# Spatial Optimization of CoCoRAHS Network in Tennessee

Joanne Logan
Department of Biosystems Engineering and Soil Science
University of Tennessee

## Abstract

CoCoRaHS (Community Collaborative Rain, Hail and Snow Network) is a non-profit, all-volunteer, community-based network of thousands of observers of all ages and backgrounds working together in all fifty states and Canada to measure and map precipitation, By using low-cost rain gauges, incorporating training and education, and taking advantage of an interactive Web-site, high quality daily rainfall data is available for natural resource, education and research applications. CoCoRAHS was established in Tennessee in 2007 and the reported rainfall data have been important to augment the information available for monitoring droughts and floods. However, the distribution of stations is less than ideal; there are no observers in 9 out of 95 counties, only 1 observer in another 13 counties, and several counties have more than 20 observers. Recruitment of volunteers has been very haphazard, with no statewide coordination to optimize the spatial distribution of the observers. Sustained and reliable observation of daily rainfall has also been a problem, with about 450 consistent observers out of more than 1500 who registered as volunteers; more than 500 observers never reported at all. In addition, very little education and outreach have taken place due to lack of involvement by teachers and schools. Logistically, there is too much redundancy and overlap with other rain gauges such as National Weather Service (NWS) Cooperative Observer and other rainfall data reported to the NWS such as ASOS (Automated Surface Observing System). To help improve the network and enhance the educational benefits, a spatial analysis was conducted to 1) find the optimal new locations for CoCoRAHS using spatial information such as topography, currently reporting CoCoRAHS locations, other rain gauge networks such as NWS and 2) optimize the recruitment of new observers for CoCoRAHS, using other spatial information relative to ideal new locations: such as schools, fire halls, master gardens, community gardens, utility plants, UT Extension offices, libraries, transportation offices, city engineering offices, and other organizations that might be interested in the educational aspects, or are open 24/7. The resulting spatial analysis can provide a list of ideal contacts to possibly recruit in this rapidly expanding and useful program.

## Introduction

The National Weather Service is responsible for most of the weather data instrumentation and observation in the U.S. However, due to the gaps in spatial coverage, other agencies and organizations, such as the Corps of Engineers and U.S.

Forest Service, have developed their own mission-specific weather data networks. In addition, many state climate offices and universities have built regional networks (mesonets) to collect weather data. CoCoRaHS (Community Collaborative Rain, Hail and Snow Network) is an example of a more grassroots, low-cost option to improved spatial coverage of weather observations.

CoCoRaHS started as a result of the devastating flash flood that hit Fort Collins, CO in July 1997. It is a non-profit, all-volunteer, community-based network of thousands of observers of all ages and backgrounds working together in all fifty states and Canada to measure and map precipitation, By using low-cost rain gauges, incorporating training and education, and taking advantage of an interactive Web-site, high quality daily rainfall data is available for natural resource, education and research applications.

CoCoRAHS was established in Tennessee in 2007 and the reported rainfall data have been important to augment the information available for monitoring droughts and floods. However, as in most states, the distribution of rain gauges in this volunteer network is less than ideal. As of this year, there were no CoCORAHS volunteer observers in 15 out of 95 counties, only 1 observer in another 13 counties, and several counties have more than 20 observers. Recruitment of volunteers has been very haphazard, with no statewide coordination to optimize the spatial distribution of the observers. Sustained and reliable observation of daily rainfall has also been a problem, with only 423 consistent observers out of the more than 1600 who registered as volunteers; in fact, more than 500 observers never reported at all. In addition, very little education and outreach have taken place due to lack of involvement by teachers and schools, as originally imagined for this program. Almost all the currently reporting onservers are individual homeowners, not associated with any agency, organization, or school.

The objectives of this study are to 1) summarize the flash flood risks in Tennessee; 2) find optimal new locations for CoCoRAHS rain gauges using spatial information such as topography and demographics, currently reporting CoCoRAHS locations, rain gauges operated by NWS and the University of Tennessee , and 3) identify possible new observers for CoCoRAHS, using spatial information relative to proposed new locations: such as schools, fire halls, master gardens, community gardens, utility plants, UT Extension offices, libraries, transportation offices, city engineering offices, and other organizations that might be interested in the educational or operational aspects of rainfall data, or are open 24/7.

Methods

- Obtain latitude and longitude of currently reporting observers from CoCORAHS admin site, add to GIS map

- Add layers: National Weather Service (NWS) Coop Stations, NWS Automated Weather Observing System (AWOS) stations, elevation, Block Groups, Counties, Geographic Information Names System (GNIS)
- Spatial Analyses to optimize location for new rain gauges

Results

Since the original premise of the establishment of the CoCoRAHS network was for improving flash flood prediction, it is interesting to note that flash floods are reported much more in Tennessee than Colorado (Table 1), at least partially due to the greater population density. However, since Tennessee has to deal with more than 100 flash floods each year, on average, improving spatial coverage of rain gauges is a smart move.

**Table 1. Flash floods Colorado vs. Tennessee**

| State | Area ($km^2$) | Population est. 2014 | Pop. Density ($\#/km^2$) | # Flash floods (1996-2013) | # Deaths |
|---|---|---|---|---|---|
| Colorado | 269,600 | 5,268,367 | 19.5 | 868 | 20 |
| Tennessee | 109,150 | 6,495,978 | 59.5 | 1933 | 29 |

More than 1600 people have signed up on the Tennessee CoCoRAHS website, but there are currently only 423 CoCoRAHS volunteers that regularly report with 266 (62%) reporting for at least 5 years, and 319 (75%) located 8 km or more from a NWS station (Cooperative and ASOS/AWOS). There are a total of 518 rain gauges used in this study, including both the CoCoRAHS and NWS. These rain gauges, if one assumes that each one represents an area with a radius of 8 km, cover 49% of the area of Tennessee.

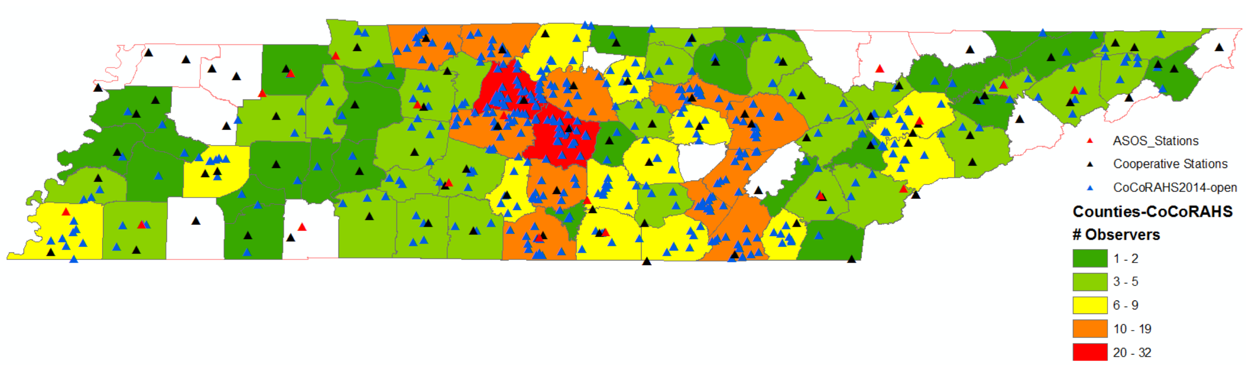
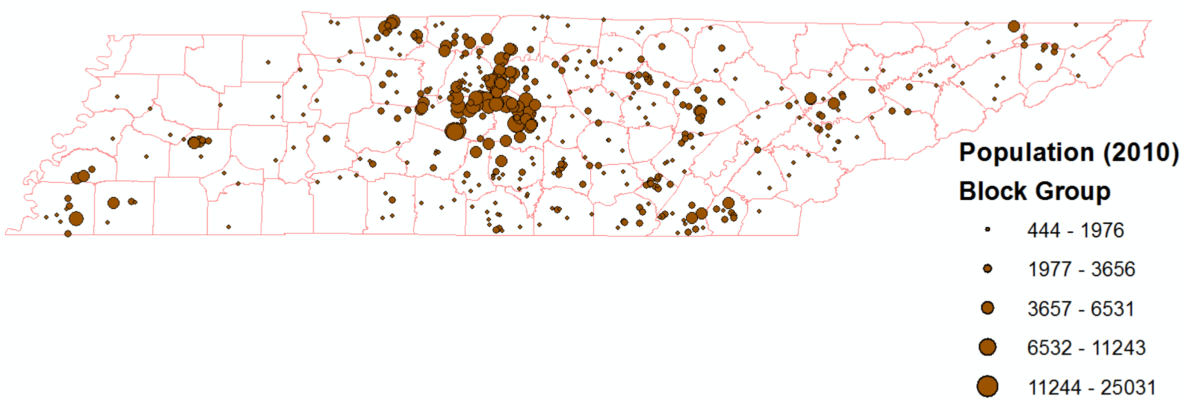



**Figure 1. Number of CoCoRAHS observers (currently open) per county, current locations of CoCoRAHS and NWS stations.**

Eighty counties out of 95 have at least 1 currently reporting CoCORAHS station (Figure 1). Only 2 counties have no rain gauge at all, including COCoRAHS and NWS. Seventeen counties have just one CoCORAHS observer, and one county, Davidson, has 32 observers (Figure 1). Using block group census data, the number of people (2010) represented by each CoCoRAHS rain gauge ranges from 444 to 25,031 (Figure 2).

If the Mission of the NWS is to protect life and property, then efforts to enhance the rain gauge network in Tennessee should focus on the areas with the highest population densities. Out of the 4014 block groups in Tennessee, 2603 (65%) have a population density of 100 per square km or more. Of these, 2453 (94%) do not have a CoCoRAHS observer located within the borders of the block group.




In addition to population density, topography is another factor that should be considered in selection of potential new locations for rain gauges. Of the 2453 block groups with high population densities and that do not have a CoCoRAHS volunteer, 316 have an average elevation greater than 300 meters, and are located in 31 different counties, most in East Tennessee. Twenty three of these block groups do not have any rain gauge from any agency within a radius of 8 km. The current focus will be to find cooperators in these block groups.

Schools and churches are likely sources for cooperators. Using the GNIS data, there are 14 schools and 38 churches located in the 23 target block groups.

Summary and Conclusions

This exercise is just one example of how to target the search for volunteers for the CoCoRAHS network. Many of the parameters can be changed, such as radius that each rain gauge is assumed to represent (currently set at 8 km), topography, and population density of the block group (currently set as greater than 100 per square km). Spatial information from additional agencies and organizations such as master gardeners, county extension offices, police stations, and fire halls can be used to augment the network of potential observers.