Proposal for Improving Air Quality Measurements using **Affordable** and low-cost **Sensors.**

by aqicn.org - November 12th 2014.

prepared for the better Air Quality Conference, November 2014

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https://www.flickr.com/photos/goldsaint/7420820294/in/photostream/

Context for Measuring the AQI

- Measuring the Air Quality Index (AQI) has at least two purpose.
  - Long term: Gather statistics, to track Air Quality improvement year-over-year and compare cities.
  - Short term: Provide information to our citizen about they are breathing *now*.
- At aqicn, we focus on citizen. What we learned they want to know is at least:
  - The real-time air quality information, i.e. data measured less than 1 hour ago.
  - Localized information, i.e. data measured close to where they are living, and not 50 KM away.

Definition of the Problem

- The 6 most common Air Quality pollutants are PM2.5, PM10, Ozone, NO2, SO2 and CO.
  - Among those, **PM2.5** is most of the time the worst pollutant (with the exception of Ozone, during summer)
  - The best situation, for reporting Air Quality to is to have station able to measure those 6 pollutants are the same time.
- The problem is that many Air Quality monitoring stations do not measure all those pollutants.
  - For those stations that do not report PM2.5 – the resulting AQI is most of the time much smaller than if a PM2.5 sensor was used.
  - So, in the context of giving information to our citizens, are those non-PM2.5 enabled station relevant? Especially if neighbor stations are measuring PM2.5?

A practical Example: Busan, South Korea

- When stations are only measuring PM10, they give an impression of better Air Quality than if the PM2.5 was measured.

- On this map from Busan, that's roughly "green" (0-50) for the PM10 stations, while it is "yellow (50-100)" for the PM2.5 stations.

- The better PM10 AQI is of course a wrong impression given to our citizens: Overall Busan is 50+

Does this mean that we should get rid of all PM10 station when reporting AQI to the Citizens? The answer is no!

Solving the PM10/2.5 mismatch

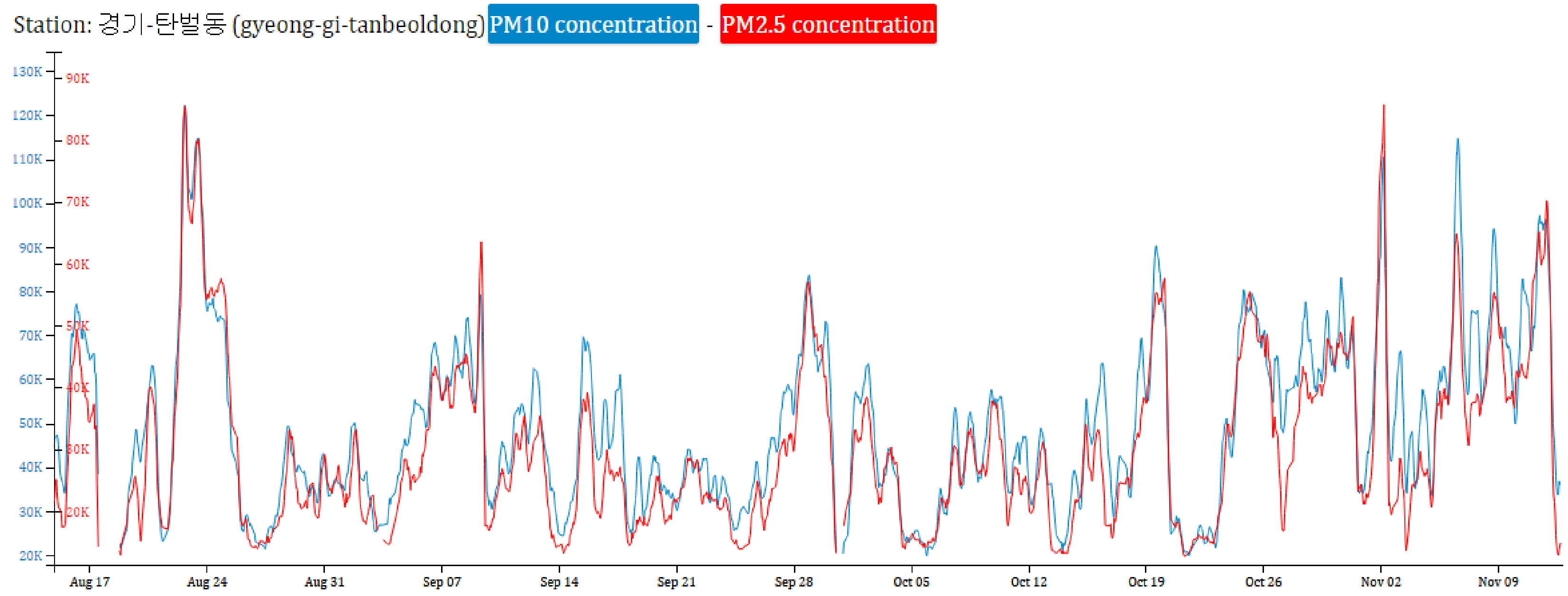
- The obvious solution for solving the mismatch between the PM10 and PM2.5 stations is to upgrade the existing equipment.

- But when budget is a constraint, or the equipment upgrade is progressive and taking several months, then alternative and affordable solution can be used.

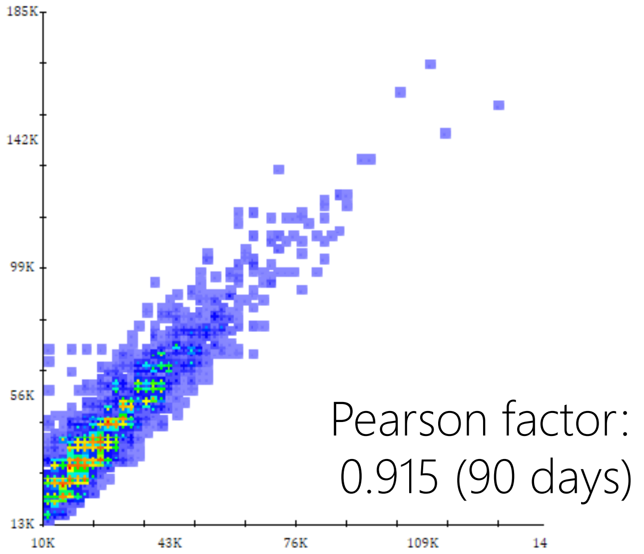
- What we have discovered is that there is a strong correlation between PM10 and PM2.5 data, and that under normal conditions, PM2.5 can be deducted by measuring PM10.

Simulation Applied to Seoul, South Korea

- Correlation between PM10 (blue) and PM2.5 (red) show very good similarity over the last 90 days.



Correlation (X:PM2.5, Y:PM10)



- Based on the above graphs, the PM2.5 mass can be deducted from PM10 as:

$$\boxed{mass_{pm25} = -313.1 + 0.616 * mass_{pm10}}$$

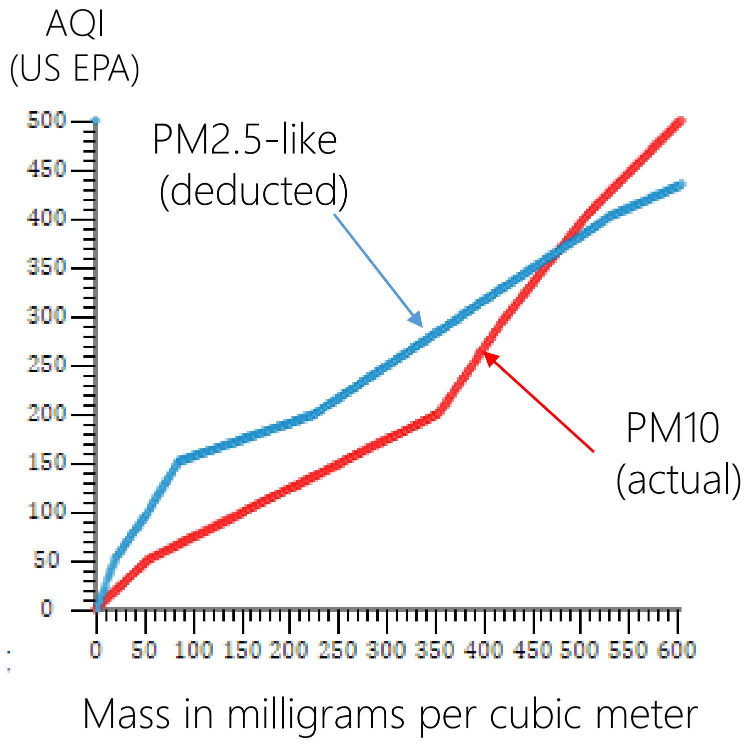
Simulation Applied to Seoul, South Korea

- Implication for the citizens

  - Mass reading are converted into AQI, and that's the AQI which is always presented to Citizen. The red line on the right show the conversion between mass and AQI for PM10.

  - Knowing the deducted PM2.5 mass it is possible to provide what we call a "PM2.5-like" AQI, i.e. the an AQI based on the PM2.5 scale and the mass deducted from the PM10 readings.

  - The graph does confirm that bellow 500 mg/m3 (~350 AQI), the AQI reported from PM2.5 stations is always higher than the one from PM10 stations.



- AQI Conversion table (from PM10 AQI to equivalent PM2.5-like AQI)

Measured PM10 AQI	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
Deducted PM2.5 AQI	9	26	40	54	61	68	76	83	92	99	116	132	149	154	158	161	164	168	171	175	178	182	185	188	192	195	199	205	212	218

What about when PM10 is the worst pollutant (1/2)

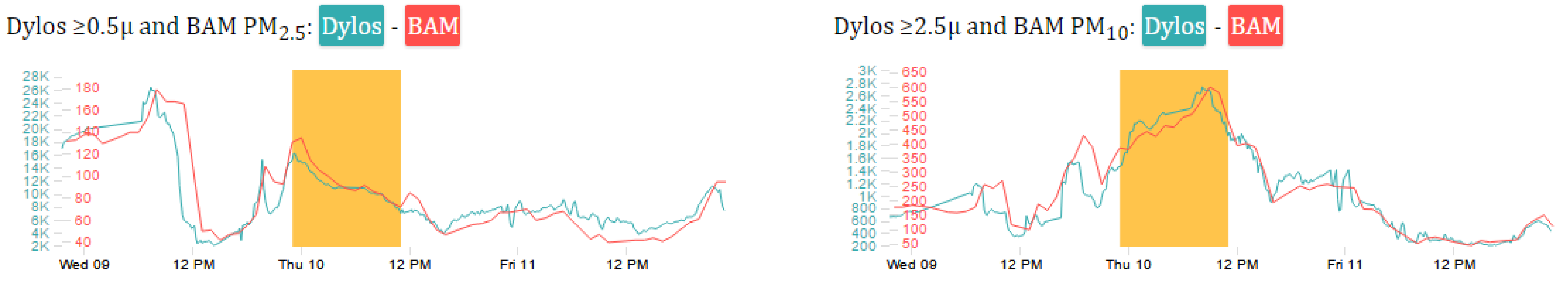
- Under specific conditions, such as strong winds creating dust re-suspension or sand storms from places like Mongolia, the worst pollutant can be the PM10 particles (even larger than PM2.5)

- When this happens, the “PM2.5-like formula” should not be applied – as otherwise deducted AQI would be much worst than the actual Air Quality.

- In order to detect the condition of “*PM10 worst than PM2.5*”, simple and affordable particle counters can be used: The idea is not to use the affordable sensor are devices measuring the mass, but instead to use them as device measuring the PM10/2.5 ratio, which they can do easily.

What about when PM10 is the worst pollutant (2/2)

- This is an example of PM2.5/PM10 readings in Beijing on Thursday, April 10th 2014, using both an affordable and low-cost Dylos particle counter (photo on the right) and and expensive met-one BAM station.



Comparative analysis of *Beijing Chaoyang Agricultural Exhibition Hall* (朝阳农展馆) BAM monitoring stations andBeijing Sanlitun Dylos monitoring station (more info about the setup.)

- Both sensors show the same trend– PM2.5 decreasing and PM10 increasing – actually, that day was one of those rare days were PM10 is the worst pollutant.
- So, using a low-cost Dylos counter, we know that we can detect abnormal PM2.5/PM10 correlation in the same way as if expensive dual PM2.5 / PM10 stations where used. Meaning is just using a low-cost sensor is enough to determine when the "PM2.5-like" equation should not be used.

Conclusion

BAM PM$_{10}$

+

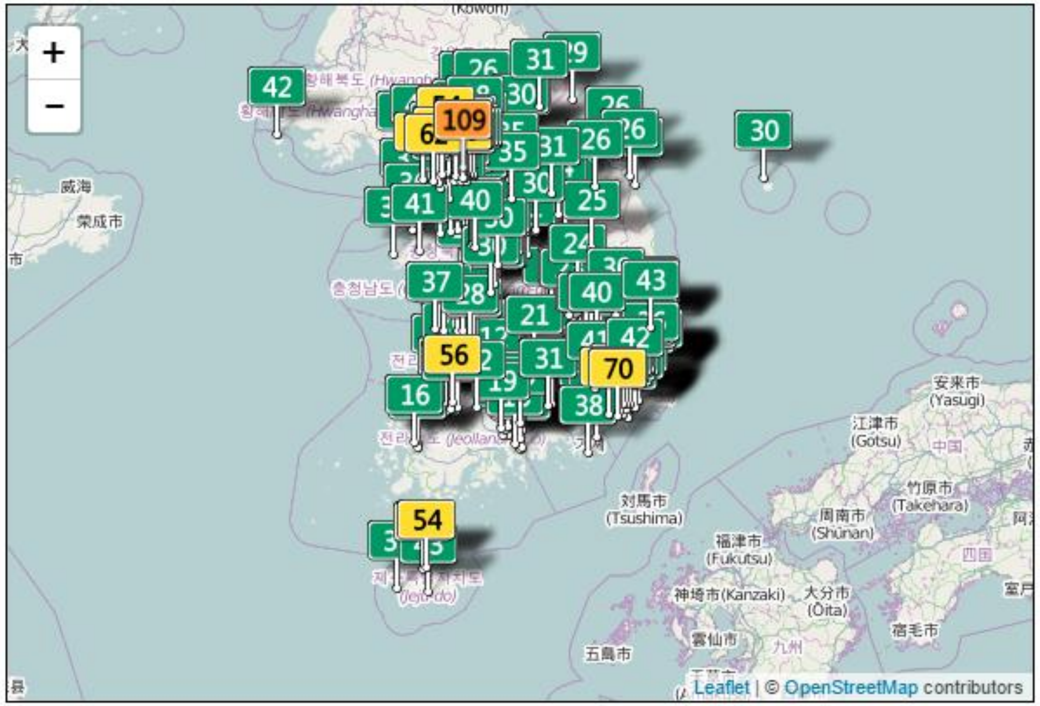
Low-cost Particle Counter

=> BAM-like PM$_{2.5}$

Which AQI should we present to our citizens?

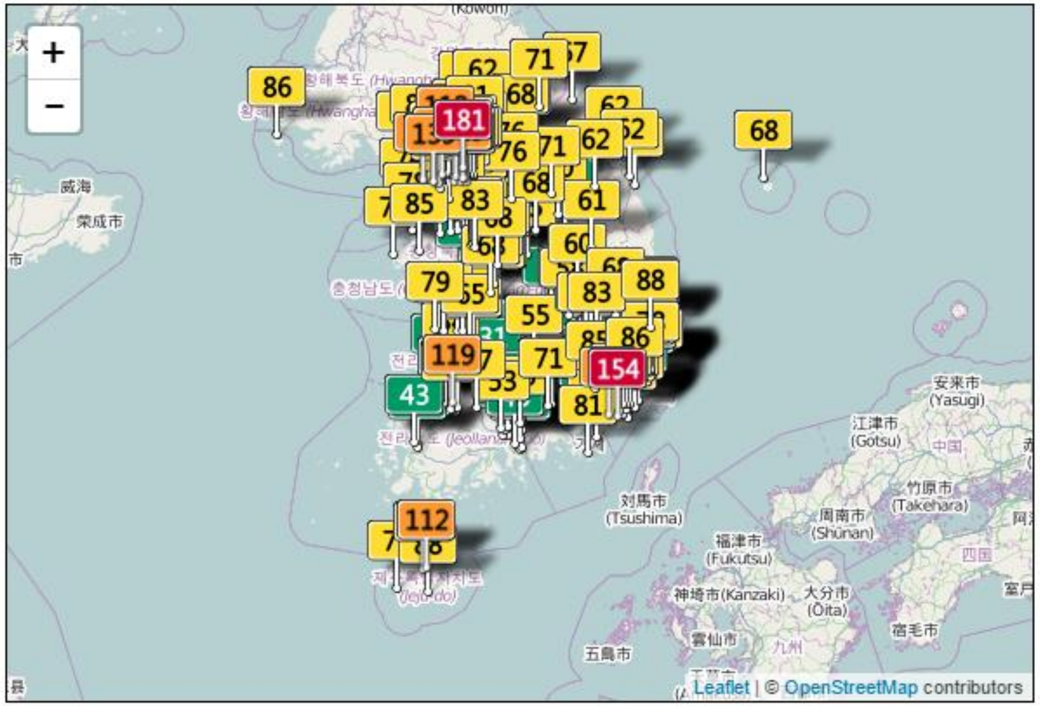
Actual PM10 AQI

(based on actual PM10 readings)



Interpolated PM2.5 AQI

(based on deducted PM2.5 mass)



Above readings are based on real-time data so are udpated hourly - Last update time: Wed Nov 12 2014, 21:00:00 GMT+0800 (China Standard Time)

http://aqicn.org/experiments/south-korea-pm25-air-quality/

Note that after the beginning of this research, the South Korean government has invested in upgrading their network with actual PM2.5 sensor, starting from Seoul and Busan and now extending to the rest of the country.

Questions?

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