Weather Forecasting: Precipitation Type

ANSWER KEY

You will use three different soundings to determine the type of precipitation (e.g., ice crystal, liquid) in the precipitation generation region. Figure 2 and Table 4 display sounding data from Little Rock, AR (LZK) for 23 December 1998 at 1200 UTC. Figure 3 and Table 5 show the data from Fort Worth, TX (FWD) for the same date and time. Figure 4 and Table 6 display radiosonde data from Detroit, MI (DTX) for 3 January 1999 at 0000 UTC. Before you begin the questions, study the soundings as you would if you were preparing a weather forecast.

1. To identify on a Skew–T diagram where precipitation is generated in the atmosphere above the radiosonde site, locate any deep layer where the air is saturated. [Note: Air can be saturated when the dew point measured at a given level is within 2–3°C of the temperature at that level.] Find the top of the highest saturated layer (i.e., saturated layer farthest from the ground) and list the pressure at this height for LZK, FWD, and DTX.

   LZK ~650 mb   FWD ~725 mb   DTX ~575 mb

2. What is the temperature at the pressure level that you identified in question #1?

   LZK ~ -2 ºC   FWD ~ +4 ºC   DTX ~ -10 ºC

3. What is the wet-bulb temperature (T_w) at the pressure level identified in question #1?

   LZK ~ -2 ºC   FWD ~ +4 ºC   DTX ~ -11 ºC

4. Identify the phase of water located at the precipitation generation regions that were identified in question 1. Specifically, is the water in liquid (i.e., $T_w > -10°C$) or ice crysal ($T_w < -10°C$) form?

   LZK = liquid or ice crystals (circle one)

   FWD = liquid or ice crystals (circle one)

   DTX = liquid or ice crystals (circle one)

5. For each of the three locations (i.e., LZK, FWD, and DTX), determine what happens to the precipitation particles as they fall toward the ground. Discuss the precipitation particles and their journey to the surface. Include in your discussion whether the particles melt, freeze, experience evaporational cooling, etc. To help with your answer, calculate the wet-bulb temperature profile for the area of interest (from the precipitation generation area down to the surface) and draw it on the soundings in Figures 2, 3, and 4.

   a. Little Rock, AR (LZK):

   Supercooled liquid water is generated above Little Rock on this day. The droplets fall through a layer of temperatures that are above freezing from about 675 to 825 mb. During this portion of the descent, the droplets remain liquid. From 850 mb to the ground, the air is unsaturated and evaporational cooling occurs. Throughout this depth of ~1.4 km, wet-bulb temperatures range from about –5 to –12°C. In this case, wet-bulb temperatures are cold enough and there likely is sufficient time for the drops to freeze completely before reaching the surface. Thus, the precipitation will fall as sleet on the ground.

b. Fort Worth, TX (FWD):

Above Fort Worth, precipitation begins as liquid (warmer than 0°C) and falls through a saturated layer to the ground. As a result, no evaporational cooling occurs, and the wet-bulb profile is identical to that of the temperature and dewpoint temperature profiles. As the precipitation descends just below 850 mb, temperatures decrease below zero. Between this level and the surface, temperatures average about –5 to –8°C. Because this layer is ~1 km deep (see Table 5), there may be sufficient time for the liquid drops to freeze completely. Because supercooled liquid water can exist within the temperature range of the sounding data, the droplets also may not freeze completely before they impact a frozen surface. Thus, the precipitation may fall as sleet or freezing rain on the ground.

c. Detroit MI (DTX):

Ice crystals are generated above Detroit and fall through a continuous layer of temperatures that are below freezing. No melting of the ice crystals occurs. As a result, the precipitation will fall as snow on the ground.

6. For each of the three soundings, identify the 850-mb temperatures (in °C) using Tables 4, 5, and 6. Based on this information alone, what precipitation type would you expect at the surface? Do these expectations agree with your conclusions above? Enter your answers in Table 7.

Table 7 – 850-mb Temperature and Precipitation Type for LZK, FWD, and DTX

Station	850-mb Temp. (in °C)	Precipitation Type	Agreement? (Y/N)
Little Rock, AR (LZK)	-3.5	snow	N
Ft. Worth, TX (FWD)	+3.8	rain	N
Detroit, MI (DTX)	-5.7	snow	Y

7. Explain any pros and cons of using the 850-mb temperature method from question 6 to estimate the precipitation type.

This is an easy method to implement because only one data value is required from the sounding. However, one data value is insufficient to diagnose the situation. As demonstrated above, significant changes to the atmosphere occur below 850 mb throughout most parts of the country. In addition, if the precipitation generated above 850 mb is not in the form of ice crystals (e.g., LZK and FWD), then this method to 'guess' the freezing-layer depth is not useful.

8. For each of the three soundings, calculate the 1000–500 mb thickness (in meters) using the information in Tables 4, 5, and 6. Based on this information alone, what precipitation type would you expect at the surface? Do these expectations agree with your conclusions above? Enter your answers in Table 8.

Table 8 – 1000–500 mb Thickness and Precipitation Type for LZK, FWD, and DTX

Station	1000–500 mb Thickness (in m)	Precipitation Type	Agreement? (Y/N)
Little Rock, AR (LZK)	5467	rain	N
Ft. Worth, TX (FWD)	5503	rain	N
Detroit, MI (DTX)	5391	snow	Y

9. Explain any pros and cons of using the thickness method from question 8 to estimate the precipitation type.

The primary ‘con’ of this method is that it is based on statistical studies east of the Rockies and, thus, pools the data from a wide variety of soundings from different regions of the country (e.g., areas that include substantially different air masses). This methods removes the details of any particular sounding and, as a result, is not appropriate for the diagnosis of mixed precipitation events, where the details of the sounding data are vital (e.g., for the Little Rock and Fort Worth cases). The primary ‘pro’ is that this method is easy to interpret because maps of 1000-500 mb thickness are straightforward to plot. Using the 5400 m thickness contour on one of these maps, it is simple to view what parts of the country may experience snow versus rain.

10. ***(Advanced Students/Meteorology Majors)*** Explain the difference between the dewpoint temperature and the wet-bulb temperature.

The dewpoint temperature is the temperature to which air must be cooled for saturation to occur given a constant pressure and constant water vapor content. The wet-bulb temperature is the lowest temperature that can be obtained by evaporating water into the air at constant pressure. In both cases, the pressure may not change. In the case of dewpoint temperature, the water vapor content may not change. However, in the case of wet-bulb temperature, the water vapor content will increase as water vapor is evaporated into the volume.