Evaluation of NMM-CMAQ and WRF-Chem during High Ozone Episodes in TexAQS-II

Focus on regional assessment
119 surface ozone stations
11 wind profilers
7 week period 8/12 to 9/30 2004

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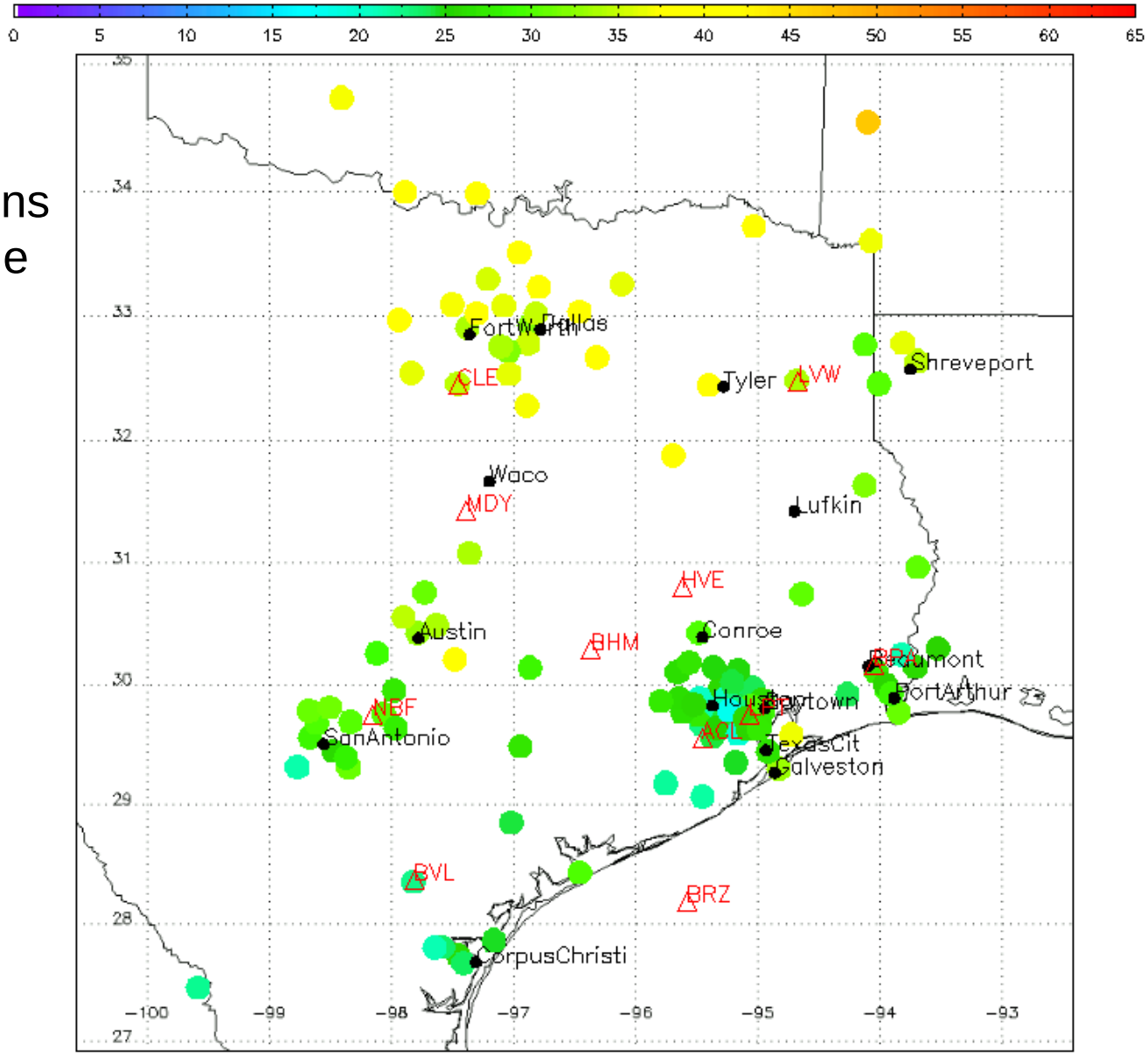
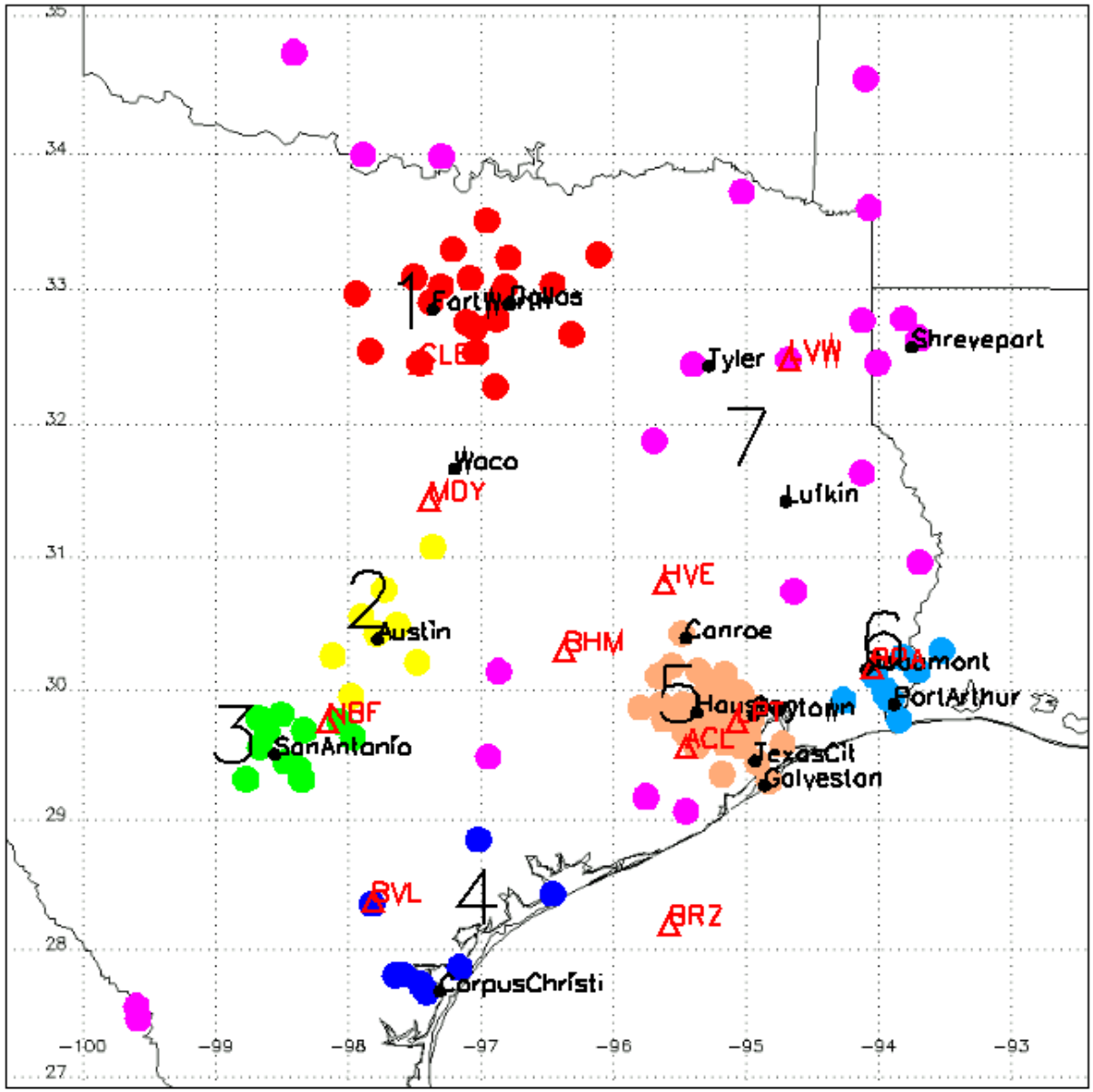
Average 8-h max ozone (8/12 – 9/30 2006)

What, if any, regional variations in max 8-h ozone existed during TexAQS-2006?



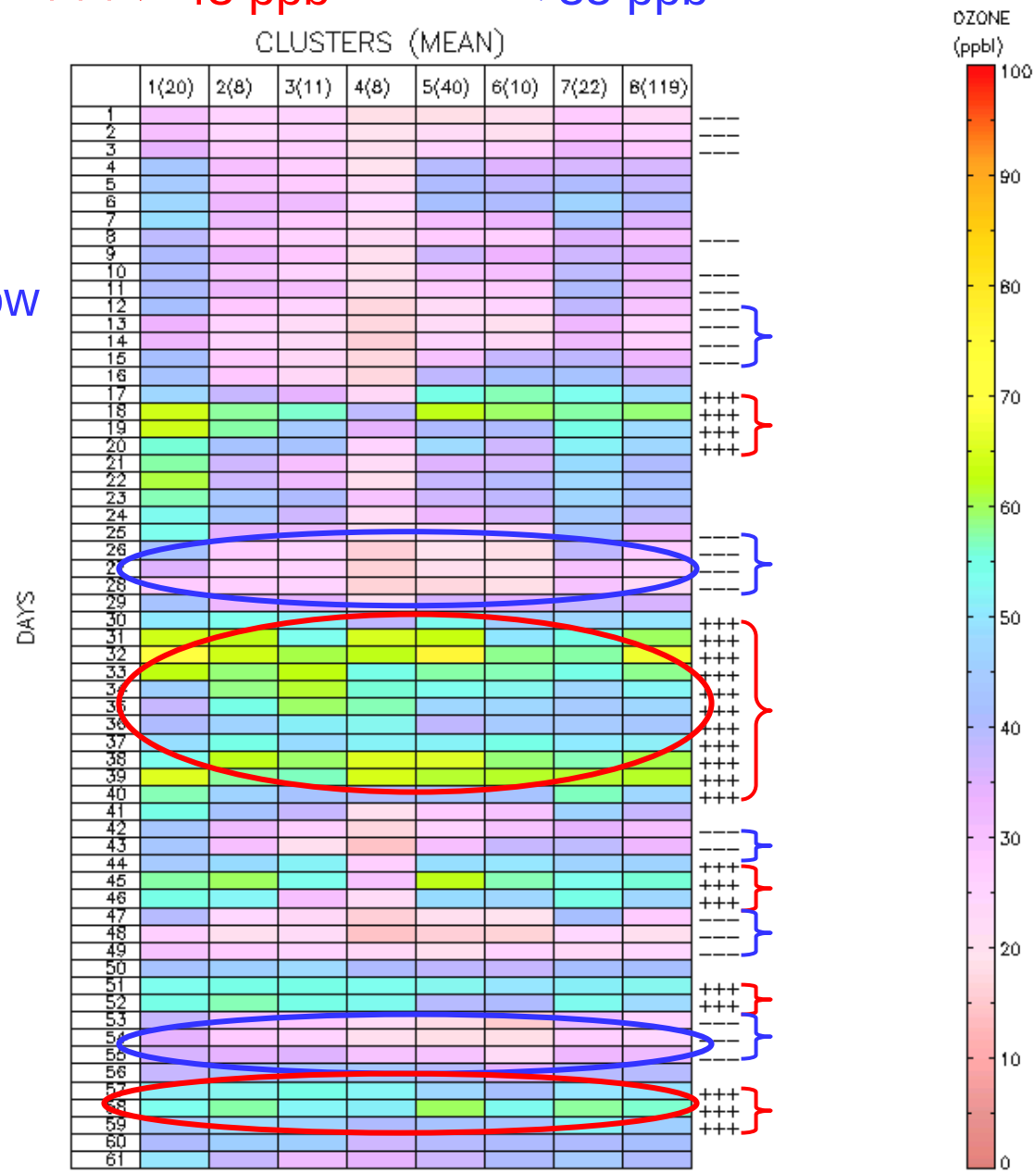
Seven Geographic Clusters

1 Dallas/FW
2 Austin
3 San Antonio
4 Corpus Christi
5 Houston
6 Beaumont /PA
7 Rural/other
8 All sites



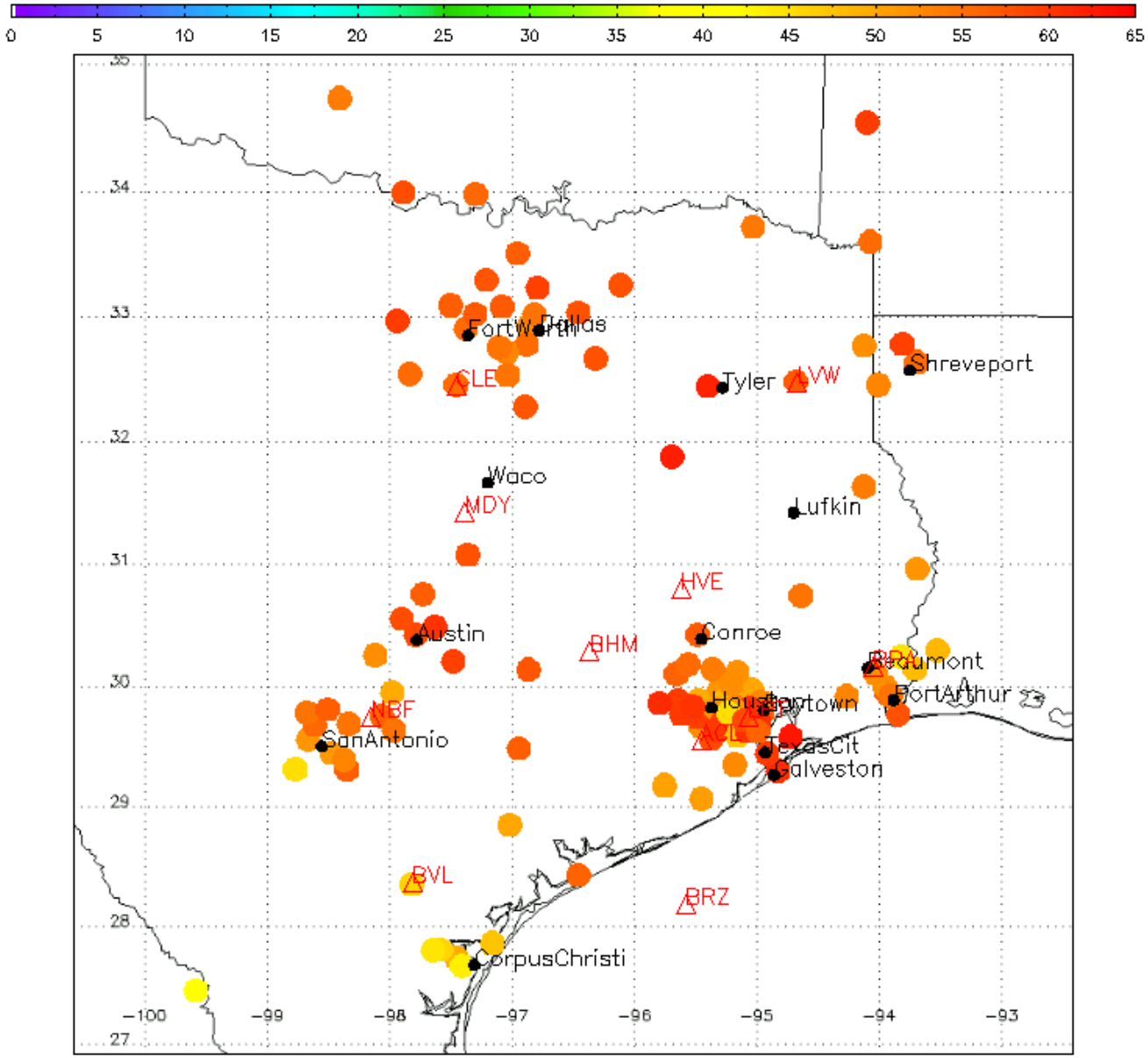
Average daily 8-h max ozone by geographic cluster

+++ > 43 ppb - - - < 35 ppb

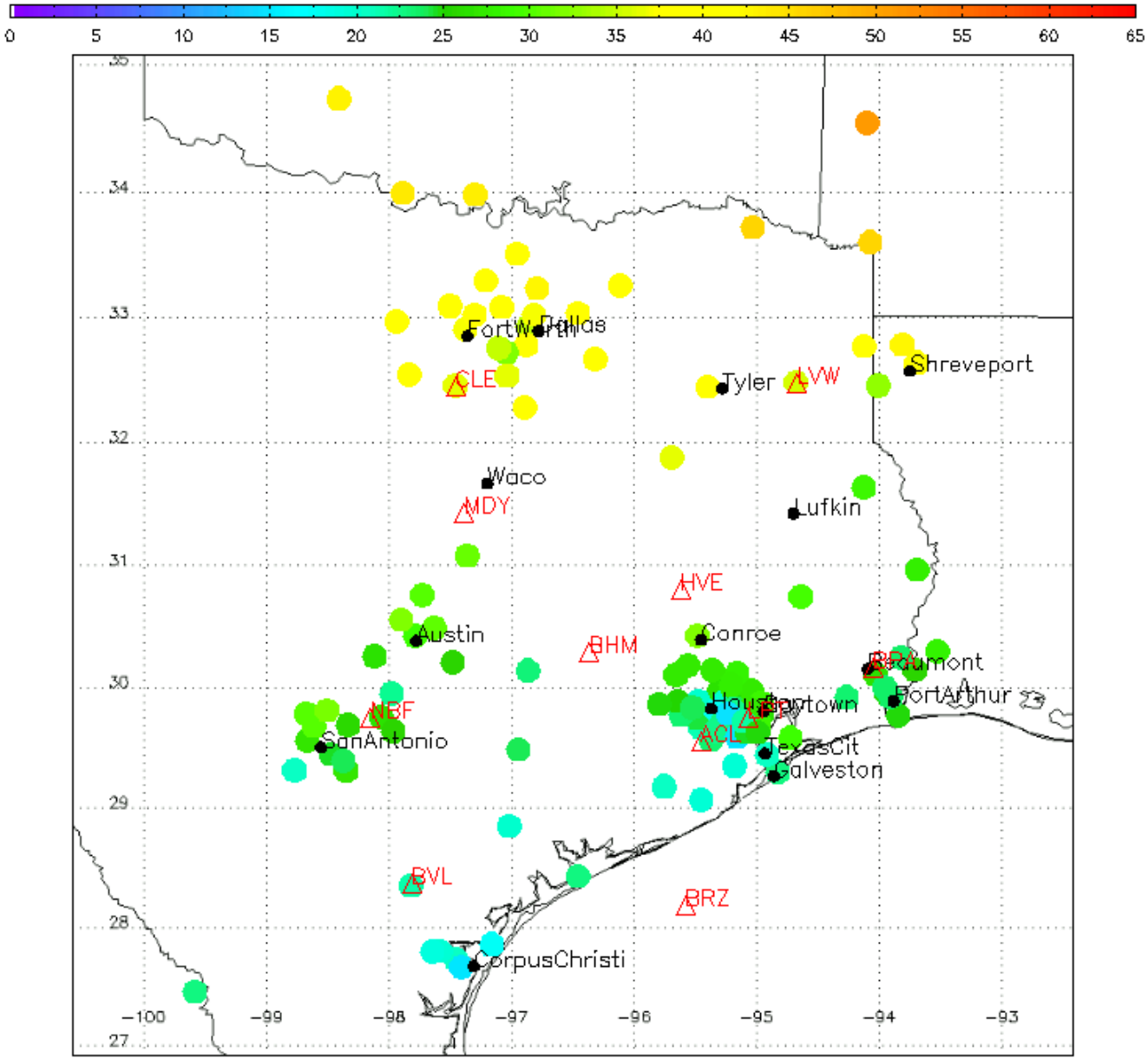


- When one cluster has low ozone, all clusters do
- 16 days of "low"ozone in 5 intervals
- When one cluster has high ozone, usually all others also do
- 23 days of "high" ozone in 5 intervals

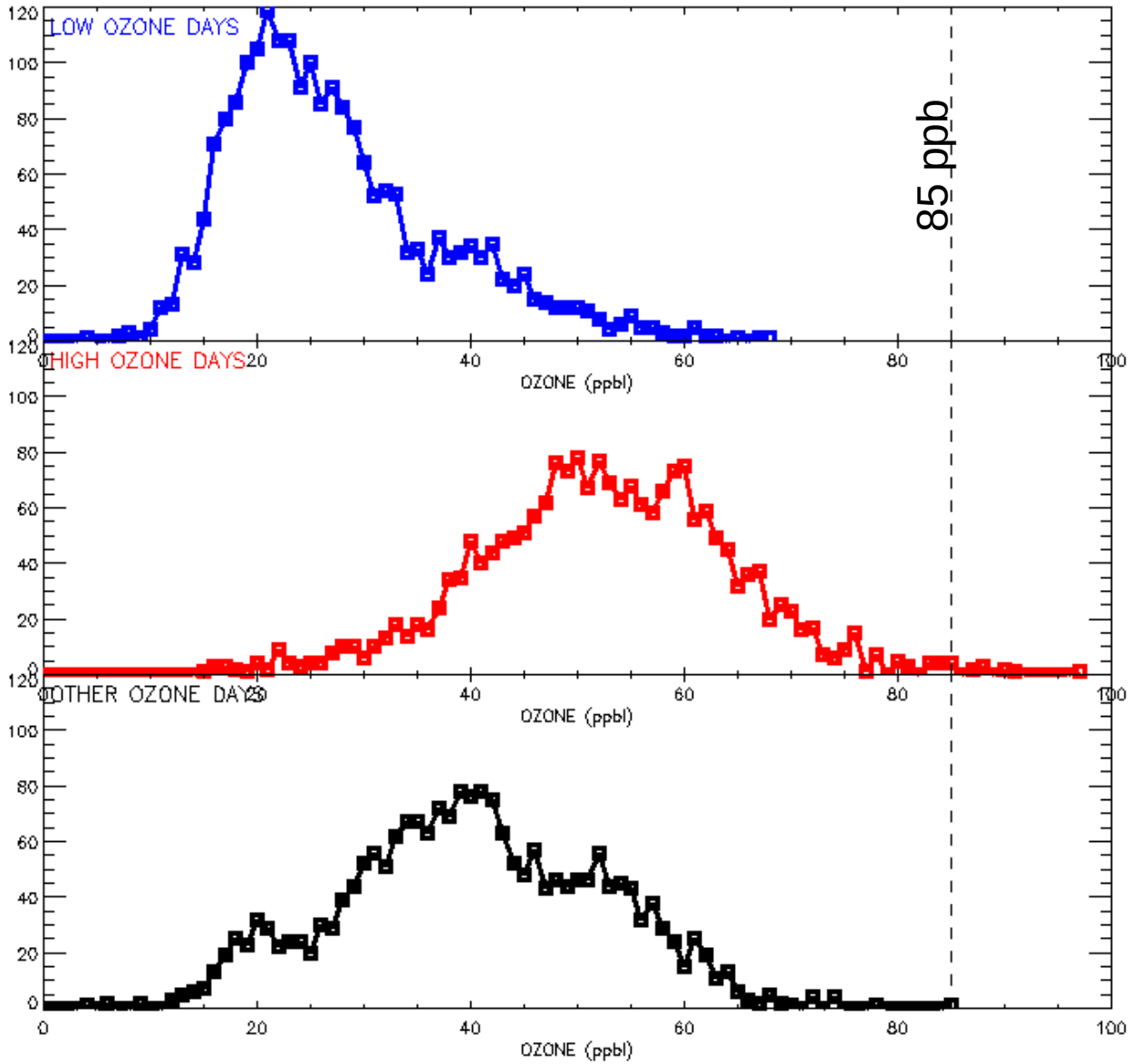
23 day high ozone composite of 8-hr max ozone



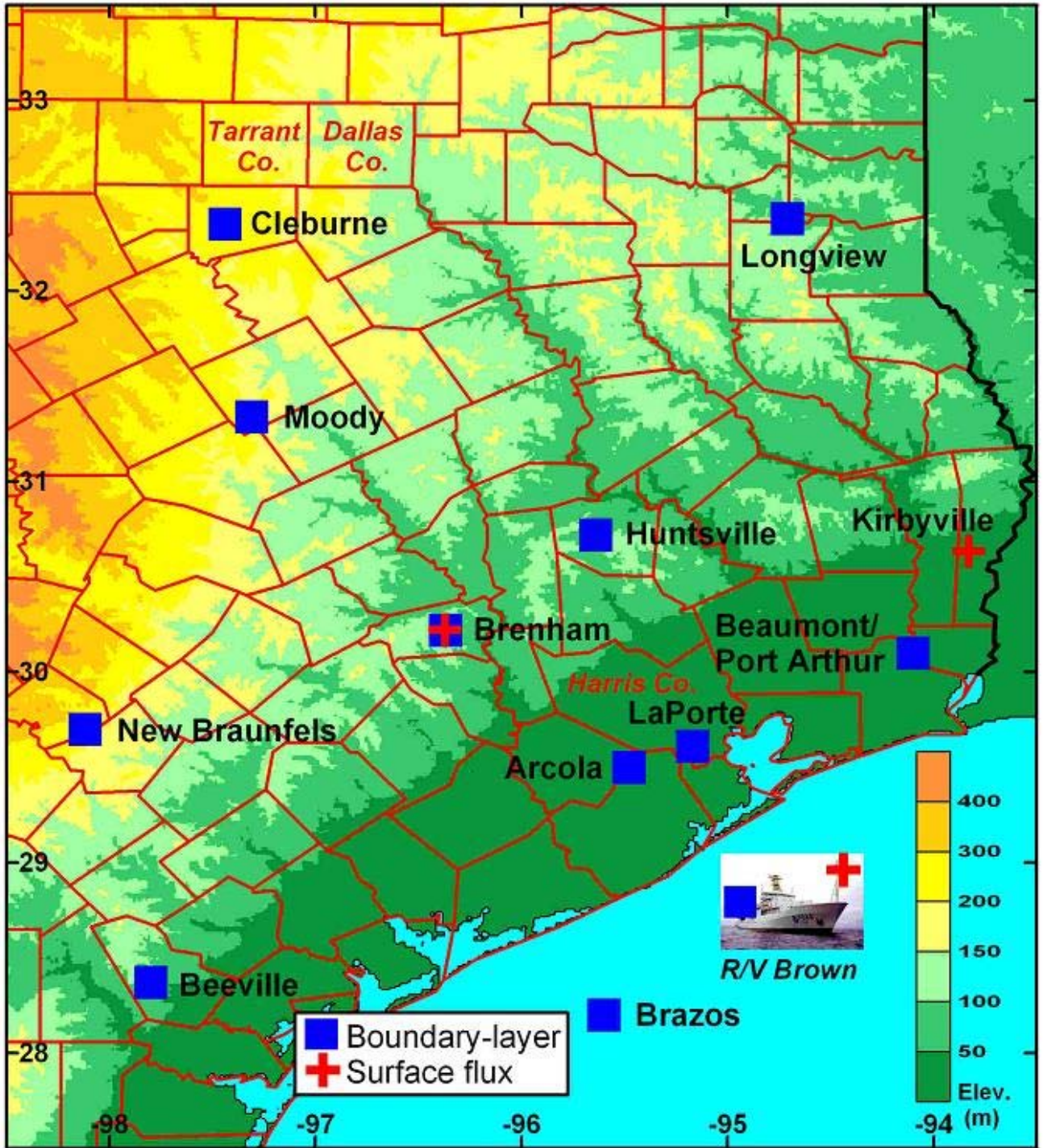
16 day low ozone composite of 8-hr max ozone



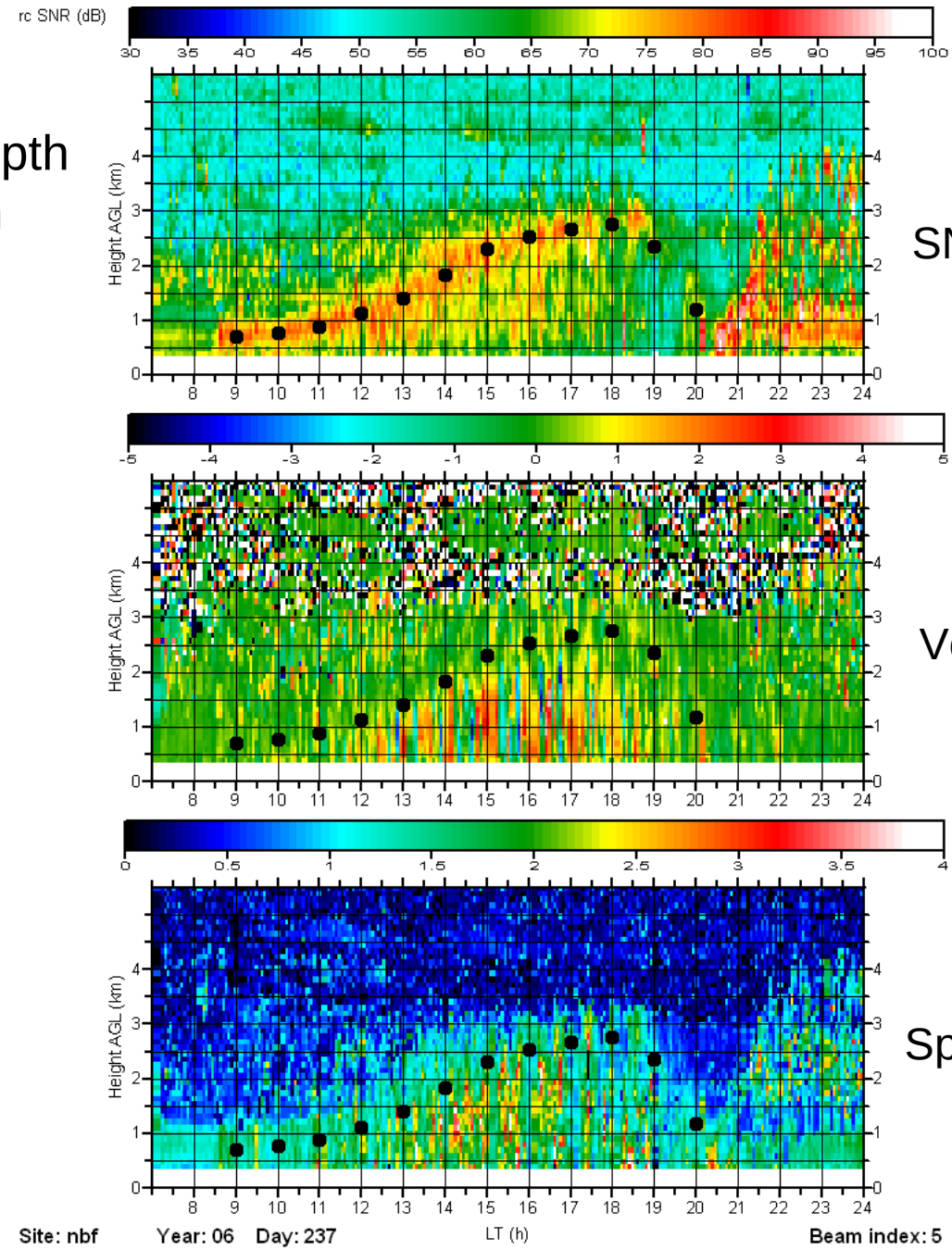
Histograms of individual station 8-h max ozone



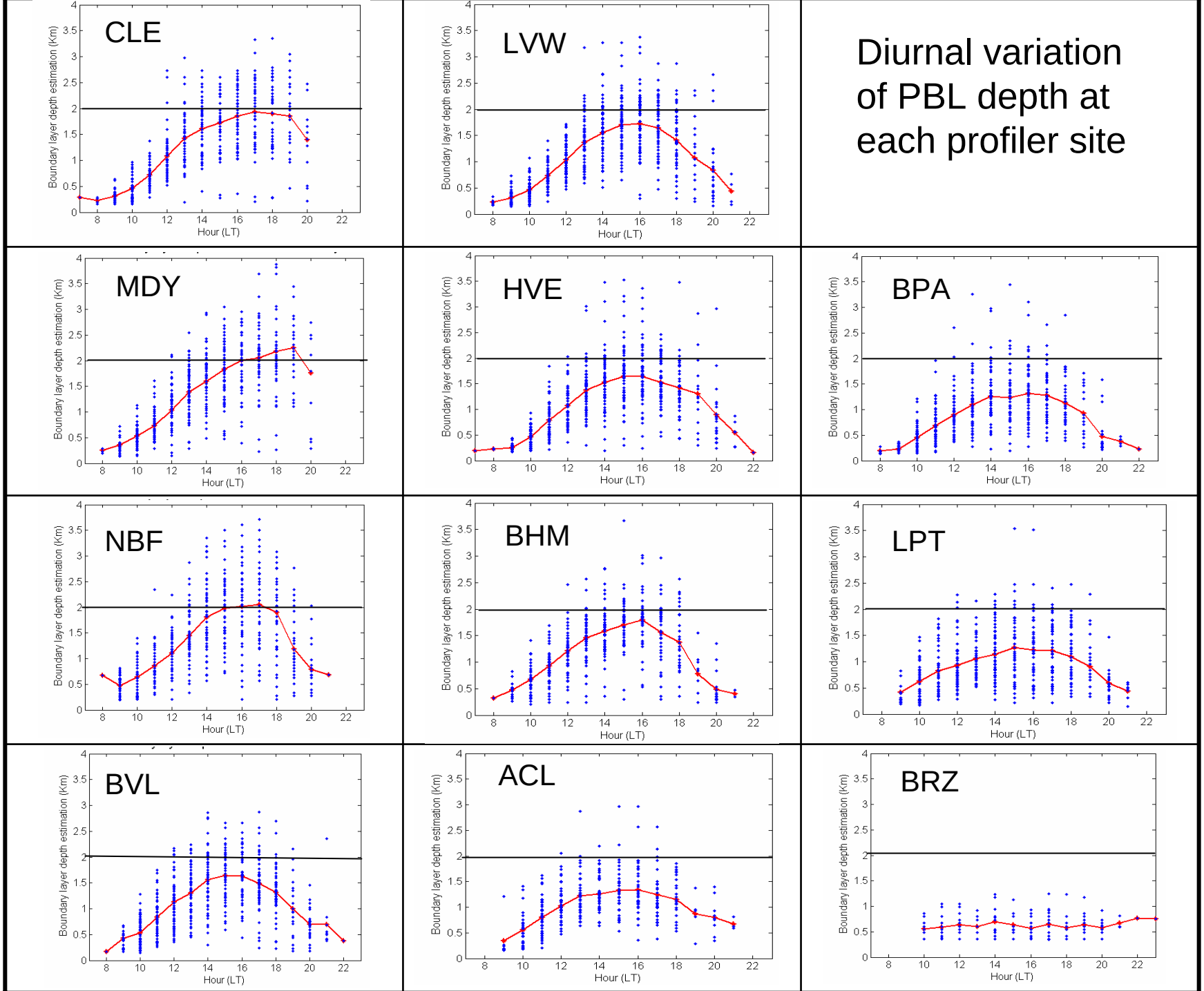
TexAQS 2004 wind profiler network



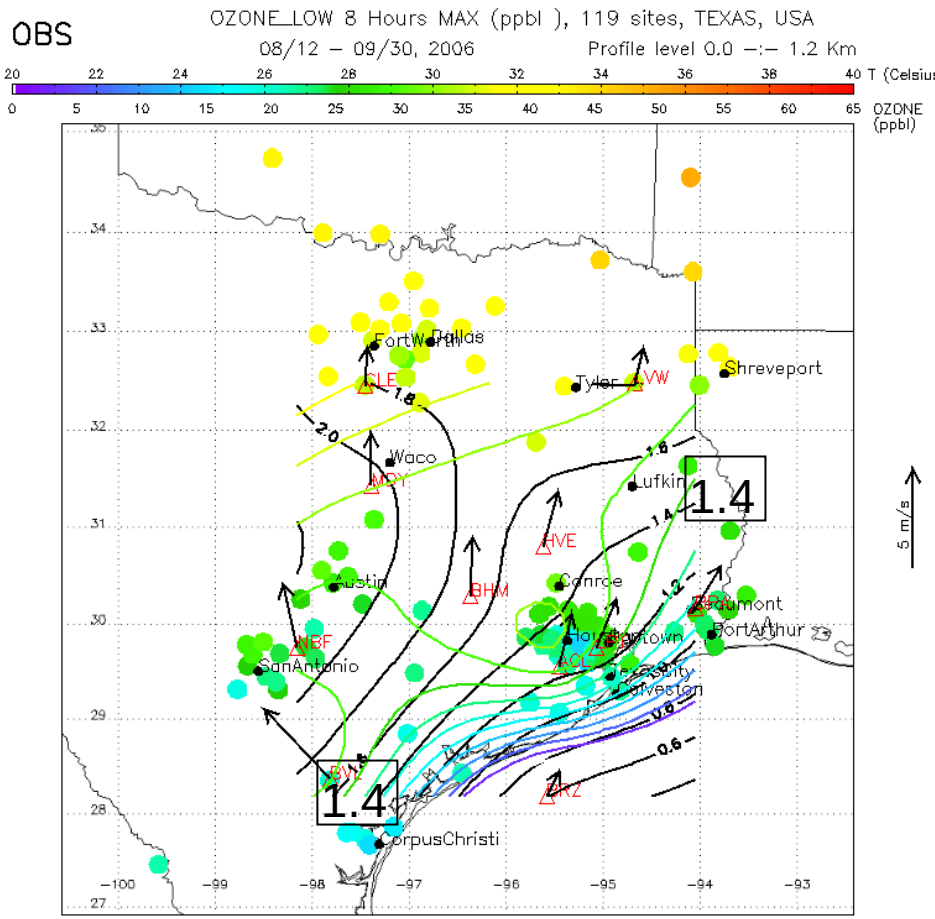
Automated PBL depth detection algorithm

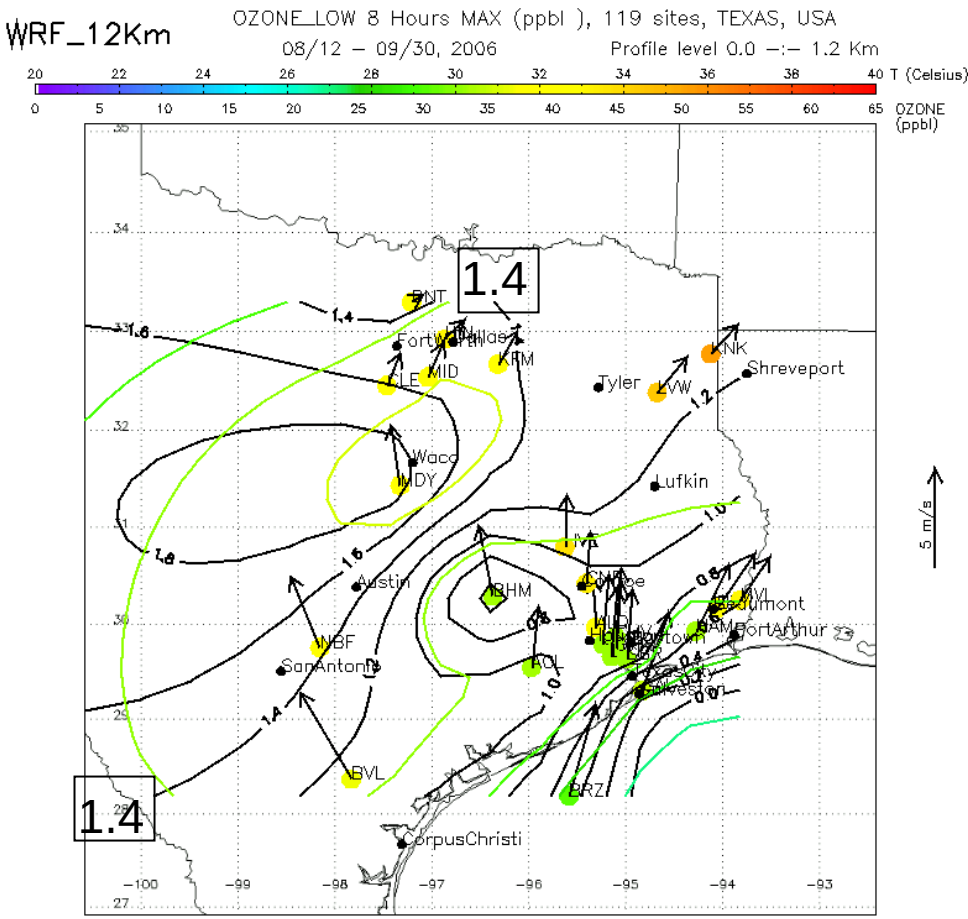


Diurnal variation of PBL depth at each profiler site



Low ozone days composite





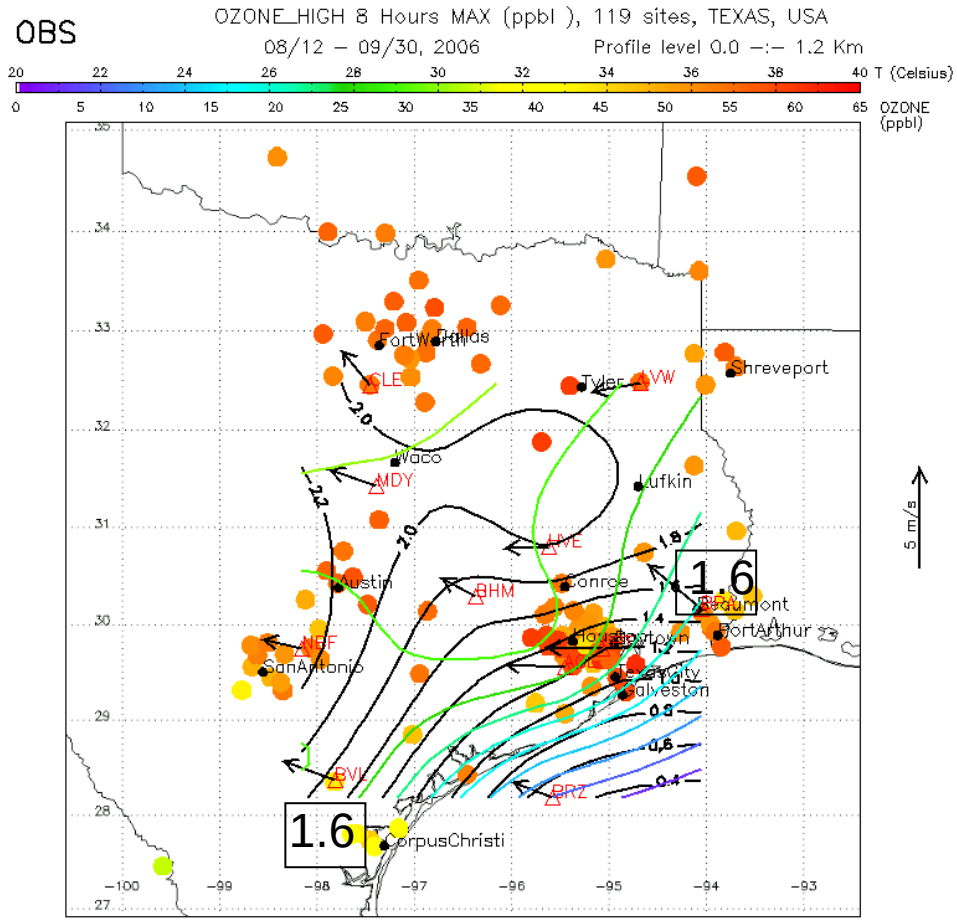
Observed

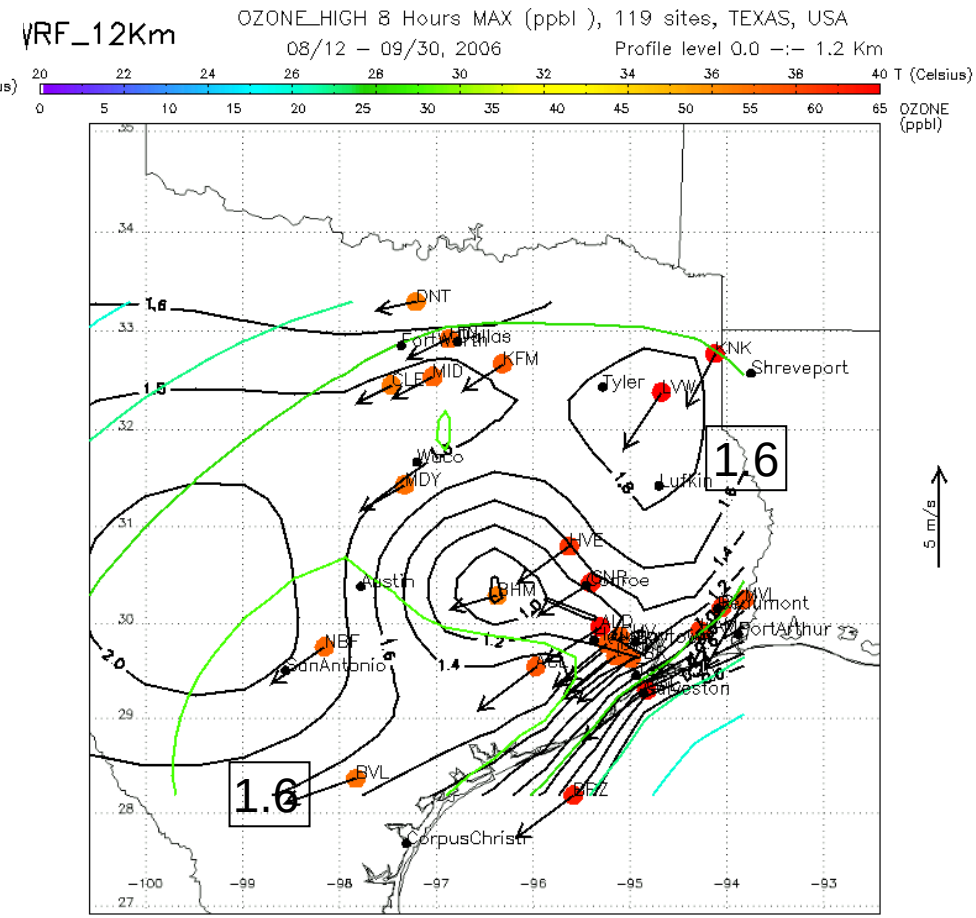
WRF/Chem-12km

- Ozone good
- Winds good
- PBL too shallow

Winds, PBL depths, RASS temperatures averaged from 19-22 UTC (13-16 LST) between 0-1200m.

High ozone days composite



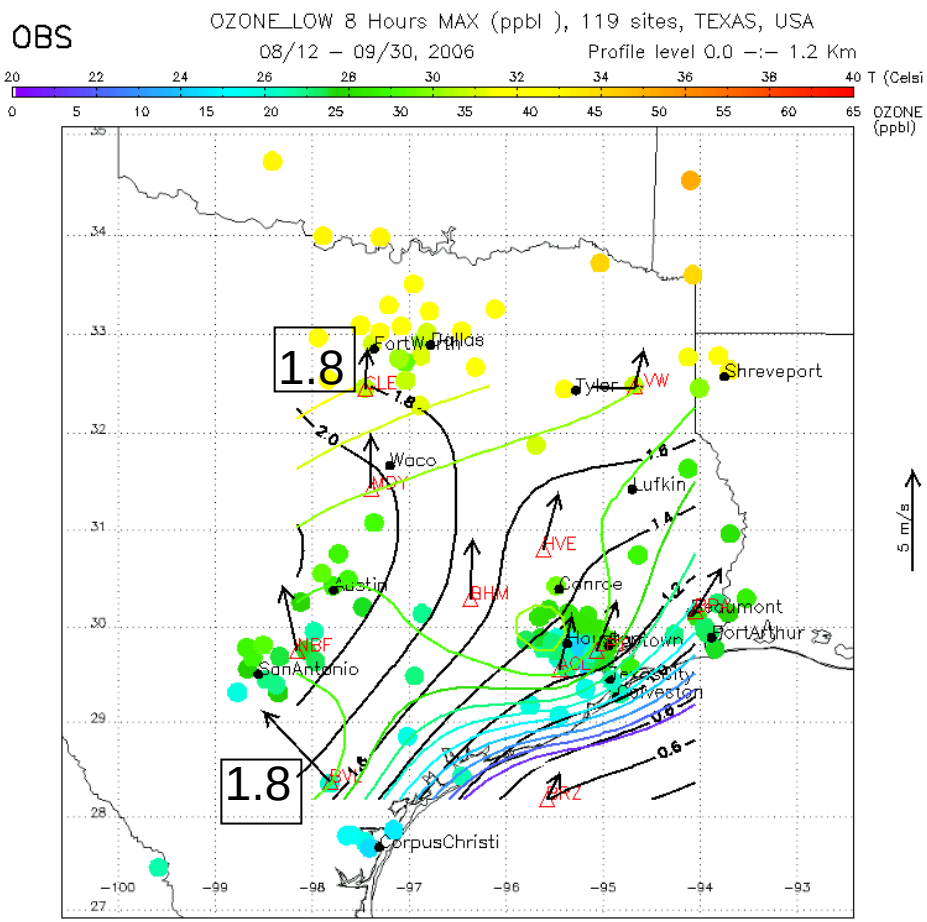


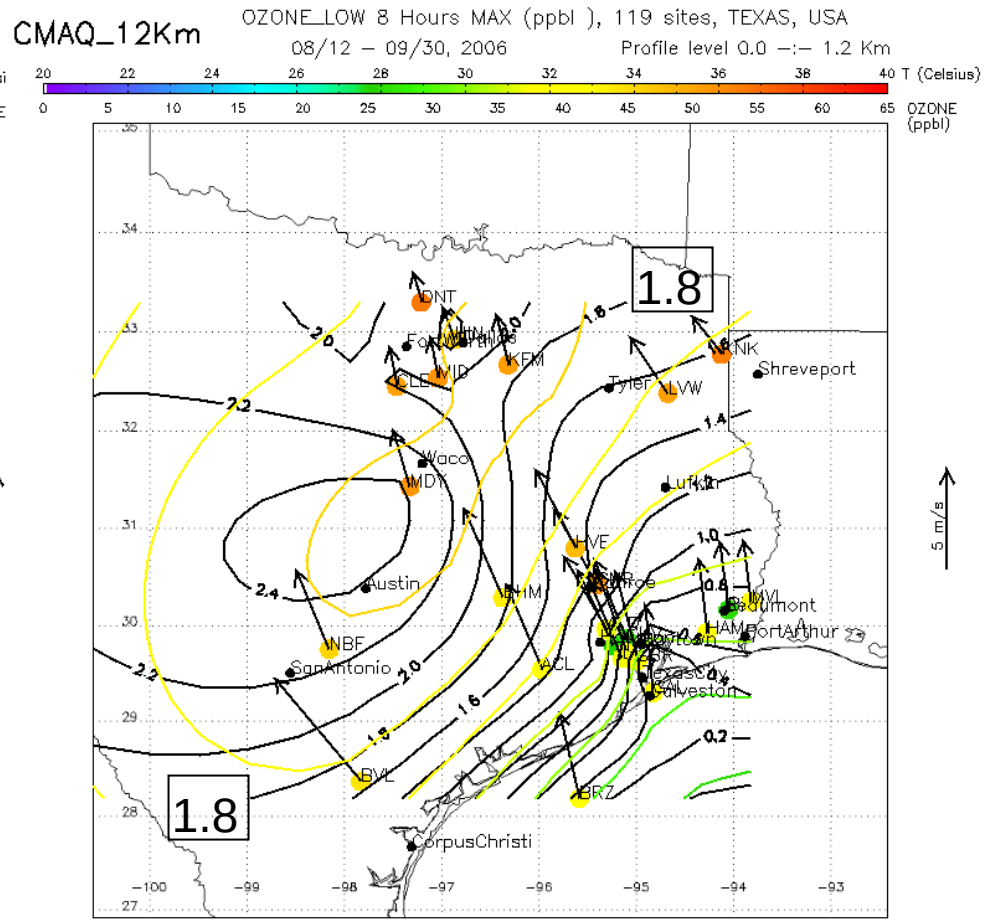
Observed

- Ozone good
- Winds too northerly
- PBL too shallow

WRF/Chem-12km

Low ozone days composite



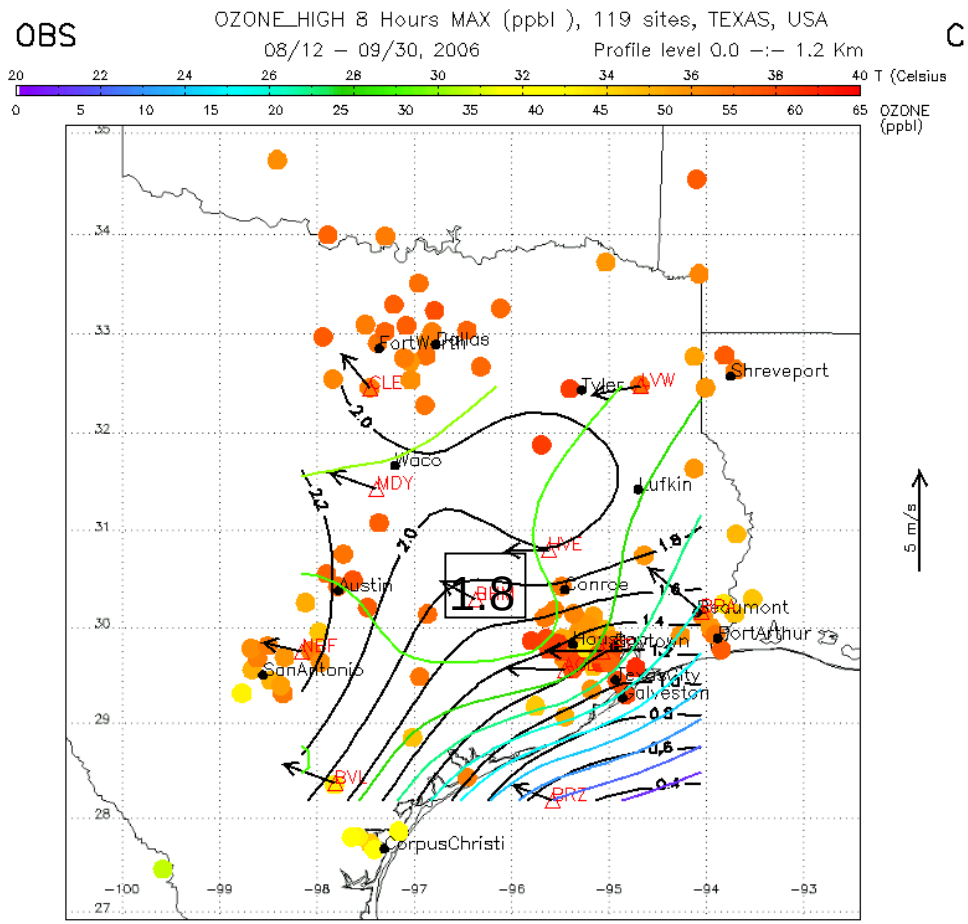


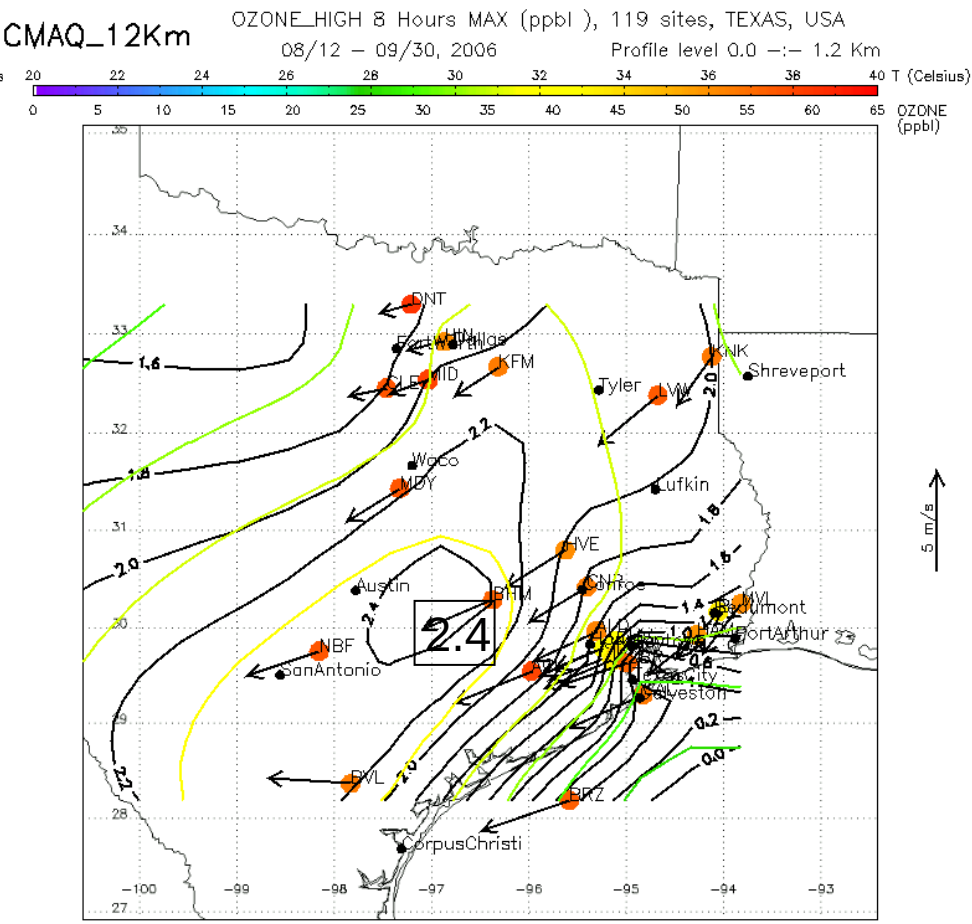
Observed

- Ozone too high (grad ok)
- Winds too easterly
- Temps too warm (2-3 C)
- PBL too deep

NMM-CMAQ

High ozone days composite

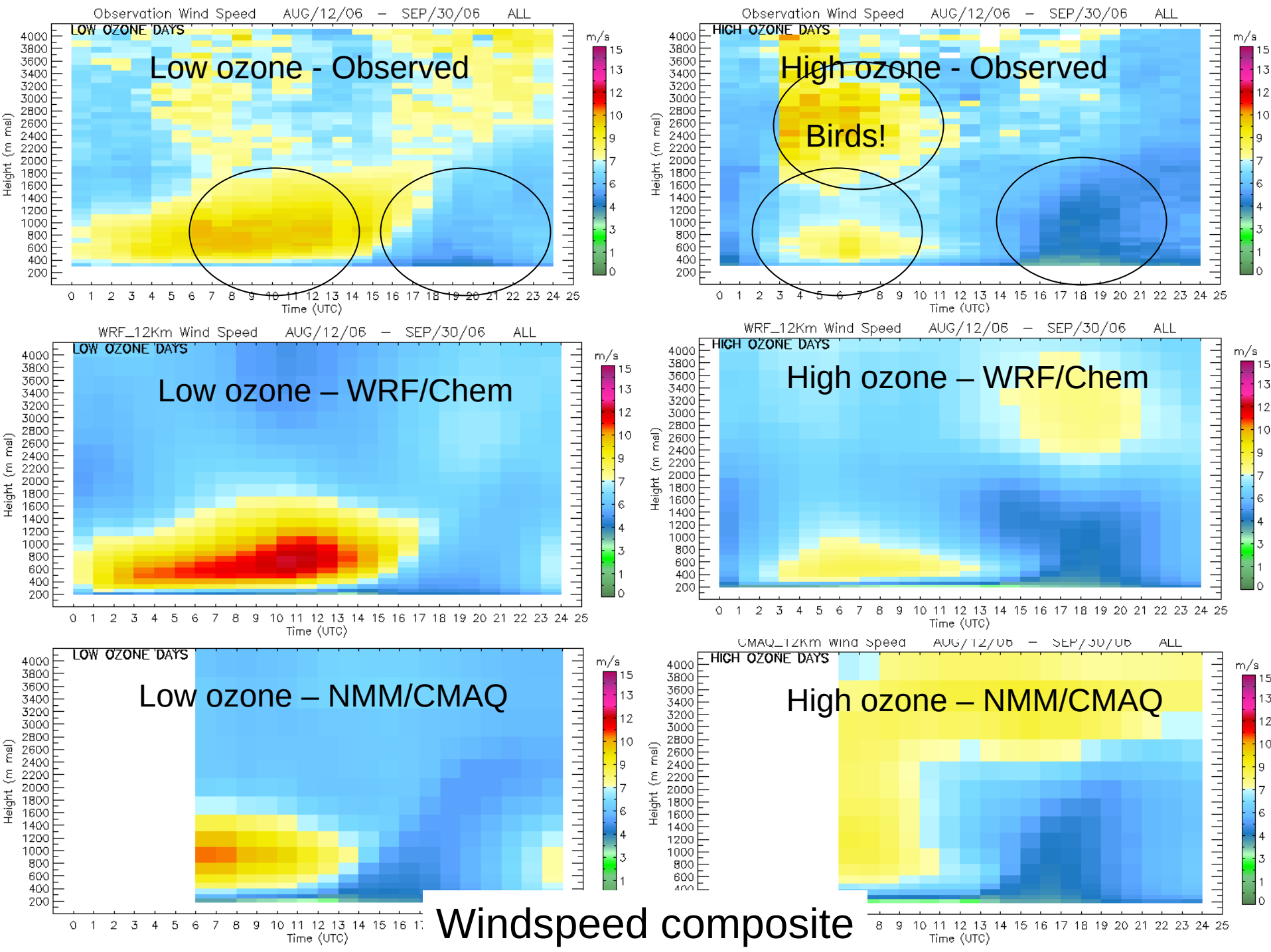




Observed

- Ozone good
- Winds too northerly
- Temps too warm
- PBL too deep (600m!)

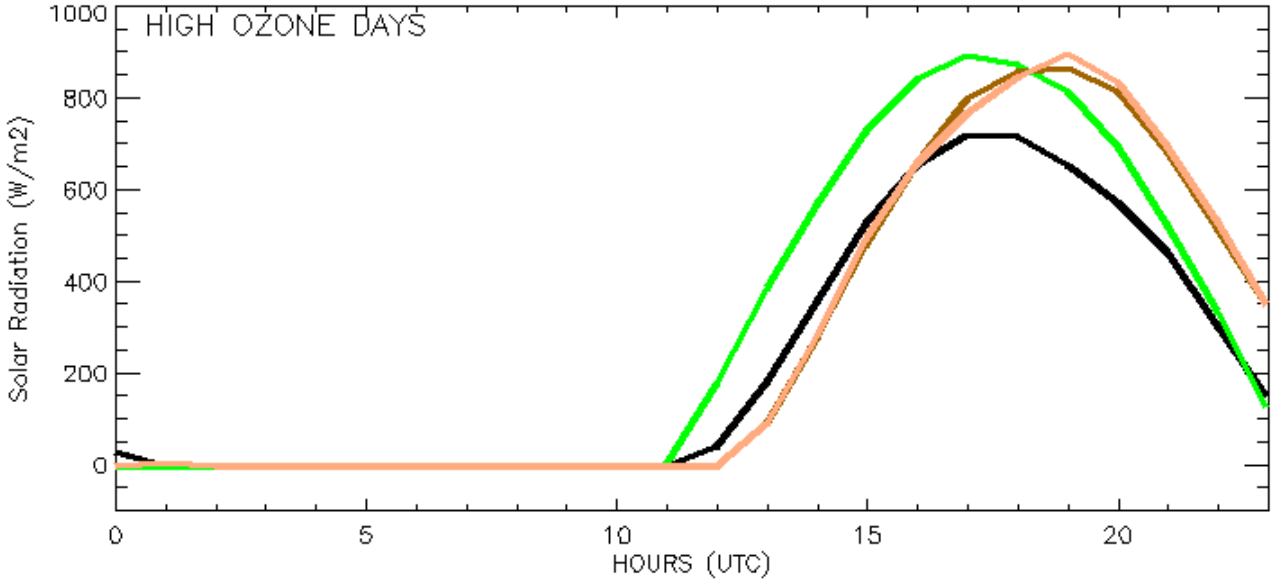
NMM-CMAQ

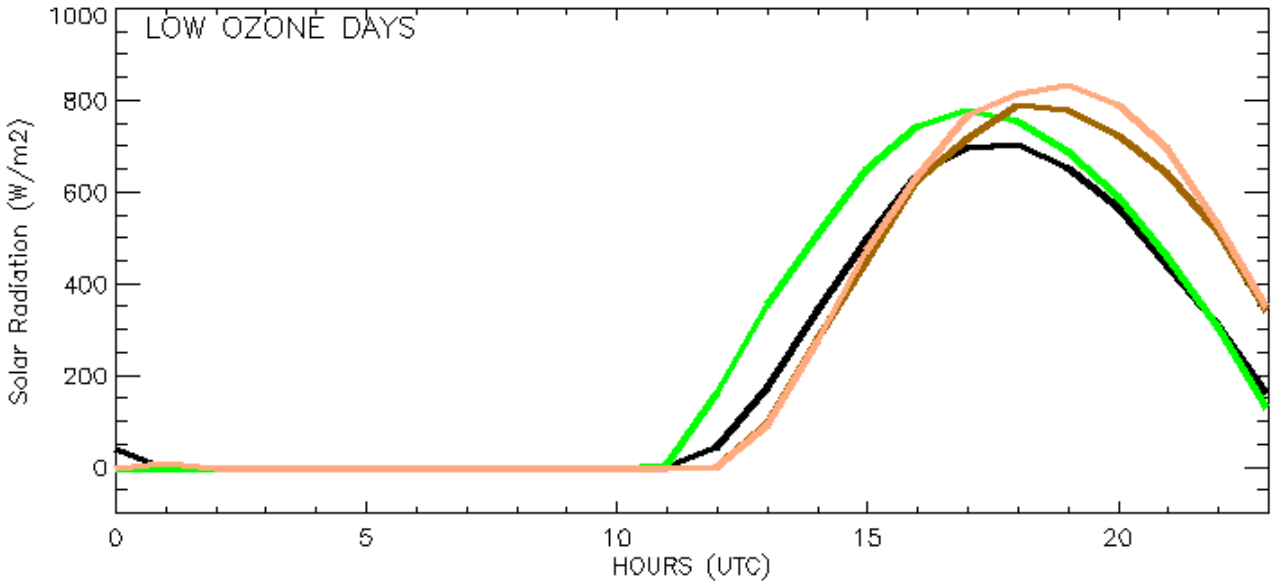


Windspeed composite

SOLAR RADIATION over 10 sites, Texas, USA 08/12/2006 – 09/30/2006

OBSERVATION WRF_36km WRF_12km CMAQ_12km





Conclusions-observations

- High and low ozone episodes tend to be regional events
- Composite of 23 high ozone days shows uniform high-zone across Texas; 16 low-ozone day composite shows a north-south gradient, with higher ozone to the north
- High ozone days have weak winds from the east; low ozone days strong winds from the south
- PBL depths show large gradient, increasing inland and to west, not much difference between high/low ozone days
- Surprisingly small differences in solar radiation between high/low ozone days

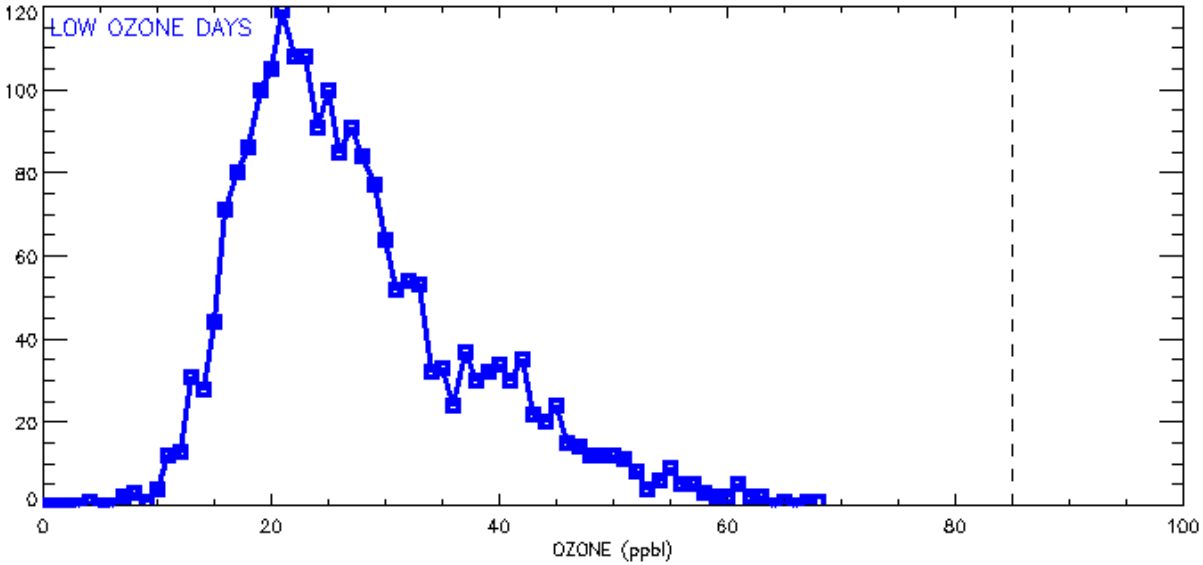
Conclusions-models

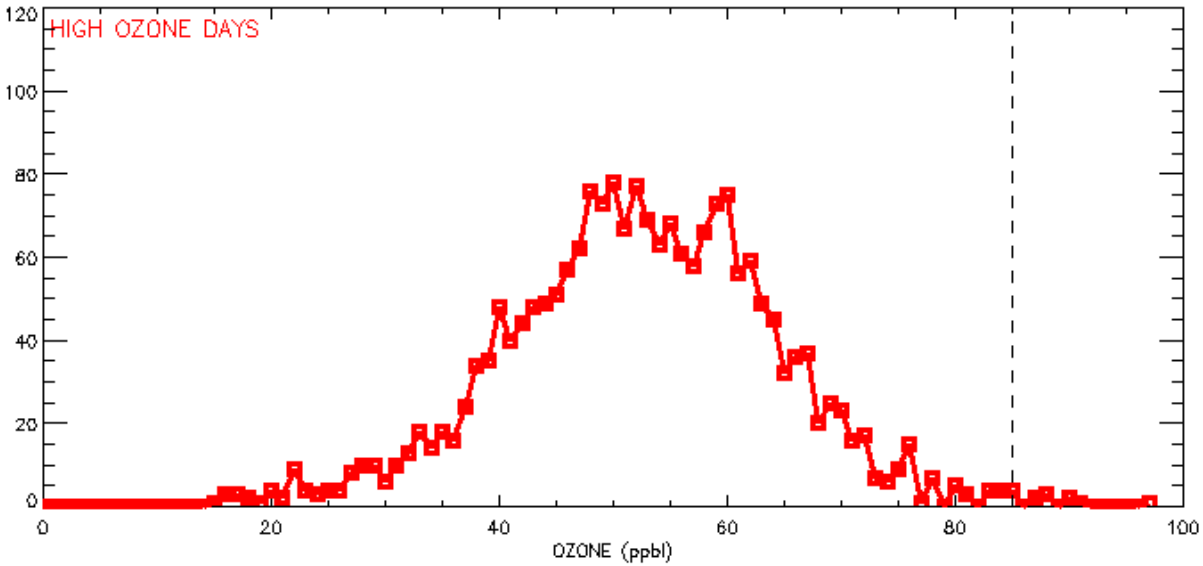
- WRF-Chem and NMM-CMAQ generally replicate the observed meteorology

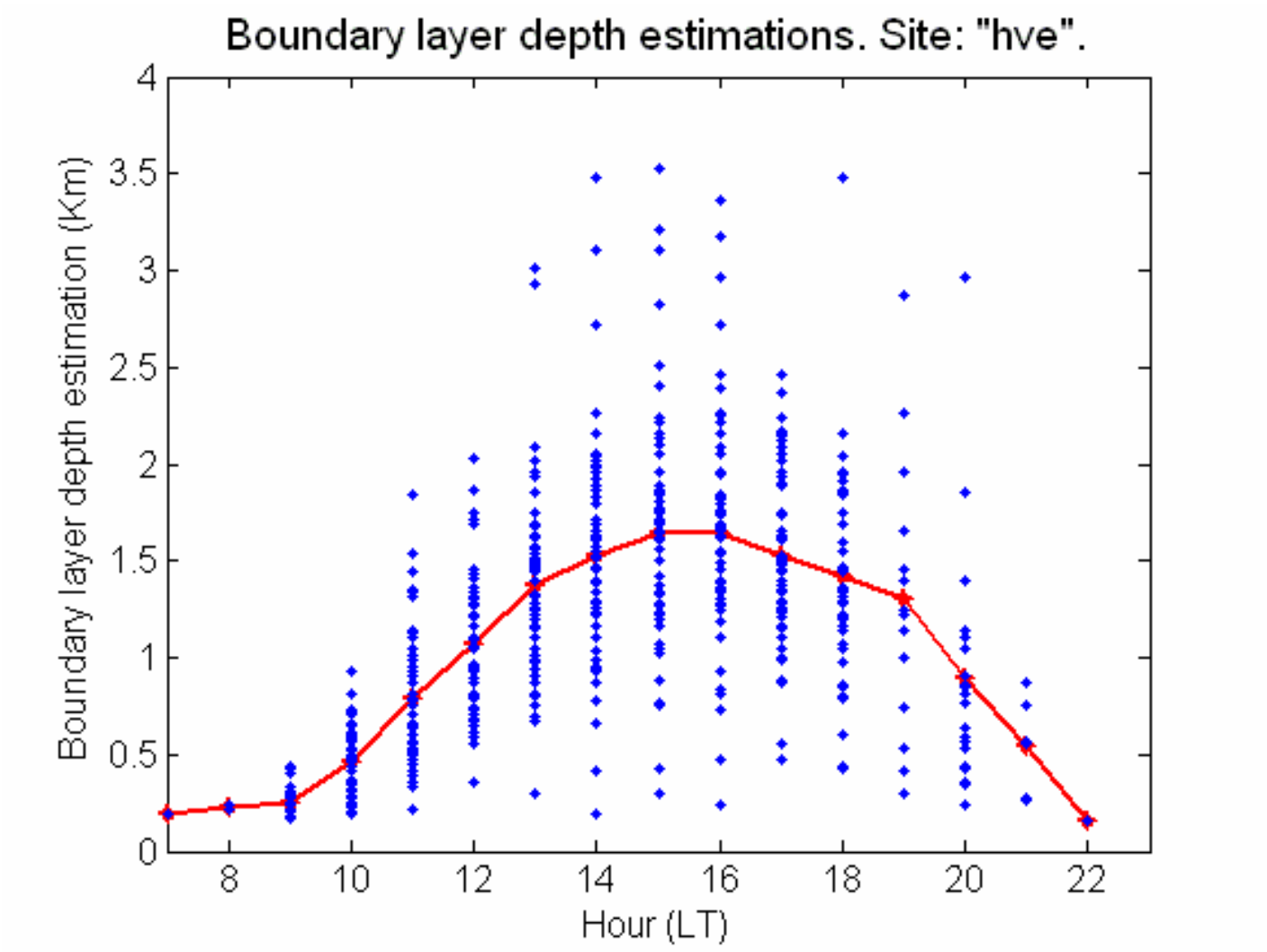
- Problems:
  - Winds: NMM too easterly, WRF too northerly; NMM does not fully simulate weak winds on high ozone days, strong winds on low ozone days
  - PBL: NMM-CMAQ too deep, WRF too shallow
  - Temp: NMM too warm
  - Solar radiation: both models over-predict, especially on high ozone days

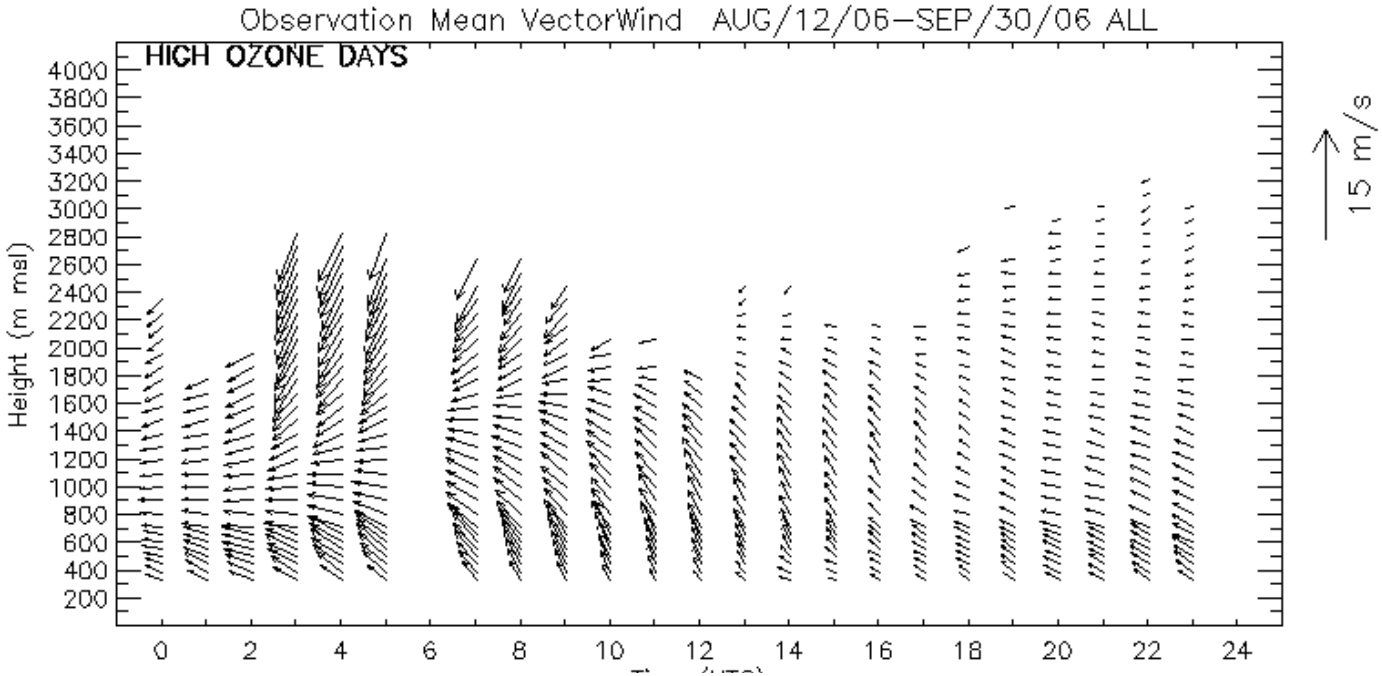
OZONE_8hrmx HISTOGRAM over 119 sites, Texas, USA

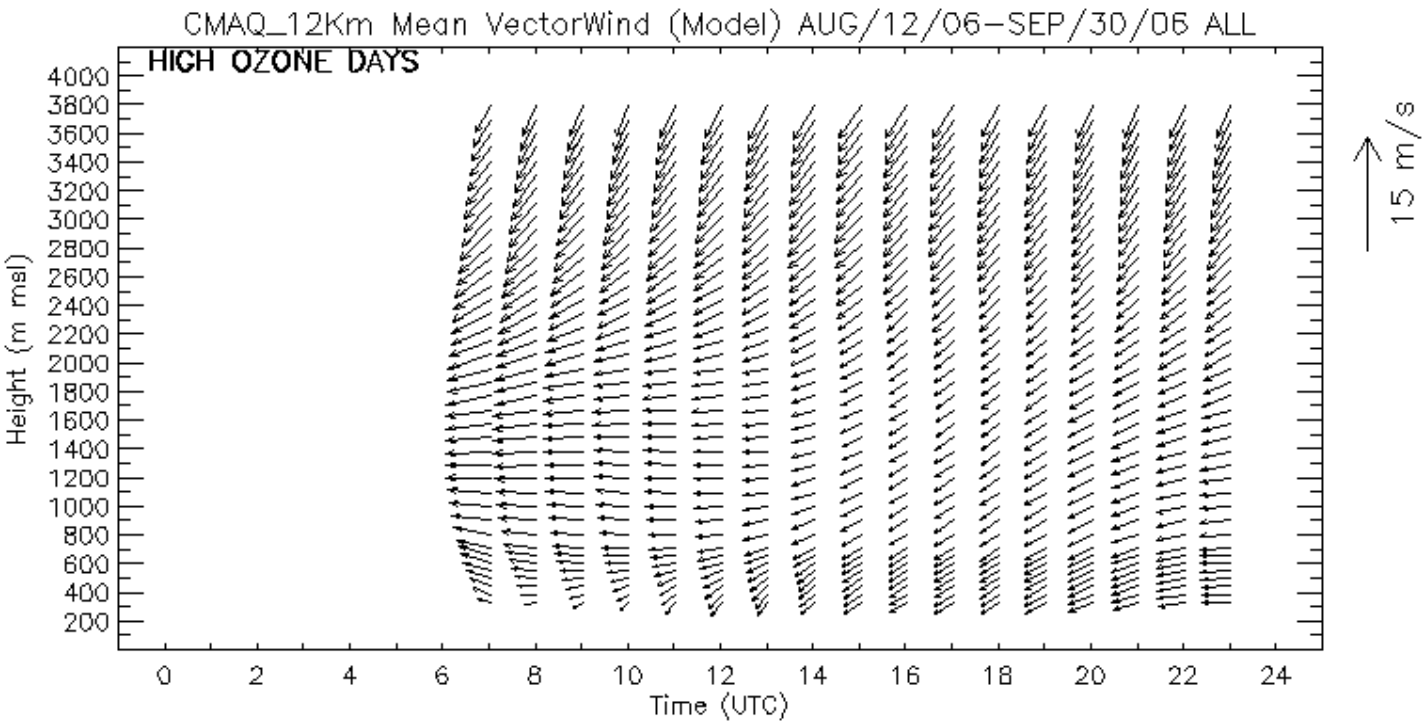
08/12/2006 – 09/30/2006

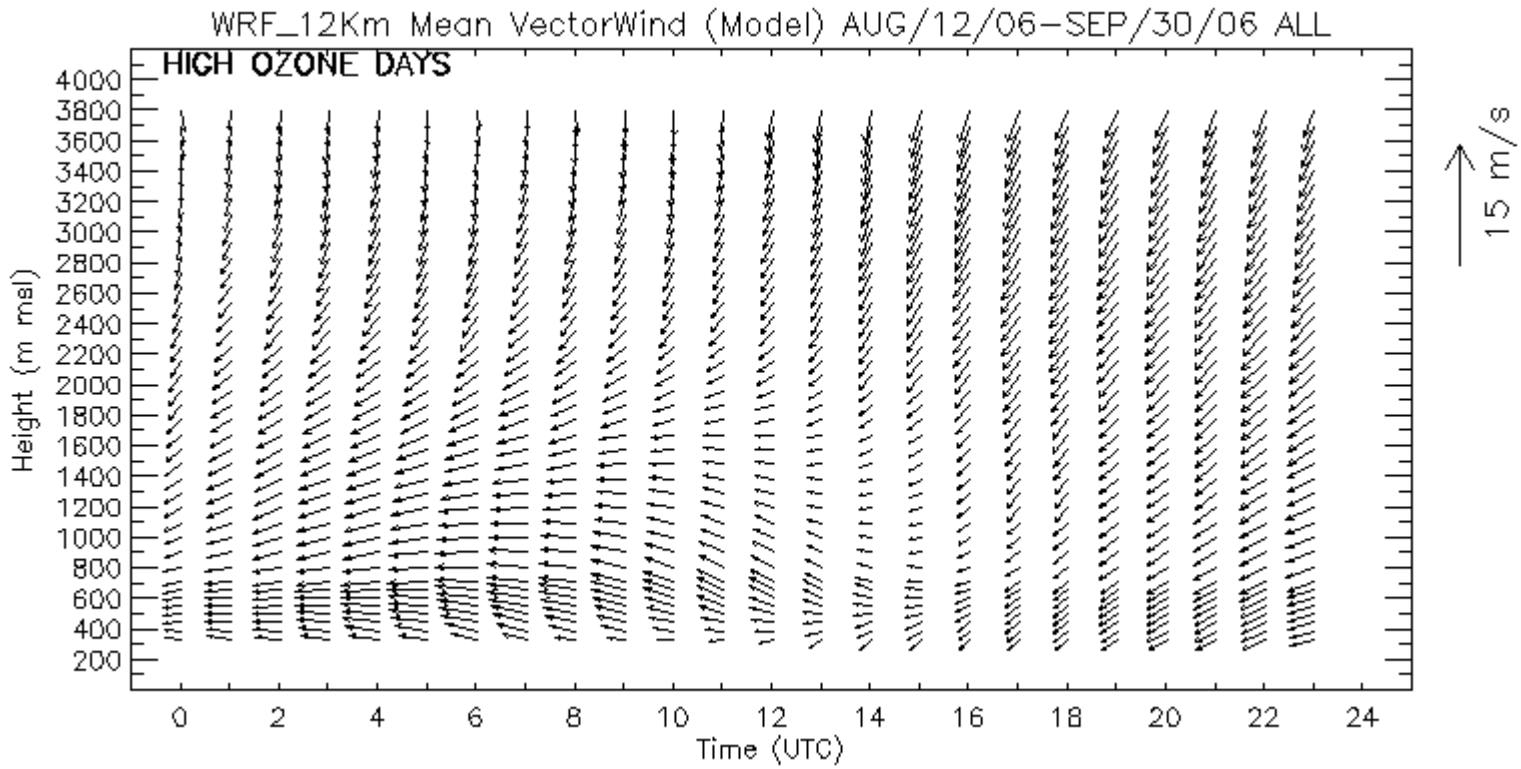


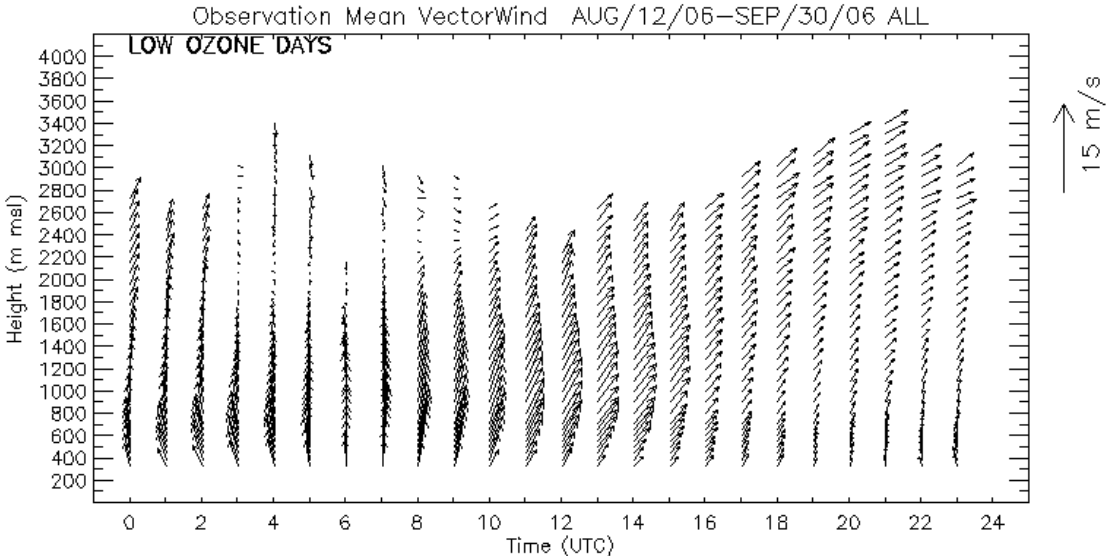


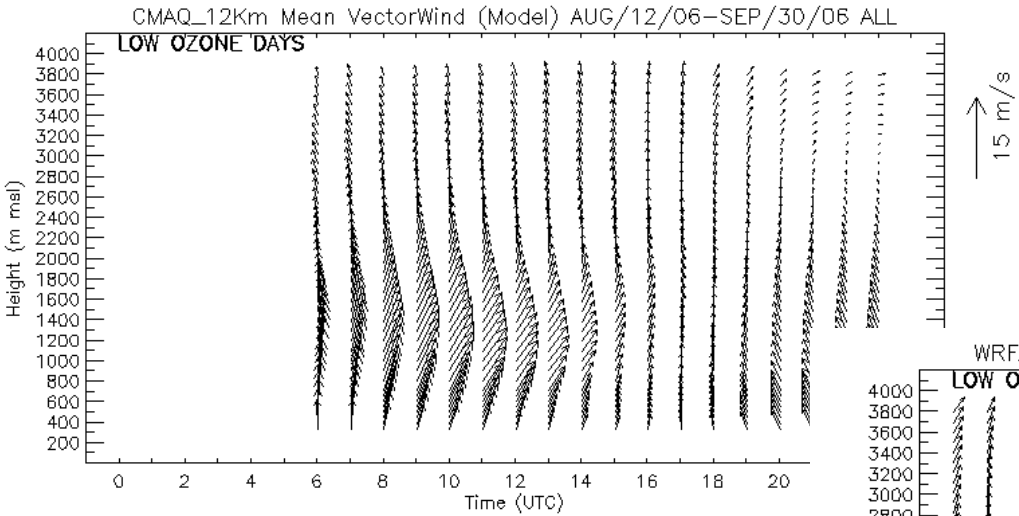

Boundary layer depth estimations. Site: "hve".
Boundary layer depth estimation (Km)
Hour (LT)
0
0.5
1
1.5
2
2.5
3
3.5
4
8
10
12
14
16
18
20
22

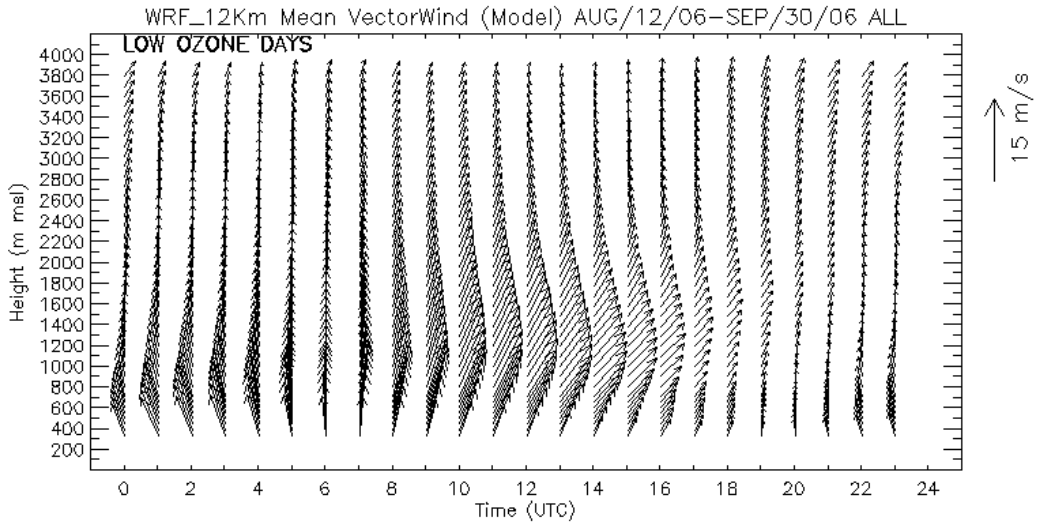

Observation Mean VectorWind AUG/12/06–SEP/30/06 ALL
HIGH OZONE DAYS
Height (m msl)
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
12
14
16
18
20
22
24
15 m/s

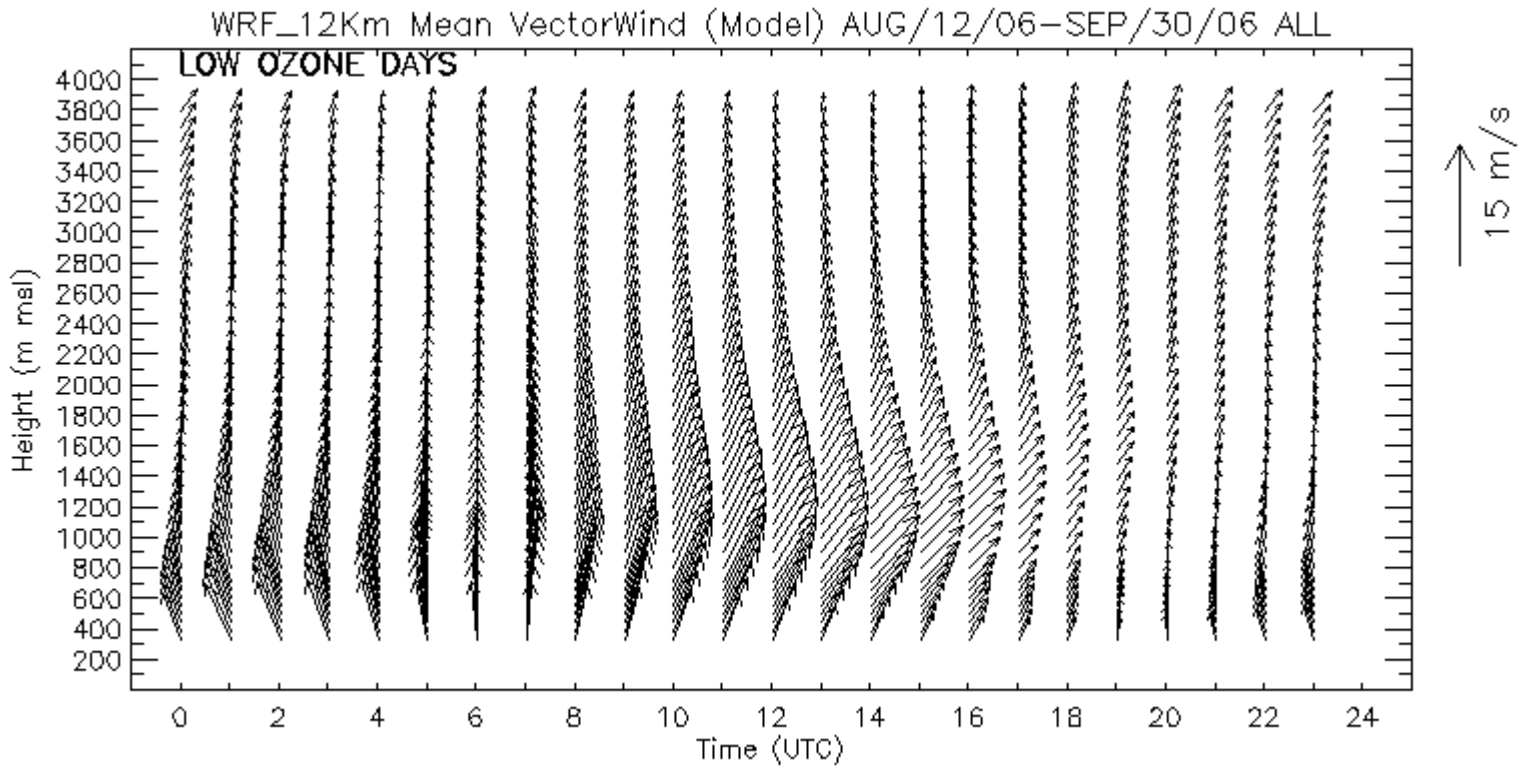

CMAQ_12Km Mean VectorWind (Model) AUG/12/06–SEP/30/06 ALL
HIGH OZONE DAYS
Height (m msl)
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (UTC)
15 m/s


WRF_12Km Mean VectorWind (Model) AUG/12/06-SEP/30/06 ALL
HIGH OZONE DAYS
Height (m msl)
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (UTC)
15 m/s


Observation Mean VectorWind AUG/12/06–SEP/30/06 ALL
LOW OZONE DAYS
Height (m msl)
Time (UTC)
15 m/s


CMAQ_12Km Mean VectorWind (Model) AUG/12/06–SEP/30/06 ALL
LOW OZONE DAYS
Height (m msl)
Time (UTC)
15 m/s


WRF_12Km Mean VectorWind (Model) AUG/12/06–SEP/30/06 ALL
LOW OZONE DAYS
Height (m msl)
Time (UTC)
15 m/s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2000
1800
1600
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (UTC)
15 m/s