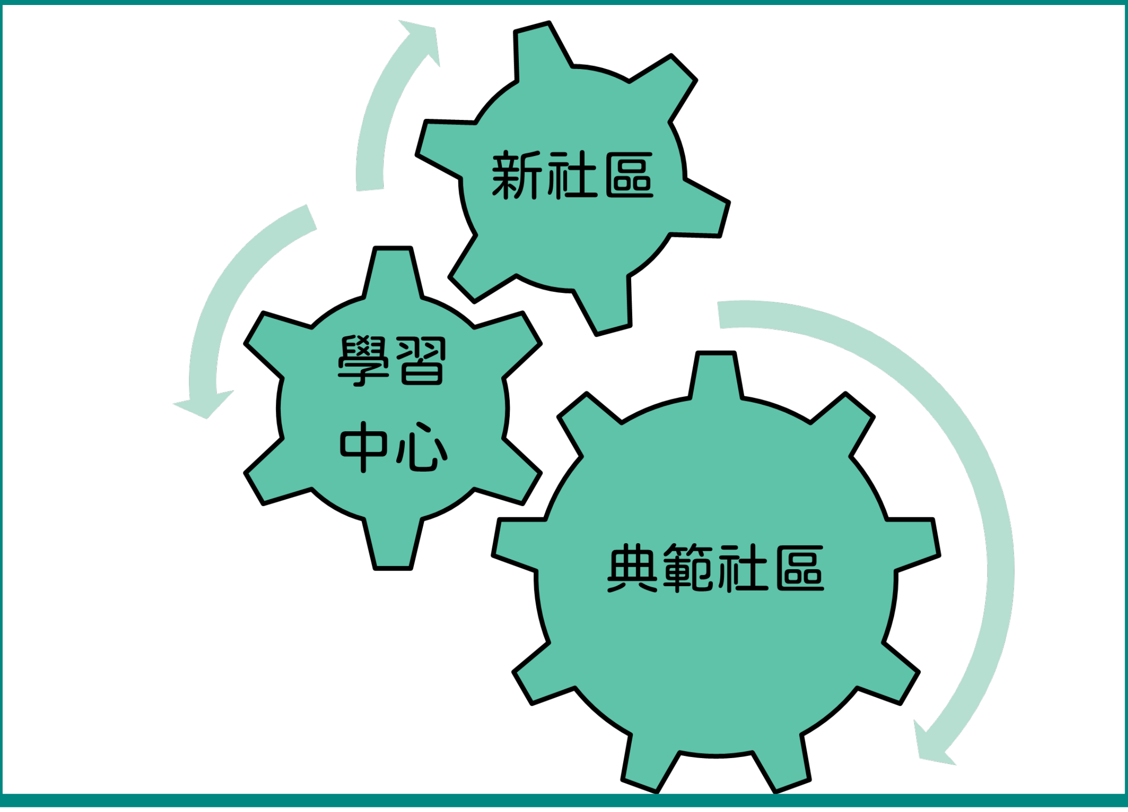
Office of Institutional Research and Social Responsibility, NTU
International Degree Program in Climate Change and Sustainable Development, NTU
Research Center for Future Earth, NTU

NEWSLETTER
Jan. 2023

SC+NTU

Shiuh-Shen, Chien. Jen-Ping, Chen. Ling-Jyh, Chen. Jehn-Yih, Juang. Ming-Kung, Chung.Yi-Huan, Hsieh. Po-Hsiung, Lin.
SC+NTU Work Team



As we welcome the new year, the SC+ team has successfully deployed environmental sensors on campus and in the community based on past efforts. The team will continue to adapt and improve both hardware and software to collect data for discussing and addressing various issues, and hopes to deepen the community's climate awareness and adaptation actions.

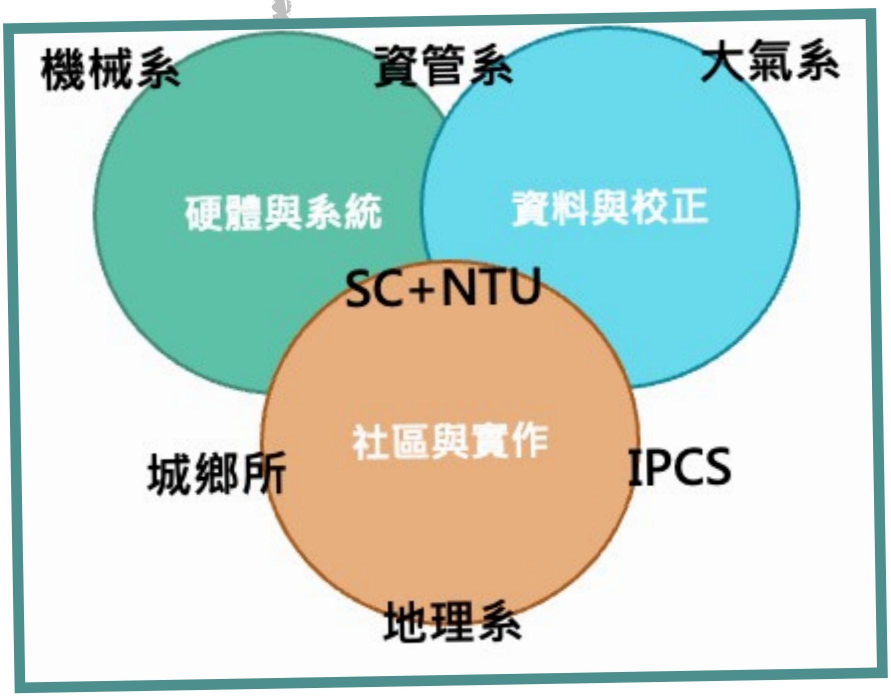
In this issue, we will share the calibration methods and results of the microsensors, aiming to improve the quality of future research by classifying the accuracy of different data and establishing calibration methods for each data. In our knowledge sharing section, we will think through a three-dimensional perspective of volumetric geography in order to better understand how human and environmental issues affect daily life.

Monthly Activities Summary

1/14

Submission of the proposal for the third phase of the USR project

After two and half years of hard work, we have created the NTU4AQ as a multi-functional environmental sensor and cloud-based management system to address various issues. We have deployed sensors on the NTU campus as well as within the community, all the while maintaining a focus on sensor calibration to ensure data quality and accuracy. For the upcoming project, we will continue to improve across multiple areas and delve deeper into community issues; aiming to define, identify, and solve relevant problems. More broadly, we continue our work to promote climate awareness and adaptive action in the community.



Achievements and Announcements

Calibration of microsensors - using maps as an example

Department of Atmospheric Sciences Zi-Han, Zhou

Introduction

The certification process before the deployment of microsensors requires that the relative error between the microsensors and monitoring equipment be ≤30% and the coefficient of variation (CV) be ≤0.2. Data should be collected for at least three days to compare the consistency of the measurement stations. Due to limitations in detection methods and performance, microsensors are mainly used to monitor data changes within a small range (100-300 meters), and abnormal data situations are used as warning purposes. Direct measurement data is less frequently used.

The advantages of microsensors are their lower cost, ease of deployment, and accessibility; however, their accuracy and precision are limited. In order to adapt to different measurement objectives and environmental variables, the goal is to establish the accuracy classification of 50 MAPS microsensors in temperature, PM2.5, and CO2, and to develop calibration methods for each data category under each classification.

Method

Correction Methods and Results

After testing, it was observed that the data from the microsensors in room G202 were affected by environmental variables. Different temperatures, humidity levels, or human activities would significantly affect the measurement errors of the microsensors. In the environment of the unoccupied G202 classroom, the space limit for calibration is within approximately 1.5 meters from the monitoring instrument. The maximum number of microsensors that can be measured simultaneously in this space is about 6 per batch, and the mutual influence and spatial scale of measuring more than 6 microsensors at the same time would seriously affect the observed data. Calibration is estimated to be carried out for more than three days per batch, and approximately 15-20 sensors can be calibrated every two weeks, including an evaluation of the damage to the sensors.

Using the average differences of the data from the already calibrated 28 MAPS sensors per minute, the temperature average difference is 2.47, and the relative error ranges from 7.5% to 9.5%, which is a result follows an overall trend. The average difference of PM2.5 is 3.12, and the relative error ranges from 12.5% to 46.9%. It is inferred that the concentration of PM2.5 in an unoccupied classroom is relatively low, and the lower value increases the percentage of relative error. Observing R2, 24 sensors have a high correlation coefficient above 0.7, and one sensor shows a moderate degree of closeness with an R2 value of 0.68. The average difference of CO2 is 10.18, and the relative errors are between 6.14% (in sensor Y47) and 1.01 to 4.37% (in other sensors). The R2 values are widely distributed between 0.19 and 0.89. Therefore, in the accuracy classification work, it is expected to be the most significant category for data correction. Additionally, there were 7 MAPS sensors that could not receive data and 7 memory cards that recorded incomplete data.

Multiple linear regression

Temperature, PM2.5 and CO2 data errors come from sensor measurement errors, temperature, humidity, etc. are mainly affected by measurement errors. Therefore, temperature calibration will provide a linear regression formula based on the measurement data for each sensor, and provide a separate linear regression formula for each MAPS.

Accuracy Classification

Considering the limitation of microsensors and its primary purpose of observing the trend of change, the accuracy classification will refer to R2, and the MAPS close to R2 will be divided into one category. The future use and distribution can refer to this data as a reference for the selection of different environments and usage purposes.

Results

1. Calculate the current R2 for each MAPS data after data calibration. PM2.5 has larger values and relatively small fluctuations, with 21 correlation coefficients reaching 0.8. Temperature and CO2 have smaller measurement values and relatively larger fluctuations, so we choose to use the third and fourth quartiles of the relative error as the screening criteria for each variable when used.
2. The temperature and CO2 were filtered based on relative error, while PM2.5 was filtered based on the correlation coefficient. The 7 devices with the largest difference were selected for each variable, which accounted for the last 25% of the devices. For temperature, the filtering criterion was 8.79 degrees, and the 7 selected devices were Y15, Y18, Y20, Y22, Y24, Y36, and Y46. For CO2, the filtering criterion was 3.265 ppm, and the 7 selected devices were Y18, Y30, Y38, Y39, Y47, Y48, and Y49. For PM2.5, the filtering criterion was 0.805, and the 7 selected devices were Y29, Y31, Y33, Y35, Y40, Y43, and Y49. The remaining 21 devices will be used based on the specific needs.

- 溫度與CO2參考相對誤差、PM2.5參考相關係數，選出誤差最大的最後1/4台

平均差	Y14	Y15	Y18	Y19	Y20	Y22	Y24	Y25	Y26	Y27	Y28	Y29	Y30	Y31
溫度	8.1	9.69	9.63	7.97	11.6	9.53	9.28	8.45	8.24	7.93	4.25	6.82	7.66	7.02
PM2.5	0.94	0.93	0.88	0.89	0.92	0.91	0.94	0.93	0.92	0.94	0.81	0.77	0.88	0.1
CO_2	2.28	1.52	3.36	2.27	2.58	1.58	1.63	1.23	2.87	1.72	1.84	1.71	4.37	2.49

平均差	Y32	Y33	Y34	Y35	Y36	Y37	Y38	Y39	Y40	Y43	Y46	Y47	Y48	Y49
溫度	7.57	7.48	7.27	7.89	9.32	7.36	8.3	8.33	7.82	7.75	9.27	8.63	8.21	6.17
PM2.5	0.81	0.78	0.83	0.78	0.84	0.85	0.84	0.82	0.79	0.68	0.85	0.87	0.88	0.73
CO_2	3.07	1.63	1.13	1.01	2.72	3.18	6.08	3.88	2.82	3.24	2.81	6.14	3.35	3.34

PM2.5 & Humidity Research

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

It is expected that the ESP32 series development board will be used instead of the Mega 2560 Pro. Apart from being cheaper, it has lower power consumption, larger programmable space, and can also be used as a WiFi board. In the future, it can be used as an indoor control system and for connectivity. However, the power consumption of wireless network connection needs to be considered and a power consumption cycle design needs to be implemented. Currently, there are no problems with the hand soldering of the three main control boards. The main issue lies in the stability of the SPI connection on the main control board. Due to the poor stability of the board itself, a significant amount of time was initially spent on resolving the issue of the SD card not connecting, but it was later discovered that the hardware was faulty. Therefore, it is planned to adopt the ESP32 series of main control boards as the future controller.

The development of NTU4AQ ver2 involves a complete reconstruction of the entire software and hardware system architecture and content. The code design has also been changed to use a more modular and functional object-oriented design method, which can be used for rapid maintenance and deployment in the future. Through pre-processor compilation, size control and version control can be achieved, and quick version switching and hardware and software debugging can be achieved through simple code switches. This is a new design direction that emphasizes the readability and universality of the code, avoiding the paralysis of the entire system due to the loss of a single function. This allows for expansion or reduction of the same hardware and software architecture according to specific needs.

In terms of the yield rate of the circuit board, currently producing the overall quantity through factory-printed circuit boards is costlier. Therefore, using breadboards as the main medium for modifications and conducting concept verification through a small number of perforated boards (stripboards) is currently recommended. Last time, using perforated boards directly led to unexpected logical and wiring problems, so breadboards should be used for concept verification instead. However, the problem of high-frequency communication still needs to be resolved because breadboards are not soldered connections and require clamping of pins, resulting in lower contact communication and structural stability, requiring special attention during debugging.

For the PM2500 series of sensors, there is a constant deviation in the absolute value of suspended particles measured in the same spatial environment. Currently, a solution has not been found and it is necessary to solve it through reading relevant documents or calibrating constant bias through calibration methods.

In the future, we plan to start developing and researching development boards such as the STM32. Since the main communication protocols we use are I2C and UART, we will start our research from these two points and their clock settings.

Science Tips

The Volume Turn: Analyzing the Complex Relationship between People and Environment

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

Opening up Google Maps to find the fastest route to our destination, we seem to be confined to a two-dimensional understanding of direction, ignoring the "sky above, ground below, and air surrounding us." In recent years, environmental issues have become a key focus of the “volume turn”, shifting away from traditional geographical research that tended to view the relationship between people and the environment in terms of "land" and themes such as agriculture, land ownership, business circles, etc. Professor Chien Shiuh-Shen of the Department of Geography at National Taiwan University notes that "land is flat, fixed, and can be precisely divided. Humans can own and control land, and from this perspective, believe that everything can be classified and summarized in a rational manner. This actually stems from Enlightenment and modernist thinking." However, volume is a concept that truly exists and needs to be reconsidered. Using geography as X, actual cases as Y, and human experience of the environment, weather, regions, and bodily sensations as Z, a three-dimensional approach to geography can be constructed through the lens of the volume turn.

Returning to the relationship between humans and the environment, through the perspective of volume-oriented thinking, we can see that environmental issues have a much deeper and more diverse impact on us. Whether it's the clouds and dust in the sky and air, pipelines and channels underground, or water in various forms (solid, liquid, and gas) that pervades our lives, these issues are beyond the scope of understanding through two-dimensional maps. How do these factors actually affect our daily lives?

Professor Chien mentioned that "Volume Geography is not only three-dimensional and stereoscopic, but also fluid, open, political, and emotional." One classic study in this field is the exploration of "Chinese cloud-water politics."

Chinese people believe that the government has the ability to "tame and manipulate" the weather, using cloud seeding technology to turn clouds into rain. This behavior changes the location of precipitation, resulting in the phenomenon of local governments in China competing for "airborne water resources." By making clouds in the sky a water resource, it has also made them a political issue.

China has taken cloud-water politics to a new level. In addition to artificial rain made by local governments for ecological and agricultural purposes, it is worth mentioning its use during the 2022 Beijing Winter Olympics.

Beijing does not have a naturally advantageous geographical climate, but it has hosted both the Summer and Winter Olympics nonetheless. Beijing is a city that often suffers from water shortages, so where does the water/snow come from to hold the Winter Olympics? There were many obstacles to overcome in the process, such as "using clouds in the sky over Hubei Province to artificially induce precipitation into reservoirs, then transporting the water through the South-to-North Water Diversion Project to Beijing, and using snow-making technology to meet the snow standards required for the Winter Olympics." This kind of artificial operation and weather engineering involves the complex relationship between China's volume geography and the politics behind the hosting of international events; a politics spanning regions and encompassing governance of both heaven and earth, along with the usual political and face-saving considerations.

Reference

期刊論文

1. 簡旭伸（2019）。再理論化量體政治: 以臺灣與中國霧霾治理為例。國科會專題研究計畫（一般研究計畫）。
2. 廖昱凱、簡旭伸（2019）。地理學中的量體轉向：領土立體化、地球物理政治與環境中的情感氛圍。地理學報，92，1-29。
3. CHIEN, Shiuh-shen*, Dong-Li HONG and Po-Hsiung LIN (2017), Ideological and Volume Politics behindCloud Water Resource Governance- Case of Weather Modification in China, Geoforum, Volume 85, pp 225-233, https://doi.org/10.1016/j.geoforum.2017.08.003

新聞報導

1. 林義宏、林俊孝（2023，3 月 8 日）。離開地球表面的一場地理學搖滾：臺大簡旭伸暢談「天 / 空 / 氣」的量體新視野。人文島嶼。資料引自 https://humanityisland.nccu.edu.tw/shiuh-shen-chien/
2. 麥小田、許書婷（2022，1 月 13 日）。綠色情報員：北京穹蒼（上）“冬奧藍”的運動進行式。rfa 自由亞洲電臺。資料引自 https://www.rfa.org/mandarin/zhuanlan/luseqingbaoyuan/grn-01132022095948.html?encoding=traditionalhttps://humanityisland.nccu.edu.tw/shiuh-shen-chien/

ABOUT OUR TEAM

SC+NTU Work Team

Principal Investigator: Shiuh-Shen Chien

Executive Consultant: Ming-Kung Chung; Yi-Huan Hsieh

R&D and Calibration Consultant: Jen-Ping Chen; Ling-Jyh Chen; Jehn-Yih Juang; Po-Hsiung Lin

Taipei Field Consultant: Jen-Ping Chen; Jehn-Yih Juang; Po-Hsiung Lin; Chih-Hao Hsieh; Chin-Lin Wei

THOD Consultant: Jen-Ping Chen; Sheng-Lin Chang; Horng-Huei Liou

Work Team: Miao-Jung Chien; Wei-Jhe Chen; Cheng-En Lin; Xin Yang; Tzu-Chun Chang; Rong-Cih, Chang; Tzu-Ya, Wang; Chieh-Hsiang, Fan

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)

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 ➤

Wenshan Community College. Daxue Village, Taipei City.

Jianguo Village, Yingge Distrint New Taipei City. Taiwan Mobile Co., Ltd

Transit-Hospital-Oriented Development(THOD) Work Team

CONTACT US ➤ https://www.facebook.com/NTUIPCS