

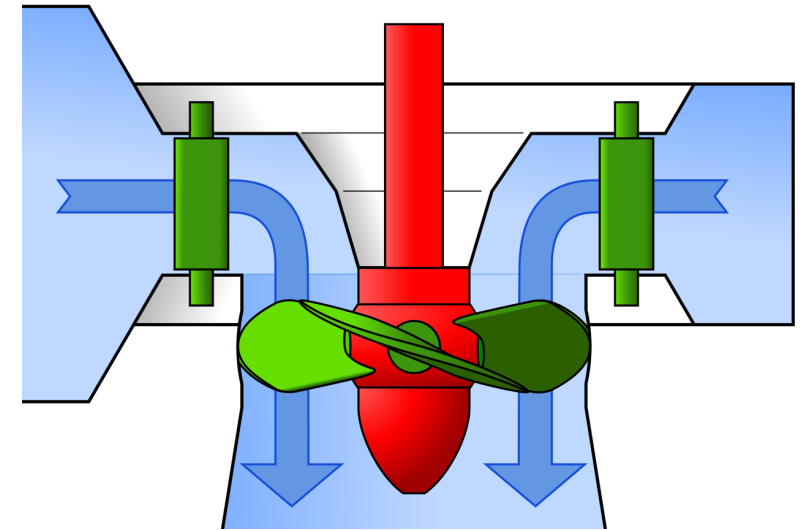
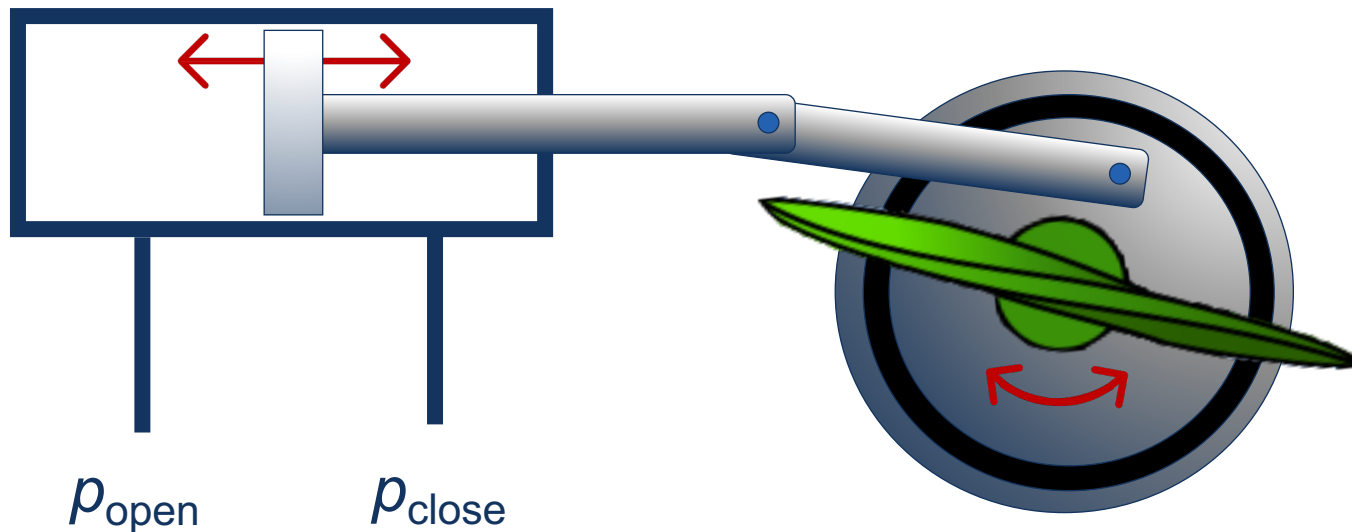
# Friction Monitoring in Kaplan Turbines

SVC FoU-dagar 2024  
Lars-Johan Sandström



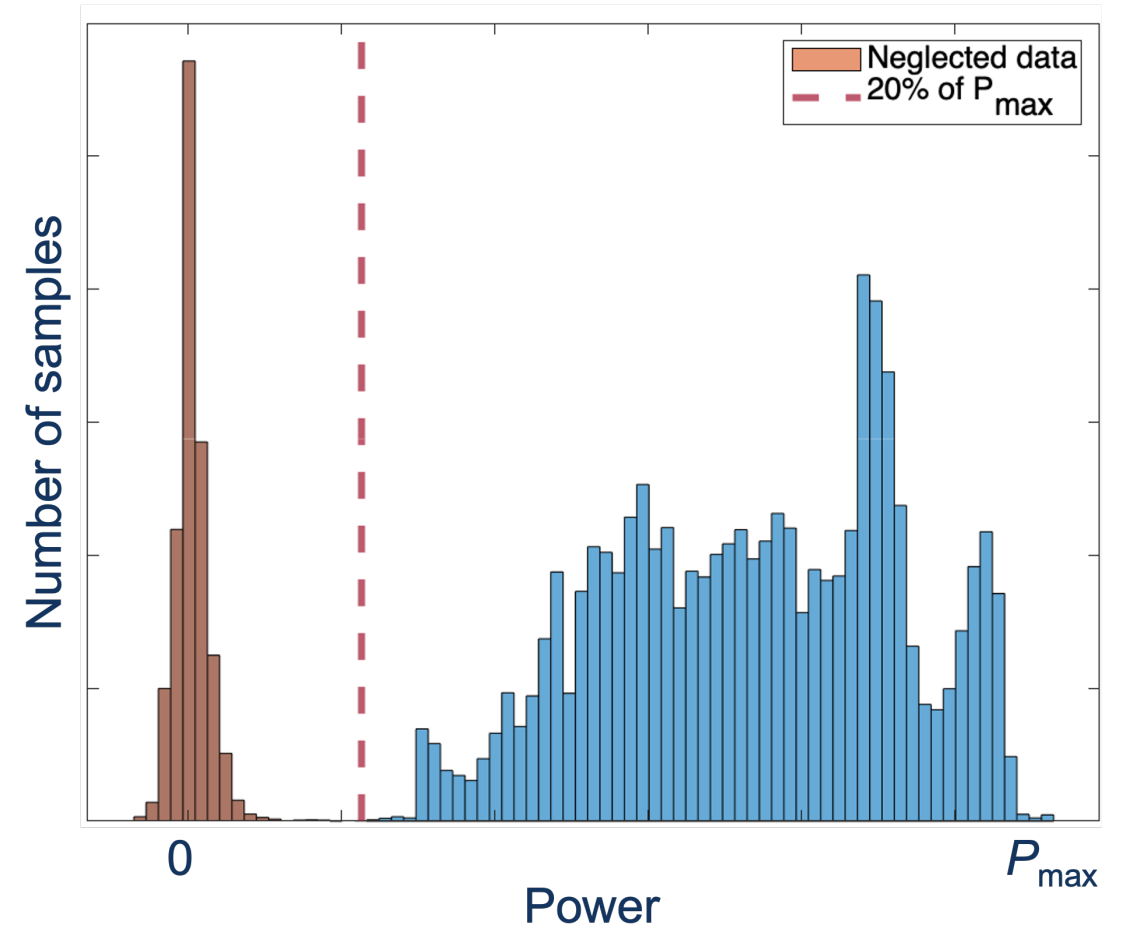
# Radial bearings with increasing friction

- Isolate friction
  - Differential pressure ( $p_{\text{close}} - p_{\text{open}}$ )

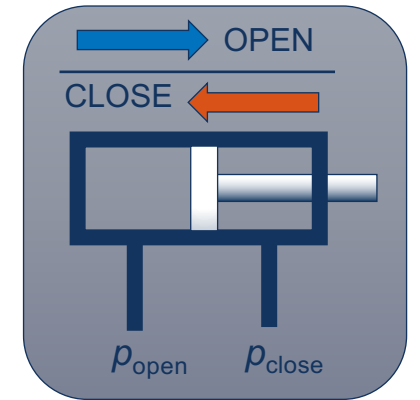
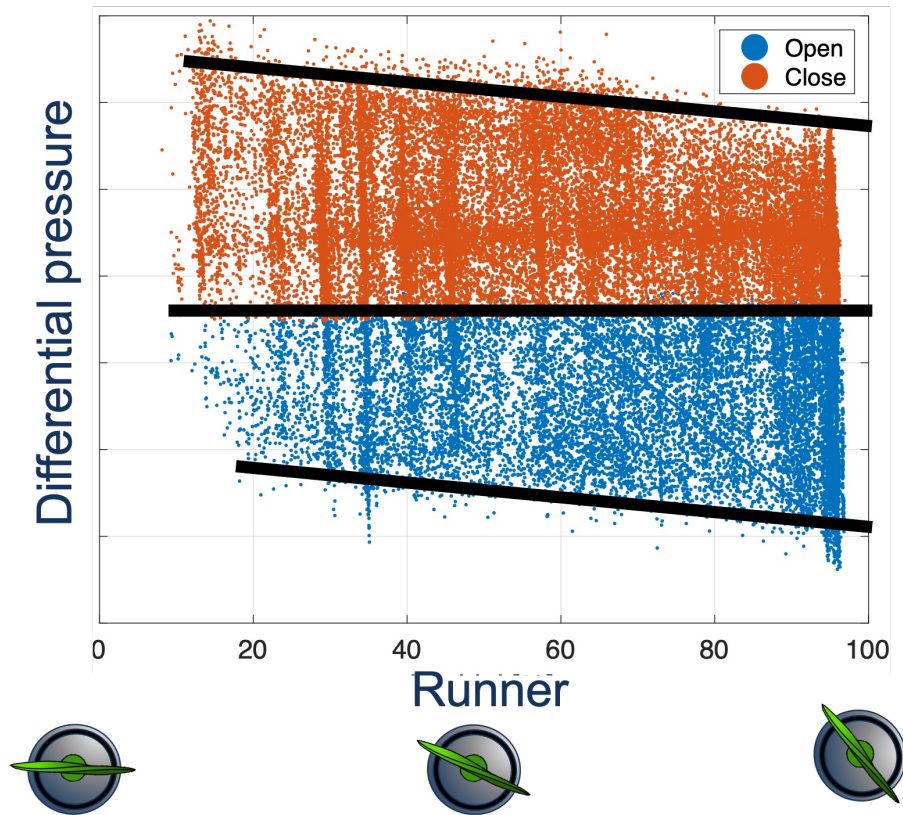


# Power range

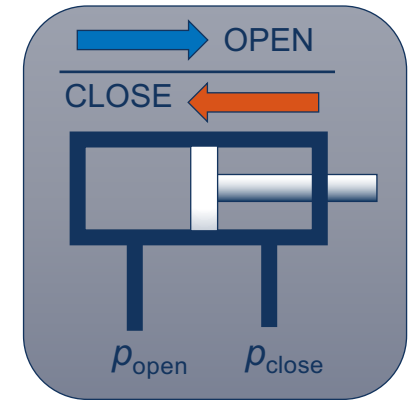
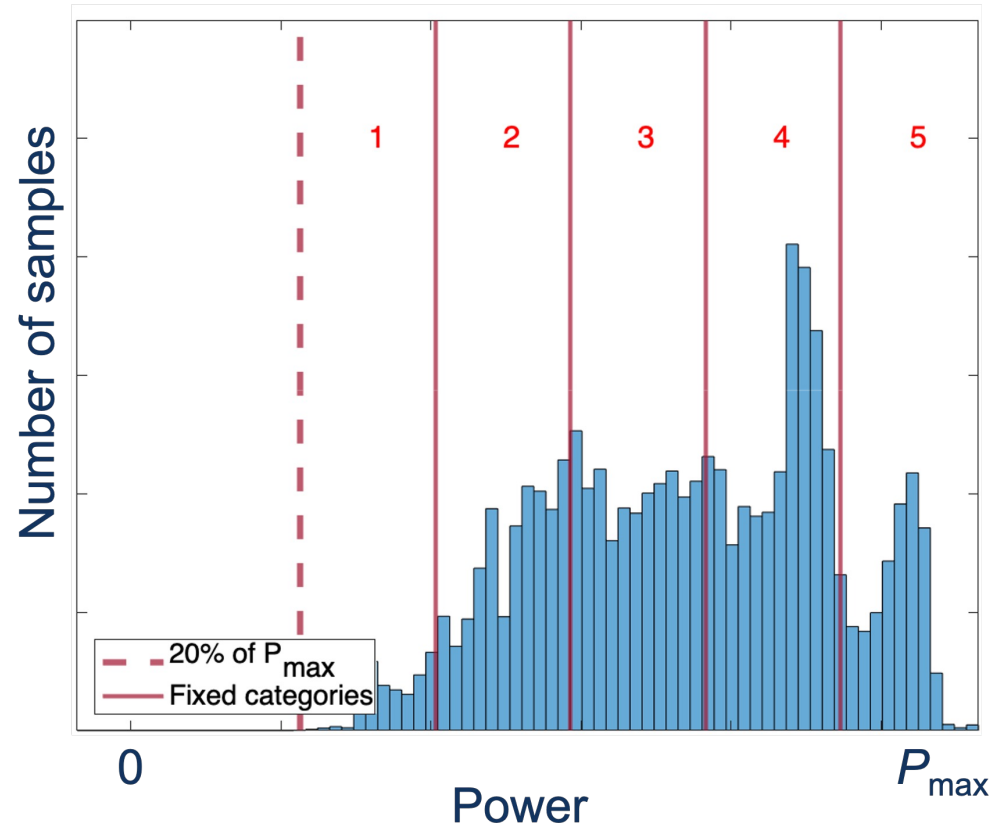
- Data < 20% of max power
  - Start/stop
- Neglect



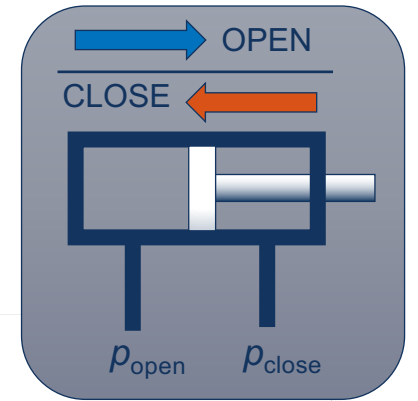
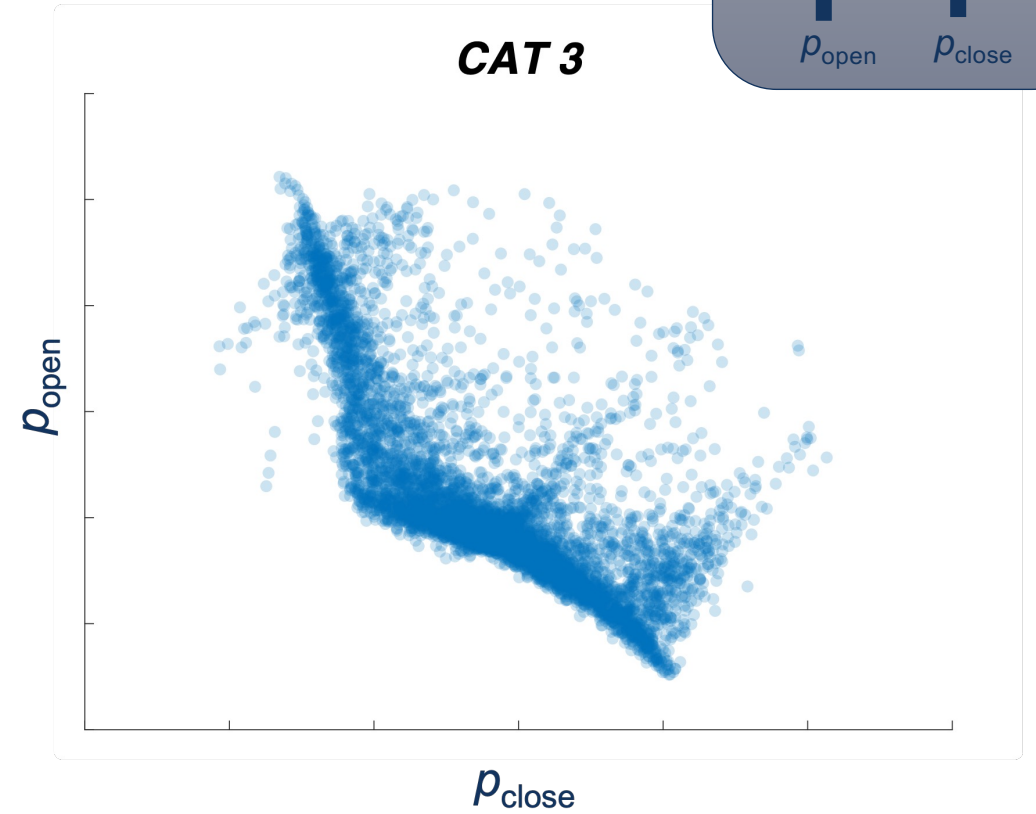
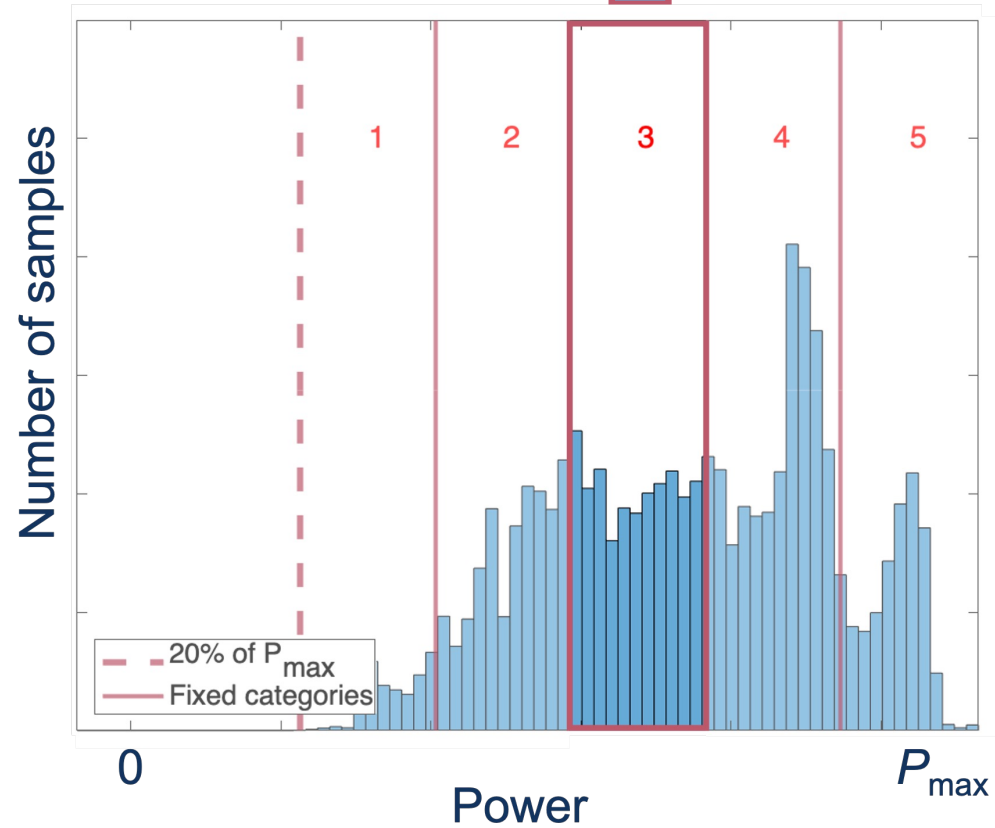
# Differential pressure



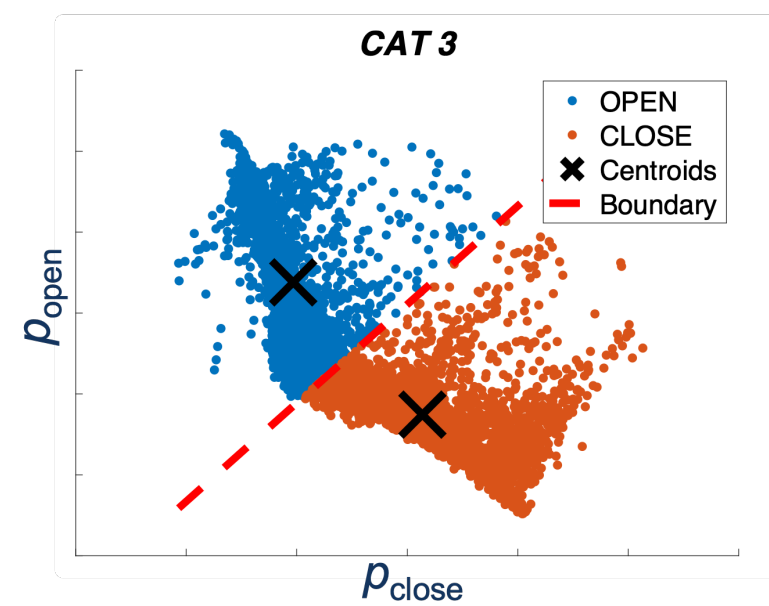
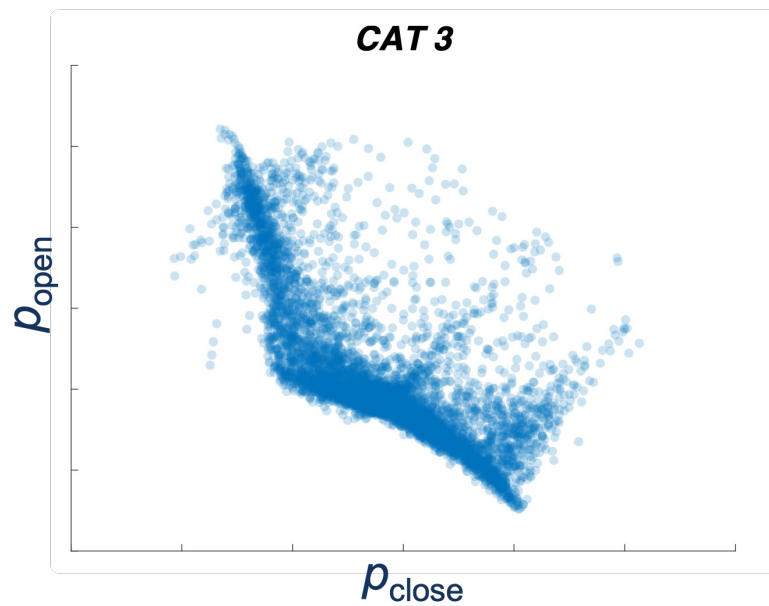
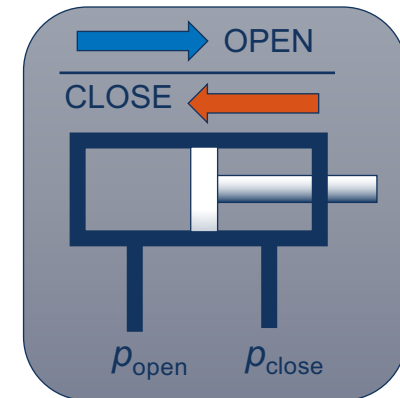
# Power categories



# Power categories

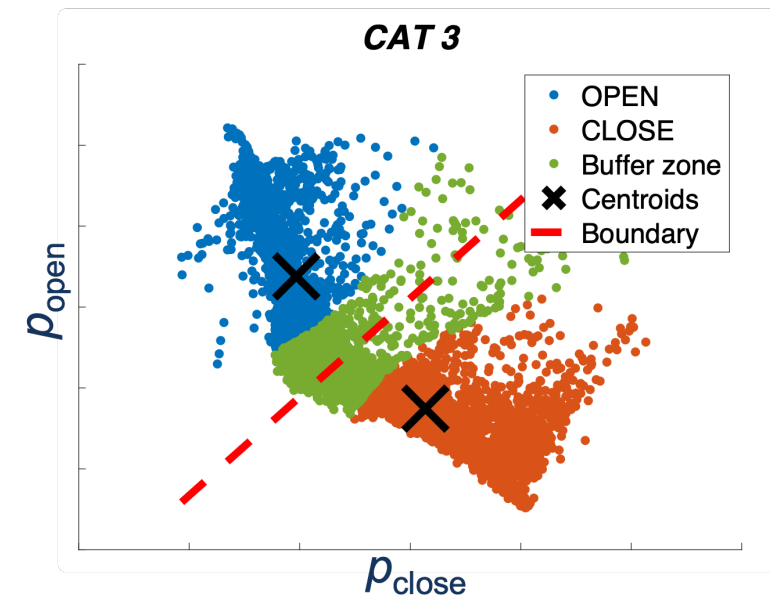
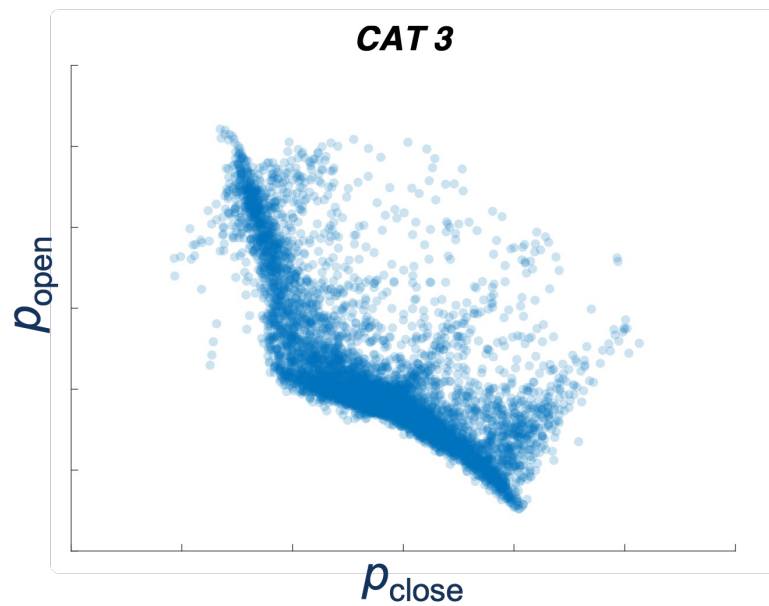
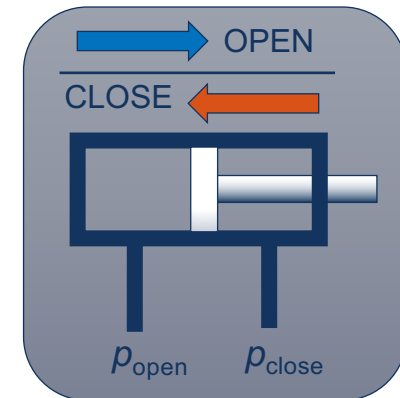


# Open / Close





# Open / Close





# Model

## ■ Data

- Ca. 6 + 6 months
- Frequency:  $T = 10$  min

## ■ Model

- Linear regression

## ■ Input

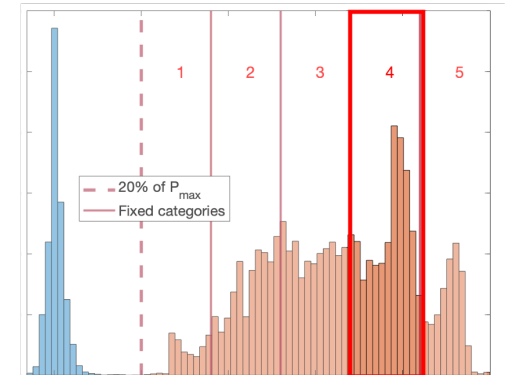
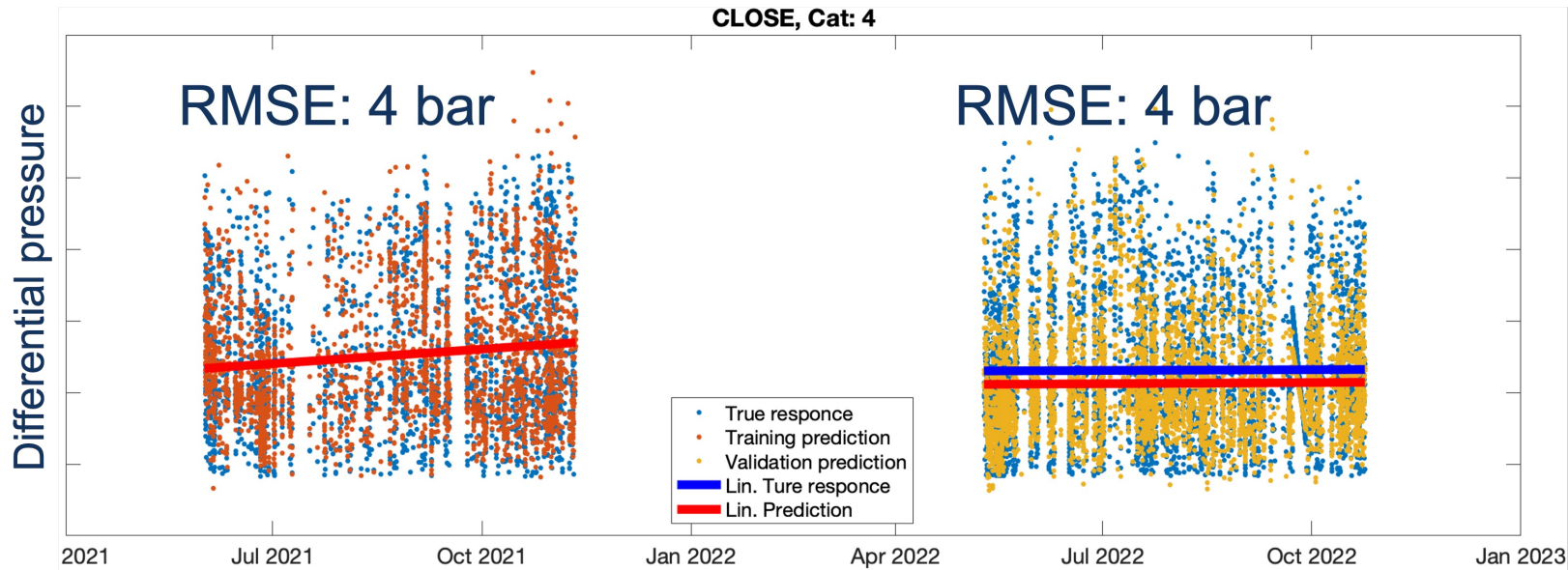
- Time
- Runner blades
- Guide vanes
- Hydraulic system pressure
- $\text{cof} = p_{\text{close}} / \text{Power}$

## ■ Output

- Differential pressure

# Model, CLOSE

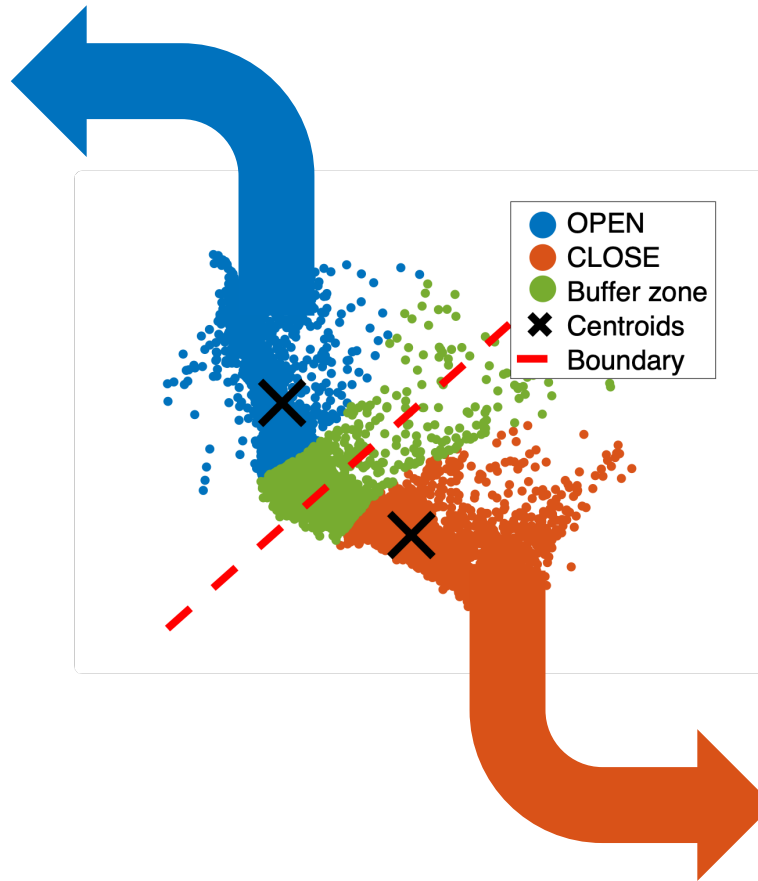
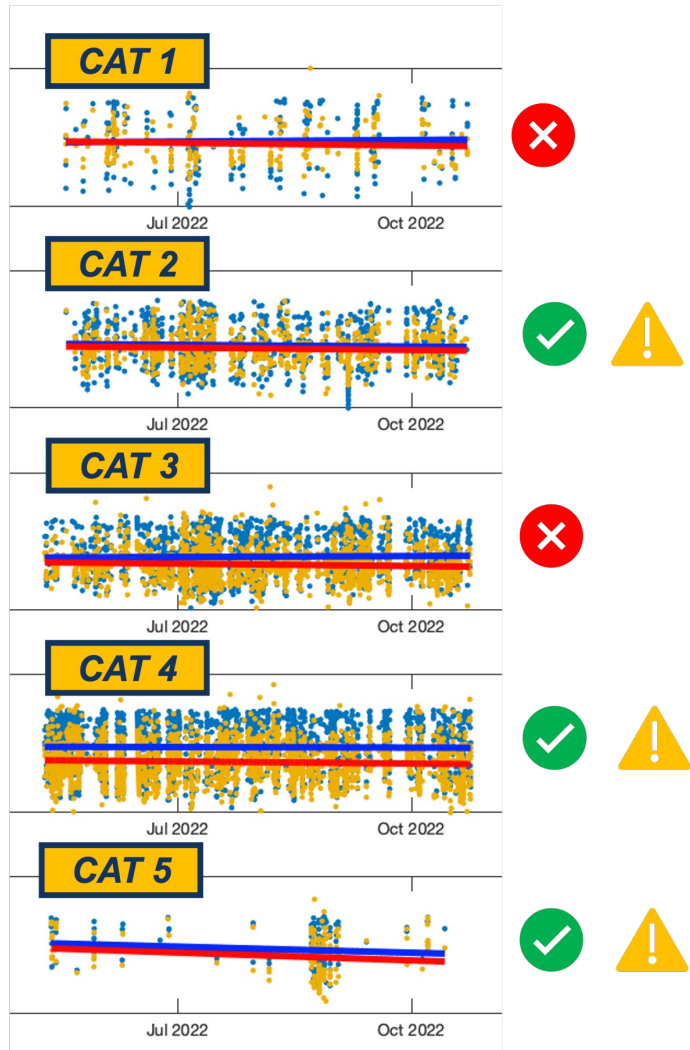
Differential pressure,  $(\rho_{\text{close}} - \rho_{\text{open}})$



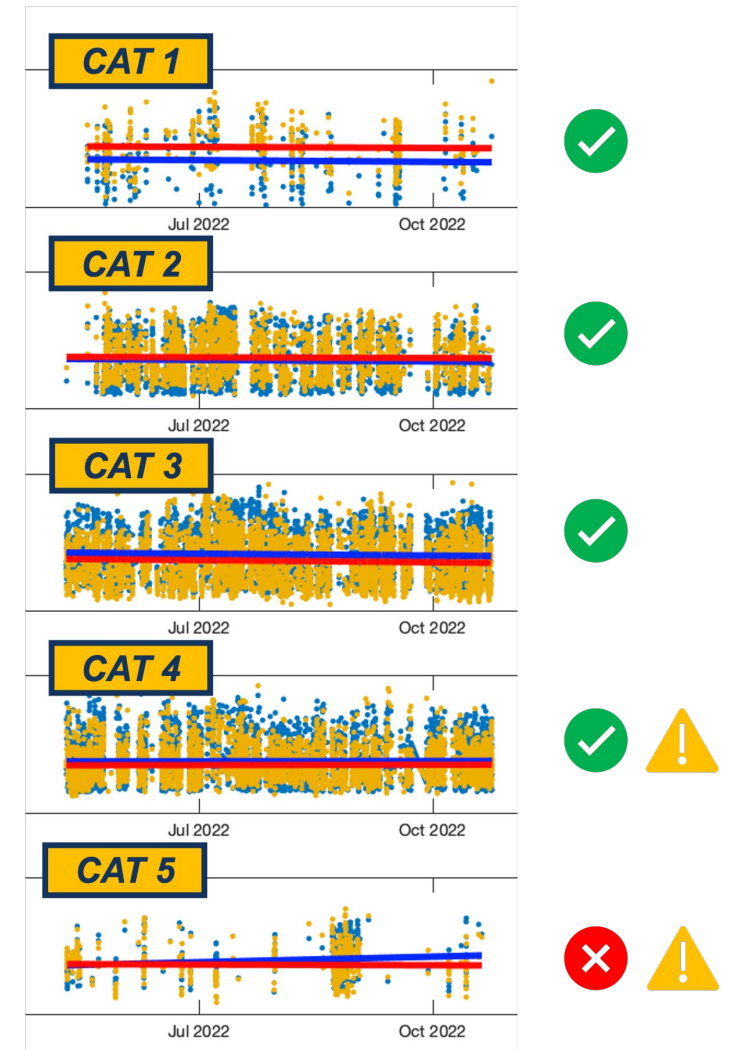
Reality:  $\Delta = 0.2$

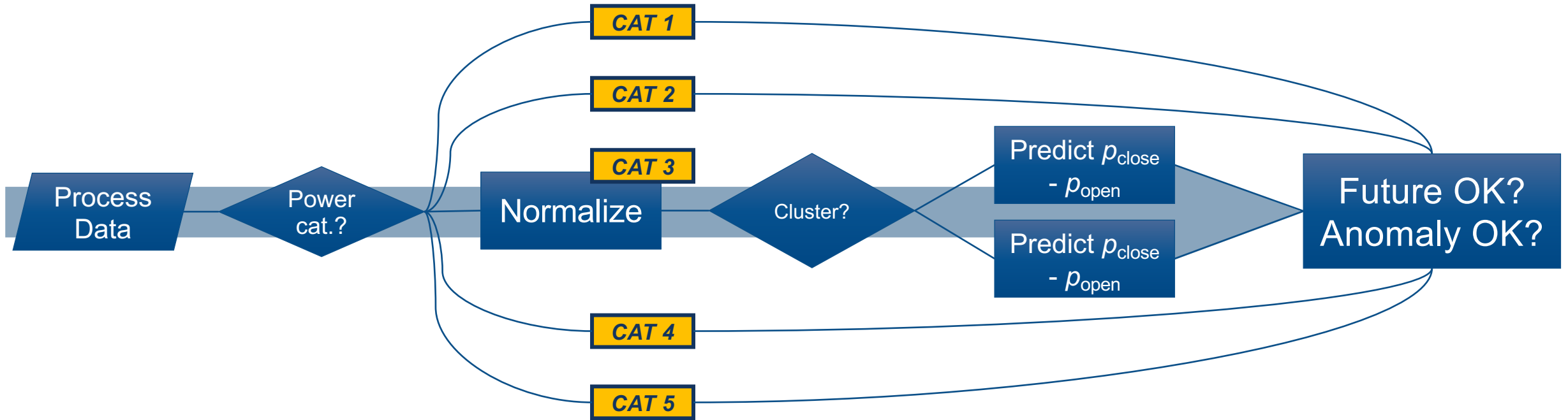
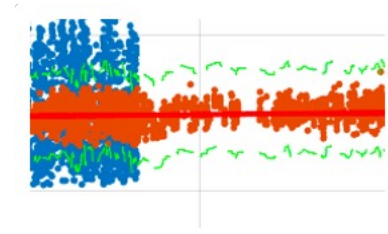
Model:  $\Delta = 0.3$

# OPEN



# CLOSE





# Kaplan runner friction

- Behavioral changes
  - Changing differential pressure
  - Predict future pressure
  - Working regime



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