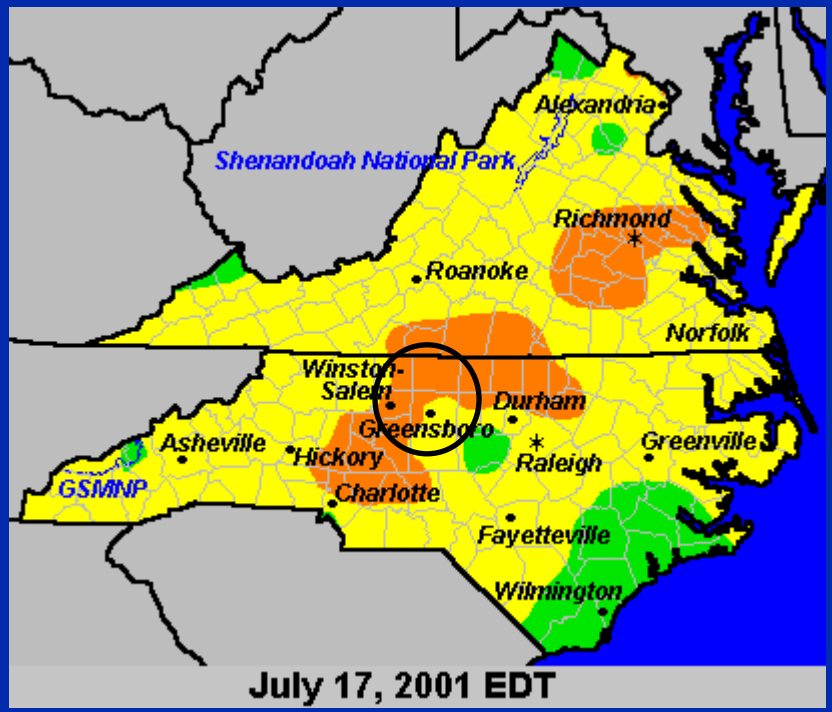
Case Studies of O_3 and $PM_{2.5}$ – Variation in North Carolina

OVERVIEW

- Demonstrate the differences between O_3 and $PM_{2.5}$ episodes
- Case 1: Stagnation with a twist
- Case 2: Ice Station Greensboro
- Case 3: Forecast “Jeopardy”
- Case 4: When the smoke alarm goes off...
- Putting it all together

Case Studies of O_3 and $PM_{2.5}$ – Variation in North Carolina

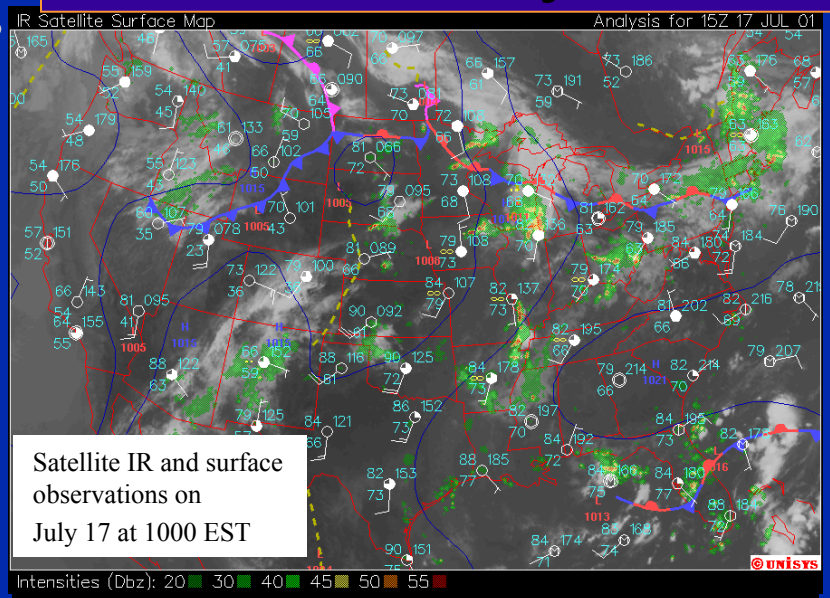


Episodes were selected to demonstrate the different processes that affect O_3 and $PM_{2.5}$ over a range of concentrations and seasons.

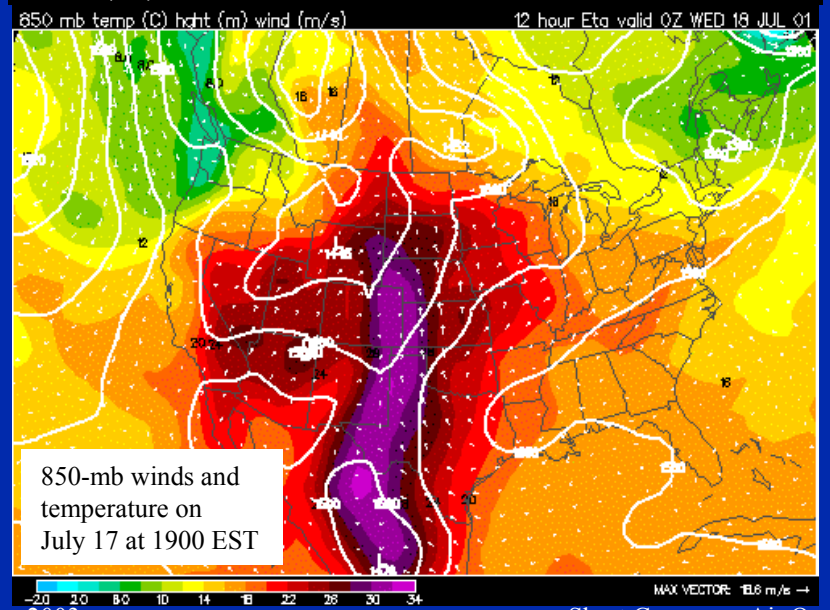
- Upper-air and surface patterns
- Vertical mixing and stability
- Transport conditions and source regions
- Clouds and precipitation
- Unusual events

Apply knowledge of meteorological processes and products to four “real-world” examples.

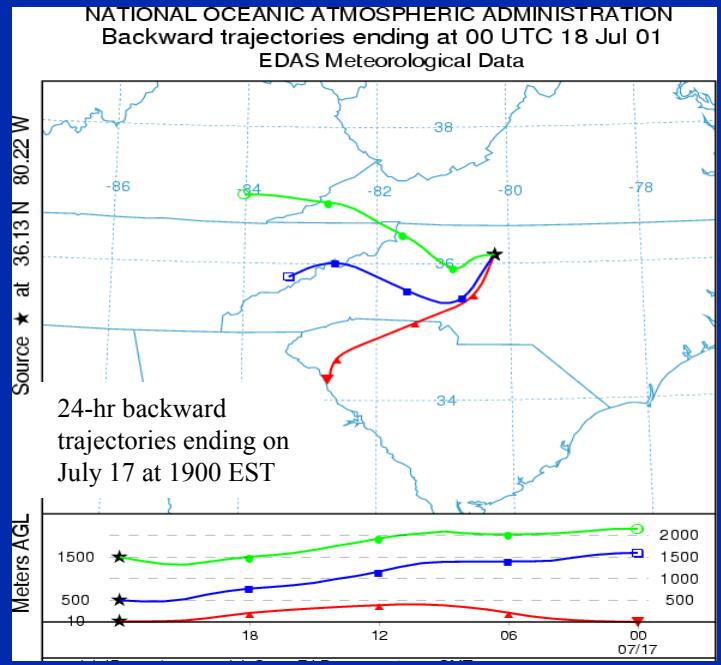
Case 1: Stagnation With a Twist
July 17 - 18, 2001 (1 of 3)



Satellite IR and surface observations on July 17 at 1000 EST



850-mb winds and temperature on July 17 at 1900 EST

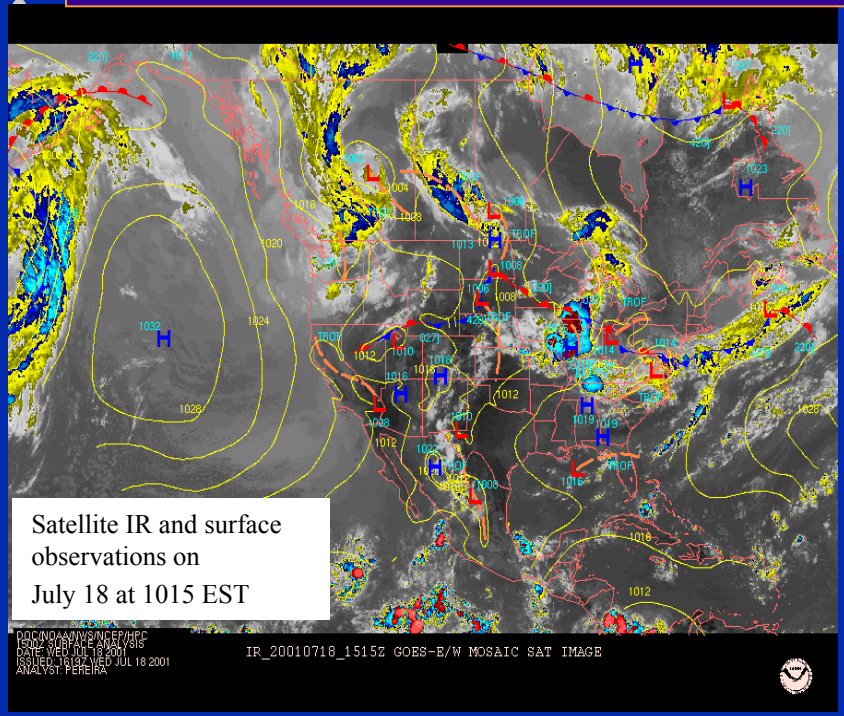


24-hr backward trajectories ending on July 17 at 1900 EST

July 17, 2001

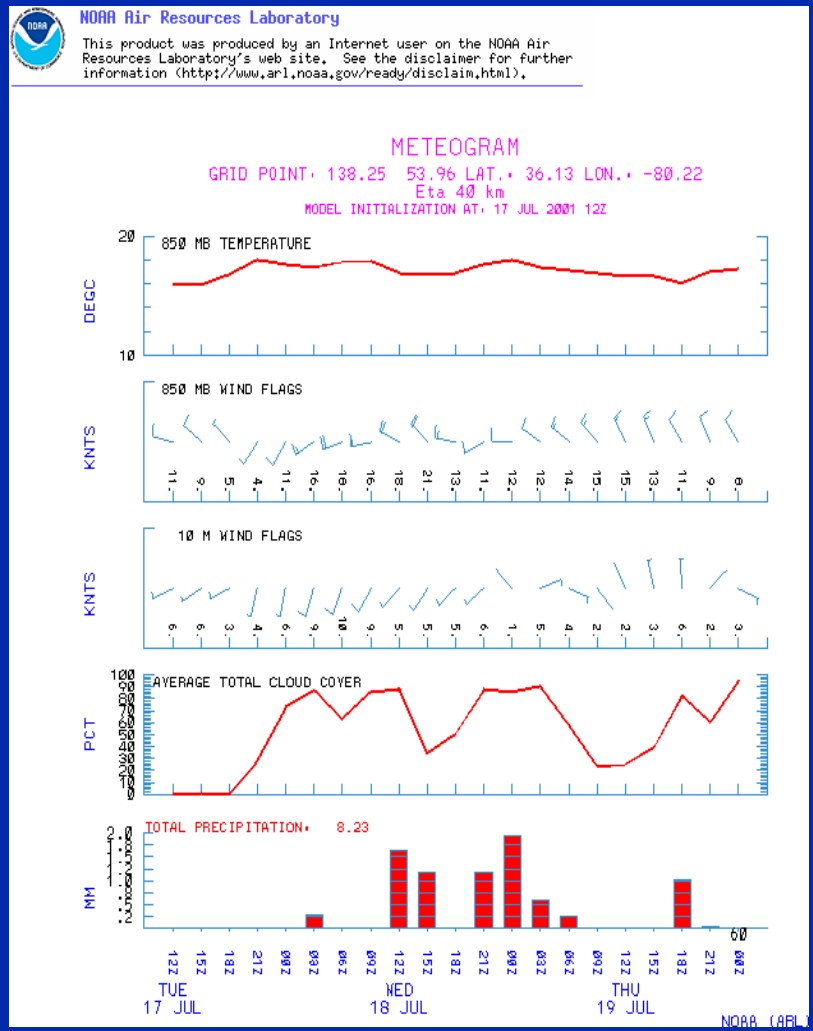
- Surface high and aloft ridge
- Warm temperatures at 850 mb
- Light winds with west-southwesterly trajectory
- Partly cloudy skies and low RH
- USG O_3 and Moderate $PM_{2.5}$

Case 1: Stagnation With a Twist
July 17 - 18, 2001 (2 of 3)



Satellite IR and surface observations on July 18 at 1015 EST

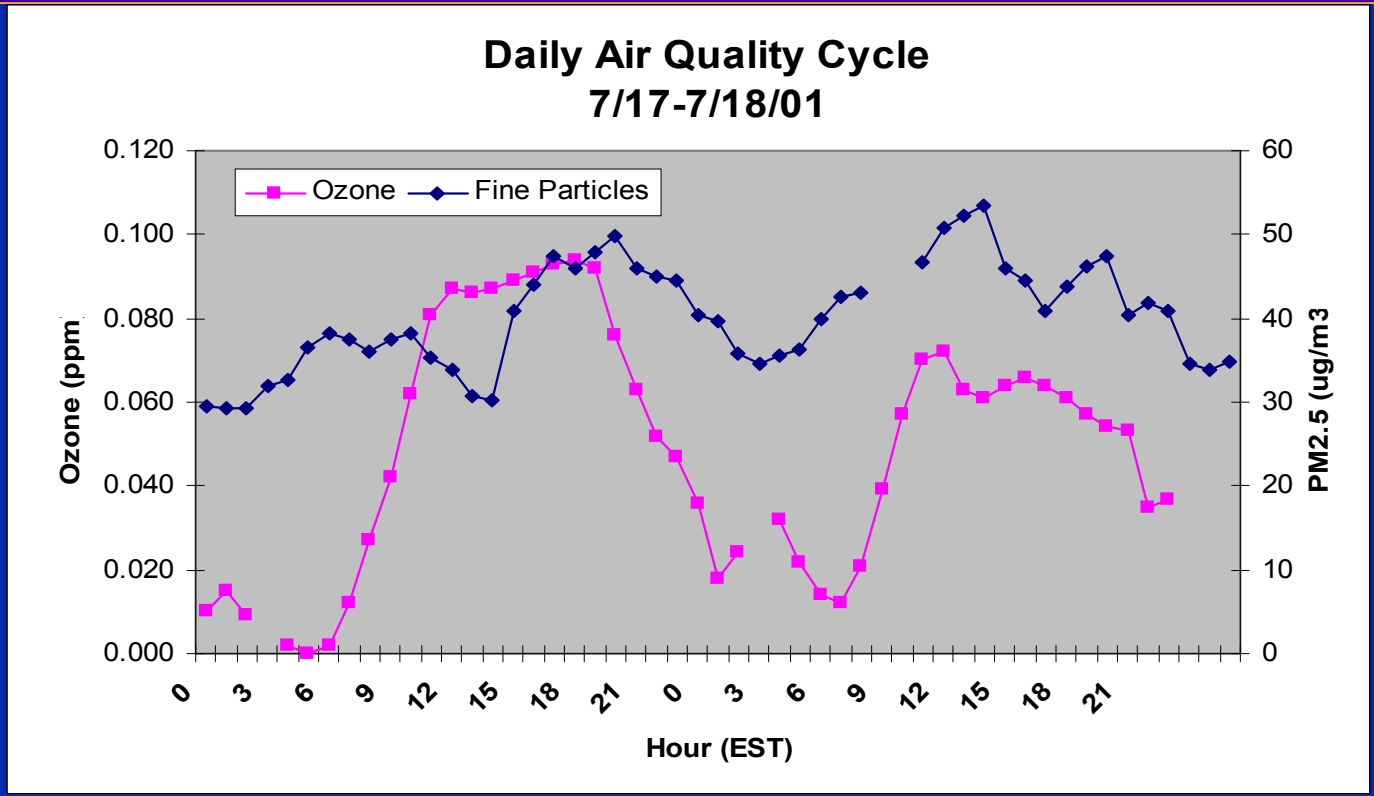
- High pressure ridge being "squeezed" from the north
- Increasing winds at 850 mb
- Clouds and precipitation move in
- Effect on air quality?



Meteogram for July 17 at 0700 EST through July 19 at 1900 EST.

July 18, 2001

Case 1: Stagnation With a Twist
July 17 - 18, 2001 (3 of 3)

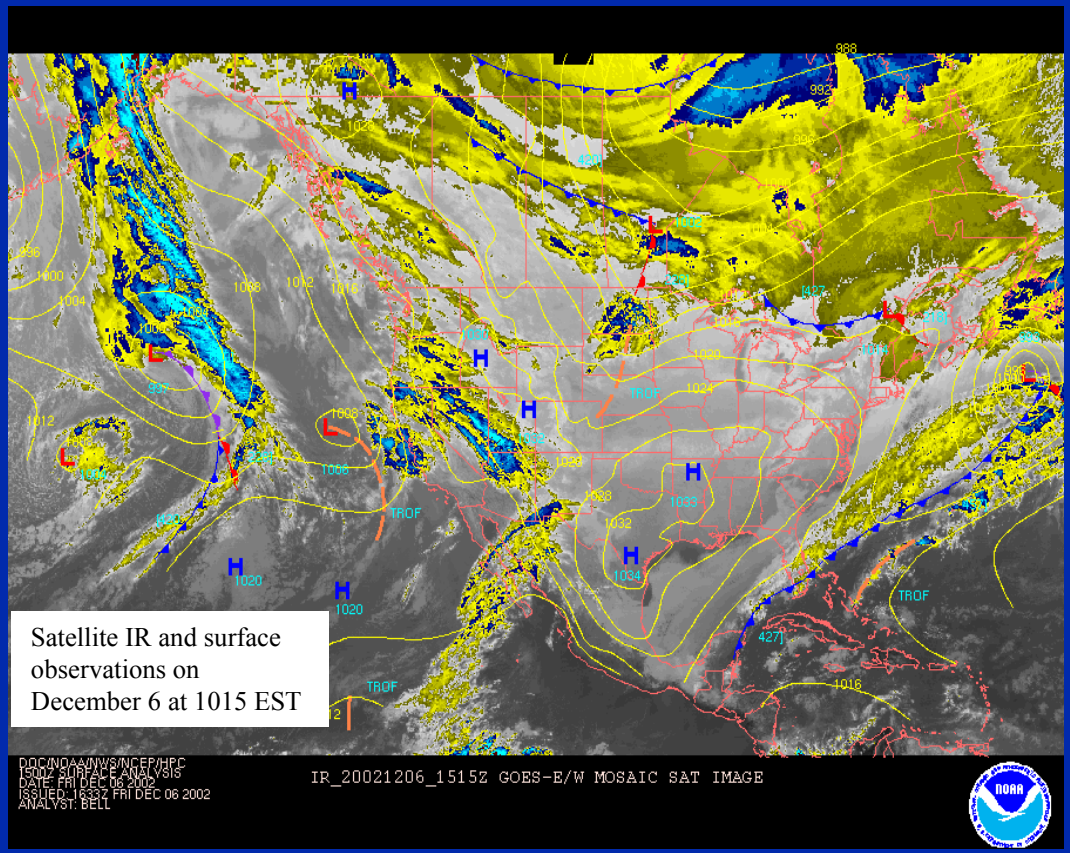


Daytime O_3 AQI

$PM_{2.5}$ AQI

Increasing cloud cover reduced ozone levels on 7/18. Continued light surface winds allowed $PM_{2.5}$ to rise as the stagnant air mass remained in place.

Case 2: Ice Station Greensboro
December 6 - 7, 2002 (1 of 3)

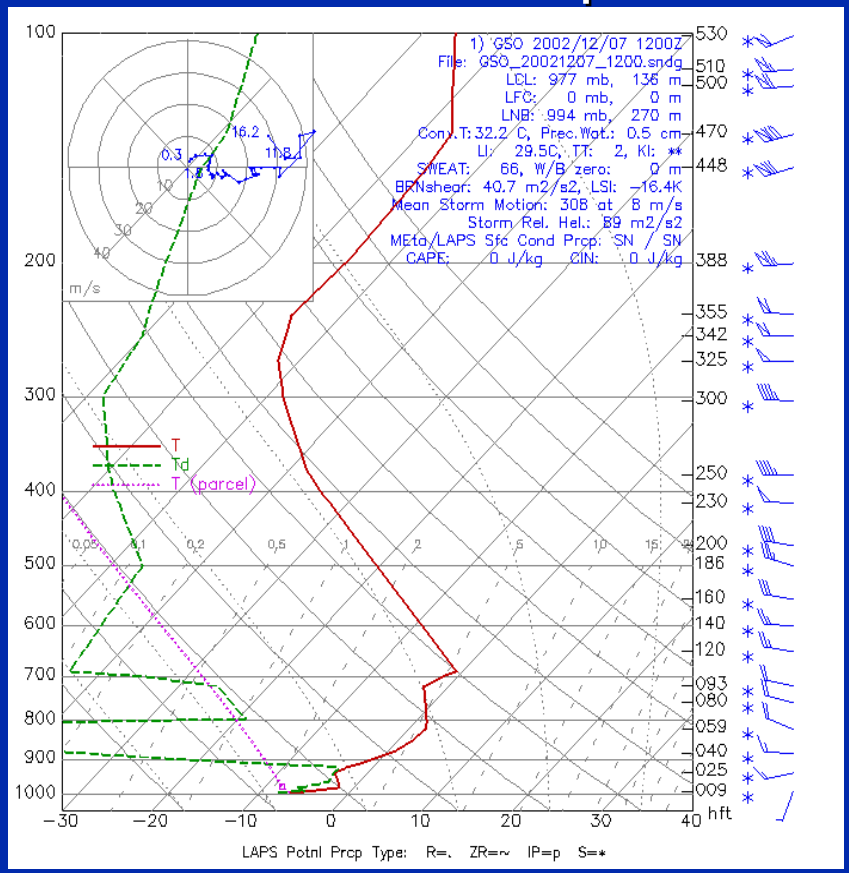


December 6, 2002

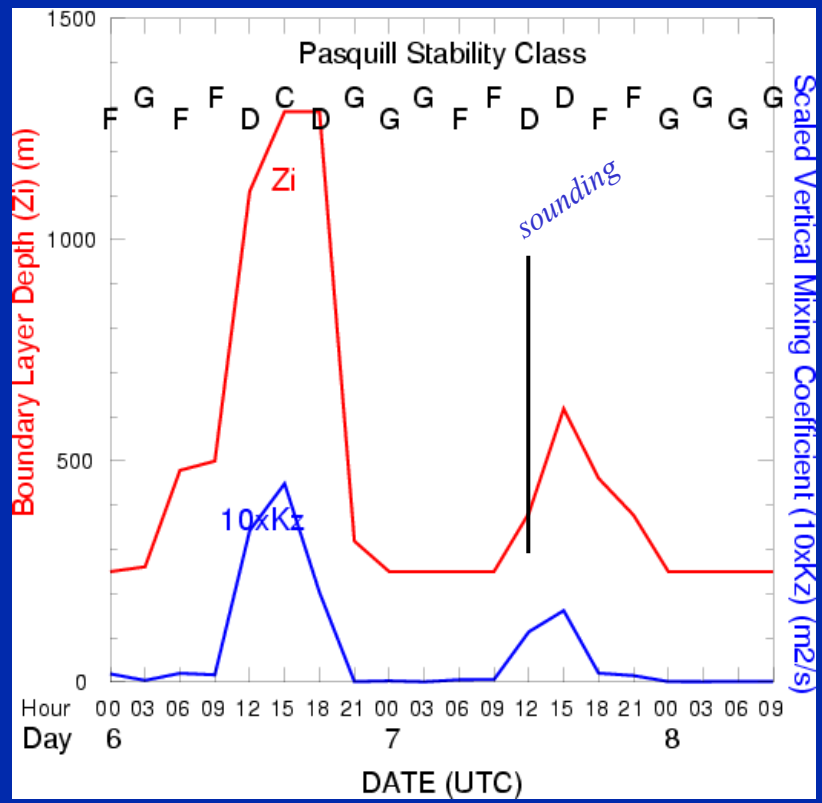
- Cold high pressure building over eastern U.S.
- Winds become lighter at the surface
- Clear skies
- Extensive ice and snow cover

Case 2: Ice Station Greensboro December 6 - 7, 2002 (2 of 3)

Inversion caps the nocturnal boundary layer



Temp. sounding on 12/7 at 0700 EST for Greensboro, NC.



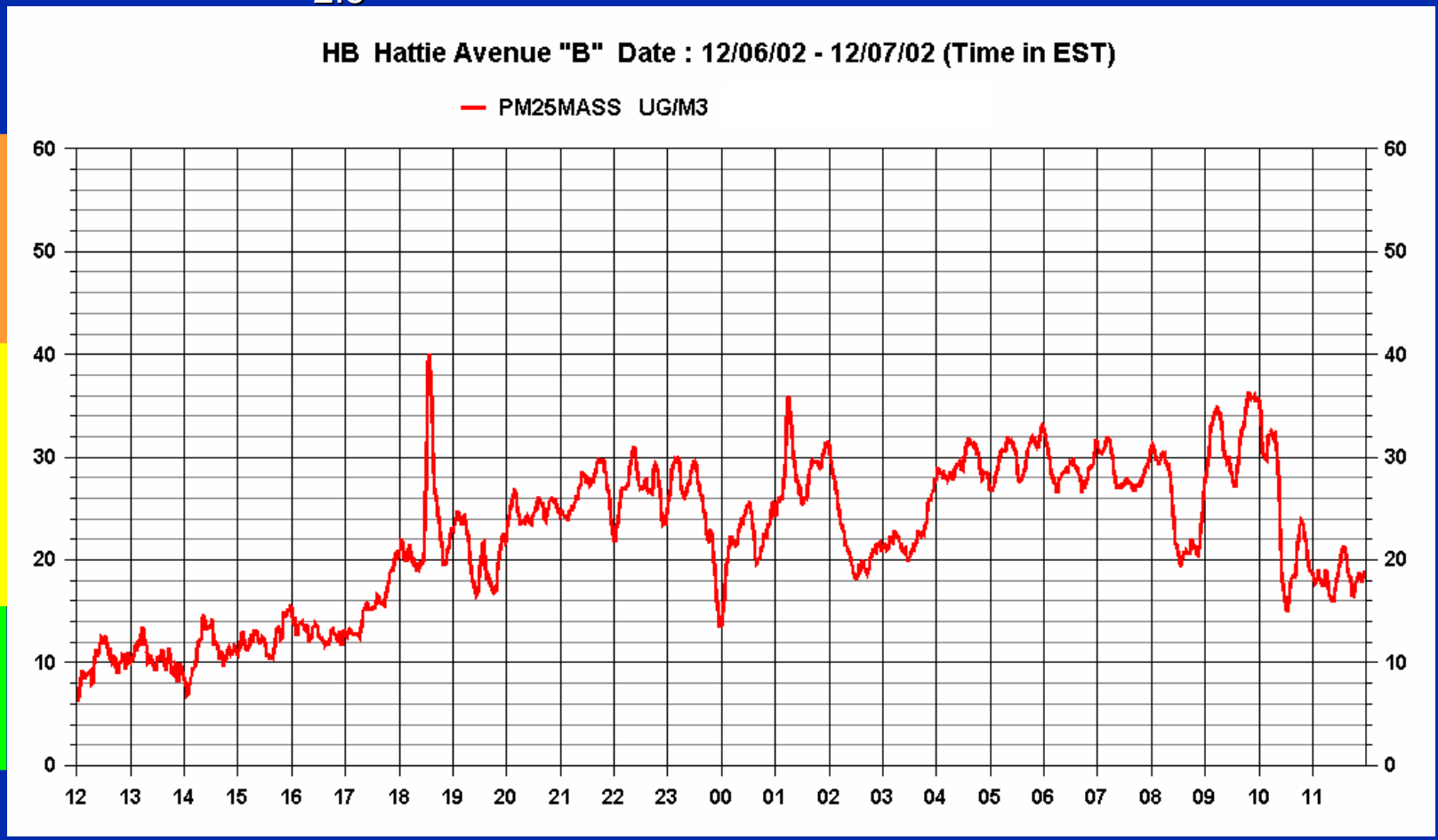
Mixing depth and stability class for 12/5 at 1700 EST (00 UTC on 12/6) through 12/8 at 0400 EST (09 UTC on 12/8).

December 7, 2002

Intense overnight inversion forms in the highly stable atmosphere. Emissions were trapped within the nocturnal boundary layer and reach higher concentrations.

Case 2: Ice Station Greensboro December 6 - 7, 2002 (3 of 3)

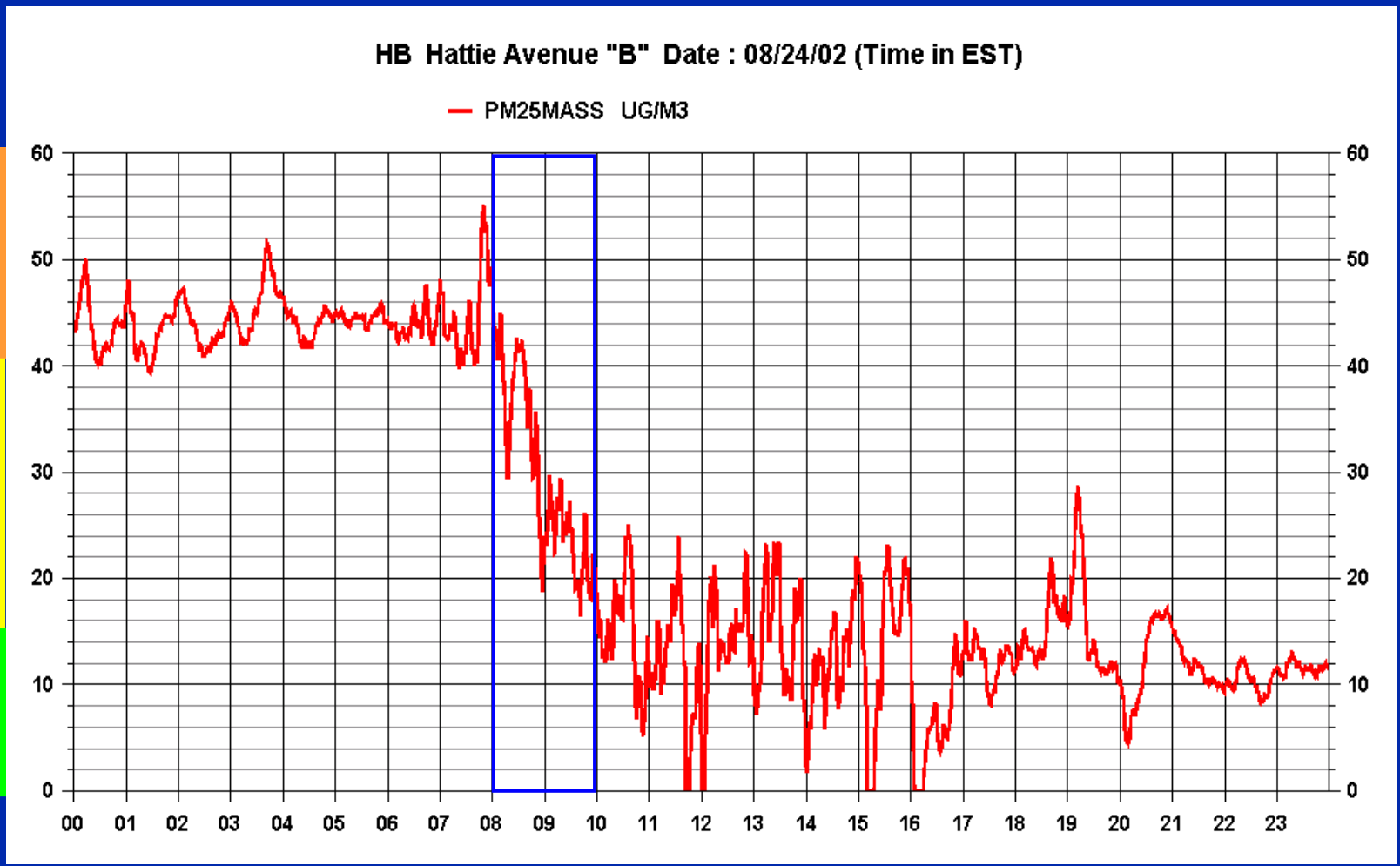
$PM_{2.5}$ increases from Good to Moderate



December 6 -7, 2002

Relatively clean (Code Green) air masses can be concentrated into Yellow or even Orange by intense nocturnal inversions during cold seasons.

Case 3: Forecast "Jeopardy" August 23 - 24, 2002 (1 of 4)

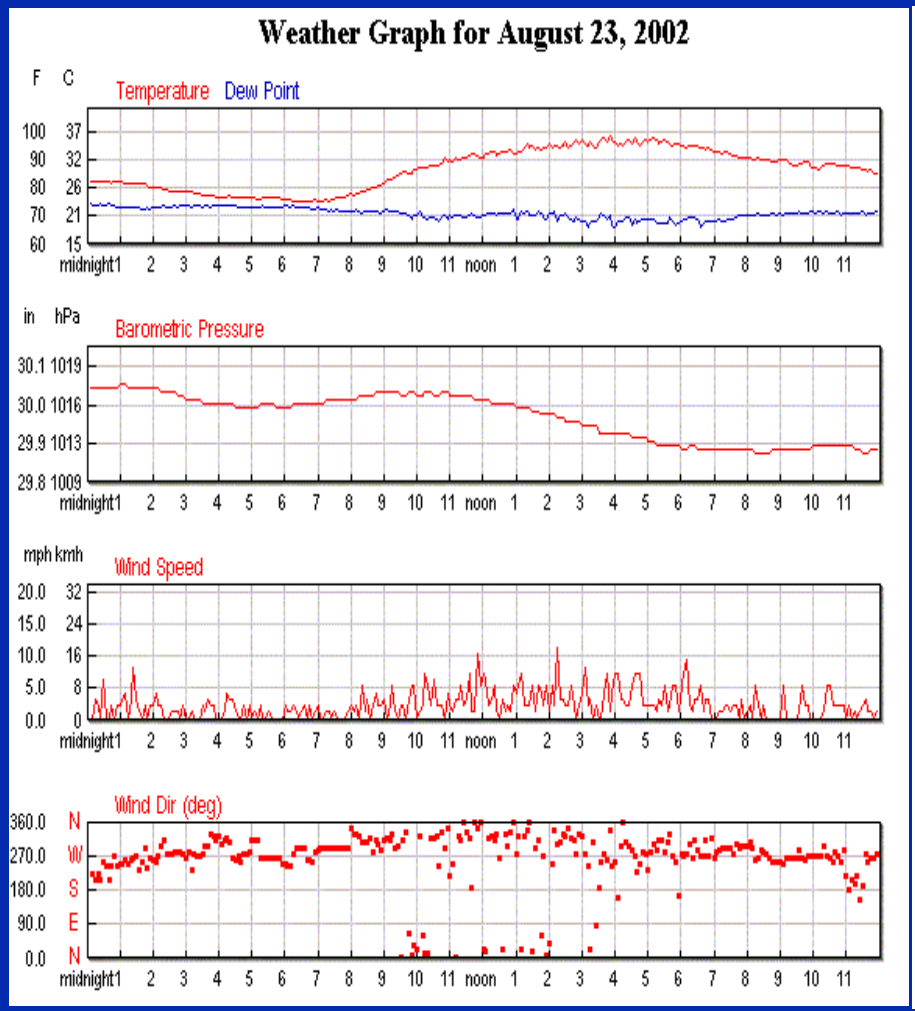


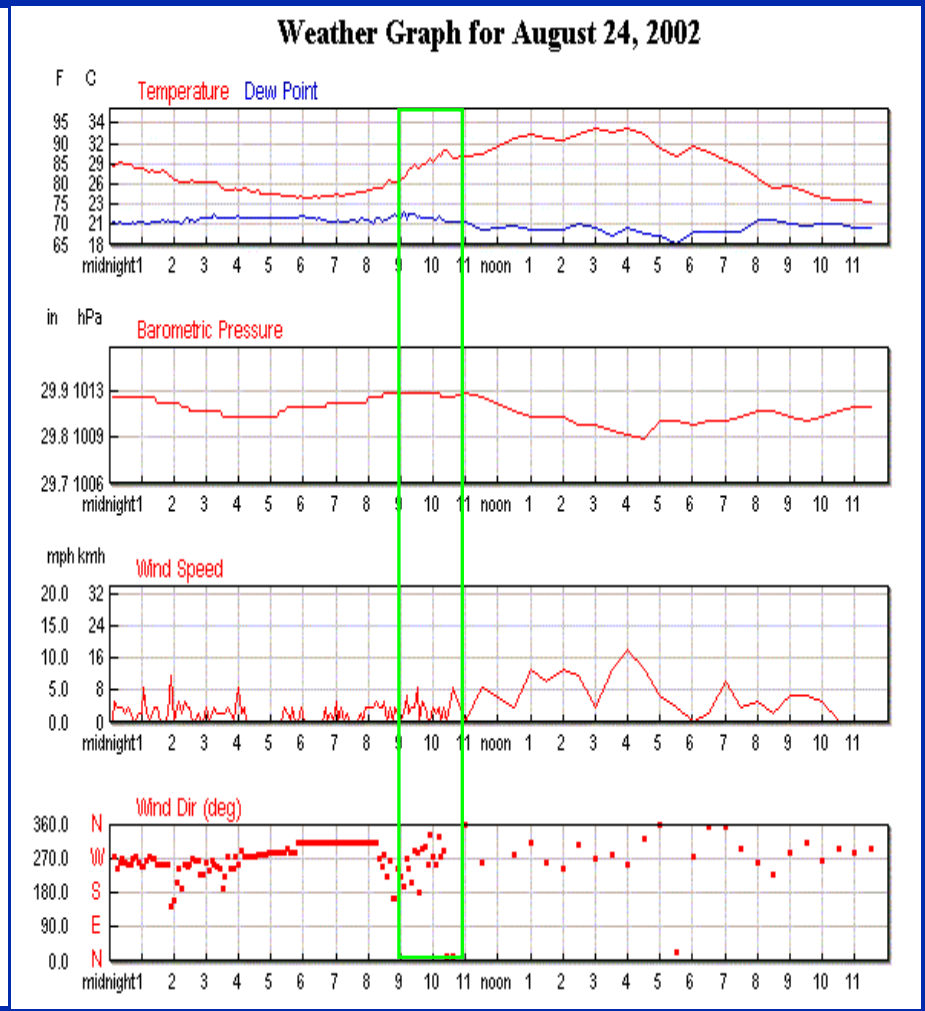
August 24, 2002

Code Orange level of $PM_{2.5}$ from 8/23 decreased dramatically between 0800-1000 EST on 8/24. What meteorological processes caused this change?

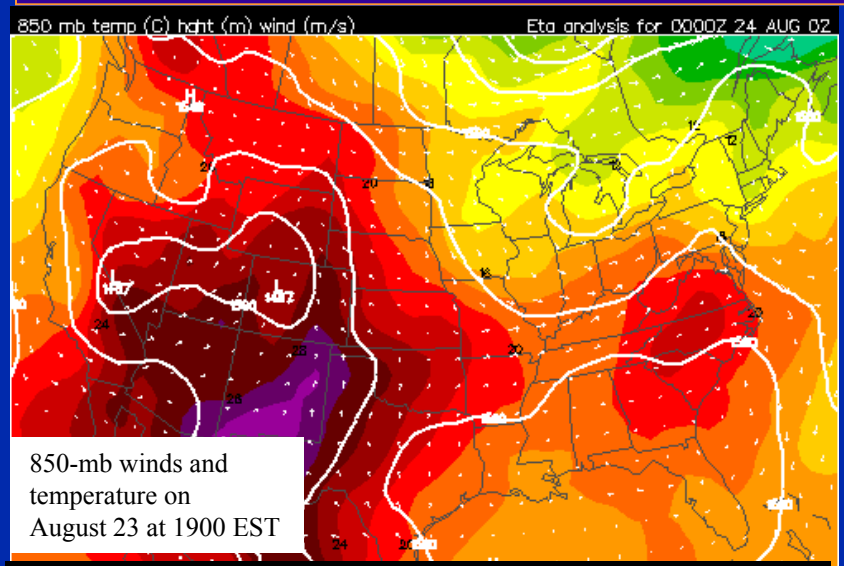
Case 3: Forecast "Jeopardy" August 23 - 24, 2002 (2 of 4)

Winston-Salem Observations (EDT)

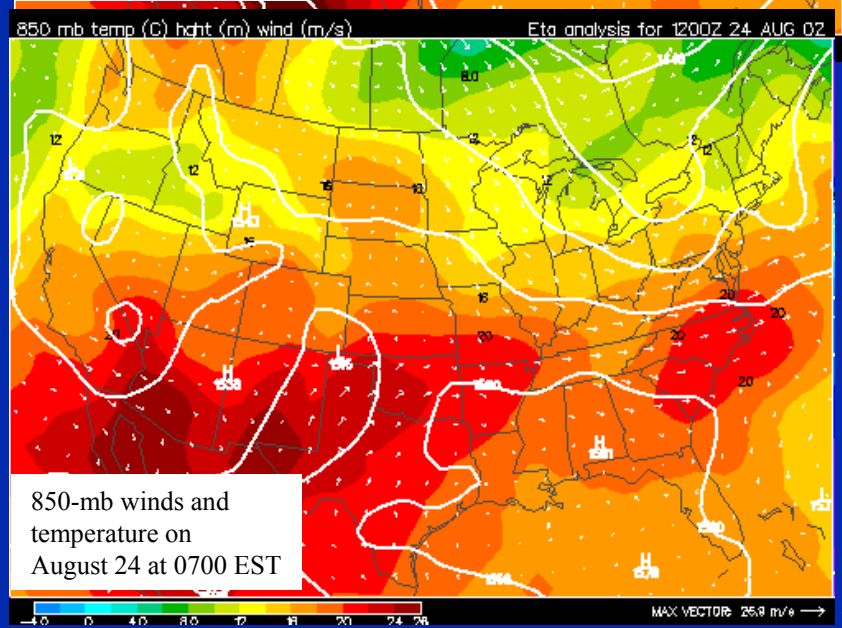




Case 3: Forecast "Jeopardy" August 23 -24, 2002 (3 of 4)

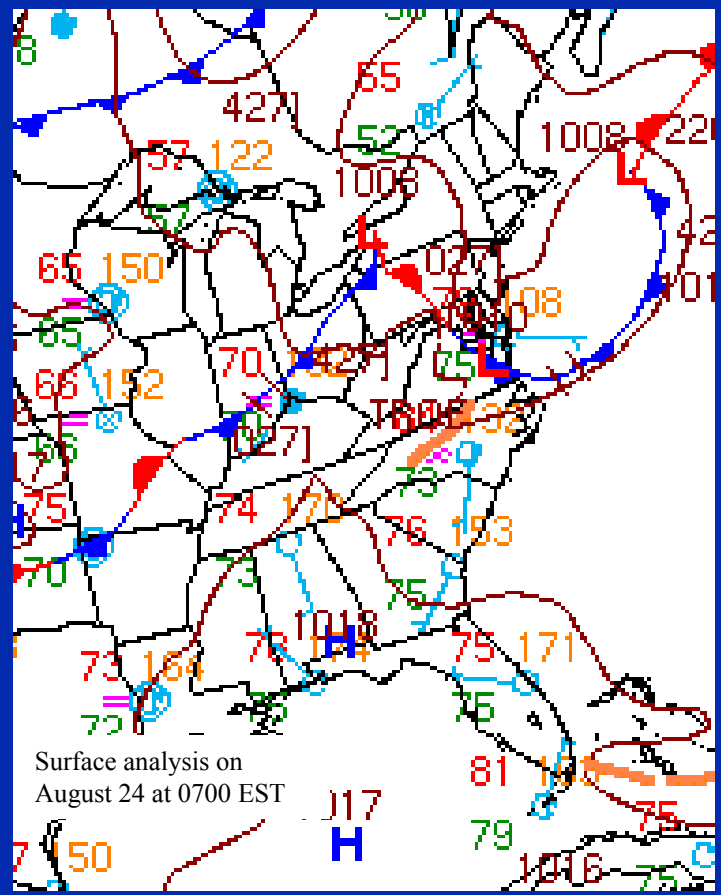


850-mb winds and temperature on August 23 at 1900 EST



850-mb winds and temperature on August 24 at 0700 EST

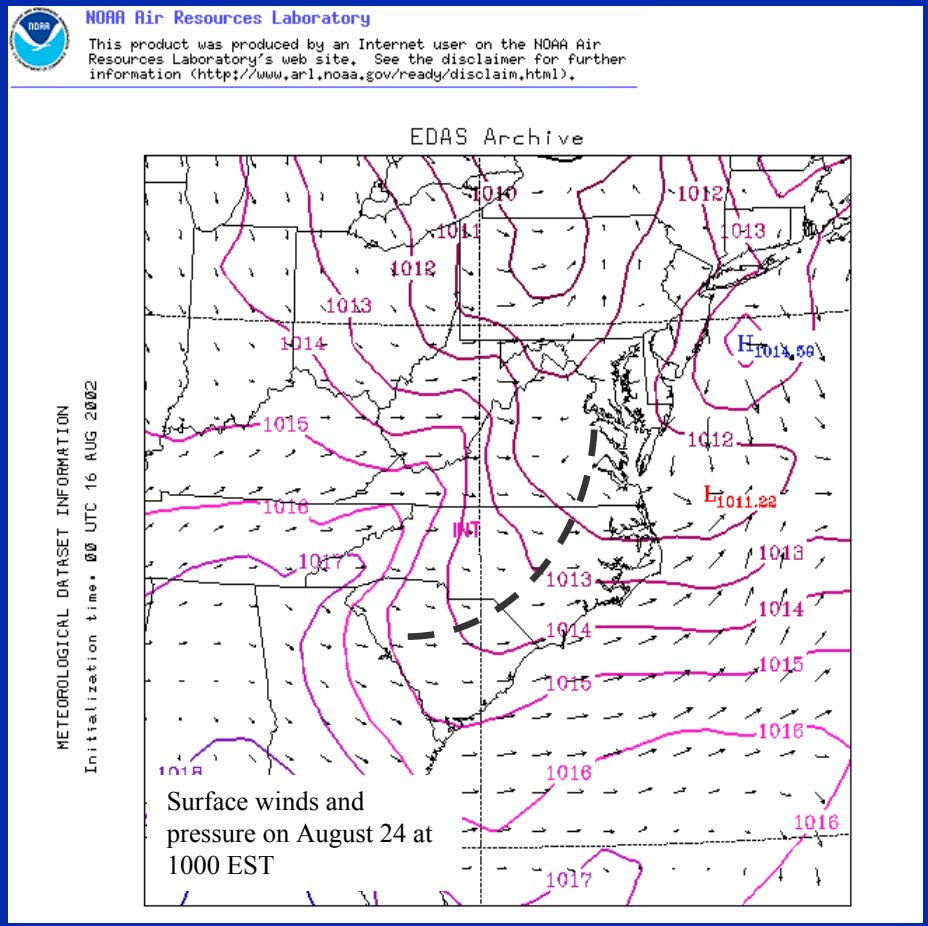
A subtle trough does the trick



Surface analysis on August 24 at 0700 EST

August 23-24, 2002

Case 3: Forecast "Jeopardy" August 23 -24, 2002 (4 of 4)



Surface winds and pressure on August 24 at 1000 EST

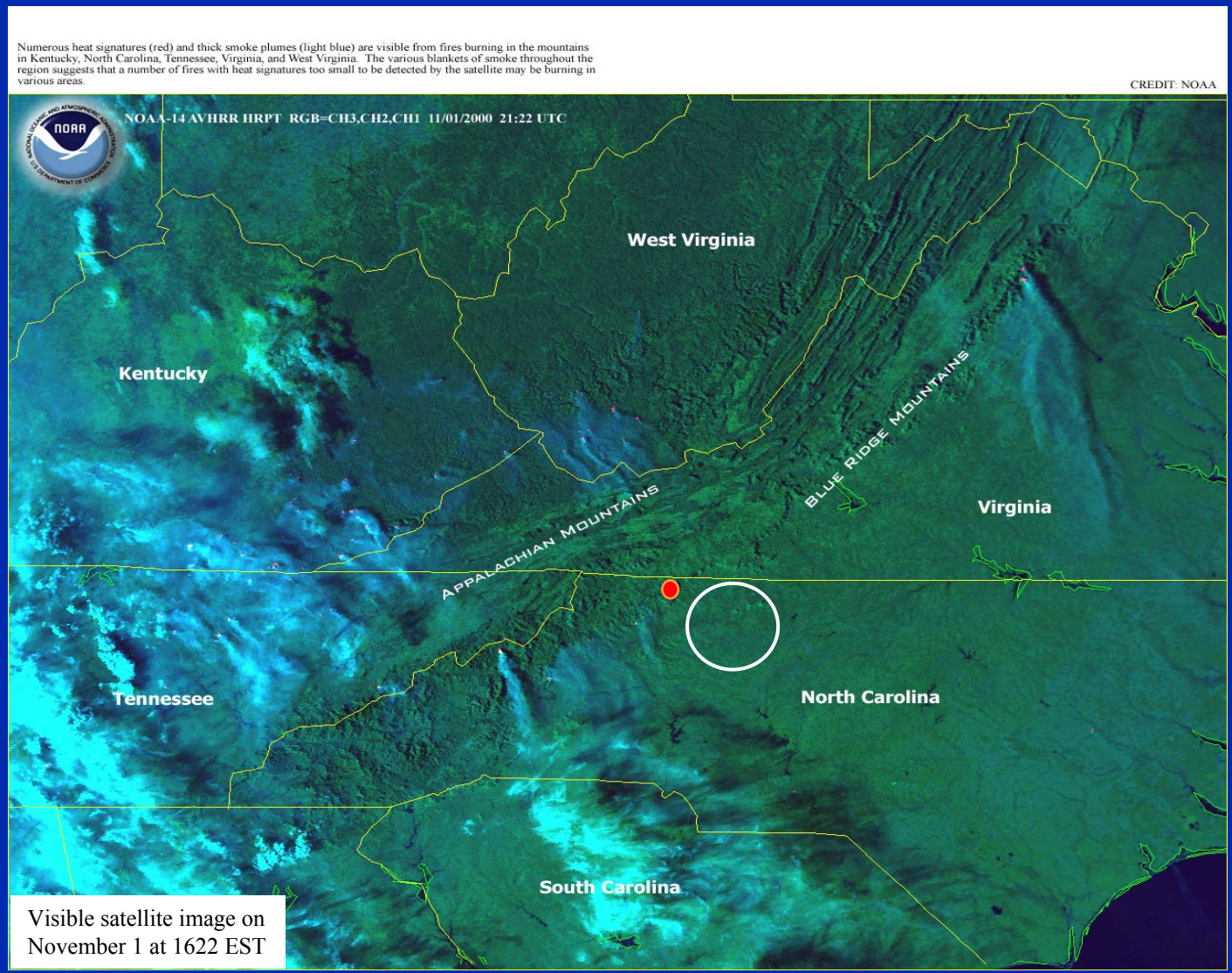
Troughs and Air Quality

Troughs can develop in the "lee" of mountains influencing the location of pollutant maxima.

- Falling surface pressure
- Low-level convergence
- Rising motion leading to clouds and precipitation
- Temporarily "stirs" the stagnant air masses

August 24, 2002

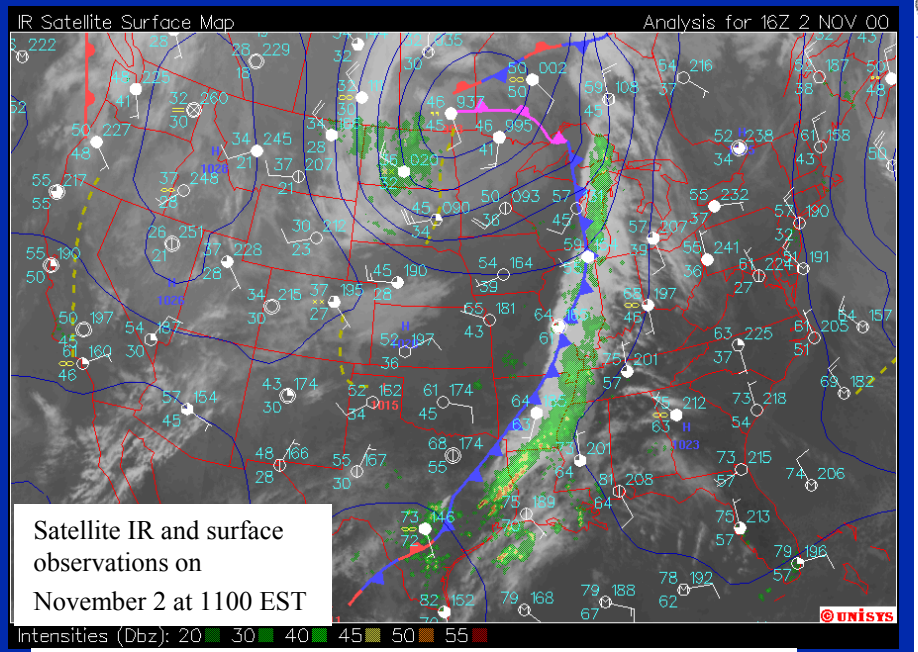
Case 4: When the Smoke Alarm Goes Off... November 2 - 5, 2000 (1 of 5)



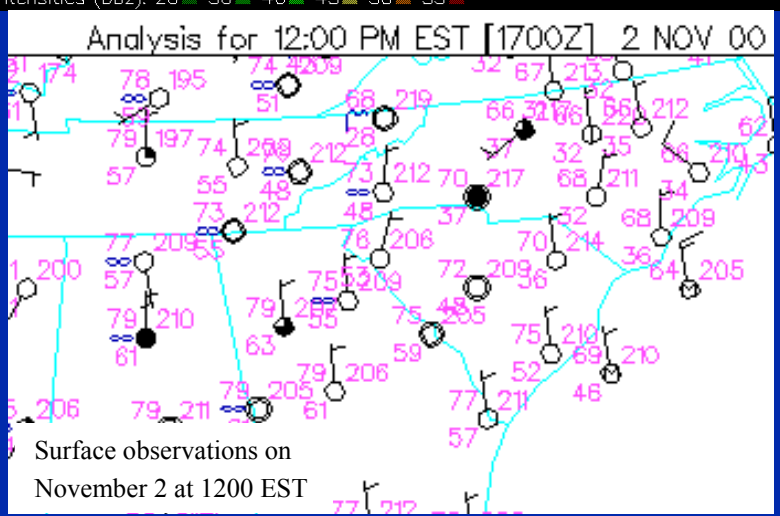
Visible satellite image on November 1 at 1622 EST

Case 4: When the Smoke Alarm Goes Off... November 2 - 5, 2000 (2 of 5)

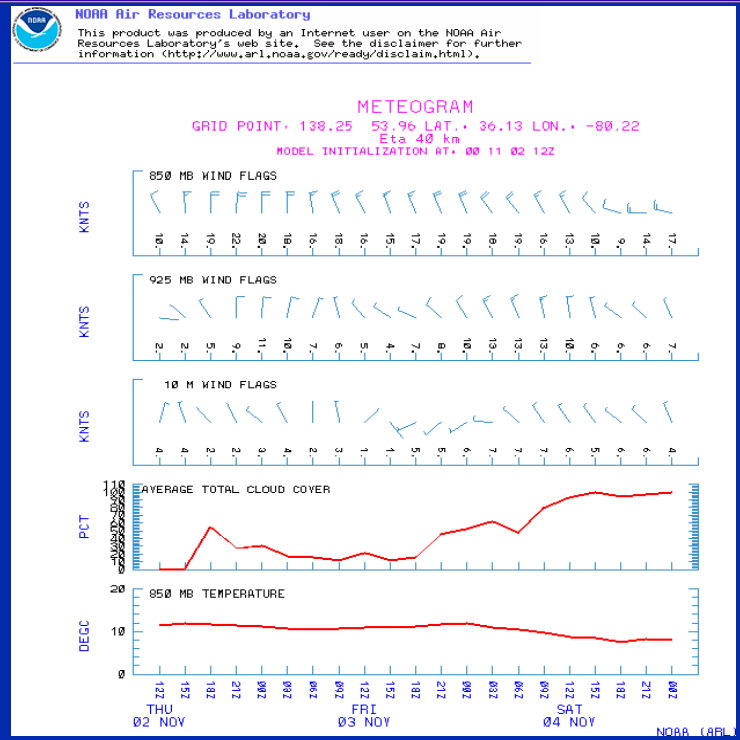
A benign weather pattern



Satellite IR and surface observations on November 2 at 1100 EST



Surface observations on November 2 at 1200 EST

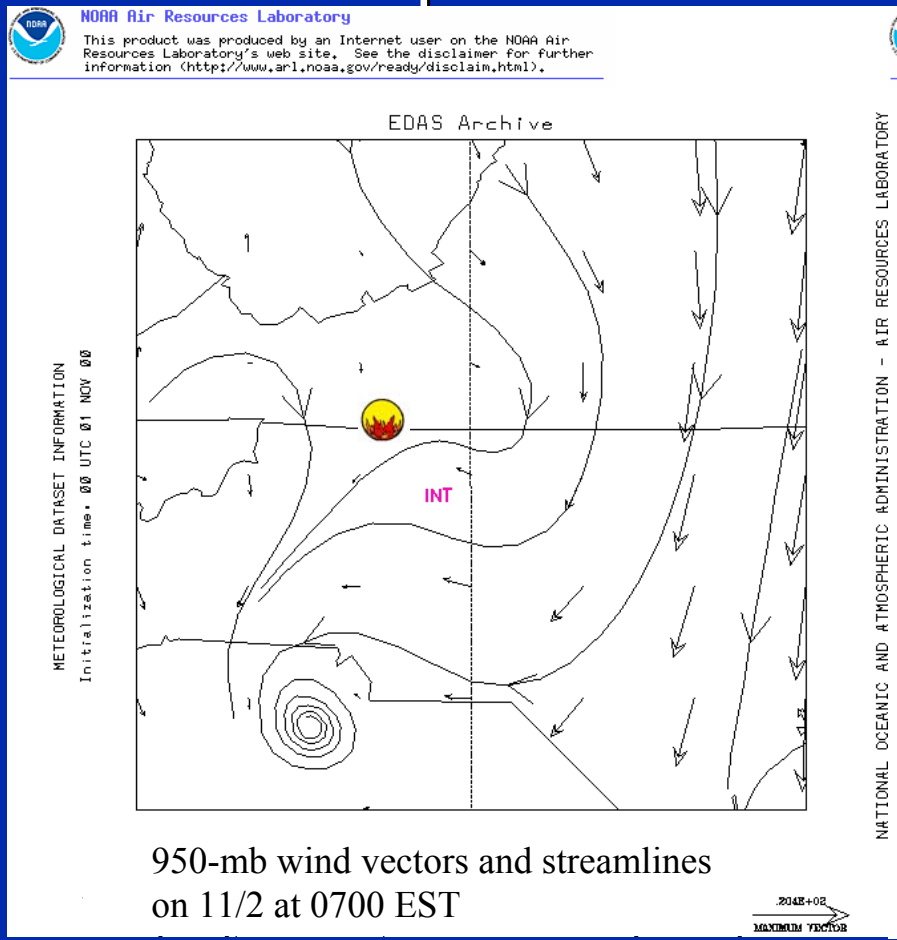


Meteogram for 11/2 at 0700 EST through 11/4 at 1900 EST

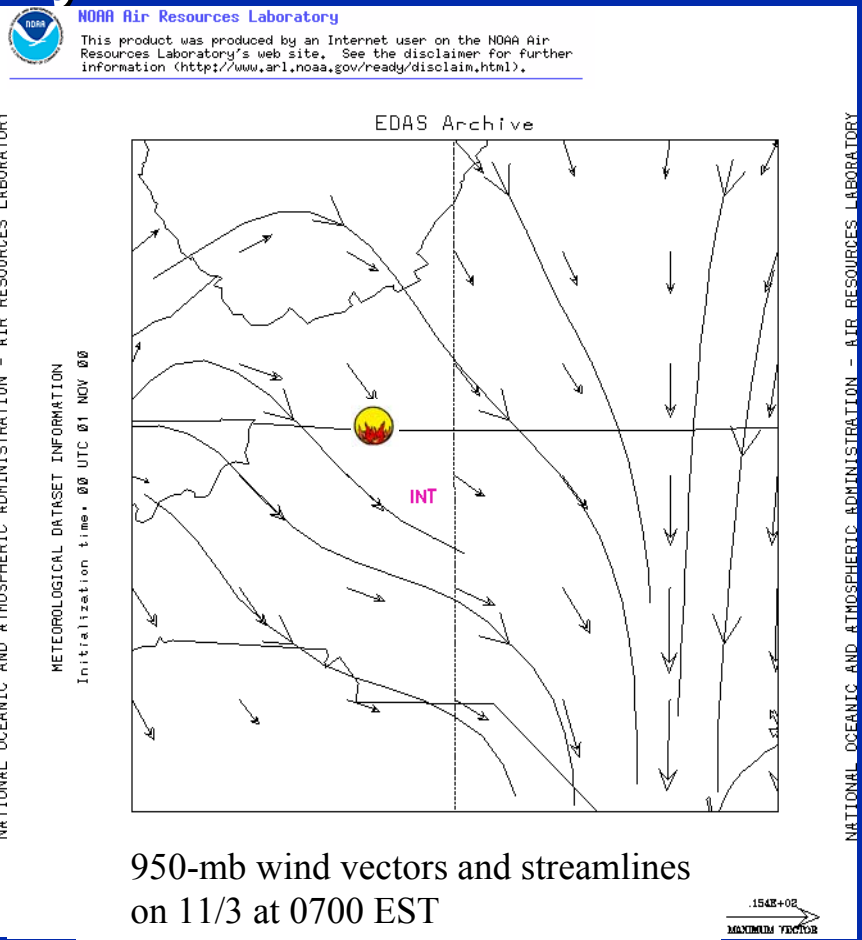
- Fairly strong ridging over the east
- Clear, warm conditions
- Light N/NE winds
- Slowly approaching cold front
- Mid-moderate $PM_{2.5}$ on 11/2/00
- Forecast for 11/3/00?

Case 4: When the Smoke Alarm Goes Off... November 2 - 5, 2000 (3 of 5)

Transport of smoke by winds caused…



950-mb wind vectors and streamlines on 11/2 at 0700 EST



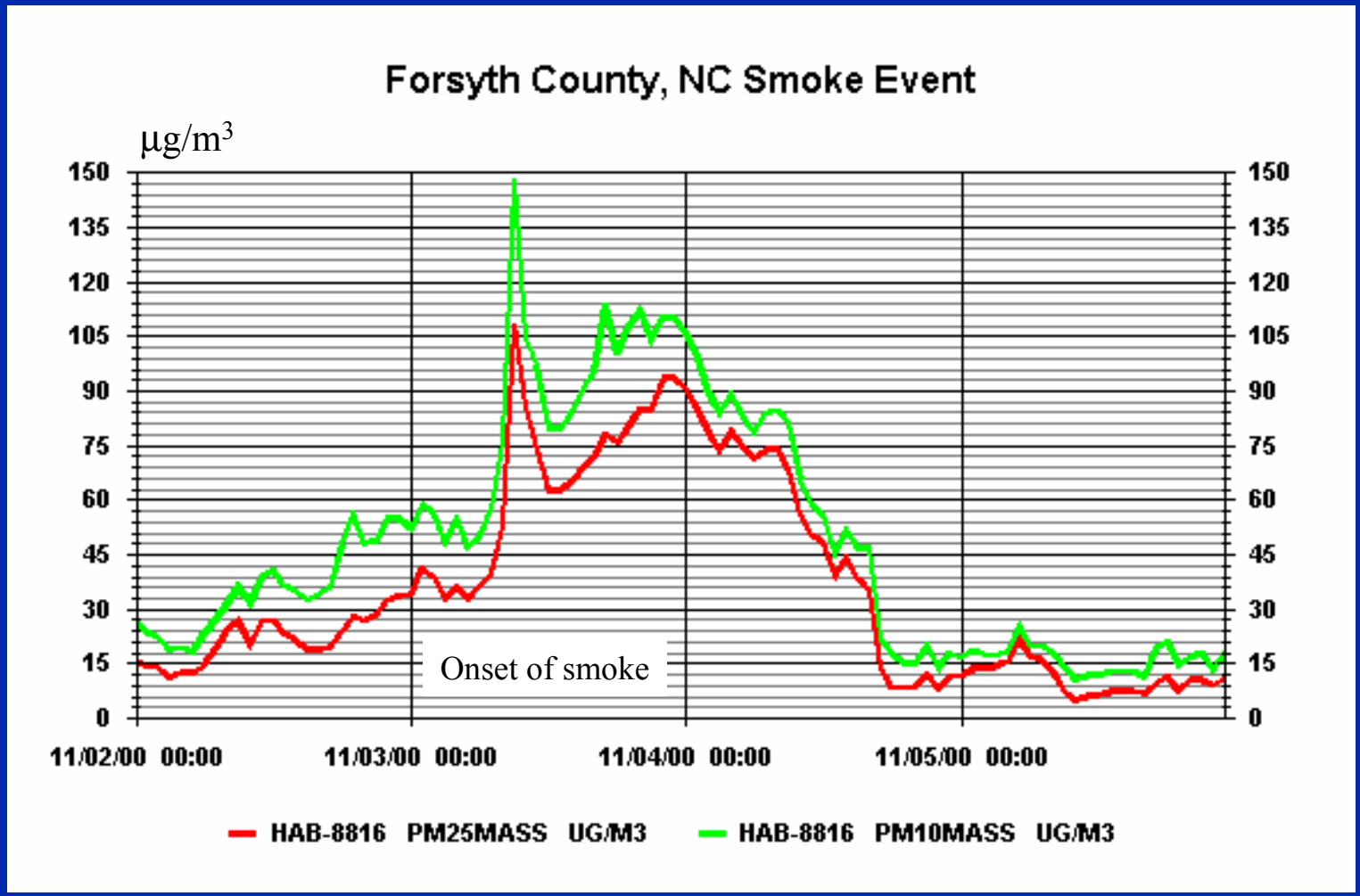
950-mb wind vectors and streamlines on 11/3 at 0700 EST

Relatively clean upstream flow from W.V. kept PM in mid-Moderate.

Wind shift overnight on 11/2-11/3 brought smoke "front" into Triad.

Case 4: When the Smoke Alarm Goes Off... November 2 - 5, 2000 (4 of 5)

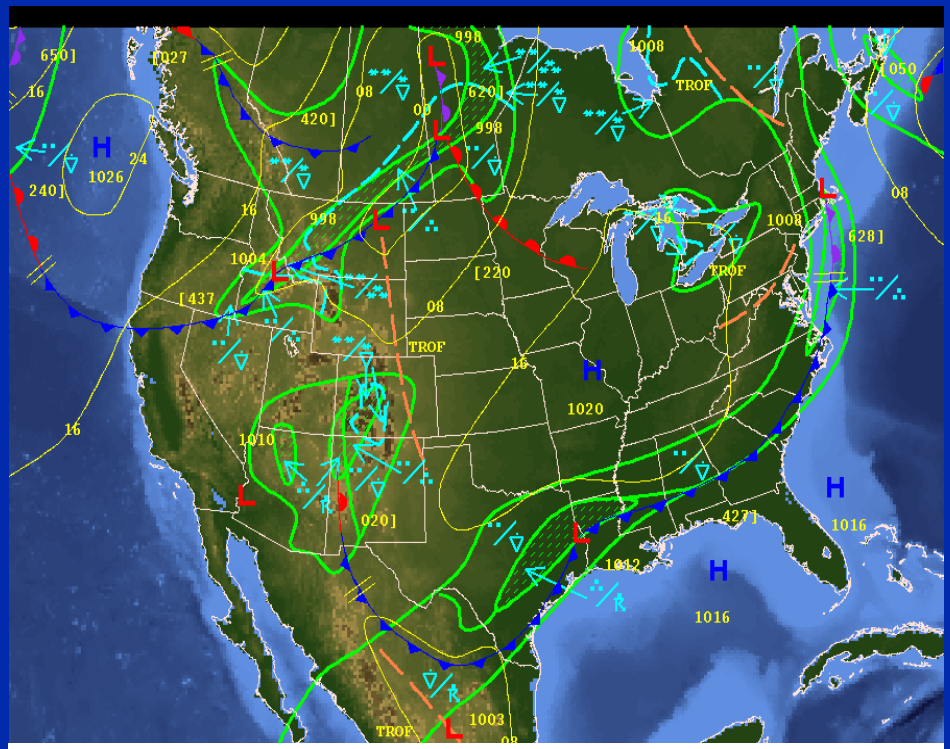
$PM_{2.5}$ levels reach Code Red



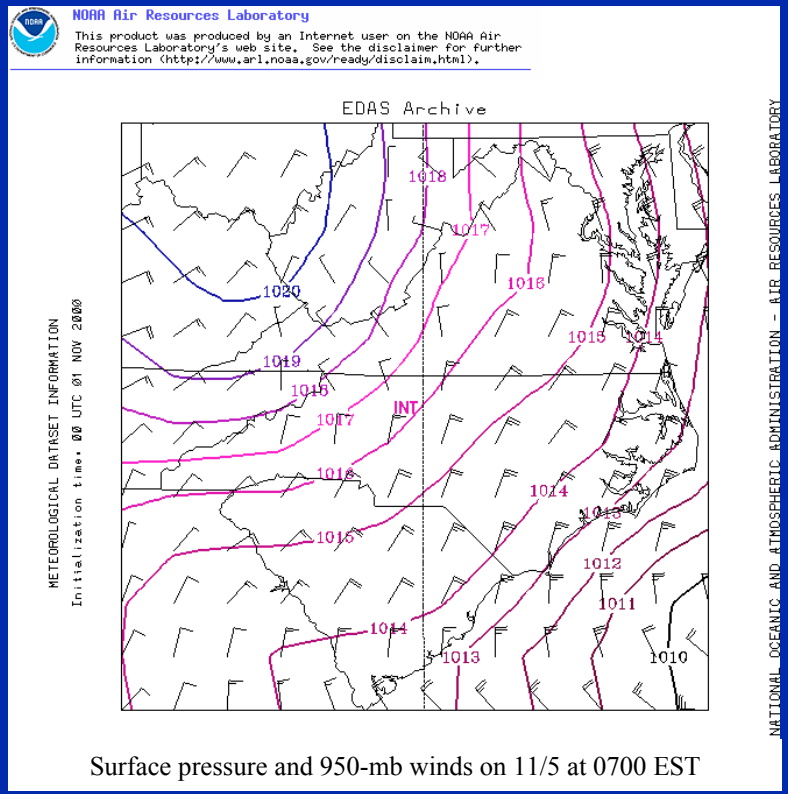
Key question: How long will the episode last? Need wind shift, increased speed, and increased mixing to dilute the air mass.

Case 4: When the Smoke Alarm Goes Off... November 2 - 5, 2000 (5 of 5)

Cold front to the rescue



NCEP 48-hour surface forecast valid on November 4 at 1900 EST



Surface pressure and 950-mb winds on 11/5 at 0700 EST

Cold frontal passage and high building in from the NW strengthened the pressure gradient, increased mixing, and steered winds away from the forest fire source region.

Putting it All Together

Process is important to case studies

Case #	UA Patterns	Surface Patterns	Inversion & Vertical Mixing	Winds & Transport	Clouds, Rain, Moisture	Unusual Events
1	****	***	***	***	***	*
2	***	***	****	**	**	*
3	***	****	**	***	**	*
4	**	***	***	****	**	****

* Lowest Importance
**** Highest Importance

Additional issues for forecast consideration

- Lake & sea breezes, mountain & valley effects
- "Calendar" effects (weekend, holiday, special events)
- Influence of nearby sources (point, mobile, area)
- Placement and treatment of continuous $PM_{2.5}$ data
- Influence of control and awareness programs (wood burning, ozone coalitions)

Summary

- Identify which processes are most important to your forecast.
- Anticipate the difference between O_3 and $PM_{2.5}$ behavior.
- Don't overlook subtle features – they can have big air quality impacts.

- Next step - Air Quality Forecasting Tools
- Questions