THE WEDGE FRONT

NATIONAL WEATHER SERVICE GREENVILLE-SPARTANBURG SC

Volume 1, Issue 1 Spring/Summer 2018

INSIDE THIS ISSUE

Our Office Newsletter - It's Back!

Welcome to the debut edition of The Wedge Front! It's been several years since our last newsletter was hot off the press here at the National Weather Service office in Greenville-Spartanburg, SC (NWS GSP) - we're extremely excited to have it back! Filled with information of past weather events, weather safety information, various services we provide, collaborative efforts with the community, and much more, you will find our newsletter tailored to the area in which we are responsible - our County Warning Area (CWA), which includes 46 counties across northeast Georgia, Upstate South Carolina and western North Carolina.

The primary goal of the National Weather Service is to protect life and property which we achieve through the dissemination of weather information, collaboration with county and state officials, outreach events, and much more! On behalf of the entire staff at NWS GSP, comprised of meteorologists, electronic technicians, and more, hope that you enjoy our office newsletter and find it beneficial.

The Wedge Front will be published twice a year (Spring/Summer and Fall/Winter), with possible issues in between. We welcome feedback, comments, and any suggestions that you may have!

NWS GSP Joins NWS Columbia for Weatherfest

NWS GSP meteorologists Sandy LaCorte and Lauren Carroll travelled to Columbia, SC on March 10, 2018 where they participated in "Weatherfest" organized by the NWS Columbia office. Weatherfest took place at EdVenture Children's Museum in Columbia, SC and included numerous NWS core partners, including the South Carolina Forest Service, South Carolina Emergency Management, and local TV stations WIS and WLTX, among many others.

Left photo: (from left to right) Meteorologists Lauren Carroll, Sandy LaCorte, Chris Rorbach, Whitney Smith, John Quagliariello, Leonard Vaughn, and Rachel Cobb stand in front of the EdVenture Children's Museum in Columbia, SC after the conclusion of Weatherfest on March 10, 2018.

Lauren and Sandy helped staff the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) booth at Weatherfest, teaching kids and adults alike the importance of volunteer weather observers to the National Weather Service mission. Kids learned how to measure rainfall using standard 4-inch rain gauges, how to determine hail size and use a hail board, and even got the chance to take "snow" measurements! Many families signed up to become volunteer weather observers for CoCoRaHS after visiting the booth, growing the network of volunteer precipitation observers in South Carolina. Best of all, everyone had fun learning about the science of precipitation and weather!

- Lauren Carroll, Meteorologist

The Experimental Probabilistic Snowfall Experiment

Professional baseball player (and amateur philosopher) Yogi Berra once said: "It's tough to make predictions, especially about the future." Berra may not have had snow forecasts in mind when he uttered this Yogi-ism, but his words apply nicely to the uncertainty inherent in all weather predictions.

Meteorologists have long acknowledged that *deterministic* forecasts (e.g. "snow accumulations around 3 inches") do nothing to convey the degree of uncertainty in the forecast. To address this information gap, the National Weather Service has begun providing *probabilistic* snowfall forecasts on an experimental basis. In years past, we might have simply featured a set range around the official forecast as a reflection of uncertainty. For example, a deterministic forecast of three inches might be conveyed as "2 to 4 inches" in text forecasts and warnings. However, all events differ. Perhaps it is reasonably possible that as little as 1 inch could fall, while it is also conceivable that 10 inches might accumulate in a worst-case scenario. The probabilistic snowfall project attempts to quantify the uncertainty by providing reasonable minimum, maximum, and exceedance graphics that have a solid scientific and mathematical basis.

The **GSP Experimental Probabilistic Snowfall Project** page is available at:

http://www.weather.gov/gsp/winter

On this page, the current official NWS forecast of storm total snow accumulations is prominently featured. (See figure 1 as an example.) In addition, "High End" and "Low End" possibilities are posted as well. (See figures 2 and 3). These ranges are derived by looking at numerous computer models and ensembles and considering all of the possible outcomes. Among those outcomes, the high and low values are selected by using a "1 in 10" chance threshold. In short, the official storm total snow accumulation should be viewed as the most likely outcome. The "Low End" value means there is a 1 in 10 chance of snow amounts of this value or less. Similarly, the "High End" value represents a 1 in 10 chance of snow amounts this high or greater.

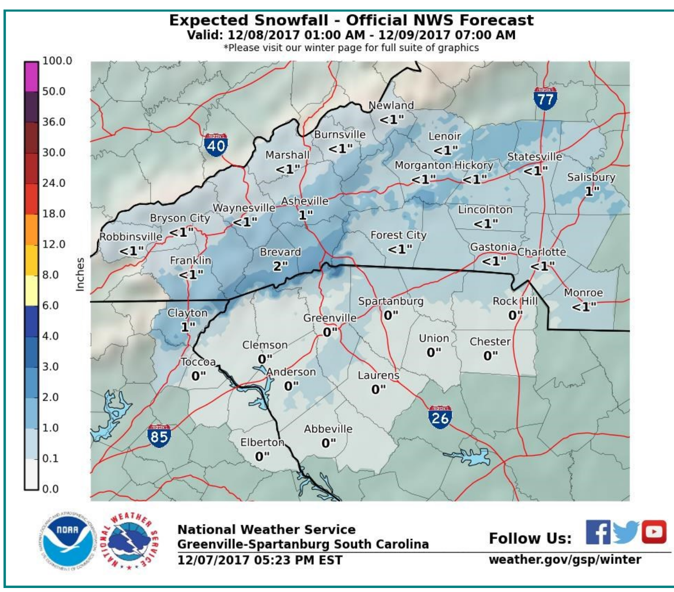


Figure 1: Official Storm Total Snow Forecast

Is this an attempt to build in a "hedge" to the forecast to widen the range? Absolutely not! Our official storm total snow forecast is the forecast we stand by as being our very best prediction based on the current state of the science and local forecasting techniques. Rather, the underlying uncertainty has always existed but now we are quantifying it for our users to help their decision making processes. For example, suppose that Billy lives in Spartanburg and he plans to visit his Aunt Martha in Hendersonville this weekend. Perhaps the forecast calls for two inches of snow, but there is a 1 in 10 chance there could be 10 inches of snow. Most people would want to know there is a 1 in 10 chance of getting stuck somewhere and being unable to travel home - even though that outcome is unlikely. While *unlikely*, this outcome is very *possible* and a savvy person will take this information into account by closely monitoring the forecast and having contingency travel plans.

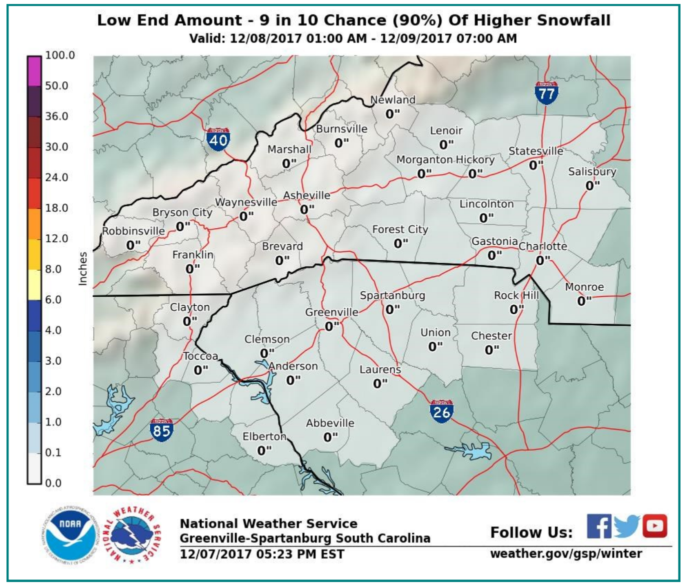


Figure 2: "Low End" Storm Total Amounts

In addition, users and partners ranging from school systems to road crews may also need probabilistic information to help balance the cost and risk of taking/not taking certain actions. More detailed information for these sophisticated users, and for members of the general public who understand probabilities, is available on the exceedance graphics and county tables farther down the web page. If numbers are your thing, take a look at these products whenever a winter storm is on the horizon. Typically, the probabilistic snow forecasts will cover events occurring within the next 72 hours of the forecast.

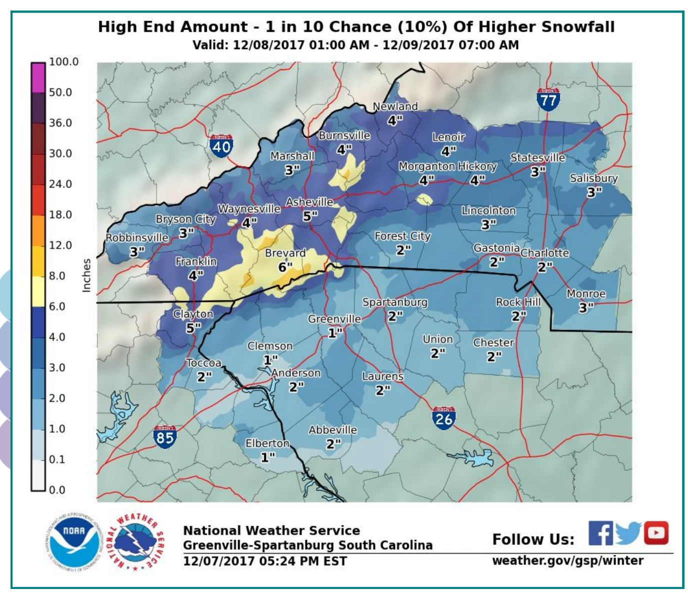


Figure 3: "High End" Storm Total Amounts

Another amateur philosopher, Mark Twain, said: "Everybody talks about the weather, but nobody does anything about it." Well, the National Weather Service is trying to address both Berra's and Twain's comments by ushering in the age of *probabilistic* forecasting. If the experimental probabilistic snow project is successful, probabilistic ice and rain amounts will likely follow. Stay tuned!

- Harry Gerapetritis, Meteorologist

Where's Baby? Look Before You Lock!

Many of you have probably heard of this campaign to prevent child heatstroke deaths in vehicles, but why are we bringing it up when it's not summer yet?

Well, first, 50% of all heatstroke deaths of children in vehicles occur when a caregiver forgets the child, who is usually strapped into a car seat. An additional 30% of deaths occur when a child has somehow gained access to the vehicle but cannot get out (the other 20% of deaths were either of unknown circumstances or the child was intentionally left in the vehicle). These are *preventable* deaths!

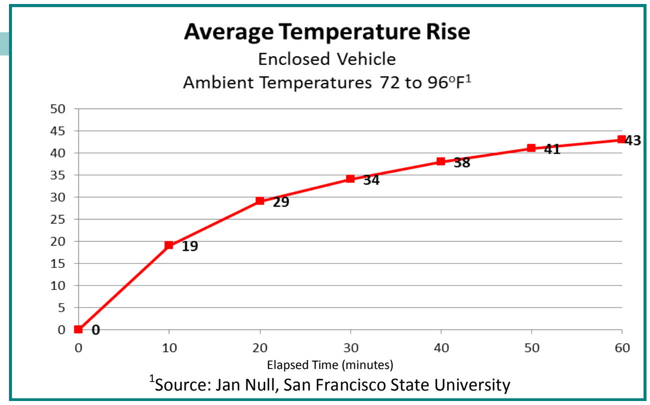
Research shows that the core body temperature associated with heatstroke in is 104°F. A core body temperature of 107°F is lethal. Children's thermoregulatory systems are not as efficient as an adult's and their body temperatures warm by 3 to 5 degrees faster than an adult's.

Research also shows that temperatures in an enclosed vehicle climb 20 degrees in 10 minutes and by over 40 degrees in an hour, as shown in the accompanying "Average Temperature Rise" graph. The same research showed that "cracking" the window made very little difference. So if the outside air temperature is 90°F, in 10 minutes the temperature inside a car has reached almost 110°F – deadly for an infant or young child. If the outside air temperature is 70°F, it does take longer for a vehicle to heat up to the same temperature, but still less than an hour. Many children who die of heatstroke in enclosed vehicles are left for many hours.

So why are we bringing this up in the spring? Because there have been documented cases of heatstroke deaths in children as early in the year as March and as late in the year as December.

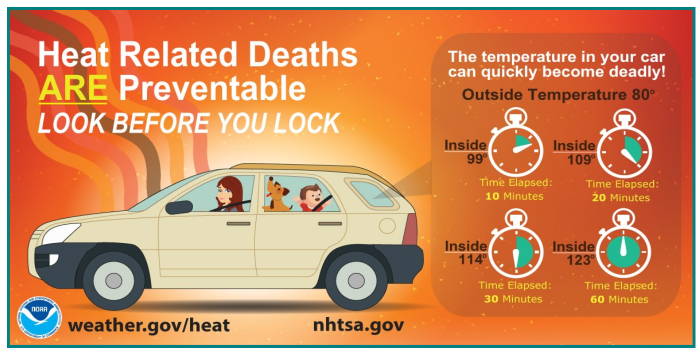
It doesn't matter where you are in the country or what time of year it is

NEVER LEAVE A CHILD UNATTENDED IN A VEHICLE, NOT EVEN FOR A MINUTE!



SAFETY RECOMMENDATIONS

- **NEVER LEAVE A CHILD UNATTENDED IN A VEHICLE, NOT EVEN FOR A MINUTE!**
- **If you see a child unattended in a hot vehicle, call 911 immediately!**
- If a child is missing, always check the car first, including the trunk.
- Be sure that all occupants leave the vehicle when unloading. Don't overlook sleeping babies.
- Always lock your car and ensure children do not have access to keys or remote entry devices.
- Teach your children that vehicles are never to be used as a play area.
- Keep a stuffed animal in the car seat. When a child is put in the seat, place the animal in the front with the driver.
- Or, place your purse or briefcase in the back seat as a reminder that you have your child in the car.
- Make "look before you leave" a routine whenever you get out of the car.
- Ensure your child's school and/or child care provider will call you if your child does not show up for school.



Additional Resources

NWS Heat Safety: http://www.nws.noaa.gov/om/heat/

Golden Gate Weather, Heatstroke Death of Children in Vehicles: http://www.ggweather.com/heat/

Where's Baby?: www.wheresbaby.org

- Trisha Palmer, Meteorologist

Spring & Summer Hazards: Are You Prepared?

The Spring and Summer months are time for outdoor activities, vacations, and fun in the sun, but don't let the sunny days and warm nights fool you! From tornadoes, lightning and floods to heat waves that can be lengthy and deadly, these seasons are filled with hazardous weather. Plan to go camping or fishing? Did you know that lightning deaths are at their peak during the summer? Learn about different weather hazards and what you should do to keep you and your loved ones safe!

When Thunder Roars, Go Indoors! See a Flash, Dash Inside!

Are you headed to the beach anytime soon? Keep in mind that beach hazards such as rip currents can occur on beautiful, quiet weather days, or stormy days. Know what a rip current is and other safety tips before heading to the beach!

Learn about Rip Currents here! https://www.weather.gov/safety/ripcurrent

Don't forget—Hurricane season begins June 1st!

Building a Weather-Ready Nation

Spring Safety: https://www.weather.gov/wrn/spring-safety

Summer Safety: https://www.weather.gov/wrn/summer-safety

- Sandy LaCorte, Meteorologist

Record Number of Tornadoes in 2017 Allows NWS Greenville-Spartanburg to Gain Experience with New Warning Techniques

Thirty-one tornadoes were confirmed within the NWS GSP CWA during 2017. This was the most tornadoes in the area since the NWS began maintaining official records of tornadoes in 1950. The active 2017 season followed a relative 5-year "drought" in tornadic activity, as a total of only 13 tornadoes were reported from 2012 through 2016. This was roughly equivalent to the average number of tornadoes that touch down in the area each year!

A silver lining in this otherwise unwelcome trend was that it allowed forecasters to gain real-time experience with new technological features that have been added to the GSP Weather Service Radar 1988 Doppler (WSR-88D) in the last few years, some of which were specifically designed to improve tornado detection.

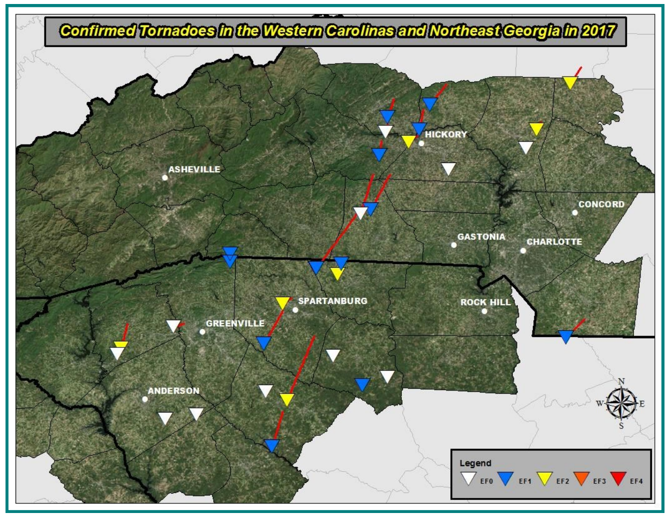


Figure 1: Confirmed tornado tracks in the National Weather Service (NWS) Greenville-Spartanburg's (GSP) County Warning Area (CWA) in 2017.

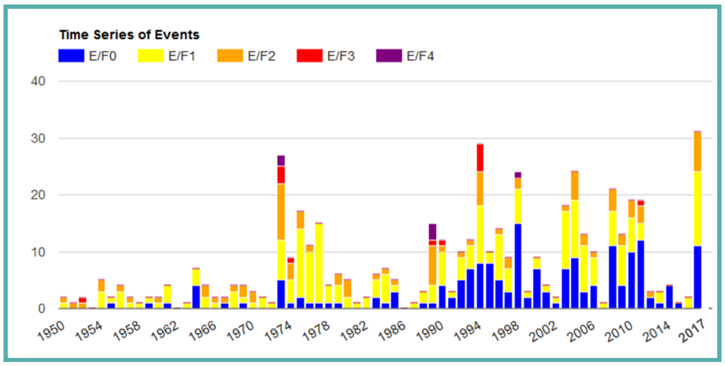
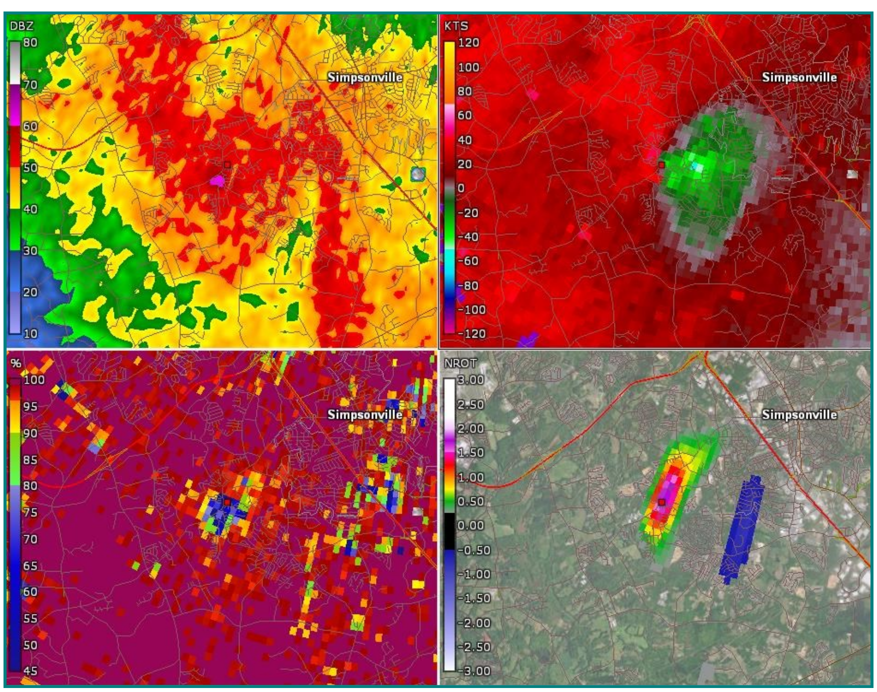


Figure 2: Confirmed tornado in the modern GSP CWA since 1950, color-coded by F/EF scale rating.

Dual Polarization Radar and the "Tornado Debris Signature"

For the first 15 years or so of its operational implementation, the WSR-88D employed only a horizontally polarized radar beam that returned two pieces of "base" information to the end user: the degree of reflectiveness of a radar target, and the direction of movement of the target relative to the radar beam. In the early 2010s, vertical polarization was added to all WSR-88Ds. This allowed the user to glean information regarding the width:height ratio of radar targets. While the initial intent of this technology was to allow for discrimination between ice and liquid particles within a cloud, other applications have since come to light, with perhaps the most important being the Tornado Debris Signature (TDS).



The Correlation Coefficient (CC) radar product is a measure of the ratio of targets that are relatively symmetrical to those that are asymmetrical within a given radar sample. If a radar returns high CC, this indicates that the individual targets within a given data sample have uniform symmetry. If CC is low, the symmetry of individual radar targets is erratic. When you think about a tornado lofting debris, you probably have a chaotic image in mind: building material, vegetation, dust, etc; in other words, materials of highly variable shapes flying through the air. The WSR-88D Correlation Coefficient product would show this debris as a concentrated area of low CC, which has been dubbed the "TDS." Since the TDS is an indication that a tornado is already in progress, it cannot be used to forecast near-term tornado development. However, it does provide forecasters with timely confirmation that a tornado is occurring, allowing them to update warning text with more specific and/or strongly worded information. In other cases, a "short, or zero lead-time" warning can be issued much more quickly than in the past, when forecasters had to wait for ground truth reports to prompt warning issuances during situations in which radar data were inconclusive. Those reports might be very slow in coming if the tornado was in a rural area.

Figure 3. Radar 4-panel of reflectivity (upper left), storm relative velocity (upper right), correlation coefficient (lower left), and "normalized rotation" (lower right) at 0.5 degree elevation of a tornadic storm near Simpsonville, SC on 30 November 2016. A concentrated area of low CC coincides with a region of strong rotation, confirming this as a TDS. This was the first TDS detected by the GSP WSR-88D.

Continued on Page 5

Impact-Based Warnings Improve Specificity of Information

Beginning in 2016, the NWS revised the format of its Tornado and Severe Thunderstorm Warning products, while also changing the wording based upon research from the field of social science. The intent of this Impact-Based Warnings project was to give forecasters greater flexibility in discriminating between "run-of-the-mill" situations and those in which there was a need to convey a heightened sense of urgency. A "Source" tag is assigned in each warning according to the following guidelines:

- **Radar indicated tornado**: in which rotation has been detected in WSR-88D velocity data
- **Radar confirmed tornado**: in which a TDS signature has been identified coincident with rotation in WSR-88D data
- ***[Source]* confirmed tornado:** in which a reliable "ground truth" report of a tornado has been received

Using a combination of ground truth reports and very specific radar guidelines, forecasters then assign a statement of expected impacts statement from the following list:

- **Base Tornado:** "Typical" tornado damage: trees and power lines down, mobile homes heavily damaged, exterior damage to houses.
- **Considerable Tornado:** Mobile homes destroyed, significant damage to houses and other permanent structures.
- **Catastrophic Tornado:** "Tornado Emergency." Houses and other permanent structures completely destroyed, typically reserved for urban areas.

It's important to understand that the wording contained in warnings and follow-up statements is based upon the information that the forecaster had at the time the warning or statement was written. Conditions can change by the second in severe weather situations. *You should never assume that a Tornado Warning containing "Radar indicated" wording can be ignored.*

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BULLETIN - EAS ACTIVATION REQUESTED
Tornado Warning
National Weather Service Greenville-Spartanburg SC
435 PM EDT SUN OCT 8 2017

The National Weather Service in Greenville-Spartanburg has issued a

* Tornado Warning for...
  Central Laurens County in Upstate South Carolina...
  Southeastern Spartanburg County in Upstate South Carolina...

* Until 515 PM EDT

* At 435 PM EDT, a tornado producing storm was located near Laurens,
  moving north at 30 mph.

  HAZARD...Damaging tornado.

  SOURCE...Radar confirmed tornado.

  IMPACT...Flying debris will be dangerous to those caught without
           shelter. Mobile homes will be damaged or destroyed.
           Damage to roofs, windows, and vehicles will occur.  Tree
           damage is likely.

* This dangerous storm will be near...
  Woodruff around 510 PM EDT.

Other locations impacted by this dangerous thunderstorm include
Enoree, Cross Anchor and Ora.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

To repeat, a tornado is on the ground. TAKE COVER NOW! Move to a
basement or an interior room on the lowest floor of a sturdy
building. Avoid windows. If you are outdoors, in a mobile home, or in
a vehicle, move to the closest substantial shelter and protect
yourself from flying debris.
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***Figure 4**. An "Impact-Based" Tornado Warning issued by NWS GSP on 8 October 2017. Recognition of a Tornado Debris Signature in radar data prompted the warning forecaster to add the "Radar confirmed tornado" tag along with an "enhanced call-to-action" statement to the warning text. Language such as this is intended to increase the sense of urgency in the need to take preventative action.*

SAILS Improves Temporal Resolution of Radar Data

Supplemental Adaptive Intra-Volume Low-Level Scan (SAILS) was implemented in the WSR-88D network several years ago as a means to provide improved temporal resolution at the lowest radar elevation scan. When the radar is operating without SAILS, it provides a single 360 degree scan at up to 14 different elevations. It typically takes a little over 4 minutes to complete a single "volume scan." When operating in SAILS, the radar performs up to 3 additional scans at the lowest elevation before tilting to higher elevations angles. The result can be radar information that updates every 90 seconds or so! This can be critical during Tornado Warning operations in our area, where tornadoes tend to develop very quickly, and where the most significant radar features are often observed at the lowest elevation scan.

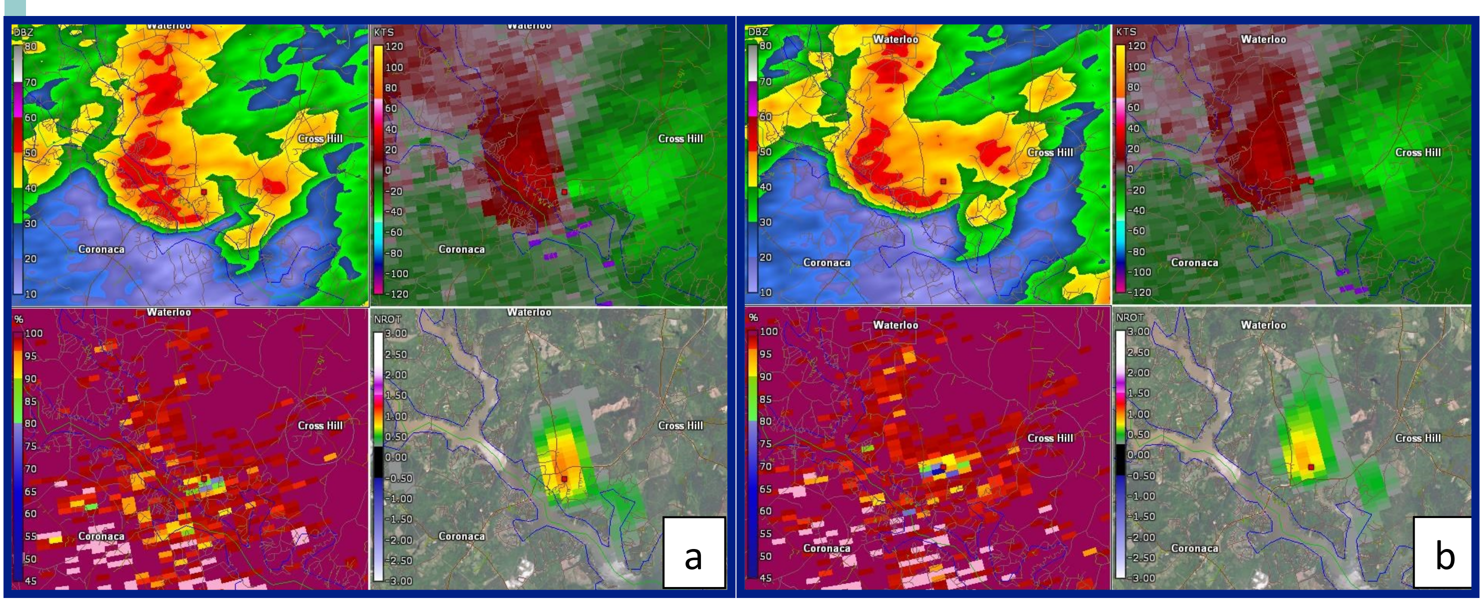


***Figure 5**. GSP radar 4-panel of a tornadic storm over Lake Greenwood on 8 October 2017 at a) 4:06 pm EDT (SAILS scan) and b) 4:08 pm EDT. Images are of the same radar products as in Fig 3. At 4:06, an area of modest rotation is analyzed coincident with an area of low CC. However, it was not clear at this time that this was a TDS signature. By 4:08 pm, the persistence of the low CC coincident with the area of rotation increases confidence that this is indeed a TDS. The extra information provided by the SAILS scan can allow forecasters to identify trends such as this much more quickly than in the past, when the time between radar scans exceeded 4 minutes.*

Continued from Page 6

Reports from the Field Still Vital to NWS Warning Operations

Despite the continuing advances in technology, weather radar will always have a plethora of limitations that will be difficult to overcome. As such, accurate reports of severe weather from reliable storm spotters, which can include emergency preparedness personnel, private citizens, and/or amateur radio operators remain the most vital piece of the puzzle in warning decision making. This was emphasized during the 23 October 2017 tornado outbreak when storms that produced multiple tornadoes over Upstate South Carolina moved into the North Carolina foothills. Radar signatures became increasingly ambiguous, and Tornado Warnings were becoming increasingly difficult to justify based upon radar data alone. However, the NWS received numerous reports of wind damage and tornado sightings from spotters and public citizens within largely rural areas of the North Carolina foothills. Supplementing these reports with data allowed warning forecasters to extend Tornado Warnings through the foothills, where four confirmed tornadoes occurred along with extensive downburst damage.

Remember, you don't have to be a trained spotter to report severe weather to the National Weather Service. We are eager to hear any reports of severe or other significant weather. Methods and guidelines for reporting significant weather to NWS GSP can be found at this website.

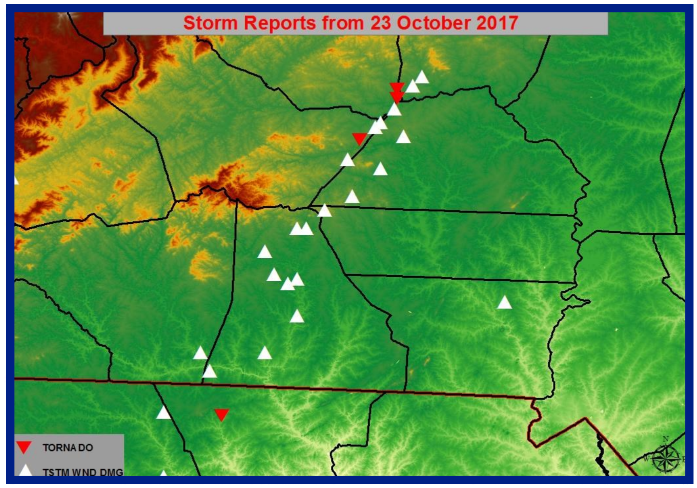
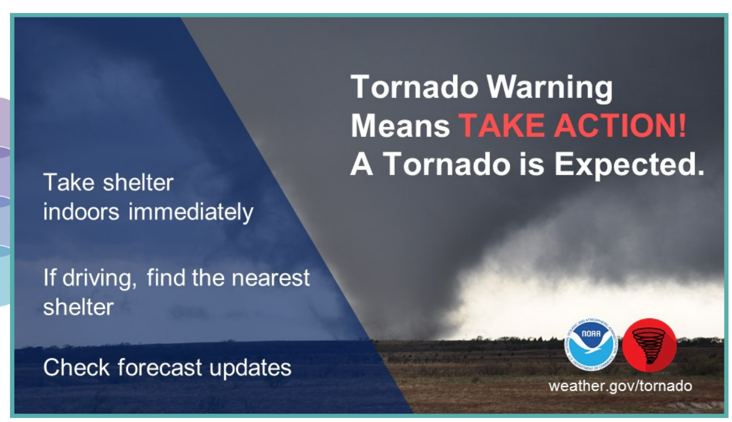


Figure 6. Storm reports of wind and/or tornado damage and tornado sightings received by NWS GSP on 23 October 2017. These reports were critical in the decision to continue Tornado Warnings through the North Carolina foothills.

Acknowledgements
All radar images were created using the Gibson Ridge Level II Analyst. The chart in Fig 2 was generated with Google Charts.

- Justin Lane, Meteorologist



The Integrated Warning Team–Partnerships in the Western Carolinas and Northeast Georgia

What is this "Integrated Warning Team" (IWT) of which you speak? Well, an IWT is an ad-hoc "team" of people/entities who are involved in the preparation and response to high-impact weather events. Generally, the IWT consists primarily of NWS, Emergency Management (local/state/federal) and broadcast media partners, but also includes (though is not necessarily limited to):

- School/university officials
- First responders
- Transportation officials (ground and air)
- Healthcare officials/organizations
- Power companies
- Forestry and agricultural groups
- U.S. and state Geological Surveys
- Amateur radio operators
- Officials with large event/outdoor venues
- Some private companies (especially those involved with weather, safety/security, and emergency management)

WFO GSP Science and Operations Officer Dr. Bill Martin moderates a Multi-School District Decision-Making Panel Discussion. Panelists from left to right: Phillip Davie (Assistant Superintendent for Administrative Support, Greenville County SC Schools), Jeanne McGowan (Safety Officer, Asheville City Schools), David Weldon (Director of Emergency Management, UNCA), and Joseph Hough (Assistant Superintendent – Auxiliary Services and Programs, Buncombe County Schools).

An IWT workshop or meeting is when a group of IWT members get together to discuss best practices, challenges, and ways to improve preparedness and response, and specifically to disseminate a unified message during severe/high-impact weather events. We held our first IWT Meeting in Charlotte in the fall of 2016, and based on its success and excellent feedback, we held our second IWT meeting on March 20 in Asheville, NC, on the campus of the University of North Carolina at Asheville (UNCA).

Around 80 representatives from the NWS, emergency management community, broadcast media, and many other state and local partners were in attendance. We were honored to have sponsorships from WLOS-TV Asheville, WHNS-TV Greenville, and the Asheville Chapter of the American Meteorological Society to help pay for snacks and lunch, while the UNCA Atmospheric Sciences Department covered the room fee and assisted with event coordination.

Presentations were given by WFO GSP meteorologists on the WeatherReady Nation initiative (Tony Sturey, Warning Coordination Meteorologist), Social Media and Impact-Based Decision Support Services (Trisha Palmer, Lead Meteorologist), and messaging – specifically pertaining to winter weather events (Jake Wimberley, Meteorologist). We also had breakouts to discuss science behind winter weather forecasting (Danny Gant, Lead Meteorologist now at Morristown, TN) and inland tropical cyclone impacts (Justin Lane, Lead Meteorologist). Dr. Laura Myers from the Center for Advanced Public Safety at the University of Alabama also gave a presentation about messaging from a social science perspective. We heard from Dr. Chris Godfrey at UNCA about his research to evaluate treefall patterns in tornadoes, and Rick Wooten at the NC Geological Survey teamed up with WFO GSP Lead Meteorologist Pat Moore to give a talk about landslides. Particularly well-received were three panel discussions: one from area EMs about their needs and relationships with the NWS; one from local school officials about how the weather drives closing and delay decisions; and one consisting of representatives from surrounding NWS offices to discuss collaboration issues on NWS forecast area borders. Participants and attendees used #GSPIWT on Twitter through the day, and a quick search can provide a nice snapshot of the event.

WFO GSP again received excellent feedback from this year's IWT Meeting; for example, Will Kehler, McDowell County NC Emergency Manager, said, "It was extremely informative and beneficial for our agency. The event itself was very well planned, with a perfect mix of lectures and breakout sessions. I also appreciate the invite to participate on the EM panel. We hope you conduct this workshop again in 2019. Thanks for all your work and for the great partnership."

We are in the initial stages of planning our third IWT meeting to be held sometime in the spring of 2019 at Clemson University.
If you are part of the IWT across the western Carolinas and northeast Georgia, we hope to see you there!

More information can be found at www.weather.gov/gsp/iwt

- Trisha Palmer, Meteorologist

The Observation Program at GSP

The National Weather Service (NWS) is responsible for providing forecasts and warnings. The first step in this process is the assimilation of weather observations. Observations are obtained from automated sensors, volunteer observers, and other established surface reporting systems. The objective of the NWS surface observation program is to provide policy and standards for observing and monitoring, and the acquisition and dissemination of data in support of the NWS and its customers.

A Cotton Region Shelter (CRS) containing maximum and minimum thermometers at the NWS Cooperative Station atop The Grove Arcade, Asheville, NC.

NWS Weather Forecast Offices (WFOs) are responsible for providing accurate and timely observation services in compliance with these national and regional policies. WFOs, like us here at GSP, conduct customer outreach within our area of responsibility to promote and assess surface observation and monitoring services.

Along with our responsibility of collecting and providing observational data, the quality of said data is paramount. Observations need to conform to standards to ensure high quality data. These demands are met in part by a thorough and effective Quality Control/Quality Assurance (QC/QA) program. Local observational data which we collect are subjected to rigorous manual and automated QC routines.

Observational data collected and quality controlled by us here at NWS GSP is vast and varied, consisting of both human and automated observed elements, meteorological and hydrological. Observational networks consist of a few managed by us here the NWS, but most consist of data shared by our numerous partners.

The primary observational programs administered by the NWS are the Automated Surface Observing System (ASOS) and Cooperative Weather Observing programs.

Partner agencies which share collected data with the NWS include, but are not limited to:

Community Collaborative Rain, Hail and Snow Network (CoCoRaHS), The Federal Aviation Administration (FAA), The United States Geological Survey (USGS), The United States Forest Service (USFS) and state Forestry Commissions, The National Park Service (NPS), The US Army Corps of Engineers, The State Climate Offices of North Carolina and Georgia, The North Carolina Flood Inundation Mapping and Alert Network (FIMAN), National MesoNet data processed by NOAA's MADIS system, select county level administered ALERT networks/MesoNets, Duke Energy, ReWa, and Woolpert, Inc.

These stations and systems employ a variety of sensor technologies, siting criteria, and observing practices. This diversity introduces variability in the quality, accuracy, timeliness, representativeness, and precision of the data being measured and reported. When differences are excessive, they are reconciled, and as appropriate, corrected in a timely fashion, in order to ensure the highest quality data.

U.S. Climate Reference Network (USCRN) site located at the NC Arboretum (Buncombe County NC). A climate monitoring system that uses high-quality instruments which measure temperature, precipitation, wind speed, soil conditions and more. This data is used to monitor climate trends and are used to support ongoing climate research. There are 100 of these sites nationwide.

A vintage 8-inch Non-Recording Standard Precipitation Gauge, the standard for precipitation measurements for over 100 years within the NWS Cooperative Observing Program.

Please check back every issue to for additional topics on NWS GSP's Observing Program.

- Chris Horne, Observing Program Leader

The Enhanced Data Display: Weather Weenies Rejoice!

Some folks need to dig deeper than just a regular forecast. They might need detailed weather information to help them make a decision, or they might need to access many kinds of weather information at once. Others are just really enthusiastic about weather, and want all the information they can get their hands on!

To handle these needs, the National Weather Service hosts a next-generation website that brings together virtually every type of weather data available from the agency. It's called the Enhanced Data Display, or EDD. This project began as an experiment several years ago, and its capabilities have grown over the years. If you just can't seem to get enough data, this site is definitely for you!

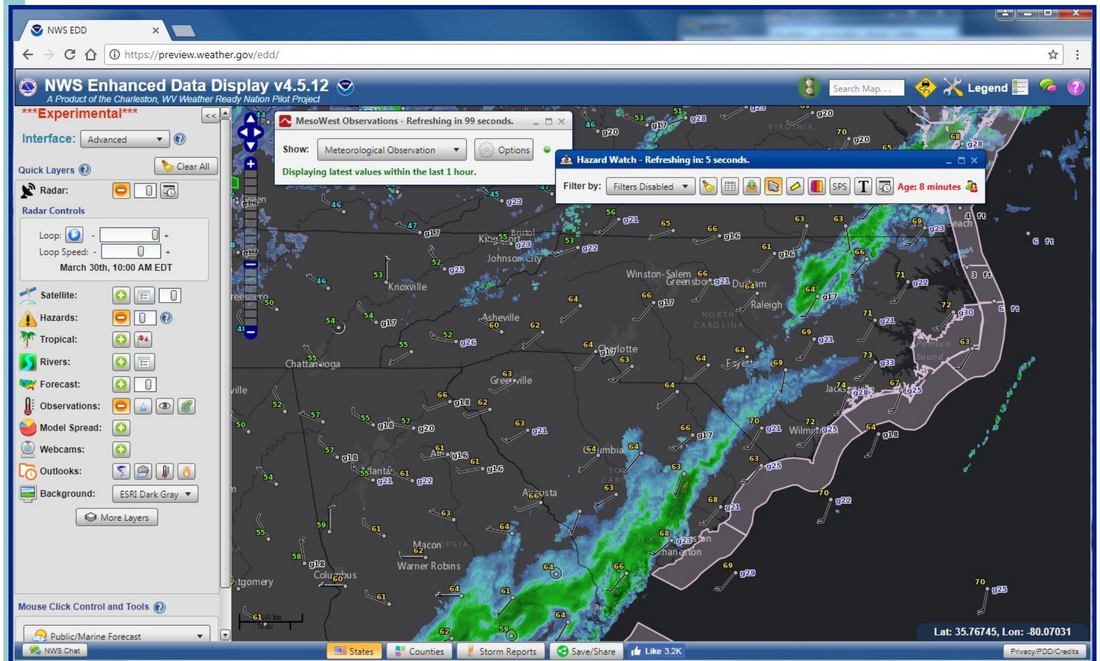


Figure 1: The Enhanced Data Display, viewed on a PC.

The EDD works on both PCs and mobile devices, but a little differently. We'll explain a little about each platform, but first we'll focus on the PC version. In any web browser, start by visiting https://preview.weather.gov/edd. It takes a few seconds to load, but that's just because it has so much capability to offer. Note that the majority of the browser window is occupied by a map. Move around the map just like you are used to doing on a map website or app. One of the main features is that you can get a forecast for anywhere you like: clicking a location on the map brings up an interactive forecast for that location.

On the left side of the EDD, you choose what layers of weather data you want to plot on the map. Click the green "+" buttons to select any number of layers; see Figure 1. *(If you're overwhelmed, it's OK! In the "Interface" box, select "Basic" until you feel comfortable using the EDD.)* Most of the plotted layers are interactive. For example, select "Hazards" and all of our watches, warnings, and advisories will appear as colored polygons on the map. You can hover the mouse or click in these polygons to find out more about what's going on in that area. Some of the layers can be animated through time, too. When you choose them, a "play button" and slider bar will appear by the name of the layer.

Take time to explore all the different map layers. If you can think of an NWS forecast product, odds are you'll find some way to plot it on the EDD. Outlook products from the Storm Prediction Center and Weather Prediction Center, tropical cyclone forecasts from the National Hurricane Center, and river stage forecasts from our River Forecast Centers are all available. If you run out of things to look at, click the More Layers button and plot to your heart's desire. It certainly can take a few minutes to really get the EDD set up the way you like. That's why the developers placed a "Save/Share" button at the bottom of the window. Clicking that button will give you a link you can bookmark or share via social media. Visiting that link will let you or someone else see the EDD set up exactly like it was set up before!

Another really cool feature of the EDD is the Travel Hazard Forecast tool, which lets you know what weather to expect if you're planning a trip. At the upper right corner of the window, click the "road sign" icon to bring up the controls for this tool. Enter any two U.S. cities as start and end points, set the time of departure, and click Go (Figure 2). The EDD will use driving directions from a popular travel website to plot your journey, calculate the times you'll be passing through different areas along the route, and summarize the weather at those places and times. Hover over parts of the displayed route to see all the details. In our example, as we approach Charleston, the chances of rain are forecast to increase (Figure 3).

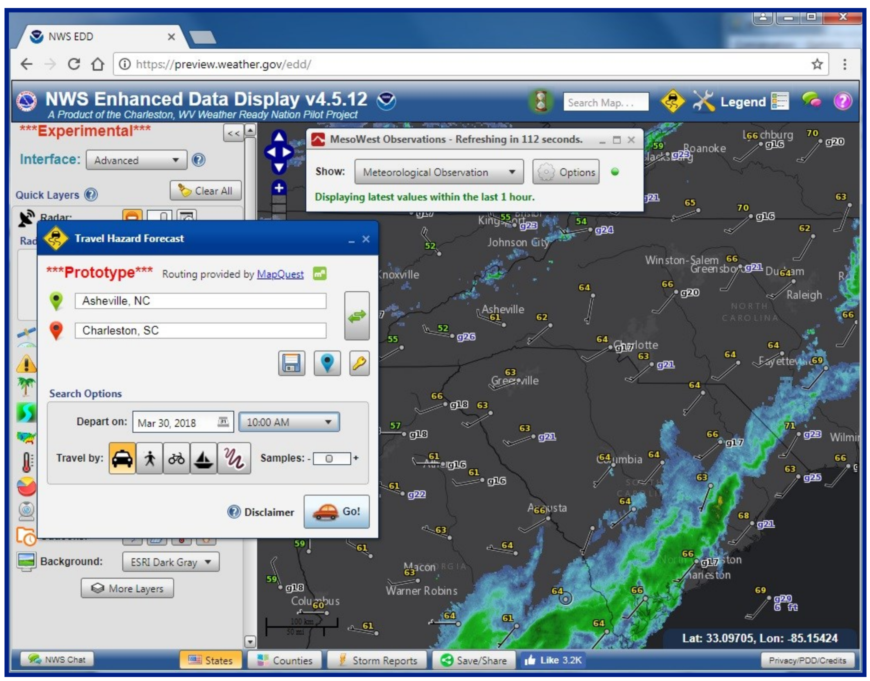


Figure 2: Travel Hazard Forecast control panel.

Continued on Page 10

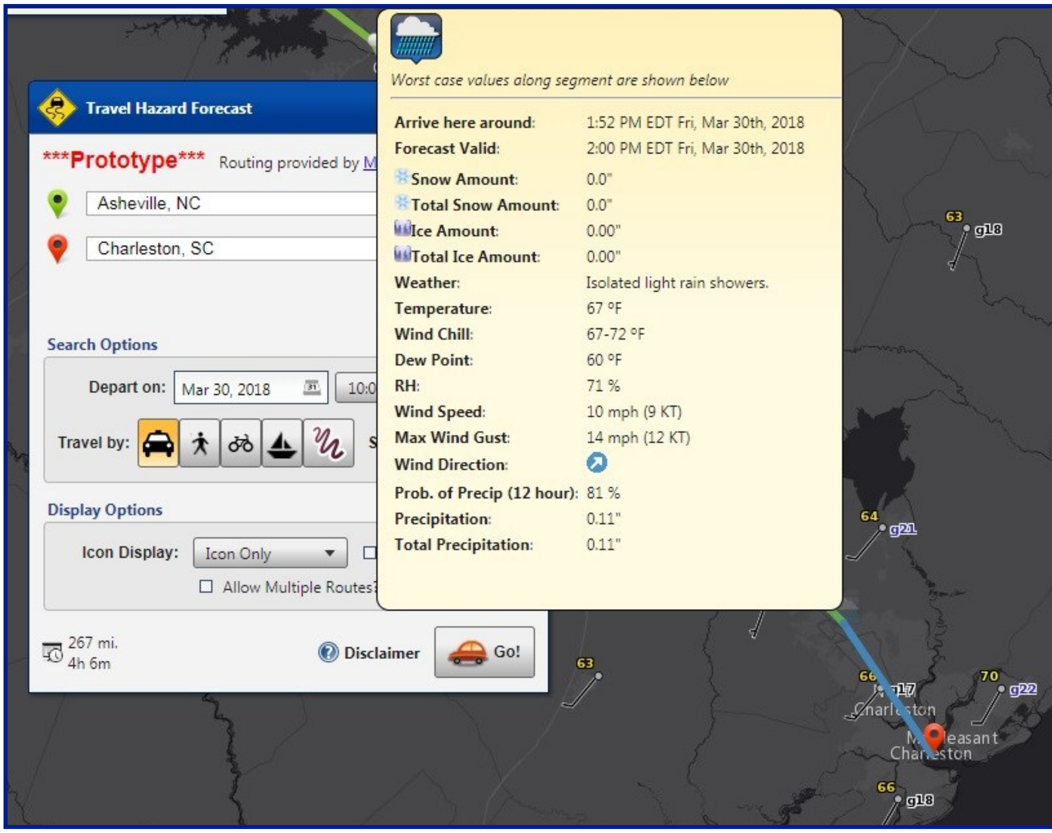
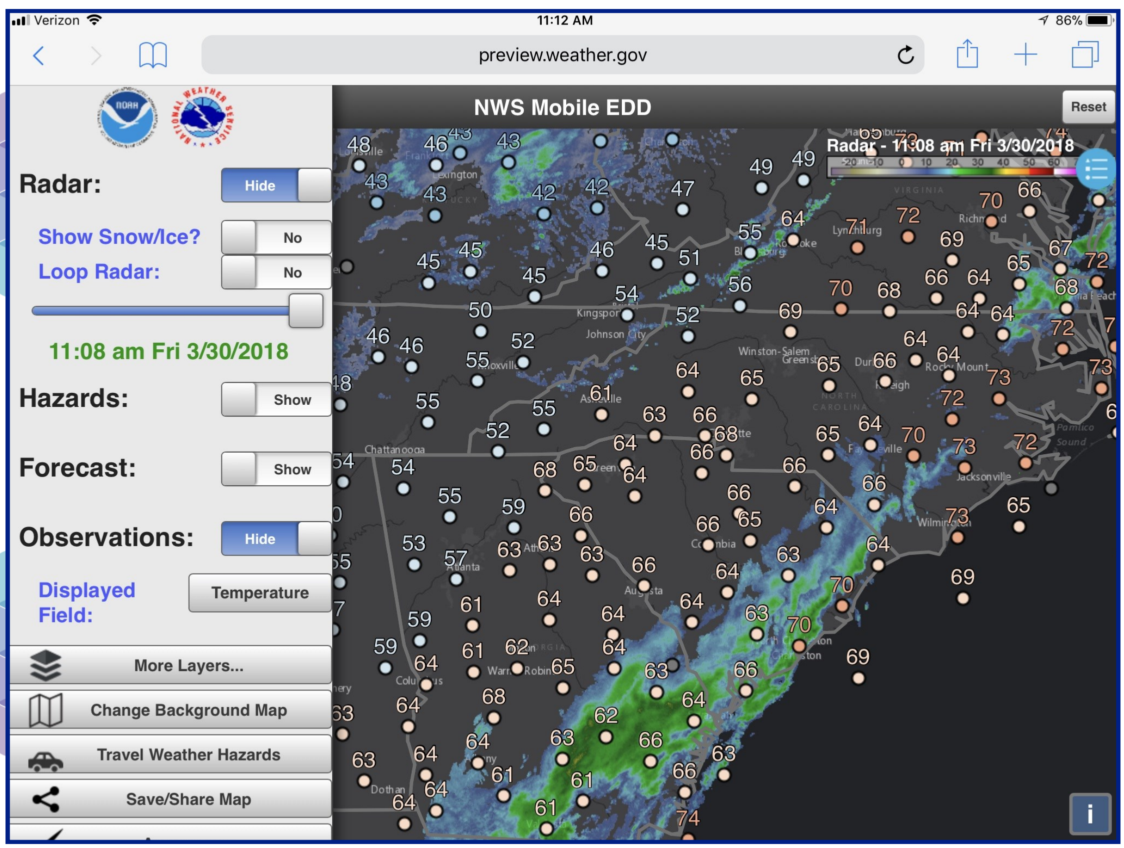


Figure 3: Hover over a part of the route in order to see the forecast for that part.

The mobile EDD has some slight differences to make it work better with a touchscreen device. The mobile version is still in development, but many of the features already work. When you visit the same URL https://preview.weather.gov/edd on a phone or tablet, the site will ask if you want to use the mobile EDD—go for it! Then, when you are ready to select map layers or to use the Travel Hazard tool, press the "Menu" button at the upper left corner to display the control panel (Figure 4). Every control you need will be in that menu.

Figure 4: The Mobile EDD, after pressing the Menu button.



The developers of the EDD have a Facebook page: https://www.facebook.com/nwsedd/. Follow it to learn about new features as they are added. You can also help improve the EDD by providing feedback. Your comments and bug reports are valuable!

- Jake Wimberley, Meteorologist

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Do Butterflies Control the Weather?

There is something called the "butterfly effect", which is the effect whereby the impacts on the weather of trivial things like the flapping of a butterfly's wings, grow over time, eventually becoming a dominant factor in what kind of weather you have. The butterfly effect concept originated from a 1952 short story by science fiction writer Ray Bradbury titled "The Sound of Thunder", and was even the main concept of a 2004 science fiction movie. The effect is not just fiction, however; and was known in some form to mathematicians long before Bradbury. In mathematics, the effect is known as "sensitive dependence on initial conditions", "non-linearity", or just "Chaos". The concept and the phrase gained considerable popularity in 1972 when the great meteorologist Ed Lorenz delivered a paper titled "Predictability; Does the Flap of a Butterfly's wings in Brazil Set Off a Tornado in Texas?".

So do you really not need to worry about cold fronts, upper-level storms systems and other non-butterfly things when forecasting the weather? No! But the butterfly effect does matter as it is the reason you can't forecast the weather with any accuracy very far into the future.

The idea behind Chaos is that small things, like the flapping of a butterfly's wings, can have big effects on the future. An extreme example might be a butterfly in Brazil causing a tornado in Texas a month later.

This may sound ridiculous at first glance, but it is actually true. In part. Think about the weather as a giant asteroid the size of Rhode Island a billion miles from Earth. Let's say it is lumbering directly towards Earth at 400 mph. At that rate it collides with the Earth in about 300 years. Now let's say there is a tiny grain of sand--this is the butterfly in our analogy--and that this grain collides with the asteroid out in space when it's a billion miles from Earth. This collision will be scarcely noticeable. That grain of sand might deflect that big, bad asteroid a mere millimeter per mile of travel. That's practically nothing. However if the asteroid's path is changed by one millimeter per mile of travel, after 1 billion miles, its trajectory will differ by 1 billion millimeters, or over 600 miles. This is no longer small and could make the difference between the asteroid striking the Earth, devastating civilization and interrupting episodes of Jeopardy, or missing the Earth altogether. Tiny events can have big effects, in the world of Chaos.

Weather is like that. Ridiculously tiny events, like the flapping of a butterfly's wings can, and do, have big effects on the future weather. The capricious actions of a butterfly probably do not really begin to affect the weather for at least a couple months, if not longer, but eventually they do.

If a butterfly matters, then so do other bugs, animals, plants, people, the shape of every grain of sand, in fact, every quantum-mechanical fluctuation of every particle in the universe matters, and will affect the weather at some, distant future time. To get back to our asteroid analogy, the weather is like that asteroid, but it is passing through space that is loaded with grains of sand. It is getting pelted by millions of sand grains every second. To predict the precise location of the asteroid in the future, you would need to account for the effect of each collision. This is too difficult.

Because there are so many butterflies and other small things, and because we have no way of knowing what they are doing, predicting the weather a long time into the future is not practical. Short-term forecasts of a couple days or so are often pretty good because these forecasts depend on big things like fronts and the jet stream. Further into the future, though, and the forecast begins to depend on smaller and smaller things; things which are too small to measure, and too numerous to keep track of. Consequently, forecasts get worse the further out you go in time.

Meteorologists have made great strides in forecasting in recent years, largely due to the development of computer models and new observing systems. Forecasts are now generally useful out 4 or 5 days into the future. Forecasts out as far as 7 days, while not very good, have some value. Because of inherent Chaos, it is believed that there is an upper limit to how far we can forecast the weather into the future, no matter how good our observations of the atmosphere and computer models get. This limit is probably about 2 weeks.

In the vein of science fiction where Chaos got its start, I'll leave you with the following thought: It may actually be possible to forecast the weather for next year, or any distance into the future. In light of all the butterflies in the world, the only way to do this is to control the weather. Clearly, if you cause the weather, then you can schedule the weather any distance into the future. Forecasting becomes a matter of looking it up in the schedule. "And how, pray tell, can we control the weather?" you may ask. Well, the atmosphere is very large and controlling it directly with, say, giant fans, heating and cooling devices, and so forth, would require vast amounts of resources and energy. That is not going to work. What might work, though, is to take a lesson from all those butterflies. If you have enough knowledge about the atmosphere, then maybe you could figure out how to perturb it in just the right way such that you get the weather you want a month or so later. Using the asteroid analogy, the idea is to bump that asteroid when it is still a billion miles from Earth in just the right way so that it is where you want it to be 400 years later. Perturbing the atmosphere might involve such things as wind baffles or sunlight reflectors to cool the surface over some small area. Irrigation of farms has been shown to affect local weather, and this could be controlled. It is a big planet, and you would probably need to have a network of weather perturbation stations around the globe. The perturbations you add to the weather would still have to be pretty big in order to overwhelm the effect of all the smaller things you don't know about, like all those butterflies.

This would still be expensive, and we can't do it now, and may never be able to, but it is something to think about.

- Dr. Bill Martin, Science and Operations Officer