

The Value of the CITIZEN WEATHER OBSERVER



by Nolan Doesken and Henry Reges

Nolan Doesken is the founder of CoCoRaHS and Henry Reges is the National Coordinator for CoCoRaHS.

Long before your neighborhood hardware store stocked a selection of easy-mounting, low-cost rain gauges, people of all walks of life were already fascinated by weather and were out taking measurements. Today, in nearly every community, there are diligent weather watchers who gaze at clouds and note the winds and the temperature. Thousands of these weather watchers are compelled to measure and record these changing weather conditions day after day—perhaps writing on a kitchen calendar or in a journal, or updating a spreadsheet on their computer. Their day isn't complete unless they check their rain gauge and write it down.

For nearly 200 years, individual observers have joined forces with other volunteers to form networks of observers. This started with the Smithsonian weather observing network of the early and mid-1800s and continued with the creation of several state weather networks in the later 1800s in collaboration with the U.S. Signal Service. By setting standards for instrumentation, observing methods, and record-keeping, these "networks" raised the quality, accessibility, and usefulness of these backyard measurements. The premier example is the remarkable and long-lived "Cooperative Network," first operated by the U.S. Weather Bureau and later the National Weather Service (NWS). This network of several thousand volunteers across the entire country has been operated continuously since 1890. Volunteer weather observers participating in these well-organized networks have helped paint a beautiful picture of the diverse climate of our nation and the remarkable, changeable daily weather that composes it.

Currently there are more than 9,000 weather observers participating in the NWS Cooperative Observer network. Most of these observers systematically measure high and low temperatures, rainfall, and snow accumulation every day. Once compiled at NOAA's National Climatic Data Center, these data build a historical archive of U.S. weather and climate that is unsurpassed in terms of longevity and spatial detail.

Through two centuries of profound social, technological, and economic changes, we have maintained the rich national tradition of backyard weather observing that has served our country very well. As we now move into the second decade of the 21st century, one might think that backyard weather measurements have become outdated and irrelevant. After all, we are con-

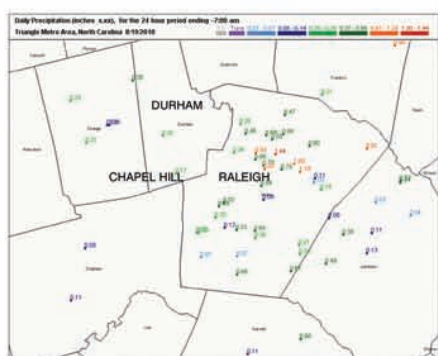
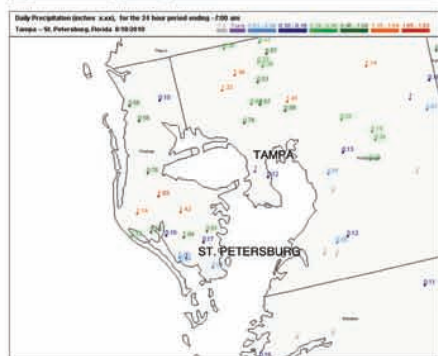
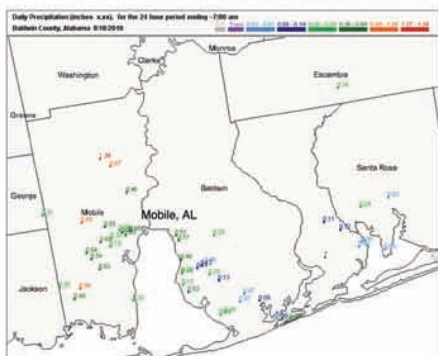
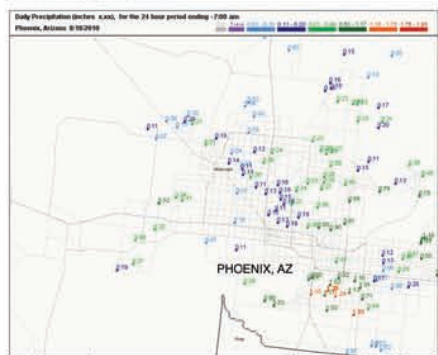
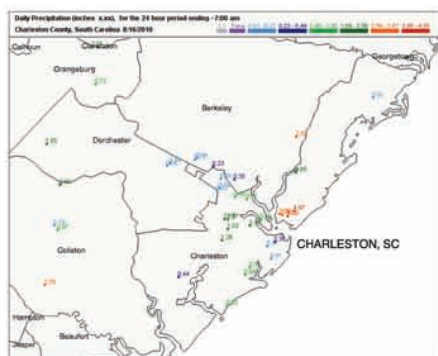
tinuously under the surveillance of ever more sophisticated satellites, weather radar, and other elaborate and expensive environmental monitoring systems. The resolution of remote sensing technology is so good that we can zoom in to our own neighborhoods. Without even looking out the window, we can access from our computers or cell phones detailed weather observations from literally thousands of data sources. You can even find maps of estimated precipitation that cover almost all of the country.

Despite seemingly unlimited access to weather information, many of us still feel compelled to ask, "How much rain fell here in my own neighborhood, and how does that compare to other parts of town?" To that end, we traipse out to our own rain gauges each day to find out for ourselves. This meteorological curiosity helps keep the NWS Cooperative Observer network alive after more than 120 years and fuels other grassroots, weather-observing efforts. Today, over 15,000 (and growing) volunteers help measure and report daily precipitation as a part of the Community Collaborative Rain, Hail, and Snow network as part of (Community Collaborative Rain, Hail and Snow network) CoCoRaHS (www.cocorahs.org). Thousands more have hooked up their home electronic weather stations to the computer network of WeatherUnderground and/or the Citizen Weather Observer Program. And tens of thousands of citizens serve as on-demand "severe weather spotters" for the NWS or participate in local TV station weather networks.

Does Anyone Use the Data?

For all of this effort, the question that we hear most often from these thousands of volunteers is "Does anyone actually look at our data?" For severe weather spotters, the answer is obvious, since the NWS relies on local storm reports for issuing and verifying weather warnings. But for the thousands of observers who report rainfall each day to CoCoRaHS and to the NWS Cooperative Observer network, the answer may not be so clear.

When you work at a State Climate Office like we do, it only takes a day on the job to see why volunteer weather observations and precipitation reports are so incredibly important. After all, precipitation and its variations affect our lives and livelihoods every day. Rain, hail, and snow have profound effects on crops, yards and gardens, forests and grasslands, homes and businesses, lakes and rivers, highways and air traffic, sales and marketing, recreation and tourism, and insects and ecosystems. Clouds and precipitation



Examples of recent daily CoCoRaHS precipitation observations for selected U.S. cities.

even affect our moods and our productivity. In any given week, businesses, individuals, and organizations seek and use precipitation data: TV meteorologists, newspapers, engineers, consultants, utilities, architects, contractors, farmers, ranchers, teachers, truckers, resort operators, restaurant chains, marketing experts, investors, and many federal and state agencies such as the NWS, the U.S. Geological Survey, the U.S. Department of Agriculture, NASA, the Environmental Protection Agency, the Federal Aviation Administration, and more.

What is so ceaselessly interesting about precipitation that makes it different from other weather elements is its remarkable variability. It really is possible for it to rain on one side of the street and not on the other. It really is possible to have twice as much rain in one year than the next. It really is possible for one county to be experiencing drought while the next county over is dealing with floods. It is this fascinating nature of precipitation that holds our attention, affects our lives, and begs for even more volunteer observers to help gather data.

Uses of Backyard Rain Gauge Data

Let's look at a few of the ways that backyard rain gauge measurements are being used.

We face questions every day related to rain, hail, and snow. Where and when did the precipitation fall? Was it rain, sleet or snow? How much fell (depth)? How widespread was it (area)? How hard did it fall (intensity)? How long did it last (duration)? How often do these storms occur (frequency)? What's the most we could get (extremes)? We try to answer these questions for individual locations and for larger areas—counties, states, or entire river basins. Special attention is given to assessing how much precipitation varies from place to place, season to season, and year to year. We make maps showing rainfall for individual days, storms, accumulation periods (weeks, months, years), and long-term averages. For stations with long records, we compute monthly averages and generate graphs showing historic seasonal cycles. Then we compare current and recent data to these long-term averages. We continuously update our information as new data arrive.

Media and Public Information

There is something very satisfying about seeing your own data appear on TV, in the newspaper, or on the Internet. There are many dedicated weather volunteers who not only report each day through existing weather networks but who go one step further. They also compile their data and share their weather reports in local newspaper articles, radio programs, Web sites, and blogs.

Sharing backyard weather measurements with the public may not be the most important use of volunteer data in the big scheme, but it is a worthy endeavor and it makes all of us just a bit more aware and appreciative of our environment. It's also a great conversation starter.

Weather Forecasting and Warnings

Here is where the rubber meets the road. Volunteer measurements help weather forecasts and warnings. Timely reports of heavy rain, snow, or hail help forecasters issue local storm warnings and advisories. Daily precipitation reports allow each daily forecast to be verified. This gradually leads to more accurate weather forecasts. Soil moisture approximated from rainfall data initializes the sophisticated weather forecast models that all weather forecasters rely on today.

For many decades, trained weather observers took hourly manual measurements at airports across the country. Beginning in the 1990s, most of the U.S. airport weather stations began converting to electronic automated observ-

ing systems. This automation saves labor costs and provides instantaneous, around-the-clock weather surveillance. However, the automated measurement of precipitation over the full range of year-round weather conditions is very difficult and expensive. Most automated gauges, such as the common and long-used “tipping bucket” rain gauge, are not always as accurate as a manual rain gauge reading. Additionally, most automated stations do not measure snow at all. Without volunteer measurements of snow, sleet, freezing rain, and hail, meteorologists would have very little to go on for those important weather elements.

Forecasters rely on radar and satellite data for instantaneous tracking of storm development and movement. Radar reflectivity is used to estimate the amount of rainfall that reaches the ground. But the radar beam rises farther above the ground and expands with distance from the radar. Accurate estimates of rainfall from radar can only be done when combined and calibrated using rain gauge data.

So while there are many automated sources of weather information today, meteorologists turn to precipitation data taken manually by volunteers to provide “ground truth.”

Putting Data to Work

Hydrology

Each morning, River Forecast Centers across the country gather precipitation data from all reliable sources. The latest data are used to help forecast water levels and flow rates for rivers all across the nation. The accuracy of these river forecasts is highly dependent on the availability of well dispersed precipitation measurements. These rainfall-based hydrologic predictions are critically important for assessing municipal water supplies, river navigation, hydropower production, and much more. Again, the professionals make use of backyard volunteer measurements from NWS Cooperative Observers and CoCoRaHS volunteers.

Things get really interesting when the big rains come or when snow melts quickly. Flood prediction is greatly aided by timely, accurate, and numerous precipitation reports and by snow-pack measurements from volunteers.

Less obvious, perhaps, is the relationship between precipitation and groundwater. The majority of communities across the country rely on groundwater for their safe and secure water supplies, and it is the precipitation received now and in the recent or distant past that recharges that precious resource. In 2004, the state of Nebraska worked with CoCoRaHS to start a statewide volunteer network called the Nebraska

Rainfall Assessment and Information Network (NeRAIN) specifically to monitor groundwater recharge.

Precipitation measurements are also used to track the quality of our water supplies. Heavy rain over urban areas may flush dirt, debris, automotive products (lubricants, coolants, etc), home and yard waste, and other pollutants into rivers and streams. In agricultural areas, fertilizers and herbicides may be washed from fields into streams and lakes by the runoff from local precipitation.

Drought

The lack of precipitation that leads to drought occurs somewhere in the United States every year and is one of our nation’s most costly natural disasters. Measurements from volunteers make it possible to assess drought conditions on national, regional, and local levels. In fact, almost all of the data that create the historic perspective that is needed to assess the extent, severity, and duration of drought come from the backbone NWS Cooperative Network. More recently, the CoCoRaHS network has become a mainstay in drought monitoring by providing local drought impacts reports and a higher density of stations that show county-level variations in drought severity.

Agriculture

From the beginning of civilization, agriculture and weather-watching have gone hand in hand. Today, farmers and ranchers track precipitation to assess crop and grazing conditions, to anticipate pest outbreaks, and to predict changes in



Heavy rain shower in progress in West Palm Beach, Florida.

HENRY REGES



Farmers and ranchers track precipitation to assess crop and grazing conditions, anticipate pest outbreaks, and predict changes in market prices. Rainfall measurements in places like this farm in Laporte, Colorado, help determine irrigation requirements, costs, and schedules.

market prices. Rainfall measurements help to determine irrigation requirements, costs, and schedules. Agricultural disaster declarations are based on local weather data. Feedlot operators track rainfall to document events that might cause runoff and effluent to escape containment.

Utilities

All across the country, municipal water providers, wastewater managers, and storm water engineers pay close attention to precipitation. Precipitation affects water supply, water demand, the cost of water, water quality, and waste water treatment. Water planners try to anticipate year-to-year variations in precipitation so they can provide a reliable water supply even when precipitation comes up short. Our nation's many power plants also keep a keen eye on the skies to make sure they have adequate water supplies to meet power plant requirements. Across the country, many utilities also participate in the NWS data collection or set up their own rain gauges.

Engineering and Architecture

Weather data are heavily used in the design and construction of our nation's critical infrastructure. The frequency, intensity, and duration

of precipitation all factor into how buildings and highways are designed and built, and how well they function and last. Local and national building codes take precipitation and snow loads (the potential weight of heavy snow) into consideration. Gutters, downspouts, curbs, storm drains, parking lots, and bridges are all designed and built based on the historical precipitation patterns in that particular area. Power transmission lines and radio, TV, and cell phone towers are designed and built to withstand the expected accumulation of ice from freezing rain. Volunteer gauge measurements of ice and freezing rain are very helpful for these purposes. Radio signals and satellite communications are affected by heavy rain and can be totally disrupted during extremely heavy storms.

Are there any manmade lakes (reservoirs) in your area? The design, construction, and maintenance of dams and spillways all take precipitation into consideration. Large dams with downstream population, nuclear power plants, and some bridges in critical locations are designed to withstand the heaviest rains that nature could potentially provide. The "probable maximum precipitation" refers to scientists' best estimates of just how much rain could fall if the "perfect storm" were to occur. These estimates

rely on all available measurements of the most extreme storms that have ever occurred.

Legal and Insurance

Attorneys and insurance professionals regularly make use of precipitation data. The official documentation of where and when precipitation fell is an important application of volunteer weather data in the United States. Examples include documentation of hail storms that damaged cars, crops, or homes, or proving to a judge and jury that snow and ice may have contributed to an accident. Millions and millions of dollars in crop insurance payments as well as automobile and homeowners claims are paid out each year based on verification from weather records.

Snow

Nearly all of the historic data that we have to track snow accumulation and the water content of snow comes from volunteers. From designing buildings to clearing streets and highways to deicing aircraft, snow data are in great demand. A whole book could be written about snow and the uses of snow data. One of the largest single users of volunteer-provided snow data today is the National Operational Hydrologic Remote Sensing Center, which combines manual measurements with aircraft and satellite data to provide nationwide products that show snowcover, depth, and water content.

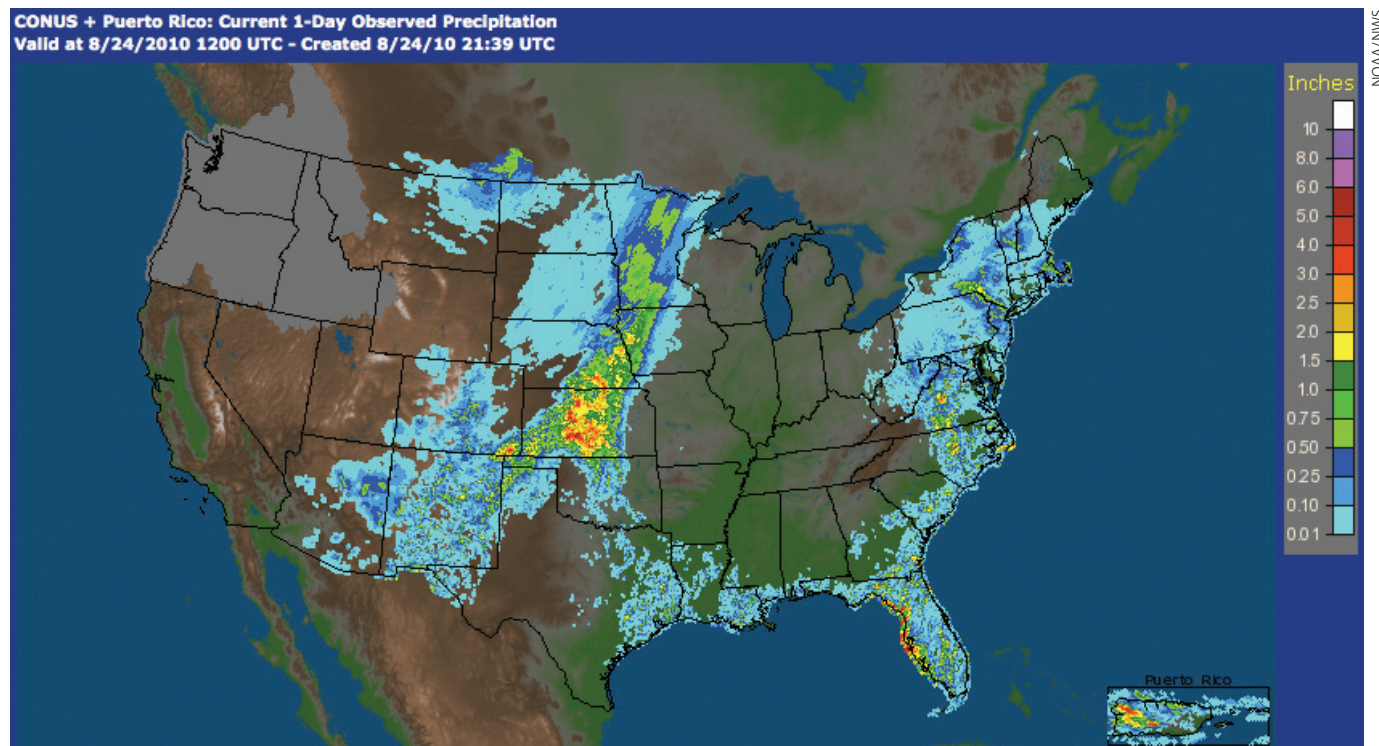
Surprise

Talk to any climatologist and you may hear entertaining stories about unusual ways precipitation data are used. From selecting wedding dates to studying the spread of diseases (West Nile was a recent example), precipitation data are often involved. We personally have answered questions about how rain affects classroom behavior in elementary schools, how it influences the onset and intensity of fall colors in New England, and how it affects the reflectivity of the stripes painted on streets and highways. Then there are the many court cases where weather conditions come into play. Precipitation data were thoroughly studied in the investigation of the mysterious murder of JonBenét Ramsey in Colorado back on Christmas day in 1996.

In the entertainment industry, rainfall can turn an outdoor event into a disaster. Did you know that large outdoor concerts and special events may require on-site rainfall measurements for insurance policy verification? And the production of high-cost, big-name movies sometimes entails assessing rainfall probabilities and verifying rainfall during outdoor filming.

Rain Gauges and Changing Climate

Never before have so many scientists and policy-makers around the world watched climate data so closely. Is it getting drier? Wetter?



National Weather Service Precipitation Analysis for 24-hour period ending at 1200 UTC August 24, 2010. These maps are updated daily and are based on a combination of radar, rain gauge and satellite data.



Snow may fall in feather-light flakes, but as it accumulates the weight can place extreme stress on buildings and trees like this deep snow in Soda Springs, California.



This photo taken from an airplane near Atlanta, Georgia, in August 2009 shows the local variability of convective showers.

Are there more floods and droughts, and are they more extreme? Data from volunteers are being used to assess climate trends and extremes. Because precipitation is naturally and historically so variable from place to place and year to year, it is not easy to quickly or accurately detect significant trends. Some northern states and New England appear to be getting wetter. Climate scientists are concerned that southern and western states might get drier in the coming years. It will take a concerted effort to maintain our observing networks so we can watch this compelling climate story unfold.

How Many Rain Gauges Do We Need?

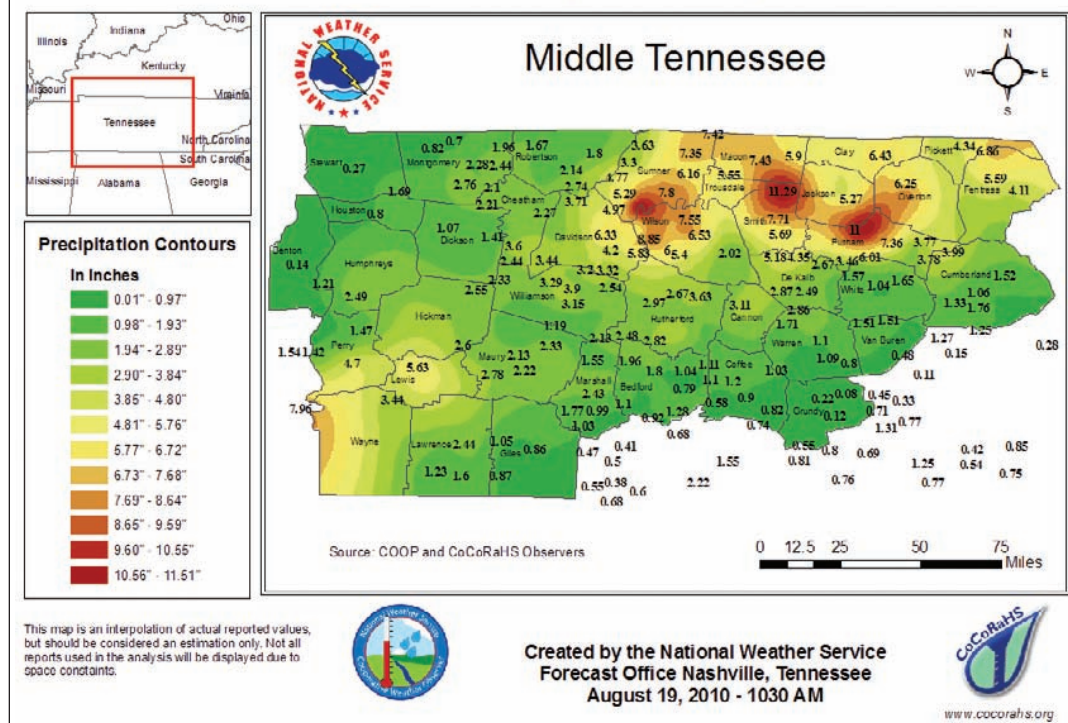
The NWS strives to maintain an average of about one station every 20 miles (every 400 square miles) across the country. This spacing is excellent for depicting state, regional, and national climate zones and patterns, but it's much too coarse for mapping individual storms, capturing extreme events, and detecting important variations in precipitation that occur on a county or community scale. For agricultural applications, gauge spacing of one station every six miles (36 square miles) to 12 miles (144 square miles) is recommended. Even that spacing is inadequate to capture significant local variations for individual storm events.

The storm that inspired the CoCoRaHS network on July 28, 1997, dropped over 14 inches of rain in one part of Fort Collins, Colorado, while other parts of town got less than two inches. Years later, where we once had only two official rain gauges, Fort Collins now has over 80 volunteers reporting in an area of about 120 square miles. To our knowledge, there has never been such a high-density volunteer precipitation network, and we have been maintaining it for more than 12 years. Still, it is barely enough to capture all the details in actual precipitation patterns, and that is the marvel and fascination of rain, hail, and snow for weather watchers. One gauge every mile is a worthy goal where there is the population density and interest to support it. For localized convective storms, even more will be appreciated.

Future

We must continue to accurately measure and report rain, hail, sleet, and snow. When the NWS Cooperative Program began in the 1800s, the leaders and volunteers had no idea we would still be using and needing their data 120 years later. When we started CoCoRaHS in 1998, we had no idea it would spread across the entire country. Likewise, we can be sure that the precipitation data we collect now and in the future

Rainfall Amounts From August 17 - August 19, 2010



National Weather Service Cooperative data combined with CoCoRaHS rainfall reports allow for improved mapping of U.S. rainfall patterns as shown in this recent example of heavy rains in Middle Tennessee.

will also have many new applications that we can't even imagine today.

Dollars at Stake

Have we convinced you that backyard rain gauges are important? Imagine building a new huge shopping center but not considering that once or twice a century, snow and ice weighing as much as 30 pounds per square foot may accumulate and damage roofs and merchandise. Or think about the \$80 million interstate highway bridge over the river, or your city's water and sewage treatment plants, or the hospital and the nearest university. Imagine if they were built without taking the variations and extremes of precipitation into account. Or imagine that meteorologists couldn't tell you that heavy rains and flooding were on the way. The data collected from backyard rain gauges is worth a whole lot!

Help Wanted

If you don't currently participate in a volunteer weather observing program, this is a great time to start. Join the CoCoRaHS effort. Be a NWS Cooperative Observer or a severe weather spotter. Set up your electronic home weather station so it can share data with the Citizen Weather Observer Program and/or WeatherUnderground. Join the fun. But don't forget! The data you collect will be put to very good use now and for many years to come.

A Big "Thank You"

We offer a huge thanks to the nation's volunteer weather observers. Special thanks go to the National Weather Service and their many staff in forecast offices across the country who help maintain the historic, valuable and essential Cooperative Observer network. Thanks also go to the staff and volunteer leaders of the Community Collaborative Rain, Hail and Snow network who are constantly recruiting and training volunteers across the country to measure their neighborhood precipitation. We also want to thank the staff and volunteer leaders of the Community Collaborative Rain, Hail, and Snow network who work together to get thousands more volunteers across the country actively involved in measuring the precipitation that falls in their neighborhoods. **W**

NOLAN DOESKEN is the State Climatologist for Colorado at the Colorado Climate Center at Colorado State University and is long-time Cooperative Weather Observer for the NWS at the Fort Collins, Colorado, weather station. Nolan also founded the Community Collaborative Rain, Hail, and Snow network (CoCoRaHS). HENRY REGES is the National Coordinator for the CoCoRaHS network, and he has helped build volunteer leadership teams to expand CoCoRaHS nationally. Henry also works at the Colorado Climate Center and is an avid traveler, gardener and photographer.