Multi-User Energy Consumption Monitoring and Anomaly Detection with Partial Context Information

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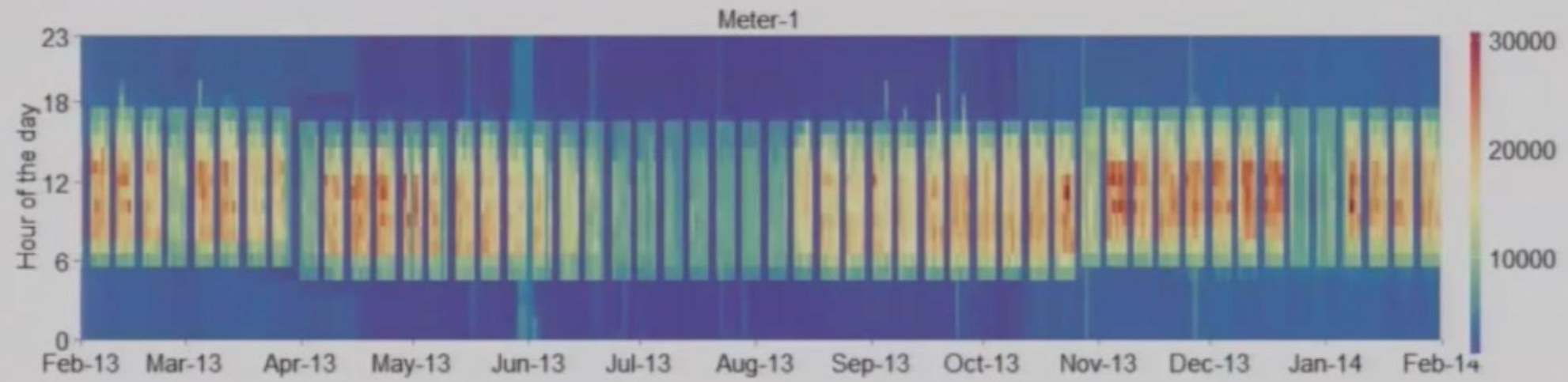
Smart electricity meters

Smart electricity meters

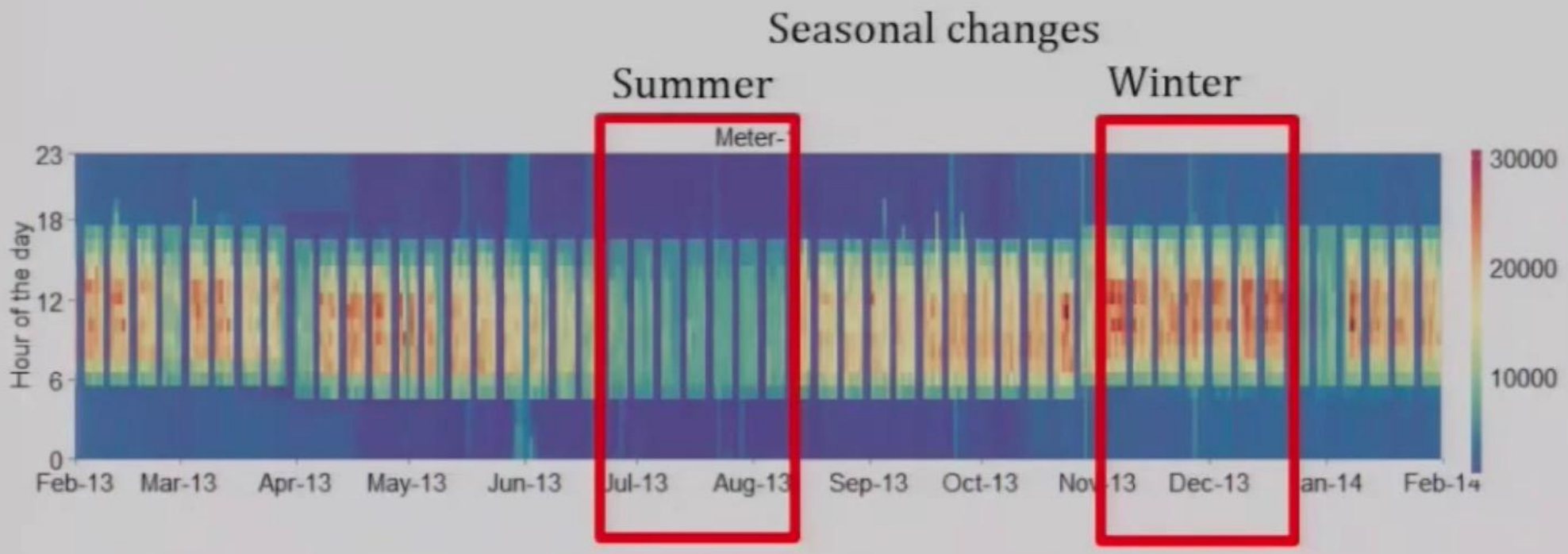
Enabler for fine-grained electricity monitoring!

Smart electricity meter data



Hourly electricity usage of a commercial building

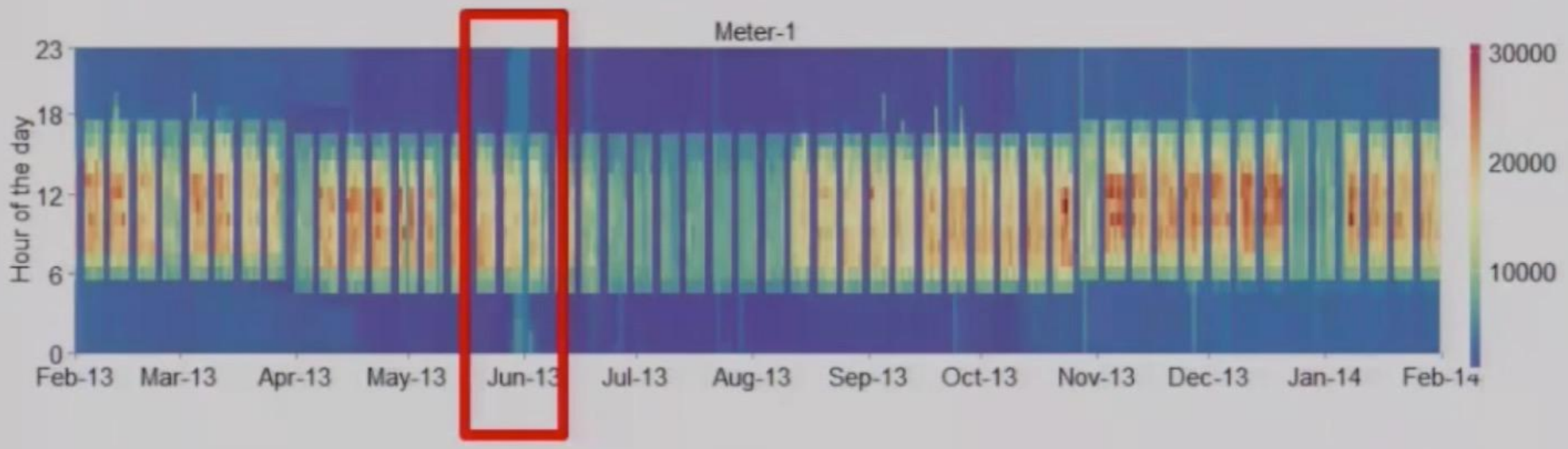
Smart electricity meter data



Hourly electricity usage of a commercial building

Smart electricity meter data

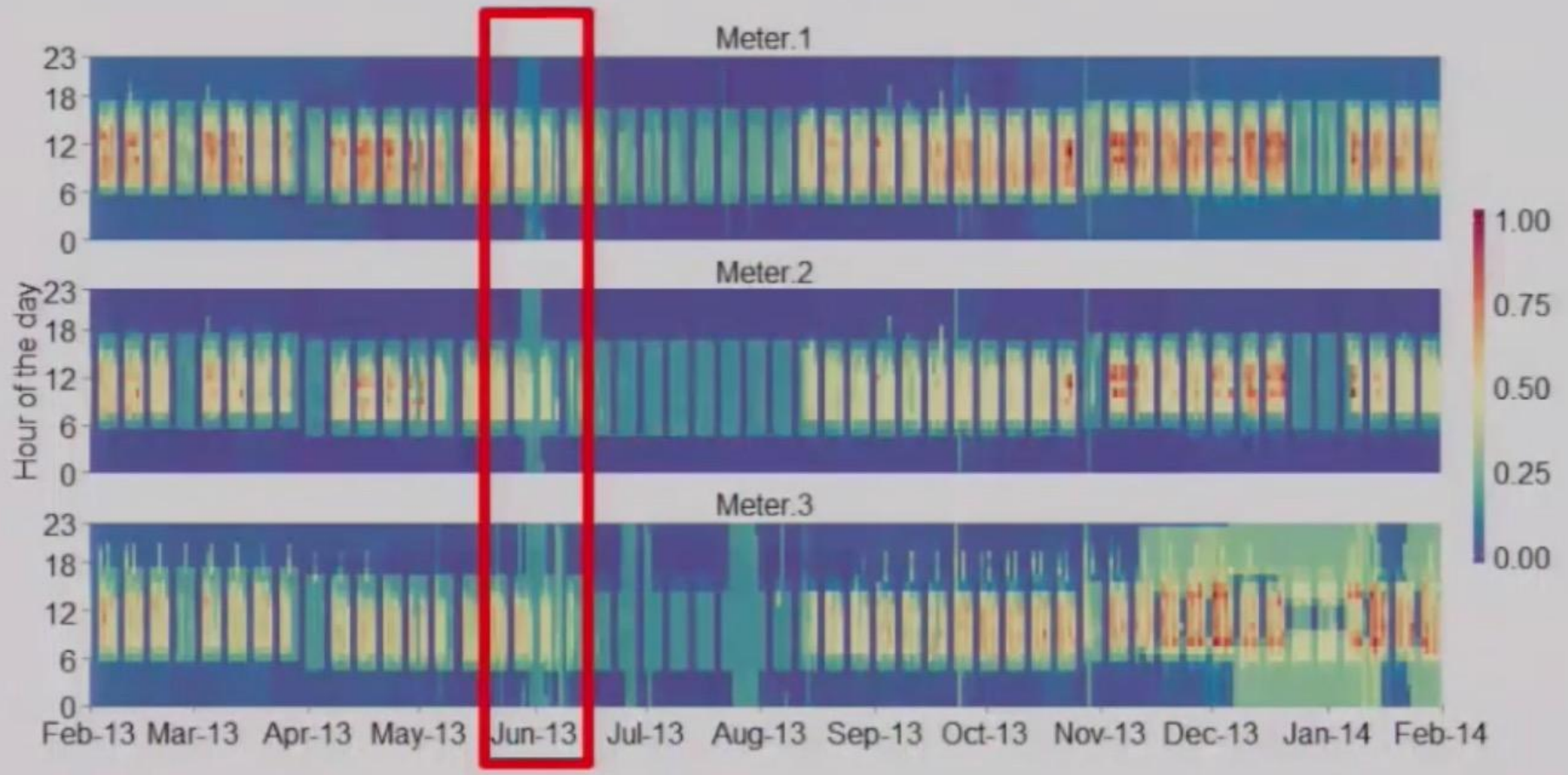
Potential abnormal energy usage event



Hourly electricity usage of a commercial building

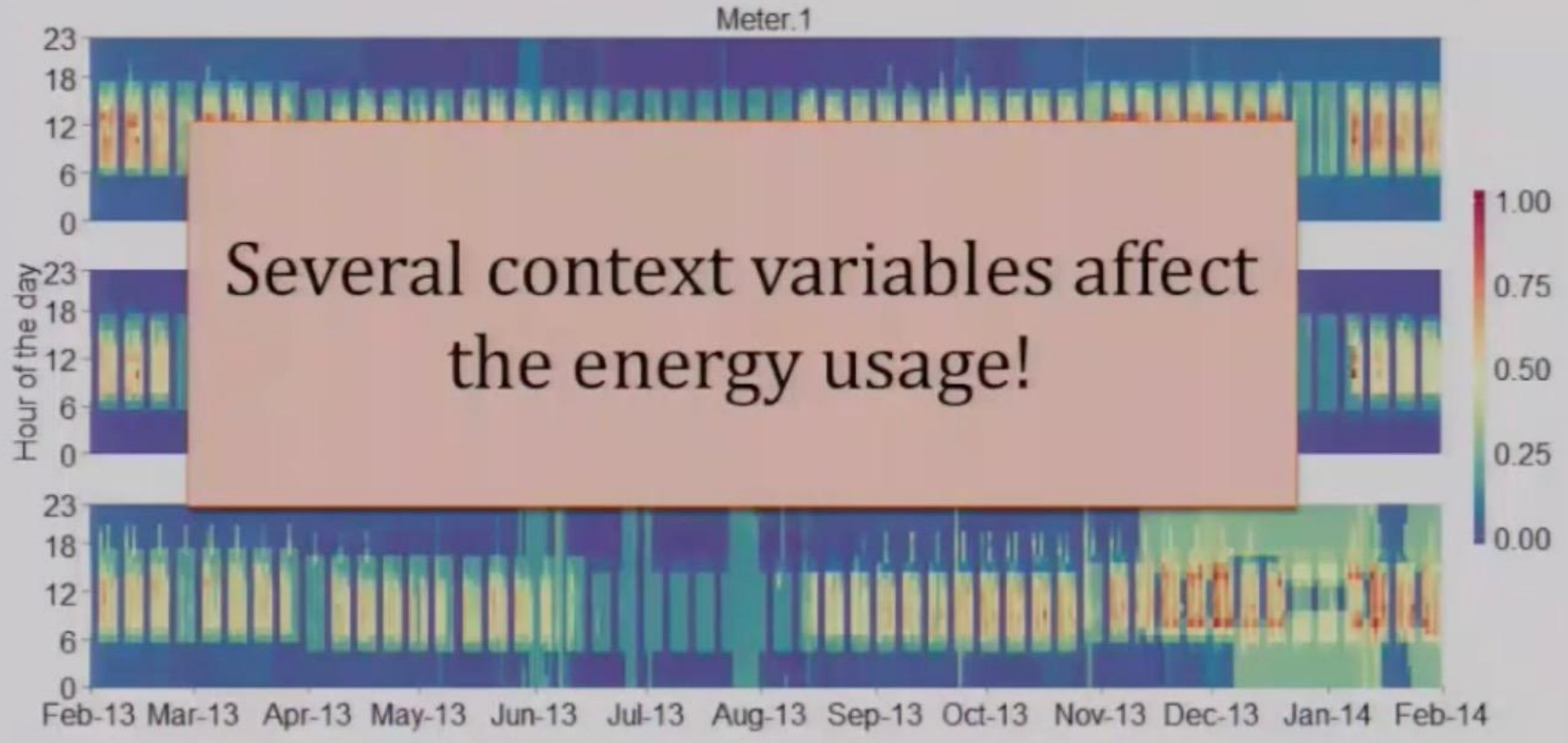
Smart electricity meter data

Might be a genuine energy usage event



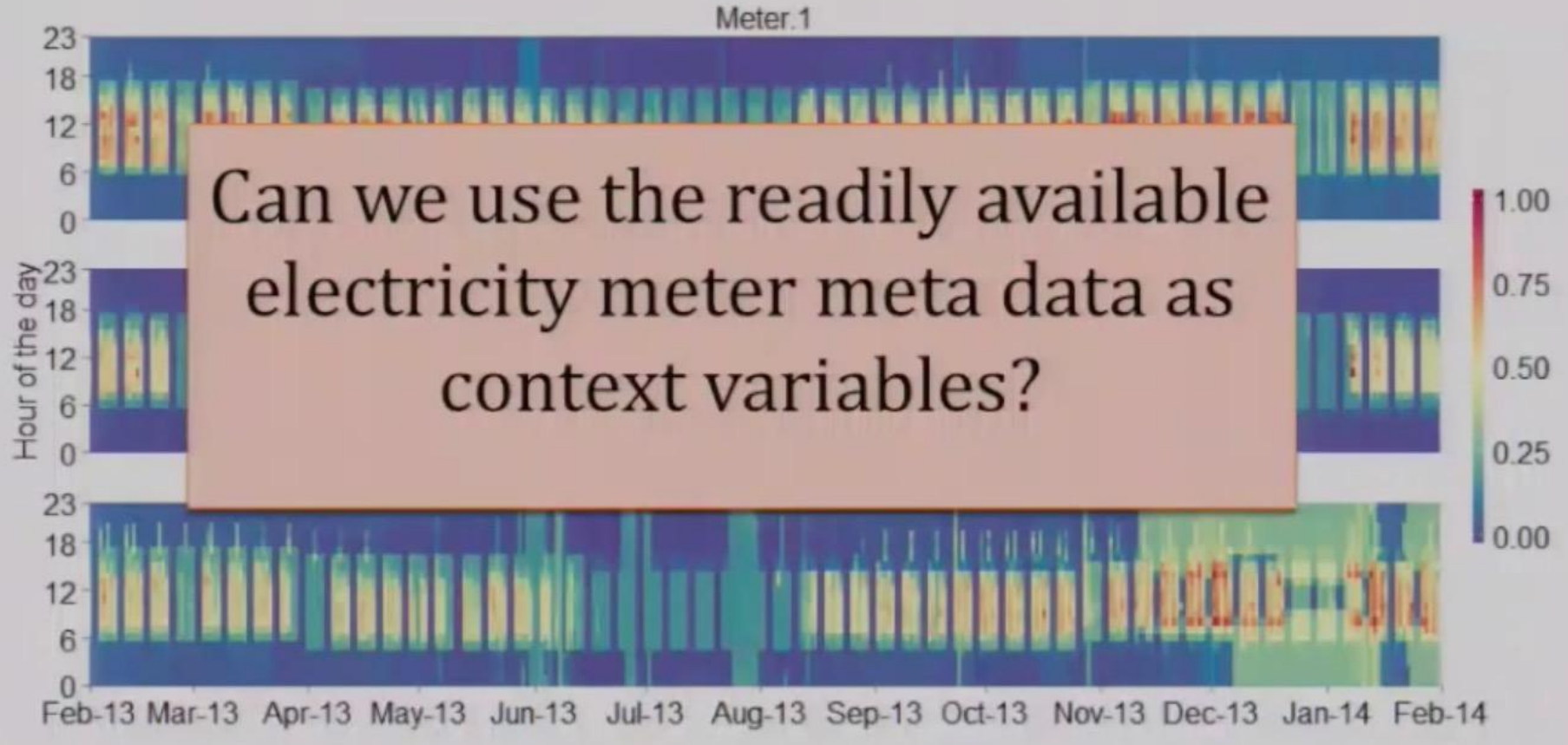
Hourly electricity usage of 3 buildings in an organization

Smart electricity meter data



Hourly electricity usage of 3 buildings in an organization

Smart electricity meter data

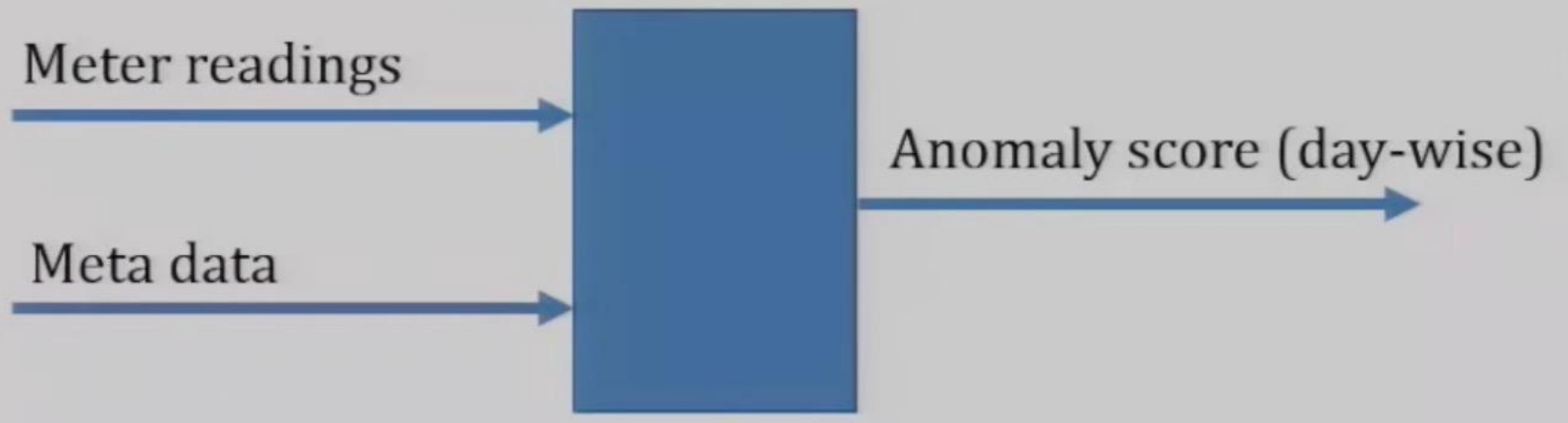


Can we use the readily available electricity meter meta data as context variables?

Hourly electricity usage of 3 buildings in an organization

Problem definition

Identifying potential abnormal energy usage events in buildings (residential and commercial) using the hourly smart meter readings and readily available meta data



Problem definition

Identifying potential abnormal energy usage events in buildings (residential and commercial) using the hourly smart meter readings and readily available meta data

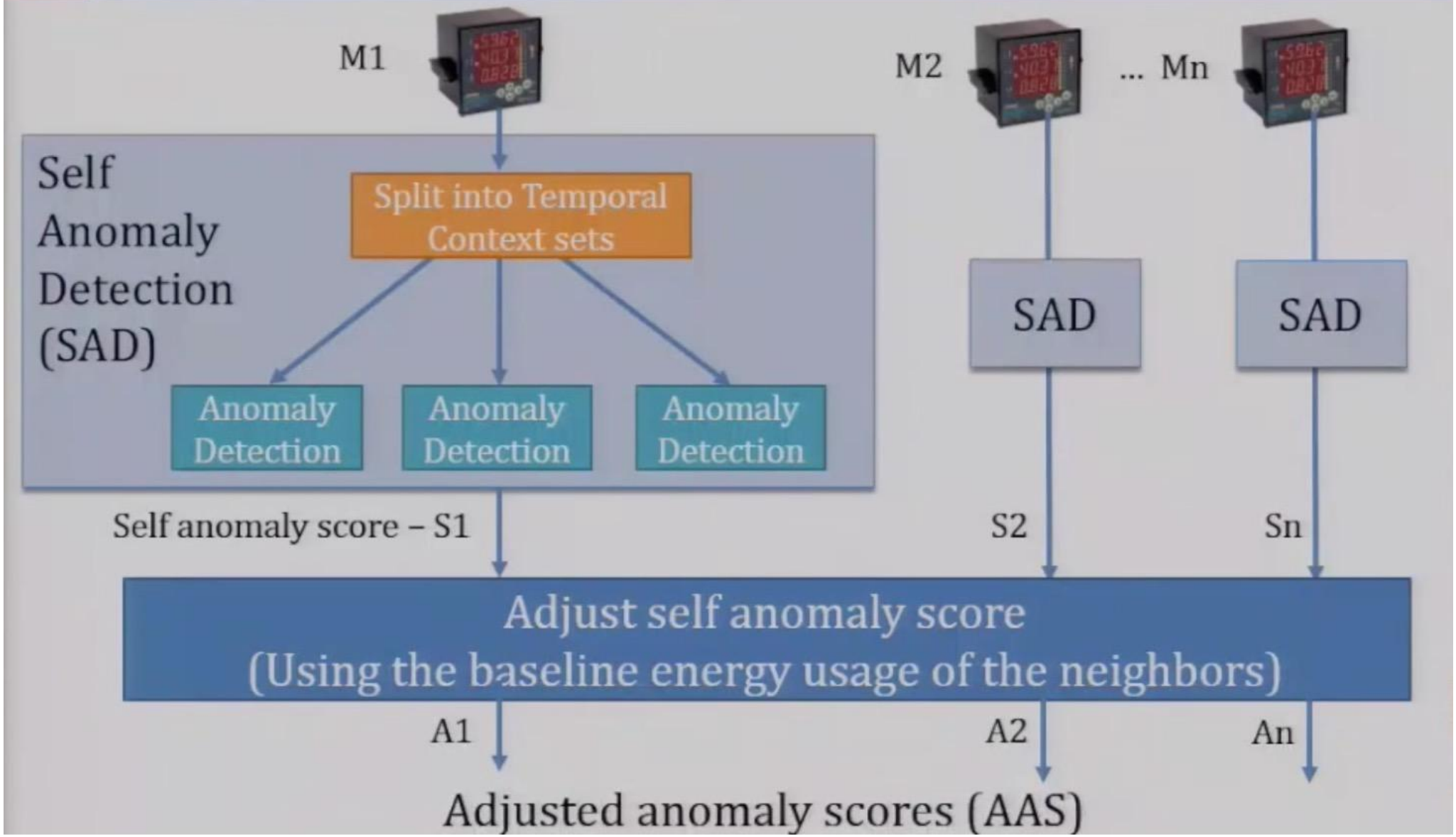
Timestamp

- Temporal context – for accounting temporal energy usage patterns e.g. day, night, holiday, seasons, etc.

Location

- Extracted neighborhood (functional/administrative) information – for accounting the effect of unknown context variables e.g. rare events.

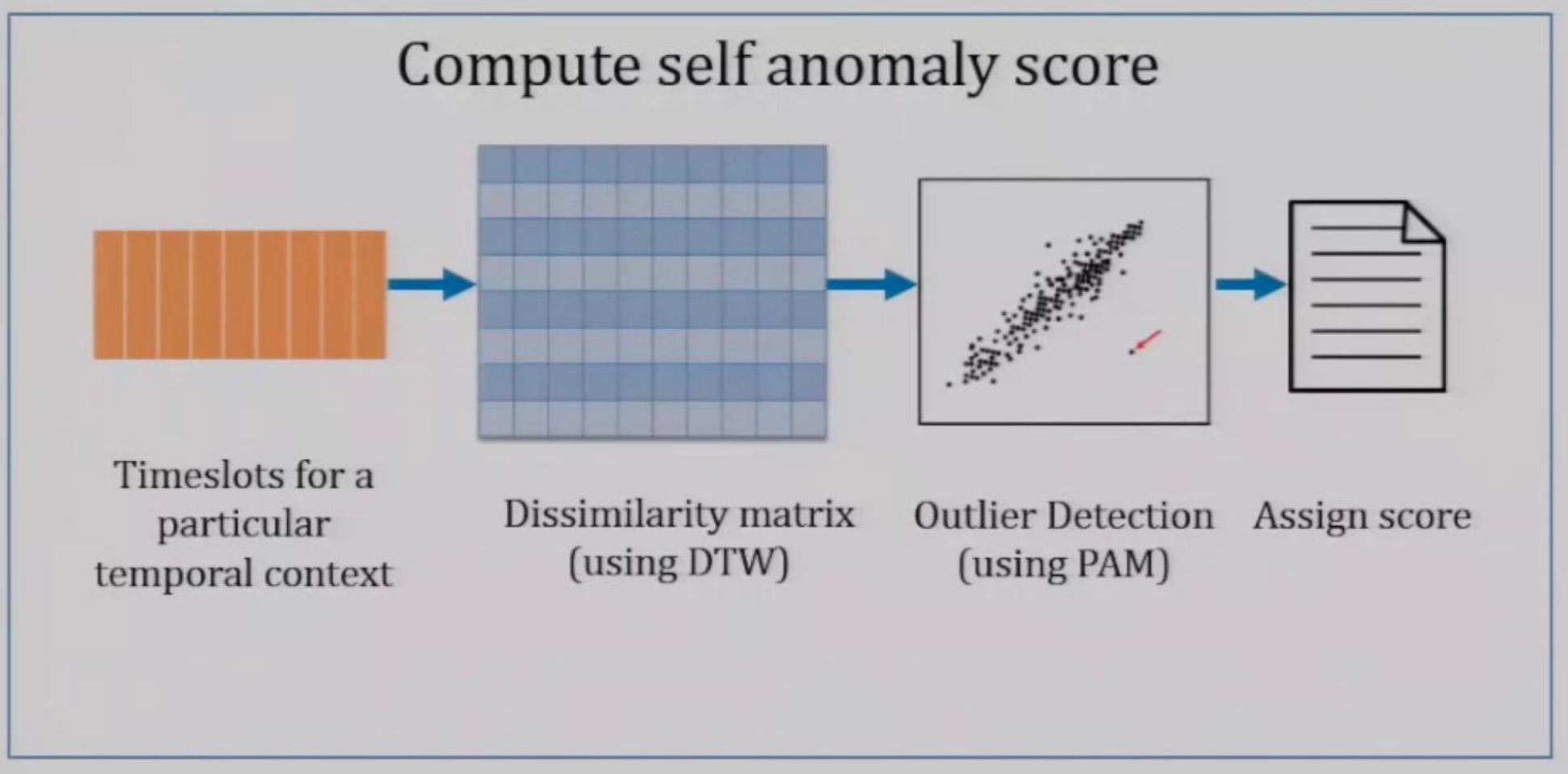
Methodology



Algorithm

1. • Split meter data based on temporal context sets
2. • Compute self anomaly score
3. • Neighborhood based adjustment

Algorithm


Compute self anomaly score
Timeslots for a particular temporal context
Dissimilarity matrix (using DTW)
Outlier Detection (using PAM)
Assign score

Algorithm

Neighborhood based adjustment

| Self Anomaly Score – W x Correlation between other meters |

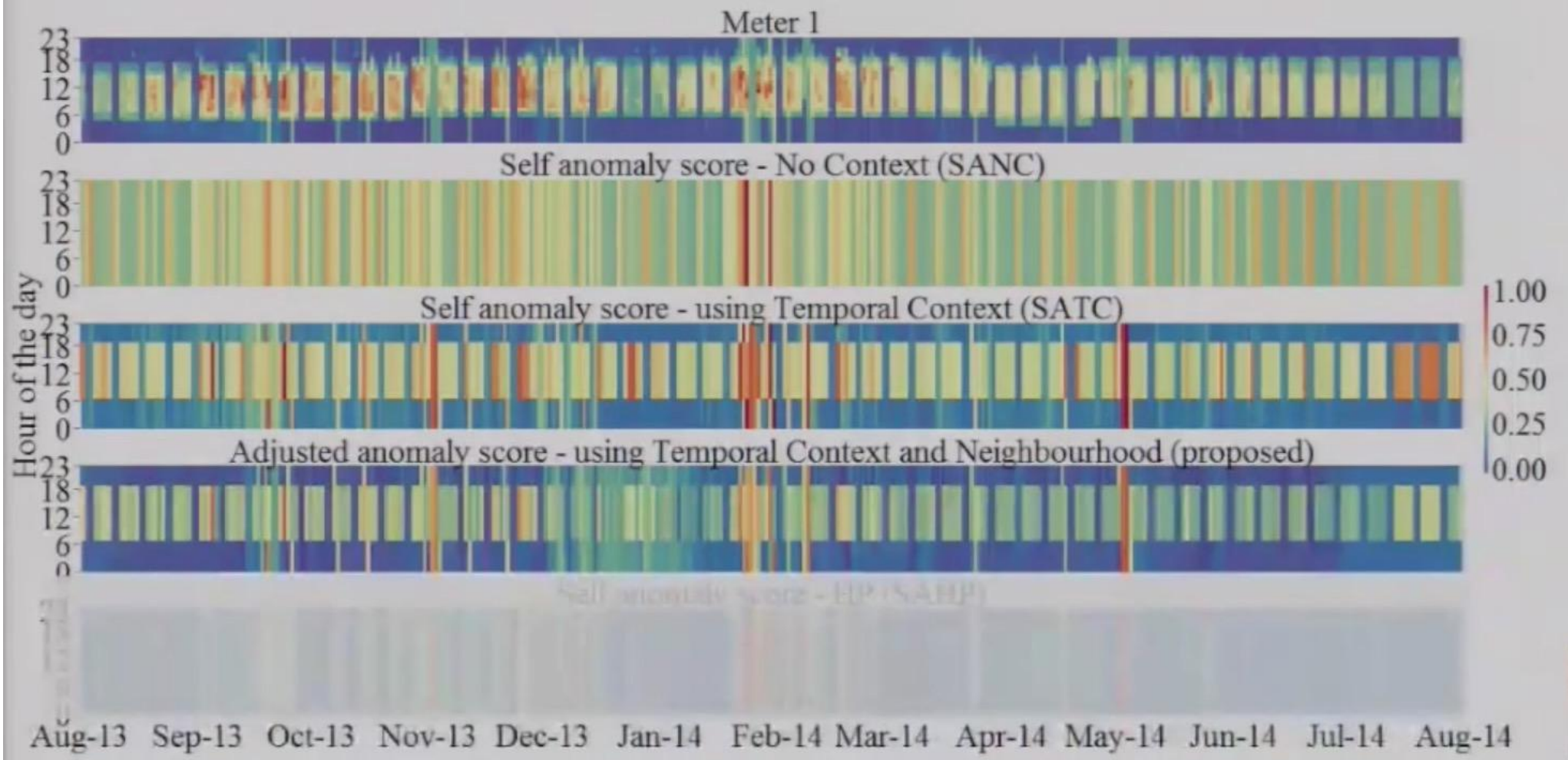
Dataset description

Properties	Commercial	Residential
Country	Sweden (KYAB)	India (IIIT-Delhi)
Building type	School	Apartment complex
# buildings	10	18
Usage	Classrooms, Office space Mostly fixed schedule	Family, Irregular schedule
Devices	Lighting, Air-conditioning, etc.	Household appliances
Data collection duration and interval	~ 3 years 1 – 10 minutes	~ 2 years 30 – 60 seconds

Experimental Setup

- Ground truth
  - Commercial - Manually annotated by the data owner
  - Residential - Injected known anomaly events
- Temporal context sets
  - Workingday-Daytime, Workingday-Nighttime, Holiday
- Neighborhood information
  - Provided by a domain expert or using existing methods
- Comparison with 3 baseline methods
  - Self Anomaly - No Context (SANC)
  - Self Anomaly, but using Temporal Context (SATC)
  - Anomaly detection HP (SAHP)
- Case by case analysis of known anomalies

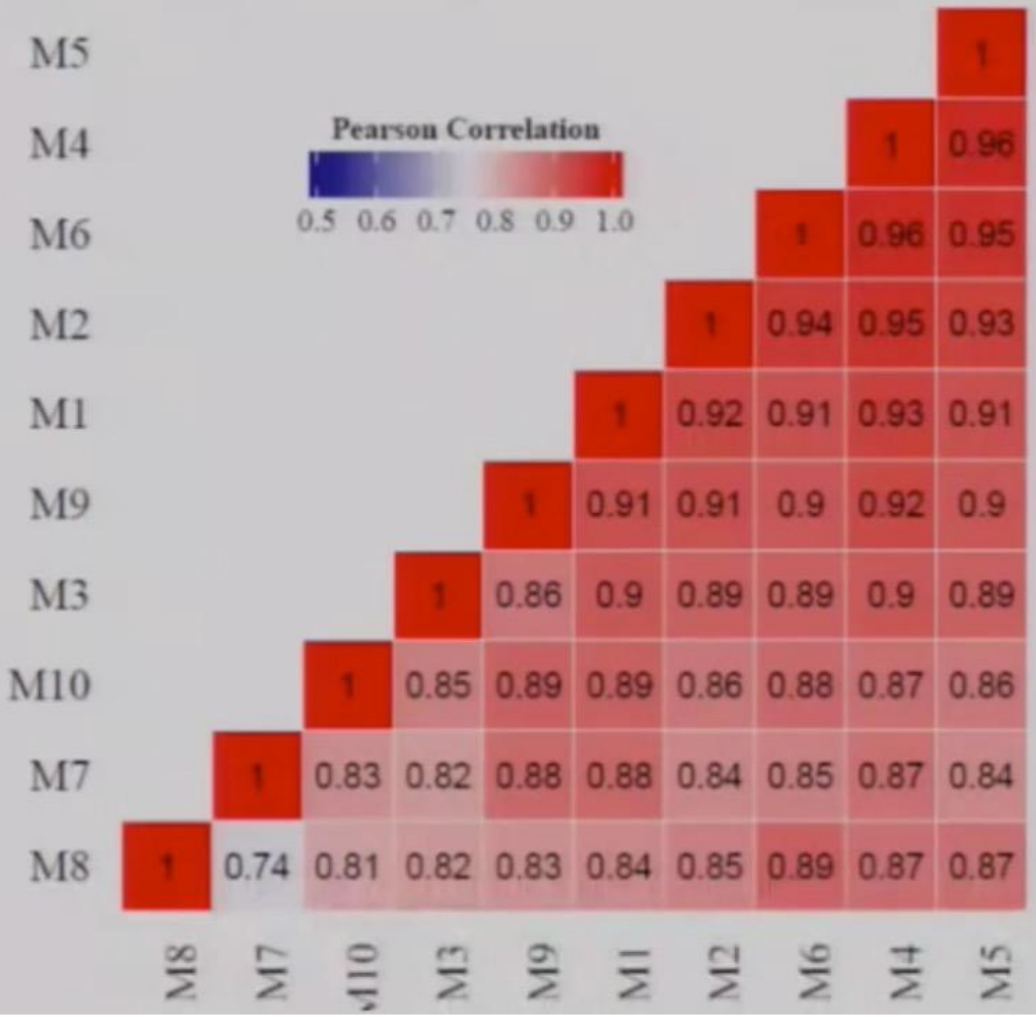
Analysis – Commercial buildings



Analysis – Commercial buildings

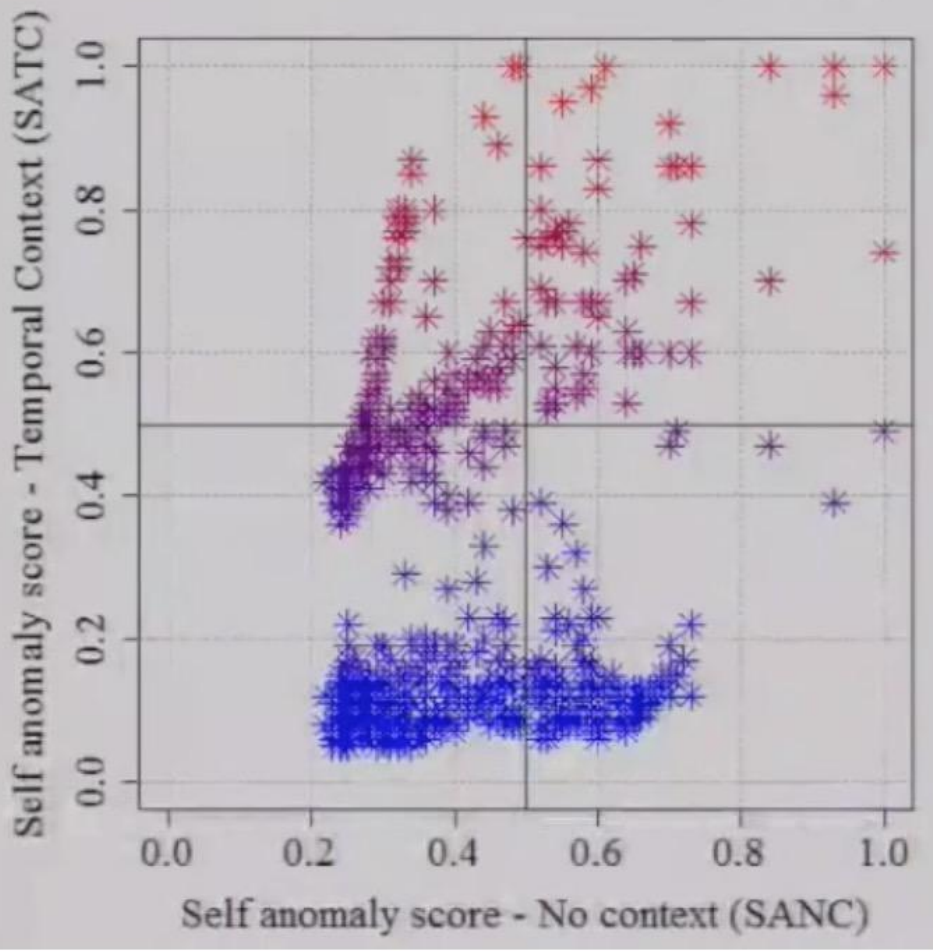
Analysis – Commercial buildings

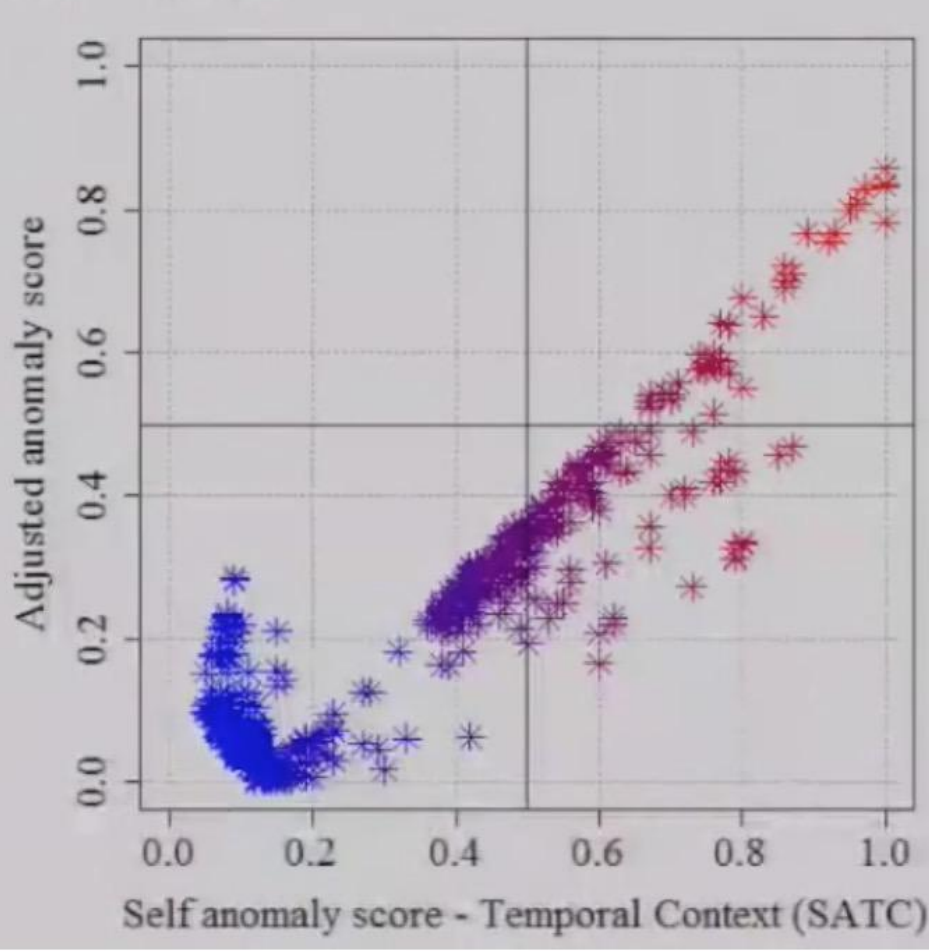
Correlation between the electricity meters for an year



Analysis – Commercial buildings

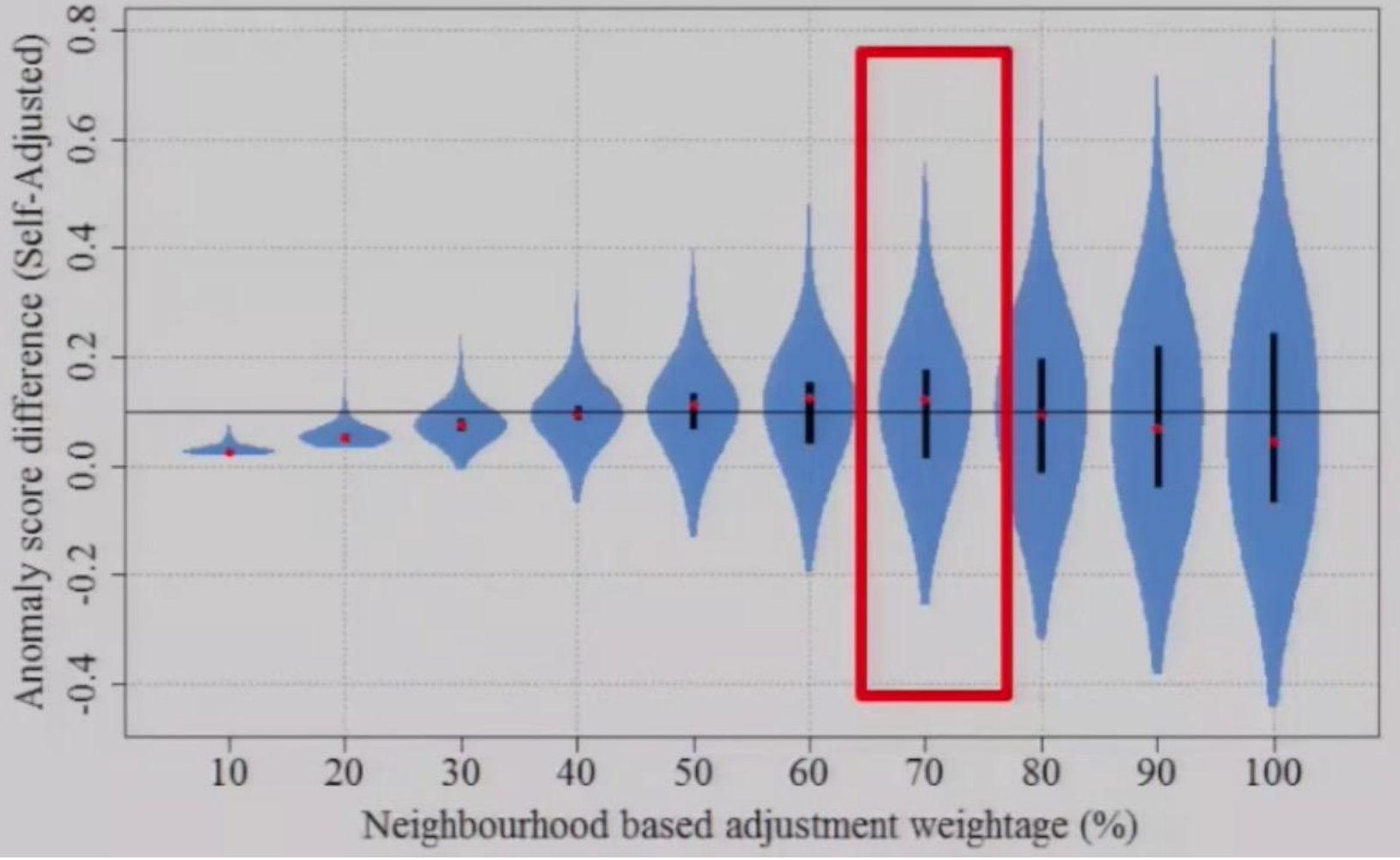
Usage of temporal context sets and neighborhood based adjustment



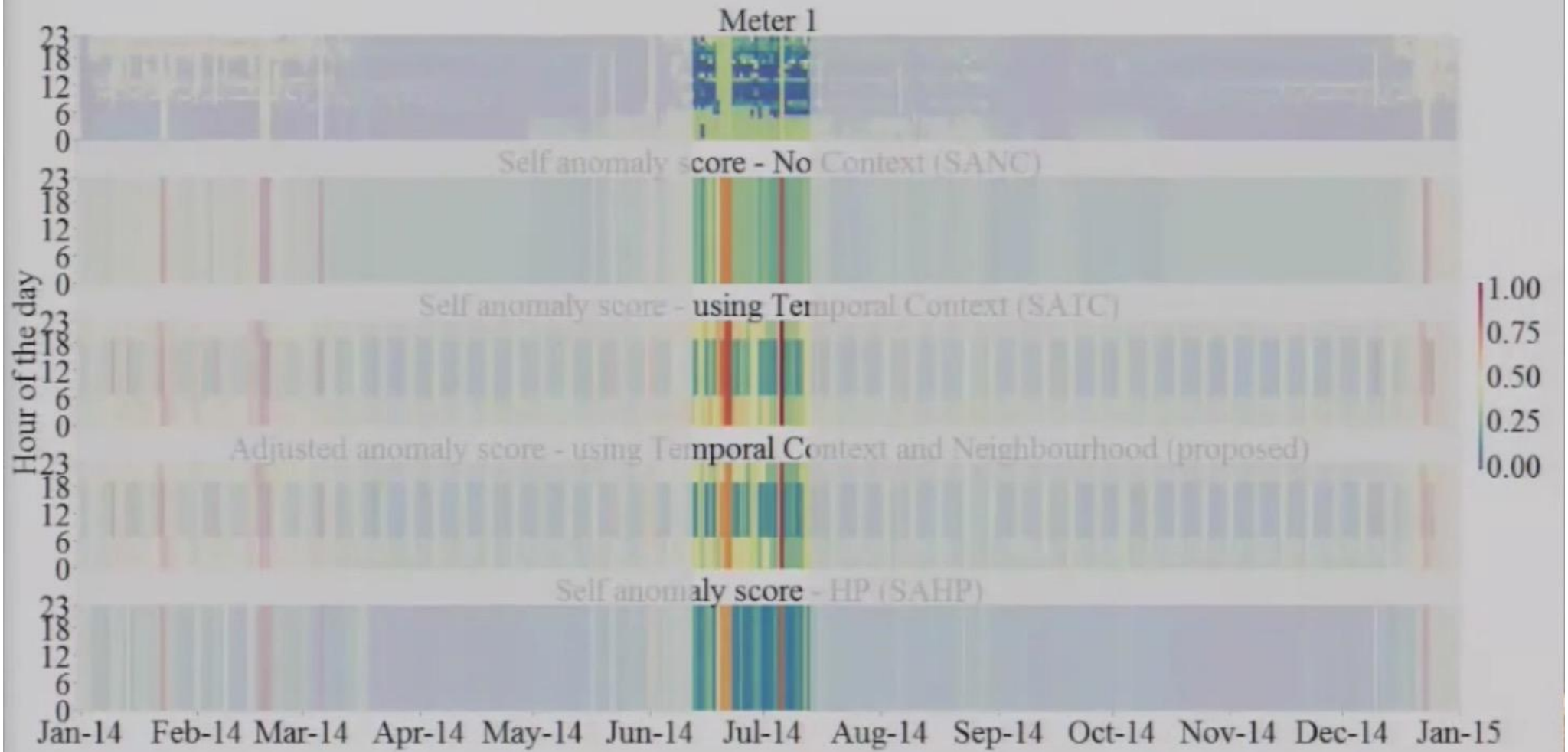


Analysis – Commercial buildings

What weightage to give for neighbors?

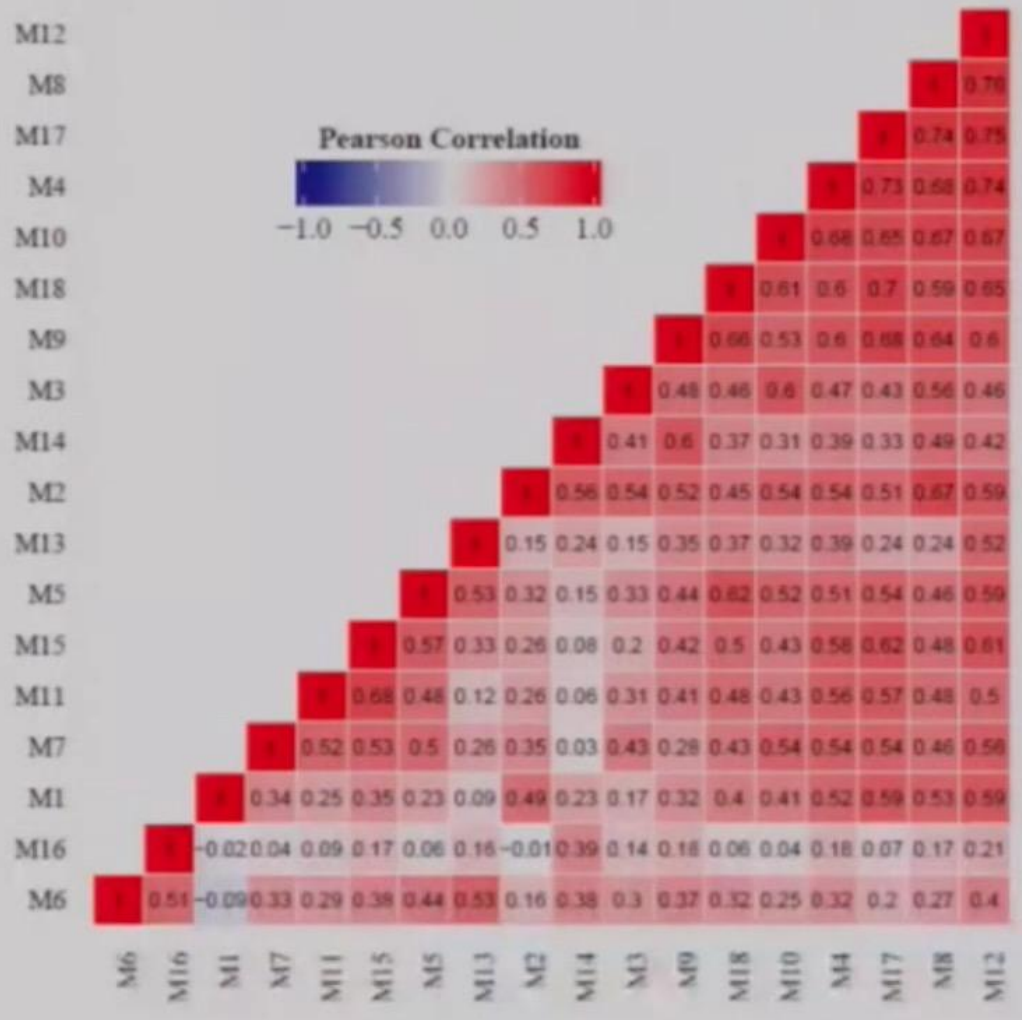


Analysis – Residential buildings



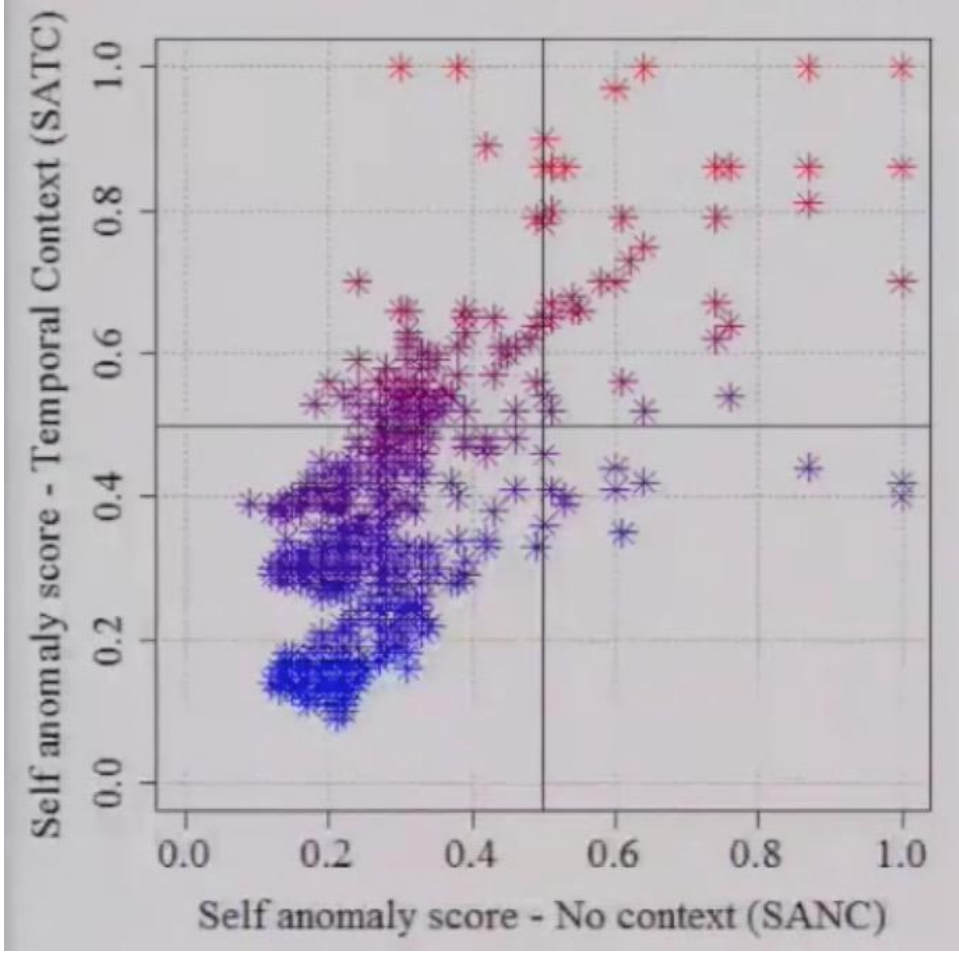
Analysis – Residential buildings

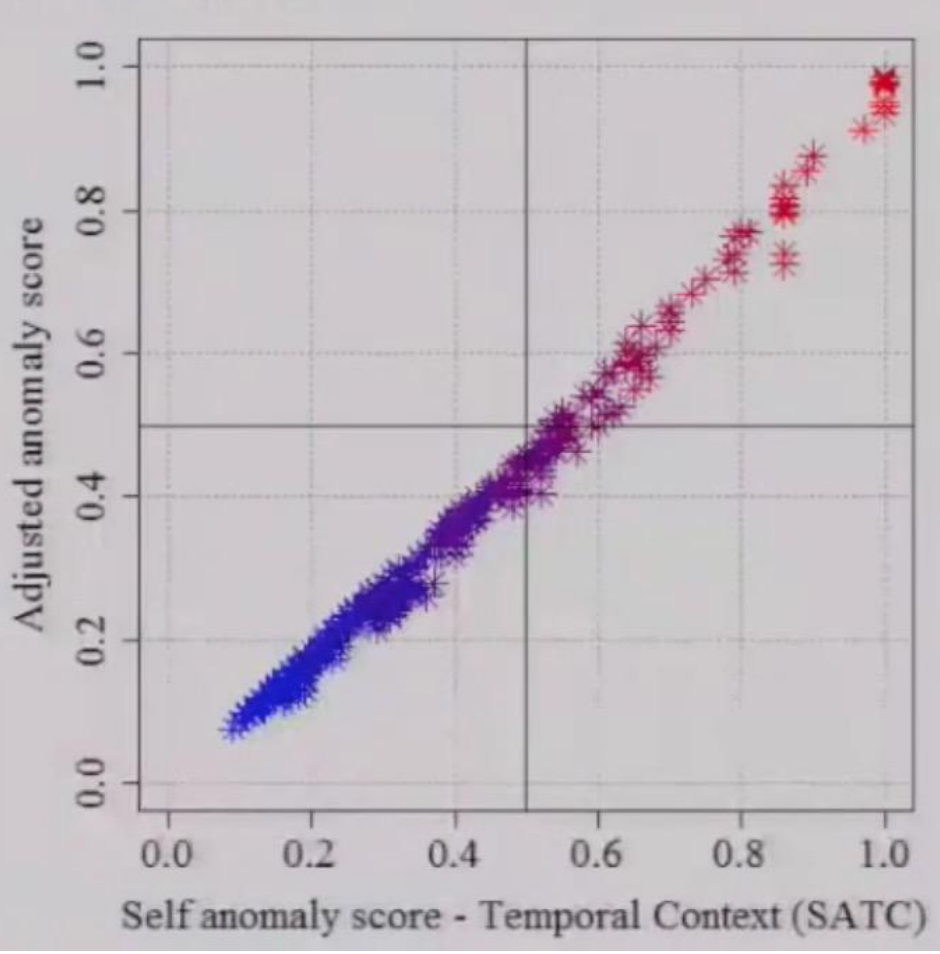
Correlation between the electricity meters for an year



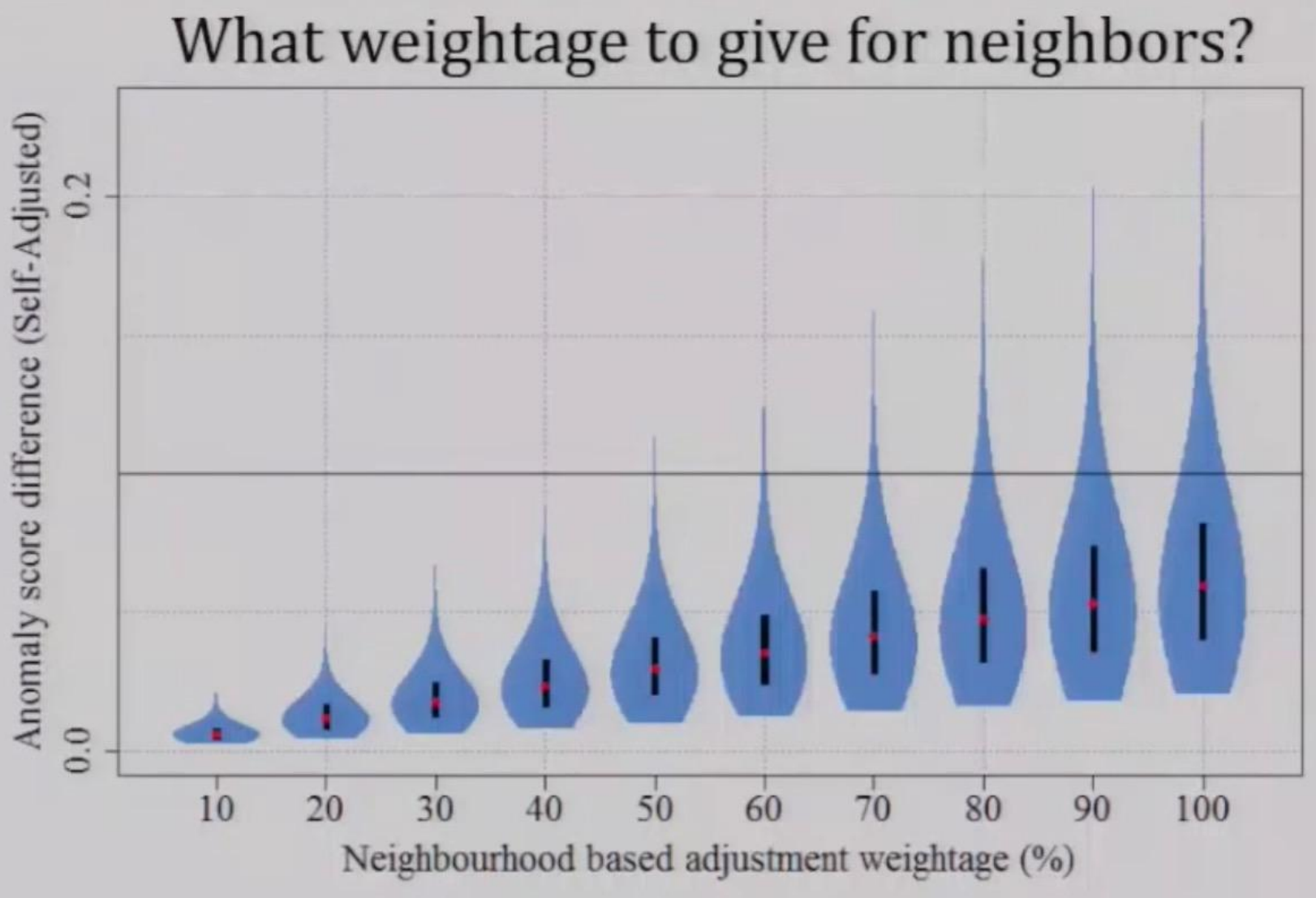
Analysis – Residential buildings

Usage of temporal context sets and neighborhood based adjustment





Analysis – Residential buildings



Conclusion

- Anomaly detection method using readily available meta data (timestamp and location) for accounting the temporal and rare events.
- Usage of temporal context and neighborhood based adjustment improves the detection accuracy. It works relatively better for commercial buildings than residential.