Weather 101: Understanding Frost

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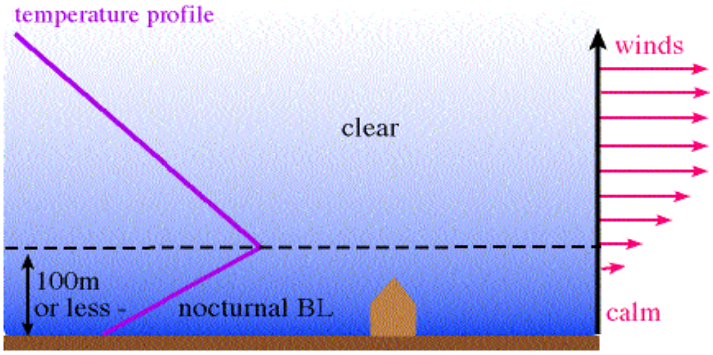
The occurrence of frost is an ongoing concern to berry growers in the Northeast. On average across New York, the date of the last frost in spring ranges from mid-April in the New York City area, to early May in the Albany area and along the Lakes. In the Adirondacks the frost-free period does not start on average until late May. A more conservative guide is given by the date after which there is only a 10% chance of seeing frost. Across the state, this date ranges from around April 20th in the City to almost June 10th in the Adirondacks. Along the Lakeshores May 10th is the approximate date, with May 20th being the appropriate date in much of the Hudson Valley.

Meteorologically frost is defined as the condition that exists when the temperature falls below 32°F. In some cases, the fuzzy layer of ice crystals that most people associate with frost may be present. This is known as hoar frost. In other instances below freezing temperatures may exist without the formation of ice crystals. This depends on how humid the air is on a given day. Typical meteorological temperature observations are taken at a height of 2 m above the ground. Therefore it is possible that a grower may observe hoar frost, while the local meteorologist is reporting a temperature above freezing.

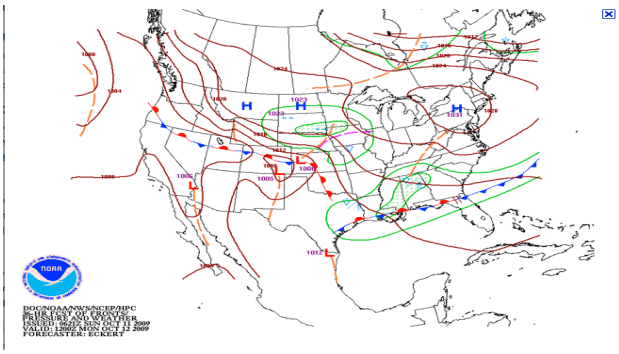
It is important to understand a bit of the physics behind the meteorological conditions that most often bring frost to our region. Frosts can be either radiative or advective. Advective frosts are referred to as freezes by the National Weather Service. These occur under windy conditions as below freezing air is transported into a region, usually from areas to the north and west of New York. Radiative frosts, are usually responsible for the last spring frost and therefore are of biggest concern to growers. These occur under clear and calm conditions. Clear skies and calm winds allow the atmosphere to cool from below. This creates a condition known as an inversion, in which temperature increases with height in the atmosphere. Thus the coldest air lies at ground level with warmer air aloft as shown in the figure below.



6 AM
No thermal turbulence
Little/no mechanical turbulence

Example of a temperature inversion near the ground. Temperature is given by the purple line, with colder temperatures to the left in the figure. Inversions usually extend upward in the atmosphere from the ground to a height of 10-1000m. Most are 100m deep as shown in the figure.

Inversions are associated with fairly easily identifiable weather patterns. Most occur with large high pressure systems are centered over an area. The high provides the calm winds and clear skies that are necessary for an inversion to form.



Weather map with a large high pressure system centered over central NY.

Not all inversions bring below freezing temperatures, so meteorologists must also consider the ambient temperature and humidity conditions when predicting a frost. A good rule of thumb is to look at the dew point observed during the evening hours. Dew points are reported in most weather observations and represent the temperature to which the air must cool before dew or (if the value is below freezing) hoar frost forms. On clear calm nights, the coldest air temperature is generally equal to the dew point.

Since most inversions are shallow, with warm (above freezing) air existing just a 100 m off the ground, mechanical means of mixing the air above a grower's field can often be used to protect a crop from frost. Typical methods of mixing the air include wind turbines, helicopters and ground-based heaters. Irrigation can also be used as a means of frost protection, since the freezing of irrigation water releases heat to the surrounding air and vegetation. Row covers also provide some degree of frost protection. However, proper site selection, particularly in upstate New York where the topography and lakes provide both favorable and unfavorable microclimates, remains an important means of minimizing the risk of frost damage and crop loss.

As a final note, climate change is likely to deliver a mixed message in terms of the risk of frost to the berry and fruit industry in New York. Over recent decades, we have seen a marked trend toward earlier dates of the last spring frost. Indeed, the frost-free season has been starting earlier and earlier in the year and the overall length of the growing season has been expanding. Unfortunately, berries do not operate off the calendar. Rather, their critical phenological stages are driven by the accumulation of degree-days. In a warming climate, these stages are also reached earlier and earlier in the year. Thus, strawberries that typically bloom in mid-May may in the future be blooming in late April or early May. Thus the risk of frost damage may in the end remain unchanged or even possibly increase.