

Ozone Production and Flux Downwind of Houston and Dallas

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TexAQS II - Principal Findings Data Analysis Workshop
29 May – 1 June 2007

Objectives:

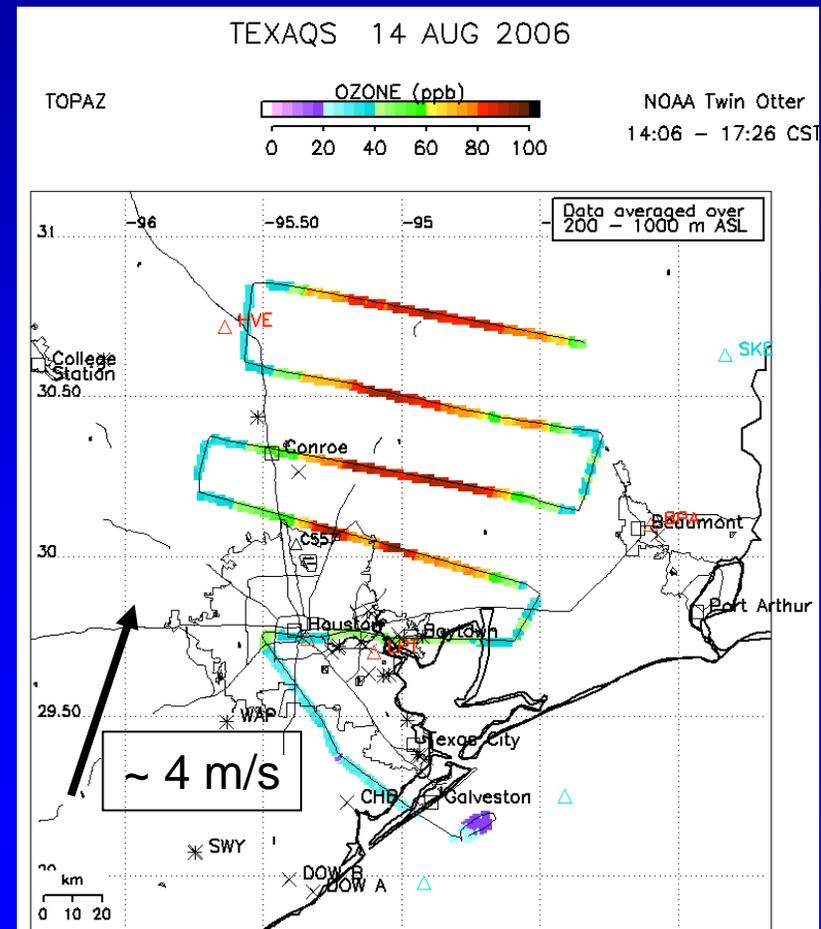
- Compute total horizontal flux of ozone produced in Houston and Dallas/Fort Worth metro areas
- Calculate ozone production rates in urban plumes

Approach:

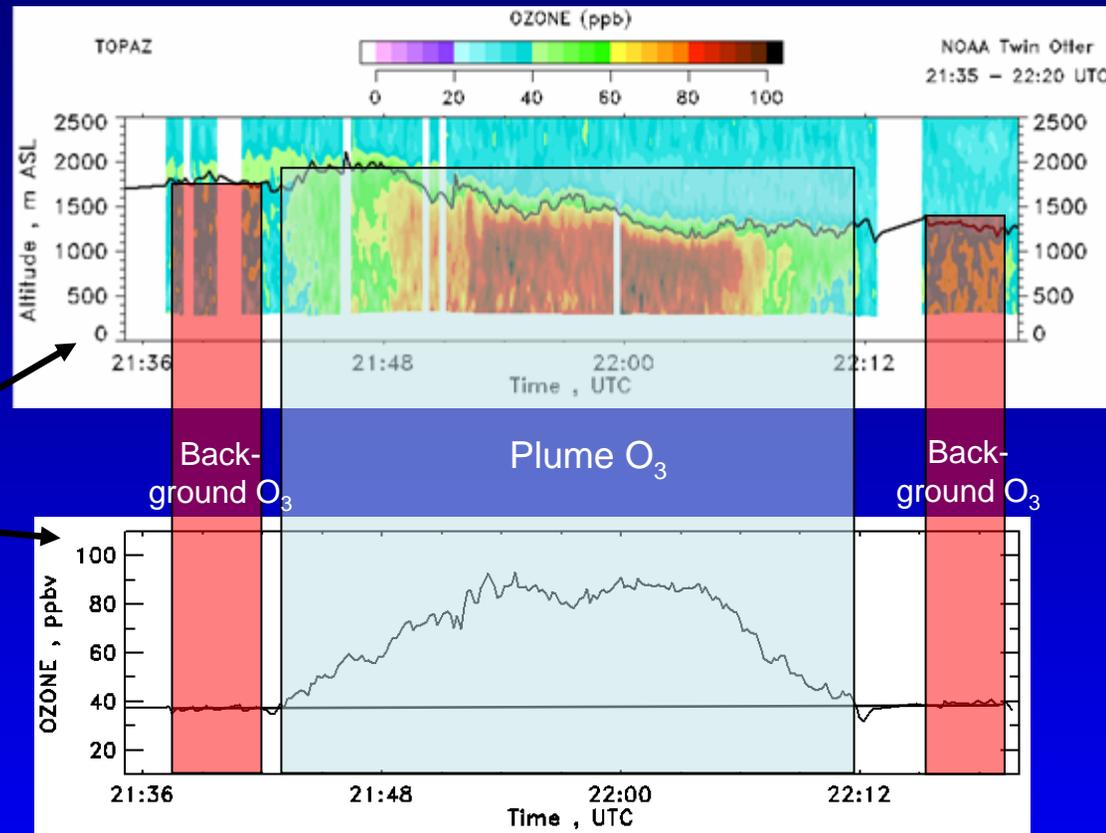
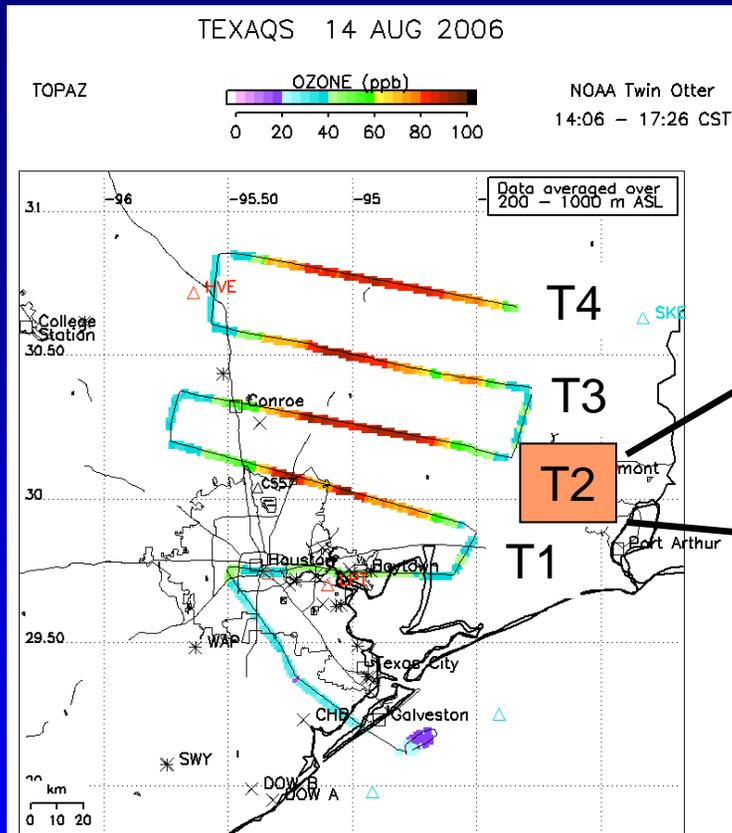
- Use airborne lidar data from flight transects downwind of metro areas and calculate plume fluxes for each transect and ozone production rates between adjacent transects
- Contrast cases from TexAQS 2006 and TexAQS 2000

Meteorological Conditions:

- Steady synoptic flow at speeds of several m/s

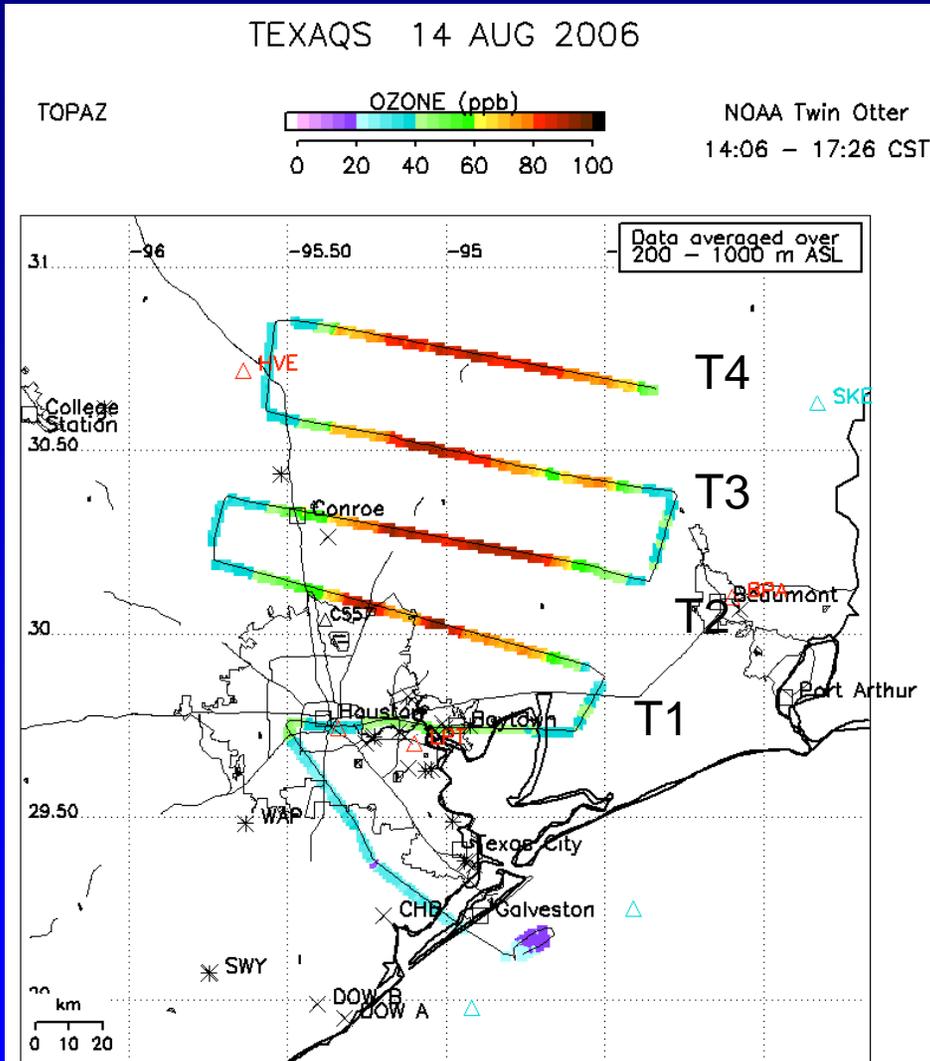


Ozone flux retrieval



- Integrate excess ozone in plume (plume O₃ – background O₃) between surface and top of boundary layer and between horizontal plume edges.
- Multiply with horizontal wind speed (from wind profiler network) to yield flux in molecules O₃ / sec for each transect.
- Angle between flight transect and plume is taken into account.

Ozone production rate retrieval



- Take difference in integrated excess plume ozone between adjacent transects.
- Divide by plume area and convert to mixing ratio.
- Divide by plume travel time between adjacent transects to yield ozone production rate in ppbv/h.

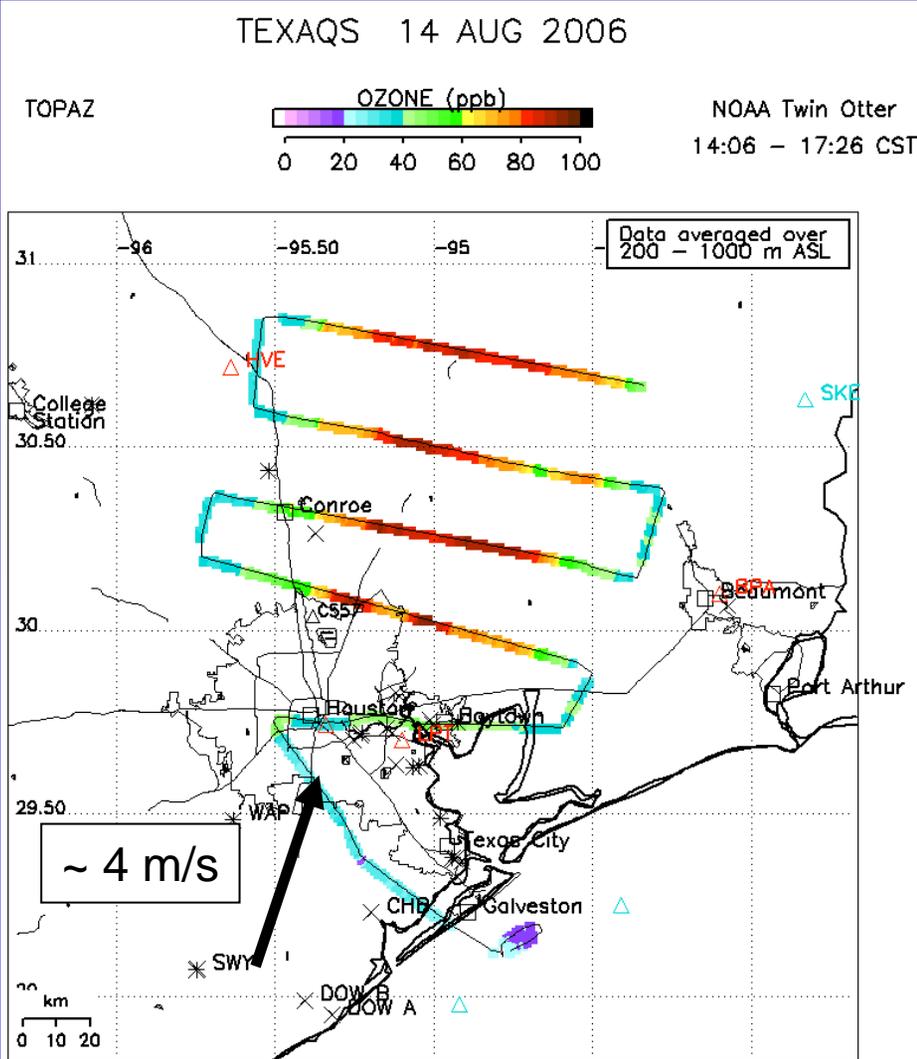
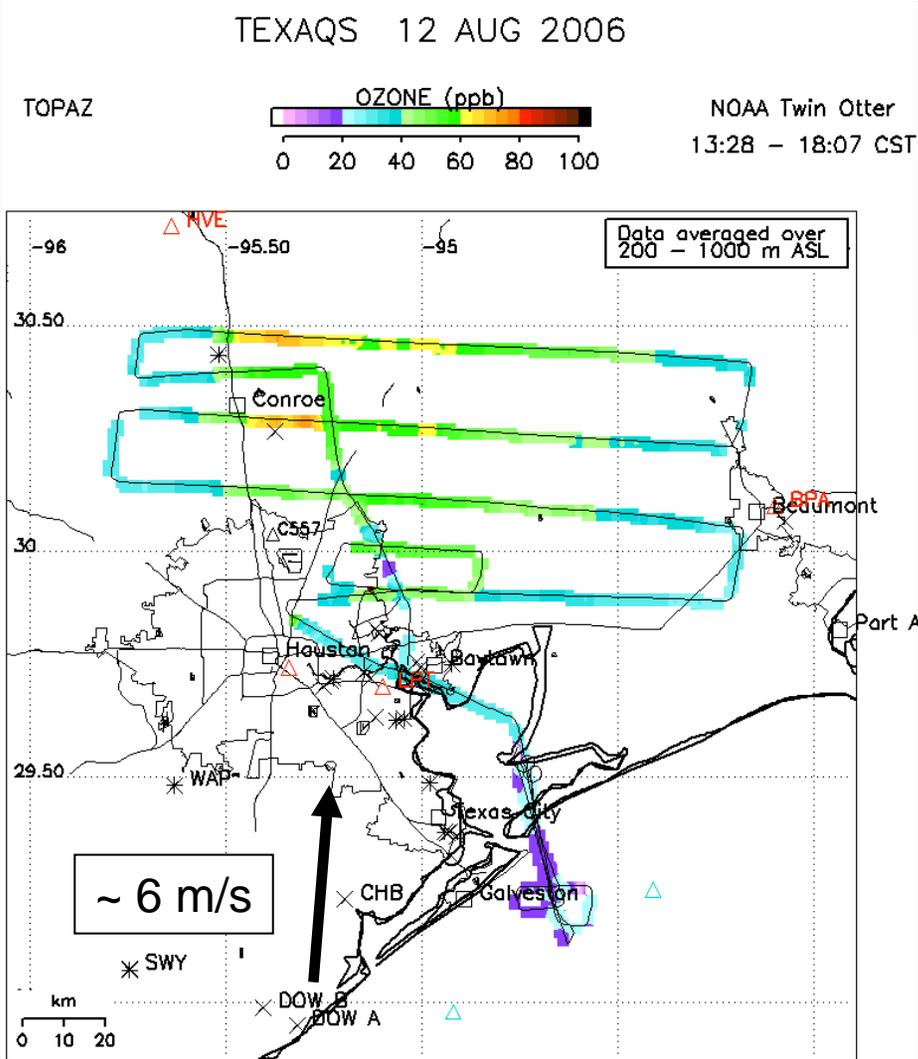
Error sources in flux & production rate calculation

- O₃ cross section < 3%
- O₃ RMS error < .2%
- Plume boundaries ~ 5%
- Background O₃ determination ~ 5%
- Wind speed ~1.0 m/s or < 25%
- Total < 30%

TexAQS II 2006

Houston: Aug 12

Houston: Aug 14

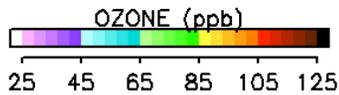


TexAQS II 2006

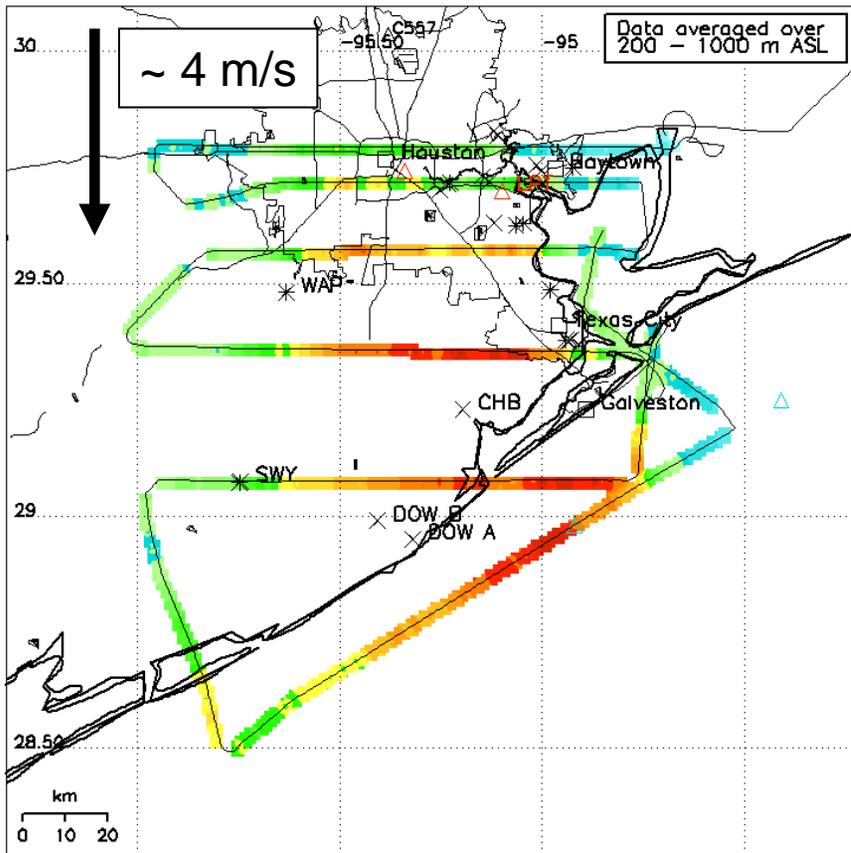
Houston: Aug 30

TEXAQS 30 AUG 2006

TOPAZ



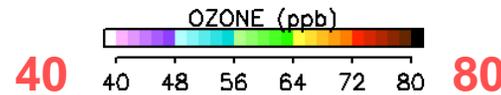
NOAA Twin Otter
13:34 - 18:03 CST



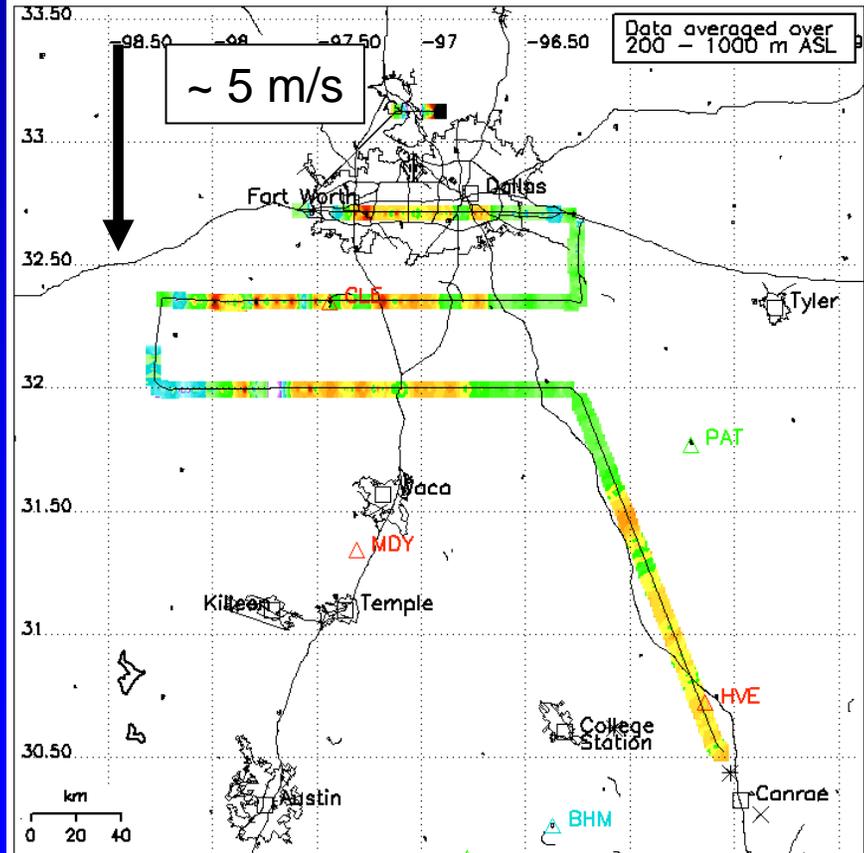
Dallas: Sep 13

TEXAQS 13 SEP 2006

TOPAZ



NOAA Twin Otter
13:32 - 17:13 CST



TexAQS I 2000

Houston: Aug 28

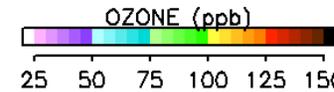
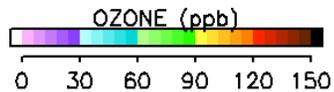
Houston: Sep 06

TEXAQS 28 AUG 2000

TEXAQS 6 SEP 2000

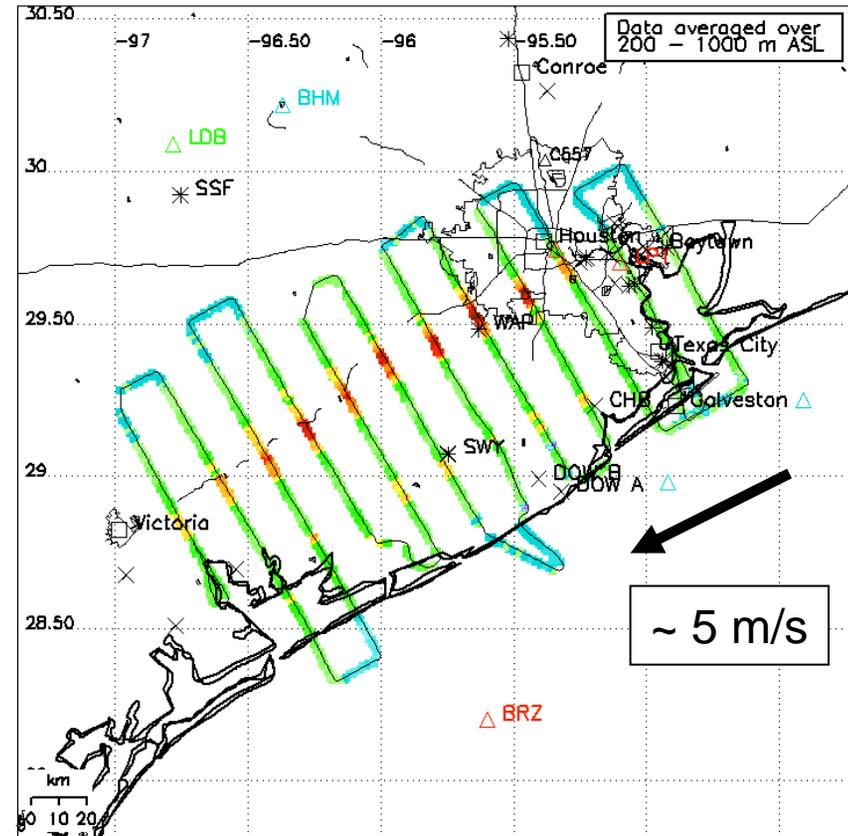
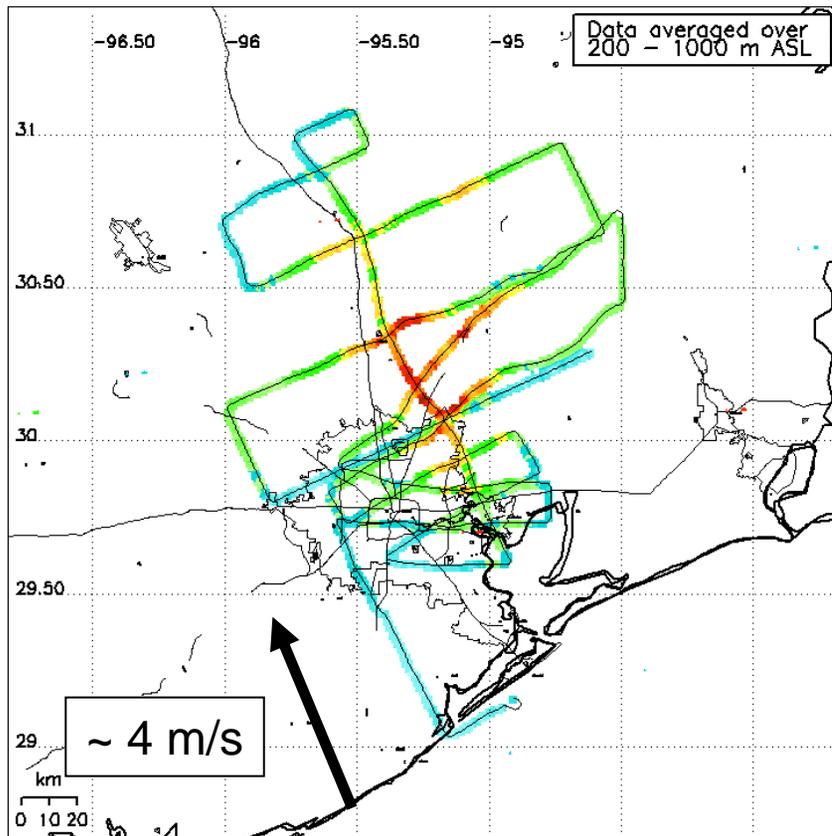
Airborne Lidar

Airborne Lidar



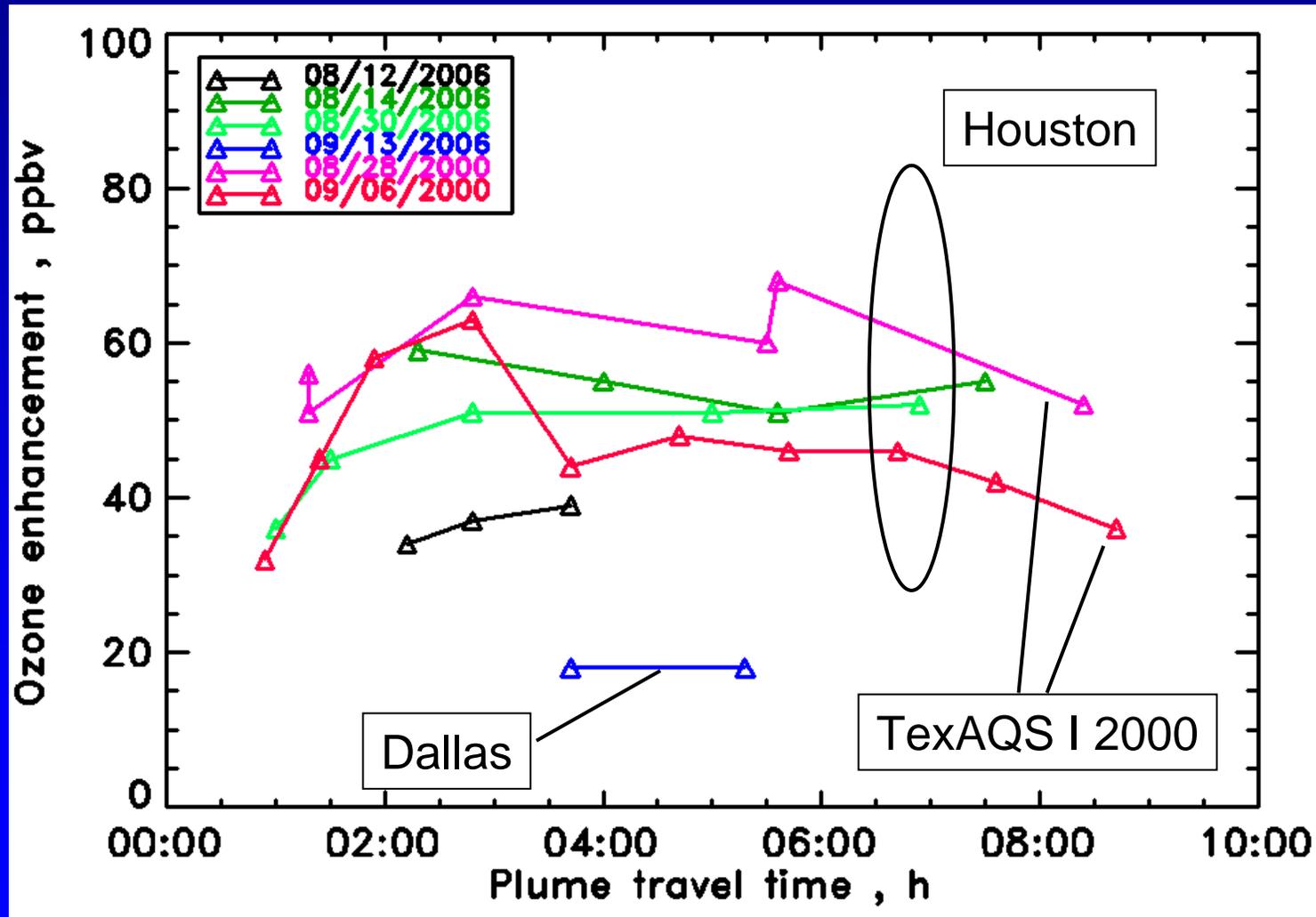
DC-3
12:06 - 18:00 CST

DC-3
10:19 - 16:20 CST

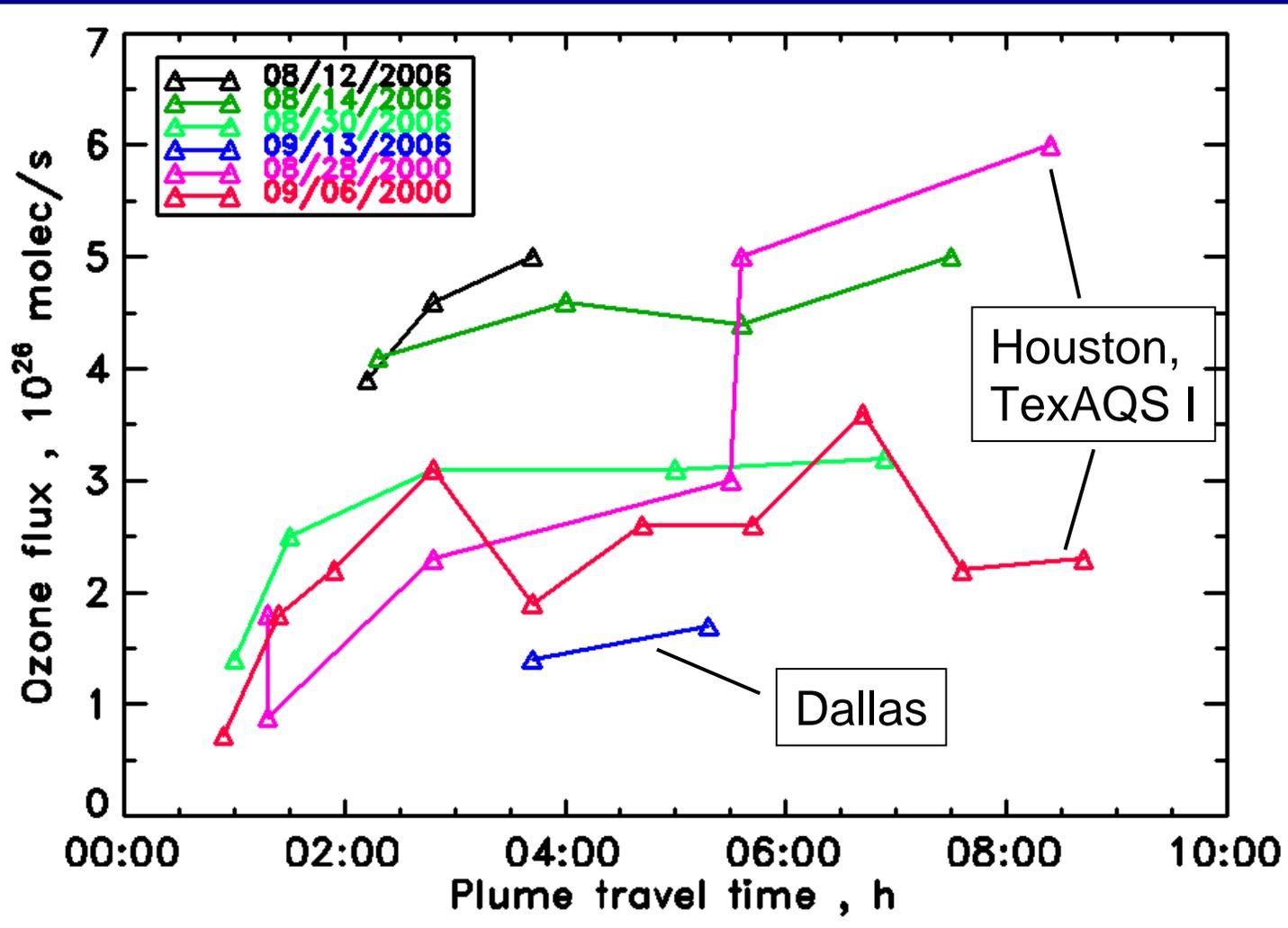


Ozone enhancement in downwind plumes

O_3 enhancement = peak O_3 in plume (95% percentile) – background O_3

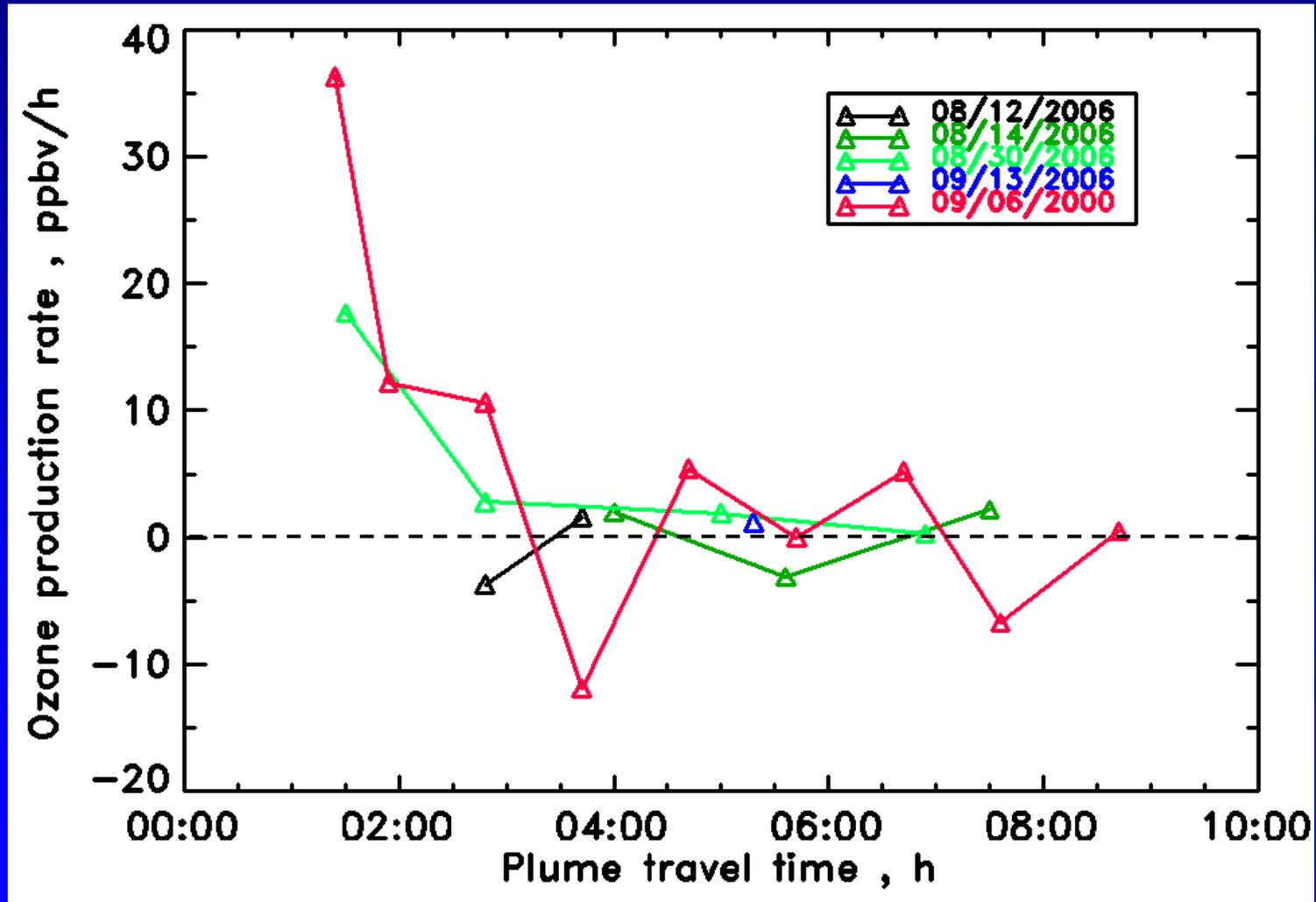


Horizontal ozone flux



Ozone production rate

(Gross rate = photochemical production - loss terms (deposition, venting, etc.))

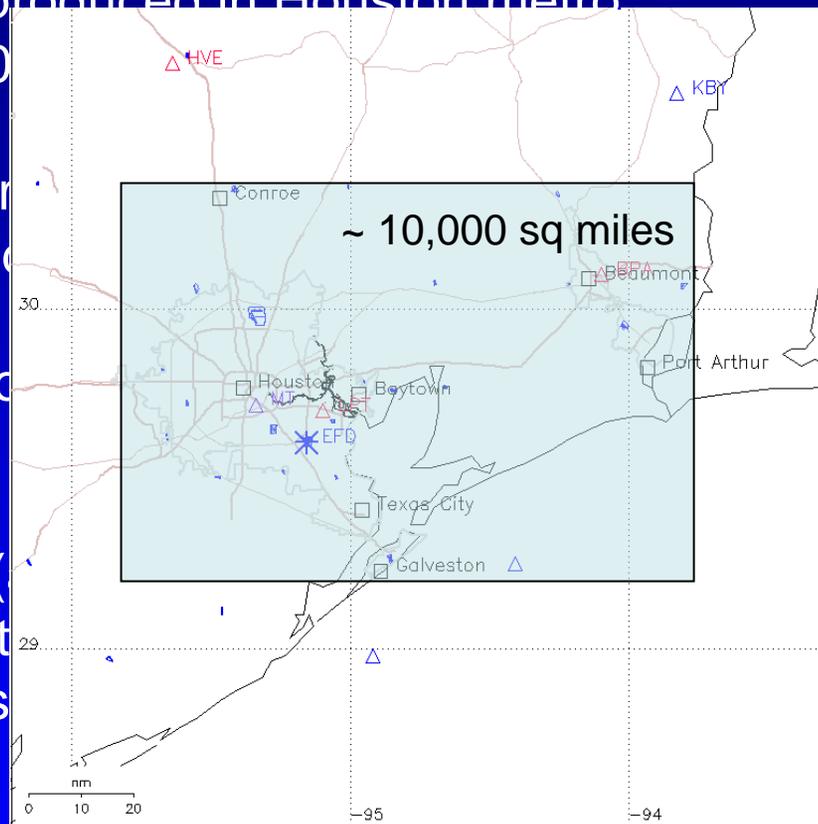


Results of flux calculations (for transects with highest flux)

Metro area	Date	Wind direction	Wind speed, m s ⁻¹	Time, CST	Back-ground O ₃ , ppbv	O ₃ enhancement, ppbv	Flux, molec O ₃ s ⁻¹
Houston	8/12/2006	S	7.3	16:57 - 17:34	29	39	5.0*10²⁶
Houston	8/14/2006	S	4.5	16:58 - 17:26	34	55	5.0*10²⁶
Houston	8/30/2006	N	3.8	17:10 - 17:43	59	52	3.2*10²⁶
Houston	8/28/2000	S	4.2	16:11 - 16:40	53	52	6.0*10²⁶
Houston	9/06/2000	NE	5.2	14:13 - 14:43	69	46	3.6*10²⁶
DFW	9/13/2006	N	4.6	15:49 - 16:34	57	18	1.7*10²⁶

Summary

- Above-background ozone flux produced in Houston metro area ranges from 3.2 to 6.0×10^{26} molec O_3 / s
- Export of ozone from DFW metro area is 3 times less than from Houston (based on 2000 data)
- Ozone enhancements in Houston are 10-20 ppb (locally even higher).
- A flux of 4.6×10^{26} molec O_3 / s (emitted over a day) is equivalent to the amount of ozone over an approx. 10,000 sq miles 2-km deep mixed layer.
- Houston ozone flux and production rates are similar for 2000 and 2006.



Future work

- Analyze additional airborne lidar cases from TexAQS 2000 and TexAQS 2006.
- Include P3/Electra (and possibly other aircraft data) from both field studies.
- Collaborate with Dave Allen's group (Mariana D. et al) in verifying flux estimates from surface network measurements.