

# Flare Sensitivity Modeling

---

**Jim Smith**  
**SETPMTC Meeting**  
**June 23, 2009**





## CAMx Ozone Modeling in SIP Development

# The Big Picture

Base Case

Day-specific meteorology and emissions;  
replicate what actually happened

Baseline Case

Day-specific meteorology and Typical emissions;  
used in RRF to predict future design values

Future Base Case

Apply future growth + on-the-books controls  
to estimate future ozone

Control Strategy Testing

Determine control strategies that will  
effectively reduce ozone

SIP

Document modeling procedures



# Flare Emissions

---

- Recently, flares have come under scrutiny as potential sources for unreported VOC emissions, especially HRVOCs.
- Aircraft observations show HRVOC concentrations that are an order of magnitude or more greater than can be explained through reported emissions.
- Ground-based observations also show a discrepancy, but much smaller (about a factor of 2 to 3).



# Flare Emissions

---

- To better understand the role of flare emissions in the HGB airshed, we ran the base case model with flare VOC emissions increased by a factor of 10, but without the PSCF-based HRVOC reconciliation.
- Two additional sensitivity runs were also conducted: increase flare emissions of HRVOCs only by a factor of 10, and also adding a “boost” of formaldehyde to the 10X HRVOC emissions (equal to 0.1 times the mass of the extra HRVOC).



# Flare Emission Sensitivities

Run Name	Description	Added PSCF-based HRVOC	Added Flare VOC	Added Flare HRVOC	Added Flare HCHO
Base Case	2006 Reg10 (Regular Base Case, Ver. 10)	23.1 tpd			
F10xVOC	Reg10 + 10X Flare VOC (no PSCF reconciliation)		321.6 tpd*	87.9 tpd	
F10xHRVOC	Reg10 + 10X Flare HRVOC (no PSCF reconciliation)			87.9 tpd	
FBoost	F10xHRVOC + HCHO Boost			87.9 tpd	9.1 tpd

\* Including 87.9 tpd of HRVOC



## Three Flare Sensitivities

---

- The modeling was conducted for all 5 2005 and 2006 episodes, but results presented here focus mainly on the 2006 TexAQS II intensive period – August 15-October 15.
- Two sub-episodes:
  - AQS 1: August 15 – September 14, 2006. This period includes the Special Emissions Inventory.
  - AQS 2: September 15 – October 15, 2006. No Special EI, but most aircraft data was collected during this period.
  - Some periods in both episodes are not included in the analysis since no fine-grid modeling was conducted on those days.



# Sensitivity Results

---

- The following slides show scatter plots comparing observed and modeled concentrations of several species at selected surface sites:
  - AQS 2 episode, September 19 – October 11, excluding dates when fine grids were not run: (September 21-24 and September 28 – October 2).
- Also shown are comparisons between data collected by the NOAA P3 aircraft and the model within the 2 km HG fine grid area:
  - Between August 31 and October 12, 2006. Most data were collected during the AQS 2 episode, including some days when fine grids were not run.



---

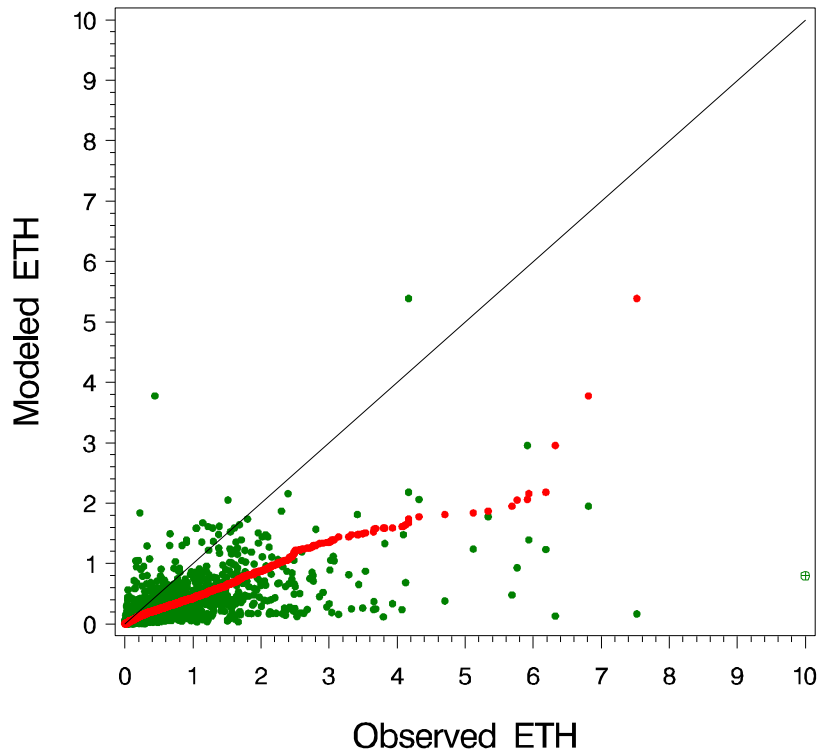
# Ethene (CB05: ETH)



# Modeled vs. Observed Ethene (ETH) Concentrations, Base Case

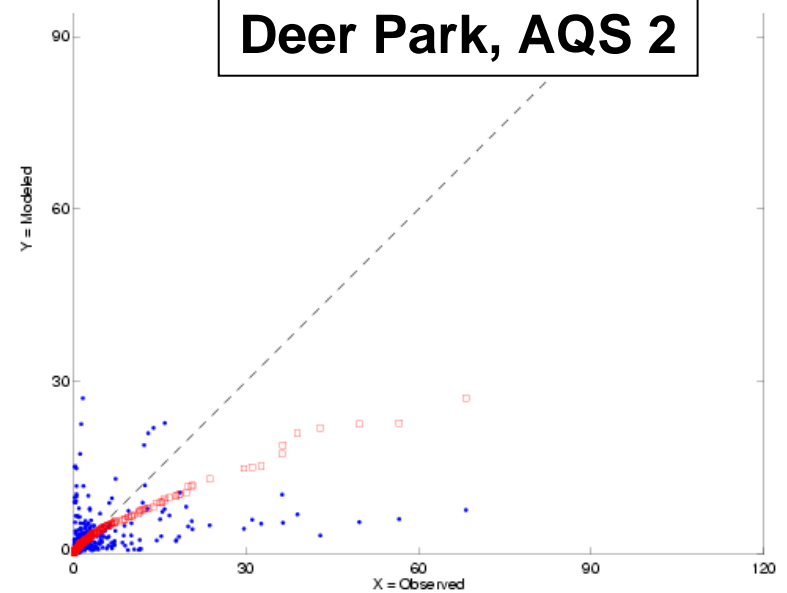
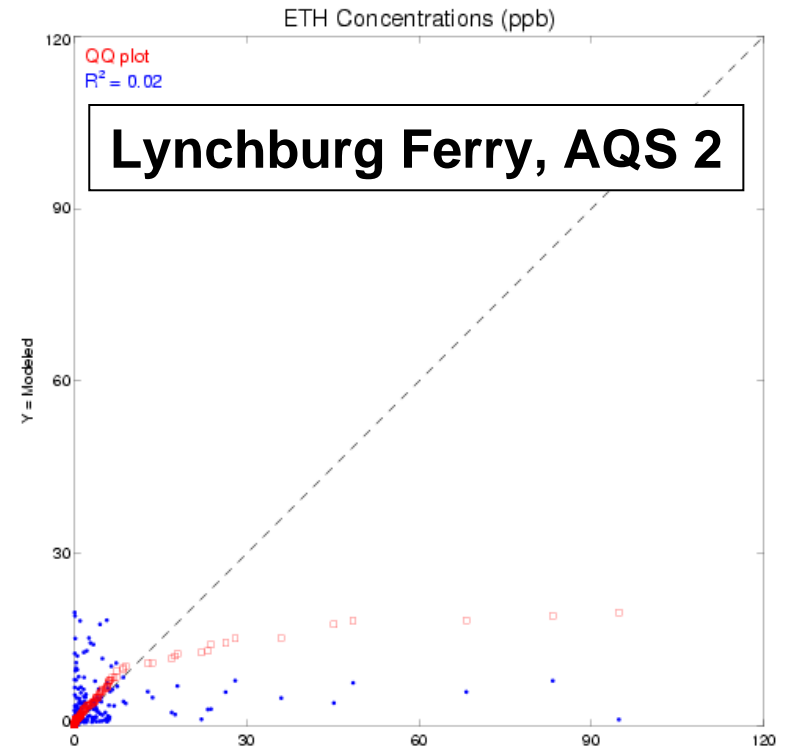
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed ETH Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
camx453\_cb05.hgb8h2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulc\_grell.hgbpa\_02

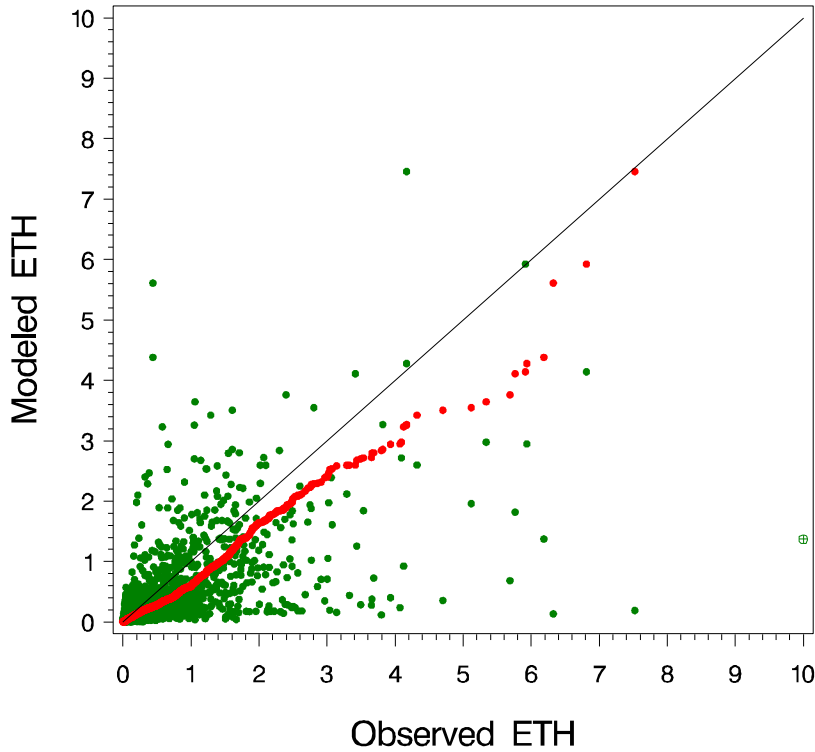




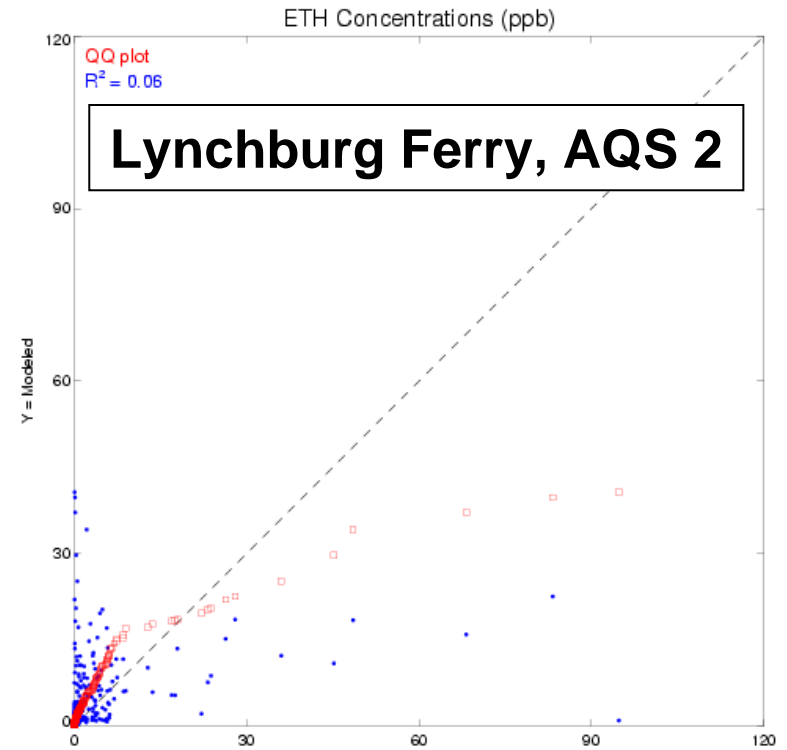
# Modeled vs. Observed Ethene (ETH) Concentrations, F10xVOC

**NOAA P3, Sep 30 – Aug 13**

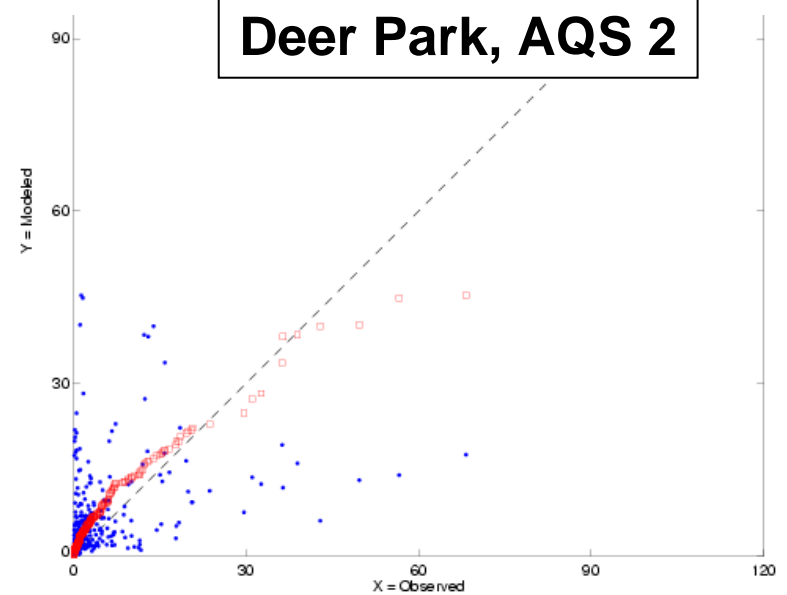
Modeled vs. Observed ETH Mixing Ratios



Modeled vs Observed: Hourly Values (20060919-20061011)  
1x453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fcdats\_newuhsst\_newutcsrlu lc\_grell.hgbpx



**Lynchburg Ferry, AQS 2**



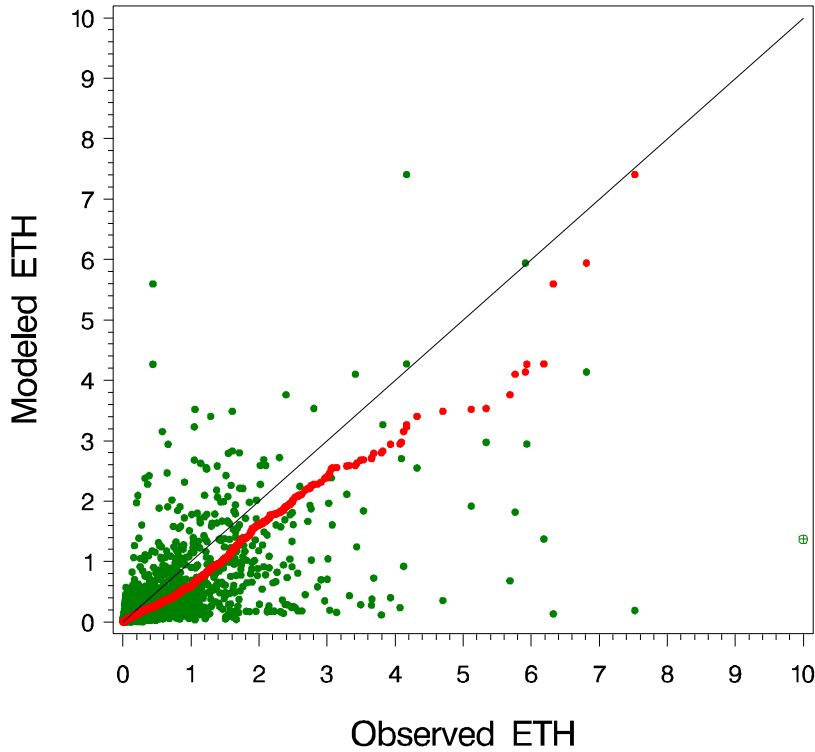
**Deer Park, AQS 2**



# Modeled vs. Observed Ethene (ETH) Concentrations, F10xHRVOC

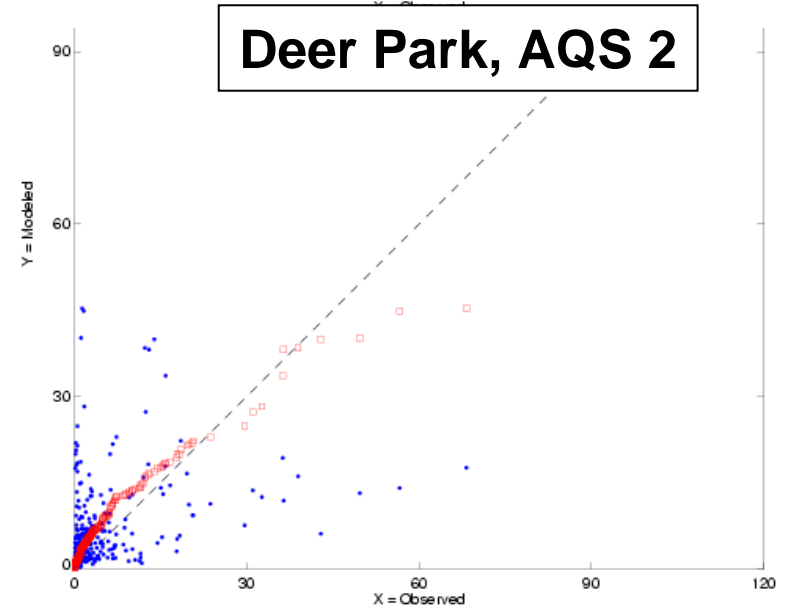
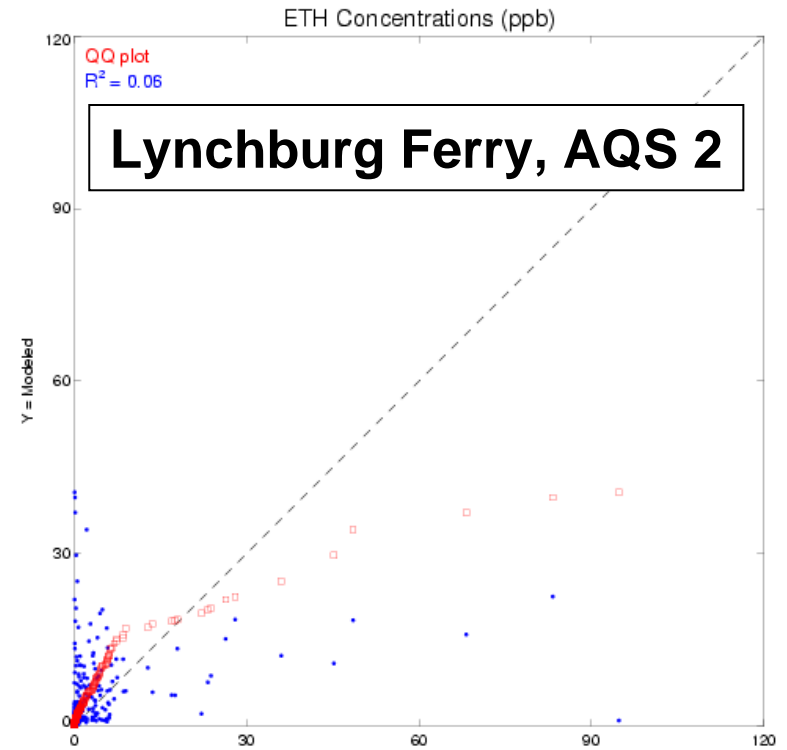
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed ETH Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
453\_cb05.hgbsh2.bc06aqs2.reg10flrHRVoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulk\_grell.hgb

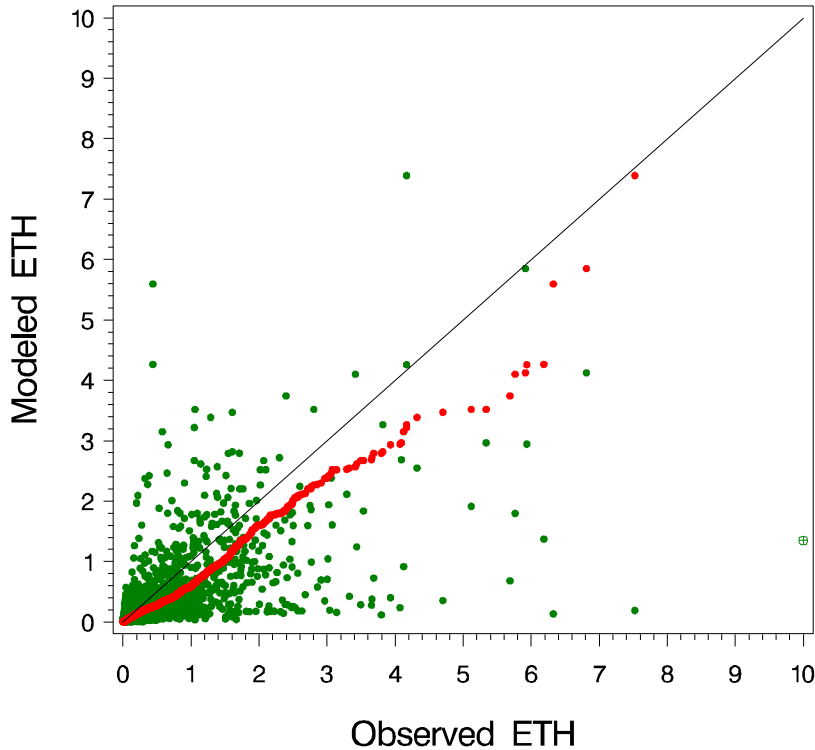




# Modeled vs. Observed Ethene (ETH) Concentrations, FBoost

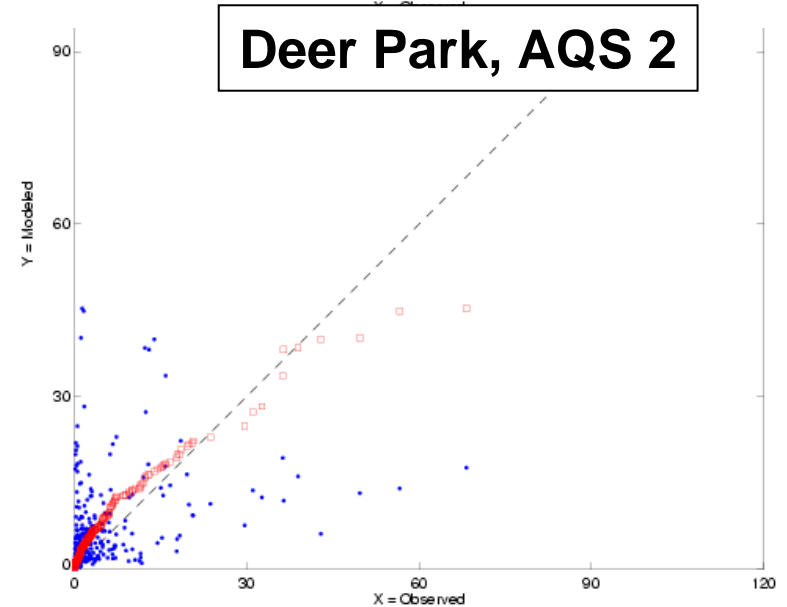
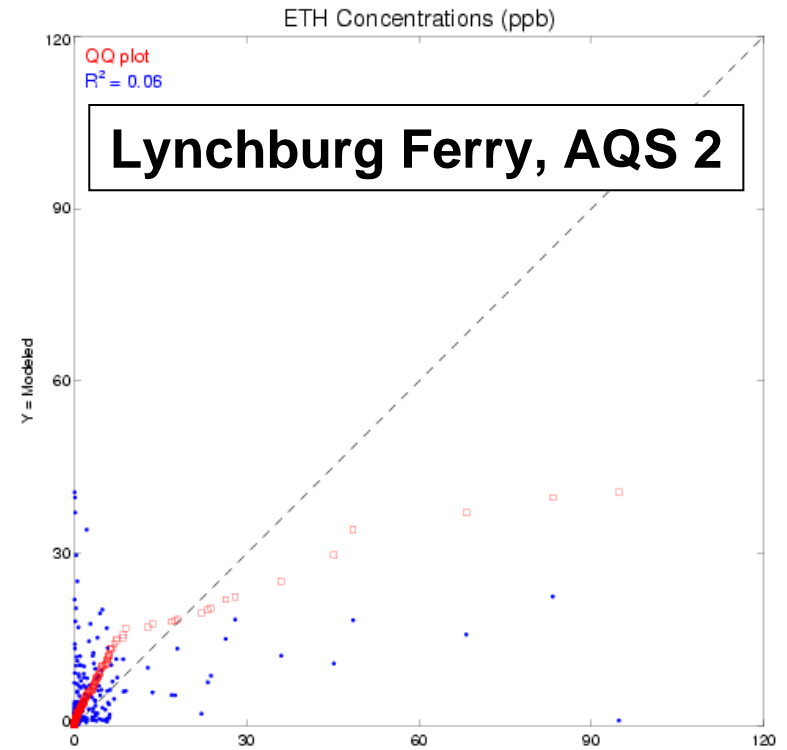
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed ETH Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
453\_cb05.hgb8h2.bc06aqs2.reg10flrHR10xF4x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgb





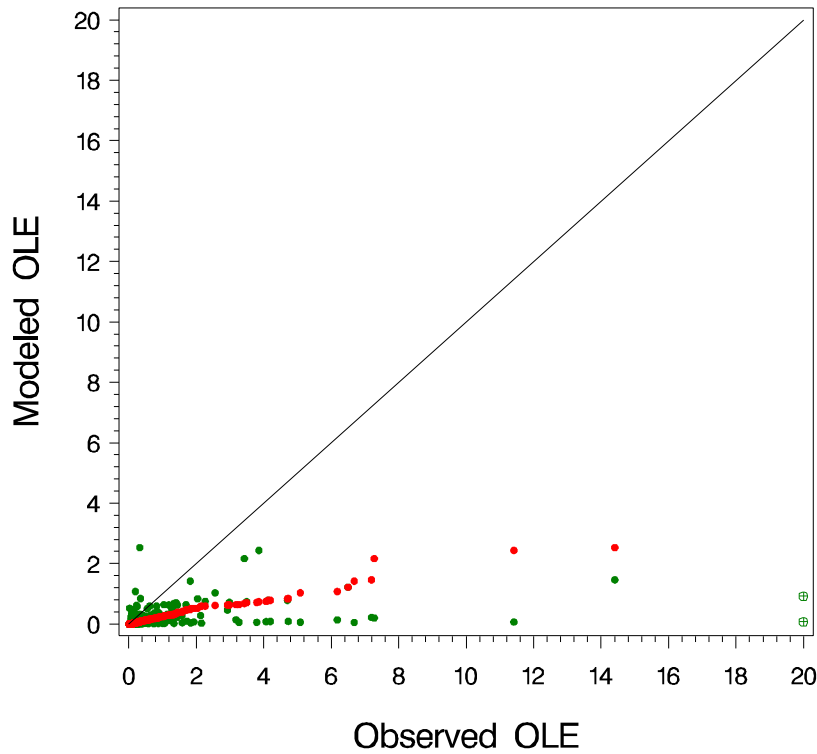
# OLE



# Modeled vs. Observed OLE Concentrations, Base Case

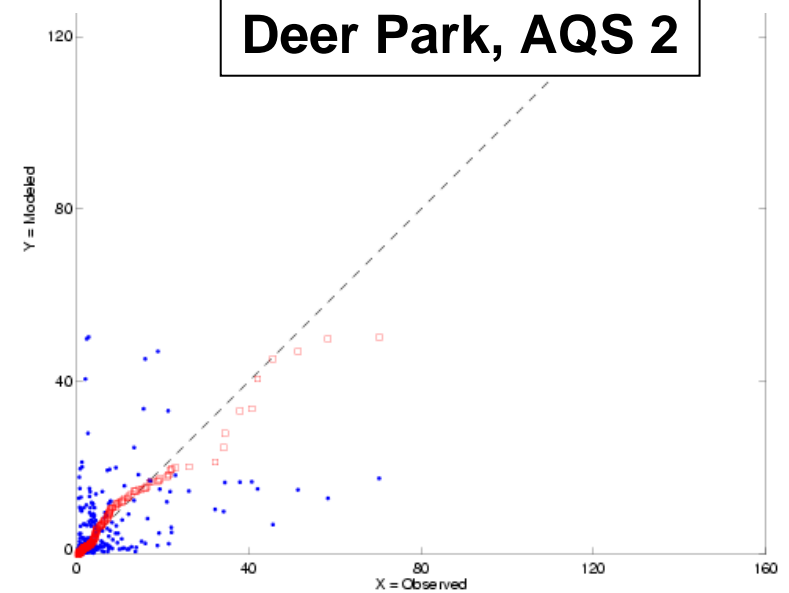
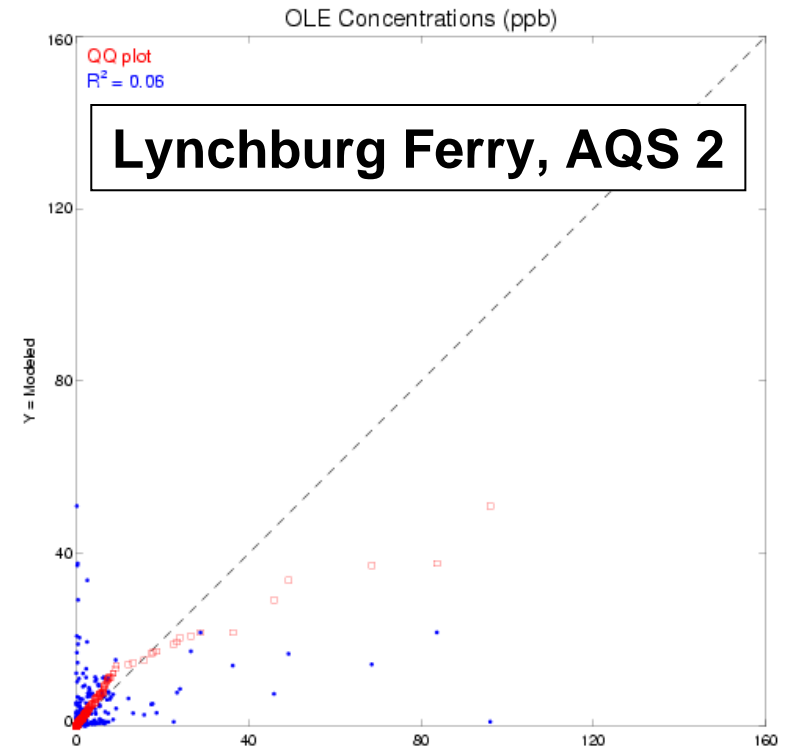
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed OLE Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs Observed: Hourly Values (20060919-20061011)  
camx453\_cb05.hgbsh2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulc\_grell.hgbpa\_02

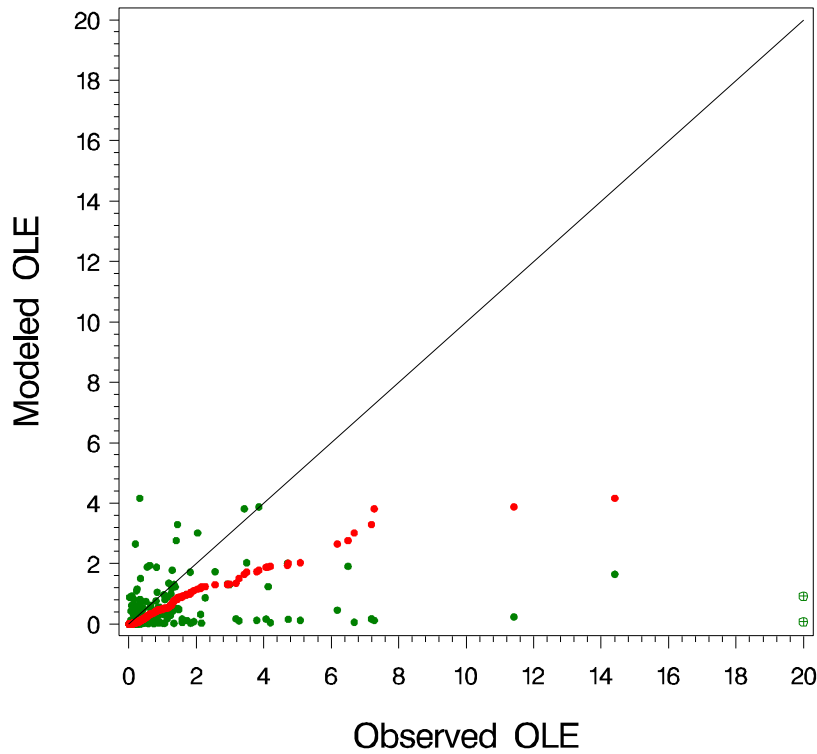




# Modeled vs. Observed OLE Concentrations, F10xVOC

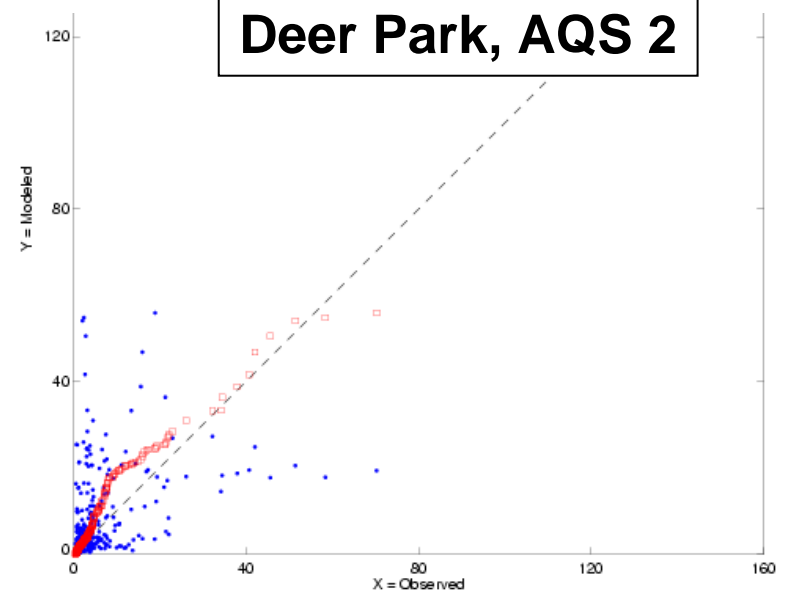
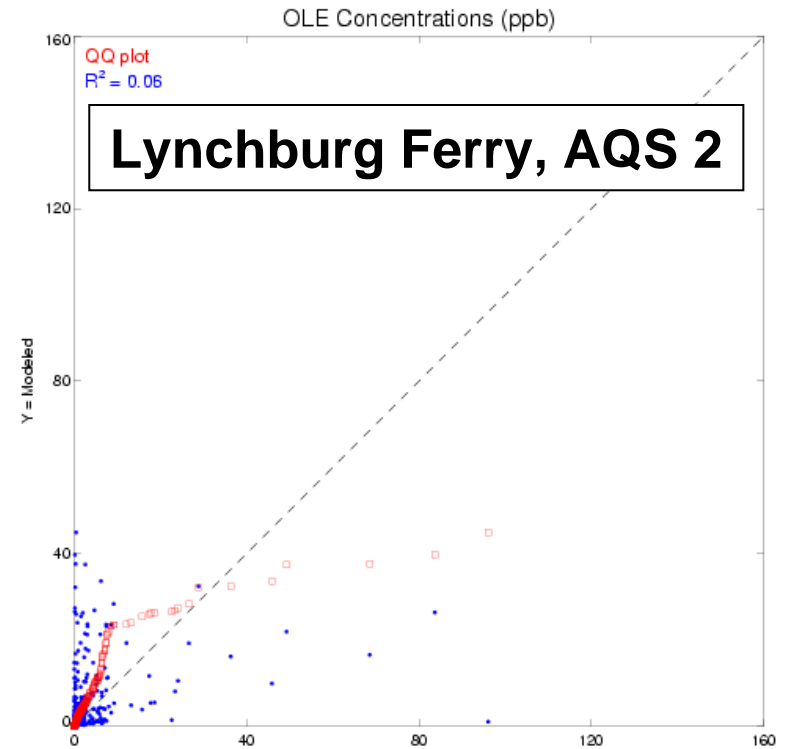
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed OLE Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs Observed: Hourly Values (20060919-20061011)  
1x453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fcdats\_newuhsst\_newutcsrlu lc\_grell.hgbpx





---

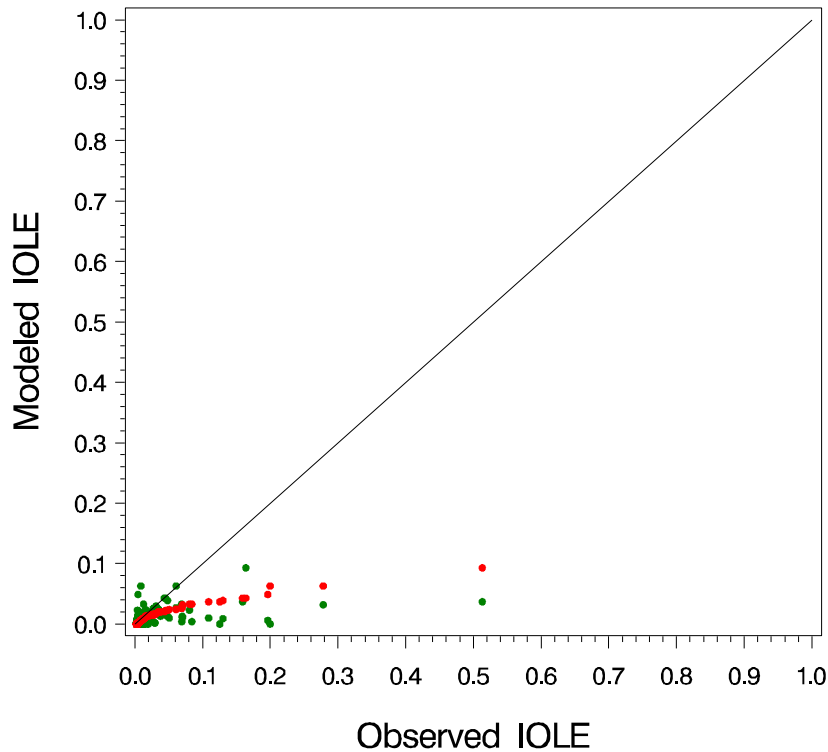
# IOLE



# Modeled vs. Observed IOLE Concentrations, Base Case

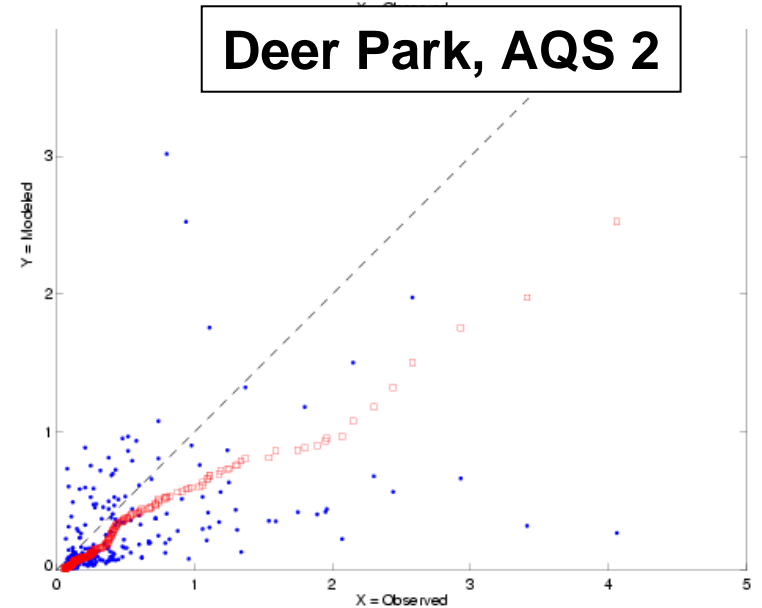
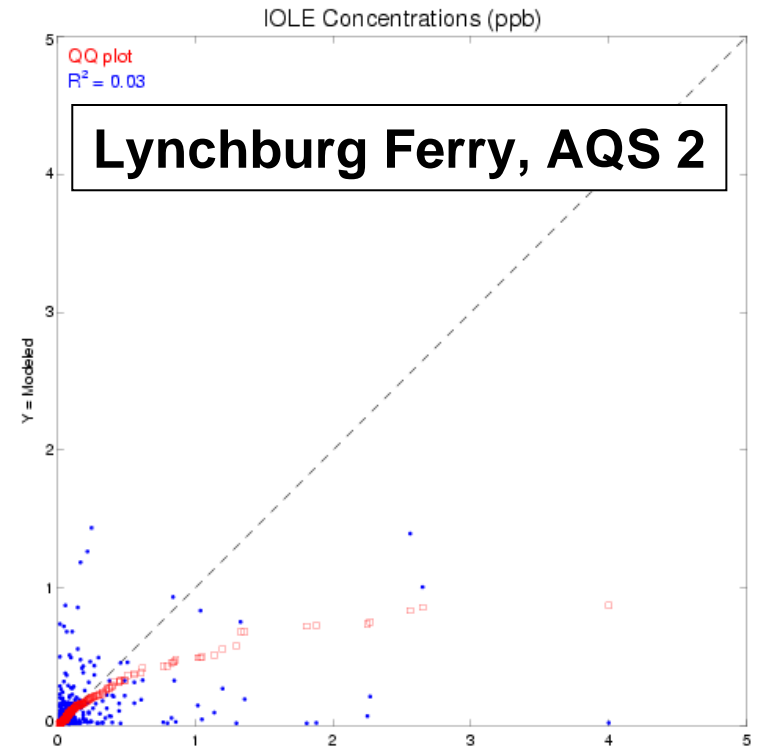
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed IOLE Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs Observed: Hourly Values (20060919-20061011)  
camx453\_cb05.hgb8h2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulc\_grell.hgbpa\_02

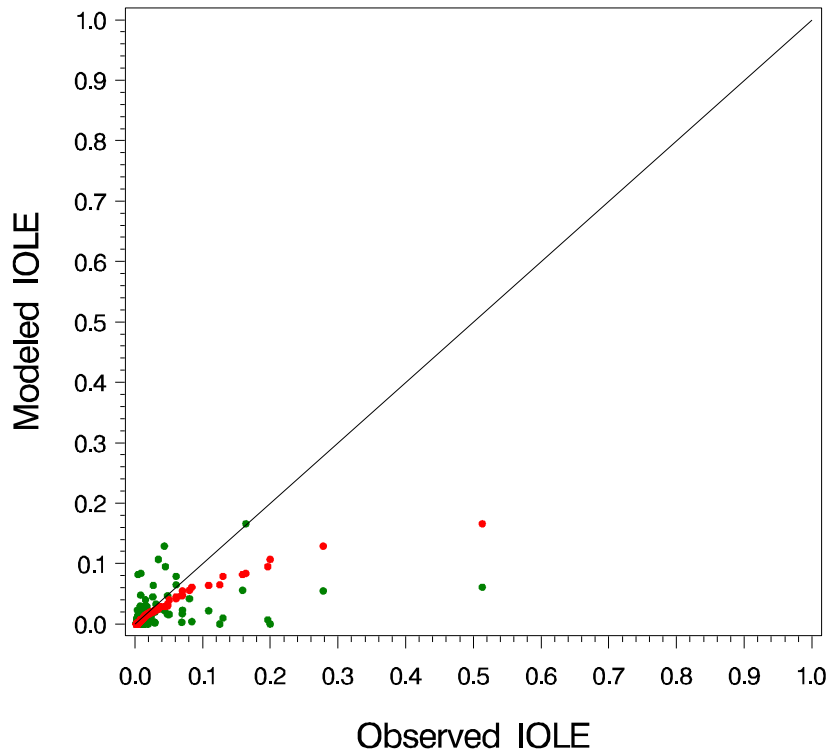




# Modeled vs. Observed IOLE Concentrations, F10xVOC

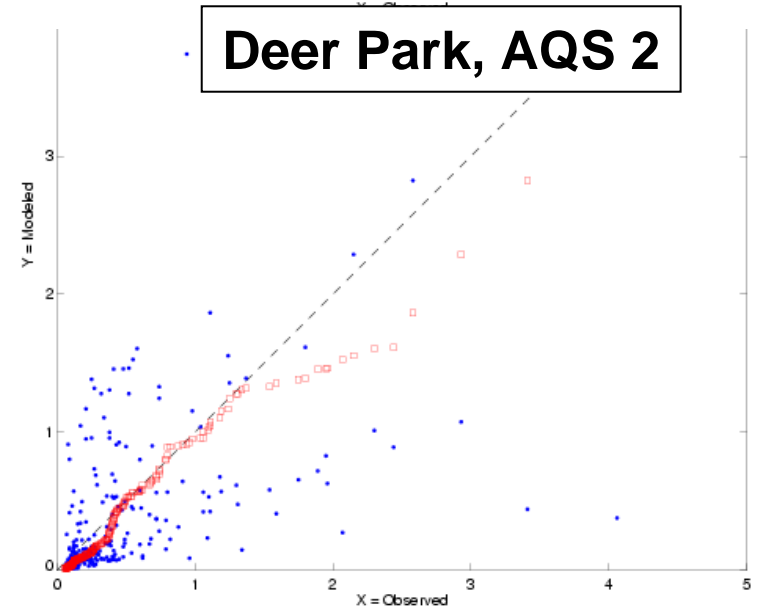
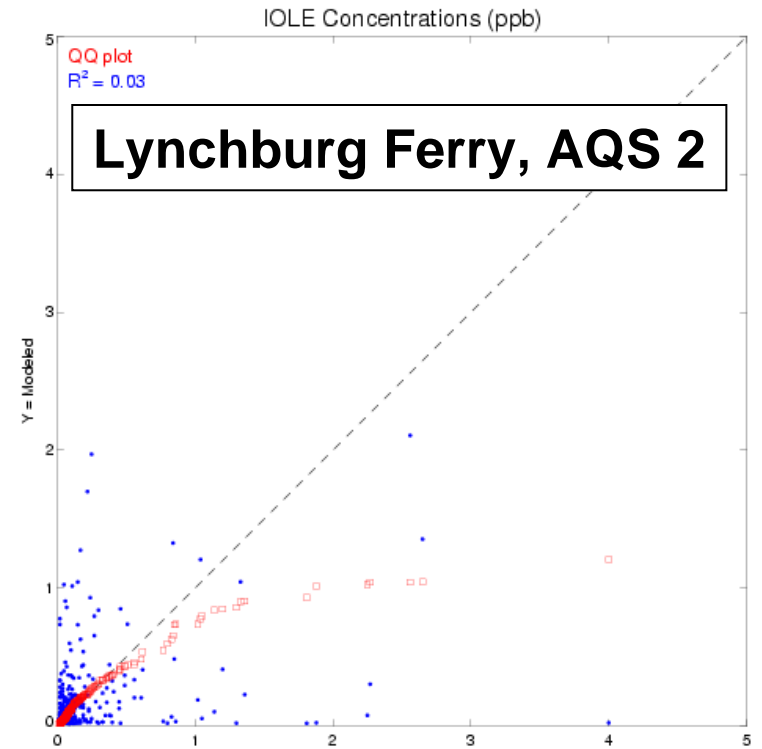
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed IOLE Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
1x453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fcdats\_newuhsst\_newutcsrlu lc\_grell.hgbpx





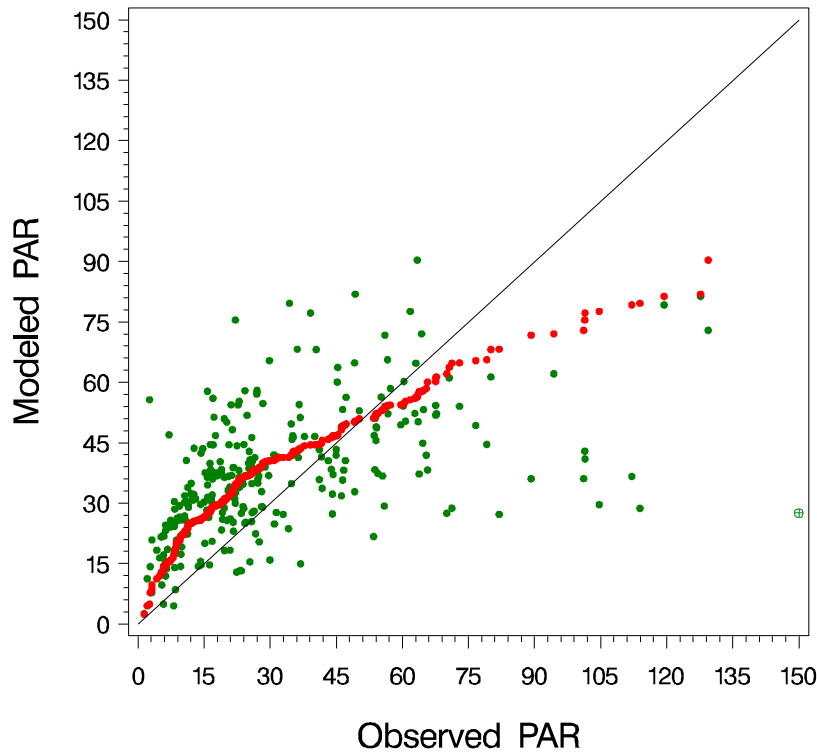
# PAR



# Modeled vs. Observed PAR Concentrations, Base Case

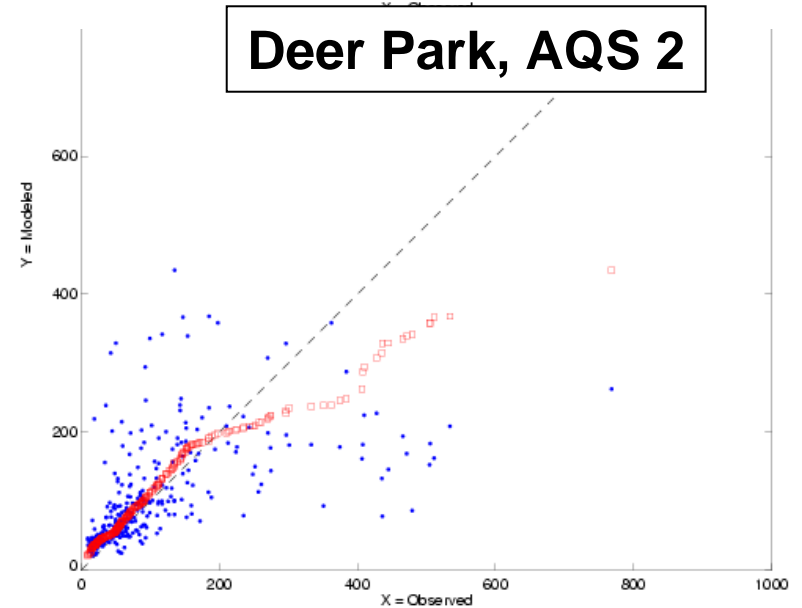
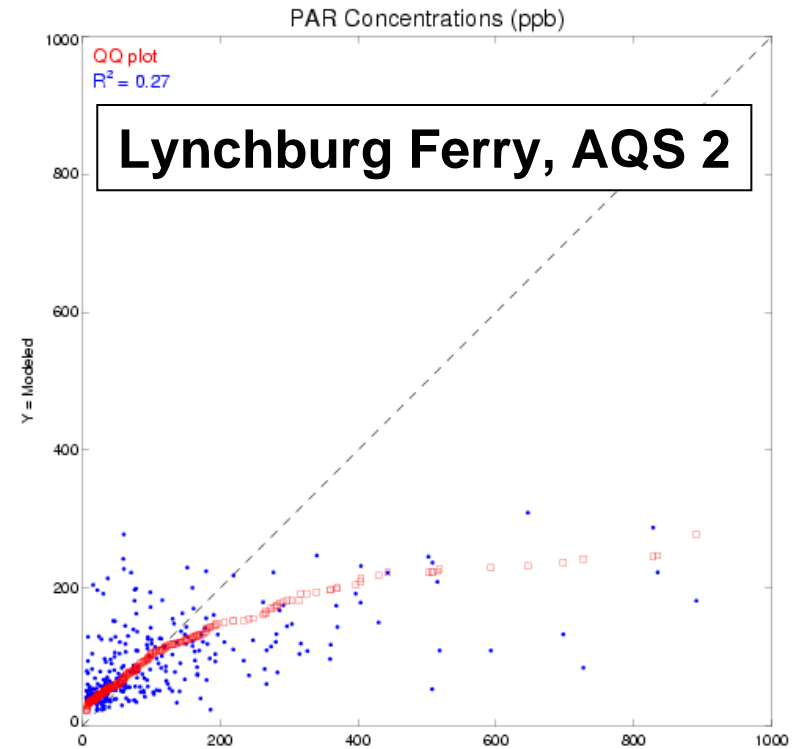
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed PAR Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
camx453\_cb05.hgbsh2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulc\_grell.hgbpa\_02

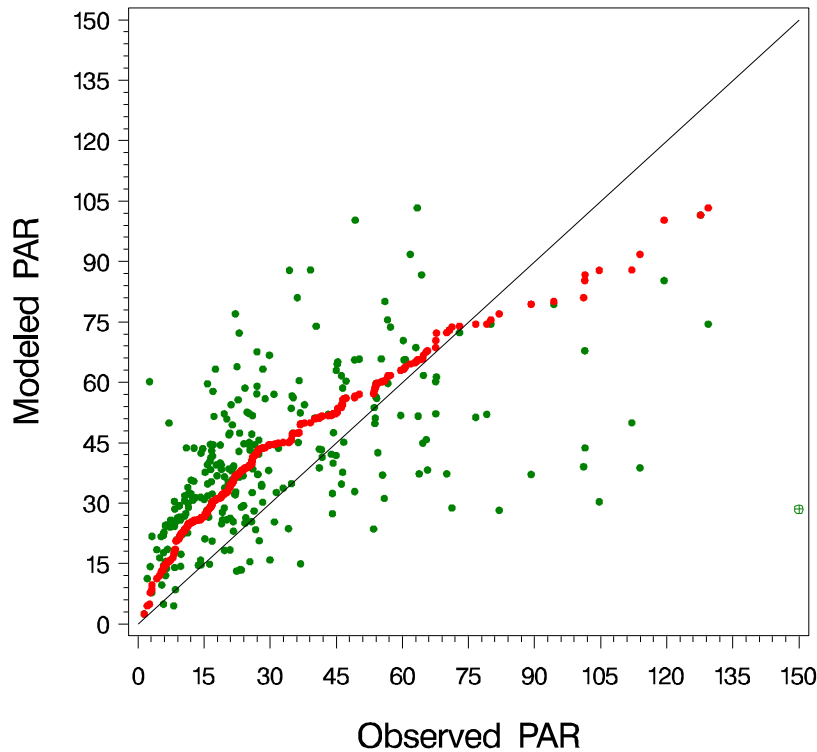




# Modeled vs. Observed PAR Concentrations, F10xVOC

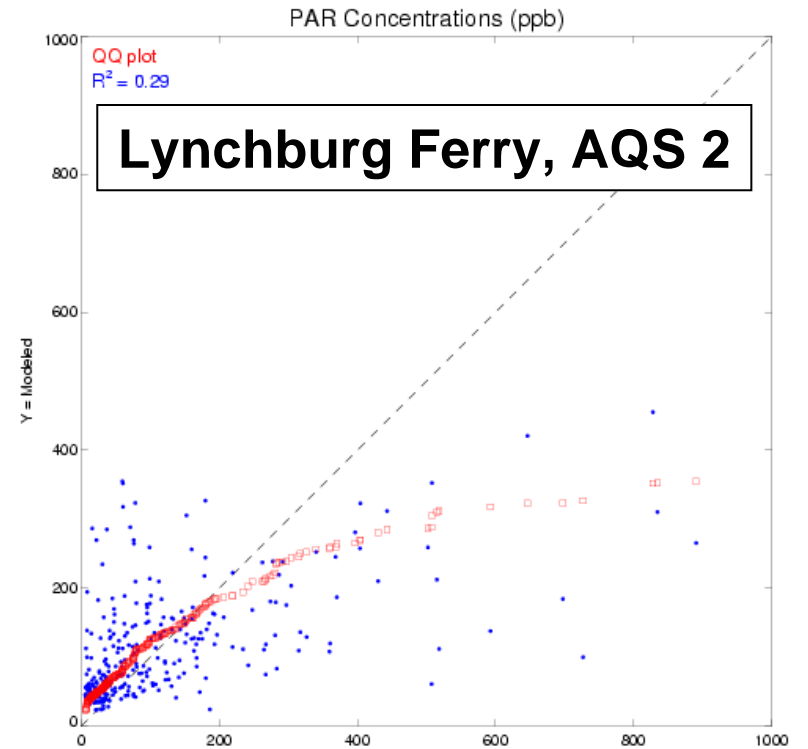
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed PAR Mixing Ratios

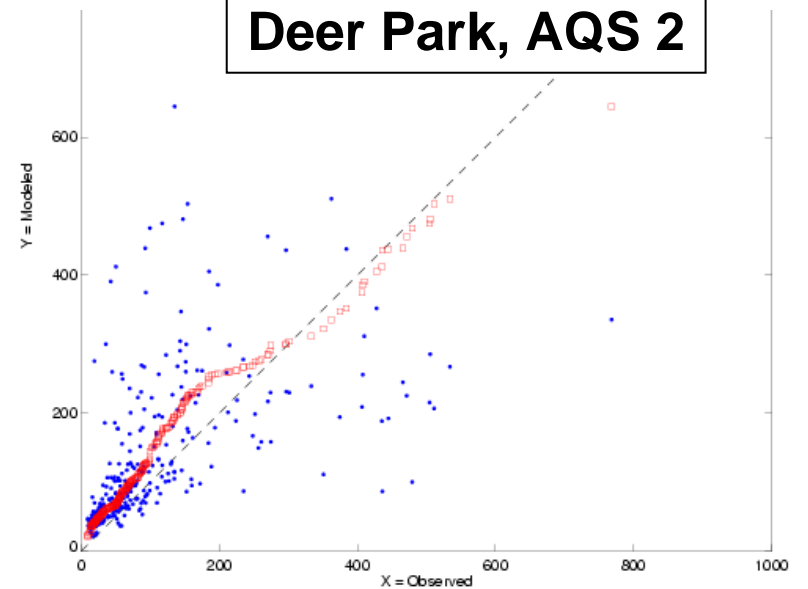


Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
1x453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fcdats\_newuhsst\_newutcsrlu\_ic\_grell.hgbpx



**Deer Park, AQS 2**

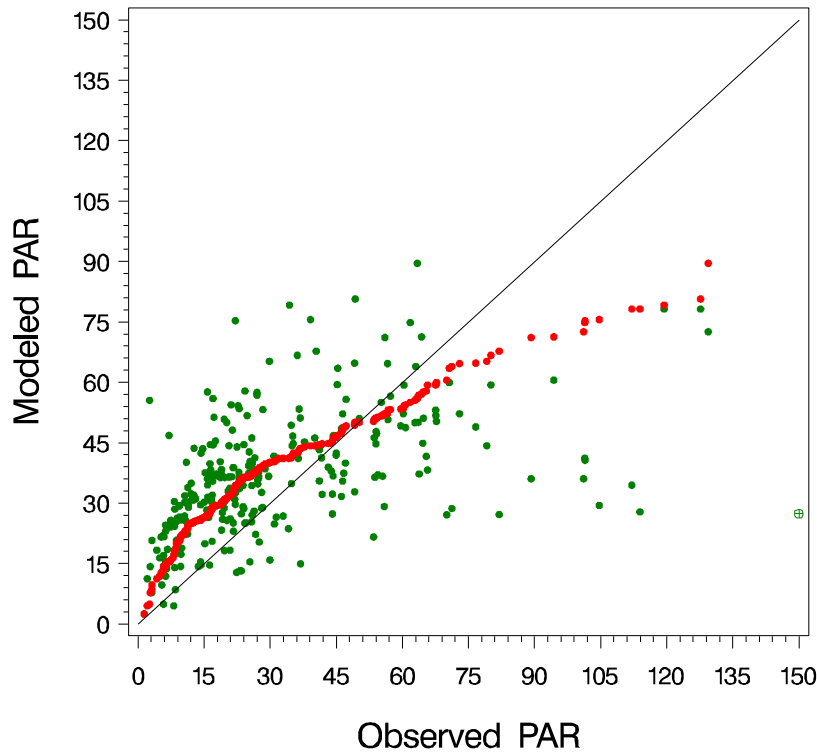




# Modeled vs. Observed PAR Concentrations, F10xHRVOC

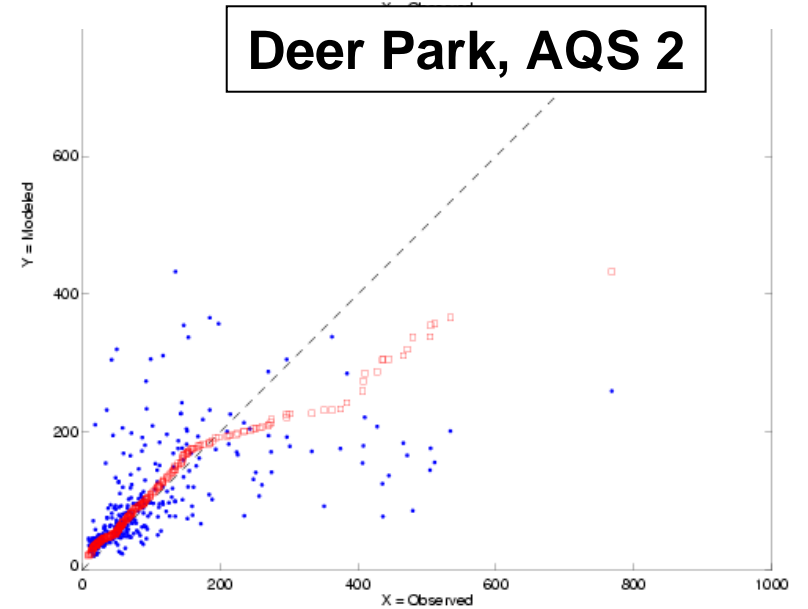
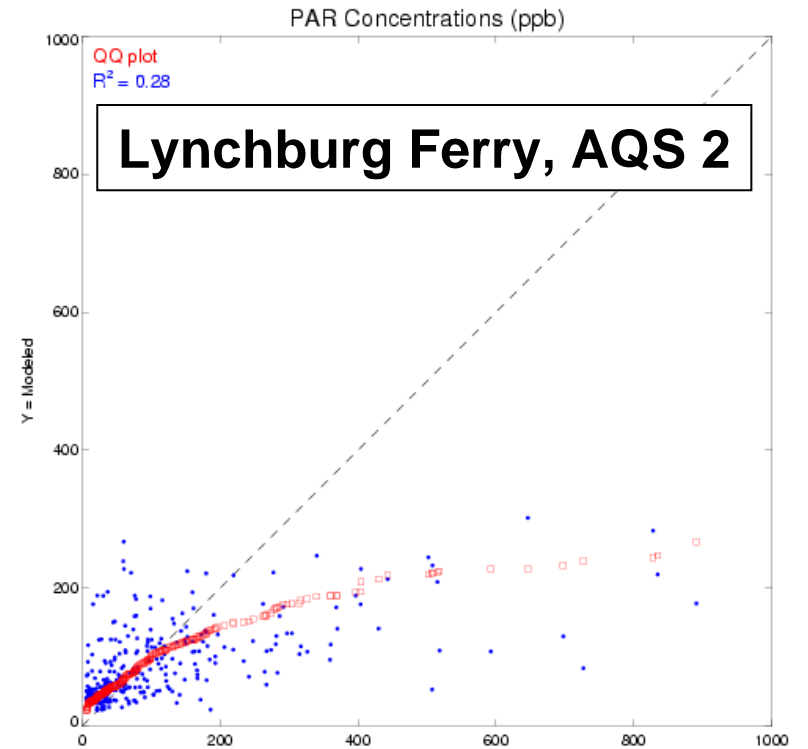
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed PAR Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
453\_cb05.hgbsh2.bc06aqs2.reg10flrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluk\_grell.hgb





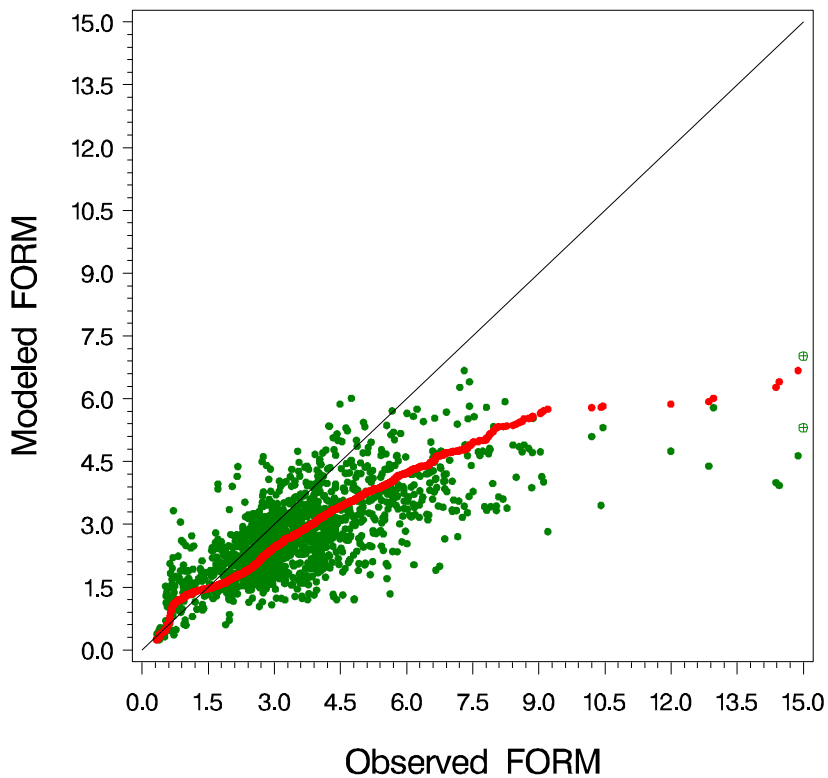
---

# Formaldehyde (CB05: FORM or HCHO)

# Modeled vs. Observed Formaldehyde (FORM) Concentrations, Base Case

**NOAA P3, Sep 30 – Aug 13**

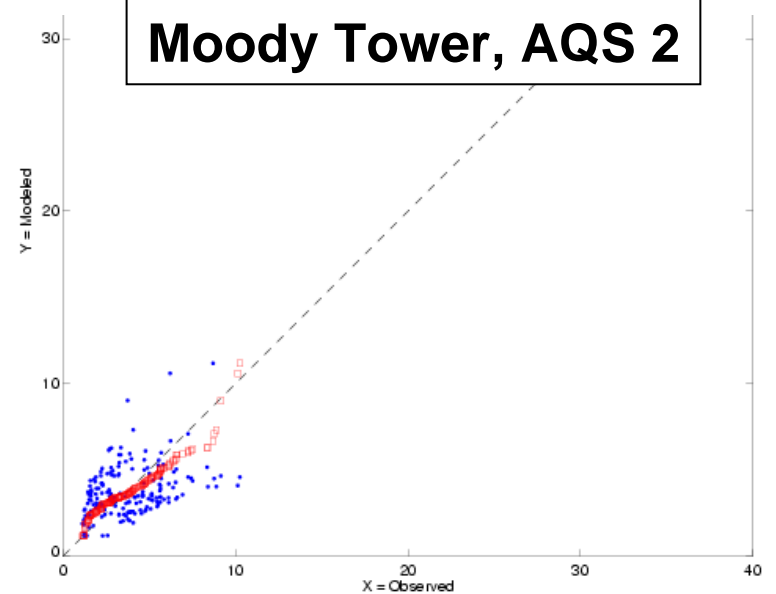
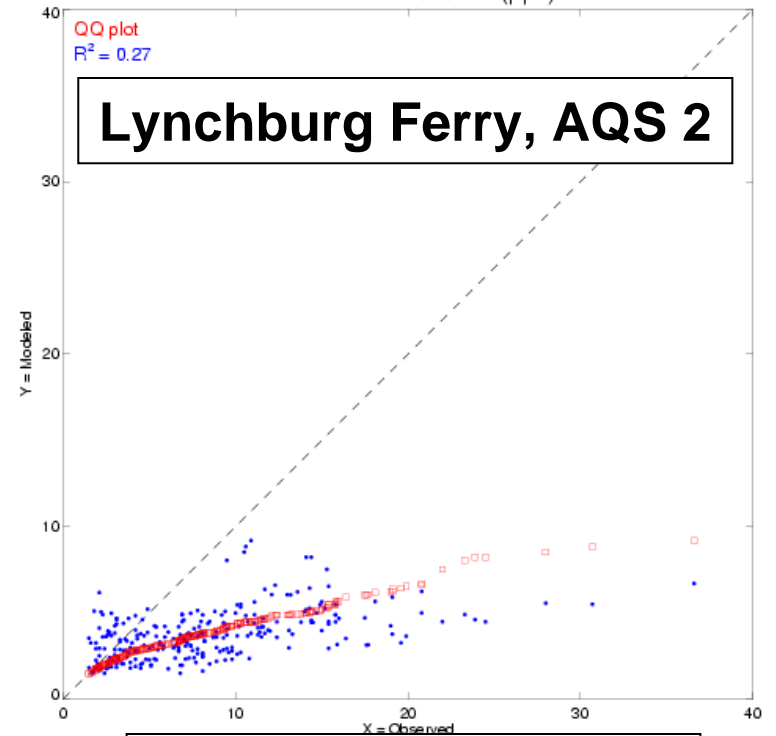
Modeled vs. Observed FORM Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
camx453\_cb05.hgb8h2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulc\_grell.hgbpa\_02

FORM Concentrations (ppb)

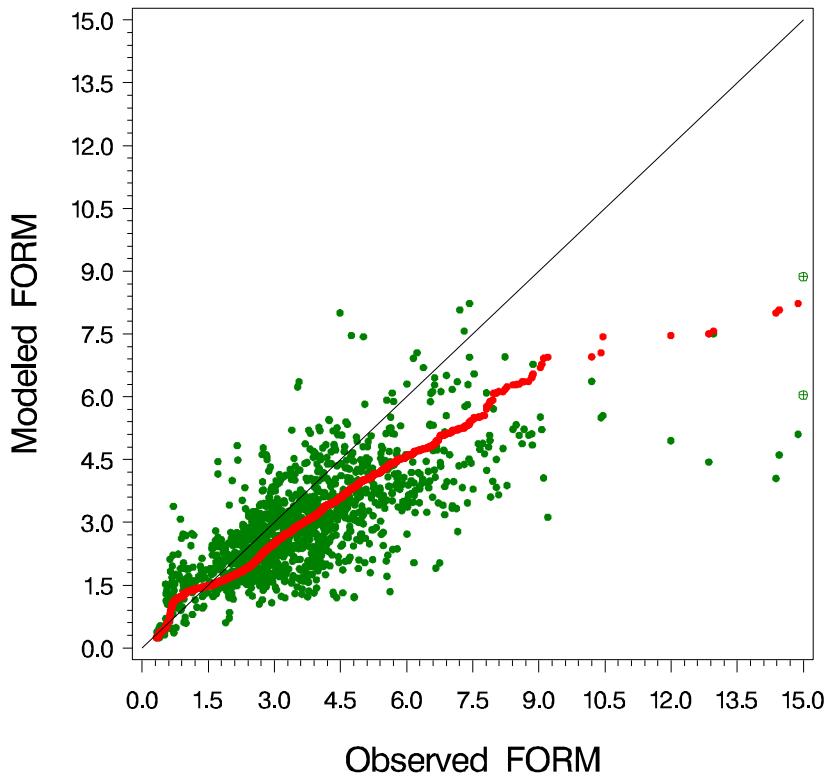




# Modeled vs. Observed Formaldehyde (FORM) Concentrations, F10xVOC

**NOAA P3, Sep 30 – Aug 13**

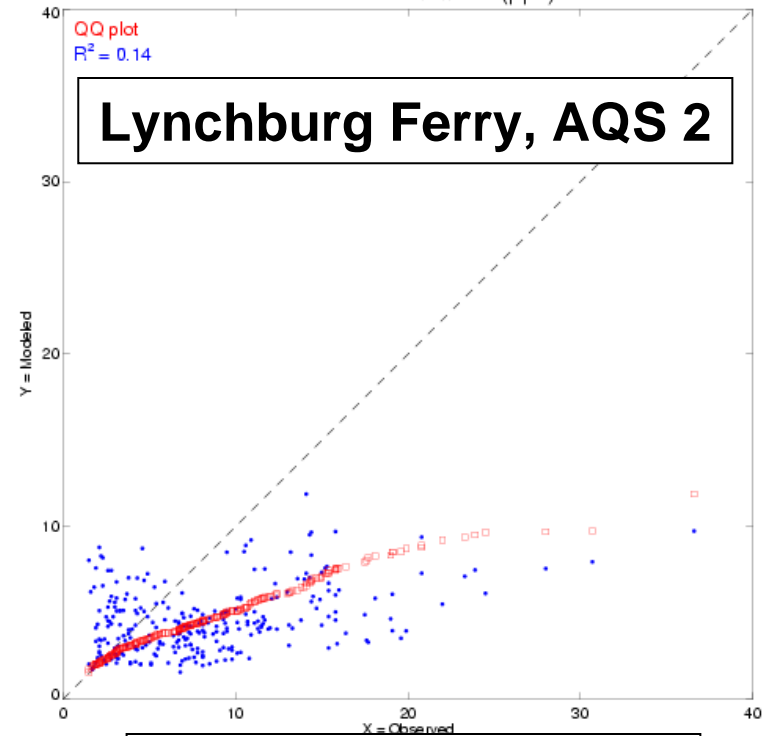
Modeled vs. Observed FORM Mixing Ratios



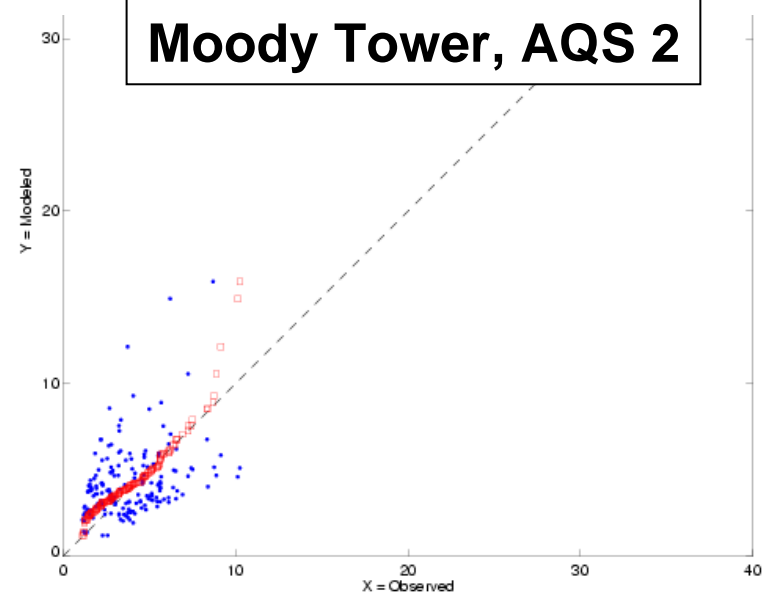
Air Quality Division • Flare Sensitivity Modeling

Modeled vs Observed: Hourly Values (20060919-20061011)  
1x453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fcdats\_newuhsst\_newutcsrlu lc\_grell.hgbpx

FORM Concentrations (ppb)



**Moody Tower, AQS 2**

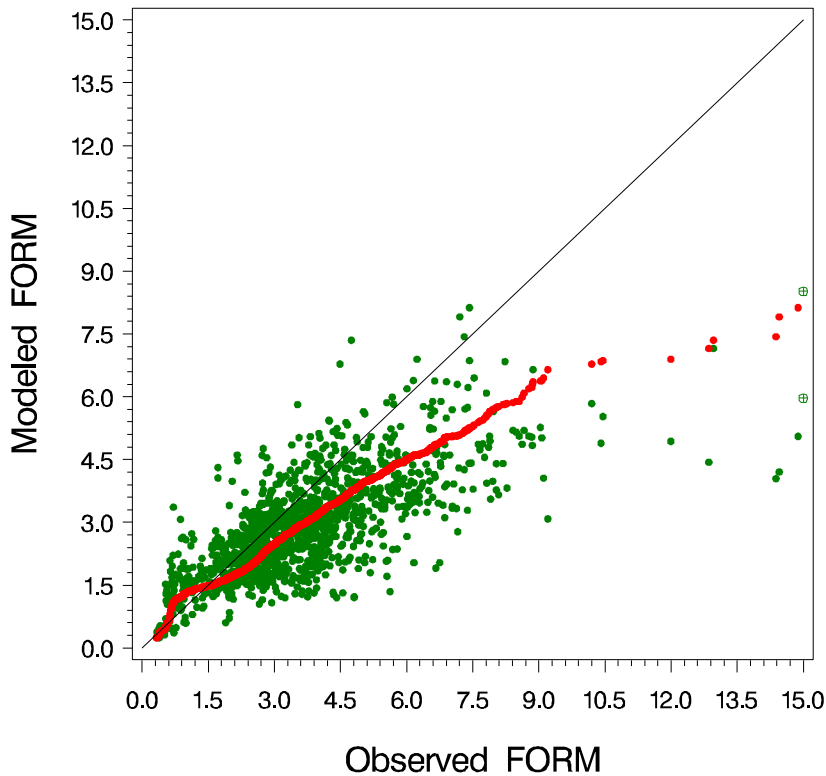




# Modeled vs. Observed Formaldehyde (FORM) Concentrations, F10xHRVOC

**NOAA P3, Sep 30 – Aug 13**

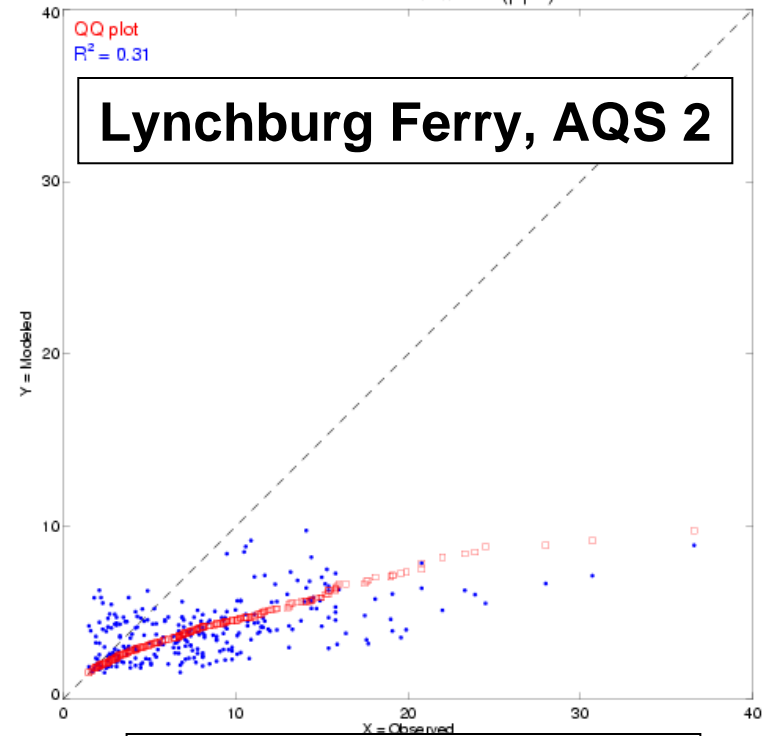
Modeled vs. Observed FORM Mixing Ratios



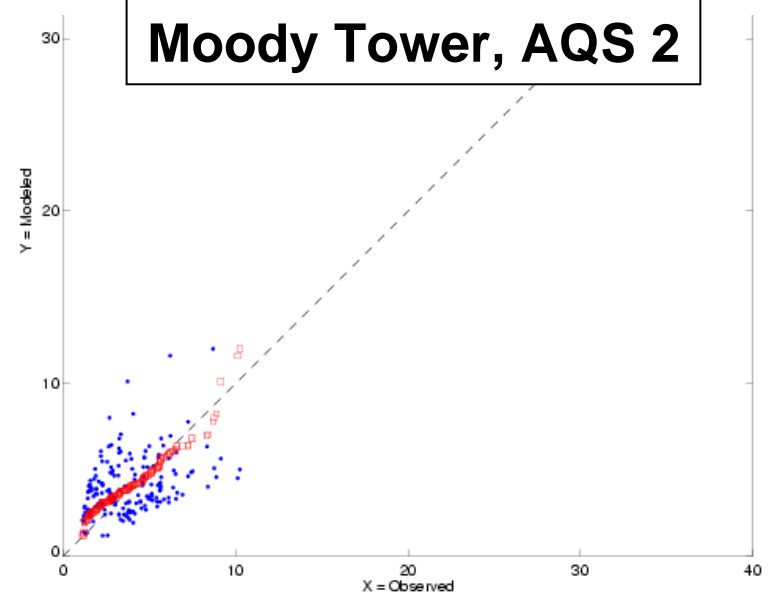
Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
453\_cb05.hgb5h2.bc06aqs2.reg10flrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluk\_grell.hgb

FORM Concentrations (ppb)



**Lynchburg Ferry, AQS 2**



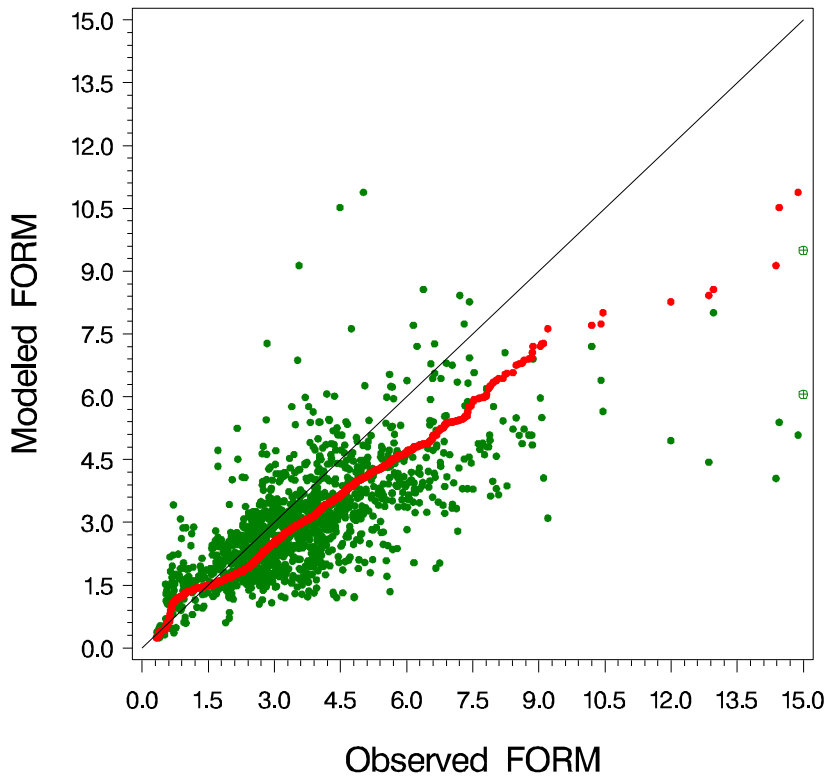
**Moody Tower, AQS 2**



# Modeled vs. Observed Formaldehyde (FORM) Concentrations, FBoost

**NOAA P3, Sep 30 – Aug 13**

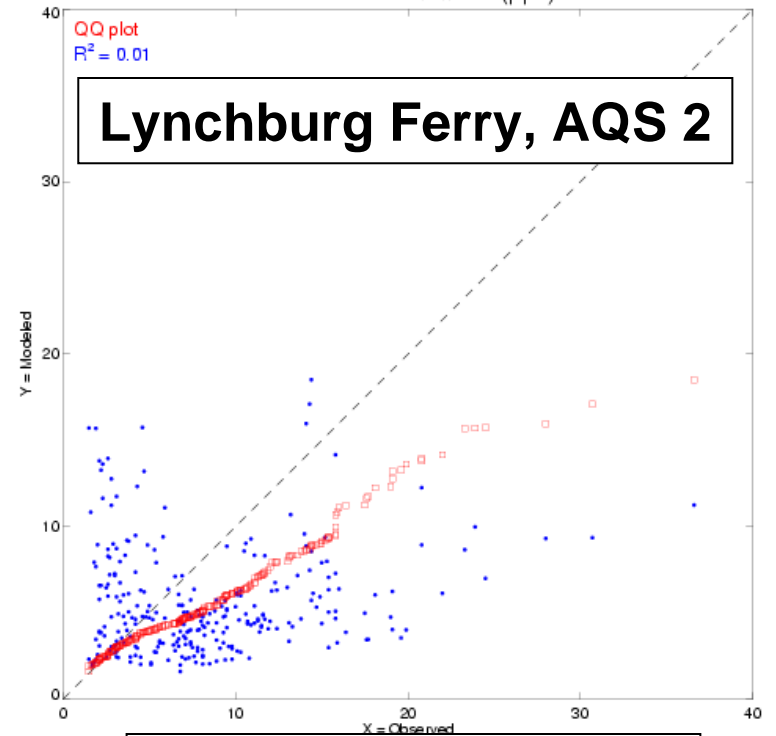
Modeled vs. Observed FORM Mixing Ratios



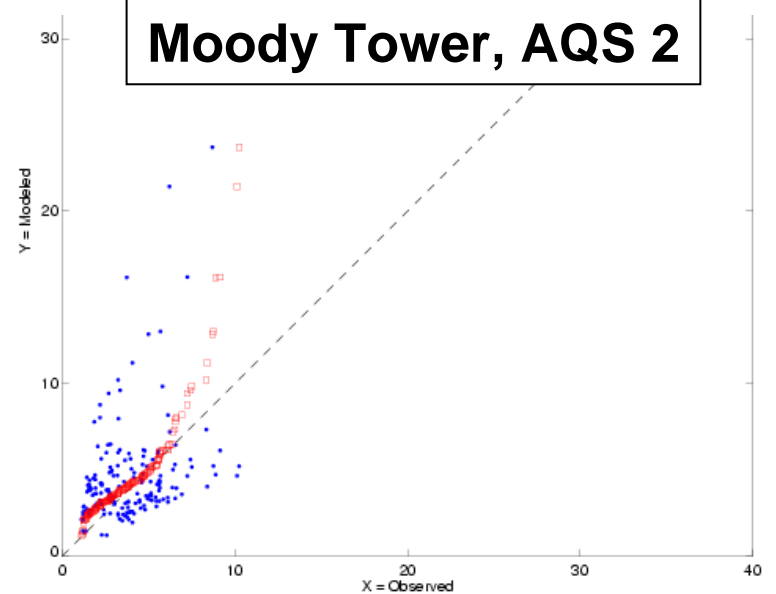
Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
453\_cb05.hgb8h2.bc06aqs2.reg10flrHR10xF4x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgb

FORM Concentrations (ppb)



**Lynchburg Ferry, AQS 2**



**Moody Tower, AQS 2**



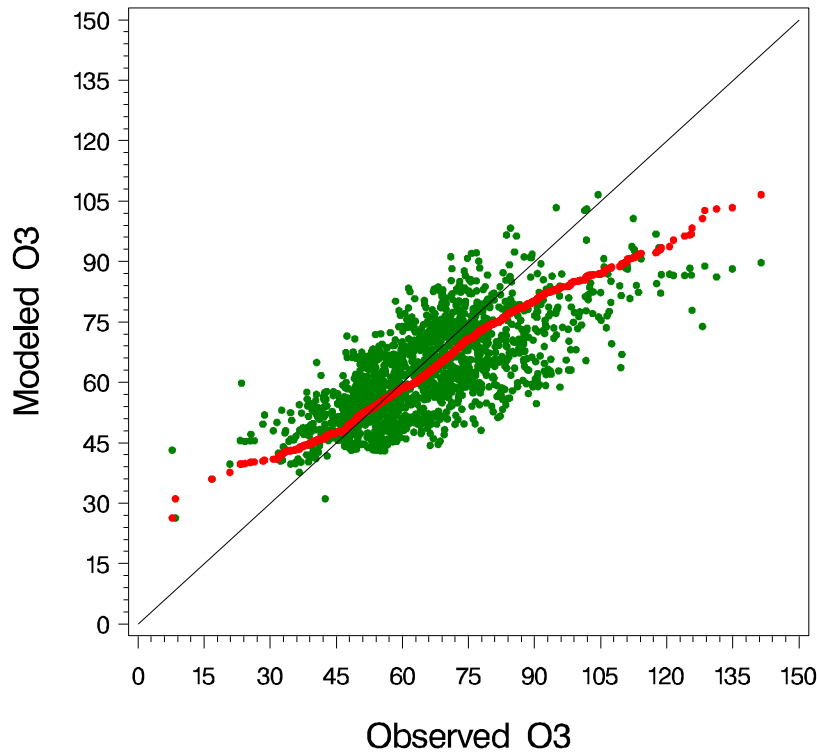
# Ozone ( $O_3$ )



# Modeled vs. Observed Ozone Concentrations, Base Case

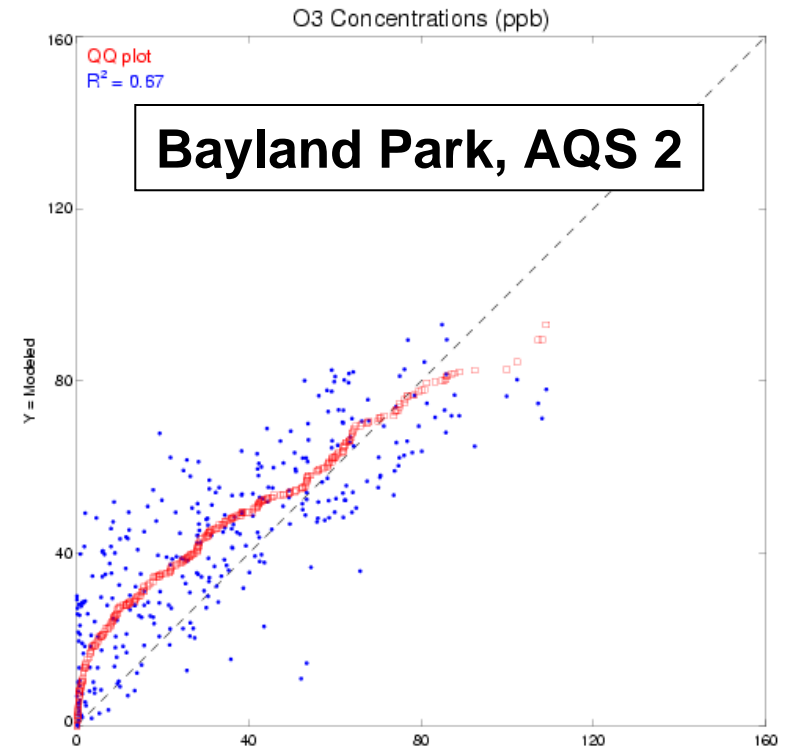
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed O3 Mixing Ratios

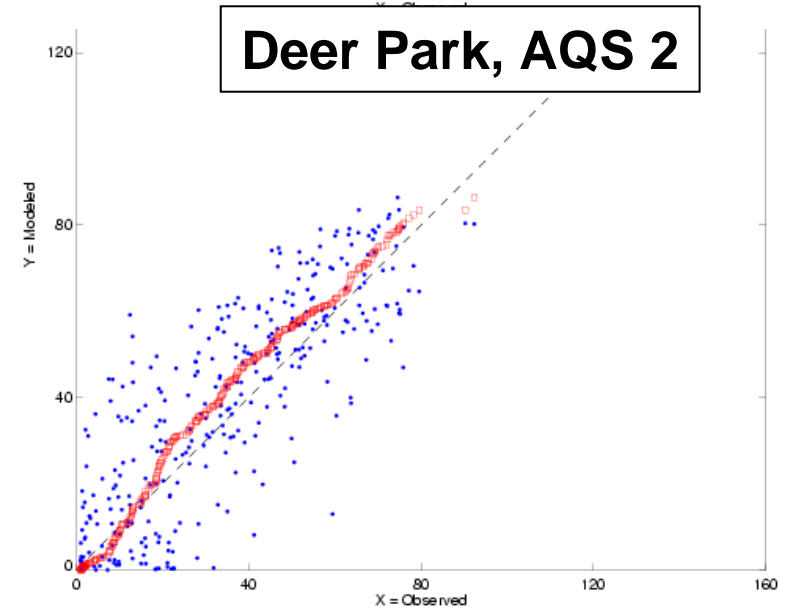


Air Quality Division • Flare Sensitivity Modeling

Modeled vs Observed: Hourly Values (20060919-20061011)  
camx453\_cb05.hgb8h2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02



**Bayland Park, AQS 2**



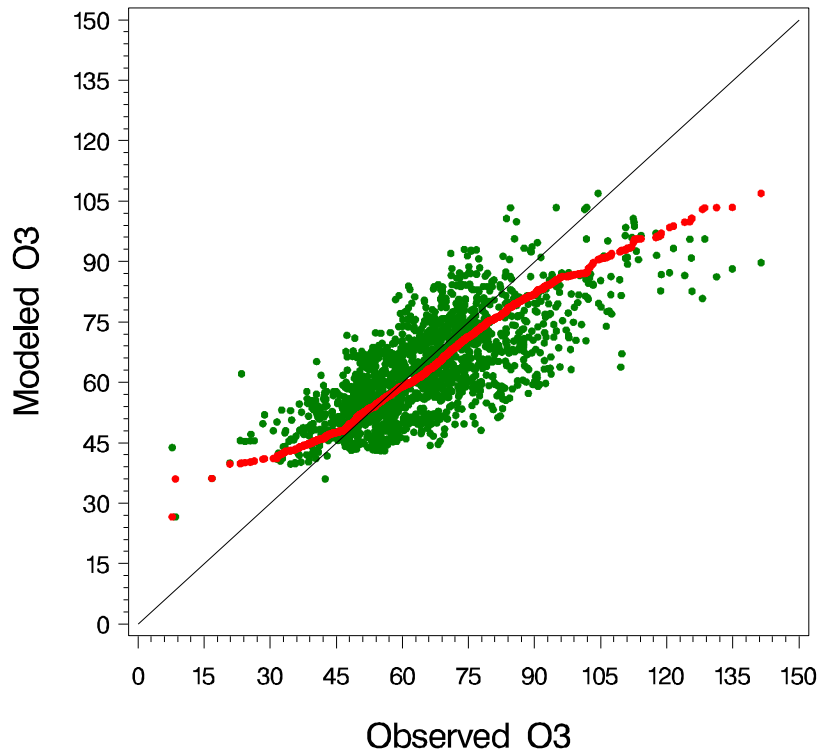
**Deer Park, AQS 2**



# Modeled vs. Observed Ozone Concentrations, F10xVOC

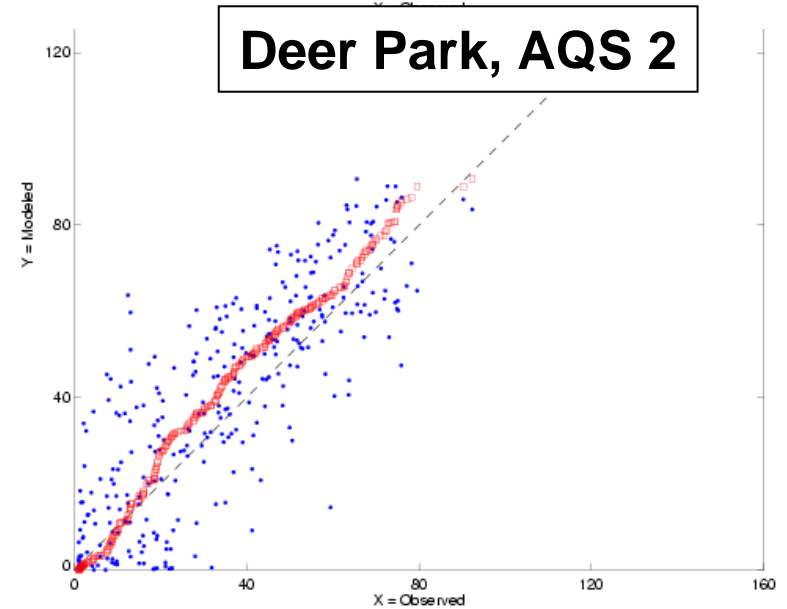
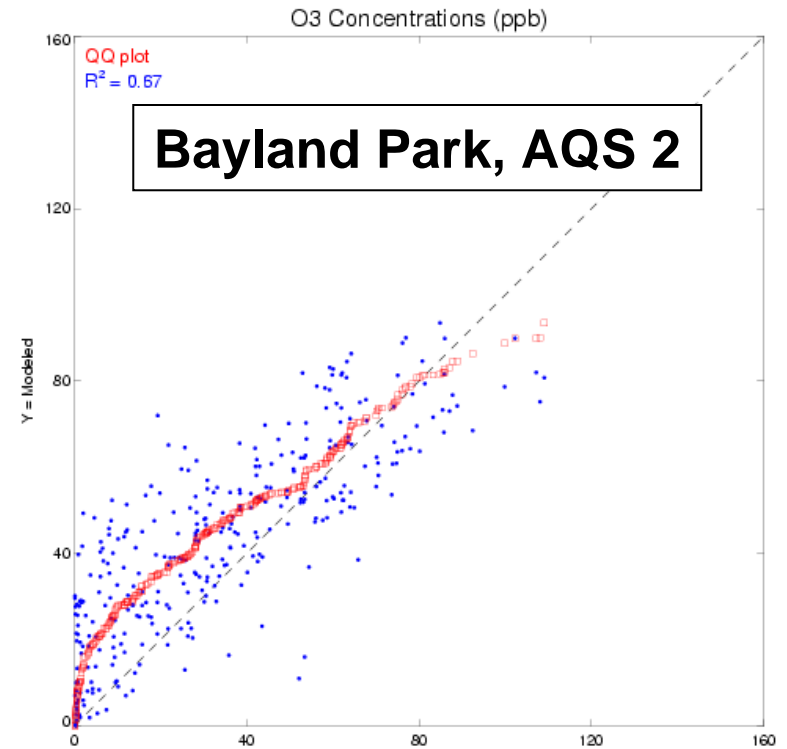
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed O3 Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs Observed: Hourly Values (20060919-20061011)  
1x453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fcdats\_newuhsst\_newutcsrluic\_grell.hgbpx

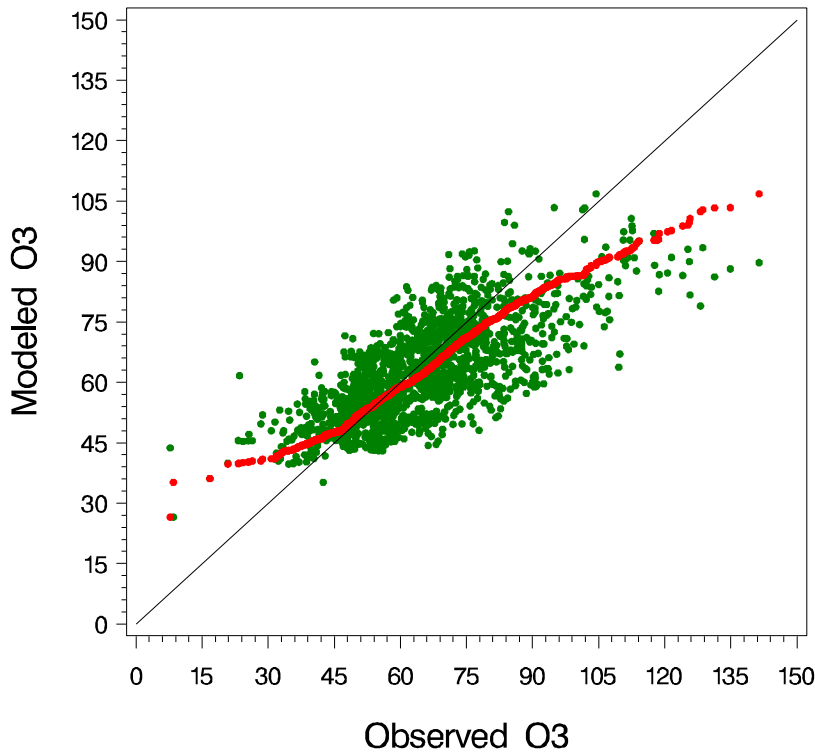




# Modeled vs. Observed Ozone Concentrations, F10xHRVOC

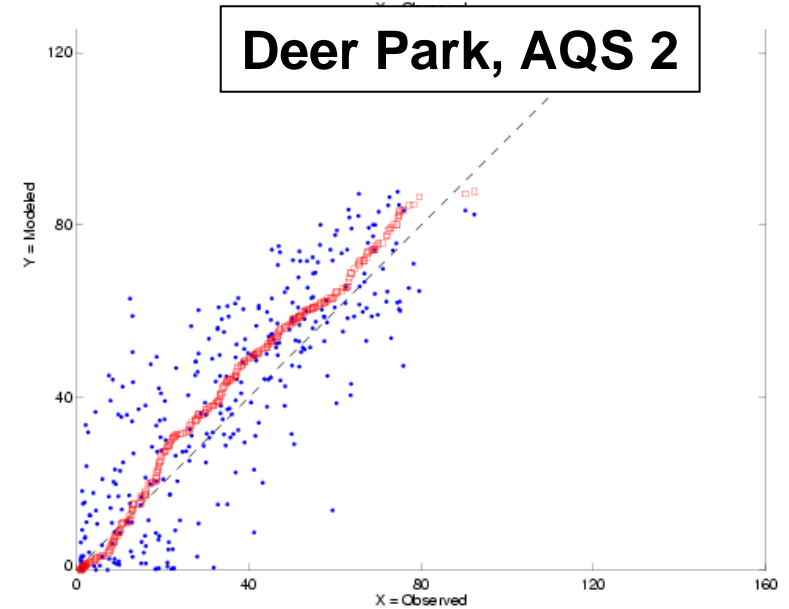
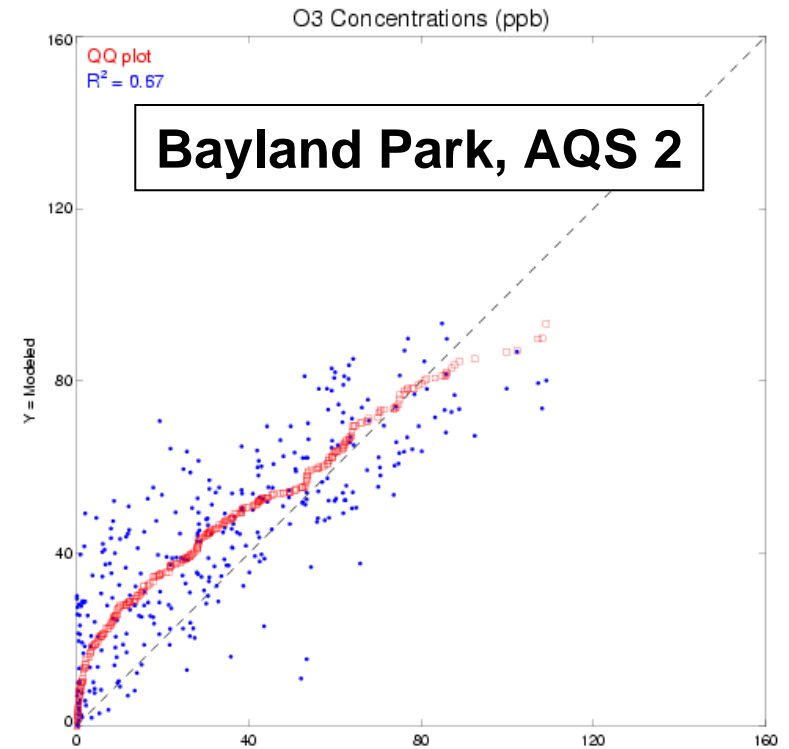
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed O3 Mixing Ratios



Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
453\_cb05.hgbsh2.bc06aqs2.reg10flrHRVoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluk\_grell.hgb

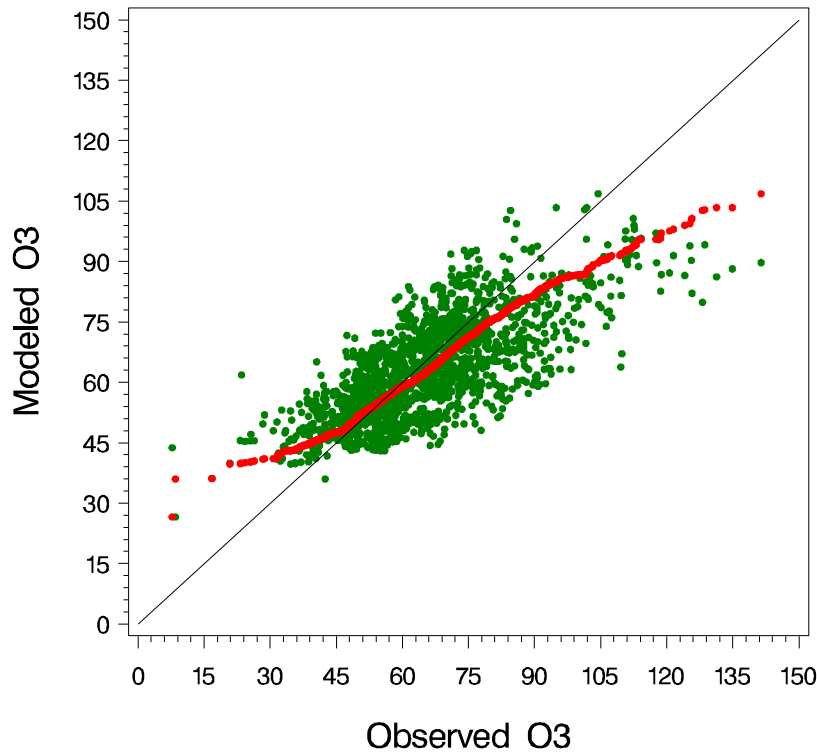




# Modeled vs. Observed Ozone Concentrations, FBoost

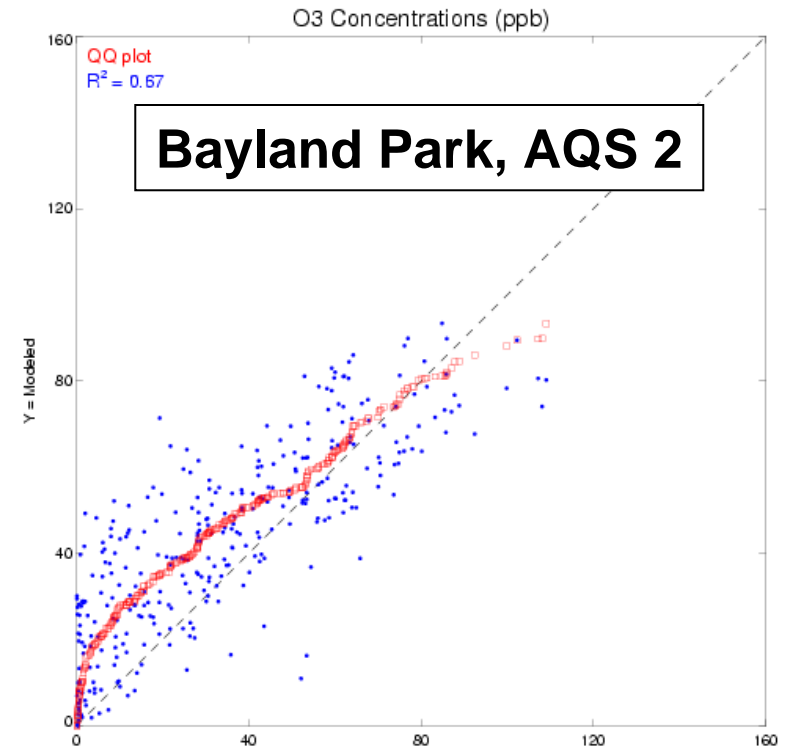
**NOAA P3, Sep 30 – Aug 13**

Modeled vs. Observed O3 Mixing Ratios

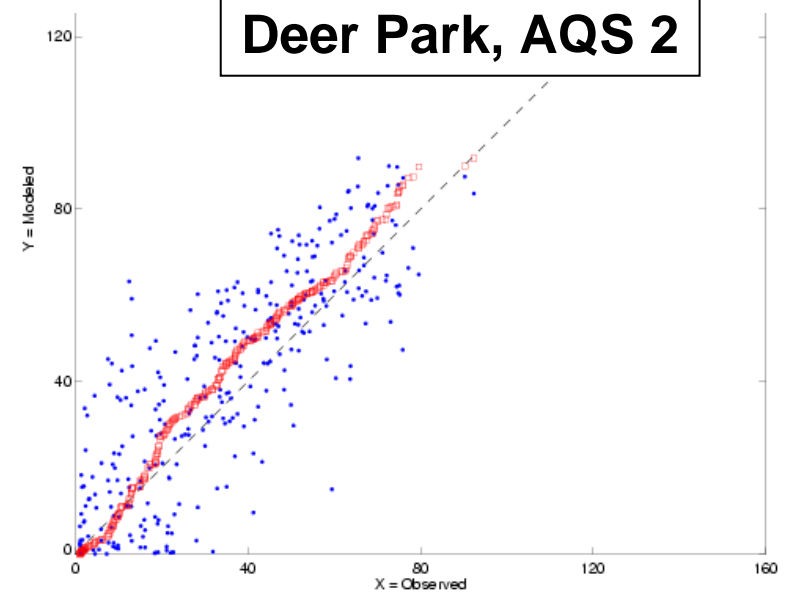


Air Quality Division • Flare Sensitivity Modeling

Modeled vs. Observed: Hourly Values (20060919-20061011)  
453\_cb05.hgb8h2.bc06aqs2.reg10flrHR10xF4x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgb



**Bayland Park, AQS 2**



**Deer Park, AQS 2**



# August 17, 2006 Case Study

---

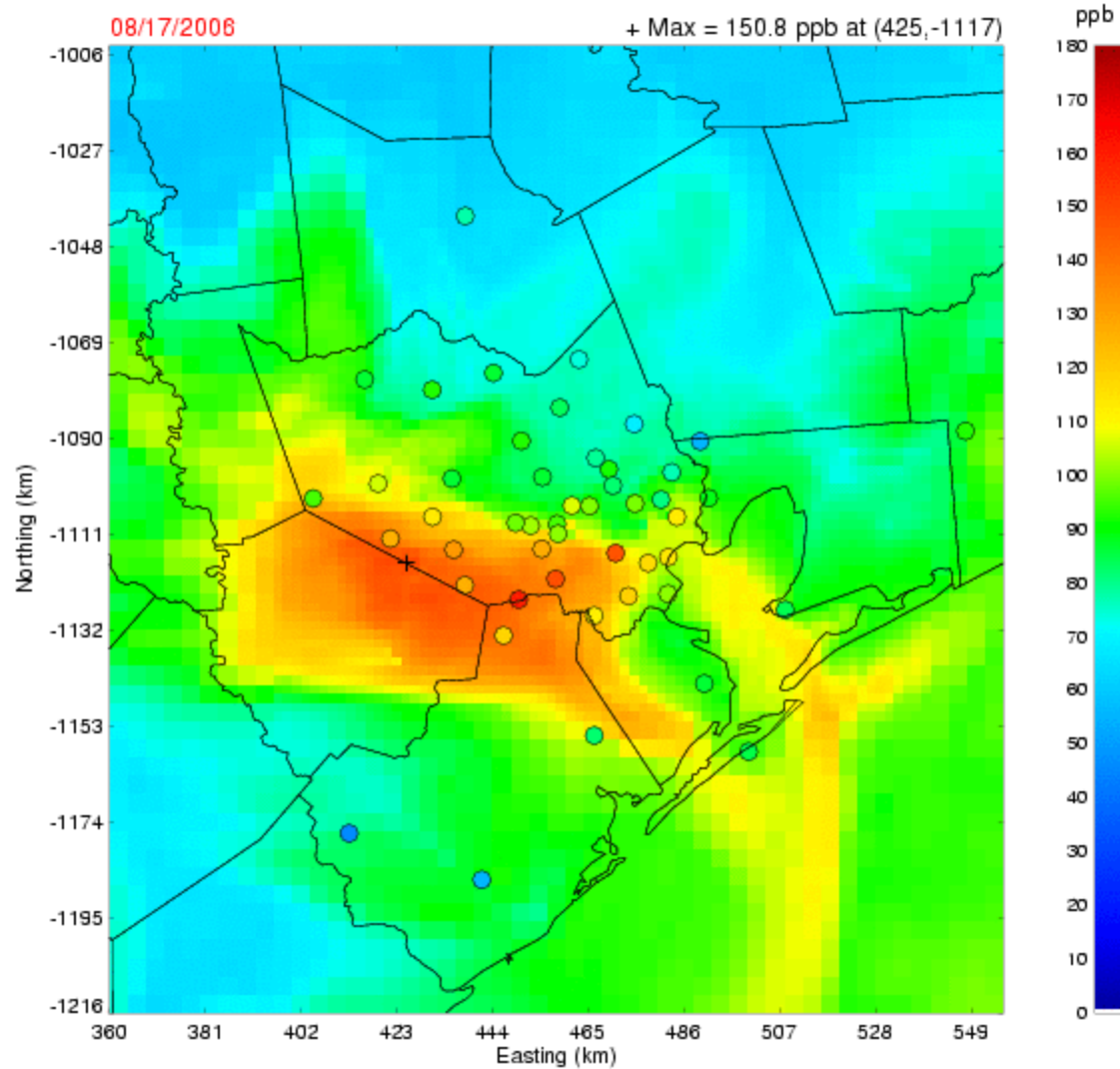
## **Base Case vs. F10xVOC**



# Base Case August 17, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10si.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluk\_grell.hgbpa\_02km

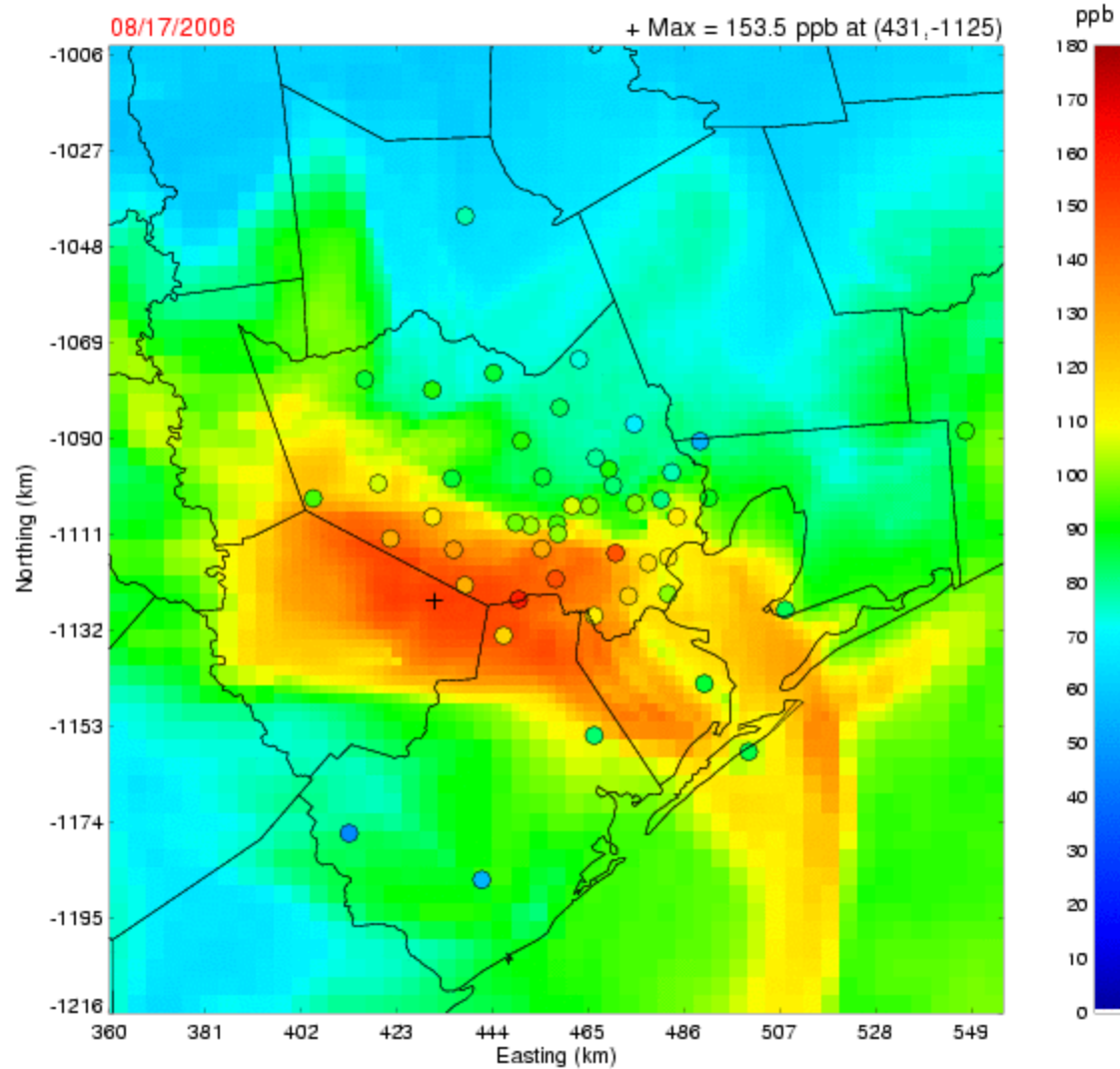




# 10X Flare VOC August 17, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10si\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km



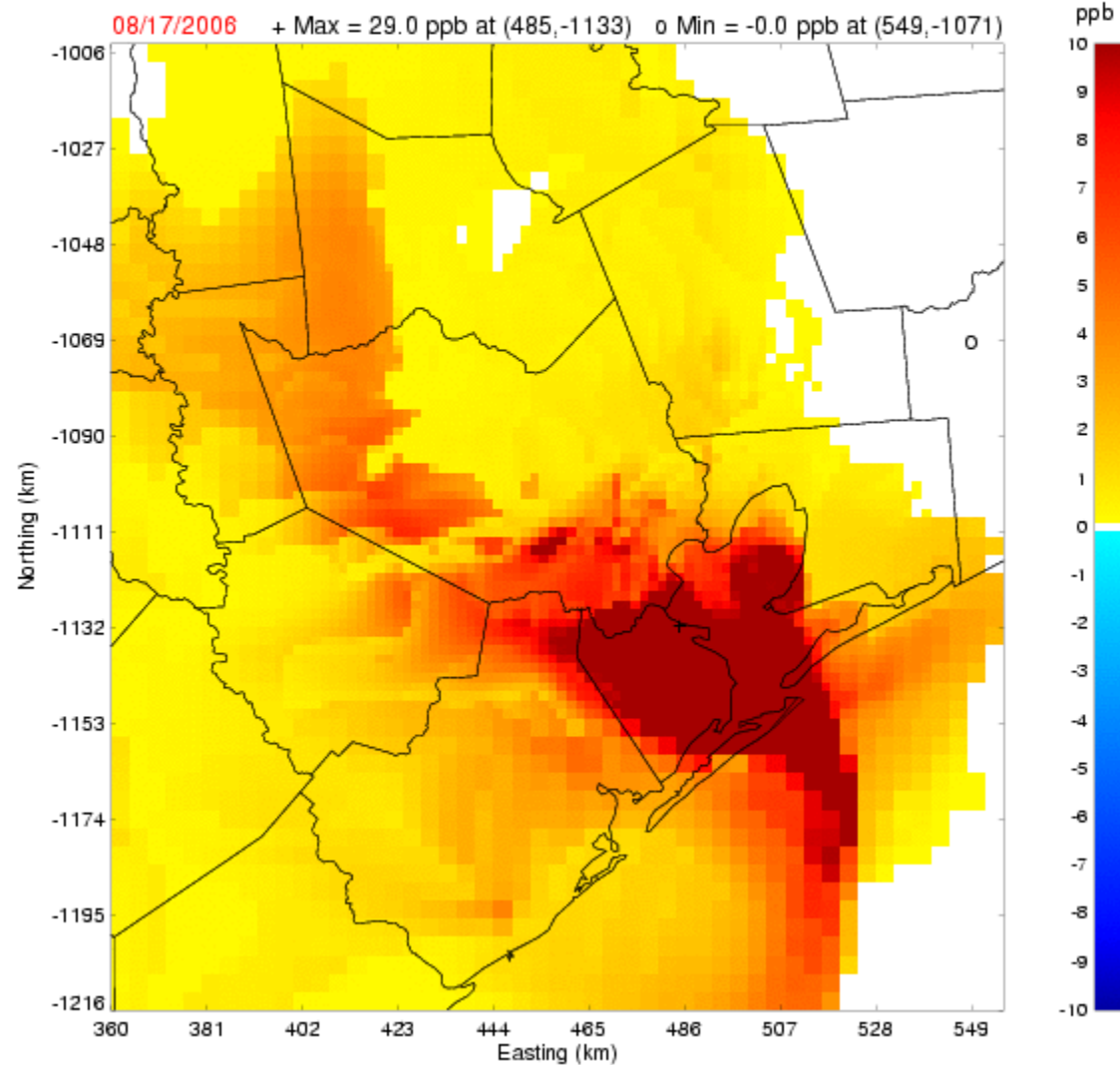


# 10X Flare VOC – Base Case August 17, 2006

Difference of Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10si\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km

- camx453\_cb05.hgb8h2.bc06aqs1.reg10si.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km





# August 17, 2006 Case Study

---

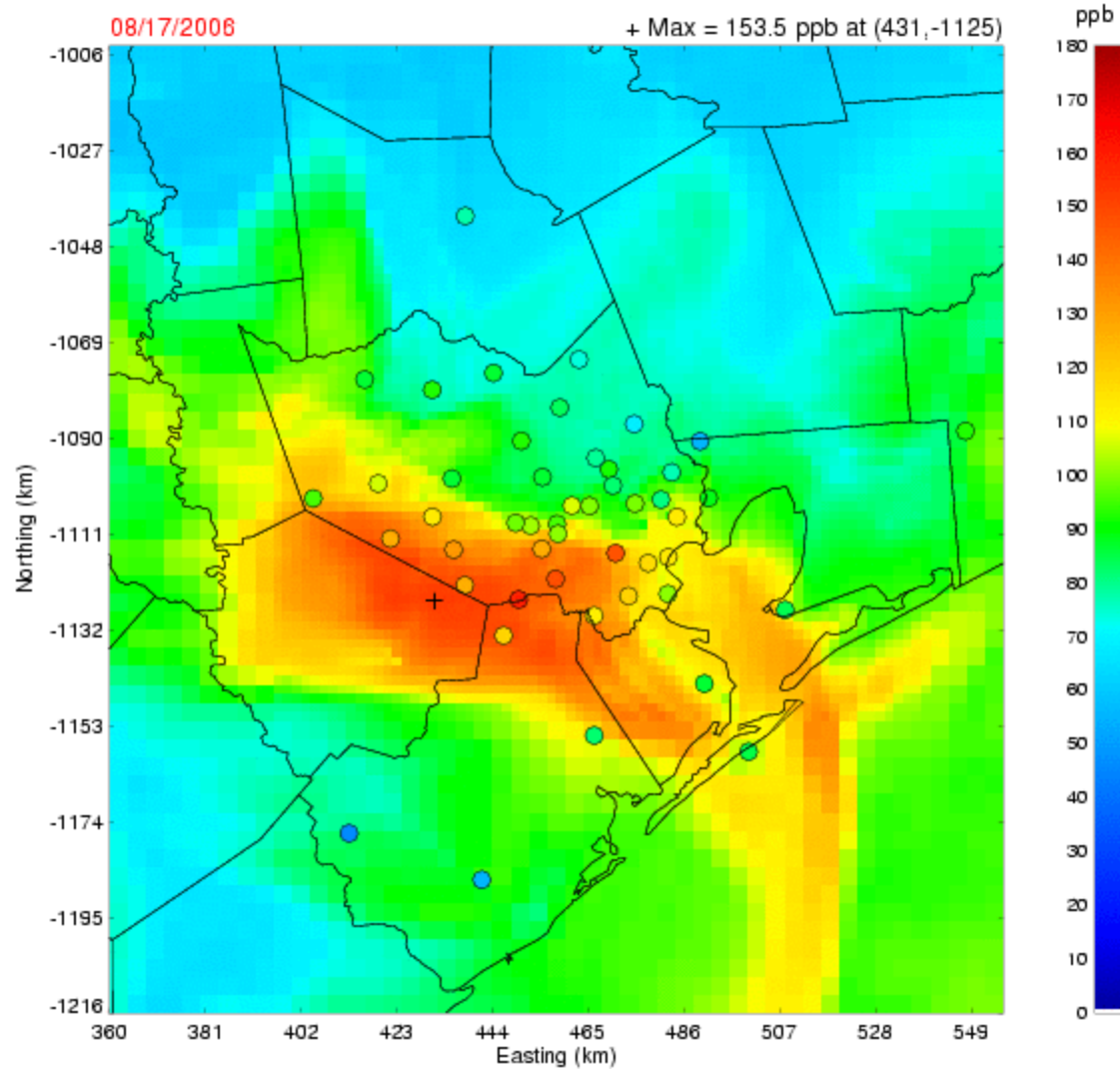
## **F10xVOC vs. F10xHRVOC**



# 10X Flare VOC August 17, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10si\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km

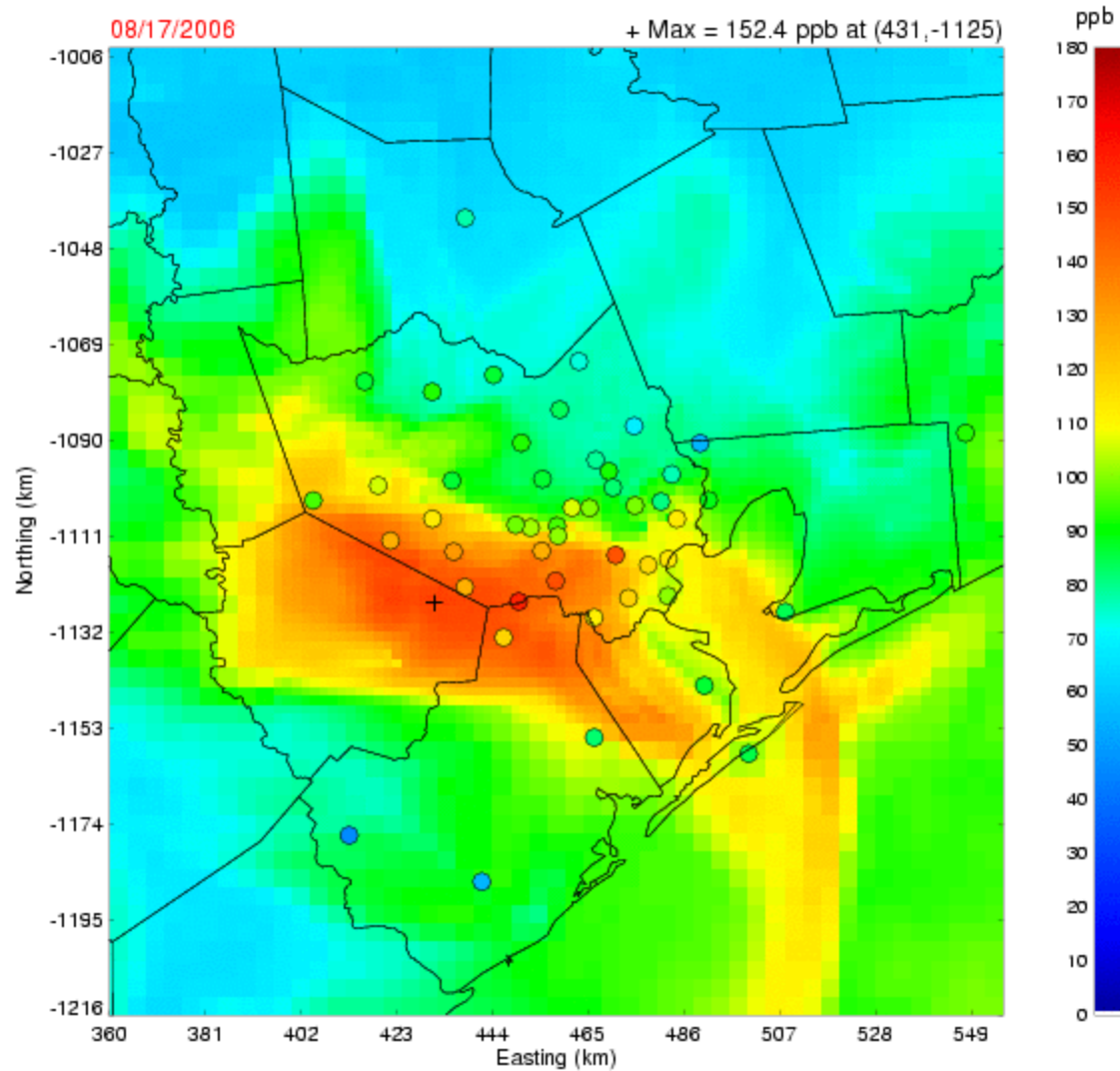




# 10X Flare HRVOC August 17, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10siflrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluc\_grell.hgbpa\_02km

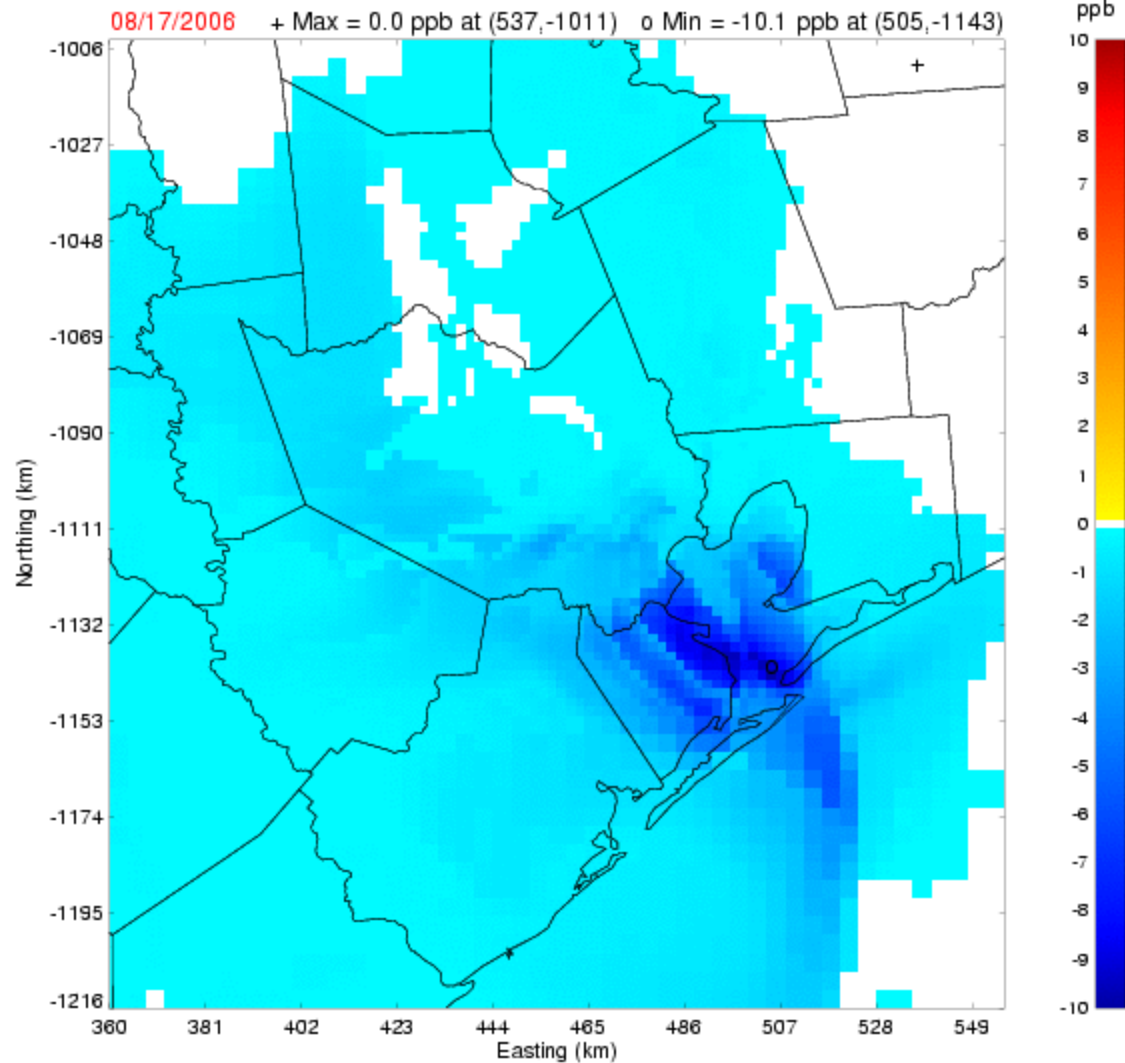




# 10X Flare HRVOC - 10X Flare VOC August 17, 2006

Difference of Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10siflrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km  
- camx453\_cb05.hgb8h2.bc06aqs1.reg10si\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km





# August 17, 2006 Case Study

---

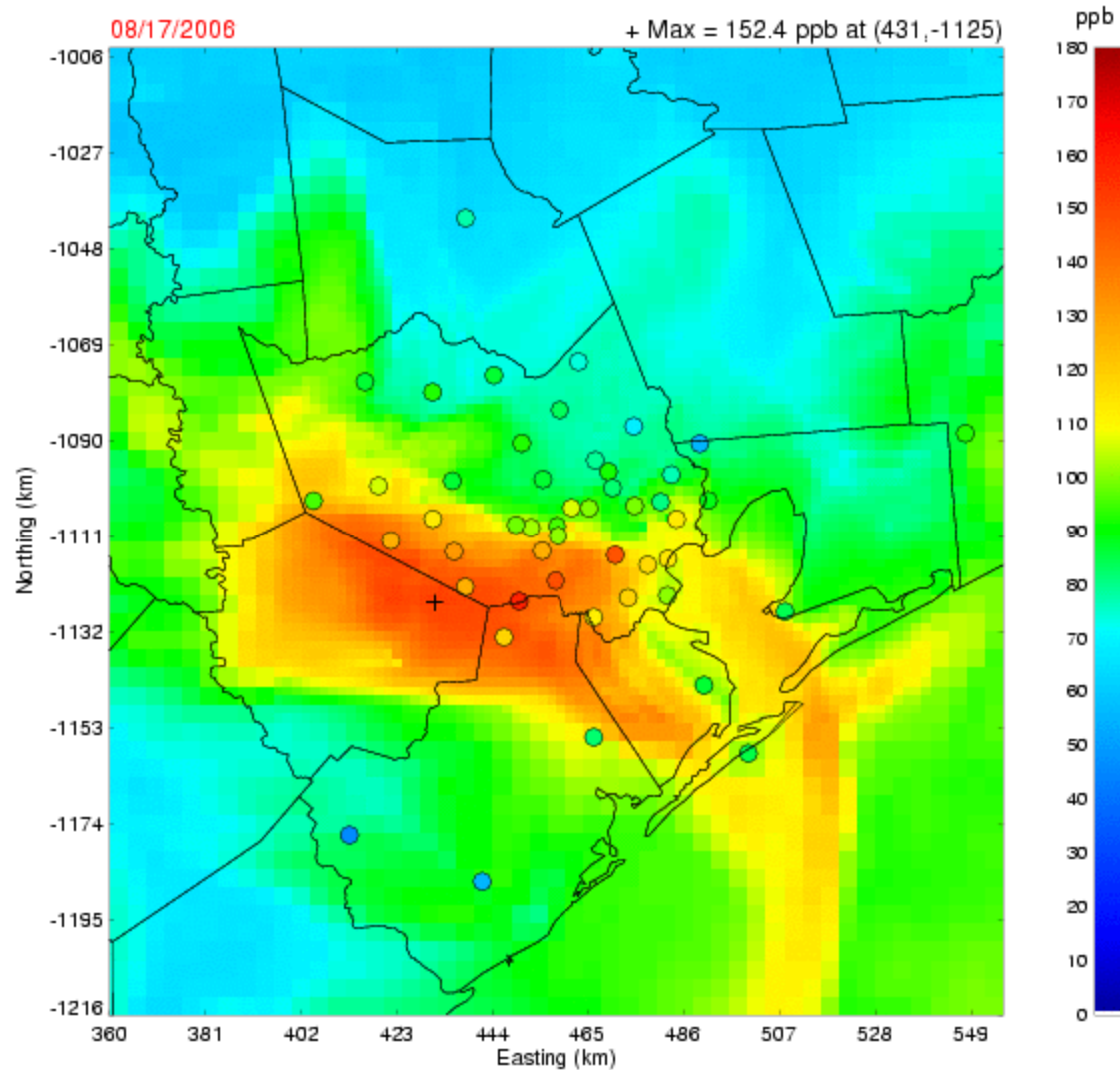
## **F10xHRVOC vs. FBoost**



# 10X Flare HRVOC August 17, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10siflrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluc\_grell.hgbpa\_02km

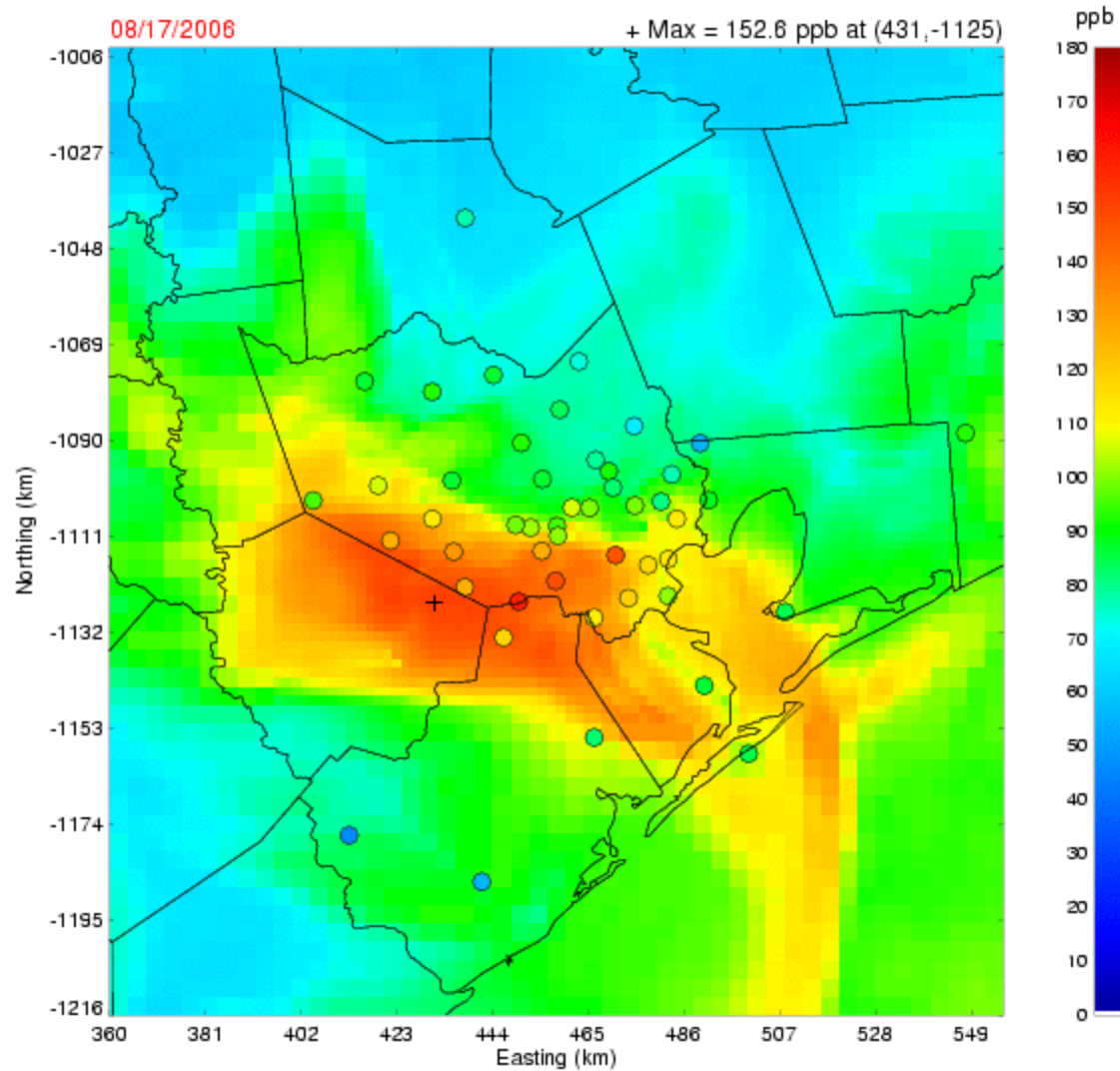




# HCHO Boost August 17, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10siflrHR10xF4x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluc\_grell.hgbpa\_02km

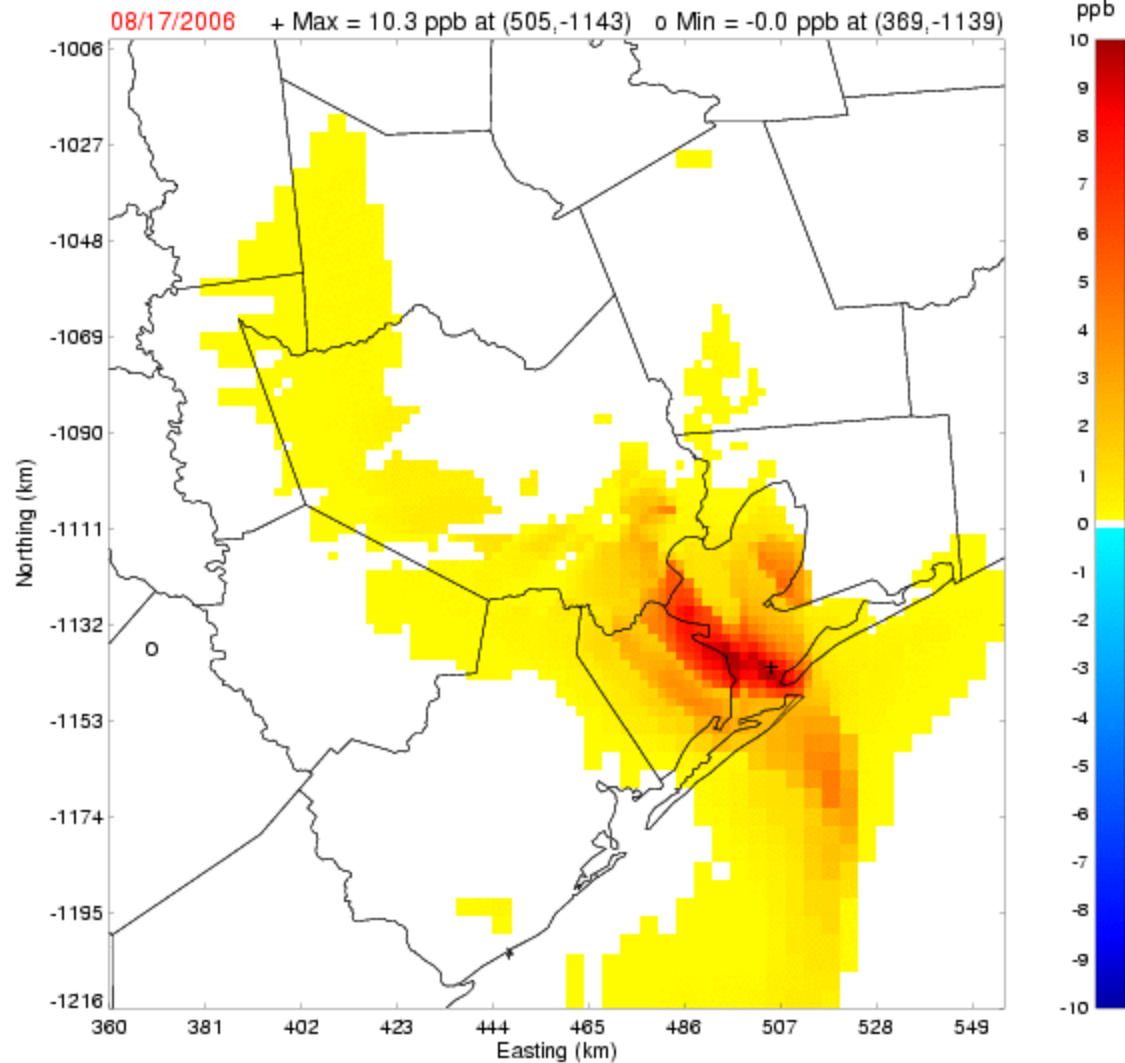




# HCHO Boost - 10X Flare HRVOC August 17, 2006

Difference of Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs1.reg10siflrHR10xF4x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km  
- camx453\_cb05.hgb8h2.bc06aqs1.reg10siflrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km





# October 6, 2006 Case Study

---

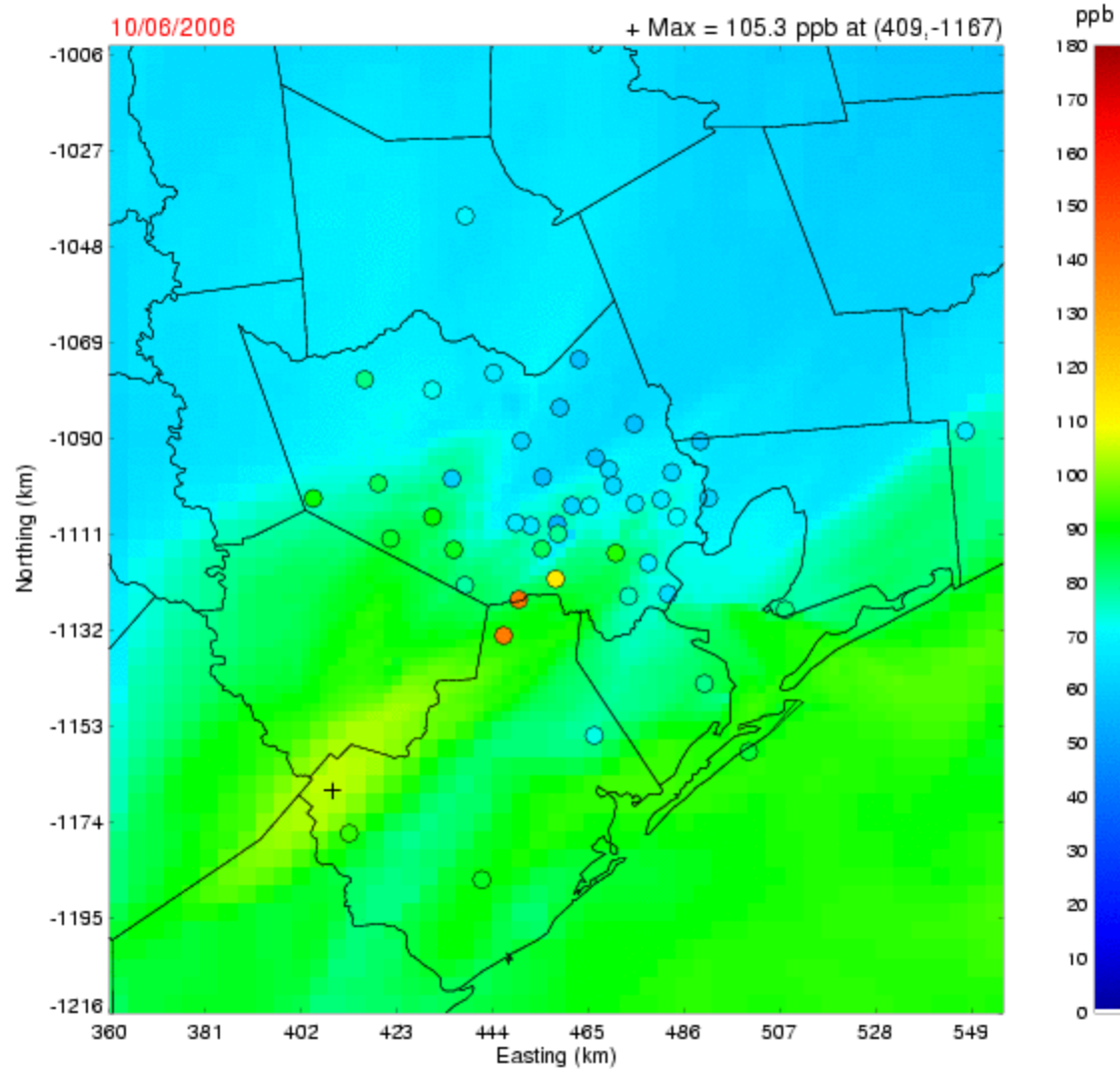
## **Base Case vs. F10xVOC**



# Base Case October 6, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsruluc\_grell.hgbpa\_02km

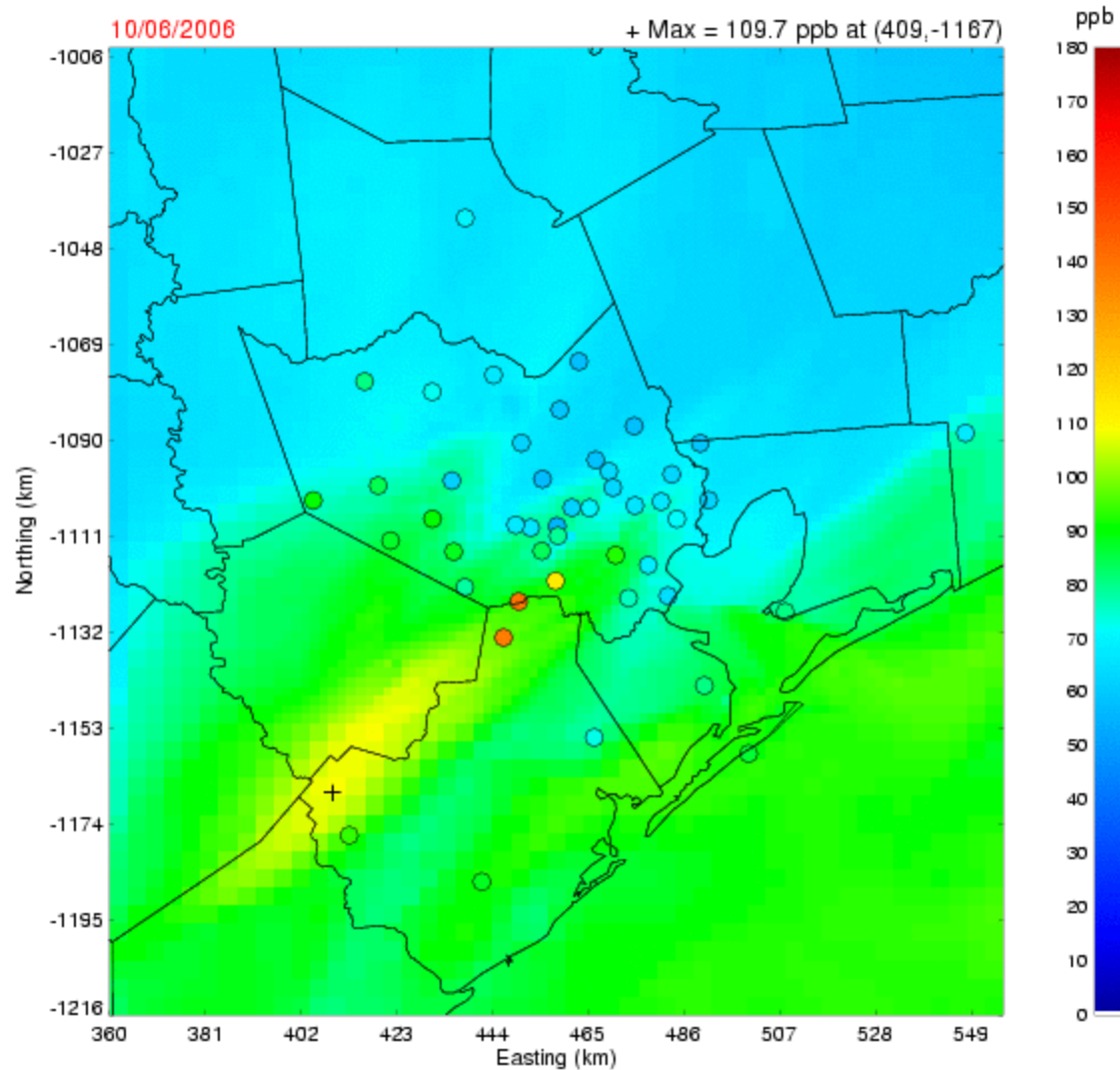




# 10X Flare VOC October 6, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km

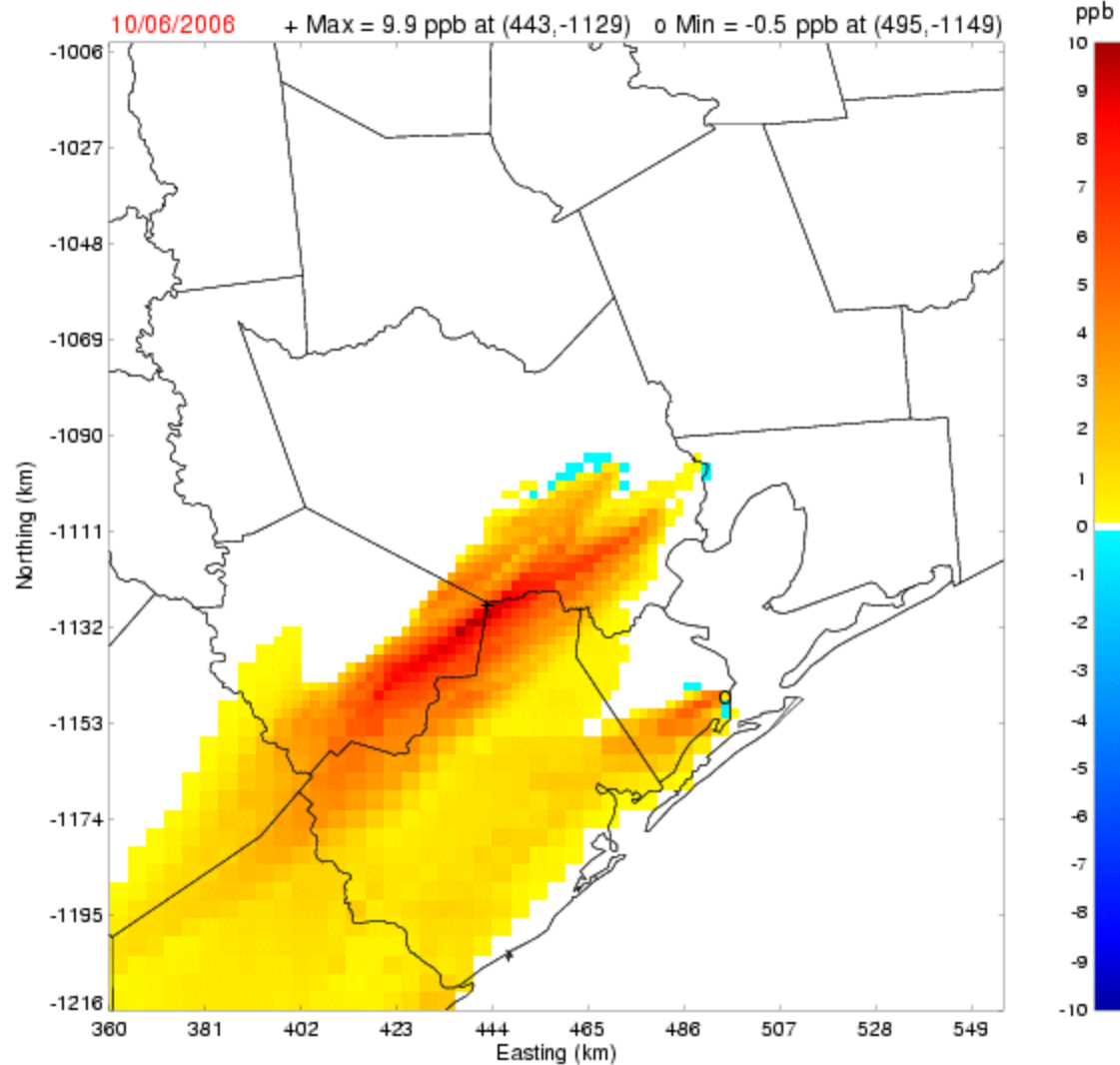




# 10X Flare VOC - Base Case October 6, 2006

Difference of Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulc\_grell.hgbpa\_02km  
- camx453\_cb05.hgb8h2.bc06aqs2.reg10.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrulc\_grell.hgbpa\_02km





# October 6, 2006 Case Study

---

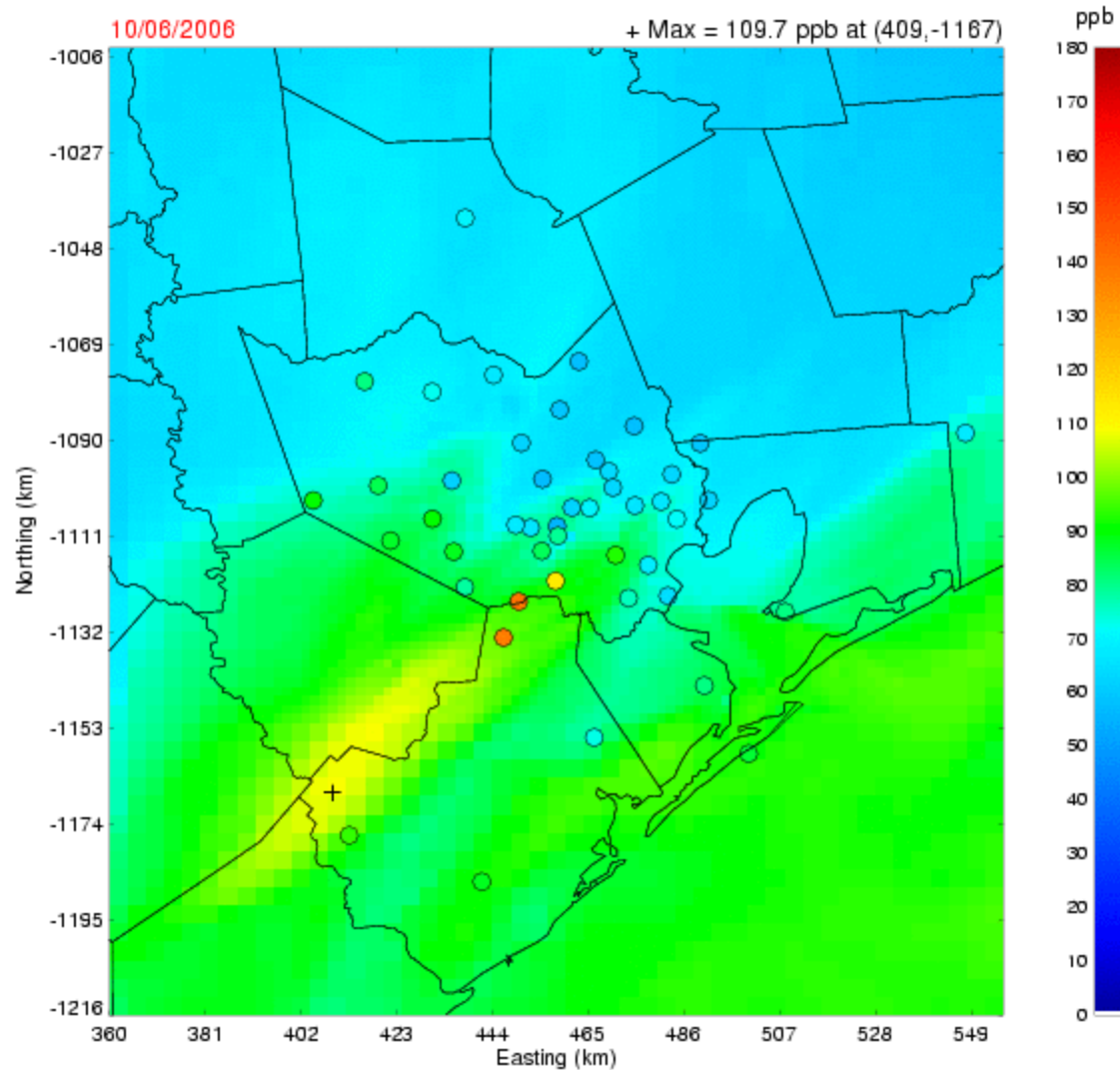
## **F10xVOC vs. F10xHRVOC**



# 10X Flare VOC October 6, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km

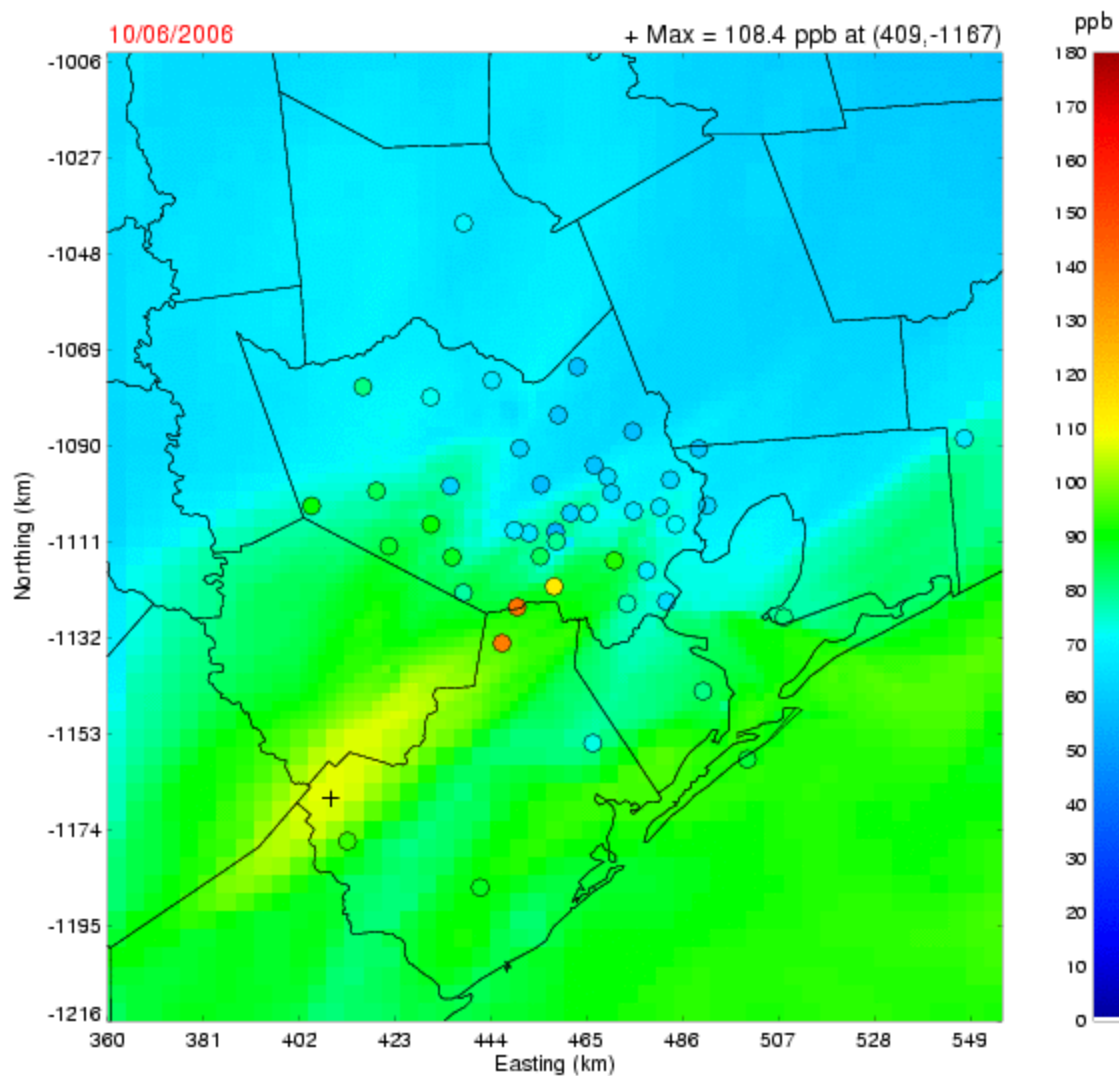




# 10X Flare HRVOC October 6, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10flrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km

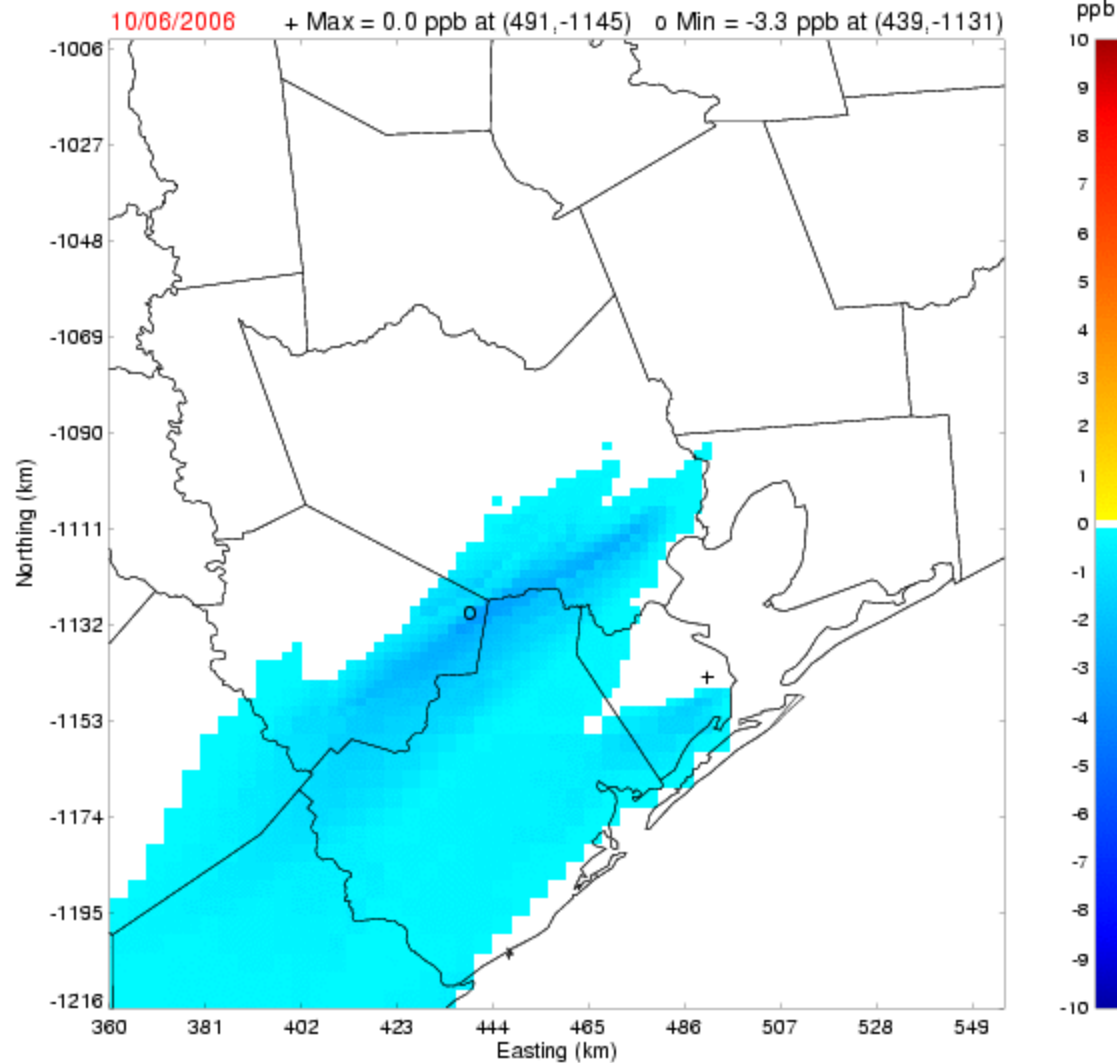




# 10X Flare HRVOC - 10X Flare VOC October 6, 2006

Difference of Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10flrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluc\_grell.hgbpa\_02km  
- camx453\_cb05.hgb8h2.bc06aqs2.reg10\_flare10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluc\_grell.hgbpa\_02km





# October 6, 2006 Case Study

---

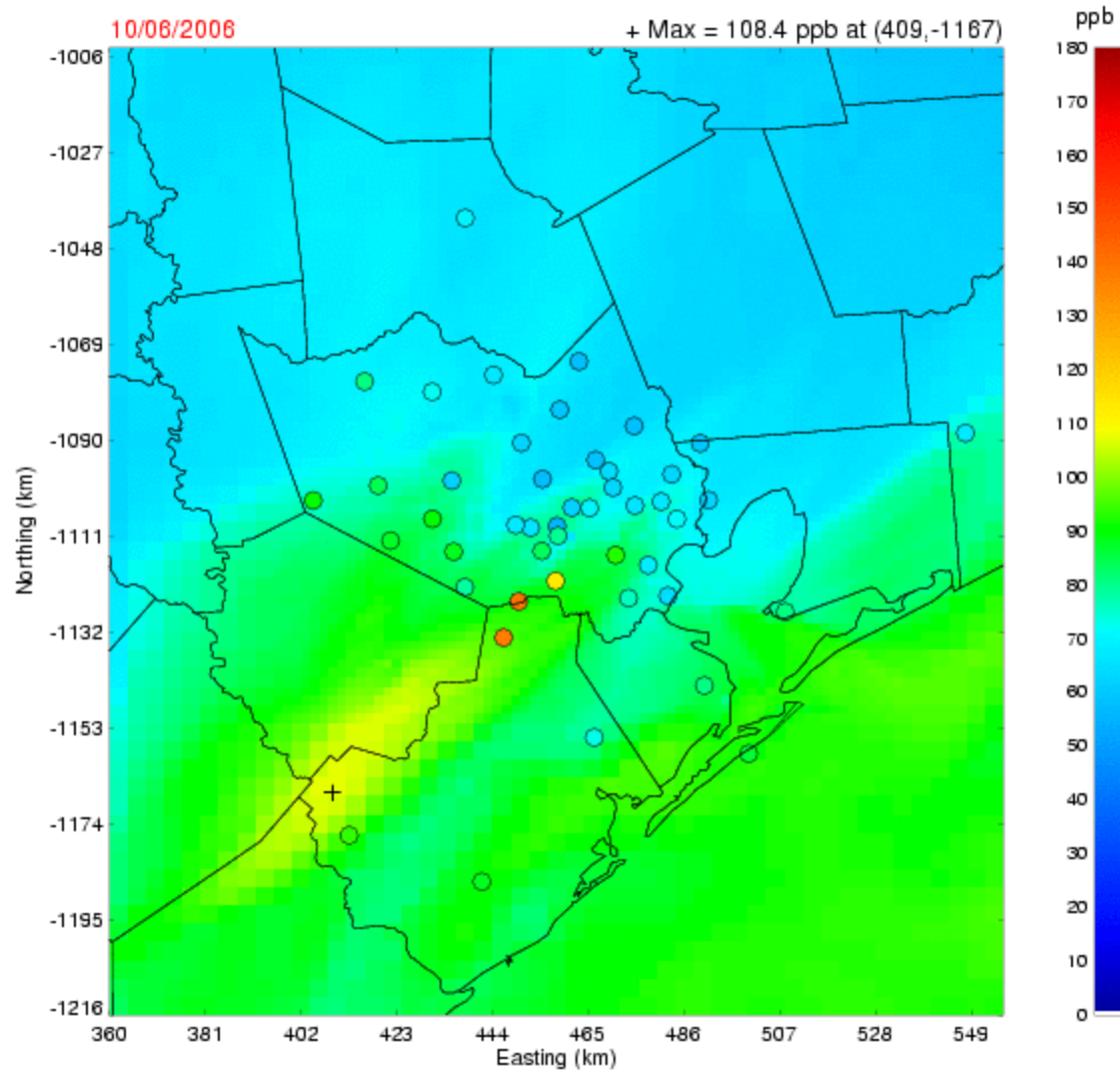
## **F10xHRVOC vs. FBoost**



# 10X Flare HRVOC October 6, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10flrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrlulc\_grell.hgbpa\_02km

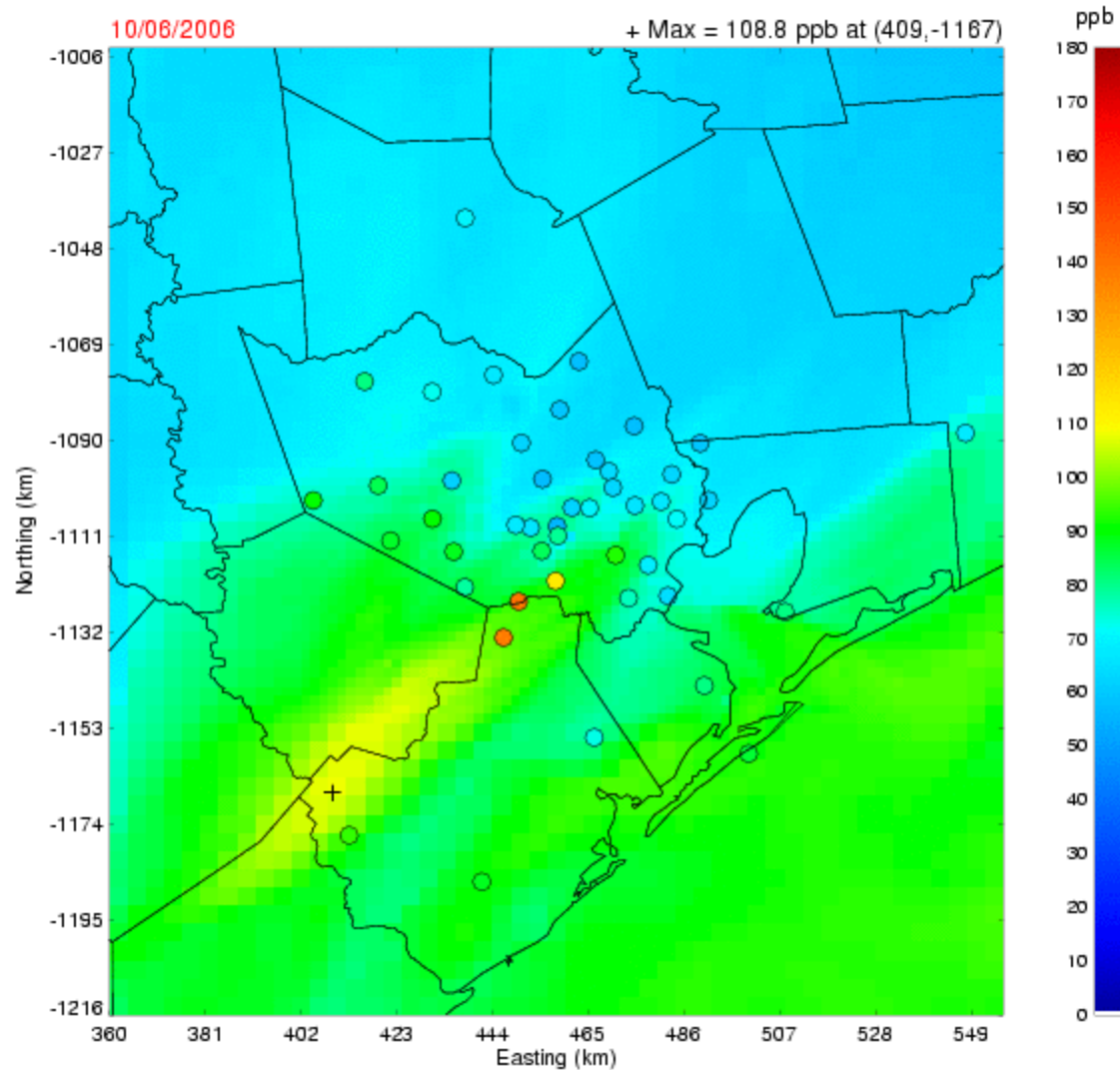




# HCHO Boost October 6, 2006

Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10flrHR10xF4x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluk\_grell.hgbpa\_02km

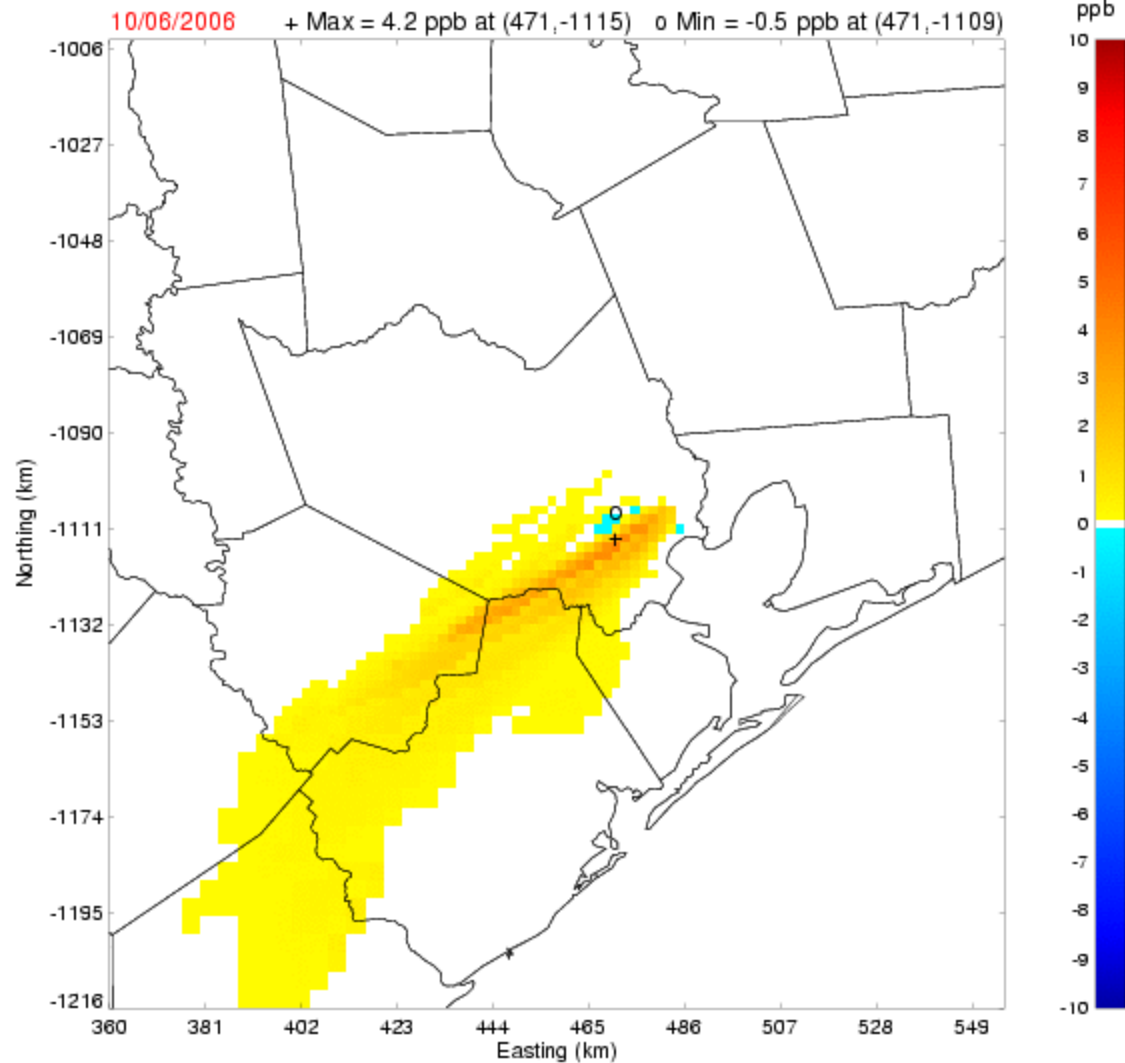




# HCHO Boost -10X Flare HRVOC October 6, 2006

Difference of Layer 1 Daily Max of Hourly Ozone Concentration (ppb)

camx453\_cb05.hgb8h2.bc06aqs2.reg10flrHR10xF4x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluk\_grell.hgbpa\_02km  
- camx453\_cb05.hgb8h2.bc06aqs2.reg10flrHRvoc10x.2006ep1\_eta\_dbemis\_fddats\_newuhsst\_newutcsrluk\_grell.hgbpa\_02km



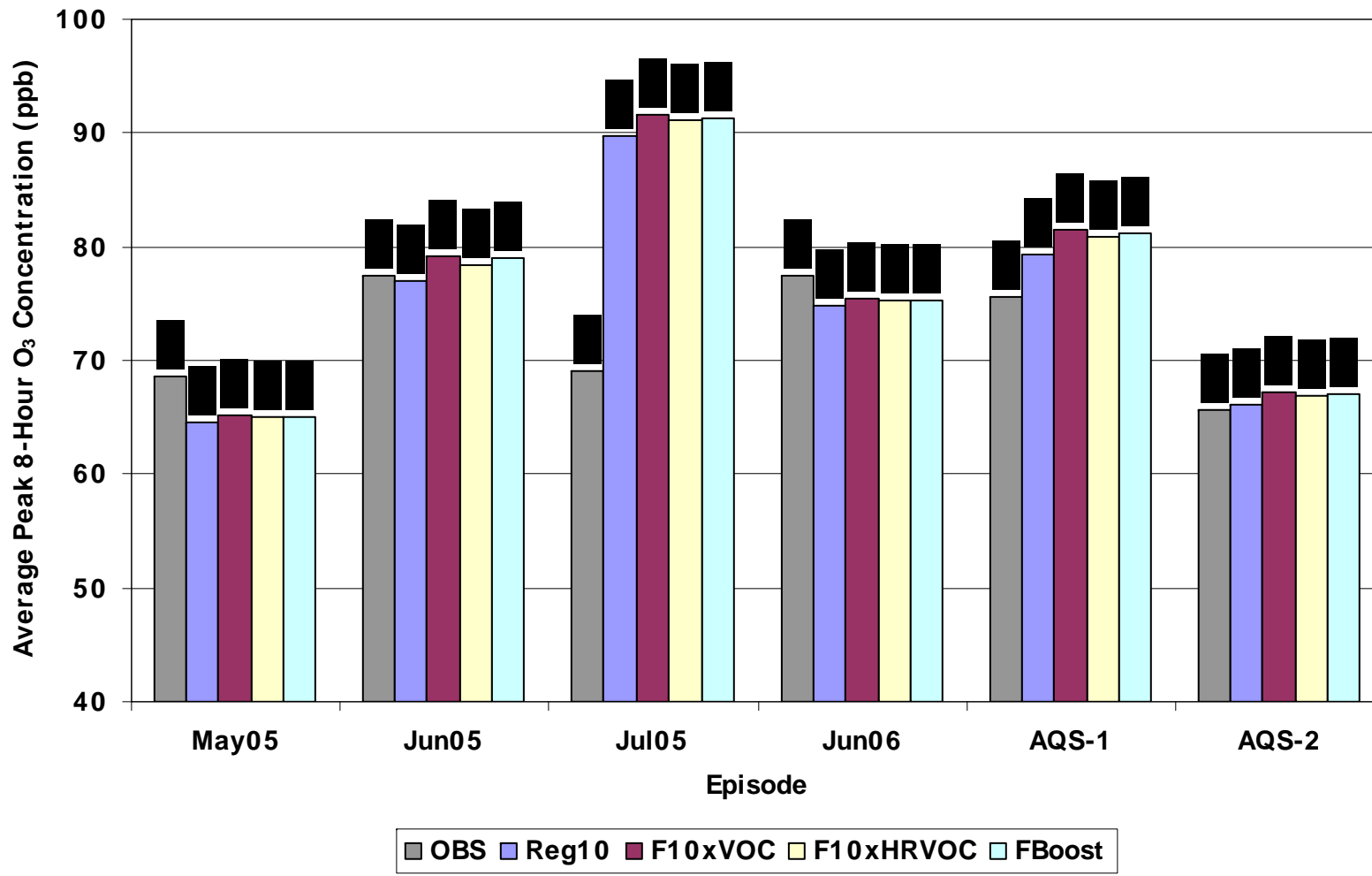


## Model Performance Summary

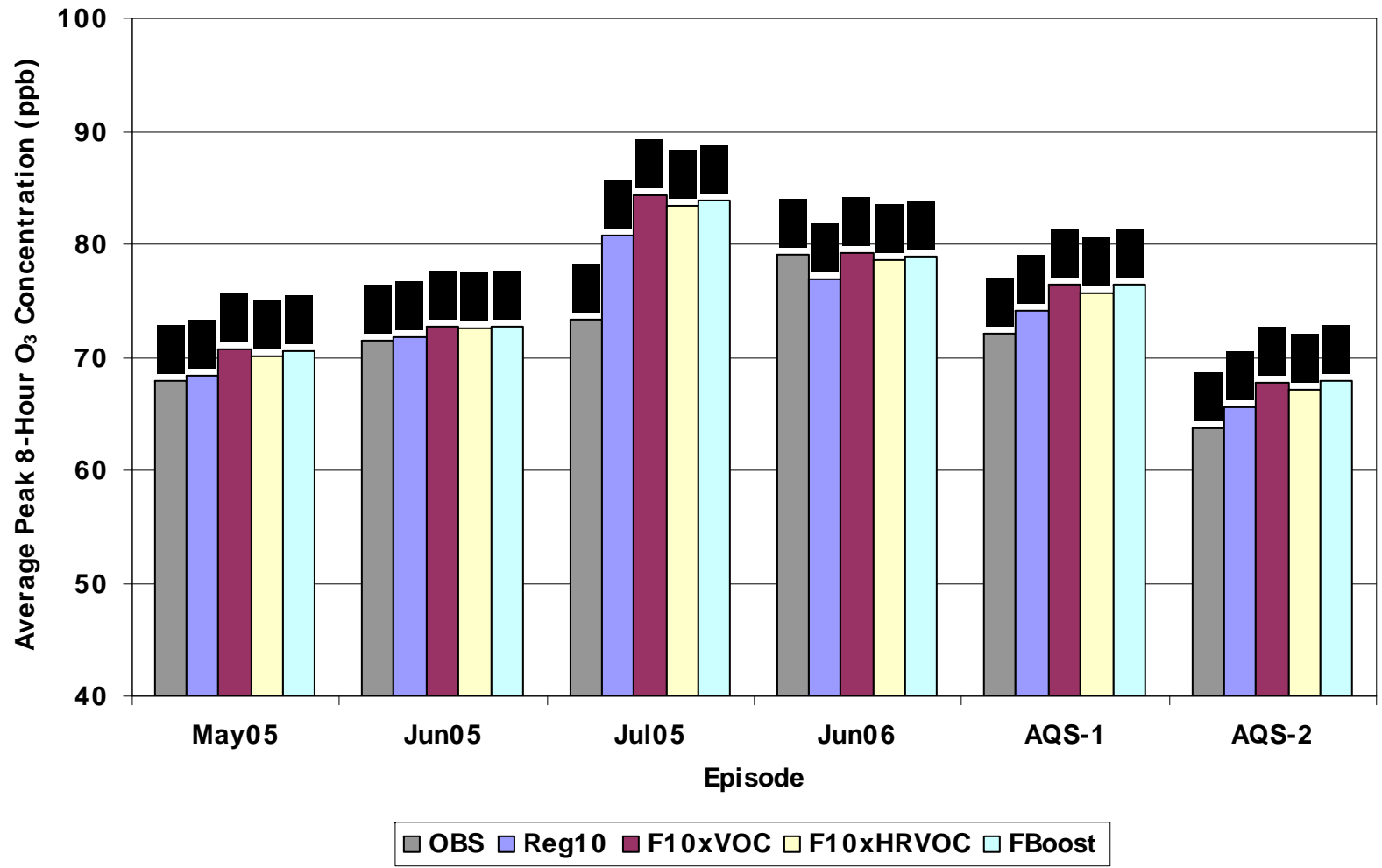
---

- The following slides show episode average maximum eight-hour ozone concentrations for Reg10 Base Case and the three flare sensitivities, compared with observed, for five important sites. Days with observed ozone concentrations  $< 50$  ppb were excluded from the averages.

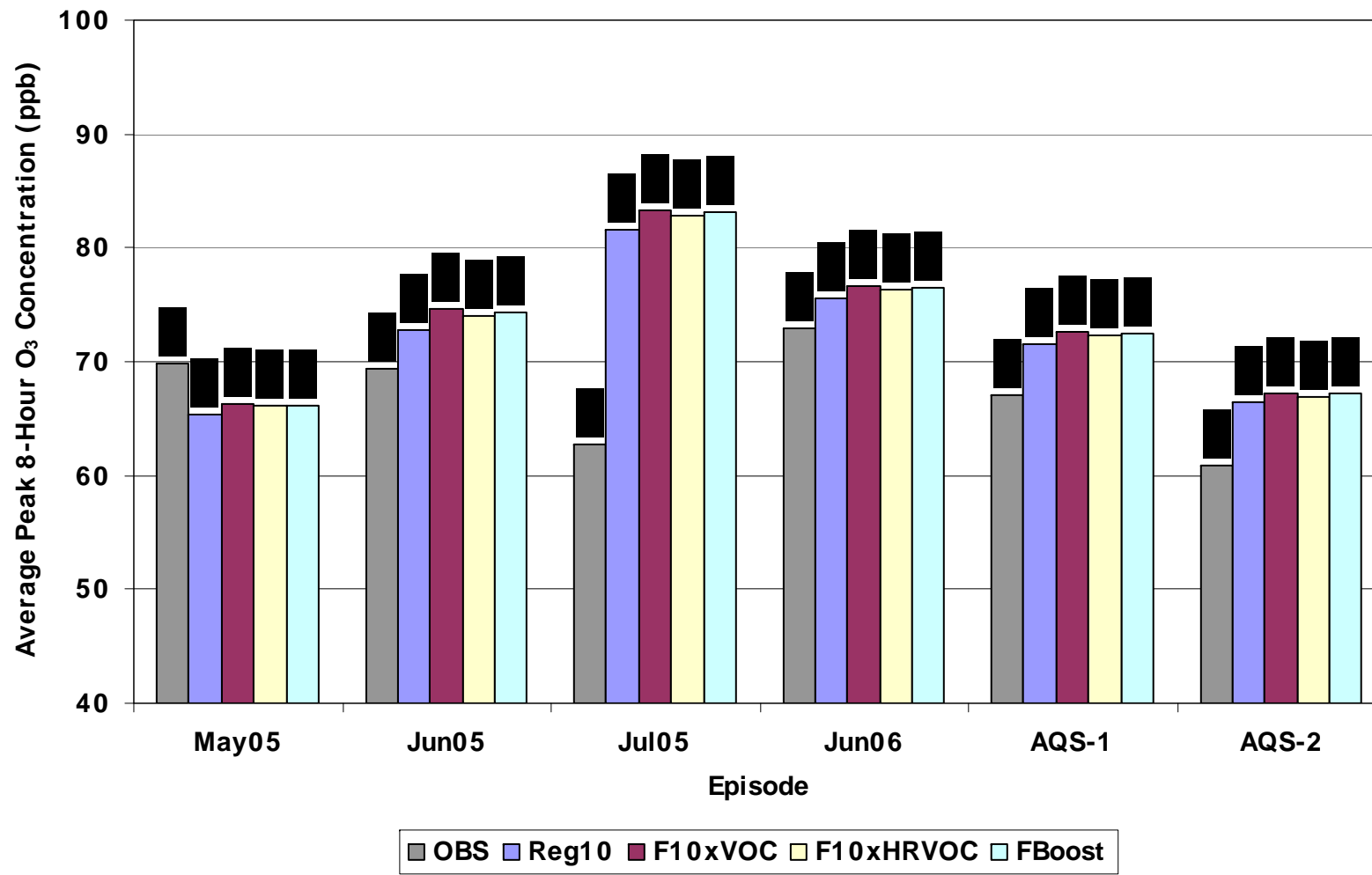
### Average Modeled 8-Hour Peak O<sub>3</sub> by Episode for 2006 Base Case and Three Flare Sensitivities Bayland Park



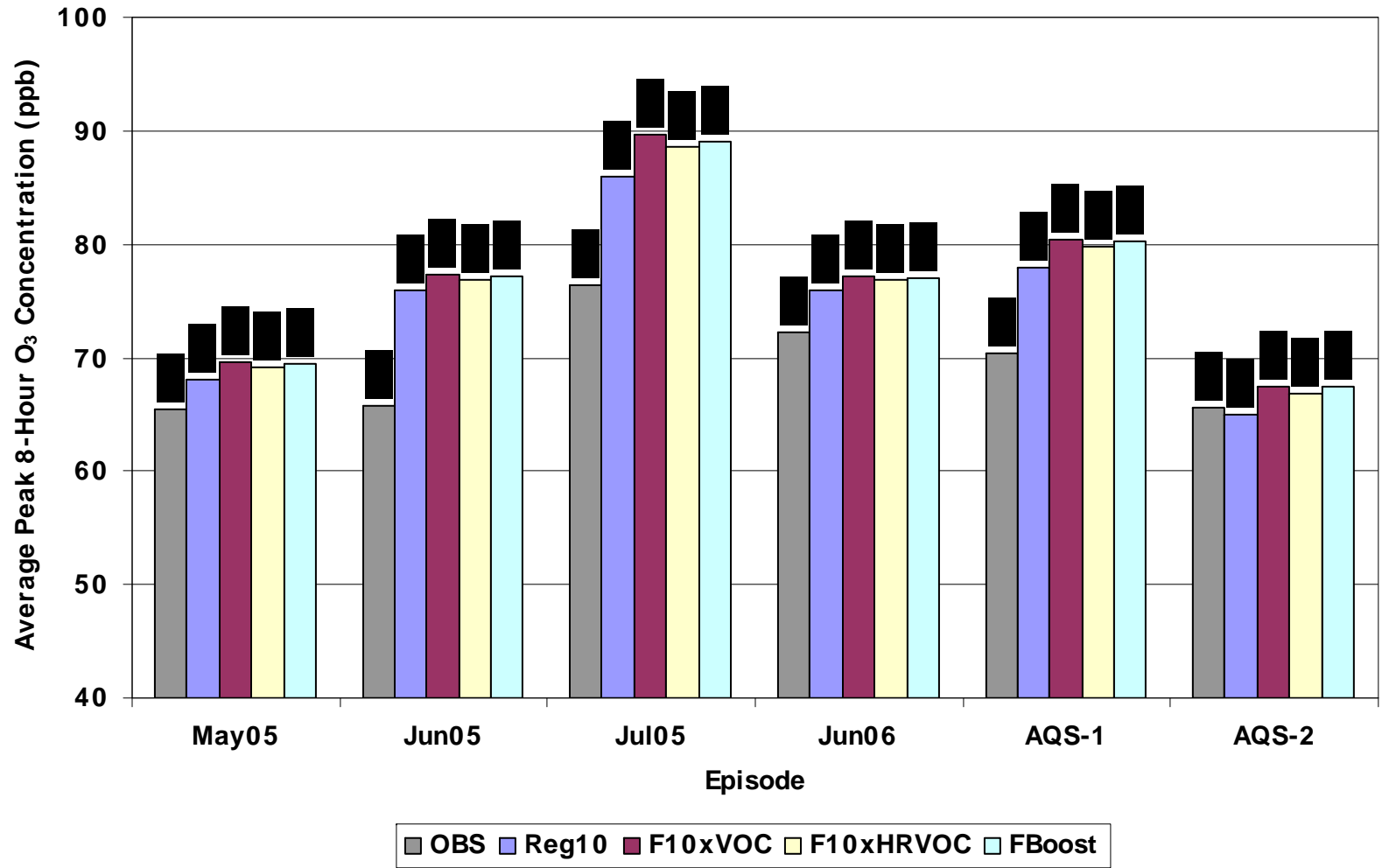
### Average Modeled 8-Hour Peak O<sub>3</sub> by Episode for 2006 Base Case and Three Flare Sensitivities Deer Park



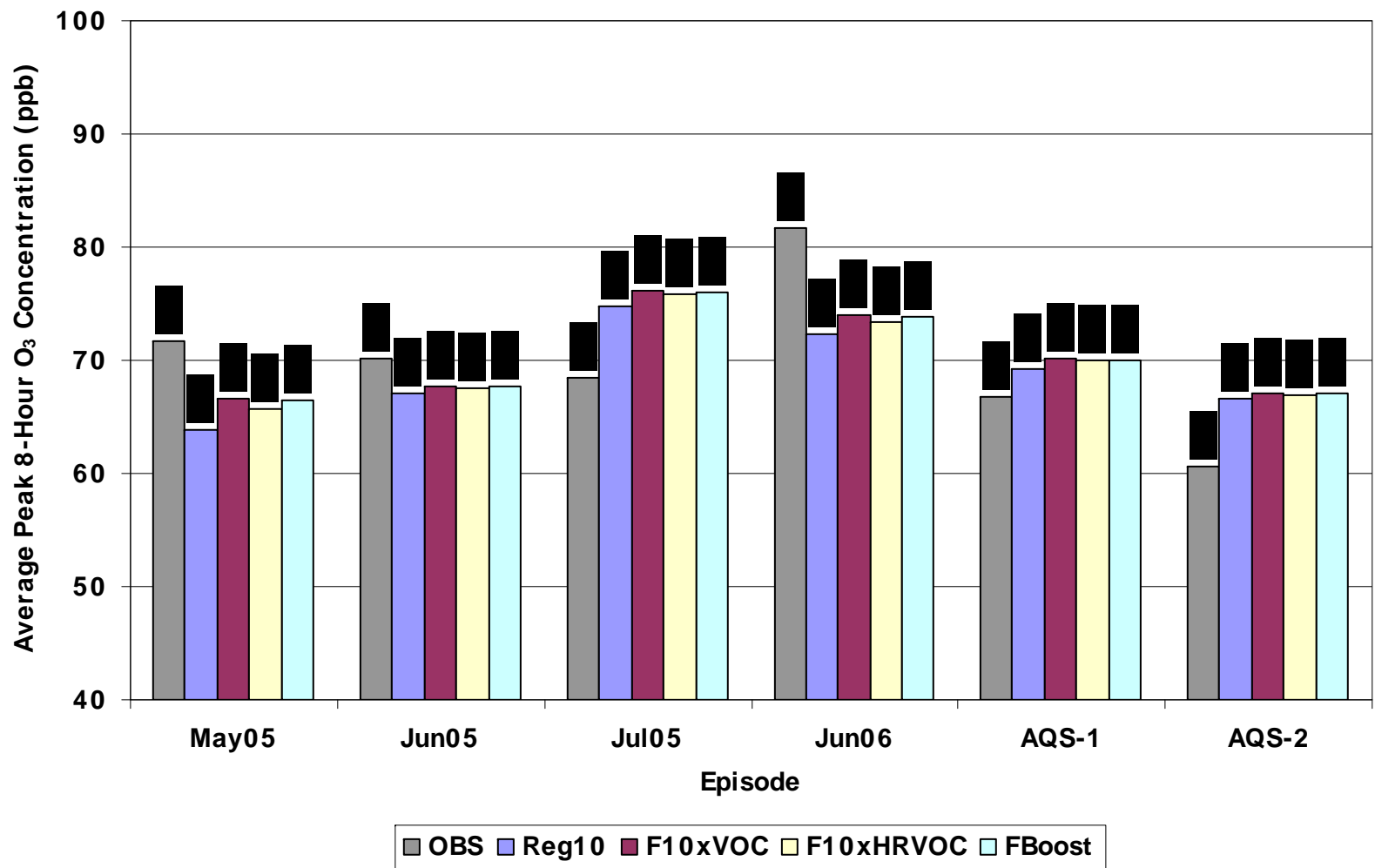
### Average Modeled 8-Hour Peak O<sub>3</sub> by Episode for 2006 Base Case and Three Flare Sensitivities Aldine



### Average Modeled 8-Hour Peak O<sub>3</sub> by Episode for 2006 Base Case and Three Flare Sensitivities Monroe



### Average Modeled 8-Hour Peak O<sub>3</sub> by Episode for 2006 Base Case and Three Flare Sensitivities Wallisville





# Summary

---

- Replacing the PSCF-based HRVOC reconciliation with a 10X flare VOC increase:
  - Greatly improves ETH and OLE concentrations compared with aircraft data, but causes some over-prediction at Deer Park and Lynchburg Ferry
  - Improves IOLE and FORM performance overall
  - Exaggerates over-prediction of PAR
  - Increases episode average peak eight-hour ozone concentrations at monitors between 0.5 and 4 ppb
  - Intensifies ozone plumes emanating from industrial areas



# Summary

---

- Compared with the 10x VOC increase, the 10xHRVOC increase:
  - Has little effect on modeled concentrations of HRVOC species
  - Reduces modeled PAR and FORM concentrations
  - Decreases episode average eight-hour modeled ozone concentrations, usually by < 0.5 ppb



# Summary

---

- Compared with the 10x HRVOC increase, the HCHO Boost:
  - Has little effect on modeled concentrations of any hydrocarbon species
  - Increases modeled FORM concentrations, improving performance except at Moody Tower where highest concentrations are over-predicted
  - Increases modeled episode average eight-hour ozone concentrations, usually by < 0.5 ppb
  - Intensifies ozone plumes emanating from industrial areas



# Summary

---

- Overall, the flare sensitivities improve performance for most species measured by the P3, but cause some over-estimation at surface sites
- Some future research topics:
  - Investigate improved vertical mixing algorithms
  - Investigate plume heights for HRVOC emission sources
  - Investigate new PSCF-based reconciliation using elevated sources