

Activity: Operation Ice Storm

Introduction

A winter storm passed through western New York and raised havoc. Over half of the trees in the area received major damage, electric and telephone lines were ripped down, and residents in a major urban center lost electrical power for up to a week and more. Deaths and injuries occurred. Schools and businesses were closed as people tried to cope with a major winter hazard — an ice storm.

Ice storms occur when a unique set of atmospheric temperatures and moisture conditions come together to produce freezing rain. Freezing rain differs from ordinary rain in a very important way. When drops of freezing rain strike a surface, some of the water immediately freezes. Quickly, freezing rains make roads and sidewalks slick and dangerous. Coatings of ice silently thicken on objects, adding weight as the glaze builds. Gradually, tree limbs and wires bend and droop from their increased burdens. Should icing continue, tree limbs begin to break and fall while electric, cable and telephone wires snap. Lights go out, furnaces stop, and many people find themselves in threatening situations.

The atmospheric data used in this activity to investigate freezing rain were collected by weather instruments carried aloft by balloons. These instrument packages, called radiosondes, rise through the atmosphere and take temperature, humidity, and other measurements. These observations are then transmitted back to Earth's surface. The humidity measurement they make is reported as dewpoint. Dewpoint is the temperature to which the air must be cooled to become saturated. Whenever the air temperature and the dewpoint have identical values, the air is saturated. Saturation is a condition which has to be met in order for a cloud to exist. In turn, clouds must be present in order for precipitation to occur.

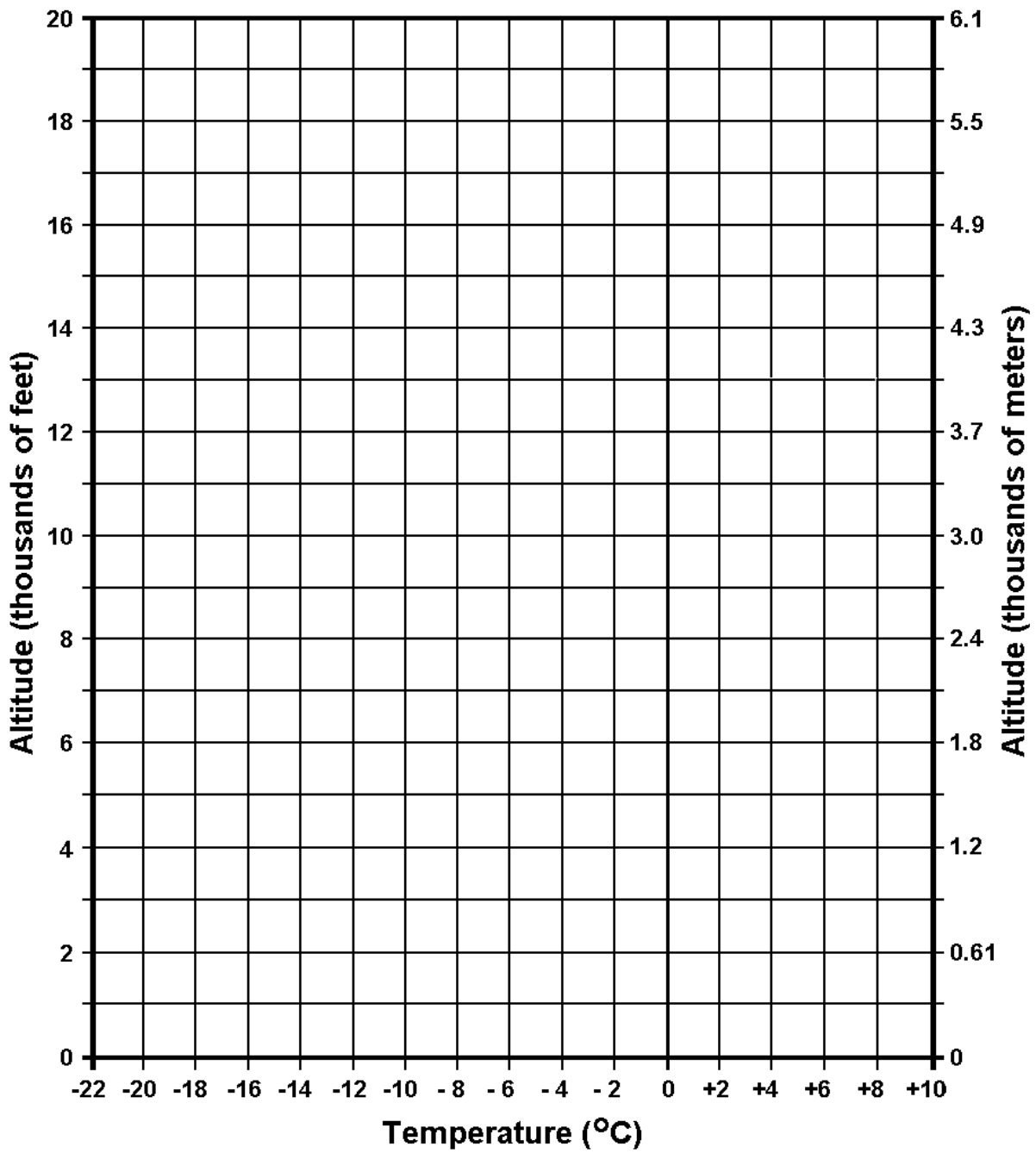
After completing this exercise, you should be able to:

- describe the atmospheric conditions that can result in freezing rain.
- trace the life history of freezing raindrops.

Activity

The radiosonde data appearing in the following table were recorded in Albany, New York on an early February morning when a freezing rain episode was in progress. Plot the values on the accompanying graph. Place a dot (•) to show temperature at a particular altitude. Use a cross (×) to show the dewpoint at the same height. If the temperature and dewpoint values are the same, draw a small circle around the dot (⊙). After plotting all the data, connect adjacent temperature values with solid straight lines to show the temperature pattern with altitude, and use dashed straight lines for adjacent

Temperature - Altitude Diagram



dewpoint values. The combination of temperature and humidity patterns that results is termed a “sounding”. It depicts conditions in the atmosphere above the reporting station at the time the data were collected.

Albany, NY – 7 AM EST – 2 February

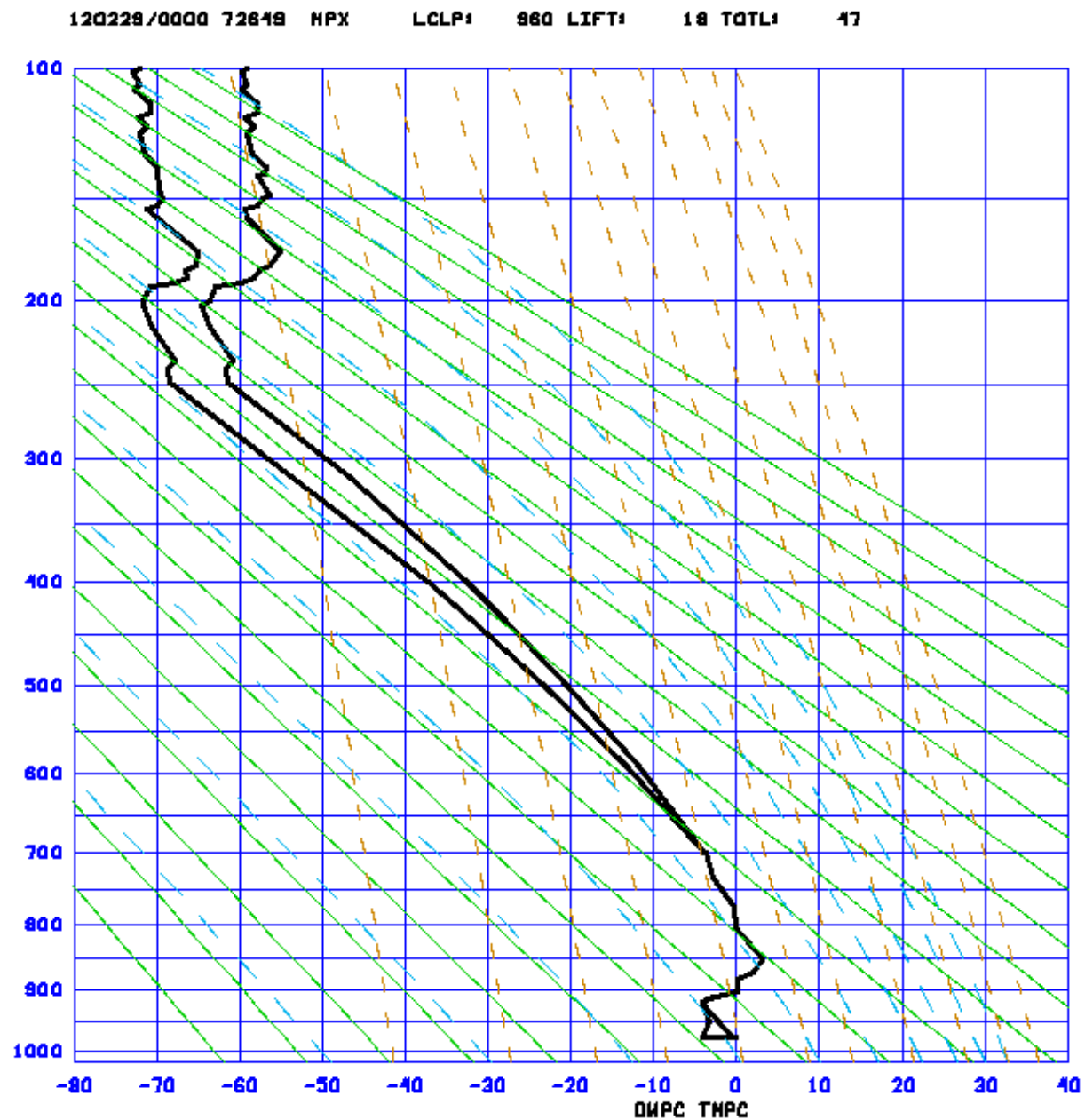
<u>Altitude (ft)</u>	<u>Temperature (°C)</u>	<u>Dewpoint (°C)</u>
18,270	– 18.3	– 21.6
13,940	– 9.5	– 11.8
9,770	– 3.5	– 3.5
6,670	+ 0.4	+ 0.4
4,660	+ 4.2	+ 4.2
2,980	+ 6.4	+ 6.4
2,050	+ 3.8	+ 3.8
1,190	– 0.5	– 0.5
570	– 0.1	– 0.1
340	– 2.1	– 2.1
(surface) 0	– 3.5	– 4.8

Use the graph with plotted data to answer the following questions:

1. Were there clouds above Albany when these data were collected? What assumption must you make in interpreting the data to answer this question?
2. Locate the top and bottom of any existing cloud layer over Albany. Draw on the graph horizontal lines that cut across the sounding at the highest and lowest points at which saturated air was reported, *i.e.* temperature and dewpoint values were the same. Since precipitation typically falls from relatively thick layers of cloud at least a few thousand feet thick, were the clouds above Albany thick enough to produce precipitation?
3. Shade lightly with your pencil the area enclosed by the vertical 0-degree line on the graph and that part of the plotted sounding showing temperatures of 0 degrees and higher. This shading highlights a layer of air in which temperatures are above freezing. Label this layer, “WARM”. Describe in your own words the conditions above Albany in terms of layers of air with above-freezing and freezing temperatures.
4. Assume that precipitation was occurring in Albany and that it originated as ice particles in the upper reaches of the existing cloud layer. What will prevent these particles from reaching the ground level as snow?
5. For freezing rain to occur as it was in Albany at the time of observation, raindrops must fall through a relatively shallow layer of freezing air immediately above the Earth’s surface. According to the table of data given to you, how thick was this layer of sub-freezing air above Albany?

6. A common place for freezing rain to occur is in advance of an approaching warm front in a winter storm system. Locate this region on a surface weather map showing a winter storm if such a map is available. Explain, based on this activity and a side-view model of warm front if it is available, why this is so.

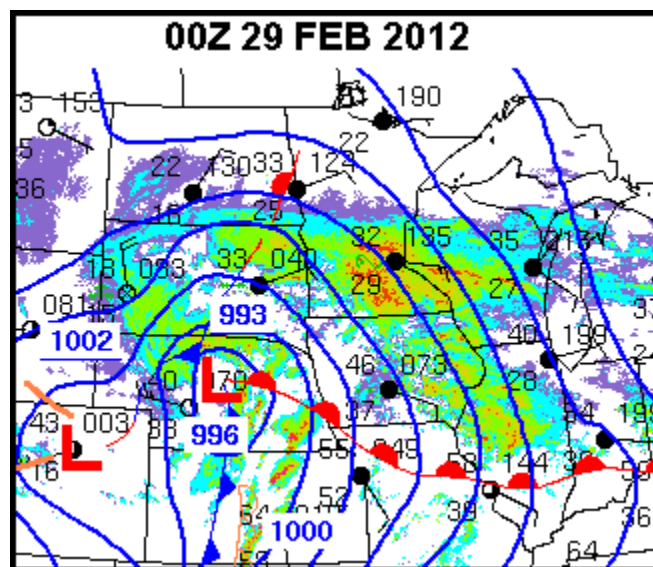
Real World Applications



The above figure is a radiosonde sounding from Minneapolis, Minnesota at 0000Z 29 February 2012 (6 PM CST Tuesday evening).

The heavy curve to the right on the Stüve diagram (atmospheric chart used here) is the temperature while the curve to the left is the dewpoint. Temperatures are along the horizontal axis in degrees Celsius, the vertical axis is pressure in millibars, decreasing upward as in the atmosphere.

1. Is the atmosphere above Minneapolis saturated, i.e. clouds probably existed? How can you tell using the temperature and dewpoint relationship?
2. Is there saturated air aloft that would be a cloud possibly producing precipitation? Is the temperature cold or warm, i.e. below or above freezing (0°C), producing snow or rain?
3. Is there a warm layer where any solid precipitation could melt to rain?
4. Is the surface temperature at or below freezing such that falling precipitation could freeze on the surface?



The surface map segment from the time of the radiosonde plot shows precipitation occurring at Minneapolis, MN, as detected by radar. The surface temperature at Minneapolis at this time was 32.0°F , freezing, and the weather symbol indicated that freezing drizzle was happening.