INTERPRETATION ARTICLE

Glazed Over

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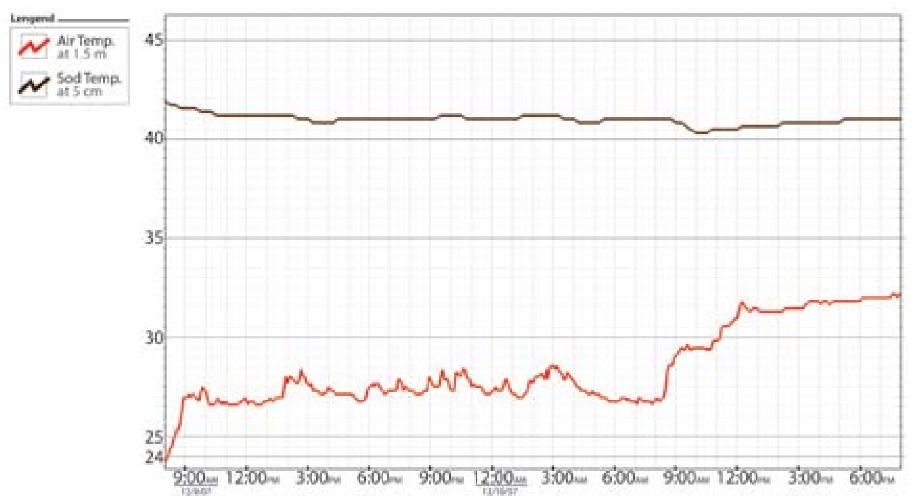
For two days this past December, a large part of Oklahoma along I-44 was encased in ice while air temperatures were below freezing (Figure 1, red line). This ice coating caused widespread power outages and destroyed many trees, causing them to fall on homes, vehicles, and power lines. The ice storm occurred on December 9-10, 2007 and took power away from nearly 1 in 5 Oklahomans. Even more sobering, this storm also took the lives of twelve people. All of the fatalities were due to motor vehicle accidents caused by the hazardous weather. Despite the severity of this event for some areas, it could have been much worse. Ground temperatures during this event were in the lower 40s (Figure 1, brown line), which kept most roads from freezing and becoming “ice-skating rinks.”

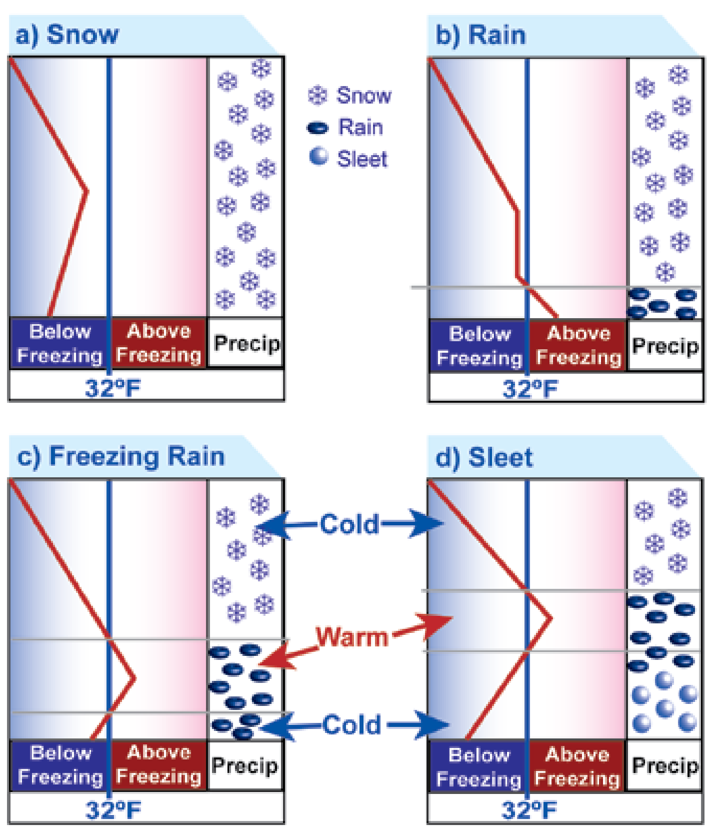
Figure 1 - Mesonet Sod and Air Temperatures in Oklahoma City December 9-10, 2007



All of this destruction was caused by a form of precipitation known as freezing rain. Nearly all precipitation starts as snow, which then forms all other types by falling through different temperature layers. As shown in Figure 2a, if the snow falls only through below-freezing (below 32ºF) air, we see snowflakes and begin to hope for a day off from school. However, if the snow falls through a layer that is warmer than freezing near the ground, the snow melts into rain (Figure 2b).

When a snowflake falls through a warm layer and then goes through a cold layer near the ground, freezing rain or sleet can occur. The main difference between freezing rain and sleet conditions is the size (or depth) of the below-freezing layer near the ground. A thick (or deep) cold layer gives plenty of time for melted snowflakes (raindrops) to refreeze into little pellets of ice known as “sleet” (Figure 2d). Freezing rain (Figure 2c) forms when the raindrops have a temperature below freezing, but do not have enough time to freeze into ice pellets. These very cold raindrops are called supercooled droplets—they have a temperature below freezing, but they are not frozen into ice. Once these droplets hit a surface that is below freezing (such as a tree or a power line), they immediately freeze into ice. →

Figure 2 - Precipitation Type Profiles



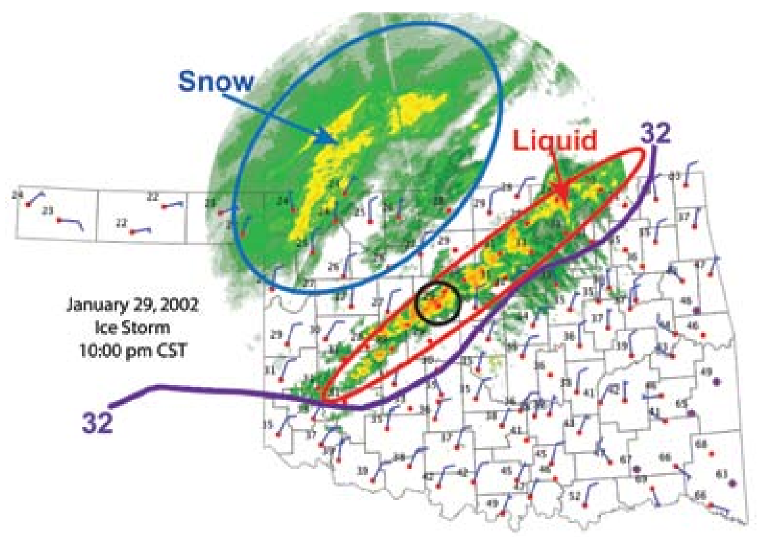
Let's follow a single snowflake as it falls and becomes a droplet of freezing rain. The snowflake starts in a below-freezing layer where it can stay a unique ice crystal. Next, it falls into a layer of above-freezing air, where it melts into a raindrop. The raindrop then falls into a shallow below-freezing layer near the ground. At this point, the raindrop cools to a temperature below freezing—it is now a supercooled droplet. As soon as the droplet hits a below-freezing surface—such as a tree, a car, or a power line—it freezes into ice. Over time, other freezing rain droplets will join our droplet and create a layer of ice. If the ice layer becomes very thick and heavy, the weight of the ice can bend and break trees.

There are several tools that meteorologists in Oklahoma can use to tell the difference between freezing rain and the other forms of precipitation. Two common tools include radar and Oklahoma Mesonet data. A radar "sees" liquid and frozen precipitation differently, so meteorologists can tell the difference between snow and rain. Snow looks like smooth, fuzzy, or feathery blobs on the radar. In contrast, rain (liquid precipitation) typically has a sharper, more cell-like appearance. These shapes, whether they are created by areas with falling snow or rain, are called "echoes" because they are the signals that the radar receives back. Both snow and rain echoes appear on the radar in Figure 3. Also shown on this plot are surface temperature, wind speed, and wind direction. If you look closely at the area with rain echoes (for example, the Mesonet station that has a black circle around it), you may notice that the surface temperature is below freezing. Therefore, it is probably freezing rain, and not ordinary rain, that is falling!

Hazards associated with winter storms include:

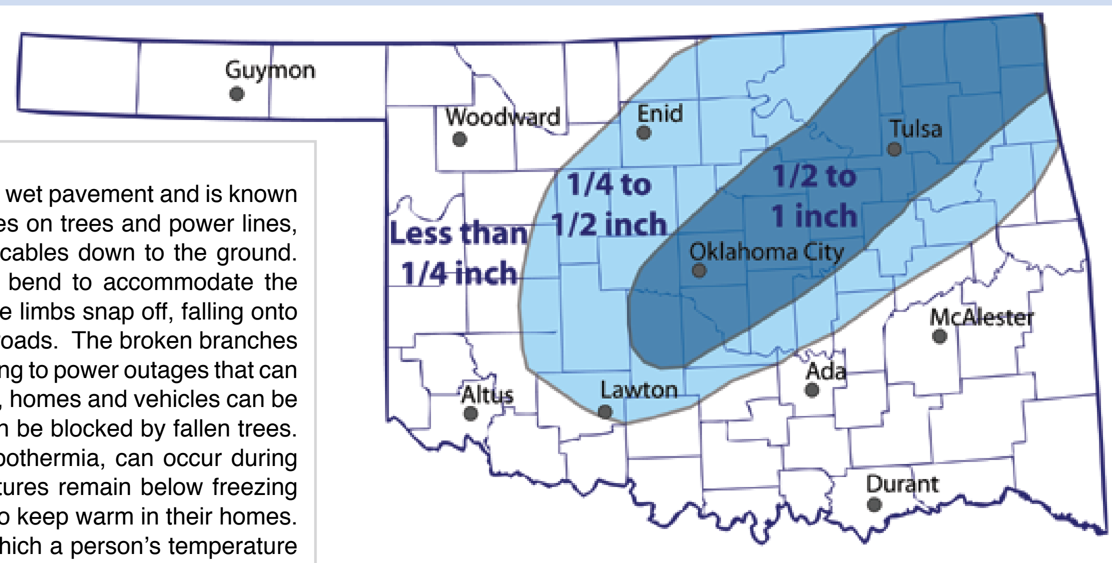
- **Automobile accidents**
- **Slipping on the ice when walking**
- **Falling tree branches and power lines**
- **Power outages**
- **Hypothermia**

Figure 3 - Radar, Mesonet air temperature (F) and winds (mph), and Freezing Line for the January 29, 2002 Ice Storm



As mentioned above, the recent ice storm could have been worse. Remember, if ground temperatures are above freezing (warmer than 32ºF), rain is not likely to freeze to roads, though bridges and overpasses may still be slick. But if ground temperatures are below freezing, roads quickly become hazardous, trees and power lines accumulate ice, and the likelihood of the hazards listed above increases. Another condition not present in the December ice storm that can make an ice storm more severe is strong wind. When strong winds accompany an ice storm, ice accumulates more on one side of an object than on the opposite side, resulting in more weight on one side. This imbalance can topple trees and poles, creating even more damage than if ice accumulates more evenly on objects.

Figure 4 - December 9-10, 2007 Ice Storm (Approximate Ice Accumulation Totals)



It doesn't take much ice to create hazardous driving conditions. Even a very thin, transparent layer of ice can cause a car accident. This thin ice looks like wet pavement and is known as black ice. As ice accumulates on trees and power lines, the weight pulls branches and cables down to the ground. When the trees can no longer bend to accommodate the extra weight, branches and large limbs snap off, falling onto power lines, cars, houses, and roads. The broken branches can tear down power lines, leading to power outages that can last days or weeks. Additionally, homes and vehicles can be badly damaged, while roads can be blocked by fallen trees. The last hazard on our list, hypothermia, can occur during long power outages if temperatures remain below freezing and there is no way for people to keep warm in their homes. Hypothermia is a condition in which a person's temperature drops at least 2 degrees below normal temperature (98.9ºF) because more heat escapes from the body than the body can produce. Left untreated, severe hypothermia can lead to death.

CLASSROOM ACTIVITY

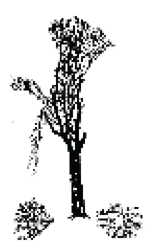
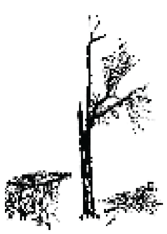
Ice and Trees

Have you noticed that tree branches often snap off in ice storms? One reason for this damage is that ice accumulation can increase tree branch weight by 30 times or more. If you tried to pick up a 30 pound weight with one hand, you would probably not be able to hold it up very long and you would drop the weight when your muscles become tired. The same happens with a tree branch—the weight of the ice becomes too much for it to hold up and so the branch wants to drop down. Unfortunately, a tree is often not flexible enough to keep its branches from breaking off.

By looking at tree damage, we can estimate how much ice has fallen. 1/4 to 1/2 inch accumulations can break small branches and weak limbs, while 1/2 to 1-inch accumulations can cause larger branches to snap off. Whether or not a tree will merely bend over with the weight of the ice, or if it will break, depends on the structure, flexibility, and health of the tree. A flexible, healthy tree is much more likely to bend over and survive an ice storm than a less flexible, diseased tree. However, even the strongest trees can be susceptible to uprooting, which can kill the tree. One way that a tree may be uprooted in an ice storm is when the top of the tree is covered with heavy ice, while the roots and the bottom of the trunk are in above-freezing temperatures (above-freezing ground temperatures). This makes the tree top-heavy, so it wants to fall over. Instead of just bending over, the tree is uprooted because the roots cannot hold the tree in the soil with the extra weight, and the center of balance, near the top of the tree.

A tree can have a lot of damage on its top and still survive. A tree's top is similar to the "flower" part of a piece of broccoli, while the stem is like the trunk of the tree. To determine whether or not a tree is likely to survive, we can use three major tree damage categories: Light, Moderate, and Severe Damage. Table 1 shows each category, along with a sketch for each.

Table I - Tree Damage Categories

 35% damage	Light Damage	Less than 50% of the top is damaged. High chance of survival.
 50% damage	Moderate Damage	50% to 75% of the top is damaged. Many trees will survive, though they may experience disease or infection in breakage areas. Torn bark, breakage at the very top, and breakage of low branches may increase the chance of infection.
 80% damage	Severe Damage	More than 75% of the top is damaged. Low chance of survival. The few trees that do survive are likely to become infected.

Tree A

Tree B

Tree C

Questions:

1. Compare the three photographs to the three damaged tree sketches.
   a. Approximately how much of Tree A was damaged?

   b. Approximately how much of Tree B was damaged?

   c. Approximately how much of Tree C was damaged?

2. Using the damage categories in Table 1, what is the damage category for:
   a. Tree A?

   b. Tree B?

   c. Tree C?

3. Imagine that you are an arborist (trained tree expert). One of your clients wants you to trim his damaged trees (Trees A, B, and C). Would you recommend that he keep all of the trees, or would you try to convince him that he should not keep all of the trees? Why? If you chose to remove a tree (or two or three), which tree or trees would you remove?

4. Looking at the amount of tree damage, how much ice do you think fell in this area? (Hint: What is the maximum amount of breakage in the area, e.g., are only small branches broken or are there larger branches broken as well?)