2018 Air Sensor International Conference

Development and Validation of Robust Protocol and Algorithms for Long Term Field Deployment of Air Sensors

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Supported by
The Hong Kong Environmental Protection Department (HKEPD), The Hong Kong Transport Department (HKTD), Personalised Real-time Air-quality Informatics System for Exposure-Hong Kong (PRAISE-HK)

HKUST 環境研究所 INSTITUTE FOR THE ENVIRONMENT

PRAISE HK

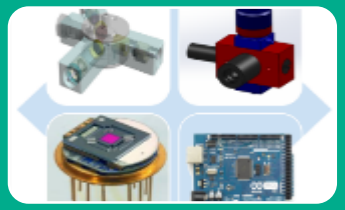
Supported by 支持機構 HSBC 滙豐

環境保護署 Environmental Protection Department

Background on sensor technology category

Compliance monitor

- High price and maintenance cost;
- High precision but requires professionals.
- Regional/local air quality instead of personal info.



“Professional” sensor

- Lower cost and small, compact, easy to deploy;
- Good performance in certain applications with different data quality objective.
- FIT FOR PURPOSE

Consumer sensors (really low cost sensors)

- Cheap and small for personal and family usage;
- Indication purpose, not scientifically reliable?

Sensor work in our group

Sensor technology and algorithm development

- Sensor head development
- Sensor lab and filed testing
- Algorithm development

Sensor system development and integration

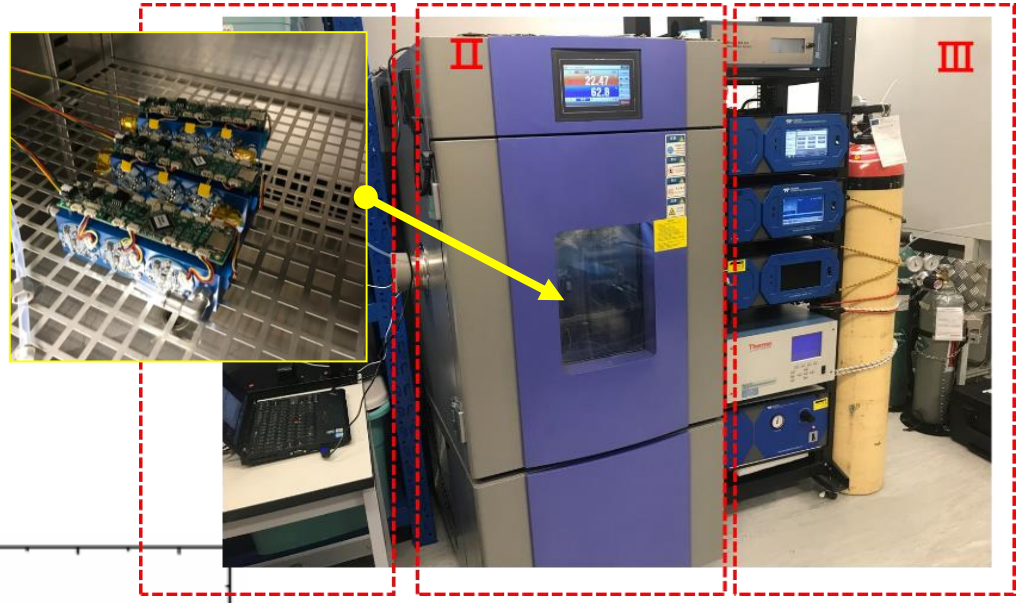
- System design and integration
- Fit-for-purpose engineering and physical solution

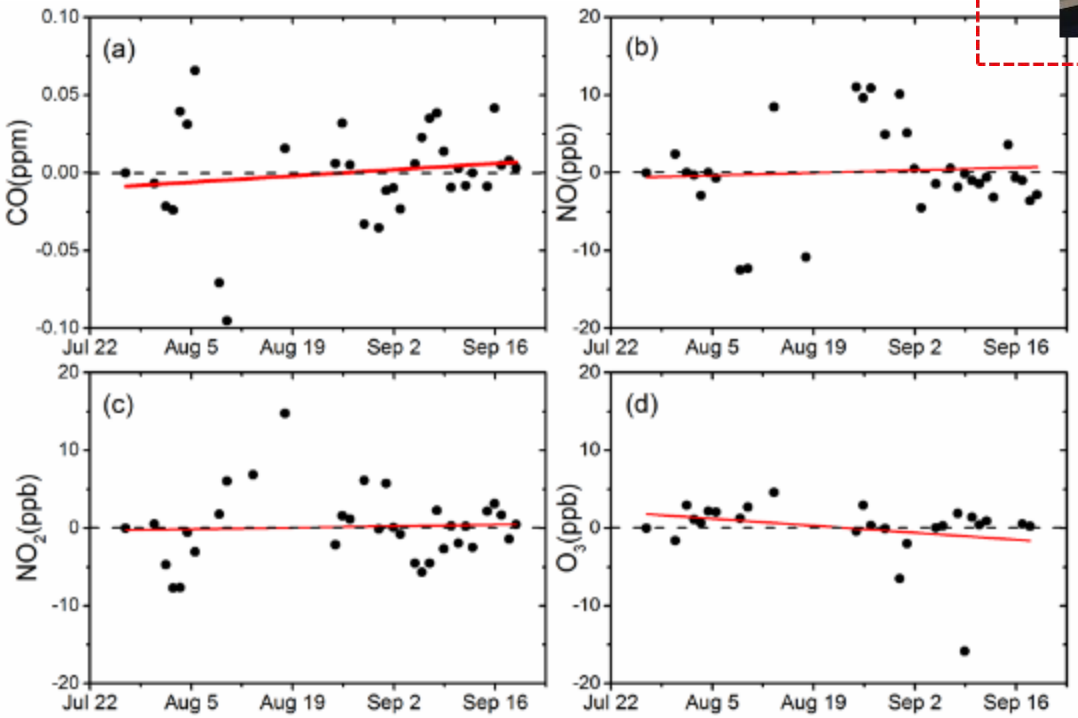
Sensor and network applications

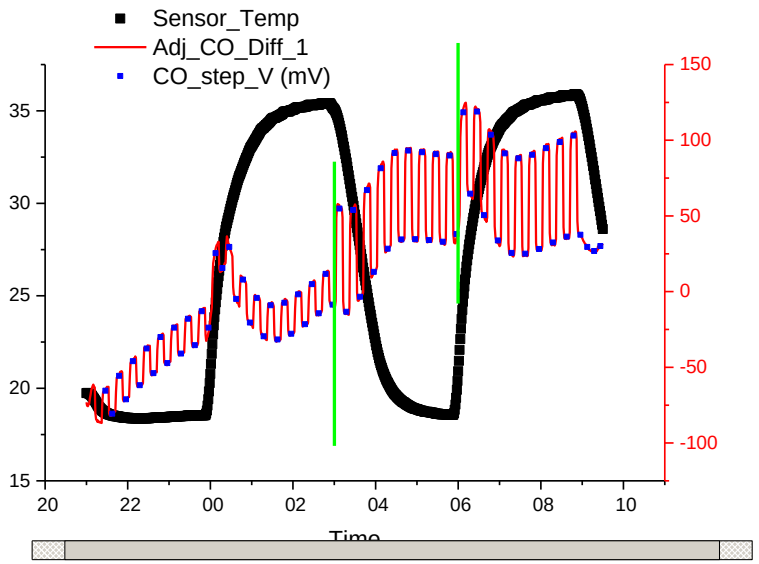
- Air science advancement
- Evidence based and informed policy making
- Community engagement

Sensor algorithm development

- **Sensors have 3 dimension of factors (Conc, Temp, RH)**
- **Reference methods deal with only 1 dimension of factor (Conc only);**
- **Drift has been a concern. QAQC is important!**







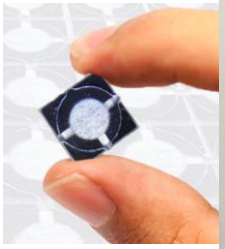
Sensor system development and integration

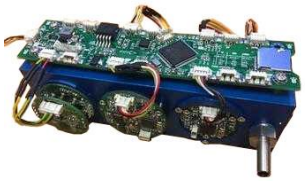
Sensor head selection → Sensor Tests Algorithm → System design Circuit design → System integration → System tests



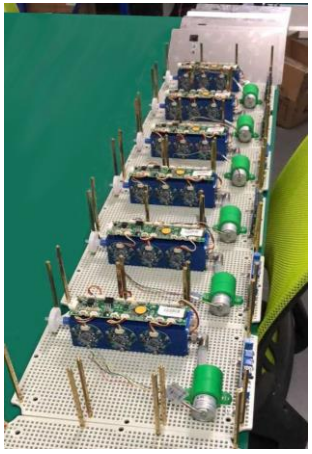


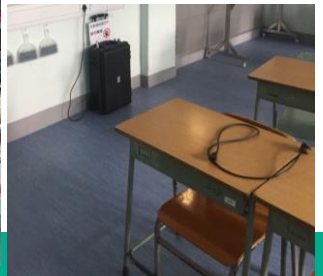




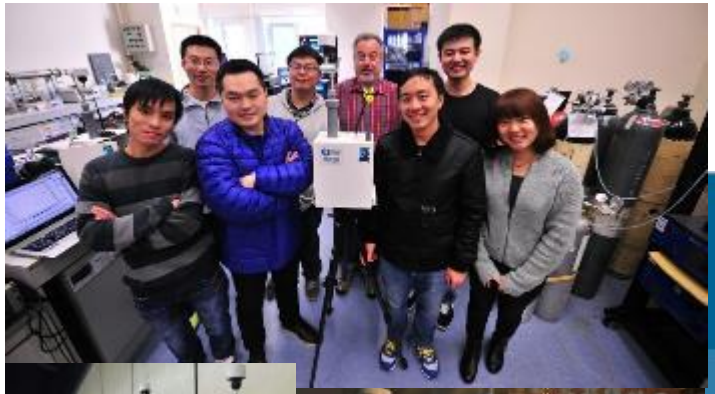




2015 Standard Chartered Green Marathon

- **Marathon sensor-based monitoring network for air quality**



In support of government initiative for "2015 Standard Chartered Green Marathon"

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Standard Chartered
Hong Kong Marathon
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Pollution sensors to line Hong Kong marathon route

Government and universities team up to install monitors and give runners instant access to data

Danny Lee
danny.lee@scmp.com

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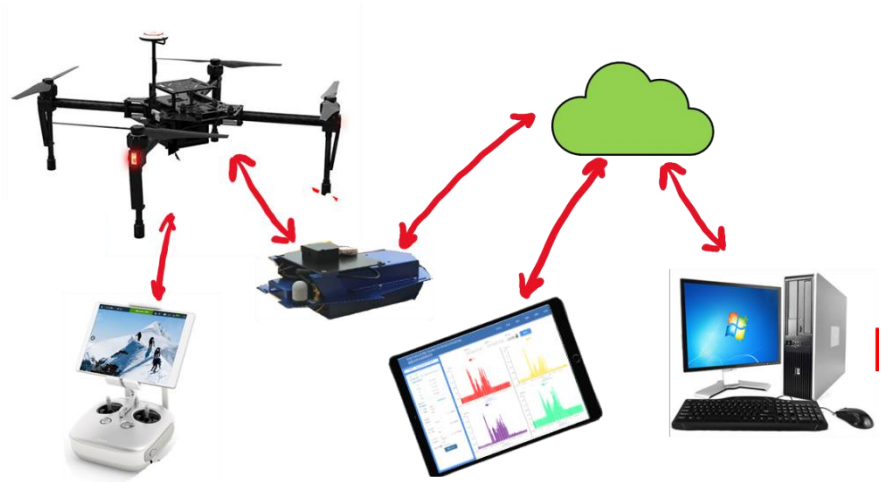
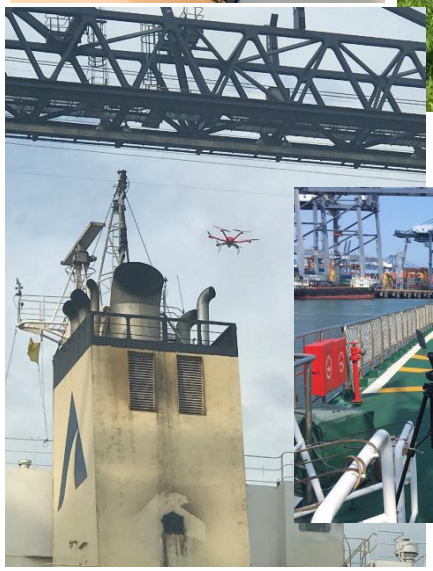
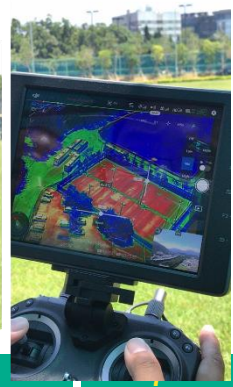
UPDATED : Monday, 27 April, 2015, 3:29pm

Airborne SIRIUS for ship emission

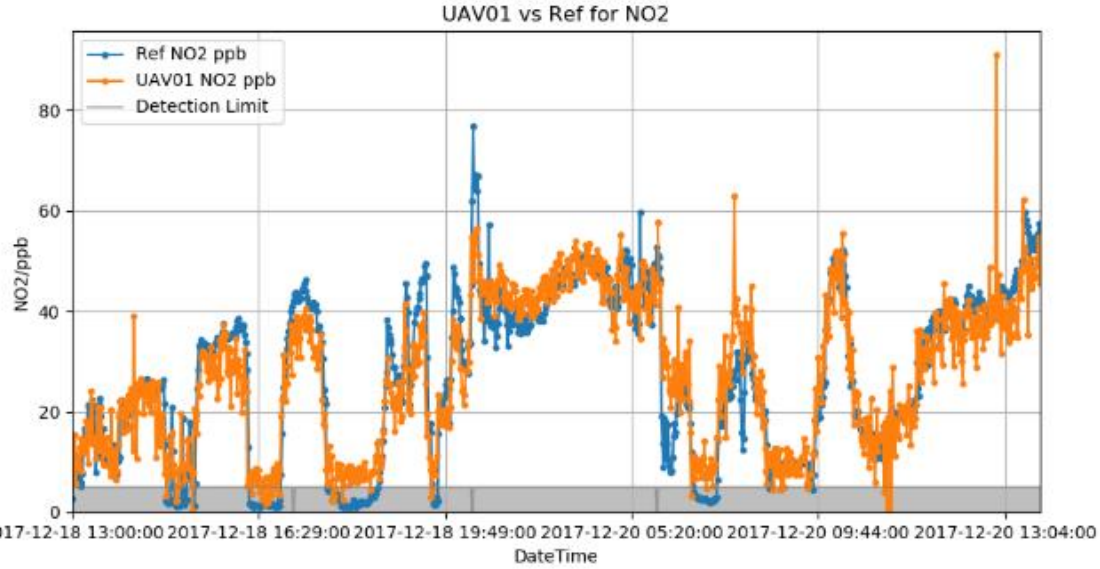
- **Airborne UAV system**
  - Thermal infrared camera for plume detection/tracking
  - 950g active flow system with sensor equipped (SO_2, NOx, VOC, CO, $PM_{2.5}$, CO_2)
  - Auto-data transmission

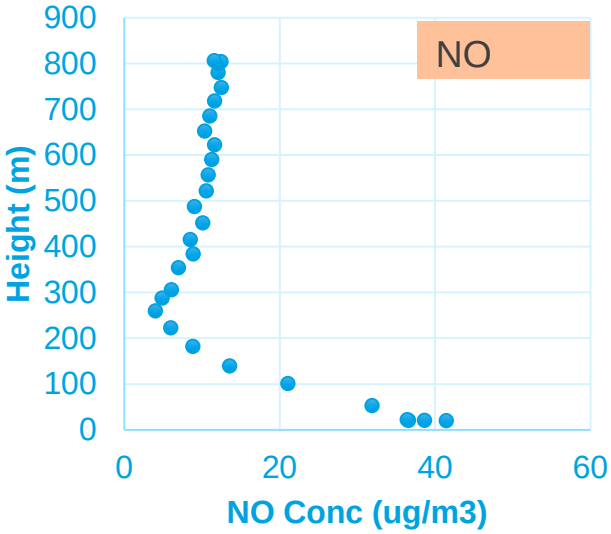


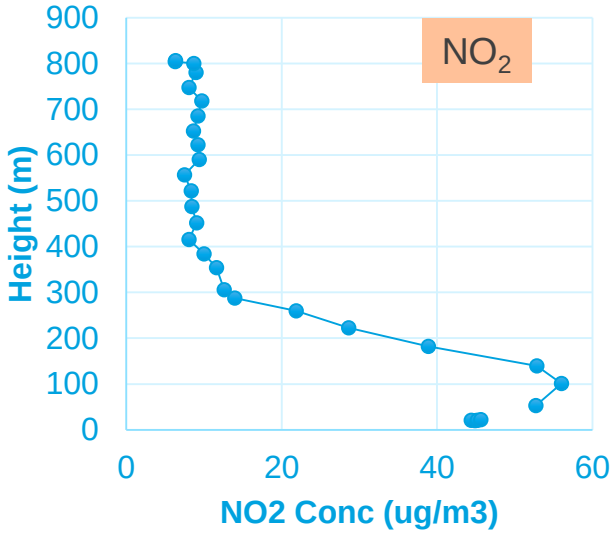




SEMC campaign (1000m elevation with reference)



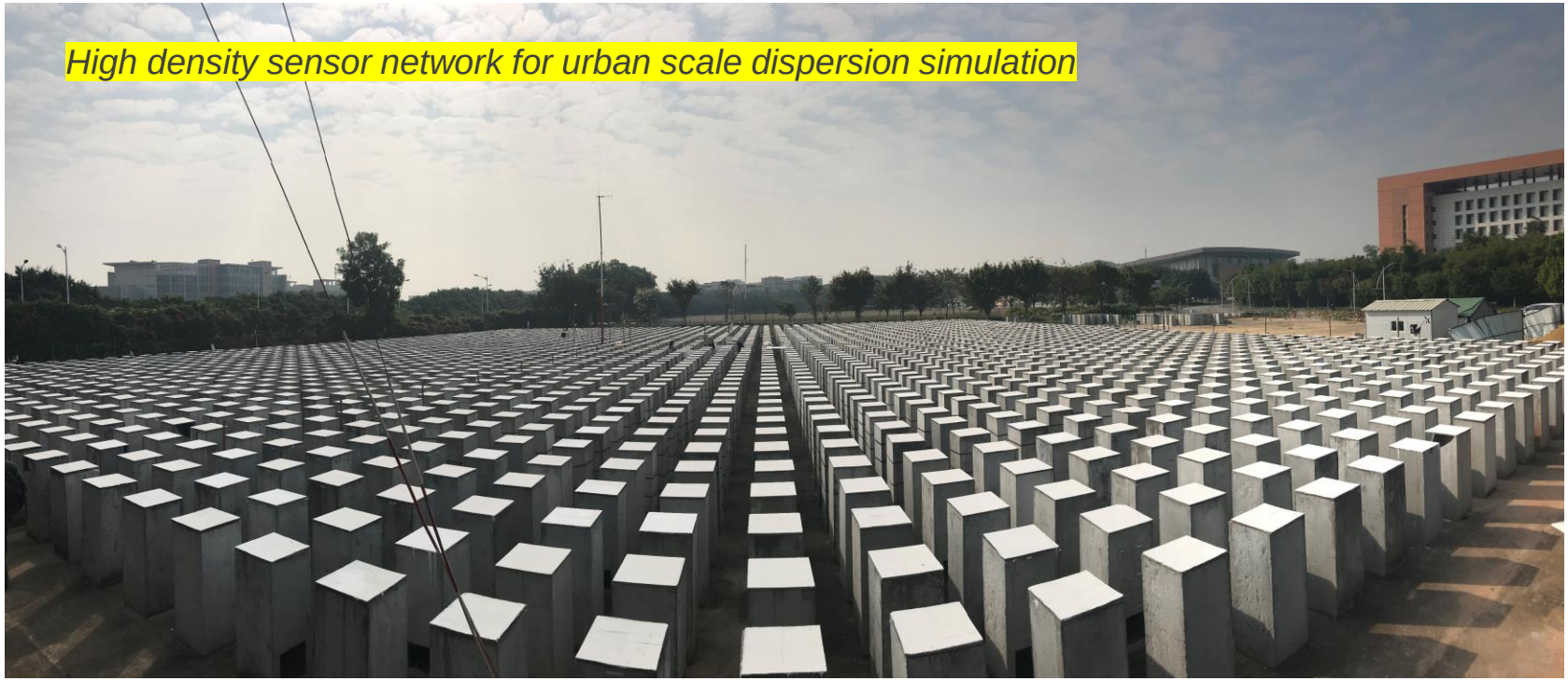


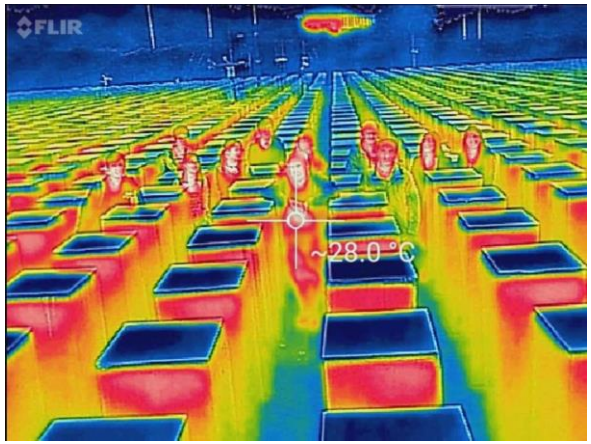


World heritage preservation

- We contribute to the preservation of the World Heritage Leonardo Da Vinci's Last Supper;
- Miniature, quiet, multi-pollutant sensor package with wireless data transmission.

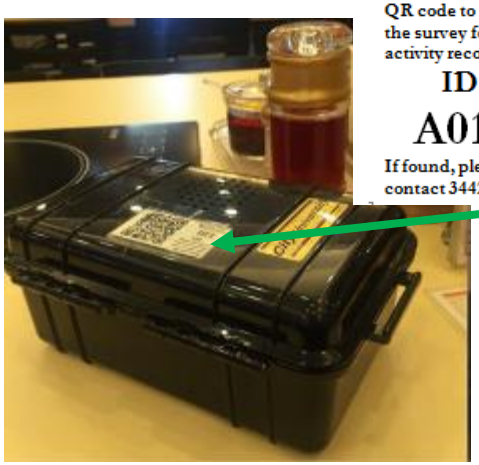
High density sensor network





Personal Exposure Kit (PEK)

- **A light weight portable sensor unit**
  - Can be carried and placed anywhere
  - Can measure, transmit + record real-time data
- **Several microenvironments**
  - Office, Home, Commuting, schools, indoor and outdoor
- **Light/motion/noise sensor** for environment differentiation.
- **QR code scanning** to record time activities.



Please scan the QR code to access the survey for time-activity recording.

ID:

A01

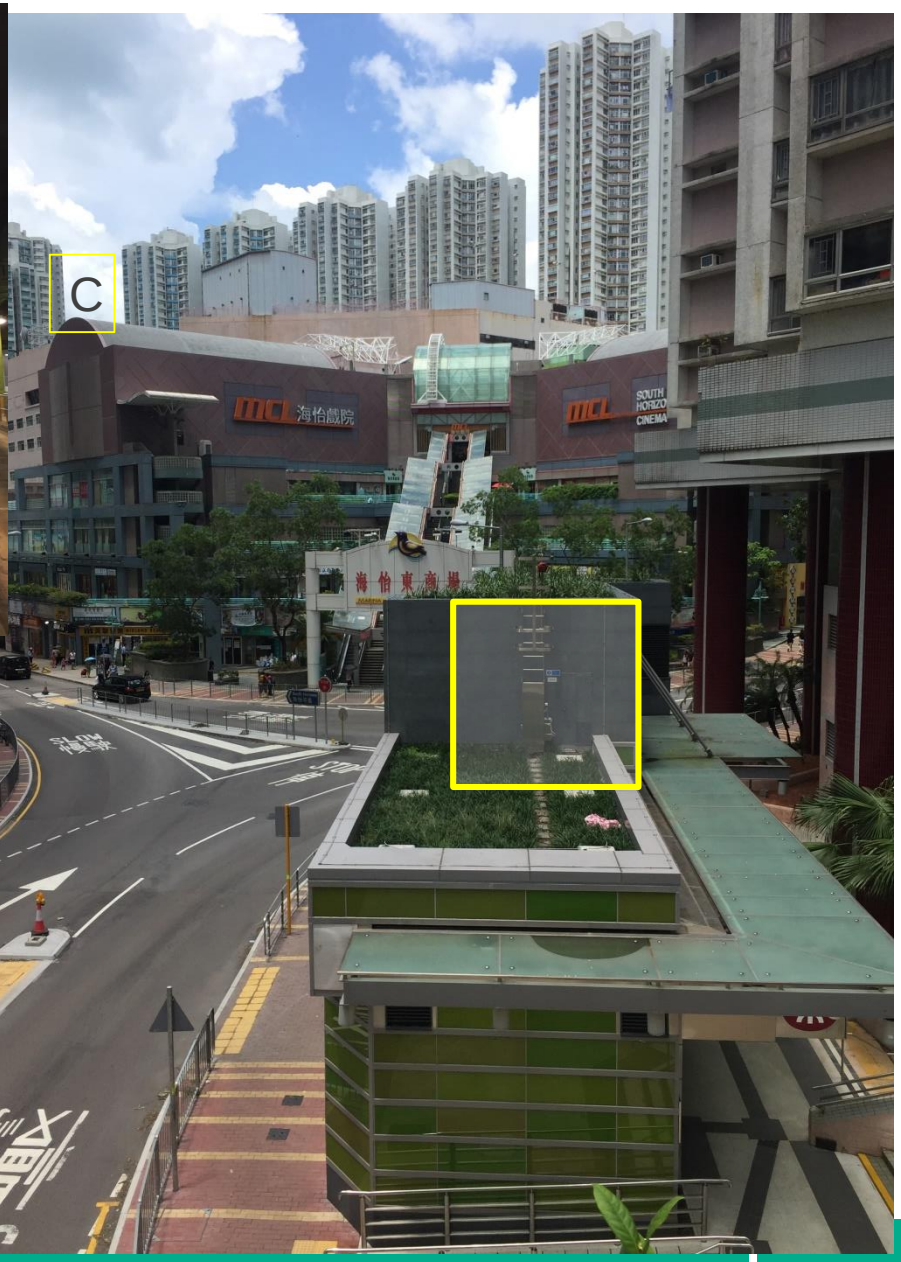
If found, please contact 3442 4731.

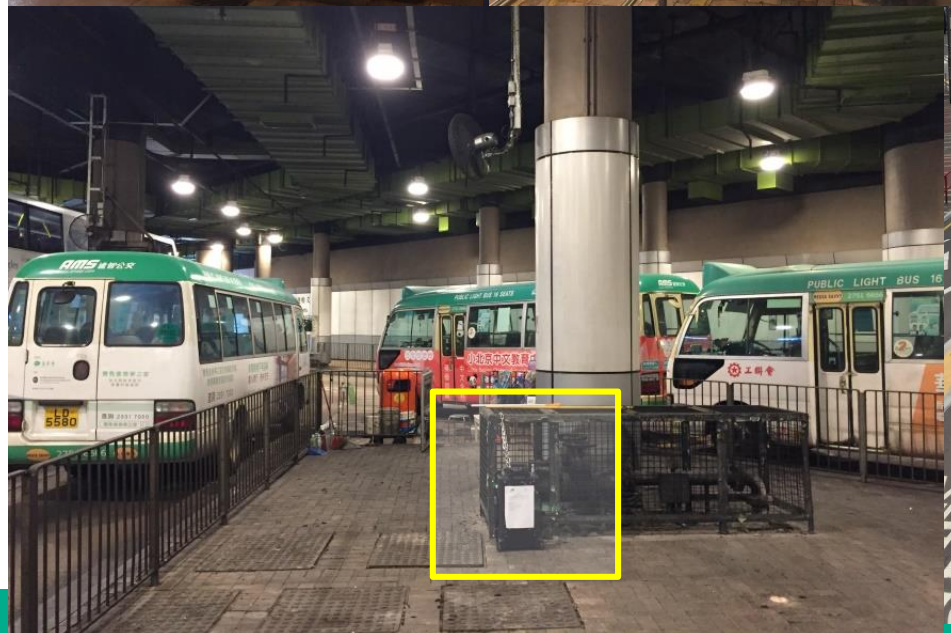
To be released in Fall 2018

Restaurant

Park

Microenvironment hotspot diagnosis

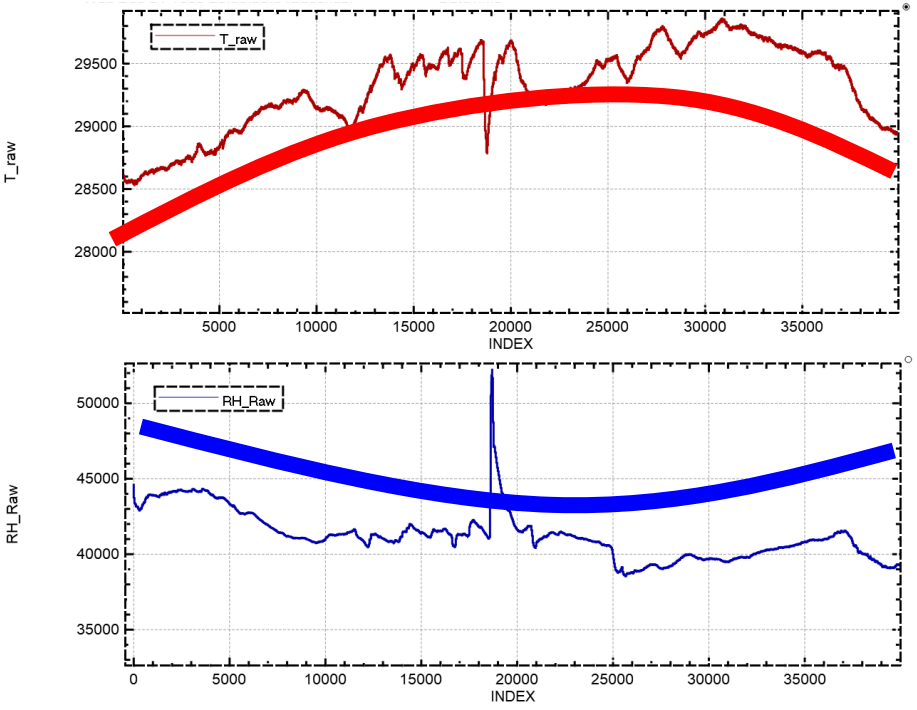




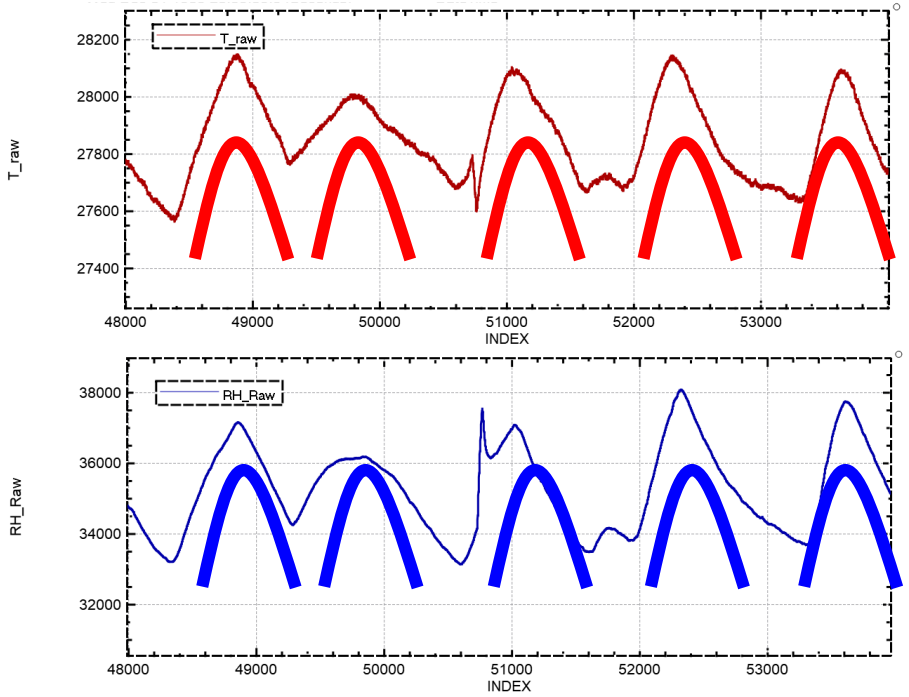
Gas sensor signal and Temp/RH

- **Temp and RH combined pattern is different in various environments: from dry to wet, from hot to cold, from ambient to indoor.**
- **Many algorithms will not accommodate such variation.**

Ambient condition

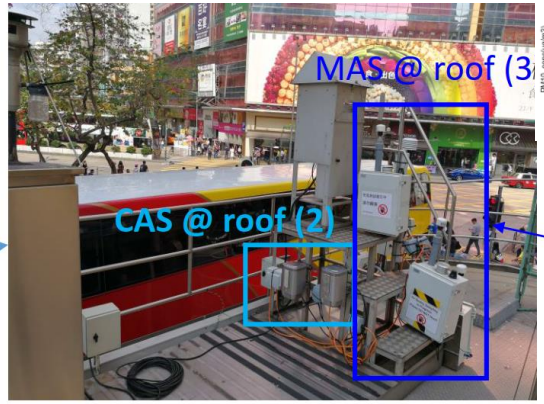


AC indoor condition



Fit-for-purpose QAQC protocol development

- Different sensor network measurement requires different levels of DQOs
- Either physical placement side by side with reference or automated quality control measures need to be implemented



PAS @ Ground (13)

PAS (13): PM_1/ $PM_{2.5}$/ PM_{10}/CO/CO_2/NO/NO_2/O_3

MAS (3): PM_1/ $PM_{2.5}$/ PM_{10}/CO/CO_2/NO/NO_2/O_3

CAS (2): PM_1/ $PM_{2.5}$/ PM_{10}/CO/NO/NO_2/O_3

AQMS: $PM_{2.5}$/PM_{10}/CO/NO_2/O_3

Distribution to microenvironments

Classroom

Library

Assembly/sport hall

Playground

Balcony/ Aisle

Roof

Shopping mall #1

Outdoor: UG/F
Indoor: 1/F
Indoor: UG/F
Indoor
(move around)

Office #3

Office #1

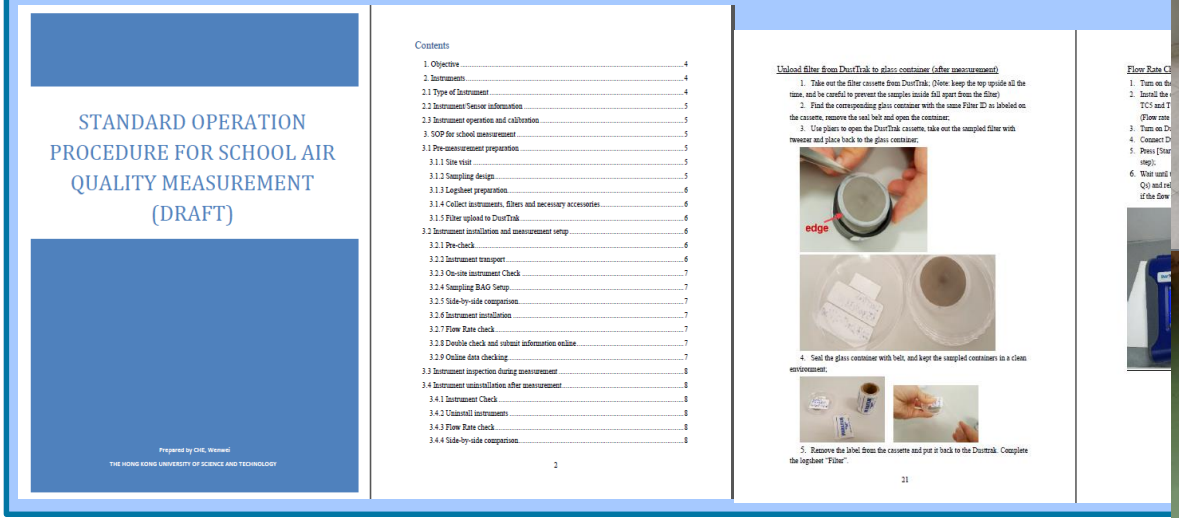
Outdoor: 16F (Roof)
Indoor: 7F
Indoor: 5F

Office #2

Office #4

Fit-for-purpose QAQC protocol development

70-page SOP for AQ measurement at school


STANDARD OPERATION PROCEDURE FOR SCHOOL AIR QUALITY MEASUREMENT (DRAFT)

Prepared by CHE, Wenwei

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

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3.4.3 Flow Rate check 8
3.4.4 Side-by-side comparison 8

2

Unload filter from DustTrak to glass container (after measurement)

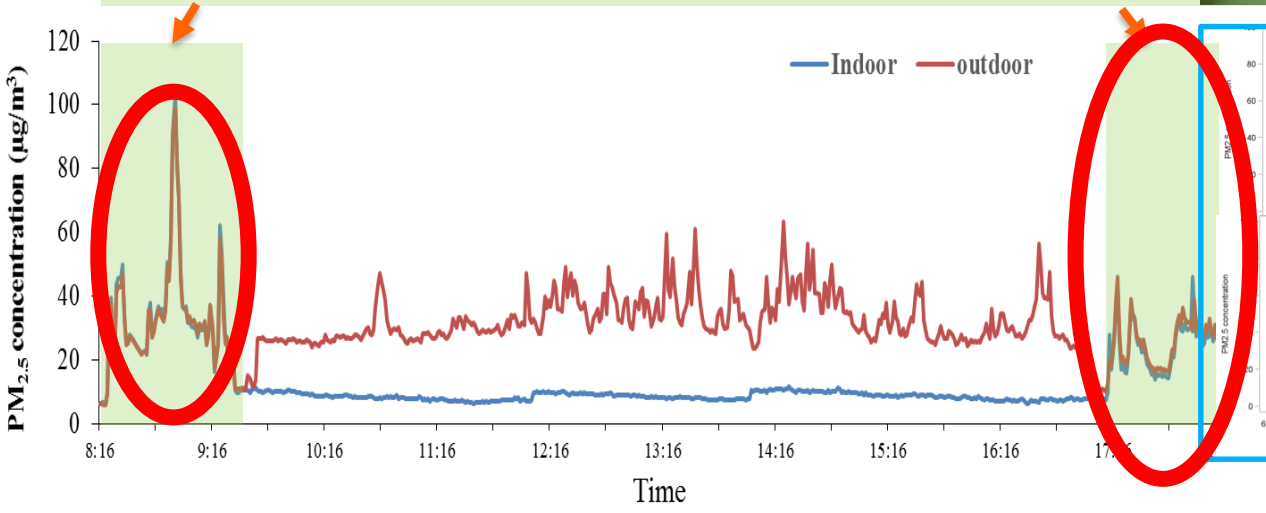
1. Take out the filter cassette from DustTrak; (Note: keep the top upside all the time, and be careful to prevent the samples inside fall apart from the filter)
2. Find the corresponding glass container with the same Filter ID as labeled on the cassette, remove the seal belt and open the container;
3. Use pliers to open the DustTrak cassette, take out the sampled filter with tweezer and place back to the glass container;

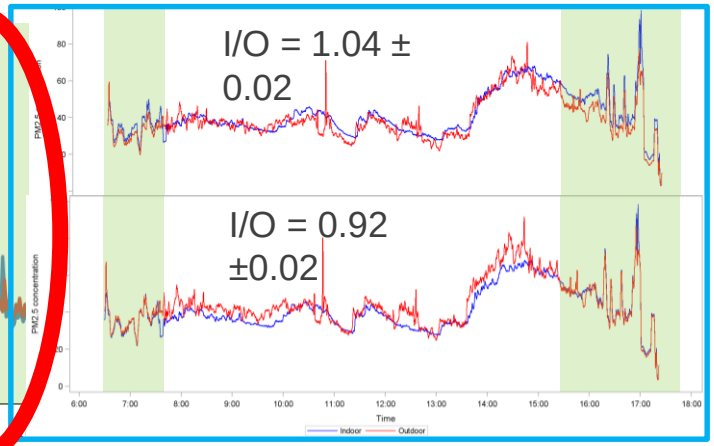
4. Seal the glass container with belt, and kept the sampled containers in a clean environment;

5. Remove the label from the cassette and put it back to the Dusttrak. Complete the logsheet "Filter".

21

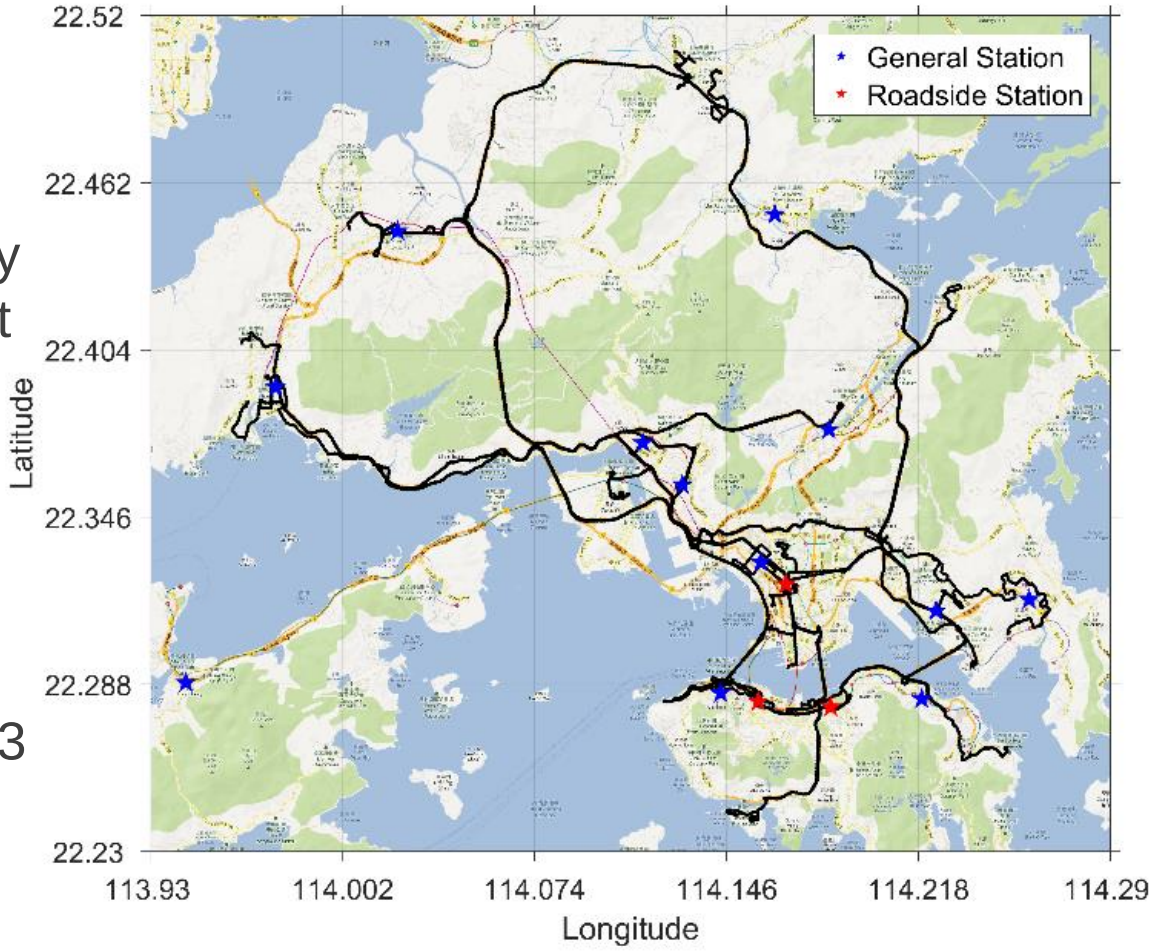
"Side-by-side" comparison before & after measurement





Mobile Air SEnsor Network (MASEN) protocol

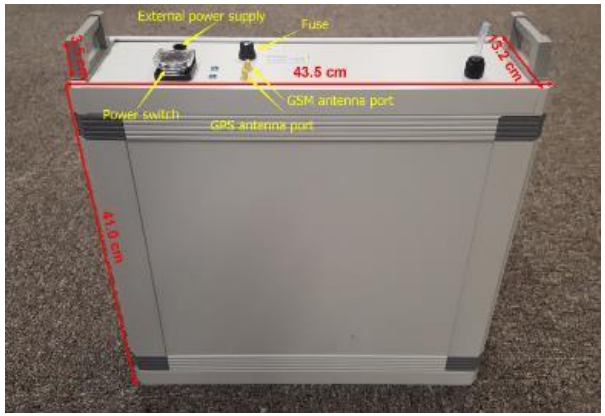
- **Experience**
  - Total of 16 selected bus routes
  - Two periods :April to May 2017 and June to August 2017
  - Covering 17/18 districts
  - Passing by 11 EPD general stations and 3 EPD roadside stations
  - Collecting more than 23.3 million data points
  - Sampling distance exceeded 92,000 km

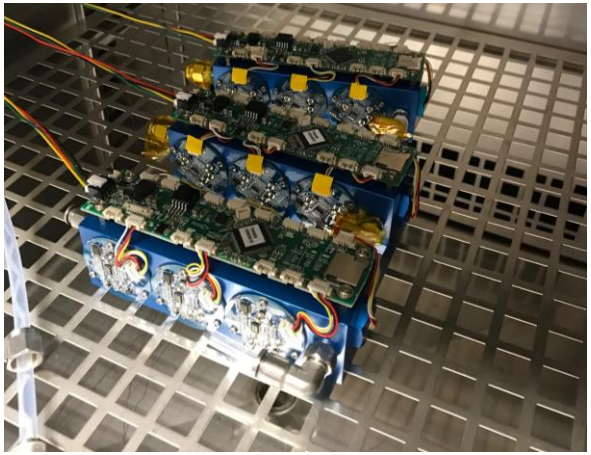


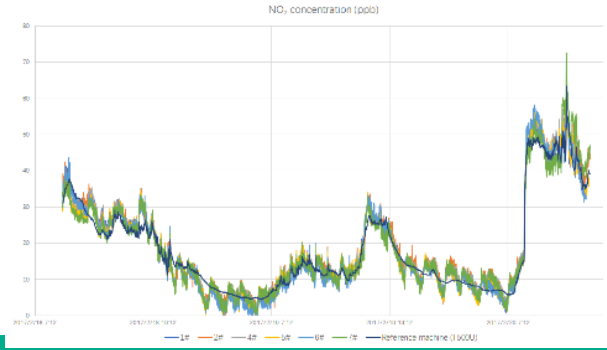
Autonomous Data Quality Control

- Compact and multipollutant solutions for traffic pollutants of $PM_{2.5}$, NOx (NO_2 &NO), CO, CO_2;
- GPS/ traffic speed data and real time transmission
- QAQC is very important for long term unattended operation!

Autonomous Data Quality Control







- Physical cutting head of PM sensor
- Self-heating for RH correction;
- Gas sensor automatic zero setting;
- Humidity control;
- Side by side testing before/after trips.

Sheath air

RH equilibrium

Data recovering w/ flash memory

AGPS accurate location

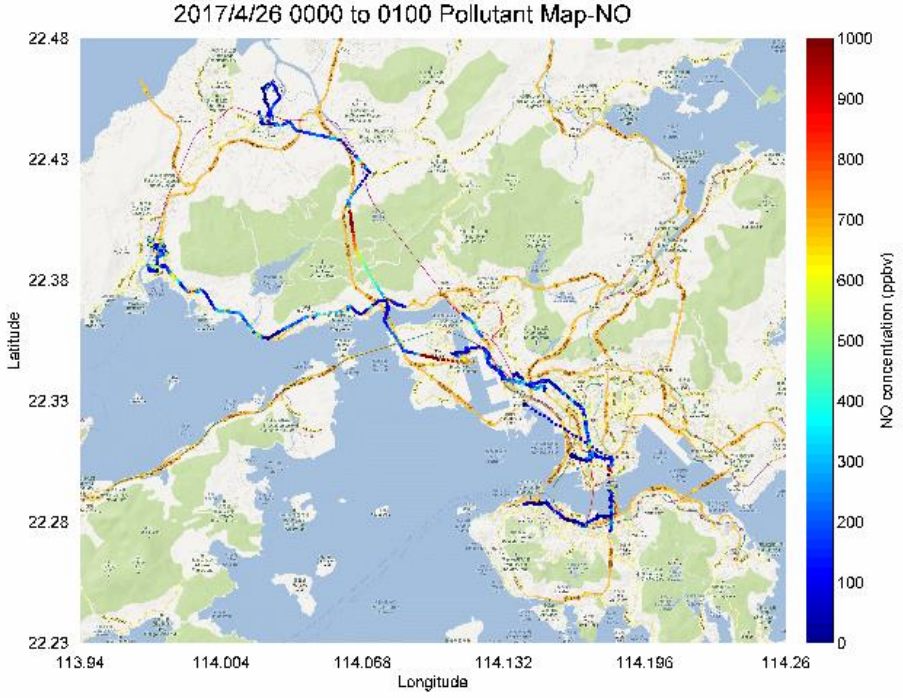
Gas auto zero function

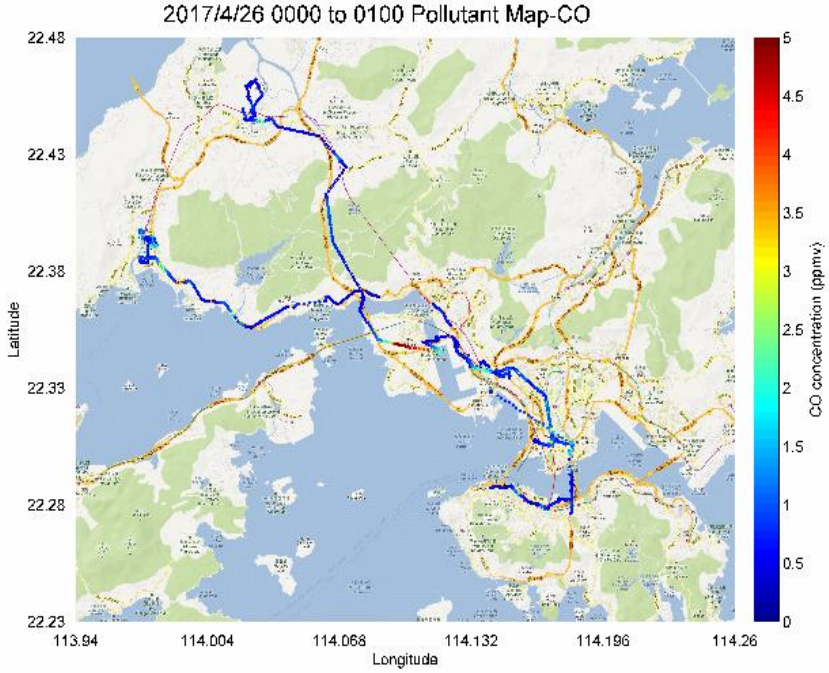
Customized PM2.5 cyclone

PTFE Teflon particle filter


2017/4/26 0000 to 0100 Pollutant Map-PM2.5
Latitude
22.48
22.43
22.38
22.33
22.28
350
300
250
200
150
100
50
PM2.5 Concentration (μg/m3)

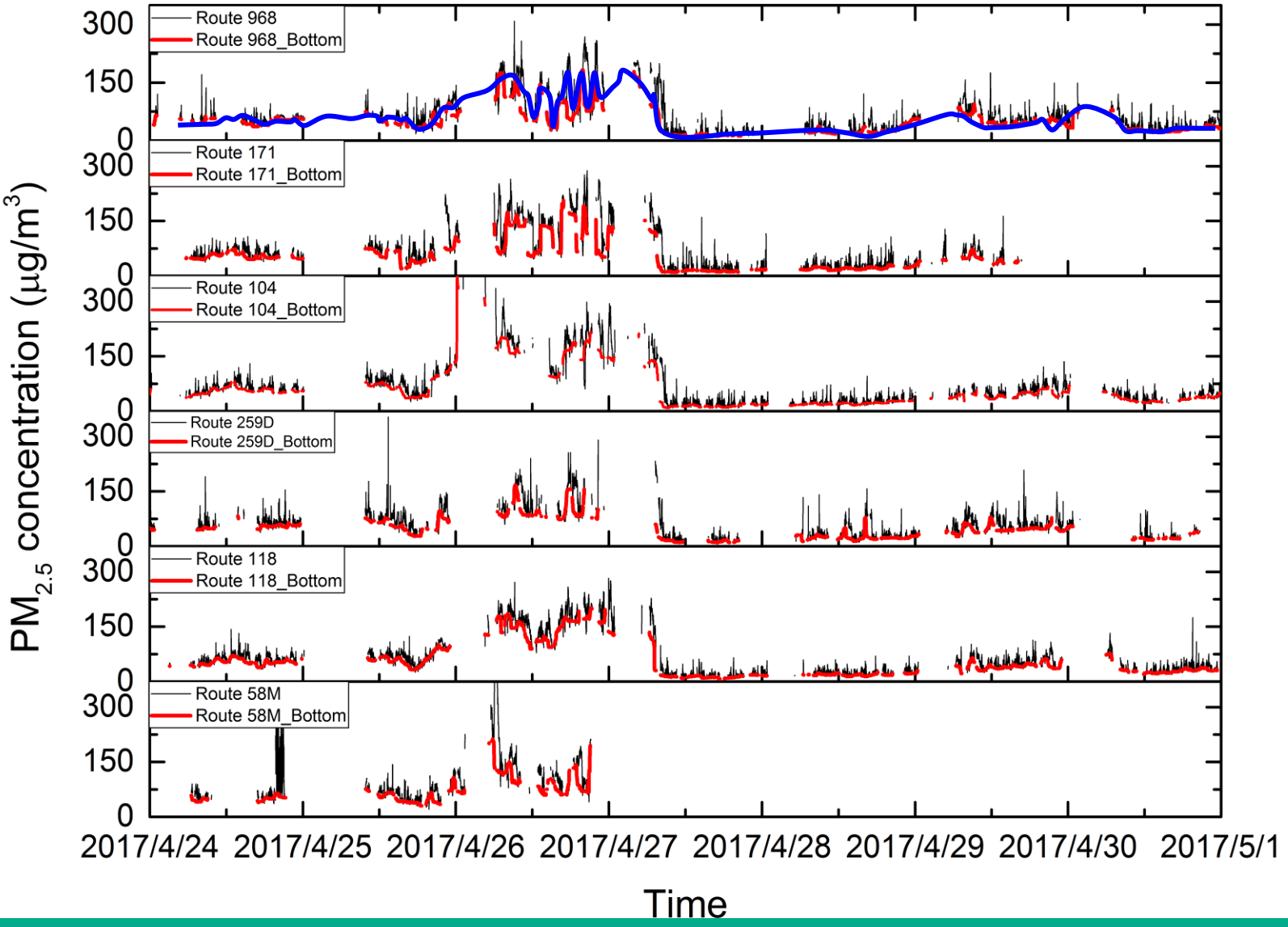

2017/4/26 0000 to 0100 Pollutant Map-NO2
Latitude
22.48
22.43
22.38
22.33
22.28
22.23
300
250
200
150
100
50
0
NO2 concentration (ppbv)
113.94
114.004
114.068
114.132
114.196
114.26
Longitude


2017/4/26 0000 to 0100 Pollutant Map-NO
Latitude
22.48
22.43
22.38
22.33
22.28
22.23
1000
900
800
700
600
500
400
300
200
100
0
NO concentration (ppbv)
113.94
114.004
114.068
114.132
114.196
114.26
Longitude


2017/4/26 0000 to 0100 Pollutant Map-CO
Latitude
22.48
22.43
22.38
22.33
22.28
22.23
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
CO concentration (ppmv)
113.94
114.004
114.068
114.132
114.196
114.26
Longitude

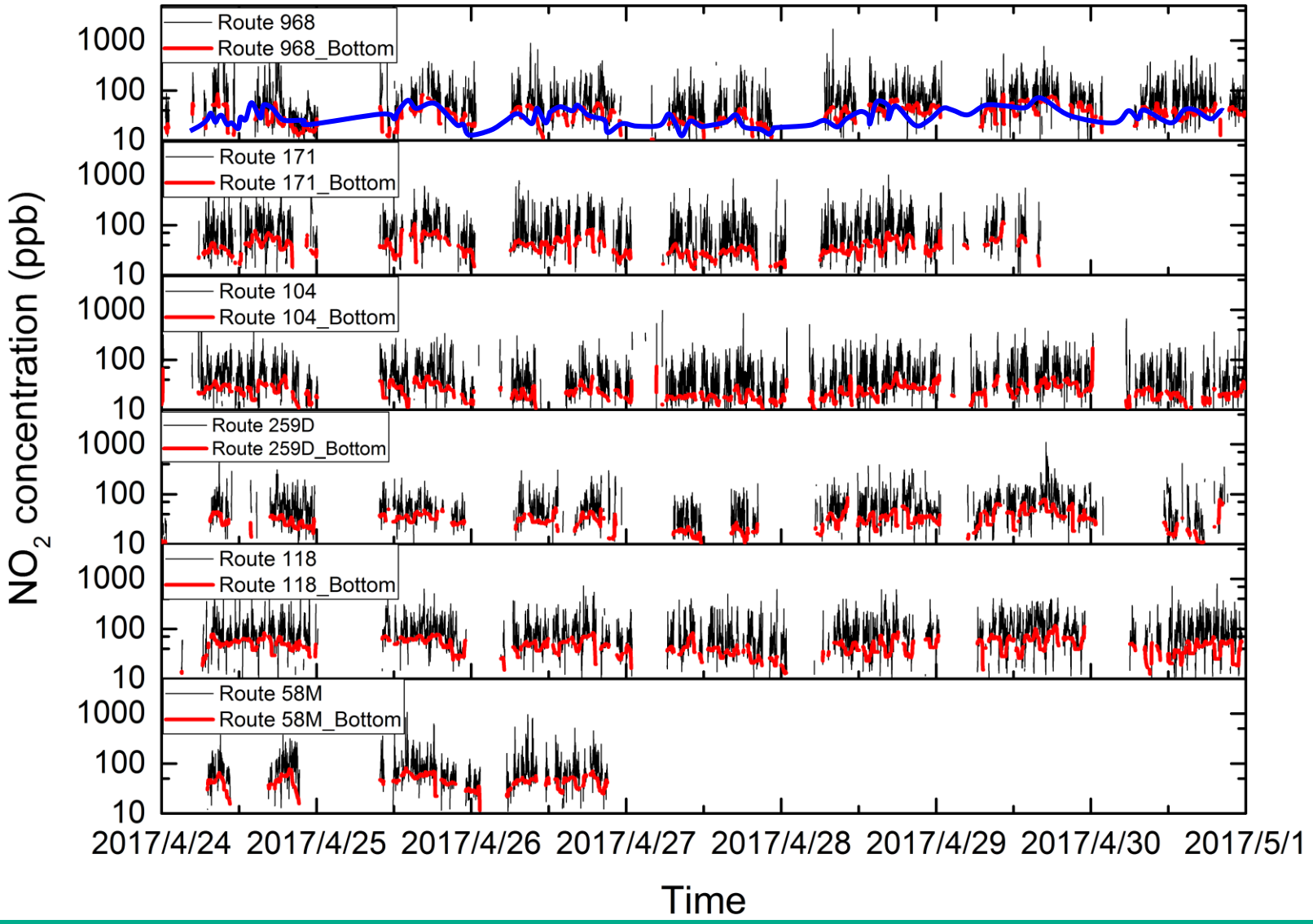
City air pollution baseline

- *SIX different routes for one week time series data.*
- *Regardless of locations and time, baseline of sensor signals agrees*

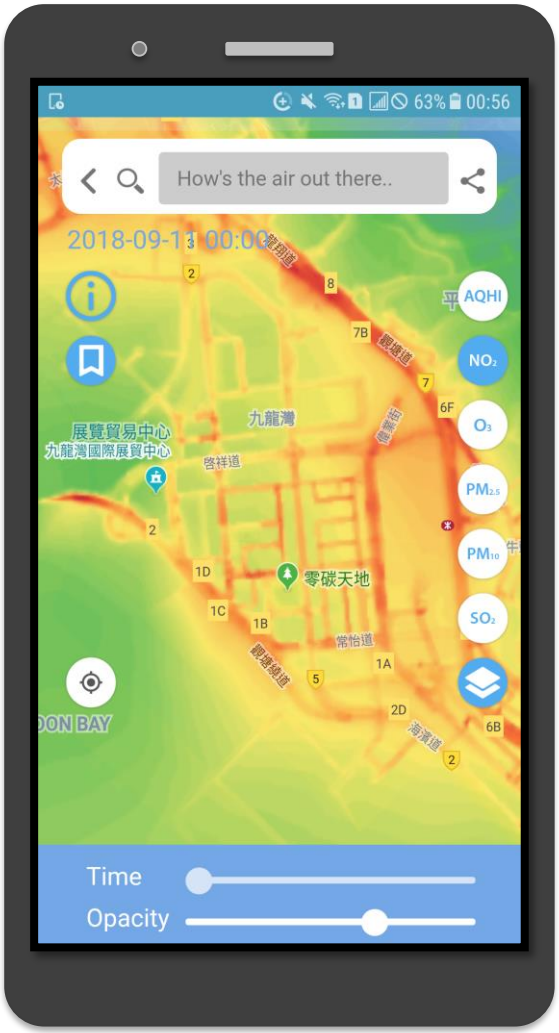


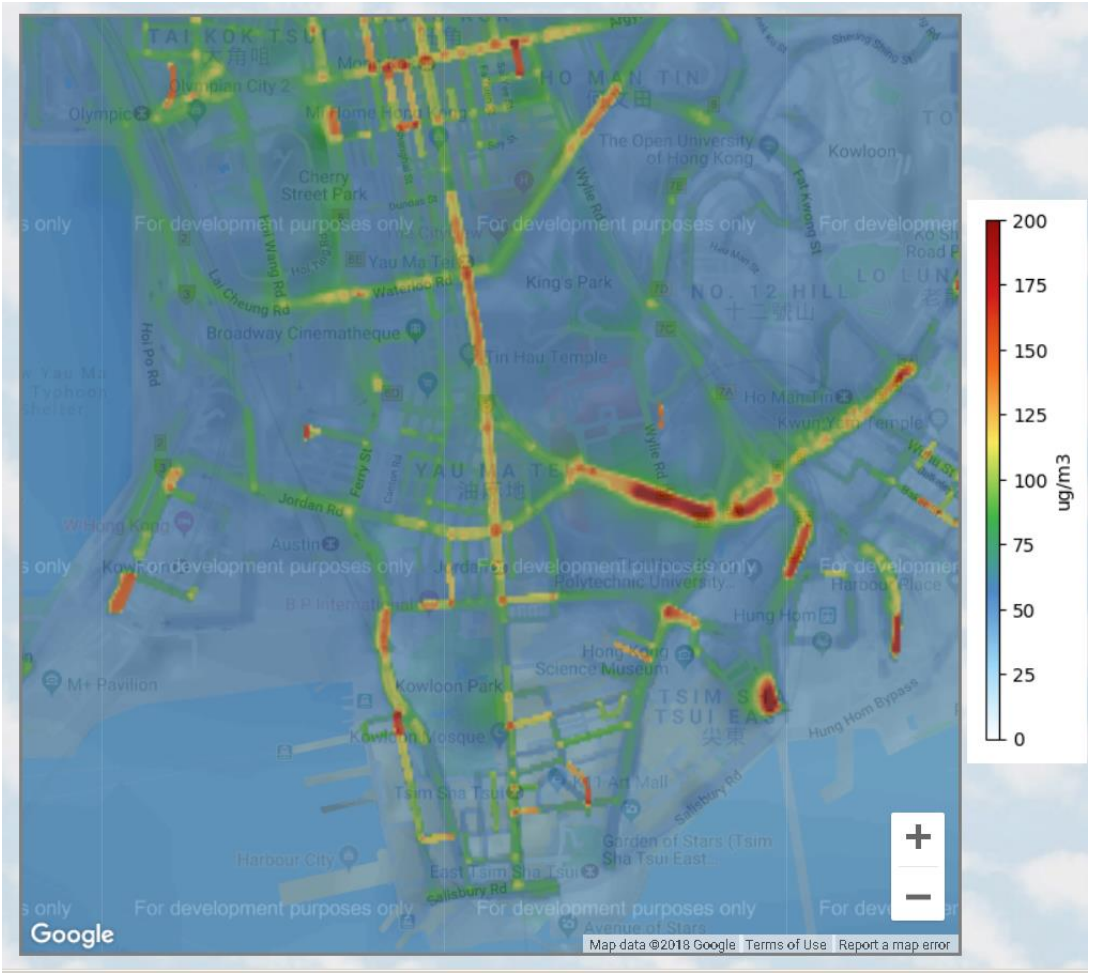
City air pollution baseline

- *SIX different routes for one week time series data*
- *Note the log scale for NO2 still shows amazing baseline agreement*



Personalised Real-time Air-quality Informatics System for Exposure-Hong Kong (PRAISE-HK)






Q.
A.