# SKYWARNEWS

National Weather Service State College, PA
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***"Working Together To Save Lives"***


## *A History of "Fronts" and Weather Forecasting*

***By Michael Dangelo, Senior Forecaster***

Have you ever wondered why meteorologists and, now, the general population refer to "fronts" when describing the weather patterns that affect us?

Well, it all started long ago (really long ago), with a young Norwegian named Vilhelm Bjerknes (born in March of 1862 – around the time of the U.S. Civil War). Vilhelm was born to a mathematician, Carl Anton Bjerknes. Young Vilhelm helped his father in researching hydrodynamics (fluid motions).

Vilhelm eventually studied in Paris and became interested in electrical waves. He was so interested that he moved to Bonn, Germany to study under Heinrich Hertz. Together the pair conducted research on electrical resonance, which later became the foundation for modern radio (Megahertz).

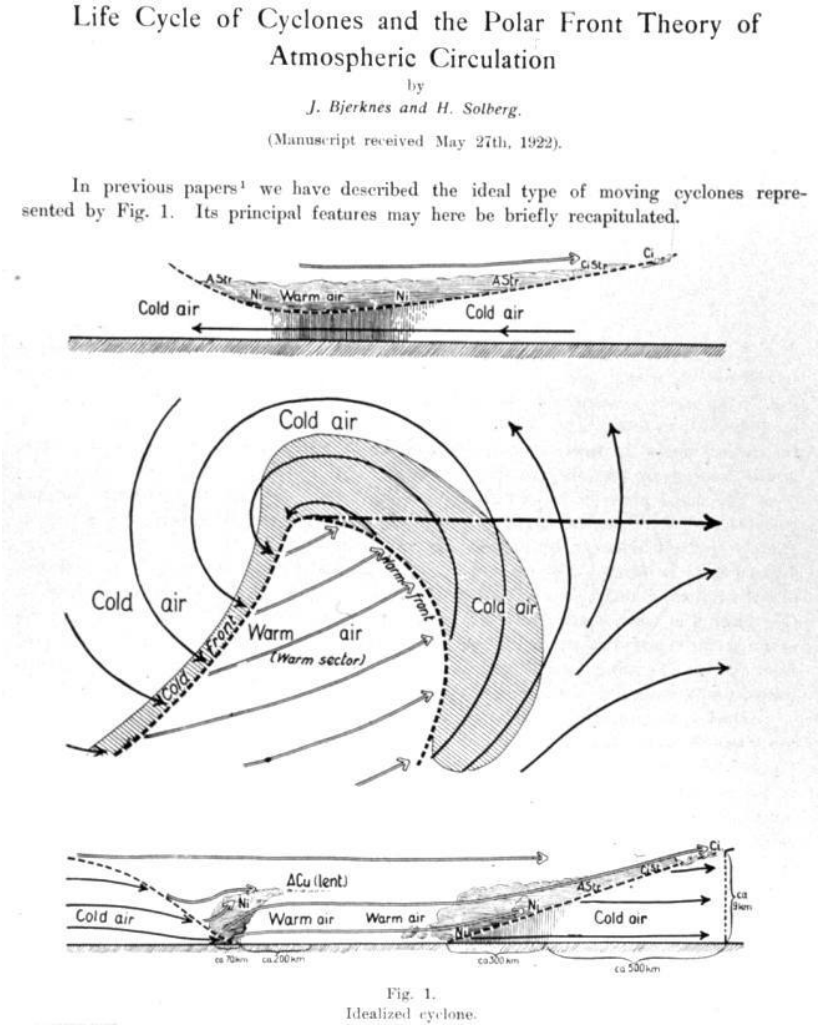
After moving back to Norway, he started lecturing in the School of Engineering in Stockholm, mainly about mathematical physics. But, he was still interested in hydrodynamics, from his work with his father.

It was in Stockholm that Vilhelm started to put together some earlier work by William Kelvin (thermodynamics) and Hermann Helmholtz (hydrodynamics). Vilhelm figured that the work of these two great minds was related and set to work to find out how. His hypothesis was that, when combined, these two theorems could be used to explain the motions in fluids. The two largest fluids on the planet are the atmosphere and the oceans. He also recognized that fluid motions caused our weather patterns.

At the turn of the 20th Century, meteorology was in its infancy, and was regarded at the time as more of an art than a science. Most meteorologists were content with observing weather from the surface of the Earth, and making assumptions about what was in between (and above) their observations. Vilhelm (as a mathematician and scientist) was not content, and searched for a more-definite answer. Vilhelm collaborated with Swedish balloonists and scientists, and an American, Cleveland Abbe, to observe the winds and pressures aloft (above the surface).

What Vilhelm came up with was the foundation for modern numerical

(mathematical) weather prediction. His "primitive equations" brought an analytical approach to a problem that had puzzled mankind for ages. In 1904, he theorized that, given enough information about the current state of the atmosphere, we could predict its future state.



Life Cycle of Cyclones and the Polar Front Theory of Atmospheric Circulation

by

*J. Bjerknes and H. Solberg.*

(Manuscript received May 27th, 1922).

In previous papers[1] we have described the ideal type of moving cyclones represented by Fig. 1. Its principal features may here be briefly recapitulated.



Fig. 1.
Idealized cyclone.

**Figure 1. Idealized Cyclone and Fronts from Bjerknes**

His research impressed many, including the Carnegie Institute (in Washington, DC), and they provided him with a generous annual funding grant for more than 30 years. He then teamed up with a geophysicist, and fellow Norwegian, Harald Sverdrup.

While working with Sverdrup in Leipzig, Germany in 1914, the First World War started. Some of his collaborators (including Sverdrup) left to return to Norway. But, Vilhelm replaced them with his son, Jacob Bjerknes, and Halvor Solberg, and tried to continue his work. But, the war made it difficult to do so.

Some influential Norwegians offered to create a new school at the Bergen Museum, in Norway, and they offered Vilhelm a prominent position there. Vilhelm accepted their offer, and he, Jacob, and Solberg returned to Norway in 1917. At the new institute, these three found they did not have the resources to properly and fully tackle the problems of numerical weather forecasting. So, while Vilhelm continued to work on the theories he developed, the others set about to try their hand at *practical* weather forecasting.

Jacob Bjerknes and Solberg used a network of weather observing stations positioned around Scandinavia to draw (by hand) surface maps, including the wind and temperature at those sites. They began to see that there were places where the wind seemed to converge, and places where the winds were discontinuous (became calm, or changed direction in a short distance). Places where the winds were discontinuous were also locations of low pressure.

Jacob and Solberg eventually published these observations on the discontinuities of winds in a cyclone (storm system) in 1919, and by 1920, others were referring to these lines of convergence as "fronts." This was

because these lines of convergence reminded them of the battle lines (fronts) that were set up during the War between two armies.

The first job at hand for the Bergen School was forecasting for their local region. Norway's main sources of commerce were fishing and shipping. The fishermen and sailors had long observed weather patterns and changes, and had come to expect certain types of weather when they observed one thing or another (e.g. red sky at night – sailor's delight). But, in 1920, the economy went downhill, fast.

This (post-war) economic crisis (along with a few fishing disasters) drove a desire for the weather forecasts that the Bergen School was making. If the sailors had a reliable method of knowing what was to come, they could make better decisions on whether to move or fish, ship or stay in port. At the same time, aviation was booming, and pilots and airports began to desire weather forecasts, as well. The government of Norway was convinced of the potential positive economic and safety impacts of weather prediction – enough so to fund the expansion of both the observations and forecasting.

Jacob and other Bergen School researchers and forecasters would then take the Cyclone Model and Polar Front Theory to the rest of the world.

We now refer to "fronts" almost every day in our forecast discussions, and conversations with people. Fronts are best described as the transition zones between differing masses of air. The air masses differ in either temperature or moisture content (or both). Cold, snow- or ice-covered places most often serve as source regions for our colder air masses. Deserts can be a source region for hot, dry air masses. Sunny, tropical oceans serve as source regions for warmer, more-moist air masses.

Where these masses collide is termed a front, now you know why.

## *The Summer in Review*

***By John La Corte, Senior Forecaster***

Another summer has come and gone in central Pennsylvania, and for the fourth year in a row, we ended up warmer than normal. While warmer than normal, figure 1 shows the departure from normal to be very unremarkable. Part of southwestern Pennsylvania averaged slightly cooler than normal, balanced out by the remainder of the state which was near or slightly above normal. At our two official climatology sites, Harrisburg and Williamsport, the season ended up about a degree above normal on average.

The summer was highlighted by a very warm start to the season where June averaged around 4 degrees above normal here in the central part of the state. Harrisburg's average of 74.5 made it the 6th warmest June since records began being kept back in 1888. Williamsport while also warm at 71.5 degrees for the month,

only managed to be the 11th warmest in the books which go back to 1895.

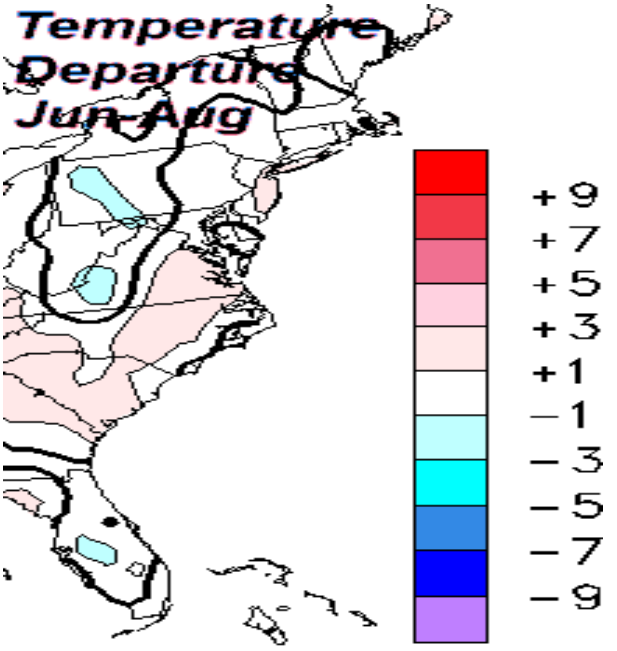



**Figure 1. Summer Temperature Departure**

After the very warm start to the season, July and August nearly balanced each other out coming in a little above and a little below normal respectively.

Precipitation-wise most of the central part of the state was below normal (figure 2). Harrisburg measured 7.16 inches of rain which was 3.28 inches drier than normal. However this still did not manage to crack the top ten list of driest summers in the state capital. Williamsport ended the summer not quite as parched as Harrisburg, mainly due to a fairly wet July. The precipitation departure for the season was .48 inches below normal which doesn't rank anywhere near the top of the list of driest summers.

Despite being warmer than normal, the number of days above 90 degrees ended up a little below normal. Harrisburg saw 15 days above 90 which was 2 below the long term average. Williamsport saw just 7 sweltering days of 90 or more which was 4 less than normal. The number of records set for temperature will also be rather forgettable with just 1 record high set in Williamsport. 95 degrees reached on June 10th broke a record for the day. No other record temperatures were set for the remainder of the season at either of the 2 sites.

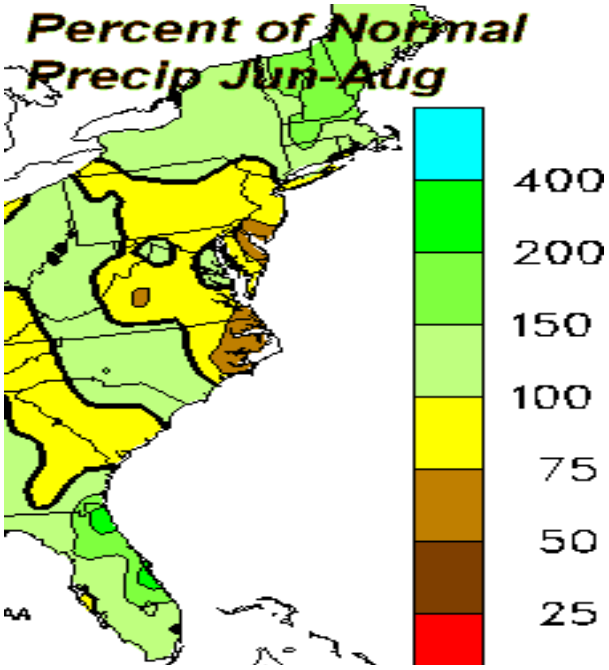



**Figure 2. Summer Precip Departure**

Another slightly contradictory indicator from this past summer was the number of days where measurable rain fell. At both Harrisburg and Williamsport the summer ended up drier than normal, however Harrisburg saw 30 days during the summer where rain fell which is exactly normal. Williamsport had rain on 36 days which was 2 above normal.

So after a somewhat mild and dry summer, will the upcoming winter bring deep snows and cold? With home heating fuels being as expensive as they are, one can only hope not. The official outlook from the Climate Prediction Center (CPC) which looks at long term trends, the state of the El-Nino/La Nina as well as several climate prediction

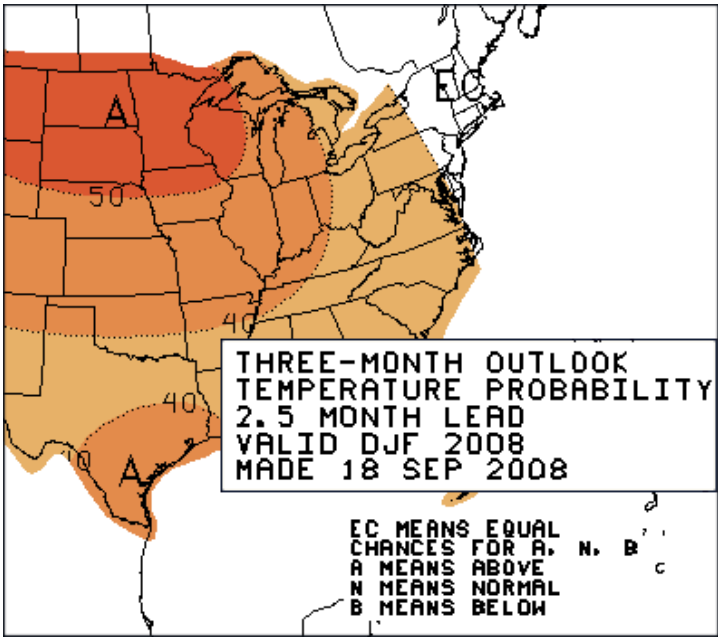



**Figure 3. Winter Temp Forecast from CPC**

models, shows a better than average chance of most of the region being above normal (figure 3). However a closer examination of the numbers shows that the chances for above normal are around 34-35% while near normal and below normal chances are around 33%. This adds up to a fairly low confidence forecast locally.

The precipitation forecast is even more nebulous with “equal chances” being the call (figure 4). This means that the large scale pattern the CPC expects has little or no predictability when it comes to the season’s upcoming precipitation, so we have the same chances of ending up normal, below or above normal by the time February ends. Admittedly not very informative but it is an honest assessment of the predictability of the pattern we are in.

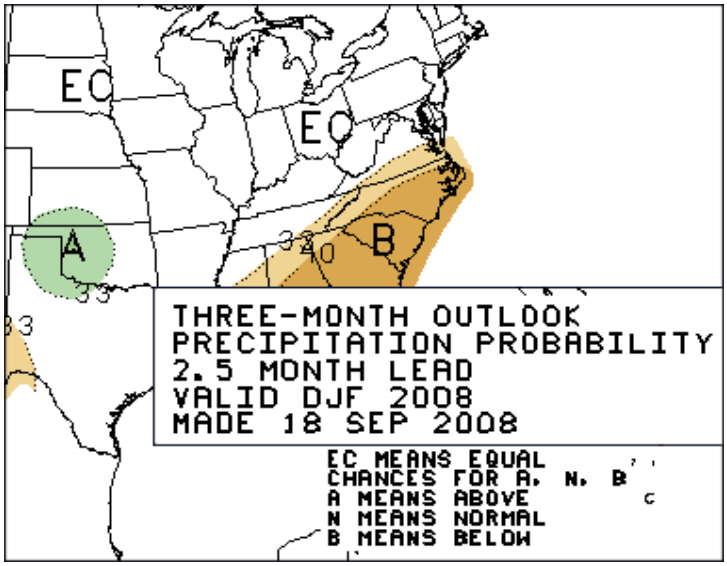



**Figure 4. Winter Forecast from CPC**

While that is the official forecast, I also like to consider other input to the big weather cauldron of long range forecasting when commenting on the upcoming winter. That age old pillar of the long range forecasting business, the Old Farmer’s Almanac is calling for a severe winter with plenty of snow. They have been at it for over 150 years so it’s always fun to read what they have to say on the subject.

Of a less subjective nature is the observation that for the first time in over 100 years there were no sun spots observed in August (figure 5). Sunspots are a measure of solar activity and while we think of the sun’s output as a “constant”, the sun’s output actually varies slightly with small peaks and lulls. Some have correlated periods of quiet sunspot activity with cooler than normal temperatures on the Earth. Could the Farmer’s Almanac forecasters be using this information for their expectations?


**Figure 5. Sunspot Picture Sep 26, 2008**

A farmer friend said she has observed her horses putting on their winter coats unusually early this year. She swears that bodes ill for the upcoming season. Others will just say "we are due" since it's been five years since we have seen a snowy cold winter. All that can be said about that is the atmosphere doesn't necessarily behave like a game of chance where a particular outcome is due because of the laws of probability.

A more valid correlation can perhaps be extracted from years where measurable snow falls over central and eastern parts of the state in October **and** the month ends up colder than normal. Of the 16 times that this has occurred since records have been kept, the following winter months saw above normal snow 15 times! Could such a high correlation be Mother Nature's way of focusing our attention on a large scale pattern that will end up with us getting plenty of use out of our snow blowers and shovels? No one really knows, but it's always fun looking at all the theories and hearing all the pontificators and seeing what happens.

See you next spring!

*Did you know that at any given moment there are over 1800 thunderstorms in progress somewhere on the surface of the earth and these produce more than 100 lightning strikes per second? The lightning bonds atmospheric nitrogen to the oxygen in the air to form nitrogen oxides. These oxides are soluble in water and are washed out the air by rain forming a dilute nitric acid. This nitric acid then reacts with minerals in the soil to for the nitrates on which plants feed. Simply put, lightning transforms the upper atmosphere into fertilizer for earthbound plants!*

- *1977 Old Farmer's Almanac*

# *The Dangers of Snow Squalls*

***By Brian J. Frugas, Meteorologist NWS Albany***

*…The following article was written by a fellow meteorologist at the NWS office in Albany New York. While it addresses mainly the upstate New York area, snow squalls are also a big concern here in central Pennsylvania so the article is very relevant to this region as well…*

Most people are aware of the dangers associated with typical winter storms, such as the coastal Nor'easters that we deal with on occasion during the winter months. The large amounts of snow and ice they can produce over a one- to two-day period can profoundly impact travel.

Lake-effect snow is another winter hazard, although this is more or less confined to locations close to the lakeshore, and thus doesn't typically have a profound impact on eastern New York and western New England. However, there is another winter danger, which can come about quite suddenly, and which can impact any portion of eastern New York and western New England. This is the frontal snow squall, the wintertime cousin of a thunderstorm. While snow squalls rarely produce large amounts of snow, their quick-hitting nature can pose a great deal of danger, especially to those traveling on roadways.

Snow squalls develop in a similar fashion to

summertime thunderstorms. These squalls usually develop in a line, either along or ahead of a powerful arctic cold front. A strong upper-level disturbance can also produce squalls.

In the summertime, thunderstorms will develop along a frontal boundary separating warm, humid air from cooler, drier air. Comparatively, in winter, snow squalls may develop along a boundary separating chilly air from more brutal arctic air pouring south from far northern Canada. As this extremely cold air moves in, both at the surface and aloft, the air being displaced is forced to rise and produce some vertical growth to the squalls (about 5,000 to 10,000 feet worth). As a rule, though, winter squalls don't grow nearly as tall as summertime thunderstorms.

The most difficult pro-squall ingredient to rustle up during winter is moisture. While summertime humidity is easily drawn north from the Gulf of Mexico and Atlantic Ocean, wintertime moisture is usually quite limited, especially with the seasonal pattern of frequent cold frontal passages that usher in cold, dry air masses from the north and west. However, the Great Lakes, and more specifically, Lake Ontario for our region, can help provide just enough additional moisture to help produce the snow squalls. Although frontal snow squalls are rare, they can occur a few times each winter season if all the right ingredients come together.

So, what exactly can be expected during a snow squall? Like thunderstorms, snow squalls are short-lived events, usually less than 30 minutes in duration. They usually are fast-moving due to the strong winds aloft associated with either the arctic frontal

boundary itself or a powerful upper-level disturbance. Within this brief period, heavy snow can occur, easily reducing visibility to below one mile. In addition, winds can gust over 35 mph, producing blowing snow, which reduces visibilities even further. This is caused by stronger winds aloft being brought down to the surface by the heavier precipitation. In some of the strongest snow squalls, thunder and lightning may also be observed, as with a summertime thunderstorm.

The main concern with snow squalls is that visibility can drop from unrestricted to less than a quarter of a mile in mere seconds. This is a danger to drivers, especially when driving at high speeds. The most dangerous highways are those that are oriented east-to-west, such as Interstate-90 and Interstate-84, since snow squalls will generally be moving west to east along a cold frontal boundary. As the visibility quickly lowers, it causes many drivers to slam on their brakes in a panic reaction. This can cause them to either skid off the road on freshly fallen snow, or cause other motorists to collide with them from behind. Many such multiple car accidents have occurred on I-80 in Pennsylvania due to wintertime snow squalls.

Many times, snow squalls will produce only an inch or two of accumulation. However, it takes only a thin coating of snow or ice to make roads dangerous, especially when the visibility is reduced. Since snow squalls usually produce only a minimal amount of accumulation, winter storm watches and warnings are rarely issued for them. The National Weather Service still has ways of keeping the public informed about snow squalls. Short-term forecasts (NOWCASTS) and, sometimes, Special Weather Statements (SPSs), will be issued when these squalls will be heading towards your area. These products can be easily found on the front page of our website (http://www.weather.gov/albany), or by listening to NOAA Weather Radio. These statements will let you know exactly when the squalls can be expected, and their estimated speed and direction of movement. In addition, you can keep up with the forecaster's thinking ahead of time by reading our Area Forecast Discussion (AFD), also posted on our website. Forecasters will often express their opinions about whether or not snow squalls will be of concern.

Keeping informed about impending snow squalls can aid you in your decision on whether or not you should alter your travel plans. Remember, it's always best to arrive at your destination safely, even if it means being a little late.

As always, we appreciate reports of any real-time weather hazards. If you encounter a snow squall, let us know, but wait until conditions improve and it's safe to do so. Information on your location, estimated lowest visibility, and amount of accumulated snow encountered will be helpful in letting others know about the impending danger.

***Think conservation is new? The following was taken from the 1909 Old Farmer's Almanac***

*Are you realizing what an asset you have in that wood lot of yours? It will pay good day's wages to you and your boys any time you happen to need a little ready money. Trim, single out, thin out. Cherish some of the bigger fellows for the saw mill. Don't try to "clear" unless you are sure the soil is right for crops. Encourage second growth pines. The match-makers, - not the hymeneal ones, - and the box board folks cannot get pine*

*enough. In these times there are conventions and conventions. Trees, coal, oil, water-power – all the natural resources – have worried looking people standing about them crying "Conservation". This means that our boy of a nation, - hitherto a wasteful boy – is beginning to think of saving for his old age.*

*During the winter evenings it will pay to make a few cheap nesting boxes for the birds. These bird homes can be fashioned from small boxes, hollowed limbs, tin cans or gourd. The entrance hole should not be over one inch in diameter for wrens, and not over one-half inches for blue birds or swallows. It may be two inches or more for martens and larger birds. The entrance should face South or West, and each box should be put up in a shady place beyond the reach of cats if possible. You will be more than repaid for your trouble by the increased destruction of noxious insects which will result if the birds occupy the boxes.*

# *Fall foliage*

***From the US Forest Service***

If you are lucky, you live in one of those parts of the world where Nature has one last fling before settling down into winter's sleep. In those lucky places, as days shorten and temperatures become crisp, the quiet green palette of summer foliage is transformed into the vivid autumn palette of reds, oranges, golds, and browns before the leaves fall off the trees. On special years, the colors are truly breathtaking.

## How does autumn color happen?

For years, scientists have worked to understand the changes that happen to trees and shrubs in the autumn. Although we don't know all the details, we do know enough to explain the basics and help you to enjoy more fully Nature's multicolored autumn farewell. Three factors influence autumn leaf color-leaf pigments, length of night, and weather, but not quite in the way we think. The timing of color change and leaf fall is primarily regulated by the calendar, that is, the increasing length of night. None of the other environmental influences-temperature, rainfall, food supply, and so on-are as unvarying as the steadily increasing length of night during autumn. As days grow shorter, and nights grow longer and cooler, biochemical processes in the leaf begin to paint the landscape with Nature's autumn palette.

## Where do autumn colors come from?

A color palette needs pigments, and there are three types that are involved in autumn color.

- Chlorophyll, which gives leaves their basic green color. It is necessary for photosynthesis, the chemical reaction that enables plants to use sunlight to

manufacture sugars for their food. Trees in the temperate zones store these sugars for their winter dormant period.

- Carotenoids, which produce yellow, orange, and brown colors in such things as corn, carrots, and daffodils, as well as rutabagas, buttercups, and bananas.
- Anthocyanins, which give color to such familiar things as cranberries, red apples, concord grapes, blueberries, cherries, strawberries, and plums. They are water soluble and appear in the watery liquid of leaf cells.

Both chlorophyll and carotenoids are present in the chloroplasts of leaf cells throughout the growing season. Most anthocyanins are produced in the autumn, in response to bright light and excess plant sugars within leaf cells.

During the growing season, chlorophyll is continually being produced and broken down and leaves appear green. As night length increases in the autumn, chlorophyll production slows down and then stops and eventually all the chlorophyll is destroyed. The carotenoids and anthocyanins that are present in the leaf are then unmasked and show their colors.

Certain colors are characteristic of particular species. Oaks turn red, brown, or russet; hickories, golden bronze; aspen and yellow-poplar, golden yellow; dogwood, purplish red; beech, light tan; and sourwood and black tupelo, crimson. Maples differ species by species-red maple turns brilliant scarlet; sugar maple, orange-red; and black maple, glowing yellow. Striped maple becomes almost colorless. Leaves of some species such as the elms simply shrivel up and fall, exhibiting little color other than drab brown.

The timing of the color change also varies by species. Sourwood in southern forests can become vividly colorful in late summer while all other species are still vigorously green. Oaks put on their colors long after other species have already shed their leaves. These differences in timing among species seem to be genetically inherited, for a particular species at the same latitude will show the same coloration in the cool temperatures of high mountain elevations at about the same time as it does in warmer lowlands.

## How does weather affect autumn color?

The amount and brilliance of the colors that develop in any particular autumn season are related to weather conditions that occur before and during the time the chlorophyll in the leaves is dwindling. Temperature and moisture are the main influences.

A succession of warm, sunny days and cool, crisp but not freezing nights seems to bring about the most spectacular color displays. During these days, lots of sugars are produced in the leaf but the cool nights and the gradual closing of veins going into the leaf prevent these sugars from moving out. These conditions, lots of sugar and lots of light, spur production of the brilliant anthocyanin pigments, which tint reds, purples, and crimson. Because carotenoids are always present in leaves, the yellow and gold colors remain fairly constant from year to year.

The amount of moisture in the soil also affects autumn colors. Like the weather, soil moisture varies greatly from year to year. The countless combinations of these two highly variable factors assure that no two autumns can be exactly alike. A late spring, or a severe summer drought, can delay the onset of fall color by a few weeks. A warm

period during fall will also lower the intensity of autumn colors. A warm wet spring, favorable summer weather, and warm sunny fall days with cool nights should produce the most brilliant autumn colors.

## What triggers leaf fall?

In early autumn, in response to the shortening days and declining intensity of sunlight, leaves begin the processes leading up to their fall. The veins that carry fluids into and out of the leaf gradually close off as a layer of cells forms at the base of each leaf. These clogged veins trap sugars in the leaf and promote production of anthocyanins. Once this separation layer is complete and the connecting tissues are sealed off, the leaf is ready to fall.

## What does all this do for the tree?

Winter is a certainty that all vegetation in the temperate zones must face each year. Perennial plants, including trees, must have some sort of protection to survive freezing temperatures and other harsh wintertime influences. Stems, twigs, and buds are equipped to survive extreme cold so that they can reawaken when spring heralds the start of another growing season. Tender leaf tissues, however, would freeze in winter, so plants must either toughen up and protect their leaves or dispose of them.

The evergreens-pines, spruces, cedars, firs, and so on-are able to survive winter because they have toughened up. Their needle-like or scale-like foliage is covered with a heavy wax coating and the fluid inside their cells contains substances that resist freezing. Thus the foliage of evergreens can safely withstand all but the severest winter conditions, such as those in the Arctic. Evergreen needles survive for some years but eventually fall because of old age.

The leaves of broadleaved plants, on the other hand, are tender and vulnerable to damage. These leaves are typically broad and thin and are not protected by any thick coverings. The fluid in cells of these leaves is usually a thin, watery sap that freezes readily. This means that the cells could not survive winter where temperatures fall below freezing. Tissues unable to over winter must be sealed off and shed to ensure the plant's continued survival. Thus leaf fall precedes each winter in the temperate zones.

## Where can I see autumn color in the United States?

You can find autumn color in parks and woodlands, in the cities, countryside, and mountains - anywhere you find deciduous broadleaved trees, the ones that drop their leaves in the autumn. Nature's autumn palette is painted on oaks, maples, beeches, sweetgums, yellow-poplars, dogwoods, hickories, and others. Your own neighborhood may be planted with special trees that were selected for their autumn color.

New England is rightly famous for the spectacular autumn colors painted on the trees of its mountains and countryside, but the Adirondack, Appalachian, Smoky, and Rocky Mountains are also clad with colorful displays. In the East, we can see the reds, oranges, golds, and bronzes of the mixed deciduous woodlands; in the West, we see the bright yellows of aspen stands and larches contrasting with the dark greens of the evergreen conifers.

Many of the Forest Service's 100 plus scenic byways were planned with autumn

color in mind. In 31 States you can drive on over 3,000 miles of scenic byways, and almost every one of them offers a beautiful, colorful drive sometime in the autumn.

**When is the best time to see autumn color?**

Unfortunately, autumn color is not very predictable, especially in the long term. Half the fun is trying to outguess Nature! But it generally starts in late September in New England and moves southward, reaching the Smoky Mountains by early November. It also appears about this time in the high-elevation mountains of the West. Remember that cooler high elevations will color up before the valleys. The Forest Service's Fall Color Hotline (1-800-354-4595) can provide you with details as the autumn color display progresses.

## *In Mosquito, a Small Tale of Climate Change*

***Beth Daley, April 2007 (used with the permission of The Boston Globe)***

UNORGANIZED TERRITORIES, Maine -- In a woodsy bog on the road between Millinocket and Baxter State Park, a mosquito that can barely fly is emerging as one of climate change's early winners.

The insect, which lives in the carnivorous purple pitcher plant, is genetically adapting to a warming world. By entering hibernation more than a week later than it did 30 years ago, the Wyeomyia Smithii mosquito is evolving to keep pace with the later arrival of New England winters.

Along with Canadian red squirrels and European blackcap birds, the mosquito -- a non biting variety found from Florida to Canada -- is one of only five known species that scientists say have already evolved because of global warming.

The unobtrusive mosquito's story illustrates a sobering consequence of climate change: The species best suited to adapting may not be the ones people want to survive. Scientists say species with short life cycles -- Wyeomyia Smithii lives about eight weeks -- can evolve quickly and keep up with changing environmental conditions as a result. Rodents, insects, and birds, some carrying diseases deadly to humans, are genetically programmed to win. Polar bears and whales, which take years to reproduce, are not.

"Rapid climate change is actually now driving the evolution of animals -- that is a dramatic event," said Christina M. Holzapfel, who, with her husband, William E. Bradshaw, has documented genetic changes in hundreds of thousands of mosquitoes at their University of Oregon lab in Eugene. The couple, both evolutionary geneticists, began collecting the mosquitoes at the bog here and in other New England locations more than 30 years ago while at Harvard University.

Until now, the effects of climate warming had been most noticeable in the Arctic, as glaciers melt. But dramatic changes are

also being seen in northern temperate zones such as New England, where the average winter temperature has risen 4.4 degrees Fahrenheit over the last 30 years. Growing seasons have lengthened, winter is arriving later, and the weather has become more erratic.

Scientists are worried that climate change, caused largely by the release of heat-trapping gases from power plants and cars, will drive evolution in unpredictable and unwelcome ways in these regions, where millions of people live. Researchers are trying to determine in more detail how species will adapt to a projected 3.2 to 7.2 degree rise in the world's average annual temperature by the end of the century. Their answers could help predict outbreaks of diseases spread by insects and rodents, and how ecosystems will change as species react at different rates to the warming.

"The world is going to be a very different-looking place," said Loren Rieseberg, an evolutionary biologist at the University of British Columbia in Vancouver. He has done rough calculations suggesting that species that take longer than two years to reproduce will not be able to keep up with the current pace of climate change. Some of the laggards will probably become extinct, he said, while others will migrate to new places.

"We are going to have very different sets of organisms living together," he said.

## *Scanning the Fall and Winter Skies for Meteor Showers*

***Barry Lambert, Senior Forecaster***

We look forward to some clear (albeit chilly or downright cold) nighttime skies and this fall and winter 2008-09 to view some of nature's most fascinating light displays, namely meteor showers. Most months of the year contain one or more meteor shower, which occur as a result of the earth passing through the debris trail left behind by comets. Some comets (such as 1P/Halley – whose location is now at the orbital distance of and opposite to Neptune) have taken a path through the solar system that leads to the earth intersecting its debris trail twice in a year. Occasionally, a slightly larger piece of debris (ice or dust particles) can lead to a more pronounced "fireball" leaving a thin, glowing trail across a long arc in the sky.

The meteor showers derive their names from the constellation where most of the fleeting and faint flashes of light originate. These distinct locations in the sky are called

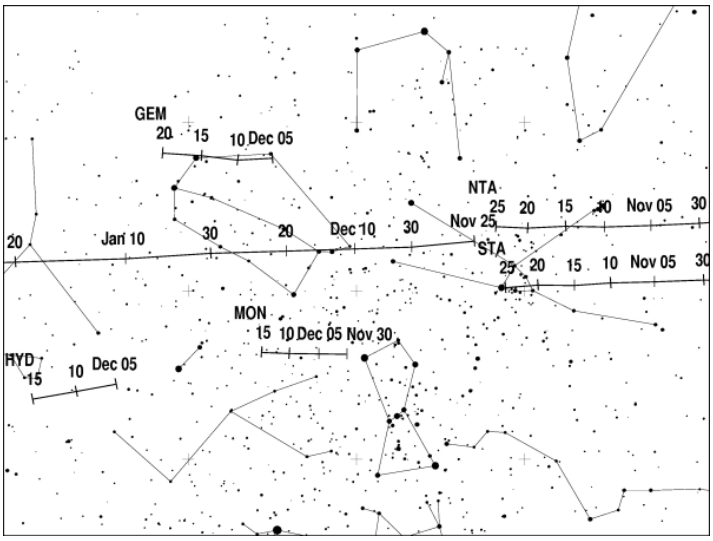
the "Radiant Point' of the meteor shower. Note the photo of a Lyrid meteor as it blazes across the sky. The Lyrids are one of the oldest meteor showers and were first recorded in Chinese astronomical records in 687 BC.

Meteors begin their flare-up then quickly vaporize about 40 to 60 miles above the Earth's surface. Surprisingly, there are "faster" meteors than others. The following list shows the speeds of some of the more significant meteor showers.

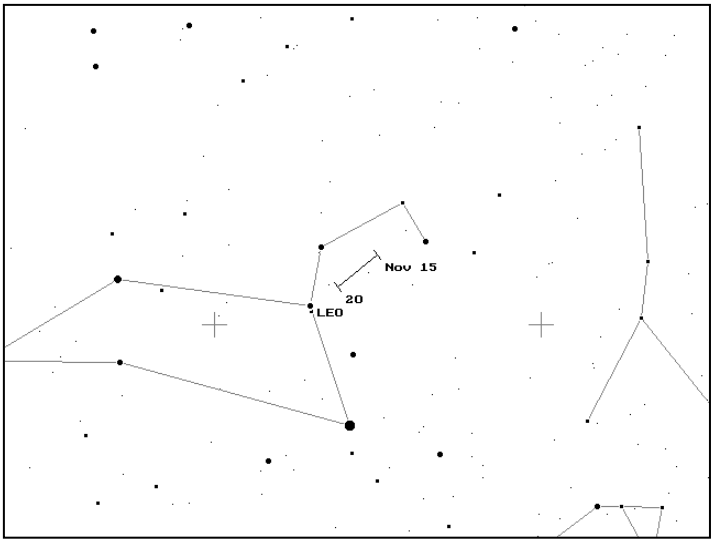
Leonids: 44 miles per second
Perseids: 38 miles per second
Orionids: 42 miles per second
Lyrids: 30 miles per second
Draconids: 14 miles per second

Regarding the path length of the visible meteor, it depends primarily on the angle at which the particle of dust races through the atmosphere. If the particle arrives at a shallow angle, it enters the atmosphere more gradually, heats up more slowly, and cuts a longer "visible" swath across the sky than if it enters in at a steep angle. The size, composition, and density of the dust particle probably also affect the length of the path.

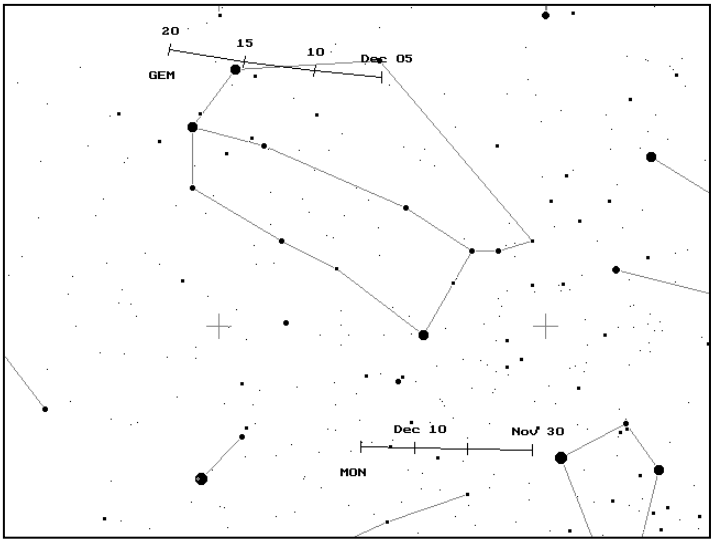
Although a few meteor showers occur in the period January through April (most notably the Quadrantids in January and Lyrids in April), some of the more "brilliant" and "reliable" meteor showers occur from May through December. Following the description of the more prominent celestial displays (below) is a map of the radiants where the meteor showers will occur.




Taurids: Predicted Maximum: Very broad maximum in early November




Leonids: Predicted Maximum: November 17, 9:00 UT (=Nov. 17, 1:00am PST; =Nov. 17, 4:00am EST)




Geminids: Predicted Maximum: December 13, ~23:00 UT (=Dec. 13, 3pm PST; =Dec. 13, 6:00pm EST)

***2009 Winter/Spring Meteor Showers:***

January 3-4 - Quadrantids: Possibly one of the best celestial shows of the Winter season. Typically comprised of 40 per hour or so bright, blue and fast (25.5 miles per second) meteors that will radiate from the constellation Bootes, some blazing more than halfway across the sky. A small percentage of them leave persistent dust trains. This shower usually has a very sharp peak, usually lasting only about an hour.

April 21-22 – Lyrids: The swift and bright Lyrid meteors disintegrate after hitting our atmosphere at a speed of 29.8 miles per second. They often produce luminous trains of dust that can be observed for several seconds.

Below is a listing of all meteor showers through the end of 2008 that you may be able to observe from about the time of this publication.

| Date | Description | Duration |
|---|---|---|
| November 5 | Taurids: Radiant--near Pleaides. 10 per hour with many fireballs. Debris from comet Encke. | 45 days. |
| November 12 | Pegasids: Radiant--Near Square. from Oct. 10 to late Nov., 10 per hour, used to be spectacular. | |
| November 17 | Leonids: Radiant--near Sickle. Most spectacular of modern showers. 1966 saw 500,000 per hour-- 140 per second. Comet Temple--Tuttle is parent. 20 per hour between 33 year shows, fastest known at 71 kps. | 4 days. |
| December 10 | Monocerids: Radiant-- near Gemini. 12 per hour. | |
| December 11 | Sigma Hydrids: Radiant--near Head. 12 per hour, fast. | |
| December 14 | Geminids: Radiant--near Castor. 60 per hour, many bright, white but few trails. Icarus, the Earth-crossing astroid seems to be the parent. | 6 days. |
| December 14 | Leo Minorids: 10 per hour, somewhat faint. Discovered by amateurs in 1971. | |
| December 20 | Delta Arietids: 12 per hour, must view in early evening, before radiant sets. | |
| December 22 | Ursids: Radiant--Little Dipper Bowl. Medium speed, 20 per hour, many with bright trails. | 2 days |

Here are a host of links to explore the fascinating world of meteors. A few of the links have a comprehensive listing of all meteor shower occurrences during 2008-09, along with where in the sky to locate them. You can toggle from this year to next in some of the links by changing the date near the end.

http://www.amsmeteors.org/

http://meteorshowersonline.com/

http://skytour.homestead.com/met2008.html

http://www.theskyscrapers.org/meteors/index.php/year/2009

http://www.space.com/spacewatch/meteor_showers_2008.html

http://en.wikipedia.org/wiki/List_of_meteor_showers

http://www.amsmeteors.org/showers.html#2008

http://home.att.net/~tangents/tech/astrocal.htm

http://www.amsmeteors.org/fireball/fireball_log2008.html#pennfb

The final link has a comprehensive listing of the many fireball sightings already reported in 2008 across the U.S. It also contains a dramatic photo and maps of the trajectory of the Pennsylvania Fireball or “Bolide” during the early evening hours (about 6:18 pm) on July 23, 2001.

# *Pennsylvania helps lead the nation in StormReady*

***Dave Ondrejik, Warning Coordination Meteorologist***

Over the last few months, Pennsylvania has helped to lead the nation in declaring counties as StormReady!

Americans live in the most severe weather-prone country on earth. Each year, Americans cope with an average of 10,000 thunderstorms, 5,000 floods, 1,000 tornadoes, and an average of 2 land falling deadly hurricanes. And this on top of winter storm, intense summer heat, high winds and other deadly weather impacts.

Some 90% of all Presidential declared disasters are weather related, leading to around 500 deaths per year and nearly $14 billion in damage. StormReady, a program developed in Tulsa, OK, helps arm America's communities with the communication and safety skills needed to save lives and property–before and during the event. StormReady helps community leaders and emergency managers strengthen local safety programs.

StormReady communities are better prepared to save lives from the onslaught of severe weather through better planning, education, and awareness. **No community is storm proof, but the StormReady program can help communities save lives**.

For the government fiscal year of 2008, Pennsylvania was tied for **fourth** in the nation with the highest number of new StormReady locations. **Since July 1, 2008 the Commonwealth of Pennsylvania lead the entire nation with newly declared StormReady Locations!!!**

Please see the national StormReady Internet page for those in PA and across the Nation that have achieved StormReady status.

http://www.stormready.noaa.gov/

This past summer we opened the StormReady process to Business and Communities (Municipalities). Thus far we have had several new Business and Communities enter the program. The first were Boeing Rotorcraft Systems and the Hershey Entertainment Complex.

Additionally we add several Communities to our list including the City of Pittsburgh, The City of Williamsport, and Carlisle Barracks.

**Juniata and Chester Counties, Williamsport, and Carlisle Barracks**, *September 2008, from left*: MIC Gary Szatkowski, NWS Mt. Holly, NJ; Teresa O'Neal, Juniata County Commissioner; Allen Weaver, Juniata County EMC; Karl Mehn, Chester County Deputy EMC; Neil Lovekin, Chester CountyEmergency Operations; Bruce Budd, MIC, NWS State College, PA; Dean Heinbach, Fire Chief, Williamsport; Tom Swiggart, Assistant Fire Chief, Williamsport; Robert French, Director, Pennsylvania EMA; LTC Sergio Dickerson, Carlisle BarracksGarrison Commander; Barry Farquhar, Director of Plans and Security, Carlisle Barracks; Barry Shughart, Force Protection Anti-terrorism Officer, Carlisle Barracks.

## *SAFETY CORNER – "Turn Around Don't Drown"*

***Pete Jung, Senior Service Hydrologist***


One half of all flood-related drownings occur when a vehicle is driven into hazardous flood waters. Why is this so? Many believe the weight of their vehicle (especially SUVs) will keep it in contact with the road surface…that it is too heavy o float. This however is a fallacy. In fact, most cars can be swept away by 18-24 inches of moving water. Trucks and SUVs do not fare much better, with an additional 6 to 12 inches of clearance. Actually, in moving water, all that needs to happen is for the vehicle to become buoyant enough for the force of the moving water to push it sideways.


How can this be avoided? The answer is quite simple – **Turn Around, Don't Drown!** Stay out of flooded roadways – the water may be much deeper than it appears as the roadbed may be washed out. Respect "Road Closed" barriers that may be posted. The same applies to anyone attempting to walk through flowing water. As little as 6 inches of rapidly moving water can sweep you off your feet.

Remember these additional safety rules:

- Consider carefully where you camp and/or park your vehicle along a stream or wash, especially during threatening conditions
- Be especially cautious at night when it is harder to recognize flood dangers
- Know when you are at risk! Keep informed of the latest weather watches and warnings from the National Weather Service with NOAA Weather Radio All Hazards or through your favorite news source.

# *Winter and other Weather Reporting Criteria for Skywarn Spotters*

***By Bill Gartner, General Forecaster & Dave Ondrejik, Warning Coordination Meteorologists***

As we head in to winter, we still need to hear from you. Your spotter reports help us to monitor ongoing winter storms, determine the need for possible changes to advisories and warnings, and provide real-time snowfall totals to the public, news media and other partners, and other NWS offices. Your reports are also used to verify our watches and warnings, as well as to prepare storm summaries and snowfall total maps of winter events. So even if you are not able to call in reports during a storm, but can give us a post-storm total snowfall, we'd still love to hear from you when the storm is over.

## What to report:

**Snow:**

- When snow accumulation reaches 3 inches
- When snow accumulation reaches 6 inches
- Storm total after the snow ends (also water equivalent if possible)
- If snow is falling at the rate of more than 1 inch per hour

**Ice:**

- Any occurrence of or accumulation of freezing rain
- Accumulation of ice of ¼ inch or more on trees or wires

**Other:**

- When forecast winter precipitation differs significantly from observed (i.e. snowing with no snow in forecast, sleet...when only snow is forecast...)

- Any other significant weather occurrence/oddity (i.e. flooding due to snow melt/ice jam, damage from strong winds not associated with a thunderstorm)

And, remember thunderstorms that produce wind damage and flooding rains are still possible even in winter.

For your convenience, a list of reporting criteria is available on our web page, www.weather.gov/statecollege. Click on "Thresholds" in the left-hand column. It is the fourth selection under the Current Hazards header.

For your interest…here are some examples:

## *Winter Precipitation*

Statements for these hazards will be issued under the header "**PHLWSWCTP** (WWUS41 KCTP)."

**For Snow alone:**

• Heavy Snow Warning: An average of 6" or more of snowfall in 12 hrs.
**OR** an average of 8" or more of snowfall in 24 hrs.

• Snow Advisory: An average of 3" or more of snowfall in 12 hrs.

• Winter Storm Watch: Possibility that Warning Criteria may be met at longer ranges (24 to 48 hrs out).

**For Lake Effect Snows (ONLY FOR Northwestern PA):**

• Lake Effect Snow Warning: An average of 6" or more in 12 hrs.
• Lake Effect Snow Advisory: An average of 3" to 5" in 12 hrs.
• Lake Effect Snow Watch: Possibility that Warning Criteria may be met at longer ranges (24 to 48 hrs out).

**For Ice alone:**

- Ice Storm Warning: 1/4" or more of ice accumulation from freezing rain
- Freezing Rain Advisory: <1/4" of ice accumulation

**Combinations of Winter Weather Hazards:**

- Blizzard Warning: Sustained or frequent gusts to 35 mph or greater AND considerable falling and/or blowing snow. These conditions must last for AT LEAST 3 hrs. (Usually associated w/6+ inches of snowfall in central PA)
- Winter Storm Warning: either 6 inches or more of snow w/some ice accum. or 1/4" ice and any snow/sleet.

- Winter Weather Advisory: A bothersome - but not damaging - combination of snow, sleet, and/or freezing rain/drizzle.

- Winter Storm Watch: Possibility that Snow, Ice Storm, or Winter Storm Warning Criteria may be met at longer ranges (24 to 48 hrs out).

- Blizzard Watch: Possibility that Blizzard Warning Criteria may be met at longer ranges (24 to 48 hrs out).

**Cold Wind Chills:**

- Wind Chill Warning: wind chills values of minus 25°F or lower.

- Wind Chill Advisory: wind chill values of minus 15°F to minus 24°F.

## *Non Precipitation Phenomena Warning Terminology*

The State College NWS Office will issue Advisories and Warnings under the header "PHLNPWCTP (WWUS71 KCTP)" for situations where the following non-precipitation phenomena are expected:

**Winds NOT associated with a specific Thunderstorm:**

- Wind Advisory: sustained winds 31 to 39 mph, for better than 1 hour - and/or wind gusts 46 to 57 mph for any duration.

- High Wind Warning: sustained winds 40 mph or greater, for better than 1 hour - and/or wind gusts 58 mph or greater, for any duration.

- High Wind Watch: Possibility that High Wind Warning Criteria may be met at longer ranges (24 to 48 hrs out).

**Widespread Frosts/Freezes, after the beginning (and before the end) of the "growing season":**

The BEGINNING of the *growing season* is set by the average date of the last freeze in spring, and normally happens during very late April to mid May in Central PA.

The NWS will then issue Frost Advisories and Freeze Warnings when appropriate, until the end of the growing season, according to the following rules:

- Frost Advisory: a widespread frost, which typically occur with mainly clear skies and light winds, and low temperatures near or slightly above freezing (33°F to 36°F).

- Freeze Warning: low temperatures across the whole county/zone at or below 32°F.

The END of the growing season occurs when most of the county/NWS zone has had it's first freeze in the autumn.

• Freeze Watch: Possibility that Freeze Warning Criteria may be met at longer ranges (24 to 48 hrs out).

**For High Heat Indices:**

• Heat Advisory: Issued when the Heat Index will be equal to or greater than 100°F, but less than 105°F.
• Excessive Heat Warning: Heat indices will attain or exceed 105°F.
• Excessive Heat Watch: Possibility that **Excessive Heat Warning** criteria may be met at longer ranges (12 to 48 hrs out).

**For Widespread Dense Fog:**

• Dense Fog Advisory: widespread areas of fog reducing the visibility to less than 1/4 mile.

## *Thunderstorm Threats*

**Severe Thunderstorm RISK Terminology** (used in **Hazardous Weather Outlooks**)

SLIGHT RISK: Severe thunderstorms are expected to be few or isolated.

MODERATE RISK: Severe thunderstorms are expected to be more organized, numerous, or widespread.

HIGH RISK: Severe thunderstorms with the potential for tornadoes, damaging windstorms, and/or large hail are expected

SEVERE THUNDERSTORM or TORNADO WATCH**:** Severe thunderstorms with large hail, damaging winds, and/or tornadoes are possible, but the exact time and location of storm development is still uncertain. A watch means be prepared for storms.

SEVERE THUNDERSTORM WARNING: A severe thunderstorm is imminent or occurring; it is either detected by weather radar or reported by storm spotters. A severe thunderstorm is one that produces winds 58 mph or stronger and/or hail 3/4 inch in diameter or larger. A warning means to take shelter.

SEVERE THUNDERSTORM WARNING A severe thunderstorm is imminent or occurring; it is either detected by weather radar or reported by storm spotters. A severe thunderstorm is one that produces winds 58 mph or stronger and/or hail 3/4 inch in diameter or larger. A warning means to take shelter.

TORNADO WARNING A tornado is imminent or occurring; it is either detected by weather radar or reported by storm spotters. A warning means to take shelter.

FLOOD WATCH Conditions are favorable for flash flooding. A watch means to get prepared for possible flooding.

FLASH FLOOD WARNING Life-threatening flooding is imminent or occurring; it is detected by weather radar, indicated by stream gauges, or reported by storm spotters. A flash flood is a flood that occurs very quickly; it is caused by heavy rainfall over a short period of time or from a dam break. A warning means to leave low-lying or flood prone areas.

# *How Common are Winter River Floods in Central Pennsylvania?*

***By Scott Kroczynski, MARFC Hydrologist andCharles Chillag MARFC Meteorologist***

Who remembers the January, 1996 river flood? This coming January will mark the 13th anniversary of this amazing winter river flood event. For those readers that need a little help recalling the scenario, this flood occurred January 19-20, 1996 as a result of unseasonably intense rainfall, remarkable snowmelt from very mild temperatures, and rapid river-ice breakup. For many locations in the Susquehanna River Basin it was and remains one of the top five highest floods. Some of you might even remember that this was the flood event that took out the old Walnut Street bridge in Harrisburg (see photo below – photo courtesy of Suzanne Yenchko, 1996).

So just how common are river floods in central Pennsylvania during the winter months? For this Skywarnews article, we decided to look at the three months of December, January and February (commonly referred to as “Meteorological Winter”) to come up with some basic river flood frequency information for a sampling of National Weather Service flood forecast points. Below is a table that shows the locations we chose and their associated flood frequency information.

| Location | Flood Stage (Ft) | River | Period | Total Floods (#) | Total Winter Floods (#) | Winter Floods (%) | Spring Floods (%) | Summer Floods (%) | Fall Floods (%) |
|---|---|---|---|---|---|---|---|---|---|
| Renovo | 16 | West Branch Susque-hanna | 1965-2007 | 10 | 2 | 20 | 40 | 20 | 20 |
| Lock Haven | 21 | West Branch Susque-hanna | 1974-2007 | 4 | 2 | 50 | 0 | 0 | 50 |
| Williams-port | 20 | West Branch Susque-hanna | 1928-2007 | 20 | 5 | 25 | 55 | 5 | 15 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Newport | 22 | Juniata | 1929-2007 | 8 | 2 | 25 | 38 | 12 | 25 |
| Sunbury | 24 | Susque-hanna Mainstem | 1967-2007 | 10 | 2 | 20 | 40 | 20 | 20 |
| Harrisburg | 17 | Susque-hanna Mainstem | 1928-2007 | 26 | 9 | 34 | 46 | 8 | 12 |

Close inspection of the last four columns in the table above yields some interesting facts. On average, for most locations in central Pennsylvania river flooding is most likely to occur during the spring months (March-May). Conversely, the season least likely to experience river flooding on average is summer (June-August). As far as winter goes, there's good news and bad news! The good news is that winter river floods, on average, are less likely to occur than spring river floods for many locations in central Pennsylvania. But the bad news is that winter river floods are generally more likely to occur than summer river floods. Not to be forgotten, in fall the likelihood of river flooding for many central Pennsylvania locations is about the same as it is in winter. Of course, our goal is to save lives and protect property - no matter how frequent, how extensive or how severe the flooding gets!

Best wishes for a flood-free winter – or for that matter, a flood-free lifetime! Please visit the NWS Middle Atlantic River Forecast

Center's web site at www.erh.noaa.gov/er/marfc/ for detailed river flood frequency information for numerous central Pennsylvania locations, and for a wealth of other information!

## *Winter Warm-up Costing N.E. Region*

***Beth Daley, January 2007 (used with the permission of The Boston Globe)***

*Editor's note: The following article centers on the effects of climate change in New England, but similar effects are being observed locally in Pennsylvania.*

At 9 p.m. on Jan. 8, 1829, school principal William Nutting pulled out a bulky brown diary in Randolph, Vt., and wrote in careful cursive: "Snow fell about 12 inches (day and night)." Three times a day for 35 years, Nutting fastidiously recorded the weather, until he died of pneumonia in 1863.

Today, Nutting's brittle diary, farmers' journals, archival photographs, and even the observations of naturalist Henry David Thoreau are being examined by scientists to address a critical question about New England's changing climate: Is it driven by man-made global warming?

Scientists face a number of uncertainties in answering the question. New England's official weather records go back about a century, limiting scientists' ability to compare the present with the distant past to assess how much of the changes they are tracking stem from global warming and how much can be explained by natural climate cycles. Unofficial records that go back farther or that measure key indicators, such as snow on the

ground or the flowering dates of plants, are from isolated locations or sometimes measured in different ways, making it difficult for researchers to draw sweeping conclusions.

Now, researchers are beginning to use a mix of cutting-edge technology and dusty historical records to piece together a clearer picture of New England's warming. They are using sophisticated computer models and techniques that can simulate some regional weather dynamics. And they are becoming sleuths to find untraditional climate data to help answer whether the changes they are seeing are unprecedented.

Some New England scientists say the weather systems in the region are so complex and so little understood that it is virtually impossible to distinguish warming caused by carbon dioxide emissions from natural temperature fluctuations. They point to this winter's (2007) balmy temperatures -- largely attributed to the El Niño weather pattern in the Pacific Ocean -- as an example of the vast, unpredictable forces that can shape the region's weather.

The increase in the region's winter temperatures began accelerating around 1970 -- the same time overall global temperatures did. Also, the temperature rise in New England is lasting longer than previous warm stretches in the past century that were attributed to natural variability. And the entire region has been affected.

Global warming is not expected to heat the world uniformly -- some places may even cool. Scientists are becoming better at using computer models, which use decades of weather observations and complicated mathematical formulas that describe the physical processes that shape the climate, to predict global warming's impact on a regional scale.

A group of specialists brought together by a Cambridge-based advocacy group, the Union of Concerned Scientists, used eight computer models to determine global warming's impact on the entire Northeast . The models' simulation of the past 100 years closely matched the observational record -- except that winters have warmed far more during the past 30 years than the models suggested.

"That's what really stood out," said Cameron Wake, a research associate professor at the University of New Hampshire who was a lead scientist in the modeling exercise. "There are dramatic changes taking place in the winter."

Wake and his colleagues are just beginning to study why winters are warming so much faster than the other seasons, but he suspects the answer may be related to why some people wear white on a hot, sunny day: The color reflects the sun's heat and keeps the wearer cooler. With less snow on the ground, the earth absorbs more of the sun's heat, warming the surface temperature. Scientists believe this amplifying effect is partly why the Arctic is warming so fast. The models analyzed by Wake and his colleagues were not able to measure this effect, called albedo.

"We do know that global climate change is happening. We know that most of it is caused by human emissions . . . and we know that it is likely already affecting New England," said Katharine Hayhoe, a research associate professor at Texas Tech University who helped lead the modeling study.

"But we just can't determine precisely how much yet."

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