An Insight into the Vertical Structure of the Atmosphere during TEXAQS-II:

Understanding the Effect of the Upper-level Meteorology on Houston's Surface Ozone Levels

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Principal Findings Data Analysis Workshop

May 29, 2007

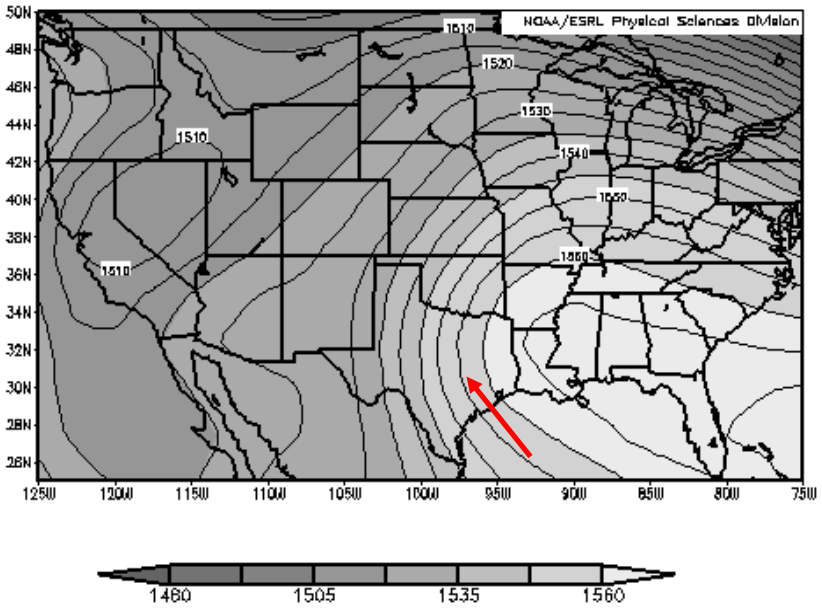
Introduction

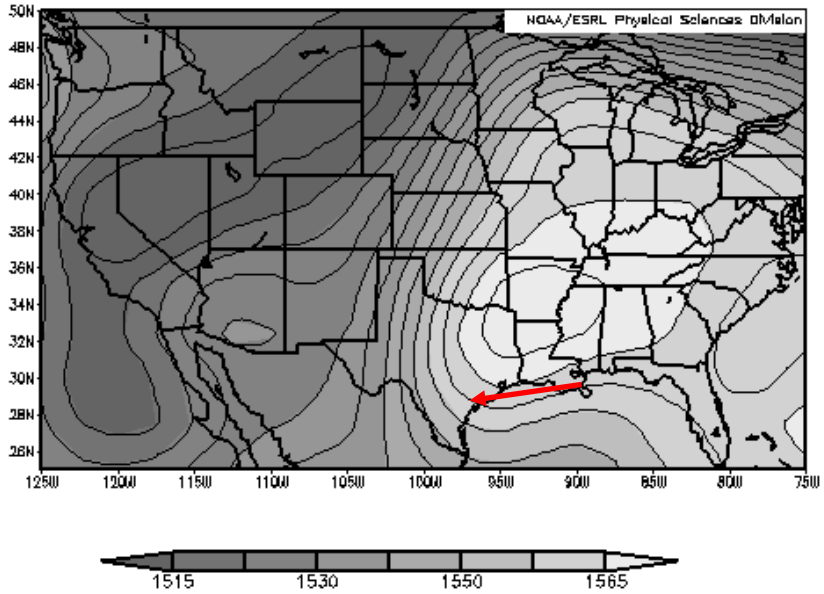
1) Composite 850 hPa maps
2) Background ozone
3) The role of frontal passages
4) Vertical ozone profiles
5) The role of elevated temperature inversions
6) Conclusions

Composite Maps / Synoptic Analysis

- Composite maps were created to understand the upper-level meteorological patterns associated with ozone episodes (8 hour average > 85 ppb)
- Source for composite maps: http://www.cdc.noaa.gov/Composites/Day/
- (National Climatic Data Center)

850 hPa Analysis (August)



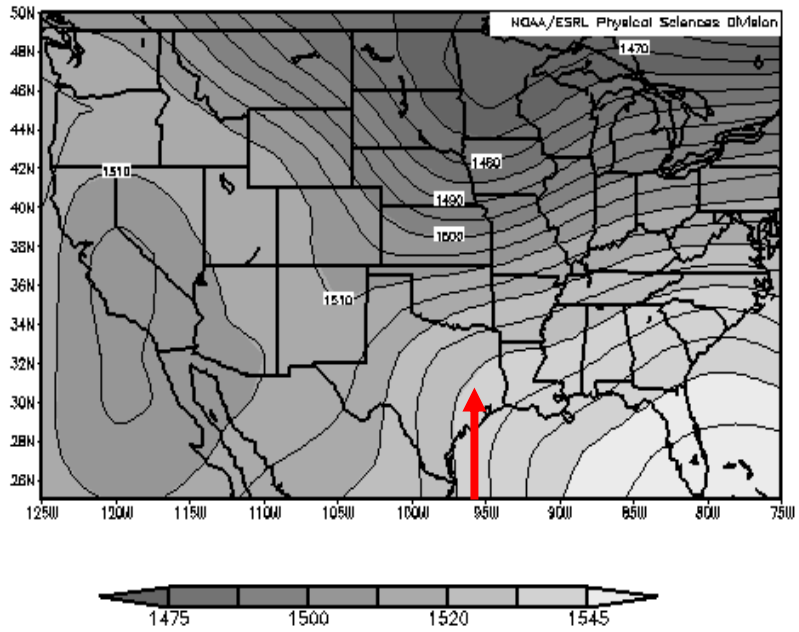


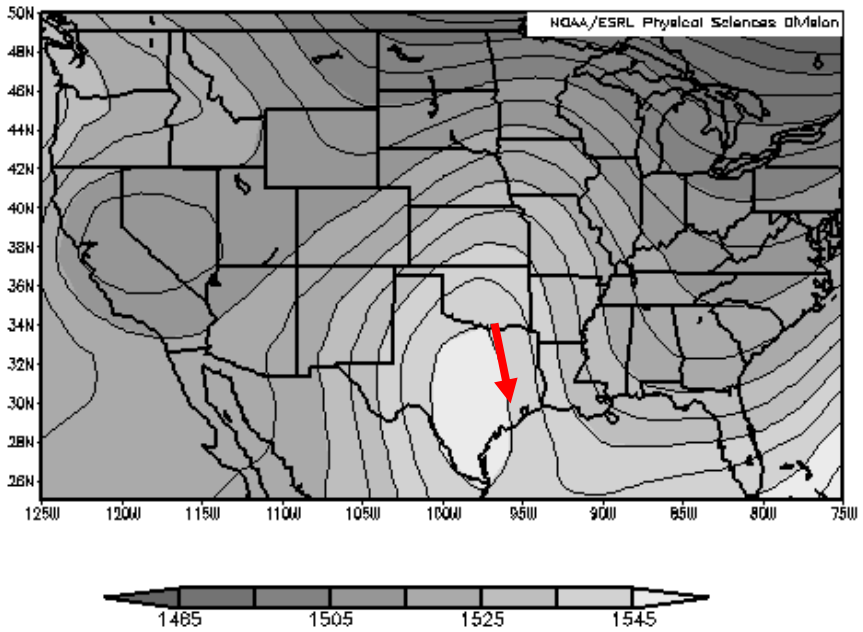
850 hPa composite map for non-episode days August 2006.

850 hPa composite map for August ozone episodes 2006

(4 episodes).

850 hPa Analysis (September)



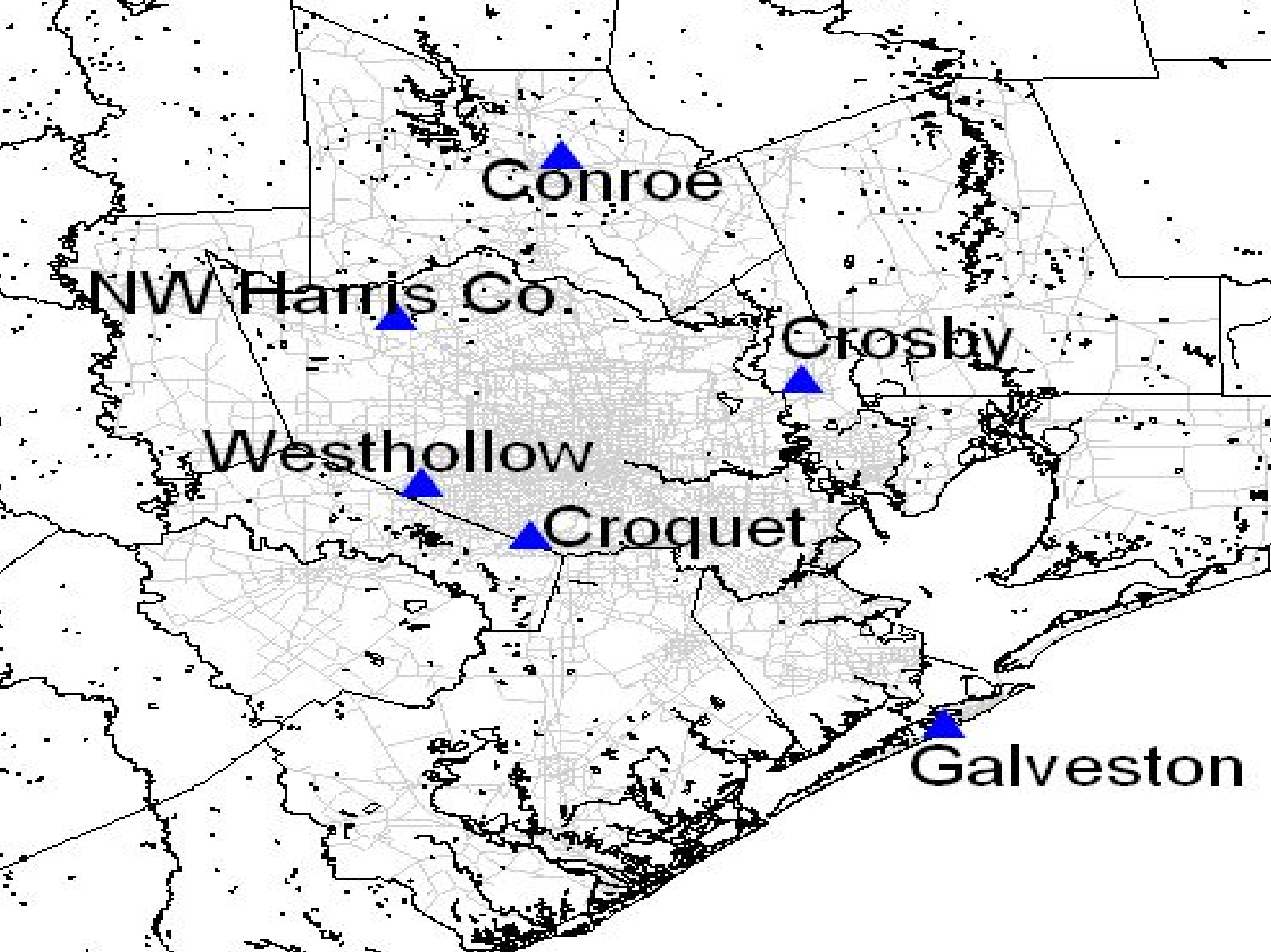


850 hPa composite map for non-episode days September 2006

850 hPa composite map for September ozone episodes 2006 (10 episodes)

Effect of Wind Direction on Background Ozone

- "Background Ozone" was defined using criteria set forth by John Nielsen-Gammon (2005)
- Defined as minimum 8 hour average peak for stations upwind of the Houston area


Conroe
NW Harris Co.
Crosby
Westhollow
Croquet
Galveston

Effect of Wind Direction on Background Ozone

Category	C1(E)	C2(Hc)	C3(SE)	C4(SW)	C5(N)	C6(S)
Average Background Ozone(ppb)	42.2	-------	31	28	52.7	20.6

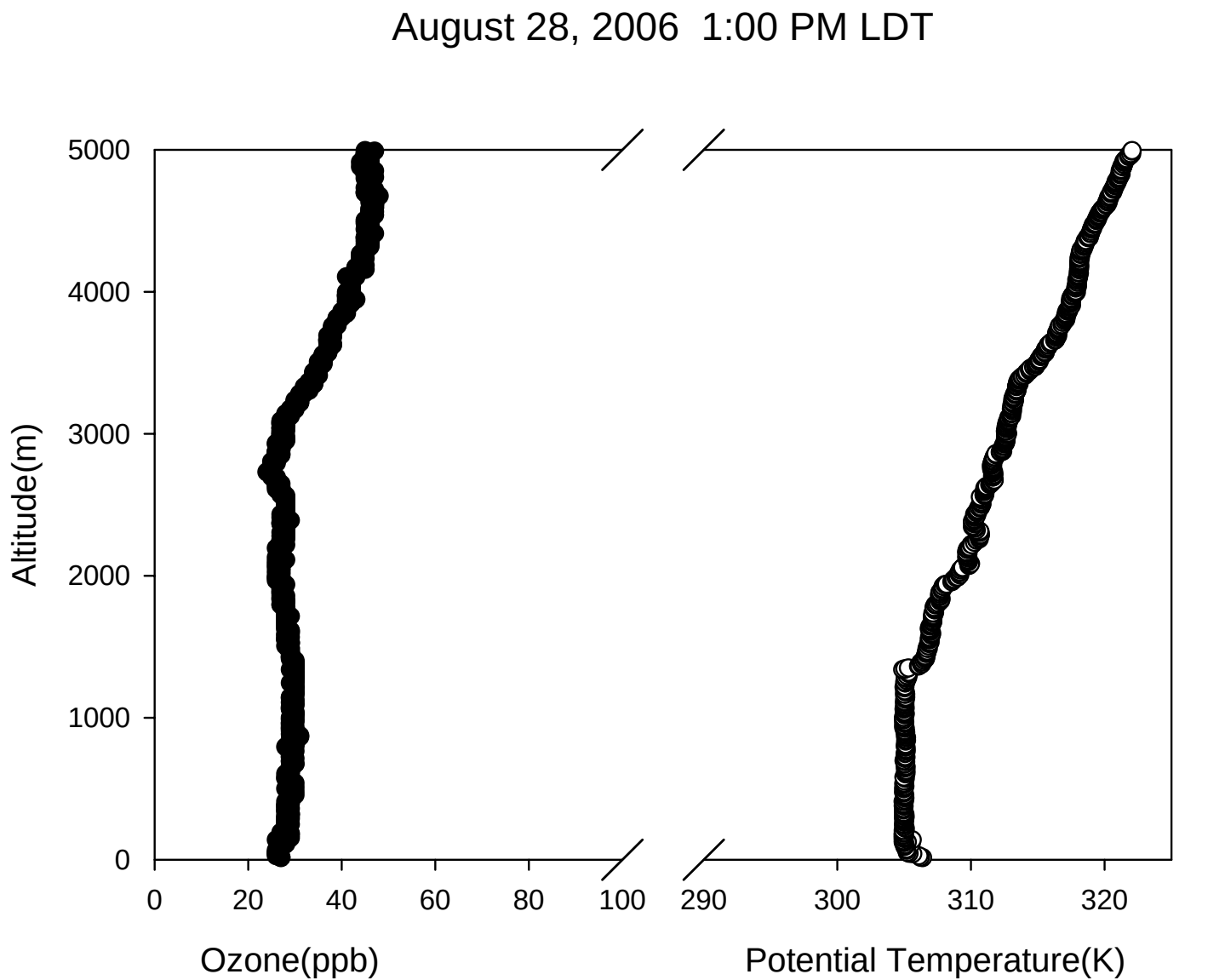
The Role of Frontal Passages on Houston's 8 Hour Ozone Peaks

Frontal Passage	Episode
8/29	8/31, 9/1, 9/3
9/5	9/7
9/12	9/13, 9/14
9/18	9/20
9/24	9/26, 9/27
9/28	none

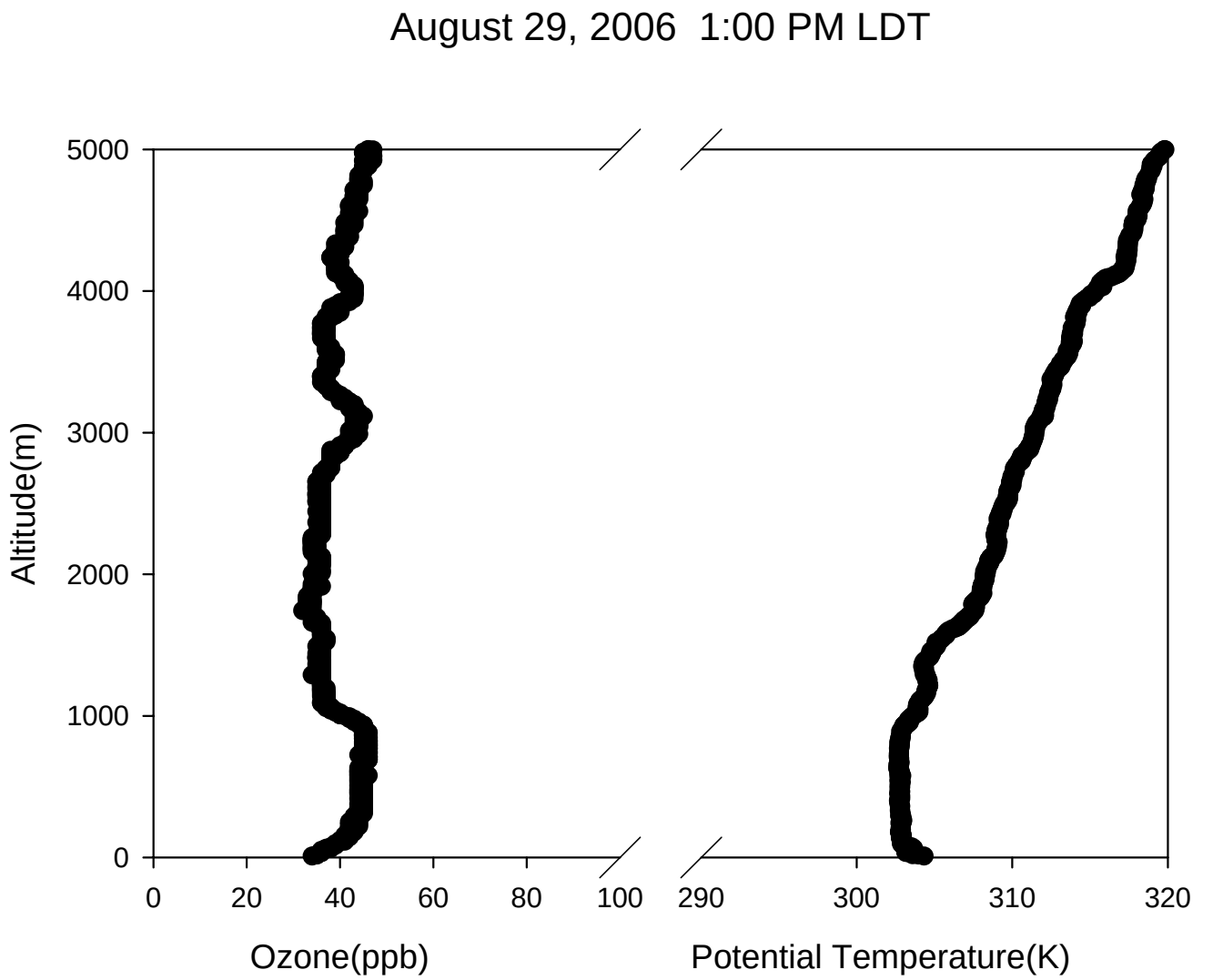
Ozonesonde Evidence

- Ozonesondes were launched by a collaboration with Dr. Gary Morris of Valparaiso University
- August 31 episode launches reveal an increase in background ozone within and above the boundary layer

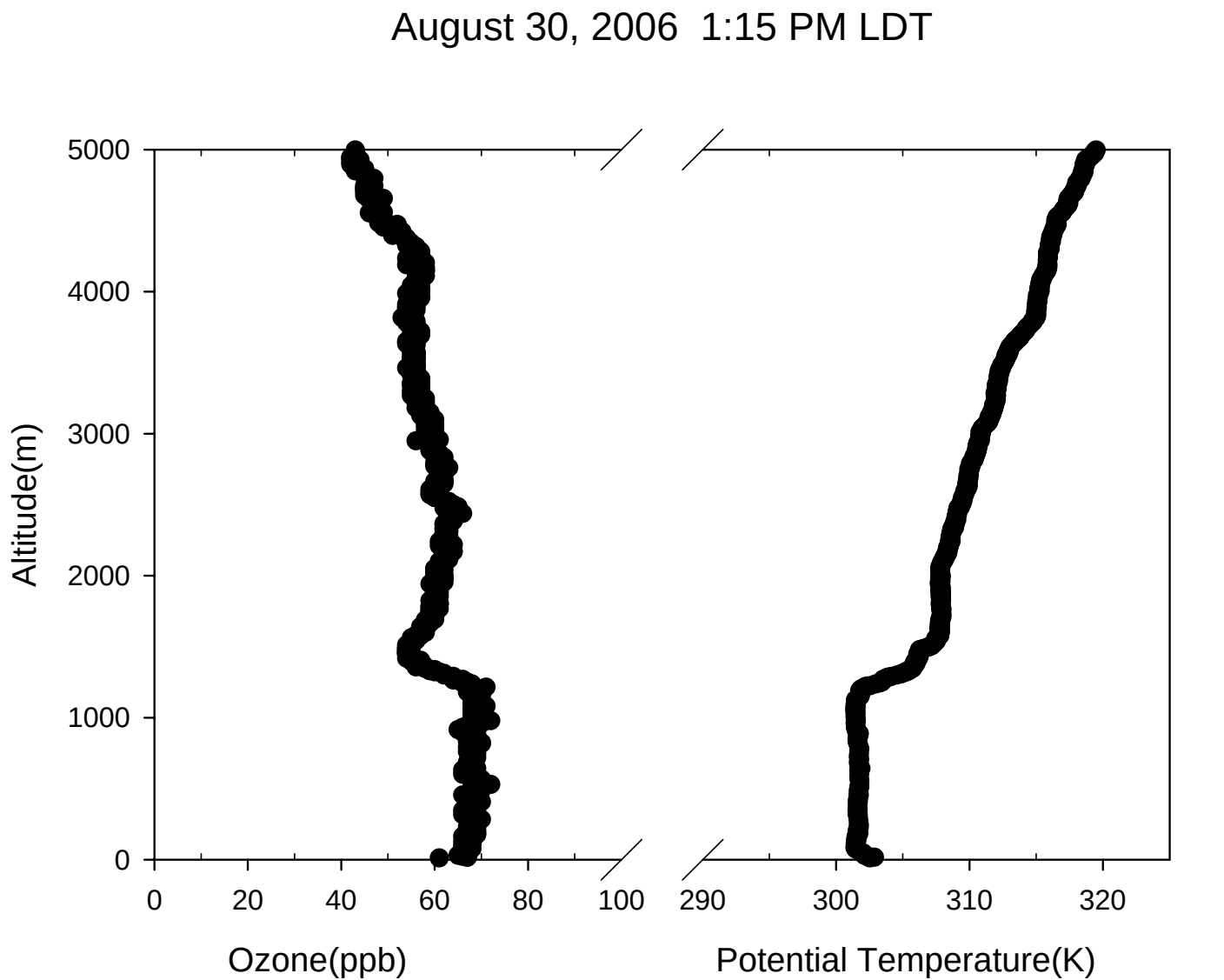
August 28 (pre-frontal)



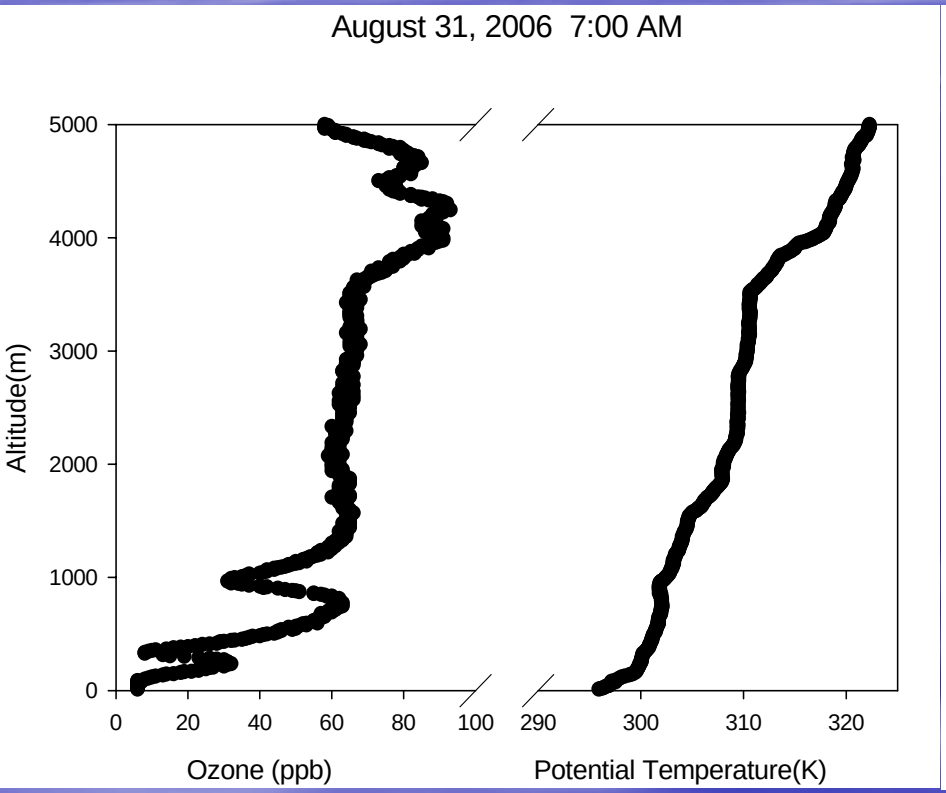
August 29 (pre-frontal)

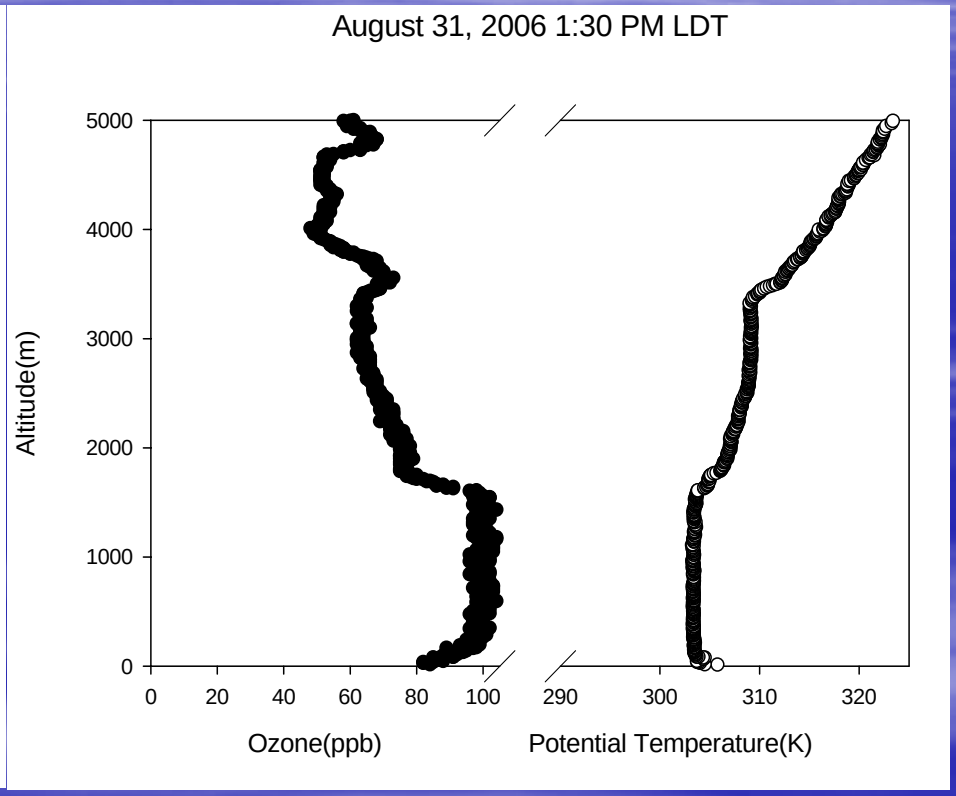


August 30 (post-frontal)

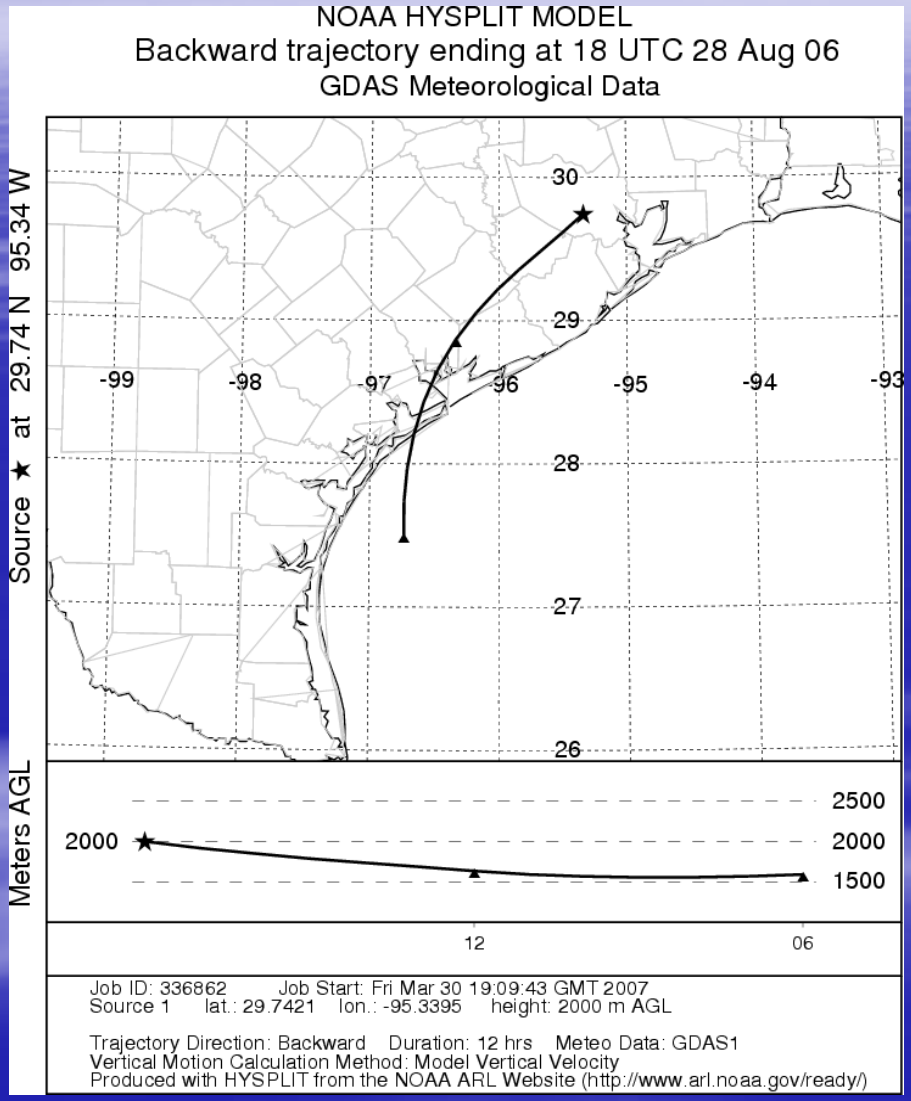


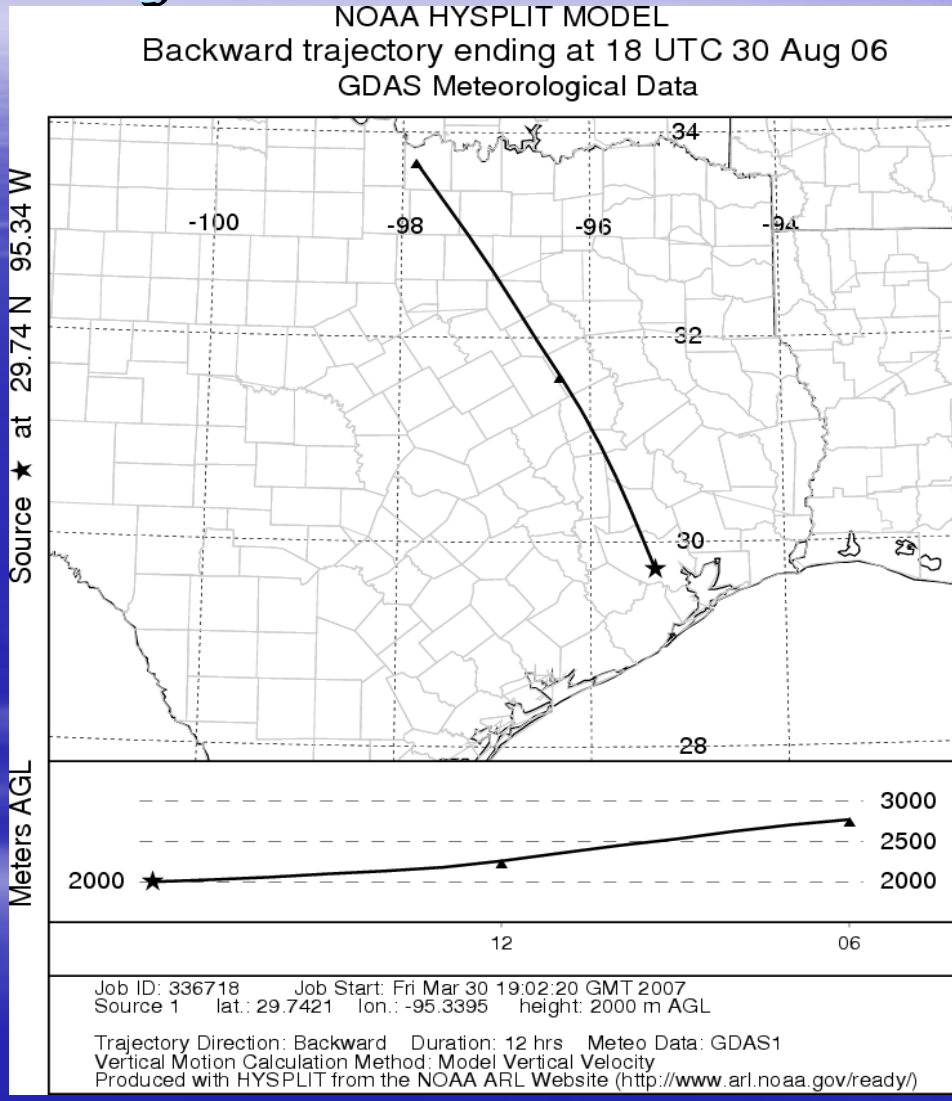
August 31 (post-frontal, episode day)





Backward Trajectories





Pre-frontal

Post-frontal

Ozonesonde Conclusions

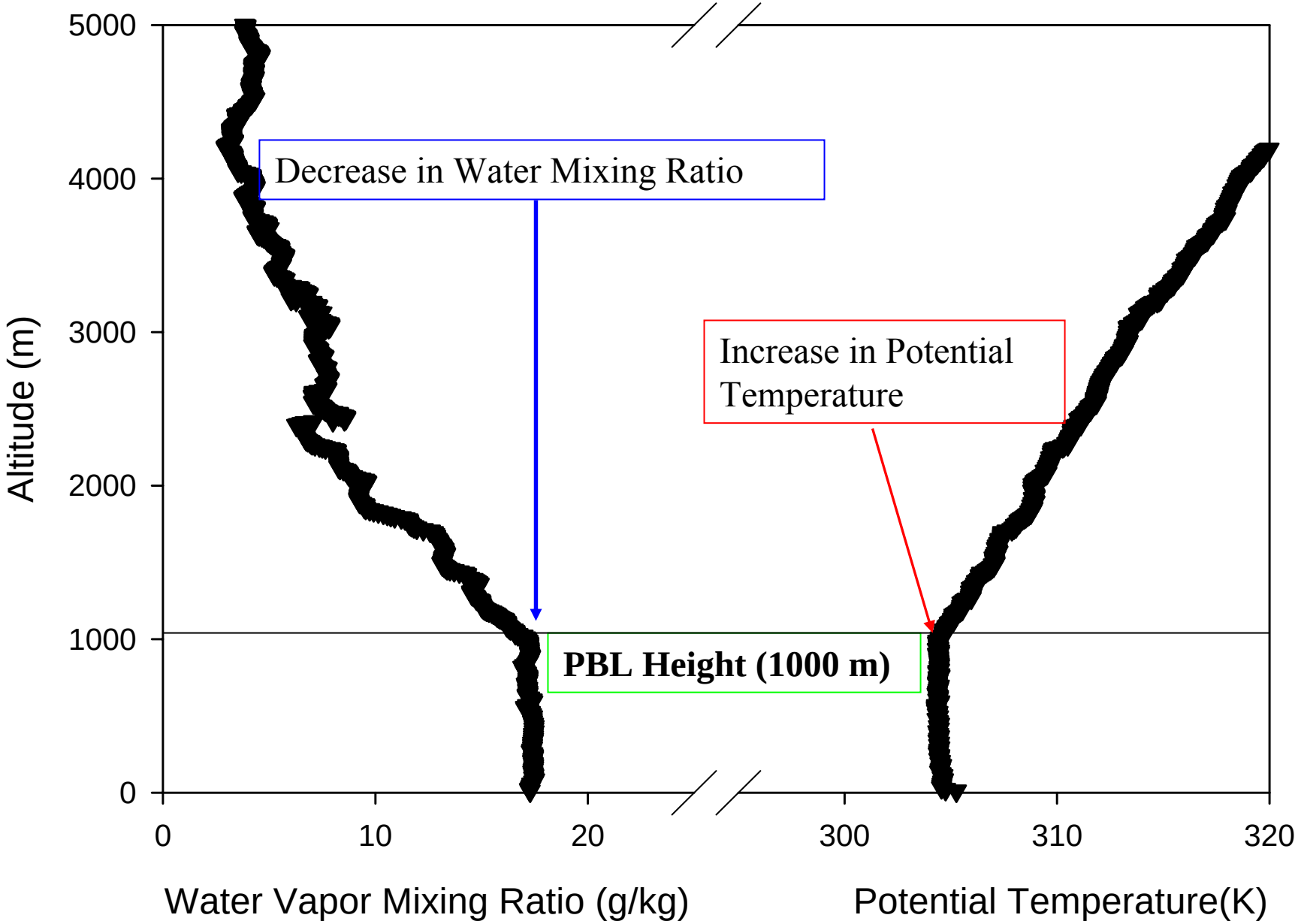
- Backward trajectories reveal continental transport likely cause for increase in background ozone aloft
- Vertical mixing may play a role by increasing surface ozone concentration, as described in Zhang & Rao (1999)

Local Meteorology: The Rawinsonde Campaign

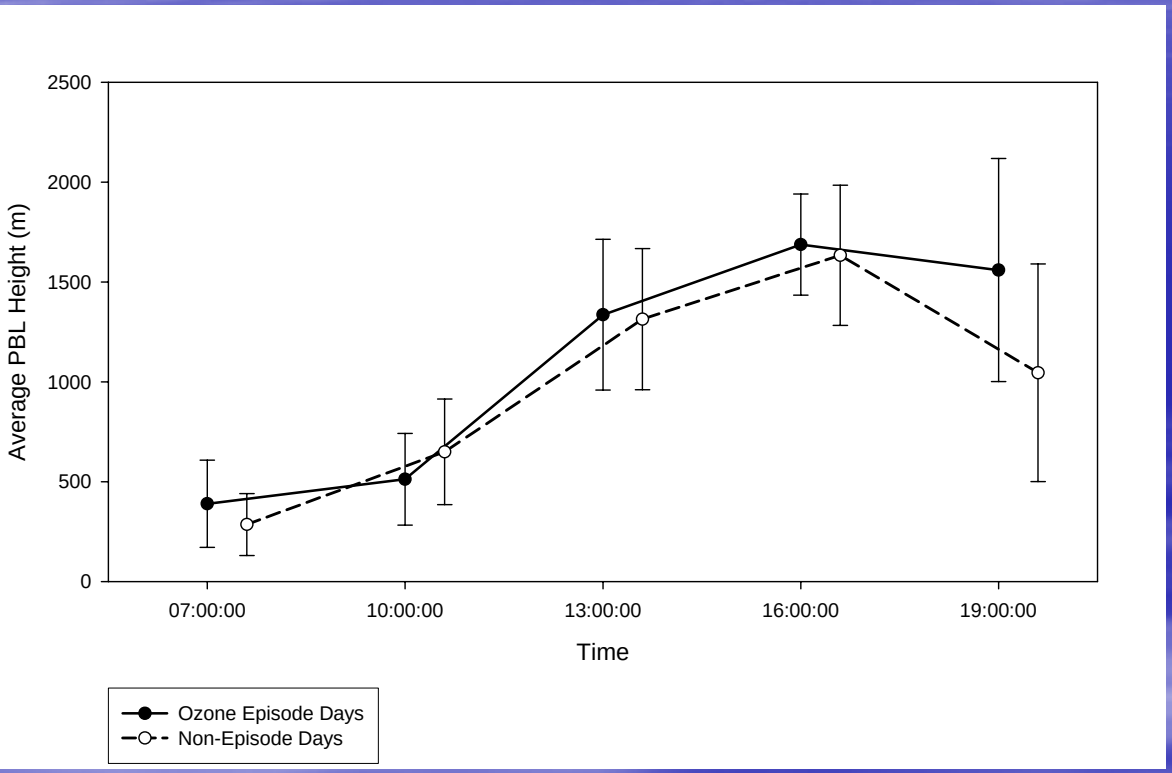
- Rawinsondes launched twice daily (7AM and 7 PM) in August and September
- During "Intensive Operations" days (IOP's), launches took place at 5 AM, 10 AM, 1 PM, 4 PM, and 10 PM
- Most IOP days had elevated ozone levels

MAQ
Mobile Art Quest
Blaffer Gallery

PBL development August 9, 2006



Effect of the PBL Height on Afternoon 8 Hour Ozone Peak

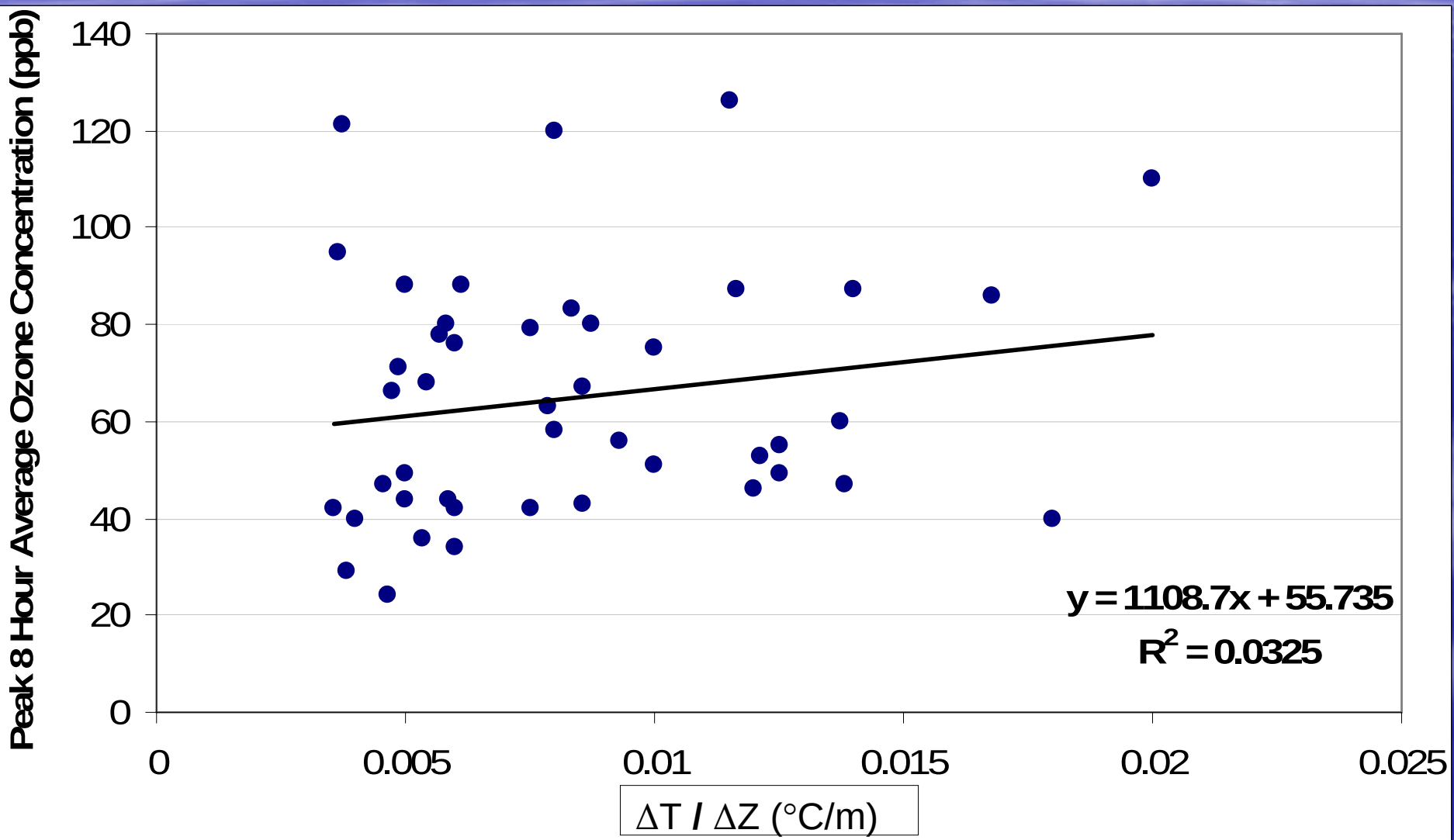


Time	Episode Days	Non-Episode Days
7:00	10	46
10:00	8	4
13:00	11	6
16:00	8	3
19:00	10	45

The Effect of the Morning Inversion Height / Strength on Houston's 8 Hour Peak Ozone Concentration

- Morning inversion height and strength has an effect of concentrating ozone precursors and may lead to higher hourly ozone peaks during the day (Berman et al., 1999)

Strength of morning inversion (°C) compared to 8 Hour Peak Ozone



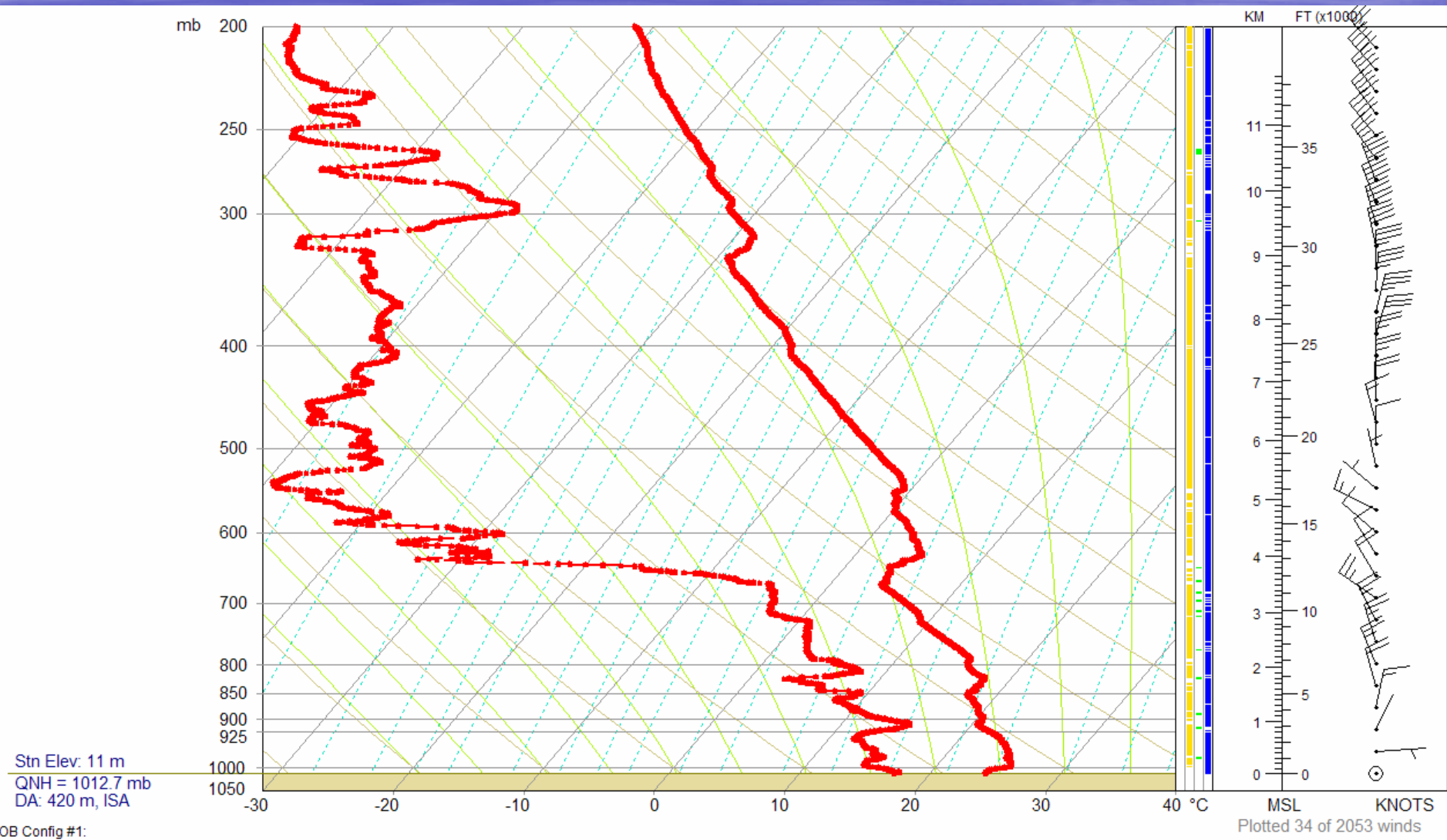
Are Elevated Inversions Related to Houston's 8 Hour Ozone Peak?

- Zhang and Rao (1999) showed that downward vertical mixing may increase observed ozone concentrations
- Subsidence may enhance this effect
- Ozone can also become trapped above and underneath this elevated inversion, and can mix downward into the boundary layer circulation (Alonso et al., 2000).

Are Elevated Inversions Related to Houston's 8 Hour Ozone Peak?

- Also, could be coincidental since ozone episodes are associated with High pressure, and a clear sky.

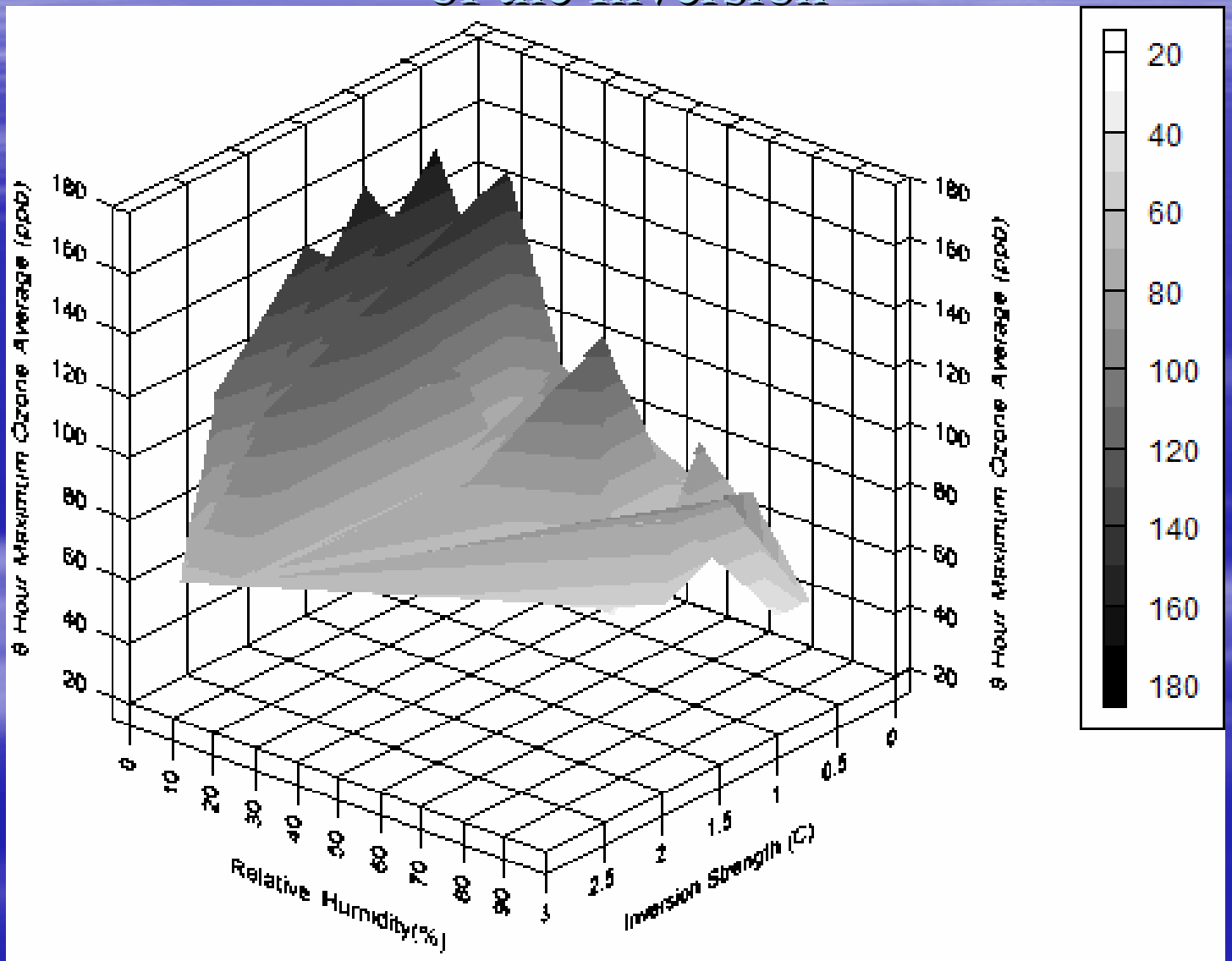
“Classic” Ozone Episode Sounding (7 AM August 31, 2006)



Elevated Inversion Analysis

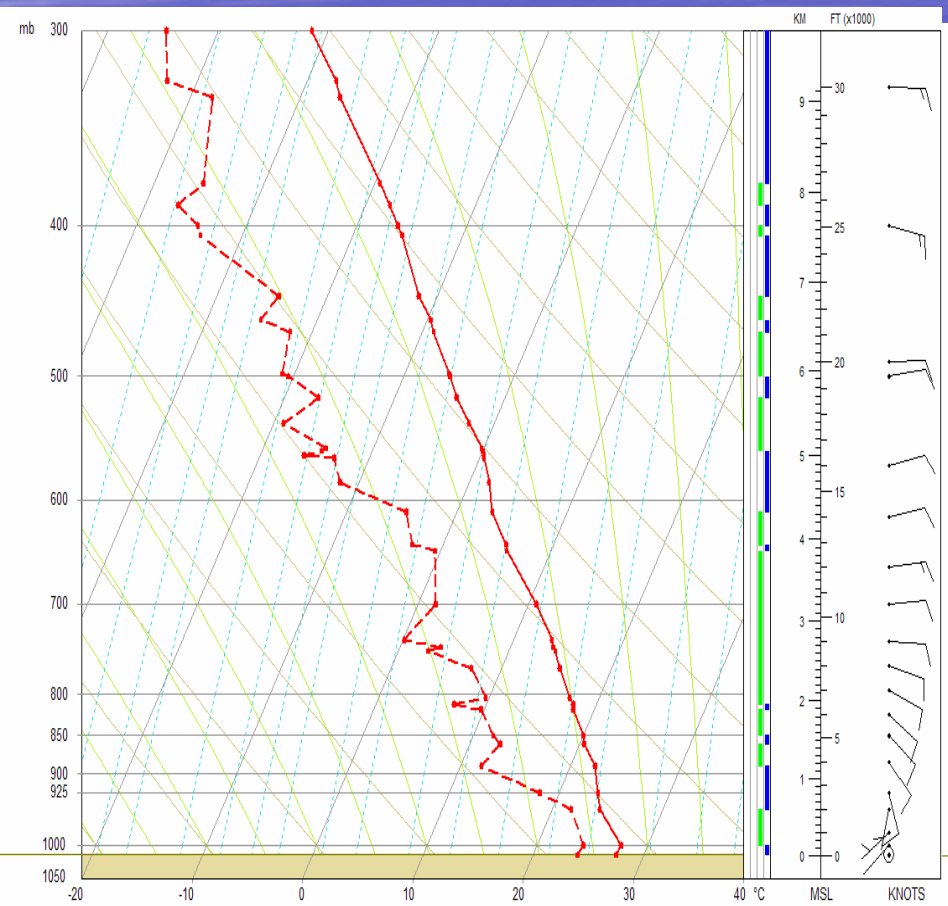
- Inversions were classified by height, strength, and moisture content
- Morning inversions were ignored

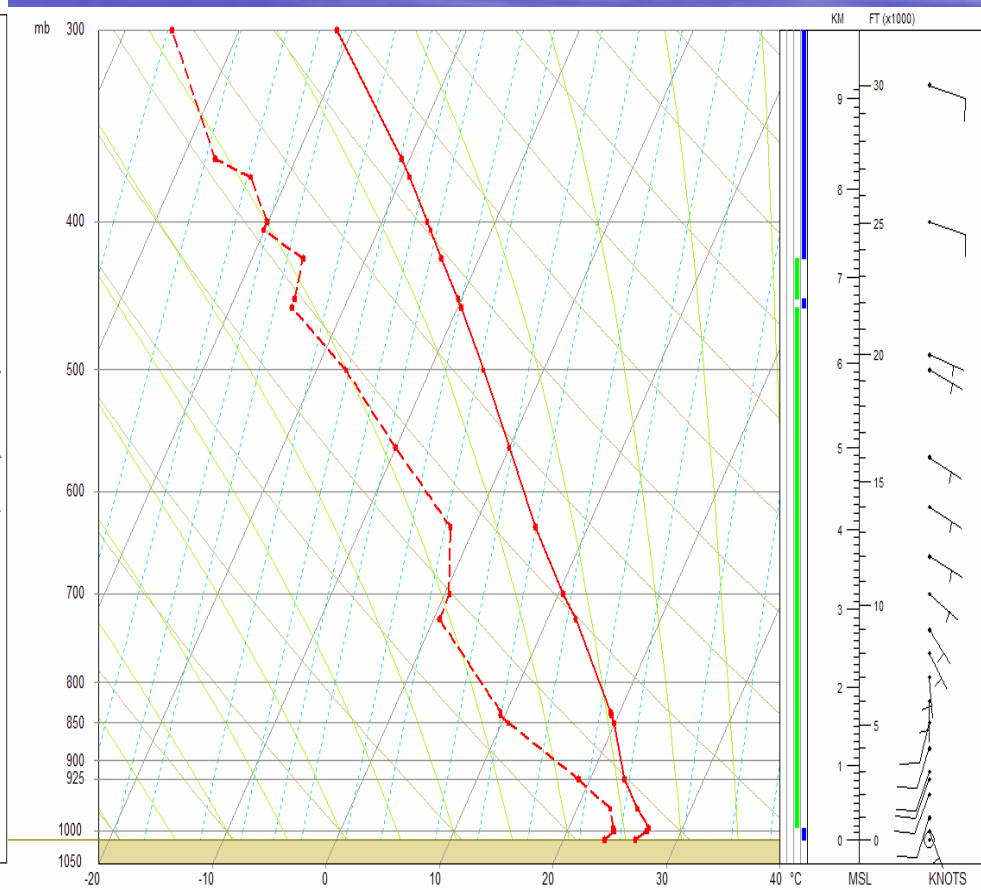
8 Hour Average Ozone Peak Compared with Elevated Inversion Strength (°C) and Relative Humidity at the Top of the Inversion



Composite Soundings

August 2006

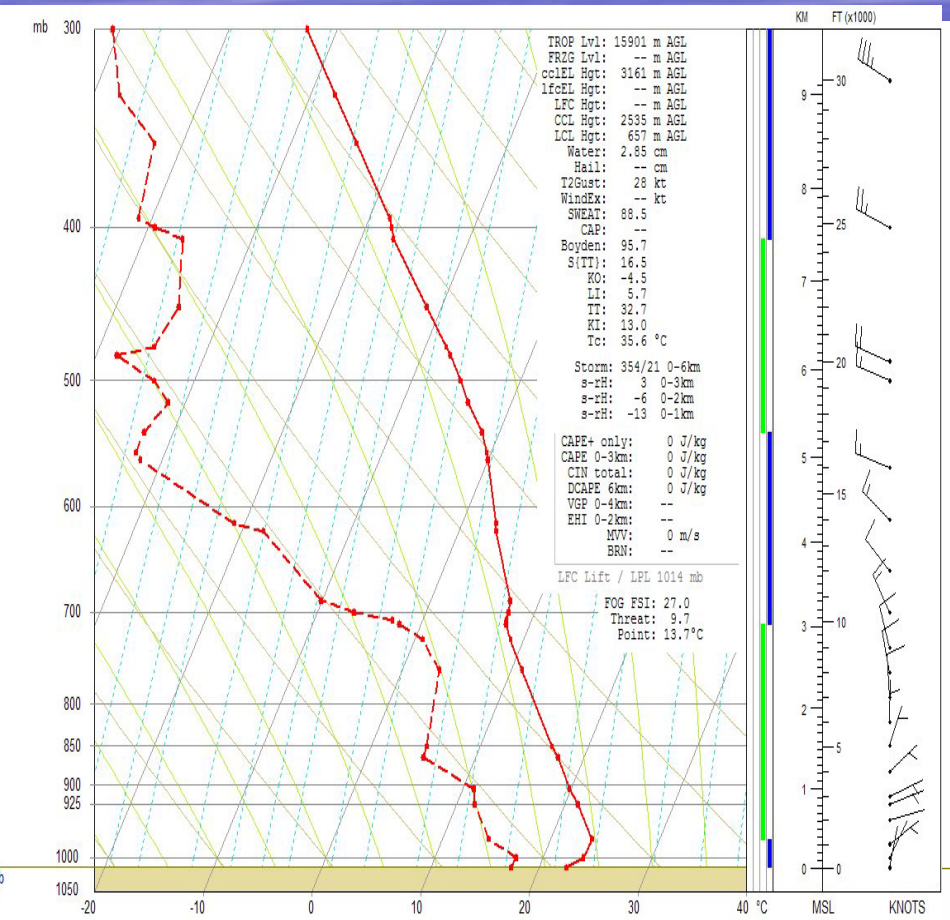


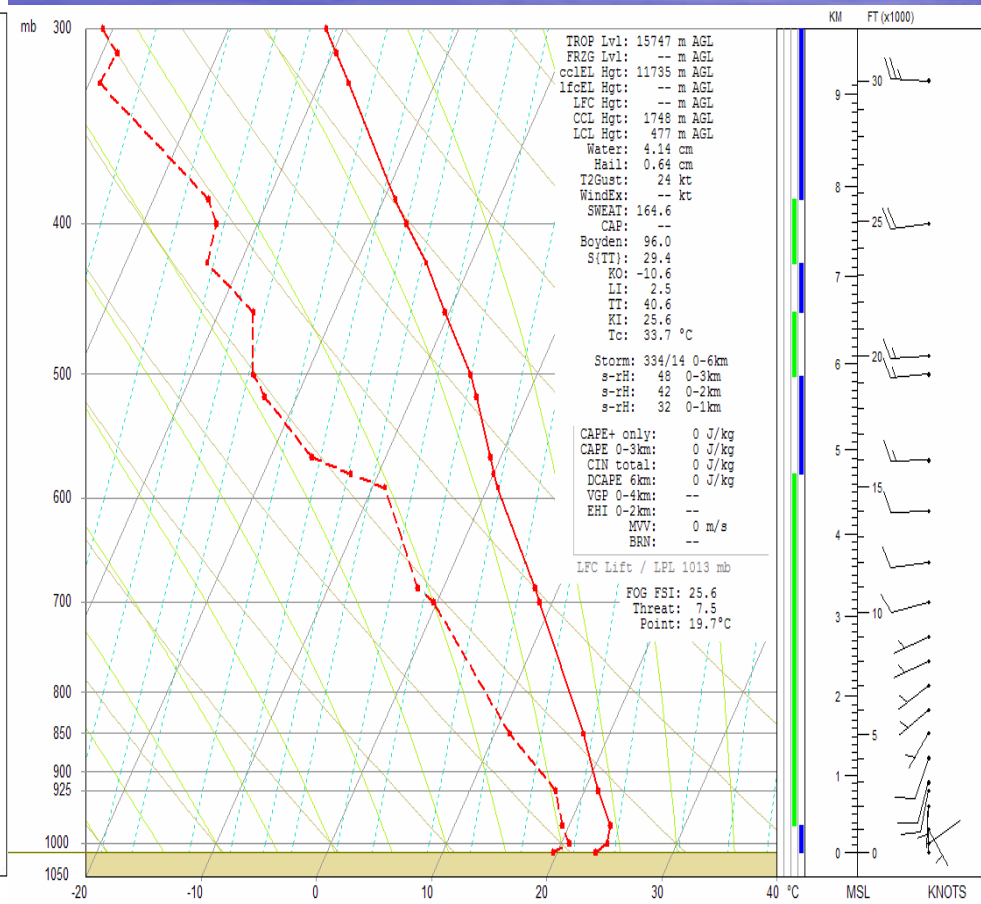


Episode Days

Non-Episode Days

September 2006





Episode Days

Non-Episode Days

Conclusions

- Composite Maps revealed upper-level ridges associated with ozone episodes
- Most of Houston's late summer ozone episodes occurred in a post-frontal environment.
- Northerly flow helps to increase background ozone, increasing the probability of an ozone episode

Conclusions

- Little relation was found between morning inversion strength and peak 8 hour ozone averages.
- There may be a delay in the PBL morning development on episode days, otherwise PBL height seemed to have little direct relation to ozone episodes in August and September 2006.

Conclusions

- Elevated inversion analysis reveals dry elevated inversions associated with episode days, however the strongest and driest inversions are not.
- Composite soundings reveal light winds in boundary layer, elevated inversions common in September episodes.

Future Possibilities

- Composite synoptic maps should be completed for other years in order to draw more general conclusions.
- Is there a relation between Houston's ozone episodes and the amount of tropical activity? (2006 was a "different" year).
- Rawinsonde launches should be completed more often in the morning, the NWS protocol should be departed from.
- Remote sensing should be added!