Houston Air Quality Update

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DISCOVER-AQ Data Workshop| Thursday, 16 February 2012
Marriott Newport News at City Center

Houston Air Quality Update

I. Air Quality trends
II. Lessons learned from previous campaigns
III. Mixed Layer insights
IV. Emissions inventory maps
V. Potential DISCOVER-AQ spiral locations

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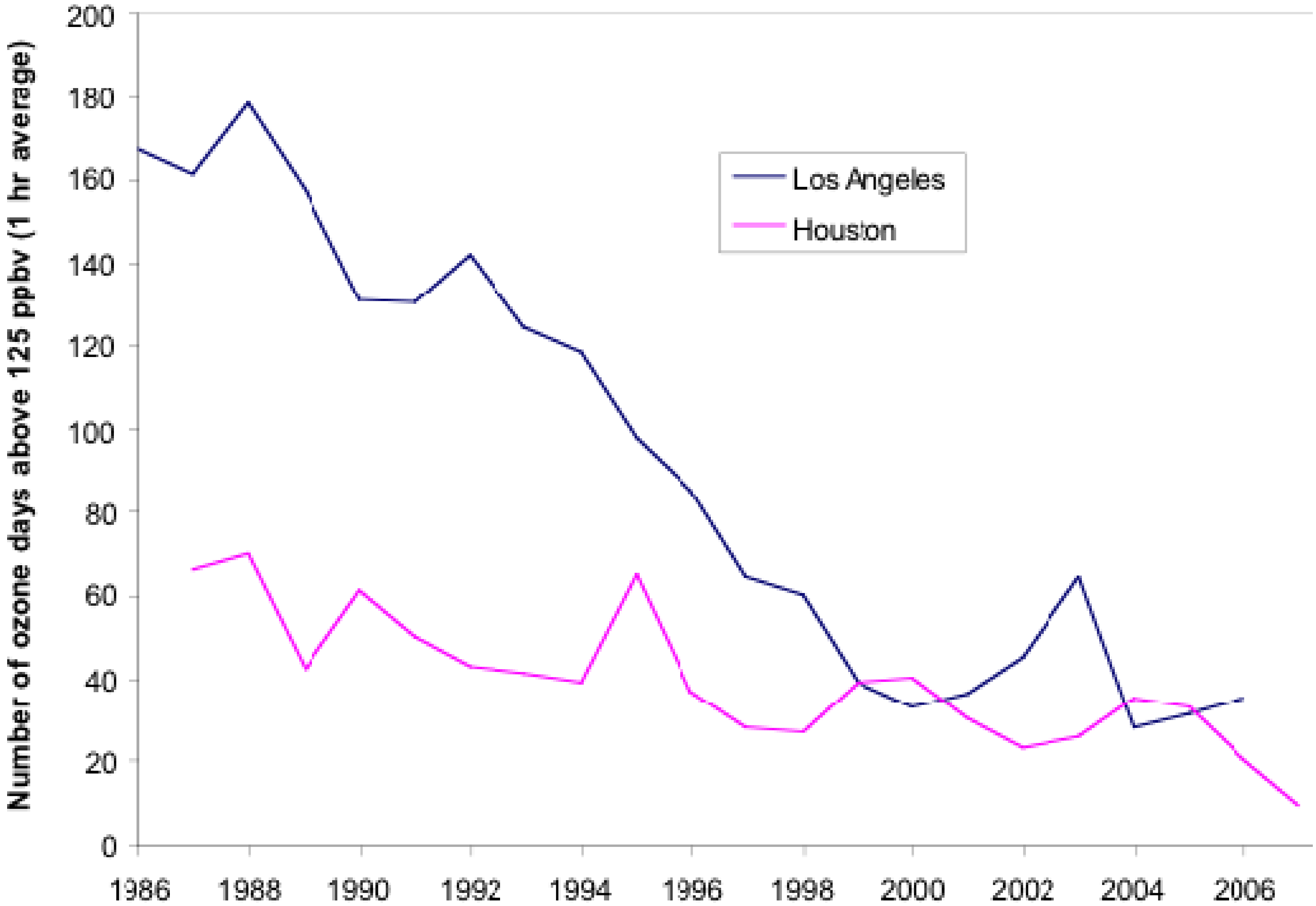
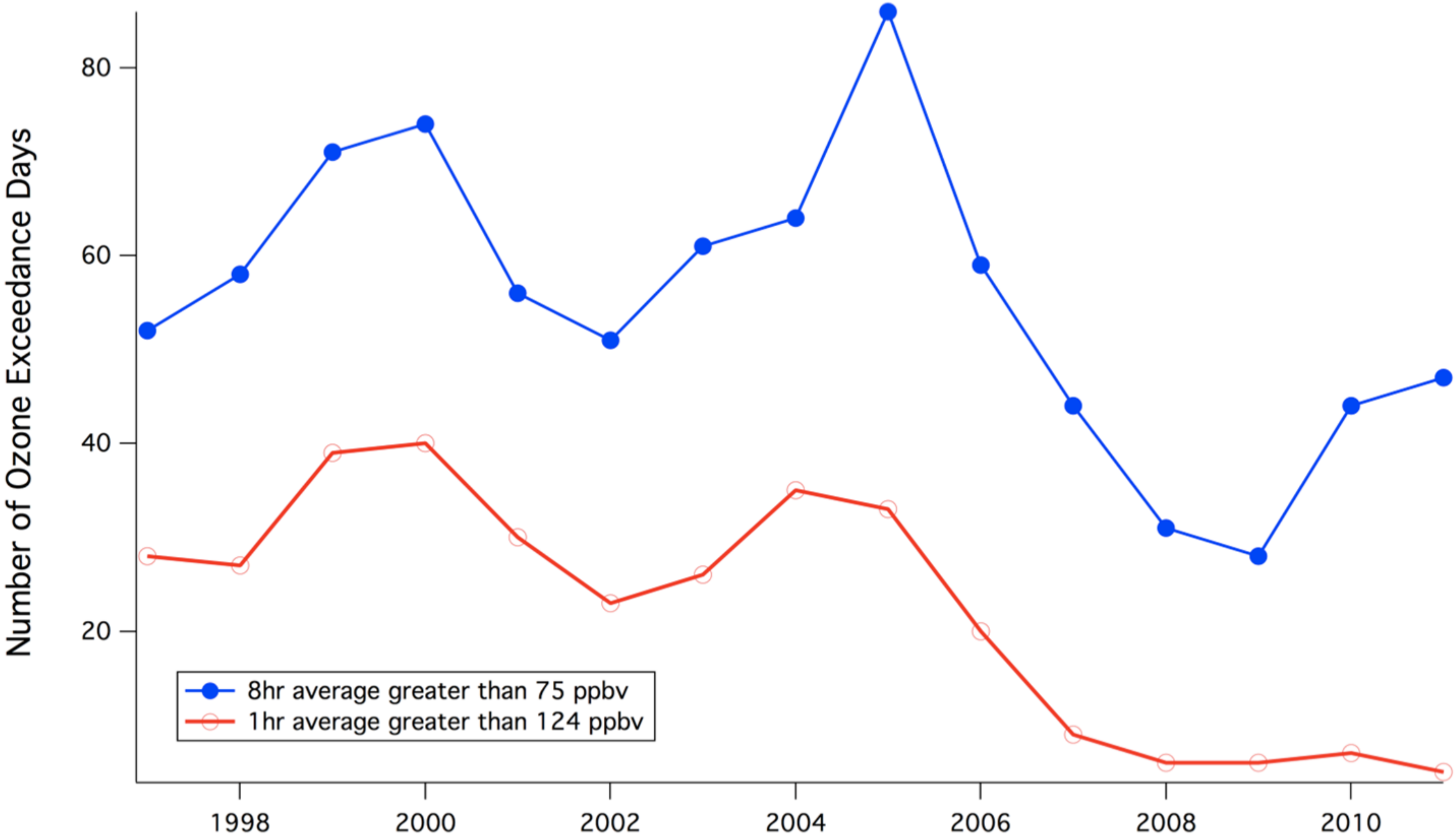
1-hr Ozone Exccedances (Houston & LA)



Source: TCEQ, CARB

Recent Houston Ozone Trend



Source: TCEQ

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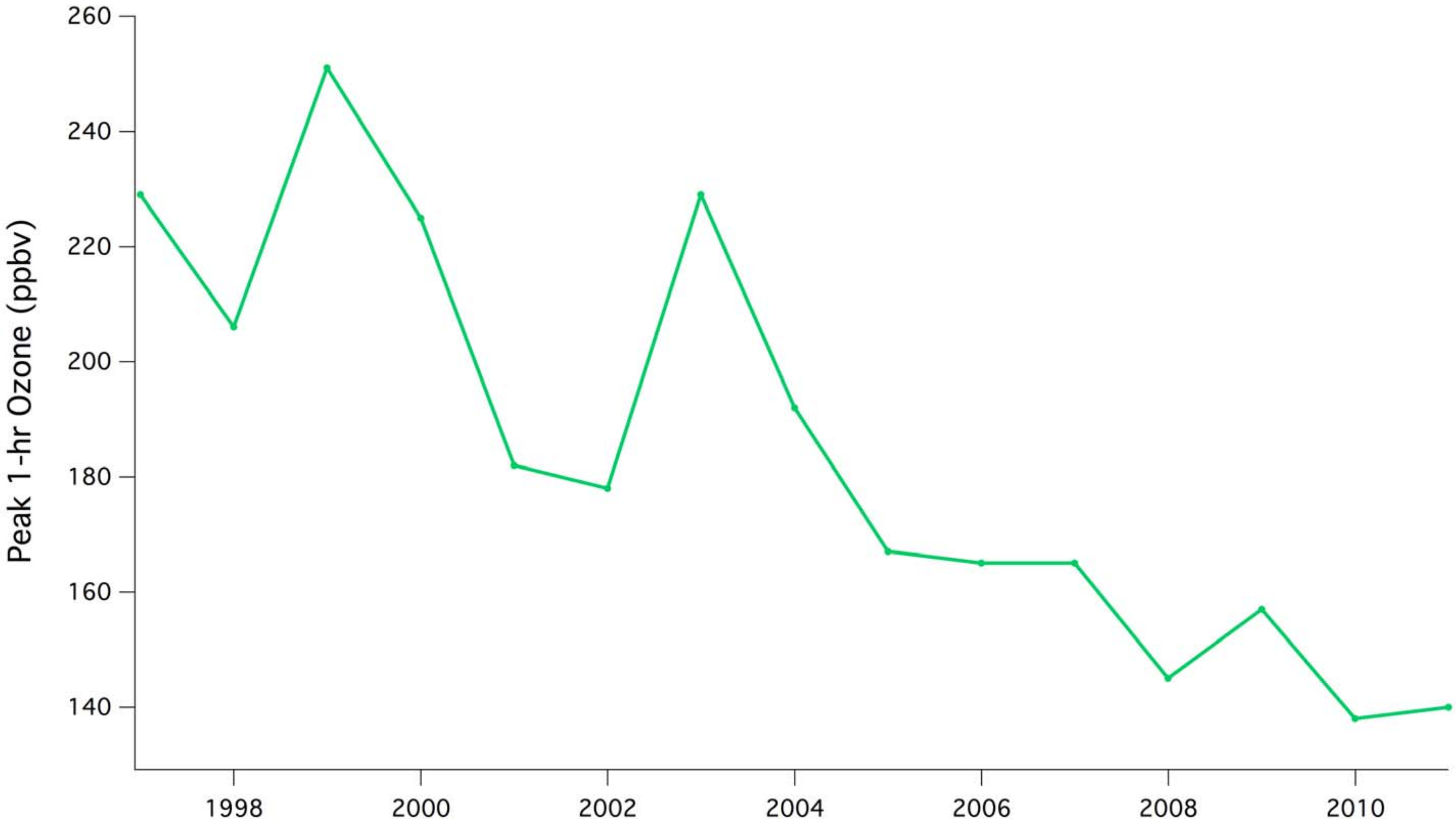
Trend in Peak 1-hr Ozone - Houston



Source: TCEQ

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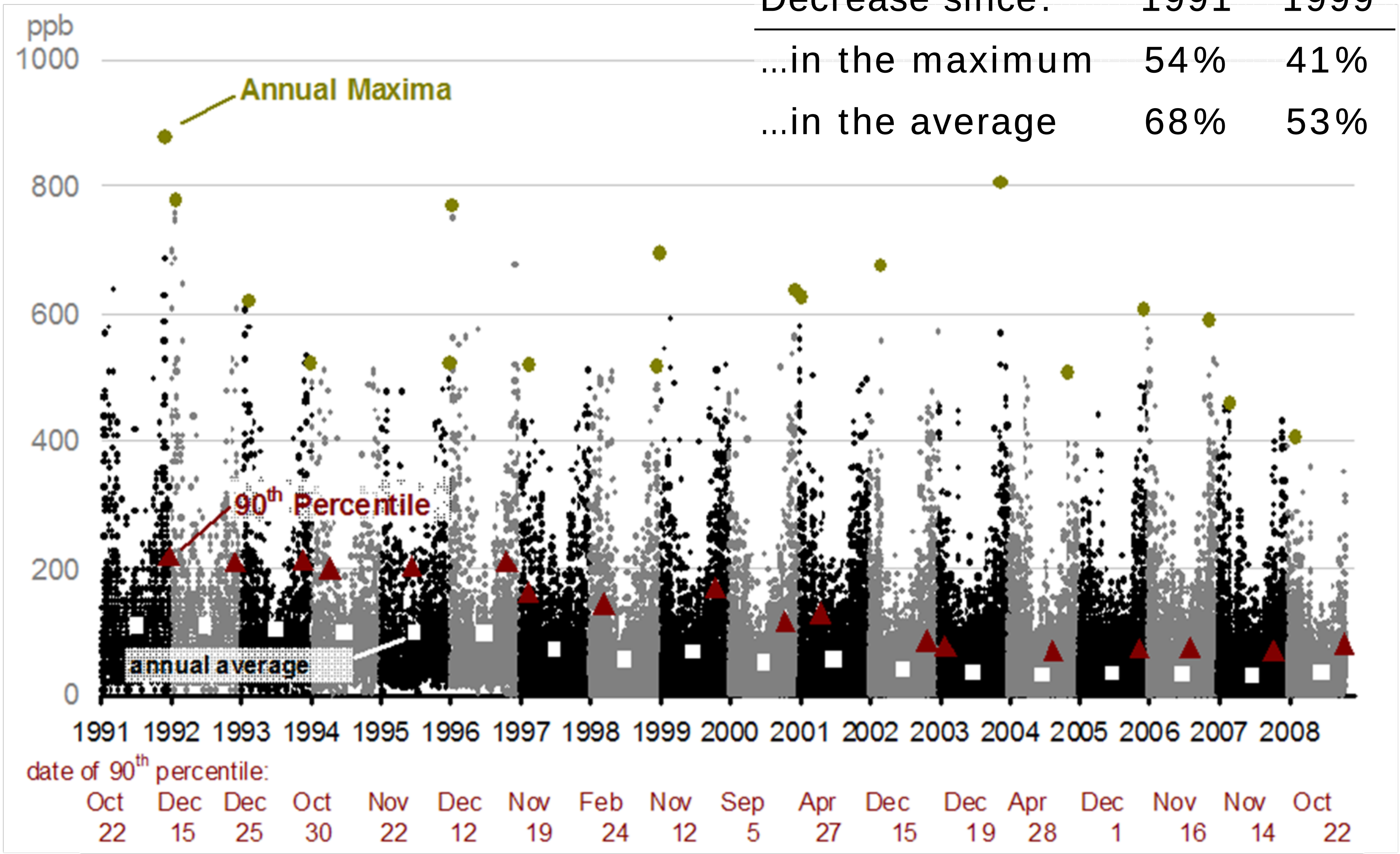
Trend in Daily Peak 1-hr NO_X - Houston



Decrease since:	1991	1999
...in the maximum	54%	41%
...in the average	68%	53%

Source: TCEQ - Kasey Savanich - Air Modeling & Data Analysis

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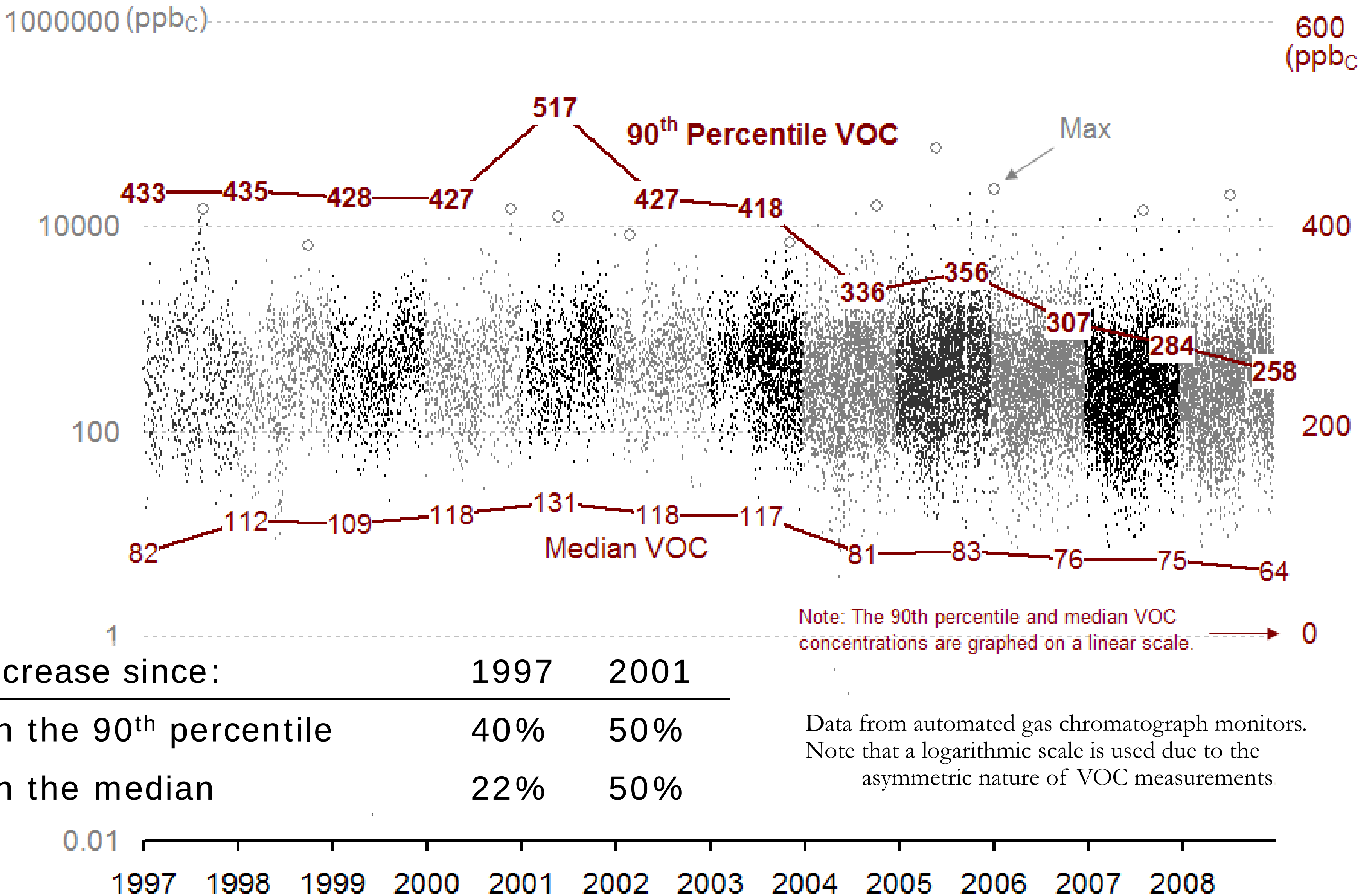
Trend in Daily Peak TNMHC - Houston



Decrease since:	1997	2001
...in the 90th percentile	40%	50%
...in the median	22%	50%

Data from automated gas chromatograph monitors. Note that a logarithmic scale is used due to the asymmetric nature of VOC measurements

Source: TCEQ - Kasey Savanich - Air Modeling & Data Analysis

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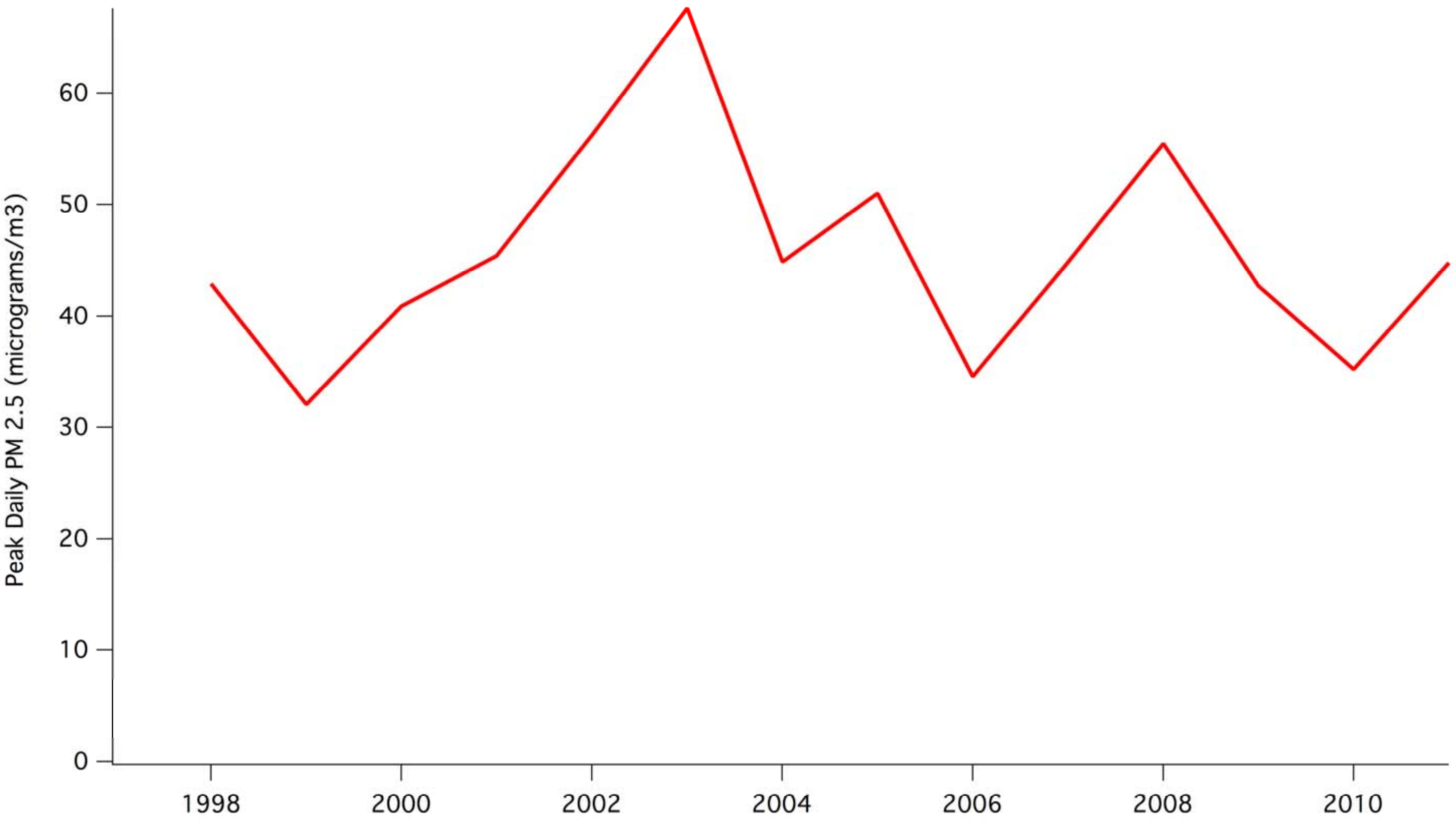
Daily Peak $PM_{2.5}$- Houston



Source: TCEQ

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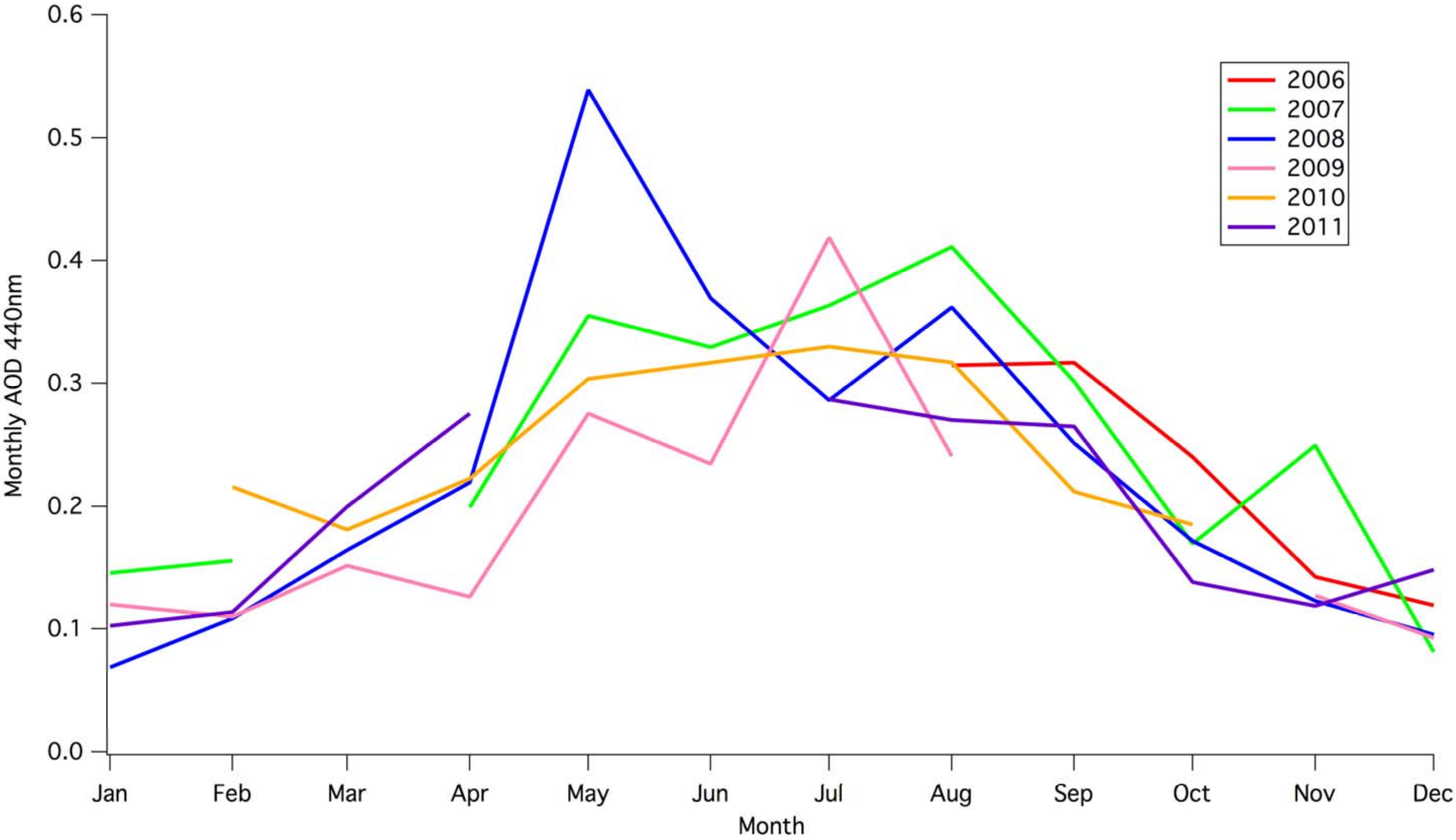
Monthly AOD Aeronet Cimel - Houston



Source: TCEQ

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PM 2.5 September 2011 – Park Place

Park Place C416 - EPA Site: 48_201_0416																								
September 2011						PM-2.5 (Local Conditions) Acceptable (POC 3) measured in micrograms per cubic meter (local conditions)														Central Standard Time				
Day	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
1	13.77	13.84	14.36	14.96	21.00	30.92	**32.89**	29.13	25.57	15.74	9.11	7.98	7.58	9.40	10.77	11.12	13.05	11.23	15.33	21.28	7.03	3.33	3.89	2.94
2	1.24	0.72	5.73	5.86	5.71	7.09	10.35	8.43	8.94	6.72	4.03	3.25	3.69	9.96	11.18	10.05	15.99	21.06	**21.62**	7.83	3.40	5.39	5.36	3.47
3	2.53	3.49	3.02	3.07	3.49	4.79	7.26	8.15	8.94	11.24	**12.36**	8.16	8.48	9.05	11.39	10.81	2.52	2.85	5.89	6.22	7.44	4.76	4.68	6.24
4	4.36	4.94	5.58	6.52	6.90	6.04	7.46	8.09	10.48	8.26	8.60	7.74	6.58	15.91	3.34	PMA	PMA	AQI	9.95	8.60	**20.91**	13.40	15.76	16.74
5	16.52	19.18	20.37	**27.03**	25.66	16.73	14.35	14.58	15.07	14.64	19.80	11.35	8.63	6.26	8.08	6.92	19.15	26.40	22.32	15.11	25.77	26.73	27.01	26.39
6	30.40	**32.91**	21.84	19.69	18.49	19.35	23.20	24.53	17.59	7.76	10.30	10.44	16.17	19.79	17.97	15.24	13.59	17.36	18.64	16.40	18.77	21.84	18.37	17.36
7	17.02	16.69	17.55	21.49	**26.81**	19.74	20.00	LIM	QAS	14.74	12.72	11.27	10.17	8.75	7.66	8.28	9.21	9.92	10.43	12.36	12.02	11.72	11.79	11.76
8	12.16	13.90	14.58	14.75	17.32	24.27	26.66	**27.91**	25.79	16.65	15.88	18.21	14.80	13.88	14.46	14.44	15.48	12.04	10.96	15.12	14.40	13.94	13.86	13.16
9	14.81	15.04	15.29	15.18	15.76	17.01	20.59	**28.93**	20.66	15.13	15.27	15.83	13.47	13.95	13.00	20.64	17.11	16.43	17.14	17.68	16.52	15.10	14.88	14.20
10	14.48	17.16	18.89	16.22	17.28	17.37	19.21	**21.39**	15.02	13.15	12.99	11.17	9.45	8.07	9.47	19.39	15.80	13.38	16.15	17.75	19.11	18.18	15.86	15.07
11	14.67	14.50	14.34	13.98	14.43	15.01	**17.42**	15.60	12.43	14.63	16.61	17.14	15.98	14.12	11.10	16.94	12.12	12.44	12.67	14.72	14.01	13.03	12.55	12.35
12	12.59	13.04	13.63	14.30	15.57	16.56	18.06	19.86	15.43	13.87	12.61	17.03	**21.72**	16.00	17.36	15.17	19.86	10.49	10.84	14.57	11.50	10.87	9.45	8.77
13	8.96	7.81	7.62	6.98	8.00	8.88	10.14	11.99	10.36	5.76	7.08	6.75	12.91	16.52	11.13	**17.94**	6.98	4.85	8.68	11.51	9.55	6.05	5.62	5.02
14	5.36	5.08	5.01	4.80	5.79	6.83	9.53	8.76	7.50	6.42	8.21	9.05	11.36	9.73	9.85	10.95	**13.93**	11.88	12.53	13.65	12.79	11.80	11.20	12.05
15	12.24	11.77	11.48	12.34	13.60	14.46	19.23	**21.33**	17.96	14.81	14.26	17.50	16.59	18.33	17.99	19.80	15.48	11.87	16.93	19.09	18.75	16.20	15.02	14.45
16	12.31	10.44	11.08	12.52	12.22	13.43	17.18	20.24	20.62	**22.24**	19.89	18.37	18.85	19.47	18.63	20.29	20.41	20.16	20.86	21.86	22.24	20.32	19.82	18.24
17	18.78	19.00	20.08	19.94	20.50	21.18	21.62	**23.89**	19.68	19.30	16.34	18.58	22.17	11.53	15.13	14.43	18.64	21.47	13.03	12.63	14.70	15.79	15.34	14.66
18	15.61	14.64	13.10	9.85	8.12	15.83	**17.44**	16.90	4.23	5.38	7.28	4.60	4.38	7.70	13.05	2.84	9.81	13.08	12.68	9.40	9.51	9.31	8.18	5.42

Source: TCEQ

TexAQS 2000

Ozone production often greater than 40 ppbv/hr (0800-1200 LT).

“Efficient” ozone production result of abundance of HRVOCs (Alkenes)

Houston Ship Channel is the Ozone “Factory”

VOC emissions were more than 10x higher than emissions inventory.

Land-Sea Breeze recirculation results in a “bad” ozone day

2006 TexAQS II & TRAMP

Large pulses of HCHO > 25 ppb (aircraft, HSC, Moody Tower). Some of HCHO is “primary” associated with excess CO (combustion)

HONO can exceed 2 ppbv at sunrise & remain at hundreds of pptv during day. HONO dominant OH source

Possible new heterogeneous HONO mechanism: $HNO_3 \rightarrow$ HONO on HOA.

$ClNO_2$ present at ppbv levels in GOM, formed via N_2O_5 and $HCl_{(g)}$

O_3 production is both NOx and VOC sensitive (NOx sensitive for 7 hours during the day).

Ozone exceedances frequently occur in post-frontal conditions (high pressure, low wind speeds, clear skies, slow growing PBL)

2009 SHARP/FLAIR

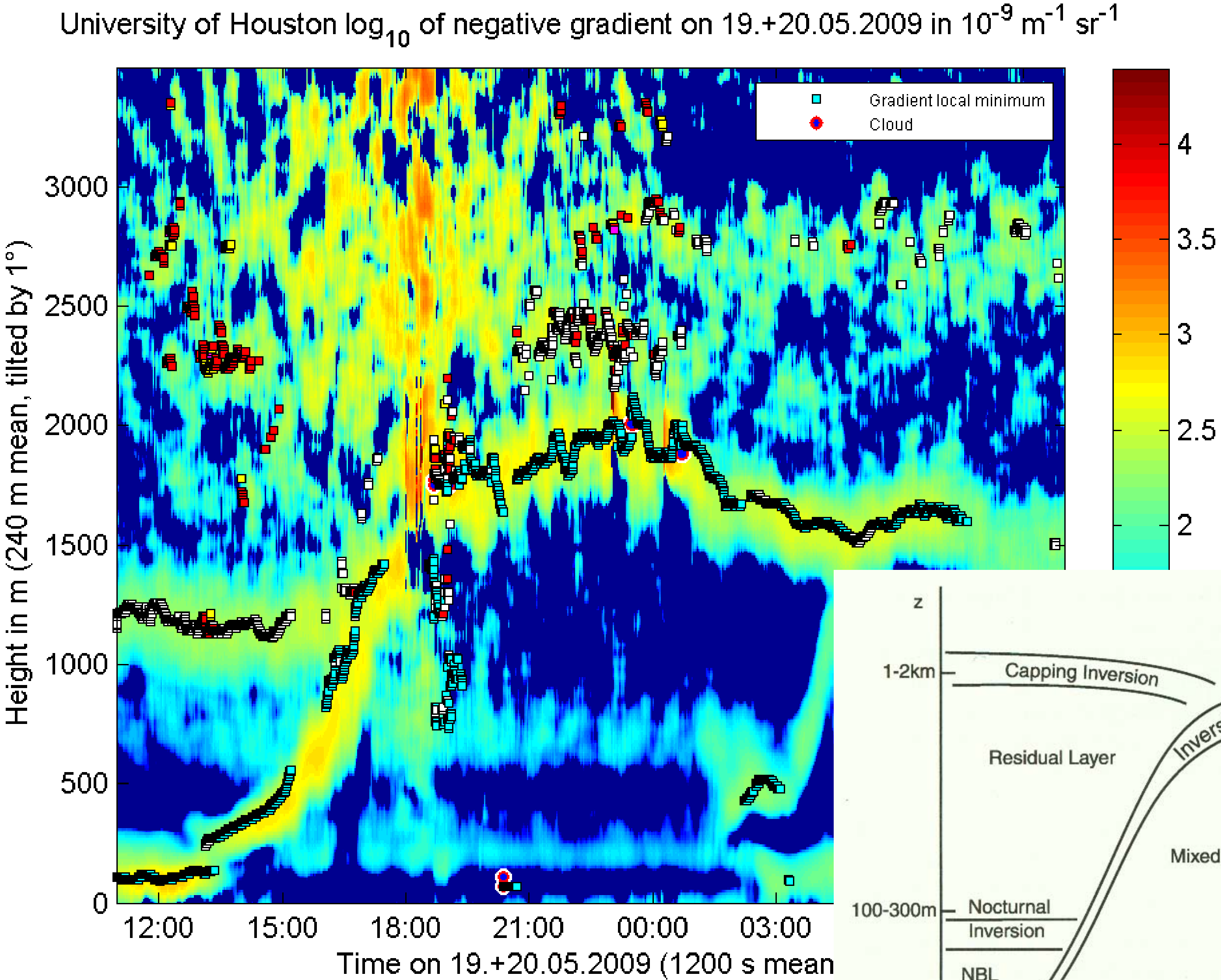
OH radical precursors, HCHO and HONO, “directly” emitted from from flares and mobile sources.

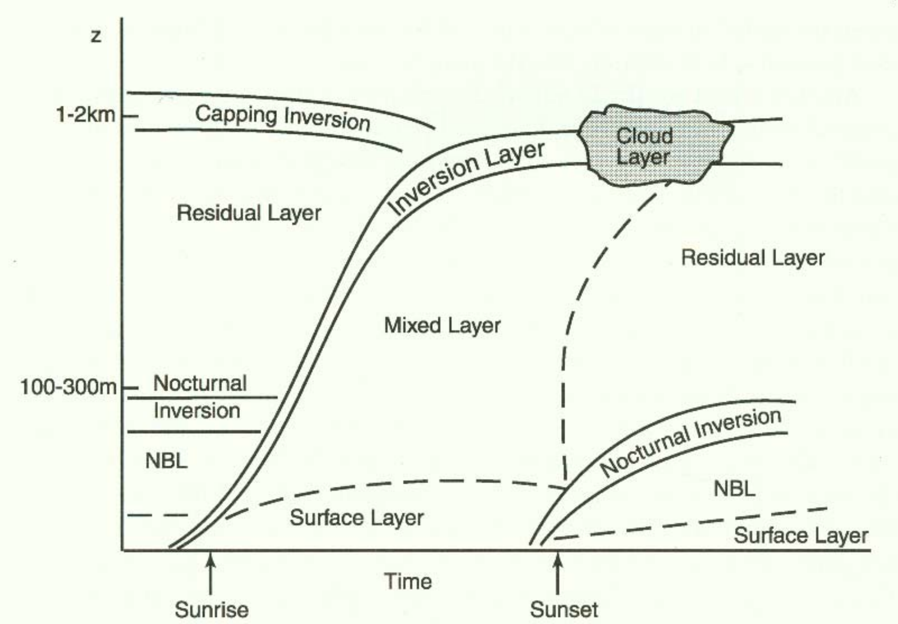
Significant levels of $ClNO_2$, HCl (correlated with HNO_3), and N_2O_5 in downtown Houston.

New HONO production parameterization: NO_2 + surface + solar irradiance.

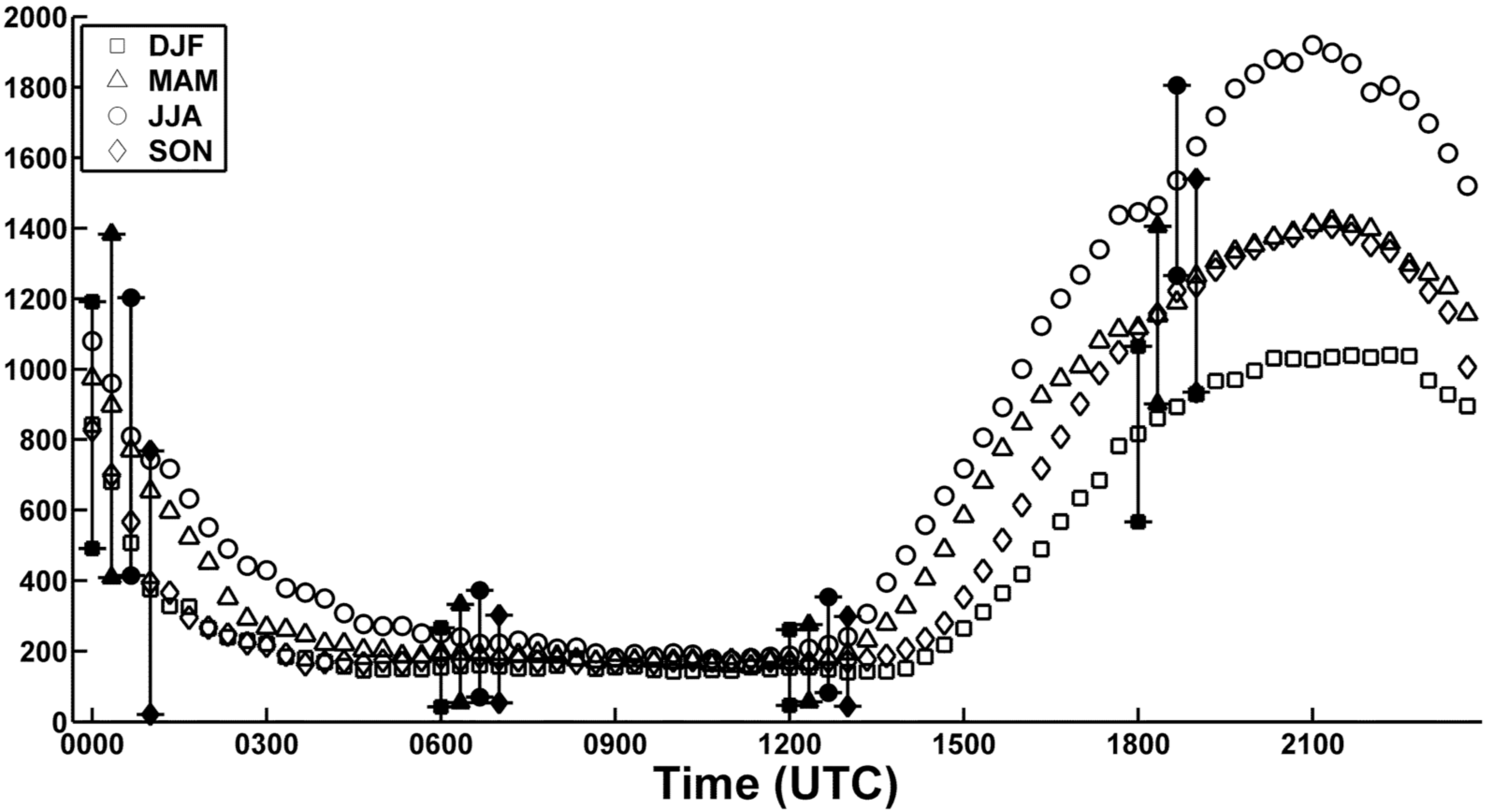
$P(O_3)$ is VOC sensitive in the early morning and late afternoon but NOx sensitive throughout the afternoon.

Aerosol LIDAR for Pollution Layer Depth



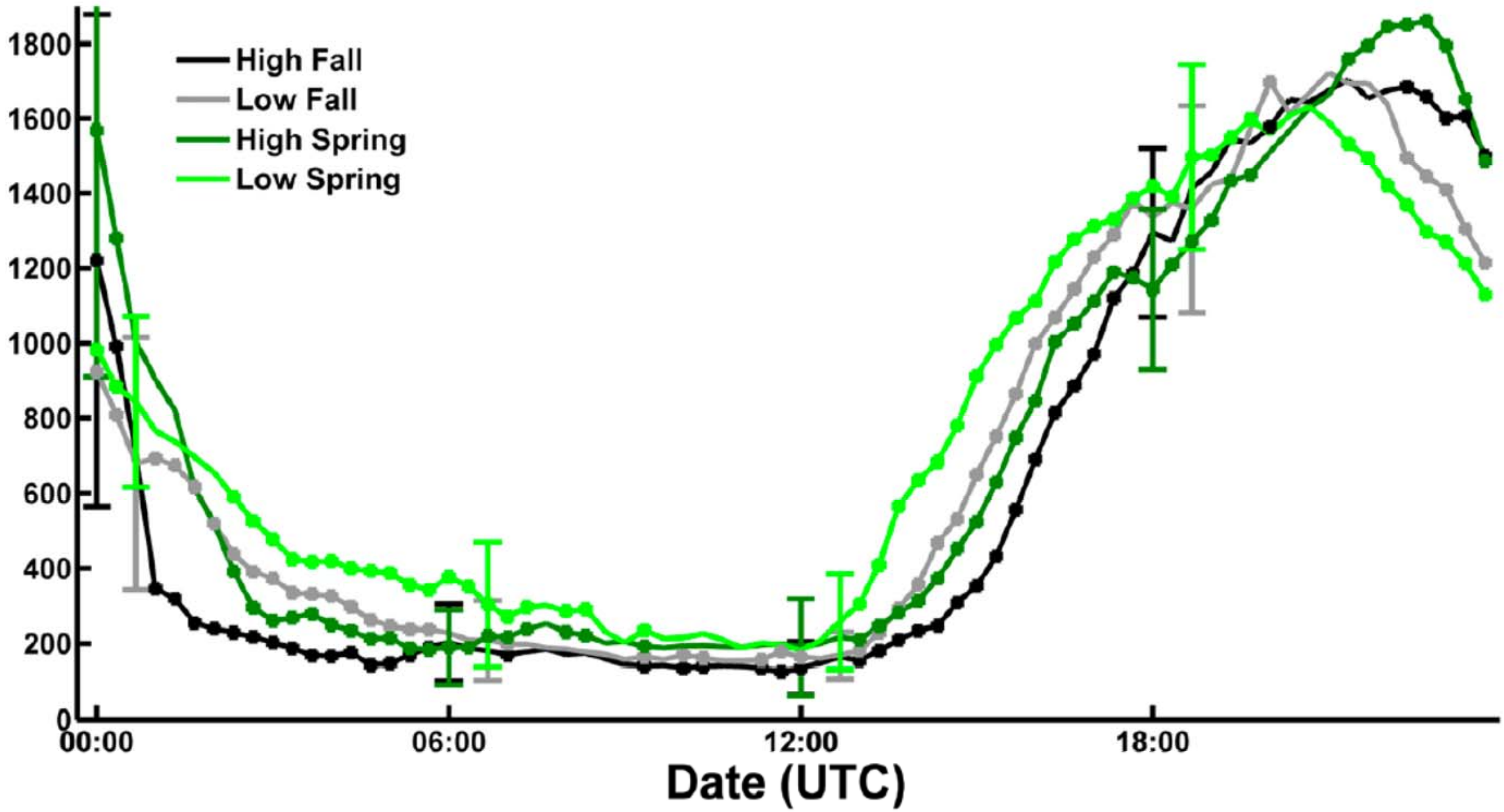


Seasonal Houston Surface Aerosol Depth



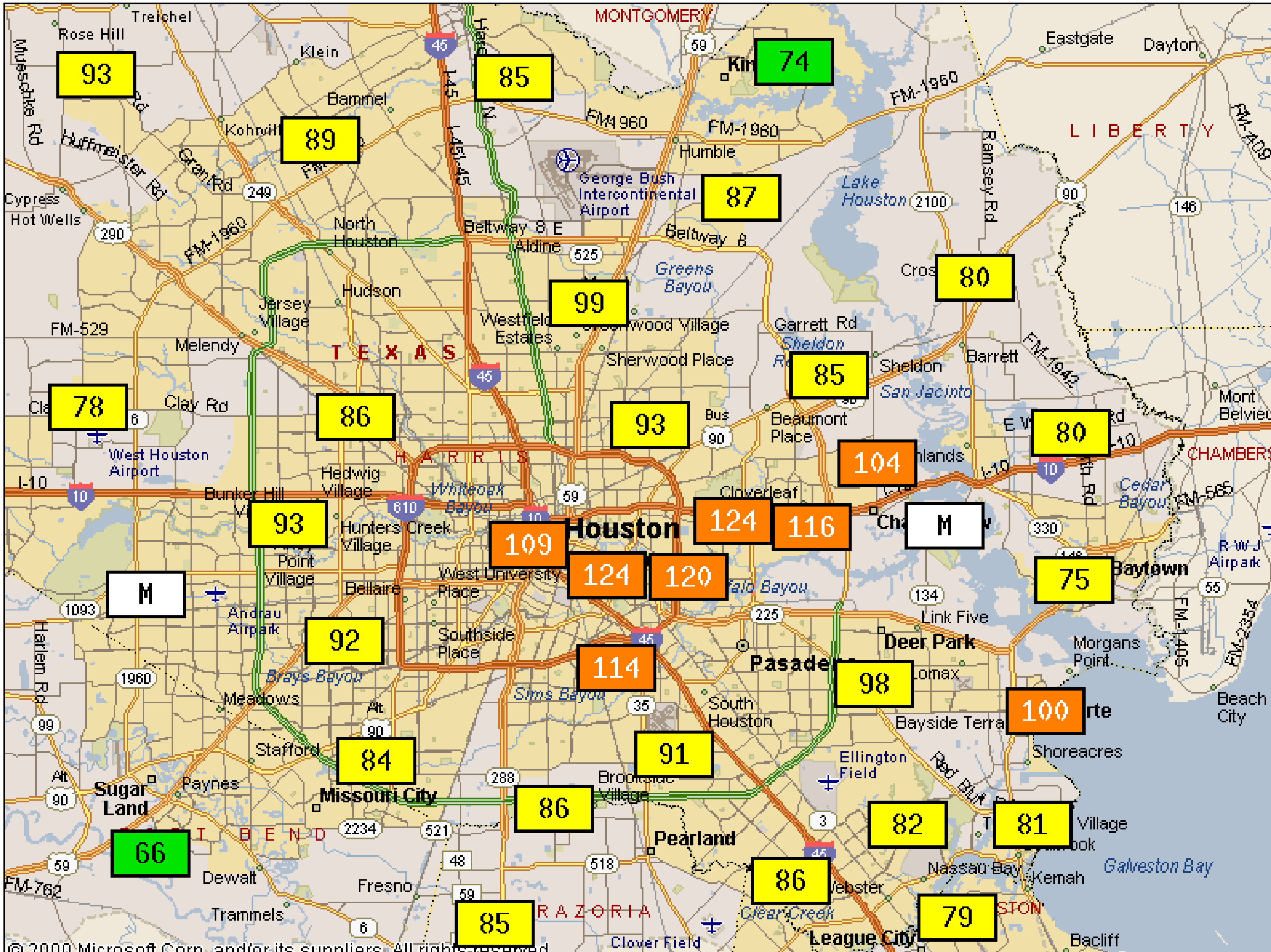
Haman et al. (2012)

Surface Aerosol Layer - High vs Low O_3 Days



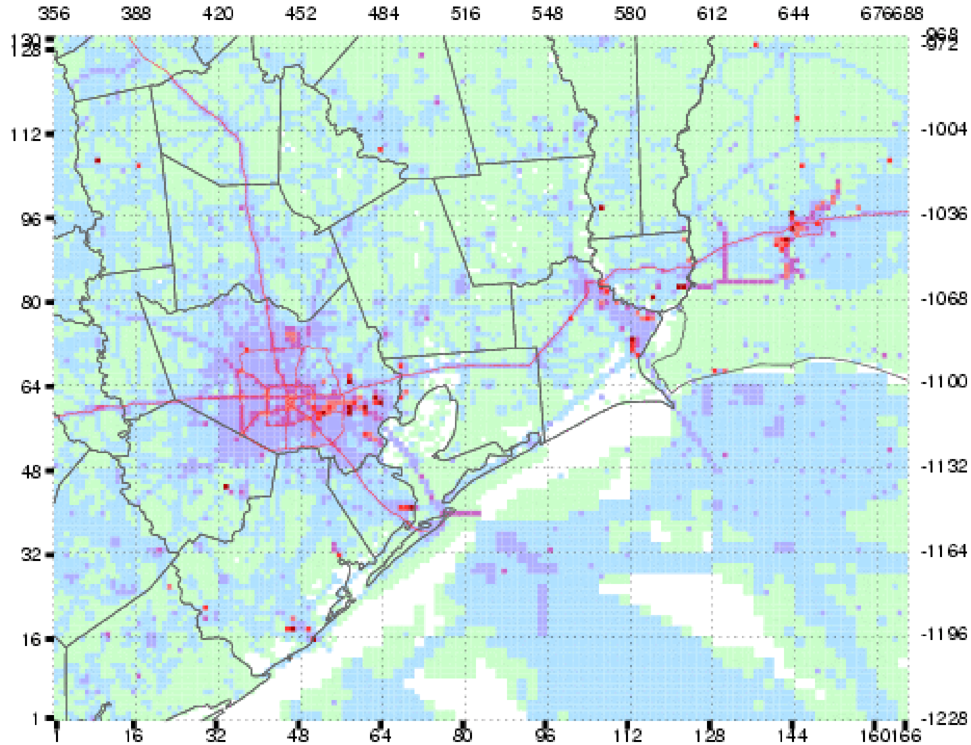
Haman et al. (2012)

Ozone Levels for Saturday May 30, 2009 14-15:00 CDT



Houston 2006 NOx Emissions

All NOx emissions, at 2km



hgb8h2.bc06aqs1.reg10si.hgbpa_02km Total Emissions, 08/15/2006: NO_x

Emissions Plotted

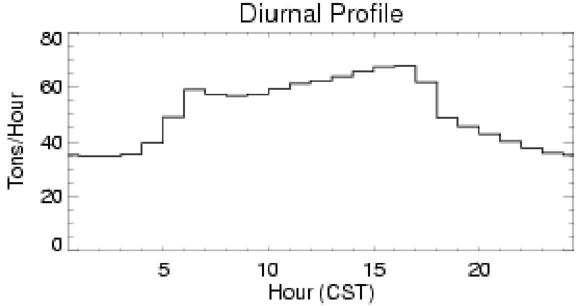
County	Tons/Day
Brazoria	62.05
Chambers	22.22
Fort Bend	51.74
Galveston	41.81
Harris	355.30
Liberty	17.92
Montgomery	27.56
Waller	7.84
HGB SUBTOTAL:	586.44
Hardin	8.63
Jefferson	72.94
Orange	48.67
BPA SUBTOTAL:	130.23
MAP TOTAL:	1221.21

Legend (Tons/Day)

< 0.00	0.00 - 0.01	0.01 - 0.10	0.10 - 0.50
0.50 - 1.00	1.00 - 2.00	2.00 - 5.00	>= 5.00

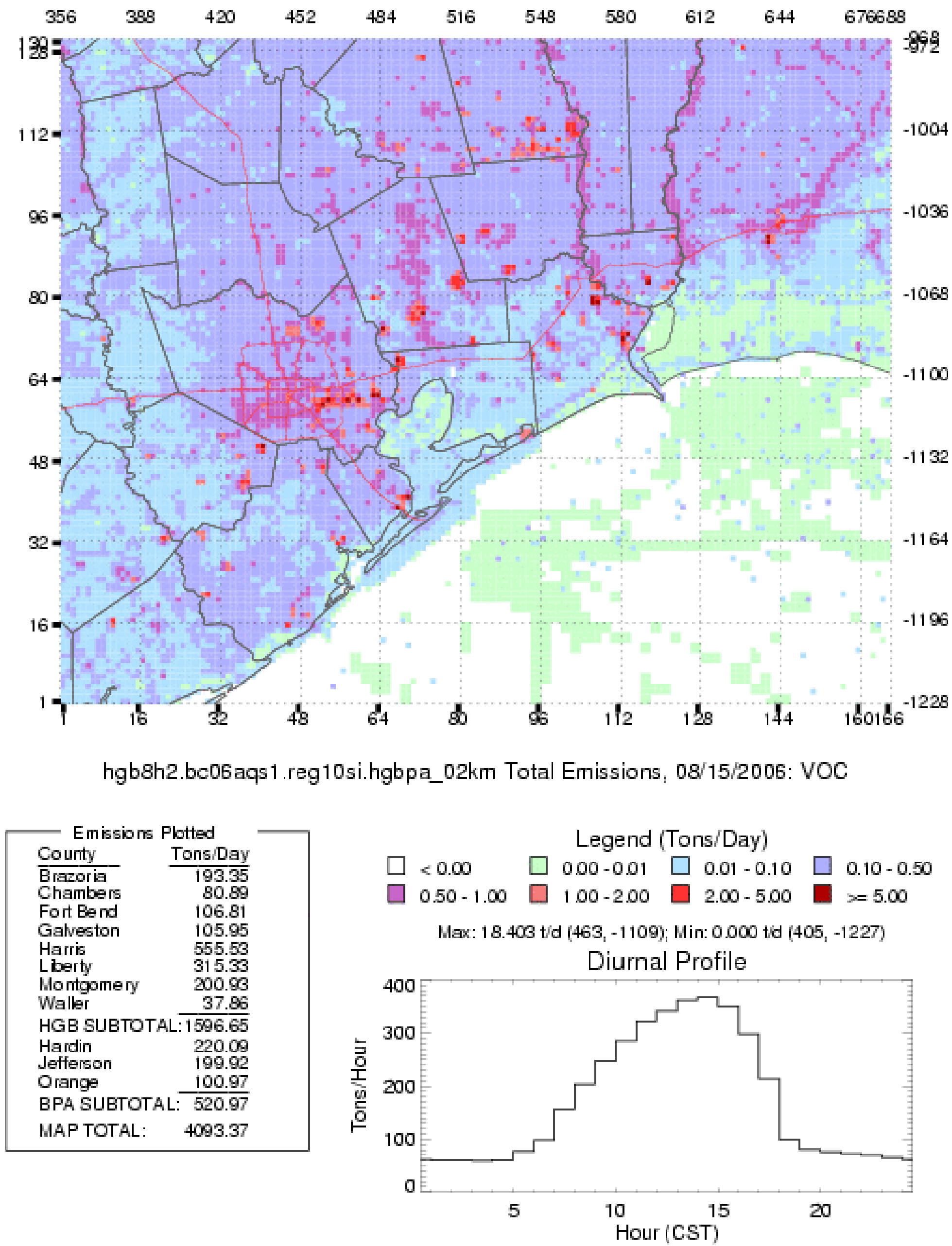
Max: 40.097 t/d (643, -1035); Min: 0.000 t/d (405, -1227)

Diurnal Profile



Mark Estes – TCEQ (2011)

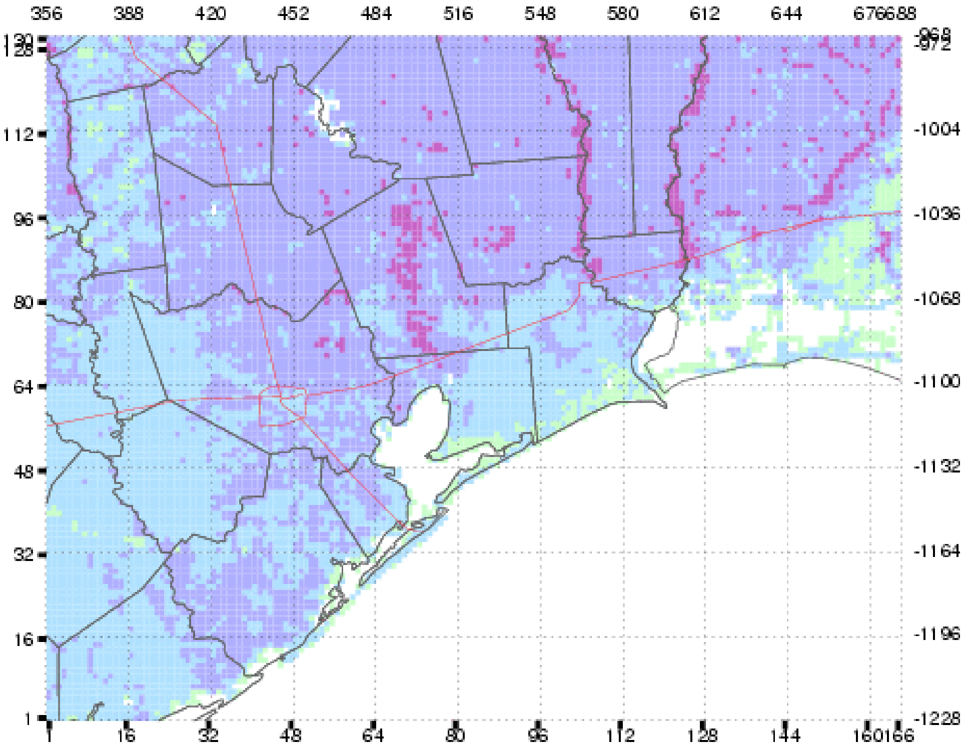
Houston 2006 VOC Emissions



All VOC emissions, at 2km (sum of Carbon Bond 05 emissions). Includes biogenic emissions. Does not include ethane or methane.

Mark Estes – TCEQ (2011)

Houston 2006 Biogenic VOC Emissions



hgb8h2.bc06a.csr.hgbpa_02km Biogenic Emissions, 08/15/2006: VOC

Biogenic VOC emissions (no methane or ethane).

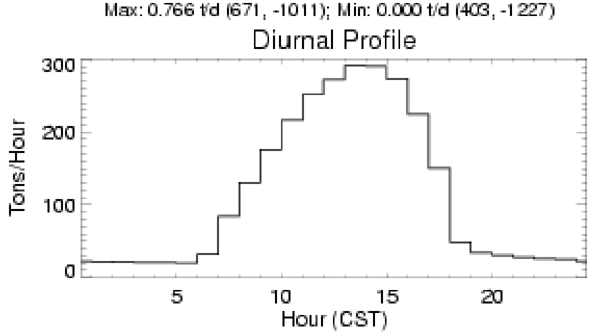
Emissions Plotted

County	Tons/Day
Brazoria	113.81
Chambers	39.04
Fort Bend	39.43
Galveston	23.63
Harris	164.20
Liberty	228.52
Montgomery	166.31
Waller	28.99
HGB SUBTOTAL:	803.94
Hardin	190.16
Jefferson	48.59
Orange	58.13
BPA SUBTOTAL:	296.88
MAP TOTAL:	2716.00

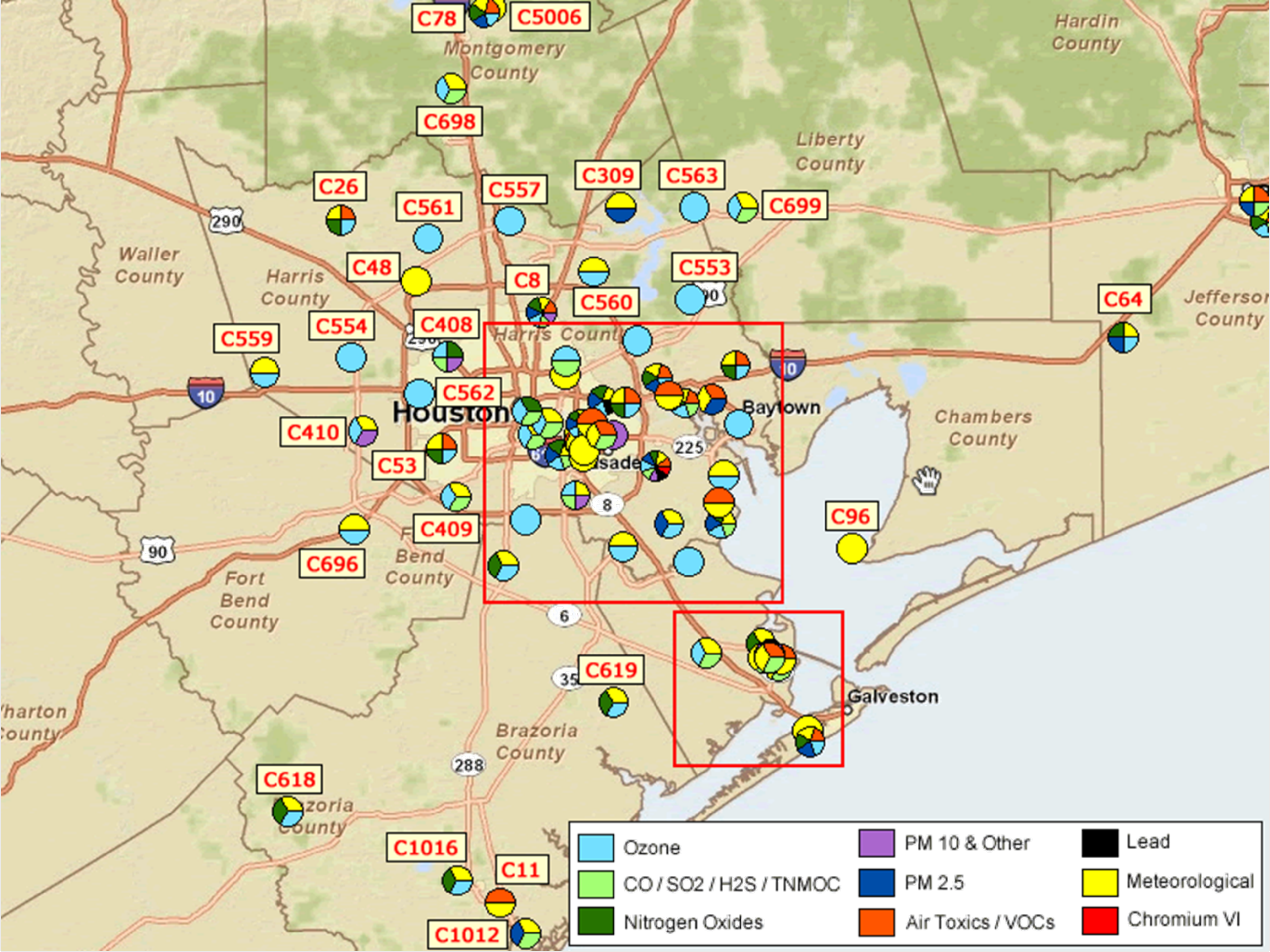
Legend (Tons/Day)

< 0.00 | 0.00 - 0.01 | 0.01 - 0.10 | 0.10 - 0.50 | 0.50 - 1.00 | 1.00 - 2.00 | 2.00 - 5.00 | >= 5.00

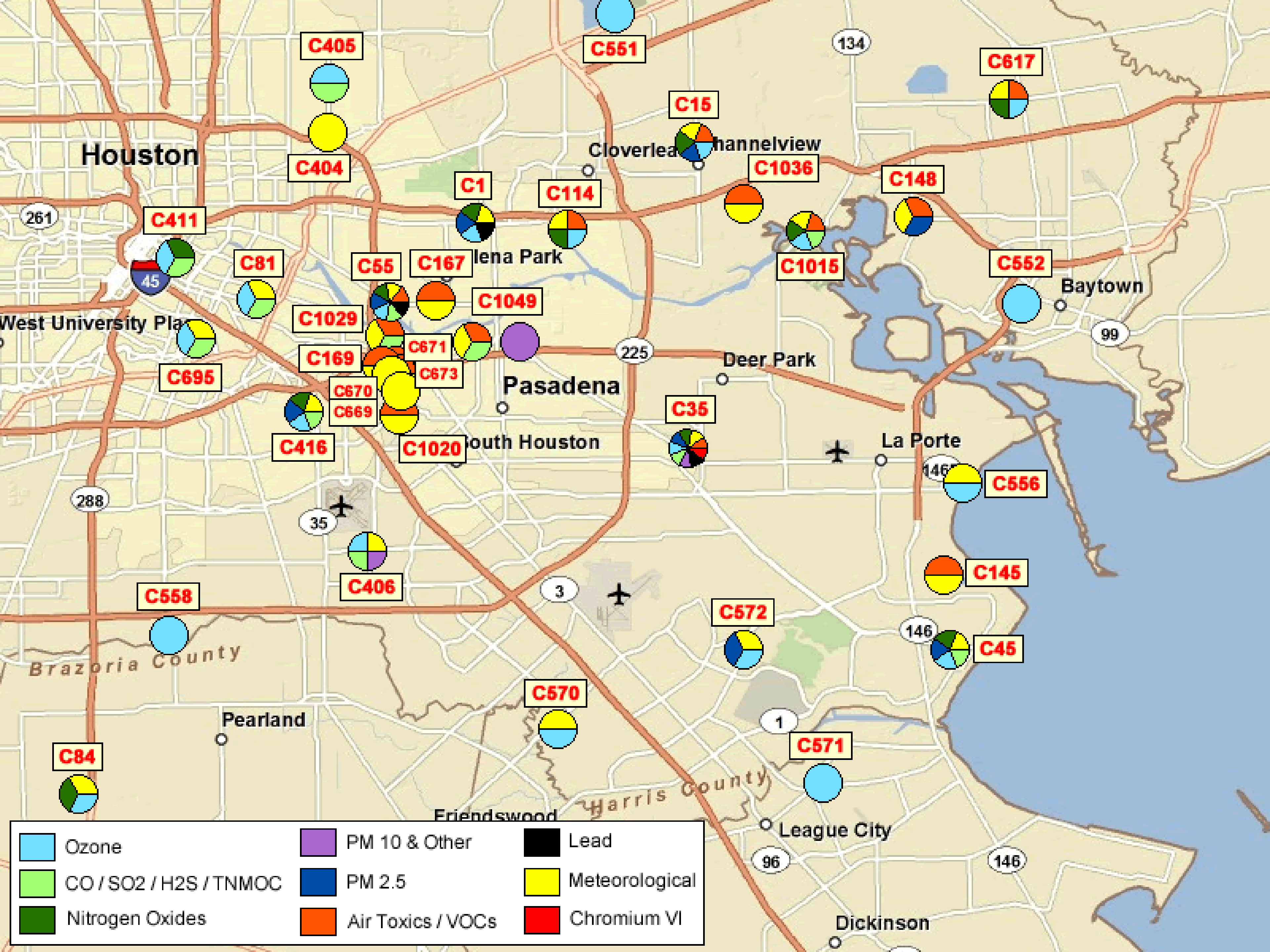
Max: 0.766 t/d (671, -1011); Min: 0.000 t/d (403, -1227)



Mark Estes – TCEQ (2011)



C78
C5006
Montgomery County
C698
Hardin County
Liberty County
C26
C561
C557
C309
C563
C699
290
Waller County
Harris County
C48
C8
C553
C560
C64
Jefferson County
C559
C554
C408
Harris County
10
C562
Houston
Baytown
C410
C53
225
Chambers County
8
C409
C96
90
C696
Fort Bend County
Fort Bend County
6
35
C619
Galveston
Brazoria County
288
C618
Brazoria County
C1016
C11
C1012
Ozone
CO / SO2 / H2S / TNMOC
Nitrogen Oxides
PM 10 & Other
PM 2.5
Air Toxics / VOCs
Lead
Meteorological
Chromium VI



Houston
C405
C404
C551
C617
C15
Cloverleaf
Channelview
C1036
C148
C1
C114
C411
C81
C55
C167
Galena Park
C1015
C552
Baytown
West University Place
C1029
C1049
C671
C169
C673
C695
C670
C669
Pasadena
Deer Park
C35
C416
C1020
South Houston
La Porte
C556
C406
C145
C558
C572
C45
Brazoria County
C570
Pearland
C571
C84
Friendswood
Harris County
League City
Dickinson
Ozone
CO / SO2 / H2S / TNMOC
Nitrogen Oxides
PM 10 & Other
PM 2.5
Air Toxics / VOCs
Lead
Meteorological
Chromium VI

Potential DISCOVER-AQ Spiral Locations

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TCEQ Recommended Sites:

C84 Manvel Croix Park—peak ozone site: currently it is the Design Value site with the highest ozone in Houston; suburban character when not downwind of Houston. Met, O_3, Nitrogen Oxides (Nitric Oxide, Nitrogen Dioxide, Oxides of Nitrogen). Large Site (with room to add more monitoring equipment. Operated by TCEQ.

C617 Wallisville Road—high industrial emissions, short-range downwind, Mt. Belvieu area, often affected by bay breeze. Met, O3, Nitrogen Oxides, Auto-GC. Large Site. Operated by URS for the industry-funded Houston Regional Monitoring (HRM) network.

C1034 Galveston 99th Street—coastal site influenced by Gulf breeze, downwind of industrial emissions with northerly winds. Met, O_3, Nitrogen Oxides, NOy, PM2.5, Canister VOCs sampled every 6th day for 24 hours.

C410 Houston Westhollow – peak ozone site, suburban character. Met and O3. Little space for additional monitors. Operated by the City of Houston.

C35 Houston Deer Park, - high industrial emissions, near La Porte airport. Met, O_3, Nitrogen Oxides, NOy, CO, Sulfur Dioxide, PM10, PM2.5, Auto-GC, Canister VOC, carbonyl cartridges, PAH/SVOC. Large Site.

C698 UH WG Jones Forest – downwind site with southerly winds, suburban character otherwise. Met, O_3 and trace-level CO measured at top of a tower. Large Site. Operated by University of Houston.

Wish List for additional measurements

Primary

Hourly measurements of boundary layer depth (radar profilers, ceilometers, radiosondes, and/or ozonesondes) at several locations, e.g., La Porte, Galveston, and Aldine.

Hourly wind profiles (radar profilers) to assist in modeling

Ozonesonde launches (UH campus) [dual channel with O_3 and SO_2 if possible]

Secondary

Solar occultation flux measurements along paths previously investigated, and especially at selected sites downwind of known or suspected sources of HRVOCs, formaldehyde, and/or SO_2 (e.g., emergency-scale flares operating at low flow, FCCU regeneration units)

Trace-level CO measurements

True NO, NO_2 measurements

Hourly formaldehyde measurements

Other LIDARs, Tethered Balloons

Full ozone calibrations at selected ozone-lite sites (e.g., Crosby, Kingwood, Tom Bass, Katy Park, Bunker Hill Village, Meyer Park, Mercer Arboretum, Atascocita)

Full access to HRM hourly data

IMACC FTIR measurements of industrial flares (see TCEQ flare study report)

ACKNOWLEDGEMENTS:

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UNIVERSITY of HOUSTON