Ozone Transport and Mixing Processes

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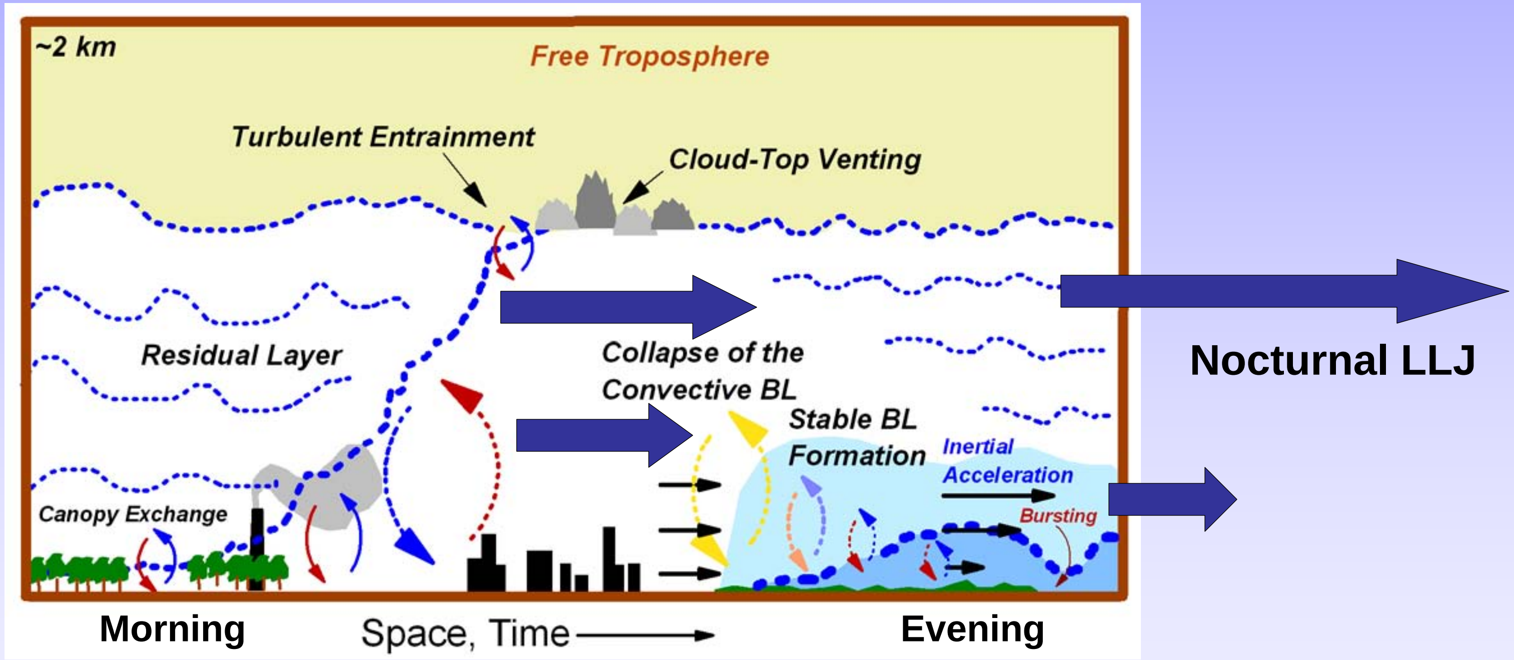
Air Quality is not just chemistry!



- Tighter standards → Increased local impact of transport
- Stagnant conditions → Smaller scale processes become important

Overview

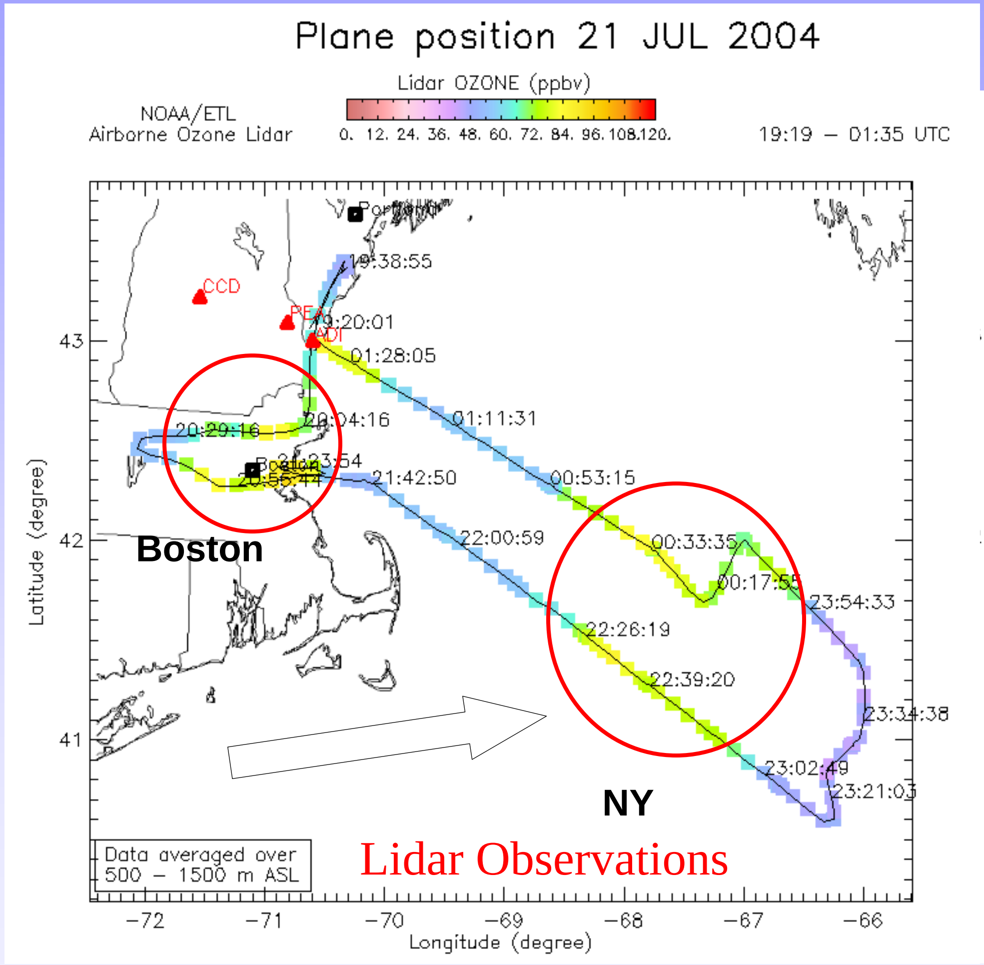
- Applying remotely-sensed ozone observations to assess modeling of Boston/New York plumes (ICARTT)

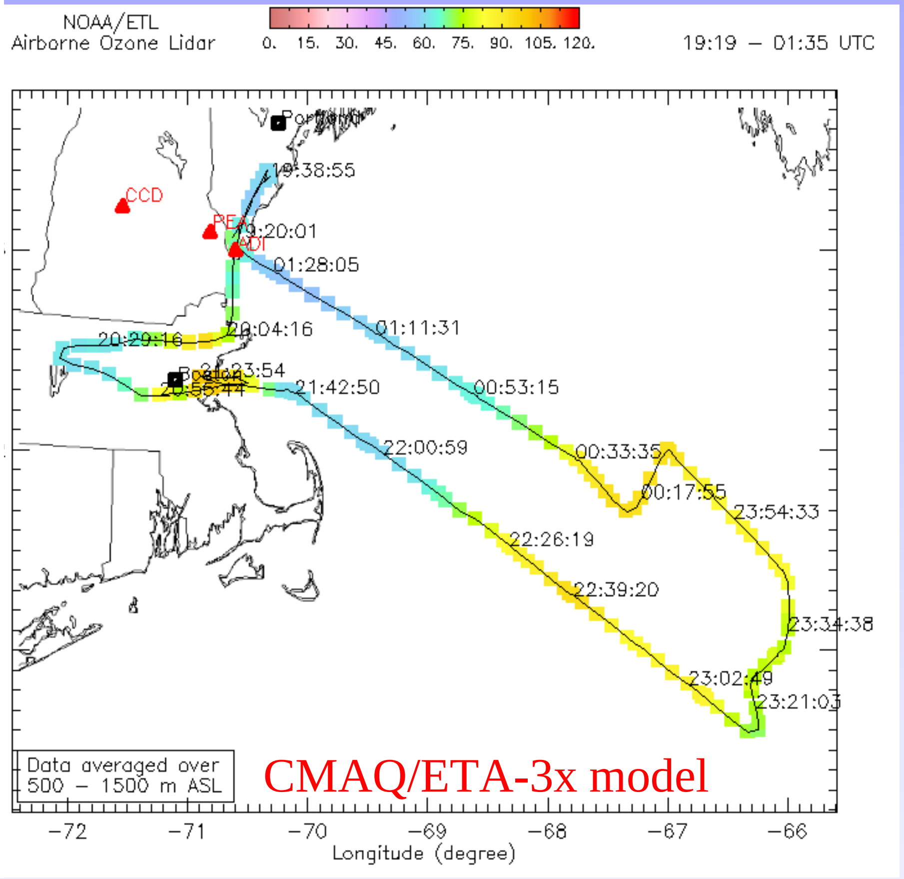
- Understanding and modeling the role of the sea breeze in high ozone events (TEXAQS)

- Estimating the large amount of ozone transported into rural regions from Houston and Dallas (TEXAQS)

- Mixing clean air to the surface at night, reducing ozone levels (TEXAQS)

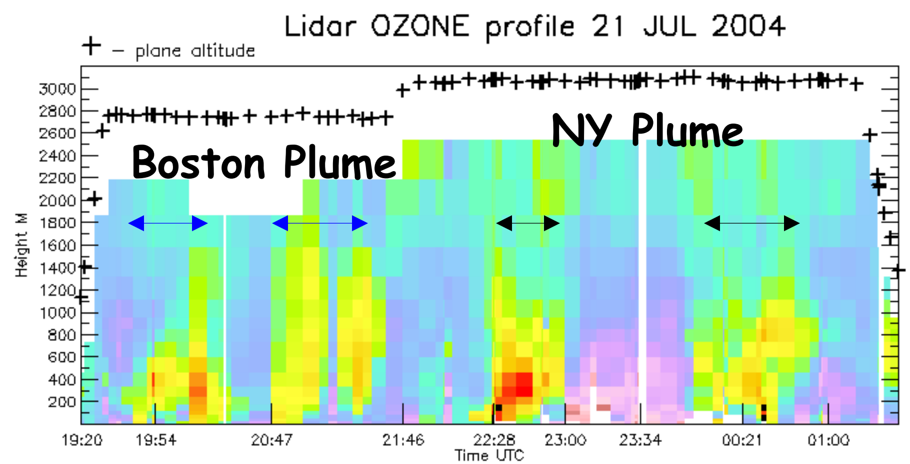
Boston and New York Plumes: Lidar/Model Validation



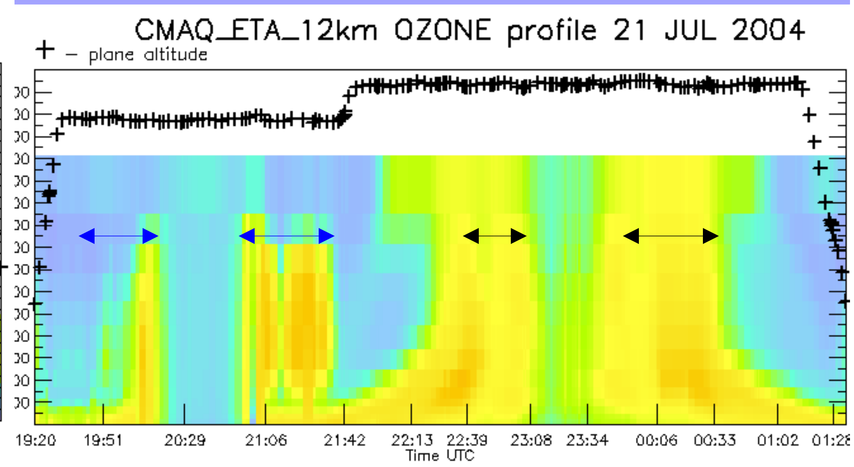


From Irina Djalakova

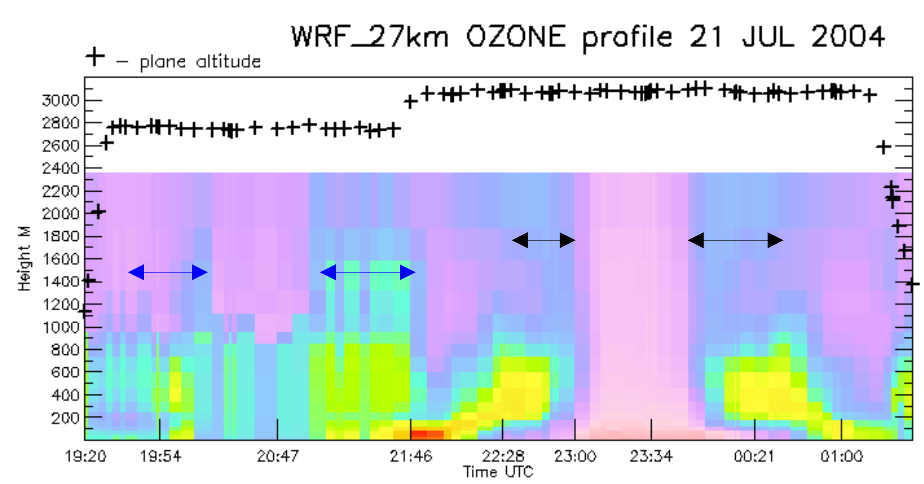
Lidar vertical ozone structure compared With CMAQ and WRF/Chem



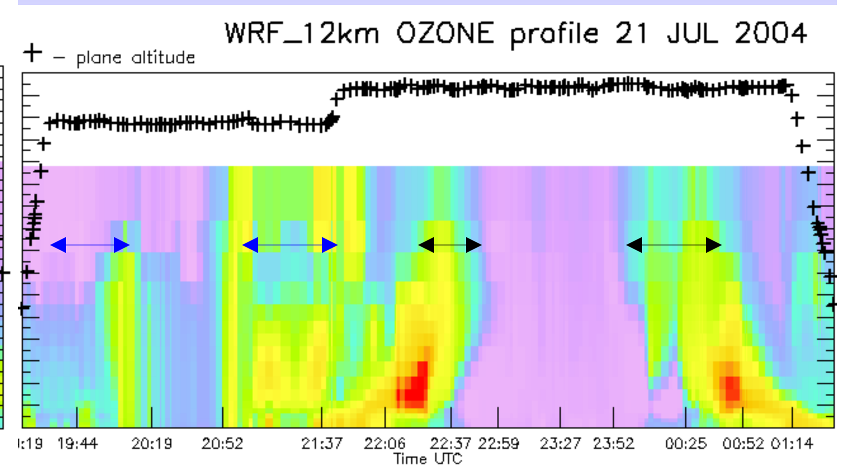
Observations



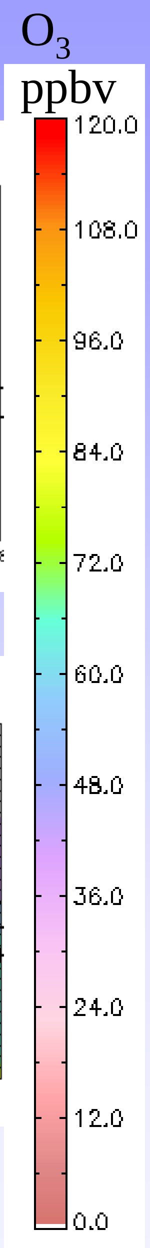
CMAQ/ETA-3x Model



Mellor-Yamada(2.5) PBL scheme

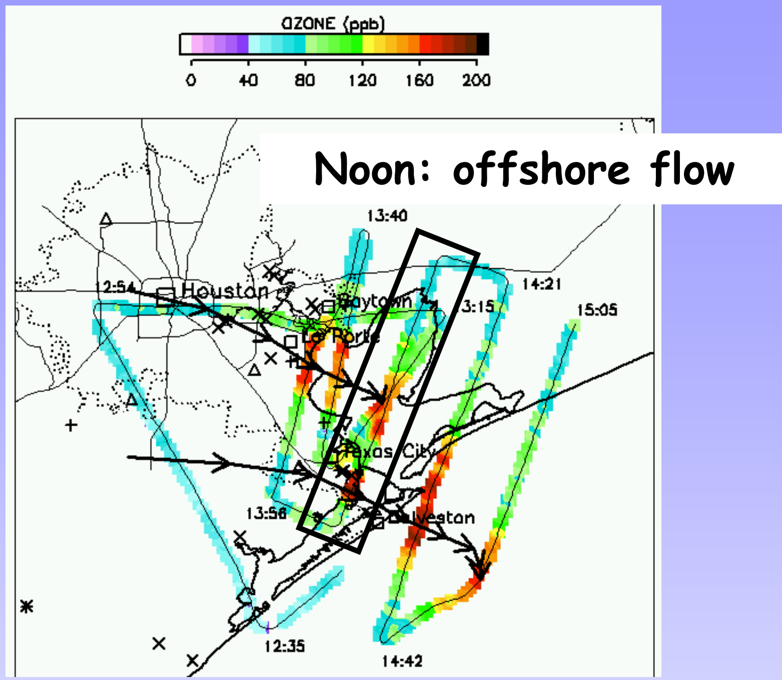


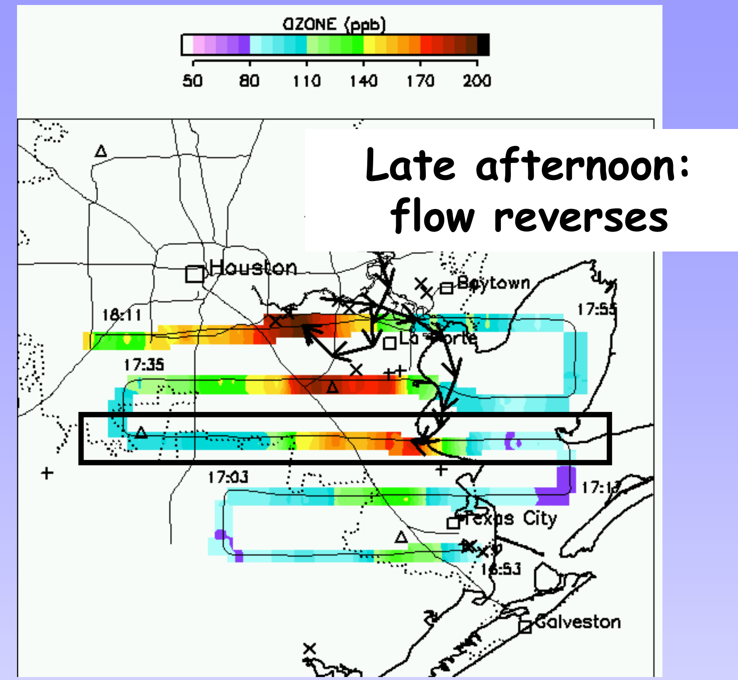
YSU PBL scheme

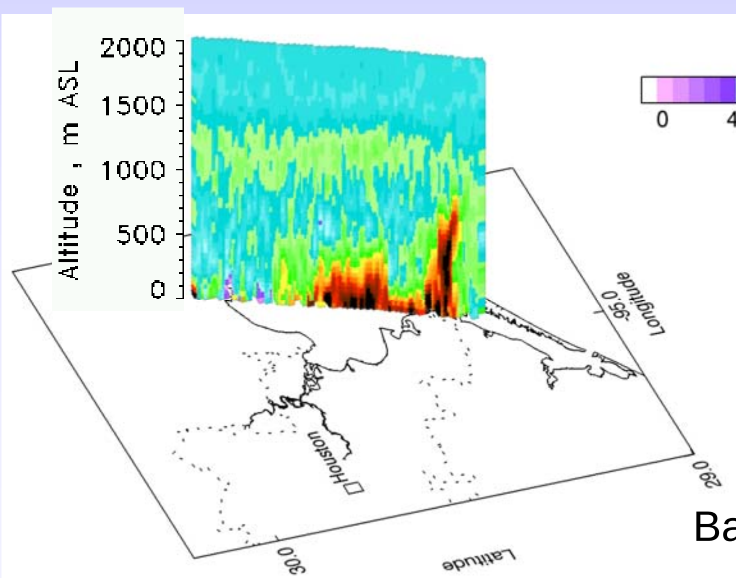


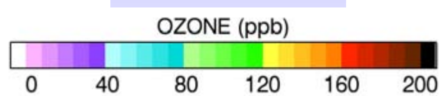
Observations of vertical structure important in selecting model PBL parameters

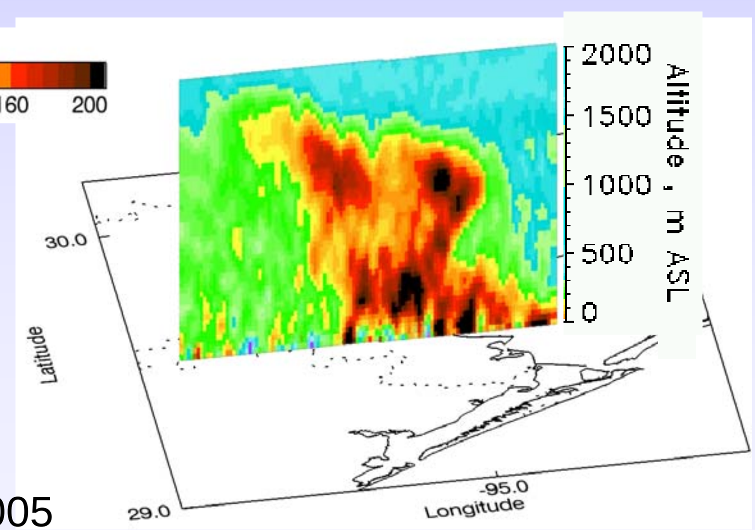
Houston: Sea breeze recirculation can lead to high ozone







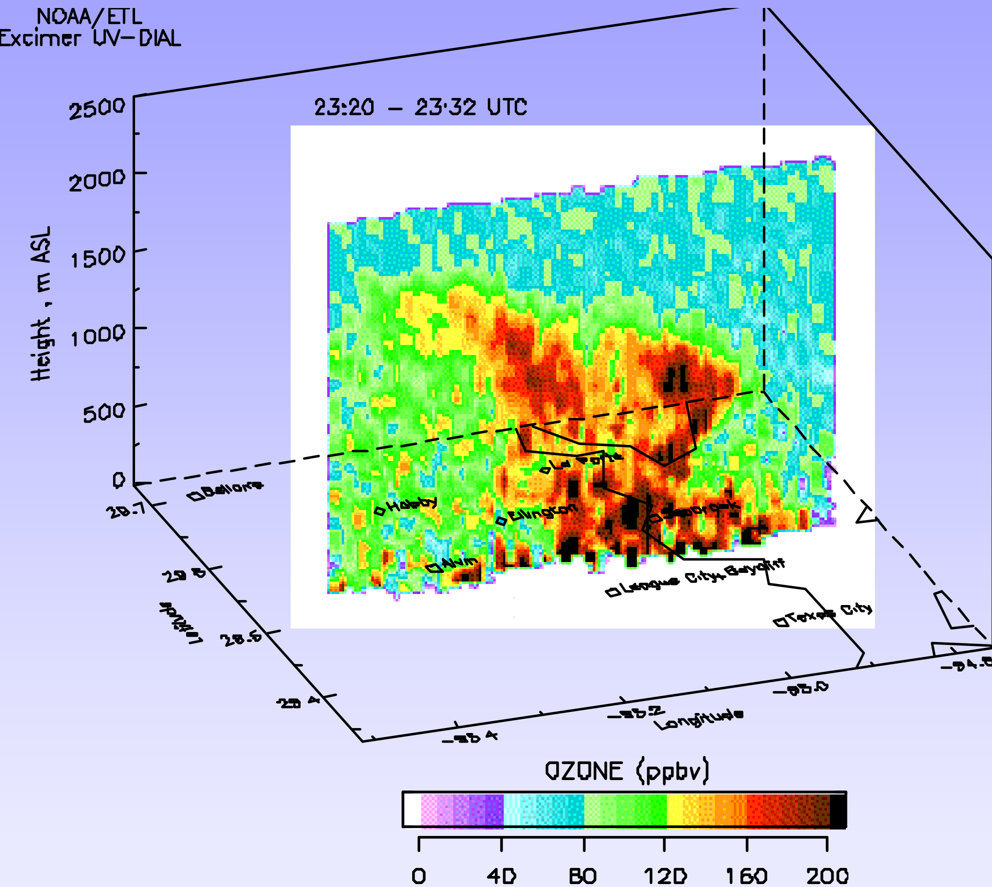


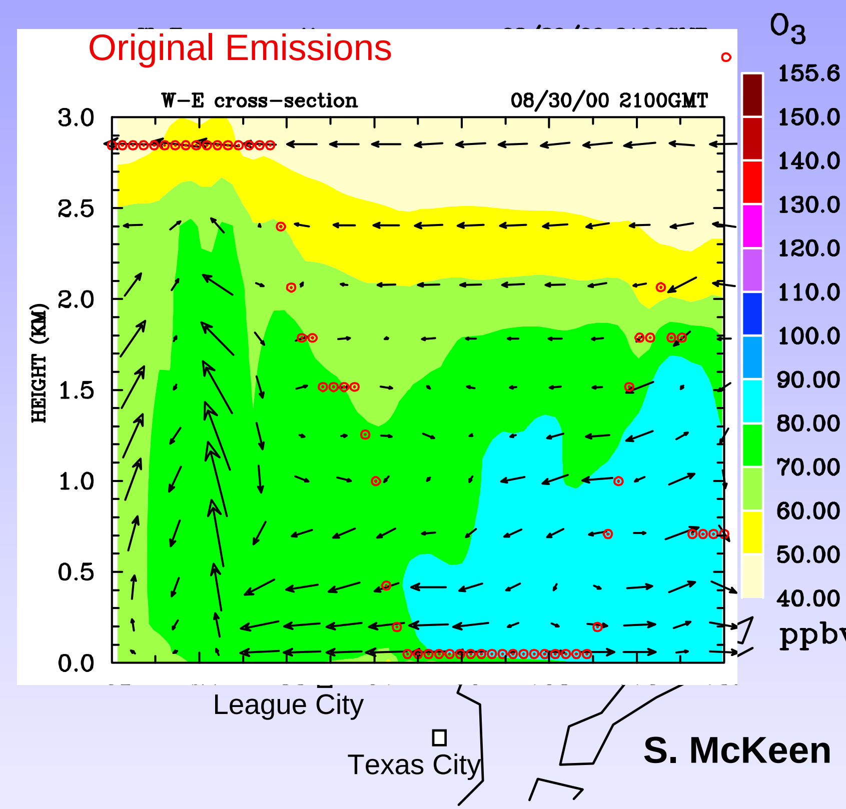


Banta et al, 2005

MM5/Chem gets the convergence right

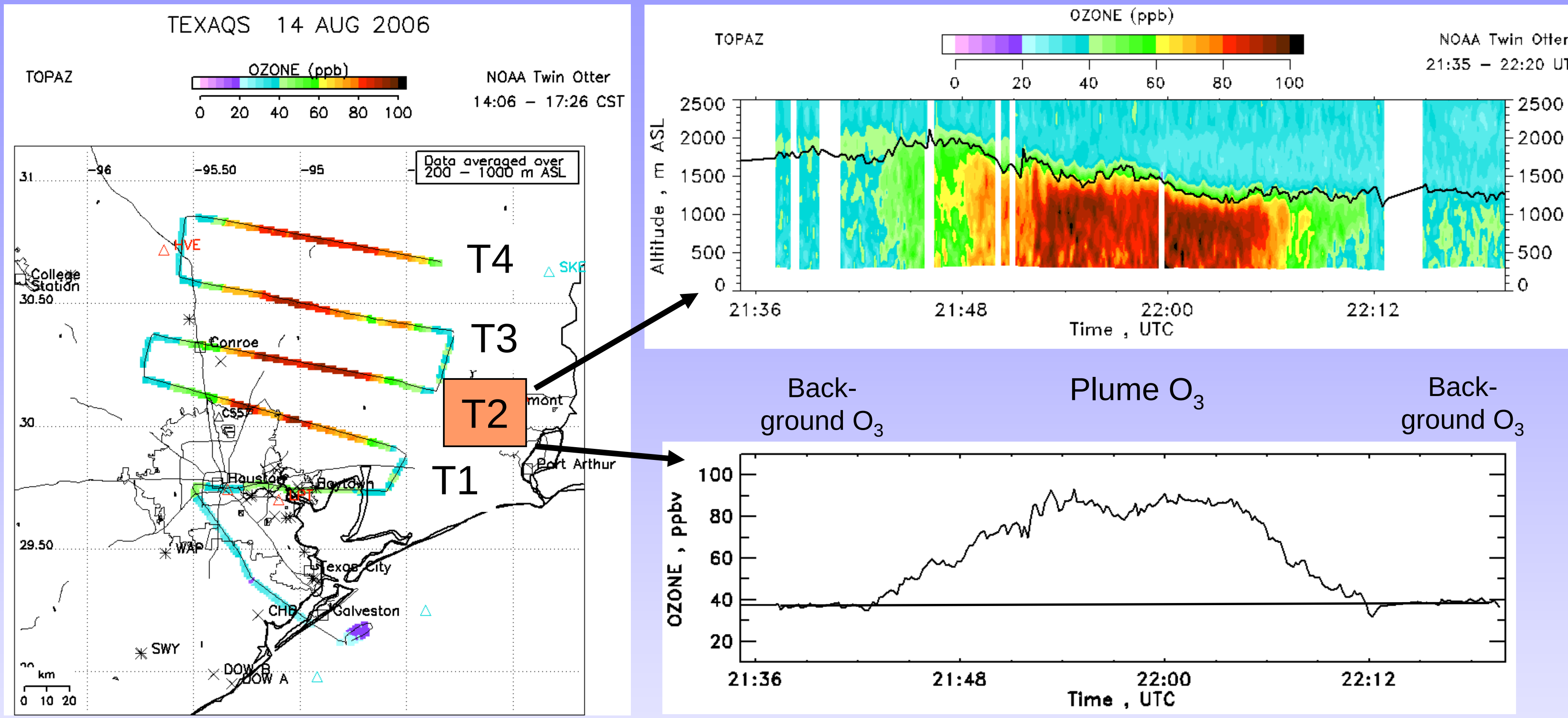
MM5/Chem model
(1.7 km horizontal resolution)





S. McKeen

Estimating ozone exported from Houston



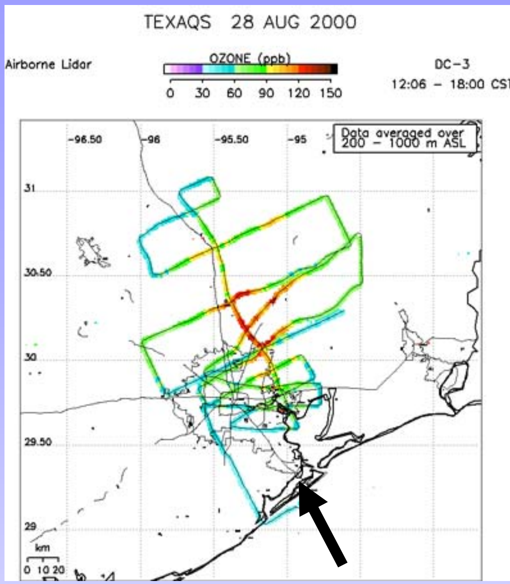
➢ Compute top of boundary layer, then integrate excess ozone in plume (plume O_3 – background O_3)

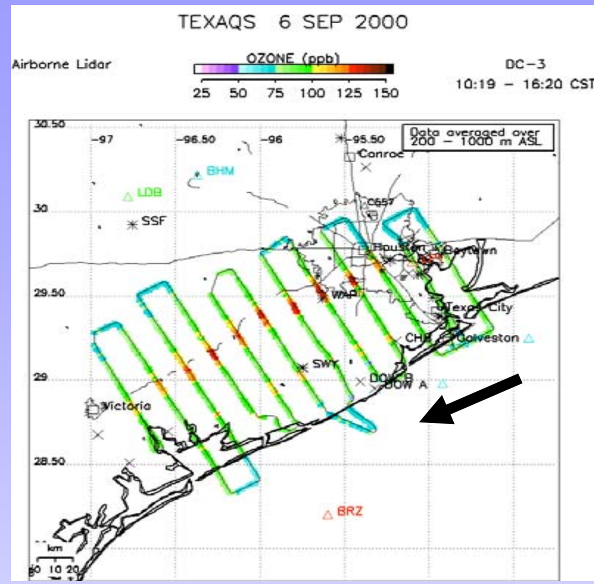
➢ Multiply with horizontal wind speed (from wind profiler network) to yield flux for each transect.

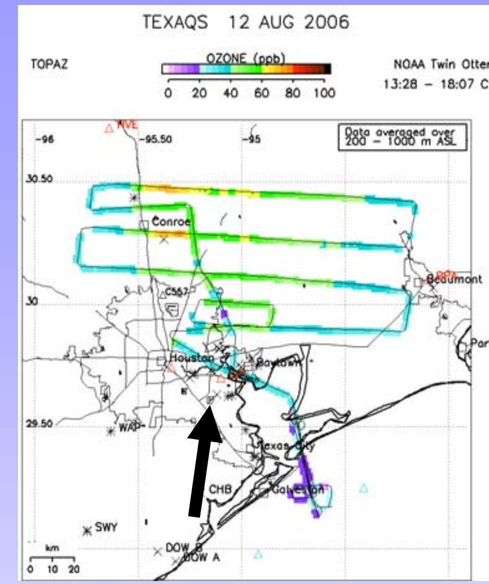
➢ For net ozone production take difference between excess ozone on successive transects and divide by plume travel time

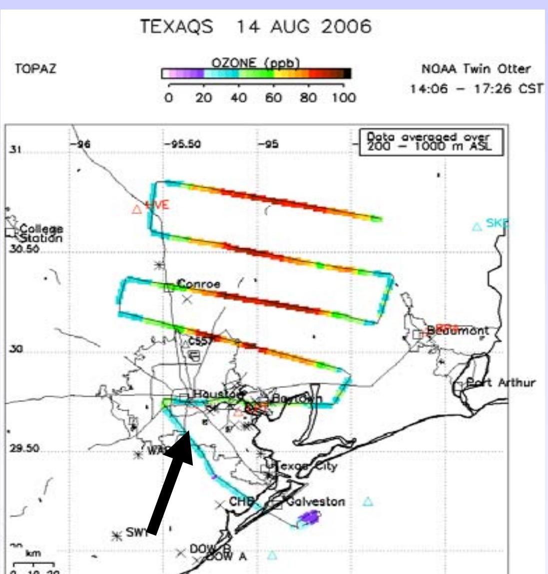
From C. Senff et al

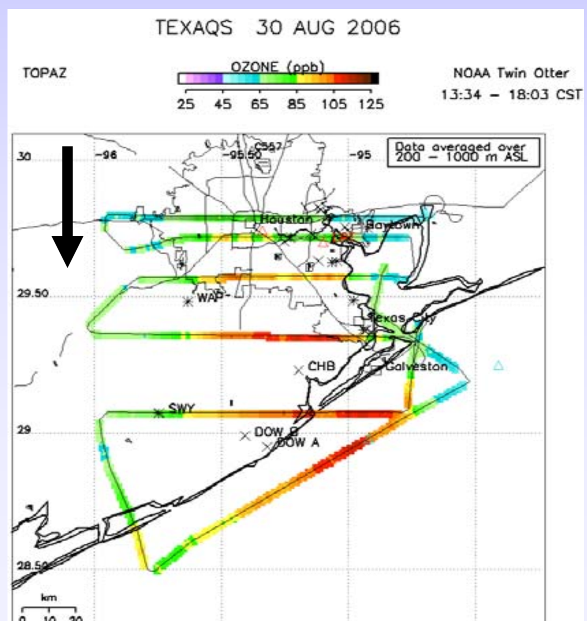
Six Houston/Dallas ozone export cases studied

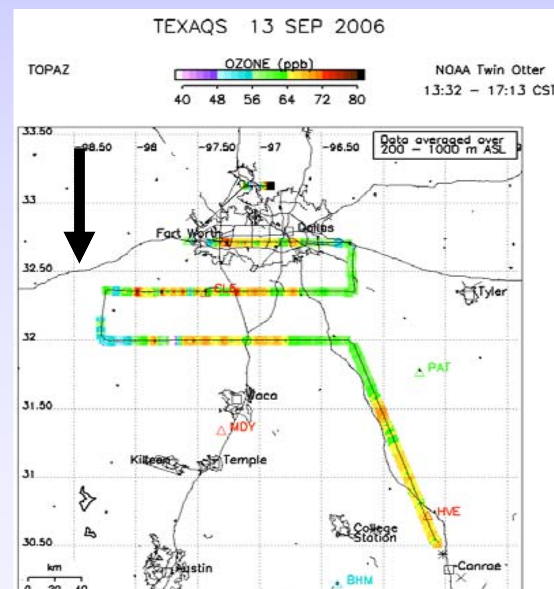




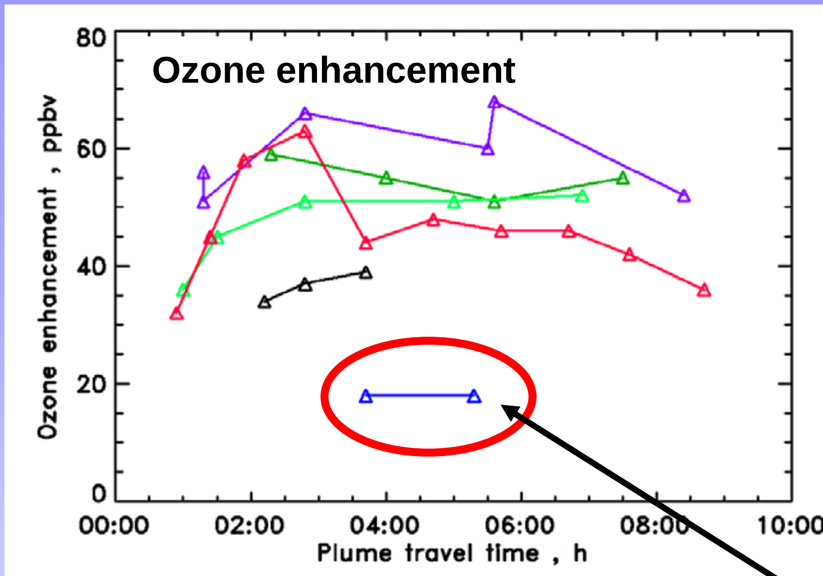


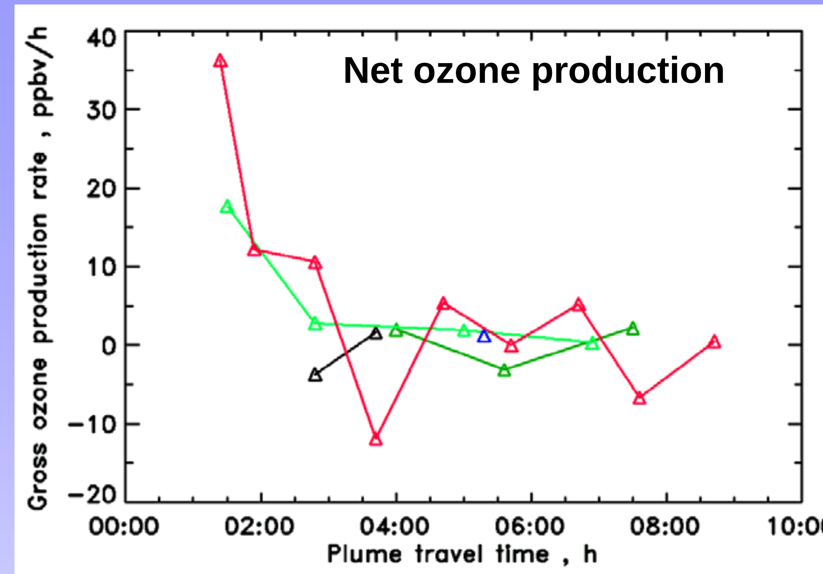




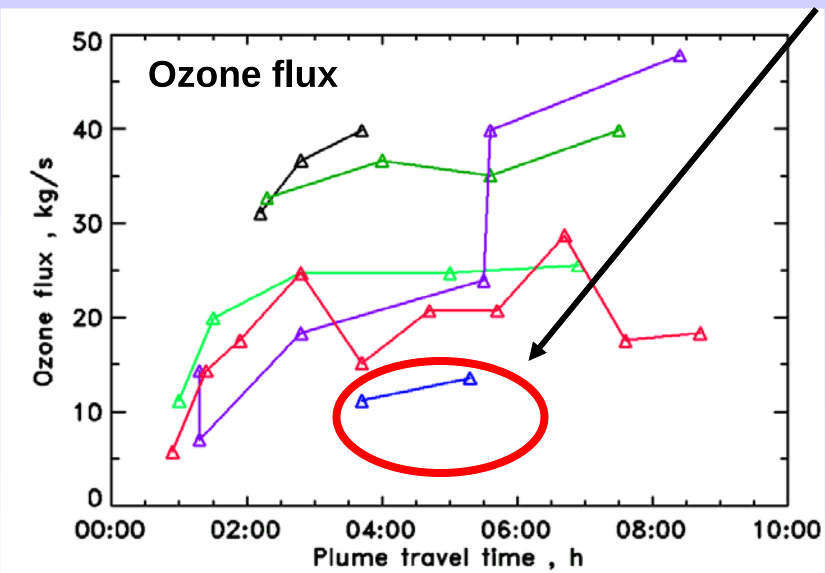


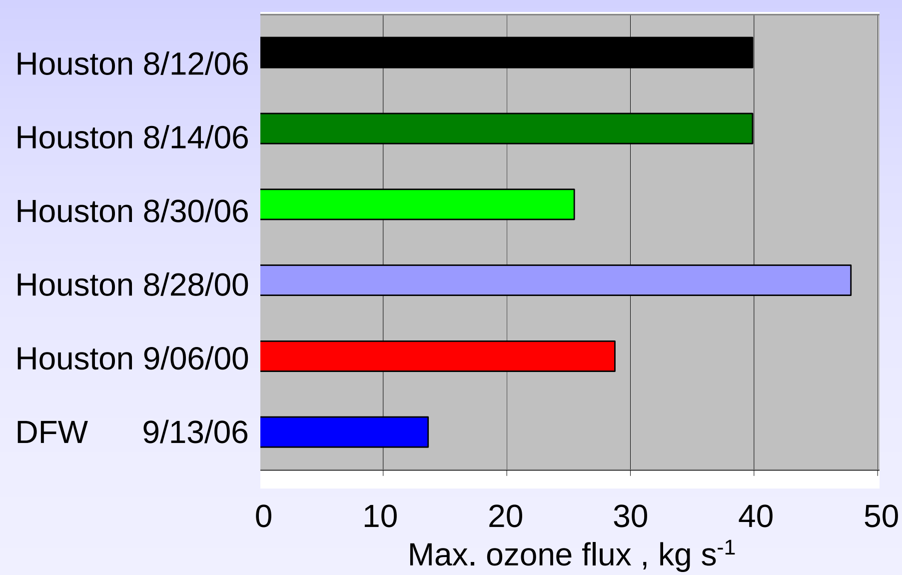
Horizontal ozone flux and net ozone production





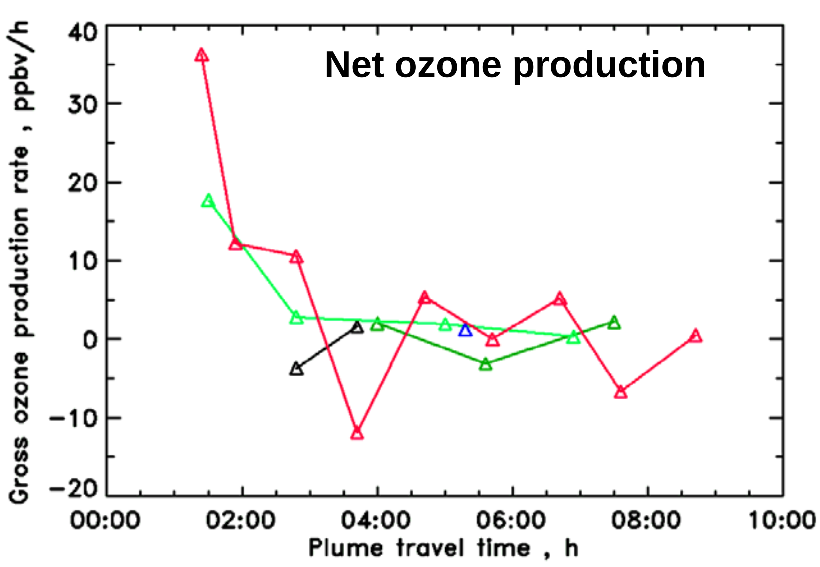
Dallas

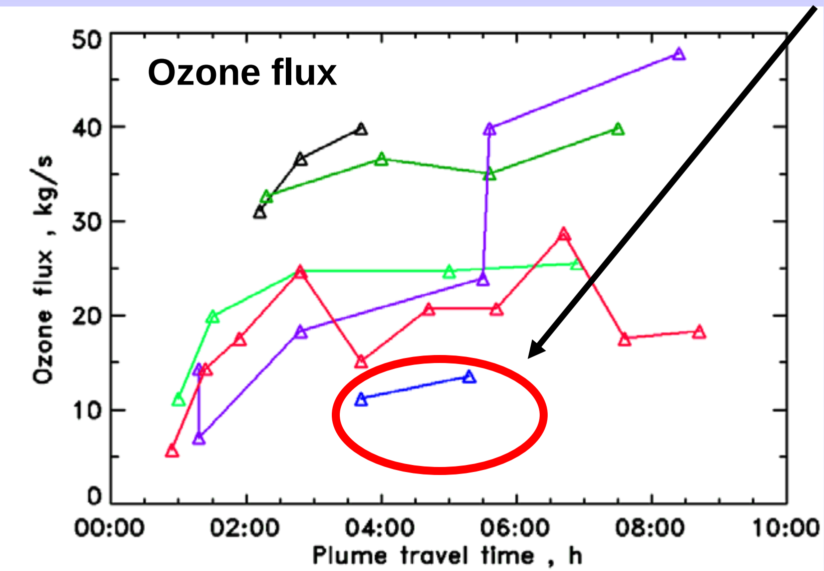




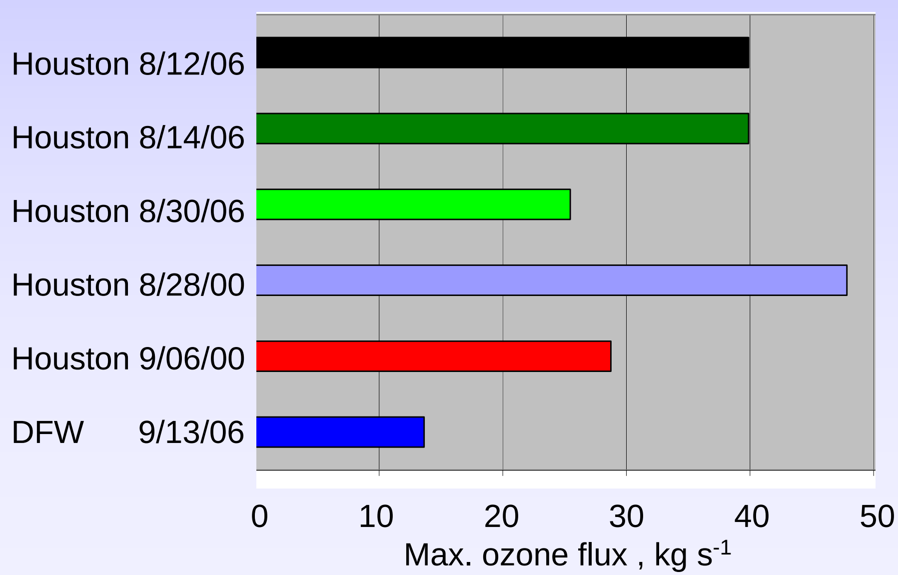
Horizontal ozone flux and net ozone production

A flux of 35 kg O_3 / s (average of all Houston cases) emitted over a day (8 hours) is equivalent to a 10-ppb increase in ozone over an approx. 10,000 square mile area, assuming a 2-km deep mixed layer

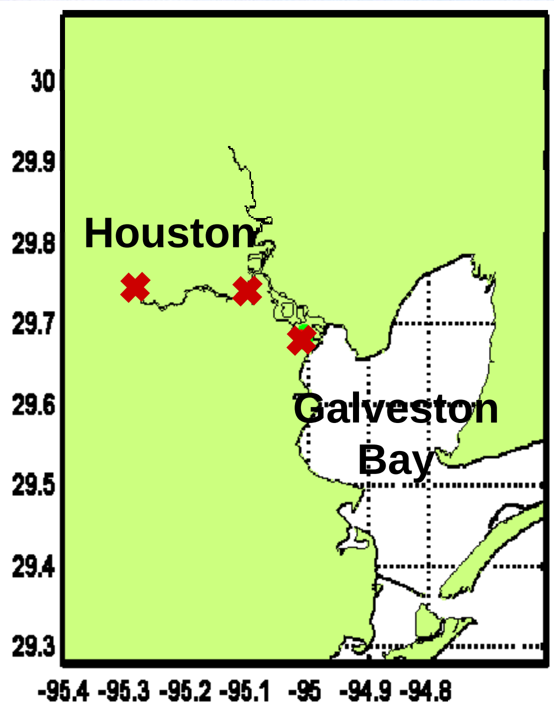




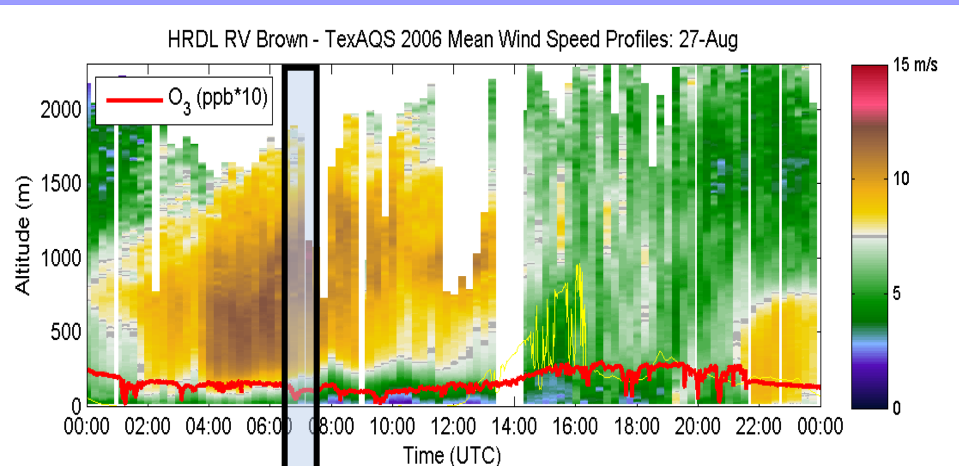
Dallas

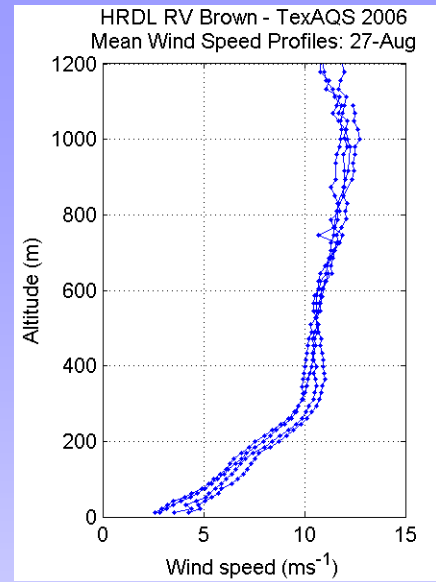


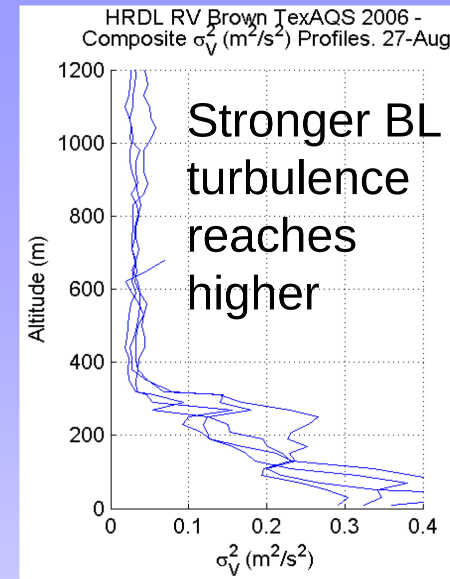
Nighttime vertical mixing



Lidar measurements show role of vertical transport



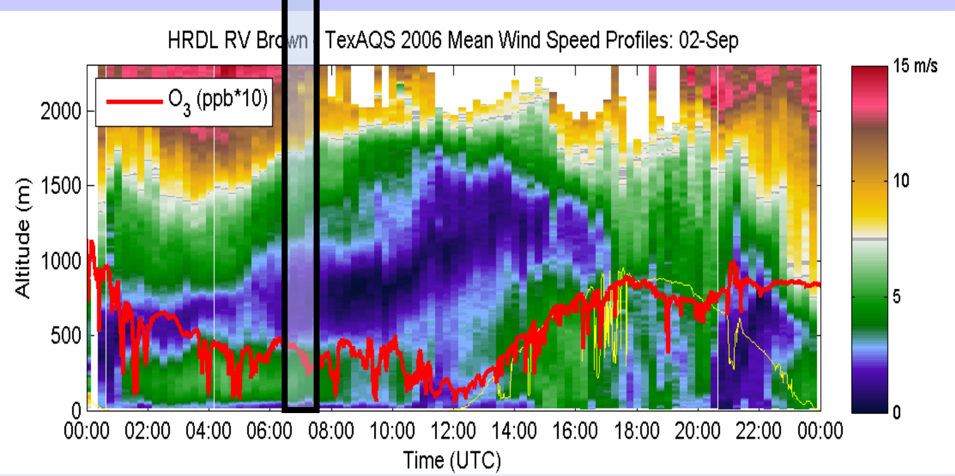


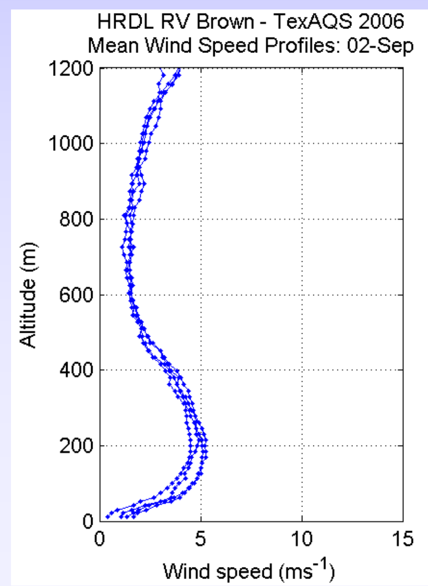


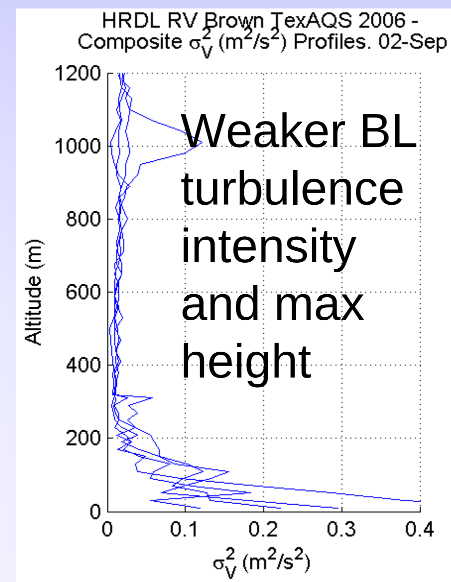
Strong LLJ

Horizontal mean wind speed

Velocity variance





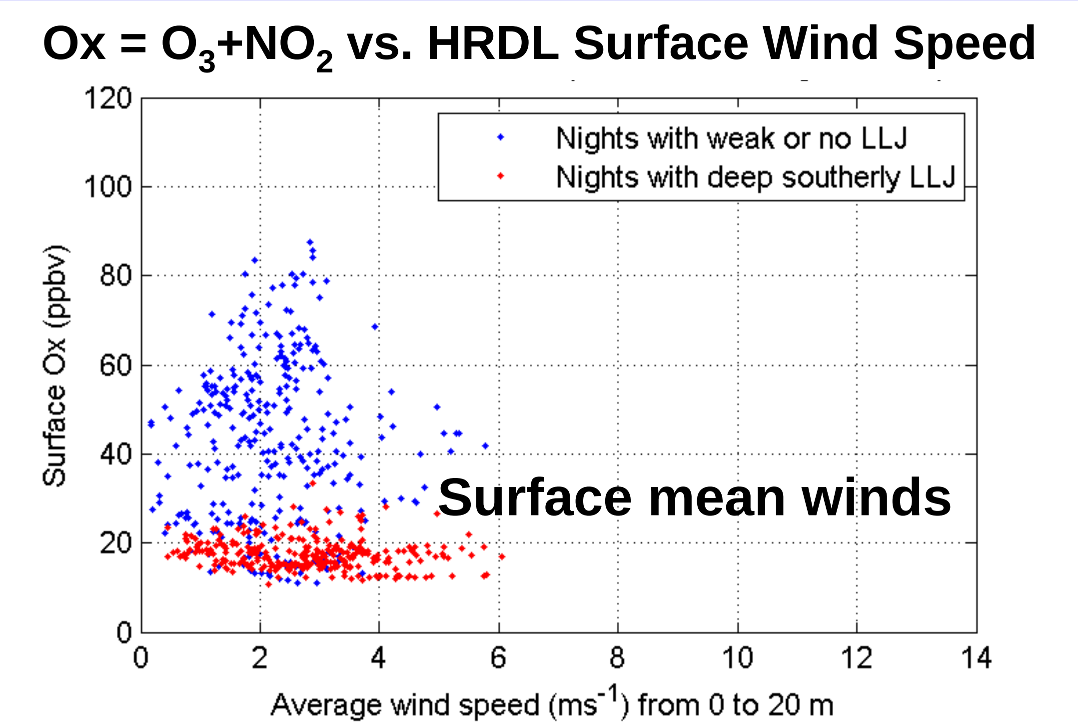


Weak LLJ

S. Tucker and A. Brewer

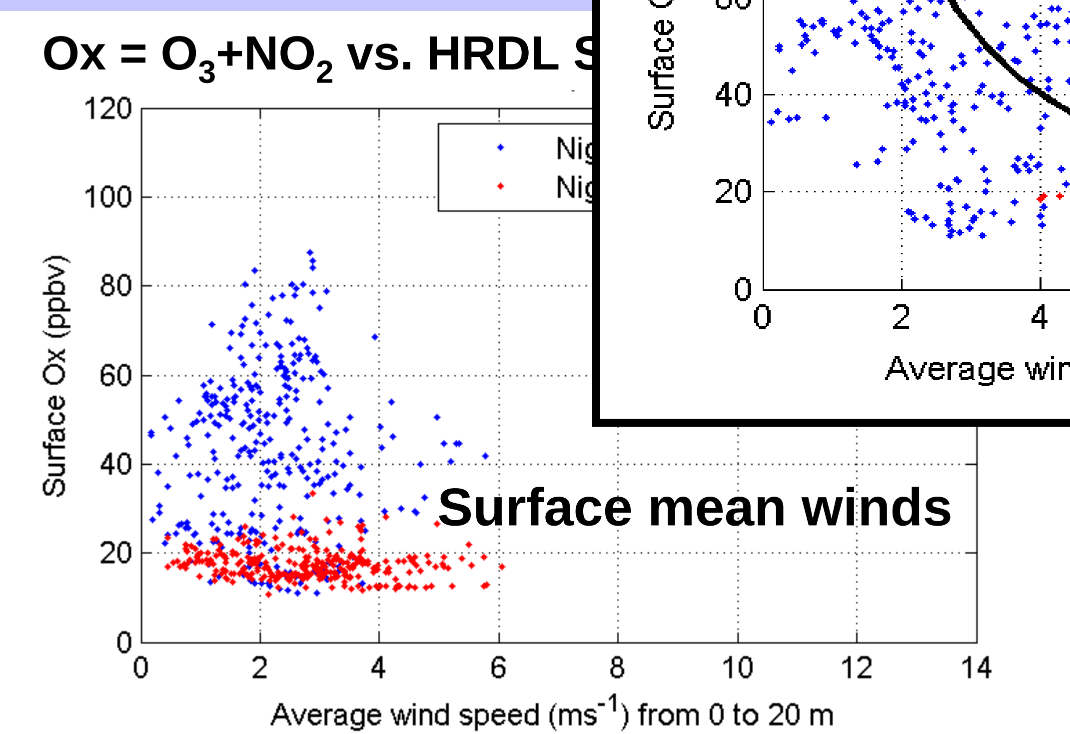
Surface ozone correlates with winds in LLJ

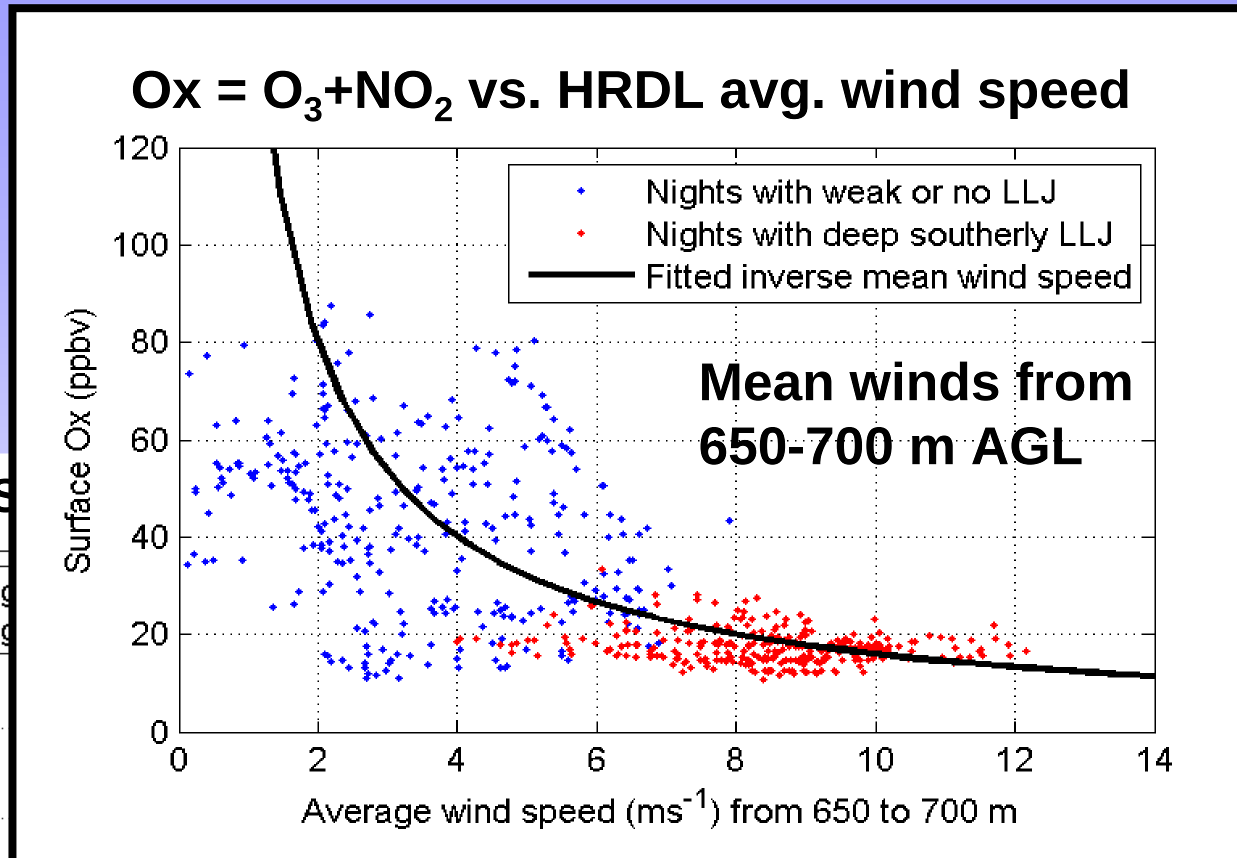
S. Tucker, 2008



Surface ozone correlates with winds in LLJ

S. Tucker, 2008





Vertical transport can affect nighttime surface ozone levels

Summary and a look ahead

- Remote sensing provides 3-dimensional observations that are ideal for assessing model capability to:
  - Predict the impact of mesoscale flows such as sea breeze on local air pollution
  - Characterize regional transport and dispersion of pollution
- Ozone exported by Houston is significant and capable of elevating background levels in rural areas.
- Vertical transport is important in mixing both clean and polluted air to the surface
- California will be challenging: long range and local transport processes, complex terrain → well-addressed by remote sensors