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Smart Energy Systems Modeling

Component Exchange during simulation

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Motivation

- Application: Energy Systems Modeling
- Combination of strengths of different modeling methods
- Exchange model components during simulation depending on different criteria

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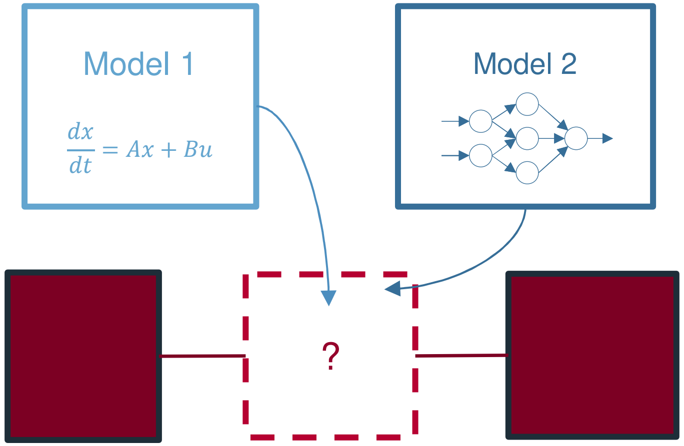
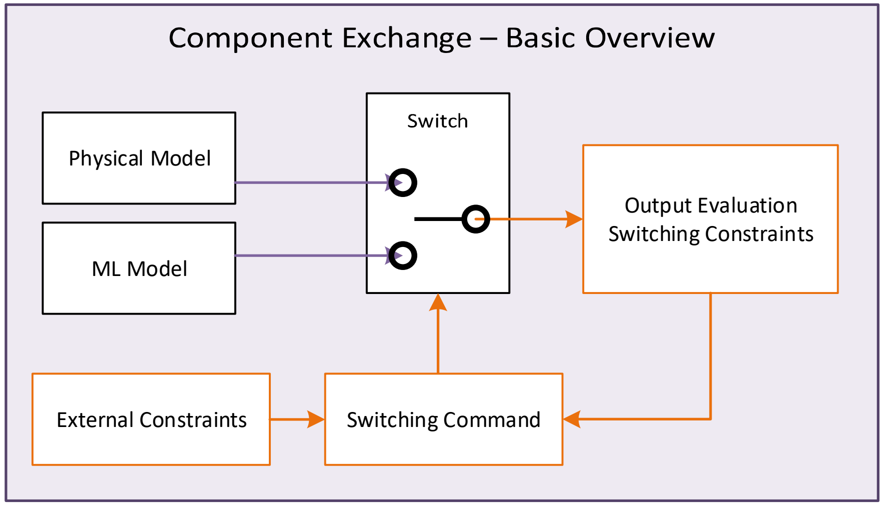


Method

Simulation – Co-Simulation Approach



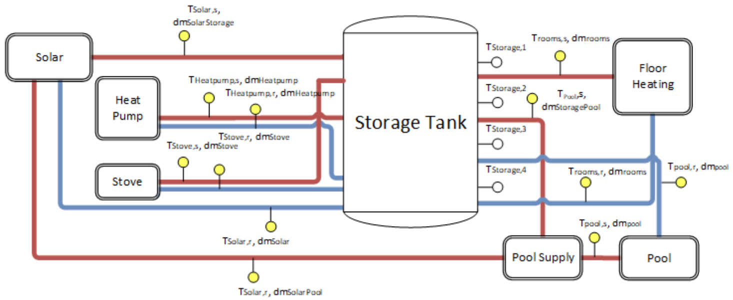
- Physical modeling in Dymola
- Data-driven modeling in Python
- Combination of Dymola and Python through co-simulation
- Evaluation of different models during simulation
- Component exchange during simulation run

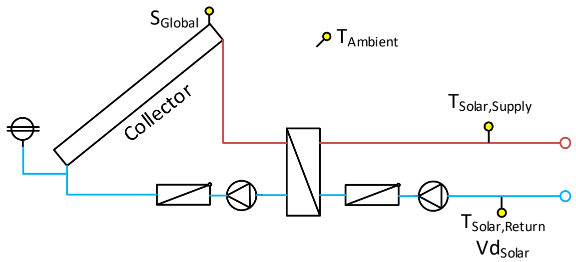
Application – Use Case

Single Family House Heating System - Solar Collector

Single Family House Heating System:

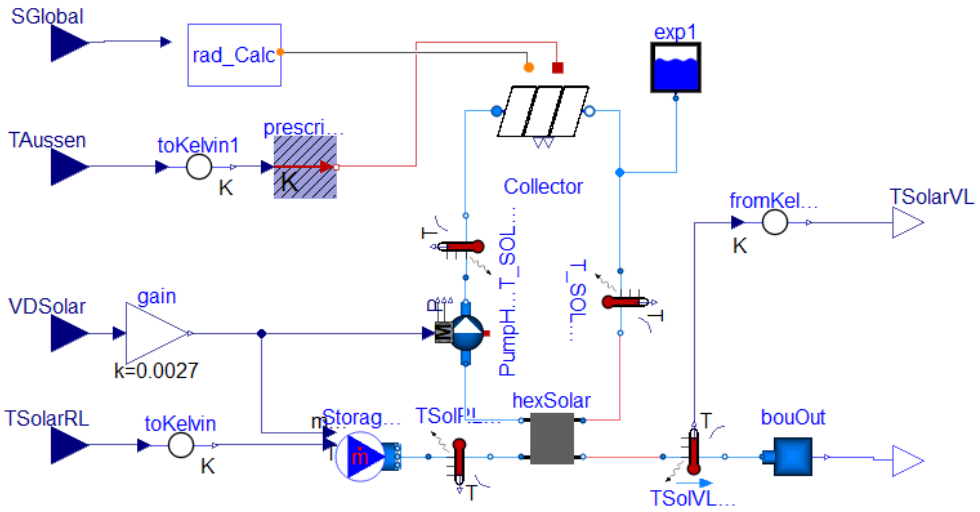
- Combined Solar Collector – Storage Tank – Heat Pump System
- 46 m² Solar Collector





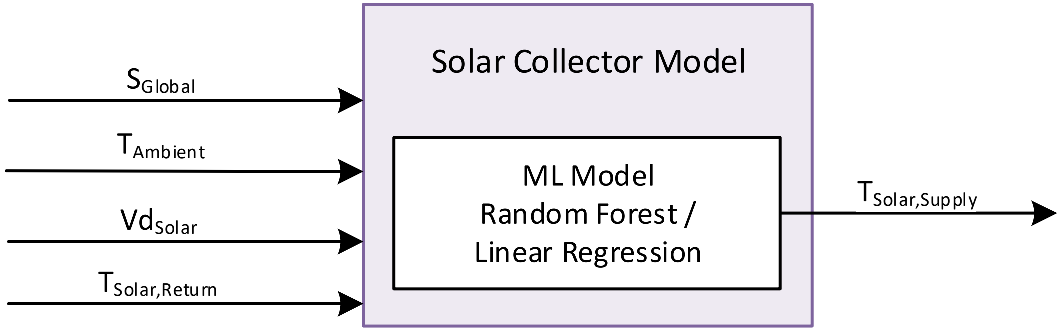
Physical Modeling

Solar Collector Model - Dymola



Data-driven Modeling

Machine Learning Models - Python

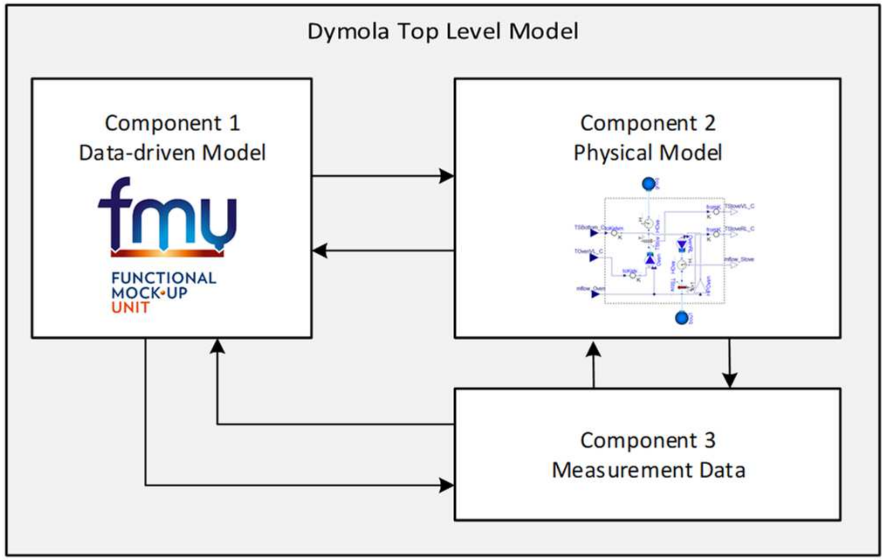


Model Architectures:
Linear Regression, Random Forest

Training Data: 2019/02 – 2019/11 (80% training, 20% validation)

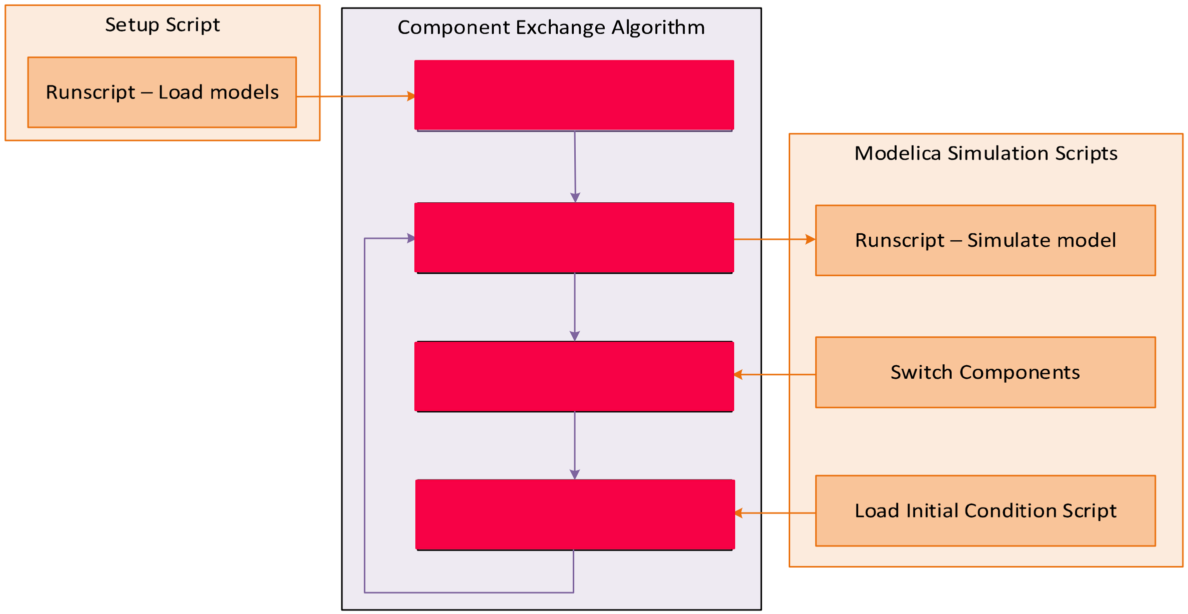
Co-Simulation

Combination of physical and data-driven models

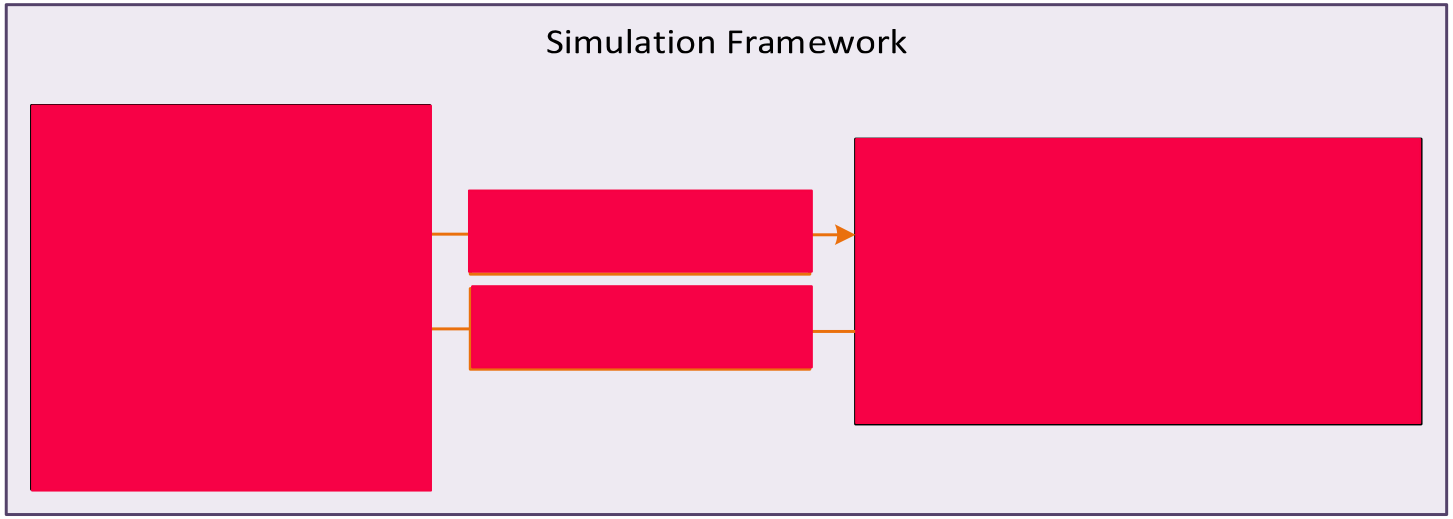


- Co-Simulation: Dymola-Python
- Simulation Master: Dymola
- Interfacing: FMI 2.0

Component Exchange Algorithm



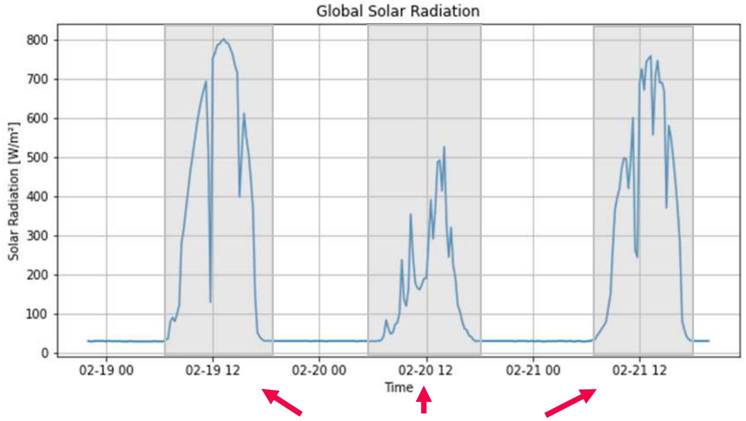
Implementation
Dymola-Python Framework



Component Exchange - Application
Solar Collector Use Case

Component exchange based on active and inactive period of solar collector – active and supporting model
Selection based on solar radiation S_{global}

Scheduling Criterion: Collector active during defined timespan



Active Collector: 8:00 – 18:00

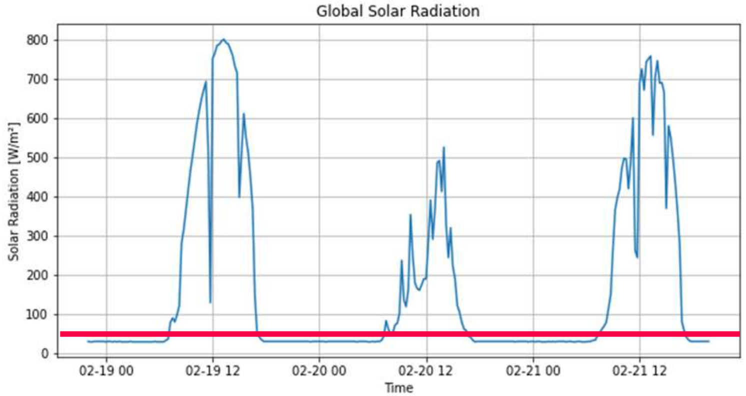
Component Exchange - Application

Solar Collector Use Case

Component exchange based on active and inactive period of solar collector – active and supporting model

Selection based on solar radiation S_{global}

Threshold Criterion: Collector active when radiation above threshold value



$S_{Threshold} = 30\ W/m^2$

Active Collector: $S_{Global} > S_{Threshold}$

Experiments

Experiment Setup

Parameter	Value
Co-Simulation Timestep	15 min
Simulation Duration	25 – 32 days

Exchange Criteria

Method	Criterion
Scheduling	Active Model: 8:00 – 18:00
Threshold	Active Model: $S_{global} > 30$ W / m²

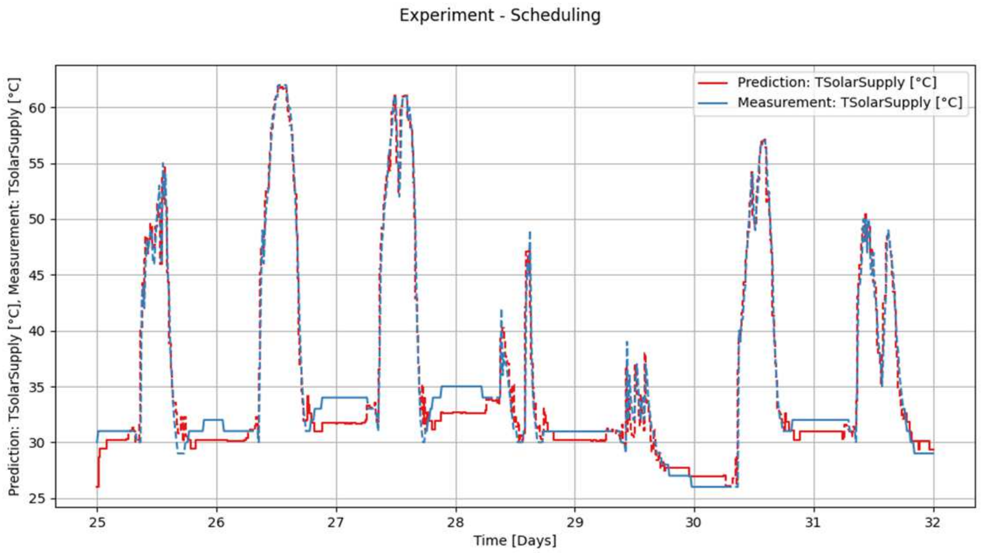
Model Selection

Active Model	Supporting Model
Linear Regression	Random Forest
Random Forest	Linear Regression
Random Forest	Physical Model

Results

Model Selection – Scheduling Algorithm

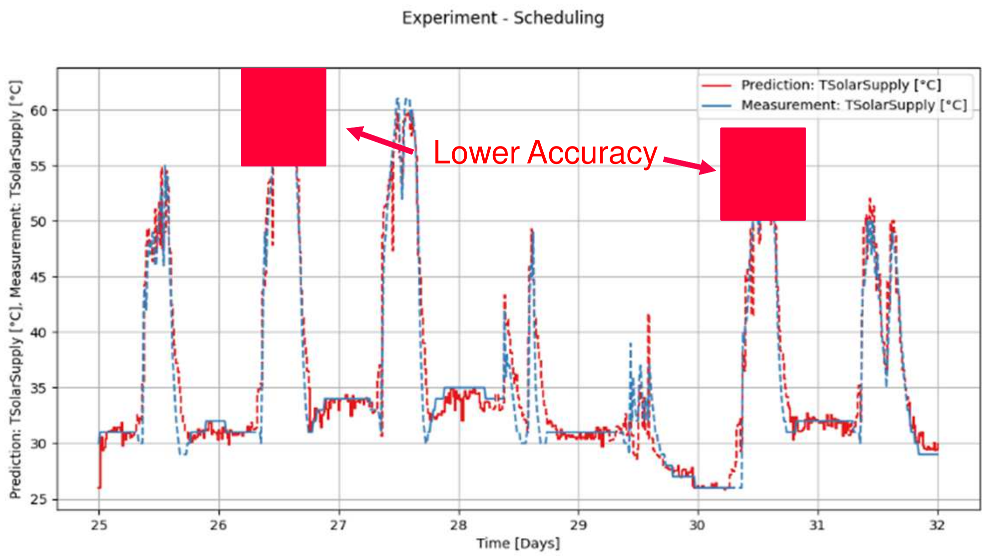
Active Model: Random Forest Regression - Supporting Model: Linear Regression



Results

Model Selection – Scheduling Algorithm

Active Model: Linear Regression - Supporting Model: Random Forest Regression

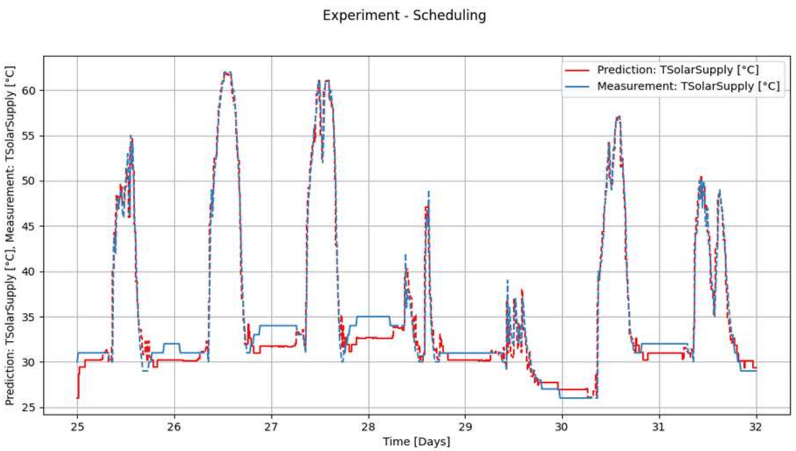


Results

Model Selection – Scheduling Algorithm

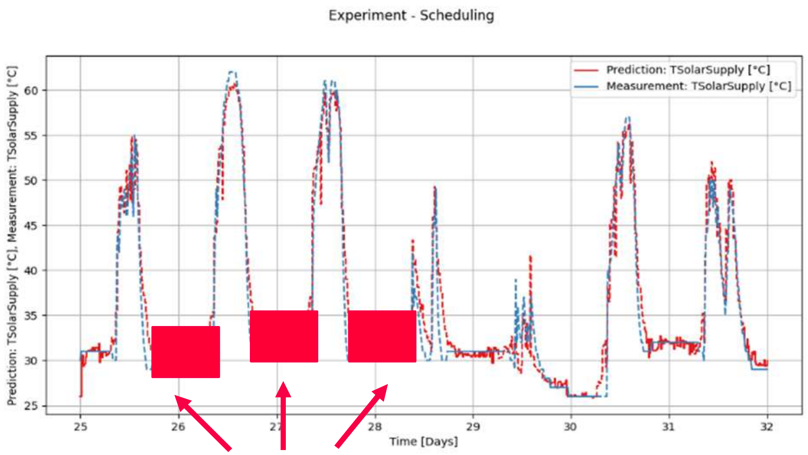
Scheduling Criterion

Active Model	Supporting Model
Random Forest	Linear Regression



Scheduling Criterion

Active Model	Supporting Model
Linear Regression	Random Forest



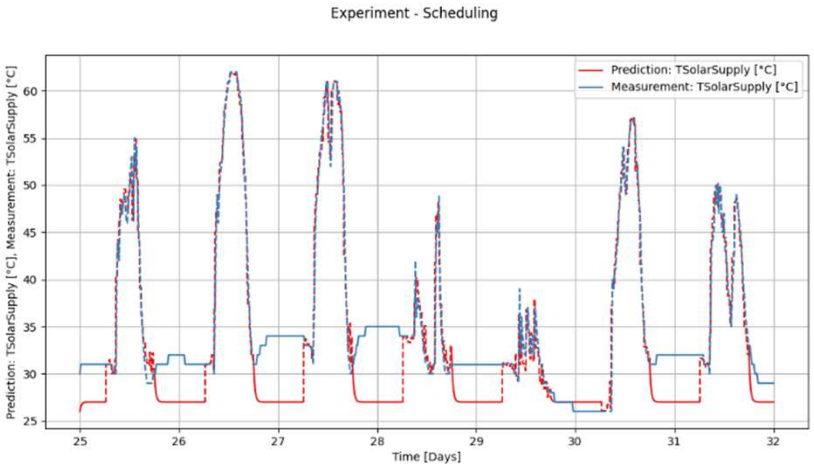
Value Fluctuations

Results

Scheduling and Threshold Criterion

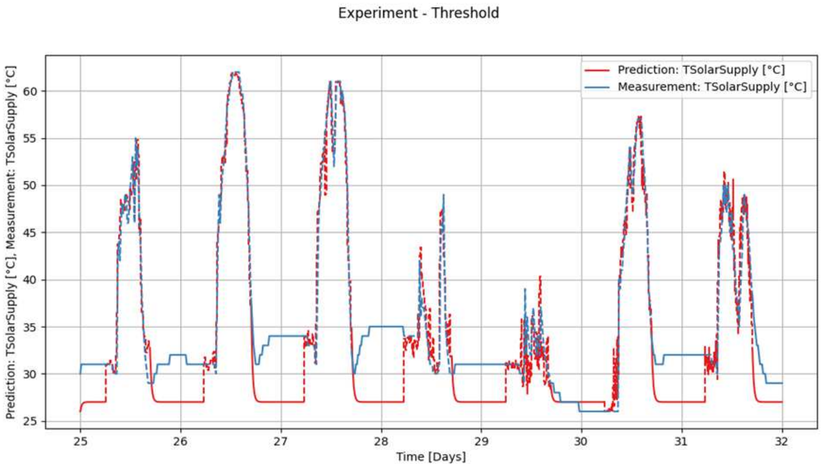
Scheduling Criterion

Active Model	Supporting Model
Random Forest	Physical Model



Threshold Criterion

Active Model	Supporting Model
Random Forest	Physical Model



Results
Performance Metrics

Scheduling Criterion

Active Model	Supporting Model	Exchange Criterion	R^2	CV-RMSE	MAPE
Linear Regression	Random Forest	Scheduling	0.936	0.062	3.87 %
Random Forest	Physical Model	Scheduling	0.921	0.094	7.94 %

Threshold Criterion

Active Model	Supporting Model	Exchange Criterion	R^2	CV-RMSE	MAPE
Linear Regression	Random Forest	S_{Global} > 30 W/m²	0.947	0.053	3.58 %
Random Forest	Physical Model	S_{Global} > 30 W/m²	0.912	0.086	7.26 %

Conclusion

Future Work

- Different applications / use cases
- Different criteria / combined criteria

Acknowledgements

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Thank you for your attention!

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