State of Air Sensors
Yesterday→ Today → Tomorrow

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Brief History of Air Quality Sensors

It started long ago.

1800s to 1900s - Canaries save lives

Canaries in coal mines provided advance warning of toxic gases.

1974 - First PID for continuous sensing

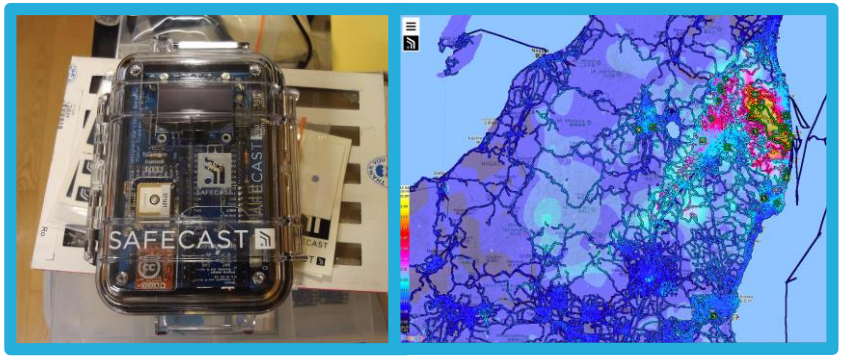
Photoionization detector (PID) introduced as a hand-held instrument to detect leaks for Volatile Organic Compounds (VOCs). First introduced in 1974, early portable PIDs were bulky, heavy (9 lbs.), and had a separate hand-held probe and a controller carried by a shoulder strap.

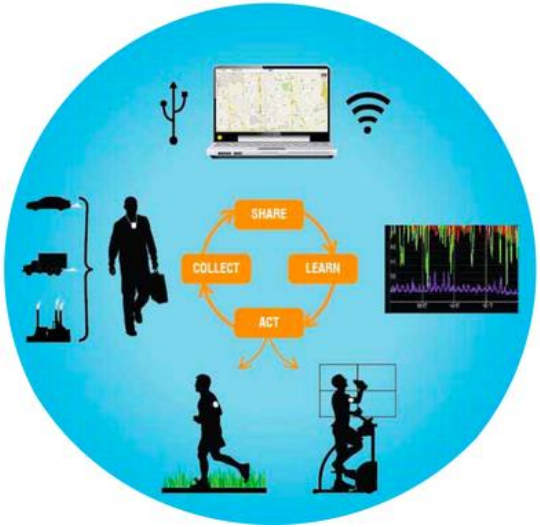
2008 - Air sensing pod used by communities

Common Sense program by Intel Berkeley built a mobile sensing pod that measured pollutants using low-cost sensors.

2011 Crowdsourced radiation data makes an impact

Safecast started in response to the meltdown of the Fukushima Daiichi Nuclear Power Plant in Japan. Where a group of volunteers quickly began monitoring, collecting, and openly sharing information on environmental radiation.



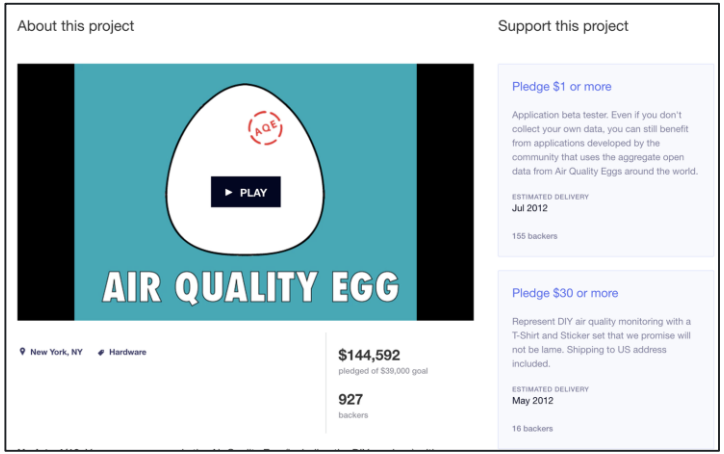


2012 - First U.S. meeting for low-cost air quality sensing

The U.S. EPA hosted the first comprehensive meeting on air quality sensors. The workshop helped set a path for EPA's low-cost air sensor program.

2012 - Low-cost sensor created by crowdfunding

Air Quality Egg funded via Kickstarter produced 800 air quality sensing eggs. The eggs measured carbon monoxide, nitrogen dioxide, temperature, and humidity using low-cost sensors, but poor accuracy of the eggs frustrated and soured many users.

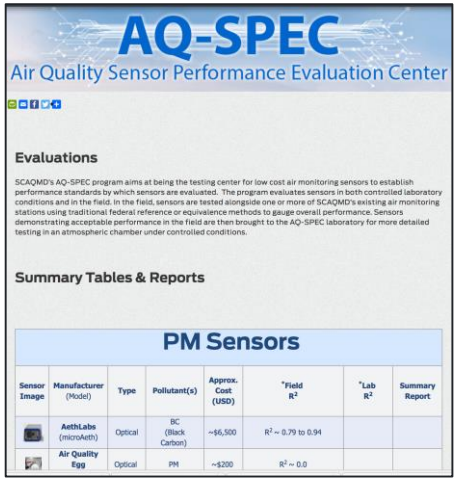


2013 - Good advice provided by U.S. EPA

Air Sensor Guidebook provided practical information on types of pollutants, what to consider when buying air sensors, steps to collect useful data, how to assess performance, and more.

2014 - Open-source PM sensor system launches

AirBeam, an open-source air sensor system, was released by HabitatMap for personal monitoring for $PM_{2.5}$. Users crowdsourced data on the AirCasting app and website to vividly show a region's particle levels.

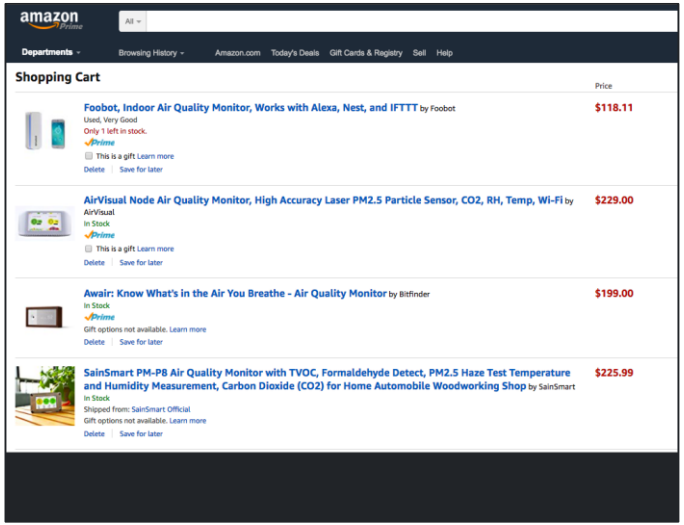


2016 - Startup and more startups

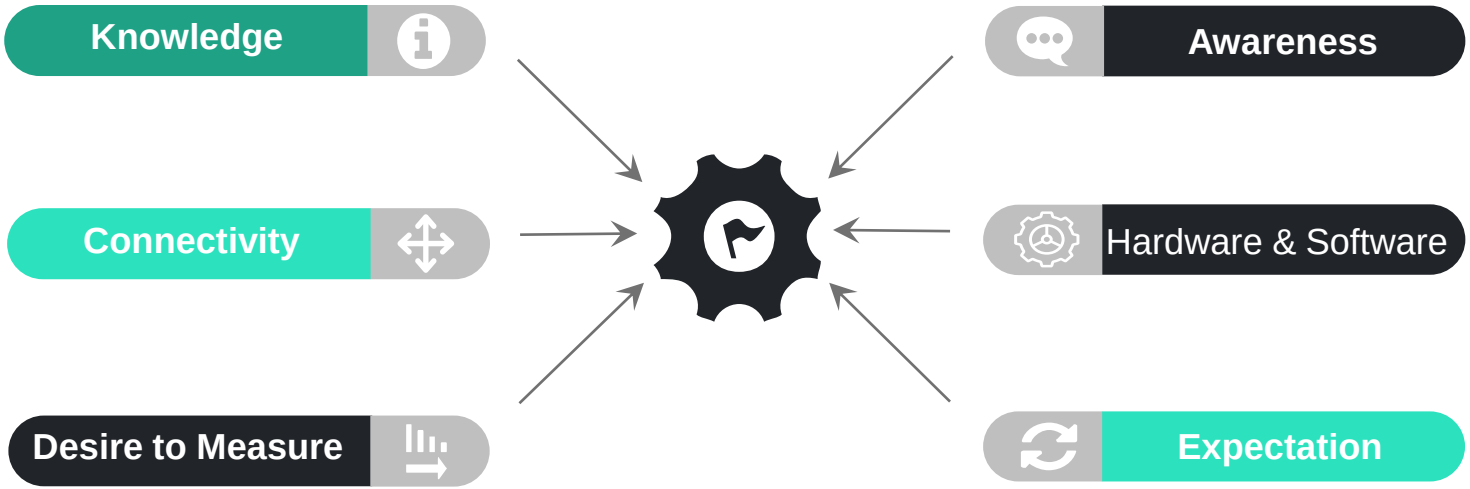
At a pace of almost one new company per week, startups seek to develop air quality sensor for the consumer market. You can buy air sensor systems for around $200 on Amazon. Many devices look beautiful with flashy apps, videos, and websites. While many of them look interesting, the accuracy and quality of the data often remains elusive.

2014 – Game-changing evaluation center launches

The South Coast Air Quality Management District in Los Angeles set up a comprehensive evaluation center for air sensors. It evaluated the accuracy and usability of commercially available, low-cost air quality sensors.



Tipping Point



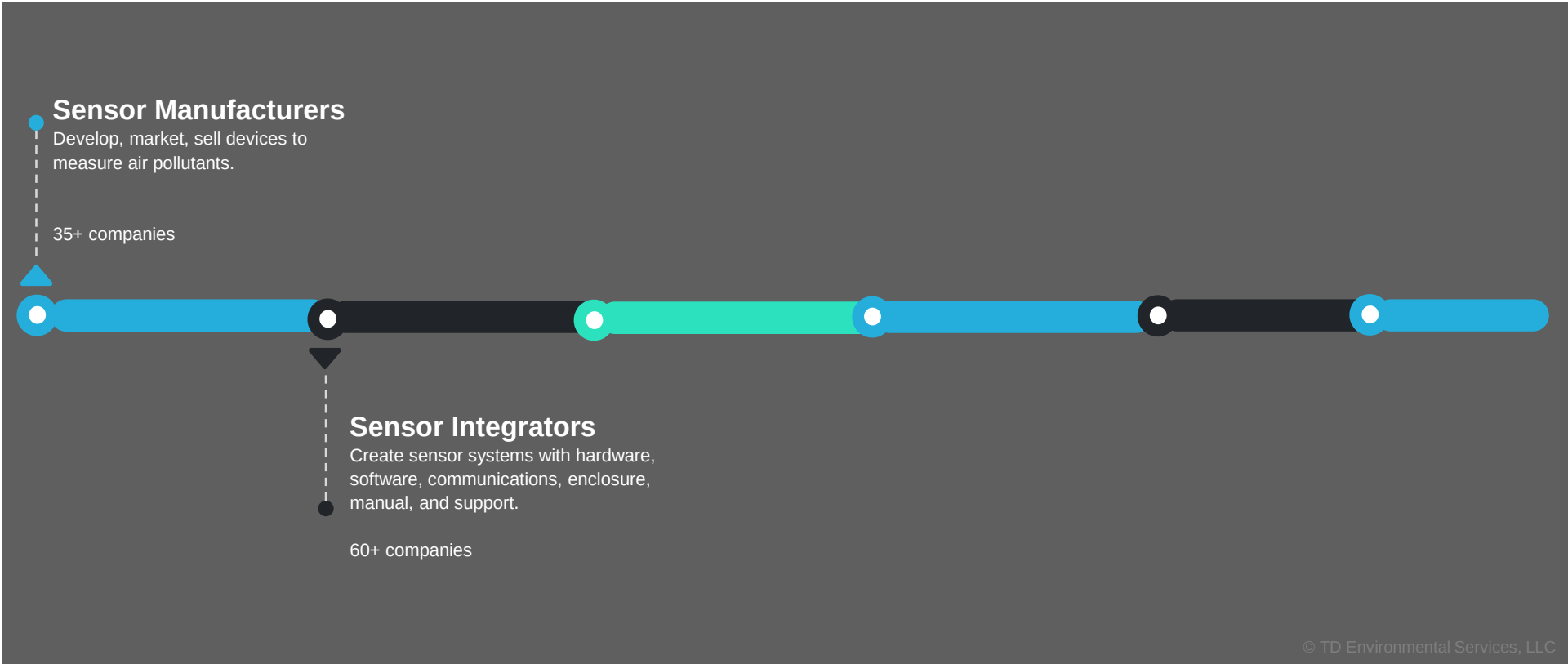
State of the Market

- Dominated by startups and small hardware/software companies
- Large unknowns about sensor performance
- Few standards exist, no regulations accepting of sensors
- Lots of interest in monitoring local air quality
- Funding for demonstration and proof-of-concept projects
- Some early results are promising

Value Chain

Lots of work needed to create actions and benefits

Definition, Roles, and Current Status



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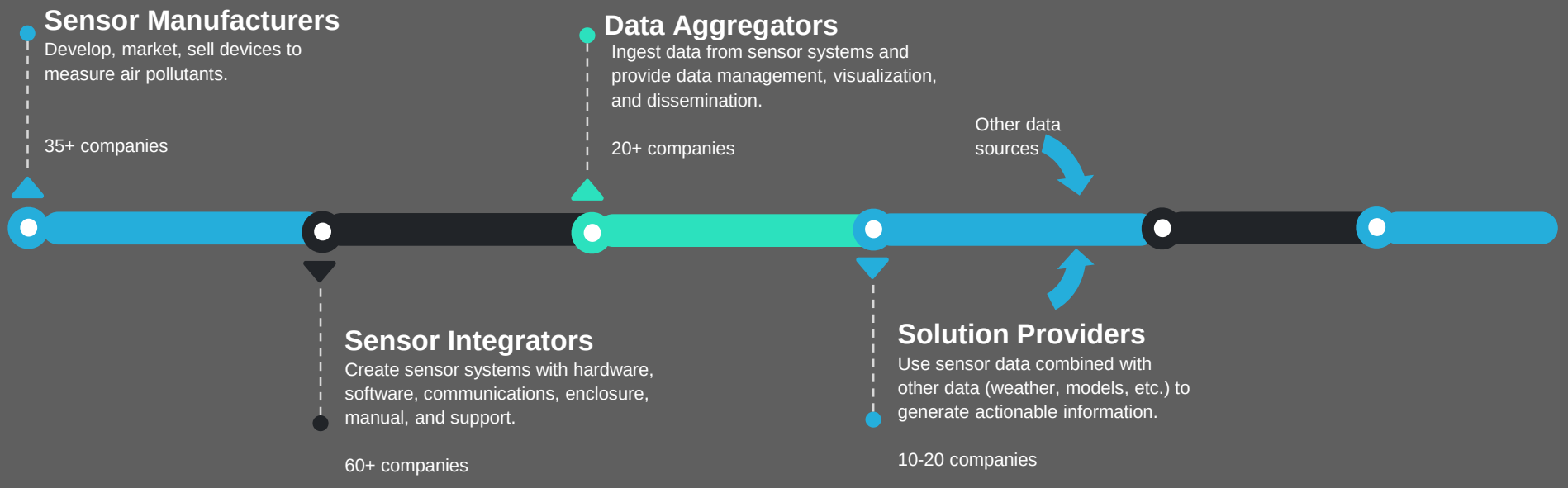

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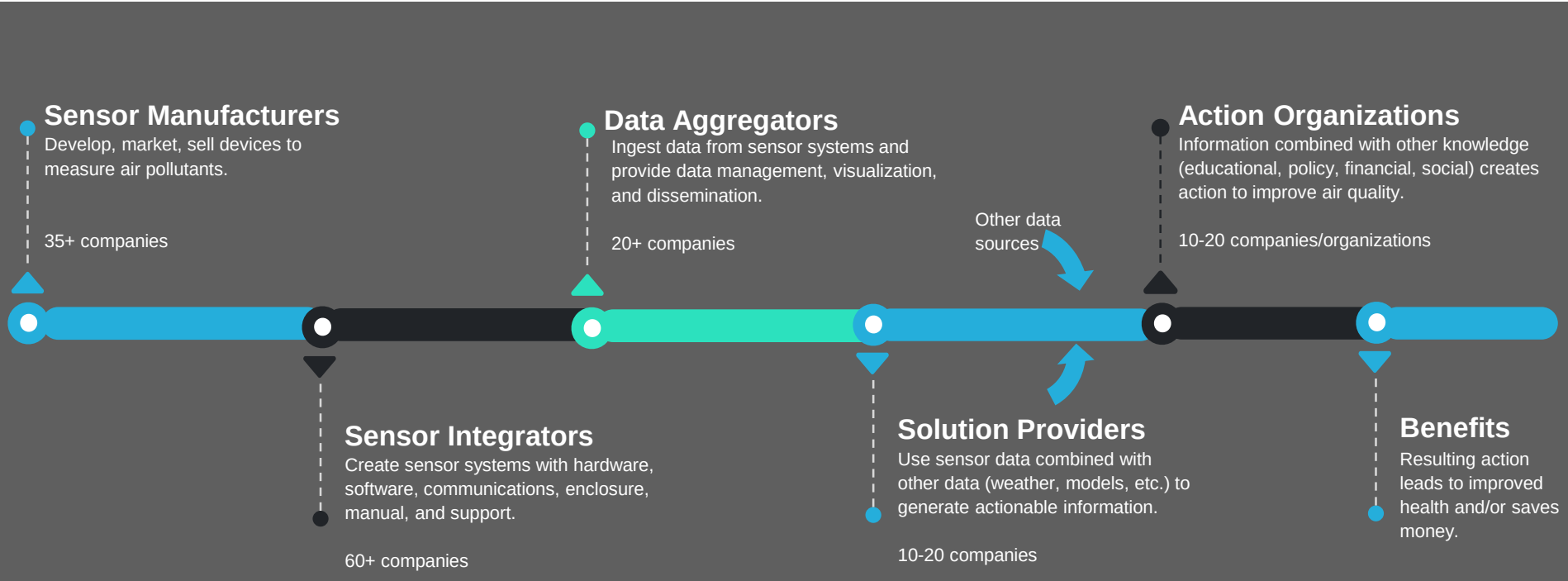


Sample Project

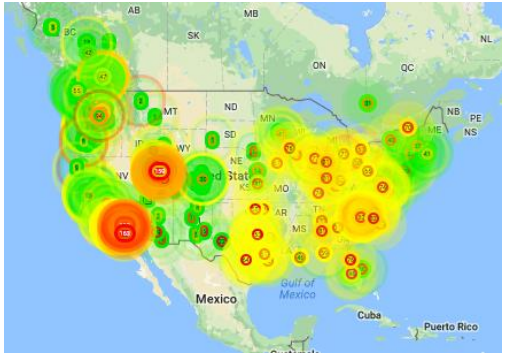
Organization: Purple Air

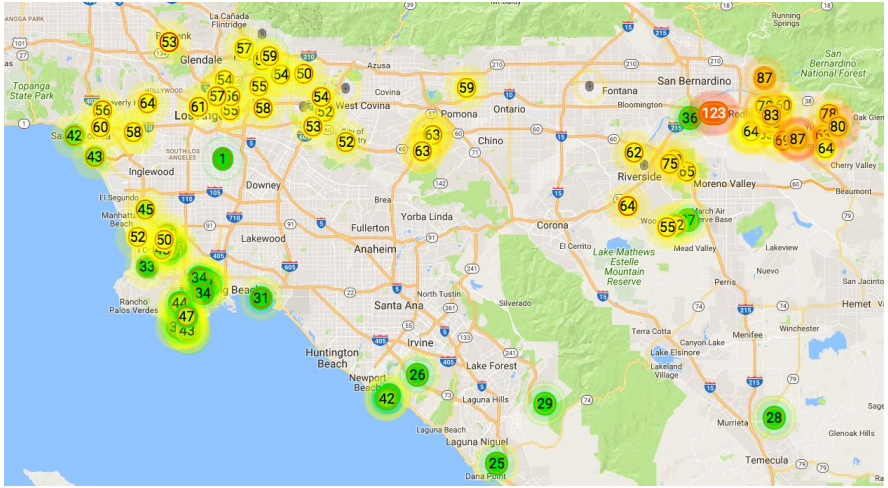
Dates: 2015+

Objectives: Helping others monitor air quality

Pollutants:

- PM_1, $PM_{2.5}$, PM_{10},
- 550 sites
- Growing rapidly (200+ per month)





"*People really care. They want to monitor PM for their health, exercising, when to open windows, buying a house, wildfire smoke, and more".* - Adrian Dybwad, Founder of PurpleAir

Sample Project

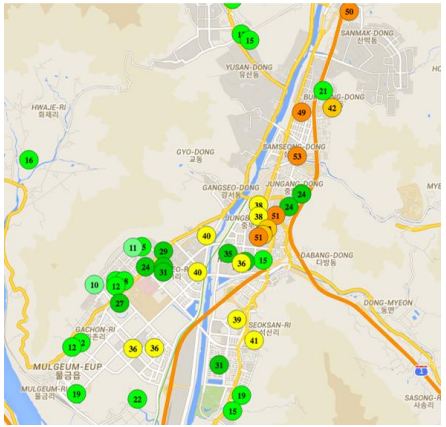
Organizations: Academia Sinica and National Taiwan Normal University

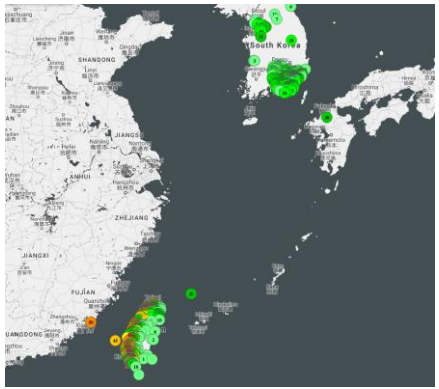
Dates: 2016+

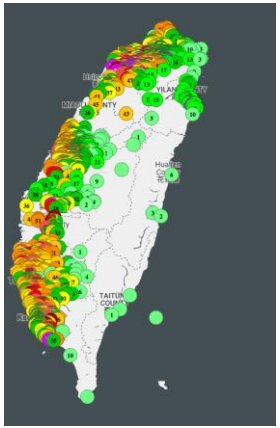
Objective: Create a participatory urban sensing framework

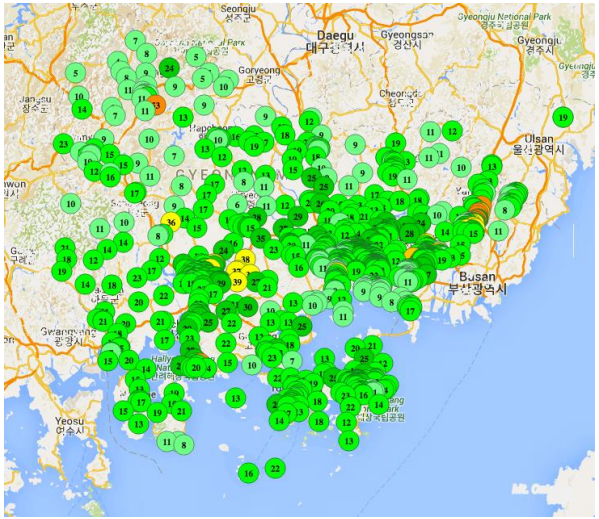
Pollutants:

- $PM_{2.5}$









Sample Project

Organization: Minnesota Pollution Control Agency

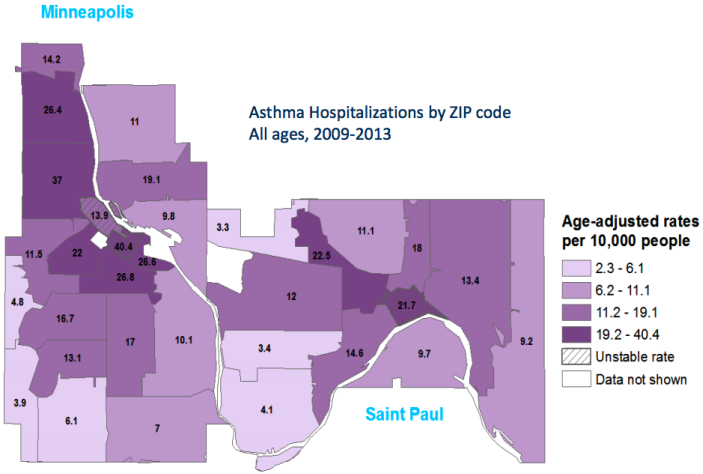
Dates: 2017-2019

Objectives:

- Better understand small-scale differences in urban air quality
- Evaluate new sensor technology to monitor air quality

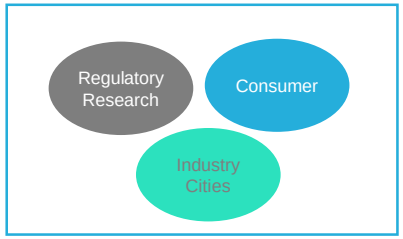
Pollutants:

- $PM_{2.5}$, Ozone, CO, SO_2, NO_x
- 50 sites (1 in each ZIP Code)



Market Evolution

Market growth in next 10 years



Market (units)

100M

10M

0.5M

Indoor Personal

Indoor Personal

Buildings

Industry

City

City

Indoor

Research Regulatory

City

Buildings

Industry

Research Regulatory

1

5

10

Time (years)

What's Needed?

Sensor Performance

Need to increase quality, durability, and longevity of air sensors (both gas and PM)

Successful Proof-of-Concepts

This new technology requires demonstration of the benefits.

Standards

Long-term business growth for regulatory, industry, and buildings will result from regulations and codes incorporating this new technology.

Ecosystem – Users & Suppliers

Ultimately create a market with users and businesses meeting their near- and long-term needs

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Air quality sensing, analytics, and insights