The NHWC Transmission

September 2016

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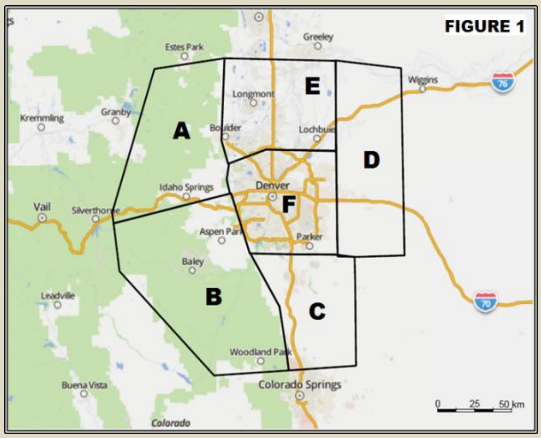
Using High-Resolution Ensemble Quantitative Precipitation Forecasts for Heavy Rainfall Prediction

Dmitry Smirnov, Dewberry

Most severe floods begin in the atmosphere as rainfall. While the overall accuracy of heavy rainfall prediction has increased dramatically over the last decade or so, Quantitative Precipitation Forecasts (QPF) of heavy rain events have remained problematic: under-prediction has been routine. The recent proliferation of high resolution weather models, roughly defined as those with spatial resolution of 4 km (2.6 miles) or less, has resulted in encouraging progress in the under-prediction problem. Meanwhile, a separate topic regarding QPF is the benefit of using ensembles. Due to the chaotic nature of the atmosphere, ensembles simulate a "plume" of theoretically equal QPF outcomes for a given starting condition. The benefit for the flood warning community is that instead of, for example, saying "there will be 1.45 inches of rainfall today", we can now say "there is a 75% chance that today's rainfall will exceed 1.00 inch". Thus, a decision maker can worry less about the inherently uncertain science of forecasting exact rainfall amounts, while gaining more knowledge about the possibility of impactful rainfall that may exceed design standards or other critical thresholds. Probabilistic or not, the key challenge is to confirm that forecasts are accurate and reliable.

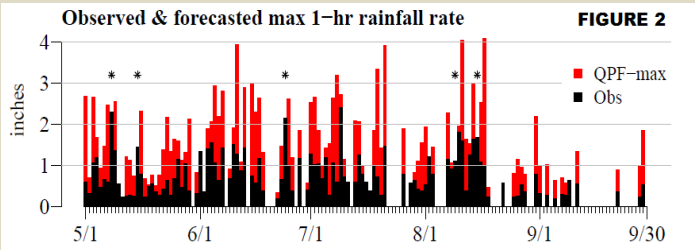
Leveraging the latest weather models to tackle the issues described above, we developed a high-resolution Heavy Rainfall Guidance Tool (hereafter, Tool) for the Urban Drainage and Flood Control District in Denver, CO. Figure 1 shows the areal extent of the Tool, which is composed of six forecast zones. One of the main goals of the Tool was to hone in on the placement of the flood threat; hence zones consist of a relatively small area, in the meteorological sense, of about 1,000 square miles.



For each zone, the Tool provides an hourly forecast of rainfall for a 24-hour period. However, with about a dozen available ensembles, an important question in designing the Tool was how to optimally process these data. The answer was guided by Denver's climate. The Tool was built for the warm season (May – Sep), during which Denver and the neighboring mountains to the west receive frequent, short-lived but intense downpours. Often these storms are of the "hit-or-miss" variety: either a location receives heavy rain, or it does not. Thus, instead of choosing the conventional approach of taking the ensemble median or mean, we opted ➡

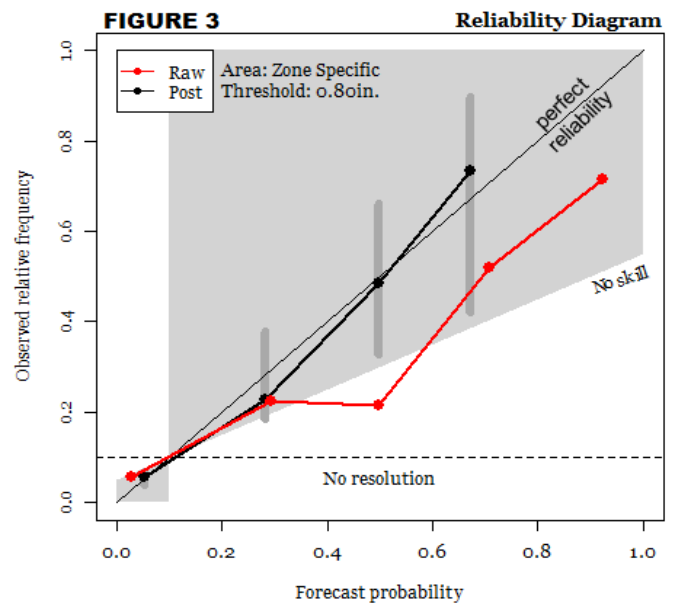
to show the maximum QPF (QPF-max), along with the probability of exceeding a specified threshold (set conservatively at 1 inch per hour). Thus, QPF-max represents a realistic worst-case scenario for a given day. Importantly, note that such a method may not work for a different climate such as the California coast where the primary flood threat comes from prolonged wintertime rainfall. There, taking the mean across the ensembles makes more physical sense.

The Tool's performance is validated each season; here, we focus on the *intensity* and *confidence* topics. Regarding *intensity*, if the Tool were perfect, QPF-max would always be greater than or equal to the observed rainfall. Figure 2 shows that during 2015, of 46 days when rain rates exceeded 0.8 inch per hour, QPF-max was higher during all but 5 of those days (denoted by asterisks in figure 2). Due to the under-prediction problem that has plagued QPF in the past, this is an encouraging result.



However, intensity alone does not describe the full picture, since an equally important component to a good forecast is *confidence*. Figure 3 shows a "reliability diagram", a metric answers the question of how reliable a probability forecast is.

Specifically, we assess the forecasts exceeding 0.8 inches per hour (due to a limited sample of 1 inch per hour events). For reference, perfect reliability is noted by the thin black line, while a forecast simply using historical climatology is shown by the dashed black line (labeled "No resolution"). Red points show the reliability of the



raw QPF data, which were used for 2015 operations. Although it is clearly better than climatology, the raw data are "overconfident" implying they are forecasted with higher probability than they are observed. Before the 2016 season, we performed a bias correction using the District's ALERT gage data. The black points in Figure 3 show that during 2016 the bias corrected data are nearly perfectly reliable. In other words, if we forecast that something will occur 50% of the time, it is actually observed 1 out of every 2 forecasts. Notably, the bias-correction step only takes several minutes and is being used operationally during 2016.

In conclusion, high-resolution weather model ensembles can be used to improve operational flood threat guidance. Performing bias-correction of raw QPF data can further improve reliability. We believe that this approach provides realistic estimates of the daily worst-case scenario QPF to supplement traditional QPF forecasts.

Questions or comments may be directed to the author at:
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Registration is Open for NHWC Northeast Regional Workshop

The National Hydrologic Warning Council is presenting

"Prepare to Protect, Advancing Community-Based Flood Warning"

at the Desmond Hotel and Conference Center in Albany, New York, September 20 – 21, 2016

This workshop has been pre-approved for 10 CECs for CFMs. Click **here** for the workshop agenda.

The 2-day workshop has a low registration fee of just $75 for NHWC members and $100 for non-members. Exhibiting and sponsorship opportunities are also available. Keep watch at this **location** for the latest information. To register, use this **link**.

The ALERT Users Group Fall Training & Meeting

will be held October 20th, 2016 at the San Diego County Flood Control Facility located at:

5500 Overland Ave., Room 120 in San Diego, California

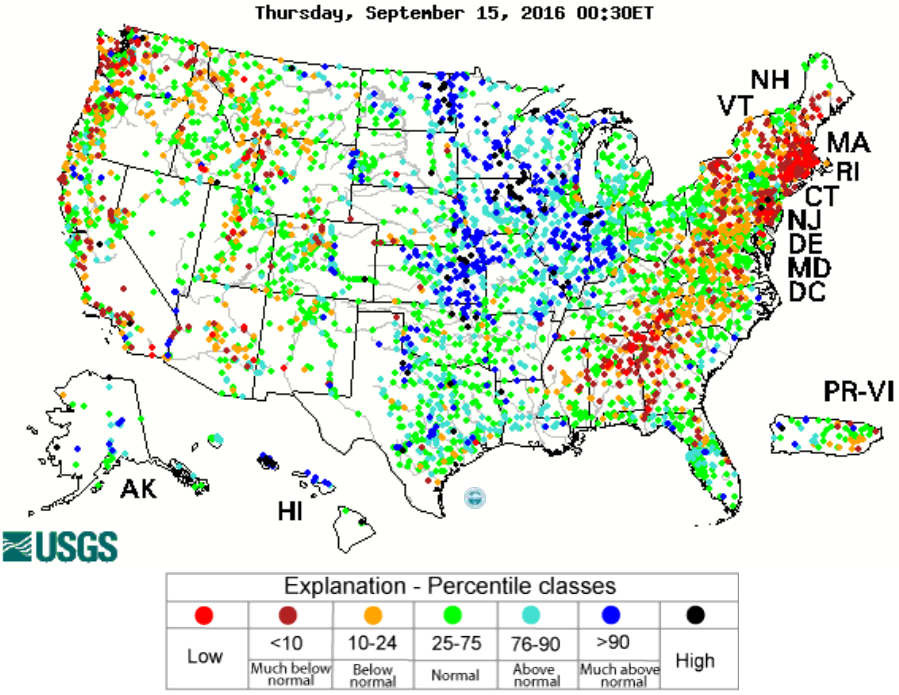
Emphases of this year's meeting will be ALERT 2, and interagency coordination and preparation for this coming winter. An afternoon technical workshop will include presentations related to ALERT system maintenance.

The workshop will finish with user reports and vendor announcements. The AUG board members are looking forward to seeing you there.

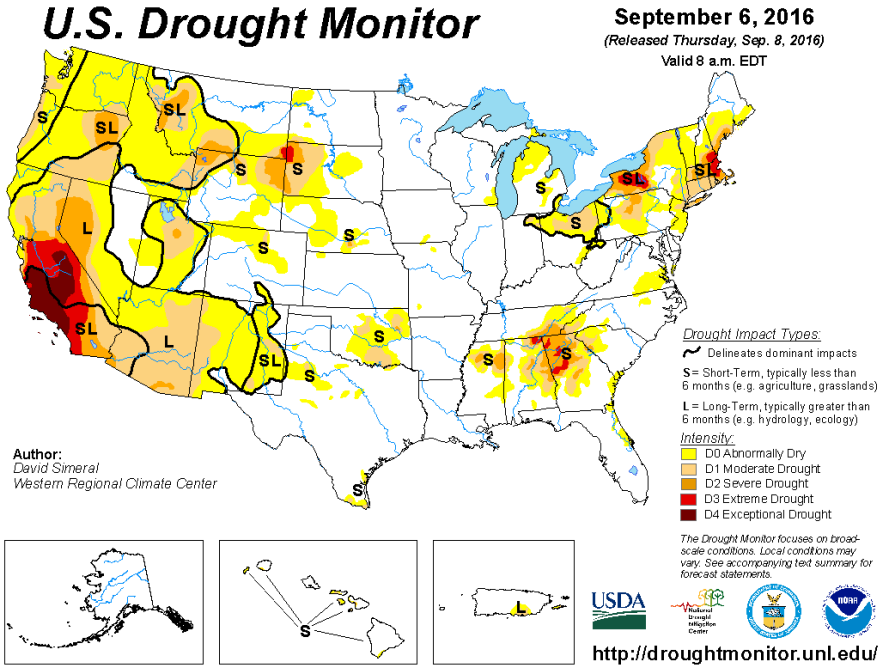
To register, please RSVP to Robert Laag at: relaag@rcflood.org or call him at (951) 955-1232 by October 14, 2016.

Download the **workshop flyer** for more information.

Hydrologic Conditions in the United States
Through September 6, 2016



Latest stream flow conditions in the United States. (courtesy USGS)



Latest drought conditions in the United States. (courtesy National Drought Mitigation Center)

October Newsletter Articles Focus:

Data Collection

The NHWC is requesting articles that focus on practices, technologies and tools used to gather and disseminate real-time hydro-meteorological data.

Please consider writing an article that highlights how your organization collects and disseminates real-time data.

Submit your article to:

editor@hydrologicwarning.org

October 7th is the deadline for inclusion in the October issue.

Future Newsletter Articles Focus

To give you more time to prepare articles, below is the article focus schedule for the next four months:

Oct - Data Collection
Nov - Hydrology
Dec - Hazard Communication & Public Awareness
Jan - Modeling/Analysis

NHWC Calendar

September 20-21, 2016 - NHWC Northeast Regional Workshop, Albany, New York

November 2-3, 2016 - 8th Annual NHWC Texas Workshop, San Antonio, Texas

June 5-8, 2017 - NHWC 2017 Training Conference & Exposition, Squaw Valley, California

General Interest Calendar

October 20, 2016 - The ALERT Users Group Fall Training and Meeting, San Diego, California

May 21-25, 2017 - American Society of Civil Engineers, EWRI World Environmental & Water Resource Congress 2017, Sacramento, California

(See the event calendar on the NHWC website for more information.)

Parting Shot

Arizona Game & Fish Department ALERT and Data Collection System

This new precipitation/ stream station was installed at the Canyon Creek Fish Hatchery, Arizona during August, 2016. This station plus other planned stations at the hatchery will use ALERT and cell networks to fulfill flood detection and data collection priorities.

Data from this and other stations in the Arizona Game and Fish Department Water Data website can be viewed at water.azgfd.gov.

The Department's Dam Safety and Hatchery programs rely on a combination of ALERT, satellite and cell networks to collect data from remote locations for public safety and management of water resources.

Photo by **Tyler Azeltine**, JE Fuller/Hydrology & Geomorphology, Inc.