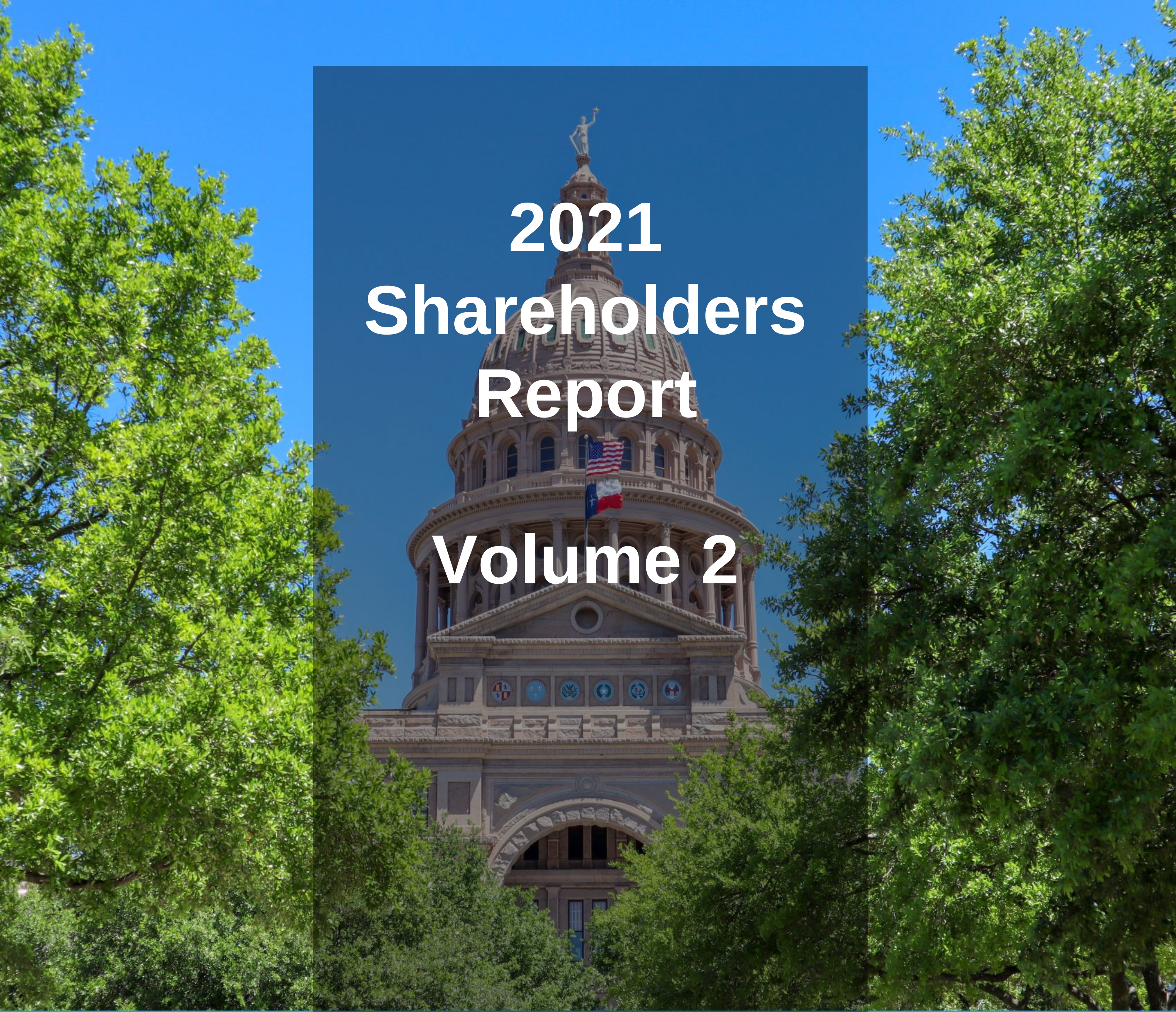

2021 Shareholders Report

Volume 2

National Weather Service
Austin/San Antonio

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Science Corner: Fog

By: Nick Hampshire, Lead Meteorologist

The start of this winter was abnormally warm with temperatures well above normal during the month of December. At the same time, we experienced several mornings of widespread dense fog and many more mornings with patchy fog across the area. Our office has been asked by the public several times, “Why has it been so foggy already this winter?” We will try to explain that here in our latest edition of the “Science Corner.”

First, let’s talk about what fog actually is. The American Meteorological Society defines fog as “water droplets suspended in the atmosphere in the vicinity of the earth’s surface that affect visibility.” To put it more simply, fog is a cloud with its base at ground level that reduces visibility. There are three well known types of fog and each can affect South-Central Texas:

- Radiation Fog: This fog forms when calm winds and clear skies allow the surface temperature to fall. When the temperature meets the dew point, the air is saturated and water droplets will develop.
- Advection Fog: This fog forms as warm and moist air moves over a colder surface, which results in the moist airmass cooling and saturating. This process also leads to water droplet formation.
- Evaporation Fog: This fog forms when cold air passes over warmer water or very moist land and typically remains very shallow to the ground.

However, the fog we have been experiencing this winter on many nights is actually a hybrid of the first two types of fog with some characteristics of both occurring. With the abnormally warm start to the season, we have only had short periods of colder weather behind several cold fronts. When cold air moves into the area, it remains in place for 2 to 3 days before the daily temperatures quickly begin to warm again. It is normally on the transition from a cold airmass to a warm airmass when north winds switch back from the south, that we see the nights with dense fog over a large portion of South-Central Texas. When this occurs we are experiencing some aspects of the advection fog, as light southerly flow during the afternoon and evenings bring in the warmer air and higher dew points, but at night when winds become calmer, the temperature cools to the higher dew points and this is when we see the most dense fog develop. We will see how the rest of the winter unfolds, but if we continue having these short bursts of colder air followed by prolonged periods of above normal temperatures, these transition period foggy nights will likely continue as well.

You can find a short video on the science of fog formation here.

Here are some good fog safety tips everyone should know while driving:

- Slow down and allow for extra time to reach your destination.
- Turn on your low-beam headlights to make yourself visible to others in front and behind of you since your taillights will be on also. Use fog lights if you have them.
- Never use high-beam headlights as they will cause a glare making it more difficult to see what’s ahead on the roadway.
- Leave plenty of space between you and the vehicle in front of you to account for sudden stops or changes in the traffic pattern.

From Frigid Cold to Giant Hail: 2021 Regional Weather Review

By: Keith White, Meteorologist

The first half of 2021 featured several memorable weather events across South-Central Texas. Things quieted down quite a bit after May, with a mild summer followed by a hot September. Significant flooding occurred in mid-October, and then we rounded out the year with the hottest December on record for the state of Texas, with more than 125 years of historical observations to draw from. Here's a rundown of some of the most impactful weather events from the last year:

January Snowstorm

When most folks think about winter 2020-2021, they remember the insanity of mid-February. But for areas north of Kerrville to San Marcos to La Grange including the Austin Metro, an early taste of what was to come arrived Jan. 10. Some locations in Travis and Williamson counties picked up 4+" of snow. See our event review document linked in the subtitle above for a full run-down of the event including some photos!

February Deep Freeze and Winter Weather

Exactly one month later on Feb. 10, the first push of a strong arctic airmass began to arrive. The first of a gauntlet of four winter precipitation events would arrive early on Feb. 11 with significant icing over many of the same portions of the Hill Country and Austin Metro area. Temperatures would continue to drop, falling below freezing in Austin for six full days (a new record) and in San Antonio for four and a half. The coldest air arrived late on the 14th and heavy snow spread across portions of the region. Accumulations up to 7.5" were recorded. For Austin and San Antonio, it was the 4th and 5th highest snowfall event on record, respectively, with data spanning over 120 years.

Following the snow, lows plummeted into the single digits across much of the area on the mornings of the 15th and 16th, easily in the top ten coldest temperatures ever recorded here. We started to warm up after that, but the impactful winter weather wasn't done yet!

Late on the 16th into the 17th, another round of freezing rain brought up to a half inch of additional ice accumulation to many of our northern counties. Then, a reinforcing cold front and another upper level disturbance allowed heavy snow to develop on the 18th across primarily western portions of our area. This event brought another 2.5" of snow to San Antonio and 11" to Del Rio, an all time record! In all, dozens of temperature and snowfall records were broken across the area and impacts were widespread and significant. When taken as a whole, it's arguably the worst week of winter weather our region has ever experienced. Again, more details are linked above.

Lots of Hail

Spring 2021 was relatively stormy, and South-Central Texas experienced a greater-than-usual amount of very large hail (>2" diameter) particularly from late March through early May. In total, 7 separate events with 2" or greater hail occurred in our region this spring (Table 1). There was also one additional 2" hail event near La Vernia on December 18th. Some more details on the Hail, Wind, and Tornado Events of March 22-25 and the April 28-May 1 period can be found in the linked event reviews, and specifics on the verification of the state record Hondo hailstone follow in the next article on page 5!

Date	Hail Size	Locations impacted
3/22-3/23	2-3"	Burnet County (2.5-3"), Leakey (3"), 7 NNE New Braunfels (2")
3/24-3/25	2"	Edwards/Real counties + Northeast Austin
4/12	3"	7 W Llano
4/15	2-2.75"	Burnet, South Williamson, North Travis counties
4/28	2-3"	Del Rio, Brackettville, Uvalde County, San Marcos
4/28 (cont'd)	4-6.4"	Medina County (largest near Hondo)
5/3	2-2.75"	Boerne (2.75"), Lakehills (2"), New Berlin (2")
5/3 (cont'd)	3-5.5"	Bexar County (up to 3" reports in San Antonio and 4-5.5" in China Grove Area)
5/9	2.5"	2 WSW Willow City (Gillespie County)

Table 1: Springtime Very Large Hail (>=2" diameter) events in South-Central Texas.

October Flooding

Significant flash flooding and river flooding took place as a result of heavy rainfall during the morning hours of Oct. 14. A slow moving boundary combined with Gulf and Pacific moisture from Hurricane Pamela resulted in two pockets of 5-10" rainfall accumulations. The first was widespread 5 to 8" totals across much of Comal County below Canyon Dam and across Hays County between Wimberley and San Marcos. This led to rises to moderate flood stage along the Guadalupe through New Braunfels and moderate to major flood along the San Marcos River from San Marcos to Luling. This water moved downstream and combined with 8 to 10" of rain that fell across Gonzales County to continue the moderate flooding along the Guadalupe from Gonzales to Cuero. Notably, Sandies Creek at Westhoff crested in major flood stage at its 3rd highest crest ever, above its crest during Hurricane Harvey, and just below the crest of the 1998 flood. Ten Flash Flood Warnings were issued in addition to the numerous River Flood Warnings. Two people perished when the vehicle they were in was caught up in floodwaters just east of San Antonio.

Record December Warmth

The memorable winter chill of mid-February was impressive, but ultimately it lasted just 7-8 days. The multiple warm spells in December summed to about two and a half weeks worth of double-digit temperature anomalies. When taken as a whole, December's monthly anomalies more than cancelled out the negative ones from February. All four of our first order climate sites of Austin Camp Mabry (ATT), Austin Bergstrom (AUS), San Antonio (SAT), and Del Rio (DRT) set about a half dozen daily records for high daytime temperatures and high minimum temperatures, and all but San Antonio (where records include a warm 1889) broke their monthly temperature record by a significant margin in December. At ATT, SAT, and DRT, no freezes were recorded before the end of 2021 (they did finally occur behind a strong cold front on January 2nd, 2022). This has only happened 3, 7, and 7 times before, respectively.

Figure 1: Flooding observed on July 6th on US-90 at Leon Creek. Photo courtesy KSAT12 News.

Everything is Bigger in Texas: The New State Record Hailstone at Hondo

By: Jon W. Zeitler, Science and Operations Officer and Aaron Treadway, Lead Meteorologist

During the evening of April 28, 2021, two supercell thunderstorms eventually merged into one and produced wind gusts of 75 to 100 mph, an EF1 tornado, and very large hail as it tracked along U.S. Highway 90 between Del Rio and San Antonio. The storm had many signs of a very strong updraft. Figure 1 shows the progression of the storm, while Figure 2 shows a bounded weak echo region, an area where the air is moving upwards in the updraft so quickly that it pushes all of the precipitation (rain and hail) up and away from the ground. While the storm produced a tremendous amount of damage along its path, the worst was in Medina County, where the combination of high winds and large hail shredded mobile homes, RVs, roofs, and windows. Figures 3 and 4 below show some of the damage in D'Hanis.

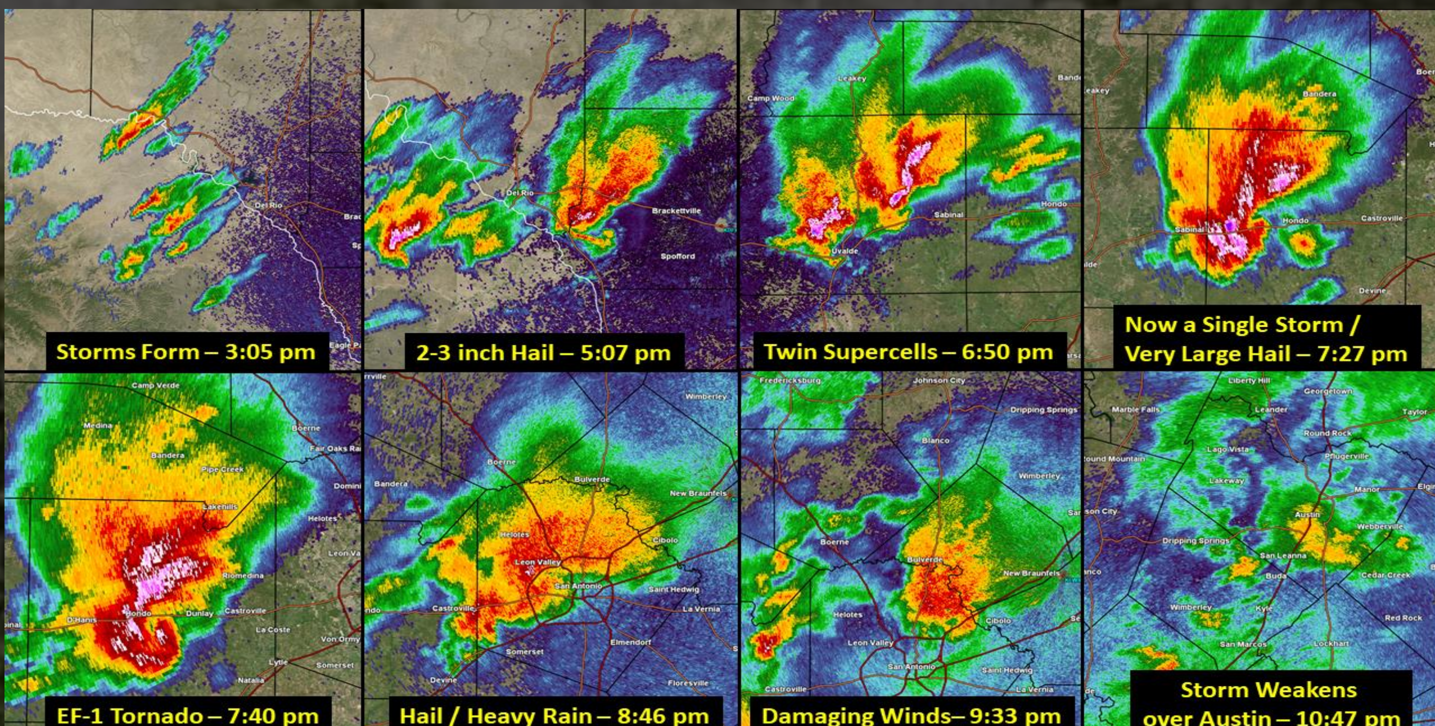


Figure 1: The progression of the supercells from development to merger to dissipation as seen from the KDFX and KEWX radars.

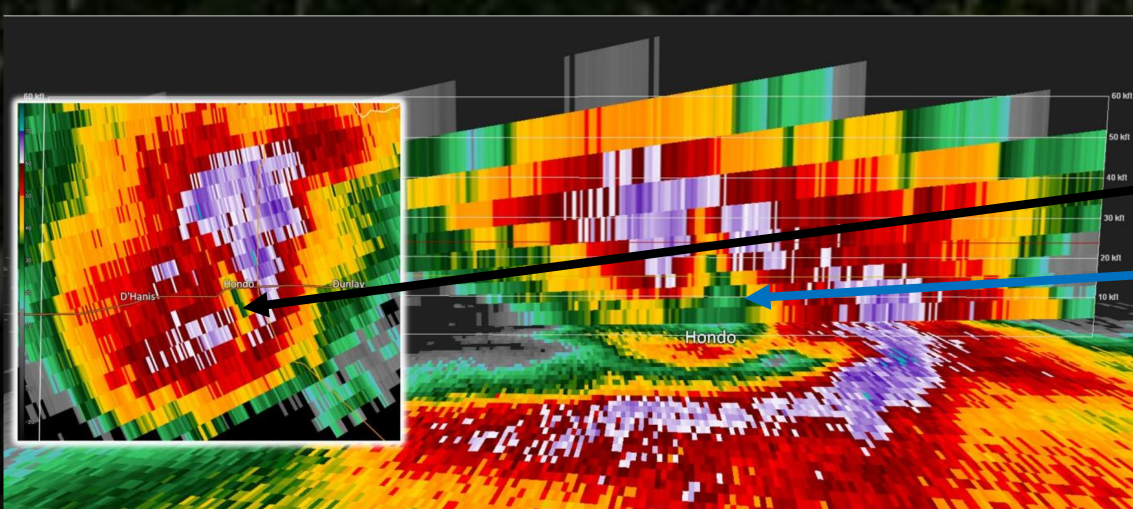


Figure 2. A bounded weak echo region, or BWER (the donut shape in the top-down image and the upside-down V shape in the cross section) on radar is indicative of a very strong updraft.

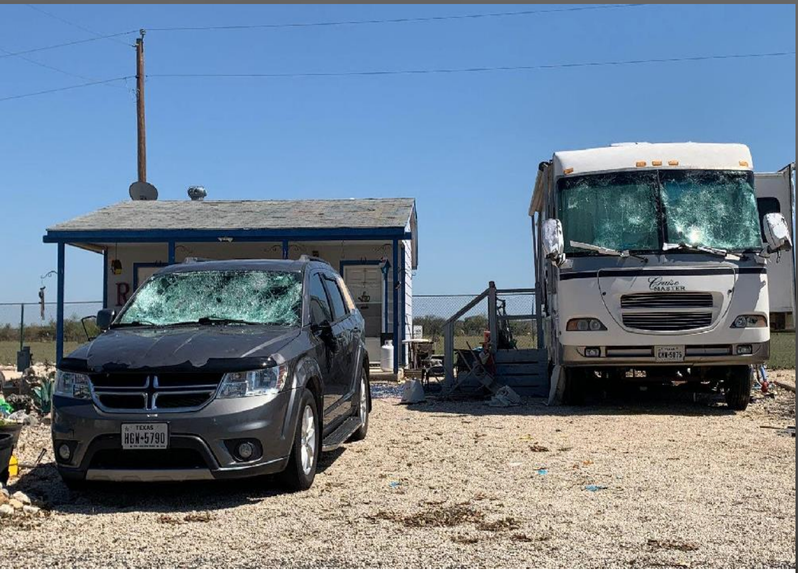


Figure 3: Extensive Damage at an RV Park in D’Hanis, TX, due to wind-driven hail. Photo by NWS Austin-San Antonio.

Figure 4: Extensive Damage to a Stripes Gas Station in D’Hanis, TX. Photo by NWS Austin-San Antonio

Besides the widespread damage, one gargantuan hailstone fell in Hondo, that ended up setting new Texas state records for maximum diameter, circumference, volume, and mass. The stone measured 6.4" in diameter, 19.7" in circumference, 40.2 cubic inches in volume, and had a weight of 1.26 pounds. To establish these new records, our office teamed up with the Office of the Texas State Climatologist (to compare the new hailstone to previous historical reports), and the Insurance Institute for Business and Home Safety (to make precision measurements and imaging of the hailstone). Figure 5 shows the hailstone shortly after it fell and Figure 6 shows the measuring and scanning process.

Figure 5: Gargantuan hailstone that fell at approximately 735 pm on April 28, 2021 at Hondo, Texas. This photo was taken between approximately 30 and 60 minutes after the hailstone fell.

Figure 6: The gargantuan hailstone was scanned and analyzed by IBHS and NWS Austin-San Antonio staff on May 6, 2021 at the finder’s home in Hondo, Texas. Photo by NWS Austin-San Antonio.

The largest credibly reported hailstone diameters in Texas prior to the April 28, 2021 storm are:

8“, Washington County, Dec. 6, 1892
7 to 8'', Winkler County, May 31, 1960
6”, Moore County, June 12, 2010
6'', Ward County, May 10, 1991

However, these prior events were missing photographs or certified measurements to be further considered for the Texas State records, so the Hondo hailstone was certified as the new record for Texas. The storm produced other gargantuan hailstones, one of which may have been nearly as big as the certified stone, but the finders broke it up and used it for margaritas!

Since our spring severe weather season is only a few months away, you can help us out by reporting hail when it occurs at your home, work, or school. A great hail report includes a photo of the hailstone(s), along with a ruler, coins, or sports balls (golf, tennis, baseball, softball), so we can easily see the size. A good example is in Figure 7. By posting the photo to Twitter and tagging us with @NWSSanAntonio and the hashtags #EWXSpotter and #txwx, we will see the reports immediately. You can also post on Facebook and tag us at US National Weather Service Austin-San Antonio, Texas.


Figure 7: Photo by Anne Duran

You can read the complete State Climate Extremes Committee report on the Hondo Hailstone from the National Center for Environmental Information Here.

Precipitation Estimation and Flash Flood Forecasting With MRMS

By: Aaron Treadway, Lead Meteorologist

The summer 2021 newsletter included an article detailing how precipitation could be estimated using the WSR-88D radars. The truest and most accurate way to measure precipitation is through direct rain gauge observations, but the radar gives us a way to estimate precipitation in areas where rain gauges may not be present, or where rainfall observations are only reported every few hours or once a day. Meteorologists use this data to issue life-saving Flood Advisories and Flash Flood Warnings. While the WSR-88Ds are excellent tools and offer several precipitation estimation products, and meteorologists can directly compare precipitation estimations from two neighboring WSR-88D radars, technology was developed in 2014 that uses multiple sensors or sources to improve the overall data output.

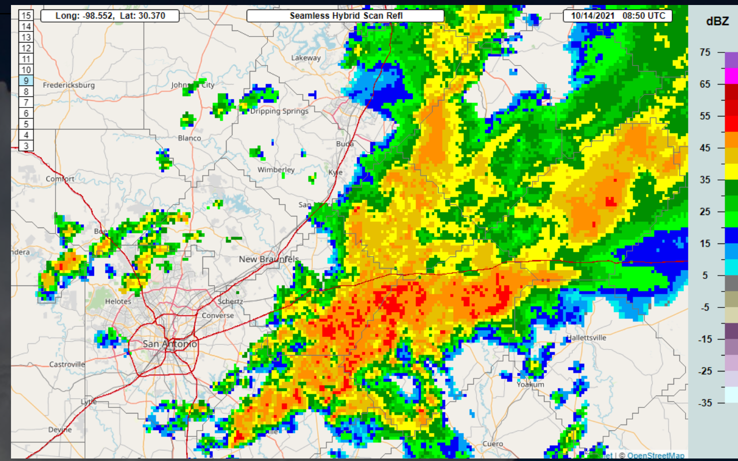
Multi-Radar, Multi-Sensor (MRMS) is a set of automated algorithms that integrates data from the entire WSR-88D network across the country in addition to surface, upper air, and satellite observations, lightning detection, and high-resolution forecast models. Compiling all of this data allows MRMS to produce a suite of products that stitch together these input products in a way that creates a seamless picture across the entire Continental United States (CONUS). Where the WSR-88D network may have some gaps, MRMS uses the other observations to help fill in some of these gaps. While MRMS includes common products like base and composite radar reflectivity, it also includes hail estimation, rotation track, and lightning products, as well as many different precipitation estimators and the Flooded Locations and Simulated Hydrographs (FLASH) suite of products. These precipitation estimators and FLASH products will be covered in the remainder of this article. Use the MRMS Operational Products Viewer to review all of the products either live or in an archive.

For the precipitation suite of products there are a trio of inputs: radar reflectivity from the WSR-88D network, rain gauges from ASOS observation stations, river gauges, and other sources, and model data (specifically the High-Resolution Rapid Refresh [HRRR]). These three inputs are used to create two distinct groups of products: products that are strictly radar-based, and others that are multi-sensor products. The first step in creating all of the precipitation MRMS products is to run the raw WSR-88D data through several quality control (QC) checks to remove non-meteorological returns, classify whether the precipitation is convection or stratiform, and then clean up any data issues caused by bright-banding or data dropouts due to beam blockages. Once the QC has been completed a product called the 'seamless Hybrid Scan Reflectivity' is created and mosaiced together across the CONUS. From this single product other MRMS precipitation products delineating precipitation type and rate are created. Other products, such as the FLASH products, then fall out of this pair of products. In summary, the MRMS system uses base data sources to create mosaiced products that then utilize models or ground truth data sources to create another tier of products.

Some of the radar-based and multi-sensor products are discussed below. The products, unless otherwise noted, have 1 km resolution and update every two minutes. This high resolution in both spatial coverage and time is key when meteorologists need to make quick decisions about Flash Flood Warnings or observe how heavy rainfall may run off into area rivers and potentially cause river flooding.

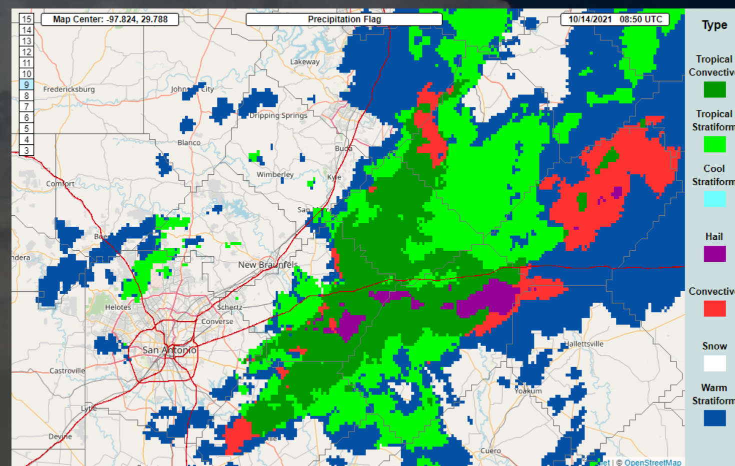
Seamless Hybrid Scan Reflectivity (SHSR)

SHSR is a QCed mosaic of the WSR-88D data network, stitching together neighboring radars. The product includes additional low level scans from the WSR-88D and can include data from upper tilts in the radar volume coverage pattern when needed. The result is one cohesive radar output for the entire CONUS.



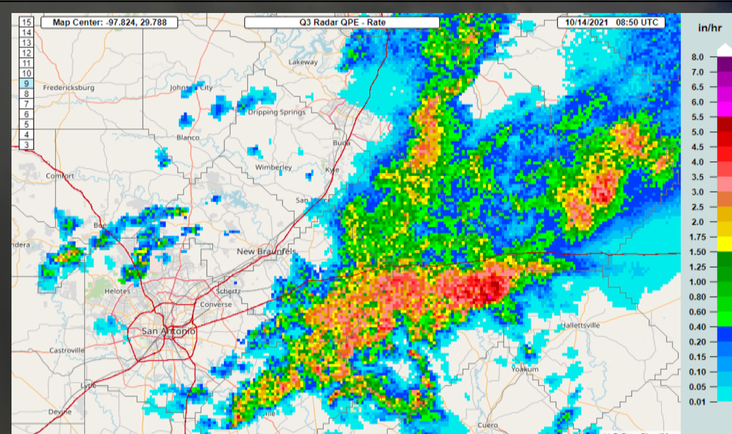
Surface Precipitation Type (SPT)

This product is created so that the MRMS processes can accurately assign a rainfall rate relationship to the type of precipitation falling. Different data, including hail algorithms, surface and wet bulb temperatures, the height of the freezing level, and the intensity of reflectivity returns are used to classify the precipitation. Stratiform rains are light to moderate, steady precipitation, while convective rains come from thunderstorms.



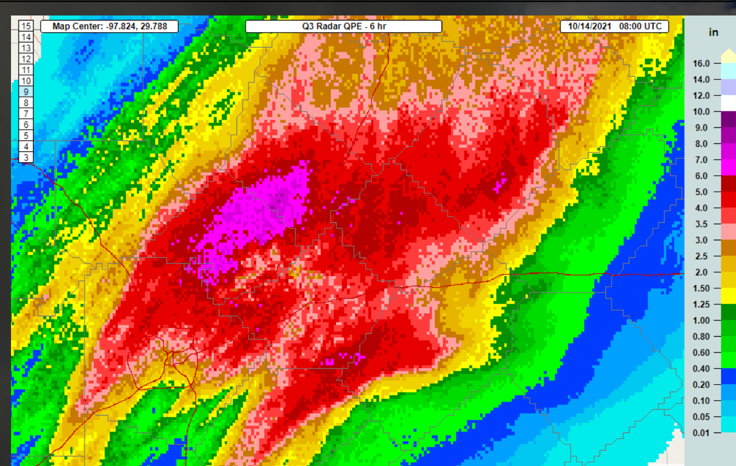
Surface Precipitation Rate (SPR)

This product uses the SPT and SHSR MRMS products along with the HRRR/RAP model to produce spatially-varying rainfall rates. This helps reduce the over and under estimation of rainfall amounts as a whole. Different rainfall rates relationships are applied to different types of precipitation identified in the SPT product, and an evaporation correction is also applied.



Radar Only and Multi-Sensor Quantitative Precipitation Estimate (QPE)

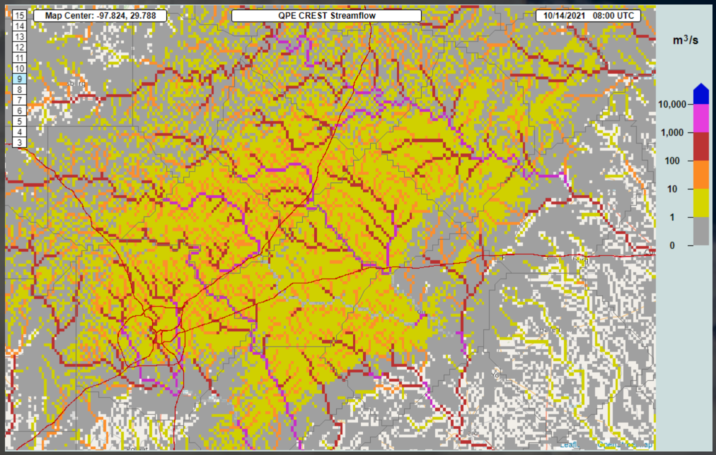
The one hour accumulation radar-only product is a summation of the SPR MRMS product over the last 60 minutes and is updated every two minutes. Longer durations are summed at the top of each hour. MRMS also uses ground truth gauge data combined with interpolation, mountain adjustments, and model estimated precipitation forecasts to produce multi-sensor QPE data that updates hourly rather than every two minutes.



The FLASH suite of MRMS products are multi-source products that use the MRMS Radar Only QPE as well as precipitation rate as inputs that are either run through a model or compared against recurrence interval or flash flood guidance data sets. There are three model derived FLASH products that attempt to simulate how the rainfall is impacting area streams and rivers, overland flow (water runoff in a city setting), and soils. The models that this data is run through each have their own unique benefits. The CREST model is better at simulating runoff and soil saturation in low-lying areas, the SAC-SMA model tends to do better with runoff in urban areas, while the hydrophobic model presents a 'worst-case scenario' and assumes that all of the rainfall becomes runoff and feeds directly into urban or river flooding rather than being absorbed by the soils. Two more data-based products compare radar QPE to either the NOAA Atlas 14 precipitation frequency data set or the flash flood guidance produced by the NWS River Forecast Centers. To learn more about the FLASH products, see the examples below. Generally, MRMS FLASH products are also 1 km in resolution but since most are being run through a model, they update every ten minutes (unless otherwise noted).

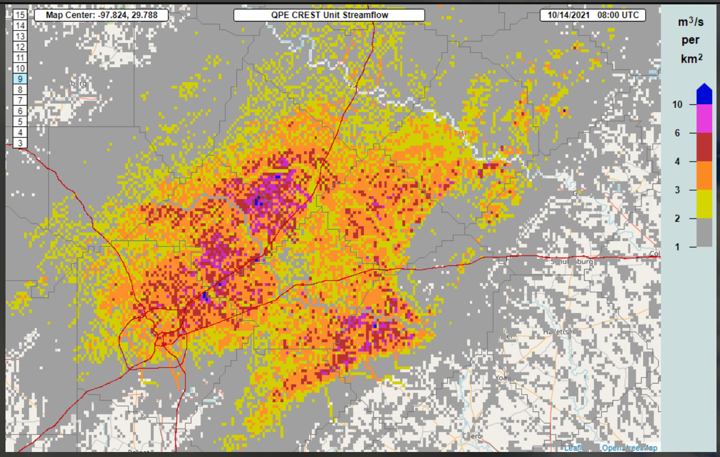
Max Streamflow

This product is the maximum surface water flow that has occurred over each point during the period (usually the last 30 minutes to the next 6 hours). The product helps visualize the areas of higher flow along stream and river networks and shows how these higher flows move downstream. This data can be compared to USGS river gauge information as well.



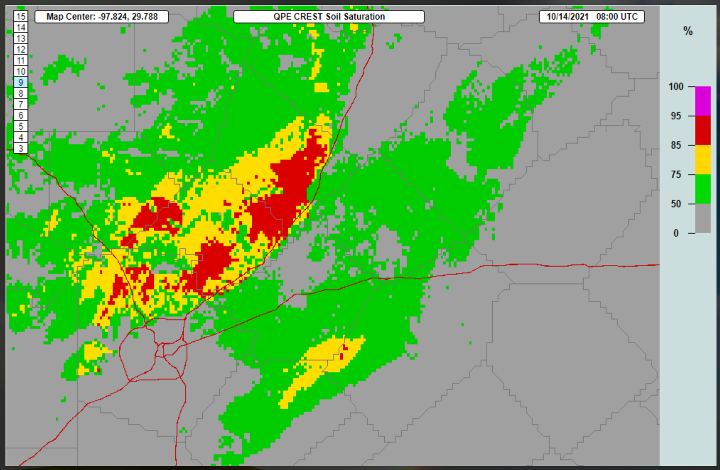
Max Unit Streamflow

This is the normalized maximum streamflow by the basin area at each grid point. This is a key product in Flash Flood diagnoses as it highlights where high flows are occurring over a normalized area. Rather than specifically looking at flow in a river system, this looks at flows over a specified area. This better represents overland flows that may be impacting urban areas.



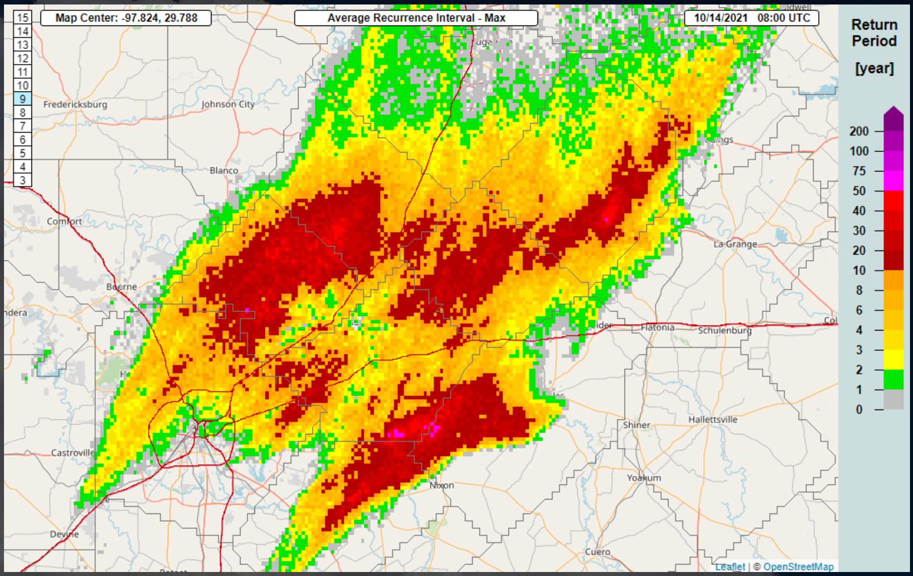
Soil Saturation

This product takes the model output water content in the top-layer soils (based on rainfall rates and runoff) and compares it to the maximum storage capacity of the area soils. This helps forecasters see antecedent soil conditions leading into a rainfall event, monitor how heavy or long duration rainfall has caused saturated soils, or begin to judge that saturated soils may produce more runoff and thus more flooding.



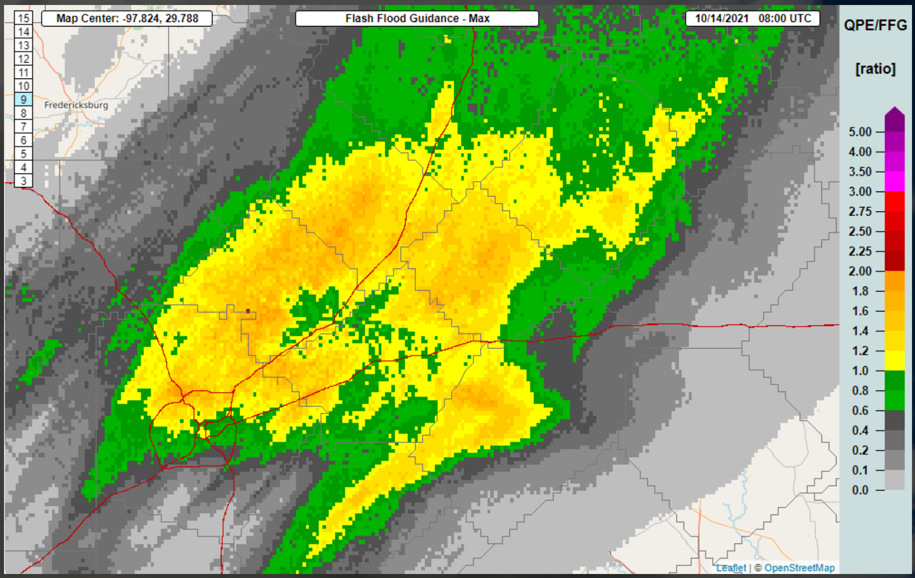
Average Recurrence Interval

This product compares the MRMS radar-only QPE to NOAA Atlas 14 precipitation frequency estimates (a dataset that looks at the history of an area and determines how often a certain rainfall amount occurs). This helps determine the rarity of a rainfall event over a given time period. It is important to remember these are precipitation return periods which do not always correlate directly to flooding.



QPE-to-FFG Ratio –

This is the MRMS radar-only QPE divided by the Flash Flood Guidance (a prediction of how much rain would need to fall for flash flooding to occur produced by the River Forecast Center) for each grid point. When the percentage reaches 100% then the amount of rain matches the predicted amount the RFC says will cause flash flooding over an area. Flash flood guidance is updated every six hours by the RFCs. This product updates every two minutes.



All of the examples above were taken from early in the morning of October 14, 2021 during the heavy rainfall event across the I-35 corridor and Coastal Plains. For additional training on the various MRMS Products search this website from the Warning Decision Training Division of the National Weather Service. Specifically look for the courses under 'MRMS Hydro Products Course' and 'FLASH Product Course'.

NWS Austin-San Antonio Welcomes New Meteorologist Andrew Quigley!

My name is Andrew Quigley, and I couldn't be more excited to be joining the staff at NWS Austin/San Antonio! I'm a born and raised Green Bay, Wisconsin boy, and will remain an unapologetic Packer fan despite my move to the Lone Star State. I completed both my undergraduate and graduate education at the University of Wisconsin-Madison, graduating with my B.S. and M.S. in Atmospheric and Oceanic Sciences in the spring of 2020 and summer of 2021 respectively. As the capstone to my master's degree, I spent last summer working on the surface analysis desk at the Weather Prediction Center in College Park, Maryland.

Like most meteorologists, I've had a passion for the weather since I was a little kid. I vividly remember flipping between Spongebob Squarepants and Storm Stories hosted by Jim Cantore after coming home in the evenings during elementary school. This passion stuck with me through my middle and high school years, which made it an easy choice to study meteorology in college. For whatever reason, my five years at the University of Wisconsin-Madison revealed my affinity for convection and its hazards, which tends to be the focal point of the research projects I am working on outside of shift hours. It goes without saying that I'm intrigued with the forecast challenges that south-central Texas storm season presents!

Outside of meteorology, I love to exercise and spend time outside. I try to lift weights several times a week, and you can catch me jogging the streets of New Braunfels once or twice weekly. Having spent my life in many Wisconsin winters, it's a refreshing change of pace to be able to wear shorts year-round! Aviation is another huge interest of mine, making the process of issuing Terminal Aerodrome Forecasts (TAFs) from the short-term desk very exciting. I'm also a huge fan of cooking and barbeque, and I'm trying to hit as many of the outstanding barbeque joints around the area as possible.

I'm thrilled to be writing the next chapter of my career in the Austin/San Antonio area, and look forward to getting into the public and learning more about y'all. It's my hope that I will be able to get involved in outreach (virtual, for now) after completing additional training over the coming weeks, so don't hesitate to introduce yourself when you see me!

National Weather Service Austin/San Antonio

2090 Airport Rd
New Braunfels, TX, 78130
(830) 629-0130

weather.gov/ewx

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Newsletter Editors:
Keith White
Jon Zeitler
Paul Yura