Winter Weather Forecasting

by Andrea Melvin

Winter weather forecasting is not an easy process. Surface temperatures along with the temperature and moisture content at different levels in the atmosphere all contribute to whether precipitation reaching the ground will be snow, sleet, freezing rain, or rain. These conditions can change in the matter of minutes.

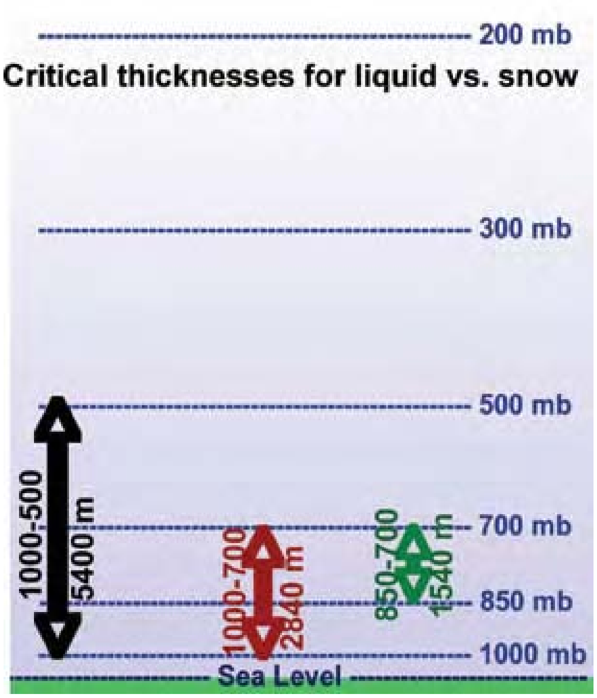
Forecasters need large amounts of data to produce reliable forecasts. Unfortunately, the data networks take measurements at different time intervals and the distance between stations differs widely from network to network. This requires the forecaster to use his/her best judgment when working with data collected at different times. For instance, surface temperatures are recorded by instruments located near the surface. The National Weather Services' (NWS) Automated Surface Observing System (ASOS) has stations across the United States that take measurements once every hour. The Oklahoma Mesonet, a statewide network, has stations in each of the states' 77 counties that take measurements once every five minutes.

The vertical temperature measurements are even more difficult to use in making a forecast. Measurements of temperature and humidity above the surface are taken by attaching instruments to balloons. The balloons called radiosondes transmit the data back to earth using radio signals. The radiosondes cost about $100 each. The NWS has 93 radiosonde stations across the country. Due to the cost, each station launches only two balloons a day. Other countries also launch radiosondes to collect upper atmospheric data. All countries launch their balloons at the same time every day so that the data can be compared. These times are 0 UTC (Universal Coordinated Time) and 12 UTC. That means in the Central Standard Time zone the balloons are launched at 6 a.m. and 6 p.m. (i.e., 7 a.m. and 7 p.m. during Central Daylight Savings time).

For Oklahoma, there is only one radiosonde station located at the Norman NWS Forecast Office. Oklahoma forecasters have to use the data collected twice a day from one station to make their vertical temperature and moisture predictions. The next closest stations are over 100 miles away. Weather conditions can change dramatically for the towns between the radiosonde stations.

Computer models are used to forecast the changes in weather conditions like temperature or humidity between data reporting schedules. The shorter the time interval between data collection updates (i.e., from radiosondes or surface networks) the more accurate the computer model output is. The time interval for upper air data is 12 hours. This long time lag between data updates can result in large differences between the actual temperature at 500 mb and the model's calculated 500 mb temperature.

As the balloon goes up, the instruments take measurements when the barometer reaches a specific pressure value. All countries are required to report data at standard pressure levels (e.g., 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20 and 10 mb). Along with temperature, pressure, winds, and humidity, the radiosonde records the height when it reaches each standard pressure value.
The pressure level heights are used to compute a "thickness" value. "Thickness" refers to how thick the layer of air is between two pressure levels. Warm air needs more room because the molecules are moving quickly and bounce off of each other when they collide. Cold air needs less space. The cold molecules do not move quickly and have fewer collisions. For example, if the 1000-500 mb layer had a thickness of 5570 meters over Madill, OK and the thickness of the 1000-500 mb layer over Chandler, OK was 5423 meters, the air at Madill is warmer than the air in Chandler.



Experienced forecasters have developed thickness thresholds to help them determine the type of precipitation to expect at the ground. A thickness threshold of 1520 meters or less for the 850-700 mb layer will generally support snow at the surface. While a 1000-850 mb layer with a thickness of 1400 will produce rain. Once you have determined the thickness of each layer and determine the most likely type of precipitation, the fun begins. If each layer's threshold points to a different precipitation type, the forecaster's job becomes even more challenging. A warm layer in the middle atmosphere will melt any snow falling from above. However, if the layer below is not cold enough or thick enough, some of the precipitation may refreeze resulting in a mixture of sleet, snow, and rain. Elevated surfaces like power lines or tree limbs with temperature at or below freezing will be coated with ice as any rain instantly freezes. When all of the layers agree on rain or snow, the forecaster can be confident in the precipitation type. The forecaster will also look at the surface temperature and/or the soil temperature. If these values are right at freezing, it could be too warm for snow to stick or too cool causing rain to become freezing rain. The following table provides the critical thresholds in meters for each of the thickness layers typically used by forecasters.

Thickness Thresholds*

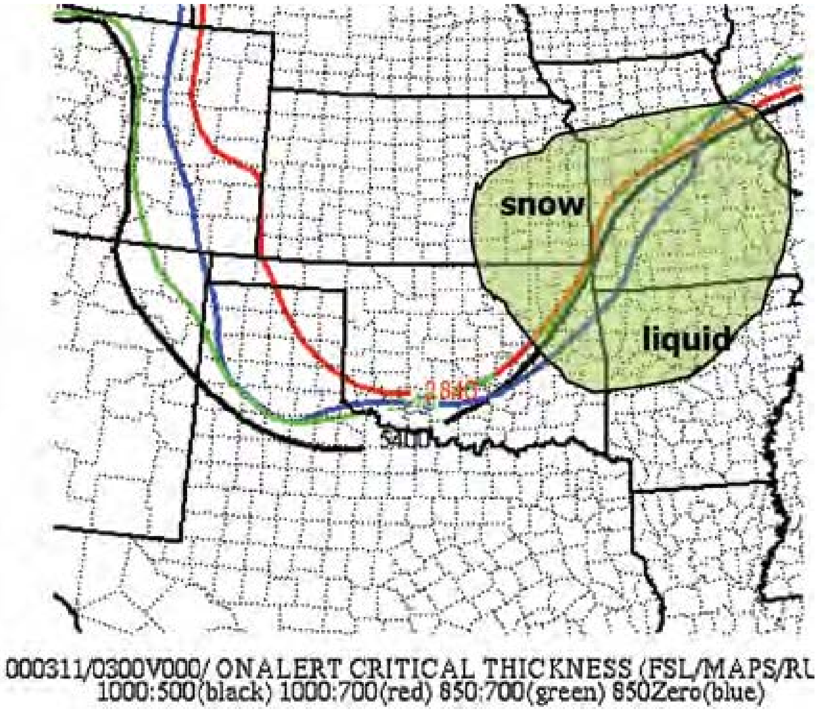
*Not valid in mountainous areas.

Layer	Flurries	Snow	Mixed Precip	Rain
850-500 mb			4050	
850-700 mb		1520	1540	1555
1000-500 mb	5240	5360	5400	5490
1000-700 mb		2800	2840	2870
1000-850 mb			1300	1325

The thickness thresholds are calculated for each of the 93-radiosonde stations. Then the values are used to create a contour for each layer which is plotted on a US map. These maps are called thickness charts or spaghetti plots. When the lines are close together, the thresholds match on the precipitation type. When the lines are far apart, the thresholds do not agree on precipitation type. Areas north of all lines will have snow if precipitation occurs. Areas south of all line will have rain if precipitation occurs. Precipitation type in areas between the lines is unknown. The spaghetti plots are created once an hour using data produce by computer models.

The spaghetti plots are a good estimate of the type of precipitation supported in each layer but surface temperatures play a huge role in what happens once the precipitation reaches the ground. Warm surface temperatures will begin the melting process focusing concerns on elevated surfaces. Snowfall accumulations may be smaller if warm surface temperatures stay above freezing melting the snow quicker than it can accumulate. However, over time, continued precipitation may lower surface temperatures below freezing allowing snow to accumulate or rain to freeze.

The next time a winter weather storm is forecasted for your area, take a look at the spaghetti plots to see how the atmosphere is torturing your local forecasters. When you feel yourself grumbling about the 6 inches of snow on your walk instead of the 1-inch forecasted, you will remember winter weather forecasting is not an easy task.



CLASSROOM ACTIVITY

During the first week of January 2005, several upper-level troughs swept past Oklahoma. The results on the ground were remarkably different. Some areas received heavy rains and flash flooding, while others received freezing precipitation and snow. The role of surface conditions and atmospheric thicknesses were very important in determining the final precipitation type deposited on the ground.

Precipitation occurs across much of Oklahoma and the Texas panhandle. Examine the critical thickness map for 6:00 a.m. on January 4, 2005.

1. In northwestern Oklahoma, what is the probable form of precipitation (snow or non-snow) as it falls from the clouds?

2. How confident are you in your answer?

3. What information makes you more or less confident in your forecasted precipitation type?

4. Does this mean it will definitely reach the surface in this form?

Compare the 6:00 pm, January 5th thickness map to the Mesonet surface temperature map. Focus on the placement of the freezing line at the surface.

5. Do the two products place the freezing line in the same place?

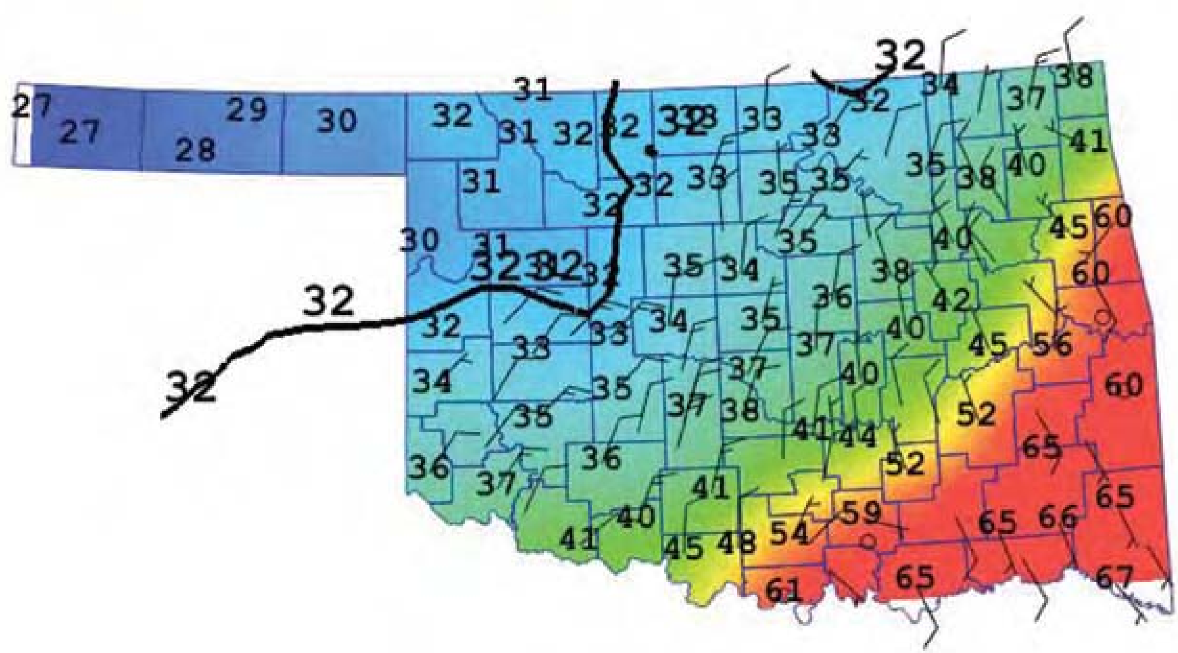
6. Which should you believe? Why?

7. If an estimated freezing line is different from the actual surface freezing line by 50 or 100 miles, what does that mean for road and utility crews?

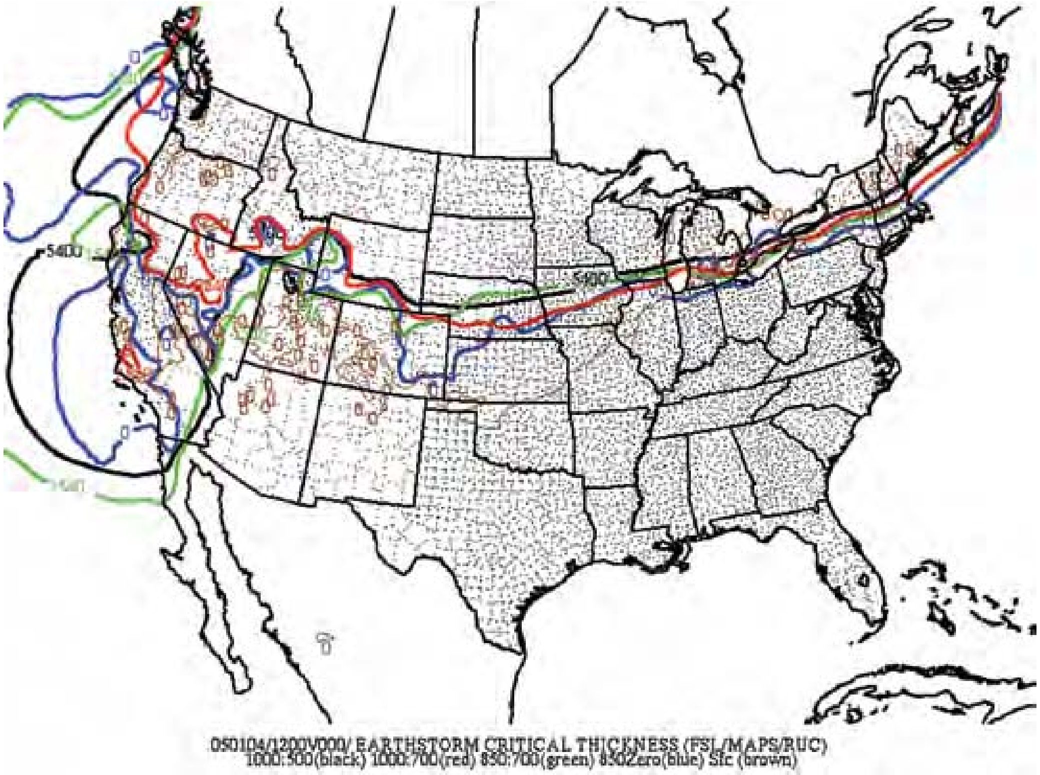
8. How might it impact schools in the area? (Think about problems bus drivers might encounter.)

A complete Case Study of this event with expert analysis of forecast and real-time products can be found at:
http://okfirst.ocs.ou.edu/train/casestudies/WinterWxLab/Jan2005.main.html .

Oklahoma Mesonet Surface Temperature Map
for January 4, 2005 at 6 p.m.



Thickness Map for January 4, 2005 at 6 a.m.



Oklahoma Mesonet Surface Temperature Map for January 4, 2005 at 6 p.m.