MPC Robustness Demo

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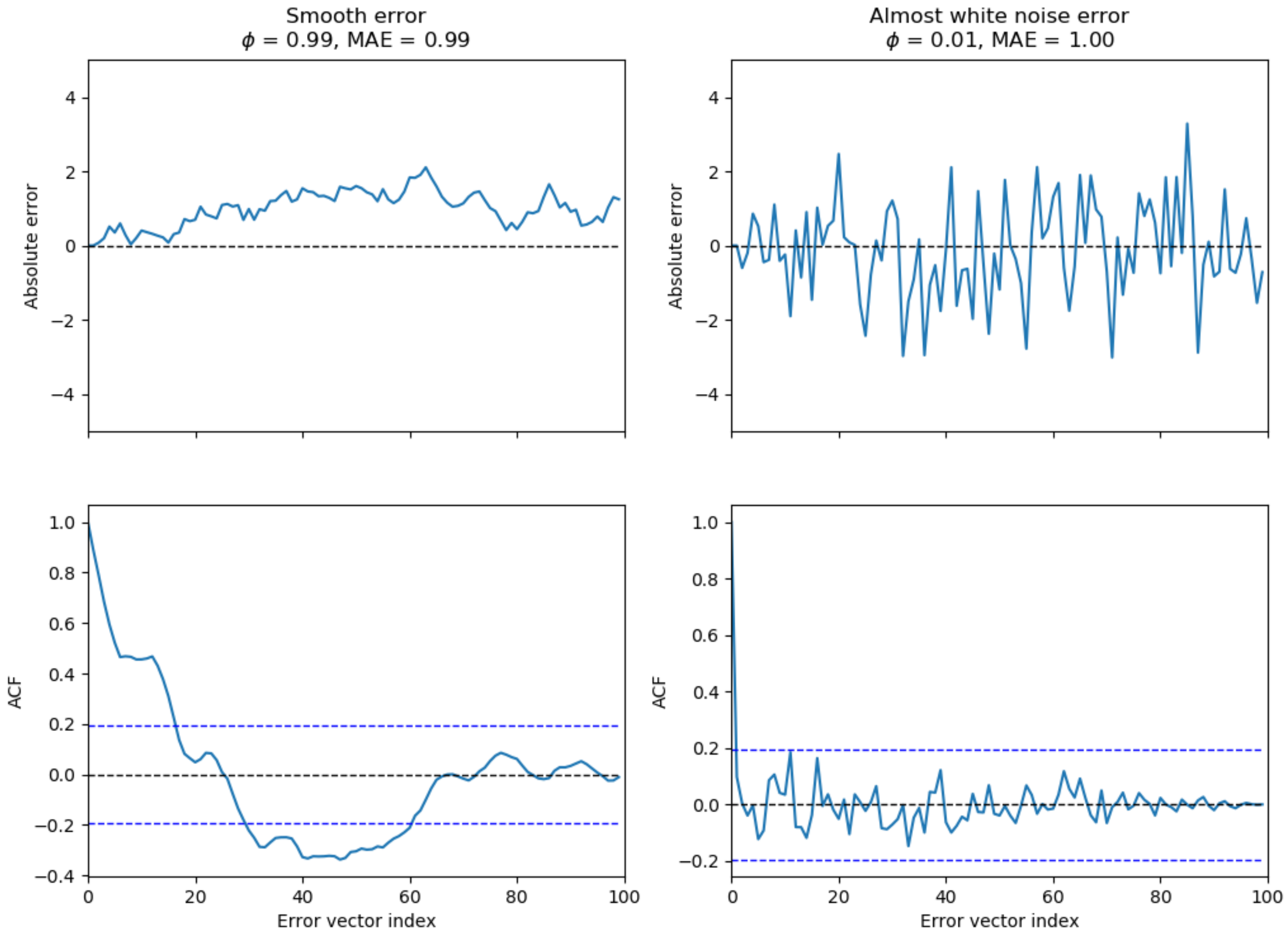
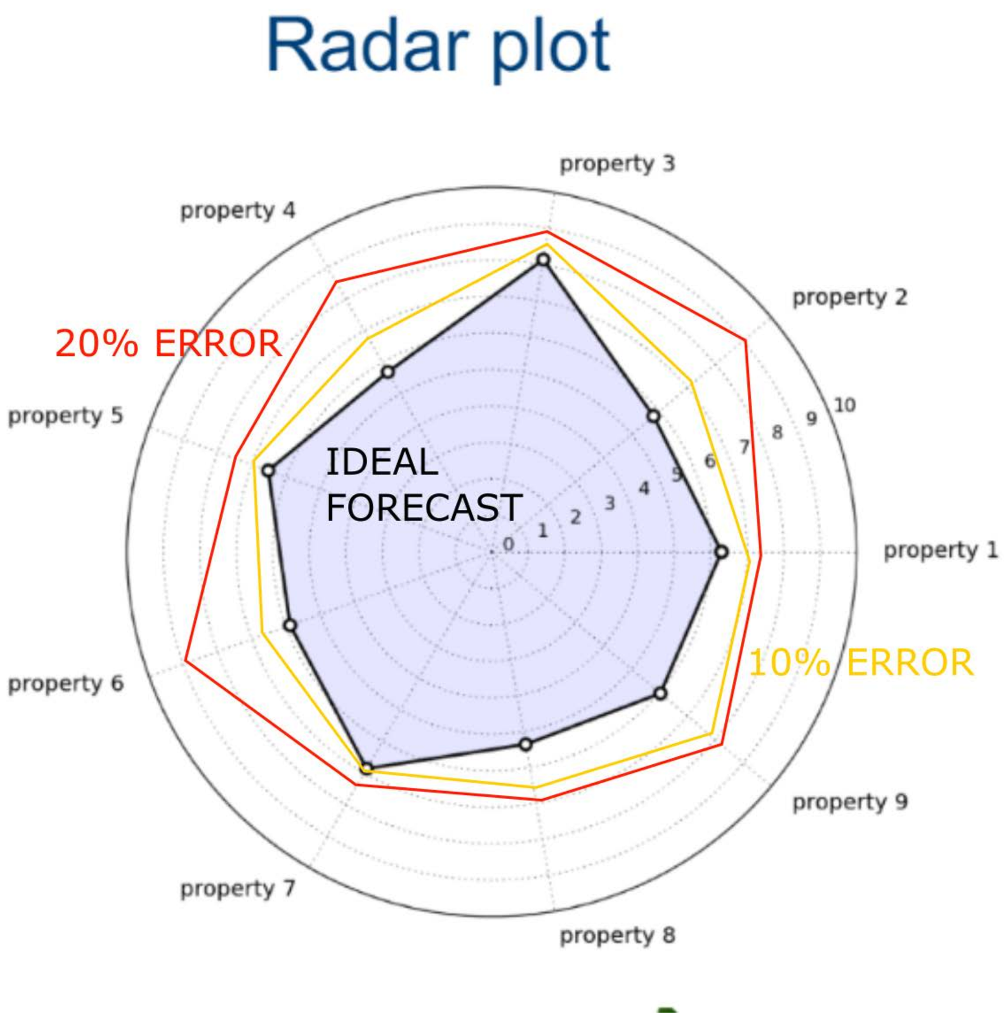
Python Package

- https://github.com/krzysztofarendt/forecast-gen

- Function generating error signals:
  - controllable autocorrelation
  - controllable mean absolute error (MAE)
  - controllable length (number of elements in a vector)



Integration With KPIs: Concept



Demo Case

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- R1C1 model calibrated to a thermal zone in the OU44 building (SDU Campus, Odense, Denmark)
- Controllable input: - heating/cooling signal *u*
- Objective: - minimize energy consumption
- Constraints:
  - indoor temperature stay within (T_{min}, T_{max})
  - *u* within (-100, 100)
- Prediction horizon: - 6h
- MPC solver: - multiple shooting method, https://github.com/sdu-cfei/mshoot, paper presenting the solver accepted to BS2019
- Control model using inaccurate forecasts for outdoor temperature, solar radiation, and occupancy

Demo Case

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Optimization problem:

$$\arg\min_{\boldsymbol{u}} \sum_{i=1}^{N} q_i^2$$

s. t.

$$T_{min,i} < T_i < T_{max,i}$$

$$-100 < u_i < 100$$

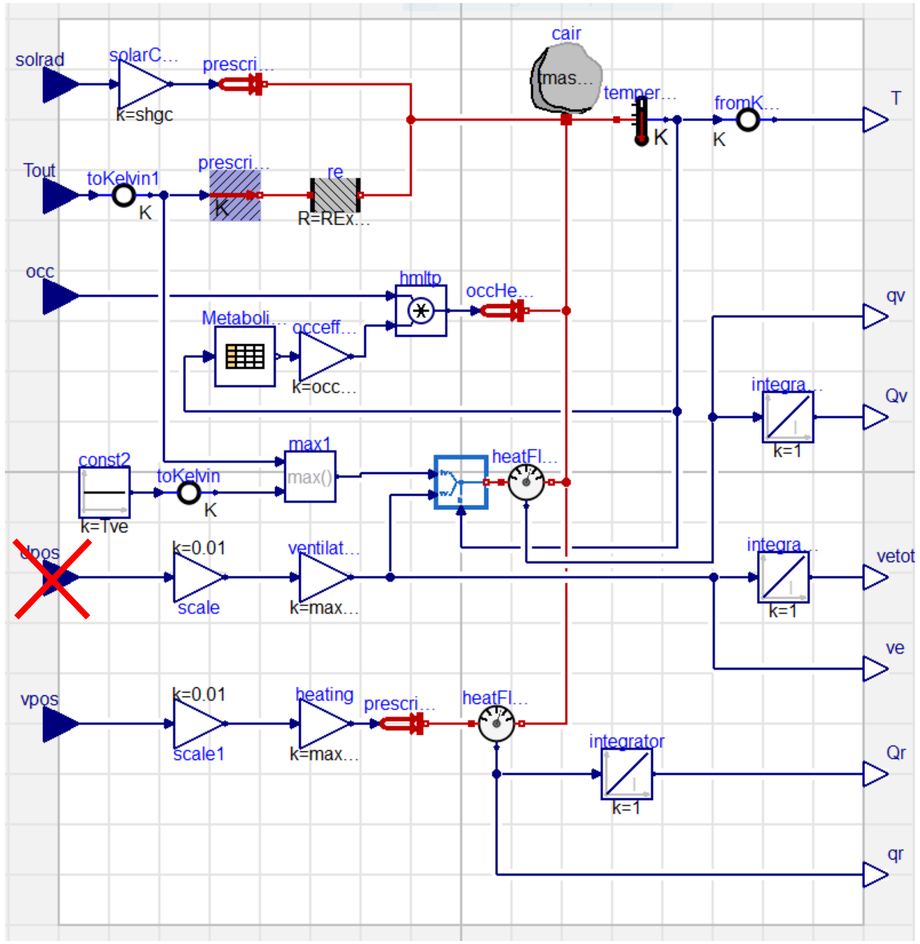
q_{sol}

T_{out}

n_{occ}

not used

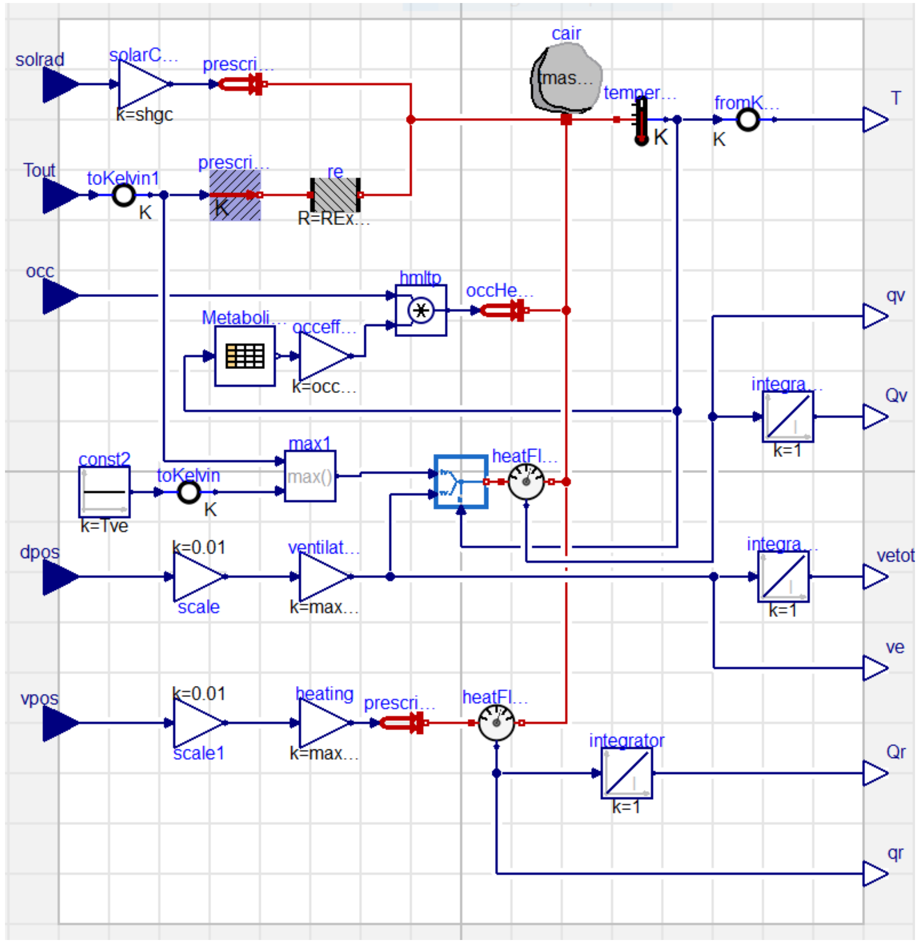
u



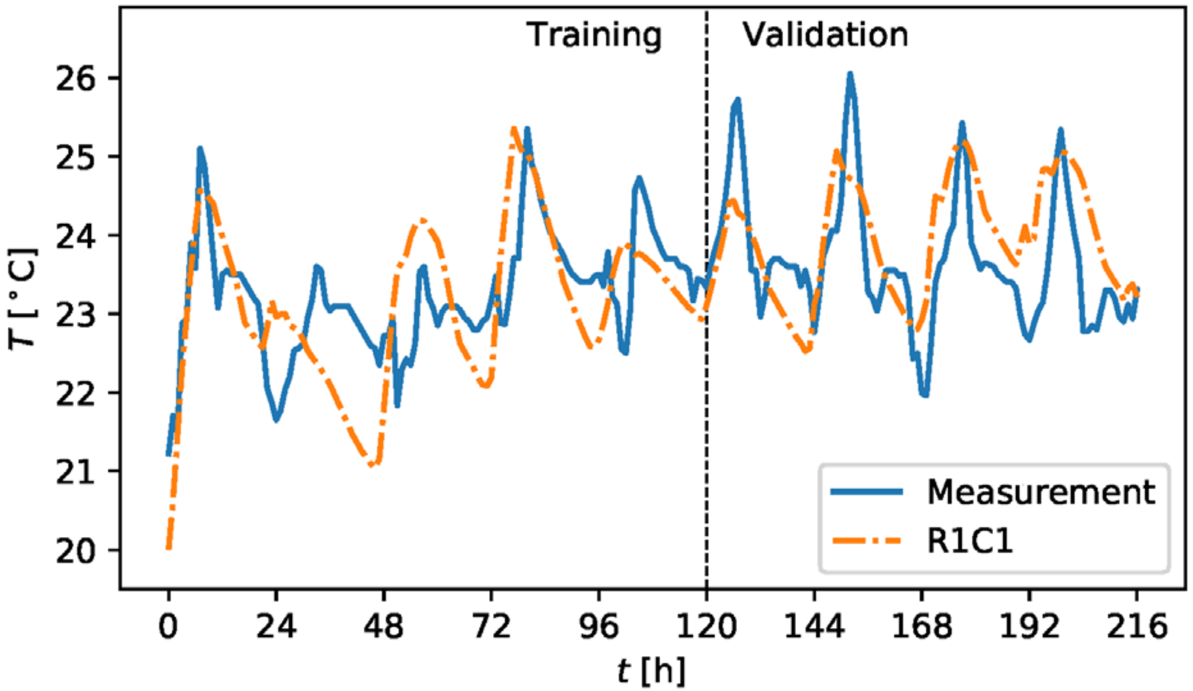
T

q

Demo Case

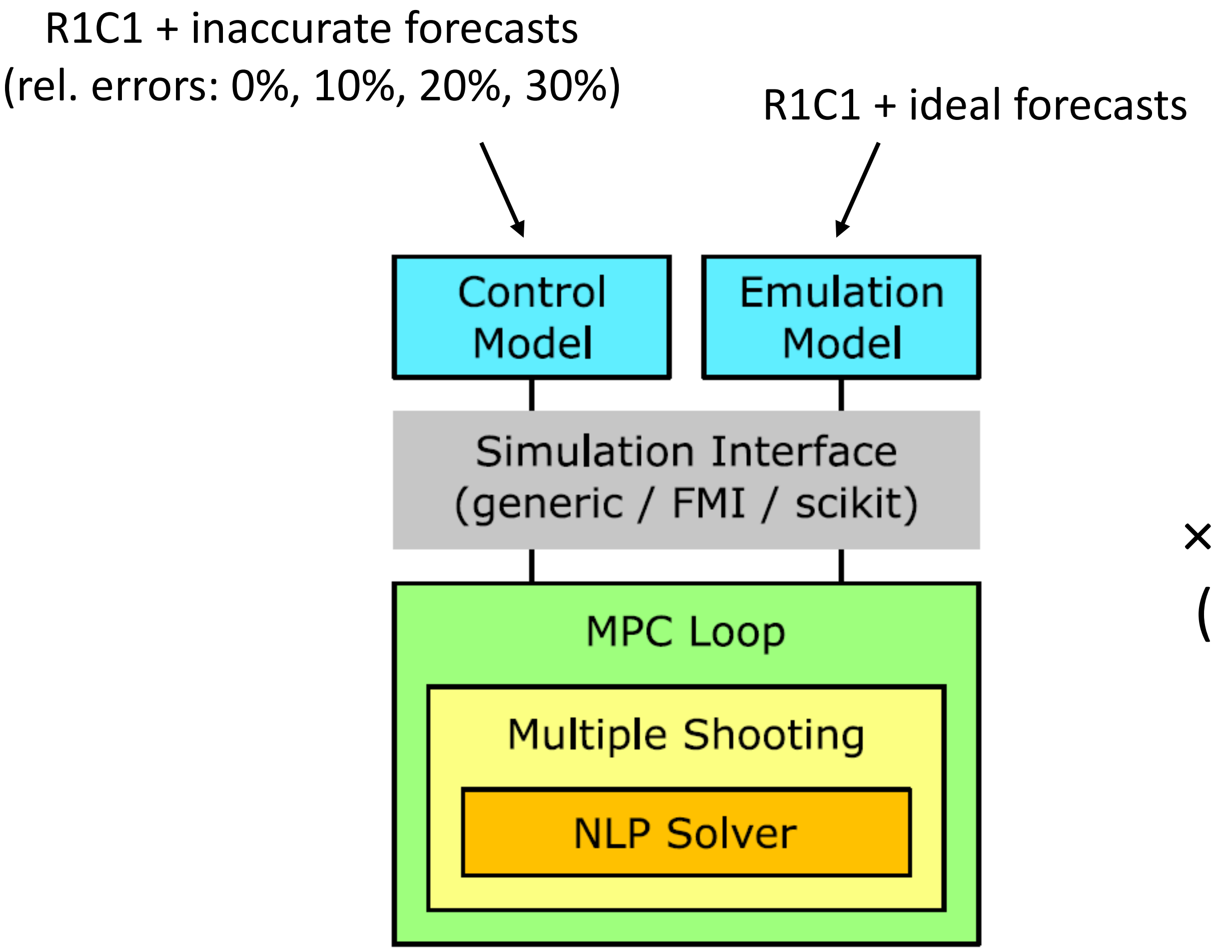


R1C1 model



Model validation
(not very accurate, but physically reasonable)

Demo Case



× 5 runs per each error level
(random errors in each run)

Inaccurate Forecasts (T_{out} profiles)

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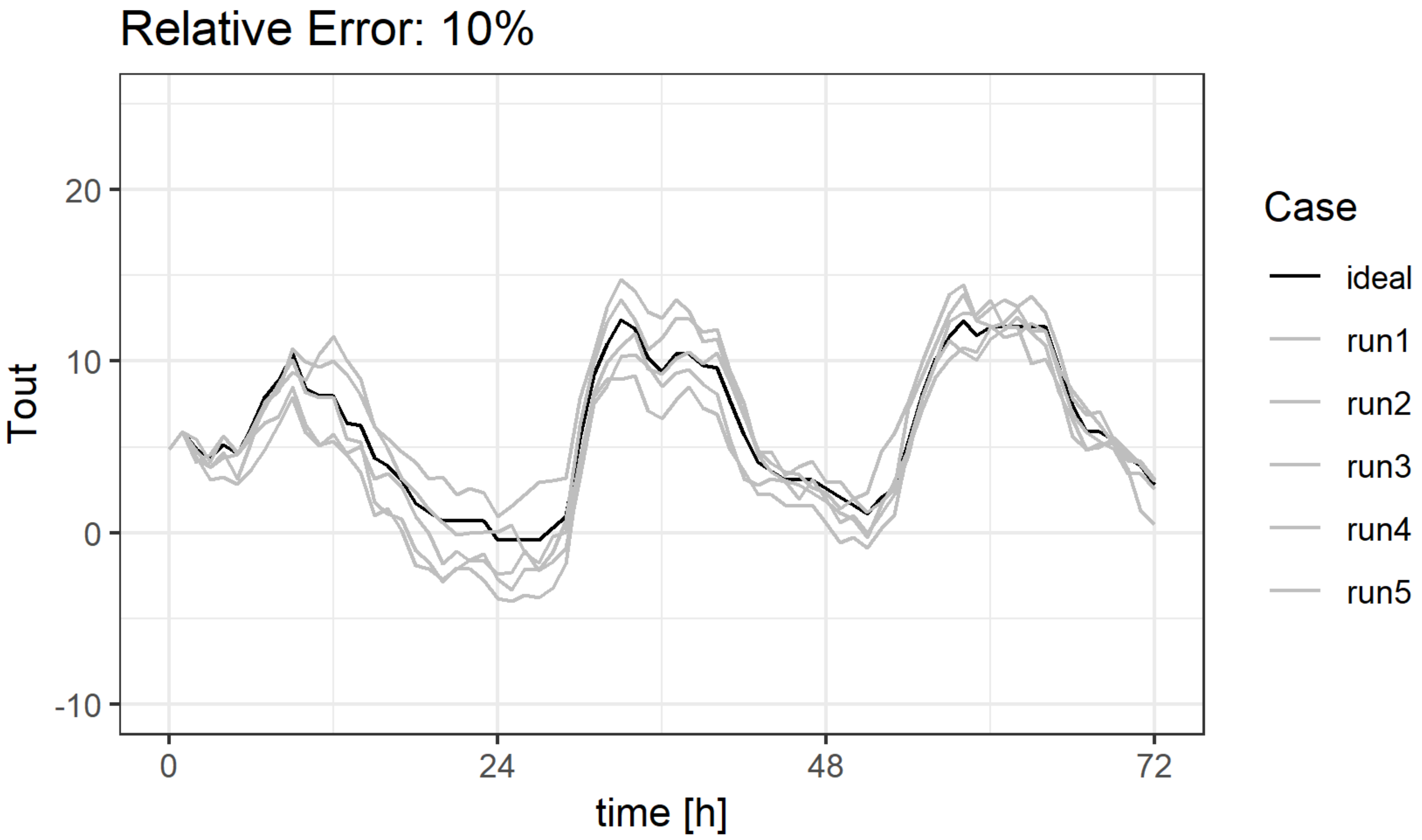
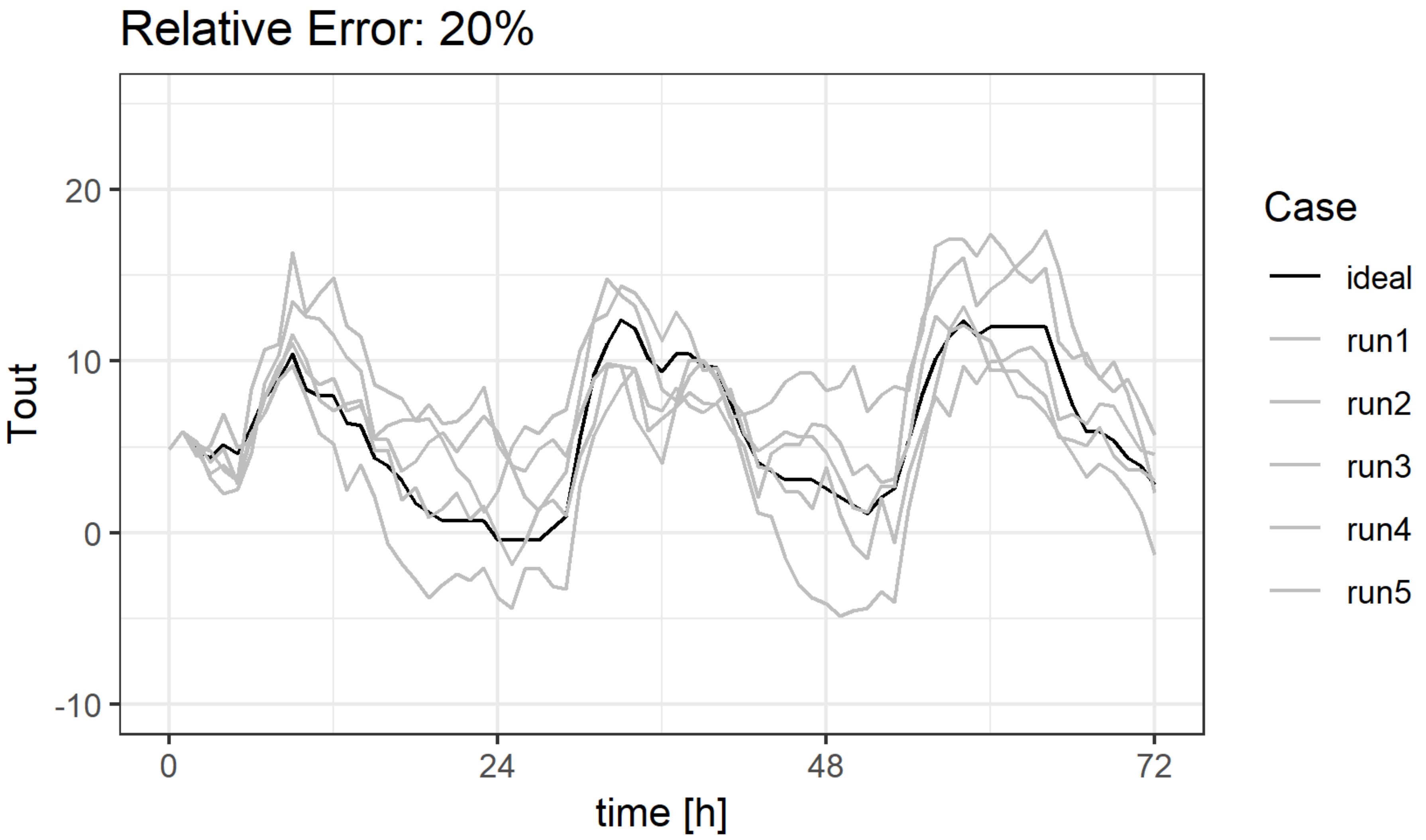
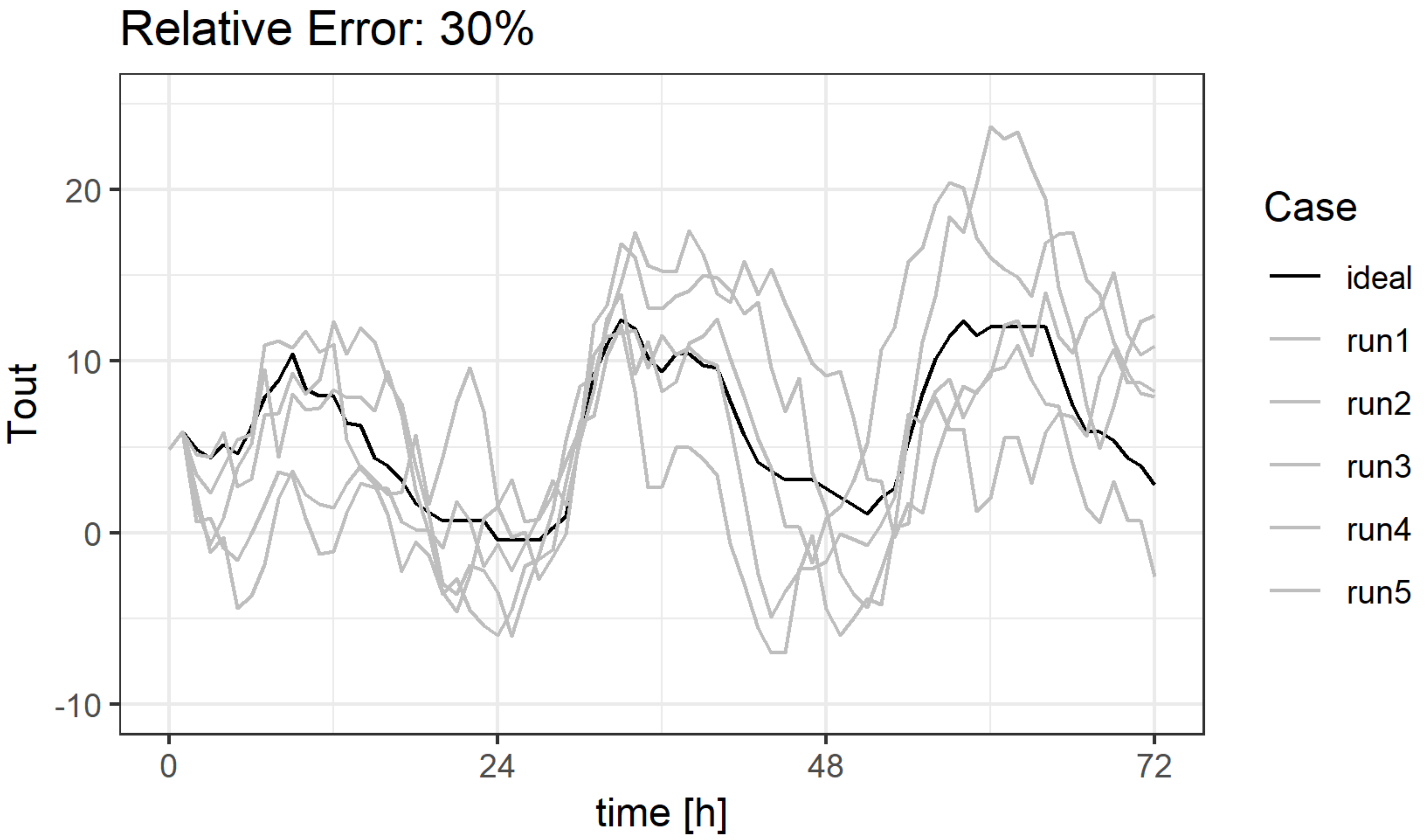


Inaccurate Forecasts (T_{out} profiles)



Inaccurate Forecasts (T_{out} profiles)



Inaccurate Forecasts: Ranges

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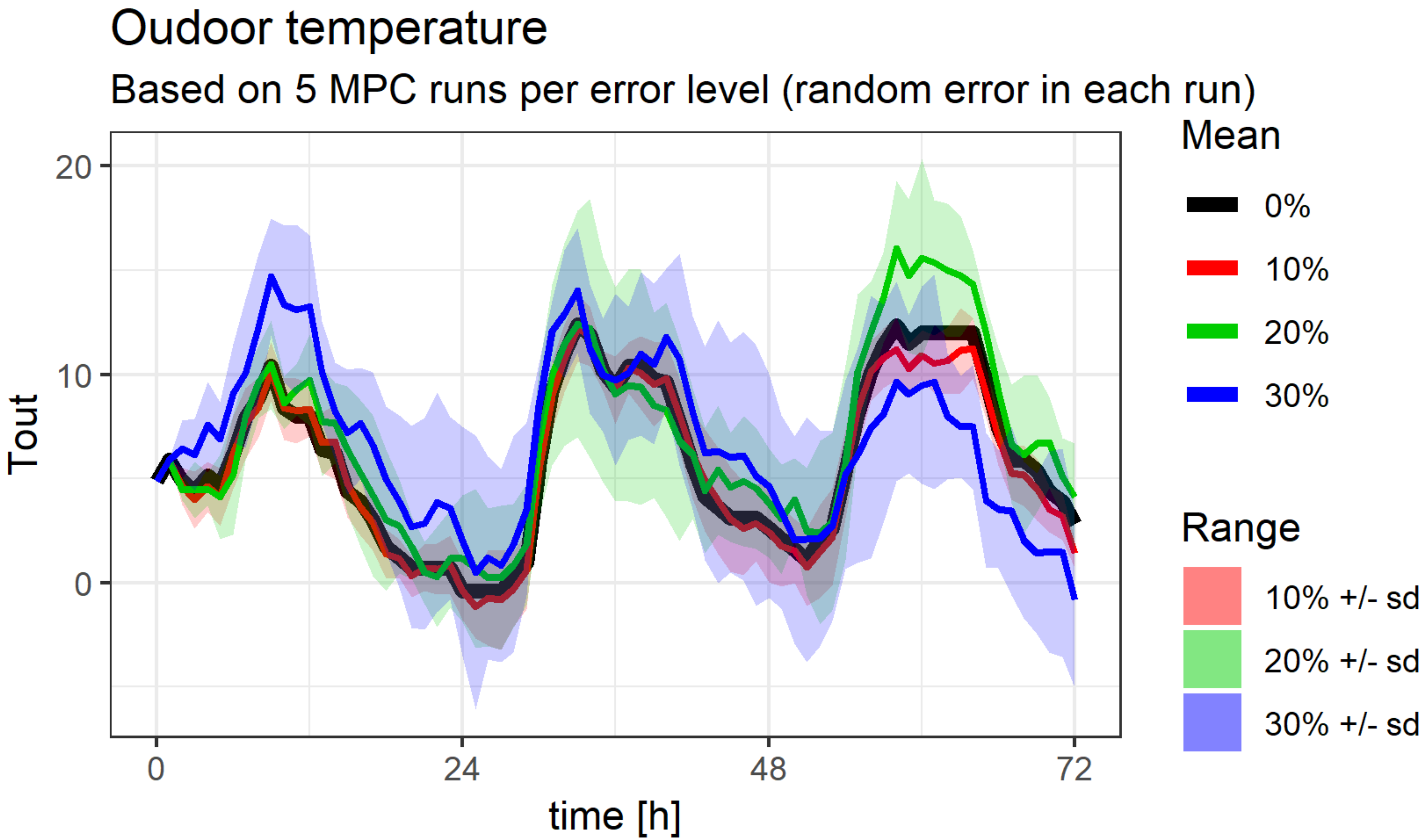
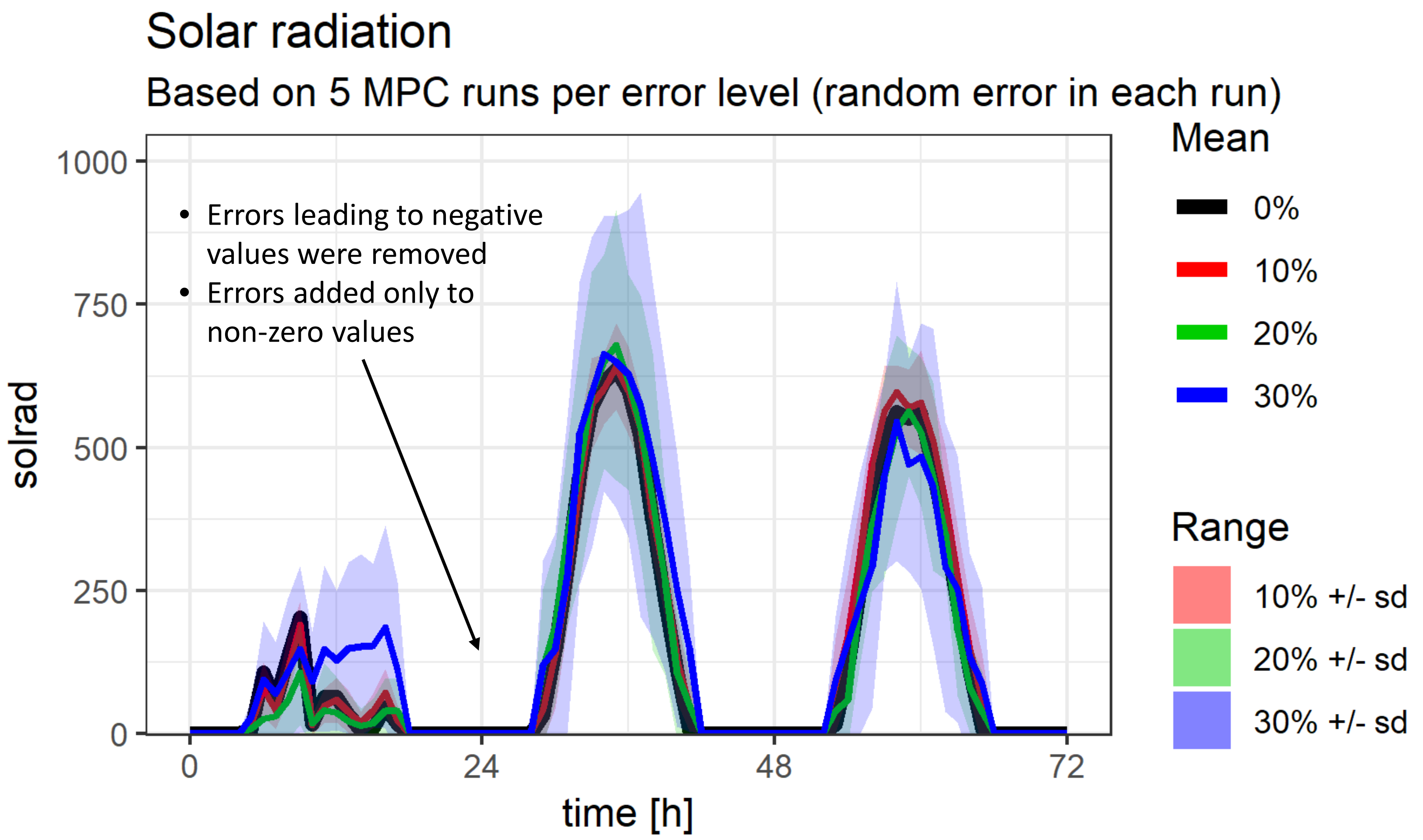


Inaccurate Forecasts: Ranges



Inaccurate Forecasts: Ranges

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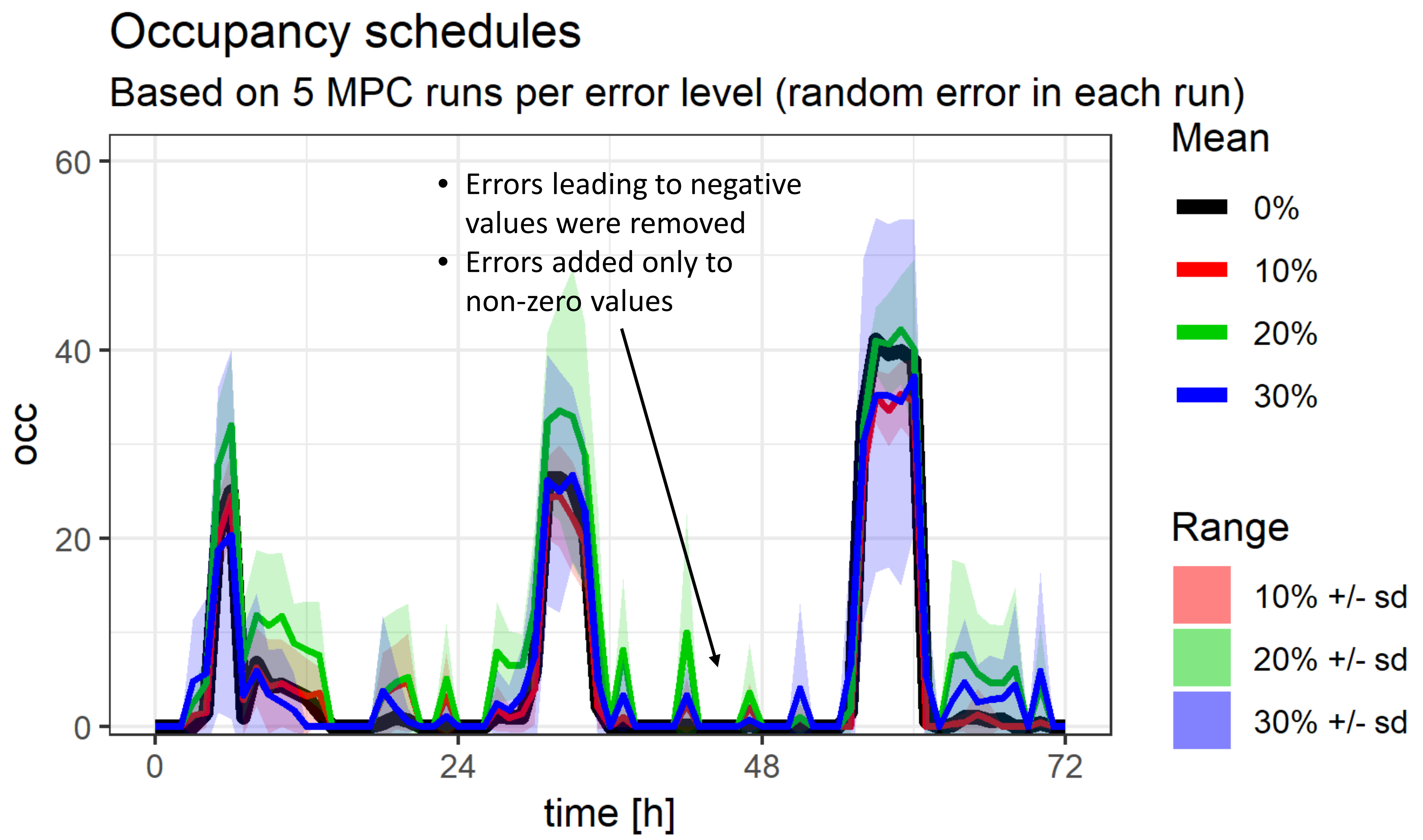

Results: Indoor Temperature

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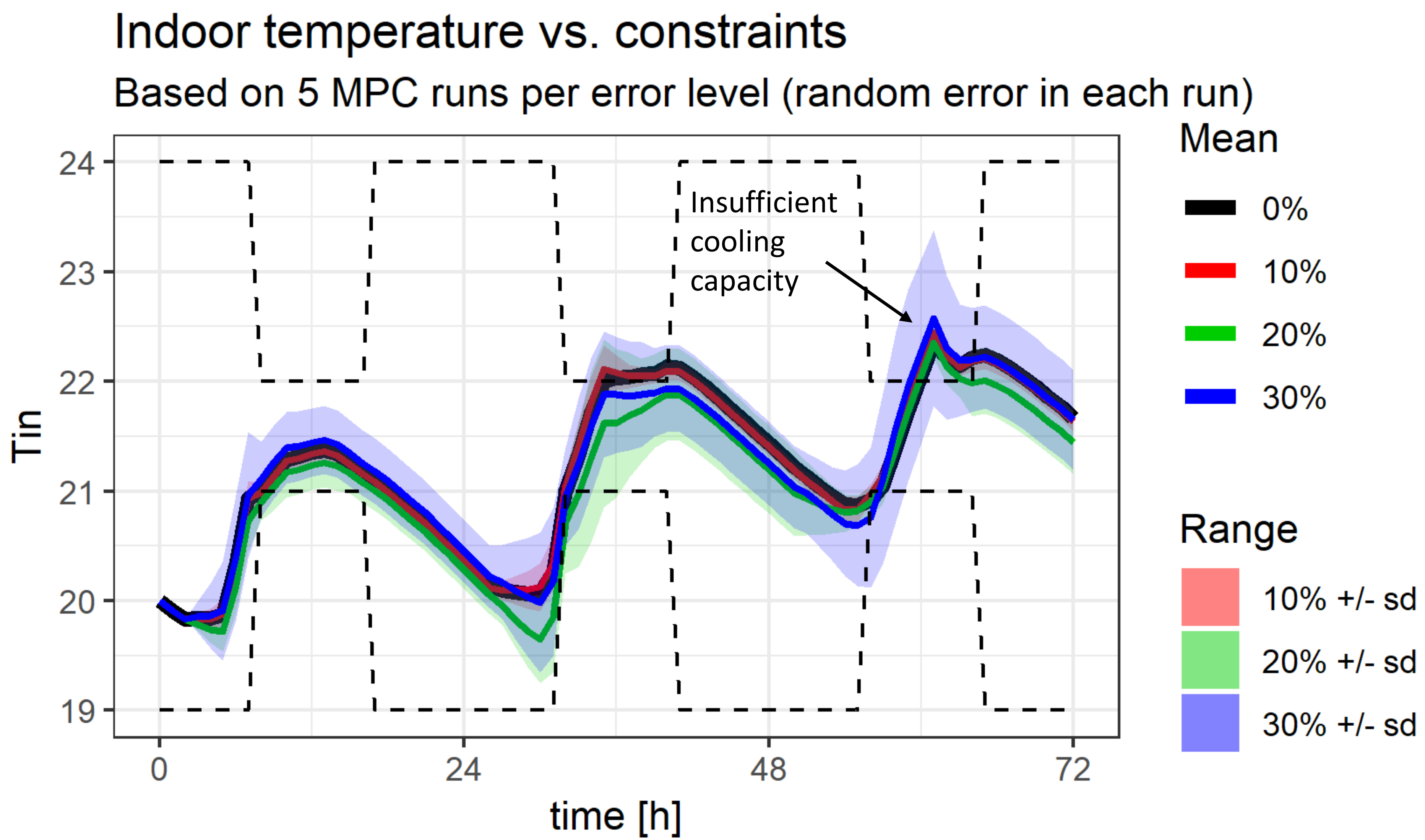
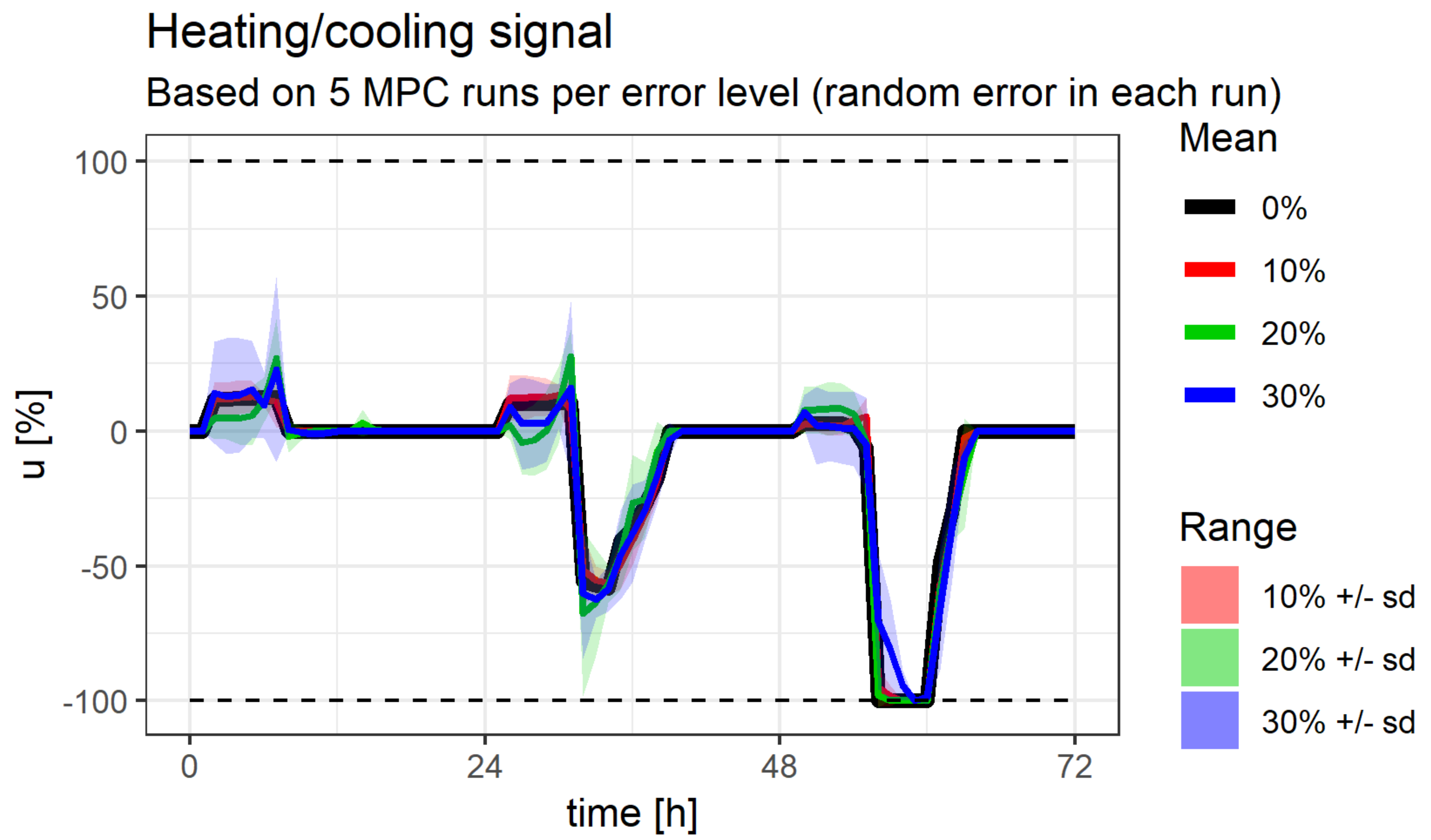
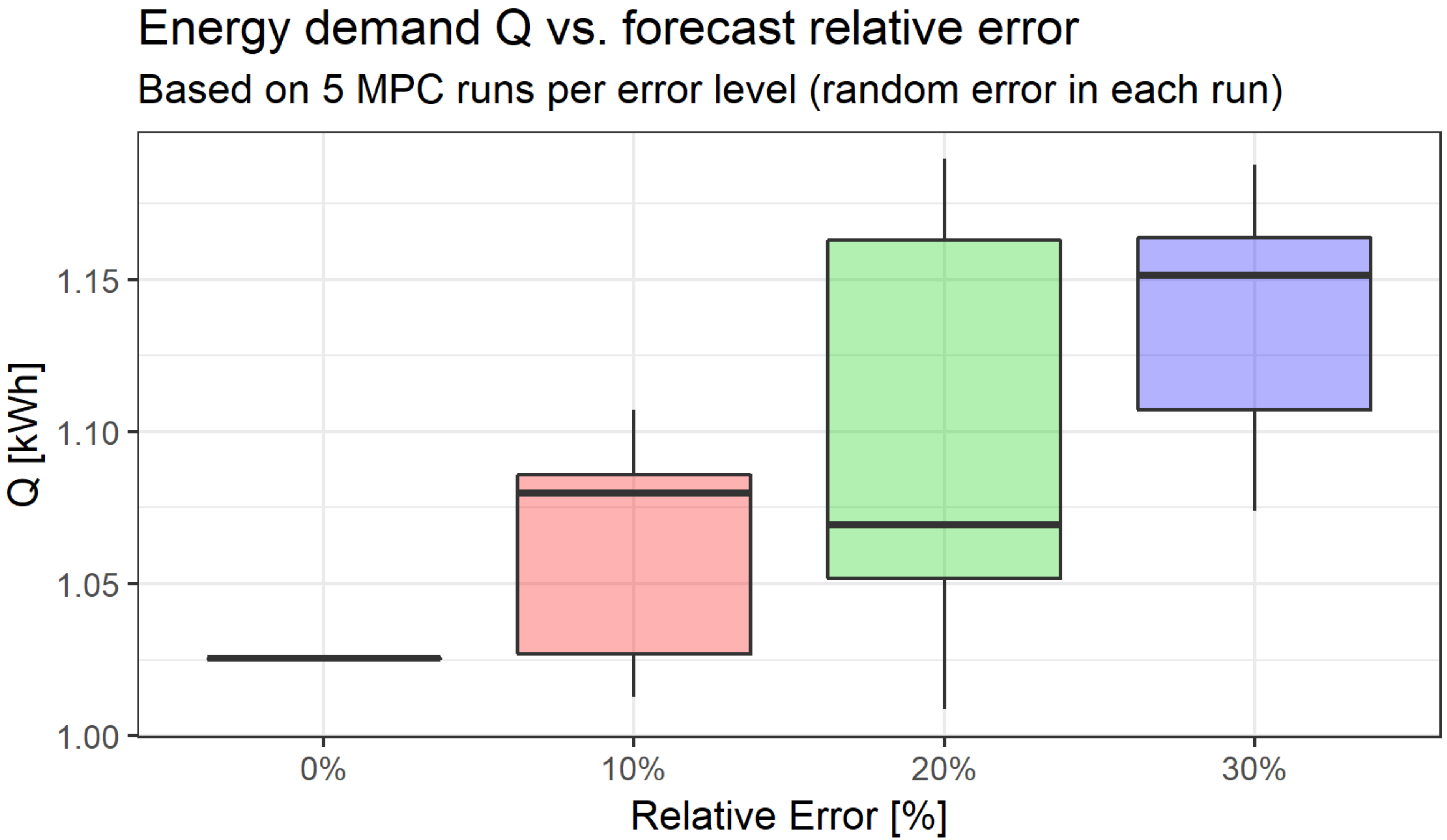


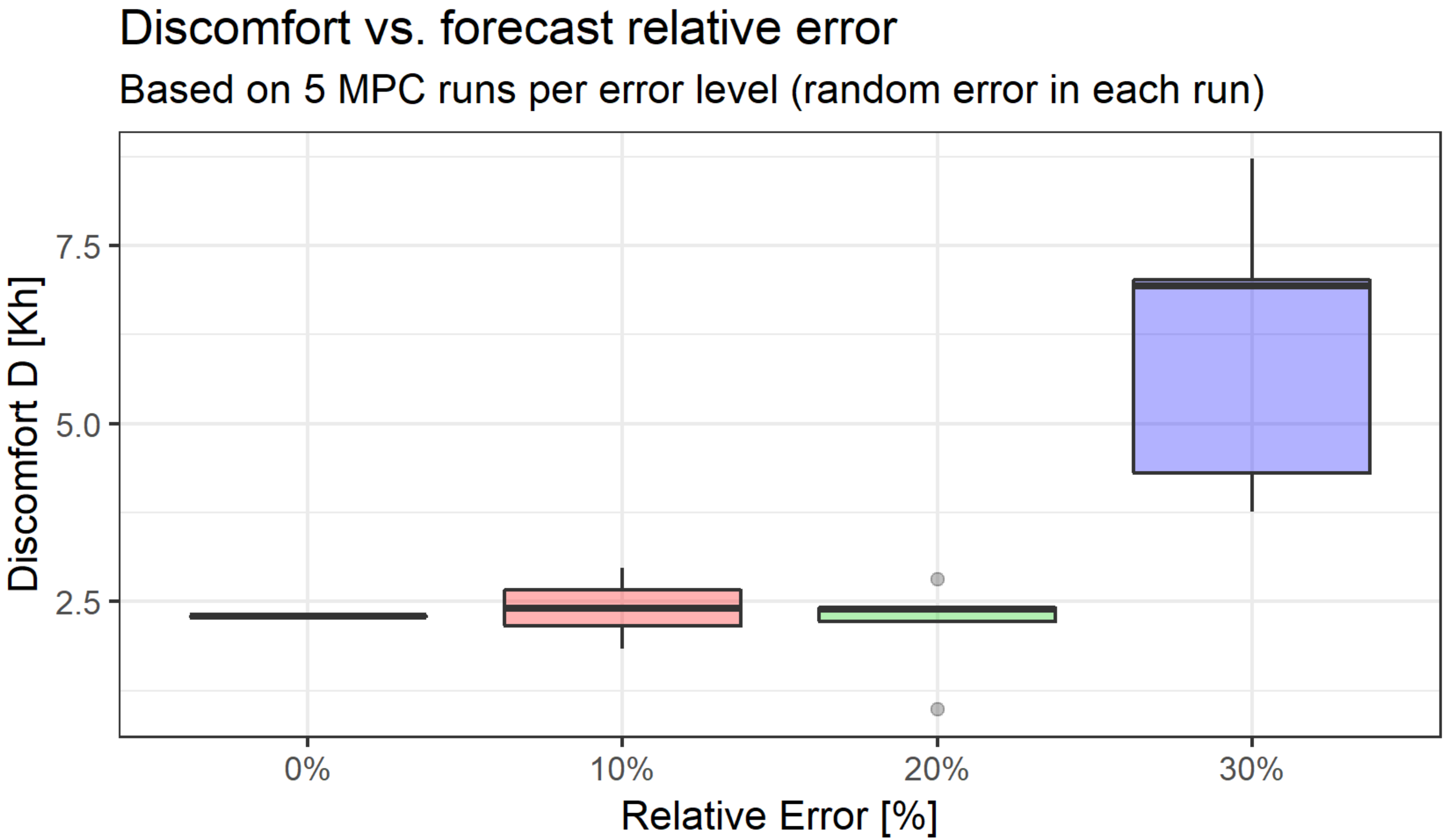
Results: Heating/Cooling Signal



Results: Energy



Results: Discomfort



Summary

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Importance with respect to BOPTEST:

- The higher error level, the worse MPC performance.
- The higher error level, the higher variation in the performance.
- Some MPC formulations are specifically designed to deal with uncertainty (e.g. Robust MPC). Using only accurate forecasts puts these approaches into a disadvantageous position.

Limitations of the analysis:

- The control model used the same static forecast for all optimization horizons. New forecasts should be made for each horizon instead.
- The current implementation of error generator is not suitable for variables which cannot go below zero (irradiance, occupancy).