SKYWARNEWS

National Weather Service State College, PA - Autumn 2007

"Working Together To Save Lives"

*An evening **red** and morning **gray***
Will set the traveler on his way.
*But an evening **gray** and a morning **red***
Will pour down rain on the pilgrim's head
-***Old Farmer's Almanac 1857***

2007-2008 Winter Outlook – La Niña Arrives, Above Normal Temperatures Expected Across Much of the U.S.

Matt Steinbugl, General Forecaster

So what does the upcoming winter season (December-February) have in store with regard to temperatures and precipitation? Will it be a warm, mild winter or cold with lots of snow? For these answers, forecasters often turn to the state of the El Niño/Southern Oscillation or ENSO for insight and clues into what the upcoming season may hold. ENSO is often thought of as a global cycle which includes La Niña, El Niño and neutral phases. Scientists rely heavily on the ENSO cycle in making

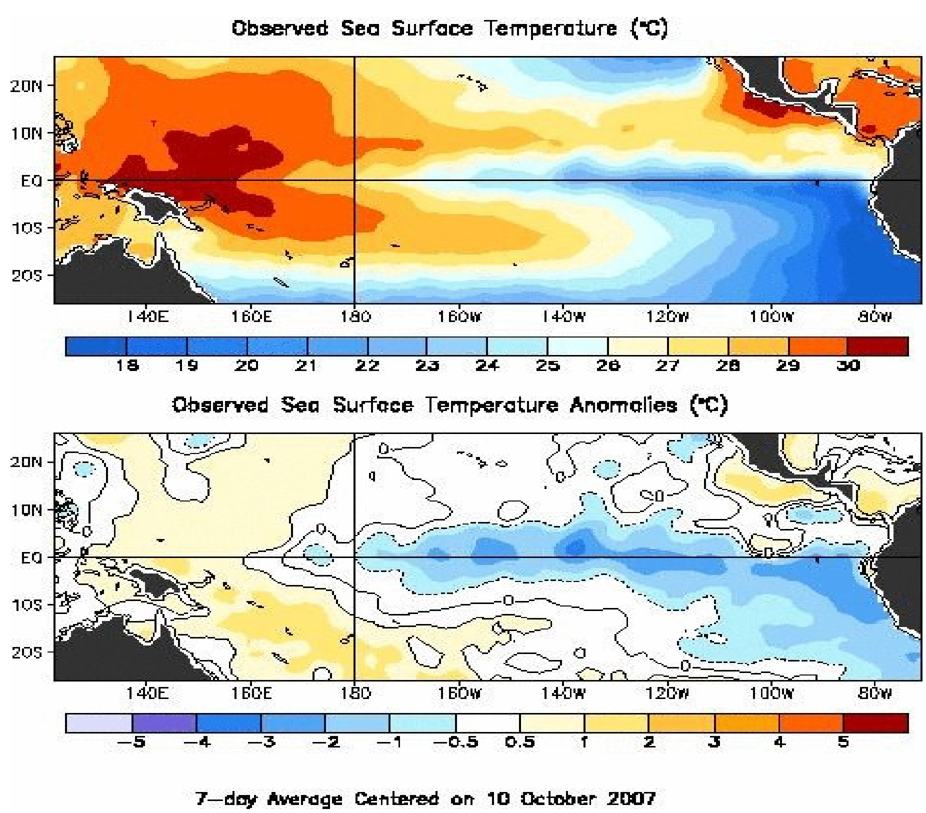

Figure 1. 7-day average of observed SSTs and SST anomalies centered on Oct 10, 2007. Note the cooler than normal departures from the mean across much of the central equatorial Pacific – signaling La Niña conditions. (NOAA/CPC)

seasonal predictions because it appears to be a necessary mechanism for maintaining long-term global climate stability by transporting heat from the Tropics to the higher latitudes.

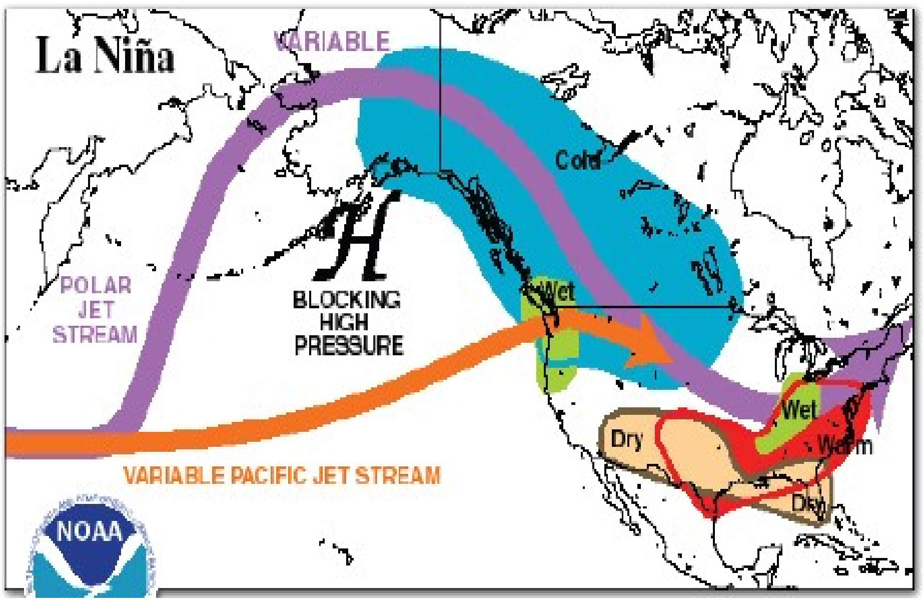

Figure 2: Typical winter patterns during La Nina. Note that much of the southern and eastern part of the country is usually warmer than normal. Additionally, much of the southern U.S. is drier than normal with the Ohio Valley typically wetter than normal. (NOAA/CPC)

So if the ENSO cycle is such a key factor in making seasonal predictions, how do scientists monitor and predict ENSO events or phases? The methodology behind making seasonal predictions can be boiled down into four main categories: data collection, indicators and indices, numerical models and research/local studies.

NOAA operates a network of 70 stationary buoys in the equatorial Pacific, called the Tropical Atmosphere/Ocean (TAO) array, which provides data about upper-ocean and sea surface conditions. Other important data come from satellites, radiosondes, and the high-density U.S. surface data network. One of the primary indicators, Sea Surface Temperature (SST), is closely monitored throughout the Pacific Ocean, including Niño 3.4, a region stretching along the equator from 170ºW to 120ºW longitude and 5ºN to 5ºS latitude. An index for monitoring and assessing the oceanic state of ENSO, known as the Oceanic Niño Index (ONI), is based on this region and represents the sea surface temperature departure from a long-term average. The ONI refers to SST departures from the 1971-2000 average in the Niño 3.4 region. NOAA Operational Definitions of El Niño and La Niña are keyed to this index as follows: El Niño: characterized by a positive ONI greater than or equal to +0.5°C La Niña: characterized by a negative ONI less than or equal to -0.5°C. To be classified as a full-fledged El Niño or La Niña episode, these thresholds must be exceeded for a period of at least five consecutive months. Numerical models have been developed to study and predict ENSO events and their effects on weather patterns throughout the world. Though by no means perfect, under certain conditions, these models can indicate which climatic conditions are likely to prevail during the next season or two. Although ENSO has been well-documented over the last several years, there is still much to be done in determining local impacts.

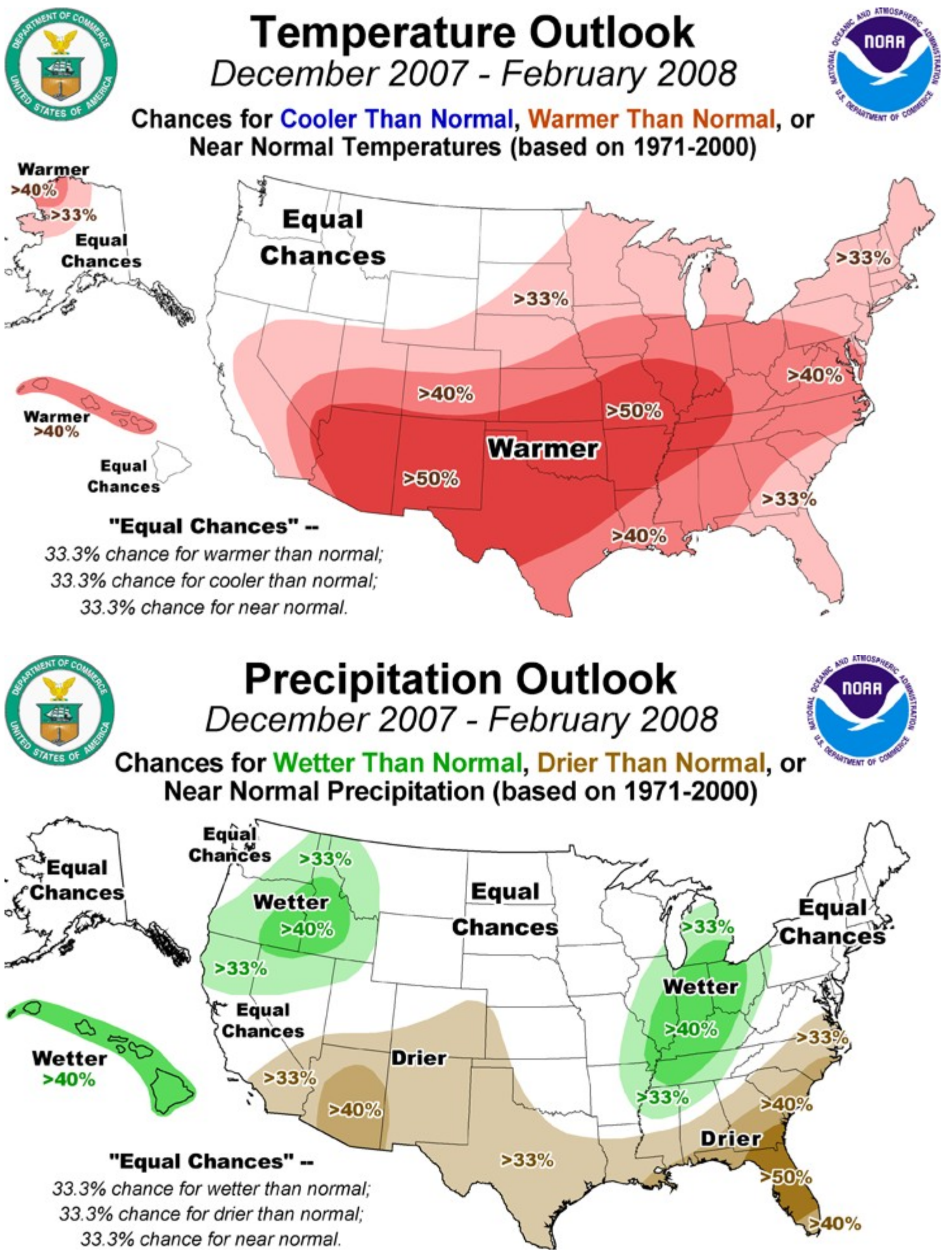

Figure 3: December 2007 – February 2008 Temperature and Precipitation Outlooks for the U.S. (NOAA)

Back in June, forecasts from NOAA's Climate Prediction Center (CPC) indicated a possible transition from ENSO-neutral to La Nina conditions by early autumn. La Niña refers to the periodic cooling of ocean surface temperatures in the central and east-central equatorial Pacific that typically occurs every 3 to 5 years. La Niña represents the cool phase of the El Niño/Southern Oscillation (ENSO) cycle, and is sometimes referred to as a Pacific cold episode. The latest analysis indicates that a weak to moderate La Niña has arrived and will likely persist through the winter. These forecasts are largely based on the following indications:

- •SST anomalies have become increasingly negative (colder-than-normal) in the central equatorial Pacific (Fig. 1).
- •Nearly all of the dynamical and statistical models predict a weak-to-moderate La Niña persisting through early 2008.
- •Recent equatorial Pacific SST trends and model forecasts indicate La Niña conditions will likely strengthen during the next several months.

La Niña conditions tend to influence wintertime atmospheric flow across the eastern North Pacific and North America.

La Niña episodes display considerable event-to-event variability and the overall effects tend to be less predictable than those for El Niño.

La Niña episodes are associated with three prominent changes in the wintertime atmospheric flow across the eastern North Pacific and North America. The first is an amplification of the climatological mean wave pattern and increased meridional flow across the continent and the eastern North Pacific. The second is increased blocking activity over the high latitudes of the eastern North Pacific. The third is a highly variable strength of the jet stream over the eastern North Pacific, with the mean jet position entering North America in the northwestern United States/ southwestern Canada. Accompanying these conditions, large portions of central North America experience increased storminess, increased precipitation, and an increased frequency of significant cold-air outbreaks, while the southern states experiences less storminess and precipitation. Also, there tends to be considerable month-to-month variation in temperature, rainfall and storminess across central North America during the winter and spring seasons, in response to the more variable atmospheric circulation throughout the period.

Based on the antecedent and current La Niña conditions, NOAA forecasters are calling for above-average temperatures over most of the country and a continuation of drier-than-average conditions across already drought-stricken parts of the Southwest and Southeast this winter. In the Northeast and the Mid-Atlantic, temperatures are expected to be above average in response to the long-term warming trend. Snowfall for the region will depend on other climate factors, which are difficult to anticipate more than one-to-two weeks in advance.

The drought-plagued Southeast is likely to remain drier-than-average due to La Niña, while temperatures are expected to be above average. In the Great Lakes and Tennessee Valley, temperatures and precipitation should be above average. The south-central Plains should see drier-than-average conditions and warmer-than-average temperatures. Above-average temperatures are also expected in the central Plains. The northern Plains has equal chances of above-, near-, or below-average temperature and precipitation.
In the Northwest, there are equal chances for above-, near-, or below-average temperatures. Precipitation should be above average in much of the region due to La Niña. Drought conditions are expected to persist in the Southwest due to La Niña, and temperatures are likely to be above average. Northern Alaska is expect to be milder–than-average, while the rest of Alaska has equal chances of above-, near-, or below-average temperatures and precipitation. In Hawaii, temperatures and precipitation are expected to be above average.

This winter is predicted to be warmer than the 30-year norm. For the country as a whole, NOAA's heating degree day forecast for December through February projects a winter 2.8 percent warmer than the 30-year normal, but a winter 1.3 percent cooler than last year.

Pennsylvania Summer 0f 2007 in Review

John La Corte, Senior Forecaster

Walking around the store recently, I noticed The Old Farmers Almanac on the shelf again. That is just one of the signs that summer is over and that shorter days and colder weather are on the way. So before the season grows gray and any raking or shoveling has to be done, I always find it comforting to go back and review the summer and attempt to recall those long-hot days laced with humidity and all the fine outdoor activities the warmth allows.

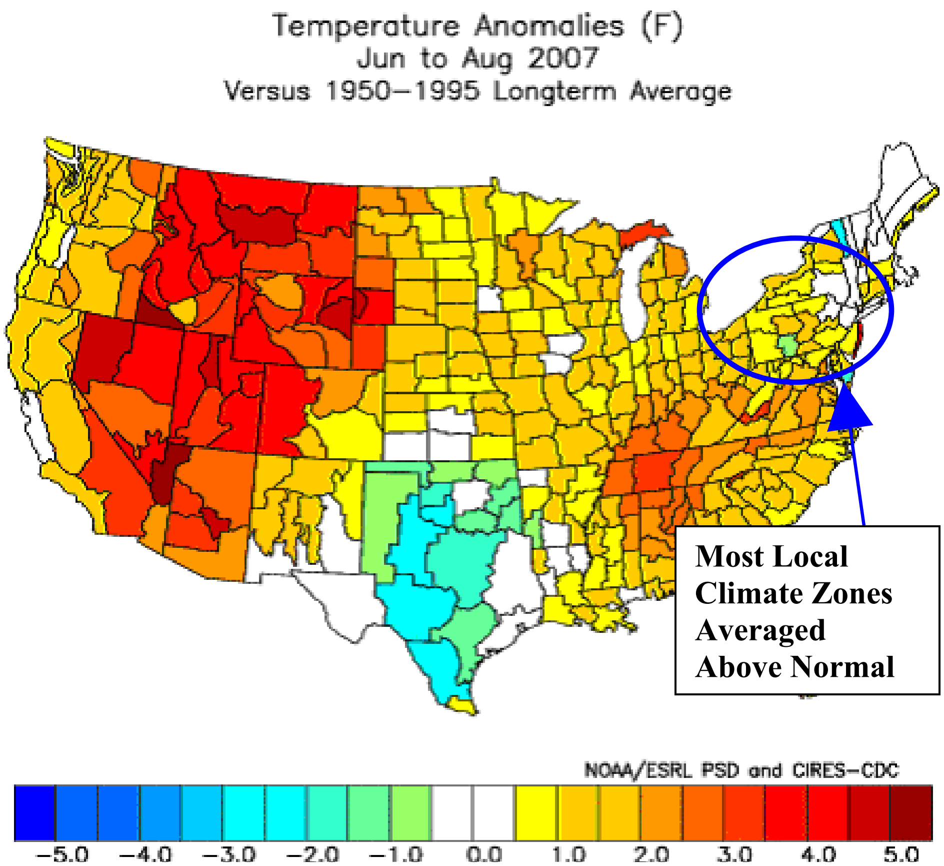

Figure 1. Summer Temperature Anomalies

While averaging above normal, the warm months were sandwiched around a “chilly” July. June and August averaged anywhere from around 3 to 4 degrees above normal. July on the other hand went the other way with some areas seeing averages as much as 3 to 6 degrees below normal. Of course there are some who might welcome a cooler than average July with that month being climatologically the warmest on the calendar. If nothing else, a little relief in mid summer can help save on cooling costs. Despite ending cooler than normal, the warmest reading of the summer in the central part of the state still managed to happen in July. It was on the 10th when the airport in Williamsport hit 100 degrees, making it the highest temperature recorded for the summer in the state.

Another measure of a summer’s warmth can often be gleaned by the number of times a location hits ninety or higher during the summer. Table 1 shows that of the eleven reporting sites chosen from around the region, seven either equaled or exceeded the normal number of days that they reach or surpass 90 degrees.

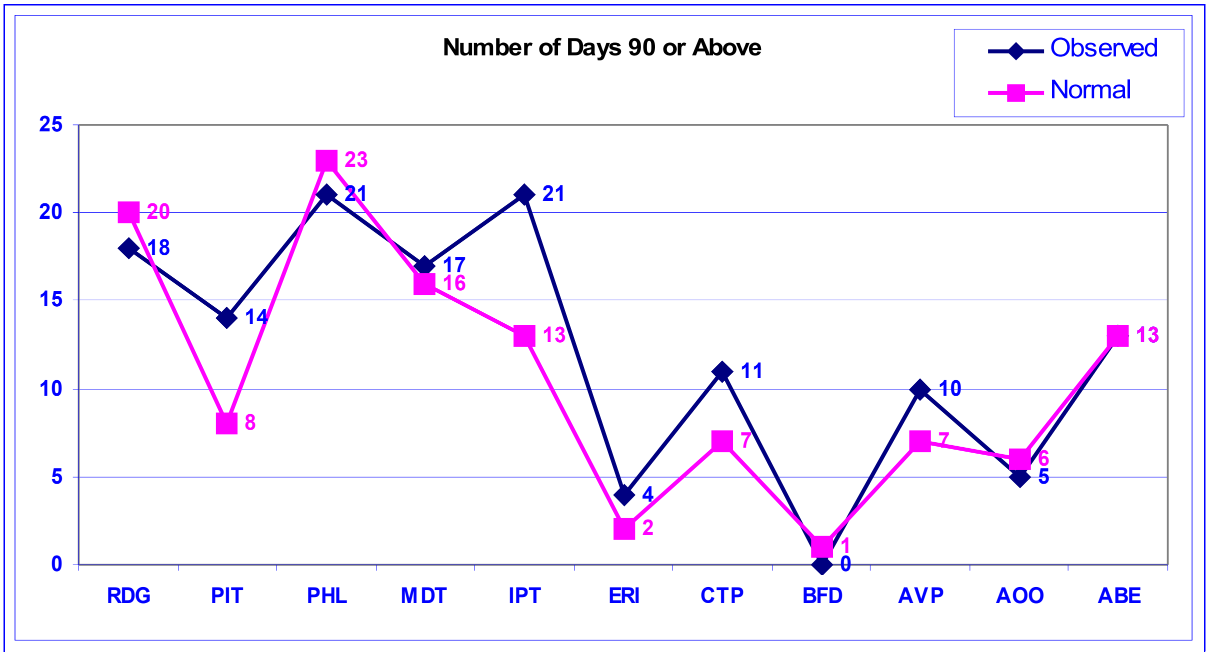

Table 1. Number of Days 90 or Above

So with the roller coaster ride of average temperatures, the summer varied from a little above to a little below normal over most of the state. In the end it ended up being not very noteworthy or record setting.

Precipitation for the summer ended up being not very far from normal in most locations. Once again it was a tale of two summers with much of June and July very dry, topped off by a very wet August. So when totaling things up the numbers average out close to normal and this is depicted in figure 2.

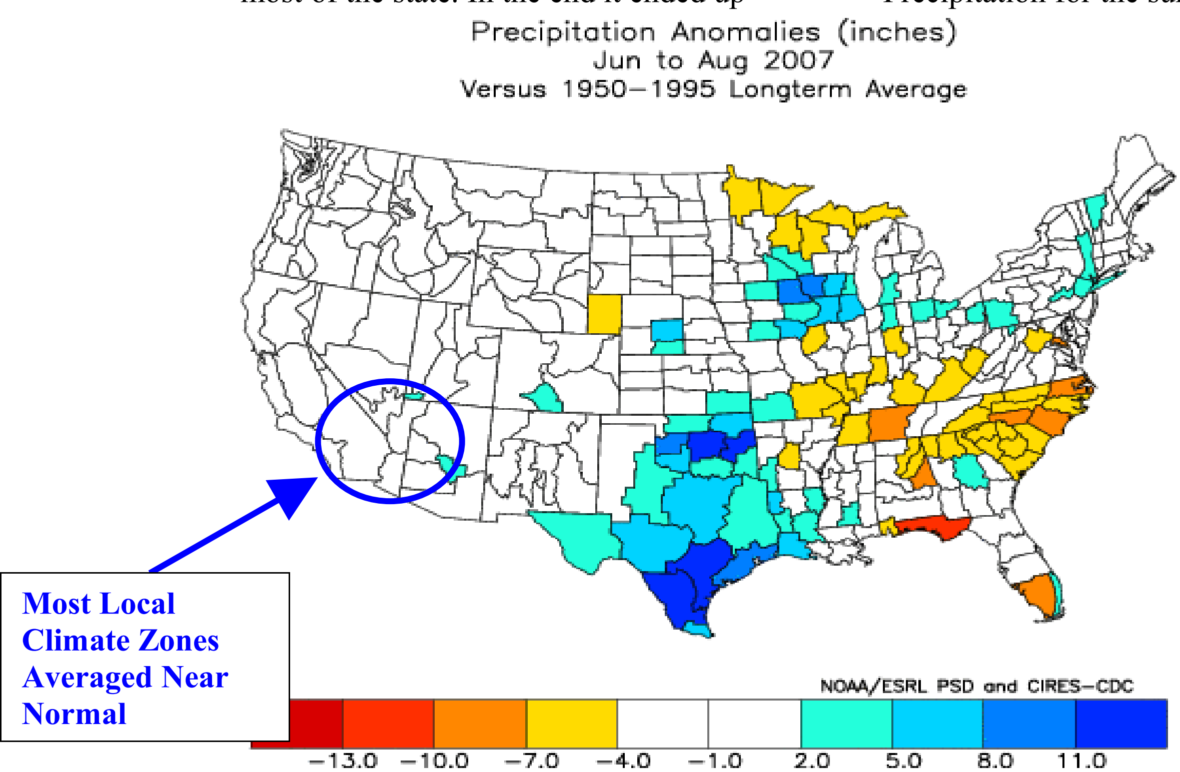

Figure 2. Summer Precipitation Anomalies

Another measure of how wet or dry a summer is can be determined by looking at the number of days that measurable precipitation fell versus the normal number of days that rain is usually observed. Figure 3 shows just 4 out the eleven reporting stations observing more days with measurable precipitation than is normal. Recall we had a very dry start to the summer so much of this represents the "catching up" that took place in August.

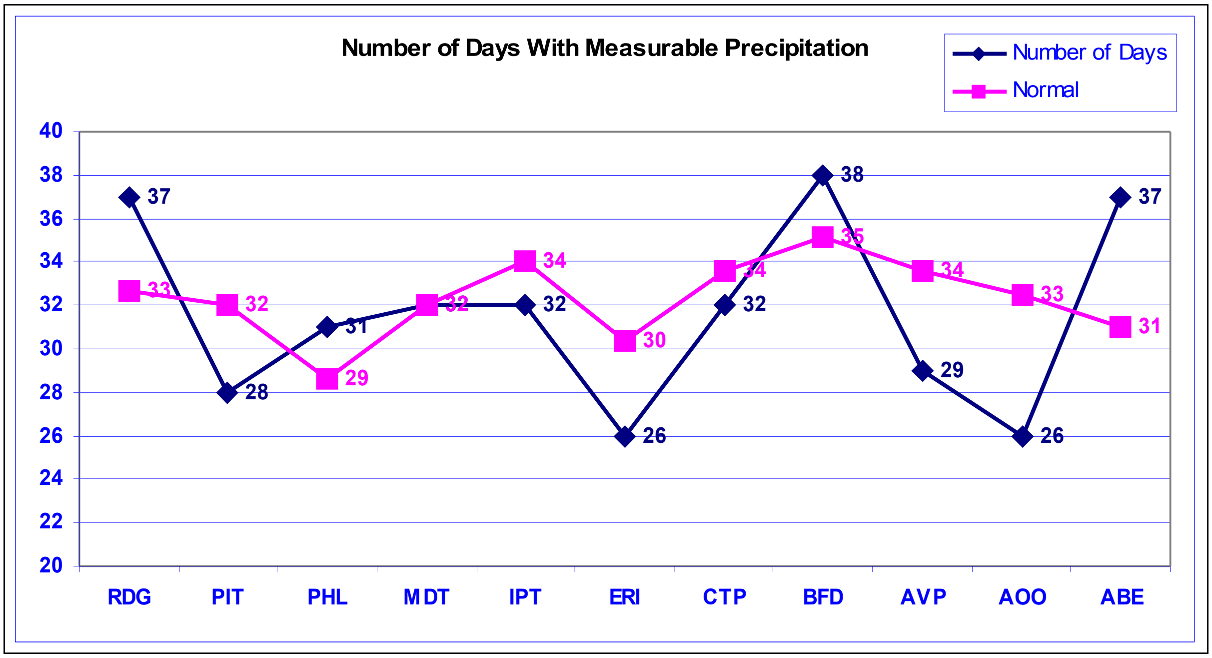

Figure 3. Summer Precipitation Anomalies

So as the pumpkins get hauled out of the fields and summer fades to a pleasant memory, we traditionally look forward and wonder what kind of winter we will have here in Pennsylvania. The Climate Prediction Center's official forecast for the northeastern United States calls for an increased chance of above normal temperatures. This is mainly due to the recent development of La Nina conditions in the South Pacific. This cooling of the tropical waters many thousands of miles away, when it occurs in the autumn has been shown to have a strong correlation to warmer than normal temperatures over much of the United States during the following winter months. Now that doesn't mean that ALL winters influenced by La Nina end up warmer than normal, it just means that statistically speaking, the chances for warmer than normal conditions increase.

What about snow? Well the "signal" here in Pennsylvania during La Nina winters isn't quite so clear. The CPC forecast calls for what they describe as "equal chances" meaning according to the forecast tools we now have available to us, the winter is just as likely to end up near, above or below average where precipitation is concerned. It sounds like a hedge but what it is saying is that we don't believe we have much skill in forecasting rain or snow under this pattern. It is preferred to say it that way rather than issue a definitive forecast that has a 2 out 3 chance of being wrong. Either way it goes, we cannot control it so why not sit back and just enjoy whatever Mother Nature throws our way? The only sure thing is that eventually the long days will return and the cold and snow will fade to memories the same way the heat and humidity have.

Woodward (Centre County) Tornado – August 7, 2007

Barry Lambert, Senior Forecaster

A nearly-stationary east to west surface frontal boundary (enhanced by rain-cooled air from an area of morning showers and thunderstorms) combined with a low-level southwesterly wind maxima to produce a few supercell thunderstorms across Central Pennsylvania during the evening of August 7, 2007 (Fig 1).

A mesoscale area of low pressure formed along the frontal boundary and combined with anomalously high surface dewpoints in the lower to mid 70s, and warm late evening temperatures in the mid 70s to lower 80s to create the instability and lift necessary for rapid thunderstorm development. The southern supercell thunderstorm maintained its intensity as it moved east southeast along the edge of the higher instability that was located across the Central Mountains and Lower Susquehanna Valley of Pennsylvania. This storm produced a rare late evening tornado near the town of Woodward in far eastern Centre County.

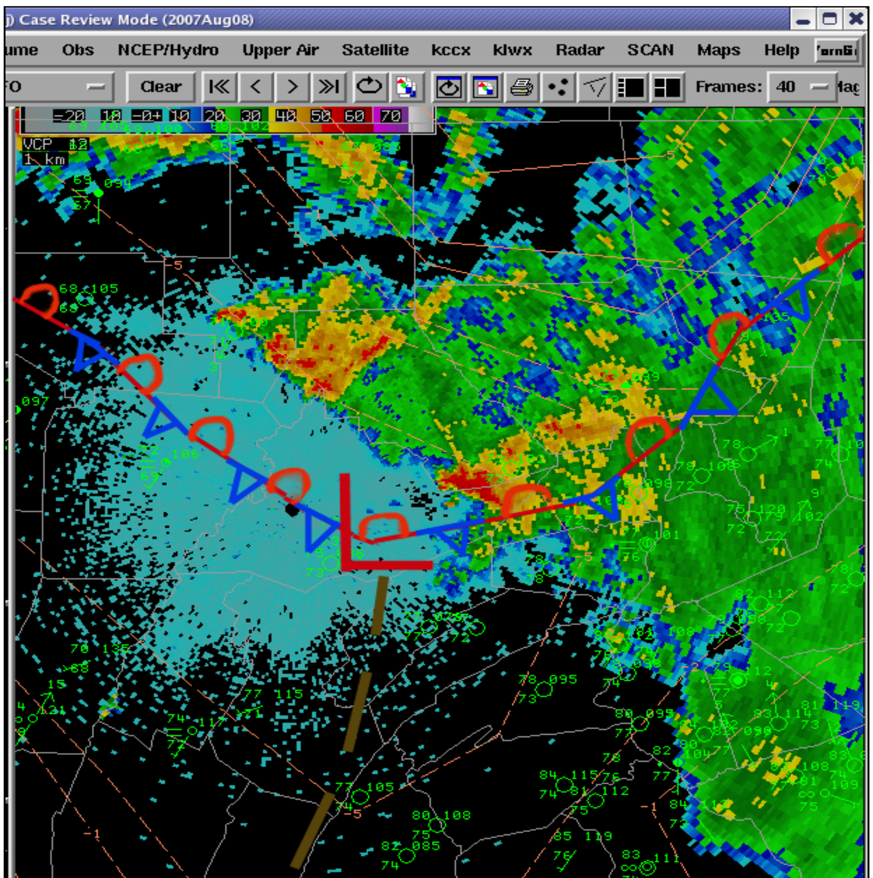

Figure 1. Surface low and fronts overlaid and 0.5 deg State College radar

The mesocyclone associated with the Centre County supercell reformed at least once (near the town of Rebersburg) to the southeast of its initial updraft. The second updraft spawned an EF1 (Enhanced Fujita Scale category 1, with winds between 86 and 110 mph) tornado which touched down near the town of Woodward in extreme Eastern Centre County around 1020 pm EDT. It produced a damage path of around 1.5 miles long and up to 400 yards wide. The tornado was on the ground for about 5 minutes and contained peak wind speeds estimated between 85 and 95 mph.

The Supercell thunderstorm responsible for the tornado formed around 9 pm EDT several miles to the northeast of the KCCX radar site in northern Centre County and traveled east along Interstate 80 (Fig 2).

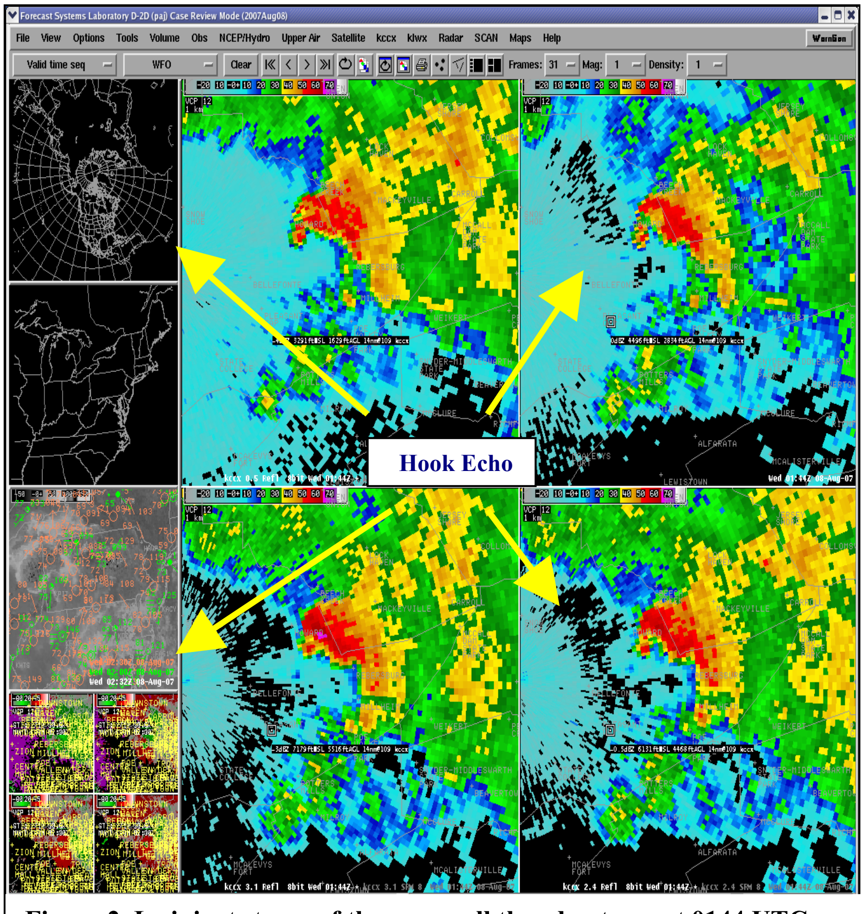

Figure 2. Incipient stages of the supercell thunderstorm at 0144 UTC showing a pronounced reflectivity "hook echo" at numerous levels of the storm (which was located 8 miles northeast of Bellefonte about 35 minutes prior to producing a tornado).

The storm developed deep cyclonic rotation near the town of Nittany around 10 pm EDT (Fig 3) prompting a Tornado Warning from the National Weather Service office in State College. The warning was issued for East Central Centre county and Southeastern Clinton county effective until 1030 pm EDT. A close examination of figure 3 shows the strong rotation in the Doppler radar velocity fields.

The bright red (away) and green (toward) colors indicate strong winds and circulation detected by the radar. It is rare to see rotation of this magnitude on the radar; it is even rarer to see a storm this strong so late in the evening. Most severe weather in Pennsylvania occurs during the late afternoon or early evening. Despite this storm forming outside of the "normal" time when severe storms usually form here in the state, forecasters were quick to act and issue the necessary warnings. Thankfully it hit a mainly rural part of the region and there were no injuries reported.

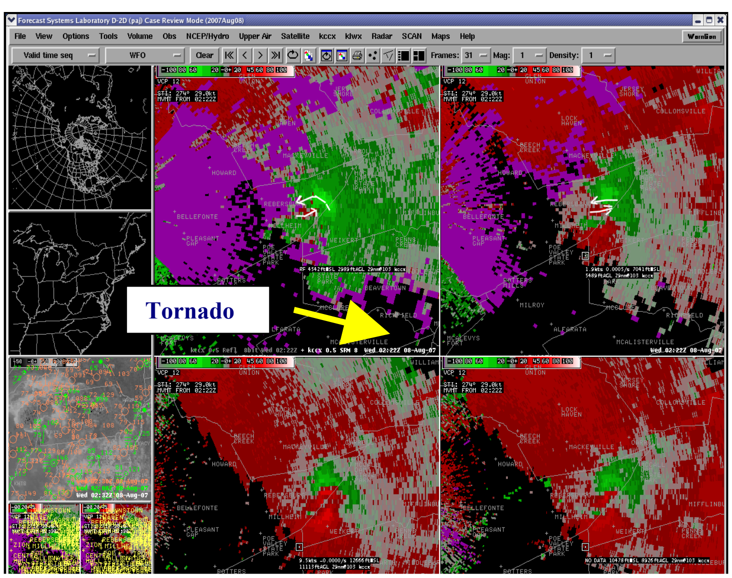

Figure 3. Doppler radar indicated strong rotation with greens showing winds toward the radar and red away from the radar.

Around the Arctic…

John La Corte, Senior Forecaster

Global Climate Change

Global warming remains a very controversial subject, but at long last a consensus is being reached within the scientific community. While there remains ample debate about what may be causing the warm up, it is now acknowledged that our Earth is indeed heating up.

While the discussion rages on about whether man is causing, contributing or merely a spectator to rising global temperatures, what cannot be debated are some of the effects that are taking place around the world, some of which are literally unprecedented in recorded history. This article will attempt to provide a brief summary of some of those effects and in some cases a few possible consequences of them.

Feedback Cycle

Since about the 1880's global temperatures have risen about 1.4 degrees with that rate of warming increasing over the last half of the 20th century. In fact the last two decades have been the hottest in the last 400 years, and possibly over the last several thousand years, this according to NASA's Goddard Institute for Space Studies. Of the 20 hottest years on record, 19 have occurred since the 1980s.

One of the most visible features being affected are the glaciers. While 1.4 degrees doesn't seem like much, that increase isn't uniform across the globe. In fact the arctic regions are warming even more, with some parts seeing temperatures rise 3 to 4 degrees on average. It is theorized that as the poles warm, snow and ice will continue to melt at an increasing rate due to the increase in the amount of solar energy being absorbed in the now snow-ice free areas. This is known as a feedback loop. Snow and ice are very efficient at reflecting solar energy. As they recede and melt away, the sun gets absorbed at increasing rates into the underlying surfaces. The feedback loop means more ice and snow melts, more sun is absorbed leading to even more snow and ice melting.

Globally, glaciers and mountain snowcaps have been receding since about 1980, with the retreat become increasingly rapid in recent years. Excluding the polar ice caps, glacial ice worldwide has decreased by 50% since the start of the 20th century. As of March 2005, the snow cap that has been atop Mt. Kilimanjaro for nearly 11,000 years has all but disappeared. Similar losses of snow and ice pack have been observed in the Andes, Alps, Himalayas, Rockies and North Cascade Mountains.

The loss of mountain glaciers can directly lead to landslides, floods and lakes overflowing. But indirect effects can be runoff declines in the summer in areas that normally rely on glacial melt for water supplies. Smaller glaciers and snow pack mean less run off and an increased potential for drought. At the current rate of shrinkage, the glaciers of the Himalayas that supply some of the worlds biggest rivers such as the Ganges, Indus, Yangtze, Mekong and Yellow could literally dry up by the year 2035. More than 2 billion people live in the drainage basins of these rivers and rely on the water for everything from agriculture to industry and recreation.

Perhaps nowhere on Earth have the receding glaciers been more prevalent than on Greenland. Satellite pictures for decades from the 1950s through 1970s showed that the largest glaciers had changed little. Suddenly in 2001 the glaciers began receding rapidly, some at a rate of more than 300 feet per day! So much for moving at "glacial speeds".

As this water melts and flows into the oceans, the logical result is a rise in sea level. It is estimated that sea level has risen more than 380 feet since the peak of the last ice age some 18,000 years ago. Since 1900 sea level has risen at a rate of about 1-2 millimeters per year, or about a tenth of an inch, increasing slightly since about 1990. The fear is that this gradual increase will not continue and that future increases could be sudden and catastrophic. Geological data suggests that polar ice has at times in the past melted rapidly. There is evidence that about 3.5 million years ago a 2 to 3 degree increase in global temperature resulted in a rapid rise in sea level of about 80 feet. The lesson is that ice responds immediately to changes in temperature.

Permafrost

One of the biggest fears regarding the feedback cycle is what effect the melting of permafrost would have. Permafrost is what the name implies, areas that have been perennially frozen. With the potential melting of this permafrost, the danger is that methane trapped within these frozen layers of earth will be released. Methane is an extremely efficient greenhouse gas. A report released in 2005 described how a huge (more than 600,000 square miles) permafrost peat bog in Siberia has begun to thaw for the first time since it was formed some 11,000 years ago. This has the potential to release as much as 70 BILLION tons of methane into the atmosphere!

With that scenario as a potential disaster headline in the future, perhaps a lesser but more immediate effect of this melting of permafrost will be an increase in the cost of maintenance of certain parts of regional infrastructure. Already the effects of melting permafrost have been observed in some arctic regions where roads, airport runways and building foundations have sunk, twisted or severely cracked. Some areas have reported that power and utility poles need to be reinforced or replaced as the ground they have been sunk in melts and softens, causing them to lean or topple.

Blueberries

For decades Maine has been considered the blueberry capital of the world, but climate change may be threatening their reign as kings of the berry world. 350 miles to the northwest, more than 3 hours north of Quebec City, they grow blueberries as well. However every four years or so a severe spring frost hits the region effectively wiping out that season's harvest. However the killing frosts have become less frequent, especially over the last 20 years. In fact the killing frosts occur only about half as frequently as they did in the 1950's. The result has been annually increasing blueberry harvests north of the border, potentially threatening Maine as the biggest supplier. Some believe this is a very real example of how global warming could play a role in shifting the economic fortunes of some areas.

It may become a reality that warmer temperatures could adversely affect things such as maple syrup harvests and the length of the skiing or snowmobiling seasons. However real impacts may arise from indirect effects when competition increases from places where the climate is becoming more conducive to such activities and products. So while worldwide demand for anti-oxidant rich blueberries grows, global warming seems to be lending an opportunity for our neighbors just across the border to become bigger players in the berry market.

Bluebirds and Pine Forests

While shrinking polar ice may threaten Polar Bears and Emperor Penguins, some lesser known but equally troubling symptoms of the warming may be the appearance of flora and fauna previously unknown to some locations. Around the Arctic, salmon are swimming into more northerly waters and barn owls are flying to regions where indigenous people have never even seen a barn.

Hornets and Bluebirds have been sighted in regions where locals lack words for them, and the lack of words to describe these newcomers does not stop at animals and plants. Words like “thunderstorm'” don't exist because they are phenomena previously not known to some areas and cultures.

Evidence exists that forests will move north and displace tundra. This will bring more species such as birds, insects and fungi. The warmer winters have already been linked to devastating pine beetle infestations in northern British Columbia. It only takes a few days of extreme cold to provide an effective natural control to these pests. The spread of these insects has in some cases resulted in the loss of as much as 50% of the native pines, and the infestation has spread into parts of Alberta. Besides the ecological and economical impact, the presence of large stands of dead-wood creates an increased risk of forest fire.

Possible Positive Effects

While many of the consequences could very well be dire, not all of the effects of global warming will necessarily be negative. Milder winters could mean fewer deaths worldwide from the spread of winter illnesses such as cold and flu. Agriculture would benefit by the spread of temperate zones further north and the extension of growing seasons. The use of carbon fuels used for winter heating would be decreased, resulting in fewer greenhouse gases, a very positive result. Over the polar north, sections of ocean that have been perennially closed or limited by ice could open up and provide shorter nautical travel routes, providing faster trade routes and even increases in tourism. Even the lowly squid could benefit, as well as those who like sushi. Consisting of mainly protein, they are extremely sensitive to changes in temperature, and many species react to warmer weather by developing larger body masses. Warmer temperatures could lead to more calamari.

The Future

While it is beyond the scope of our little newsletter here to offer an argument about what we should or should not do about climate change, hopefully it is apparent that the warming is real. The official position of our parent agency, the National Oceanic and Atmospheric Administration (NOAA) is that a consensus now exists that the Earth is warming. While the effects of a warming globe can be seen and felt in many different ways, there remains a lot of speculation about the eventual effects or consequences. What we as an agency will continue to do is build our knowledge about the forces that continue to affect and change our planet.

Thanks to articles from the Boston Globe, National geographic News, Wikipedia and NOAA for reference material for this newsletter.

Global Warming and You

Richard Grumm, Science Officer

Most of us have heard about global warming in the news and the recent award presented to former Vice President Al Gore and Intergovernmental Panel on Climate Change (IPCC). There are two primary arguments related to global warming including is global warming real and what are the causes of global warming? All of this will impact you at some point and how you will be impacted is not clear.

The first argument is whether global warming is real. It is now clear in a wide range of datasets that global warming is real. This is not only clear looking at data sets, but is become clearer as we read headlines about the warmest December on record, the warmest month on record, or the 5th warmest September on record in 2007. In 1999 most Americans learned that 1998 was the warmest year on record, nudging out the previous record holding year of 1934. More recently, 2006 moved into second place behind 1998 as being the warmest year in US history. According to NCDC 15 of the top 25 warmest years have been observed since 1980 and 6 of the 10 warmest years have occurred since 1990. Most data points to the fact that overall, global warming is real.

The IPCC and most climate analysts suggest that the impacts of global warming would be greater at high latitudes than at lower latitudes. In the northern hemisphere, bad news if you're an ice floe following polar bear, good news if you're a tropical fish. Even more bad news for the colder arctic regions is that Arctic sea ice reached record minimums during the summer of 2007. In fact, the ice retreated to an extent that most IPCC climate modelers predicted would not occur until some time between 2020 and 2040 (Fig. 1). These data show the forecasts from various climate models with the mean value shown in red. The thick black line shows the observed change in the arctic sea ice. Unless the ice grows back this winter

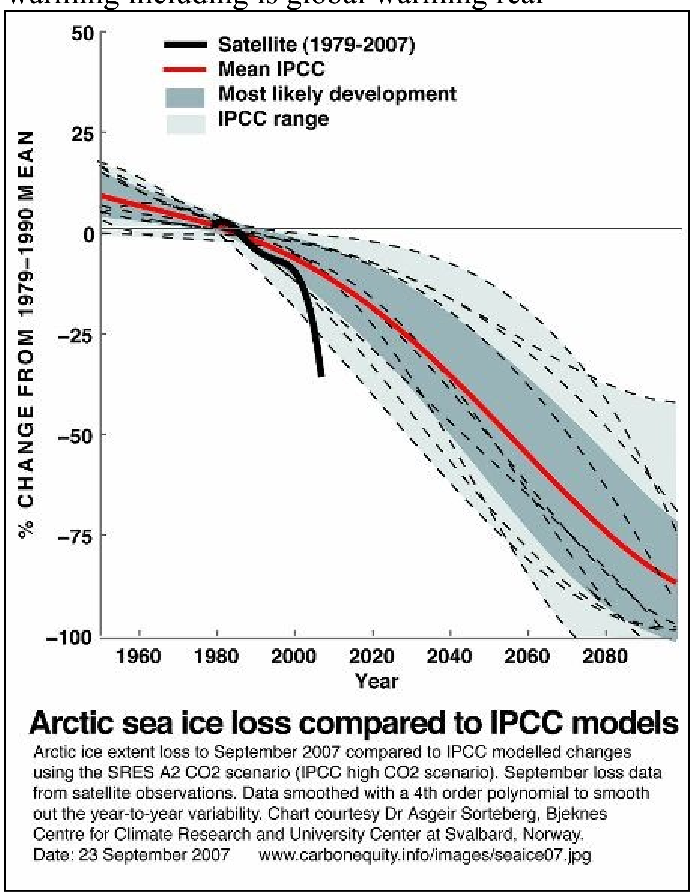

Figure 1 IPCC Arctic sea ice model predictions, the mean prediction (red) and the observed ice (black).

and retreats less next year, the current climate models have failed to predict the rapid erosion of arctic sea ice that has been observed.

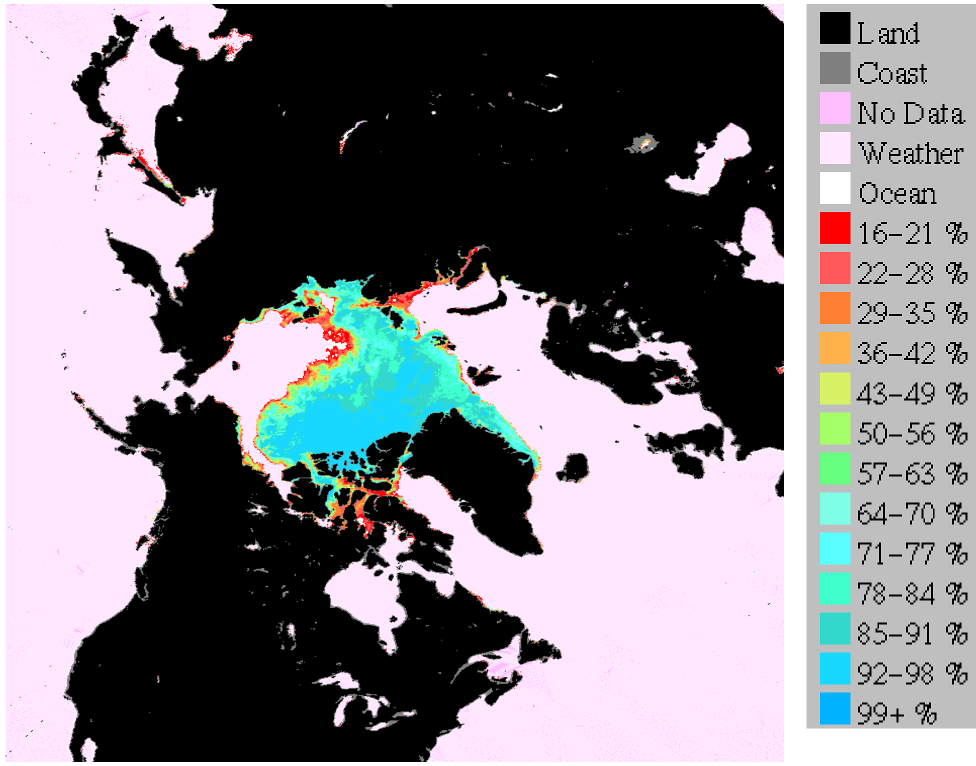

Figure 2. Analysis if Arctic ice coverage as of 22 October 2007.

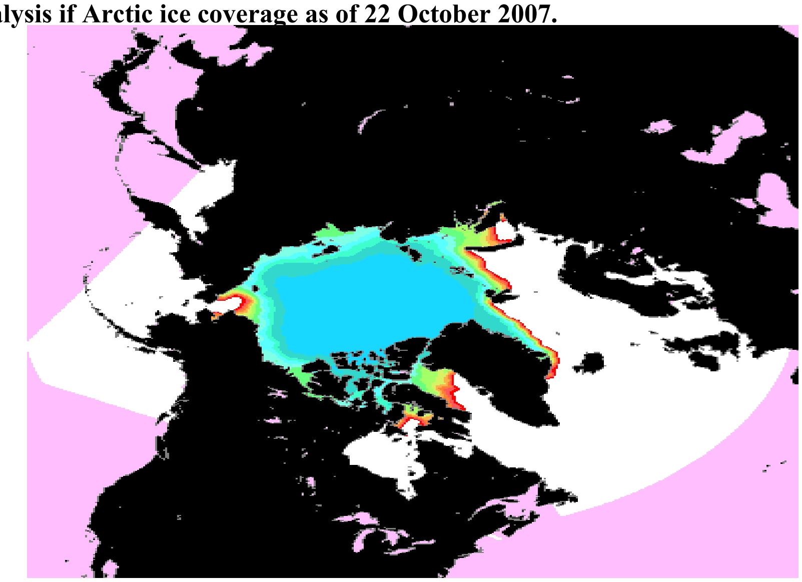

Figure 3. The expected climatological extent of Arctic sea ice as of 22 October over the past 30 years.

As we can see by examining the current Arctic Sea ice extent as of 22 October 2007 and the climatological extent of Arctic sea ice we should expect to find on 22 October in any given year, the sea ice is well below any normally expected value. These data suggest that warm conditions at higher latitudes have dramatically impacted the extent of arctic sea ice.

The lack of ice over the western Arctic Ocean could impact the early winter of 2007-08 as arctic air masses moving across this region will be modified by the relatively warm sea surface temperatures. It may be difficult to generate record cold air masses over the Arctic to bring severe cold to North America.

The second argument is the cause of global warming. This is an area where there is a wide range of opinions. The IPCC is quite confident that human's are impacting climate change. Given an all (100%) to nothing (0%) chance humans are involved in the process, the IPCC leans toward an 80 to100% figure. It should be noted that a wide range of factors influence climate and climate change. *It should also be noted that the earth's climate has proven to be historically quite changeable*. And as dramatic as our current climate change may appear, there have been other more dramatic global warming and cooling episodes in human history. In the book *The Long Summer: How Climate Changed Civilization*, Brian Fagan outlines the nearly continuous problem of climate change and its impact on the development of agriculture and the evolution of many cultures over the past 1 to 32 thousand years. In the book he examines several dramatic climatic episodes to include the climatic catastrophe of 535 AD when a volcanic eruption[1] may have caused rapid cooling over much of the planet. This may have had a dramatic impact on the evolution of societies across Europe and may have hastened the so called "Dark Ages". Thus climate change has been a part of human social evolution since the dawn of man.

The key point is that the earth's climate system has many inputs and some of them can cause rapid and dramatic change. In all likelihood, human activity and pollution is contributing to some portion of the current incremental global warming. It should be noted that greenhouse gases and human pollution are critical in our ability to model global warming and the future impacts of human activity as it relates to global warming. So, there is a high probability that human are impacting the climate.

Those who argue against human impact and its relation to global warming often site all the inputs into the system and the fact that most forecasts are based on models. Everyone involved in climate and weather predictions realizes that there is a large degree of uncertainty in these forecast systems. Additionally, the complexities of the climate system are real and for example, a major volcanic eruption could negate the potential slow and incremental impacts of human activity. The compromise position is that human activity is one part of the overall climate system and at this time it may be having in impact on the climate.

Now we come to the impact of climate change on you. It is difficult to determine the impacts of climate change on any one person. If you live in Pennsylvania and you ski in the winter, global warming will likely decrease the number of days each winter you can ski. But it could provide more opportunities for you to brush up on your tennis game or golf swing. For someone in central Pennsylvania, global warming may not seem all that bad should there be a marked increase in warmer winter days. However, a more worldly

[1] This may have been a huge volcanic eruption or a large meteor striking the ocean.

view suggests that global warming will impact agricultural and water dependent activities all over the globe. Water shortages in major cities could become a problem and water shortages could curtail agricultural activities in different regions of the globe. As described in Brian Fagan's book, large societies were often vulnerable to dramatic shifts in rainfall patterns. Civilizations rose and fell based on these patterns. Thus, global warming will likely impact agricultural patterns throughout the world. There will be winners and there will be losers. The long term effects of global warming could be devastating and we have not addressed the projected increase in sea level and its potential impacts should climate models prove correct over the next 20 to 50 years.

We all can do small things to deal with global warming and its potential impacts. We can ensure our vehicles are properly tuned to maximize fuel efficiency. We can try to consolidate trips to drive less and thus burn less fuel. We can replace old appliances with energy efficient versions and we can learn to turn our thermostats down a few degrees in winter and up a few degrees in the summer. Then there is the ever popular trend of using the newer fluorescent light bulbs which require extra care when they must be replaced. Even if it turns out human impacts on global warming are smaller than most estimates, saving energy, becoming more energy efficient, using more diverse energy sources, and demanding more efficient vehicles and appliances makes sense for everyone.

Using Machine Learning and Data Mining Techniques to Extract Information from Meteorological Data Sets

Ron Holmes, Information Technology Officer

Data mining and other machine learning concepts has become a powerful data analysis tool in recent years as computers have exponentially increased in speed. These tools are adept at taking in huge amounts of data and running various artificial intelligence algorithms to extract patterns in the data that are useful to meteorologists. They can also determine the weight or importance or parameters in the data set and weed out parameters that do not provide as much information gain as others. A lot of these tools are based on statistical analysis and require a training data set in which the forecast parameter and known outcome (observation) can be compared. Various statistics such as root mean square error, mean absolute error, probability of detection and false alarm rate are used to judge the worthiness of certain parameters in the data set. Two tools being explored at the WFO State College Office are Neural Networks and Decision Trees.

Neural Networks are modeled after the human brain in which they learn through repetitive exposure to events (the training data). The network is composed of mathematical "neurons" that learn to fire when exposed to certain data input. After the training data set is initially presented to the network there will undoubtedly be error between its prediction and the observed value. The network uses this error to adjust the weights of its neurons so that the next time the training is presented there will be less difference between predicted and observed values. In this process some neurons will be strengthened while others will be weakened. The error will gradually decrease as the network slowly learns through repetitive exposure to the input training data set. Once the error reaches an acceptable level training stops and it can be presented with new data that it has not seen before. It should then be able to recognize whether the new data is of meteorological significance or not.

Below is an image of a Neural Network being used at WFO State College to learn to recognize days on which there is a threat of tornados versus all non-tornadic days. In this particular network it is being trained with 16 meteorological parameters from a historical data set for days on which tornados were observed and ordinary days when no tornados were observed. The outcome is a prediction of either a tornadic day or not when presented with new forecast input.

Another data mining tool being used to determine the likelihood of severe weather are decision trees. Decision trees “grow” branches that lead to important data input while pruning back on branches that lead to data with little influence. The decision tree does this by comparing information gain which is a measure of how much the overall tree improves by either including that piece of data in it or leaving it out. The pruning mechanism is done by comparing the amount of information gain from each individual piece of data input as we travel down a branch that leads to a leaf which describes the classification output (usually the observed value). Those branches that do not provide additional information gain (or do worse) are pruned away. The end result is a decision tree that yields the most important data parameters at the top with branches at successively lower levels in the tree that lead eventually to leaf nodes that indicate the classification by following a particular path down a tree.

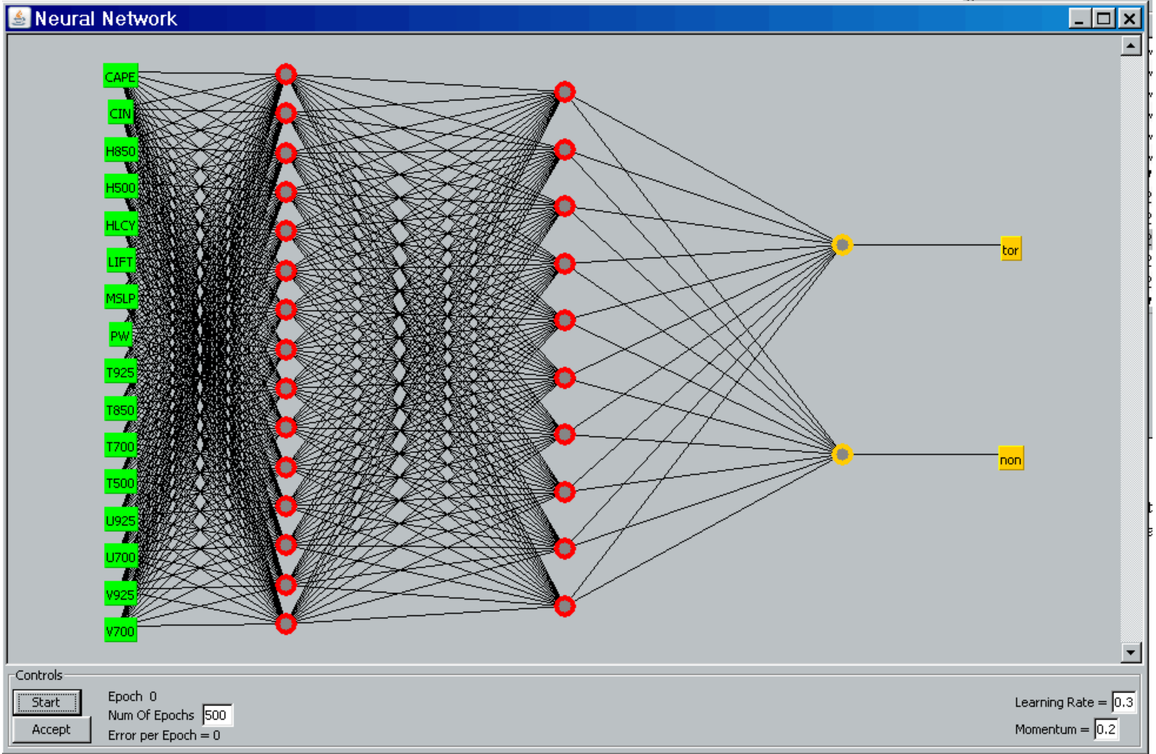

Figure 1. Neural Network Diagram

Hypothermia: a cold-blooded killer

Michael Dangelo, Senior Forecaster

Our coldest days in Pennsylvania occur in January and February. The state record coldest temperature (minus 42 degrees Fahrenheit) was set on January 5th, 1904, in Smethport. The record coldest mornings in both Harrisburg (-22 F) and Williamsport (-20 F) occurred on the same morning of January 21st, 1994. When we have a snow pack, and a clear, calm night is in the forecast in January and February, you should recognize the potential for very cold temperatures. On these coldest of nights, you should realize that it will also be easier to fall victim to a lowered body temperature – Hypothermia.

Here are some facts about Hypothermia:

A body temperature below 96 degrees Fahrenheit is called hypothermia, and it doesn't take arctic temperatures to put you at risk. Even a moderately chilly air temperature of 60 degrees is low enough to trigger hypothermia if you aren't properly clothed.

The National Institute of Aging estimates that of the 28,000 people killed annually worldwide by hypothermia (and 700 annually in the United States), the largest percentage are older people. Reasons: Some medicines, problems with circulation, and certain illnesses appear to reduce the older person's ability to resist hypothermia. Also, the older you get, the less sensitive you are to cold weather. So, your body temperature could drop to a dangerously low level without you really being aware of it. In addition, older people don't seem to shiver very effectively, which is one of the ways the body warms itself up.

Remember these tips to help prevent hypothermia:

- Dress in layers
- Always wrap up well when going outside in the cold.
- Set your thermostat to at least a toasty 70 degrees during cold weather.
- Avoid extensive exposure to breezes and drafts.
- Keep warm clothes and blankets on hand to help ward off the winter chill. Wear a warm hat, even in bed.
- Eat plenty of nutritious food, especially hot foods, and drink warm drinks several times during the day. But, avoid alcohol, as it can lower your sensitivity to cold.
- If you are elderly, or have medical problems, ask a family member or a neighbor to check on you often.
- Ask your doctor if any medicine you're taking increases your risk of hypothermia. Some drugs make it difficult for your body to stay warm.

If your temperature is 96 degrees or less, or you feel sluggish or recognize that you're having trouble thinking clearly, see your doctor immediately or go to the nearest emergency room. It's better to be overly cautious than to die of a disorder that doesn't have to be deadly.

To help someone you suspect may be suffering from hypothermia, first call an ambulance. Then lie close to the person and cover both of you with thick blankets. The hotter you get, the more warmth you can give the other person. Don't rub the person, nor handle him or her roughly, nor ask them to move around, as it can bring cold blood from the arms and legs into their core and can make things worse.

Sources: *Accidental hypothermia: a winter hazard for older people*, National Institute on Aging, 1995
Geriatrics(51,2:23)
The American Medical Association Encyclopedia of Medicine, Random House, New York, 1989

The Local 3-Month Temperature Outlook

Kevin Fitzgerald, Senior Forecaster

The Local 3-Month Temperature Outlook (L3MTO) is a new long range forecast product issued by the National Weather Service. The more familiar 3 Month Temperature Forecast (Fig. 1) provides a generalized outlook for the entire country. The L3MTO provides a more detailed outlook on the local scale. In Central Pennsylvania, forecasts are provided for the following nine cities, each representing a distinct climatic region:

- Bradford
- Ridgway
- Wellsboro
- Johnstown
- Altoona
- State College
- Williamsport
- Hanover
- Lancaster

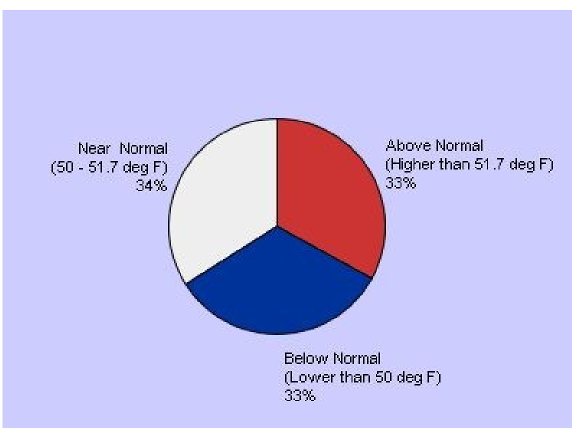

Figure 2. L3MTO Pie Chart

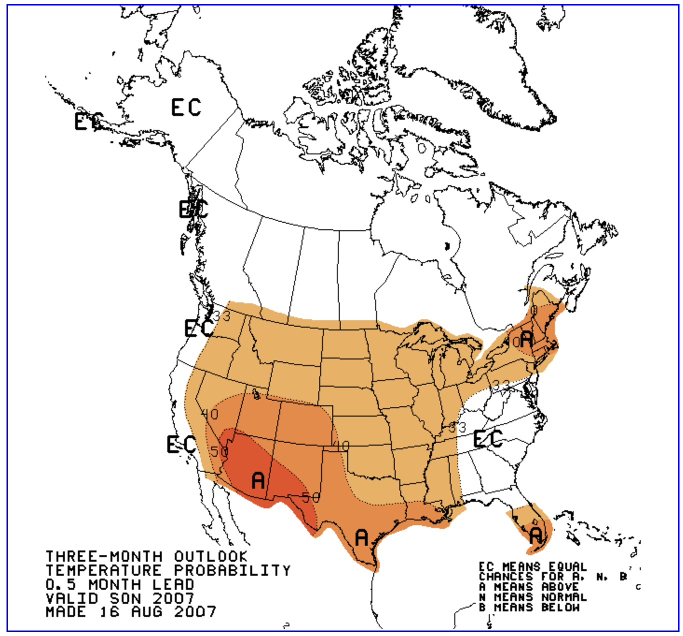

Figure 1. National 3-Month Temperature Outlook

L3MTO Pie Chart

The L3MTO Pie Chart (Fig. 2) is the simplest of the product formats. It shows the expected chance for the 3-month temperature to occur in each of three categories: Above Normal, Near Normal, and Below Normal. The larger the pie slice, the higher the chance of occurrence. A legend, located to the right of the pie chart, has three corresponding rectangles that show the actual 1971-2000 temperature values used to define the forecast categories.

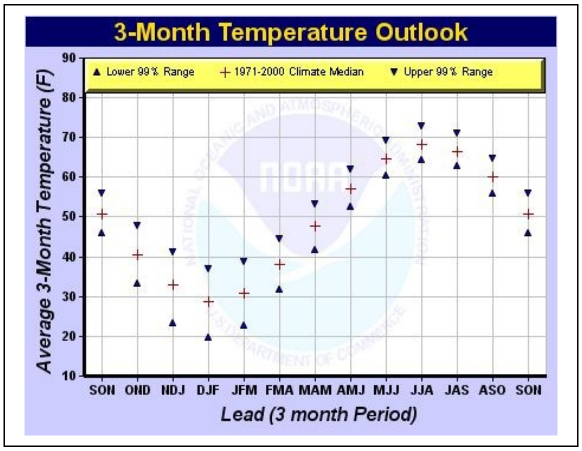

Figure 3. L3MTO Temperature Range Graph

L3MTO Temperature Range Graph

The Temperature Range Graph (Fig. 3) shows the expected range of the average 3-month temperature (in degrees Fahrenheit on the y-axis) for each of the thirteen 3-month forecast periods (x-axis). The expected temperature ranges can be viewed for five confidence intervals (or levels of expected chance):
99%, 95%, 90%, 75%, and 50%

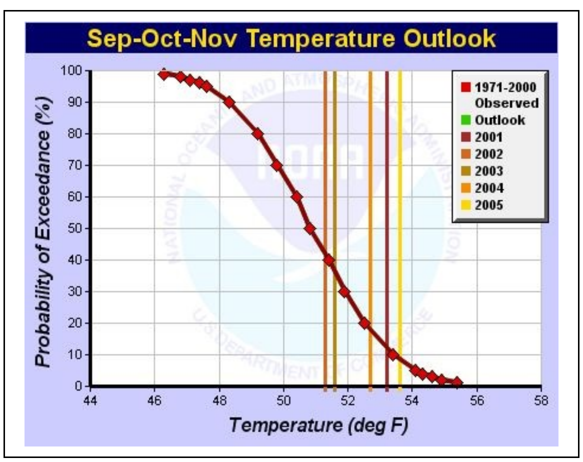

Figure 4. L3MTO Probability of Exceedance

L3MTO Probability of Exceedance

The Probability of Exceedance (POE) Graph (Fig. 4) provides the most detailed outlook information in the L3MTO suite. It shows the expected chance (y-axis, in percent) that the average 3-month daily mean temperature will exceed (or be greater than) the temperatures shown on the x-axis. The graph contains two curves: a red curve, representing the POE for the 1971-2000 reference period, and a green curve, representing the forecasted POE. The colored vertical lines represent the observed average 3-month daily mean temperatures for the past five years.

Special Case: When There is No Forecast

Under certain conditions, the methods and tools employed in the forecast process cannot produce a reliable outlook product. In these cases, there is effectively no forecast, and the "outlook" coincides with the climatological information from the 1971-2000 reference period. For the Pie Chart, this case is indicated when all three slices of the pie are shown to be about the same size. For the POE graph, the red and green curves overlap, and for the Temperature Range Graph, the values shown are the same as those for the reference period. (This is analogous to "EC" (equal chance) on the CPC national 3-Month Temperature Outlook map.) In all such cases, it is best to use the 1971-2000 reference period climatology for guidance.

SKYWARNEWS on the World Wide Web

Bill Gartner, General Forecaster

You may know that an 'electronic' version of SKYWARNEWS is available on the internet. Many of you have provided us with an email address so that we notify you when a new issue has been posted to our web site instead of you receiving a printed paper copy in the mail.

One of the reasons we started putting the newsletter online was to allow us to include color graphics and pictures. Printing in color is just too expensive. Another reason was to save on printing and mailing costs. As we recruit more spotters and the printing and postage cost increase, the more it costs to print and mail.

Looking into our crystal ball, we see a time (and it may be soon), when budget monies spent on the newsletter will get allocated to other office needs and we will not be able/allowed to mail out any printed copies. Yes, even the black and white versions.

Thus, we are encouraging all spotters to sign up now for electronic delivery/notification of the newsletter. To sign up for internet delivery of SKYWARNEWS, please send an email with 'SKYWARNEWS ' in the subject line to william.gartner@noaa.gov.

We do realize that there are those of you that do not have access to email or the internet. Our one suggestion at this point is that many libraries have free access to the internet. To our web savvy spotters, if you know of other places that offer free internet access, please drop us a line so we can share the knowledge.

To view SKYWARNEWS online, point your browser to our office's homepage www.weather.gov/statecollege. About two thirds of the way down the left hand column you will see the section heading Weather Safety. Clicking on the last entry in that section, SkyWarn Spotters, will take you to our Spotter page. The latest newsletter, this one!, is listed at the very top. Just click on it to download it. Below the current issue are links to every issue since Spring of 2000. If you are a new spotter here you will find back issues that are full of interesting articles on many different aspects of weather and weather related topics.

Forecasting Throughout the Ages

John La Corte, Senior Forecaster

Imagine, you are heading to the beach, the company picnic, a little league game or just going out for a walk. More than likely one of the biggest questions on your mind will be what's the weather going to be like? Will you need to dress warm or need an umbrella? Maybe you will need to leave early to allow for slow travel due to rain or snow. Maybe you will just cancel altogether because conditions are expected to be so bad that you don't relish the thought of being caught at the ball game in a cold downpour. Whatever your plans, you will probably check the forecast and make it a big part of your planning for the day's events.

However, the weather information we take for granted today is actually a very recent development in the history of human development. It wasn't too long ago that forecasting was done by examining the sky or relying on natural signs and folk lore. Today weather information is available everywhere from 24 hour coverage on television to countless sources via the internet. We are surely spoiled and probably find it hard to imagine what it was like a mere 50 or 100 years ago.

So what was it like before the age of TV and radio meteorologists? Somewhere in our distant past humans first peered into the sky and wondered what the weather would be like later that hour, day or perhaps even week. Important decisions have always had to be made with weather as a consideration. Perhaps they needed to plan for a hunt or had to lay out the season's crops, the forecast was important, if not crucial to daily activities and even survival. What did native peoples living on tropical coastlines do when a hurricane roared ashore? Imagine what ancient humans thought when they saw a tornado lay waste to the country side or their village. Severe cold or blizzards, these could be life threatening and surely people needed and found a way to prepare.

Ancient weather forecasters were excellent observers, attempting to correlate what was happening with what eventually what will happen. These forecasts were usually very short term in nature but could be remarkably accurate. For example, "red sky at night, sailor's delight" had it's roots in the observation that cirrus clouds on the back side of an exiting cyclone, when viewed near sunset often made for a red sky. The passing of the cyclone of course would be marked by improving weather the next day. This sort of anecdotal evidence accumulated over the generations to produce a large body of what we know as weather lore. Whether it be Wooly Caterpillars or mare's tales (cirrus clouds), looking for signs from nature about what the weather will do has been around a long time.

As early as 650 BC history recorded the Babylonians making predictions by observing cloud patterns. A few hundred years later Aristotle wrote his volumes of Meteorologica where he explained his theories about the formation of rain, clouds, hail, wind, thunder, lightning, and hurricanes. Chinese weather prediction lore extends at least as far back as 300 BC when their astronomers developed a calendar that divided the year into 24 festivals, each festival associated with a different type of weather.

Throughout the centuries, attempts have been made to produce forecasts based on weather lore and real time observations. However, by the end of the Renaissance, it became evident that these speculations were inadequate and that a greater knowledge of the atmosphere was necessary. The first steps in this process were to develop instruments that could be used to measure such atmospheric properties as temperature, humidity and pressure.

The first known design in western civilization for a hygrometer, an instrument to measure the humidity of air, was described by a German named Nicholas Cusa in the mid-fifteenth century. Italians Galileo Galilei and Evangelista Torricelli invented the thermometer (1592) and barometer (1643) respectively. Eventually temperature, humidity and pressure would be combined with observations of wind speed and direction to come up with some very good short term forecasting "rules of thumb" which can still be used today by anyone with a rudimentary home weather station. An example is noticing that the barometric pressure is falling, high clouds are thickening, temperature and humidity are rising and the wind is from the northeast. These are some of the surest signs of an approaching storm that exist in the northern hemisphere. If it's winter time here in the northeastern United States, look out, a "nor'easter" may be on the way!!

Perhaps the best known of the early weather "forecasters" was Benjamin Franklin. Unlike most people of his time, he tried to go beyond merely being affected by the weather and tried to explain the reasons for various weather-related phenomena. He even discovered some ways to predict the weather.

One of Franklin's first recorded observations of weather patterns occurred in October of 1743 when he planned to observe an eclipse of the moon. As Franklin prepared to watch the eclipse in Philadelphia, a storm moved in and clouds obscured the moon. Later he learned that people in Boston, hundreds of miles northeast of Philadelphia, were able to see the eclipse because the storm didn't arrive there until several hours after the eclipse. Intrigued, Franklin continued gathering observations and eventually deduced the direction and movement of storms. He was the first to observe that storms can move in an opposite direction from the direction of the wind. In other words, although the winds in a nor'easter may blow from the northeast, the storm can actually be moving from the southwest. In trying to explain how this weather pattern worked, Franklin accurately theorized about the existence of high and low pressure areas and proposed one of the first correct explanations for storm movement in the northern hemisphere.

Franklin was always interested in climate-related phenomena. Just six years before his death, he published a number of "Meteorological Imaginations and Conjectures." For example, he was puzzled that hail and ice could occur in the summer time. While having no way to test his ideas, he correctly deduced that the upper atmosphere was much colder than the air below it. He also wrote about fog, wind direction, insulation, and heat radiation. And we all recall his kite flying and how it related to observations of lightning. Truly Franklin was hundreds of years ahead of his time.

The modern age of weather forecasting is considered to have begun in 1837 with the invention of the telegraph. Before this time, it had not been possible to transport information about observed weather any faster than by horseback or steam train. By the 1840's the telegraph was enabling the almost real time reporting of weather conditions from wide areas. Rudimentary forecasts were made by analyzing and extrapolating these upstream conditions.

The National Weather Service we know today actually started on February 9th, 1870, when President Ulysses S. Grant signed a joint resolution of Congress authorizing the Secretary of War to establish a national weather service. This resolution required the Secretary of War "*to provide for taking meteorological observations at the military stations in the interior of the continent and at other points in the States and Territories...and for giving notice…of the approach and force of storms*."

The development of observational networks continued to grow into the nineteenth and twentieth centuries making huge amounts of data available for observation-based weather forecasting. A huge stride in our ability to forecast the weather came in the 1920s with the invention of the radiosonde. Small lightweight boxes equipped with weather instruments and a radio transmitter, radiosondes are carried high into the atmosphere by a hydrogen or helium-filled balloon that ascends to an altitude of about 30 kilometers before bursting. During the ascent, these instruments transmit information on temperature, moisture, and pressure (called soundings) back to a ground station. There, the data are processed and made available for constructing weather maps or insertion into computer models for weather prediction. This gathering of weather information through great depths of the atmosphere revolutionized weather forecasting.

Another great advance in our ability to measure and observe the weather came with the development of the satellite. For more than 40 years satellites have given forecasters routine access to observations and data from remote areas of the globe where conventional observations are not available. Since the early TIROS polar orbiter satellites in the early 1960s, satellite sensor technology has advanced tremendously. In addition to providing visual images, satellites can now also provide data that allow calculation of atmospheric temperature and moisture profiles as well as wind conditions. These data are now routinely fed into computer models, greatly augmenting the amount of atmospheric observational information gathered from the existing radiosonde network.

The latest and perhaps greatest contribution to modern weather forecasting has been the development and improvement in the area of numerical weather prediction. The idea of using mathematical equations to predict the weather was formulated in 1904 by Vilhelm Bjerknes and developed by British mathematician Lewis Fry Richardson. Early efforts by Richardson to produce a six hour forecast for the area around Munich Germany ended in failure. The forecast was wildly inaccurate and worst of all, took weeks to produce. Yet the seeds of modern day computer generated forecasts had been sewn.

Richardson's early work called for as many as 64,000 persons all working on various mathematical equations. All of these "human calculators" would transmit their results to various other persons all who would be working in the same huge room, obviously an unwieldy and unrealistic approach. This was a problem that was crying out for the development of the modern day computer. By the late 1940's the first modern computers allowed for significant progress to be made in practical numerical weather prediction efforts. By the mid 1950's numerical forecasts were being made on a regular basis.

Today supercomputers "crunch" numbers at mind numbing speeds. Billions of calculations per second are made allowing for the ingestion of immense amounts of information and the running of many numerical models several times a day. These supercomputers and models have combined to provide the most accurate weather forecasts in human history.

Still you might ask; why are weather forecasts not yet perfect? Sadly, despite our ability to measure the state of the atmosphere to a very high degree of accuracy, our measurements remain incomplete. The other half of the equation involves the models that while they are good, are not perfect. Our models still cannot COMPLETELY or PERFECTLY recreate a system as immensely complex as our atmosphere. Thus every model forecast contains errors, some small, some not so small. This is where the human forecaster steps in and hopefully adds value to these inherently imperfect pictures of the expected state of the atmosphere. Most of the time we do a pretty good job, but occasionally a forecast gets blown, it's the nature of the beast. Some atmospheric scientists say that we will never be able to completely model our atmosphere and therefore will never be able to create a model forecast that is perfect. Some foresee a day when we will be able to, but most certainly not in our lifetimes.

So while forecasting has certainly come a long way from ancients observing the state of the sky or the behavior of insects or livestock, we may never be able to achieve 100 percent accuracy. Forecasters will continue to attempt to give you our best shot at what the weather will do, but we will also have to live with the fact that we will occasionally fail. Like the baseball player that makes an out, our only solace is that we get to look forward to the approach of every new storm as another "at bat". Hopefully the next big storm that comes our way we will hit a home run.

Update Your Spotter Contact Information

By Bill Gartner, General Forecaster

Have you moved recently? Got a new phone number? Please help us to keep your contact information up to date. From time to time we call our spotters when significant weather is in their area to provide us additional 'ground truth'. Thus it is important to keep your contact information current. If any of your contact information (name, phone number/s, addresses, etc) has recently changed, please let us know.

Also, if you no longer wish to be a spotter or no longer wish to receive SKYWARNEWS, please drop us a note.

Finally, if you would like to be notified via email when a new issue of SKYWARNEWS is posted to our webpage, send us your email address, if you have not already done so. If your email address changes be sure to let us know. You wouldn't want to miss the next issue or SKYWARNEWS would you?

Send an email or 'snail mail' note to us at one of the addresses below. Thank you!

email: william.gartner@noaa.gov

U.S. mail:
William Gartner/Skywarn spotter update
NWS/WFO State College
328 Innovation Blvd, Rm #330
State College, PA 16803

Send us Your Snow and Ice Reports!

By Bill Gartner, General Forecaster

As we head toward winter, the occurrence of thunderstorms and the severe weather associated with them obviously decreases, but your importance as a storm spotter does not! In many respects, snow, freezing rain and sleet are more difficult to detect than rain and thunderstorms. Unlike warm season storms, where the precipitation type will always be rain (except of course for a little hail once in a while), temperatures near or below freezing can lead to significant differences in what type of precipitation reaches the ground. Just a few degrees difference in the temperature, at the surface and aloft, can mean the difference between wet roadways, ice coated trees and power lines, or accumulating snow.

Unfortunately, the tools we rely on to detect precipitation do not do so well with frozen and freezing precipitation. NWS Doppler radar estimates of rain are usually very accurate, but due to the physical properties of snow and ice pellets, radar does not resolve snow or sleet that well. Thanks to radar, we generally have a good idea where it is precipitating, but we do not always know in what form the precipitation is reaching the ground nor how heavy it is.

Today, most of our surface weather observation sites are automated, with a collection of instruments taking the place of human observers. Automated weather stations, such as ASOS and AWOS, do not measure snowfall accurately. Even getting an estimated snowfall based on the water equivalent of melted snow is difficult. Stations will report the water equivalent of melted snow that falls into the rain gauge but if temperatures are below freezing, snow may not melt for several hours or days later. And if it is windy, much of the snow may not fall into the gauge to get melted.

This is why we rely heavily on Skywarn spotters. Your spotter reports help us as we monitor ongoing winter storms, determine the need for possible changes to advisories and warnings, and provide real-time snowfall totals to our customers, partners and other NWS offices. Also, as mentioned in the Spring 2007 issue of SKYWARNEWS, your spotter reports are used to verify our watches and warnings. They are also used 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

A guide on how to effectively measure snow by Senior Forecaster Greg DeVoir is available in the Fall 2002 newsletter: http://www.erh.noaa.gov/ctp/safety/skywarn/Winter2002/SKYWARNNewsletter.htm

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 "What to Report" in the left-hand column. It is the fourth selection under the Current Hazards header.

How to report:

Snow and ice measurements can be reported via our web page, www.weather.gov/statecollege. In the left-hand column you can click on "Send us Reports", the third choice under the Current Hazards header. We encourage reports via the web, as it cuts down on the phone calls we receive during busy weather events. If your report is something other than a snow or ice measurement, or you do not have internet access, then please call us at 1-800-697-0010.

THANK YOU in advance for helping us to carry out our mission of protecting life and property from extreme weather...all year long.

SKYWARNEWS

National Weather Service
328 Innovation Blvd
Suite #330
State College, PA 16803

TO: