J7.7 FLASH FLOOD MONITORING AND PREDICTION VERSION 2.0: CONTINUED AWIPS MODERNIZATION

M. Thomas Filiaggi*
Stephan B. Smith
Michael Churma
Meteorological Development Laboratory
National Weather Service
Silver Spring, Maryland

Lingyan Xin
SAIC
Silver Spring, Maryland

Mark Glaudemans
Hydrologic Research Laboratory
National Weather Service
Silver Spring, Maryland

1. INTRODUCTION

Flash floods cause more deaths than any other weather-related phenomena. There are a great many different hydro-meteorological paths that can lead to a flash flood. This fact, combined with the short-fused nature of the phenomena, makes flash flood prediction an extremely challenging operational forecast problem. With the completion of its modernization, the National Weather Service (NWS) is in a better position than ever before to address the flash flood problem in a comprehensive manner.

The National Quantitative Precipitation Information Plan (Office of Meteorology 1999) presents an extensive road map to improve flash flood monitoring and prediction. To meet these requirements in the Advanced Weather Interactive Processing System (AWIPS) Build 5 time frame (2000-2002), a joint software development team was formed for the purpose of creating and maintaining the Flash Flood Monitoring and Prediction (FFMP) hydrometeorological application within the Display-2-Dimensions (D2D; Biere 1998) user environment of AWIPS. This application is an outgrowth and merging of existing capabilities within the WFO Hydrologic Forecast System (WHFS; Roe et al. 1998) HydroView application and the System for Convection Analysis and Nowcasting (SCAN; Smith et al. 1998), as well as the Areal Mean Basin Estimated Rainfall algorithm (AMBER; Davis and Jendrowski 1996). The FFMP provides continuous monitoring of rainfall accumulation and its comparison to Flash Flood Guidance (FFG) for high resolution stream basins. It will provide NWS forecasters with automated alerts when a dangerous flood situation may be developing on a given stream or catchment.

* *Corresponding author address*: M. Thomas Filiaggi, MDL/NWS, SSMC2, 1325 East-West Highway, Silver Spring, MD 20910.
e-mail: Tom.Filiaggi@noaa.gov

By seamlessly integrating the flash flood information within the AWIPS D2D, NWS forecasters will be able to interpret the hydrologic threat within the context of the evolving meteorological situation. For example, a warning forecaster will be able to monitor the initiation and movement of thunderstorms that produce heavy precipitation (as detected by radar, satellite, and lightning observations) in and around small-scale stream basins. This information, combined with short-term quantitative precipitation estimates (also mapped into stream basins), can increase warning lead times and provide more precise identification of the flash flood-threatened areas (e.g. Davis 1998). Please see Figure 1. This paper describes the basic design of the FFMP, its history, and potential future directions.

2. FFMP VERSION 1.0

The initial version of the FFMP (Smith et al., 2000) software was released in AWIPS 5.0, beginning in January 2001. This early version was designed to be a coordinated set of tools within AWIPS that allowed the forecaster to analyze current precipitation observations and short-term forecasts in order to warn for impending flash floods that can threaten life and property**.** It utilized the Digital Precipitation Array (DPA) WSR-88D Doppler Radar product, Mean Areal Precipitation (MAP) hydrological watershed basins, and official Flash Flood Guidance (FFG) to monitor and analyze flash flood potential throughout the County Warning Area (CWA). Color coded displays in both tabular and geographic form alerted the forecaster to areas where the precipitation accumulations were significant, based on either the precipitation accumulation values or their comparisons to the FFG. All of these analyses and displays could be conducted for a 1 -, 3 -, or 6 - hour duration.

FFMP version 1.0 also contained an FFG display, the FFMP Data Monitor System (DMS), and a Flash Flood Threat Indicator (FFTI), which continuously monitored the area in the CWA for extensive precipitation. The FFMP DMS was a web-based product monitor that checked to make sure all data sets necessary for FFMP to perform optimally were available to AWIPS.

3. FFMP VERSION 2.0

The next version of the FFMP software has been released in AWIPS 5.1.2. But, whereas the foundation of FFMP Version 1.0 was the DPA radar product and the MAP hydrological basins, the foundation for FFMP Version 2.0 is the Digital Hybrid Reflectivity (DHR) WSR-88D Doppler Radar product and smaller hydrological basins.

The resolution of the DHR product is 1^{o} x 1 km on a polar grid. This is an improvement over the DPA product, which was used by FFMP 1.0 and has a resolution of approximately 4 x 4 km on a quasi-cartesian grid. Also, the temporal resolution of the radar data has improved. The DHR product provides precipitation rates for a single volume scan from which scan-to-scan accumulations can be computed. The DPA provides only an hourly accumulation for each volume scan.

The resolution of the smaller basins is on the scale of 2 to 10 square miles, another improvement over FFMP 1.0, whose MAP basins had a resolution of 60 to 100 square miles. These smaller basins were delineated by the National Severe Storms Laboratory for the entire Continental United States (Cox et al. 2001). Additionally, FFMP 2.0 makes use of gridded FFG, which began being transmitted by the River Forecast Centers across the country in 2001.

Such foundational changes provided the opportunity to re-design FFMP. FFMP mimics the data storage schema used by AMBER and makes use of additional AWIPS utilities, methods, and coding practices, such as progressive disclosure, to enhance the performance of workstations and servers on an AWIPS system. Additional user control and flexibility have also been added to make it easier for forecasters to make use of FFMP and the data it presents. (Please see Figures 3 and 4.)

FFMP Version 2.0 also provides the functionality to create a time trend for particular basins (see Figure 2). The Basin Trend provides comprehensive flash flood information for one basin at a time.

FFMP 2.0 retained the FFTI and FFMP DMS, with slight modifications.

4. FUTURE DIRECTIONS

The FFMP portion of AWIPS will become the basic, reliable tool for assisting forecasters with their flash flood decisions. The current version of FFMP will continue to be scrutinized for ways to improve performance and usability. Additional data sets, such as Rain Gage and Quantitative Precipitation Forecast (QPF) data (i.e., SCAN 0-1 hr QPF (Kitzmiller 1998), the 1-hr flash flood potential (Fulton and Seo 2000), the SCAN 0-3 hr QPF (Kitzmiller et al. 1999), the LAMP QPF (Charba 1998)) will be used to provide additional assistance to forecasters.

5. ACKNOWLEDGMENTS

The authors would like to thank Jeff Zimmerman, Tom Graziano, and Roger Pierce for their work in developing the requirements for SCAN/FFMP. We are gratefull to Bob Davis and Paul Jendrowski for the development and operational demonstration of AMBER as well as guidance in the design of the small-basin monitoring function of FFMP. The critical basin delineation work conducted by Ami Arthur, Gina Cox, and Ken Howard at NSSL is very much appreciated.

6. REFERENCES

Biere, M., 1998: The WFO-Advanced Two-Dimensional display software design. *Preprints 14th International Conf. on Interactive Information and Processing Systems*, Phoenix, Amer. Meteor. Soc., 376-379.

Charba, J. P., 1998: The LAMP QPF Products. Part I: Model Development. *Wea. Forecasting*, **13**, 934-965.

Cox, G. M., A. T. Arthur, D. L. Slayter, and N. R. Kuhnert, 2001: National basin delineation and flash flood database creation. *Preprints Symposium on Precipitation Extremes: Prediction, Impacts, and Responses,* Albuquerque, Amer. Meteor. Soc., 221-224.

Davis, R. D., 1998: Detecting the time duration of rainfall: A controlling factor of flash flood intensity. *Preprints Special Symposium on Hydrology*, Phoenix, Amer. Meteor. Soc., 258-263.

_____, and P. Jendrowski, 1996: The operational Areal Mean Basin Estimated Rainfall (AMBER) module. *Preprints 16^{5h} Conf. on Weather Analysis and Forecasting,* Norfolk, Amer. Meteor. Soc., 332-335.

Fulton, R. A., D.-J Seo, 2000: A prototype operational 0-1 hour radar-based flash flood potential algorithm. *Preprints 15th Conf. on Hydrology*, Long Beach, Amer. Meteor. Soc., (this volume).

Kitzmiller, D. H., 1998: The AWIPS 0-1 hour rainfall forecast algorithm. *Preprints 15th International Conf. on Interactive Information and Processing Systems*, Dallas, Amer. Meteor. Soc., 175-178.

_____, M. R. Lilly, and S. D. Vibert, 1999: Probabilistic 0-3 hour rainfall forecasts from an extrapolative-statistical technique utilizing radar, satellite, and lightning observations. *Preprints 29th Conf. on Radar Meteorology*, Montreal, Amer. Meteor. Soc., 876-879.

Office of Meteorology, 1999: The modernized end-to-end forecast process for quantitative precipitation information: Hydrometeorological requirements, scientific issues, and service concepts. NOAA, U.S. Dept. of Commerce, 187 pp.

Roe, J., M. Glaudemans, C. Gobs, P. Taylor, and J. Zimmerman, 1998: Implementation of modernized hydrologic operations and services in the National Weather Service: Overview and status. *Preprints Special Symposium on Hydrology*, Phoenix, Amer. Meteor. Soc., J25-J30.

Smith, S. B., J. Roe, M. T. Filiaggi, M. Glaudemans, M. E. Churma, L. Xin, and R. Erb, 2000: Flash flood monitoring and prediction in AWIPS Build 5 and beyond. *Preprints, 15th Conf. on Hydrology*, Long Beach, Amer. Meteor. Soc., 229-232

______, T. Graziano, R. Lane, W. Alexander., M. Eilts, J.T. Johnson, J. Wilson, R. Roberts, D. Burgess, D. Kitzmiller, R. Saffle, R. Elvander, S. Zubrick, J. Schaefer, S. Weiss, and D. Imy, 1998: The System for Convection Analysis and Nowcasting (SCAN). *Preprints 16th Conf. on Weather Analysis and Forecasting, 14th International Conf. on Interactive Information and Processing Systems*, Phoenix, Amer. Meteor. Soc., J22-J24.

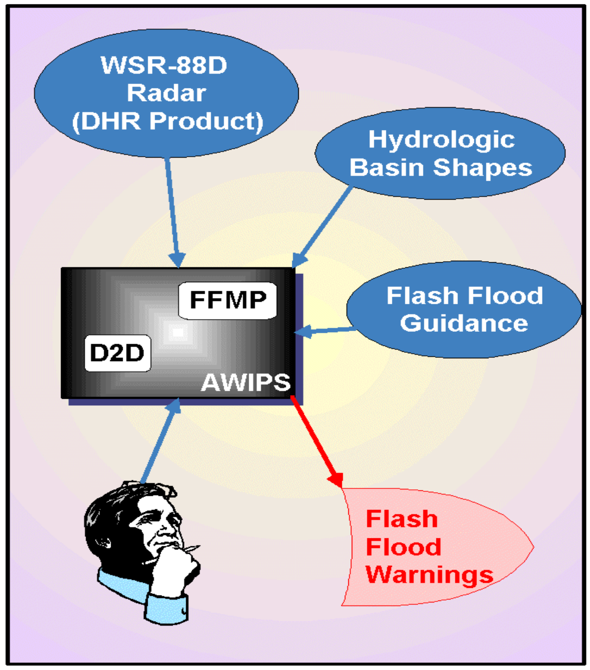


Figure 1 Basic flow diagram, describing how FFMP is used as a flash flood diagnostic tool.

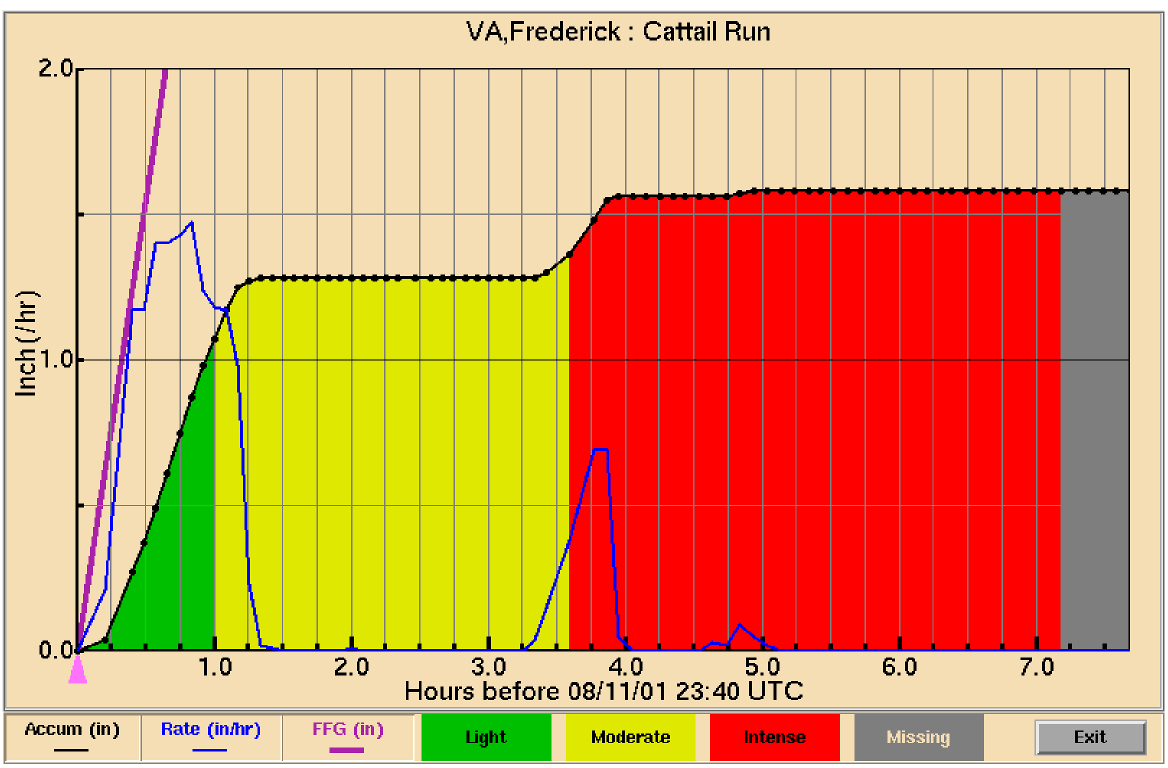
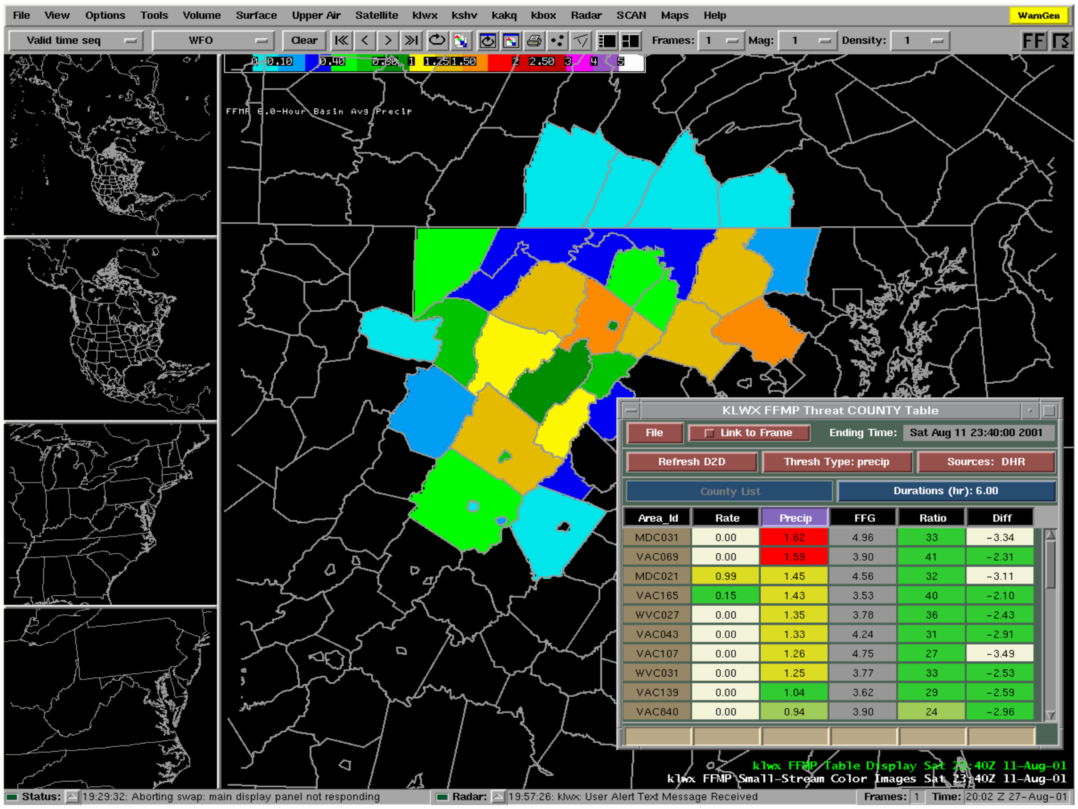
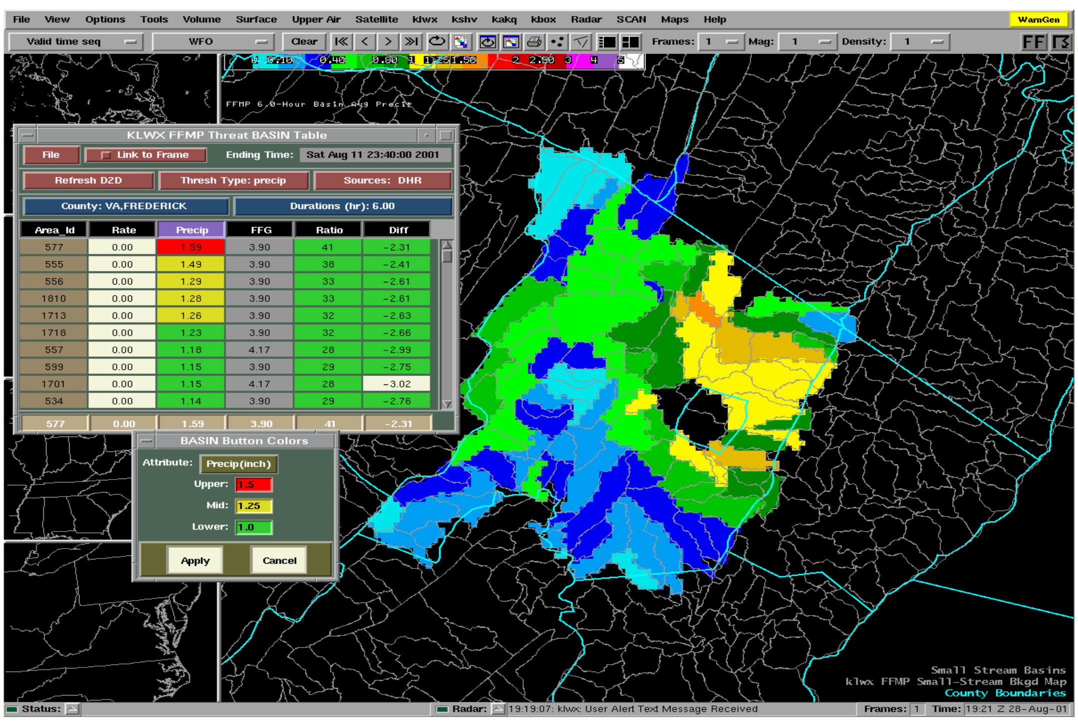


Figure 2 The Basin Trend for Cattail Run, a basin in Frederick County, Virginia. The colors are set to represent accumulated precipitation





Figures 3&4 AWIPS D2D display showing 6 - hour accumulated precipitation from the DHR product for both counties (top) and basins within a specific county (bottom). The Basin Tables are also shown, listing the data for all counties in the CWA (top) and basins in that same specific county (bottom). The forecaster will begin at the county scale, where the counties will be color coded according to the 'worst' basin it contains, then the forecaster can zoom in to investigate a specific county's basins.