Office of Institutional Research and Social Responsibility, NTU
International Degree Program in Climate Change and Sustainable Development, NTU
Research Center for Future Earth, NTU

NEWSLETTER
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SC+NTU

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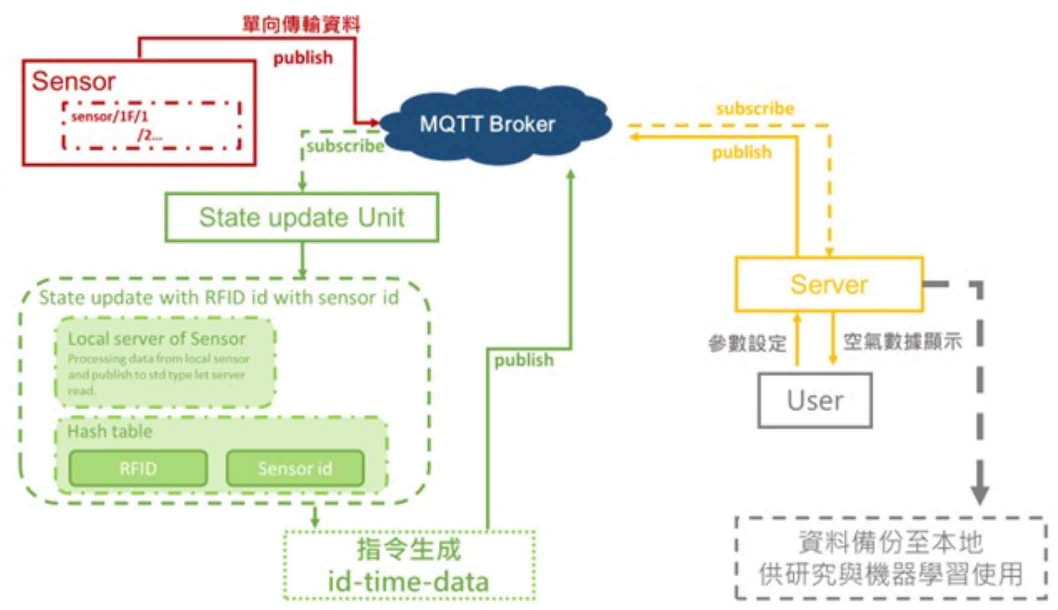
SC+NTU Work Team



The SC+ team has been dedicated to the issue of comfort for a long time. We focus on comfort in various settings, from indoor and outdoor environments on campus and in the community. The microsensors developed by our team have provided valuable data throughout the journey, facilitating subsequent analysis and discussions on related issues.

In this research update, we will be sharing recent discussions on the topic of residential comfort, with a specific focus on comfort in NTU campus dormitories and residences. We aim to understand the potential correlations between carbon dioxide levels, occupancy, ventilation systems, and sleep duration within these spaces. Continuing with the theme of comfort, our knowledge sharing section will explore the new perspectives and assistance that interdisciplinary collaborations can bring when addressing environmental issues.

Monthly Activities Summary

2/8

IPCS Future Course Planning

SC+ discussed plans to collaborate on introducing additional elements to the course. In addition to using microsensors to detect environmental data, it was decided to incorporate the use of power meters. This will allow students to operate the meters and gain an understanding of the distribution and proportion of electricity usage in classrooms.

2/23

Sensor Data Inventory

Over the past three years, the team has accumulated a significant amount of sensor data. However, due to various reasons, occasional gaps in the data remain an issue. Therefore, it is important for students to review and organize the data from the past three years to identify which seasons or time periods have complete data and which ones have issues. This inventory will provide valuable insights for future analysis and ensure a clear understanding of the data distribution over different time periods.

Achievements and Announcements

Campus Dormitory Comfort

SC+ Work Team intern I-Ling, Fang

As the primary type of on-campus residency, dormitories are where students spend a significant amount of time engaging in daily activities and studying. Based on personal experiences and feedback from students regarding the air quality in dormitories, many people have mentioned feeling stuffy. This could be due to the small size of the bedrooms, which can lead to higher carbon dioxide levels when there are more people present. High levels of carbon dioxide not only cause negative physical symptoms such as drowsiness, dizziness, and nausea but also reduce cognitive abilities. Therefore, by conducting actual measurements, we hope to assess the air quality in dormitories and propose suggestions to improve it overall.

In this study, MAPs microsensors were installed in the bedrooms and corridors of the Female Dormitory 3 on the NTU campus. The objective was to measure CO2 concentration in the bedrooms with different numbers of occupants and to assess the impact of various ventilation methods on CO2 dissipation rates. Under the conditions of air conditioning turned on and doors and windows closed, the CO2 concentrations exceeded the indoor standard value of 1000 ppm after 15 hours for 1 person, 2,800 ppm for 2 persons, and 4,100 ppm for 3 persons. Looking at the more health-relevant standard of 2500 ppm, it took approximately 10 hours to reach this level for 2 persons and only 4 hours for 3 persons. These findings indicate that even within a relatively short period, the CO2 levels in the bedrooms exceeded both the indoor air quality standard and the health-relevant threshold.

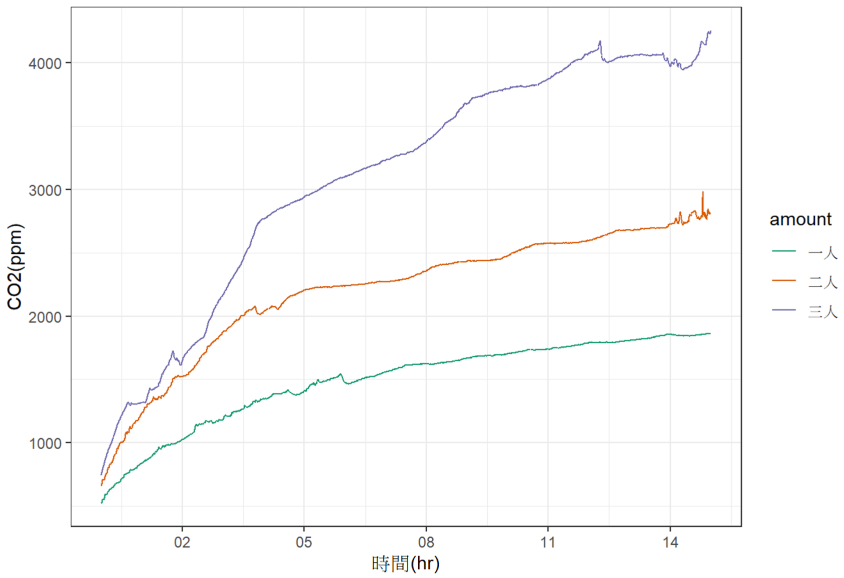


Figure 1: CO2 concentrations under different rates of occupancy

The dormitory's ventilation equipment mainly consists of windows facing outside and corridor windows facing the dormitory courtyard, as well as electric fans and exhaust fans. Considering that occupants would turn off electrical appliances when leaving, this study only considered windows as ventilation devices. Four scenarios were examined: no windows opened, both the outside windows and corridor windows opened simultaneously, only the outside windows opened, and only the corridor windows opened. The CO2 dissipation under each scenario was observed. Based on the results of the experiment, it was found that the group with both outside windows and corridor windows opened was able to reduce the CO2 concentration from 2000 ppm to near background levels within one hour, which was the fastest among the four scenarios. In the scenarios where only the outside windows or only the corridor windows were opened, the CO2 concentration dropped below 500 ppm after two hours. However, in the scenario where no windows were opened, the dissipation rate of indoor CO2 was very slow. After 5 hours, there was a reduction of approximately 500 ppm, and even after 60 hours, there was still approximately 500 ppm of CO2 measured indoors.

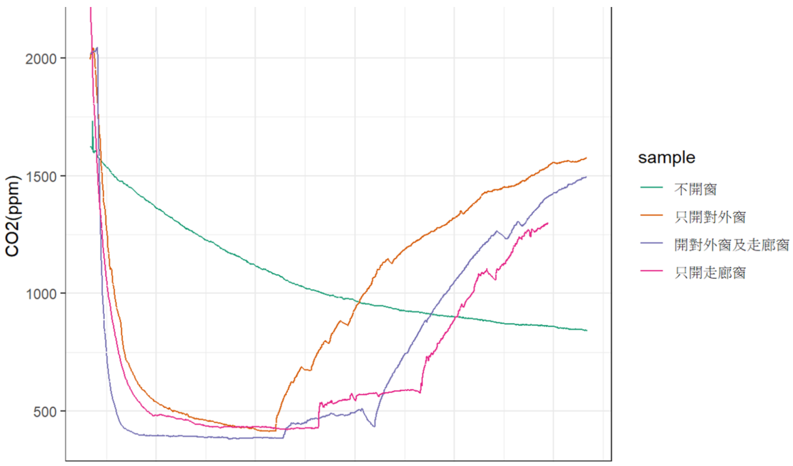


Figure 2: CO2 concentration under use of different ventilation equipment

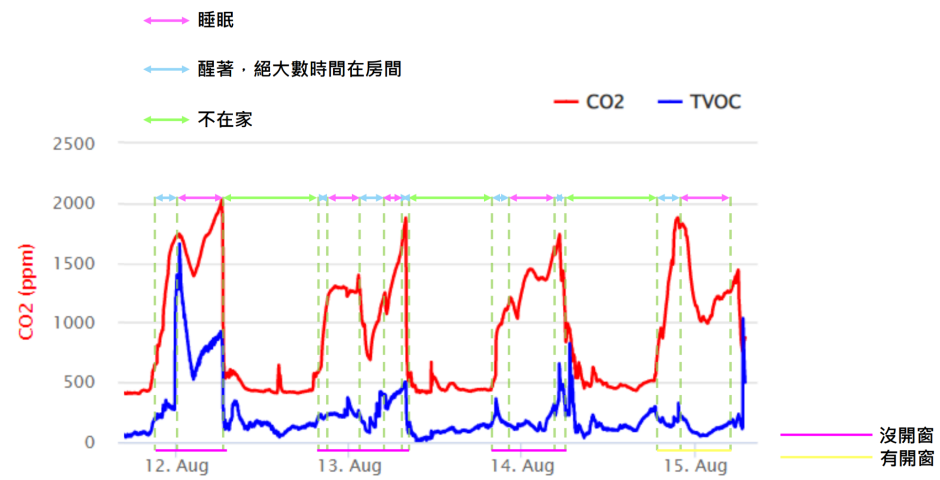
To understand the differences in ventilation among the four scenarios, Johnson, D. L. et al. (2018) proposed an indoor CO2 concentration model to calculate the ventilation rates (m3/hr) for each situation. The background outdoor CO2 concentration was assumed to be 400ppm, and the indoor volume was 52.264m3. The calculated ventilation rate for the scenario with windows completely closed was 1.41 m3/hr. The scenario with both windows facing outside and corridor windows open had a ventilation rate of 16.83 m3/hr, while the rates for only opening the windows facing outside and only opening the corridor windows were 13.75 m3/hr and 13.65 m3/hr, respectively. Based on these calculations, it can be concluded that the scenario with both windows open (facing outside and corridor) had the best ventilation rate, followed by the scenario with only the windows facing outside open, the scenario with only the corridor windows open, and finally the scenario with windows completely closed. The difference in ventilation rates is significant between the scenario with windows completely closed and the other three scenarios with open windows, with the ventilation rate for opening both corridor and windows facing outside being more than 10 times higher than the scenario with windows completely closed.

The experiment mentioned above reveals the real issue of high CO2 levels in dormitories. Moreover, if we consider the real-life scenario of four people staying in the dormitory simultaneously, the CO2 concentration could be even higher. Therefore, it is important to address and improve the CO2 levels in dormitory settings. Opening windows is the simplest way to reduce CO2 concentration. It is recommended to ventilate the room by opening windows before going to bed and upon waking up in the morning. This practice can effectively lower the indoor CO2 levels. Additionally, placing green plants in the dormitory can help reduce CO2 through photosynthesis. It is advisable to choose plant varieties that can perform photosynthesis under high CO2 concentrations, such as poinsettias and African violets. Furthermore, humans are the primary contributors to indoor CO2 levels. Reducing the number of people indoors can also help lower CO2 concentration. It is worth discussing whether it is suitable for so many people to occupy the same-sized space in terms of CO2 levels. Addressing these factors and implementing appropriate measures can significantly improve the CO2 levels and overall comfort in dormitory environments.

Initial Exploration of Home Comfort

SC+ Work Team and Department of Atmospheric Sciences Chieh-Hsiang, Fan

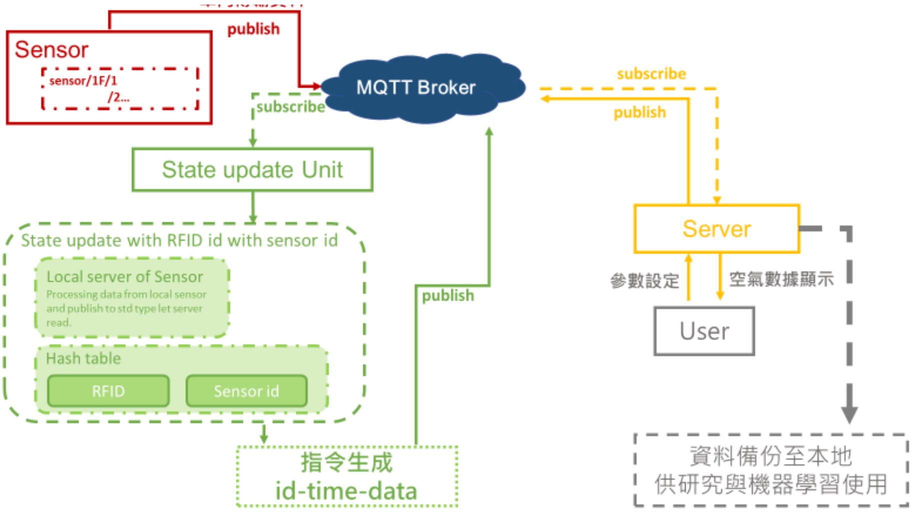
During the sleep process, there is a noticeable period of time with a significant decrease in CO2 concentration, which is speculated to be related to the depth of sleep. If the sleep quality is high, it may lead to a significant reduction in the body's CO2 consumption, resulting in more CO2 being dispersed outside the room than what the body exhales. This experiment was conducted with the room's doors and windows tightly closed. Therefore, if there is an opportunity, it may be considered to install multiple devices for observation. It is hoped that a convenient recording app or small device, such as a body monitoring wristband, can be used to record the actual physiological state for comparison. In future research, there may be progress in terms of feasibility, and it can be applied to mechanisms such as personnel activity reporting.



Currently, we are developing a small sensor based on the ESP32 microcontroller. We plan to integrate it with a new type of CO2 sensing element called XENSIV™ PAS CO2, manufactured by Infineon. The ESP32's Wi-Fi functionality will be utilized to transmit the measured CO2 data. However, the main challenge of the system lies in the requirement of a 12V power supply. Therefore, an additional power supply module, specifically a DC-DC boost module, is expected to be used. To accommodate the variable load, capacitors will be added to provide short-term high current loads and stabilize the 12V power supply. We have already successfully integrated the ESP32 with other sensors such as the BME280 (temperature, humidity, pressure), SGP30 (TVOC, alcohol, eCO2), XENSIV™ PAS CO2 (CO2), and PM5003 (PM10, PM2.5, PM1 optical sensing). The ESP32 will be connected to Wi-Fi to push the data to an MQTT broker, and other terminals will be used to update and connect to the server.

The current plan is to use an update unit to modify and batch push the data through a local processing server. This unit can serve as a data relay station for a floor or a room area, or it can serve as a sensor unit update node for a building. In the future, automatic registration and deregistration will be achieved using RFID tags, and the settings can be configured using an unchangeable ID and its corresponding hash map. The State Update unit can be implemented using a Raspberry Pi as a node, and multiple MQTT brokers can be used for distributed control and debugging, not limited to just one.

The current architecture is mainly as follows:



The MQTT broker in the diagram can have multiple IP addresses to provide the broker functionality. Regarding the architecture of the RFID-based automatic registration system for online/offline status, it is designed to facilitate future users who may not have hardware-related knowledge. The system utilizes automated electronic detection and tagging to mark the online/offline status and update the state. By reducing the need for manual handling, it allows human resources to be allocated more efficiently towards research and handling tasks rather than tedious paperwork and form registration.

The State Update unit, in addition to recording latitude and longitude during setup and storing it in the database, it also generates instructions to be sent to the MQTT broker and even enables sensor portability for future indoor-outdoor universal systems. This allows it to approach the functionality of NTU4AQ. It can utilize 4G LTE transmission or automatic detection of status and functionality. It also provides a text interface for setting the location, facilitating easy setup and maintenance, and enabling users to quickly go online/offline and update their status.

The current design does not include a specific error prevention system. The initial design involves the regional State Update unit for updates and scanning the machine at the maintenance center for a two-tier error prevention approach. Ultimately, control will be implemented through switches or by isolating data transmission through network blocks to achieve database isolation. State Update will be used to update the unit and implement hierarchical control, avoiding the transmission of invalid data.

To assign the corresponding RFID numbers to the sensors, an initialization and burning system needs to be designed. This system will set the ID during the firmware burning process. It is planned to use EEPROM memory blocks for data storage and design burning hardware to automate the linking of the external casing with the internal ID. This will prevent any manual errors in matching the data names of NTU4AQ with the actual machine names.

By conducting dual testing using both Wi-Fi and 4G, it is possible to avoid the problem of having no signal in repair factories and thus accelerate maintenance operations.

The functionality of a hash table is similar to mapping RFID data to the corresponding registration system, associating the data with the experimental field, zone, ID, or name. In addition to storing the received data in the State Update unit, implementing this functionality in other workspaces or experimental projects can also prevent issues caused by the failure of the central server (MQTT) or data loss. This approach effectively distributes risks and allows for the option to disable uploading data to the central server, ensuring data confidentiality and regional integrity. Data transmission and recording can be performed within the local network, further enhancing data security.

Science Tips

Cross-domain collaboration: Solving problems and expanding a new human-environment perspective

Abstract by Wei-Jhe, Chen (from the interview article "Humanities Island" by Yi-Hung, Lin)

Walking down the street, a burst of hot exhaust fumes hits, accompanied by strong mixed odors and even noisy sounds. By establishing a "sensible" "environmental comfort of the air," the general public is enabled to feel and understand the environment in which they are living. In addition to his expertise in geography, Dr. Chien Shiuh-Shen also collaborates with schools and communities, using the concept of citizen science to promote "environmental literacy" and strives to improve people's learning and living through the application of volumetric geographical knowledge.

The problems addressed in modern geography are highly complex and require interdisciplinary collaboration to gain a deeper understanding. Dr. Chien Shiuh-Shen emphasizes that this collaboration goes beyond the boundaries of social sciences and extends to natural sciences, humanities, as well as various practical and field domains.

Design/ Bo-Si, Lin

"In the past, students dozed off in class, and both teachers and students blamed each other." "We collaborated with the Taiwan University's Office of Academic Affairs to install miniature sensors in various large classrooms, and discovered that the high concentration of carbon dioxide was a ventilation problem." Additionally, sensors can measure the operating time of streetlights, noise levels across the campus, and more.

Science Tips

Using miniature sensors for wind, light, humidity, temperature, air quality, noise, and other environmental factors is Professor Chien Shiuh-Shen's secret weapon. Through these sensors, it is possible to identify areas that are dirty, noisy, hot, or dim, and by providing open information, it helps establish a localized "environmental comfort" index to assist residents in quickly understanding their surroundings

Figure 1: NTU4AQ in Daxue Village

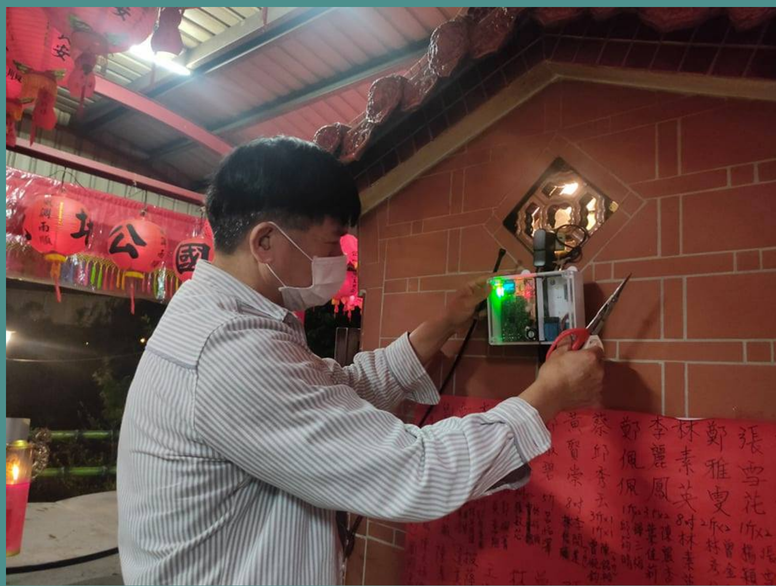


Figure 2: MAPS6 in Jianguo Village

This environmental comfort health check system includes machine development, measurement calibration, and information system establishment; highlighting the need for interdisciplinary collaboration across fields such as natural sciences, mechanical engineering, information management, and community development in order to effectively address environmental issues.

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ABOUT OUR TEAM

SC+NTU Work Team

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International Degree Program in Climate Change and Sustainable Development (IPCS)

The International Degree Program in Climate Change and Sustainable Development, as its name suggests, is an interdisciplinary degree program that encompasses a global perspective. Established by the College of Science, the program is a joint effort among NTU faculty members from both scientific research and humanities backgrounds. In dealing with climate change and sustainable development, we instrument in-depth teaching in a wide range of topics. Students are required to bring their knowledge and skills to the table and approach environmental issues from a multi-angled perspective. They are encouraged to break free from traditional views on sustainability and think outside the box. Students are expected to be motivated learners, thinkers, analysts, and most important of all, practitioners. Our ultimate goal is to cultivate students' ability in interdisciplinary problem-solving in dealing with the complexity of climate change issues.

ABOUT OUR TEAM

Location Aware Sensing System (LASS)

LASS
Location Aware Sensing System

The Location Aware Sensing System (LASS) is an important maker community in Taiwan, and it is also the creator of air boxes, water boxes, and other micro-sensing devices. LASS focuses on the integration of citizen technology and spatial information, aiming to design and implement an environmental sensing system with local characteristics through the integration of hardware and software. The community strives to promote open source and public welfare as the main axis, and to create customers instilled with a 'self-creator' spirit, develop low-cost environmental monitoring equipment with an open software and hardware architecture so that the public may build a set of sensing systems that meet their specific needs through a self-made process. At the same time, LASS also adopts and open attitude towards sensing data and allows volunteers to use environmental monitoring data uploaded to the cloud system by other partners in the community in order to build a real-time monitoring network.

PARTNERS ➤

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