Texas Air Quality Study - TexAQS II

A Brief Background and

Applications Related to Forecast Model Evaluations

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Outline

- Study goals and objectives

  From a NOAA perspective

- Measurement platforms and “super site”
- Real-time AQ forecast model verification
  - Forecast model background
  - Evaluations based on surface networks
  - Comparisons to aircraft observations
- Rapid Science Synthesis (8/31/07)

2006
The Texas Air Quality Study

NOAA's Objectives In TexAQS II

NOAA's Focus was on Climate Change and Air Quality

- **Emissions Verification** - petrochemical, urban, power plant, marine
- **Transport and Mixing** - intra- and inter-regional transport, boundary layer/free Troposphere
- **Chemical Transformation** - O_3 and PM, Day and Night
- **Aerosol Properties and Radiative Effects** - Regional haze, direct and indirect effect, satellite validation
- **Forecast Models - Diagnostic evaluations**, chemical data assimilation

Today

For More Information http://esrl.noaa.gov/csd/2006/

TexAQS II Participants

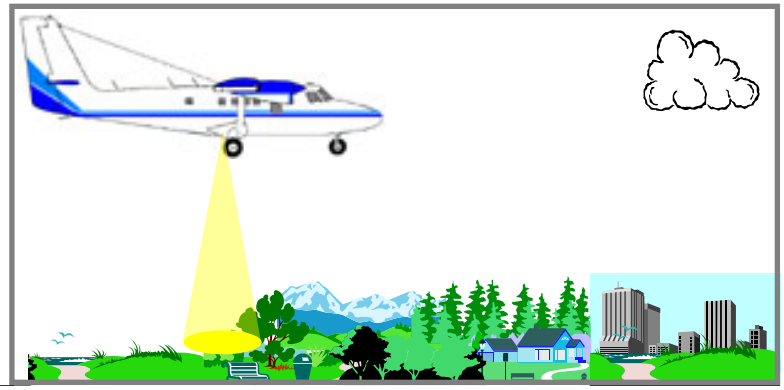
- Texas Commission on Environmental Quality (TCEQ)
- Research Scientists
  - Federal: NOAA, NASA, DoE, NSF, EPA
  - Texas Universities (U of Houston, U of Texas , Texas A&M, Lamar, Rice, Texas A&M Kingsville, U of Texas Arlington, Baylor, Texas Tech)
  - Other National and international experts
- Non-Government Research Institutions: Texas Environmental Research Consortium (TERC), Houston Advanced Research Center (HARC), Texas Air Research Center (TARC), Houston Regional Monitoring (HRM) Network
- Local Governments
- Contractors
- Industry

NOAA's Assets In TexAQS II

NOAA WP-3D Aircraft - urban and power plant plume studies, emissions verification, regional and inter-regional transport, day/night O_3/PM chemistry, aerosol optics

NOAA R/V Ronald H. Brown - marine chemistry, marine emissions, chemistry in the land/bay/sea breeze recirculation, coastal emissions, satellite validation, aerosol physics, chemistry, optics.

NOAA LIDAR Aircraft - regional distribution of O_3 and PM, urban and power plant plume studies, regional and inter-regional transport, boundary layer evolution and variability.



In Addition: Wind profiler network, Instrumented tall tower, flux towers

Additional Platforms In TexAQS II

NOAA / Univ. of New Hampshire Smart Balloon - Lagrangian air mass tracking, ozone concentrations and profiles.

Navy / Cal. Tech. CIRPAS Twin Otter - Aerosol formation and growth, evolution of aerosol chemical, physical, and optical properties during transport, aerosol - cloud interactions including aerosol impacts on the optical properties of clouds.

NASA King Air - Airborne aerosol lidar, regional aerosol formation and transport, satellite validation

Baylor University Piper Aztec - Regional ozone formation and transport, emission verification.

Moody Tower "Super Site"

B. Lefer & B. Rappenglueck

Instrumentation

Gas-phase Chemistry

Aerosol Composition

Aerosol Optics

Radicals

LIDAR

DOAS

UH Moody Tower

- 18 story tall building (200 ft tall)
- 30 ft Met Tower
- representative site with no direct surface emission impacts

AQ Forecast Models During TexAQS II

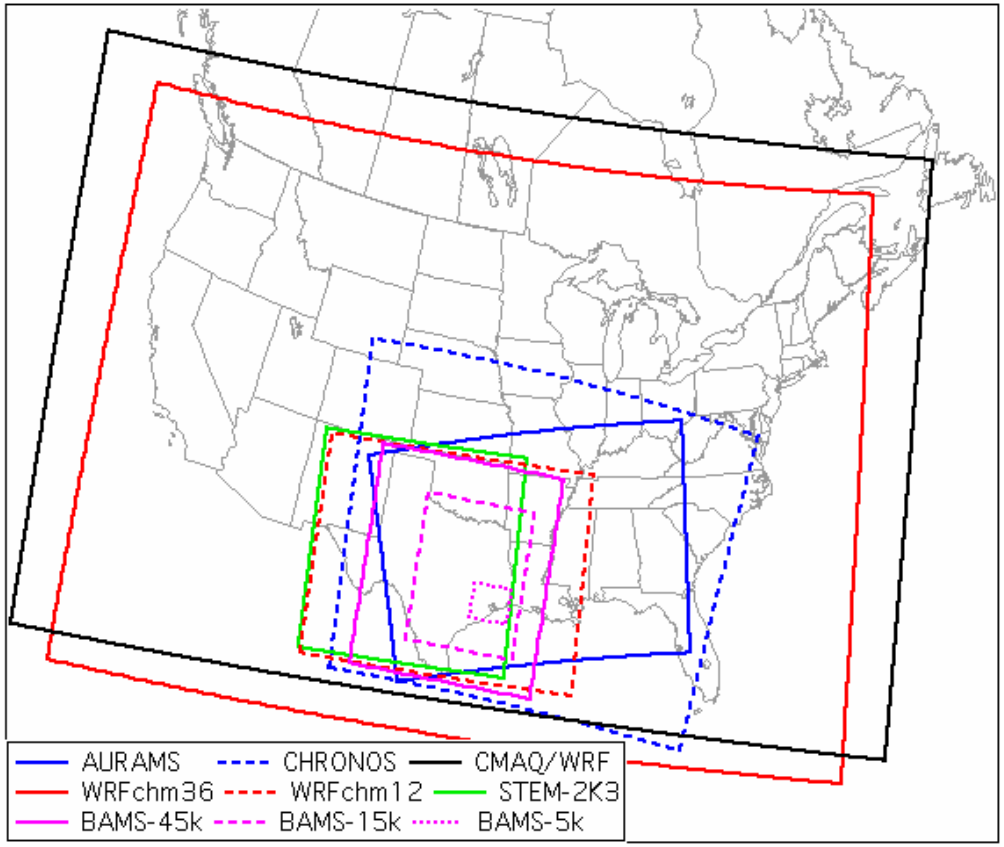
9 Real-time AQ Forecast Models Archived by NOAA/ESRL/CSD

Jeff McQueen and Pius Lee (NOAA/NWS) - CMAQ/WRF (5x - developmental in 2006)
Georg Grell, Steven Peckham (NOAA/ESRL/GSD) -WRF/Chem
Youhua Tang (NOAA/NWS) and Greg Carmichael (U of Iowa) - STEM
John McHenry, Carley Coats (Baron AMS) - BAMS
Wanmin Gong (Environment Canada) - AURAMS
Veronique Bouchet (Environment Canada) - CHRONOS

4 Additional Real-time Forecasts by University of Houston

Daewon Byun (U of H), John Nielsen-Gammon (TAMU) - CMAQ/MM5

Real-time Forecast Models Forecasting During the Summer of 2006

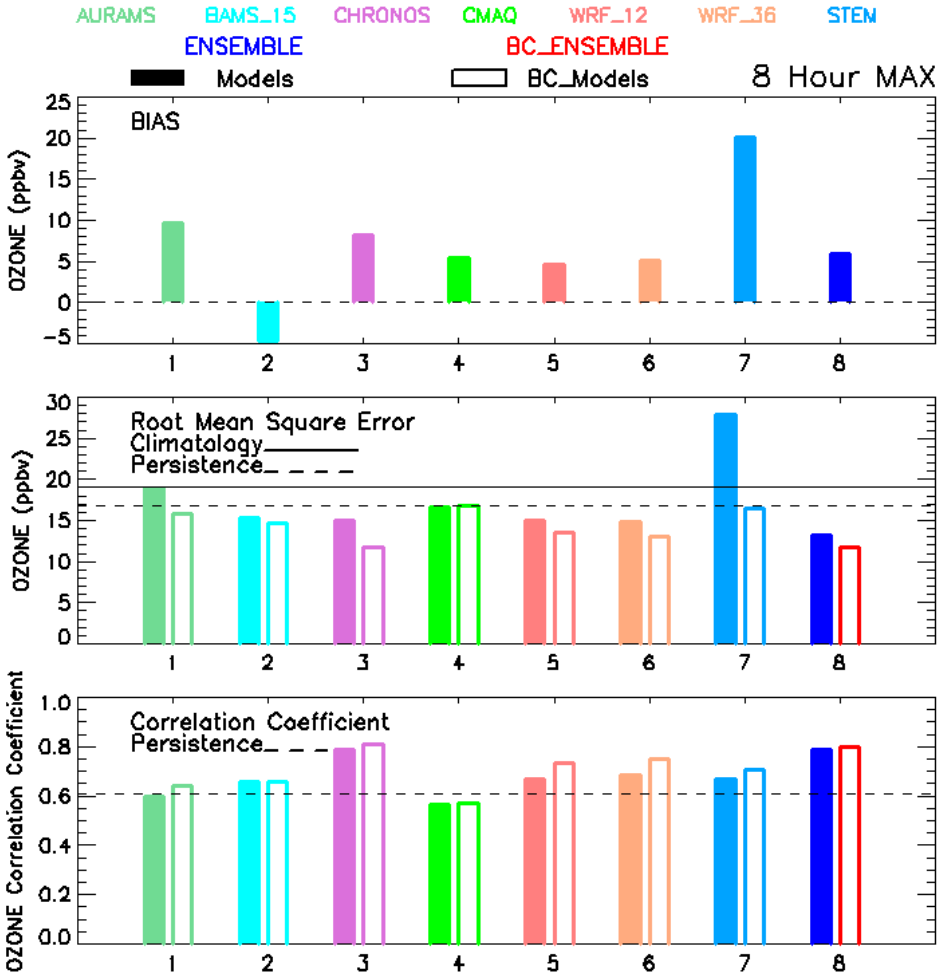


Model:	Emission Inventory:
→ AURAMS - 28km	Canadian National Inv.
→ CHRONOS - 21km	
→ CMAQ/WRF(5x) - 12km	National 2001 inv., grown to 2006
BAMS - 45km	
→ BAMS - 15km	
BAMS - 5km	
→ WRF/CHEM - 36km(*)	NEI-99, NOAA/ESRL/CSD 2004 CEMS
→ WRF/CHEM - 12km(*)	
WRF/CHEM/NMM 40km	
→ STEM(2K3) - 12 km	Vukovich (2005 base)

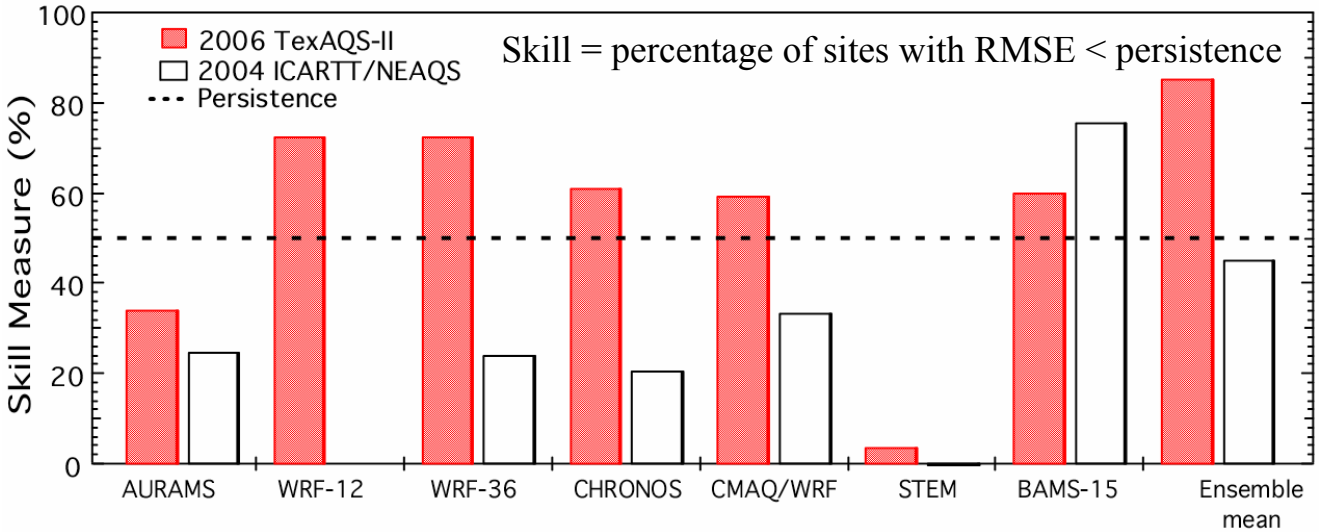
(*) Indicates a retrospective run

→ Indicates models used in analysis

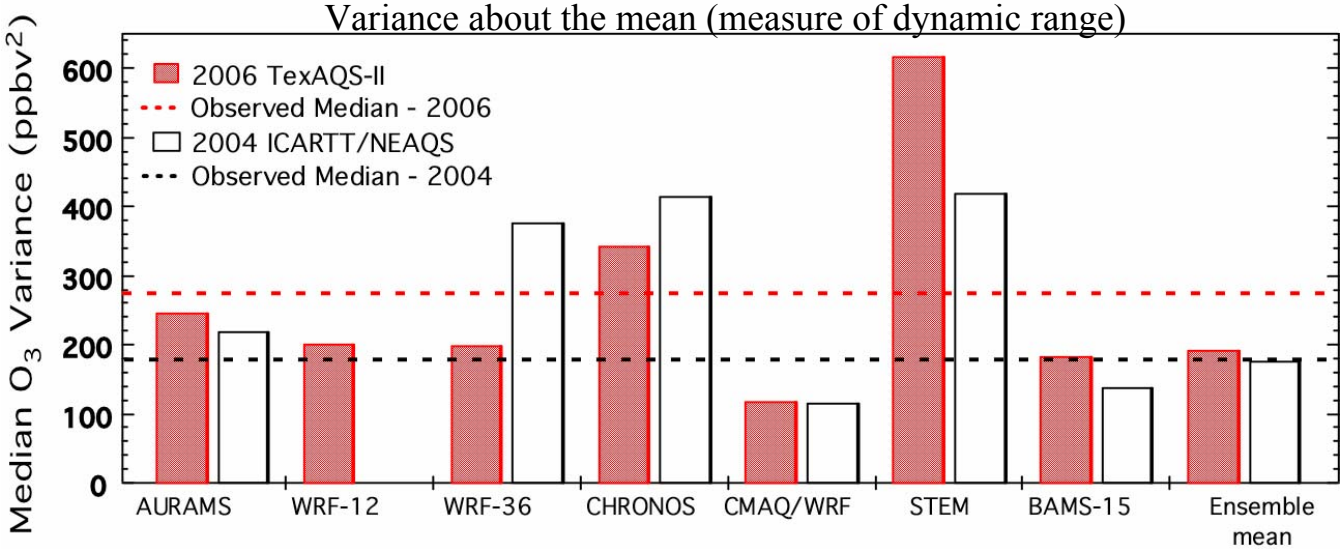
Maximum 8-hr average O_3 statistics for 119 AIRNow monitors in East Texas 8/12/06 - 9/30/06 (Jim Wilczak and Irina Djalalova, NOAA/ESRL/PSD)



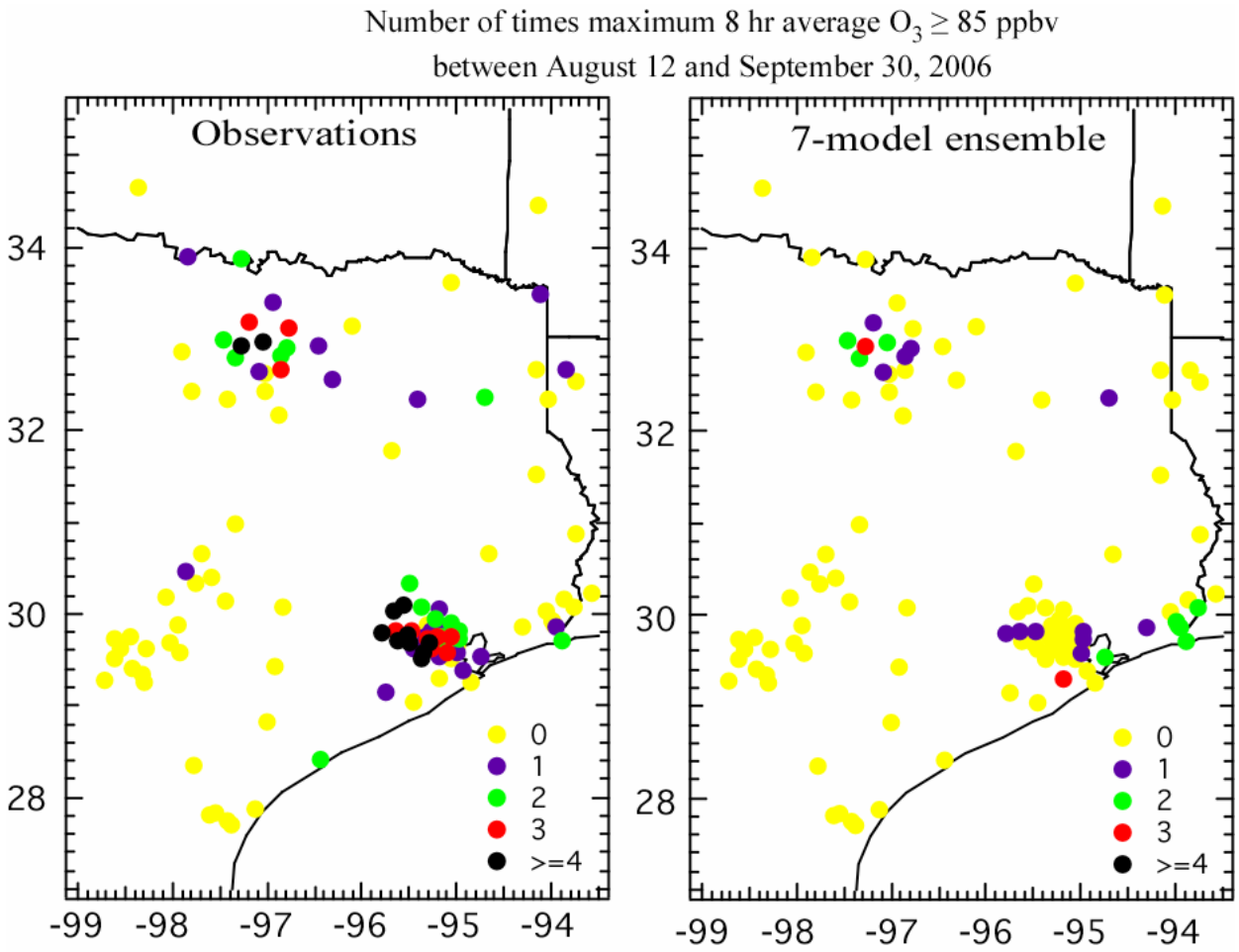
2006 versus 2004 surface O_3 statistics (no bias corrections)



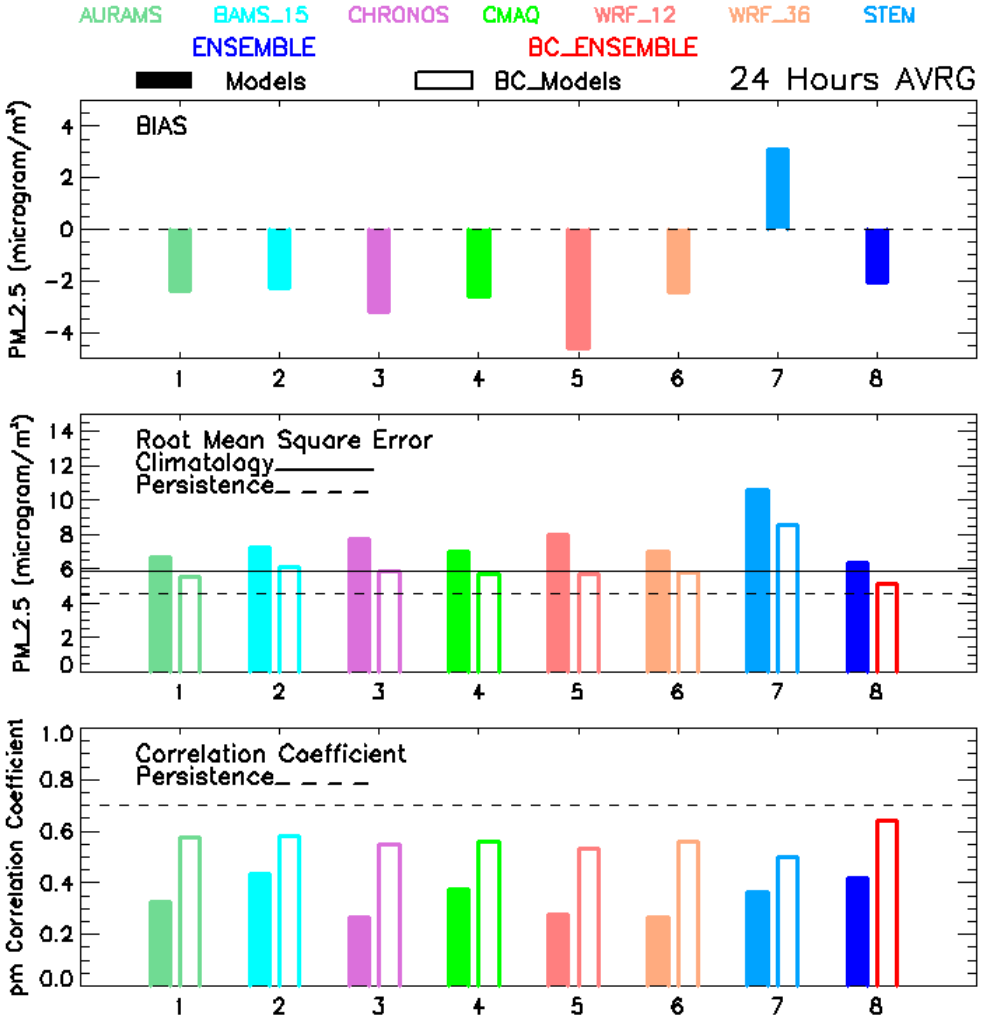
Variance about the mean (measure of dynamic range)



Number of exceedences of maximum 8-hr average $O_3 \geq 85$ ppbv 8/12/06 - 9/30/06



24-hr average $PM_{2.5}$ statistics for 38 AIRNow monitors in East Texas 8/13/06 - 9/30/06 (Jim Wilczak and Irina Djalalova, NOAA/ESRL/PSD)



Web-page for NOAA-P3/AQ forecast model comparisons:
http://esrl.noaa.gov/csd/2006/modeleval/

- Individual horizontal transects and vertical profiles (~11000 plots)
- Summary statistics - daytime (10:00am - 6pm), 400 -670 m alt. (31 plots)

  Fly the aircraft through the model results
  Store grid average observations for each model - no interpolation

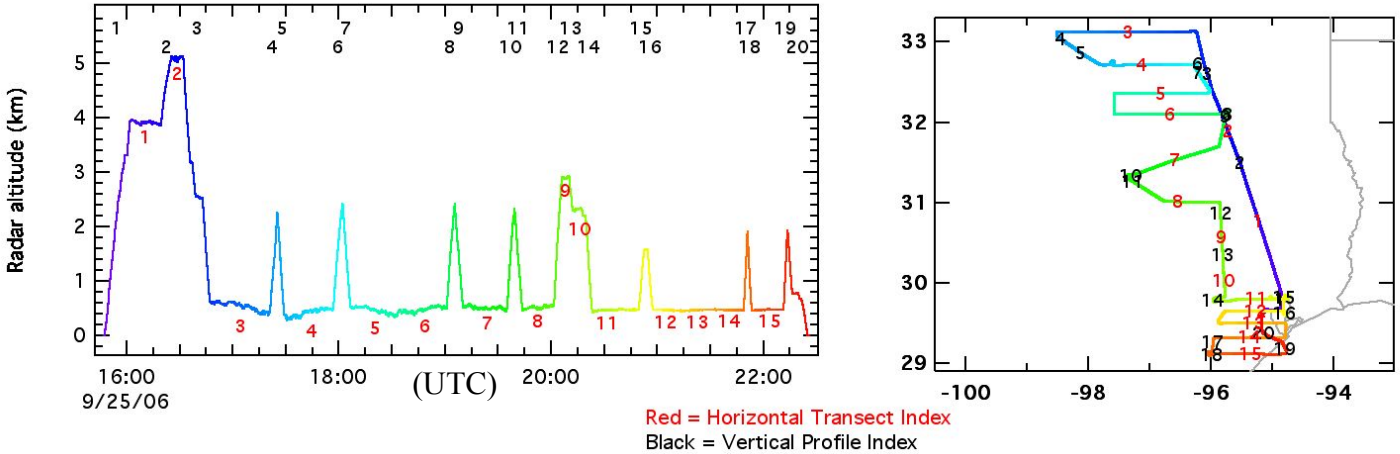
- Upwind and Downwind Fluxes along horizontal transects (~200 plots)

  350 meter to 670 meter (AGL) P3 horizontal transects
  (Houston, Dallas, East Texas Power Plants)
  Inflow condition
  Flux of gas/aerosol in excess of inflow condition

- Downwind Flux ratios (~200 plots)

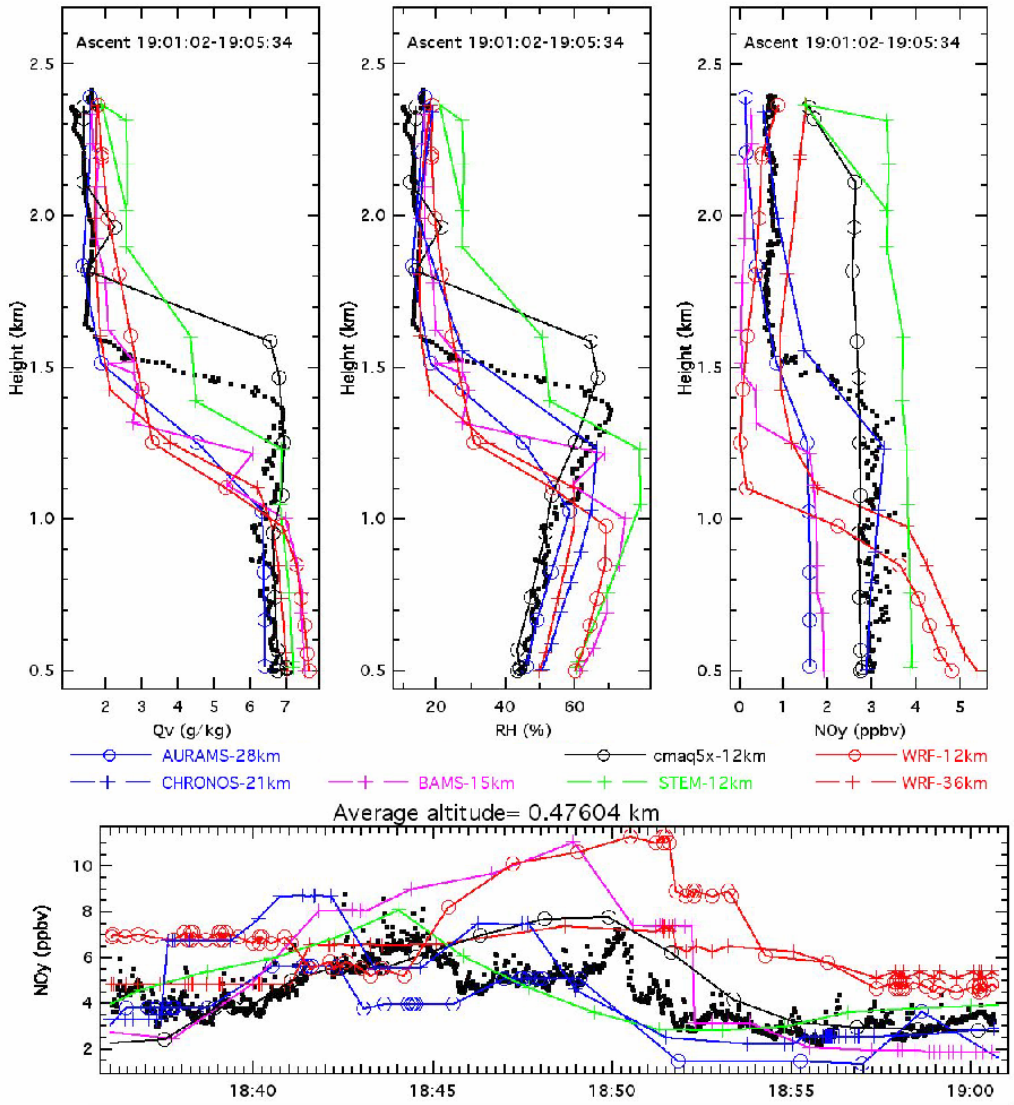
  Ratios of excess gas/aerosol flux downwind of sources

Horizontal Transects (300 to 670 m AGL)
Both Upwind and Downwind of Sources in September

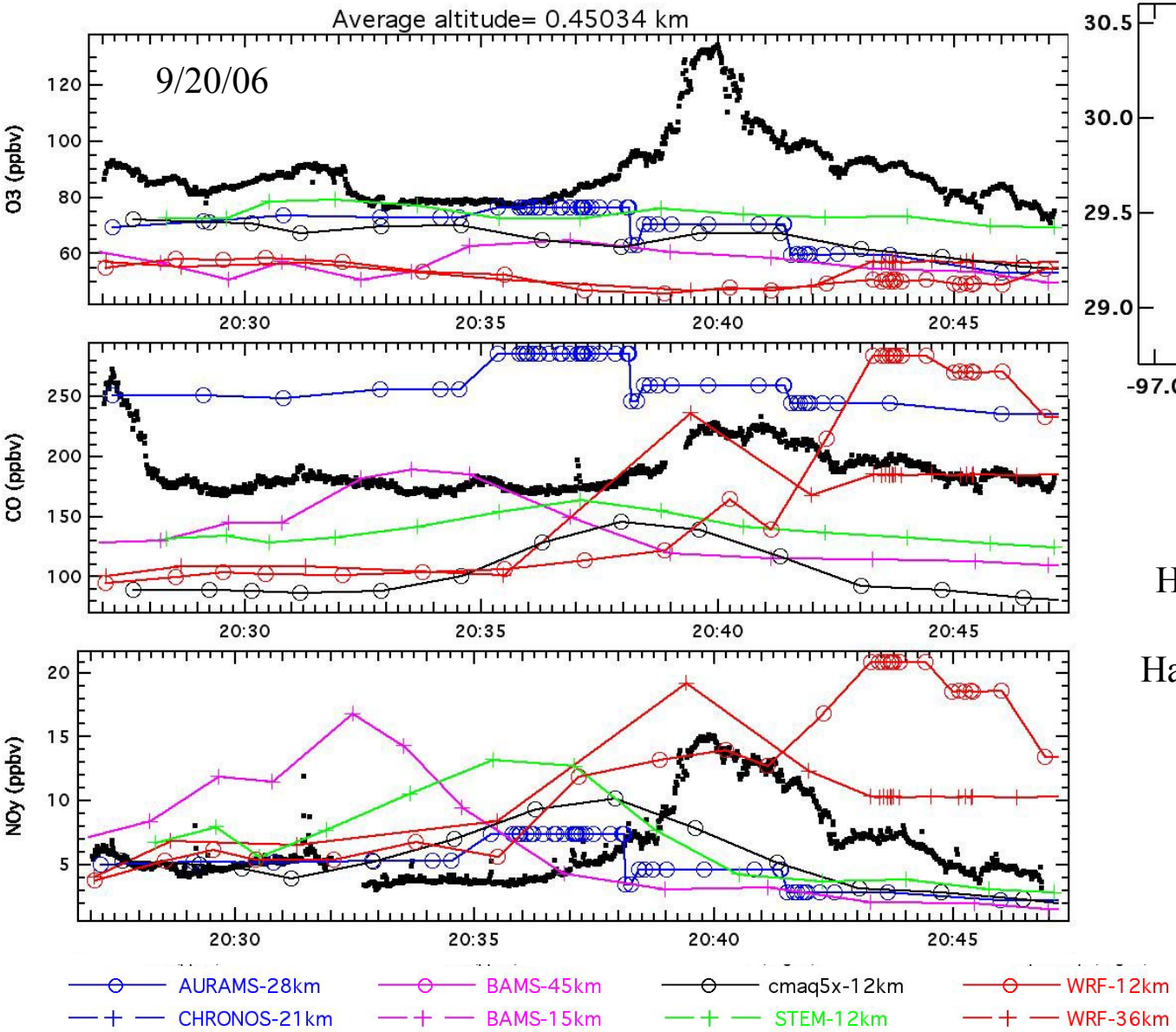


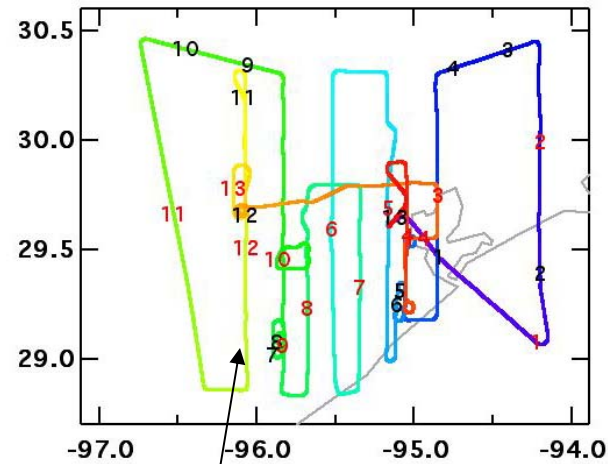
	Sept. 13, Dallas	5.0 m/s	northerly
	Sept. 15, Houston	4.5 m/s	southeasterly
	Sept. 16, East TX stacks	6.0 m/s	southerly
	Sept. 19, Houston	7.5 m/s	northeasterly
	Sept. 20, Houston	5.0 m/s	easterly
	Sept. 21, Houston	9.5 m/s	southerly
→	Sept. 25, Dallas	3.0 m/s	northerly
	Sept. 25, Houston	6.0 m/s	northerly
	Sept. 26, Houston	3.0 m/s	northeasterly
	Sept. 27, Houston	5.5 m/s	southerly
	Sept. 29, Houston	3.5 m/s	southerly

Example of vertical profiles and a horizontal transects 80 km downwind of Dallas, 9/25/06



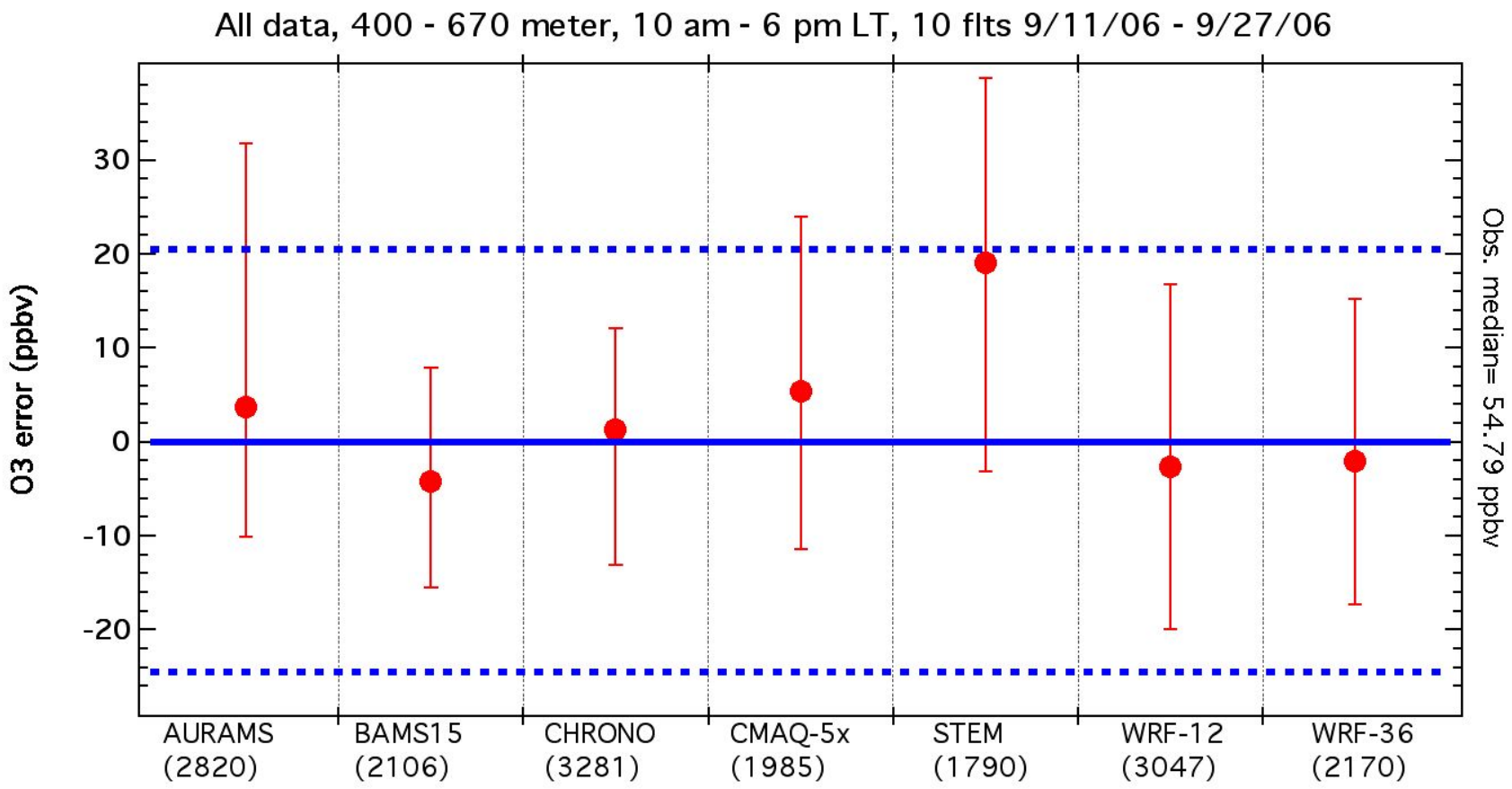
Example of Horizontal Transect for 9/20/06



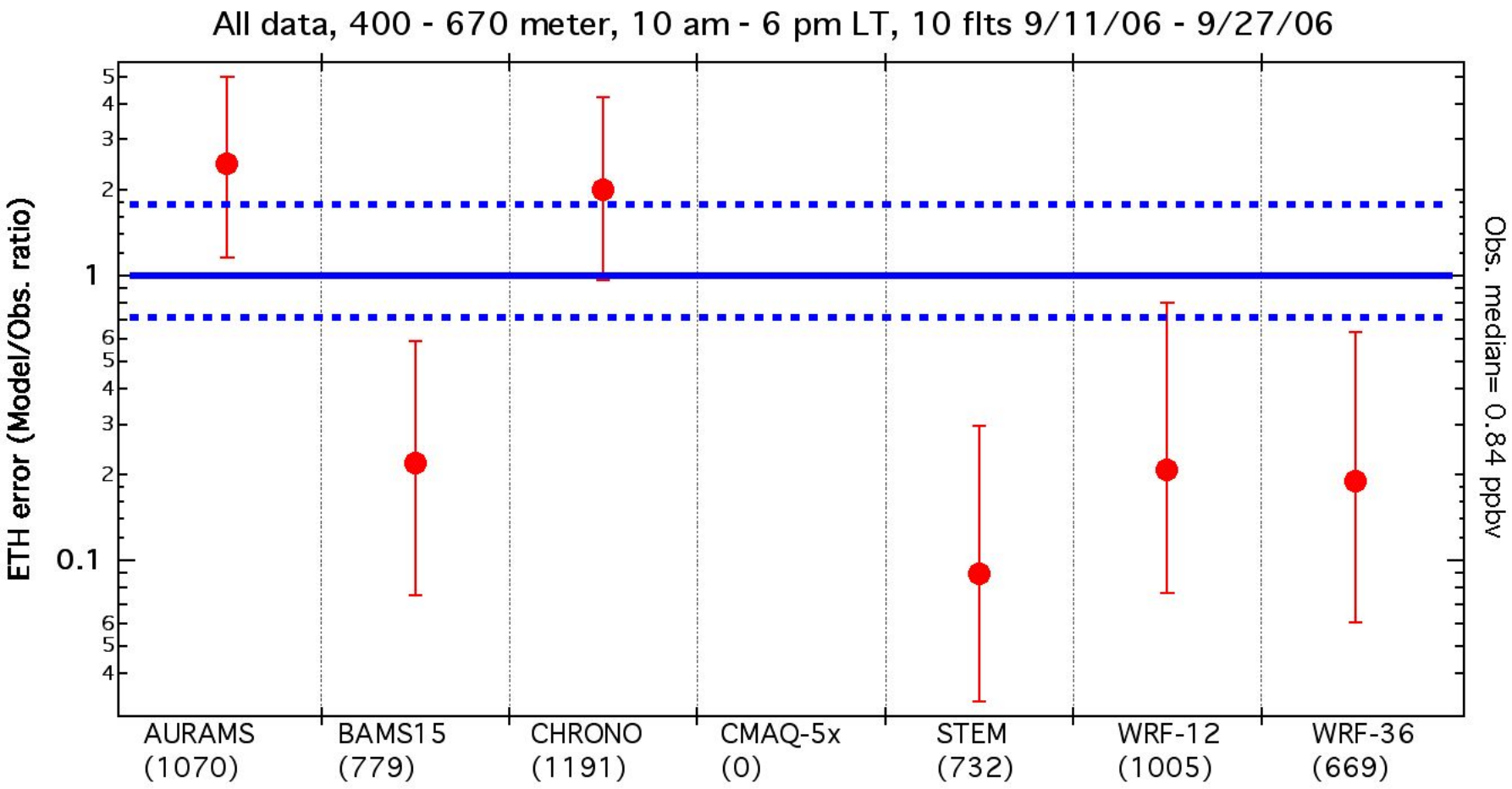


Horizontal Transect #12
70 km downwind of
Harris County Courthouse

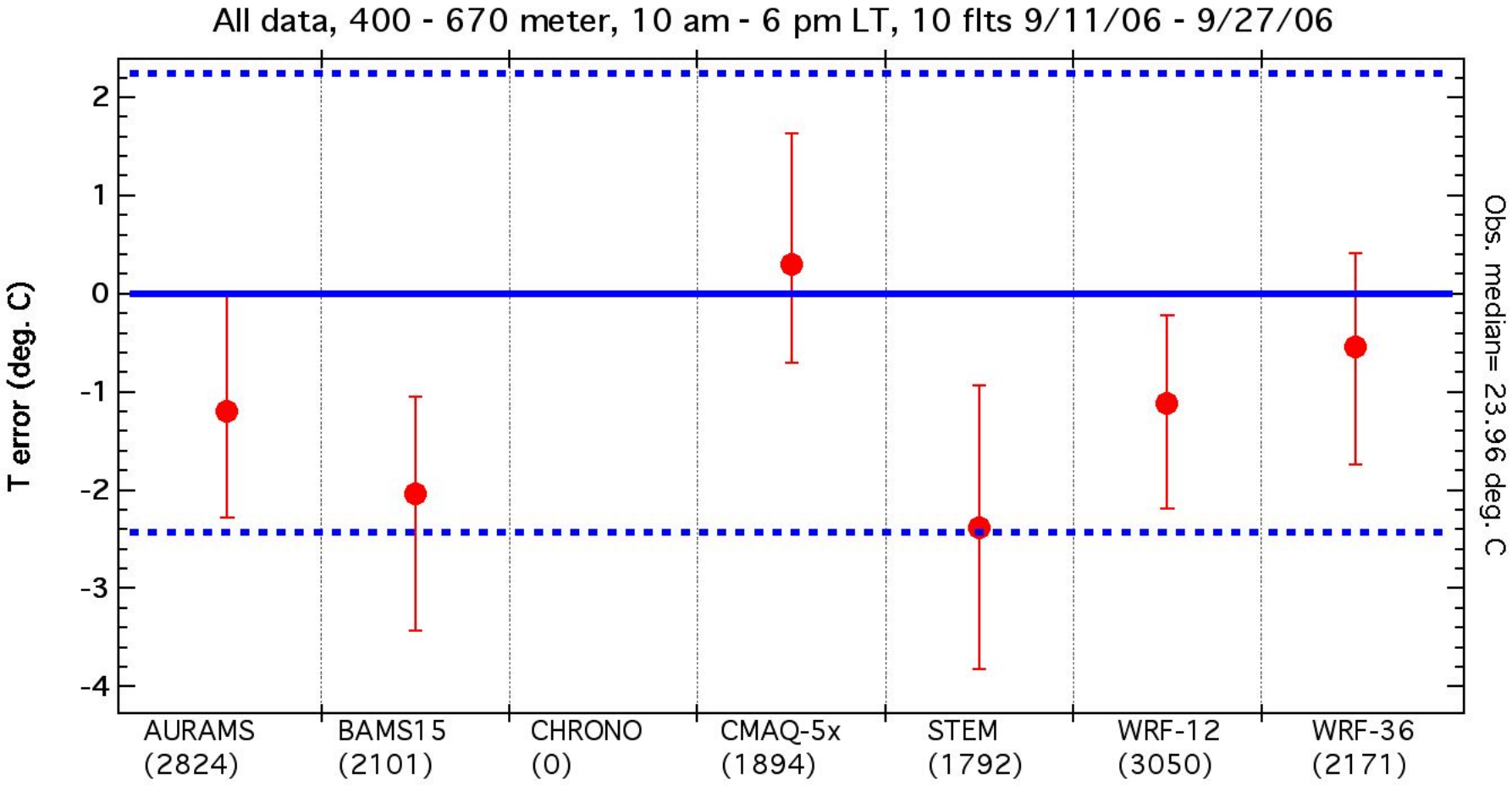
Model to model bias comparisons for O_3 in the mid-day PBL



Model to model bias comparisons for Ethylene in the mid-day PBL



Model to model bias comparisons for Temperature in the mid-day PBL



Fluxes upwind and downwind of sources
(300 to 670 m AGL horizontal transects)

1) Upwind mixing ratio or concentration (average, X_{upwind})

2) $\vec{v} \bullet \vec{n}$ (where $\vec{n}$ is normal vector <u>perpendicular to aircraft heading</u>)

3) Total flux (above background) through the plane defined by the aircraft heading

$$\sum (X_i - X_{upwind})(\vec{v_i} \bullet \vec{n})$$

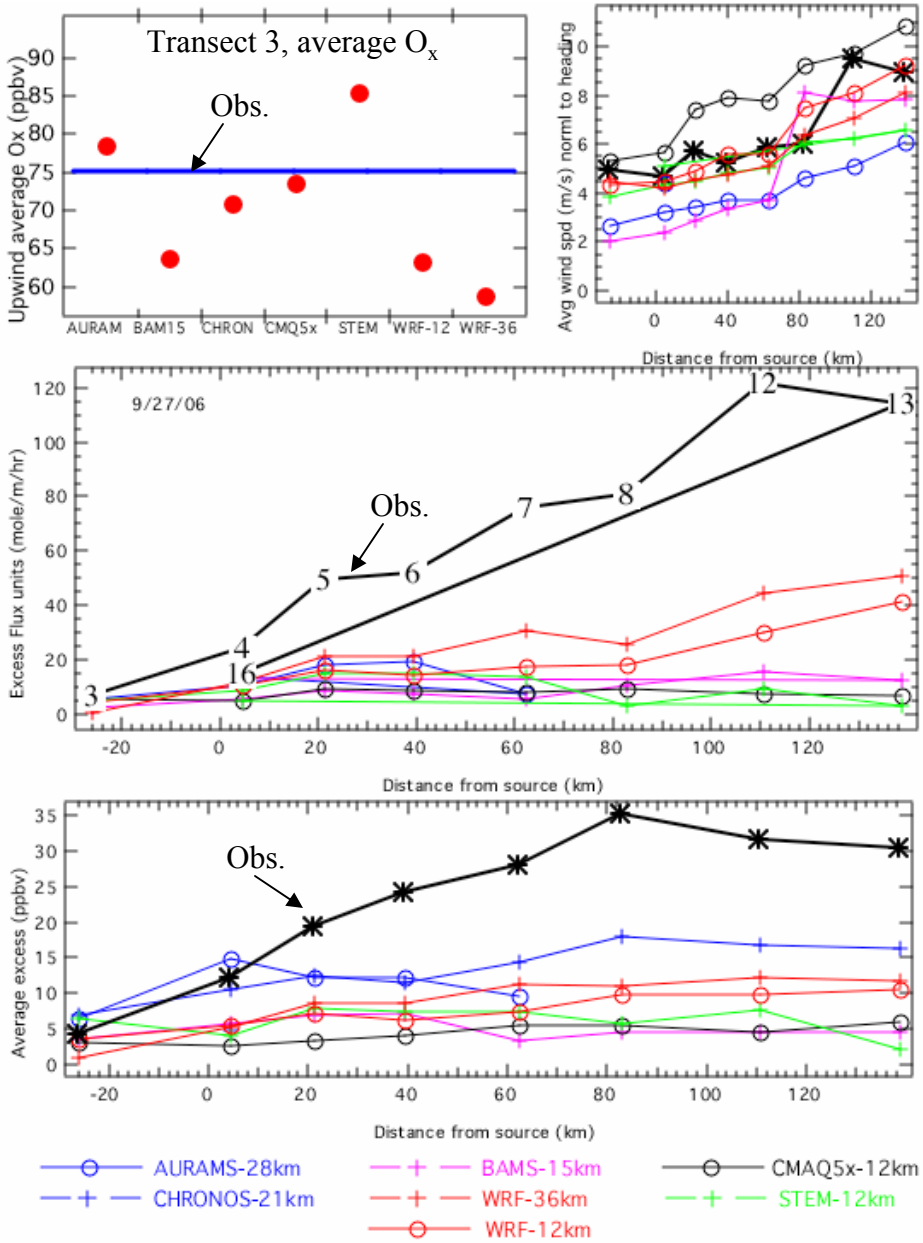
[if $X_i > X_{upwind}$, otherwise 0]

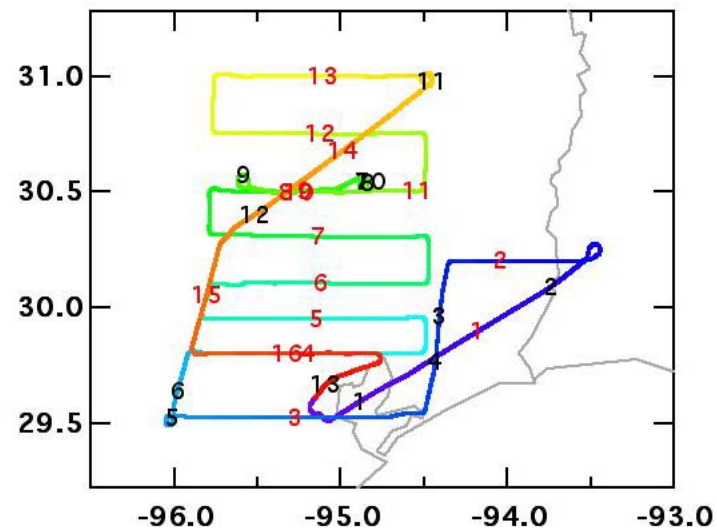
4) Average mixing ratio above background

Applied identically to observations and models

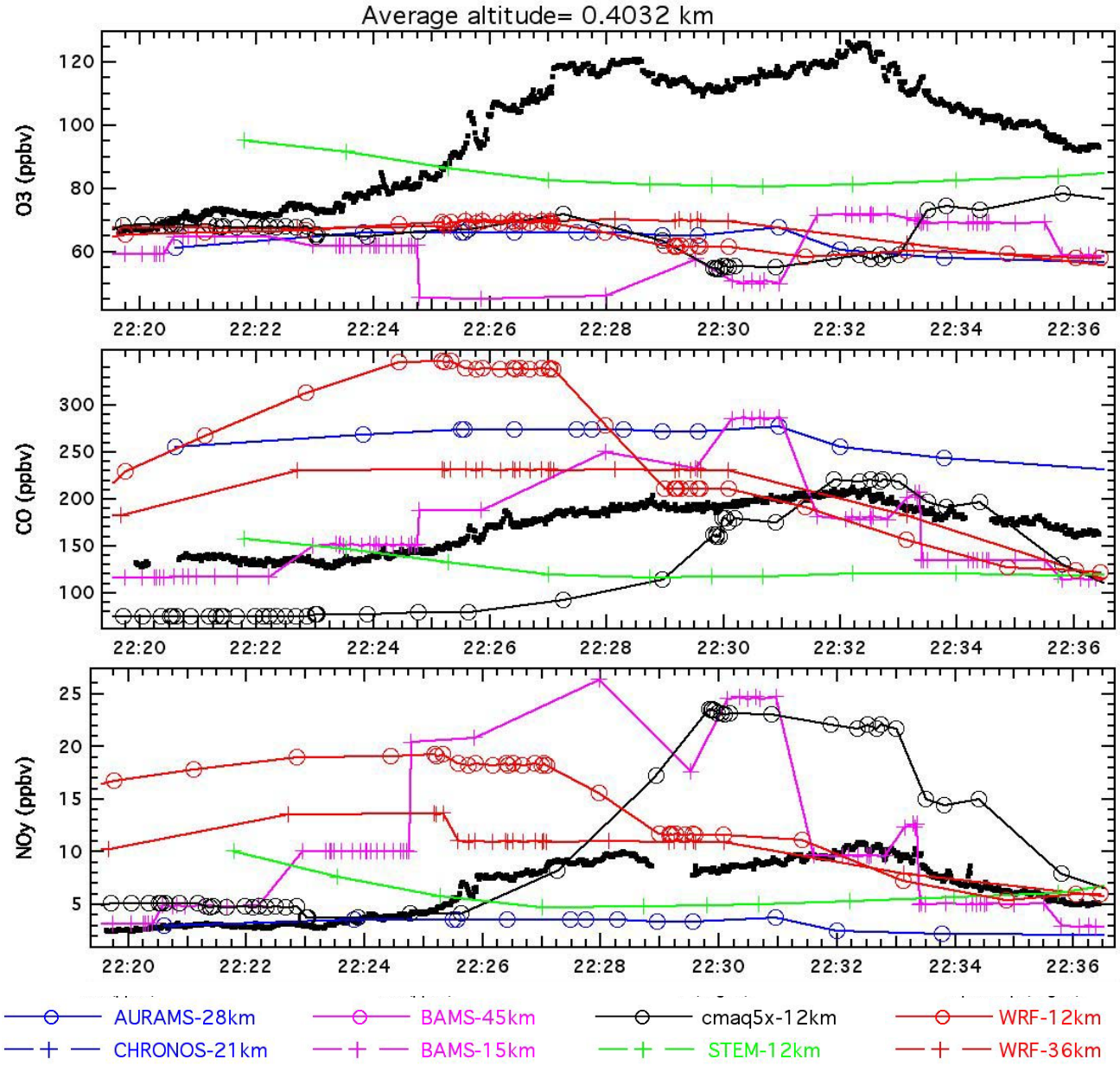
Flux units - moles/hr per meter(vertical)

9/27/06 - High O_3 downwind of Houston, recirculation from previous day

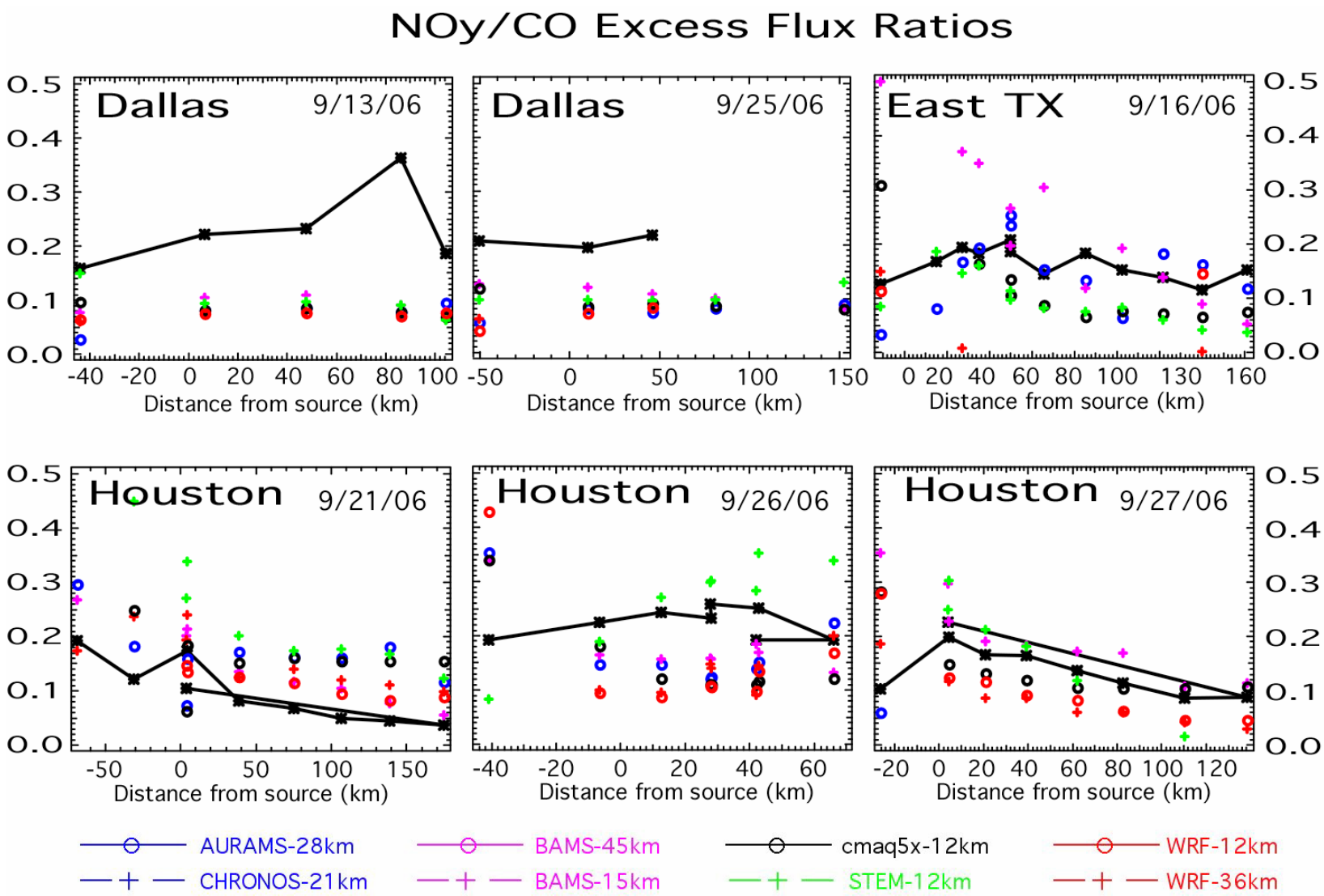




9/27/06 - 110 km north of Houston



Surrogates for relative emission comparisons



Summary:

From Surface Analysis:

1) Houston 8-hr max. O_3 exceedences are not predicted by models
2) 24-hr average $PM_{2.5}$ predictions can not beat persistence

From Aircraft Analysis:

1) Highest O_3, narrow plumes in Houston missing in models
2) PBL parameterizations influence biases of precursors
3) Model under-predictions of Houston anthropogenic HRVOC
4) Evidence for high CO emissions in all models relative to NOy