Overview of the Benzene and Other Toxics Exposure (BEE-TEX) Field Study

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BEE-TEX Field Study

- The Benzene and other Toxics Exposure (BEE-TEX) Study was a field study of **human exposure** to and **source attribution** of the air toxics: benzene, toluene, ethyl benzene and xylenes (BTEX), plus other HAPs (e.g., formaldehyde, 1,3-butadiene).

- The study was conducted in the Houston Ship Channel neighborhoods of Manchester, Galena Park, and Milby Park in February of 2015.

- The study cost about $1 million and was funded by U.S. Fish & Wildlife, Coastal Impact Assistance Program (CIAP) through Harris County, Texas.
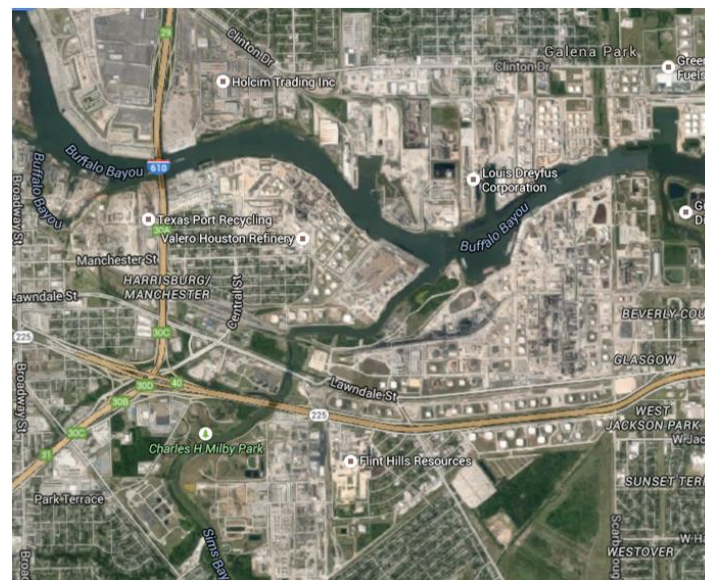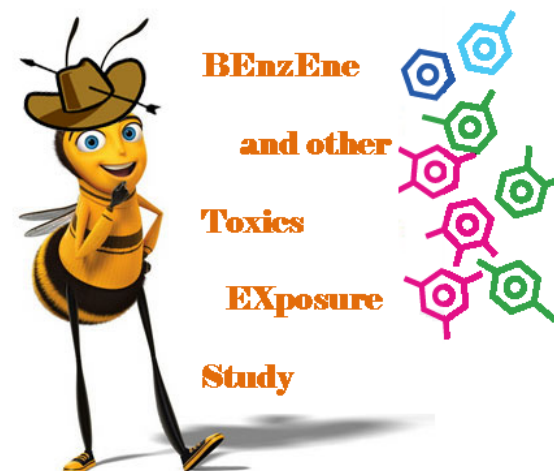
BEE-TEX Methodologies

- Portable cultured human lung cells (UNC)
- Real time monitoring (~1 s TR, <1 ppb LOD) based on three mobile platforms (Aerodyne, HARC, UH)
- Real time data broadcasting (HARC)
- Computer-Aided Tomography (CAT) scans based on Differential Optical Absorption Spectroscopy (DOAS) remote sensing (UCLA)
- Micro-scale 3D Eulerian chemical transport model for real time source attribution and plume reconstruction within ~30 min to 1 hr of CAT-DOAS or mobile lab observations (HARC)

Cultured Human Lung Cells

- UNC deployed *in vitro* technique in which living lung cells were exposed to polluted air delivered across an air-liquid interface.

- Cell toxicity & inflammation measured based on releases of specific proteins and enzymes.

- Genomics testing of exposed lung cells may confirm response to carcinogens present in air.

- Cell responses may indicate exposure to specific classes of pollutants (e.g., aldehydes).

QCL
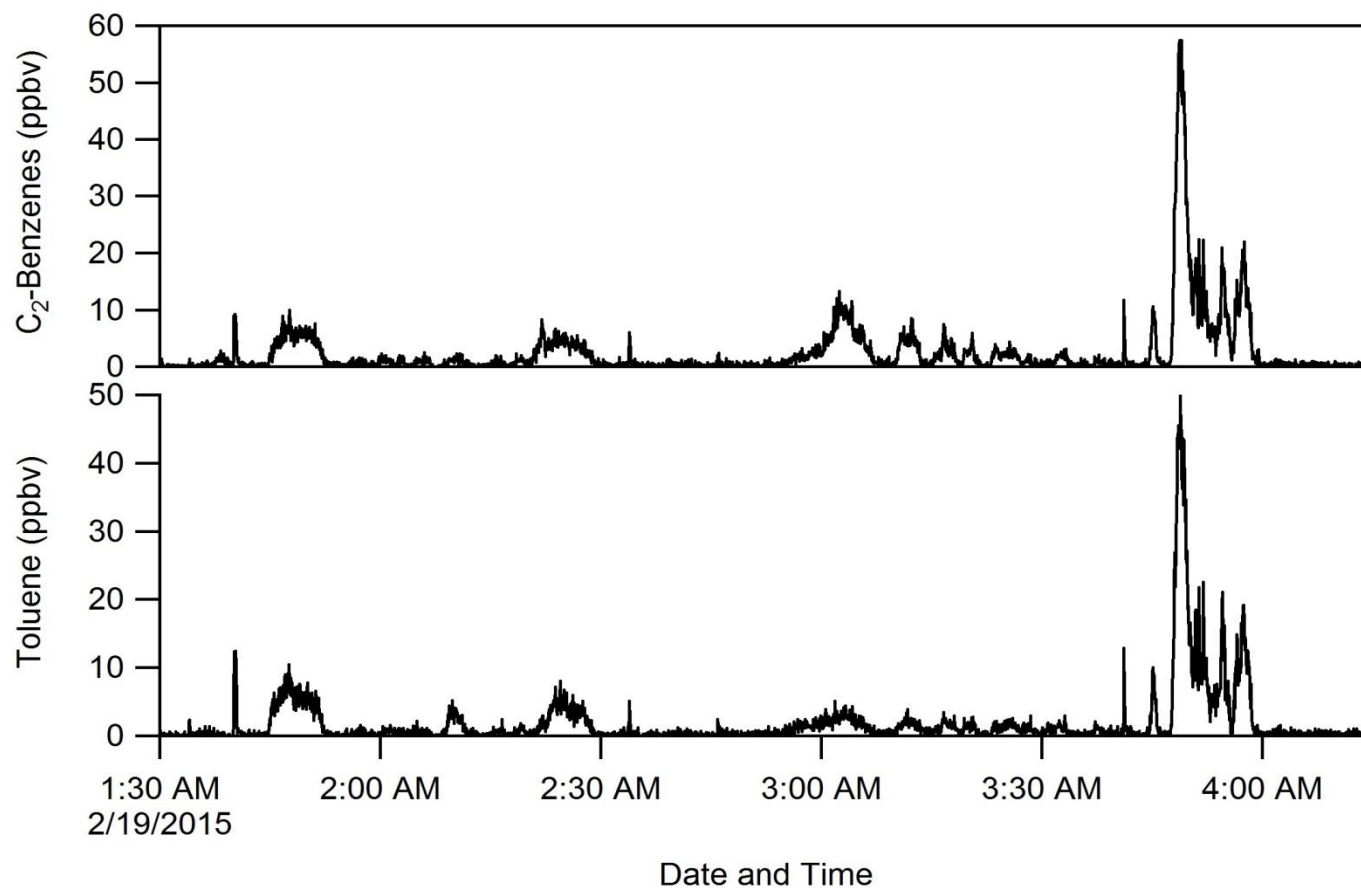
PTR-MS
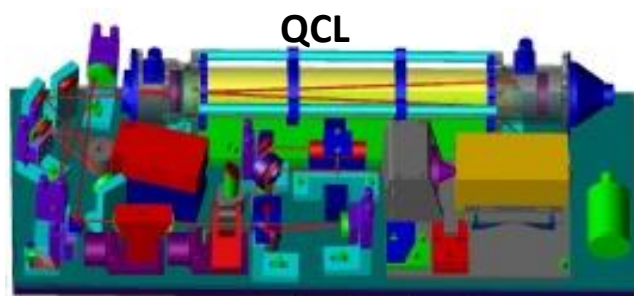
Real Time Data Broadcasting
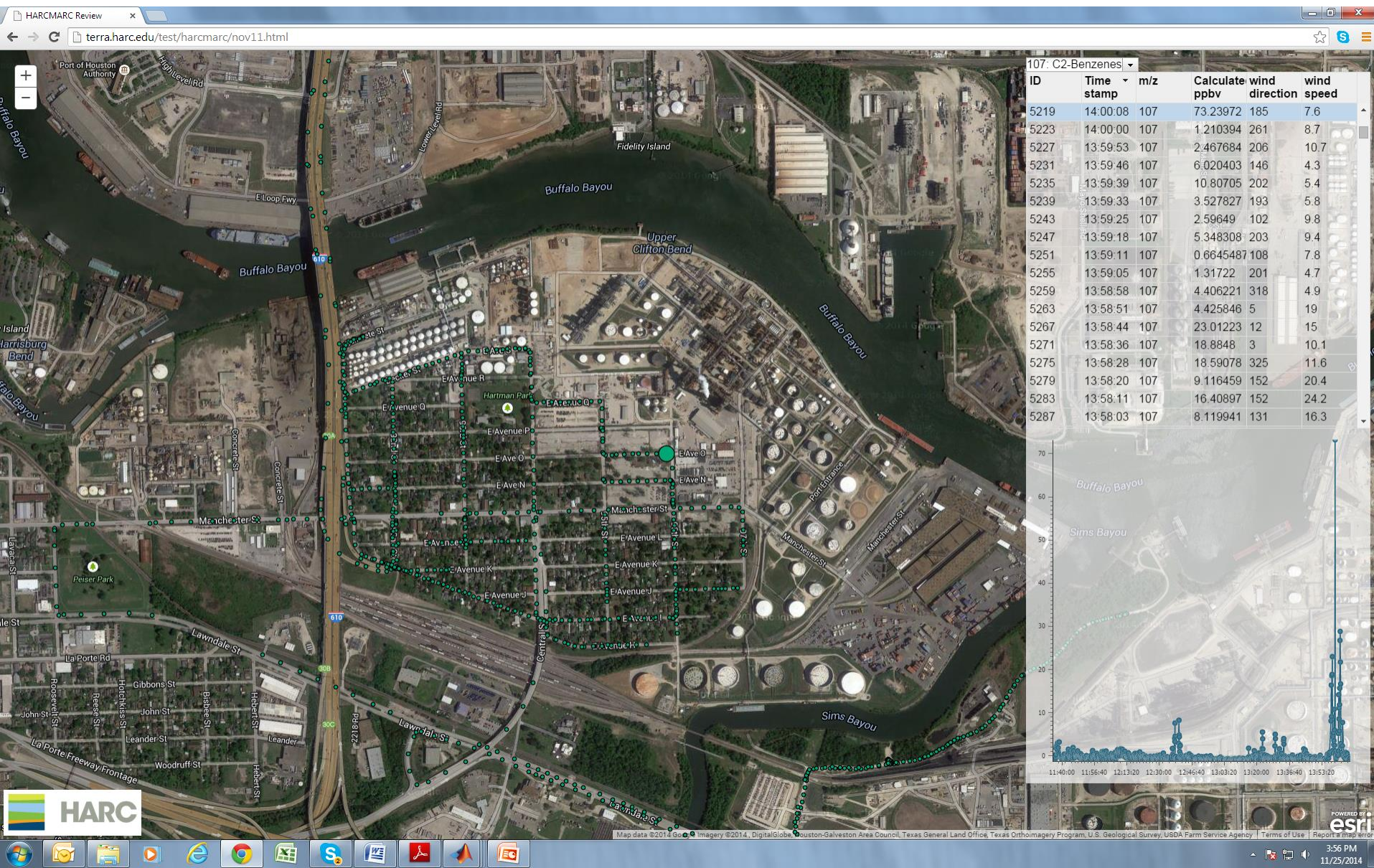
Computer-Aided Tomography

LP-DOAS Measurements on Feb 19 from 4:01:27 – 4:26:20 AM LST

Path ID	Path Length (m)	Toluene (ppb)	m-Xylene (ppb)	p-Xylene (ppb)
M1	770	15.12	4.00	1.83
H4	740	2.53	0.92	0.19
H1	513	20.91	6.89	2.75
M2	1203	3.39	0.33	0.05
H2	526	39.87	11.17	4.74
M3	270	1.42	1.51	0.60
H3	689	11.05	1.95	0.64

HARC Mobile Lab Measurements on Feb 19 from 1:30 – 4:15 AM LST

February 19, 1:30-4:15 AM

AREA
EPLLL
EPTTL EPHLL
TRAIN
91AFUG
47AD5409

Mobile Lab Toluene Msmt

ppbv
- 0 - 2
- 2 - 10
- 10 - 20
- 20 - 50

Model Grid
Pipeline
NEI Point Sources
Major Implicated Source
UH aerosol Lidar

CAMS
Clinton
Galena Park 2nd Street
Manchester/Central

HARC

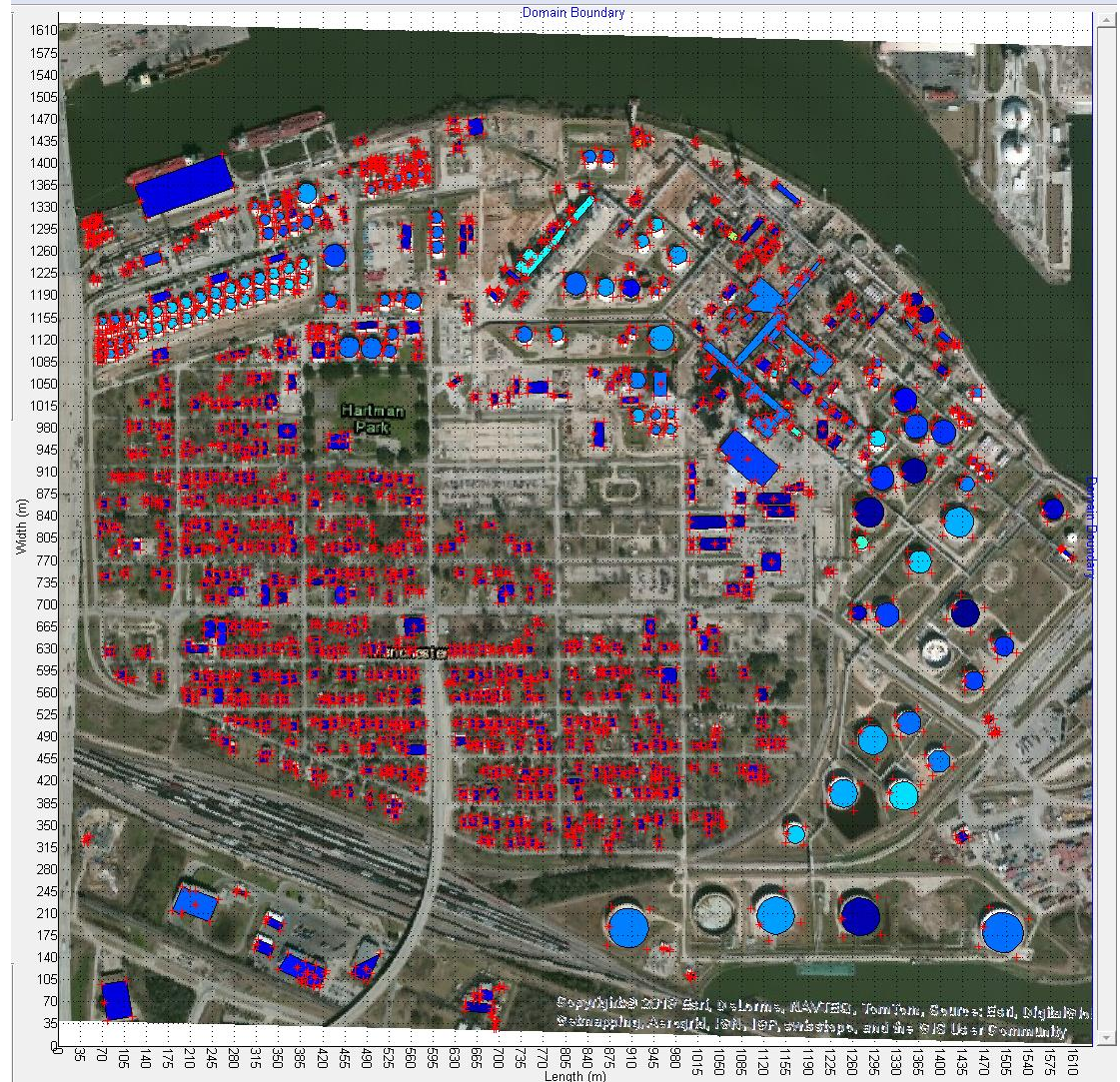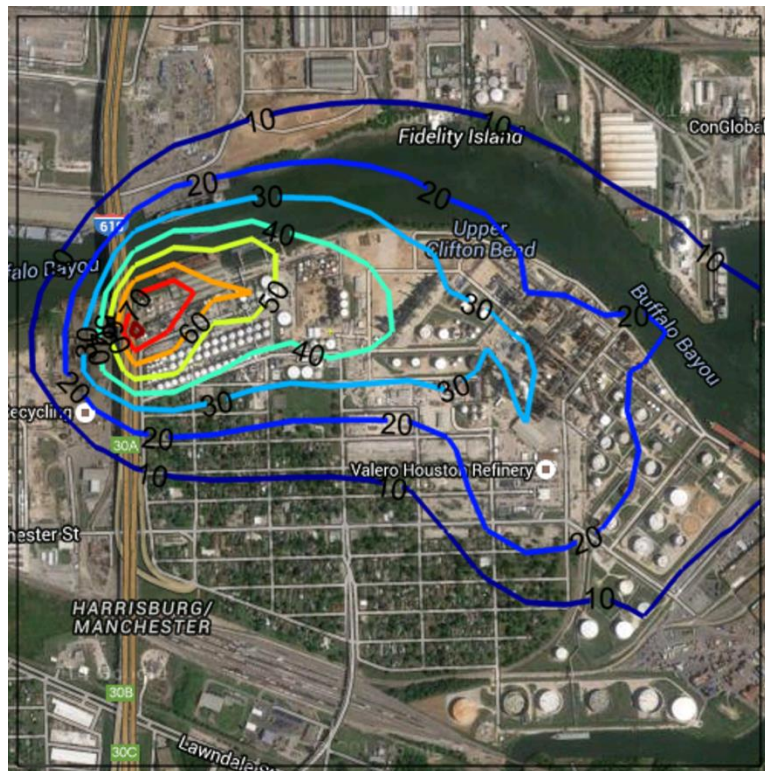0   0.25   0.5   1 Kilometer

N

Service Layer Credits: Esri, HERE, DeLorme,
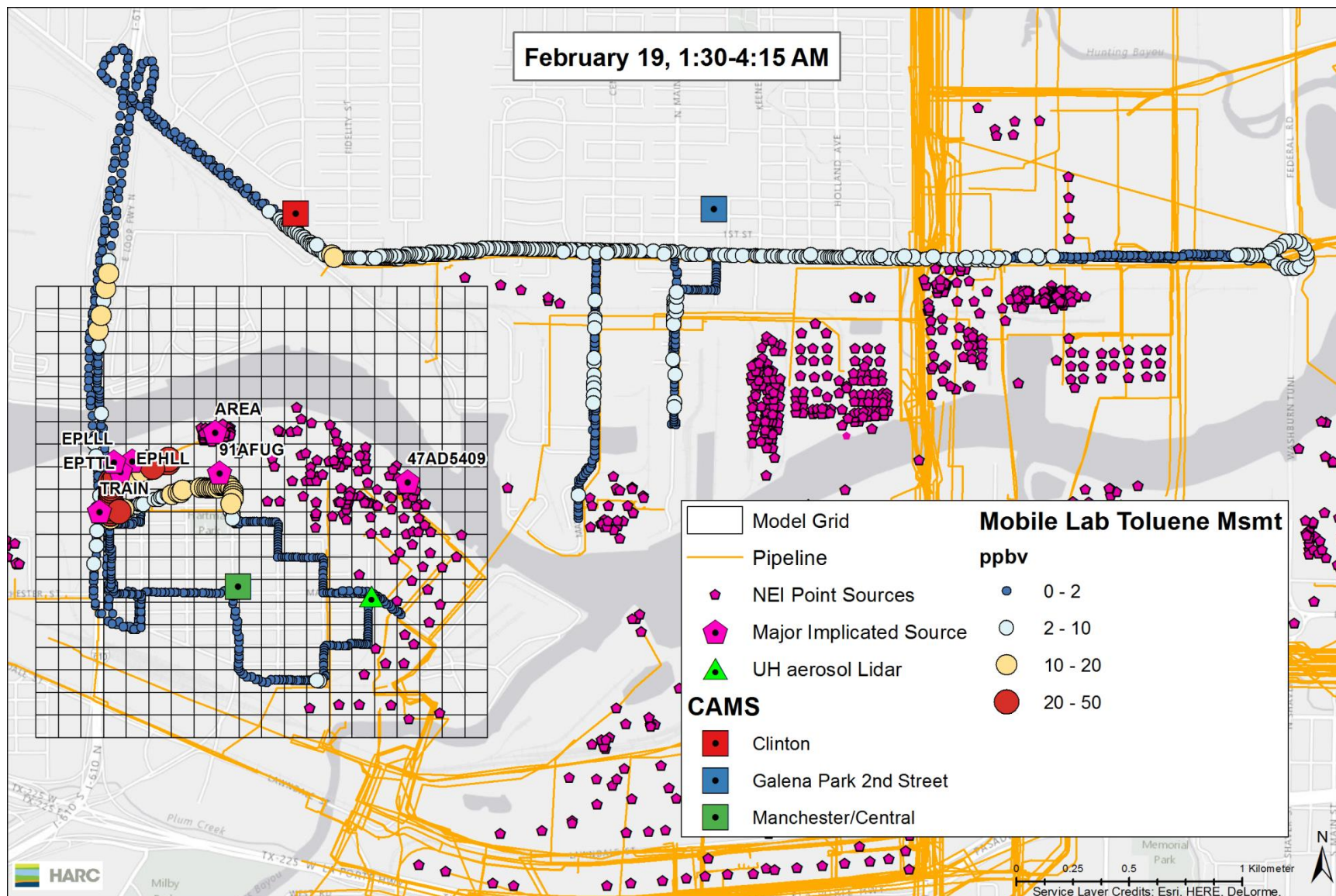
HARC 3D Micro-Scale Model

- Neighborhood scale 3D Eulerian air quality model.

- Very high resolution (~20 s time, ~200 m horizontal).

- Uses QUIC model and LIDAR data to extrapolate wind observations.

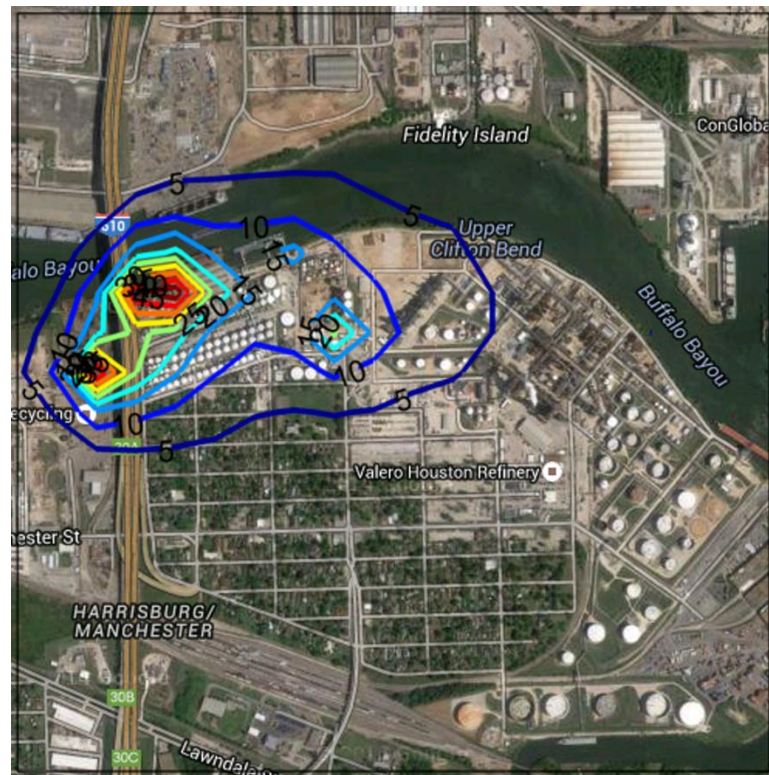- Forward and inverse mode (adjoint method + 4Dvar).

Toluene Plume, Feb 19 at ~4 am

CAT Scan

Mobile Lab-based Reconstruction

Source Attribution for Manchester ~4 am, February 19, 2015

| Emission Point Number (EPN)	Toluene Emissions (kg/hr)		Xylene Emissions (kg/hr)	
	CAT	PTR-MS	CAT	PTR-MS
TRAIN	2.41	0.79	2.42	0.90
EPTTL	1.90	0.63	1.90	0.64
EPLLL	1.70	0.61	1.70	0.63
91AFUG	1.51	0.40	1.51	0.41
47AD5409	0.28	0.28	0.28	0.32
AREA	0.89	0.20	0.89	0.24
EPHLL	2.21	0	2.21	0.03

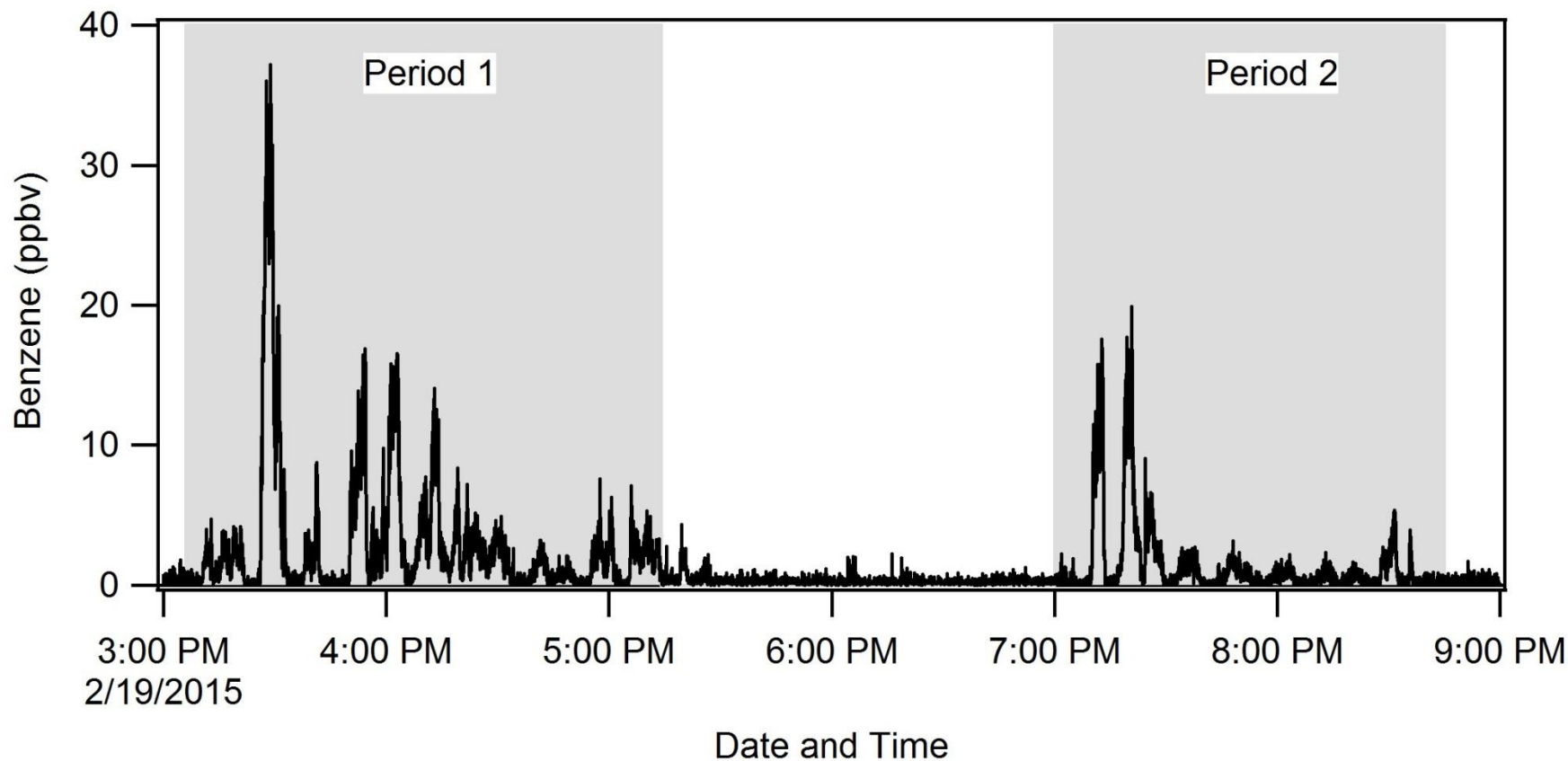# Galena Park Benzene Plume, Feb 19 pm
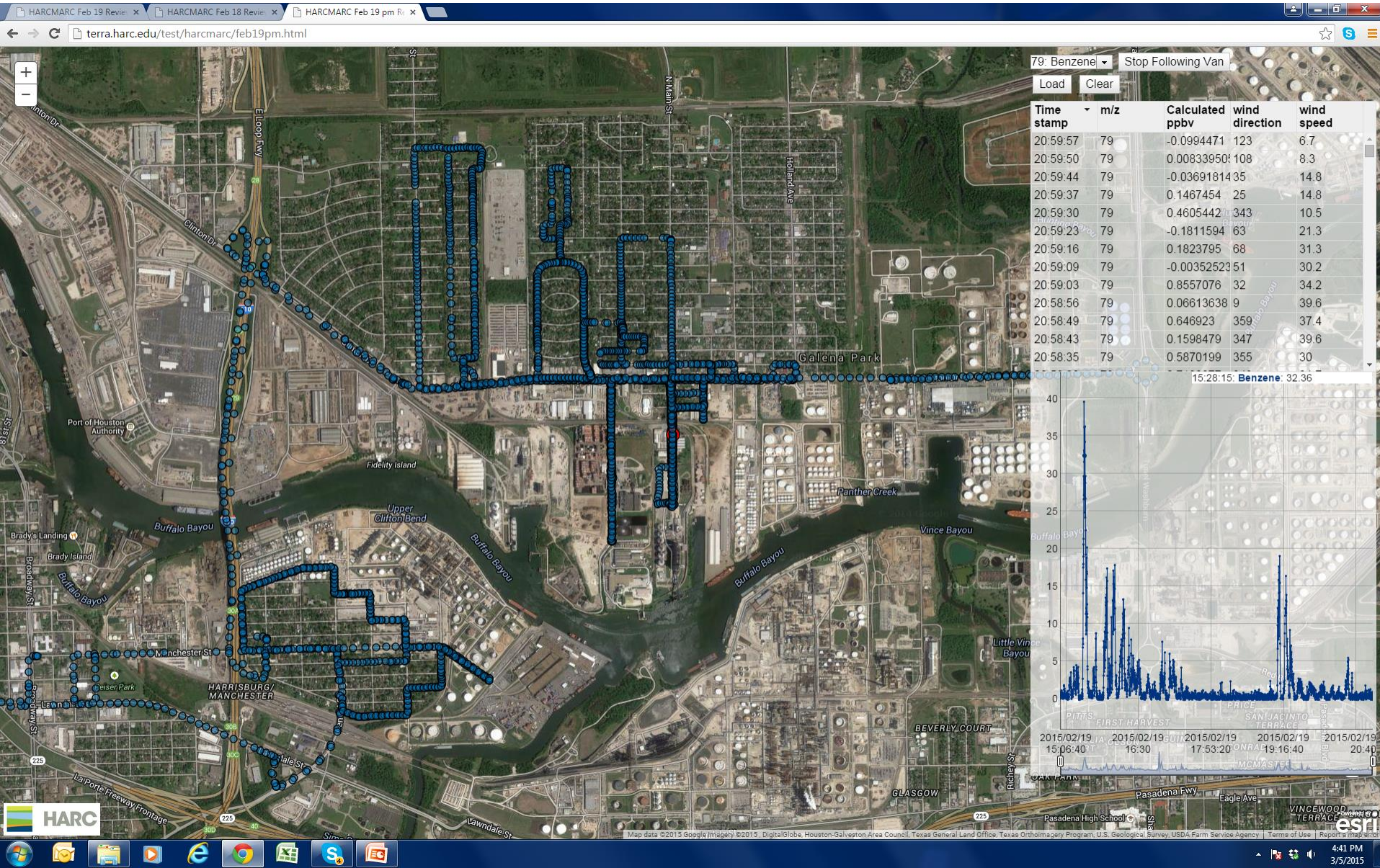
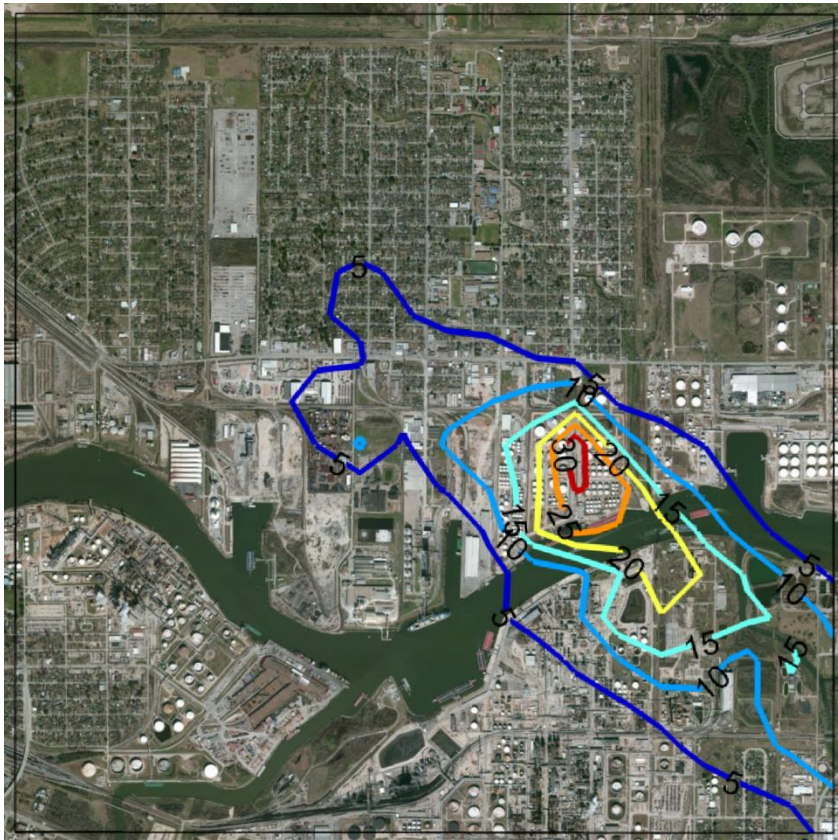# Pipeline Network, Point Sources, and Mobile Lab Measurements of Benzene in Galena Park Analysis Grid
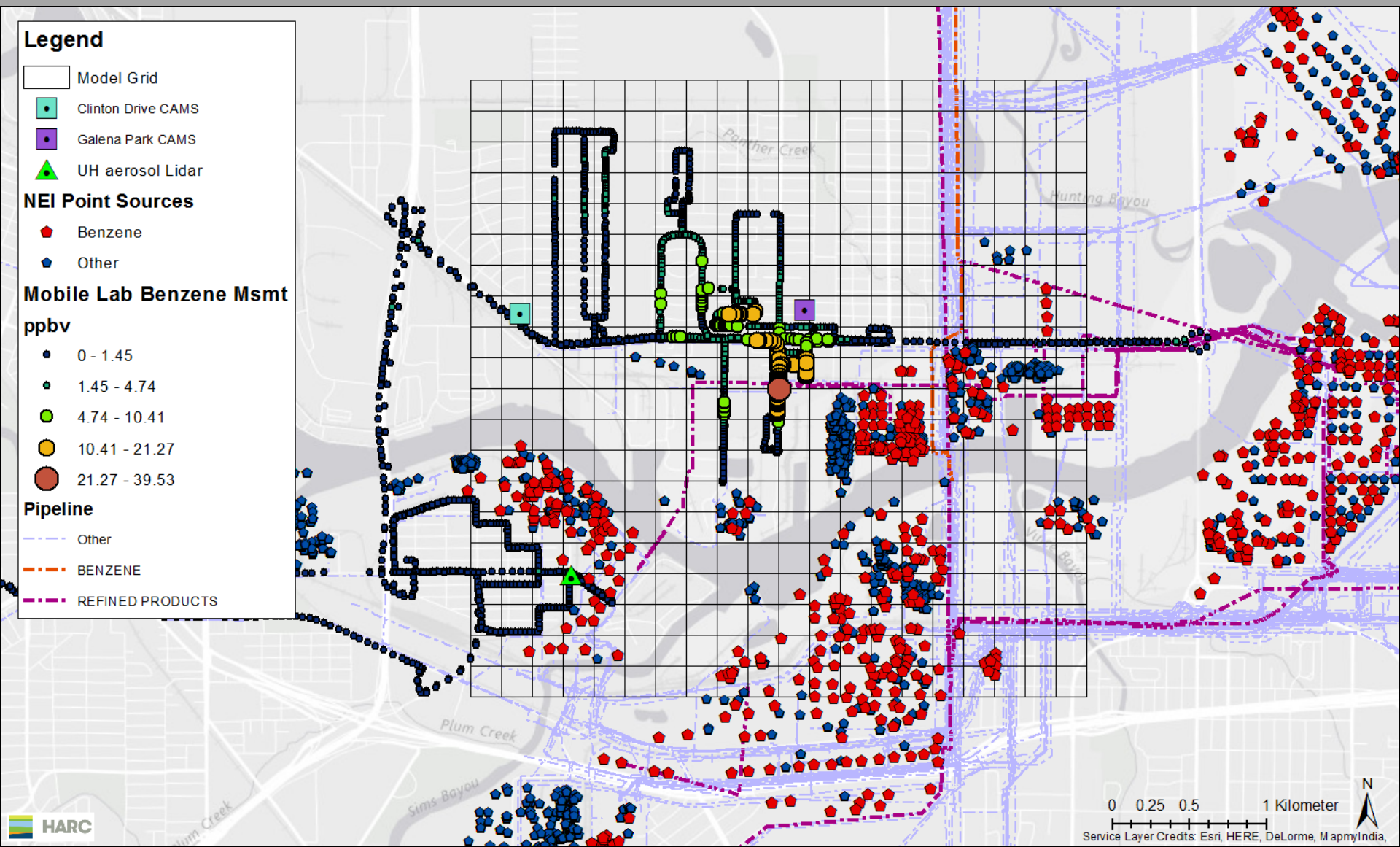
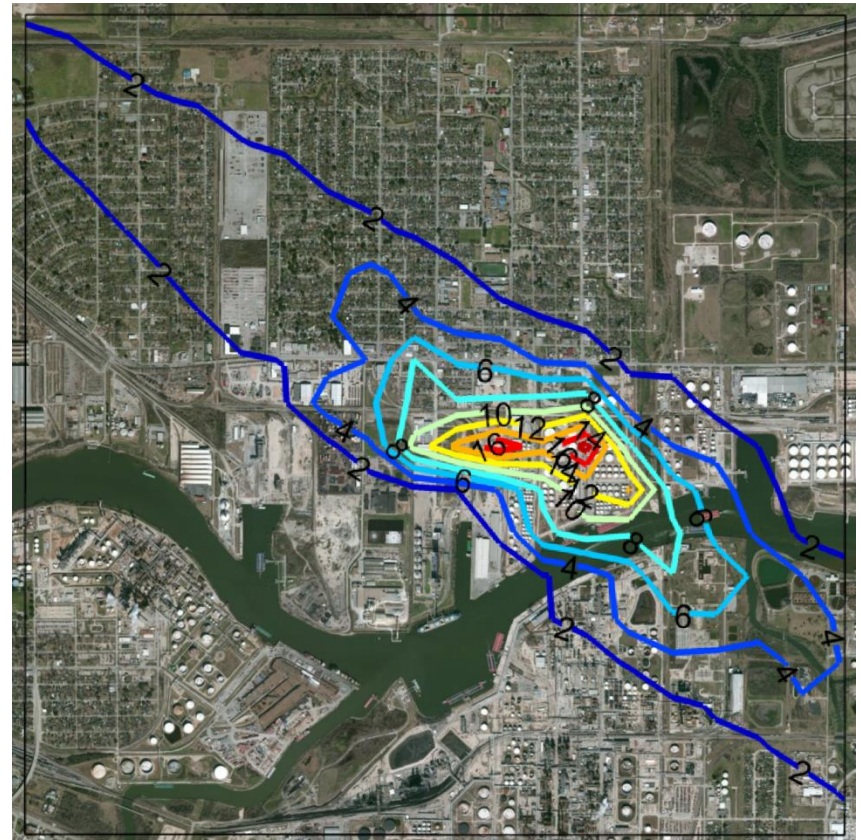Tanker at Kinder Morgan port terminal from 8:52 AM – 3:19 PM

Barges at Kinder Morgan port terminal from 4:23 PM – 6:41 PM

Model Plume Reconstruction for Ambient Benzene (ppbv)

15:06 – 17:14 LST (Period 1)   19:00 – 20:45 LST (Period 2)

Galena Park Benzene Source Attribution 15:06 – 17:14 LST, 2/19/2015

Emission Point Number (EPN) or Pipeline ID	Average UTMx (m)	Average UTMy (m)	Emissions (kg/hr)
8 pipeline segments with ID 56121 to 56156	283433.7	3290833	2.97
SD2 (marine loading flare), WTCR (tank truck loading flare)	284029	3290550	2.37
BD2 (marine loading flare)	284205.6	3290463	1.97
TR10 (rail car and tank truck loading flare)	284099	3290509	1.94
29 pipeline segments with ID 59697 to 61076	284433.7	3290233	1.60
104 pipeline segments with ID 57442 to 59880	284433.7	3290433	1.37
201 pipeline segments with ID 60905 to 89418	284633.7	3290033	1.31
81 pipeline segments with ID 59477 to 60990	284633.7	3290233	1.29
8 pipeline segments with ID 60935 to 70805	284433.7	3290033	1.28
1 pipeline segment with ID 62374	284833.7	3290033	1.24
3 pipeline segments with ID 56110 to 56202	283833.7	3290833	1.08
5 pipeline segments with ID 63583 to 85520	285033.7	3289833	1.08
T187-1, T80-18 (storage tank stacks)	283892.8	3290827	1.06
4 pipeline segments with ID 56101 to 57129	284033.7	3290833	1.04
2 pipeline segments with ID 56130 to 56383	283033.7	3290833	1.02

Galena Park Benzene Source Attribution 19:00 – 20:45 LST, 2/19/2015

Emission Point Number (EPN) or Pipeline ID	Average UTMx (m)	Average UTMy (m)	Emissions (kg/hr)
3 pipeline segments with ID 56110 to 56202	283833.7	3290833	0.98
6 pipeline segments with ID 56113 to 56202	283633.7	3290833	0.81
SD2 (marine loading flare), WTCR (tank truck loading flare)	284029	3290550	0.75
1 pipeline segment with ID 56130	283233.7	3290833	0.63
BD2 (marine loading flare)	284205.6	3290463	0.54
TR10 (rail car and tank truck loading flare)	284099	3290509	0.49
T25-3, T12-5, T12-1, T12-10, T12-3, T25-10, T25-15, T25-14, T25-17, T25-4, T25-6, T25-8, T25-7 (storage tank stacks)	284215.6	3290619	0.46
T187-1, T80-18 (storage tank stacks)	283892.8	3290827	0.43
29 pipeline segments with ID 59697 to 61076	284433.7	3290233	0.41
T12-24, T12-30, T80-20, T80-19, T12-28, T25-12, T25-13, T25-19, T25-18 (storage tank stacks)	284049.6	3290625	0.41
104 pipeline segments with ID 57442 to 59880	284433.7	3290433	0.40
4 pipeline segments with ID 56101 to 57129	284033.7	3290833	0.39
T12-27, T12-25, T12-29 (storage tank stacks), VCU1A&B (thermal oxidizer flare)	284053.7	3290491	0.37
81 pipeline segments with ID 59477 to 60990	284633.7	3290233	0.36
1 pipeline segment with ID 62374	284833.7	3290033	0.33

Galena Park Feb 19 Benzene Event Total Domain Emissions (kg/hr)

Time Period	Point Sources	Pipelines	Total Emissions
Afternoon	16.43	34.73	51.16
Evening	5.59	10.69	16.29
2011 NEI	8.27	0	8.27

Environmental Health Insights
BEE-TEX Supplement

- Concentrations of 1,3-butadiene in Manchester (~0.17 ppb) exceed the EPA's E-5 lifetime cancer risk level of 0.14 ppb. (Yacovitch et al., 2015)

- Exposed lung cell mRNA was used to determine the level of expression of 249 immune-related genes and 730 pan cancer related genes.

- 11 genes showed significant differential expression when exposed to ambient pollution in comparison to clean air. (Vizuete et al., 2016)

Conclusion

- We can now **monitor entire communities** in **real time** and accurately **map hot spots** in ambient concentrations of air pollutants.

- We can now **attribute** observed **hot spots** of air pollutants **to specific emission points at facilities,** and **quantify emissions in real time** based on ambient measurements obtained **outside the fence line**.