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WHAT GOOD IS A DENSE VOLUNTEER NETWORK FOR MEASURING RAIN AND HAIL?

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1. INTRODUCTION – The establishment of the Community Collaborative Rain and Hail Study (CoCo RaHS).

Many years of climate monitoring in Colorado and interacting with the citizens of the state revealed the following, and not terribly surprising, facts.

- Precipitation is highly variable in time and space, and a large number of measurements are needed to accurately define rainfall patterns from individual storms.
- Existing rain gauge networks are inadequate for resolving local-scale variations.
- Local precipitation variations have significant and detectable impacts.
- Remote sensing may have the capability to detect hail and quantify local variations in precipitation, but the accuracy and reliability of these estimates are still limited.
- Almost no hail data are routinely collected for climatological studies.
- There is an extreme public interest in rainfall and hail patterns. Weather enthusiasts exist in practically any area and are happy to help collect important data.
- Weather data collection affords great educational opportunities – locally relevant, not abstract – easy to grasp – well suited to applications.
- The measurements of rain and hail can be accomplished with simple and low cost instruments.
- Students and their teachers are seeking opportunities to participate in beneficial research, and the process of climatological data collection and analysis are clearly aligned with many of the current national and state education "standards."

The Colorado Climate Center has always made use of climatic data collected by the National Weather Service Cooperative Program, but the density of observations from this network, while better than most other sources, still prove inadequate for documenting precipitation patterns from convective storms. In the past, consideration has been given to establish a volunteer program focused on rainfall and hail observations to supplement existing data sources but was too big of a task.

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Two things happened, however, to motivate the establishment of a dense volunteer network in Colorado. The Internet and the rapid increase in the number of citizens with Internet access during the late 1990s created new opportunities in volunteer data collection. But the real impetus was an extreme rainfall episode in July 1997 over northeastern Colorado that was largely missed by existing surface observations and which was seriously underestimated by National Weather Service radar. Following this event, hundreds of citizens shared rain reports and personal recollections to help analyze in great detail the heaviest rainstorm ever observed over an urban area in Colorado (Doesken and McKee, 1998). It took several months to assemble and analyze all the data, but in the end extremely detailed and accurate rainfall maps were produced from volunteer reports that have since been used extensively by meteorologists, hydrologists, engineers, emergency managers, teachers, researchers, insurance adjustors, attorneys and many others.

After the 1997 floods, and motivated by the incredible show of interest by individuals and families in helping scientists better understand storms, a systematic effort to recruit, train and equip volunteers was begun. In the spring of 1998 the Community Collaborative Rain and Hail Study (CoCo RaHS) was begun. In the four years since then, over 900 volunteers over northeastern Colorado have been equipped with 4-inch diameter high capacity rain gauges and with foam pads covered with aluminum foil to measure and count the number and size of hail stones. Many observers have also been trained to measure and report snowfall. The result is a large and growing network of volunteers providing a high density of precipitation measurements (Table 1).

Table 1. CoCO RaHS volunteers equipped and trained to measure and report rain and hail.

Year	Number of new Volunteers	Primary Targeted areas
1998	122	Fort Collins and vicinity
1999	206	Larimer, Weld and Adams Counties
2000	291	East-central Colorado
2001	309	Morgan and Boulder Counties

As the number of volunteers and the area of the project has expanded, the Colorado Climate Center has begun to rely on local volunteer coordinators to recruit and train volunteers from their own communities.

Much of the 2001 expansion was accomplished with the help from a team of volunteers committed to improving precipitation monitoring in their own communities. Also, several sponsors have contributed money that has allowed students an opportunity to help with the project and receive pay for their efforts. In four years, CoCo RaHS has employed a total of 19 student interns helping with volunteer training, with data collection, with webpage and outreach materials and with analyzing hail data.

Each day of CoCo RaHS data shows very clearly why a dense network of rainfall observations is so important to confidently document precipitation patterns. It also points out the value of radar as a tool for defining the time and space characteristics of precipitation but that calibration of radar-rainfall relationships is essential.

Examples of rainfall patterns for a pair of storms observed by network volunteers appear in Figures 1 and 2. A map of CoCo RaHS hail reports is shown in Fig. 3. Typical storm dimensions during the summer are in the range of two to four miles, with storm centers often only a mile or less in diameter. Only with a station density of one or more observing sites per square mile can some storms be detected. Even the very large heavy storms as shown in Figure 2 may only be a few miles across. The maximum one-day rainfall report since CoCo RaHS began was 6.22 inches in southeast Greeley on July 14, 2001. Hail is even more localized. Events like May 17, 2000 (Fig. 3) where hail was reported at hundreds of locations is the exception, not the rule.

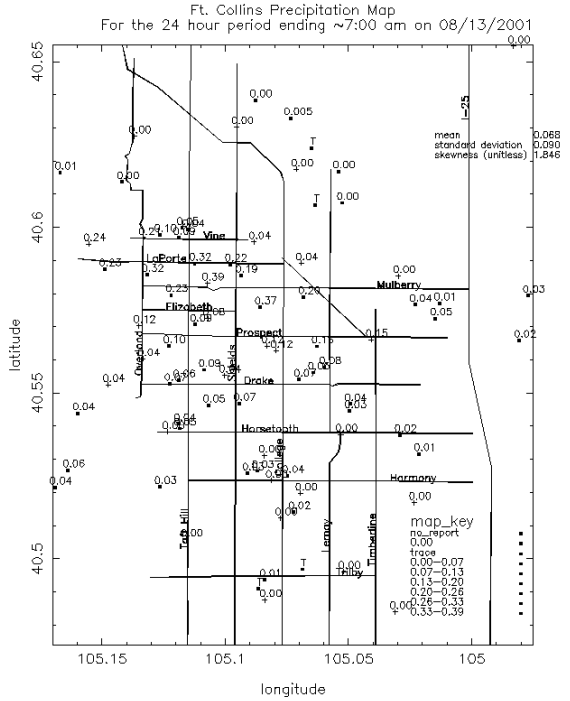

Figure 1. Rainfall (in inches) for the 24-hour period ending at 0700 MDT August 13, 2001 over Fort Collins, Colorado.

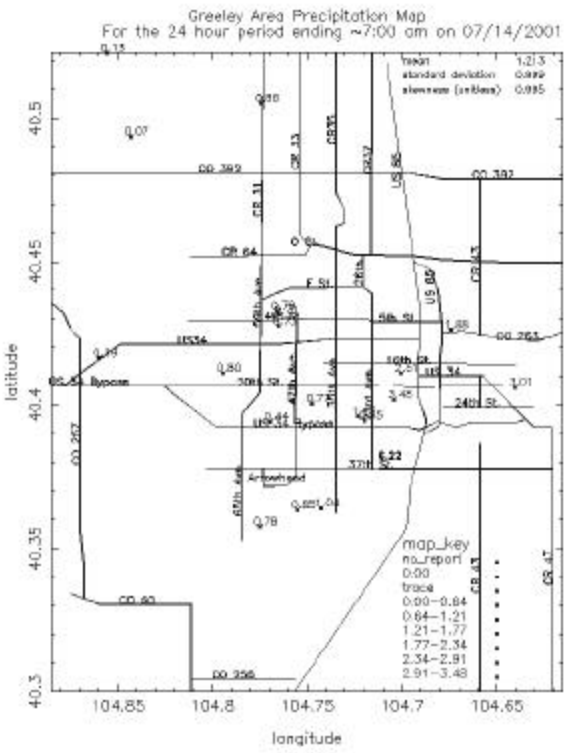

Figure 2. Rainfall (in inches) for the 24-hour period ending at 0700 MDT July 14, 2001 over Greeley, Colorado.

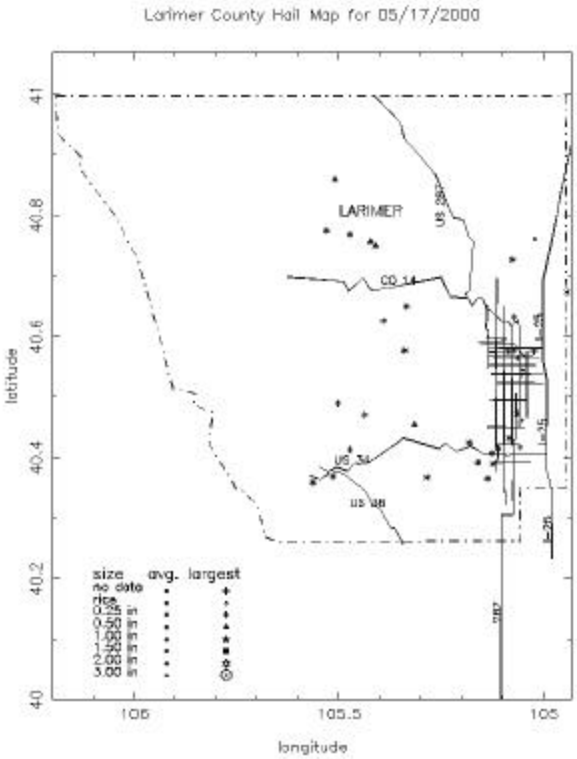

Figure 3. CoCo RaHS hail reports for May 17, 2000 over Larimer County, Colorado.

2. USES AND APPLICATIONS OF DATA

The Colorado Climate Center has been involved in many areas of applied climatology since its creation in the mid 1970s, but CoCo RaHS has stirred the greatest interest and garnered the most widespread and enthusiastic support. As of early 2002, more than two dozen organizations have helped support getting the project going, and many have become annual contributors. Some 750 rain gauges have been donated by local, state and federal agencies and private businesses to help promote the program and encourage citizen participation. Service organizations, boy scout troops, and 4-H clubs have pitched in time and resources to help make thousands of hail pads for use by CoCo RaHS volunteers. And why such interest? The simple fact is that the local variations in precipitation, particularly during the convective season, are both fascinating to the public and important for many applications. In four years we have seen thousands and thousands of hits to the CoCo RaHS website at http://www.cocorahs.com.

Of particular interest is the diverse set of sponsors and organizations using the data from a dense volunteer networks in operations, planning or research. We have begun to assemble a list of some of the known users of CoCo RaHS data. Here are some of the applications that have been documented so far.

Education:
- Teachers have used CoCo RaHS data for math and science exercises
- Teachers encouraging students to help collect data
- Teacher training/enhancement opportunities

Risk Management:
- Insurance industry use of data to document hail occurrences
- USDA monitoring for agricultural losses and potential disaster declarations

Weather Forecasting:
- Both National Weather Service and private forecasters access CoCo RaHS data for forecast verification

Meteorological Research:
- Radar-rainfall relationships
- Remote sensing of hail
- Satellite rainfall
- Rainfall depth-area relationships

Agricultural Research:
- USDA and Colorado State University have been using rain and hail information in “precision agriculture” research
- Field-scale evaluations of cropping systems and fertilizer applications
- Crop yield evaluations

Municipal Utilities:
- Storm water runoff
- Rainfall/wastewater relationship
- Long-term rainfall patterns and design storm definition
- Water use, evapotranspiration, and irrigation water demand
- Larimer County mosquito control

Business and industry applications:
- Rainfall and construction schedules
- Snow removal
- Roofing contractors – hail documentation

Resource Management:
- Precipitation and water supply relationships
- Forest and grassland productivity
- Wildfire potential
- Post fire runoff characteristics
- Crop assessments

Emergency Management:
- Information source for severe storm and flash flood warnings
- General improved public education and awareness in weather risks

Each month, more CoCo RaHS users appear. NASA, for example, has contacted us about design and use of hail pads for verifying hail in the vicinity of the Kennedy Space Center. Entomologists studying insect migrations over the Rocky Mountains have examined local Front Range rainfall patterns and their effect on insects.

3. SUMMARY OF THE COCO RAHS EXPERIENCE

Four years of operation of a web-based dense network of volunteer precipitation reports has shown a large, diverse and growing set of users and uses of the data. It has not been difficult to recruit large numbers of excellent, enthusiastic volunteers willing and able to help collect high quality precipitation data. Some only participate for a season or a year, but many are committed to helping the project as long as data collection and entry is easy and quick, and where there is not a requirement to report every day. While our emphasis has been on warm-season data collection, enough volunteers have offered to measure year-round that our winter precipitation monitoring is also very successful. Observations of winter precipitation show that while not as spatially variable as convective precipitation, variations over short distances are still the rule, not the exception.

Sponsorship if this program has been impressive, and new sponsors emerge each year to help support the costs of equipping and training volunteers and paying for student interns to help oversee

communications and data quality. Only with the help of the Internet, could so many volunteers participate in such a direct and personal way. But it does take work and committed leadership. Other states considering taking on this activity need to know that even with volunteer help, staff time must be committed.

The educational opportunities associated with CoCo RaHS are nearly endless. Informal education of volunteers of all ages continues with training sessions, special talks and seminars, field trips (the Colorado Front Range does afford many field trip opportunities such as the National Center for Atmospheric Research) and more. Last year, a one-day "Rocky Mountain Weather and Climate Workshop" specifically for weather volunteers attracted nearly 100 attendees. Opportunities for teacher training and student involvement also abound. In 2001, a science teacher from eastern Colorado interned at the Colorado Climate Center. Participating teachers are creating lesson plans that other teachers can access through the CoCo RaHS website.

4. GOALS FOR 2002 AND BEYOND

- Expand CoCo RaHS into the Denver metro area this year with at least 200 new volunteers.
- Expand into the higher mountains to begin to show differences in the scale of storms and rainfall variations from high elevations to the eastern plains.
- Seek funding for full-time CoCo RaHS coordination with a goal of supplementing the NWS Cooperative program with a station density 10 times that of the existing program, and even greater in and near urban areas.
- Establish Great Plains regional CoCo RaHS to involve local communities and their citizens in the study of Great Plains precipitation patterns.

To learn more about Community Collaborative Rain and Hail, visit the web site at http://www.cocorahs.com

5. ACKNOWLEDGEMENTS

This work was funded by the National Science Foundation under grant number EAR-9907671.

6. REFERENCES

Doesken, N.J., and T.B. McKee, 1998: An analysis of rainfall for the July 28, 1997 flood in Fort Collins, Colorado. Climatology Report 98-1, Dept. of Atmos. Sci., CSU, Fort Collins, CO, 55 pp.