High Density Air Sensors: The Power of Next Generation Monitoring for Better Human and Environmental Health.

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elm

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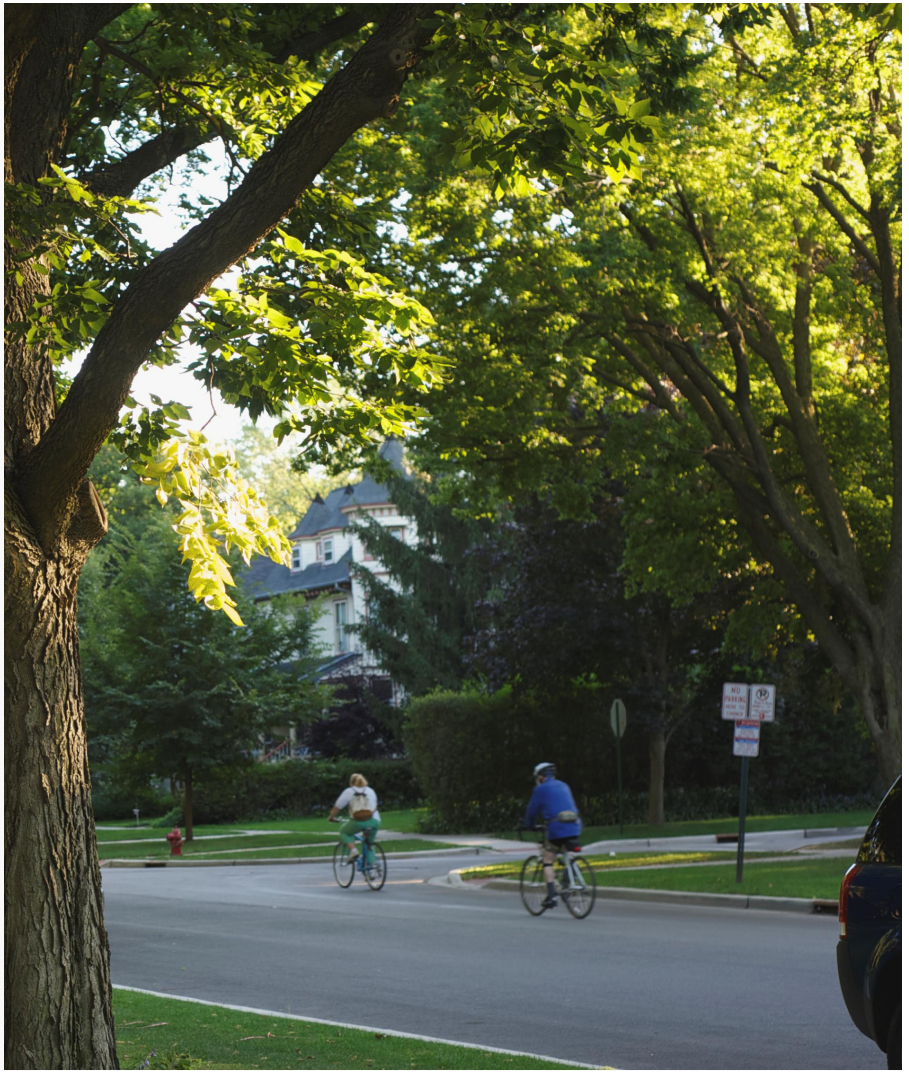


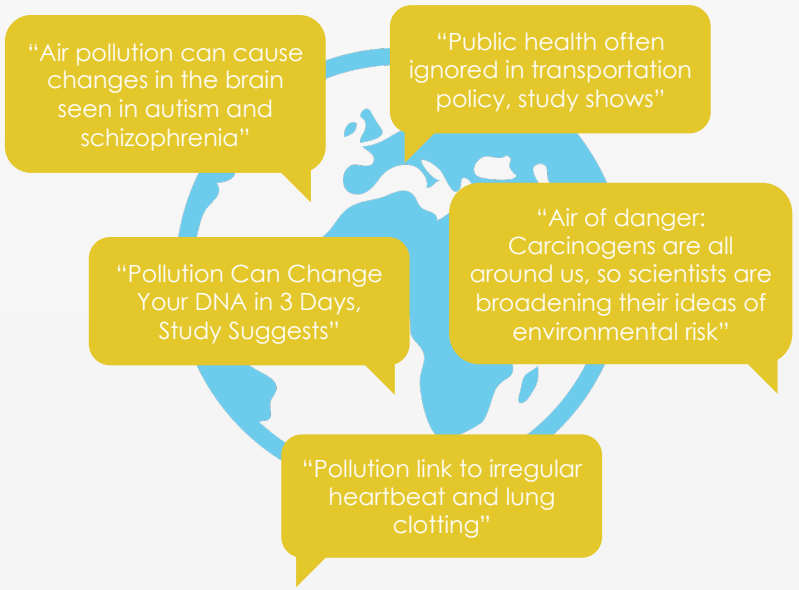
Summary

- Background / Why air monitoring needs new technology
- Elm sensor network experiences in year 1
  - Performance
  - Events
  - Trends
- Where are we headed and how will we get there.

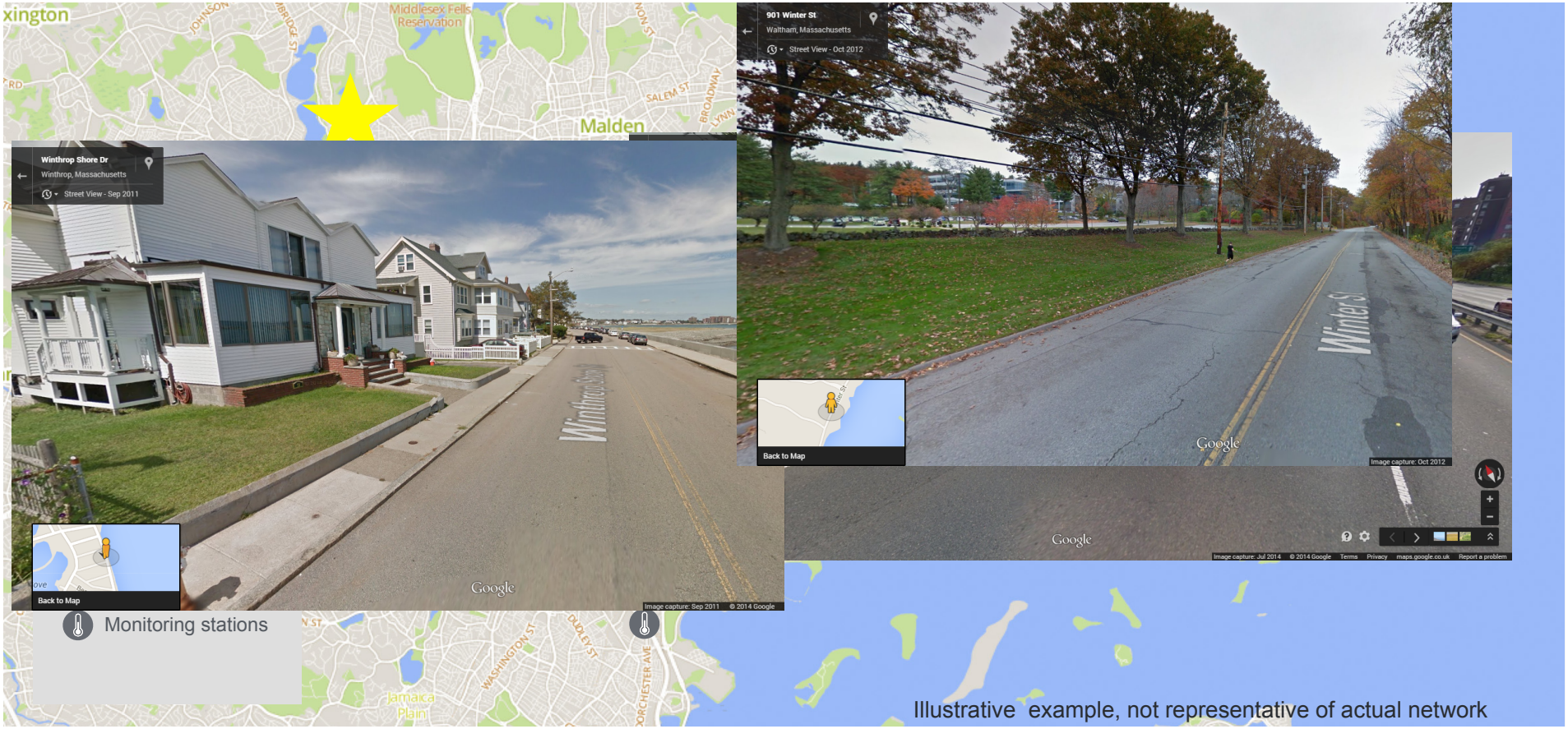
Mass Market Understanding of Air Quality

MARKET TRENDS

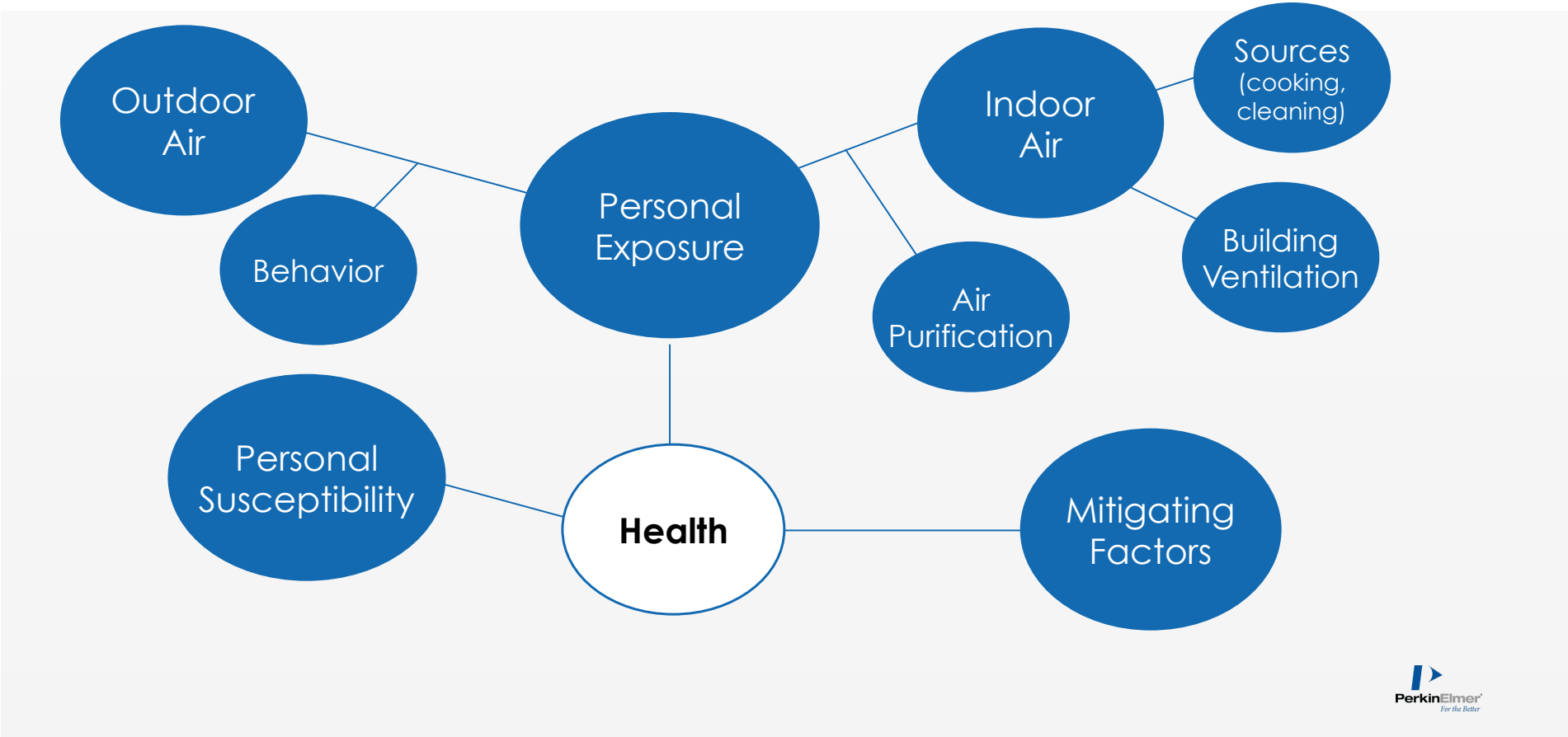
- Population shift into **mega-cities** is **driving increased exposure** to **poor environmental conditions**
- **Environmental conditions** are known to **negatively impact human health**, with continually strengthening research in scientific community
- **High cost of health care** resulting **from chronic conditions**
- **Cities and municipalities want better data to drive policy decisions** and to demonstrate the benefits of those decisions to stake holders
- **Industry** is looking to **understand their actual environmental impact to plan actions proactively** rather than waiting for regulation and imposed requirements



We Simply Cannot Deploy Enough Stations



Better Air, Better Life



State of the Air Monitoring

~$200
1 per family?

$20k +
10-20 per city

Cost

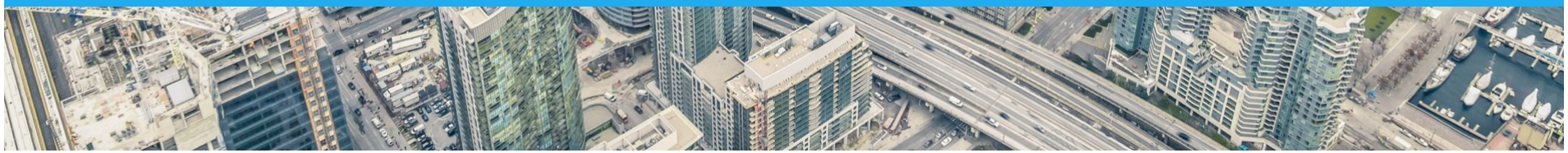
Complication

Bringing clarity to air and health

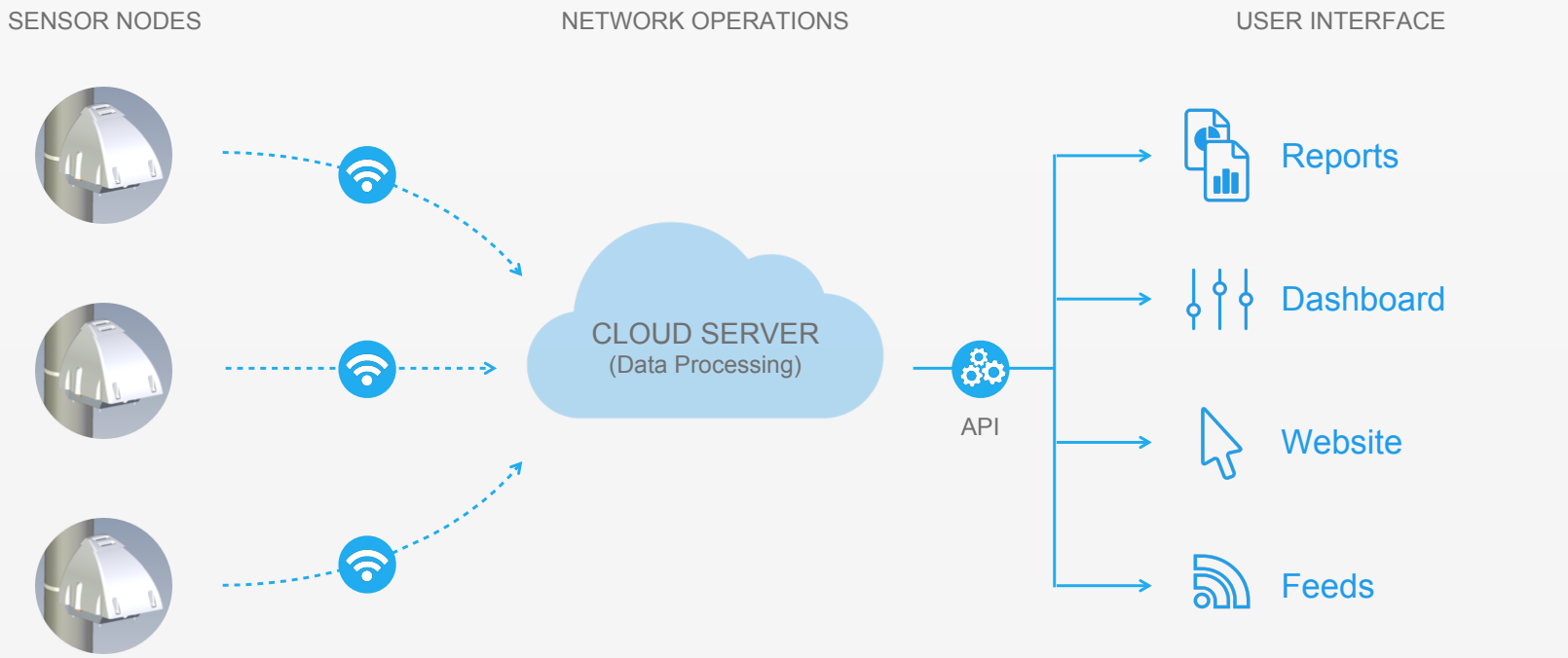
High density
sensor networks

Data to drive decisions;
real time, online, mobile

Data for every location



Network overview



Sensor technology is complimentary to monitoring stations

Practical Experience with Elm

- Comparisons with reference methods
- Local events detected in the network
- How density improves data

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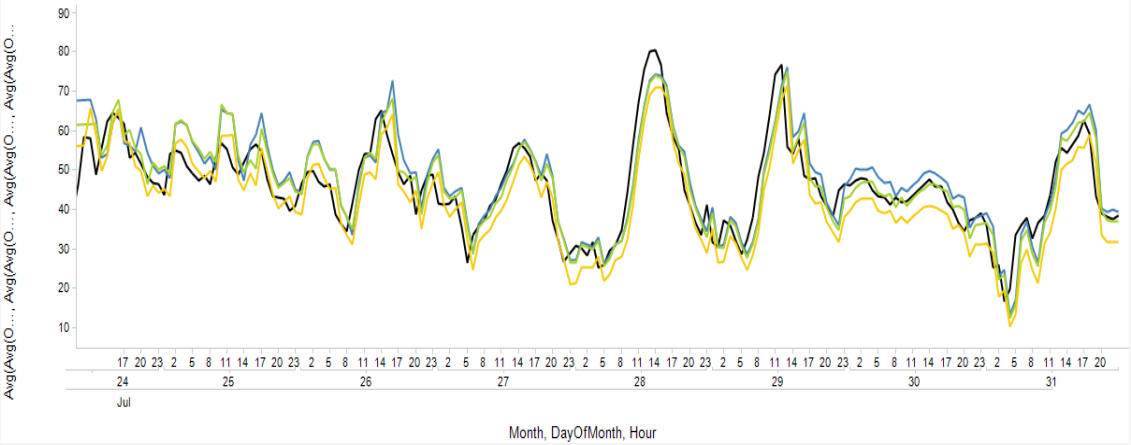
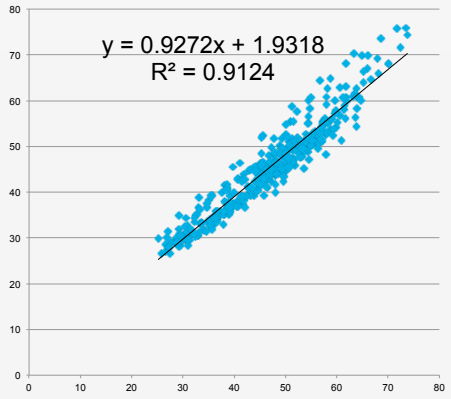
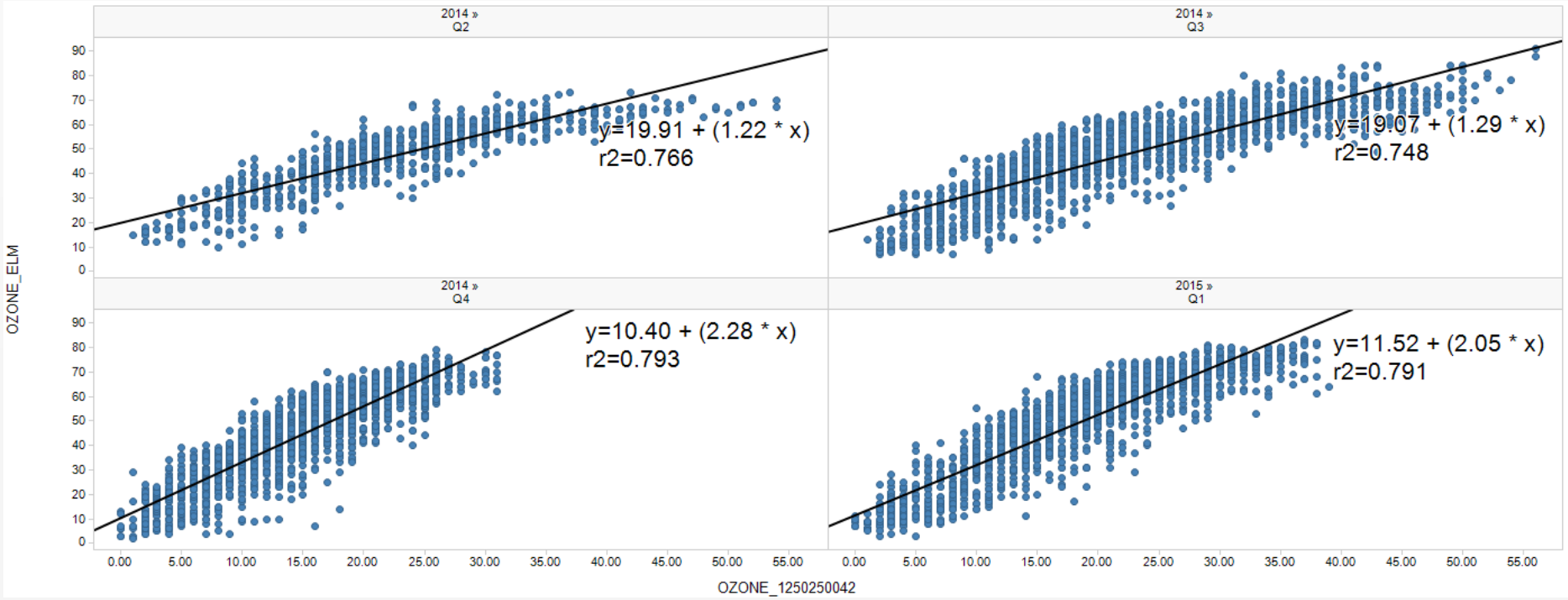
Ozone colocation – CO, USA

Element	Ozone			Units
Averaging period	5 min	1 Hour	8 Hour	Time
True value average	45.4			ppb
Average absolute error	6.0	5	3	ppb
Average percentage error	15	12	6	%
Error Standard Deviation	5.2	4.1	2.8	ppb
R squared	0.68	0.76	0.91	N/A

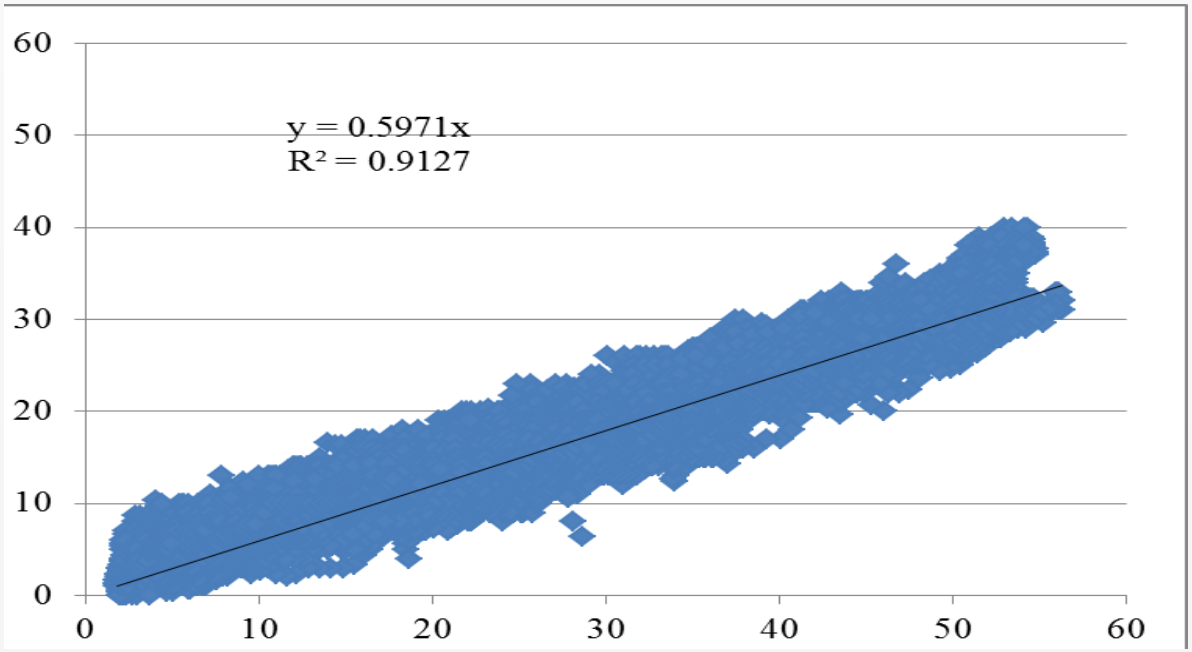




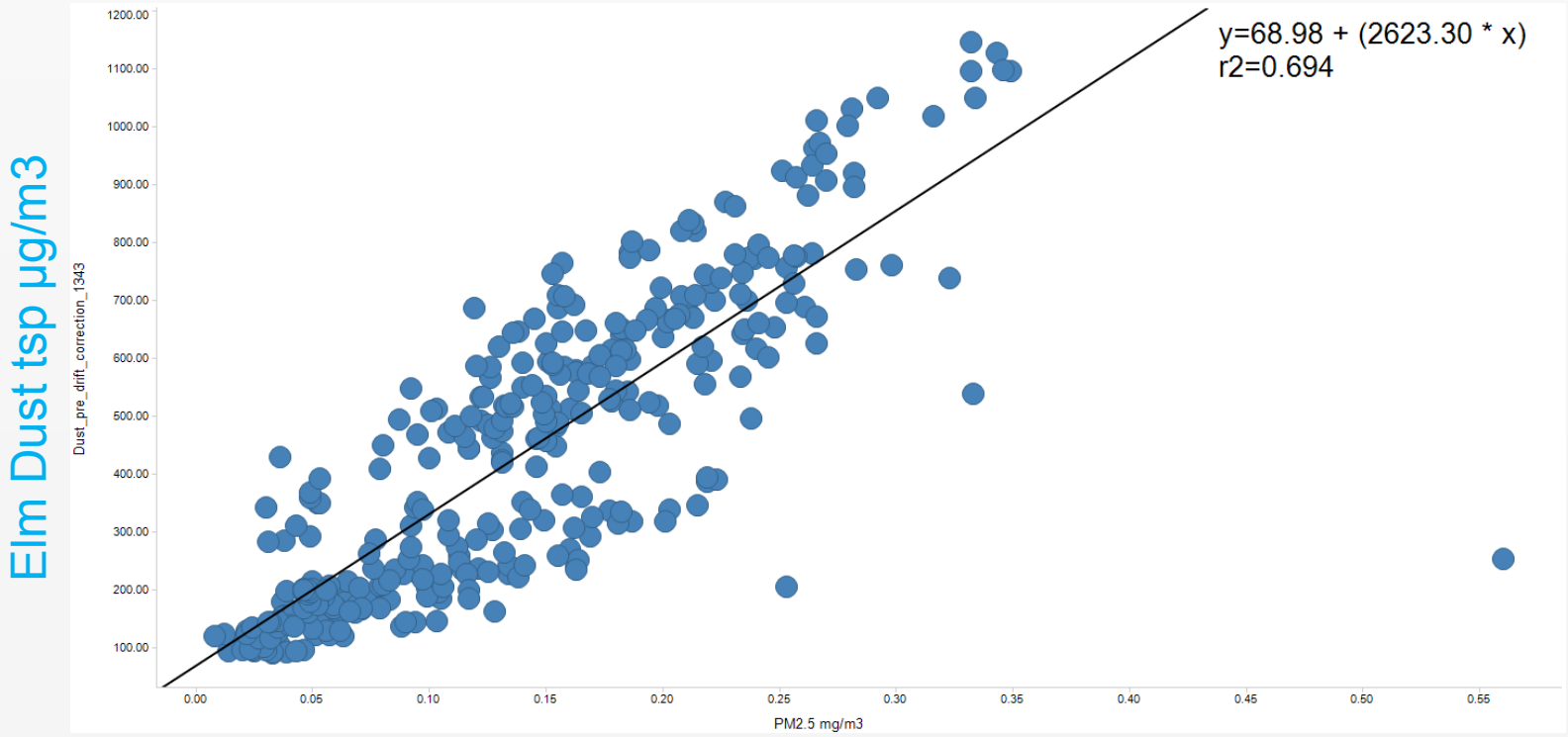
Elm O3 vs EPA O3 Boston (10 months)



ELM O3 Asia Reference Comparison



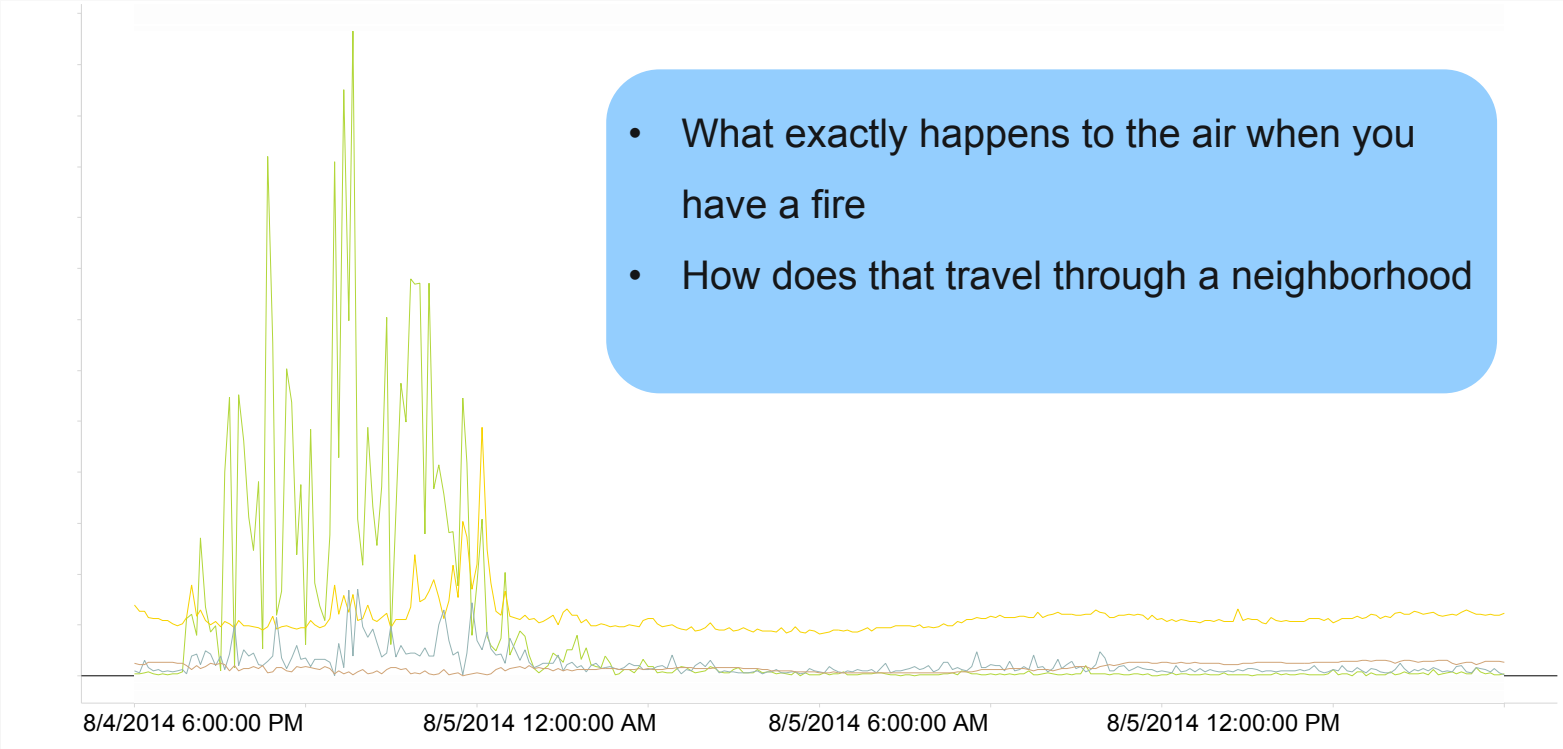
ELM PM Asia Reference Comparison



Where are we headed and how we will get there?

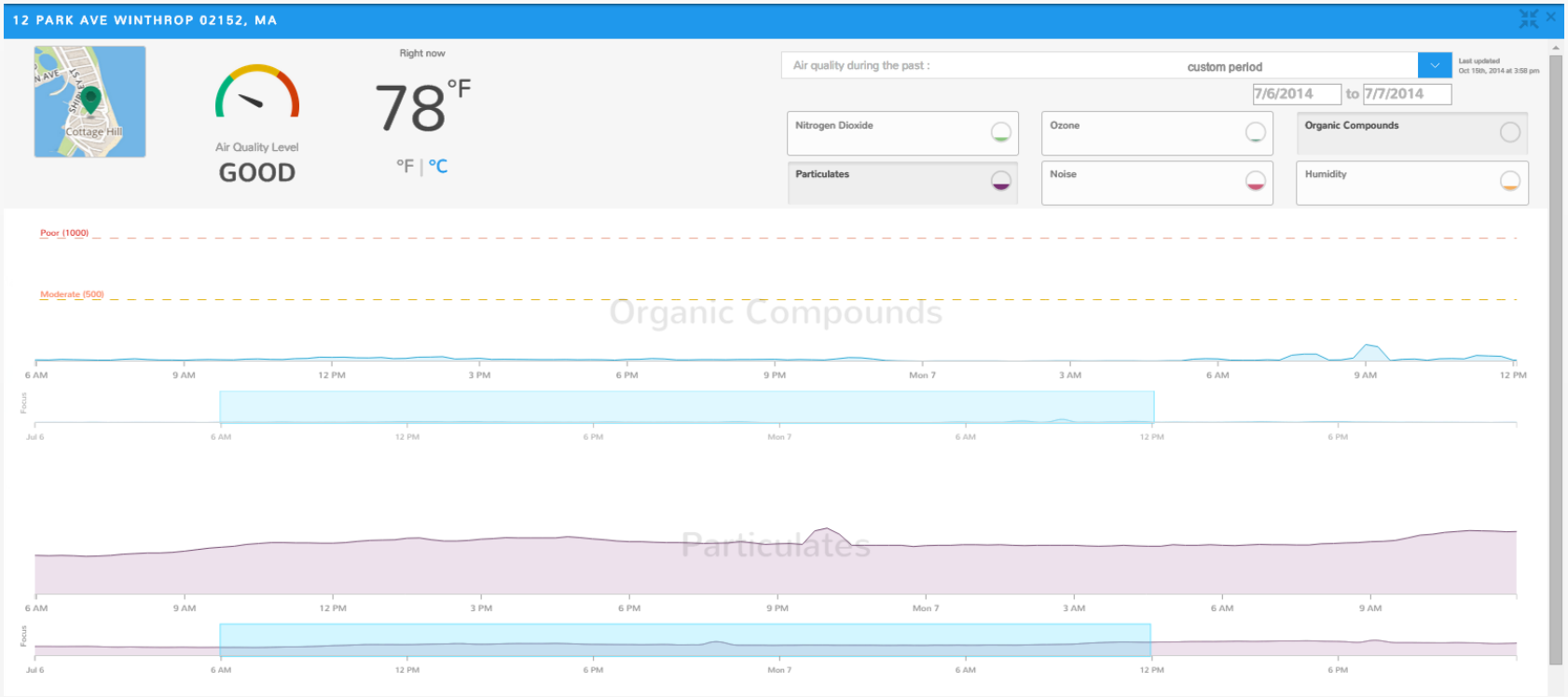
- Demonstrate the value of truly local real-time pollution data
- Create effective mechanisms to operate low cost networks
- Communicate the relevant information to the right audience
- Overcome new issues
- Make the data even more valuable

The Back Yard Bonfire

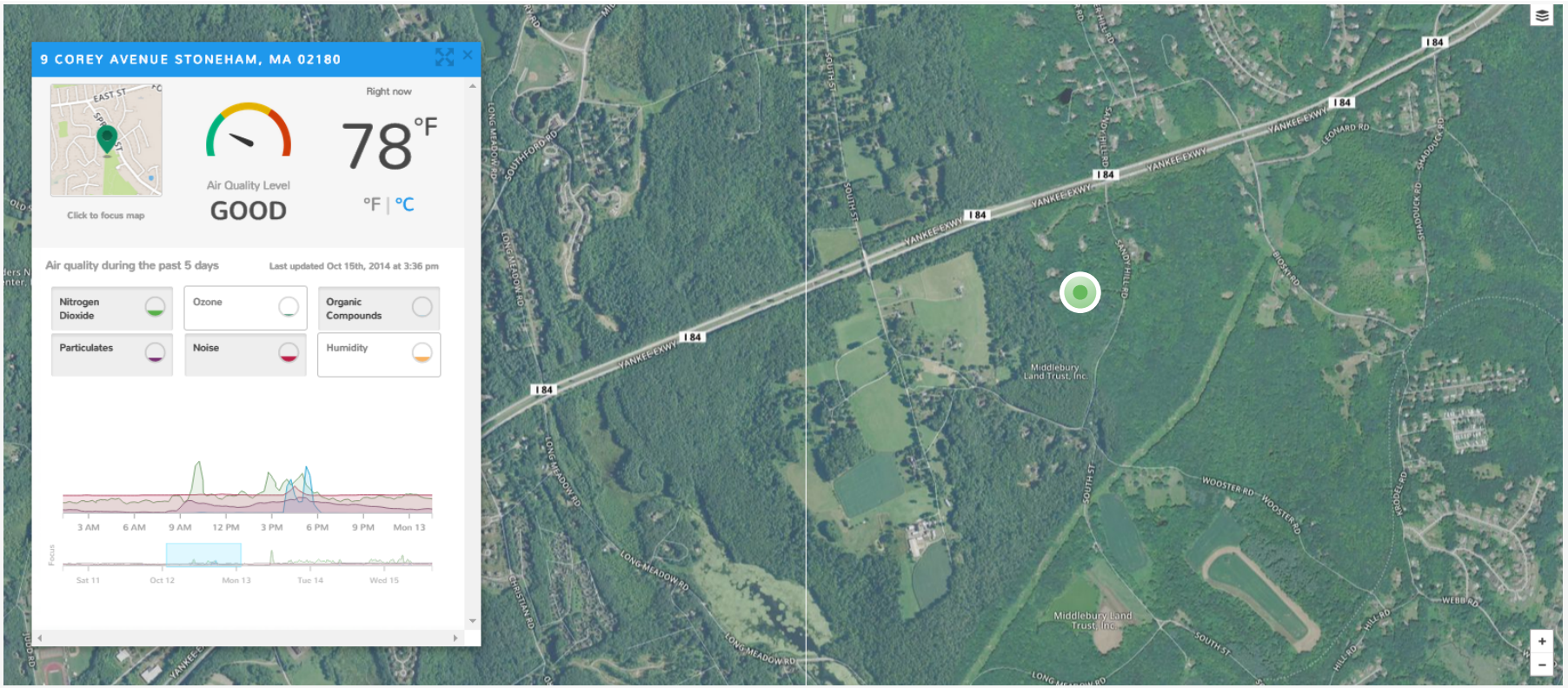


- What exactly happens to the air when you have a fire
- How does that travel through a neighborhood

July 4th

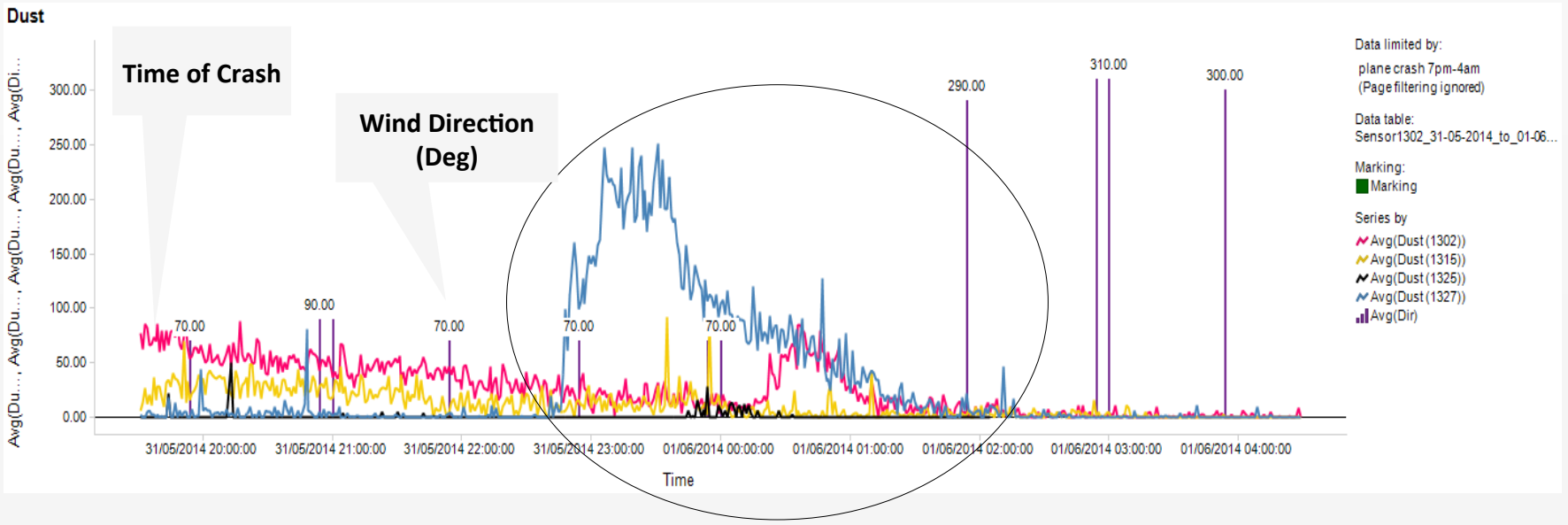

12 PARK AVE WINTHROP 02152, MA
Cottage Hill
Air Quality Level
GOOD
Right now
78°F
°F | °C
Air quality during the past :
custom period
7/6/2014 to 7/7/2014
Nitrogen Dioxide
Ozone
Organic Compounds
Particulates
Noise
Humidity
Poor (1000)
Moderate (500)
Organic Compounds
6 AM 9 AM 12 PM 3 PM 6 PM 9 PM Mon 7 3 AM 6 AM 9 AM 12 PM
Focus
Jul 6 6 AM 12 PM 6 PM Mon 7 6 AM 12 PM 6 PM
Particulates
6 AM 9 AM 12 PM 3 PM 6 PM 9 PM Mon 7 3 AM 6 AM 9 AM
Focus
Jul 6 6 AM 12 PM 6 PM Mon 7 6 AM 12 PM 6 PM

Yard Care

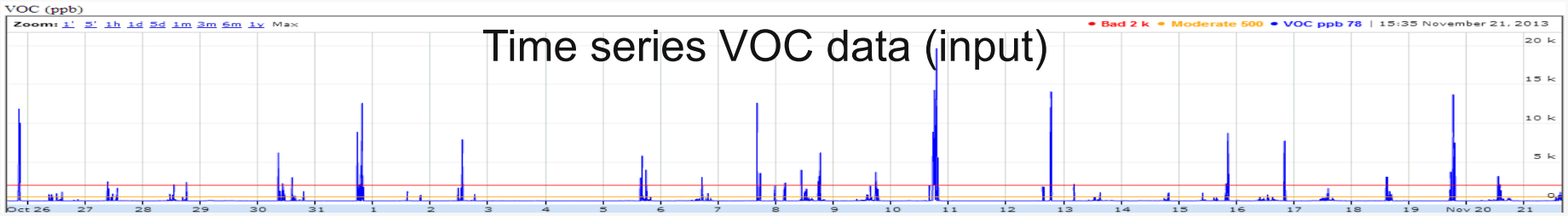

9 COREY AVENUE STONEHAM, MA 02180
Right now
78°F
Air Quality Level
GOOD
°F | °C
Click to focus map
Air quality during the past 5 days
Last updated Oct 15th, 2014 at 3:36 pm
Nitrogen Dioxide
Ozone
Organic Compounds
Particulates
Noise
Humidity
3 AM
6 AM
9 AM
12 PM
3 PM
6 PM
9 PM
Mon 13
Sat 11
Oct 12
Mon 13
Tue 14
Wed 15
I 84
YANKEE EXWY
SOUTH ST
SAND HILL RD
LONG MEADOW RD
SOUTHFORD RD
LEONARD RD
SHADDUCK RD
BOSART RD
WOOSTER RD
HILL RD
WEBB RD
Middlebury Land Trust, Inc.

TSP Resulting from a Jet Crash

Importance of Meteorological Data

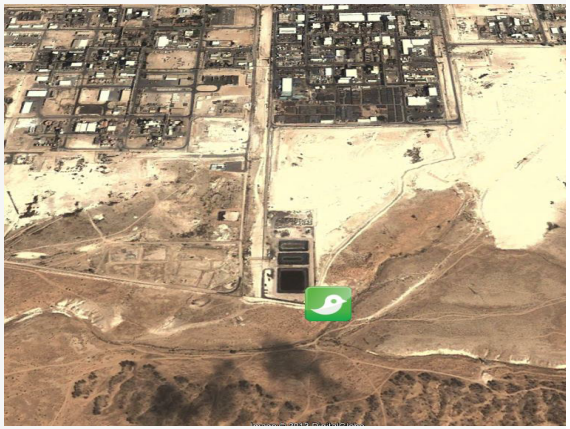


Back Trajectory to VOC Sources

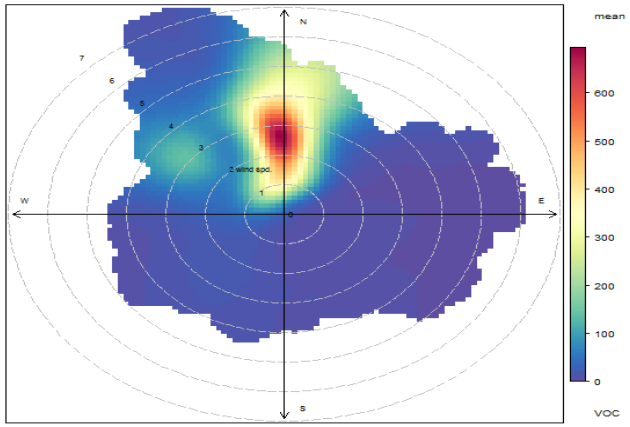


Time series VOC data (input)

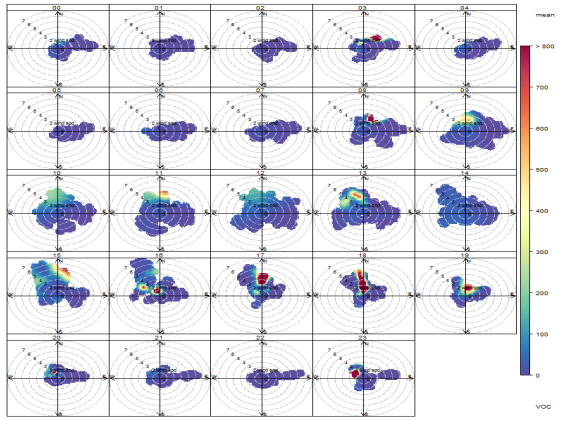
Location



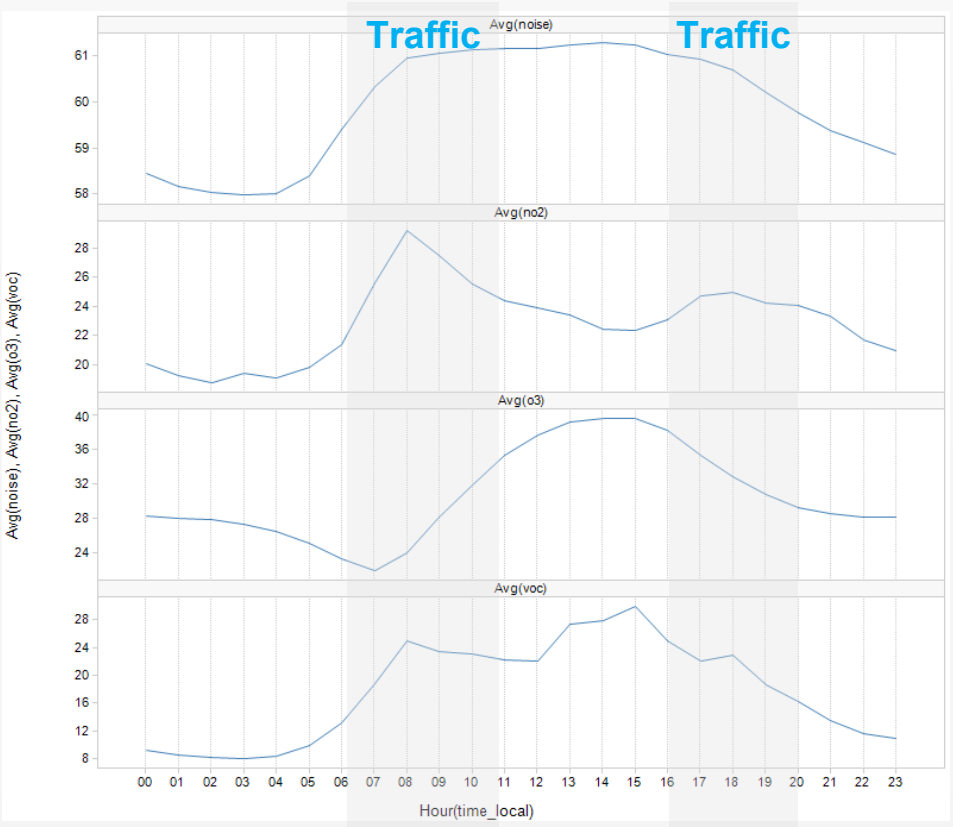
Source direction

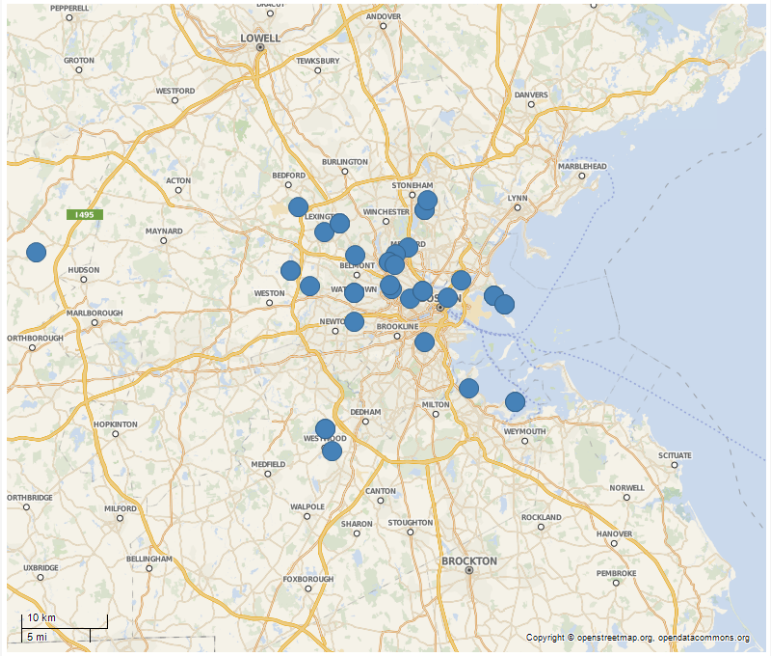


Time analysis

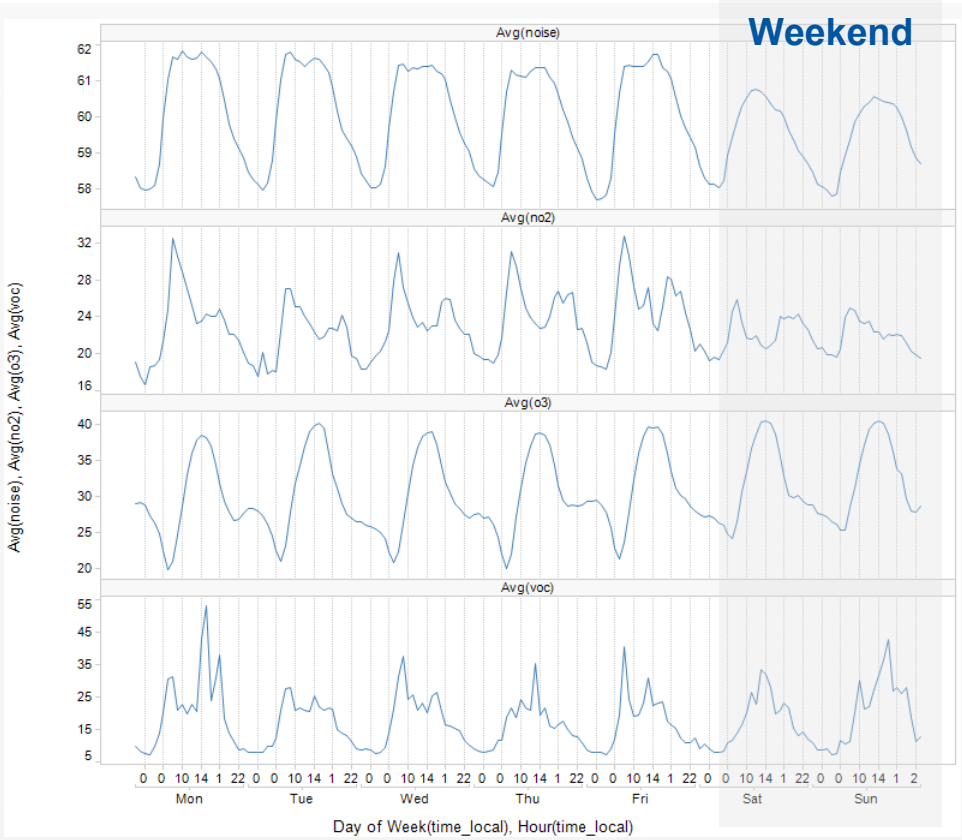


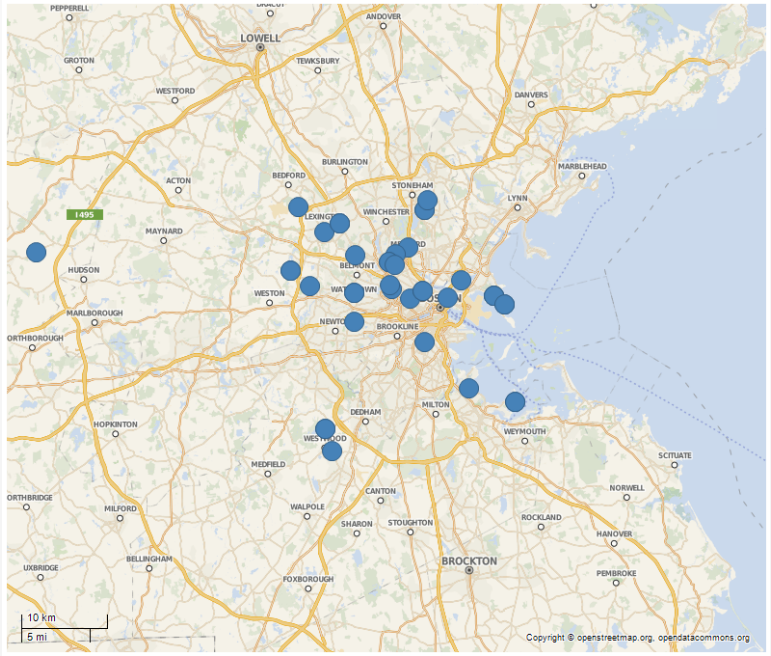
Boston's Diurnal Pattern – 25 units averaged over 6 months



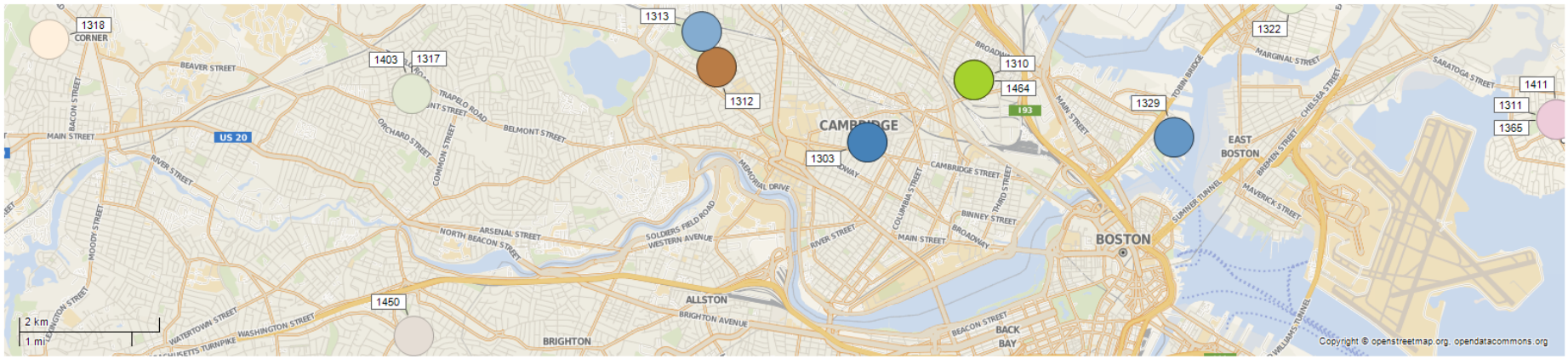


Boston Weekly Pattern –25 units averaged over 6 months

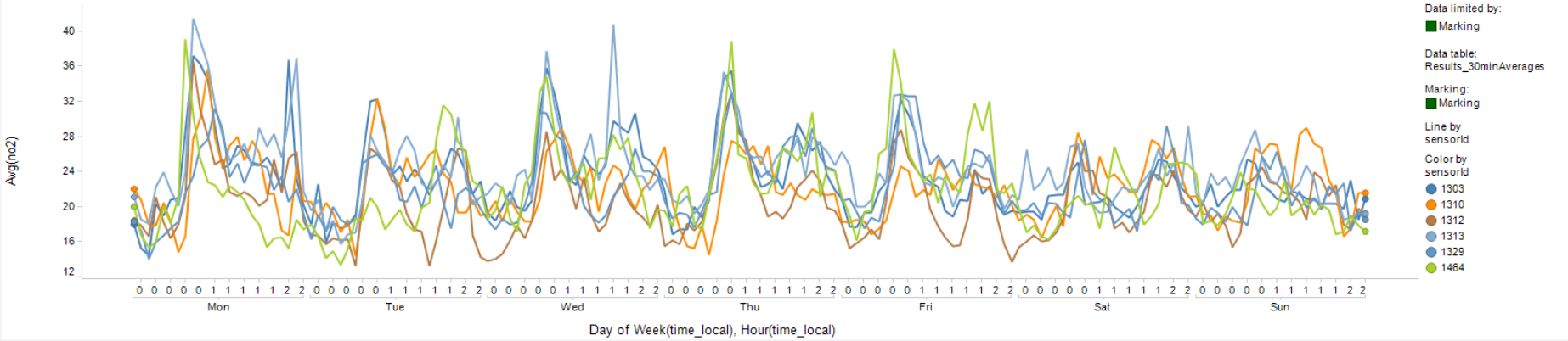




Boston Weekly Pattern – No2 6 units nearby



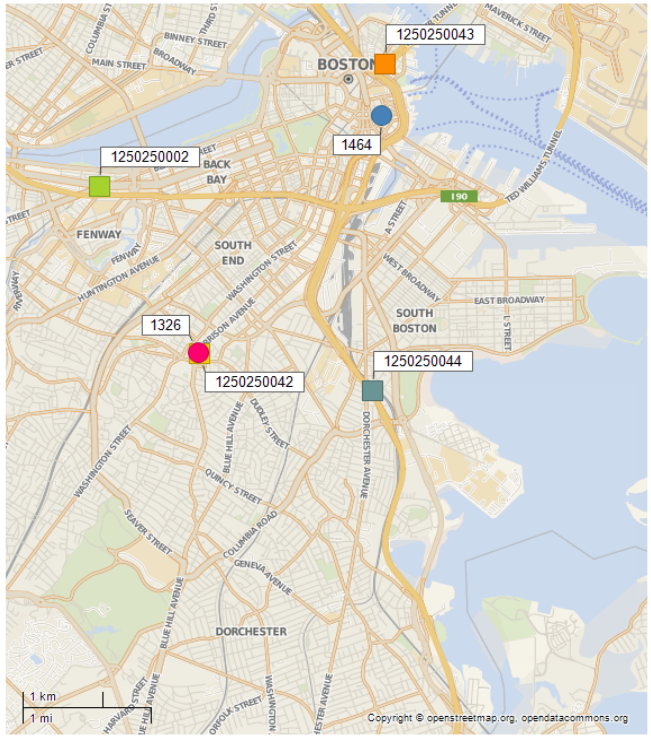
Weekly pattern each station NO2 6 months averages



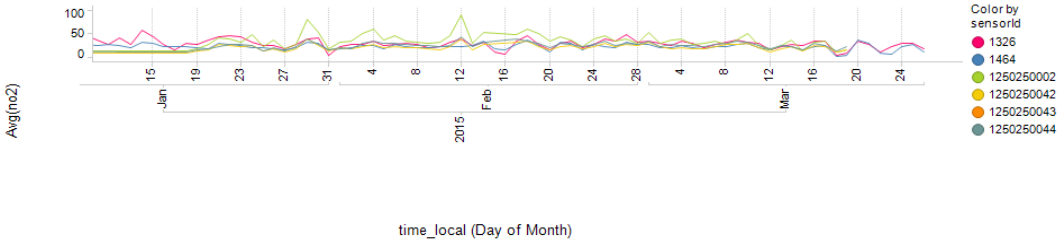
NO2 Boston vs close AQM stations

1464 and 1326 are elm, vs AQM referance

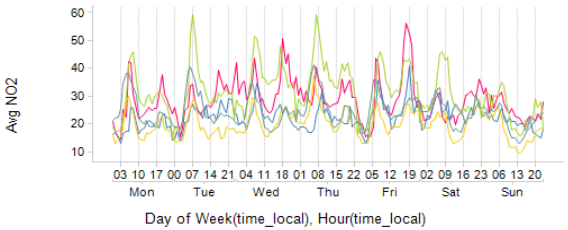
Square shapes - AQM stations
Round shapes - elm stations



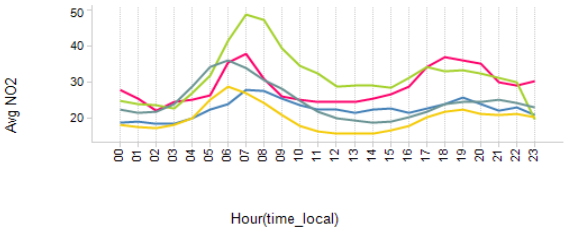
30min Average data for NO2 Daily Avergae



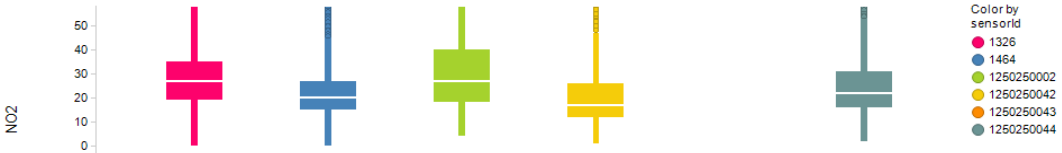
By day of week and hour



By hour of day



Data Distribution



	1326	1464	1250250002	1250250042	1250250043	1250250044
Median	27	20	27	17	(Empty)	22
Avg	28.8605	22.4705	31.6076	19.9376	(Empty)	24.7201
Min	0	0	4	1	(Empty)	2
Max	279	274	163	72	(Empty)	76

sensorId

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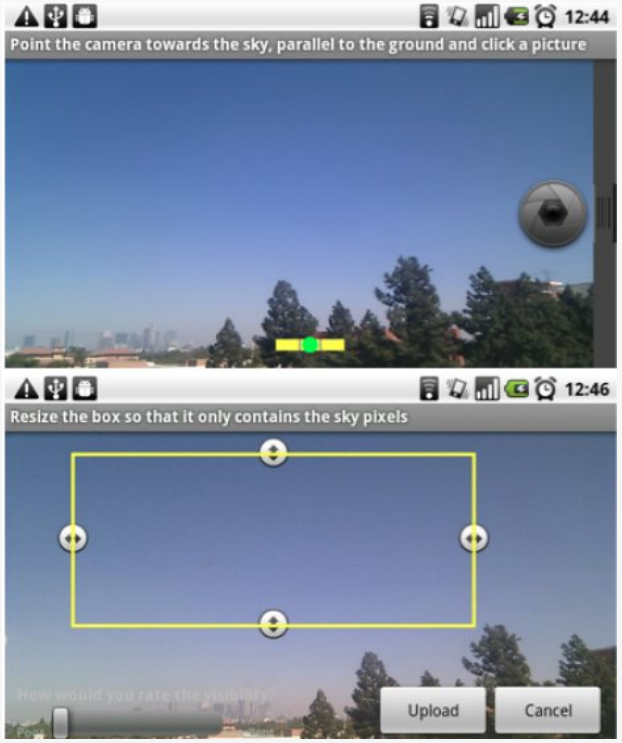
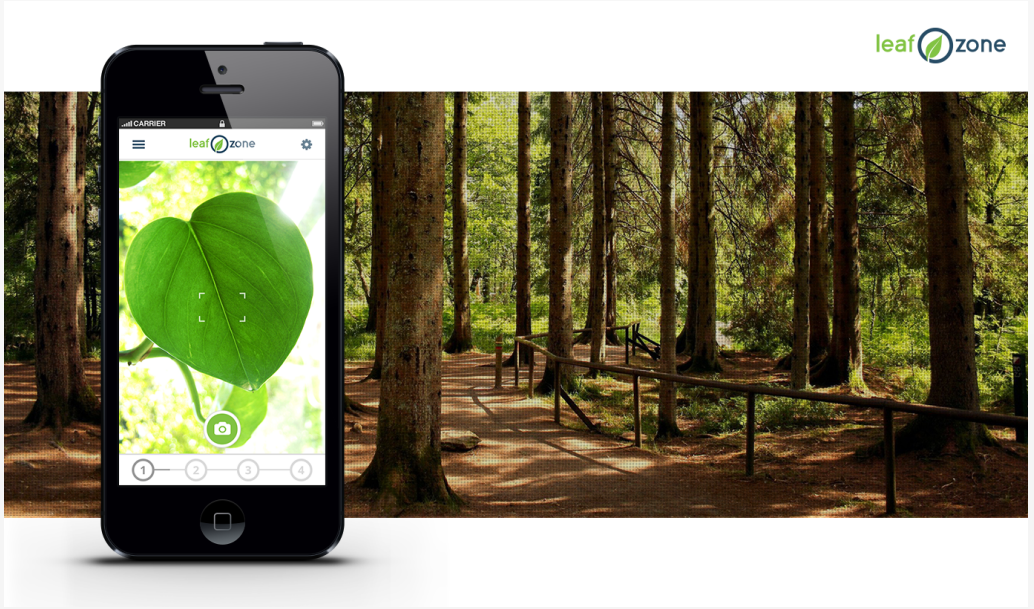
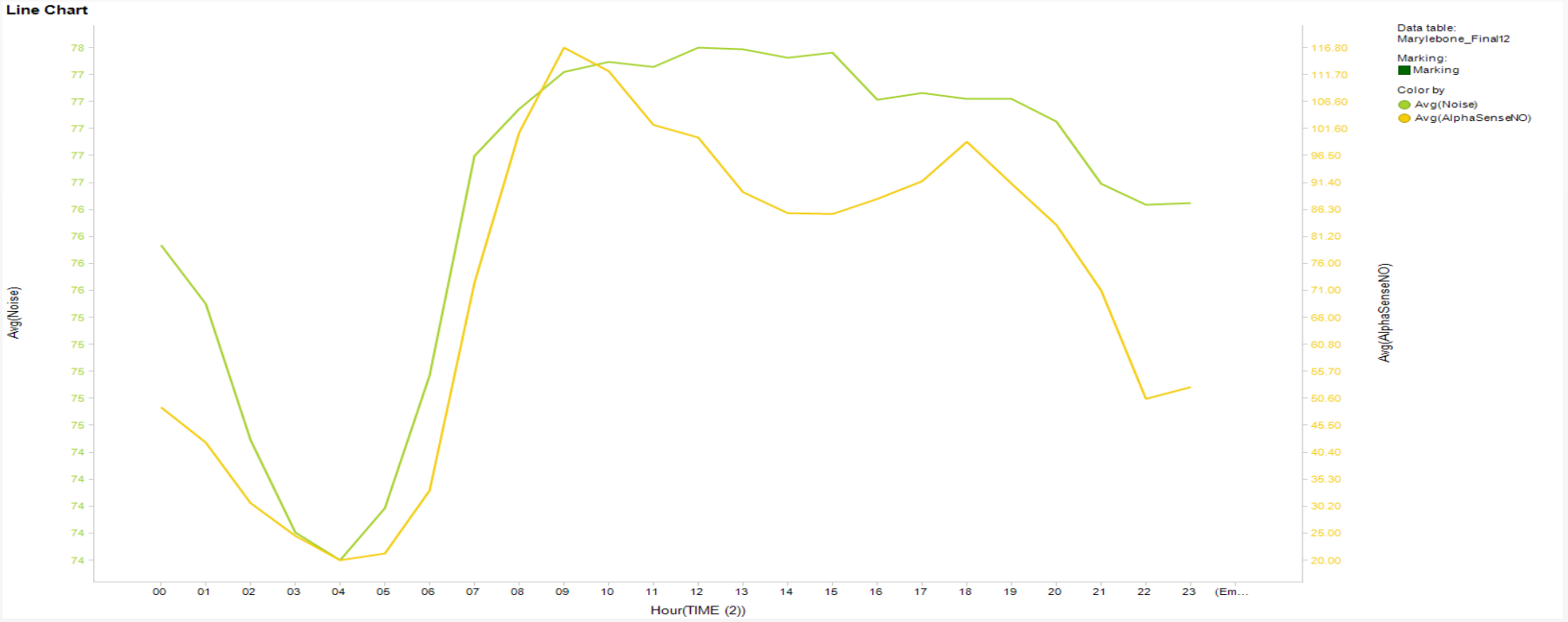
How can we add even more to the data?

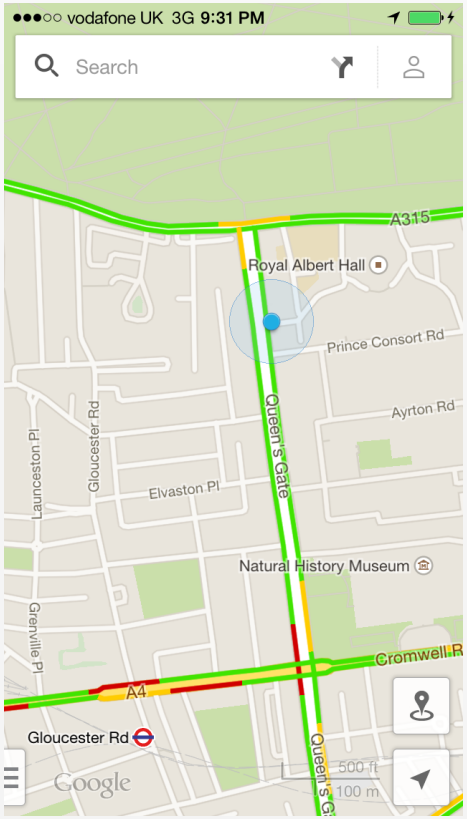




Noise Vs NO


Line Chart
Avg(Noise)
78
77
77
77
77
77
76
76
76
76
75
75
75
75
75
74
74
74
74
74
Avg(AlphaSenseNO)
116.80
111.70
106.60
101.60
96.50
91.40
86.30
81.20
76.00
71.00
66.00
60.80
55.70
50.60
45.50
40.40
35.30
30.20
25.00
20.00
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 (Em...
Hour(TIME (2))
Data table:
Marylebone_Final12
Marking:
Marking
Color by
Avg(Noise)
Avg(AlphaSenseNO)

What will truly dense networks enable?



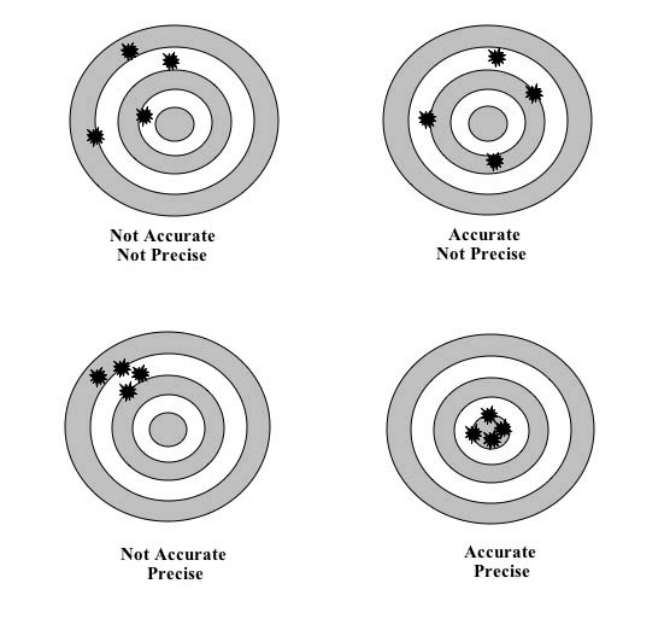
Valuable insights

- Real-time decisions and recommendations
  - Be it traffic management, walking to school, where to jog… eventually where public health risks are highest?
- The ability to understand your exposure
  - Ubiquitous devices or mobile sensors
- Individualized exposure data
- Data to link exposure with health
- Event detection

What are the new Challenges will we face?

- Enabling the masses to measure will bring up a whole series of complications. Relevant info for the right audiences.
- Litigation and indicative data?
- How do you rationalize historical legislation and standards with new technology?
- What about industry?
  - Networks can enable industry to further improve their processes.
  - Risk of measuring something that is not mandatory.

How do we communicate the relevant information to the relevant audience?



- Providing technical audiences a means to evaluate the performance of the system real-time.
- Tools to fully use heterogeneous air quality data.
- Explaining complicated ideas such as precision and accuracy of a dynamic system to lay people.
- Summarizing it in a means that is most useful in the specific setting.

Putting it together – how we will get there.

- Demonstrate the value of the data to many stakeholders including the public.
- Deliver the information in through customized applications that enable specific decisions.
- Make the data personal and interesting, enabling people to make decisions they feel good about.
- Make it social
- Make it positive - Air pollution exposure is often something we have some control over. Empower people.