Arkansas Flash Floods and heavy rainfall-Draft

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1. INTRODUCTION

Training convection associated with deep moisture and a strongly southerly low-level jet brought heavy rainfall to central Arkansas 10-11 June 2010. The heavy rains triggered flash flooding along two rivers in southwestern Arkansas. The flooding along these rivers killed around 16 people¹. Estimates suggest the water level in the rivers rose at 6-8 feet per hour. The Little Missouri River at 3.81 feet at 0200 IS CDT and crested at 23.39 feet at 530AM CDT.

The National Weather Service in Little Rock, Arkansas (KLZK) issued flash flood warnings for the region and posted a summary of the event. The radar and observations suggested that 6.78 inches fell at Hopper in Montgomery County, 6.55 inches at Glenwood, in Pike County and 5.64 inches at Mount Ida. The KLZK radar suggested some very heavy rains also fell over northeasternmost Texas.

The NWS also issued a public information statement showing areas affected by flash flooding. These data suggest that most of the impacts began around 0300 CDT with reports coming in from about 305 AM through 445 AM. The report at 313 AM in the Albert Pike Recreation area suggest that potentially 12 people were killed by the flood. The fast rising water and rapidly rising rivers occurred before dawn, killing over a dozen people camping in remote valleys and camp sites. The water rose rapidly reducing time to respond.

Meteorologically, this was a tough forecast. Events of this type are not well predicted by numerical models and ensembles. Even high resolution models perform poorly in these weakly forced convectively driven events. Despite this, the NCPE SREF and NAM provided useful clues that if convection developed, heavy rainfall and flash flooding could be an issue.

This note will attempt to document the meteorological conditions associated with the flash flood event of 10-11 June 2010. The focus is on the patterns and signals in the pattern to help forecast flash flood events.

2. METHODS and Data

With the exception of radar images, all data shown were plotted using GrADS (Doty and Kinter 1995).

The pattern was reconstructed used the NCEP GFS and NAM and were possible the JMA 1.25x1.25 data (Onogi et al. 2007). All data were plotted in GrADS (Doty and Kinter 1995). The severe weather data was overlaid on the JRA data. The higher resolution NCEP NAM is used to show the conditions during the event.

¹ Initial reports 12 people 11 June increased to 16 on 12 June (Wall Street Journal) with many still missing.
The anomalies were computed from the NCEP/NCAR re-analysis data (Kalnay et al 1996) as describe by Hart and Grumm 2001 and Grumm and Hart 2001. Unless otherwise stated, the base data was the NAM and the means and standard deviations were computed by comparing the NAM to the NCEP/NCAR 30-year climatological values.

For brevity times are referred to in the format of 11/0300 for 11 June 2010 at 0300 UTC. Due to GMT verse local time (CDT) issues some of the times will have a 10 June time stamp. Days here will be defined by GMT times.

3. Results
   i. overview of the pattern

Figure 1 shows the NAM 00-hour forecasts of precipitable water (PW) and PW anomalies at the onset and after the flooding. These data show the initial east-west boundary with high PW air to the south, then the surge of 3-4SD PW air into and over Arkansas between 10/1800 and 11/0600 UTC. The surge of high PW air with the largest anomalies over southwestern Arkansas coincided closely with the period of heavy rainfall and the flooding.

The 850 hPa winds and total wind anomalies (Fig. 2) showed a surge of 1 to 3 SD above normal winds into Arkansas around 10/1800 and 11/0600 UTC. Strong low-level winds would support back building storms. With the significant PW
anomalies, this is a potentially favorable pattern for heavy rainfall.

The 850 hPa u and v-wind anomalies are not shown. The v-winds were very similar to the total wind anomalies; this was a south-southwesterly flow event. The 250 hPa winds are also not shown as the westerlies were well north of the affected region. Figure 3 shows the 500 hPa pattern over North America. The gradient support the westerlies was well north of Arkansas. Generalized positive height anomalies dominated the region with a week mid-level trough or split in the 500 hPa visible over the region. Perhaps this was an indication of a weak short-wave aloft.

ii. Forecasts

Forecasting localized heavy rainfall is still one of the more significant challenges in weather forecasting. Many convective events are poorly forecast. This event was relatively well predicted from a pattern and potential point of view. However, the discrete nature of the convection made it nearly impossible to predict the location and amounts of heavy rainfall.

NCEP SREF QPF’s valid at 11/1200 UTC are shown in Figures 4-6. These data show that the SREF predicted rainfall over Arkansas. But event short range forecasts from 11/0300 UTC had difficulty predicting anything close to the heavy rainfall observed. As will be shown, getting the pattern produced the potential for rainfall. The extremely short-range forecasts showed the threat of over 2
inches of rainfall in 6-hours. Convection was critical to this forecast and the 32 km SREF as at least 24 hours in advance (Figs. 7-9). The 11/0300 UTC forecasts showed about all members with +2.5 SD PW anomalies right over Arkansas. Though not shown, the 2SD anomalies were in all forecasts but the forecasts from 09/1500 ad difficulty with the convective scale processes.

The probability of 2.5SD or greater PW anomalies in the SREF was focused over Arkansas. The location varied little between forecast cycles though the probabilities changed. But clearly, for two days out the PW threat was well predicted by the SREF. The 2SD anomalies were even higher probability outcomes though only one example was shown here.

Figure 12 shows a more traditional anomaly plot. These data show the potential for modestly heavy rainfall over Arkansas.

iii. Radar and rainfall

The Little Rock (KLZK) radar is shown in Figure 14. These data showed a pivot near that Station marked RUF in the image when the loop was run in high speed. These data showed the evolution of an

Figure 3. As in Figure 1 except for 500 hPa heights (m) and height anomalies.
MCS over the region with repeat echoes. This was a classic radar set-up for heavy rainfall knowing the antecedent conditions including the extremely high PW and PW anomalies and the strong southerly winds into the region.

The rainfall data is shown in Figures 15 & 16. Figure 15 shows the total estimate rainfall over Arkansas for the period of heavy rainfall. These data show a large area of 100 mm (4 inches) and a focused area of 125 mm (5 inches) and a small area of 150 mm (6 inches of rainfall). The 6-hourly data (Fig. 16) shows that the rain fall before 10/1800 UTC was very light and south of the high impact area. Moderate rains of 16-32mm were observed by 11/0000 UTC and again ending at 11/0600 UTC. However, these data show that the significant rainfall was observed between 11/0600 and 11/1200 UTC when a large 48 mm (2inch) area and locally over 96 mm of rainfall occurred. Clearly the heaviest rainfall came fast and furious after 11/0600 UTC (Fig. 16d).

4. Conclusions

A deadly flash flood event impacted southwestern Arkansas mainly before sunrise on 11 June 2010. The heavy rainfall caused rapid rises on creeks and two rivers which produced flash flooding. As of this writing 16 people lost their lives in this tragic flash flood event.

The KLZK radar suggested an MCS moved over the region producing heavy rainfall. Clearly over 5 inches of rain fell over a wide area with locally heavier amounts. This led to rapid rises in the rivers within hours of the heavy rainfall, thus producing the fatal flash flood. A flash flood is defined here as rapid

flooding within 6-hours of the onset of heavy rainfall.

The signal here was weak and favored convective precipitation. Increased potential for heavy rainfall was likely related to the anomalous PW field over the State. The modestly anomalous 850 hPa winds also pointed toward the potential for heavy rainfall and back building storms.

Figures 4-6 and Figure 12 showed the potential for heavy rainfall about 1/5 to 1/3 of the observed amounts. These course 32km data were not likely to get the convective processes correct. And they did not. Neither did the high resolution models. The large QPF, potential for convection and back building were clues to be vigilant. The 2 to 2.5SD PW air with strong southerly flow were clues that heavy rainfall could be significant. The most workable clue was the persistent forecasts of 2 to 3SD PW anomalies right over Arkansas in an environment conducive for heavy rainfall.

Flash flood events are poorly forecast. But knowing the signals and vigilance in the face of deep moisture and high PW anomalies are both valuable and useful signals to heighten situational awareness. Both the radar (Fig. 14) and the rainfall data (Figs. 15 & 16) show that the rainfall came fast and focused from convection. Clearly the extremely heavy rains came between 11/0600 and 11/1200 UTC.

The GOES-IR imagery (Fig. 17) suggests an MCS came into the region out of Texas with enhanced cold cloud tops. However, the heavy rain in the flash flood affected region of Arkansas appears to have had heavy rainfall after 11/0600 UTC (Fig. 16c) when the IR cloud tops were warming (Fig. 17 bottom row). This
suggests warm rain processes and a Subtle Heavy Rainfall Signatures (SHARS: Spayd and Scofield 1983) like event over Arkansas during the period of heavy rainfall.

5. Acknowledgements
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6. References


Figure 5. As in Figure 4 except initialized at 2100 UTC 10 June 2010 showing precipitation (mm) to exceed a) 12 mm in 6 hours, b) 25 mm in 12 hours, d) 12 mm in 24 hours and e) 50 mm in 12 hours. Contours in powers of 2 mm. Shading in percent.
Figure 6. As in Figure 4 except NCEP SREF initialized at 0300 UTC 11 June 2010 showing precipitation (mm) to exceed a) 12 mm in 6 hours, b) 25mm in 6 hours, d) 35 mm in 6 hours and e) 50 mm in 6 hours. Contours in powers of 2 mm. Shading in percent.
Figure 7. As in Figure 6 except SREF flood potential showing a) 850 u-wind anomalies of -2.5SDs or less, c) 850 hPa winds 2.5 SD or greater, c) precipitable water anomalies greater than 2.5SDs and d) mean sea-level pressures less than -1.5SD or less.
Figure 8. As in Figure 7 except for SREF initialized at 0900 UTC 10 June.
Figure 9. As in Figure 7 except for SREF initialized at 2100 UTC 10 June.
Figure 10. As in Figure 7 except SREF flood potential showing a) 925 u-wind anomalies of -2.5SDs or less, c) 925 hPa v-winds 2.5 SD or greater, c) precipitable water anomalies greater than 2SDs and d) 925 hPa winds less than -1.5SDs below normal. Return to text.
Figure 12. SREF forecasts of 1.00 inches or more QPF from the 1500 UTC 10 June SREF. Upper panel shows the probability of 1 inch or more QPF and the mean 1.0 inch contour and the lower panels show the ensemble mean QPF and each members 1 inch contour.
Figure 13. NAM forecast from 0000 UTC 11 June 2010 valid at 1200 UTC 11 June showing (left) PW and PW anomalies and 925 hPa winds and v-wind anomalies. Right side shows the mean sea level pressure and anomalies and the total accumulated QPF (mm).
Figure 14. Sequence of KLZK radar.
Figure 14c. 0858 and 1156 UTC radar.
Figure 15. Total rainfall over Arkansas from the Stage-IV data valid 1800 UTC 10 June through 1200 UTC 11 June 2010.
Figure 16. As in Figure 15 except for 6 hour QPE (mm) ending at a) 1800 UTC 10 June, b) 0000 UTC 11 June, c) 0600 UTC 11 June, and d) 1200 UTC 11 June 2010.
Figure 17. GOES IR Images in 2-hour increments upper left is 1915 UTC 10 June ending image bottom left if 1115 UTC 11 June 2010. Top row left to right 1915, 2115, 2315 Middle row 0115 0315 0515 Bottom row 0715 0915 1115.
PRELIMINARY LOCAL STORM REPORT
NATIONAL WEATHER SERVICE LITTLE ROCK AR
REPORTS FOR JUN 11 2010

..TIME... ...EVENT... ...CITY LOCATION... ...LAT.LON...
..DATE... ...MAG.... ...COUNTY LOCATION..ST.... ...SOURCE....
..REMARKS..

0305 AM  FLASH FLOOD     ALBERT PIKE RECREATION  34.37N 93.88W
06/11/2010                   MONTGOMERY         AR   LAW ENFORCEMENT

HIGH WATER PROBLEMS WERE REPORTED AT THE ALBERT PIKE RECREATION AREA.

0313 AM  FLASH FLOOD     ALBERT PIKE RECREATION  34.37N 93.88W
06/11/2010                   MONTGOMERY         AR   EMERGENCY MNGR

*** 12 FATAL *** THIS INFORMATION IS PRELIMINARY.
EMERGENCY MANAGEMENT REPORTS AT LEAST 12 FLASH FLOOD FATALITIES AT THE ALBERT PIKE CAMPGROUND IN THE SOUTHWEST CORNER OF MONTGOMERY COUNTY. A SEARCH IS UNDERWAY AT THIS TIME FOR ADDITIONAL CAMPERS...BUT IT IS UNKNOWN HOW MANY OTHER PEOPLE MIGHT BE MISSING.

0330 AM  FLASH FLOOD     ALBERT PIKE RECREATION  34.37N 93.88W
06/11/2010                   MONTGOMERY         AR   LAW ENFORCEMENT

LAW ENFORCEMENT WAS TRYING TO MOVE CAMPERS TO SAFER LOCATIONS AROUND THE ALBERT PIKE RECREATION AREA...WITH HIGH WATER RESCUES EXPECTED.

0445 AM  FLASH FLOOD     ALBERT PIKE RECREATION  34.37N 93.88W
06/11/2010                   MONTGOMERY         AR   LAW ENFORCEMENT

WATER RESCUES WERE TAKING PLACE IN THE ALBERT PIKE RECREATION AREA.

0445 AM  FLASH FLOOD     CADDO GAP              34.40N 93.62W
06/11/2010                   MONTGOMERY         AR   LAW ENFORCEMENT

AT LEAST SIX INCHES OF WATER WAS OVER HIGHWAY 8 BETWEEN NORMAN AND GLENWOOD.

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