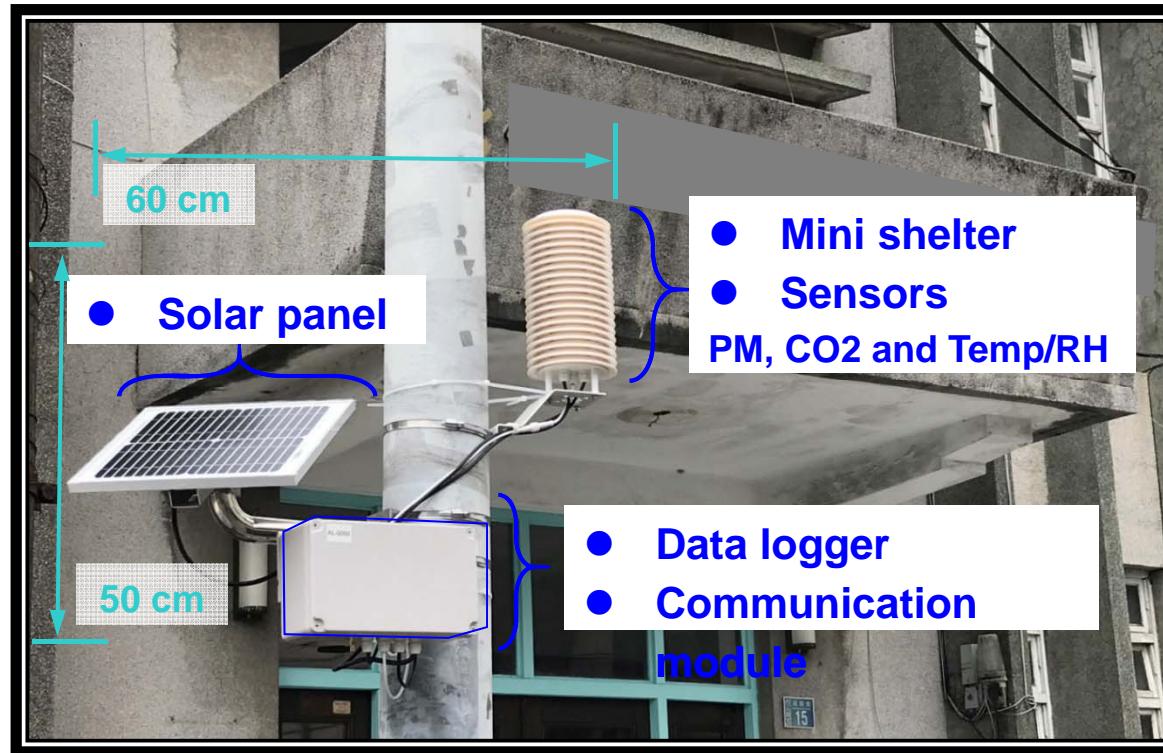


Introduction of AS-LUNG-P, AS-LUNG-O, and other environmental sensors

Chun Hu Liu

2019-09-02

AS-Lung outdoor (AS-Lung-O)



AS-Lung-O

- Sensors
 - PM(PM_1 , $PM_{2.5}$, PM_{10}), temperature, relative humidity(RH), CO2
- Power supply system
 - Battery, solar power and DC power
 - the battery can support long-term monitoring under sufficient sunshine (ex: sunshine hour longer than 4 hours/day which has cover the period of 10:00 to 14:00)
- Data storage
 - SD card, cloud data server
- Log interval
 - 15 sec(online mode), 1 min(Sleep mode), 5 mins(Sleep mode) , 10 mins(Sleep mode)
 - Online mode: continue monitoring
 - Sleep mode: power save
- Data transmit to cloud
 - WiFi, 3G/4G and NB-IoT(Narrowband Internet of Things)

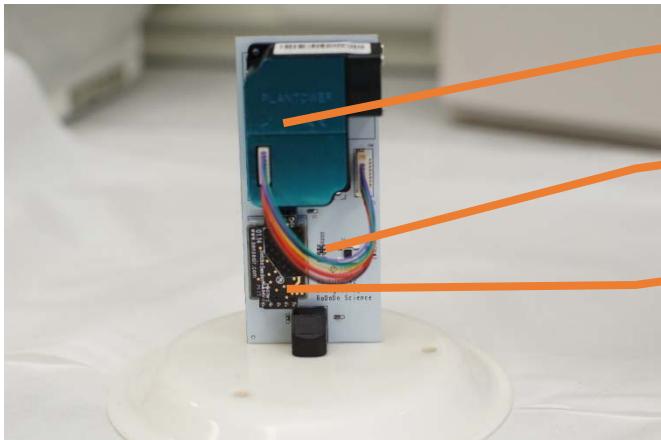
More information about NB-IoT:

https://en.wikipedia.org/wiki/Narrowband_IoT

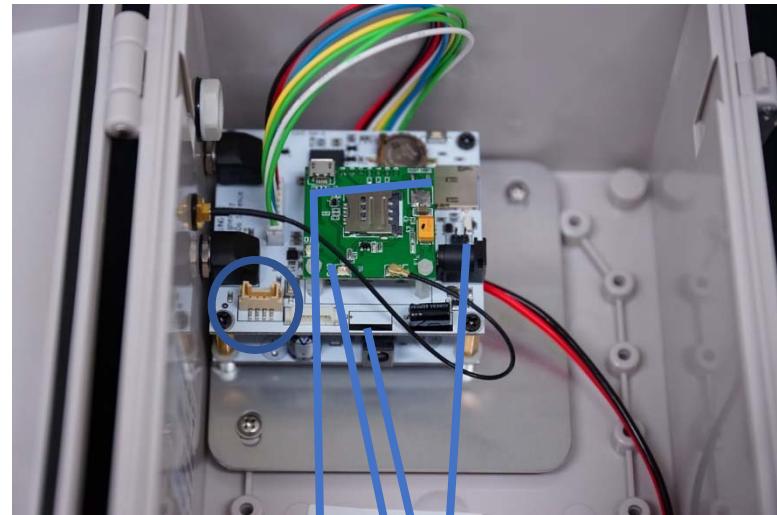
AS-Lung outdoor (AS-Lung-O)



Data logger
mini shelter
4G antenna
Signal cable

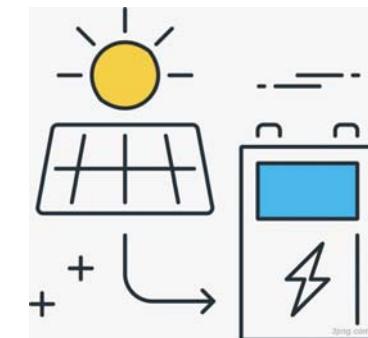
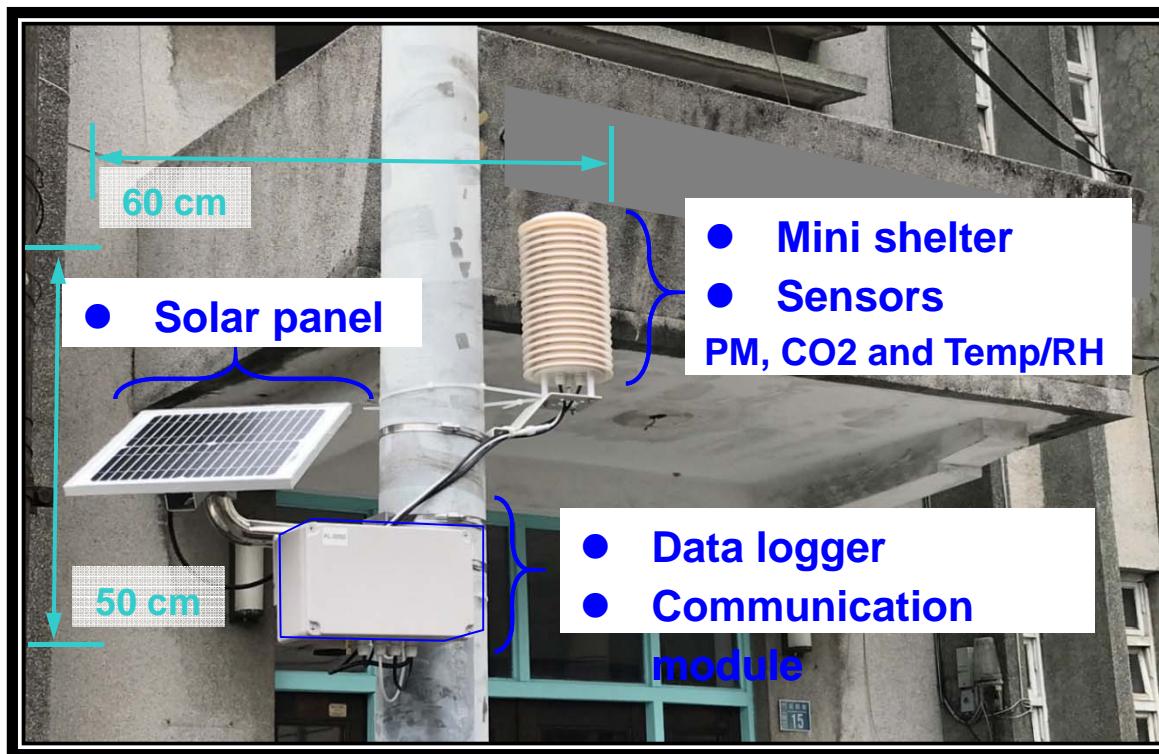


PM Sensor
Temp/RH Sensor
CO2 Sensor



SD card
Battery power
Solar power
4G module

AS-Lung-O



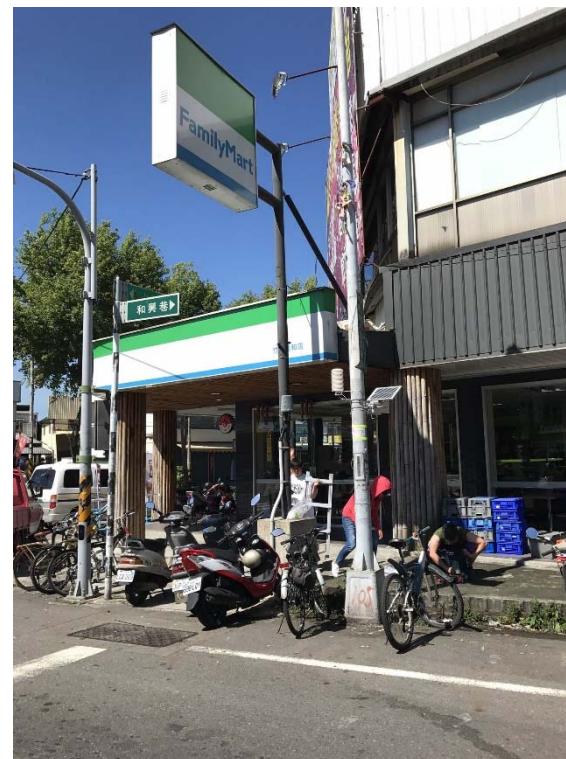
SanDisk



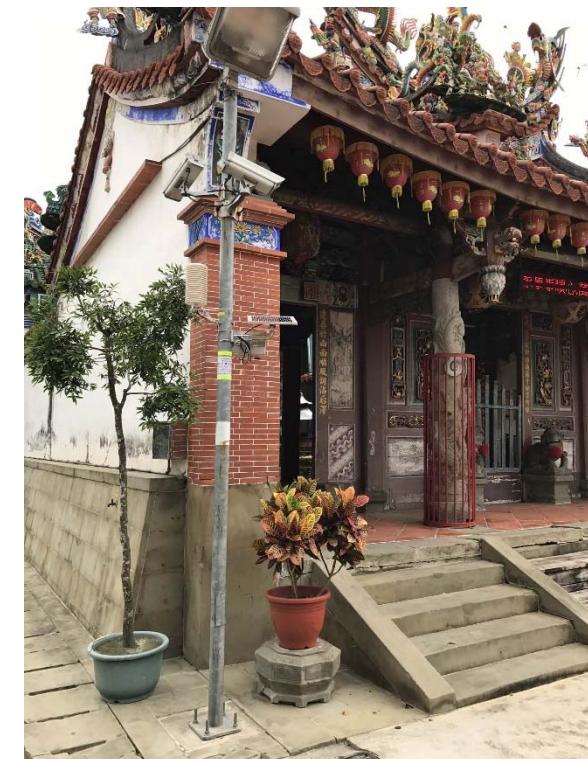
AS-Lung-O setup examples



Fix site



Street site

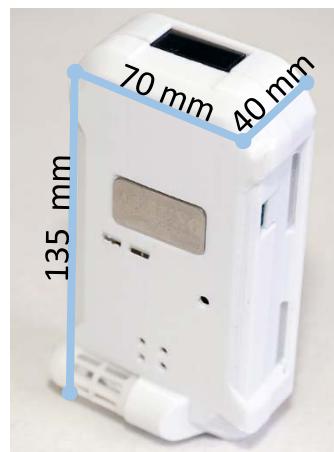


temple site

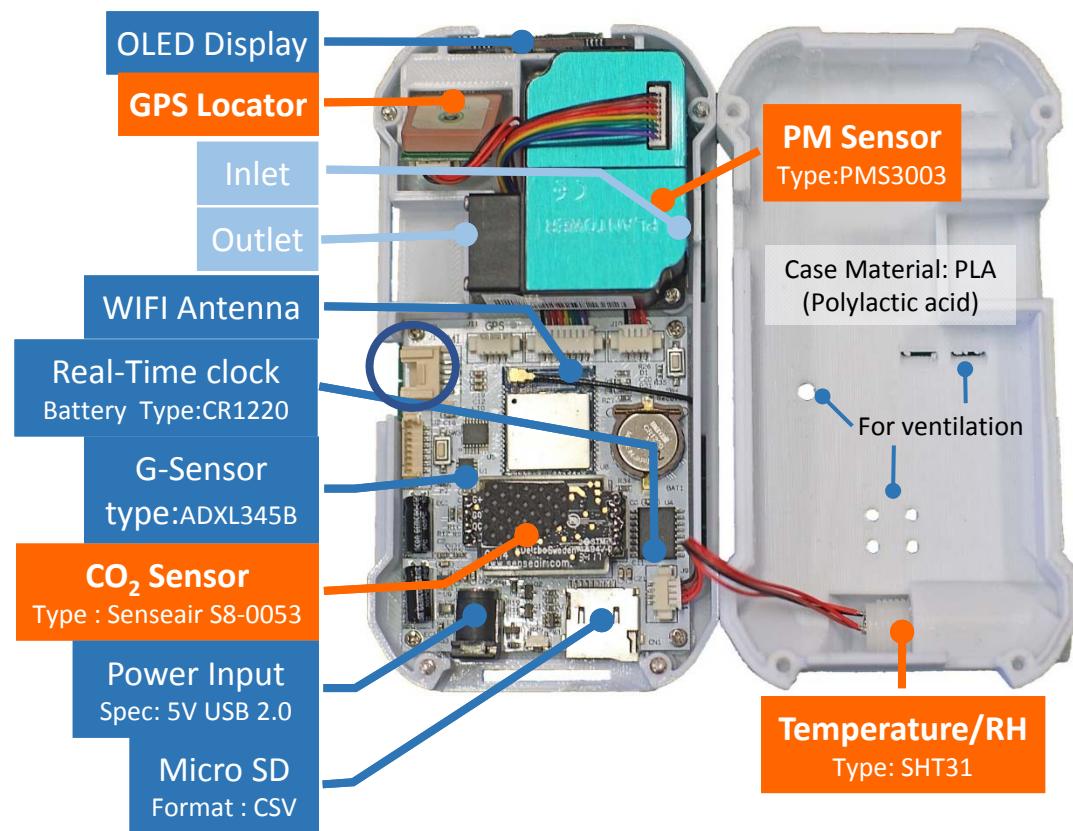
Tripod, power line pole, traffic light pole or street light pole

AS-Lung portable (AS-Lung-P)

- Weight : 153g
- With a mobile battery: 410g



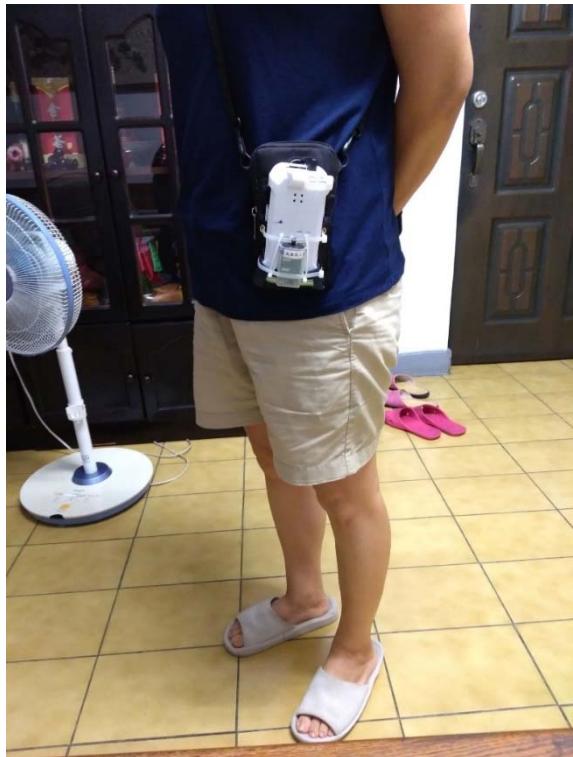
█ Sensors
█ Supporting system



AS-Lung-P

- Sensors
 - PM(PM_1 , $PM_{2.5}$, PM_{10}), temperature, relative humidity(RH), CO_2 , GPS, motion sensor
- Power supply system
 - Battery and DC power
- Data storage
 - SD card, cloud data server
- Log interval
 - 15 sec(online mode), 1min(Sleep mode), 5 mins(Sleep mode), 10 mins(Sleep mode)
 - Online mode: continue monitoring
 - Sleep mode: power save
- Data transmit to cloud
 - WiFi
- OLED

AS-Lung-P setup examples



crossbody bag



handbag



waist pack

Log interval & communication mode

Types	Comm. Mode	15 sec	1 min	5 mins	10 mins
AS-Lung-P	None	✓	✓	✓	✓
	WiFi	✓			
AS-Lung-O	None	✓	✓	✓	✓
	WiFi	✓			
	3G/4G		✓	✓	✓
	NB-IoT*		✓	✓	✓

*: additional NB-IoT module is required



With log interval more than 15 secs, please make sure mobile power will not auto off!!
With a led in the mobile power is suggested, turn it on, mobile power will not auto off.

Monitoring time with battery and without data transition

	15 sec	1 min
AS-Lung-P (10050 mAh)	48 hours	7 days
AS-Lung-O (28000 mAh)	Not suggested	10 days

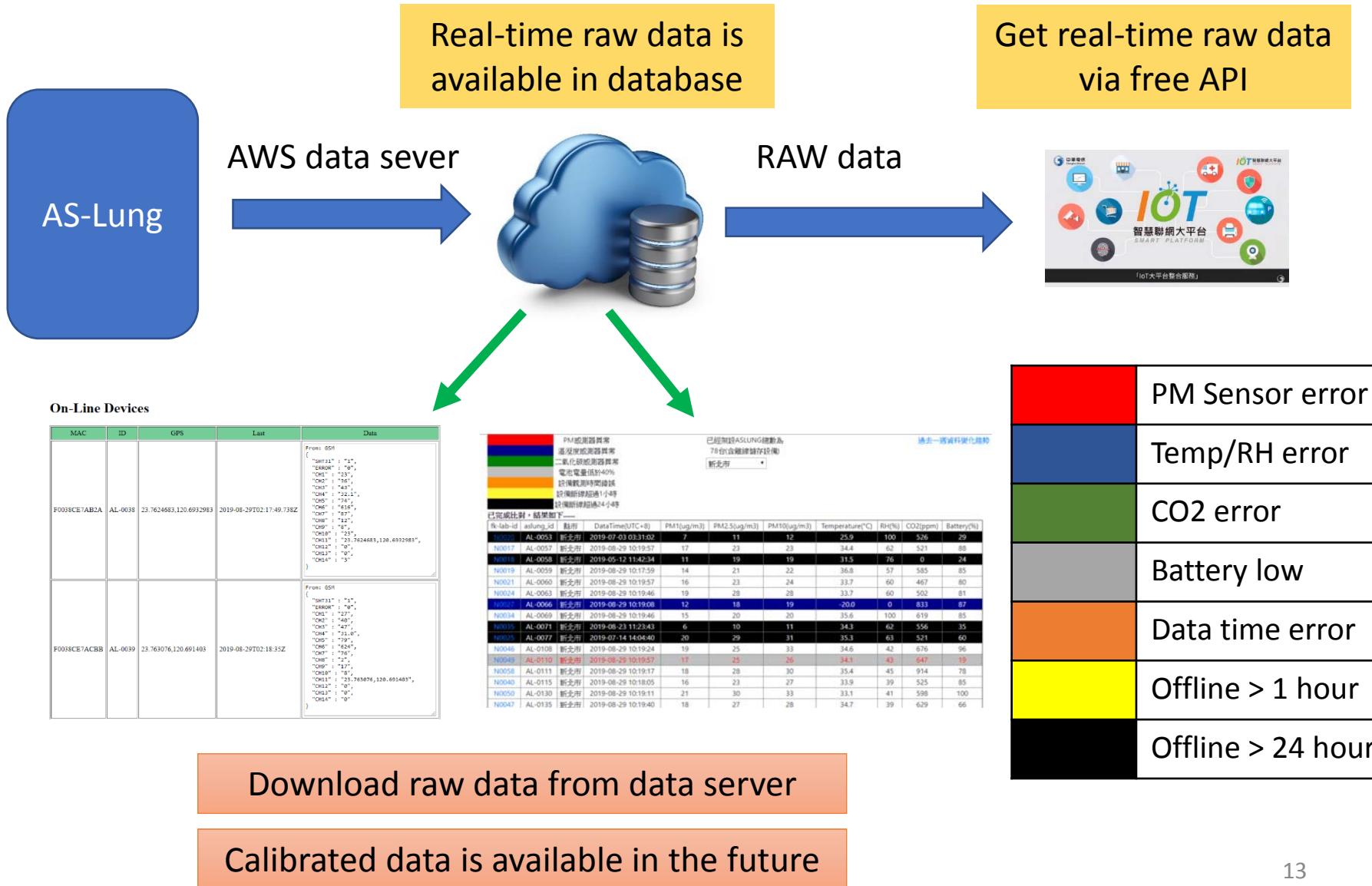
If solar power is not available in the street level site, renew battery per 7 days is suggested.

Data format in SD card

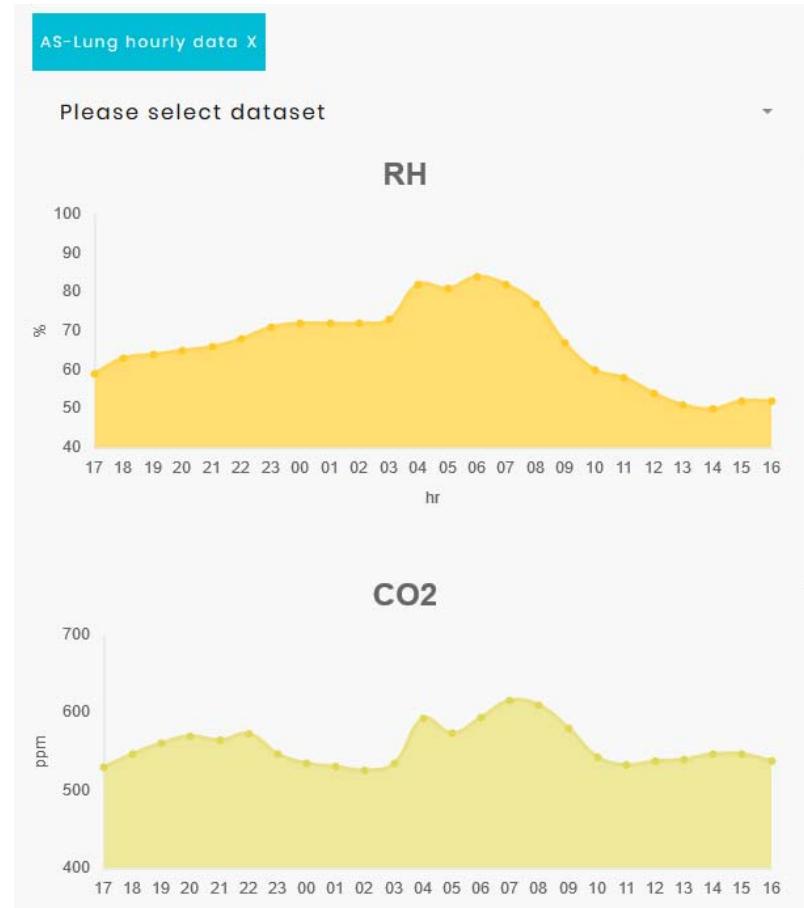
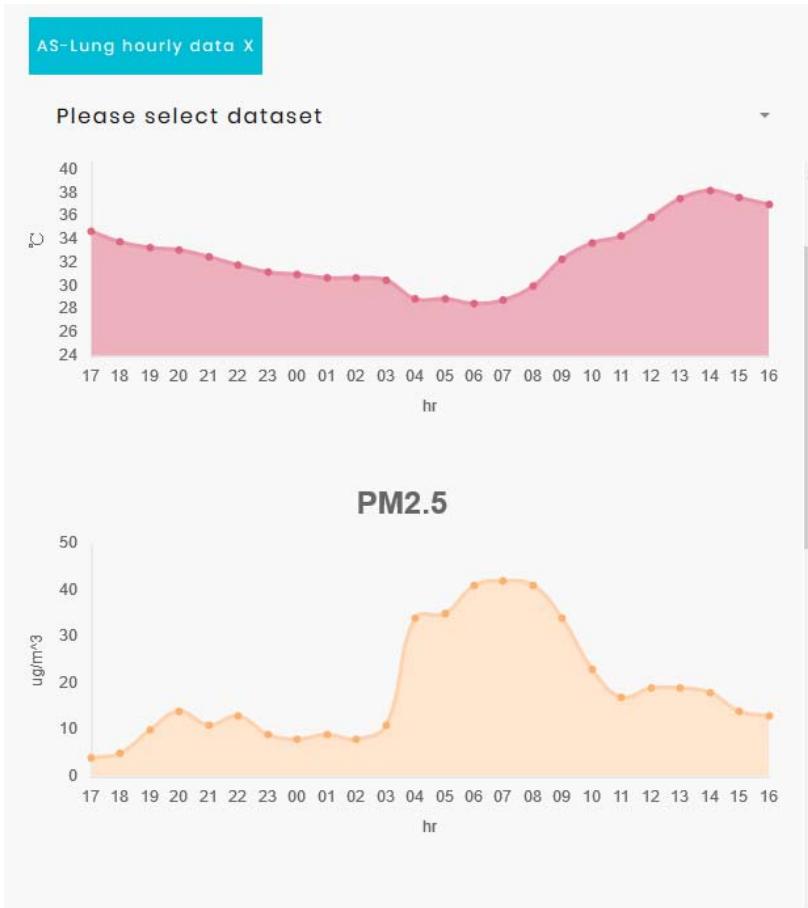
- File size: with sampling rates of 1 minutes, roughly 125 MB data will be generated in one year
- Data file format:
 - csv file: raw data , easily show in Excel or SPSS software
 - Local time in SD card
 - If calibration factors are available, raw data will be adjusted to calibrate data

id	date	time	sht_t	sht_h	pml	pm25	pm10	co2	:
0C9A4249DB71	2019/3/4	10:27:15	21.6	68.6	30	45	57	1148	
0C9A4249DB71	2019/3/4	10:27:45	21.7	68.8	20	30	31	880	
0C9A4249DB71	2019/3/4	10:28:00	21.7	69.6	19	29	30	735	
0C9A4249DB71	2019/3/4	10:28:15	21.7	67.3	19	28	30	613	
0C9A4249DB71	2019/3/4	10:28:30	21.8	68.8	19	26	28	606	
0C9A4249DB71	2019/3/4	10:28:45	21.8	67.5	18	25	27	594	
0C9A4249DB71	2019/3/4	10:29:00	21.9	67	17	24	25	584	

Data in cloud data server



Last 24 hours data



AS-Lung data download

DATASET

Dataset
AS Lung 觀測資料

Date
2019-08-01 ~ 2019-08-02

Monitoring site

City
all
台中市 南投縣 宜蘭縣 花蓮縣 台東縣 台北市 新北市
桃園市 新竹市 苗栗縣 基隆市 新竹縣 雲林縣 嘉義市
台南市 高雄市 屏東縣

高雄市
三民區 小港區

OR

AS-Lung ID

每輸入一個ID請按下「空白鍵」來區隔，可以同時查詢多個ID (Each time you enter an ID, press the "blank button" to separate it. You can query multiple IDs at the same time.)

PREVIEW **DOWNLOAD**

Parts list of AS-Lung

AS-Lung-O

- Mini shelter: PM, temperature/RH and CO₂ sensors
- Data logger: mainboard, SD card, 4G module, solar power charger
- Solar power panel
- Battery
- LCD monitor

AS-Lung-P

- AS-Lung-P: mainboard, SD card, PM, temperature/RH, CO₂ and motion sensors
- GPS
- Battery
- LCD monitor



Mohd Talib Latif
Sawal Hamid Md Ali
Kemal Maulana Alhasa
Mohd Shahrul Mohd Nadzir

Atmospheric Chemistry and Air Pollution Research Group
Centre of Earth Science and Environment, Faculty of Science and Technology
Universiti Kebangsaan Malaysia

- Expensive
- High power consumption
- Heavy
- Bulky
- Poor mobility
- High maintenance



Example of gas analyzer

Outline

- What is AiRBOX Sense
- Applications
- Hardware
- How is the performance?
- Cloud-based post-processing of data



We developed the entire system of AiRBOX and used Alphasense (UK) sensors.

- Real-time continuous monitoring small system of the 6 criteria air pollutants: particulate matter ($PM_{2.5}$ & PM_{10}), nitrogen dioxide (NO_2) and ozone (O_3) Sulphur dioxide (SO_2) and carbon monoxide (CO).
- Currently, AiRBOX is focus on common criteria air pollutants.
- Sensing device is well calibrated that delivers scientifically accurate data in a wide variety of environmental conditions.
- IoT communications platform that makes real-time data available wirelessly and gives access through an API value to the end users.
- Web interface accessed via browser on mobile Apps, tablet or PC, where you can see all your data in one place and set alerts on parameters of concern.
- Quick and easy to install, and relocate at different location in less than 10 minutes.



AiRBOX V3.0

Technical Specification

Parameters	Sensors	Range	Detection limit	correlation	Resolution (alphasense)	Accuracy
PM _{2.5} & PM ₁₀	Alphasense OPC	0-1200 μgm^{-3}	1 μgm^{-3}	$r^2=0.5-0.6$	1 μgm^{-3}	$\sim<\pm 7 \mu\text{gm}^{-3}$
Nitrogen Dioxide	Alphasense EC	0- 5 ppb	2 ppb	$r^2=0.71$	1 ppb	$\sim<\pm 5 \text{ ppb}$
Carbon Monoxide	Alphasense EC	0-30 ppm	0.02 ppm	$r^2=0.88$	0.02 ppm	$\sim\pm 5 \text{ ppb}$
Sulphur Dioxide	Alphasense EC	0-200 ppb	0.2 ppb	$r^2=0.71$	1 ppb	$\sim<\pm 5 \text{ ppb}$
Ozone	Alphasense EC	0-200 ppb	2 ppb	$r^2=0.72$	1 ppb	$\sim<\pm 5 \text{ ppb}$

Note: Accuracy is determined by the bias of cross-comparison/validation with standard reference method

• Particulate matters (OPC) were compared and validated with GRIMM aerosol spectrometers provided by The National University of Malaysia.

• All electrochemicals (EC) were compared and validated with Thermo Scientific Gas analysers for CO, NO_x, SO₂ and O₃ provided by The Department of Environment Malaysia.

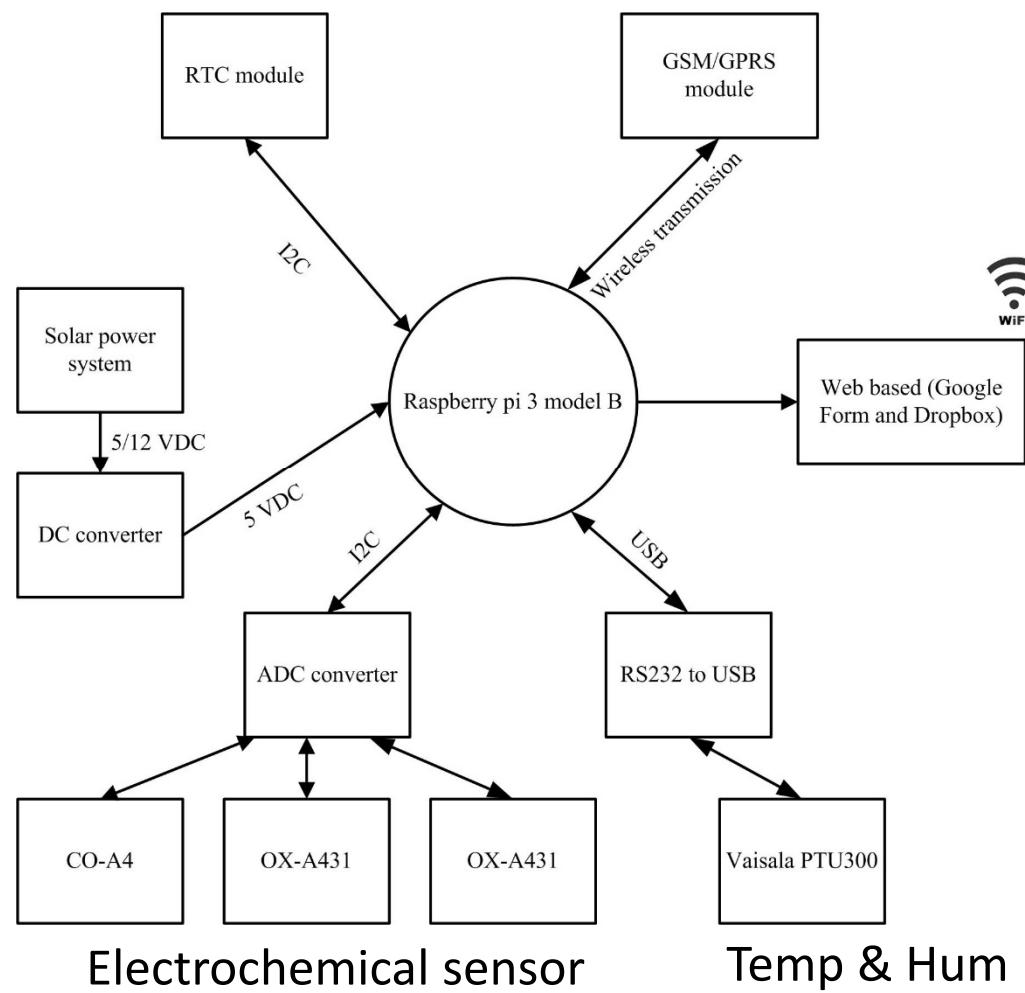
APPLICATIONS

- Smart city
- Early warning system for Air Pollution Disasters
- 3D Mapping pollution sources
- Roadside monitoring networks
- Assistance for the standard references monitoring stations
- Community exposure studies
- Protecting health and safety of students, workers and community

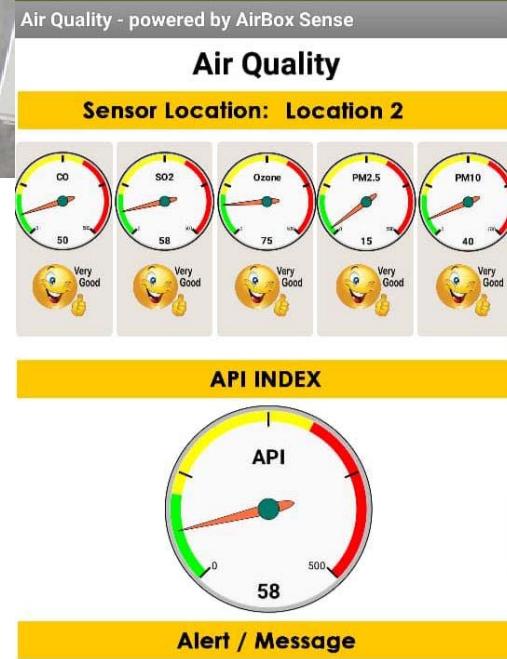
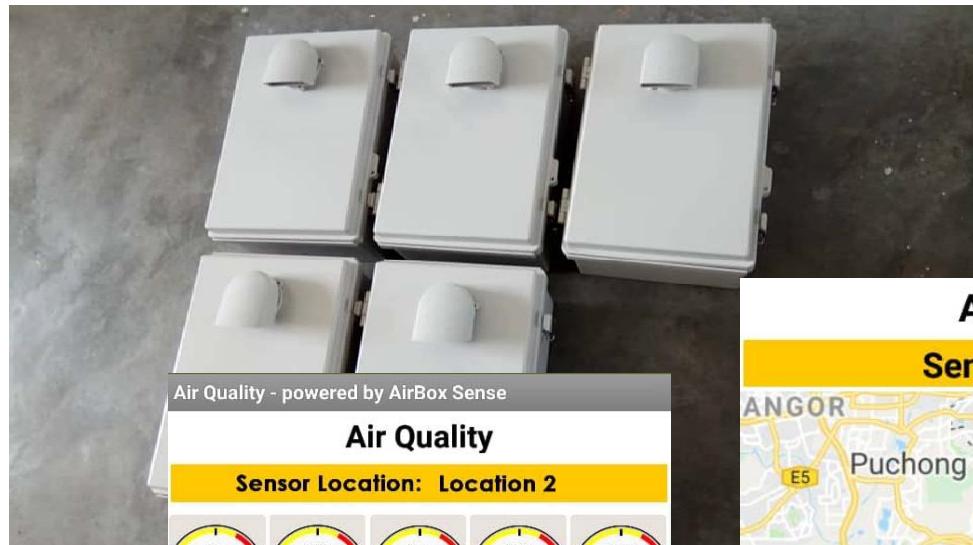
The Heart of AiRBOX

- The sensor element
- Sampling capability
- Power systems, including batteries and power supply.
- Sensor signal processing
- Data storage
- Data transmission capability (WiFi, GPRS)
- Server-side software for data treatment
- Housing and weatherproofing

Hardware Development

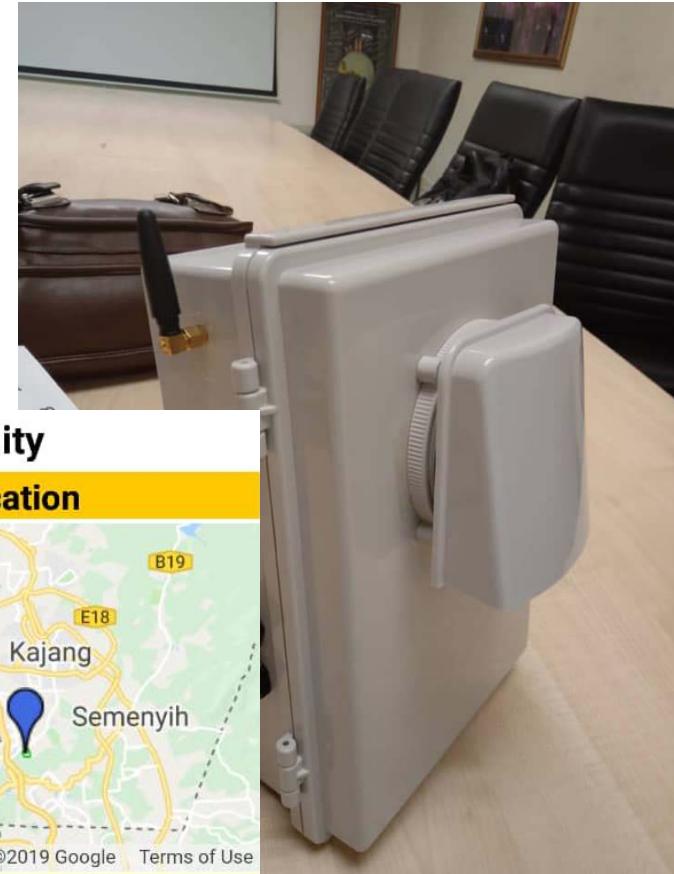


AiRBOX for production



Sensors Status

Location	API	Status
Sensor Location 1	6	
Sensor Location 2	593	
Sensor Location 3	.	
Sensor Location 4	.	



Mobile APPS and websites

ThingSpeak™

Channels ▾ Apps ▾ Community Support ▾

My Channels

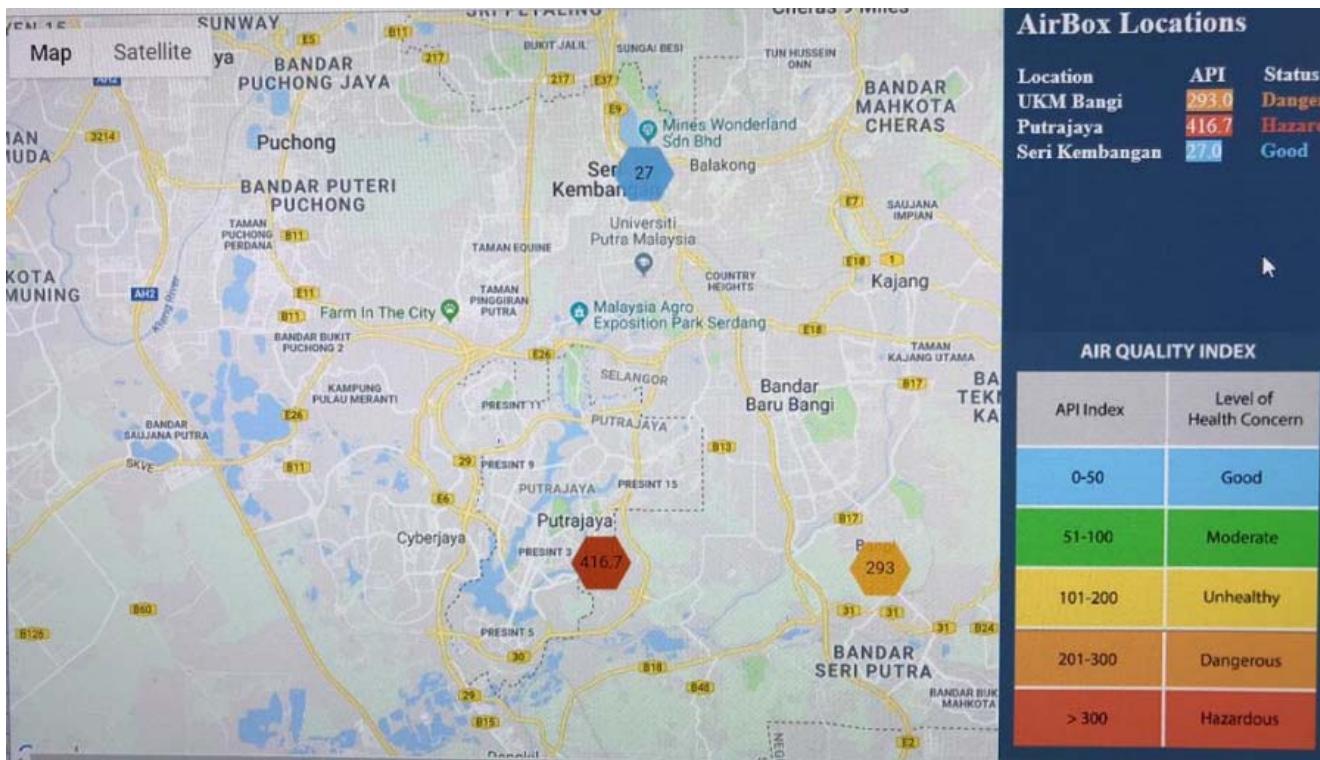
New Channel

Search by tag

Name	Created	Updated
Airbox ver 1.0 ghg sensor ndir co2 sensor, raspberry pi 3, low cost	2016-02-01	2019-03-22 07:05
Private Public Settings Sharing API Keys Data Import / Export		
AirBOX Ver 1.0_Gases gas sensor, alphasense, low cost gas sensor	2018-10-22	2019-03-21 20:46
Private Public Settings Sharing API Keys Data Import / Export		
AirBOX ver 1_particulate matters opc_n2 sensor, raspberry pi 3, low cost	2018-10-22	2019-03-21 21:32
Private Public Settings Sharing API Keys Data Import / Export		
Raw_data low_cost sensor	2018-10-29	2018-10-29 18:58
Private Public Settings Sharing API Keys Data Import / Export		
ProcessedData	2019-01-12	2019-02-27 14:47
Private Public Settings Sharing API Keys Data Import / Export		
UKM_AIRBox Sensor	2019-01-31	2019-05-03 12:00
Private Public Settings Sharing API Keys Data Import / Export		

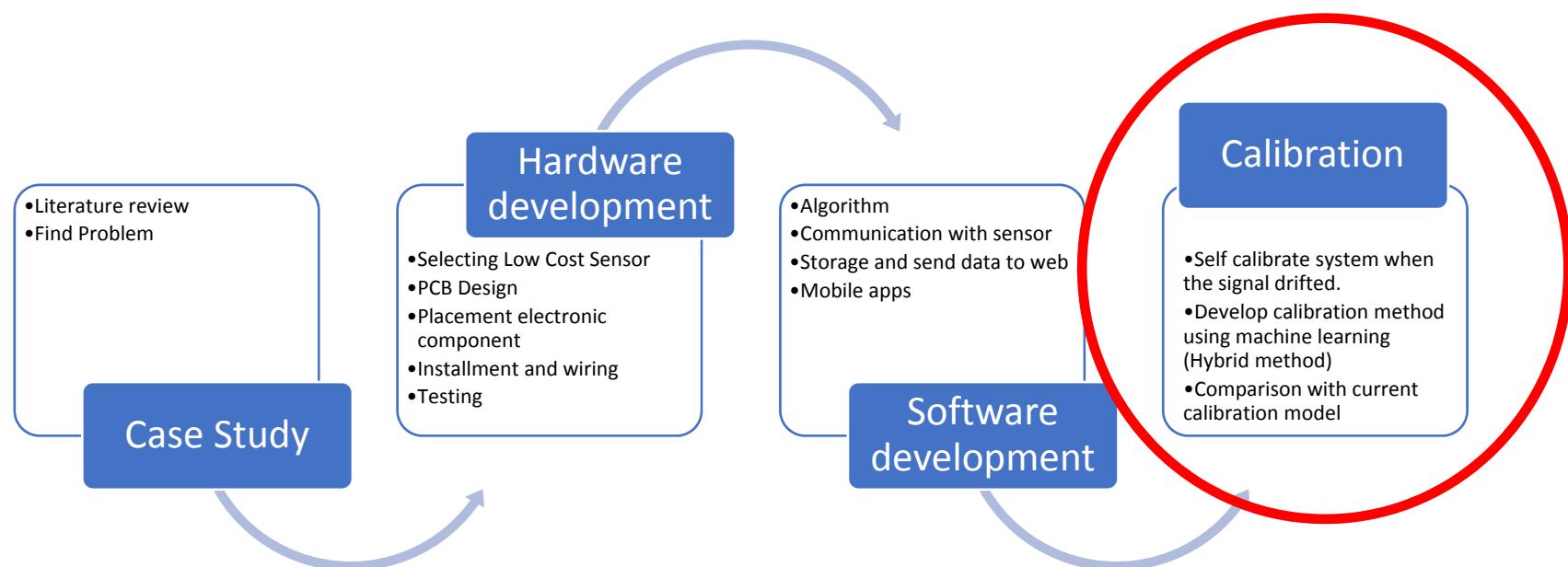


Dashboard



Note: this is a test experiment for AQI calculation, data from AiRBOX will generate in the website where formula AQI will applied and automatically calculate for end users. AQI calculation is referred to the USEPA formula.

We emphasize in Quality Control (calibration and cross-validation)



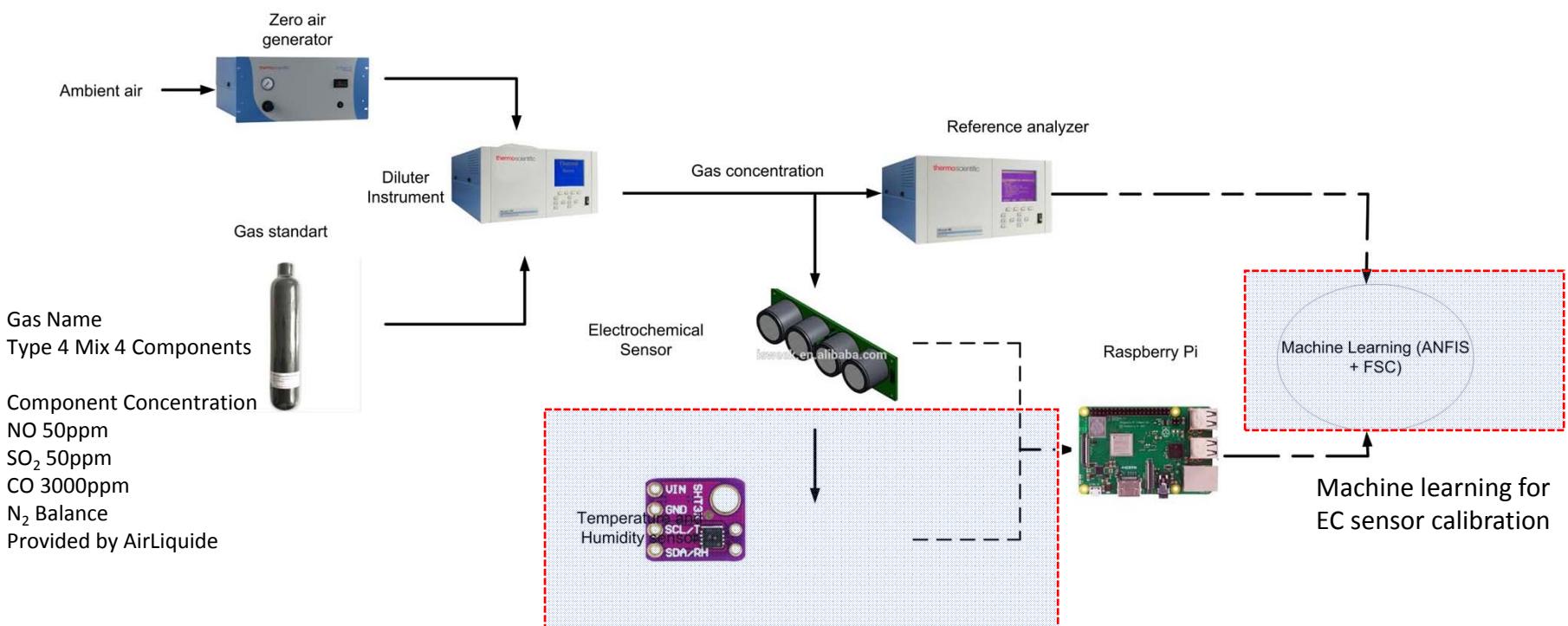
AiRBOX Sense for various gases (future development)

alphasense
THE SENSOR TECHNOLOGY COMPANY

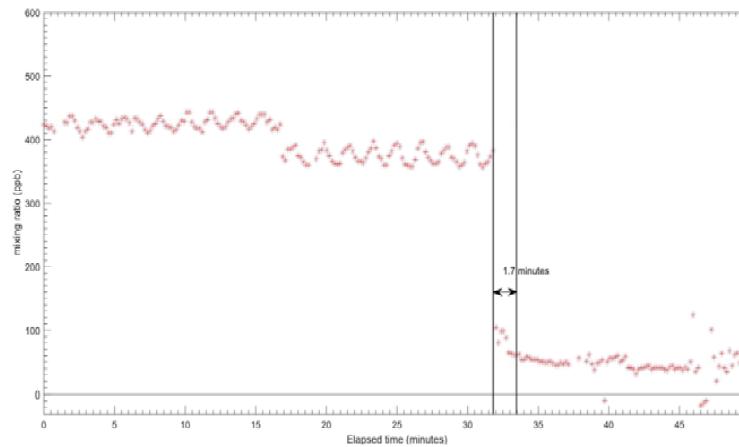
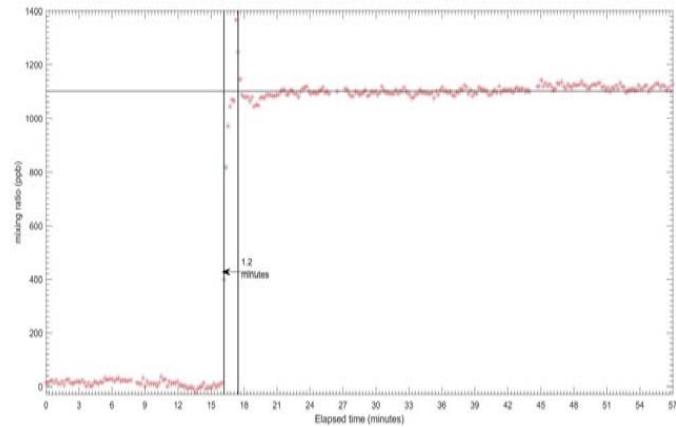


Type of Transducer	Air Pollutant	Prototype/Device
Electrochemical	NO ₂ , NO, O ₃ , CO, SO ₂ , H ₂ S	
Spectroscopic and NDIR	CO ₂ , CH ₄ , specific VOCs	
Photo-Ionisation Detector	total VOCs	
Optical Particulate Counter	PM ₁₀ , PM _{2.5} , PM _{1.0} , BC	
Metal Oxides	NO ₂ /NO, O ₃ , CO, SO ₂ , H ₂ S, VOCs	
Pellistors ENEA	CH ₄ , hydrocarbons	

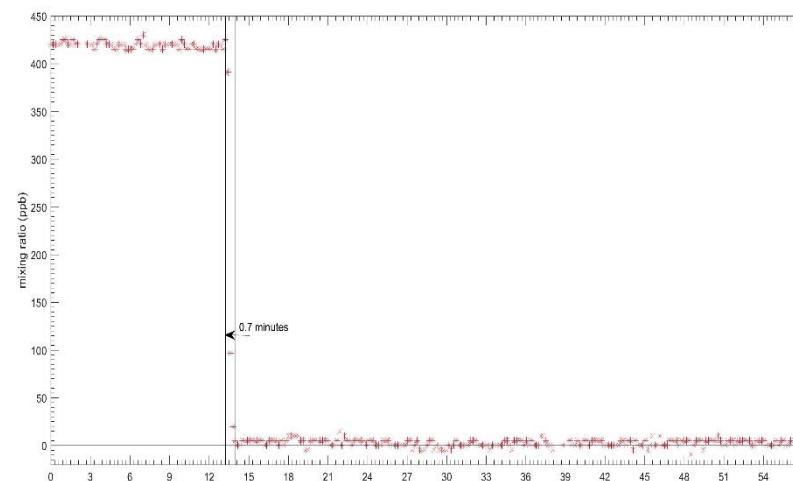
How we Calibrate and Cross-comparison for AiRBOX



Sensitivity experiment-University of Cambridge

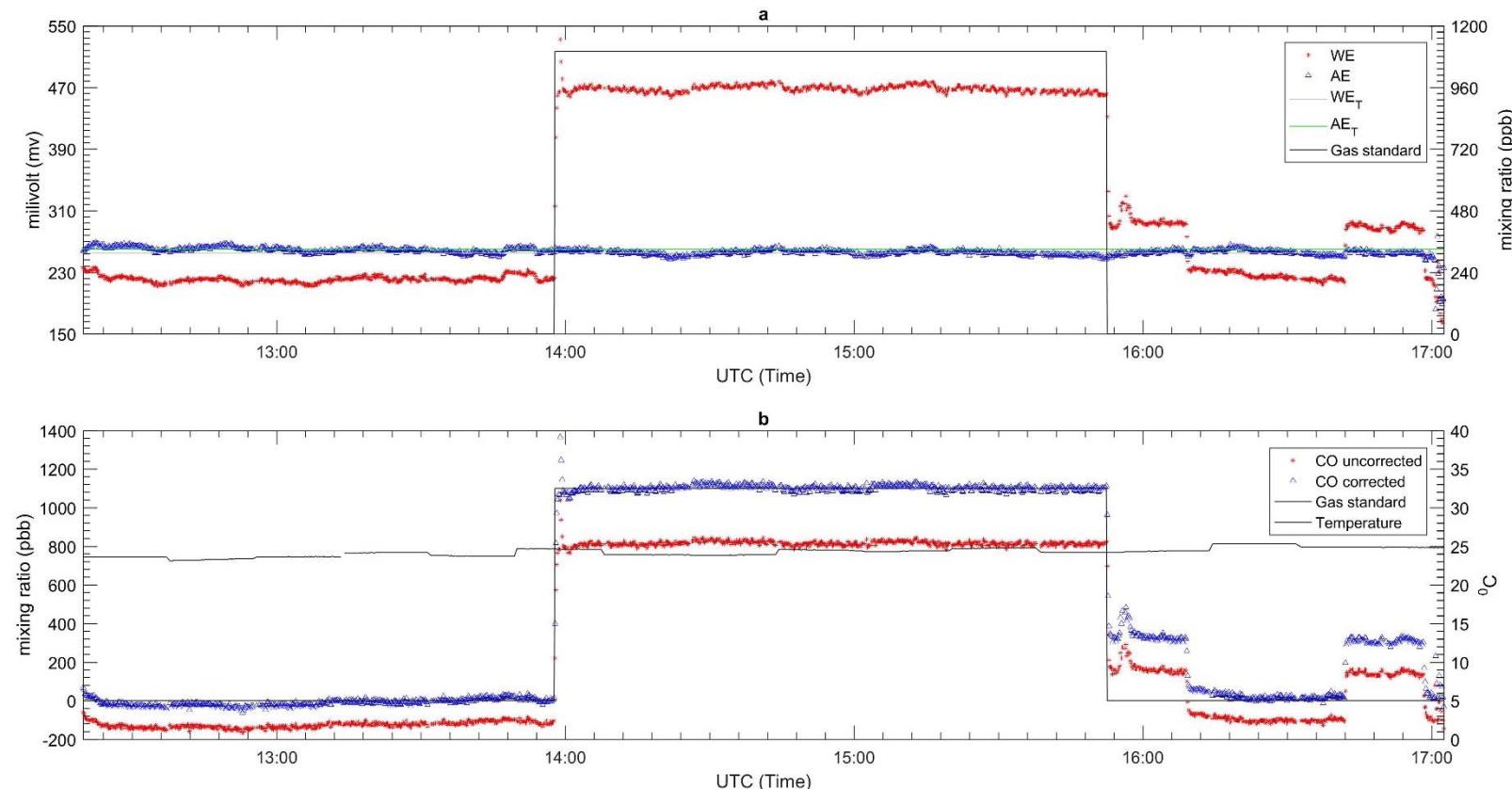


The response time



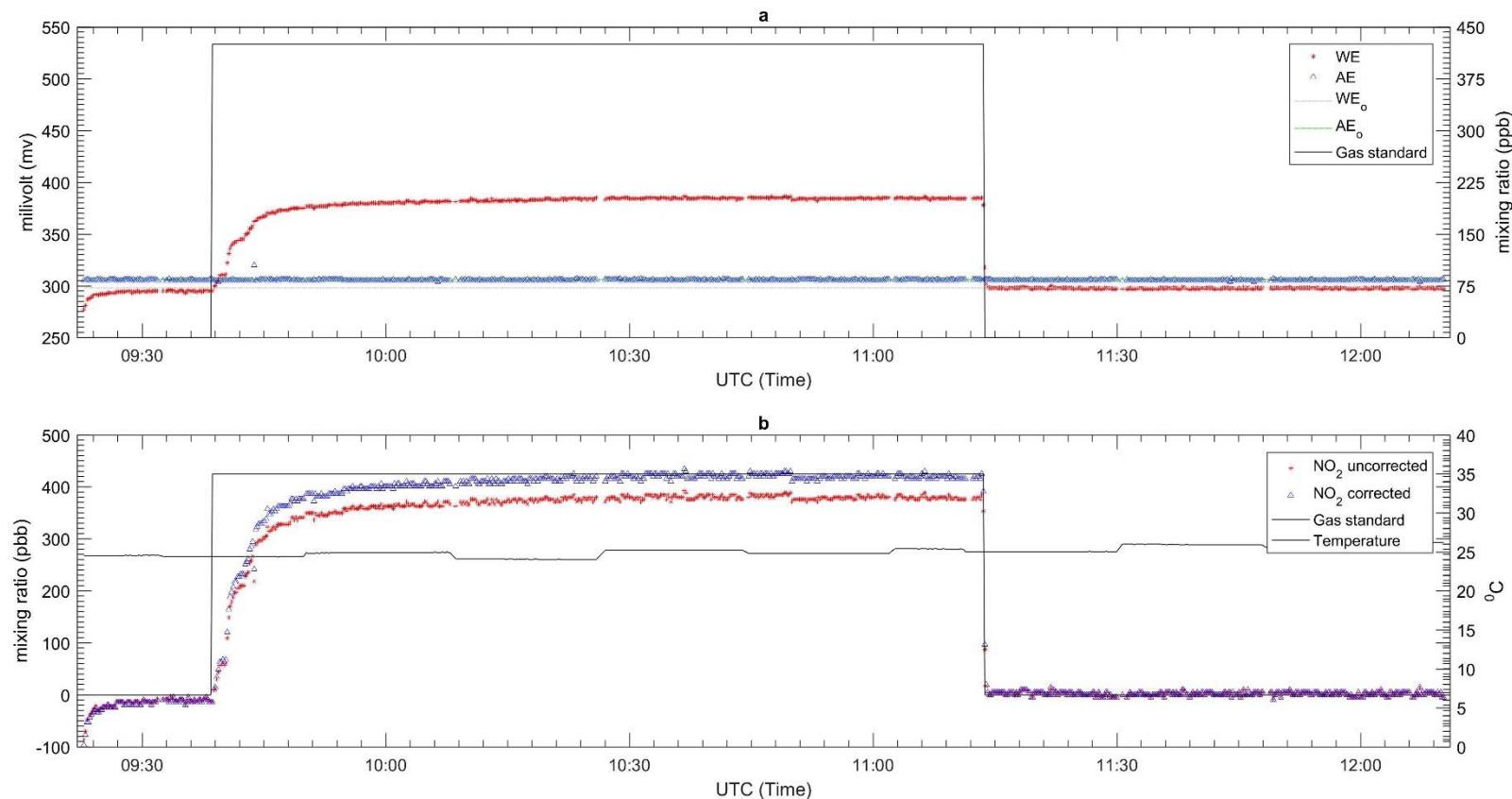
Ozone (O_3)

Carbon Monoxide (CO)



Carbon Monoxide (CO)

Nitrogen Dioxide (NO_2)

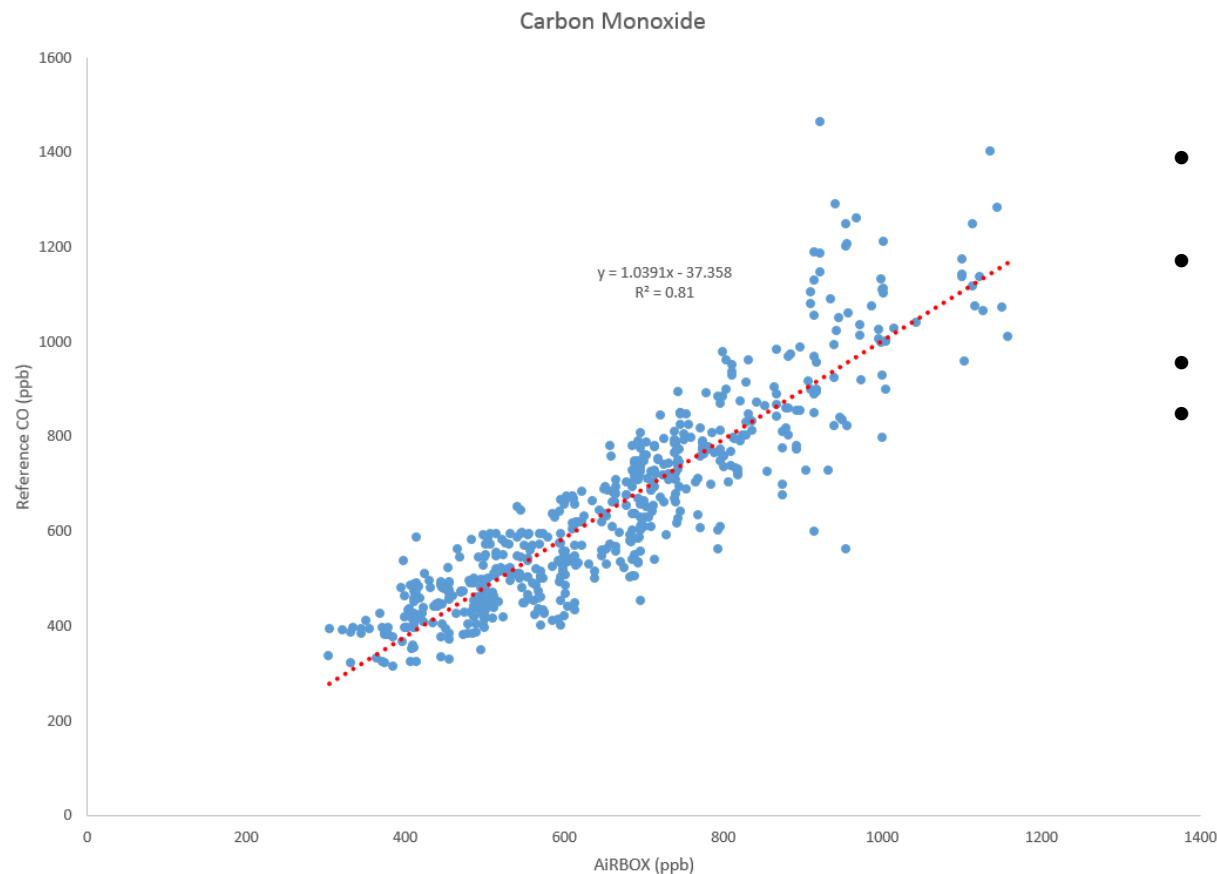


Nitrogen Oxide (NO)

VALIDATION CROSS-COMPARISON: PUTRAJAYA MONITORING

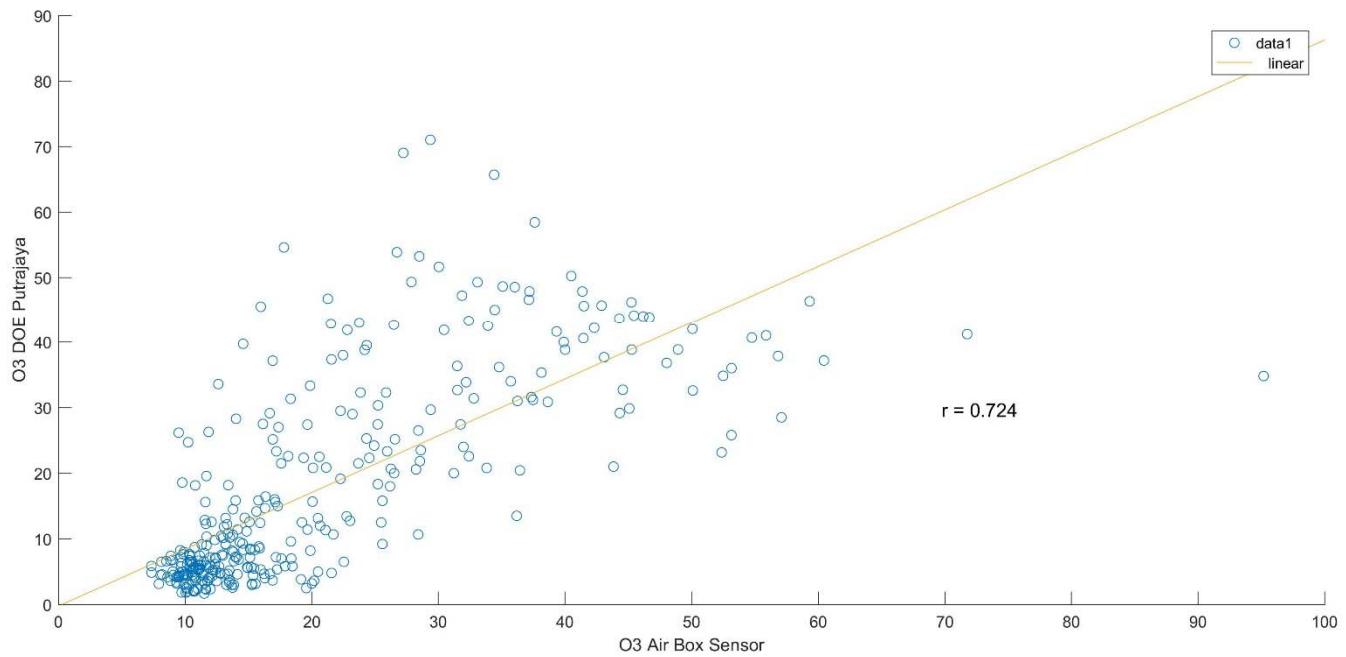


Correlation from validation with Reference CO

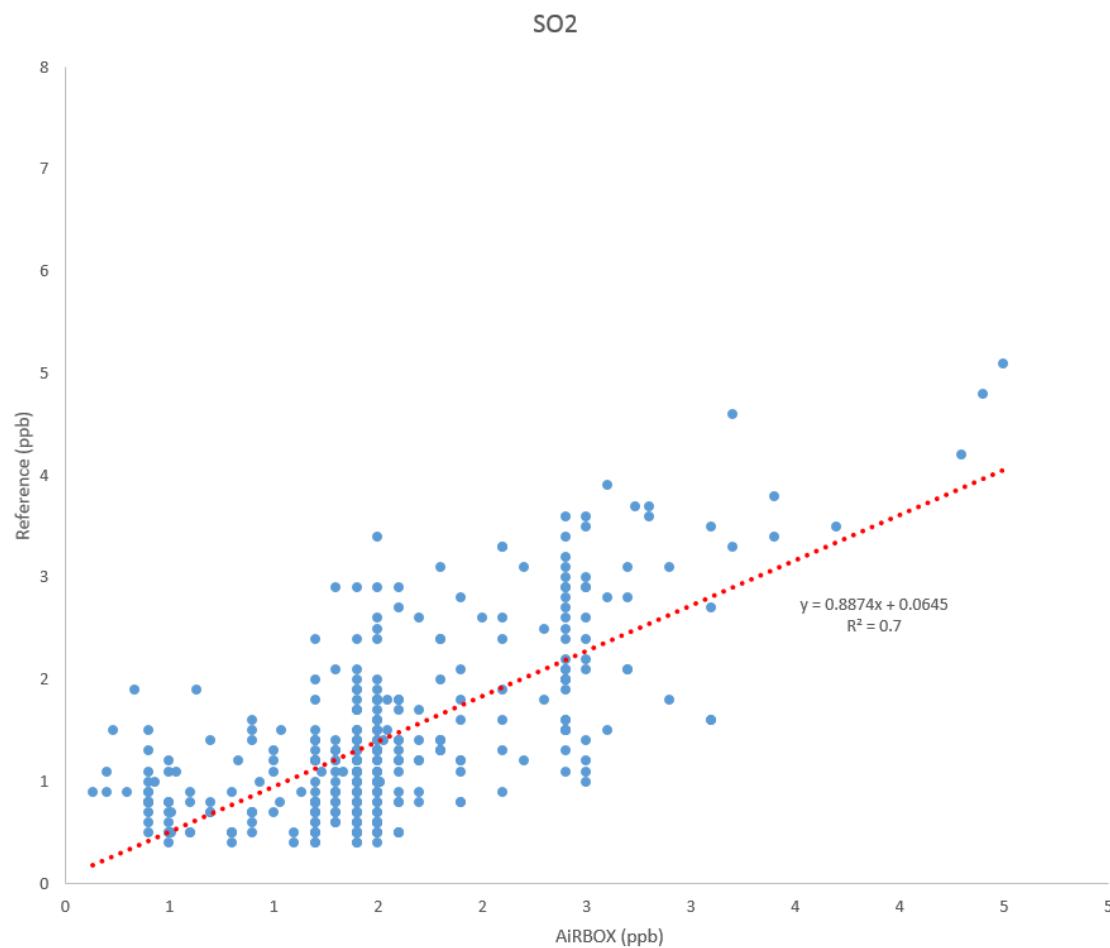


- The period of validations were conducted ~ 1 month.
- SO₂, NO₂ and PM Conducted at DOE, Putrajaya
- O₃ conducted at UKM Campus
- SO₂ was 3 weeks due to power problem at the DOE site.

3



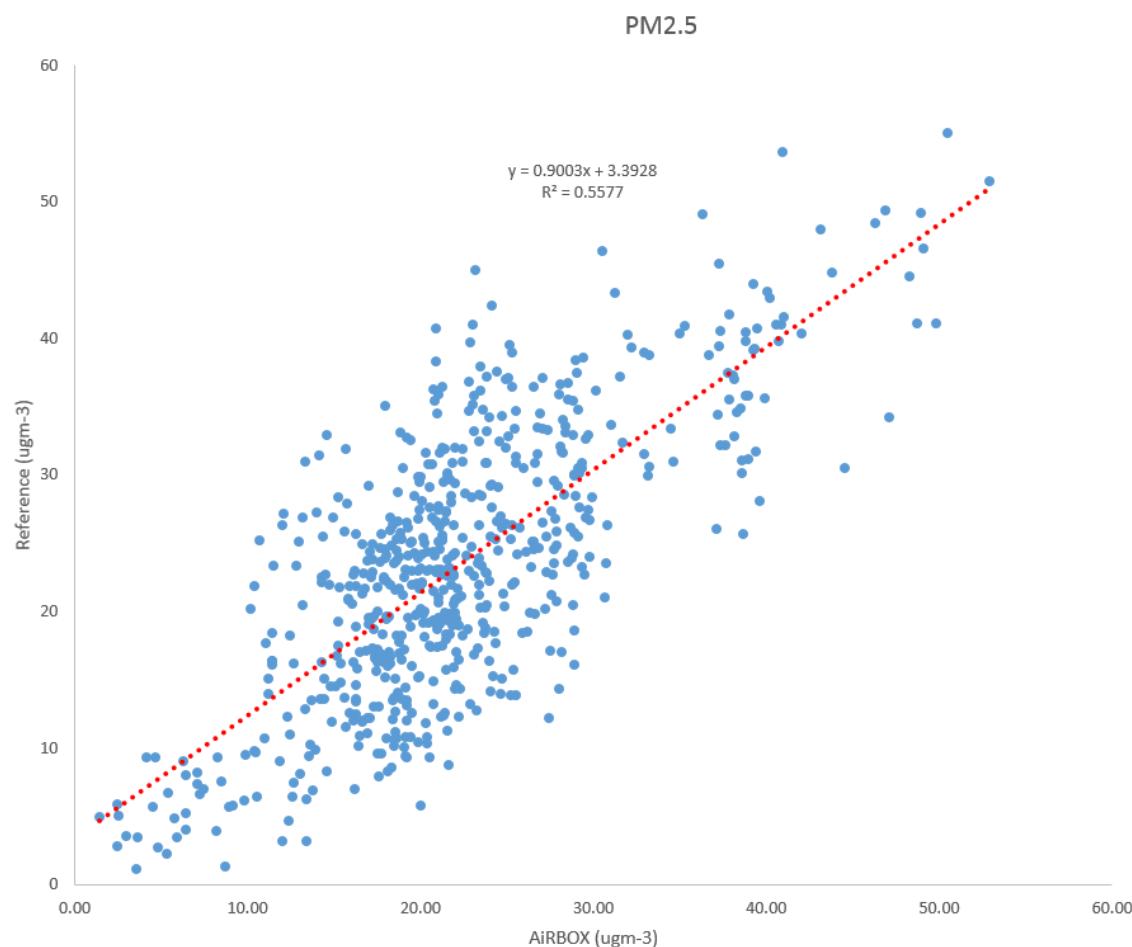
SO_2



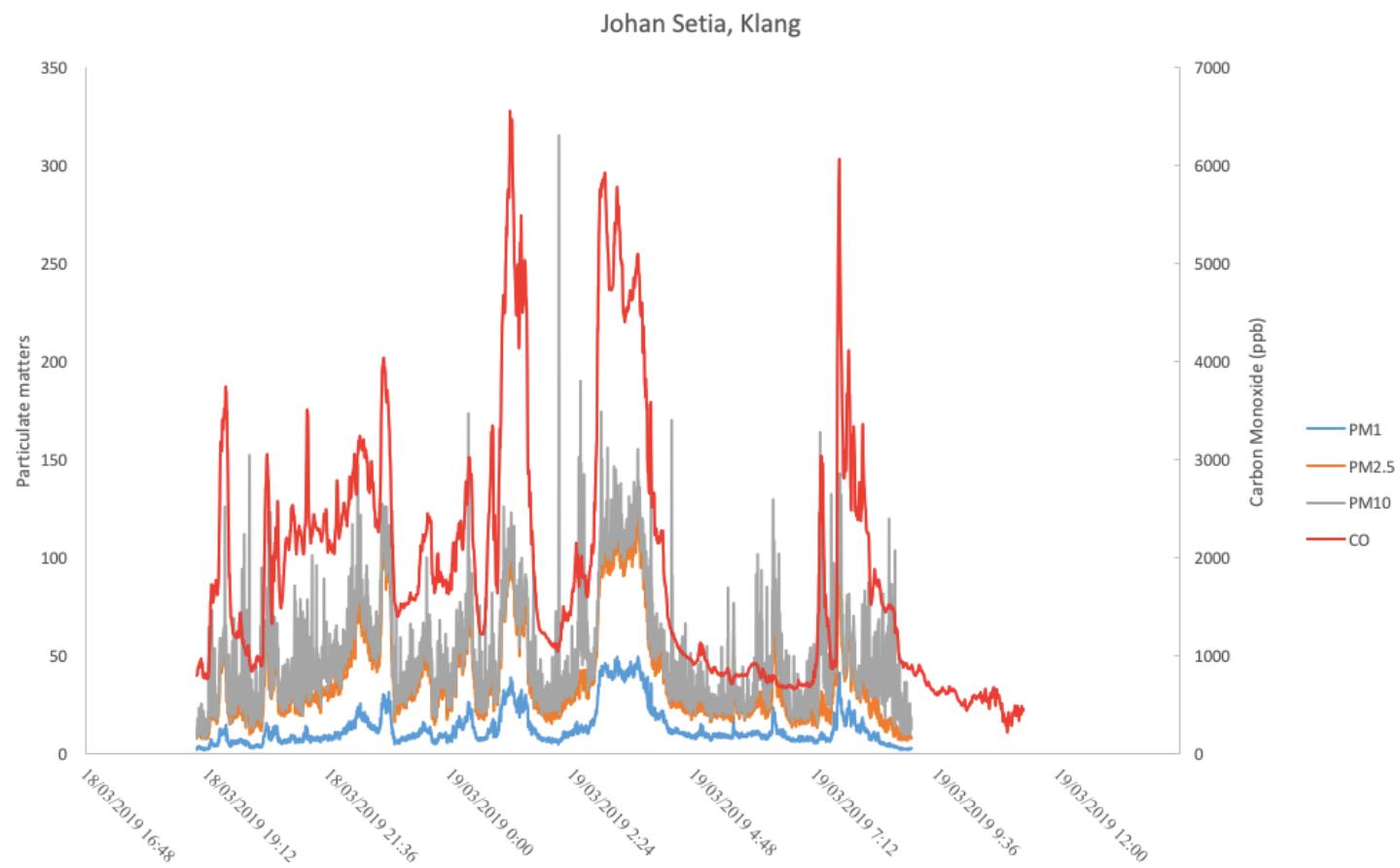
PM₁₀



PM_{2.5}



HAZE EPISODE 2019



Conclusion

- The results showed that AiRBOX was in close agreement with the reference instrument by the Department of Environment in Putrajaya.
- Strong correlation between AiRBOX and standard reference instrument for O₃, CO, NO₂, SO₂ and PM ($\sim r > 0.6$)- for OPC and EC.
- 'AiRBOX should not substitute but supplement routine environmental monitoring equipment/devices.
- AiRBOX will be the Future Routine Environmental Networks.
- Green Routes through the city or access to information about air-pollution load at specific local address might be future goals for AiRBOX Sense
- THREE AiRBOX are still running since June 2018 at UKM Campus, Shah Alam and Putrajaya for monitoring 6 criteria air pollutants.
- Long-term validation between AiRBOX and Reference analysers is still on-going to investigate the stability and data accuracy-precisions.
- Cross-comparison with Cranfield University AQMESH and AMNodes for Newton Project
- Currently, FIVE AiRBOX will be commissioning for Petaling Jaya City Council (MBPJ) for SMART CITY program.
- We are still conducting experiments on the influences of humidity and temperature effects on those measured gases(6 criteria) and particulates.



Publication



Article

Calibration Model of a Low-Cost Air Quality Sensor Using an Adaptive Neuro-Fuzzy Inference System

Kemal Maulana Alhasa ¹, Mohd Shahrul Mohd Nadzir ^{2,3,*}, Popoola Olalekan ⁴,
Mohd Talib Latif ², Yusri Yusup ⁵, Mohammad Rashed Iqbal Faruque ¹, Fatimah Ahamad ³,
Haris Hafizal Abd. Hamid ^{2,6}, Kadaruddin Aiyub ⁷, Sawal Hamid Md Ali ⁸, Md Firoz Khan ³,
Azizan Abu Samah ⁹, Imran Yusuff ¹⁰, Murnira Othman ², Tengku Mohd Farid Tengku Hassim ¹¹
and Nor Eliani Ezani ¹²

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rashed@ukm.edu.my (M.R.I.F.)

² School of Environmental and Natural Resource Sciences, Faculty of Science and Technology,
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haris@ukm.edu.my (H.H.A.H.); murnira@ukm.edu.my (M.O.)

³ Centre for Tropical System and Climate Change (IKLIM), Institute of Climate Change,
Universiti Kebangsaan Malaysia, Bangi 43600, Selangor, Malaysia; fatimah.a@ukm.edu.my (F.A.);
mdfiroz.khan@ukm.edu.my (M.F.K.)

⁴ Department of Electrical Engineering, Universiti Teknologi PETRONAS, Seri Iskandar, 31720 Seri Iskandar, Perak Darul Ridzuan, Malaysia.







UKM cipta alat lebih kecil, murah pantau kualiti udara

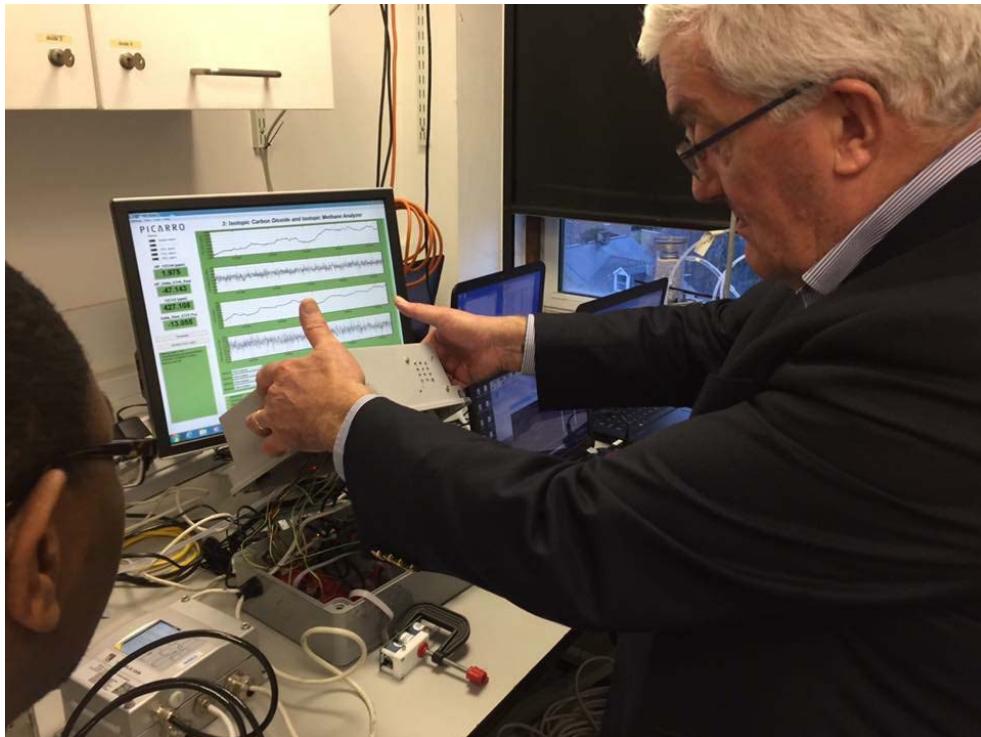
Rahmat Haron

11 Jan 2019, 12:03 tengahari (Dikemaskini 11 Jan
2019, 12:03 tengahari)



AiRBOX in Antarctica

ACKNOWLEDGEMENT





UNIVERSITY
of York



UNIVERSITY
OF MALAYA



UNIVERSITY OF
CAMBRIDGE



PAKAR SCIENO TW
Integrated Environmental Solutions



INTELLECTUAL PROPERTY CORPORATION OF MALAYSIA
(MyIPO)

REGISTRAR'S NOTICE NO.4/2019

NOTIFICATION OF DELAY IN PROCESSING PATENT
APPLICATIONS AND/OR REGISTRATIONS

PLEASE BE INFORMED that following a temporary interruption of the SPHI system, there will be some delay in processing patent applications and/or registrations from **6th December 2018**.

A handwritten signature in blue ink, appearing to read 'W' or 'Will'.

Registrar of Patent
Intellectual Property Corporation of Malaysia (MyIPO)
18 March 2019

AIR SENSOR
For Citizens

- High density Air grid monitoring
- Mapping air pollution sources
- Roadside monitoring networks
- IoT (Internet of Things) platform
- Community exposure studies
- Protecting health and safety

SMART AIR QUALITY SENSOR
Your Environmental Expert

Designed by:
INNOSENS TECHNOLOGY SDN BHD
We Sense, We Care

Powered by:
AIRBOX SENSE

Innosens Technology Sdn Bhd
8 Jalan Selasih U12/25B
Seksyen U12, Cahaya Alam
40170 Shah Alam
Selangor Darul Ehsan
innosensestech@gmail.com

AIRBOX SENSE
IP Patent No: PI2019001635

What is AIRBOX Sense?

- A small weather-proofed monitor that measures and reports key urban air pollutants and environmental parameters in real-time
- A flexible communications platform that transfers real-time data wirelessly, and gives you access through an API
- A web interface accessed via browser on your phone, tablet or PC where you can see all your data in one place and set alerts on parameters of concern
- A remote technical support service that maximises the useful life of the sensors while keeping high quality data flowing

What does it Measure?

- Nitrogen Dioxide (NO₂)
- Carbon monoxide (CO)
- Sulphur dioxide (SO₂)
- Ozone (O₃)
- Particulate matters (PM10 & PM 2.5)
- Relative humidity
- Temperature

The first step in protecting human health and the environment is to conduct a survey to better understand the air quality situation. The next step is to take necessary actions for reducing the air pollution through abatement planning. To be able to do this, one needs to understand the causes, effects and consequences of air pollution and abatement strategy planning.

AIRBOX SENSE

Air quality sensors for citizens and authorities design for 'SMART CITY'.

Find out more: AiRBOX Brochure



THANK YOU