Building Simulation 2021

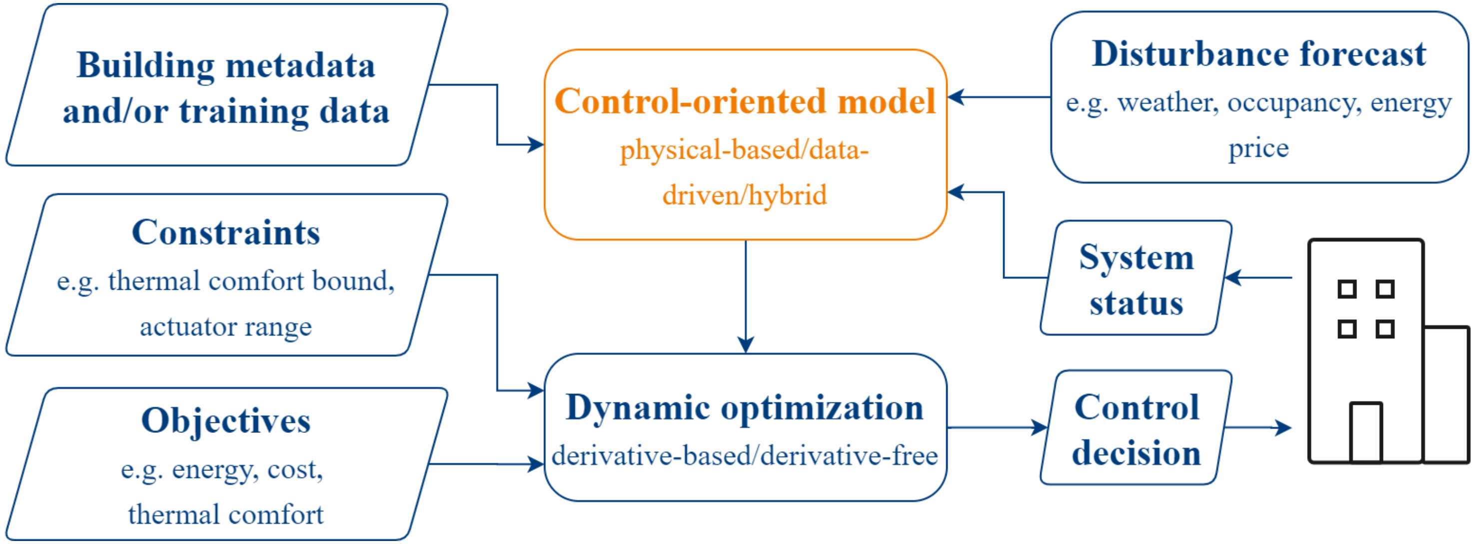
Data requirements and performance evaluation for control-oriented models

Sicheng (James) Zhan, szhan@u.nus.edu

CONTENTS

Background

- The necessity of optimal control in buildings
- The importance of control-oriented models in building optimal control
- The difficulty of obtaining these models hindering actual MPC application
- An attempt to promote the scalability from a modeling perspective

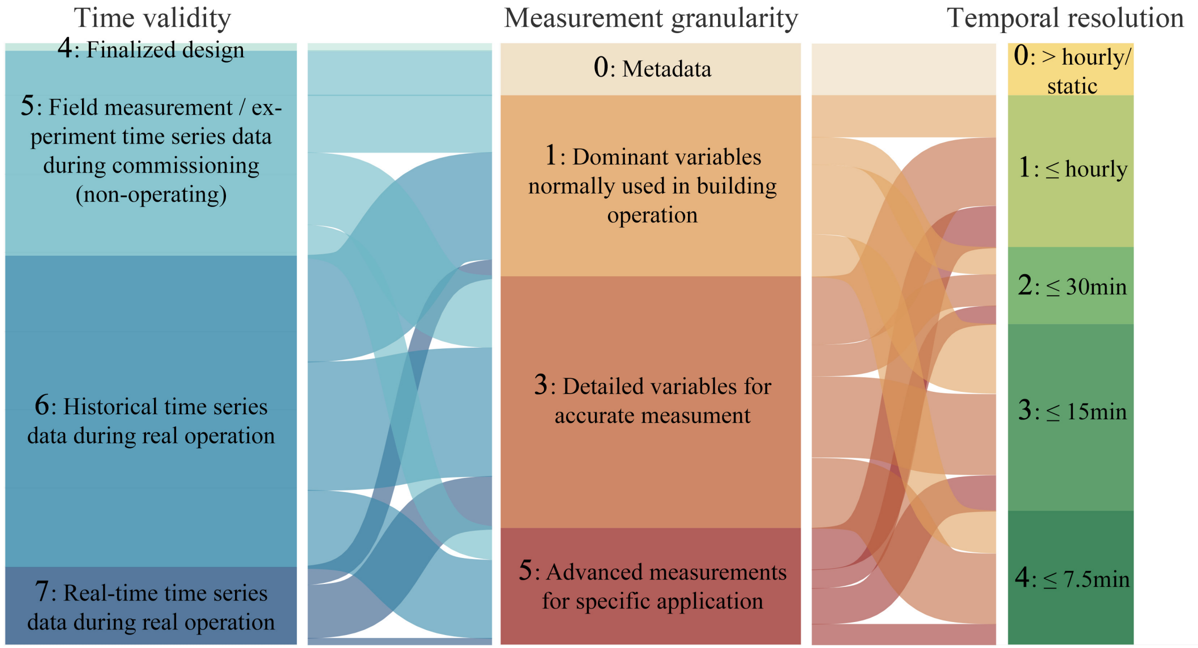


Research gaps

- The data availability varied across buildings, making past results less generalizable. A data quantification framework is required.

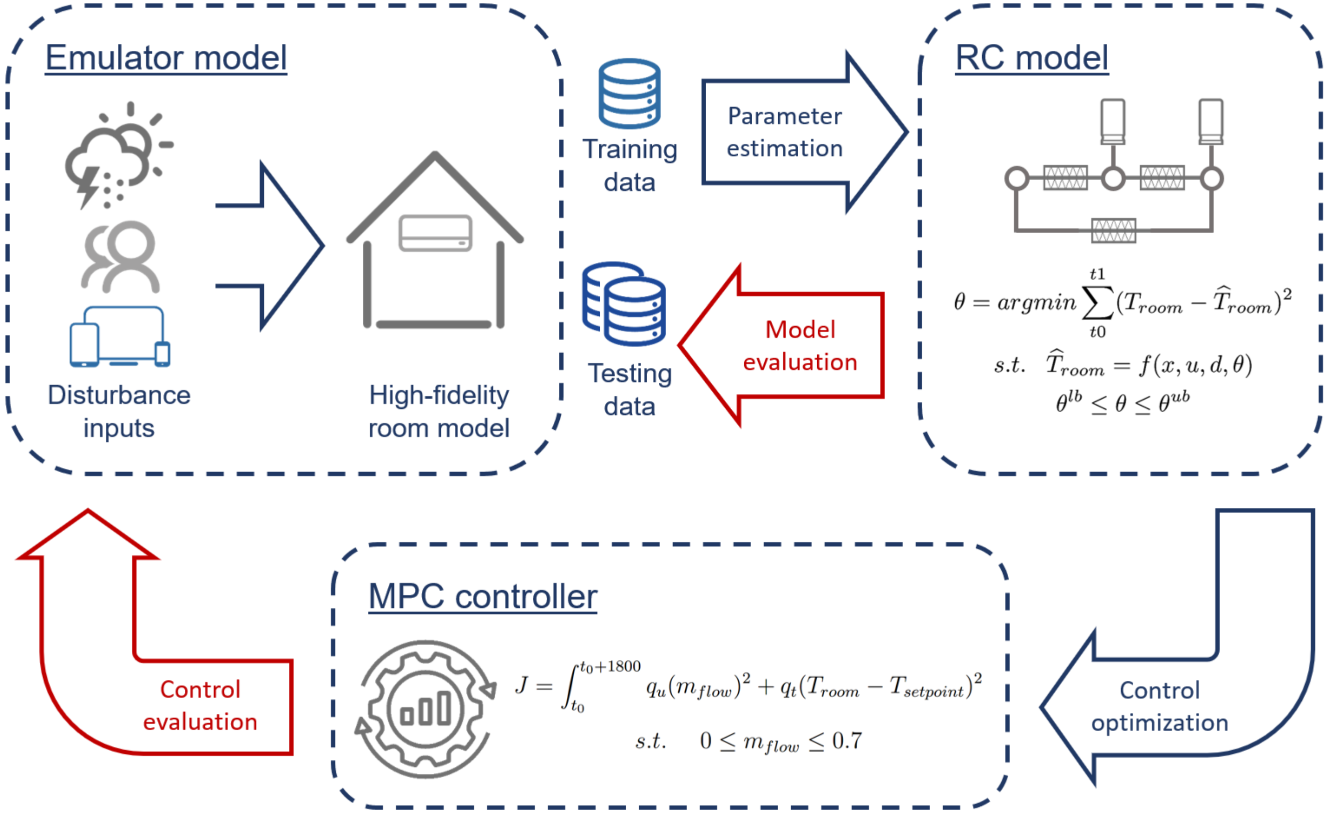
- Comparative study is needed to determine which level of data is necessary: e.g. none/schedule/plug load/CO2 for internal heat gain

- Most studies evaluated model by prediction error, few have systematically investigate model evaluation in the control context



Methodology

- High-fidelity single-room models built in Modelica Buildings library (lbnl)
- Actual internal disturbance data (collected in Beehub)
- RC models with 3 different complexity
- Model identification and control based on non-linear programming



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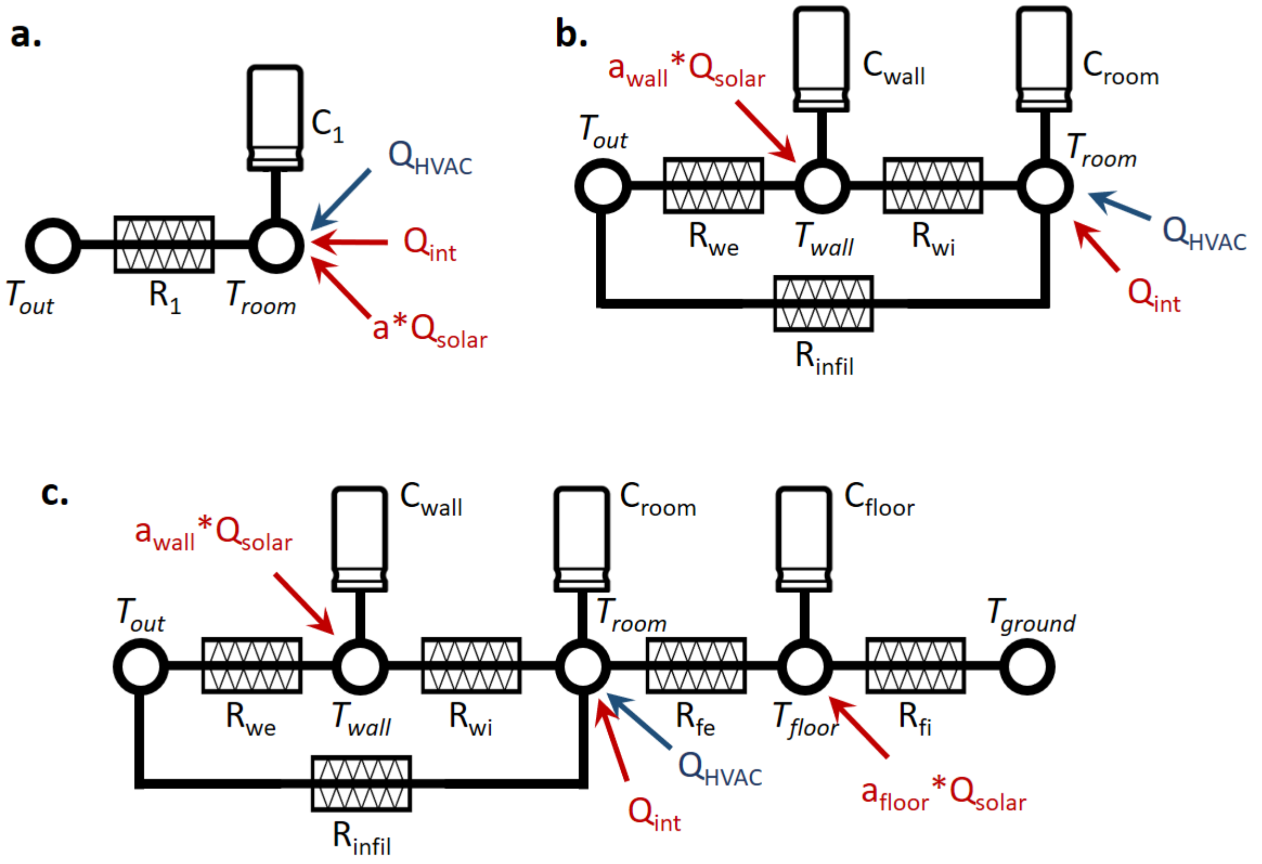

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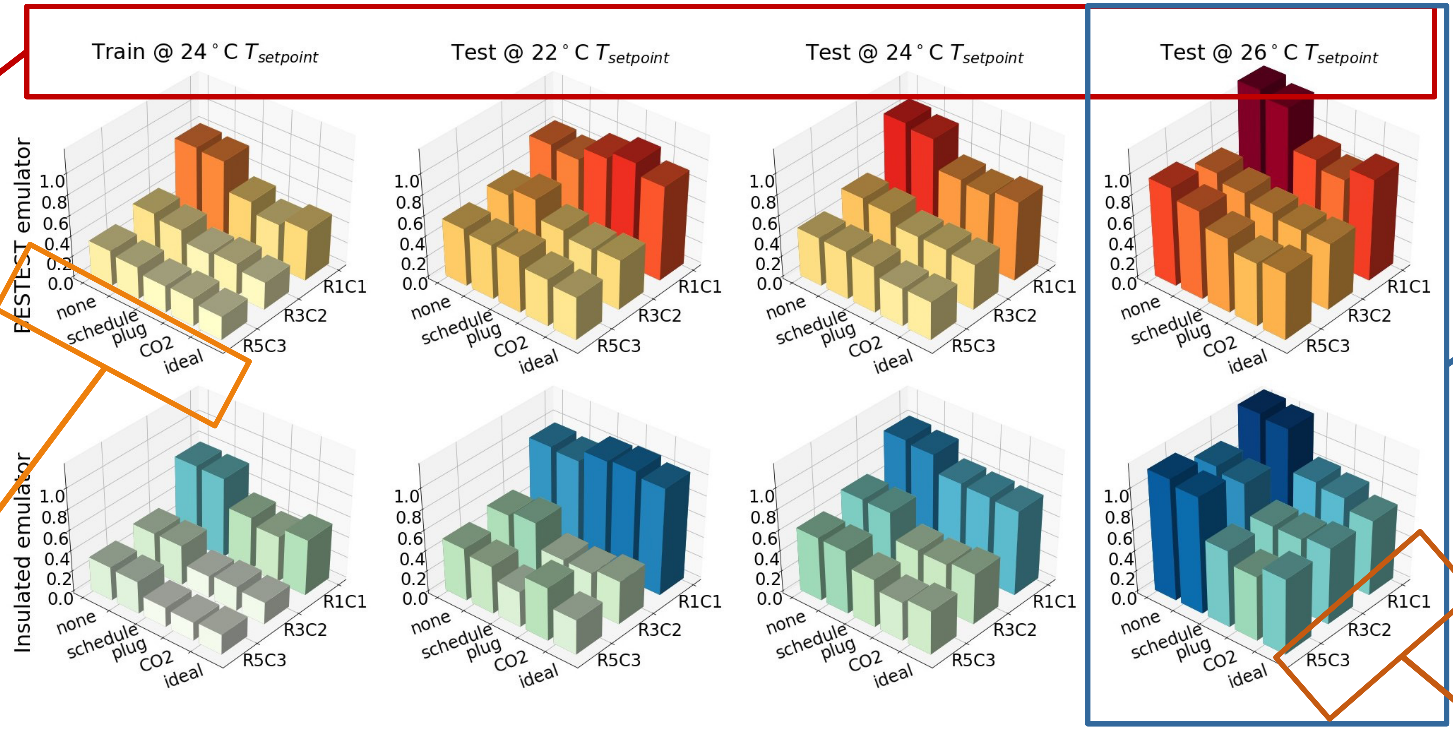
Table 1: Summarized design of experiments.

Subject	Variations
Emulator	BESTEST, Insulated (higher internal load percentage)
RC model sturcture (parameters)	R1C1 ($R1, C1, a$), R3C2 (R_{wi}, $R_{we}, R_{infil}, C_{room}, C_{wall}, a_{wall}$), R5C3 ($R_{wi}, R_{we}, R_{fi}, R_{fe}$, $R_{infil}, C_{room}, C_{wall}, C_{floor}$, a_{wall}, a_{floor})
Internal heat gain input (parameters)	No input, Design schedule(Cap), Plug load(a_{plug}, b), CO_2 ppm(a_{CO_2}, b), Ideal measurement

Results_RMSE

Train at 24°C and test at 22, 24, and 26°C



Error gets larger at 26°C, when the cooling load is relatively small

Plug load and CO2 better than no input and schedule. The difference is more significant when the room is more insulated

R3C2 and R5C3 perform similar and better than R1C1

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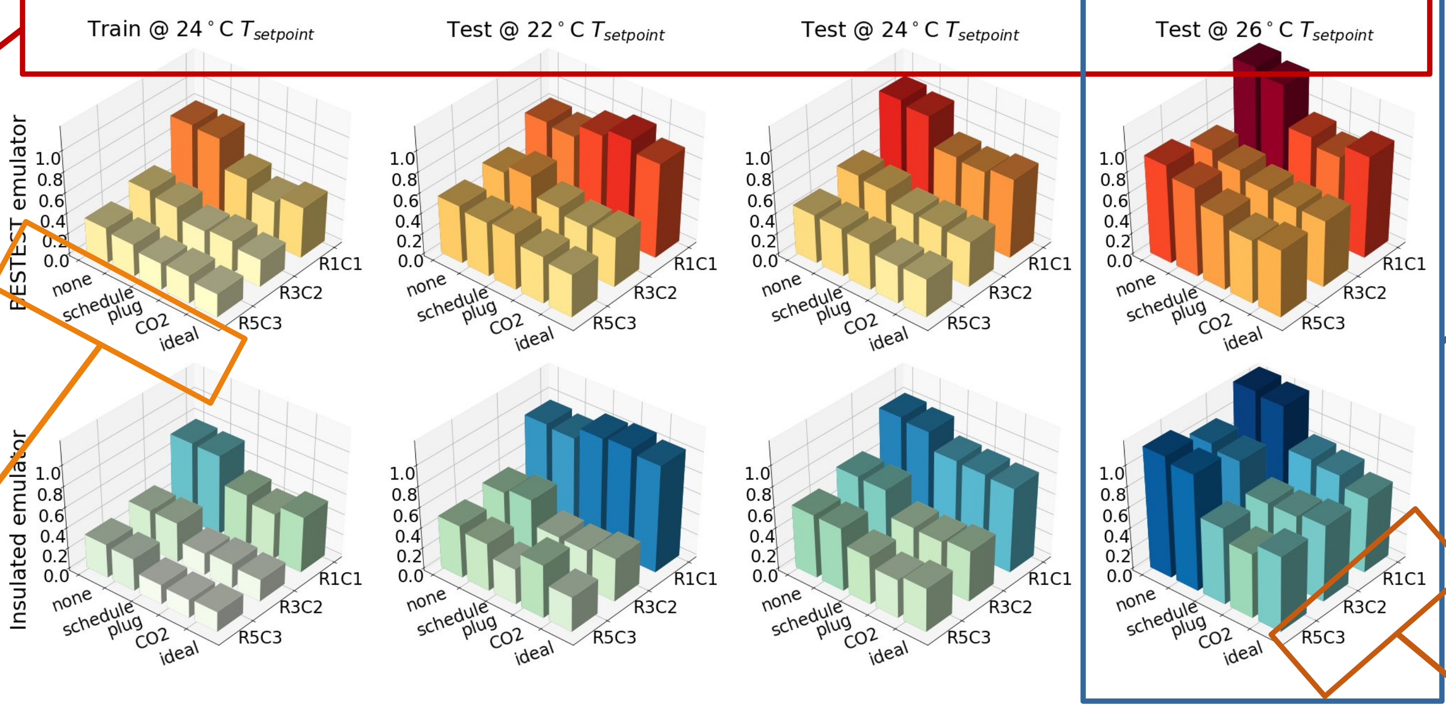

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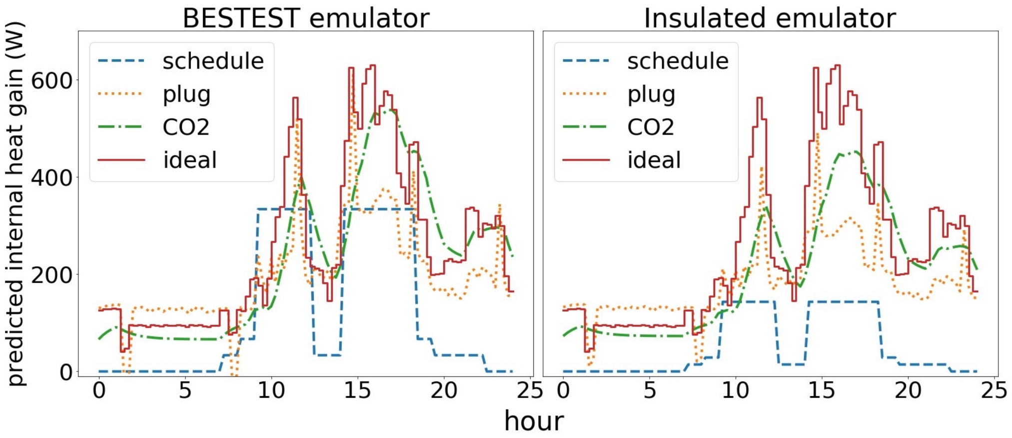

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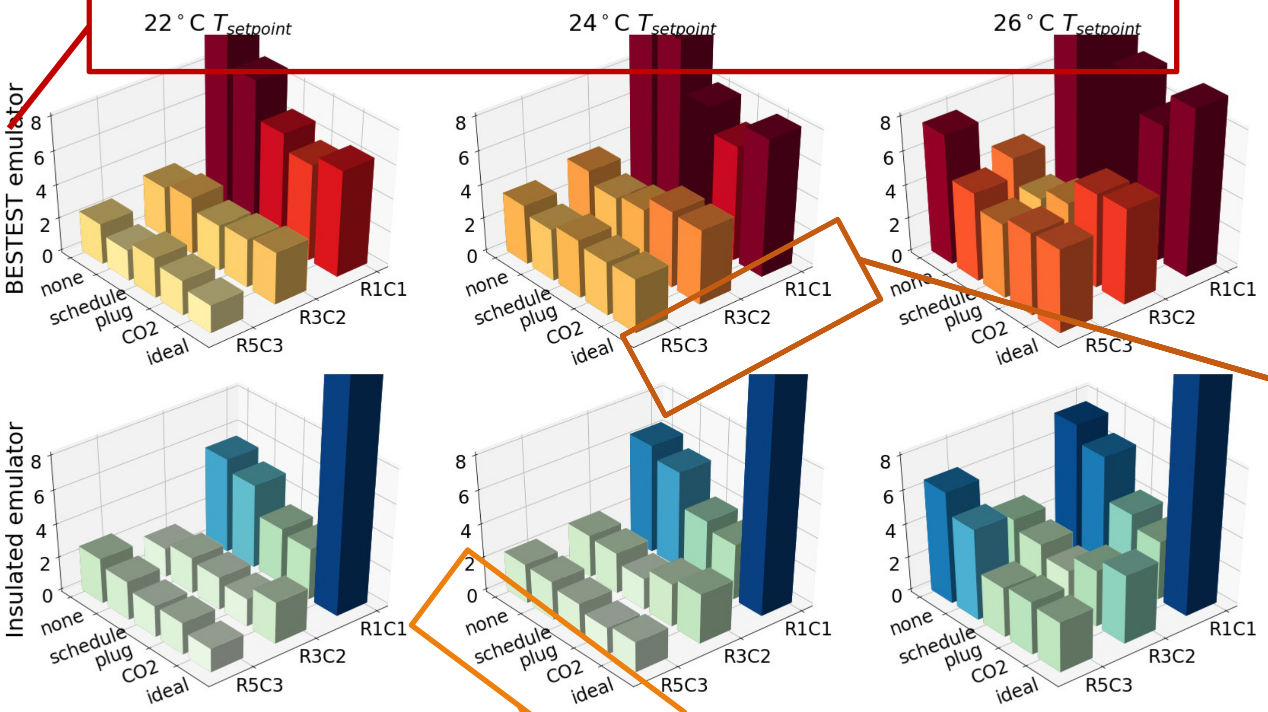
Results_control

Much worse control results under 26°C



R5C3 perform slightly better than R3C2 under 22 and 24°C

No significant difference among alternative inputs

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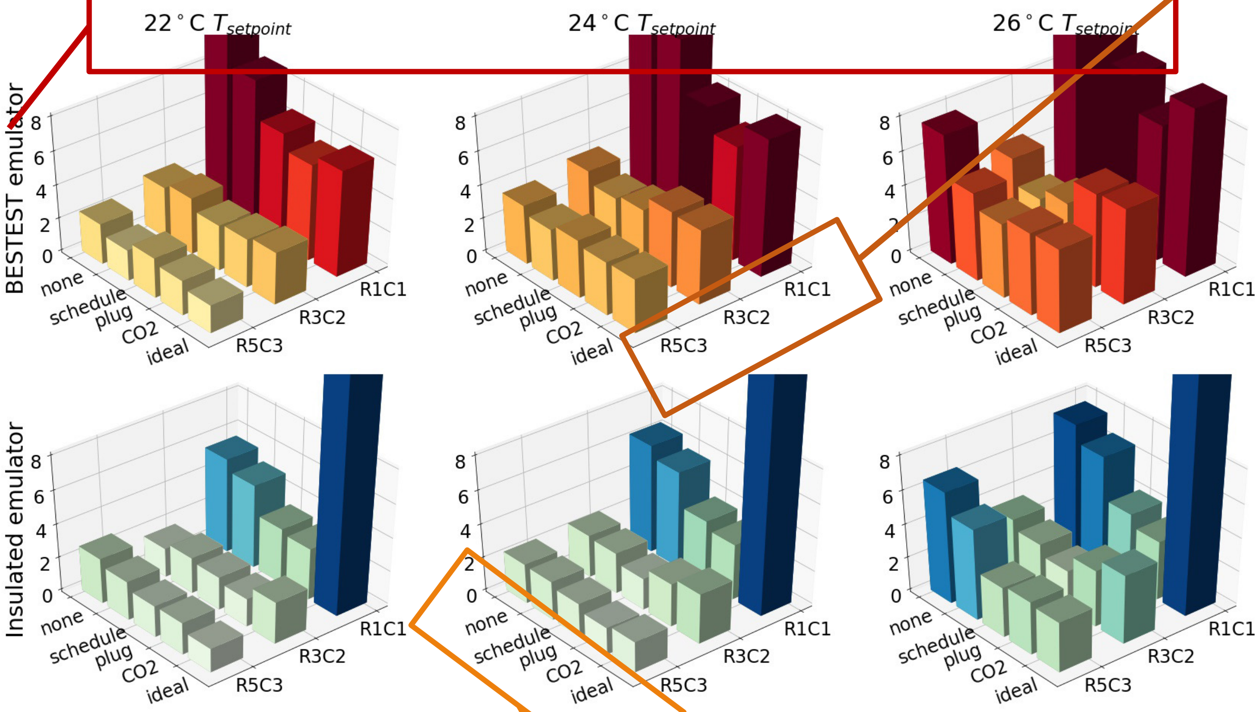

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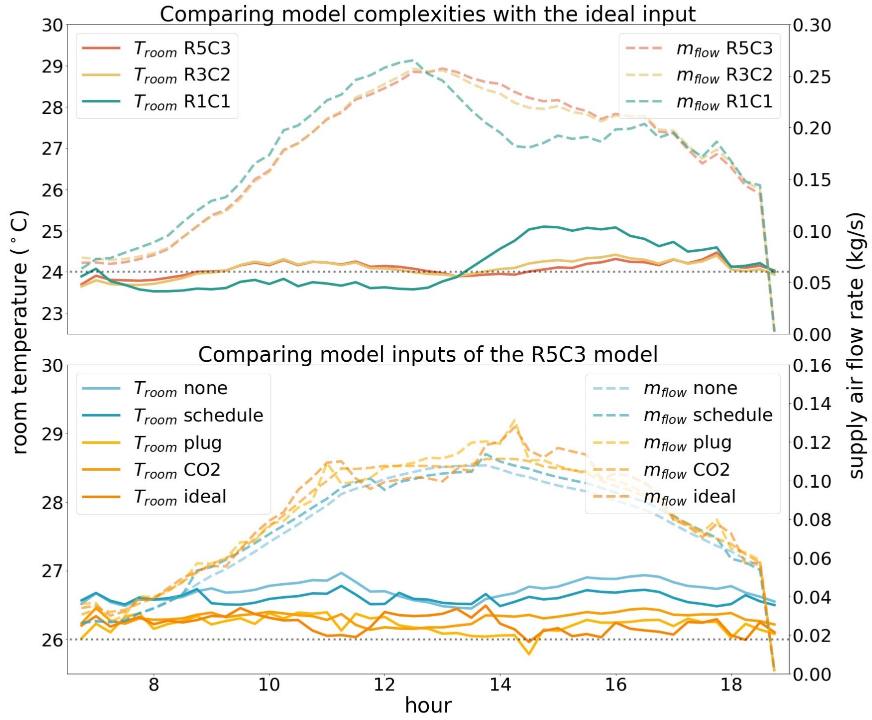


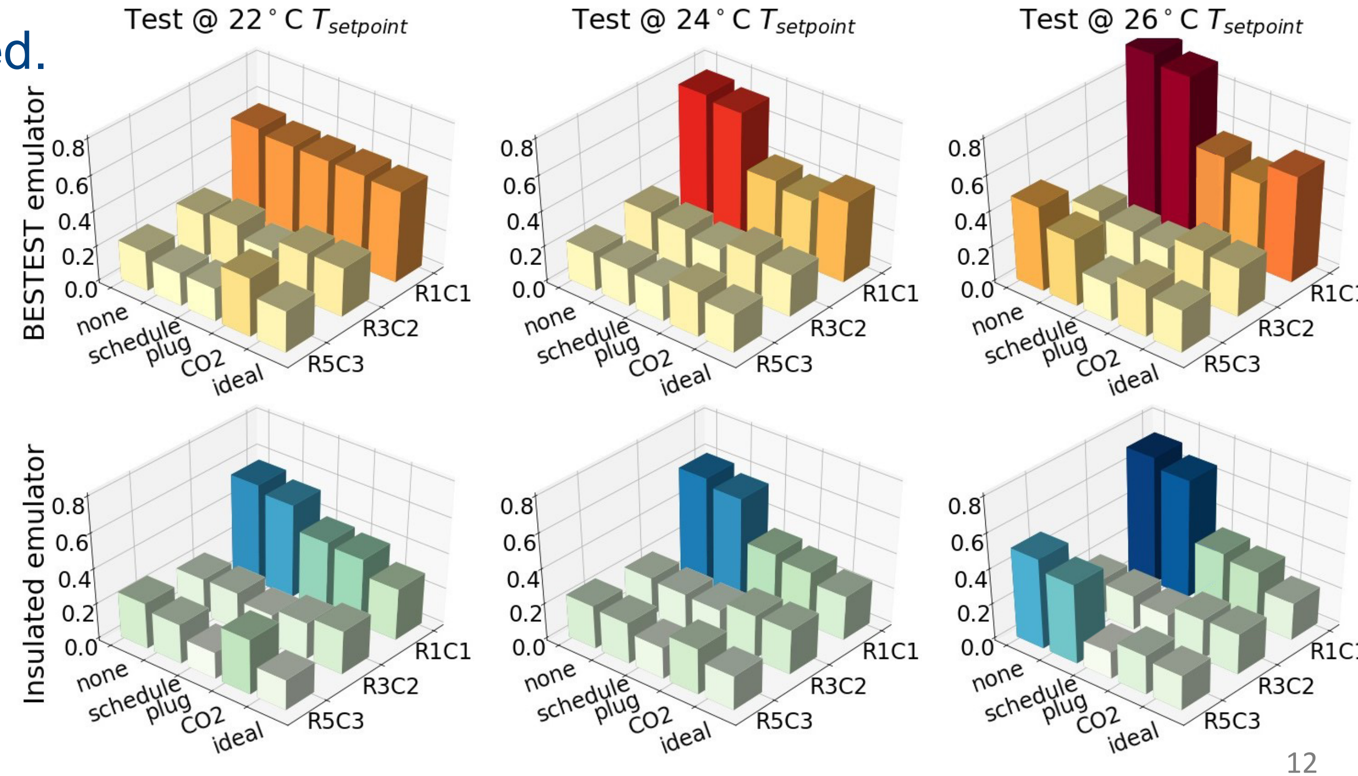
Discussion #1: towards more an informative metric

- RMSE captured the general trend but not always correspond, making it a necessary but not sufficient indicator

- Short-term RMSE is more promising but still limited

- A more informative indicator is needed.

Instead of telling which one is slightly better, it is more important to detect when it will be bad.



Discussion #2: granularity and complexity

- Higher granularity for internal heat gain has merits, more significant when the prediction horizon is longer

- Better representation of internal heat gain also improves the models by help estimating other heat gains in model identification

- Internal heat gain parameters (capacities and coefficients) could be compromised to better fit the training data (possibly overfit), especially when the model is less expressive

Applies to other types of model

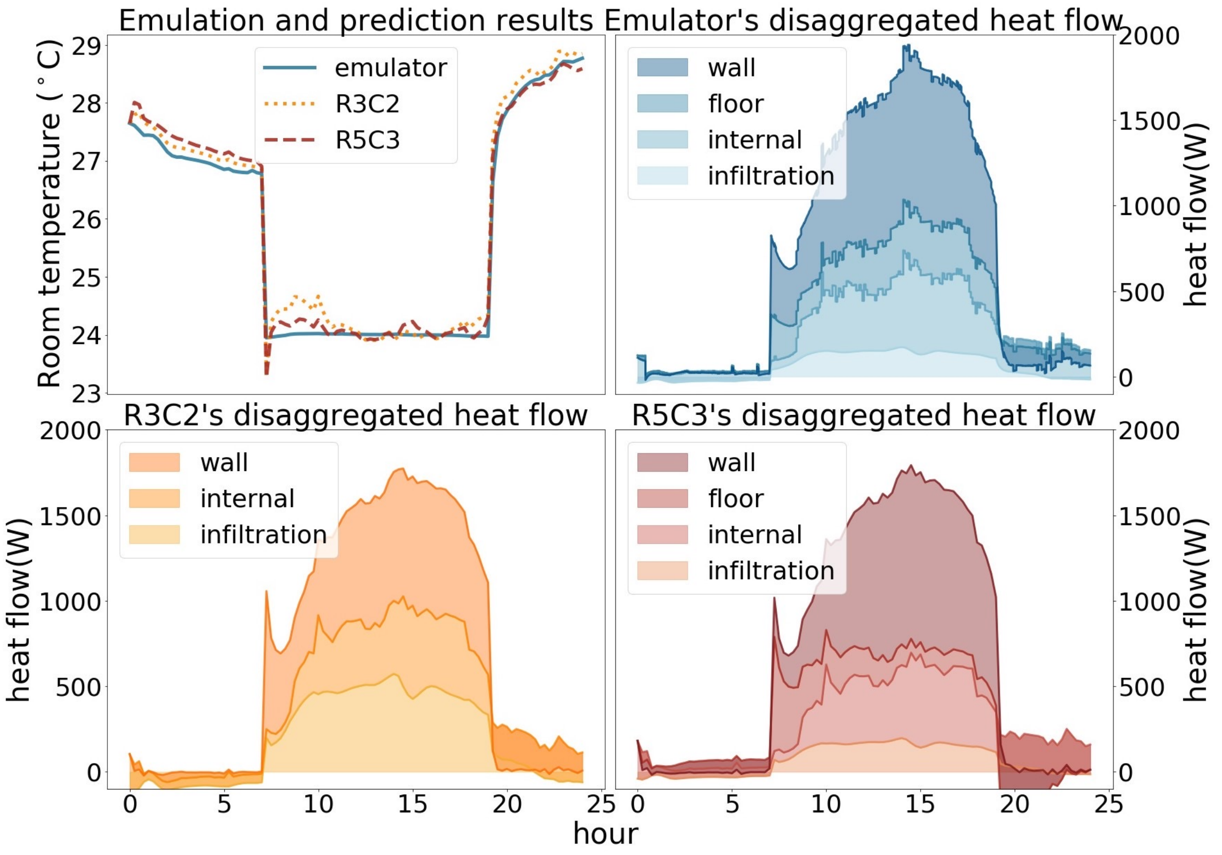
- Design schedule is a good enough estimate for MPC in typical offices

Discussion #3: what makes a good model

- Models don't have to be physically authentic to accurately predict the building thermal response

- Multi-output identification results in more physical models but not more accurate room temperature prediction

- Similar situation when calibrating the high-fidelity model for BEEHUB



Q & A

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