Texas Commission on Environmental Quality

Air Quality in Texas: Scientific and Regulatory Perspectives in 2008

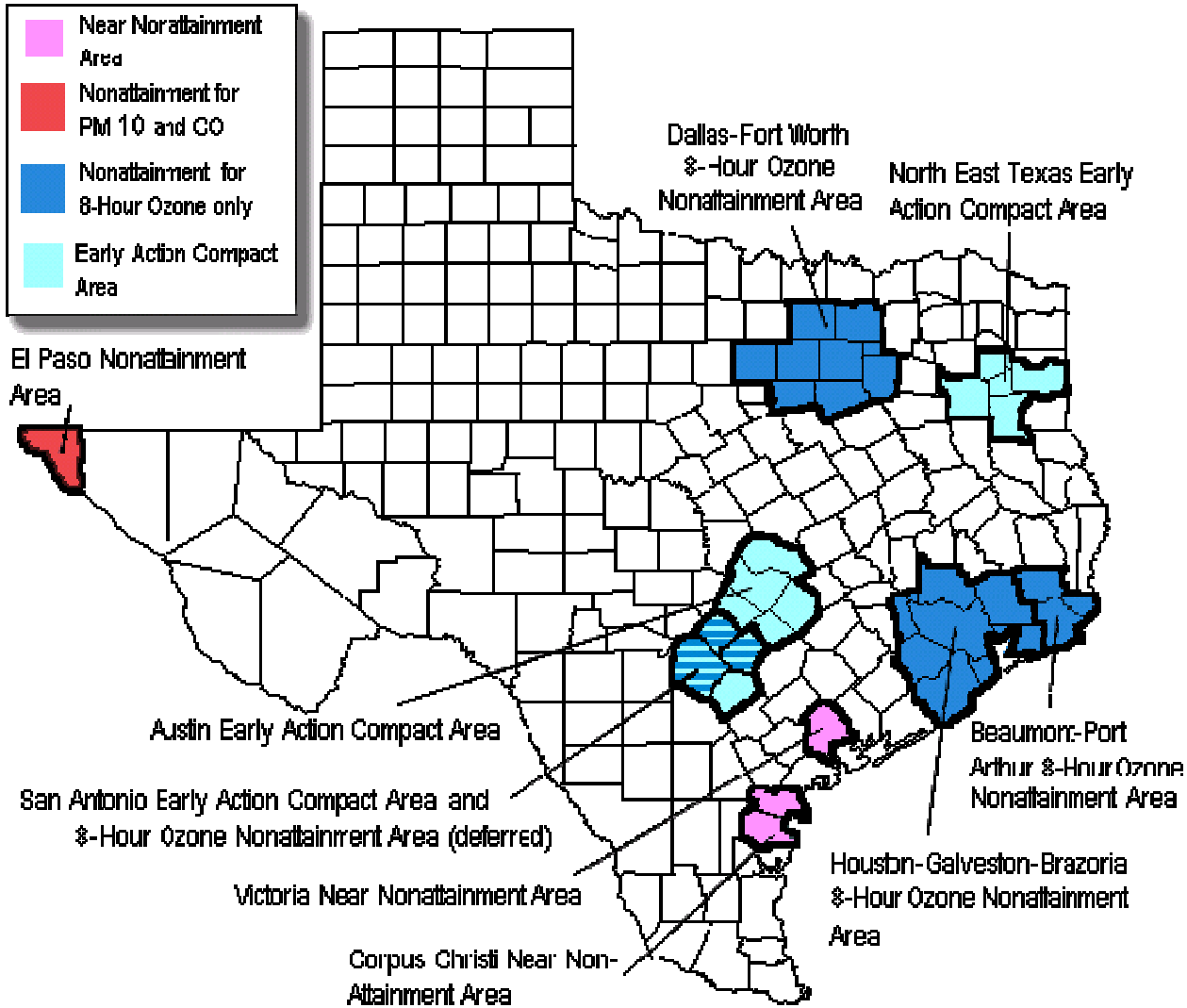
25th Minerals Management Service
Information Transfer Meeting
7 January 2009

Jim Smith

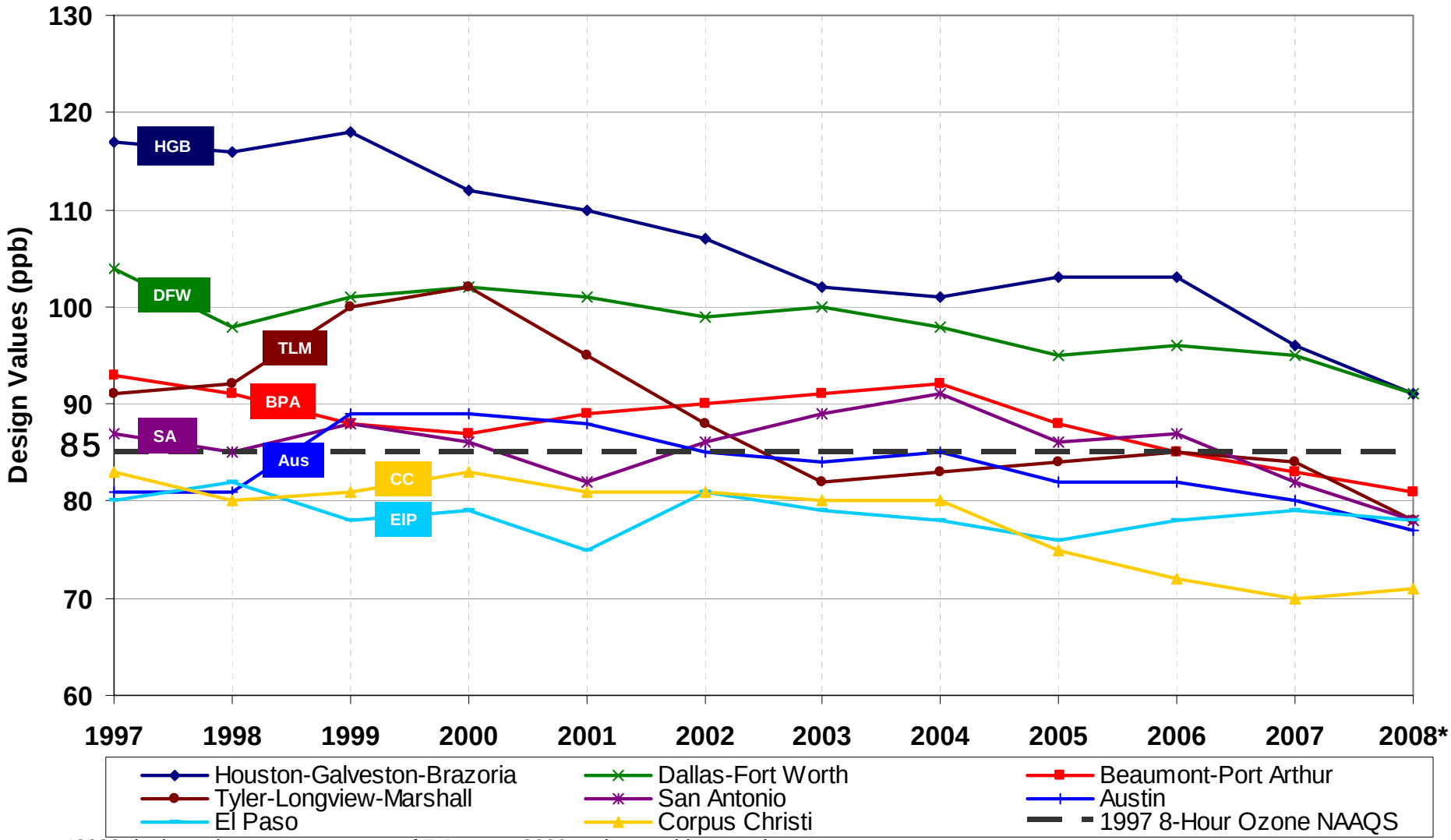
Texas Commission on Environmental Quality
Austin, Texas

Air Quality Trends in Texas

Ozone Nonattainment and Near Nonattainment Areas



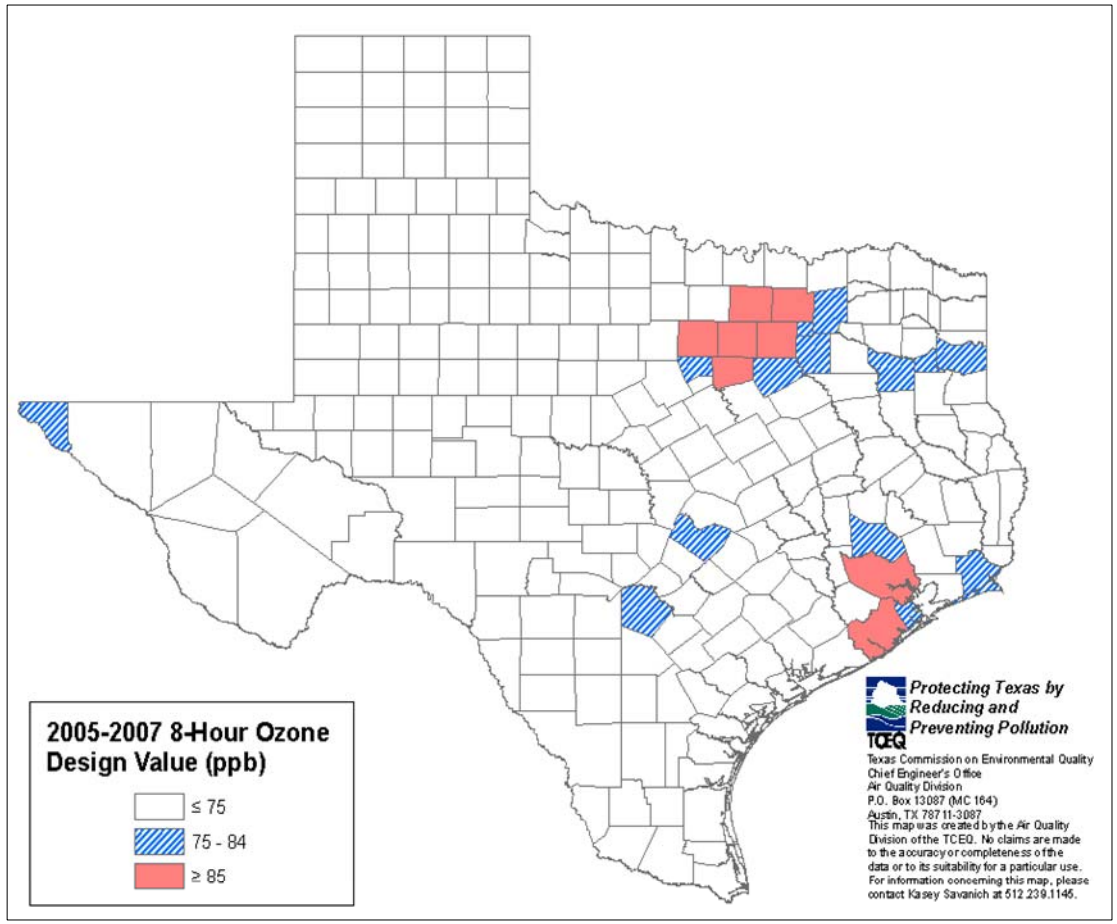
Eight-Hour Ozone Design Values in Texas (1997-2008*)



*2008 design values are current as of 5 January 2009 and are subject to change.

Counties Monitoring Over Revised Ozone Standard of 0.075 ppm

Region	County	2007 8-Hr Ozone DV (ppb)*
HGB	GALVESTON	84
HGB	MONTGOMERY	84
TLM	GREGG	84
TLM	SMITH	80
TLM	HARRISON	77
DFW	HOOD	84
DFW	ROCKWALL	78
DFW	ELLIS	78
DFW	HUNT	76
DFW	KAUFMAN	76
BPA	JEFFERSON	83
SAN	BEXAR	82
AUS	TRAVIS	80
ELP	EL PASO	79



*2007 design values based on average of 2005 to 2007 data. To exceed the revised standard the design value must be greater than or equal to 75 ppb.

Recent Regulatory Milestones

Houston/Galveston/Brazoria

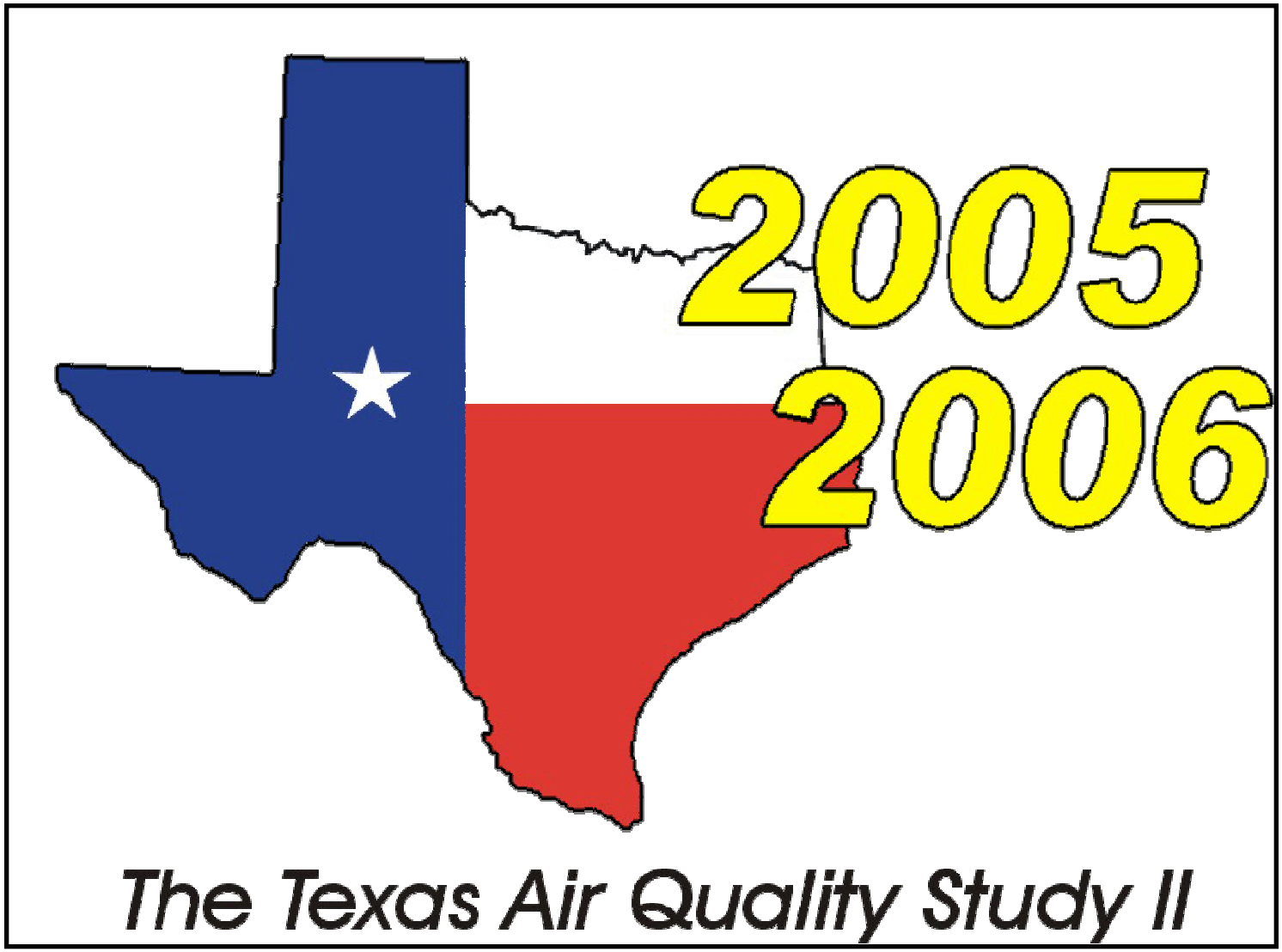
- **Governor Perry requests reclassification from moderate to severe**
  - **Granted 1 October 2008 by EPA**
  - **SIP revision due date 15 April 2010**
  - **2019 attainment date (2018 attainment demonstration)**

Dallas/Fort Worth

- **Attainment demonstration SIP revision for the 1997 8-hour ozone standard**
  - **Submitted to EPA in June 2007**
  - **2010 attainment date**
  - **EPA proposed conditional approval on 14 July 2008**
  - **After certain TCEQ enhancements, EPA granted final conditional approval on 17 December 2008**

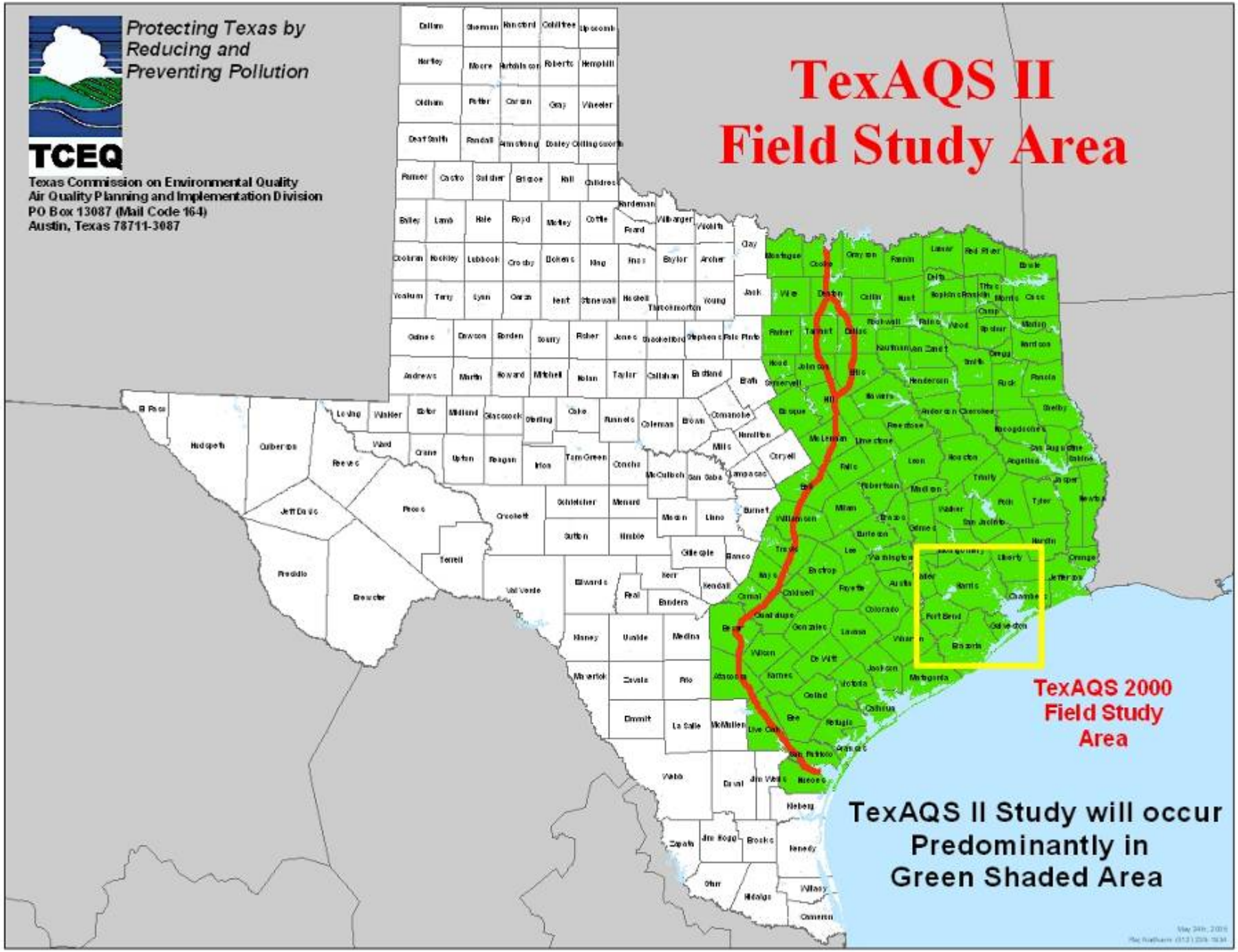
Beaumont/Port Arthur

- **BPA Redesignation Request and Maintenance Plan adopted by TCEQ on 10 December 2008**


2005
2006
The Texas Air Quality Study II

What was TexAQS II

- **The Second Texas Air Quality Study (TexAQS II) was developed to address questions left unresolved by the highly-successful TexAQS 2000.**
- **TexAQS II drew together hundreds of the nation's top air quality scientists for an 18-month study of air pollution in the eastern half of Texas.**
- **The study ran from May 2005 into October 2006, with a 2½-month intensive study period from 1 August through 15 October 2006.**


Protecting Texas by Reducing and Preventing Pollution
TCEQ
Texas Commission on Environmental Quality
Air Quality Planning and Implementation Division
PO Box 13087 (Mail Code 164)
Austin, Texas 78711-3087
TexAQS II
Field Study Area
TexAQS 2000
Field Study
Area
TexAQS II Study will occur
Predominantly in
Green Shaded Area

Study Participants

- **Governmental Agencies:**
  - **National Oceanic and Atmospheric Administration**
    - **Office of Oceanic and Atmospheric Research –**
      - **Earth System Research Laboratory**
      - **Pacific Marine Environmental Laboratory**
      - **Atlantic Oceanographic and Meteorological Laboratory**
      - **Air Resources Laboratory**
    - **National Weather Service**
    - **National Environmental Satellite, Data, and Information Service**
    - **Office of Marine and Aviation Operations**
  - **National Center for Atmospheric Research**
  - **Environmental Protection Agency**
  - **Department of Energy**
    - **Pacific Northwest National Laboratory**
    - **Argonne National Laboratory**
    - **Los Alamos National Laboratory**

Study Participants

- **Governmental Agencies (cont.):**
  - **Department of the Interior**
    - **Minerals Management Service**
  - **National Aeronautics and Space Administration**
    - **Jet Propulsion Lab**
  - **National Science Foundation**
  - **Department of Defense (Navy)**
  - **Tennessee Valley Authority**
  - **Texas Commission on Environmental Quality**
  - **Local Entities**
    - **Alamo Area Council of Governments**
    - **Capital Area Council of Governments**
    - **City of Corpus Christi**
    - **City of Victoria**

Study Participants

- **Institutes of Higher Education**
  - **University of Texas – Austin**
  - **University of Houston**
  - **Texas A&M University**
  - **Texas Tech University**
  - **Rice University**
  - **Lamar University**
  - **Baylor University**
  - **North Carolina State University**
  - **University of Miami**
  - **University of Colorado – Cooperative Institute for Research in Environmental Sciences**
  - **University of Washington – Joint Institute for the Study of Atmosphere and Ocean**

Study Participants

- **Institutes of Higher Education (cont.)**
  - **Georgia Tech University**
  - **California Institute of Technology**
  - **Valparaiso University**
  - **University of North Carolina, Chapel Hill**
  - **University of New Hampshire**
  - **University of Alabama-Huntsville**
  - **Fort Hayes State University**
  - **Pennsylvania State University**
  - **University of California at Los Angeles**
  - **University of California at Santa Cruz**
  - **Portland State University**
  - **Washington State University**

Study Participants

- **Institutes of Higher Education (cont.)**
  - **University of Massachusetts**
  - **University of Rhode Island**
  - **University of Iowa**
  - **Howard University**
  - **University of Manchester (UK)**
  - **Chambers University of Technology (Sweden)**
  - **Scripps Institute of Oceanography**

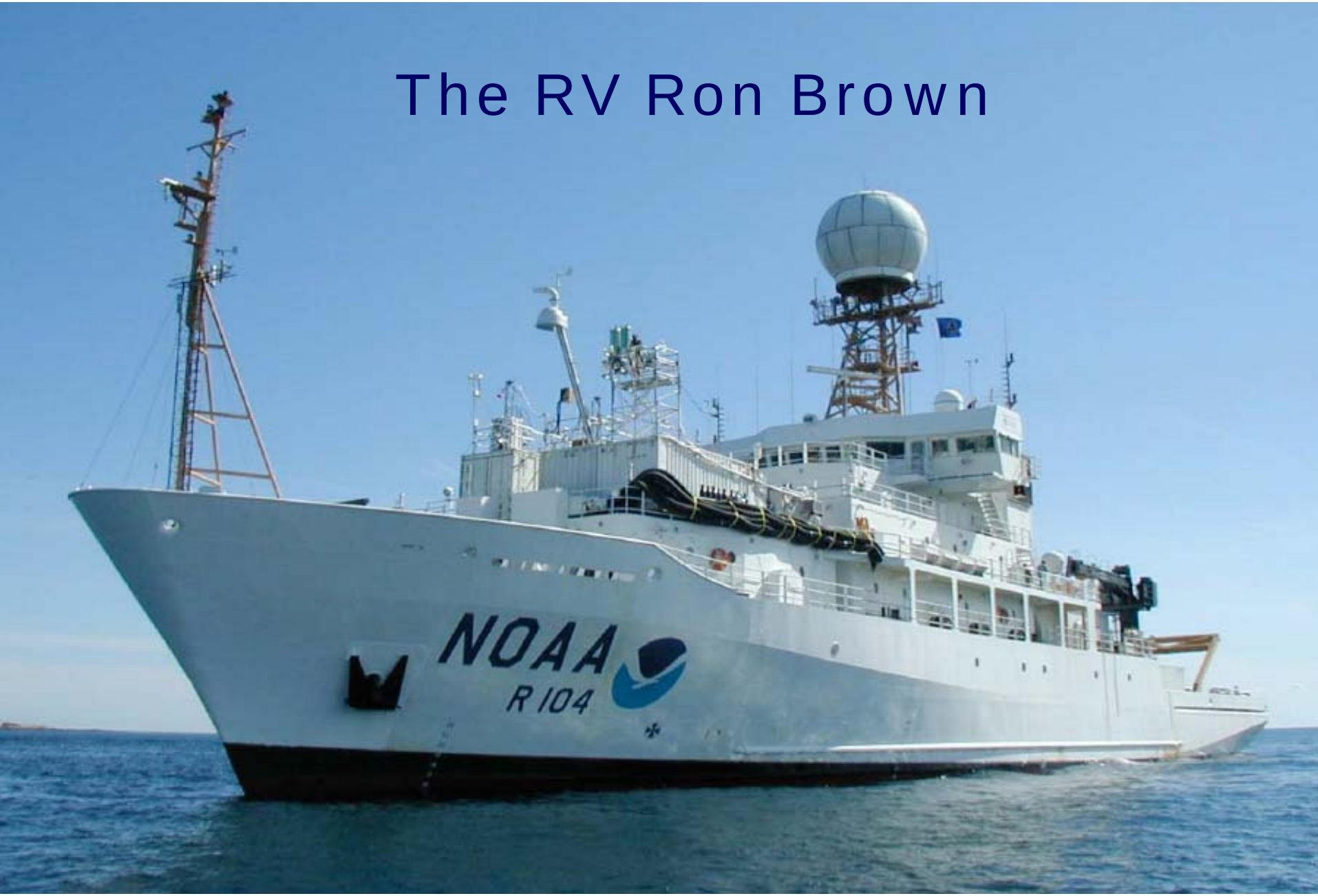
Study Participants

- **Other Participating Organizations**
  - **Meteorological Service of Canada**
  - **Environment Canada**
  - **California Air Resources Board**
  - **URS**
  - **Shell Oil Corp.**
  - **ExxonMobil Corp.**
  - **Aerodyne Research Inc.**
  - **SensorSense (Netherlands)**
  - **Science Systems and Applications, Inc.**
  - **Texas Environmental Research Consortium (TERC)**
  - **Houston Advanced Research Center (HARC)**
  - **Texas Air Research Center (TARC)**
  - **Houston Regional Monitoring (HRM) Network**
  - **Environ Corp.**
  - **Sonoma Technology Inc.**

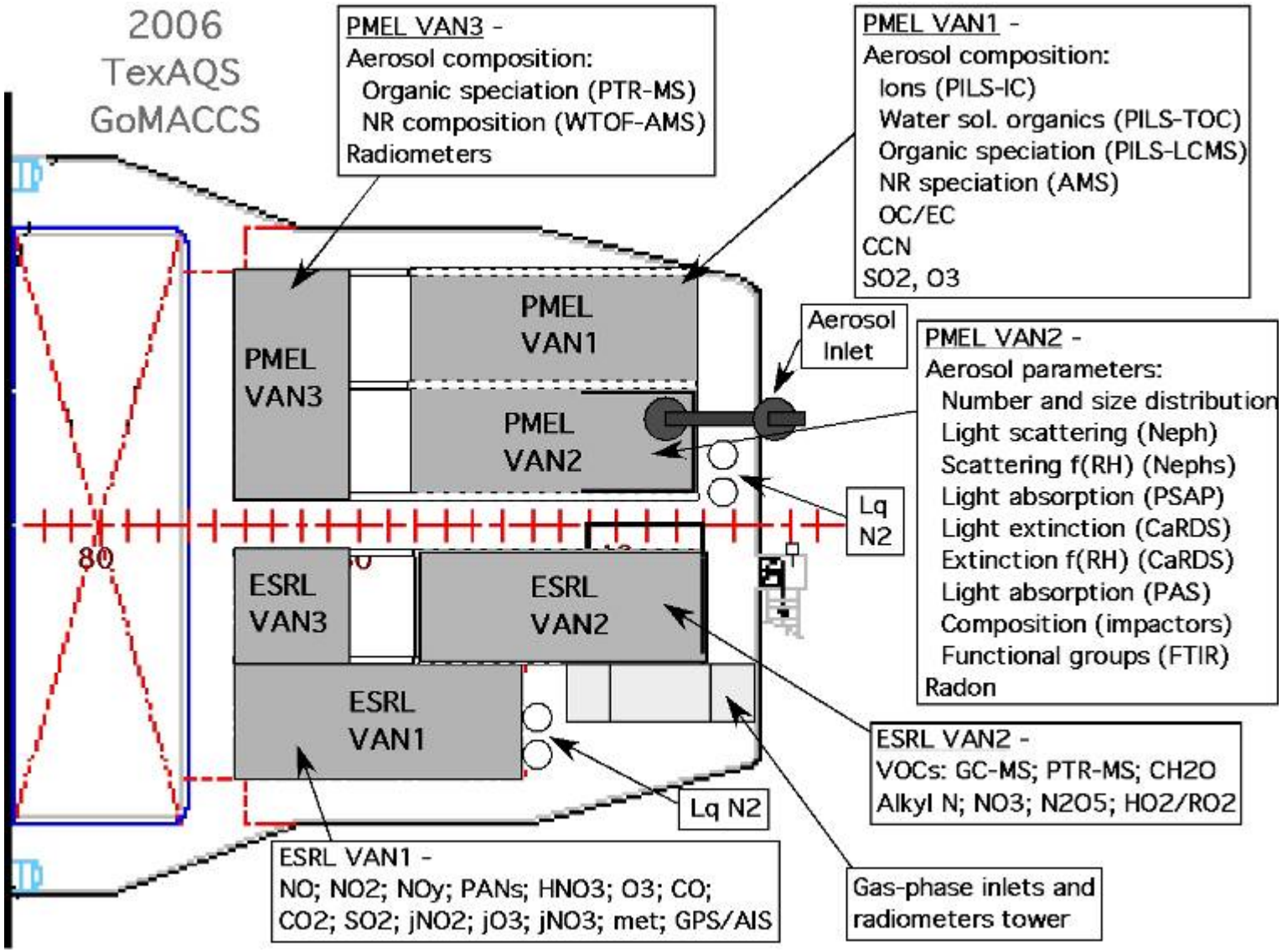
Sampling Platforms

- **NOAA Research Vessel Ronald H. Brown**
- **NOAA WP-3D Orion**
- **Moody Tower**
- **Baylor Aztec**
- **Houston Triangle**
- **Solar Occultation Flux & UV/Visible Zenith Sky**
- **NOAA Twin Otter**
- **Satellites**
- **Radar Profiler Network**
- **Enhanced Surface Monitoring Network**
- **Balloons/Sondes**
- **TexAQS II Special Inventory**
- **Specialized Aircraft Measurements**

The RV Ron Brown

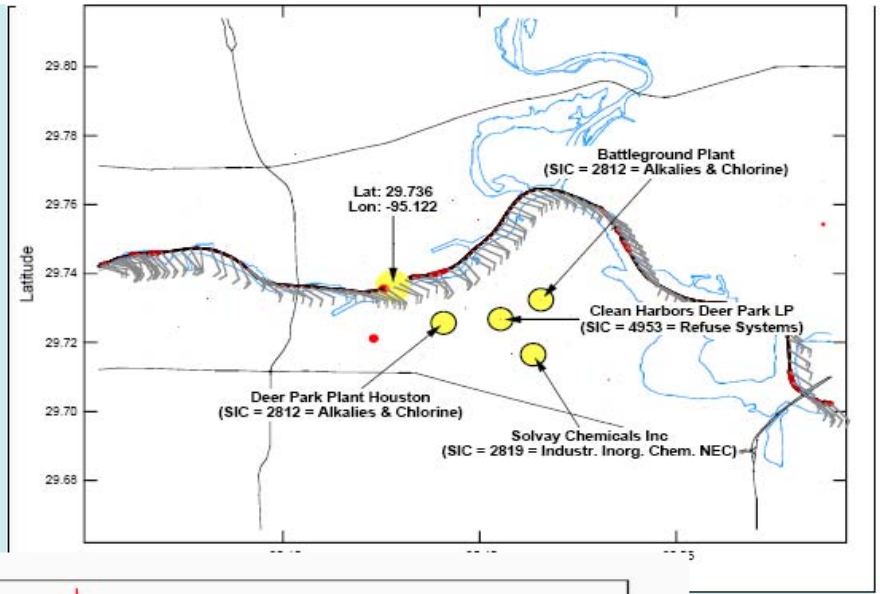


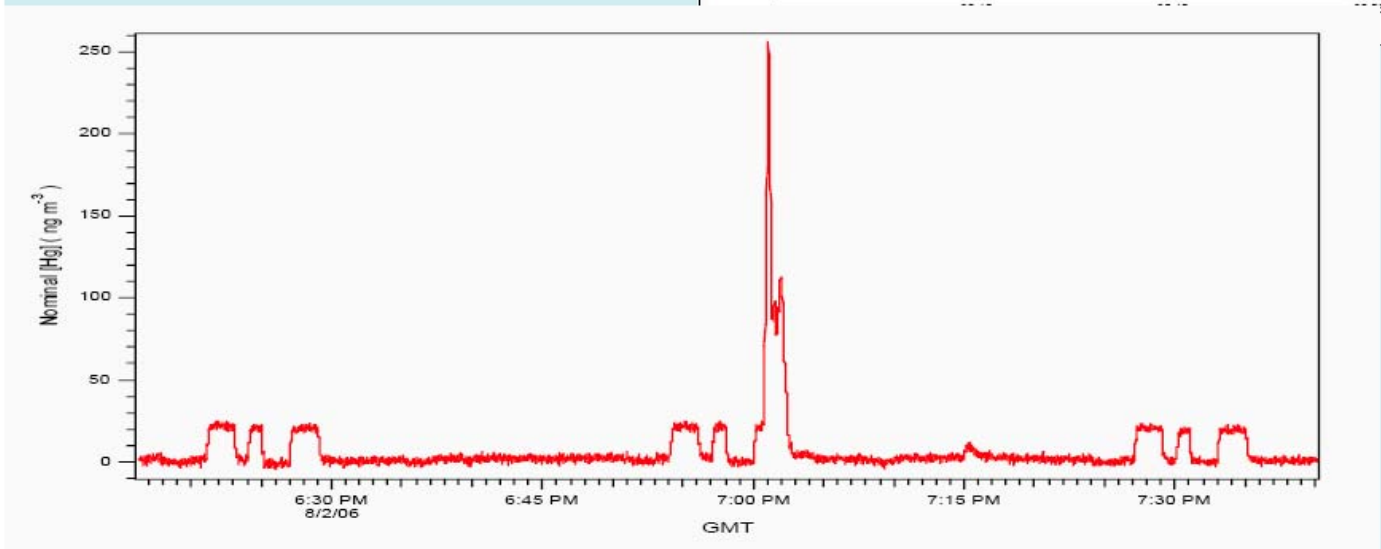
The RV Ron Brown



TexAQS II Example – Gas Phase Hg

2 August up the ship channel

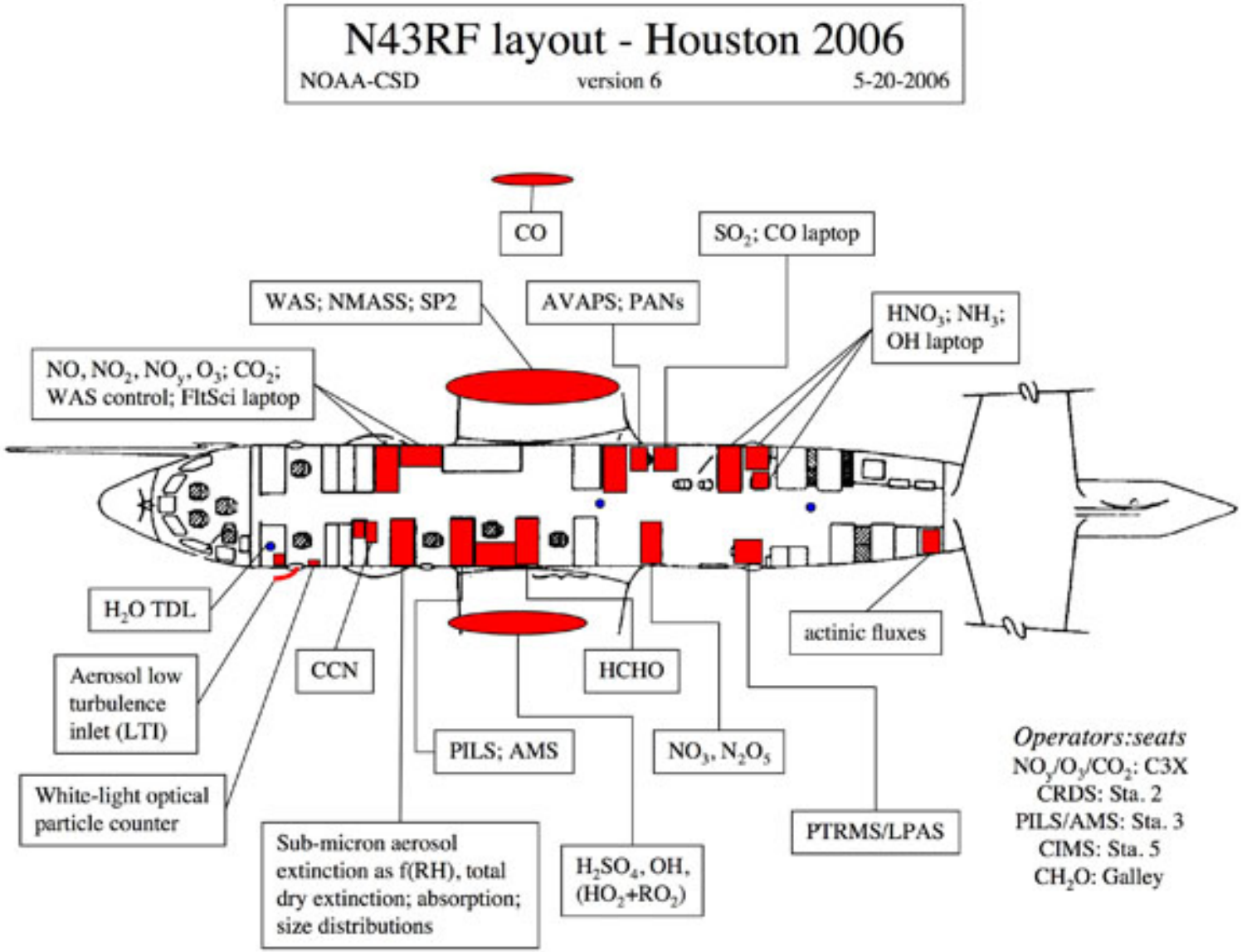




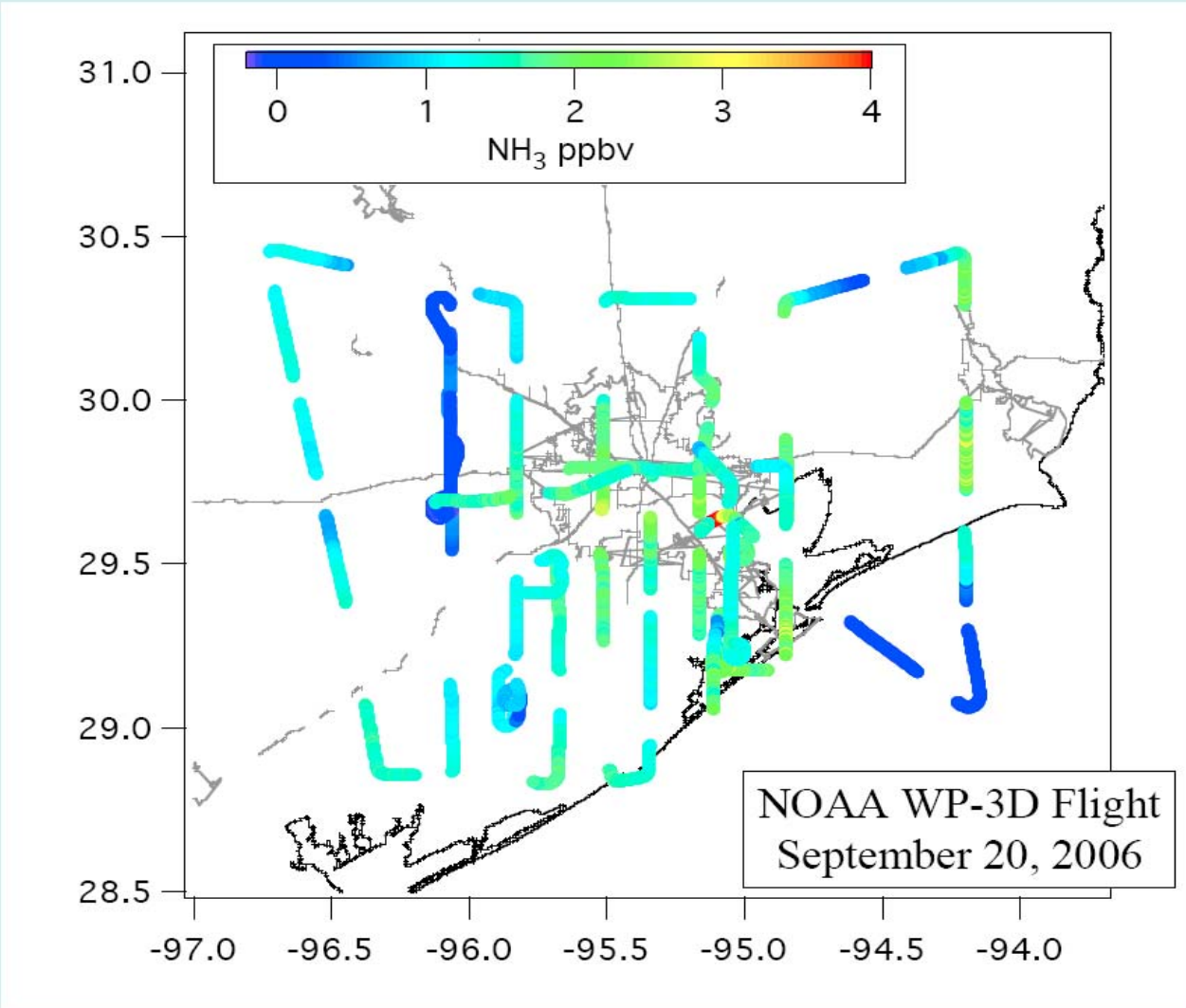
Fortin and Ryerson 2006

NOAA WP-3D Orion

NOAA WP-3D Orion



TexAQS II Example – NH3

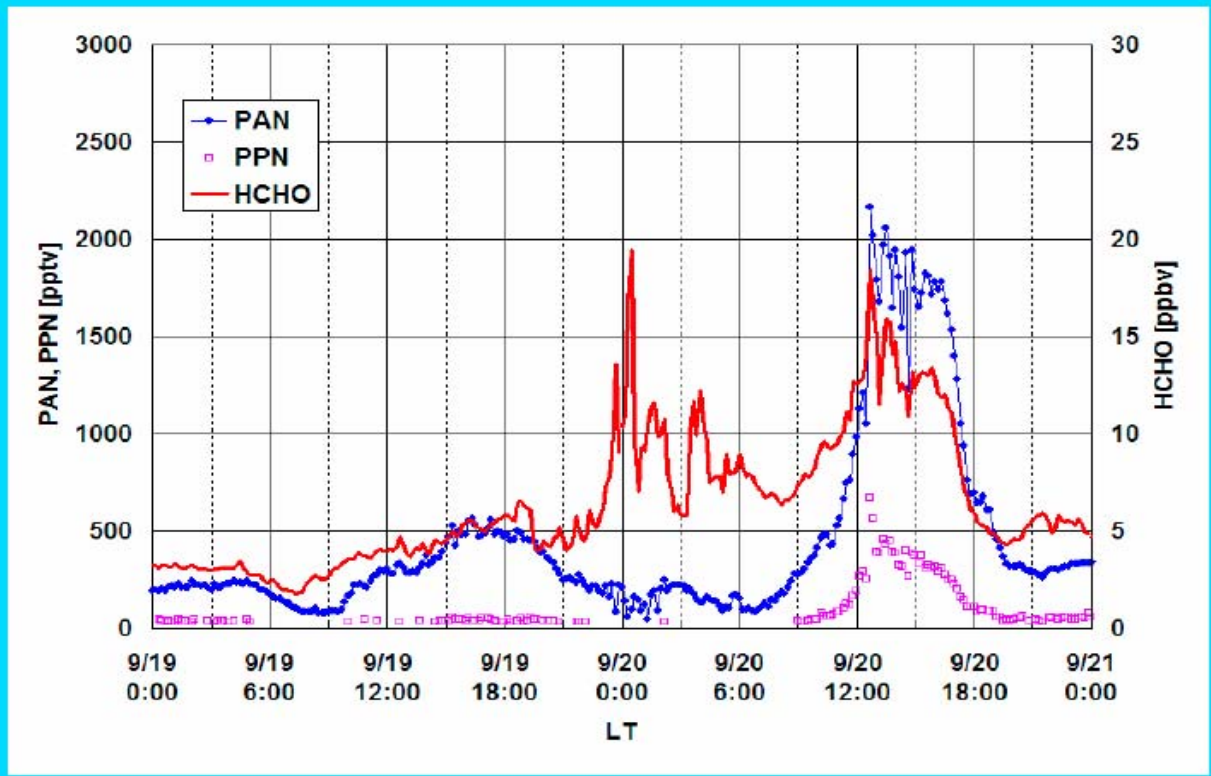


Nowack and Herndon 2006

Moody Tower, University of Houston

TexAQS II Example - HCHO

Time Series: Nighttime

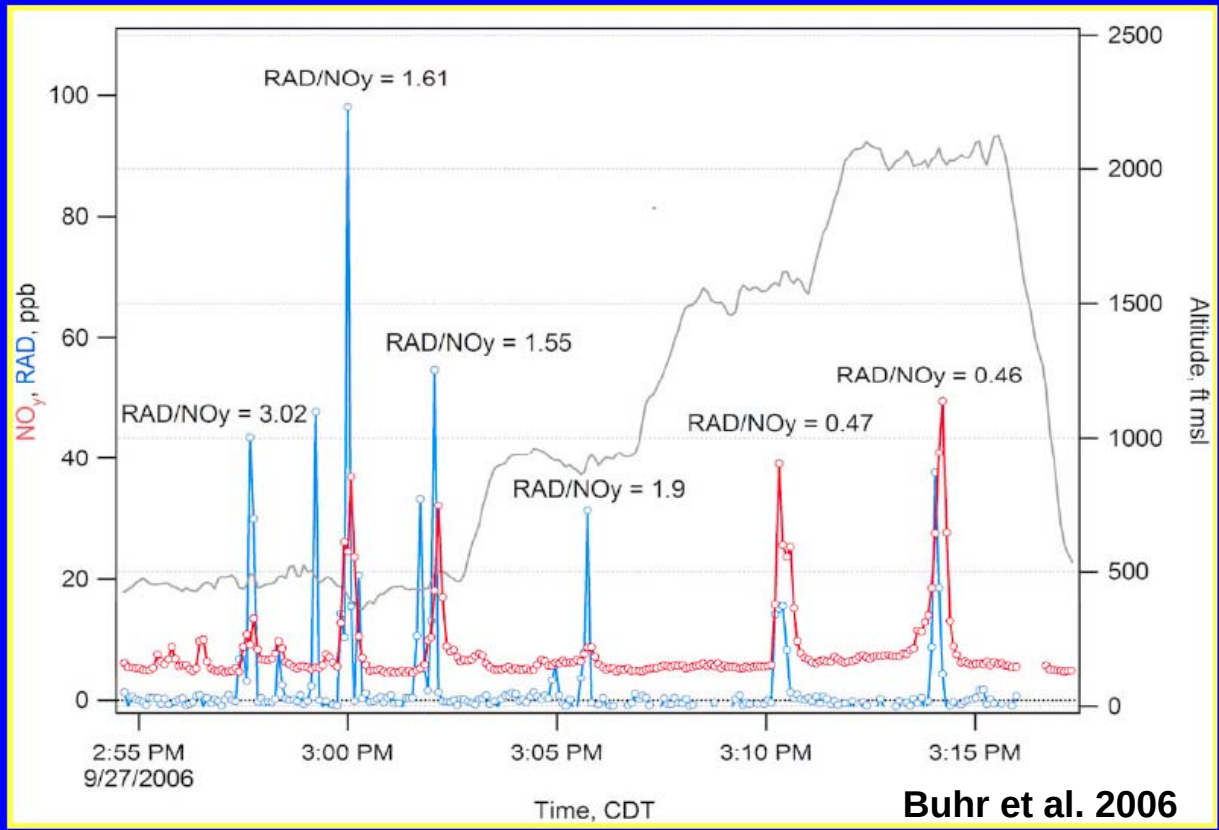


Leuchner and Rappengluck 2006

The Baylor Aztec

TexAQS II Example – Reactive Alkenes/NO_Y

sweeny emissions



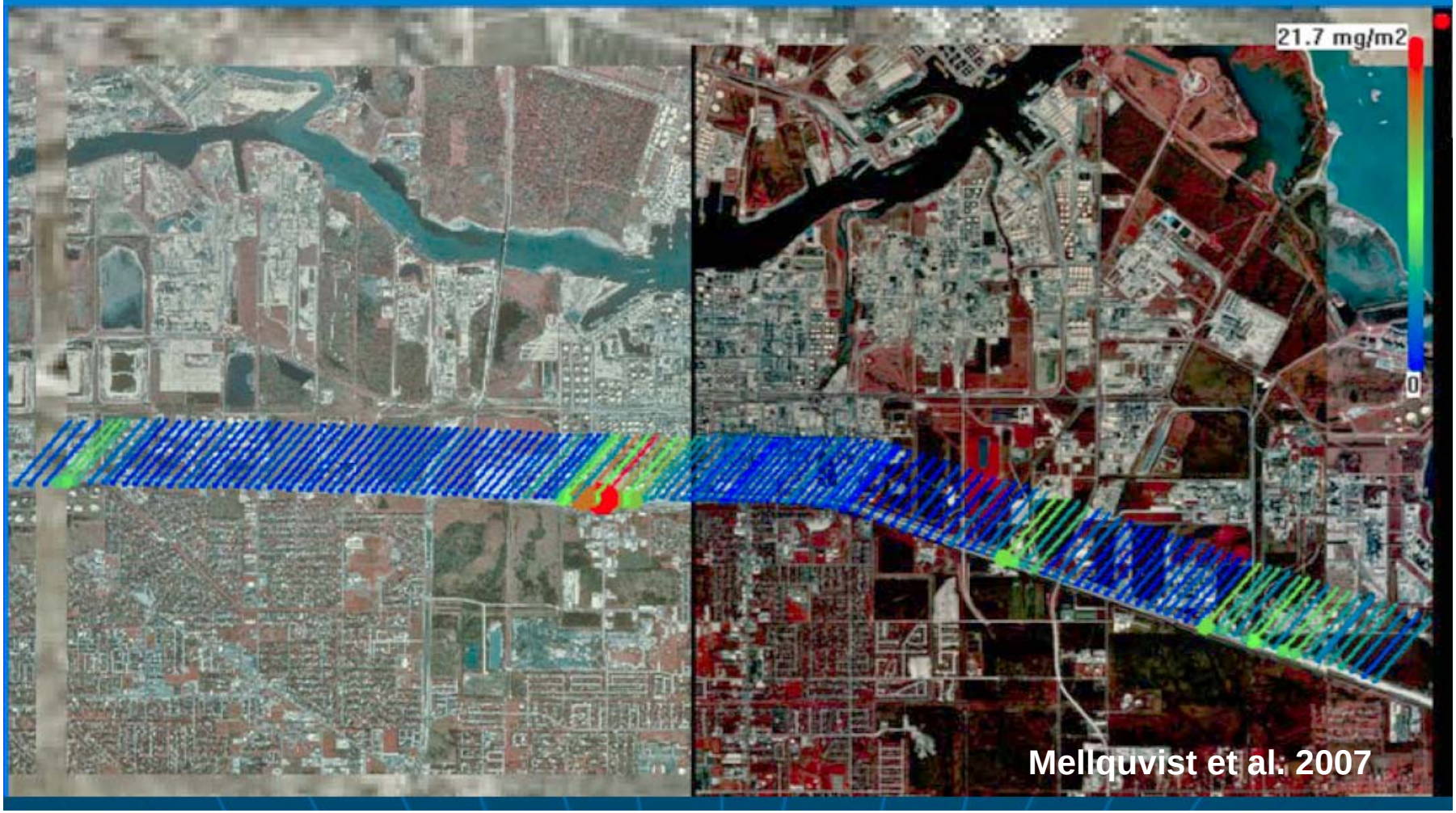
Buhr et al. 2006


Solar Occultation Flux


UV/Vis zenith sky

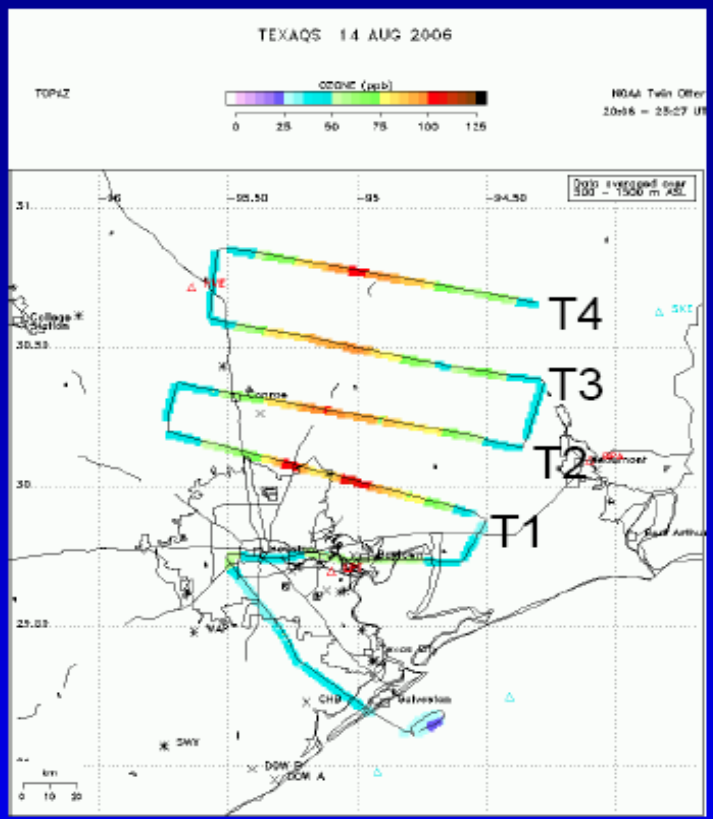
TexAQS II Example - Ethene

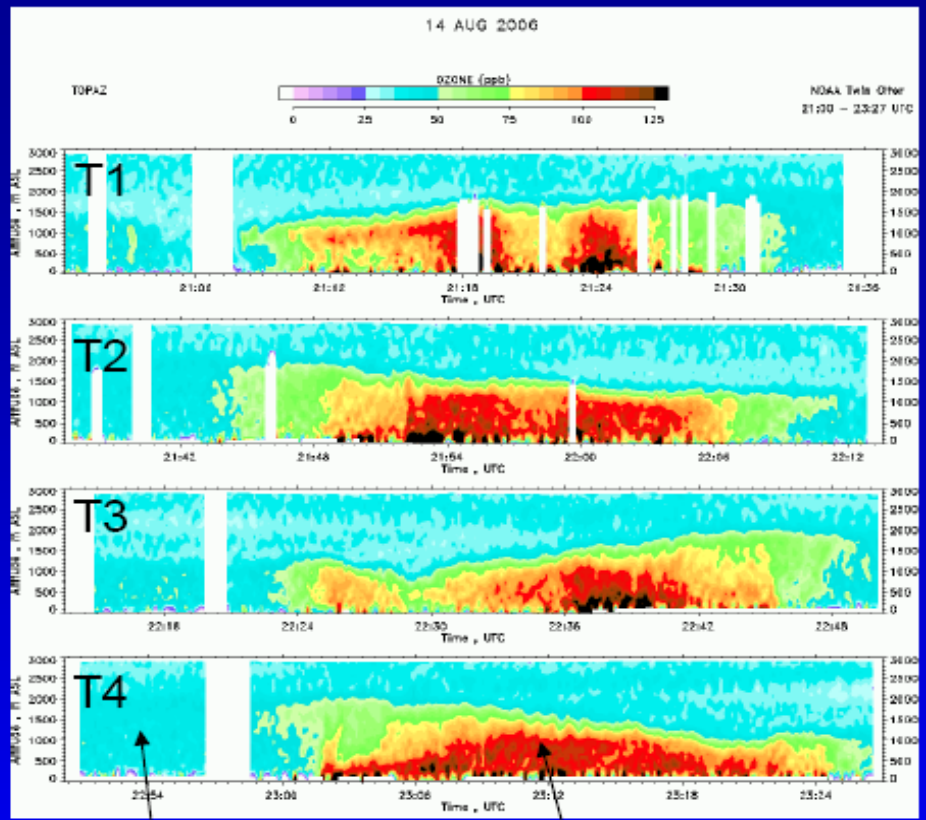
Ethene emission measured by SOF in HSC on Sept 19 at 9:00, (4 distinct source can be observed, corresponding to inividual emissions varying between 100 and 200 kg/h)



NOAA Twin Otter

TexAQS II Example – Vertical O_3 Profiles



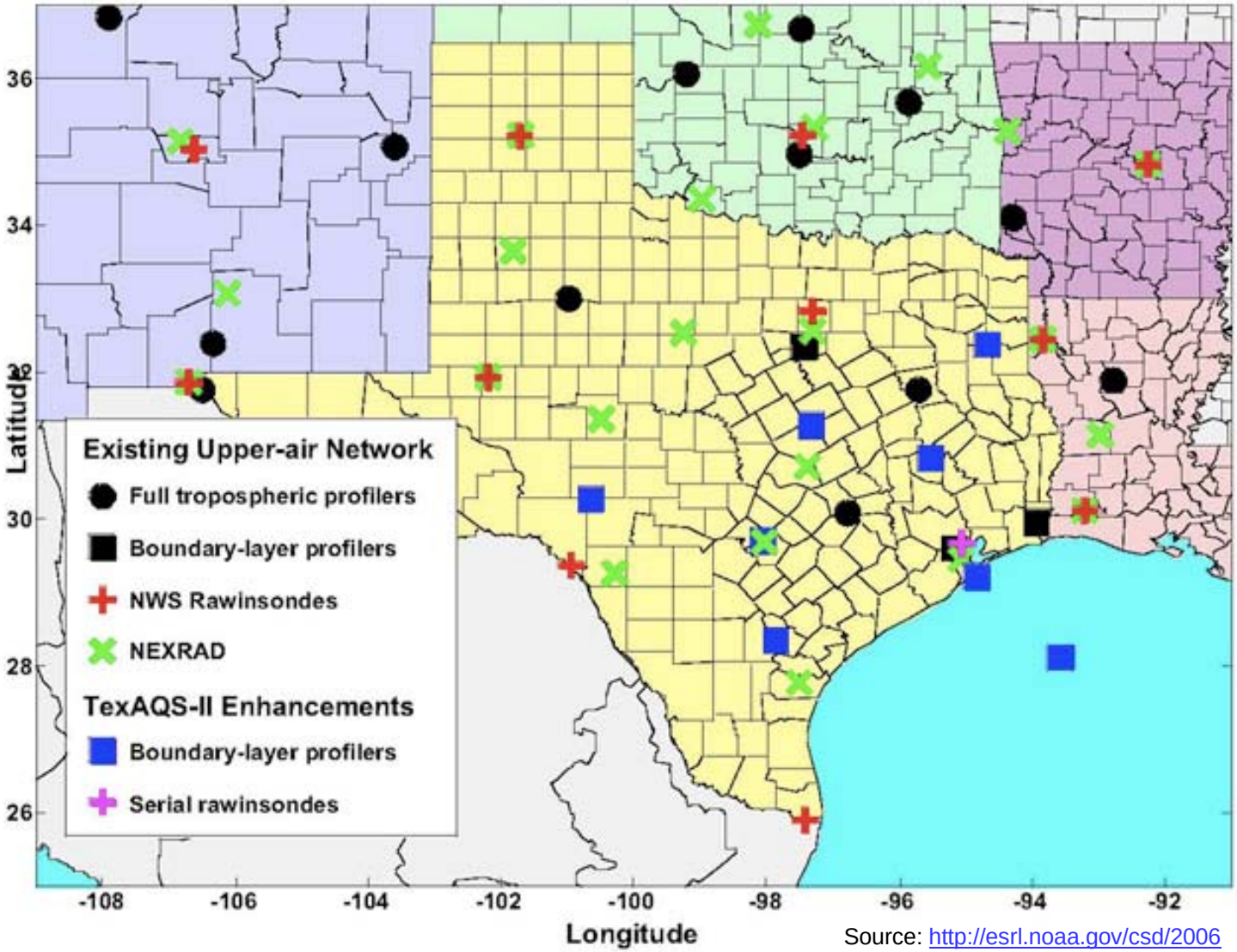


Background O_3

Plume O_3

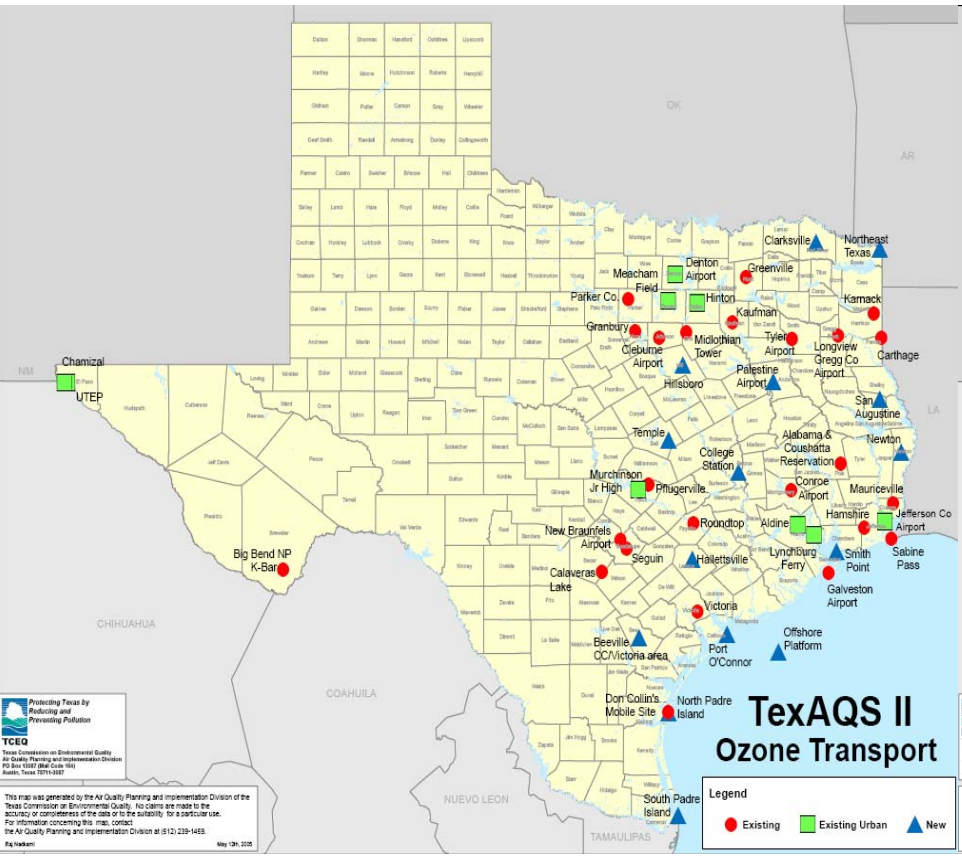
Senff et al. 2006

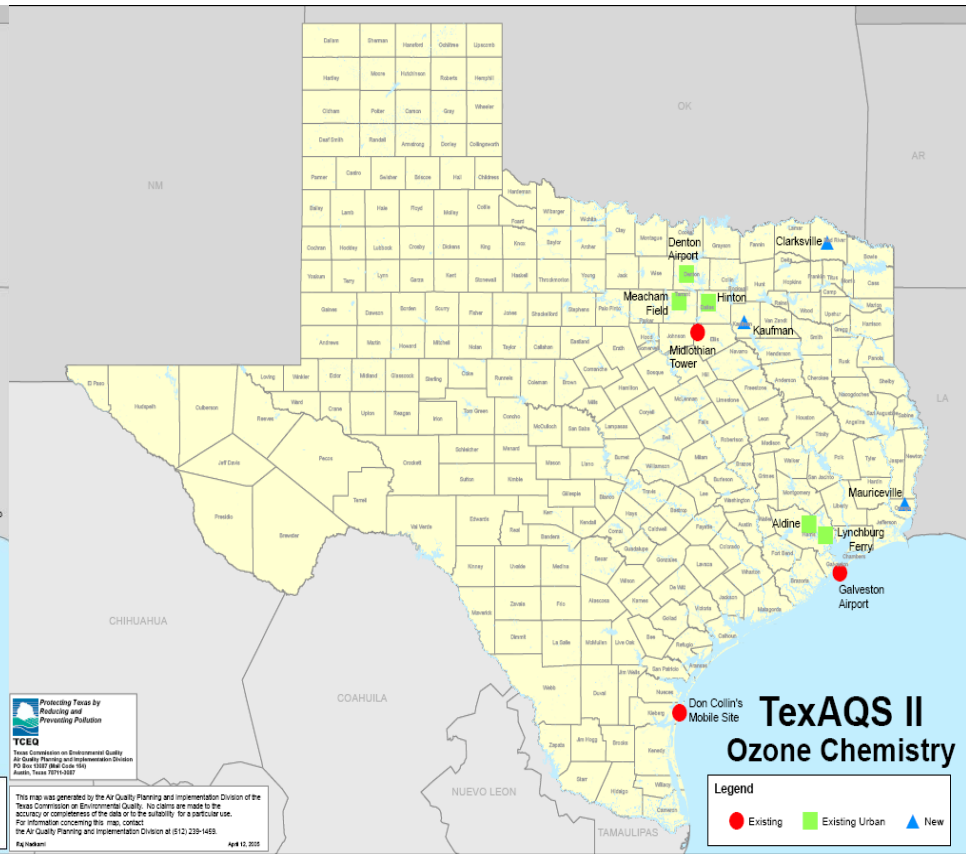
NOAA Profiler Network



Source: http://esrl.noaa.gov/csd/2006

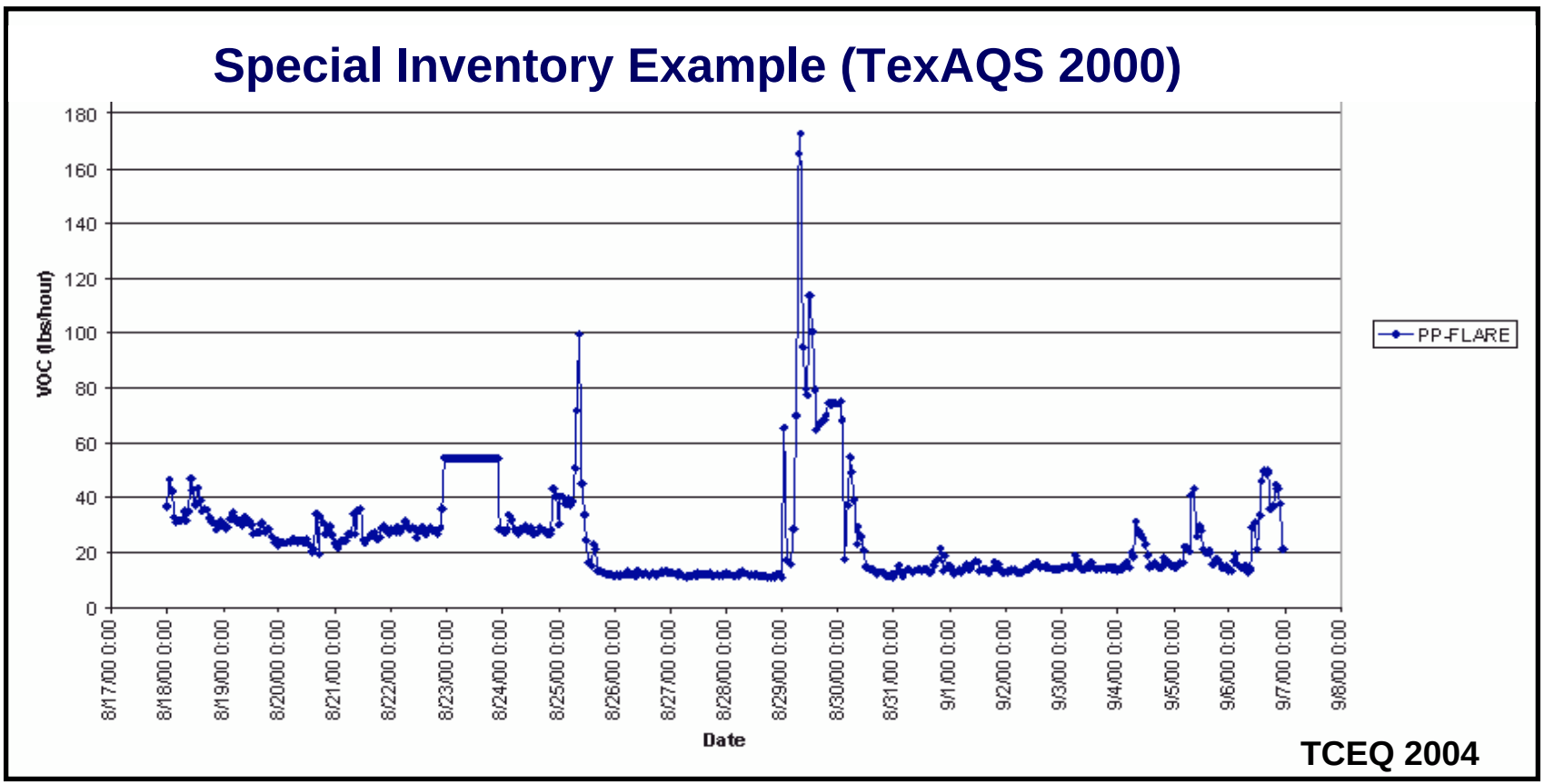
Enhanced Surface Monitoring Networks



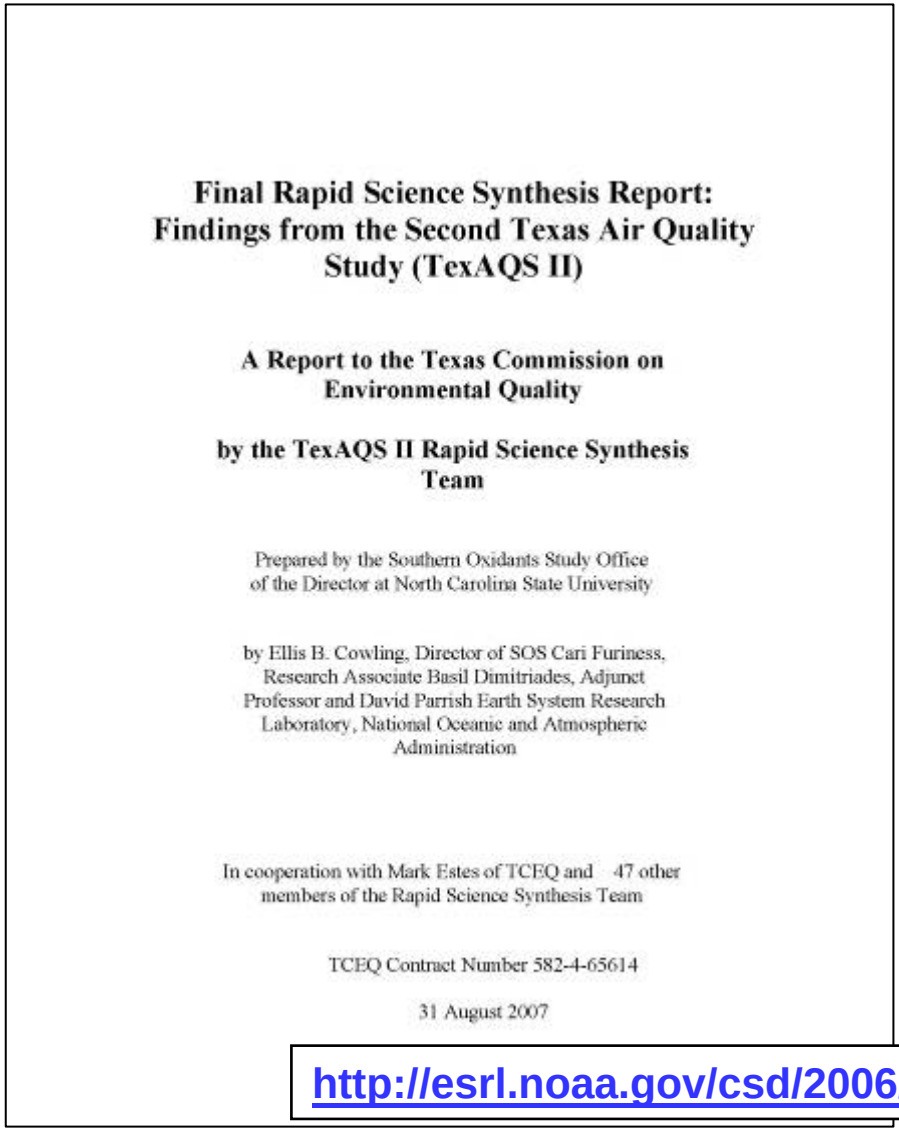


Special Emissions Inventory

- **Hourly emissions of NO_X and selected highly-reactive VOCs from 141 companies statewide, (mostly in the Houston area). 15 August – 15 September 2006.**



The TexAQS II Rapid Science Synthesis Report



Final Rapid Science Synthesis Report: Findings from the Second Texas Air Quality Study (TexAQS II)

A Report to the Texas Commission on Environmental Quality

by the TexAQS II Rapid Science Synthesis Team

Prepared by the Southern Oxidants Study Office of the Director at North Carolina State University

by Ellis B. Cowling, Director of SOS Cari Furiness, Research Associate Basil Dimitriades, Adjunct Professor and David Parrish Earth System Research Laboratory, National Oceanic and Atmospheric Administration

In cooperation with Mark Estes of TCEQ and 47 other members of the Rapid Science Synthesis Team

TCEQ Contract Number 582-4-65614

31 August 2007

Purpose: Address 12 high priority SIP-related science questions identified by the TCEQ … to help fulfill the Commission's responsibility to develop scientifically sound State Implementation Plans by which to attain the 8-hour National Ambient Air Quality Standard for ozone.

http://esrl.noaa.gov/csd/2006/rss/rsstfinalreport083107.pdf

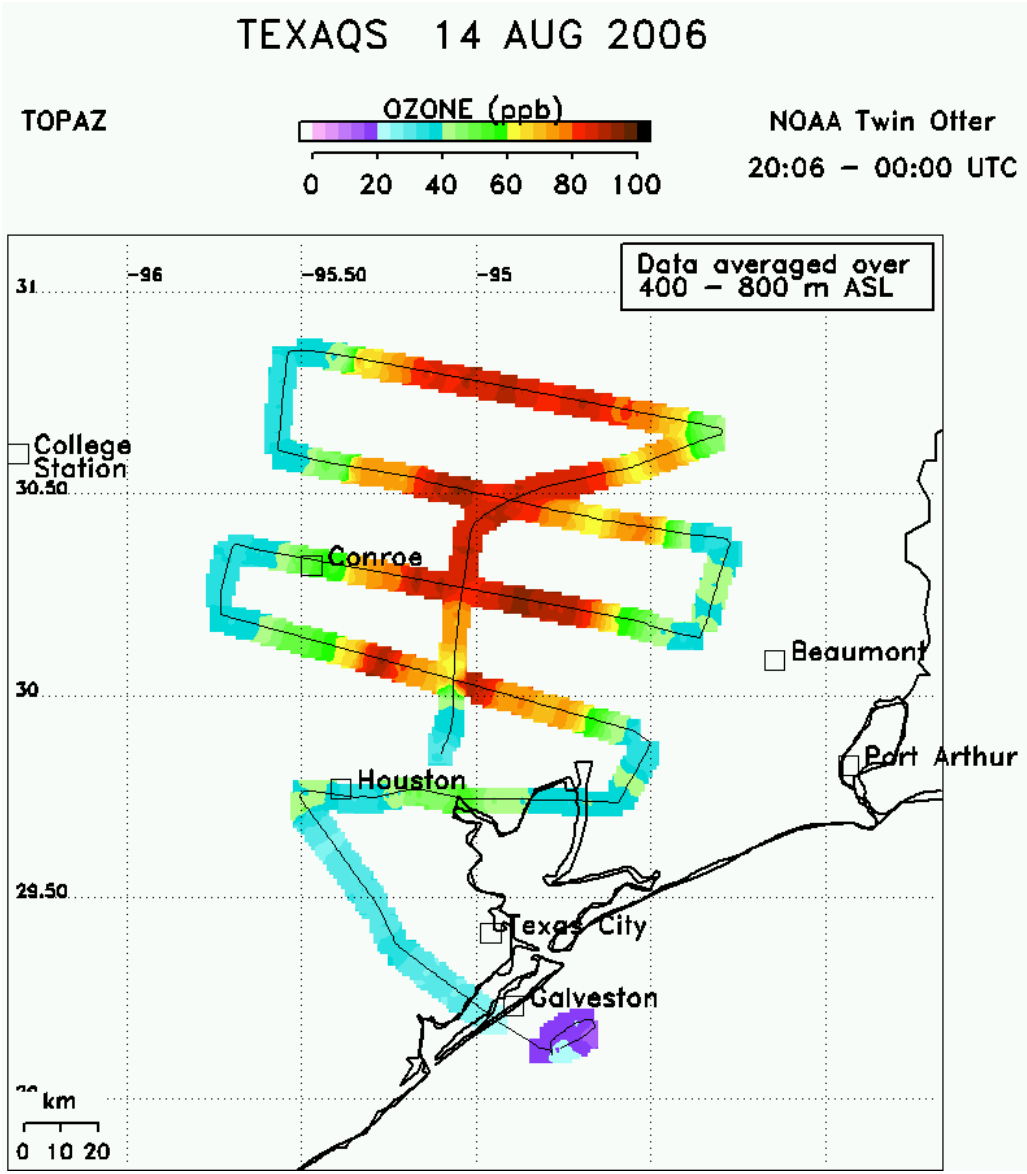
Top ~~Ten~~ Nine Findings from the Rapid Science Synthesis

Courtesy of Mark Estes
TCEQ Air Modeling and Data Analysis Section

Top Ten Finding #1

Background ozone in southeast Texas can be higher than 85 ppbv, but it's usually about 50 ppbv.

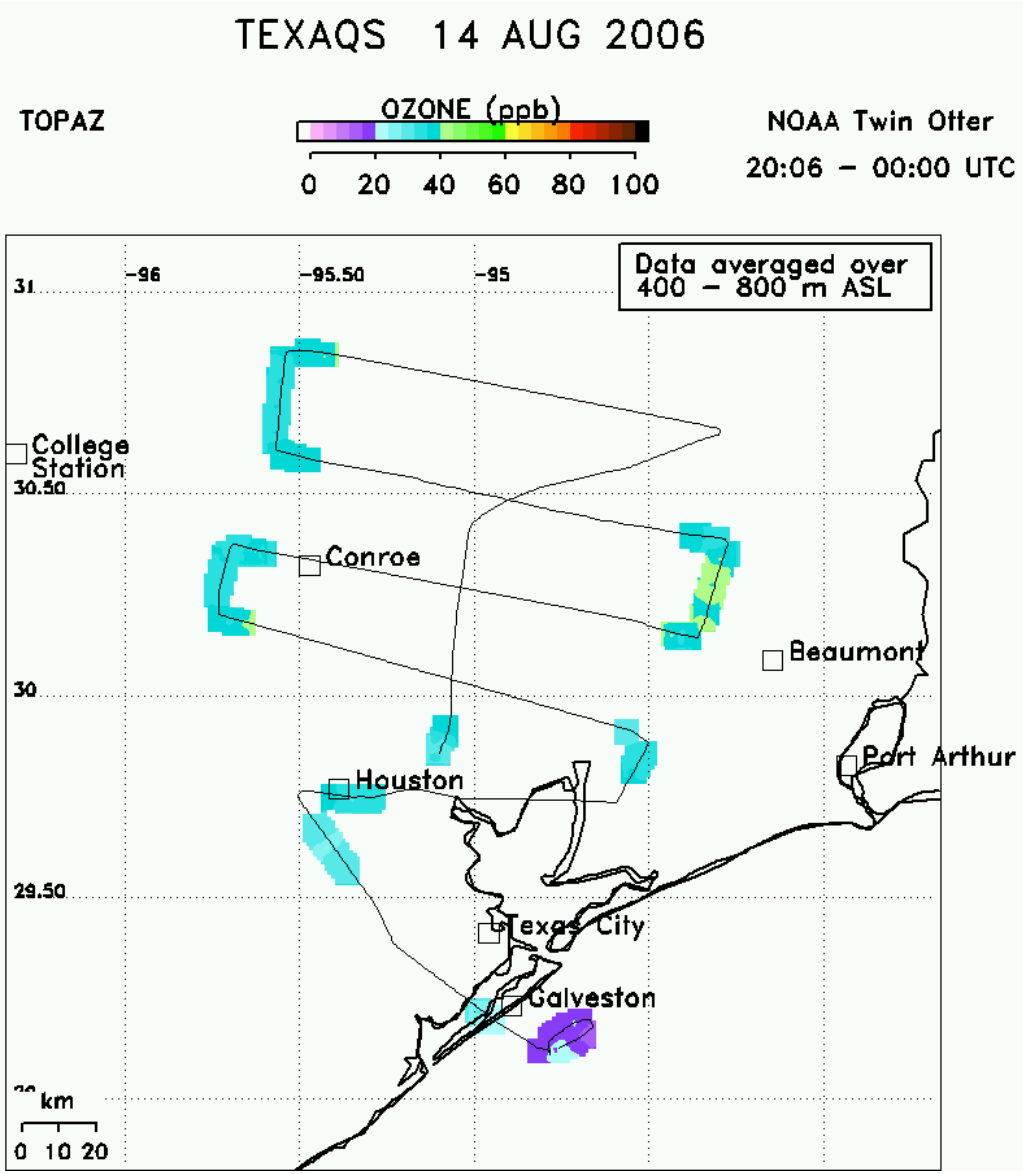
Background ozone measurements from lidar



1) Average O_3 data between 400 and 800 m ASL

Hardesty et al. 2007

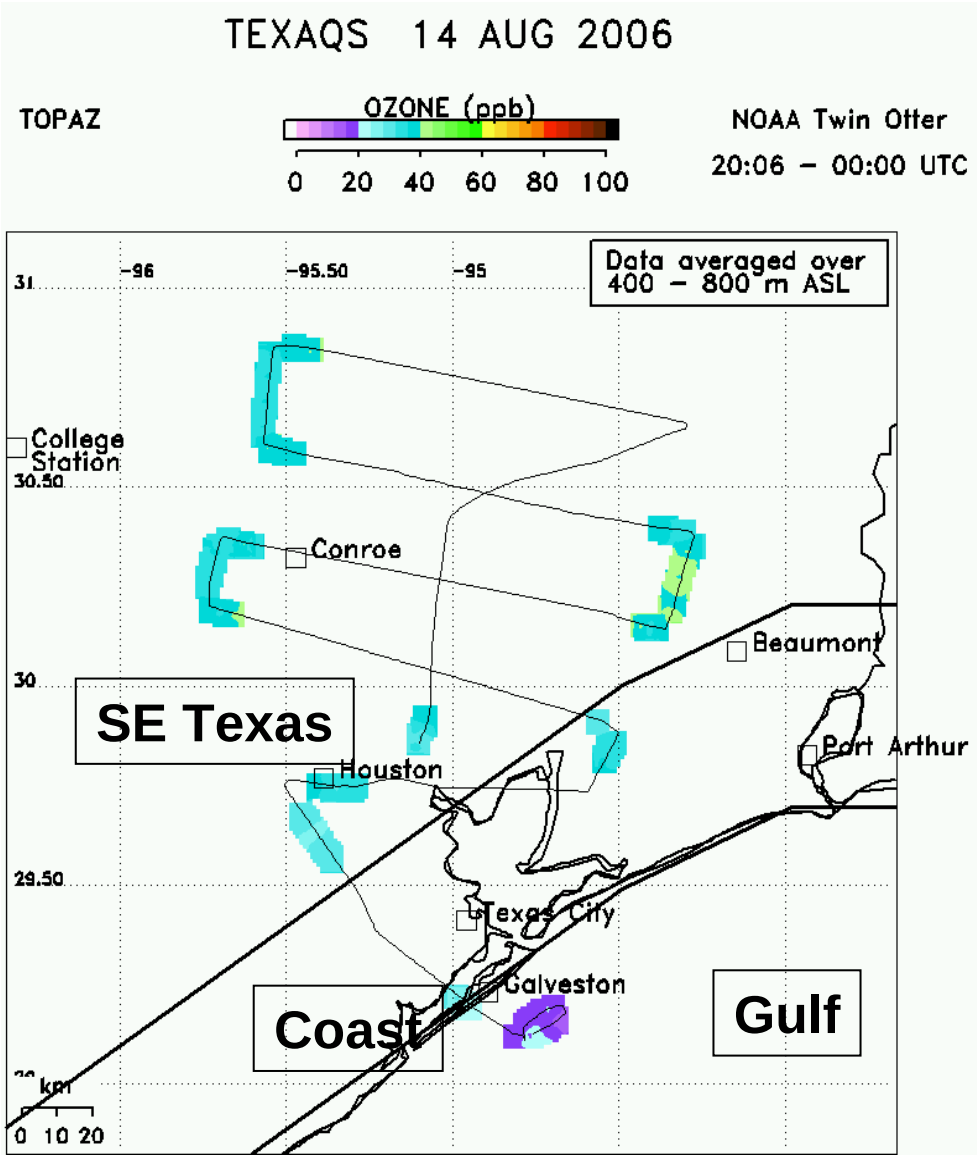
Background ozone measurements from lidar



1) Average O_3 data between 400 and 800 m ASL

2) Remove O_3 plume data

Background ozone measurements from lidar

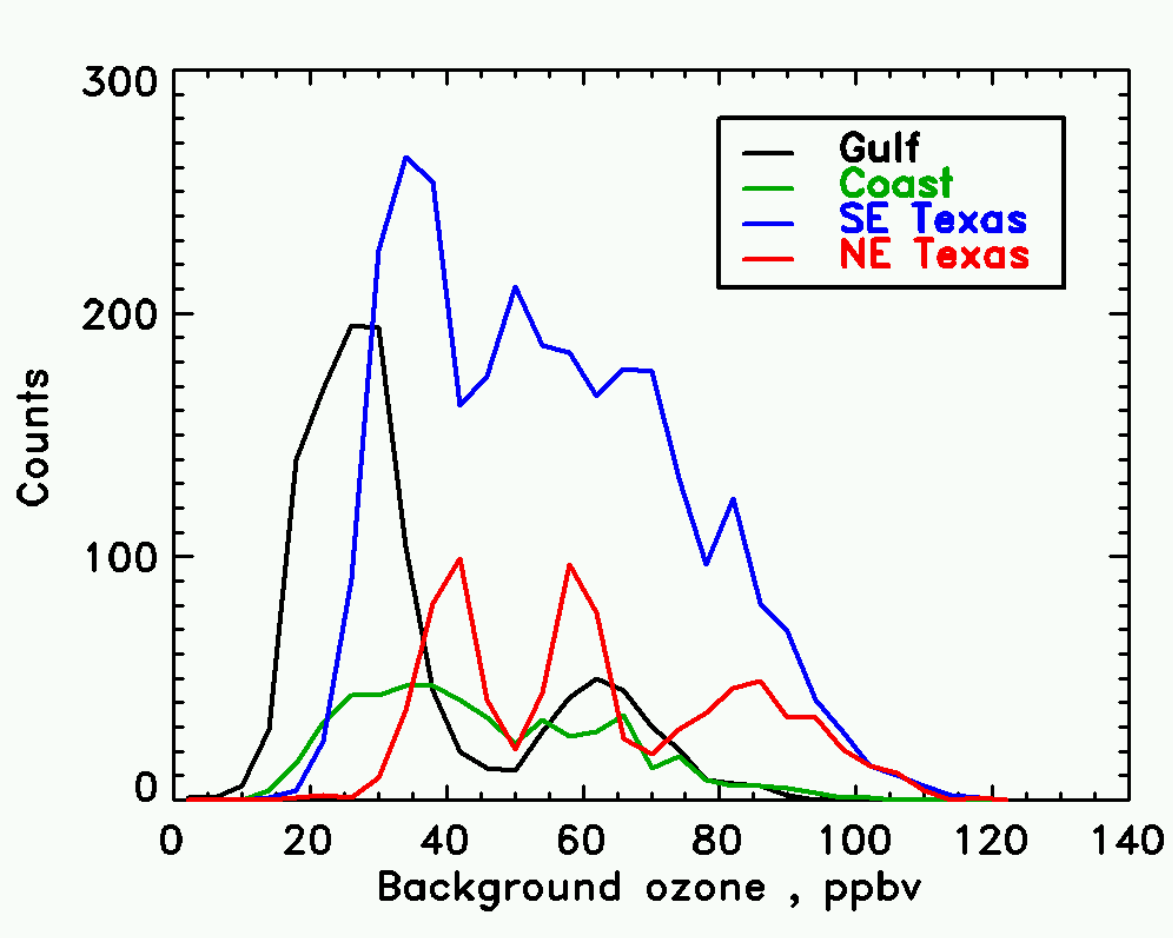


1) Average O_3 data between 400 and 800 m ASL

2) Remove O_3 plume data

3) Sort by region

Background ozone by region



Region	Background O_3, ppbv
Gulf	39
Coast	46
SE TX	51
NE TX	61

Hardesty et al. 2007

Data from all 21 TOPAZ flights

Top Ten Finding #2

“Background ozone” may include recirculated pollution

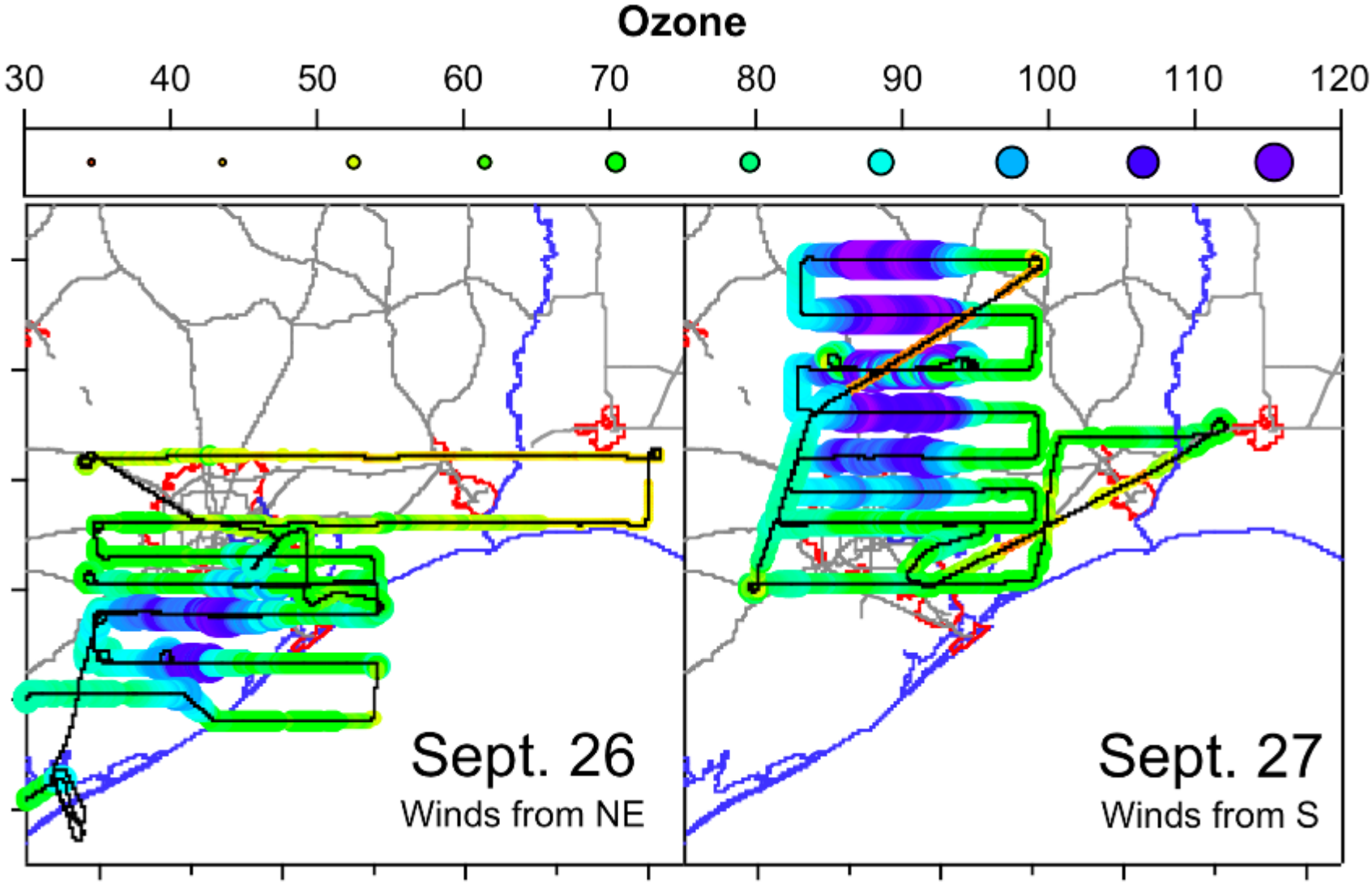
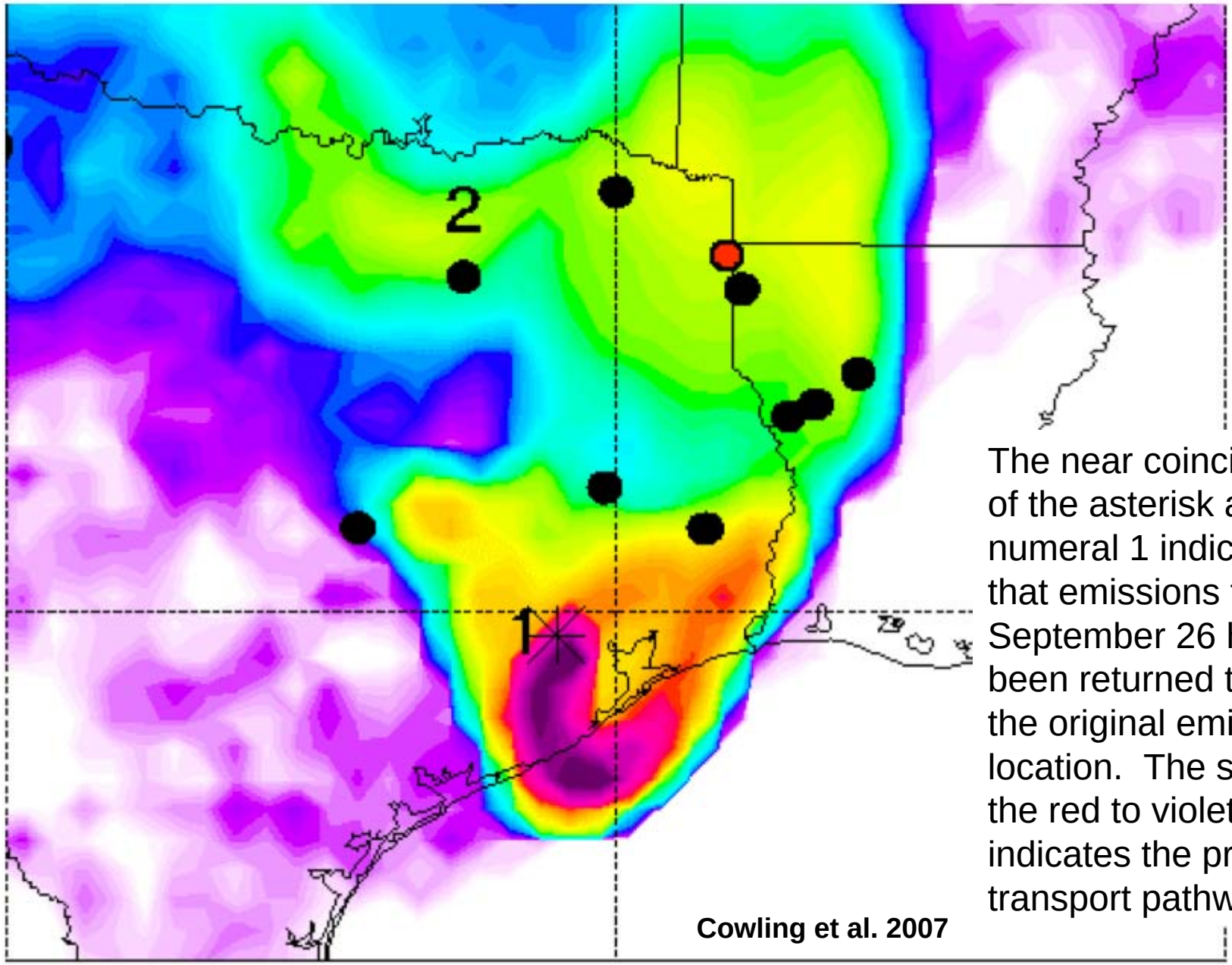


Figure G5: WP-3D flight tracks within the boundary layer in the HGB area on two successive flights color-coded and sized according to the measured O3 concentration.

Cowling et al. 2007



Cowling et al. 2007

The near coincidence of the asterisk and the numeral 1 indicates that emissions from September 26 have been returned to near the original emission location. The shape of the red to violet colors indicates the primary transport pathways.

Top Ten Finding #3

NO_X emissions from shipping are substantial in the Houston-Galveston area and are of the same magnitude as power plant emissions.

Marine Vessel vs. Stationary Source Emissions

1. Emission factor comparison.

	Molecules / 1000 Molecules CO_2		
Emission Source	**NO_2**	**CO**	**SO_2**
Ships (SSD; this work)	21 ± 8	5.6 ± 5.6	6.0 ± 3.5
Parish PP (Coal; NG)[a]	0.23	0.51	1.87
San Jacinto PP (NG)[a]	0.22	0.22	0.003

[a]Source: US EPA 1999 NEI; updates to 2004 from CEMS data by Greg Frost at NOAA/ESRL

2. Aggregate emissions comparison.

	2004 Point Source Emissions[1] (tons per day)		
County (Texas)	**NO_2**	**CO**	**SO_2**
Brazoria	53.77	16.81	138
Fort Bend	22.31	23.17	150
Galveston	24.62	11.95	16
Harris	113.23	53.08	72
Ships (this work)[2]	25	6.3	4.3

[1]Source: US EPA 1999 NEI; updates to 2004 from CEMS data by Greg Frost at NOAA/ESRL
[2]Ship activity data from Eastern Research Group, 2004 (Freeport & Texas City excluded)

Williams et al. 2007

Top Ten Finding #4

Industrial emissions

↓

Narrow plumes of HRVOCs+NOx

↓

Rapid & efficient ozone formation

↓

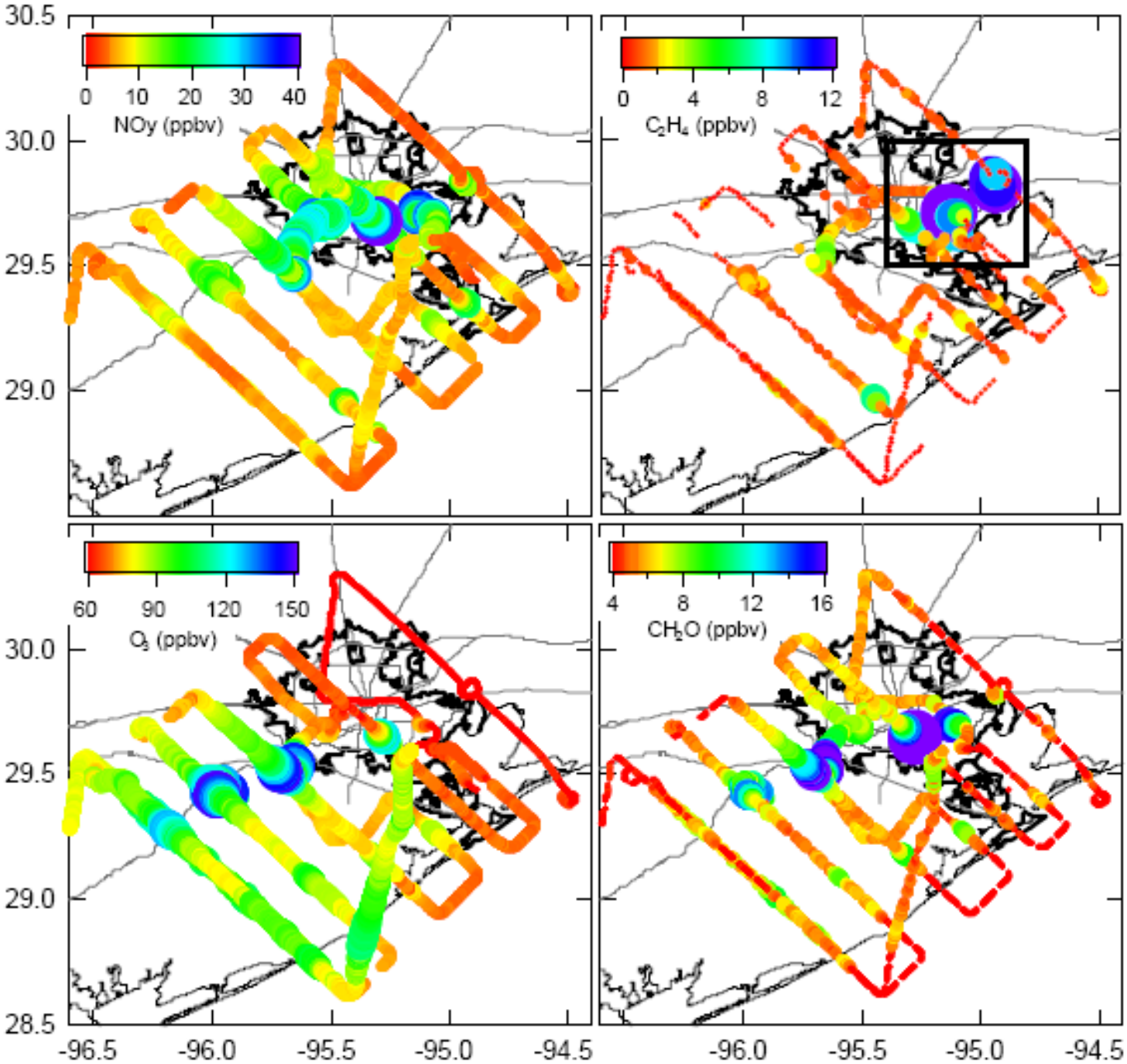
Narrow plumes of high ozone

+

Wind shift (bay breeze/coastal oscillation)

=

“Transient” High Ozone



6 October 2006 flight by NOAA P3 aircraft.

Winds from ENE.

Measurements shown were taken below 1.5 km AGL.

The symbols are sized and color-coded according to the indicated concentrations.

A close approach to Parish has been omitted from NOy data.

Cowling et al. 2007

Top Ten Finding #5

Ethene concentrations have decreased by about 40% since 2000.

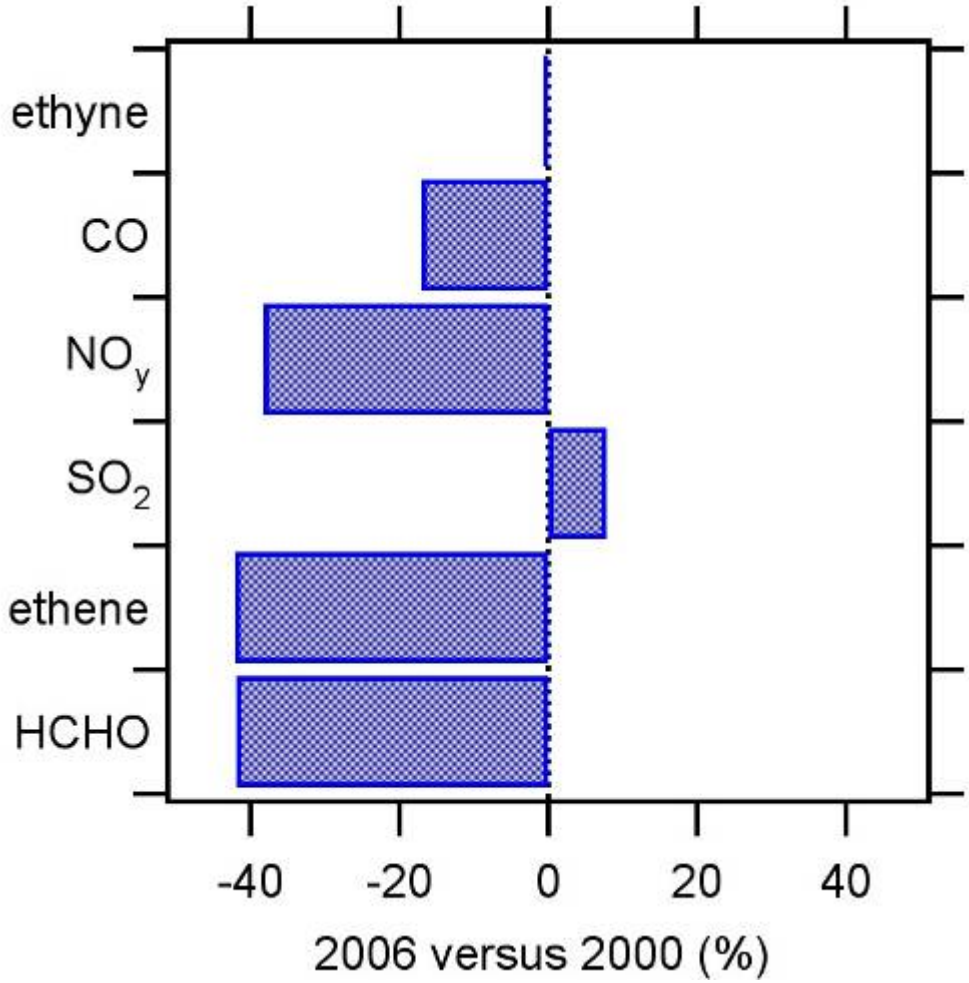


Figure C3: Difference in median mixing ratio for several trace gases measured from the NOAA WP-3D inside a box around Houston and below 1000 m altitude.

Cowling et al. 2007

Top Ten Finding #6

Ethene emissions are apparently still underestimated, by as much as a factor of 10.

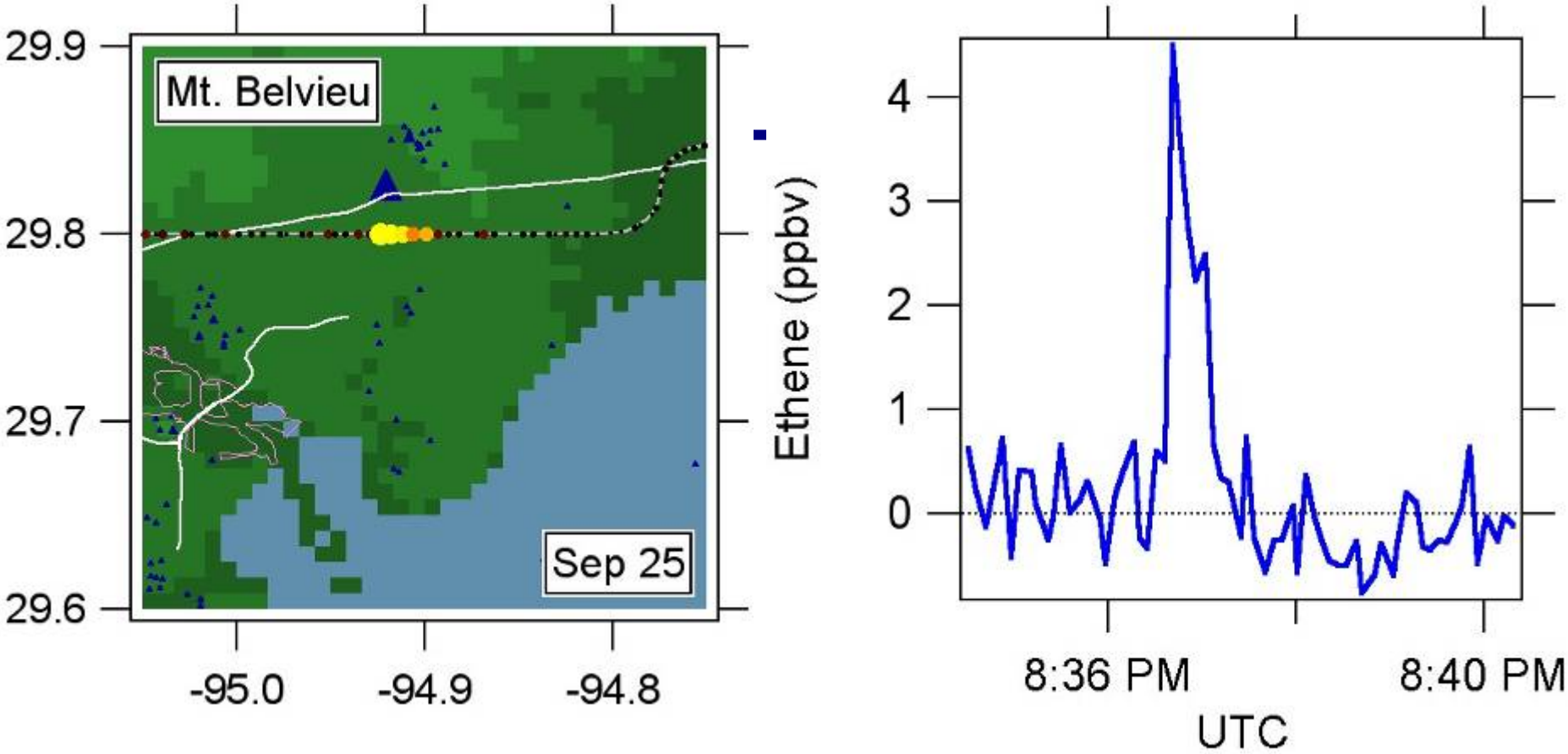
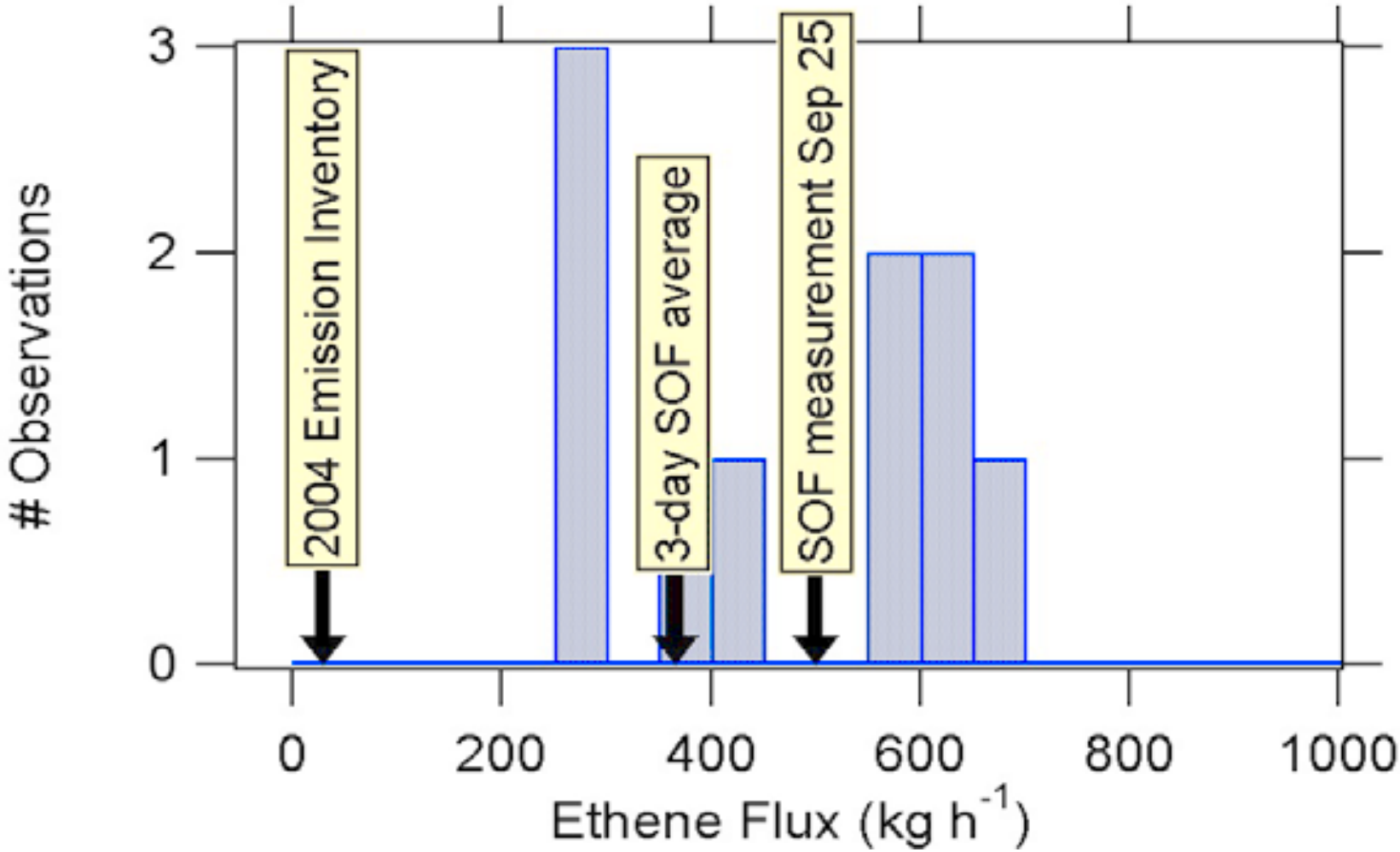


Figure C5: Transect of the WP-3D just downwind from the Mont Belvieu complex to the northeast of HSC color-coded by ethene measured by LPAS. Ethene sources from the 2004 TCEQ point source database are indicated by the blue triangles, with the size proportional to the source strength. The measured time series of ethene for this transect is shown on the right.

Cowling et al. 2007

Histogram of Emission Fluxes Determined from Aircraft Data

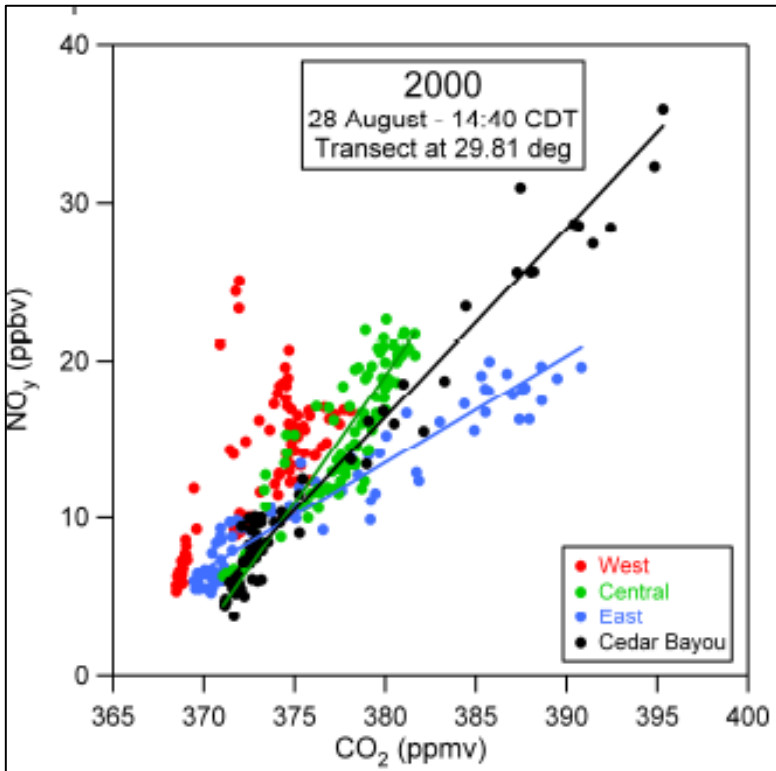


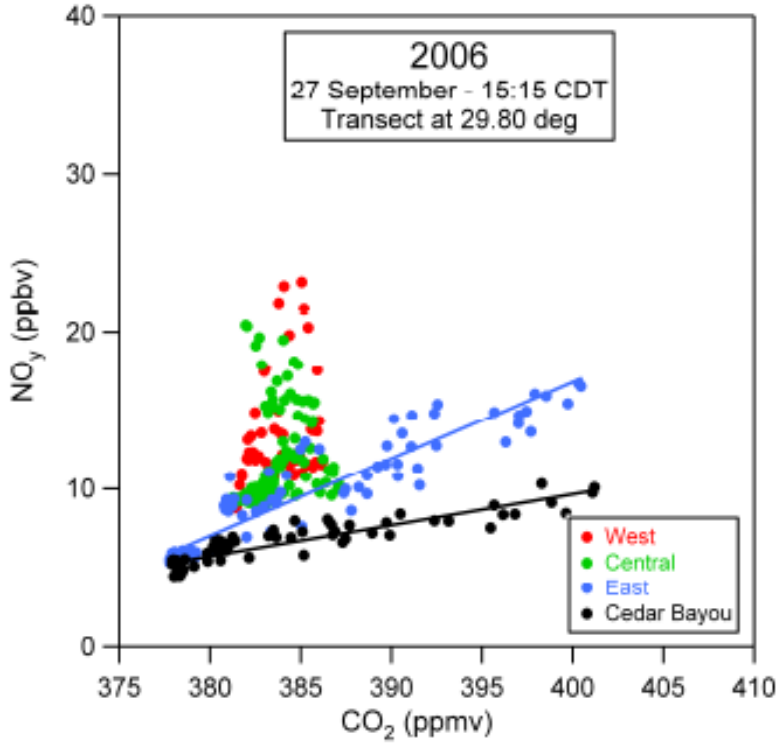
Cowling et al. 2007

Top Ten Finding #7

Power plant NO_X emissions have decreased substantially since 2000. CEMS-based emission estimates are accurate.

Evidence of NO_X Reductions





	NO_y / CO_2 Ratio	
	2000	2006
• Central Ship	1.62 ± 0.16	—
• East Ship	0.72 ± 0.07	0.49 ± 0.05
• Cedar Bayou	1.21 ± 0.12	0.20 ± 0.03

Cowling et al. 2007

Source: Washenfelder et al. 2007

Top Ten Finding #8

The formaldehyde observations are usually consistent with secondary formation, but in a few instances, they are consistent with either emission or very rapid formation.

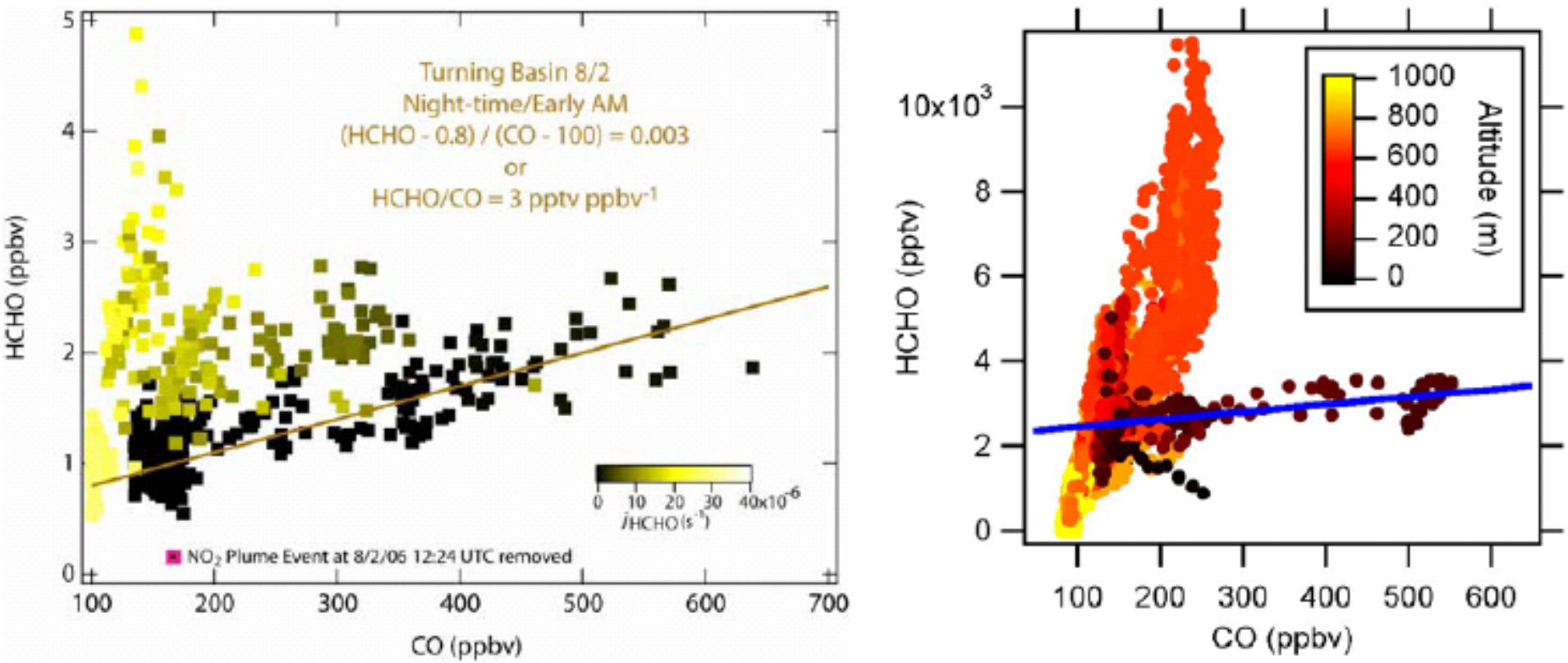


Figure E2. Relationships of HCHO to CO concentrations obtained onboard the *Ronald H. Brown* in the turning basin at the western end of the HSC (left panel), and from the WP-3D during a nighttime, missed approach at Montgomery County airport to the north of Houston.

Cowling et al. 2007

Top Ten Finding #9

For both Houston and Dallas:

Local contributions to 8-hour ozone exceedances = regional contributions to 8-hour ozone exceedances.

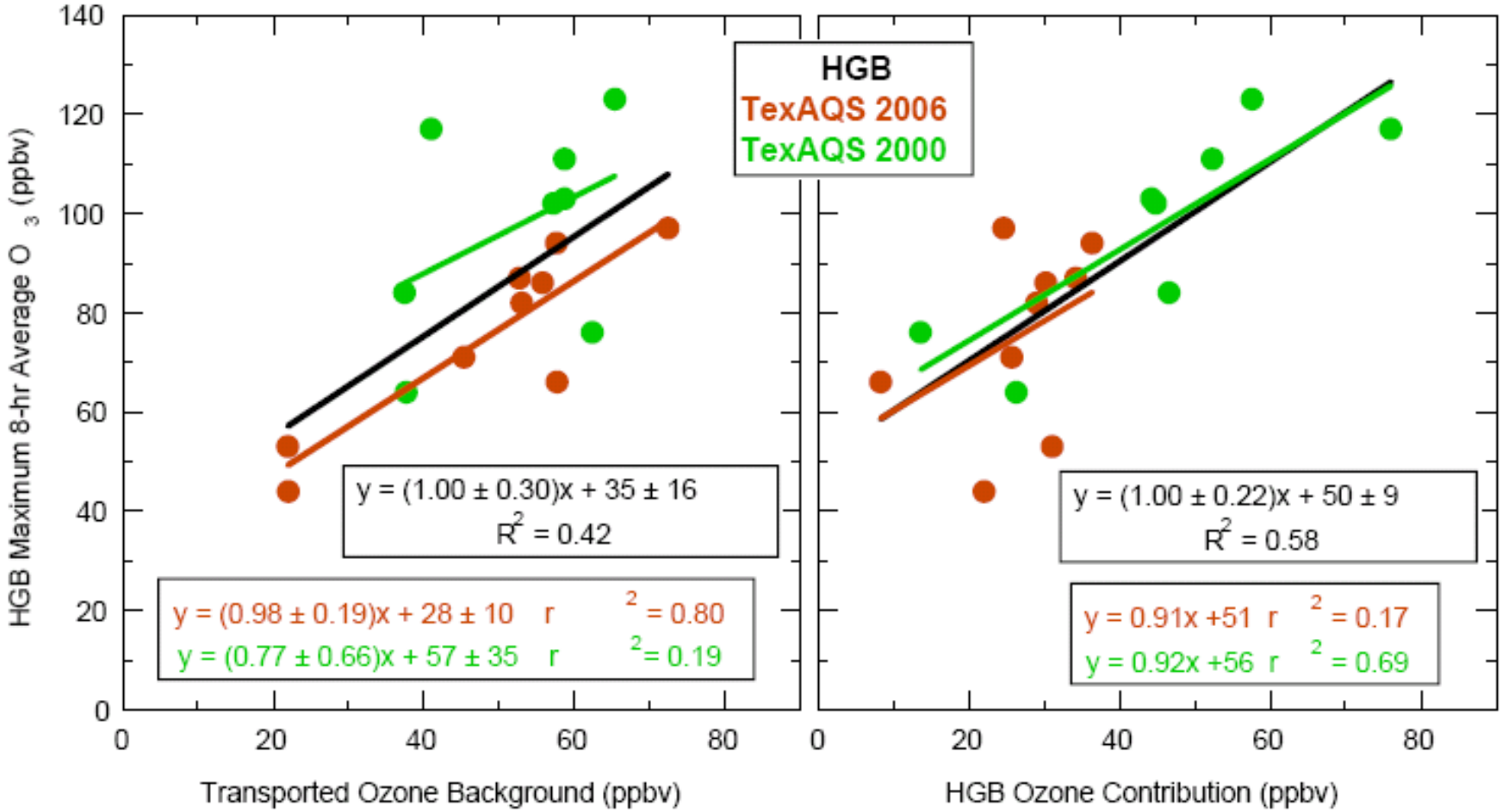


Figure H6. Measured peak 8-hour-average O3 in the HGB area as a function of the background ozone transported into the region (left) and the local HGB contribution to that peak (right). The background ozone was determined from aircraft transects upwind and across the HGB region on seventeen days in 2000 and 2006. The HGB contribution is derived from the difference between the measured peak and the background.

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