Colorado Flood Threat Bulletin – Final 2012 Report

Project PDA - 1227

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Celebrating 75 Years

INTRODUCTION

Colorado is threatened seasonally by different forms of flooding including ice jams, flash floods, spring snowmelt and river flooding. Causes of this flooding vary with the season and include abnormal periods of hot weather during the spring snowmelt, severe thunderstorms and general storms during the spring and monsoon thunderstorms during the summer and early fall. This project is design to provide Colorado emergency managers and first responders with a daily county-specific assessment of flood and flash flooding threat in their county.

The Colorado Flood Threat Bulletin (FTB) concept was developed by Kevin Houck, Colorado Water Conservation Board (CWCB) and John Henz, a Certified Consulting Meteorologist working for an engineering company in 2006. The pilot program began in May 2006 and continued into September 2006. In 2007 a competitive five-year award of the program was made to John Henz, project manager at HDR Engineering, Inc.

In 2012 another competitive award was made to Dewberry Engineering, Inc, with John Henz as project manager. The program runs from May 1 through September 30 and requires the daily issuance of flood threat bulletin describing the flood threat in Colorado and the issuance of a 15-day Flood Threat Outlook to identify periods of locally heavy rainfall and conversely the development of drought conditions due to lack of precipitation. Meteorologists providing the forecasts included John Henz, Ryan Towell and Robert Rahrs of Dewberry.

Daily Flood Threat Bulletin

The Daily Flood Threat Bulletin (Daily FTB) is designed for daily issuance during the contract period by 11:00 AM. The FTB outlines the daily threat of flooding across the State, the nature of the threat and the time period in which the threat of flooding would be the greatest in County-specific manner. Additional information includes a characterization of the threat of attendant severe weather (tornadoes, high winds, hail) and the probability of most likely thunderstorm hourly rainfall rates and/or amounts.

The threat of flooding is conveyed to the user community through the use of graphics and text. The graphical component to the product includes a map of the State of Colorado with county boundaries and a color coded threat to succinctly illustrate the range of flooding threats across Colorado. The evolution of this presentation to a more communicative graphical form enhanced the spatial and temporal threat areas visualization.

The spatial coverage of the threat was available by clicking on a threat icon at the top of the page. The resulting graphic showed the areas of highest threat and a forecasted approximation of the temporal distribution associated with the type of thunderstorm/general storm system forecast. The spatial threat graphic is issued to users on days of high threat or when the National Weather Service issues either Flash Flood or Flood Watches.

These updates will include a presentation of the highest flood threat areas based on using predicted radar reflectivity patterns from the WRF-ARW (Storm Prediction Center, NOAA), WRF-UA (University of Arizona) and/or the HRRR Model (NCEP-NOAA). The recent availability of these three different model predicted radar reflectivity/precipitation accumulation fields add an objective spatial dimension to characterization of the daily flood threat. The links the WRF models are provided below:

http://www.atmo.arizona.edu/products/models/wrf_d01_0/mdbz.html
http://www.atmo.arizona.edu/products/models/wrf_d01_0/wrf_precip_tot.html
http://www.nssl.noaa.gov/wrf/PUB/

The U of A and Storm Prediction Center models are run daily and the HRRR-NCEP model is run every hour. While Dewberry acknowledges that these models are new, they provided a reasonable objective estimate of where the heaviest rainfall was likely to fall. The Dewberry meteorologist used the output from these three models and their own expertise to develop the spatial coverage threat estimate for Colorado. The model and forecaster experience will also be used to develop the "Storm Threat Window" for each County.

Flood Threat Outlook

The second product is a bi-weekly Flood Threat Outlook (FTO) issued to address the 7 to 15 day threat of flooding across the state. This product addresses both the extended threat of flooding and a precipitation outlook by river basin. This product is mostly textual in nature and was typically structured by breaking down the extended outlook into 'windows' of flooding threats" and their location. Dewberry proposes to issue this product twice-a-week every Monday and Friday by 1:00 PM for the subsequent 7 to 15 day period in a format.

Dewberry developed a graphic presentation of the long range precipitation outlook to supplement the verbal tabular form of the FTO used currently. The visual tool focused on each major river basin area and provides the user with a quick look into the precipitation future of that basin for the next two weeks.

Daily Statewide Precipitation Map

In 2006 John Henz led a team that produced the initial CWCB daily map of estimated 24-hour precipitation totals through the merging of Storm Total Precipitation (STP) products produced by National Weather Service NEXRAD WSR-88D radars located at Watkins, Grand Junction and Pueblo in Colorado, in Cheyenne, Wyoming and in Goodland, Kansas. This product was produced through use of Geographic Information Systems (GIS) software which allowed for quick, seamless integration of data from different sources and resulted in a clean presentation for the user community.

The 2006-2011 version of the daily STP product included a brief discussion of the accuracy of the STP product through use of available observations primarily the Community Collaborative Rain, Hail and Snow Network (CoCoRahs) of daily precipitation reports available in the early/mid-morning hours of each day. In the past five years additional state-wide data bases have become ready available for inclusion in the precipitation data base. These data bases are available through the MaDIS web site interface and are readily available for inclusion in the user viewable base precipitation field. Some of the data bases are available from Urban Drainage & Flood Control District, Colorado Department of Transportation and APRNET as an example.

For 2012, Dewberry provided a continuation of the STP service through use of an ArcWeb software and website/database package led by Stu Geiger and the Dewberry GIS experts. Dewberry will propose to establish an ArcMap application on the internet where individuals can perform user-specific functions for viewing the data including 'zoom in' functions where additional GIS 2-Dimensional data such as county roads and landmarks can be overlaid for a refined definition of where strong thunderstorms occurred the prior day. In addition, CoCoRahs data (as described above) will be incorporated into the mapping function so that point-by-point comparisons of the STP/observed data can be assessed.

Dewberry is capable of developing this daily data base into a user community retrievable data base that is described in the Other Service section of this response if CWCB requests. In summary, the more data

that counties/municipalities can supply for the website, the more information can be incorporated in the data overlay when the user "zooms in" to a particular area. Dewberry issued this product by 9:00 AM daily for the period of May 1st to September 30th, 2012. A copy of the STP with a statewide STP map was created for the CWCB flood information webpage on a daily basis. In addition, this product was archived daily.

PERFORMANCE METRICS

Dewberry will provide several performance metrics related to both the forecasting of the flood threat and the delivery of the forecasts. The Table below shows both the September and final year to date number of Flood Threat Bulletins provided, the percent of FTB's provided by Colorado-based meteorologists (John Henz and Rob Rahrs) and the number of all products, FTB's, FTO's and STP's provided on time. In each case Dewberry the CWCB-established metrics.

Table 1 2012 FTB CWCB Performance Metrics

Metric	Sept Score	Sept Percent	YTD Score	YTD Percent
Number of Flood Threat Bulletin Forecasts Provided by Colorado-based Meteorologists	23 / 30	75%	112 / 153	73%
Flood Threat Outlooks Provided by Colorado-based Meteorologists	8 / 8	100%	40 / 43	93%
Statewide Total Precipitation Products	30/30	100%	142/153	93%
Number of Products Provided on Time	64/ 68	94%	342/365	94%

Forecast Metrics

The daily FTB flood threat forecasts were verified on their ability to both identify days when flood treats were realized and the approximate location of the predicted flooding. By its nature this verification is somewhat subjective. Here are the rules and information sources used to verify the forecast by Dewberry:

1. Primary verification sources were the National Weather Service (NWS) reports of flash flooding and/or severe weather, CoCoRahs precipitation reports, NWS precipitation reports, Storm Total Precipitation fields from NWS WSR-88D Doppler radars and verifications of flash flooding in the Urban Drainage & Flood Control District's Flash Flood Prediction Program.
2. A flash flood day was declared when reports of flash flooding were received, WSR-88D STP exceeded 1.00 inch or surface rainfall amounts exceeded 1 inch. On severe weather days a report of hail and/or a tornado and rainfall over 0.50 inch/15-30 min indicated a minor flooding threat.
3. A forecast was declared a hit when observed flooding events occurred in the predicted flood threat area. A miss was declared whenever no flooding events occurred in the forecast area or occurred outside the forecast area.

This simple verification scheme was sufficient to provide a useful evaluation of the 2012 FTB performance. The table below shows seven columns of information. The first column is the month and the second is the number of successful forecast days in that month. The third column shows the number of days non-forecast flooding events occurred while the fourth column shows the number of days flood events were forecast but did not occur. The fifth column shows the number of flash flood days that occurred. The sixth column shows the number of event days correctly forecast and the final column shows the number of event days not forecast.

Table 2 2012 FTB Forecast Metrics by month

Month	Correct FTB Forecasts	Observed Flood Days missed	Flood Days Forecast that did not occur	Number of flood days per month	Number of observed flood days predicted	Number of observed flood days not predicted
May	26/31	3	2	8	5	3
June	26/30	3	1	13	10	3
July	27/31	1	3	18	17	1
August	25/31	1	5	15	14	1
September	28/30	2	0	10	8	2
Total	132/153 (86%)	10	11	64	54 (84%)	10 (16%)

A review of Table 2 shows that on a daily basis looking at both correct forecasts of flood days and non-flood days the FTB correctly identified the flood threat 86 percent of the time. The false alarm rate was only 14 percent which is considered slightly above the average skill score of 80 percent.

Most importantly the number of correct observed flood days forecast was 84 percent. It is unfortunate that 16 percent of the flood days were not anticipated. Of the 10 event days missed 7 days occurred when thunderstorm outflow boundaries moved unstable air off the moist plains into a previously dry area that then erupted into isolated heavy rain producing storms. Rainfall on these days was less than 1.50 inches and no fatalities or serious damage was noted.

Dewberry's forecast performance was especially accurate on three primary flash flooding days: June 6 and 7 and July 30. On each of these days high flash flood threat and the locations of the threat were highly accurate. On June 6 over $161 million dollars of damage occurred and on June 7 over $170 million occurred in areas along the Front Range but focused on the southern third of the Denver metro area. Damage was produced by combinations of large hail, serious flash flooding and several tornadoes in Elbert, Jefferson, Douglas and Arapahoe Counties. ON July 30 serious flash flooding in both the El Paso Waldo Burn area and in Colorado Springs. $15 million dollars of damage was done to bridges, roads, cars and structures in the floods and mud slides. No injuries or deaths were reported miraculously on these days.

CHARACTERIZATION OF THE FORECAST PERIOD WEATHER

A review of the spring and summer weather of 2012 shows that period of May began with a deep drought observed in most of the state. Severe fires erupted throughout the state but especially along the Front Range from May into early July. Severe thunderstorms occurred in early June but rainfall was limited and often damage from the storms did more bad than the precipitation did well for local agriculture. By July the Southwest Monsoon began and dampened the western half of the state from early July into early September. Table 3 shows the key periods each month. Clearly July and August were the most active months for the FTB program.

Table 3 below shows the monthly number of significant flooding days and where events were reported. You will note that the number of days does not appear to jive but that is because some days reported both severe weather and flooding in NWS files.

Table 3 Key weather events for the 2012 FTB program

Month	UDFCD flood event days	NWS severe days	NWS flash flood days	Number and percent of flood days	Big flood event dates
May	1	8	2	8/31 25%	19-25
June	6	11	4	13/30 40%	4-8, 12-16
July	10	15	12	18/31 60%	3-9, 11-13, 15-17, 27-31
August	2	7	11	15/31 50%	9-11, 22-28
September	1	4	8	10/30 30%	25-29
Total	20	45	37	64/153 41%	

This report includes two CD disks which contain all FTB, STP and FTO products, all shape files associated with them and all the weather data used for forecasting and verification. The files are organized by product and month to facilitate access to the information.

This report is meant to convey primarily the metrics of the Flood Threat Bulletin program's 2012 performance. Another report will be generated before the 2013 season for use in familiarizing the user community with the FTB program and the many enhancements Dewberry has brought to the product.