Common Environmental Parameters Associated with Heavy Precipitation and Flash Flood Events Over Southwest Arkansas, East Texas, and North Louisiana

Jason Hansford, Brandi Richardson, and Ken Falk – National Weather Service, Shreveport, Louisiana

Introduction

Located within a few hundred miles from the warm waters of the Gulf of Mexico, the Ark-La-Tex (consisting of Southwest Arkansas, North Louisiana, and Northeast Texas) is often the breeding ground for heavy rainfall and flash flooding. Its geographic location and proximity to the Gulf of Mexico allows for cold frontal systems and attendant upper level troughs to be greatly influenced by the sub-tropical climate. In addition, tropical systems occasionally affect the region during the summer months.

Six heavy rainfall and flash flood events between 2006 and 2010 were analyzed, and the synoptic and mesoscale conditions that contributed to the excessive rainfall in each case were identified. Rainfall totals in these events ranged from 4.00 to 16.00 inches in 24 hours. Common environmental parameters identified during the analysis were used to create a Flash Flood Decision Flow Chart for use by meteorologists to assist in determining whether a Flash Flood Watch should be issued.

Flash Flood Case Events

Six heavy rainfall / flash flood events were analyzed using the National Weather Service's (NWS) Weather Event Simulator (WES):

16 October 2006 - Widespread flash flooding across North-central Louisiana (Rainfall totals 3.00 – 10.00 inches with isolated amounts of 16.00 inches)

13 May 2008 - Flash flooding across Shreveport and Bossier City, Louisiana (Rainfall totals 4.00 – 8.00 inches)

19 August 2008 - Localized flash flooding in El Dorado, Arkansas (Rainfall totals 3.00 – 5.00 inches)

2 September 2008 - Widespread flash flooding across North-central Louisiana associated with Hurricane Gustav (Rainfall totals 4.00 – 12.00 inches)

29 October 2009 - Widespread flash flooding across extreme Eastern Texas, Northwest Louisiana, and Southwest Arkansas (Rainfall totals 4.00 – 10.00 inches)

10 June 2010 - Flash flooding across portions of Northeast Texas (Rainfall totals 4.00 – 10.00 inches)

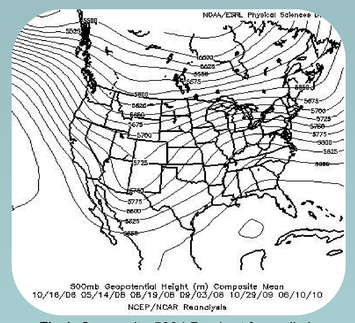

Fig.1 Composite 500 hPa chart from all six cases studied, showing a large trough over AZ/NM, with shortwaves ejecting northeast across the Ark-La-Tex.

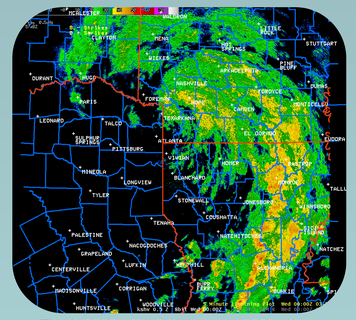

Fig. 2 0000 UTC 3 September 2008 KSHV WSR-88D reflectivity depicting training storms in the rainbands of the remains of Hurricane Gustav

Results

Flash Flood Decision Flow Chart

Deep atmospheric moisture from surface to 500 hPa with precipitable water values greater than 48 mm (1.90 inches).

Strong 500 hPa trough over Arizona / New Mexico, or hurricane or tropical storm moving over the forecast area.

Surface dewpoint temperature greater than or equal to 17C (63 F) degrees.

START HERE:

Look at the 3 boxes above. If any of the 3 criteria above are not met, heavy rainfall is not expected. If all 3 criteria above are met, continue down the chart by looking at the 3 secondary boxes directly under this box.

Upper level diffluence over forecast area.

Depth of warm layer between LCL and freezing level at least 3.5 km (11500 ft) deep.

Southwest, south, or southeast 850 hPa winds of at least 10 m/s (20 kts) over the forecast area.

Surface moisture convergence greater than or equal to 25 g/kg/12 hrs will help focus and enhance rainfall.

If all 3 secondary criteria above are met, heavy to torrential rainfall with flash flooding will likely occur. A Flash Flood Watch is recommended. The boxes to the left and below contain more information.

If all 3 secondary criteria above are not met, see box to the right.

Heavy rainfall may occur in isolated locations, but most areas will not see widespread flash flooding.

If the surface boundary intersects the 850 hPa theta-e ridge, which should be greater than 340 K, rainfall amounts may be enhanced.

If ground is saturated from previous rainfall, flash flooding will be enhanced.

If surface boundary is oriented parallel to 850-300 hPa storm motion vector, heavy rainfall may occur along or on the moist side of the boundary. If surface boundary is perpendicular to mean storm motion vector, the heavy rainfall will be near the surface boundary.

Elevated moisture source in the form of a Pacific jet can enhance rainfall amounts.

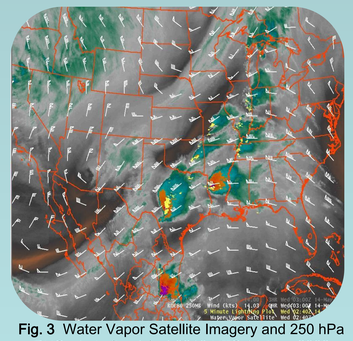

Fig. 3 Water Vapor Satellite Imagery and 250 hPa RUC winds (knots) at 0240 UTC 14 May 2008 showing Pacific moisture feed, upper level trough over AZ/NM border, and upper level diffluence over Northeast TX and North LA.

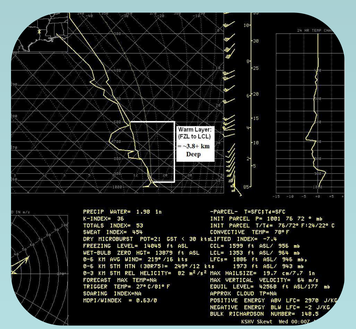

Fig. 4 KSHV Raob at 0000 UTC 14 May 2008 showing the depth of warm layer (3.8 km), depth of low level moisture, and the precipitable water (1.98 in).

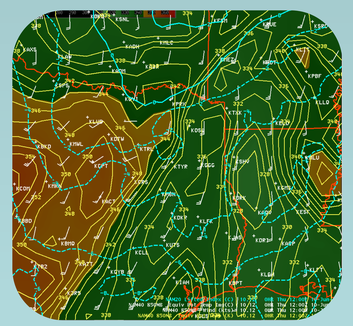

Fig. 5 GFS model 850 hPa Theta-E in Kelvin (yellow lines) and winds in knots at 1200 UTC 10 June 2010

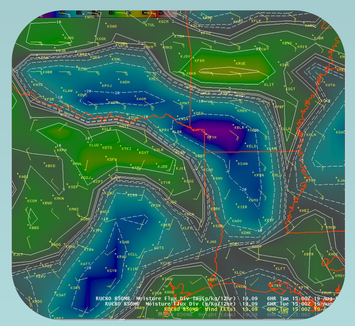

Fig. 6 RUC 80 km Surface Moisture Flux Convergence (dashed lines) in g/kg/12 hrs at 1500 UTC 19 August 2008. Wind barbs are in knots.

Acknowledgments

The authors thank NOAA – ESRL Physical Sciences Division for the use of their high resolution North America Regional Reanalysis data and composite generation tools, Dr. Boniface J. Mills for his efforts in the early stages of the study, David Gore (Northeast Louisiana Skywarn) for Figure 7, and Keith Stellman (WCM at the National Weather Service Office in Shreveport) for Figure 8.

Common Parameters Associated with Heavy Rainfall

Synoptic Scale Features

- One of these three types of synoptic systems should be present over the forecast area (Fig. 1):
  - *Synoptic Continental* – Deep upper level 500 hPa trough over AZ/NM, with shortwave troughs ejecting to the east in the resultant southwest flow.
  - *Tropical* - Tropical cyclone or remnants of a tropical cyclone
  - *Hybrid* - Synoptic systems enhanced by tropical moisture
- Upper level diffluence (Fig. 3)
- Deep atmospheric moisture from surface to 500 hPa with precipitable water values of 48 mm (1.90 in) or greater (Fig. 4)
- Elevated moisture source from the eastern Pacific advecting northeast along the subtropical jet (Fig. 3)
- Warm cloud layer depth (LCL to freezing level) greater than or equal to 3.5 km (~11,500 ft) (Fig. 4)
- Moderate mixed-layer CAPE greater than or equal to 1000 J/kg (Fig. 4)

Low Level Features

- Southwest, south, or southeast winds of at least 10 m/s (20 kts) at 850 hPa, with corresponding surface or 850 hPa moisture flux convergence greater than or equal to 25 g/kg/12 hrs (Fig. 6)
- Surface dewpoints of 17˚ C (63˚ F) or greater
- Slow moving surface trough / cold front / outflow boundary oriented *parallel* to the 850-300 hPa mean wind (storm motion) suggests heavy rainfall along and in advance of the front in the form of train echoes. Surface trough / cold front / boundary *perpendicular* to the 850-300 hPa mean wind (storm motion) suggests heavy rainfall along the front, but of shorter duration (Figs. 9 and 10)
- Surface trough/cold front/outflow boundary lies within a surface or intersecting an 850 hPa theta-e ridge greater than 340K (Fig. 5)

Fig. 7 Flash Flooding from the remnants of Hurricane Gustav in Monroe, LA, 2 September 2008.

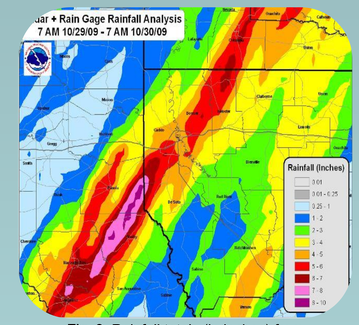

Fig. 8 Rainfall totals (in inches) from 29 October 2009.

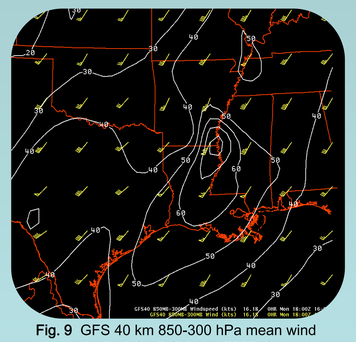

Fig. 9 GFS 40 km 850-300 hPa mean wind analysis at 18 UTC 16 October 2006. Solid lines denote isotachs contoured every 10 knots.

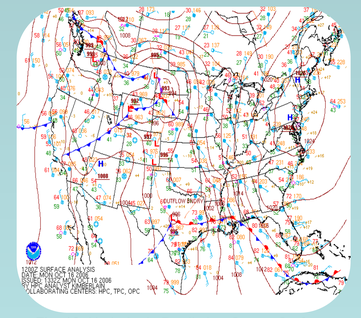

Fig. 10 Hydrologic Prediction Center Surface Analysis at 1200 UTC 16 October 2006 depicting an example of a slow moving or stationary frontal boundary near the flash flood area (North Louisiana).