# *Next Generation Emission Measurements for Fugitive, Area Source, and Fence Line Applications*

U.S. EPA Region 4 Air Monitoring Workshop - April 14, 2016

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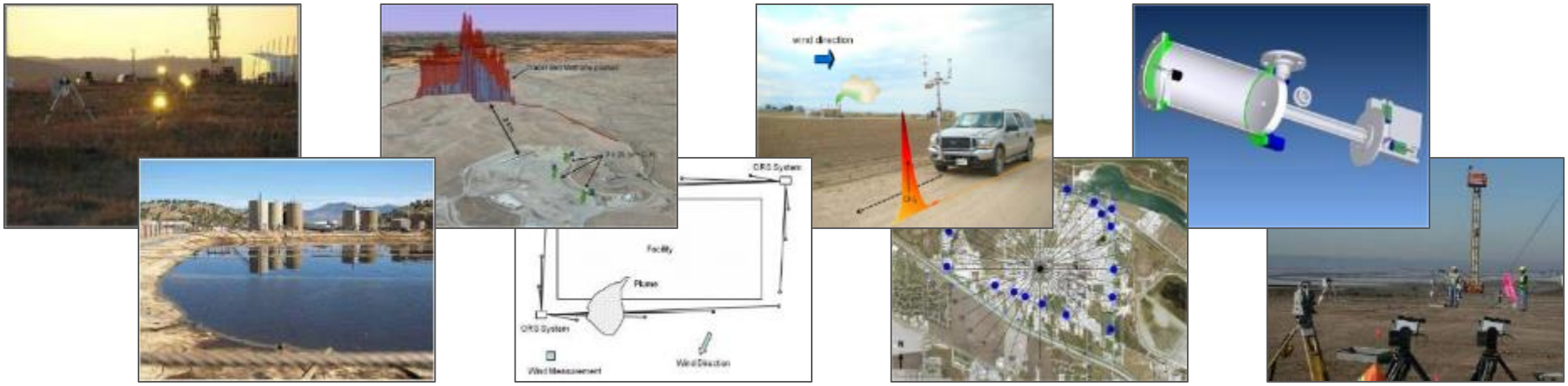
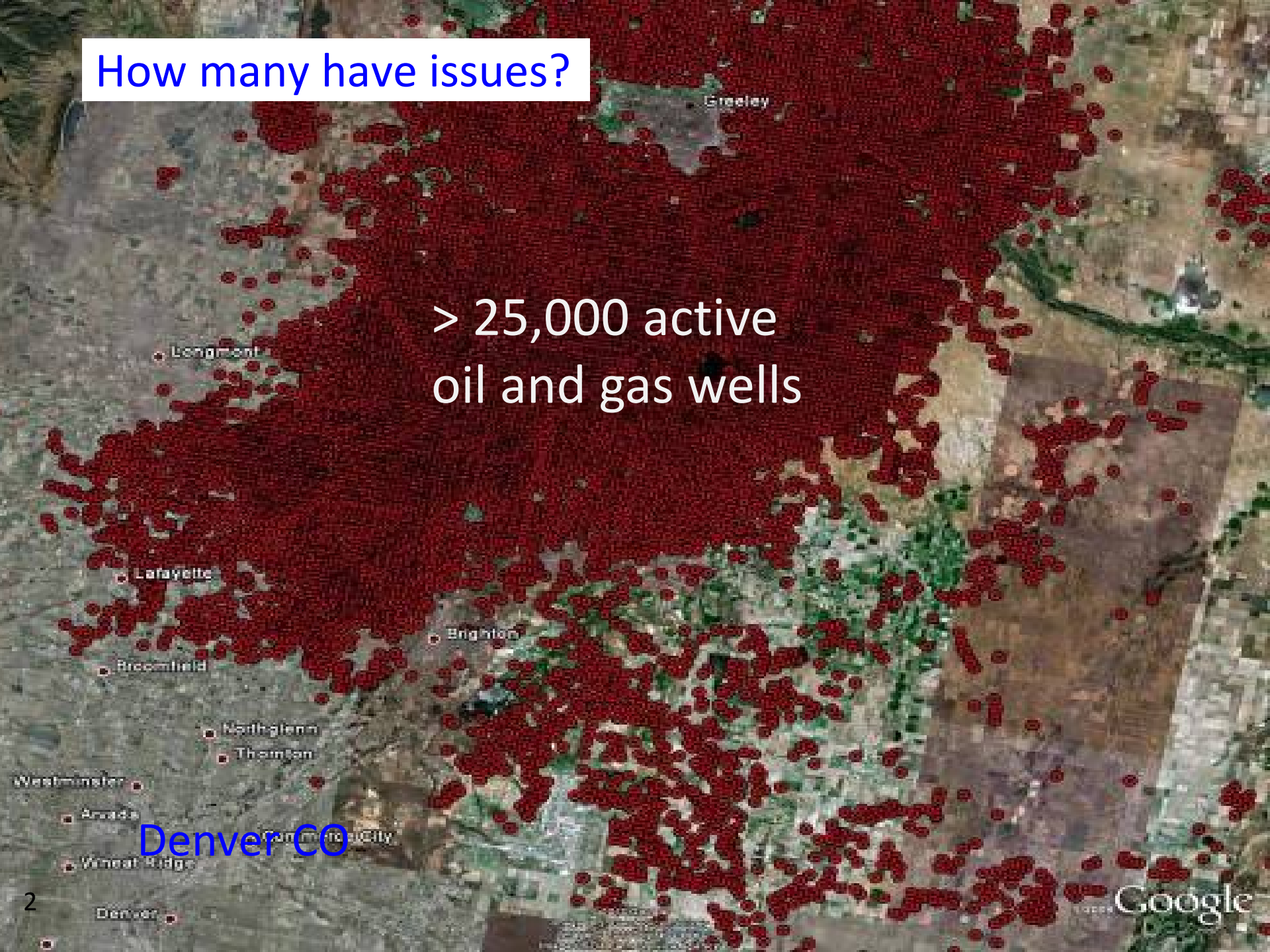
*J. DeWees, R. Merrill, D. Nash - U.S. EPA Office of Air Quality Planning and Standards*



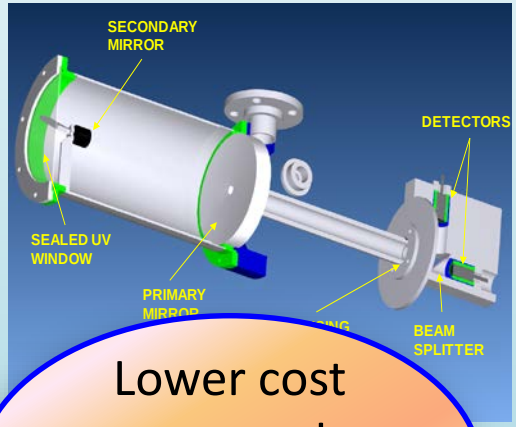
# How many have issues?




Where’s the leak?

# Next Generation Emissions Measurement (NGEM)

## Deep UV optical sensor

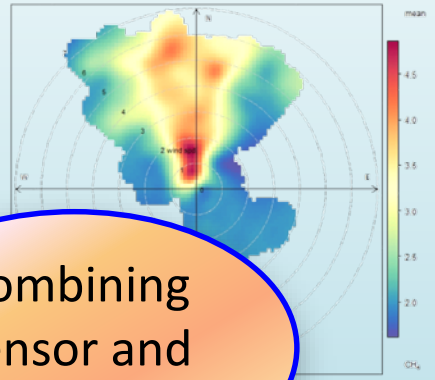



Lower cost open-path optical systems

## Drive-by leak inspection

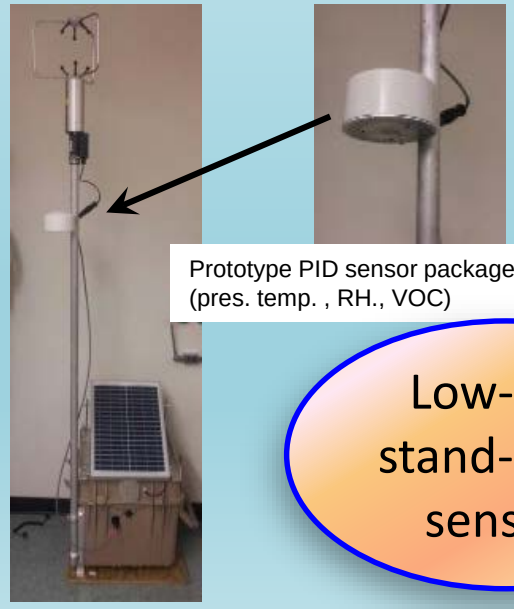
Mobile inspection systems

## New leak-location algorithms



Combining sensor and wind data

## Drop-in-place sensor packages



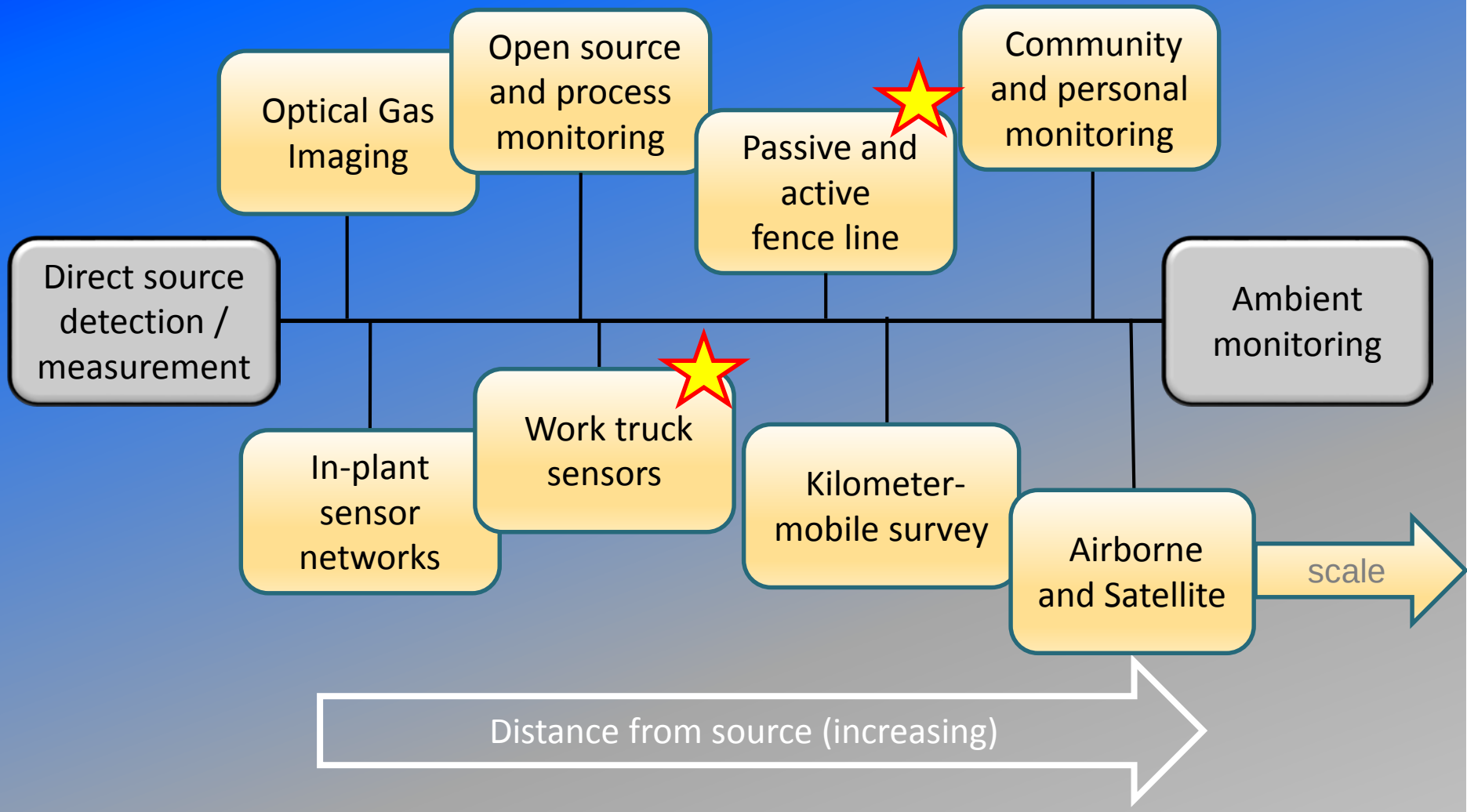
Prototype PID sensor package (pres. temp. , RH., VOC)

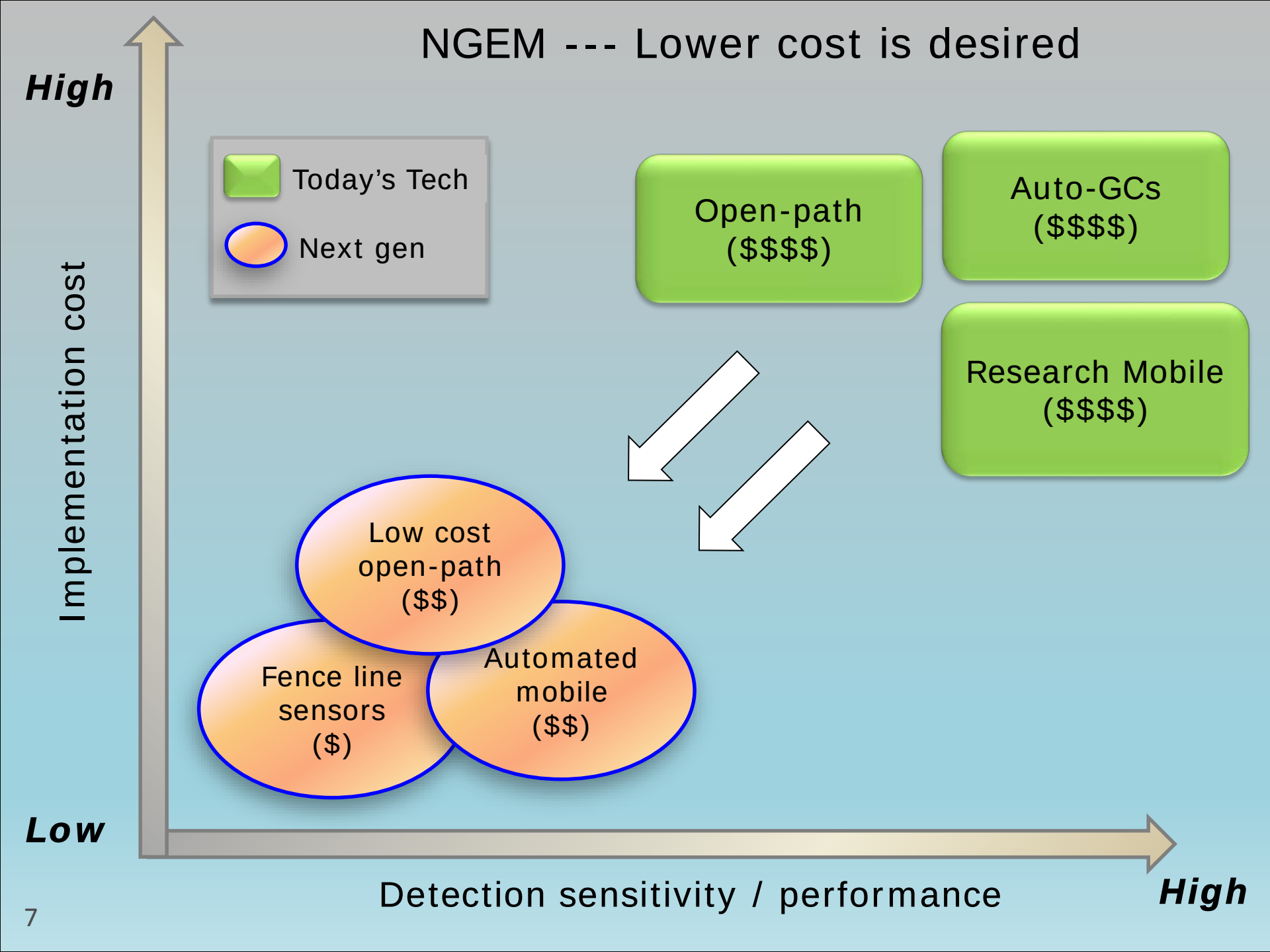
Low-cost stand-alone sensors

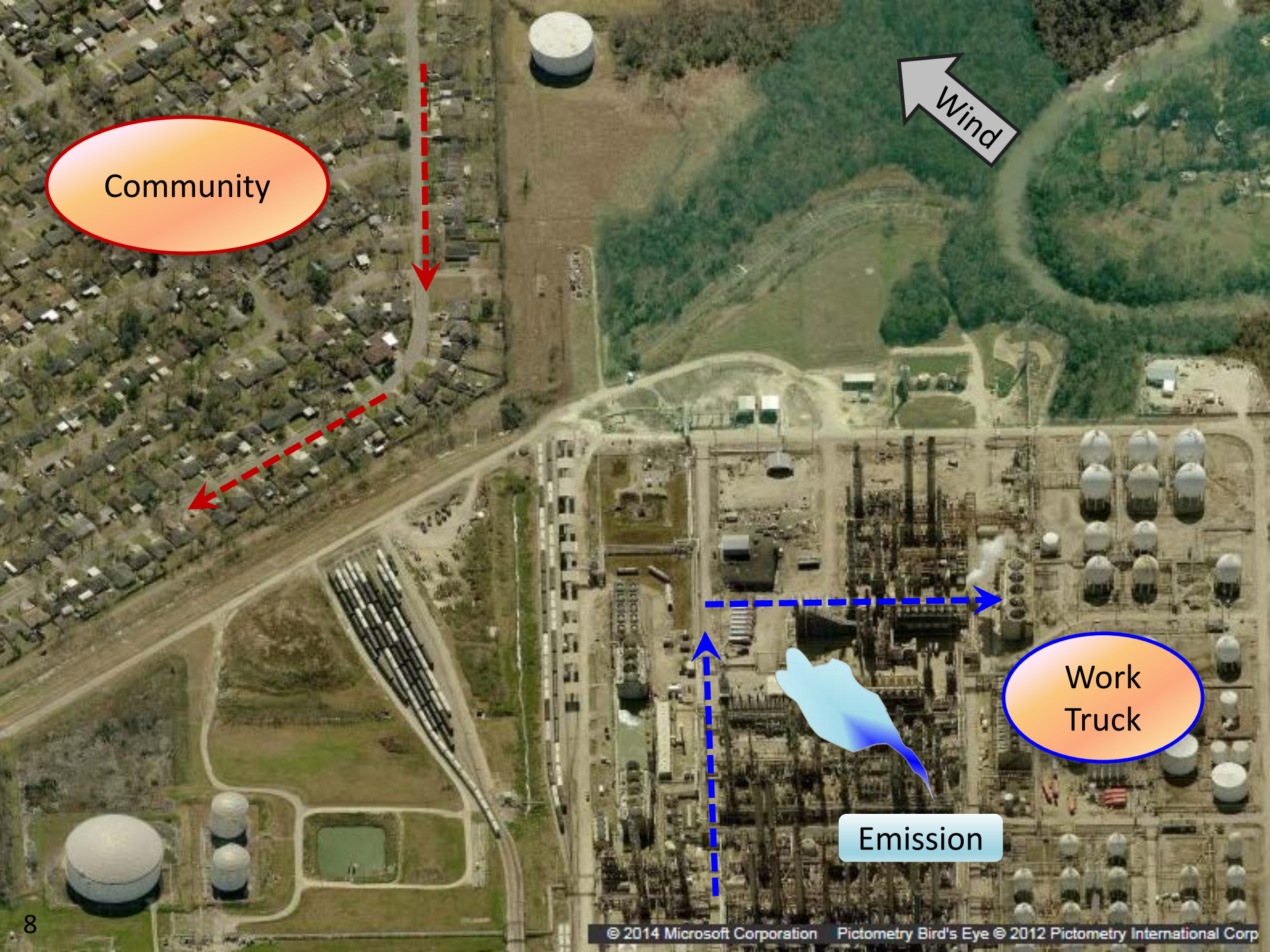

Wind
NGEM
typically in between
Emission
© 2014 Microsoft Corporation
Pictometry Bird's Eye © 2012 Pictometry International Corp

# NGEM Tools

*Some now, some future*




NGEM --- Lower cost is desired
High
Implementation cost
Low
Today's Tech
Next gen
Open-path
($$$$)
Auto-GCs
($$$$)
Research Mobile
($$$$)
Low cost
open-path
($$)
Fence line
sensors
($)
Automated
mobile
($$)
Detection sensitivity / performance
High


Community
Wind
Work Truck
Emission
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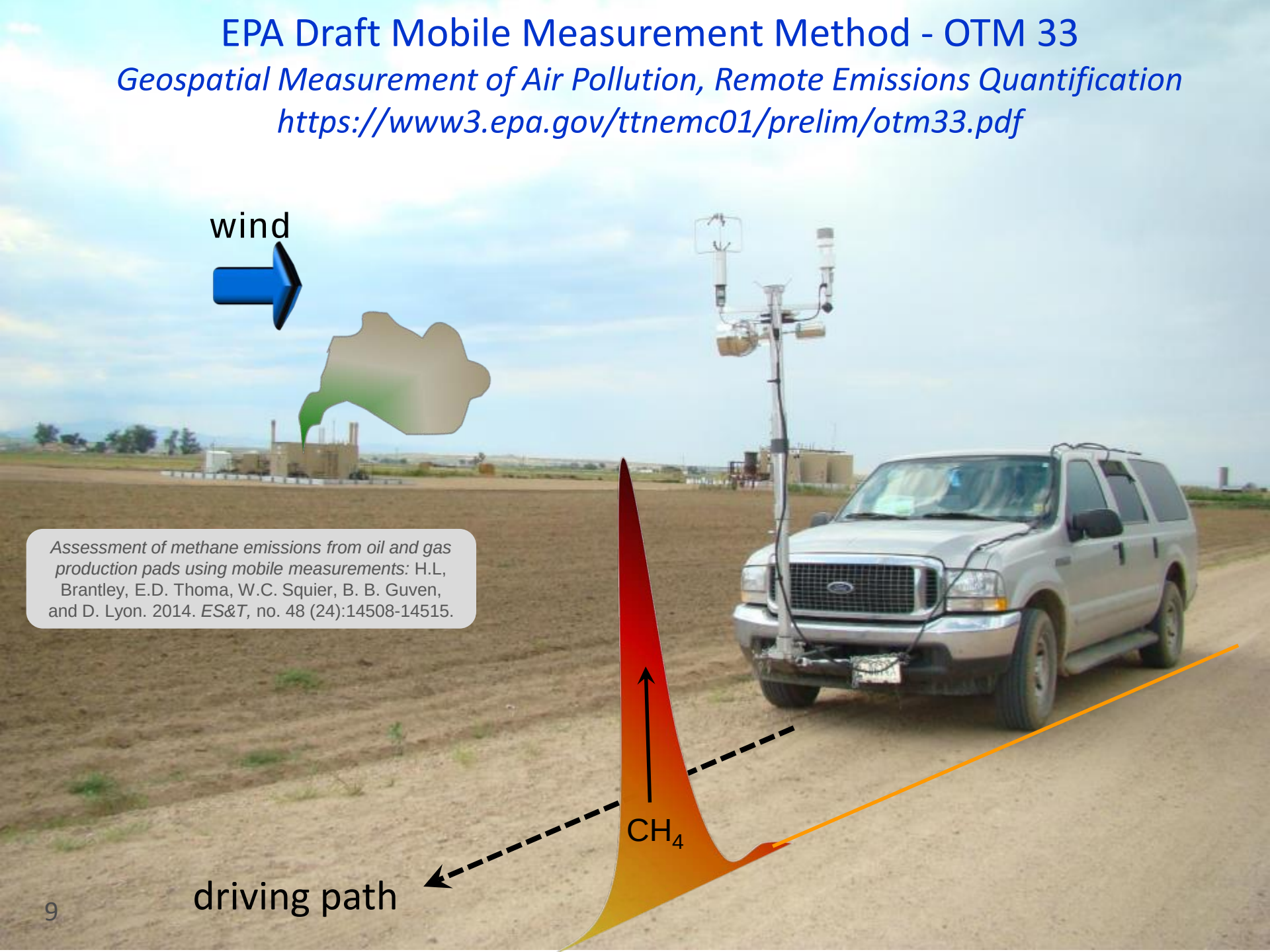
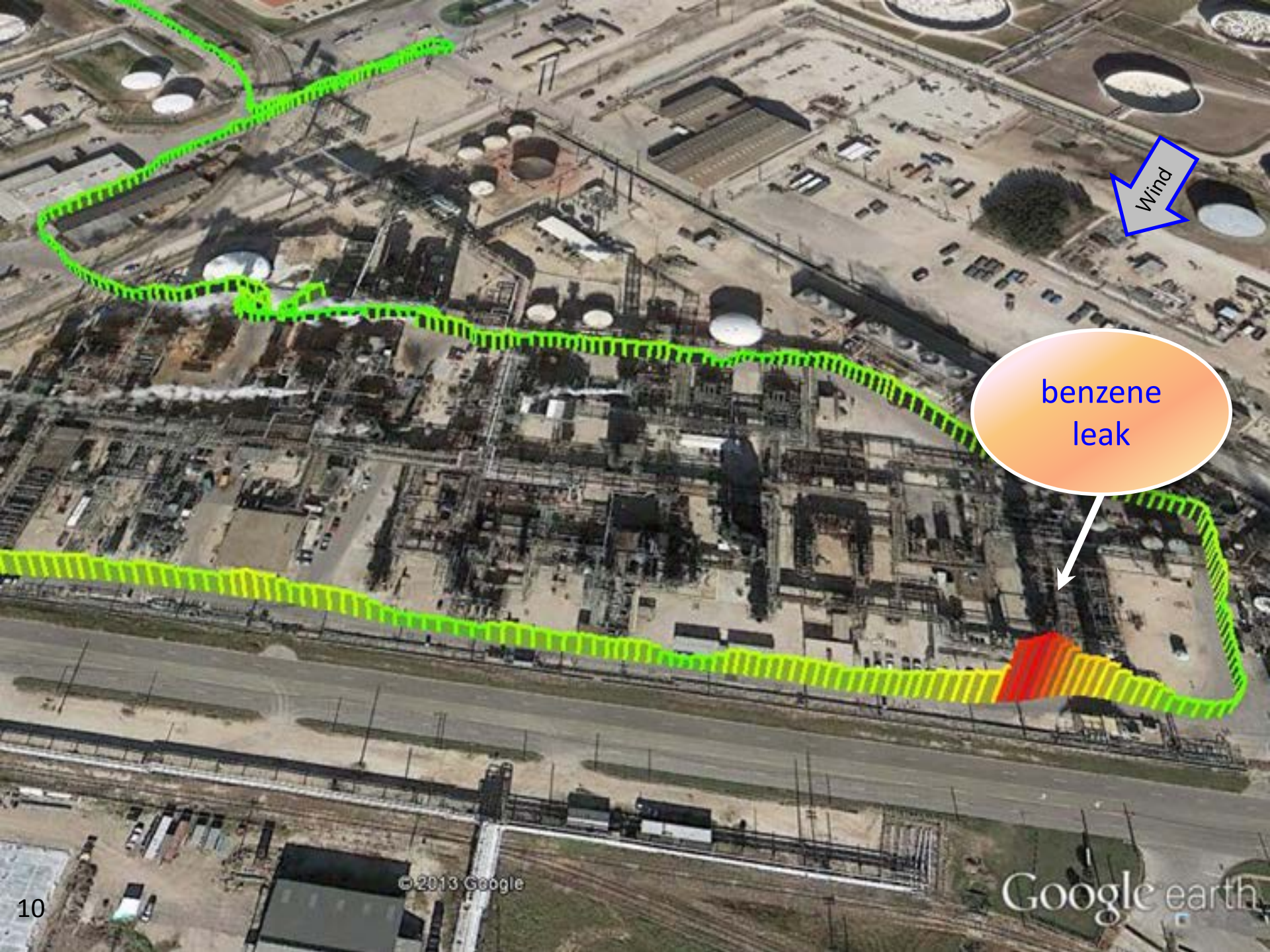
# EPA Draft Mobile Measurement Method - OTM 33

*Geospatial Measurement of Air Pollution, Remote Emissions Quantification*

*https://www3.epa.gov/ttnemc01/prelim/otm33.pdf*

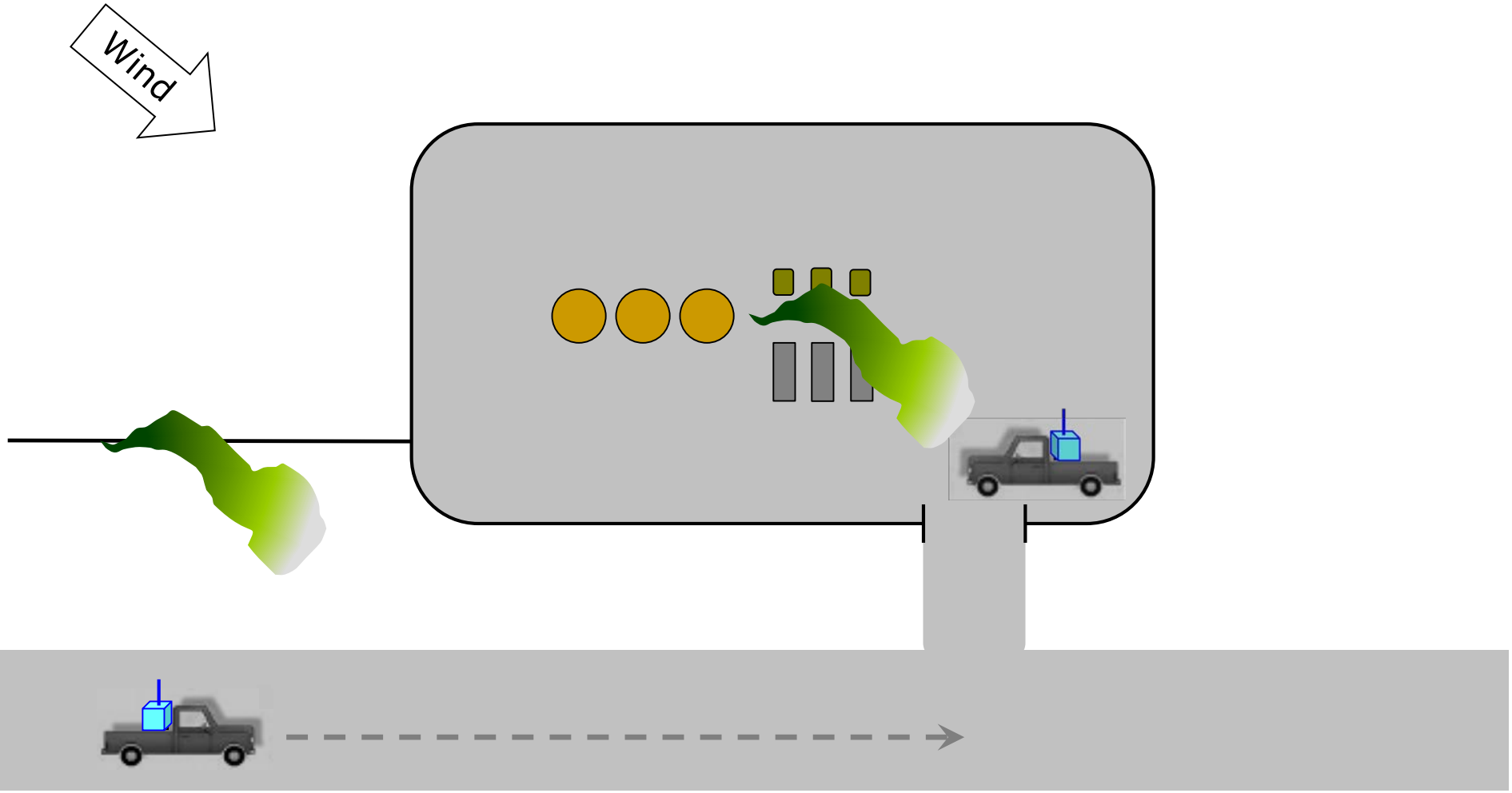



*Assessment of methane emissions from oil and gas production pads using mobile measurements:* H.L, Brantley, E.D. Thoma, W.C. Squier, B. B. Guven, and D. Lyon. 2014. *ES&T,* no. 48 (24):14508-14515.


Wind
benzene
leak
© 2013 Google
Google earth

# Work truck sensors - Find issues in many places

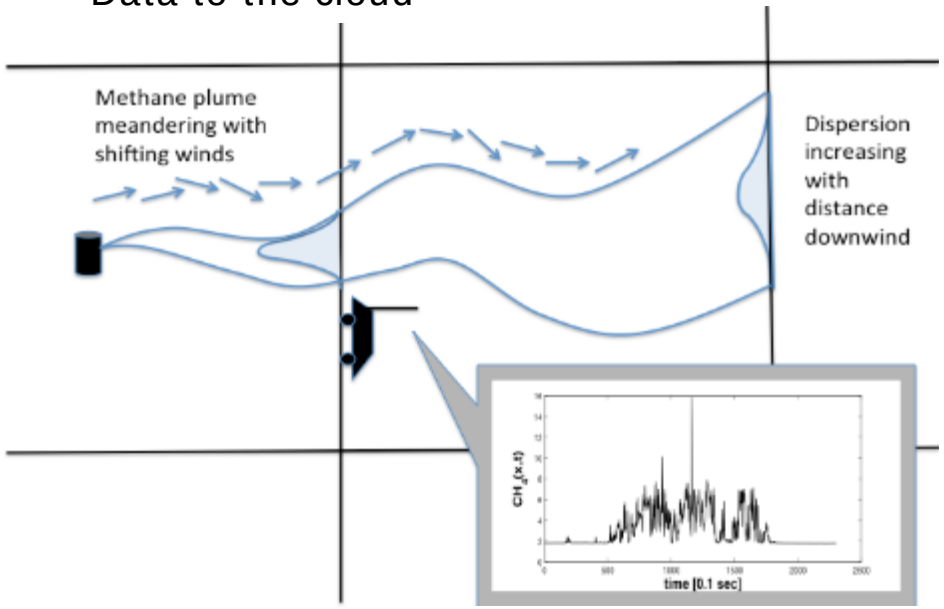
*Consider upstream oil and gas*



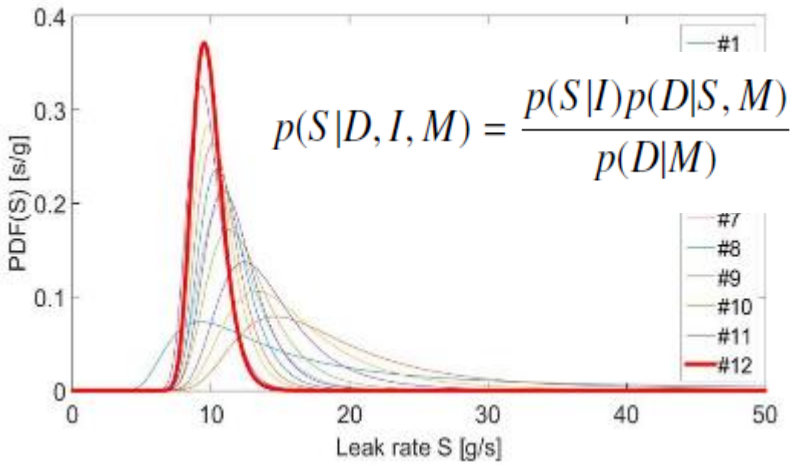

FLIR
HI OFF
AUTO
HIST
WH
7/19/10 1.32.34PM

# Automated mobile sensing …..is it possible?

"Data to the cloud"




Bayesian forms




Near and mid-field inverse models

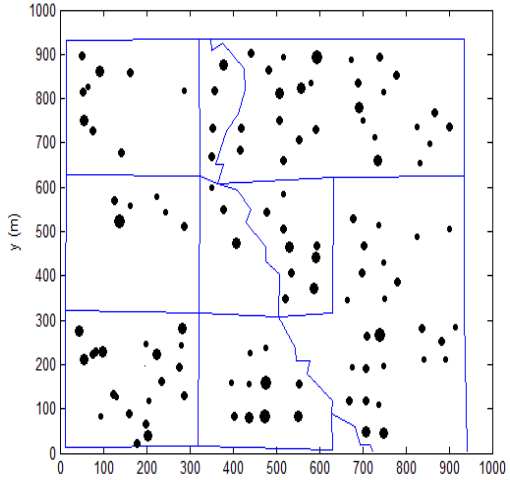
$$\bar{C}(x_v, y_v, z_m) = \frac{D_y(x', y', \vec{m}) D_z(x', z_m, \vec{m})}{U(x')} S(x', y')$$

$$D_z(x', z_m, \vec{m}) = \frac{A}{\bar{z}} \exp\left(-\left(\frac{B z_m}{\bar{z}}\right)^s\right)$$

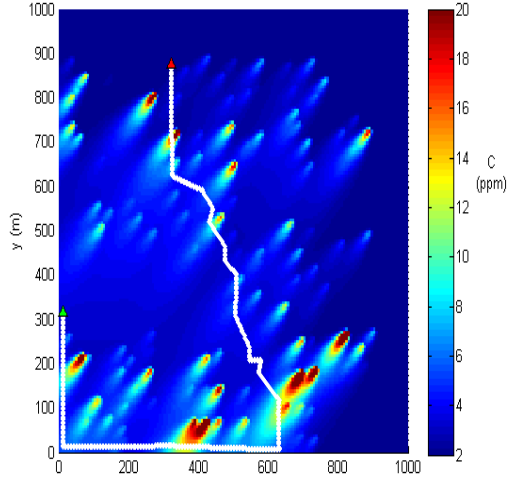
$$D_y(x', y', \vec{m}) = \frac{1}{\sqrt{2\pi}\,\sigma_y} \exp\left(-\frac{1}{2}\left(\frac{y'}{\sigma_y}\right)^2\right)$$

$$\sigma_y = a z_o \frac{\sigma_v}{u_*} \left(\frac{x'}{z_o}\right)^p$$

Well pad locations and production levels



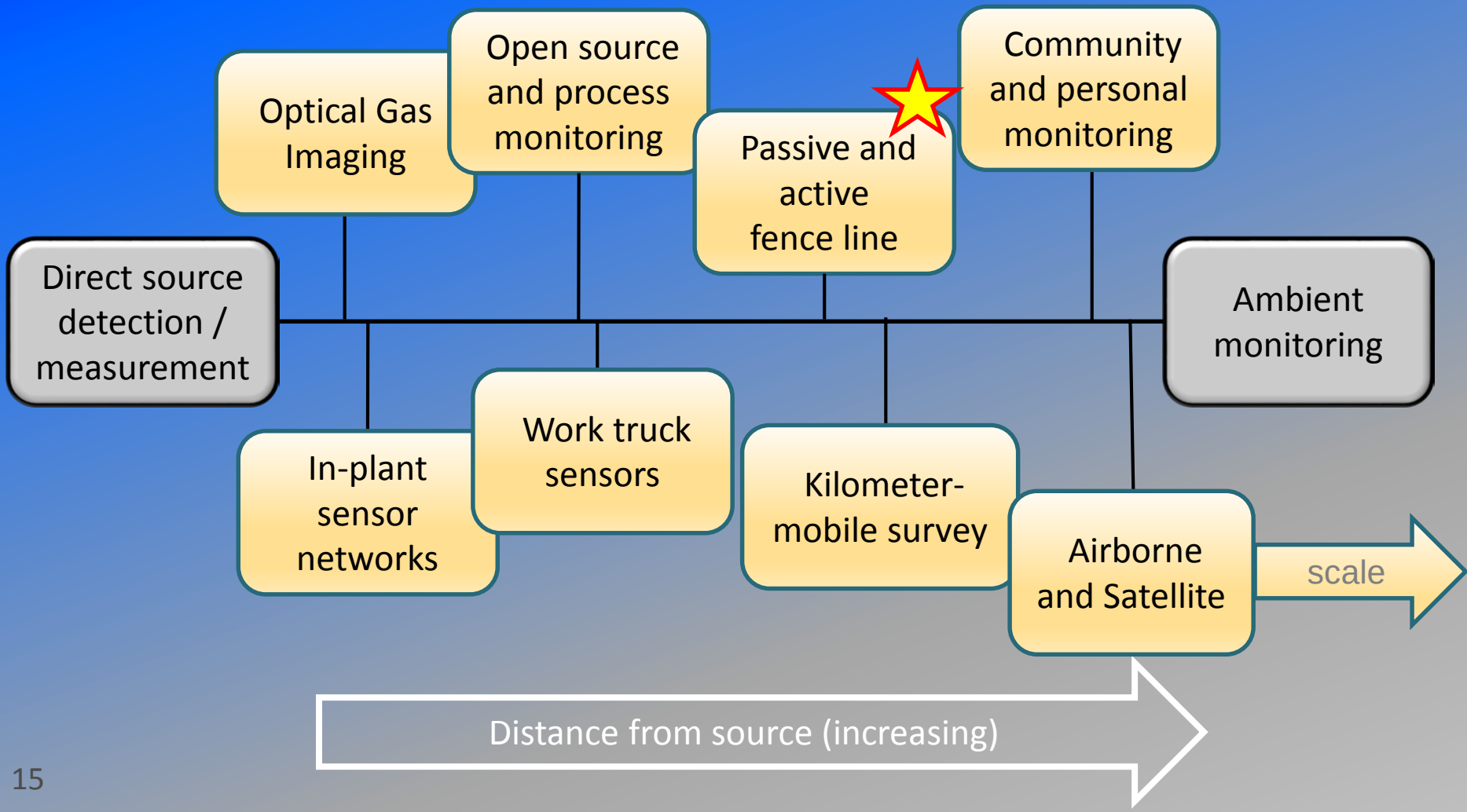

Opportunistic and planned path

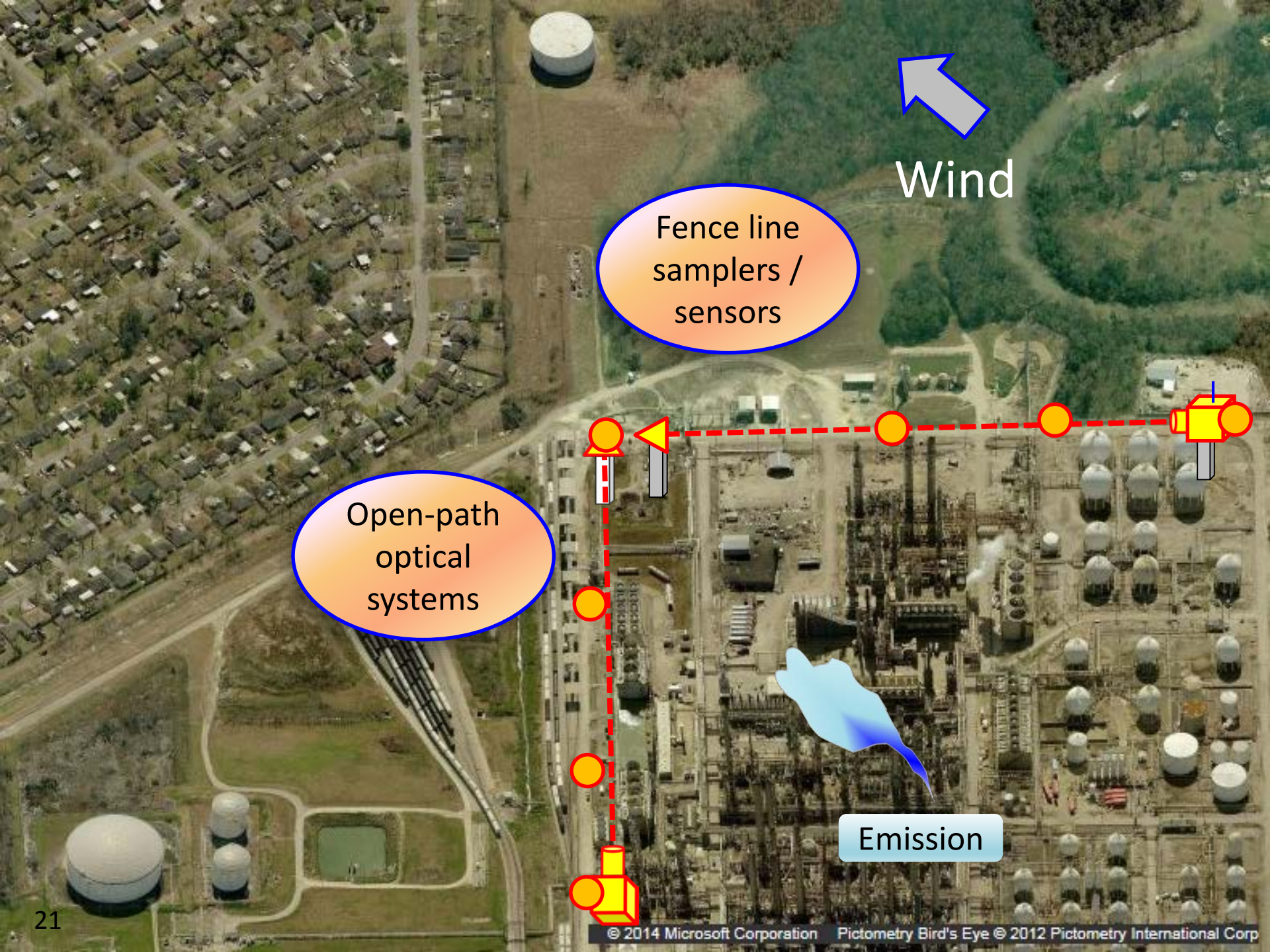





*A Mobile Sensing Approach for Regional Surveillance of Fugitive Methane Emissions in Oil and Gas Production:* J. D. Albertson, T. Harvey, G. Foderaro, P. Zhu, X. Zhou, S. Ferrari, S. Amin, M. Modrak, H.L. Brantley, and E.D. Thoma; (2016), ES&T 2016, 50 (5), pp 2487-2497

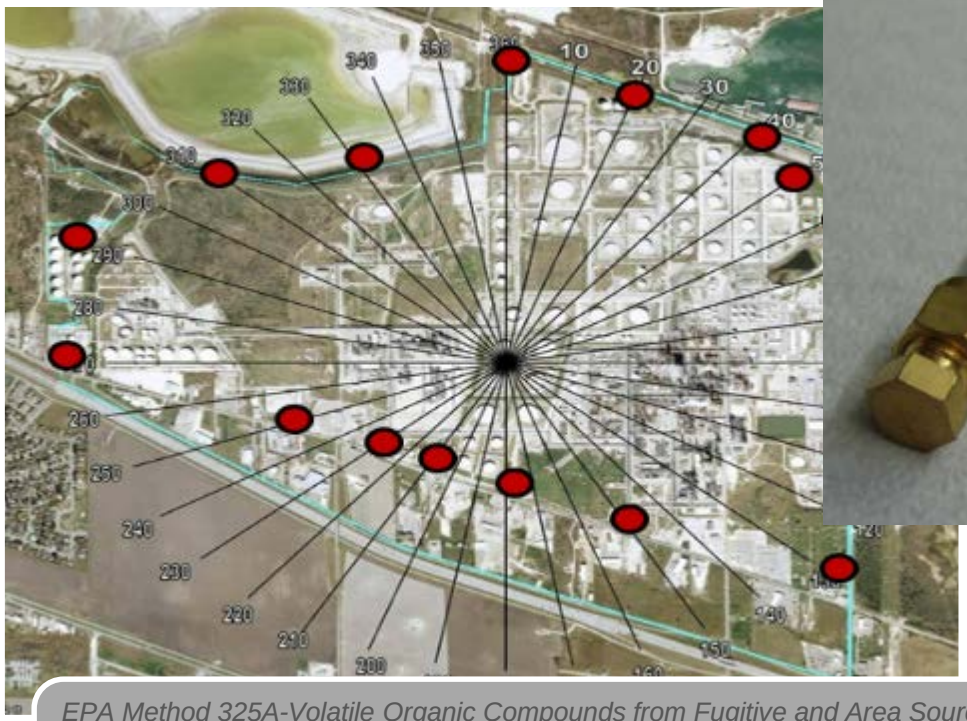
# Source NGAM Tools
## *Some now, some future*




Wind
Fence line samplers / sensors
Open-path optical systems
Emission
© 2014 Microsoft Corporation
Pictometry Bird's Eye © 2012 Pictometry International Corp

# EPA Method 325 A,B

- Screening check for benzene at refinery fence line
- Two-week, time-integrated passive samplers
- Laboratory GC analysis




*EPA Method 325A-Volatile Organic Compounds from Fugitive and Area Sources: Sampler Deployment and VOC Sample Collection. 40 CFR Part 63, Subpart UUU[EPA-HQ-OAR-2010-0682; FRL-9720-4], RIN 2060-AQ75, Petroleum Refinery Sector Risk and Technology Review and NSPS.*

*Facility fenceline monitoring using passive samplers: E.D.* Thoma, M. C. Miller, K. C. Chung, N. L. Parsons, and B. C. Shine. 2011. Facility fenceline monitoring using passive samplers. Journal of the Air & Waste Management Association no. 61 (8):834-842.

# South Philly Passive Sampler and Sensor Study

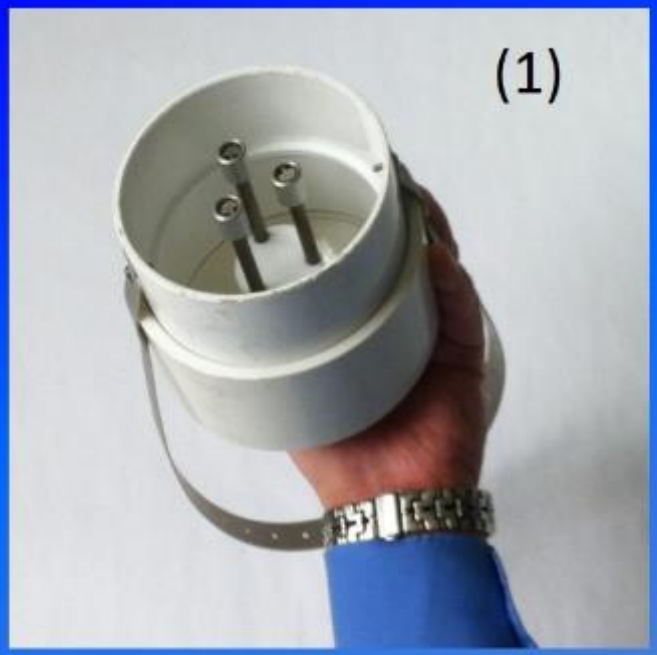
*An applied research effort with multiple objectives*

Field work in Philly: June 2013 - March 2015

EPA Region 3, EPA ORD, EPA OAR, and the City of Philadelphia AMS

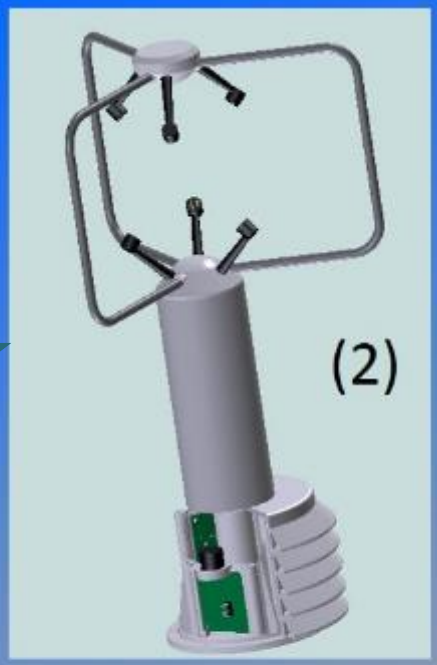
- Support development of:
  - Facility fence line measurement methods
  - Advanced LDAR concepts
  - Near source tools for communities
- Improve understanding of:
  - Benzene (and BETX) spatial concentration profiles
  - Time-resolved monitoring and modeling

South Philadelphia Passive Sampler and Sensor Study, E. D. Thoma, H. L. Brantley, K. D. Oliver, D. A. Whitaker, S. Mukerjee, B. Mitchell, B. Squier, T. Wu, E. Escobar, T. A. Cousett, C. A. Gross-Davis, H. Schmidt, D. Sosna, H. Weiss. JAWMA (in review); and iterim conference version in *Proceedings of the 108th Annual Conference of the Air & Waste Management Association*, June 23-26, 2015, Raleigh, NC.

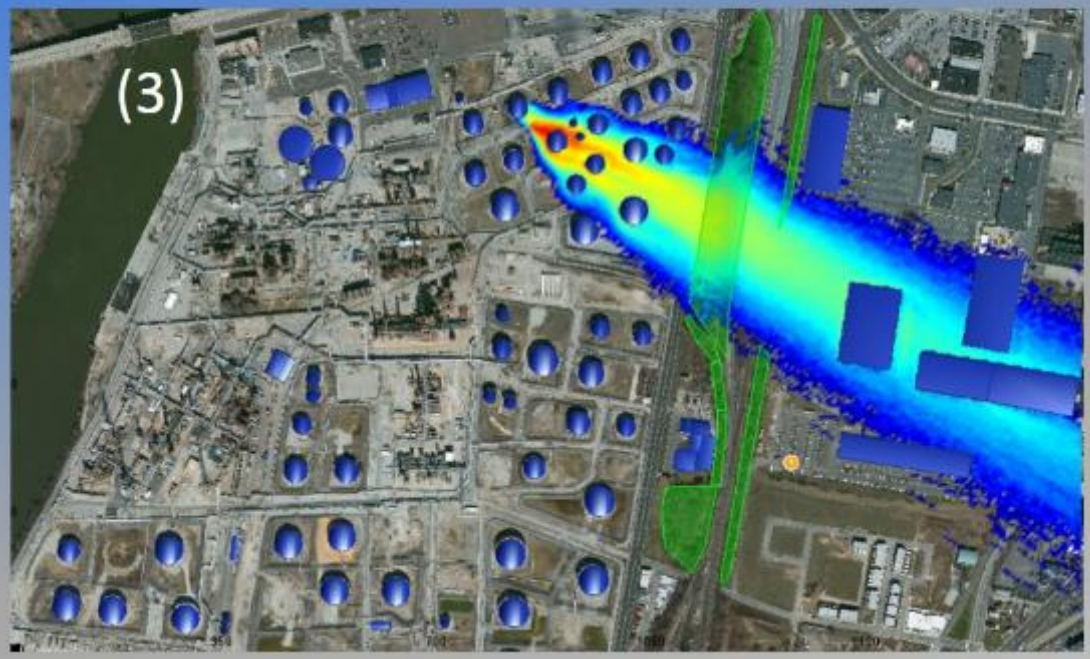



## Project Elements

(1) Passive Samplers ★
(2) Fence line Sensors ★
(3) Advanced Modeling ★
(4) Optical Remote Sensing (City-AMS)



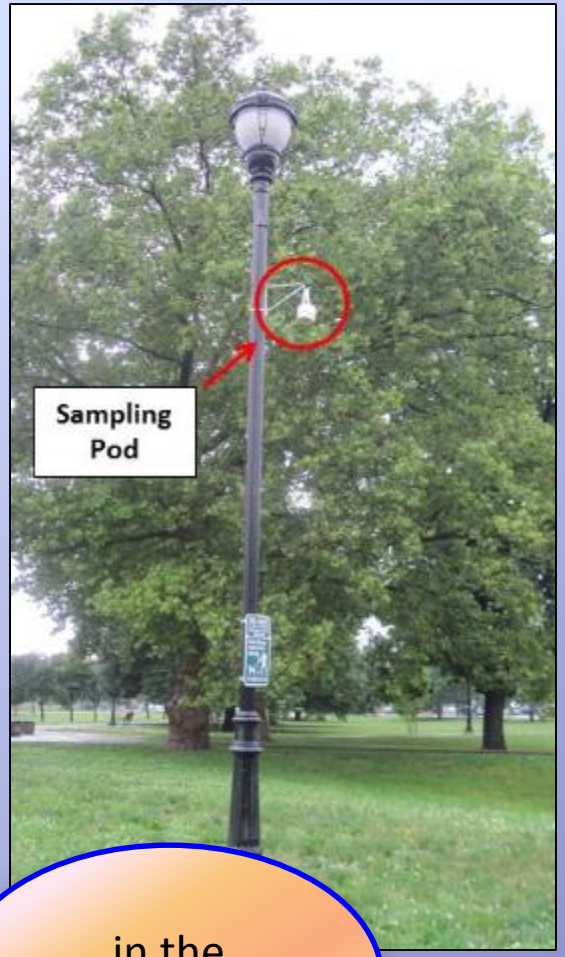




# Deployment Area in South Philly

# Philly PS deployment examples

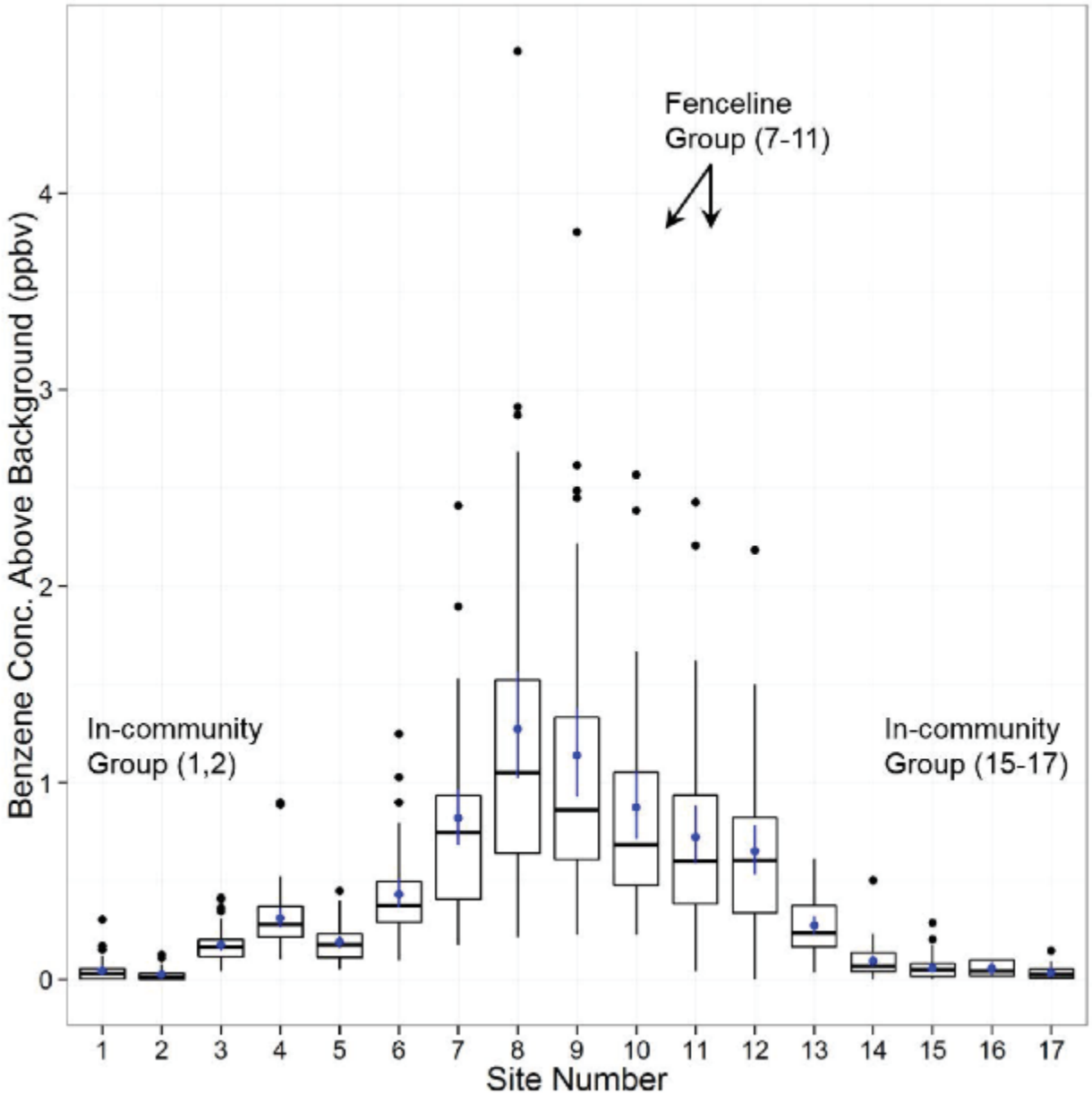




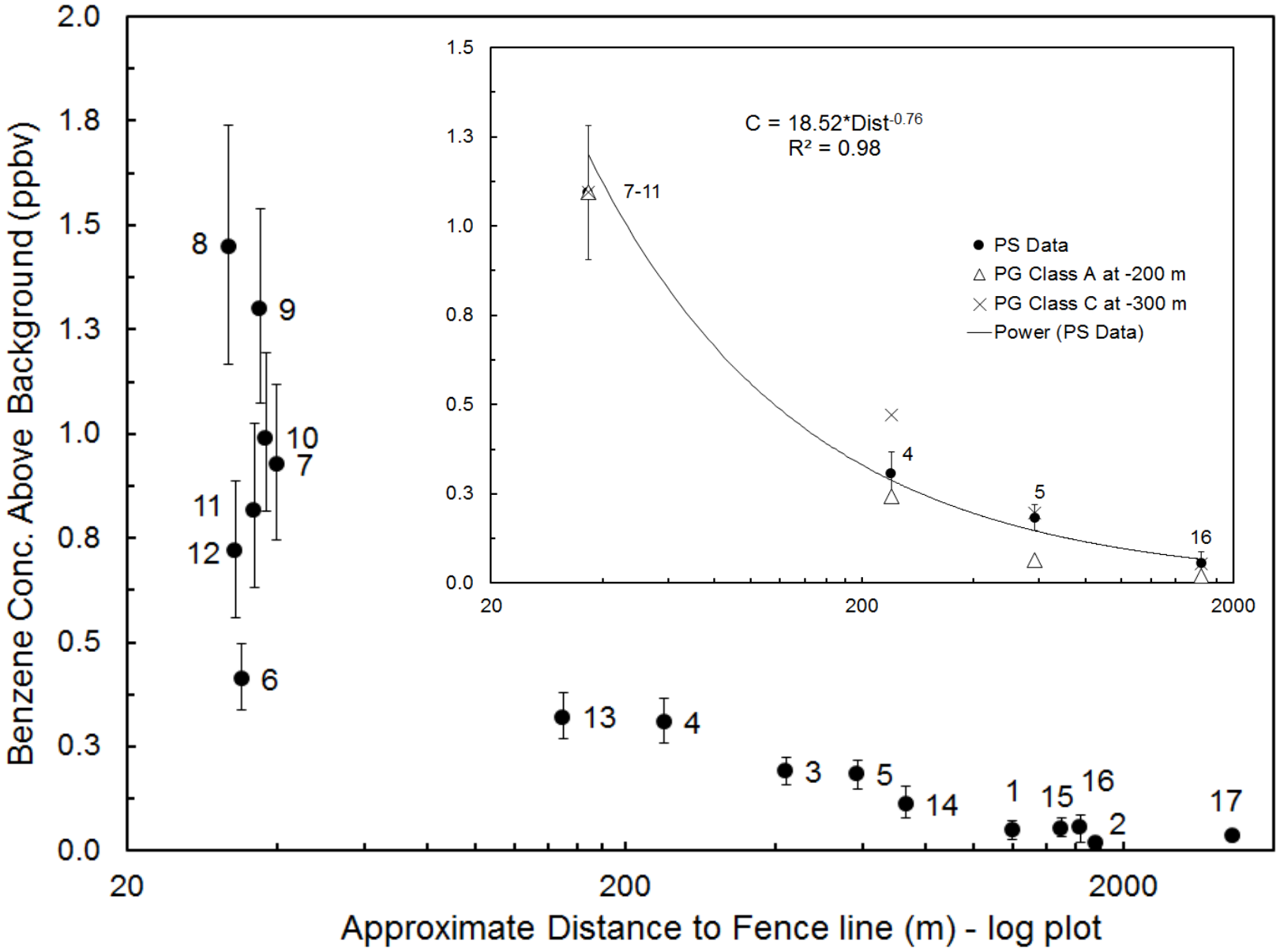



in the community

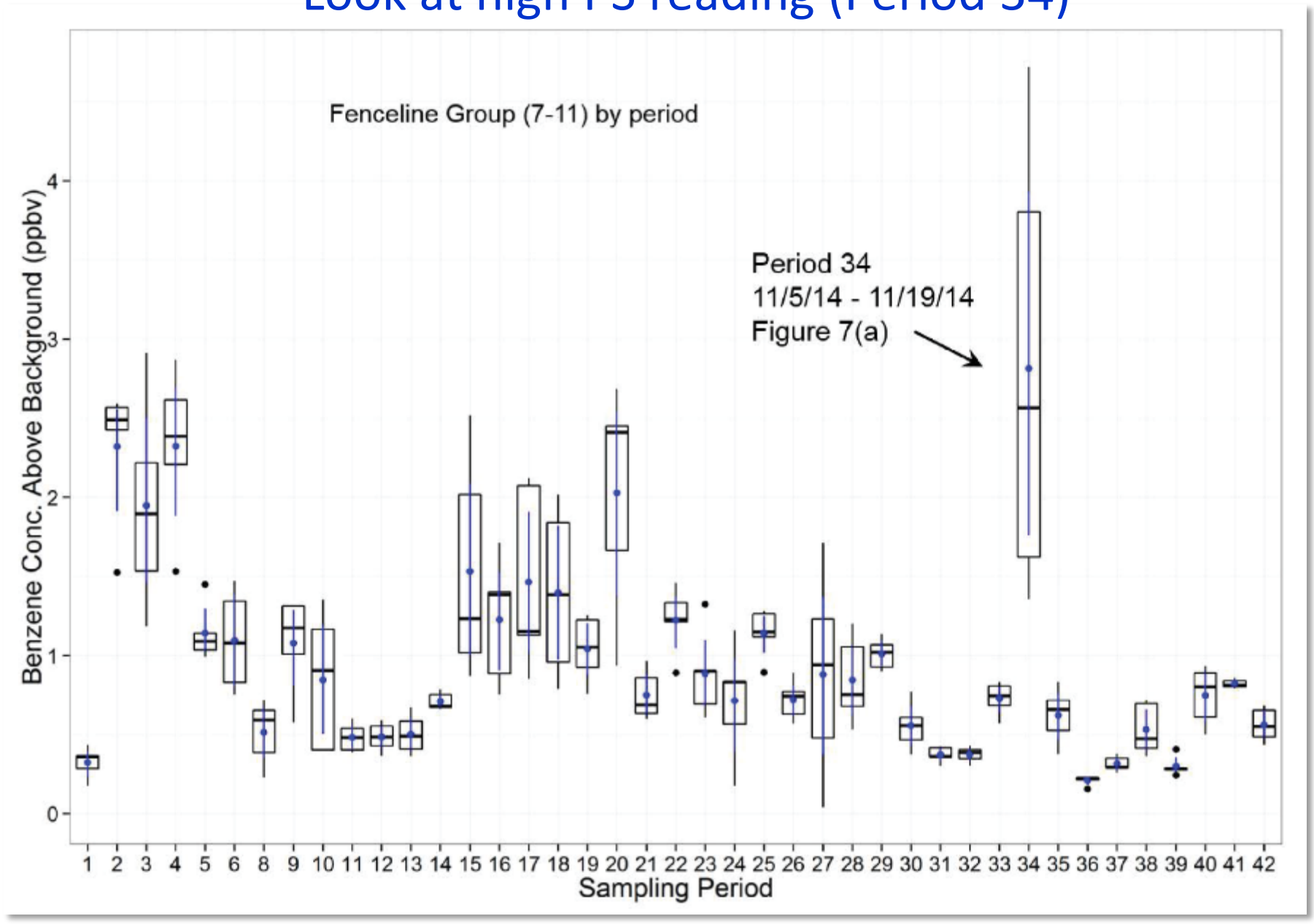
# Philly Passive Sampler (PS) Benzene Results, June 2013 - March 2015

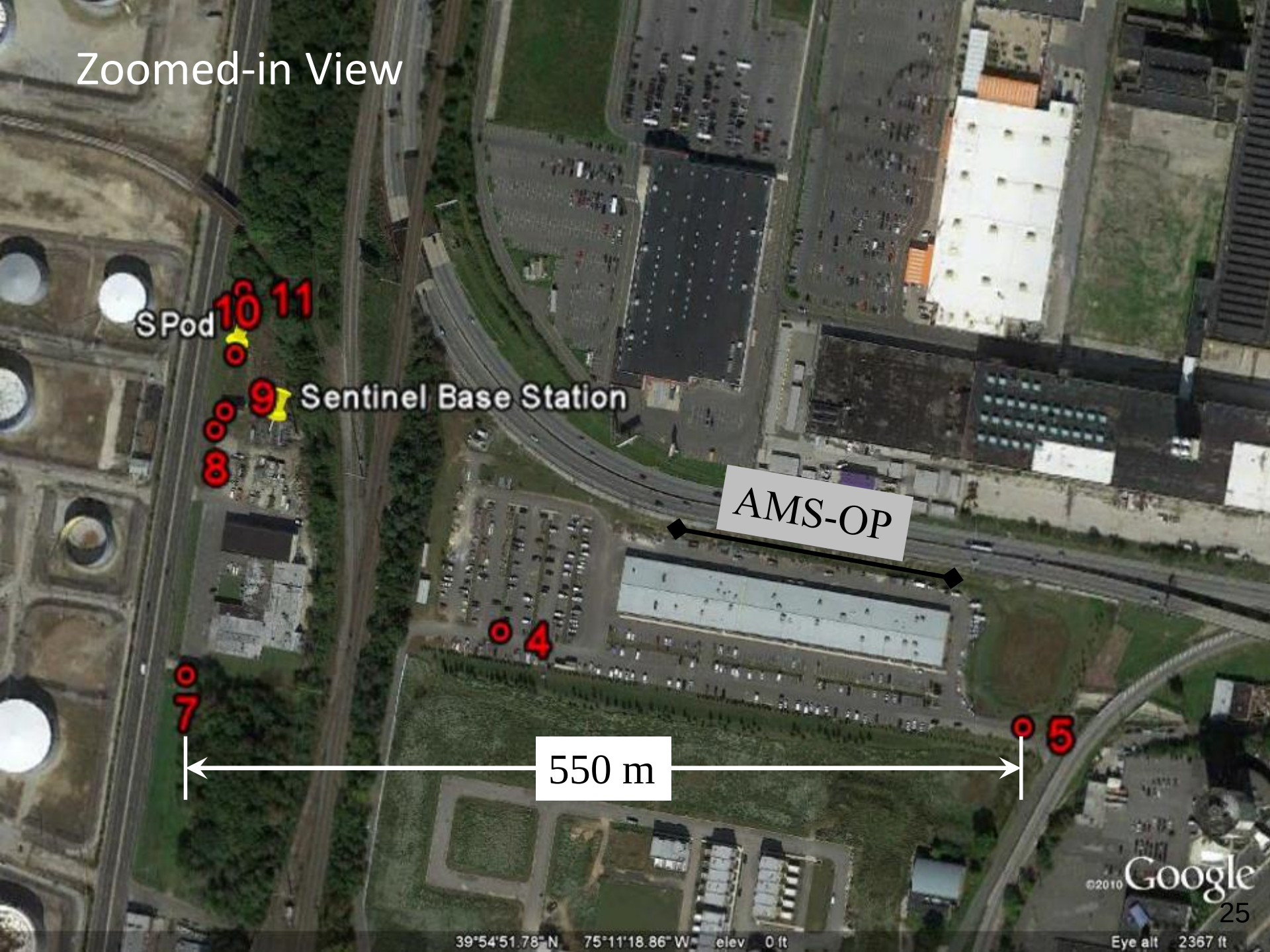


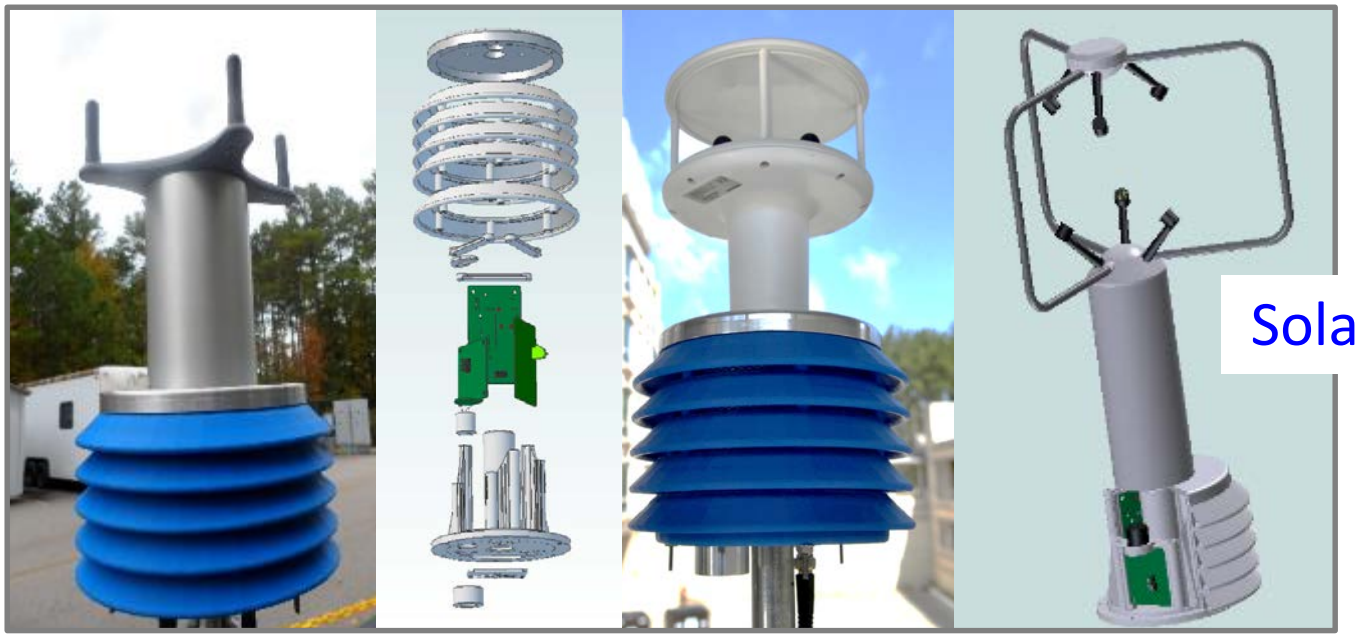
# Investigating Benzene Concentration Gradients



# Look at high PS reading (Period 34)



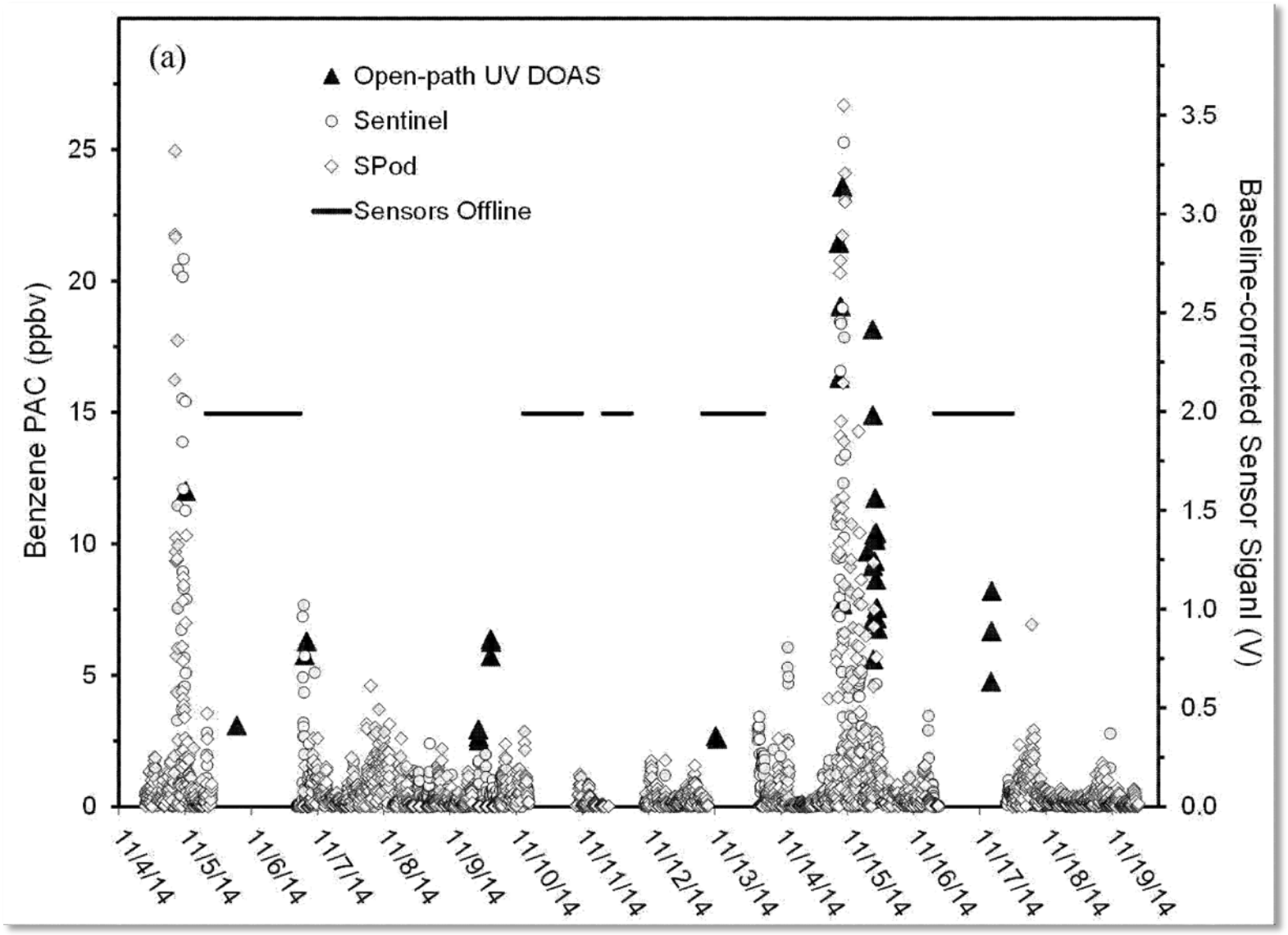

Zoomed-in View
S Pod
10
11
9
Sentinel Base Station
8
AMS-OP
4
7
5
550 m
©2010 Google
39°54'51.78" N 75°11'18.86" W elev 0 ft
Eye alt 2367 ft



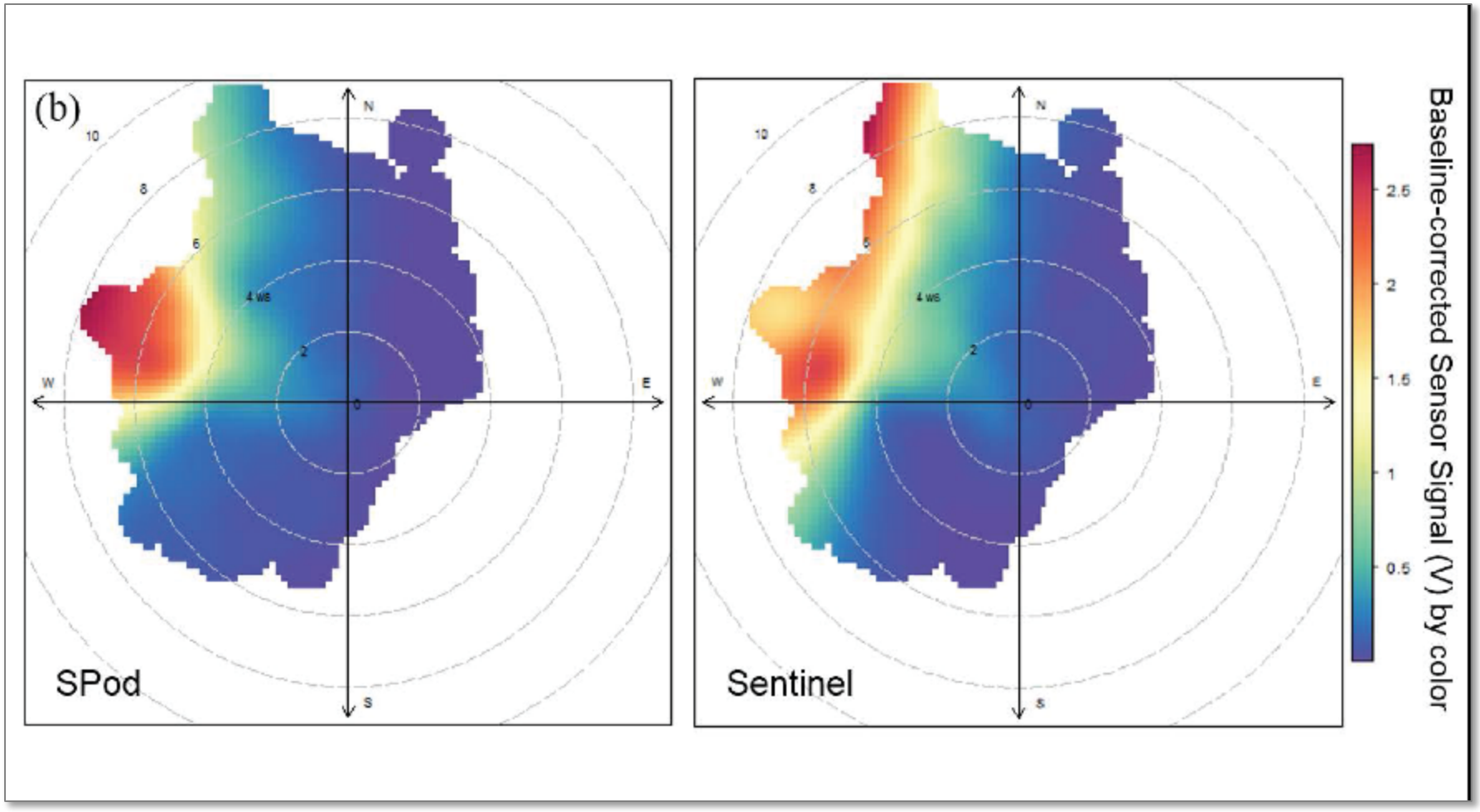
Solar Powered SPods

City of Philadelphia
UV DOAS system


# SPod Sensor and UV DOAS for Period 34



# SPod basic back trajectory example for 11/15/14



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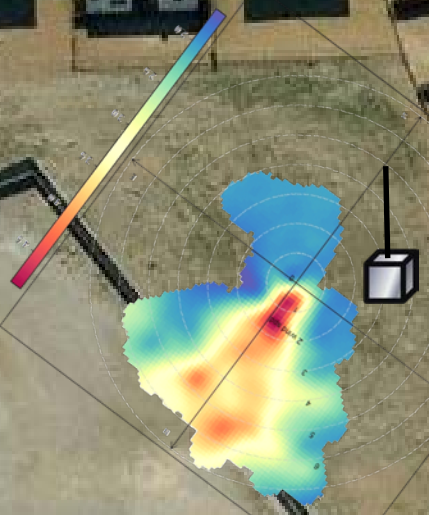
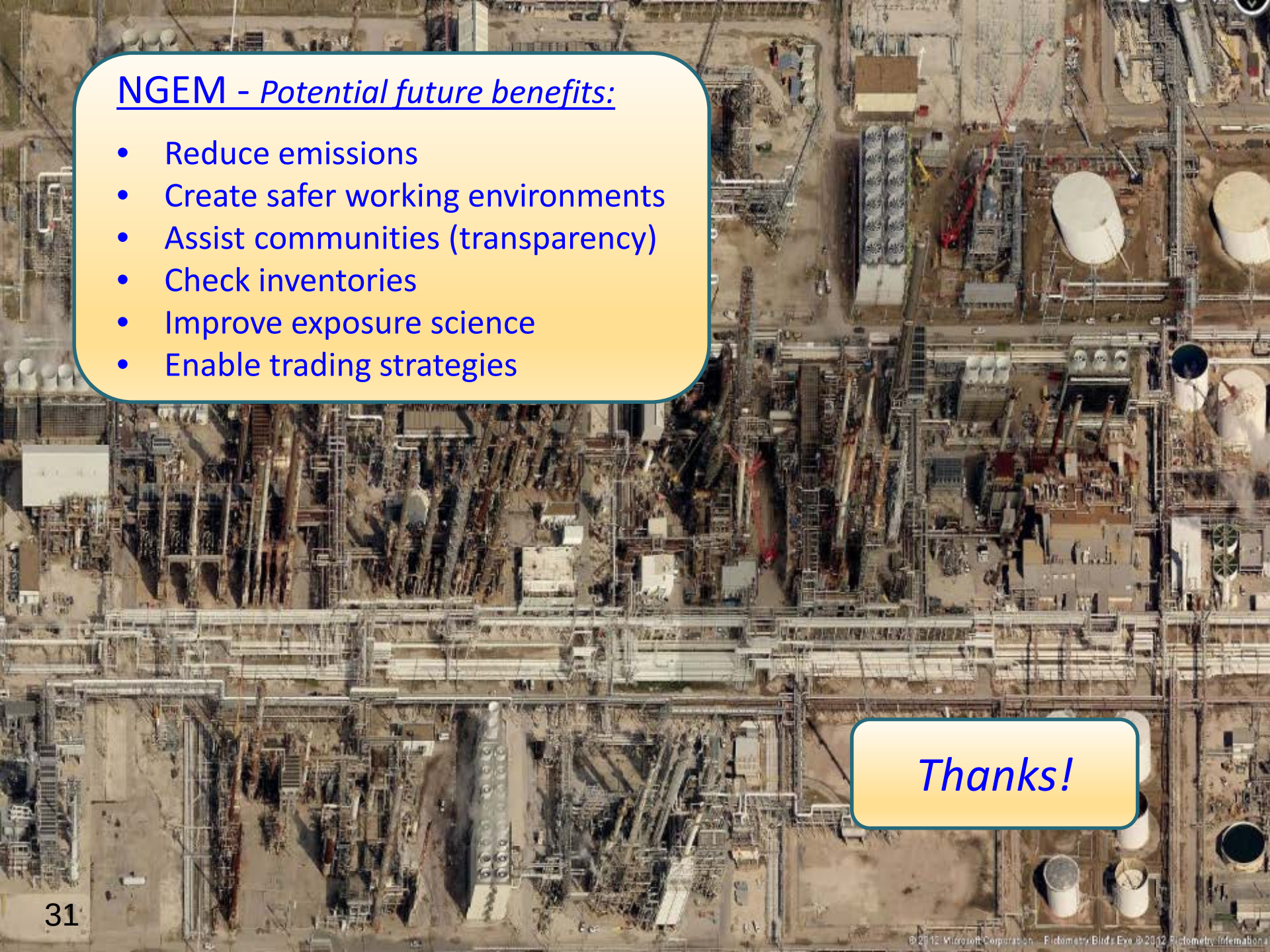




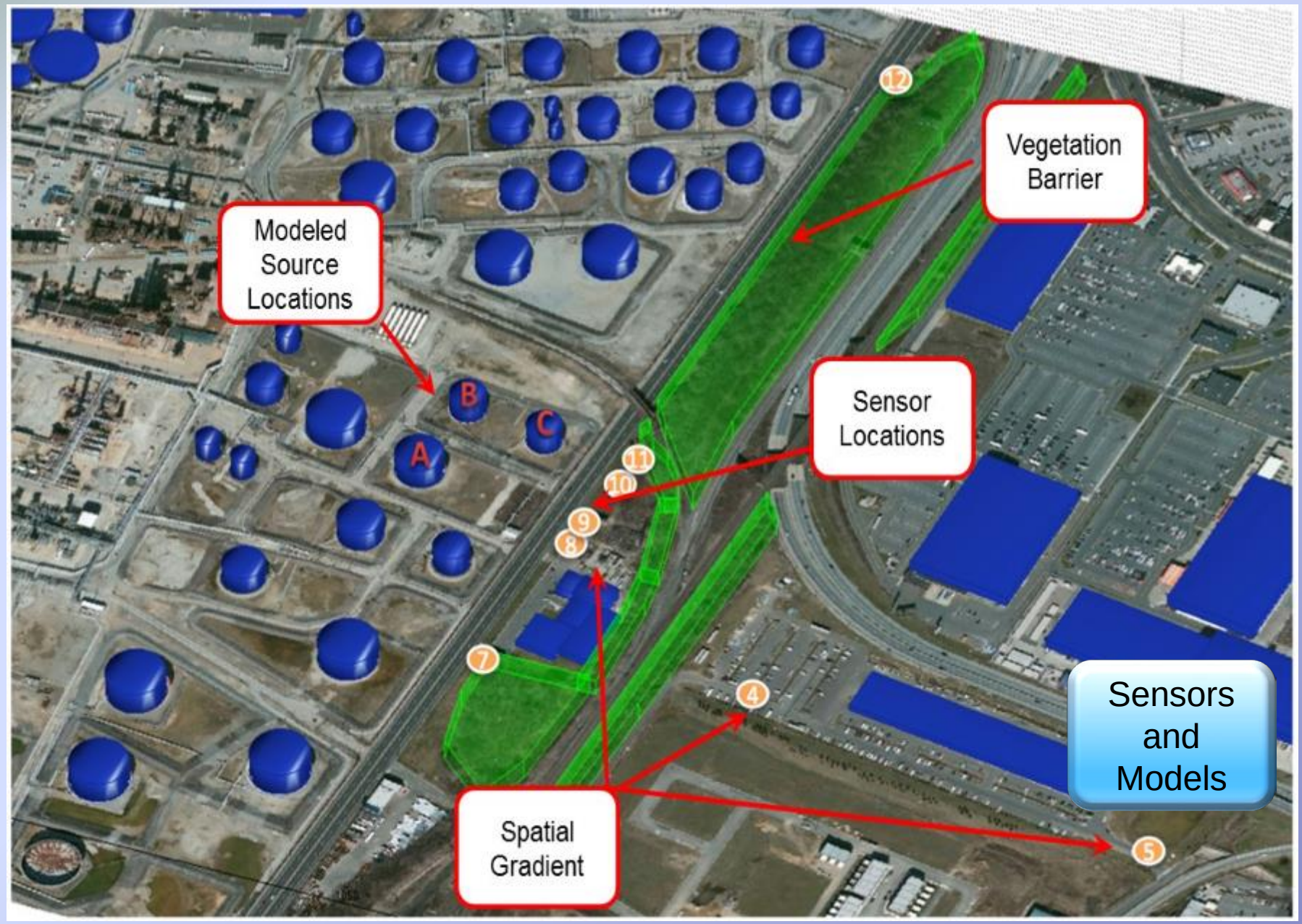
## NGEM - *Potential future benefits:*

- Reduce emissions
- Create safer working environments
- Assist communities (transparency)
- Check inventories
- Improve exposure science
- Enable trading strategies

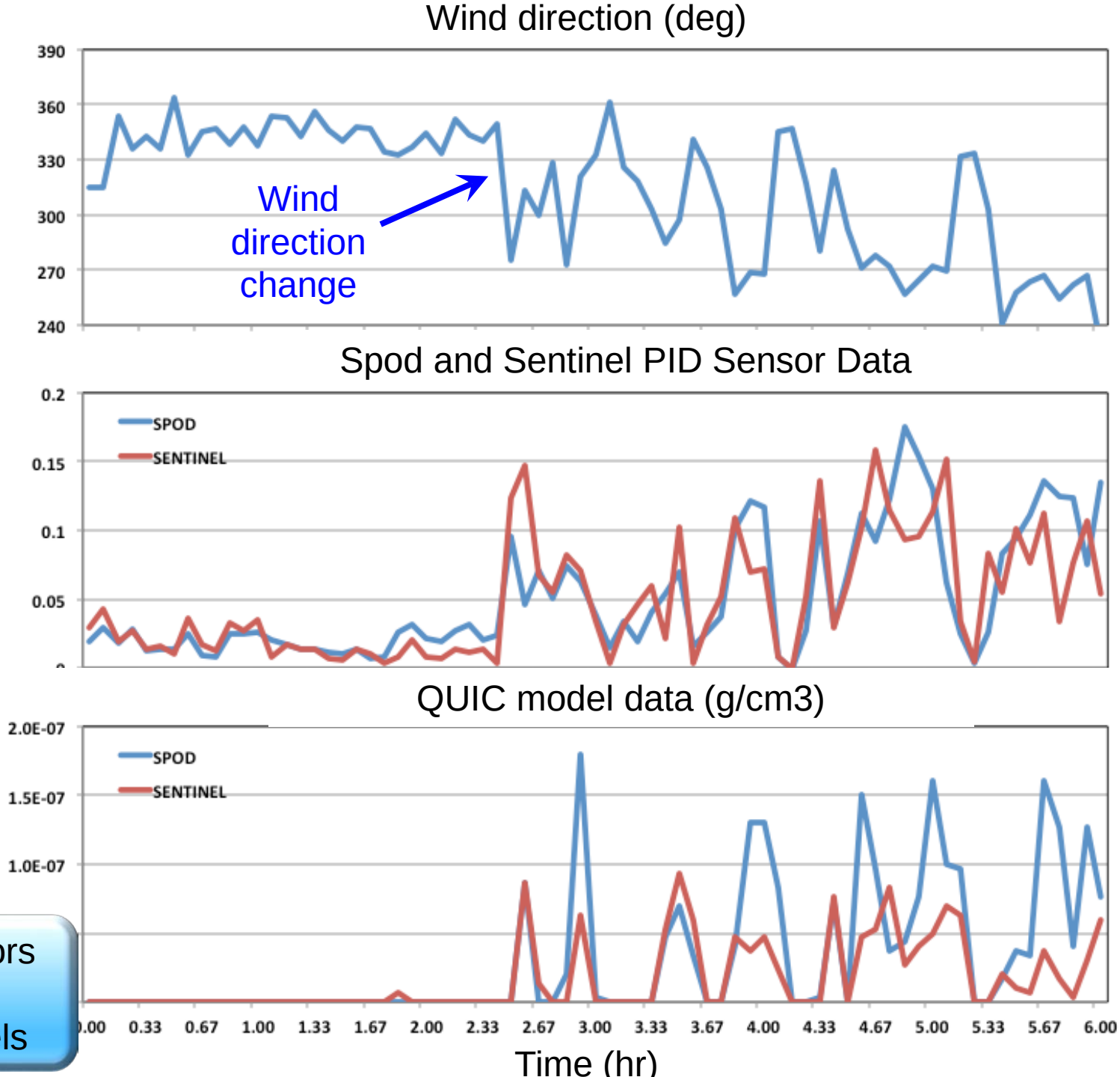
*Thanks!*

Backup Slides

# Los Alamos National Lab Quick Urban & Industrial Complex (QUIC) Model



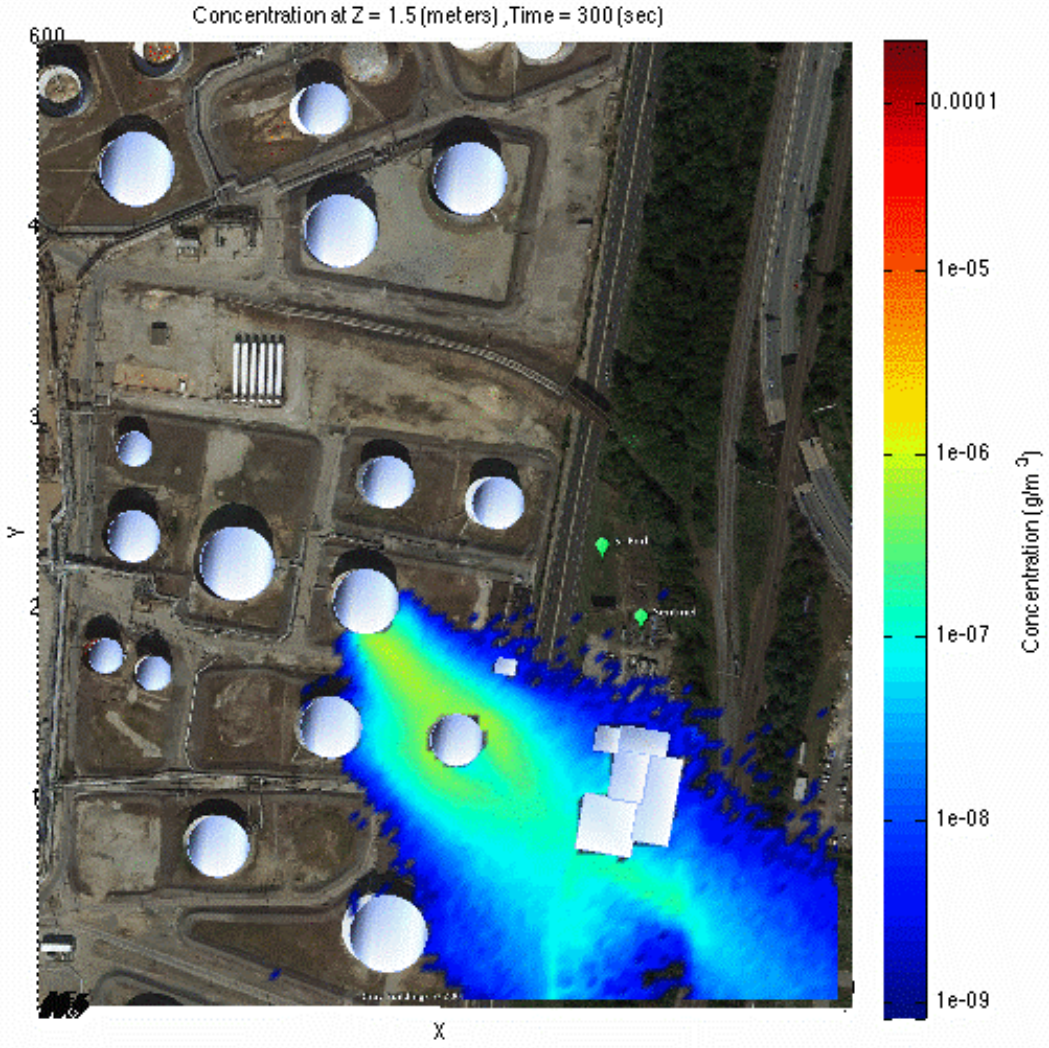
Measured Data and QUIC model Run 7/05/14, 6 hours




Sensors and Models

Draft 062015

# QUIC model Run 7/05/14 6 hours – illustrative example
This is a simulated source at an assumed location (not a real emission plume)




Sensors and Models