

# **New Research for the Texas SIP: A Science-Policy Synthesis**

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# TERC Research Program

- Texas Environmental Research Consortium (TERC) formed to promote air quality research to support SIP for Houston and later DFW.
- Since 2002, TERC has funded over \$10 MM of research (NOAA CIAP + TX HB1365).
- For FY2006-2007, TERC will deploy \$5-6 MM in additional TERP funds for AQ research (TX HB 2481), including some from the NTRD program.
- Purpose of Science-Policy Synthesis is to guide allocation of funds to support TexAQS 2 + SIPs.

# Key Dates for 8-Hour SIPs

<b>SIP Revision</b>	<b>Proposal Documents Due</b>	<b>Adoption Documents Due</b>
DFW	5/17/2006	11/15/2006
HGB	11/15/2006	6/16/2007
Regional Haze	5/2007	11/2007

External input should be submitted about 3 months prior to each official date.

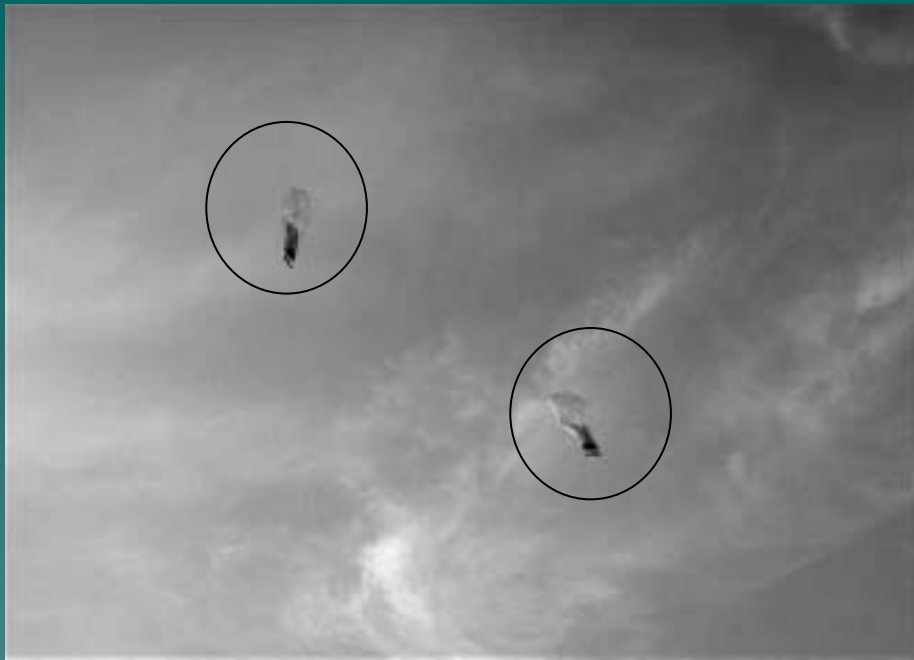
# TERC 2005

## Major Program Elements

- *TexAQS II 2005 Field Study*
  - Southeast Texas Transport Study (H39)
  - Northeast Texas Plume Study (H44, H44.A)
  - Real Time Meteorology and Air Quality Forecasting (H45)
- *SIP Modeling for DFW and HGB*
  - 8-Hr O<sub>3</sub> Conceptual Model (H12.8HRA)
  - Out-of-State Transport Impacts on DFW (H35)
  - HGB Model Sensitivity Analysis (H12.8HRB)
  - Urban Heat Island Modeling (H17.A)
- *Control Strategy Assessment*
  - HRVOC Emission Event Controls (H12.EE)
  - Out-of-State EGU Controls (H36)
  - Mobile Source Controls (H18.A, H37, H42)
  - Monitoring Strategy Assessment (H31)

# TexAQS II 2005

- Southeast Texas Transport Study (H39)
  - Tetroons as air parcel trajectory markers
  - Chase aircraft to measure ozone chemistry
- Northeast Texas Plume Study (H44, H44.A)
  - Aircraft to measure EGU plume impacts on DFW
  - UAH Lagrangian particle modeling for flight planning
- Real-time Forecasting (H45)
  - Meteorological forecasts by Texas A&M
  - Air Quality forecasts by University of Houston
- Supporting Instruments (H48, H56)
  - C-Band Radar (3-D wind profiling)
  - Proton Transfer Reaction Mass Spectrometry (VOCs)



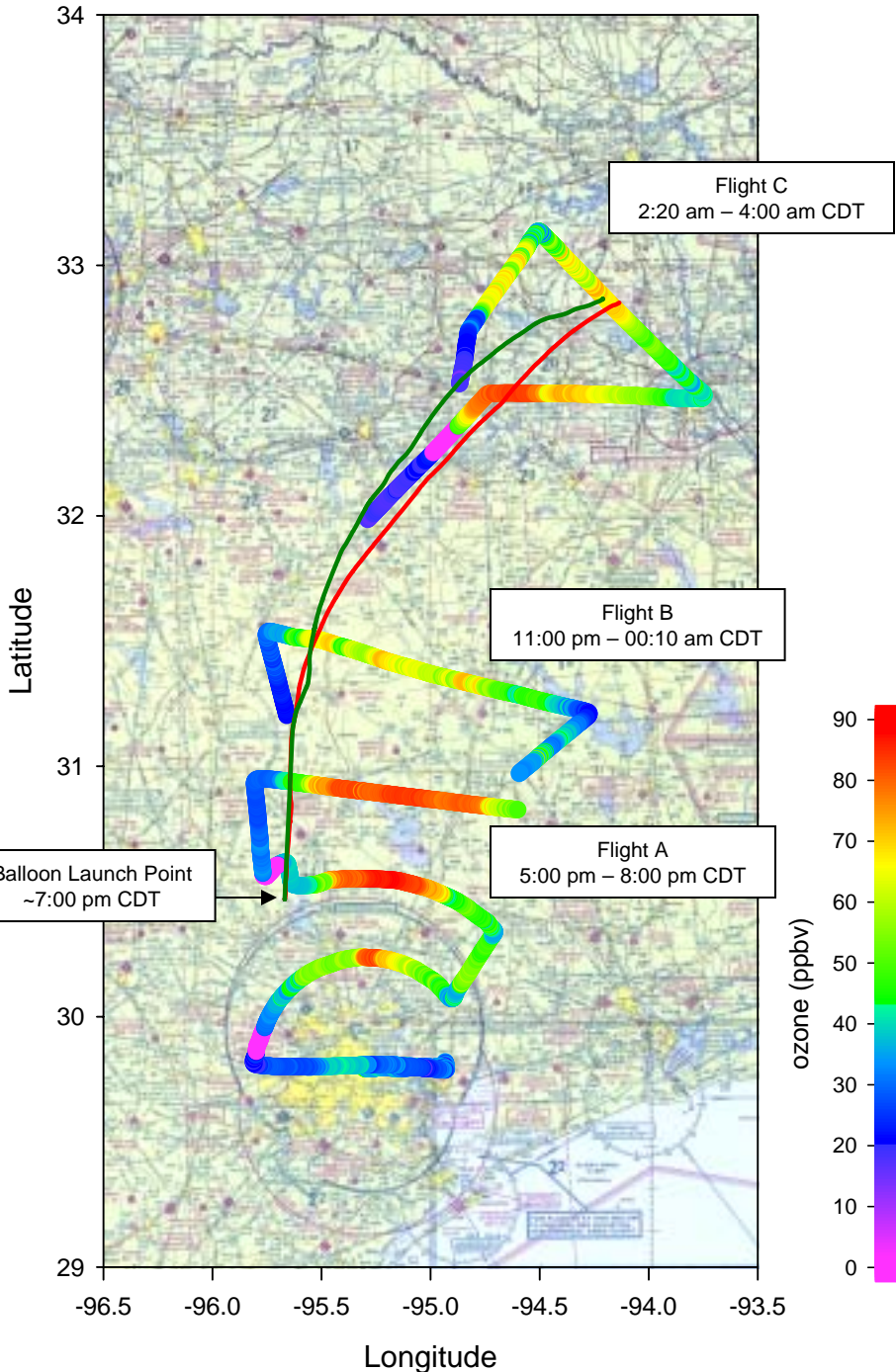
Real-time flight planning program on the aircraft, with the communication software used to track the balloons. This software, and associated satellite links and modems, allowed the pilots to safely navigate in the vicinity of the balloons.



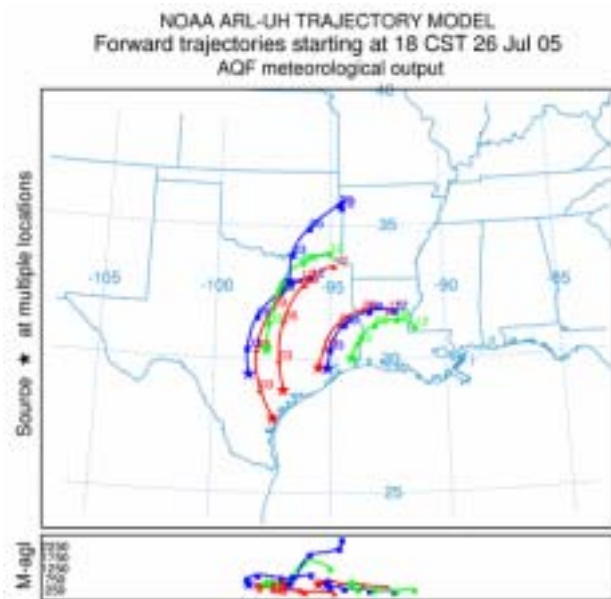
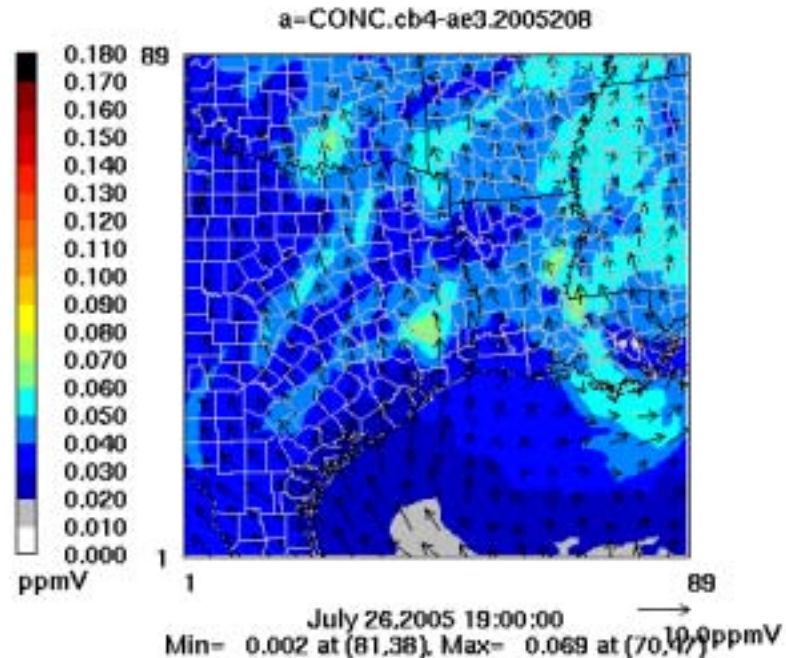
Two balloons shortly after launch (in circles) on July 26, ~0700 PM, LST. One balloon was programmed to fly at a constant altitude while the other made a series of soundings that provided information on the vertical stability of the atmosphere and winds.

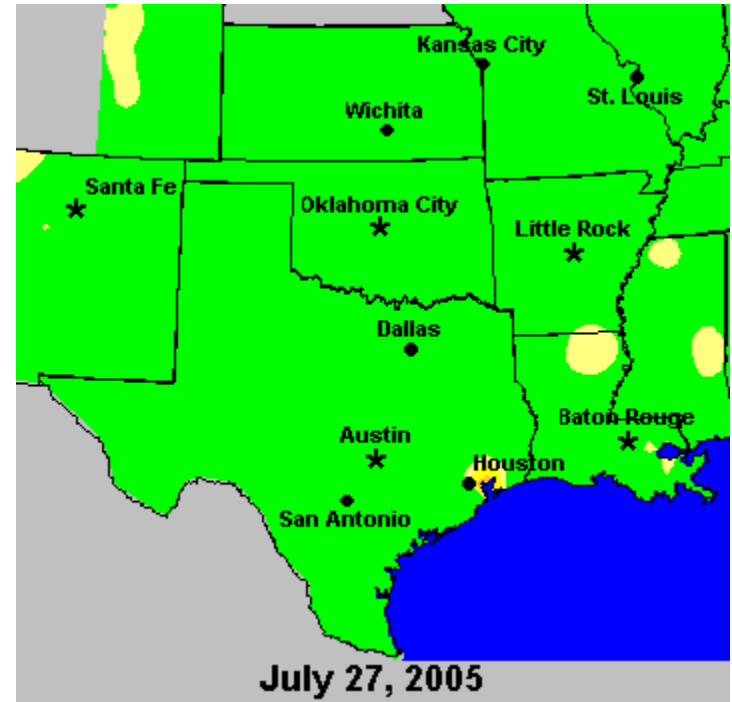
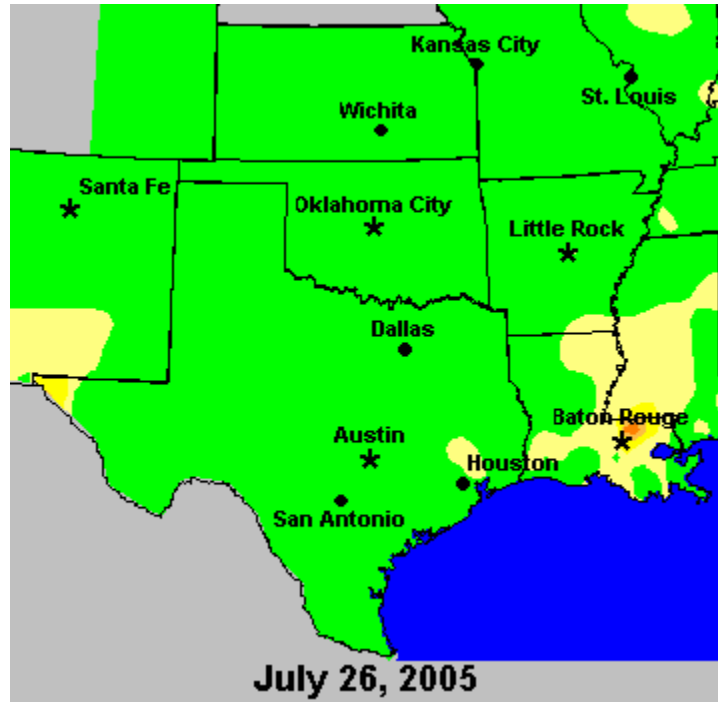


# Ozone: July 26-27, 2005

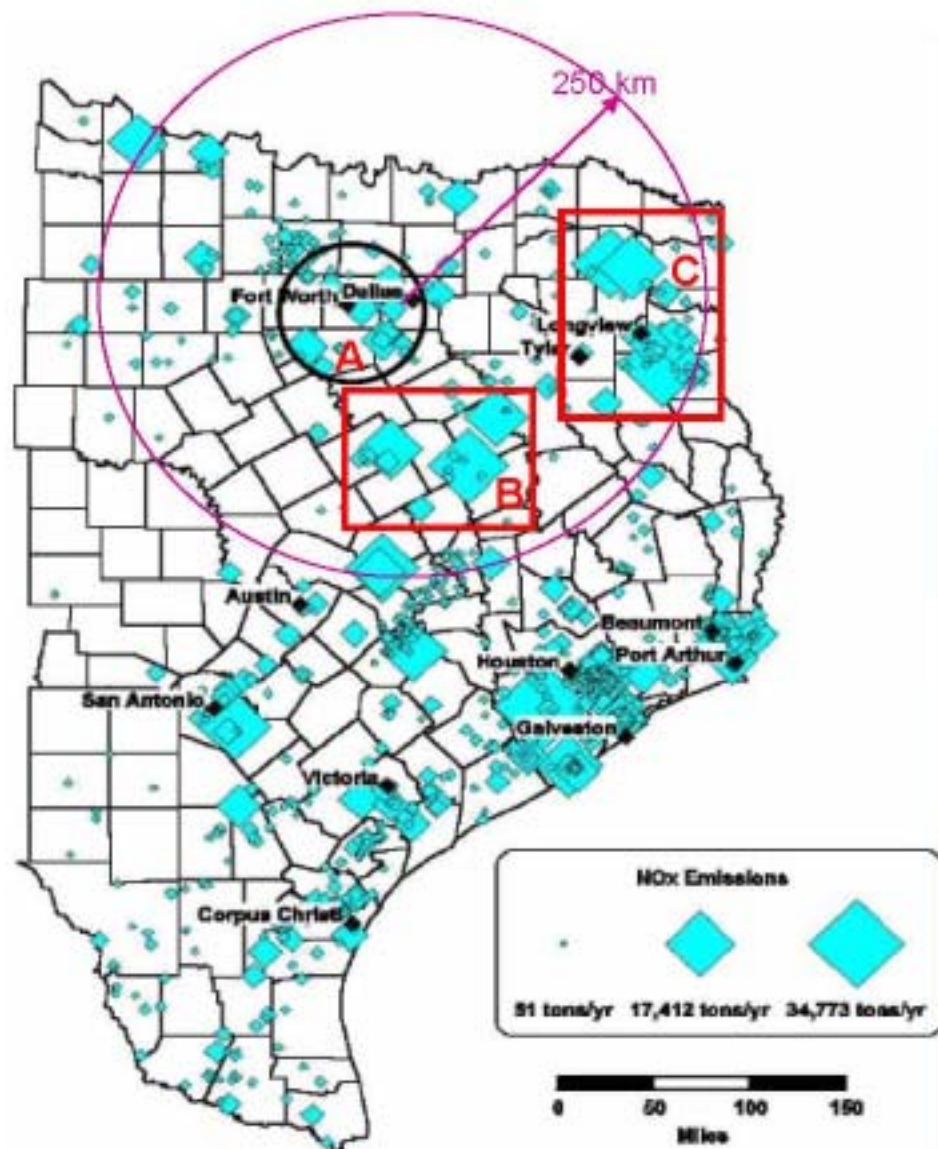


# O3 Layer 1

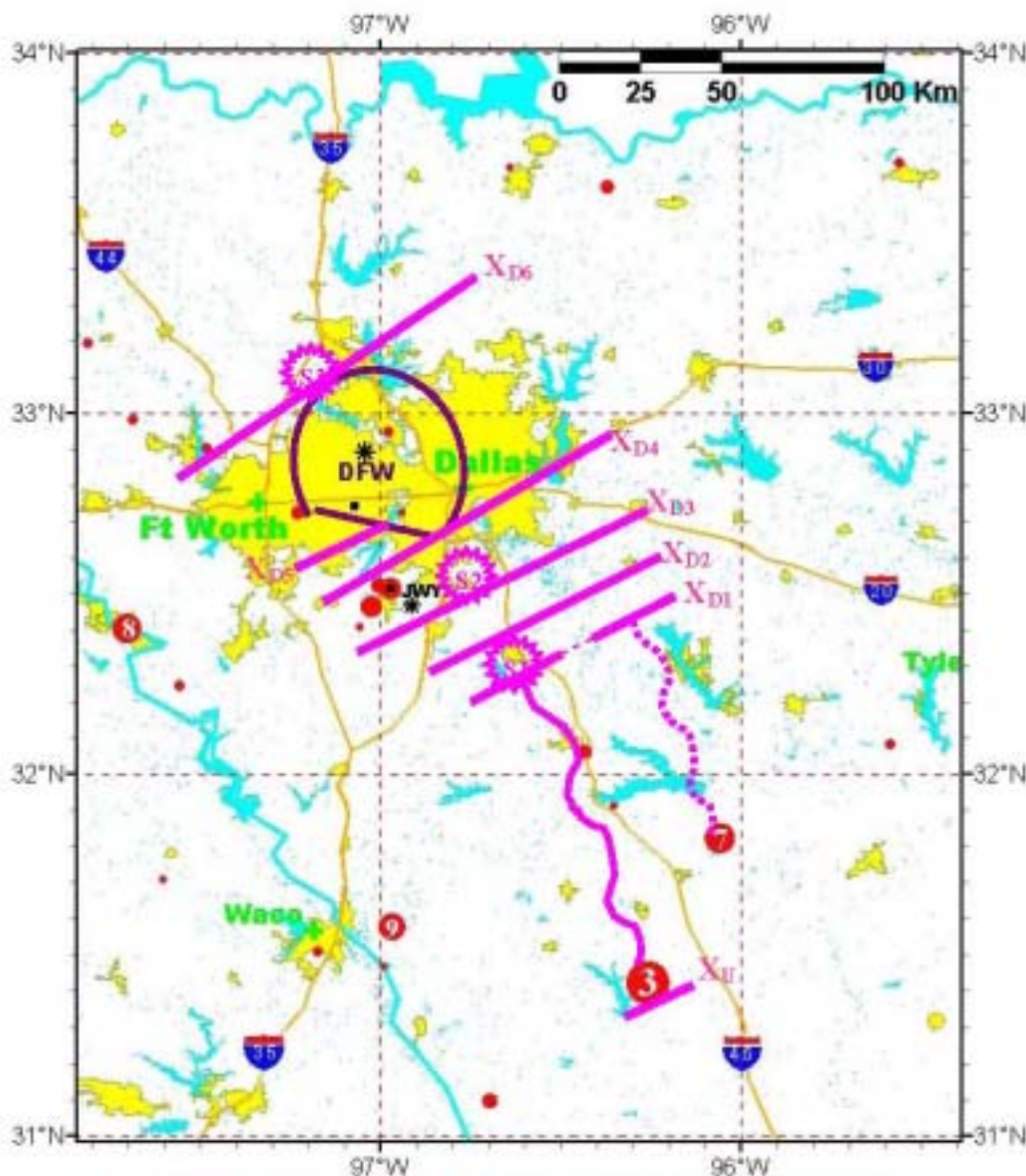




Images from EPA's Air Now site show the observed 1-hr peak ozone on July 26 and 27. Green is below 60 ppb.



**Figure 2.** (a) A map of E. Texas and surrounding states showing a climatology of 24-hour back-trajectories from the four-county DFW ozone non-attainment area on high-ozone days during summers 1999-2001, and (b) a map of E. Texas showing major NO<sub>x</sub> sources. In (b), the NETPS study area of radius 250 km from Dallas is highlighted and delineated into three zones A, B, C. The impact on DFW ozone of NO<sub>x</sub> sources in these zones will be the principal goal of NETPS (adapted from Breitenbach, 2003).



**Figure 15. Sample Flight Plan: Zone B**  
**--- Limestone/Big Brown Powerplants**

**Flight Plan (Limestone ~0330 release)  
 (Big Brown ~ 0430 release)**

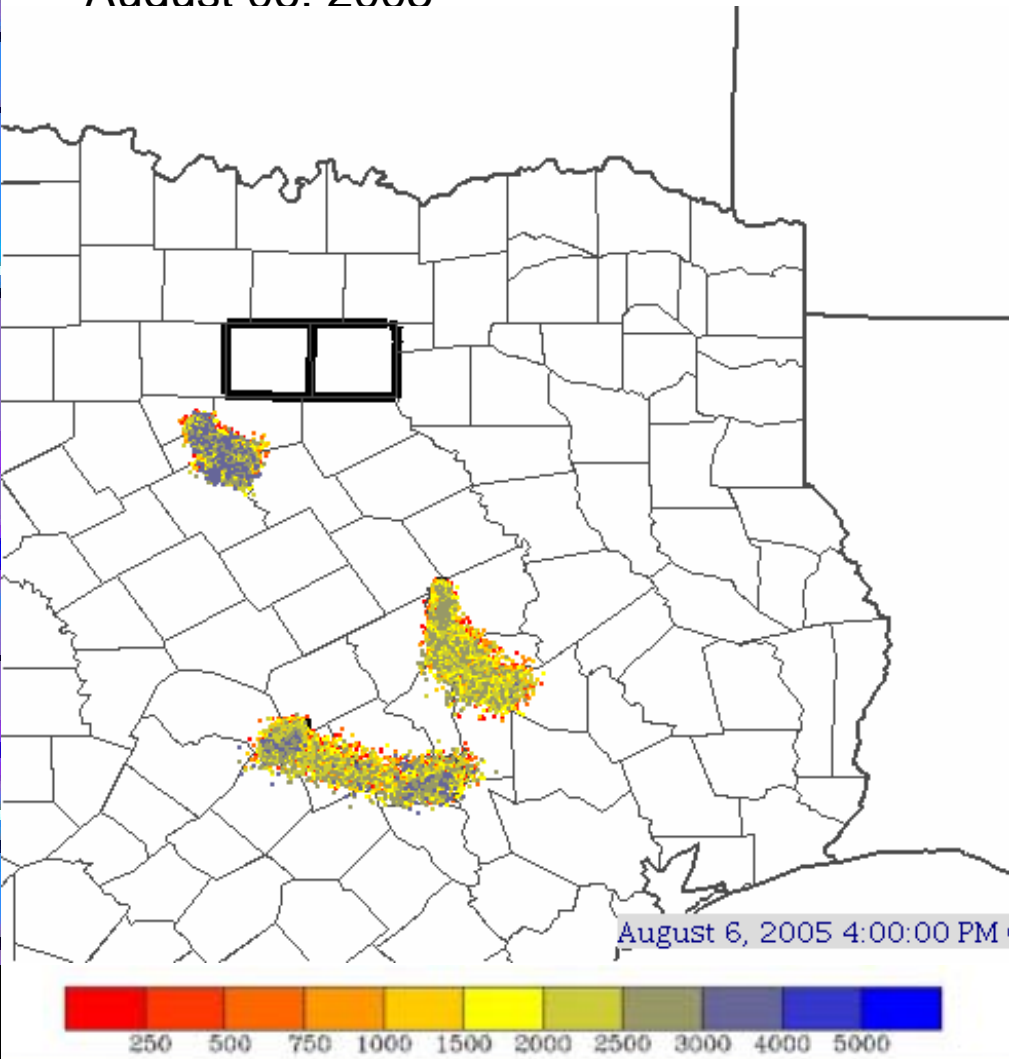
- 0645 Take-off (JWY)
- 0645-0725 Ferry to  $X_U$
- 0725-0810  $X_U$  IT(5nm, 1000') and  
 Limestone plume tracking,  $X_U$  to  $X_{D1}$  (~60nm)
- 0805-0850 Sampling at  $X_{D1}$  (~5h)  
 $S_1(L, 5000'+)$ ; HC1  
 IT(L & BB+ @ ~ plume heights)
- 0855-0955 Sampling at  $X_{D2}$  (~6h)  
 2T(plumes+, ~40nm @ 1000', 2000')  
 HC2-bg
- 1000-1100 Sampling at  $X_{D3}$  (~7h)  
 IT(plumes+upwind of Ellis CO sources, 50nm+,  
 @ 1500');  $S_2(L, Z_1+)$  HC3-L
- 1115-1145 Land/refuel at JWY
- 1145-1150 TO/ferry to  $X_{D4}$
- 1150-1310 Sampling at  $X_{D4}$  (~ 9h) --- L+B+Ellis CO  
 2T(~55nm @ 1500', 3000') HC4 (E)
- 1250-1320 Sampling at  $X_{D5}$  (Ellis CO plumes)  
 2T(plumes+, <20nm, @ 1000', 2500') HC5(E)
- 1320-1345 Ferry to  $X_{D6}$
- 1345-1525 Sampling at  $X_{D6}$  (Downwind of No-Fly))  
 2T(~60nm @ 1500', 3000' and 90 knots)  
 $S_4(P, Z_1+)$ ; HC6-bg
- 1525-1545 Ferry/Land JWY

**Total flight time used: 8h 30min**

Long ferry speed ~ 125+ knots  
 Plume sampling speed ~ 80 knots

MM5 Winds Aug 06, 2005 4:00:00 PM CDT

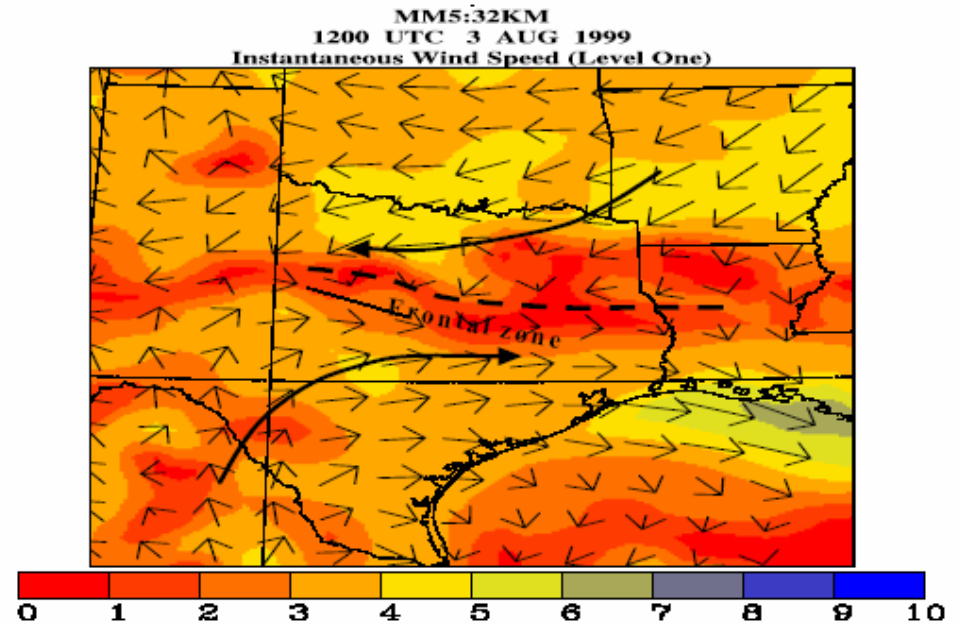
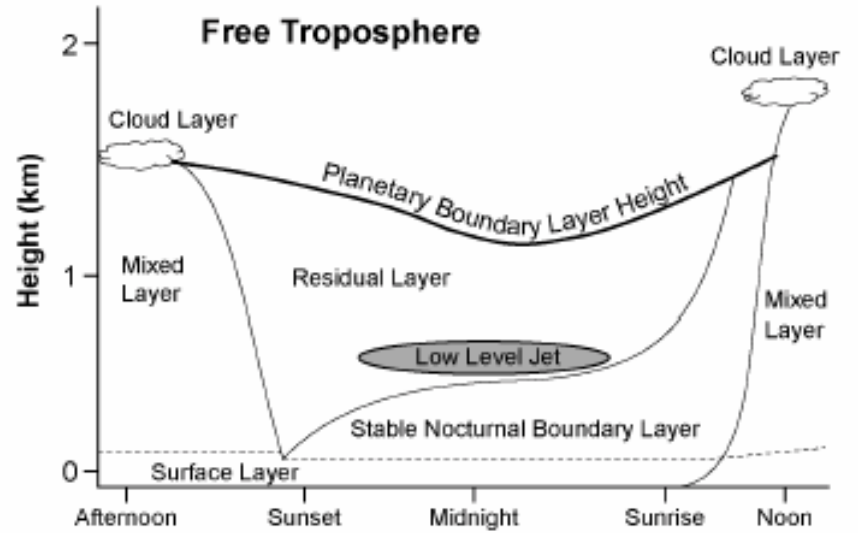
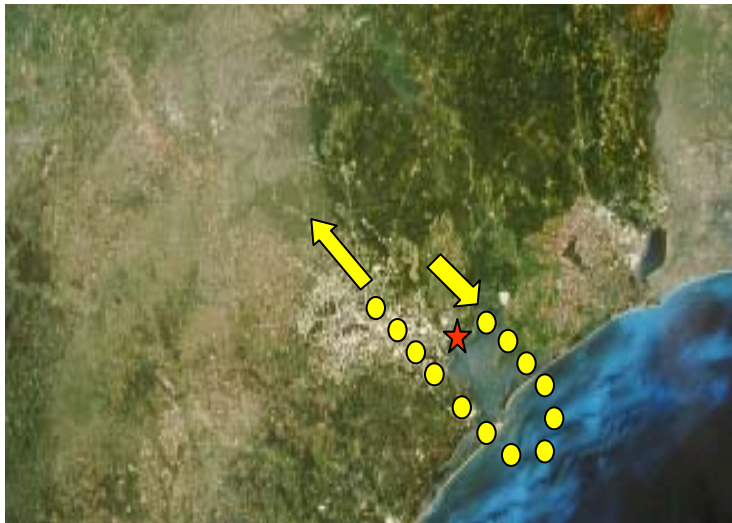
12-hour Lagrangian Particle Model run, August 06, 2005



# TexAQS 2006 Research Needs

## Meteorological Mechanisms

<b>Mechanism</b>	<b>Importance to Air Quality</b>
Sea Breeze	Slow wind rotation traps pollution over Houston, allowing ozone to “cook” longer.
Nocturnal Jet	A fast night-time wind near the surface can spew pollution large distances downwind.
PBL Evolution	PBL height determines the concentration of ozone precursors and the efficiency of ozone formation.
Cumulus Convection	Cumulus towers rapidly vent pollution to free troposphere where it can be transported long distances. Slow subsidence around cumulus towers can also entrain pollution back into PBL.
Vertical Diffusion	Transfers pollution from surface to higher levels, raising O <sub>3</sub> (high NO <sub>x</sub> ) or diluting O <sub>3</sub> (low NO <sub>x</sub> ).
Stationary Front	Causes “dead zones” allowing O <sub>3</sub> to “cook” longer or bring pollution down from free troposphere.



# DFW SIP Modeling

- Main projects (TCEQ and TERC)
- Transported and Local Ozone
- Response to Local Controls
- DFW “Problem Statement”
- Research Needs

# TCEQ Projects

- Conceptual model (2003)
  - August 13-22, 1999 episode selected
- Ozone model development (2004)
  - MM5, CAMx, transport assessment, response to controls for 2010
- Updated ozone modeling (2005)
  - Updated transport assessment, response to controls for 2010
  - Supplemental modeling period (8/23 to 9/1/99)

# TERC Projects

- H27 Transport Assessment (2004)
  - Source apportionment (APCA) and zero-out
- H28 Control Technology Assessment (2004)
- H12.8HRA Conceptual Model (2004)
- H35 Transport Assessment (2004/2005)
  - Improved MM5 and CAMx modeling
  - APCA and zero-out transport and CAIR assessments
- H36 Control Technology Assessment (2005)
  - Controls in upwind states

# Ozone Transport

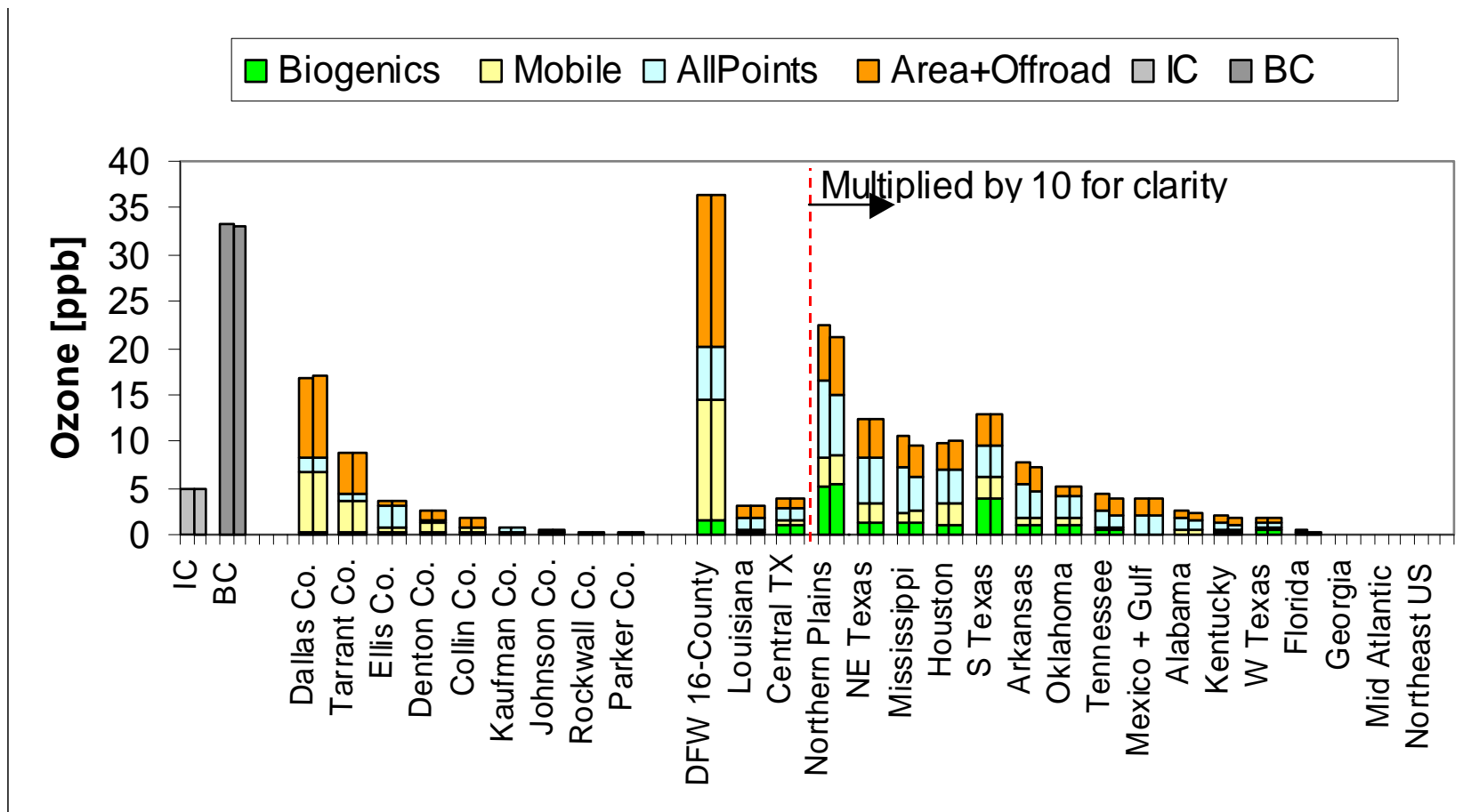
## ■ Modeling

- Strengths: quantitative source assignments, multiple methods (APCA, zero-out), directly related to SIP modeling
- Limitations: modeling uncertainties, limited episodes available for analysis

## ■ Upwind/downwind analysis

- Strengths: based on ambient data, many episodes
- Limitations: limited monitoring network, assumes ozone is additive, difficult to assign upwind sources

# 2010 Average 8-Hour Ozone Contribution to DFW 9-County Area

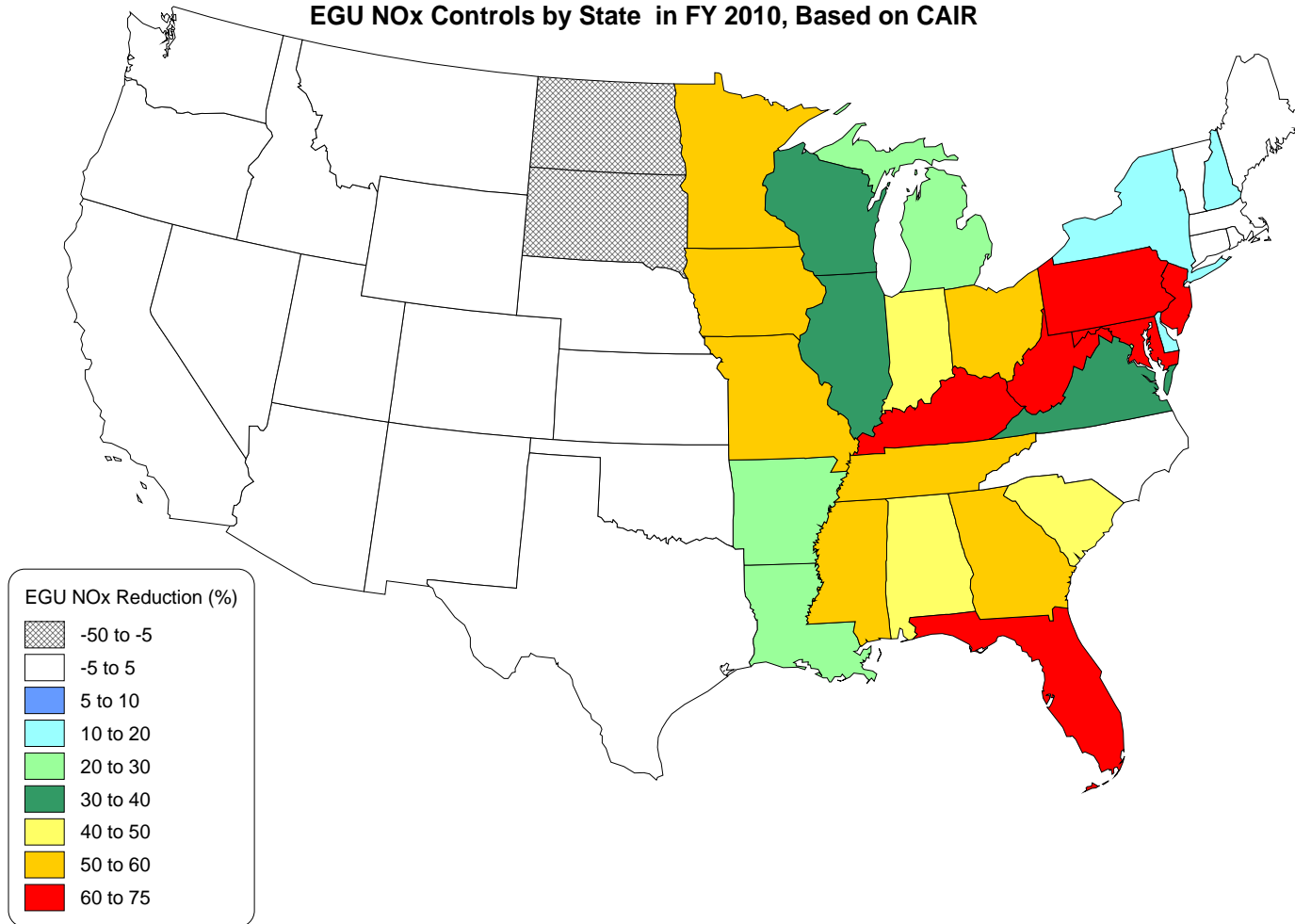


Run-34 Base Ozone = 90.8 (left bar)

Run 36-CAIR Ozone = 90.5 (right bar)

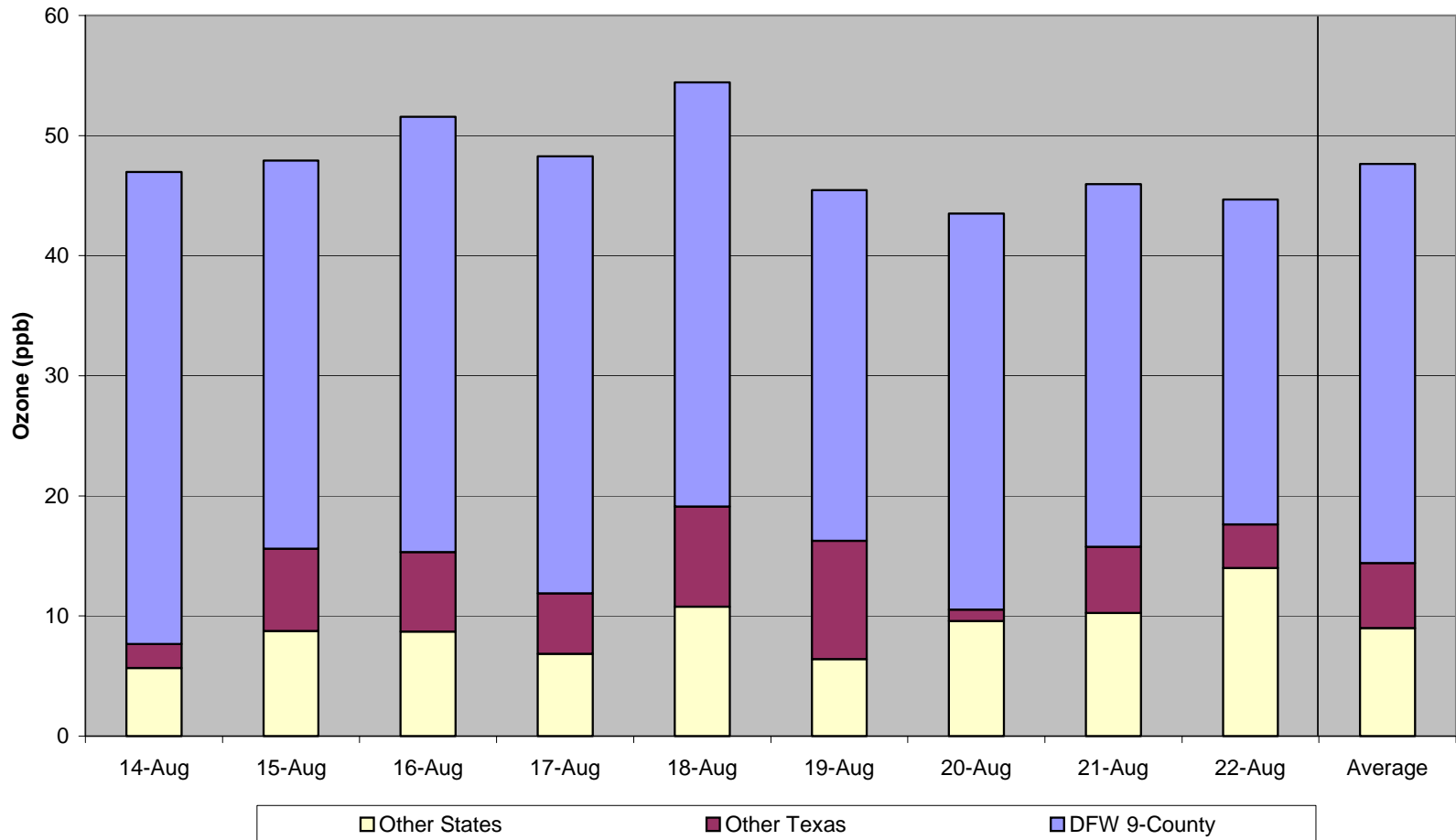
# CAIR Modeling NOx Controls

EGU NOx Controls by State in FY 2010, Based on CAIR



# Transport Varies by Day

**DFW Future Case Daily Anthropogenic Ozone Contributions**  
Average Contribution to Ozone in All Cells > 85 ppb in 9-county area, Run 34sa.fy2010



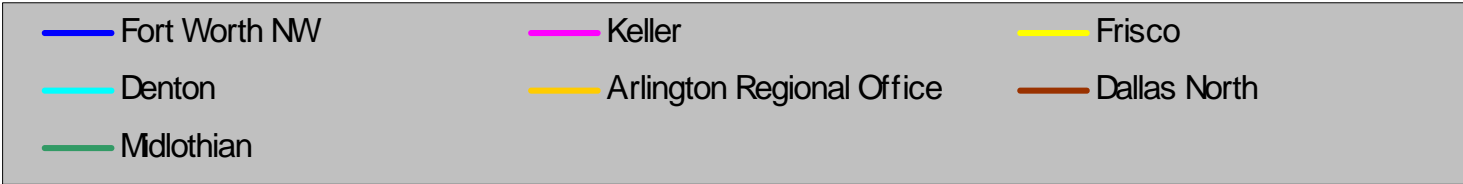
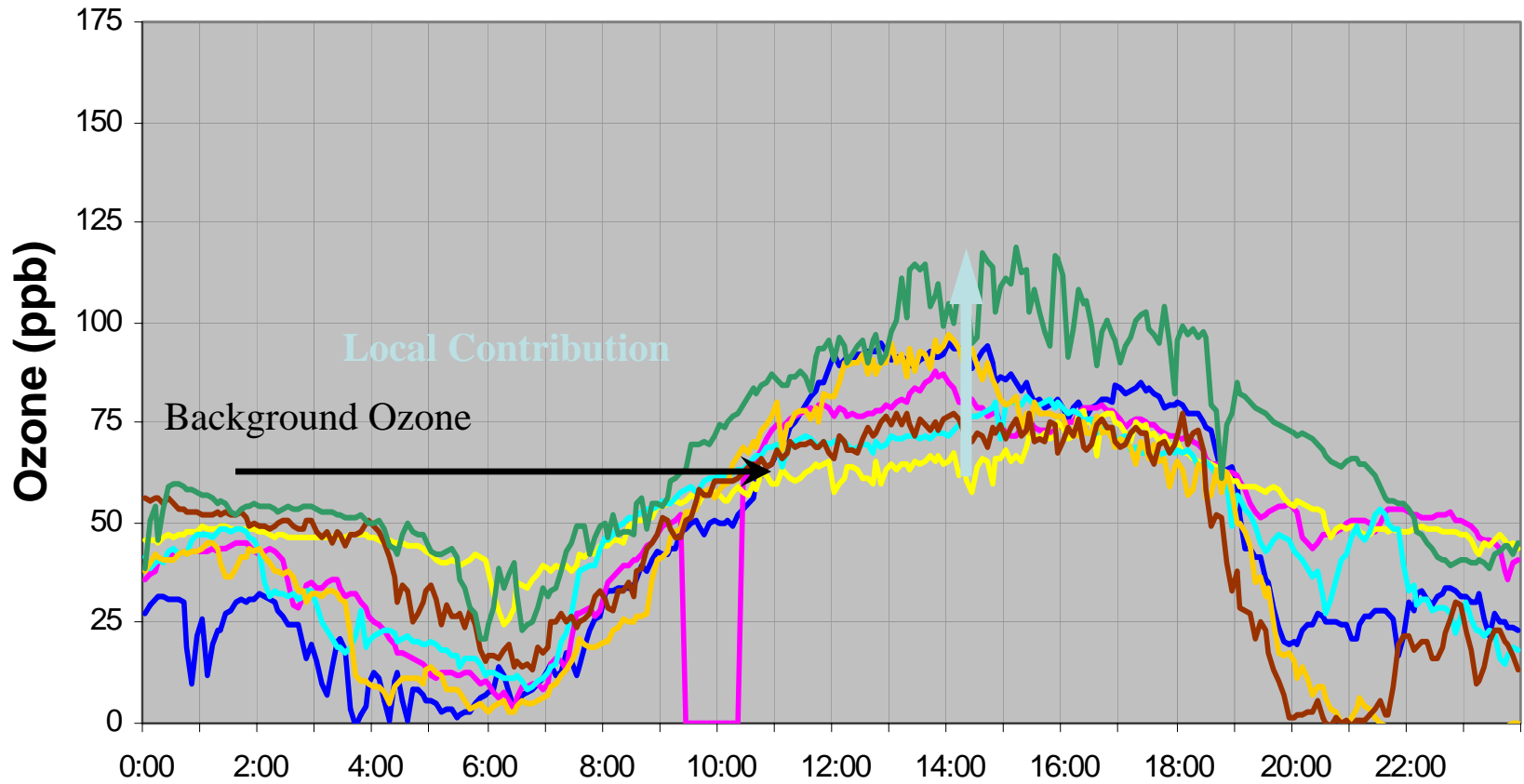
# Background Ozone and Transport

- Episode Average APCA Contributions to 8-Hr O<sub>3</sub> Exceedances in DFW during August 1999 (H27)

<b>Source Category</b>	<b>Ozone Contribution</b>
Intra-State Transport	11.7 ppb
Out-of-State Transport	11.3 ppb
Model Boundary Conditions	31.3 ppb
<b>Total Background</b>	<b>54.3 ppb</b> (agrees with H12.8HRA)
<b>Local Production</b>	<b>39.5 ppb</b>

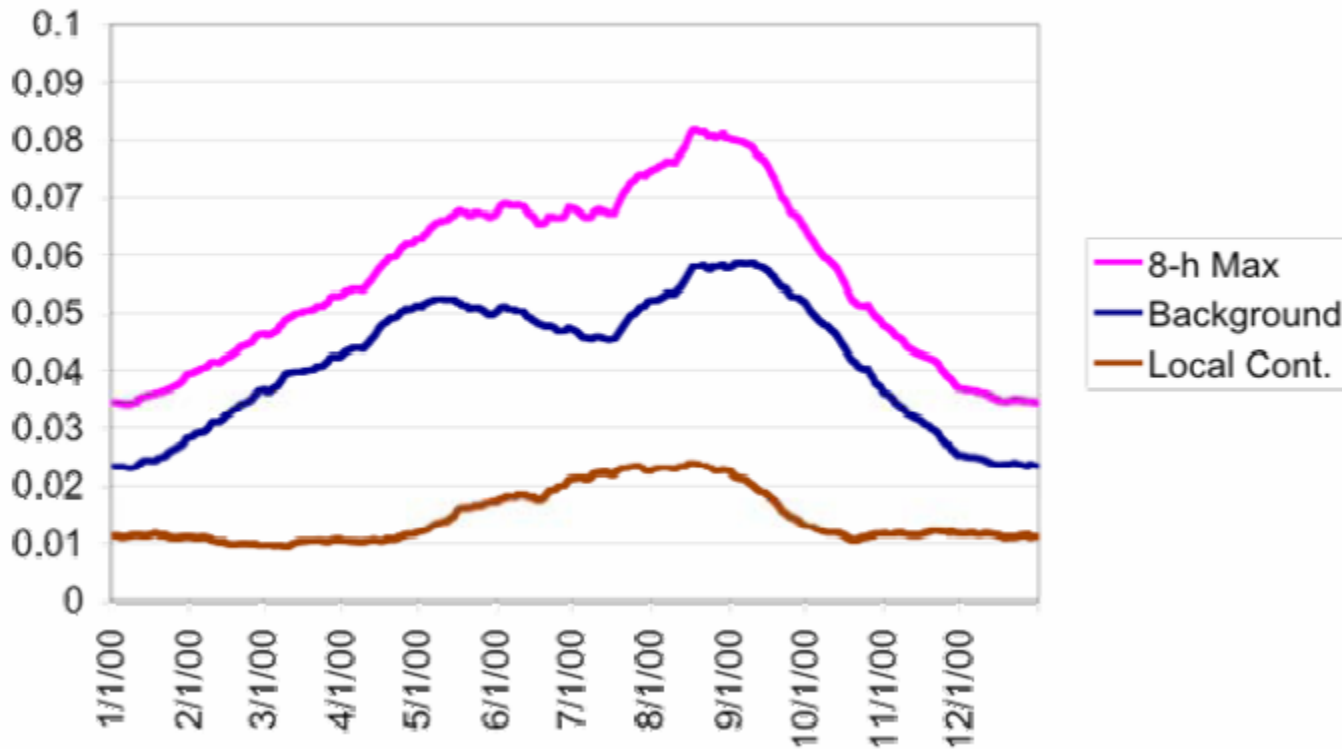
- Natural background ozone (~20 ppb) vs. anthropogenic background ozone (~34.3 ppb) vs. local ozone (~39.5 ppb)
- CAIR rule impact on DFW < 0.3 ppb (H35)
- Houston and BC contribution uncertainty ~2 ppb (H35)

# DFW Ozone August 20, 1999



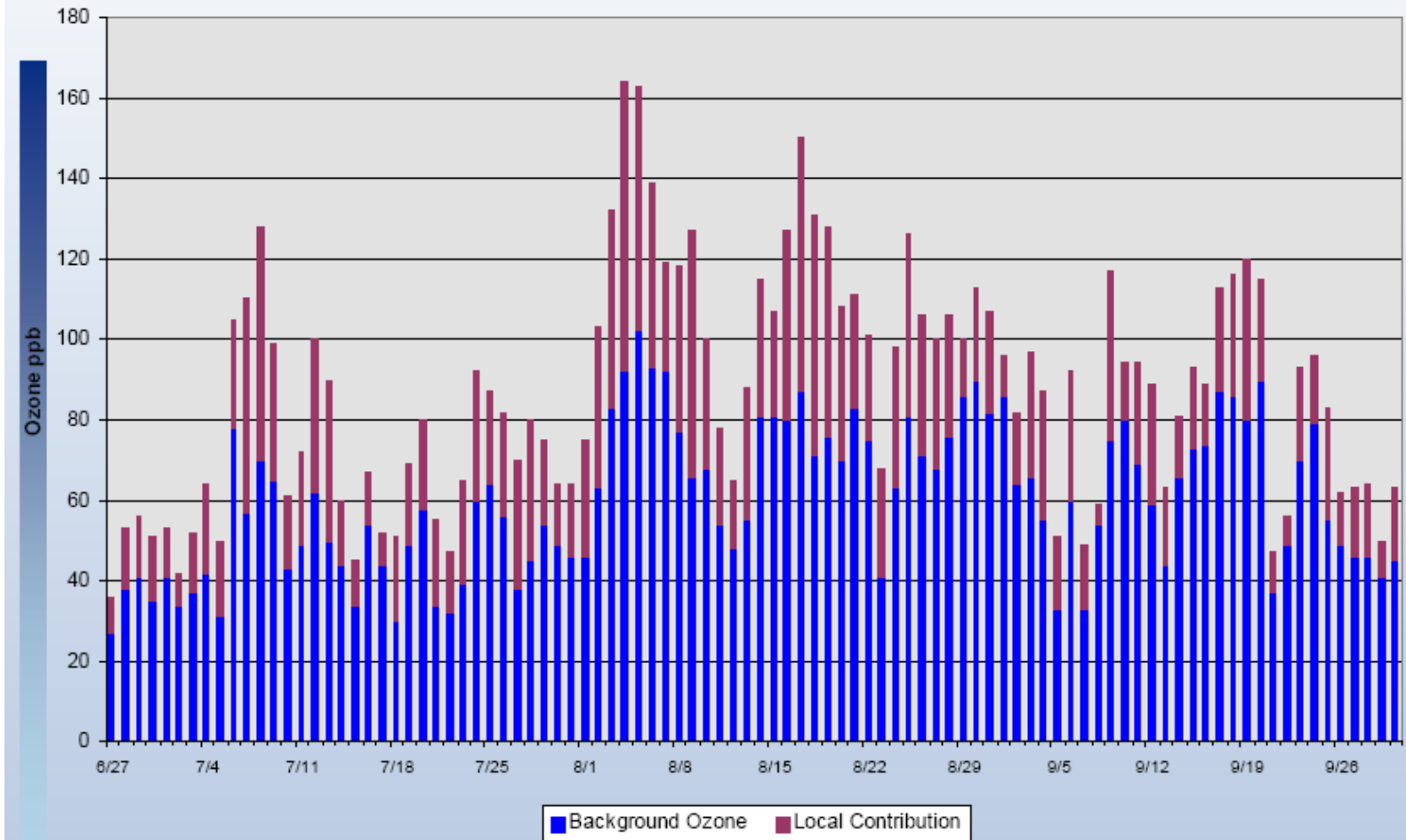
# H12.8HRA Upwind/Downwind

DFW 8-h Ozone on Days Without Precipitation



Six year average

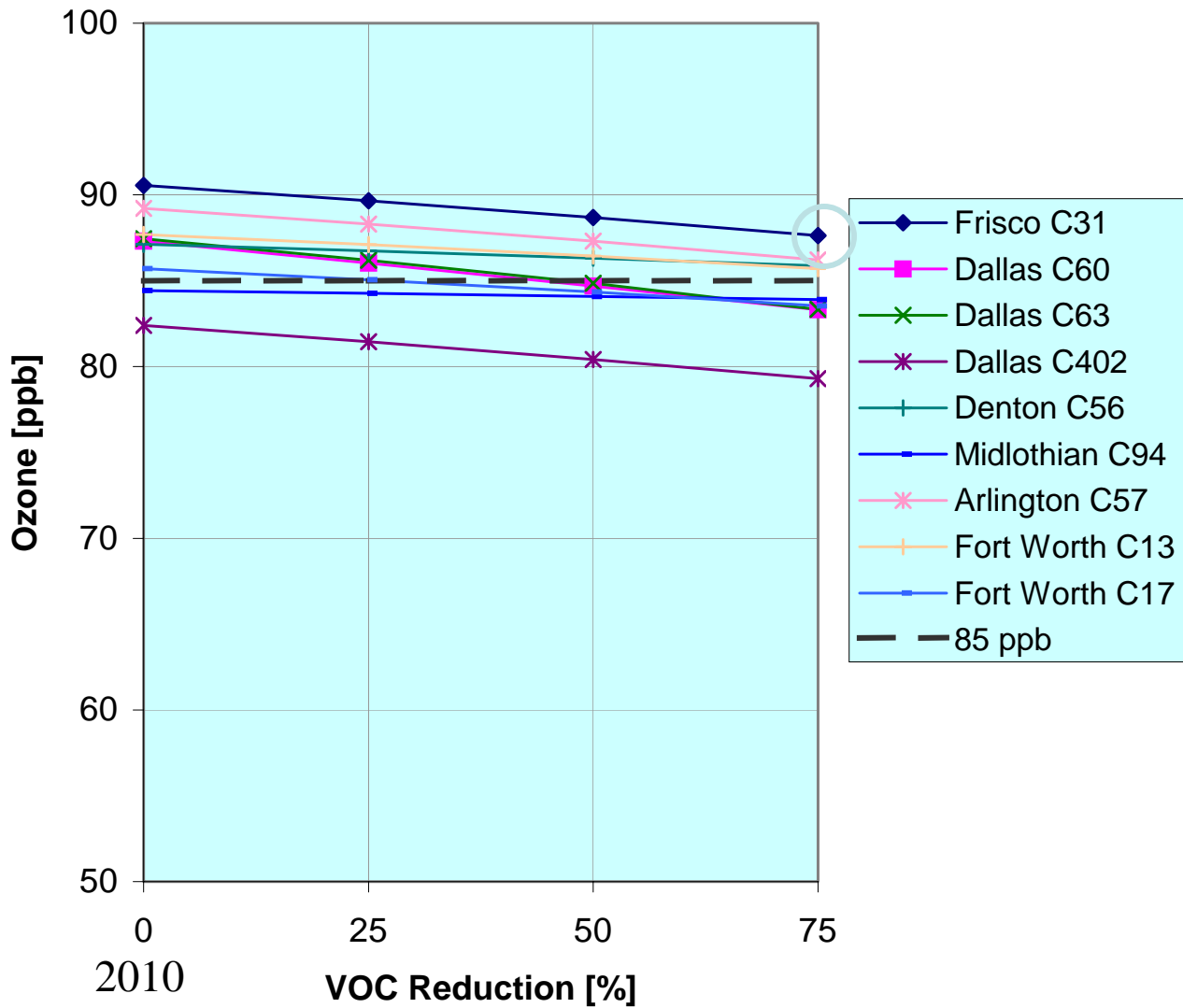
# TCEQ Upwind/Downwind by Day



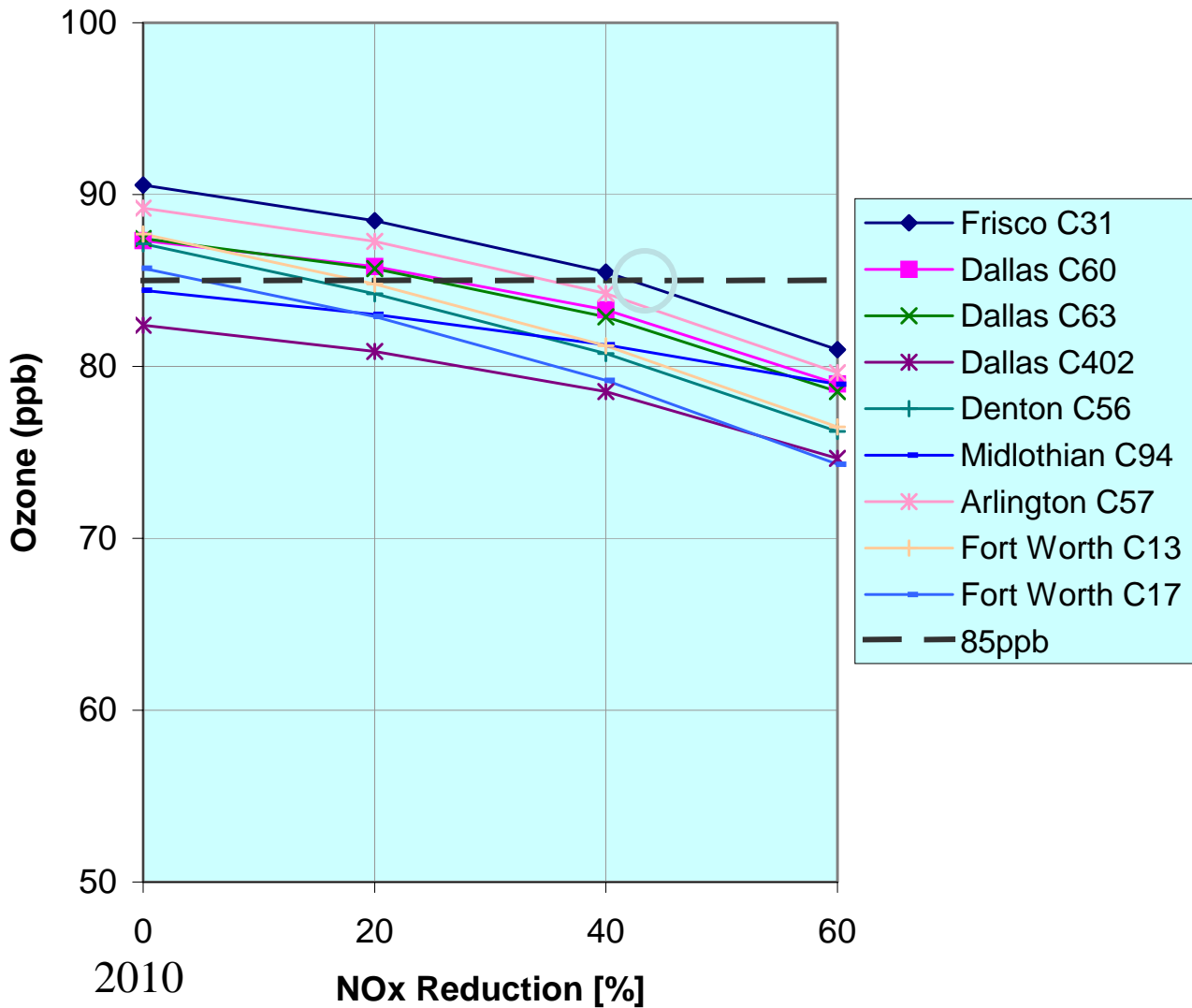
# Response to Local Controls

- 2010 Response to VOC and/or NO<sub>x</sub> reductions
  - 9-county DFW “across-the-board” reductions
- Impact of model updates and episode extension
  - Model updates improved 1999 performance and caused little change in 2010 emissions response
  - Similar relative reduction factors found for core (8/15 to 8/22) and extension (8/23 to 9/1) periods
  - Emission responses are closely related to the DFW emission inventory

**Design Value-Scaled 2010 DFW 8-Hour Ozone  
VOC Reductions, Aug 23-Sept 1, 1999 Extension**

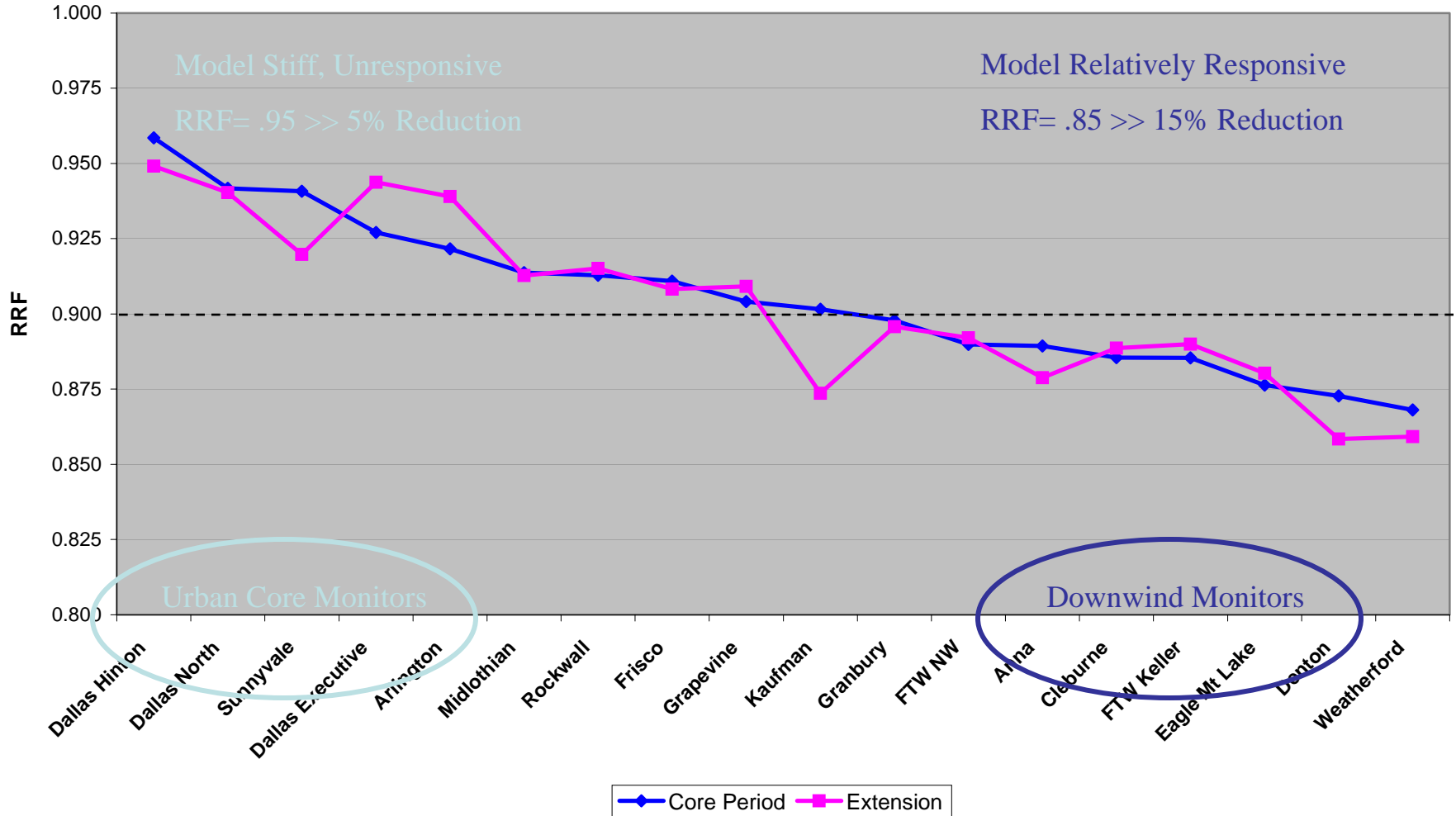


### Design Value Scaled 2010 DFW 8-Hour Ozone NOx Reductions, Aug 23-Sept 1, 1999 Extension

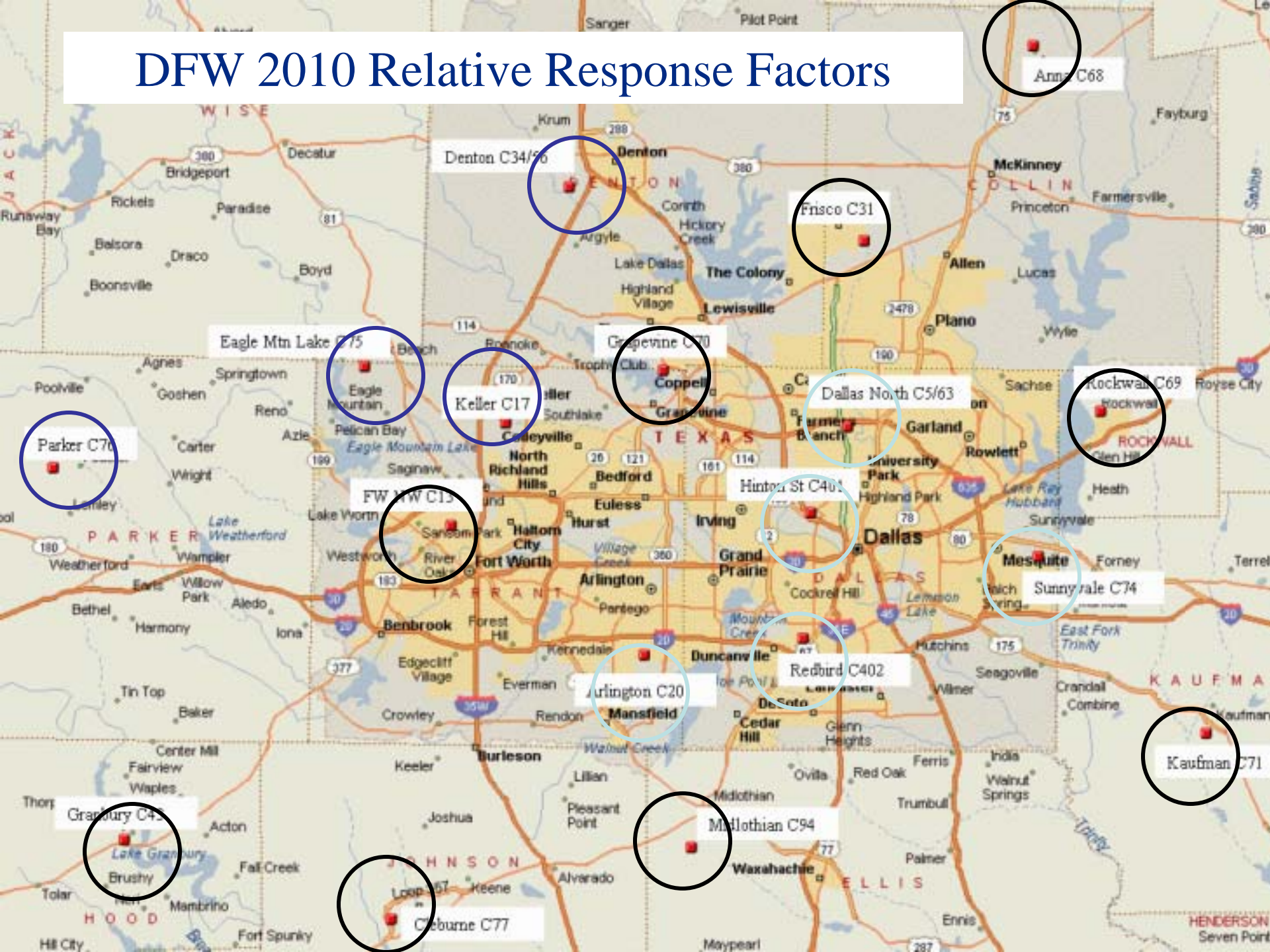


# DFW Monitor Specific 2010 Relative Reduction Factors

## Core vs Episode Extension, Sorted by Core RRF



# DFW 2010 Relative Response Factors



# DFW “Problem Statement”

- High ozone reflects local contribution plus background
- NOx reductions are needed to reduce local ozone production
  - Role of urban/suburban biogenic VOC
    - High enough to limit effectiveness of anthropogenic VOC reductions
    - Not high enough to make ozone very responsive to NOx reductions
  - VOC strategies in urban core have some benefits
- Reduced ozone transport also needed
  - Inter-State and intra-State

# SIP Modeling

## East Texas Research Needs

- Better treatments of transport and chemistry of O<sub>3</sub> and precursors aloft, both night and day.
- Improved simulation of vertical exchange between the surface and layers aloft.
- Better characterization of emissions sources at large distances upwind.
- Include seasonal behavior of background ozone.
- Improved modeling of LU/LC and biogenics.
- Better boundary conditions (link to global model?).

# SIP Modeling

## DFW Research Needs

- Monitoring for ozone precursors
  - More sites and species (NO<sub>x</sub>, VOC, CO, SO<sub>2</sub>)
  - Long-term trends -- beyond field study
- Control strategy catalogue
  - Local and regional (work in progress)
  - Mine existing results for contribution estimates
  - Coordinate with regional haze SIP
- DFW urban/suburban biogenic VOCs
  - Check and refine these critical emissions
- Integrate future land-use planning with SIP
  - Long-term urban growth patterns

# SIP Modeling

## HGB Research Needs

- Better quantification/resolution of HRVOC emissions.
- Better tree speciation in modeling biogenic emissions.
- Better treatment of Galveston Bay influence.
- Vastly improved meteorology (sea breeze, night-time winds, vertical mixing, etc.)
- More detailed ozone chemistry, including OVOCs, radical sources and sinks, and reactive nitrogen.
- Incorporation of springtime episodes to account for 8-hour design values and to satisfy EPA guidance.
- More certainty as to how ozone responds to control strategies (SIP model has too much VOC and NO<sub>x</sub>; grossly inefficient O<sub>3</sub> production).

# Control Strategies

## Major Findings

- Significant OVOC co-benefits to controlling annual, but not event, HRVOC emissions.
- Concentrated HRVOC hot spots are unlikely to result from HRVOC emissions trading.
- Need many (~20) more VOC speciation monitors to detect emission events in Houston.
- Locomotive NO<sub>x</sub> emissions may be 32% lower for HGB, 26% lower for DFW, compared to previous estimates.
- NO<sub>x</sub> from major sources such as EGUs in some States are subject to less stringent control than in Texas.
- Possible emission reduction benefits from CA LEV II.
- TERP emission reductions could fall short of SIP goals, particularly in the Houston region.

# Control Strategies

## Research Needs

- We need to determine the feasibility and effectiveness of out-of-State controls beyond CAIR rule to reduce transport.
- We need to find new alternatives to previously proposed control strategies.
  - Better assess impacts of CA LEV II adoption.
  - Reduce NO<sub>x</sub> from compressor engines.
  - Study benefits of controlling OVOCs.