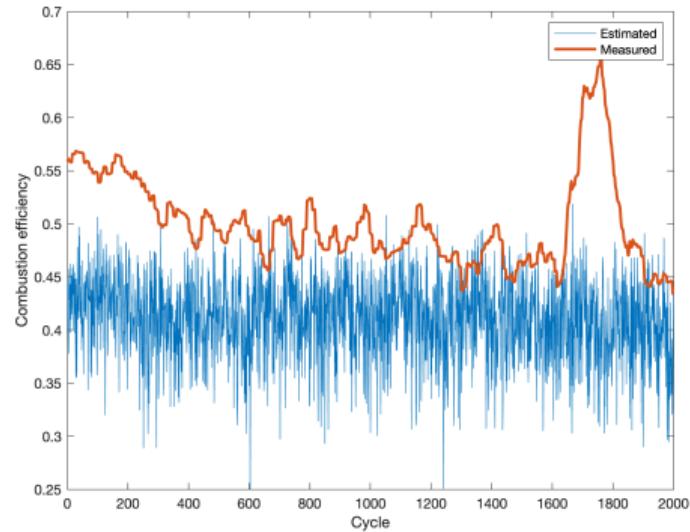
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.0 SOI42: Simulator Results



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

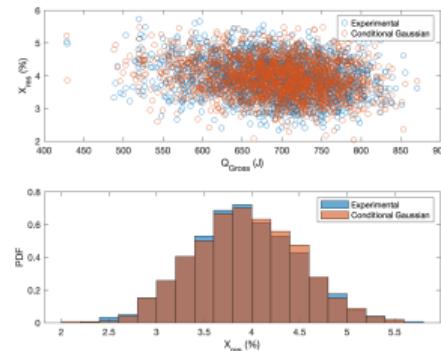
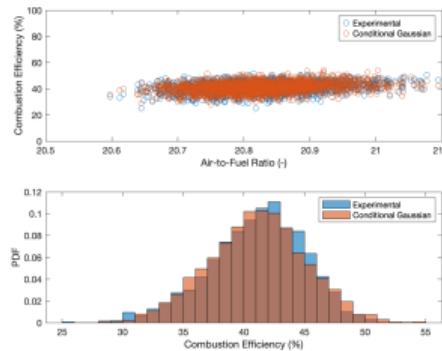
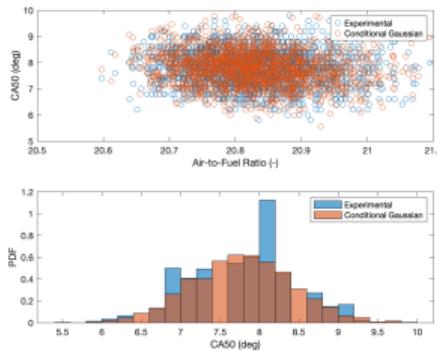


DI8.0 SOI43: Parametric models

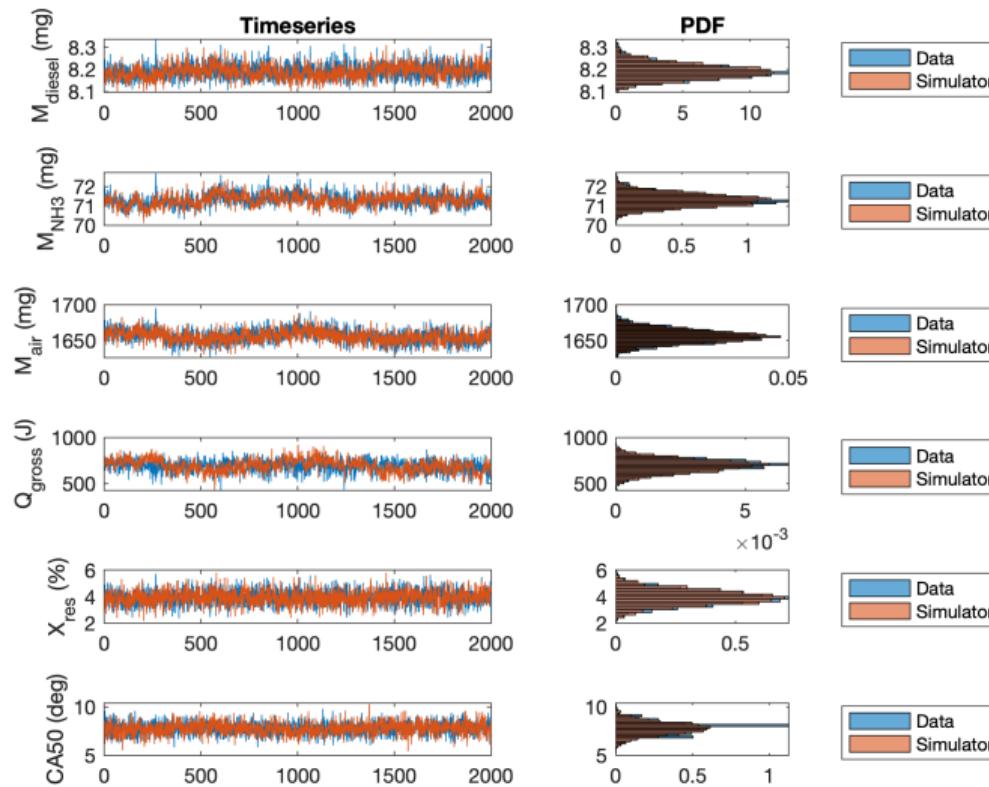
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

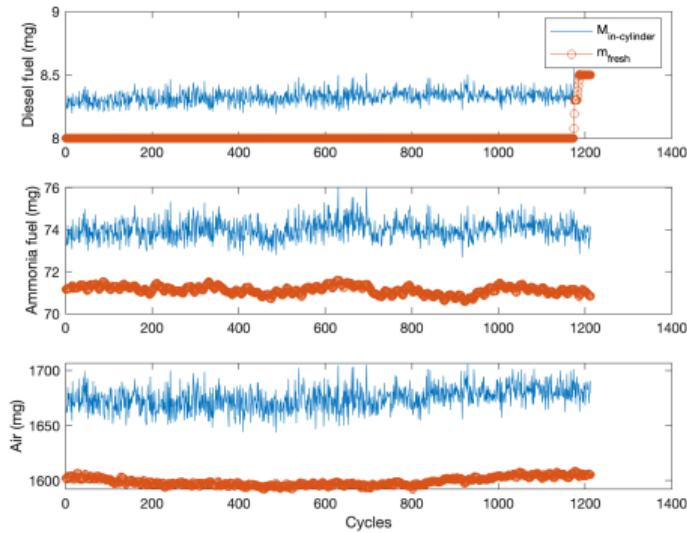
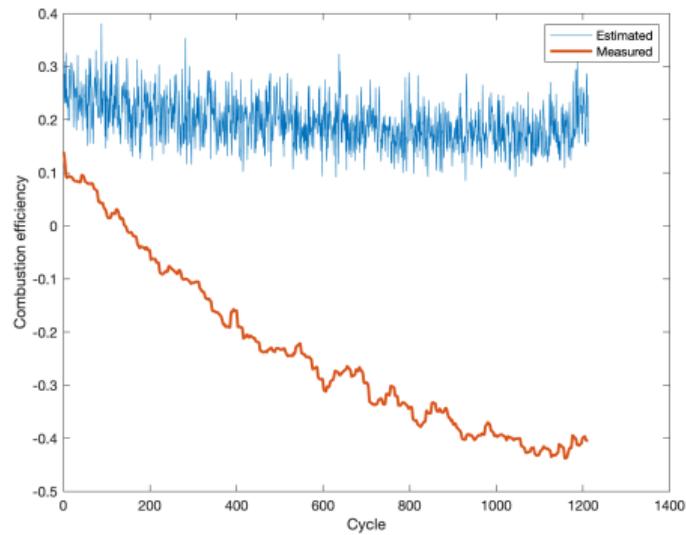
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.0 SOI43: Simulator Results



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

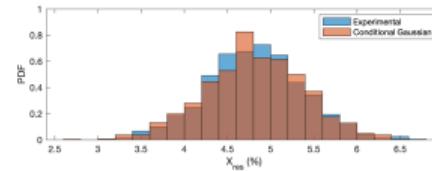
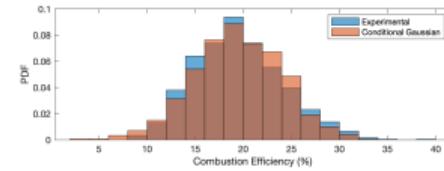
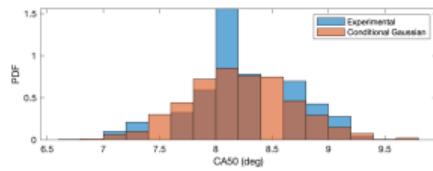
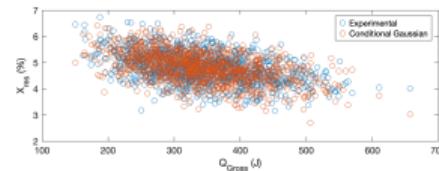
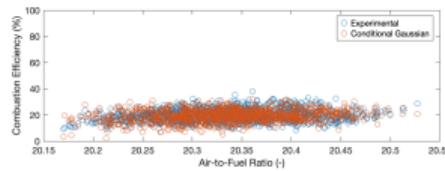
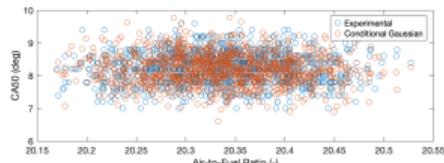


DI8.0 SOI44: Parametric models

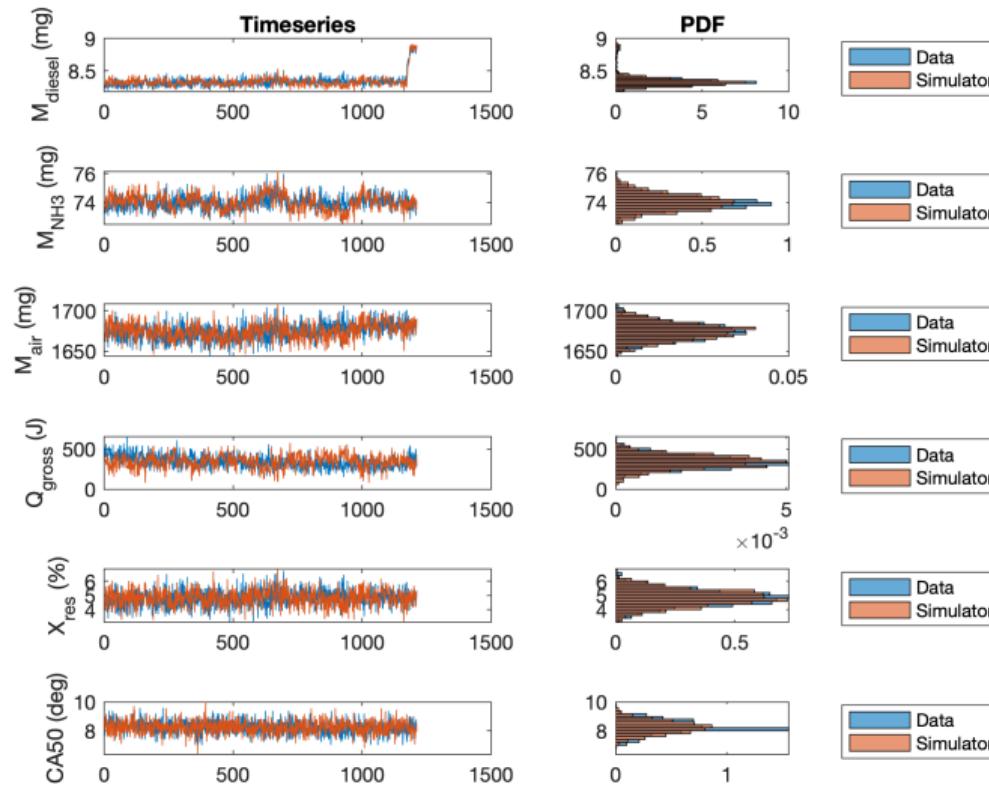
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

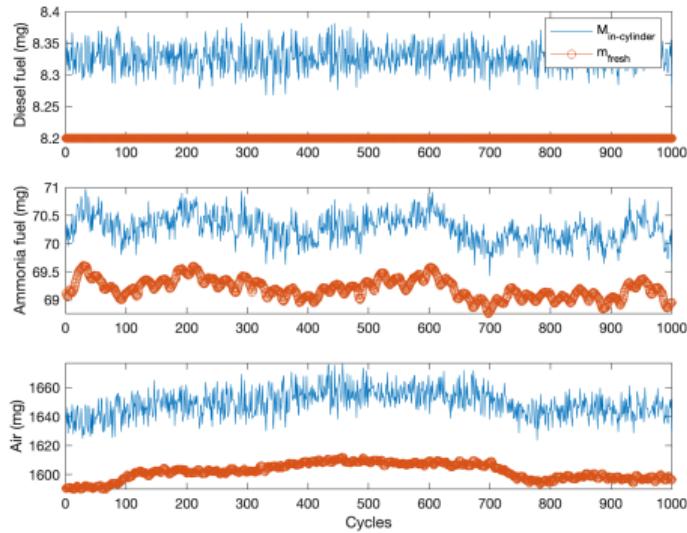
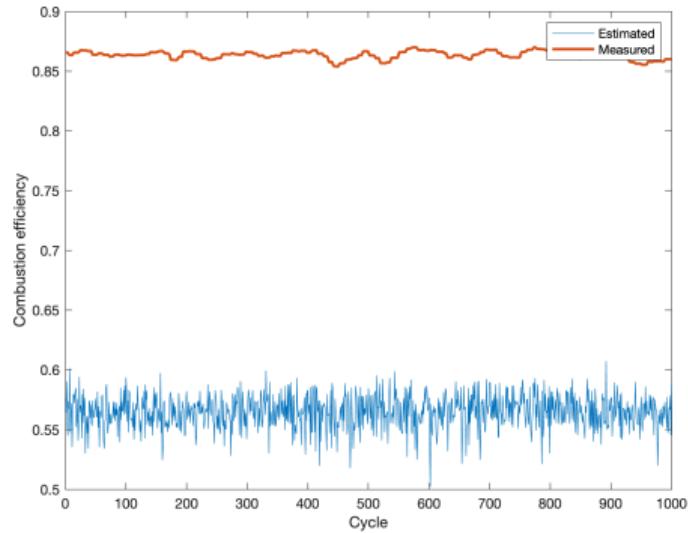
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.0 SOI44: Simulator Results



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

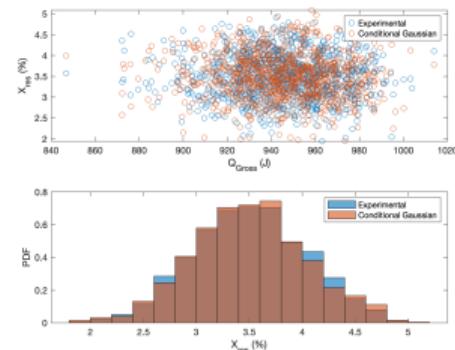
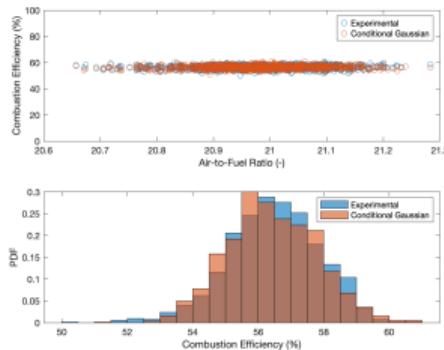
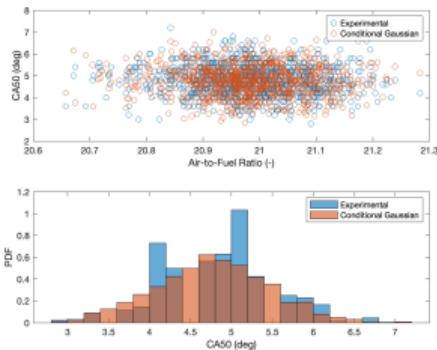


DI8.2 SOI42: Parametric models

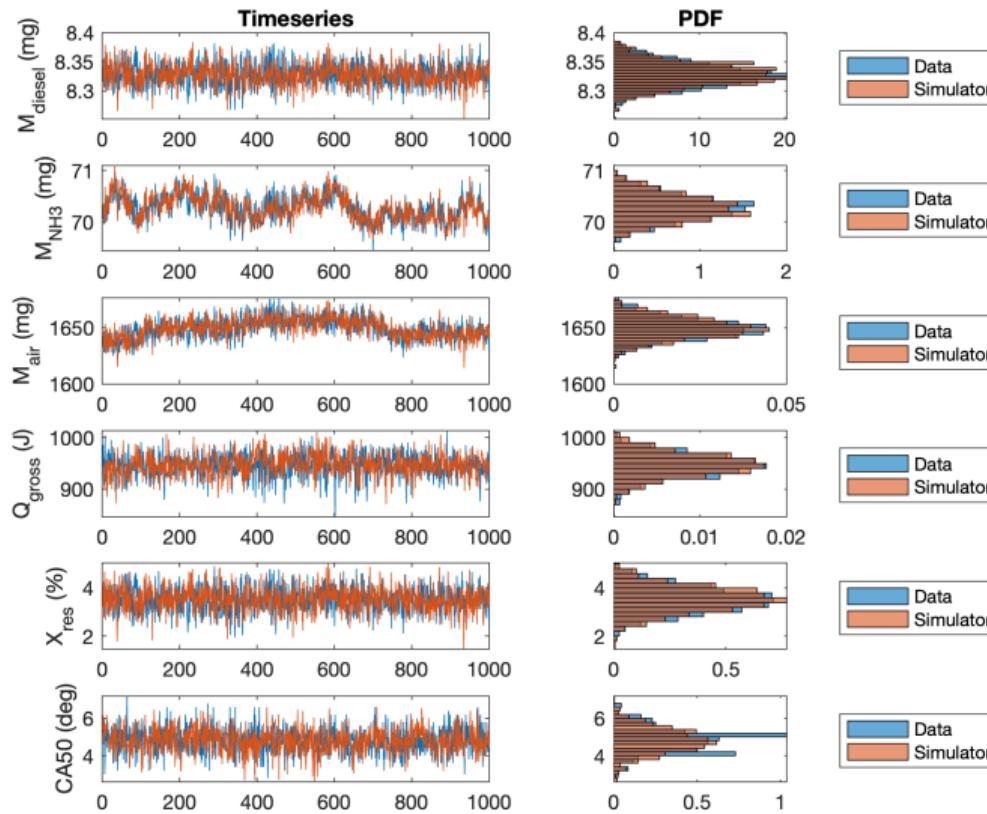
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

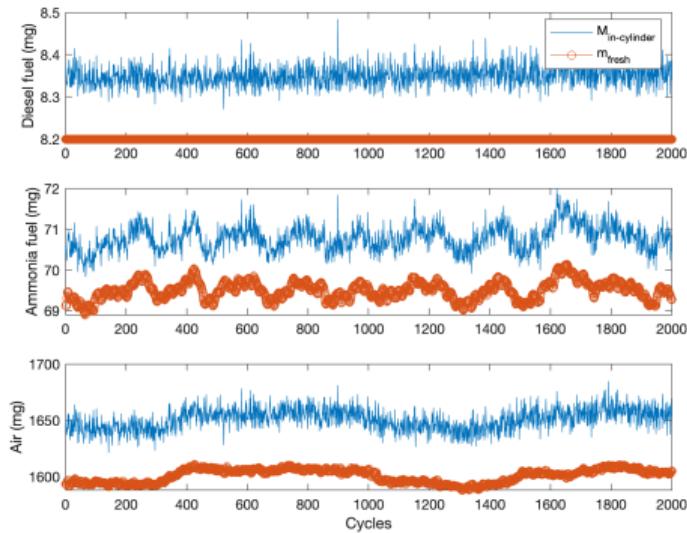
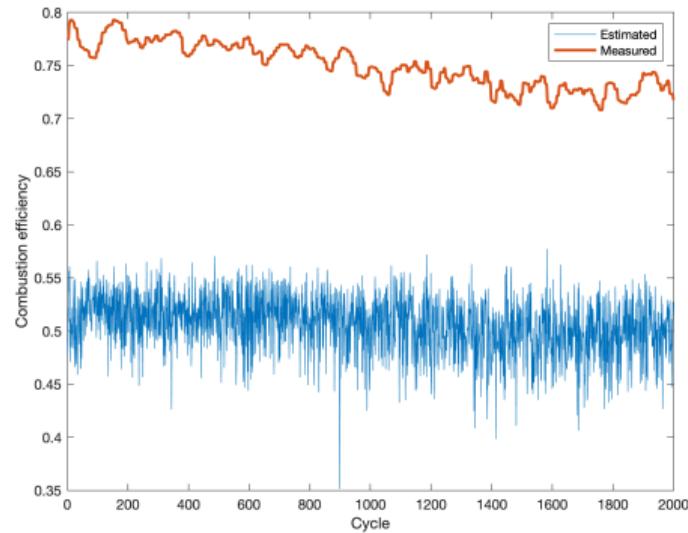
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.2 SOI42: Simulator Results



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

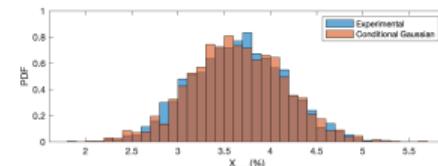
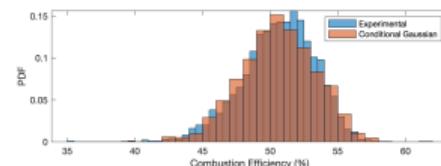
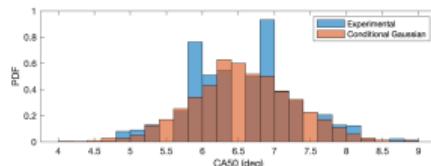
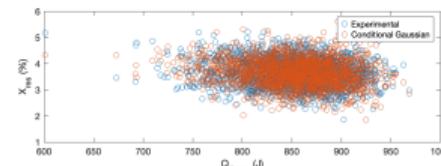
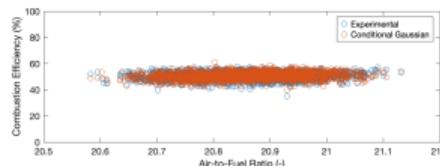
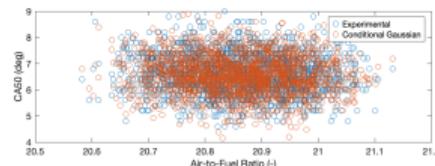


DI8.2 SOI43: Parametric models

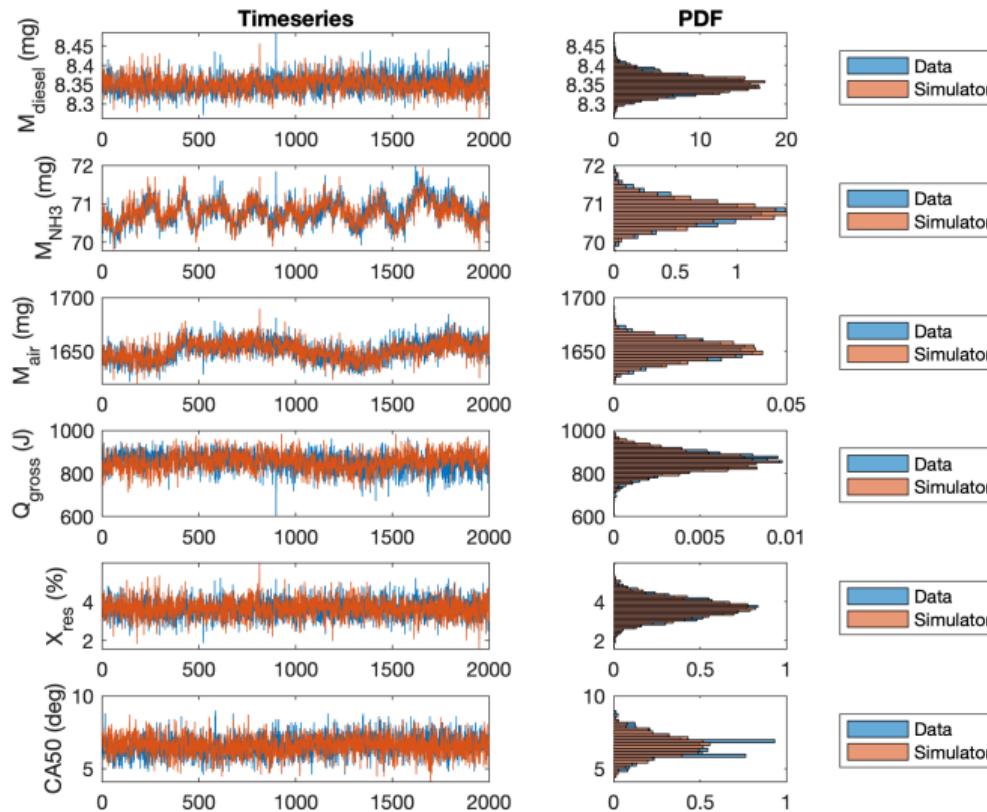
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

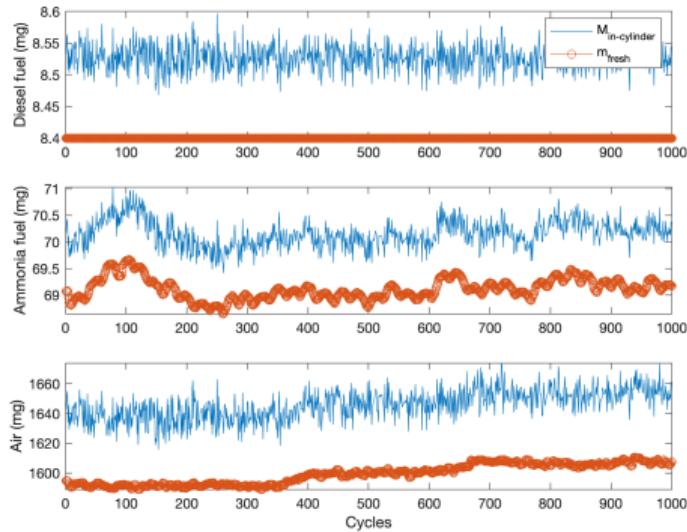
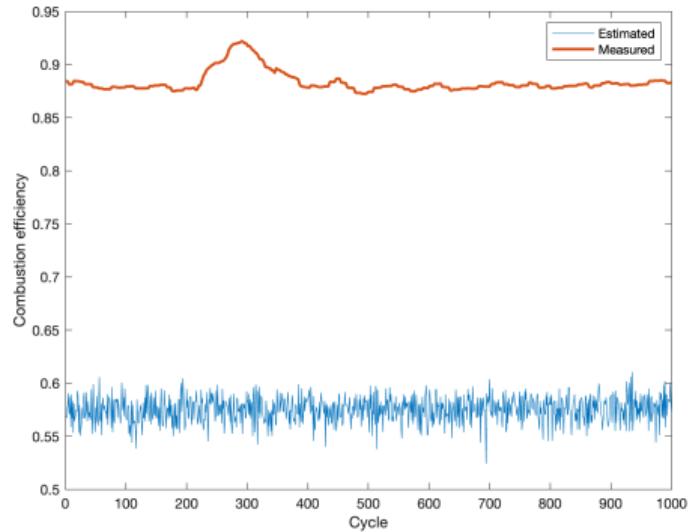
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.2 SOI43: Simulator Results



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

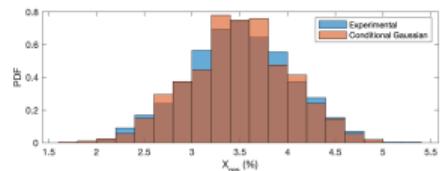
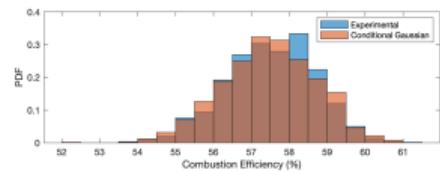
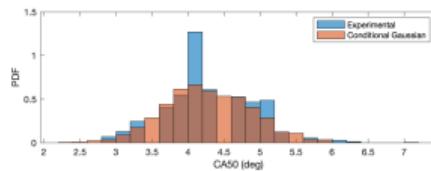
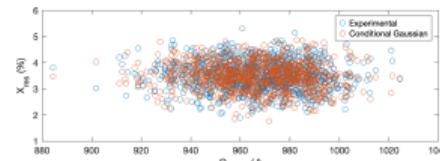
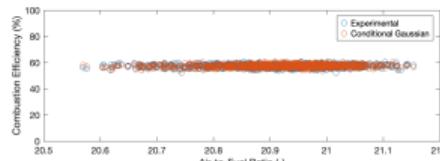
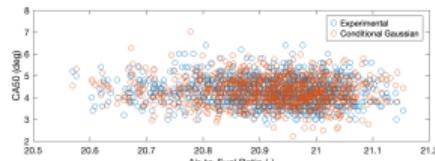


DI8.4 SOI42: Parametric models

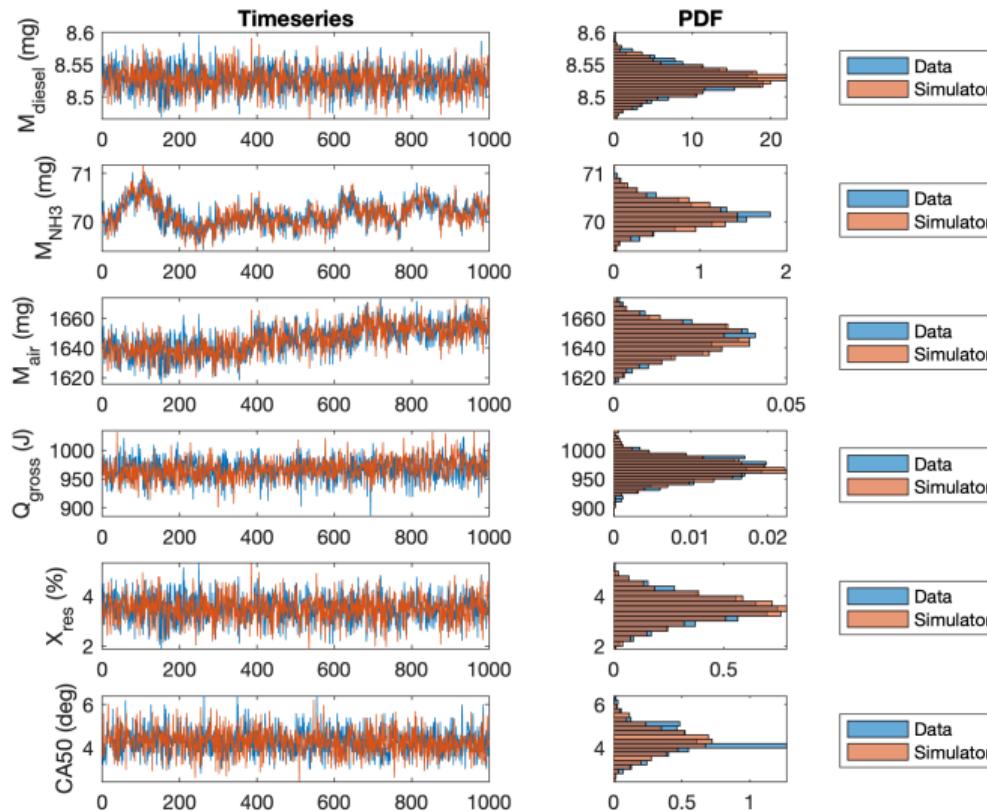
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

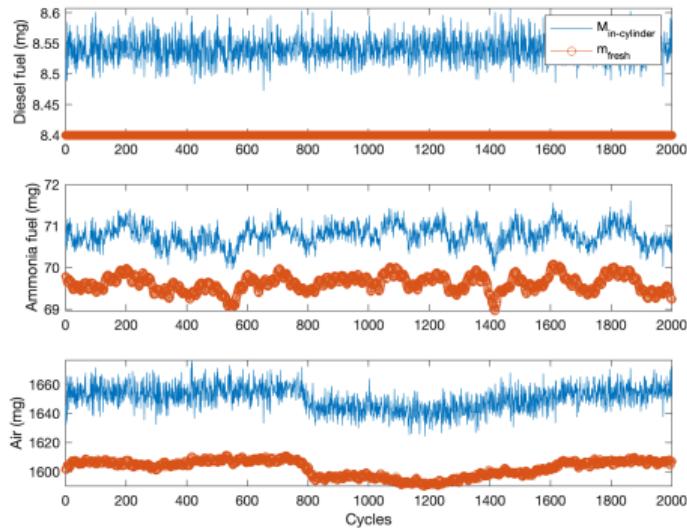
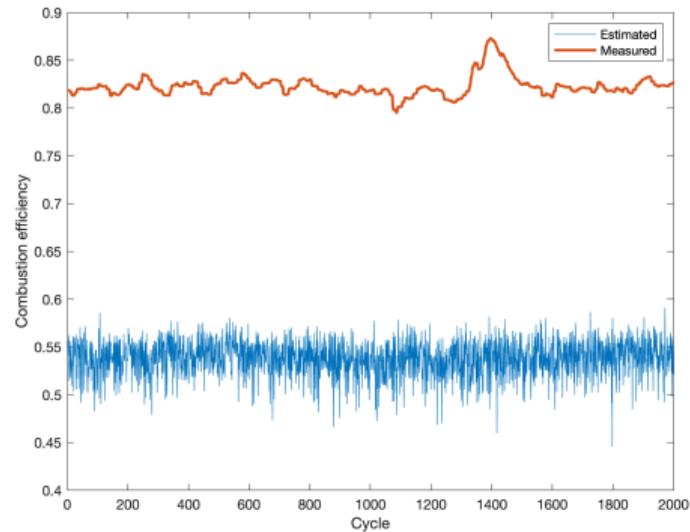
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.4 SOI42: Simulator Results



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

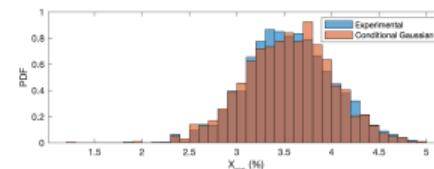
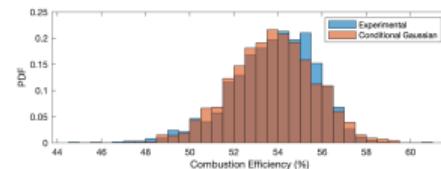
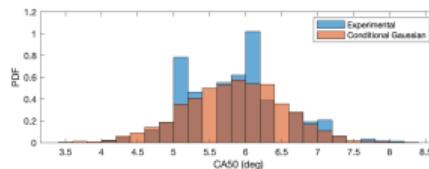
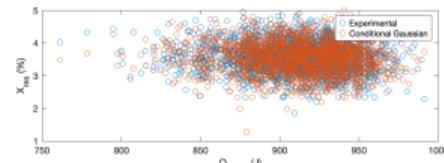
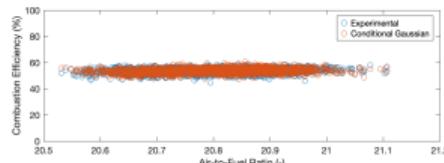
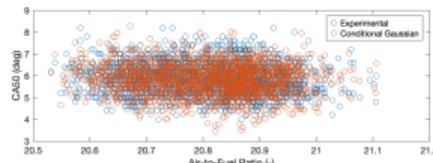


DI8.4 SOI43: Parametric models

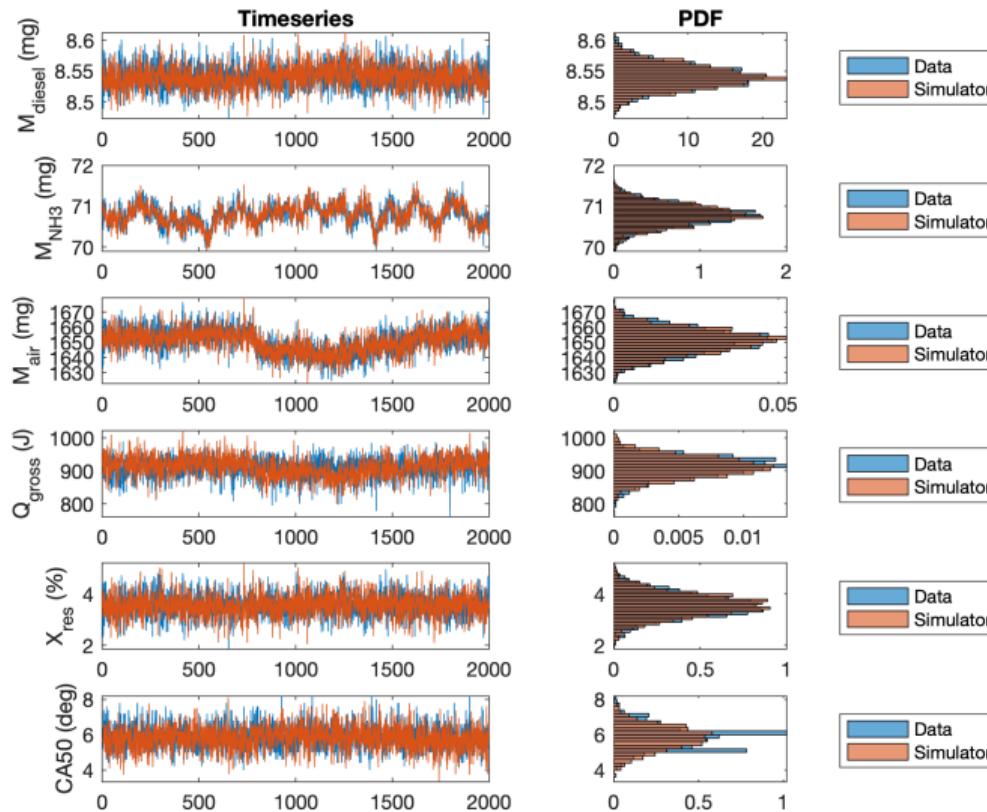
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

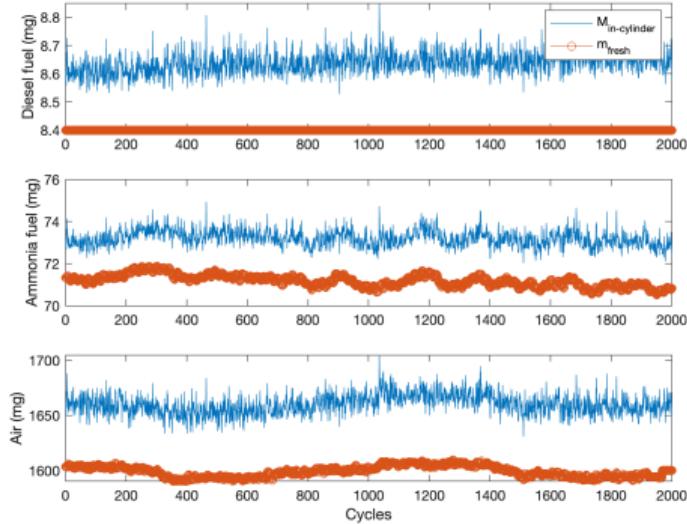
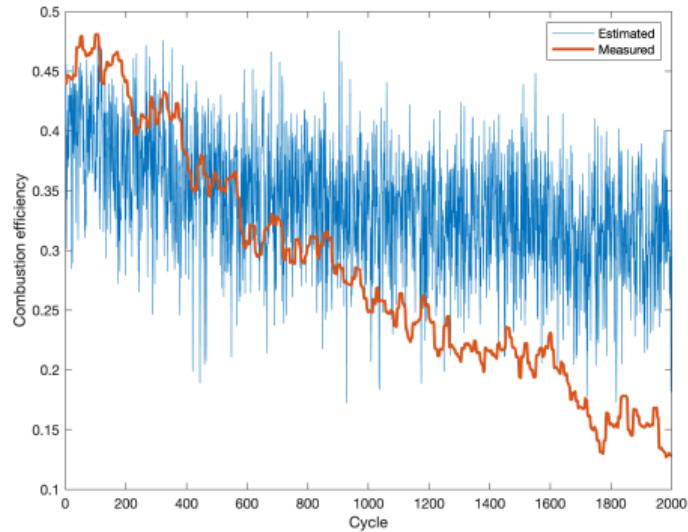
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.4 SOI43: Simulator Results



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

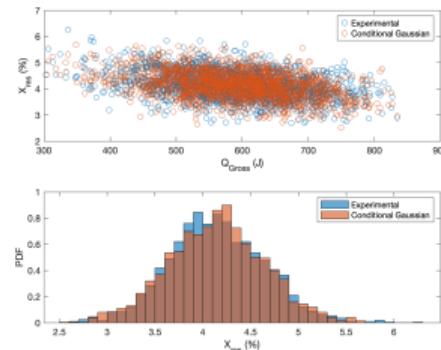
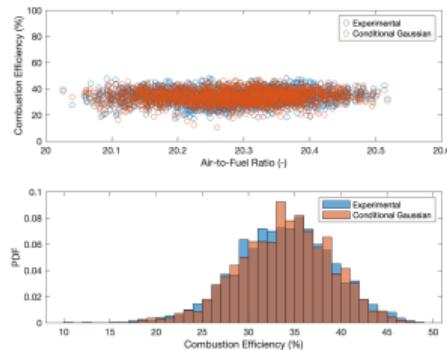
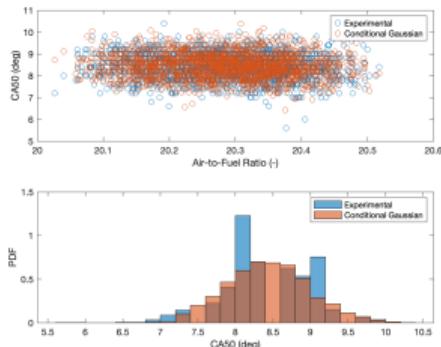


DI8.4 SOI44: Parametric models

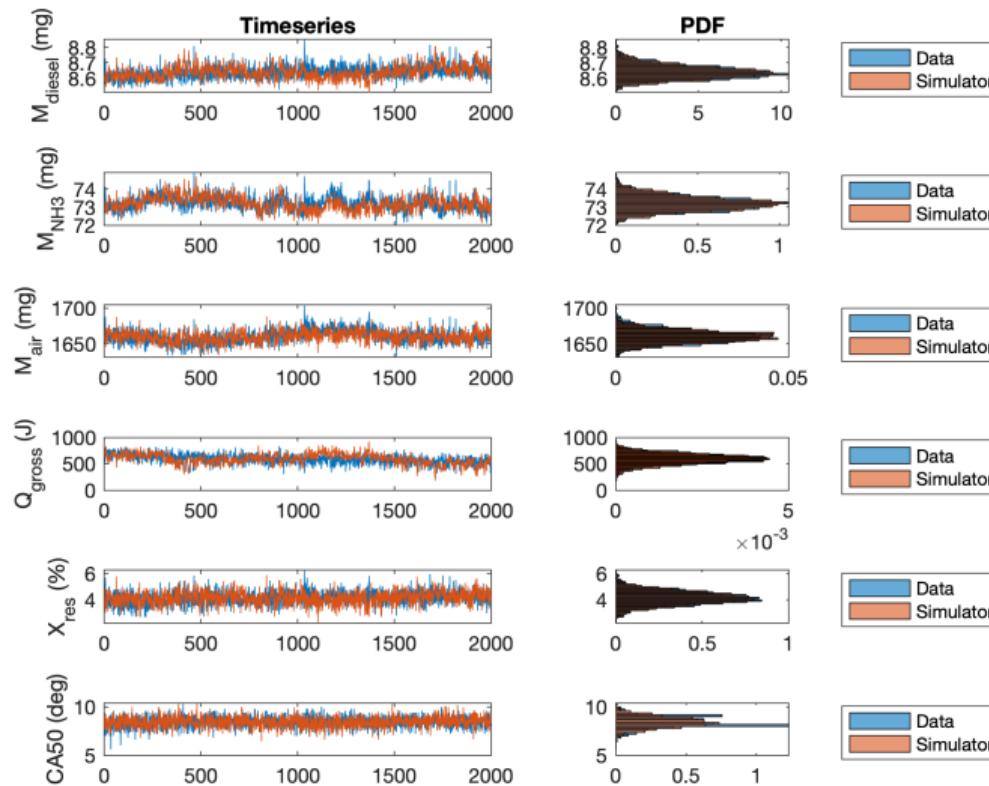
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

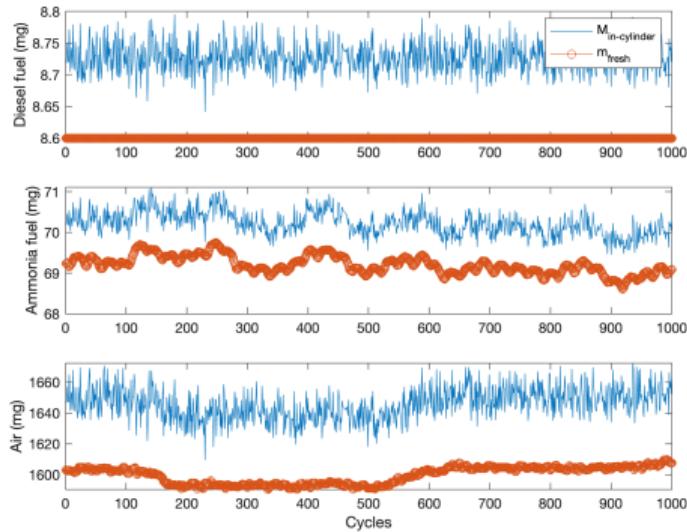
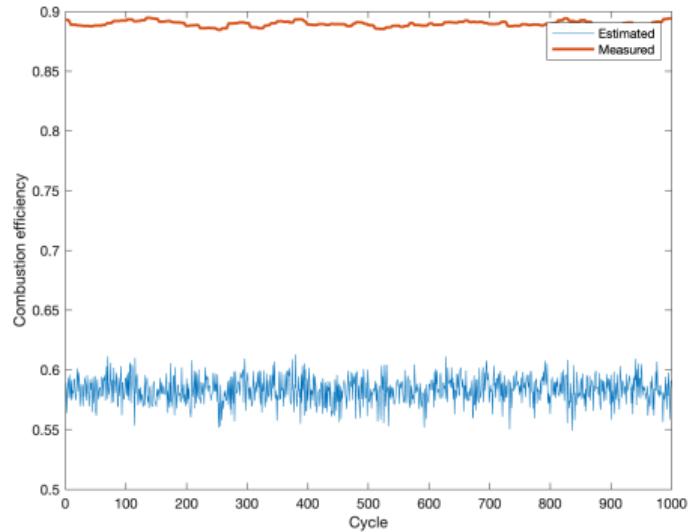
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.4 SOI44: Simulator Results



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

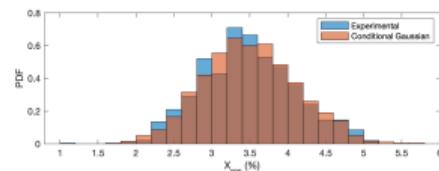
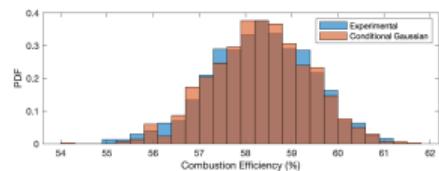
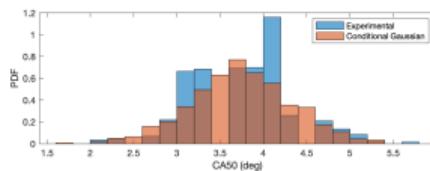
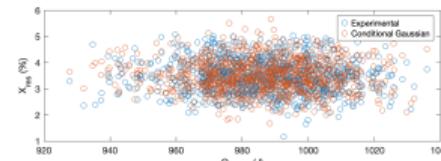
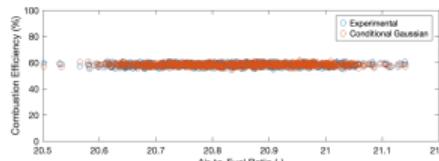
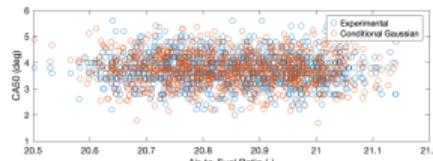


DI8.6 SOI42: Parametric models

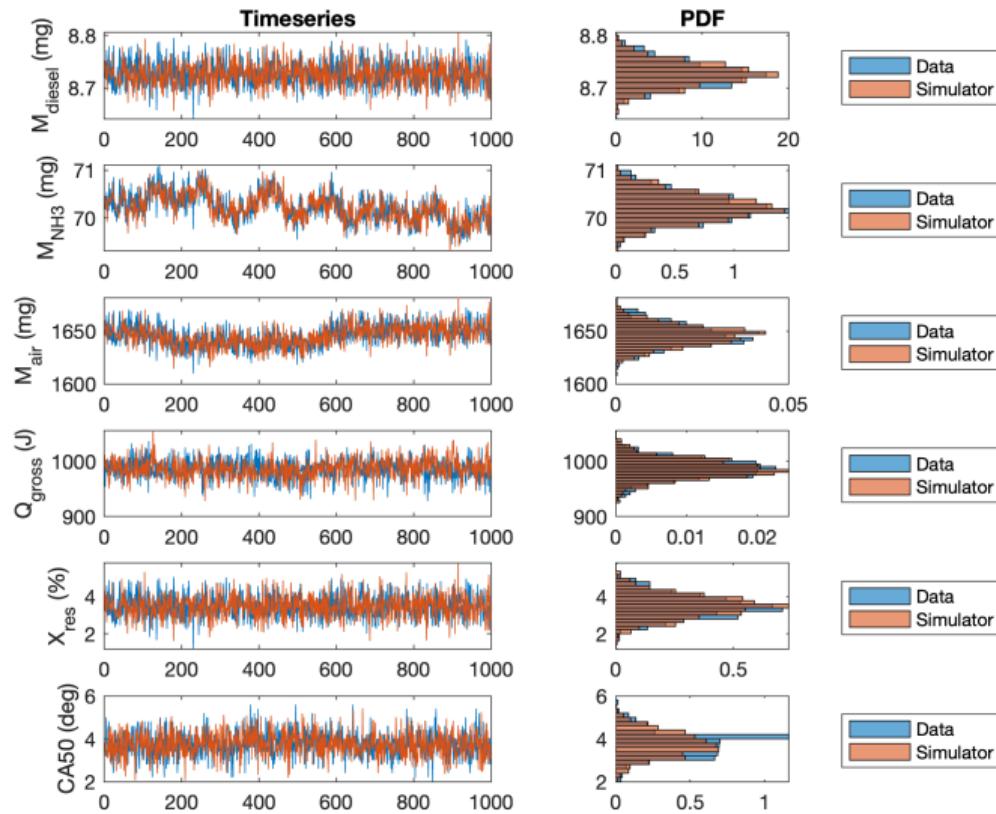
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

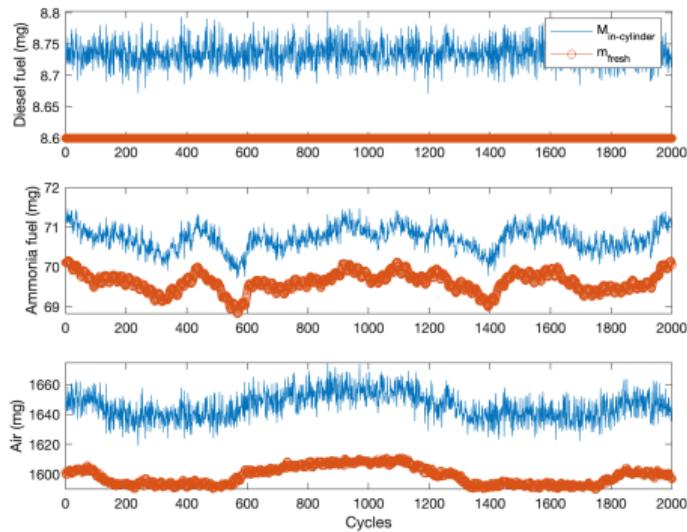
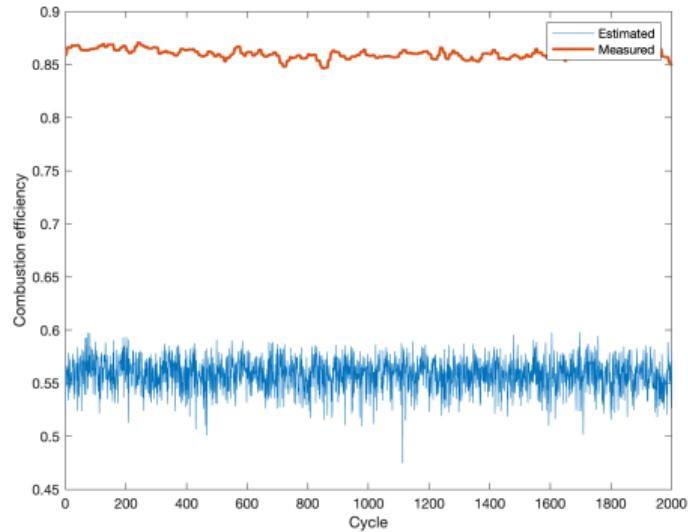
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.6 SOI42: Simulator Results



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

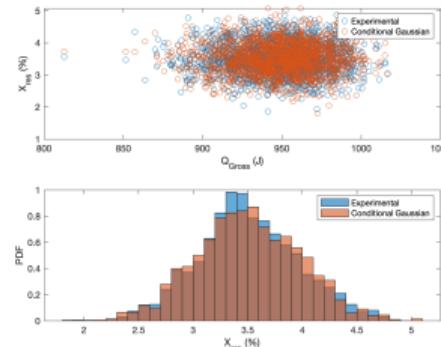
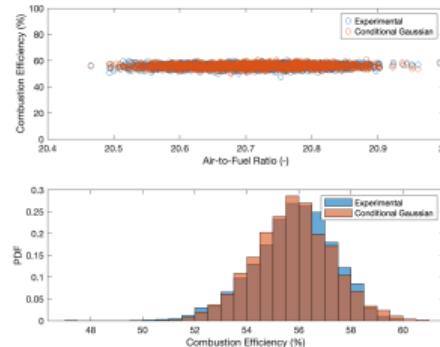
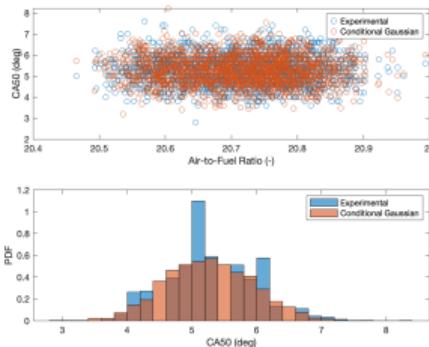


DI8.6 SOI43: Parametric models

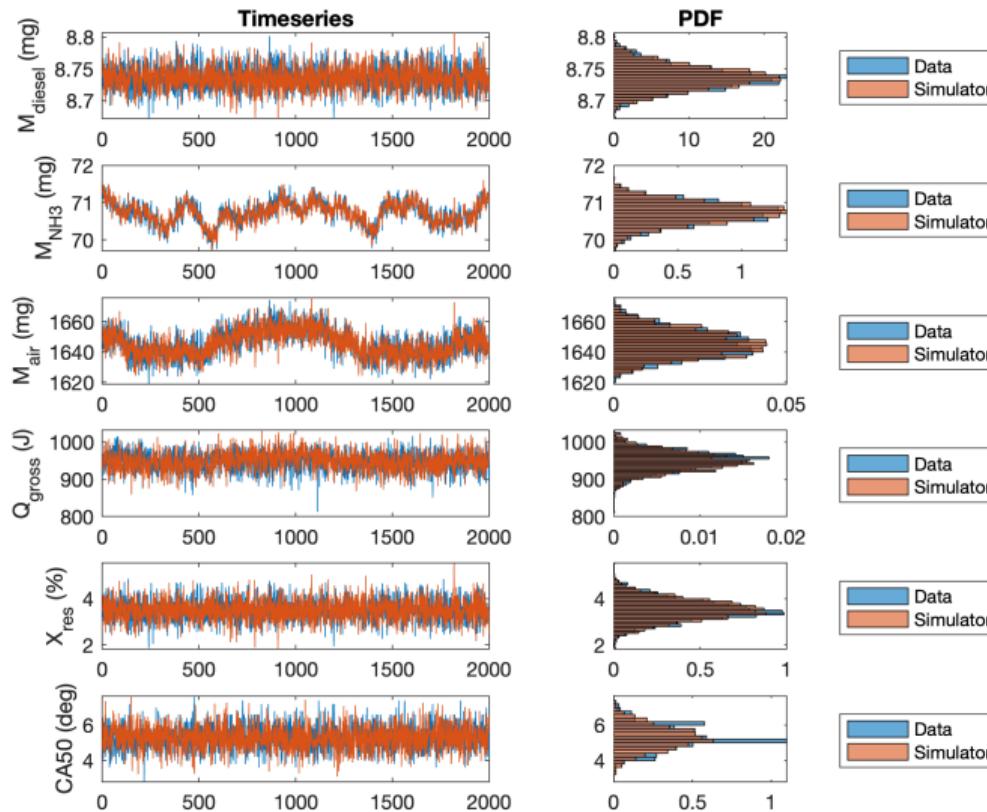
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

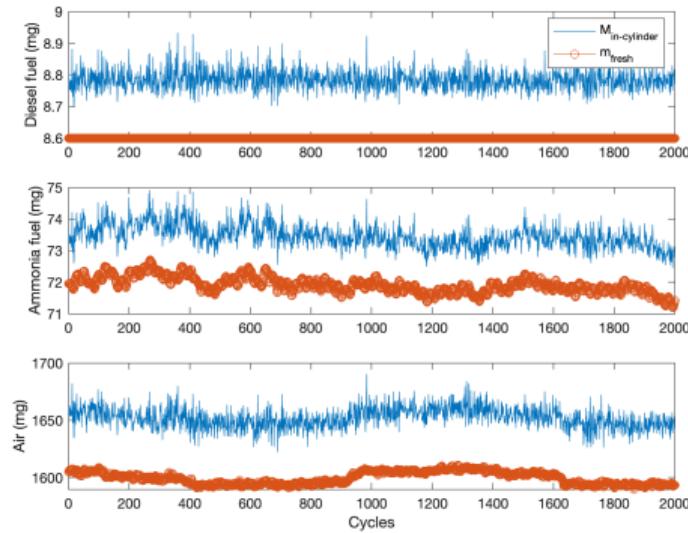
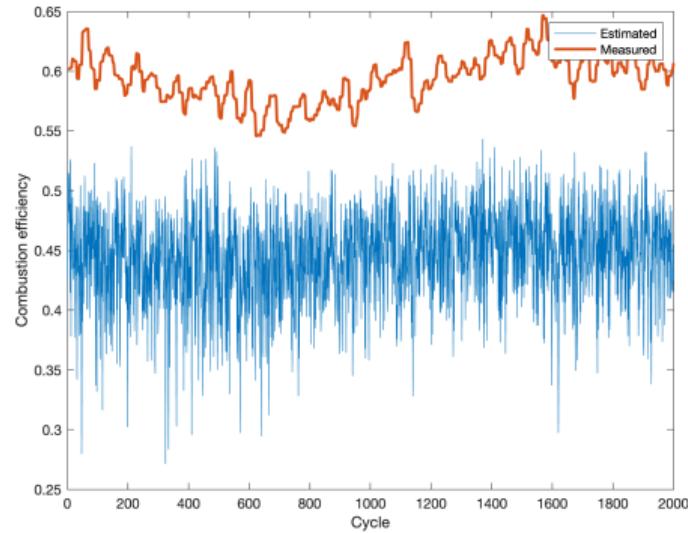
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.6 SOI43: Simulator Results



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

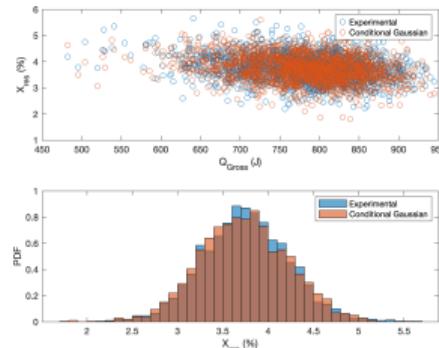
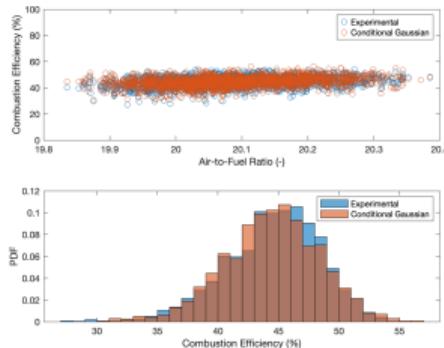
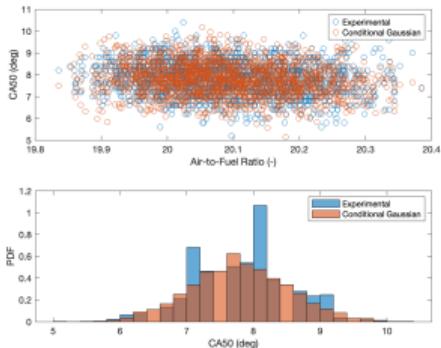


DI8.6 SOI44: Parametric models

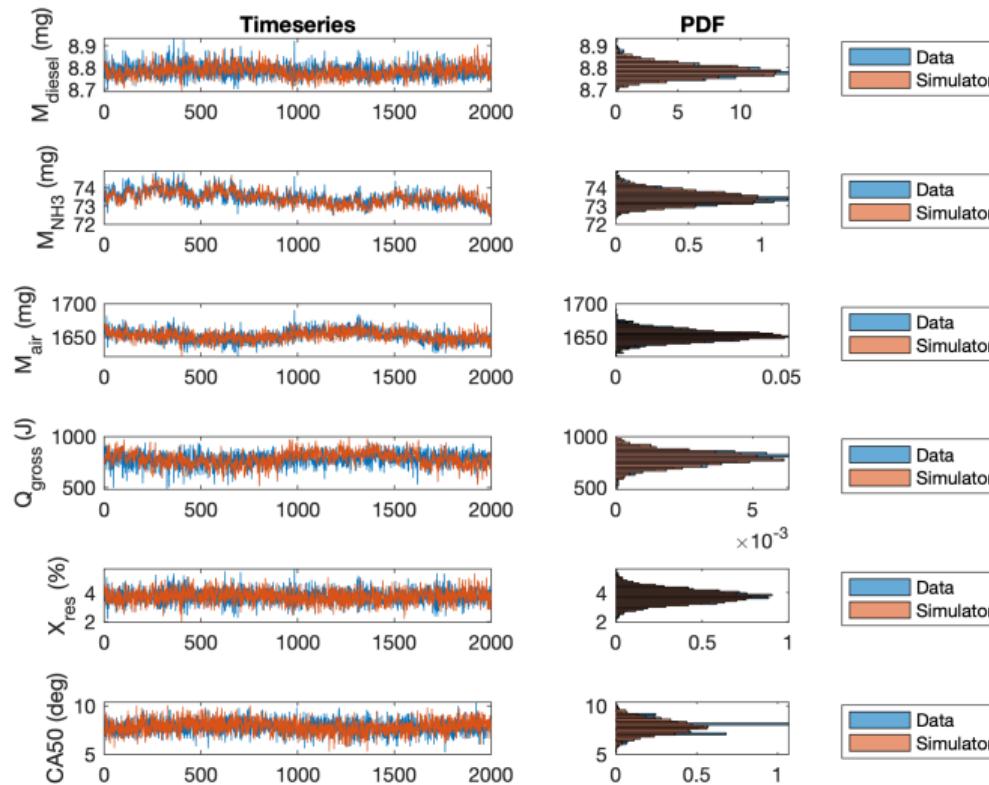
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

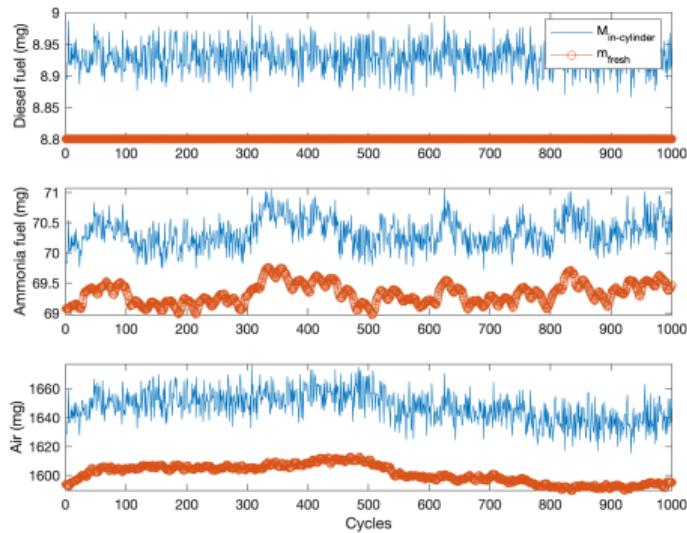
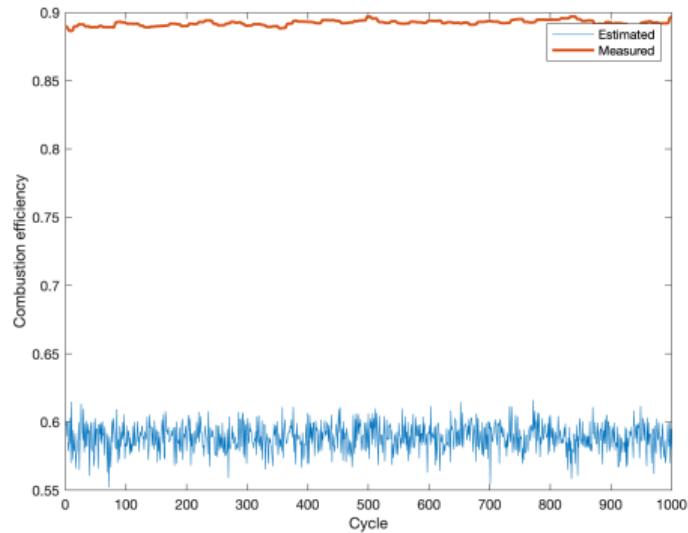
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.6 SOI44: Simulator Results



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

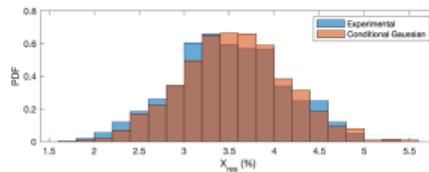
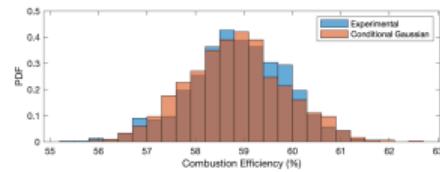
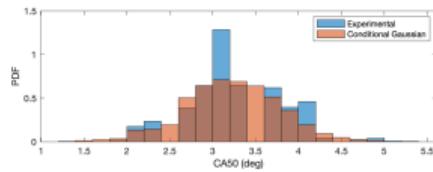
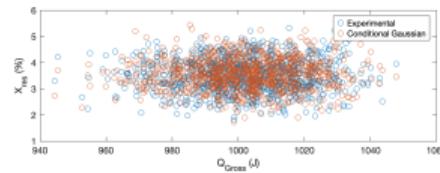
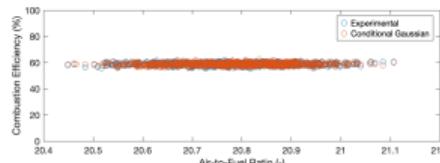
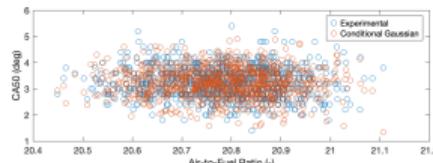


DI8.8 SOI42: Parametric models

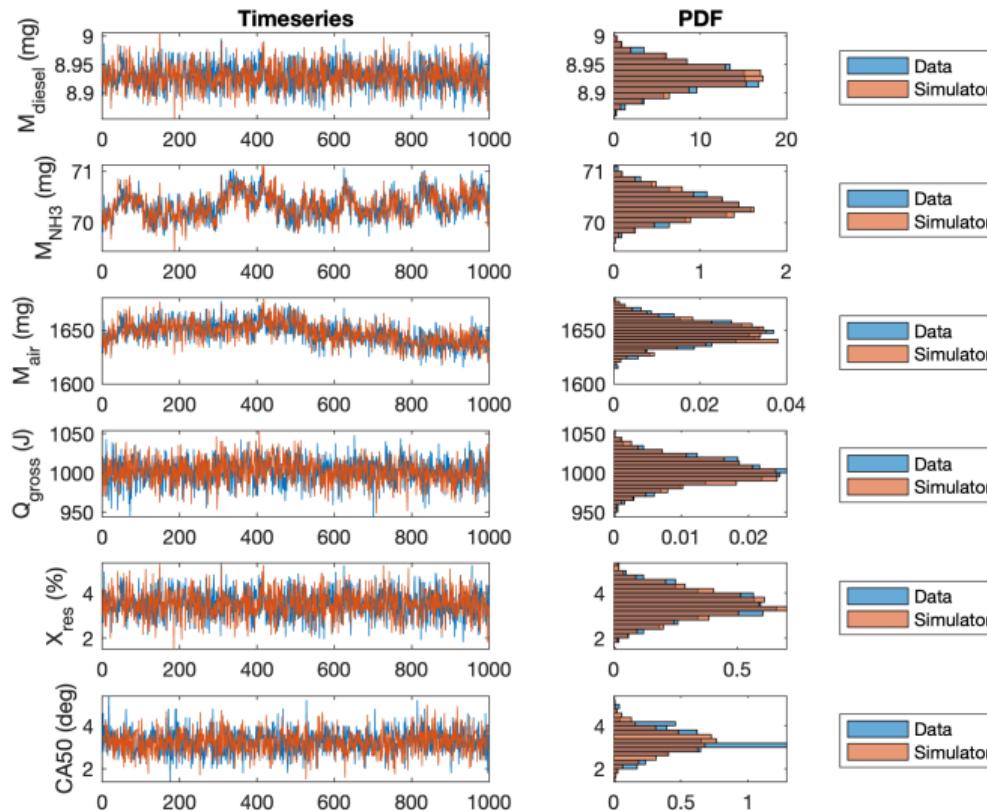
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

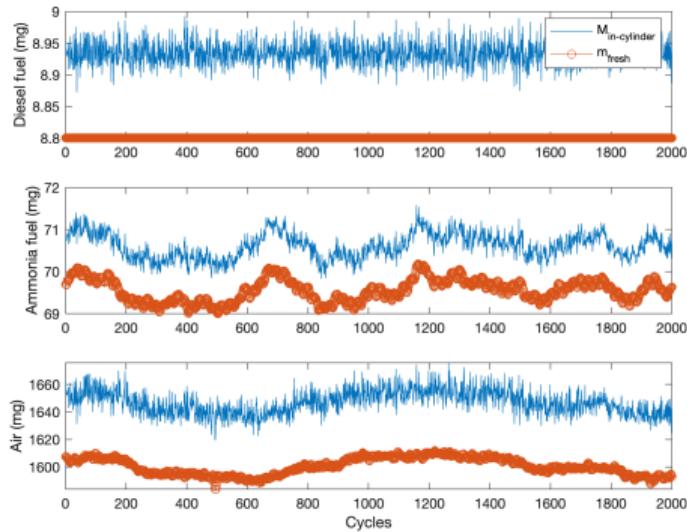
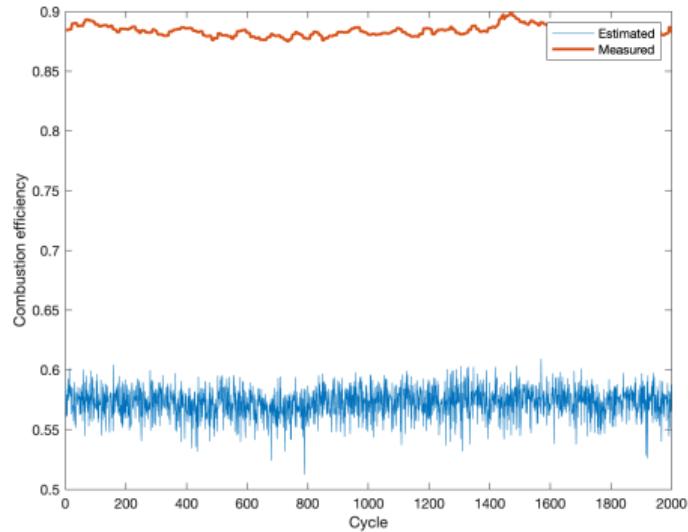
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.8 SOI42: Simulator Results



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

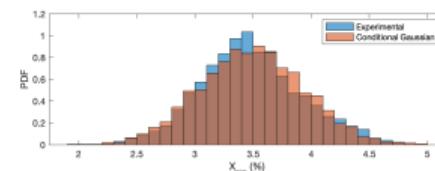
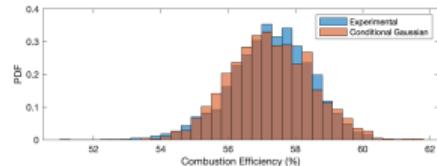
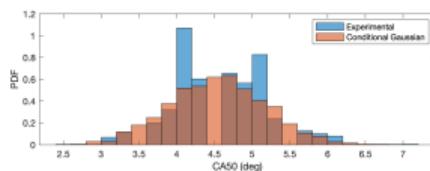
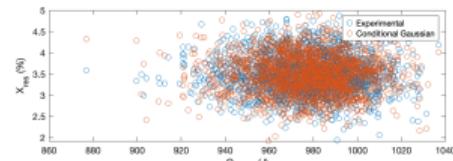
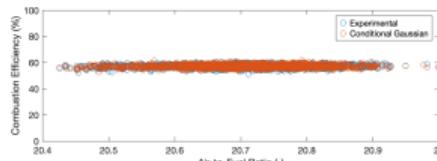
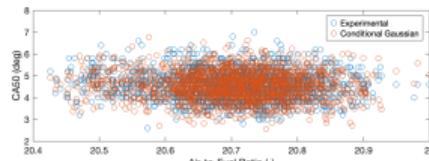


DI8.8 SOI43: Parametric models

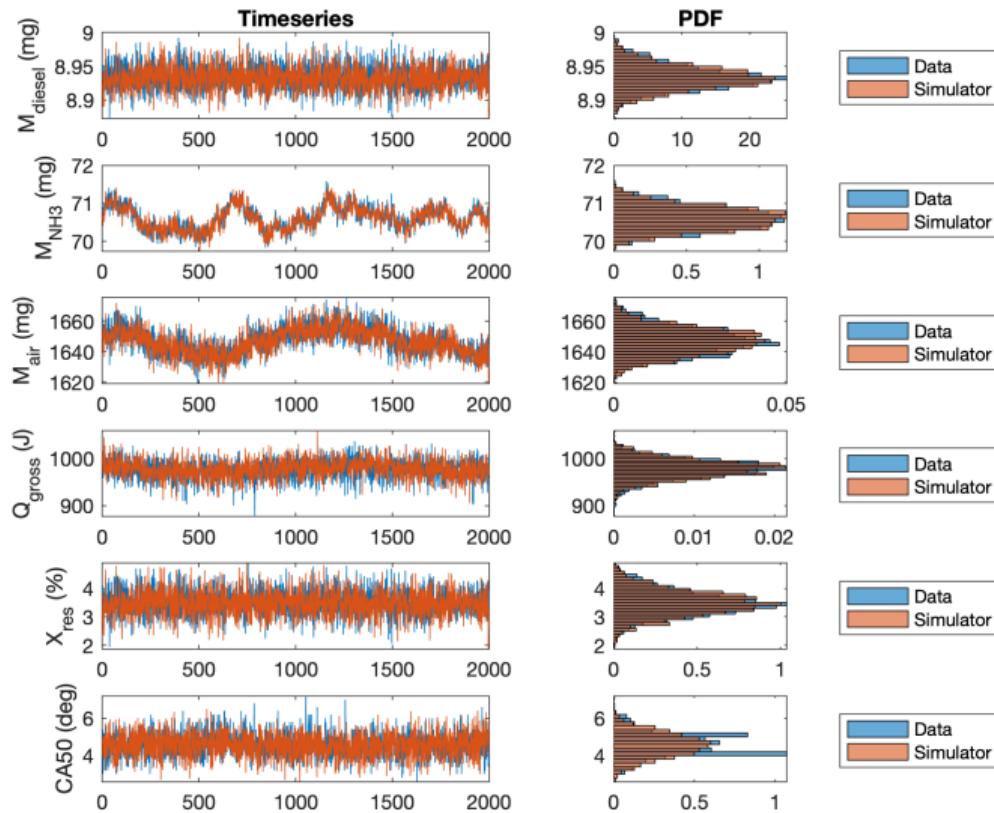
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

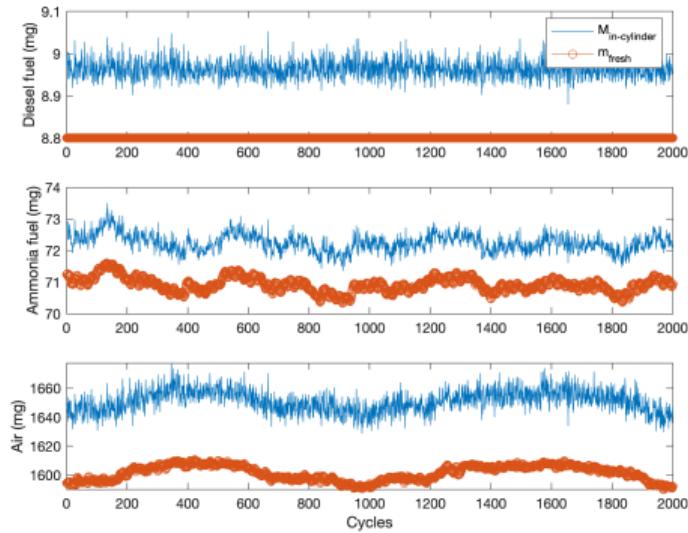
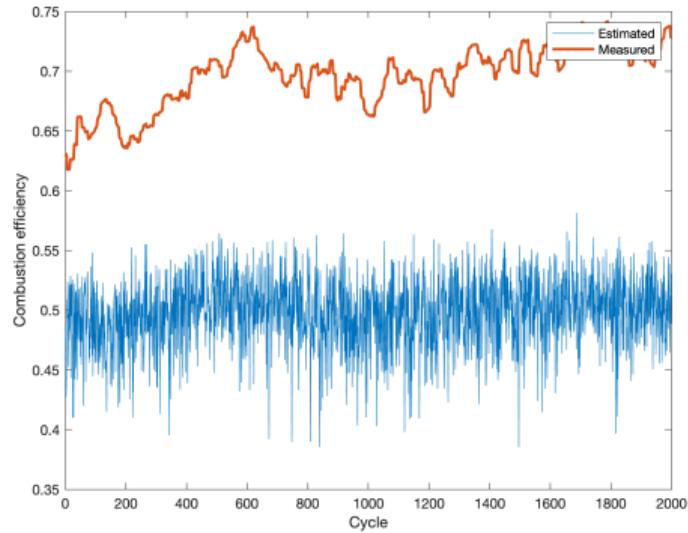
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.8 SOI43: Simulator Results



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

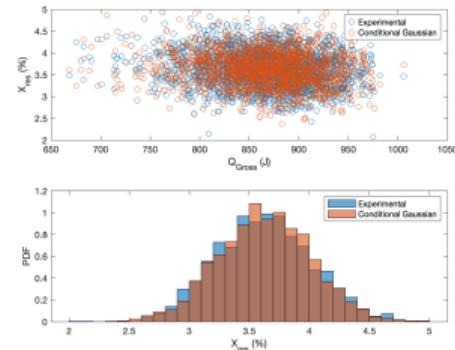
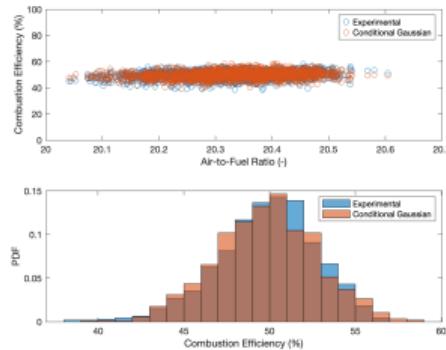
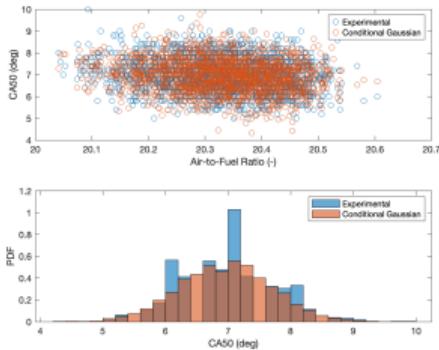


DI8.8 SOI44: Parametric models

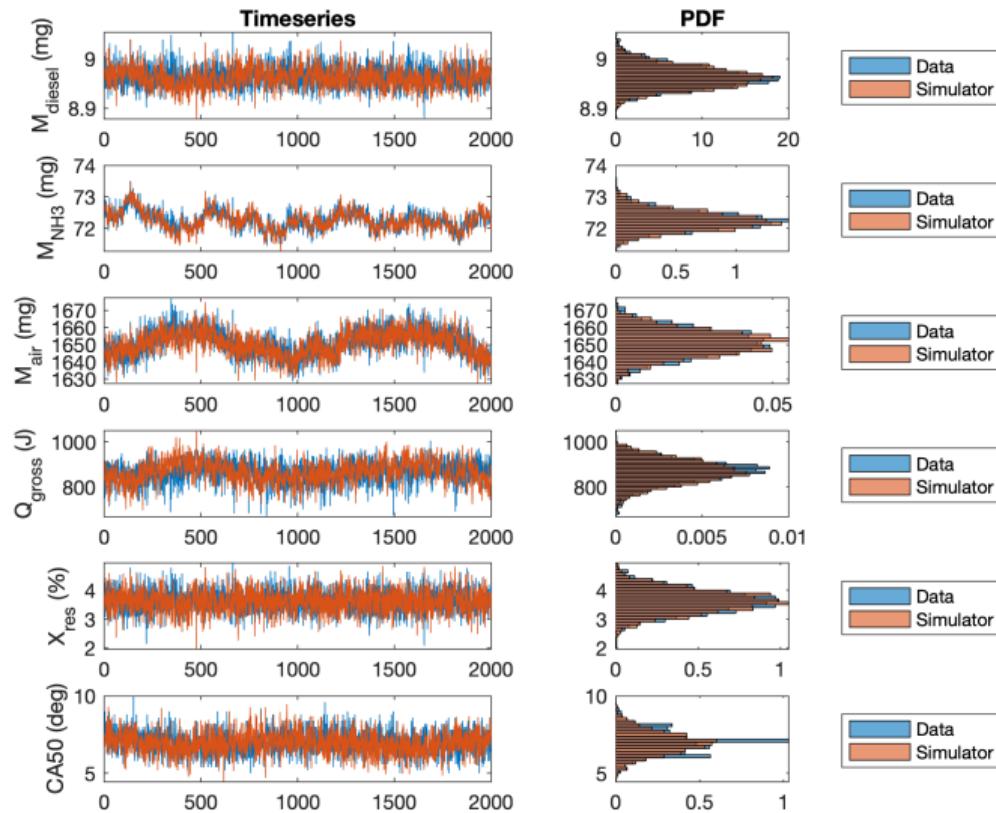
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

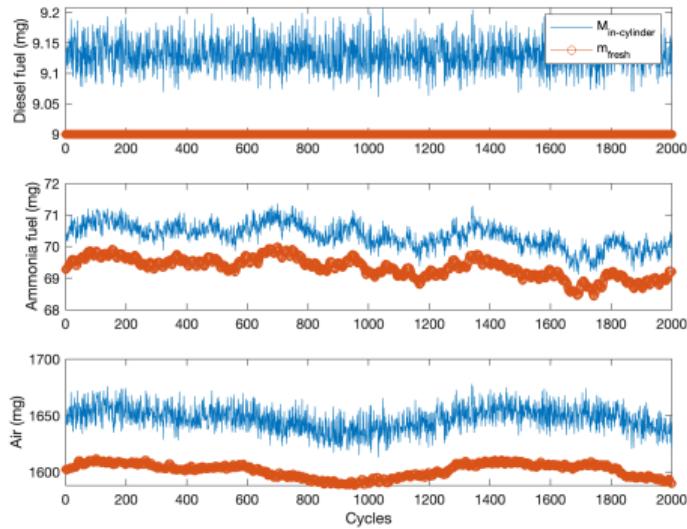
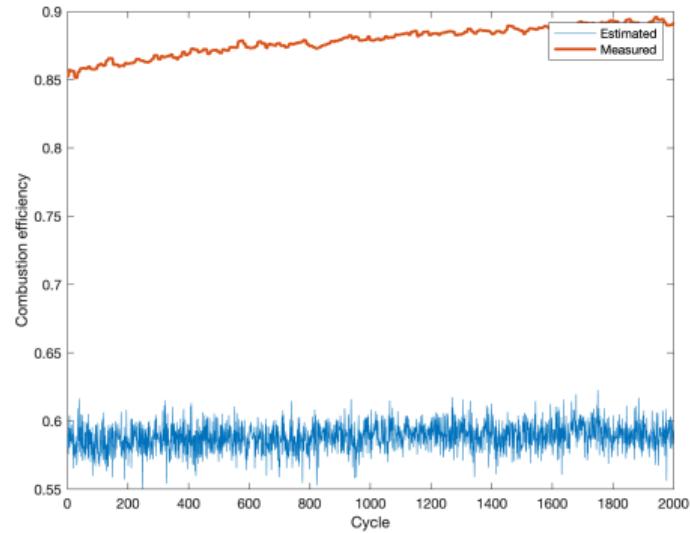
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI8.8 SOI44: Simulator Results



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

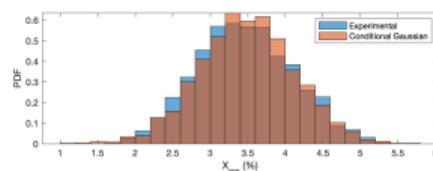
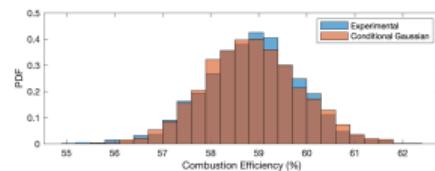
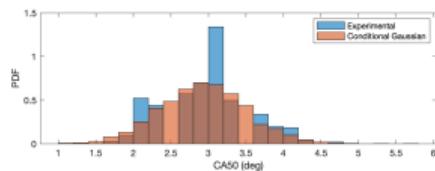
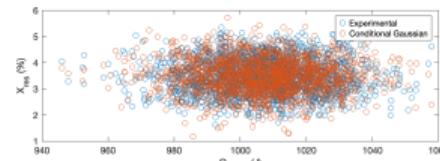
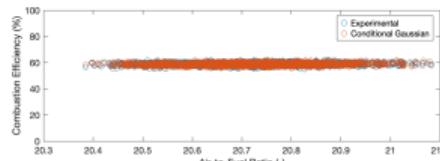
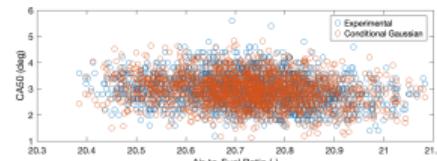


DI9.0 SOI42: Parametric models

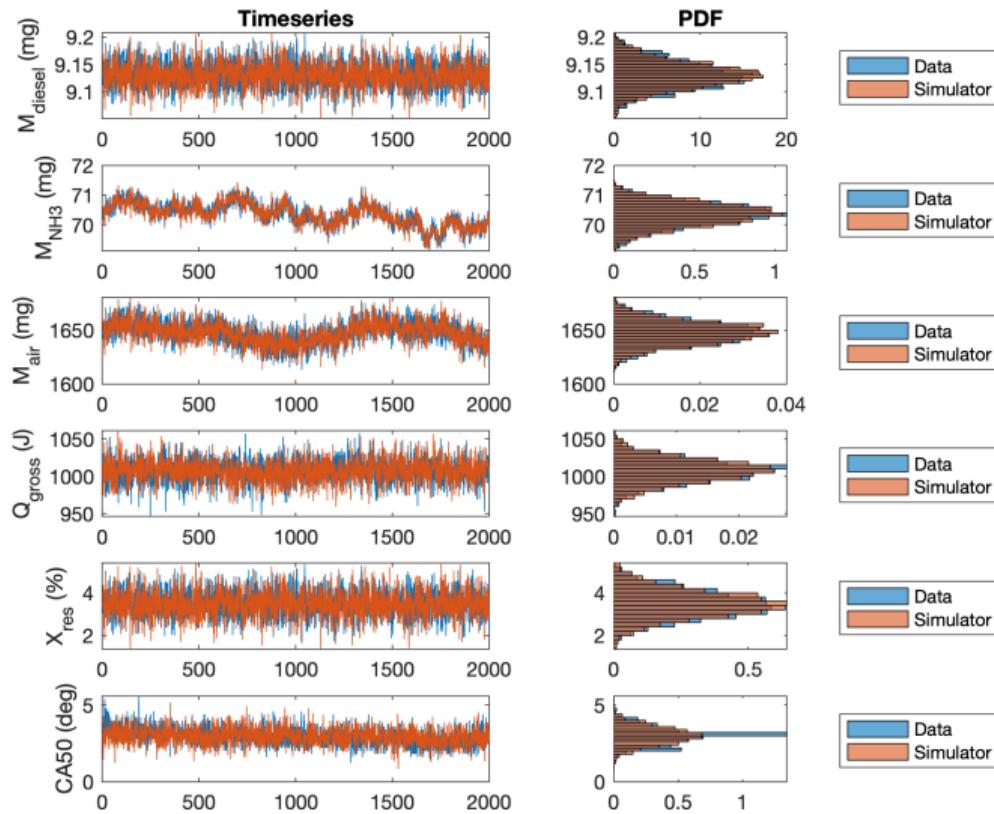
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

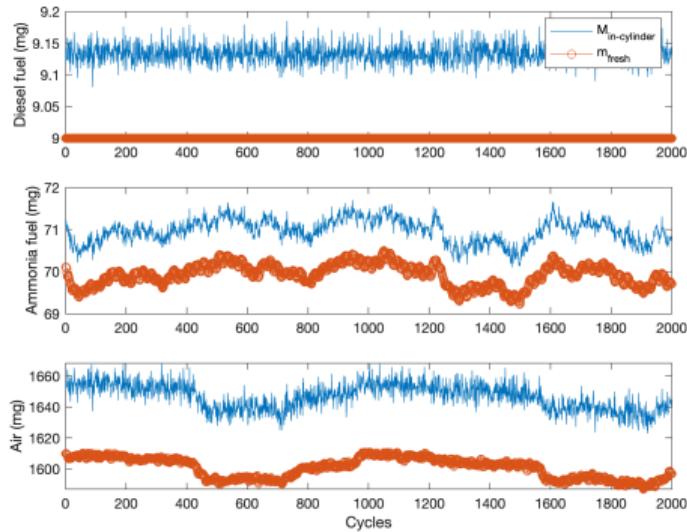
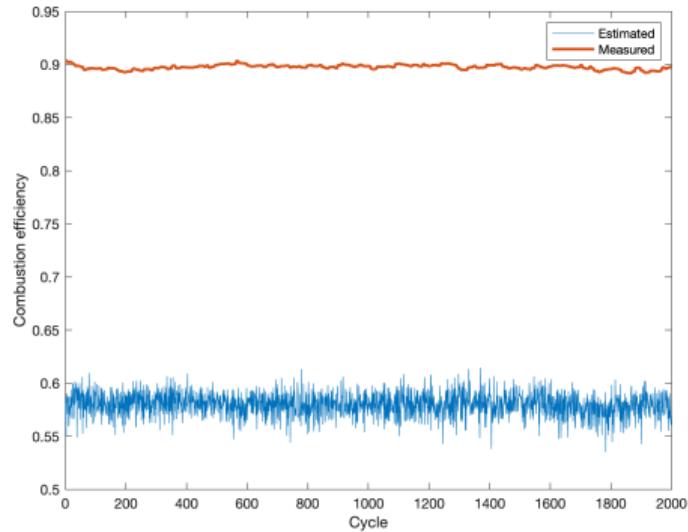
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI9.0 SOI42: Simulator Results



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

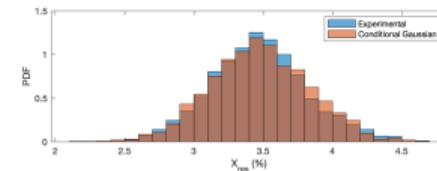
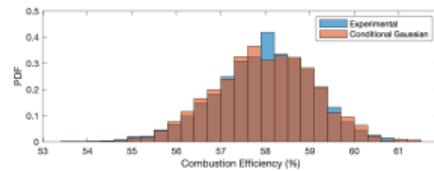
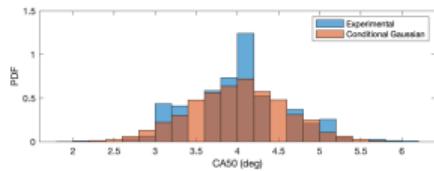
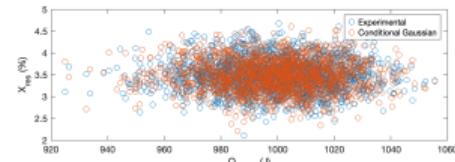
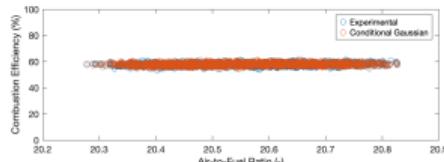
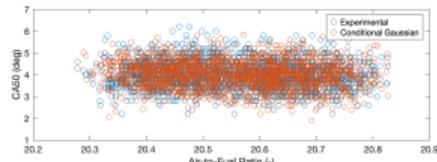


DI9.0 SOI43: Parametric models

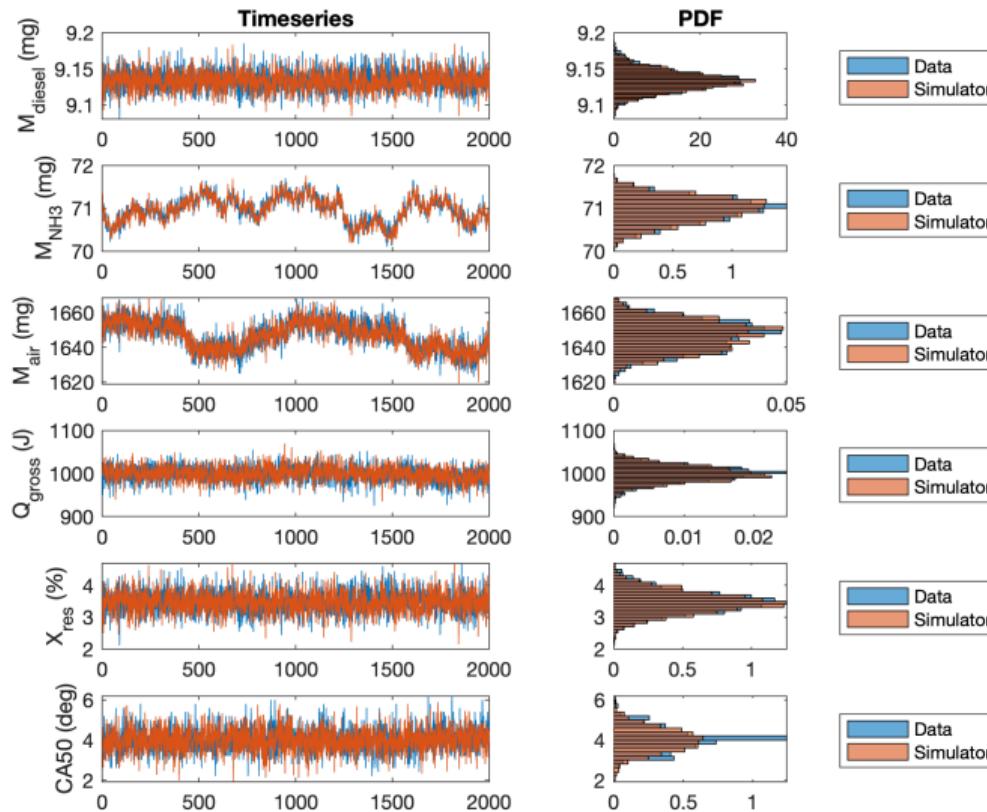
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

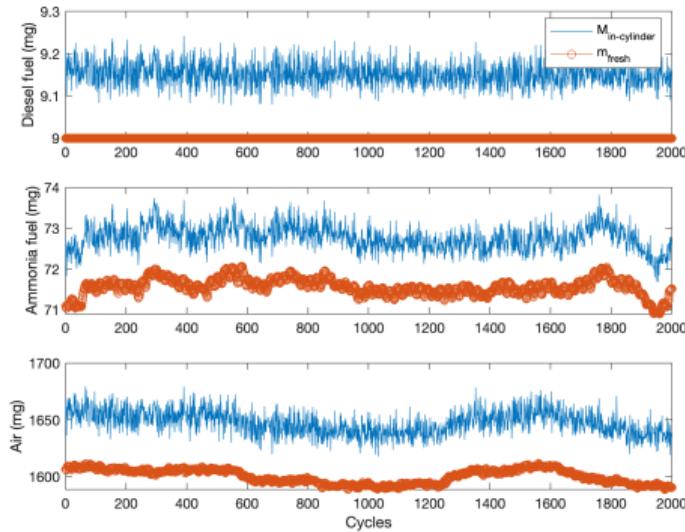
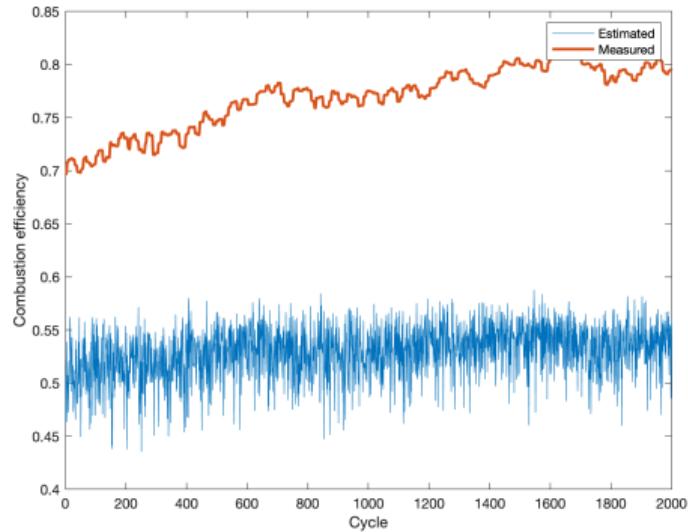
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI9.0 SOI43: Simulator Results



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

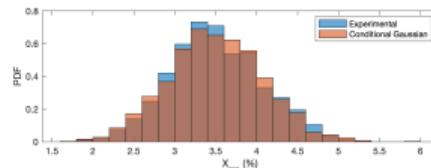
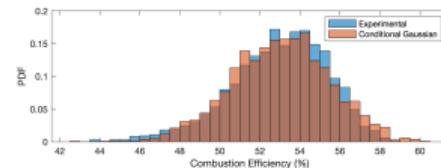
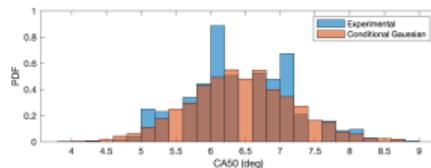
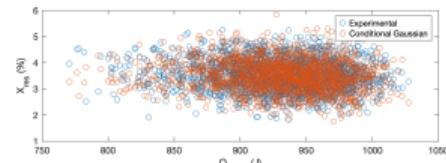
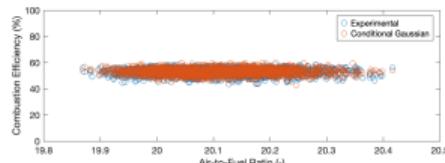
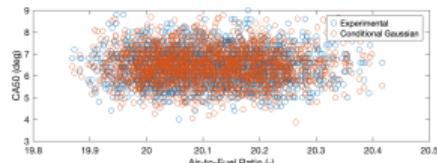


DI9.0 SOI44: Parametric models

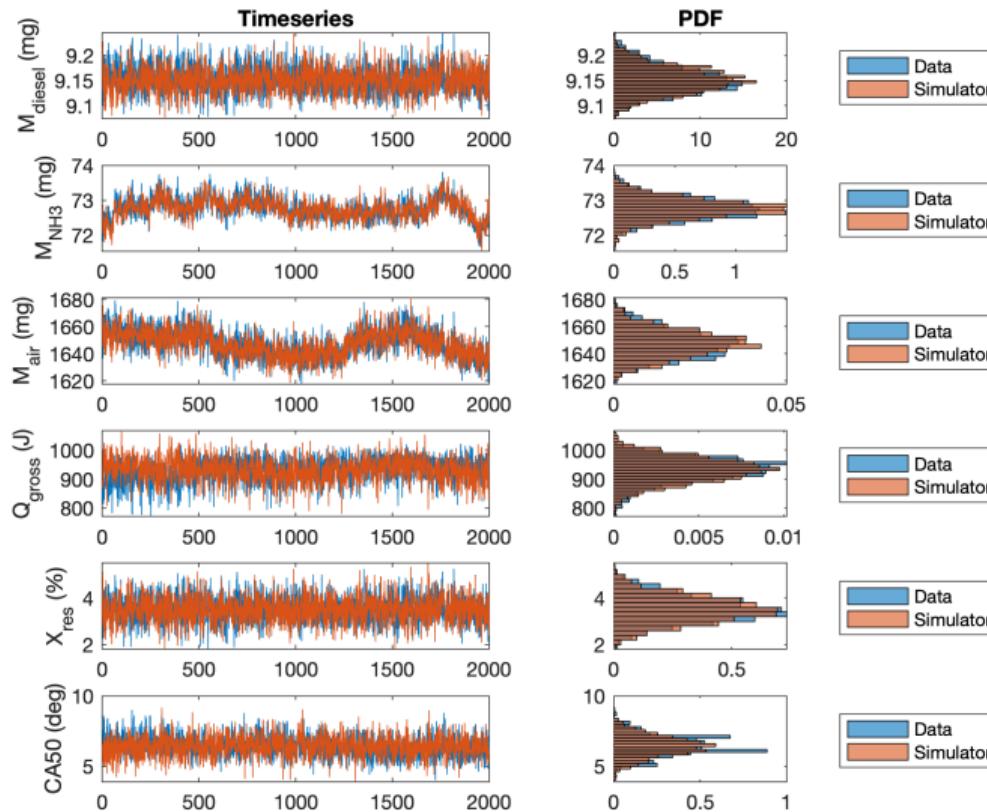
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

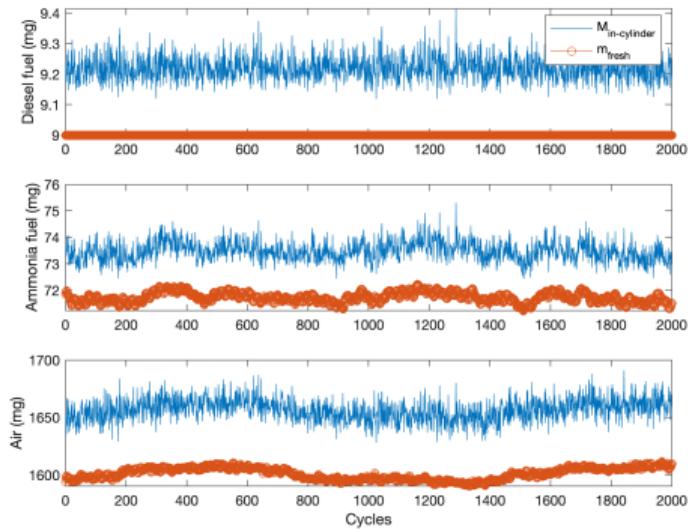
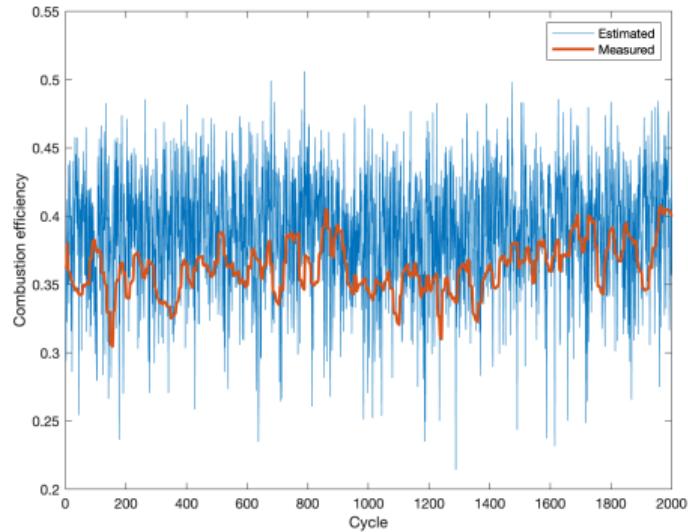
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI9.0 SOI44: Simulator Results



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

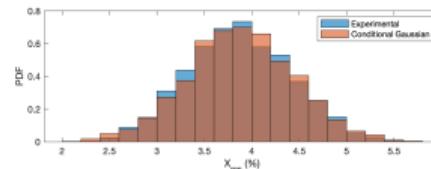
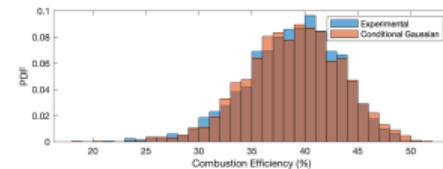
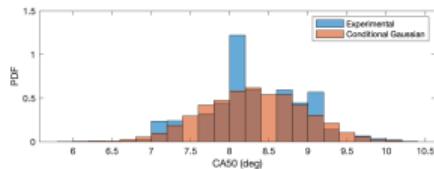
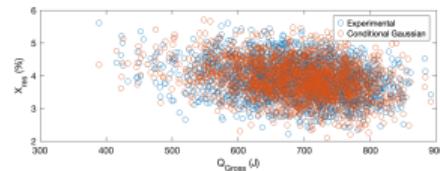
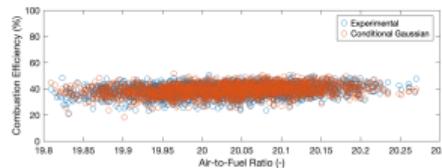
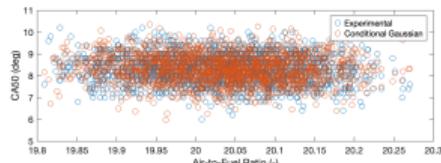


DI9.0 SOI45: Parametric models

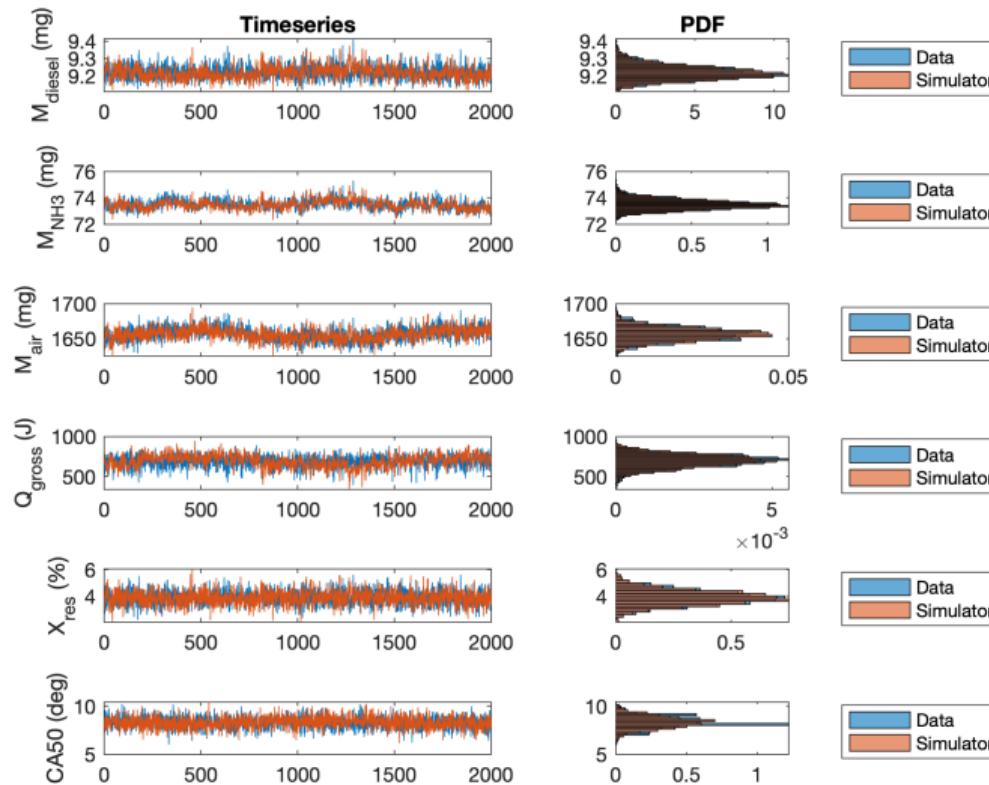
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

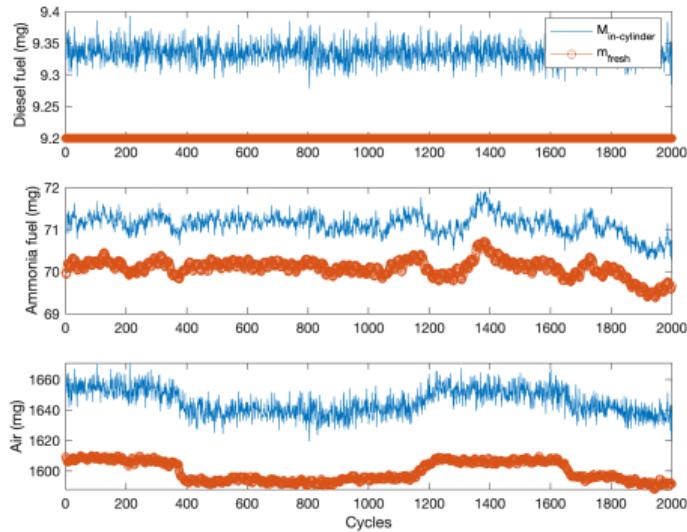
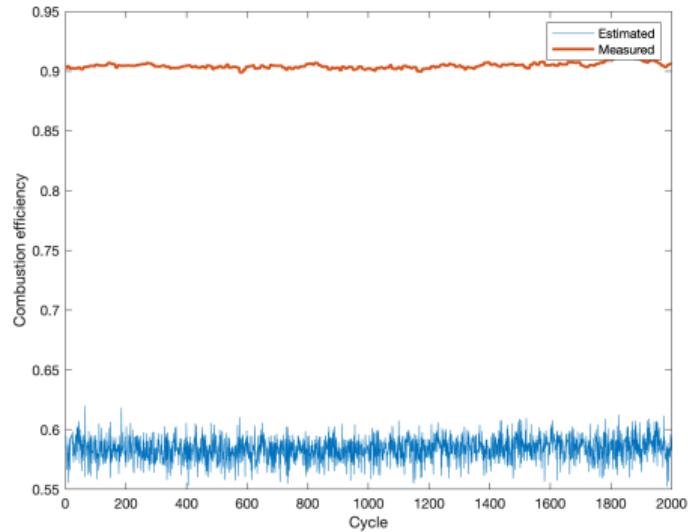
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI9.0 SOI45: Simulator Results



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

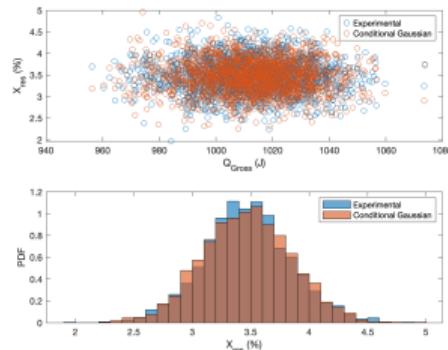
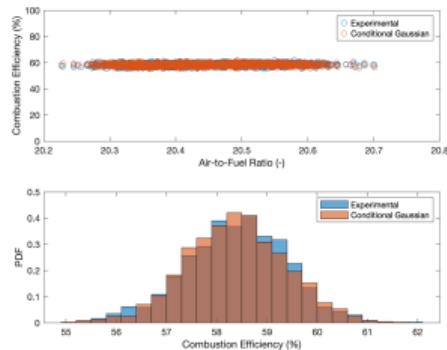
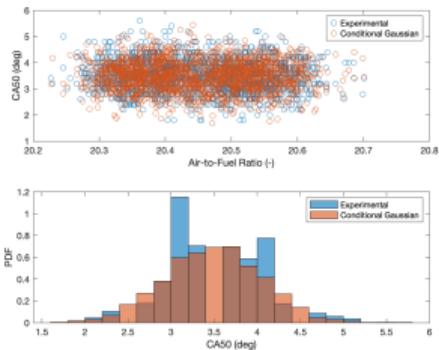


DI9.2 SOI43: Parametric models

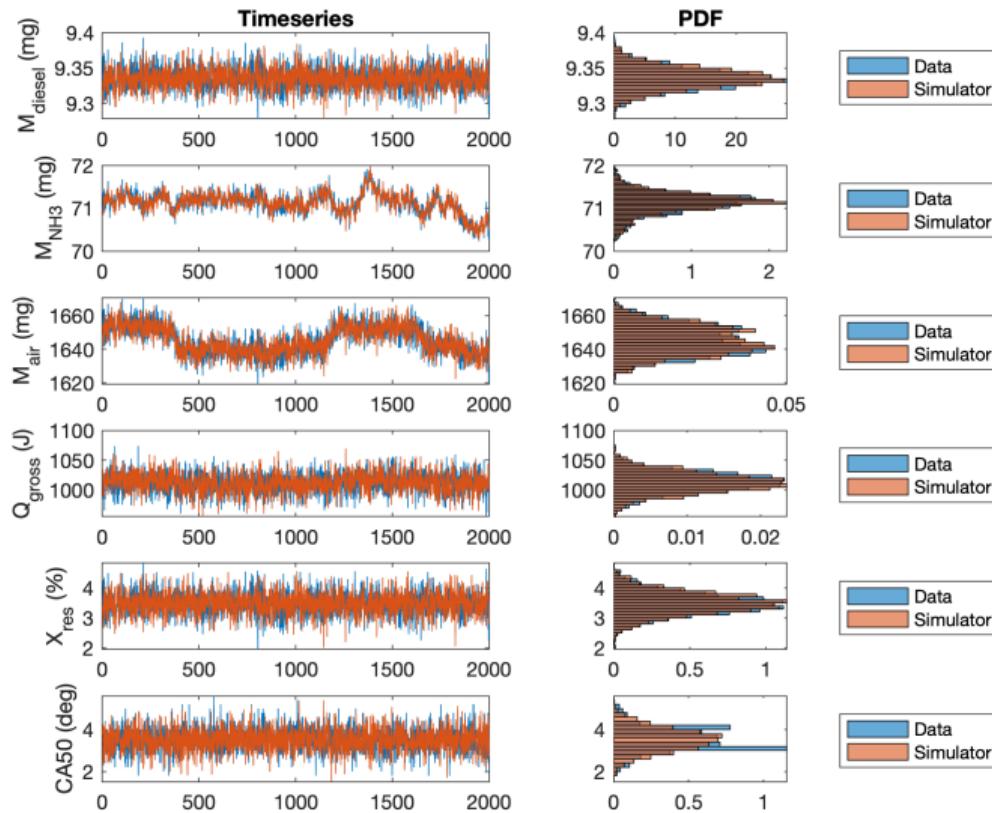
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

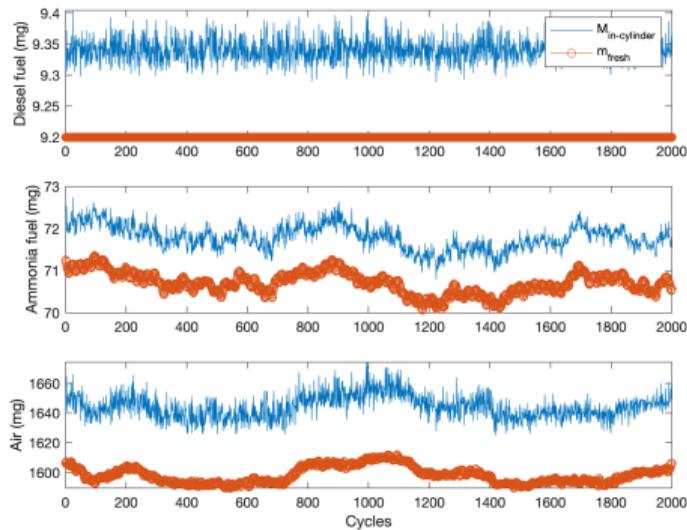
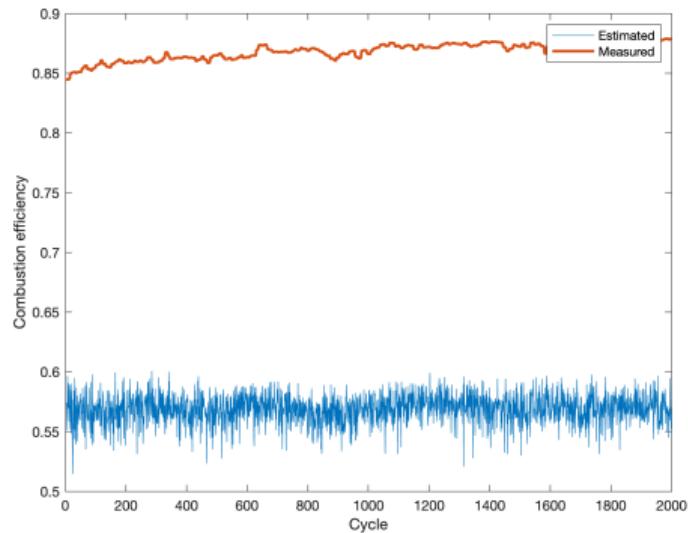
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



DI9.2 SOI43: Simulator Results



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

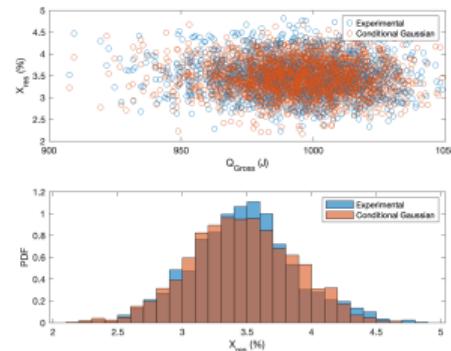
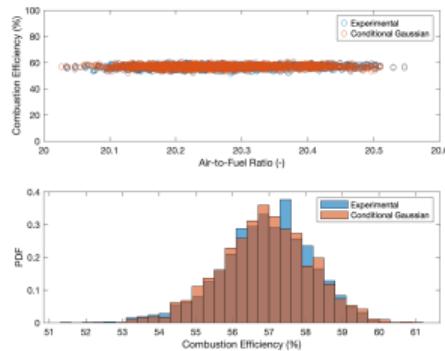
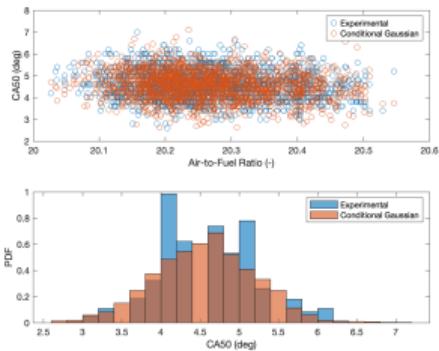


DI9.2 SOI44: Parametric models

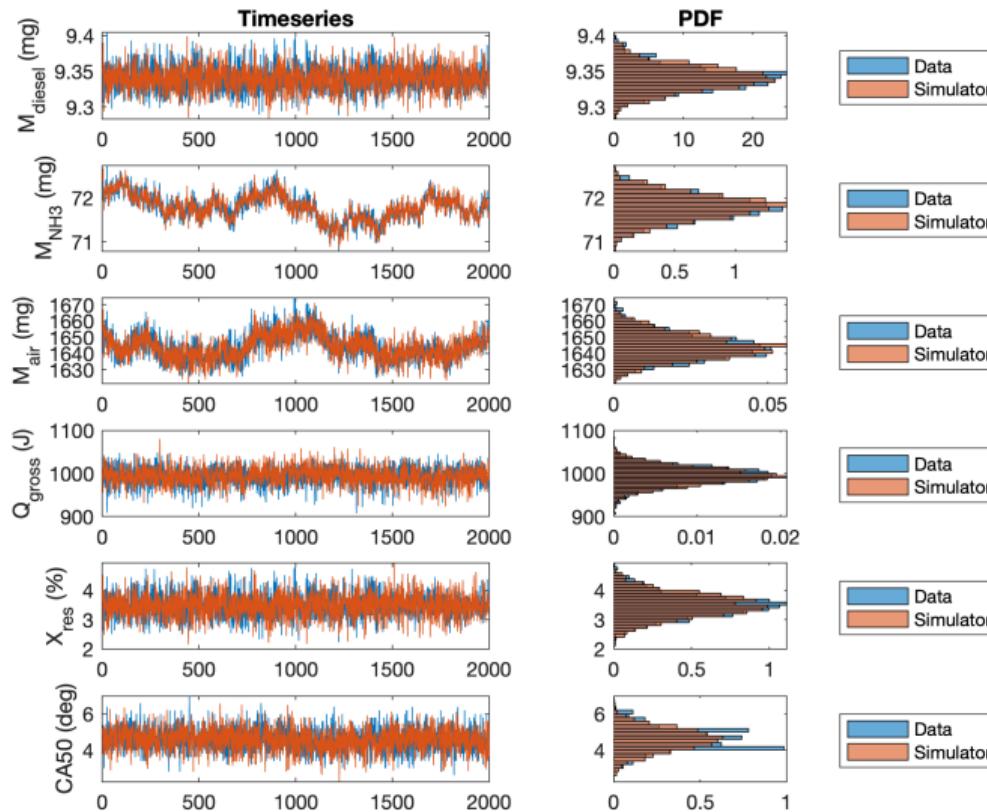
$$\text{CA50} \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} & \text{SOI}^{\text{dsl}} \end{bmatrix} \sim \mathcal{N}(\mu_{\text{CA50}}, \Sigma_{\text{CA50}})$$

$$\eta_c \mid \begin{bmatrix} M_{\text{fuel}}^{\text{dsl}} & M_{\text{fuel}}^{\text{NH}_3} & M_{\text{air}} \end{bmatrix} \sim \mathcal{N}(\mu_\eta, \Sigma_\eta)$$

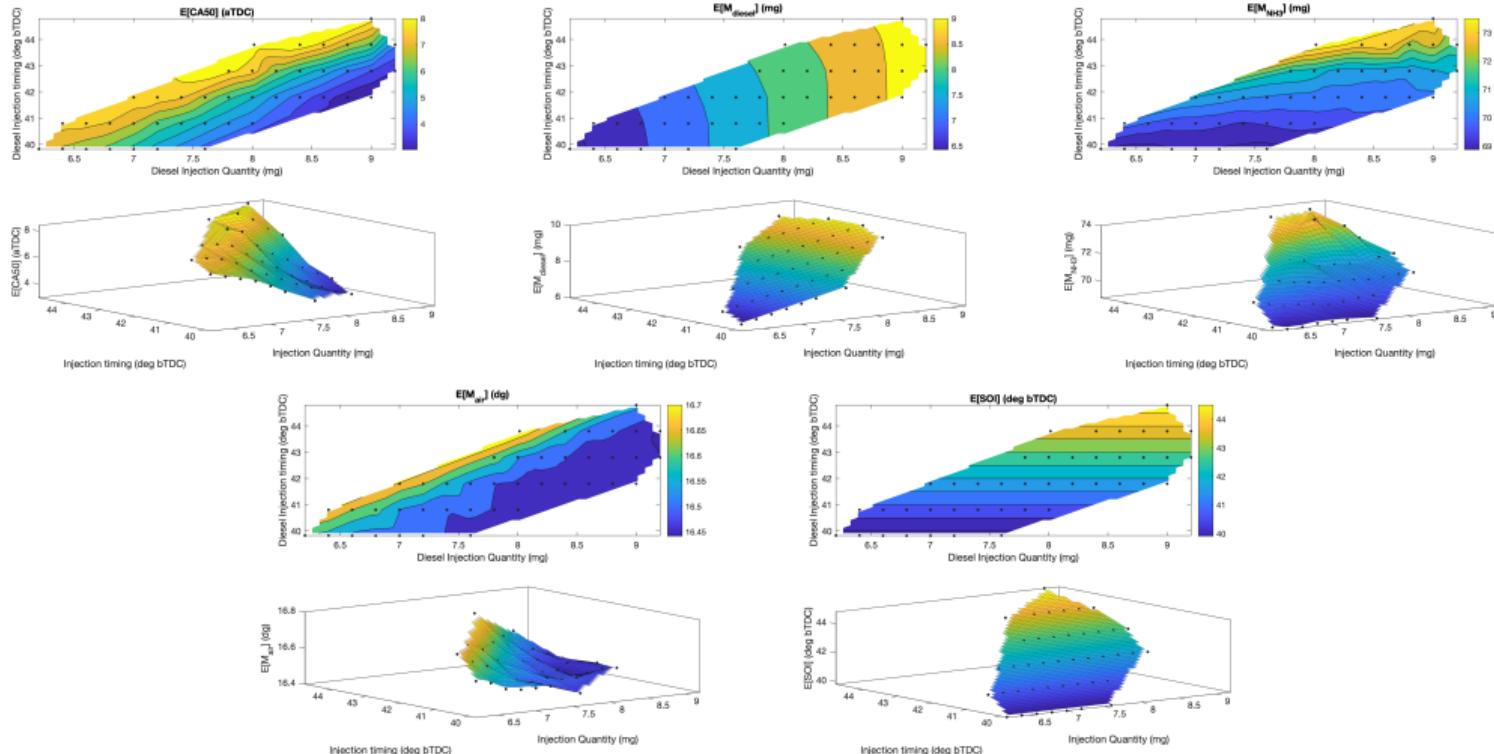
$$X_{\text{res}} \mid Q_{\text{gross}} \sim \mathcal{N}(\mu_X, \Sigma_X)$$



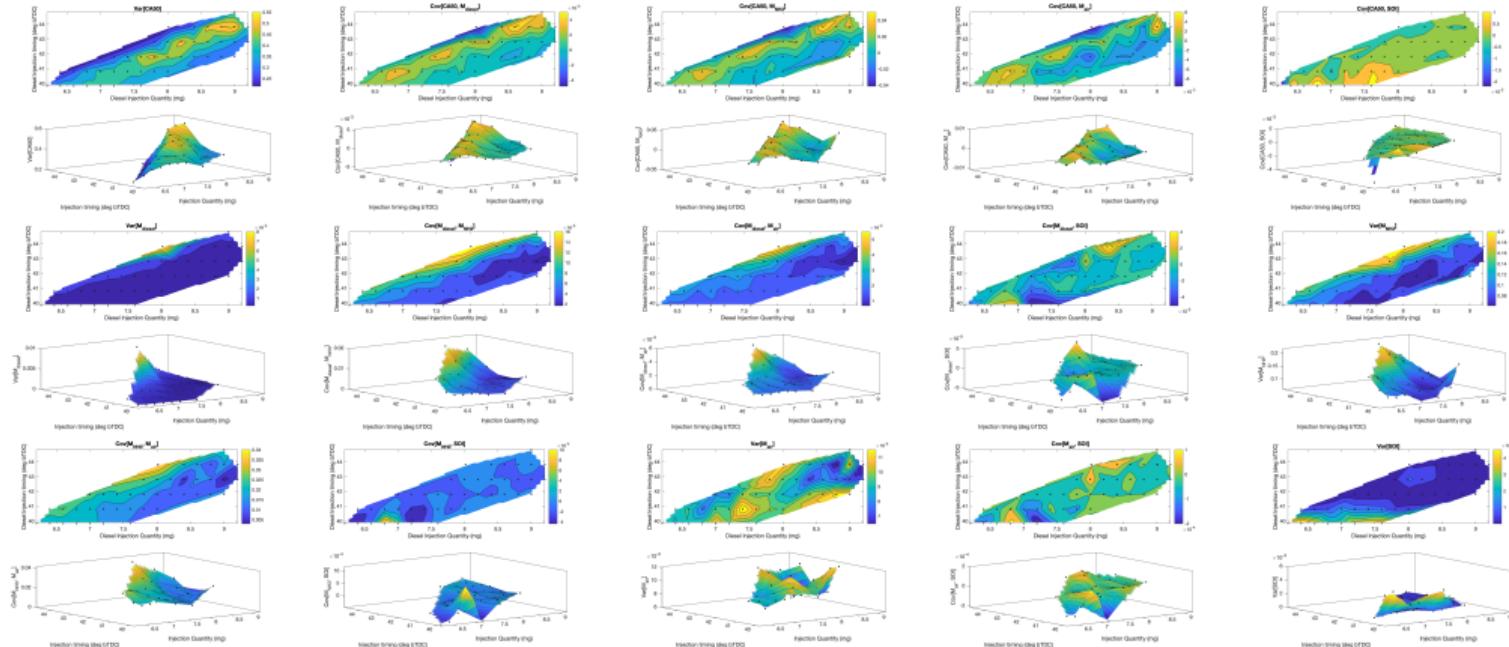
DI9.2 SOI44: Simulator Results



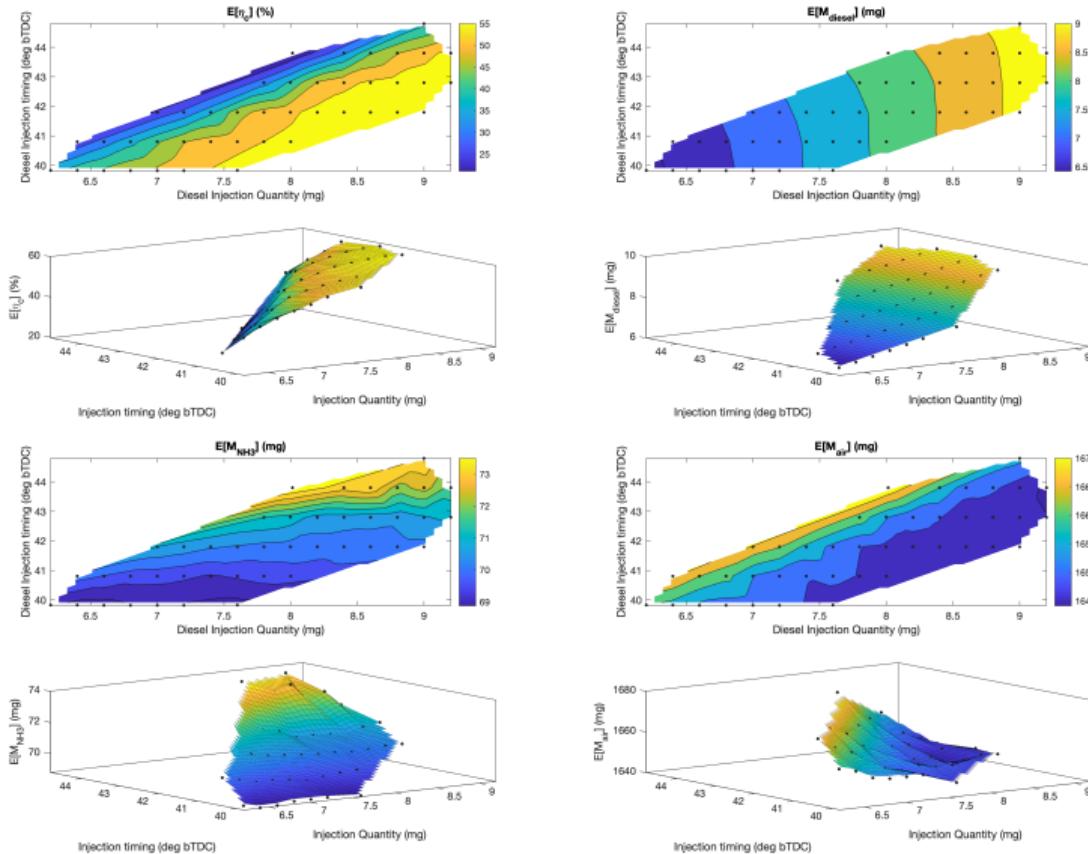
Model parameter μ_{CA50} as function of DI strategy



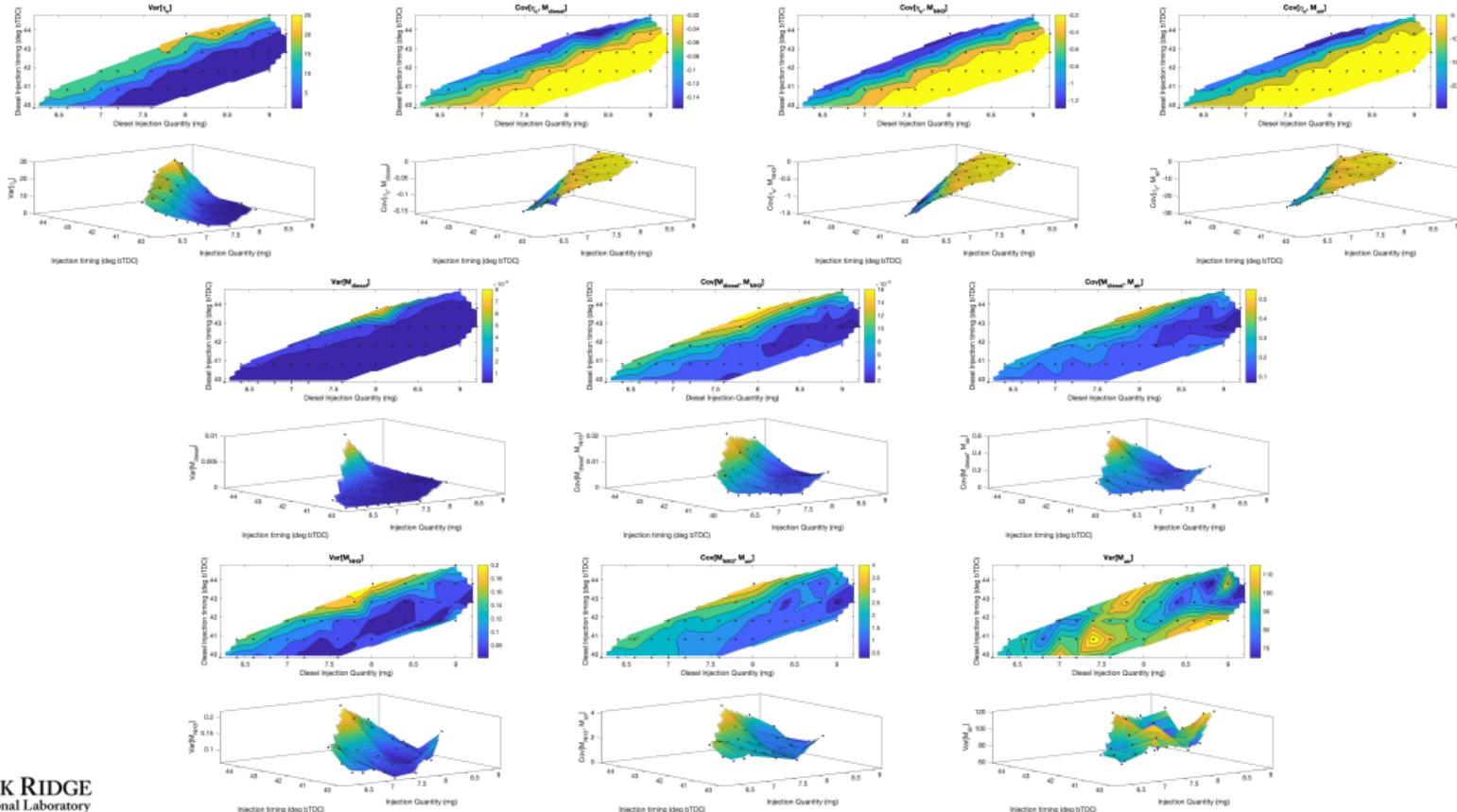
Model parameter Σ_{CA50} as function of DI strategy



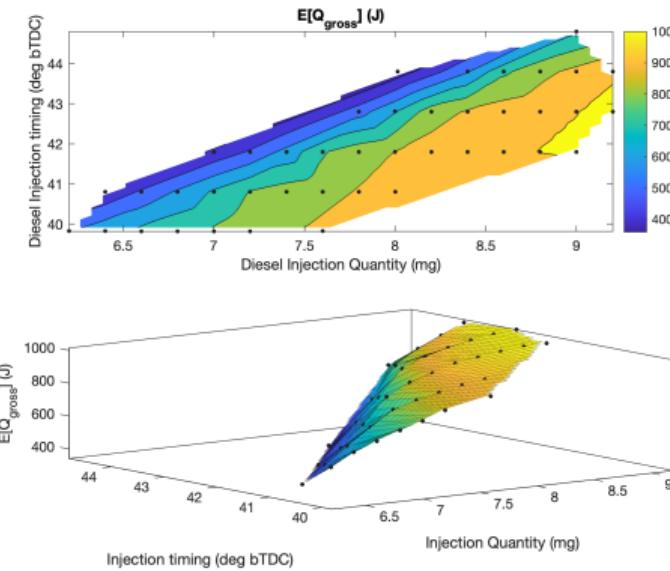
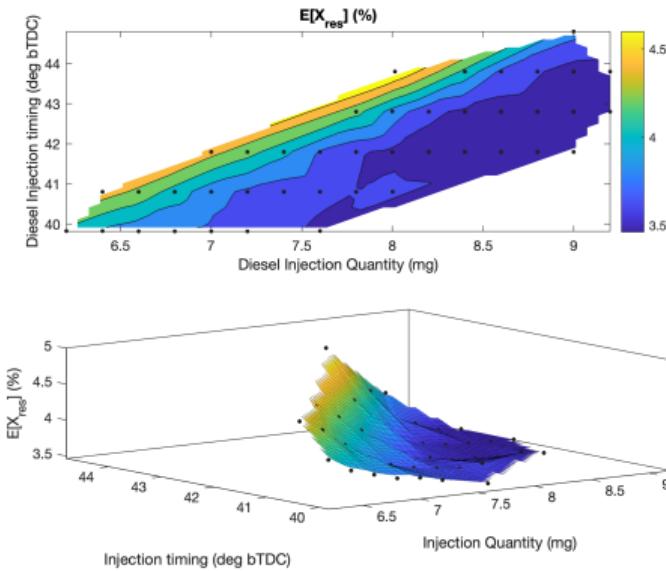
Model parameter μ_η as function of DI strategy



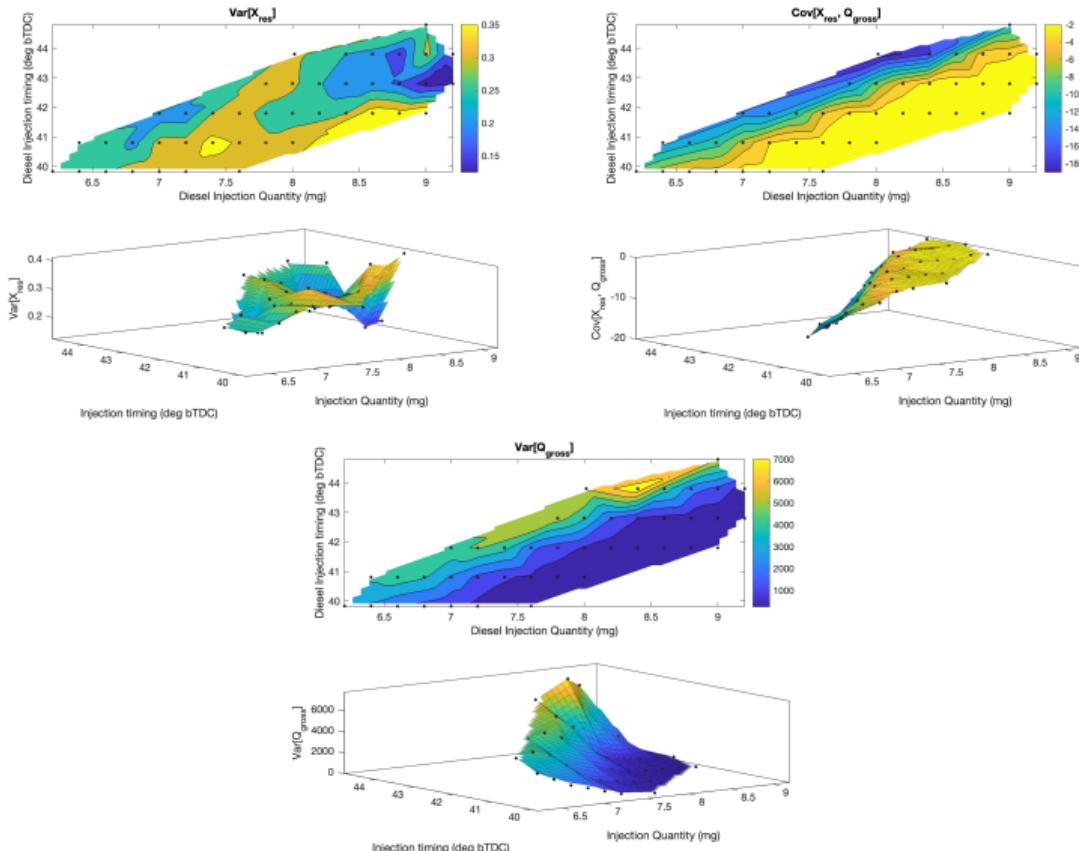
Model parameter Σ_η as function of DI strategy



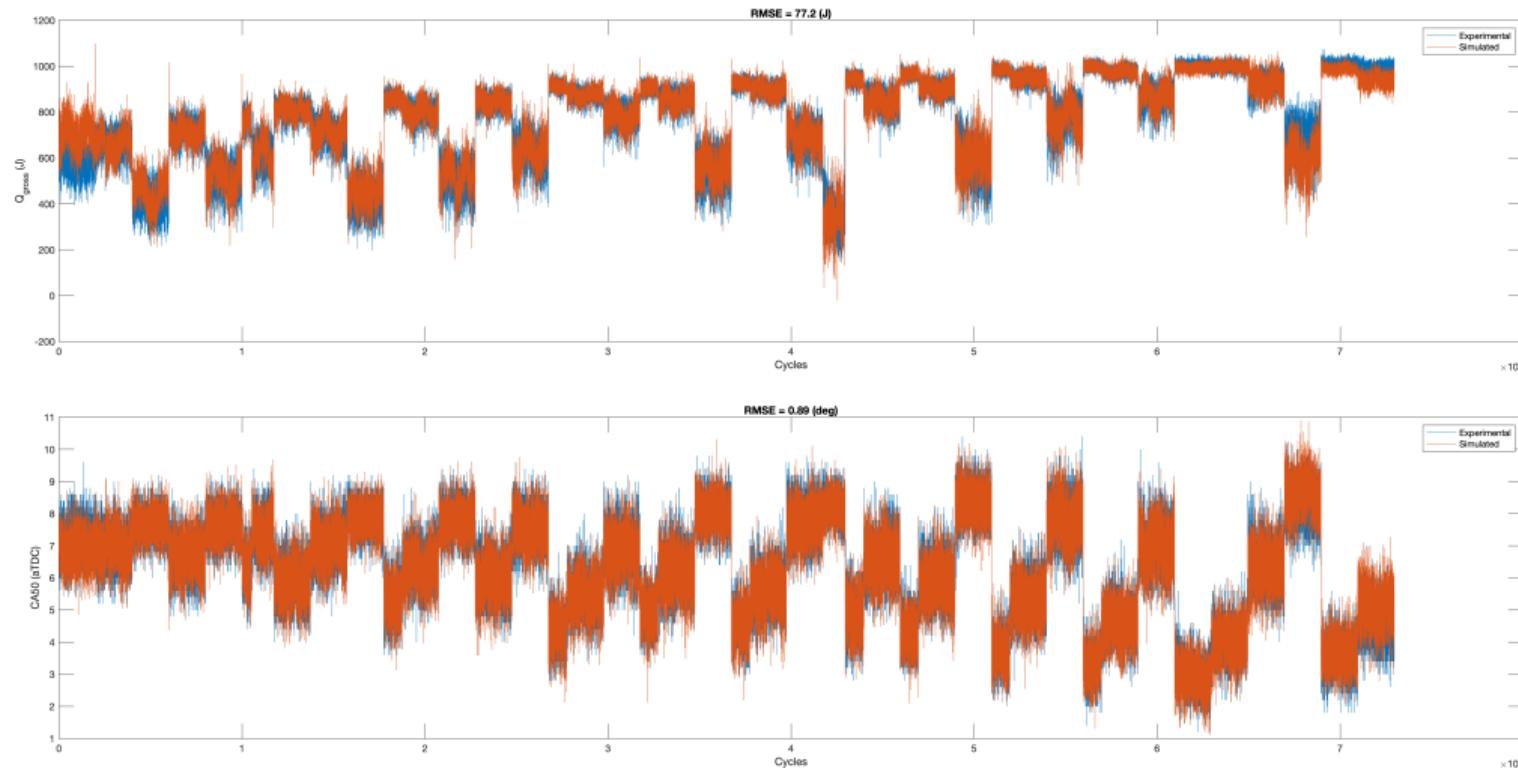
Model parameter μ_X as function of DI strategy



Model parameter Σ_X as function of DI strategy



Model performance



Control diagram

