# Final Report: A Hydrometeorological Assessment of an Eastern Kentucky/Appalachian Flash Flooding

## University: Western Kentucky University

University Researcher: Dr. Rezaul Mahmood

NWS Offices: WFO at Louisville, KY and Jackson, KY

Name of NWS Researcher Preparing Report: Michael McLane and Christopher Smallcomb

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### Section 1: Summary and Project Objectives

Flash floods are considered one of the most serious natural disasters in the United States (Maddox *et al.*, 1979). They are also regarded as "one of nature's worst killers" (AMS, 2000, pg 1338). Eastern Kentucky (EKY) frequently experiences flash flooding (Bhaskar *et al.*, 1996) and resultant loss of property and lives. Local topography, along with meteorological forcing, enhances the magnitude of damages in EKY, presenting challenges to forecasters. *Therefore, this project investigated hydrometeorological conditions associated with flash flood events in EKY.*

*We selected the flash flood event of August 3, 2001 from a series of major events.* This particular event was selected because of the forecasting challenge it presented and the magnitude of damage (2 deaths; total property loss: $13 million). *Our communication with the Jackson, KY National Weather Service (NWS) Forecast Office and the feedback we have received also played an important role in this selection.* There is a lack of scientific studies on flash flooding in the Appalachian region. Hence, we expect that the analysis of this event will provide further insight into the development of the storm, its synoptic setting, role of terrain, and forecasting issues. In addition, this study will provide a better understanding of the processes associated with flash flooding in EKY. This, in turn, will aid forecasters during the prediction process and, hopefully, well-informed forecasts will save lives and reduce property damage in the future.

### Section 2. Project Accomplishment/Findings

We have taken the following steps to successfully complete this study. Observed data was analyzed in consultation with the Jackson, KY WFO. A number of MM5 model runs, to better understand the event, were completed in collaboration with the Louisville WFO.

- We have used data from various observation networks/platforms, including, coop, METAR, upper air, radar and satellite, along with model output to analyze the underlying conditions for this event.

- Evaluated land surface hydrology by assessing recent-past precipitation and stream data. This helped us to determine the role of the land surface for this flash flood event.

- We have tested the usefulness of the Kain-Fritsch and the Grell cloud parameterization schemes in simulating this event. Two different domain configurations were used for these runs. It was found that for this particular event Grell et al. scheme simulated development of the rain event relatively satisfactorily. Currently, we are performing additional sensitivity tests which are beyond the scope of this proposal. The results suggest that relatively benign condition with significant moisture supply can produce notable flash flooding and can be a challenge for the forecaster.

- The results agree with the Maddox framework for flash flooding that many of such events occur under not so spectacular meteorological events and become a forecasting challenge.

- This project allowed us to devote student and faculty time for making the MM5 operational at the Western Kentucky University for teaching and research. In our opinion it will have significant impacts on student learning in the future.

- Helped to initiate flash flooding and modeling related work at WKU in collaboration with the NWS.

- Christina Henry, a graduate student from Western Kentucky University, presented papers at the AMS Weather Analysis and Forecasting meeting in Washington, DC. She also presented a paper at a special session focusing on hydroclimatology. This session was sponsored by the Climate Specialty Group and Water Resources Specialty Group of the Association of American Geographers. She also presented papers at the annual meetings of the Kentucky Academy of Sciences and the Southeastern Division of the Association of American Geographers.

- Christina Henry is currently writing her MS thesis on this topic and planning to defend by the end of Fall, 2005 semester. You will be provided with a copy after completion.

- We plan to submit manuscripts to journals based on this work. You will be provided with copies after publication.

- Another graduate student (Mark Baldwin) started his thesis research on Appalachian Flash Flooding. In addition, one undergraduate student (Jessica Phillips) completed independent research on this topic. These are additional accomplishments.

- The activities related to this project opened up other opportunities of collaboration between WKU and the NWS.

**Section 3: Benefits and Lessons Learned: Operational Partner Perspective**

- Helped to formalize collaboration between WKU and the NWS in various educational activities.

- Provided the groundwork for future collaborative activities.

- Christina Henry presented a paper on preliminary findings at the NWS Jackson, KY Weather Forecast Office in June 2004. NWS Personnel attended the presentation by Christina Henry at NWS Jackson, KY detailing progress completed on the project to date. This presentation dovetailed well with ongoing heavy precipitation and flash flood interoffice teletraining and provided NWS staff increased awareness of contributing factors for heavy precipitation and flash flood events in the Appalachian region. An additional presentation, summarizing the final findings of the study, will be given to NWS Jackson, KY staff in December 2005 or January 2006.

- Research knowledge gained through this study was integrated by the NWS Jackson, KY Science and Operations Officer into a heavy precipitation / flash flood Weather Event Simulator (WES) case study, enhancing the training of forecast staff in heavy precipitation pattern recognition.

- NWS participants and WKU researchers collaborated in writing a conference paper and will participate in writing journal papers based on this research.

**Section 4**: **Benefits and Lessons Learned: University Partner Perspective**

- Several WKU students have begun additional research on other significant flash flooding events in Appalachia. Several have presented papers at various professional meetings (please see below).

- Students took the lead in writing professional papers.

- New course material on hydrometeorology of flash floods and their forecasting challenge was introduced into WKU's curriculum.

- This study helped initiate research in flash flooding and atmospheric modeling at WKU. In addition to the MM5, we are currently working towards implementing the RAMS model for further research.

- Helped in starting collaboration with the NWS. This will have a significant benefit to our activities (WKU student and faculty).

**Section 5: Presentations and Publications**

**Publications: Directly related to this project---**

Henry, C, Mahmood, R., Smallcomb, C., McLane, M., and Champlin, D. 2005. The evolution of a warm season severe eastern Kentucky flash flood. ***Proceedings of 21st Conference on Weather Analysis and Forecasting.*** American Meteorological Society, Boston. pp. 1-11. (www.ametsoc.org)

**Additional related publications (inspired by this project):**

Baldwin, W. M. and Mahmood, R. 2005. An assessment of key aspects of warm and cool season severe flash flooding in the Southern Appalachians. ***Proceedings of 21st Conference on Weather Analysis and Forecasting.*** American Meteorological Society, Boston. pp. 1-12. (www.ametsoc.org)

**Presentations: Directly related to this project---**

Paper, titled, "The evolution of a warm season severe eastern Kentucky flash flood" was presented at the **21st Meeting of the Weather Analysis and Forecasting**, Washington, DC, 1-5 August, 2005.

Paper, titled, "The life cycle of a warm season severe eastern Kentucky flash flood" was presented at the **101st Annual Meeting of the Association of American Geographers**, Denver, CO, 5-9 April, 2005.

Paper, titled, "The evolution of a severe eastern Kentucky flash flood" was presented at the **90th Annual Meeting of the Kentucky Academy of Sciences,** Murray, KY 4-6 November, 2004.

Paper, titled, "Life cycle of a severe eastern Kentucky flash flood" was presented at the **59th Annual meeting of Southeastern Division, The Association of American Geographers,** Biloxi, MS 21-23, November, 2004.

**Additional related presentations (inspired by this project):**

Paper, titled, "An assessment of key aspects of warm and cool season severe flash flooding in the Southern Appalachians" was presented at the **21st Meeting of the Weather Analysis and Forecasting**, Washington, DC, 1-5 August, 2005.

Paper, Title, "A meteorological comparison of a cool season and warm season flood Event in the Southern Appalachians" was presented by William Baldwin at the **Sigma Xi Student Conference** in Bowling Green, KY, 9th April, 2005. **WINNER OF THE SECOND PRIZE.**

Paper, titled, "An assessment of May 2, 2002 flash flood of Buchanan County, Virginia" was presented at the **101st Annual Meeting of the Association of American Geographers**, Denver, CO, 5-9 April, 2005.

Paper, titled, "An analysis of May 2, 2002 severe flash flooding of Buchanan county, Virginia" was presented at the **90th Annual Meeting of the Kentucky Academy of Sciences,** Murray, KY 4-6 November, 2004. **[Winner of the first prize: Student (Jessica Philips) paper competition]**

Paper, titled, "An investigation of May 2, 2002 flash flood of Buchanan county, Virginia" was presented at the **59th Annual meeting of Southeastern Division, The Association of American Geographers,** Biloxi, MS 21-23, November, 2004.

**Section 6: Summary of University/Operational Partner Interactions and Roles**

We believe significant collaboration was initiated between the University/Operational Partner partners based on this research project. The partners visited each others facilities, presented and wrote papers, exchanged research ideas, and discussed future collaborative activities. In summary, we suggest that this project has helped to foster intellectual exchange between the educational institution (WKU) and the NWS.

**Section 7: References**

Bhaskar, N. R., M. French, and G.K. Kyiamah. Characterization of Flash Floods in Eastern Kentucky. Copyright: 1996: Kentucky Water Resources Research Institute, University of Kentucky. http://www.uky.edu/WaterResources/WORKS11.HTML

Maddox, R., C. F. Chappell, and L.R. Hoxit. 1979. Synoptic and Meso-α Scale Aspects of Flash Flood Events. Bulletin of the American Meteorological Society. 60, 115-123.

The American Meteorological Society. 2000. Policy Statement: Prediction and Mitigation of Flash Floods (Adopted by the AMS Council on 14 February 2000). Bulletin of the American Meteorological Society. 81, 1338-1340.