NOAA Technical Memorandum NWS ER-62

UNITED STATES OF AMERICA DEPARTMENT OF COMMERCE

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LOCALLY HEAVY SNOW DOWNWIND FROM COOLING TOWERS

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Scientific Services Division
Eastern Region Headquarters
December 1976

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(Continued On Inside Rear Cover)

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Robert M. White, Administrator

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George P. Cressman, Director

LOCALLY HEAVY SNOW DOWNWIND FROM COOLING TOWERS

Reese E. Otts
WSFO Charleston, West Virginia

1. INTRODUCTION

Previous studies have speculated about the environmental impact of cooling towers at power plants. Of particular concern has been the extent to which heat and moisture pollution may influence the behavior of the atmosphere. Hanna and Swisher (1971) concluded that the heat and moisture pollution from a power center could be of sufficient magnitude to affect the atmosphere significantly in the mesoscale.

2. OBSERVATIONS

Two locally heavy snowfalls were observed near Charleston, West Virginia in synoptic situations which experienced forecasters normally associate with light snowfall or snow flurry activity. In both cases, the heaviest snowfall occurred downwind from the John E. Amos Power Plant (2900 MWe), a complex that includes three of the largest cooling towers in the United States. The power plant is located about fifteen miles west northwest of Kanawha County Airport, the location of the National Weather Service observation site.

Informal visual observations in the first case led to speculation that the cooling towers may have contributed to the heavier snowfall. In the second case, observations by National Weather Service personnel and others provided stronger evidence that the cooling towers may have contributed to the heavy snowfall.

In the first case, on December 22, 1975, the Kanawha County West Virginia Sheriff's Communications Center reported one to two inches of snow in the South Charleston/St. Albans area at 4:00 A.M. EST, with heavy snow still in progress. No other locations in West Virginia were reporting heavy snow. The National Weather Service at Kanawha Airport, about four miles northeast of the area mentioned, reported only very small snowflakes with no accumulations. Consequently, the heavy snowfall was attributed to a local shower which was forecast to soon end.

However, by 7:00 A.M., the localized storm was continuing with accumulations estimated of three to five inches. Using all available data, the area of heavy snow was estimated to be about eight miles wide and twenty miles long (Figure 1.). The West Virginia Department of Highways reported the only road problems in the state were in that area. Documentation as to the actual extent was poor.

During this snowfall, cooling tower No. 2 at the Amos Plant, was not operative, tower No. 1 was operating at about 90% of full capacity, and tower No. 3 at about 80%. The average amount of water evaporated from the three towers at full capacity is 19,000 gallons per minute as described by Smith et al.

In the second case, the snow began about 7:00 A.M. EST, January 4, 1976. By 9:00 A.M., over two inches of snow had fallen on the ridge that runs parallel to the Kanawha River, just north of downtown Charleston. South of the river, there was no snowfall and the sun was visible most of the morning. Snow accumulation was over by 1:00 P.M.

Reliable snow depth measurements taken at 12:00 noon, January 4, 1976, were obtained from Office of Emergency Services volunteer weather observers. As their reports were plotted, a pattern emerged. Subsequently, calls were made to schools, rural post offices, service stations, and others who might have measured the snowfall. A well defined area was revealed (Figure 2.). Two inches or more occurred in about 100 square miles (two to four miles wide and twenty-five miles long). Within this area was a narrow band (one to two miles wide and twelve miles long) with depths of four to six inches. The National Weather Service at Kanawha Airport was in the band of heavier snow with four inches on the ground by noon. Although light showers did occur elsewhere in the state, no snowfall of more than one inch was reported over West Virginia that day. During this heavy snowfall, all three cooling towers at the Amos Power Plant operated at about two-thirds capacity until 8:00 A.M. and at full capacity after 8:00 A.M.

In the cases described, the snowfall occurred almost directly downwind from the Amos Power Plant. Winds aloft from Huntington, West Virginia upper air soundings indicated the average winds from 1,000 feet to 4,000 feet were compatible with the plume from the plant being blown over the heavier snowfall areas (Figures 1. and 2.).

In the first case, the winds were from the north northwest with the heavy snow occurring to the south southeast of the power plant. In the second case, the winds were from the west at the lowest levels veering to west northwest at 4,000 feet. The heavy snow occurred east southeast of the plant.

3. DISCUSSION

Evidence is presented which indicates that moisture and heat added to the atmosphere by large cooling towers may contribute significantly to heavy snowfalls in localized areas of West Virginia. Given favorable atmospheric conditions and proper geographical settings, mesoscale atmospheric phenomenons may be significantly influenced by the discharge from large cooling towers.

Close examination of the two cases presented here indicates that a low-level temperature inversion is a key meteorological factor (Figures 3, and 4.). Moist unstable air below the inversion was separated from dry, relatively stable air above. The input of heat and moisture from near the surface would have been trapped below the inversion and would have contributed to the precipitation processes in the lower layers of the atmosphere. With the occurrence of precipitation, latent heat released through the process of condensation could further contribute to instability and enhance the precipitation processes.

Both heavy snow events occurred in a penetrating cold air mass characterized by cyclonic curvature of the flow pattern. This most often occurs in the region during post cold-frontal situations following the northeast movement of a low-pressure center.

The average temperature of the layer from the ground to the bottom of the inversion was about minus 12°C, a temperature that is very favorable for nucleation and precipitation formation.

Geographical influences were likely involved. As the air moved toward the east and southeast over more rugged terrain, orographic lifting probably occurred. The importance of this effect cannot be determined here, but further observations of the effects of cooling towers in relatively flat terrain should verify or negate this proposal.

4. SUMMARY

Conditions favoring the development of locally heavy snows downwind from cooling towers appear to be as follows:

a. A strong influx of cold air into the area.

b. High relative humidity and an unstable lapse rate in the lower layers of the atmosphere.

c. A strong inversion layer near 5,000 feet (1,500 meters), topping the unstable lower layer.

d. Cyclonic curvature of the flow pattern.

e. An average temperature of minus 10°C or colder in the lower layer (from the ground to the bottom of the inversion).

f. Some initial orographic lifting or some other type of forced ascent to the airflow.

Strongest effects occur downwind from the source near the axis of the mean wind in the 1,000 - 4,000 foot layer.

5. CONCLUSIONS

Two heavy snowfalls near Charleston, West Virginia appear to have been induced by large cooling towers. In each case similar meteorological and geographical conditions prevailed. Mesoscale phenomena may be significantly influenced by large man-made sources of heat and moisture.

Forecasters suspecting such influences in their area should closely inspect the precipitation patterns when favorable conditions exist. Knowledge of these influences can provide the potential for "fine-tuning" the local weather forecasts.

ACKNOWLEDGMENTS

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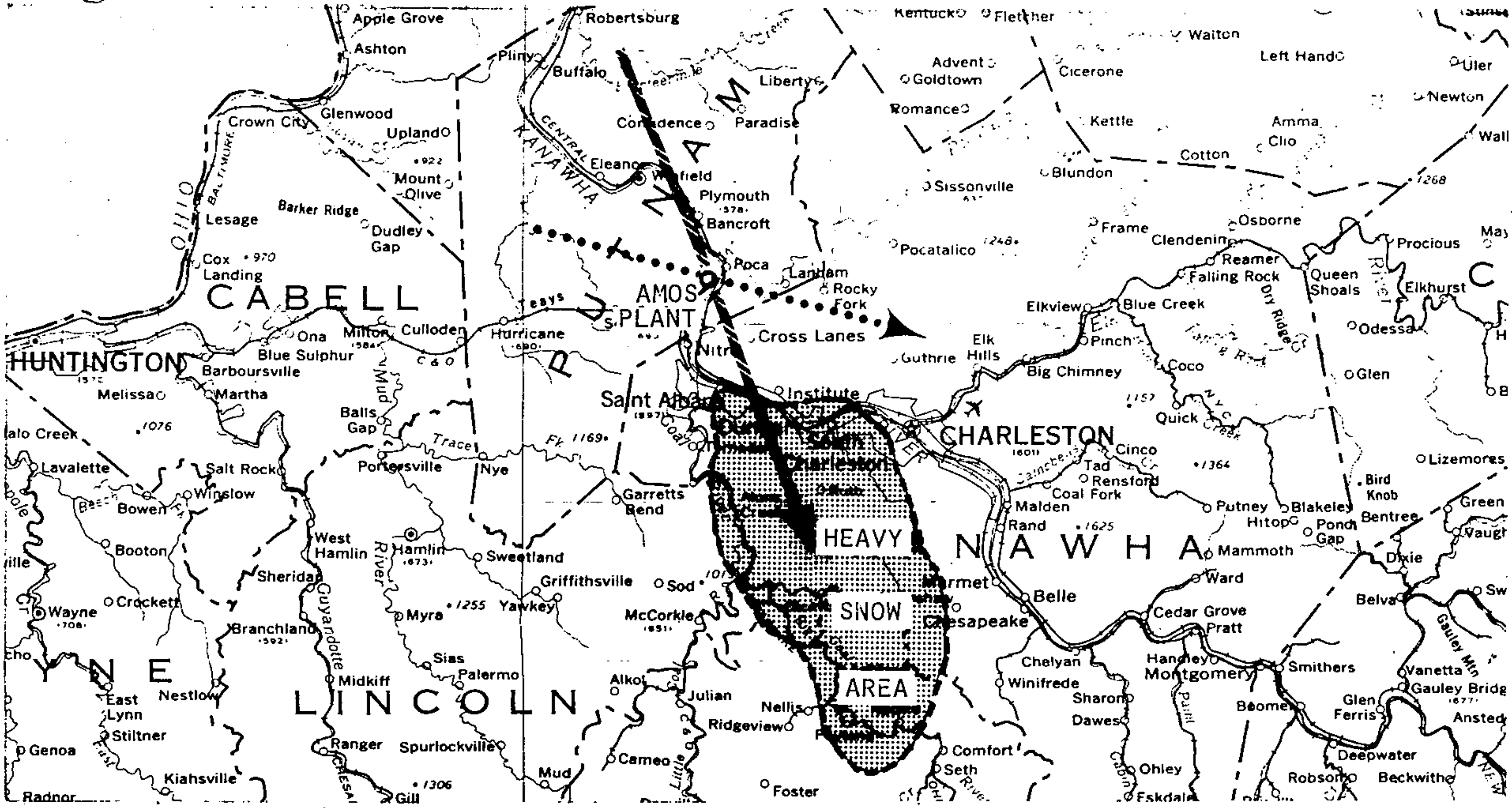


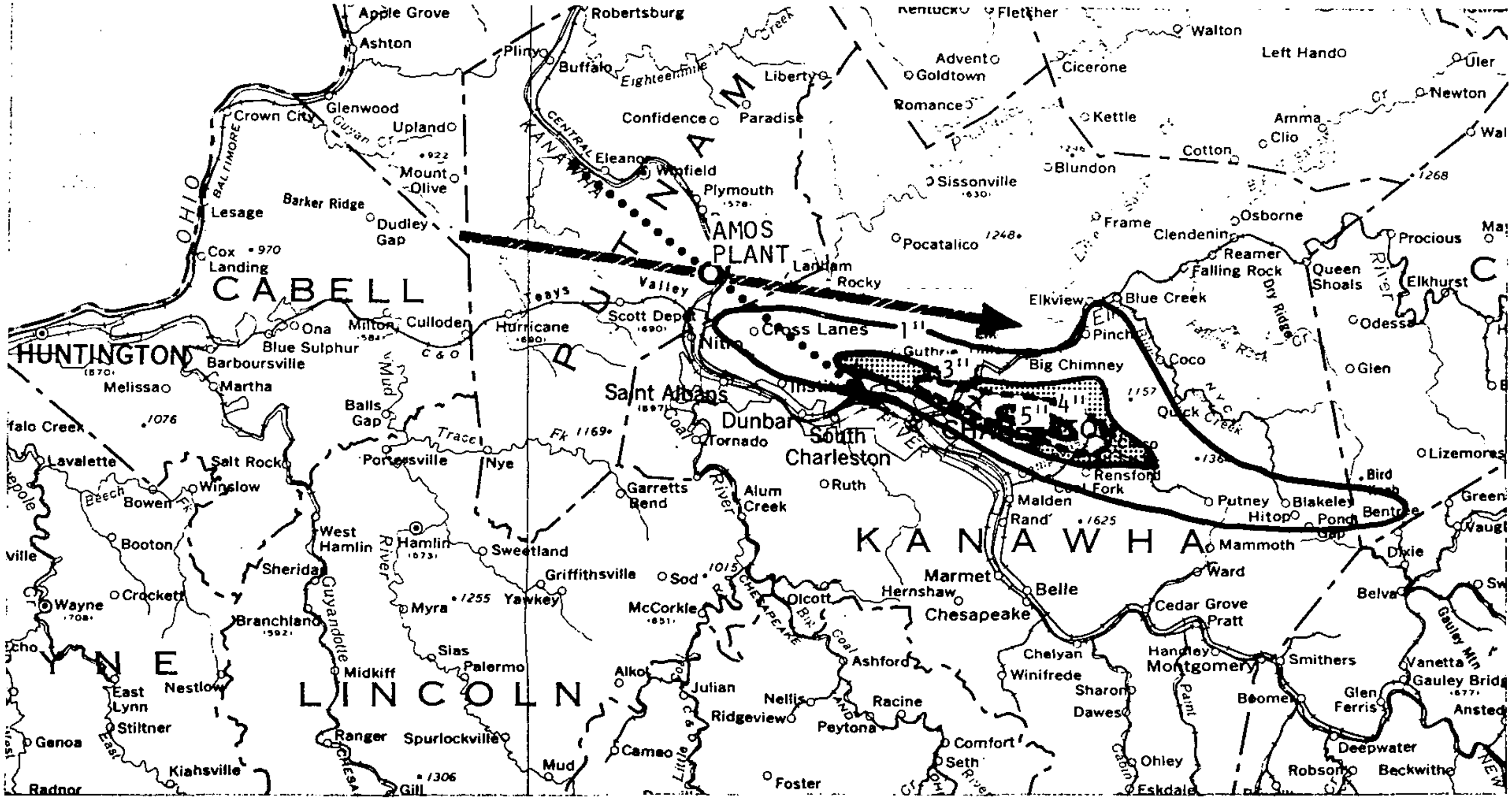
Mean Surface Wind Direction at Charleston, WV
5:00 AM - 9:00 AM EST

Mean Wind Direction 1000-4000 ft.
12Z (Huntington, WV)

10 0 10 20

SCALE: 1:500,000
One inch equals approximately 8 miles

Figure 1. Heavy Snow Area of December 22, 1975



Mean Surface Wind Direction at Charleston, WV
8:00 AM - 11:00 AM EST

Mean Wind Direction 1000-4000 ft.
12Z (Huntington, WV)

10 0 10 20 miles

SCALE: 1:500,000
One inch equals approximately 8 miles

Figure 2. Snow Depth Kanawha County, West Virginia
12 Noon January 4, 1976

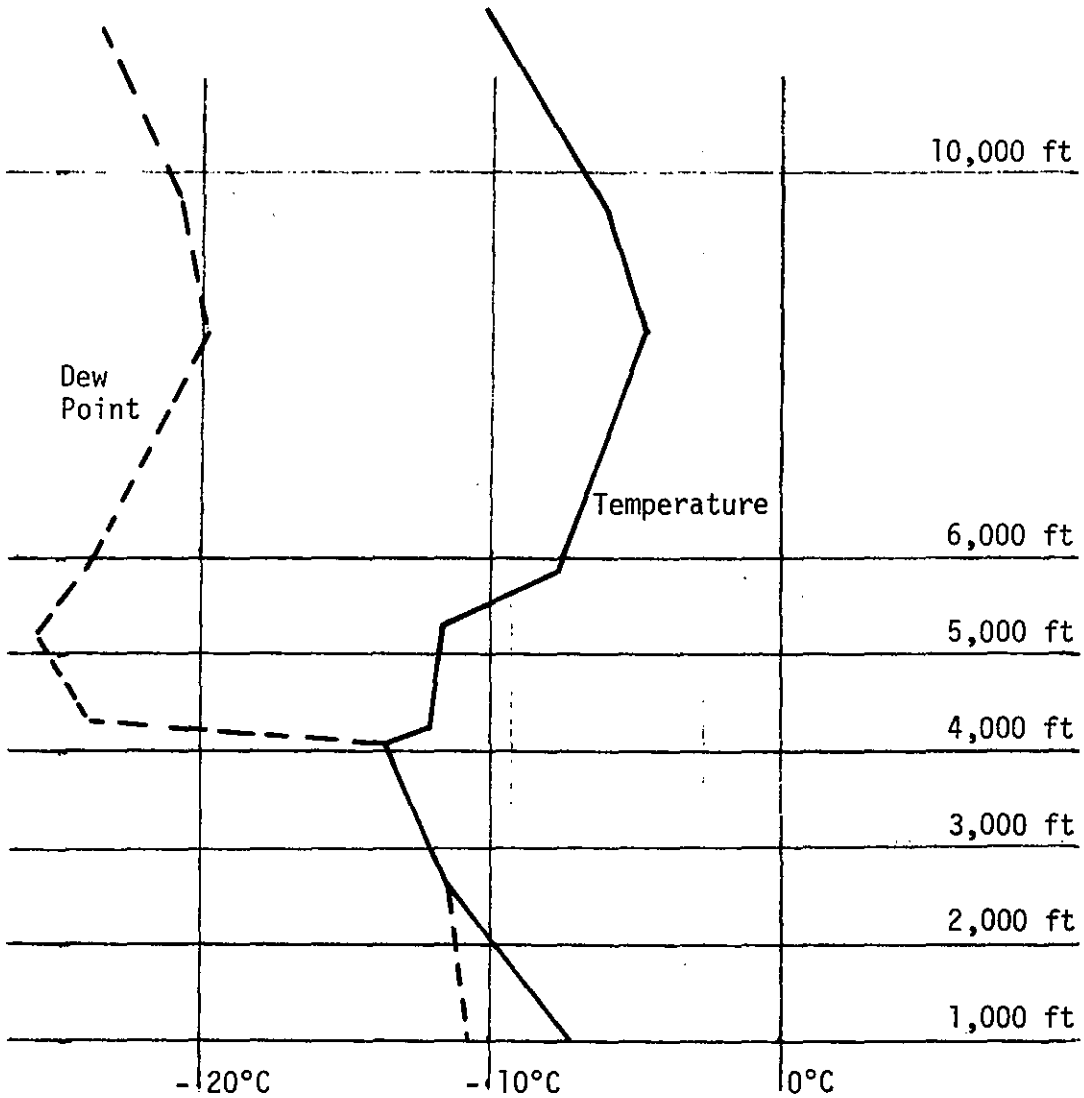


Figure 3. Upper Air Sounding - Huntington, West Virginia
1200Z (7:00 AM EST) December 22, 1975

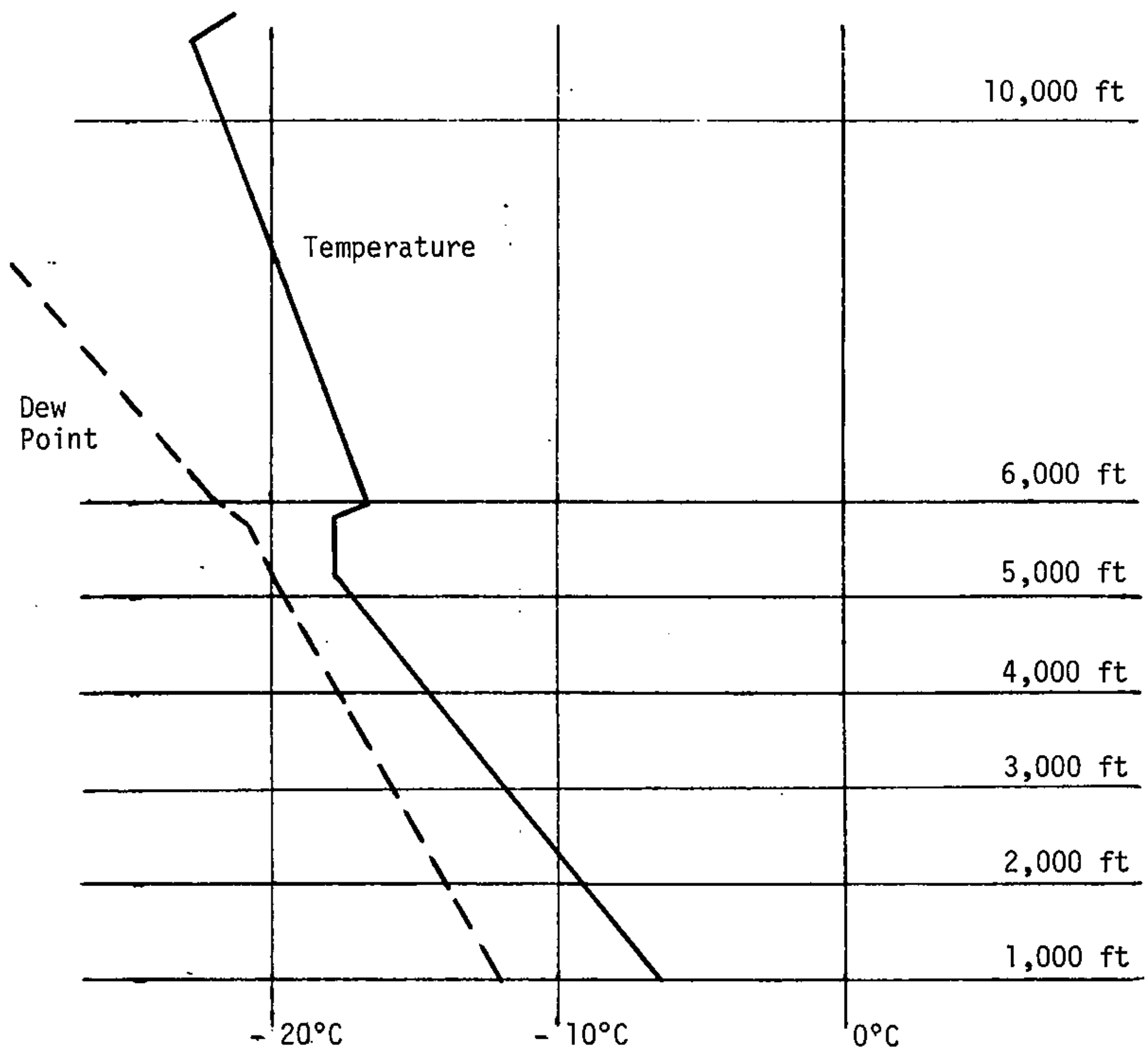


Figure 4. Upper Air Sounding - Huntington, West Virginia
1200Z (7:00 AM EST) January 4, 1976