National Volunteer Precipitation Monitoring Network Nearly Complete

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In September, Arizona and Delaware became the 48th and 49th states to join the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network, an organization of volunteer observers who help measure and map precipitation. Minnesota, the final hold-out, planned to join by the end of the year. The national network aims to have 20,000 active volunteers by the end of 2010. The need for data-sharing between established networks, the growing use of municipal gauge networks for stormwater management and flood-warning operations, and the intense interest of rural communities in weather conditions for agricultural planning have been instrumental in the growth of such volunteer-based observation networks.

Development of CoCoRaHS began in Colorado following an extreme weather event: the heavy precipitation and resultant flooding in Fort Collins on July 28, 1997. At the time, the Department of Atmospheric Science at Colorado State University supported a small collection of gauges throughout the city. These were operated principally by graduate students to support ground-truth verification of precipitation observations by a CSU-operated radar facility east of the Colorado Front Range urban areas. Both the radar and rain-gauge network captured the detailed structure of the 31-hour, orographically-influenced rain event that led to extensive urban flooding, killing five people and causing catastrophic damages.

By the following spring, Colorado State Climatologist Nolan Doesken had proposed and begun organizing a statewide network of volunteer observers. Their goal was to obtain detailed, high-density observations of widely varied and disparate precipitation regimes that are common amidst the complex topography of the Rocky Mountains and western United States.

Arizona is Convinced

When Wyoming agreed to join CoCoRaHS in 2003, the move toward building a national network was born. Recently in Arizona, State Climatologist Nancy Selover was impressed by the quality of training provided to network coordinators and observers, and the quality of CoCoRaHS leadership and leaders' enthusiasm for interaction with both professional meteorologists and volunteers. Among the benefits she saw of Arizona joining CoCoRaHS were the development of a contiguous web of observers across the semi-arid Southwest, enhanced communication between professional and citizen scientists leading to education of the public in meteorological and hydrological observations, and the potential contribution of volunteers to the larger-scale cooperative effort that could result in significant scientific practices or products. By the end of September, more than 200 volunteers throughout Arizona had signed up and begun reporting precipitation observations.

Participation in the CoCoRaHS network requires purchasing a 4-inch-diameter high-capacity rain gauge, available through the organization's web site (*www.cocorahs.org*) for $23, and attending a brief training session, either online or at locations throughout the state, on how to operate the gauge and report observations. Under NOAA sponsorship, National Weather Service (NWS) weather forecast offices (WFOs) provide regional coordination of CoCoRaHS observers in their service areas and work with state coordinators to educate and guide volunteers.

Nearly 2,000 volunteers in Arizona already participate in the *RainLog.org* network supported by SAHRA at the University of Arizona. CoCoRaHS encourages Rainlog members to join CoCoRaHS as well. Both programs ask members to record and report their observations online within two hours of 7:00 AM local time. Exceptions include observations of extreme events, in which both networks are deeply interested. Once an observation is entered by a volunteer, it becomes available in both list and map form on the CoCoRaHS web site (see map).

RainLog is popular and widespread throughout Arizona, and is spreading into surrounding states and Mexico; anyone with any gauge may join. Support is provided via website, email, and phone. Rainlog emphasizes data visualization and quality assurance/quality control analysis of data; several research, drought monitoring, and educational efforts utilize its output.

Consistency is Key

Rainlog is less useful for NWS-WFO practices that demand uniform information processing for coordination and accuracy from one forecast region to another. CoCoRaHS insists on a specific gauge type and, under the direction of individual NWS-WFO and state-level coordinators across the country, has a network of observers that is both extensive and uniformly trained, allowing reliable large-scale, ground-based studies of precipitation events. Furthermore, the geographic scope of CoCoRaHS and its coordination with NWS overlap with the SKYWARN network of storm spotters, another NOAA-sponsored volunteer community of trained weather observers working directly with local weather forecast offices.

Volunteer-based networks with rigid standards for education of participants, data collection, and quality assurance have earned the endorsement and trust of professional meteorologists in many regions. In Arizona, meteorologists at the Phoenix and Flagstaff NWS offices say they may incorporate CoCoRaHS observations in formulating weather watch and warning statements because the program has developed such a positive reputation with regard to education as well as data quality and accuracy, lending an extra measure of credibility to the growth of citizen science in our communities.

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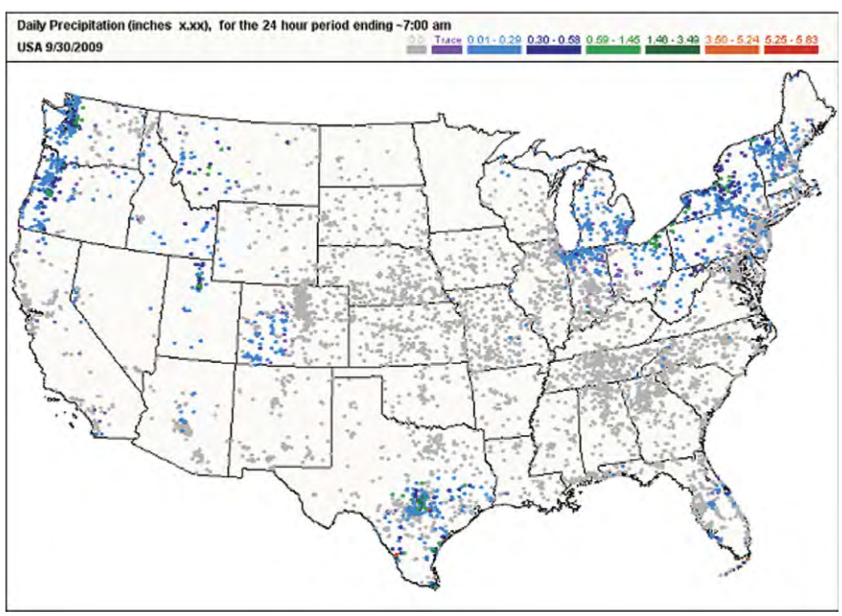

Screen shot from CoCoRaHS website: national precipitation reports for the 24 hours ending at 7:00 AM on September 30, 2009.

Predicting Post-Fire Runoff in a Southern California Watershed

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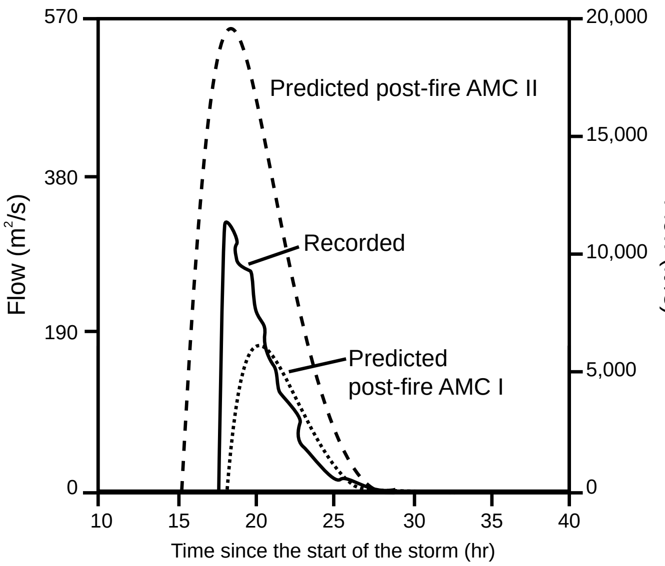
On July 4, 2007, the Zaca fire broke out in Santa Barbara County, California, and burned 375 square miles before it was contained on Sept. 2, 2007, making it the second largest wildfire in California's recorded history. Studies in southern California have shown that wildfires significantly affect precipitation-runoff processes, producing changes in basin hydrology that include a shift toward greater runoff volumes and higher-magnitude peak runoff rates.

In light of these possible changes and the approaching wet season, Santa Barbara County Flood Control became increasingly concerned about the impacts of high river flows on infrastructure downstream of the burn area, particularly the Santa Maria River Valley levees that protect the city of Santa Maria and more than 20,000 residents from flooding. The county clearly required a predictive tool to rapidly assess the threats posed by upcoming storms and guide decisions about whether monitoring or other preventative action would be necessary to avoid flood damage.



Recorded and predicted post-fire hydrographs for the Santa Maria River at Garey Bridge. AMC I and AMC II refer to dry and average initial moisture conditions. Predictions are based on recorded rainfall.

After some research, the modeling program HEC-HMS (developed by the U.S. Army Corps of Engineers) was adopted because it is well documented and can be used to generate predictions within minutes of receiving rainfall forecast data. HEC-HMS predicts runoff volume using the Soil Conservation Service curve-number approach, which allows adjustments for fire-related alterations in land cover. A spatially detailed map of curve numbers was generated using GIS and maps of soil type and land cover; average values were then computed for each subbasin. Other data entered into the program include subbasin and stream-channel characteristics such as surface roughness, as well as information on rain-gauge locations, channel losses, and baseflow. Once these basin parameters are established, only predicted rainfall and initial baseflow data are needed to model an event. As output, the program produces streamflow hydrographs at all defined locations of interest.

A charred hillslope on the Santa Cruz trail between Santa Cruz Station and Flores Flat Camp in October 2007.

Photo: Bryan Conant

Testing the Program

The program was first run using data from historical rainfall events to confirm it would provide reasonable indicators of the magnitude and timing of peak channel flows. A high degree of accuracy was neither expected nor considered necessary for the intended use. The curve-number methodology was originally developed using data collected on small, low-gradient agricultural plots; therefore, its reliability when applied to larger, steeper watersheds with other types of cover is diminished. It has, however, been shown to give better predictions when vegetative conditions are poor (Wood and Blackburn, 1984), much like one would expect after a fire, and has been used with some success to predict post-fire runoff elsewhere (for example, Earles and others, 2004).

To model post-fire conditions, the detailed pre-fire curve number and overland roughness maps were altered to account for fire-induced changes indicated on the burn severity map provided by the U.S. Forest Service. Curve numbers in the burn area were adjusted upwards to reflect potential soil hydrophobicity and reduced infiltration, interception, and evapotranspiration caused by the loss of vegetation. Overland roughness coefficients were reduced to account for lowered overland flow resistance. Post-fire averages were then computed for each subbasin.

First Storm Arrives

The first significant post-fire storm arrived on Jan. 4, 2008, when antecedent moisture conditions were still dry but nearing average (that is, 5-day antecedent rainfall total greater than 0.5 inch). Model predictions based on rainfall forecasts issued that morning showed a large peak occurring in the Santa Maria River around 6:00 AM on Jan. 5. From this information, the county was able to anticipate the need for overnight and early morning monitoring along the Santa Maria River Valley levees. Indeed, a peak flow of 11,320 cubic feet per second (cfs), approximately a 9-year flood event, was recorded in the river at 2:14 AM on Jan. 5. Later model runs using rainfall data collected during the storm gave peaks that bounded the observed peak and a time of arrival of between 2:30 AM and 4:00 AM (see chart), suggesting that some of the initial mismatch between predicted and recorded peaks was caused by inaccuracies in the rainfall forecast, spatially sparse forecast data, and the fact that antecedent moisture conditions were borderline between dry and average.

The recorded peak greatly exceeded what would have been expected prior to the fire. From historical records of 24-hour rainfall totals, the magnitude of the Jan. 4 storm was less than that of a 2-year event. Model predictions for the pre-fire condition suggest that peak flow would have ranged from 0 to 5,650 cfs (approximately a 3-year flood event) for dry to average antecedent moisture conditions, which is consistent with historical flow records and the experience of county staff.

Throughout the remainder of the storm season, the model proved useful for minimizing unnecessary trips to the levee and instead focusing resources on monitoring and flood-control preparations during times with greater potential for larger river flows.

In August 2009, the La Brea Fire engulfed previously unburned portions of the watershed upstream of the Santa Maria River Valley levees. The county is updating its program for use during the 2009-10 winter storm season.

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