A Summary of mixing heights and three-dimensional ozone structure observed during TexAQS II

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Recognizing the instrument development efforts of Alan Brewer, Richard Marchbanks, Janet Machol, and Dan Law

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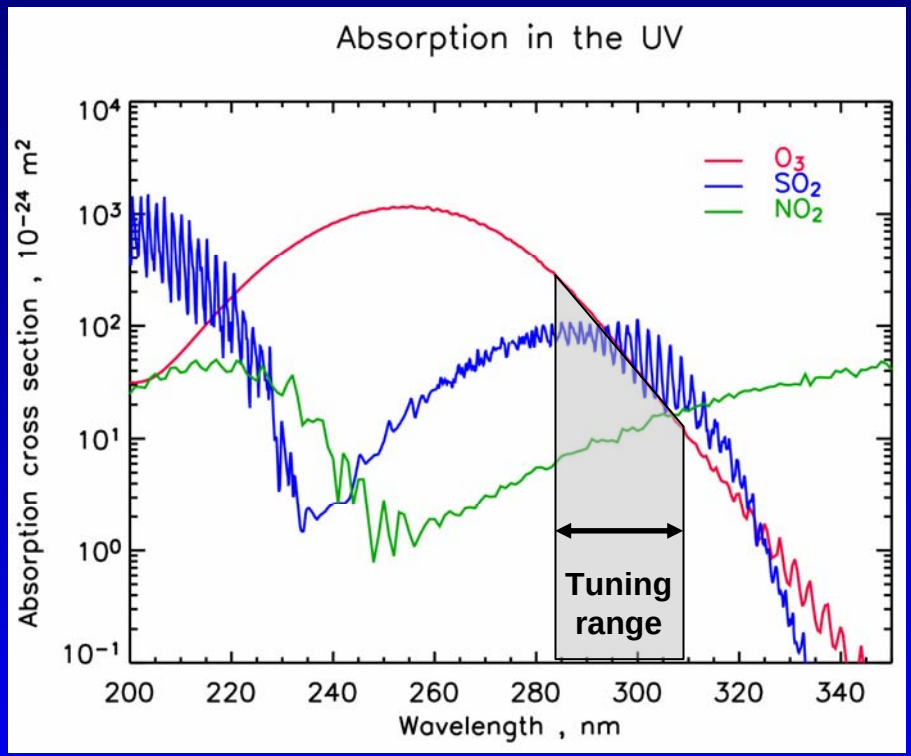
Outline of Talk

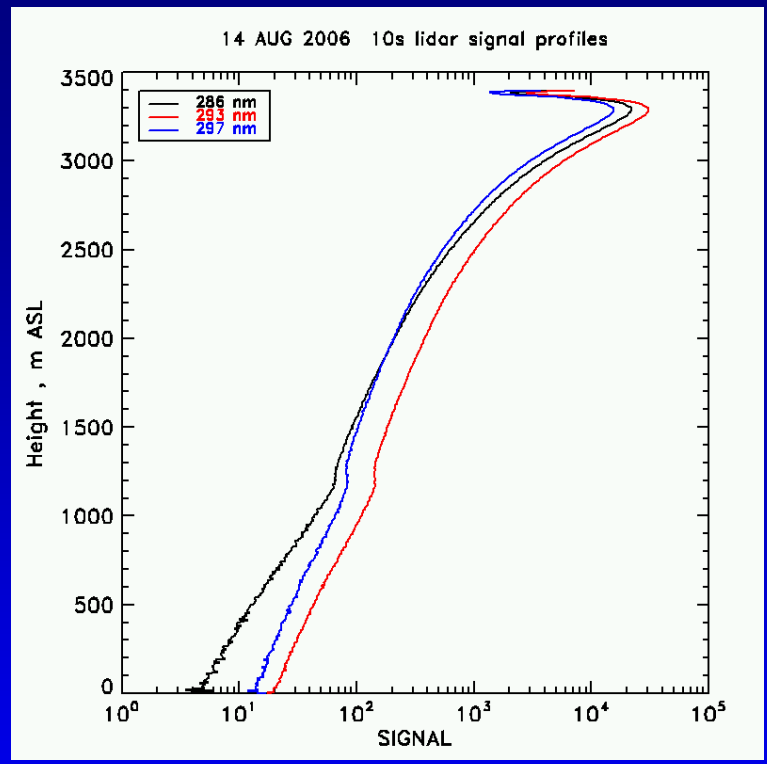
- A new airborne ozone lidar: characteristics and performance during TEXAQS 2006
- Ozone measurements over East Texas: spatial variability and background levels
- Import of ozone from Beaumont/Port Arthur and Louisiana
- Variability of mixing layer depths and relationship to ozone observations

NOAA's New Ozone/Aerosol Lidar

- New, all solid state design
- Designed for deployment in the NOAA Twin Otter
- Measures ozone from 400 m below flight altitude to just above the surface
- Resolution: 90 m vertical, 500 m horizontal
- Precision: 5-15 ppb (degraded near the surface under high ozone conditions

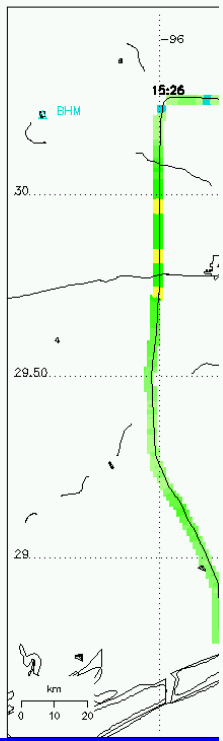
Lidar measurements of ozone profiles

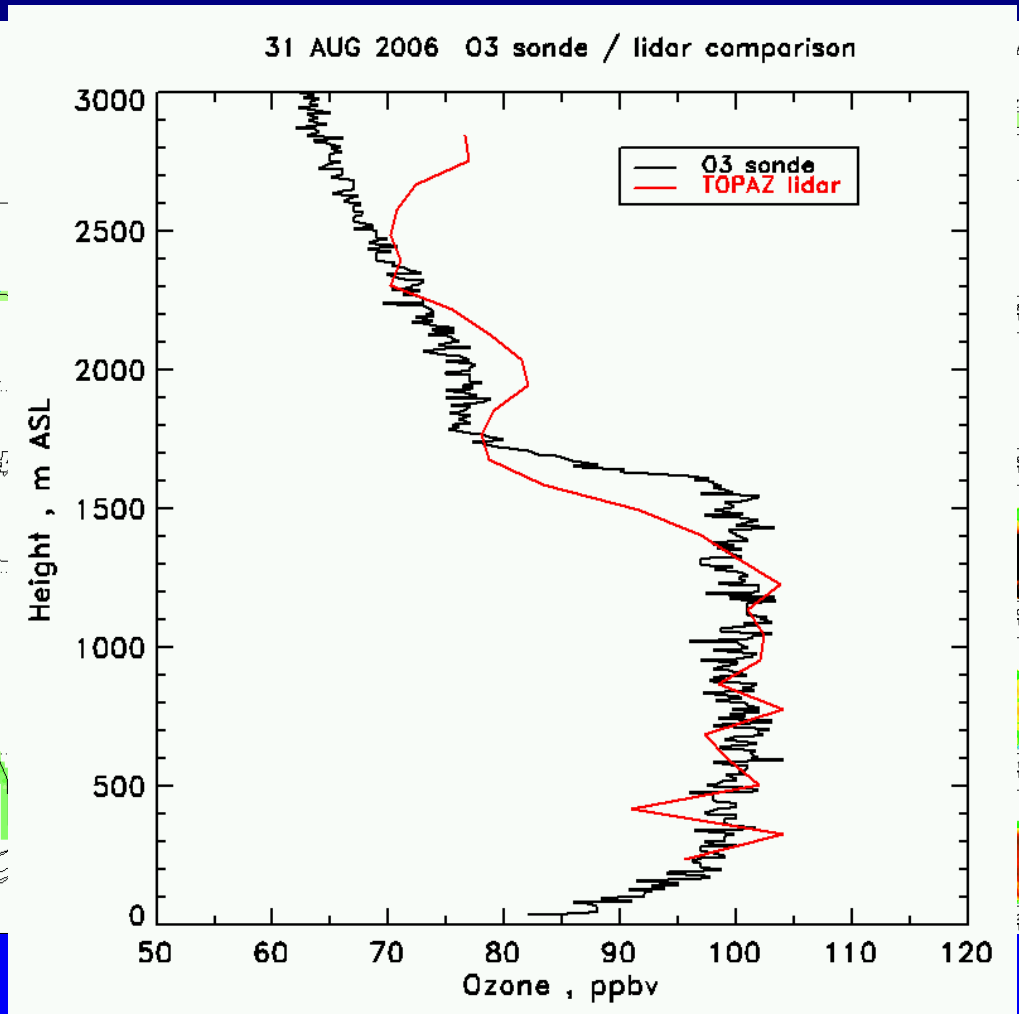


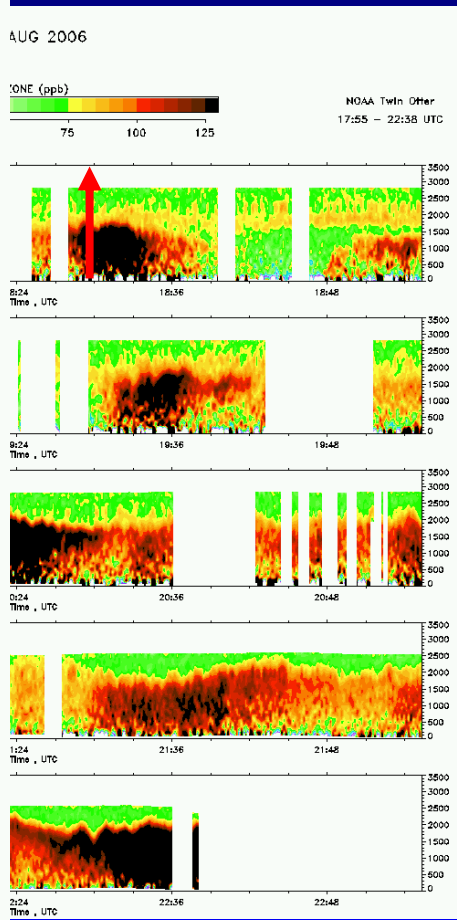


- Three wavelengths allow flexibility for high/low ozone conditions
- Measurement is degraded during
  - Intermittent clouds
  - High ozone where lowest range gate signals weak

Comparison with sonde August 31

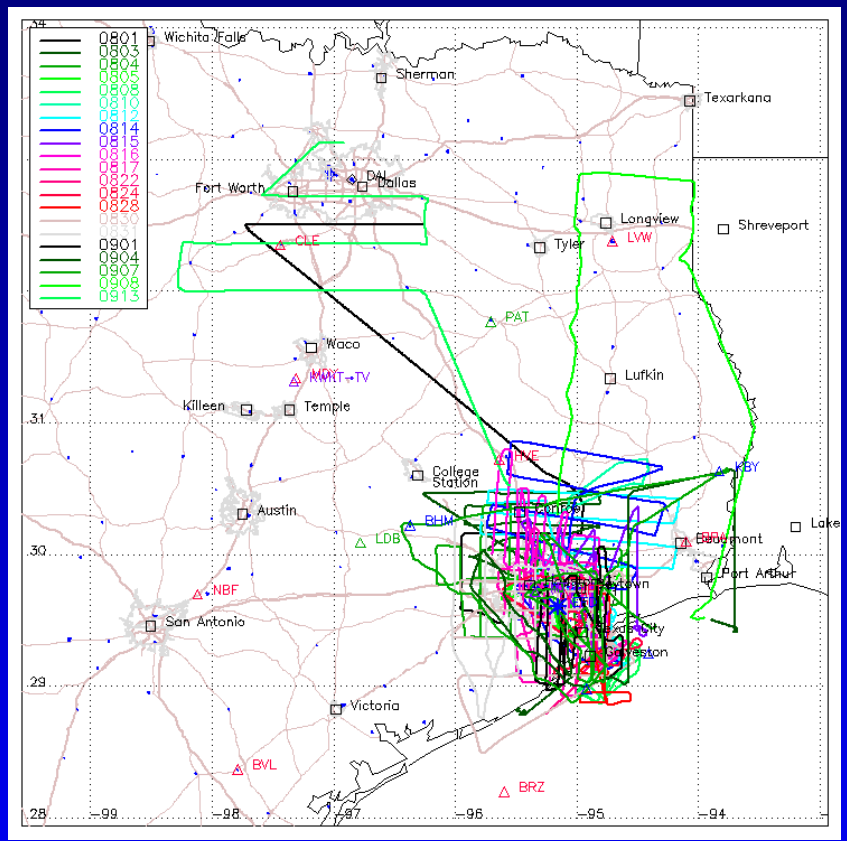


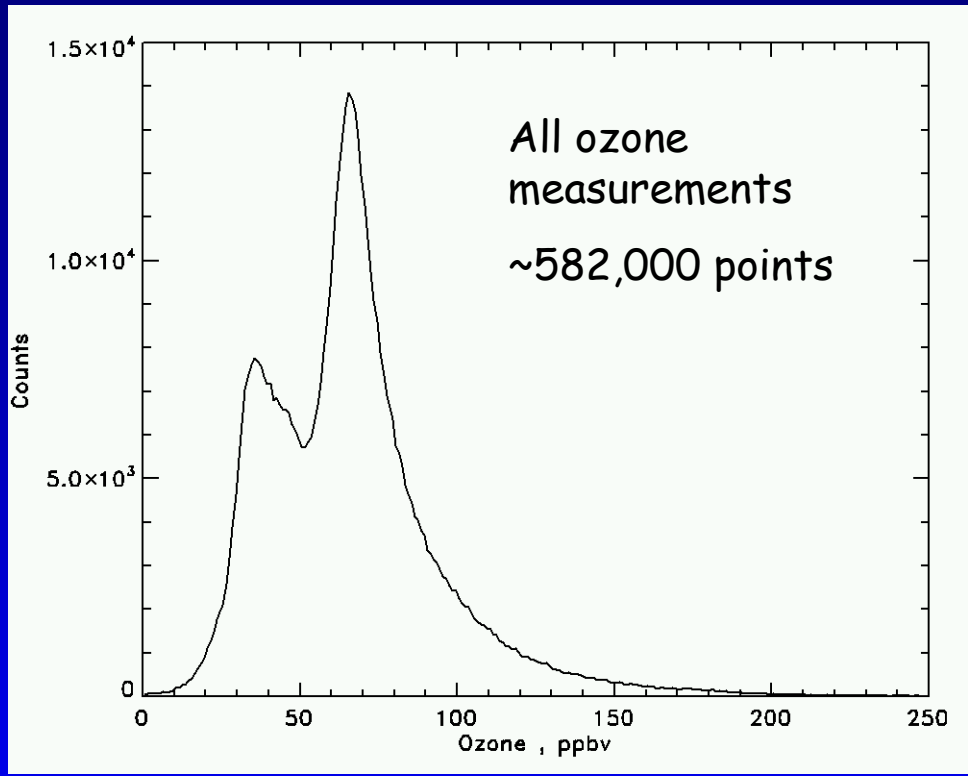




- More sonde comparisons in September to be processed

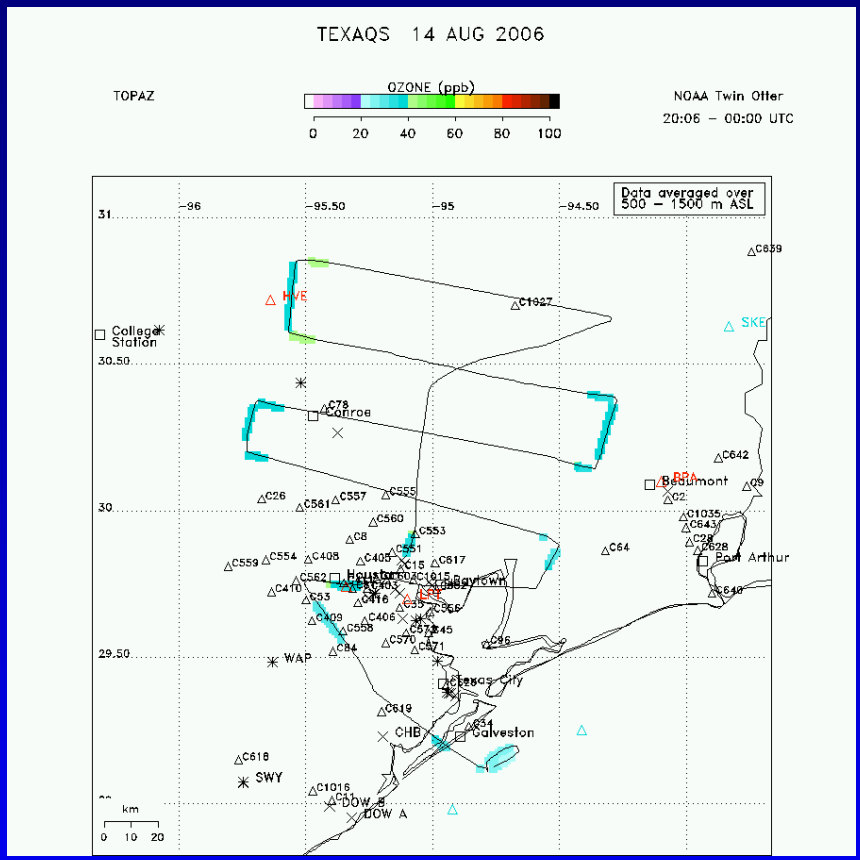
Measurements during TEXAQS 2006

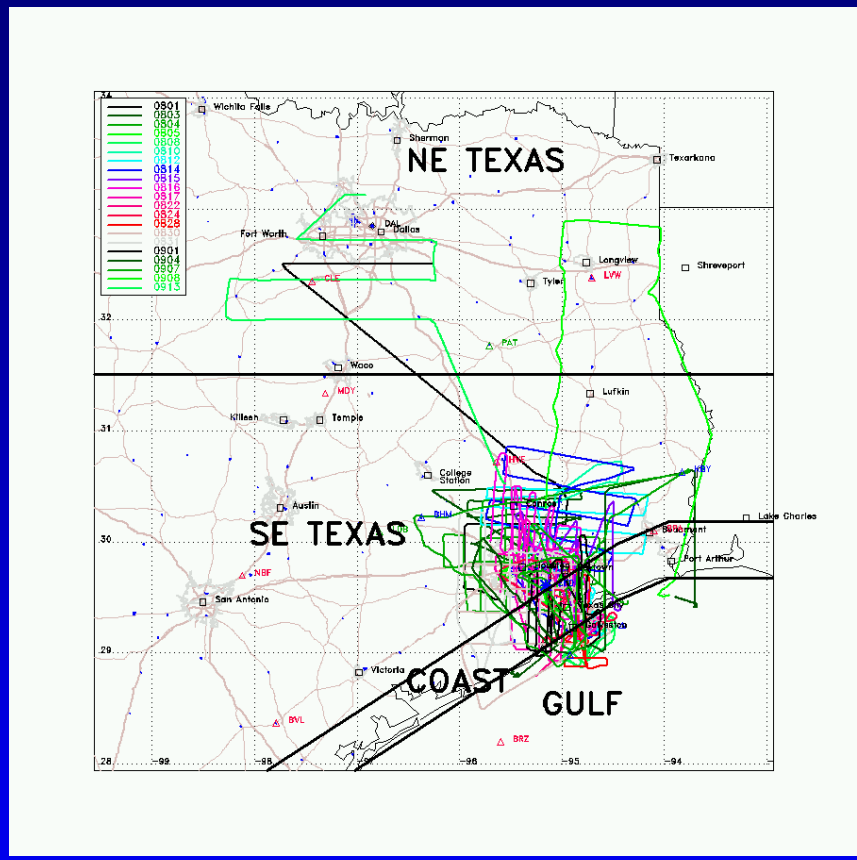




- Aircraft on site from 1 August to 15 September
- 20 data flights plus transit flight
- 70 hours of data
- 1 profile every 10 seconds provided ~ 25000 independent profiles of ozone and aerosol backscatter

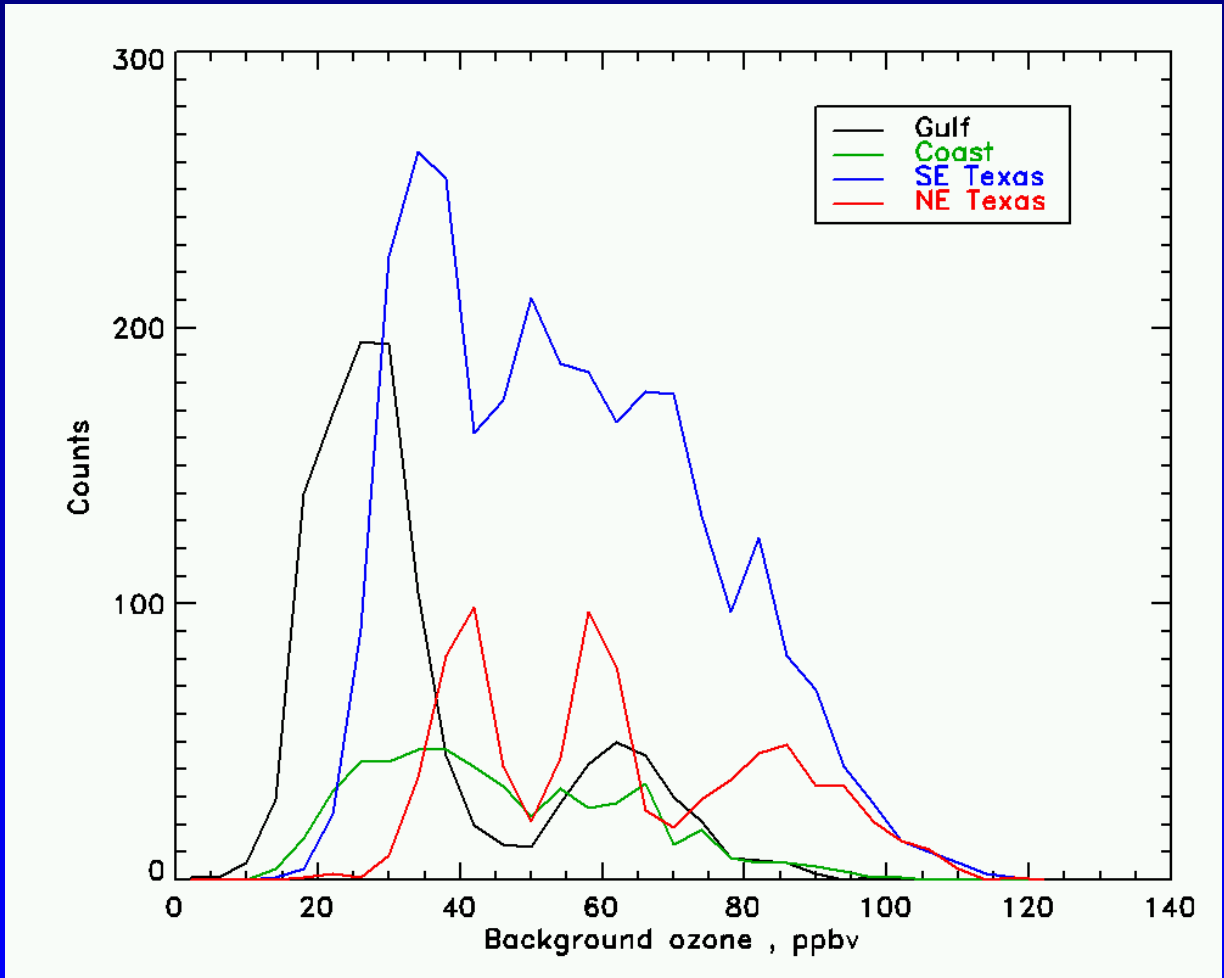
Characterizing Regional Ozone Background





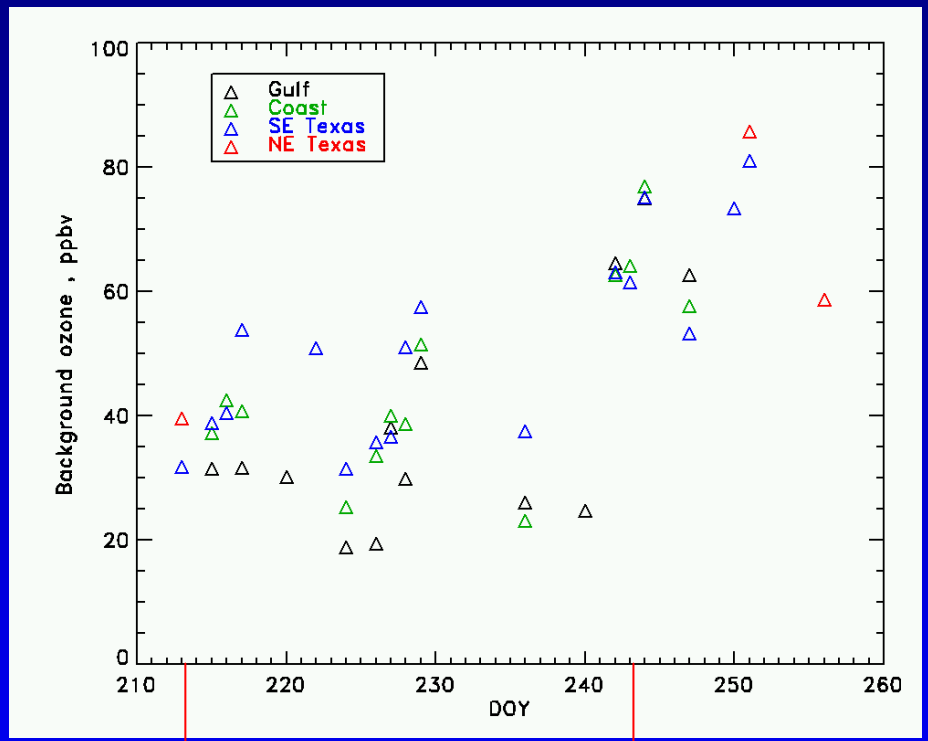
- Technique
  - Develop data set of measurements eliminating "in-plume" measurements
  - Average ozone from 400 – 800 m elevation
  - Compute wind direction from profiler trajectories
  - Parse by wind direction (indicative of source), date, and region
- Four regions chosen for analysis

Background Measurements: All days



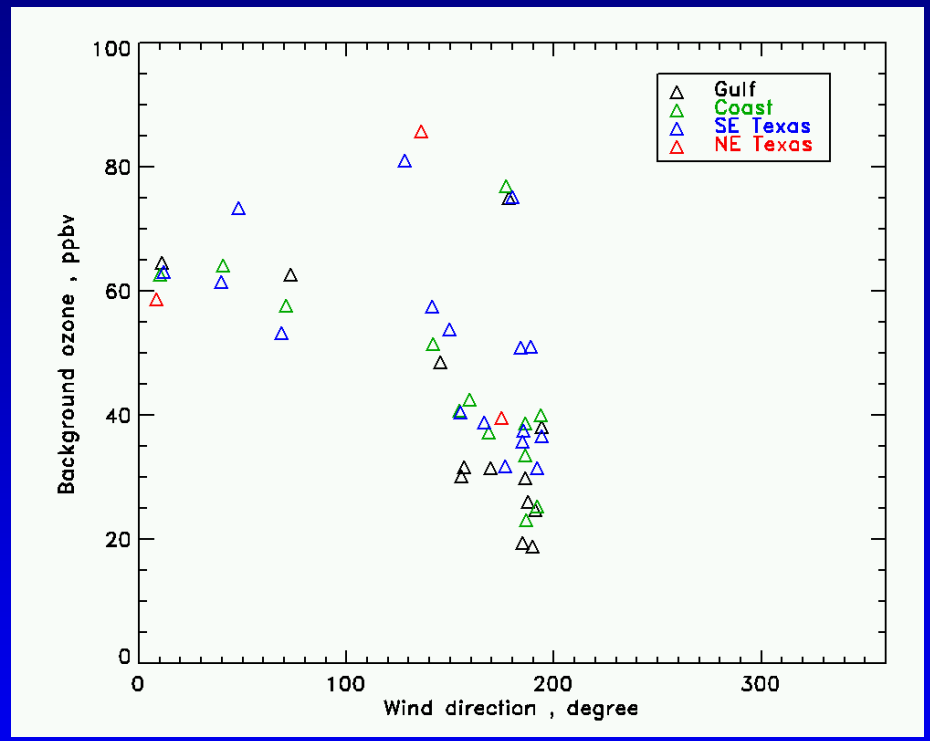
Caveat: Areas not uniformly sampled

Background versus day and wind direction

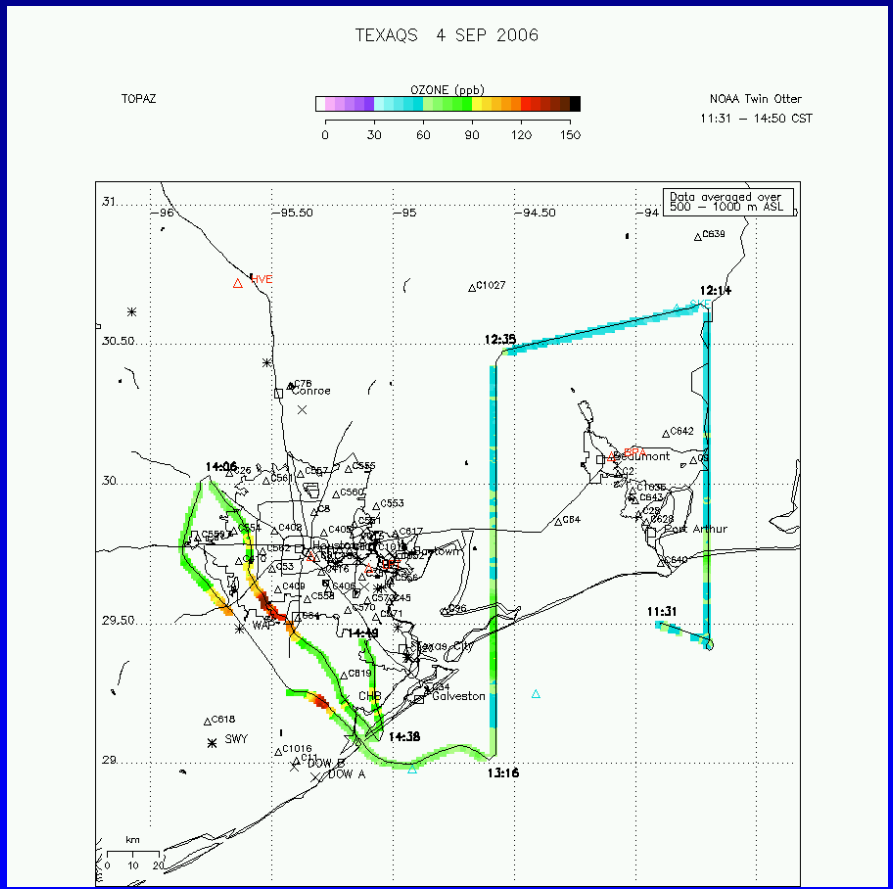


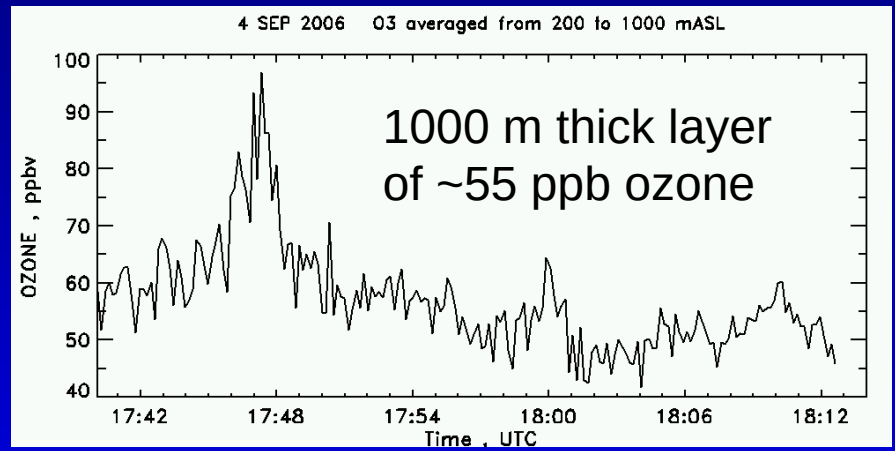
August

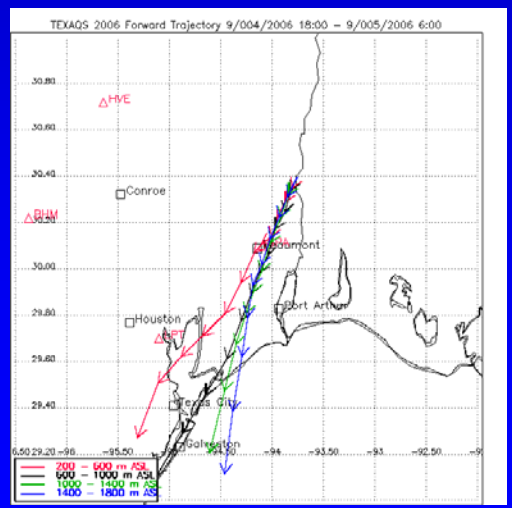
September



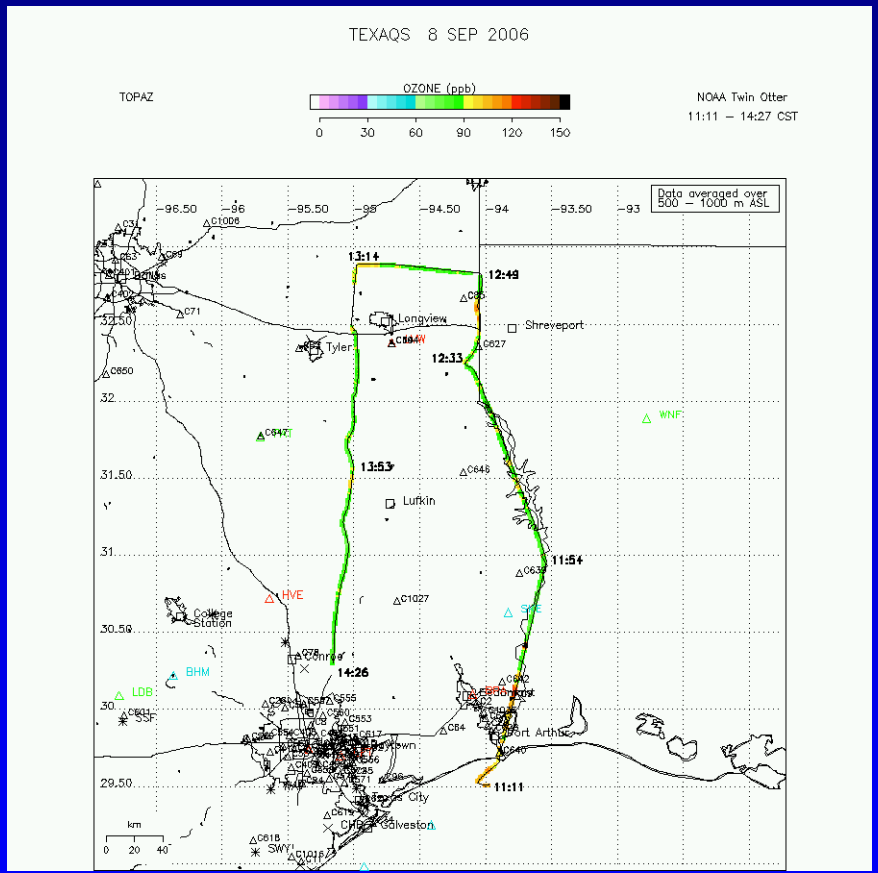
Import of ozone from the east: September 4

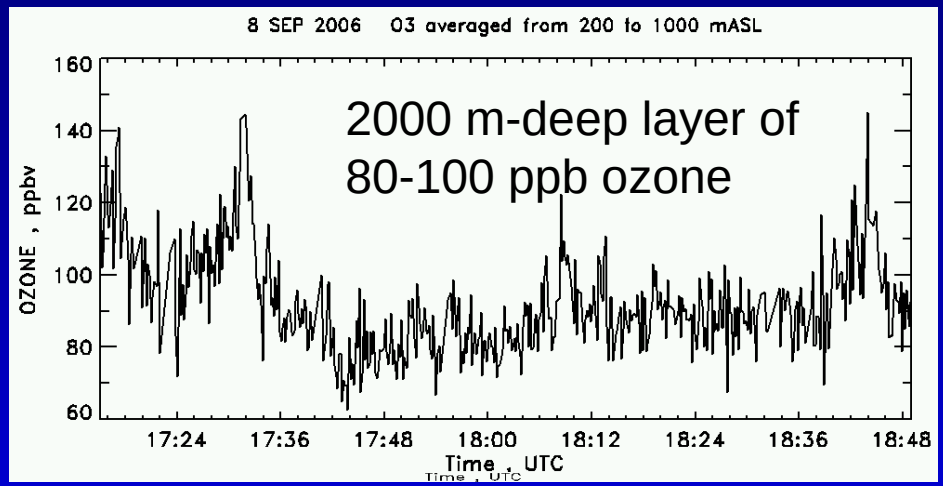


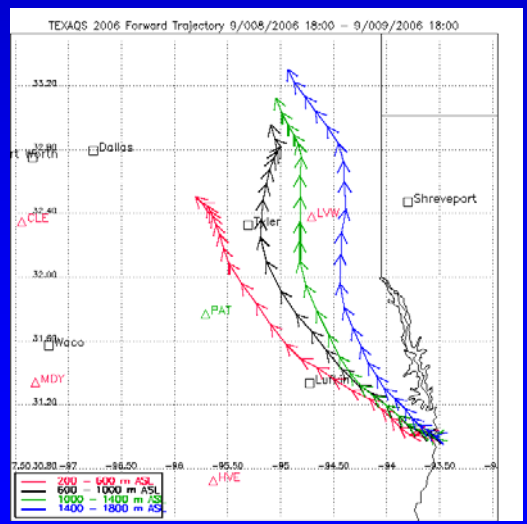




Import of ozone from the east: September 8 case

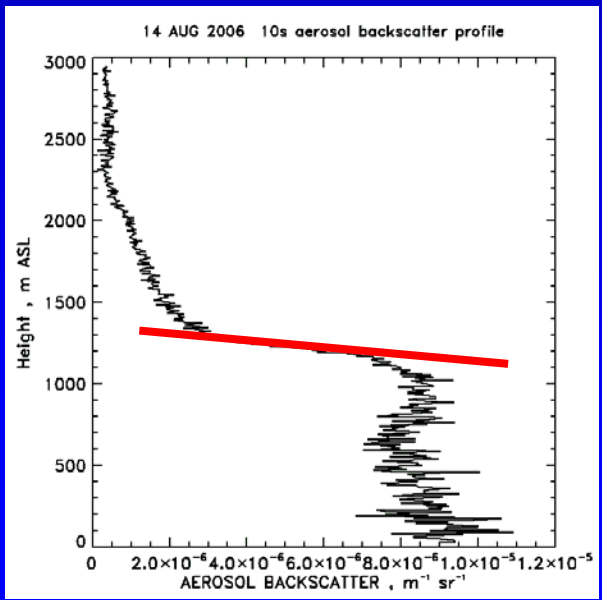


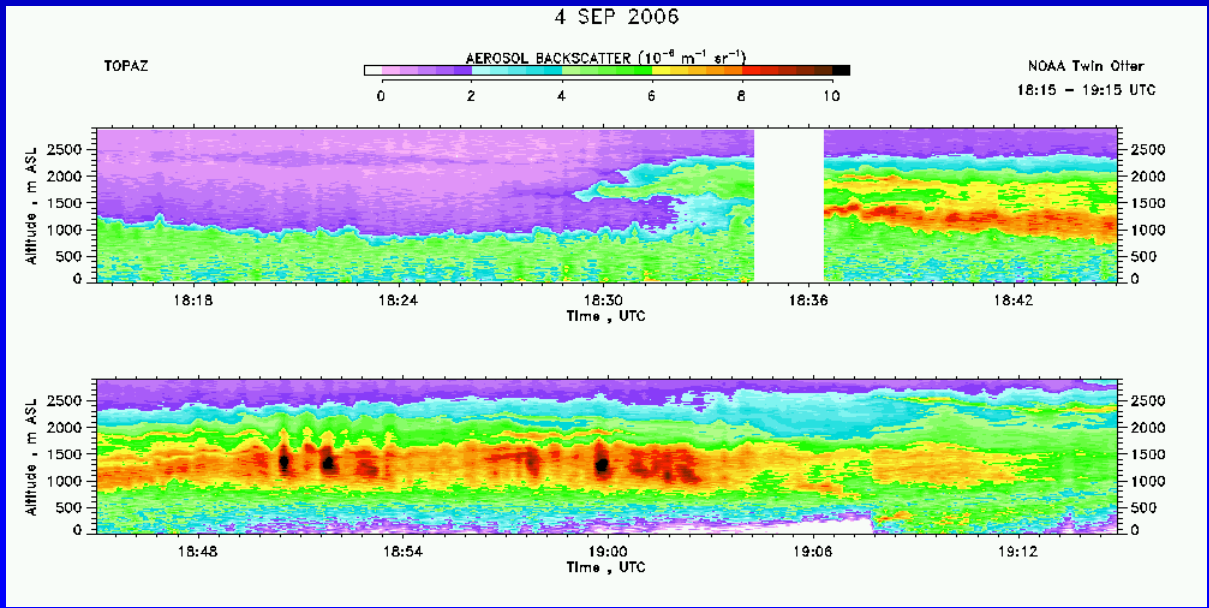




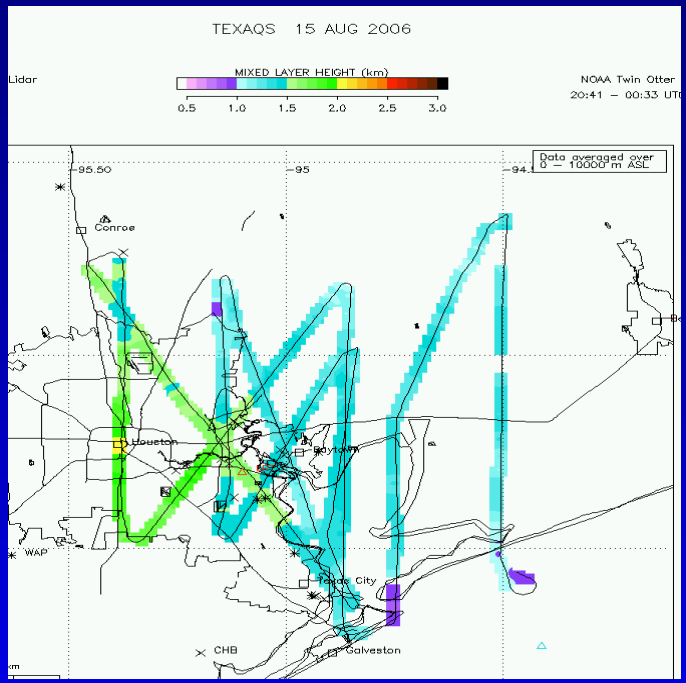
BL height retrieval with TOPAZ

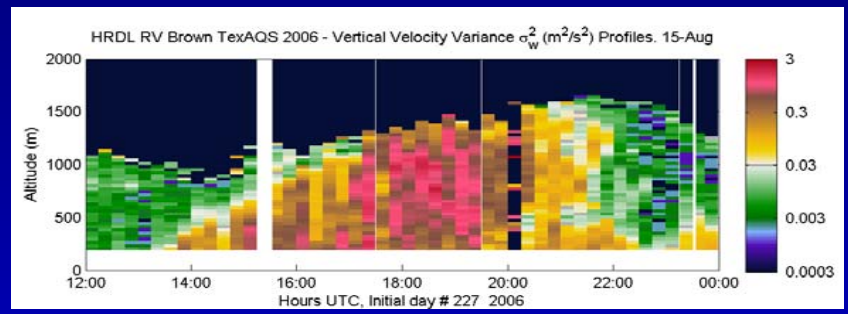
- Use aerosol backscatter contrast between free troposphere and boundary layer
- Apply wavelet technique to detect maximum backscatter gradient at top of mixed layer
- Technique works well if lower free troposphere is clean, but retrieval becomes difficult if contrast in aerosol loading between free troposphere and mixed layer is poor

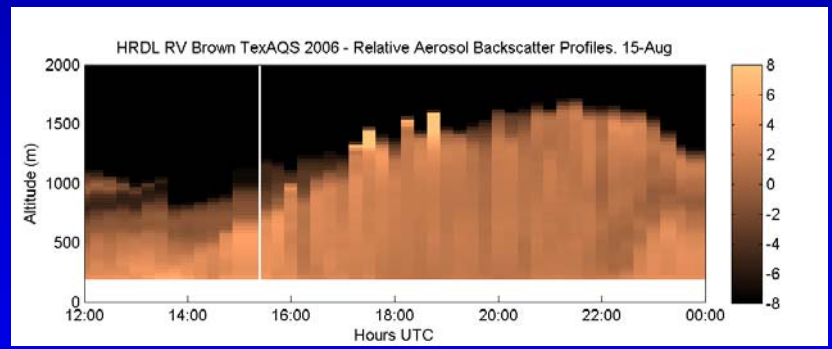


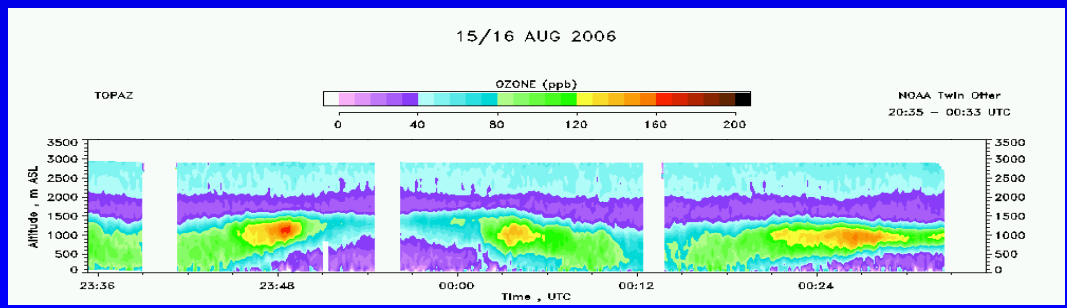


August 15: Sea breeze intrusion

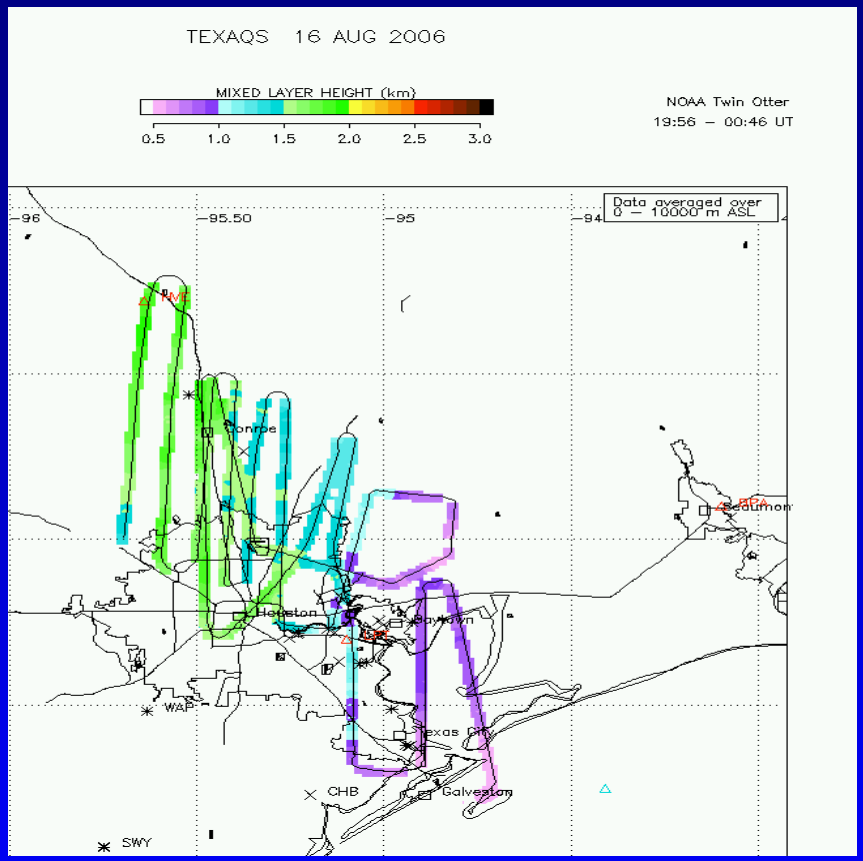


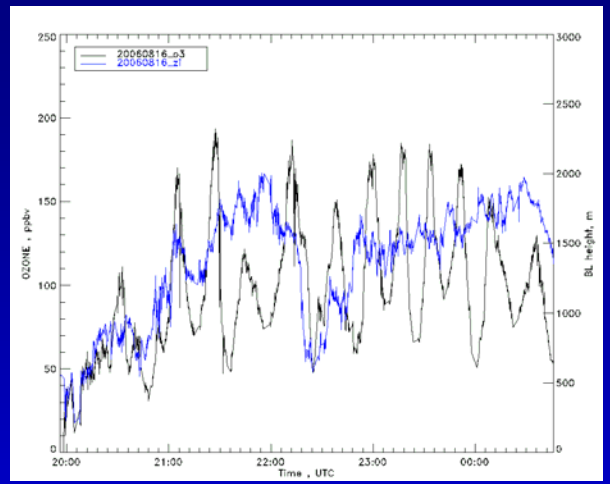


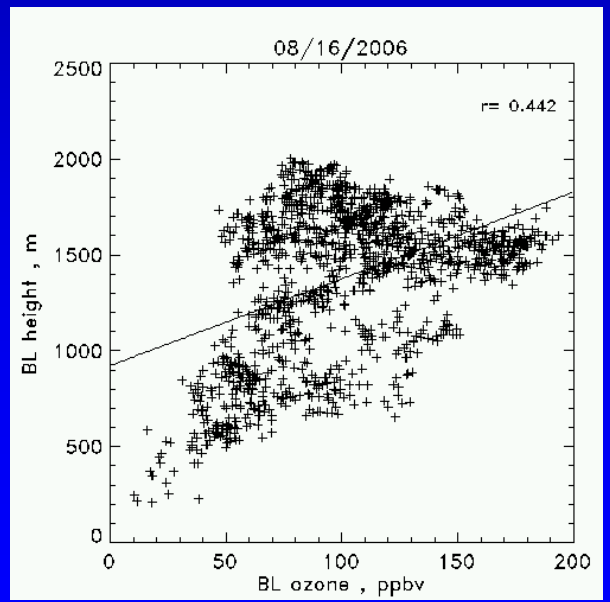




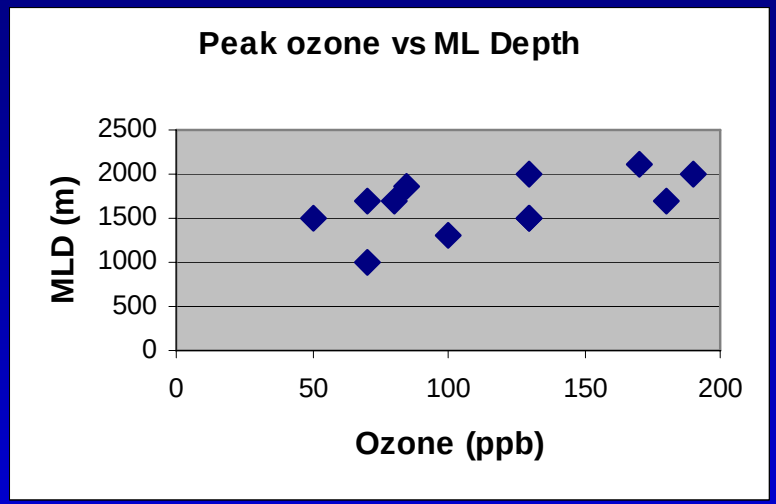
Ozone/MLD relationship – August 16

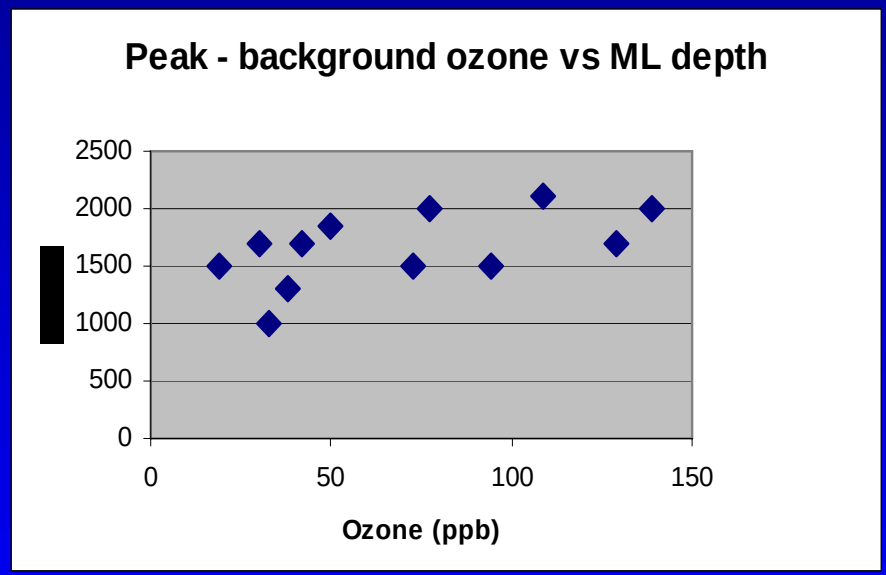


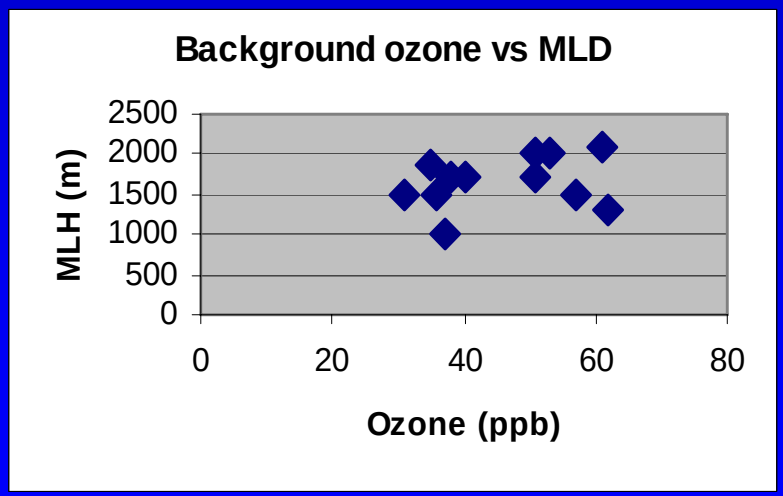




How does ozone/MLD relationship vary from day to day?





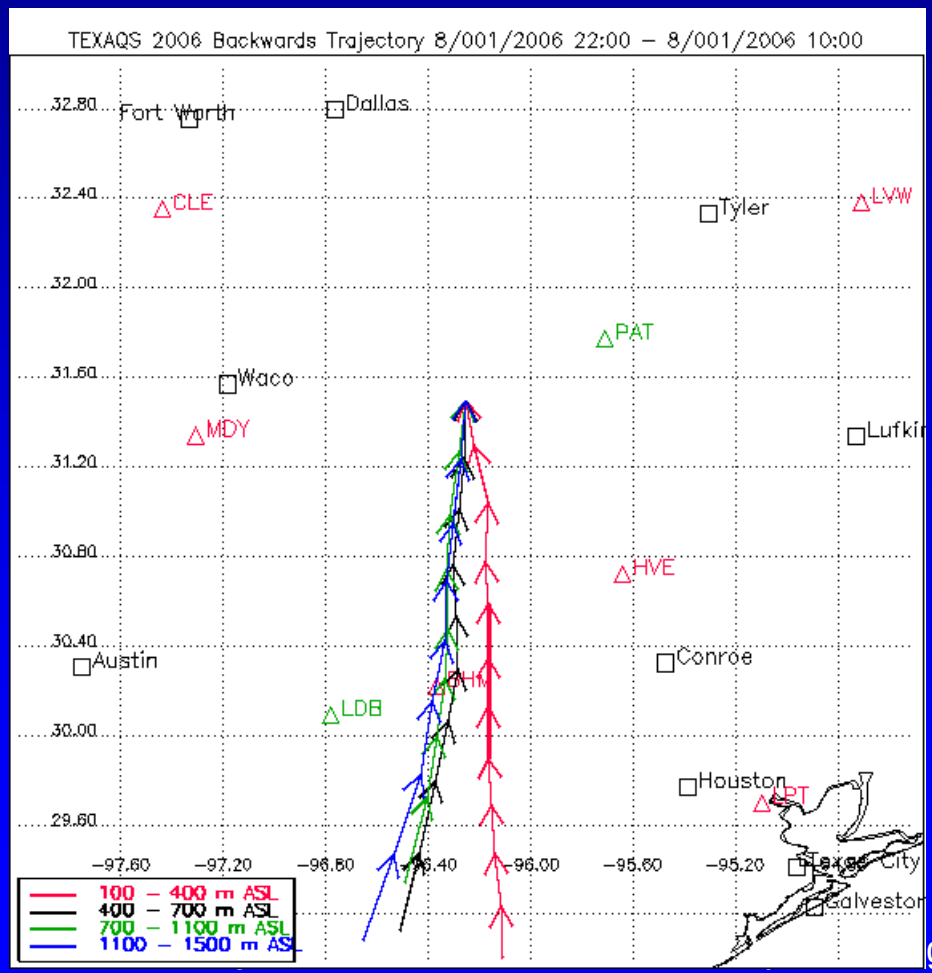


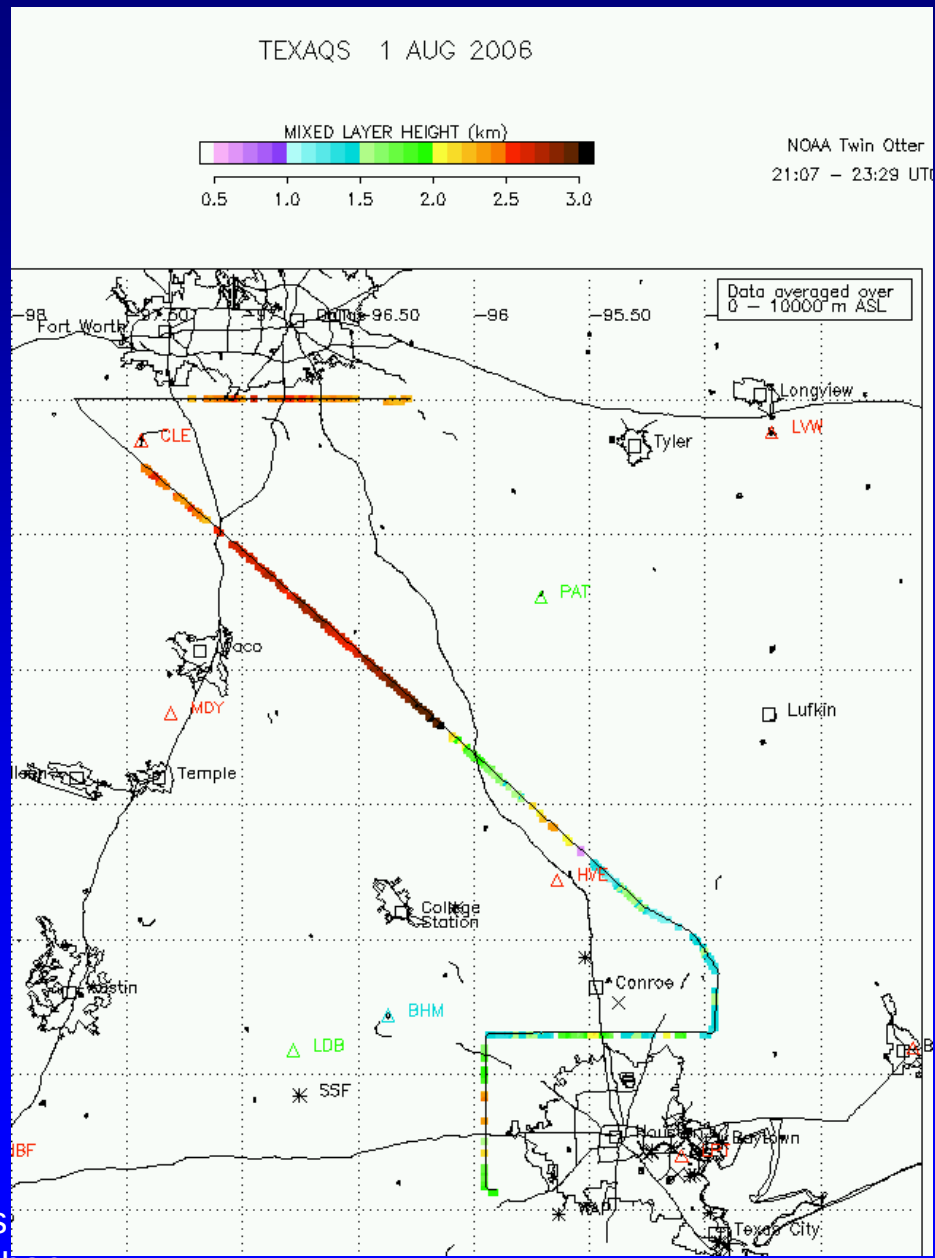
Summary

- New ozone/aerosol lidar operated well during TEXAQS II
- Characterized background ozone variability versus region, wind direction and date
- Mixing layer depths tended to be higher west and north of Houston, lower over the bay and gulf
- Mixing layer depths across plumes showed little correlation with ozone values
- On a day to day basis, higher ozone values somewhat associated with deeper mixed layers

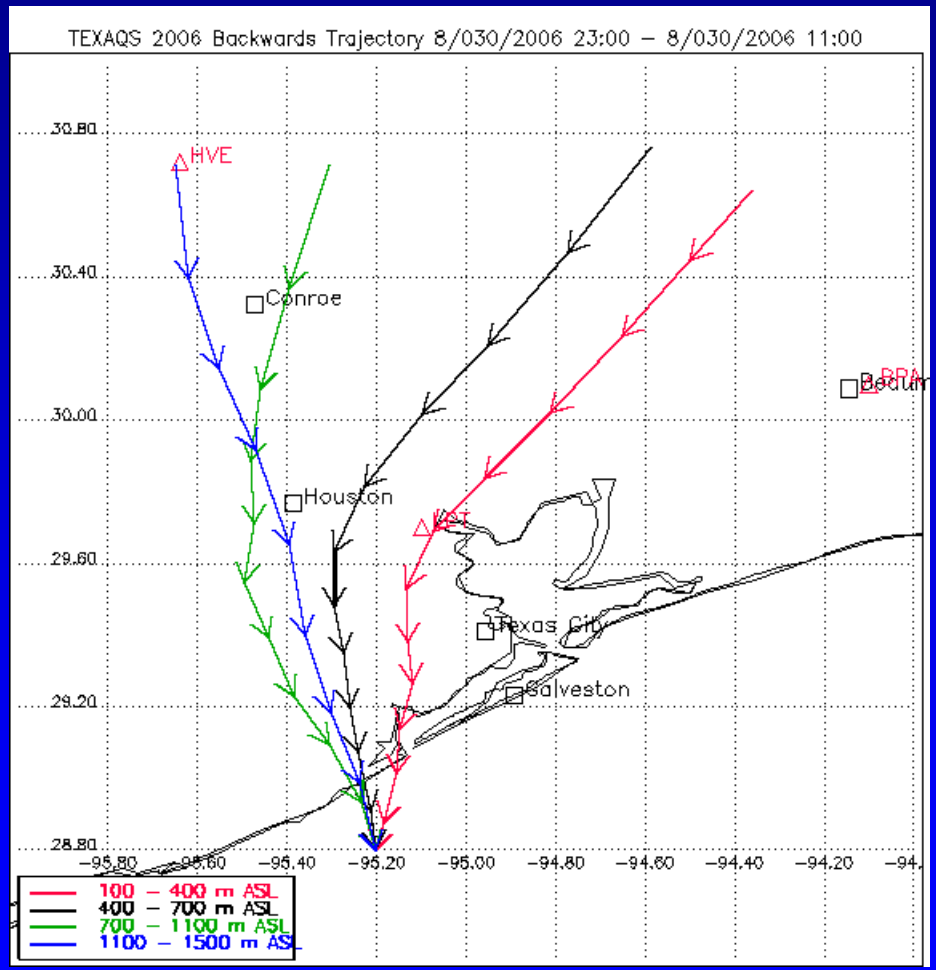
Southerly flow: Aug 01

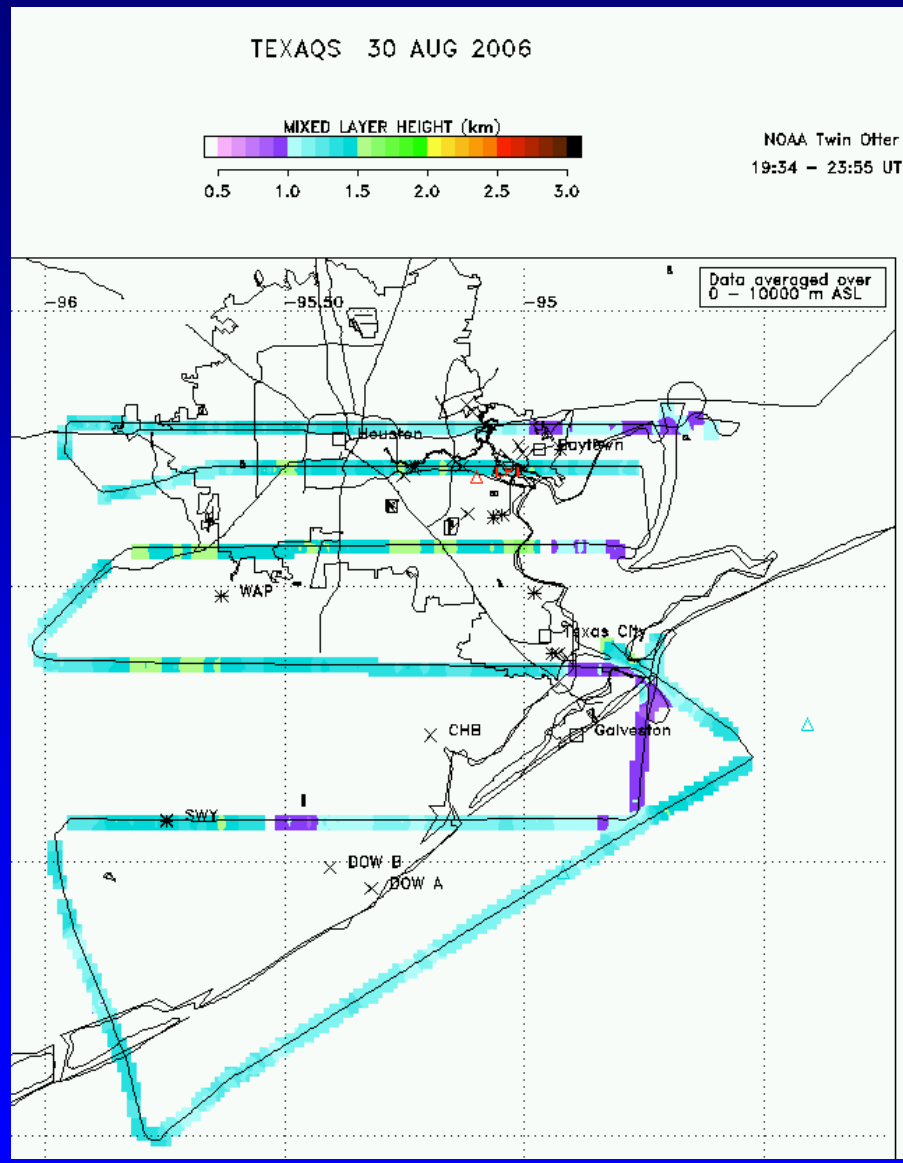
Dallas – Houston on transit flight





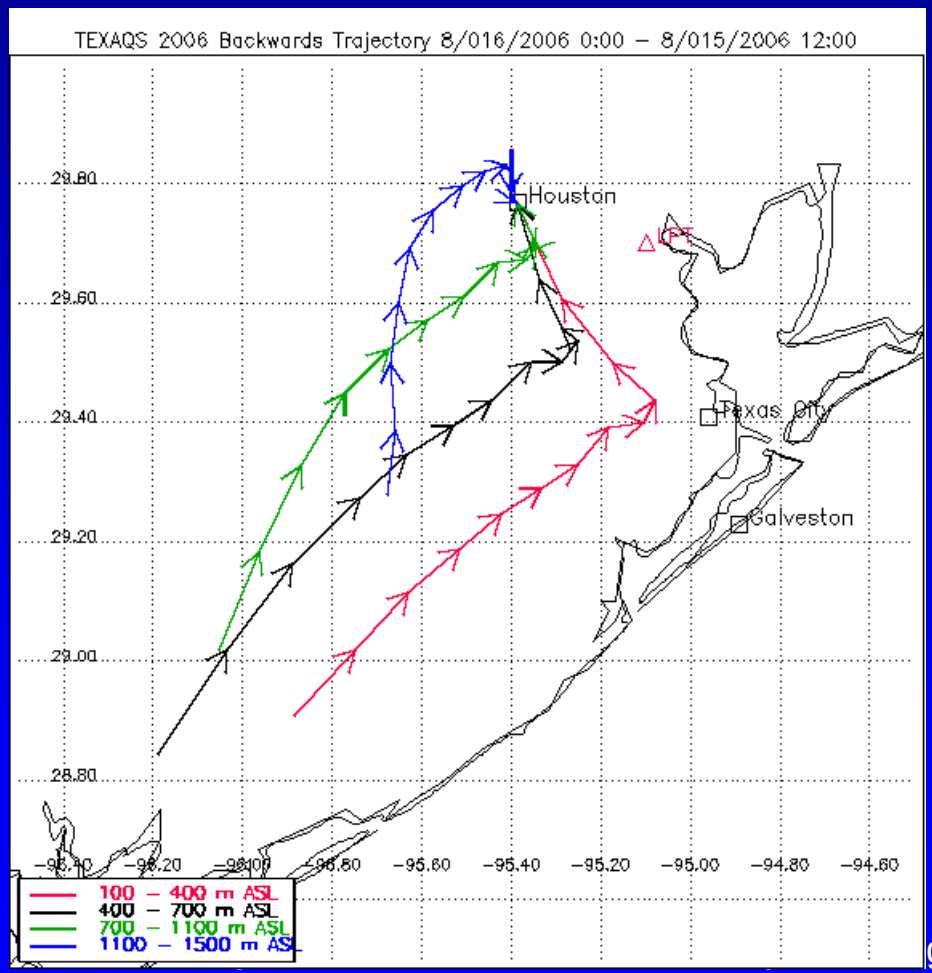
Northerly flow: Aug 30

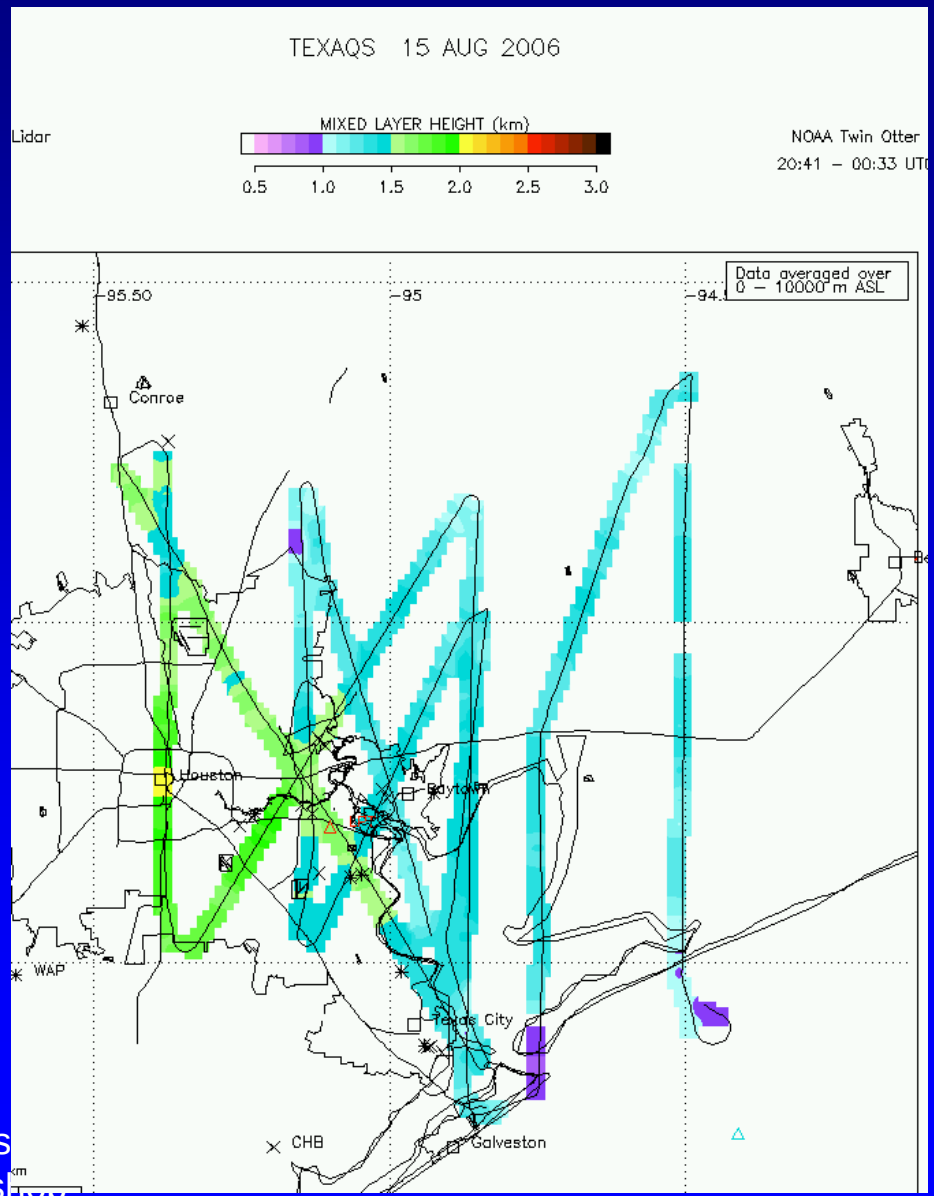




Flow reversal: Aug 15

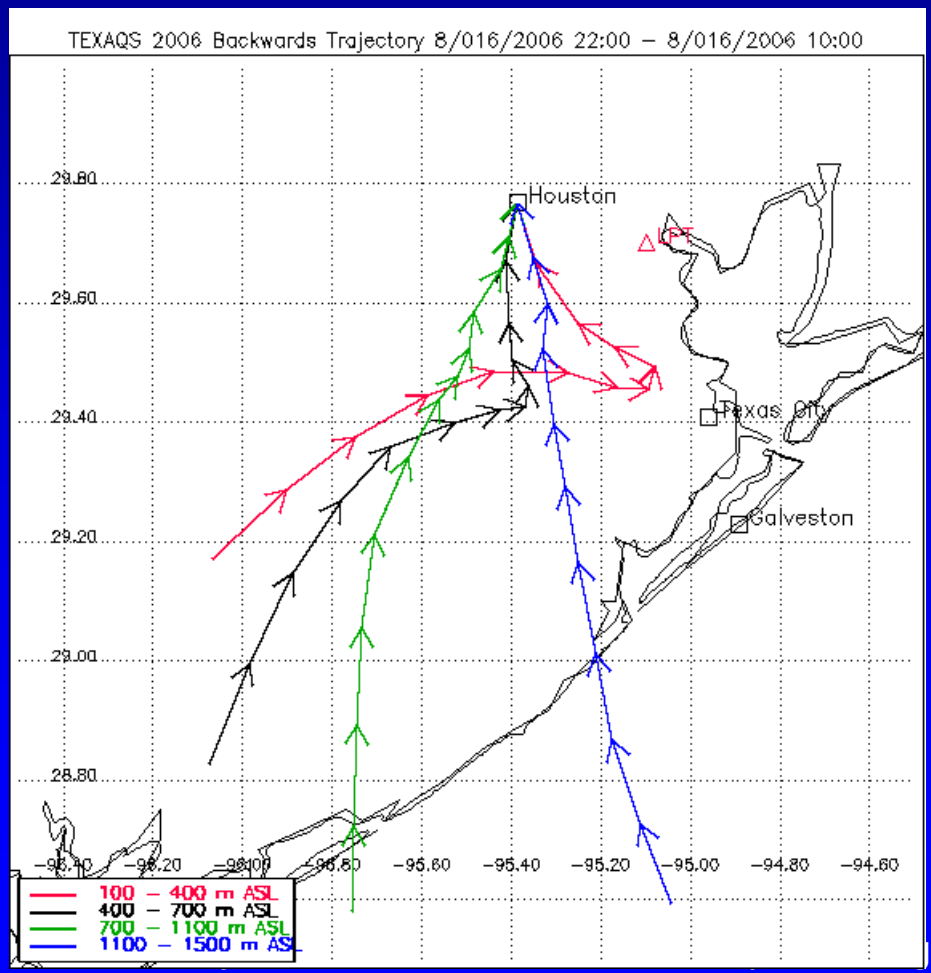
Sea breeze onset: ~ 15 CDT

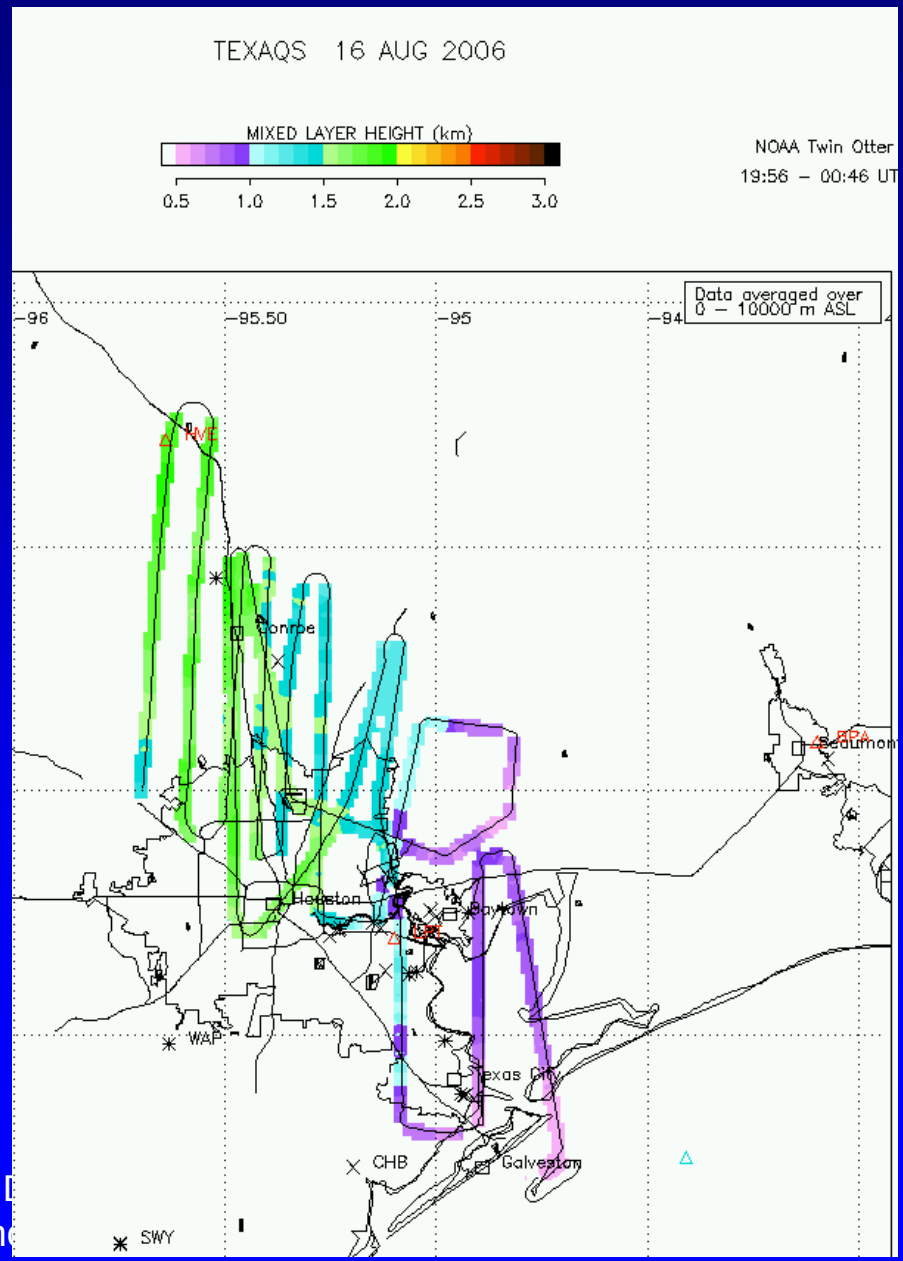




Flow reversal: Aug 16

Sea breeze onset: ~ 12 CDT





Preliminary Findings

- Patterns of mixing height spatial variability in the Houston area are generally very similar to what was observed during the TexAQS 2000 study.
- Boundary layer heights over land in the Houston area (in particular north of Houston) appeared to be somewhat lower compared to TexAQS 2000. This may be related to the fact that 2000 was a drought year in SE Texas (warmer temps, lower soil moisture), while the summer of 2006 was close to the climatological norm in terms of temperature and wetter than normal in June & July.

Further analysis:

- Correlate radiometric surface skin temperature measurements with lidar-derived mixing heights
- Investigate the impact of mixing height variability on peak ozone concentrations and compare to TexAQS 2000 findings

Stay tuned!