Nonlinear State Estimation with Examples

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Overview

1. Modified Four Tank System
2. Continuous Stirred Tank Reactor

Modified Four Tank System

We will consider two cases of the modified four tank system:

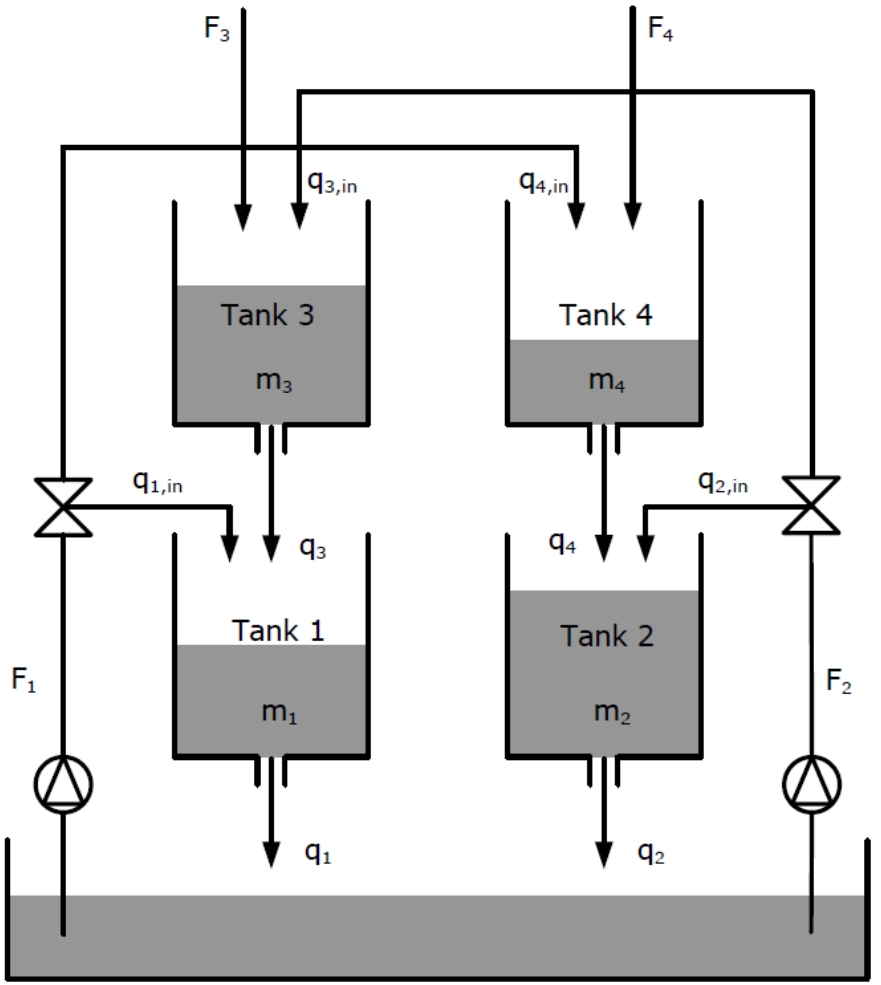
1. Heights in all four tanks are measured.
2. Heights in the two bottom tanks are measured.

In both cases, the disturbances are piece-wise constant functions where each section is normally distributed around the mean

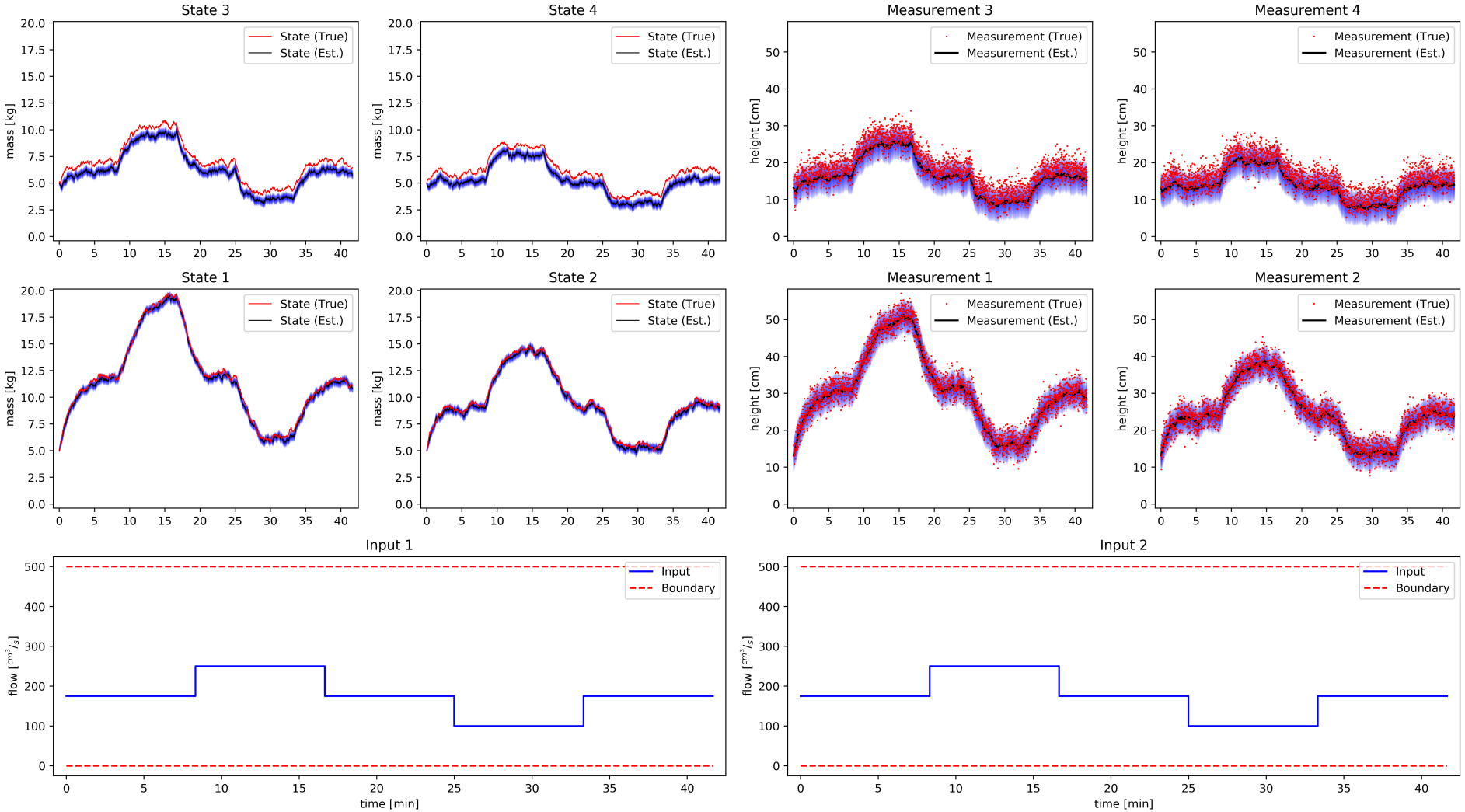
$$\boldsymbol{d}(t) = \begin{bmatrix} \boldsymbol{F}_3(t) \\ \boldsymbol{F}_4(t) \end{bmatrix},$$

where $\boldsymbol{F}_n(t) = \boldsymbol{F}_{n,k}$ for $t_k \leq t < t_k + \Delta t$ and $n \in \{3, 4\}$, where Δt denotes a simulation interval. Each constant section is then drawn from the distribution

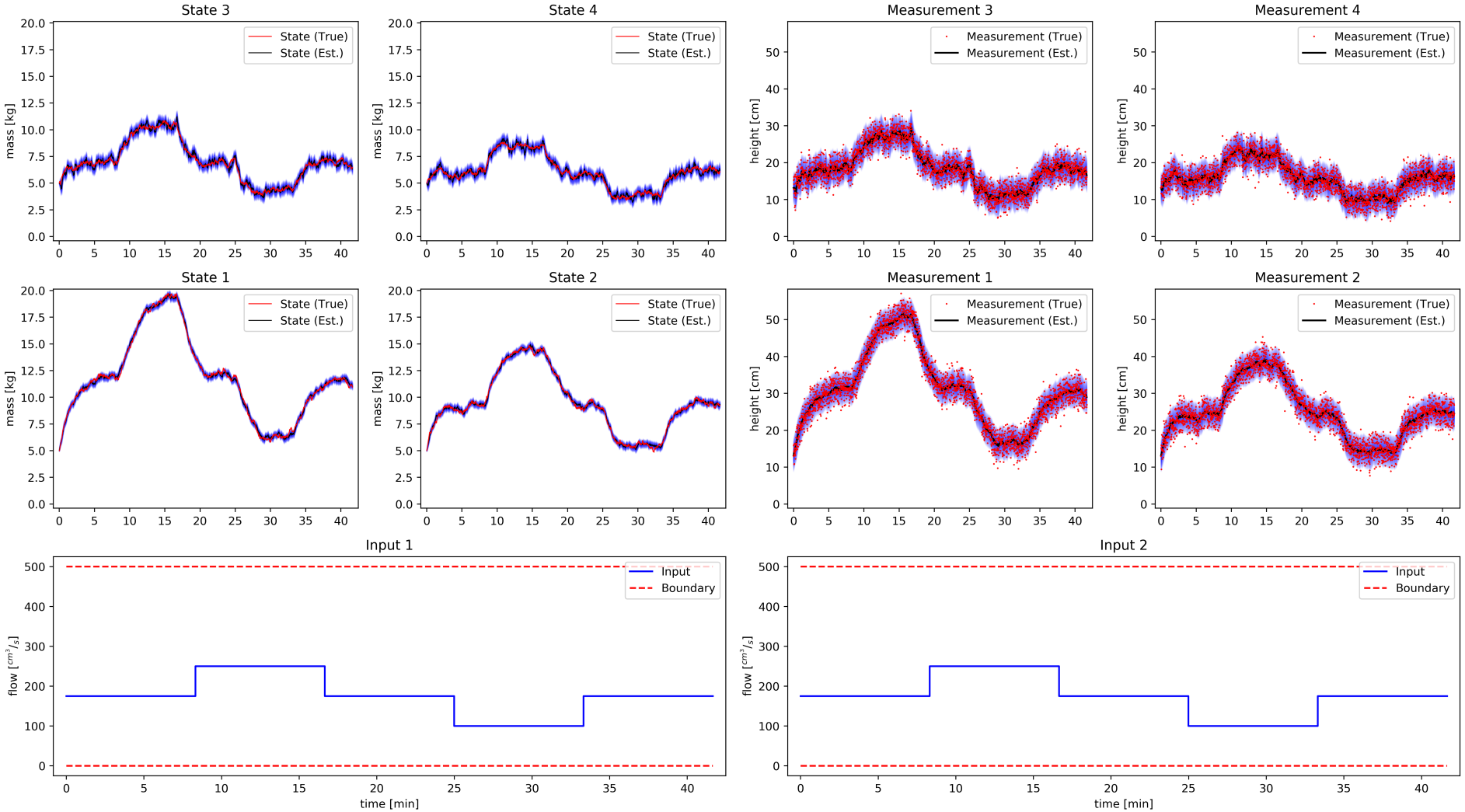
$$\begin{bmatrix} \boldsymbol{F}_{3,k} \\ \boldsymbol{F}_{4,k} \end{bmatrix} \sim \mathcal{N}\left(\begin{bmatrix} \bar{F}_3 \\ \bar{F}_4 \end{bmatrix}, \begin{bmatrix} Q_{F,3} & 0 \\ 0 & Q_{F,4} \end{bmatrix} \right).$$



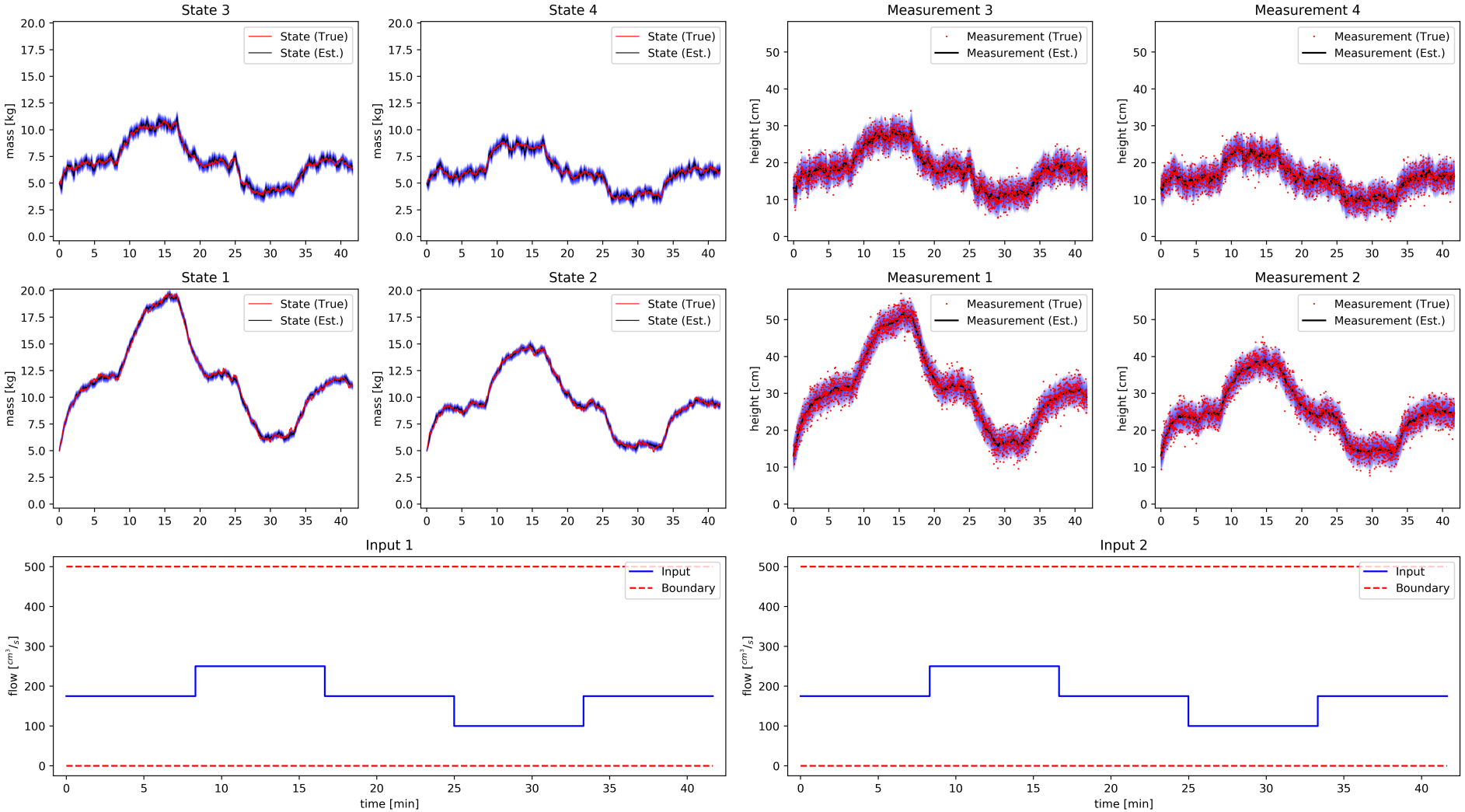
MQTP Case 1: CD-EKF



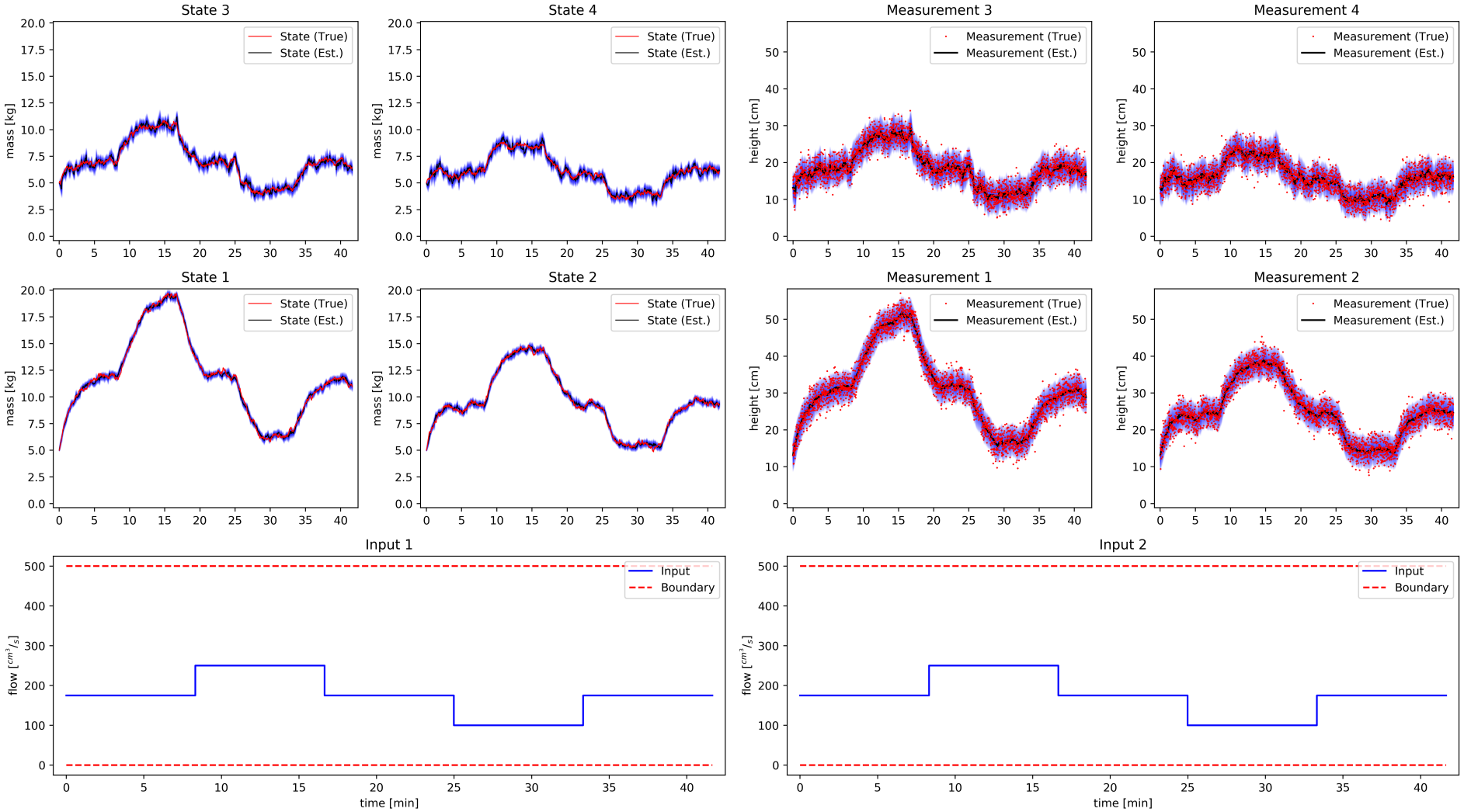
MQTP Case 1: CD-UKF



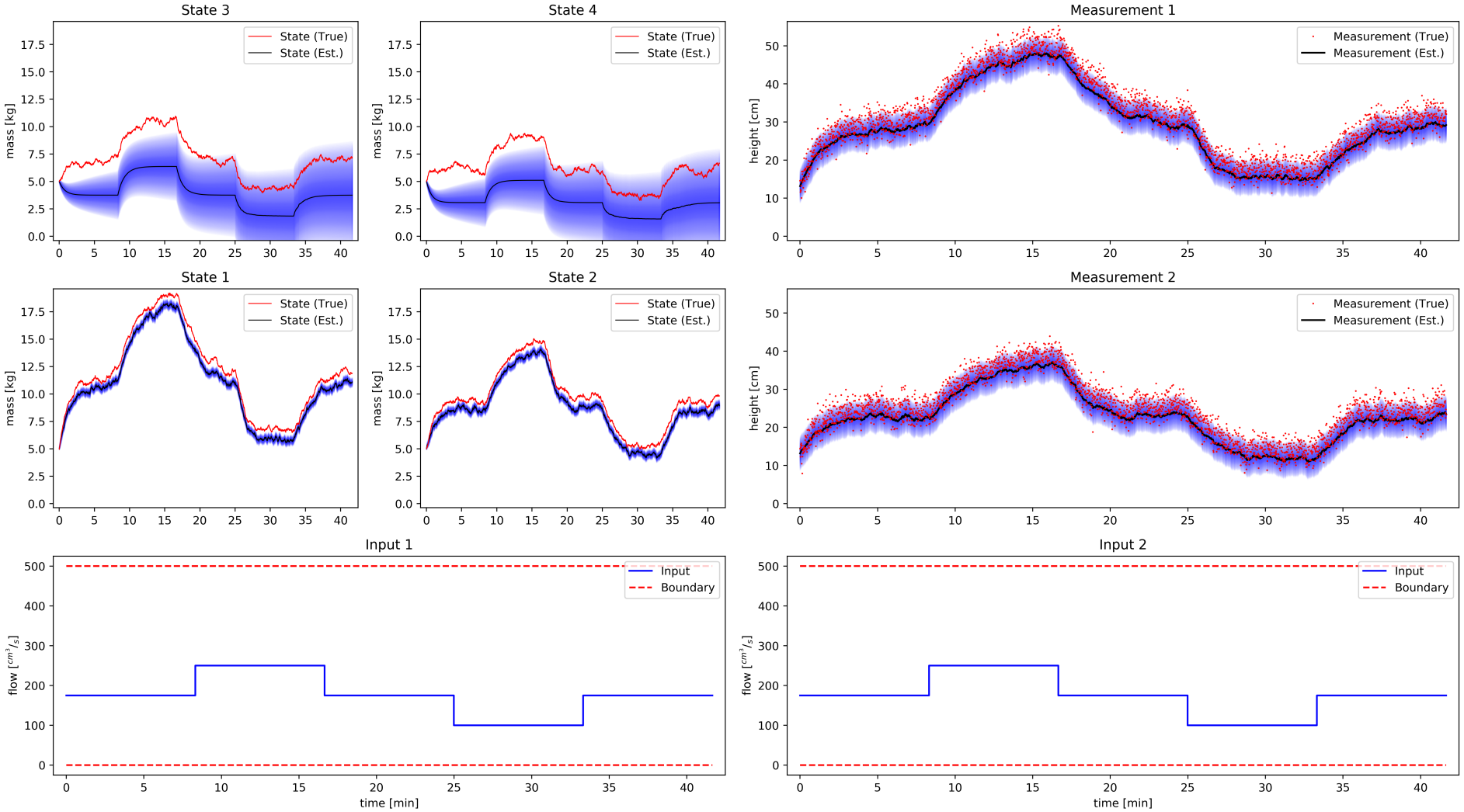
MQTP Case 1: CD-EnKF



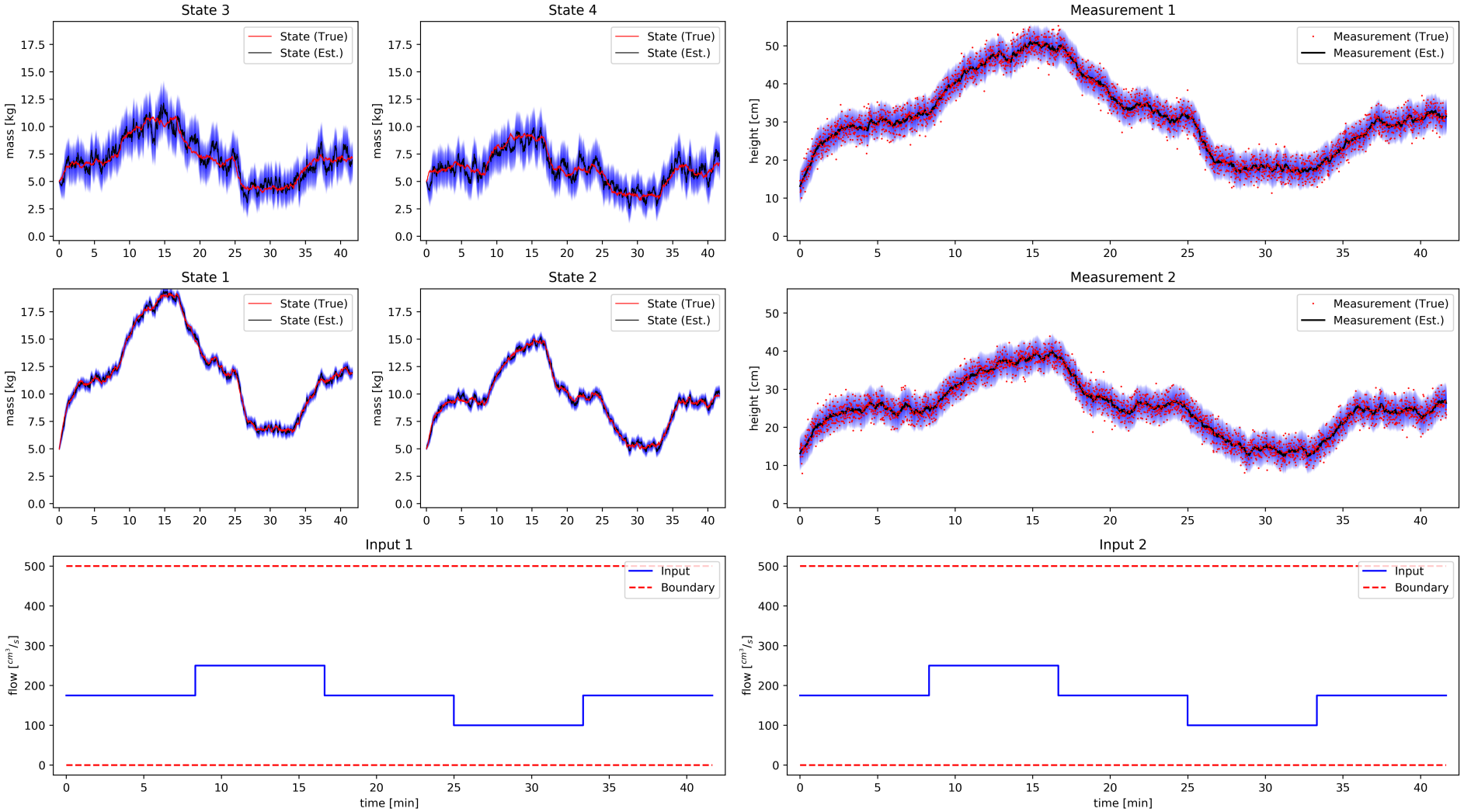
MQTP Case 1: CD-PF



MQTP Case 2: CD-EKF



MQTP Case 2: CD-UKF



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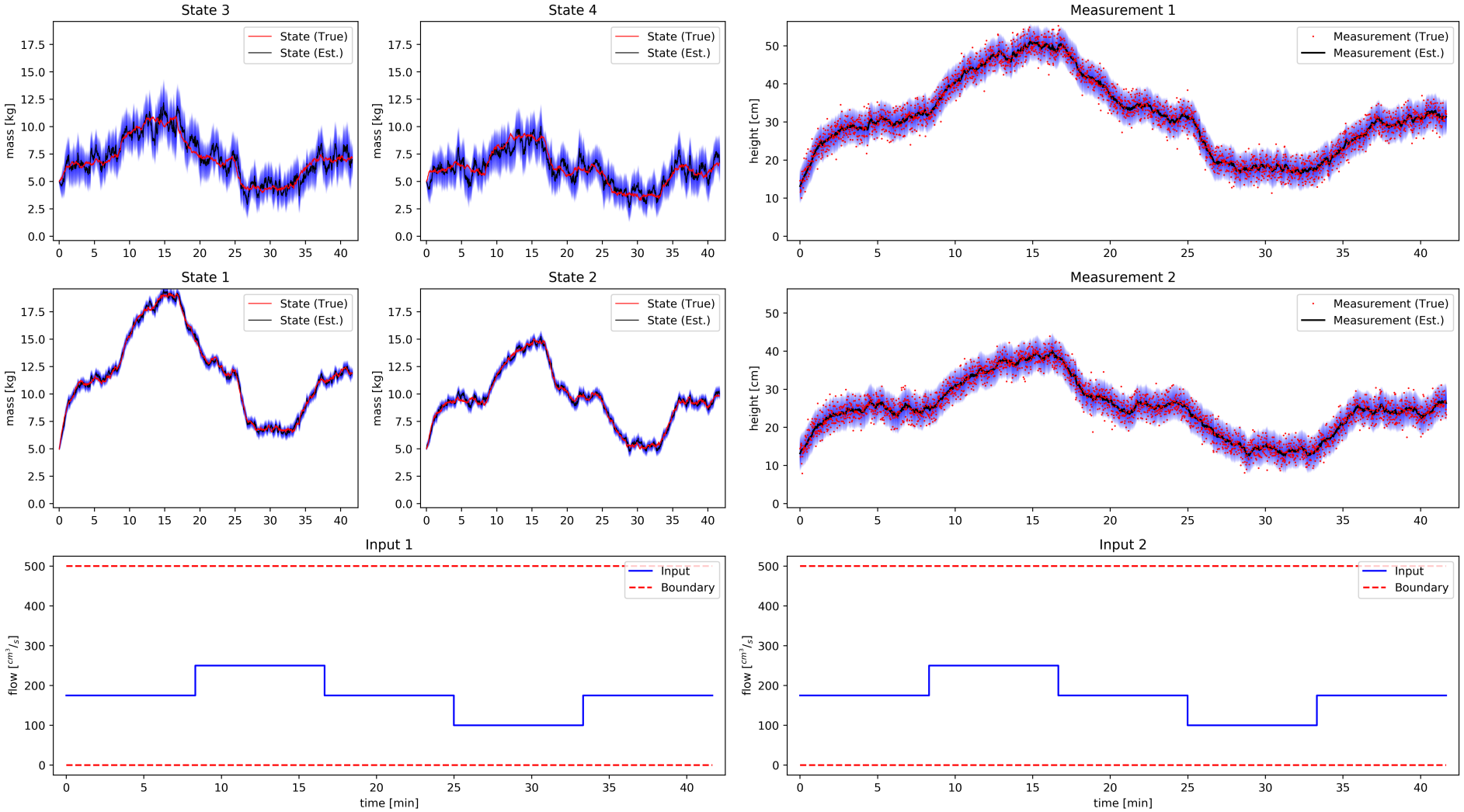
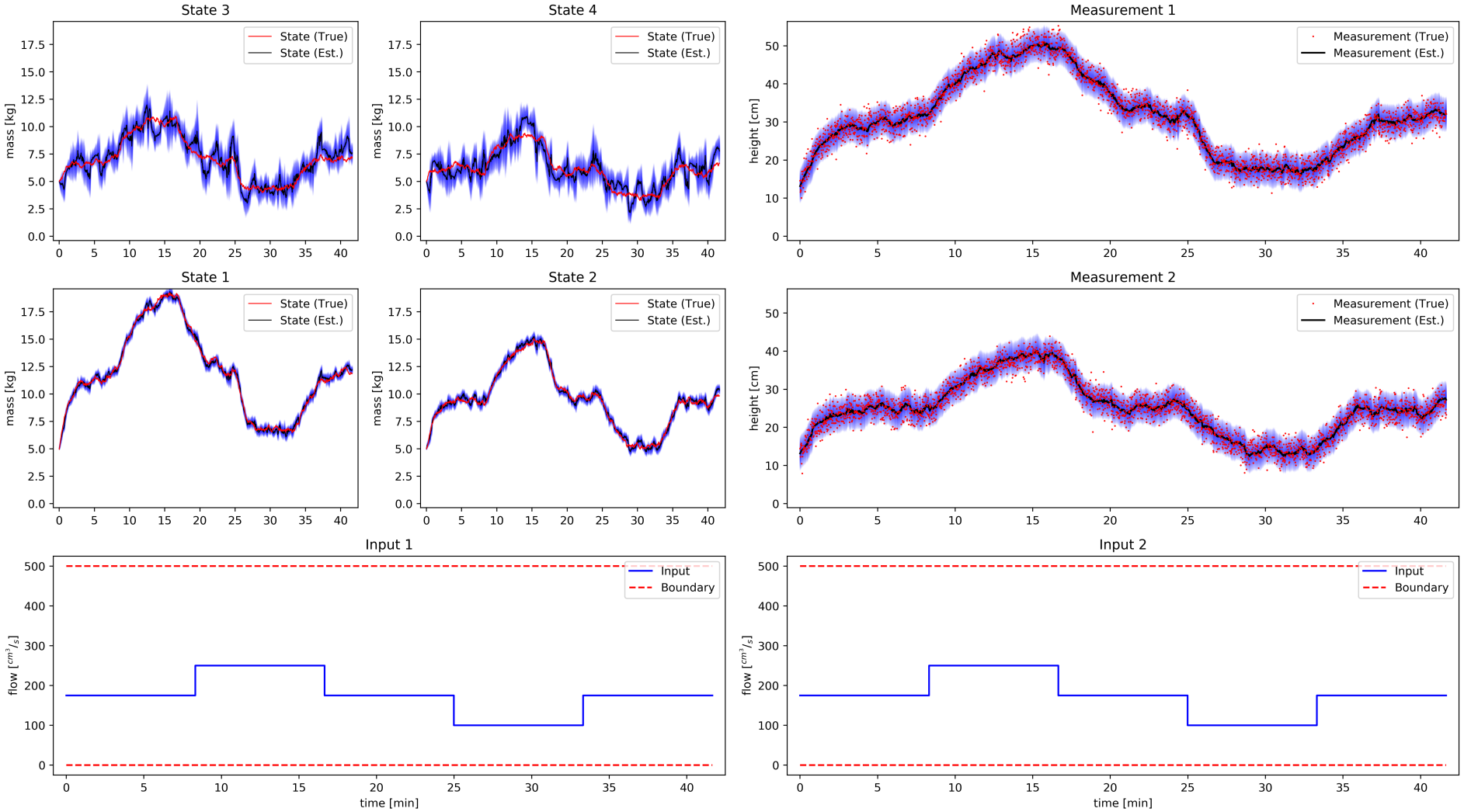
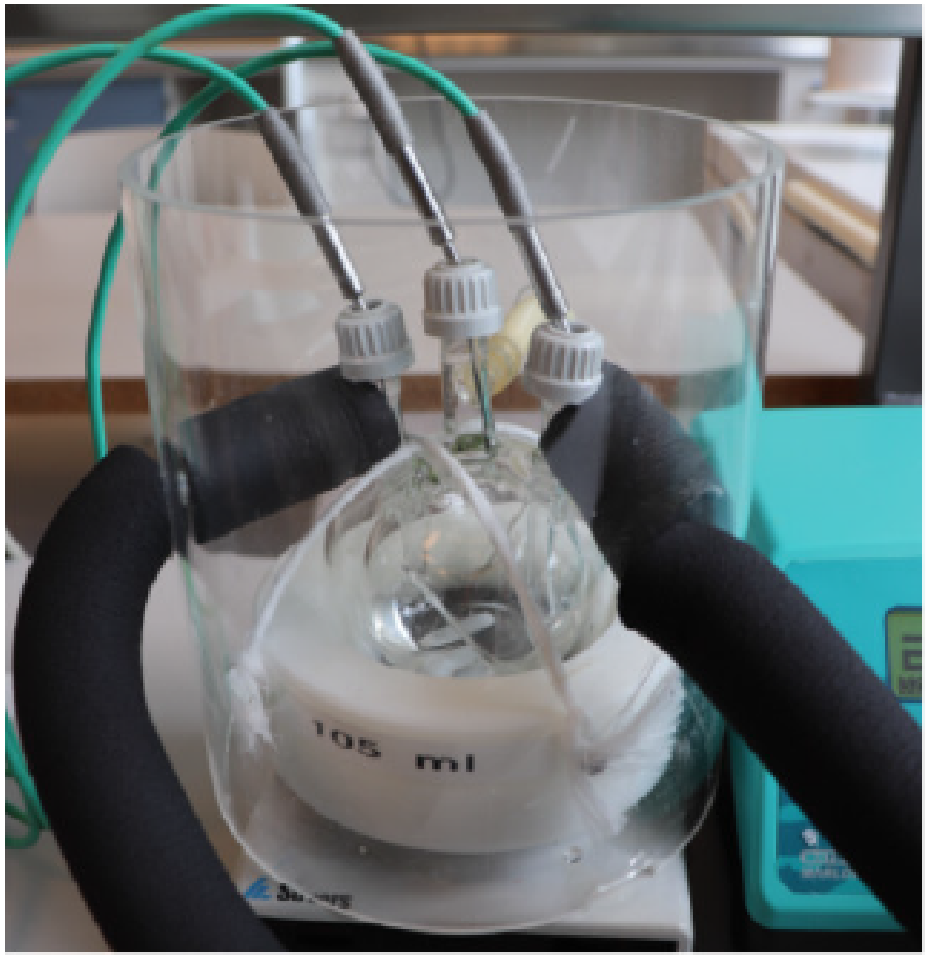


MQTP Case 2: CD-PF

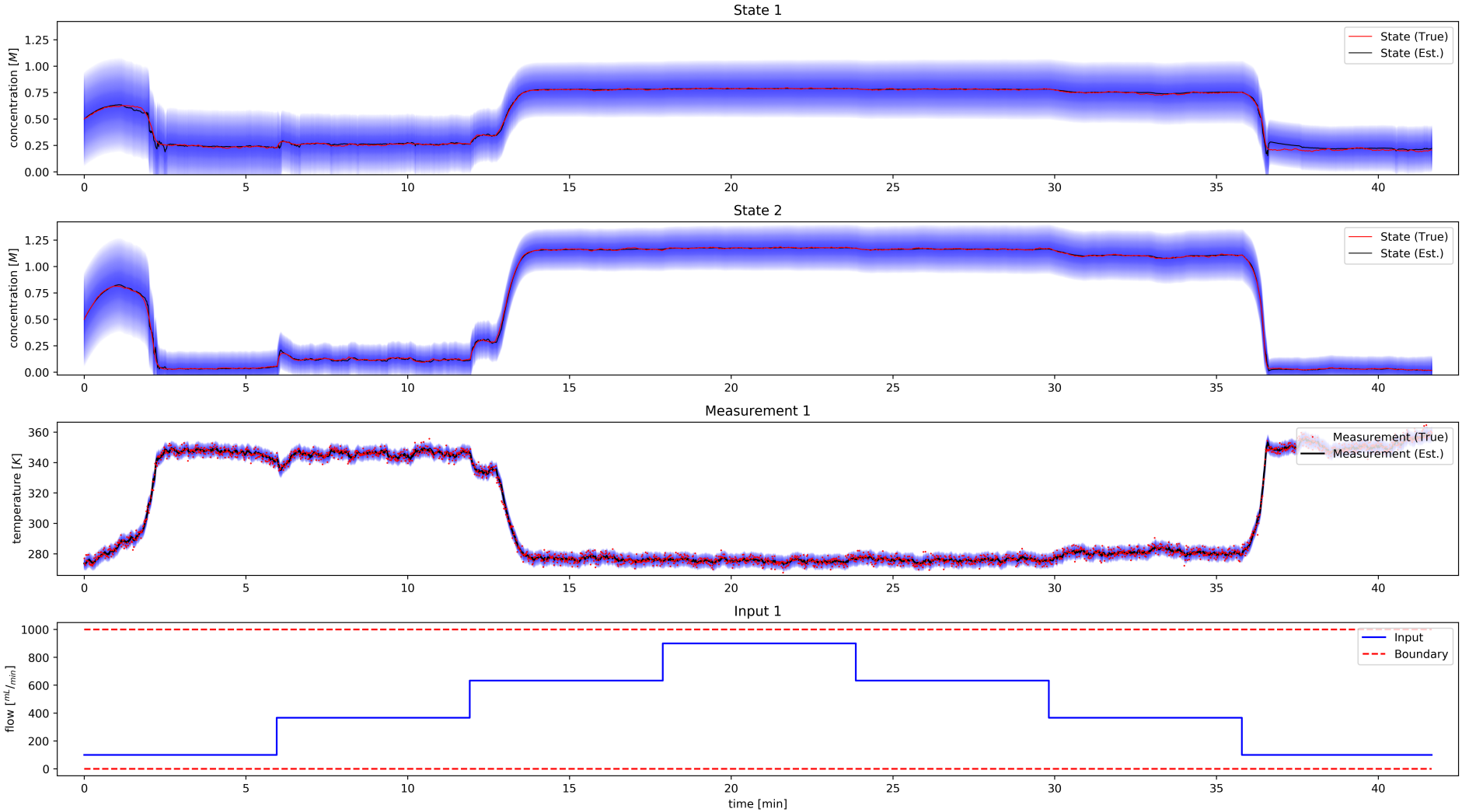


Continuous Stirred Tank Reactor

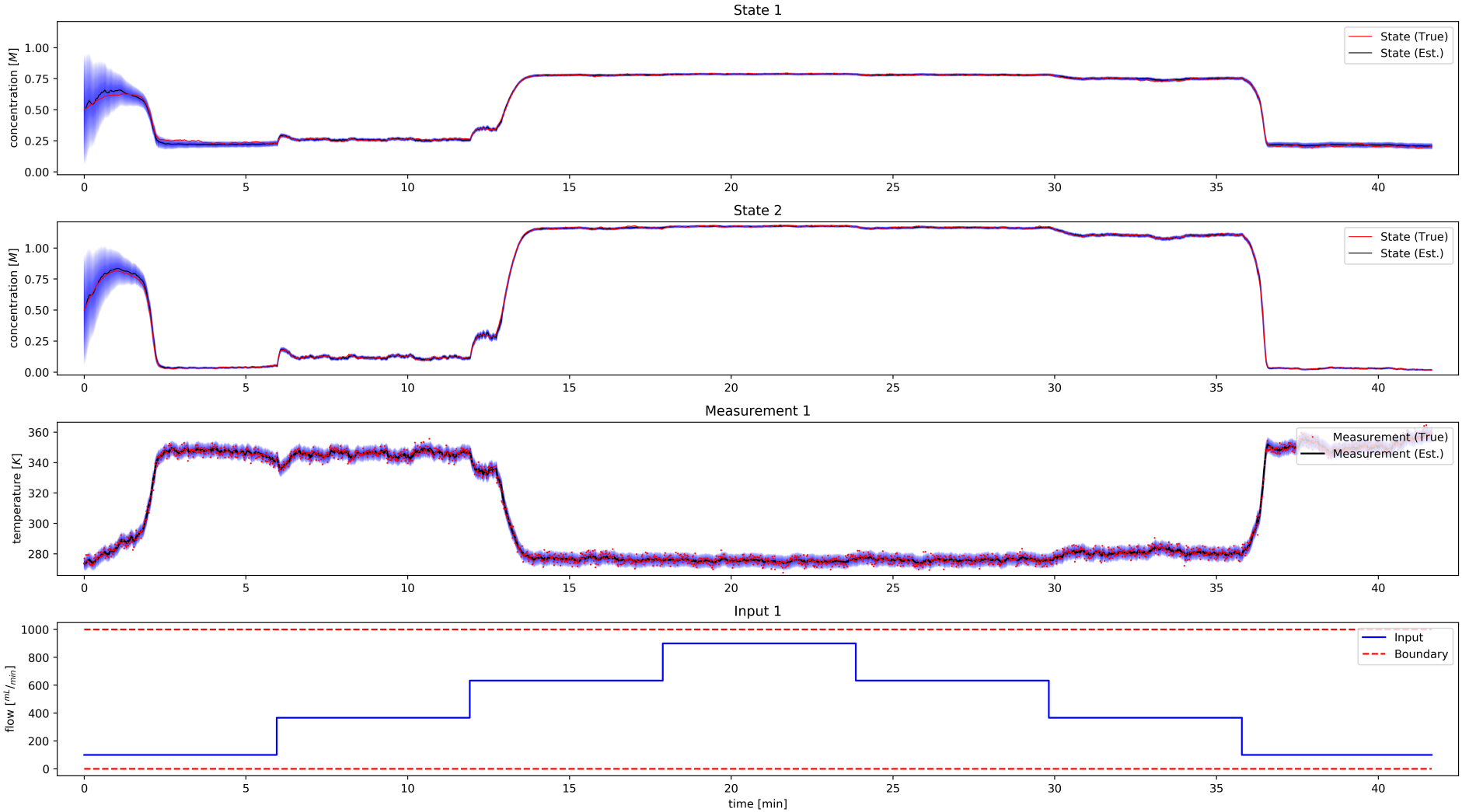
For the CSTR, we consider a case where we measure only the temperature in the reactor. From this measurement, we estimate the concentrations of the two reactants in the system.



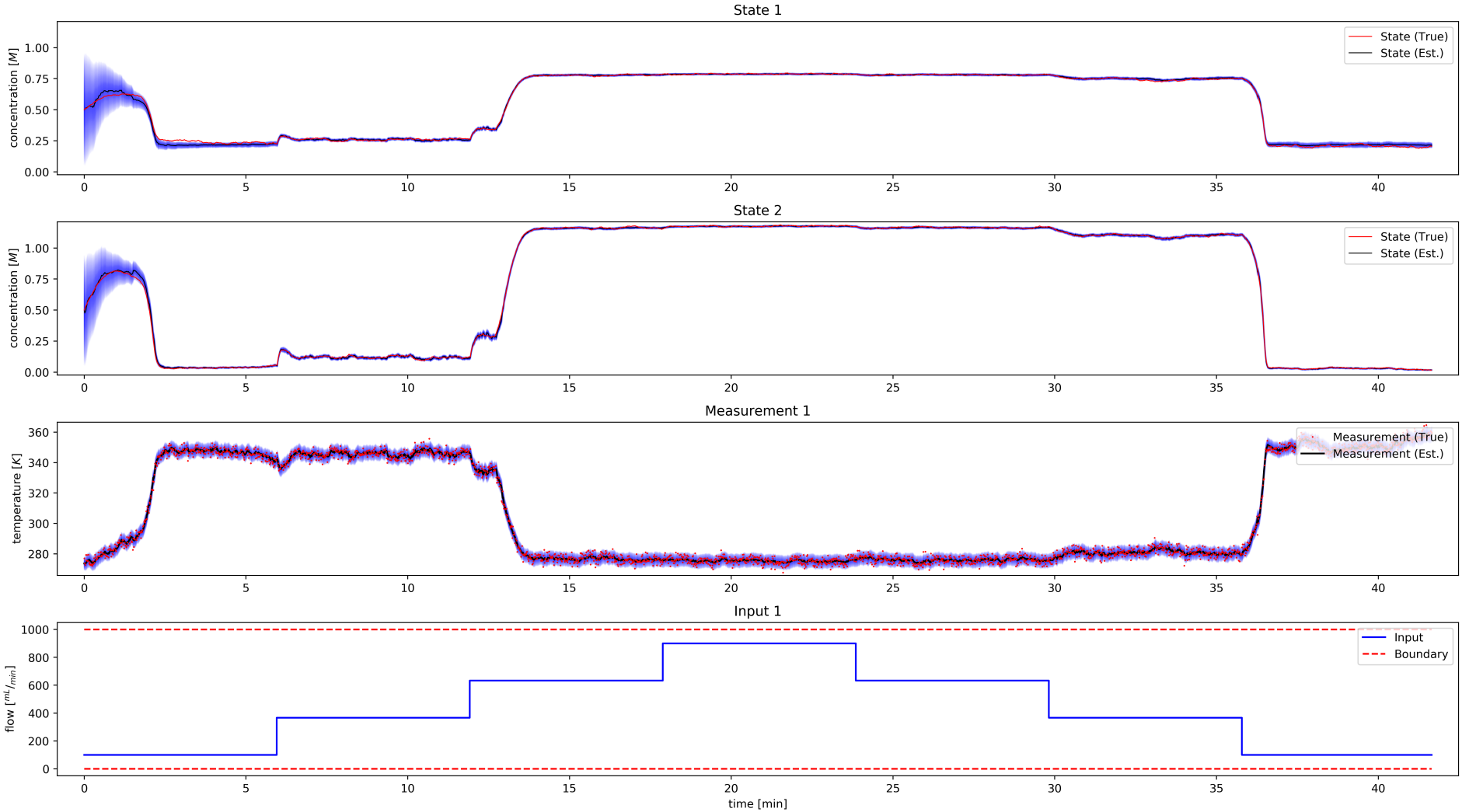
CSTR Case 1: CD-EKF



CSTR Case 1: CD-UKF



CSTR Case 1: CD-EnKF



CSTR Case 1: CD-PF