

Notes for MPR "Morning Edition", Jan. 29, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment

1. Word of the Week: Climate Anomaly

From the Greek (an = not and homalia=even or normal) meaning not even (uneven), irregular or abnormal. Used in other disciplines like math, geology, optics and biology. In climatology refers to deviations from normal conditions. Climatic anomalies are occurring all the time around the world. Droughts, floods, heatwaves and coldwaves are manifestations of these anomalies. Many are more subtle and not necessarily malignant in terms of effect. There are typically 10 to 12 significant temperature (positive or negative) or precipitation (wet or dry) anomalies going on around the world at any time. For example eastern Europe has had a 9 week cold snap this winter which is continuing, while southern Brazil and Argentina have had 10 weeks of surplus precipitation.

There are three dimensions to climatic anomalies: their magnitude or severity (degree of deviation from the norm); their areal extent, how big of an area do they affect; and their duration, how long do they last. Large order change in all three of these dimensions usually produces very significant climate impacts.

2. Almanac

For example, our record high temperature in Minneapolis/St Paul for this date (Jan. 29) is 49 degrees F. This occurred in 1931 right in the middle of a 13 week positive temperature anomaly which saw one of the warmest winters on record. In fact that year was one of the very few when Minnesota farmers seeded crops in March rather than late April or May.

3. Topic: El Nino Southern Oscillation (proposed)

ENSO is a phenomena which occurs along the equatorial Pacific in a region extending from the west coast of South America to the east coasts of northern Australia and Indonesia. It is a coupling of atmospheric pressure and oceanic sea surface temperature which oscillates east and west in this region. When the pressure pattern shows strong negative deviations in the eastern equatorial Pacific (lower pressure) and the ocean temperatures off the west coast of South America rise significantly above normal (due to migration of surface waters from the western Pacific), then an El Nino event is set in motion. El Nino (Spanish for the Christ child) was the name given to the annual warming of the Peruvian coastal waters which usually peaked during Christmas time. However, now it refers to the periodic intense positive deviations (climate anomaly) in sea surface temperature there which effect the weather on a global scale.

El Nino events occur about every 3 to 7 years, last from 3 or 4 months up to 2 years and have been well studied back to 1935 by climatologists.

They are mentioned in Peruvian literature back into the 1800s, because their effect on that country is to ruin the anchovy harvest (due to abnormally warm coastal waters), change the mixture of coastal marine life and brighten the desert with flowers (due to abnormally abundant precipitation accompanying the lower atmospheric pressure pattern).

Because the changes in sea surface temperature and atmospheric pressure patterns are so large, the impacts are felt in mid latitudes as well as the tropics. Thus the global climate connection.

Patterns resulting from El Nino events which we see in the United States include heavier than normal winter precipitation in the southeastern coastal states, and mild winter temperatures in the Pacific northwest and northern plains (including Minnesota). The exceptionally mild winter of 1991-1992 in the upper midwest was attributed to an El Nino event.

The Climate Assessment Center in Washington D.C. released an El Nino advisory earlier this month, stating that although normal tropical conditions had been observed during the summer, the climate anomaly had been strengthening since November and it is expected that an El Nino event will be fully in place by late this month. Thus we might expect to see some highly unusual climate patterns appear again in 1993.

Notes for MPR "Morning Edition", Program of August 6, 1993

For: Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Earlier this week (Wednesday morning), many places in Minnesota reported very low temperatures, with several readings in the low to mid 40s. Embarrass in NE Minnesota even reported temperatures in the high 30s. Actually, on Tuesday the following places set or tied record low maximum temperature records...Alexandria 66 degrees, Hibbing 59 degrees, Grand Rapids 63 degrees, Park Rapids 65 degrees, and Redwood Falls 69 degrees. This intrusion of cold Canadian air the first week of August was last experienced in 1978.

1. Word of the Week: **Photoperiodic and Thermoperiodic Responses**

These terms are used to describe the nature of plant response to the surrounding environment. Photoperiodic response refers to plant or organism response to changing daylength, for example the flowering mechanism of some plants is triggered by shortening days. Thermoperiodic response refers to plant or organism responses to changes in temperature, primarily the rhythmic or cyclical fluctuations in temperature which occur daily or seasonally. For example the rate that some crops ripen is triggered by temperature (see below), or the rate that perennial crops go into dormancy in the late fall and break dormancy in the early spring.

2. Almanac (typical high of 83 and low of 60)

MSP records for August 6 are a high of 97 in 1916 (by the way the low temperature that date was a very sticky 76) and a low of 48 in 1977.

Greatest precipitation ever on this date is 1.44 inches in 1928. Incidentally, August of that year brought 12.28 inches of rainfall to Albert Lea, just about ruining the small grain harvest.

3. Topic of the Week: Tomato ripening

In past weeks we have talked about how environmental conditions relate to strawberry production, blueberry production, and rhubarb. This week, I thought we could look at tomatoes.

Though somewhat late like everything else in the garden this year, tomato ripening has begun; and without earlier than normal frost we might expect to harvest tomatoes between now and the first of October.

The maturation or ripening of the tomato fruit is at least partially a thermoperiodic response. That is to say it is closely related to the duration of temperature within a certain range. The development of lycopene (red pigments) and carotene (yellow pigments) is regulated by temperature. The temperature range we experience in August (say typically 55 to 75 degrees) is conducive to more rapid development of the red and yellow coloring in tomatoes. As we progress toward the fall, the rate at which unripened tomatoes will change to red or yellow (depending on variety) will actually accelerate or quicken, as the temperature range becomes more favorable.

4. International extremes this week: 122 degrees at Kuwait Airport, 119 degrees at Blythe and Thermal California. -127 degrees in Antarctic

Over 17.5 inches of rain in Hitoyoshi, Japan.

More later

Notes for MPR "Morning Edition", Feb. 12, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment

Bob and I discussed the idea of doing something on the relationship between climate and snow removal/street maintenance considerations.

1. Word of the Week: Vernal Equinox

Vernal derives from the Latin **vernalis** or **vernus** meaning spring, something which occurs in the spring, e.g. vernal blooms, vernal migrations of birds, vernal springs. Equinox also derives from Latin terms, **aequus** meaning equal and **noctis** meaning night. Thus this term refers to the time in spring when the sun's center passes over the equator (on its migration from the southern to the northern latitudes), and day and night for each point on the Earth's surface are of equal length. This occurs approximately March 21 each year.

Everyone knows that we are now gaining daylight. Our days are approximately 1.5 hours longer now than they were on Christmas Day. As we approach the vernal equinox we will gain daylight at a faster rate. Whereas the first week of January we gained 7 minutes of daylight, over this next week we will gain nearly 21 minutes.

2. Almanac

Records for today's date (Feb. 12) are a high of 59 in 1990 and a low of -30 in 1875. According to our records for St Paul, last time we had to have street plowing on this date was in 1965 and the last time we had a thunderstorm on this date was 1984 when we had 0.42 inches of rain and drizzle fall on top of 15 inches of snow cover - a real mess!

3. Topic of the Week: Climatology, Snow Removal and Street Maintenance

Our topic for this week is climatology and snow removal/street maintenance considerations. A general rule of thumb used by the St Paul Streets Department for the declaration of snow emergency plowing is a snowfall of 4 inches or greater. In a typical year we might have 3-4 snow emergencies declared for the purposes of street plowing. I examined the climate records for the period 1949-1992 and found that this is also the approximate number of snowfalls equal to or greater than 4 inches which we experience each year. Of the last 44 years, there have only been three when this snowfall criteria was never achieved - 1960, 1964 and 1990. On the other hand there have been a number of years when this snowfall criteria was achieved

numerous times - 1951, 1962, 1969, 1982, 1983, and 1991, each of which corresponds to a busy year for the street maintenance department. Climatological analysis of the snowfall records for the past 4 decades (the 50s, 60s, 70s, and 80s) indicates that the 1960s and 1980s were far worse than the 1950s or 1970s in terms of frequency of snow storms which caused snow emergencies to be declared. Of the last 28 snow storms of 4 inches or greater in the Twin Cities, 12 have occurred in November and 7 in March. Some of the need for snow removal operations in March has been alleviated by warm temperatures immediately following the storms.

With respect to street maintenance, it is common knowledge that highly fluctuating temperature and moisture conditions are the chief climatic adversaries to paved roads. Asphalt is more subject to cracking as a result of moisture penetration in the presence of freeze-thaw cycles and thermal expansion and contraction caused by large day-night temperature differences, episodic temperature variations (spells of warm days followed by spells of frigid days), and variations in solar radiation which can heat the surface dramatically. Over the past 6 weeks Twin Cities temperatures have averaged anywhere from 5 degrees below normal to 15 degrees above normal. Soil frost depths vary from 1 to 2 feet. And solar radiation has been highly variable, with a few bright sunny days interspersed with spells of prolonged cloudiness and fog. These are all conditions which favor development of cracks and potholes. Thus we might anticipate that a number of these will be developing and in evidence as we approach spring in Minnesota.

Notes for MPR "Morning Edition", Feb. 19, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment

Thank God for global warming! Think how cold it might be today without it.

We were going to talk about the urban heat island effect this Friday and I prepared some material accordingly.

1. Word of the Week: Convection

This derives from the Latin **convectio** or **convehere** which means "to bring together." In physics it refers to motion or mixing of fluids due to differences in density. In meteorology it refers to motions of air that result in the transport and mixing of properties such as temperature and moisture. Free convection is motion that is caused by differences in air density, such as when still air over pavement is heated and will rise. Forced convection is motion brought about by mechanical forces, such as wind gusts.

2. Almanac

Records for today's date (Feb. 19) are a high of 57 in 1981 and a low of -28 in 1870. We have had as much as 8.3 inches of snow fall on this date (1952). At this time in 1981, we were in the middle of perhaps the warmest week of February ever recorded in the Twin Cities. We lost 5 inches of snow cover in 2 days as max temperatures averaged over 54 degrees F for the week and lows averaged 33 degrees F, a temperature we have not seen as a high this week.

3. Topic of the Week: The Urban Heat Island

The noted climatologist Helmut Landsberg was one of the first to use this term and describe how the development of an urban area modifies the local environment. Urban areas host a higher concentration of atmospheric pollutants, present rougher surface

terrain which affects wind fields, and are composed of different surface materials which affect heat storage and convection. The following table summarizes some of the observed effects of urban heat islands.

Elements Comparison with Rural Environment

Cloud cover	5 to 10 percent greater
Fog, winter	100 percent more
Fog, summer	30 percent more
Precipitation	5 to 10 percent more
Snowfall	5 percent less
Rain days with less than .02 in.	10 percent more
Relative humidity, winter	2 percent less
Relative humidity, summer	8 percent less
Solar radiation	15 to 20 percent less
Ultraviolet radiation, winter	30 percent less
Ultraviolet radiation, summer	5 percent less
Duration of sunshine	5 to 15 percent less
Pollutants	
Solid particles	10 times more
Gases	5 to 25 times more
Mean annual temperature	0.5 to 1.0 degrees C
Annual heating degree days	10 percent fewer
Annual mean wind speed	20 to 30 percent less
Frequency of calms	5 to 20 percent more

Some local effects related to the urban heat island of the Twin Cities are:

Longer frost free growing season. 15 to 25 days longer than in the surrounding rural areas of Anoka, Scott, Carver and Dakota counties. Earlier green-up of lawns and gardens in the spring. Later freeze up in the fall of local area lakes than in surrounding rural counties. Average wind speeds that are 10 to 20 percent less than in surrounding rural areas. Generally higher average temperatures, more heating degree days, and more precipitation are evident in the Twin Cities when compared with surrounding rural areas. For example let's look at February climate data and annual heating degree days for MSP and some surrounding communities.

Location (County)	February Ave. Temp (degrees F)	February Ave. Precip (inches)	Ave. Annual Heating Degree Days (base 65 degrees)
MSP-Airport (Hennepin)	17.9	0.88	7981

Rosemount (Dakota)	17.2	0.94	8048
Buffalo (Wright)	17.0	0.77	8091
Jordan (Scott)	14.9	0.62	8618
Forest Lake (Washington)	17.3	0.77	8157

—

Though we experience somewhat higher precipitation, because of the amount of pavement in the MSP area, there is a much higher amount of runoff as well.

To: Greg Magnuson, Bob Potter, John Bischoff, and Stephanie Curtis
From: Mark Seeley
Re: Suggestions for Morning Edition, Friday, February 24th

Gary McDevitt and I will be prepared to discuss the Spring Snowmelt Flood Outlook for the upper midwest, but there currently is very little to discuss. The Red River of the North in the upper reaches of Minnesota and North Dakota may have some moderate to high potential, but the Minnesota and Mississippi Basins show little threat at this time. Soil moisture reserves across the state are near normal or above normal in many places. I can ask Gary how different March weather scenarios would play out in the flood outlook.

The alternative topic which I have included now for two weeks is a general summary of the positive departures in temperature this winter. Actually since August, every month has shown a positive temperature departure so far (6 months, Sep-Jan). With the bitterly cold temperatures we experienced earlier this month it looked like we would break that trend, not so. The recent string of mild days has actually brought our average temperature for February so far back into the above average range.

Yes indeed the days are getting longer. We have gained 65 minutes of daylight so far this month and will pick up another 75 minutes by the Vernal Equinox on March 20th.

Mr. Dick Seavey a math teacher from Burnsville and regular listener called to ask why we don't report the variation as well as the average conditions during the almanac segment each Friday. He raises a very good point in that the variation about the average daily max and min temperature changes throughout the year. For example, the variation (expressed as a standard deviation) in wintertime daily max and min temperature is roughly twice that of the summer months. Thus, a daily max or min which is 10 degrees above average is much more unusual in the summer months than during the winter.

In an effort to provide more information and to educate listeners about the variability in Minnesota's climate, I would like to routinely include the extremes, the average high and low and the standard deviations of temperature in the almanac segment each Friday. The standard deviation of daily max and min temperature will define the limits associated with roughly two thirds of all values for that particular day.

Almanac: Average maximum temperature is 30 (plus or minus 13 degrees standard deviation) and the average minimum is 12 (plus or minus 14.5 degrees standard deviation).

MSP records for today's date include: a maximum temperature of 57 degrees in 1931; a minimum temperature of -20 degrees in 1967; record precipitation of 1.90 inches in 1930; record snowfall of 3.8 inches in 1962; and record snow depth of 27 inches in 1967.

The 1.90 inches of rainfall which fell on this date in 1930 is the greatest amount of precipitation from a single February

storm in the Twin Cities.

Scanning the state climatic data base: the all-time high for today's date is 67 degrees at Pipestone (SW MN) in 1958; the all-time low is -46 degrees at Red Lake Falls (Red Lake County) in 1955.

1981 was memorable for being an unusually early spring in Minnesota. Temperatures were so warm in February, that some small grains (wheat and oats) were planted during the last week of February and first part of March in southern counties. Hard to imagine, but true, as there was a general absence of snow cover and shallow soil temperatures shot up into the 40s and 50s during late February.

Words of the Week: Hydrology and Hygrology

These two are sometimes confused. Hydrology is taken literally from the Greek (hydro=water, logy=study) as the study or science of water, including its properties, origins, and distribution. Important components of hydrology are the study of evaporation, precipitation, infiltration, percolation, runoff, and ground water. The hydrologic cycle describes the interchange of water between the land, the atmosphere and the oceans (or lakes). A hydrograph is a graphical depiction of the stage or discharge of a river or stream as a function of time. This is very important to monitor along the major rivers in Minnesota during the early spring. In recognition of the overall importance of hydrology, the University of Minnesota offers an undergraduate minor in Water Resources, and a multidisciplinary graduate studies program in this subject as well (the latter is a new program at the university).

Hygrology is taken literally from the Greek (hygo=moist, logy=study) as the study of water vapor in the atmosphere. It is really the study of humidity variation. A hygrograph is a graphical depiction of the humidity of the air as a function of time. An instrument which graphically records both the temperature and humidity over time is called a hygrothermograph.

Community and Observer Notes:

Topic: El Nino and Submarine Volcanic Activity

A recent article by Daniel Walker (University of Hawaii) in the Transactions of the American Geophysical Union suggests a correlation between seismic activity along the East Pacific Rise (near Easter Island) and El Nino events. The six most significant occurrences of El Nino since 1964 show very close correspondence to increased submarine seismic activity. Speculation is that the hydrothermal plumes from volcanic activity release energy (as magmatic heat) and nutrients to the middle and upper levels of the Southern Pacific Ocean several months prior to an El Nino event. Cause and Effect? Not clear, but scientists are continuing to study the linkage, some using satellite derived measures of the sea surface opacity in hopes of detecting hydrothermal plumes.

Topic alternative: Warm Winter

This has been a topic of conversation in many coffee shops for the past several weeks. The table below shows the relative ranking of the November through January period in terms of historical warmth. The average temperature for the three month period is calculated from preliminary data. Departure from normal is determined from using the 1961-1990 average for the November through January period. Historical ranking for warmth is based on record periods varying from 33 years at Hibbing to 175 years at MSP. To interpret the departure from normal for the three month period, bear in mind that the standard deviation from the historical records is only about 3-4 degrees.

Location	Ave Temp Degrees F	Departure from Normal Nov-Jan	Historical ranking (place/no. years)	Last period as warm (yr)
Twin Cities	27.0	+6.0	10th/175yr	1941-42
Intl Falls	19.8	+8.8	4th/85yr	1920-21
Duluth	22.8	+6.7	1st/47yr	-----
Crookston	19.6	+7.6	13th/105yr	1957-58
Hibbing	21.7	+8.2	1st/33yr	-----
Olivia	23.9	+5.1	20th/110yr	1980-81
Willmar	23.2	+5.5	7th/64yr	1980-81
Lamberton	25.9	+5.9	1st/34yr	1960-61
Waseca	25.6	+6.2	7th/80yr	1957-58
Rochester	25.5	+5.1	1st/47yr	-----

Notes for MPR "Morning Edition", Feb. 26, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment

Bob and I discussed the idea of doing something on the relationship between climate and snow removal/street maintenance considerations. I have also included a possible alternative topic.

1. Word of the Week: Diurnal Cycles

This derives from the Latin root **diurnalis** meaning daily or recurring every day. It is used in many sciences besides meteorology, including botany and zoology for example to describe the daily pattern of behavior in plants and animals. In meteorology and climatology there are many elements with distinct diurnal cycles: temperature, humidity, solar radiation, and wind for example. In the Twin Cities area typically the lowest wind speeds occur around 6 am and the highest around 3 pm. This diurnal cycle is observed with the aerial application of herbicides and pesticides during Minnesota growing seasons. Often pilots will only apply these compounds during the morning hours before winds pick up.

2. Almanac

Records for today's date (Feb. 26) are a high of 64 in 1896 and a low of -22 in 1897. The high of 64 degrees is also our all-time highest temperature recorded during the month of February. Most snowfall on this date is 7 inches in 1936. The greatest snow depth which we have experienced in the Twin Cities this late in the season is 26 inches on February 26 1962 and again in 1967. Our current snow depth reported by the National Weather Service is 8 inches.

3. Topic of the Week: Climatology, Snow Removal and Street Maintenance

Our topic for this week is climatology and snow removal/street maintenance considerations. A general rule of thumb used by the St Paul Streets Department for the declaration of snow emergency plowing is a snowfall of 4 inches or greater. In a typical year we might have 3-4 snow emergencies declared for the purposes of street plowing. I examined the climate records for the period 1949-1992 and found that this is also the approximate number of snowfalls equal to or greater than 4 inches which we experience each year. Of the last 44 years, there have only been three when this snowfall criteria was never achieved - 1960, 1964 and 1990. On the other hand there have been a number of years when this snowfall criteria was achieved numerous times - 1951, 1962, 1969, 1982, 1983, and 1991, each of which corresponds to a busy year for the street maintenance department. Climatological analysis of the snowfall records for the past 4 decades (the 50s, 60s, 70s, and 80s) indicates that the 1960s and 1980s were far worse than the 1950s or 1970s in terms of frequency of snow storms which caused snow emergencies to be declared. Of the last 28 snow storms of 4 inches or greater in the Twin Cities, 12 have occurred in November and 7 in March. Some of the need for snow removal operations in March has been alleviated by warm temperatures immediately following the storms.

With respect to street maintenance, it is common knowledge that **highly fluctuating** temperature and moisture conditions are the chief climatic adversaries to paved roads. Asphalt is more subject to cracking as a result of moisture penetration in the presence of freeze-thaw cycles and thermal expansion and contraction caused by large day-night temperature differences, episodic temperature variations (spells of warm days followed by spells of frigid days), and variations in solar radiation which can heat the surface dramatically. Over the past 6 weeks Twin Cities temperatures have averaged anywhere from 12 degrees below normal to 15 degrees above normal. Soil frost depths vary from 1 to 2 feet. And solar radiation has been highly variable, with a few bright sunny days interspersed with spells of prolonged cloudiness and fog. These are all conditions

which favor development of cracks and potholes. Thus we might anticipate that a number of these will be developing and in evidence as we approach spring in Minnesota.

Possible Alternative for Discussion: March months which have come in "like a lion and out like a lamb" or in "like a lamb and out like a lion." Using temperature records for the first and last week of March for the Twin Cities, spanning 1900-1992.

<u>"In like a lamb/out like a lion"</u>	<u>"In like a lion/out like a lamb"</u>	1921
	1920	
1923		1925
1924		1943
1934		1945
1937		1955
1964		1978
1966		1989

Temperature records confirm these years, 14 in all, fell into one category or the other.

But 14 out of 93 years is only 15 percent of the time when this old saying has been true, at least based on temperature standard deviations for March.

March begins on Monday of this next week and it looks like the first week of March will be mild.

Notes for MPR "Morning Edition", March 5, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment

"Here before the dying embers
I sit and weigh my last regrets;
When I'm right no one remembers;
When I'm wrong no one forgets."
-A Weatherman's Lament

March is such a huge transition month with so many changes going on climatically, I thought I might address topics which educate and help explain some of the climatic processes. Please tell me if this is too ambitious.

1. Almanac

Records for today's date (March 5) are a high of 62 in 1846 and a low of -15 in 1836, both set last century. 20th century records are a high of 56 in both 1937 and 1987 and a low of -14 set in 1960. Record precipitation is 0.70 inches in 1961 and record snowfall is 11.2 inches in 1915.

The 2nd through the 5th of March, 1966 produced one of the worst blizzards in history for central and northern Minnesota. Areas were paralyzed by high winds and snowfalls of over 2 feet. Drifts up to 20 feet closed many roads in some northern counties. Snowmobiles were about the only usable form of transportation. About 3 inches of ice along with high winds brought many power lines down in the Duluth area. The heavy snowfall set up April floods on the Red River of the North and the headwaters of the Mississippi.

2. Words of the Week: Latent Heat and Sensible Heat

Latent heat refers to the heat energy consumed or released in the phase change of water. It can be expressed in a variety of energy units. Let's use calorie, which is (under specified conditions) the energy required to raise the temperature of 1 gram of liquid water by 1 degree C. Specifically, about 80 calories of heat energy are consumed to melt 1 gram of ice and conversely, 80 calories are released when 1 gram of liquid water freezes. Additionally it takes 580 calories of heat energy to evaporate 1 gram of liquid water and conversely when 1 gram of liquid water is released from the vapor phase (as in condensation and precipitation from clouds) 580 calories are released to the atmosphere.

Sensible heat (air temperature which we can sense) refers to the heat flow between a relatively warm surface (soil or pavement for example) and the air above it or conversely when the air overlaying a surface is warmer than the surface. On a typical day the sun heats the surface

to a temperature which is warmer than the overlaying air and sensible heat flow begins to warm the air near the surface. A second type of sensible heat flow occurs when a warm air mass, say from the southern plains makes its way north to Minnesota and heats the surface over which it passes.

3. Topic of the Week: Heat Transfer

This time of year as we approach spring a great deal of heat energy is being consumed in reducing ice and snow cover and evaporating surface water (the latent heat process). Relatively little of the daily solar radiation (now approximately 300 calories per day) goes into heating up the soil (the sensible heat process) until we lose the snow cover and evaporate most of the moisture from the surface of the soil. Even then a good deal of energy will be required to remove the frost from the soil. Currently our frost depths range from 1 to 2.5 feet. Once all of this happens, our soils will heat up much more rapidly and we will see a larger spread between our daytime high temperatures and nighttime lows.

In the spring months when conditions are dry, we tend to have some of the largest swings in temperature. This is the result of two factors: the rapidly increasing daylength and sun angle in spring which brings about greater daytime heating of the surface (especially if it is dry); and secondly substantial differences in the temperature of air masses (tropical versus polar) which pass across our state. The typical diurnal range in temperature (difference between overnight low and daytime high) for this time of year is between 15 and 20 degrees. Yet under dry spring conditions in years past we have experienced some remarkable daily changes in temperature. Some examples: March 30, 1963 Twin Cities reported a morning low of 30 degrees and the afternoon high under bright sunny skies and strong southerly winds reached 77 degrees. There was no snow and soils were dry. Crookston in northwestern Minnesota reported a low of 20 degrees and a high of 74 degrees on April 28, 1926. Again no snow and a dry soil. Montevideo in Chippewa County on April 17, 1950 reported an afternoon high of 70 degrees after a morning low of 6 degrees. And perhaps most astoundingly, Lamberton on April 3, 1982 reported a high temperature of 78 degrees and a low of 7 degrees, a 71 degree spread within 24 hours. Once again, no snow cover and dry soils.

Even with snow cover, air mass differences can have quite an effect, as with Wadena in north-central Minnesota on April 17, 1988 when with 20 inches of snow cover they reached a high of 73 degrees in the afternoon under a maritime tropical air mass, then plummeted to 19 degrees as a polar air mass moved down out of Canada.

Possible alternative topics:

Soil Frost:

Soil frost occurs nearly every year in Minnesota. It is a rare year when our soils do not freeze at least a few inches. There are at least three important characteristics of soil frost: the date that the soil first begins to freeze, the average maximum depth which it freezes, and the date that the last layer of frost comes out of the soil. The initial soil freezing date ranges from the last week of November in northwestern Minnesota to the third week of December in southeastern counties. The maximum depth of frost under sod is typically 20 inches in southern Minnesota to 40 inches in west-central counties. The time of occurrence for the maximum depth of frost is near the end of February to first week of March in southern counties and second week of March in northern Minnesota. In the spring as we lose snow cover, the soil thaws from both the top and the bottom, such that the last remaining layer of soil frost is usually several inches below the surface. Typical last dates for soil frost range from March 25 to April 15th. Soil moisture, snow depth and vegetative cover all greatly affect soil frost.

This year, soil frost depths have generally been a bit less than normal and in many places the thawing process has begun.

Heating Degree Days:

Heating degree days are computed from daily maximum and minimum temperatures, using a base value of 65 degrees. For example, if the maximum and minimum temperature for a day are 40 and 20 degrees, respectively, then the daily mean is 30 degrees. The difference between this and the 65 degree base is 35 heating degree days. This number is summed on a daily basis during the heating season to provide a cumulative value which year to year serves as an index of the energy demand for residential and commercial heating. In the Twin Cities the average HDD for an annual basis (computed from July through June) is 7981. This year we have been very close to the average, despite having a number of warm spells in the winter.

The daily observation time for recording temperatures can have an important impact on HDD for a given location. The Twin Cities record is based on true calendar date observations taken from midnight to midnight. For other locations, the observations may be taken either in the morning (typically 8 am) or the afternoon (typically 5 pm). When the thermometers are reset at these times they can show significant carryover effects, with 8 am being near the usually time of minimum temperature and 5 pm sometimes near the time of maximum temperature. Thus a relatively larger number of HDD might accumulate at a site with an 8 am observation, and a relatively smaller number of HDD at a site with a 5 pm observation time.

Notes for MPR "Morning Edition", March 12, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment

We talked about discussing soil frost this week, so I have prepared accordingly.

1. Almanac:

Records for today's date (March 12) are a high of 69 in 1990 and a low of -10 in 1856. Lowest minimum temperature this century for the date has been -8 in 1956. Record precipitation is 1.10 inches which fell as 11 inches of snow in 1899. The 7.5 inches of snow which fell in Brainerd on Tuesday of this week was their biggest snowfall during the 2nd week of March since 1963. It probably prolonged the cross country skiing season for them by at least a few days.

2. Word of the Week: Soil Porosity

Soil porosity refers to the relative pore volume in a soil. It is usually expressed as a fraction, i.e. 0.3 to 0.6. Pore spaces are filled with either air or water. Coarse textured soils like sand are less porous than more finely textured soils (silt loam). That's because the individual pore spaces in sand though greater in size are far fewer in number than in finer textured soils.

Along with porosity, soil moisture and organic matter content are important factors that influence soil freezing in winter, which is our topic for today.

3 Topic of the week: Soil Frost

Soil frost occurs nearly every year in Minnesota. It is a rare year when soils do not freeze at least a few inches. There are at least three important characteristics of soil frost: the date that the soil first begins to freeze, the average maximum depth which it freezes, and the date that the last layer of frost comes out of the soil. The average initial soil freezing date ranges from the last week of November in northwestern Minnesota to the third week of December in southeastern counties. The average maximum depth of frost under sod is typically 20 inches in southern Minnesota to 40 inches in west-central counties. The time of occurrence for the maximum depth of frost on average is near the end of February to first week of March in southern counties and second week of March in northern Minnesota. In the spring as we lose snow cover, the soil thaws from both the top and the bottom, such that the last remaining layer of soil frost is usually several inches below the surface. This is why so often in the early spring we see a number of ponds which appear in farm fields seemingly disappear over night as the soil profile finally thaws and allows all of the surface moisture to infiltrate and migrate to lower layers. Typical last dates for soil frost range from March 25 to April 15th. Snow depth and vegetative cover all greatly affect soil frost.

This year, soil frost depths have generally been a bit less than normal and with the above normal temperatures from the first week of March, in many places the thawing process has begun both from the top and the bottom

Soil frost has been a significant factor in some of the most severe Minnesota floods particularly on the Red River of the North which runs along the Minnesota-North Dakota border. In 1989, the Wahpeton-Breckenridge area on the southern end of the Red River Valley experienced one of its worst floods. Contributing factors were 12 inches of snow in March on top of an already significant snow cover (46 inches for the season), rapid melting and rain storms in early April, an ice dam on the river, and persistent soil frost which limited infiltration into soils. Residential and city property damage in Breckenridge (Wilkin County) along totaled over \$ 3 million.

In 1979, the Grand Forks (ND)-East Grand Forks (MN) area along the Red River Valley experienced one of its worst floods. There were areas where the river was out of its banks by several miles. Contributing factors were again 12 inches of snow in March on top of an extensive existing snow cover (50 inches for the season), a relatively rapid April melt, heavy April rains, and persistent soil frost. 40 counties were declared federal disaster areas as thousands of acres of farm land were inundated.

Possible Alternative: Heating Degree Days

Heating degree days are computed from daily maximum and minimum temperatures, using a base value of 65 degrees. For example, if the maximum and minimum temperature for a day are 40 and 20 degrees, respectively, then the daily mean is 30 degrees. The difference between this and the 65 degree base is 35 heating degree days. This number is summed on a daily basis during the heating season to provide a cumulative value which year to year serves as an index of the energy demand for residential and commercial heating. In the Twin Cities the average HDD for an annual basis (computed from July through June) is 7981. This year we have been very close to the average, despite having a number of warm spells in the winter.

The daily observation time for recording temperatures can have an important impact on HDD for a given location. The Twin Cities record is based on true calendar date observations taken from midnight to midnight. For other locations, the observations may be taken either in the morning (typically 8 am) or the afternoon (typically 5 pm). When the thermometers are reset at these times they can show significant carryover effects, with 8 am being near the usually time of minimum temperature and 5 pm sometimes near the time of maximum temperature. Thus a relatively larger number of HDD might accumulate at a site with an 8 am observation, and a relatively smaller number of HDD at a site with a 5 pm observation time.

Notes for MPR "Morning Edition", March 19, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment

Thanks for the article you faxed about the wild weather and possible causes. Peter Leavitt is well known on the east coast and does make long range predictions.

We talked about discussing wind climatology this week and particularly comparing Rochester (which is seemingly has greater winds) with other parts of the state.

March has so far given us typically variable weather, with the first 9 days of the month averaging over 10 degrees above normal and the most recent 9 days (March 10-18) averaging over 11 degrees below normal. But if we think we were cold this week, look at the following average temperatures reported for the second week of March:

<u>Location</u>	<u>(lat x long)</u>	<u>avg. temp.</u>
Resolute	(74 43 94 53)	avg. temp. -31 F
Hall Beach	(68 46 81 15)	avg. temp. -35 F
Shepard Bay	(68 48 93 25)	avg. temp. -35 F
Eureka	(79 58 85 55)	avg. temp. -34 F

These are weather stations in the Northwest Territories of Canada. Still lots of cold air up there!

1. Almanac:

Records for today's date (March 19) are a high of 72 in 1910 and a low of -15 in 1875. Lowest minimum temperature this century for the date has been -7 in 1923. Last time we had a temperature above 60 degrees on this date was the 62 we had in 1991. Record precipitation is 1.09 inches which fell in 1897, and the record snowfall is just shy of 9 inches (8.8) which occurred in 1943. Normals are a high of 39 and a low of 20.

This average temperature for this last week (March 12-18) was the lowest ever for this time of year at many places in the state. Low temperature records were set or tied at Brainerd, Rosemount, St Cloud, Park Rapids, Rochester, and Fairmont to name a few.

2. Word of the Week: **Isotach**

I must be careful with this word and spell it for listeners because there are two scientific terms which sound the same but mean different things. **Isotac** is a word used in glaciology which refers to an equiglacial line connecting points where ice melts at the same time each spring. **Isotach** is a term used in meteorology and climatology to refer to a line connecting points of equal wind speed (velocity) on a map. This is used to show the regional distribution of wind forces, either at the surface or aloft. The word derives from the Greek **isos** meaning equal and **tachos** meaning swiftness.

3. Topic of the week: Regional winds

Bob, you made the comment that Rochester reports wind speeds that nearly always exceed those from MSP Airport. Climatology of wind supports your observation, as average wind speeds at Rochester are uniformly greater throughout the year than those reported from MSP. Rochester airport reports average monthly wind speeds 3 to 4 mph greater than MSP airport. Both anemometers sit at about 20 feet above the ground situated near an airport runway. One difference is that Rochester airport is at an elevation of 1297 feet and MSP airport is at 834 feet. Thus Rochester is measuring wind at a position which is 463 feet higher in the regional landscape. This by itself could lead to somewhat greater wind speed values there.

Wind speeds generally are greater in western Minnesota than in the eastern part. A wind farm which was brought into operation outside Marshall, MN last year is now producing wind generated power from several wind turbines for local electricity users in and around that community. The wind generators are installed along the Buffalo Ridge to take advantage of the relatively higher position in the landscape. Five wind turbines outside Marshall can produce up to 600 Kw/hr of power (@ 120 Kw/each). NSP plans to produce 25 to 100 Megawatts of power from wind turbine installations over the next several years.

The following are possible alternatives (A): I had thought of commenting on the big storm in the east last week, but that will be old news and I don't believe I can add much.

A1. Word of the Week: Vernal Equinox

Vernal derives from the Latin **vernalis** or **vernus** meaning spring, something which occurs in the spring, e.g. vernal blooms, vernal migrations of birds, vernal springs. Equinox also derives from Latin terms, **aequus** meaning equal and **noctis** meaning night. Thus this term refers to the time in spring when the sun's center passes over the equator (on its migration from the southern to the northern latitudes), and day and night for each point on the Earth's surface are of equal length. This occurs approximately March 21 each year. This year, it will occur at 8:41 am tomorrow morning (Saturday March 20th).

Everyone knows that we are now gaining daylight. Our days are approximately 3.25 hours longer now than they were on Christmas Day.

Around the time of the vernal equinox we are gaining daylight at a very fast rate. Whereas the first week of January we gained 7 minutes of daylight, over this past week we have gained nearly 23 minutes.

A3. Topic of the Week: Climatology, Snow Removal and Street Maintenance

Our topic for this week is climatology and snow removal/street maintenance considerations. A general rule of thumb used by the St Paul Streets Department for the declaration of snow emergency plowing is a snowfall of 4 inches or greater. In a typical year we might have 3-4 snow emergencies declared for the purposes of street plowing.

I examined the climate records for the period 1949-1992 and found that this is also the approximate number of snowfalls equal to or greater than 4 inches which we experience each year. Of the last 44 years, there have only been three when this snowfall criteria was never achieved - 1960, 1964 and 1990. On the other hand there have been a number of years when this snowfall criteria was achieved

numerous times - 1951, 1962, 1969, 1982, 1983, and 1991, each of which corresponds to a busy year for the street maintenance department. Climatological analysis of the snowfall records for the past 4 decades (the 50s, 60s, 70s, and 80s) indicates that the 1960s and 1980s were far worse than the 1950s or 1970s in terms of frequency of snow storms which caused snow emergencies to be declared. Of the last 28 snow storms of 4 inches or greater in the Twin Cities, 12 have occurred in November and 7 in March. Some of the need for snow removal operations in March has been alleviated by warm temperatures immediately following the storms.

With respect to street maintenance, it is common knowledge that highly fluctuating temperature and moisture conditions are the chief climatic adversaries to paved roads. Asphalt is more subject to cracking as a result of moisture penetration in the presence of freeze-thaw cycles and thermal expansion and contraction caused by large day-night temperature differences, episodic temperature variations (spells of warm days followed by spells of frigid days), and variations in solar radiation which can heat the surface dramatically. Over the past 6 weeks Twin Cities temperatures have averaged anywhere from 5 degrees below normal to 15 degrees above normal. Soil frost depths vary from 1 to 2 feet. And solar radiation has been highly variable, with a few bright sunny days interspersed with spells of prolonged cloudiness and fog. These are all conditions which favor development of cracks and potholes. Thus we might anticipate that a number of these will be developing and in evidence as we approach spring in Minnesota.

Notes for MPR "Morning Edition", March 26, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment. I am planning on being there earlier than normal this week, for a program at 6:40 am. I hope that is still your plan.

1. Word of the Week: **Occultation Ring**

From the Latin **occultatio** meaning to hide or conceal. Used in astronomy to refer to eclipses of stars and planets by the moon, where their light is then hidden from us on Earth. In meteorology and climatology this term is used in radiation measurement to refer to the "shadow band" attached to a pyranometer or radiometer. Its' purpose is to obscure the direct radiation from the sun, allowing the instrument to measure only the diffuse (scattered) radiation from the sky and clouds. This ring must be adjusted regularly to allow for the changing angle of the sun.

2. Almanac

All-time record high temperature for this date is 79 degrees in 1845 and the record low is -15 in 1843. Records for this century are a high of 74 in 1991 and a low of 0 in 1955 and 1965. Record precipitation is 1.02 inches in 1921 and record snowfall is 8 1/2 inches in 1936. The last major snow storm on this date was 3 1/2 inches back in 1983. 1946, 1968, and 1986 saw very warm temperatures dominate the last week of March, with many high temperatures in the 70s and some in the 80s. In fact 1968 was so warm and dry at this time, many farmers were already in the field working across southern Minnesota.

3. Topic of the Week: Climatology, Snow Removal and Street Maintenance

Our topic for this week is climatology and snow removal/street maintenance considerations. A general rule of thumb used by the St Paul Streets Department for the declaration of snow emergency plowing is a snowfall of 4 inches or greater. In a typical year we might have 3-4 snow emergencies declared for the purposes of street plowing. I examined the climate records for the period 1949-1992 and found that this is also the approximate number of snowfalls

equal to or greater than 4 inches which we experience each year. Of the last 44 years, there have only been three when this snowfall criteria was never achieved - 1960, 1964 and 1990. On the other hand there have been a number of years when this snowfall criteria was achieved numerous times - 1951, 1962, 1969, 1982, 1983, and 1991, each of which corresponds to a busy year for the street maintenance department. Climatological analysis of the snowfall records for the past 4 decades (the 50s, 60s, 70s, and 80s) indicates that the 1960s and 1980s were far worse than the 1950s or 1970s in terms of frequency of snow storms which caused snow emergencies to be declared. Of the last 28 snow storms of 4 inches or greater in the Twin Cities, 12 have occurred in November and 7 in March. Some of the need for snow removal operations in March has been alleviated by warm temperatures immediately following the storms.

With respect to street maintenance, it is common knowledge that highly fluctuating temperature and moisture conditions are the chief climatic adversaries to paved roads. Asphalt is more subject to cracking as a result of moisture penetration in the presence of freeze-thaw cycles and thermal expansion and contraction caused by large day-night temperature differences, episodic temperature variations (spells of warm days followed by spells of frigid days), and variations in solar radiation which can heat the surface dramatically. So far this month our local temperatures have passed through the freezing mark of 32 degrees over 40 times, with daytime heating causing thawing conditions on road surfaces only to be followed by refreezing at night. Over the past 6 weeks Twin Cities temperatures have averaged anywhere from 12 degrees below normal to 15 degrees above normal. Soil frost depths vary from 1 to 2 feet. And solar radiation has been highly variable, with a few bright sunny days interspersed with spells of prolonged cloudiness and fog. These are all conditions which favor development of cracks and potholes. Thus we might anticipate that a number of these will be developing and in evidence over the next few weeks.

Possible Alternative Topic

Heating Degree Days:

Heating degree days are computed from daily maximum and minimum temperatures, using a base value of 65 degrees. For example, if the maximum and minimum temperature for a day are 40 and 20 degrees, respectively, then the daily mean is 30 degrees. The difference between this and the 65 degree base is 35 heating degree days. This number is summed on a daily basis during the heating season to provide a cumulative value which year to year serves as an index of the energy demand for residential and commercial heating. In the Twin Cities the average HDD for an annual basis (computed from July through June) is 7981. This year we have been very close to the average, despite having a number of warm spells in the winter.

The daily observation time for recording temperatures can have an important impact on HDD for a given location. The Twin Cities record is based on true calendar date observations taken from midnight to midnight. For other locations, the observations may be taken either in the morning (typically 8 am) or the afternoon (typically 5 pm). When the thermometers are reset at these times they can show significant carryover effects, with 8 am being near the usually time of minimum temperature and 5 pm sometimes near the time of maximum temperature. Thus a relatively larger number of HDD might accumulate at a site with an 8 am observation, and a relatively smaller number of HDD at a site with a 5 pm observation time. When comparing heating degree days from one location to another or from one year to another, be sure that they are based on the same time of observation.

Notes for MPR "Morning Edition", March 26, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment. I am planning on being there earlier than normal this week, for a program at 6:40 am. I hope that is still your plan.

1. Word of the Week: **Occultation Ring**

From the Latin **occultatio** meaning to hide or conceal. Used in astronomy to refer to eclipses of stars and planets by the moon, where their light is then hidden from us on Earth. In meteorology and climatology this term is used in radiation measurement to refer to the "shadow band" attached to a pyranometer or radiometer. Its' purpose is to obscure the direct radiation from the sun, allowing the instrument to measure only the diffuse (scattered) radiation from the sky and clouds. This ring must be adjusted regularly to allow for the changing angle of the sun.

2. Almanac

All-time record high temperature for this date is 79 degrees in 1845 and the record low is -15 in 1843. Records for this century are a high of 74 in 1991 and a low of 0 in 1955 and 1965. Record precipitation is 1.02 inches in 1921 and record snowfall is 8 1/2 inches in 1936. The last major snow storm on this date was 3 1/2 inches back in 1983. 1946, 1968, and 1986 saw very warm temperatures dominate the last week of March, with many high temperatures in the 70s and some in the 80s. In fact 1968 was so warm and dry at this time, many farmers were already in the field working across southern Minnesota.

3. Topic of the Week: Climatology, Snow Removal and Street Maintenance

Our topic for this week is climatology and snow removal/street maintenance considerations. A general rule of thumb used by the St Paul Streets Department for the declaration of snow emergency plowing is a snowfall of 4 inches or greater. In a typical year we might have 3-4 snow emergencies declared for the purposes of street plowing. I examined the climate records for the period 1949-1992 and found that this is also the approximate number of snowfalls equal to or greater than 4 inches which we experience each year. Of the last 44 years, there have only been three when this snowfall criteria was never achieved - 1960, 1964 and 1990. On the other hand there have been a number of years when this snowfall criteria

was achieved numerous times - 1951, 1962, 1969, 1982, 1983, and 1991, each of which corresponds to a busy year for the street maintenance department. Climatological analysis of the snowfall records for the past 4 decades (the 50s, 60s, 70s, and 80s) indicates that the 1960s and 1980s were far worse than the 1950s or 1970s in terms of frequency of snow storms which caused snow emergencies to be declared. Of the last 28 snow storms of 4 inches or greater in the Twin Cities, 12 have occurred in November and 7 in March. Some of the need for snow removal operations in March has been alleviated by warm temperatures immediately following the storms.

With respect to street maintenance, it is common knowledge that highly fluctuating temperature and moisture conditions are the chief climatic adversaries to paved roads. Asphalt is more subject to cracking as a result of moisture penetration in the presence of freeze-thaw cycles and thermal expansion and contraction caused by large day-night temperature differences, episodic temperature variations (spells of warm days followed by spells of frigid days), and variations in solar radiation which can heat the surface dramatically. So far this month our local temperatures have passed through the freezing mark of 32 degrees over 40 times, with daytime heating causing thawing conditions on road surfaces only to be followed by refreezing at night. Over the past 6 weeks Twin Cities temperatures have averaged anywhere from 12 degrees below normal to 15 degrees above normal. Soil frost depths vary from 1 to 2 feet. And solar radiation has been highly variable, with a few bright sunny days interspersed with spells of prolonged cloudiness and fog. These are all conditions which favor development of cracks and potholes. Thus we might anticipate that a number of these will be developing and in evidence over the next few weeks.

Possible Alternative Topic

Heating Degree Days:

Heating degree days are computed from daily maximum and minimum temperatures, using a base value of 65 degrees. For example, if the maximum and minimum temperature for a day are 40 and 20 degrees, respectively, then the daily mean is 30 degrees. The difference between this and the 65 degree base is 35 heating degree days. This number is summed on a daily basis during the heating season to provide a cumulative value which year to year serves as an index of the energy demand for residential and commercial heating. In the Twin Cities the average HDD for an annual basis (computed from July through June) is 7981. This year we have been very close to the average, despite having a number of warm spells in the winter.

The daily observation time for recording temperatures can have an important impact on HDD for a given location. The Twin Cities record is based on true calendar date observations taken from midnight to midnight. For other locations, the observations may be taken either in the morning (typically 8 am) or the afternoon (typically 5 pm). When the thermometers are reset at these times they can show significant carryover effects, with 8 am being near the usually time of minimum temperature and 5 pm sometimes near the time of maximum temperature. Thus a relatively larger number of HDD might accumulate at a site with an 8 am observation, and a relatively smaller number of HDD at a site with a 5 pm observation time. When comparing heating degree days from one location to another or from one year to another, be sure that they are based on the same time of observation.

Notes for MPR "Morning Edition", April 16, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Word of the Week: **Phenology**

From the Greek, Latin and French root words of **pheno** or **phainomenon** meaning to appear, to pass or to show. Used in Biology to describe the relationship between climate and periodic observable biological phenomena, such as the migration of birds, budding and flowering of plants and trees etc.

Not to be confused with **phrenology** which is the study of the conformation of the skull based on the belief that it indicates mental ability and character.

This is the time of year that many biological phenomena are observed (some say are renewed or reborn) in Minnesota. The state has many keen phenological observers.

2. Almanac

Record high for today is 88 degrees in 1964 and the record low is 10 degrees in 1875. The lowest temperature on this date during this century was 20 degrees back in 1907. The greatest amount of precipitation has been 0.78 inches in 1916 and the greatest snowfall 5 inches in 1961.

During this week in 1983 (specifically the 13th and 14th of April), eastern Minnesota experienced one of the worst late season snow storms ever. Parts of Rice, Goodhue, Steele, Dakota, and Waseca Counties reported accumulations of over 16 inches. The Twin Cities officially had over 13.5 inches. Winds of 40 to 50 mph on the 14th created near blizzard conditions in some places and toppled a 90 foot light tower at municipal stadium in St Cloud. In rural Minnesota counties, some newborn calves were killed by the near blizzard like conditions. Nearly 275 MTC buses were stuck, schools were closed and the Twins-California Angels game scheduled for the Metrodome was postponed because the dome roof developed a tear caused by a broken lightning rod.

3. Topic of the Week: Lake Ice Out Dates

Historically April is usually the month when most lakes around

the state lose their ice cover. This typically ranges from the first week of April in the southern most counties to near the end of the month in the far northern counties. But as most phenological observers have reported this year, ice out dates on many lakes, especially in southern counties are quite late, up to 10 days to 2 weeks late in some places. The lose of ice on central and northern Minnesota lakes may not be as late (relative to normal) depending on temperature conditions over the second half of the month. On the other hand, if temperatures remain below normal, as they have been for the first half of the month, there may still be some ice on northern lakes close to the time of the fishing opener next month.

Most phenological events in Minnesota show great variability. For example, the range from earliest to latest for elderberry buds to open around the Twin Cities area in the spring is 40 days, having been as early as March 13 and as late as April 21. This year they have opened about 10 days to two weeks later than normal. There is great variability associated with ice out dates on Minnesota lakes as well. For example, the earliest ice out date reported for White Bear Lake is March 29, 1981, while the latest date is May 4, 1950 - a 37 day difference. Or Detroit Lake in Becker County, where the earliest ice out was on March 23, 1910 and the latest May 17, 1950 - a 55 day difference.

For many shallow lakes in Minnesota, the ice out date correlates closely with the date that the frost comes completely out of the soil, and the field working season can begin for farmers. As of yesterday (April 15) soil temperatures at the 4 inch depth were:

Crookston.....39	Becker.....40	Lamberton.....39
Morris.....39	Staples....41	Waseca.....41
Rosemount...36	Cloquet....31	Grand Rapids...44
Roseau.....44	Westport....41	Rice.....40
Park Rapids....42		

In some places the frost came out of the soil earlier this month, but other places still have a frost layer down around 2 to 3 feet below the soil surface.

Notes for MPR "Morning Edition", April 23, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Last week we discussed some aspects of phenology or the relationship between climate and periodic observable biological phenomena like the migration of birds, and budding and flowering of plants. This week we have had some very nice days which have accelerated some of the phenological events. But early April has certainly been ugly across southern Minnesota with temperatures averaging 2 to 5 degrees below normal, strong winds, rain and snow. On the other hand, the northwestern part of the state has had a rather mild dry month as evidenced by the amount of planting which is going on up there.

Some places in southeastern Minnesota have received a good deal of snow this month, among them Caledonia in Houston County which has reported over 14 inches. This April will rival that of 1973 and 1962 for most snow in this part of the state. All of the moisture has delayed the field working season for agriculture.

Some people doing field work this week have reported seeing dust devils or whirl winds forming and moving across fields. These are sometimes formed when there is strong surface heating and a superadiabatic lapse rate (rapid cooling of air with height above the ground) accompanied by fairly moderate regional wind flows (15 to 20 mph).

1. Word of the Week: **Transmissivity**

From the root words **trans** meaning over or across and **mittere** meaning to send (both Latin). In meteorology as well as in physics this word is used to describe the fraction of radiation which passes through the Earth's atmosphere and reaches the surface. For example at the top of the Earth's atmosphere radiant energy striking a surface placed normal (perpendicular) to the sun will receive approximately 1360 Watts per square meter. That radiation is reduced as it passes through the Earth's atmosphere by absorption and reflection primarily from water vapor, atmospheric aerosols and particularly clouds. The fraction of radiation which reaches the Earth's surface then is a measure of the transmissivity of our atmosphere (the ability of our atmosphere to transmit radiation). It varies both geographically and over time. For example now during the spring in Minnesota, typical clear day transmissivity is about .72 to .76. This will decline as we move toward summer to about .67 to .70., then begin to rise again in the fall. Highest clear day transmissivities are generally in the winter.

2. Almanac (means are high 50s for highs, high 30s for lows)

For this date the record high is 86 degrees in 1990 and the record low is 17 degrees in 1850. Record low this century is 19 degrees which occurred in 1910. Record precipitation is 1.5 inches in 1840 and record snow is 1.6 inches in 1988.

This week in 1980 many places across the state experienced their highest temperature ever for so early in the spring. In the Twin Cities the mercury hit 95 degrees on April 21. Elsewhere observers at Browns Valley, Montevideo, Campbell, Ada, and Georgetown as well as Fargo (ND) reported highs of 100 degrees and Hawley in central Clay County of northwestern Minnesota reported 101 degrees on April 22nd. Temperatures this high had never before been observed in April.

3. Topic of the Week: Ice Out Dates and Phenology (continued)

Last week we discussed ice out dates on Minnesota lakes and the fact that they were a bit late this year. Historically April is usually the month when most lakes around the state lose their ice cover. Many observers reported ice going out on the 19th and 20th, earlier this week (Minnetonka and Lake Itasca to name two). For many lakes in Minnesota ice out has been late coming this year but not anywhere near a record.

Most phenological events in Minnesota show great variability. For example, the range from earliest to latest for elderberry buds to open around the Twin Cities area in the spring is 40 days, having been as early as March 13 and as late as April 21. This year they have opened about 10 days to two weeks later than normal. Lilac buds have started to swell and open this week though and they are only about 4 to 6 days later than normal, as plants have caught up by having some warmer temperatures recently.

There is great variability also associated with ice out dates on many of Minnesota's lakes. For example, the earliest ice out date reported for White Bear Lake is March 29, 1981, while the latest date is May 4, 1950 - a 37 day difference. Or Detroit Lake in Becker County, where the earliest ice out was on March 23, 1910 and the latest May 17, 1950 - a 55 day difference.

For many shallow lakes in Minnesota, the ice out date correlates closely with the date that the frost comes completely out of the soil, and the field working season can begin for farmers. As of yesterday (April 15) soil temperatures at the 4 inch depth were reaching the 60s in the sands of central Minnesota, the 50s in the heavier textured soils in the south and the 40s in some of the forested soils of northern Minnesota.

Notes for MPR "Morning Edition", Program of April 30, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Spring phenology has been our topic over the past two weeks and one follow up to that is the first appearance of wood ticks reported locally by Dick Riemenschneider of the City of Woodbury earlier this week.

Today (April 30) is Arbor Day, a day for planting trees, a ceremonial act of spring dating back to 1872 in Nebraska. May has been declared Arbor Month in the state of Minnesota. There will be a good deal of planting and educational activities about the value of trees. It is worth noting the many advantages trees bring to the local environment.

-In recent years with the research on global climate change we have learned that trees take up large quantities of carbon dioxide on a global scale. When used in the home landscape they can also provide a buffer from nearby sources of dusts, odours, other aerosols and noise.

-They are planted in the rural landscape to provide wind protection, to reduce soil erosion potential, and to provide wildlife habitat.

-In the residential landscape trees provide selective shading in the summer, somewhat reducing air conditioning needs..particularly when placed on south or west facing exposures to protect roofs, windows and air conditioning units from direct sunlight. In winter, trees (especially evergreens) can provide protection from northerly and westerly winds which may tend to carry off heat from buildings more rapidly. They also tend to alter the local radiation balance, as they have lower albedo (reflectivity) and help reduce long wave radiation loss to the atmosphere at night.

1. Words of the Week: **Forecasts and Outlooks** (what's the difference?)

Forecasts and outlooks differ both in their content and temporal reference. Generally forecasts refer to fairly specific ranges of temperature, humidity, sky conditions, and winds, as well as precipitation probabilities and amounts. These are estimated for periods ranging from a few hours ahead to 5 days ahead. Forecasts are updated at least once every day and in the case of zone forecasts for today, tonight and tomorrow they are updated on a 6 hourly basis. When weather conditions warrant they are also updated more frequently than that as in the case of severe

thunderstorms and such.

Outlooks typically refer to periods ranging from 6 days ahead to 90 days ahead. Standard products from the National Weather Service include the 6-10 day outlook, the 30 day outlook and the 90 day outlook (sometimes referred to as the seasonal outlook).

Outlooks generally refer to expected temperature and precipitation conditions with respect to normal for a particular time of year.

Thus, they indicate probabilities that temperatures will be warmer or colder than average or precipitation will be greater or lesser than average. Unlike forecasts, outlooks are not updated everyday. 6-10 day outlooks are provided at 3 pm every Monday, Wednesday and Friday. 30 day outlooks are generally released on or near the last day of each month and near the middle of the month, while 90 day outlooks are released near the end of each month for the following 3 month period.

2. Almanac (means of low 60s for max, low 40s for min)

For this date the record high is 91 degrees in 1934 and 1952 and the record low is 24 degrees in 1846 and again in 1903.

Record precipitation is 1.53 inches in 1954 and record snow is 3.1 inches in 1984. By the way this is the latest into the spring that we have ever recorded over 3 inches of snowfall. At Virginia, MN in the northeast, 4.6 inches of snow fell on May 31, 1946 if you can believe that!

It is often said that "April showers bring May flowers." Recently a Minnesota Master Gardener asked me about the differences in April and May rainfall characteristics. First of all, average May precipitation exceeds average April precipitation by about 0.50 to 1 inch nearly everywhere in the state. On average, locally we record nearly 10 days with measurable precipitation in April and nearly 12 days in May. In April of 1924 and 1978 we recorded measurable precipitation on 17 days, while in April of 1987 we recorded measurable precipitation on only 3 days. This April we have recorded measurable precipitation on 12 days.

In 34 of the past 93 years we have had measurable rainfall on this date. But only 6 times in the past 93 years have we received over 1/2 inch of rainfall on this date.

3. Topic of the Week: The Recent 30 and 90 Day Outlooks

To be released Thursday afternoon, April 29th. I will be prepared to discuss these.

In answer to Bob Potter's inquiry about winds, April is the windiest month of the year and has proven to be such this year so far.

Notes for MPR "Morning Edition", Program of April 30, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Spring phenology has been our topic over the past two weeks and one follow up to that is the first appearance of wood ticks reported locally by Dick Riemenschneider of the City of Woodbury earlier this week.

Today (April 30) is Arbor Day, a day for planting trees, a ceremonial act of spring dating back to 1872 in Nebraska. May has been declared Arbor Month in the state of Minnesota. There will be a good deal of planting and educational activities about the value of trees. It is worth noting the many advantages trees bring to the local environment.

-In recent years with the research on global climate change we have learned that trees take up large quantities of carbon dioxide on a global scale. When used in the home landscape they can also provide a buffer from nearby sources of dusts, odours, other aerosols and noise.

-They are planted in the rural landscape to provide wind protection, to reduce soil erosion potential, and to provide wildlife habitat.

-In the residential landscape trees provide selective shading in the summer, somewhat reducing air conditioning needs..particularly when placed on south or west facing exposures to protect roofs, windows and air conditioning units from direct sunlight. In winter, trees (especially evergreens) can provide protection from northerly and westerly winds which may tend to carry off heat from buildings more rapidly. They also tend to alter the local radiation balance, as they have lower albedo (reflectivity) and help reduce long wave radiation loss to the atmosphere at night.

1. Words of the Week: **Forecasts and Outlooks** (what's the difference?)

Forecasts and outlooks differ both in their content and temporal reference. Generally forecasts refer to fairly specific ranges of temperature, humidity, sky conditions, and winds, as well as precipitation probabilities and amounts. These are estimated

for periods ranging from a few hours ahead to 5 days ahead. Forecasts are updated at least once every day and in the case of zone forecasts for today, tonight and tomorrow they are updated on a 6 hourly basis. When weather conditions warrant they are also updated more frequently than that as in the case of severe thunderstorms and such.

Outlooks typically refer to periods ranging from 6 days ahead to 90 days ahead. Standard products from the National Weather Service include the 6-10 day outlook, the 30 day outlook and the 90 day outlook (sometimes referred to as the seasonal outlook).

Outlooks generally refer to expected temperature and precipitation conditions with respect to normal for a particular time of year.

Thus, they indicate probabilities that temperatures will be warmer or colder than average or precipitation will be greater or lesser than average. Unlike forecasts, outlooks are not updated everyday. 6-10 day outlooks are provided at 3 pm every Monday, Wednesday and Friday. 30 day outlooks are generally released on or near the last day of each month and near the middle of the month, while 90 day outlooks are released near the end of each month for the following 3 month period.

2. Almanac (means of low 60s for max, low 40s for min)

For this date the record high is 91 degrees in 1934 and 1952 and the record low is 24 degrees in 1846 and again in 1903.

Record precipitation is 1.53 inches in 1954 and record snow is 3.1 inches in 1984. By the way this is the latest into the spring that we have ever recorded over 3 inches of snowfall. At Virginia, MN in the northeast, 4.6 inches of snow fell on May 31, 1946 if you can believe that!

It is often said that "April showers bring May flowers." Recently a Minnesota Master Gardener asked me about the differences in April and May rainfall characteristics. First of all, average May precipitation exceeds average April precipitation by about 0.50 to 1 inch nearly everywhere in the state. On average, locally we record nearly 10 days with measurable precipitation in April and nearly 12 days in May. In April of 1924 and 1978 we recorded measurable precipitation on 17 days, while in April of 1987 we recorded measurable precipitation on only 3 days. This April we have recorded measurable precipitation on 12 days.

In 34 of the past 93 years we have had measurable rainfall on this date. But only 6 times in the past 93 years have we received over

1/2 inch of rainfall on this date.

3. Topic of the Week: The Recent 30 and 90 Day Outlooks

To be released Thursday afternoon, April 29th. I will be prepared to discuss these.

In answer to Bob Potter's inquiry about winds, April is the windiest month of the year and has proven to be such this year so far.

Notes for MPR "Morning Edition", Program of May 7, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Mr. Kirk Brown of the Twin Cities Tree Trust listened to last weeks comments about Arbor Day and the benefits of trees in residential landscaping. He passed along some information from studies done by the DNR, the University of Minnesota, USDA Forest Service and the Minnesota Public Service Agency. He pointed out that the proper placement of trees in the home landscape saves even more heating energy than cooling energy. Listeners can contact the Energy Information Center of the Department of Public Service if they want more information on this.

If there are other phenological observations of Spring to mention I may try to cover them. I don't know when mushroom hunting season begins but I will ask around.

1. Word of the Week: **Cumulonimbus Clouds**

Typical of late spring and summer. Large dense clouds with great vertical development, dark at the bottom and bright at the top. The top is like a turret or sometimes an anvil shape. The cloud base may be as low as 2000-3000 feet and the cloud top as high as 50,000 to 60,000 feet. Capable of bringing heavy rainfall, hail and damaging winds. Water droplets usually compose the lower portion of the cloud and ice crystal, snowflakes or hail stones in the upper reaches. Internal vertical and downward wind velocities can be substantial in the range of 45 to 70 mph. They can occur in isolation or in groups, sometimes forming squall lines. We are definitely beginning the season for them.

2. Almanac (means of mid 60s for max, mid 40s for min)

For this date the record high is 92 degrees in 1963 and the record low is 26 degrees in 1885. The coldest this century on this date has been 31 degrees in 1906, 1907, and 1931. The last time we had a frost locally on this date was in 1989. Record precipitation is 1.31 inches in 1933 and there has been snow in the Twin Cities on this date but only three times, in 1907, 1938, and 1945. Snowfall in May is a more frequent occurrence in northern Minnesota where at Virginia in the northeast, 4.6 inches of snow fell on May 31, 1946 if you can believe that!

In 36 of the past 93 years we have had measurable rainfall on this date. That's 39 percent of the time. Only 5 times in 93 years have we received rainfall over 1/2 inch on this date.

Hudson Bay experienced 50 degree temperatures for the first time

this spring a few days ago, although it was still -16 degrees up at Eureka on Ellsmere Island in the far Northwest Territories.

3. Topic of the Week: Winds and the Beaufort Scale

Bob asked about April winds last week. Of course wind speed is measured with an anemometer, but before the invention of this instrument, wind speeds were estimated using visual observations. In 1805 the British Admiral Sir Francis Beaufort developed a scale of wind force for use at sea. His scale of wind force ranged from 0 for dead calm conditions to 12 for hurricane conditions. Each point on his numeric scale was characterized by observable effects of winds on ships sails. He thus used his ship as an instrument for measuring wind speeds. In later years, his scale was adapted to land based observations experimentally and thus used by weather observers to estimate wind speeds on land.

Marine and shipping forecasts in the United Kingdom (both for the Irish Sea and the English Channel) still refer to the Beaufort Scale, and ships captains are expected to know it. I will give some examples.

If we continue to have dry conditions prevail in the Red River Valley, we may yet see some serious wind erosion in that area.

Notes for MPR "Morning Edition", Program of May 14, 1993

For: Bruce MacDonald, Nancy Cole, and Loren Omoto

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Phenology comment courtesy of Neil Anderson of the Plant Pathology Department: Most lilacs are starting to bloom this week (near the normal date for this phenological event) and there is a significant association between this phenological event and the appearance of the first **Morchella esculenta** (Morel mushrooms). Their development has also been accelerated by the 10 degree rise in soil temperatures which has occurred over the past 7 to 10 days, along with the recent rains we have received. So if you can stand the cold and damp conditions of this weekend, it would be a good one to hunt mushrooms in southern and central Minnesota.

1. Word of the Week: **Hygrometer**

This derives from the Greek **hygro (moist or wet)** and **meter (measure)**, an instrument to measure the water vapor content of the air. There are many types which use somewhat different principles. The dew point hygrometer is composed of a polished metal surface or mirror which is cooled slowly until condensation forms on its surface. A photoelectric cell detects the formation of dew and the temperature of the surface at that moment is then recorded.

Sometimes confused with a **hydrometer** which is a floating instrument used in physics to measure the specific gravity of liquids.

2. Almanac (means of upper 60s for max, mid 40s for min)

Record maximum temperature for today's date is 95 degrees set in 1932. On the same date Redwood Falls reached 99 degrees. Record low temperature is 30 degrees in 1839. Record low temperature this century is 32 degrees set in 1907. Northeastern Minnesota had frost on this date last year.

Record rainfall for this date is 1.28 inches in 1916 and record snowfall is a trace which fell in 1927.

3. Topic of the Week: Dew Point

This is an expression of humidity defined as the temperature to which a sample of air must be cooled (without the addition or subtraction of water vapor or change in pressure) in order to cause condensation of its water vapor content (dew formation). At this point relative humidity becomes 100 percent. It is called a conservative expression of humidity because it changes very little across a fairly wide range of temperature and pressure, unlike

relative humidity which changes with both.

It can be determined from measurement (1) with a dew point hygrometer, (2) from known temperature and relative humidity values, or (3) from the difference between dry and wet bulb temperatures using tables. It is recorded as an hourly observation along with temperature, wind, sky conditions, atmospheric pressure, and other variables by National Weather Service Offices.

Generally the highest dew points occur during June, July, and August. In fact during July and August dew points are at or above 60 degrees nearly 50 percent of the time. The maximum dewpoint on this date (May 14) has been 67 degrees and the minimum 19 degrees.

Early evening dew point temperature is a fair indicator of the absolute overnight minimum temperature that might be expected. When dew points are high overnight loss of long wave radiation will be relatively small moderating the normal temperature drop during the night. When dew points are low, the surface tends to surrender long wave radiation more readily to the atmosphere and temperatures drop more precipitously during the night.

It is a fairly good index of human comfort and of potential energy in the atmosphere. With respect to comfort we rely primarily on wind and the vapor deficit (the degree to which the air is not saturated) to carry off heat and moisture from our bodies. This process consumes energy by evaporating perspiration which in turn makes us feel cooler than we would feel if we were absorbing an equivalent amount of energy. At high dew points (above 60 degrees, especially above 70s degrees) the driving force (or drying power) provided by the vapor deficit becomes relatively small and the water vapor released by our bodies is more in equilibrium with the water vapor in the surrounding atmosphere. In this condition we do not experience the cooling effect and can in fact become quite uncomfortable as heat and moisture do not dissipate readily from our bodies.

With respect to potential energy when dew forms, energy is released to the atmosphere. For each gram of liquid water condensed from water vapor 585 calories are released. High dewpoints (60s and 70s) occur with relatively high temperatures when the capacity of the air to hold water vapor is at its highest. Therefore in specific terms, the water vapor held in that air can be very large. This is obvious when you consider the frequency with which you have to empty the water in basement dehumidifiers during the summer months. The great volume of water vapor held by the air in summer can be likened to a great volume of water held back by a dam. The potential energy present is very large and can be released in a destructive manner if the dam is disturbed (for example by an earthquake). In a similar manner, under conditions when the atmosphere has a very high dew point, the tremendous volume of water vapor can be unleashed in a destructive manner if it is disturbed by say a frontal passage or instability which causes it to rise and begins the condensation process as the air passes through the cooler layers aloft. This causes cumulonimbus clouds (thunderstorms) to form, which generally produce some of the most intense rains. Often in

climatological data there will be an association between observations of high dew points and thunderstorms. In Minnesota we have seen dew points as high as 80 degrees (June 22, 1983 and July 19, 1983). The dew point approached 80 degrees on July 23, 1987 when we received 9.15 inches of rainfall (7.58 inches falling in a 3 hour period)

Notes for MPR "Morning Edition", Program of May 21, 1993

For: Bruce MacDonald, Nancy Cole, and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment. (REVISED)

The cool temperatures of late do have some advantages:

The size, color and duration of blooming plants are enhanced.

We can open the windows and ventilate our homes, yet sleep comfortably during cool nights.

Mosquito development is delayed.

Most Minnesota public schools which are not air conditioned can still be comfortable enough for students and teachers to concentrate, and not wish they were outside.

Winter damaged turf on golf courses can recover more easily.

Many gardeners have waited patiently to put in sensitive seed or transplant tomatoes and other plants which they started indoors earlier this spring. The cold temperatures (lows in the 30s) experienced around the state during this week may persist yet for one more week.

Of course, some places in northern Minnesota have climates that are even more restrictive to garden crops. For example at Cloquet (not far from Duluth), frost has occurred on nearly every date in June at some time this century, as well on on 4 dates in July and 17 dates in August.

Extremes for the upcoming Memorial Day Weekend, when many Minnesotans traditionally embark on their first camping weekend, have ranged from 24 degrees at Tower and Cook (1966 and 1981) in northeastern Minnesota to 107 degrees at Redwood Falls (1934). On May 31, 1946 Virginia, Minnesota recorded 4.6 inches of snow. So campers beware, be prepared for almost any kind of weather! But at least the cold temperatures have held back the mosquito populations so far.

About 35 percent of the time (33 times in 93 years) it rains on Memorial Day and about 28 percent of the time the temperature reaches 80 degrees.

1. Word of the Week: **Virga**

From the Latin word meaning twig or wand, this term refers to a veil or shaft of rain hanging from the base of a cloud deck, but never reaching the ground as the droplets evaporate in drier air below the cloud base. These are seen in spring and summer in particular in Minnesota often as a result of convective or instability showers from isolated clouds.

2. Almanac (means of around 70 for max, upper 40s for min)

Record maximum temperature for today's date is 92 degrees set in 1964. Record low temperature is 32 degrees in 1844. Record low temperature this century is 34 degrees set in 1979. We have had a frost on each of the first 24 days of May at least once this century, except for the dates of the 19th and the 21st.

Record rainfall for this date is 3.16 inches in 1906 and record snowfall is a trace which fell in 1931.

3. Topic of the Week: Spring weather as an indicator of summer?

The cool temperatures recently have been primarily attributed to a stationary low pressure system over the Hudson Bay in Canada which is pumping cool air and cloudiness down our way. It shows little sign of movement and may persist into next week as the outlook suggests. Meanwhile, the western states are being dominated by high pressure ridging which is expected to bring them continued warmth.

Since the 1st of March we have had weekly temperatures average below normal 7 weeks and above normal 4 weeks. For both March and April, most of Minnesota recorded below normal temperatures. Are below normal temperatures for two consecutive months like that in the spring precursors of a cool summer? No, but of the 27 cases this century in which we have recorded below normal temperatures in March and April, June has turned out to be below normal as well in 21 years, regardless of May temperature trends.

The cool conditions of last summer were officially attributed to the volcanic aerosols from Mt. Pinatubo's eruption during 1991 which were still circulating in the stratosphere. However, recent estimates from satellite data indicate that in the northern hemisphere, stratospheric particle concentrations have decreased considerably (less than 40 percent of the peak values observed in 1992) and may be back to normal by the end of 1993, barring future eruptions of other volcanoes.

Notes for MPR "Morning Edition", Program of May 28, 1993

For: Bruce MacDonald and Nancy Cole

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Terms of the Week: **POP** and **QPF**

In precipitation forecasting, two type of guidance are used: The probability of precipitation (POP) and quantified precipitation forecasts (QPF).

There are two dimensions to POP: one is used as an average probability or chance of receiving precipitation at a point in a forecast zone, given that a large number of storms with the exactly the same characteristics would affect that location. Secondly the POP is used to indicate the expected areal coverage of the precipitation across the forecast area.

QPF guidance is provided to forecasters every 12 hours and refers to the amount of precipitation expected to occur at at least one point in the forecast area over a 24 hour period. Typically this might range from 0.1 to 0.5 inches.

2. Almanac (means of low 70s for max, around 50 for min)

Record maximum temperature for today's date is 98 degrees set in 1934. Record low temperature is 28 degrees in 1842. Record low temperature this century is 36 degrees set in 1965. In fact, from May 27 to May 30 in 1965, lows ranged from 33 to 38 degrees and there was a trace of snow around the Twin Cities.

Record rainfall for this date is 2.08 inches in 1899 and record snowfall is a trace which fell in 1965.

3. Topic of the Week: Flash Floods

The word flood is both a noun and a verb. As a noun it references a disastrous event (most religions refer to a great flood). As a verb it implies a flow which exceeds capacity (as in "I am flooded with complaints about my terrible forecasts). I will be speaking of the noun primarily.

On an earlier program we talked about spring floods in Minnesota and the five critical factors related to their occurrence: frozen soil; heavy snow cover; rapid thaw; high soil moisture; and above normal spring rainfall. A second kind of flooding is **flash flooding** and this week happens to be Flash Flood Awareness Week in Minnesota. Our National Weather Service has been broadcasting and distributing information about flash floods and safety rules to follow all week.

In one sense flash floods can be more threatening than spring floods because of the relatively brief time allowed for reaction. At least a few flash flood rainfall events occur each year in our state. Flash floods occur within a few hours of very heavy rainfall or dam failures or a levee breakage. Flash flood potential is modified by high soil moisture storage, which inhibits the ability of the soil to take up rainfall, thereby increasing runoff. When total runoff over a particular drainage basin exceeds the normal carrying capacity of the main channel and tributaries there is potential for flash flooding.

In highly urbanized watersheds where much of the vegetation has been replaced by buildings and pavement, runoff is generally increased. In the countryside, the increased use of parks and recreational areas in and along river and stream channels has increased the exposure of the public to flash flooding.

Two of the most noteworthy flash floods in the United States occurred during the 1970s. On June 9-10, 1972 the northern Black Hills in SD received up to 14 inches of rain, with most of it falling over a 4 hour period of time. The resulting flash flood was compounded by the collapse of the Canyon Lake Dam above Rapid City. Over 230 people lost their lives and over \$150 million in property damage occurred

On July 31, 1976 10 to 12 inches of rain fell over the Big Thompson Canyon area in Colorado in a 5 hour period. The river quickly exceeded its banks by some 20 feet and washed away roads, bridges, campgrounds and resorts, killing over 150 people and causing \$29 million in property damage.

July 21-22 of 1972 brought the "Grand Daddy" of Minnesota Flash Floods to the central portion of the state. The heavy thunderstorms started about mid-afternoon on the 21st and last all night to daybreak on the 22nd. Todd, Morrison, Crow Wing, and Cass Counties received the heaviest precipitation. Fort Ripley in the SW corner of Crow Wing County reported a total of 10.84 inches in 24 hours. An analysis by the State Climatology Office showed that 8 inches or more of rainfall occurred over an area of approximately 1500 square miles - this is roughly the equivalent volume of a 100 square mile lake that averages 10 feet deep. This storm caused over \$20 million in damage and claimed 1 life.

Most recently, earlier this month on May 7-8 heavy rains in the Marshall area (Pipestone, Murray, Rock, Lincoln and Lyon County produced a flash flood. Precipitation exceeded 6 inches in some areas and caused roads to wash out and a dam to fail.

In Minnesota the estimated return period for a 5 to 6 inch rainfall in a 24 hour period is 100 years. A 4 inch rainfall occurring over a period of 6 hours also has a return period of 100 years.

To help the National Weather Service with the issuance of flash flood watches and warnings, many of the hundreds of weather observers in the state will call into the office anytime rainfall exceeds 2 inches.

These reports are rapidly combined with soil moisture assessments and river gauge readings to provide forecasters with needed guidance.

Notes for MPR "Morning Edition", Program of June 11, 1993

For: Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Well, we reached a dew point of 71 degrees on Tuesday (6/8) which made us feel a bit uncomfortable. This was the highest dew point since last September 16th. Dew points in the 70s are somewhat unusual in Minnesota and generally associated with thunderstorm type weather. But many crops like higher dew points and tend to grow faster when they occur.

Speaking of crops, it would appear that nearly two million acres of soybeans are yet to be planted in Minnesota (about 1/3 of the intended acreage). And in Iowa, less than 50 percent of the soybean acreage has been planted, marking one of the latest planting seasons in recent memory.

1. Word of the Week: **Thermal lag**

We know that the sun heats the earth, but the resulting heat produced by the absorption of solar radiation is not immediately evident, there is always a delay. This term refers to that delay. For example sunrise now is about 5:30 am local time and sunset about 9 pm. Solar noon, or the maximum altitude of the sun overhead occurs about 1:15 pm. But this does not correspond to the time of the maximum daily temperature, which this time of year occurs from 3 to 5 pm, or about 2 to 4 hours after the maximum receipt of solar radiation. The same thermal lag is evident in the seasons, as the maximum daylength and receipt of solar radiation occurs around the summer solstice, June 21st, but the highest temperatures of summer typically occur in later July. It takes awhile for the earth to absorb the sun's energy and reradiate it to heat the air.

2. Almanac (means of mid to upper 70s for max, mid 50s for min)

Record maximum temperature for today's date is 98 degrees set in 1821. The warmest this century has been 96 degrees in 1956. The all-time record for this date in Minnesota is 100 degrees which occurred at Tracy in the southwestern part of the state (Lyon County) also in 1956. The record low temperature of 40 degrees was set in 1874 and repeated in 1903. Parts of northern Minnesota reported frost on this date back in 1985, 1969, 1963, and 1958.

Record rainfall for this date is 2.58 inches in 1975. Most would think that a rainfall record of that size would be associated with a severe thunderstorm, as many of our records are. However, this record rainfall occurred as part of 33 consecutive hours of rain which fell beginning at 3 am on the 11th and lasting until 11 am on the 12th.

June of 1975 was also a busy month for severe weather in the state, as there were 50 funnel cloud sightings reported.

3. Topic of the Week: Dew Point

This is an expression of humidity defined as the temperature to which a sample of air must be cooled (without the addition or subtraction of water vapor or change in pressure) in order to cause condensation of its water vapor content (dew formation). At this point relative humidity becomes 100 percent. It is called a conservative expression of humidity because it changes very little across a fairly wide range of temperature and pressure, unlike relative humidity which changes with both.

It can be determined from measurement (1) with a dew point hygrometer, (2) from known temperature and relative humidity values, or (3) from the difference between dry and wet bulb temperatures using tables. It is recorded as an hourly observation along with temperature, wind, sky conditions, atmospheric pressure, and other variables by National Weather Service Offices.

Generally the highest dew points occur during June, July, and August. In fact during July and August dew points are at or above 60 degrees nearly 50 percent of the time. Since 1945, the maximum dewpoint on this date (June 11) has been 71 degrees and the minimum 31 degrees.

Frequency distributions for hourly dewpoint temperatures of 70 or above for the summer months are:

June 3% July 9% August 7% September 2% (1945-1990)

Early evening dew point temperature is a fair indicator of the absolute overnight minimum temperature that might be expected. When dew points are high overnight loss of long wave radiation will be relatively small moderating the normal temperature drop during the night. When dew points are low, the surface tends to surrender long wave radiation more readily to the atmosphere and temperatures drop more precipitously during the night.

It is a fairly good index of human comfort and of potential energy in the atmosphere. With respect to comfort we rely primarily on wind and the vapor deficit (the degree to which the air is not saturated) to carry off heat and moisture from our bodies. This process consumes energy by evaporating perspiration which in turn makes us feel cooler than we would feel if we were absorbing an equivalent amount of energy. At high dew points (above 60 degrees, especially above 70s degrees) the driving force (or drying power) provided by the vapor deficit becomes relatively small and the water vapor released by our bodies is more in equilibrium with the water vapor in the surrounding atmosphere. In this condition we do not experience the cooling effect and can in fact become quite uncomfortable as heat and moisture do not dissipate readily from our bodies.

With respect to potential energy when dew forms, energy is released to the atmosphere. For each gram of liquid water condensed from water vapor 585 calories are released. High dewpoints (60s and 70s) occur with relatively high temperatures when the capacity of the air to hold water vapor is at its highest. Therefore in specific terms, the water vapor held in that air can be very large. This is obvious when you consider the frequency with which you have to empty the water in basement dehumidifiers during the summer months. The great volume of water vapor held by the air in summer can be likened to a great volume of water held back by a dam. The potential energy present is very large and can be released in a destructive manner if the dam is disturbed (for example by an earthquake). In a similar manner, under conditions when the atmosphere has a very high dew point, the tremendous volume of water vapor can be unleashed in a destructive manner if it is disturbed by say a frontal passage or instability which causes it to rise and begins the condensation process as the air passes through the cooler layers aloft. This causes cumulonimbus clouds (thunderstorms) to form, which generally produce some of the most intense rains. Often in climatological data there will be an association between observations of high dew points and thunderstorms. In Minnesota we have seen dew points as high as 80 degrees (June 22, 1983 and July 19, 1983). The dew point approached 80 degrees on July 23, 1987 when we received 9.15 inches of rainfall (7.58 inches falling in a 3 hour period)

Notes for MPR "Morning Edition", Program of June 18, 1993

For: Bruce MacDonald, Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Where's the ark? People in southern Minnesota, particularly along the Minnesota River Valley must be asking this question over the past few days. A good deal of land intended for crops this year will probably be left alone. I have been in Olivia, Renville, Granite Falls, Marshall, New Ulm, and Mankato this week and seen many fields with last years corn stalks, but nothing yet planted this year.

1. Word of the Week: **Precipitable water**

Last week we discussed dew point, which is one measure of the water vapor in the air. Precipitable water is another measure used often by meteorologists. More specifically it is the liquid equivalent of water vapor in a vertical column of air. Thus it represents the depth of liquid that would result if all of the water vapor were wrung out of the atmosphere by condensation at a particular point in space and time. Atmospheric profiles are taken twice daily by instrumented balloons (radiosondes) to characterize the vertical patterns in temperature, humidity, pressure and wind away from the Earth's surface. (troposphere layer 35,000 ft or so). Calculations of precipitable water are made from these measurements and used in guidance for providing quantified precipitation forecasts (which have been very useful this week!)

Incidentally, over the past 48 to 72 hours precipitable water calculations from the Gulf all the way up to Minnesota have shown values which are 150 to 200 percent of normal for this time of year, indicating broadscale atmospheric support for the very heavy rains we have been experiencing.

Bear in mind that of the total planetary water supply, only less than 0.1 percent is found in the atmosphere, where the average residence time for water vapor is about 10 days, but may vary from hours to weeks before it condenses out again as liquid in the form of precipitation.

2. Almanac (means of mid to upper 70s for max, upper 50s for min)

Record maximum temperature for today's date is 98 degrees set in 1953. The highest temperature ever on this date which I found in the state data base was 102 degrees at Hallock (northern Red River Valley area) which occurred in 1933 and again in 1961. The record low temperature of 39 degrees was set in 1876. The coldest June 18th this century was 46 degrees in 1950.

Of course, last year we experienced widespread ground frosts on

the summer solstice weekend and saw some damage to field corn across the upper midwest.

Record rainfall for this date is 1.21 inches in 1865.

3. Topic of the Week: Impacts of the Wet and Cool Spring

At least Nine counties in southwestern Minnesota (Nobles, Brown, Lyon, Rock, Cottonwood, Murray, Pipestone, Lincoln, and Redwood) have petitioned for disaster declarations (to obtain federal assistance like low interest loans) recently as a result of the late planting season which has been compounded by further rain and hail damage in the area. Dave Menge, the Congressman from that area and a member of the House Agriculture Committee has assisted with that effort. Late planting alone has reduced the potential production in the state this year by tens of millions, if not hundreds of millions of dollars.

Now flooding is a threat along some of the southern Minnesota river basins. The Redwood River rose 6 to 7 feet over a 4 to 8 hour period early Thursday as a result of the very heavy rains across southern Minnesota. Marshall reported over 6 inches of rain and Redwood Falls nearly 5 1/2 inches. The Cottonwood and Redwood River Basins responded with rapid rises. Three to four inch rains were common along the Minnesota River Valley, but being so large, the river flow there will be somewhat slower to respond. It is expected to crest at Jordan on or about June 25th according to the River Forecast Center. Still, even before the heavy rains of this week, the Minnesota River flowing at Jordan was at 24,500 cfs, probably in the 95th percentile for this time of year, given that the median flow in June is only 6644 cfs.

Since May 1st the precipitation totals across southern Minnesota and many parts of Iowa are almost phenomenal. (may use some examples here). The area around Marshall in Lincoln County has already had two storms which dumped over 5 inches of rain apiece (May 8 and June 17) and were only 40 days apart. The climate statistics show that return periods for rainfall amounts this great are supposed to be every 40 to 50 years, not 40 days!

The bottom line is that many soils throughout the state are saturated and the amount of runoff will continue to be very high from any forthcoming rains.

To: Bob Potter, Jim Bickal, John Bischoff, and Stephanie Curtis at Minnesota Public Radio

From: Mark Seeley, Extension Climatologist

Re: Commentary for Morning Edition, Friday, June 27th

Topic: The Palmer Drought Severity Index (PDSI)

The prolonged dry spell since April 1st has had some serious impacts on perennial and annual vegetation around the state, but perhaps most pronounced in central and east central Minnesota. These areas are designated to be in a moderate drought according to the Palmer Drought Severity Index (PDSI) used by NOAA's Climate Analysis Center.

The PDSI indicates the degree of prolonged and abnormal moisture excess or deficiency. It was derived by Wayne Palmer, a former government climatologist and has been in use for many decades. It is used to evaluate and assess the scope, severity, frequency and impact of prolonged abnormal periods of dry or wet weather. Historically, the PDSI has been used to assess irrigation and livestock water supplies, fire danger, river and reservoir levels, and pasture and range conditions.

The PDSI might be considered a checkbook type balancing of water demand and supply. Precipitation and soil moisture are considered on the supply side, and evaporation and/or evapotranspiration (consumption by vegetation) are considered on the demand side. Temperature and precipitation data taken from the cooperative climate network are evaluated for each climate division (Minnesota has nine) in the United States, and the PDSI values computed and published each Monday afternoon.

The PDSI scale is as follows.....

4.0 and above	extreme moist spell
3.0 to 3.99	very moist spell
2.0 to 2.99	unusual moist spell
1.0 to 1.99	moist spell
.5 to .99	incipient moist spell
.49 to -.49	near normal
-.50 to -.99	incipient drought
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 and below	extreme drought

Readers of WeatherTalk can track the PDSI for Minnesota and other states using the following Internet Web Sites...

<http://nic.fb4.noaa.gov:80/data>
(shows weekly tabular values for each climate division by state)

<http://www.usda.gov/oce/waob/jawf/wxcb.html>
(shows historical maps of PDSI values)

http://nic.fb4.noaa.gov/products/analysis_monitoring/regional_monitoring/palmer.gif
(shows color coded maps of PDSI updated biweekly)

Almanac Segment:

Local Almanac:

Twin Cities Almanac for June 27th:

The average MSP high temperature for this date is 81 degrees F (plus or minus 8 degrees standard deviation), while the average low is 61 degrees F (plus or minus 7 degrees standard deviation).

MSP Local Records for June 27th:

MSP weather records for this date include: highest daily maximum temperature of 104 degrees F in 1934; lowest daily maximum temperature of 61 degrees F in 1911; lowest daily minimum temperature of 44 degrees F in 1925; highest daily minimum temperature of 79 degrees F in 1933; record precipitation of 2.00 inches in 1953.

Average dew point for June 27th is 59 degrees F, with a maximum of 76 degrees F and a minimum of 42 degrees F.

State Records:

All-time state records for June 27th:

Scanning the state climatic data base: the all-time high for this date is 108 degrees F at New London (Kandiyohi County) in 1934; the all-time low is 30 degrees F at Tower (St Louis County) in 1992.

Words of the Week: Staubosphere or Konisphere

Staubosphere was a term coined by S. Cyril Blacktin during the dustbowl years of the 1930s. It refers to the dust content of the atmosphere. A more common term is konisphere, which refers to the dust content in the lower atmosphere as measured by a koniscope or konimeter. A koniscope measures the optical properties of the atmosphere then estimates the dust content, while a konimeter actually samples the air and collects microscopic dust particles on a sticky film surface.

In the central plains states, dust content is clearly higher during prolonged drought periods and even briefly higher during spring tillage and planting when soils are disturbed by tractors and associated implements like plows, chisels, disks and cultivators.

Forecast for June 28-July 4th:

not available at this time

Notes for MPR "Morning Edition", Program of July 2, 1993

For: Bruce MacDonald, Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Just some preliminary suggestions for Friday.

1. Word of the Week: Flood Stage

There are many definitions of flood stage. It is a somewhat arbitrarily based local measurement which may be several years old used to indicate a threshold above which a river or stream exceeds its normal channel banks and begins to cause damage. (Sometimes this is referred to as bank full). Flood stage is also an index which is used to trigger certain local responses such as alerting local sewage treatment plants, spill-ways, locks, and river traffic to take precautionary action.

Floods generally produce some health risk as they overwhelm local sewage treatment plants which may be located along the river channel. Or in some cases communities have coupled systems which handle both storm runoff and sewage together. The high volumes of storm runoff generated by heavy rainfall cause the system capacity to be exceeded and sewage along with the storm water must be discharged into the river.

This month saw a record or near record flood reported at several sites along southern Minnesota river basins. At Mankato a record of 32.7 ft was set for the Minnesota River, replacing the old record of 29.1 ft. Flood stage there is considered to be 19 ft.

For many basins, records show that water levels are higher than they have every been for so late into the year. Many earlier flood records are associated with the usual spring runoff periods of March, April and/or early May.

2. Almanac (typical highs near 80, lows near 60)

Records for July 2nd are a high of 96 in 1911 and a low of 49 in 1924. The record high of 96 degrees is the lowest maximum temperature record for the month of July. 26 of the 31 days in the month have maximum temperature records of 100 degrees or greater.

Record precipitation is 1.62 inches which occurred in 1903.

3. Topic of the Week: Agricultural Impacts

There are serious and far-reaching agricultural impacts resulting

from the cool wet season so far. Flood damage on several hundred thousand acres in southern Minnesota; significant proportion of acreage will be left idle or planted to a cover crop; and retarded crop development will reduce yields and make for a difficult harvest season. Combined with clean-up costs, impacts on incomes, tax revenues, transportation suspension, and other factors will all greatly effect local and state economy. Must try to be realistic and not overly optimistic.

Notes for MPR "Morning Edition", Program of July 9, 1993

For: Bruce MacDonald and Nancy Cole

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Some suggestions for Friday. By the way, thank you for the interesting Reuter's news stories this week.

Further crests are expected on some rivers as they remain above flood stage, but these crests will all be less than those of last month. One is expected along the Minnesota at Savage on July 11 and one is expected on the Mississippi at St Paul on the 12th. In addition the outlook continues to favor wetter than normal conditions in Minnesota during July.

1. Word of the Week: **Normal**

This is a term used in climatology to refer to an average value of some parameter or measurement which has been observed for a prolonged period of time. It might refer for example to a average daily, weekly, monthly or annual temperature for a particular location. Or perhaps the average hours of sunshine, wind speed, direction, or total precipitation. Many common reports of the weather will not only give current conditions, but the deviation of those conditions from the climatic normal. The standard calculation of climatic normals always refers to the most recent 3 decades of data. Thus, currently when we describe how relatively drier, wetter, warmer, cooler, etc it is we mean with respect to the average values for the 1961-1990 period.

2. Almanac (typical highs in the low 80s, lows near 60)

MSP records for July 9th are a high of 99 in 1921 and 1923, and a low of 48 in 1895. The coldest temperature locally this century is 50 degrees which occurred in 1961. Warmest ever in the state on this date was 108 degrees at Canby (Yellow Medicine County) in 1936. I imagine Canby Creek was dry at that time.

Record precipitation is 1.50 inches which fell on this date in 1889. The only rainfall amount of 1 inch or greater which has occurred on this date during this century was 1.43 inches in 1932.

3. Topic of the Week: How often does normal occur?

157 years of data for eastern Minnesota shows that average July rainfall is 3.38 inches with a standard deviation of 2.22 inches. The current 30 year normal for July precipitation is 3.53 inches. The first 8 days of the month this year have yielded 3.51 inches of precipitation, so we are already essential at normal. In fact

the first several hours of the month (July 1st) produced over an inch of rainfall locally.

In 157 years of recording July precipitation the extremes have been 0.11 inches in 1936 and 17.9 inches in 1987. How often has the grand mean (average of 157 years) occurred? Never! The following table summarizes a portion of the frequency distribution for July rainfall:

within 0.10 inches of normal	2 years
within 0.20 inches of normal	6 years
within 0.50 inches of normal	21 years
within 1 inch of normal	65 years

So, 41 percent of the time we receive July rainfall that is plus or minus 1 inch of normal. That leaves room for a lot of year to year variation, as evident by the 17.9 inches of rainfall in July of 1987 followed by the 1.17 inches in 1988.

Somewhat similar distributional characteristics apply to temperature. The hundred year mean for January in eastern Minnesota is 13 degrees, but this has only occurred once, actually we have been within 1 degree of the January mean 11 times this century.

Generally with respect to understanding climatic impacts, it is more important to know something about the general distribution of a climatic variable (central tendencies and extremes help) than it is to know the average. You can bet that the climatic anomaly being experienced along the Minnesota and Mississippi River Basins this year will weigh heavily in the design criteria for any new structures such as bridges and levees which might be built in the next several years.

Notes for MPR "Morning Edition", Program of July 16, 1993

For: Bruce MacDonald, Bob Potter and Nancy Cole

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Got your reply to my suggestions earlier. Regarding forecasters ability to predict major flood producing rainfall, there is a tendency to over forecast and predict large amounts to occur over a rather large area (at least in part this stems from the quantified precipitation forecast guidance), when in reality most such storms produce large amounts of rainfall but in a smaller area than predicted. Another important dimension of precipitation forecasting, especially for heavy thunderstorms is lead time limitations. The overall size and trajectory of large convective complexes and organized thunderstorms such as in squall lines is very hard to determine until only hours (or in extremely rare cases minutes) before they occur. This is one of the principle reasons we use a system of watches and warnings to alert the public about severe weather. Watches designate when conditions might produce severe weather and usually describe an area which is thousands of square miles in extent. Warnings are released when strong storms are actually observed moving along a certain path that might cover 10s or hundreds of square miles.

The persistence and spatial extent of the heavy precipitation events this summer are so rare that many forecasters are caught in the dilemma of trying to forecast events and conditions which they themselves have likely never experienced. THIS YEAR HAS BEEN THAT UNUSUAL!

1. Word of the Week: **Jet Stream**

Jet streams were discovered by pilots during WWII as they greatly affected several bombing missions during the war. Even today jet streams affect the flight planning for everyday commercial airlines. As for example, the flight time from MSP to Paris might be affected by as much as 2 hours depending on whether the plane is traveling with the jet stream or against it.

Most people recognize this as a term used to describe a relatively high speed ribbon or current of air aloft, typically in mid latitudes at a height of 6-7 miles above the Earth's surface. There are different types of jet streams which affect the weather in different parts of the world. For Minnesotans, the polar front jet stream found in the middle latitudes is a primary influence on the weather we experience. This jet stream generally exhibits relatively high wind speeds (100 to 200 mph) and is stronger in the winter than in the summer because of the greater north-south temperature differences. The polar jet is generally in more southerly latitudes in winter as polar air masses push farther south. It then migrates to more northerly latitudes in summer as the temperature gradient lessens. On an annual basis, this jet stream may be found between 30 and 50

degrees north latitude.

The jet stream provides a relatively high speed pathway for the propagation of low and high pressure systems, and thus the movement of frontal systems is generally along the axis of the jet. As air moves into the zone of maximum wind speeds, air mass divergence occurs and leads to upward movement of air, a fall of pressure at the surface and development of storm systems. This spring, the jet stream has remained to the south of Minnesota much later resulting in a persistence of associated storm activity along its axis which has affected the major river basins in the area. Now nearly two months later than usual, there are signs that it is migrating further north.

2. Almanac (typical highs in the low 80s, lows near 60)

MSP records for July 16th are a high of 102 in 1926 and a low of 51 in 1911 and again in 1958. The highest temperature ever on this date was 108 degrees as Redwood Falls in 1936.

Record precipitation is 1.28 inches which fell on this date in 1908. The last 1 inch rain fell in 1984. (1.12 inches)

3. Topic of the Week: Further Impacts of Cool Temperatures

Should we continue the second half of July as the first, we will experience a 5th consecutive month of below normal temperatures in southern Minnesota. Consequently, the accumulated cooling degree days (accumulated daily mean temperatures above a base of 65) for this season are substantially lower than normal. Air conditioning usage is way down. Historically, only 4 years have had fewer CDD in the months of May and June (1915, 1916, 1945, and 1960). In fact, we have actually accumulated a few heating degree days this month, but that's not terribly unusual.

Watering of yards, golf courses and ball fields has been seen very little this year. Plant water needs have pretty well been taken care of by mother nature. Evaporation measurements for May and June totaled only 12.5 inches compared to normal evaporation of 15 to 16 inches. Most new plants have established a shallow root habit this year as a result of the abundant moisture, thus if we hit a prolonged dry period later this summer, some plants may actually yet show symptoms of wilting.

For the climate of May and June this year, the closest analogies are 1957 and 1908. I can discuss these a bit if you like

Notes for MPR "Morning Edition", Program of July 23, 1993

For: Bruce MacDonald, Bob Potter and Nancy Cole

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Word of the Week: **Damping effect**

This is a term used in a number of disciplines - electronics, acoustics, aeronautics, etc. The context I want to describe is with garden mulches. Damping is a verb meaning to choke, stifle, deaden, retard, discourage, etc. The damping effect of mulches in the garden is to reduce the daily temperature range in the soil (making it much less than the air temperature range for example), and to reduce the evaporative loss of moisture. Mulches also help control weeds, and some mulches if they are reflective enough make it difficult for flying insects to locate the plants which they most like to feed on.

2. Almanac (typical high of 84 and low of 61)

MSP records for July 23th are a high of 105 in 1934 and a low of 46 in 1850 (old Pioneer records). On the same date Redwood Falls was 108 degrees. The coldest temperature locally this century has been 50 degrees in 1978.

Record precipitation for this date is the all-time record in the Twin Cities for a single day, 9.15 inches ending at midnight on July 23, 1987. Another 0.85 inches fell after midnight making the single storm total 10 inches. This was far in excess of the previous record rainfall from a single storm of 7.8 inches which occurred in June of 1892. The monthly total of 17.9 inches for July of 1987 remains the record for a single month in the Twin Cities area. The dew point hit 80 degrees that day which has happened a very few times this century. Some areas reported up to 12 inches, with some intensities as high as 1.5 inches in 15 minutes. Over 8600 residents and 264 commercial properties were damaged to the tune of \$21 million.

3. Topic of the Week: Cycles

We have talked on this program about a number of cycles, the daily or diurnal cycle of temperature, seasonal cycles, the El Nino Southern Oscillation cycle, the hydrologic cycle. There are several other interesting cycles to discuss.

There is the annual cycle in atmospheric carbon dioxide associated with the relative absence and presence of vegetation in the northern

hemisphere. Atmospheric carbon dioxide being consumed more abundantly during our growing season, and building up in concentration during our winters.

Another cycle is the Hale double sunspot cycle which occurs roughly every 22 years. This is called a double cycle because the time between maximum and minimum sunspot activity is roughly 11 years, but the polarity of the magnetic field of sunspots reverses at the beginning of each new period of activity. There have been some studies showing correlations between drought periods in parts of the northern mid-latitudes and this 22 year cycle of sunspots.

There are other cycles associated with sunspot activity and with Earth-Sun orbital relationships, but we can discuss those another time.

Notes for MPR "Morning Edition", Program of July 23, 1993

For: Bruce MacDonald, Bob Potter and Nancy Cole

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Word of the Week: **Damping effect**

This is a term used in a number of disciplines - electronics, acoustics, aeronautics, etc. The context I want to describe is with garden mulches. Damping is a verb meaning to choke, stifle, deaden, retard, discourage, etc. The damping effect of mulches in the garden is to reduce the daily temperature range in the soil (making it much less than the air temperature range for example), and to reduce the evaporative loss of moisture. Mulches also help control weeds, and some mulches if they are reflective enough make it difficult for flying insects to locate the plants which they most like to feed on.

2. Almanac (typical high of 84 and low of 61)

MSP records for July 23th are a high of 105 in 1934 and a low of 46 in 1850 (old Pioneer records). On the same date Redwood Falls was 108 degrees. The coldest temperature locally this century has been 50 degrees in 1978.

Record precipitation for this date is the all-time record in the Twin Cities for a single day, 9.15 inches ending at midnight on July 23, 1987. Another 0.85 inches fell after midnight making the single storm total 10 inches. This was far in excess of the previous record rainfall from a single storm of 7.8 inches which occurred in June of 1892. The monthly total of 17.9 inches for July of 1987 remains the record for a single month in the Twin Cities area. The dew point hit 80 degrees that day which has happened a very few times this century. Some areas reported up to 12 inches, with some intensities as high as 1.5 inches in 15 minutes. Over 8600 residents and 264 commercial properties were damaged to the tune of \$21 million.

3. Topic of the Week: Cycles

We have talked on this program about a number of cycles, the daily or diurnal cycle of temperature, seasonal cycles, the El Nino Southern Oscillation cycle, the hydrologic cycle. There are several other interesting cycles to discuss.

There is the annual cycle in atmospheric carbon dioxide associated with the relative absence and presence of vegetation in the northern hemisphere. Atmospheric carbon dioxide being consumed more abundantly

during our growing season, and building up in concentration during our winters.

Another cycle is the Hale double sunspot cycle which occurs roughly every 22 years. This is called a double cycle because the time between maximum and minimum sunspot activity is roughly 11 years, but the polarity of the magnetic field of sunspots reverses at the beginning of each new period of activity. There have been some studies showing correlations between drought periods in parts of the northern mid-latitudes and this 22 year cycle of sunspots.

There are other cycles associated with sunspot activity and with Earth-Sun orbital relationships, but we can discuss those another time.

Notes for MPR "Morning Edition", Program of July 30, 1993

For: Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Well, the jet stream has migrated further north yet and it would appear that we are set up for somewhat of a dry spell. Except for a possibility of widely scattered showers on Saturday, the entire next week looks to be dry with below normal temperatures and plenty of sunshine.

I have recently come across a new magazine called "STORM" advertised as the "world weather magazine". Published by Ulick Publishing Company in Batavia, IL, it is available by subscription and will soon be available on newsstands in B. Dalton and Barnes and Noble. It has many interesting articles about weather and climate issues and impacts. I don't necessarily want to promote the magazine, but it would make interesting reading for some listeners. Shall I mention it?

1. Word of the Week: **lysimeter**

This is a device used to measure the percolation and evaporation of moisture within the soil. It is based on measuring the weight change of an isolated monolith (block) of soil very precisely. The monolith is usually isolated from the surrounding soil using some kind of liner and it is set upon a precision scale for keeping track of its weight. Precipitation adds to the weight of the monolith, while evaporation, percolation and runoff reduce its weight. When the values of deep percolation and runoff are small (that is the soil profile is not completely saturated and rainfall intensity is not particularly high) daily evaporation can be considered to be the rainfall plus the daily change in weight in the monolith. For days without rainfall, it is usually just the weight change each day. Weight changes equivalent to less than 1 mm per day of water are detectable.

2. Almanac (typical high of 83 and low of 60)

MSP records for July 30th are a high of 100 in 1933 and a low of 50 in 1889 (old Pioneer records) and tied in 1971.

Greatest precipitation ever on this date is 1.75 inches in 1873. Other notable rainfall events on this date are listed below:

1904	1.31	1951	1.22	1956	1.37	1961	1.05
1968	1.20						

At this time in 1968 many counties in south-central Minnesota were seeing an end to the wettest July on record. New Ulm received 12.58 inches in July of that year. Additionally

both Springfield (8.52 inches) and North Mankato (8.60 inches) set July rainfall records.

For this July, it looks like Luverne, Lakefield, and Worthington will all set rainfall records for the month, marking the 2nd consecutive month of record rainfall amounts. (10-12 inches)

3. Topic of the Week: Some International Weather Highlights

We have been inundated so much in recent weeks with news about the flooding in the midwest, that I thought it would be interesting to highlight some of the significant weather events and impacts going on in other areas of the world.

- Earlier this month parts of southwestern Japan had received 30 to 45 inches of rainfall within a months time, with parts of Kyushu reporting 50 inches, an average daily rainfall of 1.75 inches each day. In just the last few days some additional 2 to 3 inch rainfalls have occurred there, putting seasonal accumulations of rainfall as much as 30 inches above normal.
- Weather this month has not been particularly favorable for harvesting winter grains in northern Europe. England, France, Germany, Poland, and the Czech Republic have all had heavier than normal rains disrupt their harvesting activity and in some cases knock the ripened grain down. In just the past few days the weather has continued to be wetter and cooler than normal.
- In South America, unusually cold air dominated parts of Brazil and Argentina earlier this month. Freezing temperatures burned off some winter winter in the vegetative and reproductive stages, but did not reach the coffee and citrus growing areas. They are experiencing drier and cooler weather there yet this week.
- Southern portions of Mexico have continued to be extremely wet following the 8 to 10 inch rains which Hurricane Calvin dumped earlier in the month near Acapulco (July 5-9). Last week as much as 4-5 inches of additional rain fell and it was raining again there yesterday.

As for extreme weather conditions this week, the following are from the world weather wire:

134 degrees on 7/25 in Oman (east of Saudi Arabia along the Arabian Sea)
-109 degrees on 7/27 at Vostok Station Antarctica
Over 22 inches of rain at Mangalore, India (in the midst of monsoon season)

Notes for MPR "Morning Edition", Program of August 13, 1993

For: Bruce MacDonald, Greg Magnuson, Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

We're finally getting some summer like weather in late August. Still haven't reached 90 degrees officially at the MSP Weather Service, but several other places in the state have. Highs so far this week include: 91 Intl Falls 92 Alexandria 92 Redwood Falls 90 Park Rapids 90 Perham 95 Crookston 96 Fargo 90 Lambertson 92 La Crosse Dew points have been uncomfortably high as well ranging from the mid 60s to mid 70s. Only two summers in the history of local record keeping have never reached the 90 degree mark, 1902 and 1915.

1. Word of the Week: **Tensiometer**

Taken for its root meaning, this is an instrument used to measure tension. Specifically in agricultural meteorology, it is used to measure the moisture content of soil as held by surface tension against the forces of gravity. It is commonly made of a porous, permeable ceramic cup which is connected through a tube to a pressure or vacuum gage, usually a U shaped tube. The rise and fall of liquid in the tube is indicative of the tension held moisture in the soil layer being measured.

2. Almanac (typical high of 78 and low of 55)

MSP records for August 27 are a high of 99 in 1926 and a low of 42 in 1887. The coldest temperature this century was 44 degrees in 1967, 1971, and 1986. Redwood Falls was 102 degrees on this date in 1973 with an overnight low of 78 degrees, just a bit too uncomfortable for most of us.

Greatest precipitation ever on this date is 2.80 inches in 1978. The last 1 inch rainfall was 1.23 inches in 1981.

3. Topic of the Week: Fair Weather

The word fair is derived from old Middle English usage and has many different meanings. It may be used as an adjective, adverb, verb, or noun. Such as fair skin, fair maiden, to play fair, fair catch, to hit a ball fair, to go to the fair, as is popular in Minnesota right now. In this context it is an exhibition of wares, farm products, amusements, along with competitions and food, food, food.

The word fair has been used to describe a particular weather condition for ages, as in "the weather faired as the night went on," or "fair skies are expected for star gazing," or "the parade will go on whether the weather be fair or foul." Generally speaking to use the word fair a forecaster must ascertain that sky conditions will either be clear or with only a few higher level clouds, winds will be light, and temperature conditions will not deviate significantly from seasonal normals. To be honest, although this term is still used around the world in English speaking countries, National Weather Service personnel probably use it less today than they used to. This is due to the public expectations for more accurate forecasts and the implementation of technology that allows the forecaster to be more precise about specific weather elements and events, particularly their timing.

In the early days of the U.S. Weather Bureau (under the USDA) when forecasts were provided to local communities either by mailing them on

postcards or sending them by telegraph, a system of flag signals was used to post the forecasts in town for local residents. Each town had a designated forecast displayman (maybe the postmaster, local weather observer, sheriff, banker, or train station manager). This person would receive the Weather Bureau Forecast and then display the appropriate flag or flags to designate expected conditions. A plain white flag alone would indicate fair weather; a blue flag would indicate that precipitation was expected. Various combinations of square flags, triangular flags, and colored flags would indicate other types of weather conditions. Even as late as the 1960s and 1970s a bank building in downtown Minneapolis would display a colored ball (weather ball) indicating what the weather was going to be.

At some of the early Minnesota State Fairs, a system of flags was probably used to indicate expected weather conditions. In fact during the early 1890s when there were two Weather Bureau Offices in the Twin Cities, one in St Paul and one in Minneapolis, there was quite a rivalry between forecasters in the two offices. There were competitions arranged and public debate about which office provided the public with the best forecasts.

The Future Farmers of America are the official State Fair weather observers and have been for many years. They report hourly temperature and rainfall conditions throughout the duration of the fair. They used to run a competition to forecast the amount of rainfall which would occur during the fair. The FFA members nearly always out forecasted the State Climatologist and the Manager of the National Weather Service. I think they stopped running the contest some years ago.

In addition the DNR State Climatology Office operates an automated weather station on the State Fair Grounds which continuously records air and soil temperature, humidity, wind speed, direction, solar radiation, and rainfall. Readings from this weather station can be viewed from the DNR Building on the Fairgrounds. It is not uncommon for conditions at the fair to vary somewhat from those reported at the MSP airport by the National Weather Service. Since the fair forms its own kind of 'microclimate.'

Over the 130 years of Minnesota State Fairs there have probably been many fair weather days, but probably even more memorable unsettled days. High temperatures many times reaching the 90s, and at least once (September 3, 1974) a frosty morning with a low of 32 degrees. One of the most unsettling evenings during the State Fair was probably, August 30, 1977, when one of the heaviest thunderstorms to ever hit the Twin Cities occurred, dropping 7.28 inches at the airport between 8:30 pm and midnight. This obviously caused severe flooding, but primarily in the south Metro area. The State Fair Grounds actually recorded a mere 4.5 inches of rain. Still I wonder how many fairgoers brought their rainfly (poncho) or umbrella that evening.

4. Poem of the Week: Found in the Weekly Weather Crop Bulletin for September 15, 1895.

THE QUIET LIFE (by Alexander Pope)

Happy the man whose wish and care
A few paternal acres bound,
Content to breath his native air
In his own ground.

Whose herds with milk, whose fields with bread;
Whose flocks supply him with attire,
Whose trees in summer yield him shade,
In winter fire,

Blest, who can unconcernedly find

Hours, days and years slide soft away,
In health of body, peace of mind,
Quiet by day,

Sound sleep by night; study and ease,
Together mixed; sweet recreation;
And innocence, which most doth please
With mediation.

Thus let me live, unseen, unknown,
Thus unlamented let me die,
Steal from the world, and not a stone
Tell where I lie.

Notes for MPR "Morning Edition", Program of August 13, 1993

For: Bruce MacDonald, Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

I had a call last week about soil temperatures, which like air temperatures have been below normal most of the summer. Soil temperatures are usually measured with buried thermistors or thermocouples by inserting them horizontally into the soil at fixed depth intervals. The most common depths measured are 4, 8, 20, and 40 inches. Soil temperatures are measured at over 2 dozen locations around the state, usually where agricultural or horticultural research is being done. Currently at a depth of 4 inches, soil temperatures are ranging from the upper 70s to mid 80s during the day and 65 to 70 degrees at night.

1. Word of the Week: **Sultriness**

This term derives from swelter or sultry which refers to hot and humid weather conditions, making the air feel "close" or "oppressive." Forecasters may use the term when they are predicting high dew points, combinations of high temperature and high humidity. It is more commonly a term used in forecasting in the tropics, but certainly applied this week in Minnesota.

2. Almanac (typical high of 80 and low of 57)

MSP records for August 13 are a high of 98 in 1880 and a low of 48 in 1860 and 1924. On this date in 1965, Canby in Yellow Medicine County reported 104 degrees, while on this date in 1916, Cloquet in Carlton County reported a low of 31 degrees.

Greatest precipitation ever on this date is 2.90 inches in 1887. The last 1 inch rainfall on this date was 1966 when we received 1.03 inches.

3. Topic of the Week: Apparent temperatures

This has been used more commonly since about 1980 to refer to what various temperature and humidity combinations feel like based on human physiology and clothing science and the need for the body to maintain a thermal equilibrium. It particularly applies to the summer months, because relative humidity is much less important to human comfort when air temperatures are below 40 degrees F.

When relative humidities are very low, as in arid conditions, say below 30 percent, the air can actual feel cooler than indicated by

a thermometer, because of evaporative cooling effects on the skin. On the other hand, when relative humidities are high, say above 60 percent, then we can feel warmer than the air temperature indicated by a thermometer because of the increased resistance to moisture and heat loss by our bodies (particularly if there is little air movement).

Earlier this week we experienced temperatures between 85 and 90 degrees with relative humidities of 55 to 65 percent. These conditions produced apparent temperatures of 90 to 100 degrees. According to the general heat stress index used by the National Weather Service, this level of apparent temperature can produce sunstroke, heat cramps, or heat exhaustion with either prolonged exposure or excessive physical activity.

Many thousands of Minnesotans are undoubtedly in the midst of training for various running events like the Twin Cities marathon coming up in October. Those who run daily or every other day need to at least occasionally adjust their workout schedules for the weather conditions. For example, an athlete who runs at a pace of 6 minute miles may workout for 3 hours in temperatures of 70 degrees or less if the relative humidity is below 50 percent. But if the humidity is at 70 percent or higher at the same temperature, he or she may exert just as much energy (and risk heat stress) to run for only 1 to 2 hours. Over exertion in the conditions like we experienced this week can cause severe enough stress to disrupt or set someone back from their workout schedule in preparation for a long distance running event. Very early morning or late evening jogging is usually done to avoid higher temperature conditions and direct effects of higher sun angles and hence greater solar radiation.

4. International Highlights: High of 121 degrees F at Abadan, Iran and Kuwait Airport this week. Apparent temperatures of 119 in Iran. Low of -98 degrees at Vostok, Antarctica. -3 to -5 degrees wind chill in far northern Canada, Resolute Bay and Mould Bay. Southwestern Japan continues to get hammered with heavy rains, 14-16 inches this week. 12 to 13 inch rains in the Phillipines earlier this week as a result of Typhoon Robyn.

Notes for MPR Special "Morning Edition", Program of September 1, 1993

For: Greg Magnuson, Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Bearing in mind that I am part of a panel discussion at the State Fair today (1 pm in the Ag/Hort Building) called "Rain, Rain Go Away", I have tried to prepare a brief summary of 1993 weather and its impacts along with some other material.

Looks like the middle Atlantic states dodged one today, as Hurricane Emily hung off the coast and proceeded to move north to northeast.

1. Almanac (typical high of 77 and low of 54)

MSP records for September 1 are a high of 97 in 1913 and a low of 36 in 1974. In fact the record lows for the first 4 days of September were all set during 1974 when frost brought an abrupt end to the growing season around the state. Frost occurred in the Twin Cities on the 3rd of September that year and many places reported temperatures in the 20s, including 29 at Zumbrota 28 at Springfield 28 at Lambertson 26 at Brainerd 27 at St Cloud 28 at Morris

Greatest precipitation ever on this date is 1.05 inches in 1926. On this date in 1969, Caledonia in extreme southeastern Minnesota received 3.22 inches of rain resulting in some local flooding.

2. Topic of the Week: 1993 Weather Revisited

The spring and summer of 1993 combined to produce one of the wettest periods in Minnesota's recorded climate history. Rainfall was notable for its volume, persistence and spatial coverage. The unceasing showers began in mid April in southeastern Minnesota and spread through central and southwestern counties in May. Field preparation and planting were delayed significantly in southern Minnesota. Torrential rains just before Mother's Day led to significant urban and rural flooding in the Marshall and Pipestone areas.

The deluge continued during June, drenching many areas of the southern one third of Minnesota with more than 10 inches of rain. Some locations reported June totals exceeding 15 inches, which set all-time records for the month of June. The pivotal rainfall event of the period was a large storm system that struck southern Minnesota on June 16th and 17th. Four or more inches of rain fell across much of the Minnesota River basin. Falling on already saturated ground and swollen water bodies, the rain led to large scale flooding.

July and August brought a continuation of the extremely wet weather. Heavy rains persisted in southern Minnesota, but also began to affect the west and north. West central, northwestern, and

northeastern Minnesota encountered flooding problems due to downpours that often dropped many inches of rain in just a few hours. Some areas of southern Minnesota reported record setting monthly rainfall totals for July and nearly all reported above normal rainfall for August as well. Many areas have received 150 to 200 percent of normal rainfall for the months of May through August, setting all-time historical records for the 4 consecutive months. A number of communities have reported over 30 inches of rainfall in this period, exceeding what is a **normal annual** amount of precipitation, unprecedented in the historical records for Minnesota, some going back as far as 1836.

The deluge led to numerous problems for nearly all elements of society. Rising rivers and streams damaged private property and endangered lives. Roads and bridges were damaged and often closed, hindering transportation. Heavy rains flooded croplands, eroded soils, hampered or eliminated field work, instigated various crop diseases and dramatically decreased production potential of major crops. Weather sensitive industries such as construction and outdoor recreation were negatively impacted. A preliminary estimate of flood related damages was conservatively placed at more than one billion dollars by the Governor's office.

Temperature:

Starting in February of this year, monthly temperatures have consistently averaged below 30 year normals, although the recently completed August data show that we have broken that trend (with normal August temperatures). Many locations in the state have experienced 6 consecutive months of below normal temperatures, with the largest negative departures occurring in March and June.

The relatively cool temperatures during the growing season combined with the late planting dates have drastically altered normal crop development across the state, particularly so in southern Minnesota counties. Growing degree day (GDD) accumulations for the period May through August are some of the lowest this century, matched somewhat by those of last year and of 1915.

Even with a return to somewhat normal temperatures for the balance of the growing season, crop maturation will be significantly delayed. Without frost corn can be expected to mature the first or second week of October if normal temperatures prevail. Thus it would appear very likely that much of the corn acreage in the state will be caught in an immature stage when frost occurs this fall.

Both the 30 day and 90 day outlooks released at the end of August favored a continuation of the near to below normal temperature trend in Minnesota and the upper midwest, as well as above normal precipitation. Thus serious consideration should be given to harvesting and drying immature, high moisture content crops this fall.

Notes for MPR Special "Morning Edition", Program of September 10, 1993

For: Greg Magnuson, Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Almanac (typical high of 73 and low of 50)

MSP records for September 10 are a high of 104 in 1931 and a low of 37 in 1917. In fact that record high (104 degrees) is the all-time high temperature for the month of September for the Twin Cities. On that same date in 1931, Morris and Canby in western Minnesota reported a high of 106 degrees and Wheaton reported a high of 108 degrees. That concluded one of the hottest weeks of the growing season and many crops were literally burning up in the field.

Greatest precipitation ever on this date is 3.00 inches in 1836, which was the first year that precipitation records were kept in this area (at old Ft Snelling). The greatest rainfall this century on this date is 1.93 inches back in 1913.

2. Word of the Week: **Isoryme**

As with previous terms we have discussed, iso means equal. Isolines or lines of equal value are used to produce a number of analyzed meteorological or climatological maps. Ryme refers to the granular ice structures produced by some forms of frost. Thus isoryme means a line on a map which indicates an area or pattern of equal frost incidence.

3. Topic of the Week: Types of Frost

Because crops in Minnesota this year are so far behind normal development, most corn and soybean producers are quite concerned about frost killing the crops before they reach maturation. This would lead to further reductions in the yields of what might be termed "mediocre crops" at best.

The basic definition of frost is when the temperature falls to 32 degrees or less at the Earth's surface. It also refers to frozen dew or ice crystals which form on cold surfaces such as a plant leaf, a sidewalk, or a car windshield. There are many types of frost. Hoarfrost or white frost is caused by sublimation of ice crystals on cold objects like branches of trees and shrubs or telephone wires. Listeners might recall that we had a number of these occur locally late last winter and in the early spring. White frost occurs predominately because the air is saturated with water vapor at or near the freezing point. When the air is dry and

freezing temperatures still occur, vegetation dies and turns color producing a "black frost" so named because of the darkened color of dying leaves and stems.

There are two other types of frosts: radiative and advective. Radiation frosts occur usually with clear skies and calm winds. Under these conditions the long wave radiation emitted by earthbound surfaces escapes much more readily and temperature inversions develop as air near these cold radiating surfaces becomes chilled and heavy. There is large spatial variability with radiation frosts because local landscape features have large effects on the nature and distribution of these "cold pockets" of air. For example, low spots in a field away from any shelterbelts or obstructions usually show frost first, while areas around ponds or trees, and on the tops of hills often escape these types of frosts. On the other hand, advection frost usually results from the intrusion of a large-scale cold air mass (often an arctic or polar air mass with very high central barometric pressure) accompanied by moderate to strong winds which do not allow an inversion to develop. These sometimes occur following the passage of a strong low pressure system in the fall. Frost occurs nearly everywhere in the landscape. This condition is sometimes referred to by farmers or forecasters as a "hard freeze."

Across the southern third of Minnesota, where most of the state's corn and soybean crops are grown, first fall frost dates range from the last couple of days in September to the 5th or 6th of October based on a 50 percent probability of occurrence. These probabilities shift by about 10 percent for each 3 to 4 days either side of these dates. Thus for the Rochester area, where the 50 percent probability date for fall frost is September 30th, the probability of frost by September 23rd would be 30 percent and by October 7 it would be 70 percent. Unfortunately, most row crops in southern Minnesota need to go past the first week of October to reach full maturation this year.

Notes for MPR "Morning Edition", Program of September 17, 1993

For: Greg Magnuson, Nancy Cole and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

A few miscellaneous notes: Driving to the Southwest Experiment Station in Lamberton, MN early on Wednesday morning, I noticed frost damage on a number of soybean fields west of Sleepy Eye on Hwy 14. East and north of Sleepy Eye and up to the Twin Cities, it appears that persistent cloud cover overnight must have prevented frost from occurring. In low lying rural areas up and down western Minnesota, minimum temperatures from 28 to 32 were noted that morning. It will take a few days to assess which crops and how much acreage were damaged by that frost.

A number of people have remarked about how short the days are becoming. Actually, we are losing daylight at the rate of better than 3 minutes per day now as we approach the autumnal equinox on the 22nd of September (when the overhead sun passes over the equator on its migration south). That adds up to a good deal of time each week. No wonder it is so noticeable.

1. Almanac (typical high of around 70 and low of upper 40s)

MSP records for September 17 are a high of 96 in 1895 and a low of 34 in 1943. The highest temperature on this date which has occurred this century is 93 degrees back in 1955.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 98 degrees back in 1955, which was recorded at Bird Island and Tracy. The all-time low temperature for this date was 18 degrees recorded at Cook (in western St Louis County) back in 1959.

Greatest precipitation ever on this date is 1.86 inches in 1856. The last heavy rain on this date was 1.70 inches back in 1942.

2. Word of the Week: **Carotenoid**

This is the term for the yellow and red pigments produced in plant leaves (actually hydrocarbons) which become more visible as chlorophyll (the green pigment) breaks down in the fall season. There is a relationship to climate, as late summer or early fall moisture stress (drought) can reduce the brilliant appearance of these pigments.

3. Topic of the Week: Autumn Colors

Former State Climatologist Earl Kuehnast of the DNR studied the relationship between fall color and climate conditions. Among other things he found that it takes 3 night of temperatures in the 30s to initiate leaf color change and 7 to 10 nights of temperatures in the 30s to reach peak fall color. Both the cooler temperatures of fall and the shorter days help trigger the breakdown of chlorophyll (the green plant pigment), and allow the beauty of other pigments to show through including carotenoid, xanthophyll, and anthocyanin (the red and purple pigments). Usually sunny cool weather permits a buildup of plant sugars which contribute to more brilliant plant pigments in the leaves. In northern Minnesota there have been between 4 and 7 nights with temperatures in the 30s so far this month, and in central Minnesota there have been 3 to 5 such nights. Southern counties have only recently been getting their first overnight exposures to temperatures in the 30s.

If hard freezes occur too early in the fall, they can damage plant leaves before the change in pigment and thus diminish fall color. Additionally, rainy and windy periods can take leaves down rather quickly, particularly after they start to turn color. Kuehnast found that the duration of fall colors can range from just a few days up to two or three weeks depending on the weather.

The sumac and maples are showing up even in southern Minnesota now and there is likely to be an acceleration in color change now that we have seen a number of nights with temperatures in the 30s, especially in western, central and northern Minnesota counties.

I will try to have more about this on Thursday or certainly Friday morning.

REVISED THURSDAY, SEPTEMBER 23

Notes for MPR "Morning Edition", Program of September 24, 1993

For: Greg Magnuson, John Bischoff and Perry Fanelli

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

Frosts last week and over the weekend brought an end to the growing season in many central and northern counties of Minnesota. Thursday morning of this week saw some frosts occur as well, with low 30s and even upper 20s on the sandier soils of central Minnesota. It would appear that outside the Twin Cities, only south-central and southeastern counties have not yet experienced some frosts this fall.

Precipitation this month has been highly variable, but many places have received 1 to 2 inches this week, predominately from Sunday through Wednesday. Much of this has resaturated soils which are still wet below from the excess rainfall this summer. A difficult harvest season may be at hand unless these soils dry out considerably in the next few weeks.

1. Almanac (typical high of upper 60s and low of mid 40s)

MSP records for September 24 are a high of 89 in 1935 and a low of 30 in 1942.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 94 degrees back in 1935, which was recorded at Canby. The all-time low temperature for this date was 22 degrees recorded at Cook (in western St Louis County) back in 1967.

Greatest precipitation ever on this date is 1.06 inches in 1934 And on this date in 1942 we had a trace of snow fall in the Twin Cities.

2. Words of the Week: Leaching and Denitrification

These terms are only sometimes used by meteorologists and climatologists. They are used a much more commonly by soil scientists and farmers when they are discussing fertilizer options. Leaching refers to the movement or washing out of soluble constituents (chloride, bromide, sulfate or nitrate) within the soil by percolation of water. Moisture moves through successive soil layers by gravity. In many agricultural soils the moisture is stored there until it is removed by plant roots during the growing season. But in some soils, deeper percolation occurs, depositing these soluble materials into aquifers which may be sources of drinking water or water for irrigation. Potential leaching losses are governed by soil moisture, soil texture as well as rainfall frequency and intensity.

Denitrification is the biological process in the soil where nitrate nitrogen is converted into a gas and lost through the soil surface to the atmosphere. This process occurs more rapidly under warm and moist conditions and in fine textured soils. Unlike leaching which represents an environmental concern with respect to ground water quality, denitrification losses are not an environmental threat but nevertheless can represent an economic loss with respect to a farmers fertilizer program.

3. Topic of the Week: Other plant responses to fall

Last week, Bob and I talked about the most visible plant response to fall weather - all of the color changes. But there are other responses going on which are not so visible. For many perennial plants, carbohydrate production (the result of photosynthesis) is being stored increasingly in the roots now. Plants which go dormant for the winter are also starting the "hardening" process in order to prepare for the severe climate usually endured from December through February. Taking alfalfa as an example, solutes are being stored, cellular water content is decreasing, bound water concentration is increasing and structural changes are occurring in the cells protoplasm. As a result of the hardening process, plant tissues can stand exposures to severe cold temperatures much better. This process is enhanced by sunny cool weather in the fall (we have been having cool weather, but relatively little sunny weather).

Another response to fall is that homeowners start to fertilize their lawns. Lawns can use both ammonium and nitrate forms of nitrogen fertilizer, but ammonium forms are by far more stable and persistent in the soil. Fall is a good time to apply nitrogen because soil temperatures are dropping which means that the biological processes (involving soil bacteria) that transform ammonium forms of nitrogen (non-mobile) to nitrate form (mobile form) are greatly reduced. In this condition, our lawns can use the nitrogen much more efficiently, since it won't be leached or denitrified (volatilized) and much of it will still be available next spring in the soil to "kick-start" our lawn into action when the weather conditions become suitable. Soil temperatures around the state at the 4 inch depth are currently ranging from the mid 50s to low 60s during the day and mid 40s to low 50s at night. Usually there would be a wider range from day to night, but many soils are wet right now which tends to keep the temperature range more narrow. This combination of soil temperature and moisture is currently not suitable for efficient fall fertilizer yet, and most listeners may want to wait other week or two before they fertilize the lawn.

Notes for MPR "Morning Edition", Program of October 1, 1993

For: Greg Magnuson, John Bischoff and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

We have a public lecture at the university next week, which a number of listeners might be interested in. It is the inaugural address for the Kuehnast Lecture Series in Meteorology/Climatology and Their Application. Professor Stan Changnon of the Illinois Water Survey, and a well know researcher in the atmospheric sciences, will present a lecture entitled "Is Climate Still Important." This will occur at 3 pm on Tuesday, October 5th in Room 335 Borlaug Hall on the St Paul Campus. The public is invited. It is certainly a timely topic given this years climatic events and their impact.

Did you know that the current week (well technically Sept 27 to October 3) climatically correponds to the time of year when we experience the highest frequency of clear-days? A paper by colleagues Donald Baker and Richard Skaggs (at the university) analyzed the clear day frequencies week by week throughout the year, going back over a 30 year period in the north-central states and found that the current week historically has the most clear days (0 cloud cover). This roughly corresponds to the onset of "Indian Summer", a period defined as mid to late autumn when skies are generally clear, winds are calm, days are sunny and hazy with comfortably warm temperatures and cool nights. In New England, the same definition applies except that this period always occurs after the first killing frost of the season. In our region, it may occur before or after the first frost. The term Indian Summer dates back to at least 1778 and probably originated from the way native American Indians used the last spells of good weather in the autumn to increase their winter stores of supplies and food. According to the Glossary of Meteorology, the corresponding period in Europe is sometimes referred to as "Old Wives Summer."

Speaking of frosts, a number of places around the state have reported more than one frost this month. Most recently on Wednesday morning of this week, temperatures ranged from 27 degrees Crookston, Park Rapids, Perham, and Roseau, to 33 degrees at Rochester. I think locally we had about 36 degrees, so many of our urban gardens escaped any damage.

1. Almanac (typical high of mid 60s and low of low 40s)

MSP records for October 1st are a high of 86 in 1897 and a low of 24 in 1974. The warmest this century has been 85 back in

1967, 1976, and 1989. On this date last year, several communities in western Minnesota reported highs of around 90 degrees.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 93 degrees at Madison, MN back in 1963 (Lac Qui Parle County). The all-time low temperature for this is 14 degrees at Grand Rapids back in 1918.

Greatest precipitation ever on this date is 1.03 inches in 1878. The most we have had this century is 0.63 inches in 1907.

2. Words of the Week: Leaching and Denitrification

These terms are only sometimes used by meteorologists and climatologists.

They are used a much more commonly by soil scientists and farmers when they are discussing fertilizer options. Leaching refers to the movement or washing out of soluble constituents (chloride, bromide, sulfate or nitrate) within the soil by percolation of water. Moisture moves through successive soil layers by gravity. In many agricultural soils the moisture is stored there until it is removed by plant roots during the growing season. But in some soils, deeper percolation occurs, depositing these soluble materials into aquifers which may be sources of drinking water or water for irrigation. Potential leaching losses are governed by soil moisture, soil texture as well as rainfall frequency and intensity.

Denitrification is the biological process in the soil where nitrate nitrogen is converted into a gas and lost through the soil surface to the atmosphere. This process occurs more rapidly under warm and moist conditions and in fine textured soils. Unlike leaching which represents an environmental concern with respect to ground water quality, denitrification losses are not an environmental threat but nevertheless can represent an economic loss with respect to a farmers fertilizer program.

3. Topic of the Week: Other plant responses to fall

Previously, Bob and I talked about the most visible plant response to fall weather - all of the color changes. But there are other responses going on which are not so visible. For many perennial plants, carbohydrate production (the result of photosynthesis) is being stored increasingly in the roots now. Plants which go dormant for the winter are also starting the "hardening" process in order to prepare for the severe climate usually endured from December through February. Taking alfalfa as an example, solutes are being stored, cellular water content is decreasing, bound water concentration is increasing and structural changes are occurring in the cells protoplasm. As a result of the hardening process, plant tissues can stand exposures to severe cold temperatures much better. This

process is enhanced by sunny cool weather in the fall.

Another response to fall is that homeowners start to fertilize their lawns. Lawns can use both ammonium and nitrate forms of nitrogen fertilizer, but ammonium forms are by far more stable and persistent in the soil. Fall is a good time to apply nitrogen because soil temperatures are dropping which means that the biological processes (involving soil bacteria) that transform ammonium forms of nitrogen (non-mobile) to nitrate form (mobile form) are greatly reduced. In this condition, our lawns can use the nitrogen much more efficiently, since it won't be leached or denitrified (volatilized) and much of it will still be available next spring in the soil to "kick-start" our lawn into action when the weather conditions become suitable. Soil temperatures around the state at the 4 inch depth are currently ranging from the low to high 50s during the day and low to mid 40s at night. Usually there would be a wider range from day to night, but many soils are wet right now which tends to keep the temperature range more narrow.

Notes for MPR "Morning Edition", Program of October 8, 1993

For: Greg Magnuson, John Bischoff and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

It has already been mentioned that September was a very cold month, second coldest this century for us in the Twin Cities. That statement is true for most of the state, as only 1965 and in some cases 1918 were colder Septembers. For farmers, it was the exact opposite from what they hoped for and needed to finish off the crop maturation process.

Just for your information, Wednesday October 6th was a very warm day, one of the warmest around the region this year. Some of the reported high temperatures were:

MSP 81	Alexandria 86	Hibbing 80	Rochester 81
St Cloud 83	Redwood Falls 90	Lamberton 90	Morris 88
Waseca 85	Park Rapids 86	Rosemount 84	Cloquet 79

These high temperatures were 20 to 28 degrees **above** normal and a rarity for this year. In fact there were only 6 warmer days this entire year at Redwood Falls and Lamberton. Almost like inserting a mid July day into the first week of October.

1. Almanac (typical high of low 60s and low of high 30s)

MSP records for October 8th are a high of 84 in 1966 and a low of 25 in 1876 - the old pioneer records. The coldest this century was back in 1989 when the low reached 27 degrees.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 90 degrees at Montevideo in 1980 (Chippewa County). The all-time low temperature for this date is 11 degrees at Roseau in 1917.

Greatest precipitation ever on this date is 1.43 inches in 1970. This is also the earliest date in October when we have received measurable snowfall, 0.3 inches back in 1959.

2. Words of the Week: **Heliograph** (Sunshine recorder)

Helio is the Greek word for sun and graph meaning to write or record. This is an instrument used to record the hours of sunshine. One version passes the sun's rays through a lens which is focused on a rotating drum lined with scaled blueprint paper (usually showing hours).

The rays burn a pattern on the paper as it rotates throughout the day, with the length of the pattern showing the number of hours and minutes the sun was shining. This instrument is still used in some places today.

3. Topic of the Week: Other plant responses to fall

Previously, Bob and I talked about the most visible plant response to fall weather - all of the color changes. But there are other responses going on which are not so visible. For many perennial plants, carbohydrate production (the result of photosynthesis) is being stored increasingly in the roots now. Plants which go dormant for the winter are also starting the "hardening" process in order to prepare for the severe climate usually endured from December through February. Taking alfalfa as an example, solutes are being stored, cellular water content is decreasing, bound water concentration is increasing and structural changes are occurring in the cells protoplasm. As a result of the hardening process, plant tissues can stand exposures to severe cold temperatures much better. This process is enhanced by sunny cool weather in the fall.

Christmas trees go through a hardening process as well and for this reason, many of the needles start to lose greenness this time of year. A good deal of Christmas tree harvesting is done in the month of October before the needles start to lose their greenness. Tree color will remain green until the Christmas season if they are left outdoors in a cool moist environment. Christmas tree growers usually prune from mid June to mid July before the trees set new buds for next year's growth. Like any other tree, tolerance to climatic stress increases with age of the tree. Christmas trees seedlings can die rather readily if they must endure a drouthy period right after planting, but usually after one or two years growth they are much hardier with respect to climatic stress.

(Note: The above is provided courtesy of my visiting father-in-law who is a Christmas tree grower in Michigan.)

Notes for MPR "Morning Edition", Program of October 15, 1993

For: Greg Magnuson, John Bischoff and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Almanac (typical high of low 60s and low of high 30s)

MSP records for October 15 are a high of 85 set in 1947 and tied in 1968. The record low is 21 degrees set in 1876 (old pioneer records), but the lowest this century has been 26 degrees in 1974.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 93 degrees at Madison, MN (Lac Qui Parle County) in 1958. In fact a number of cities in southern and western Minnesota reported 90s on that date. The all-time low temperature for this date is 11 degrees at Park Rapids and Itasca State Park in 1937.

Greatest precipitation ever on this date is 1.24 inches in 1966 and snow fell on this date in both 1943 and 1976, but just in trace amounts.

2. Words of the Week: **Terrestrial Radiation, Extra-Terrestrial Radiation and Global Radiation** (differentiation)

These are terms used by meteorologists and climatologists to describe different features related to Earth's radiation balance. **Terrestrial radiation** is the term used to describe the total infrared radiation being emitted from the Earth's surface. Much of this is captured (absorbed) by water vapor and gases in the atmosphere keeping the planet habitable. **Extra-terrestrial radiation** is the term used to describe the radiation received from the sun which strikes the top of the Earth's atmosphere (basically unimpeded radiation). As this radiation passes through the atmosphere it is scattered, absorbed and reflected, such that only a percentage of it actually reaches the Earth's surface. The radiation which reaches the Earth's surface, both directly from the sun as well as from diffuse sky radiation is termed **global radiation**. This is typically measured on a horizontal surface and represents the energy available to heat the Earth's surface or to evaporate water.

3. Topic of the Week: Observational networks in Minnesota

There are many climatological observations made in the state. Most of these are designed to meet the needs of federal, state or local government agencies. Some of the agencies and organizations which operate either networks of volunteer observers or networks of automated weather stations include: the University of Minnesota Agricultural Experiment Station, Minnesota Department of Natural Resource,

Metropolitan Mosquito Control District, Deep Portage Conservation Reserve, Soil and Water Conservation Districts, Future Farmers of America, Minnesota Department of Transportation, Federal Aviation Administration, Minnesota Pollution Control Agency, and National Weather Service.

There are several classes of climatological stations:

A first order climatological station is where hourly records of pressure, temperature, humidity, wind, sunshine and precipitation are kept. In addition, synoptic or 6 hourly observations of the amount and type of cloud cover and weather condition are recorded. This type of station is typically staffed 24 hours like the National Weather Service Forecast Offices in the Twin Cities, Duluth, International Falls, and Rochester. (Generally 3-6 per state)

Second order climatological stations record many of the same data which first order stations record, except they don't provide 24 hour coverage. They do record the daily maximum and minimum temperature, precipitation and hours of sunshine, along with synoptic (6 hourly observations) and aviation observations. This type of station exists at St Cloud and at some of the smaller airports around the state. (Generally 5-10 per state)

Third order climatological stations or sometimes referred to as substation include most of the National Weather Service volunteer observers around the state who record daily maximum and minimum temperatures along with precipitation. Some also take special observations (i.e. snow depth, wind, evaporation), but usually only once per day. (Generally 100-250 per state)

Precipitation stations are generally those where volunteers record the total amount of liquid precipitation received each day in some type of gage. Some will also record the type and duration of precipitation. In Minnesota we have around 1400 observers of precipitation.

Automated weather stations use electronic instrumentation wired to some small microprocessor or computer which records hourly values of temperature, pressure, humidity, wind, etc. These data are transmitted to some central location on an hourly or daily basis to be used operationally or to be archived into a climatological data base.

(Note synoptic observations might include: cloud type, coverage, height, pressure tendency, dew point, and weather type)

Notes for MPR "Morning Edition", Program of October 22, 1993

For: Greg Magnuson, John Bischoff and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Almanac (typical high of mid 50s and low of mid 30s)

MSP records for October 22 are a high of 81 set just last year. The record low is 17 degrees set in 1873 (old pioneer records), but the lowest this century has been 20 degrees in 1936.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 85 degrees at Lake City, MN in 1899. The all-time low temperature for this date is a very chilly 2 degrees at Hallock in 1936.

Greatest precipitation ever on this date is 1.10 inches in 1856 and 1 inch of snow fell on this date in 1925. In fact October of 1925 was one of the snowiest, with snowfall ranging from 2 to 12 inches around the state.

2. Word of the Week: **Snow Pillow**

This is not a pillow made of snow, nor is it a pillow to sleep in the snow with. It is the name of an instrument used to measure the water content of snow by weight. It is laid on top of the soil or just below the soil surface and weight changes due to accumulating snow cover on top

of this instrument are recorded. Knowing the weight change and the area of the snow pillow surface, the water equivalence can be calculated.

Snow pillows are usually made of inch-thick stainless steel and range in size from 3 to 20 square feet. The weight of snow resting on the pillow is converted to an electrical signal by transducers and the water content

of the snow is calculated using the known surface area of the pillow.

There are over 1700 snow survey courses throughout the United States (mostly in the western states) operated by the USDA Soil Conservation Service and many of them are equipped with snow pillows and other electronic sensors which transmit their data to central computers using radio and satellite systems.

3. Topic of the Week: Snow cover and duration

We are rapidly approaching the start of the snow season for the state. The historical records show that measurable snowfalls have occurred on every date in October from the 18th to the 31st. In the 45 years since 1948, we have recorded measurable snowfall in October 16 times. Northern areas of the state have recorded measurable October snowfall 20 to 25 times over the same period of time. And of course we all remember Halloween of 1991.

However snow cannot generally accumulate on the ground until soil temperatures fall into the 30s. Thus even when we experience snows in October, it very rarely remains as permanent winter snow cover.

A study by our late state climatologist Earl Kuehnast showed that the average date for the first 1 inch snow cover ranges from October 30 at Crane Lake, Minnesota (northern St Louis County) to as late as December 1st down at Albert Lea, Minnesota. The average duration of snow cover during the winter varies considerably as well, ranging from 85 days in southwestern Minnesota to over 160 days in the arrowhead region. For the Twin Cities specifically, the average first snow cover date is November 22 and the average duration of snow cover is about 100 days.

Using the 100 plus years of record at Farmington, MN in Dakota County, we find that 7 times 1 inch snow cover has occurred by the end of October. On the other hand, there have been 3 occasions when 1 inch or greater snow cover did not occur until after Christmas. I would venture a guess that we probably had deeply frozen soils conditions during those winters. The depth of freezing in the soil as well as the severity or magnitude of cold temperatures which occur in the rooting area of soil are highly governed by the onset of permanent snow cover. Generally speaking, early snow covers help insulate the soil and prevent it from freezing as deeply or as severely.

I will try to add more before Friday.

Notes for MPR "Morning Edition", Program of November 12, 1993

For: Greg Magnuson, John Bischoff and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

International Comment:

While we have been having a cooler than normal fall season in the midwest, many places in South America have been having a very warm spring. Parts of Argentina, Paraguay, and Bolivia reported temperatures over 105 degrees last week. Like us, parts of the former Soviet Union are experiencing rather chilly temperatures this fall, with some areas reporting lows of -35 to -40 last week.

1. Almanac (typical max of low 40s and min of mid 20s)

MSP record high for November 12 is 62 set in 1952. The record low is -4 degrees set in 1966. Record precipitation on this date is 0.90 inches in 1965 and record snowfall is 8.5 inches in 1940.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 70 degrees at Beardsley (Big Stone County) in 1941. The all-time low temperature for this date is -21 degrees at Cook (St Louis County) in 1966. As you can imagine there was a relatively fresh snow cover on the ground at the time. This gets back to a term we discussed last January, **albedo**, which refers to the ratio of the amount of radiation reflected by a surface to the amount of radiation incident upon it. The albedo of the surface can make a big difference during the winter season, as bare ground or forests may reflect only 10 to 20 percent of the incident solar radiation, while fresh snow may reflect 80 to 90 percent. Thus absorption of radiation which heats the air is greatly reduced with snow cover. Bear in mind that during the months of November and December, solar radiation is very low to start with because of the low sun angle and high frequency of cloudy days. Nearly 100 percent of our daily low temperature records during the winter months have occurred with the presence of snow cover.

A Reminiscence: 54 years ago, the Armistice Day Blizzard

On this morning 54 years ago (1940) most Minnesotans were caught in the grip of this terrible storm. Locally, glaze and sleet which

began on the 11th changed over into snow, accompanied by very strong winds and a severe drop in temperature - this lasting throughout the balance of the day and most of the next (the 12th). A very intense low pressure system passed across the state from south to north, passing over Lake Superior. Winds reached gusts as high as 63 mph in eastern parts of the state.

Snowfall accumulations were:

MSP 16.8"	Collegeville 26.6"	Milaca 19.3"
Meadowlands 24"	Bird Island 16.7"	St Peter 15"

And snow drifts as high as 20 feet were reported in the Willmar area.

All transportation services were disrupted or stopped. Hundreds of cars were abandoned. Tens of thousands of people were without power or telephone service, and at least 49 people lost their lives, many of them to exposure as the temperature dropped over 40 degrees in some places. Twenty duck hunters died who were stranded out on islands on the Mississippi River in SE Minnesota. Agriculturally speaking, this occurred before the days of climate-controlled poultry housing, and thousands of birds perished. The turkey losses alone were estimated at \$500,000.

2. Word of the Week: **The Minnesota Desert**

Not the same as Minnesota Dessert - crumb cake or apple streusel! This term is sometimes used by my colleague Professor Donald Baker to puzzle his students. Where is the Minnesota Desert? It is in our homes, offices, and classrooms. When does it occur? Primarily in winter. Why? Because the capacity of the atmosphere to hold water vapor is dependent on its' temperature. Outside air on a November night might be at a temperature of 25 F degrees. Say that there is fog or a low cloud ceiling, and therefore atmospheric humidity outside is at 100% (saturation). When that air is drawn into a building and heated, say to a conservative 68 degrees F, the value of saturation vapor pressure (the partial pressure due to the presence of water vapor in the air) rises from about 4.5 mb to over 23 mb. If we assume no change in water vapor content as the air enters a building, then the relative humidity drops from 100 percent to 19 percent, due to the heating of the air.

That's a rather modest example of relative humidity change in November. By January when temperature differences between outside and inside air are more extreme, relative humidity can fall from 100 percent outside to just 2 or 3 percent inside. That's as dry as any natural desert you will ever find. Fortunately, plants, showers, sinks, washers, bathtubs and humidifiers help to increase the humidity inside buildings, but the dry throats, noses, eyes, lips and skin that we sometimes experience in the winter months are often caused by "the Minnesota Desert."

3. Topic of the Week: More on the History of the National Weather Service (from D. Whitnah's book)

The birth of the Weather Service was really an appropriation of \$15,000 by the Congress in 1871 which started a monitoring and storm forecast program by the U.S. Army Signal Service. This was primarily to provide information for military stations and shipping traffic on the Great Lakes and along the Atlantic seaboard. By 1905, the Congressional appropriation was up to nearly \$1.5 million, and for 1993 it was around \$450 million.

Previously, we discussed local competition among forecasters (St Paul Office versus the Minneapolis Office) here during the 1890s and how the Weather Bureau Chief had to put a halt to it, as staff were getting too much media attention deriding each others abilities. In addition there were others outside the Weather Service who promoted their forecasting prowess and competed with the government forecasters, sometimes stealing government forecasts and promoting them as their own or offering "much better long range forecasts" for a fee. This prompted some action by Congress to prohibit counterfeiting of government forecasts. In 1905 a law was passed which stated that:

"any person who shall knowingly issue...any counterfeit weather forecasts..., falsely representing such forecaststo have been issued ...by the Weather Bureau or.....other government service, or interfere with any weather or storm flag or weather map...displayed or issued by ...the Weather Bureau..shall be deemed guilty of a misdemeanor, and on convictionbe fined a sum not exceeding \$500, or be imprisoned not to exceed 90 days, or be fined and imprisoned at the discretion of the court."

As for those who made a living selling long range forecasts..they were described by officials of the Weather Bureau as pseudo-scientists, astrologers, clairvoyants, fortune-tellers, charlatans, trance mediums, and social parasites who took advantage of people's superstitions and ancient beliefs. And back then, long range forecasting was considered anything beyond 2 days!

Of course the Weather Bureau had a monopoly on weather forecasting back then. Today, there are many private meteorologists who provide healthy competition for government forecasters. Although the National Weather Service still provides all the forecast guidance information (i.e. numerical circulation models, radar, satellite and surface observations) forecaster's interpretations of this guidance and data can still vary considerably, primarily based on different expectations for the timing and areal extent of major weather features (fronts, jet stream, pressure centers).

Notes for MPR "Morning Edition", Program of November 5, 1993

For: Greg Magnuson, John Bischoff and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

1. Almanac (typical max of high 40s and min of upper 20s)

MSP records for November 5 are a high of 70 set in 1975. The record low is just 3 degrees set in 1951. Record precipitation on this date is 0.93 inches in 1948 and record snowfall is 4.2 inches in 1959. Our daylength now is just over 9 3/4 hours and we will lose approximately another 1 1/4 hours of daylight by the winter solstice on December 21st. Then daylength will begin to increase once again. It is a tough time of year for those who suffer from a light deprivation malady.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 78 degrees at Madison (Lac Qui Parle County) in 1975. The all-time low temperature for this date is -16 degrees at Detroit Lakes (Becker County) in 1951.

2. Word of the Week: **The Minnesota Desert**

Not the same as Minnesota Dessert - crumb cake or apple streusel! This term is sometimes used by my colleague Professor Donald Baker to puzzle his students. Where is the Minnesota Desert? It is in our homes, offices, and classrooms. When does it occur? Primarily in winter. Why? Because the capacity of the atmosphere to hold water vapor is dependent on its' temperature. Outside air on a November night might be at a temperature of 25 F degrees. Say that there is fog or a low cloud ceiling, and therefore atmospheric humidity outside is at 100% (saturation). When that air is drawn into a building and heated, say to a conservative 68 degrees F, the value of saturation vapor pressure (the partial pressure due to the presence of water vapor in the air) rises from about 4.5 mb to over 23 mb. If we assume no change in water vapor content as the air enters a building, then the relative humidity drops from 100 percent to 19 percent, due to the heating of the air.

That's a rather modest example of relative humidity change in November. By January when temperature differences between outside and inside air are more extreme, relatively humidity can fall from 100 percent outside to just 2 or 3 percent inside. That's as dry as any natural desert you will ever find. Fortunately, plants, showers, sinks, washers, bathtubs and humidifiers help to increase the humidity inside buildings, but the dry throats, noses, eyes, lips and skin that we sometimes experience in the winter months are often caused by "the Minnesota Desert."

3. Topic of the Week: More on the History of the National Weather Service (from D. Whitnah's book)

The birth of the Weather Service was really an appropriation of \$15,000 by the Congress in 1871 which started a monitoring and storm forecast program by the U.S. Army Signal Service. This

was primarily to provide information for military stations and shipping traffic on the Great Lakes and along the Atlantic seaboard. By 1905, the Congressional appropriation was up to nearly \$1.5 million, and for 1993 it was around \$450 million.

Previously, we discussed local competition among forecasters (St Paul Office versus the Minneapolis Office) here during the 1890s and how the Weather Bureau Chief had to put a halt to it, as staff were getting too much media attention deriding each others abilities. In addition there were others outside the Weather Service who promoted their forecasting prowess and competed with the government forecasters, sometimes stealing government forecasts and promoting them as their own or offering "much better long range forecasts" for a fee. This prompted some action by Congress to prohibit counterfeiting of government forecasts. In 1905 a law was passed which stated that:

"any person who shall knowingly issue...any counterfeit weather forecasts..., falsely representing such forecasts ...to have been issued ...by the Weather Bureau or....other government service, or interfere with any weather or storm flag or weather map...displayed or issued by ...the Weather Bureau..shall be deemed guilty of a misdemeanor, and on conviction ...be fined a sum not exceeding \$500, or be imprisoned not to exceed 90 days, or be fined and imprisoned at the discretion of the court."

As for those who made a living selling long range forecasts..they were described by officials of the Weather Bureau as pseudo-scientists, astrologers, clairvoyants, fortune-tellers, charlatans, trance mediums, and social parasites who took advantage of people's superstitions and ancient beliefs. And back then, long range forecasting was considered anything beyond 2 days!

Of course the Weather Bureau had a monopoly on weather forecasting back then. Today, there are many private meteorologists who provide healthy competition for government forecasters. Although the National Weather Service still provides all the forecast guidance information (i.e. numerical circulation models, radar, satellite and surface observations) forecaster's interpretations of this guidance and data can still vary considerably, primarily based on different expectations for the timing and areal extent of major weather features (fronts, jet stream, pressure centers).

4. Response to another listeners question: Andrew Nimick of Apple Valley writes that sometimes at night before his son Stephen falls asleep, the boy expresses a fear of being awakened by lightning and thunder, which apparently woke the youngster up a number of times this spring and summer. Mr. Nimick asked about the frequency of thunder and whether until next Spring. or not he is safe in telling Stephen that there will not be any more

Pretty safe Mr. Nimick. Thanks to the records kept at the State Climatology Office, I was able to examine the statistics on the occurrence of thunder in the Twin Cities by month for approximately a 45 year period. The frequency distributions for November, December, January, February and March show the following:

1.9 percent of all days in November (26/1350 days)
0.7 percent of all days in December (10/1395 days)
0.1 percent of all days in January (2/1364 days)
0.6 percent of all days in February (7/1232 days)
3.4 percent of all days in March (46/1364 days)

The frequencies become 20 to 25 percent of all days by June and July. But for the winter season I think pleasant dreams are in order for young Stephen.

Notes for MPR "Morning Edition", Program of December 17, 1993

For: Greg Magnuson and Bob Potter

From: Mark Seeley, University of Minnesota

Re: For your review and comment.

The Winter Solstice occurs at 2:26 pm next Tuesday, December 21st, when the noon day sun's migration to southern latitudes will be maximum. That is the midday sun will be shining directly over the Tropic of Capricorn at 23.5 degrees south latitude. So what?, you say! Well, at least we can start looking forward to longer days, as the noon day sun begins its journey back toward the equator where it will arrive on the Vernal Equinox on or about March 21st.

1. Almanac (typical max of mid 20s and min of mid single digits)

MSP record high for December 17 is 53 set in 1939. The record low is -19 degrees set in 1849 (old Pioneer records). The coldest this century has been . Record precipitation for December 17 is 0.81 inches in 1908 which is also the record snowfall snowfall date with 10.8 inches.

Scanning the State Climate Data Base other records of note are: The all-time state high temperature is 63 degrees in 1939 at Farmington in Dakota County. The all-time low temperature for this date is -36 degrees at Baudette (Lake of the Woods County) in 1983.

2. Words of the Week: **Buran and Purga (poorga)**

These are terms used in different parts of Siberia (former Soviet Union) to describe a blizzard-like storm. In central Siberia and southern Russia a Buran is dreaded by livestock managers and herdsmen as historically animal losses have been great from these storms. In northern Siberia, a purga is often accompanied by biting winds from the northeastern tundra which drive the wind chill index to extreme values.

3. Topic: Bob's questions

Why are we getting this dreadful warm weather? Isn't this like last winter? What about spring?

Answer: At least part of the explanation is based on the split jet stream flow across the U.S. which has been a prevalent climatic feature of the first half of the month. This prevents or tends to diminish exchange of air masses which give us the wide temperature

swings we sometimes see in winter. Mild Pacific air passes across the state, with enough moisture to keep us cloudy and particularly keep our overnight minimum temperatures from getting too low. The temperatures we have recorded so far this month are even more mild than those of the last two Decembers. In fact, if December ended today, the mean monthly temperature (around 30.5 F) would rival that of 1913 for the warmest December this century. The warmest all-time incidentally was 1877 which averaged nearly 34 degrees.

I find little correlation between climatic trends and patterns in the winter and those of the spring. Some researchers have been examining correlations such as those as well as correlations of climatic patterns during and following El Nino events. I don't believe that we can attribute our December weather pattern to El Nino at this point, but maybe I will be proven wrong.

Do the warm winters of the past few years affect the "average" or "normal" temperatures used in the Almanac? How so?

Yes to some degree depending on what "normals" you are talking about - daily, weekly or monthly. A positive temperature departure of say 10 degrees for any particular day in the winter can alter a 30 year normal for that day by only a few tenths of a degree. Because of averaging, positive and negative temperature deviations from normal tend to be largest for individual days and smallest for months. For example on the 13th of the month, the minimum temperature recorded was 36 degrees, the normal low is 7 degrees. If this value were substituted in the 30 year normals for minimum temperature it would raise the normal minimum for the 13th to 8 degrees. That's somewhat of an extreme case. The recent weekly deviations in temperature have averaged about 4 to 6 degrees.

The current "normal" temperature for the month of December based on 1961-1990 (the WMO standard for normals) is 17.8 degrees. If we throw out the first 3 years ('61, '62, and '63) and recalculate for the most recent 30 years (which include the mild Decembers of '91, '92, and '93) the normal changes to 18.7 degrees.

4. Remembering the coldest December of the century - 1983.

December of 1983 was the coldest December of this century, averaging only 3.7 degrees, about 15.5 degrees below normal. Only 1822, 1831, and 1872 in the old Pioneer records show a colder December average temperature. Perhaps the most memorable features of that December were the snow depth and the wind chills which occurred around Christmas time. For several days, snow depth was 20 inches or greater and beginning on the 22nd and running through to the 24th (Christmas Eve), wind chill values were in the -60 to -80 range. The maximum temperature on the 23rd was -17 degrees,

one of the coldest maximum temperatures ever in December.
Heating Degree Days for the month totaled 1901, 441 more than
normal.