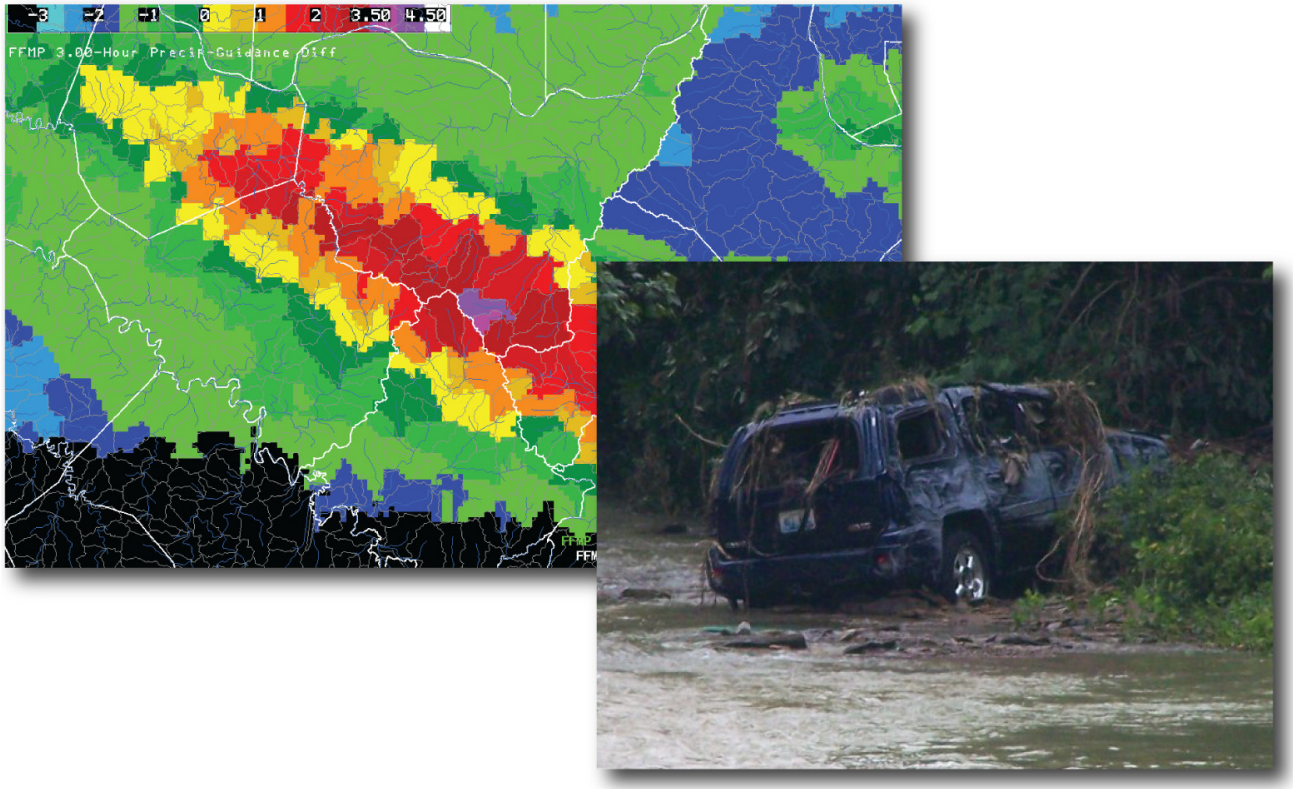
FLASH FLOOD WARNING BEST PRACTICES



SIMULATION GUIDE: JULY 20-21, 2010 EVENT

Presented by:
The Warning Decision Training Branch

Facilitator Version

Acknowledgments

Special thanks to the following people for their time and assistance with this new course and the WES simulation:

- The staff of the Wilmington, OH Weather Forecast Office who provided the data and input for this WES simulation. WDTB would like to especially thank Seth Binau for providing his time and knowledge for this event and for reviewing this simulation.
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Cover image is of the following:

- AWIPS D2D screen capture of rainfall difference compared to the FFMP three-hour flash flood guidance
- A vehicle destroyed by the flash flooding in Lewis County, KY - Courtesy of Joanie Bloomfield, Dennis Brown, and the Lewis County Herald

Ed Mahoney, Chief

Warning Decision Training Branch

Training Division, OCWWS

March 31, 2011

Document History

The document history is provided to track any updates or changes to the WES simulation guide. The version number, seen at the bottom of every page, will be updated as each significant change is made to the simulation guide.

Version	Date	Description
1.0	March 31, 2011	Initial Release

To provide feedback, comments, or ideas related to this document, please visit our web site at: http://www.wdtb.noaa.gov

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1: How to Use This Document

Welcome to the ***July 20-21, 2010 Event*** Simulation Guide! The purpose of this guide is to provide the training facilitator at a forecast office with case-specific materials needed to prepare and deliver effective simulations in support of the new ***Flash Flood Warning Best Practices*** course. This simulation complements the material provided in the Flash Flood Warning Best Practices module and other previous training detailing basin-based flash flood warnings and the use of a "Flash Flood Emergency" in an extreme flash flood event.

Since this document outlines the answers to the challenges of the event, it is specifically meant for the use of the training facilitator only.

It is recommended that you use the materials provided here, since they are specifically tailored to the events of July 20-21, 2010. You may choose to use this simulation to help design additional training exercises related to flash flood warnings, heavy rain forecasting, and the use of the Flash Flood Monitoring and Prediction (FFMP) application. You may also choose to use the materials provided here as a template for training with other flash flooding cases.

In order to create effective simulations with this case, you will need to familiarize yourself with the details of this event. We recommend installing the case first, followed by reading each section in order with the static data available in a D-2D display. See Table 1-1 for a description of the layout of this document.

After reviewing the simulation guide and becoming familiar with the details of this event, you, the training facilitator, will be ready to begin loading this simulation in a displaced real-time (DRT) mode for the trainee. You will need to understand the performance objectives associated with this simulation, which is related to the new Flash Flood Warning Best Practices course and the Flash Flood Warning Decision Making with FFMP-Advanced course. You will be able to evaluate the trainee's performance either during or after the simulation. Each performance objective has a corresponding suggested evaluation criteria to allow you to assess the trainee's performance, all of which are provided in Chapter 4 of this document.

Table 1-1: Simulation Guide Layout
Chapter 1: How to Use This Document
This introduction describes the overall content and use of the simulation guide.
Chapter 2: The July 20-21, 2010 Event Overview
The event overview provides a summary of the key components of the event and an overview of the meteorological and hydrological components of the event.
Chapter 3: Background Information
The background information provides details regarding the WES simulation, including the WES build and AWIPS data provided with the case.
Chapter 4: Simulation Suggestions
A description of the simulation, including the performance objectives and evaluation criteria, are detailed in this chapter.
Appendix A: Storm Reports
This appendix lists the storm reports related to this event for the Wilmington, OH CWA and neighboring CWAs. A map of the storm reports is also provided.
Appendix B: SPC Products
This appendix provides the SPC Day One Convective outlook for the event. There were no mesoscale discussions or severe weather watches for this event.
Appendix C: HPC Products
This appendix provides various HPC products regarding heavy rainfall probabilities and quantitative precipitation forecasts (QPFs).
Appendix D: WESSL Script
This appendix provides the WESSL script that is used in the simulation.
Appendix E: Support Material
This appendix provides supplemental material to assist in the learning experience, including details on built-in procedures and CWA maps.

This simulation contains effective ways of incorporating immediate feedback to the trainee without training facilitator interaction, and it is possible for the trainee to start and complete the training without the training facilitator present. However, training research indicates that ***one-on-one*** training where the ***training facilitator and trainee participate together for the optimum learning experience*** is the most effective way to run a simulation. While time consuming, this can insure that:

1. The trainee remains focused on the objectives of the simulation,

2. The trainee receives essential feedback on his/her performance, and

3. The training facilitator develops a solid understanding of how well the trainee comprehends the training and how well the trainee transfers the training to application.

In order to manage a simulation session, the training facilitator must be able to run a simulation as documented with the WES install and testing instructions included with the WES software. The simulation will be much more relevant if the local AWIPS customizations (e.g. preferences, procedures, color tables, etc.) are ported to the WES machine as outlined in the WES installation instructions. For more information regarding the WES and its installation, visit http://www.wdtb.noaa.gov/tools/wes/index.htm.

For more information regarding the new ***Flash Flood Warning Best Practices*** course, visit http://www.wdtb.noaa.gov/courses/ffw_bp/index.html.

2: The July 20-21, 2010 Event Overview

During the afternoon and evening hours of July 20, 2010, a multi-threat severe weather event was unfolding across the Missouri and Ohio River valleys. The primary severe weather threats near the Wilmington, OH (ILN) county warning area (CWA) were damaging winds and isolated tornadoes. This threat was setup by a short-wave trough moving through the region combined with 25 to 30 kts of 0-3 km shear, as seen by WSR-88D vertical wind profiles. A tornado was reported by law enforcement near the town of Trafalgar in Johnson County, IN. There were also a few wind reports in western West Virginia, which resulted in downed trees and power lines.

An east-west oriented quasi-stationary boundary was located across southern IN/OH and northern KY. Dewpoint temperatures south of the boundary were in the low to mid 70's Fahrenheit. The 925-850 mb winds were from the west-southwest at 25 to 30 kts with strong moisture convergence focused along the northern KY border. This low-level flow was enhanced by a vorticity maximum and a mesoscale convective vortex (MCV) in this region. Mean storm layer flow (850-300 mb) was generally from west to east at about 25 kts. However, Corfidi vector analysis for the region showed that overall system motion would be to the southeast at 5-10 kts, leading to a possibility of training storms and an increased flash flood threat if upwind development occurred along the downstream gradient of the moisture transport.

The 0000 UTC sounding from ILN depicted a very moist vertical profile for this region (not shown). The precipitable water (PW) value was approximately two inches, which is at the 99th percentile and two standard deviations above normal for the month of July (see Figure 2-1). RUC40 point soundings near the OH/KY border at 0400 UTC along with plan view analysis showed PW values at or above 2.50 inches, which would be some of the highest values ever seen there based on the chart in Figure 2-1. These soundings were also characterized by tall, skinny convective available potential energy (CAPE) profiles with values less than 1000 J/kg (overnight values near the OH/KY border during the event were estimated to be about 200 J/kg). Low lifting condensation levels (LCLs) and high freezing layer heights (approximately 15-17 kft.) led to a deep warm cloud layer (approximately 10-15 kft.) and predominant warm rain processes.

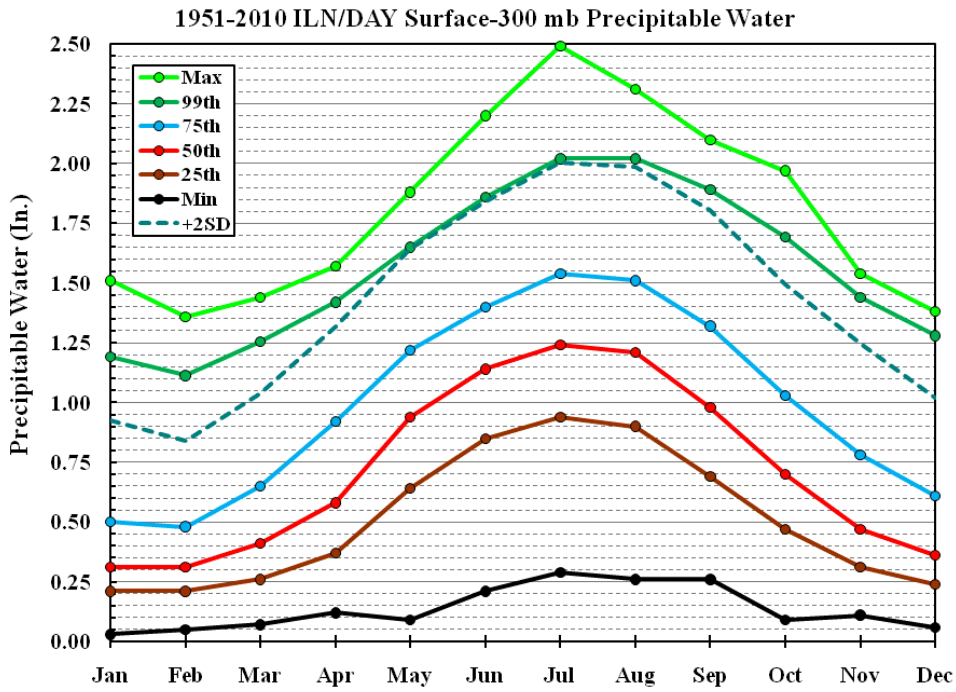

Figure 2-1: 1951-2010 monthly climatology of precipitable water (PW) from surface to 300 mb at ILN. The bright red line represents the mean PW for the area, the dark green line represents the 99th percentile, the light green line represents the maximum value, and the dashed line represents +2 standard deviations. More point PW climatologies can be located at http://www.crh.noaa.gov/unr/?n=pw.

From a hydrologic standpoint, the southern part of the ILN CWA is characterized by hilly terrain comprised of numerous small creeks and tributaries. The land use is generally croplands and pastures on the western half of the area and broadleaf deciduous forests in the eastern half. Soil types are very complex, but can be generally characterized as silt loam or silty clay loam. This generally means that the soil is not very porous in nature; thus, the infiltration rate and hydraulic conductivity, the ability of water to move through a porous medium, can not handle any significant amounts of rainfall.

Antecedent precipitation played a vital role in providing a high soil moisture content prior to the 20-21 July 2010 event. Figure 2-2 shows the multi-sensor precipitation estimator (MPE) rainfall totals from 12-20 July 2010 over the area. Areas along the southern ILN CWA border, notably Lewis County, KY and Scioto County, OH, have received two to five inches of rainfall, which is about 150% to 400% above their normal rainfall average (see Figure 2-3). Approximately one to two inches of that precipitation fell over the four days prior to this event (not shown).

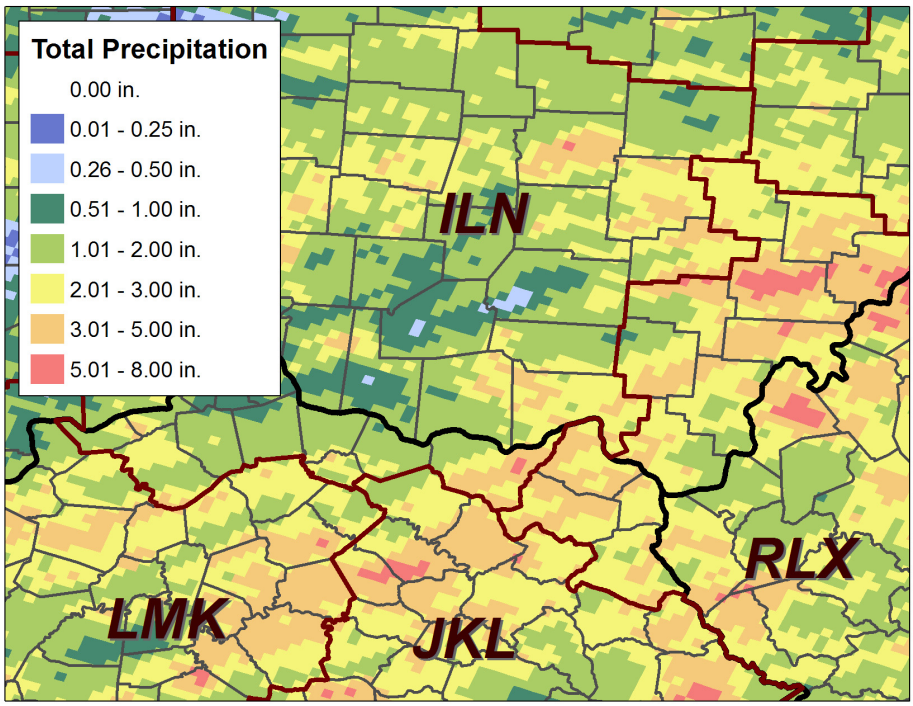

Figure 2-2: Multi-sensor precipitation estimator (MPE) rainfall totals for the period 12-20 July 2010 for the southern part of the ILN CWA and adjoining CWAs.

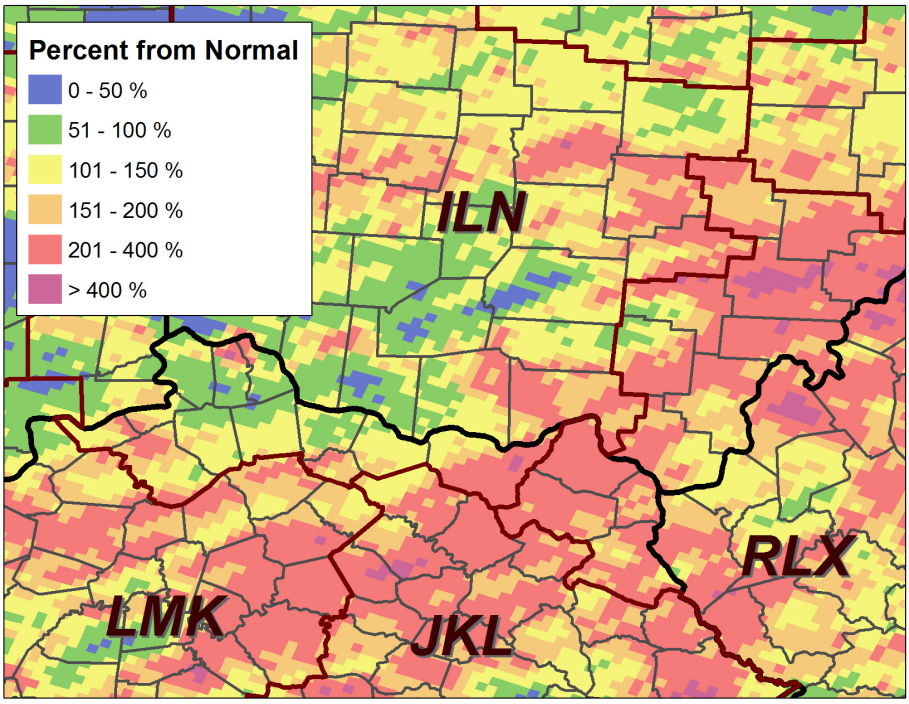

Figure 2-3: Percent from normal precipitation for the period 12-20 July 2010 for the southern part of the ILN CWA and adjoining CWAs.

As the aforementioned late evening severe weather threat diminished around 0200 UTC, the focus shifted towards flash flooding. Storms now extended along the boundary stretching along the Ohio River from northern Pendleton County, KY to Lewis County, KY and into the Charleston, WV (RLX) CWA, notably Carter County, KY and Greenup County, KY. Rain rates with these storms were at or above four inches per hour. Individual storm motion was rather quick at 25 kts, but the quasi-stationary boundary led to training over the CWA border with the Jackson, KY (JKL) area of responsibility. The first flash flood warning was issued for Lewis County at 0211 UTC, with warnings for Bracken, Mason, and Scioto Counties issued soon thereafter. To show the chronology of the event during the overnight hours, Figure 2-4 displays the KILN WSR-88D radar from 0001 UTC to 0700 UTC 21 July. Figure 2-5 displays the 3-HR difference from flash flood guidance (FFG) during the event from 0304 to 0954 UTC 21 July.

As most of the flash flood warnings were expiring at 0600 UTC, a new warning was issued for Mason County and most of Lewis County. The new warning was strongly worded, characterizing the flash flood threat as “dangerous and potentially life-threatening” (see Page 3-10 for the entire warning text). The storm reports received so far were of numerous road closings in both counties, ongoing home evacuations were in eastern Mason County, and water starting to enter homes in Tollesboro in Lewis County, KY. The office was also receiving reports of swift water rescues and a possible fatality in extreme southern Scioto County, OH, an area that has received nearly half the rainfall amount of Mason and Lewis Counties.

More reports came in between 0600 and 0700 UTC about “extreme” flooding, including swift water rescues and home evacuations not only in Mason and Lewis Counties, but also in the neighboring Fleming and Rowan Counties in KY (JKL CWA). At this time, river gauges were recording stage height increases at a rate of 1.0 to 1.5 ft./hr. The KILN WSR-88D estimated that six to eight inches of rain have fallen in this area with the anticipation of additional precipitation. Flash flood guidance (FFG) was now being exceeded by three to four inches for the 3-HR and 6-HR time periods. Even the 1-HR FFG has been exceeded by over an inch at numerous basins. The combination of the extreme rainfall totals, the significant FFG exceedance, the severe nature of the flash flooding reports, and the fact that this is occurring at night in rural areas led to the issuance of a flash flood statement for the warning for Mason and Lewis Counties at 0649 UTC with a “Flash Flood Emergency” for Lewis County, KY. The entire warning text for this statement can be viewed on Page 3-11.

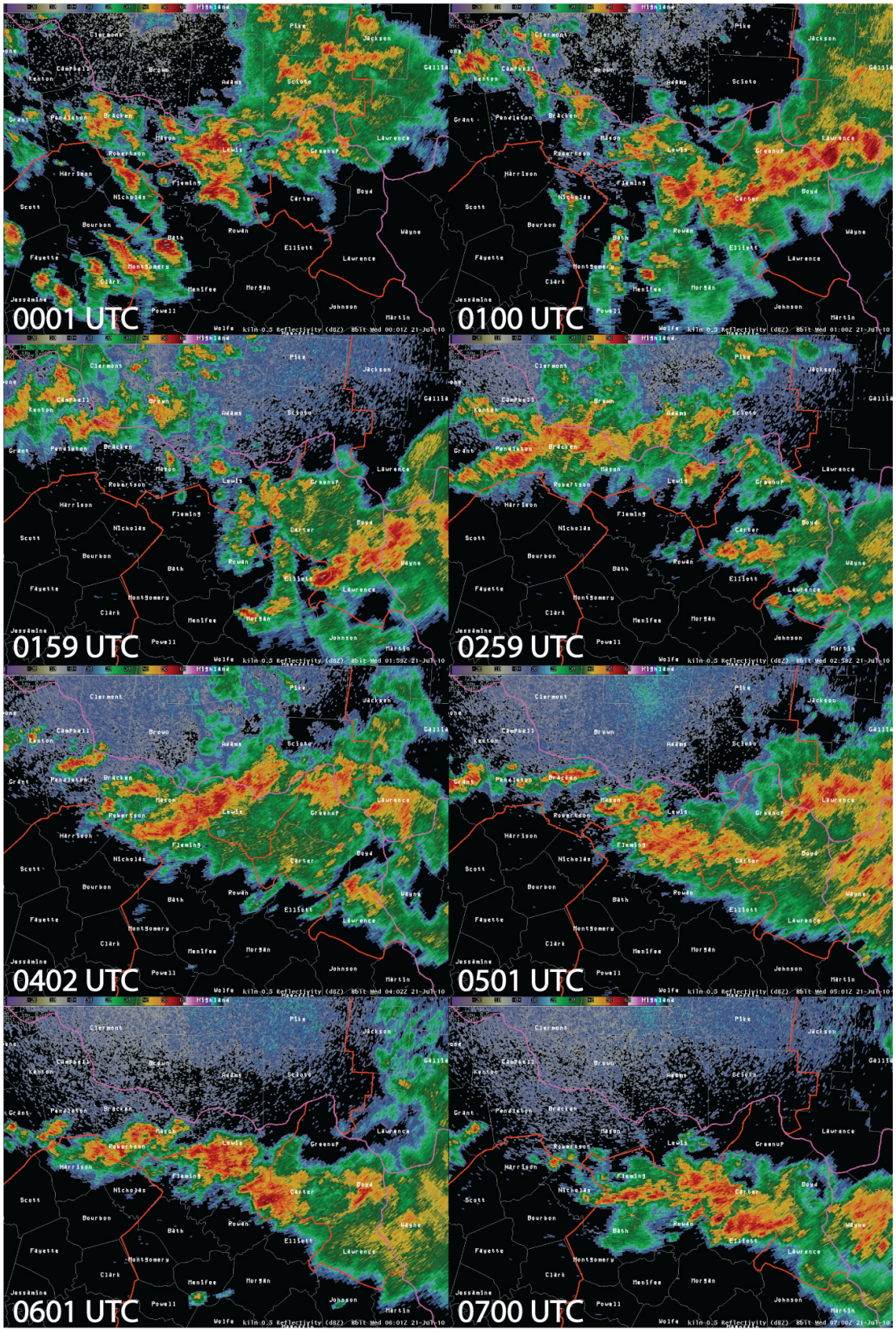

Figure 2-4: Evolution of the 0.5° base reflectivity from the KILN WSR-88D from 0001 UTC to 0700 UTC 21 July 2010.

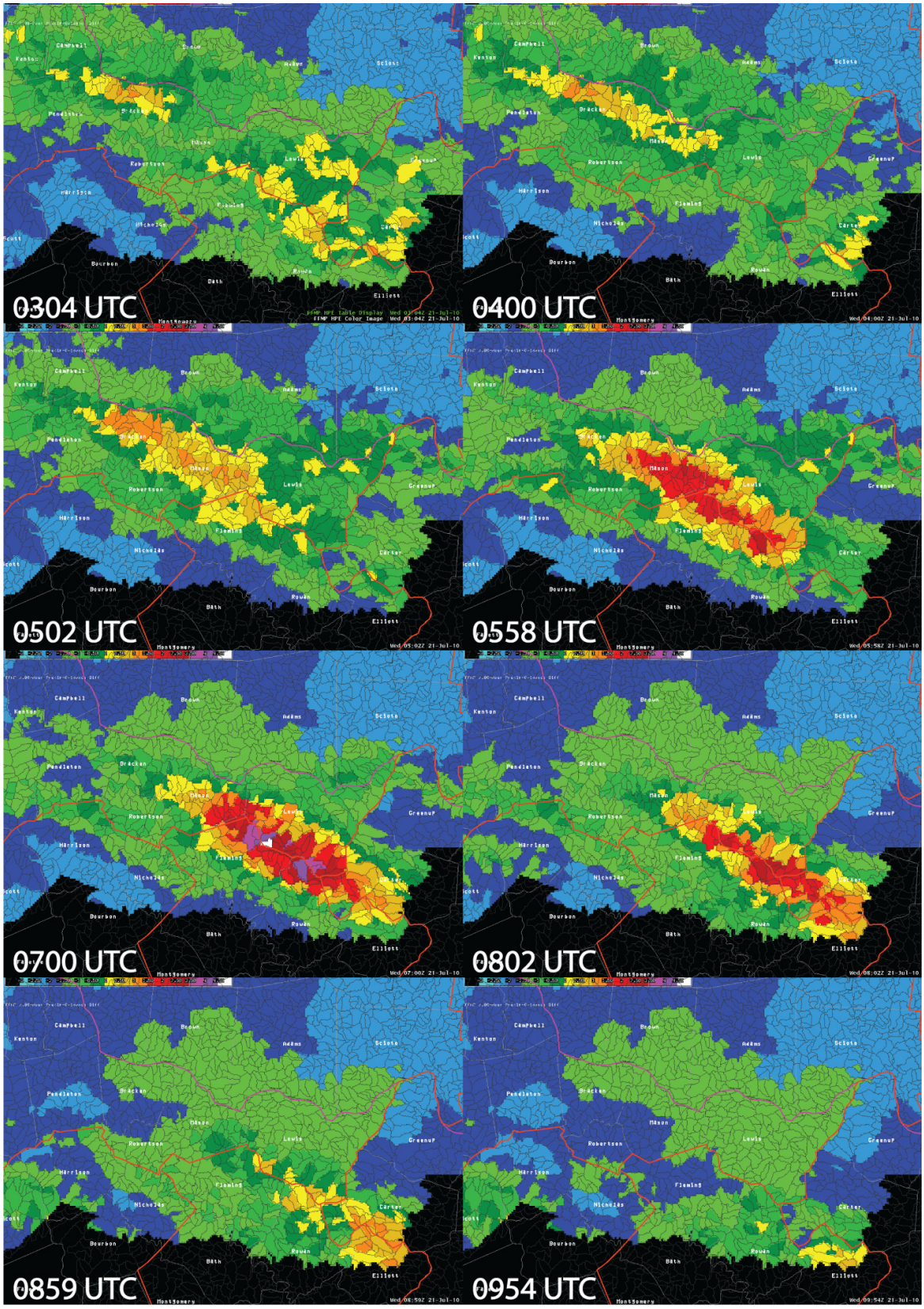

Figure 2-5: Evolution of the 3-HR difference from FFG from 0300 UTC to 1000 UTC 21 July 2010.

Final rainfall totals for the event were estimated by radar to be six to nine inches across southern Lewis County and northern Fleming County. The majority of the rain fell within a three to four hour period. To put in perspective the rarity of this event, rainfall totals were compared to a precipitation frequency analysis for this region, as computed by the National Weather Service (NWS) Hydrometeorological Design Studies Center (HDSC). The graph shown in Figure 2-6 depicts the annual recurrence interval of one-hour, three-hour, and 24-hour precipitation totals and the maximum precipitation values estimated for each temporal period in southern Lewis County, KY. Maximum one hour precipitation was estimated at 2.63”. A one-hour total of that magnitude is seen here about once every 40 years according to Figure 2-6. However, the three-hour total (5.53”) and the 24-hour total (8.84”) were considered as an event that occurs about once every 1000 years.

Even though the rains ended before 1000 UTC, the threat for significant downstream flooding continued. Some rivers and creeks were increasing at a rate of 2.0 to 2.5 ft./hr. during the morning hours, with small rivers cresting at over 25 ft. during the afternoon hours of 21 July. Areas along the Kinniconick Creek in Lewis County saw some of the worst flooding in the ILN CWA, with the stage height increasing from 3.25 ft. at 2000 UTC 20 July to its crest at 27.48 ft. at 1745 UTC 21 July (see Figure 2-7). Another example of river flooding is shown in Figure 2-8 with the Little Sandy River in Grayson, KY, which is located in Carter County (RLX CWA). The river from 0300 to 0700 increased at a rate of 2.5 ft./hr. and cresting at 25.12 ft. at 2000 UTC 21 July. This was the 13th highest river crest ever recorded for this area. The river remained above flood stage (21 ft.) for approximately 21 hours.

The final impacts of the flooding were devastating. There were two fatalities as a result of the flash flooding. A 53-year-old female was swept away by the flood waters while trying to get to higher ground in the Franklin Furnace area (Scioto County, OH). A 72-year-old female in Fultz, KY (Carter County - RLX CWA) was in her mobile home when it was washed off its foundation and pushed some 200 yards downstream into a bridge. Her body was recovered three days later near the Little Sandy River. Numerous homes and businesses were destroyed or suffered major damage throughout northern Kentucky. Swift water rescues and home evacuations were common across many counties. Bridges at low-water crossings were swept away or had major structural damage. Several roads and highways were closed due to sections being swept away by floodwaters and/or bridges missing or damaged. Total damage was estimated at over $10 million.

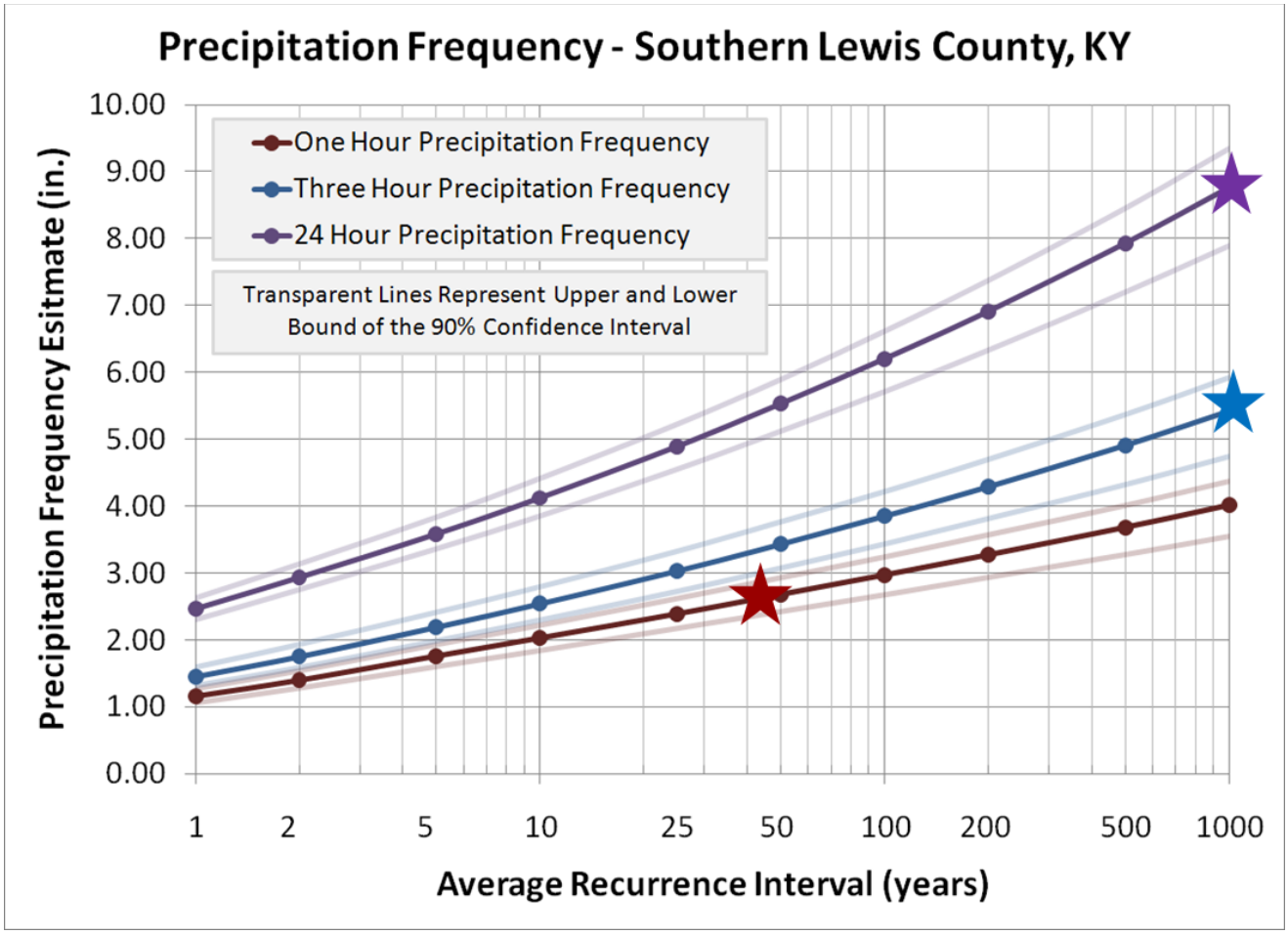

Figure 2-6: Precipitation frequency analysis for southern Lewis County, KY for one-hour (red), three-hour (blue), and 24-hour (purple) precipitation totals. The average recurrence interval (years) is shown here in a logarithmic scale. The solid lines represent the frequency for each temporal period, while the transparent lines represent the upper and lower bounds of the 90% confidence interval. The stars represent the maximum estimated values for each temporal period found in southern Lewis County. Note how rare the three-hour and 24-hour estimates are for this region. Precipitation frequency analysis for some states can be found at the following website: http://hdsc.nws.noaa.gov/hdsc/pfds/index.html.

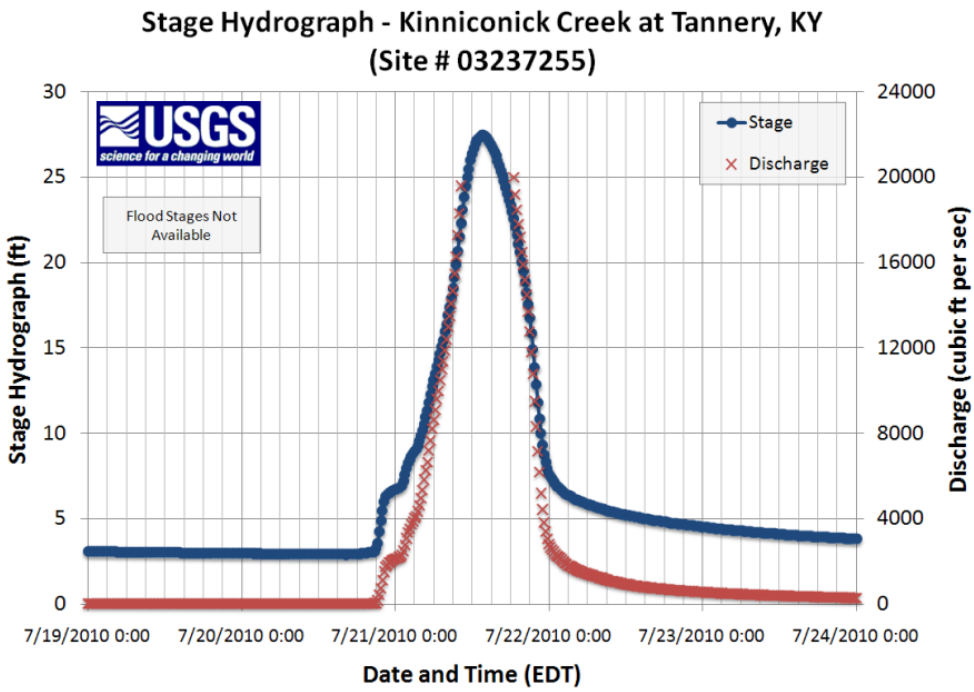

Figure 2-7: Stage hydrograph for Kinniconick Creek at Tannery, KY. The blue line represents the stage height (ft.). The red trace indicates the water discharge in cubic feet per second (cfs). Note that the gauge here cannot measure above 20,000 cfs.

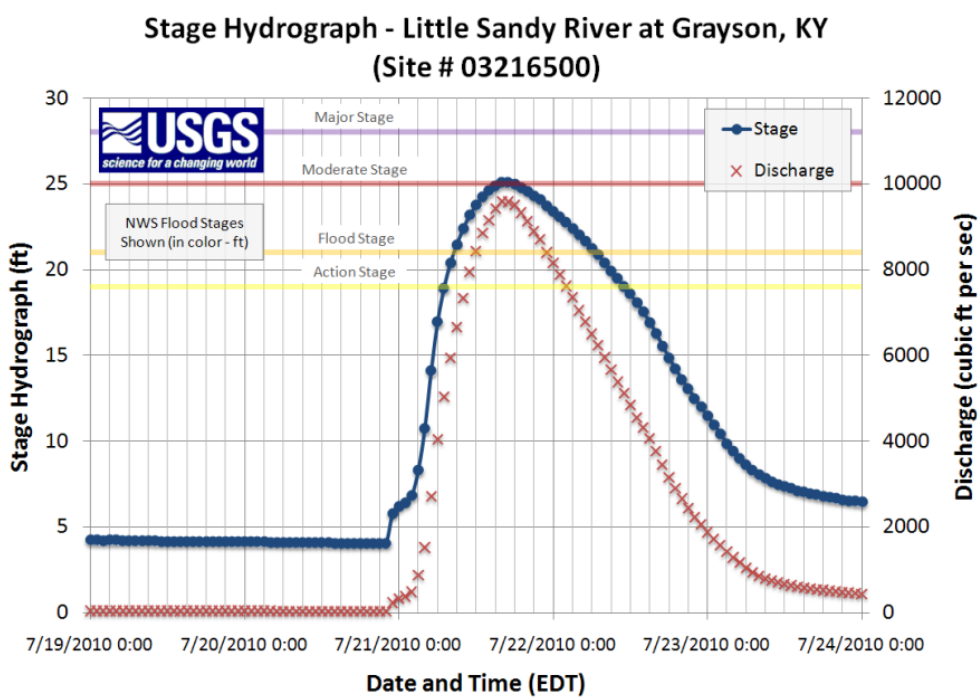

Figure 2-8: Same as Figure 2-7 except for the Little Sandy River at Grayson, KY.

It should be noted that this was not a synoptically anomalous event. Figure 2-9 shows the anomalies in sea-level pressure, U-wind and V-wind components, and precipitable water. The only parameter shown here with a greater than +1 standard deviation for the ILN CWA is the precipitable water (described earlier on Page 2-1 and Figure 2-1). Although an increased area of precipitation was shown for the area in the HPC precipitation products (Appendix D), this flash flood event was driven primarily by mesoscale forces. Therefore, being able to identify details in the mesoscale analysis is key to recognizing and forecasting a localized high-end flash flood event, such as the 21 July 2010 “Flash Flood Emergency” in Lewis County, KY.

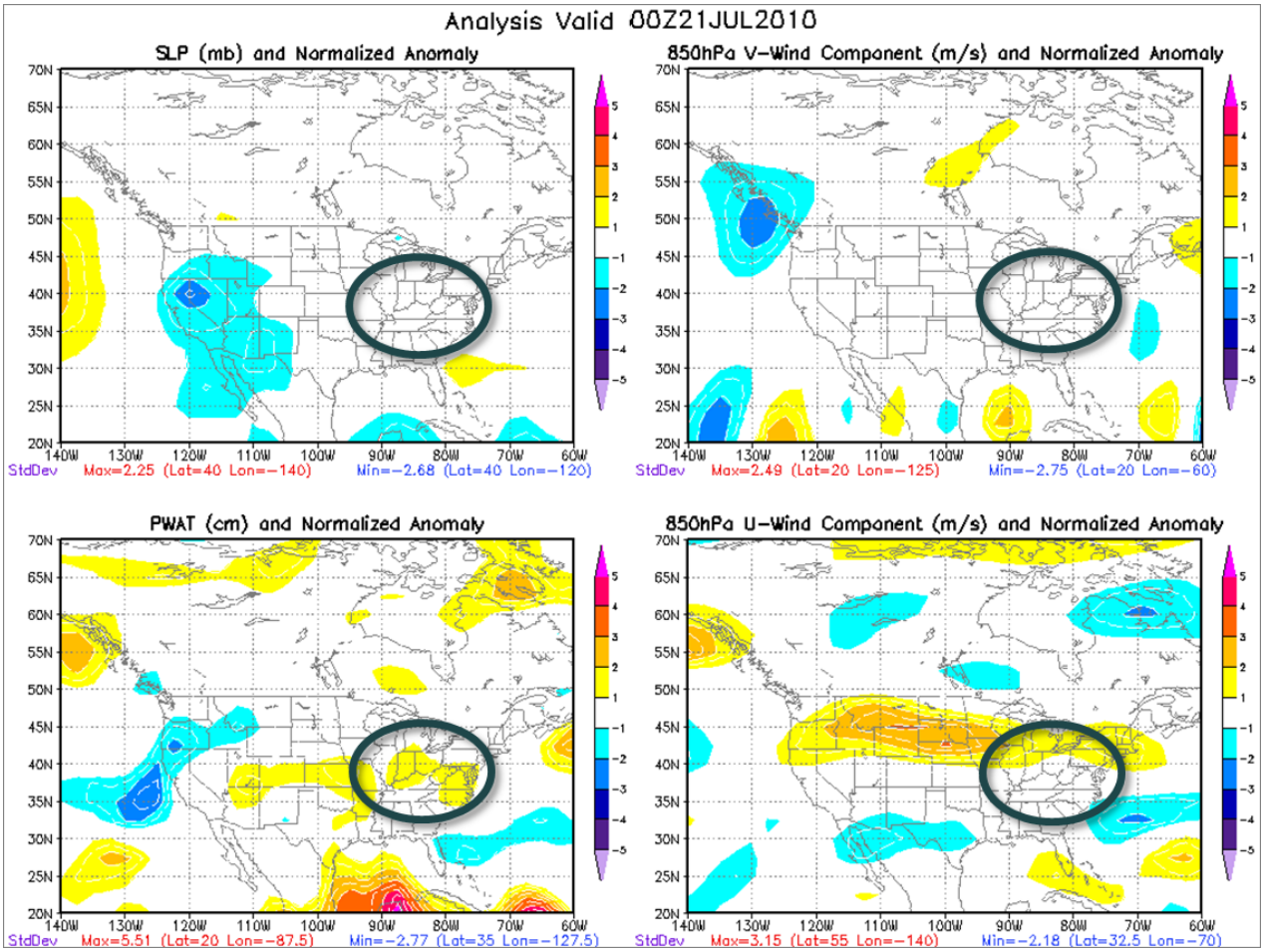

Figure 2-9: Standardized anomalies from NCEP/NCAR Reanalysis data valid 0000 UTC 21 July 2010. The upper-left panel displays the anomalies in sea-level pressure, the upper-right panel depicts the anomalies in 850 mb V-wind component, the bottom-right panel depicts the anomalies in the 850 mb U-wind component, and the bottom-left panel displays the anomalies in precipitable water. Warm (cool) colors represent positive (negative) anomalies. The area of interest is circled in each panel.

3: Background Information

I. Weather Event Simulator

This simulation requires that you have at least WES9.2 loaded on your WES machine. Do not continue with these simulations until you have successfully installed and tested WES9.2 in a simulation. Full information on this can be found at http://www.wdtb.noaa.gov/tools/wes/index.htm

II. Loading the Case from DVD

There is one install DVDs for the July 20-21, 2010 Event simulation that was shipped to each AWOC facilitator. This case occupies approximately **18 GB** of disk space when converted to a Displaced Real Time (DRT) format, so please plan your disk space accordingly.

A README file is provided on the install disk. A copy of the README file is also provided in Appendix E: Support Materials. This README file will provide instruction on how to install the case from the DVD, converting the case data into DRT format, and how to start the simulation.

III. Data Characteristics

The original data set came from the Wilmington, OH (ILN) Weather Forecast Office (WFO), and most data is accessible during the simulations. While there may be some incomplete or missing data due to the archiving process and to reduce the overall size of the case on your WES hard drive, there is enough data present for the trainee to be able to satisfy the learning objectives.

This section will outline some of the datasets available for use during this DRT simulation.

Radar Data:

The radar data provided in Table 3-1 lists the available radars for this case, the location of the radar, the time period of available radar data, and the Volume Coverage Pattern (VCP) used during the time period available. The 0.5° mosaic reflectivity will use all three radars listed here. The Four-Dimensional Storm Cell Investigator (FSI) is also available for KILN and KJKL.

Table 3-1

Radar ID	County and State	CWA	Time Period Available (UTC)	VCP
KILN	Clinton County, OH	ILN	0001 - 0958	12
KJKL	Breathitt County, KY	JKL	0000 - 0959	12
KCLE	Cuyahoga County, OH	CLE	0003 - 0951	212

Upper Air Data:

Table 3-2 lists all of the relevant sounding locations for this case. Only the 0000 UTC 21 July 2010 soundings will be available during the simulation.

Table 3-2

Upper Air ID and Locations	CWA	Location With Respect to ILN
KILN - Cincinnati, OH	ILN	---
KOHX - Nashville, TN	OHX	Southwest
KILX - Lincoln, IL	ILX	West
KGSO - Greensboro, NC	RAH	South-southeast
KDTX - Detroit, MI	DTX	North

Model Data:

Table 3-3 shows the model data provided for this case. The horizontal resolution of each model is presented for some datasets. Please note the times available for each model. Some files are missing or have been removed in order to reduce the overall size of the case on your WES hard drive.

Table 3-3

Model	Containing Folder	Model Runs Available
LAPS	LAPS	0000 - 0900 UTC (Hourly)
MSAS	MSAS	0000 - 0900 UTC (Hourly)
Eta (40 km)	CONUS212	0000 UTC
GFS (40 km)	CONUS212	0000 UTC and 0600 UTC
MesoEta (40 km)	CONUS212	0000 UTC and 0600 UTC
SREF (40 km)	CONUS212	0300 UTC and 0900 UTC
Eta	GRID218	0000 UTC and 0600 UTC
RUC2	GRID236	0000 - 0900 UTC (Hourly)
ECMWF_HiRes	LATLON	0000 UTC
ENSEMBLE	LATLON	0000 UTC
GFSGuide	LATLON	0000 UTC and 0600 UTC
UKMET	LATLON	0000 UTC and 0600 UTC
LAMP	NDFD	0000 - 0900 UTC (Hourly)
MOSGuide	NDFD	0000 UTC
NamDNG5	NDFD	0000 UTC and 0600 UTC
RTMA	NDFD	0000 - 0900 UTC (Hourly)

Satellite Data:

The majority of the satellite and satellite-derived products are available only for the ***eastConus*** directory for this simulation from 0015 UTC to 0945 UTC 21 July 2010. Since there are numerous satellite base and derived products, this guide will not list them here.

Procedures:

We have created a few procedures to help with some basic threat assessment for this event. The procedures can be accessed by selecting *Procedures* in the *File* menu of the D-2D display. A basic list of the provided procedures are shown here in Table 3-4. The details of each procedure are provided in Appendix E: Support Materials. ***Users are encouraged to create their own procedures***.

Table 3-4

Procedure Name	Procedure Bundle	Basic Description	Page
Sfc_Analysis	MesoAnalysis	Surface observations and winds (streamlines) with IR satellite	E-7
PW_MoistTrans	MesoAnalysis	Low-level (925-850 mb) moisture flux divergence and transport vectors with precipitable water	E-8
Corfidi_Vectors	MesoAnalysis	Four panel display featuring Corfidi vectors, CAPE, vorticity, divergence, and frontogenesis	E-9
KILN_Analysis	Radar_FFMP	0.5° reflectivity and one-hour, three-hour, and storm-total precipitation	E-10
FFMP_ILN	Radar_FFMP	Pre-built display for FFMP with various maps displayed	E-11

FFMP Data:

FFMP data were computed from the DHR files available from the three radars provided in this simulation (KILN, KJKL, and KCLE). HPE and Bias-HPE (BHPE) data are also available for this simulation. Table 3-5 provides the details on the flash flood guidance (FFG) being used in this case. Because the 6-HR FFG is not available until after 0600 UTC, the analysis done during the simulation will be focused on the 1-HR and 3-HR FFG.

Table 3-5

FFG Period	Containing Folder	Valid Time
One Hour (1-HR)	OHRFC1	0100 UTC
Three Hour (3-HR)	OHRFC3	0300 UTC
Six Hour (6-HR)	OHRFC6	0600 UTC

When using FFMP, ensure that the student has the following settings during the simulation:

- Under the *Config* menu, make sure that the "*Worst Case*" aggregate feature is turned on to show the worst case data instead of basin averages.
- Also under the *Config* menu, make sure that "*Link to Frame*" is also turned on so the table is linked with the scenario time in the D-2D.
- Under the *Layer* menu, make sure that "*All and Only Small Basins*" is selected for the greatest basin detail.
- When doing downstream basin traces, make sure that "*Downstream Only*" is selected from the *Click* menu.

IV. WESSL

The WESSL script utilized for this DRT simulation will help pace the simulation and provide critical information for the trainee. A copy of the WESSL script used in this simulation is provided in Appendix D: WESSL File. An introductory Articulate presentation will load immediately after the simulation begins. This presentation will provide an overview of this simulation, some background hydrological and meteorological information, and the learning objectives for this case. As the simulation progresses, the WESSL script will display relevant information for the forecaster, notably local storm reports and river gauge data.

Some prompts enabled by the WESSL script will require a user response to the questions provided. Information on how to retrieve the file containing the trainee's responses are outlined in Performance Objective #6 - WESSL Questions in Chapter 4: Simulation Suggestions on Page 4-39.

At the conclusion of the simulation, another Articulate presentation will appear providing a full debrief of the case. This debrief will present an overview of the event for the CWA, how the forecast office handled the event, and relevant hydrometeorological data. This debrief will also describe the issuance of the "Flash Flood Emergency" by the ILN forecast office in this case. The last slide of the presentation will provide links to two interactive web pages. These pages contain the details for each local storm report, stage hydrographs for local waterways, CoCoRaHS gauge data, and FFMP basin trace animations.

Loading the appropriate saved WES macro will automatically insert the correct WESSL file for the simulation.

V. Notes from the Office

After identifying the particular case to use for the Flash Flood Warning Best Practices course, we had a few opportunities to discuss this scenario with Seth Binau, the SOO at the Wilmington, OH office. Here is a summary of how events transpired, including the point at which the decision was made by two forecasters to use a “Flash Flood Emergency” for Lewis County, KY:

The event started as a severe weather threat for strong winds and tornadoes during the evening of July 20th. As the primary severe weather threat shifted towards flash flooding, two forecasters handled the flash flood warning responsibility. Multiple warnings were issued between 0200 and 0500 UTC that covered Bracken, Mason, Lewis, and Scioto Counties (see Figure 3-1). During the first few hours of the event, the office did not receive any reports from Lewis County other than minor street flooding. Heavy rains have also fallen across southern Scioto County, OH and western Lawrence County, OH (RLX CWA).

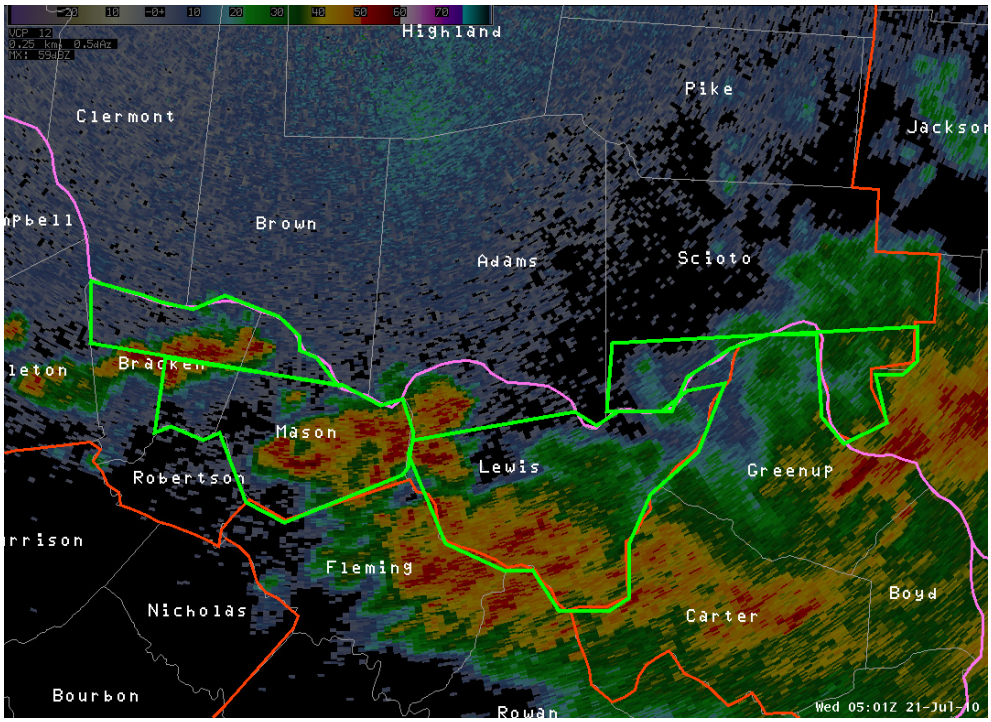

Figure 3-1: Flash Flood Warnings (green) issued by ILN between 0200 and 0500 UTC. The pink (red) borders represent state (CWA) boundaries.

The earlier warnings for Bracken, Lewis, and Mason Counties were replaced with a new flash flood warning for Mason and Lewis Counties at 0559 UTC (see Figure 3-2). A call was made earlier to Lewis County officials, but there were still only a few reports of flooding, some road closures, and a few home evacuations. The WFO alerted the officials for the potential of very serious flash flooding for southern Lewis County with additional storms training over the area. This message was quickly relayed to the local fire departments.

Over the next hour, the WFO started getting reports of what was deemed as “extreme” flooding in Lewis County. FFMP was showing 3-HR and 6-HR FFG being exceeded by about 3”-4” over numerous basins (see 3-HR FFG difference in Figure 3-3) with storm-total precipitation reaching 6”-8”. Also during this time, the office was also receiving reports of swift water rescues and a possible fatality near Franklin Furnace, OH in Scioto County. This was a result of the combined 3”-4” of rain that fell here, plus the downstream runoff from western Lawrence County. When comparing this to Lewis County, Scioto County received about half as much rainfall in an area defined by greater FFG values.

At 0649 UTC, a “Flash Flood Emergency” was issued for Lewis County in a Flash Flood Statement. This was the forecasters’ reasoning behind the issuance of the “Flash Flood Emergency”:

- FFMP showed 3-HR and 6-HR FFG exceeded by 3”-4” across several basins that are prone to flash flooding.
- There were reports of serious flooding, including the possible fatality, in southern Scioto County where rainfall amounts were half of what was received in Lewis County. It is also noted that the FFG is higher in Scioto County than in Lewis County.
- The event was occurring during the middle of the night in a region where there are a number of remote areas that are hard to be reached by law enforcement officials.
- There are two areas within Lewis County where several streams conjoin, specifically near Charters and a region near Kinniconick and Camp Dix. Because of the nature of the flash flooding, these areas were specifically mentioned in the 0649 UTC follow-up statement.

For your reference, the flash flood warning issued at 0559 UTC and the flash flood statement issued at 0649 UTC containing the “Flash Flood Emergency” wording for Lewis County are provided on Page 3-10 and Page 3-11.

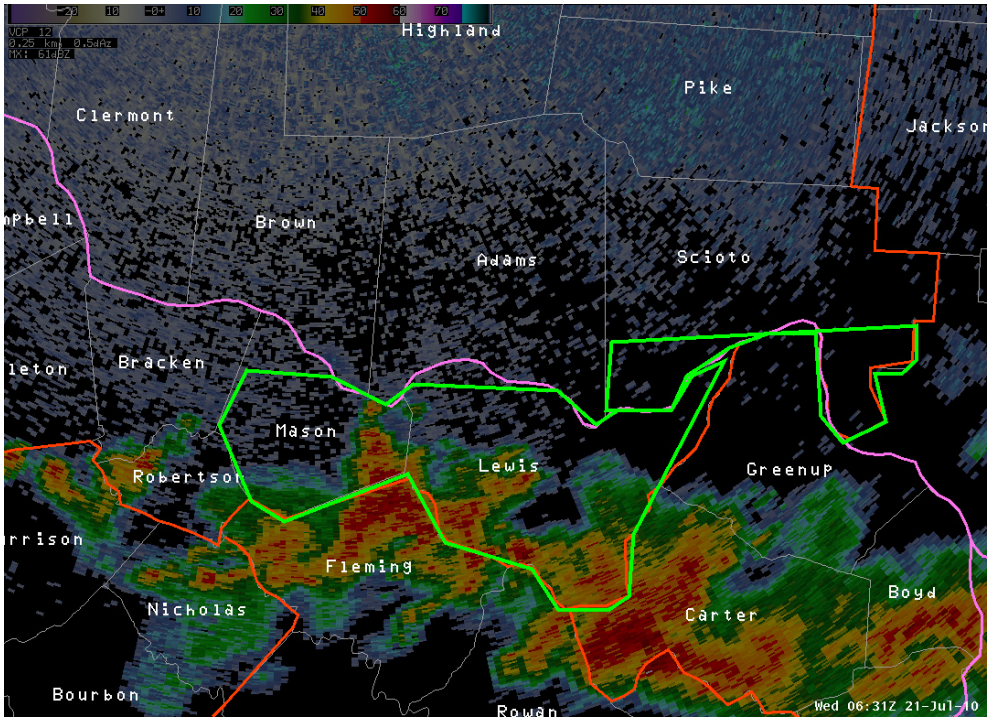

Figure 3-2: Flash Flood Warnings (green) issued by ILN that were in effect after 0600 UTC. The pink (red) borders represent state (CWA) boundaries.

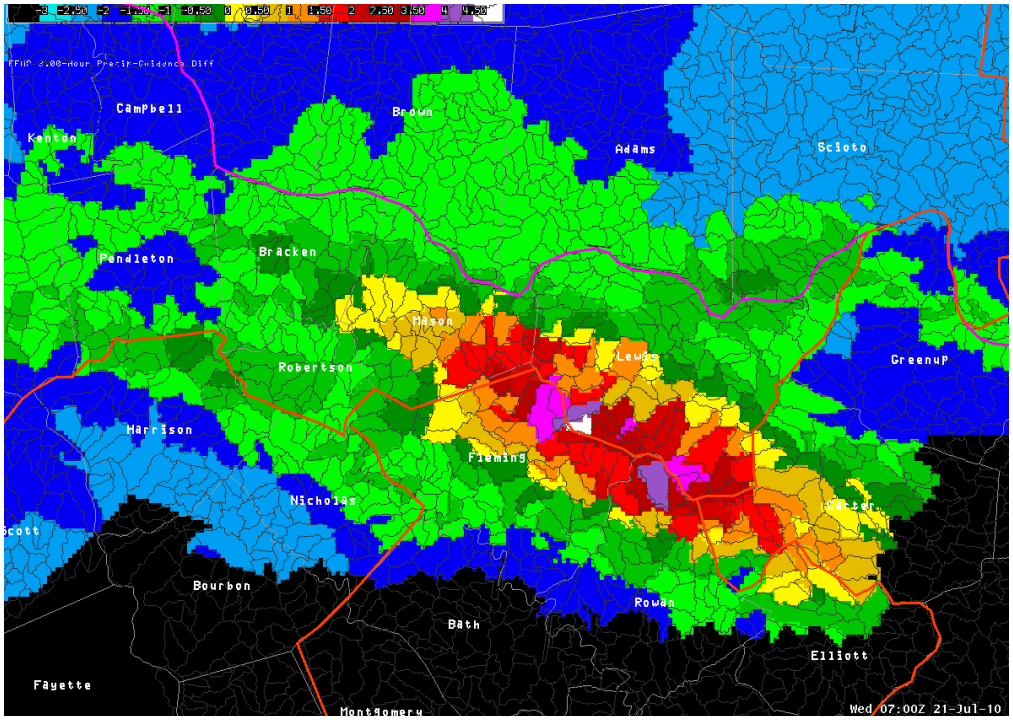

Figure 3-3: FFMP 3-HR difference from QPE at 0700 UTC. The pink (red) borders represent state (CWA) boundaries.

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000
WGUS51 KILN 210559
FFWILN
KYC135-161-210945-
/O.NEW.KILN.FF.W.0040.100721T0559Z-100721T0945Z/
/00000.0.ER.000000T0000Z.000000T0000Z.000000T0000Z.OO/

BULLETIN - EAS ACTIVATION REQUESTED
FLASH FLOOD WARNING
NATIONAL WEATHER SERVICE WILMINGTON OH
159 AM EDT WED JUL 21 2010

THE NATIONAL WEATHER SERVICE IN WILMINGTON HAS ISSUED A

* FLASH FLOOD WARNING FOR...
  LEWIS COUNTY IN NORTHEAST KENTUCKY...
  MASON COUNTY IN NORTHERN KENTUCKY...

* UNTIL 545 AM EDT.

* AT 148 AM EDT...RADAR AND LAW ENFORCEMENT INDICATED DANGEROUS AND
POTENTIALLY LIFE-THREATENING FLASH FLOODING OCCURRING IN MASON AND
LEWIS COUNTIES...WHERE UP TO 6 INCHES OF RAIN HAVE FALLEN SINCE LATE
THIS AFTERNOON. LAW ENFORCEMENT REPORTED WIDESPREAD ROAD
CLOSURES ACROSS MASON AND LEWIS COUNTIES...IN ADDITION TO HOME
EVACUATIONS.

* ADDITIONAL THUNDERSTORMS MOVING THROUGH THE AREA WILL PRODUCE AN
ADDITIONAL ONE TO TWO INCHES OF RAIN THROUGH 4 AM...WHICH WILL
EXACERBATE ONGOING FLOODING...CREATING A LIFE-THREATENING SITUATION.

AREAS AT GREATEST RISK FOR DANGEROUS FLASH FLOODING INCLUDE
LOCATIONS NEAR THE NORTH FORK LICKING RIVER IN MASON COUNTY
INCLUDING LEWISBURG...AND LOCATIONS NEAR KINNICONICK CREEK AND
GRASSY FORK IN LEWIS COUNTY INCLUDING KINNICONICK AND CAMP DIX. IN
ADDITION...WASHINGTON...MAYSVILLE...MURPHYSVILLE...TOLLESBORO AND
RIBOLT MAY ALSO EXPERIENCE FLASH FLOODING.


PRECAUTIONARY/PREPAREDNESS ACTIONS...

ACT QUICKLY TO PROTECT YOUR LIFE IF YOU ARE IN A LOW LYING AREA...
ALONG A CREEK...STREAM OR IN AN AREA EXPERIENCING FLOODING. MOVE TO
HIGHER GROUND IMMEDIATELY.

NEVER DRIVE INTO AREAS WHERE WATER COVERS THE ROAD. ONLY A FEW INCHES OF
RAPIDLY FLOWING WATER CAN QUICKLY CARRY AWAY YOUR VEHICLE. FIND AN ALTER-
NATE ROUTE OR WAIT UNTIL THE WATER RECEDES.

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000
WGUS71 KILN 210649
FFSILN

FLASH FLOOD STATEMENT
NATIONAL WEATHER SERVICE WILMINGTON OH
249 AM EDT WED JUL 21 2010

KYC135-161-210945-
/O.CON.KILN.FF.W.0040.000000T0000Z-100721T0945Z/
/00000.0.ER.000000T0000Z.000000T0000Z.000000T0000Z.OO/
MASON KY-LEWIS KY-
249 AM EDT WED JUL 21 2010

...FLASH FLOOD EMERGENCY FOR LEWIS COUNTY...

EXTREME FLASH FLOODING IS OCCURRING IN LEWIS COUNTY...AND A FLASH
FLOOD WARNING REMAINS IN EFFECT FOR LEWIS AND MASON COUNTIES UNTIL
545 AM EDT.

AT 240 AM EDT...LAW ENFORCEMENT REPORTED THAT VERY SEVERE FLASH
FLOODING IS ONGOING IN SOUTHERN LEWIS COUNTY. NUMEROUS REPORTS WERE
RECEIVED OF RESIDENTS TRAPPED DUE TO HIGH WATER...AND WATER RESCUES
ARE ONGOING ACROSS MUCH OF SOUTHERN LEWIS COUNTY.

RADAR INDICATES THAT ANYWHERE FROM 4 TO 9 INCHES OF RAIN HAVE FALLEN
SINCE THIS EVENING...AND ADDITIONAL THUNDERSTORMS WILL LIKELY DROP
ANOTHER ONE TO TWO INCHES OF RAIN THROUGH 4 AM. THIS WILL EXACERBATE
ONGOING FLOODING...AND CREATE AN EXTREMELY DANGEROUS AND LIFE
THREATENING SITUATION.

EXCESSIVE RAINFALL ACROSS SOUTHERN LEWIS COUNTY WILL FLOW INTO SALT
LICK AND KINNICONICK CREEKS...CAUSING DANGEROUS FLASH FLOODING
DOWNSTREAM TOWARD VANCEBURG AND GARRISON.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

THIS IS AN EXTREMELY DANGEROUS AND LIFE THREATENING SITUATION! DO NOT
ATTEMPT TO TRAVEL UNLESS YOU ARE IN AN AREA SUBJECT TO FLOODING OR
UNDER AN EVACUATION ORDER. IF YOU ARE IN A LOW LYING AREA...ALONG A
CREEK...STREAM OR IN AN AREA EXPERIENCING FLOODING...TAKE ACTION NOW
TO PROTECT YOUR LIFE. SEEK HIGHER GROUND IMMEDIATELY.

&&
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4: Simulation Suggestions

I. Introduction

Defining effective performance objectives and evaluation criteria are essential to a successful simulation. The performance objectives outlined here are provided as recommendations for the simulation and coincide with the learning objectives from the ***Flash Flood Warning Best Practices*** course. A simulation guide is also provided for the student with the performance objectives and evaluation criteria outlined within it. However, the facilitator is encouraged to modify these objectives or create new ones to tailor the training to any specific needs. The student should have a clear understanding of the objectives prior to starting the simulation.

There is only one displaced real-time (DRT) simulation for this event, which is localized for the Wilmington, OH (ILN) Weather Forecast Office (WFO). The simulation will run from 0415 UTC to 0630 UTC on 21 July 2010. During this simulation, the student will analyze the following:

- Mesoscale environment
- Observed and model-derived Skew-T diagrams
- Radar observations and trends
- FFMP data and trends

The job-sheet style approach will allow the student to systematically analyze the event during the simulation. The student will be responsible for issuing flash flood warnings for the impacted regions and later issue follow-up statements for their warnings, as described by the simulation schedule outlined on Page 4-4. The student should use appropriate wording and call-to-action statements within their warning products, including the use of a "*Flash Flood Emergency*."

Additional information will be provided during the running of the simulation. An introductory Articulate presentation will appear during the opening minute of the simulation. This presentation will provide the student with vital information needed to become familiar with case while gaining local knowledge of the hydrological characteristics of the area, including topography, soil characteristics, and any antecedent precipitation.

A WESSL script will be enabled to help pace the simulation and to provide extra datasets for the student. Local storm reports (LSRs) and information regarding river stage heights will appear during the simulation, which will assist the student in realizing the magnitude of the event as it unfolds. Feel free to modify the WESSL file provided as you tailor the simulation to your needs. As mentioned in Chapter 3: Background Information, some prompts enabled by the WESSL script will require a user response to questions posed to the student. Each question will appear unannounced to the student and will ask him/her about non-meteorological aspects of the severe weather operations, such as coordination with other WFOs and warning decision making regarding the usage of a "*Flash Flood Emergency*." This material is presented to you on Page 4-39.

Another Articulate presentation will appear at the end of the simulation, which will debrief the student on the event and what he/she should have learned from working this simulation. The presentation will discuss both the meteorological and hydrological impacts from the event and how the ILN WFO handled the event, including their issuance of a "*Flash Flood Emergency*." At the end of the presentation, the student will have access to the following interactive maps:

- Local Storm Report Map:
    - Extensive details of each LSR
    - Pictures from Lewis County and one video from the town of Olive Hill, KY
- Post-Brief Map:
    - CoCoRaHS rain gauge data
    - Stage hydrographs from USGS river gauge data
    - One-Hour and Three-Hour basin trace flash animations (includes rain rate, QPE, FFG thresholds, KILN 0.5° reflectivity, and difference from FFG)

****** Remember to review the performance objectives and evaluation criteria prior to running the simulation ******

II. Simulation - July 20-21, 2010 Event

Simulation Information:

WFO Localized -- Wilmington, Ohio (ILN)

Simulation Start Date/Time -- 0415 UTC 21 July 2010

Simulation End Date/Time -- 0630 UTC 21 July 2010

WES Macro -- ILN-0415-21July2010

Overview:

This simulation will focus on the flash flood event that occurred in the southern part of the Wilmington, Ohio (ILN) county warning area (CWA). Rainfall started falling in the southern part of the CWA around 2000 UTC 20 July and continued on-and-off into the overnight hours. A quasi-stationary boundary is located in a moisture-rich environment over southern Ohio and northern Kentucky. Several waves of storms have now developed along this boundary as the simulation begins. Some flash flooding has been reported within the CWA where high water is being reported across several roads in the town of Augusta in Bracken County, KY.

The objectives of this simulation are as follows:

1. Complete an environmental analysis and determine the flash flood threat and magnitude.
2. Understand radar and FFMP observations and trends and apply this knowledge to flash flooding situations.
3. Issue appropriate flash flood warnings and follow-up statements, including the use of a "*Flash Flood Emergency*."

The student is expected to generally follow the schedule shown on the next page. The simulation is provided in a job-sheet type format to maximize the learning experience from the event while providing an opportunity to issue flash flood warnings in a DRT environment.

Schedule for Trainee:

The following schedule is a basic timetable of the simulation. The time spent on each performance objective may vary.

- 0415-0430 UTC (15 mins): **Pre-Brief Presentation**
- 0430-0500 UTC (30 mins): **Performance Objective #1 -** Mesoscale Analysis
- 0500-0520 UTC (20 mins): **Performance Objective #2 -** Radar and FFMP Analysis - Part I
- 0520-0540 UTC (20 mins): **Performance Objective #3 -** Issuing Flash Flood Warnings
- 0540-0610 UTC (30 mins): **Performance Objective #4 -** Radar and FFMP Analysis - Part II
- 0610-0630 UTC (20 mins): **Performance Objective #5 -** Issuing Flash Flood Statements

*The **Post-Brief Presentation** will appear at the end of the simulation and will run for approximately 15 minutes.*

****** Before you begin this simulation...***

1. Review the case and the simulation guide in order to completely understand the event and the objectives prior to starting the simulation for the student.
2. Make sure that the student has a copy of the student guide with him/her. It will be beneficial if the student reviews the guide and objectives before starting the simulation.
3. Ensure that the student has a readily accessible map of the CWA (see Appendix E for a copy of the CWA map).
4. Take the time to test the simulation and make sure it runs properly before being used for training purposes.

Performance Objectives:

Performance Objective #1 -- Mesoscale Analysis

Time Period -- 0430 UTC to 0500 UTC

The mesoscale analysis is important here to characterize the environment and forcing involved in this case since it is not synoptically evident. A short-term (3-4 hour) analysis can help identify the flash flood potential for localized areas.

Evaluation Criteria 1.1 - First perform a basic surface analysis for the region. Load the procedure ***Sfc_Analysis*** from the ***MesoAnalysis*** procedure bundle into a blank D-2D pane. This procedure contains METAR observations, surface winds (as streamlines), and satellite IR imagery. Make sure that you scroll back in time to the RUC40 0400 UTC model output.

**** If you are having problems loading this procedure, refer to **Surface Analysis** on Page E-7 in Appendix E for the procedure details. ****

1. Identify the location of the boundary based on surface streamlines and IR satellite at 0400 UTC. Scroll between the 0000 UTC and 0400 UTC time frame. Describe the movement of this boundary between 0000 UTC and 0400 UTC.

   Answer - *The boundary is located from central IL and extends across southern IN, over the OH/KY border, and into WV at 0400 UTC (see Figure 4-1). The boundary does have a slow southward movement between 0000 UTC and 0400 UTC, but it can also be described as quasi-stationary. Although the location of the boundary is somewhat hard to determine by using the surface observations, the surface wind streamline analysis and the overlay of the IR satellite will help in identifying its locaton.*

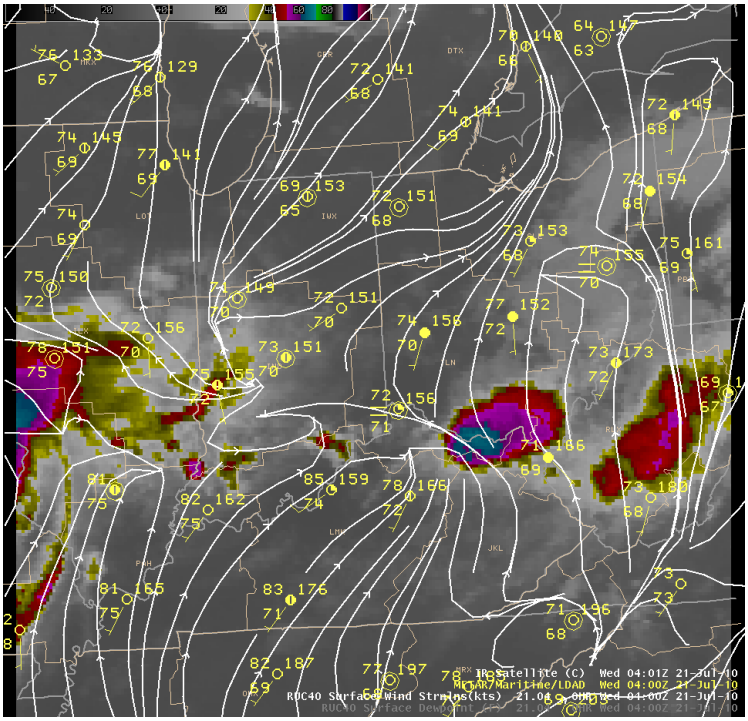


Figure 4-1: Infrared satellite image overlaid with surface observations and RUC40 surface winds streamlines (kts) at 0400 UTC.

2. Bring the image back to the 0400 UTC analysis. Perform a basic surface analysis using the METAR observations provided in the procedure. You can increase the density of the number of METAR stations to help your analysis.

Answer - *Surface temperatures are in the low 80's Fahrenheit south of the boundary in western KY/TN and in southern IL while temperatures are generally in the low-to-mid 70's Fahrenheit north of the boundary in northern and central IL/IN/OH. Dew point temperatures are in the mid 70's Fahrenheit southwest of the ILN CWA and the aforementioned boundary, while the dew points are around 70°F north of the boundary. Observed surface winds are generally from the south-southwest at 5 kts across the entire region. Winds are more southerly over central OH and the Appalachian Mountains in WV/VA.*

Evaluation Criteria 1.2 - The next step is to evaluate the moisture content of the atmosphere. In another D-2D pane, load the procedure ***PW_MoistTrans*** from the ***MesoAnalysis*** procedure bundle. This procedure displays the precipitable water, 925-850 mb moisture transport vectors, and 925-850 mb moisture convergence. Again, make sure that you scroll back in time to the RUC40 0400 UTC model output.

**** If you are having problems loading this procedure, refer to **Precipitable Water and Moisture Transport** on Page E-8 in Appendix E for the procedure details. ****

1. What are the general precipitable water values (in inches) across southern Ohio and northern Kentucky? Are these values considered to be above normal for this region (see Figure 4-2)?

Answer - *Precipitable water values are over 2.00 inches across southern OH and northern KY. The RUC40 analysis places a contour of 2.50 inches along the OH/KY border. These values of precipitable water are at or above the 99th percentile for this part of the country.*

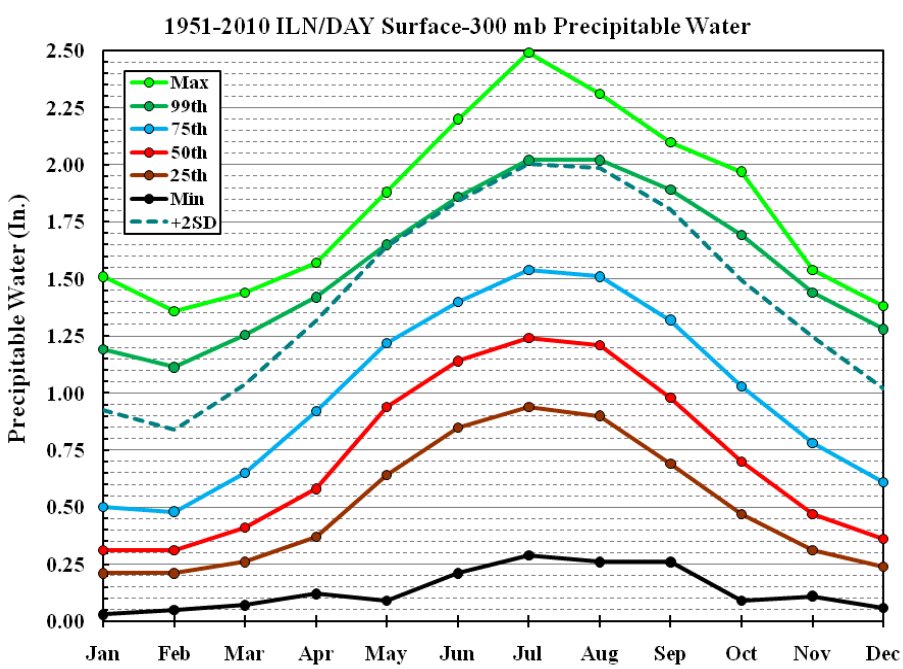


Figure 4-2: Precipitable water climatology from the surface to 300 mb for the ILN sounding from 1951-2010. All the solid lines represent a specific percentile, as seen in the legend, with the red line representing the mean precipitable water for each month. The green dashed line represents +2 standard deviations from normal.

2. Where are the maximum values of 925-850 mb moisture convergence located in this region?

Answer - *The maximum values of 925-850 mb moisture convergence are located along the KY border from south-central IN to eastern WV.*

3. Move forward in time to the three-hour RUC40 forecast at 0700 UTC. Are there any significant changes to the location and magnitude of the precipitable water and moisture convergence in this region?

Answer - *The areas of > 2.00 inches precipitable water shifted slightly south in the three-hour forecast but remains in the same general location from southern IL to WV. This trend is similar for the area of enhanced moisture convergence. It should be noted that some of the higher convergence values are no longer in OH and are concentrated in northern KY. In general, this means that the overall area of moisture convergence remains in the same area over the short-term period. The model does hint at some weakness in the convergence field near the OH/KY/WV border; however, the magnitudes of both of these parameters remain fairly unchanged.*

Evaluation Criteria 1.3 - Now evaluate the Corfidi Vectors and the atmospheric flow/instability for this region using the RUC 40 output at 0400 UTC. In another D-2D pane, load the procedure ***Corfidi_Vectors*** from the ***MesoAnalysis*** procedure bundle and set to 0400 UTC.

**** If you are having problems loading this procedure, refer to **Corfidi Vectors and Atmospheric Flow/Instability** on Page E-9 in Appendix E for the procedure details. ****

1. The top left panel contains the 850-300 mb mean wind (which represents the storm-scale steering flow), 850 mb winds, and Corfidi Vectors overlaid onto the 0.5° mosaic reflectivity. What does the wind and Corfidi Vector analysis tell you about the convective movement and duration potential?

   Answer - *You can estimate that the individual storm motion is from west to east at around 25 kts, and based on the Corfidi Vectors, the overall line of storms will be slowly moving southward at around 10 kts or less with upwind propagation (Figure 4-3). Here, we can expect training storms moving eastward along this slow moving boundary.*

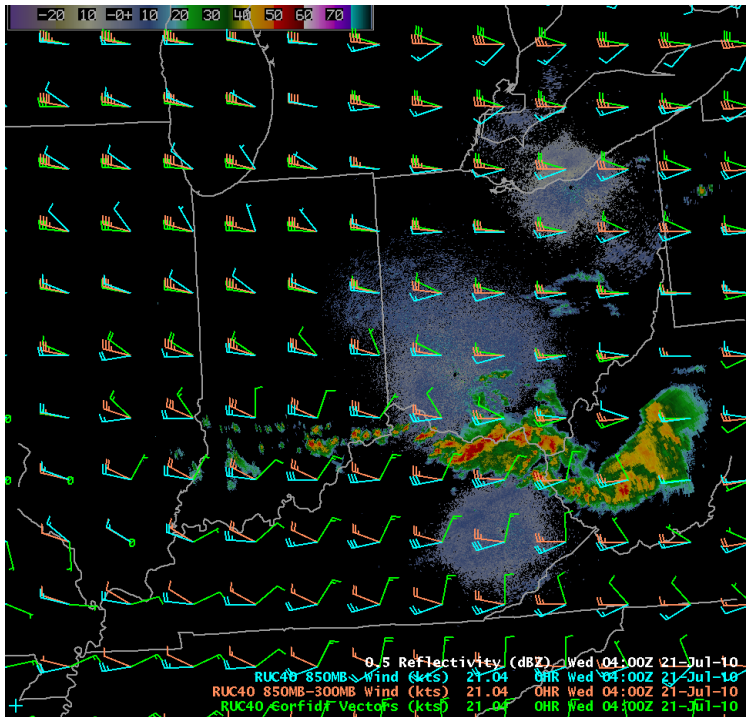


Figure 4-3: KILN 0.5° reflectivity overlaid with RUC40 850-300 mb mean wind (orange), 850 mb winds (light blue), and Corfidi Vectors (green).

2. The top right panel contains 925-850 mb vorticity, winds, and moisture transport. Describe the location of the vorticity maximum and what impact it has on the low-level flow around the southern part of the ILN CWA.

Answer - *The vorticity maximum is located in northern KY, approximately where the CWAs of ILN, Jackson, KY (JKL), and Louisville, KY (LMK) intersect. This vorticity maximum is enhancing the southerly flow over KY (925-850 mb winds from the WSW at 30 kts), which is increasing the moisture transport into the region and into the E-W oriented boundary.*

3. The bottom left panel displays the 0-3 km most-unstable convective available potential energy (MUCAPE) for the region. What are the approximate values of MUCAPE in the ILN CWA?

Answer - *MUCAPE is approximately 200-600 J/kg over southern OH into northern KY within the ILN CWA.*

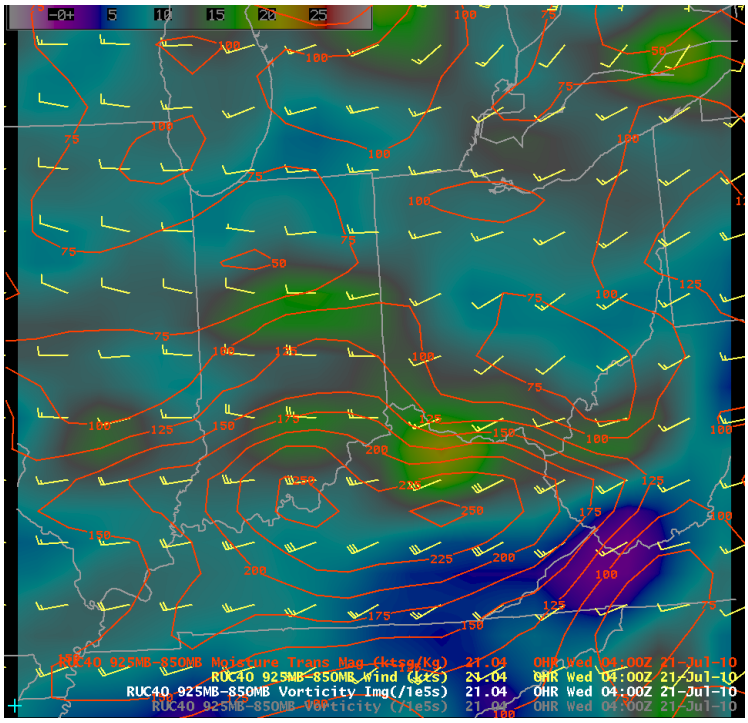


Figure 4-4: RUC40 925-850 mb vorticity (image), 925-850 mb winds (yellow barbs), and 925-850 mb moisture transport magnitude (red contours).

4. The bottom right panel displays 925-850 mb divergence, frontogenesis, and moisture transport. At 0400 UTC, where are the maximum values of convergence and frontogenesis located? Based on the 925-850 mb moisture transport vectors (this panel) and magnitude image (top right panel), where are the convergence and frontogenesis maxima in relation to the maximum moisture transport? And what can you imply from this?

Answer - *Both the maximum values of divergence and frontogenesis are located along the KY border from south-central IN to western WV. These maxima are located on the downstream gradient of the strong moisture transport over northern KY. This implies that there is a very strong moisture flux into the area of strongest forcing, which will help assist the precipitation efficiency for the area.*

5. Advance the RUC40 analysis to the three-hour forecast at 0700 UTC. Describe the evolution of the environment between 0400 UTC and 0700 UTC based on the parameters shown in this section.

Answer - *The vorticity, convergence, and frontogenesis maxima are located farther east along the OH/WV border. However, the convergence and frontogenesis maxima are noticeably weaker in the three-hour RUC40 forecast. The student should also note the secondary convergence/frontogenesis maxima located in northern KY south of the ILN CWA. The vorticity maxima is still enhancing the westerly flow over KY; thus, a strong moisture transport still exists into the region.*

Mean storm motion still remains at 25-30 kts from the west-northwest over the area, while the magnitude of the Corfidi vectors still remain unchanged. This still suggests the possibility of training storms over the area if there is continued convective development along the boundary. MUCAPE values remain relatively unchanged for the area with the higher MUCAPE values remaining well to the south and west of the ILN CWA.

Overall, if there is still convective development through the next three hours, the influx of moisture and the low-level forcing will still be in place over the same general area. These factors will be needed to produce the greater rainfall duration, rates, and overall efficiency that will lead to a significant flash flooding event.

Evaluation Criteria 1.4 - Load into a blank D-2D pane the 0000 UTC 21 July 2010 sounding from Cincinnati, Ohio (ILN). Examine the different parameters shown in Table 4-1 and write your answers in the table.

Table 4-1

Skew-T Parameter	Answer
Moisture Depth: Determine how deep the moisture profile is for this sounding. In the answer column, write the approximate height (in mb and feet) of the top of the moist layer.	*~ 380 mb* *~ 26,000 feet*
Precipitable Water: Find the parameter *Precip Water* in the text shown below the sounding and write down the value (in inches).	*2.00 inches*
LCL: Write down the LCL height (in mb and feet) as it is described in the parameters below the sounding.	*909 mb* *3,157 feet*
Sub-Cloud Layer: Determine the depth of the sub-cloud layer by subtracting the elevation of the sounding location (1,063 feet) from the LCL height.	*2,094 feet*
Height of the Freezing Level: Write down the height of the freezing level (in feet) as described in the parameters provided with the Skew-T.	*14,219 feet*
Warm Cloud Layer: Determine the depth of the warm cloud layer (in feet). To do this, subtract the height of the LCL from the height of the freezing level.	*11,062 feet*
Mean Layer Flow: Write down the direction and magnitude (in kts) of the 0-6 km winds as shown in the parameters below the sounding.	*From 259° at 23 kts*
CAPE Profile: Describe the CAPE profile of this sounding. Write down the CAPE value (*Positive Energy Abv LFC)* in J/kg. Then describe the CAPE profile of this sounding (i.e., tall and skinny CAPE, short and fat CAPE, etc.)	*860 J/kg* *Tall and skinny CAPE*

Evaluation Criteria 1.5 - In another D-2D pane, set the zoom to *WFO* scale and load *Points* from the *Tools* menu. Place one of the points over Lewis County, KY at approximately 38.6°N, 83.4°W. Open a *Volume Browser* and change the product type to *Sounding*. Load a RUC40 sounding for the point over Lewis County. Conduct an analysis on the RUC40 sounding at 0400 UTC 21 July 2010 using Table 4-2.

Table 4-2

Skew-T Parameter	Answer
Moisture Depth: Determine how deep the moisture profile is for this sounding. In the answer column, write the approximate height (in mb and feet) of the top of the moist layer.	*Dewpoint profile ends at 300 mb (~ 32,000 feet). Assume the entire profile is moist.*
Precipitable Water: Find the parameter *Precip Water* in the text shown below the sounding and write down the value (in inches).	*2.51 inches*
LCL: Write down the LCL height (in mb and feet) as it is described in the parameters below the sounding.	*977 mb* *1,127 feet*
Sub-Cloud Layer: Determine the depth of the sub-cloud layer by subtracting the elevation of the sounding location (873 feet) from the LCL height.	*254 feet*
Height of the Freezing Level: Write down the height of the freezing level (in feet) as described in the parameters provided with the Skew-T.	*16,260 feet*
Warm Cloud Layer: Determine the depth of the warm cloud layer (in feet). To do this, subtract the height of the LCL from the height of the freezing level.	*15,133 feet*
Mean Layer Flow: Write down the direction and magnitude (in kts) of the 0-6 km winds as shown in the parameters below the sounding.	*From 260° at 23 kts*
CAPE Profile: Describe the CAPE profile of this sounding. Write down the CAPE value (*Positive Energy Abv LFC)* in J/kg. Then describe the CAPE profile of this sounding (i.e., tall and skinny CAPE, short and fat CAPE, etc.)	*120 J/kg* *Tall and skinny CAPE*

Evaluation Criteria 1.6 - After examining the mesoscale environment and soundings, complete the checklist in Table 4-3 for the southern Ohio and northern Kentucky region. After answering all of the questions in the checklist, write a brief summary on the atmospheric conditions in place over the southern part of the ILN CWA and how conducive it is for flash flooding. The summary should include a short-term forecast for the next three to four hours for the southern part of your CWA.

Table 4-3

Checklist	Yes	No
Is there a quasi-stationary forcing mechanism (i.e., boundary)? A slow moving line segment or numerous storms moving along a boundary can lead to increased rain duration over areas.	*X*	
Does an abnormally high amount of precipitable water exist over the region?	*X*	
Is there a considerable amount of moisture transport and convergence over the area? High amounts can lead to strong moisture flux into storms and better rainfall efficiency and rates.	*X*	
Are there low LCL heights over the area?	*X*	
Does a deep warm cloud layer (i.e., > 10,000 ft) exist in this area based on the soundings? This can imply that warm rain processes will be dominant and better precipitation efficiency.	*X*	
Is there weak mean cloud layer flow (i.e., layer winds generally less than 10 kts) over the region? Weak flow can lead to very slow moving or nearly stationary storms.		*X*
Are the Corfidi vectors weak (i.e., approximately 10 kts or less) over the region, which could signify slow system movement?	*X*	
Are the CAPE values relatively small over the area? Recall that moderate CAPE is not required for flash flooding events since they can potentially lead to significant DCAPE, which could lead to cold-pooling and forward propagation.	*X*	
Was there a significant amount of antecedent precipitation that fell over the region prior to the start of the simulation? Recall this information from the pre-brief presentation.	*X*	

Answer - *A nearly quasi-stationary boundary characterized by a long E-W convergence gradient and moisture transport extends along the OH/KY border. This moisture transport is characterized by a 30 kt low-level jet (LLJ) at the 925-850 mb level that is being enhanced by a vorticity maximum located over northern KY. Surface dew points along and south of the boundary are in the low to mid 70's Fahrenheit with precipitable water values well above 2.00 inches. Model and observed soundings display a very deep vertical moisture profile with a thin CAPE profile and a deep warm cloud layer, which are key ingredients for greater rain rate values and rainfall efficiency. Low-level convergence and frontogenesis exist along this boundary and is located on the downstream gradient of the strong moisture transport. This area of ascent will enhance the potential for continued convective development and/or enhancement along the aforementioned boundary due to a significant moisture flux into any developing storms due to the LLJ and vorticity maxima. Combined with quasi-zonal storm mean layer (850-300 mb) winds at 25 kts with the Corfidi Vectors representing a weak southerly motion of the boundary, this suggests the possibility of training storms along this boundary and extended durations of moderate to heavy rainfall.*

For the short-term forecast, the vorticity maximum is expected to move eastward into WV as the boundary slowly moves south. With the vorticity maximum continuing to enhance moisture transport and low-level flow into an area of sustained mesoscale ascent, this forcing can lead to the increased development of training storms and flash flooding over the next three to four hours over the southernmost part of the CWA (more specifically, areas along the Ohio River and southward into northern KY). Considering the previous rainfall totals in the region and ground saturation levels (described in the pre-brief articulate presentation), any substantial future rainfall totals can lead to significant flash flooding. Overall, the student should consider the basic meteorological ingredients (i.e., rainfall rate, duration, and efficiency) in his/her analysis and short-term forecast for this event.

Performance Objective #2 -- Radar and FFMP Analysis - Part I

Time Period -- 0500 UTC to 0520 UTC

Evaluation Criteria 2 - During this part of the simulation, you will take a look at real-time radar observations and FFMP data. Document any areas that have received a significant amount of rainfall within the ILN CWA. Use FFMP to determine what basins have exceeded the 1-HR and 3-HR flash flood guidance (FFG) and by how much. Observe any radar and basin trends to determine what areas will exceed FFG in the near future.

Do not issue any warnings during this time period! A WESSL pop-up window will appear at 0520 UTC to inform you when you can start issuing warnings. This message will also signify the end of Performance Objective #2 and the beginning of Performance Objective #3. The evaluation criteria for the flash flood warnings are defined in Evaluation Criteria 3 beginning on Page 4-22.

Recommendations and Notes for Your Analysis:

- This event is occurring along the southern part of your CWA border and it is about equidistant between the Wilmington, OH WSR-88D (KILN) and the Jackson, KY WSR-88D (KJKL). You can use both radars to help with your analysis on precipitation accumulation; however, this simulation focuses on the KILN WSR-88D data.
- Be aware that as you start your analysis, there are a lack of reports for your area. Therefore, you will have to rely on reports from other areas and create comparisons to determine the severity of the flash flooding.
- Remember to go to the Layers menu in FFMP and set it to "*All and Only Small Basins*" for the greatest basin detail.
- Make sure that FFMP has been set to "*Link to Frame*" and that the frame count is set to a low number. FFMP is a memory-intensive program and could become sluggish.
- When using FFMP, focus on the 1-HR and 3-HR difference product to assist in determining the magnitude of the flash flooding. Please note that 6-HR FFMP data is currently not available.
- Be cognizant of the downstream flow of runoff from the basins receiving the heavy precipitation. You can make FFMP editable in D-2D and then right click the basin in the display to see downstream traces.

We have provided two procedures to assist you during your analysis:

- ***KILN_Analysis***
- ***FFMP_ILN***

Both of these procedures are located in the ***Radar_FFMP*** procedure bundle. The ***KILN_Analysis*** procedure is a four-panel display containing 0.5° base reflectivity along with one-hour precipitation, storm-total precipitation, and an image combination of one-hour and three-hour FFG. The ***FFMP_ILN*** procedure is a pre-built display for FFMP with various maps overlaid onto FFMP (e.g., cities, CWA borders, etc.).

**** If you are having problems loading these procedure, refer to **KILN WSR-88D Radar Analysis** on Page E-10 and **ILN FFMP Analysis** on Page E-11 within Appendix E for the procedure details. ****

Answer - *Because this is a period where we allow the student to just analyze the radar and FFMP data for flash flooding potential, we did not pose any questions to them. However, as an instructor, you can monitor the student's progress during this time by observing and asking questions about his/her analysis.*

Here is a list of features and trends that are relevant to the evolving flash flooding event in southern OH and northern KY:

- *By looping the radar data back to around 0300 UTC, the student should see a significant multicell complex moving through Mason and Lewis Counties from 0315 UTC to 0440 UTC (Storm #1 in Figure 4-5). The student should also recognize the additional areas of convection behind this complex (Storms #2-5 in Figure 4-5) from 0330 UTC to 0520 UTC. It should be noted that these areas of convection become more enhanced as they pass over Bracken and Mason Counties (see Figures 4-5b through 4-5d). The impacts of the storm growth over Bracken and Mason Counties can be seen in the increase of the one-hour precipitation totals over the region.*

- *From 0330 UTC to 0430 UTC, there is a weak mesoscale convective vortex (MCV) moving eastward from the area over Highland and Brown Counties towards Pike County (see Figures 4-5a and 4-5b). This MCV is providing a local enhancement of the vorticity and flow into the boundary, which could explain the growth of convection over Bracken and Mason Counties. It is also possible that the MCV influenced the increase in precipitation over southern Adams and Scioto Counties.*
- *Rainfall totals in southern Lewis County were approximately 2”-3.5” at 0341 UTC (see Figure 4-6a) before the multicell complex (designated as Storm #1 in Figure 4-5) moved in the area. After Storm #1, the overall storm total precipitation from KILN was approximately 3”-4.5” in the area (Figure 4-6b). As the cells continue to train over the same area, the student should recognize by the end of this analysis period that portions of southern Lewis County are approaching 6” of precipitation for the event (Figure 4-6c).*
- *Another area that has seen a significant amount of precipitation is the extreme southeastern portion of Scioto County, OH. During this analysis period from 0500 UTC to 0520 UTC, the heaviest precipitation is leaving this area. Rain rates were estimated to be around 1.5” to 2.5” per hour with storm totals approaching 4.5”. Areas to the east of Scioto County (i.e., Lawrence County) have radar estimated totals approaching 6” of rain (Figure 4-6c). It should be noted that 1-HR (3-HR) Flash Flood Guidance (FFG) is 1.53” (1.97”) in extreme southeastern Scioto County and that this area sits downstream from western Lawrence County (not shown).*
- *Using the 1-HR FFG and FFMP data, a widespread area in southeastern Mason County and southern Lewis County into northern Fleming and Rowan Counties (Jackson, KY CWA) have exceeded 1-HR FFG with multiple basins exceeding FFG by > 0.50” (see Figure 4-7b). Some of the basins along the southern border of Lewis County have exceeded 1-HR FFG by over 200% (see Figure 4-7c). More isolated areas of FFG exceedance exist in eastern Bracken County and extreme southeast Scioto County into western Lawrence County (Charleston, WV CWA).*

- *Using the 3-HR FFG and FFMP data, there is a large swath of 3-HR QPE > 1.75" from Bracken County southward to southwest Lewis County (see Figure 4-8a). Another swath of 3-HR QPE > 1.75" exists from northern Greenup County through southeaster Scioto County into Lawrence County. Most of these areas have exceeded 3-HR FFG. However, the area from Bracken County to southwest Lewis County have generally exceeded 3-HR FFG by over 1.00" with one basin on the Bracken/Mason County line exceeding FFG by > 1.50" at 0518 UTC (see Figure 4-8c). Here, the student should recognize that a significant portion of the extreme southern part of the ILN CWA have exceeded both the 1-HR and 3-HR FFG. Although the student has not received any significant reports from that region, he/she should recognize the potential magnitude of the event, especially with more rain expected over the same area.*

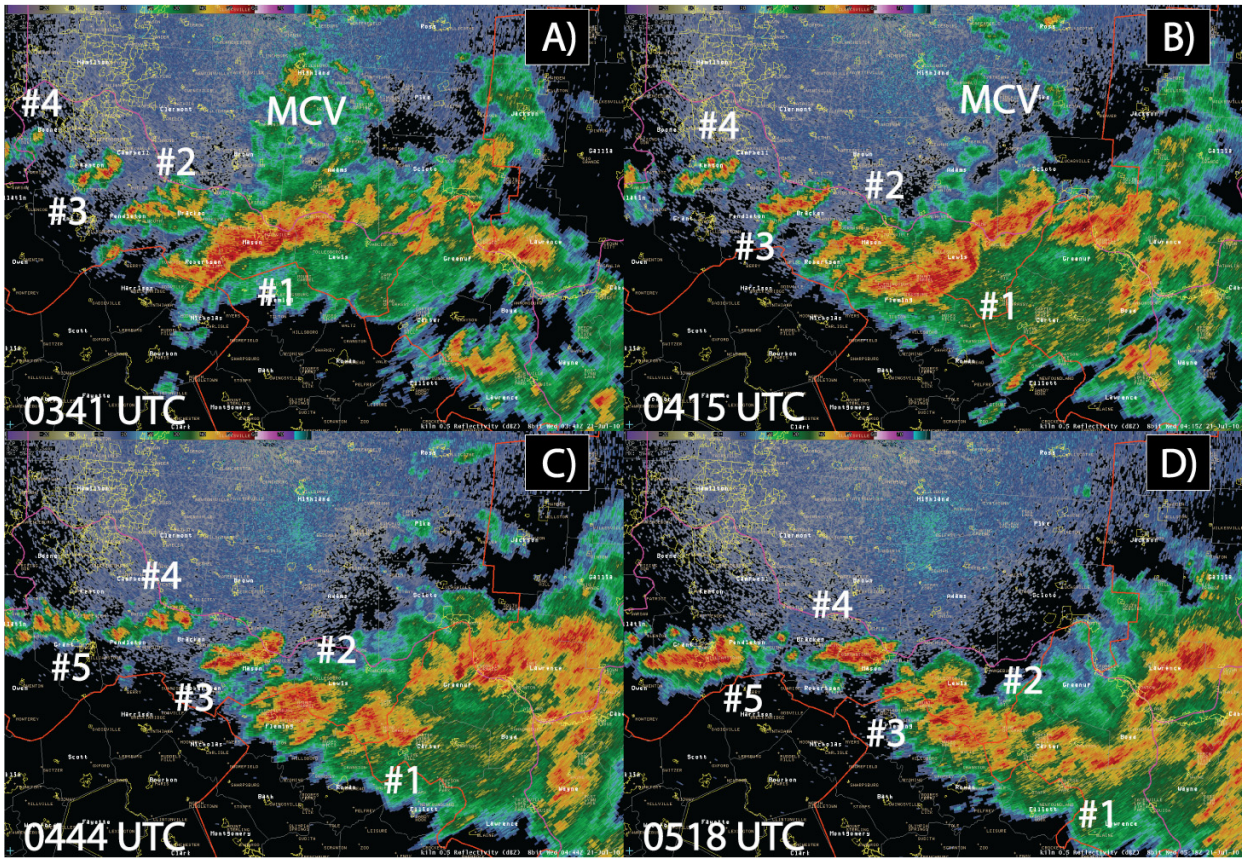


Figure 4-5: KILN 0.5° reflectivity at A) 0341 UTC, B) 0415 UTC, C) 0444 UTC, and D) 0518 UTC. Multicell convection that trains over Mason and Lewis Counties are denoted as #1 through #5 on each map.

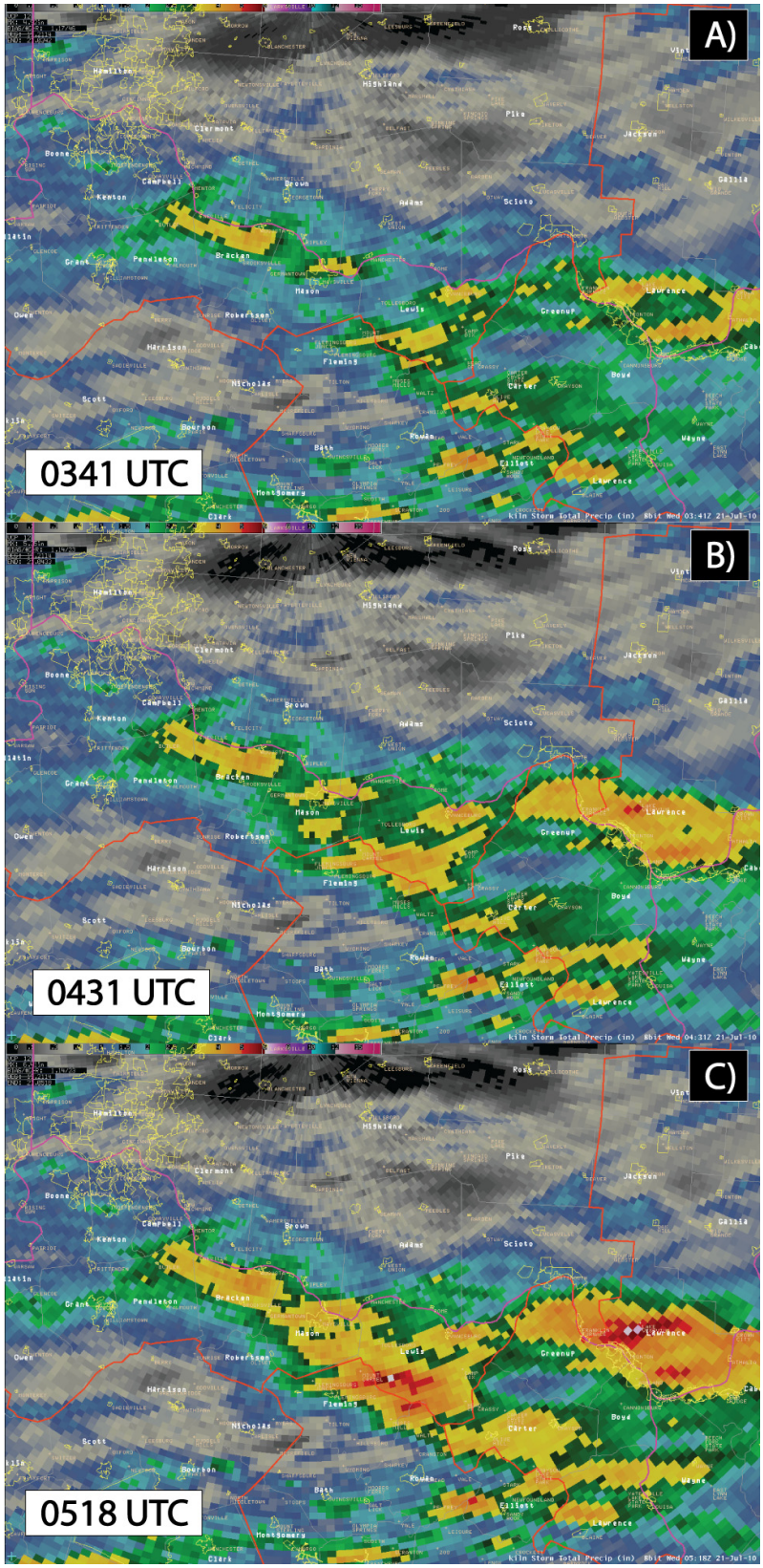


Figure 4-6: KILN storm total precipitation at A) 0341 UTC, B) 0431 UTC, and C) 0518 UTC.

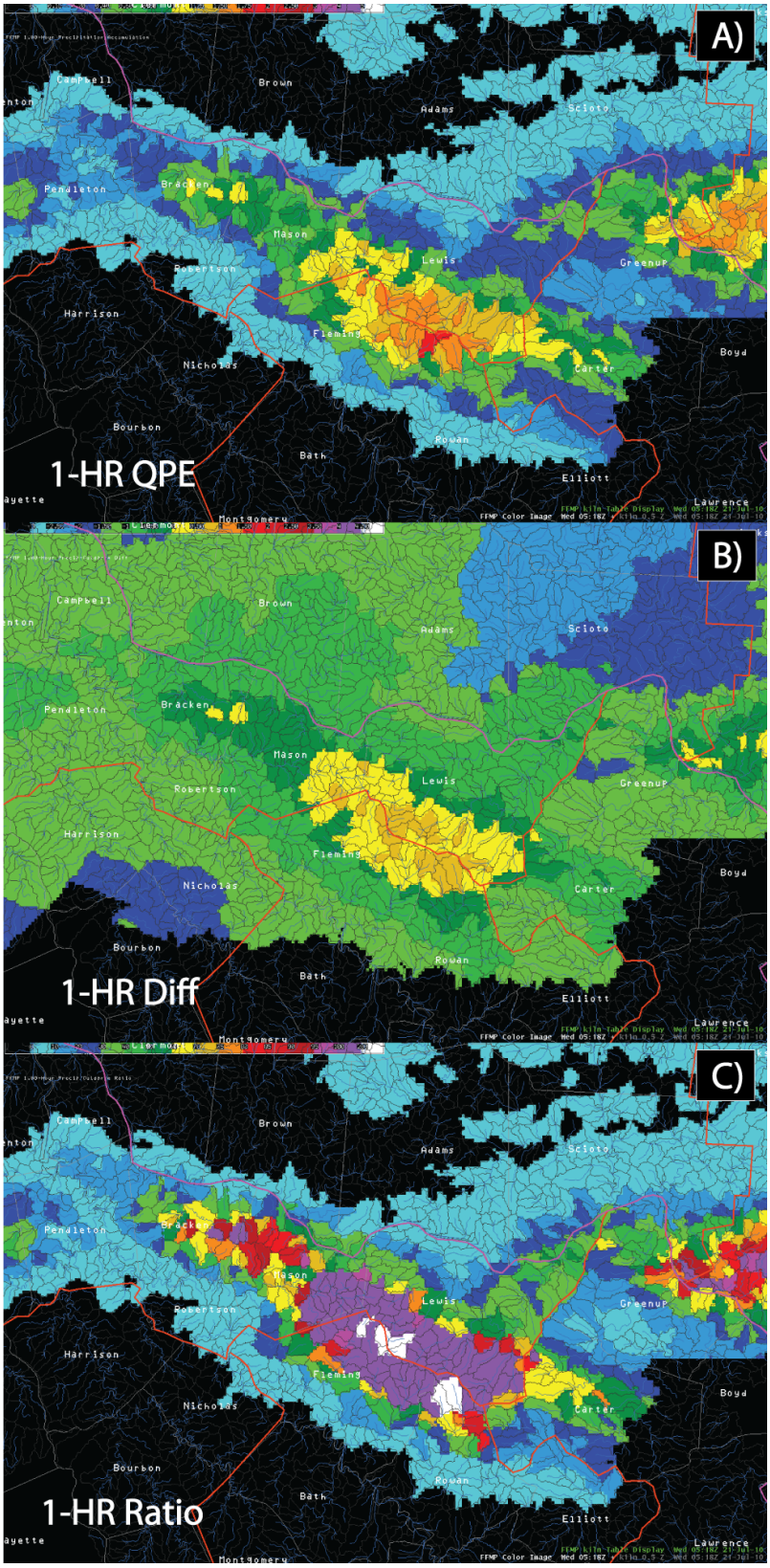


Figure 4-7: FFMP analysis at 0518 UTC for A) 1-HR QPE, B) 1-HR difference from FFG, and C) 1-HR ratio from FFG.

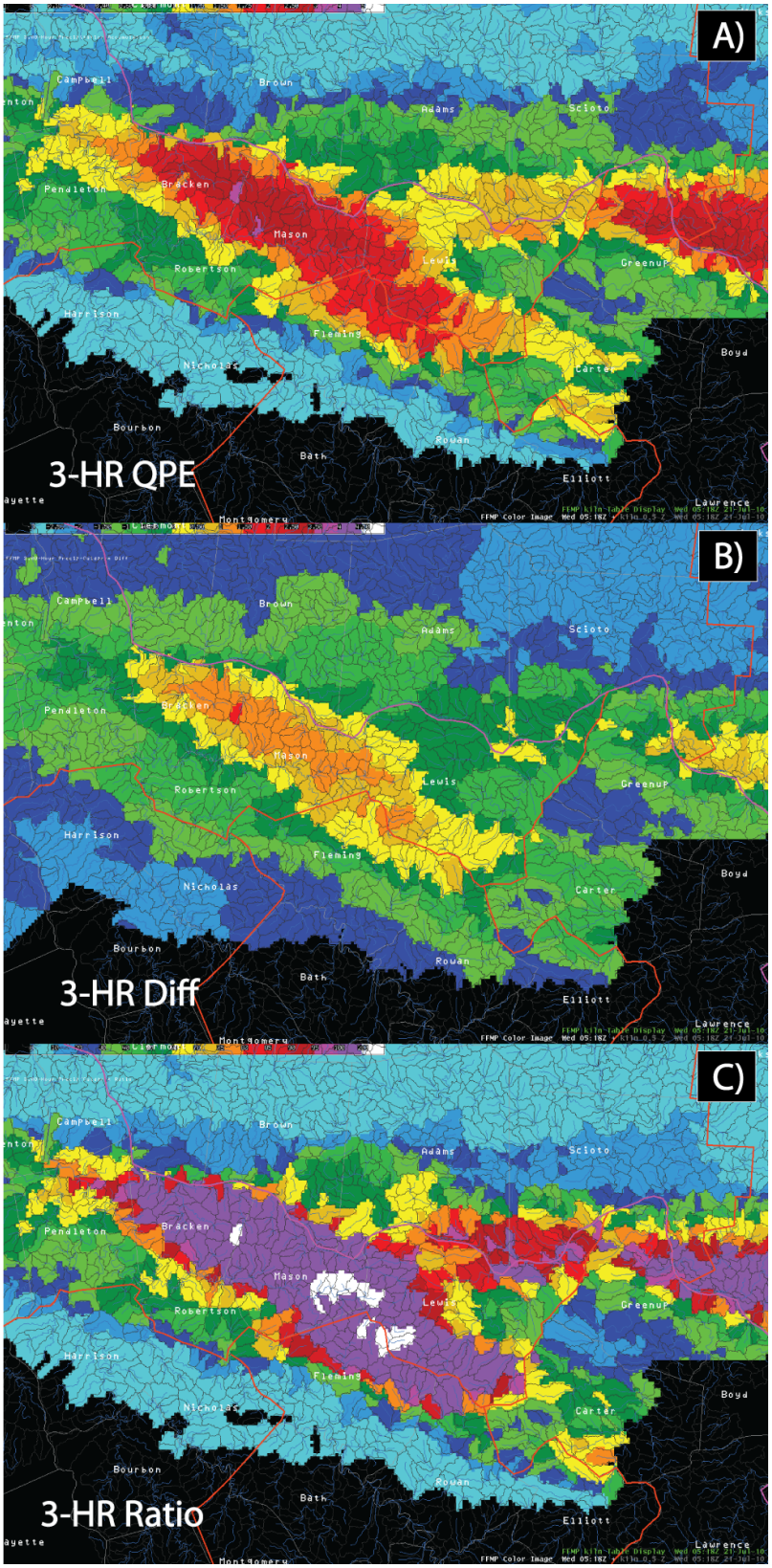


Figure 4-8: FFMP analysis at 0518 UTC for A) 3-HR QPE, B) 3-HR difference from FFG, and C) 3-HR ratio from FFG.

Performance Objective #3 -- Issuing Flash Flood Warnings

Time Period -- 0520 UTC to 0540 UTC

Evaluation Criteria 3 - Demonstrate the ability to issue effective *Flash Flood Warnings* for the impacted regions. Ensure that the flash flood warnings cover the threat area and also accounts for the immediate downstream basins. Also, make sure that the warnings clearly describe the magnitude of the threat and use appropriate call-to-action statements. Remember not to issue one large warning because of the differences in flash flood magnitude and anticipated and/or continued flash flooding based on radar and FFMP trends.

Once you have finished issuing your flash flood warnings, you can move on to Performance Objective #4 to continue your radar and FFMP analysis.

> ***Answer -*** *One recommended way of issuing the flash flood warnings for this event is to issue three separate warnings for the area (see Figure 4-9). The first warning can cover most of Bracken County and parts of eastern Pendleton County in northern KY. The second warning can encompass all of Mason County and most of Lewis County. This flash flood warning could also cover the extreme southern parts of Adams and Brown County in southern OH where FFG has also been exceeded. The third warning can cover the extreme southern portions of Scioto County and parts of extreme northeast Lewis County. This warning polygon will have an unusual shape since it is being split by Greenup County, KY due to a CWA boundary (RLX CWA). This recommended example is similar to what the ILN forecast office did from 0200 UTC to 0500 UTC (see Figure 3-1 on Page 3-7).*
>
> *Here are some notes for our example warning polygons regarding the warning text and potential impacts:*
>
> - *<u>Bracken and Pendleton Counties</u>: For this area, it appears that the heavy rains are ending for this region. Due to the fact that the rain is now concluding and that there is a lack of recent flash flooding reports, the duration of the flash flood warning does not have to be more than 60 to 90 minutes. Enhanced wording is not necessary for this warning.*

- *<u>Mason and Lewis Counties</u>: This area has seen an extensive amount of precipitation already. Radar trends show that more heavy rain is expected for this area. Therefore, this warning would have the strongest wording out of the three warnings shown in this example. However, the lack of reports does add a degree of difficulty in understanding the current and potential magnitude of the flash flooding in the area. This warning can also encompass the southernmost sections of Adams and Brown Counties since FFG has been exceeded here, too. However, these areas drain directly into the Ohio River and will unlikely see additional rainfall runoff from the north. The duration of the warning should be approximately three to four hours, and it should contain some enhanced wording based on the amount of precipitation combined with the exceedance of the 1-HR and 3-HR FFG. Call-to-action statements should mention how dangerous and potentially life-threatening this situation can be.*
- *<u>Scioto and NE Lewis Counties</u>: The rainfall in this area has diminished recently; however, the student should recognize that the combined runoff from rainfall over Scioto County and neighboring Lawrence County, OH (RLX CWA) could exacerbate any flooding situation there. A long duration flash flood warning (i.e., approximately two to three hours) would be appropriate for this situation. Call-to-action statements should include wording such as seeking higher ground and not to drive into areas where water is covering roadways. Just like the Mason and Lewis County warning, a lack of storm reports adds a degree of difficulty in assessing the potential magnitude of the flooding.*

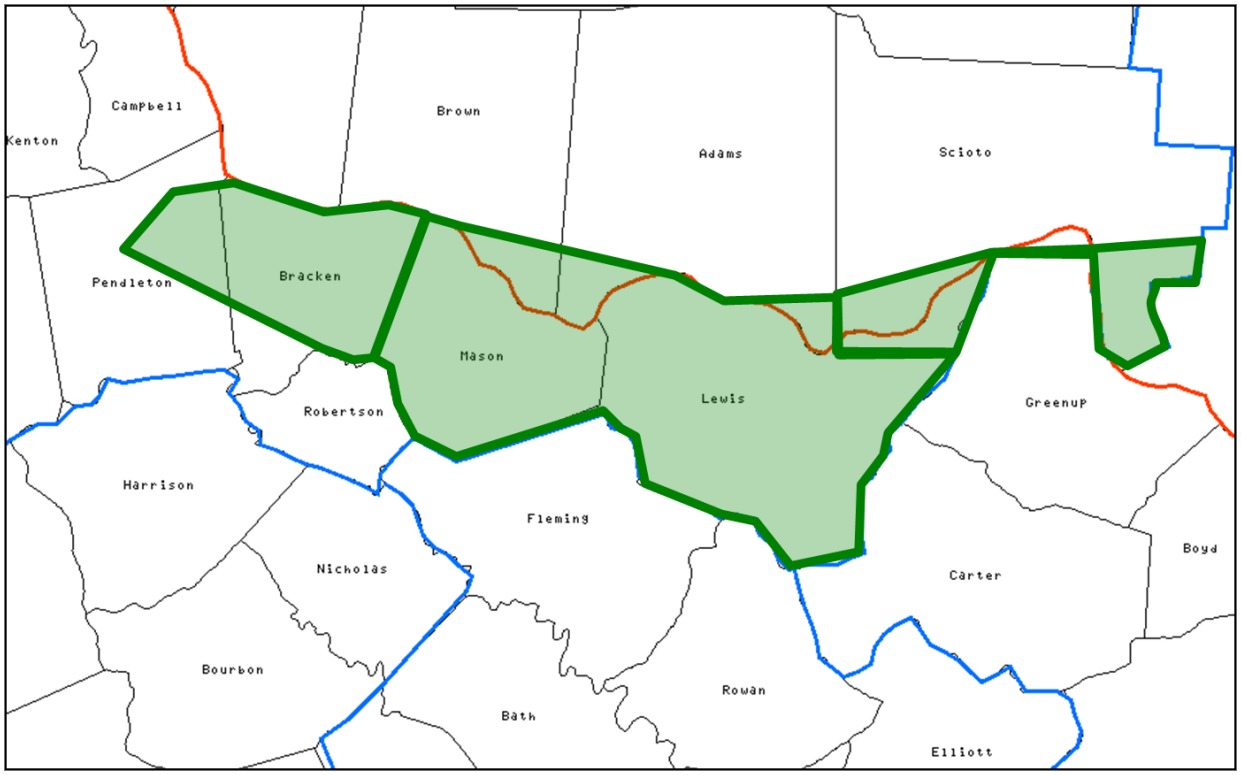


Figure 4-9: Example flash flood warning polygons that the student could issue during Performance Objective #3.

Performance Objective #4 -- Radar and FFMP Analysis - Part II

Time Period -- 0540 UTC to 0610 UTC

Evaluation Criteria 4 - This is a continuation of the radar and FFMP data analysis that you completed in Performance Objective #2. Again, identify any areas that have received a significant amount of rainfall within the ILN CWA. Use FFMP to determine what basins have exceeded FFG and by how much. Continue observing any radar and basin trends to determine what areas will continue to exceed FFG in the near future.

Do not issue any flash flood statements for your warnings during this time period! A WESSL pop-up window will appear at 0610 UTC to inform you when you can start issuing follow-up statements for your warnings. This message will also signify the end of Performance Objective #4 and the beginning of Performance Objective #5. The evaluation criteria for the flash flood statements are defined in Evaluation Criteria 5 beginning on Page 4-32.

Recommendations and Notes for Your Analysis:

- Focus on the ratio and difference from 1-HR and 3-HR FFG and their rate of increase over the analysis period. You can use basin trend graphs to assist in your analysis of the situation. Take note of areas that have significantly exceeded FFG (e.g., basins that have exceeded 3-HR FFG by over three inches and/or 300%). The FFMP products based on the 6-HR FFG will be available after 0600 UTC.
- Take note of any incoming storm reports, including those outside of your area of responsibility. Compare these reports with the rainfall totals and FFG in their respective areas. This can help provide an understanding of what might be happening in areas where you are lacking storm reports.
- Be cognizant of the downstream flow of runoff from the basins receiving the heavy precipitation. The combination of the antecedent precipitation and the rainfall totals already received to this point guarantees that the top layers of soil are completely saturated and rainfall is being converted directly into runoff.
- After 0600 UTC, you will receive some river gauge data from the USGS. Although the stage heights are unremarkable at this time, please note their rates of increase. Note that it takes time for rivers and creeks to respond to heavy rains based on flood-routing and time-of-travel.

We have provided two procedures to assist you during your analysis:

- ***KILN_Analysis***
- ***FFMP_ILN***

Both of these procedures are located in the ***Radar_FFMP*** procedure bundle. The ***KILN_Analysis*** procedure is a four-panel display containing 0.5° base reflectivity along with one-hour precipitation, storm-total precipitation, and an image combination of one-hour and three-hour FFG. The ***FFMP_ILN*** procedure is a pre-built display for FFMP with various maps overlaid onto FFMP (e.g., cities, CWA borders, etc.).

**** If you are having problems loading these procedure, refer to **KILN WSR-88D Radar Analysis** on Page E-10 and **ILN FFMP Analysis** on Page E-11 within Appendix E for the procedure details. ****

Answer - *This is a continuation of the analysis the student performed in Performance Objective #2. Again, as an instructor, you can monitor the student's progress during this time by observing and asking questions about his/her analysis. It is during this part of the simulation where the significant flooding reports are now coming into the office while the 3-HR FFG is being exceeded by 1.5" and/or 200% due to storm total precipitation now approaching 6"-7".*

Here are a list of features and trends relevant to the continuously evolving flash flooding event in southern OH and northern KY:

- *Starting with radar trends, the third cell in line (identified as Storm #3 in Figure 4-10) is now leaving the southern part of Lewis County at the beginning of the analysis period. Storm #4 enters Lewis County around 0544 UTC (Figure 4-10b) and continues to move across the southwest and southern portions of the county. Storm #5 continues to intensify over Bracken and Robertson Counties as it moves toward Mason, Lewis, and Fleming Counties. A sixth storm has developed along this line (labeled as Storm #6 in Figure 4-10b through 4-10d), but it will pass to the south of the area that has seen the most rain.*

- *The student should recognize that the greatest precipitation totals within the ILN CWA are now located across southern Lewis County. By 0610 UTC, KILN radar estimated totals are now approaching 7.50" with a large portion of Lewis County having seen over 6.00" (Figure 4-11). Using trends from the one-hour precipitation product (not shown), the student should recognize that it is possible for this region to expect another one to two inches of rain for this area, especially when you consider the movement of Storm #5 into southern Lewis County (Figure 4-10).*
- *With the 1-HR FFMP analysis, a number of basins have a seen an average of 1.50" - 1.75" over the last hour, with a few basins having accumulated over 2.00" of rain (see Figure 4-12a). There is still a significant area from central Mason County to southern Lewis County and even portions of northern Fleming and Rowan Counties (Jackson, KY CWA) that have exceeded the 1-HR FFG (Figures 4-12b and 4-12c) with some basins exceeding FFG by over 1.00". There are two separate areas where the FFG has been exceeded by over 200%:* ***1)*** *Extreme southern Lewis County and northern Rowan County with the passage of Storm #4 and* ***2)*** *southeast Mason County, southwest Lewis County, and northern Fleming County with the approach of Storm #5 into Lewis County.*
- *Analysis of the 3-HR FFG shows the developing extreme nature of the flash flooding event in northern Kentucky, especially in Lewis County. Areas from central Mason County through southern Lewis County have seen over 3.00" over the past three hours, with one basin already accumulating over 4.00" by 0610 UTC (Figure 4-13a). Most of this region has exceeded the 3-HR FFG by over 1.50" (Figure 4-13b) and by 200% (Figure 4-13c). Over a dozen basins in this area, mostly near the southern border of Lewis County, have already exceeded FFG by over 300%. Based on the radar trends and analysis, this area could expect to see up to two more inches on top of the rain that has already fallen, exacerbating the ongoing flash flooding situation.*

(Answer continues on Page 4-30)

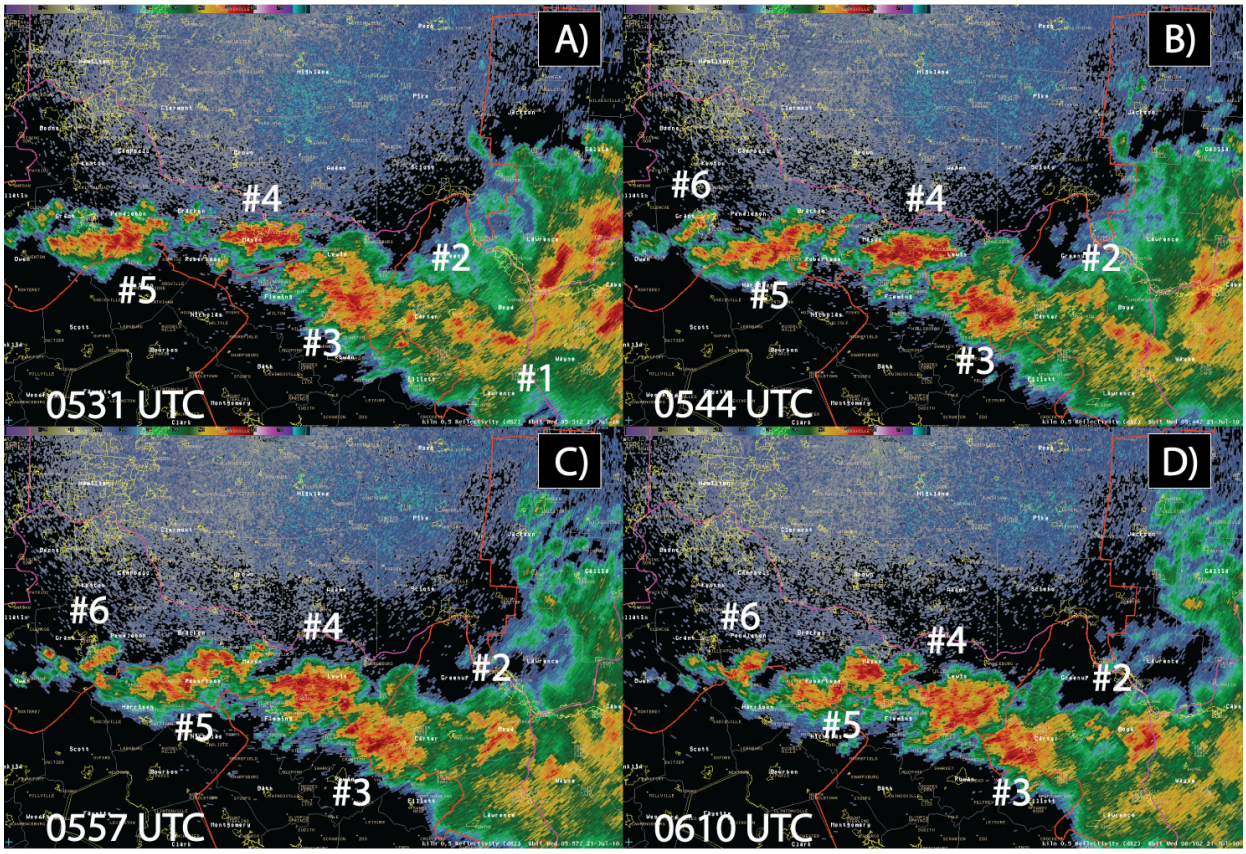


Figure 4-10: KILN 0.5° reflectivity at A) 0531 UTC, B) 0544 UTC, C) 0557 UTC, and D) 0610 UTC. Multicell convection that trains over Mason and Lewis Counties are denoted as #1 through #6 on each map.

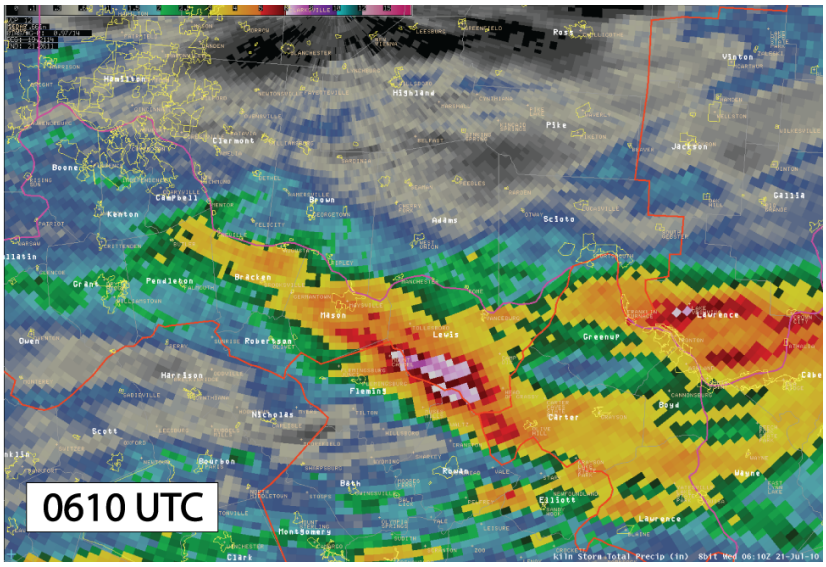


Figure 4-11: KILN storm total precipitation at 0610 UTC.

- *During the period from 0535 UTC to 0610 UTC, the student will receive seven local storm reports (LSRs). Of those seven, only four are within the ILN CWA while the other three are from the surrounding CWAs via HAM radio or NWSChat. You can view these reports in the copy of the WESSL script provided for you in Appendix D. These reports play a critical role in the student's analysis of the flash flooding situation. Since there are very few reports from southern Lewis County, the student will have to rely on the other reports in order to gauge the situation in that region. One of the most critical reports that the student should recognize is the severe flash flooding in extreme southern Scioto County. The Scioto County report states that there are ongoing water rescues with homes being inundated and one possible fatality. The student should recognize that this area generally received three to four inches of rain with added runoff from the heavier rains in Lawrence County. When compared to Lewis County, Scioto County received nearly two inches less rainfall in an area that has a greater 1-HR and 3-HR FFG. Once the student makes this comparison, this should help him/her paint a grim picture for the residents of Lewis County.*
- *One way to analyze the flash flooding is the basin trend graph. Shown in Figure 4-14 is the basin trend graph for a basin on the North Fork Licking River (FFMP ID 2959). There are number of observations that can be learned from these basin trend graphs that provide insight into the significance of this event. Looking at the rain rates, the student can recognize the two period of rainfall: 1) the current event and 2) the first period of rainfall ending approximately 4.5 hours ago. With the rain rates, there are some substantial periods of greater than 2 in./hr. with some periods approaching 4 in./hr. Using this basin example, approximately 5.75 inches of rain has fallen here since 0000 UTC 21 July. Most of this rain fell in the past two hours. The precipitation totals at this time have currently exceed 1-HR FFG by over one inch, exceed 3-HR FFG by three inches, and exceed 6-HR FFG by four inches. These trends can be seen throughout the areas of greater precipitation totals.*

(Answer continues on Page 4-33)

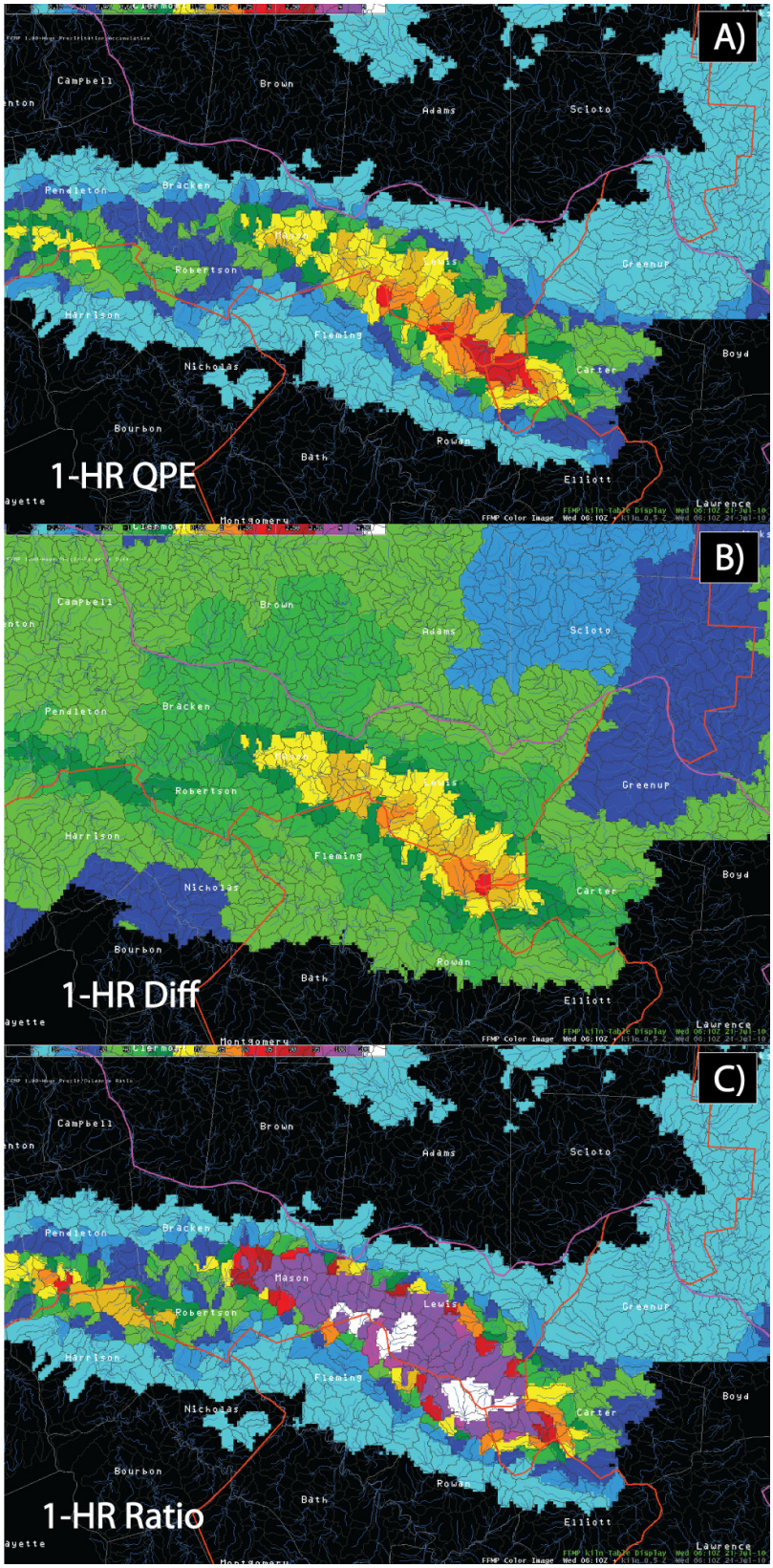


Figure 4-12: FFMP analysis at 0610 UTC for A) 1-HR QPE, B) 1-HR difference from FFG, and C) 1-HR ratio from FFG.

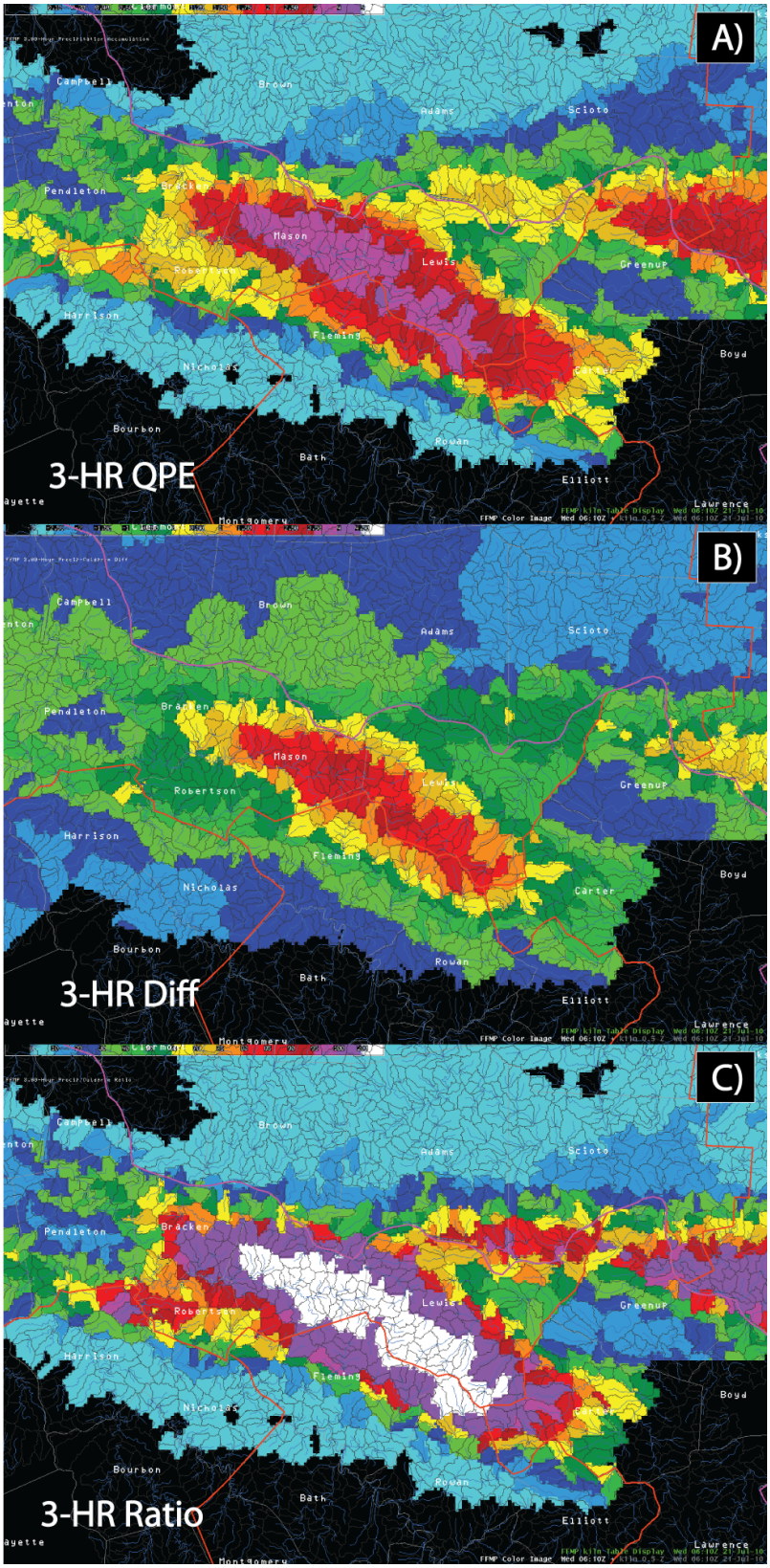


Figure 4-13: FFMP analysis at 0610 UTC for A) 3-HR QPE, B) 3-HR difference from FFG, and C) 3-HR ratio from FFG.

- *At 0602 UTC, the student will receive information on some of the river gauges in the area via the WESSL script (Appendix D). Although the river levels provided are not at flooding levels, it is their recent trends that the student should recognize. The Kinniconick Creek at Tannery, KY has seen an increase of 1.3 ft in the past hour and is downstream of the greatest precipitation in Lewis County. The student should recognize that this trend will only increase based on the time-of-travel and flood routing in the area. The river gauge on the Little Sandy River at Leon, KY can provide some insight as to what might happen on the Kinniconick Creek. Here, the river has risen over 1.5 ft/hr over the past three hours while rising approximately one foot in the past 30 minutes.*
- *With the anticipation of another storm moving into Lewis County and having to receive the runoff from the rains in northern Fleming and Rowan Counties, this is where the "Flash Flood Emergency" should be considered.*

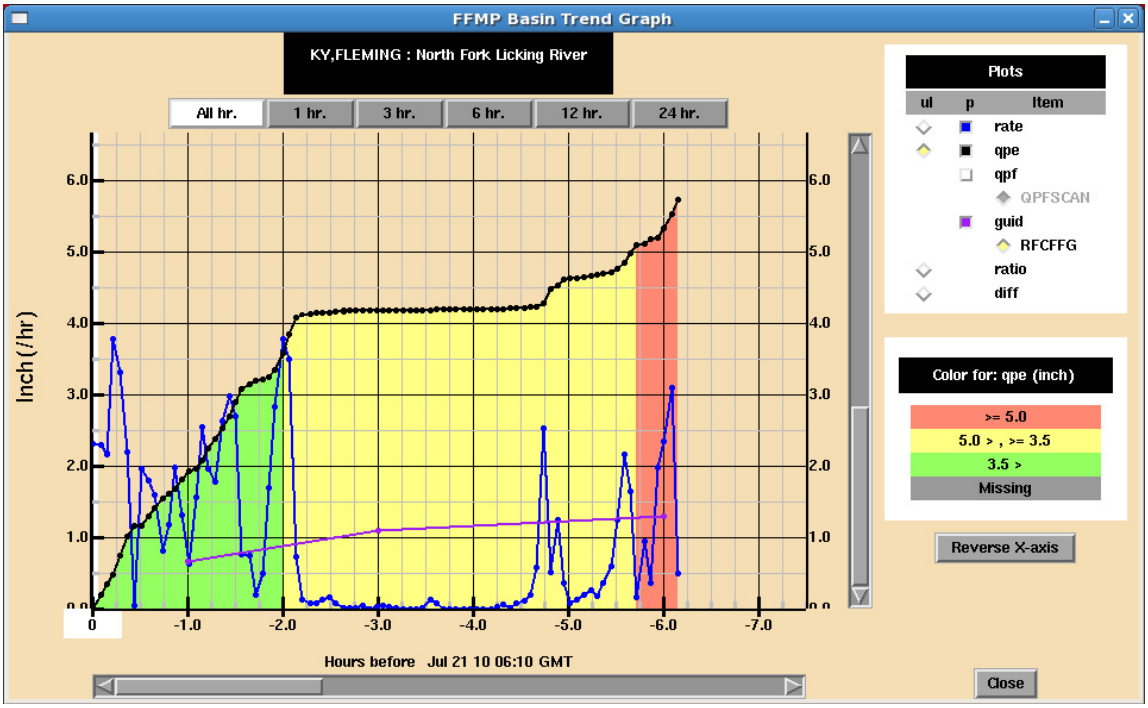


Figure 4-14: FFMP basin trend graph for a basin for the North Fork Licking River (FFMP ID 2959) at 0610 UTC. The QPE trace is shown in black with the color fill, the instantaneous rain rate trace (in./hr.) is shown in blue, and the FFG trace is shown in purple.

Performance Objective #5 -- Issuing Flash Flood Statements

Time Period -- 0610 UTC to 0630 UTC

Evaluation Criteria 5 - In the final part of the simulation, you will now issue *Flash Flood Statements* for the *Flash Flood Warnings* issued earlier in the simulation. Determine what region of your CWA is currently experiencing extreme flooding based on your FFMP analysis and the flooding reports you have received over the past hour and issue a "Flash Flood Emergency" for the appropriate area. Make sure that your follow-up statements clearly describe the magnitude of the threats for each warning polygon and use appropriate call-to-action statements. A copy of the template for a flash flood statement containing the "Flash Flood Emergency" wording is available on Page 4-38.

Try to compare the rainfall totals and flooding to previous events in order to evaluate the magnitude of the event. Due to a lack of river and stream gauges in the area, you do not have much to work with regarding the hydrologic response to the rainfall. However, an update on some of the river gauge data in the region was provided in the WESSL just after 0600 UTC. Also, here are a couple of significant events that have impacted the region near the Ohio River that are either within or near the ILN CWA:

- ***May 1-2, 2010*** -- Areas south of the Ohio River, notably Mason and Lewis Counties in Kentucky, received over five inches of rain. Numerous roads were closed due to flooding in both counties, and the Kinniconick Creek was flowing over its banks near Petersville. Outside of the ILN CWA, Tygarts Creek near Greenup, KY (RLX CWA) recorded a record crest of 24.40 ft. on May 3rd. The town of Olive Hill in Carter, Co. (RLX CWA) had five feet of water in the downtown area.
- ***May 18, 2001*** -- Counties along the Ohio River received five to eight inches of rainfall over a six day period (14-19 May 2001) with the majority of the rain falling on 18 May 2001. Some of the most notable flash flooding occurred in Scioto County, OH, where numerous roads were closed with a number of houses and a fire department evacuated.

Note that the simulation is ending at 0630 UTC. A post-brief presentation will open up during the final minute of the simulation. Make sure that you have all of your flash flood statements issued before the simulation concludes.

Answer - *To continue with the warning example shown in the answer for Evaluation Criteria 3 in Performance Objective #3, the rainfall threat has ended for the warnings issued for Bracken/Pendleton Counties and Scioto/Lewis Counties. However, the rainfall and flash flood situation for the area encompassed by the warning for Mason and Lewis Counties is considered extreme.*

Based on the exceedance of the FFG shown in the FFMP data and the storm reports from Mason and Lewis Counties, a "Flash Flood Emergency" should be issued for Lewis County, KY. Here was the reasoning behind the issuance of the "Flash Flood Emergency" for this county:

- *One-hour FFG is currently being exceeded by 1"-1.5" in some of the basins in Lewis County with radar estimated one hour rainfall totals approaching 2" to 2.5".*
- *Three-hour FFG is currently being exceeded by 2.5"-3" in some of the more flash flood prone basins. Another cluster of storms with rain rates around 4 in./hr. will be moving over this region soon, further increasing the exceedance of the three-hour FFG to over 3.5"-4" in some locations (FFG ratio ranging from 300% to possibly over 500%).*
- *One of the biggest factors is the comparison of the reports to Scioto County, OH to Mason and Lewis County, KY. Homes have been inundated and water rescues are ongoing in southern Scioto County, especially in the town of Franklin Furnace. The student also received a report of a possible fatality and multiple injuries in this region. Here, the student should recognize that southern Scioto County has received about two inches less precipitation than Lewis County and that the FFG values are higher in Scioto County than in Lewis County. Having the student draw that comparison between these two counties is key to recognizing the extreme nature of this event as it unfolds.*
- *Neighboring counties that are bordering the ILN CWA (notably Fleming and Rowan Counties in the JKL CWA) have received extreme reports of flooding, including swift water rescues and home evacuations. Rainfall totals and FFG are similar to that of southern Lewis County.*

- *This event is happening during the overnight hours. Most people will be asleep and would be unaware of the flash flooding dangers. Water rescues and home evacuations are ongoing in numerous areas due to quickly rising flood waters. The darkness will also conceal areas that are impassable or bridges that have been washed away.*

Here are some notes for what should be included in the flash flood statements for the example warning polygons issued earlier in Performance Objective #3:

- *<u>Bracken and Pendleton Counties</u>: The threat for any rain has now ended. Any flash flooding in this area will begin to recede while the runoff is now being routed to larger creeks and rivers. There should be a significant increase in river stage heights across the area. If the flash flood warning is expected to expire soon, then the student can issue a statement saying that the warning will be allowed to expire and will be followed up by a flood warning to highlight the expected downstream river flooding. The student is not expected to issue a flood warning in this simulation.*
- *<u>Mason and Lewis Counties</u>: This area has seen a highly abnormal amount of precipitation already with some reports of extreme flooding in this area and the neighboring counties to the south (Fleming and Rowan Counties - JKL CWA). Radar trends show that more rain is expected for this area. Therefore, the follow-up statement for this warning would contain a "Flash Flood Emergency" for Lewis County. Specifics on some of the flash flood reports, including areas of water rescues and evacuations, should be added to the statement. Details on precipitation totals and additional rainfall should be addressed in the warning. Call-to-action statements should include wording such as "extremely dangerous" and "life-threatening" and include actions to protect life and seek higher ground. This flash flood statement with the use of the "Flash Food Emergency" wording should be properly formatted, as seen in the training from the Flash Flood Emergency Best Practices Course and NWS Instruction 10-922 (see Page 4-36).*

- *<u>Scioto and NE Lewis Counties</u>: Just like the warning for Bracken and Pendleton Counties, the rainfall in this area has also concluded. However, with the report of swift water rescues, home evacuations, and possible loss of life, the flash flood warning should remain in effect for this region. The significance of these reports are a by-product of the initial rainfall combined with the downstream runoff from the east. Strongly worded call-to-action statements, including such wording as "life-threatening" should be used. The text should also include the reports from the Franklin Furnace area to describe the dangers of the situation. However, there is no need to use a "Flash Flood Emergency" here because no extra rainfall is expected and the flooding should begin to recede soon.*

Flash Flood Statement Containing the "Flash Flood Emergency" Format from NWS Directive 10-922:

```
WGAAii cccc ddhhmm (BBB)
FFSxxx

FLASH FLOOD STATEMENT
NATIONAL WEATHER SERVICE <city, state>
hhmm am/pm time_zone day mon dd yyyy

stCNNN-NNN-NNN-ddhhmm-
/k.CON.cccc.FF.W.####.yymmddThhnnZB-yymmddThhnnZE
/0000.s.ic.000000T0000Z.000000T0000Z.000000T0000Z.OO/
<county #1>-<county #2>-<county #n>-
INCLUDING <THE CITIES OF> location...location
hhmm am/pm time_zone day mon dd yyyy

...THE FLASH FLOOD WARNING REMAINS IN EFFECT UNTIL <hhmm am/pm time_zone>
FOR <geographic area>...

...A FLASH FLOOD EMERGENCY FOR <geographic area>...

<current hydrometeorological situation and expected impacts>.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

<call-to-action statement> (optional)

&&

LAT...LON nnnn nnnn

$$

<Name/Initials/Forecaster ID> (optional)
```

Performance Objective #6 -- WESSL Questions

Embedded in the WESSL script are a few questions regarding communication, collaboration, and reasoning for issuing a Flash Flood Emergency in regards to this event. You can look at Appendix D for a copy of the WESSL script used in this simulation. The interactive windows provided in the WESSL script allows the student to answer the questions that are presented and stores his/her answers to the case folder. You can retrieve the responses by accessing the following text file:

/data/awips/2010Jul21/wessl/WESSL_ILN.log.YYYYMMDD_HHMM

where "YYYYMMDD_HHMM" represents the date and time that the student responded to the questions.

Evaluation Criteria 6.1 - The following question was presented to the student at 0515 UTC:

"How would you coordinate with WFO RLX and WFO JKL on the potential flooding situation along your CWA borders?

Answer - *The communication and collaboration between the three offices is two-fold in this case. The first aspect of the coordination should focus on the issuance of flash flood warnings and ensuring that there is a consistent message across the CWA borders through these warnings. The other aspect of the coordination is the exchange of local storm reports. This area is not heavily populated and is generally defined by rural areas (some are quite remote). The relay of reports between the three WFOs will help in identifying the severity of the flooding, especially when compared to radar estimated precipitation totals and FFMP basin analysis. This will also be critical if upstream areas drain into basins located within the INL CWA.*

Evaluation Criteria 6.2 - The following question was presented to the student at 0540 UTC:

"What factors should you consider when determining the use of a Flash Flood Emergency?"

Answer - *This list of factors that should be considered for a Flash Flood Emergency are as follows:*

- *Reports of water rescues and evacuations*
- *Lives threatened due to rapidly rising water*
- *Time of day and societal impacts*
- *Significant exceedance of FFG at any temporal level*
- *Rarity of the event (frequency of precipitation totals and/or flood levels)*
- *Communication with Emergency Managers and other officials on the significance of the event and current impacts*

Appendix A: Storm Reports

I. ILN CWA Storm Data

All storm reports shown here were retrieved from the NWS Verification website.

Report	Location	Date/Time (UTC)	Event Type
1	**Bracken County (KY)** Augusta 0.9 WSW Augusta 0.9 W Augusta 0.4 NNE Augusta	07/21/10 0353 07/21/10 0530	**Flash Flood (due to Heavy Rain)**
	High water was across several roads in Augusta due to heavy rainfall.		
2	**Mason County (KY)** 3.0 SE Maysville 1.9 ESE Maysville 1.3 WNW Springdale 1.1 W Springdale	07/21/10 0533 07/21/10 0620	**Flash Flood (due to Heavy Rain)**
	Numerous roads were closed due to high water. Some families were evacuated from their homes in eastern portions of the county.		
3	**Lewis County (KY)** Kinniconick 1.1 S Kinniconick 1.0 SW Kinniconick 0.9 W Kinniconick	07/21/10 0538 07/21/10 0558	**Flash Flood (due to Heavy Rain)**
	Several roads were closed across the southern half of the county due to high water. The high water also made it to some homes in the area.		
4	**Mason County (KY)** Lewisburg 1.6 NNW Lewisburg 0.4 W Marshall 1.0 S Marshall	07/21/10 0600 07/21/10 0620	**Flash Flood (due to Heavy Rain)**
	Numerous roads were closed due to high water caused by heavy rainfall.		

Report	Location	Date/Time (UTC)	Event Type
5	**Scioto County (OH)** Franklin Furnace 1.9 SW Gennetts 1.7 S Gennetts 0.8 ESE Franklin Furnace	07/21/10 0616 07/21/10 0745	**Flash Flood (due to Heavy Rain)**

Multiple homes were flooded in the area due to heavy rainfall. Two homes were destroyed, two homes sustained major damage, and several homes received minor damage. In addition, there were multiple water rescues. There was one fatality during the event. The fatality was a female who was outside trying to get to higher ground when she was swept away in the flash flooding. In addition to the fatality, there were four injuries. All of the flooding reports and the fatality occurred in the Franklin Furnace area.

Direct Fatalities: F53OU

6	**Lewis County (KY)** Camp Dix 1.1 NNW Camp Dix 1.7 NE Camp Dix 1.1 E Camp Dix	07/21/10 0640 07/21/10 0945	**Flash Flood (due to Heavy Rain)**

Widespread flash flooding occurred across the southern portions of the county. Numerous people were trapped and had to be rescued.

7	**Mason County (KY)** Washington 1.2 WNW Washington 1.6 SW Washington 1.1 S Washington	07/21/10 0742 07/21/10 0945	**Flash Flood (due to Heavy Rain)**

A bridge was washed out due to flash flooding. Flash flooding was widespread around the area.

8	**Lewis County (KY)** Tollesboro 2.6 W Tollesboro 1.0 SW Cottageville 1.4 N Ribolt 1.0 SE Ribolt	07/21/10 0842 07/21/10 0945	**Flash Flood (due to Heavy Rain)**

Numerous roads were washed out due to flash flooding. In addition, there were multiple water rescues from homes. At least three mobile homes and a grocery store were swept off their foundation. Major damage occurred to residences, businesses, vehicles, and roads across southern portions of the county.

Report	Location	Date/Time (UTC)	Event Type
9	**Lewis County (KY)** Camp Dix 1.6 NW Camp Dix 2.4 N Camp Dix 1.9 NW Rugless	07/21/10 0945 07/21/10 1700	**Flood** **(due to Heavy Rain)**
	This flooding is a continuation from the earlier flash flooding in the area.		
10	**Lewis County (KY)** Tollesboro 2.7 SSW Cottageville 1.3 SSE Cottageville 1.8 NNE Tollesboro	07/21/10 0945 07/21/10 1700	**Flood** **(due to Heavy Rain)**
	This flooding is a continuation of the earlier flash flooding.		
11	**Mason County (KY)** Washington 1.9 W Washington 2.3 WSW Washington 1.2 SSE Washington	07/21/10 0945 07/21/10 1700	**Flood** **(due to Heavy Rain)**
	This flooding is a continuation of the earlier flash flooding.		

Training thunderstorms moved across northern Kentucky and south central Ohio beginning during the late evening hours and continuing into the overnight hours.

II. JKL CWA Storm Data

Report	Location	Date/Time (UTC)	Event Type
12	**Elliott County (KY)** 1.1 NNW Bruin 1.6 NE Bruin 1.3 E Bruin 0.5 WNW Bruin	07/21/10 0525 07/21/10 0900	**Flood** **(due to Heavy Rain)**

Three feet of water was reported to have been across Highway 7 in Bruin.

13	**Fleming County (KY)** 0.3 NW Mt. Carmel 0.3 NNE Mt. Carmel 0.2 E Mt. Carmel 0.2 W Mt. Carmel	07/21/10 0525 07/21/10 0730	**Flash Flood** **(due to Heavy Rain)**

Some residents were being evacuated due to flooding.

14	**Fleming County (KY)** 0.7 NNW Dalesburg 1.0 WSW Mt. Carmel 1.0 ESE Dalesburg 0.7 WSW Dalesburg	07/21/10 0525 07/21/10 0730	**Flash Flood** **(due to Heavy Rain)**

Water was coming into homes in Dalesburg. Local citizens were evacuating. KY 57 was still impassable in some areas.

15	**Fleming County (KY)** 0.8 NW Foxport 0.6 NNE Foxport 0.5 SE Foxport 0.8 SW Foxport	07/21/10 0525 07/21/10 0730	**Flash Flood** **(due to Heavy Rain)**

Water was coming into homes in Foxport and over area roadways. Some residents were forced to evacuate their homes.

16	**Fleming County (KY)** 1.2 SW Mt. Carmel 0.8 SSE Mt. Carmel 0.6 NNE Beechburg 1.1 NW Beechburg	07/21/10 0525 07/21/10 0900	**Flash Flood** **(due to Heavy Rain)**

Three feet of water was reported to have been running over a bridge in the Mt. Carmel area.

Report	Location	Date/Time (UTC)	Event Type
17	**Fleming County (KY)** 1.3 SW Dalesburg 0.8 S Dalesburg 1.8 S Dalesburg 2.1 SW Dalesburg	07/21/10 0525 07/21/10 0730	**Flash Flood** **(due to Heavy Rain)**

Water was over the bridge along Maddox Rd. near KY 57.

18	**Fleming County (KY)** 1.8 WNW Wallingford 1.3 NE Wallingford 1.6 SE Wallingford 1.0 NW Goddard	07/21/10 0525 07/21/10 0730	**Flash Flood** **(due to Heavy Rain)**

Water was over Hwy 1013 at Muses Mill Rd. near Wallingford and also near Park Lake.

19	**Rowan County (KY)** 0.6 NNW Triplett 1.2 NE Triplett 1.1 E Triplett 0.1 SW Triplett	07/21/10 0525 07/21/10 0730	**Flash Flood** **(due to Heavy Rain)**

People had to be rescued from numerous trailer homes in Triplett.

20	**Rowan County (KY)** 2.4 NNE Waltz 4.5 NNE Triplett 3.5 ENE Triplett 0.9 N Triplett	07/21/10 0525 07/21/10 0730	**Flash Flood** **(due to Heavy Rain)**

Rising water near Buckner Branch of Triplett Creek caused three people to have to be rescued.

21	**Elliott County (KY)** 1.0 WNW Stephens 0.6 NNW Stephens 0.1 NW Stephens 0.9 W Stephens	07/21/10 0530 07/21/10 0900	**Flood** **(due to Heavy Rain)**

The road was closed at the intersection of Hwys 409 and 486 in Stephens. A rock slide was also reported in the county.

A line of training thunderstorms caused flooding in Elliott, Fleming, and Rowan Counties on July 21st, resulting in multiple road closures and evacuations.

III. RLX CWA Storm Data

Report	Location	Date/Time (UTC)	Event Type
22	**Carter County (KY)** Soldier 0.8 NE Olive Hill Airport 1.0 S Willard 3.0 N Norton Branch 2.0 W Rose Hill	07/21/10 0115 07/21/10 0945	**Flash Flood** **(due to Heavy Rain)**

Streams such as Tygart Creek, Little and Big Sinking Creeks, Henderson Branch, Smith Run, and Mills Branch saw major flash flooding. A 72-year-old woman drowned. Her mobile home was washed off its foundation and pushed some 200 yards to a bridge. The home broke into pieces at the bridge. Her body was not found until three days later near the mouth of the creek with the Little Sandy River. Downtown Olive Hill was flooded again. The crest was about a foot in downtown, compared to four to five feet during the flood in May. Nineteen homes were destroyed in the county with major damage to 60 to 70 others. Most of the damage was concentrated in the Grahn and Fultz vicinity. Around a half-dozen vehicles were washed into Little Sinking Creek. Several private and a few public bridges were destroyed.

Governor Steve Beshear declared a state of emergency. Carter County was included in the FEMA disaster declaration number 1925.

Direct Fatalities: F72MH

23	**Lawrence County (OH)** Hanging Rock 3.0 NW Pedro 3.0 NW Aid 2.0 E Scottown Proctorville South Point	07/21/10 0125 07/21/10 0945	**Flash Flood** **(due to Heavy Rain)**

Around 150 properties reported damage. Of that number, about 30 to 35 homes sustained major damage or were destroyed. Two county timber bridges were washed away. A historic double stone arch bridge at Lake Vesuvius was severely damaged. It was built in the 1930s. Several private bridges and culverts were also damaged or destroyed, creating access issues. One school was damaged along with some churches. Debris, including large boulders, also slid off unstable hillsides onto roads.

A lot of the damage was concentrated in the Storms Creek. That was along and near Route 93. Yet, even along Solida Creek north of South Point, damage occurred. Overall, Hampton, Upper, Elizabeth, and Fayette Townships reported the most damage in the county. Some of this same area was flooded during May of 2010.

(Summary continues on next page)

Report	Location	Date/Time (UTC)	Event Type

Thankfully, there were no fatalities in Lawrence County. One male resident along Route 93 woke up in a thunderstorm around 0100 EST. He was going to back his truck out of the garage and drive to check on another property. The electricity was out. Luckily, he got a flashlight and noticed his private driveway bridge was washed away before attempting to leave.

24	**Cabell County (WV)** Huntington 0.6 E Huntington Newlon Airport 0.6 N Dudley Gap 1.0 W Salt Rock	07/21/10 0215 07/21/10 0415	**Flash Flood (due to Heavy Rain)**

Minor street and stream flooding occurred. Several roads were closed with one to two feet of water covering them. Flooding to dwellings was limited to runoff of seepage into basements.

25	**Kanawha County (WV)** St. Albans	07/21/10 0220	**Thunderstorm Wind (EG 50 kts)**

Several trees were blown down in the downtown area.

26	**Kanawha County (WV)** Charleston Elkview	07/21/10 0230	**Thunderstorm Wind (EG 50 kts)**

Several trees were blown down, some fell onto power lines.

27	**Kanawha County (WV)** Nitro 0.5 W Upper Falls 0.3 E Sproul 0.8 ENE West Charleston	07/21/10 0230 07/21/10 0830	**Flash Flood (due to Heavy Rain)**

A few residences in Saint Albans and near the town of Tornado received water in their homes. Street and underpass flooding was common. A water rescue was needed in the Rock Lake Drive underpass.

28	**Wayne County (WV)** 0.8 E Kenova 1.0 ENE Mineral Springs 2.1 NE Kiahsville 0.7 SSW Bowen	07/21/10 0230 07/21/10 1000	**Flash Flood (due to Heavy Rain)**

Report	Location	Date/Time (UTC)	Event Type

Streams such as Miller Fork, Wilson Creek, Toms Creek, and White Creek flooded roads. Water got around some mobile homes leaving debris next to their underpinnings. About a half-dozen private culverts under driveways were damaged. Residential gas meters were damaged by high water. Street flooding in Kenova caused vehicles to stall. There was at least one water rescue.

29	**Greenup County (KY)** South Shore York Bellefonte Greenup Grays Branch Limeville	07/21/10 0255 07/21/10 0945	**Flash Flood** **(due to Heavy Rain)**

Since the heaviest rains fell over the northern portions of the county, most of the stream and street flooding was concentrated near the Ohio River communities. Several roads were closed in Worthington and Greenup. There was a water rescue in Lloyd.

30	**Lincoln County (WV)** Alkol Mud Pleasant View NNW Griffithsville	07/21/10 0500 07/21/10 0900	**Flash Flood** **(due to Heavy Rain)**

The Left Fork of the Mud River folded Bulger Road an the local fire station.

31	**Boyd County (KY)** 1.0 WNW Summit 3.0 E Summit 3.0 E Boltsfork 2.0 W Boltsfork	07/21/10 0615 07/21/10 0915	**Flash Flood** **(due to Heavy Rain)**

Overflowing streams blocked roads, including portions of Route 5. However, damage to dwellings was minimal.

32	**Carter County (KY)** Olive Hill 1.1 SE Wesleyville 1.3 SSE Pactolus 1.5 NE Rosedale	07/21/10 0945 07/22/10 0245	**Flood** **(due to Heavy Rain)**

After a night of flash flooding, the larger streams and the Little Sandy River were still flooding across roads and fields. The crest at Grayson on the Little Sandy River was near 25 feet during the late afternoon on the 21st. Flood stage is 21 feet. Damage was minor compared to the earlier flash flooding.

Report	Location	Date/Time (UTC)	Event Type
33	**Greenup County (KY)** South Shore 1.0 W Load 2.0 S Argillite 2.0 SE Greenup	07/21/10 0945 07/22/10 0345	**Flood** **(due to Heavy Rain)**

High water lingered on the larger streams and the Little Sandy River, but with little damage. The crest on the lower portion of Tygart Creek was 19.9 feet compared to 24.4 feet back in the May 2010 flood.

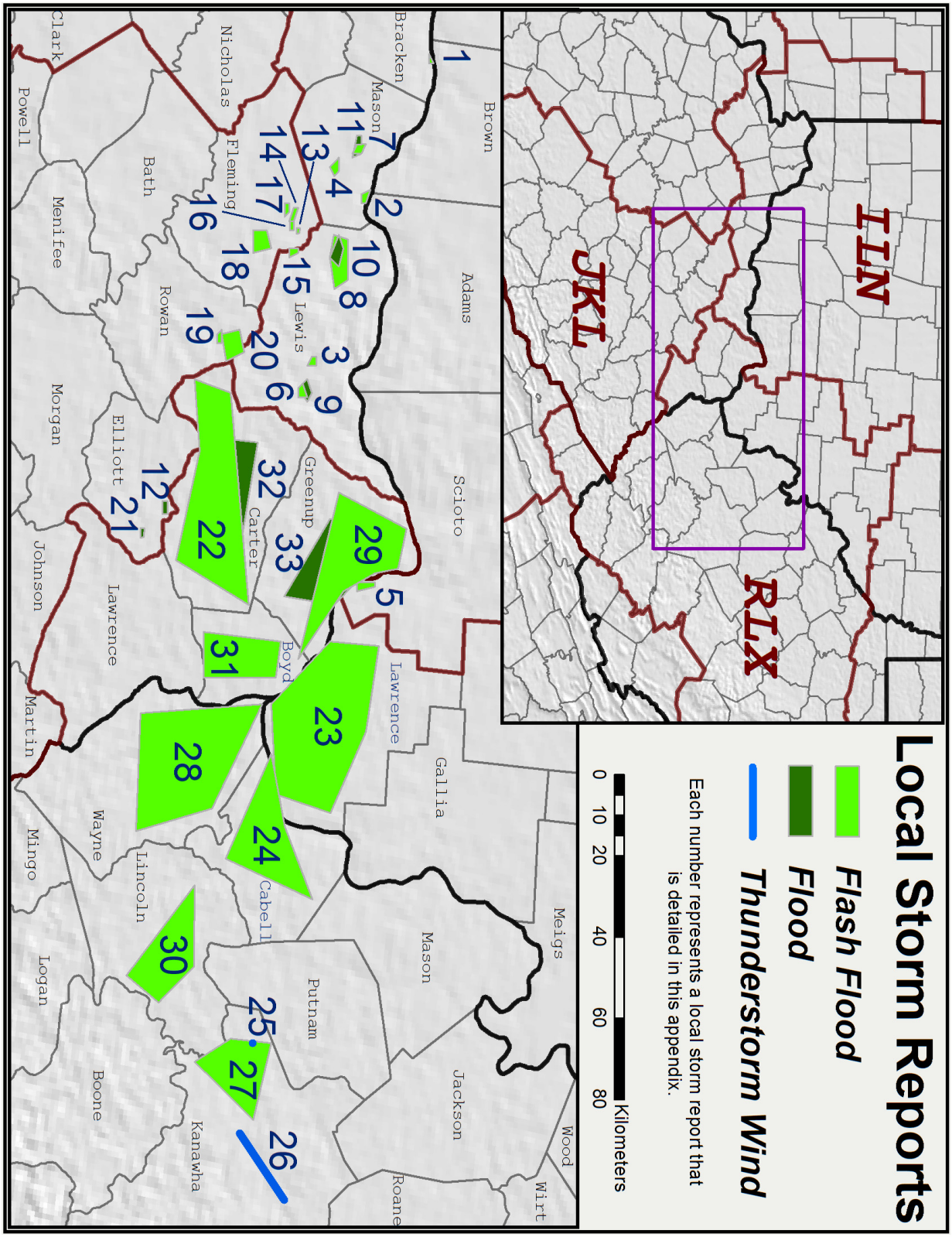
Well south of a frontal boundary, a moist and unstable air mass resided over the Ohio Valley. The ground was already wetter than normal from previous rains. A southwest and west wind along with daytime heating formed showers and thunderstorms during the afternoon of the 20th. Overnight, more storms formed along a leftover east to west boundary. That allowed for repetitive showers from portions of northeast Kentucky into extreme southern Ohio and western West Virginia.

The main period of rain was from around 1400 EST on the 20th to 0100 EST on the 21st. In northeast Kentucky, the highest rain totals were in western and southern portions of Carter County. The cooperative observer at Grayson Lake had 6.21 inches in the 24 hours ending on the morning of the 21st. Olive Hill measured 5.57 inches. Nearby, the automatic gauge at Globe had 5.2 inches. The cooperative observer at Grayson measured 3.37 inches. In Greenup County, Warnock had 2.45 inches but amounts increased toward the Ohio River. The city of Greenup measured 3.27 inches and the Greenup Lock and Dam had 2.96 inches.

The heaviest rain amounts ran west to east across Lawrence County. This rain maximum started near Hanging Rock and Pine Grove. The higher rain totals ran east to near Lake Vesuvius, Kitts Hill, Linnville, and Scottown. An automatic gauge at Kitts Hill measured a total of 4.47 inches of rain, with three inches falling in three hours. The rain total at Proctorville was 4.01 inches, while South Point measured 3.35 inches. The stream gauge at Aid along Symmes Creek jumped from six feet to a crest around 18 feet overnight.

In West Virginia, after some severe thunderstorms during the afternoon, water issues were the main concern overnight. The main period of rain was from mid-afternoon on the 20th into the predawn hours of the 21st. Rain amounts of three to four inches were common in parts of Wayne, Cabell, Lincoln, Putnam, and Kanawha Counties. The city of Wayne measured 3.84 inches of rain in the 24 hours ending at dawn on the 21st, with 1.75 inches falling in two hours. Pea Ridge and Saint Albans both measured around 3.5 inches.

IV. Storm Report Map - All CWAs



Appendix B: SPC Products

Provided here is the valid SPC Day One convective outlook for the nation. There were no severe weather watches or mesoscale discussion in effect for the ILN area during the simulation.

Convective Day 1 Outlook
Valid 210100 UTC - 211200 UTC

SPC AC 210102

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
0802 PM CDT TUE JUL 20 2010

VALID 210100Z - 211200Z

...THERE IS A SLGT RISK OF SVR TSTMS ACROSS PARTS OF THE CNTRL PLAINS...MID-MO VALLEY...MID-MS VALLEY...AND OH VALLEY...

...THERE IS A SLGT RISK OF SVR TSTMS ACROSS PARTS OF THE NRN PLAINS...

...THERE IS A SLGT RISK OF SVR TSTMS ACROSS PARTS OF THE UPPER GREAT LAKES...

...THERE IS A SLGT RISK OF SVR TSTMS ACROSS PARTS OF THE CNTRL AND NRN HIGH PLAINS...

...THERE IS A SLGT RISK OF SVR TSTMS ACROSS PARTS OF SE VA AND ERN NC...

...CNTRL PLAINS/MID-MO VALLEY/MID-MS VALLEY...
AN MCS IS ONGOING IN NE KS AND CNTRL MO LOCATED ALONG THE NRN EDGE OF STRONG INSTABILITY WITH OBJECTIVE ANALYSIS SHOWING MLCAPE VALUES JUST SOUTH OF THE BOWING LINE-SEGMENT IN THE 2500 TO 4000 J/KG RANGE. THIS COULD FUEL THE LINE ESEWD ACROSS THE REMAINDER OF MO INTO SRN IL THIS EVENING. THE ST LOUIS WSR-88D VWP SHOWS UNIDIRECTIONAL WINDS WITH 20 TO 30 KT OF FLOW AT 1 TO 2 KM. THIS ALONG WITH SFC DEWPOINTS IN THE UPPER 70S F AND STEEP LOW-LEVEL LAPSE RATES SHOULD RESULT IN A WIND DAMAGE THREAT WITH THE MCS EARLY THIS EVENING. HAVE MAINTAINED A SMALL 30 PERCENT WIND PROBABILITY IN ERN MO AND SRN IL ALONG THE EXPECTED TRACK OF THE MCS.

FURTHER WEST...ACROSS THE CNTRL HIGH PLAINS...A PRONOUNCED LOW-LEVEL JET WILL STRENGTHEN THIS EVENING WITH SCATTERED THUNDERSTORMS POSSIBLY DEVELOPING ALONG THE NOSE OF THE LOW-LEVEL JET IN NRN KS AND SERN NEB. STEEP MID-LEVEL LAPSE RATES AND MODERATE DEEP LAYER SHEAR SHOULD BE SUFFICIENT FOR A SEVERE THREAT TONIGHT WITH THE STRONGER CELLS SO HAVE MAINTAINED THE SLIGHT RISK IN THIS AREA. A FEW SEVERE STORMS WILL ALSO BE POSSIBLE THIS EVENING ACROSS SE CO WHERE OBJECTIVE ANALYSIS SHOWS 2500 TO 3500 J/KG OF MLCAPE AND 40 KT OF DEEP LAYER SHEAR.

...NRN PLAINS...
SCATTERED THUNDERSTORMS ARE ONGOING IN NRN ND JUST AHEAD OF A SHORTWAVE TROUGH EVIDENT ON WATER VAPOR IMAGERY. THIS ACTIVITY IS LOCATED IN A POCKET OF MODERATE INSTABILITY WITH OBJECTIVE ANALYSIS SHOWING MLCAPE VALUES IN THE 1500 TO 2000 J/KG RANGE ACROSS NRN AND ERN ND. THIS COMBINED WITH 40 TO 50 KT OF DEEP LAYER SHEAR AND STEEP MID-LEVEL LAPSE RATES SHOULD SUPPORT A THREAT FOR HAIL WITH THE MORE INTENSE CORES FOR A FEW MORE HOURS.

...UPPER GREAT LAKES...
A LINE OF THUNDERSTORMS IS CURRENT ONGOING FROM THE NRN END OF LAKE MICHIGAN SSWWD ACROSS FAR ERN WI AND IS JUST AHEAD OF A SHORTWAVE TROUGH EVIDENT ON WATER VAPOR IMAGERY OVER THE FAR WRN PART OF THE GREAT LAKES. OBJECTIVE ANALYSIS SUGGESTS THAT MODERATE INSTABILITY IS IN PLACE ACROSS NRN LOWER MI AND THIS MAY HELP CONVECTION TO REINTENSIFY AFTER CROSSING LAKE MICHIGAN. HAIL AND STRONG GUSTY WINDS WILL BE POSSIBLE ESPECIALLY WITH THE MORE INTENSE SHORT BOWING LINE-SEGMENTS. HAVE MAINTAINED A SMALL SLIGHT RISK ACROSS NRN LAKE MI AND PARTS OF WRN LOWER MI.

...SE VA AND ERN NC...
SCATTERED THUNDERSTORMS ARE ONGOING IN SERN VA AND ERN NC ALONG A SF TROUGH AND AXIS OF MODERATE TO STRONG INSTABILITY. OBJECTIVE ANALYSIS CURRENTLY SHOWS ABOUT 20 KT OF FLOW AT 850 MB WITH STEEP LOW-LEVEL LAPSE RATES. THIS ENVIRONMENT ALONG WITH UNIDIRECTIONAL WIND PROFILES SHOULD BE SUFFICIENT FOR A FEW DAMAGING WIND GUSTS WITH THE MORE INTENSE CELLS FOR A FEW MORE HOURS.

...UPPER OH VALLEY...
A CLUSTER OF STORMS CURRENTLY OVER NERN KY...SWRN OH AND SERN IND IS ONGOING ON THE NERN EDGE OF STRONG INSTABILITY AHEAD OF A SUBTLE SHORTWAVE TROUGH EVIDENT ON WATER VAPOR IMAGERY. THIS CONVECTION SHOULD CONTINUE TO MOVE EWD INTO THE CNTRL APPALACHIAN MTNS THIS EVENING WHERE REGIONAL WSR-88D VWPS SHOW 25 TO 30 KT OF 0-3 KM SHEAR. THIS ALONG WITH THE INSTABILITY SHOULD BE SUFFICIENT FOR STORM ROTATION AND A MARGINAL TORNADO THREAT MAY CONTINUE FOR

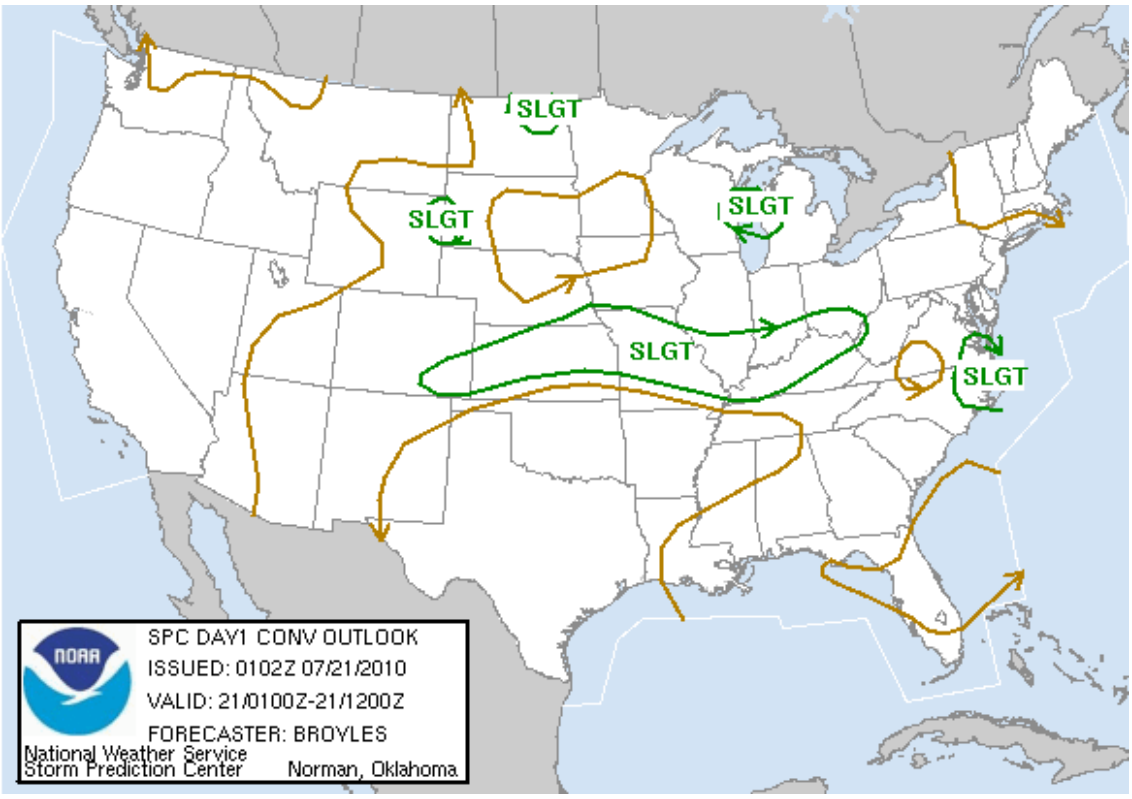
ANOTHER HOUR OR SO. STRONG GUSTY WINDS MAY ALSO ACCOMPANY THE MORE INTENSE CELLS.

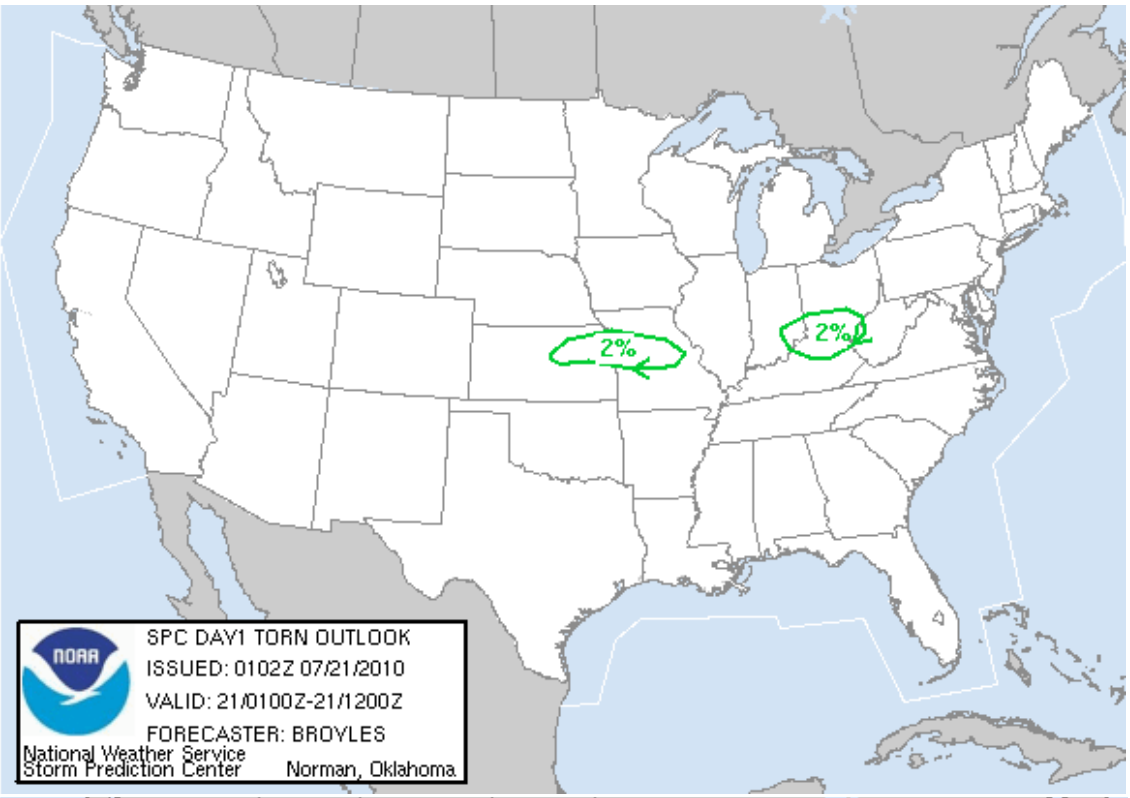
...CNTRL AND NRN HIGH PLAINS...
THUNDERSTORMS ARE BEGINNING TO DEVELOP ACROSS NE WY ALONG AN AXIS OF INSTABILITY. THIS CONVECTION SHOULD MOVE SEWD INTO THE BLACK HILLS AREA WHERE WSR-88D VWPS SHOW 50 TO 60 KT OF DEEP LAYER SHEAR. THIS ALONG WITH STEEP MID-LEVEL LAPSE RATES SHOULD BE SUFFICIENT FOR SUPERCELLS WITH LARGE HAIL. A WIND DAMAGE THREAT COULD ALSO ACCOMPANY THE MORE INTENSE CELLS ESPECIALLY IF A SHORT-LINE SEGMENT CAN ORGANIZE.

..BROYLES.. 07/21/2010

CLICK TO GET WUUS01 PTSDY1 PRODUCT

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 0600Z

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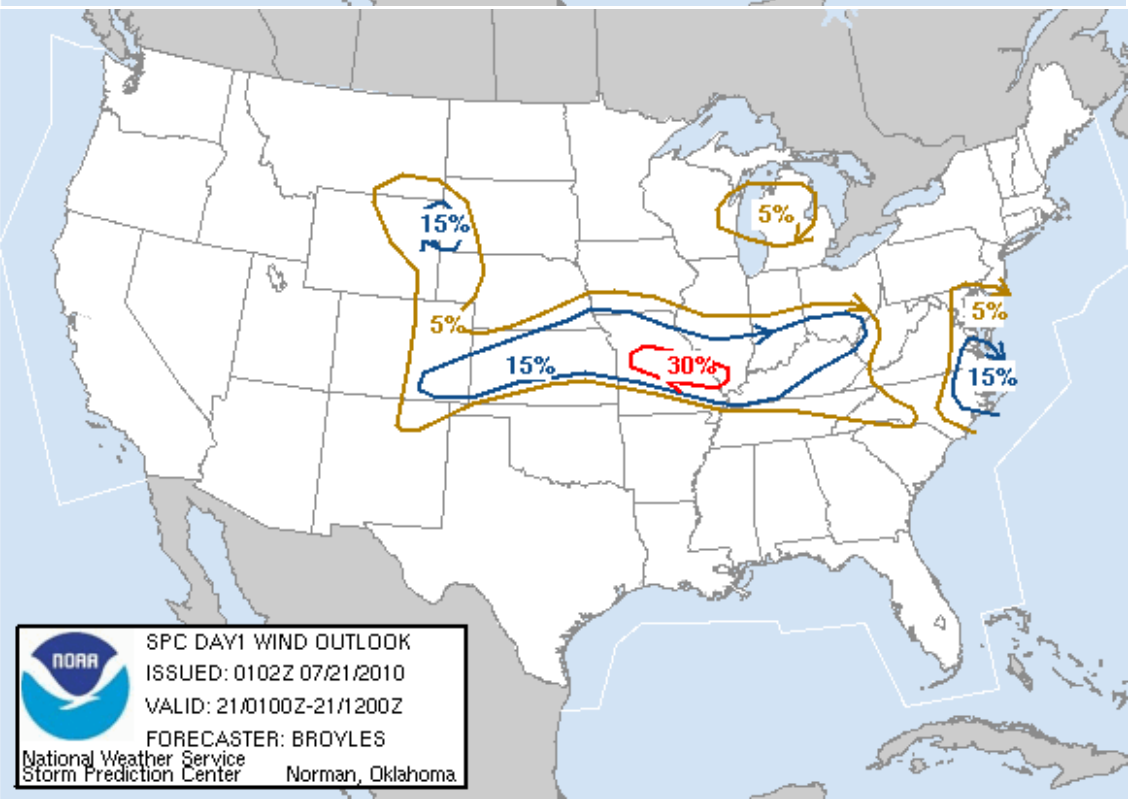
National Weather Service
Storm Prediction Center
Norman, Oklahoma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SPC DAY1 WIND OUTLOOK
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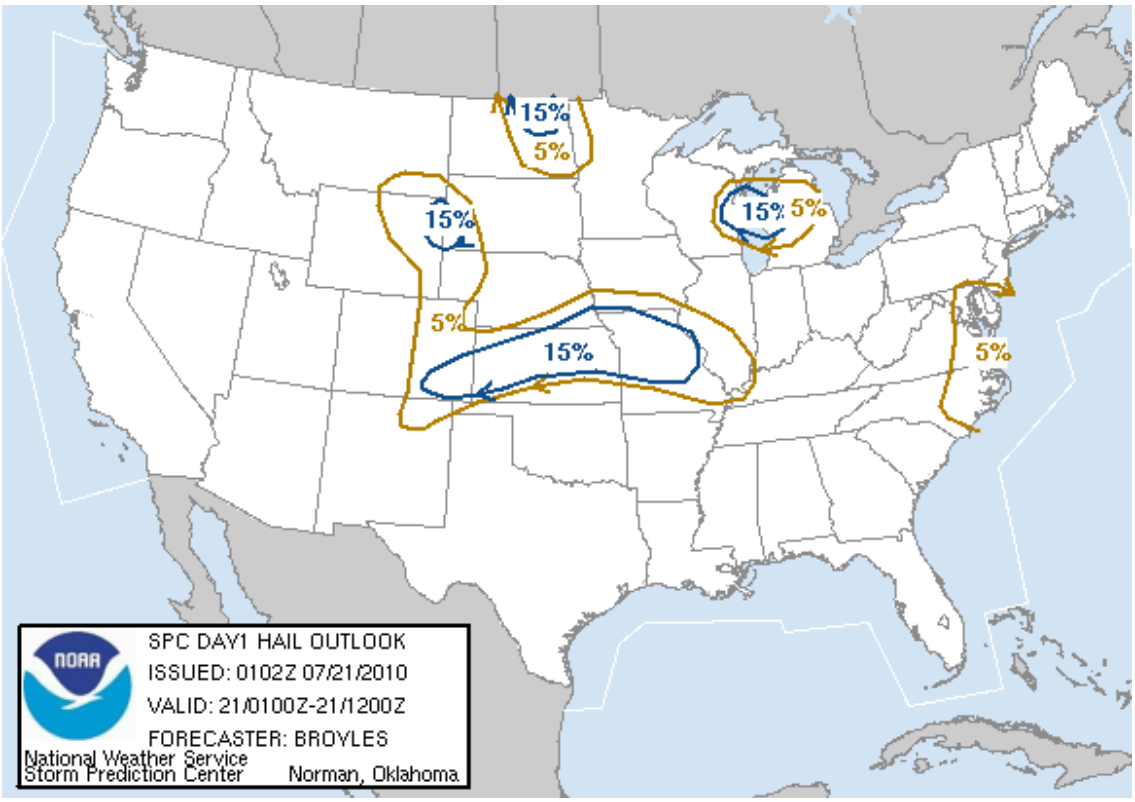
FORECASTER: BROYLES
National Weather Service
Storm Prediction Center
Norman, Oklahoma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5%
SPC DAY1 HAIL OUTLOOK
ISSUED: 0102Z 07/21/2010
VALID: 21/0100Z-21/1200Z
FORECASTER: BROYLES
National Weather Service
Storm Prediction Center
Norman, Oklahoma

Appendix C: HPC Products

I. Introduction

This section contains all of the relevant Hydrometeorological Prediction Center (HPC) precipitation products. These products are valid during the simulation or become valid at the end of the simulation. The products will be displayed by type in the following order in this Appendix:

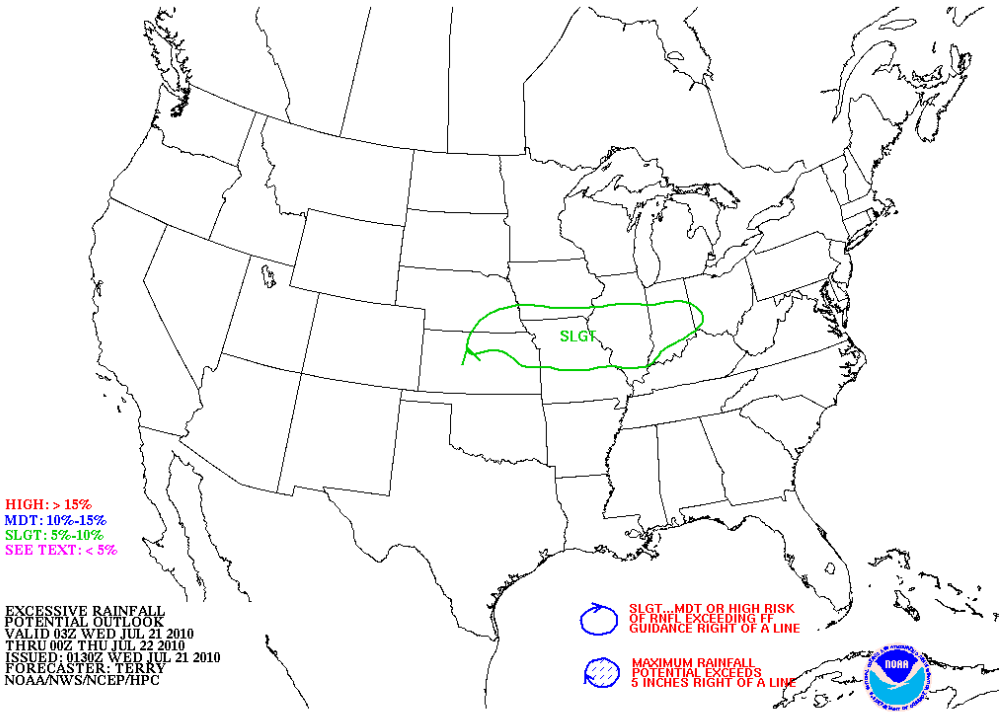
- **Excessive Rainfall Potential Outlook**
  - Graphic and Discussion -- Valid 0300 UTC 21 July to 0000 UTC 22 July
  - Graphic and Discussion -- Valid 0600 UTC 21 July to 1200 UTC 22 July
- **Quantitative Precipitation Forecast**
  - Issued Around 2200 UTC 20 July -- 6 HR QPF, 12 HR QPF, 24 HR QPF, and Discussion
  - Issued Around 0600 UTC 21 July -- 6 HR QPF, 12 HR QPF, 24 HR QPF, and Discussion

For the Excessive Rainfall Potential Outlook images, the colored contours and text represent the following probabilities:

- **SEE TEXT: LESS THAN 5% PROBABILITY**
- **SLGT: 5% - 10% PROBABILITY**
- **MDT: 10% - 15% PROBABILITY**
- **HIGH: GREATER THAN 15% PROBABILITY**

II. Excessive Rainfall Potential Outlook

Day 1 Outlook -- Valid 0300 UTC 21 July to 0000 UTC 22 July



EXCESSIVE RAINFALL DISCUSSION
NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD
957 PM EDT TUE JUL 20 2010

...VALID 03Z WED JUL 21 2010 - 00Z THU JUL 22 2010...
...REFERENCE AWIPS GRAPHIC UNDER...DAY 1 EXCESSIVE RAINFALL...

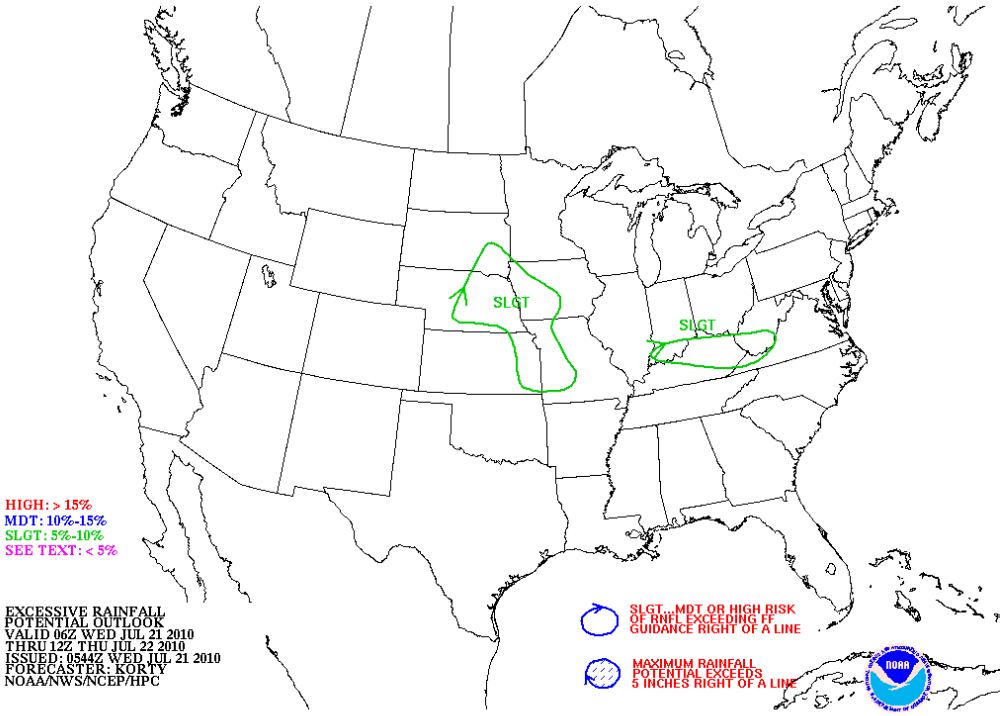
SLIGHT RISK OF RAINFALL EXCEEDING FFG TO THE RIGHT OF A LINE FROM
30 N HYS 40 SSE HDE 10 ENE HSI 25 SW FET AIO 20 SE OXV
15 WNW GBG 10 W C75 20 SW IKK 30 SE IKK 15 WNW GUS 25 NNE MIE
35 NNW DAY DAY 10 S MGY 10 WNW CVG 35 S BAK 15 N HNB 15 WNW EHR
MDH 20 WSW SAR 35 E VIH 10 SSW VIH 30 W AIZ 40 SW SZL 40 S IXD
20 E UKL 15 NE EMP 25 SSE MHK 30 W MHK 25 NNW SLN 25 ENE RSL RSL
30 N HYS.

THIS IS A LOW CONFIDENCE FCST..GIVEN QUITE VARYING MDL QPF
SOLNS..SO DIDN'T CHG THE PREVIOUS FCST MUCH AT ALL AND KEPT A LRG
AREA OUT GIVEN LOW FF GUIDANCE VALUES ALREADY IN PLACE. 00Z RAOBS

SHOWED AMS IS VRY MOIST AND UNSTABLE FM THE CNTRL PLAINS EWD INTO THE OH VLY..WITH PWS NR OR ABV 2 INCHES..AND AS HI AS 2.55 INCHES AT TOP..AND LIS AS LOW AS -8. THIS VRY MOIST AND UNSTABLE AMS..ALG WITH S/WVS MOVG ALG THE SRN EDGE OF THW WLYS..SUPPORTS THE CONTD THREAT OF CLUSTERS OF CNVCTN MOVG OUT OF THE CNTRL PLAINS EWD INTO PTNS OF THE MID/LWR OH VLY. PROB IS THAT MDLS ARE NOT IN AGREEMENT IN TIMING OF THE S/WVS..WITH THE GFS AGAIN CONTAMINATED BY FEEDBACK ISSUES..THUS THE MDL QPF SOLNS ARE ALL OVR THE PLACE. THINKING ATTM IS THAT CNVCTN WL CONT TO DVLP TUE NGT FM ERN KS/SERN NE INTO CNTRL/NRN MO AND SRN IA VCNTY OF SFC FNTL BNDRY AND IN AXES OF STGR LLJ/HIER PWS..WITH SOME WKR ACTIVITY TRYING TO MOV INTO PARTS OF THE LWR AND MID OH VLY. SOME LCL 1-2 INCH RNFL AMTS IN A COUPLE OF HRS AND 3+ INCH TOTALS THIS ENTIRE PD PSBL ESP ERN KS/ERN NE INTO MO AND SRN IA..WITH MORE ISOLD HVIER RAINS PSBL EWD INTO THE LWR AND MID OH VLY.

TERRY
$$

Day 1 Outlook -- Valid 0600 UTC 21 July to 1200 UTC 22 July



EXCESSIVE RAINFALL DISCUSSION
NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD
216 AM EDT WED JUL 21 2010

...VALID 06Z WED JUL 21 2010 - 12Z THU JUL 22 2010...
...REFERENCE AWIPS GRAPHIC UNDER...DAY 1 EXCESSIVE RAINFALL...

SLIGHT RISK OF RAINFALL EXCEEDING FFG TO THE RIGHT OF A LINE FROM
30 SSW BMG 25 SSW CVG HTS 20 N LWB 20 SSE LWB 10 WNW MKJ
30 NNE 1A6 20 SSW FTK 15 ESE EVV 15 SSW AJG 30 SSW BMG.

E/W ORIENTED MSTR CNVGNC AXIS STRETCHING ALONG THE OH RIV VLY EWD
INTO THE APLCNS COULD CONTINUE TO BE THE FOCUS FOR A NARROW BAND
OF HVY CNVCTV RAINS FOR THE NEXT 6 TO 12 HOURS. WEAK VORT NOW
ADVANCING EWD FM VICINITY OF SRN IL COULD ENHANCE CNVCTV DVLPMNT
ALONG THIS E/W AXIS HENCE THE SLGT RISK AREA OVR AREAS WHERE FFG
NUMBERS ARE RELATIVELY LOW. COULD SEE SPOTTY 2.00 INCH RNFL AMTS
IN A SHORT PD OF TIME GIVEN THE POTENTIAL FOR THE TRAINING OF CELLS.

SLIGHT RISK OF RAINFALL EXCEEDING FFG TO THE RIGHT OF A LINE FROM
35 SE ANW 30 W MHE 10 E HON 20 W BKX 25 NW SHL 15 NE SLB
10 ESE AMW OXV 25 SSE LWD CDJ 10 ESE DMO 15 S AIZ 20 E SGF JLN
10 WNW PPF 30 SSE EMP 25 WSW FOE 35 NNE MHK 15 WSW BIE
25 WSW HSI 20 S LXN 25 WNW LXN 35 SE ANW.

THE SLGT RISK AREA OVR THE CNTRL PLAINS/LWR MO VLY REGION IS A
COMBO OF TWO SEPARATE EVENTS. THE NORTHERN PORTION OF THE AREA FM
ERN NE INTO IA IS PRIMARILY A FUNCTION OF SYNOPTIC SCALE FORCING
AS SHRTWV ENERGY LIFTING NEWD FM THE CNTL ROCKIES HELPS TO LIFT HI
PWS POOLING IN A FVBL BAROCLINIC ENVIRONMENT LYING ACROSS THE
AREA. MODEL QPFS WHILE DISAGREEING ON EXACT PLACEMENT ALL AGREE
THE POTENTIAL EXISTS FOR SGFNT RNFL HERE. MEANWHILE...THE AREA
FARTHER TO THE SOUTH INVOF SERN KS/SWRN MO IS MORE DEPENDENT ON
MESOSCALE FORCING AS ONGOING CNVCTN INVOF CNTRL KS LEAVES A COOLER
POCKET OF AIR INVOF OF A WEAK SFC TROF TO AID THE LIFTING PROCESS.
THERE WILL BE CONTG STG NEWD FLUX OF MOIST AND UNSTBL AIR INTO
THIS REGION THRU THE NEXT 24 HRS OR SO WHILE BROADLY DIV FLOW
ALOFT WILL BE IN PLACE TO ENHANCE CNVCTV DVLPMNT. THIS AREA IS
OBVIOUSLY MORE SPECULATIVE THAN THE FIRST BUT SGFNT RNFL TOTALS
ARE POSSIBLE IF ONGOING CNVCTN CONTINUES OR REDVLPS LATER TODAY.
IN ANY CASE..EXPECT LOCALIZED 2.00 TO 3.00 INCH RNFL AMTS IN A FEW
HOURS ANYWHERE WITHIN THE TWO AFOREMENTIONED AREAS WITH SPOTTY
FIVE PLUS INCH TOTALS BEING POSSIBLE.

KORTY
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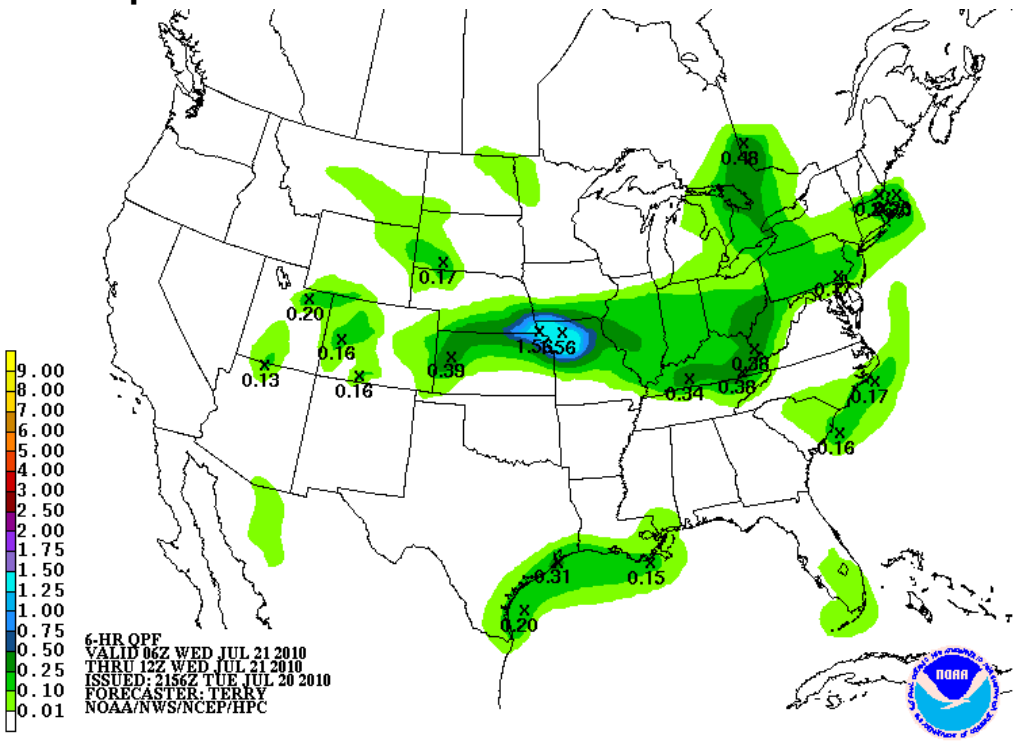
III. Quantitative Precipitation Forecasts

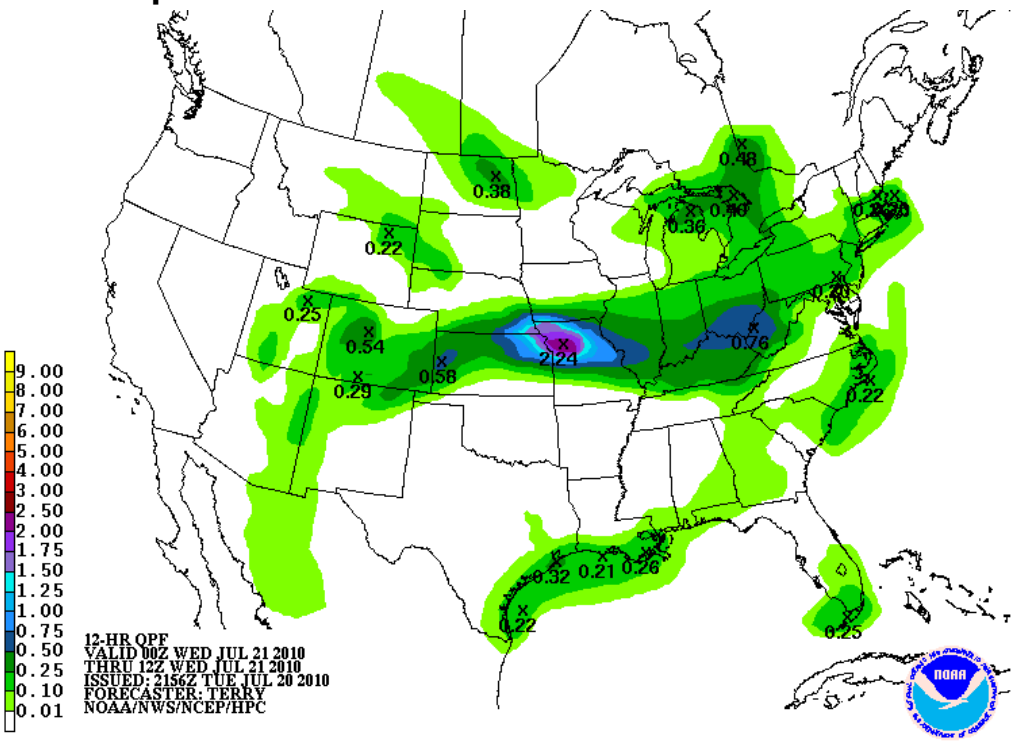
Products Issued Around 2200 UTC 20 July *(In Order Displayed)*

6 Hour QPF Graphic -- Valid 0600 UTC 21 July to 1200 UTC 21 July
12 Hour QPF Graphic -- Valid 0000 UTC 21 July to 1200 UTC 21 July
24 Hour QPF Graphic -- Valid 0000 UTC 21 July to 0000 UTC 22 July
Discussion

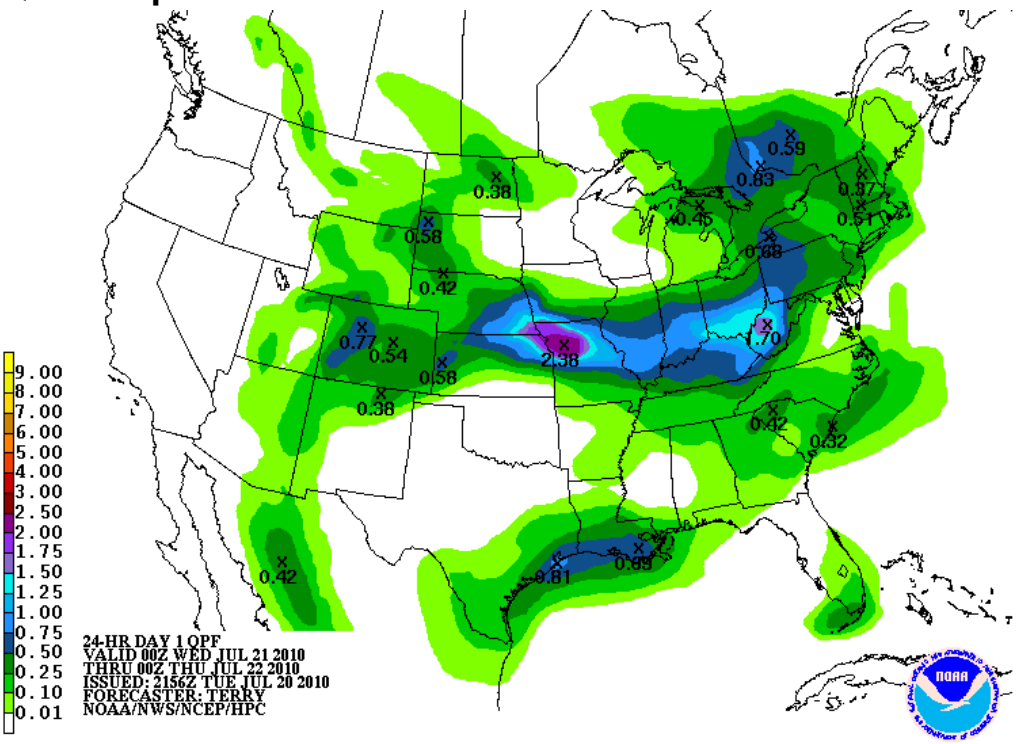
6 Hour QPF Graphic



12 Hour QPF Graphic



24 Hour QPF Graphic



QUANTITATIVE PRECIPITATION FORECAST DISCUSSION
NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD
559 PM EDT TUE JUL 20 2010

FINAL DAY 1...DAY 2 AND DAY 3 QPF DISCUSSION
VALID JUL 21/0000 UTC THRU JUL 24/0000 UTC
REFERENCE AWIPS GRAPHICS UNDER...PRECIP ACCUM - 24HR

THE 18Z MDL RUNS WERE IN VRY GOOD AGREEMENT WITH THE 12Z RUNS..AT LEAST MASS FIELD-WISE..SO MADE ONLY
MINOR CHGS TO THE PRELIM DAY 1 QPF..MSTLY ERY IN THE PD BASED ON RECENT RADAR IMAGERY/SATL PIX TRENDS.

DAY 1...

...CENTRAL PLAINS TO THE MID ATLANTIC...
ANOTHER SUMMER TIME DIURNAL CONVECTIVE CYCLE CHALLENGE ON DAY 1. PRE-EXISTING OUTFLOW BOUNDARIES AND A STALLED MOISTURE DISCONTINUITY/FRONT DRAPED FROM WEST TO EAST ACROSS THE PLAINS...TENNESSEE/OHIO VALLEYS AND THE CAROLINAS WILL BE THE FOCAL POINT FOR MERGING CLUSTERS OF SHOWERS AND THUNDERSTORMS FROM THE KS/NE BORDER EWD INTO CENTRAL/SOUTHERN ILLINOIS EARLY IN THE PERIOD. ONE OR MORE OF THE CLUSTERS WILL DEVELOP INTO A LONG-DURATION MCS LATE TONIGHT...THEN MOVE ALONG THE NRN FLANKS OF THE UPPER RIDGE ACROSS THE OHIO/TENNESSEE VALLEYS-CENTRAL APPALACHIA TO THE MID-ATLANTIC SHORELINE. LATE IN THE PERIOD...THE CONVECTIVE CYCLE RE-FIRES OVER THE CENTRAL PLAINS...AND FOLLOWING THE CONTINUITY OF THE PREVIOUS SHIFT...THE 18Z PACKAGE FOCUSED THE HEAVIEST RAINFALL OVER SERN NE/NW MO...THEN DOWNWIND/EASTWARD AS ELEVATED CONVECTION DEVELOPS ALONG AND NORTH OF THE SHARP MOISTURE/H85 WIND BOUNDARY/FRONT. SEVERAL AREAS OF ELEVATED CONVECTION DEVELOP IN THE LATTER HALF OF THE PERIOD...IE IN WESTERN/CENTRAL KS AND SRN OH/IN/NRN KY. HAD TO COMPROMISE BETWEEN THE GFS/NAM HERE...USING A GOOD DEAL OF THE LATEST HI-RES SOLUTION...ARW/HWRF GUIDANCE...TO SMOOTH OUT THE TIMING/STRENGTH DIFFERENCES BETWEEN MODELED MCS DEVELOPMENT CYCLES...AND DOWNWIND PROPAGATION ALONG THE MOISTURE DISCONTINUITY.

..UPPER MISSISSIPPI VALLEY EASTWARD TO THE GREAT LAKES...
MULTIPLE SHORTWAVES ORIGINATING IN TRICKY ZONAL FLOW WILL MOVE EASTWARD ALONG THE US/CANADIAN BORDER FROM SRN ALBERTA TO THE UPPER GREAT LAKES AND WRN ONTARIO BY THE END OF DAY 1. EARLY IN THE PERIOD...DIURNAL CONVECTION FIRES ALONG THE MT/ND BORDER THEN ATTEMPTS TO HOLD TOGETHER AS THE MID-LEVEL FORCING AND SPEED SHEAR ALOFT SUSTAINS ISOLATED TO SCATTERED SHOWERS THROUGH TONIGHT. THIS

AREA OF MID-LEVEL FORCING MIGRATES THROUGH THE UPPER GREAT LAKES ON WEDNESDAY...AND COMBINED WITH THE DIURNAL HEATING CYCLE...GENERATES A SECOND ROUND OF CONVECTION ACROSS WI/MI EWD INTO SRN ONTARIO. THE PRIMARY DIFFERENCE IN THE QPF SEEMS TO BE TIED TO THE DEPTH OF THE SHORTWAVE...IE HOW WELL IT CAN REMAIN ORGANIZED IN THE SFC-H85 LAYER...GIVEN THE ENVIRONMENT THIS WAVE IS APPROACHING IS FAIRLY STABLE. THE SECOND STRONGER SHORTWAVE COMBINED WITH LOCAL LOW-LEVEL WIND CONVERGENCE AND A SLIGHTLY COOLER AIRMASS ALOFT...GENERATES SOME MID-LEVEL WARM ADVECTION ACROSS THE NORTHERN HIGH PLAINS ON WEDNESDAY AFTERNOON WITH CONVECTION DEVELOPING ALONG THE SOUTHERN MTN RANGES OF SRN MT/NRN WY EWD INTO THE DAKOTAS. SOME QPF VARIANCE IN THE TIMING OF THE LEAD SHORTWAVE WEDNESDAY AFTERNOON ACROSS UPSTATE NEW YORK. MANUAL GRAPHICS BLENDING THE 12Z/NAM AND GFS-P HERE AND OVER THE NRN HIGH PLAINS IN ASSOCIATION WITH THE SECOND SHORTWAVE DURING THE LATTER HALF OF THE DAY 1 FORECAST PERIOD.

...DESERT SOUTHWEST...FOUR CORNERS TO THE CENTRAL ROCKIES...
GOOD AGREEMENT FOR A SLIGHT WWD RETROGRESSION OF THE MID/UPPER-LEVEL RIDGE ALONG 30-35N LAT INTO WEST TEXAS AND THE SRN PLAINS STATES...SHOULD BE ABLE TO GENERATE SOME MID-LEVEL MONSOONAL MOISTURE AND WEAK DYNAMICS AROUND THE WRN PERIPHERY OF THE RIDGE AXIS. THIS ALLOWS FOR DECENT OUTFLOW OFF THE HIGHER TERRAIN AND DOWNWIND INTO THE ADJACENT VALLEYS. HERE AGAIN...THE 12Z/NAM AND GFS-P HAVE A DECENT HANDLE ON THE HIGHER QPFS DURING THE HEATING CYCLE...WITH THE NAM PROBABLY A BIT OVERDONE...IE ITS SLOWER SOLUTION ALLOWING MORE MOISTURE FROM THE 4 CORNERS TO DRIFT NWD ALONG THE WYO/CO/UT BORDER. IN EITHER CASE/SOLUTION...CONFLUENCE IS CENTERED ALONG THE WEST AND SOUTHWEST FACING SLOPES OF THE DIVIDE...THEN CHANNELED EASTWARD INTO THE FRONT RANGE...WHERE LOCAL SFC FLOW AND UNSTABLE AIRMASS WILL BE IN PLACE TO PROMOTE ADDITIONAL CONVERGENCE...LIFT AND CONVECTION ACROSS THE CENTRAL HIGH PLAINS.

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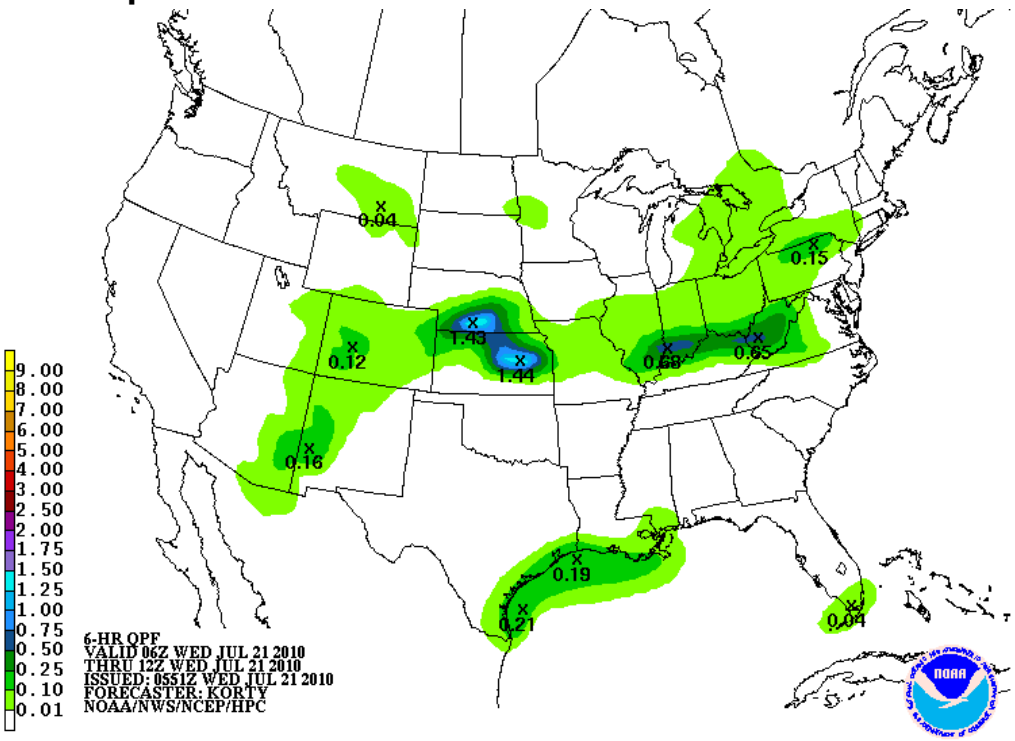
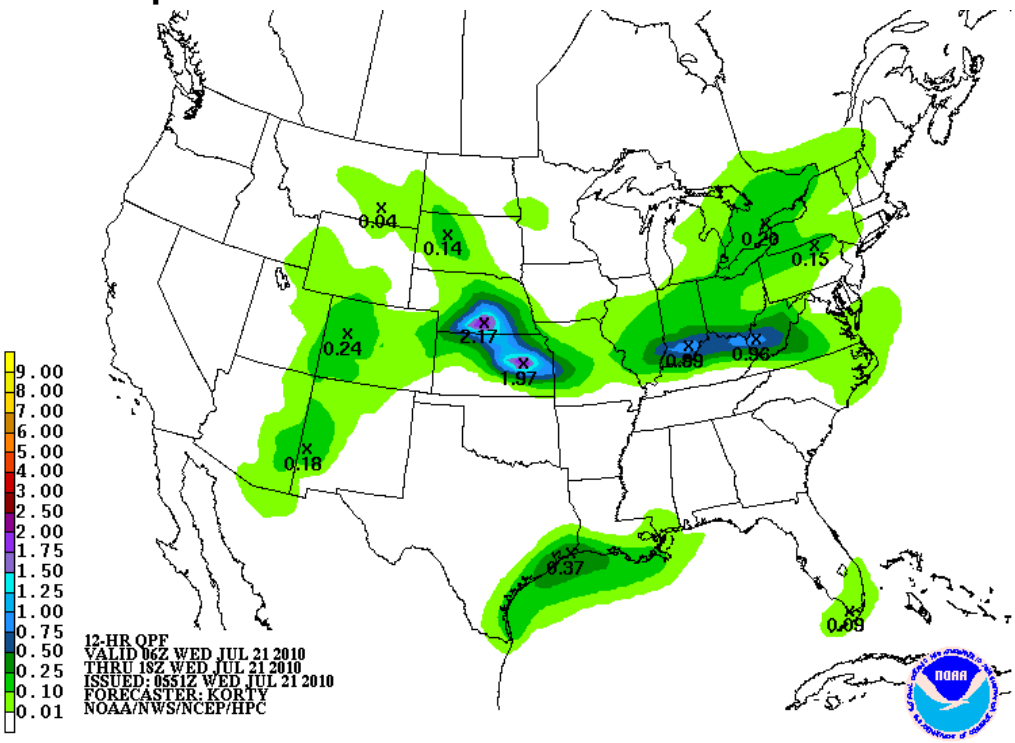
Products Issued Around 0600 UTC 21 July *(In Order Displayed)*

6 Hour QPF Graphic -- Valid 0600 UTC 21 July to 1200 UTC 21 July
12 Hour QPF Graphic -- Valid 0600 UTC 21 July to 1800 UTC 21 July
24 Hour QPF Graphic -- Valid 0000 UTC 21 July to 0000 UTC 22 July
Discussion

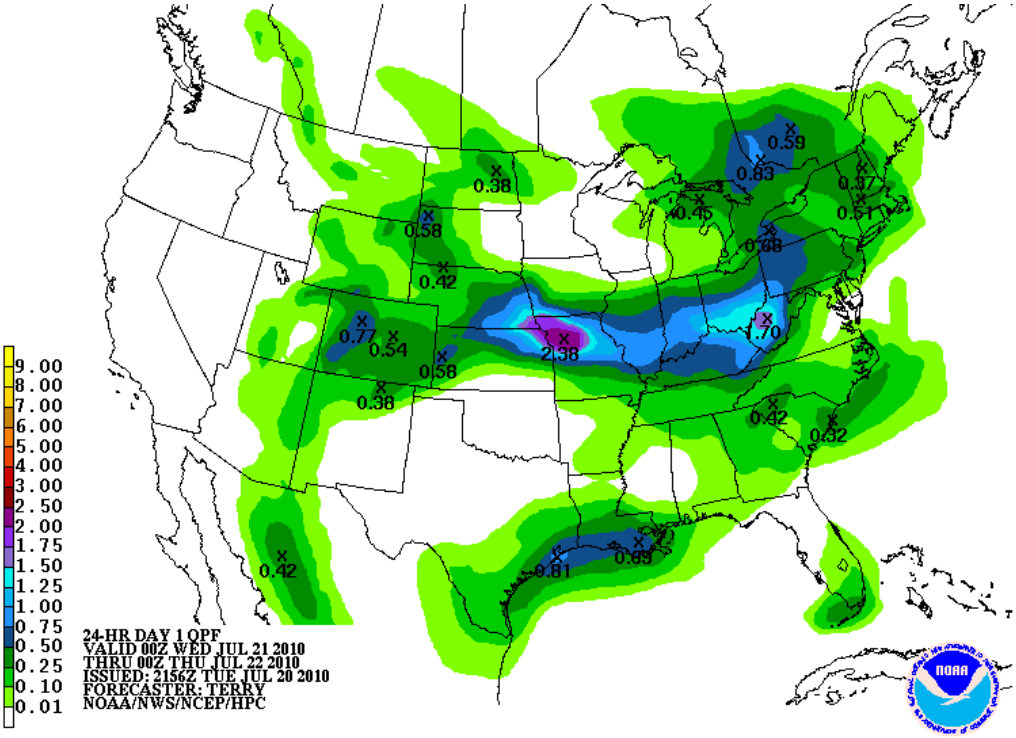
6 Hour QPF Graphic



12 Hour QPF Graphic



24 Hour QPF Graphic



QUANTITATIVE PRECIPITATION FORECAST DISCUSSION
NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD
251 AM EDT WED JUL 21 2010

PRELIM DAY 1 QPF DISCUSSION
VALID JUL 21/1200 UTC THRU JUL 22/1200 UTC
REFERENCE AWIPS GRAPHICS UNDER...PRECIP ACCUM - 24HR

DAY 1...

...OH VLY TO CNTRL APLCNS..

E/W ORIENTED MSTR CNVGNC AXIS STRETCHING ALONG THE OH RIV VLY EWD INTO THE APLCNS COULD CONTINUE TO BE THE FOCUS FOR A NARROW BAND OF HVY CNVCTV RAINS. WEAK VORT NOW ADVANCING EWD FM VICINITY OF SRN IL COULD ENHANCE CNVCTV DVLPMNT ALONG THIS E/W AXIS RESULTING IN VERY HVY RNFL TOTALS. IN ADDITION..MSTR CNVGNC AHEAD OF CDFNT PUSHING SWD INTO OH VLY LATER TODAY AND EVNG COULD SET THE STAGE FOR ANOTHER ROUND OF SHWRS AS HGT FALLS CONTRIBUTE TO THE DYNAMIC FORCING.

...CNTRL U.S...

AREA OF SGFNT RAIN OVR THE CNTRL U.S. IS A COMBO OF TWO SEPARATE EVENTS. THE NORTHERN PORTION OF THE AREA INVOF THE NRN/CNTRL PLAINS AND UPPER MIDWEST IS PRIMARILY A FUNCTION OF SYNOPTIC SCALE FORCING AS SHRTWV ENERGY LIFTING NEWD FM THE CNTL ROCKIES HELPS TO LIFT HI PWS POOLING IN A FVBL BAROCLINIC ENVIRONMENT LYING ACROSS THE AREA. MODEL QPFS WHILE DISAGREEING ON EXACT PLACEMENT ALL AGREE THE POTENTIAL EXISTS FOR SGFNT RNFL HERE. QUESTION REMAINS WHETHER THE MODEL QPFS WILL AGAIN BE DISPLACED TOO FAR NORTH WITH THE EVENT AS HAS BEEN THE CASE FOR THE PAST SEVERAL DAYS. FOR NOW OPTED TO STAY ON THE SRN EDGE OF GUIDANCE GIVEN RECENT HISTORY. MEANWHILE..THE AREA FARTHER TO THE SOUTH INVOF ERN KS/WRN MO IS MORE DEPENDENT ON MESOSCALE FORCING AS ONGOING CNVCTN INVOF CNTRL KS LEAVES A COOLER POCKET OF AIR INVOF OF A WEAK SFC TROF TO AID THE LIFTING PROCESS. THERE WILL BE CONTG STG NEWD FLUX OF MOIST AND UNSTBL AIR INTO THIS REGION THRU THE NEXT 24 HRS OR SO WHILE BROADLY DIV FLOW ALOFT WILL BE IN PLACE TO ENHANCE CNVCTV DVLPMNT. THIS AREA IS OBVIOUSLY SPECULATIVE GIVEN MODELS OFFER LITTLE SUPPORT FOR THE SCENARIO THOUGH SOME OF THE MODEL RH FIELDS OFFER A HINT AT THE POTENTIAL HERE.

...NERN PORTION OF NATION...

STG SHRTWV TROF AND ASOCTD CDFNT WILL PRESS ACROSS THE NERN U.S. TODAY TRIGGERING WIDESPREAD SHWR ACTVTY. MODEL QPFS OFFERING ALL TYPES OF VARIATION TO THE RNFL POTENTIAL HERE AND FOR NOW ATTEMPTED TO USE THE GFS PARALLEL MASS FIELD DETAILS...AS WELL AS WHERE THERE WAS SOME MODEL QPF AGREEMENT FOR THE PLACEMENT HERE.

...SWRN U.S TO THE CNTRL ROCKIES...

AMPLE MSTR...WEAK PIECES OF SHRTWV ENERGY LIFTING NEWD ACROSS THE AREA AND WEAKLY FVBL RT ENTRANCE REGION JET DYNAMICS SHOULD SET THE STAGE FOR CONTG SHWRS ACROSS THE AREA.

...NRN PORTION OF ROCKIES EWD TO THE NRN PLAINS...

NRN STREAM SHRTWV ENERGY SHEARING EWD THRU FAST WLY FLOW WILL TRIGGER SHWRS ACROSS THIS WIDE AREA OF THE NATION. STAYED CLOSE TO THE GFS PARALLEL HERE FOR QPF WHICH HAS AHD SOME CONTINUITY FOR THE PAST FEW RUNS THOUGH WAS A LITTLE MORE CONSERVATIVE ON TOTALS.

KORTY
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Appendix D: WESSL File

```
#
#   WESSL Script - ILN Flash Flood
#
#   21 July 2010
#
#   Start: 0415 UTC
#   End: 0630 UTC
#

04:15:00 07/21/10 -text {The simulation has now started. Stand by for a Pre-Brief
Presentation...}


04:15:30 -command "firefox file:///data/awips/2010Jul21/wessl/PreBrief/player.html"


04:31:00 -text {A trained spotter named Paula has called to report a rainfall measurement of
1.00" over the past 20 minutes approximately three miles ESE of Tollesboro, KY. Paula has
received a storm total of 3.00" of rainfall so far.}
-image /data/awips/2010Jul21/wessl/images/0431.jpg


05:10:00 -text {Your office has placed phone calls for any flash flooding reports to the emer-
gency managers and local law enforcement offices of both Mason and Lewis Counties. So
far, they do not have much to report other than minor street flooding across their counties.}
-image /data/awips/2010Jul21/wessl/images/0510.jpg


05:15:00 -response -text {“How would you coordinate with WFO RLX and WFO JKL on the
potential flooding situation along your CWA borders?” Type your answer below in the pro-
vided text box.}


05:20:00 -text {At this point in the simulation, you should start issuing your flash flood warn-
ings for the area. Assume that there are previous warnings in effect, and that they are all
about to expire. Remember that your warning polygons should encompass the threat area
and downstream basins. Also, make sure you use appropriate wording and call-to-action
statements in your warning text.}
-image/data/awips/2010Jul21/wessl/images/FFW_Warngen.jpg
```

05:26:00 -text {This report came across the NWSChat from the Jackson, KY (JKL) WFO:

Residents in the town of Bruin, KY have called in to report three feet of water across Highway 7 in town.} -image /data/awips/2010Jul21/wessl/images/0526.jpg

05:29:00 -text {You have just made a phone call to the NWS WFO in Jackson, KY. You just asked the forecaster-in-charge if they have received any reports near their CWA border, since you are having difficulties in getting reports from counties within your CWA. Here is the forecaster's response:

"We just got off of the phone with the Fleming County Sheriff Office. Water has been entering homes in the towns of Dalesburg, Mt. Carmel, and Foxport. Evacuations are ongoing in all of these locations. Numerous local roads and highways are impassible, including KY Highway 57. Also, a bridge in the Mt. Carmel area is reported to have three feet of water flowing over it."} -image /data/awips/2010Jul21/wessl/images/0529.jpg

05:35:00 -text {A Mason County sheriff is reporting that numerous roads have been closed in Mason County due to high water. Some families have been evacuated from their home in eastern Mason County.} -image /data/awips/2010Jul21/wessl/images/0535.jpg

05:38:00 -text {A Lewis County sheriff is reporting that several roads across the southern half of Lewis County have been closed due to high water. This includes the city of Kinniconick, KY. Flood waters have also been reported entering homes near Tollesboro, KY.}
-image /data/awips/2010Jul21/wessl/images/0538.jpg

05:40:00 -response -text {“What factors should you consider when determining the use of a Flash Flood Emergency?” Type your answer below in the provided text box.}

05:45:00 -text {This report came across the NWSchat from the Charleston, WV (RLX) WFO:

The Greenup County emergency manager is reporting that most side roads in the town of Greenup, KY are impassable due to high water. Also, there was a water rescue in the town of Lloyd, KY.} -image /data/awips/2010Jul21/wessl/images/0545.jpg

05:56:00 -text {The Scioto County emergency manager called to report that multiple homes have been flooded in the area of Franklin Furnace, OH. Water rescues are ongoing in the area. There is also an unconfirmed report of a fatality along with others being injured.}
-image /data/awips/2010Jul21/wessl/images/0556.jpg

06:00:00 -text {Law enforcement officials in Mason County have called to report that roads have now been closed near the towns of Lewisburg and Marshall due to high water.}
-image /data/awips/2010Jul21/wessl/images/0600.jpg

06:02:00 -text {Here are a list of recent stage heights and trends for the area valid as of 0600 UTC. Data has been provided by the United States Geological Survey:

1) North Fork Licking River in Mt. Olivet, KY (Bracken Co.) -- Current stage is at 5.92 ft. The river has been rising at over 1 ft./hr. for the past three hours.

2) Kinniconick Creek at Tannery, KY (Lewis, Co.) -- Current stage is 8.27 ft. The creek has risen over 5.2 ft. since 0030 UTC and 1.3 ft. in the past hour.

3) Little Sandy River at Leon, KY (Carter, Co. - JKL CWA) -- Current stage is 10.3 ft. The river has been rising at a rate of 1.5 ft./hr. since 0300 UTC and has risen a foot in the past 30 minutes.} -image /data/awips/2010Jul21/wessl/images/Stages.jpg

06:05:00 -text {A message is coming across the HAM radio that fire fighters are responding to trapped residents and swift water rescues on Buckner Branch in Rowan County (JKL WFO). Some fire fighters from the Route 377 Fire Department are reporting that they cannot reach the station house because of the flooding.}
-image /data/awips/2010Jul21/wessl/images/0605.jpg

06:07:00 -text {This report came across the NWSChat from the JKL WFO:

An emergency manager near the town of Triplett, KY stated that swift water rescues are underway at trailer homes in the area.} -image /data/awips/2010Jul21/wessl/images/0607.jpg

06:10:00 -text {At this point in the simulation, you should start issuing your follow-up statements for the flash flood warnings you issued earlier. Remember to use the storm reports that you have received as a way to gauge the severity of the event along with the FFMP data and trends. Make sure you use appropriate wording and call-to-action statement in your statements, including the use of the "Flash Flood Emergency" wording as needed.}
-image /data/awips/2010Jul21/wessl/images/FFW_Warngen.jpg

06:29:00 -text {The simulation is now coming to an end. Stand by for a Post-Brief Presentation...}

06:29:30 -command "firefox file:///data/awips/2010Jul21/wessl/PostBrief/player.html"

Appendix E: Support Materials

This Appendix includes:

WES Installation and Run Simulation Instructions README file --- Page E-3

A map of the Wilmington, OH CWA --- Page E-5

A map of the Area of Interest --- Page E-6

Procedure Details:

Surface Analysis --- Page E-7
Precipitable Water and Moisture Transport --- Page E-8
Corfidi Vectors and Atmospheric Flow/Instability --- Page E-9
KILN WSR-88D Radar Analysis --- Page E-10
ILN FFMP Analysis --- Page E-11

A SADRT form for use during the simulation --- E-12

A student debrief worksheet --- E-13

A trainer debrief worksheet --- E-14

A sample warning log provided for use in the simulations --- E-15

WES Installation and Run Simulation Instructions

To install the WES exercises from the DVD:

1. Ensure that you are logged in as ***fxa*** in a terminal window on your WES machine.

2. Insert the DVD for this WES case into your DVD drive of your WES machine.

3. In the terminal window, change the directory to the DVD drive folder.

   EXAMPLE: ***cd /media/CDROM***

4. Run the install script found on this disk.

   csh install-2010Jul21-case.csh /media/CDROM /data/awips

   ##
   NOTE: If you decide to install the case in a directory other than /data/awips, please ensure that you create a symbolic link from the installation location to /data/awips. For example, if you installed the case into /wesdatamount, you would create the following link:

   ln -sf /wesdatamount/2010Jul21 /data/awips/2010Jul21
   ##

5. A prompt will appear in the terminal window asking if you want to proceed with the installation. Press ***y*** to continue.

6. When the completion message appears, type in the following commands before ejecting the disk:

   cd ..
   eject /media/CDROM/

7. Once this is finished, you will be ready to start the simulation. Please note that the case has already been converted to the displaced real-time (DRT) format and that the FFMP data has already been created for you.

To start the WES exercise:

1. Open a terminal window if one is not already open and start the simulation by typing in the command below:

   start_simulator

2. Click on '***Run Simulation***' in the WES Simulation window. A window will appear stating that all D-2D windows should be closed before starting. Ensure that all D-2D displays are closed and click '***OK***.'

3. To load the WES exercises, click on '***Load Saved Settings***' in the Simulation Entry window. Select the WES macro ***ILN-0415-21July2010***. Ensure that all the information is correct, including the WESSL script.

4. Click '***OK***' and wait for the WES Simulation Control window to appear. Ensure that the data are correct and click '***OK***.'

5. The WESSL script will start running and a window will appear asking for you to start a new D-2D session. To do this, open a new terminal window and type in the following command:

   start_awips

6. Ensure that the correct path and localization are selected (e.g., /data/awips/2010Jul21 ILN). Make sure that the '***Start AWIPS Text Workstation Control***' is also selected and click '***OK***.'

7. Ensure that the time in the D-2D is in real-time format. To change the time in the D-2D display, left-click on the time in the lower right corner of the screen. Click on '***Use current real time***' and then '***OK***.'

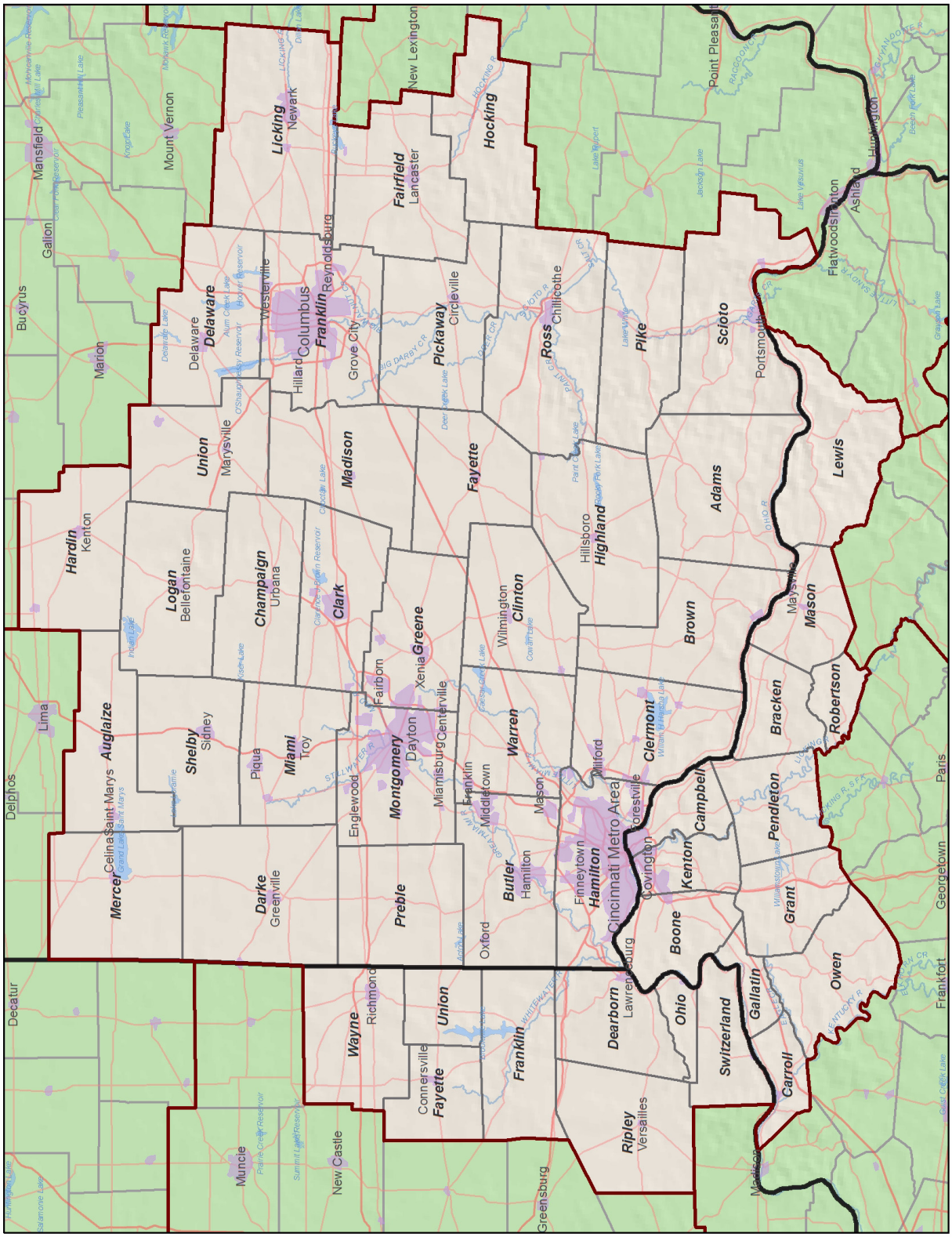

Figure E-1: A map of the Wilmington, OH (ILN) CWA.

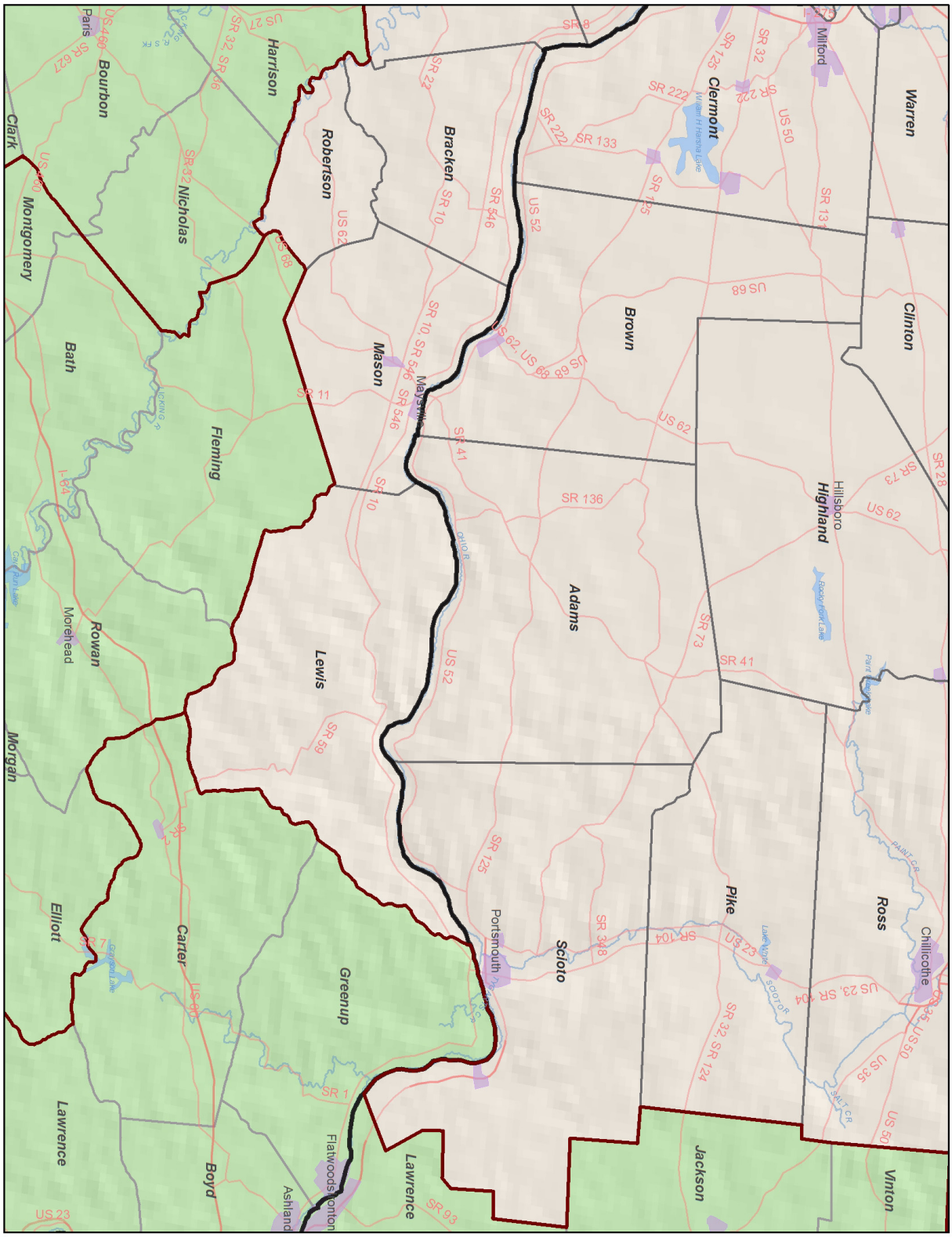

Figure E-2: A map of the Area of Interest for this case.

Procedure Details

Surface Analysis

Contents: This procedure will provide a basic surface analysis overlaid with GOES IR satellite images. Surface winds shown in streamlines will help in the identification of any boundary in the analysis, especially any quasi-stationary boundaries that are important to flash flooding.

Procedure Bundle: MesoAnalysis

Procedure Name: Sfc_Analysis

Model: RUC40

Procedure: Set a D-2D pane to a single-panel display and to the State scale. Load the following products into the D-2D display (in order):

-- GOES IR Satellite
-- METAR Observations
-- RUC40 Surface Winds (right-click on product and select “Load as Streamlines”)

Load the following from the *Maps* menu:

-- CWAs

Precipitable Water and Moisture Transport

Contents: This procedure will focus on the amount of precipitable water in the atmosphere and the low-level moisture transport for the region. In combination with the surface analysis, areas of enhanced and focused moisture flux and convergence at a quasi-stationary boundary can lead to repeated convective growth along the boundary.

Procedure Bundle: MesoAnalysis

Procedure Name: PW_MoistTrans

Model: RUC40

Procedure: Set a D-2D pane to a single-panel display and to the State scale. Load the following products into the D-2D display (in order):

-- 925-850 mb Moisture Transport Vectors (aka, Moisture Flux)
-- 925-850 mb Moisture Flux Divergence (contours and image)
-- Layer Precipitable Water

Load the following from the *Maps* menu:

-- CWAs

Corfidi Vectors and Atmospheric Flow/Instability

Contents: This procedure allows the user to analyze different ingredients that contribute to the flash flood potential. The four-panel display will assist in the analysis of Corfidi vectors, vorticity, moisture transport, convergence, CAPE, and frontogenesis.

Procedure Bundle: MesoAnalysis

Procedure Name: Corfidi_Vectors

Model: RUC40

Procedure: Set a D-2D pane to a four-panel display and to the State scale. Load the following products into the D-2D display (in order):

Top Left Pane:
- -- 850-300 mb Winds
- -- 850 mb Winds
- -- Corfidi Vectors
- -- Mosaic 0.5° Reflectivity

Top Right Pane:
- -- 925-850 mb Vorticity (load as image)
- -- 925-850 mb Winds
- -- 925-850 mb Moisture Transport Magnitude (aka, Moisture Flux Magnitude)

Bottom Left Pane:
- -- 0-3 km MUCAPE (contours and load as image)

Bottom Right Pane:
- -- 925-850 mb Divergence
- -- 925-850 mb Pettersen Frontogenesis (load as image)
- -- 925-850 mb Moisture Transport Vectors (aka, Moisture Flux)

KILN WSR-88D Radar Analysis

Contents: This four-panel display allows the student to view various base and derived precipitation products and compare it against an image toggle of one-hour and three-hour flash flood guidance. Here, the 0.5° reflectivity can be viewed along with the radar estimated one-hour and storm-total precipitation from the KILN WSR-88D.

Procedure Bundle: Radar_FFMP

Procedure Name: KILN_Analysis

Procedure: Set a D-2D pane to a four-panel display and to the WFO scale. Load the following products into the D-2D display (in order):

Top Left Pane:
-- KILN 0.5° Reflectivity

Top Right Pane:
-- KILN One-Hour Precipitation

Bottom Right Pane:
-- KILN Storm Total Precipitation

Bottom Left Pane:
-- One-Hour HPE Flash Flood Guidance (select Image Toggle)
-- Three-Hour HPE Flash Flood Guidance

Hold down the right mouse button and select “Load to All Panels.” Then load the following from the *Maps* menu:

-- CWAs
-- States
-- County Names
-- Cities
-- Urban Boundaries

ILN FFMP Analysis

Contents: This is a basic display created for the use of FFMP analysis during the simulation. Along with the small stream basins and basin links, this map will also display such things as county warning area boundaries and county names to help with the situational awareness. Remember to configure your FFMP once loaded for optimal use during the simulation.

Procedure Bundle: Radar_FFMP

Procedure Name: FFMP_ILN

Procedure: Set a D-2D pane to a single-panel display and to the WFO scale. Also set the number of frames for D-2D to a low number (preferably “1”). Load the following products into the D-2D display (in order):

-- FFMP ILN Table (select Image Toggle)
-- KILN 0.5° Reflectivity

Hold down the right mouse button and select “Load to All Panels.” Then load the following from the *Maps* menu:

-- FFMP Small Stream Basins
-- FFMP Small Stream Basin Links
-- CWAs
-- States
-- County Names

To configure your FFMP Table, select “*All & Only Small Basins*” from the Layer menu and “*Link to Frame*” from the Config menu.

Name _____ **SADRT- Situation Awareness Decision Requirements Table**

Stop Time:

Assessments so far?
What watches/warnings if any do you have out?
What are you worried about now?
What data is most important right now?
What data or information do you need that you're not getting? Are there any system status issues?
What is this situation going to look like in ( )hours/minutes?
What will be your next action?

Stop Time:

Assessments so far?
What watches/warnings if any do you have out?
What are you worried about now
What data is most important right now?
What data or information do you need that you're not getting? Are there any system status issues?
What is this situation going to look like in ( )hours/minutes?
What will be your next action?

Trainee_____ **Scenario Debrief Worksheet** Date_____ Trainer_____

Trainee Form

Challenges	**How am I doing?**				**Specific Examples from Scenario**
	Great	OK	Shaky	Clueless	
Science					
- Understanding/Applying Conceptual model					
- Discriminating severity					
Technology					
-Use of Applications (WARNGEN, FFMP, SCAN, procedures, etc)					
-Use of data sets					
Human Factors					
- Getting/Maintaining SA					
- Managing workload					
- Threat communication to public					
- Managing sectors/boxology					
What would you do different next time? (Filled out with trainer after debrief)					
Follow up actions you'd like to take:					

Trainee _____ **Observation and Assessment Record (OAR)** Date _____ Trainer _____

Trainer Form

Challenges	**Examples of what trainee is doing: Good**	**Examples of what trainee is doing: Other**
Science		
- Understanding/Applying Conceptual model		
- Discriminating severity		
Technology		
-Use of Applications (WARNGEN, FFMP, SCAN, procedures, etc)		
-Use of data sets		
Human Factors		
- Getting/Maintaining SA	.	
- Managing workload		
- Threat communication to public		
- Managing sectors/boxology		

Follow up actions:

Team Members: **Warning Log** **Today's Date**

_____/_____ Simulation Location/Date _____ Page #_____

Warning Type
Tornado - T
Svr Tstm - S
Flash Flood - F
Svr Wx Statement - SVS
Nowcast - **NOW**

List Basis for Warnings (In order of importance):
1 - Reflectivity; 2 - SRM; 3- Base Velocity;
4 - MESO; 5- TVS; 6 - VIL; 7- Precip; 8 - Other Alg
9 - Loop; 10 - Report; 11 - Other (explain)

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init.	ver

Basis:	Location and type of wx expected:

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init.	ver

Basis:	Location and type of wx expected:

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init.	ver

Basis:	Location and type of wx expected:

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init.	ver

Basis:	Location and type of wx expected:

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init.	ver

Basis:	Location and type of wx expected:

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init.	ver

Basis:	Location and type of wx expected:

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init.	ver

Basis:	Location and type of wx expected: