Research Questions Prompted by the CitiSense Air Quality Monitoring System

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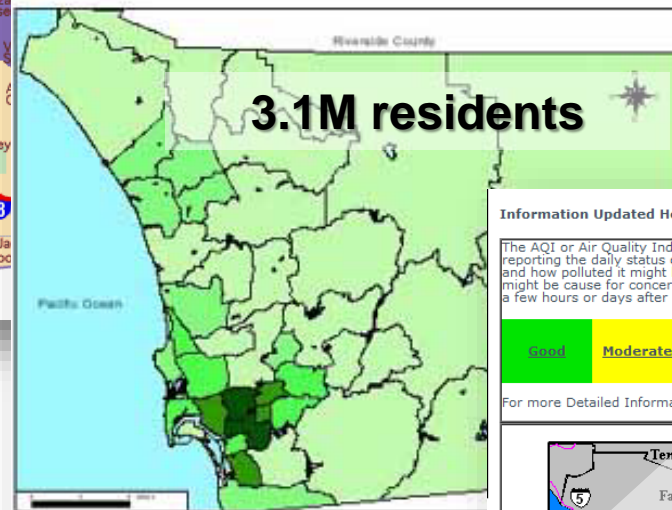# Air Quality? Didn't we solve that in the 70's?

89% 1/2 29

50% 30% 4M

So how is it affecting you? No idea.

4000 sq. mi.

3.1M residents

Information Updated Hourly

The AQI or Air Quality Index (color coded, as it appears below) is the tool most used for reporting the daily status of our air quality in the County. It tells us of the air's condition and how polluted it might be, the associated health effects, if any, and, whether there might be cause for concern. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air.

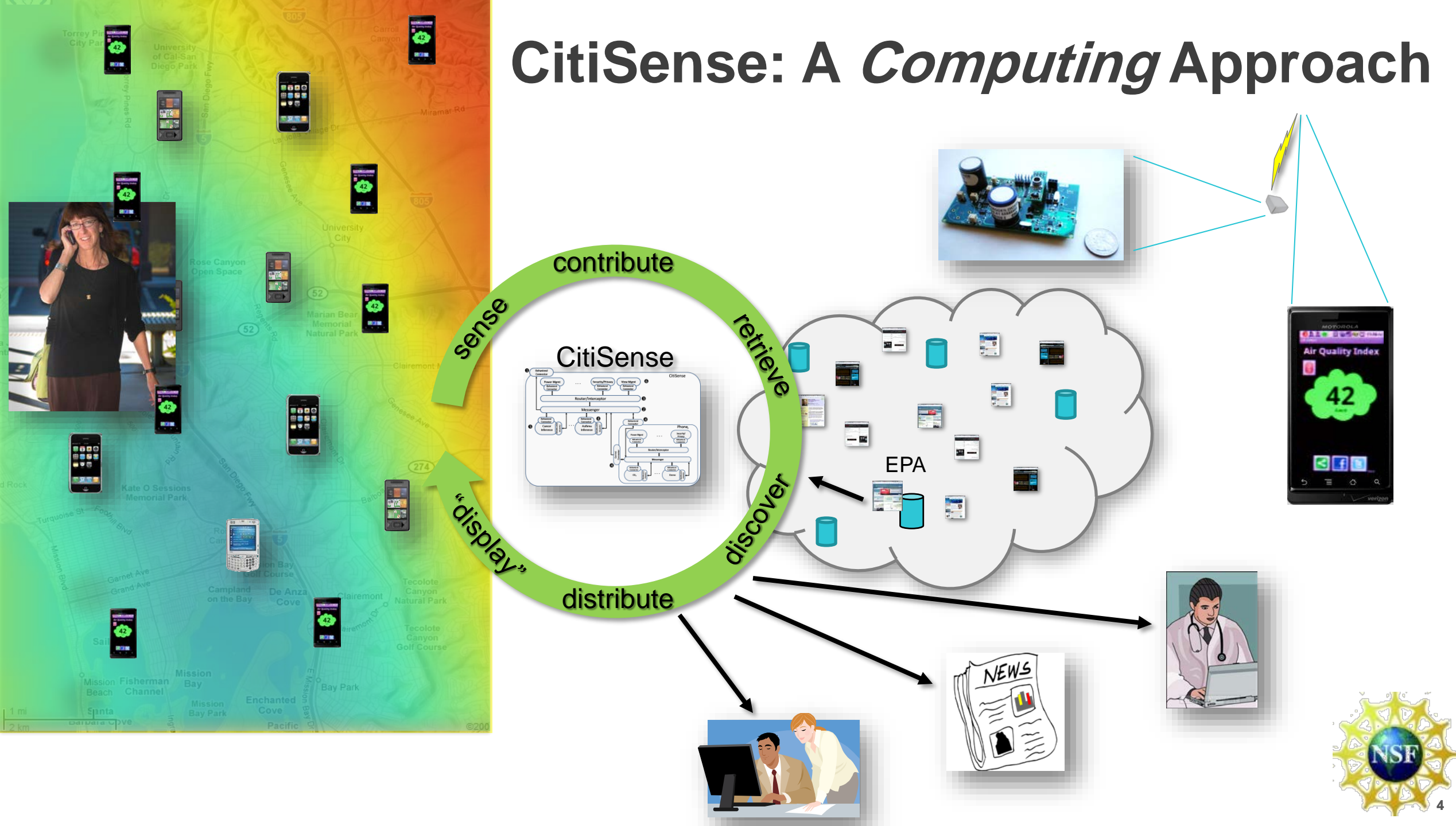| Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	Hazardous

For more Detailed Information on Particle Pollution - Click here!

10 EPA Monitoring Stations

San Diego Region
PM2.5
October 5, 2009
9:00 pm PDT

CitiSense: A *Computing* Approach

CitiSense

contribute

sense

retrieve

"display"

discover

distribute

EPA

Air Quality Index

42

CitiSense Components

Piero Zappi

Celal Ziftci

Nima Nikzad

Nakul Verma

my Instantaneous
Air Quality

miAQI
20
Good
CO at 5:36 PM

updated just now

v0.5.29

Bill Griswold shared **a link**.
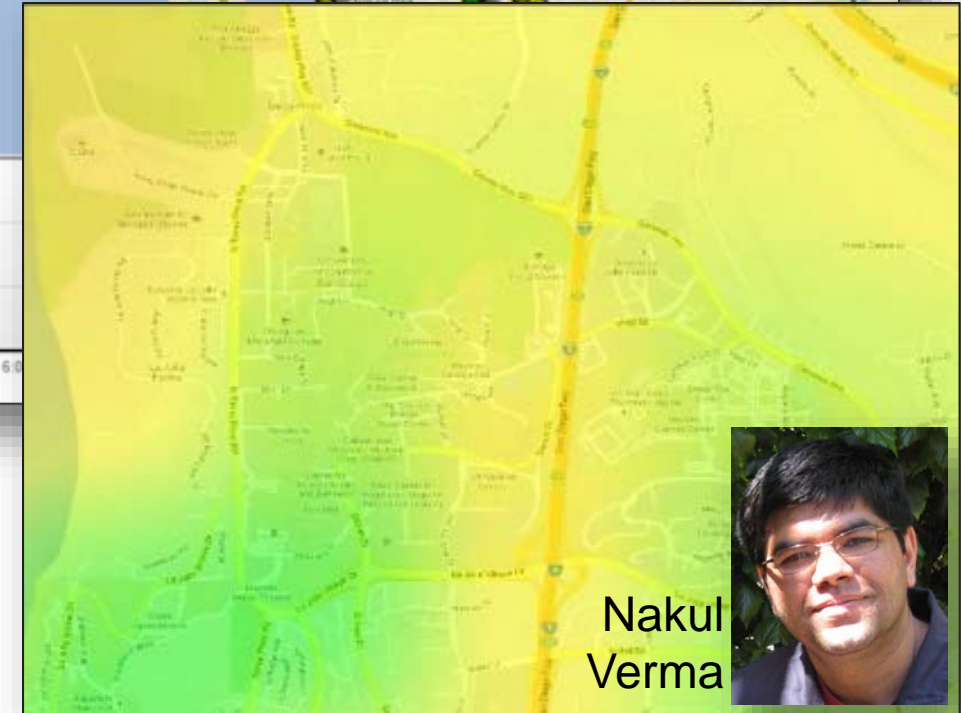
CitiSense Interactive Air Quality Map
citisenseci.ucsd.edu
Check out the air quality map for where I have been today

Like · Comment · Share · Thursday at 10:46pm
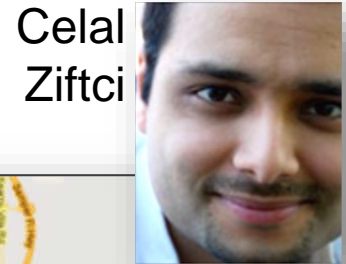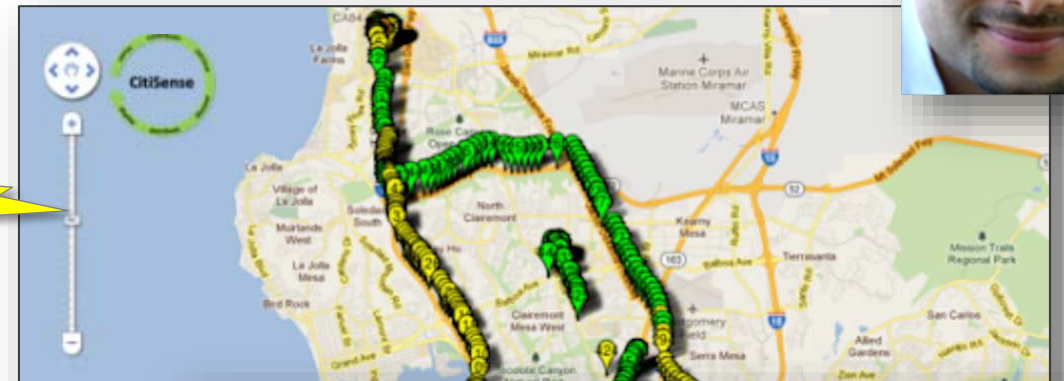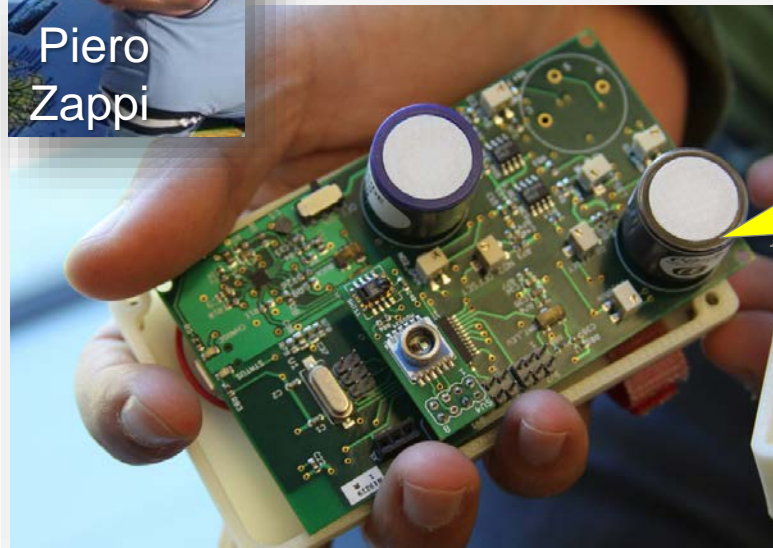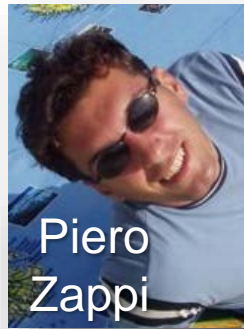
Pollution levels vary widely by locale

Individual exposures vary widely compared to reported EPA "AQI"

Same Road, Different Exposure

Those who are doing the most to clean the air are paying a price

Poor and youth more affected

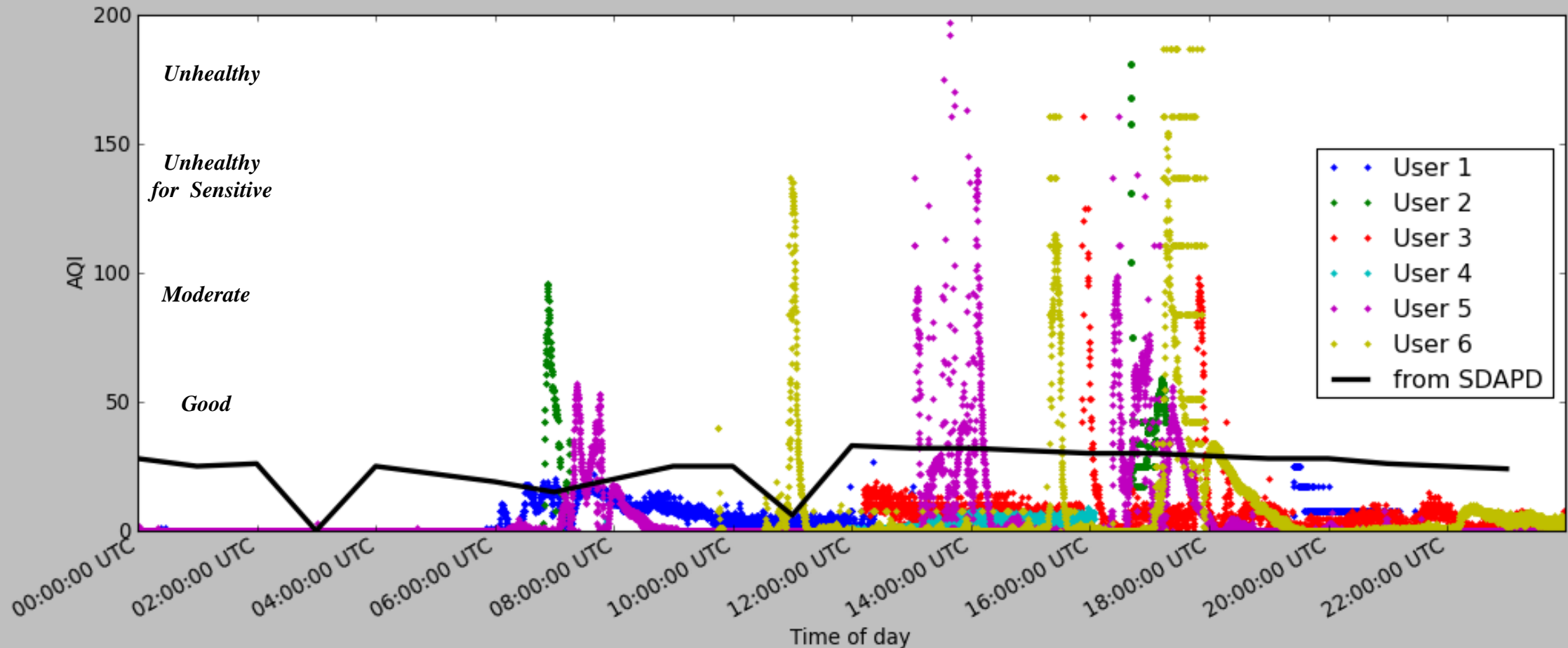Highlights potential of participatory systems like CitiSense

System-Level Research Problems

How can we affordably collect high-resolution, high-accuracy (air quality) data, at scale, to guide public policy?

- Preliminary answers from CitiSense:
  - Commodity sensors (connected to commodity mobile devices)
  - Personal mobile; also fixed, drone…
  - Machine learning
- Encountered two unanticipated research problems
  - Power management
  - Data quality

Mobile Power Management

- Techniques
  - duty cycling
  - batching
- Tradeoffs
  - availability
  - resolution
  - timeliness
  - code modularity

Nima Nikzad

- Idea 1: Programming support for delaying expensive operations until cheap (piggybacking)
  - E.g., don't use WiFi until another service turns it on
  - New operation, "WaitUntil" in front of key network calls, etc.
  - Runtime monitoring of system service states
- Idea 2: Govern by quality-of-service decls on objects
  - Data-flow analysis finds object paths through WaitUntil's
  - At run-time, log the time a tracked object spends at WaitU
  - When object's specified delay is used up, WaitUntil terminates immediately
- Incremental, but not really modular power management
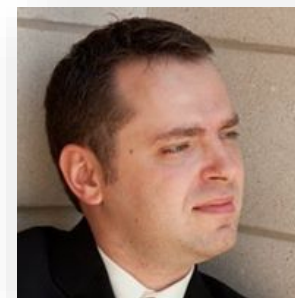
Octav Chipara, Marjan Radi, and Farley Lai (U. Iowa)

Data Quality: The Dirty Secret

- Calibration
- Cross-sensitivity
- Air flow
- Rate of change
- Warm-up time
- Context
- *…?*

- Idea: *crowd-enabled field calibration*
  - Field data naturally varied by context
  - But less controlled
- More machine learning
  - use redundancy of readings among sensors and over time to identify readings not predicted by ML, hence "out of bounds"
- Context capture, fed into ML
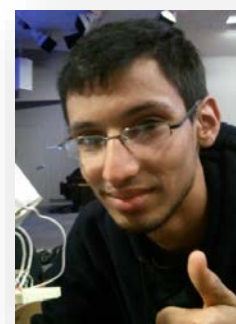- In early modelling phase

Sanjoy Dasgupta

Mike Hannigan (CU Boulder)

Ashley Collier (CU Boulder)

Tajana Rosing

Max Menarini

Sharad Vikram

Christine Chan

Kevin Patrick (Preventive Medicine)

Promise, in progress

Mass commodity sensing of our environment shows potential

- We have the elements of an architecture
- Challenges remain, e.g.
  – Power management
  – Data quality

More at http://citisense.ucsd.edu