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Learning the dynamic of clusters of vertices in a graph for District Heating Network simplification

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Keywords

- District Heating Network
- Aggregation process
- Learning on graphs
- Recurrent neural network
- Model reduction

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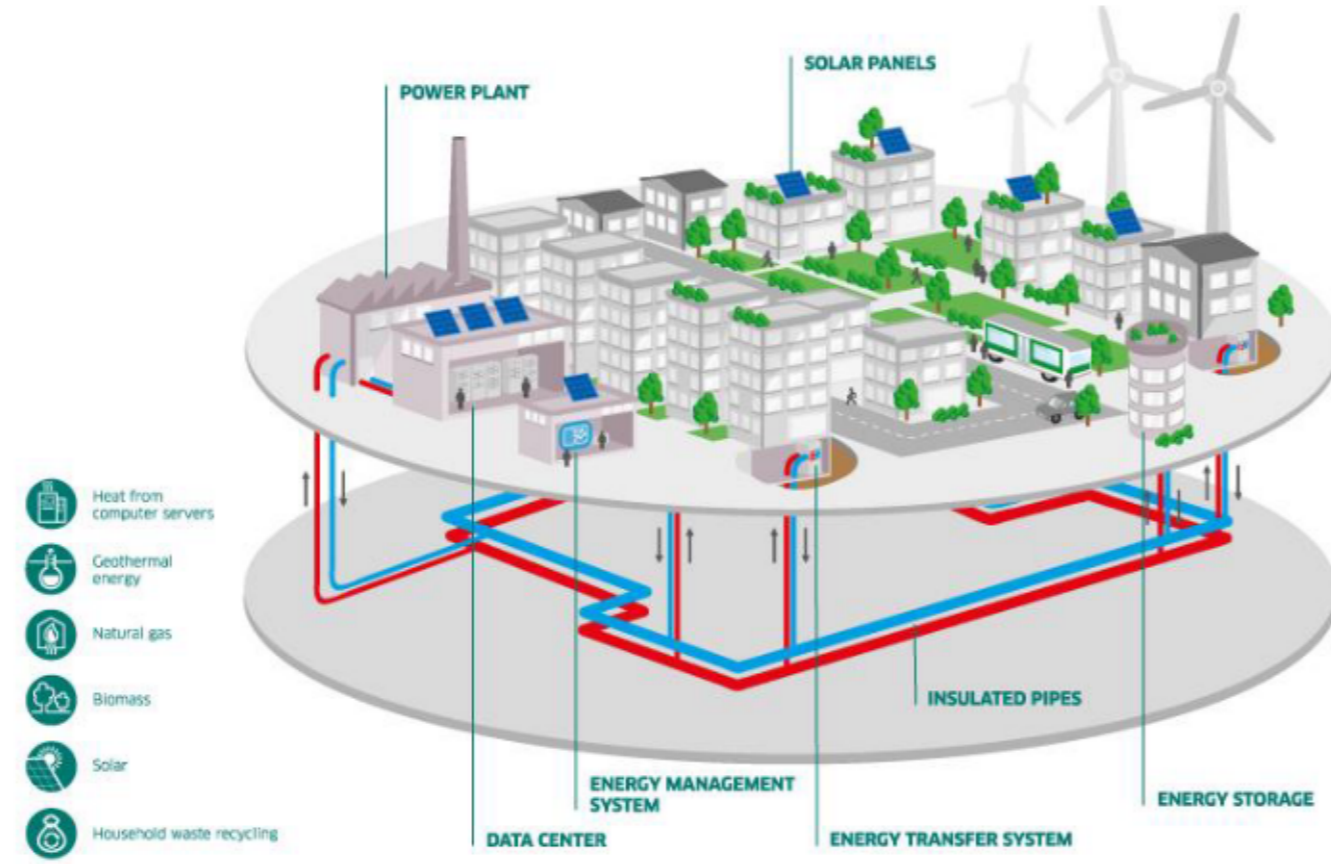


Contact information



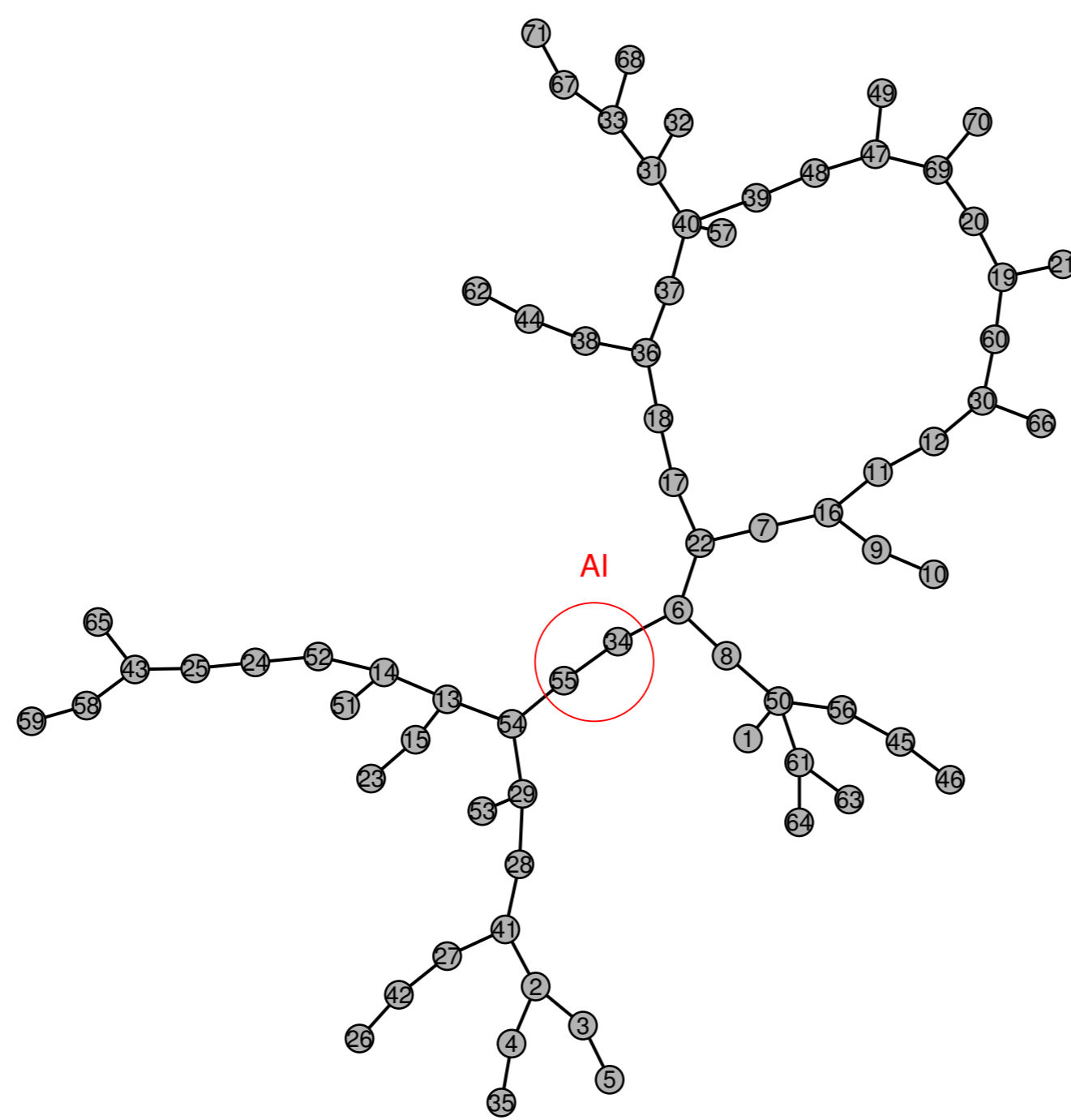
SCAN ME

District Heating Network



- Reduction of **GHG** emissions
- Optimal control for high energy **efficiency**
- Integration of **Renewable sources**

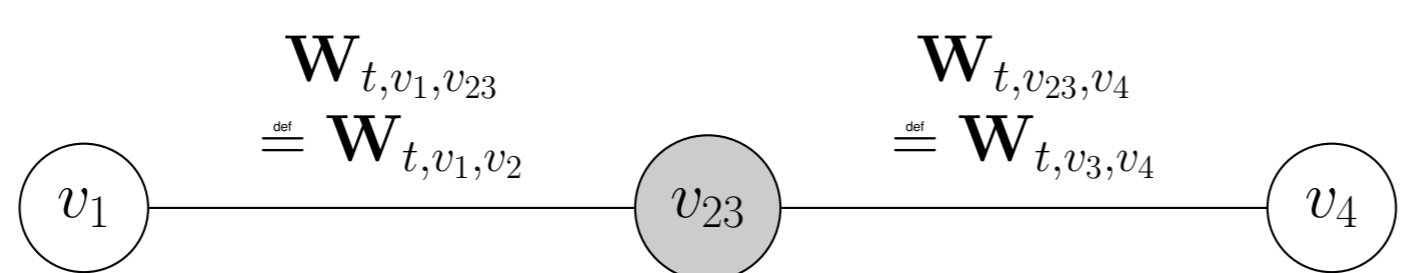
Problematic & Objective



$$\text{Cost of simulation} = \mathcal{O}(T * (|\mathcal{V}| + |\mathcal{E}|))$$

Aggregation methodology

Series of graphs $\mathbf{W} \in \mathbb{R}^{T \times |\mathcal{V}| \times |\mathcal{V}|}$ with multi variate time series signals $\{\mathbf{X}^s, \mathbf{X}^r, \mathbf{X}^p, \mathbf{X}^d\} \in \mathbb{R}^{4 \times T \times |\mathcal{V}|}$



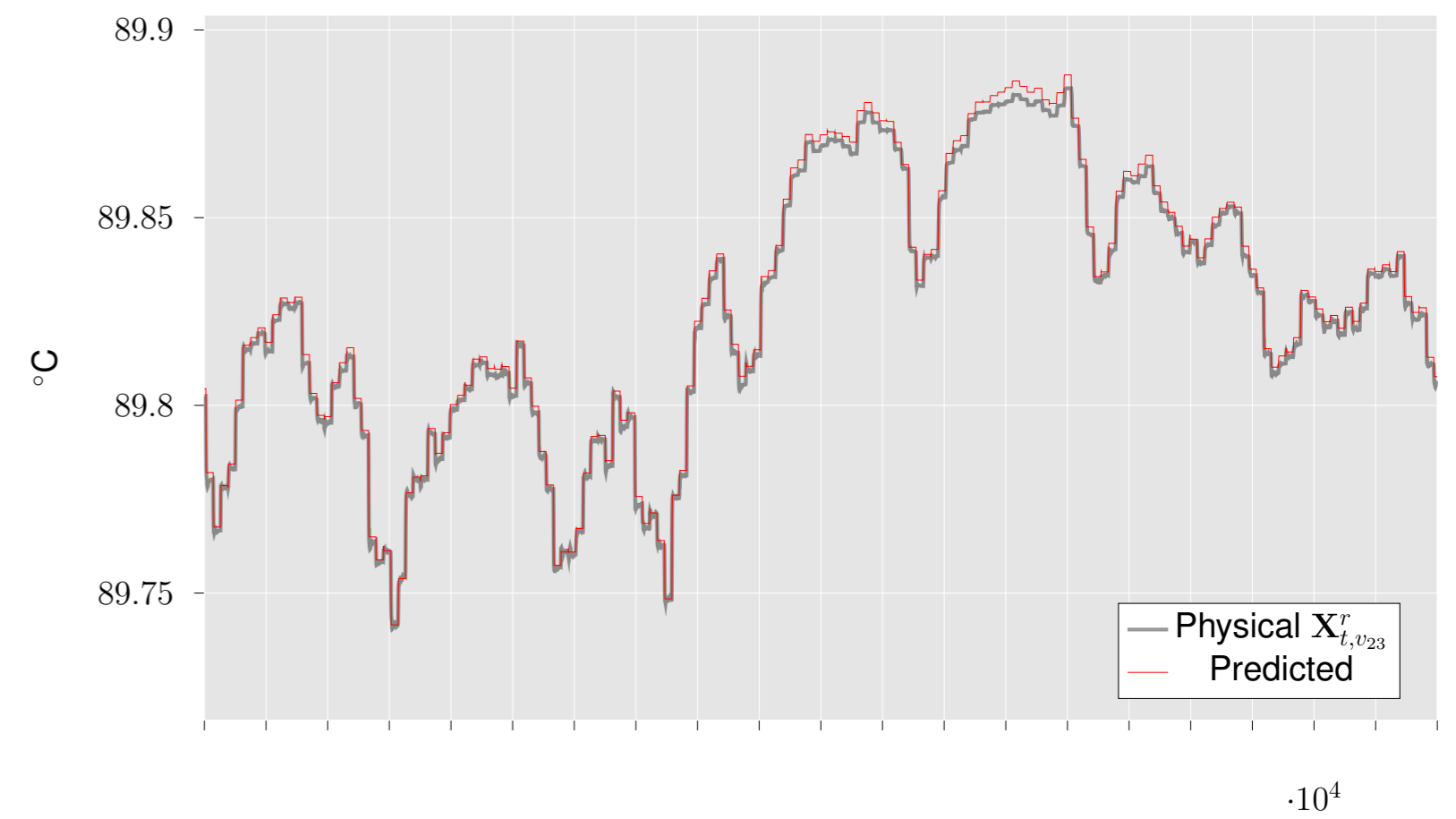
$$\begin{cases} \mathbf{X}_{t,v_1}^s \\ \mathbf{X}_{t,v_1}^r \\ \mathbf{X}_{t,v_1}^p \\ \mathbf{X}_{t,v_1}^d \end{cases} \quad \begin{cases} \mathbf{X}_{t,v_{23}}^s \equiv \mathbf{X}_{t,v_3}^s \\ \mathbf{X}_{t,v_{23}}^r \equiv \mathbf{X}_{t,v_2}^r \\ \mathbf{X}_{t,v_{23}}^p \\ \mathbf{X}_{t,v_{23}}^d \end{cases} \quad \begin{cases} \mathbf{X}_{t,v_4}^s \\ \mathbf{X}_{t,v_4}^r \\ \mathbf{X}_{t,v_4}^p \\ \mathbf{X}_{t,v_4}^d \end{cases}$$

$$\forall i, j, t, \mathbf{W}_{t,i,j} \equiv \begin{cases} \exp\left(-\frac{\pi \mathbf{H}_{i,j} \mathbf{L}_{i,j} \mathbf{D}_{i,j}}{CM_{t,i,j}}\right) & \text{if } (i, j) \in \mathcal{E} \\ 0 & \text{otherwise} \end{cases}$$

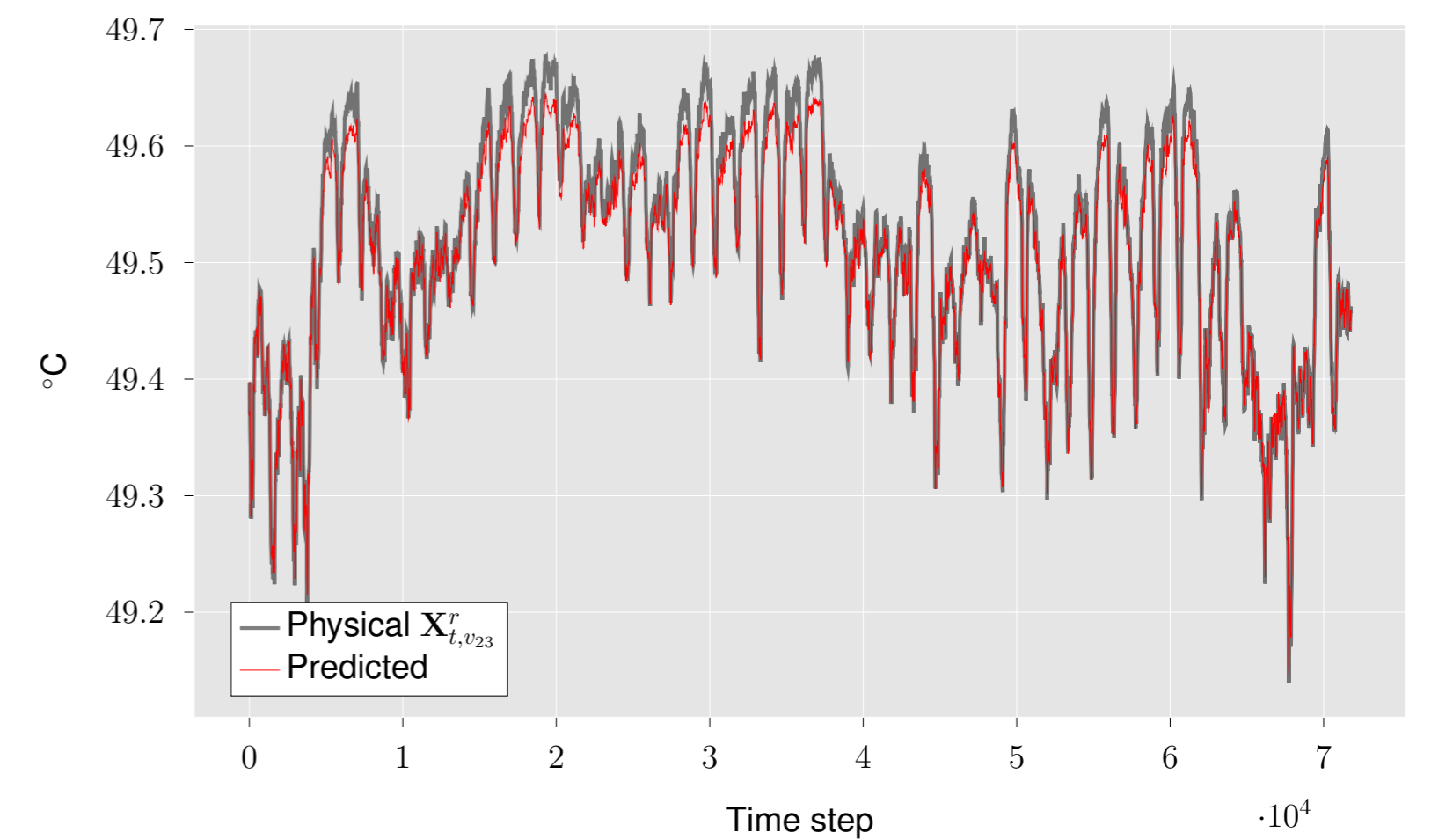
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Performance on test set

- Recurrent neural network with GRU cells
- Supply temperature learned with **MAE**(°C) = $5.6 \cdot 10^{-3}$

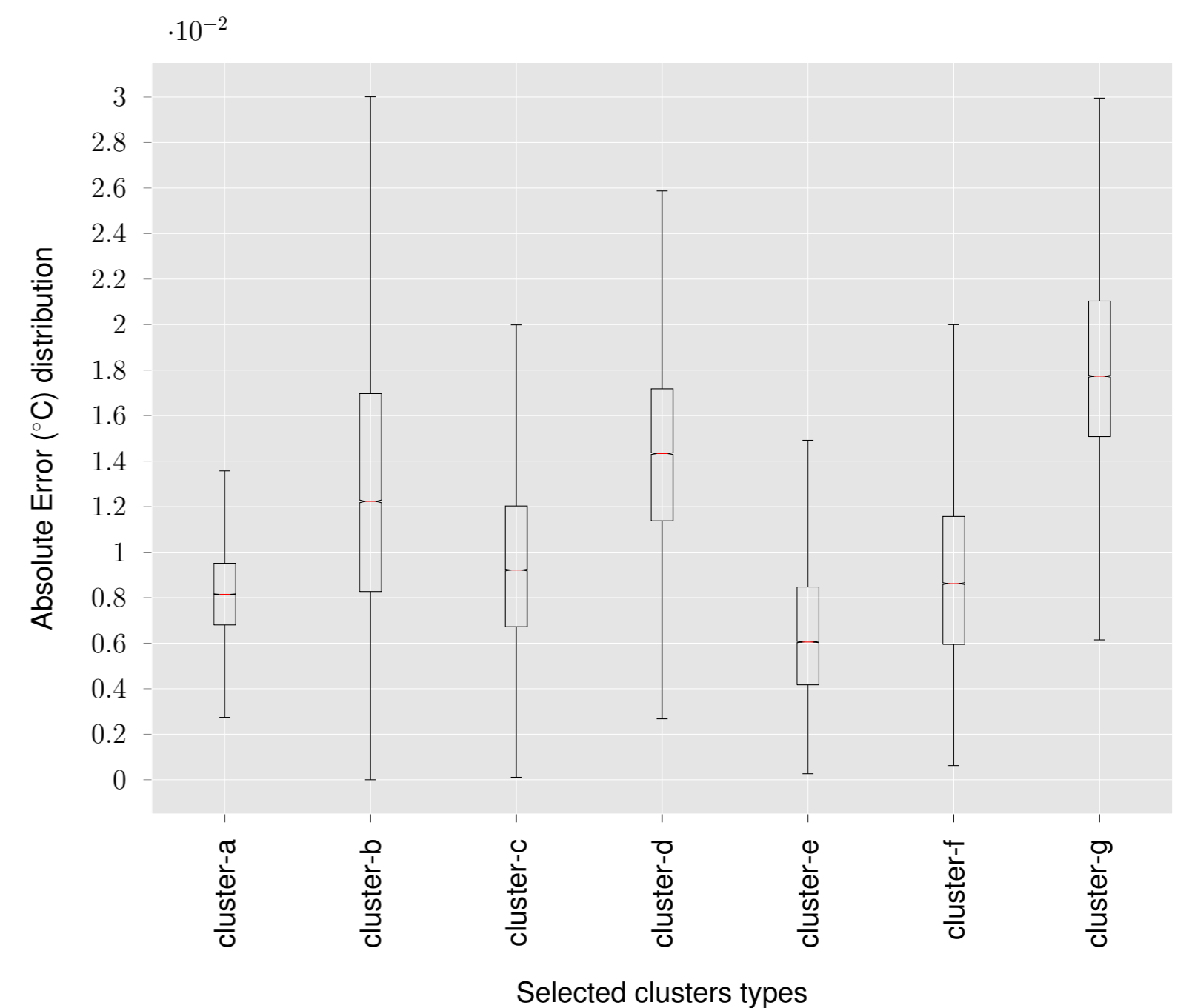


- Return temperature learned with **MAE**(°C) = $9.2 \cdot 10^{-3}$



Further validation

Methods further validated on different clusters



Perspectives & next steps

- Identify objective-driven **metrics** for pertinent clusters
- **Community detection** model based on identified metrics
- **Coupled AI and physical** simulation approach for large DHNs
- Clusters **structures-aware** learning models

