EPA Ozone Attainment Demonstration and Houston, TX

William Vizuete, Harvey Jeffries, Evan Couzo

www.unc.edu/~vizuete
airquality@unc.edu

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Outline

• 2004 HGB SIP: 1-hr ozone
• EPA Attainment Method: 8-hr ozone
• Analysis of measured ozone data
• Analysis of model predictions
• Conclusions
2004 1-hr Ozone SIP

- TCEQ recognized importance of HRVOC emission events
- TCEQ proposed and EPA accepted innovative mitigation plans
- Dual-Ozone management: routine (typical) and episodic releases
- Compliance with HRVOC controls
  - Polymer production facilities reported to have spent up to $2.4 million\(^1\)
  - IR cameras: 2005 identified and reduced more than 7,000 tons per year of VOC emission\(^2\)
  - TCEQ has reported significant reductions in annual averaged measured concentrations of HRVOC

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\(^2\)TCEQ, *Forecast for Houston: Air Quality Improving. Natural Outlook* 2008;
Design Value Trends

Comparison of 2005 DVb, 2006 DVb, 2007 DVb, & 2009 Dvr

- 2005 TCEQ
- 2006 TCEQ
- 2007 DVb
- 2009 Dvr
EPA $O_3$ Attainment Method

**Mean Relative Reduction Factor at monitor**

$$DV_{F,m} = DV_{B,m} \times RRF_m$$

“weighted” DV based on observed 2004-2008 $O_3$ data at monitor

“average” estimated future DV
If it is below standard, monitor is in compliance of NAAQS

2018 “typical” emissions modeled with 2005 & 2006 daily meteorology

$$RRF_m = \frac{\text{Mean predicted future peak 8-hr daily max “near” monitor}}{\text{Mean predicted baseline peak 8-hr daily max “near” monitor}}$$

2006 “typical” emissions modeled with 2005 & 2006 daily meteorology
EPA $O_3$ Attainment Method

• Assumes daily variability in meteorology, not emissions, is main driver for high ozone
• Assumes fourth-highest ozone mixing ratios over a 3-5 year period are caused by the same emissions; ignores possibility of highly variable stochastic emissions
• Assumes that the meteorological conditions in the future and baseline year are identical
Study design

• Is EPA’s 8-hr ozone attainment test sufficient for Houston TX?
• Observational Metric: Design Value Baseline (DVB)
• Modeling Metric: Relative Reduction Factor (RRF)
Observational Data
### Observational Data

<table>
<thead>
<tr>
<th>Monitor Name</th>
<th>Abbreviation</th>
<th>CAMS No.</th>
<th>AIRS No.</th>
<th>DV&lt;sub&gt;B&lt;/sub&gt;</th>
<th>RRF</th>
<th>DV&lt;sub&gt;F&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wallisville</td>
<td>WALV</td>
<td>617</td>
<td>48-201-0617</td>
<td>92.0</td>
<td>0.959</td>
<td>88.2</td>
</tr>
<tr>
<td>Deer Park</td>
<td>DRPK</td>
<td>35</td>
<td>48-201-1039</td>
<td>92.0</td>
<td>0.958</td>
<td>88.1</td>
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<tr>
<td>Bayland Park</td>
<td>BAYP</td>
<td>53</td>
<td>48-201-0055</td>
<td>96.7</td>
<td>0.900</td>
<td>87.0</td>
</tr>
<tr>
<td>Monroe</td>
<td>HSMA</td>
<td>406</td>
<td>48-201-0062</td>
<td>90.3</td>
<td>0.934</td>
<td>84.3</td>
</tr>
</tbody>
</table>

![Map of monitoring stations]
# Air Quality Model Data

**TCEQ Regulatory Modeling**
- Base Case: reg10 and reg10si
- Future: cs04
- Met: `eta_dbemis_fddats_newuhsst_newutcrslulc_grell.v45`

<table>
<thead>
<tr>
<th>Developer</th>
<th>Model Software</th>
<th>Simulation Period</th>
</tr>
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<tbody>
<tr>
<td>TCEQ</td>
<td>CAMx v4.51</td>
<td>2005-05-19 to 2005-06-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005-06-17 to 2005-06-30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005-07-26 to 2005-08-08</td>
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<tr>
<td></td>
<td></td>
<td>2006-05-31 to 2006-06-15</td>
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<tr>
<td></td>
<td></td>
<td>2006-08-13 to 2006-09-20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2006-09-16 to 2006-10-11</td>
</tr>
</tbody>
</table>

**TCEQ**=Texas Commission on Environmental Quality  
**CB05**=Carbon Bond Mechanism version 5
Observational Metric Analysis

The model's mean Relative Reduction Factor is calculated at each monitor, \( m \), as:

\[
RRF_m = \frac{\text{Mean predicted future peak 8-hr daily max "near" monitor}}{\text{Mean predicted baseline peak 8-hr daily max "near" monitor}}
\]

"weighted" DV based on observed 2004-2008 \( \text{O}_3 \) data at monitor 2018 “typical” emissions modeled with 2005 & 2006 daily meteorology

If it is below standard, monitor is in compliance of NAAQS

\[
DV_{F,m} = DV_{B,m} \times RRF_m
\]

“average” estimated future DV
Ozone Design Value Plot

- Design value is three year average of 8-hr max ozone concentrations
- “Bar” is design value
- “o” are the three 8-hr max ozone values used for the design value
- “arrow” 8-hr resultant wind vector
- “+” is 1-hour max ozone in the 8-hour window
Non-typical Ozone Criteria

- Change in hourly $O_3 > 40$ ppb
- Change over two hours $O_3 > 60$ ppb
Distribution of TOCs & NTOCs (25 Monitors: 2000-2009)
Number of NTOC Events Have Declined Dramatically Since 2005

Yearly Distribution of Observed NTOC any criteria

Observations: 2000 - 2009
25 monitors
Ozone Violations

Figure 5-4: Number of Monitors and Ozone Exceedance Days in the HGB Area

From TCEQ 2009 8-H Ozone SIP Proposal, Chapter 5, page 5-16.²

²Note: there are a total of 50 O₃ data sites in the SIP 4-km domain, not all regulatory.
## Filtered Design Values

### 2006

<table>
<thead>
<tr>
<th>Monitor</th>
<th>DVb</th>
<th>RRF06</th>
<th>DVf</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAYP</td>
<td>96.7</td>
<td>0.899</td>
<td>86.9</td>
</tr>
<tr>
<td>HSMA</td>
<td>89.7</td>
<td>0.934</td>
<td>83.7</td>
</tr>
<tr>
<td>DRPK</td>
<td>92.0</td>
<td>0.959</td>
<td>88.2</td>
</tr>
<tr>
<td>WALV</td>
<td>92.0</td>
<td>0.960</td>
<td>88.3</td>
</tr>
</tbody>
</table>

### 2006

<table>
<thead>
<tr>
<th>Monitor</th>
<th>DVb</th>
<th>RRF06</th>
<th>DVf</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAYP</td>
<td>88.7</td>
<td>0.899</td>
<td>79.7</td>
<td>-7.2</td>
</tr>
<tr>
<td>HSMA</td>
<td>82.3</td>
<td>0.934</td>
<td>76.9</td>
<td>-6.8</td>
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<td>DRPK</td>
<td>86.3</td>
<td>0.959</td>
<td>82.8</td>
<td>-5.4</td>
</tr>
<tr>
<td>WALV</td>
<td>82.3</td>
<td>0.960</td>
<td>79.0</td>
<td>-9.3</td>
</tr>
</tbody>
</table>
Summary

• Dramatic reductions in number of NTOC since 2005
• $DV_B$ uses a 5 year average including period of significant change
• NTOC still impact current $DV_B$s
• Dual approach 7-9 ppb difference in $DV_F$ equivalent to significant across the board NOx/VOC controls
Modeling Data Analysis

The model's mean Relative Reduction Factor (RRF) is calculated at each monitor, $m$, as:

$$ RRF_m = \frac{\text{Mean predicted future peak 8-hr daily max "near" monitor}}{\text{Mean predicted baseline peak 8-hr daily max "near" monitor}} $$

"weighted" DV based on observed 2004-2008 $O_3$ data at monitor

"average" estimated future DV
If it is below standard, monitor is in compliance of NAAQS

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$$ RRF_m = \frac{\text{Mean predicted future peak 8-hr daily max "near" monitor}}{\text{Mean predicted baseline peak 8-hr daily max "near" monitor}} $$

2006 "typical" emissions modeled with 2005 & 2006 daily meteorology
Relative Reduction Factor Components
Observation and Modeling Data
Observation vs. Base Case

Observations
One Hour Ozone Change vs Resultant 1-H Ozone Value
25 Monitors for 2005 through 2009

Base Case Model Predictions
Predicted One Hour Ozone Change vs Predicted Resultant 1-H Ozone Value
21580 Grid Cells (grid_02k_in_04k) during 2005_06_hg_TCEQ (BC) episode
Base Case vs. Base Line Model Predictions

Predicted One Hour Ozone Change vs Predicted Resultant 1-H Ozone Value
21580 Grid Cells (grid_02k_in_04k) during 2005_06_hg_TCEQ (BC) episode

Total GridCell-Hours of Data = 7229300
first criterion NTDC-behavior, 73 points

Predicted One Hour Ozone Change vs Predicted Resultant 1-H Ozone Value
21580 Grid Cells (grid_02k_in_04k) during 2005_06_hg_TCEQ (BL) episode

Total GridCell-Hours of Data = 7229300
first criterion NTDC-behavior, 68 points
Hourly Distribution of NTOC
Conclusions

• Houston has dual ozone phenomena
• EPA attainment demonstration methodology recognizes one type of ozone phenomena
• Control strategies using Base Line modeling may not be as effective
• Although less frequent NTOC still impact design values
• Further investigation of cause of NTOC behavior in regulatory modeling needed
Acknowledgements

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• Thanks to Mark Estes, Jim Smith, for supplying TCEQ SIP modeling input and allowing us to pursue these questions

• Thanks to Jim Wilkinson Alpine Geophysics and Tom Tesche Climate & Atmospheric Research Associates for discussions