FALL 2020 | SKYWARN NEWSLETTER

THE KEYSTONE CROSSWIND

National Weather Service
State College, PA

What's inside?

WELCOMING OUR NEW WARNING COORDINATION METEOROLOGIST, JONATHAN GUSEMAN

Hello All!

I am extremely excited to have the opportunity to serve you as the newest Warning Coordination Meteorologist at NWS State College. It's been a busy month and a half getting acquainted with central Pennsylvania, but my family and I are enjoying our new home, especially the gorgeous fall colors!

I'm originally from about 45 minutes southeast of Cincinnati, OH and most recently lived in the beautiful hilly terrain of eastern Kentucky. I love the outdoors and am a big sports fan (hoping to take a few trips to Pittsburgh and Philly to see some Cincinnati games from time to time)!

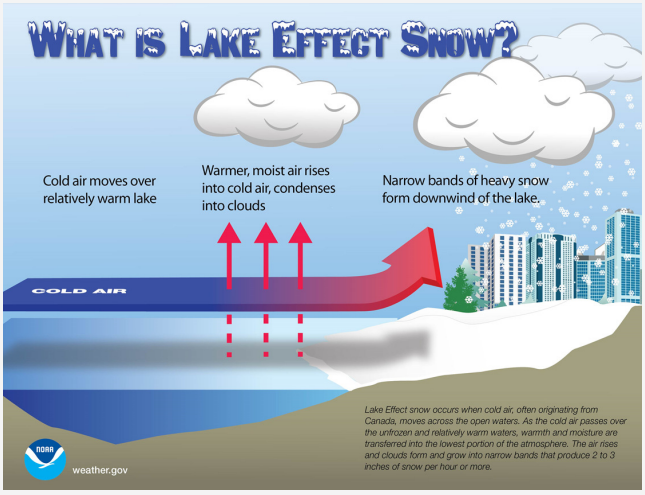
We are always striving to better our services to you. It is truly incredible to see the number and quality of projects being diligently worked on at the office, and I consider myself very fortunate to get to be a part of them and this hard-working team. I look forward to serving you alongside an experienced and enthusiastic staff at NWS State College!

- Jonathan Guseman

WHAT IS LAKE-EFFECT SNOW?

by Meteorologist Steve Travis

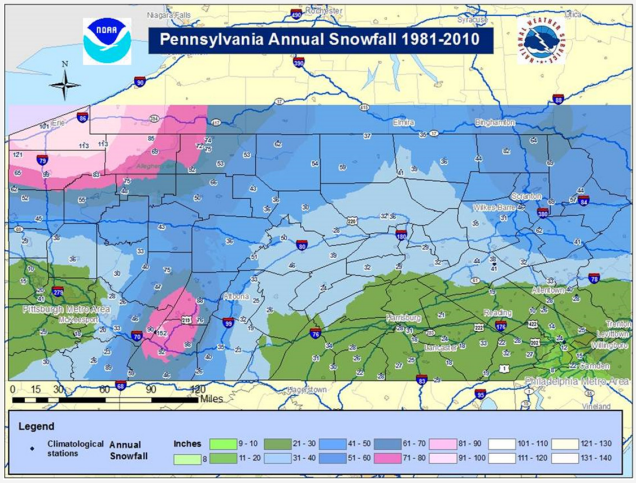
When you think about big snow storms in Pennsylvania, what comes to mind? Perhaps a particularly heavy snowfall from a Nor'easter? Did you know there is a weather phenomenon that creates significantly more snow in some parts of Pennsylvania every year? We're talking of course about lake-effect snow! Lake-effect is responsible for the majority of snow that falls over northwestern Pennsylvania and in part, much of the upslope snow over the Laurel Highlands. It occurs typically late in the late fall and early winter when cold air from Canada moves over the relatively warmer waters of the Great Lakes. Later in winter, the lakes are much colder, or even partially frozen over, which makes it harder for lake-effect to form.

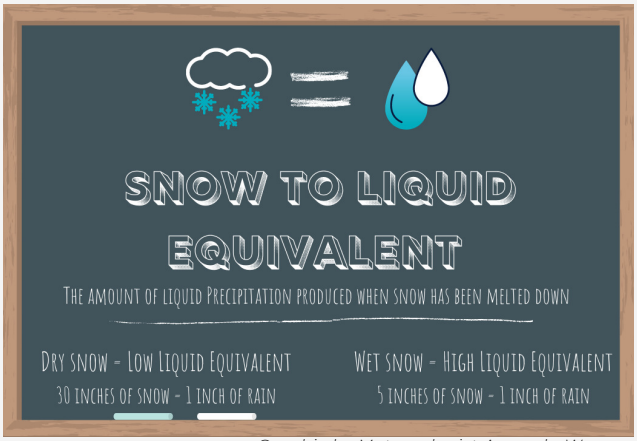


The main driver behind lake-effect snow is the temperature difference between the lake waters and the air aloft. Meteorologists typically look at the temperature of the air about a mile above the ground and compare that to the lake water temperature. If the air aloft is 13˚C (about 23˚F) colder than the lake water, then lake-effect snow will be possible. We also look for fairly uniform winds (low wind shear), both in speed and direction, at different levels of the atmosphere. The other key ingredient is moisture, which is essential for the formation of clouds and precipitation. As that cold, Canadian air moves over the Great Lakes it picks up moisture which condenses into clouds and eventually precipitates out as snow.

When all the right ingredients come together, the result can be extremely heavy snow! Some of the heaviest lake-effect snow is found east of Lake Ontario in New York. In 1966 a lake-effect snow storm brought 102 inches of snow to Oswego, NY. Another storm in 2001 downwind of Lake Erie brought 81.5 inches to Buffalo, NY. A little closer to home, you may remember the Christmas Day event in Erie, PA in 2017. 65.1 inches of snow fell over a two day period which set a PA state record for two-day snowfall.

Although we don't see snow quite like that in the NWS State College County Warning Area, we still see plenty of lake-effect snow, especially in Warren and McKean Counties. Notice the pink areas in the northwest on the annual snowfall graphic below: that is where the heaviest lake-effect occurs in PA. Though amounts drop off quite a bit to the south and east, heavy bands of snow can still reach to I-80 and I-99 on occasion and bring major travel impacts.





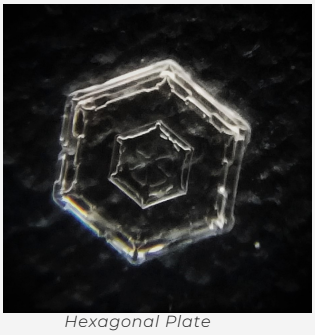
Graphic by Meteorologist Amanda Wagner

ICE CRYSTAL MORPHOLOGY & HOW TO TAKE YOUR OWN PHOTOS

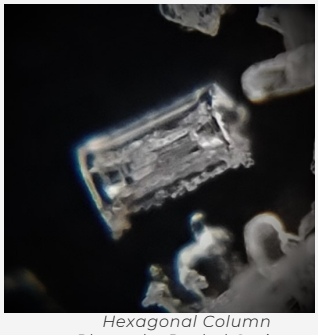
by Meteorologist Rachel Gutierrez

Have you ever heard the phrase “no two snowflakes are alike”? Let’s explore this! In the academic world, “ice crystals” refer to individual plates, dendrites, columns, etc. The term “snowflake” refers to the aggregates of these ice crystals, or the large clumpy snow we see falling during the wintertime.

The two base morphologies (or primary habits) of ice crystals are plates and columns. In the figure below, on the left, we can see a classic hexagonal plate. Ice crystals always form hexagons. This is due to the molecular structure of ice. Once the initial hexagon is established, the plate may continue to grow as a plate, or it may start to grow into a hexagonal column, as we see in the image on the right.

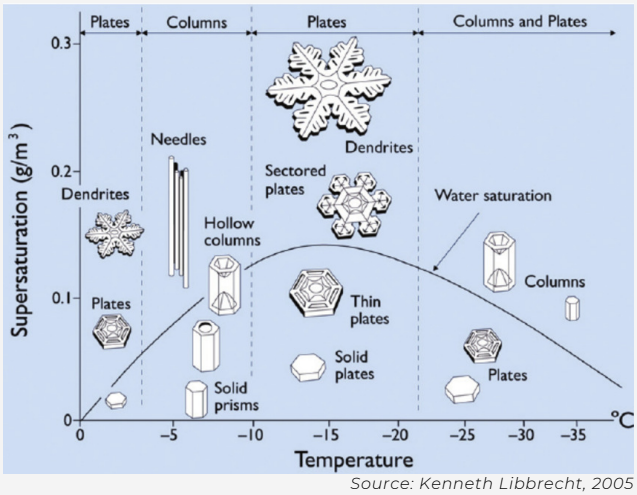


Hexagonal Plate



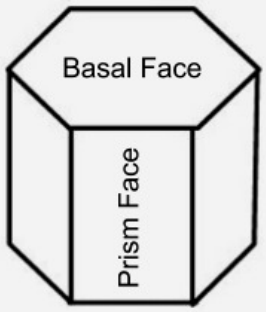
Hexagonal Column
Photos by Rachel Gutierrez

Temperature determines the type of the initial ice crystal: plate or column. The next figure shows how the temperature regime controls the morphology of the primary habit. At the warmest temperatures (0˚C to -3˚C) plates dominate the primary habit. Between -3˚C and -8˚C columns dominate the habit. Then, it switches back to plates between -8˚C and -22˚C. The primary habit alternates based on the temperature regime.

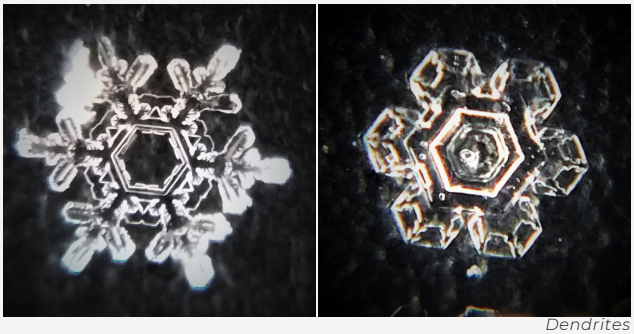


Source: Kenneth Libbrecht, 2005

Let’s take a look at a hexagonal crystal. There are two primary faces on an ice crystal: the basal face and the prism face. We can see the locations of the basal and prism face in the diagram below. If water molecules are added to the basal face and the basal face grows as a result, the final crystal will be a column. If molecules are added to the prism face, the prism face will grow and the crystal will remain growing as a hexagonal plate.

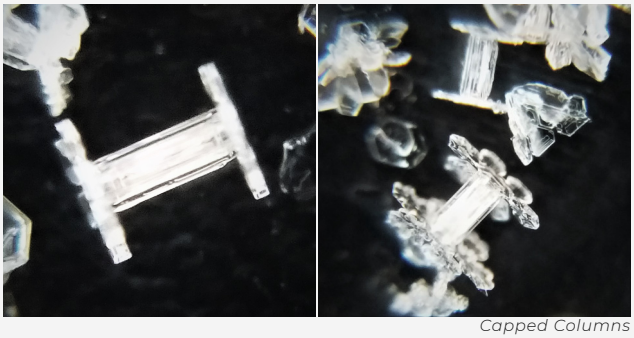


From there, once the base morphology (primary habit) is determined, a secondary habit may form. A secondary habit is any habit that grows beyond the primary habit of the plate or column, such as a dendrite. Supersaturation (with respect to ice) governs the growth and resulting shape of the ice crystal. Supersaturation describes the amount of water vapor in the air. In simple terms, a very moist environment can be described as “supersaturated” while a dry environment can be described as “undersaturated”. A very moist environment is needed to grow ice crystals in the first place. But why does this degree of moisture matter? The larger the supersaturation (or the more water vapor available to grow an ice crystal), the more interesting, intricate, and large the ice crystal can be.



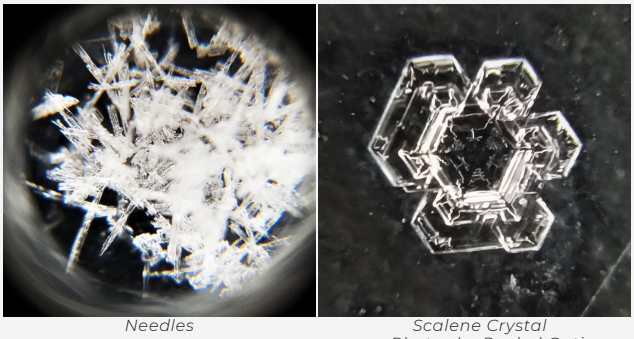
Dendrites
Photos by Rachel Gutierrez

Unique temperature and supersaturation regimes can produce unique ice crystals! For example, a column that develops in one temperature regime may travel to a different part of the cloud that has a different temperature, supporting the growth of plates. This may lead to plates growing on the edges of a column, resulting in a “capped column”!



Capped Columns
Photos by Rachel Gutierrez

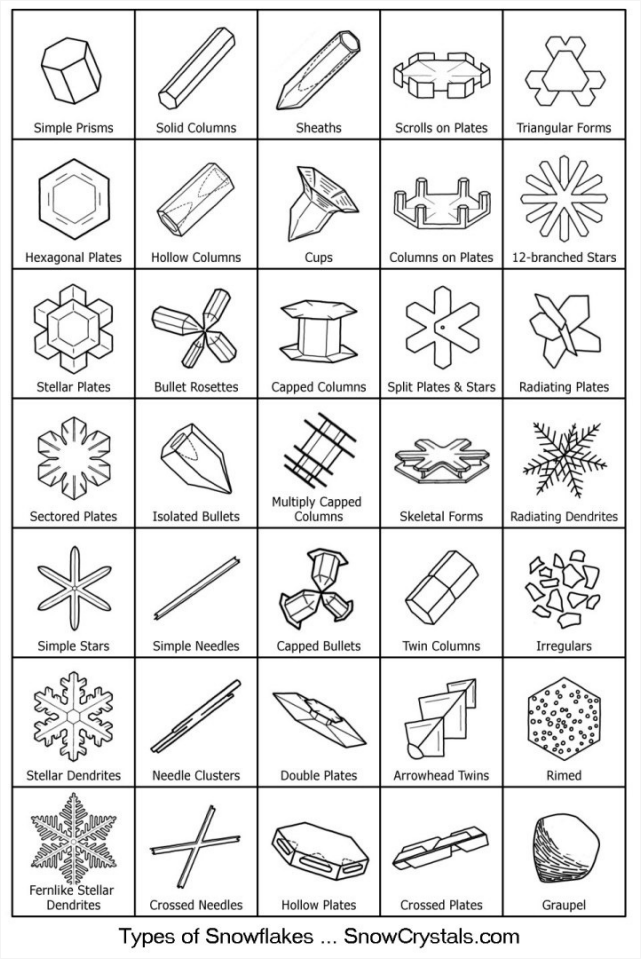
Ice crystals can grow into many different unique shapes such as: needles, bullet rosettes, and capped columns. Ice crystals can also experience “hollowing”, which is when the inside of the crystal hollows out under unique temperature and supersaturation conditions. While most ice crystals are symmetrical, there are some cases in which differing growth conditions may lead to anisotropic growth that will lead to an asymmetrical crystal. These asymmetrical crystals are sometimes called "scalene".



Needles

Scalene Crystal
Photos by Rachel Gutierrez

Take a look at the variety of unique ice crystals that exist! Source: SnowCrystals.com



Types of Snowflakes ... SnowCrystals.com

Now what about that phrase “no two snowflakes are alike”? Well, if two ice crystals were to grow in the exact same temperature regime, the exact same supersaturation regime, experience the same amount and sequence of variations in the environment, and were to take a similar path within the snowstorm, then yes, two ice crystals may look exactly alike. However, given how difficult it is to achieve such exact conditions in nature between two ice crystals, most (if not nearly all) ice crystals will be different!

Get ready to take some awesome pictures this coming winter! You can take your own ice crystal pictures using a smartphone! Simply acquire an attachable microscope (example pictured on the next page) that can fit over your camera lens (mine costs less than $10). You may need to remove your smartphone case in order for it to fit properly. The only other thing you need is a dark-colored flat surface to use as the backdrop for the crystals (I use a black binder).

Make sure that your backdrop has been outside in the cold for a long time otherwise your ice crystals will melt when they fall onto your chosen backdrop. Practice focusing your microscope lens before taking pictures of ice crystals. Once you have your materials, you'll be ready to impress friends and family with your amazing ice crystal photos! Simply let the ice crystals fall onto your backdrop, focus your lens over the crystals, and you're on your way to becoming a snowflake photographer. Happy photographing!

Example of an attachable microscope for a smartphone

Graphic by Meteorologist Amanda Wagner

2020 YEAR IN REVIEW

by Meteorologist John Banghoff

2020 has been full of ups and downs in many respects, and the weather in Central Pennsylvania has been no different. Here we'll review a few of the weather highlights - records, trends, and otherwise noteworthy weather phenomena.

A "Spring" Day and a "Summer" Night

RECORD WARMTH
TIES RECORD
NOT A RECORD

	January 11		January 12	
	Record High Temperature	2020 Observed Temp	Record High Temperature	2020 Observed Temp
Altoona	63° (1975)	66°	66° (2017)	60°
Bradford	65° (2018)	63°	58° (2018)	58°
Harrisburg	71° (1975)	69°	65° (2017)	69°
Johnstown	62° (1963)	64°	66° (1898)	59°
Williamsport	65° (1975)	66°	64° (2018)	65°

Data courtesy of NOAA Online Weather Data: https://w2.weather.gov/climate/xmacis.php?wfo=ctp

/NWSStateCollege /NWSStateCollege @NWSStateCollege www.weather.gov/ctp

The year started out on the warm side, with a burst of warm conditions on January 11th and 12th. High temperatures in the 60s and lows in the upper 50s set records at several climate sites. And then, following the 12th warmest January in state history, average temperatures in February and March were the 10th warmest respective months in the state's 126-year period of record.

The Winter That Wasn't...

Meteorological Winter = December – February

	Altoona	Bradford	Harrisburg	State College	Williamsport
2019 – 2020 Dec - Feb Snowfall	5.0"	52.0"	5.1"	9.6"	10.2"
Rank (Period of Record)	3rd (51 years)	45th (86 years)	3rd (132 years)	4th (128 years)	11th (126 years)

Data courtesy of NOAA Online Weather Data: https://w2.weather.gov/climate/xmacis.php?wfo=ctp

/NWSStateCollege /NWSStateCollege @NWSStateCollege www.weather.gov/ctp

The warm start to 2020 resulted in a top-5 least snowy meteorological winter at several climate sites across the region. 4.9" of Harrisburg's 5.9" snow total fell during the month of January, with 3.9" falling in one storm on January 7th. Otherwise, snowfall was hard to come by. The one exception was Bradford, which benefited from an extended lake effect snow season. Lake Erie's ice extent was only at 0.5% by the end of February, well below the average of 65%!

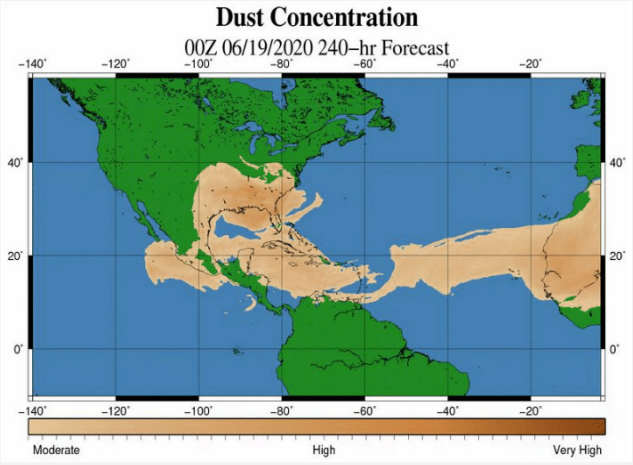
Coldest May Temperatures on Record

LOWS	Altoona	Bradford	Harrisburg	Johnstown	State College	Williamsport
Coldest May Low Temp	25°	18°	31°	26°	27°	28°
Date	5/11/66	5/5/74	5/11/66	5/11/66 5/19/79 5/10/83 5/8/2020	5/9/66	5/14/66 5/5/66 5/1/31
Saturday Observed Low Temp	26°	22°	33°	23°	27°	29°
Rank	2nd	T-6th	4th	1st	T-1st	T-4th
HIGHS	**Altoona**	**Bradford**	**Harrisburg**	**Johnstown**	**State College**	**Williamsport**
Coldest May High Temp	41°	34°	43°	41°	37°	44°
Date	5/9/66	5/9/66	5/5/1917	5/9/47 5/6/2020	5/9/66	5/1/63 5/8/47
Saturday Observed High Temp	40°	36°	46°	35°	41°	46°
Rank	1st	T-3rd	T-2nd	1st	T-4th	T-5th

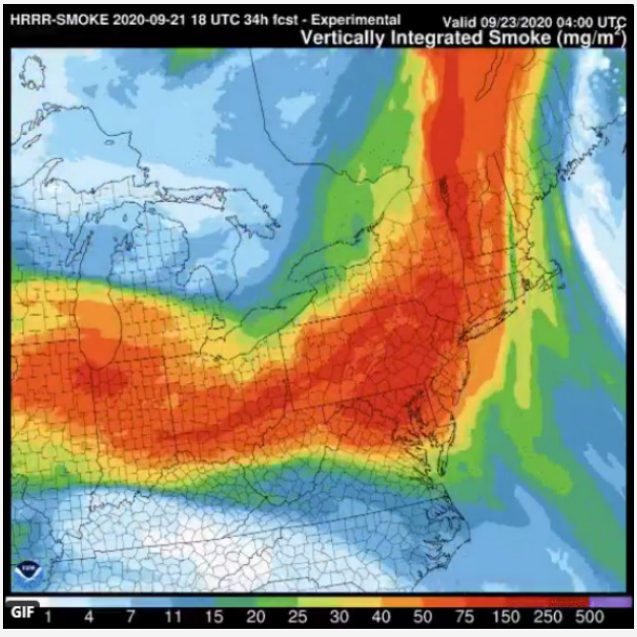
Data courtesy of NOAA Online Weather Data: https://w2.weather.gov/climate/xmacis.php?wfo=ctp — NATIONAL WEATHER SERVICE — State College · PA

The most extreme event of the year occurred during the second weekend in May as a continental polar air mass originating in northern Canada pushed all the way into the southeastern US. Low and high temperatures in Pennsylvania on May 9th were not only record-setting for the date, but the top-5 coldest temperatures ever recorded in the month of May. Lows in the 20s and highs in the 30s-40s were 15 and 25 degrees below-normal, respectively. Adding insult to injury, snow-deprived Harrisburg received a trace of snowfall on May 9th. For more on this remarkable event, visit our webpage at the link below: weather.gov/ctp/RecordColdMay92020

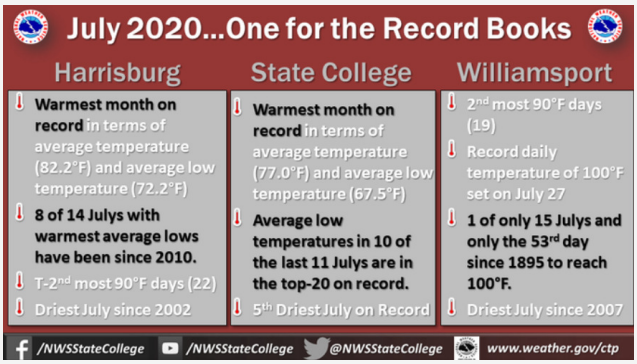
As May turned to June and Spring turned to Summer, all eyes were on the tropics. Hurricane season got off to a fast start but was halted by the arrival of a large plume of Saharan Dust in late June. Some dust actually made its way all the way into Pennsylvania. At the time, nobody could have foreseen another airborne particulate stealing the show later in the year.



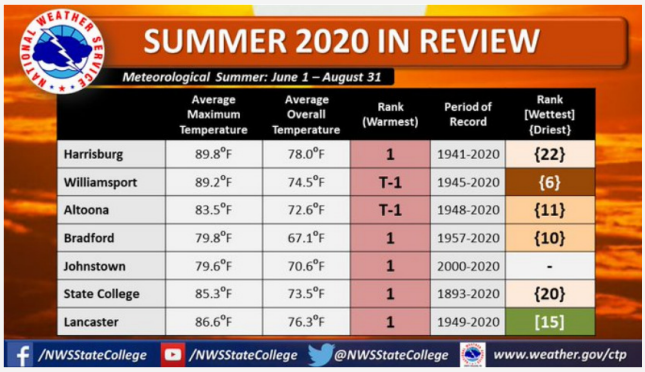
Record aerial coverage of wildfires out west sent incredible concentrations of smoke high in the atmosphere, resulting in the advection of wildfire smoke into Pennsylvania on numerous occasions during the months of September and October. Although the concentration of smoke was low enough and altitude high enough to prevent any health impacts, the presence of smoke limited inbound radiation from the sun and resulted in high temperatures being a few degrees cooler than they would have been in the absence of the wildfire smoke. Hazy skies and a filtered sun were sights to see.



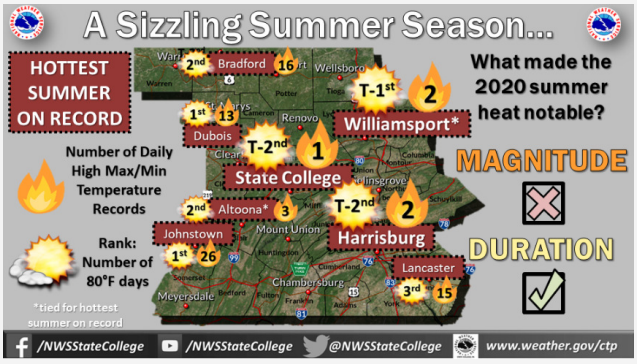
By the second half of June, a persistent east coast ridge had developed, bringing warm temps and a notable lack of precipitation. This pattern continued into July and the numbers speak for themselves, with Pennsylvania recording the 2nd warmest July on record in terms of average temperature.



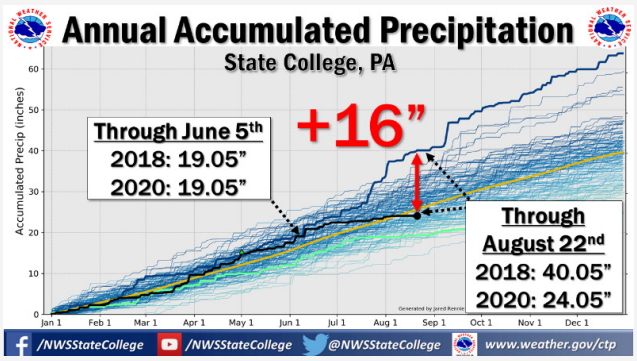
By the end of August, all of the major climate sites in the NWS State College forecast area had recorded their hottest summer on record in terms of average temperature. A record like that can be set one of two ways: (1) extreme heat (a reasonable number of really hot days) or (2) persistent moderate heat.



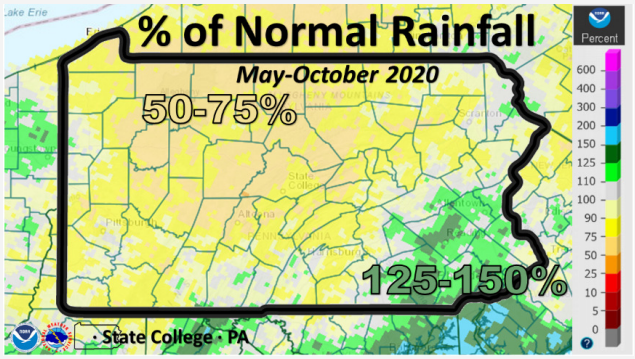
The summer of 2020 was achieved by the latter. State College only set 1 daily high max/min temperature record and Williamsport and Harrisburg only set 2 daily high max/min temperature records over the period. The summer of 2020 is best described as one with a lot of warmth, but barely any extreme heat.



Another defining feature of the second half of 2020 has been persistent drought conditions. Up until early June, State College was on pace with the record-setting 2018 rainfall mark. By mid-June, however, the faucet was basically turned off and a deficit began to develop. Rainfall year-to-date dropped below normal by mid-August and drought conditions have continued to worsen.

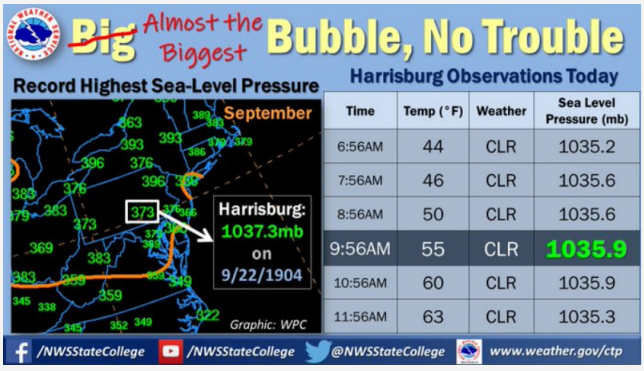


The percentage of normal rainfall map below speaks for itself in terms of ongoing drought conditions. The remnants from Hurricane Isais brought 4"+ of rainfall to already-saturated eastern PA at the end of July, while the drought-stricken central and western parts of the Commonwealth remained rain-free.



In response to ongoing drought conditions, many parts of central and northern Pennsylvania have been placed in Severe Drought (D2). The extent of areas in Severe Drought (10.8% of the state as of 10/20) is the most since 2002. Drought Warnings have been in effect for Clinton, McKean, and Potter County with Drought Watches in effect for 27 more counties.

Another interesting tidbit was the near-record-setting high pressure system that moved over Pennsylvania on September 21st. The sea level pressure of 1035.9 mb fell only 1.4 mb below the highest pressure ever recorded at Middletown Airport. Such high pressure brought widespread sunshine to the Commonwealth!



Graphic by Meteorologist Amanda Wagner

COMET NEOWISE

by Meteorologist Bill Gartner

Comet NEOWISE treated skywatchers and stargazers alike to a beautiful spectacle this Summer. From July into early August the comet appeared each evening on the northwest horizon then lifted up into the scoop of the Big Dipper/Ursa Major before fading during the early morning hours. Along with fortunate position and timing increasing chances for maximum viewing, the weather seemed to cooperate too. Midsummer nights are usually quite humid in central Pennsylvania, but "thanks" to less thunderstorms than usual (which led to the burgeoning drought), many evening skies were extraordinarily clear due to lower humidity.

"Comet C/2020 F3 (NEOWISE) was discovered on March 27, 2020 – not from Earth's surface – but from by a space observatory some 326 miles (525 km) above Earth's surface. It's named for its discoverer, the Near Earth Object Wide-field Infrared Survey Explorer, aka NEOWISE, which was launched by NASA in 2009". Source: https://earthsky.org/space/how-to-see-comet-c2020-f3-neowise

Just binoculars (or a decent cell phone camera) provided stunning details including a beautiful tail.

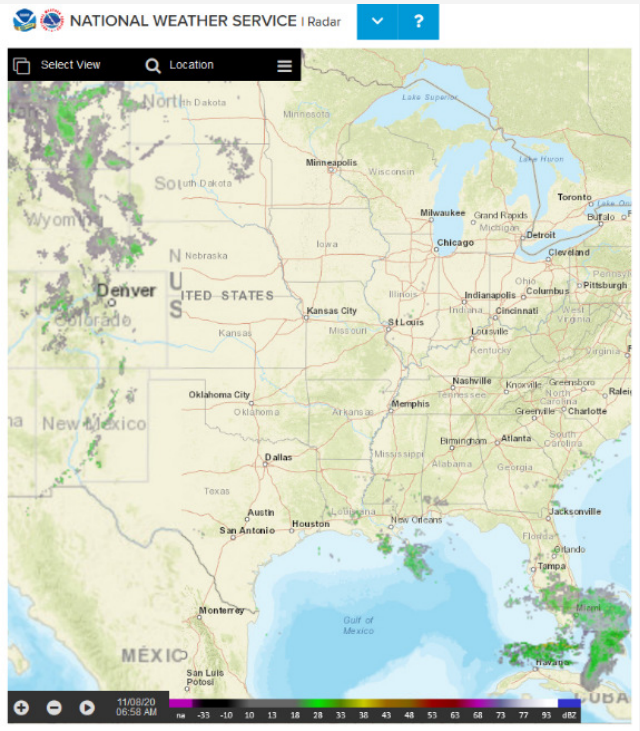
Photo by Rachel Gutierrez

THE NWS RADAR DISPLAY IS CHANGING

by Lead Meteorologist Mike Dangelo

A perhaps long-overdue update to the NWS radar display is slated for early this winter.

The update to the interface will allow much more flexibility in the display, including new map options and overlays, and even more radar data available for display. The new design puts the radar information on top of a familiar map interface, similar to many other web sites you may visit when dealing with geo-spatial information.

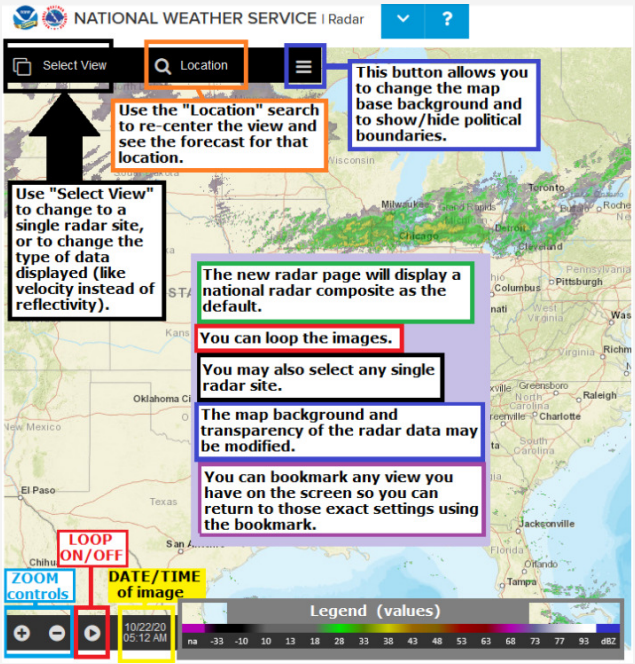


The new interface

In light of the significant changes, we have put together a tutorial to walk you through most of the routine tasks (https://www.weather.gov/ctp/newRadarTutorial).

As of mid-November, the new display is being tested live at: https://preview-radar.weather.gov/.

When the change is complete, the new display should be available at: https://radar.weather.gov/.



Quick reference guide

Truth be told, the new radar display is such a big change that even our meteorologists had difficulty navigating it at first. So, we encourage you to become familiar with the new display-interface. Warning: The preview site can be very slow to load the data onto the map, but we believe that sluggishness should go away when the switch is thrown to make the new display operational.

EARLY SNOW CLIMATOLOGY

by Lead Meteorologist Kevin Fitzgerald

As the days grow cooler and the leaves begin to fall across Pennsylvania, thoughts turn to when the first snowflakes will fly across the Commonwealth. Although an accurate prediction of the first snow is usually only possible several days in advance, climatology can tell us when it's most likely to occur, as well as the earliest and latest extremes. The average date of the first measurable snowfall ranges from early November across the Northwest Mountains, to early December across the Lower Susquehanna Valley. Although most years are fairly close to the averages, there can be large year to year variations, as the table below shows.

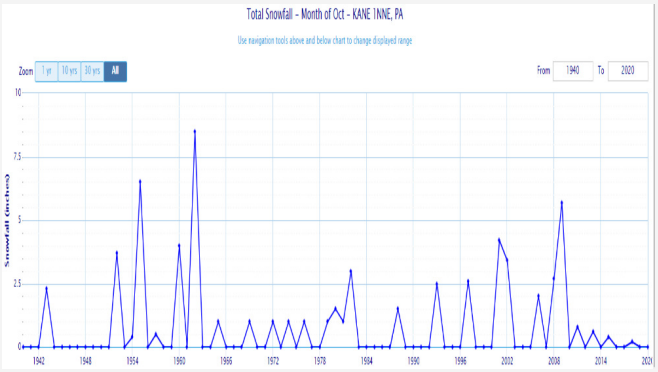
First Snow Climatology

CITY	EARLIEST DATE	AVERAGE DATE	LATEST DATE
KANE	SEP 21 (1956)	NOV 4	DEC 3 (1985)
EBENSBURG	SEP 30 (1993)	NOV 10	DEC 18 (1998)
CONFLUENCE	OCT 4 (1974)	NOV 19	JAN 17 (2005)
BRADFORD	OCT 11 (1988)	NOV 7	DEC 16 (1998)
WARREN	OCT 12 (1988)	NOV 9	DEC 11 (1948)
WILLIAMSPORT	OCT 15 (2009)	NOV 23	JAN 16 (1924)
RIDGWAY	OCT 16 (2009)	NOV 16	DEC 21 (1946)
TAMAQUA	OVC 16 (2009)	NOV 29	JAN 23 (2007)
WELLSBORO	OCT 16 (2009)	NOV 13	DEC 15 (1979)
SOUTH MOUNTAIN	OCT 17 (1977)	DEC 3	JAN 26 (1992)
CHAMBERSBURG	OCT 19 (1972)	DEC 2	JAN 21 (2007)
HARRISBURG	OCT 19 (1972)	DEC 1	JAN 23 (1890)
SHIPPENSBURG	OCT 19 (1972)	DEC 1	JAN 24 (1992)
YORK	OCT 19 (1972)	DEC 9	JAN 26 (1992)

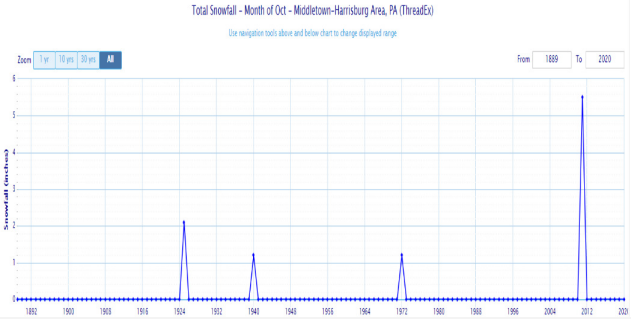
The statistics above are based on data from the NWS Cooperative Observer Network over the last 50-100 years. However, historical records indicate even earlier snowfalls occurred across Pennsylvania during the 1800s. The earliest record of snow in Pennsylvania came on August, 26 1885, when snow showers were sighted at Harvey's Lake, just west of Wilkes Barre. The Annals of Buffalo Valley (Linn 1877) reported a heavy snowstorm on October 5th of 1836, after which snow was reported one and a half feet deep across Penns Valley in eastern Centre County.

In those years in which an early snow occurs, many mistakenly assume that it means a snowy winter is on the way. However, that is not always the case. For instance, the early snowfall of October 19th 1972 was followed by one of the least snowy winters on record across the Lower Susquehanna Valley, where just 4.5 inches was recorded at York and 8.3 inches at Shippensburg.

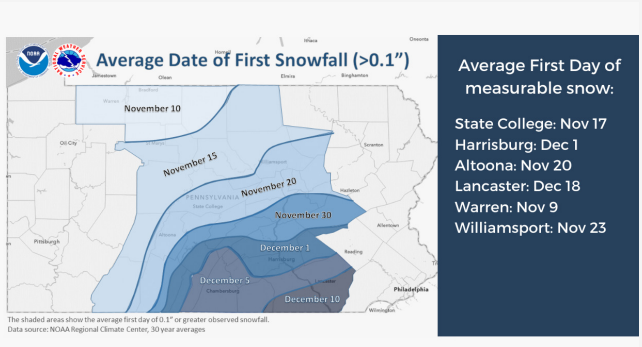
Frequency of early snowfalls across Central Pennsylvania can be measured by the number of years in which measurable snow was recorded during October. Below is a graph for Kane Pa, indicating October snow is likely about once every three years.



A similar chart for Harrisburg reveals the rarity of October snow across the Lower Susquehanna Valley, where only 4 of the last 125 years saw measurable snow.



State College Oct 16, 2009: record earliest snow.



Graphics by Meteorologist Amanda Wagner

UPDATES ON NATURE

by Meteorologist Dave Martin

UPDATE ON HAZARDS IN NATURE: In recent years, there has been a tendency for more extreme weather events. This may have an influence on insects, animals, and disease. In the last several newsletters I have written several articles on various subjects such as Lyme disease and the decline of Monarch Butterflies. I have also discussed chronic wasting disease (CWD).

The big problem this year as folks know has been COVID-19. The first wave of the virus hit back in late winter and early spring. A second wave showed up this summer, now a larger wave is taking place. Like other viruses such as the common cold and the seasonal flu, COVID seems to become more of a problem in cold weather. COVID first showed up in Wuhan, China in December 2019. The disease is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). This virus is deadly to some, but others may not even know they have it. Aside from this virus, other viruses are important for controlling bacteria. It is mother nature's way in keeping things in check.

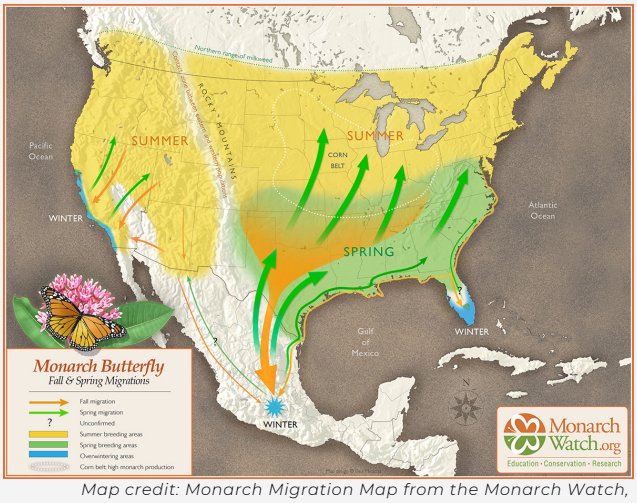
Hot temperatures in the summer on surfaces such as roads and metal objects would help kill the COVID virus. UV rays from the sun also kill the COVID virus. At the current time, there is no cure for the virus. One or more vaccines could be coming out shortly, but it will take time to get a vaccine out to the entire world. Staying healthy with proper rest, diet, and exercise may help; but following CDC and other government guidelines are about the best we can do at this point.

UPDATE ON TICKS: Ticks continue to be a significant problem in Pennsylvania. Aside from Lyme disease, ticks can carry the Powassan virus. The Powassan virus is not as common as Lyme's disease, but has no cure. Unlike Lyme, the tick only has to be on a person for a few minutes for transmission. Within two to three hours of being bitten by a tick infected with the Powassan virus, one may notice headaches, nausea, vomiting, muscle weakness, memory loss, and problems with speech. Unlike Lyme, no rash forms.

Graphic by Meteorologist Amanda Wagner

Folks spending time outside should check for ticks upon coming inside. Putting clothes in the drier for 15 minutes should kill most of the ticks. Allow another 5 minutes for electric dryers. Also allow extra time for damp clothing. After drying the clothes, then one could wash them. The heat kills the ticks, more so than the water.

MONARCH BUTTERFLY UPDATE: After doing better in 2019, the number of butterflies is down again this year. At least some of the problem was that the winter weather in Mexico last winter was hard on the butterflies. Not many were seen across central Pennsylvania or western New York late this summer or early this fall.



Map credit: Monarch Migration Map from the Monarch Watch, designed by graphic artist Paul Mirocha

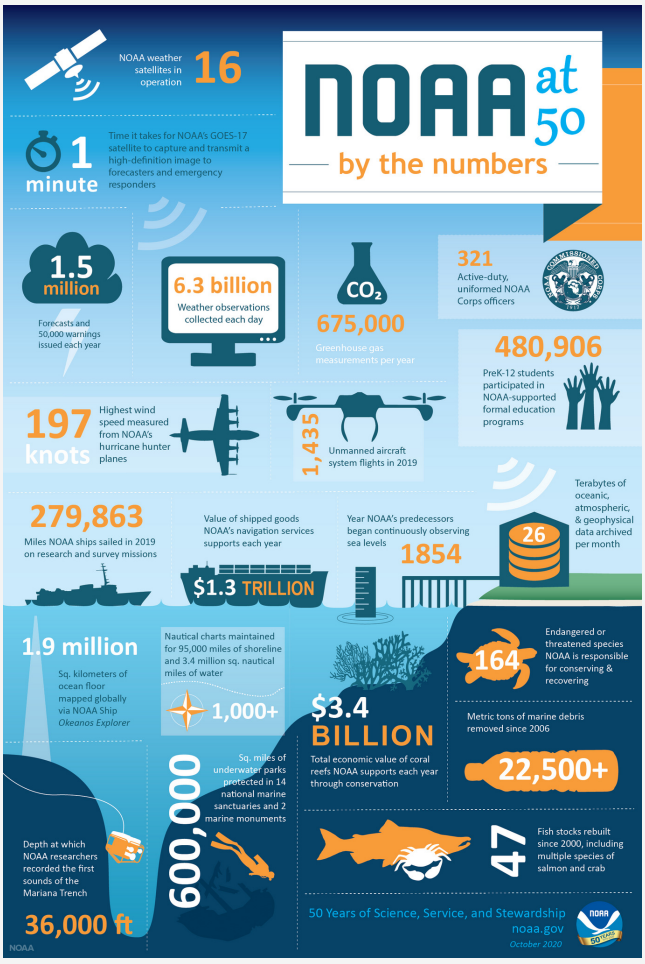
While the warm season is over for another year, folks can help out next year by not destroying native milkweed. Monarch Butterflies need this plant to survive and breed. Spraying along hedge rows, roads, and trails often destroys the native milkweed plants.

SUMMARY: Again, just a few notes on warm and cold season hazards. Education is a big part of understanding our planet and how to handle these issues.

NOAA TURNS 50 THIS YEAR!

by NOAA

Since its inception in 1970, NOAA has become a world-class forecasting and resource management agency with a reach that goes from the surface of the sun to the depths of the ocean floor.



Our unique science mission benefits every American life every day in positive ways, including keeping Americans safer and contributing to greater U.S. economic growth than ever before. In the next 50 years, NOAA will advance innovative research and technology, answer tough scientific questions, explore the unexplored, inspire new approaches to conservation, and continue its proud legacy of science, service, and stewardship.

Our strength is in our people and our partnerships. So many have dedicated their lives to this agency. They love their work and the mission, and it shows. The passion of our workforce throughout the generations has made us who we are. Because of the people who shaped our beginnings, here are some of the ways we serve the nation today:

We are a global leader in environmental science and technology, helping the world adapt to our changing planet.
We are innovating, pushing forward with new research, cutting-edge technologies, and ground-breaking scientific discoveries that will help us better understand our planet.

We are building a Weather-Ready Nation.
We remain at the forefront of weather science, making earlier and more accurate forecasts, equipping emergency responders so communities are informed and prepared for natural disasters. Our forecasts save lives, protect property, boost the U.S. economy and strengthen national security.

We are leading stewards of a cleaner, healthier, more sustainable ocean.
We are leading stewardship of our ocean by ensuring the long-term sustainability of our fisheries, protecting vulnerable marine species and their habitat, and supporting aquaculture.

We power the blue economy.
We are exploring, mapping, and observing our nation's waters — and preserving our underwater parks and coastal reserves. NOAA supports resilient coasts, working waterfronts, marine commerce, and sustainable seafood for a thriving economy.

We are harnessing big data.
We are providing a truly integrated digital understanding of the Earth from data collected by satellites, ships, aircraft, and a vast network of environmental monitoring systems. NOAA leverages this data to help keep the public safe, promote the nation's economic security, protect and manage resources, and enhance our understanding of the planet.

We are strong because of our community.
We achieve all of this with strong partnerships and a high performing, diverseworkforce. We provide new opportunities in science and seek new discoveries thatwill help build resilience and sustainability throughout the nation and the world.

Our workforce is as diverse as our mission. We are biologists, meteorologists, oceanographers, technicians, engineers, communicators, climatologists, hydrologists, educators, analysts, and more. We work in the field and in the office, in planes, under water, on beaches, and on ice. We work on ships above water and send unmanned robots below. We launch technology into space so we can keep a watchful eye on our home from above the clouds. We measure, count, and innovate. We protect. We respond. We partner. We connect science to life. We deliver our science to you.