Next Generation Air Monitoring

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Haha! Where'd you get those old phones?!
Do they do anything other than make calls?
KABOOM
KIRK AND SPOCK TRAVEL BACK IN TIME TO 2014

Disclaimer

Mention of trade names, commercial products or services does not constitute endorsement or recommendation of use.

Overview

- Recent EPA Workshops, Webinars, and Resources
  - Office of Research and Development (ORD) Air, Climate, and Energy (ACE) Research Program
  - EPA Handbook: Optical Remote Sensing for Measurement and Monitoring of Emissions Flux
  - 2014 National Ambient Air Monitoring Conference
  - EPA Environmental Technology Verification Program (1995-2013)
- Innovative Air Monitoring Projects
  - Real-time Metals Monitor
  - Voluntary Emissions Reduction Agreement (VERA)
  - Corpus Christi Ship Channel SO_2

ORD Air, Climate, and Energy (ACE) Research Program

- Determined that low cost sensor technology was an area of growing interest
- Worked to stimulate development of inexpensive, highly portable sensors for use by citizens, community groups, schools, researchers, and government agencies
- Variety of intended applications including science education, research, air pollution exposure, and environmental justice

Next Generation Air Monitoring (NGAM) Workshops

- (March 26, 2012) Next Generation of Air Monitoring: Apps and Sensors for Air Pollution (ASAP)
  [https://sites.google.com/site/airsensors2013/background]
- (Nov. 6-7, 2012) NGAM2: Understanding Regional Needs and Exploring Solutions
  [https://sites.google.com/site/airsensors2013/background]
- (March 19-20, 2013) Air Sensors 2013: Data Quality & Applications
  [https://sites.google.com/site/airsensors2013/home]
- (June 9-10, 2014) Air Sensors 2014: A New Frontier
  [https://sites.google.com/site/airsensors2014/home]

NGAM Initiative

- Based on recommendations of ASAP 2012 (1st NGAM Workshop) a research initiative was proposed that would:
  - Continue dialogue between sensor developers and EPA on sensor performance;
  - Perform a market survey of low cost sensors associated with gas phase measurement of NO_2 and O_3;
  - Develop lab facilities and protocols that would be needed to evaluate such sensors for basic performance characteristics;
  - Establish a communication strategy for engaging sensor developers about the planned laboratory research, and;
  - Seek out and establish collaborative research agreements between the EPA and interested sensor developers.

NGAM Efforts

- Next Generation Air Monitoring Workshops held in 2012, 2013, and 2014
- July 2014 Webinar; Sensor Technology-State of the Science
- Resources published for air sensor citizen science toolbox
  - Air Sensor Guidebook
  - Sensor Evaluation Report
  - Mobile Sensors and Applications for Air Pollutants

http://www.epa.gov/research/airscience/next-generation-air-measuring.htm

NGAM Take Away

- Despite lower accuracy of low-cost sensors they still offer potential to fill in gaps and provide information
- Explosive growth in wearable sensors, especially medical applications
- Some sensors (O_3 and NO_2) compare favorably, others have work to do
- Data interpretation – messaging key to prevent confusion, i.e., short-term values compared to long-term standards
- "Data quality is a key issue since data of poor or unknown quality is less useful than no data since it can lead to wrong decisions."[1]

[1] Snyder, E., Tim Watkins, P. Solomon, E. Thoma, R. Williams, G. Hagler, D. Shelow, D. Hindin, Vasu Kilaru, AND P. Preuss. Changing the Paradigm of Air Pollution Monitoring. ENVIRONMENTAL SCIENCE AND TECHNOLOGY. John Wiley & Sons, Ltd., Indianapolis, IN, 47(20):11369-11914, (2013).

EPA Handbook: Optical Remote Sensing (ORS) for Measurement and Monitoring of Emissions Flux

- EPA published to encourage wider use and understanding of ORS technology
- Designed to assist the “non-spectroscopist”
- Handbook is divided into five sections:
  - Section 1: Discusses what ORS means and how this technology can be used.
  - Section 2: Describes the different technologies that are currently available that are considered “optically remote”.
  - Section 3: Explains how to use and calculate emission flux.
  - Section 4: Discusses “other” data that needs to be collected to understand and better validate and verify ORS data.
  - Section 5: Overview of how to validate and verify the data.

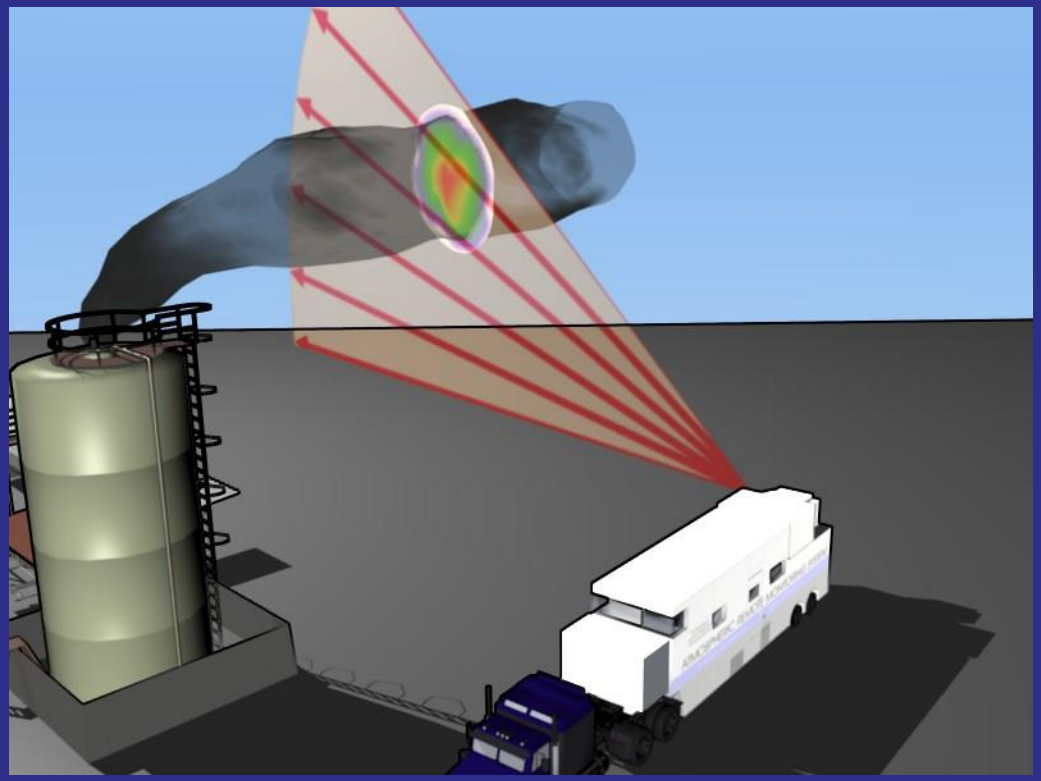
http://www.epa.gov/ttnemc01/guidlnd/gd-052.pdf

Thermal Infrared (IR) Cameras

- Creates images using IR absorption/emission properties of chemical species.
- Primarily used to detect large leaks from process equipment and storage tanks.
- Pro: Economical
- Con: Qualitative vs Quantitative

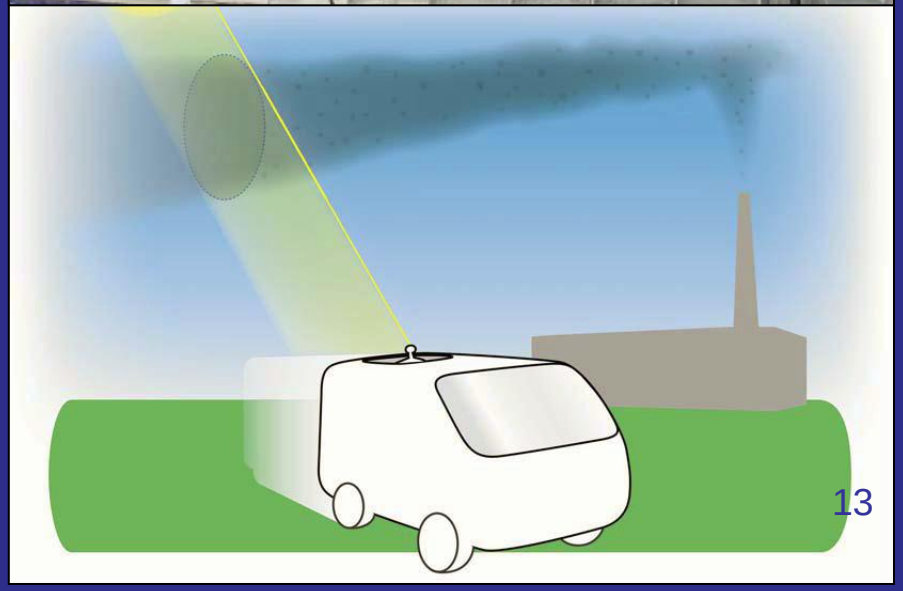
LIDAR/DIAL

- Lasers are directed into the atmosphere and concentrations are derived from the backscatter of light.
- Pro: Ability to spatially resolve the concentration of a single compound, or class of compounds.
- Con: High cost of the associated equipment.



Solar Occultation Flux (SOF)

- Uses solar broadband IR or UV/visible spectral radiation as the light source instead of a laser source.
- Pro: Faster than DIAL and easier to automate. Can be operated while moving.
- Con: Difficulty in separating emissions sources that are close together. Not viable at night or early/late in the day.



2014 National Ambient Air Monitoring Conference

- EPA/NACAA hosted in Atlanta, Georgia, August 11-14
- Occurs every two years
- NGAM track included in 2014 agenda
- Papers and presentations will be posted here:

http://www.epa.gov/ttn/amtic/naamc.html

EPA Environmental Technology Verification Program (1995-2013)

- Created in 1995 to help accelerate the entrance of new environmental technologies
- Operations concluded at end of 2013
- ETV has verified the performance of nearly 500 environmental technologies
- Verification reports and statements, protocols and test plans, and other program resources are available here:

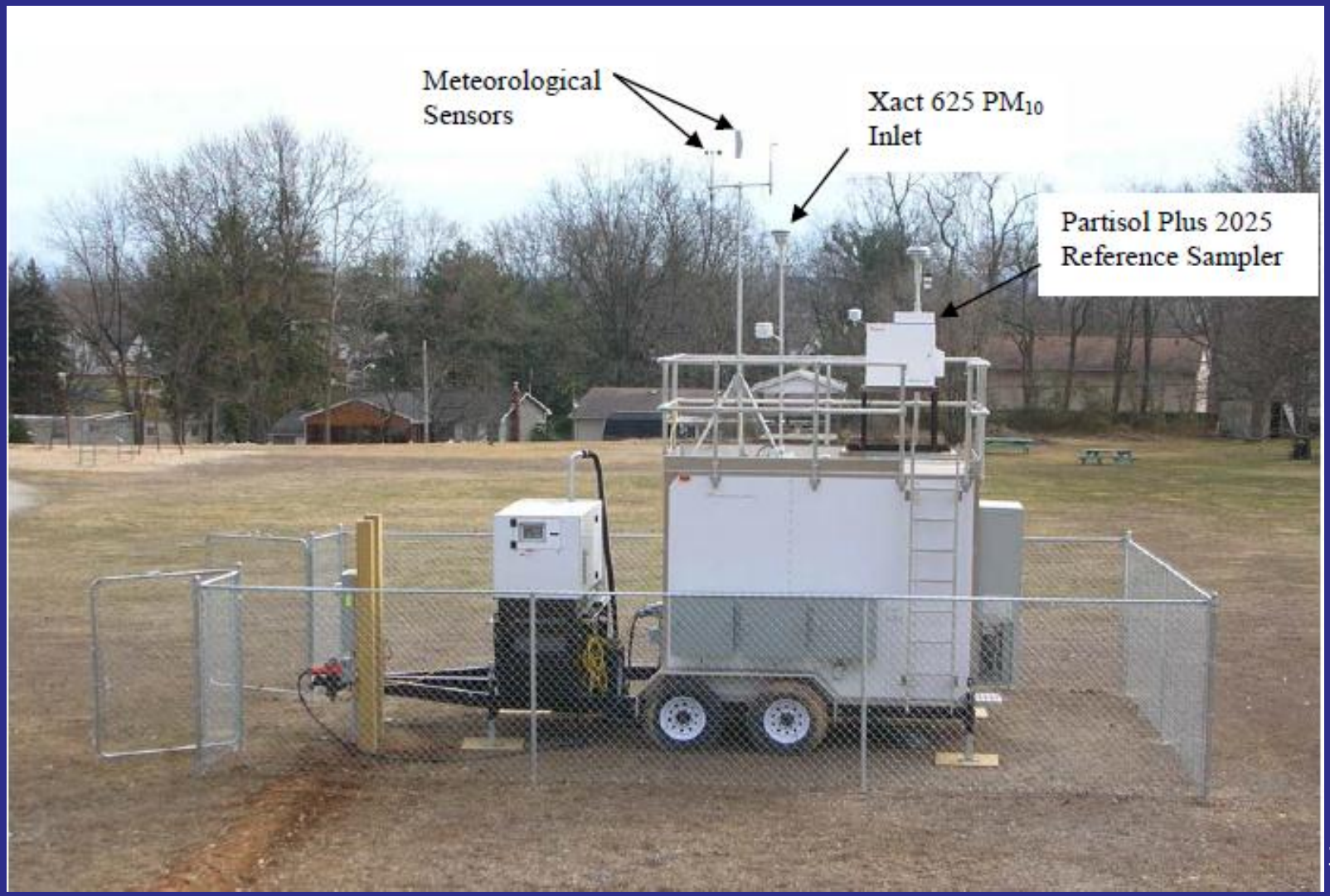
  http://www.epa.gov/etv

Innovative Monitoring Projects

Real-time Metals Monitor

- Resulted from an agreed judgment negotiated by the State of Texas
- Use of Cooper Environmental Services X-ray based continuous metals monitor, i.e., Xact-625, at fence line
- Testing protocol modeled after EPA ETV study
- Target metals include arsenic, cobalt, molybdenum, lead, nickel, and vanadium
- Scheduled to begin fall 2014

Xact 625 Set-up



Voluntary Emissions Reduction Agreement

- January 2005: TCEQ evaluation of Houston area monitoring data identifies Milby Park area for 1,3-butadiene (BD) reductions
- February 2005: Milby Park Auto-GC brought on-line; provides near real-time hourly measurements
- May 2005: Companies present proposals for BD reductions
- June 2005: Goodyear and Texas Petrochemicals sign Voluntary Emission Reduction Agreements (VERAs) with TCEQ

Fence Line Monitoring

- TPC - open path FTIR (5 min or less resolution)
- Goodyear - automated GC System (15 min resolution)

Area Map


Milby Park AutoGC
Goodyear AutoGC #1
Goodyear AutoGC #2
TPC North FTIR
TPC South FTIR
Image Landsat
1082 ft
Google earth

Fenceline FTIR

Importance of Monitoring

- Initially identified the issue
- Identified facilities contributing to ambient concentrations
- Helped identify specific equipment areas and/or activities with butadiene emissions (initially and on-going)

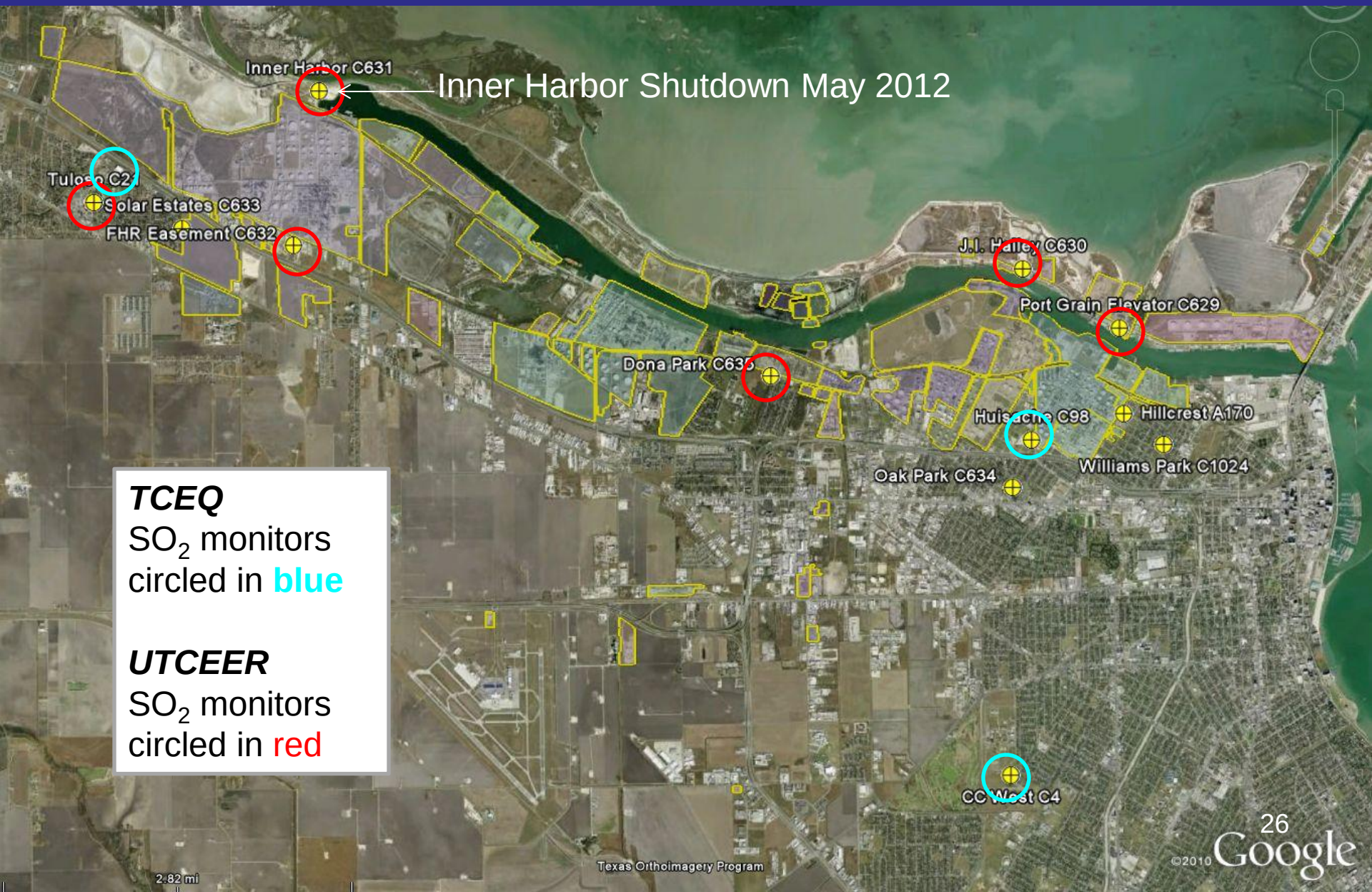
Importance of Monitoring (continued)

- Provides an alert mechanism to identify periods of elevated butadiene
- Used to evaluate impact on “downwind” neighborhoods
- Measures progress towards goal

Corpus Christi Ship Channel SO_2

- Several monitoring sites are operated by the University of Texas in Corpus Christi.
- With new 2010 SO_2 NAAQS, one non-regulatory UT site (J.I. Hailey) was found to be above the standard.
- TCEQ worked cooperatively with the port and port industries to identify the source(s) beginning early 2011.

SO_2 Monitors in Corpus Christi



View from J.I. Hailey

View from J.I. Hailey

Efforts to Identify Source(s)

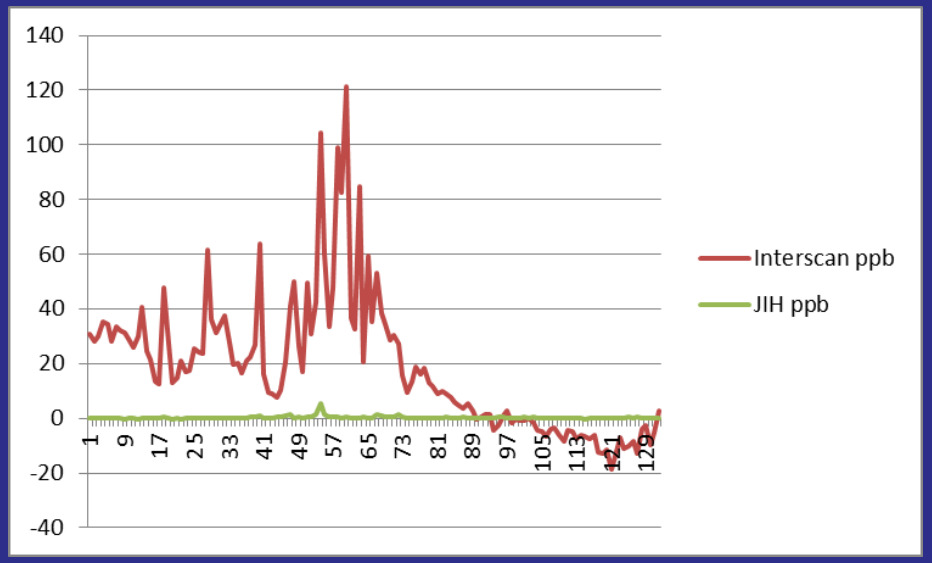
- TCEQ issues automated e-mail alerts when elevated SO_2 is measured.
- Port and port industries gathered info in response to alerts (e.g., CEMS, vessel traffic, field observations, etc.).
- TCEQ evaluated/reviewed “new” technologies.

New Technologies

- INTERSCAN 4000 Series Digital Portable Analyzer
  - battery-operated unit with integral sample pump
  - detection element is an electro-chemical voltametric sensor
- Ground Based UV and IR Imaging Systems

Portable Analyzer

- Recommended by monitoring contractor
- Battery powered, no AC power
- Performed well in another application
- Collocated with JIH site
- Did not compare well to FEM:

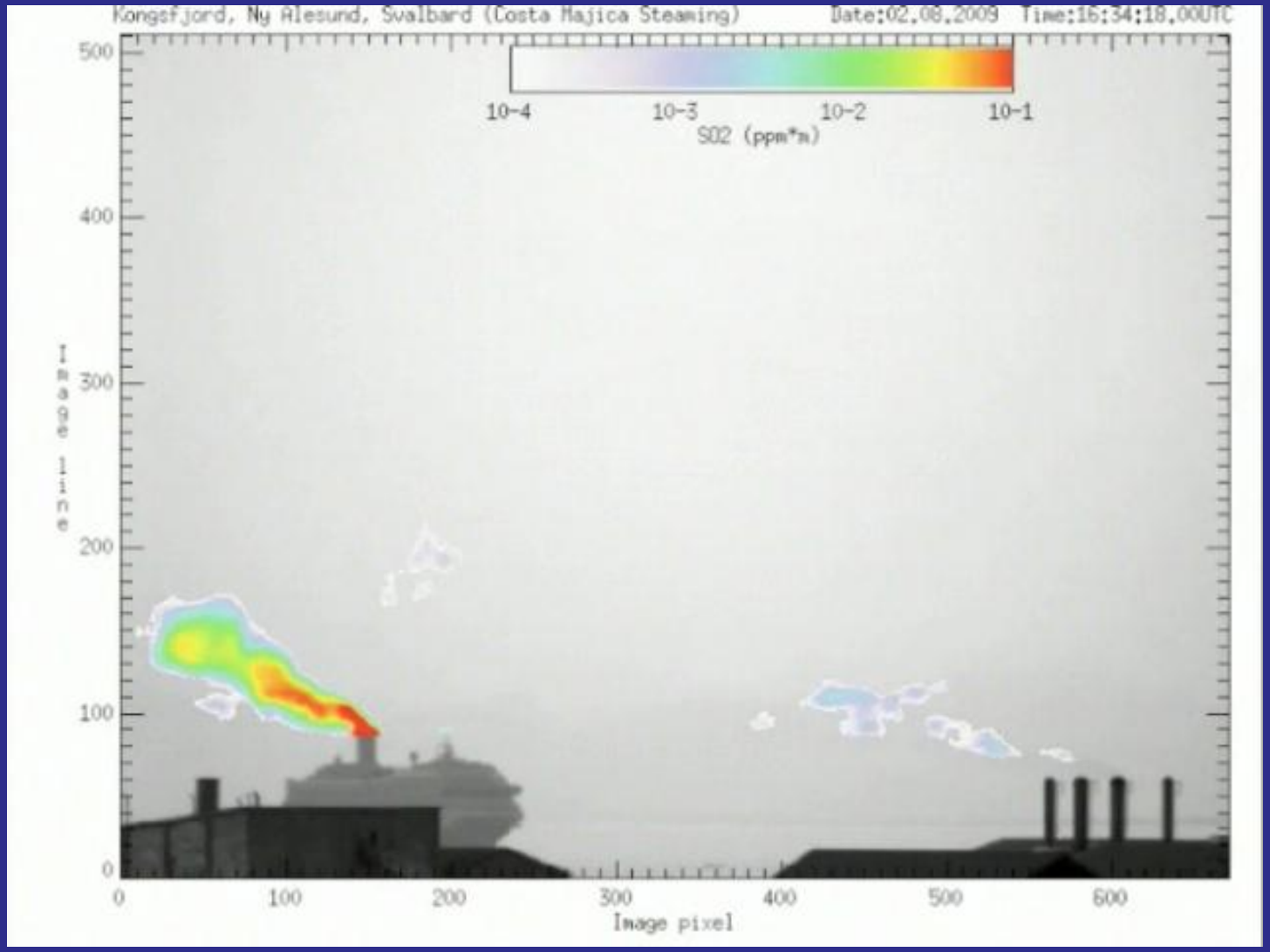


UV and IR Imaging Systems

- Developed through research at the Norwegian Institute for Air Research (NILU)
- Field tested over previous years within volcano research, environmental research, and industrial and ship emissions monitoring.
- Now being commercialized by a new venture, PortEYE AS at:

http://www.niluinnovation.com/Ventures.aspx

SO_2 Imaging


Kongsfjord, Ny Alesund, Svalbard (Costa Majica Steaming)
Date:02.08.2009 Time:16:34:18.00UTC
10-4
10-3
10-2
10-1
SO2 (ppm*m)
Image line
Image pixel
0
100
200
300
400
500
600

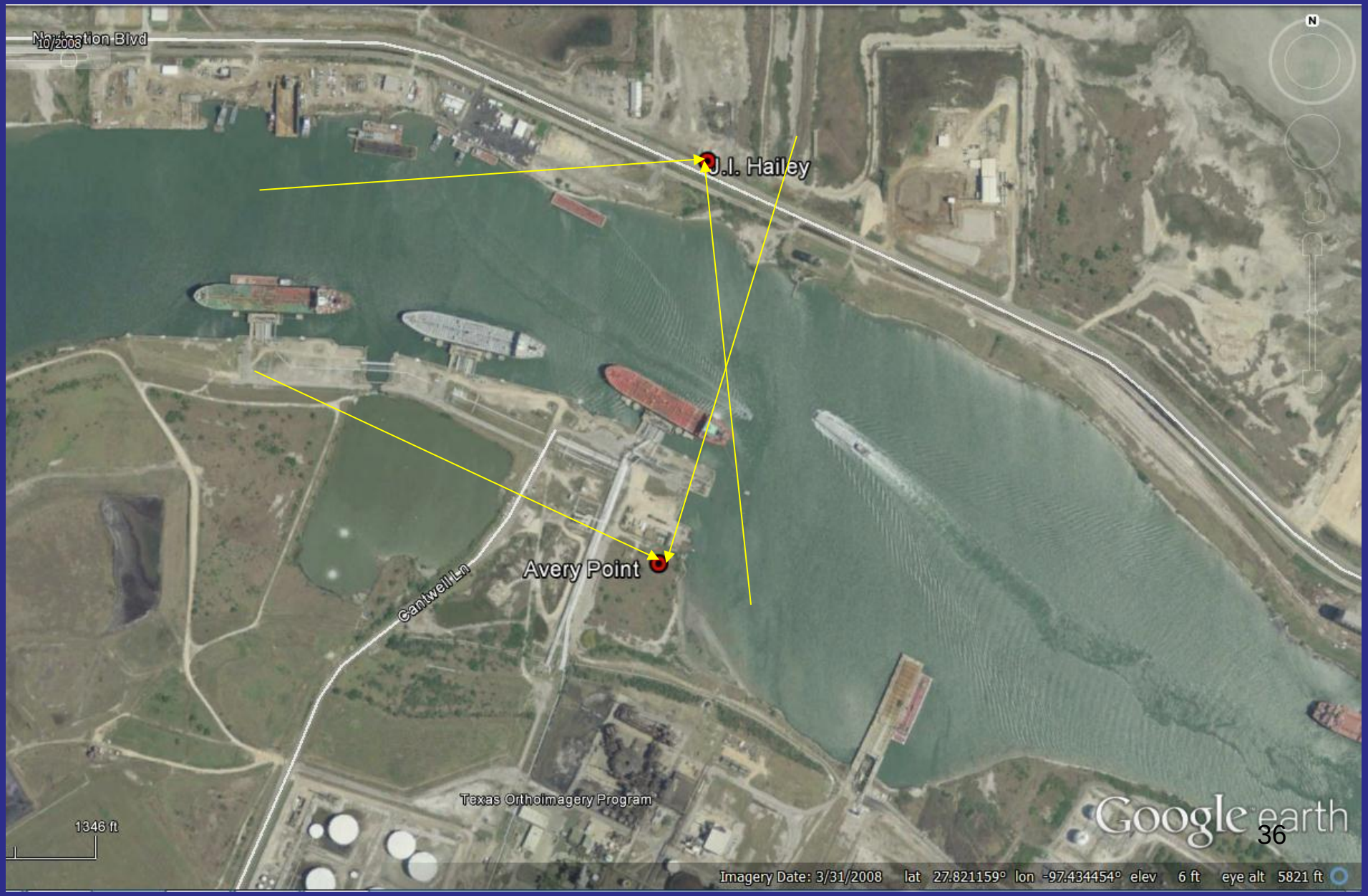
Imaging Systems

- **Envicam-2 Fast UV Multispectral Imaging Camera**
  - Envicam-2 ideal for monitoring emissions from industrial complexes and ships. Tested at several erupting volcanoes and at industrial plants in Australia, Romania, South Africa, and Norway.
- **NicAIR Infrared Imaging Camera**
  - NicAIR is a thermal infrared imaging camera used to measure gases and particles in the atmosphere from a safe distance (ground based up to 20 km) and can operate 24 hours a day.
- **Vendor was unable to deliver product per timeline**.

Corpus Christi Outcome

- TCEQ installed “upwind/downwind” site (Avery Point) south of UT’s J.I. Hailey (JIH)
- Avery Point SO_2 monitor was a designated Federal Equivalent Monitor (FEM, Thermo 43C)
- Operated for two years (2012 and 2013)
- Data from Avery Point and JIH, combined with ship traffic, pointed to ocean-going ships as the source of elevated SO_2
- New fuel regulations are correlated to decreasing SO_2 emissions measured at Avery and JIH.
- Current JIH design value (47 ppbv) below the 2010 SO_2 NAAQS

Primary SO_2 Sources: Ships



What's Next

Expect to see:

- New and improved imaging tools
- Ability to quantify
- Automation with less human technique

Rebellion Photonics
Gas Cloud Imaging System

Rebellion Photonics Gas Cloud Imager Propylene Gas Release.

Traditional IR Camera viewing the same release.

Slide courtesy of Rebellion Photonics

Rebellion Photonics
Gas Cloud Imaging System

Slide courtesy of Rebellion Photonics

Questions?