JP3.4 FINDING FACTORS FOR FATAL FLASH FLOODS IN MISSOURI

Elizabeth A. McCoy* and Neil I. Fox
University of Missouri, Columbia Missouri

1. INTRODUCTION

A survey of fatal flash floods in Missouri since 1990 was conducted. The reasons for examining these cases were two-fold: to gain an understanding of the hydro-meteorological factors that lead to fatal flash flooding and to determine how improvements in warnings can be made. The findings from two case studies will be presented in this paper. The first case occurred on 04-05 October 1998 near Kansas City and St. Joseph Missouri. The second case study examined the event of 07 May 2000 over east-central Missouri.

These events were chosen for several reasons. Firstly, the two events present two different hydrological considerations as the first event occurred primarily in an urbanized area while the second event occurred in a more rural setting. Secondly, different meteorological conditions led to the two events. The first event was supported by a quasi-stationary frontal boundary, while the second case developed due to rainfall from a mesoscale convective system. Both cases were floods of historical proportions. Finally, the cases were of interest due to the numbers of fatalities and the amount of damage that was associated with them.

This paper will first present an overview of the meteorological conditions that led to the extreme rainfall events. It will also provide a brief description of the hydrological aspects of the two cases. It will also examine the types and timing of the warnings issued and will examine the causes of fatalities during the flooding. It is hoped that a better understanding of how floods occur and how people respond to warnings will be gained and may reduce the number of fatalities associated with flash floods.

2. METEOROLOGICAL OVERVIEW

2.1 04-05 October 1998

Several thunderstorms producing extremely heavy rain caused severe flash flooding over west-central Missouri during this event. The environment prior to the event was conducive to convection and heavy precipitation. Data was taken from the 0000UTC soundings of 04 October from Springfield, MO and Topeka, KS, which are the two nearest ascent sites to the area of concern. Dewpoint depressions in the lower levels (up to 850 hPa) were quite small, ranging from 0.5°C to 9.0°C. The surface flow was southerly which allowed warm moist air to flow into the region from the Gulf of Mexico. The winds through the lower atmosphere showed fairly strong directional shear, which is conducive to thunderstorm development. However, the wind speed remained low, with strongest speeds on the order of 30 knots. This would have aided in the development of nearly stationary thunderstorms.

The main focusing mechanism for the thunderstorm activity was a quasi-stationary frontal system. This is one of the common situations described by Maddox et al (1979). The warm front had drifted northeastward towards west central Missouri by 0000UTC on 04 October. By 1200UTC heavily precipitating thunderstorms could be found both south and west of the Kansas City, MO area (Figure 1). The thunderstorms were relatively slow moving and convection continued to redevelop over the same areas (Figures 2-3). These factors allowed for heavy precipitation to fall over the same areas for an extended period of time.

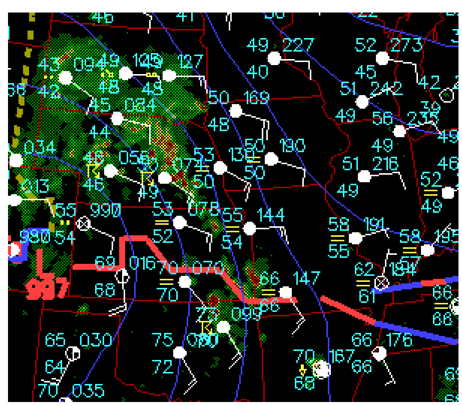

Figure 1. Surface Analysis 1200 UTC 04 October 1998 (from Unysis).

*Corresponding author address: Elizabeth McCoy 373 McReynolds Hall, Columbia MO 65211. e-mail: eam1cf@mizzou.edu

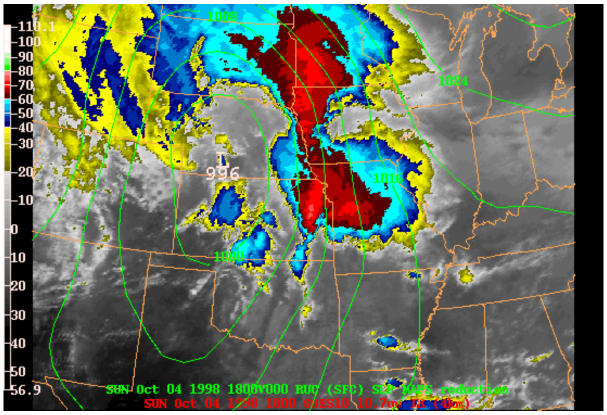

Figure 2. Satellite and Surface Isobars 1800 UTC 04 October 1998 (from UCAR-COMET).

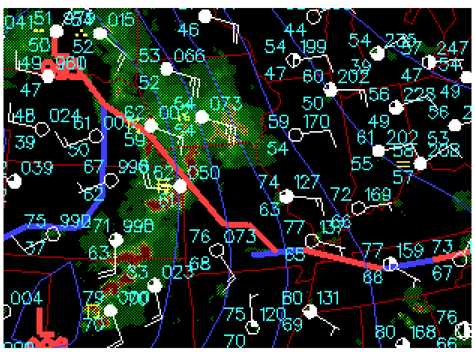

Figure 3. Surface Analysis 0000 UTC 05 October 1998 (from Unisys).

The precipitation totals varied widely over the area (Figure 4). Gages at Kansas City, MO airport and St. Joseph, MO recorded totals of 71.88 mm and 61.47 mm respectively. In the storm event reports, however, much heavier amounts were recorded in the area. Some areas received as much as 76.2 mm to 127 mm in 2 hours. The highest 24-hour rainfall totals of 177.8 mm were reported in Ray and Carroll counties.

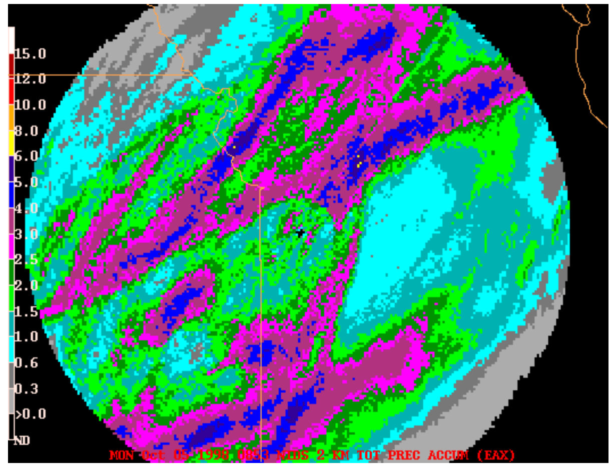

Figure 4. Radar accumulation precipitation totals 05 October 1998 (from UCAR-COMET).

2.2 07 May 2000

Thunderstorms produced extreme flash flooding over east central Missouri during the overnight and early morning hours of 6-7 May 2000. Glass et al. (2001) describe the conditions before the event as "benign". Initially the case lacked the recognizable surface features characteristic to flash floods described by Maddox et al (1979). The environment prior to the storm was supportive of convection. Data taken from the 00UTC sounding from Springfield, MO show that the Lifted Index was only -1°C, but the K Index was a 38. This was accompanied by a high precipitable water value of 36.58 mm, which is 185 percent of normal (Market et al. 2001). Fairly strong and persistent southerly low-level flow had allowed for substantial low-level moisture to be transported to the area from the Gulf of Mexico region.

The storm was spawned by a midlevel cyclonic vortex that can be seen over northeastern Oklahoma earlier on 6 May 2000. This system produced heavy rainfall over Oklahoma as well (Figure 5). By 0000UTC on May 7 (Figure 6) the midlevel vortex can be located over central Missouri, which began to produce thunderstorms between 0100-0200UTC (Glass et al. 2001). Continual convective development led to a nearly stationary system for several hours.

Rainfall totals associated with this storm were quite dramatic. Over 305 mm of rain fell over a fairly broad span of Franklin county Missouri, with unofficial reports of up to 406 mm west of Union, MO (Glass et al. 2001). According to the event record for the storm, the rain fell at a rate of 76.2 mm per hour from about 0800 to 0900UTC.

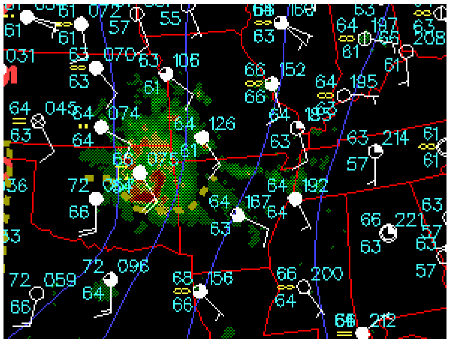

Figure 5. Surface Analysis 1200 UTC 6 May 2000 (*from Unisys*).

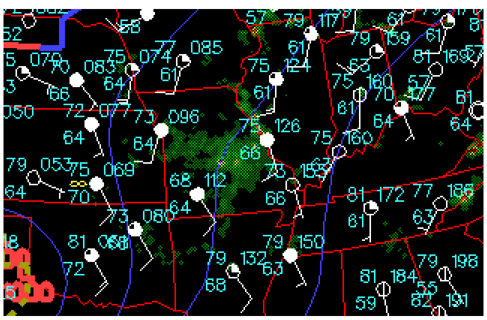

Figure 6. Surface Analysis 0000 UTC 7 May 2000 (*from Unisys*).

3. HYDROLOGICAL OVERVIEW

One important consideration for the 04-05 October case was antecedent precipitation. It had rained on 6 out of 7 days prior to the event, so the soil in the area was quite saturated. Also, much of the area is urbanized, with a relatively high amount of impervious surfaces such as concrete or asphalt. This coupled with saturated soil meant that almost all of the precipitation would become runoff, which would exacerbate any flash flooding. The Brush Creek watershed runs through Kansas City and it experienced quite severe flash flooding. Many of the deaths in the case were associated with flooding along this watershed. Many roads throughout the area were covered by 1 to 2 meters of water.

The area affected by the 07 May 2000 event is a more rural area than that considered in the other case study. The worst flooding occurred in the Flat Creek watershed, which runs through Union, MO. This creek rose almost 4.5 meters from the rainfall (NCDC). Many other streams in the area also flooded causing damage to several areas.

4. WARNINGS AND RESPONSE

At time of manuscript publication, only warning from the Kansas City storm event were available to analyze, although some information was available about the event near St. Louis. The warnings for the Kansas City storm (4-5 October) came from the National Weather Service Office at Pleasant Hill. They were produced with fairly large lead times of around 30 minutes. The numerous warnings clearly stated the danger of driving into flooded waterways. Even with these clear warnings against driving into floodwaters, many people drove into flooded roadways. Seven people died when their vehicles were overcome on a bridge over Brush Creek. Witnesses reported that several motorists drove into waters even after being warned against such actions.

Warnings issued by the St. Louis National Weather Service Office for 7 May 2000 were discussed in the storm report of the event. The report stated that two apartment complexes were evacuated, which saved countless lives. Despite the extremely heavy rainfalls and subsequent flooding, only two people lost their lives.

5. SUMMARY

This article examines several factors that have lead to fatal flash floods in Missouri. Two case studies were chosen for a variety of reasons. These included having different meteorological situations and differences in the type of land cover in the area affected by the flash floods. The first event occurred over the Kansas City area on 4-5 October 1998. This event was associated with a slow moving cold frontal system that allowed for convective development to occur over the same area for an extended period of time. The second event happened the night of 7 May 2000 over Franklin and surrounding counties in east central Missouri. This flash flood event was associated with a midlevel cyclonic vortex and an accompanying mesoscale convective system. While these two events had different underlying causes, they both produced extremely heavy rainfalls and flash flooding of historic proportions. Both events had fatalities associated with them. The event in Kansas City had more fatalities in total, with seven people losing their lives on a single bridge. However, it seems that the warning issued from the respective NWS offices were of exception lead-time and strongly worded, so the forecasters performed their duties very well. Many of the deaths can be attributed to ignoring advice given in the warnings.

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