August 26, 2011: Evidence of an Exceptional Event?

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Presented to: Southeast Texas Photochemical Modeling Technical Committee
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Outline

- August 26, 2011
  - Ozone
  - Meteorological Parameters
  - Smoke/Fire Emissions
- A Clear Causal Relationship Exists
  - Timing
  - Louisiana Monitors
  - Other HGB Monitors
  - Wildfires in US
  - Trajectory
  - GOES
Outline (cont.)

- Calipso
  - No Exceedance but for the Event
    - Background Ozone
    - Surrogate Day Analysis
A Clear Causal Relationship Exists
Unique Timing of Hourly PM2.5 and Ozone at Houston East on August 26, 2011
Houston East PM2.5 and Ozone on August 26, 2011

Houston East Hourly Ozone and PM$_{2.5}$ on August 26, 2011

- Hourly PM2.5 (Valid)
- Hourly PM2.5 (suspect/invalid)
- Hourly Ozone

Hourly PM2.5 (μg/m$^3$)

Hourly Ozone (ppb)

Hour of the Day (CST/LST)
Houston/Galveston/Brazoria Monitor Values for August 26, 2011
Western HGB Ozone Sites

<table>
<thead>
<tr>
<th>HGB Monitoring Site (Houston East, West to East in Longitude)</th>
<th>Daily Maximum One-Hour Ozone Concentration (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston East (CAMS 1)</td>
<td>Mean 128</td>
</tr>
<tr>
<td>Northwest Harris County (CAMS 26)</td>
<td>Median 94</td>
</tr>
<tr>
<td>Houston Westhollow (CAMS 410)</td>
<td>75th% 91</td>
</tr>
<tr>
<td>Bunker Hill Village (CAMS 562)</td>
<td>95th% 102</td>
</tr>
<tr>
<td>Houston Bayland Park (CAMS 53)</td>
<td>Mean 110</td>
</tr>
<tr>
<td>Houston Lang (CAMS 408)</td>
<td>75th% 98</td>
</tr>
<tr>
<td>Houston Croquet (CAMS 409)</td>
<td>95th% 117</td>
</tr>
<tr>
<td>Lake Jackson (CAMS 1016)</td>
<td>Mean 80</td>
</tr>
<tr>
<td>Conroe Relocated (CAMS 78)</td>
<td>75th% 90</td>
</tr>
<tr>
<td>Manvel Croix Park (CAMS 84)</td>
<td>95th% 117</td>
</tr>
<tr>
<td>Houston Texas Avenue (CAMS 411)</td>
<td>Mean 106</td>
</tr>
</tbody>
</table>

Mean & August 26, 2011
Eastern HGB Ozone Sites

Daily Maximum One-Hour Ozone Concentration (ppb)

- Houston East (CAMS 1)
- Houston Aldine (CAMS 8)
- Houston Regional Office (CAMS 81)
- Houston Park Place (CAMS 416)
- Houston North Wayside (CAMS 405)
- Houston Clinton (CAMS 403)
- Deer Park (CAMS 35)
- Channelview (CAMS 15)
- Lynchburg Ferry (CAMS 1015)
- Seabrook Friendship Park (CAMS 45)
- Galveston 99th Street (CAMS 1034)
Regional Monitor Values
PM$_{2.5}$ Values in Louisiana

PM$_{2.5}$ Daily Maximums at monitors in Louisiana show a trend towards increasing monitor values over August 24$^{th}$ and August 25$^{th}$ going into August 26$^{th}$. 
Maximum daily ozone values at Louisiana monitors in the Baton Rouge and Lake Charles areas show clear evidence of a westward trend of increasing ozone values on August 24-26.
Fires
Fire Locations

August 20

August 21

August 22

August 23

August 24

August 25

August 26
Trajectory Evidence
## Trajectory Source Areas

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Description</th>
<th>Duration (hrs)</th>
<th>Southwest Corner of Matrix</th>
<th>Northeast Corner of Matrix</th>
<th>Total Trajectories in Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lat (deg)</td>
<td>Lon (deg)</td>
<td>Lat (deg)</td>
</tr>
<tr>
<td>1</td>
<td>OK/KS/TX</td>
<td>84</td>
<td>33°</td>
<td>-103°</td>
<td>40°</td>
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<tr>
<td>2</td>
<td>AR/LA/MS</td>
<td>84</td>
<td>28°</td>
<td>-95°</td>
<td>37°</td>
</tr>
<tr>
<td>2b</td>
<td>AR/LA/MS</td>
<td>48</td>
<td>28°</td>
<td>-95°</td>
<td>37°</td>
</tr>
<tr>
<td>3</td>
<td>MN/ND/S</td>
<td>84</td>
<td>43°</td>
<td>-105°</td>
<td>50°</td>
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<tr>
<td>4</td>
<td>ID/MT/WY</td>
<td>84</td>
<td>41°</td>
<td>-118°</td>
<td>49°</td>
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<tr>
<td>5</td>
<td>OR/WA</td>
<td>84</td>
<td>41°</td>
<td>-125°</td>
<td>49°</td>
</tr>
</tbody>
</table>
Incoming Trajectory Height
Matrix 6 for Incoming Trajectories
Trajectory Termination in Houston East Area

250 meters

500 meters

750 meters

1000 meters

Over the 48 hours prior to the 1-hour ozone exceedance, mixing layer heights over Houston East C1 varied substantially, contracting from 2-3 km during the day to about 50 meters at night.

Source: NOAA HYSPLIT model, matrix option.

Method: This chart shows minimum, maximum and mean mixing layer heights, for each hour of the day, beginning at the time of the exceedance (2:00 p.m. August 26, 2011, right-hand axis) and extending back 48 hours (3:00 p.m. August 24, 2011). The matrix was defined as an 11 x 9 grid of cells 0.01° latitude by 0.01° longitude, centered over Houston East C1.
GOES Satellite Imagery
NOAA Satellite Interpretation on August 26, 2011

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1515Z August 26, 2011


“Southcentral US:

A ridge of high pressure over NE TX continues to hold smoke from emissions earlier this week from the fires in ID/MT and WY. This smoke is thin with small linear shaped pockets/strands of moderate smoke covering all of KS, OK, TX, LA and NM with portions of smoke affecting SW AR, and SW MS and the coastal Gulf of Mexico from Brownsville, TX over to Mobile, AL. Smoke over SE KS/E OK/SW AR and LA is moving SEward into the Gulf, while influence from the upper level ridge is moving smoke in TX, W OK, W KS due south into Old Mexico and southwestward across NM starting to move into SE AZ.”
Descriptive Text Narrative for Smoke/Dust Observed in Satellite Imagery Through 0330Z August 26, 2011


“Oregon/Montana/Wyoming/Idaho:
Several wildfires in Oregon, Montana, Wyoming, and Idaho are producing locally dense smoke that is observed moving east as thin density plumes this evening.”

“Central Plains/Mississippi River Valley:
An expansive area of smoke ranging from thin to very dense covers much of the central US. Thin density smoke stretches across the northern, central, and southern plains as well as the entire Mississippi Valley as far south and east as Alabama and Kentucky, respectively. Moderate density smoke mainly covers the upper and middle Mississippi Valley while dense smoke is observed only in the eastern Dakotas, Minnesota, and Iowa. This detached smoke has originated from numerous fires in Idaho, Wyoming, and Montana that have been burning over the past several days.”
GOES Image on August 26, 2011

Haze/smoke over Houston
GOES Image on Afternoon of August 26, 2011

Smokey haze covering the upper Texas Gulf Coast
CALIPSO SATELLITE IMAGERY
CALIPSO BACKGROUND

- NASA orbiting instrument/satellite using LIDAR, Imaging Infrared Radiometer, and Wide Field Camera.
- Launched in 2006 with Sun-synchronous orbit.
- LIDAR produces high-resolution vertical profiles of aerosols and clouds.
CALIPSO is on a North-to-South trajectory on August 26, 2011, between 1:41:26 PM and 1:54:54 PM (CST).

Houston Area View of CALIPSO Orbital Track
CALIPSO Horizontal Averaging Plot

Smoke Plume approximately 80 km wide
No Exceedance but for the Exceptional Event
Background Ozone
Background is defined as the second lowest ozone measurement in the HGB area at the time of the area’s maximum daily peak ozone in the HGB area.
Surrogate Day Analysis
Five Surface Back Trajectories Identified Similar to August 26, 2011
## Meteorological Comparison of Candidate days to August 26

<table>
<thead>
<tr>
<th>Date</th>
<th>Avg Speed Mil/hr</th>
<th>Temp F°</th>
<th>O3 ppb</th>
<th>Solar Rad* Langley/min</th>
<th>Flow Reversal</th>
<th>Precip.* in.</th>
<th>RH* %</th>
<th>Surface Pattern</th>
<th>Cloud Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/26/2011</td>
<td>3.6</td>
<td>78</td>
<td>98</td>
<td>128</td>
<td>Yes</td>
<td>0.0</td>
<td>53</td>
<td>High pressure over Texas</td>
<td>Clear Skies</td>
</tr>
<tr>
<td>8/27/2009</td>
<td>2.13</td>
<td>77.5</td>
<td>90.8</td>
<td>111.6</td>
<td>Yes</td>
<td>0.00</td>
<td>73.8</td>
<td>High pressure with front over north Texas</td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>8/29/2009</td>
<td>3.92</td>
<td>75.1</td>
<td>89.6</td>
<td>69.4</td>
<td>Yes</td>
<td>0.03</td>
<td>89</td>
<td>Post frontal passage</td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>11/3/2009</td>
<td>3.04</td>
<td>55.2</td>
<td>74.7</td>
<td>41.4</td>
<td>Yes</td>
<td>0.00</td>
<td>88.6</td>
<td>High pressure with front over north Texas</td>
<td>Clear</td>
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<tr>
<td>8/17/2010</td>
<td>2.87</td>
<td>80.2</td>
<td>96.3</td>
<td>73.5</td>
<td>Yes</td>
<td>0.00</td>
<td>87.0</td>
<td>High pressure with front over north Texas</td>
<td>Mostly Cloudy</td>
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<tr>
<td>8/15/2011</td>
<td>3.39</td>
<td>79.2</td>
<td>97.3</td>
<td>48.4</td>
<td>Yes</td>
<td>0.00</td>
<td>82.2</td>
<td>High pressure with stationary front over Louisiana</td>
<td>Partly Cloudy</td>
</tr>
</tbody>
</table>

* Used data from Clinton Dr.; Downloaded on August 5, 2013

- Avg wind speed (6:00-14:00) LST
- Avg solar radiation (6:00-14:00) LST

<table>
<thead>
<tr>
<th>date</th>
<th>area</th>
<th>event_type</th>
<th>count</th>
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<tbody>
<tr>
<td>8/26/2011</td>
<td>HGB</td>
<td>AIRSHUTDWN</td>
<td>2</td>
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<tr>
<td>8/26/2011</td>
<td>HGB</td>
<td>AIRSTARTUP</td>
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<tr>
<td>8/26/2011</td>
<td>HGB</td>
<td>AIR_MAINTENANCE</td>
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<td>HGB</td>
<td>AIR_UPSET</td>
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<td>TOTAL EVENTS</td>
<td>48</td>
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<td></td>
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<td>TOTAL EVENTS</td>
<td>53</td>
</tr>
</tbody>
</table>

The surrogate day actually had more active upsets than the exceptional event day. Undertaking a more detailed comparison of emissions incidents would be prohibitive.
Special Recognition

• AMDA Data Analysis Team:
  – Dave Westenbarger
  – Jonathan Steets
  – John Jolly
  – Fernando Mercado

• Monitoring Division
  – Bryan Lambeth
  – Lindsey Jones