COCORAHS — A NATIONAL CLIMATE OBSERVING SYSTEM OF VOLUNTEER OBSERVERS PROVIDING A "GAUGE-FULL" OF DATA FOR CLIMATE APPLICATIONS

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1. BACKGROUND AND HISTORY OF COCORAHS

CoCoRaHS (The Community Collaborative Rain, Hail and Snow Network), celebrated its tenth anniversary in the summer of 2008. The network began with a few volunteers along the Front Range of Colorado in response to a devastating localized flash flood in Fort Collins, Colorado in July 1997. In the spring of 1998, a small project was initiated to involve the local community in tracking and reporting storms utilizing the Internet. Originally, the primary goal was to not be caught off guard again by any future intense and localized storms.

Several dozen enthusiastic volunteers signed up and attended training sessions to learn how to measure and report rain and hail from their homes. Each volunteer was equipped with a four-inch diameter high capacity plastic rain gauge for measuring rain and foil wrapped squares of Styrofoam for measuring hail (Figure 1.).

Figure 1. CoCoRaHS Rain Gauge and Hail Pad

In its' earliest days, CoCoRaHS was simply a Web-based method for collecting timely, useful and spatially detailed local rainfall and hail observations. It soon became apparent, however, that some participants were extremely interested in learning more about weather and climate while helping measure precipitation. Education and outreach grew in priority as means of engaging, motivating and retaining volunteers.

The number of participants and the geographic bounds of the project have grown each year. In 1999 we added snowfall to our list of precipitation measurements so that volunteers could participate year round. Funding from the National Science Foundation in 2000 and 2003 allowed the network to hire staff and to begin to expand beyond the state of Colorado (Cielli at al, 2005).

In 2006, CoCoRaHS was the recipient of one of NOAA's Environmental Literacy grants encouraging outreach and partnership with NOAA offices across the country. Thanks to excellent relations with NOAA's National Weather Service and their regional and local offices across the country, CoCoRaHS has grown from 15 states and 2,000 active participants in January 2007 at the time of the AMS 16th Conference on Applied Climatology to over 11,000 volunteers in 35 states today (Figure 2.). Since CoCoRaHS first began in 1998, more than 15,000 individuals and families from as young as preschool to as old as 90 have signed up to help. In any given week, 50 to 150 new volunteers are registering online to help measure rain, hail and snow.

With the anticipated addition of California to the network in October 2008, North Dakota in November 2008 and several others in line for 2009, CoCoRaHS is quickly headed to becoming the largest source of daily precipitation observations in the United States.

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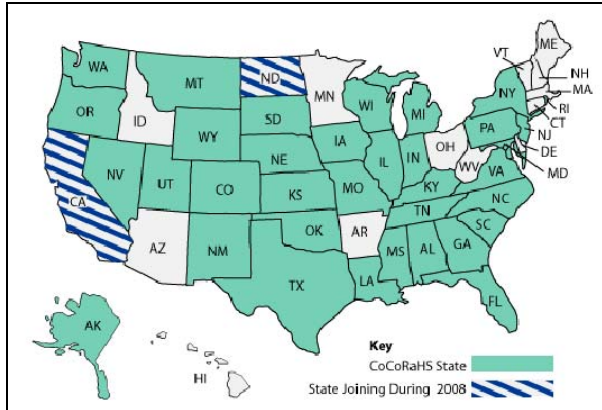
Figure 2. CoCoRaHS States, August 2008

2. NATIONAL FOCUS

With the addition of Utah to the network in June 2008, CoCoRaHS now reaches from the Atlantic Ocean to the Pacific. Each state has a coordination team composed of state and regional coordinators who help to mold the shape of CoCoRaHS within their individual states. Numerous volunteers from universities, climate offices, state and national government agencies make up these teams. With local leaders in place, natural bridges are created for local outreach as well as state and regional applications of the data observed.

Participants check their rain gauge each morning and use the CoCoRaHS website to submit their local report. http://www.cocorahs.org As the data from thousands of individuals are assembled each day, a larger national picture emerges. Storm systems that sweep across the country (Figure 3) are measured and described with surprising detail. With the Southeast and Gulf coasts now dotted with CoCoRaHS observers, the network is well positioned to capture for the first time the complex rainfall patterns from tropical systems. CoCoRaHS data supplement and enhance the official weather observing networks to add accuracy and detail. A spatially dense rain gauge network spanning the country also becomes a great resource for monitoring the development of drought. Because precipitation is so important, and precipitation patterns are always so variable, there will continue to be a need for this type of information. But the human element of CoCoRaHS cannot be overlooked. Volunteers enjoy an ongoing opportunity to learn about local and regional weather and climate, water resources and scientific discovery through their simple backyard measurements.
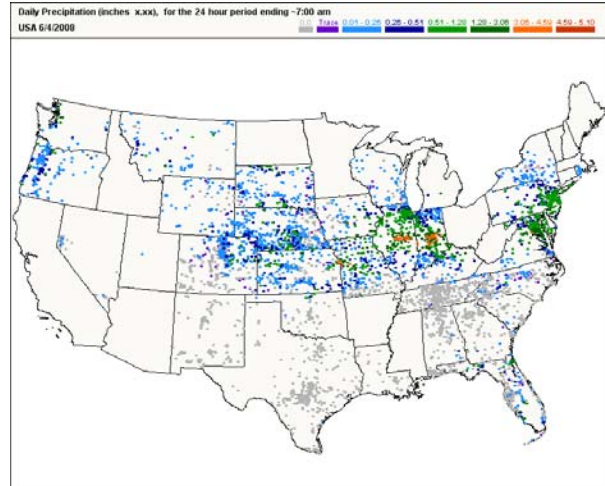

Figure 3. National daily CoCoRaHS precipitation map: 4 June 2008

3. APPLICATIONS

With the large amount of data available, CoCoRaHS is becoming a rich resource for many weather and climate applications.

Since volunteers of all ages help measure and report precipitation, one might wonder about the quality of the data. With CoCoRaHS's emphasis on education, the primary goal is participation. New participants may make a few errors, but quality control conducted by local and state coordinators helps refine the data to research quality. Feedback to observers through the quality control process is instructive and improves future observations.

There are now ten years of daily precipitation data and hundreds of new data points in northern Colorado. Clear indications of preferred storm tracks and moisture patterns are now appearing. For example, in Fort Collins where at least 50 volunteers report regularly, the southwest part of town has proven to reliably get more moisture than other areas. In fact, over ten years a nearly 25% difference in annual precipitation has been observed from the drier areas of NE Fort Collins to the wetter SW parts of the city. Similar patterns have been noted in other Colorado cities pointing out that traditional rainfall maps may not be accurately representing the strength and orientation of local precipitation gradients.

For most of the country, CoCoRaHS precipitation data span less than two years. This is not enough time for many climate applications. But with thousands of reports coming in each day, we can quickly begin to explore characteristics of daily precipitation frequencies and amounts and

examine how those vary seasonally and geographically.

Daily precipitation reports were assembled for six states with large concentrations of CoCoRaHS weather observers. Daily precipitation frequencies were normalized to show the percent of days receiving precipitation amounts of various categories: zero-trace, 0.01-0.09 inches, 0.10-0.24". 0.25 – 0.49", 0.50-0.99", 1,00–1.99" and two inches and greater. Since there was less than a complete year of data for some states, we only compared winter, spring and summer frequencies.

Precipitation Frequencies

Figure 4 compares the frequency of daily precipitation amounts for Colorado, Florida, Illinois, Maryland, Oregon and Tennessee. These states were chosen since they represented diverse climatic regions of the country and had sample sizes of several thousand daily observations each month. Keep in mind that less than one complete year of CoCoRaHS daily precipitation amounts are available for some of these states. These distributions may change when more data are added, but they give an idea of the type of analysis and comparisons that can be easily performed using CoCoRaHS data.

For January 2008 (Figure 4a), measurable precipitation (0.01 inches or greater) was reported in 64% of the daily precipitation observations in Oregon. This percentage decreased to 41% in Maryland, 37% in Illinois, 31% in Tennessee, 30% in Florida and only 26% in Colorado. In five out of these six selected states, the category that accounted for the greatest number of precipitation days was 0.01 to 0.09". The exception was Oregon where persistent wet weather occurred the entire month. Their most common precipitation categories were 0.25 – 0.49" and 0.50" – 0.99". These accounted for 18% and 15% of all precipitation reports, respectively.

Seasonal differences in precipitation characteristics are easily spotted. By July 2008 (Figure 4b), Oregon was clearly the driest of these six selected states with only 6% of all reports having measurable precipitation and very few reports of moderate or heavy rainfall amounts. Florida, on the other hand, had measurable precipitation 59% of all reports including fairly large frequencies of moderate and large daily rainfall amounts. Nearly 10% of all daily precipitation reports – including zeros and trace amounts – were equal to or great than 1.00". Illinois ranked second with nearly 6% of all daily reports equaling or exceeding one inch. Interestingly, while precipitation processes are

dramatically different in winter compared to summer, for Colorado, Illinois, Maryland and Tennessee, the relative frequency of precipitation was quite similar between January and July 2008.
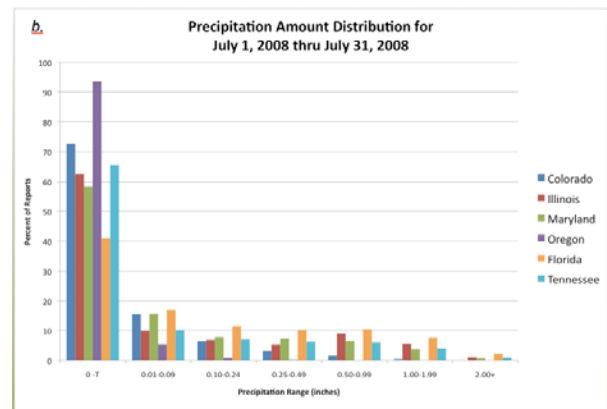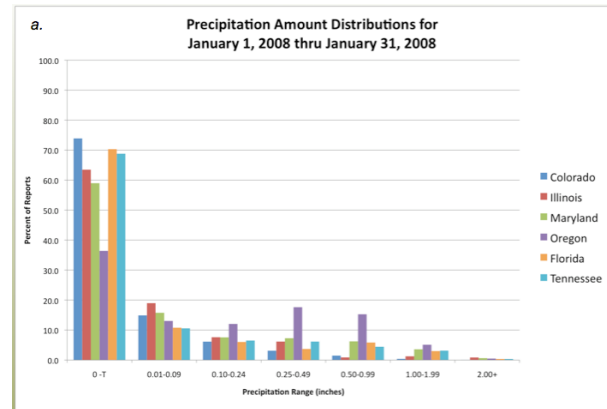

Figure 4. Normalized frequency distribution (expressed in percent of total number of observations) of daily precipitation amounts for Colorado, Florida, Illinois, Maryland, Oregon and Tennessee. a) January 2008 and b) July 2008

Hail Characteristics

CoCoRaHS volunteers are encouraged to submit special reports each time hail is observed at their locations. When reporting hail, observers note the time the hail began, how long it lasted, and various properties of the hail including average, largest and smallest stone diameter, the approximate number of stones per unit area, stone hardness and color, accompanying rain and wind conditions, and the type of damage done by the hail. Not all volunteers report hail, and not all information categories are filled out for each storm. Nevertheless, nearly 2,000 individual reports of hail were submitted for the seven-month period January – July 2008. The CoCoRaHS database makes it possible for anyone to view and

analyze hail information sorting data by a number of categories.

Using the 2008 data for all participating CoCoRaHS states and storm duration, timing and stone size distribution all likely vary seasonally and geographically, but for demonstration purposes all data are simply lumped together here. Figure 5 shows the time of day distribution for all reported storms January – July 2008. Not surprisingly the least likely time of day for hail based on this data set is early morning and the most likely time is late afternoon. There is some chance that storms with small hail may be underreported for those hours when many people are trying to sleep, but the same may apply for the midday hours when many CoCoRaHS volunteers are away from home at work, school or elsewhere. Overall, the time distribution appears very realistic.
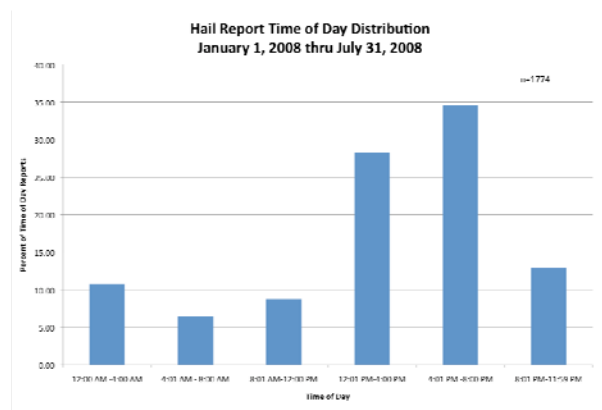

Figure 5. Distribution of CoCoRaHS hail reports based on the time of day hail was observed to begin falling. This summary includes all hail reports from all states participating in CoCoRaHS during the period 1 January through 31 July 2008.

Figure 6 shows that the majority of hail events last no more than five minutes. Long-lived hail storms lasting 30 minutes are longer do occur but account for less than 2% of reported hail events.

Severe weather spotter reports used to assess hail storm climatologies generally only include hail stone size information when the storms produce hail of 3/4 inch diameter or larger. CoCoRaHS encourages participants to report any and all hail, regardless of diameter. The data for January through July 2008 show that only about 25% of hail reports included stones with a diameter of ¾ inch or greater (Figure 7). Only 10% of the reports indicated average stone sizes for a storm of ¾ inch or greater. Stones up to 4.5" diameters have been reported but are very rare. By far the most common stone diameter is ¼ inch – often referred to as "pea-sized" hail.
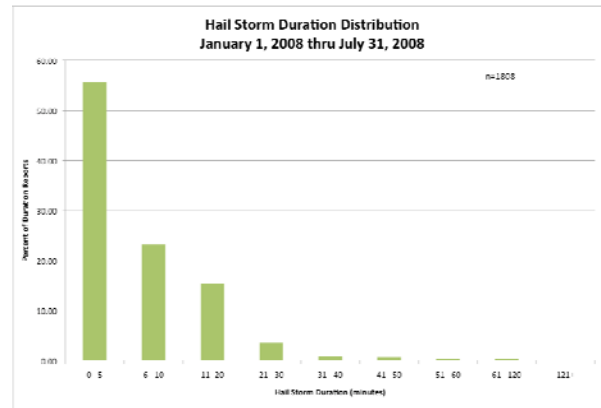

Figure 6. Frequency distribution of CoCoRaHS hail storm duration. This summary includes all hail reports that included storm duration information from all states participating in CoCoRaHS during the period 1 January through 31 July 2008.
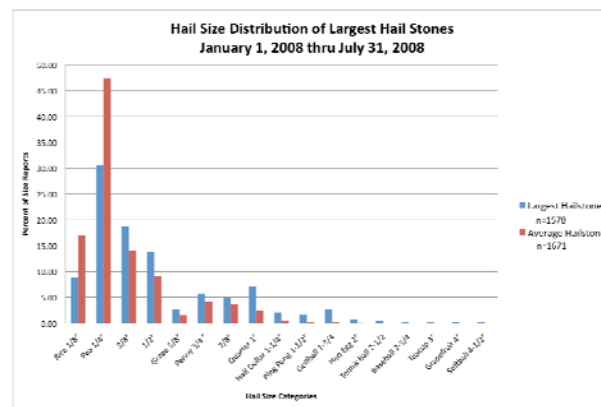

Figure 7. Relative frequency distributions of average and maximum observed hail stone diameters expressed in units of fractions of an inch. This summary includes all hail reports that included stone diameter information from all states participating in CoCoRaHS during the period 1 January through 31 July 2008.

Based on the reporting options provided, it is clear that 5/8" diameter is not often selected. One inch diameter (U.S. quarter-sized) and 1 ¾" (golf ball sized) are selected more frequently than surrounding categories.

When all states are participating in CoCoRaHS (possibly by the end of 2009) and several years of data have been collected, it will be possible to quickly perform statistical analysis of hail properties in the U.S. that were never before possible on this scale. CoCoRaHS hail information provides a unique dataset not available from other sources. Because of this,

more emphasis will be place on training observers to observe and report hail to add to this new national data resource. Already a number of commercial entities have become aware of CoCoRaHS. Insurance companies, roofing companies, roofing material manufacturers and aircraft engineers are among a growing list of private companies making use of CoCoRaHS hail information.

Snow data and applications

So far, the data set of nationwide daily snowfall, snow depth and water content measurements from CoCoRaHS are fairly limited. Where snow has been measured now for several years by CoCoRaHS volunteers in Colorado, Wyoming and the Central Great Plains, the results are very encouraging. Snow is sometimes difficult to measure, but CoCoRaHS volunteers are trying hard to collect high quality data. No analyses are shown here, but based on preliminary investigation the data are of good quality and suitable for use in various climate applications.

4. CONCLUSIONS

What began as a small local volunteer network focused on observing and reporting local heavy rains from thunderstorms, is quickly growing into a nationwide grassroots precipitation network providing high quality rain, hail and snow data. While the period of record for CoCoRaHS data remains short, the spatial extent and local station density is well suited for many climate applications. Alone or in combination with official data sets like the "Summary of the Day" data from the National Weather Service Cooperative Observer Network, CoCoRaHS data are recommended for climate monitoring and research. As the network continues to grow to new areas and longer data records, CoCoRaHS will become an ever better resource for applied climatology.

5. ACKNOWLEDGEMENTS

This work would not be possible without the generous help from thousands of volunteers measuring and reporting precipitation each day.

6. REFERENCES

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