



*Air & Waste Management Association, Measurement Methods  
and Technology, March 15-17, 2016*

# **Performance Assessment of a Solar- powered Air Quality and Weather Station Placed on a School Rooftop in Hong Kong**

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Nicky YF Lam<sup>2</sup>, and Ronald Williams<sup>1</sup>

1. United States Environmental Protection Agency, Office of Research and Development
2. City University of Hong Kong
3. Hong Kong Environmental Protection Department
4. Arcadis



# Background

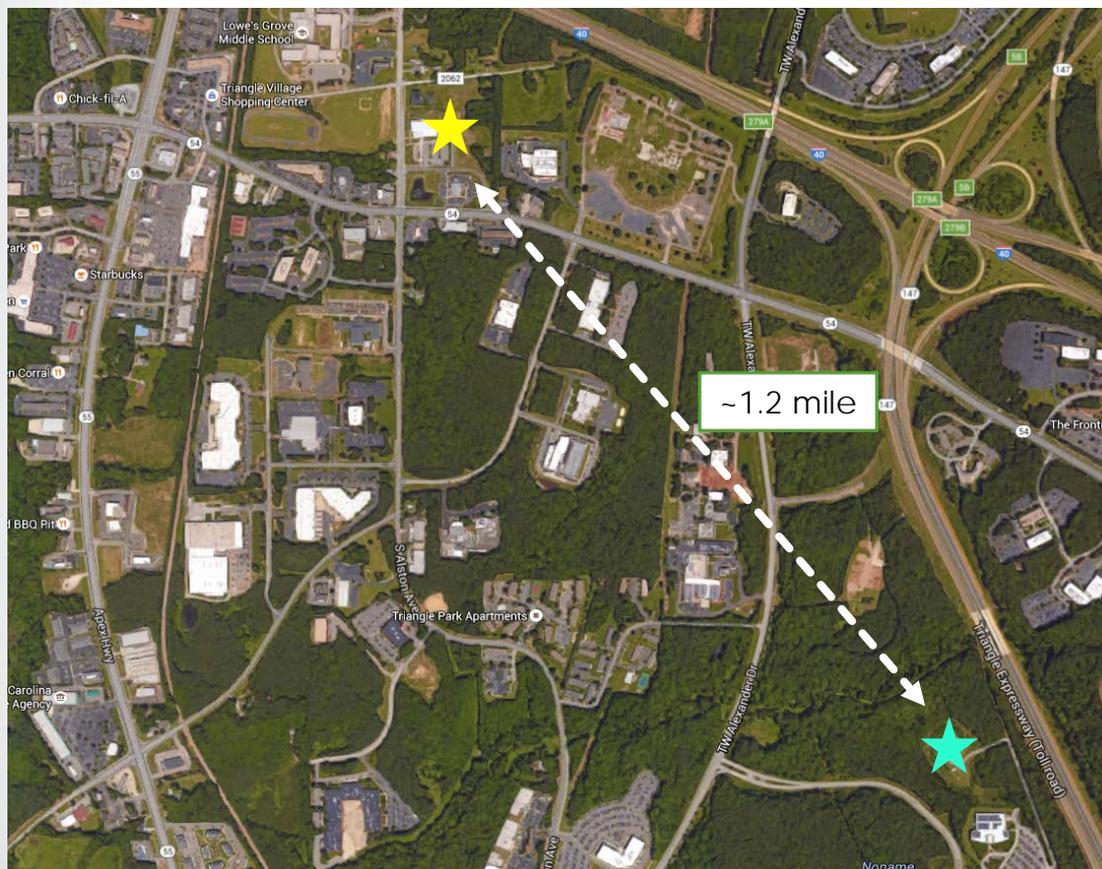
- The Village Green Project original prototype has operated in Durham, North Carolina since June, 2013, outside a public library.
- Measurements include:
  - Ozone (OEM-106-L, 2B Technologies)
  - PM<sub>2.5</sub> (pDR-1500, Thermo Scientific)
  - Wind speed and direction
  - Temperature (ambient, enclosure)
  - Humidity (ambient and enclosure)



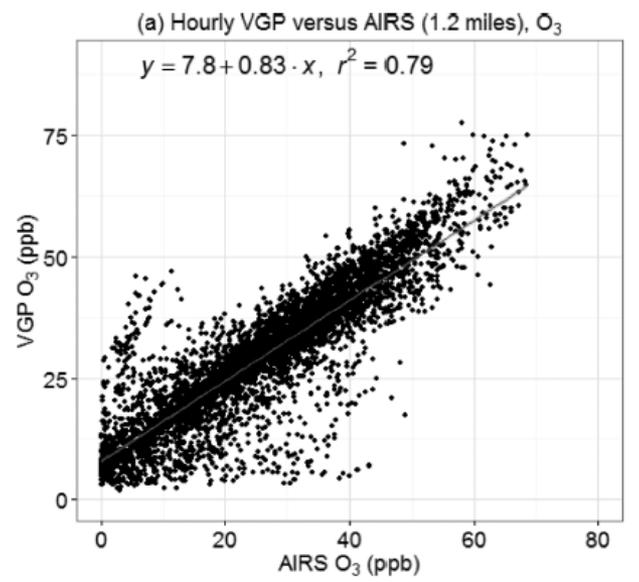


# Background

- A comparison of the Durham, NC location and a nearby reference monitoring station was conducted:



Ozone data comparison over a 10-month period of time

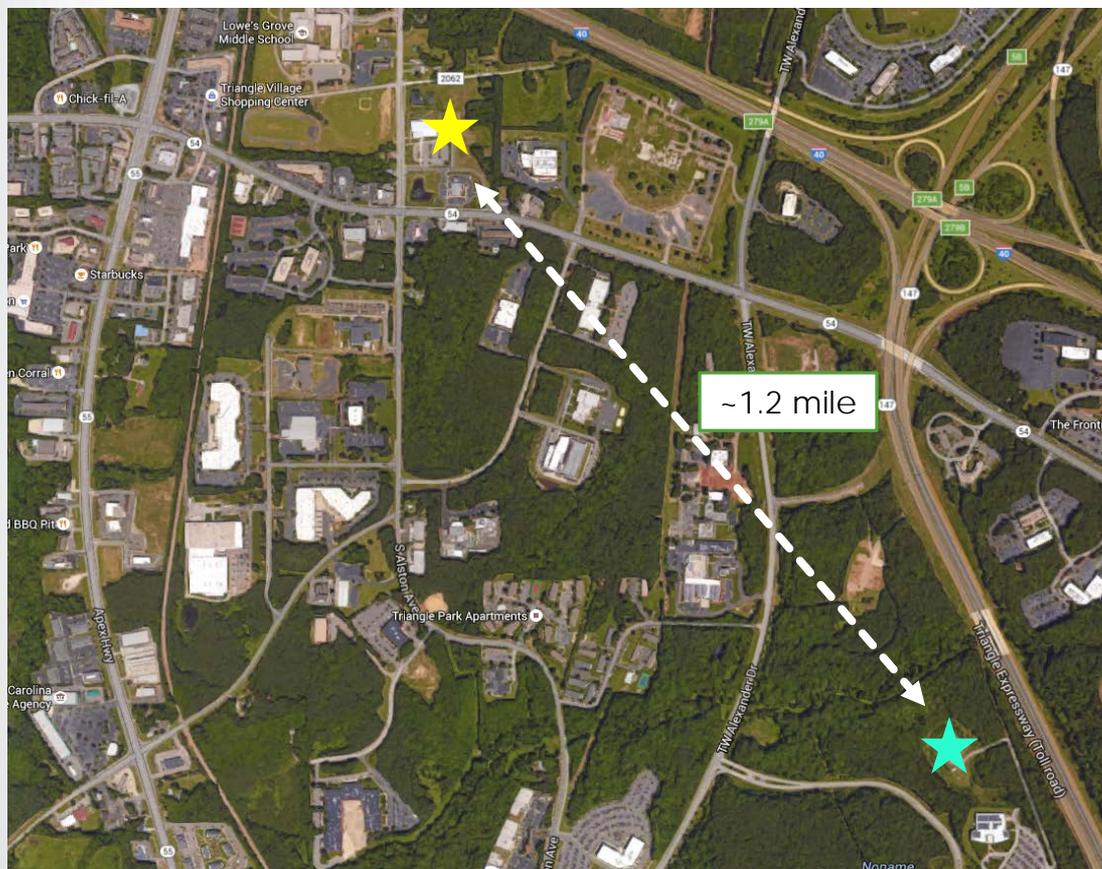


Maximum ~ 75 ppb

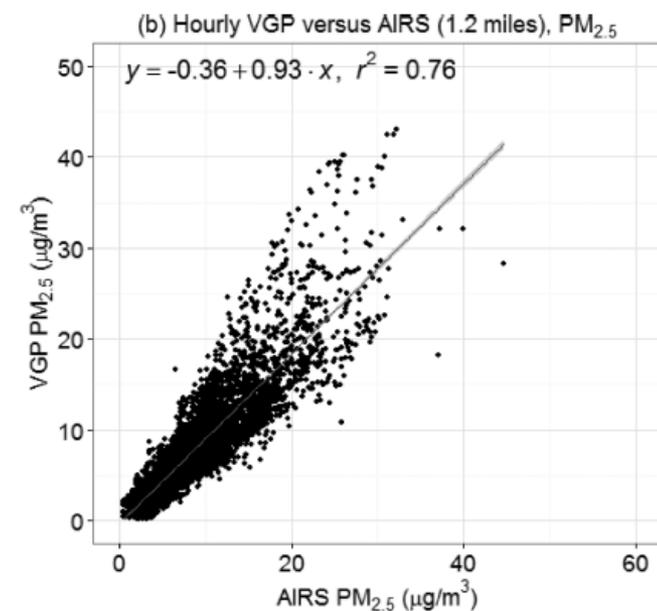


# Background

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PM<sub>2.5</sub> data comparison over a 10-month period of time

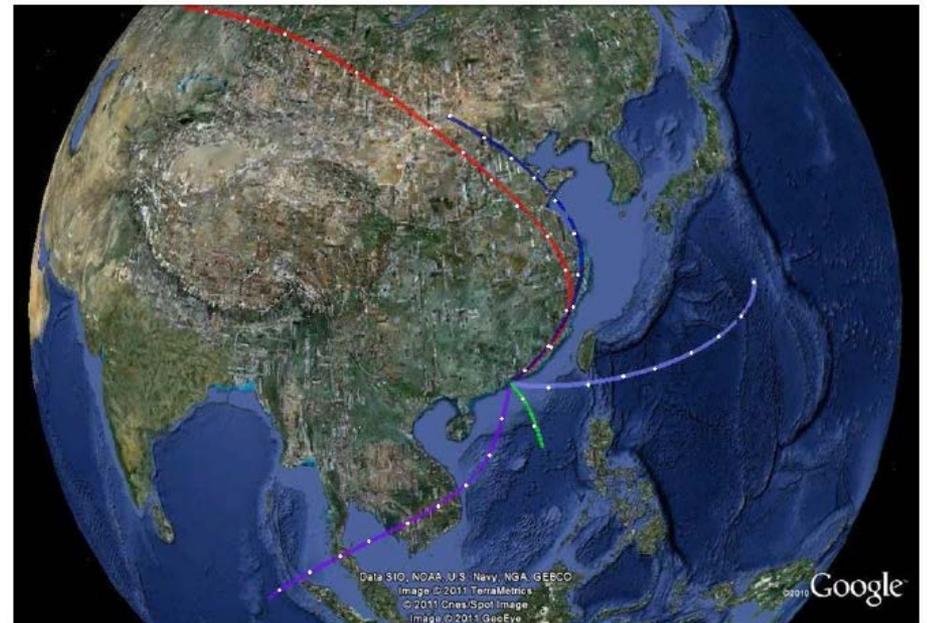
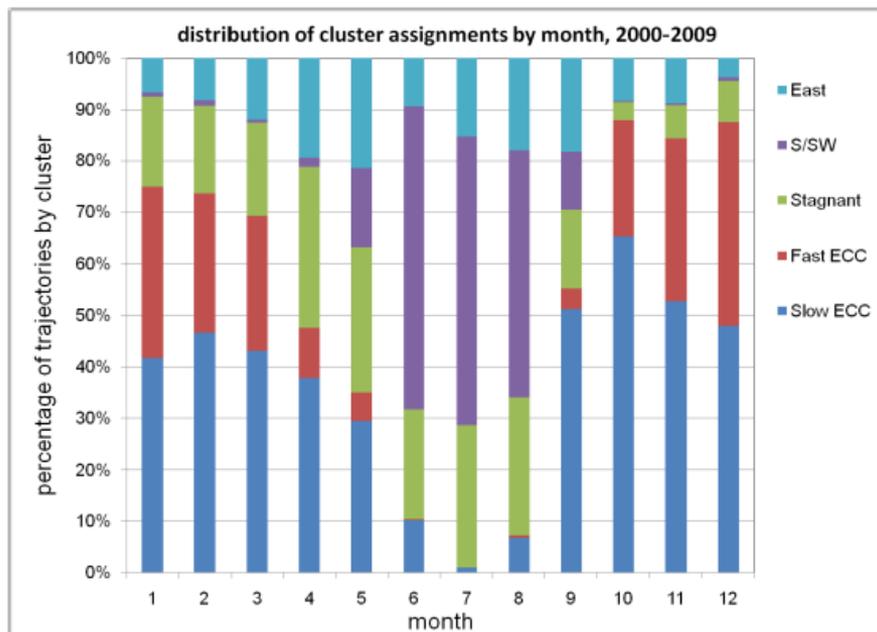


Maximum ~ 40 µg m<sup>-3</sup>



# Hong Kong field study

- As part of an international collaboration between the US EPA and the Hong Kong Environmental Protection Department, both organizations decided to work together to test the system in Hong Kong.
- A minimum of a full year test was desired, to capture the significant shifts in meteorology and pollution transport that occur in the area.

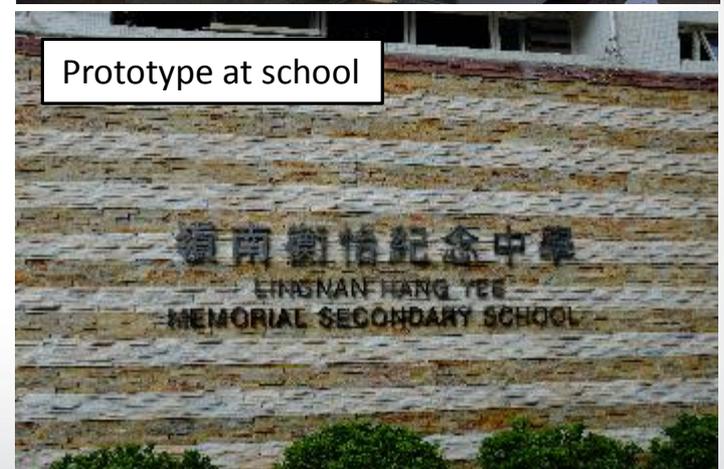
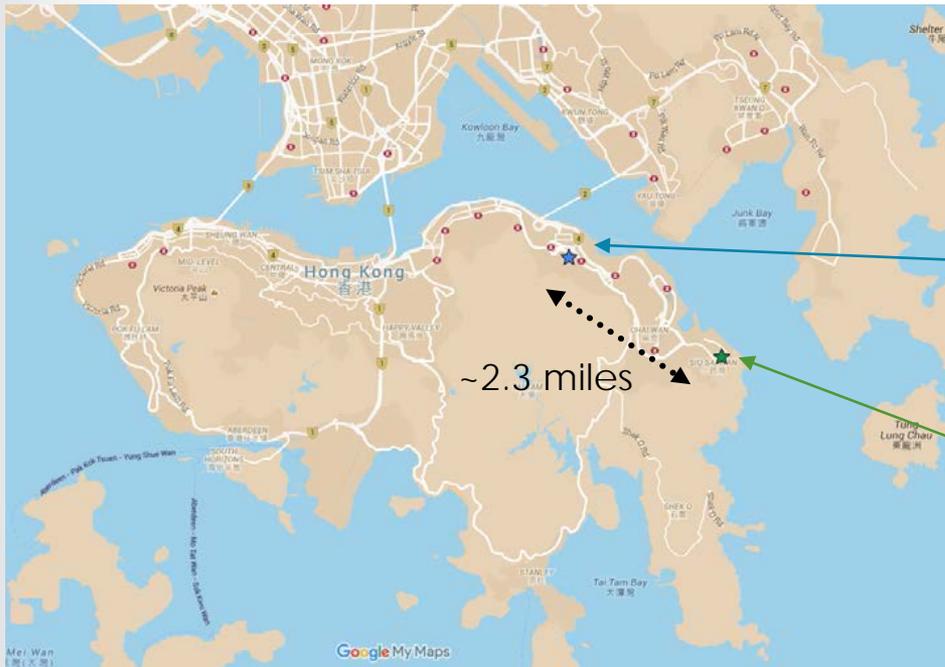


Air mass transport trends in Hong Kong, originally shown in Lau et al., 2012, Integrated data analysis and characterization of particulate matter in Hong Kong, Final Report. AS09-056-FR



# Hong Kong field location

- With goals of testing the system performance as well as educational outreach, a secondary school located on a heavy populated area of Hong Kong Island was selected.





## Hong Kong field location

- Visiting the location, it was quickly determined that a roof-mounted structure would be a better fit.

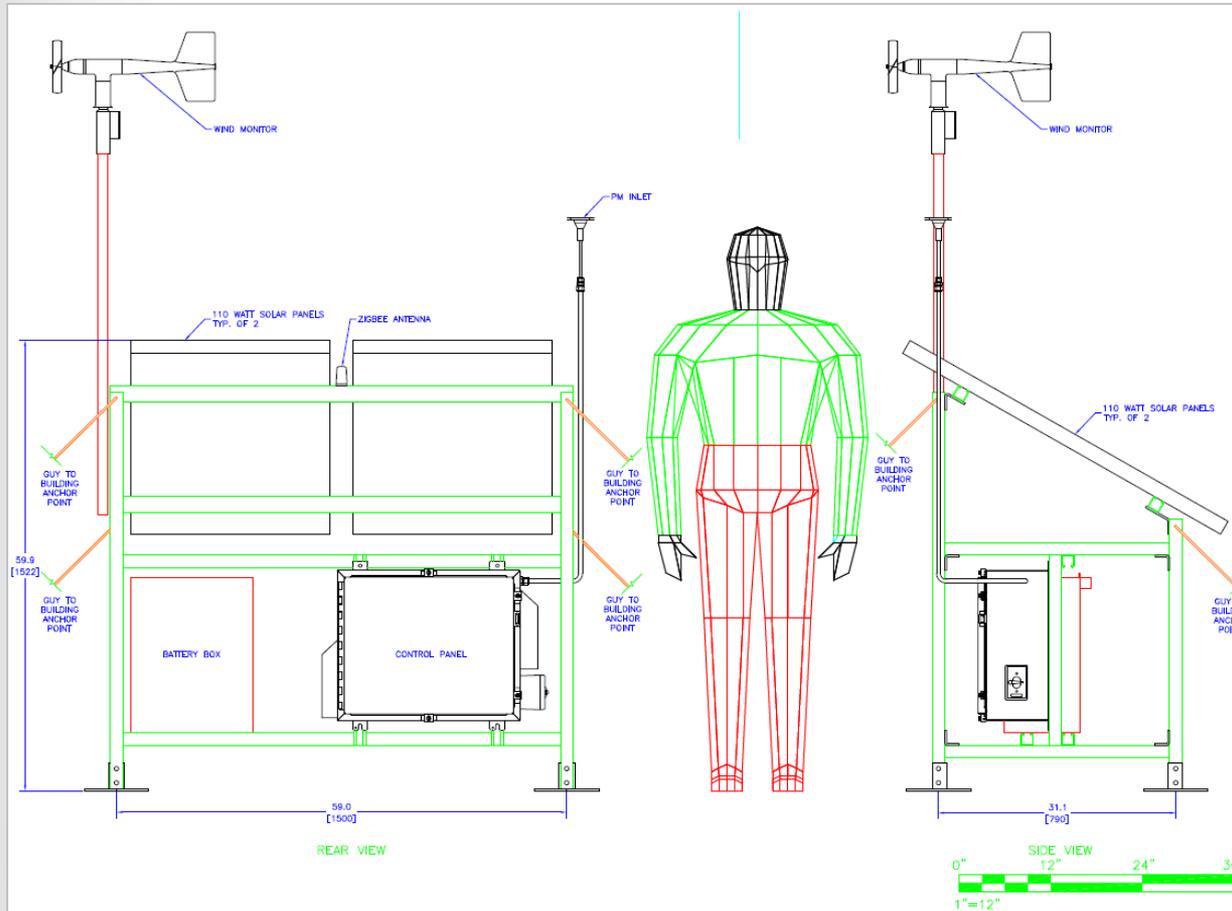


The school had a walk-out roof with easy access and existing solar panels. Tall residential towers surround the school.





# Prototype build



- The station was redesigned to be compact and ready to mount to a flat roof.
- Instruments and power system remained identical to the Durham, NC prototype.
- Communications was modified based upon collaboration with City University of Hong Kong.



## Prototype build

- The built version was tested at the US EPA facility in Research Triangle Park, NC, then shipped to Hong Kong.





# Hong Kong field deployment

- After receiving a permit to build a concrete base and secure the prototype to the school roof, station was installed for operation.



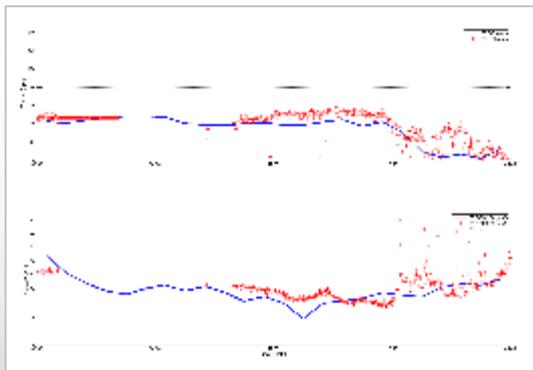
CityU students received training on station maintenance from the Bobby Sharpe (EPA/ARCADIS project engineer)





# Hong Kong field deployment

- USEPA and City University of Hong Kong coordinated to have data feed transmit by ZigBee radio transmission to a CityU monitoring box, followed by then transmission by LAN to CityU servers.
- Data saved a daily text files, 1 minute readings.
- CityU developed MATLAB script to email out daily plot of recorded data.



ZigBee



LAN



<a href="#">data_2016-02-12.txt</a>	2016-02-12 17:33	74K
<a href="#">data_2016-02-13.txt</a>	2016-02-13 23:59	128K
<a href="#">data_2016-02-14.txt</a>	2016-02-14 23:59	128K
<a href="#">data_2016-02-15.txt</a>	2016-02-15 19:02	41K
<a href="#">data_2016-02-16.txt</a>	2016-02-16 23:56	126K
<a href="#">data_2016-02-17.txt</a>	2016-02-17 16:57	46K
<a href="#">data_2016-02-18.txt</a>	2016-02-18 17:31	32K
<a href="#">data_2016-02-19.txt</a>	2016-02-19 14:23	44K

MATLAB script  
daily email



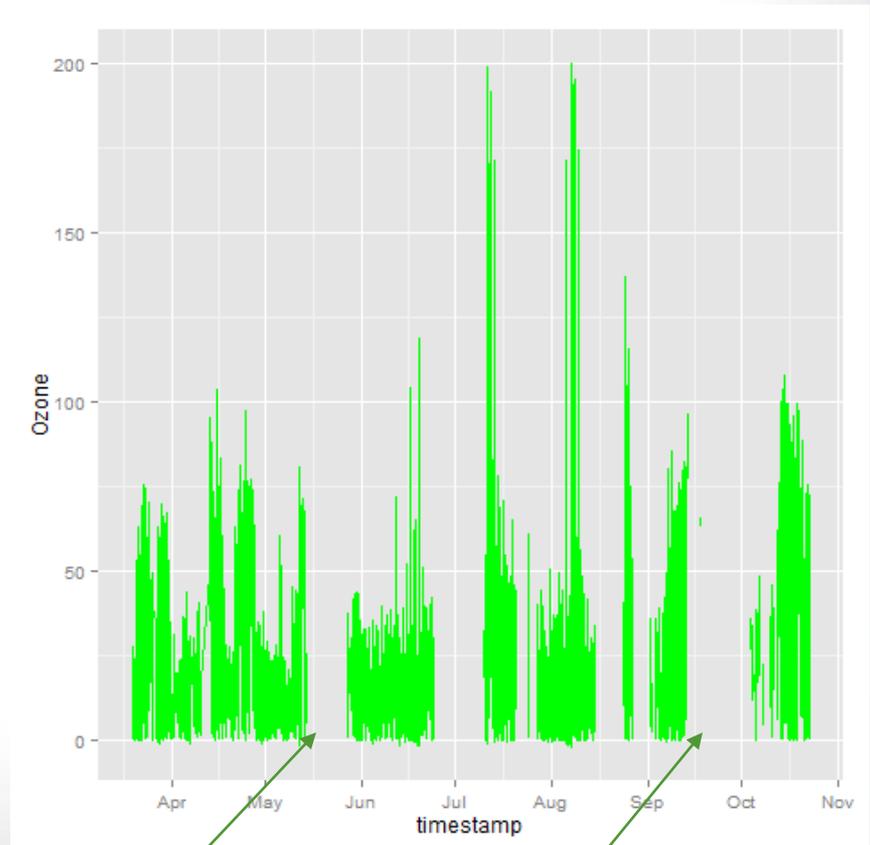
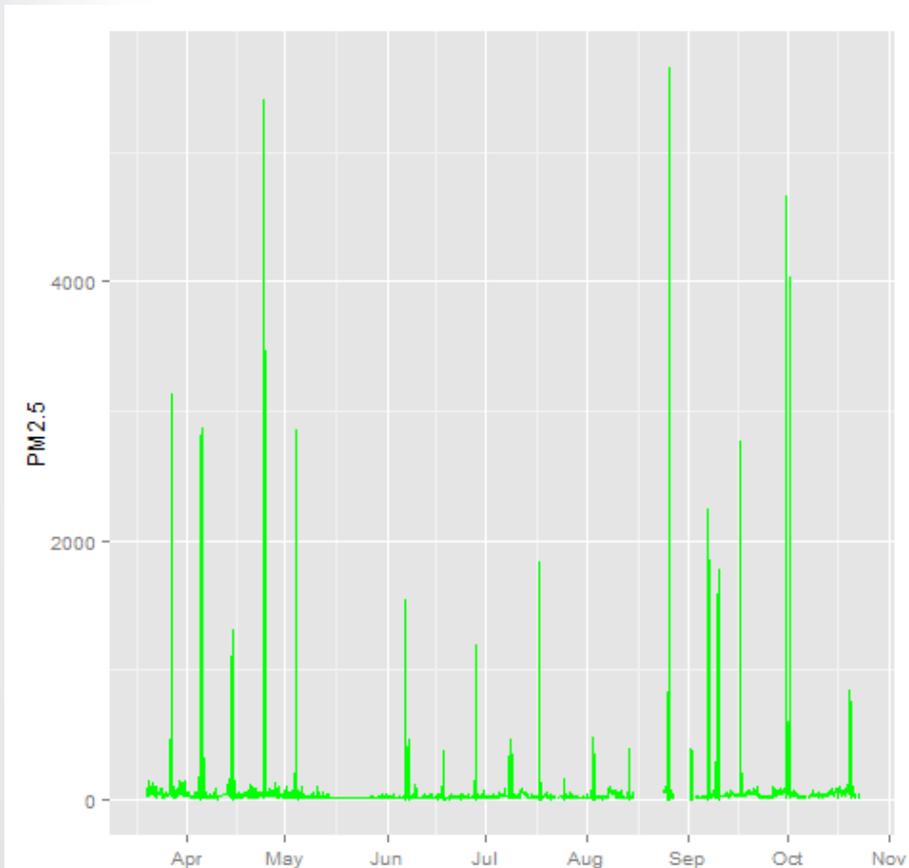


# System performance

- Preliminary data analysis of the first 6 months of data (April – October, 2015)

Brief, high excursions in 1 min  $PM_{2.5}$  data (possible nearby emissions?).

Ozone data also had some periods of higher minute-to-minute noise, but typically at power cycle



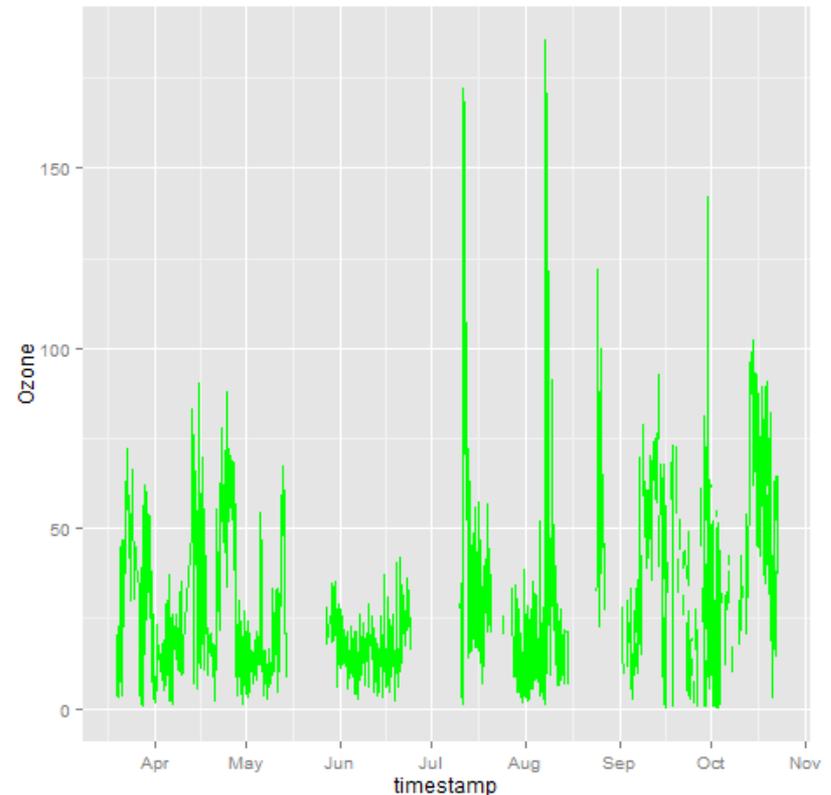
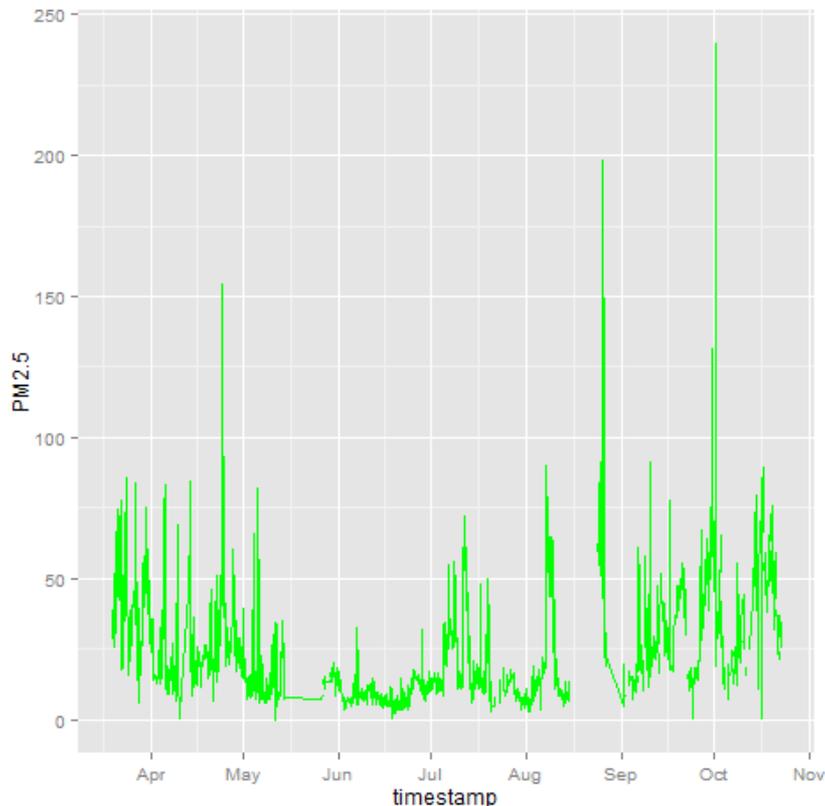
Some longer data gaps in ozone due to an on-site visit required to re-establish data logging



# System performance

- Preliminary data analysis of the first 6 months of data (April – October, 2015)

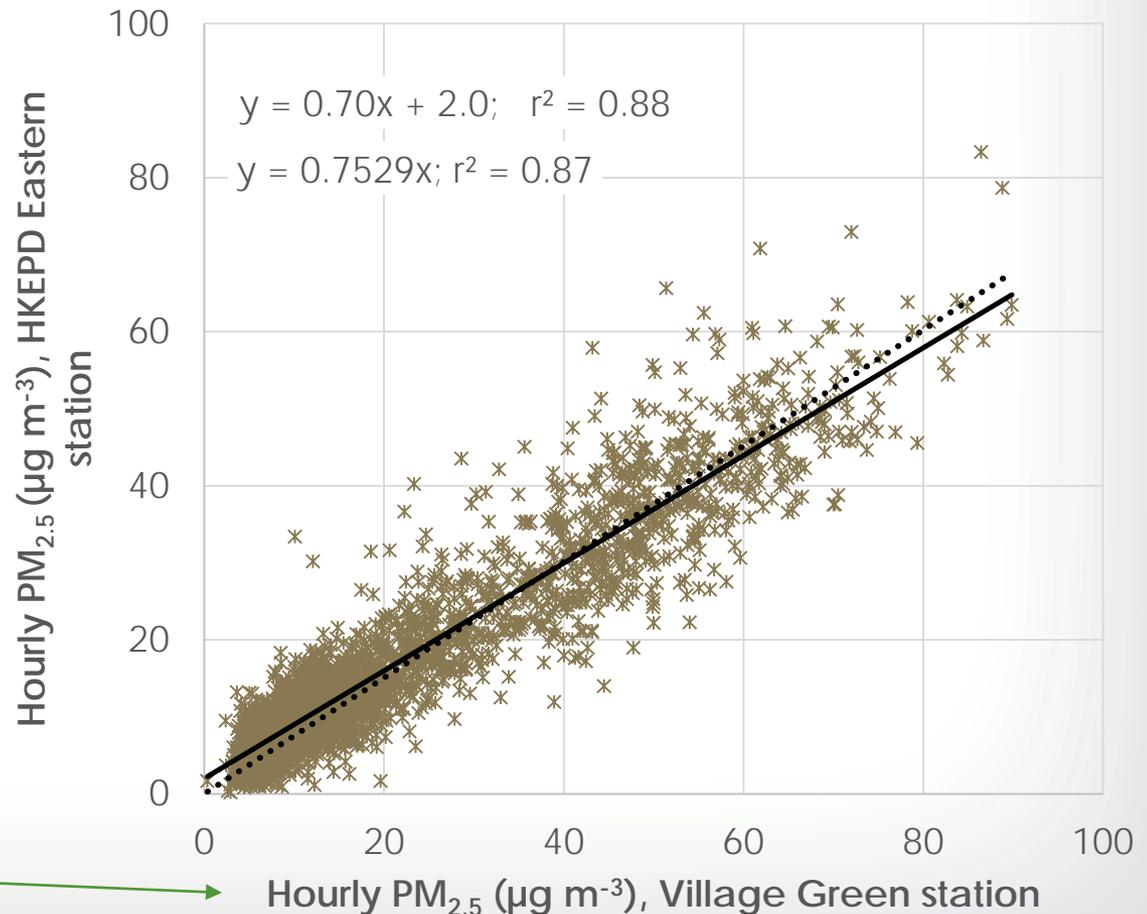
Brief excursions generally negligible at longer averages





# System performance

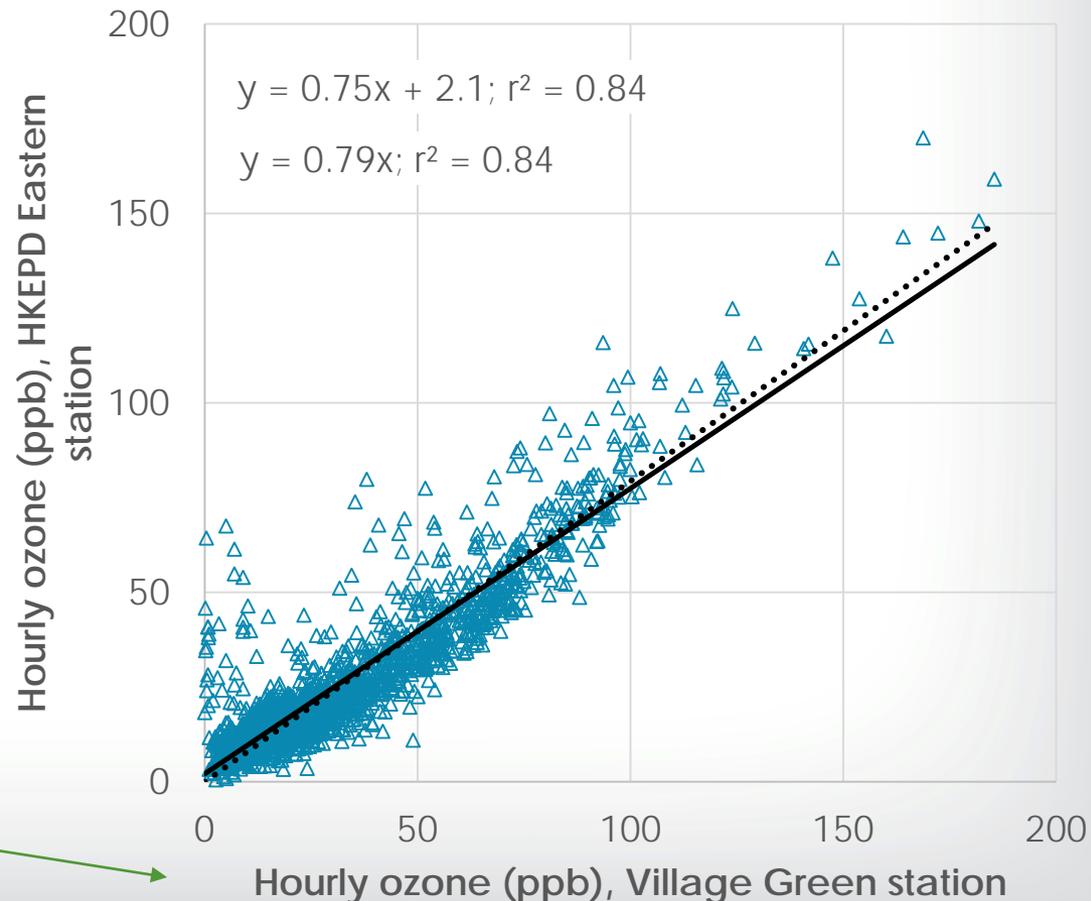
- Comparison with HKEPD data:
  - 2619 hours of valid  $PM_{2.5}$  data from Village Green station (76% of measurement period)
  - Max  $PM_{2.5} \sim 85 \mu g m^{-3}$





# System performance

- Comparison with HKEPD data:
  - 1956 hours of valid ozone data from Village Green station (57% of measurement period)
  - Max ozone ~160 ppb



- Rooftop version of the Village Green station maintained good correlation with nearby reference monitor over an extended period of time, under subtropical weather conditions with multiple major storm events

## PAST AUGUST IN HONG KONG ONE OF THE HOTTEST ON RECORD

By [Coconuts Hong Kong](#) September 3, 2015 / 12:49 HKT

ENVIRONMENT & HEALTH HONG KONG

**It's a washout: Heavy rain, strong winds to hit Hong Kong as tropical depression set to be**

Rain, wind, and a lot of cloud: Hong Kong has a wet and wild week ahead thanks to tropical cyclone Vamco

Ernest Kao  
ernest.kao@scmp.com

PUBLISHED : Monday, 14 September, 2015, 10:06am  
UPDATED : Monday, 14 September, 2015, 3:09pm

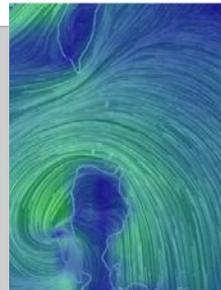
## Hong Kong braces as tropical storm Linfa approaches

By: [Agence France-Presse](#)  
July 10, 2015 2:28 AM



Women take photos from a viewing deck overlooking Hong Kong's Victoria harbor as Typhoon Linfa approaches on July 9, 2015. (AFP Photo/Isaac Lawrence)

s with swells and occasional heavy  
ression pushes across the South



A file picture of Hongkongers battling wet weather in Admiralty. Photo: SCMP Pictures

SHARE



Oct 2015

Sept 2015

July 2015



## Summary

- Data collection is ongoing
  - Station to stay in place until at least one year is complete, with potential extension under discussion.
  - Co-location of other monitors at school may occur (reference monitors, lower cost sensors)
- Further analysis will include:
  - Full-year and seasonable comparison with Eastern station
  - Wind directional trends
  - Evaluation of any apparent temperature or humidity-related artifacts in the VG station data



## Aknowledgements

- Lingnan Hang Yee Memorial Secondary School
  - Ms. LI Sau Yee
  - Mr. TANG Chi Yung
  - Mr. LAM Wai Kit
  - Mr. LO Cheuk Wai
- US EPA ORD Innovation Team, Air Climate and Energy Program, National Risk Management Research Laboratory, National Exposure Research Laboratory
- Hong Kong Environmental Protection Department: Connie Luk, Eve Zhang
- City University of Hong Kong: Joe Ka Chun Wong



## Questions?

- Points of contact:

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City University of Hong Kong: Zhi Ning, [zhining@cityu.edu.hk](mailto:zhining@cityu.edu.hk)