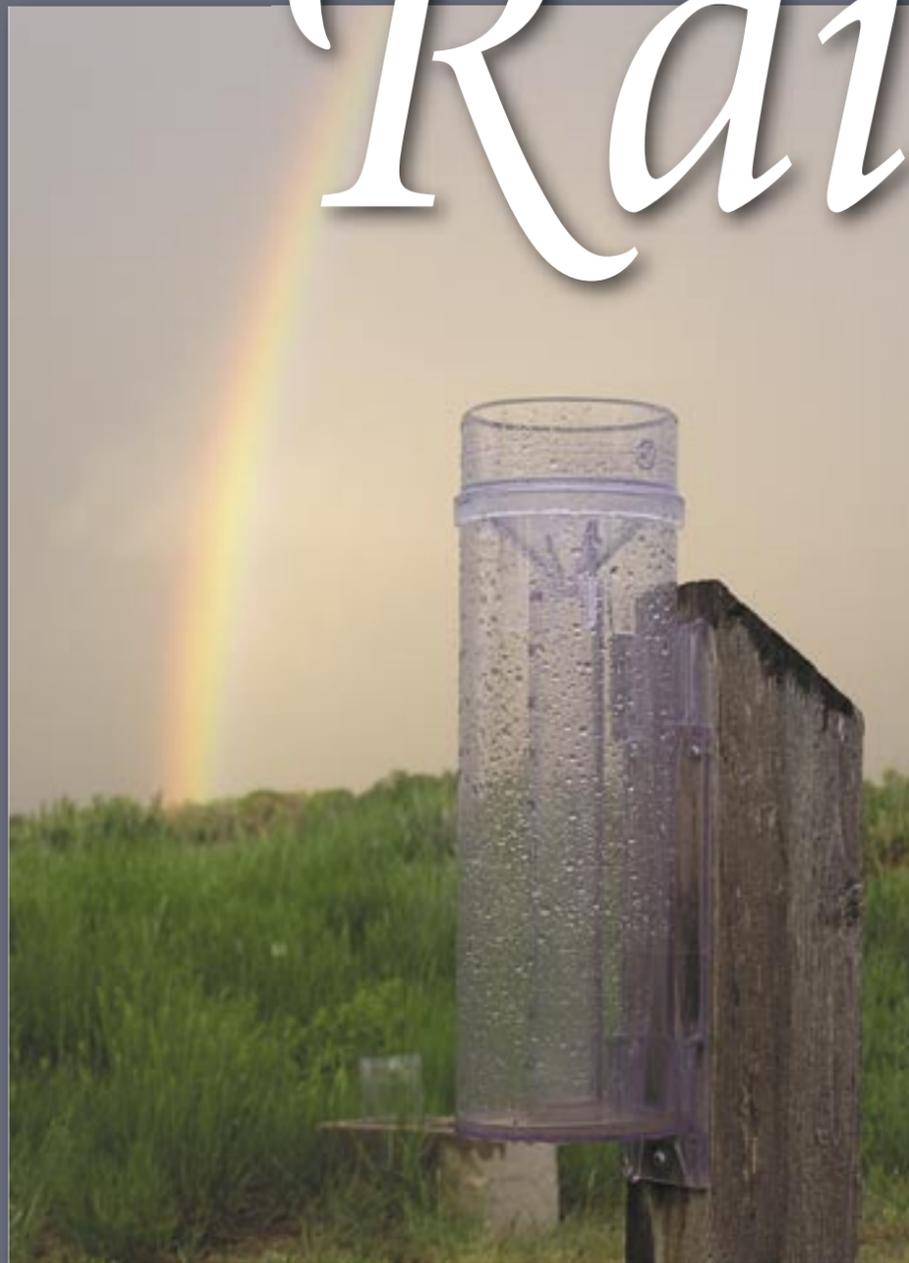


Let it Rain



HENRY REGES

How one grassroots effort brought weather into America's backyards

NOLAN DOESKEN

In the summer of 1997, the city of Fort Collins, Colorado, was inundated by a storm that dumped more than 12 inches of rain on the area in a 24-hour period. In the wake of the tempest, as rescue workers assessed the damage, many in the area asked how weather forecasters could have failed to warn them about the flood danger until the storm was nearly over. Local meteorologists realized that their existing system for collecting and disseminating information was not capable of handling events such as the storm that summer. Ultimately they concluded that a new system for observing and collecting weather data on a smaller scale was needed. Nolan Doesken, the Assistant State Climatologist at the Colorado State University Department of Atmospheric Science, was one of the meteorologists who questioned the lack of data. In the months that followed, Doesken and his colleagues launched what would become known as the Community Collaborative Rain, Hail and Snow network, or CoCoRaHS, which uses volunteers to collect weather data that is used to create a more detailed picture of weather patterns.

In honor of the program's 10-year anniversary, founder Doesken examines how CoCoRaHS got its start, what it has accomplished so far, and where it is headed.

A Noticeable Gap

I awoke on the morning of July 28, 1997, to a steady, light rain and heavy, dark clouds in the sky. The scene did not look particularly ominous or unusual, but little did I know that 12 hours later, Fort Collins would be experiencing one of the worst rainstorms to hit Colorado in years.

Overnight, parts of our town had received two inches of rain, a sizeable amount in this area of the United States. We later found out that Laporte, just a few miles northwest of Fort Collins, had received nearly 10 inches of rain over an area of just a few square miles; radar had only shown a small, localized shower there the previous night and gave no indication that more than an inch of rain had fallen.

In Fort Collins, the sky remained cloudy throughout the day on the 28th. The system at play over the area was the result of cool, humid air being pushed up against the eastern foothills of the Rocky Mountains by a high pressure area over the northern plains behind a fairly strong summertime cold front. Along the Front Range, "upslope" conditions, where winds

out of the east bring moist air up the east face of the Rockies, contribute to many major storms.

The rain eventually resumed, reaching peak intensity between 9:30 and 10 p.m. As the intensity of the storm increased, I never thought to call the National Weather Service or the county emergency manager to relate to them what was happening in Fort Collins; I assumed they were tracking the storm in detail using what was then the very new WSR-88D Doppler radar, which has rainfall estimation capabilities. In addition, Fort Collins had a very active local network of severe weather spotters led by Jim Wirshborn of Mountain States Weather Services. Storm tracking had become a priority in the area after the 1976 Big Thompson Flood, which ravaged a mountain canyon between the towns of Estes Park and Loveland, Colorado, claiming more than 140 lives. However, neither the radar nor the storm spotters were tracking this storm; there were many other more impressive-looking storms in other parts of the state that evening, and this one seemed to escape notice.

At 4 a.m. on the 29th, the university administration called to inform me that the weather station building on the main campus was flooded and I needed to assess damages. When I arrived, I was stunned by what I saw; water stretched for hundreds of yards and debris was everywhere. Our weather station had been flooded, but most of our equipment had survived. Only one of the 5 rain gauges had functioned properly—the historic NWS standard rain gauge stood intact, showing that just over 6 inches of rain had fallen. In 110 years of data collection at our office, that was the most rain that had ever fallen in one day.

In the aftermath of the storm, Fort Collins officials took stock of the damage. Several people had lost their lives, and the level of destruction across the university campus and other areas of town was extensive. All told, the damage exceeded \$200 million.

people interested in helping measure future storms, and we realized that we had on our hands a real opportunity to engage the public in meteorology.

We immediately thought of a small grassroots project launched earlier that year to collect localized hail data. In the spring of 1997, a group of us at Colorado State University's Colorado Climate Center had received a small grant from the Cooperative Institute for Research in the Atmosphere to involve high school students from northern Colorado in a project to help investigate hail. The concept was for the students to recruit volunteers from around the state to collect data on hail in their backyards to get a better idea of the larger picture of hail patterns across Colorado. However, despite the students' enthusiasm and efforts, the overall response to the hail project was polite but underwhelming. That changed after the storm in July. With the help of funds and assistance from FEMA, the Colorado Office of Emergency Management, the NWS, Mountain States Weather Services, and the Fort Collins Stormwater Utility Office, we decided to take the fledgling volunteer hail network and reshape it into a citizen rain and hail network that could provide the kind of high-definition weather data we needed.

In April 1998 we began advertising at local schools, in flood-affected neighborhoods, and across the university. The local "oldies" radio station, which targets the over-60 crowd, aired a public service announcement about the new network. Nearly 200 people came to the first public meeting, and even more attended the volunteer training sessions. On June 12, 1998, with help from local high school students, we launched www.cocorahs.org, which allows volunteers to report rain and hail measurements from their backyards and immediately see their data plotted on city maps. Several dozen volunteers began sending in rainfall reports each day. Not surprisingly, every storm showed dramatic and fascinating local patterns and variations in precipitation. CoCoRaHS was born.

Impressive Growth

Since 1998, interest and participation in the program has grown each year, and the network has spread to encompass numerous additional counties across Colorado and the United States. In 2002, a severe drought gripped Colorado, making it nearly impossible to recruit new volunteers. But with each dry month water supplies diminished, and Colorado's water providers began preaching conservation to the public. CoCoRaHS volunteers were among the first to recognize and vocalize the severity of the drought and the need to conserve. Impressed by the volunteers' dedication, several organizations, including the Colorado Water Conservation Board, stepped forward to support and encourage CoCoRaHS. In 2003 the National Science Foundation Informal Science Edu-

In 2006 alone, [CoCoRaHS] volunteers contributed about 45,000 hours of time monitoring precipitation.

After the deluge, my fellow meteorologists and I dropped our regular office work and began surveying the storm. Using newspaper articles, radio announcements, and e-mail messages, we reached out to people who had rain gauges or other receptacles to help us measure and map the storm.

The response was overwhelming. More than 300 people provided valuable information, and eventually we were able to piece together the story of the storm. It was surprisingly localized, covering only a few square miles. Nearly 8 inches of rain fell at my house, and nearly 12 inches fell at my office. We identified a core of rainfall exceeding 14 inches over southwest Fort Collins, immediately uphill from the campus. This was by far the heaviest rain ever observed over an urbanized area in Colorado.

Then Came CoCoRaHS

In the months that followed, our analysis of the Fort Collins flood-producing rains was used in a number of studies, reports, and presentations for insurance, legal, and other purposes. The rainfall at the core of the storm was 3 times greater than the expected "100-year storm." While very small in area, the storm was the first of this magnitude to deliver a direct blow to a modern Front Range city. It was also 1 of only 12 storms in recorded history in Colorado to produce more than 10 inches of rain in one day.

The *Coloradoan*, the local Fort Collins newspaper, published the rainfall map we had created following the storm, and the response we saw from that publication was impressive. We began to receive calls from



A rainstorm photographed by a CoCoRaHS volunteer in Wyoming.

cation Program provided funds to our organization so we could reach out to rural communities of the western Great Plains. Wyoming joined the project, followed by Nebraska and Kansas. In each state, different organizations took an interest in the program and expanded the ranks of volunteers.

In addition, we added snow measurement to the program to accommodate the importance of frozen precipitation in the hydrologic cycle in the Rocky Mountain West. Previously, we had shied away from measuring snow because it is difficult to obtain accurate measurements. However, volunteers expressed enthusiasm for the challenge. Several hundred of them attended special training sessions to learn how to measure snow and its water content accurately.

By 2005, CoCoRaHS had more than 1,000 active volunteers. To accommodate the growing scale of the network, we added a significant educational component with annual workshops for volunteers, local seminars, picnics, and other gatherings, as well as online training materials, videos, and customized lesson plans for school teachers who want to involve their students. We also linked with conservation districts, Master Gardeners, and other local organizations to encourage education through the seemingly basic but actually very important measurement of rain.

In recent years, a number of additional states have asked to join the CoCoRaHS network. By June 2007,

19 states plus the District of Columbia had joined, and more than 8,000 volunteers had contributed their time and efforts to CoCoRaHS. Currently, about 4,000 of those volunteers are active, and dozens more join each week. They encompass a wide swath of society, ranging from young children with an interest in weather, to families collecting data as a way of spending time together, to senior citizens enjoying making a contribution to science, to farmers with a personal interest in the weather. In 2006 alone, these volunteers contributed about 45,000 hours of time monitoring precipitation. In 2006 NOAA's Office of Education also joined the funding partnership for CoCoRaHS to encourage greater citizen participation in the study of weather, climate, and water throughout the nation.

The Tools of the Trade

The average person with a mild interest in weather and the related sciences likely believes that measuring precipitation is easy. However, the reality is that measuring the accumulation of rain and the water content of snow and other forms of precipitation is a challenging and inexact process. Despite considerable investment in efforts to improve instrumentation, surprisingly little progress has been made in the past century to improve the accuracy of precipitation measurements in the United States. One can spend thousands of dollars for



A CoCoRaHS hail pad after being hit by large hail during a storm.

a rain gauge that still only provides approximate results during certain weather conditions.

In other words, measuring rain that is gently falling straight down is fairly easy, and many gauges perform well. However, interferences such as a change in intensity or the addition of wind, freezing rain, sleet, hail, and snow tamper with the measurements. Wind can deflect precipitation particles around the gauge; updrafts can reduce the amount of precipitation falling into a gauge; or bugs, debris, and spiderwebs can clog and confuse otherwise functional gauges. Large raindrops can splash out, hail can bounce, and snow and freezing rain can stick to the rim. Trees, buildings, and other obstacles can also block or boost precipitation totals, depending on wind and rainfall intensity. Sensitive mechanical and electronic gauges can fail or fluctuate with changes in temperature, wind, and barometric pressure. As a result, engineers have yet to design an instrument that can accurately measure precipitation under all weather conditions.

Because of these challenges, we decided that CoCoRaHS volunteers should use the simplest tools to take measurements. One such tool is a 4-inch-diameter clear plastic rain gauge that holds more than 11 inches of rain but can measure tiny increments of precipitation (0.01 inch) as accurately as the NWS' traditional Standard Rain Gauge, which has been used for more than 100 years. Studies at Colorado State University that have compared various rain gauges for more than 10 consecutive years have shown that this simple gauge performs well both in winter and summer. Under most conditions, this plastic gauge measures precipitation

within +/- 3 percent of the NWS' standard rain gauge. In low humidity climates such as Colorado's, the gauge appears to outperform the official NWS gauge by reducing evaporation losses.

Meanwhile, the hail pads we use at CoCoRaHS are made of 1x12-inch square blocks of open-core Styrofoam wrapped tightly in a sheet of extra-heavy duty aluminum foil. When the pad is tightly secured to a firm, flat surface, hailstones leave craters that make it easy to identify the number, size, hardness, and direction of motion of the hail stones. There have been a few instances when all that was left after an extreme hail storm were a few fragments of foam and foil, but in most instances, the hail pads can withstand the storm and vividly show the impacts from stones as small as 1/8 inch in diameter up to the size of baseballs.

The measurement of snow for CoCoRaHS volunteers is still as basic as sticking a ruler in the snow and determining the depth. While this sounds simple, accurate snow measurement remains one of the tougher challenges of weather observation, because snow melts, settles, blows, and drifts. Wind-driven snow collects unevenly, creating drifts and bare spots, and also tends to deflect around the precipitation gauge instead of collecting inside. This results in what climatologists refer to as "undercatch," where the water content of snow in the gauge is less than what actually fell and landed on the ground.

Finally, while numbers and measurements are crucial, they do not tell the whole story. Thus an important feature of CoCoRaHS data-gathering and observing is the "Daily Weather Comments" section of the website. This section provides an opportunity for our volunteers to record a brief narrative of the weather conditions they observed during the past day. These comments are archived and can be accessed by date, state, and county.

More Precipitation Data, Please

Of the basic observable elements of our weather and climate system—sunshine, clouds, temperature, humidity, wind, pressure, precipitation, and evaporation—the element that varies the most is precipitation. It is possible for it to be pouring in the back of a house while the sun is shining in the front, especially when it comes to convective showers and thunderstorms. Traditionally, our nation's network of airport weather stations provides detailed data, but the stations are spaced about every 50 to 100 miles across the country. The NWS Cooperative Weather Observation Program, which is composed of citizen weather observers, fills many gaps, with stations approximately every 20-25 miles (one per 400 to 625

square miles). However, precipitation patterns can vary substantially in a short distance and are often only crudely defined by these existing official networks. Near mountains, coastal areas, and anywhere that thunderstorms rumble, weather stations need to be closer together in order to expose variations. Since CoCoRaHS began in 1998, we have seen that having one or more stations per square mile is ideal. That is a data luxury that atmospheric scientists rarely enjoy, but in parts of Colorado and several other states, CoCoRaHS volunteers are making that possible. With so many weather enthusiasts in the United States, such high-definition precipitation observations are possible in many parts of the country.

Mapping the Benefits of CoCoRaHS

We created CoCoRaHS as a rain detection and mapping project to ensure that storms like the one that hit Fort Collins in July 1997 would not take another community by surprise. It is easy to appreciate the value of timely reports of heavy rain, hail, or snow, and how they can help weather forecasters, emergency managers, and the local media.

But there are many other important uses for high-definition precipitation data. For example, radar engineers use CoCoRaHS hail data in their efforts to utilize dual polarity radar beams to distinguish rain from hail, and NASA has tested automated hail sensors alongside CoCoRaHS hail pads in order to improve hail monitoring near the launch pads. Meanwhile, structural engineers use CoCoRaHS hail data to investigate hail-resistant materials, as well as snowfall and water content data to improve estimates of the weight and load on buildings and roofs after heavy precipitation events. Agricultural researchers use high-density rain and hail data collected by CoCoRaHS volunteers to assess variability of crop development and yield, while atmospheric scientists routinely utilize CoCoRaHS data in combination with other weather data sources to verify and evaluate the performance of new weather prediction models.

Having a better understanding of precipitation patterns benefits the public as well. Precipitation excesses and shortages affect crop yields and food prices all across the country and around the world. In addition, precipitation affects transportation and is a factor in the design and construction of highways, bridges, airports, and railroad tracks. Meanwhile, drought is arguably one of the most pervasive, costly, and widespread of all natural hazards that we face, and during a drought the average citizen is likely to face water restrictions that affect day-to-day life; CoCoRaHS observers are trained and encouraged to report "0.00" for days without rain, because the lack of precipitation is just as important as its presence.

Plans for the Future

By 2009, we expect that at least 30 states will be

New Life For an American Tradition

Volunteer weather observation stands right up there with baseball and apple pie as a storied and ongoing American tradition. Ben Franklin, Thomas Jefferson, and George Washington were all competent and dedicated weather observers. For example, Jefferson kept a journal of weather reports for several decades. In the early 1800s, the Smithsonian Institute established an early American network of citizen weather observers that was maintained for several decades and helped define the climate resources of our young nation. By the 1880s, many states had established their own state weather networks to begin the process of better defining weather patterns, climate resources, and variations on a more localized county level.

In 1890, when the first nationwide civilian weather service was established, the U.S. Weather Bureau (originally within the U.S. Department of Agriculture) began uniting these state networks to form the nationwide "Cooperative Weather Observation Program," with the aim of measuring and recording temperature and all forms of precipitation across the nation. Remarkably, 117 years later, the "Co-op" network still exists and is very similar to its original incarnation, with more than 7,000 volunteer weather stations spread across the United States. With nearly 120 years of continuous observations, this is the original national climate observation network. While there is no such thing as perfect data, the co-op is by far the best information resource available today for detecting and tracking long-term climate variations, drought, and other extreme events. It is also the best source for assessing trends in temperature and precipitation to show if and how much our climate is truly warming.

actively involved in CoCoRaHS, and the number of volunteers is projected to grow to as many as 25,000 by 2010. Our ultimate goal is to employ one or more volunteers per square mile over populated urban and suburban areas. Over rural areas, we hope to have at least one person per township, which is approximately every 36 square miles. Although we know it will take some time to reach this goal, we anticipate that doing so will provide a treasure trove of precipitation information that will benefit science, the public, and the environment for years to come. **W**

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If you are interested in joining the CoCoRaHS network please go to www.cocorahs.org and click on "Join CoCoRaHS." If CoCoRaHS is not currently active in your state but you are interested in helping get it started, send an e-mail to info@cocorahs.org. You may also call the CoCoRaHS national coordinator, Henry Reges, at (970) 491-1196.