ESF OFFICE OF SUSTAINABILITY & SARBEL LAB

Campus Air Quality Monitoring

Summary Report

A one-year overview of the indoor environmental quality monitoring initiative.

Overview

The ESF Office of Sustainability and the Sustainable and Resilient Built Environment Lab (SARBEL) Lab have spent the past year monitoring indoor environmental quality across campus buildings. A network of IoT-based sensors, supported by dedicated outdoor weather stations, has continuously tracked carbon dioxide (CO_2), particulate matter ($PM_{2.5}$), total volatile organic compounds (TVOCs), temperature, relative humidity, lighting and sound level in classrooms, offices, corridors, and common areas.

This report summarizes what the initiative sets out to do, the approach taken to make sense of a large and continuous stream of sensor data, and why this kind of monitoring matters for the campus. It intentionally does not present device-level results or specific findings; a detailed technical report is available on request through the Facilities Office or the SARBEL Lab.

What We Did

The project combined continuous sensor monitoring with building operations data to build a complete picture of how ESF's buildings perform day to day. The general approach included:

- **Deploying and maintaining** a distributed sensor network across a representative mix of classrooms, offices, corridors, and common spaces, with outdoor reference points for context.
- **Cleaning and reconstructing** the resulting dataset, using standard time-series methods to handle brief sensor outages and communication gaps common to long-term field deployments.
- **Characterizing** daily, weekly, and space-type patterns in each parameter to understand how conditions typically evolve over the course of a day and across the week.
- **Comparing** sensor data with building operating schedules, including HVAC run times and scheduled space use, to see how closely ventilation tracks actual activity.
- **Evaluating** indoor air quality against established ASHRAE and EPA reference guidelines, using complementary methods that look at both how often and how long conditions fall outside recommended ranges.

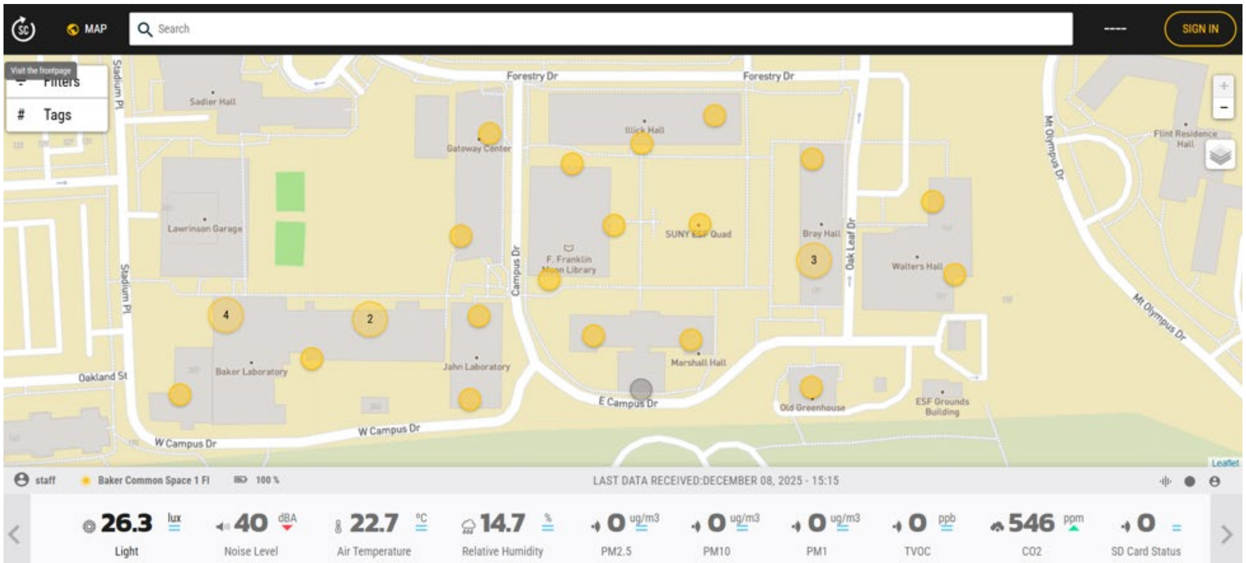


Figure 1. Sensor deployment across ESF campus buildings, viewed on the SARBEL data portal.

Why It Matters

Indoor environmental quality has a direct impact on health, comfort, and the ability to teach, learn, and work effectively. Continuous, building-wide monitoring gives ESF something that occasional spot checks cannot: an ongoing, data-driven view of how spaces actually perform for the students, faculty, and staff who use them every day. This matters because healthy indoor spaces are a shared responsibility, not just a maintenance line item. Grounding decisions in measured conditions means students and staff can trust that their classrooms and offices are being looked after with real evidence, not assumptions. It helps ensure that ventilation and building systems respond to how spaces are actually used, supporting wellbeing and comfort campus-wide. And it reflects ESF's broader mission as an environmental institution: modeling the kind of transparent, data-informed stewardship of the built environment that the college teaches others to pursue.

Example Visualizations

The analysis produces several standard types of visualizations for each monitored space. The examples below illustrate the kind of output the project generates; device-identifying labels and specific result values have been removed.

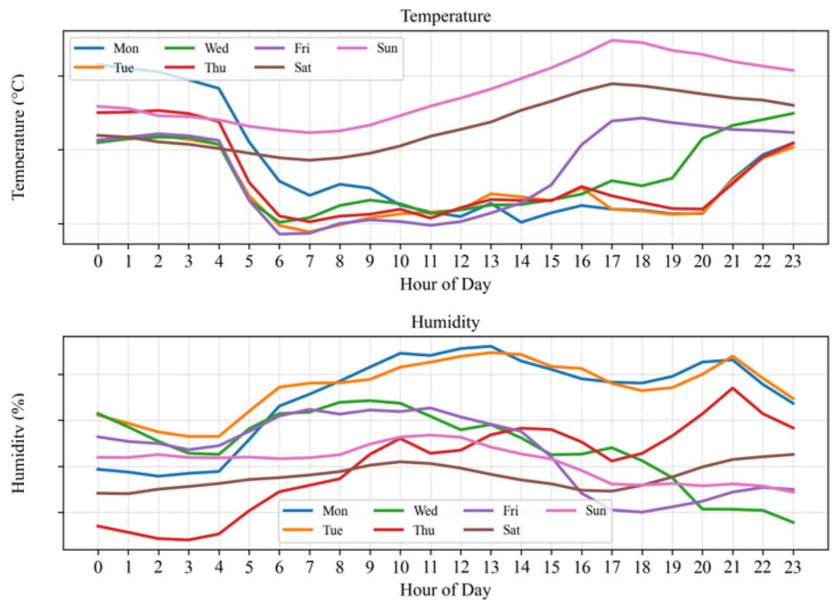


Figure 2. Illustrative weekday temperature and humidity pattern for a representative monitored space.

Recognizing that HVAC schedules and occupancy patterns differ across weekdays, a second analysis disaggregated the data by each day of the week. For each sensor and each parameter, seven averaged curves (Monday through Sunday) were generated. This step helps identify:

- Variations in CO_2 and sound levels on teaching vs. non-teaching days
- Differences in thermal and humidity control across the week
- Whether certain days experience anomalous behavior

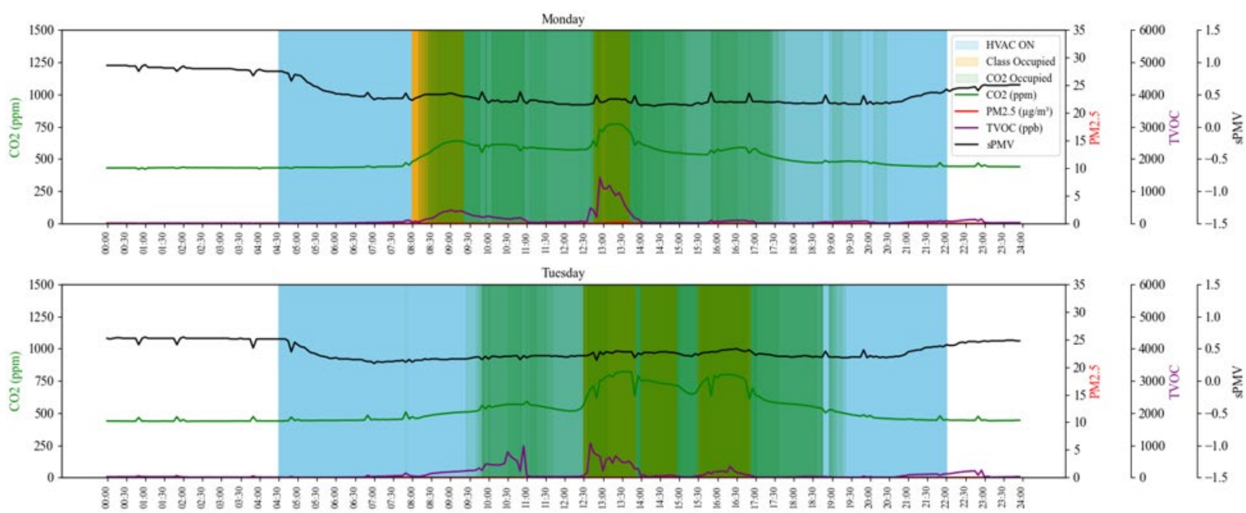
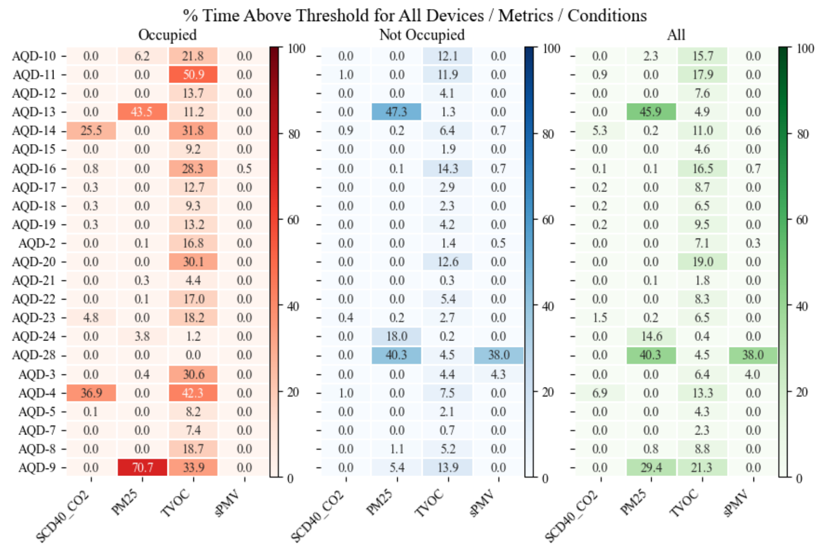


Figure 3. Illustrative combined view of CO_2, PM2.5, TVOC, and comfort index (sPMV) alongside HVAC operation and occupancy schedule for a representative space.

To further understand occupancy patterns in relation to observed sensor behavior, a combined visualization approach was developed. Relevant time-series elements, including class schedule, HVAC operation, CO_2-based occupancy estimates, and the core indoor environmental quality parameters (CO_2, PM2.5, TVOC, sound level, temperature, and humidity), are plotted together in a unified, stacked chart format for each monitored space.

Figure 4. Illustrative time-above-threshold summary across monitored devices, metrics, and occupancy conditions. Device labels and result values are masked.



This metric quantifies the percentage of time a parameter exceeds an established reference threshold, providing an immediate indication of ventilation adequacy: the higher the share of time above threshold, the poorer the ventilation performance for that space and condition. Comparable thresholds are applied to CO_2, TVOC, PM2.5, and comfort index (sPMV). This approach aligns with industry standards and is widely applied in RESET, WELL, and related academic studies. Results are typically expressed as percentile summaries, illustrated below.

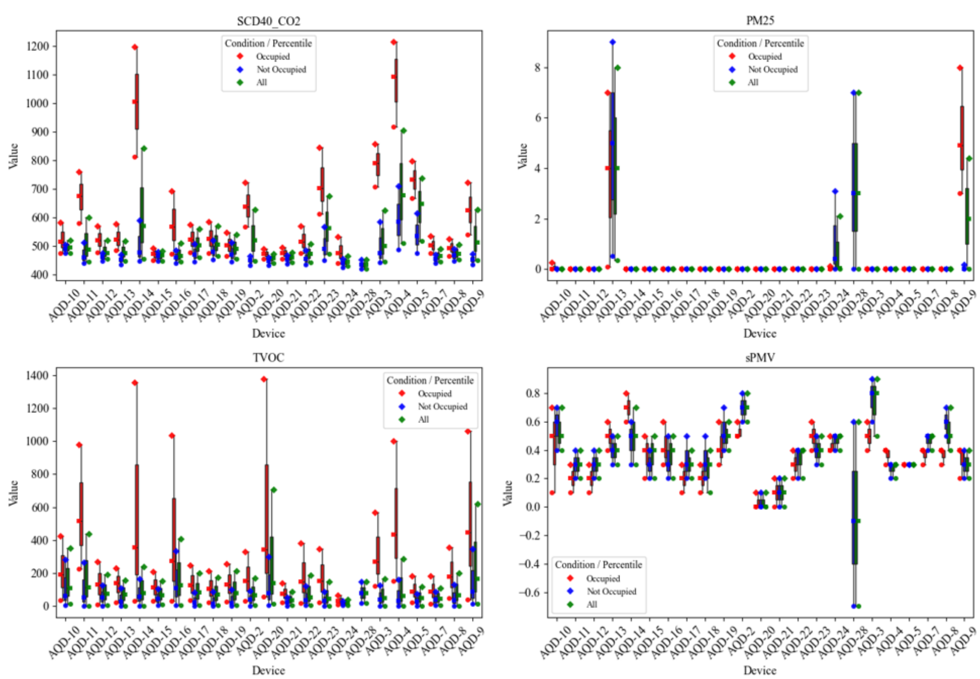


Figure 5. Illustrative percentile-based comparison (50th, 75th, 90th) across monitored devices and parameters. Device labels are masked.

Percentile-Based Classification: Because indoor pollutant distributions are often skewed, percentile statistics (50th, 75th, 90th) provide a more robust characterization than simple averages. The highest relevant percentile is then used to classify each space.

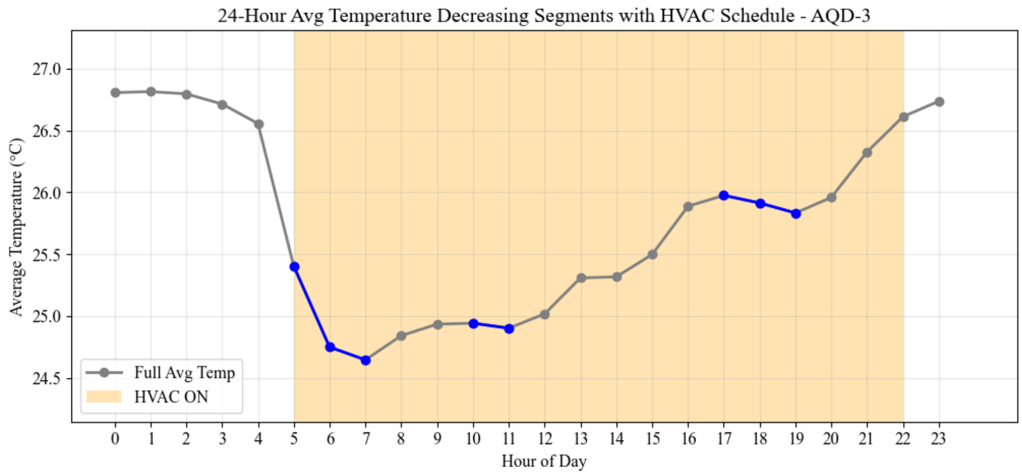


Figure 6. Illustrative example of a temperature-stabilization analysis following HVAC activation.

By analyzing temperature and humidity stabilization periods, the analysis estimates how quickly a space reaches thermal equilibrium after HVAC activation, how long that adjustment period typically lasts, and whether the pattern repeats consistently across the day. This helps indicate whether a space is achieving its expected ventilation and comfort response.

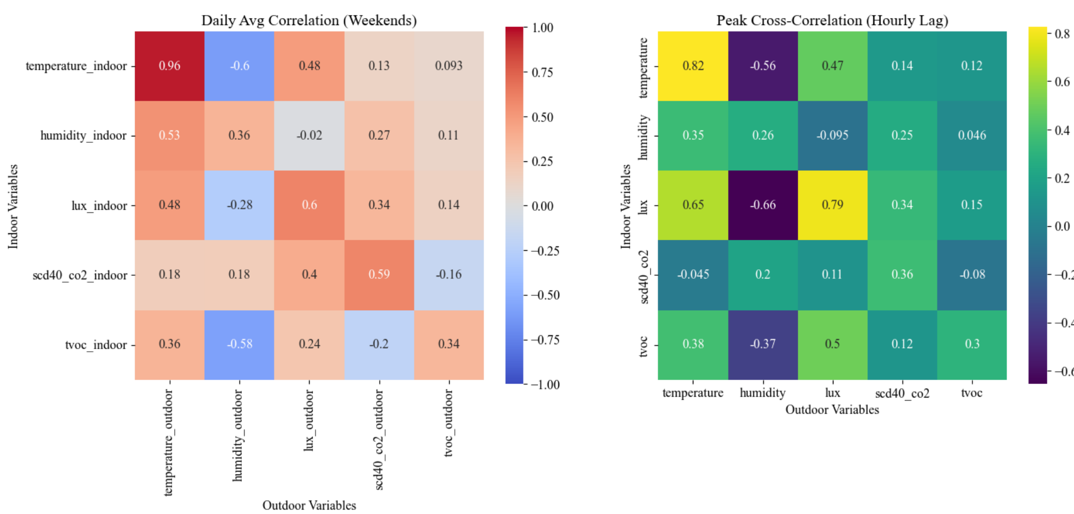


Figure 7. Illustrative indoor-outdoor correlation analysis for a representative pair of monitoring points. Device labels are masked.

Daily and weekly relationships between indoor and outdoor PM2.5, VOC, and temperature can also be examined to assess how closely conditions track one another.

- **Left heatmap:** Shows the correlation between each indoor sensor variable and each outdoor variable on the same day. High values mean indoor conditions closely track outdoor conditions without delay.

- **Right heatmap:** Shows the maximum correlation observed when shifting outdoor data by certain minutes, indicating how strongly each indoor variable responds to delayed outdoor changes.

Learn More

24 hours most recent data is available through the SARBEL data portal at **portal.sarbel.org** The full technical report, including device-level results and detailed findings, can be made available upon reasonable request through the ESF Facilities Office or the SARBEL Lab.

Questions about this initiative can be directed to **Michael Amadori** in the Office of Sustainability or **Dr. Shayan Mirzabeigi**, Primary Investigator for the SARBEL Lab, Department of Sustainable Resources Management.

> *The data collection, analysis, and visualizations summarized in this report were carried out by Fahad Iqbal, Graduate Research Assistant, SARBEL Lab. His employment was supported by the ESF's career office (summer 2025) and the Empire State Summer Corps (summer 2026), physical resources for the project were partially funded by the SARBEL Lab and the Office of Sustainability.*

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