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# THE COMMUNITY COLLABORATIVE RAIN, HAIL AND SNOW NETWORK (COCORAHS)— "INFORMAL ATMOSPHERIC SCIENCE IN THE COMMUNITY: WHAT CAN WE ACCOMPLISH?"

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## 1. HISTORYOF THE NETWORK

An earlier paper (Reges, et al, 2006) concisely summarized the history of CoCoRaHS. "CoCoRaHS, the Community Collaborative Rain, Hail and Snow Network, is an example of a "Citizen Science" project where volunteers help collect data important to scientists and not readily available from other sources. Volunteers of any age and background, but with a common interest in watching the weather, take daily measurements of rain, hail, and snow using low-cost measurement tools; 4-inch diameter high capacity plastic rain gauges and aluminum foil-wrapped Styrofoam hail pads (Figure 1). With the help of basic instruction and with frequent interaction with participating scientists, volunteers are able to collect and share data of considerable scientific value. There are very few sources of reliable snowfall observations in the U.S. and very little quantitative data on hail stone properties, so CoCoRaHS is quickly becoming a popular source of data to support remote sensing, weather forecasting and other atmospheric and hydrologic research (Cifelli, et al, 2005)."

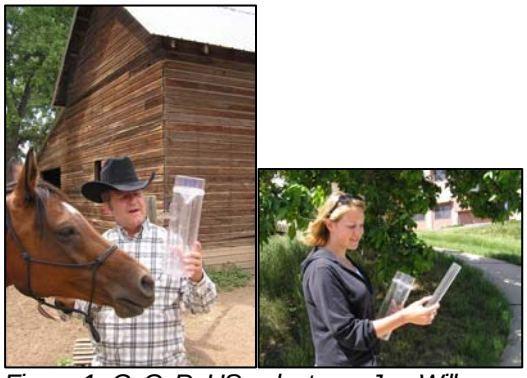

*Figure 1. CoCoRaHS volunteers Joe Willey and Jill Kennedy reading their rain gauges .*

CoCoRaHS came into existence in 1998 as the Colorado Collaborative Rain and Hail Study. A flash flood that claimed several lives in Fort Collins, Colorado in July of 1997 pointed out the extreme local variations in rainfall possible from convective storms and the important role individuals can play in measuring, mapping and reporting precipitation. At first the project was very small with only a few dozen volunteers in Northern Colorado reporting precipitation on a website created by local high school students. Each year since then the project has grown as more people and organizations get involved. In 2003, thanks to a National Science Foundation Informal Science Education grant, the network took its largest step and expanded into the Central Great Plains. Today the network is growing rapidly with over 2,000 active participants in eleven states (Colorado, Nebraska, Kansas, Wyoming, New Mexico, Texas, Missouri, Indiana, Pennsylvania, Maryland, Virginia and the District of Columbia) each administered by state leaders and regional or local county coordinators (Figure 2). Volunteer participation is now increasing spontaneously, mostly by word of mouth, with new applications arriving every day.

Volunteers can report by phone, but most enter data on-line using an interactive web site: http://www.cocorahs.org.

Current observations as well as past data are immediately available in map and table form for participants, project scientists and the public to view (Figure 3). Where there are large numbers of participants, remarkably detailed observations of storm precipitation patterns are now being gathered.

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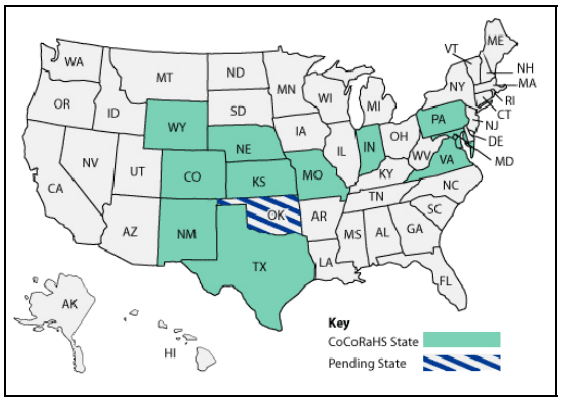


*Figure 2. 2006 participating states in the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS).*

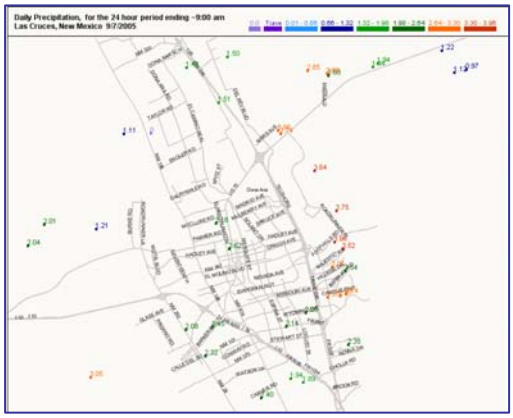

*Figure 3. A typical CoCoRaHS city map as viewed via the Web.*

By providing high quality, accurate measurements on the internet, the observers are able to supplement existing official weather networks with very detailed local data from their neighborhoods. Data collected in Colorado since 1998 show that to be able to accurately map rainfall patterns from summer convective storms, a density of at least one station per 3-4 square kilometers is ideal. Over sparsely populated rural areas at least one station per 100 square kilometers is desirable.

## 2. COCORAHS—OUR MAJOR ACCOMPLISHMENTS

CoCoRaHS over the past 8 years has demonstrated the ability to recruit, train and motivate a large number of weather volunteers to successfully collect data of great and diverse value. As this motivated trained corps of citizens collects data from their communities, there is a two fold effect. First, the citizens learn to track the various patterns of rain, hail and snow in their communities as well as their states, developing and broadening their knowledge of weather that impacts their daily lives. Secondly, there is the added benefit that the data are immediately made available and are valuable for all types of research, weather prediction, hydrologic prediction, agricultural applications, natural resources studies, general education and much more.

We have also shown that we CoCoRaHS is not limited to citizens of a certain age. Through self selection we have seen CoCoRaHS empower and educate people from as young as elementary school to citizens still going strong in their late 80's.

### Accurate Measurements

The question we are asked most often by scientists and other professionals interested in precipitation data is "How do we know your data are any good?" With 8 years of experience and well over 1 million daily precipitation observations now in our database, we are convinced that CoCoRaHS precipitation data are at least as accurate as any other existing source of precipitation data being collected in the U.S. today. We have evaluated the performance of the gauge used by CoCoRaHS volunteer and found it to be a very worthy gauge comparable to official National Weather Service standard rain gauges (Doesken, 2005). While observers do make errors, and not all our data are flawless, our emphasis on rain gauge placement, observing procedures and data quality along with our frequent e-mail instructions and reminders have produced a very dedicated team of observers. Also, seeing data instantly compared to many other nearby stations makes it easy to identify potentially flawed observations. Computerized methods for intercepting potential errors before they reach the database continues to improve data quality. But most importantly, CoCoRaHS makes use of a small team of "data quality volunteers" who scan all data

reports each day, spot potential errors, contact observers for those stations, and confirm or edit these questionable data. This "real time" quality assurance is a core value of CoCoRaHS and lets new volunteers know how committed we are to quality data.


*Figure 4. A CoCoRaHS "hail pad" from a 2002 Boulder, Colorado hailstorm.*

**Hail Measurement**

Our volunteers may not realize it, but very little quantitative data about hail is collected in the U.S. There are no observing systems that monitor the number, size, color, density and damage potential from hail stones. CoCoRaHS is collecting the most comprehensive data on hail storms anywhere in the country. Citizen's armed with a hail pad (Figure 4) record a footprint of hailstorms that strike their neighborhood. These hail pads capture impressions of the hails stones. They are then returned to Colorado State University for analysis. The pad, in combination with a citizen's hail report helps us to learn a great deal about the characteristics of each storm. We are also collecting an impressive on-line database including digital photos of each damaged hail pad that anyone across the world could access to investigate hail characteristics.

**Mapping**

Another strong area that CoCoRaHS has demonstrated is the ability to map rain, hail and snow at the state and county level. Through our Web site, citizens post their daily data, which appears immediately in map form. With eleven states now reporting, it is truly amazing to see the various precipitation patterns across the states on any given day. This alone is an incredible learning tool for understanding the variable nature of precipitation.

*Figure 5. Volunteers at the CoCoRaHS "1,000 Hail Pad Making Saturday" in Fort Collins, Colorado*

**Community Building**

People of all ages can participate in CoCoRaHS without ever leaving their local neighborhood. Yet they are a part of something much bigger. "Community"—belonging and corporately supporting activities that benefit others—is an important aspect of CoCoRaHS. Our network brings together volunteers of many different backgrounds for the purpose of learning more about weather and climate. The more who participate, the more we can learn. We need each other. Through events like the "1,000 Hail Pad Making Saturday" (Figure 5), where over 85 volunteers of all ages came together to manufacture over 1,500+ hail pads in just three hours on a Saturday morning, and volunteer appreciation picnics, citizens who likely never meet are brought together and leave as a community.

**State Recruiting**

We have learned that there is a strong desire for CoCoRaHS in many states. As we slowly expand into new states we have learned that it is important to development team building partnerships with organizations that have a vested interest in what we are doing. For example, partnerships with Cooperative Extension, Conservation Districts, the US Dept. of Agriculture Natural Resources Conservation Service, Farm Service Agency, State Climatologist Offices, Universities and the

National Weather Service have helped grow the network and provide a strong infrastructure helping to sustain the network. Many of our state and county coordinators have stepped forward from among these organizations.

## 3. NEW AND INTERESTING THINGS THAT WE ARE LEARNING

As the number of volunteers increase, the duration of data collected lengthens, and the number of states involved expands, we are learning more and teaching others about precipitation characteristics.

### Weather Patterns

Since the states of Maryland, Virginia, and Pennsylvania joined during the Fall of 2005 followed by Missouri and Indiana this past winter, it has rained and/or snowed somewhere across our eleven-state CoCoRaHS ***every day***. This is a great example of how weather patterns progress across the country. On any given day there is always a storm somewhere between Northwest Wyoming and Southwest New Mexico all the way to the East Coast.

**View Data : List Hail Reports By Day**

Display Date: 3/12/2006 Get Reports

Showing 15 Records.

| Date | Time | Station Number | Station Name | Average | Largest | Photo | State | County | View |
|---|---|---|---|---|---|---|---|---|---|
| 3/12/2006 | 8:23 PM | KS-CR-1 | Pittsburg 0.7 WSW | 1/4" Pea Size | 1/4" Pea Size | -- | KS | Crawford | |
| 3/12/2006 | 5:00 PM | MO-BN-1 | Columbia 3.4 WNW | 1 3/4" Golf Ball Size | 3" Teacup Size | -- | MO | Boone | |
| 3/12/2006 | | MO-BN-2 | Columbia 1.4 NNW | NA | 1 1/2" Ping Pong Ball Size | -- | MO | Boone | |
| 3/12/2006 | 5:10 PM | MO-BN-8 | Columbia 4.2 W | 3/4" Penny Size | 1 1/2" Ping Pong Ball Size | -- | MO | Boone | |
| 3/12/2006 | 2:28 AM | MO-CY-1 | Pleasant Valley 0.5 NNE | NA | 2 1/2" Tennis Ball Size | -- | MO | Clay | |
| 3/12/2006 | 7:30 AM | MO-CY-1 | Pleasant Valley 0.5 NNE | NA | 3/8" | -- | MO | Clay | |
| 3/12/2006 | 10:32 PM | MO-GR-2 | Battlefield 3.6 NNE | 1" Quarter Size | 2 3/4" Baseball Size | -- | MO | Greene | |
| 3/12/2006 | 6:40 PM | MO-GY-1 | | NA | 1 1/4" Half Dollar Size | -- | MO | Grundy | |
| 3/12/2006 | 7:20 PM | MO-GY-1 | | NA | 1" Quarter Size | -- | MO | Grundy | |

*Figure 6. Hailstone Distribution for Missouri Counties, 12 March 2006*

### Instant Analysis

CoCoRaHS volunteers, as well as scientists and the general public, can do instant analysis using our Web site (www.cocorahs.org) on a variety of data. A good example is our new ability to do frequency distributions of hail stone sizes, snowfall totals, or daily precipitation amounts.. With two simple clicks of the mouse anyone can produce a frequency distribution of hail stone sizes for a specific state or county (Figure 6). This capability for hail has never been available anywhere before. A fifth grader in Missouri can do this just as easily as a climatologist in Colorado. Similar analysis of other types of precipitation are available as well.

### Snow Data

Despite wonderful advances in technology, point observation of snowfall are less available nationally now than they have been at other times in recent history. Radar doesn't measure snow well, while satellite-based products have many limitations. With our local volunteers CoCoRaHS is providing snow measurement capabilities never before afforded in this country. The National Weather Service Cooperative Observer program provides approximately one observation per 625 square miles across the U.S. But CoCoRaHS data have shown that variations in snow accumulation cannot be well defined at that scale. In several Colorado cities, there are approximately one CoCoRaHS observer per square. We know that even manual observations of snowfall have some uncertainty due to issues of drifting and melting, but with a high density of observations we are able to show quantitatively the range and errors associated with point measurements of snowfall. This will contribute significantly to our understanding of long-term snowfall records in the U.S.

### Drought Monitoring

The western U.S. drought of 2002 was a turning point for CoCoRaHS. What began as a network established for studying storms out of necessity became a drought monitoring network. Participants, noticing

the prolonged lack of precipitation, were among the first in their communities to recognize the need for water conservation. Several new data analysis tools on the CoCoRaHS website make it possible to quickly assess precipitation totals over previous weeks, months and years to identify areas most lacking in precipitation. For example, parts of New Mexico went over 4 months with no measurable precipitation from late October 2005 into February 2006. Dona Anna County in southern New Mexico for the 7-month period from mid October 2005 through mid May, 2006 only received an average of 0.32" of precipitation—indicated extreme drought even for this normally dry area.

## 4. OUR VISION FOR COCORAHS

CoCoRaHS has a lot to show for a few years, a bunch of plastic rain gauges, stacks of Styrofoam and aluminum foil, and a bunch of enthusiastic volunteers. But the potential for the future is so much greater. Our vision includes:

### A Nationwide Precipitation Monitoring Network

In the next several years CoCoRaHS has the momentum and potential to go from a few core states to becoming a nationwide network of individuals working together, having fun, learning bunches while measuring and mapping rain, hail and snow across the entire country. With the potential for hundreds of new observers in each state, we can improve flood forecasting, we can document the frequency and intensity of extreme storms, we can identify localize rainfall patterns, and we can track the development of local or regional droughts. Every state will have its own unique patterns and special applications. Through collaboration, CoCoRaHS has the ability to enhance our Nation's existing precipitation networks, such as the National Weather Service's Cooperative Network, and has the potential to create the best, comprehensive precipitation monitoring network of all time.

### Showing how Scientists, Engineers and Resource Professionals Utilize Precipitation Data

Where ever we go, we find that most people have a limited view of the importance of measuring precipitation. Most connect the measurements to the daily weather forecast and perhaps the growth of their grass or their crops. We would like people to see, appreciate and feel ownership in the fact that precipitation is one important "local index" of the entire global climate system. By observing precipitation locally, we advance science discovery and resource management locally and globally.

### A Greater Appreciation for the Hydrologic Cycle. Rural and Urban

CoCoRaHS provides a platform where the measurement of precipitation can become the focal point for an understanding the hydrologic cycle. Seeing the relationship of precipitation to the hydrologic cycle, the differences from urban to rural environments, and helping people realize that "the weather is our water" no matter where we area, we would like to help lead a collaborative national educational program "Walking Through the Water Year"

## 5. CONCLUSION

As CoCoRaHS continues to grow over the next several years, both local communities and the nation as a whole will benefit from the broader impacts of the network in many of the ways mentioned in this paper. It is exciting to think that what is happening in eleven states today can have the same effects and benefits in the remaining thirty-nine tomorrow.

## 6. ACKNOWLEDGEMENTS

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## 7. REFERENCES

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