



# THE BIG CHILL

Frosts and freezes are a fact of life on golf courses. Here's a primer to share with your facility.

Ed Brotak, Ph.D.

Photo by Cappi Thompson



When temperatures drop below freezing on a golf course, a variety of problems can arise with the turfgrass, trees and ornamentals that make up your property.

Frost damage to flowers, buds and even young leaves can be unsightly but usually causes no permanent damage and doesn't affect play. Damage or potential damage to the turf canopy that makes up the greens, fairways and roughs is another story. Delays in starting times to allow frost to dissipate can wreak havoc on tee times and make for some angry guests. To understand what we're dealing with, we must know exactly what is going on.

### **The nature of the problem**

So what exactly is frost? Frost is the formation of white ice crystals on an exposed outside surface. When the temperature of a surface drops to the dewpoint in the air, condensation will occur. If the temperature is below freezing, the water vapor will transition directly to a solid, which we see as the familiar white frost crystals. If the surface temperature is above freezing, the condensation will be liquid dew droplets. The occurrence of frost on a plant surface will not cause any harm in and of itself. Similarly, snow collecting on a plant surface will not directly harm the plant structure.

The major concern is not the freezing of water vapor on the outside part of the plant but rather what happens to the water inside the plant. If this water freezes, plant tissue damage is possible, if not likely. For annual plants, this can be a death sentence — their more delicate inner tissue can be irreparably damaged by the expansion caused by the freezing water (think of what happens to frozen water pipes).

Grass is a hardier perennial that can tolerate internal ice crystals. However, if there is an additional physical force, such as someone stepping on the frozen blade of grass, the internal ice crystals can splinter and puncture the tissue. This can cause the leaf to eventually die.

What could this mean? As Tony Bertels, the superintendent at Swope Memorial

Damage to plants during a frost occurs inside the plant — not on the exterior. Annual plants' inner tissue can be irreparably damaged from expanding freezing water.

*GCM file photos*

Golf Course in Kansas City, Mo., says, it means "unsightly brown 10½, triple-D footprints all over the greens!" The visible damage will remain until new grass leaves replace the dead ones, and this takes time. In addition, the added stress placed on the plant during this process can cause thinning or even death.

So the important point here is that the below-freezing temperatures do the damage, not the frost itself. In fact, visible frost will not occur even when temperatures drop below freezing if they do not match the dewpoint level. This so-called "black frost" does the real damage. Visible frost is, however, a good warning sign that plant damage has occurred or may occur.

### **How the air cools**

There are basically two ways temperatures can cool down to the frost/freeze point — radiative and advective cooling.

#### *Radiative cooling*

In accordance with basic physics, all surfaces above absolute zero radiate heat. During the day, this is usually not a problem since the earth's surface gains more energy from incoming sunlight than it loses. But when the sun goes down, the surface radiates heat out into space and is not replaced, meaning the surface temperature falls and will continue to fall until more energy is coming in than going out. This means the low temperature usually occurs around sunrise, so sometimes a frost/freeze won't occur until just before it gets light. There are even times when frost begins forming after sunrise and even after greens are starting to be mowed for the day.

Clear skies and light winds present the ideal conditions for radiative cooling. The clear skies allow the radiative heat to escape into space. Clouds, on the other hand, will trap some of the escaping heat, thus slowing the cooling process. In fact, anything that covers or shades the surface will slow the cool-

ing process (and also slow the radiative warming process in the morning).

Wind factors in because it plays a key role in what is known as the vertical temperature profile. The surface itself is a better radiator than the air and will cool faster than the air (think the opposite of the daytime, when the surface is often hotter than the air). By being in contact with the colder surface, the air itself is actually being cooled from below. Therefore, temperatures actually increase with height as you get above the surface, a phenomenon called nocturnal inversion.

Wind will mix the air, bringing

down warmer air from above and raising surface temperatures. Higher winds will speed this process, while light-to-calm winds allow for the maximum cooling effect. The increase of temperature with height during the nocturnal inversion can be dramatic. At times, temperatures a few feet above the surface can be above freezing while the surface itself is experiencing a frost or freeze. Thermometers even at standard eye level can give misleading readings in these situations.

Radiation frost/freeze events are often very localized and very dependent on topography and elevation. In these

this case, the cold air moves into or advects into a region. By definition, these events are associated with wind. Clear skies also are not necessary.

Under these conditions temperatures decrease with height — there is no nocturnal inversion. Higher elevations are more prone to damage. These are the classic freeze events with no visible frost. The cold air mass involved is very dry, and the temperature almost never reaches the very low dewpoint. Preventive measures, which will be discussed later, are usually of little help for these often widespread events.

Of the two situations described above, the radiative frosts usually pose the greater risk since they are more common during the early and late parts of the growing season when the grass and vegetation are more susceptible to damage. For most regions, advective freezes occur during the dormant colder months.

### Forecasting frost

If you are into looking at weather maps, there are specific things to look for that would indicate frost/freeze problems. As previously mentioned, radiational cooling situations usually occur with clear skies and light-to-calm winds. These conditions often are found directly under a high-pressure area. Typically, this will occur a day or two after the passage of a cold front. The air mass itself is normally warming at this point but the radiational cooling at night is maximized. The advective freeze situations often occur immediately after cold frontal passage. The winds are still up and the skies may not have cleared yet. But the cold air mass has not had a chance to moderate.

In terms of forecasting, advective situations are easier to forecast. They are large-scale events that are handled well by computer forecast models. They can often be forecast days in advance. Radiational frosts/freezes are more difficult to forecast due to their localized nature. They are very dependent on local effects such as topography. Computer models have a hard time with such small-scale features. As a general rule, besides clear skies and little wind, you need dry air that can also aid the cooling process. One thing to keep in mind is that on

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Radiative frosts are more damaging than advective cooling frosts because they're more common during the early and late parts of the growing season when grass is more susceptible to damage.

relatively calm situations, the colder, denser air sinks down to lower levels, what we call "cold air drainage." Valleys are colder than surrounding hills and are more prone to frost/freeze damage.

#### *Advective cooling*

The other potentially damaging situation is called an advective freeze. In

“radiational days” you can have wide swings of temperature as much as 40 F between the high and low. So a warm day does not preclude the chance of a frosty night.

### Professional help

If you don't want to try forecasting on your own, you can check out the National Weather Service (NWS) forecast. It's best to go online to get the most detailed forecasts. Try [www.weather.gov](http://www.weather.gov), which should take you to a map of the United States. Click on your location on the map and this will take you to the nearest local NWS Office, where you can get the latest information.

The NWS differentiates frosts from freezes in context of the weather situation. Frosts are the radiational events with clear skies and light-to-calm winds with visible frost forming. Air temperatures can be as high as the mid 30s (keep in mind the surface temperature is colder in these situations). Freezes are

For example, if on average the last occurrence of 32 F is on April 15, no warnings will be issued before that date. This is standard policy regardless of the actual start of the growing season that year. In other words, if there had been an unusually warm early spring and plants had already begun developing, there would still be no official warnings issued before April 15.

### What can you do about frosts/freezes?

In terms of preventing frost/freeze damage, the best tip is one many superintendents will have little influence over — site selection. Pay special attention to low-lying areas, since cold air drains into these “frost pockets” on those radiational cooling nights. Maximizing early-morning sunshine and watching shading on the east side of a putting green can also help.

To get a more specific idea when cold temperatures are a risk, check the frost/

don't want a soggy green or one that is covered with ice.

Covers are another alternative sometimes used by farmers and home gardeners. The cover, whatever it may consist of, will limit radiational cooling at night. For golf courses, besides the costs involved, this is a labor-intensive approach and not really practical for greens that are still being used. Greens covers are widely used in winter to protect immature or otherwise susceptible greens until spring.

Usually the best thing to do is let nature take its course (no pun intended). Hopefully the morning sun will quickly warm the grass surfaces. Until then, keeping people off the course is the best way to prevent damage. Staff members, especially the mowing crew, need to be aware of frost/freeze conditions. Educating your guests about the potential damage they may cause is the best way to head off the complaints about the delayed starts.

“We will post literature explaining frost damage to the golf course,” Bertels says of the policies at his facility. “During a frost delay, I try and make myself available around the clubhouse to explain the ramifications of frost damage and the necessity of the delays.”

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Ed Brotak, Ph.D., was a long-time professor of atmospheric sciences at the University of North Carolina, Asheville.

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the advective events with wind and usually no visible frost. Air temperatures are 32 F or less.

Also the NWS uses terminology such as warnings, watches and advisories. A warning means that a damaging event is very probable in the immediate future or is already occurring. A watch is used when the damaging event is possible but the timing or extent is still uncertain. The term advisory is used by the NWS exclusively for nonsevere weather events and therefore may also be used for frost/freeze situations.

Issuance of frost/freeze warnings by the NWS varies locally due to differences in the normal growing season. Warnings will be issued in the fall until a widespread killing frost/freeze has occurred, ending the growing season. In the spring, warnings will only be issued after the date of the average last freeze.

freeze records from the NWS. They have probability charts for the last occurrence of 32 F temperatures in the spring and first in the fall. In addition, low temperature records for each day are probably kept by a nearby weather service office. The data are available either from the local NWS office or from the National Climatic Data Center ([www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)).

What actions can be taken to lessen damage? Irrigation is a standard method employed in agriculture. The physics behind it involve the release of latent heat when water freezes. When a substance goes from a liquid to a solid, it gives up heat. In actual practice, surface temperatures will be held around freezing as long as liquid water is available. Light watering can attenuate some frost/freeze effects. Obviously this method has its limitations for greens since you