SAPIENZA
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Mining Sensor Data to Evaluate Indoor Environmental Quality of Public Educational Buildings

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Summary

- IoT platform in schools
- Data availability
- Thermal comfort
- Conclusion

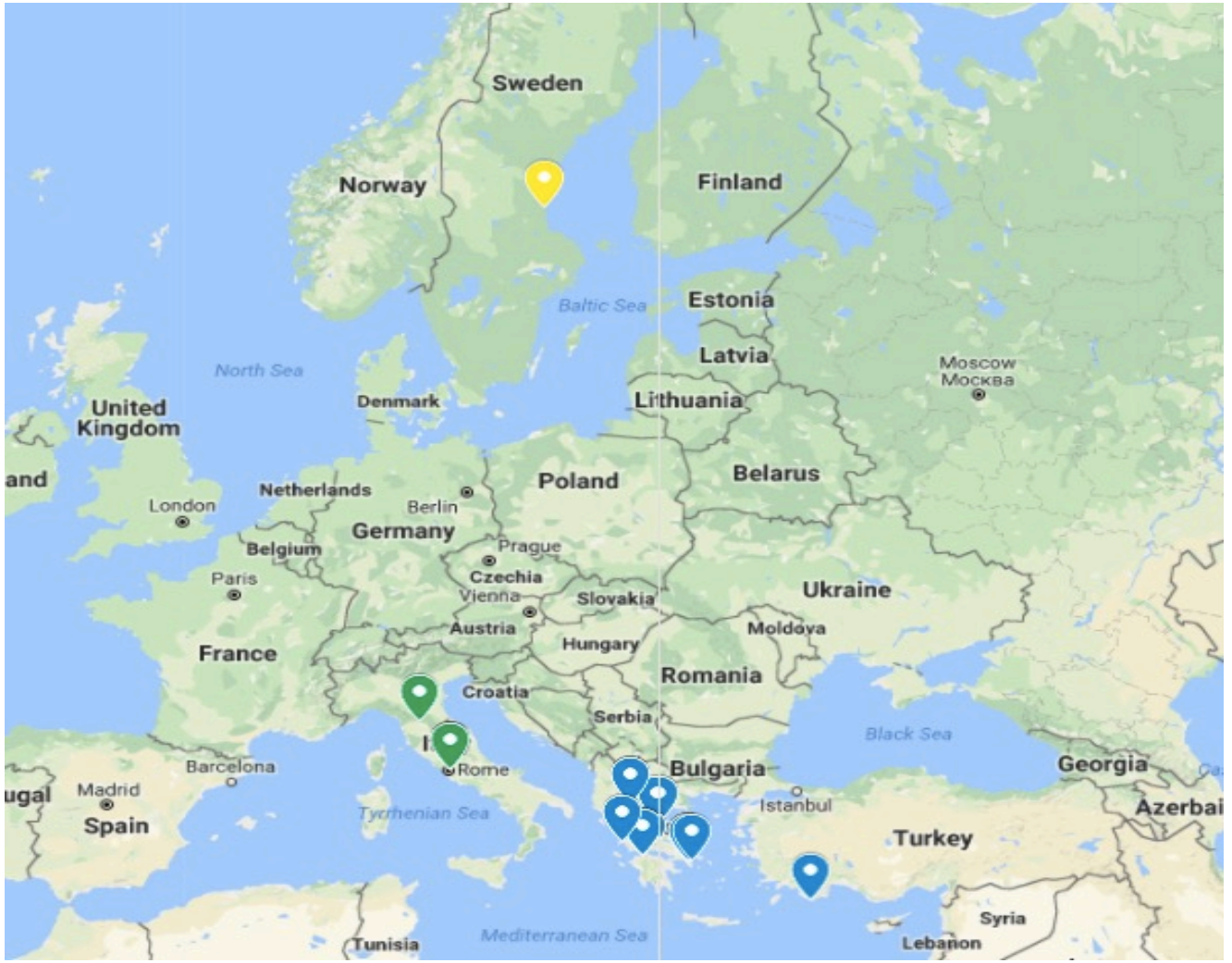
Internet of Things in Schools

- The network of
- Vehicles, Home appliances, smart devices…
- To exchange data through Internet

Deploy IoT Infrastructure → Collect Real-World Measurement → Analysis and Evaluate → Propose Evidence-based Suggestions → Optimize Environment Quality

Platform Overview

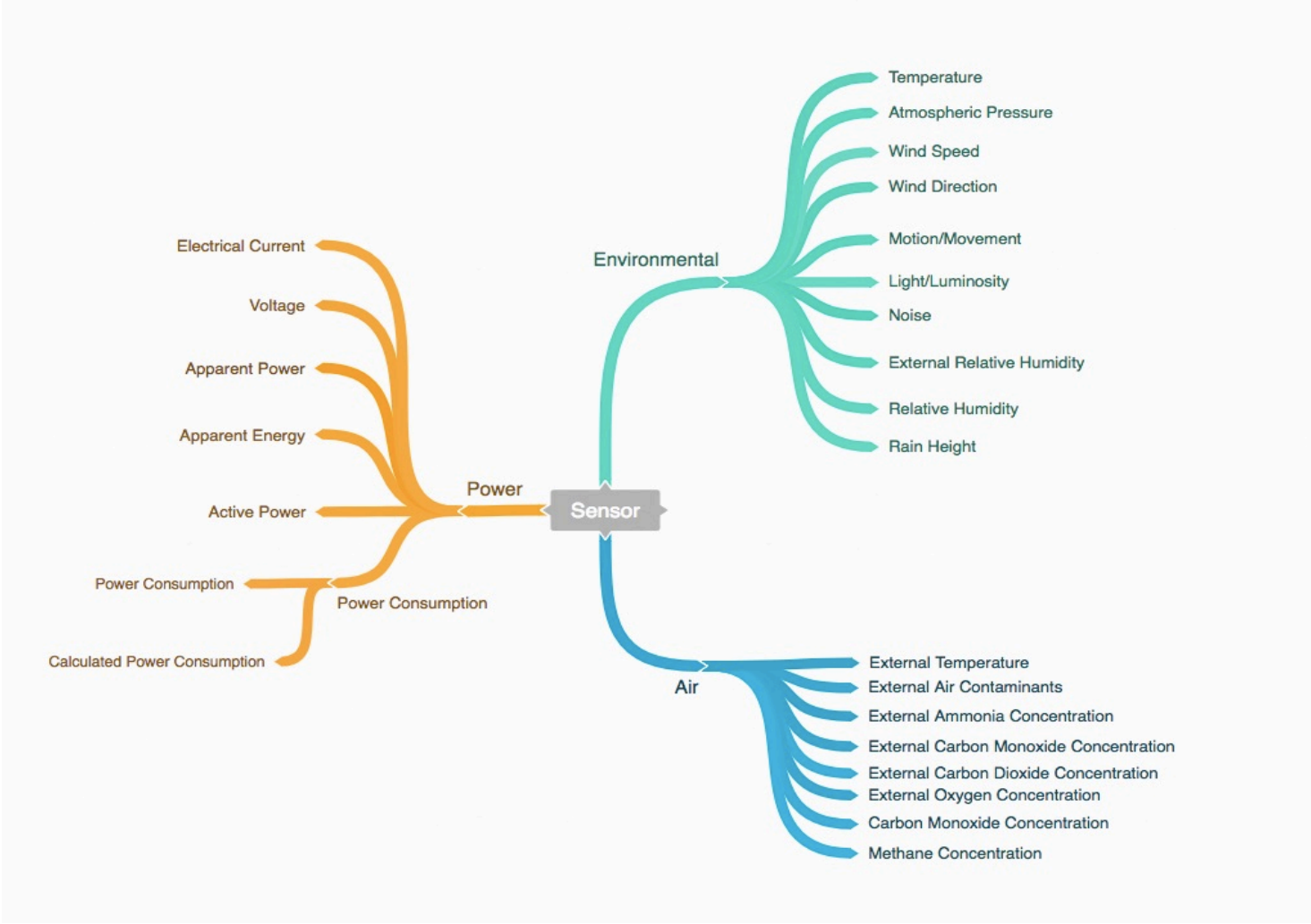
- 12 schools in Greece
- 2 schools in Italy
- 1 school in Sweden
- Over 900 teachers
- Over 5500 students
- From primary school to university



Sensor Deployment

- Sensing Points: 725
  - Power consumption devices
  - Indoor environmental comfort devices
  - Outdoor weather stations devices
  - Atmosphere stations

- Time coverage : over 2 years
- Total Data Size: 14-15 Gigabytes

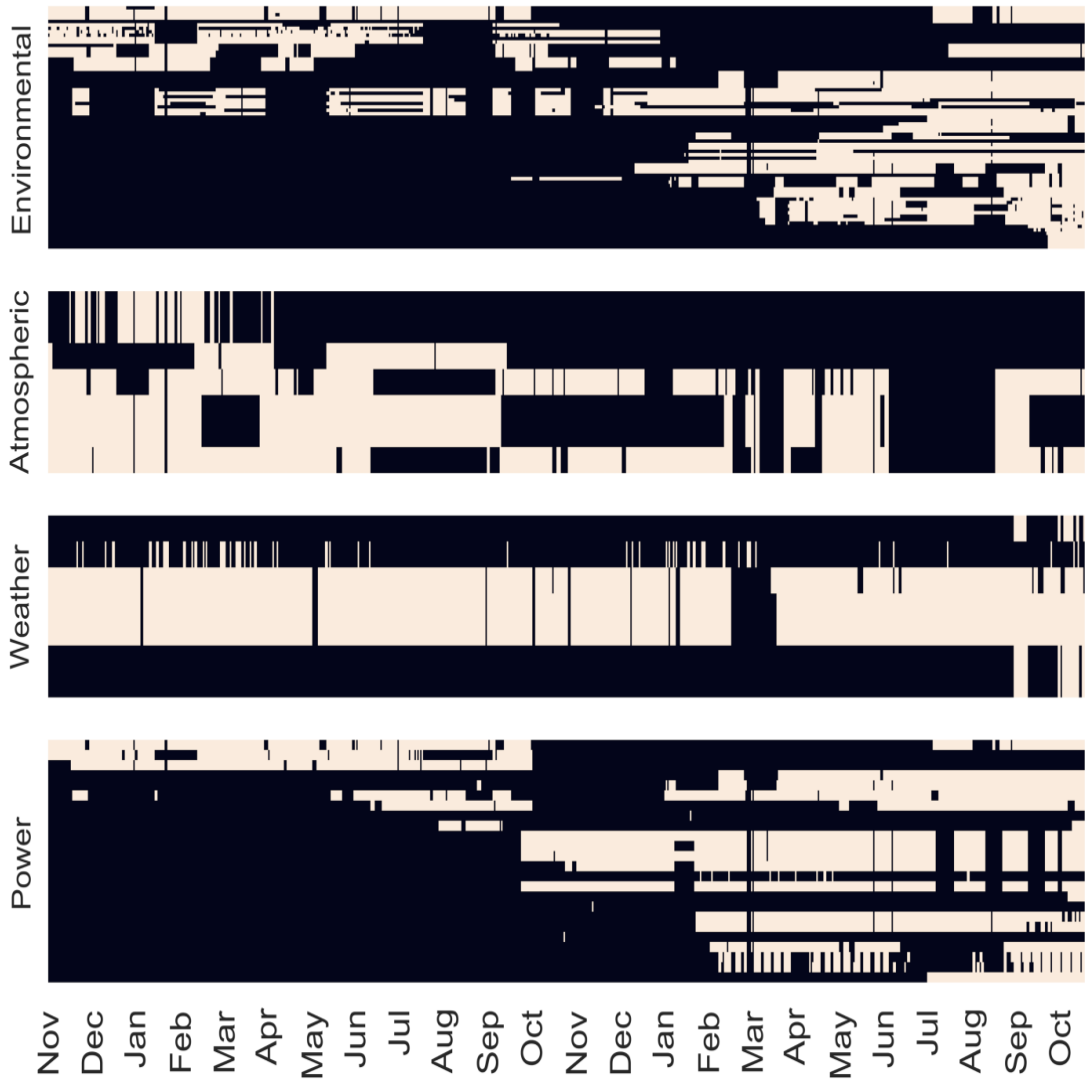


Availability - Missing Data

- When processing data from the low-cost IoT devices, first problem is missing data
- Check the data by categorizing types for the devices, we can see: different types show different stability for uploading the data into the platform

Missing data is caused by :

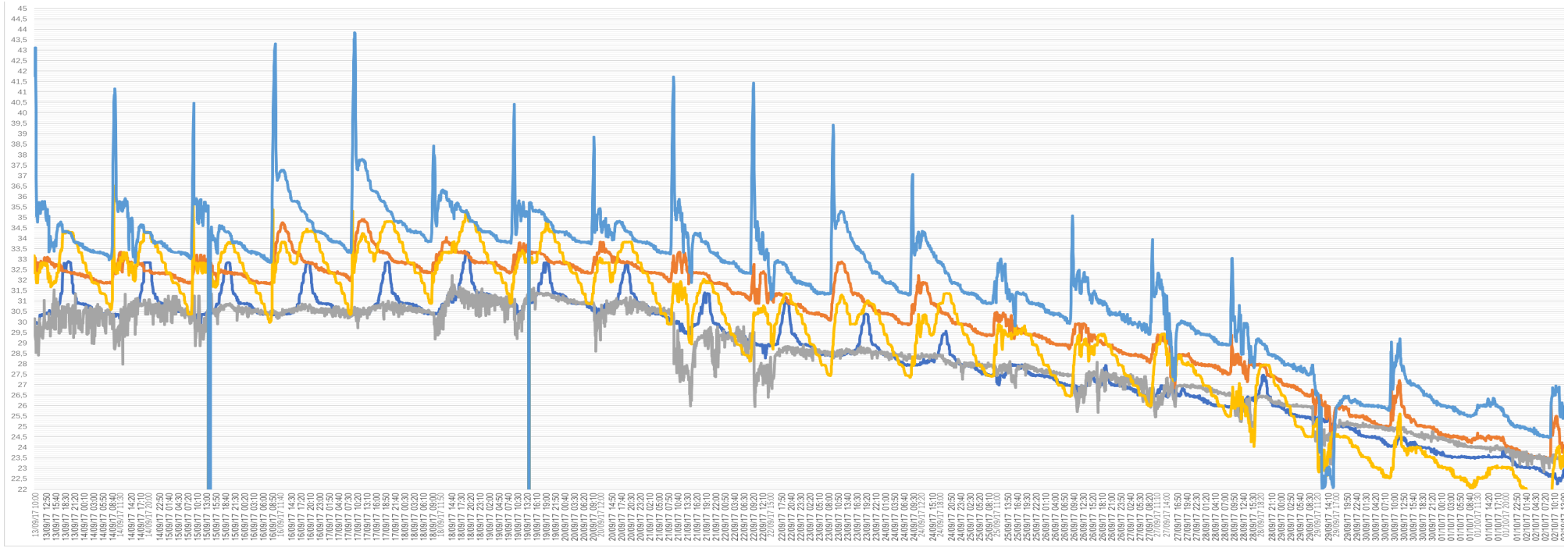
- Power-off
- Devices are broken
- Connections are broken
- Installed in the wrong place



Availability - Outliers

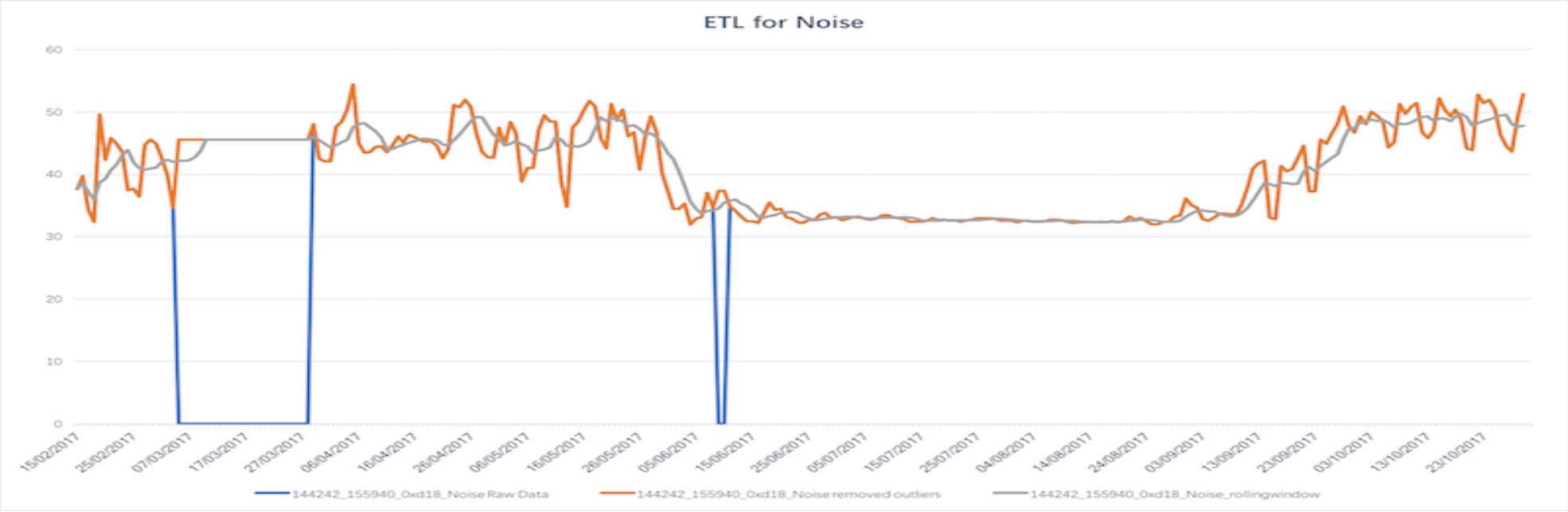
The identification of outliers is based on the **interquartile range (IQR)**

- Using the upper and lower quartiles Q3 (75th percentile) and Q1 (25th percentile).
- The lower boundary = Q1-3×IQR The upper boundary = Q3+3×IQR Where IQR=Q3-Q1
- If a value is outside the boundaries [Q1-3×IQR, Q3+3×IQR] it is flagged as an outlier.



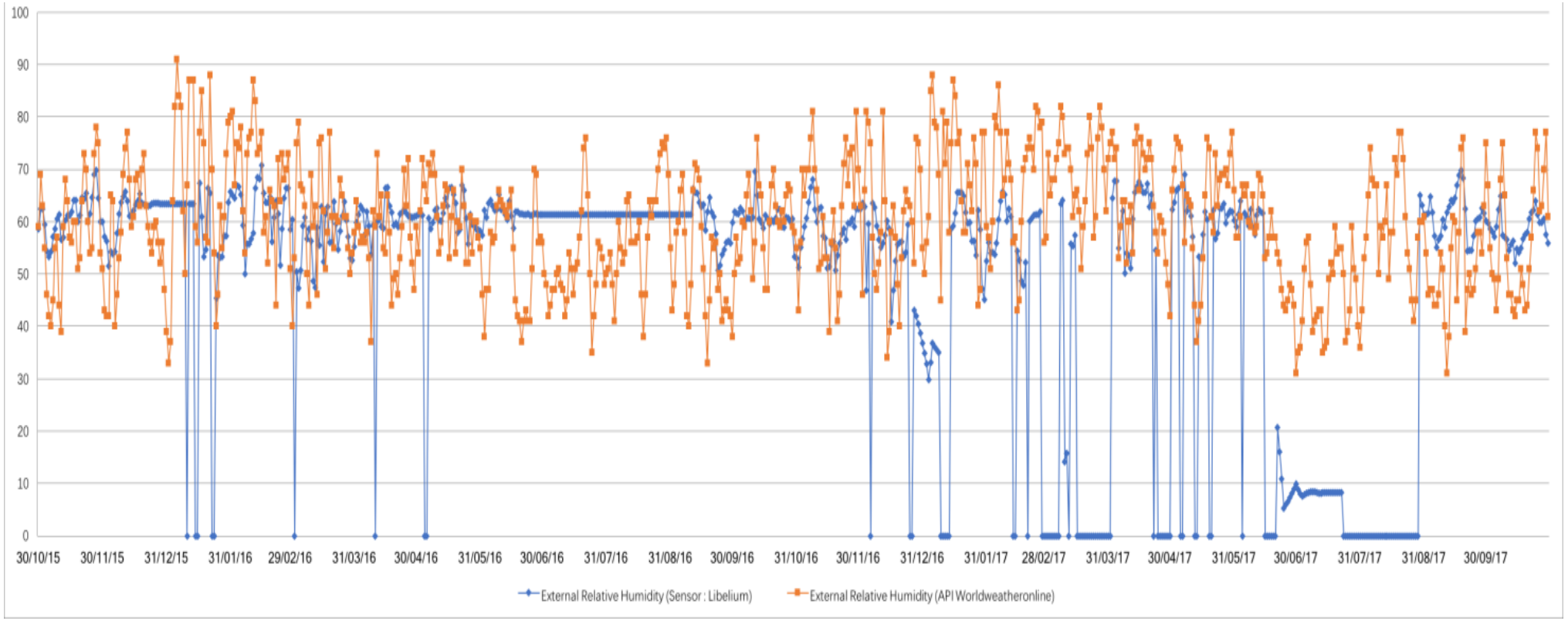
Availability - Moving Windows Average

- Fill-in those values using a simple local algorithm that introduces historic values for the specific time period.
- Smooth out short-term fluctuations



Data Retrieved From Internet

- For historical weather data: worldweatheronline.com
- For real-time weather data: openweathermap.org



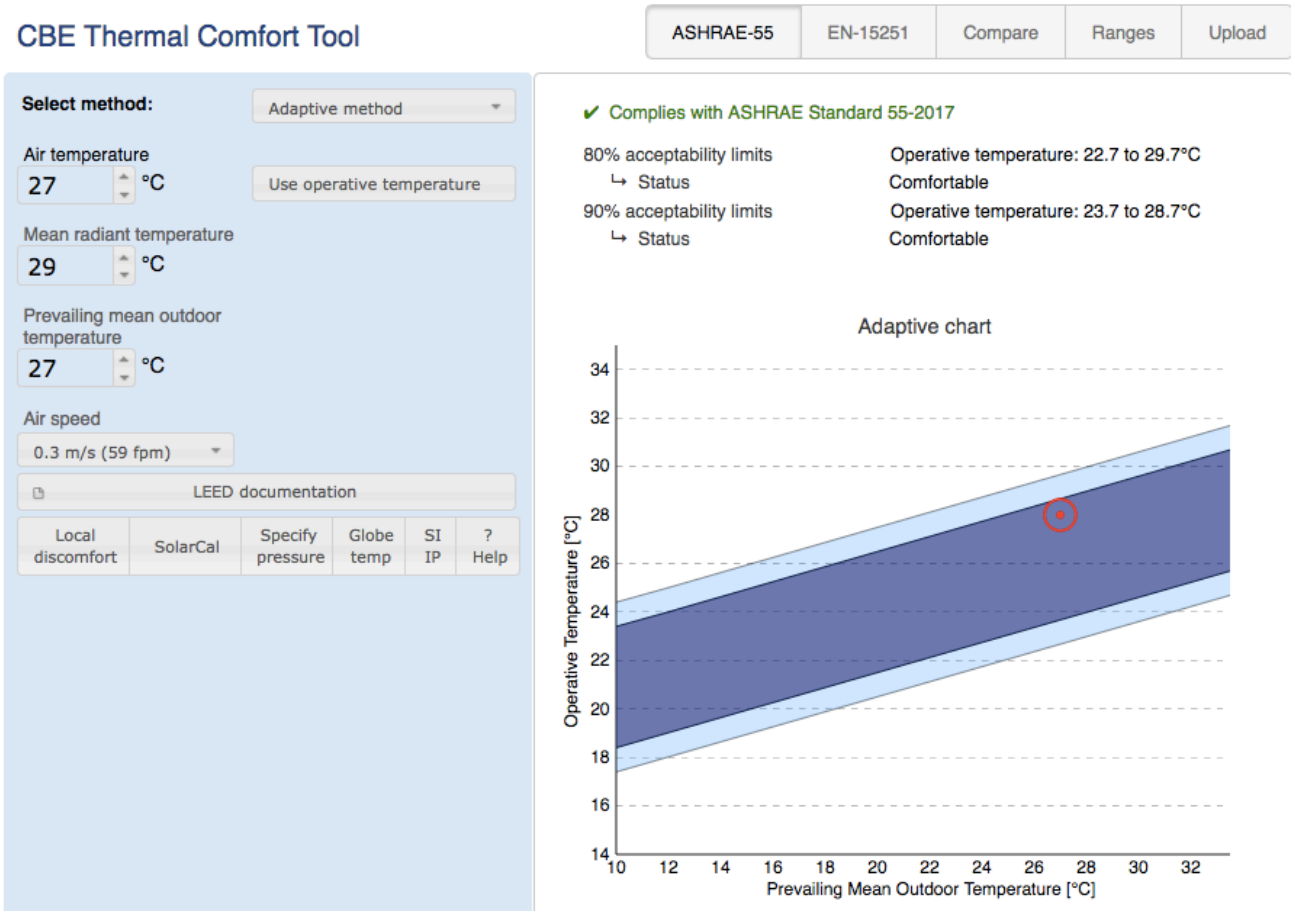
Thermal Comfort

- Comfortable environment improves academic result
- Balance of heat exchange
- Condition of mindset is not easy to evaluate

Comfort Tool From Berkeley

ANSI/ASHRAE Standard 55: a standard to evaluate the thermal indoor environments comfort

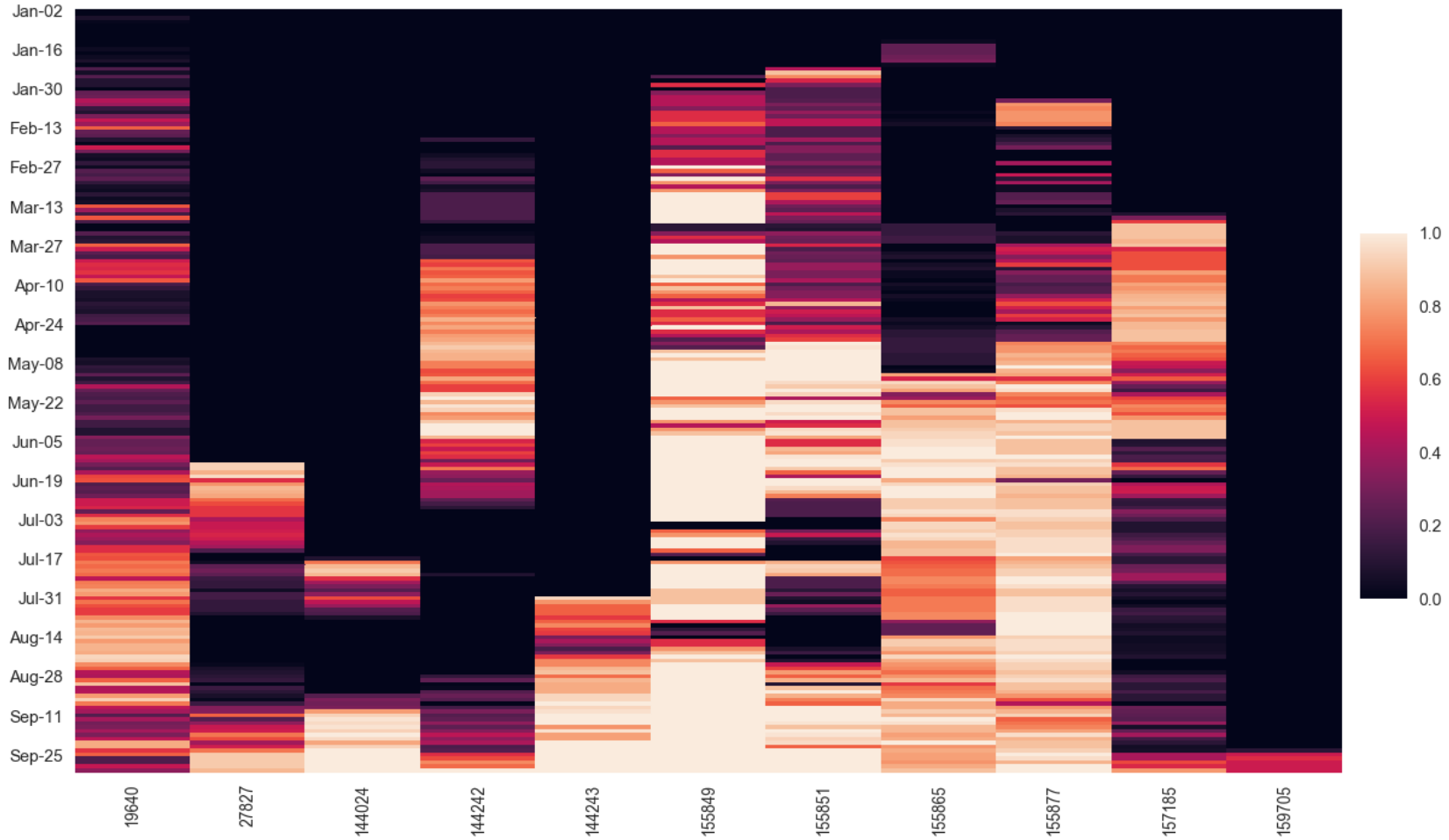
- Air speed
- Metabolic rate of a human
- Clothing level to protect the human body from heat or cold
- Humidity of the air
- **Means radiant temperature (a radiant transfer between human body and the environment)**
- **Air temperature**



Thermal Comfort Evaluation

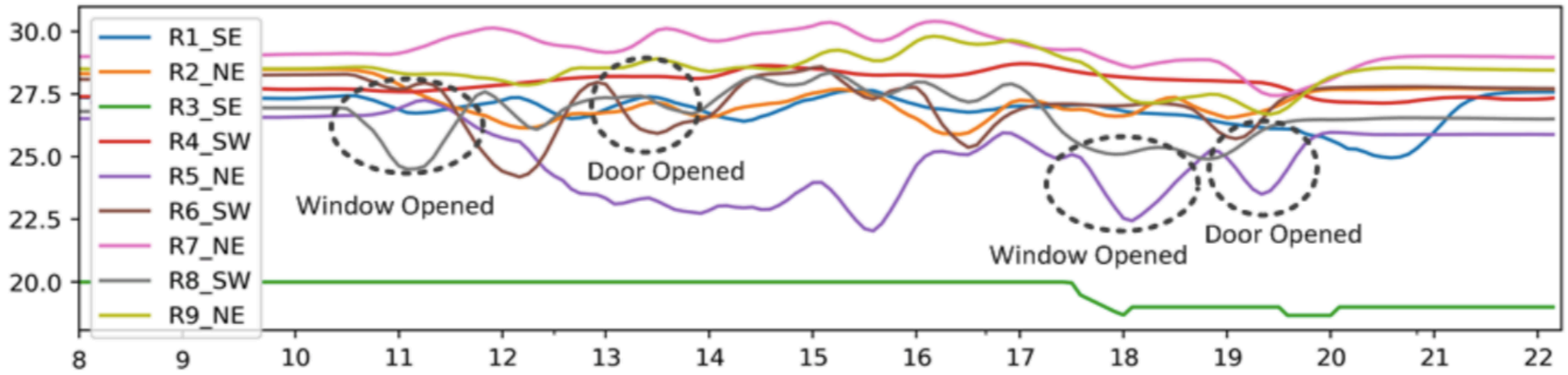
Average comfort on all the rooms for each school

- Jan 1st – Sep 30th 2017
- Monday-Friday
- 8:00-16:00



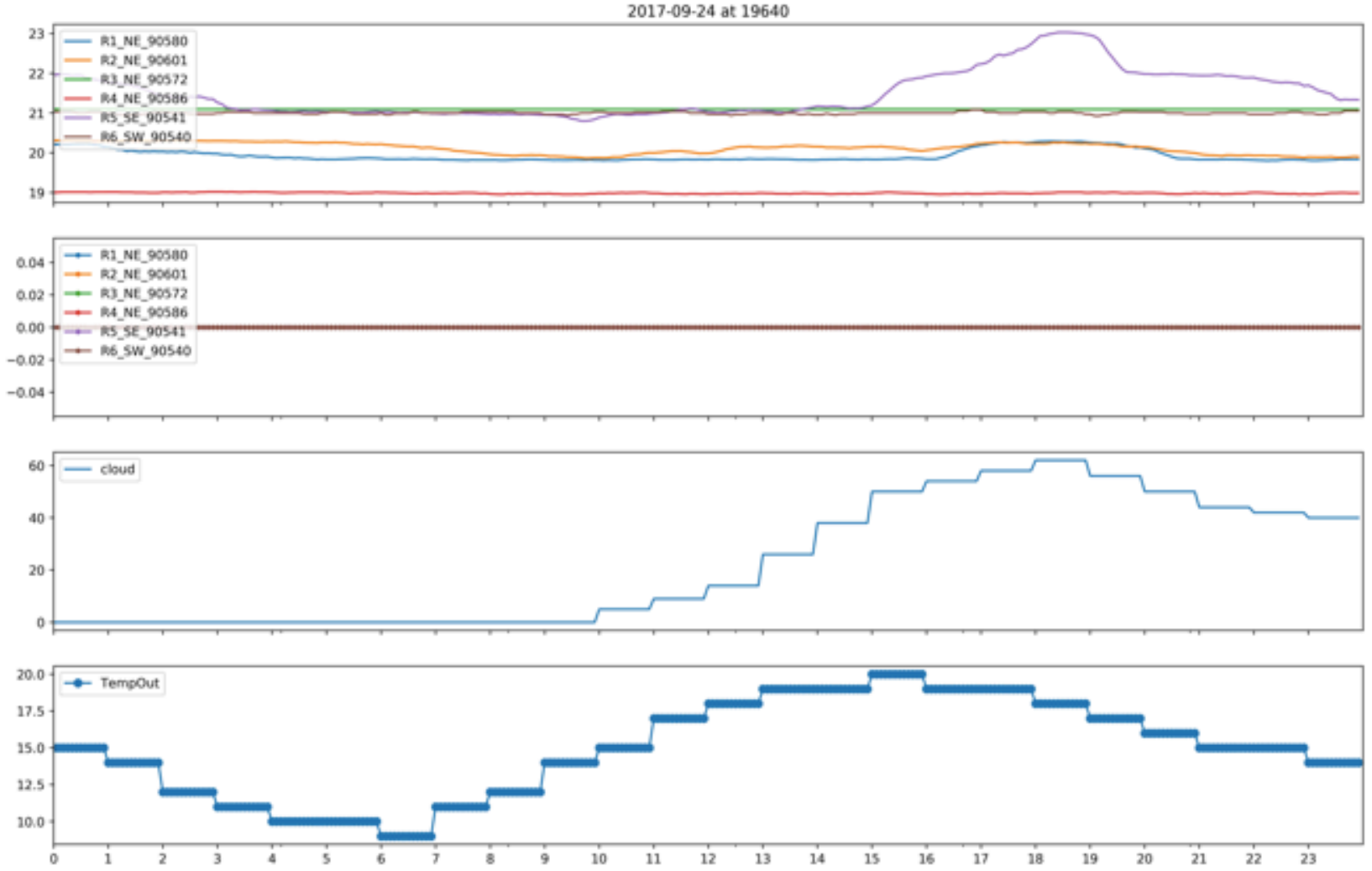
Comfort With Human Intervention

- When there is a window open or a door opened the temperature decrease immediately
- With fresh air circulating , the room could easily be adjusted into comfort condition



Comfort Without Human Intervention

- Indoor temperature change (pic 1)
- No human activity(pic 2)
- Sunny during the day and cloudy at night(pic 3)
- Little bit cold in the early morning but comfort temperature in the afternoon(pic 4)



Conclusion

1. Collected data for evidence-based insights
2. Implemented the binary classifier to indicate the comfort
3. Identified similarities among the best performance classrooms
4. Identified the impact on the comfort of the classrooms
5. Revealed how to adjust the conditions within poorly performance classrooms

- Possible future steps are to focus on the indoor air quality, visual comfort, acoustic comfort to provide a better environment status in school buildings.

Publications

1. IEEE International Conference on Communications (ICC) 2018

   Symposium on Communications QoS, Reliability, and Modeling

   "A Fog Computing-oriented, highly scalable IoT framework for Monitoring Public Educational Buildings”

2. IEEE International Conference on Pervasive Computing and Communications (PERCOM) 2018

   Workshop on Pervasive Sensing for Sustainable Smart Cities and Smart Buildings

   "On Mining IoT Data for Evaluating the Operation of Public Educational Buildings"

Thank you