

微觀校園,宏觀未來: 地理STEAM校本微氣候監測預報網路

Micro Campus, Macro Future: School-Based Microclimate Monitoring and Forecasting Network in Geography and STEAM education

11 Dec 2024

Learning & Teaching Expo 2024



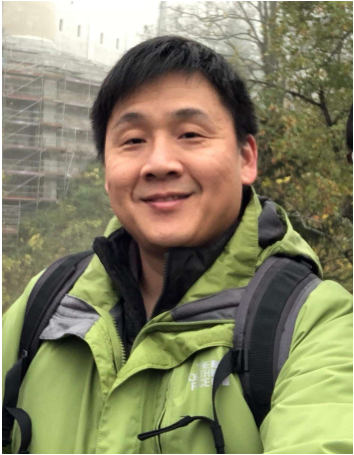
Learning &
Teaching Expo 2024
學與教博覽2024

11-13 Dec 2024
Hall 3B-E, Hong Kong
Convention & Exhibition Centre

Prof. Nicky Y.F. LAM

Associate Professor

Urban Climate and Air Pollution Laboratory
Department of Geography (HKU)



Prof. Nicky Yun Fat LAM
Associate Professor of HKU Geography

- Physical Geographer
- Scientist in Air Pollution and Climate
- Chartered Energy Engineer (HKIE)



Climate and Air Pollution
Modelling



Sensor Application and
Community Network



Geography-based STEM

Motivation

Recent barriers in microclimate research and Geography / STEAM education in HK:

- Limitations in urban-scale observation data
- High spatiotemporal variability in urban environment / high heterogeneity in urban area
- Lack of innovative and motivational activities for student participations
- Self-boundaries on subject disciplines

Research Methods

Approach 1: Development of Meteorological Observation Facilities with Citizen Science Initiatives

Hierarchical Framework

1. Citizen Science (Weather Station)	Prof. (Acad.)	CENTRALIZED
2. Community Weather Station (with non-academic)	Prof. (Acad.)	
3. Local-level Weather Station	Prof. (Acad.)	DECENTRALIZED
4. No Technology (Citizen Science)	Prof. (Acad.)	

**EVERYONE CAN BE A SCIENTIST
& EVERYONE CAN CONTRIBUTE THE SCI. SOCIETY**

Urban Analytics + STEM Education = Win-Win Solution?

Results & Discussion

- 01 Community Science Data Access maps
- 02 Prof - Student Collaboration at Local High Schools
- 03 Community Requirement Survey in Six The Districts
- 04 Citizen Data Group and Prof Network
- 05 Research Project and Mutual Collaboration

Community Network (Co-WIN)

Fig. 1. A proposed network of weather observation facilities in Hong Kong (1) - 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030.

Fig. 2. A typical summer weather in Hong Kong (1) - 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030.



Motivation



THE GLOBAL GOALS
For Sustainable Development



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Urban Climate and Air Pollution Laboratory
香港大學 THE UNIVERSITY OF HONG KONG

03



Motivation

#Smart Cities (智慧城市)

#Citizen Science (公民科學)

#Urban Heat Resilience (城市耐熱性)

#University-Government-School Partnership (大學、政府、學校合作)

#Geography-STEAM Education (地理-STEAM教育)



MULTIDISCIPLINARY approach

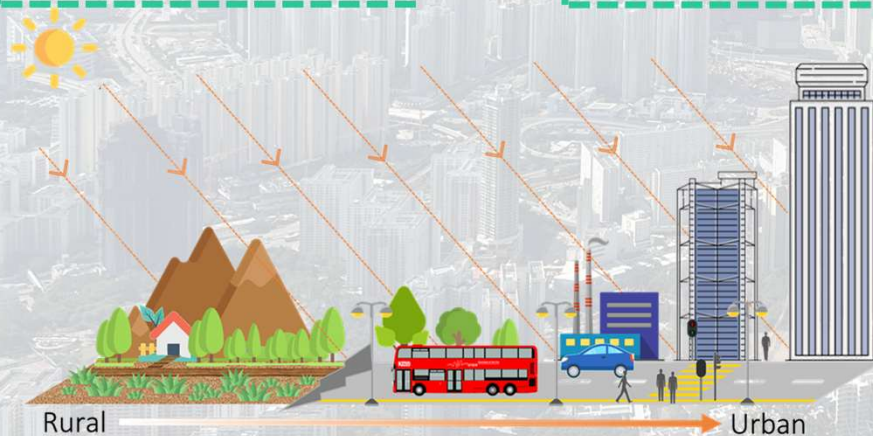
Education Advancement (Citizen Science)

+

Sci-Engineering Solutions (IoT / Modelling)

+

Social Interventions (Education)

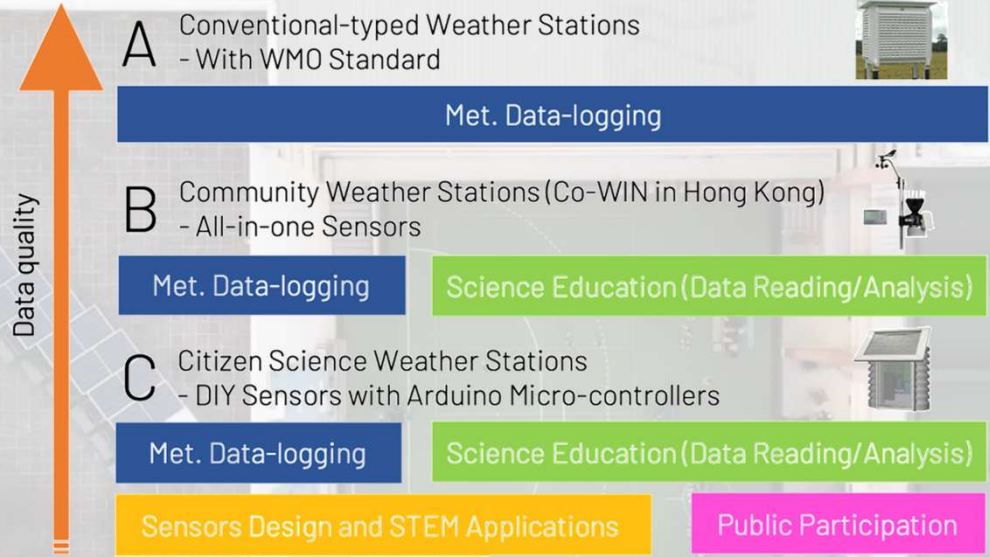


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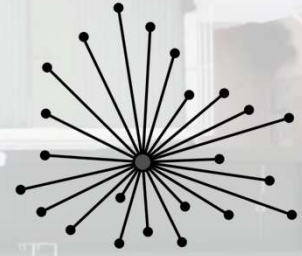
Approach 1: Development of Meteorological Observation Facilities with Citizen Science initiatives

Hierarchical Framework



Data quality ↑

Community Engagements ↓



CENTRALIZED



DECENTRALIZED

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Urban Analytics + STEM Education = Win-Win Solution?



Approach 1: Development of Meteorological Observation Facilities with Citizen Science initiatives



- Tailor-made your own AWS design
- Powered by renewable energy
 - High sensor expandability
 - Real-time data transmission (Wi-Fi/LoRa/Zigbee)

Conventional weather station (AWS – Automatic Weather Station)

Co-WIN community weather station (DAVIS Vantage Pro2)

Citizen Science weather station (Arduino-based 3D print)

Connecting STEAM with Urban Analytics via GEOG



Approach 1: Development of Meteorological Observation Facilities with Citizen Science initiatives



Connecting STEAM with Urban Analytics via GEOG



Research
Methods



Approach 2: Comprehensive School-based Microclimate Assessment and Resilience Project

Citizen Science Applications

DIY low-cost sensors (Students) and measurement campaigns

Provide students the opportunities to participate and understand their own campus.

FLIR Drone Thermal Sensing

“Hotspots” detection with FLIR drone camera

Inspect the heat spatiality information at various campus locations



Meteorological Data Observation

Real-time LoRa co-location measurement (Temp, RH, air pressure, solar radiation)

Provide multi-level ground observation for microclimate at school

CFD Modeling

Computational fluid dynamics simulation (ENVI-met) for detailed spatiotemporal info.

Investigate how wind profile, solar angle and building design may interact with microclimate



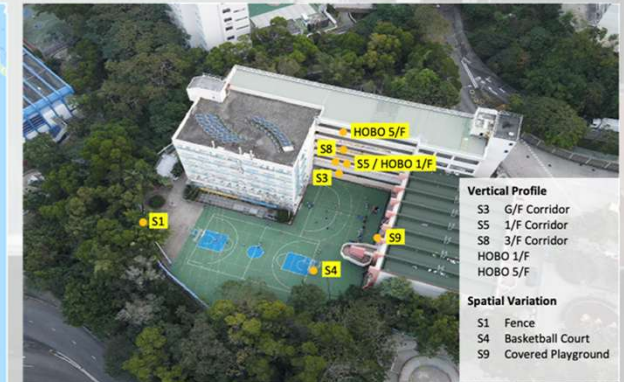
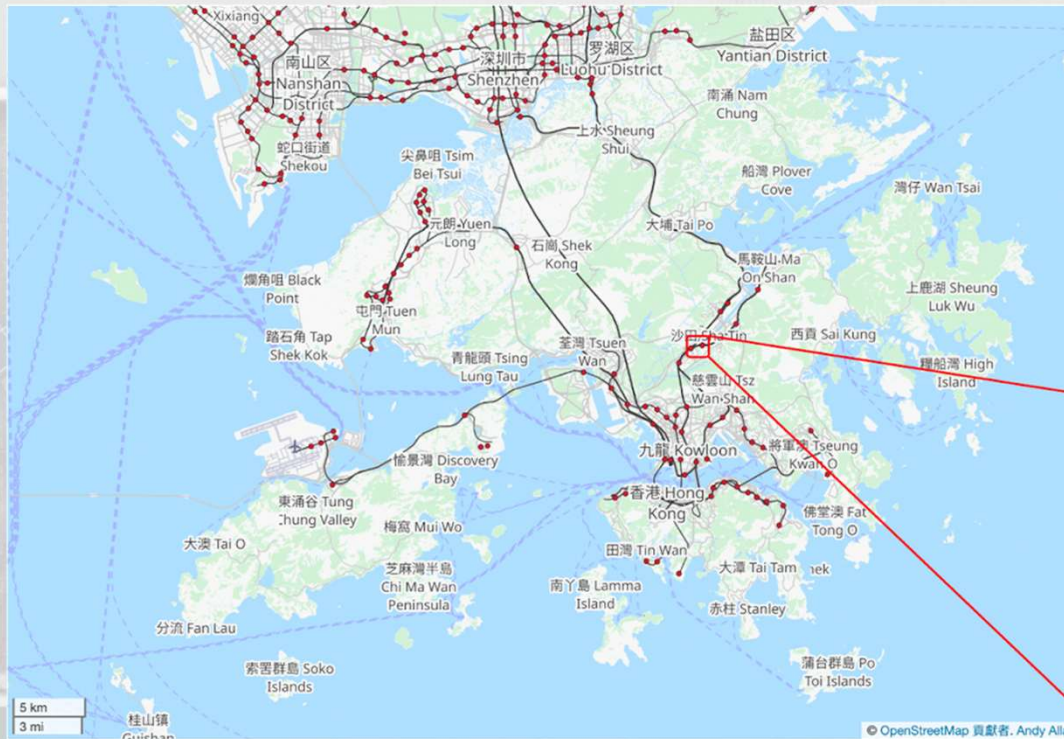
Multi-Source Assessment
+
Collaborative Research



Research
Methods



Approach 2: Comprehensive School-based Microclimate Assessment and Resilience Project



Selected Site: Sha Tin Methodist College (沙田循道衛理中學)

Geography: Compulsory subject for junior high (Form 1 to 3)

Elective subject for senior high HKDSE (Form 4 to 6)



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Research
Methods



Approach 2: Comprehensive School-based Microclimate Assessment and Resilience Project

Student engagement in school-based studies

- DIY and operate low-cost sensors for field work studies
- Conduct survey with fellows to identify campus “Hotspots” (Qualitative)
- Observation data analytics (Quantitative)





Results & Discussion

01 Community Science Data Advancements

02 Multi-Source Observation at Local High Schools

03 Community Measurement Survey in Sha Tin District

04 Citizen Data-Driven Heat Forecast

05 University-Entrepreneurial Collaboration

Community Network (Co-WIN)

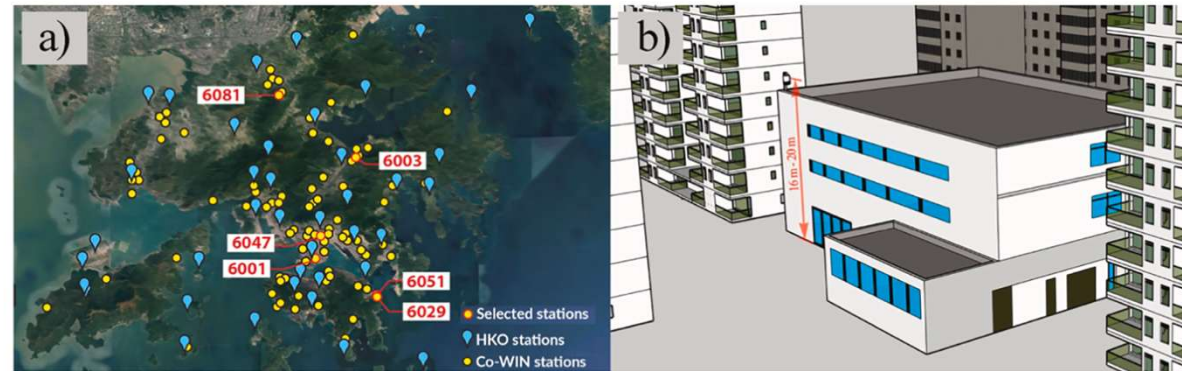


Fig. 1. a) Geographic distribution of Co-WIN and HKO weather stations in Hong Kong (Google, 2020), and b) Co-WIN AWS being installed on the rooftop of a school.

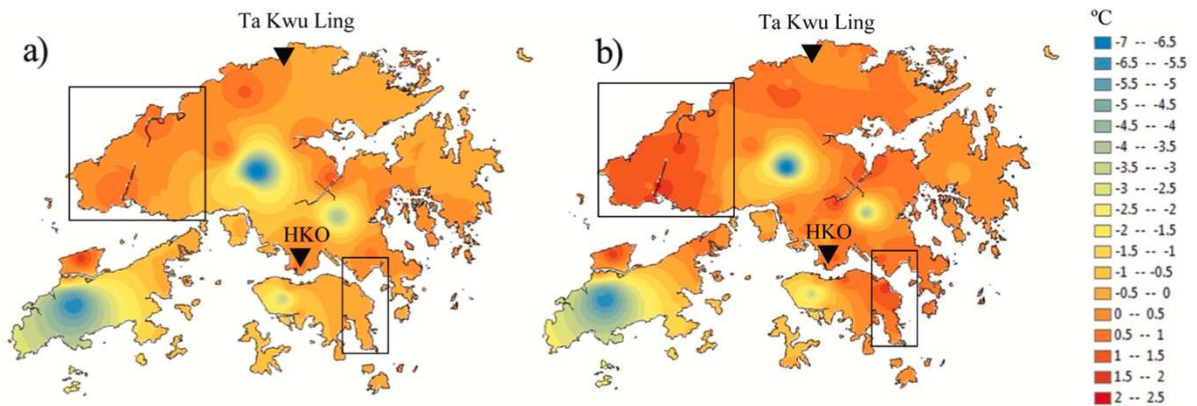


Fig. 8. Variation of temperature contrast with HKO rural station (i.e., Ta Kwu Ling) from spatial interpolation: a) HKO data (40 stations) and b) HKO with Co-WIN data (95 stations).

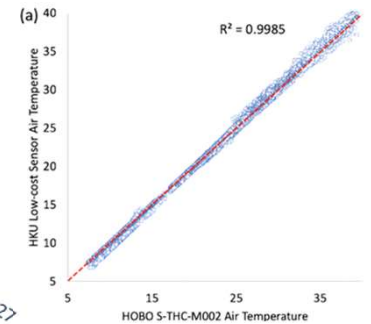
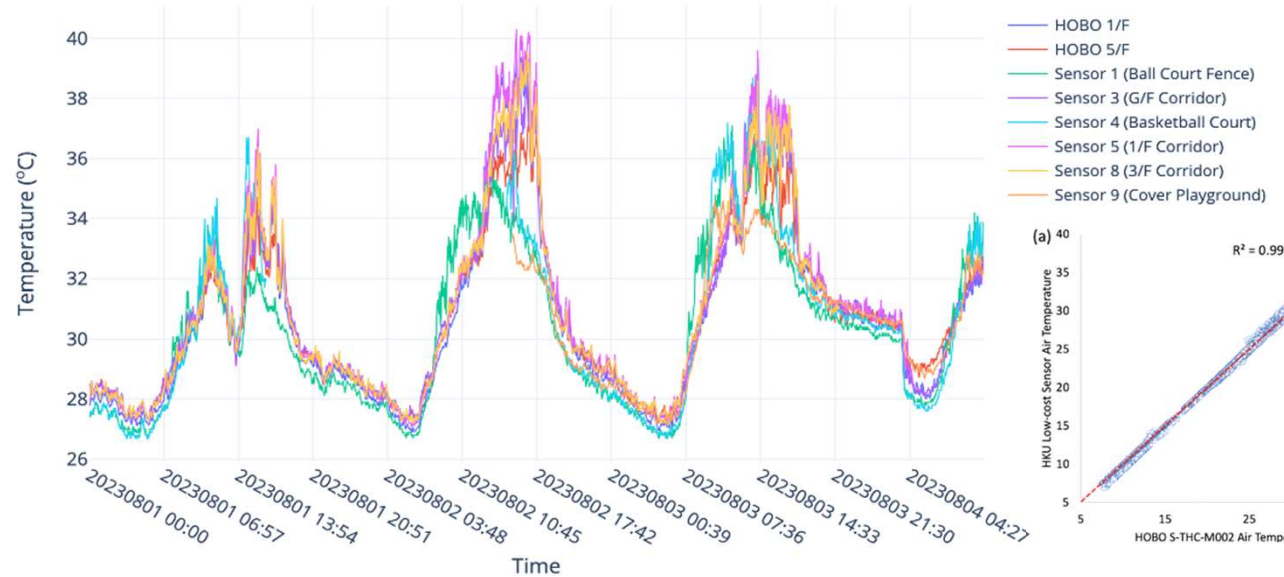




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Multi-data Fusion at Sha Tin Methodist College

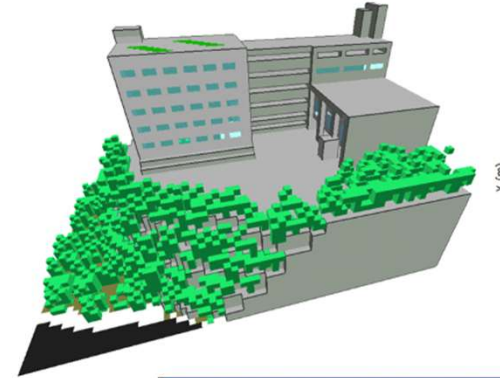
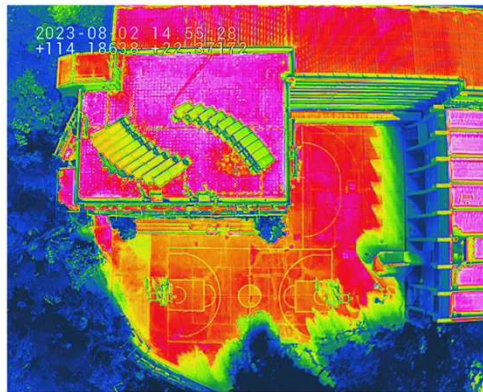
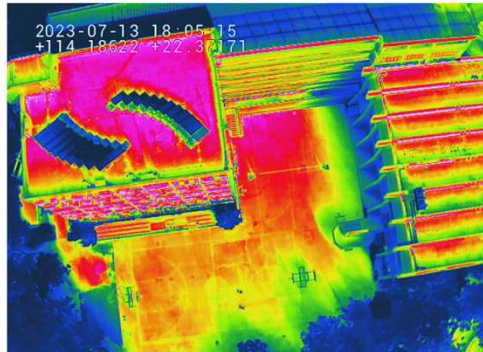




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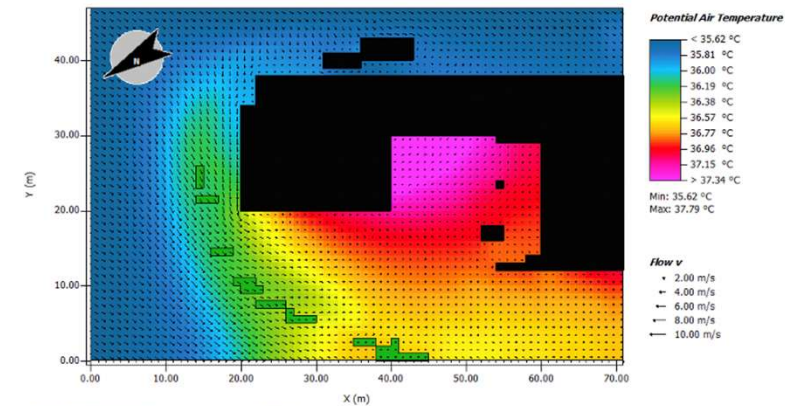
Multi-data Fusion at Sha Tin Methodist College



Envi-MET CFD Model

v.s.

FLIR UAVs Sensing

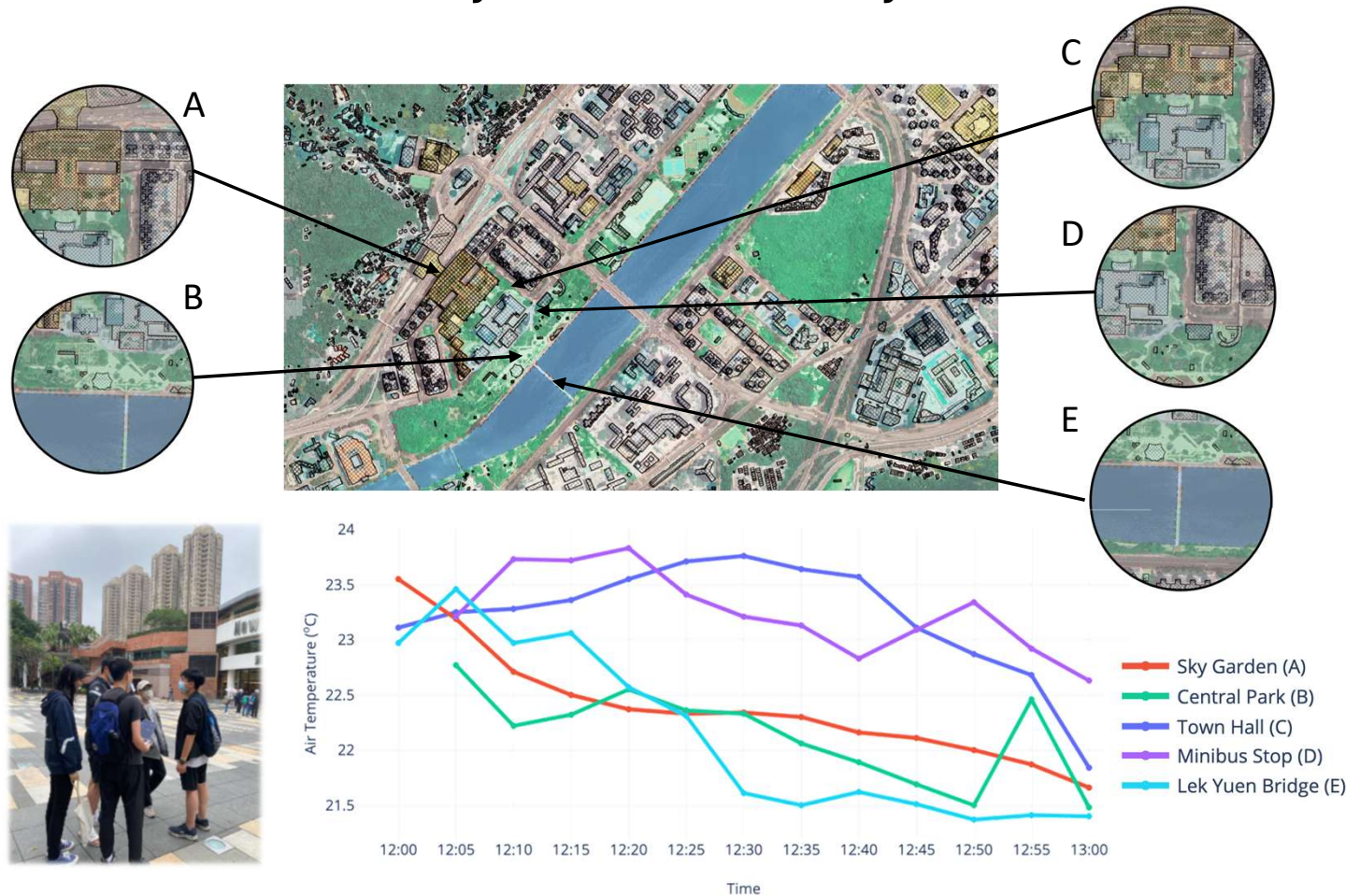




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Measurement survey at the community district

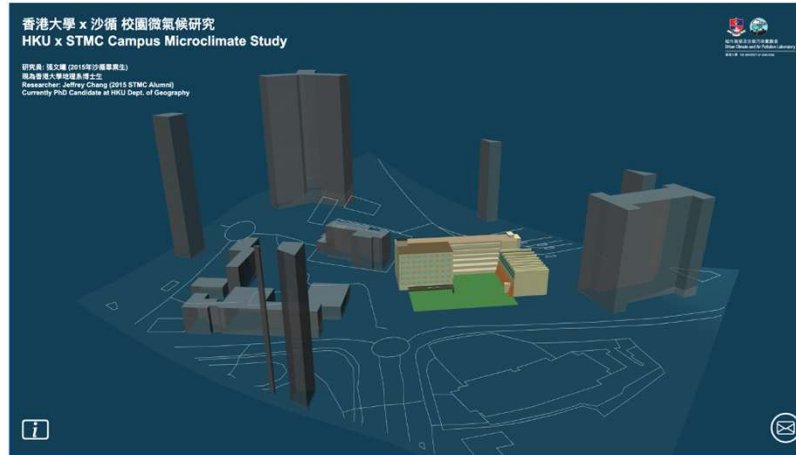




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School-based extreme heat resilience forecast



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香港大學 x 沙撈越 校園微氣候研究計劃
 HKU x STMC Campus Microclimate Study

- 公民科學應用
Citizen Science Applications
- 氣象數據監測
Meteorological Data Observation
- FLIR無人機感測
FLIR Drone Thermal Sensing
- 流體熱力學模型
CFD Modeling

→ 以全新角度揭示空間熱分布不均現象
 A brand-new angle in revealing the unevenly distributed spatial heat problem

→ 把校園在環境測量教育方面的合作
 School collaboration in environmental measurement and education advancement

→ 為學校制熱措施制定實時預測系統
 Generate alert forecast for heat resilience measurement at school

研究員: 張文穎 (2015年沙撈越畢業生) - 現為香港大學地理系博士生
 Research PIC: JEFFREY CHANG (2015 STMC Graduate) - Currently PhD Candidate @HKU Geography

$$\text{Comfortability Index (CI)} = T - 0.55 * (1 - \text{RH}/100) * (T - 14)$$

T = Dry bulb temperature (°C)
 R = Relative humidity (%)

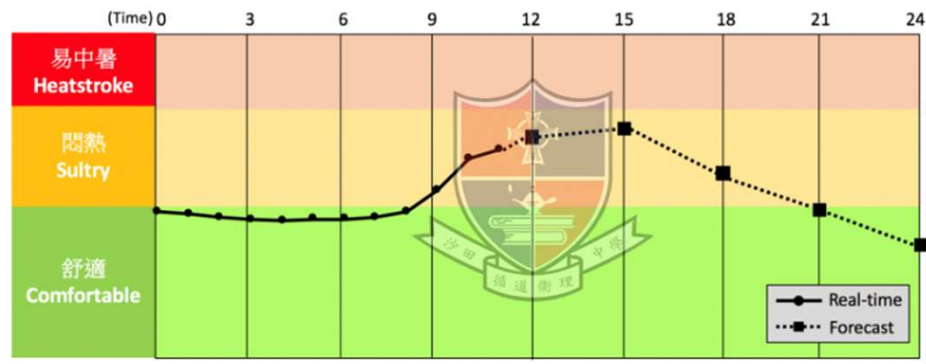


Illustration of coupling citizen science network with Regional Climate Model or simply API's from HKO weather district forecast

Chang, J. M.-H., Lam, Y. F., Lau, S. P.-W., & Wong, W.-K. (2021). Development of fine-scale spatiotemporal temperature forecast model with urban climatology and geomorphometry in Hong Kong. *Urban Climate*, 37, 100816-. <https://doi.org/10.1016/j.uclim.2021.100816>



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University-Entrepreneurial Collaboration

Start-up Company under HKU Entrepreneurship Programme



- Education Purpose / Non-Profit Organization typed
- Foster knowledge exchange with sustainable business mode

Bridging GEOGRAPHY & STEM Education together



Research Collaborators:



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Part 2:
利用自動氣象儀
進行校本微氣候實地考察的經驗分享

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劉潤牛先生

《地理電子學習教材套:氣候變化》
2.0 版 課程總監

齋色園主辦可觀自然教育中心暨天文館



Concluding Remarks

Interdisciplinary approach for microclimate analytics



<https://youtu.be/iqqzq6OljsQ?si=32gk9XvkhntlQ1E6>



Concluding Remarks

Interdisciplinary approach for microclimate analytics

- STEM initiatives brings **Opportunities** to:
 - Expansion of urban-met observation network
 - Capability of user/location-specific weather alerts
 - Tailor-made model forecast for decision making processes at school
- A novel experiment on coupling the
STEM Education & Scientific Numerical Modelling
- Win-Win situation for urban analytics research and education advancement



Acknowledgement & Special Thanks



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Mr. Jeffrey Chang (PhD Candidate)
Mr. Tommy Cheuk (MPhil Candidate)
Mr. Kin Lee (Senior Research Assistant)
Mr. Tim Ko & Stone Leung (Student RA)



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Publications

Lam, Y.F., Ong, C.W., Wong, M.H., Sin, W.F., Lo, C.W., 2021. Improvement of community monitoring network data for urban heat island investigation in Hong Kong. *Urban Climate* 37, 100852. <https://doi.org/10.1016/j.uclim.2021.100852>

Chang, M.H., Lam, Y.F., Lau, P.W., Wong, W.K., 2021. Development of fine-scale spatiotemporal temperature forecast model with urban climatology and geomorphometry in Hong Kong. *Urban Climate* 37, 100816. <https://doi.org/10.1016/j.uclim.2021.100816>.

Lee, T.C., Wong, W.K., Tam, K.H., 2018. Urban-focused weather and climate services in Hong Kong. *Geosci. Lett.* 5, 18. <https://doi.org/10.1186/s40562-018-0119-6>

Hong Kong Observatory, 2017. New generation of Community Weather Information Network Co-WIN 2.0 microclimate station launched. <https://www.hko.gov.hk/en/Press-Releases/102033/New-generation-of-Community-Weather-Information-Network-Co-WIN-20-microclimate-station-launched> (accessed 19th August, 2021).



Thank you ~



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