Investigation of a Low Cost Sensor-Based Leak Detection System for Fence Line Applications

Wan Jiao, Eben Thoma, Halley Brantley, Bill Squier, Bill Mitchell, Elsy Escobar, Mark Modrak, Shahrooz Amin, Garrett Wiley

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Talk Overview

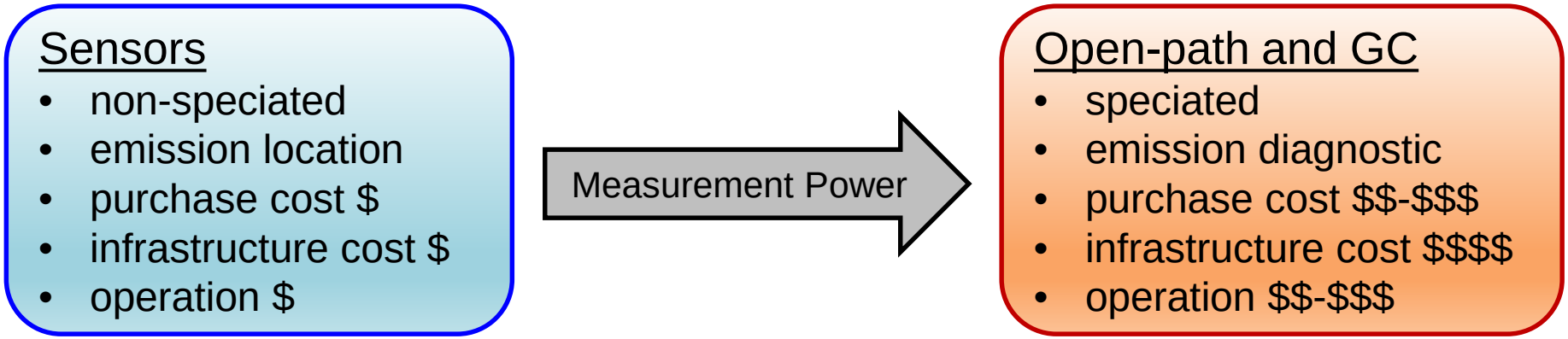
- Introduce EPA's SPod and Sentinel low cost time-resolved fenceline sensor concepts
- Discuss design and data analysis
- Describe learning from first deployment
- Summary and next steps

See E. Thoma, W. Jiao, et al. "South Philadelphia Passive Sampler and Sensor Study" Paper # 2015-A-34-AWMA: Session Thu PM 1 (this room) for additional information on first deployment in South Philly

Background

- EPA proposed refinery fenceline monitoring with passive samplers (PS)

  Session Thu PM1 (this room) -- PS and method 325 A,B
- PS is time-integrated (does not provide real-time information)
- Time-resolved measurements can help identify location of emissions
- There is a range of emerging time-resolved fenceline technologies
- These systems vary by cost and performance (tools in the tool box)



EPA's prototype SPod and Sentinel systems

- **Sensor-based**
  leak detection systems
  for fenceline applications

- Low end of the cost and performance curve
- Measures wind and integrated VOC concentrations
- Can help support PS fenceline monitoring by determining the origin of emissions

Two basic types:

Drop-in-place SPod ($)

Wind and concentration measurements

SPod is solar-powered

Sentinel can carry other instruments (e.g. micro GC) But needs power

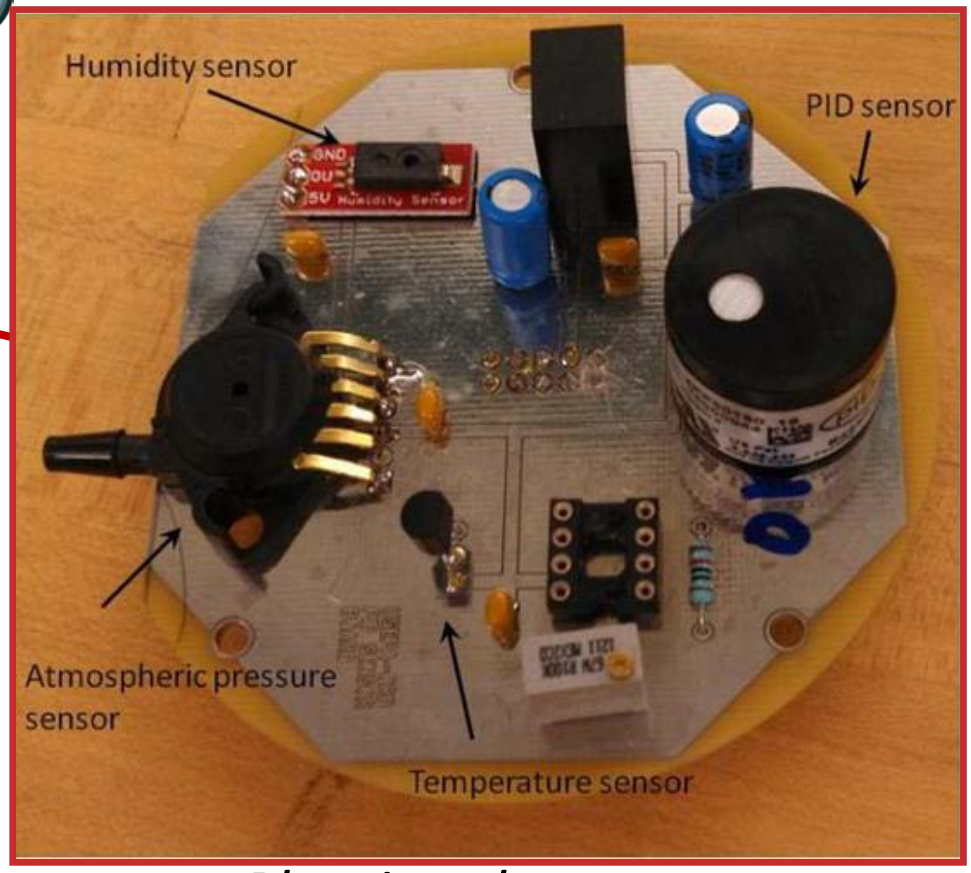
Both can be “networked”

Fixed-placed Sentinel ($$)

SPod is very simple

Drop-in-place
SPod ($$)

EPA Sensor Board
with PID VOC sensor

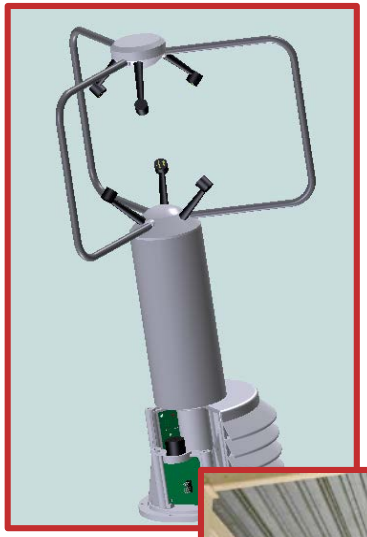


Plug-in other sensors (when ready)

SPod version 2 – on display

$1500 to $3500
(several options under development)

- Commercial wind sensor
- 3D-printed housing (base)
- Micro computer
- EPA rev 2 sensor board
- Solar powered
- All designs and code open source



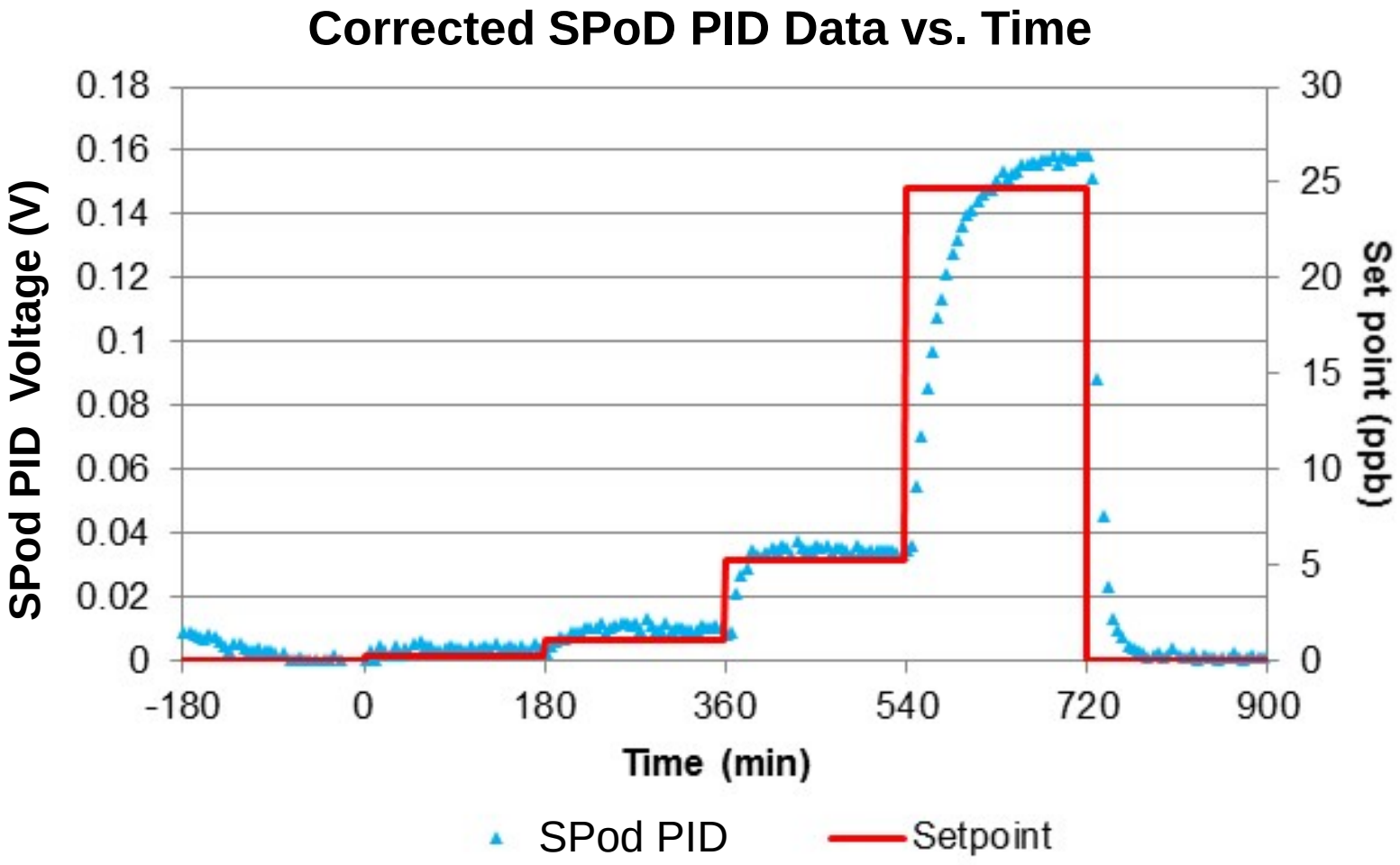
SPoD and Sentinel Sensors

Component/model	Manufacturer
PID sensor, white or blue PID-Tech plus® (DL: ppb)	Baseline-Mocon, Lyons, CO
Relative humidity sensor, HIH-4030	Honeywell, Morristown
Pressure sensor, MPX4115AP	Freescale Semiconductor, Tempe, AZ
Temperature sensor, MCP9700A	Microchip Technology, Chandler, AZ
3-D sonic anemometer, 81000V	RM Young Company, Traverse City, MI

Objectives of Initial Testing

- Explore “uncontrolled” low cost PID sensors
- Are they sensitive and will they survive? ✓
- Do signal levels drift? *Yes, version 1 drifts a lot*
- What kind of data analysis can be performed?
- Can SPods (and Sentinels with PIDs) detect emissions in a continuous fenceline application with no operator intervention?

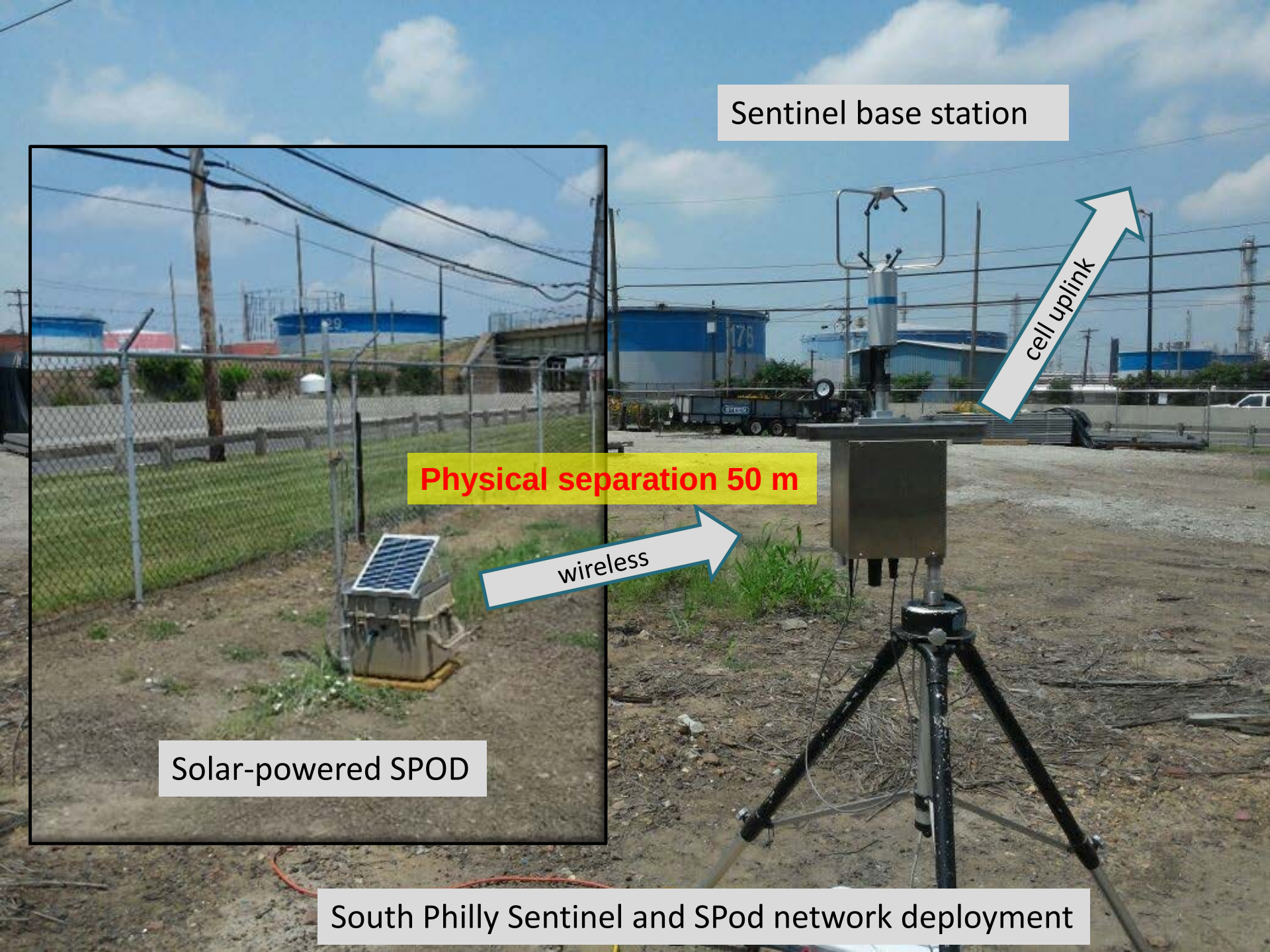
Laboratory Sensitivity Tests (drift is corrected)



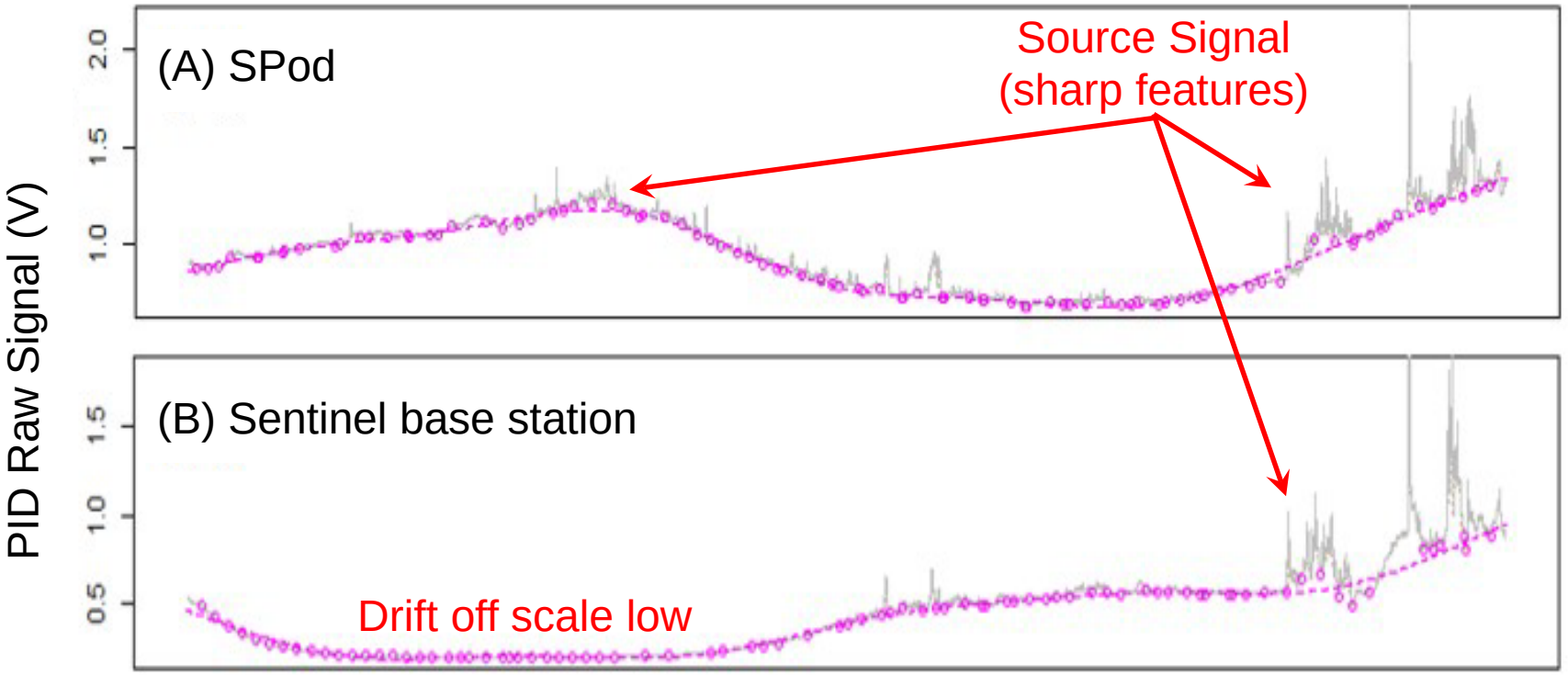
Next Generation Air Monitoring (NGAM) VOC Sensor Evaluation Report, R. Williams, A. Kaufman, S. Garvey, U.S. EPA, (in review).

Sampling Location: South Philadelphia

See E. Thoma, W. Jiao, et al. “South Philadelphia Passive Sampler and Sensor Study” Paper # 2015-A-34-AWMA: Session Thu PM 1 (this room) for additional information on first deployment in South Philly

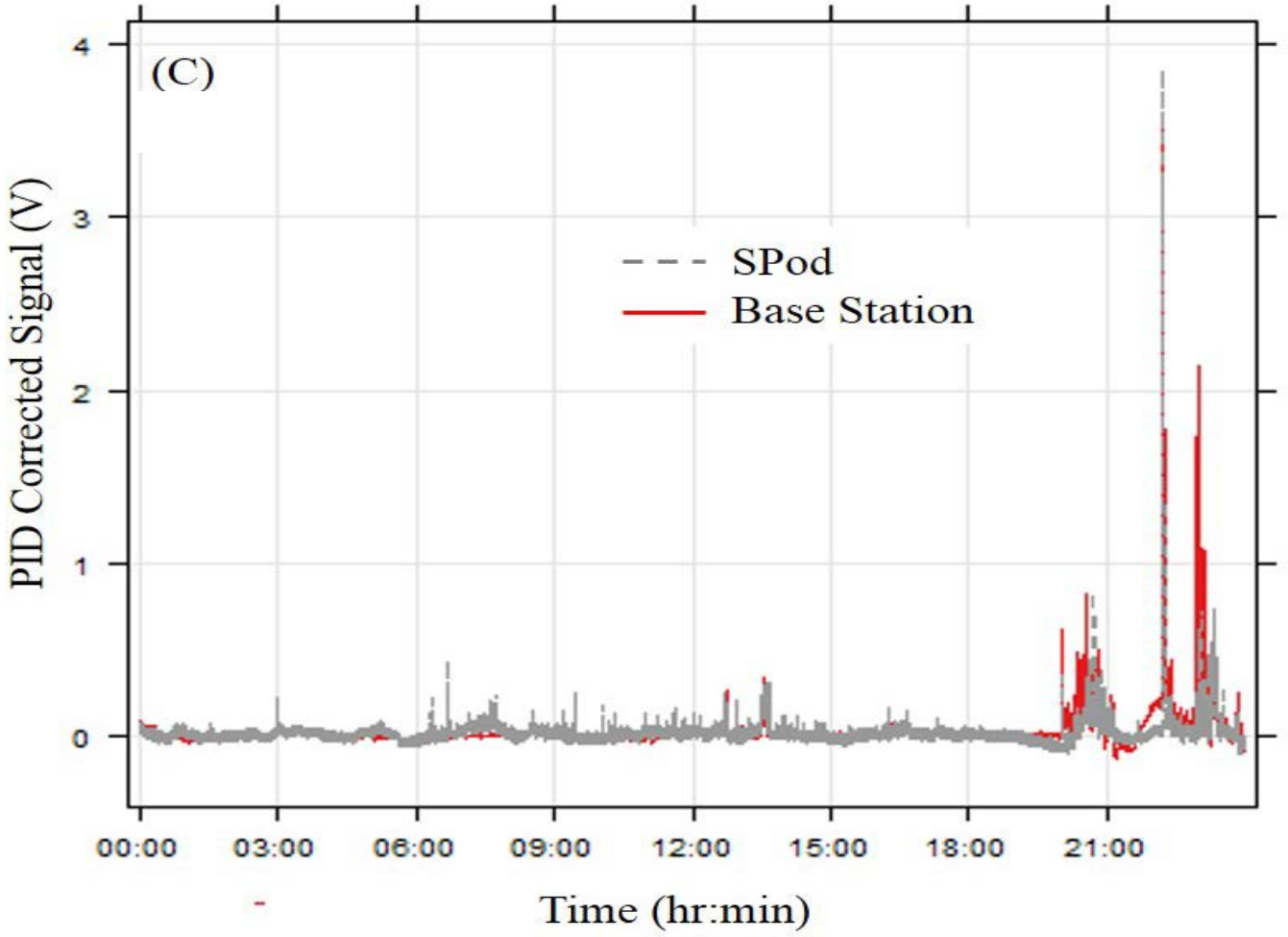

Sentinel base station
cell uplink
Physical separation 50 m
wireless
Solar-powered SPOD
South Philly Sentinel and SPod network deployment

In the field in Philly:
Baseline drift identification and removal algorithm



- Drift off scale (high and low) was a big issue with version 1 deployment
- Signal is composed low frequency (urban background and system drift) and high frequency (sharp features) from local fugitive emissions ***(gray line)***
- Baseline drift identified by a spline of minimums method ***(purple line)***

Baseline drift removed leaving only the fugitive emission signal

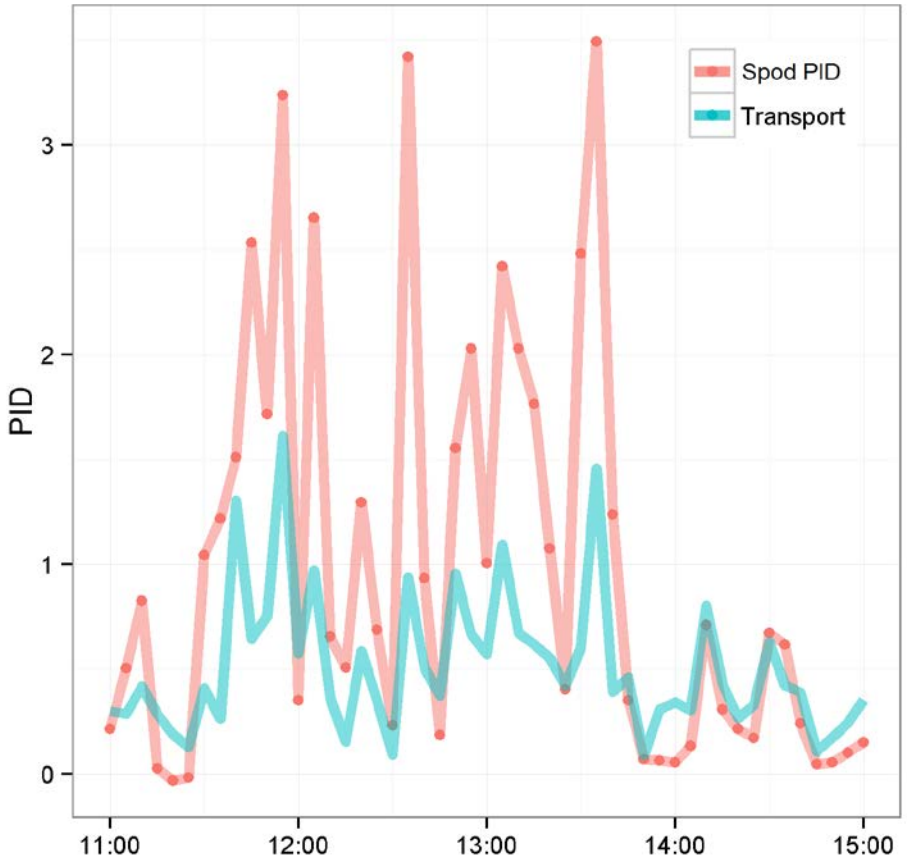


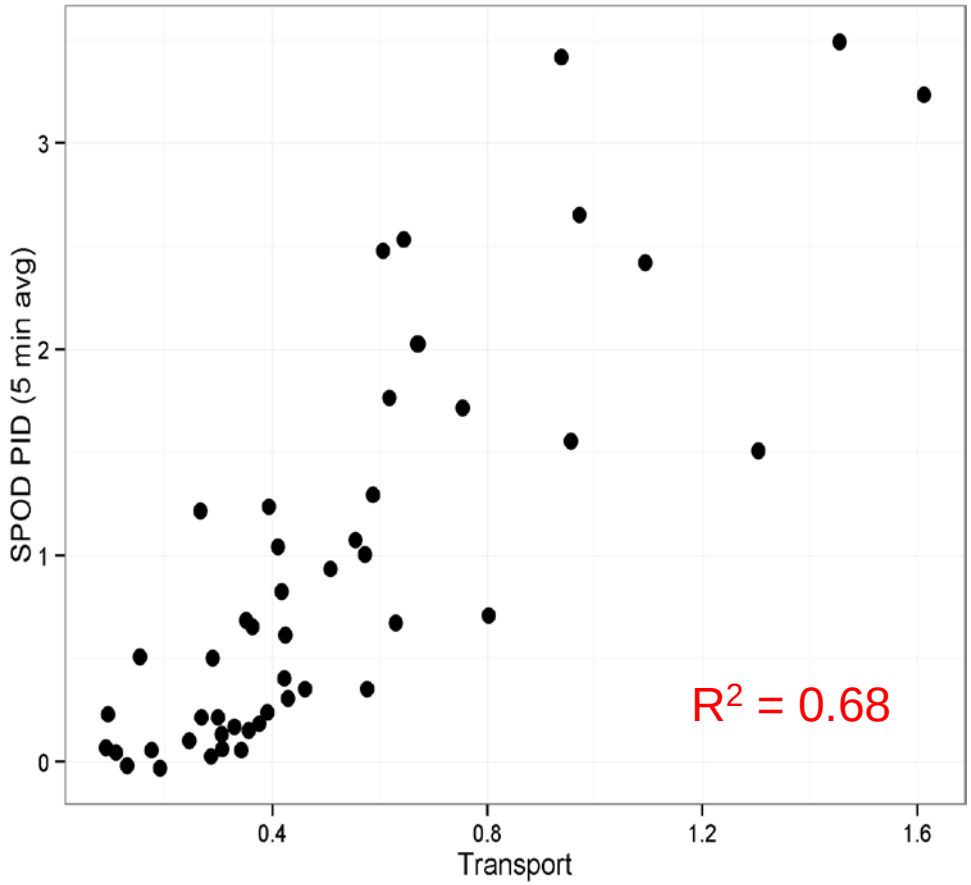
Baseline drift (slowly varying background and sensor drift), subtracted off of the raw signal leaving only sharp features from the local source.

Version 2 SPod

- The drift of the senor will be reduced in the Version 2 SPod
- Should eliminate “off scale” problem but think background correction will still be needed
- New design uses an improved PID from Baseline Mocon (more stable)
- Also uses a higher resolution DAQ so electronic gain can be reduced
- Testing started June, 2015

Combining time-resolved PID concentration information and wind data to locate the emission source

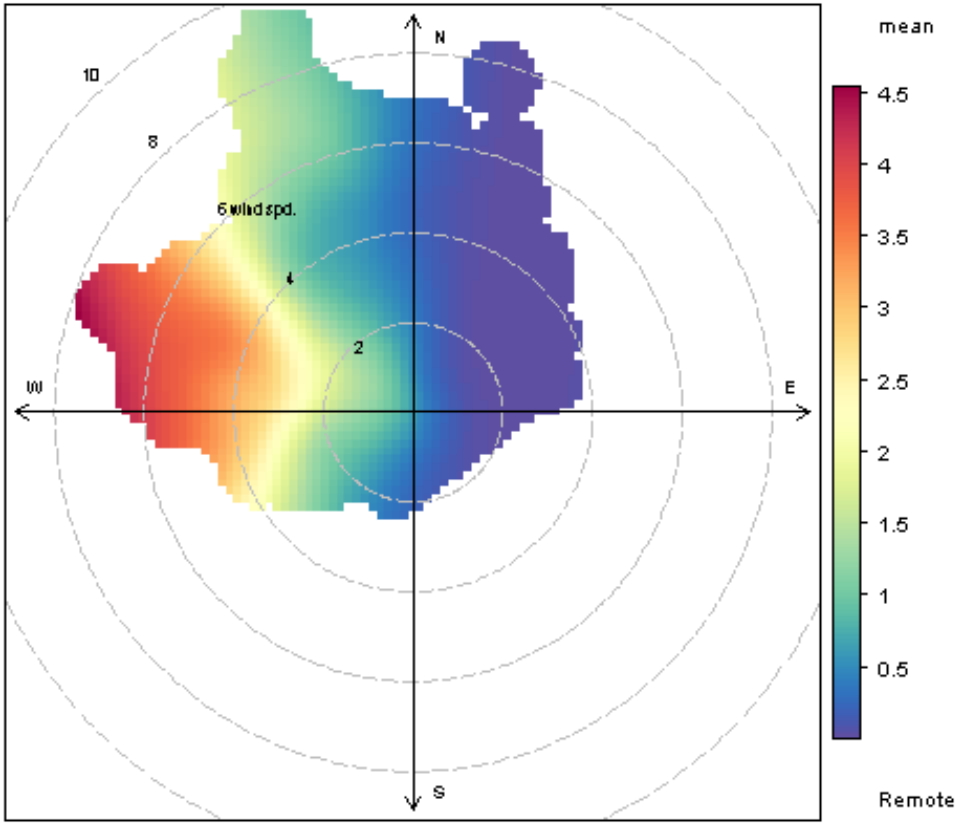




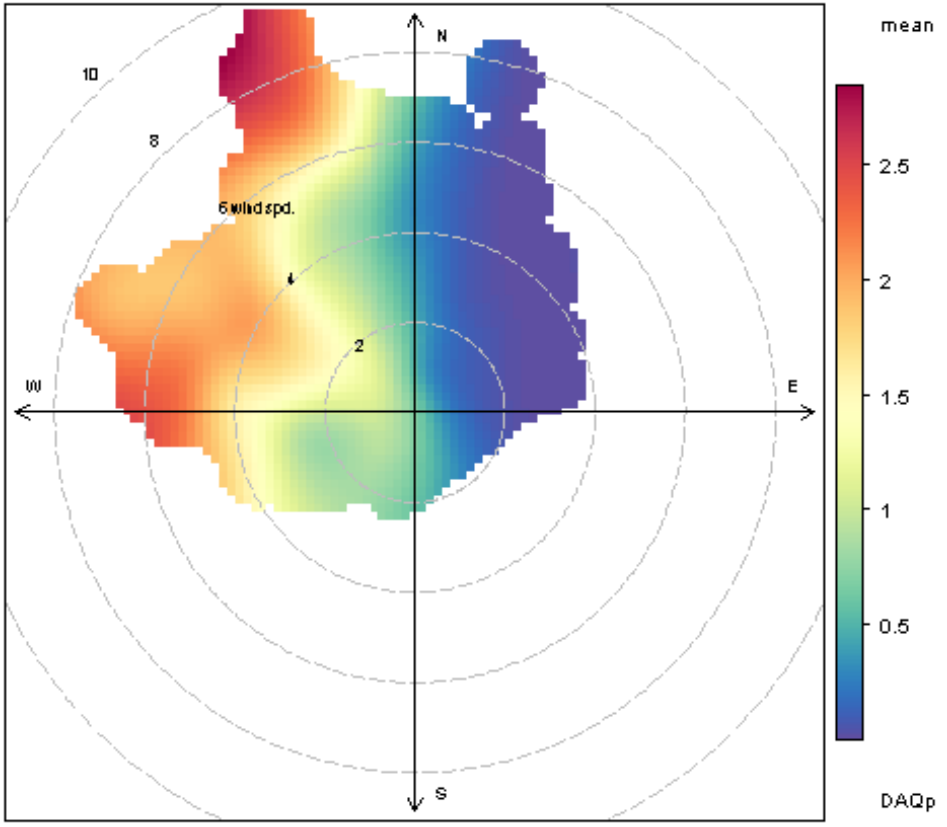
- Correlations exist between the PID signal and wind direction providing information on the location of the upwind source
- There are several ways to process these data (here is one)

Combining time-resolved PID concentration information wind data to locate the emission source

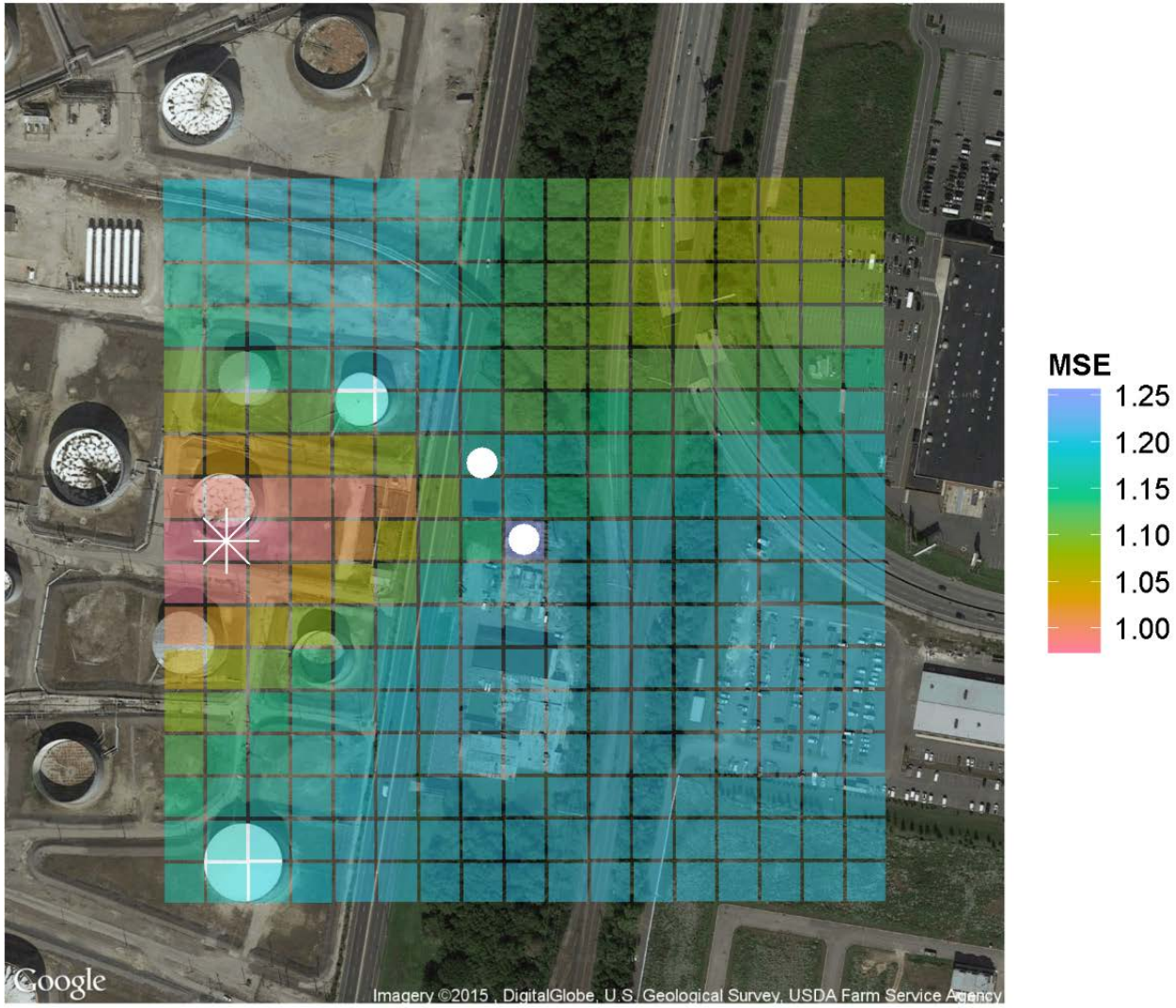
Spod



Sentinel



Can use also regression analysis to inform source location



Summary and next steps

- SPod and Sentinel are low cost time-resolved fenceline sensor concepts (open-source design)
- Preliminary field data shows PID-based systems are sensitive and robust
- Uncontrolled PIDs in Version 1 drift a lot
- Baseline correction algorithms can help separate near-field source signal from background and sensor drift
- Version 2 sensors should be more stable (in testing)
- Algorithm development continues
- More field deployments in planning stages

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