New insights into Houston air quality from the Houston Network of Environmental Towers (H-NET)

Barry Lefer, James Flynn, Christine Haman
Department of Earth and Atmospheric Sciences
University of Houston

“Recent advances in our understanding of Texas Air Quality: A tribute to Daewon Byun”

April 19, 2011
09:00 – 05:00
University of Houston – Hilton

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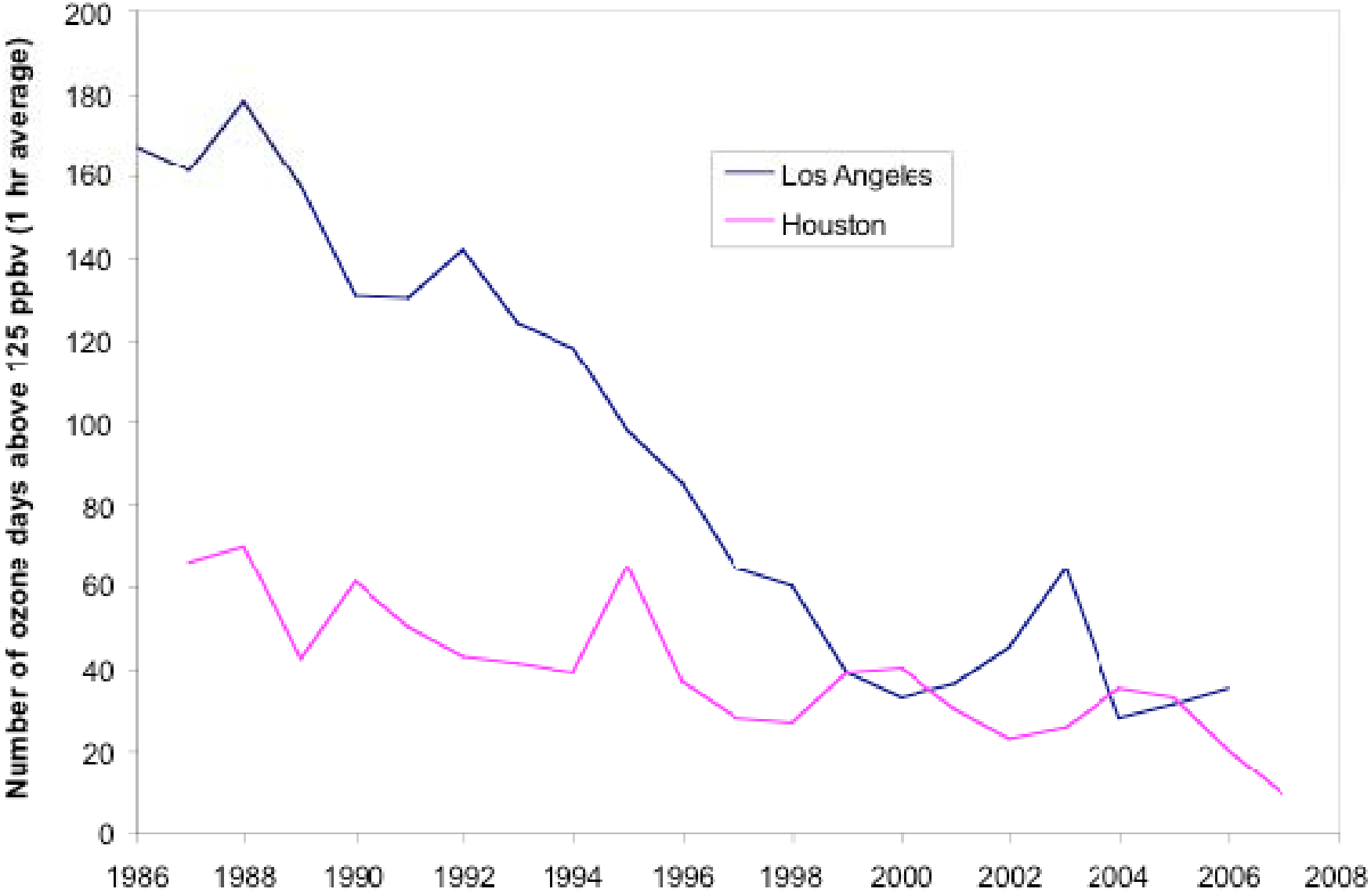
Tale of Two Cities



Source: TCEQ, CARB

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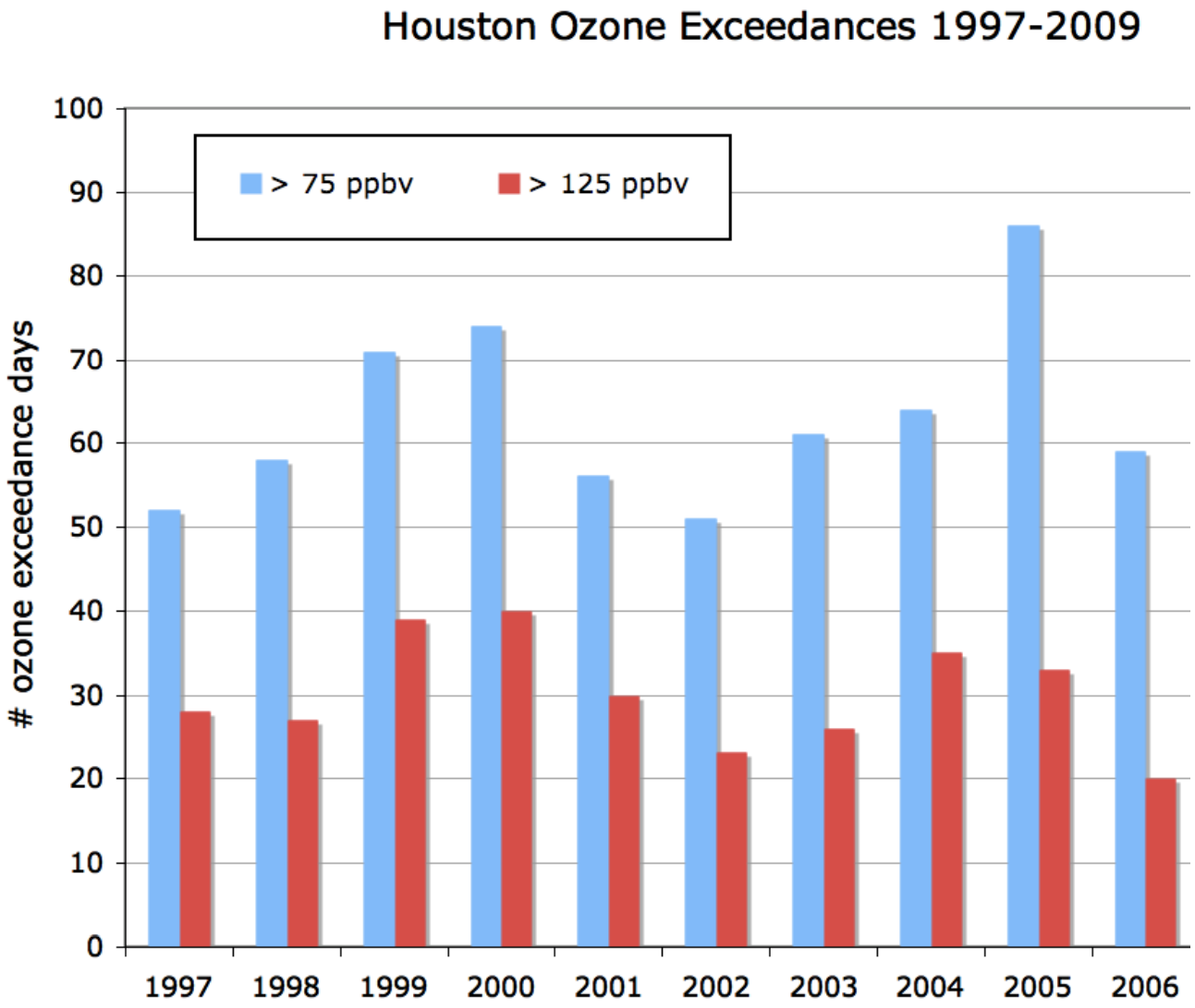
Houston Ozone Trends



Source: TCEQ

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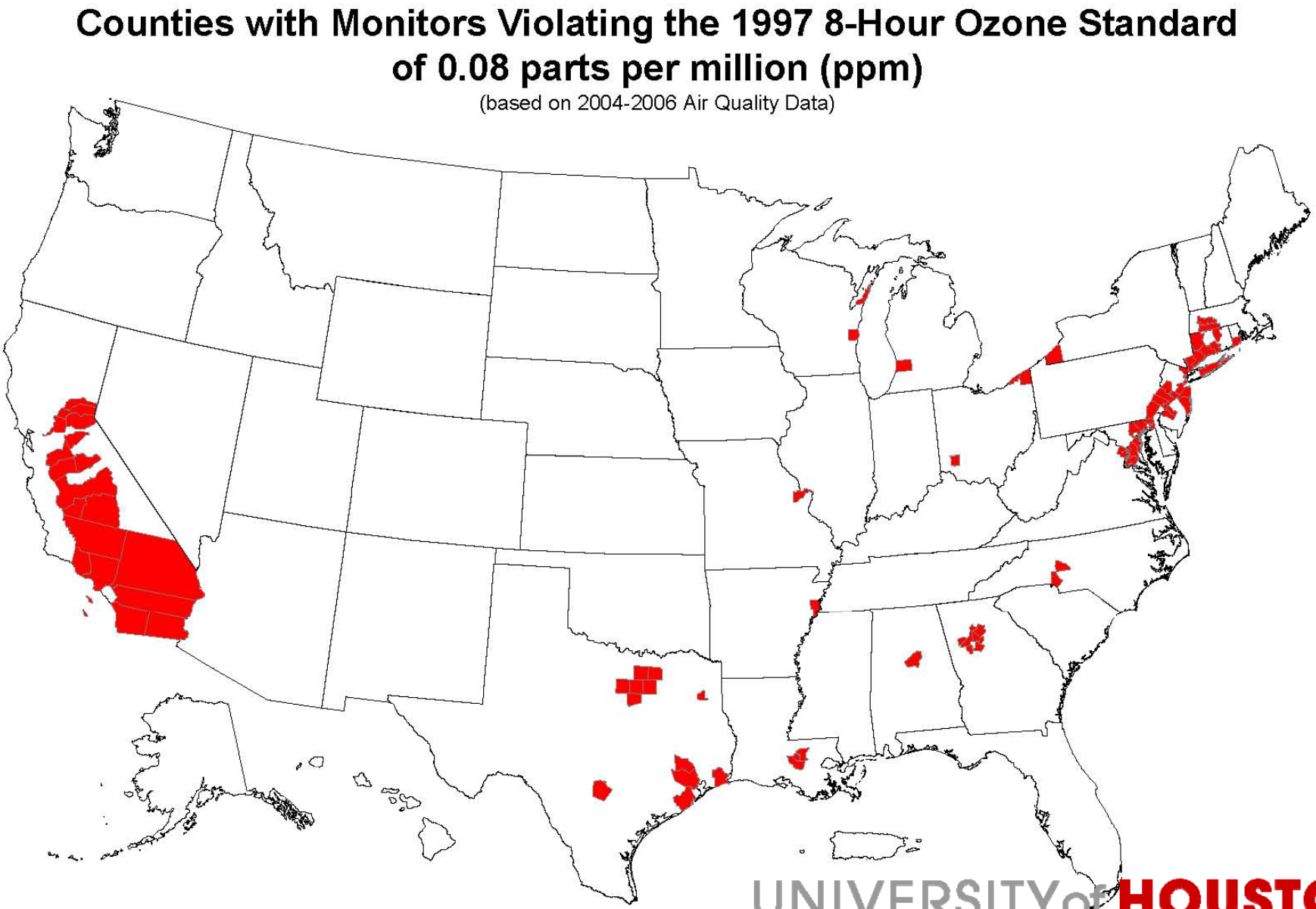
Where is ozone a problem? 2004-2006



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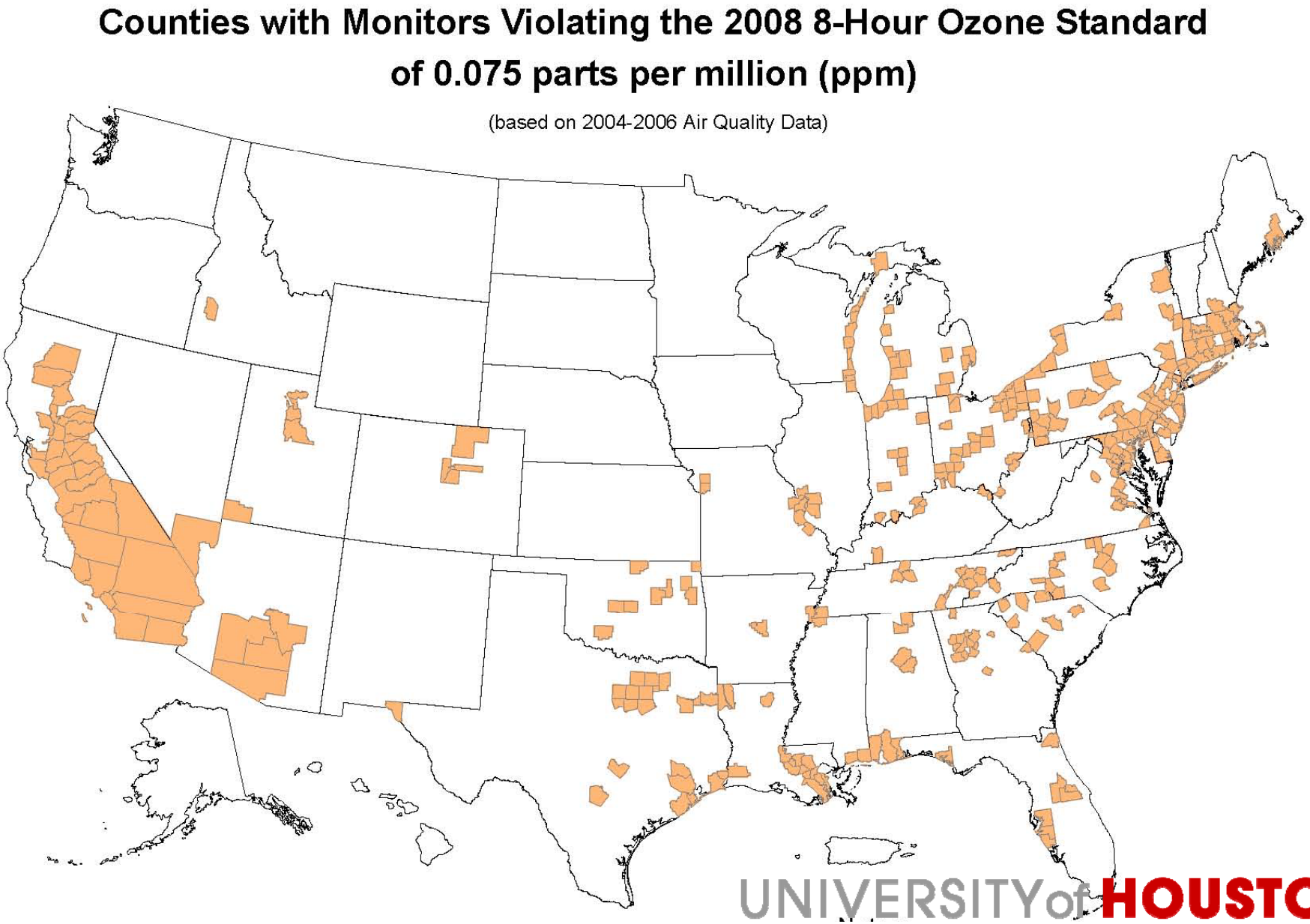
Where is ozone a problem? 2004-2006



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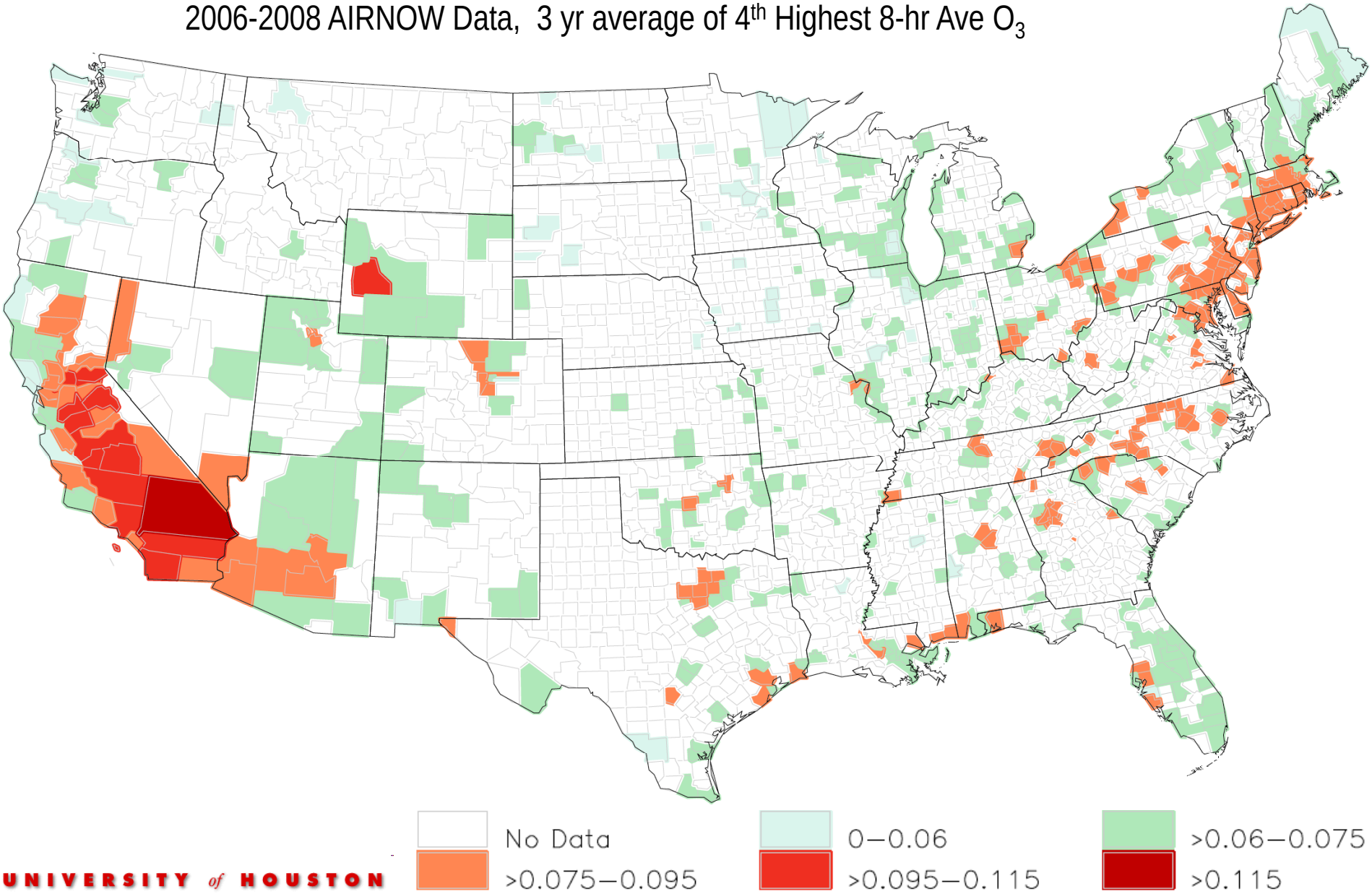
Where is ozone be a problem in the U.S.?

2006-2008 AIRNOW Data, 3 yr average of 4th Highest 8-hr Ave O_3



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SHARP 2009

SHARP Study of Houston Atmospheric Radical Precursors

B. L. Lefer
B. Rappenglueck
E. P. Olaguer
R. Griffin
J. Stutz
J. E. Dibb
X. Ren
W. Brune
B.T. Jobson

W. Luke, G. Mount, X. Y. Yu, M. Shauck, S. C. Herndon
L. G. Huey, S. Dasgupta, R. Zhang, S. North, D. Collins, G. Morris,
J. L. Jimenez, J. Melqvist

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Early Morning Hydroxyl Radical (OH) Source

$$HONO(g) + h\nu \longrightarrow \dot{O}H(g) + \dot{N}O(g) \qquad \lambda < 400\ nm$$

Nitrous acid	Hydroxyl radical	Nitric oxide

Mid-Morning Hydroxyl Radical (OH) Source

$$HCHO(g) + h\nu \longrightarrow H\dot{C}O(g) + \dot{H}(g) \qquad \lambda < 334\ nm$$

Formal-dehyde → Formyl radical + Atomic hydrogen

$$\dot{H}(g) + O_2(g) \xrightarrow{M} H\dot{O}_2(g)$$

Atomic hydrogen + Molecular oxygen → Hydroperoxy radical

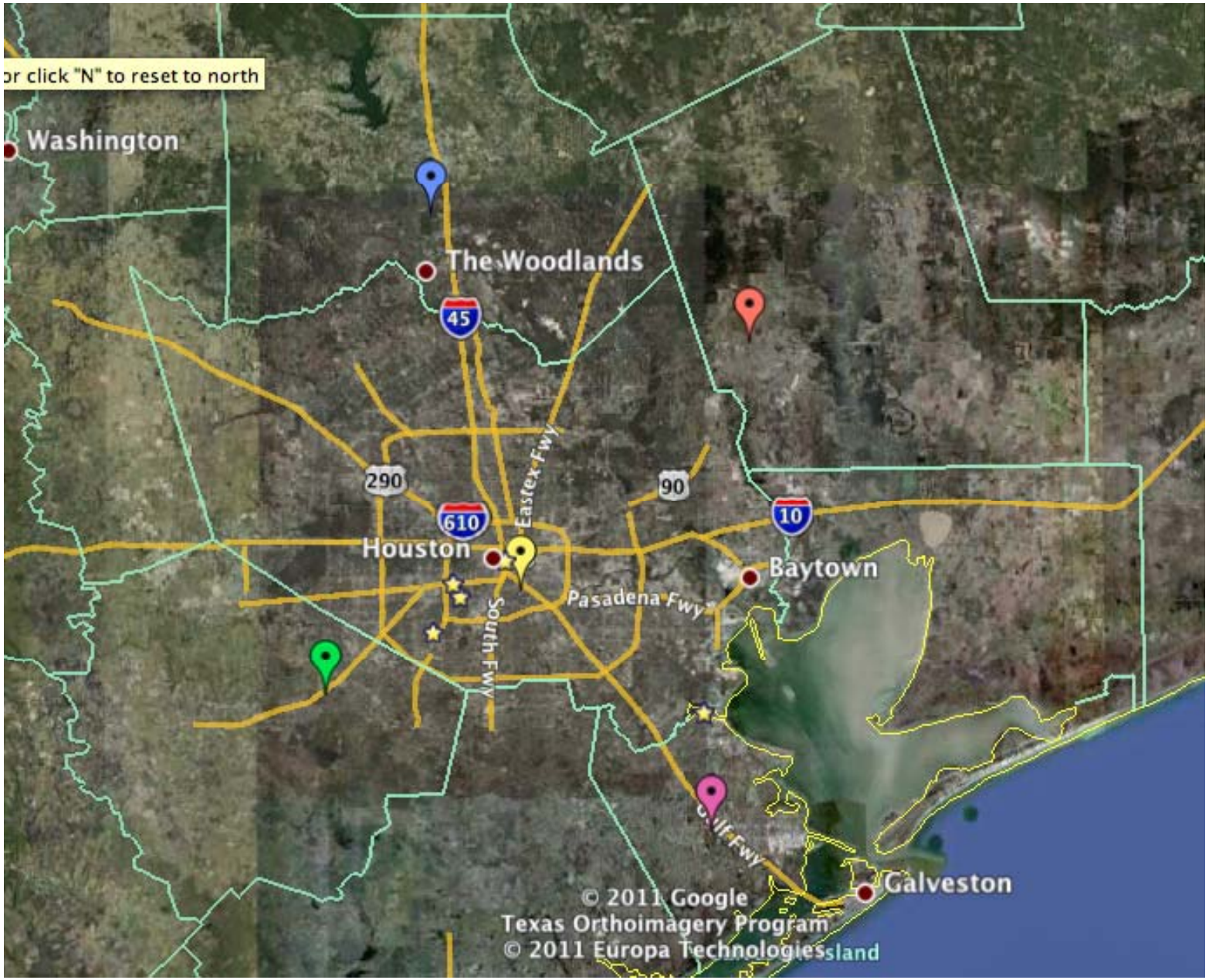
$$H\dot{C}O(g) + O_2(g) \longrightarrow CO(g) + H\dot{O}_2(g)$$

Formyl radical + Molecular oxygen → Carbon monoxide + Hydroperoxy radical

$$\dot{N}O(g) + H\dot{O}_2(g) \longrightarrow \dot{N}O_2(g) + \dot{O}H(g)$$

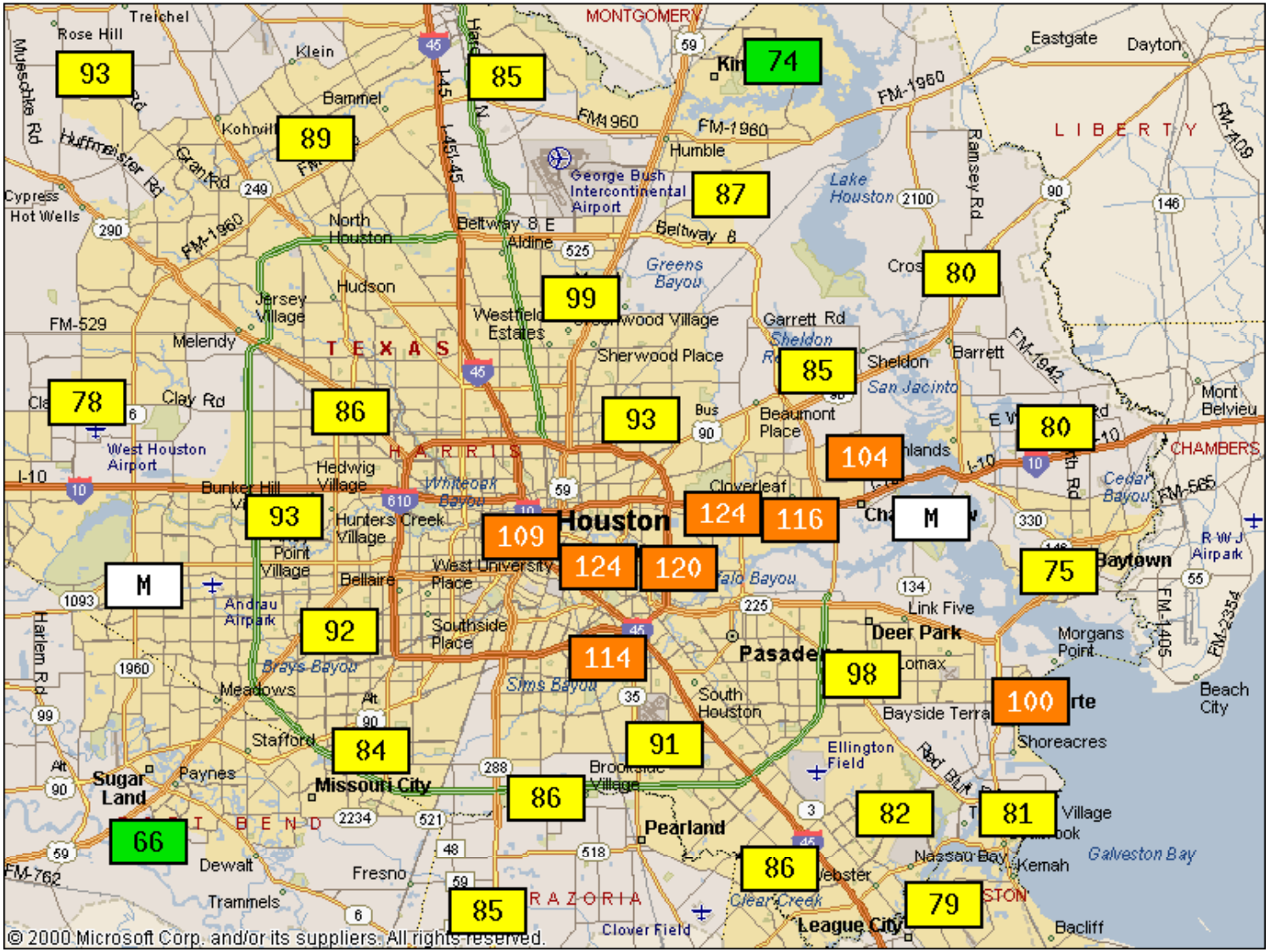
Nitric oxide + Hydroperoxy radical → Nitrogen dioxide + Hydroxyl radical

Five Additional AQ Monitoring Sites



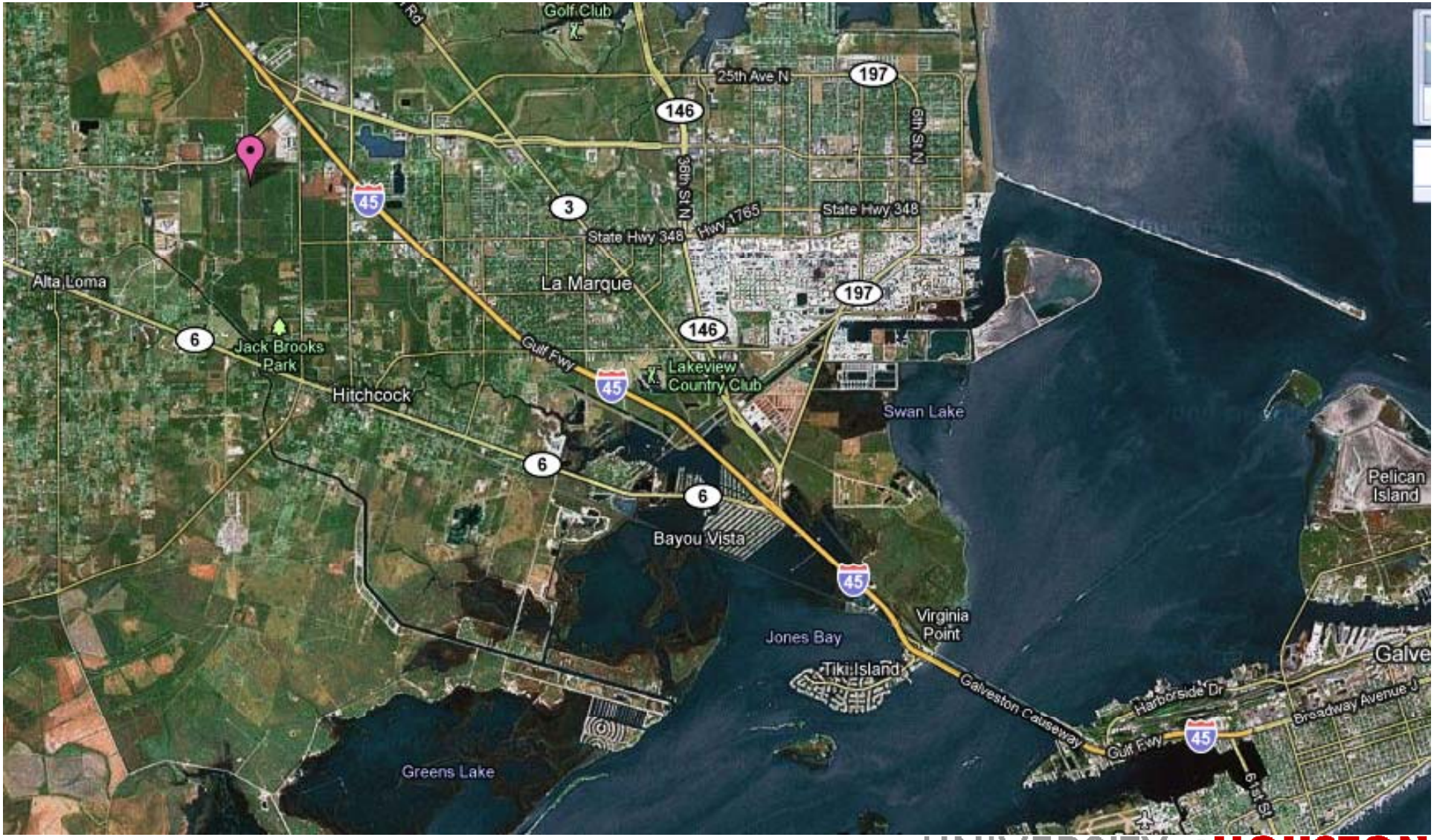
TCEQ, EPA, and other local monitoring sites

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



UH Coastal Research Center

Latitude: 29.3879, Longitude: -95.0414



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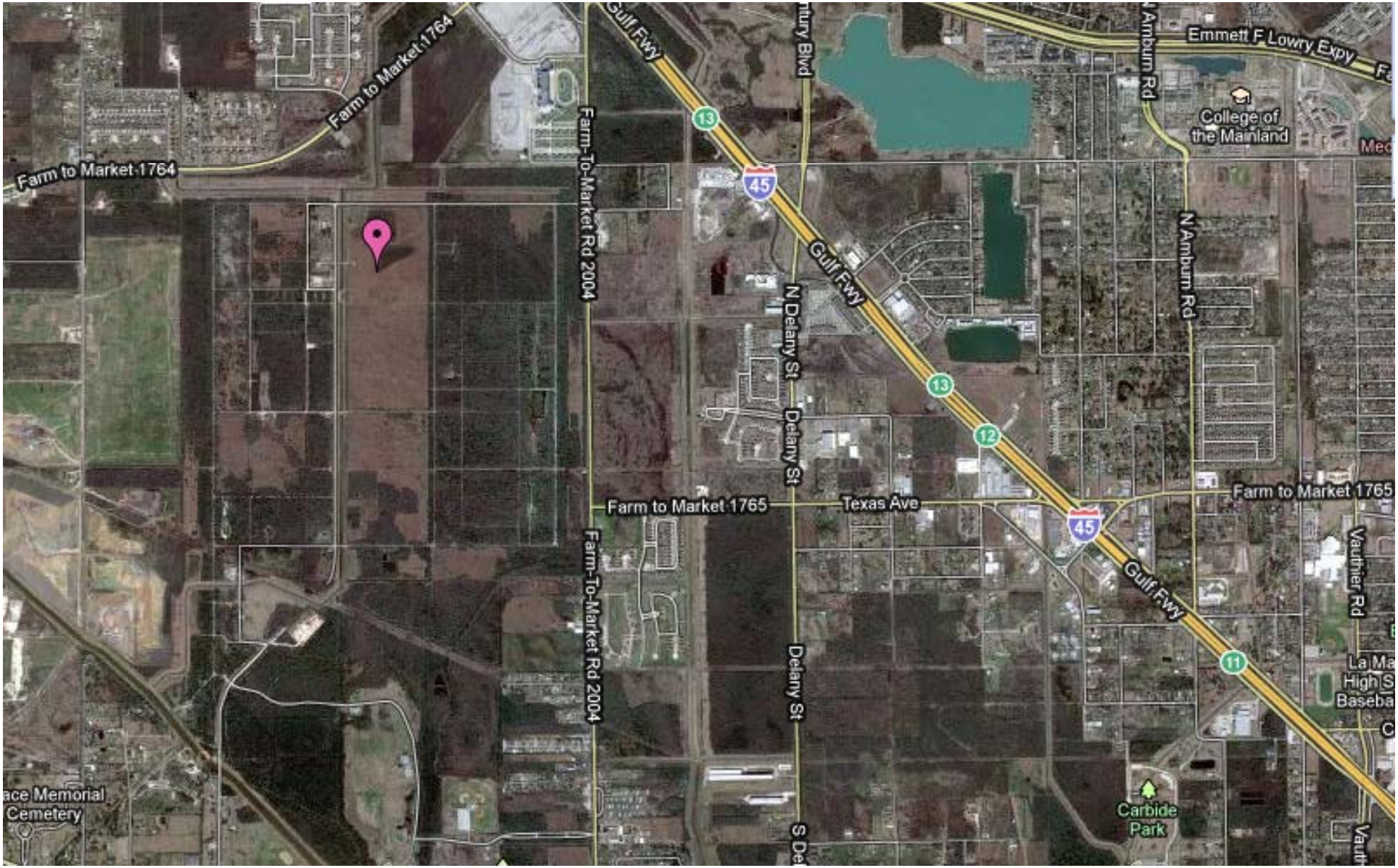
UH Coastal Research Center



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UH Coastal Research Center

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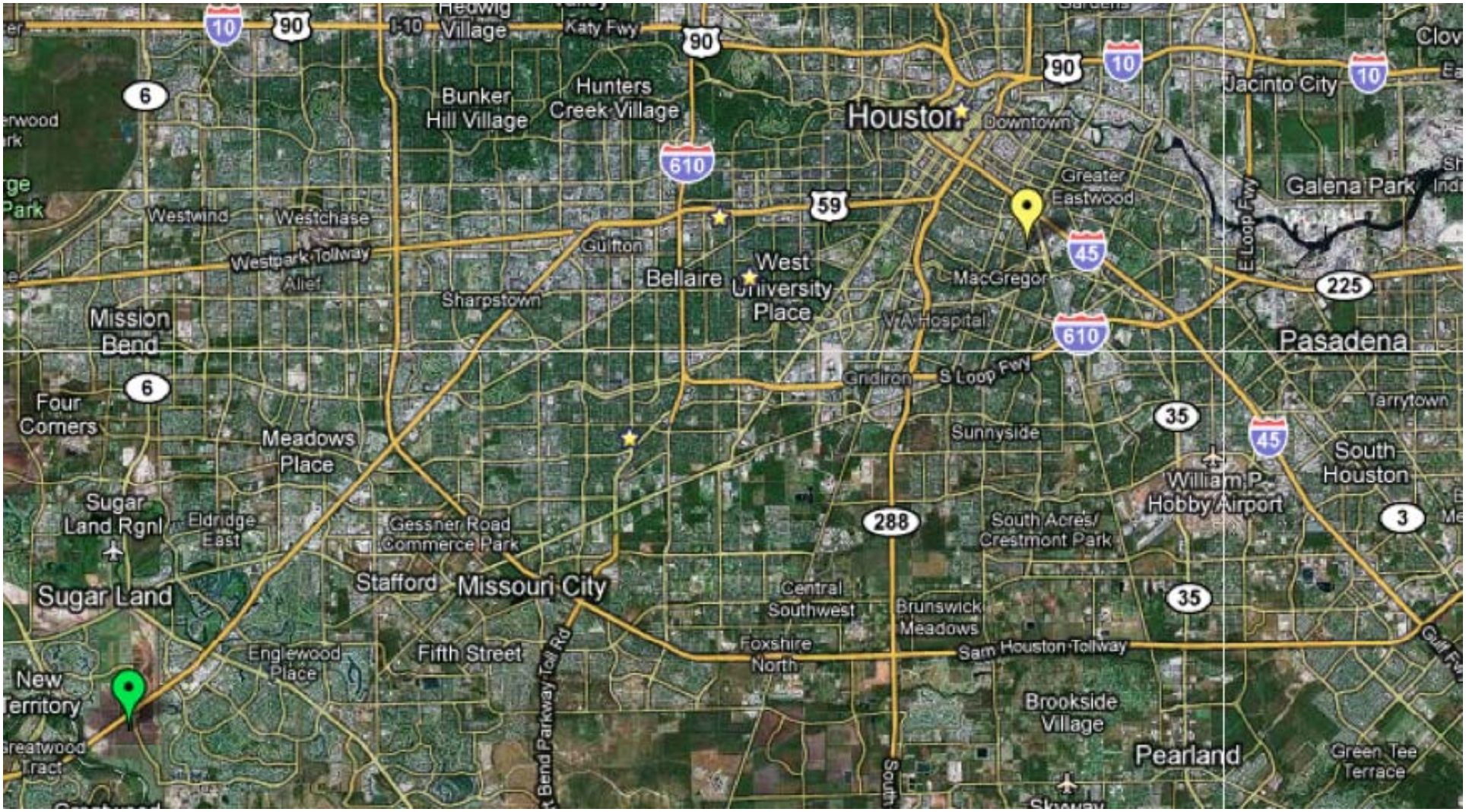
UH Sugar Land



UH Sugar Land

UH Sugar Land

UH Sugar Land

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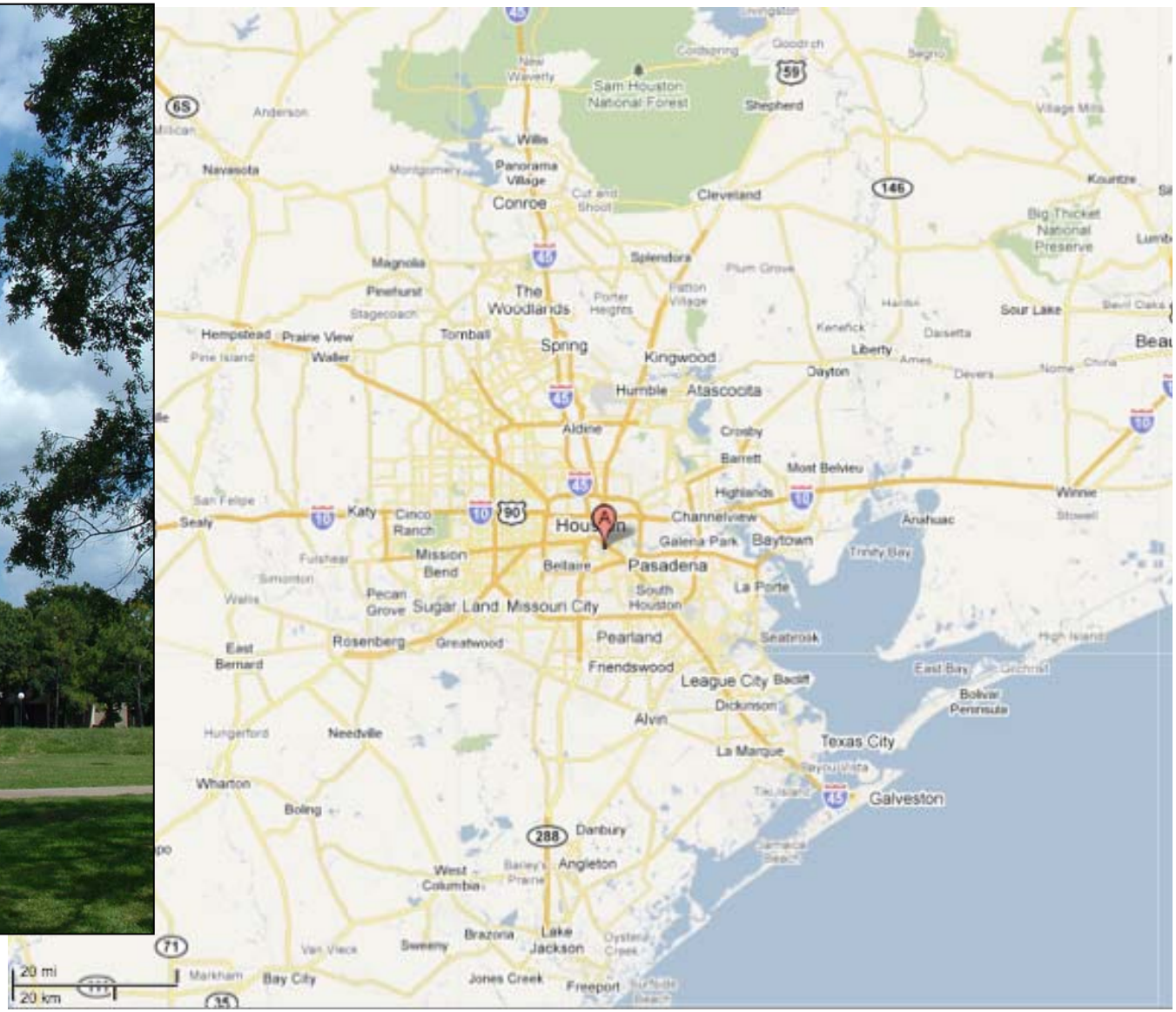
Moody Tower



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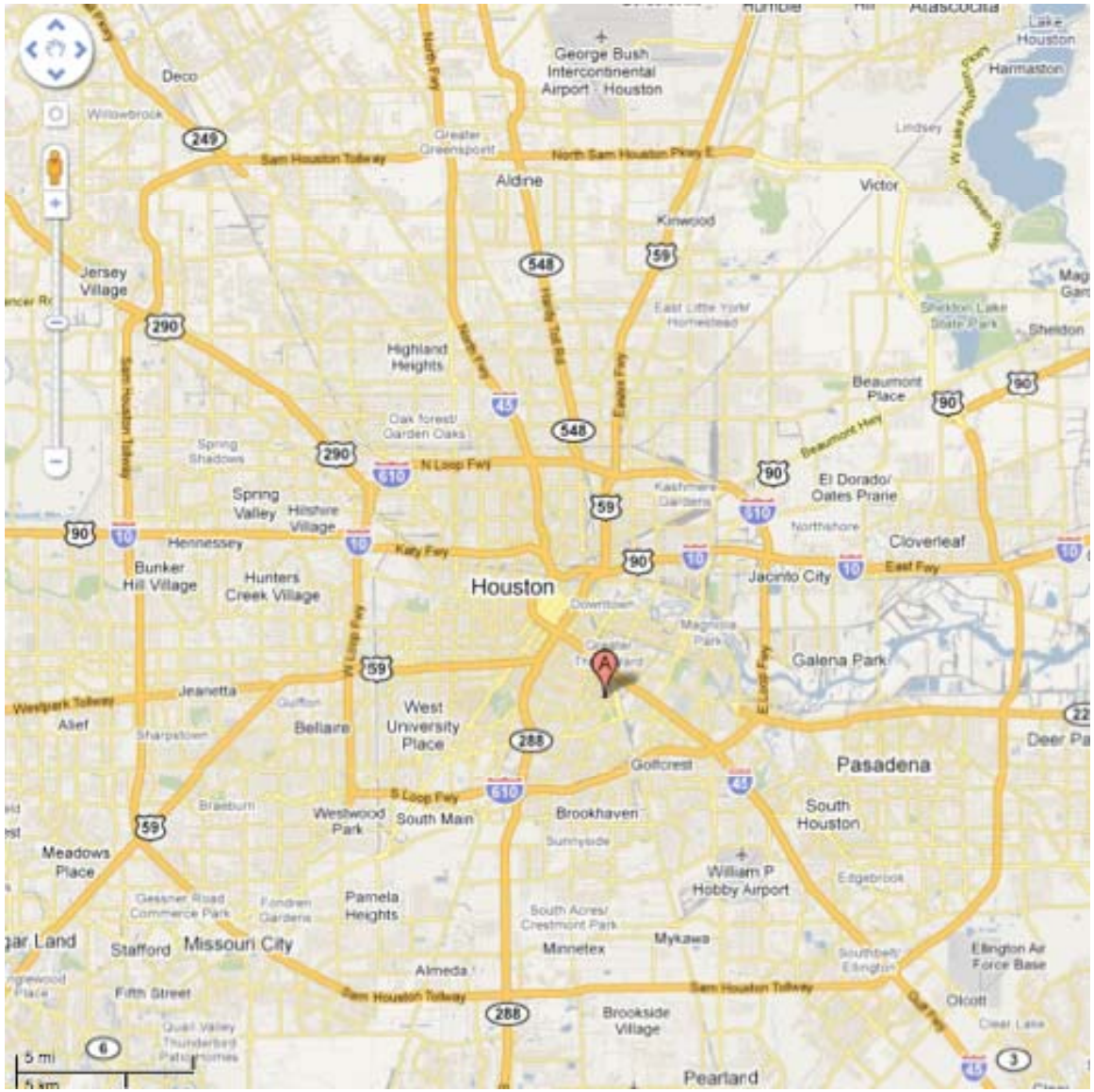
Moody Tower



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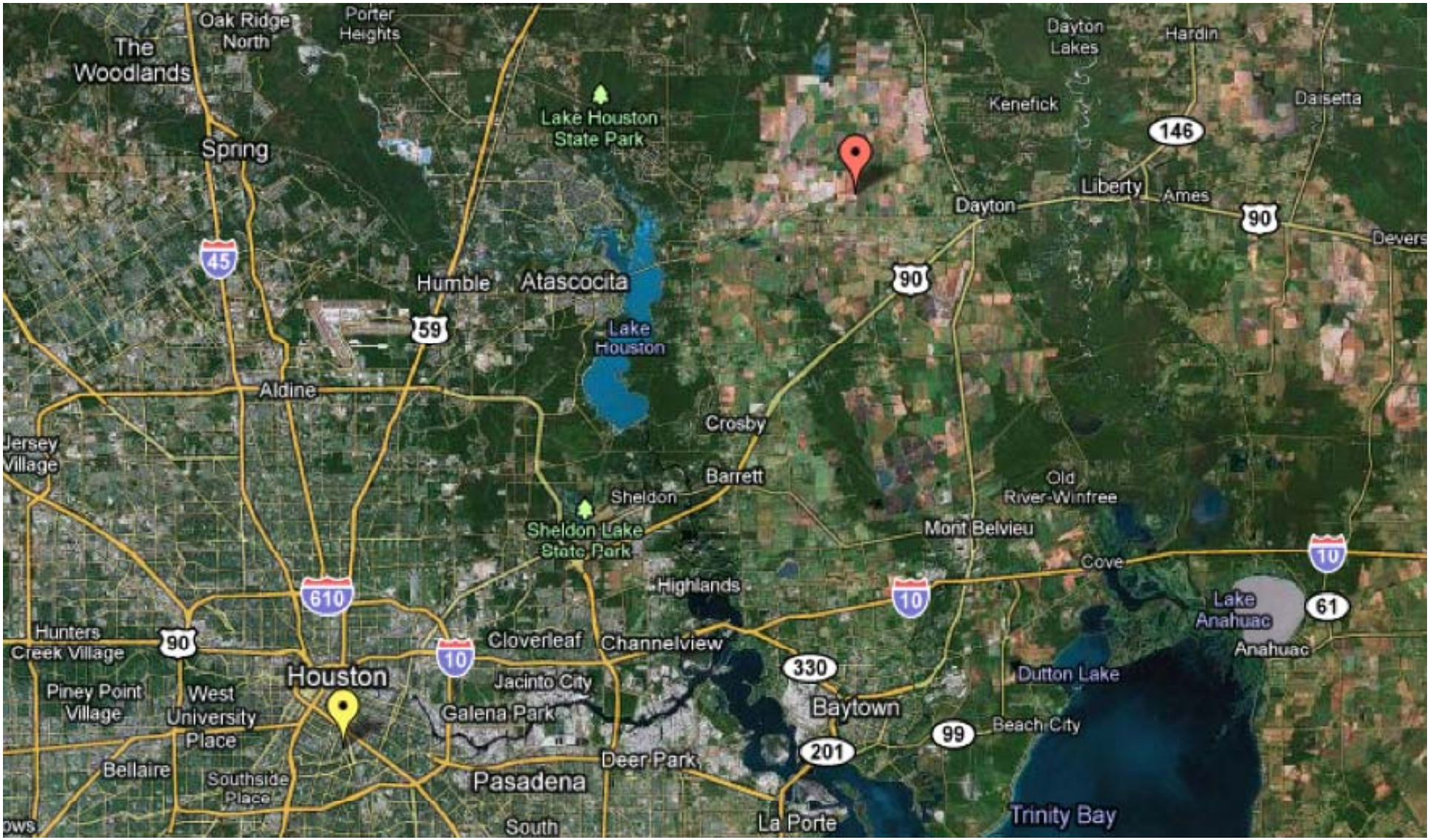
Moody Tower View

http://129.7.48.166

Moody Tower

UH - West Liberty

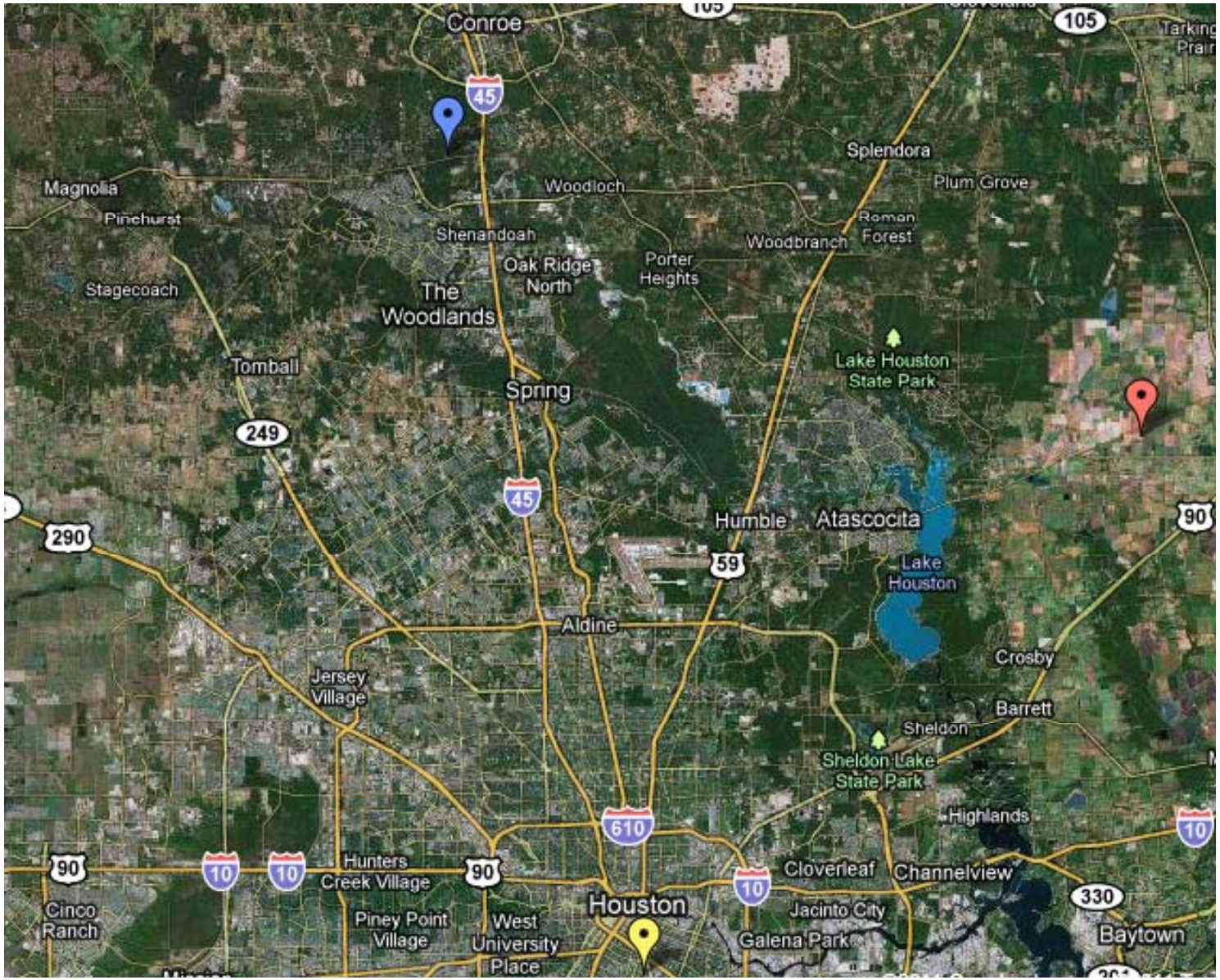


UH - West Liberty

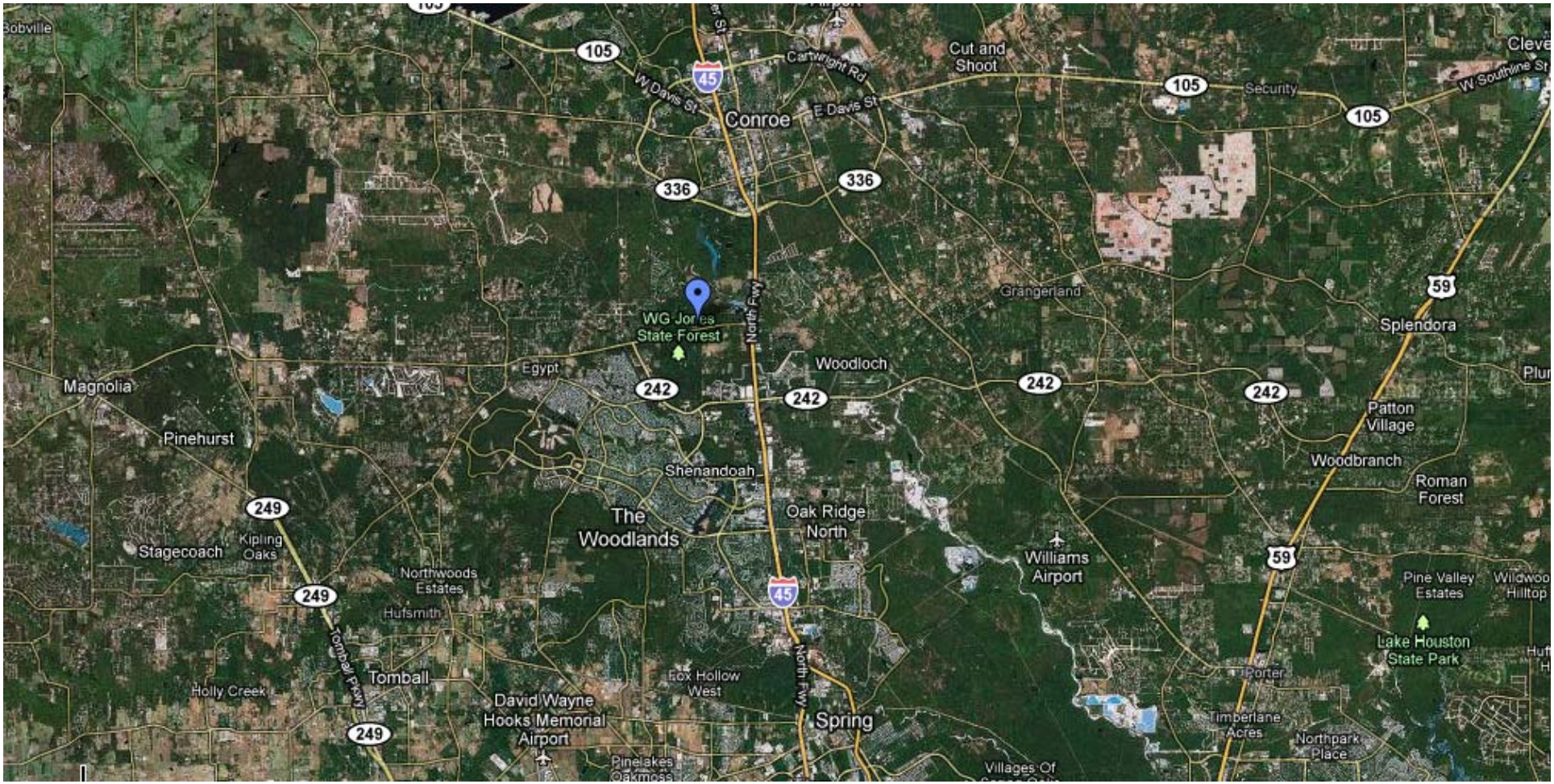
UH - West Liberty

UH - West Liberty

UH – Jones Forest



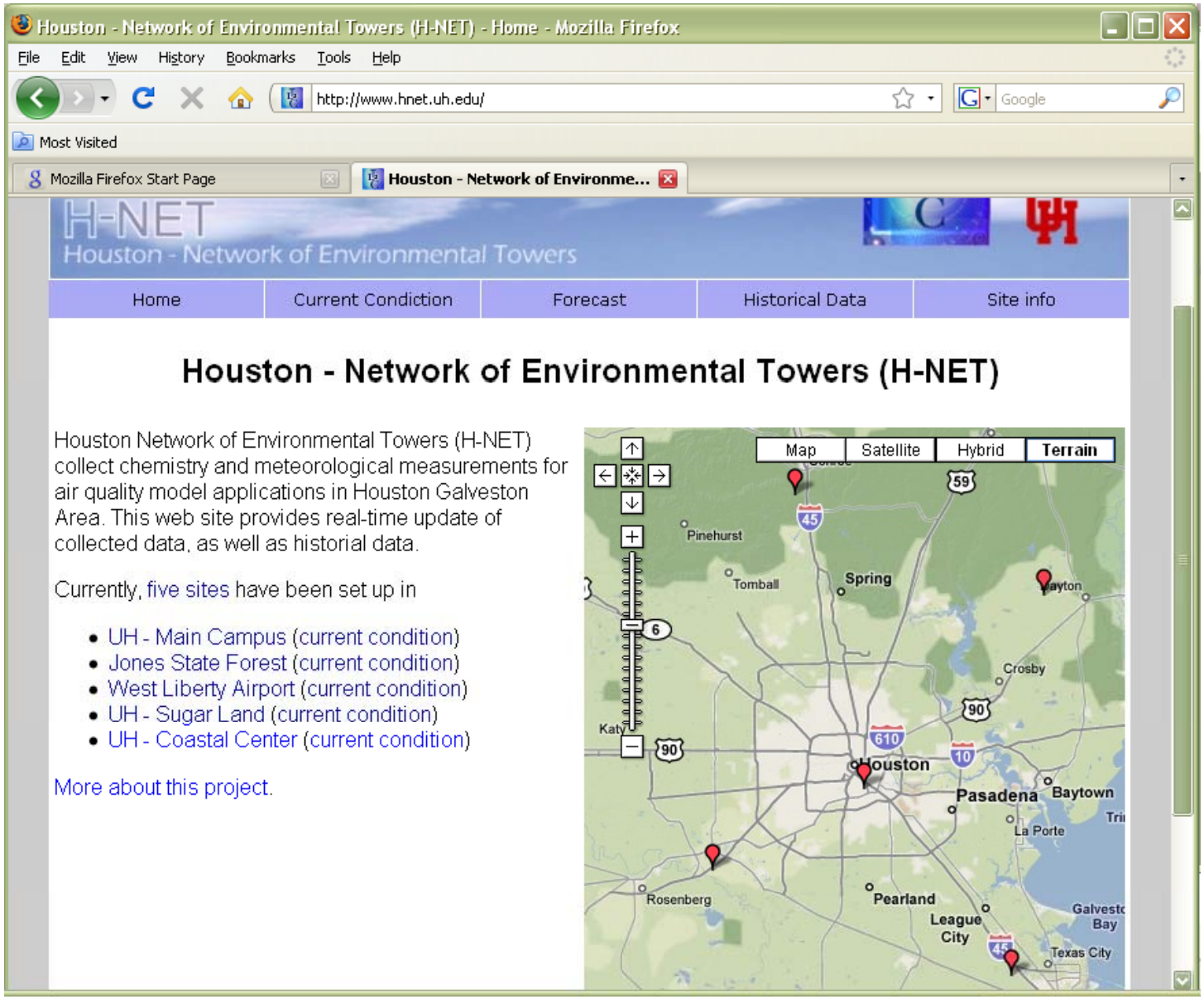
UH – Jones Forest



UH – Jones Forest

UH – Jones Forest

Five Additional AQ Monitoring Sites



GulfStar Grid

H-NET
Houston - Network of Environmental Towers

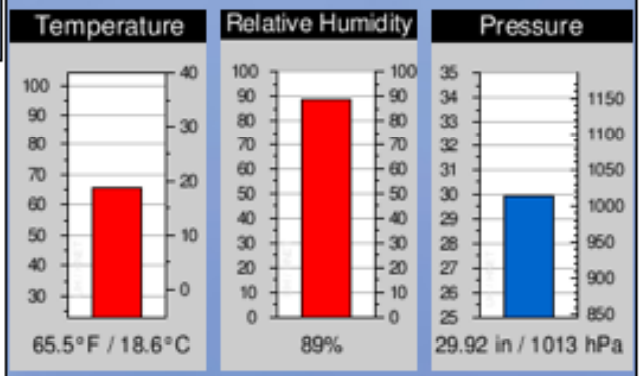
Home | Current Condition | Forecast | Historical Data | Site info

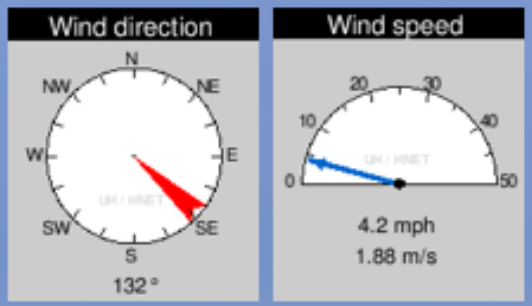
Current Conditions at UH - Sugar Land (Site Info)

Date/Time	2011-02-22 11:10 PM
Temperature	18.6°C (65.5°F)
Relative Humidity	89%
Wind	132° at 4.2 mph (1.88 m/s)
Barometer	1013 hpa (29.94 in)
Precipitation (24 hr)	0.00 in (0.00 mm)
Date/Time	2011-02-22 11:11 PM
Ozone	24 ppbv
CO	93 ppbv

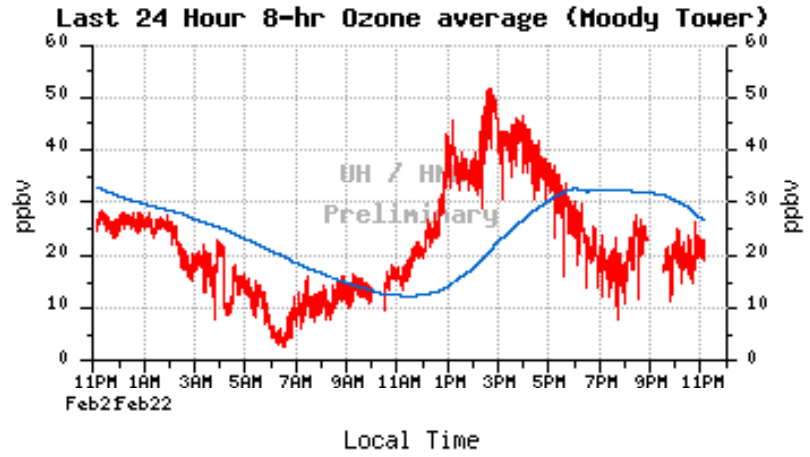
Last 24 hour Highs/Lows

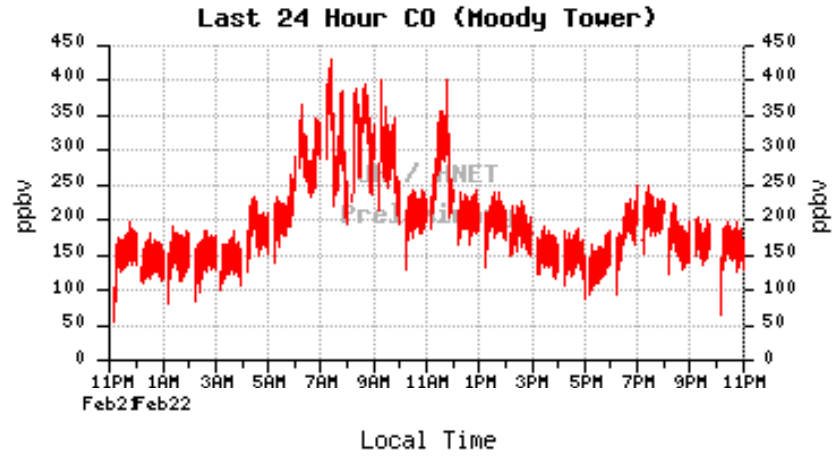
High Temp	25.1°C 77.2°F	at 03:10 PM
Low Temp	15.8°C 60.5°F	at 06:59 AM
High Relative Humidity	96.0%	at 05:30 AM
Low Relative Humidity	55.8%	at 04:49 PM
High Pressure	1015.4 hPa 30.0 in	at 11:07 AM
Low Pressure	1010.7 hPa 29.8 in	at 11:10 PM

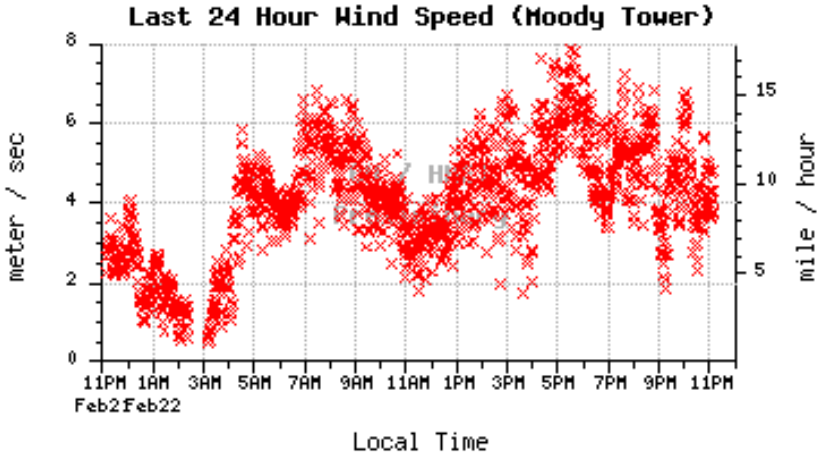


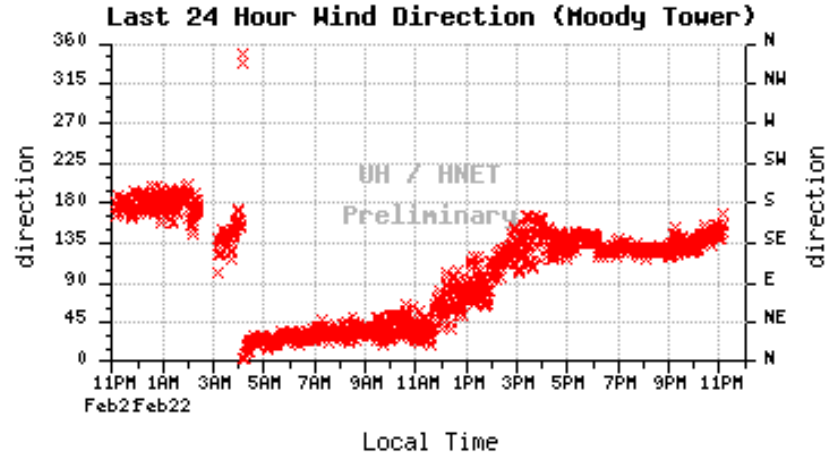


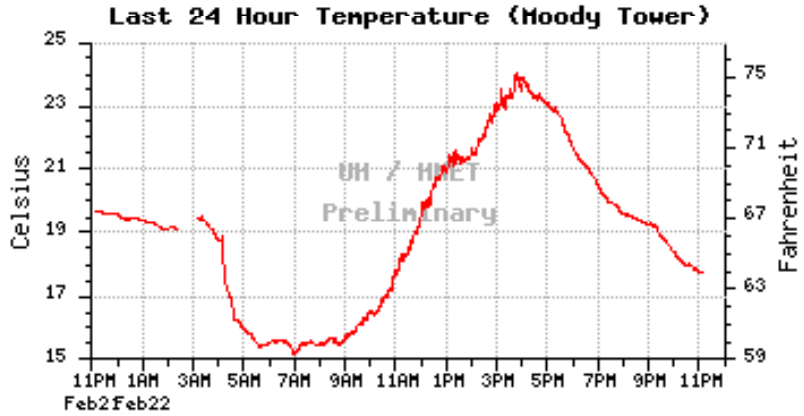
LAST 24 Hours Graphs

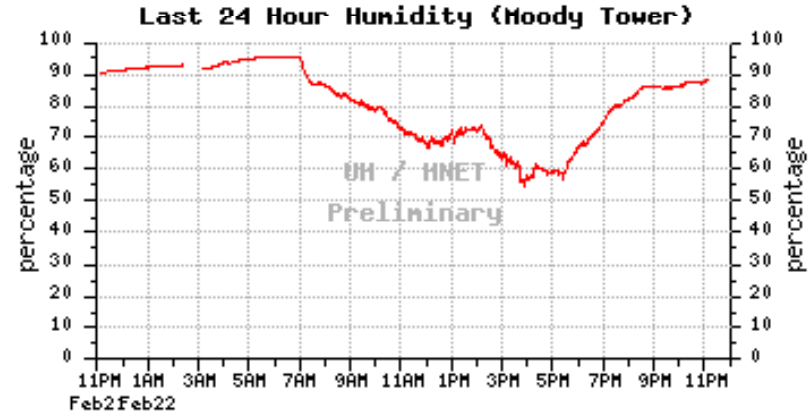

Last 24 Hour 8-hr Ozone average (Moody Tower)
ppbv
UH / HNET
Preliminary
11PM 1AM 3AM 5AM 7AM 9AM 11AM 1PM 3PM 5PM 7PM 9PM 11PM
Feb2Feb22
Local Time


Last 24 Hour CO (Moody Tower)
ppbv
UH / HNET
11PM 1AM 3AM 5AM 7AM 9AM 11AM 1PM 3PM 5PM 7PM 9PM 11PM
Feb2Feb22
Local Time


Last 24 Hour Wind Speed (Moody Tower)
meter / sec
mile / hour
11PM 1AM 3AM 5AM 7AM 9AM 11AM 1PM 3PM 5PM 7PM 9PM 11PM
Feb2Feb22
Local Time


Last 24 Hour Wind Direction (Moody Tower)
direction
N
NW
W
SW
S
SE
E
NE
N
UH / HNET
Preliminary
11PM 1AM 3AM 5AM 7AM 9AM 11AM 1PM 3PM 5PM 7PM 9PM 11PM
Feb2Feb22
Local Time


Last 24 Hour Temperature (Moody Tower)
Celsius
Fahrenheit
UH / HNET
Preliminary
11PM 1AM 3AM 5AM 7AM 9AM 11AM 1PM 3PM 5PM 7PM 9PM 11PM
Feb2Feb22


Last 24 Hour Humidity (Moody Tower)
percentage
UH / HNET
Preliminary
11PM 1AM 3AM 5AM 7AM 9AM 11AM 1PM 3PM 5PM 7PM 9PM 11PM
Feb2Feb22

2010 Peak 8-hr Ozone Events

2010 Sorted by Maximum Value							
Location	Region	CAMS	AQS	Date	Time	Value	POC
UH Moody Tower C695	12	695	48_201_0695	August 11 2010	11:00	102	1 N
Houston Aldine C8/AF108/X150	12	8	48_201_0024	May 3 2010	11:00	97	2
Northwest Harris Co. C26/A110/X154	12	26	48_201_0029	May 3 2010	10:00	96	2
UH WG Jones Forest C698	12	698	48_339_0698	September 14 2010	10:00	96	1 N
Sheldon C551	12	551	48_201_0551	October 16 2010	10:00	95	1 N
Seabrook Friendship Park C45	12	45	48_201_1050	May 4 2010	10:00	95	1
Manvel Croix Park C84	12	84	48_039_1004	May 28 2010	10:00	94	1
Northwest Harris Co. C26/A110/X154	12	26	48_201_0029	September 15 2010	11:00	94	2
Crosby Library C553	12	553	48_201_0553	October 8 2010	11:00	94	1 N
Meyer Park C561	12	561	48_201_0561	May 3 2010	10:00	94	1 N
UH Moody Tower C695	12	695	48_201_0695	May 26 2010	10:00	94	1 N
UH WG Jones Forest C698	12	698	48_339_0698	April 28 2010	11:00	94	1 N
Eagle Mountain Lake C75	4	75	48_439_0075	June 4 2010	12:00	94	1
Park Place C416	12	416	48_201_0416	August 11 2010	10:00	93	1
Mercer Arboretum C557	12	557	48_201_0557	May 3 2010	10:00	93	1 N
Mercer Arboretum C557	12	557	48_201_0557	September 14 2010	10:00	93	1 N
Clear Lake High School C572	12	572	48_201_0572	October 16 2010	10:00	93	1 N
Seabrook Friendship Park C45	12	45	48_201_1050	October 8 2010	09:00	93	1
UH WG Jones Forest C698	12	698	48_339_0698	April 21 2010	11:00	93	1 N
Keller C17	4	17	48_439_2003	June 4 2010	11:00	93	2
Manvel Croix Park C84	12	84	48_039_1004	October 7 2010	11:00	92	1

2010 Peak 1-hr Ozone Events

2010 -- Sorted by Maximum Value								
Location	Region	CAMS	AQS	Date	Time	Value	POC	Hours Exceeded
UH WG Jones Forest C698	12	698	48_339_0698	August 2 2010	16:00	149	1 N	1
UH Moody Tower C695	12	695	48_201_0695	August 11 2010	13:00	142	1 N	2
Texas City 34th St. C620	12	620	48_167_0056	October 8 2010	12:00	138	1 N	1
HRM-3 Haden Road C603/A114	12	603	48_201_0803	July 16 2010	14:00	135	1 N	1
Wallisville Road C617	12	617	48_201_0617	May 18 2010	13:00	133	1 N	1
Crosby Library C553	12	553	48_201_0553	October 8 2010	16:00	131	1 N	1
Mercer Arboretum C557	12	557	48_201_0557	August 2 2010	14:00	131	1 N	1
UH Moody Tower C695	12	695	48_201_0695	July 24 2010	13:00	131	1 N	1
Atascocita C560	12	560	48_201_0560	August 2 2010	13:00	130	1 N	1
Lynchburg Ferry C1015/A165	12	1015	48_201_1015	July 16 2010	14:00	130	1	2
UH Moody Tower C695	12	695	48_201_0695	August 10 2010	14:00	129	1 N	2
Houston East C1/G316	12	1	48_201_1034	July 16 2010	16:00	129	2	1
Houston Aldine C8/AF108/X150	12	8	48_201_0024	August 3 2010	14:00	127	2	1
Channelview C15/AH115	12	15	48_201_0026	August 1 2010	15:00	126	3	1
Park Place C416	12	416	48_201_0416	August 11 2010	13:00	126	1	1
Baytown Wetlands Center C552	12	552	48_201_0552	August 1 2010	14:00	126	1 N	1
Houston East C1/G316	12	1	48_201_1034	August 3 2010	13:00	125	2	1
POC (Parameter Occurrence Code): a code used to correctly separate data from multiple instruments at one site.								
N - Data from this instrument does not meet EPA quality assurance criteria and cannot be used for regulatory purposes.								

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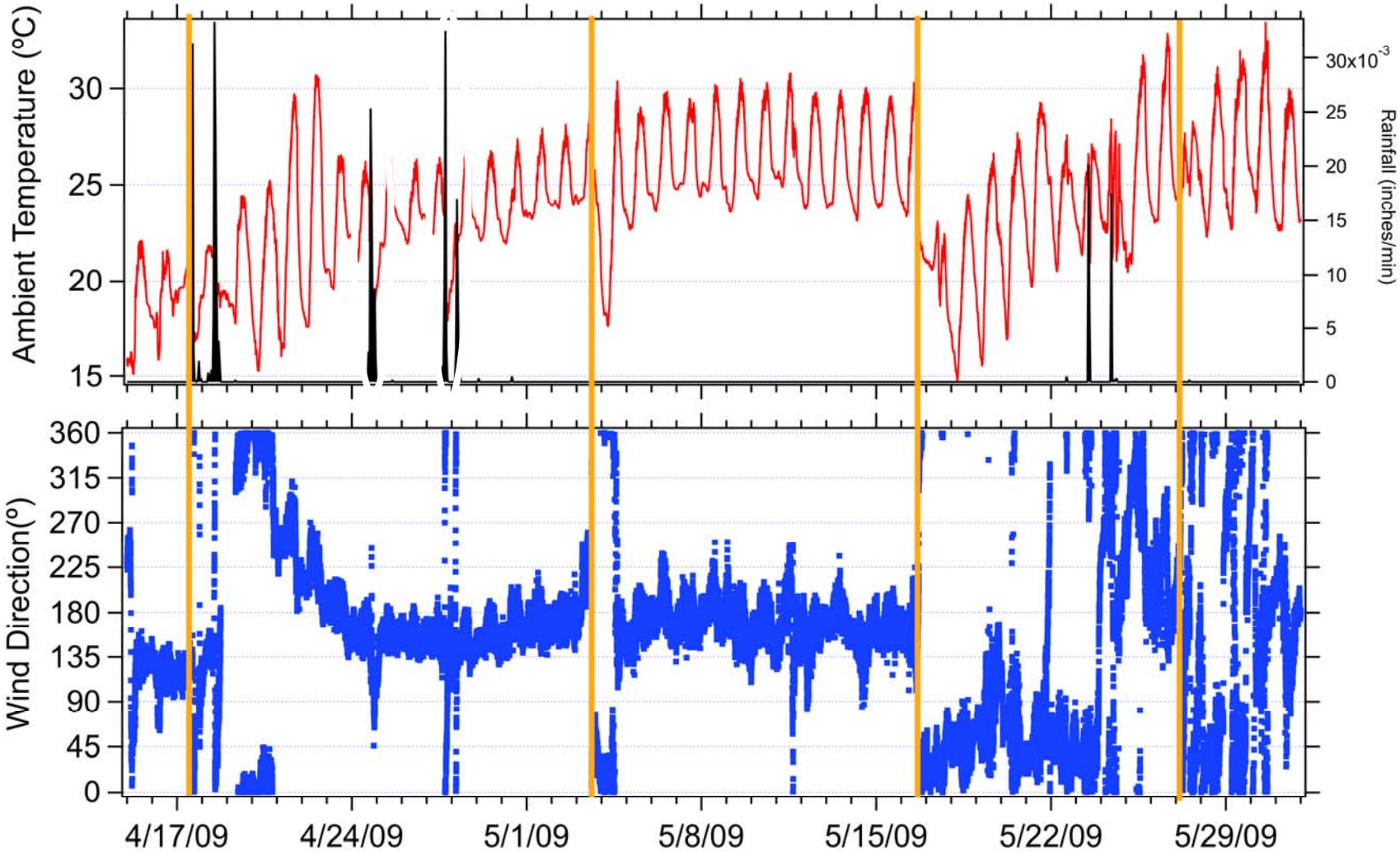
Meteorological Conditions



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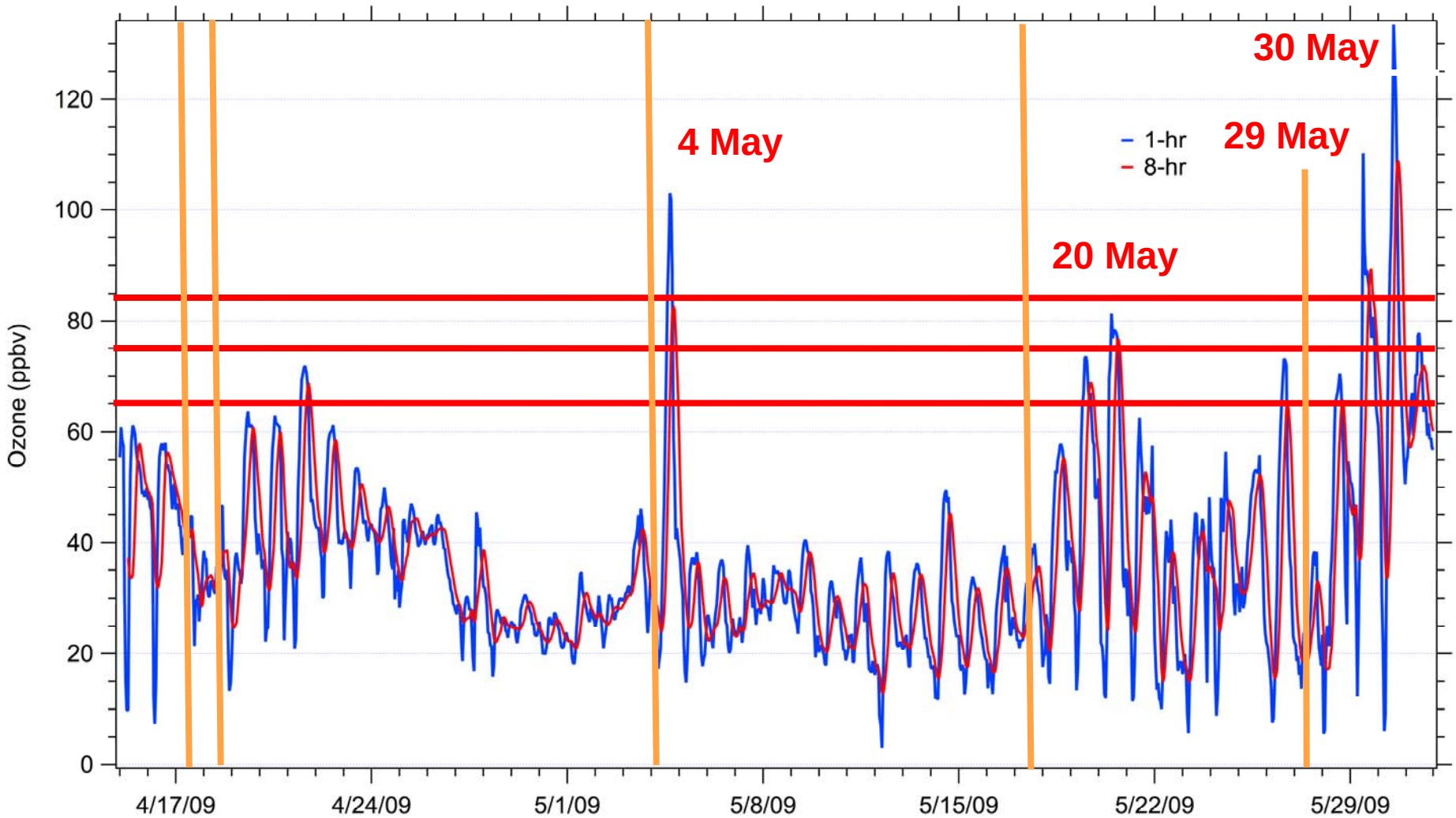
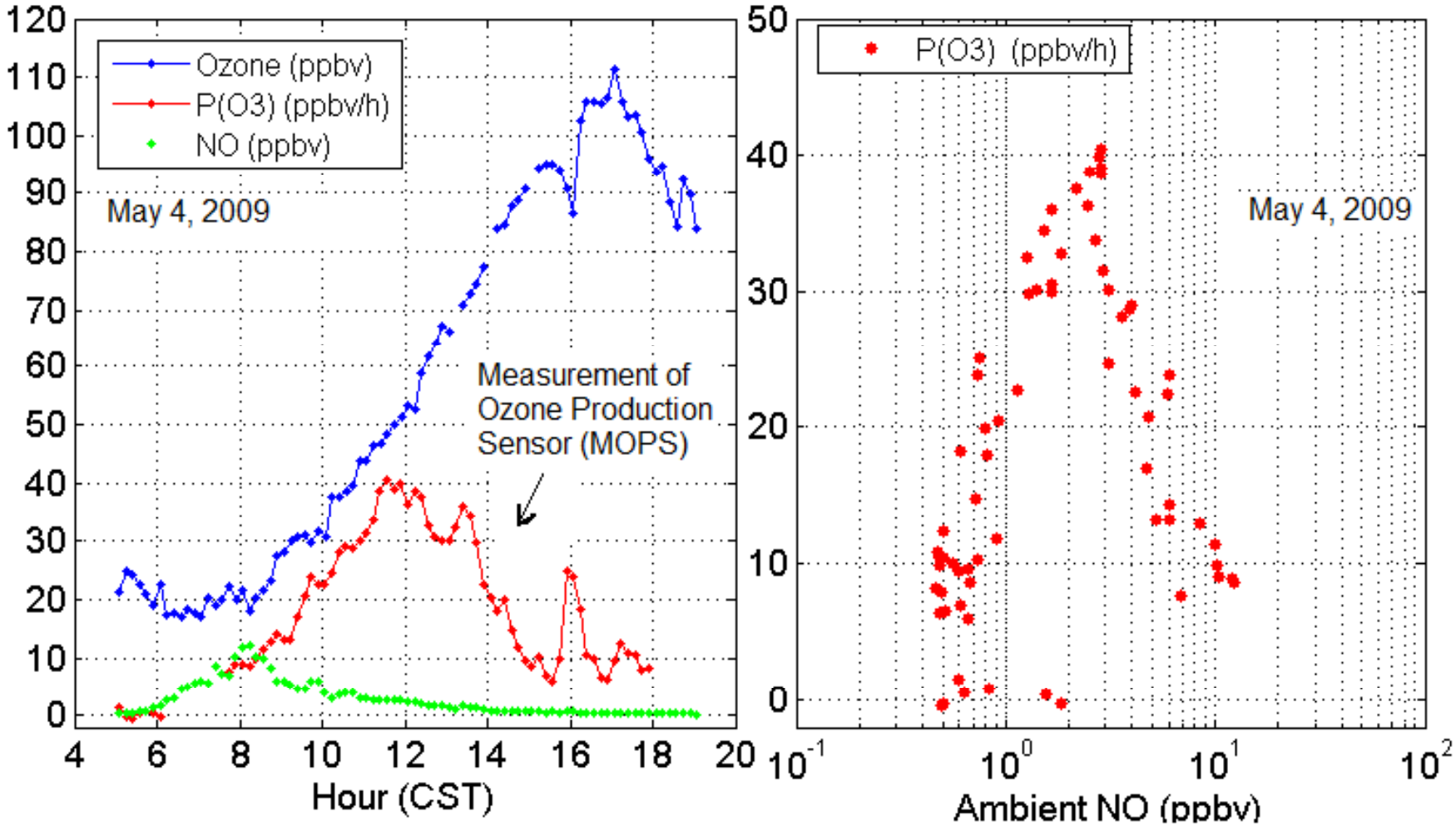
Ozone

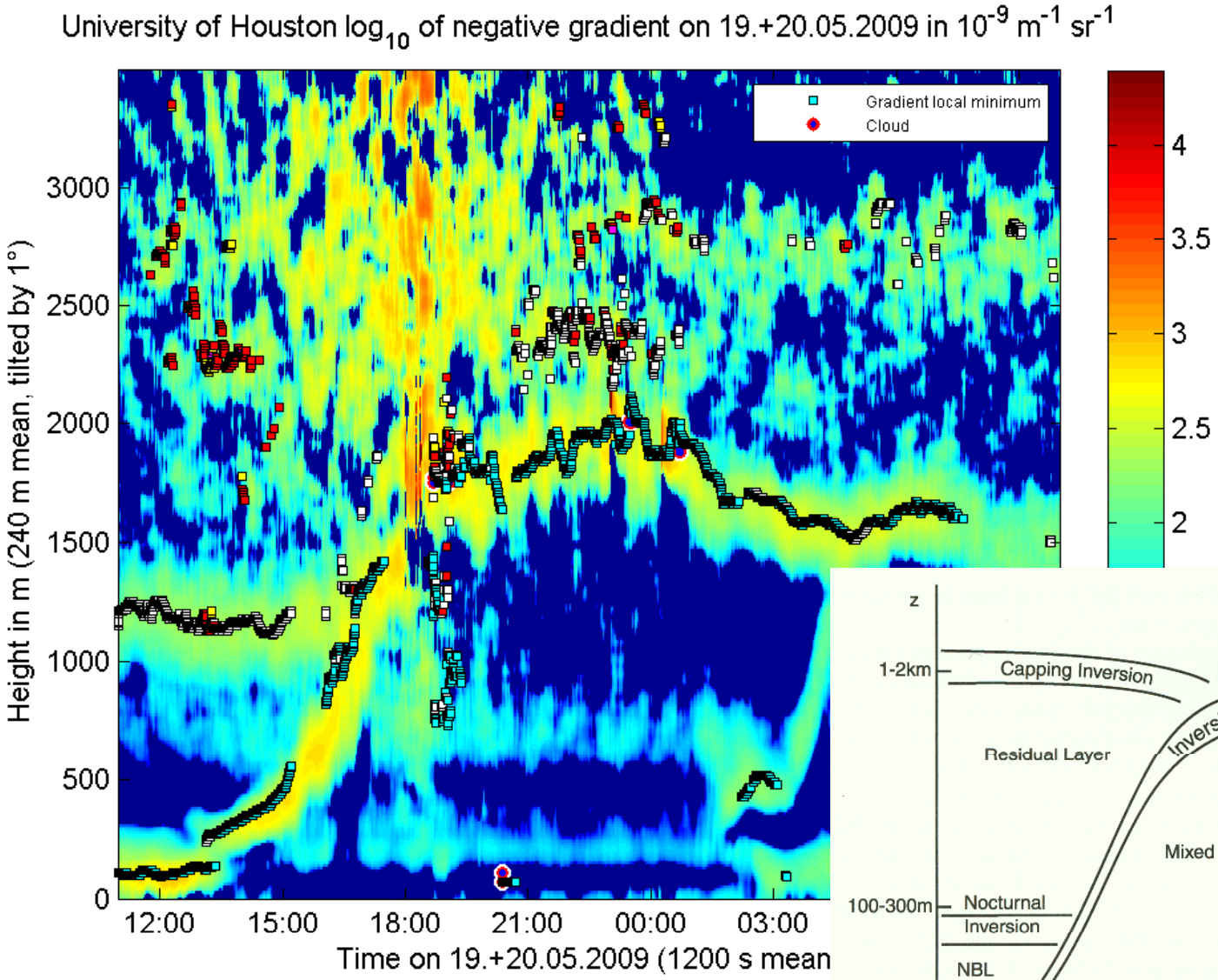

30 May
4 May
29 May
20 May
1-hr
8-hr
Ozone (ppbv)
0
20
40
60
80
100
120
4/17/09
4/24/09
5/1/09
5/8/09
5/15/09
5/22/09
5/29/09

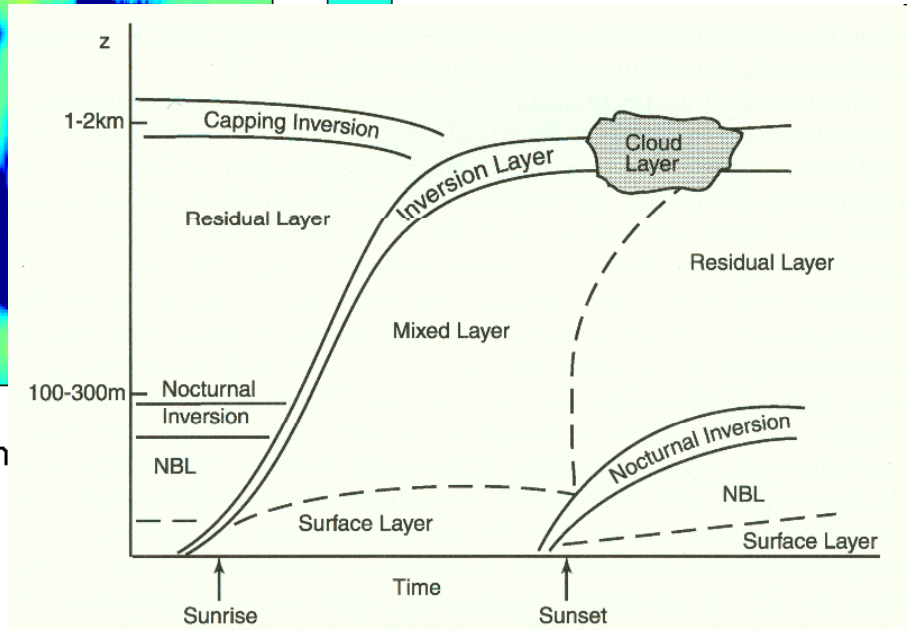
Ozone Production Sensor



Direct measurement of ozone production in Houston and correlation with ambient NO. May 4, 2009. Measured P(O3) will be compared with modeled P(O3) to test mechanisms. Measured P(O3) also can be compared with calculated P(O3) from peroxy radicals and NO. Cazorla, M. and Brune, W.

UH Aerosol LIDAR for Boundary Layer Height Measurements





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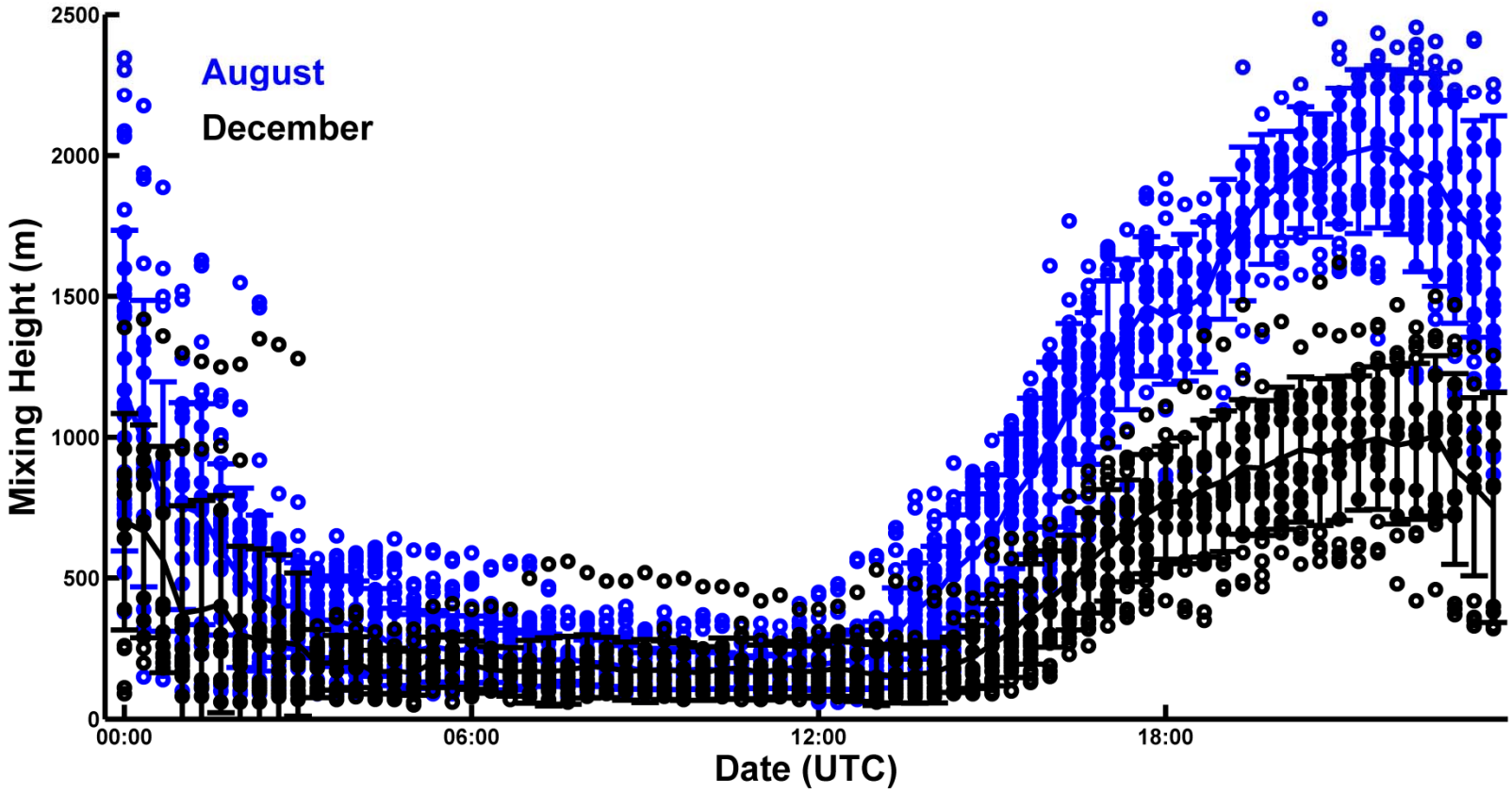
UH Aerosol LIDAR for Boundary Layer Height Measurements



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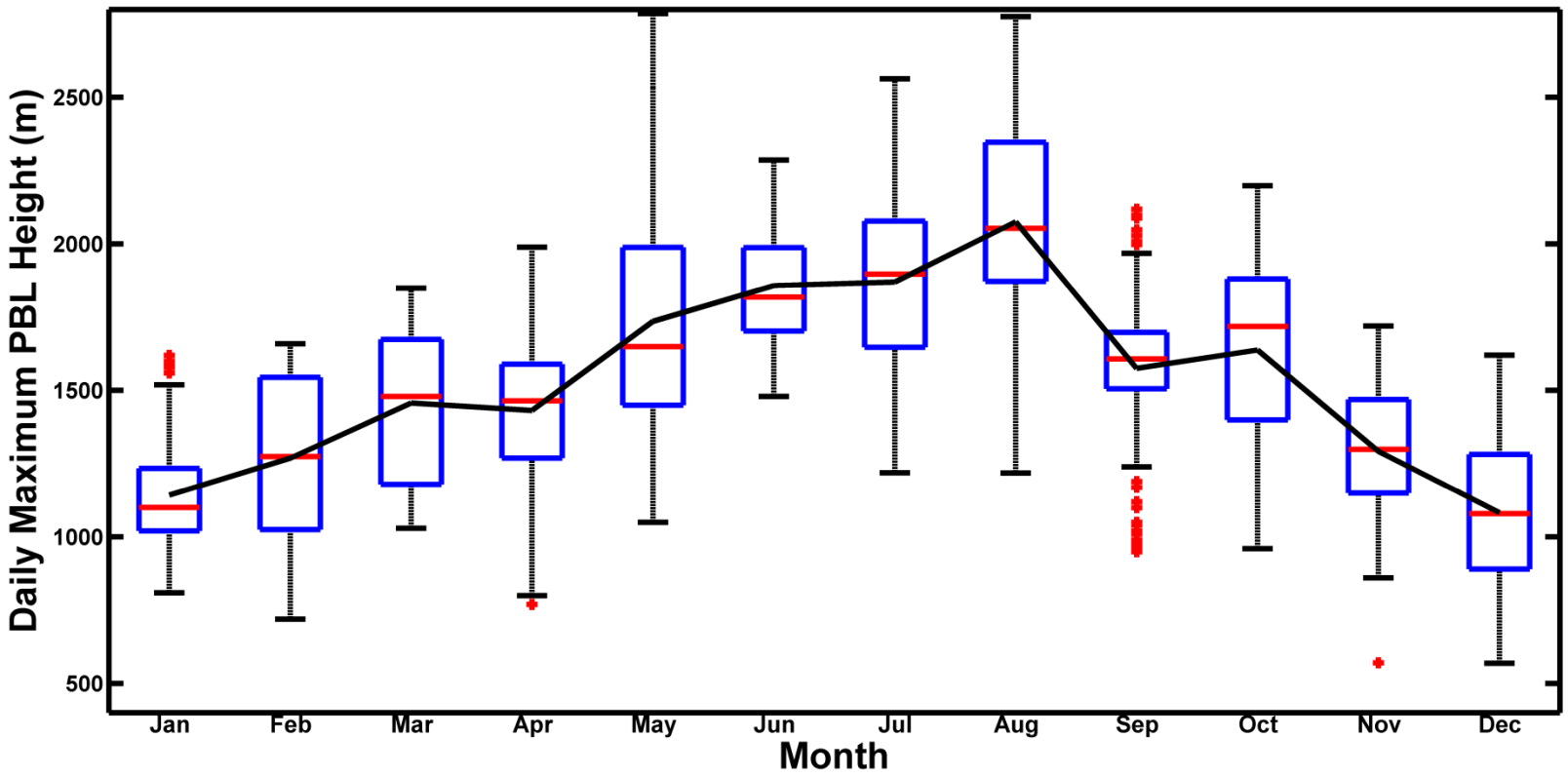
Daily Peak BLH and variation in monthly bins



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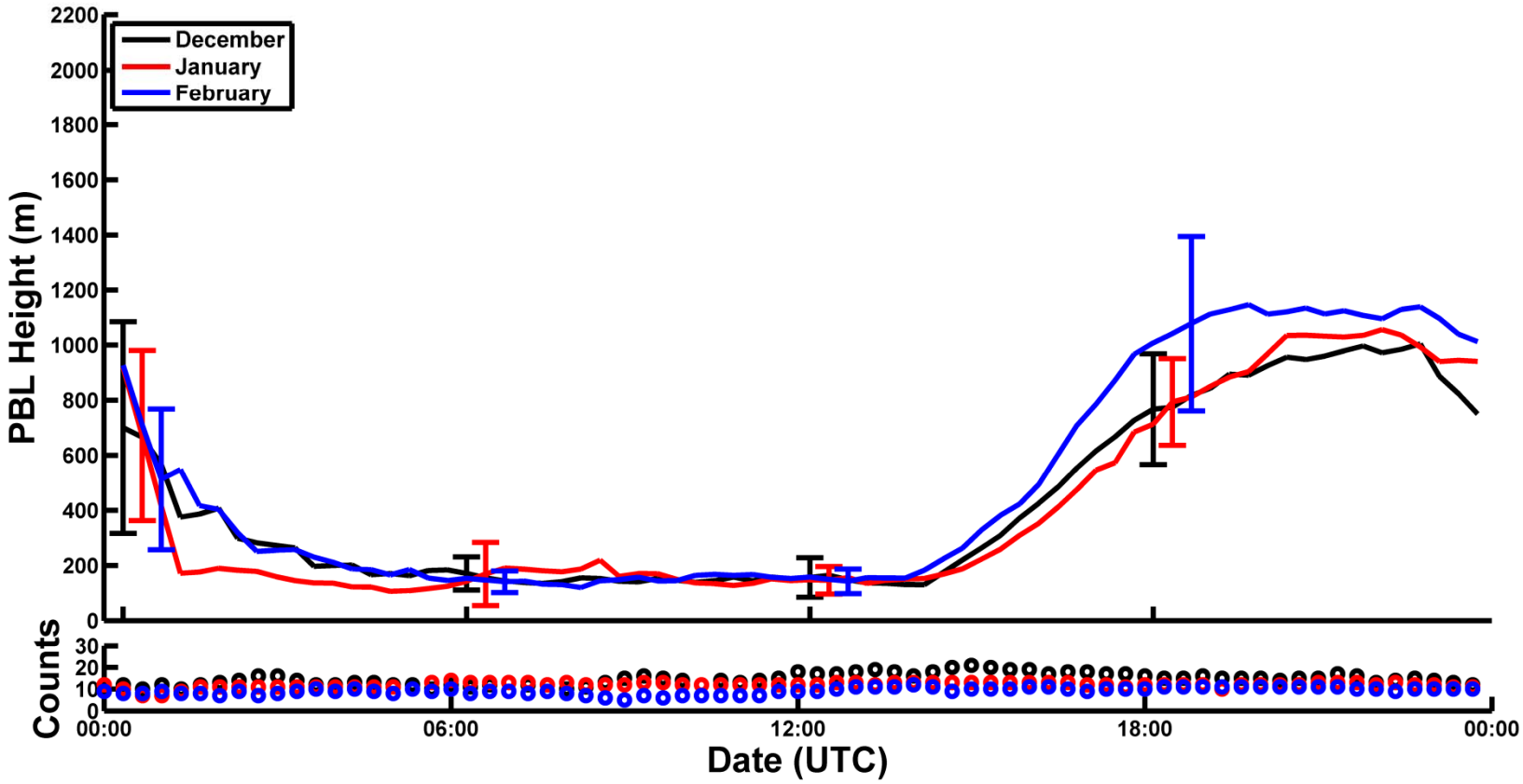
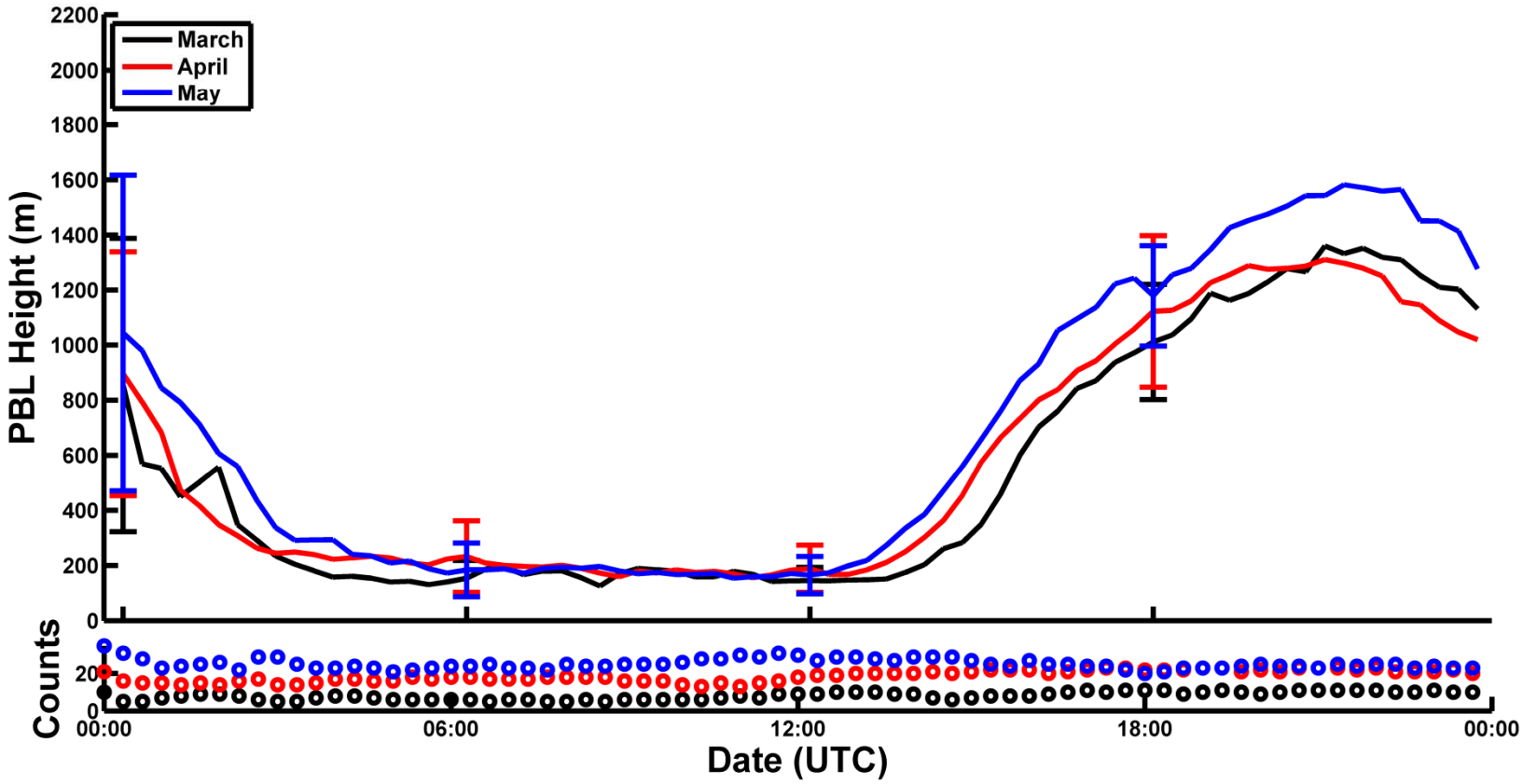
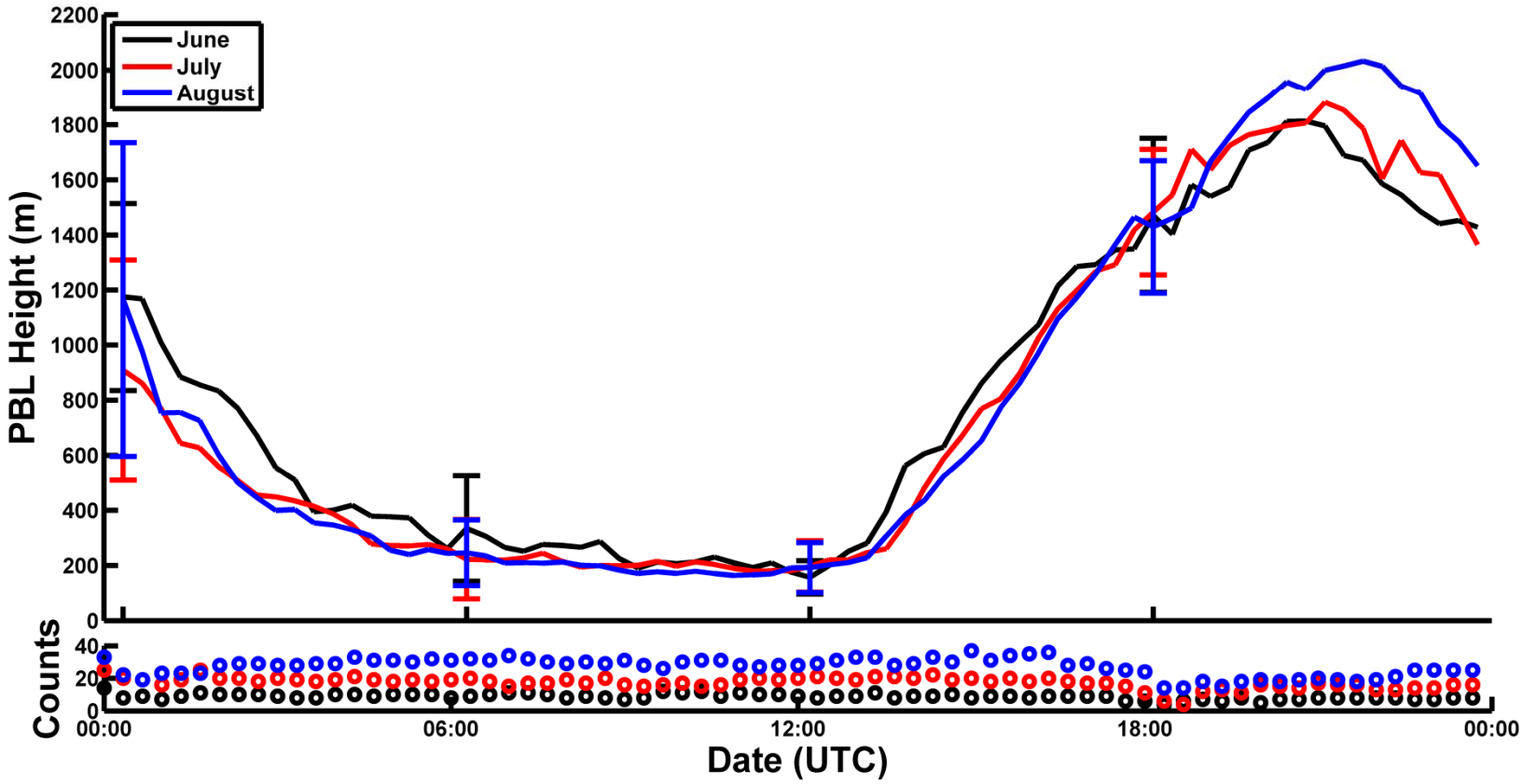
Winter (DJF) BLHs



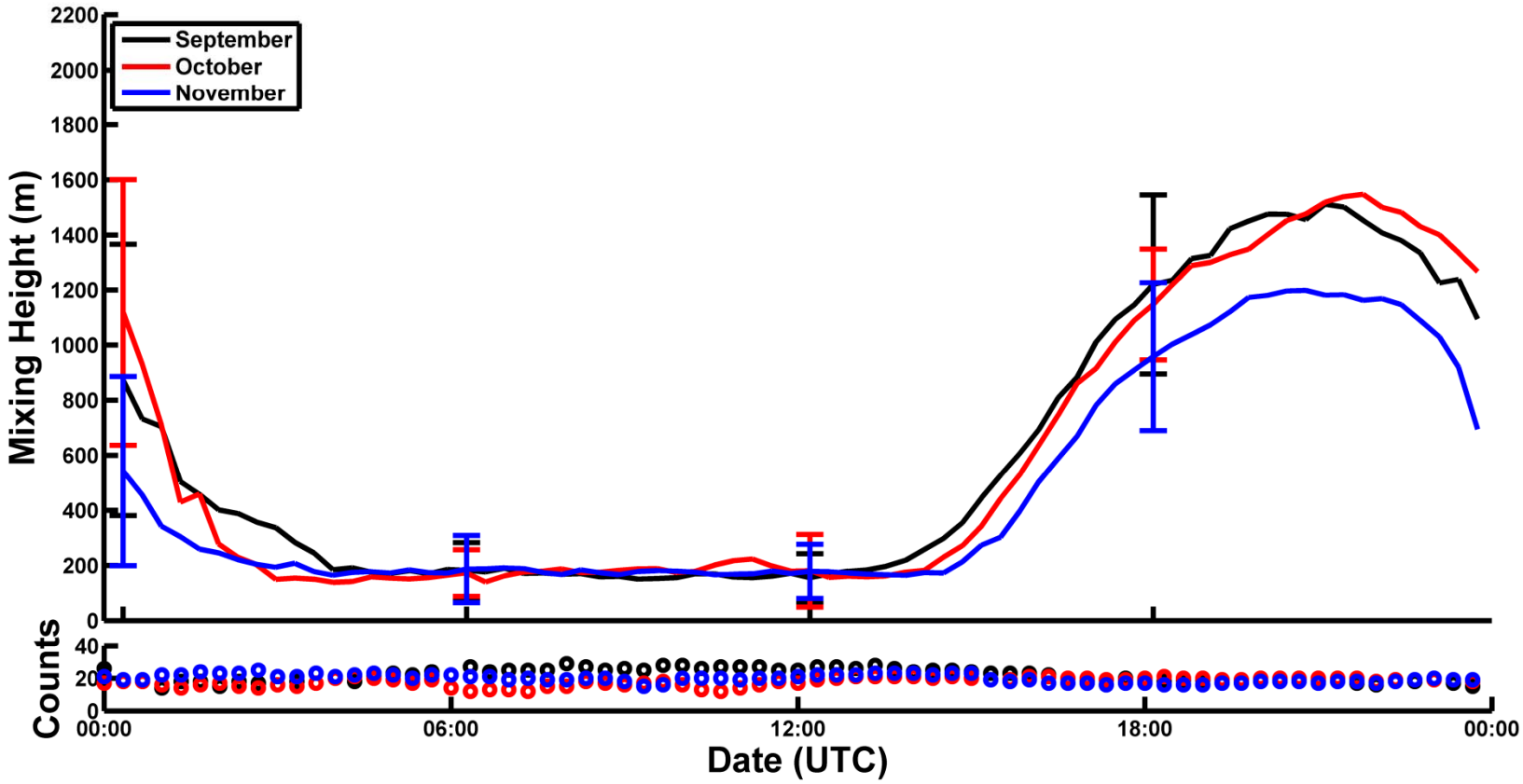
Spring (MAM) BLHs



Summer (JJA) BLHs



Fall (SON) BLHs



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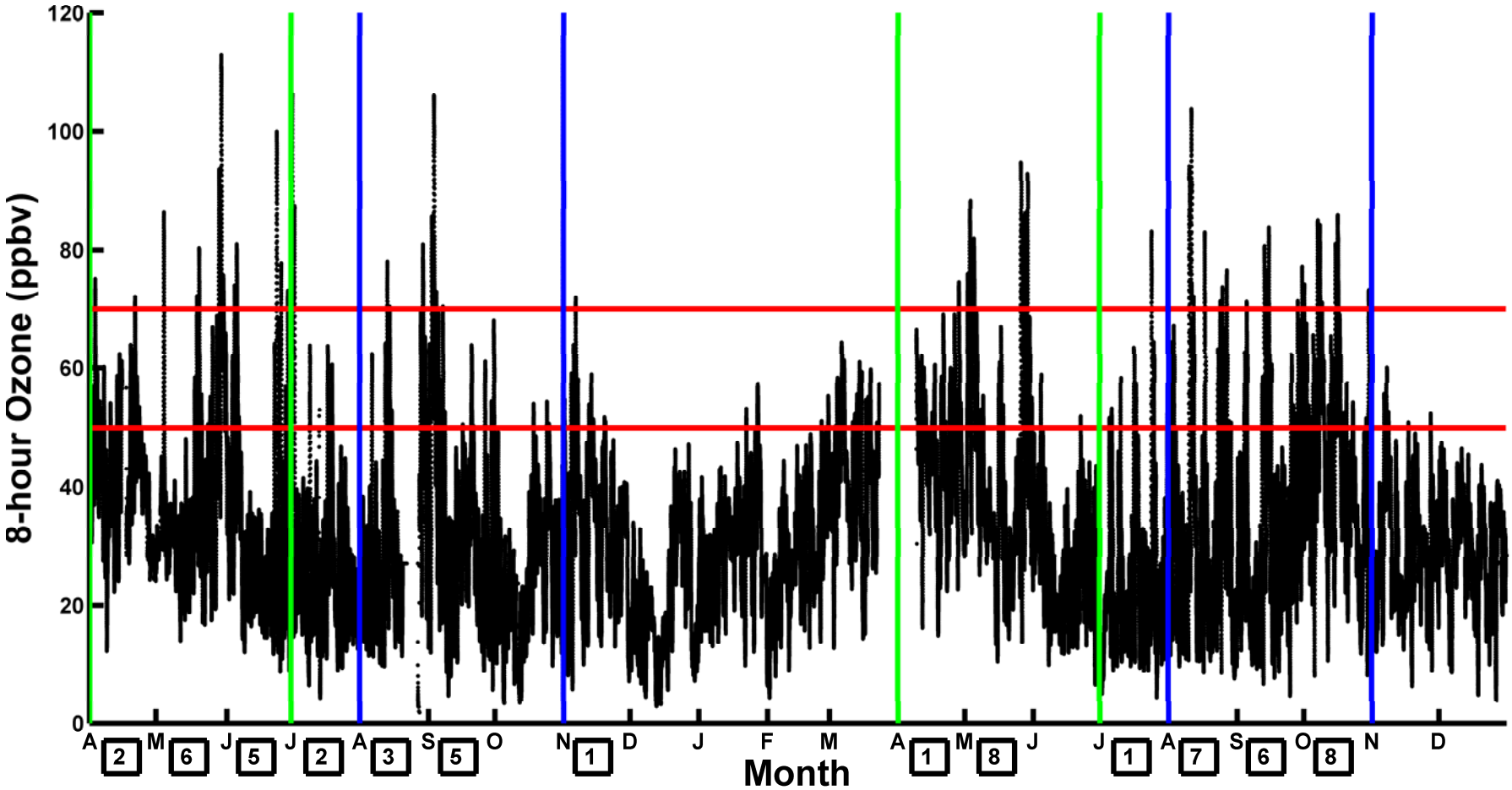
Moody Tower 8-hr Ozone April 2009 – December 2010



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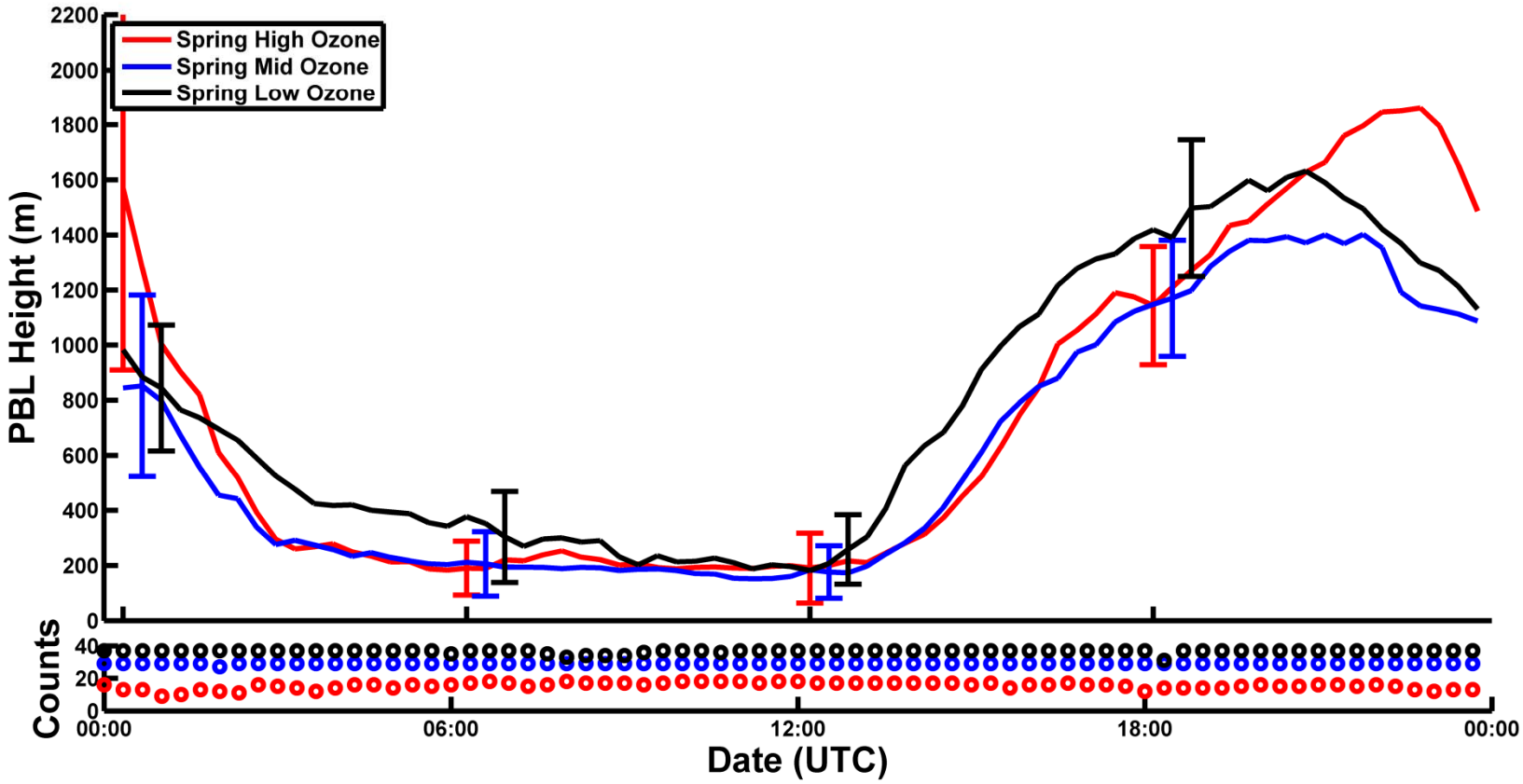
Moody Tower – Year to Year Ozone Variability

Season	Number of High Ozone Days	Mean 8-hr Ozone (ppbv)	Std Dev (ppbv)	Max 8-hr Ozone (ppbv)
Spring 2009	13	82.6	12.5	113.0
Fall 2009	8	79.3	12.2	106.0
Spring 2010	9	84.6	6.9	94.7
Fall 2010	21	79.1	8.6	103.8
7/1/2009				106.2
7/2/2009				87.4
11/6/2009				71.8
7/24/2010				83.2

Moody Tower – BLH on Low vs High Ozone Days (Spring)



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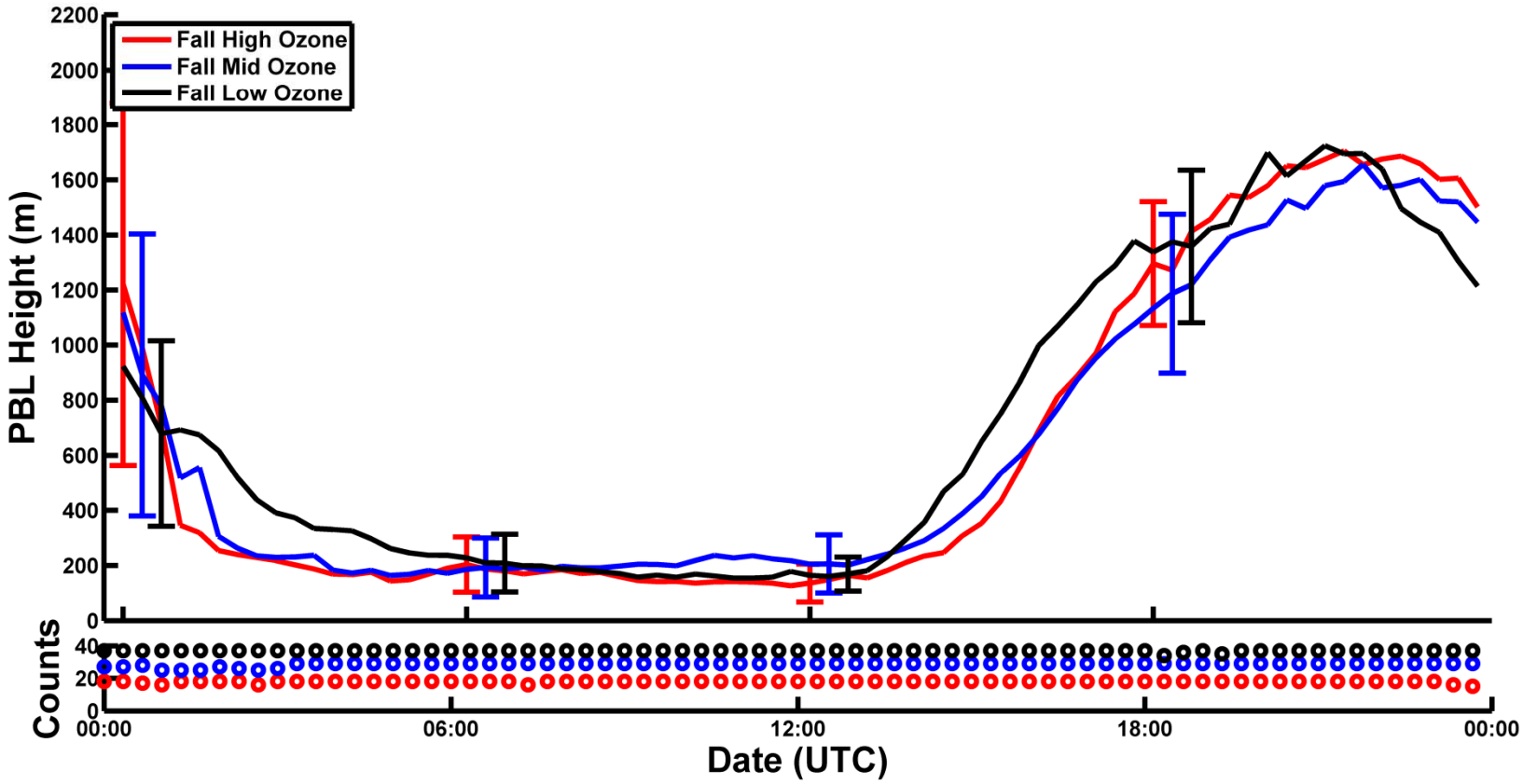
Moody Tower – BLH on Low vs High Ozone Days (Fall)



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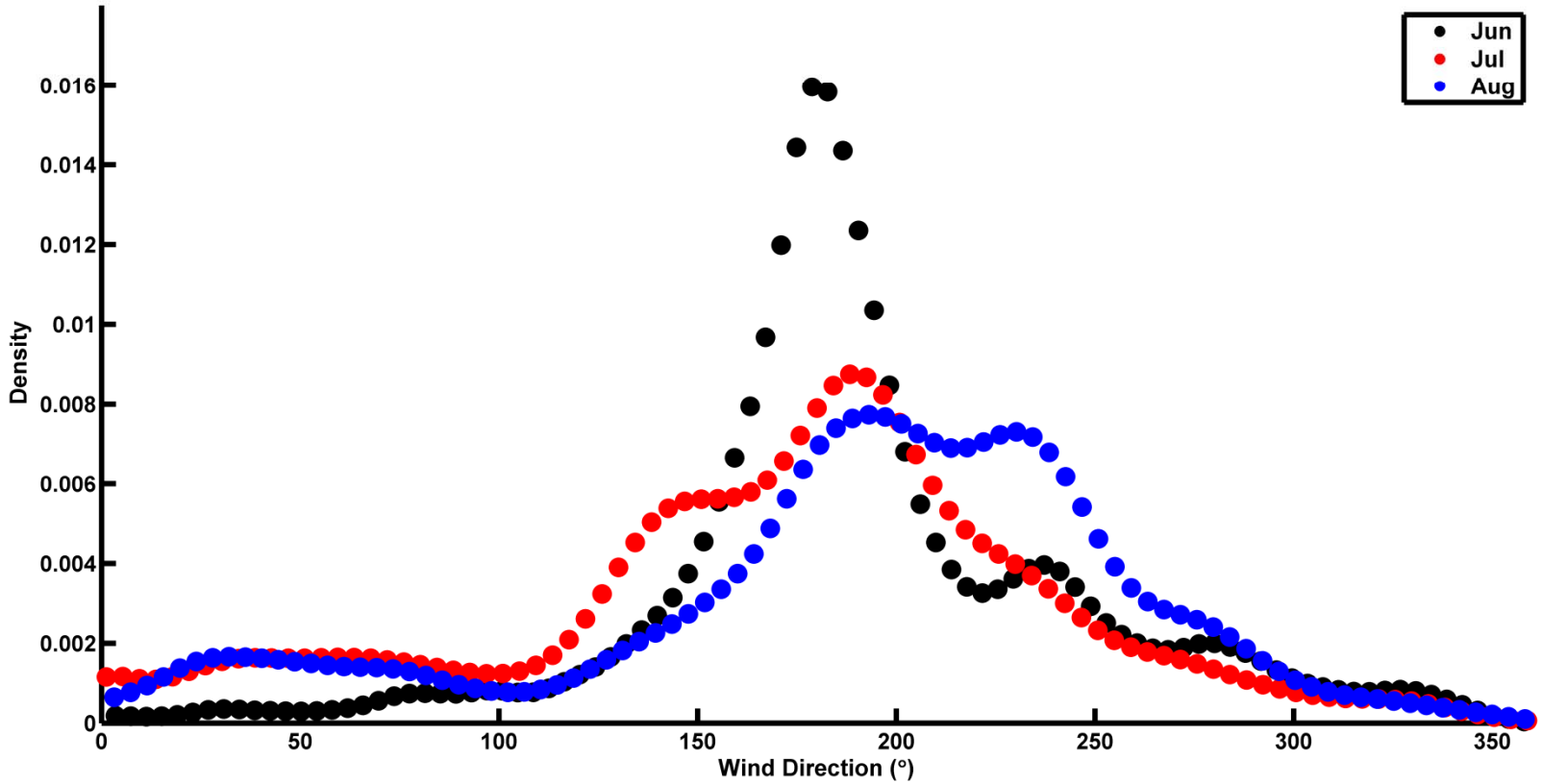
Moody Tower – Monthly Wind Direction (Summer)



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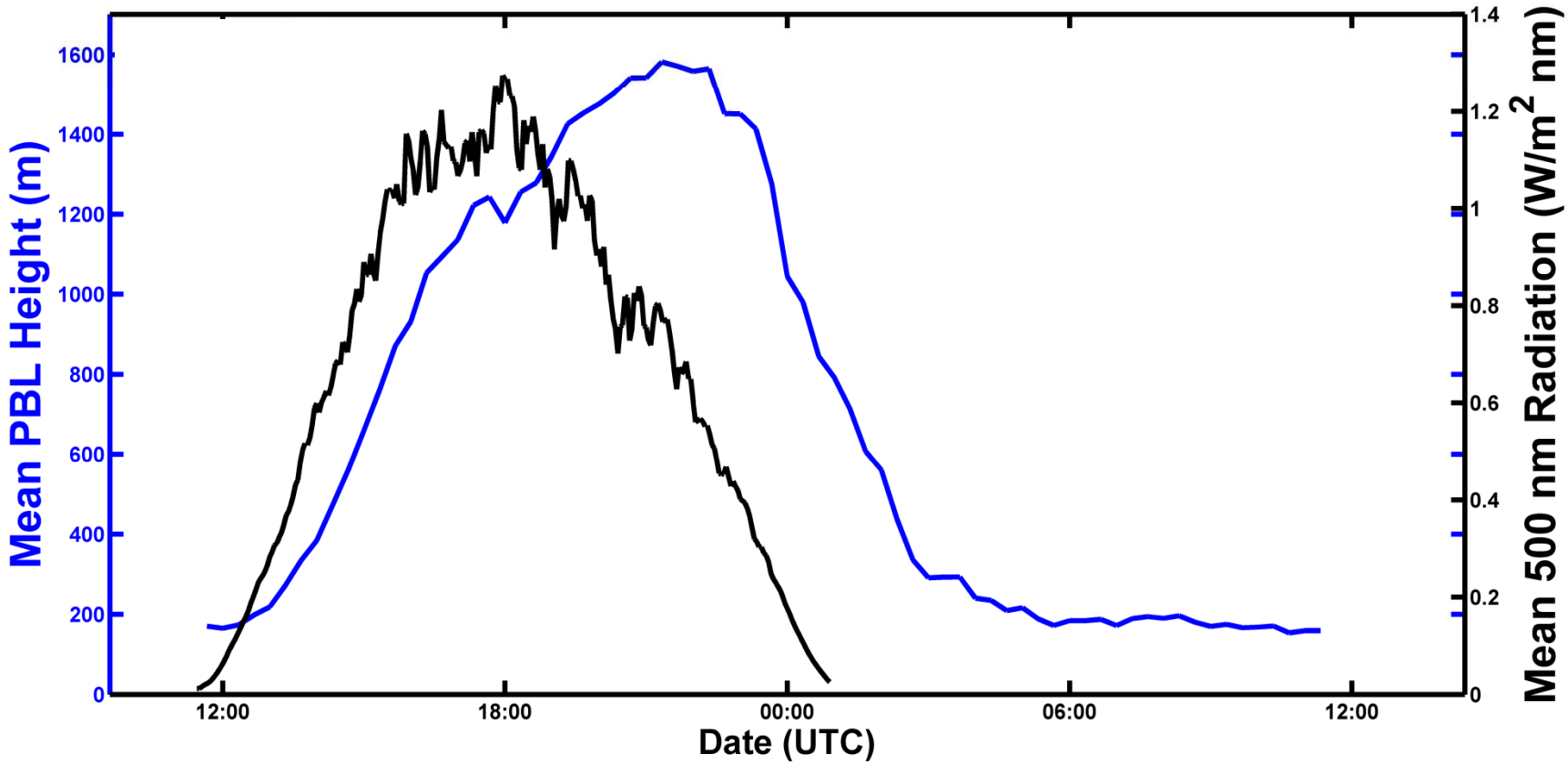
PBH Height and Solar Radiation



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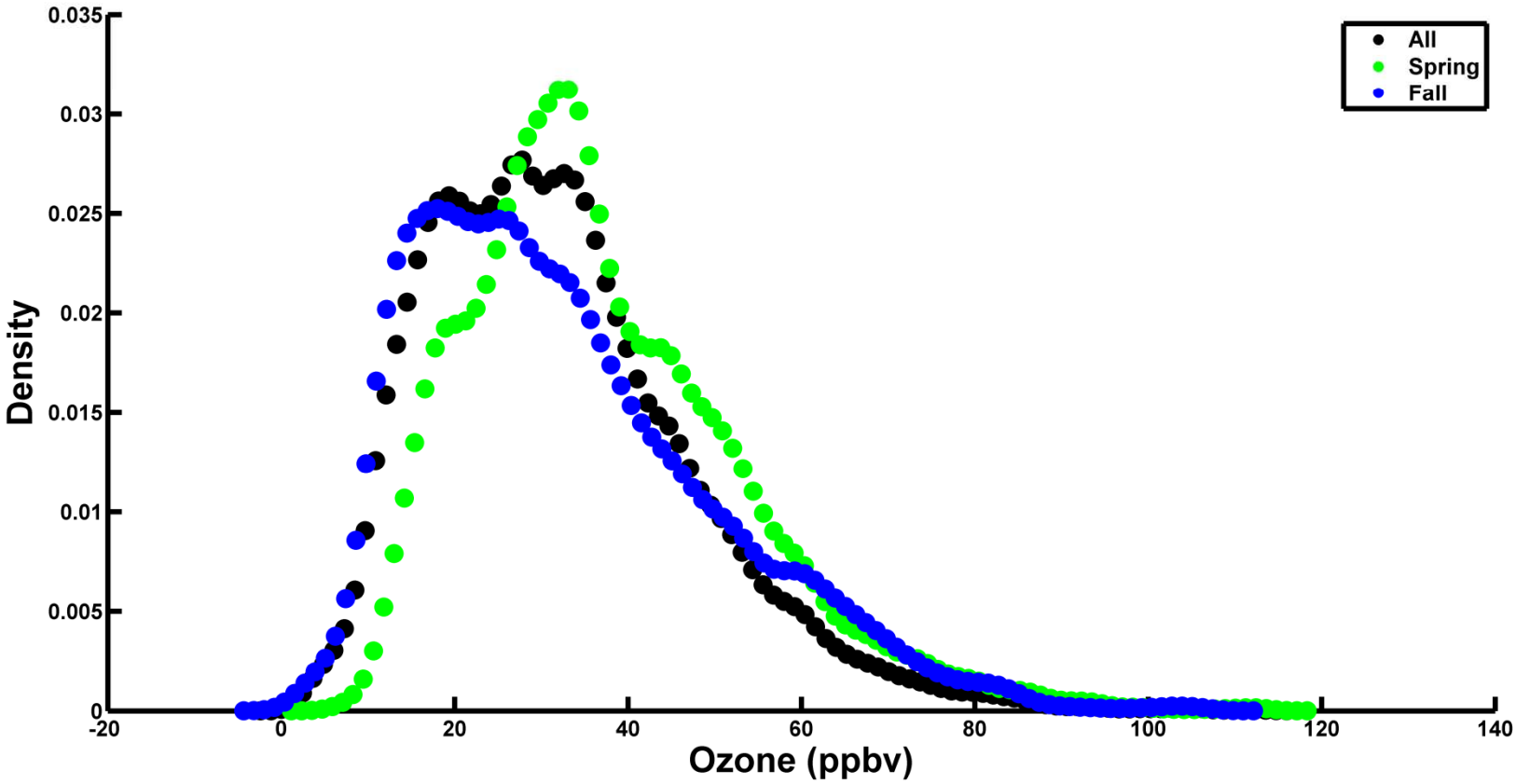
Ozone Histograms (8-hr Average)



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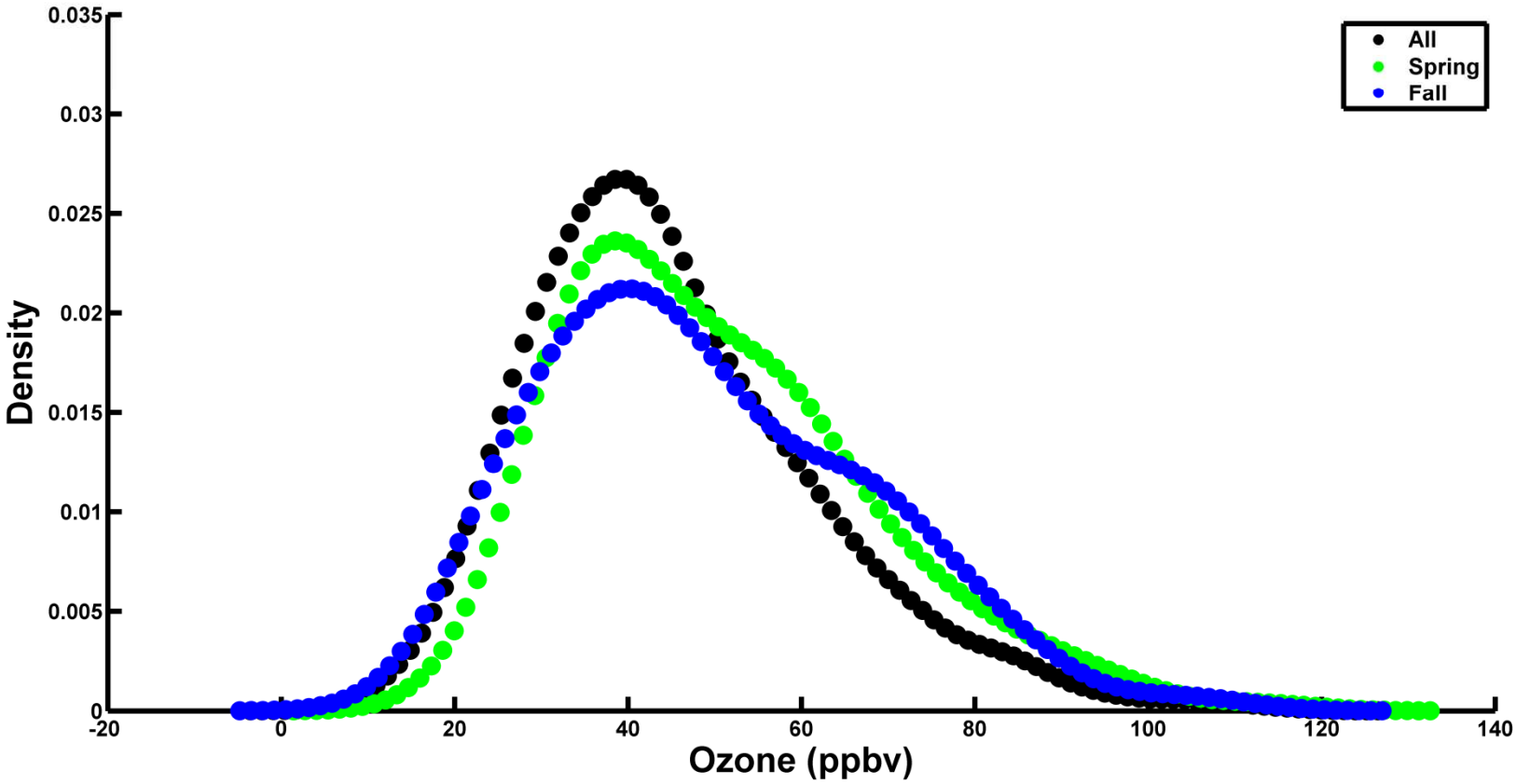
Ozone Histograms (Peak 8-hr Average)



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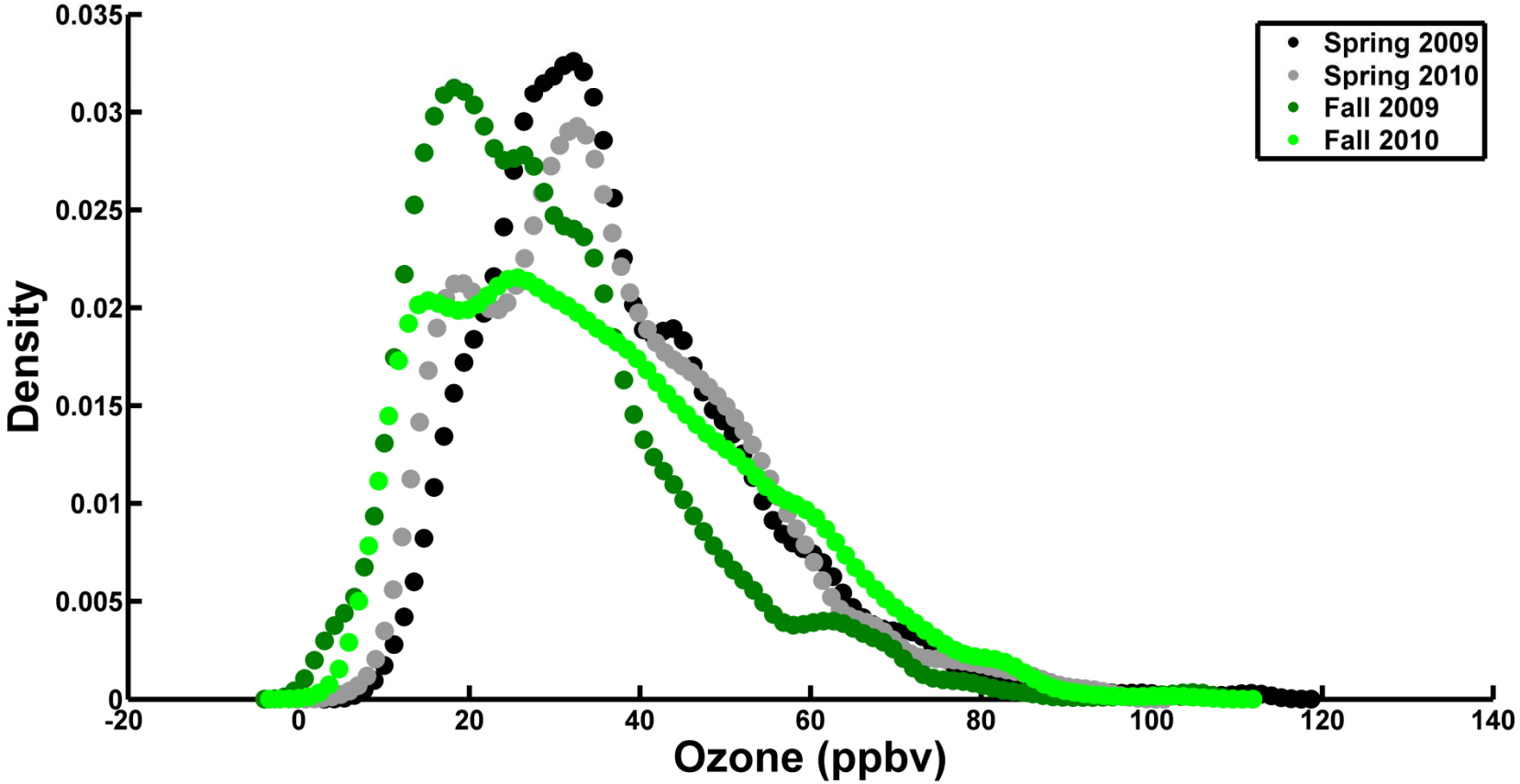
Spring and Fall Ozone Histograms (Peak 8-hr Average) 2009 vs. 2010



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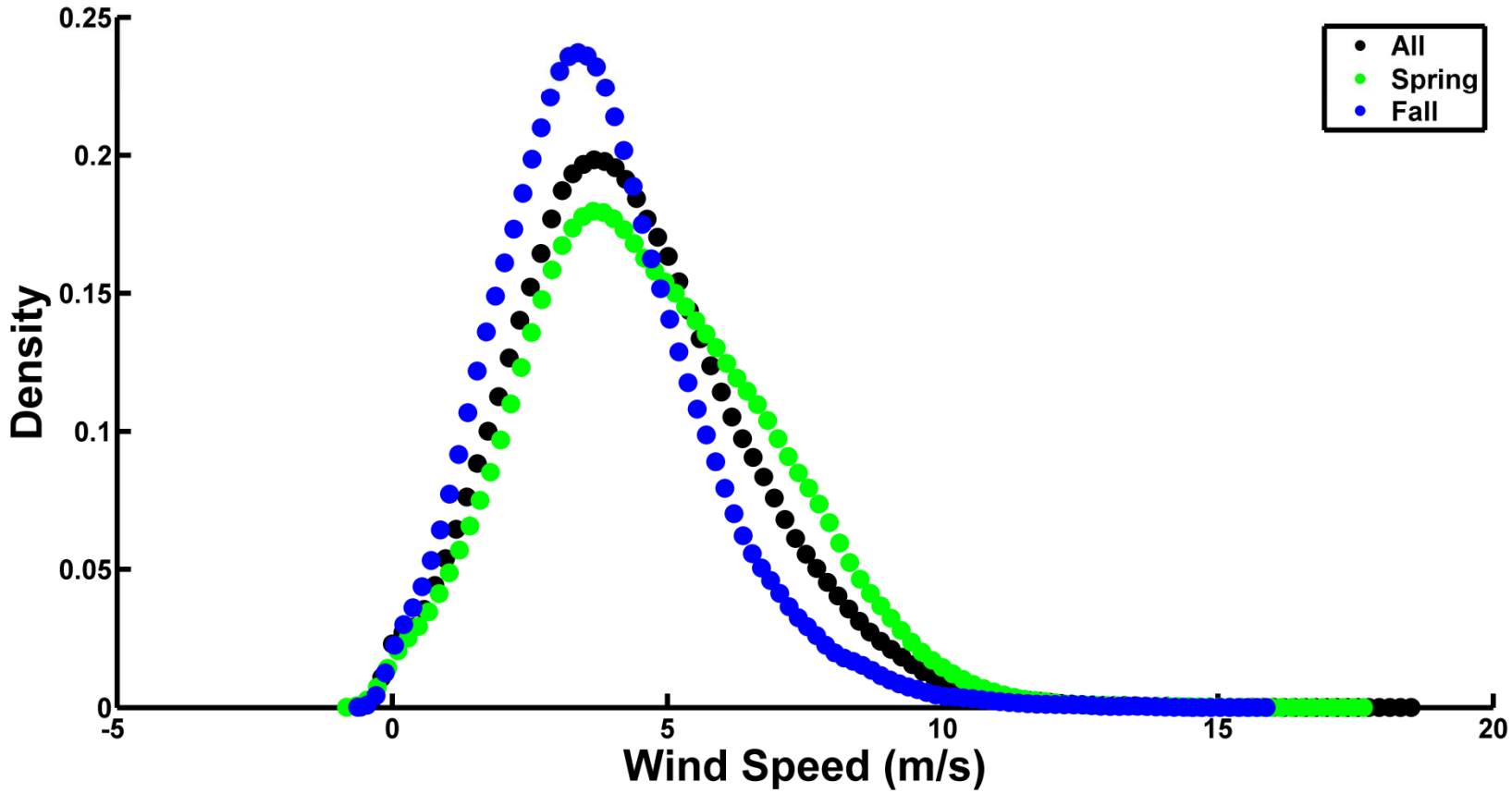
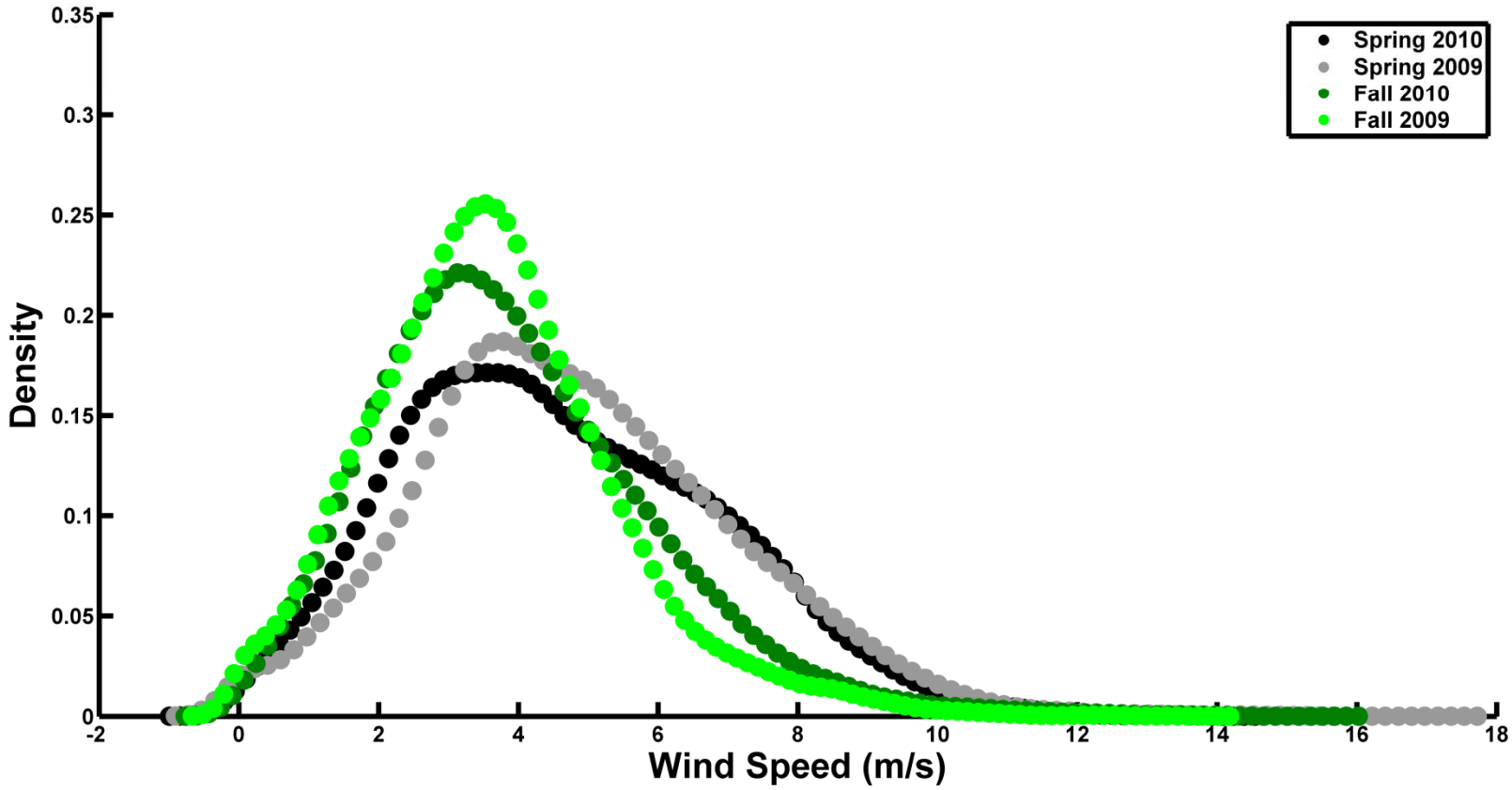
Spring and Fall Windspeed Histograms



Spring and Fall Windspeed Histograms
2009 vs. 2010



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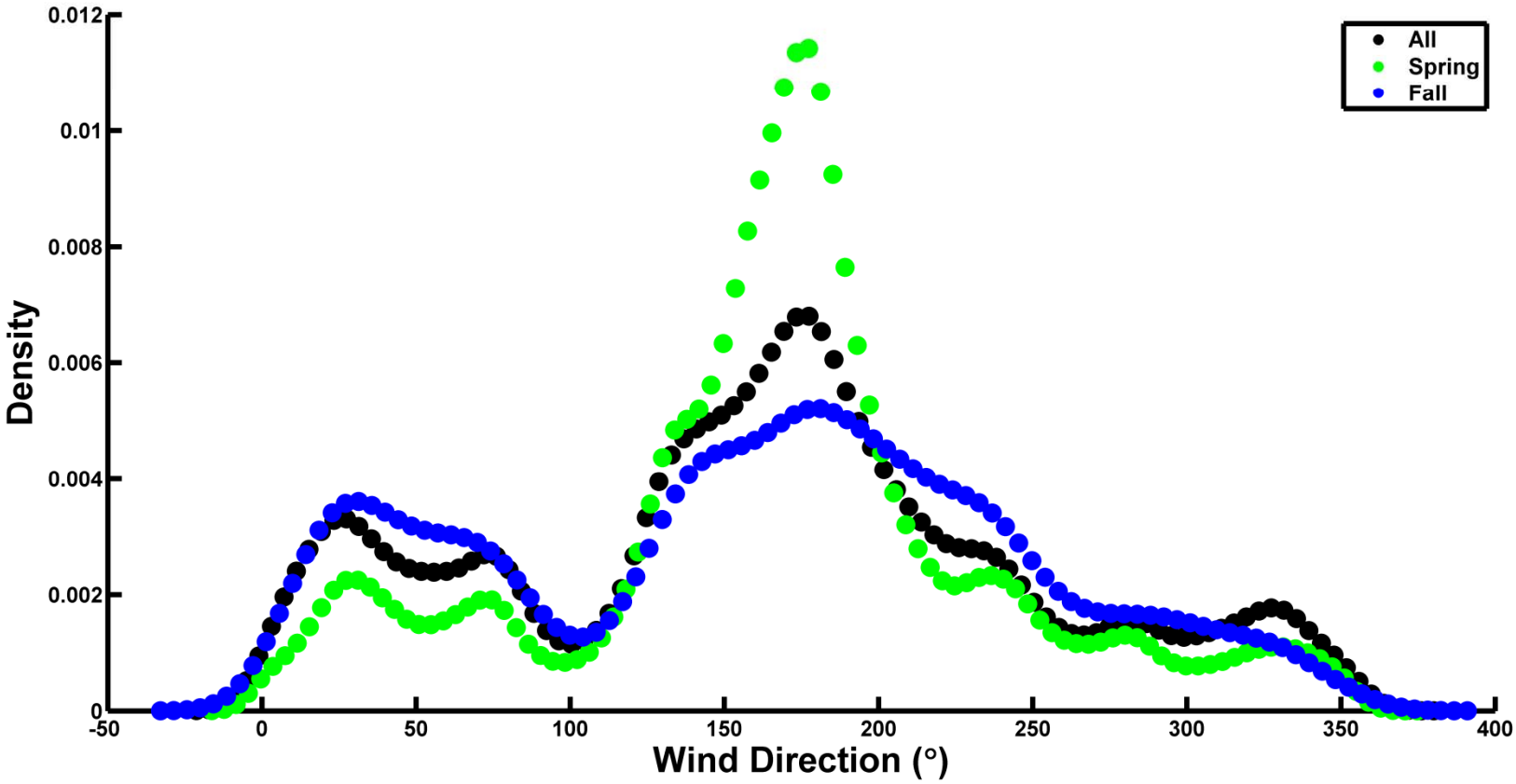
Spring and Fall Wind Direction Histograms



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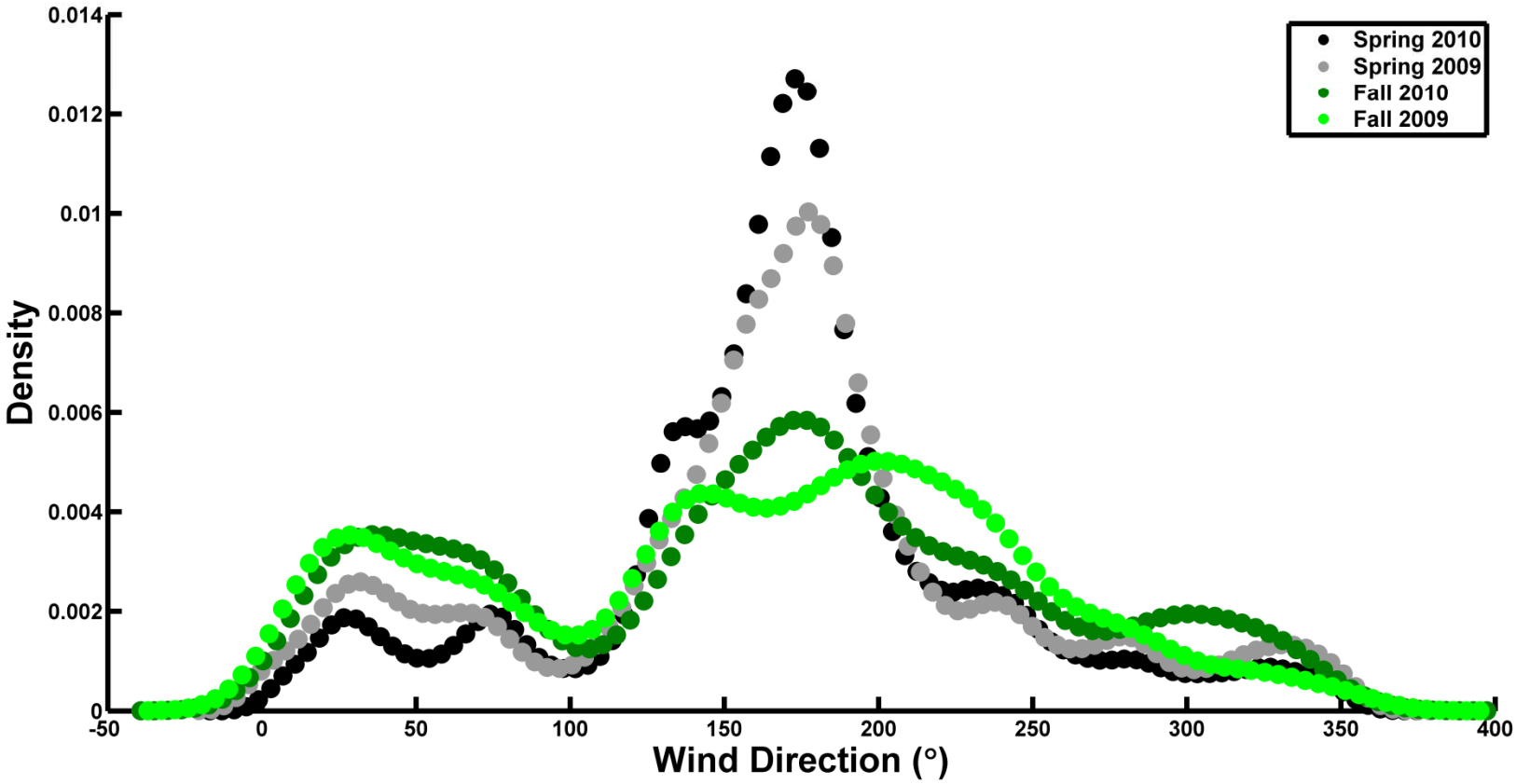
Spring and Fall Wind Direction Histograms
2009 vs. 2010



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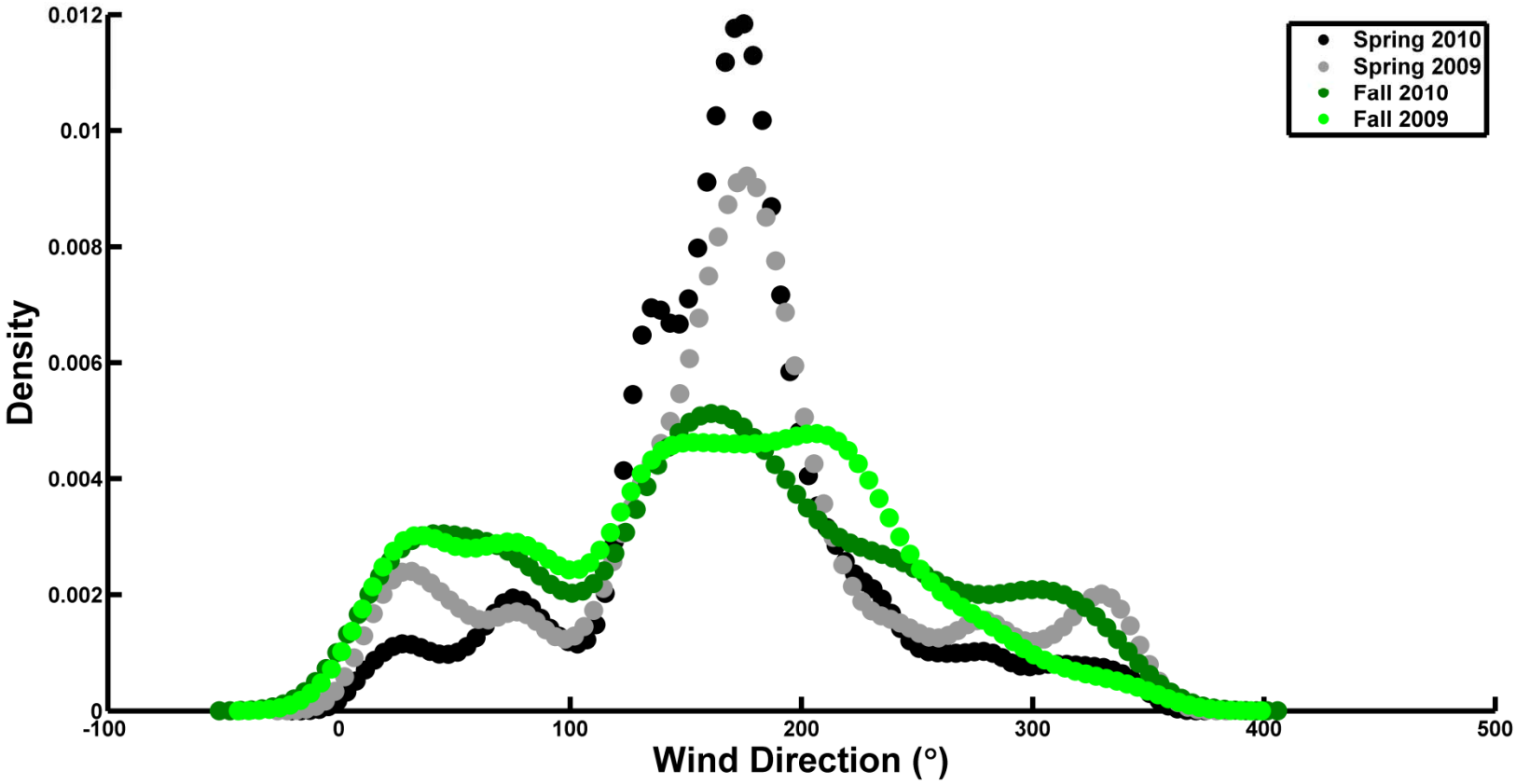
Spring and Fall Wind Direction Histograms
2009 vs. 2010
Daylight Hours (8am – 6pm)



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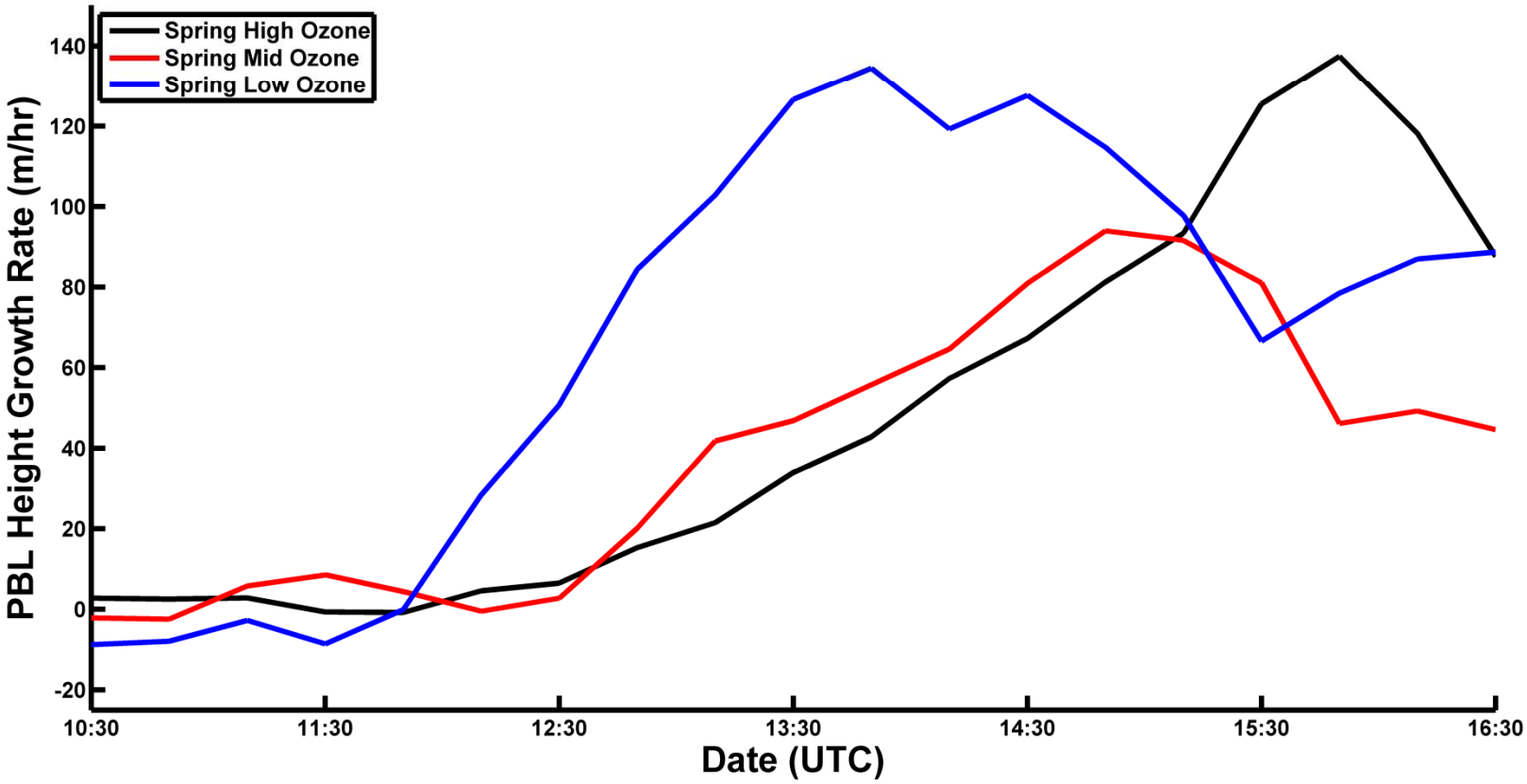
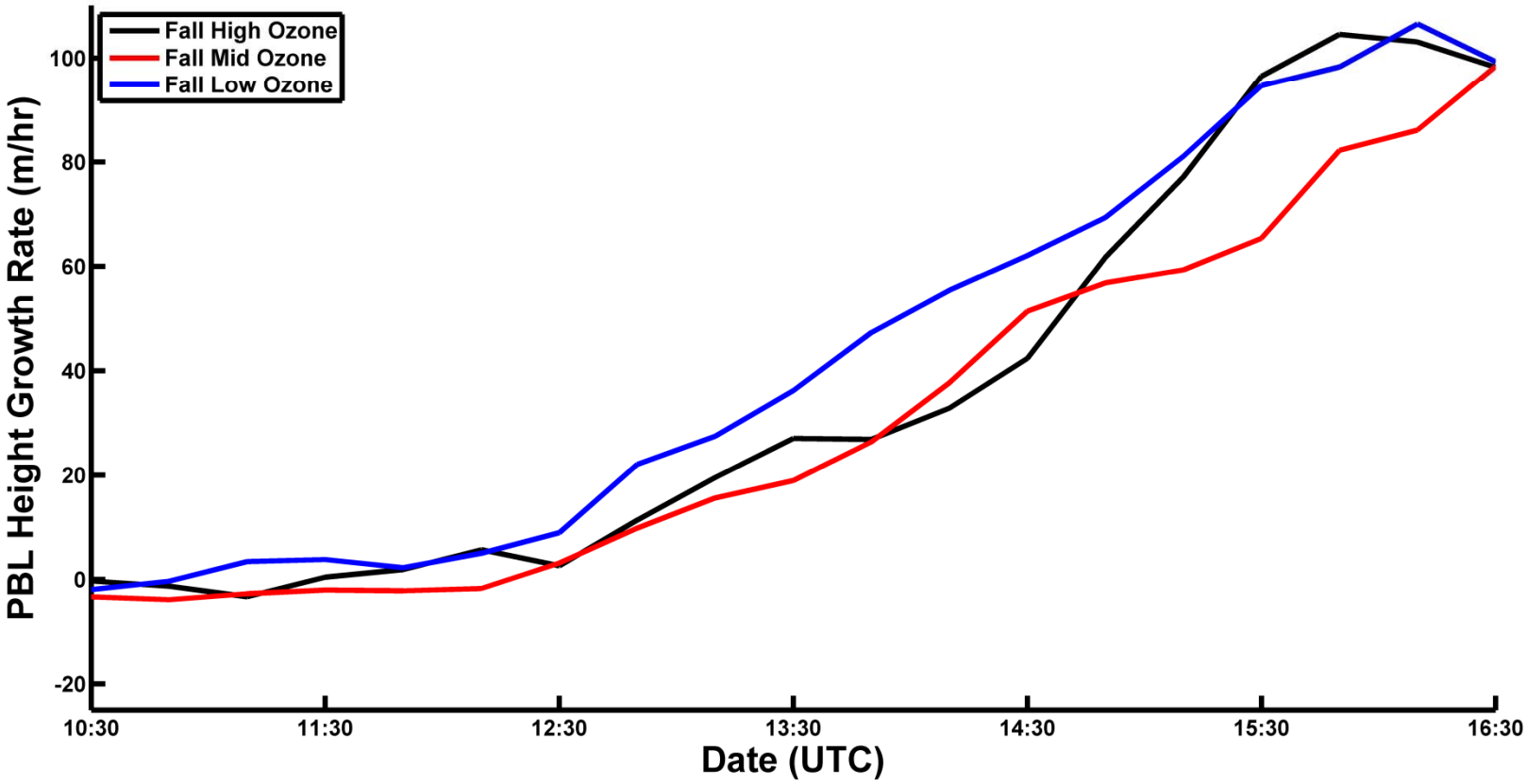
Spring BLH Growth Rates
High vs Low Ozone Days



Spring BLH Growth Rates
High vs Low Ozone Days



Future Plans / Needs

2011 Summer:

- Dallas Ground Site
- Solar Occultation Flux – Houston & Dallas
- Dallas Aircraft Measurements
- Ozonesonde launches Oklahoma and Houston

TREX 2013 (Texas Regional transport EXPeriment)

ACKNOWLEDGEMENTS:

TCEQ

EPA

HARC

University of Houston